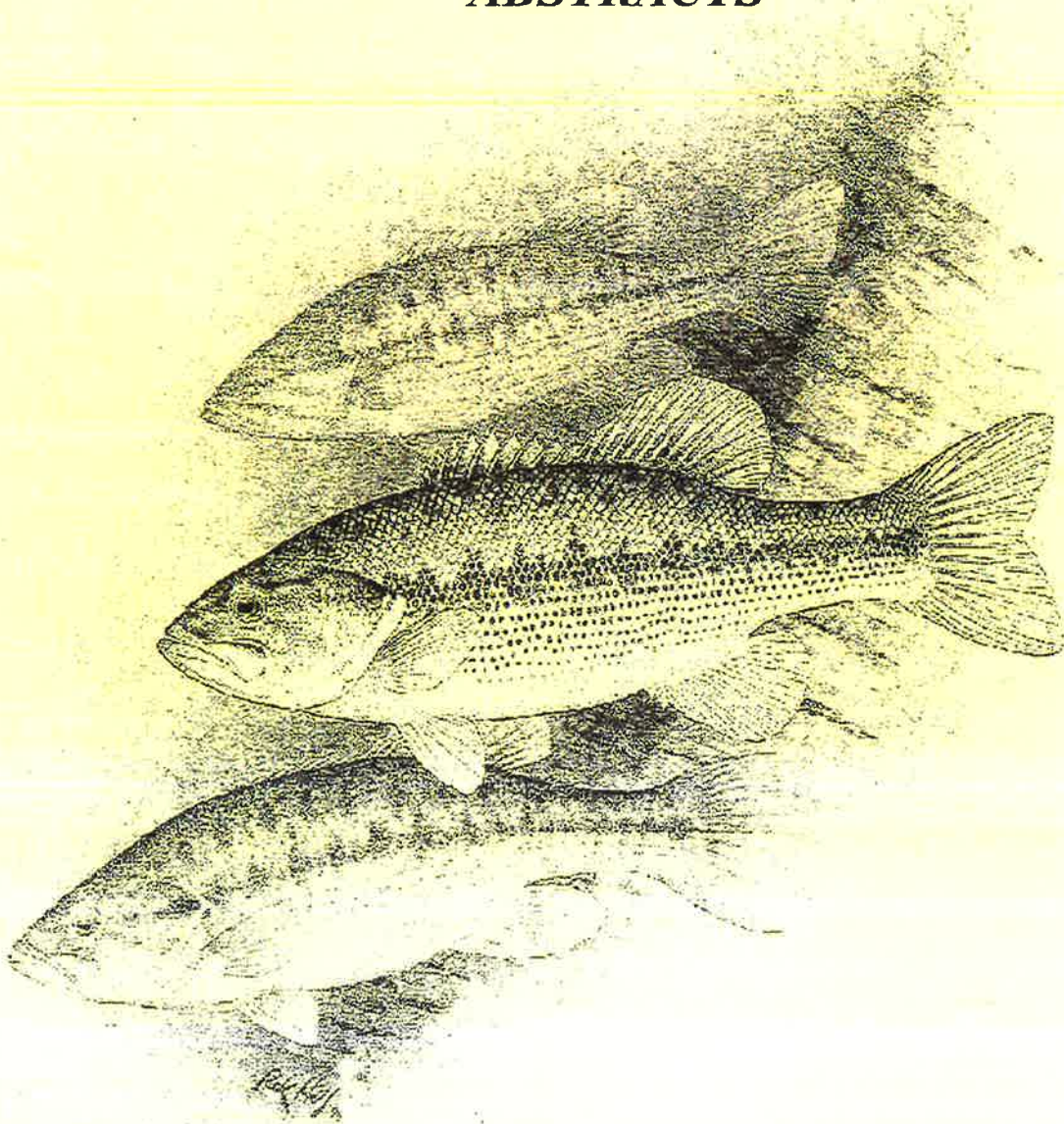

SOUTHERN DIVISION 1998 MIDYEAR MEETING

FEBRUARY 26 - MARCH 1, 1998

LEXINGTON, KENTUCKY

ABSTRACTS



Sponsored By:

Kentucky Department of Fish and Wildlife Resources

Kentucky Chapter of the American Fisheries Society

West Virginia Chapter of the American Fisheries Society

1998 Southern Division AFS Midyear Meeting Committee

Program Co-Chairmen Jarrad Kosa & Gerard Buynak

Local Arrangements Benjy Kinman
Tim Slone
Kerry Prather

Registration Scott Morrison

Fund Raising/Groveling Jeff Crosby
Bill Mitchell
Jarrad Kosa

Party Man Benjy Kinman

Supreme Commander Admiral Wayne Davis

Chief Engineer Bill Mitchell

Financial Mismanagement Kevin Frey

Printing/Mailing KY DFWR

Student Affairs Bruce Saul

Word Processing Engineer Karen Hukill

Two Computer Geeks Michael Metz
Steve Czajkowski

TABLE OF CONTENTS

Session	Page
For Hire Symposium.....	1
Tailwater Trout Symposium	4
Black Bass Biology and Management.....	9
Freshwater Fisheries Management.....	14
Lotic Fisheries Ecology and Management.....	19
Warmwater Streams Symposium.....	23
Mussel Ecology and Management.....	25
Striped Bass Biology and Management.....	31
Marine and Estuary Biology.....	34
Reservoir Fisheries - Biology and Management.....	36
Aquaculture and Fish Physiology.....	41
Clupeids: So Much More Than Bait.....	46
River/Streams - Biology and Management.....	50
Evaluating Fisheries Techniques.....	55
Poster Presentations.....	61

FOR HIRE SYMPOSIUM

SOUTHEAST REGION HEADBOAT SURVEY AND GULF OF MEXICO RED SNAPPER, *LUTJANUS CAMPECHANUS*, STATISTICS

Robert Dixon, Michael Burton, Roger Mays and Peggy Willis, U.S. Dept. Of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southeast Fisheries Science Center, Beaufort Laboratory, 101 Pivers Island Road, Beaufort, NC 28516-9722

Abstract. The headboat survey conducted by the Beaufort Laboratory, Southeast Fisheries Science Center, National Marine Fisheries Service was designed to measure the landings and size of fishes taken from for-hire recreational vessels that regularly carry seven or more anglers to fish in the Exclusive Economic Zone (EEZ), and includes vessels from Cape Hatteras, North Carolina to the Texas-Mexican border. Indices of the quality of reef fishing are based on annual landings, catch per unit of effort (CPUE), length frequency, and mean weight. Landings and fishing effort are obtained from trip reports completed by vessel personnel. Lengths (mm) and weights (kg) of individual fishes are collected by port agents during dockside sampling of landings. Red snapper, *Lutjanus campechanus* are prized by recreational anglers throughout the Southeast Region but are especially important to the headboat fishery in the Gulf of Mexico. In 1988, the first stock assessment of the red snapper population in the Gulf of Mexico indicated that red snapper was significantly overfished and that reductions in fishing mortality rates were necessary to rebuild the stock to a recommended 20% spawning stock potential ratio. Since 1990, regulations on the recreational harvest of red snapper include decreasing bag limits (7 to 5 fish/angler) and increasing size limits (13 to 15 inches TL). Landings and CPUE (number of red snapper) from the headboat fishery have not indicated any trends. However, landings (weight of red snapper) have increased from 172,000 kg/year (1990) to over 600,000 kg/year (1993-1996) and CPUE (weight) increased from 1.4 (1990) to 3.6 (1995) and 3.8 (1993, 1994, 1996). The percent of large fish (>500 mm) in headboat landings have increased from 3-7% (1986-1992) to 11-15% (1993-1996).

"GONE FISHING" - SOCIODEMOGRAPHIC CHARACTERISTICS OF SALTWATER CHARTER, HEADBOAT, AND PIER ANGLERS IN THE SOUTH CAROLINA COASTAL REGION

Kim Iverson, Ray Rhodes, and Aja Lynch, South Carolina Department of Natural Resources, Marine Resources Division, Office of Fisheries Management, PO Box 12559, Charleston, SC 29422-2559

Abstract. A survey of saltwater recreational anglers was completed to examine selected socio-economic characteristics of anglers using saltwater charter fishing boats, party boats and fee-based fishing piers in the coastal region of South Carolina. This research was initiated in response to socio-economic data needs identified by the SC Department of Natural Resources, especially with regard to visiting saltwater anglers. Primary data was collected by randomly distributing self-administering questionnaires to anglers participating in charter, party boat and pier fishing trips. During 1996, 7,225 usable questionnaires were collected with 71% (5,142) of these respondents representing about 6% of all reported charter and party boat angler trips. Anglers who were visitors comprised 95%, 87%, and 66%, respectively, of salt water charter, party boat, and pier anglers. Most visiting anglers were from SC (22%) (mainly inland counties) and coastal border states, North Carolina (20%) and Georgia (8%). The survey findings show that visiting saltwater anglers are a major consumer segment of coastal recreational fishing services. These findings, along with other data, will be used (1) to estimate the aggregate economic impact of recreational fishing services in the coastal region and (2) to analyze how sociodemographic factors could influence future fishing effort associated with these services.

THE COASTAL ECONOMIC IMPACT OF RECREATIONAL CHARTER, HEADBOAT, AND PIER ANGLERS IN SOUTH CAROLINA

Ray Rhodes, Kim Iverson, Aja Lynch, South Carolina Department of Natural Resources, Marine Resources Division, Office of Fisheries Management, PO Box 12559, Charleston, SC 29422

Abstract. A sample of 1,754 recreational saltwater charter, headboat, and pier anglers fishing in SC during 1996 provided expenditure data. Average expenditures per day fished were calculated for SC coastal residents and nonresidents. Aggregate expenditures by charter and headboat anglers were estimated using expenditure averages and daily logbook data. Averages from the pier angler were expanded to the population total expenditures by using monthly data provided by pier operators. An input-output analysis of the aggregate expenditures by these coastal resident and non-resident anglers was conducted using the IMPLAN model and coastal county economic data. Economic impact models such as IMPLAN are designed to determine the "direct effect" of increased (decreased) purchases like headboat fees and lodging but also simulate "indirect" and "induced effects" of these purchases. The estimated total economic impact of nonresident charter, headboat, and pier anglers in the SC coastal region exceeded \$25 million during 1996. A reduction of "for hire" fishing related expenditures could result in a reduction of coastal businesses serving these nonresident anglers if not a temporary unemployment in the coastal region. The uses and abuses of economic impact assessment procedures will be discussed.

PILOT TESTING OF ALTERNATIVE SURVEY METHODS FOR ESTIMATION OF ANGLER FISHING EFFORT AND CATCH FROM CHARTER BOATS

David Van Voorhees, U.S. Department of Commerce National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Fisheries Statistics and Economics Division, F/STI, 1315 East-West Highway, Silver Spring, MD 20910

Abstract. The National Marine Fisheries Service (NMFS) is working with the cooperation of the Gulf States Marine Fisheries Commission (GSMFC), the Alabama Department of Conservation and Natural Resources (ALDCNR), the Florida Department of Environmental Protection (FLDEP), the Louisiana Department of Wildlife and Fisheries (LDWF), and the Mississippi Bureau of Marine Resources (MBMR) to develop more efficient survey methods for the estimation of fishing effort and catch from charter boats. The Marine Recreational Fishery Statistics Survey (MRFSS) of the NMFS currently relies on a random-digit-dialing telephone survey of fishing effort by residents of coastal county households. This method is relatively inefficient for estimating charter angler fishing effort because most charter anglers are not coastal residents. The NMFS has funded pilot tests of two new charter boat survey methods -- a pilot telephone survey of charter boats and a pilot logbook panel survey of charter boats. Both pilot surveys use a list of charter boats as a sampling frame. Data collections for the pilot surveys started in September, 1997, and will continue through August, 1998, to allow a full year of side-by-side comparisons with the current MRFSS method. The GSMFC is coordinating conduct of the pilot telephone survey by LDWF, MBMR, ALDCNR and FLDEP. The NMFS Panama City Lab is conducting the pilot logbook panel survey in the Florida Panhandle area. This presentation will explain the pilot survey designs, review preliminary pilot survey results and address differences among the alternative survey methods in respondent burden, response rates, and the relative precision of estimates.

COOPERATIVE DATA COLLECTION FOR BETTER FISHERY MANAGEMENT IN THE FOR-HIRE SECTOR

Robert Beal and Connie Young-Dubovsky, Atlantic States Marine Fisheries Commission, 1444 Eye Street, N.W. Sixth Floor, Washington, D.C. 20005

Abstract. The Atlantic Coastal Cooperative Statistics Program (ACCSP) is a state-federal cooperative program to improve the collection and management of recreational and commercial fisheries statistics on the Atlantic coast. The ACCSP is composed of 23 participating agencies, including the National Marine Fisheries Service, the U.S. Fish and Wildlife Service, the 15 Atlantic coast states from Maine through Florida, the District of Columbia, The Potomac River Fisheries Commission and the Atlantic State Marine Fisheries Commission. Over the past two years, the ACCSP has been developing the data collection reporting requirements and methodologies for commercial and recreational fisheries, including for-hire fisheries. The current program provides for stratification of charter boats and headboats, with guideboats categorized with charter boats. Standard definitions have been developed for each of these fishing sectors to ensure consistency in collected information among agencies. A minimum set of standard data elements will be collected on the for-hire fisheries, to include catch and effort data, biological information, and social and economic data. The methodology for collecting for-hire information will be evaluated during 1998 through a three-way evaluation study. The methods to be evaluated during this pilot study include: 1) 100% mandatory logbook reporting to collect both catch and effort data, 2) a telephone survey using a for-hire vessel sampling frame for effort data, and 3) the Marine Recreational Fisheries Statistics Survey (MRFSS) effort estimates. The pilot study proposed for funding under the ACCSP will involve the states of South Carolina, Maine and New Hampshire.

OPERATION AND ECONOMICS OF THE CHARTER AND PARTY BOAT FLEETS IN THE SOUTH ATLANTIC STATES

Anthony J. Fedler and Stephen M. Holland, Department of Recreation, Parks and Tourism, PO Box 118208, University of Florida, Gainesville, FL 32622-8208

Abstract. This presentation will provide an update of an ongoing project to collect economic and operational information on the charter/party boat fleet in the South Atlantic States. The project compares, updates, and extends findings of previous studies conducted in 1978 and 1988. A representative sample of captains operating from North Carolina to Florida are being interviewed to document fishing activity, quantify business performance, estimate economic impacts, identify problems facing the industry, and examine regulatory impacts on the "for hire" fishing sector.

THE IMPACT OF FISHERY REGULATIONS ON "FOR HIRE" RECREATIONAL FISHING BUSINESSES AND THEIR CUSTOMERS: AN INDUSTRY PERSPECTIVE

Tom Swatzel, Capt. Dick's Marina, PO Box 306, Murrells Inlet, SC 29576

Abstract. "For hire" recreational fishing businesses such as head and charter boat operators face a dilemma of maintaining customer demand for fishing trips in the face of mounting fishery regulations. Most operators acknowledge their stake in healthy fish stocks for the future of their businesses, and as a result, understand the need for reasonable recreational fishery regulations. A problem is educating fishery management decision makers on the impacts of regulations on head and charter boat customers, and the overall importance of the industry to the local or regional economy.

Observations of customer behavior while purchasing fishing trips and engaged in fishing, provides good insight into the effects of size and/or bag limits on customer perception of a fishing trip's value. Without adequate information of this nature, fishery regulations can be crafted that might meet management objectives, but have an unnecessarily adverse impact on customer demand for trips.

On a federal level, the Magnuson-Stevens Fishery Conservation and Management Act requires fishery councils to quantify the economic impacts of proposed regulations on user groups. In most fishery management plans, projected economic impacts on commercial users are listed to the dollar. However, there is little information available to quantify regulatory impacts on head and charter boat businesses and as a result, fishery management decision makers tend to look skeptically at the economic importance of recreational fishing businesses in implementing regulations.

TAILWATER TROUT SYMPOSIUM

GUNPOWDER FALLS - A CASE HISTORY IN SUCCESSFUL TAILWATER SALMONID MANAGEMENT

Howard Stinefelt, Maryland Department of Natural Resources, 20901 Fish Hatchery Road, Hagerstown, MD 21740

Abstract. A high quality, self-sustaining brown trout fishery was developed in a 17-mile tailwater section of Gunpowder Falls below Prettyboy Reservoir, Baltimore County, Maryland. Improved instream flows (minimum flow 11.5 cfs), introduction of quality stocks of brown trout, cessation of stocking hatchery trout on wild trout populations, and implementation of catch and return regulations in the upper 7.2 miles resulted in extremely rapid increases in standing crops of wild trout. Ten years of trout population studies (1987-1996) conducted at 5 electrofishing stations within the catch and return area, showed the standing crop of all trout species yearling and older, increased from 5 to 100 pounds per acre. Brown trout make up 93% of the population with the remainder comprised of mostly rainbow and some brook trout. Downstream of the catch and return area where adult trout continue to be stocked for put-and-take fishing (5 trout per day, bait permitted), wild trout populations at two stations have increased from 4 to 23 pounds per acre.

As a result of our efforts, Gunpowder Falls is now the premier trout stream in Maryland and is listed by Trout Unlimited as among America's best 100 trout streams.

CREATING A FISHERY IN THE BRIDGEWATER TAILRACE, NORTH CAROLINA

Christopher J. Goudreau, North Carolina Wildlife Resources Commission, Route 6, Box 685, Marion, NC 28752-9229, and R. Duane Harrell, Duke Power Company, 13339 Hagers Ferry Road, Huntersville, NC 28078-7929.

Abstract. Studies in 1993 documented the existence of 46 fish species in the 29-km section of Catawba River between Lake James and Lake Rhodhiss, but game species were rare. Water chemistry parameters were considered to be normal. Water temperature ranged from 8-22°C, and low (<5 mg/L) dissolved oxygen concentrations were restricted to a 3-km river segment from August - September. The lack of game fish was felt to be limited by reproductive success, possibly due to significant sediment input from a major tributary. In an attempt to establish fishable game fish populations, annual stockings of 30,000 fingerling smallmouth bass (1994-1997) and brown trout (1996-1997) were made. Boat electrofishing conducted in September 1996 and 1997 was limited, preventing the calculation of fish density or survival. Age and growth information determined from scales in 1996 were suspect, especially for brown trout which showed 1-2 false annuli. Calculations from otoliths in 1997 indicated growth of smallmouth bass was slow (206 mm age 3) but very fast for brown trout (246 mm at age 1). W_r was high for smallmouth bass under stock size (mean 102), but declined for quality fish (mean 92). Mean W_r was 82 for brown trout under stock size, increasing to 95 for preferred fish. Stocking and fish and habitat sampling will continue for several more years to determine which species is best suited for local conditions.

RESPONSE OF A COLDWATER STREAM FISH ASSEMBLAGE TO FLOW AUGMENTATION

Scott M. Smith, Virginia Department of Game and Inland Fisheries, 910 Thomas Jefferson Road, Forest, VA 24551.

Abstract. Many relationships have been derived from stream discharge and habitat, but few studies have examined relationships among stream discharge, habitat, and fish populations. I examined a coldwater stream fish assemblage before (1992-93) and after (1995-present) flow augmentation. Minimum flows in the Dan River, Virginia were changed from approximately 1.5 cfs to 8.9 cfs in 1994 (mean annual flow without project impacts = 73 cfs). In general, this stream became deeper and wider following flow augmentation although the degree of change varied among mesohabitats (pools, runs, riffles). Width and depth measurements were not significantly different ($\alpha=0.10$) between flow levels with the exception of runs, which became significantly deeper (mean depth and maximum depth). While the data is incomplete, brown trout *Salmo trutta* densities appear to have increased while densities of other species have shown no trends. Brown trout numbers were significantly greater in all mesohabitats following increases in flows, while brown trout biomass significantly increased in riffles and runs. The brown trout population may have expanded due to an increase in available habitat associated with the flow augmentation.

IDENTIFYING FACTORS LEADING TO VARIABLE TROUT REPRODUCTIVE SUCCESS IN ARKANSAS TAILWATER RIVERS

Danielle R. Painter and Thomas J. Kwak, Arkansas Cooperative Fish and Wildlife Research Unit, Department of Biological Sciences, University of Arkansas, Fayetteville, AR 72701.

Abstract. Brown trout, *Salmo trutta*, reproductive success in White River tailwater is highly variable, resulting in the need for supplemental stocking. A better understanding of physical and biotic factors contributing to reduced survival and variation among tailwaters will facilitate fisheries composed of greater proportions of wild populations to increase the quality of the fish and fishery. Fecundity was estimated from 12 female brown trout collected prior to spawning from four tailwater sites. Brown trout from one tailwater known for reproductive failure had significantly lower fecundity measures and condition factors than those of three other sites, while there was no difference among other sites with higher reproductive success. Brown trout spawning occurred from October 11 to November 23, and fry emergence began February 23. Significant among-site differences were found for spawning and fry microhabitat variables; however, variables fell within optimal ranges reported in the literature. There were no significant differences in spawning gravel quality to percent fines obtained by freeze-core sampling. Significant differences were found among sites for fry and juvenile density, but not for their size. Ongoing investigations into trout early life history may reveal additional influential factors to improve trout reproductive success and increase the proportion of wild fish in these systems.

TROUT POPULATION RESPONSE AND MICROHABITAT USE OF REHABILITATED HABITAT IN AN OZARK TAILWATER RIVER

Jeffrey W. Quinn and Thomas J. Kwak, Arkansas Cooperative Fish and Wildlife Research Unit, Department of Biological Sciences, University of Arkansas, Fayetteville, AR 72701

Abstract. Habitat rehabilitation was completed following catastrophic flooding in the White River below Beaver Lake Dam, Arkansas, using techniques developed in small streams. We evaluated trout response to rehabilitation at reach and microhabitat scales. We estimated trout populations and determined microhabitat use in modified and reference reaches. The ratios of total trout abundance (density and biomass) in the modified reach, relative to that of the reference reach, increased after rehabilitation - evidence that the modified reach supported more fish after rehabilitation. Analyses for individual trout species were variable, possibly due to density-dependent processes. Cover increased significantly in the modified reach after rehabilitation, with the majority of additions found at the low-flow, land-water interface. This strategy increased bank stabilization and provided additional cover for trout during high flow, when trout were observed associated with velocity refugia. In summary, we measured increased supportive capacity for trout after rehabilitation that appeared to be associated with the addition of cover, but the pattern varied among trout species.

PUBLIC VS PRIVATE FISHING RIGHTS ON A NAVIGABLE TAILWATER - THE JACKSON RIVER CASE

Larry O. Mohn, Virginia Department of Game and Inland Fisheries, PO Box 996, Verona, VA 24482

Abstract. The Gathright Dam project, built by the U.S. Army Corps of Engineers, was completed in 1981. As mitigation for inundating 12 miles of the Virginia Department of Game and Inland Fisheries owned Jackson River, the Corps agreed to establish a public coldwater fishery below the dam. Gathright was designed for summer flow augmentation with none of the flow and dissolved oxygen problems associated with many of the other southeastern tailwaters. As a result, the 19 mile coldwater fishery was projected to be one of the best in the region. However, riparian landowners began several legal challenges in 1981 that ultimately resulted in a September 1996 Virginia State Supreme Court ruling giving exclusive private fishing rights to some riparian landowners despite the fact that the Jackson River had been ruled to be legally navigable. The legal argument used successfully by Jackson River landowners has since been used in New York to close a section of the famous Salmon River to public fishing and could be a threat to public resources throughout the east coast region.

SURVIVAL AND POPULATION SIZE OF RAINBOW TROUT AND BROWN TROUT IN THE SOUTH FORK OF THE HOLSTON RIVER, TENNESSEE

Mark L. Nemeth and Phillip W. Bettoli, Tennessee Cooperative Fishery Research Unit, Box 5114 Tennessee Technological University, Cookeville, TN 38505, Francis C. Fiss, Tennessee Wildlife Resources Agency, PO Box 40747, Nashville, TN 37204

Abstract. The South Fork of the Holston River in east Tennessee last year received over 900 hours per hectare of fishing pressure. The 20-km tailrace is stocked annually with about 72,000 catchable rainbow trout *Oncorhynchus mykiss*, 11,000 brown trout *Salmo trutta*, and some natural reproduction by both species occurs. To obtain more information about the survival of trout in this tailrace, four microtagged cohorts of rainbow trout (>5800) and one cohort of brown trout (16,670) were stocked between March and September 1997. Survival was investigated by electrofishing each month and conducting a creel survey. Rainbow trout stocked in early summer survived better than trout stocked earlier in the year. Brown trout survived better than rainbow trout stocked at the same time. A change-in-ratio mark-recapture technique estimated the combined population of rainbow trout and brown trout at 56,493 fish in the first 16 km of the tailrace; total trout biomass was estimated to be 214 kg/hectare. The number of wild brown trout less than 270 mm total length was 18,522.

PERFORMANCE OF STOCKED SALMONIDS IN THE CANEY FORK RIVER BELOW CENTER HILL DAM, TENNESSEE

George J. Devlin and Phillip W. Bettoli, Tennessee Cooperative Fisheries Research Unit, Tennessee Technological University, Box 5114, Cookeville, TN 38501, Francis C. Fiss, Tennessee Wildlife Resources Agency, PO Box 40747, Nashville, TN 37204

Abstract. Population characteristics of rainbow trout (*Oncorhynchus mykiss*) and brown trout (*Salmo trutta*) stocked into the Caney Fork River below Center Hill Dam in 1997 were investigated. Three cohorts of rainbow trout ($N \geq 7,000$) and one cohort of brown trout ($N = 16,500$) were microtagged and stocked during the spring and summer of 1997. The river was sampled monthly by electrofishing to assess the survival, growth, condition, and movement of trout. Electrofishing catch per unit of effort (CPUE) for rainbow trout stocked in March declined linearly ($r^2 = 0.92$) and CPUE reached zero within 167 days. The CPUE for rainbow trout stocked in June declined rapidly ($r^2 = 0.93$) and approached zero within 102 days. Brown trout stocked in May did not exhibit a decline ($r^2 = 0.07$) in CPUE. Early stocked rainbow trout grew faster (13 mm and 21 g/month) than later stocked rainbow trout (8 mm and 5 g/month). Brown trout grew 10 mm and 9 g/month. All tagged cohorts exhibited a decline in condition throughout the study. Brown trout stocked at the lower end of the tailwater exhibited continual upstream movement; rainbow trout displayed little appreciable movement. A mark-recapture experiment in April 1997 estimated that 2,826 brown trout and 4,818 rainbow trout overwintered.

AN ASSESSMENT OF THE CLINCH RIVER TROUT FISHERY BELOW NORRIS DAM, TENNESSEE

Phillip W. Bettoli, Tennessee Cooperative Fishery Research Unit, Tennessee Technological University, Box 5114, Cookeville, TN 38505

Abstract. Fishing pressure and rates of return of stocked trout were estimated using a roving creel survey on a 20-km reach of the Clinch River. Survival, growth, and standing crop of overwintering trout were estimated by stocking cohorts of microtagged trout and electrofishing fixed transects. Annual fishing pressure totaled 98,957 h and pressure during each two-week period was inversely related to turbine discharges ($r = 0.76$; $P = 0.01$). Rates of return for cohorts of catchable (>200 mm total length, TL) rainbow trout *Oncorhynchus mykiss* ranged from 1% to 45%. Microtagged rainbow trout stocked as fingerlings grew 0.7 mm and 1.0 g/day; brown trout *Salmo trutta* fingerlings grew 0.4 mm and 0.6 g/day. Annual survival rates for fingerling brown trout and rainbow trout were excellent (52% and 26%, respectively) compared to catchable rainbow trout (2%-6% survival). Change-in-ratio estimates of the number of trout >200 mm TL that overwintered in 1996-1997 were 44,355 (rainbows) and 11,404 (browns) and total standing crop was estimated at 112 kg/hectare. Natural mortality was more important than fishing mortality in regulating the abundance of most cohorts of catchable rainbow trout stocked in 1996, despite the fact that survival varied inversely with fishing pressure.

RESPONSE OF RESIDENT HOLDOVER BROWN TROUT (*SALMO TRUTTA*) AND RAINBOW TROUT (*ONCHORYNCHUS MYKISS*) DURING MARGINAL THERMAL CONDITIONS OF SUMMER IN THE HIWASSEE RIVER, POLK COUNTY, TENNESSEE

Gary G. Williams, Tennessee Valley Authority, Water Management, 17 Ridgeway Road, Norris, TN 37828

Abstract. Radio telemetry was used to determine if brown trout (*Salmo trutta*) and rainbow trout (*Oncorhynchus mykiss*) were vacating their summer habitats in search of refuge as a result of marginal water temperatures in the Hiwassee River (Appalachia tailwater) in Polk County, Tennessee. Eleven resident holdover brown trout and 13 resident holdover rainbow trout greater than 14 inches were surgically implanted with radio transmitters equipped with temperature sensors. Study results showed that none of the tagged fish throughout the study migrated into a thermal refuge such as cooler tributaries, closer proximity to the source of coldwater in the tailwater, spring seeps above or below ground, deep pools, etc. Ambient thermal monitoring showed that maximum average daily water temperatures were approximately 19.4°C (67°F) through the period between September and October when tailwater temperatures are typically the warmest. It has been previously hypothesized that water temperatures were thought to be the limiting factor influencing numbers of resident-holdover fish. We recommend that other mechanisms should be considered to be the limiting factors on growth and survival of trout rather than thermal habitat conditions.

BLACK BASS BIOLOGY AND MANAGEMENT

IMPACT OF LOCALIZED HARVEST ON THE SMALLMOUTH BASS POPULATION OF LAKE MOOMAW, VIRGINIA

D. A. Garren, J. J. Ney and S. L. McMullin, Department of Fisheries and Wildlife, Virginia Polytechnic Institute and State University, 100 Cheatham Hall, Blacksburg, VA 24060-0321

Abstract. Smallmouth bass *Micropterus dolomieu* congregate in the headwaters of Lake Moomaw, a 1024-ha flood-control reservoir, during the spring spawning period, where they are vulnerable to a shore-based, harvest-oriented fishery. We estimated the headwaters bass harvest in 1995-96 by creel survey, then used tagging and telemetry to assess the significance of the harvest to the whole-lake bass population. Electrofishing surveys of juvenile bass distribution were conducted to examine impacts on recruitment. The headwaters fishery accounted for 17% of the annual smallmouth bass harvest in lake Moomaw; the combined annual harvest removed only 12% of the adult population. Bass spawning occurred throughout the lake. The headwaters fishery is a high-profile activity which, during 1995-96, had a low and sustainable impact on the Lake Moomaw smallmouth bass population.

PATTERNS IN ABUNDANCE AND PREY USE AMONG ADULTS OF THREE BLACK BASS SPECIES IN A TROPHICALLY HETEROGENOUS OKLAHOMA RESERVOIR

James M. Long and William L. Fisher, Oklahoma Cooperative Fish and Wildlife Research Unit, 404 LSW, Oklahoma State University, Stillwater, OK 74078

Abstract. In an attempt to control an increasing spotted bass *Micropterus punctulatus* population, a differential harvest regulation was imposed on three black bass species in Skiatook Lake, Oklahoma. Spatial abundance and prey use patterns of adult largemouth *M. salmoides*, smallmouth *M. dolomieu*, and spotted bass were determined. In Spring 1997, fish were sampled by nighttime electrofishing to assess the potential for competition among these species. Skiatook Lake exhibited a longitudinal trophic state gradation from eutrophy in the upper end to oligotrophy in the lower end, based on chlorophyll-a concentrations. Largemouth bass catch per unit effort (CPUE) was similar among strata ($P = 0.453$). Smallmouth bass CPUE was significantly greater in the lower lake ($P < 0.001$) and was highly correlated with secchi depth ($P < 0.001$, $r = 0.70$). Spotted bass CPUE was significantly lower in Hominey Creek ($P = 0.013$), an uplake stratum, but was greater than both largemouth and smallmouth bass CPUE in most areas of the lake. Spotted bass and largemouth bass CPUE was not correlated with dissolved oxygen, conductivity, chlorophyll-a, or secchi depth. Largemouth and smallmouth bass consumed more fish whereas spotted bass ate more insect. The potential for competition exists even though black bass were segregated by prey and habitat usage.

ASSESSMENT OF THE UPPER PICKWICK RESERVOIR SMALLMOUTH BASS FISHERY AFTER IMPLEMENTATION OF A 356 MM MINIMUM LENGTH LIMIT

Jeffrey W. Slipke and Michael J. Maceina, Department of Fisheries and Allied Aquacultures, Auburn University, AL 36849

Abstract. To protect and enhance the nationally recognized smallmouth bass *Micropterus dolomieu* fishery in the headwaters of Pickwick Reservoir, a 356-mm minimum-total-length limit was established in 1991. We sampled smallmouth bass in the fall of 1995 and spring of 1996 to determine if the regulation had any effects on the population characteristics of this fishery. A creel survey was conducted during 1996 to estimate angler effort, catch, and harvest of smallmouth bass, and to evaluate angler values, opinions, and practices. Electrofishing catch rates for juvenile (<280 mm) and adult (≥ 280 mm) smallmouth bass significantly ($P < 0.05$) increased compared to pre-regulation data (1988). Growth rates and total annual mortality were similar before and after the regulation. Year-class abundance fluctuated greatly and was negatively related to discharge through Wilson Dam from April through July, which corresponds to the spawn and post-spawn periods. The angler catch rate for smallmouth bass nearly doubled, while the harvest rate decreased by nearly an order of magnitude. Smallmouth bass anglers released 98% of their catch, the same percentage who reported practicing catch-and-release. While the regulation appeared to improve the quality of this fishery, the catch-and-release philosophy practiced by most smallmouth bass anglers cannot be overlooked as an important factor that has, and will continue to positively influence this fishery.

EVALUATION OF PROCEDURES TO REDUCE DELAYED MORTALITY OF BLACK BASS FOLLOWING SUMMER TOURNAMENTS

Gene Gilliland, Oklahoma Fishery Research Laboratory, 500 E. Constellation, Norman, OK 73072

Abstract. Mortality of black bass *Micropterus spp.* was estimated in 1995 and 1996 following a series of ten fishing tournaments on six Oklahoma reservoirs. During the first year's trials, contestants were not given any special instructions on fish care. However, each tournament used the same weigh-in procedures. Initial mortality averaged less than 4% in both seasons. Mean total mortality ranged from 3% following spring events to 39% following summer tournaments. During 1996, working with summer events only, contestants were divided into groups that followed different fish care procedures. Initial mortality was again low, averaging less than 2%. Mortality of bass weighed by contestants that were given no special instructions was 32%. Among the contestants using fresh-water flow-through aeration only, total mortality averaged 18%. Bass that were confined in live wells where the water was recirculated, was cooled with ice and treated with non-iodized salt had a mean total mortality of 14%.

Our recommendations to tournament anglers on reducing delayed mortality of bass caught and released after summer tournaments were 1) to run live well aerators continuously, not on automatic timers, and 2) to provide a less stressful live well environment and reduce delayed mortality even more, recirculate water that is cooled with ice and treated with salt.

GROWTH AND DENSITY OF AGE-0 LARGEMOUTH BASS IN ALABAMA IMPOUNDMENTS: EFFECTS OF LARVAL SHAD ABUNDANCE AND SPAWNING TIMES

Michael S. Allen, Department of Fisheries and Aquatic Sciences, University of Florida 7922 NW 71st Street, Gainesville, FL 32653; James C. Greene, Frederick J. Snow, Michael J. Maceina, Dennis R. DeVries. Department of Fisheries and Allied Aquacultures, Auburn University, Auburn, AL 36849

Abstract. We examined daily otolith rings and estimated density, age, and growth of age-0 largemouth bass *Micropterus salmoides* collected from nine Alabama impoundments using shoreline rotenone sampling. In addition, we examined a variety of factors thought to be related to growth and density of age-0 largemouth bass. Reservoirs classified as eutrophic (≥ 8 mg chlorophyll *a*/m³) had higher crustacean zooplankton densities, higher larval shad *Dorosoma* spp. densities, and higher densities and faster growth of age-0 largemouth bass than oligo-mesotrophic reservoirs (<8 mg chlorophyll *a*/m³). Based on an index of climate for each lake (long-term cooling degree days), reservoirs in the southwest portion of the state had warmer climates, combined with earlier mean largemouth bass swim-up dates; age-0 largemouth bass in these systems exhibited the densities and were among the most rapid growth rates we found. Alternately, peak larval shad densities occurred later in spring in these southwestern reservoirs. Therefore, fast growth and high density of age-0 largemouth bass was related to larval shad spawning dates. Although previous work has shown that larval shad may reduce zooplankton and indirectly inhibit age-0 largemouth bass growth and eventual recruitment, results of this study suggested that recruitment of largemouth bass may be higher in lakes with high larval shad densities than in lakes with intermediate or low larval shad densities. However, timing of larval shad-largemouth bass spawning may be critical to recruitment of largemouth bass, with an early spawn of largemouth bass followed by a late spawn of larval shad yielding strong largemouth bass year classes.

FIRST YEAR GROWTH AND SURVIVORSHIP OF JUVENILE LARGEMOUTH BASS IN A NORTH CAROLINA RESERVOIR

James R. Jackson and Richard L. Noble, Department of Zoology, Campus Box 7617, North Carolina State University, Raleigh, NC 27695-7617.

Abstract. Growth rates, as measured by changes in mean length through time, were determined for nine cohorts of juvenile largemouth bass *Micropterus salmoides* captured via shoreline electrofishing from 1987-1995 in B. E. Jordan Lake, North Carolina. Mean daily growth rates (mm/day) from July through October varied from 0.05-0.39 and in all cases were most parsimoniously described by linear models. No relationship was observed among annual variations in survivorship and growth rate during the first growing season. Collections of yearling largemouth bass provided little evidence of size-selective overwinter mortality, and survivorship from July through the following spring was similar among all cohorts, despite variations in growth rate and fall mean lengths. Data from individually marked juvenile bass in 1991 similarly failed to indicate a strong relationship between growth and survival.

PROFILE OF A TROPHY LARGEMOUTH BASS FISHERY AT BRIERY CREEK LAKE, VIRGINIA

Dan Wilson, Virginia Department of Game and Inland Fisheries, HC 6, Box 46, Farmville, VA 23901

Abstract. The development of a trophy largemouth bass (*Micropterus salmoides*) fishery was a primary management objective when Briery Creek Lake was developed in the mid 1980's. Before impoundment, Briery's limited pool was renovated with rotenone to remove undesirable species, and standing timber was left in over half of the lake. This 342 ha Virginia reservoir was stocked with Florida largemouth bass (FLMB) and northern largemouth bass (NLMB) fingerlings at a ratio of 3:1 in 1986 and 1987. Nearly 400 juvenile largemouth bass were collected from October 1989 through May 1991 and electrophoretically analyzed to determine survival and phenotype ratios. Forty-nine percent were determined to be first-generation hybrids between NLMB and FLMB and 27% were second or later generation hybrids, suggesting that founding stocks were not pure northern or Florida strains. The initial 457 mm minimum size limit on bass was changed to a 305-381 mm slot limit in 1991 following a stockpiling of intermediate size bass and a major reduction of sunfish forage. Ninety-two state citations (minimum of 3.6 kg) have been awarded to Briery Creek Lake anglers from 1992-1996, with 23 of these fish weighing over 5.4 kg. The number of bass citations decreased in 1996 and again in 1997 despite the large quantity of 'trophy hunters' visiting the lake. Sampling has shown a steady reduction in growth rates from 1990-1996, with a dramatic decline in the sunfish forage since 1993. A higher slot limit may be proposed in 1998 to further reduce intermediate size bass and protect the trophy size bass for which Briery has become famous.

SPATIAL HETEROGENEITY IN LARGEMOUTH BASS WITHIN KINKAID LAKE, ILLINOIS

Michael W. Garthaus, Kentucky Department of Fish and Wildlife Resources, 30 Scenic Acres Drive, Murray, KY 42071. Roy C. Heidinger, Cooperative Fisheries Research Laboratory and Department of Zoology, Southern Illinois University at Carbondale, Carbondale, IL 62901-6511

Abstract. The objective of the study was to determine if there were spatial differences in proportional stock density, relative weight, and age and growth of largemouth bass (*Micropterus salmoides*) in Kinkaid Lake, Illinois. Kinkaid Lake is located in Jackson County, Illinois, and was impounded in 1971. The lake has a surface area of 1,113 ha and a maximum depth of 22 m. Spatial heterogeneity was found in the largemouth bass population between two sites within Kinkaid Lake. Overall, bass from the Ava site exhibited better population structure, condition, and growth rates than bass from the marina site. Reservoirs in southern Illinois can have largemouth bass populations exhibiting spatial differences in population structure, condition, and age and growth.

EVALUATION OF SPAWNING BENCH USE BY *MICROPTERUS* SPECIES IN CENTER HILL RESERVOIR, TENNESSEE

Robert B. Row and Frank J. Bulow, Department of Biology, Tennessee Technological University, Cookeville, TN 38505

Abstract. As reservoirs age, they often lose woody habitat that may be essential cover for successful fish reproduction. The purpose of this study was to evaluate the use of spawning benches to increase smallmouth bass (*Micropterus dolomieu*) spotted bass (*Micropterus punctulatus*), and largemouth bass (*Micropterus salmoides*) production. In 1996, United States Army Corps of Engineers personnel and volunteers installed 80 spawning benches in two test coves of Holmes Creek Embayment of Center Hill Reservoir. Each spawning bench consisted of an 8 - 10 ft (2.4 - 3.0 m) slab of oak attached to two or three 8" or 12" (20.3 - 30.4 cm) cinder blocks laid on the shoreline. Benches were placed at various elevations and either parallel or perpendicular to the shoreline. Spawning benches were intended to provide cover under which fish could spawn. During the spring, summer, and fall months of 1996 and 1997, we evaluated the use of these spawning benches. SCUBA gear was used to dive 100-m transects in both test and control coves for observation of fish nesting. *Micropterus* species were observed using 66% of the benches for nesting (27 nests at the 41 spawning benches observed). Spotted bass were observed using the benches for nesting 16 times (39% use), smallmouth bass 9 times (22%), and largemouth bass twice (5%). Spotted bass preferred a soft substrate, a gradual slope (21-30%), 12" block size, and a perpendicular arrangement of the benches. Smallmouth bass preferred hard substrate, a gentle slope (13-20%), 12" block, and a parallel arrangement. No preference was determined for largemouth bass because only two nests were found. Nighttime shoreline electrofishing was conducted for the months of July, August, and September of 1995-1997 to compare young-of-year densities in test and control coves prior to and after bench installation.

A TROPHY BASS TRAGEDY: OVER-COOKING THE FORMULA AT LAKE FUQUA

Larry Cofer, Oklahoma Department of Wildlife Conservation, HC 32, Box 580, Lawton, OK 73501

Abstract. Based on its history of producing largemouth bass *Micropterus salmoides* over 3.6 kg, Lake Fuqua was one of ten Oklahoma reservoirs designated as "Trophy Bass" lakes. The objectives were to improve angler satisfaction by maintaining or increasing catch rates of bass (all sizes), and increasing catches of trophy bass in selected state waters. Management strategies were regulating harvest with highly restrictive length limits, stocking Florida-strain bass, and maintaining quality bass habitat. Lake Fuqua was regulated by a 356-558 mm slot limit for bass beginning in 1990, after anglers caught an Oklahoma state record largemouth and many others over 3.6 kg in the late 1980s. Sampling through 1993 indicated that the harvest restriction did increase the abundance of slot-sized bass in the lake, but relative weights of protected bass were slightly lower. Anglers were encouraged to harvest bass below the slot limit, and the limit was raised to 406-584 mm in 1995 to reduce the competition and improve condition of bass. By 1997, however, relative weights had declined significantly and bass reproduction was impaired. Anglers complained about low catch rates and emaciated bass, and recorded catches of "trophy" largemouth bass declined through the period. Accordingly, the trophy bass slot regulation was suspended at Lake Fuqua.

FRESHWATER FISHERIES MANAGEMENT

RESULTS OF A 10-INCH MINIMUM SIZE LIMIT ON CRAPPIE AT CHEROKEE RESERVOIR, TENNESSEE

Doug Peterson, Tennessee Wildlife Resources Agency, Region IV, 6032 W. Andrew Johnson Highway, Talbott, TN 37877

Abstract. A 10-inch minimum length limit on crappie *Pomoxis* spp. was imposed on Cherokee Reservoir March 1, 1989. The primary objectives of the size restriction were to: 1) maintain or increase the pounds harvested, and 2) increase the catch rate (fish caught and released).

The pre- and post-effects of this size limit on the size structure, condition, relative density, growth, and harvest of crappie were evaluated. Fall trapnetting was used to collect crappie for length-frequency distribution, relative weight, catch-per-unit-effort, and age and growth determinations. Summer cove rotenone population studies were used to determine reproduction success. Daytime creel census was used to evaluate harvest, catch and harvest rates, and mean weight. The creel census was also used to determine angler opinion of the size limit.

The objectives of the regulation were met. Angler compliance was good. The opinion poll conducted on the size limit revealed that the fishermen were in favor of the regulation.

ASSESSMENT OF INTERNAL ANCHOR TAGS FOR BLACK CRAPPIE AND WHITE CRAPPIE

Scott D. Kirk and Michael J. Maceina, Department of Fisheries and Allied Aquaculture, Auburn University, AL 36849

Abstract. Tag-shedding and mortality rates of internally anchor tagged crappie, *Pomoxis nigromaculatus* and *P. annularis*, were determined for crappie over a ten-week period in two 0.10-ha ponds. One hundred crappie (229 mm - 356 mm) were implanted with internal anchor tags type Floy-89SL and given a pelvic fin clip. An additional 100 crappie (229 mm - 363 mm) served as control fish. In each pond fifty tagged and fifty control fish were stocked. The overall survival rate was 83% for tagged crappie and was slightly lower ($P < 0.10$) than the 91% for control crappie. The overall tag shedding rate was 2.4%. At termination, body condition indices (K) were similar between tagged and control fish. Length-frequency analysis indicated no significant size dependent mortality between both tagged and control crappie. Internal anchor tags may produce more accurate tag returns than traditional Floy FD-68B T-bar anchor tags due to lower tag shedding rates. In conjunction with a Crappiethon, we found that the shedding rate of Floy FD-68B T-bar anchor tags was 19% over a nine-week period. Although internally anchor tagged crappie suffer slight induced tag mortality, low tag shedding rates make internal anchor tags a viable crappie tagging technique.

RELATIONS BETWEEN RESERVOIR HYDROLOGY AND CRAPPIE RECRUITMENT IN ALABAMA

Michael J. Maceina and Marc. R. Stimpert, Department of Fisheries and Allied Aquacultures, Auburn University, AL 36849

Abstract. The relation between reservoir hydrology and recruitment of black crappie *Pomoxis nigromaculatus* and white crappie *P. annularis* was examined in 11 Alabama reservoirs. Estimates of recruitment were derived from 1) catch rates of age-1 fish in the fall with trap nets and 2) from residuals associated with catch-curve regressions of age 3 to 7 fish captured in the spring with electrofishing gear. In eight low retention (long-term average 2-9 days) stable water level reservoirs, greater year-class production was related to low winter (January to March) retention prior to crappie spawning and to higher post-winter (April to December) retention when these fish were age 0. These variables explained about 60% of the variation in crappie year-class abundance. Higher production of young crappie was nearly always associated with both winter retention 6 d or less and post-winter retention greater than 11 d. In three reservoirs that fluctuated 1.8 m or more per year and expressed longer retention (long-term average > 15 d), short winter retention and higher water levels in winter prior to crappie spawning were both associated with greater year-class abundance; hydrologic conditions during and after crappie spawning were not related to crappie recruitment. In these water-level regulated reservoirs, maintenance of higher water levels in the winter prior to crappie spawning could enhance reproductive success.

EXPLORING THE WARMWATER HYPOTHESIS IN KENTUCKY AND OHIO RESERVOIRS

R. Scott Hale, Ohio Division of Wildlife, Inland Fisheries Research Unit, 10517 Canal Road, SE, Hebron, OH 43025

Abstract. Growth rates of juvenile (age-1) and adult (age-2) white crappie *Pomoxis annularis* decreased during summer in a thermally stratified Kentucky reservoir. Monthly growth rates and epilimnetic temperature and oxygen data at Rough River Lake supported the warmwater hypothesis that reservoir epilimnions characterized by high temperatures and low dissolved oxygen during summer may limit crappie growth. Instantaneous growth in length decreased for both age classes as temperature increased, whereas only growth of juveniles significantly decreased as dissolved oxygen decreased. Growth rates differed consistently among juvenile and adult white crappies, although instantaneous growth in length and weight were strongly correlated for both ages. Juveniles grew more rapidly than adults and completed most of their annual growth during April-July. Growth rates of adults peaked in June-July in three of five years, and one and two months later during other years. Reduced growth rates for both age classes were common during July. Minor length differences in April among five year classes of each age did not result in growth advantages during April-October. Minimal somatic growth was detectable through a secondary growing season of October-April for three of four year classes.

Thermal characteristics were determined with remote temperature monitoring devices (Hobotemps) in each epilimnion of 11 Ohio reservoirs in the northeastern, central, and southern portions of the state during May-November. The monitors provided hourly temperature data at 1, 3, 5 and 7 m near the dam and 1 and 3 m near the headwaters. The summer temperature profiles indicated which Ohio reservoirs reach temperatures that affect the success of crappie populations under the premise of the warmwater hypothesis.

Further exploration of the relations between seasonal growth patterns and water temperature and dissolved oxygen is a promising avenue for understanding reservoir biology and management. Identifying generalities of abiotic and biotic links and quantifying compensatory fishery responses to environmental factors will help set expectations for fisheries and provide direction for fishery managers.

CRAPPIE POPULATION CHANGES FOLLOWING IMPLEMENTATION AND SUBSEQUENT REMOVAL OF RESTRICTIVE HARVEST REGULATIONS ON FT. SUPPLY RESERVOIR, OKLAHOMA

Jeff Boxrucker, Oklahoma Fishery Research Laboratory, Oklahoma Department of Wildlife Conservation, 500 E. Constellation, Norman, OK 73072

Abstract. The objective of this presentation is to detail the changes in the white crappie *Pomoxis annularis* population structure on Ft. Supply Reservoir prior to, during, and following removal of restrictive harvest regulations. Annual fall trap-net samples have been collected since 1983. Spring creel data have been collected since 1987. The 1983-1989 trap-net samples indicated that the crappie population was dominated by fast-growing age-1 and age-2 individuals. The percentage of age-3 and older crappie in the population never exceeded 10% during this time period. The fishery was supported by a single year class (age 2). Mortality rates of age-2 crappie averaged 73%. Tagging studies in 1987 and 1988 indicated that annual angler exploitation was 40%.

A 255-mm minimum length limit with a 15-fish daily creel regulation was imposed on January 1, 1990. Trap-net catch rates of crappie >200 mm and >250 mm increased following the restrictive harvest regulations. Percentage of crappie age-3 and older exceeded 10% 4 of the 6 years that the regulation was in effect. Mortality rates of age-2 crappie averaged 53% from 1990-1995. The improvements in crappie population structure evidenced by the trap-net samples were not reflected in the creel data. Fishing pressure steadily declined. Angler catch rates improved during the length limit but harvest rates declined to 0.4 fish/h and remained fairly stable. Angler acceptance of the regulation was poor in spite of numerous public forums and articles in the local media. The restrictive harvest regulations were removed on January 1, 1996.

Fishing pressure has not improved since the restrictive regulation was removed. Crappie harvest estimates from spring 1996 were twice the spring 1995 estimates. The increase in harvest was due to harvest of crappie between 200 and 250 mm previously protected by the length limit. The increase in harvest was reflected in a 50% decline in trap-net catches in fall 1996. However, local anglers are now satisfied with the fishery.

UNDERSTANDING MIDWESTERN CRAPPIE (*POMOXIS* SPP.) COMMUNITIES

T.W. Spier and R.C. Heidinger, Fisheries Research Laboratory and Department of Zoology, Southern Illinois University, Carbondale, IL 62901

Abstract. The black crappie *Pomoxis nigromaculatus* and white crappie *P. annularis* are popular sportfish in the U.S., but managing their communities can be difficult. Determining the composition of the communities may be troublesome since they may include a significant number of hybrids. Also, crappie tend to overpopulate and produce stunted populations consisting of multiple age classes. Few studies have reported the extent of crappie hybridization in Midwestern U.S. reservoirs. Black and white crappie are sympatric in many Illinois impoundments and thus have the opportunity to hybridize. Allozyme electrophoresis was used to examine the extent of crappie hybridization in Illinois. Seven hundred crappie from 7 impoundments were screened at 3 diagnostic loci. Between 0 and 5% of crappie were found to be hybrids. Stunted black and white crappie from 2 Illinois populations were PIT tagged, stocked into experimental ponds, and offered high densities of fathead minnows (*Pimephales promelas*). Linear regression analysis showed that older crappie did not grow as well as younger crappie of similar size (black crappie $p = 0.0001$, $R^2 = .4713$). These results suggest that crappie communities in Illinois do not contain a substantial amount of hybrids. Also, the growth of crappie in communities which consist of older cohorts may not respond to management strategies as quickly as those which contain younger age classes.

ANGLER BASED CHARACTERISTICS OF A RIVERINE-SPAWNING WALLEYE FISHERY

Christopher J. O'Bara, R. Judd Cornell, D. Keith Weaver, Center for the Management, Utilization and Protection of Water Resources, Tennessee Technological University, PO Box 5033, Cookeville, TN 38505, and Douglas Peterson, Tennessee Wildlife Resources Agency, 6032 Andrew Johnson Highway, Talbott, TN 37877

Abstract. Anglers traditionally seek walleye in southeastern rivers during the annual spawning runs. The walleye population in Norris Reservoir consists of both a lake-spawning cohort and a riverine-spawning cohort. During the late-winter and early-spring, the two major tributaries of Norris Reservoir, the Clinch and Powell rivers, provide angling opportunities for both bank and boat anglers. A roving-creel survey was employed during an eight-week period (mid-February through mid-April) to assess the walleye fishery in these two rivers. Angling effort was 68,692 hours (+/- 12,921) in 1995, 55,202 (+/- 8,017) in 1996, and 40,839 (+/- 4,273) in 1997. High water flows contributing to decreased angling opportunities were one factor which resulted in reduced effort in 1997. Angling effort was significantly greater for the larger and easy to access Clinch River in all years. Mean catch rates (no./hr) were not significantly different for both rivers between 1995 and 1996, but were significantly different in 1997. Mean harvest rates were significantly different for both rivers in 1996, but not between 1995 and 1997. Cumulative total catch was significantly different between 1997 and the other two years. Estimated total catch was 20,712 (+/- 8,560) in 1995, 10,518 (+/- 3,381) in 1996 and 3,523 (+/- 1,081) in 1997. Percent of walleye caught that were harvested increased from 35% in 1995 to 80% in 1997. The reduced catch and total catch, as well as the increased percent harvested suggests that recruitment may be problematic in this fishery.

RECRUITMENT FAILURE OF WALLEYE IN NORRIS RESERVOIR, TENNESSEE

Christopher J. O'Bara, Christopher L. Centraccio, Charles Drumright, Center for the Management, Utilization and Protection of Water Resources, Tennessee Technological University, PO Box 5033, Cookeville, Tennessee 38505, and Douglas Peterson, Tennessee Wildlife Resources Agency, 6032 Andrew Johnson Highway, Talbott, TN 37877

Abstract. Walleye *Stizostedion vitreum* are an important sportfish in many southeastern reservoirs and large rivers. Norris Reservoir, a large tributary reservoir of the Tennessee River, was historically noted for both riverine and reservoir spawning populations of walleye. Horizontal experimental gill nets have been employed since 1993 to evaluate the reservoir-residing walleye population in Norris Reservoir and to evaluate possible effects of recently introduced alewife *Alosa pseudoharengus* on pelagic fish populations. Sampling was conducted monthly from May through November in the lentic section of the reservoir. Larval fish collections were taken in late-winter and early spring in 1996 and 1997 throughout the system. No larval walleye were collected in either 1996 and 1997, although several other species were noted. Age-0 walleye CPUE (no./net-night) were not significantly different in the Fall 1993 and 1994. No Age-0 walleye have been collected since the Fall 1994. Age-1 CPUE were not significantly different from 1993 through 1995, but no Age-1 walleye have been collected in 1995, 1996 and 1997. Angler creel surveys also indicate that reduced recruitment to the fishery has occurred and the harvest is currently dominated by larger and older individuals. Consequently, it appears walleye have not successfully reproduced in Norris Reservoir since 1994. Concurrent with the reproductive failure of walleye has been a significant increase in the abundance of alewife. Alewife CPUE has increased significantly since 1994 and are now the most abundant clupeid inhabiting the reservoir. An extensive stocking program is recommended to mitigate the loss in natural reproduction.

EVOLUTION OF VIRGINIA'S ANGLER RECOGNITION PROGRAM

Ed Steinkoenig, Virginia Department of Game & Inland Fisheries, 1320 Belman Road, Fredericksburg, VA 22401

Abstract. One largely accepted tenet among today's anglers when measuring the quality of fishing is that large fish have more "value" than small ones. The Virginia Department of Game and Inland Fisheries started recognizing large or trophy-sized fish in 1962 when three Trophy Fish Citations were issued. The number of awards issued annually since 1962 has increased dramatically, peaking in 1988 when 10,055 citations were processed. The 35-year mean is 3,622 citations. Striped Bass (*Morone saxatilis*), largemouth bass (*Micropterus salmoides*), sunfish (*Lepomis* sp.) and channel catfish (*Ictalurus punctatus*) comprised 42% of citations. Useful information generated by this program includes trophy catch trend analysis by species, date and waterbody. The output provides an excellent public relations tool for communication with media, constituent groups, and individual anglers.

LOTIC FISHERIES ECOLOGY AND MANAGEMENT

NO NET LOSS OF BROOK TROUT DISTRIBUTION IN AREAS OF SYMPATRY WITH RAINBOW TROUT IN TENNESSEE STREAMS

Richard J. Strange and James W. Habera, Department of Forestry, Wildlife and Fisheries, University of Tennessee, Knoxville, TN 38916

Abstract. Lower elevations of brook trout *Salvelinus fontinalis* distribution in 25 streams in East Tennessee were determined during 1991-1995 to evaluate changes related to encroachment and possible replacement by rainbow trout *Oncorhynchus mykiss* since surveys conducted from 1978-1984. No efforts to remove rainbow trout or enhance brook trout populations were made in these streams during the 7-16 year intervals between surveys. Compared to earlier distributions, brook trout receded (lower elevation increased) in 9 streams (36%), advanced (lower elevation decreased) in 8 streams (32%) and did not change in 8 streams (32%). The average change in stream length occupied by brook trout was a 109-m increase (SE=82) with a mean annual rate of 8 m (SE=6). Neither average change nor annual rate was significant ($P>0.19$). Additionally, the uppermost elevation at which rainbow trout were present (determined in 10 streams) increased in 4 streams and decreased in 6. The average change in stream length occupied by rainbow trout was a 158-m decrease (SE=151) with a mean annual rate of -14 m (SE=13). Neither average change nor mean annual rate was significant ($P>0.30$). We conclude that rainbow trout are not currently affecting the downstream limit of most brook trout populations where the two species occur sympatrically in Tennessee. These data support an emerging theory that the distributional limits of brook and rainbow trout in sympatry in the southern Appalachians ebb and flow upstream and downstream over time.

ANGLER BASED CHARACTERISTICS OF A LARGE TAILWATER FISHERY

Scott Porter and Christopher O'Bara, Center for the Management, Utilization and Protection of Water Resources, Tennessee Technological University, PO Box 5033, Cookeville, TN 38505

Abstract. Large tailwaters provide an easily accessible area for anglers to enjoy fishing. A modified bus stop creel survey was employed to evaluate the fishery downstream of the Watts Bar Dam, Tennessee. The survey has been conducted since April 1996. Ninety-six percent of all anglers resided in Tennessee, with most 62%, residing in adjacent counties. Non-Tennessee anglers resided in 12 states including Georgia, Illinois, Indiana, and Kentucky. Seventy-one percent of the parties encountered were bank anglers. Bank anglers fished primarily for sauger (15%), catfish (13%) and white bass (11%). Boat anglers primarily sought catfish (27%), sauger (14%), black bass (11%) and white bass (11%). Anglers expended an estimated 277,284 (+/-986) hours from April 1996 through March 1997. Peak effort was in March 1997 with a general decline in effort during the late summer. Seasonal trends were evident with peak sauger angling effort in December-February period and catfish greatest in the summer months. Catch and harvest rates generally exceeded that for adjacent reservoirs (Watts Bar and Chickamauga reservoirs).

INDEX OF BIOTIC INTEGRITY (IBI) DEVELOPMENT FOR THE INTERIOR PLATEAU AND WESTERN ALLEGHENY ECOREGIONS OF KENTUCKY

Karen L. Smathers, Michael R. Mills, Ron E. Houpp, and John F. Brumley, Kentucky Division of Water, 14 Reilly Road, Frankfort, KY 40601

Abstract. Karr's (1981) original Index of Biotic Integrity (IBI) was developed using third-order midwestern streams. In order to accurately assess fish communities in other areas, the IBI should be calibrated and/or modified to "fit" the region. One objective of Kentucky Division of Water's Reference Reach Program was to sample a number of least-impacted or reference sites within all ecoregions in Kentucky, and then to use the data obtained to adapt the metrics of the IBI for each ecoregion. Forty reference reach sites were established across the state and were sampled twice yearly between 1992 and 1995. Twenty-six of the sites were in the Interior Plateau or Western Allegheny ecoregions. Metrics were calibrated for headwater and wadable streams in the Interior Plateau and Western Allegheny ecoregions using methods outlined by Karr et al. 1986, Ohio EPA 1987 and Simon 1991. Maximum species richness lines were developed for nearly all metrics in order to determine the 5, 3, and 1 scoring criteria. Some new metrics were found to be more effective than the original ones when calculating an IBI at headwater sites. Several original metrics were modified for use at wadable sites.

INVERTEBRATE COLONIZATION OF WOOD INTRODUCED INTO A SOUTHEAST LOUISIANA STREAM

Donna M. Drury and William E. Kelso. School of Forestry, Wildlife, and Fisheries, Louisiana State University, Baton Rouge, LA 70803

Abstract. Removal of woody debris during stream alteration programs reduces habitat diversity, disrupts predator-prey relationships, and results in an overall loss of macroinvertebrate cover. Woody debris is a dominant macroinvertebrate substrate in southeastern coastal plain streams, and we investigated the rate at which invertebrates colonize newly introduced wood, differences in colonization rates between magnolia *Magnolia grandiflora* and water oak *Quercus nigra* debris, and the effects underlying substrate on colonization dynamics. Two units of twelve branches (0.91 m long, 1.3-2.5 cm diameter) of magnolia and water oak were introduced into the Bogue Falaya River at two sites over sand and gravel substrates. Branches were sampled weekly for four weeks, biweekly for two months, and monthly for four months. Data from weeks 1-4 indicate that the debris-associated macroinvertebrate assemblage is dominated by Trichoptera, and Ephemeroptera are the most diverse order colonizing (greatest number of genera) the branches. There does not appear to be substantial differences in colonization rates between tree species. Substrate type does appear to effect colonization number.

WHAT LIVES IN THAT STREAM? VIRGINIA'S STATEWIDE STREAM SURVEY PROGRAM: PLANS, PROTOCOLS, AND PROGNOSTICATIONS

John R. Copeland, Virginia Department of Game and Inland Fisheries, Draper Aden Building, 2206 S. Main Street, Suite C, Blacksburg, Va 24060-6620. Karle Woodward, Virginia Department of Game and Inland Fisheries, HC 6, Box 46, Farmville, VA 23901

Abstract. In 1997, the Virginia Department of Game and Inland fisheries began a statewide headwater stream sampling program. While the project allows us to exercise our curiosity for "what lies beneath the surface", the primary goal is to develop and maintain a fisheries database and classification system for our headwater streams and use it to direct restoration, management, and habitat protection efforts. Project objectives include: (1) identifying streams that do or could support sustainable fisheries through restoration and/or management efforts; (2) developing a long-term monitoring plan to evaluate changes in fish communities related to large-scale anthropogenic impacts; and (3) determining the distribution of threatened and endangered species in relation to drainage basin, habitat, and fish community attributes. Project protocols are borrowed from existing fish and habitat sampling programs like those of the U.S. Geological Survey and the Ohio Environmental Protection Agency. In 1977, survey areas were delineated by using U.S. Department of Agriculture Natural Resource Conservation Service watersheds. In 1998, we plan to survey larger geographic areas by sampling within U.S. Geological Survey hydrologic units or biologically similar "regions" resulting from overlaying drainage and physiography. Collaborative work is being conducted with Dr. Paul Angermeier at Virginia Tech to develop models for determining optimum sampling regimes within geographic areas and for predicting species presence or absence in unsampled locations. The presence and absence models may provide a basis for us to prognosticate on stream reaches where restoration, management, and habitat protection efforts could be directed.

**DESCRIPTIONS OF SIX NEW SPECIES WITHIN THE *ETHEOSTOMA SPECTABILE* COMPLEX
(PERCIDAE: SUBGENUS *OLIGOCEPHALUS*) FROM KENTUCKY**

Patrick A. Ceas, Department of Biological Sciences, Eastern Kentucky University, Richmond, KY 40475

Abstract. An ongoing morphological and allozymic examination of variation within the *Etheostoma spectabile* complex has revealed the existence of nine previously unknown taxa, and has confirmed specific status for two previously recognized subspecies. Each of the new species is distinguished morphologically on the basis of modal differences for certain meristic counts and breeding male coloration. Diagnosis and distributional data for six of the new species found in Kentucky and Tennessee are presented. One species, endemic to Pond River system (Green River drainage), has a range of approximately 600 square kilometers. Another species, endemic to the Dix River system (Kentucky River drainage), also has a relatively small range. Although presently common within their ranges, these two species remain susceptible to habitat destruction and may warrant protection.

**EVALUATION OF THE NUTRITIONAL VALUE OF CRAYFISH AS FORAGE FOR CHANNEL
CATFISH**

Joseph E. Flotemersch. SBI, Inc., 3411 Church Street, Cincinnati, OH 45244, Louis R. D'Abramo, and Donald C. Jackson, Department of Wildlife and Fisheries, Mississippi State University, Mississippi State, MS 39762

Abstract. Two taxa of crayfish were evaluated relative to their potential value as a dietary source of essential amino acids and essential fatty acids for channel catfish (*Ictalurus punctatus*) of the Yockanookany Floodplain-River Ecosystem. One crayfish taxon was a terrestrially burrowing crayfish (*Cambarus (Lacunicambarus)* sp.) and the other a stream dwelling non-burrowing crayfish (*Procambarus (Ortmannicus) acutus*). Comparative analyses of tissue levels and nutrient requirements revealed that both taxa of crayfish are excellent sources of essential amino acids and essential fatty acids for channel catfish. Peak foraging on crayfish by Yockanookany River channel catfish was documented to be prior to peak occurrence of eggs in channel catfish. Therefore, crayfish probably serve as a significant nutrient source of essential amino acids and essential fatty acids for vitellogenesis in channel catfish of this ecosystem.

WARMWATER STREAMS SYMPOSIUM

ANGLER ATTITUDES AND RESPONSE TO A REGULATION CHANGE ON AN OZARK STREAM SMALLMOUTH BASS FISHERY

Brian K. Wagner, Mark L. Oliver, Stephen P. Filipek, and Kenneth E. Shirley, Arkansas Game and Fish Commission, #2 Natural Resources Drive, Little Rock, AR 72205

Abstract. Crooked Creek is a small, Ozark stream located in north-central Arkansas, and nationally known as a smallmouth bass (*Micropterus dolomieu*) fishery. Concerns over the continued quality of this fishery have been expressed to biologists by anglers since the mid-1980's. In January 1992, the minimum length limit was increased from ten inches to 14 inches and the daily creel limit was reduced from six to two smallmouth bass per day. A creel survey was conducted June of 1989 through May of 1995, providing data spanning these regulation changes. Seven hundred eight-nine interviews involved anglers from 18 states and the District of Columbia. Over the period of the survey, there was no change in percent non-resident anglers, median travel distance, or use of guides. Interviewed anglers avidly sought smallmouth bass on streams (58% did so 10+ times per year), frequently on Crooked Creek (44% did so 10+ times per year). Anglers were very satisfied with their trips (88%) but less so with the number (56%) and size (42%) of fish caught. Most anglers said they harvested no fish on trips to the creek, and this was even more common after the regulation change (50% before versus 77% after). The majority of anglers were supportive of more restrictive regulations, particularly the increased minimum length limit that was imposed during the study (87% approval). Anglers were more supportive of regulations in general after the regulation change. The creek was fished an average of 372 hours per hectare, with a harvest of 25.1 smallmouth bass weighing 13.1 kg per hectare. Catch rates were very high, with a mean of 1.33 per hour. After the regulation change, pressure and catch rate remained high, but harvest and yield were severely reduced. The new regulations appear to have the support of anglers and should lead to improved fishery quality.

EFFECT OF INCREASED LENGTH AND REDUCED CREEL LIMITS ON AN OZARK STREAM SMALLMOUTH BASS POPULATION

Stephen P. Filipek, Mark L. Oliver, Brian K. Wagner, and Kenneth E. Shirley, Arkansas Game and Fish Commission, #2 Natural Resources Drive, Little Rock, AR 72205

Abstract. In response to angler concerns regarding a perceived decline in the quality of the smallmouth bass fishery in Crooked Creek, an Ozark highland stream located in North Central Arkansas, extensive fish population and physio-chemical sampling was conducted from 1986-1994, and a creel survey was conducted from 1989-1995. Data from this sampling led to the imposition of a 356-mm (14 inch) minimum length limit, 2 fish/day creel limit in January 1992. The regulation changes resulted in no significant change in smallmouth population density or growth rate but did result in a dramatically improved size structure. Biomass increased significantly. Populations above 250 mm, 300 mm and 350 mm more than doubled within 2 years. Angler use remained very high and anglers were satisfied with both their trips and the regulations. Angler catch rates increased but harvest and yield decreased. Physio-chemical analyses revealed a decline in water quality in Crooked Creek during the study period.

CROOKED CREEK: POLITICS, SCIENCE, AND HUMAN USE

April Layher, Stephen P. Filipek, and Mark Oliver. Arkansas Game and Fish Commission, #2 Natural Resources Drive, Little Rock, AR 72205

Abstract. Crooked Creek is an 80-mile long Northwest Arkansas stream which runs almost completely through private lands from its headwaters in Boone County to the White River. Historically, Crooked Creek is known for its beautiful scenery and excellent smallmouth bass fishing. Over the recent decades, gravel removal from the creek has increased dramatically and today represents a major disturbance for the aesthetic, hydrologic and fisheries values of the stream. In 1996, an intensive effort was made by concerned citizens and state agencies to stop gravel mining by declaring Crooked Creek an Extraordinary Resource Water Body through the authority of the Arkansas Department of Pollution Control and Ecology. Although unsuccessful, this effort further generated a lawsuit filed through the office of the Arkansas Attorney General to declare Crooked Creek a navigable stream, thereby making the stream substrates property of the state and preventing private restrictions to public use of the waterway. As the lawsuit proceeds, politics and science will be major factors in determining the future of this valuable resource.

POPULATION CHARACTERISTICS OF FLATHEAD CATFISH IN SOUTHEASTERN COASTAL RIVERS

Christopher Thomason, South Carolina Department of Natural Resources, 230 Westfield Street, Barnwell, SC 29812 and Robert Weller, Georgia Department of Natural Resources, Fitzgerald, GA

Abstract. A synopsis of the current status of flathead catfish inhabiting coastal rivers of South Carolina and Georgia will be provided. An ongoing effort to assess the population structure of this newly introduced predator and its impact in historic fisheries will be discussed.

MANAGEMENT OF SMALLMOUTH BASS USING THE ECOREGION CONCEPT

Stephen P. Filipek, Brian K. Wagner, Leslie G. Claybrook, Ralph Fourt, Robert Limbird, Mark L. Oliver, Tom Penniston, Carl Perrin, and Stuart Wooldridge, Arkansas Game and Fish Commission, #2 Natural Resources Drive, Little Rock, AR 72205, Richard Standage, USDA Forest Service, PO Box 1270, Hot Springs, AR 71913, Rex Robbins, Arkansas Smallmouth Bass Club, 4711 Arlington, AR

Abstract. Smallmouth bass are found in almost half of Arkansas counties and are a popular sportfish. These fish inhabit only the clear, cool waters of the Interior Highlands in the state composed of the Ozark, Ouachita, and Boston Mountains. Historically, smallmouth bass were managed as just another black bass with no specific regulations put on them until the early 1980's. At that time, a statewide length limit of 254 mm TL was imposed in combination with a reduction in the daily creel limit from 10 to 6 fish/d. Work by Arkansas Department of Pollution Control and Ecology and Arkansas Game and Fish Commission (AGFC) personnel demonstrated that fish communities in the six different physiographic, or ecoregions, were noticeably different and this difference was attributed to the difference in soil types, fertility, vegetative communities, land uses, and land surface forms. AGFC biologists took this ecoregion concept one step further and demonstrated a difference in the densities and growth of smallmouth bass from the Ozark Highlands, ecoregion and the other ecoregions of the state inhabited by smallmouth (Ouachita Mts., Boston/Arkansas River Valley). A management plan based on these differences across ecoregions was formulated for smallmouth bass in Arkansas. Higher minimum length limits were imposed on the more fertile Ozark Highlands ecoregion, while less productive areas had lower length limits, matching the streams capacity.

A REVIEW OF WARMWATER STREAM FISHERIES MANAGEMENT IN THE SOUTHEASTERN UNITED STATES

Christopher J. O'Bara and Joshua Crunk, Center for the Management, Utilization and Protection of Water Resources, Tennessee Technological University, PO Box 5033, Cookeville, TN 38505

Abstract. Warmwater streams and rivers provided anglers ample opportunities to enjoy fishing in a diverse setting. Southeastern streams and rivers are inhabited by a wide range of sportfish including the sunfishes, black basses, catfishes, true basses, and percids. Fishery management programs vary as much as potential fisheries. Although novel to most states, management techniques to enhance warmwater lotic fisheries are becoming more widespread. A review of southeastern state's programs will be provided including regulations, stocking, and habitat enhancements

MUSSEL ECOLOGY AND MANAGEMENT

MANAGING COMMERCIAL MUSSEL SHELL HARVEST

Don Hubbs, Robert Todd, and C. Freddie Couch, Tennessee Wildlife Resources Agency, Ellington Agricultural Center, PO Box 40747, Nashville, TN 37204

Abstract. Commercial harvest of freshwater mussel shells has grown into a multi-million dollar business in Tennessee. Mussel shells harvested in Tennessee are shipped to Japan and other countries. Once there, they are cut and polished into beads that are surgically implanted into marine oysters to form cultured pearls. Annual harvest varies according to market demand; normally 1,500 to 4,000 tons are exported from Tennessee each year. Approximately 50% of the shells exported from the United States are harvested in Tennessee. This harvest drives an industry that employs 2,000 to 3,000 people and produces revenues exceeding \$60 million a year in Tennessee. Intensive harvesting of freshwater mussels has routinely depleted areas of their legal-sized commercial shell stocks. Greater than 90% of Tennessee's mussel harvest occurs on Kentucky Reservoir whose mussel stocks are harvested almost immediately after attaining legal size. Large mussel shells have become increasingly valuable as supplies dwindle. This disparity in the price of legal and plus legal-sized mussel shells and non uniformity of shell size limits among states has lead to increased violations of closed harvest areas within Tennessee and other states, increasing shell prices, and harvest rate correlates with elevated violation of commercial mussel regulations. In response to this growing problem the major shell producing states of Alabama, Arkansas, Kentucky, and Tennessee have recognized disparity in shell size limits as a major factor in illegal harvest of mussel populations. To rectify this situation, the states met in 1996 along with several other shell producing states and decided to work toward uniform size regulations for the major categories of commercial mussel shell.

MONITORING THE IMPACTS OF ZEBRA MUSSELS ON NATIVE MUSSELS IN THE OHIO RIVER

Patricia Morrison, U.S. Fish and Wildlife Service, Ohio River Islands National Wildlife Refuge, PO Box 1811, Parkersburg, WV 26102

Abstract. The Ohio River is home to over 50 species of native freshwater mussels, including ten federally endangered species. Zebra mussels *Dreissena polymorpha* first entered the Ohio River in 1991. Since 1995, a cooperative of federal, state and private partners have been working together to maintain a network of monitoring sites along the mainstem Ohio River to track the status of zebra mussels and the condition of native mussels in infested areas. Zebra mussel densities continue to build at most of the sites. Some of the sites are experiencing a significant decline in native mussel density, condition and survival. Native mussel mortality (expressed as percent fresh-dead animals) is approaching 40% at three of the lower river sites. In addition to the objective of providing a river-wide assessment of the zebra mussel problem, the data gathered provides critical information needed for management of the imperilled native fauna: identifying populations most at risk, and the "threshold" for rescue or relocation of at-risk species.

COMPARISON OF PHYSIOLOGICAL RESPONSES OF A REPRESENTATIVE FRESHWATER MUSSEL (*VILLOSA IRIS*) AND THE ASIAN CLAM (*CORBICULA FLUMINEA*)

Braven B. Beaty and Richard J. Neves, Virginia Cooperative Fish and Wildlife Research Unit, Virginia Tech, Blacksburg, VA 24061

Abstract. Rainbow mussels (*Villosa iris*) and Asian clams (*Corbicula fluminea*) were deployed in cages at eight sites within the Clinch River watershed, VA to determine differences in responses of six physiological parameters. Mussels and clams were collected at a site in Little River, Russell County, VA and were moved to cages at five sites in the Clinch River, and one site each in Copper Creek, Stock Creek, and Little River. After 30 days, animals were removed from the cages, sacrificed, dissected, and the tissues frozen. Glycogen content, RNA:DNA ratio, and activities of acetylcholinesterase, phosphofructokinase, fructose-1,6-bisphosphatase, and cellulolytic enzymes were measured on various tissue fractions from each species. The experiment was performed in fall (September-October), spring (May-June), and summer (July-August). Differences ($p < 0.05$) were found among sites for all six parameters, as well as among seasons and between species. Patterns of variation among sites were different for the two species. Using Asian clams as surrogates for unionids must be verified as valid for each field monitoring case.

MUSSEL HARVEST IN ARKANSAS (1993-1996)

Tim Burnley, Stan Todd, and Jeff Fairwick, Arkansas Game and Fish Commission, 1201 N. Main, Brinkley, AR 72021

Abstract. Historically, mussels were harvested for the production of buttons and supported a thriving industry in Arkansas. Today, mussel shell is used primarily for seed pearls in the production of cultured pearls in Japan, China, and Australia. Mussel harvest and value increased from 1993 (191 tons, \$1450/ton) to 1995 (1096 tons, \$2360/ton), decreased slightly in 1996, and plummeted in 1997. License sales showed the same pattern with 289 sold in 1993, 518 sold in 1995, and only 58 sold in 1997. The discovery of a previously little harvested bed of mussels on Macon Bayou made 1995 an unusual year with three-ridges and washboards comprising 89.5% of the harvest by species and 45.3% of the total harvest coming from Macon Bayou. Mussel harvest and value are controlled by many factors which make it difficult to predict future harvest. However, industry experts expect continued depressed market conditions in 1998. Even though tremendous headway in collecting accurate harvest data has been made, research into mussel life histories and ecology is needed for better management of this valuable resource.

PRELIMINARY ASSESSMENT OF A FRESHWATER MUSSEL (*MOLLUSCA: BIVALVIA*) COMMUNITY IN THE LICKING RIVER AT BUTLER, PENDLETON COUNTY, KENTUCKY

Bryce E. Daniels and Guenter A. Schuster, Department of Biological Sciences, Eastern Kentucky University, Richmond, KY 40475

Abstract. An ongoing community analysis is being conducted to assess the impacts of anthropogenic factors on a freshwater mussel (*Bivalvia: Unionidae*) assemblage in the Licking River at Butler, Pendleton County, Kentucky. The level of recruitment (i.e., reproduction) taking place will be determined by the presence of glochidia (unionid larvae) in stream drift, glochidial encystment on the fins and gills of fish hosts, and juvenile mussels within the sampling areas. Preliminary analysis of drift net samples has yielded 18 glochidia and 102 juvenile *Corbicula fluminea*, the exotic Asian clam, in approximately 150-m³ of stream drift. Quantitative sampling, consisting of substrate excavation of randomly selected 0.25-m² plots, has resulted in the discovery of juveniles of five species of native mussels, including three juveniles of the federally endangered fanshell, *Cyprogenia stegaria*. Preliminary importance values were calculated for every unionid species quantitatively sampled, by taking a sum of each species' relative abundance, relative frequency, and relative volume. This method has shown the spike, *Elliptio dilatata*, to be the most important species occurring in the sampled areas. A combination of qualitative and quantitative searches has yielded 26 extant unionid species within the area. Anthropogenic factors in the drainage, and the presence of large numbers of *C. fluminea*, have had an impact on the resident mussel species. This analysis provides baseline population parameters on each species encountered that can be used in future monitoring efforts at this biologically and historically significant site.

THE EFFECTS OF WATER TEMPERATURE ON ZEBRA MUSSEL POPULATION DYNAMICS IN AN ARKANSAS RESERVOIR

Andrew N. Dick, Charles J. Gagen and Joseph N. Stoeckel, Fisheries and Wildlife Biology Program, Arkansas Tech University, Russellville, AR 72801

Abstract. Zebra mussels (*Dreissena polymorpha*) are known to alter limnological conditions and adversely impact man-made structures in heavily infested waters. We have sampled all life-stages of zebra mussels in Lake Dardanelle, AR since 1993. Following their discovery in 1992, the population has grown exponentially. Peak densities of settling juveniles increased from below detection in 1993, to millions/m² in the spring of 1997. However, a die-off of approximately 80% all size classes coincided with unusually high water temperatures (>30°C for one week) during July of 1997. In more southern reservoirs, high adult mortality in the summer produces a zebra mussel population dominated by juveniles. In more northern latitudes, adult zebra mussel populations can reach higher densities, but fluctuate considerably due primarily to die-offs of the oldest cohorts. Thus, mesotrophic reservoirs in the mid-south provide unique conditions for zebra mussels; where, years of favorable conditions punctuated by episodes of high water temperature, can produce exponential population growth followed by massive die-offs. We expect future exponential increases in zebra mussel densities to be periodically disrupted by sustained high water temperature. We hypothesize that a model incorporating air or water temperature could be used to predict the magnitude of thermal-induced zebra mussel die-offs.

EVALUATION OF CONSTRUCTION IMPACTS, RELOCATION, AND HABITAT ENHANCEMENT ON UNIONID MUSSELS; WHAT WE HAVE LEARNED AND FUTURE CONSIDERATIONS

Heidi L. Dunn, Ecological Specialists, Inc., 114 Algana Court, St. Peters, MO 63376

Abstract. Unionids are frequently relocated from construction sites to mitigate impacts, particularly to endangered species. However, past relocation monitoring has been minimal and data suggests low recovery and possibly survival of unionids following relocation. Additionally, construction impact areas are often based on anecdotal information and few studies have tested the adequacy of buffer zones around construction, barge spudding and mooring, and streambank disturbance. Another seldom considered issue is construction area recolonization and habitat enhancement. Unionids were relocated from eight construction areas in six different rivers between 1987 and 1997. Monitoring varied among relocation studies from one to ten years, and frequently included monitoring of relocated and resident unionids. Factors contributing to high recovery and survival include using field personnel familiar with unionids, selecting a relocation area with a stable substrate and a similar unionid community that is near the collection area, keeping animals moist or in water, and avoiding extreme temperatures and overcrowding. Unionids within construction/demolition areas were monitored in two studies. Unionids were affected by construction up to 5 m from cofferdams and by pier demolition up to 16 m from piers. Methods of enhancing unionid habitat during construction were considered in two construction projects. Substrate was stable one year after relocation, and a few unionids had recolonized construction areas. Future mitigation of construction projects needs to include evaluation of buffer zones and habitat enhancement, as well as, survival of relocated unionids.

RELATIONSHIP BETWEEN MUSSEL DENSITY AND SURVIVAL DURING AND FOLLOWING A 30-DAY QUARANTINE PERIOD

Robert D. Quinn and James B. Layzer, U.S. Geological Survey/Biological Resources Division, Tennessee Cooperative Fishery Research Unit, Tennessee Technological University, Cookeville, TN 38505

Abstract. In response to the introduction of zebra mussels into the Cumberland and Tennessee river drainages, unionids translocated from these river systems are routinely quarantined for 30 days. To date, little is known about the factors that may affect survival during quarantine. Therefore, we conducted five quarantine experiments between May and December of 1996. Our objective was to determine the highest density for quarantining the freshwater mussel *Fusconaia ebena* that would still result in high overall survival, and negligible risk of zebra mussels surviving or escaping visual detection. During most experiments, *F. ebena* were held at densities of 50, 100, 150, 200, 250, and 300 per 760 L. These unionids were fed a dehydrated culture of *Spirulina platensis* at a rate of 0.05 g/unionid/3d. Apparent trends in mortality during and following the quarantine were inconsistent among seasons. For instance, mortality was density dependent in October and ranged from 26% in the lowest density tank to 68% in the highest density tank; however, mortality in November did not exceed 1% for any density tested. Overall survival of the 30-day quarantine period seemed to follow a pattern of seasonal variation with the highest survival during May and November, and the lowest survival during July. This seasonal variation in survival closely paralleled a previously identified trend in condition of *F. ebena* at this site.

HOST FISH SUITABILITY FOR GLOCHIDIA OF *LIGUMIA RECTA*

Jason R. Khym and James B. Layzer, U.S. Geological Survey/Biological Resources Division, Tennessee Cooperative Fishery Research Unit, Tennessee Technological University, Cookeville, TN 38501

Abstract. In the early 1900's, several fish species were identified as hosts for the black sandshell, *Ligumia recta*. Recent attempts to propagate *L. recta* with two of the reported hosts (bluegill *Lepomis macrochirus* and largemouth bass *Micropterus salmoides*) have produced inconsistent results and few juveniles. We conducted this study to determine which of the reported hosts were the most suitable for metamorphosing juvenile *L. recta*. Reported hosts were artificially infested with glochidia of *L. recta* and placed into 38 or 114 liter aquaria depending on fish size. Juvenile metamorphosis occurred from 15 to 48 days and varied according to water temperature. Bluegills and largemouth bass produced relatively few or no juveniles in three trials. Although similar numbers of glochidia encysted on all hosts, >10X more juveniles metamorphosed on sauger *Stizostedion canadense* compared to other hosts tested.

IMPACT OF ZEBRA MUSSELS AND COMMERCIAL MUSSEL HARVEST ON NATIVE UNIONID MUSSELS IN WESTERN KENTUCKY

James B. Sickel, Jeffrey J. Herod, and Darren P. Reed, Department of Biological Sciences, Murray State University, Murray, KY 42071

Abstract. Native unionid mussels in western Kentucky have been examined over the past 20 years with three major surveys in Kentucky Lake: 1980-81, 1988-89, and 1995-96; one major survey in Lake Barkley in 1994; and numerous minor studies in the lower Cumberland River, Tennessee River and Ohio River. The progress of the zebra mussel invasion in the lower Ohio River has been examined since its first appearance in 1991. Significant changes in the Kentucky Lake unionid community are reflected in a reduction in density of some commercial species, especially *Quadrula quadrula* and *Megaloniais nervosa*, while some commercial species are experiencing successful reproduction and increase, e.g. *Amblema plicata*. We suggest that harvest size limits are too small for *M. nervosa* and *Q. quadrula*, while the limits for *A. plicata* are adequate. Although mortality of undersized mussels caught on brails averages 50%, and there has been a significant change in the community composition, the overall density of mussels has not changed significantly since 1980. Zebra mussels are attached in large numbers to essentially every unionid in the lower Ohio River, and mortality of unionids is now indicated. However, although their numbers are increasing, few zebra mussels occur in the Tennessee and Cumberland rivers. Supporting funds for this project were received from the Mussel Mitigation Trust, Murray State's Center for Reservoir Research and the Shell Exporters of America, Inc.

GONAD DEVELOPMENT IN ZEBRA MUSSELS (*BIVALVIA: DREISSENIDAE*) FROM THE TENNESSEE AND OHIO RIVERS

Karen A. Brinkley, James B. Sickel, and Leon Duobinis-Gray, Department of Biological Sciences, Murray State University, Murray, KY 42071

Abstract. Zebra mussels were collected from 2 sites in Kentucky Lake and 1 site in the Ohio River monthly between March 1996 and February 1997 with the aid of SCUBA. Specimens were fixed in 10% buffered formalin, dehydrated, embedded in paraffin, sectioned and stained with hematoxylin and eosin. Sections from each specimen were histologically examined, sexed and assigned to gametogenic stages based on gamete morphology and gonad maturity. Gonad maturity was determined by types and arrangement of tissue in the gonad. Six gametogenic stages were observed during the reproductive season. The stages were identified as resting, early development, later development, ripe, spawning, and redevelopment. Kentucky Lake zebra mussels matured and spawned slightly later than those in the Ohio River. By June, zebra mussels in both rivers were at approximately the same stage in reproductive development. Redevelopment of eggs in the gonad suggested that eggs were continually shed until the redevelopment stage was reached in mid-October. Gonad development of males and females appeared to be synchronous. The reproductive season lasted approximately one month longer in Kentucky Lake than in the Ohio River. Supporting funds for this project were received from the Mussel Mitigation Trust, Murray State's Center for Reservoir Research, and the Shell Exporters of America, Inc.

ANNUAL VARIATIONS IN ZEBRA MUSSEL (*DREISSENA POLYMORPHA*) VELIGER DENSITIES THROUGHOUT 1996 AT DAM 52 ON THE LOWER OHIO RIVER

Darren P. Reed, Jeffrey J. Herod, and James B. Sickel, Department of Biological Sciences, Murray State University, Murray, KY 42071

Abstract. Zebra mussel veliger densities throughout 1996 were monitored at one site at the Army Corps of Engineers Lock and Dam 52, on the Lower Ohio River near Brookport, IL. The spawning season was determined to have occurred between mid-June and early September. The presence of veligers within water samples taken during the spawning period showed a bimodal distribution. One large peak of 30,000/m³ occurred in late July, with a second smaller peak of 8,000/m³ in mid-August. The presence of multiple peaks indicates the possibility of more than one spawning event within the lower Ohio River for one season. Veligers first appeared at a water temperature of 21°C. When spawning ended in September, the water temperature was 22°C. Veligers continued to be found through November at which time the water temperature fell to 10°C. The lowest temperature at which veligers were observed was 7°C, in March. Results of this study show that zebra mussels in the lower Ohio River are naturally reproducing and the occurrence of spawning appears to be synchronous. The presence of larvae at such low temperatures in March suggests that veligers are capable of delaying settlement and overwintering in the planktonic stage. Supporting funds for this project were received from the Mussel Mitigation Trust, Murray State's Center for Reservoir Research, and the Shell Exporters of America, Inc.

STRIPED BASS BIOLOGY AND MANAGEMENT

EFFECTS OF SALTWATER ON SURVIVAL, GROWTH, AND NUTRITIONAL CONDITION OF JUVENILE STRIPED BASS *MORONE SAXATILIS*

Anthony S. Overton, Maryland Cooperative Fish and Wildlife Research Unit, 1120 Trigg Hall, University of Maryland Eastern Shore, Princess Anne, MD 21853; M. J. Van Den Avyle, Georgia Cooperative Fish and Wildlife Research Unit, D. B. Warnell School of Forest Resources, University of Georgia, Athens, GA 30602

Abstract. Juvenile stages of striped bass, *Morone saxatilis*, depend on estuarine productivity for rapid growth and the habitat diversity of estuaries for protection from predation. Suitability of estuaries as nursery areas may be influenced by salinity. To examine the influences of salinity, four age groups (67, 91, 112, 133 days) of juvenile striped bass were reared in the laboratory at three different salinities (0, 5, and 10‰) and two temperatures (25, 28°C) to test the effects of salinity on survival, growth rate, and nutritional condition. Nutritional condition was measured by Liver Somatic Index (LSI), lipid cell size, and RNA/DNA ratios. Survival exceeded 98% throughout the entire experiment. Growth rates in 25°C were highest in 5 and 10‰, but salinity did not affect growth at 28°C. Cell size was not affected by salinity in any of the tests. Salinity had no effects on mean LSI and RNA/DNA ratio at 25°C, but those values were lowest at 5‰ in 28°C. Data collected by the Georgia Cooperative Fish and Wildlife Research Unit show the juvenile striped bass are most abundant on the freshwater side of the freshwater/saltwater interface. Our results suggest that factors other than salinity are probably contributing to the spatial distribution of the juveniles.

PRESCRIBING FISH HATCHERY PRODUCTION OBJECTIVES FOR OPTIMIZING STOCK ENHANCEMENT PROGRAMS: A CASE HISTORY FROM STRIPED BASS MANAGEMENT

Mike Van Den Avyle, Cooperative Research Units Program, 1875 Century Blvd., Suite 200, Atlanta, GA 30602

Abstract. Hatchery production objectives have often been viewed as constraints rather than components of fishery management efforts. In many cases, the lack of knowledge of fish performance in receiving waters has impaired the development of clear objectives for hatchery production, essentially decoupling management into separate "hatchery" and "post-stocking" phases. This separation often prevents optimization of the overall management effort. In a study of post-stocking survival of striped bass *Morone saxatilis* in the Savannah River, GA-SC, the relative cost and survival of three size classes of hatchery-reared fish were evaluated during 1990-1996. Based on per-fish production cost, stocking of the smallest size class (phase I, 20-35 mm TL) would have been recommended. However, by adding information obtained for estimated survival of fish at 48-h post-stocking, it was concluded that the intermediate size class (advanced phase I, 60-80 mm) was superior. However (again), by adding information about survival of stocked fish to age 2, the largest size class (phase II, 175-250 mm) was considered optimal for future stocking efforts. Differences between conclusions reached at various points in the rearing-stocking chronology indicate the sensitivity of management decisions to the type of information available and the need for comprehensive information to allow a (seemingly) correct decision. In this case, recruitment to the adult stock was optimized by stocking fewer, larger, more costly fish, and the findings were incorporated into hatchery production objectives.

REPRODUCTIVE SUCCESS OF STRIPED BASS IN THE OGEECHEE RIVER, GEORGIA

Thomas G. Meronek, Georgia Dept. Of Natural Resources, Wildlife Resources Division, Fisheries Section, 22814 Hwy 144, Richmond Hill, GA 31324

Abstract. Reproductive success of striped bass *Morone saxatilis* in the Ogeechee River, Georgia was assessed by trawling, bi-weekly from May to September, to determine the mean annual juvenile abundance index (JAI). Comparisons with historical data were made to determine the population status. Overall, JAIs, for the years 1985 and 1988-1994, were similar ($P > 0.05$), but were lower than JAIs for the period 1982-1984. Regression equations were evaluated for accuracy in predicting the striped bass JAI from mean June flow (MJF). The regression equation, $JAI = 0.49254 + (.0031362 \times MJF)$, $r^2 = 0.97$, was the most accurate when MJF was less than 2,000 CFS. When MJF was greater than or equal to 2,000 CFS, a natural log transformation of JAI and MJF yielded the most accurate regression equation for determining the JAI: $[\ln JAI = -7.2329 + (1.1370 \times \ln MJF)]$, $r^2 = 0.76$. The JAI was related to subsequent electrofishing catch per unit effort (ECPUE) of age II fish by the equation: $[ECPUE \text{ age II} = 0.19230 + (0.14126 \times JAI)]$, $r^2 = 0.91$. A strong age II year class will likely be produced for years when the JAI is predicted to be 0.89 fish/1000m³ or greater.

THE IMPACTS OF STOCKING STRESS AND LARGEMOUTH BASS PREDATION ON THE SURVIVORSHIP OF JUNVEILE STRIPED BASS STOCKED IN SMITH MOUNTAIN LAKE, VIRGINIA.

Daniel P. Michaelson, Kentucky Department of Fish and Wildlife Resources, 2744 Lake Road, Prestonsburg, KY 40653

Abstract. Smith Mountain Lake, Virginia supports a successful put-grow-take striped bass *Morone saxatilis* fishery. Empirical analysis of striped bass stocking has shown an inverse relationship between number of fingerling striped bass stocked and survival to age 1. Predation mortality by largemouth bass *Micropterus salmoides* was considered as one source of poor first year survival of striped bass in Penhook and Waterwheel stocking coves at Smith Mountain Lake. It was necessary to estimate largemouth bass population size, diet composition, and daily consumption (bioenergetic modeling) to determine the total number of striped bass lost to predation. Diet analysis revealed that age-0 striped bass made up a maximum of 2.5% of largemouth bass diets in the month following stocking; adult alewives constituted more than 60% by weight. The estimated number of striped bass lost was only 360 (0.1%) in 1994 and 3,062 (1.2%) in 1995. Bioenergetics simulations demonstrated that predation could become significant in the unlikely event that the contribution of striped bass to largemouth bass diets increased to 10% or more. Based on results from diet analysis and a prey preference laboratory study, alewives appear to buffer predation of age-0 striped bass during the month after stocking. In 1994 and 1995, largemouth bass predation did not result in substantial mortality of stocked fingerling striped bass.

POPULATION SUBDIVISION OF STRIPED BASS IN SOUTH CAROLINA COASTAL RIVERS: MANAGEMENT IMPLICATIONS

J. Bulak, South Carolina Department of Natural Resources, 1921 Van Boklen Road, Eastover, SC 29044. D. Allen and C. Thomason, South Carolina Department of Natural Resources, 1324 Dunbarton Boulevard, Barnwell, SC 29812. B. Ely, Department of Biological Sciences, University of South Carolina, Columbia, SC 29208. R. Dunham, Southeastern Cooperative Genetics Project, Swingle Hall, Auburn University, Auburn, AL

Abstract. The coastal rivers of South Carolina contain striped bass *Morone saxatilis* populations of varying sizes. Historically, striped bass populations in these rivers had received relatively minimal attention and were intermittently augmented by hatchery-produced progeny from the Santee-Cooper system. In recent years, population and genetic surveys of coastal rivers, primarily the Combahee River, were conducted to better define population structure, inter-river migration, and the success of hatchery stockings. Combahee River tagging studies revealed minimal inter-river migrations and produced a Schnabel population estimate of approximately 500 striped bass > 300 mm TL. Hatchery stocking of 10,000 phase II fingerlings in 1990 resulted in a 25% contribution to that cohort. An allozyme survey revealed low genetic diversity but suggested differences among rivers. Three polymorphic, nuclear PCR-RFLP markers showed population subdivision among the State's three major drainages, the Pee Dee, Santee, and ACE basin. Based on these recent surveys, a policy of treating each major drainage as a distinct management unit and stocking coastal rivers with endemic broodstock has been suggested. Possible summer habitat limitations in Combahee river is now a primary research question.

MARINE AND ESTUARY BIOLOGY

GULF TOADFISH REPRODUCTIVE STRATEGIES

Susan J. Allee and Wayne A. Bennett, University of West Florida, Department of Biology, 11000 University Parkway, Pensacola, FL 32514

Abstract. Gulf toadfish, *Opsanus beta*, are poorly represented in ecological studies and their reproductive strategies relatively undefined. Our preliminary investigations into breeding seasons and mating behaviors of a Florida gulf toadfish population have revealed several unique and previously undocumented strategies. Ten replicates, each with 5 nest types, were placed in the field and observed from February until November for toadfish activities. Gulf toadfish appear to participate in a bi-peaked breeding season. Males established nests and females oviposit during the month of May, then all fish disappear until late July and breeding resumed in September. Male and female toadfish apparently discriminate between nest types differently. Females preferred nests with one opening over those that are accessible to the surrounding environment through multiple openings. Males, however, showed distinct preferences between the five different nest types based on characteristics of each nest. Males that occupy nests adjacent to other male-occupied nests appear to have greater reproductive success than lone males, contradicting the traditional view that toadfish are highly aggressive and territorial. Male gulf toadfish do not appear to aggressively defend any territory beyond their immediate nest site, an observation which may explain why males in groups experience greater reproductive success.

DISTRIBUTION AND ABUNDANCE OF THE BAY ANCHOVY, *ANCHOA MITCHILLI*, IN THE HUDSON RIVER ESTUARY

P. A. Klose, S. B. Brandt, and K. H. Hartman, Great Lakes Center at Buffalo State College, 1300 Elmwood Avenue, Buffalo, NY

Abstract. Bay anchovy (*Anchoa mitchilli*) are one of the most abundant fish species in Atlantic coastal waters and in many east coast estuaries. Bay anchovy play an important role in the food web of the Hudson River Estuary both as a size selective zooplanktivore and major prey of recreationally and commercially fished piscivores. Measures of bay anchovy abundances in the Hudson River Estuary are not available. We used high-frequency (120 kHz), split-beam echo sounding to assess the abundance and spatial distribution of bay anchovy from May to September 1996 and 1997 in the Hudson River Estuary from Newburgh, NY to Sandy Hook, NJ. Composition of acoustic targets was determined from midwater trawl catch data. The estuary was divided into 15 geographic regions from north to south. Distributions and densities of anchovy were determined from acoustic sampling for each geographic region for each month and compared to the prevailing environmental conditions. Preliminary results have shown significant differences between distributions of larval and adult bay anchovy. The highest densities of larval anchovy occurred near Indian Point in August while peak densities of adults were found in the Yonkers region in July.

POPULATION ASSESSMENT OF THE VERMILION SNAPPER, *RHOMBOPLITES AUROREBENS*, FROM THE SOUTHEASTERN UNITED STATES

Charles S. Mannoch, III, Jennifer C. Potts, Michael L. Burton and Douglas S. Vaughn, National Marine Fisheries Service, Beaufort Laboratory, 101 Pivers Island Road, Beaufort, NC 28516

Abstract. Changes in the age structure and population size of vermilion snapper, *Rhomboplites aurorubens*, from North Carolina through the Florida Keys were examined using records of landings and size frequencies of fish from commercial, recreational, and headboat fisheries from 1986-1996. Population size in numbers at age was estimated for each year by applying separable virtual population analysis (SVPA) to the landings in numbers at age. SVPA was used to estimate annual, age-specific fishing mortality (F) for four levels of natural mortality ($M = 0.20, 0.25, 0.30, \text{ and } 0.35$). Although landings of vermilion snapper for the three fisheries have declined, minimum fish size regulations have resulted in an increase in the mean size of fish landed. Age at entry and age at full recruitment were age-1 and age-3 for 1986-1991, compared with age-1 and age-4, respectively, for 1992-1996. Levels of mortality from fishing (F) ranged from 0.38 - 0.61 for the entire period. Current spawning potential ratio (SPR) is 21% or 27% depending on the natural mortality estimate. SPR could be raised to 30% or 40% with a reduction in F, or by increasing the age at entry to the fisheries. The latter could be enhanced now if fishermen, particularly recreational, comply with minimum size regulations.

SPAWNING ACTIVITY OF THE BAY ANCHOVY, *ANCHOA MITCHILLI*, IN THE HUDSON RIVER ESTUARY

T. P. Bassista and K. J. Hartman, West Virginia University, Division of Forestry, Department of Fisheries, PO Box 6125, Morgantown, WV 26505

Abstract. Bay anchovy (*Anchoa mitchilli*) eggs, larvae, and adults were collected in the Hudson River Estuary from May through September, 1996 and 1997, to determine spawning location and season, daily spawning time, and spawning frequency. Spawning takes place in the entire estuary where salinities are greater than 5 ppt. The spawning season started in late May to early June in 1996 and 1997, respectively, when water temperatures reached 18 degrees (C). Spawning was completed by September for both years. We found that the bay anchovy begin spawning by 2200 hours and were done spawning by 0400 hours. Greater than 90% of adult female bay anchovies spawn on a given evening. We also found that greater than 98% of spawning fish were 2 years old or greater. The findings of this study differ somewhat from that observed in the Chesapeake Bay. In the Chesapeake, anchovy spawners are primarily age-1 fish. The differing reproductive demographics suggests a latitudinal difference in bay anchovy populations.

A COMPARISON OF A PHYSIOLOGICAL RESPONSE OF WILD AND POND-REARED, HATCHERY RED DRUM *SCIAENOPS OCELLATUS*, TO CAPTURE BY HOOK AND LINE

E. Ashley Gallman and J. Jeffery Isely, South Carolina Cooperative Fish and Wildlife Research Unit, Clemson University, Clemson, SC 29634, Joseph R. Tomasso, Jr., Department of Aquaculture, Fisheries and Wildlife, Clemson University, Clemson, SC 29634 and Theodore I.J. Smith, Marine Resources Research Institute, South Carolina Department of Natural Resources, PO Box 12559, Charleston, SC 29422

Abstract. Red drum *Sciaenops ocellatus* is an estuarine dependent species that is economically important for sport fisheries throughout its range. Hatchery stocking and strict management regulations have been implemented in recent years in an attempt to supplement recruitment. The objective of this study was to evaluate the effect of length of play on the magnitude of the physiological stress response of red drum. Stress responses of wild and pond-reared hatchery red drum were also examined to determine if any differences existed between the two groups. Plasma cortisol concentrations were used as an indicator of the primary stress response. Additionally, circulating glucose concentrations and osmolality were used as indicators of the secondary stress response. Osmolality also served as an indicator of osmoregulatory dysfunction. Plasma lactate concentrations were measured to establish the magnitude of anaerobic metabolism and fatigue. Preliminary results indicate that wild and hatchery red drum both respond physiologically to capture by hook and line. The physiological response was similar between both wild and hatchery groups of fish. Fish size or length, however, may be a significant variable in determining the magnitude of the stress response. It also appears that fish captured in warmer water temperatures elicit a more severe response than those captured in cooler water temperatures.

RESERVOIR FISHERIES - BIOLOGY AND MANAGEMENT

FACTORS AFFECTING SUMMER DISTRIBUTION AND MOVEMENT OF PADDLEFISH (*POLYODON SPATHULA*) IN KEYSTONE RESERVOIR, OKLAHOMA

Craig Paukert and William Fisher, Oklahoma Cooperative Fish and Wildlife Research Unit, Oklahoma State University, 404 Life Sciences West, Stillwater, OK 74078

Abstract. Our objective was to determine the effects of water chemistry and hydrology on the diurnal and nocturnal movement rates and distributions of paddlefish *Polyodon spathula* in Keystone Reservoir. Ultrasonic telemetry was used to monitor six paddlefish throughout the summer. Paddlefish were located during three, three day-long daytime and three, three night-long nighttime trips. At each location, a global positioning coordinate and 1-m profiles of water chemistry were taken. Paddlefish moved more at night (mean=784 m/h) than during the day (mean=348 m/h). Nighttime movement rates were negatively correlated with reservoir height, inflow, and discharge; there were no significant correlations for daytime movements. Fish location was also correlated with reservoir height, inflow and discharge, although daytime location was more strongly correlated than nighttime location. Paddlefish were located in the less conductive Arkansas Arm and below the Cimarron River/Arkansas River confluence. Although the Arkansas and Cimarron arms of the reservoir were similar in temperature and dissolved oxygen, conductivities were double in the Cimarron arm, which may deter paddlefish from entering this tributary in summer. However, paddlefish move up the Cimarron River to spawn in spring.

DENSITY AND NATURAL MORTALITY OF PADDLEFISH, *POLYODON SPATHULA*, IN AN UNFISHED CUMBERLAND RIVER SUBIMPOUNDMENT, SOUTH CROSS CREEK RESERVOIR, TENNESSEE

Edwin A. Boone, Jr., Kentucky Department of Fish and Wildlife Resources, 120 Fish Hatchery Road, Morehead, KY 40351, and Tom J. Timmons, Hancock Biological Station, Murray State University, PO Box 9, Murray, KY 42071-0009

Abstract. South Cross Creek Reservoir is a 192 hectare subimpoundment of the Cumberland River (Lake Barkley) within Cross Creeks National Wildlife Refuge, Tennessee. Between April 1989 and March 1991, 542 harvestable-sized (>75 cm) paddlefish, *Polyodon spathula*, were measured, tagged, and returned to the reservoir. Using the Fisher-Ford method, we estimated the population at 1,689 paddlefish with an annual survival rate of 91%. The reservoir contains a higher density of paddlefish, 8.8 per hectare, than Lake Barkley (Cumberland River). A low level of exchange occurs between paddlefish in South Cross Creek Reservoir and Lake Barkley, with immigration and emigration occurring during spring flooding when the Cumberland River overflows into the subimpoundment. Fish movement appears to be more dependent on the water temperature at the time of flooding than the level of flooding. If the water temperatures does not exceed 10°C, the paddlefish may not be stimulated to migrate to spawning areas outside of the subimpoundment.

EXPLOITATION AND MORTALITY OF PADDLEFISH, *POLYODON SPATHULA*, IN THE LOWER TENNESSEE AND CUMBERLAND RIVERS

Tom J. Timmons and Tyrone A. Hughbanks, Hancock Biological Station, Murray State University, PO Box 9, Murray, KY 42071-0009

Abstract. We examined the paddlefish *Polyodon spathula* fishery in the lower Cumberland and Tennessee rivers. Exploitation was 20.0% in Lake Barkley (155 fish), 25.4% in the Kentucky Dam tailwater (185), and 14.4% in Kentucky Lake (174). Most of the exploitation was commercial in Kentucky Lake (88%) and sport in Lake Barkley (65%) and the Kentucky Dam tailwaters (64%). We compared the Kentucky Lake commercial paddlefish harvest during the winter spawning run of 1991-1992 with the 1985-1986 season. The 1985-1986 harvest followed high roe prices, resulting in high annual mortality (69%). Annual mortality was lower (32%) in 1991-1992. We aged sections from 245 jaws, representing age-classes 3-21 and a mean age of 10 years. Age of first reproduction was 6 years for males and 8 years for females. The majority of paddlefish were harvested in the lake where they were tagged, but a few individuals moved among the major tributaries of the Mississippi River. Even with total exploitation of 14.4%, the status of the paddlefish population in Kentucky Lake improved in 1992. There were more older paddlefish than observed six years before; the mean length and weight increased; and there were more gravid females. Area and seasonal closures appear to have the greatest potential for effective management of paddlefish in Kentucky Lake.

FACTORS ASSOCIATED WITH RECRUITMENT OF SAUGER *STIZOSTEDION CANADENSE* IN TENNESSEE AND CUMBERLAND RESERVOIRS, TENNESSEE, 1990-1997

Michael Fischbach and Phillip W. Bettoli, Tennessee Cooperative Fishery Research Unit, Tennessee Technological University, Box 5114, Cookeville, TN 38505

Abstract. Indigenous sauger *Stizostedion canadense* in mainstream impoundments of the Tennessee and Cumberland rivers, Tennessee, support important seasonal fisheries; however, sauger stocks supporting individual fisheries are characterized by extreme fluctuations in abundance. Experimental gill nets were used to sample sauger in four Tennessee River reservoirs and one Cumberland River reservoir from 1990 to 1997 and catch-per-unit-effort was calculated to index year-class strength. Age-1 sauger abundance was modeled as a function of the amount of water discharged and number of fingerlings stocked in previous years. Age-1 sauger catches in two upper Tennessee River reservoirs were directly related to total discharges the previous spring (February to April; $r > 0.86$; $P = 0.0001$); a similar relationship existed in Old Hickory reservoir on the Cumberland River ($r = 0.77$; $P < 0.05$). No significant relationship between spring discharges and subsequent age-1 sauger catches were evident in two lower Tennessee River reservoirs. Current models suggest that total February-April discharges between 7.9 and $19.9 \times 10^9 \text{ m}^3$ may enhance recruitment below Tennessee River dams. Fingerling stockings and age-1 sauger catches were not related in the upper Tennessee River or Cumberland River; however, age-2 sauger catches in Old Hickory reservoir were strongly related to the number of fingerlings stocked two years earlier ($r = 0.99$; $P = 0.0001$).

WALLEYE MOVEMENT, DISTRIBUTION, AND HABITAT USE IN LAUREL RIVER LAKE, KENTUCKY

John D. Williams, Kentucky Department of Fish and Wildlife Resources, 2073 North Highway 25W, Williamsburg, KY 40769

Abstract. Walleye *Stizostedion vitreum* movement, distribution, and habitat use in Laurel River Lake were determined by radio-tracking 35 walleye for 605 days (mean = 249 days) from March 1994 through November 1995. The goal of this study was to increase the angler utilization of walleye, a put-grow-take fishery in Laurel River Lake. Walleye movement (as measured in distance between weekly locations) was highest during the spring (median = 120 m/day) and lowest during the summer (median = 53 m/day). Maximum area encompassed by walleye varied from 33-1,547 ha, with 82% of walleye encompassing areas > 300 ha. Activity areas ranged from 2-590 ha with 75% of walleye utilizing areas < 300 ha. During the summer, most walleye confined their activities to specific areas of the lake and were often located in the same area during consecutive weeks. Walleye were widely distributed throughout the lake during each season, although only two walleye remained in the upper Laurel River arm during July and August, probably due to lack of coolwater habitat ($< 25^\circ\text{C}$) in that section. Walleye predominately utilized standing timber located only in the coves on an annual basis (54%) and even more (60%) in the summer. During summer stratification (June-August), walleye selected water temperatures averaging 23.0°C for a mean depth of 6.1 m. Walleye gradually moved deeper as summer progressed, which coincided with an increase in the median depth of the thermocline. Walleye were most active at night, with mean peak movements occurring near dusk (2100-2200 h), at 0300-0400 h, and near dawn (0600-0700 h). Walleye typically moved out of the timbered coves at night and either traveled along the shoreline, suspended at the edge of timber near the mouth of the cove, or suspended in open water in the main lake. Walleye usually returned to the same cove by morning, although walleye occasionally returned to a nearby cove. A report on the findings of the study was provided to anglers in an "angler report" during the spring 1997. Walleye harvest and angler success are expected to increase in Laurel River Lake as anglers use this information.

SEASONAL MIGRATION AND ANNUAL EXPLOITATION OF WALLEYE IN GREERS FERRY LAKE, ARKANSAS AS DETERMINED BY A TAG REWARD STUDY

Thomas R. Bly, Arkansas Game and Fish Commission, Heber Springs, AR 72543; Carl A. Perrin, Arkansas Game and Fish Commission, Conway, AR 72032

Abstract. A tag reward study was initiated in March 1996, in an effort to obtain information on seasonal migration, annual exploitation, and spawning sub-populations of walleye (*Stizostedion vitreum*) in Greers Ferry Lake, Arkansas. A total of 516 walleye were captured and tagged during the spawning season with reward tags having values of \$5, \$20, or \$100. A minimum of 125 walleye from each main tributary (South Fork-125, Middle Fork-128, Devil's Fork-131) and the main lake (132) were tagged. Tag returns were corrected for tag loss/mortality and non-reporting of tags. Upon the completion of the first year, there have been 128 tag returns revealing an estimated exploitation rate of 34.9%. Tag returns revealed that walleye traveled an average of 8.4 miles with a minimum distance of 0.0 miles and a maximum distance of 27.0 miles before capture. Tag return data revealed wide dispersal and integration of sub-populations after spawning. Recapture data revealed that 96.7% of recapture, tagged walleye returned to their point of origin to spawn. The harvest of walleye 355 mm and larger was greater than anticipated. Walleye sub-populations are site specific for spawning but readily integrate during the remainder of the year.

CREEL SURVEY COMPARISON OF ALL ANGLERS VS. HOOK-AND-LINE ANGLERS, LAKE OUACHITA, ARKANSAS

Stuart J. Wooldridge, Arkansas Game and Fish Commission, Hot Springs, AR; William M. Bivin, Arkansas Game and Fish Commission, Fayetteville, AR

Abstract. A 3-year creel survey (1995-97) of Lake Ouachita, Arkansas was conducted to compare spear fishing pressure and harvest with "all angler" pressure and harvest for this 16,000 hectare reservoir. Fishing pressure averaged 39.3 hour/ha/yr with total fish harvest averaging 8.6 kg/ha/yr for all anglers. Spear fishing pressure averaged 0.5 hr/ha/yr with a mean total fish harvest of 0.2 kg/ha/yr. Mean annual total harvests by all anglers of major game species were: 52,255 kg, striped bass (*Morone saxatilis*); 22,078 kg, largemouth bass (*Micropterus salmoides*); 8,892 kg, channel catfish (*Ictalurus punctatus*); 5,053 kg, black crappie (*Pomoxis nigromaculatus*); 4,965 kg, walleye (*Stizostedion vitreum*). Mean total harvests by spear fishermen of these same species were: 557 kg, walleye; 440 kg, channel catfish; 407 kg, largemouth bass; 150 kg, black crappie; 25 kg, striped bass. Mean harvest rates for all anglers compared to spear fishermen were 0.27 fish/hr and 0.32 fish/hr, respectively. Spear fishermen targeted primarily walleye and catfish while hook-and-line anglers targeted black bass and striped bass. Spear fishing pressure and harvest accounted for 1.2% and 1.9%, respectively, of total pressure and harvest exerted on Lake Ouachita. Management recommendations will include spear fishing as a viable option for harvesting game species from this underutilized fishery.

EFFECTS OF WHITE PERCH INTRODUCTION ON FISH COMMUNITY STRUCTURE OF B. EVERETT JORDAN RESERVOIR, NORTH CAROLINA

Russell K. Wong, Richard L. Noble, James R. Jackson, Department of Zoology, Campus Box 7617, NC State University, Raleigh, NC 27695-7617, and Scott L. Van Horn, NC Wildlife Resources Commission Falls Lake Office, 1142 I-85 Service Road, Creedmore, NC 27522

Abstract. White perch (*Morone americana*) are opportunistic feeders capable of early maturation, high fecundity and indiscriminate broadcast spawning at early spring temperatures. These characteristics enable white perch to invade lentic freshwater systems where juveniles occupy the littoral zone and adults the limnetic. We documented the invasion and community impacts of white perch in Jordan Lake through lakewide gillnet catches of adults and shoreline electrofishing of juveniles. Adult white perch catches increased almost exponentially from 1990-95. Concurrent increases in relative abundance of juveniles were recorded until 1997 when a year-class failure reduced juvenile abundance to pre-1991 levels. Diet analysis indicates that young-of-year white perch in Jordan Lake are zooplanktivorous and insectivorous in spring, shifting primarily to insectivory in summer. White perch remain insectivorous through several growing seasons until they exceed 200 mm at which time juvenile shad and bluegill begin to appear in their diets. However, white perch in Jordan Lake remain predominantly insectivorous unlike other freshwater populations of adult white perch. We hypothesize that this failure to shift to piscivory is responsible for the low condition of white perch adults in Jordan Lake.

BOATING ANGLERS AND MARINA PREFERENCES WITHIN A NATIONAL WILDLIFE REFUGE: THE CASE OF CRAB ORCHARD LAKE

David R. Huennekens and Jean C. Mangun, Department of Forestry, Southern Illinois University, Carbondale, IL 42901

Abstract. Crab Orchard National Wildlife Refuge (CONWR) occupies a unique position among the USFWS refuge system due to its four-fold management objectives: wildlife, recreation, agriculture, and industry. Recreational boating is a major activity with three marinas located on Crab Orchard Lake (COL). The purpose of this study is to characterize boating anglers who patronize COL marinas in terms of sociodemographics, recreational activity, and service preferences in order to assist CONWR decisions about concessionaire contracts. A census of 400 marina slip renters was conducted during summer 1997. Data analysis used a summated scale to quantify perceptions that boating anglers have of other pleasure boaters; the correlation between perceptions about marina management and overall satisfaction was explored. Results indicate a homogeneous population of boating anglers at COL marinas, somewhat younger than hypothesized (mean age 51 years old; 60% employed; 25% retired). Boating anglers express no strong preference for fish cleaning stations or fish equipment retail sales, but do prefer to have live bait, fuel and oil, and security provided. Boating anglers express high regard of houseboaters and low regard of jet skiers. There is a strong positive correlation between regard for marina management and overall satisfaction. These results will be integrated by CONWR into a new marina management plan that recognizes the importance of human dimensions input.

AQUACULTURE AND FISH PHYSIOLOGY

TOXICITY OF AMMONIA AND NITRITE TO SHORTNOSE STURGEON

Q. C. Fontenot and J. J. Isely, South Carolina Cooperative Fish and Wildlife Research Unit, Clemson University, Clemson, SC 29634, and J. R. Tomasso, Jr., Department of Aquaculture, Fisheries and Wildlife, Clemson University, Clemson, SC 29634

Abstract. Ammonia and nitrite concentrations can easily reach toxic levels when fish are kept at high densities. We determined 96 hour LC50 values for ammonia and nitrite for juvenile shortnose sturgeon. The LC50 value for ammonia was preliminarily determined to be 151 mg/l total ammonia-nitrogen. Most of the mortality during the ammonia trials occurred within the first 24 hours. The LC50 value for nitrite was preliminary determined to be 10 mg/l total nitrite-nitrogen. Mortality during the nitrite toxicity trials occurred throughout the 96 hour period, which suggests a slow rate of nitrite uptake for shortnose sturgeon.

RATES OF GAIN AND LOSS OF HEAT TOLERANCE IN CHANNEL CATFISH

Wayne A. Bennett, Susan J. Allee, Thomas L. Beitinger, and Robert W. McCauley. University of West Florida, Department of Biology, 11000 University Parkway, Pensacola, FL 32514

Abstract. Thermal acclimation dynamics of channel catfish, *Ictalurus punctatus*, were quantified using time-series critical thermal maxima (CTMaxima) determination. Data consisted of CTMaxima determined for 57 groups of 10 fish each. Respective CTMax values ranged from 30.9 to 42.1°C for acclimation temperatures between 10 and 35°C and increased 0.45°C per 1°C increase in acclimation temperature. Heat tolerance accrument progress in a smooth, decreasing geometric pattern, whereas attrition was interrupted after 24 h by a consistent 72 h acclimation stasis. Acclimation times were influenced directly by the magnitude of the temperature change and inversely by final acclimation. Interrelationships among these parameters are accurately described by highly significant multiple regression models ($P < 0.0001$; $R^2 > 0.98$). The models predict that fish transferred from 10 to 20, 20 to 30, or 30 to 35°C are reacclimated within 21, 12, and 3 d, respectively. Reciprocal transfers resulted in respective reclamation times of 54, 30 and 9 d. These times are twice those previously measured for this species using resistance time studies; however, the differences are probably related to the disparate methodologies. Although acclimation was fastest at higher temperatures, acclimation times were driven by smaller differences between initial and final CTMaxima and not increased acclimation rates.

HORMONE INDUCED OVULATION OF ROBUST REDHORSE (*MOXOSTOMA ROBUSTUM*)

Gregory L. Looney, Warm Springs Fish Technology Center, 5151 Spring Street, Warm Springs, GA 31830; Timothy A. Barrett, Georgia Dept. Of Natural Resources, Wildlife Resources Division - Fisheries, Route #2 Box 219R, Richmond Hill, GA 31324; James L. Shelton, Jr. Warnell School of Forest Resources, University of Georgia, Athens, GA 30602

Abstract. The study objectives were to evaluate the efficacy of hormone induced ovulation of female robust redhorse, *Moxostoma robustum*.

The robust redhorse (RRH) is a large (maximum size about 760 mm TL) catostomid that was re-discovered in the Oconee River, GA, on 8 August 1991, near the mouth of Commissioner Creek. Estimated population size is 1,000 - 3,000 individuals, most of which are quite old (10 - 26 years). There has been no evidence of substantial recruitment in the past ten years.

A temporary spawning facility was constructed adjacent to the bank of the Oconee River, Georgia. This site was chosen due to its proximity to known spawning aggregations of RRH and its secure boat launching facility. The brood fish holding and spawning system consisted of nine to twelve 1,800-L circular tanks, one to two 115 L anesthesia tanks, a 1-1/2 horse power water pump, a 1/4 horse power air blower, and one or more gasoline powered generators. Females were stocked at a rate of 3-5 individuals per tank and males were stocked at a higher density of 5-10 individuals per tank due to limited tank space. Due to the large size of this fish and the need to minimize stress during handling, an anesthetic (Metomidate) was administered prior to physical examinations and spawning. In 1995, five hormone treatment regimes were evaluated; Carp Pituitary Extract (CPE), Human Chorionic Gonadotropin (HCG), CPE plus a resolving dose of HCG, an analog of Luteinizing Hormone - Releasing Hormone (LH-RHa), and Ovaprim®. A sterile saline solution was used as the control. The three hormone treatment regimes found to be most effective in 1995 (Ovaprim®, HCG, CPE) were re-evaluated in 1996, comparing them to the same control used in 1995. Of the 21 females used in the study in 1995 (4 with Ovaprim®, 3 with CPE, 3 with HCG, 4 with LH-RHa and 3 with the combination of CPE and HCG), all of the females in the Ovaprim® treatment spawned, 2 of the CPE females spawned, 2 of the HCG females spawned, none of the LH-RHa females spawned, and 1 of the females in the combination spawned. Of the 17 females in the study in 1996 (4 with Ovaprim®, 5 with CPE, and 4 with HCG) all of the females in the Ovaprim® treatment spawned, none of the CPE females spawned and 1 of the HCG females spawned. None of the fish in the 1995 or 1996 control treatments spawned.

FATTY ACID CHARACTERIZATION OF FISHES: ITS USES IN FISHERY MANAGEMENT

Martha Wells, Jacki Dow, Frederick Moody, Charlotte McCracken and Christopher O'Bara, Center for the Management, Utilization and Protection of Water Resources, Tennessee Technological University, PO Box 5033, Cookeville, TN 38505

Abstract. The characterization of fatty acid of fishes has been used primarily in forensic related-tasks or in the aquaculture industry. The premise of the characterization is that fatty acid profiles of a given fish should partially reflect its feeding habits, as well as its environment. Investigators have successfully demonstrated that for black and white crappie, and largemouth bass fatty acid profiles can be used as a means to differentiate individuals as to their origin. In an effort to provide an easier and more efficient method, supercritical fluid extraction (SFE) method was compared to the traditional Folch method. Fish samples were prepared using both methods as defined by a factorial screening study. Fatty acid concentrations were compared using a comparison t-test and results showed no significant differences. Wild black crappie of several age classes from Norris Reservoir and Chickamauga Reservoir, as well as largemouth bass and walleye from TWRA Eagle Bend Hatchery and Doakes Nursery Pond were compared using both methods. In addition, striped bass, Cherokee bass and white bass were evaluated from Cherokee and Norris reservoirs. No significant differences were found between methods, but significant differences were found between origins (i.e. reservoirs, hatcheries). Interestingly, within a reservoir, no differences were found between age classes indicating a fairly permanent mark. The identification of introduced fish into an environment has always been important in the evaluation of stocking programs. It appears that the use of fatty acid profiles is a viable approach to identifying fish in stocking programs. The method is self-marking, non-lethal, long-lasting, and with new analytical methods, efficient.

INORGANIC FERTILIZATION OF WALLEYE (*STIZOSTEDION VITREUM*) HATCHERY PONDS

Rod Middleton, Kentucky Department of Fish and Wildlife Resources, 120 Fish Hatchery Road, Morehead, KY 40351, and Brian C. Reeder, Dept. Of Biological and Environmental Sciences, Morehead State University, Morehead, KY 40351

Abstract. Some Ohio hatcheries have experienced increased fish yields and reduced anoxia in hatchery ponds fertilized with inorganic fertilizer, when compared to those fertilized with organic fertilizer. At Minor Clark Hatchery in Morehead, Kentucky, we fertilized three hatchery ponds (0.41 ha) using traditional hatchery methods, and three with inorganic nutrients. Organic fertilization included adding chopped hay, soybean meal, alfalfa meal, potash, and 9-18-9 fertilizer. Inorganic fertilization used 28-0-0 fertilizer and phosphoric acid. By monitoring weekly, inorganic fertilization kept pond N (ammonium and nitrate) concentrations at $600 \mu\text{g L}^{-1}$ and SRP concentrations at $30 \mu\text{g l}^{-1}$. Survival in organic ponds averaged 87% ($382 \text{ kg fish ha}^{-1}$); in inorganic ponds we only had 37% survival ($177 \text{ kg fish ha}^{-1}$). It may be that inorganic fertilization is ineffective in southern hatcheries; however, exceptionally cold spring weather may have affected our results.

CONTROL OF HATCHING WITH ENVIRONMENTAL OXYGEN PRESSURES IN THE WALLEYE, *STIZOSTEDION VITREUM*

Sarah M. Blank and John J. Just, School of Biological Science, University of Kentucky, Lexington, KY 40506

Abstract. Most aquatic embryos grow inside a proteinaceous egg case from which they must escape to complete development. Oxygen consumption increases during embryonic development while surface area for gas exchange remains constant thus hypoxia may be a natural stimulant for the release of hatching enzymes. A repeated measures experiment was utilized to examine hypoxia as a stimulant of hatching. Embryos, 6-20 day post-fertilization (PF), raised at 10-12°C were exposed to nitrogen (0% O₂), air (20% O₂), oxygen (100% O₂) and mixture of air and nitrogen (10% O₂) and percent hatch was recorded at 10 min. intervals for 90 min. A minimum of four experimental units consisting of 15 embryos in a 50 ml vial containing 10 ml of pond water were used for each treatment at each developmental time period. Control embryos first hatch on day 17 PF reaching 5% hatch with 100% hatch occurring on day 21 PF. Hypoxia (10% O₂) induced premature hatching on day 18 PF as the percent hatch of those embryos exposed to environments of 10% oxygen, 20% oxygen, and 100% oxygen was 67%, 54% and 13%, respectively. Percent induced hatching increased in an age dependent fashion as demonstrated by comparing day 18 PF (above) to day 19 PF embryos exposed to the same three oxygen environments (10, 20, or 100%) resulting in 92%, 57% and 23% hatch, respectively. Walleye embryos were sensitive to anoxia. Exposure of day 18 and 19 post-fertilized embryos to anoxia for 40 min. and 60 min. resulted in 33% and 100% mortality, respectively within 24 hours. Hyperopia (100% O₂) delayed hatching for at least three hours in 18, 19, and 20 day post-fertilized embryos.

WALLEYE FEED TRAINING IN CAGES AND THE EFFECTS OF DIETARY PROTEIN AND STOCKING DENSITY ON GROWTH IN PONDS

Shawn D. Coyle and James H. Tidwell, Aquaculture Research Center, Kentucky State University, Frankfort, KY 40601

Abstract. Walleye (*Stizostedion vitreum*) were evaluated under pond production conditions for 3 years. Walleye fingerlings (13.1 g) were feed trained in cages (3.5 m³) suspended in ponds using automatic feeders. After 47 days, 45% of the initial population was healthy and actively feeding. Feed trained fingerlings (19.9 g) were then stocked into six 0.04 ha ponds at 18,525 fish/ha and fed a 40% protein diet once daily to satiation. After 184 days (first summer growth season), fingerlings averaged 97.3 g. The second season compared growth of juvenile walleye (127.5 g) fed practical diets containing two protein levels (44 and 53%). At the end of 12 months (November 1995-November 1996) fish fed the 53% protein diet had higher individual weights (352.6 g) than fish fed the 44% protein diet (306 g). The third season compared fish growth at two stocking densities: 2,875 fish/ha and 5,750 fish/ha. After 163 days, weight gain was greater for fish stocked at 2,875 fish/ha than at 5,750 (147.8 and 109.4 g, respectively) as was specific growth rates (0.91 and 0.67, respectively).

EFFECTS OF PROTEIN LEVEL ON GROWTH AND BODY COMPOSITION OF HYBRID BLUEGILL

Laura G. Tiu, Carl D. Webster and James H. Tidwell, Aquaculture Research Center, Kentucky State University, Frankfort, KY 40601

Abstract. Growth, survival, and body composition were evaluated in two feeding trials using juvenile hybrid bluegill (*Lepomis cyanellus* X *L. macrochirus*). In Experiment 1, hybrid bluegill (20 g) were stocked into 1.250m³ cages at a rate of 300 fish/cage and fed diets containing 35, 40, 44, or 48% protein for 12 weeks. No significant differences ($P < 0.05$) in individual length, individual weight, specific growth rate (SGR), condition factor (K), and feed conversion ratio (FCR) were found among treatments and averaged 13.4 cm, 47.4 g, 1.02%/day, 1.96, and 4.06, respectively. In Experiment 2, fifteen hybrid bluegill (15 g) were stocked into 110-L aquaria and fed one of four diets containing 28, 32, 36, or 38% protein for 10 weeks. Fish fed a diet containing 38% protein had higher ($P < 0.05$) percentage weight gain (265%) than fish fed diets containing 28% (203%) and 32% (219%) protein, but were not significantly different ($P > 0.05$) compared to fish fed a diet containing 36% protein (251%). Results from these studies indicate that hybrid bluegill can be fed a practical diet containing 35-36% protein. Further refinement of diet formulation may allow producers to reduce diet and production costs.

FISH HEALTH IN THE EMERGING AQUACULTURE INDUSTRIES OF KENTUCKY AND VIRGINIA

Robert M. Durborow, Cooperative Extension Facility, Kentucky State University, Frankfort, KY 40601, and M. David Crosby, Cooperative Extension Program, Virginia State University, Petersburg, VA 23806

Abstract. In Kentucky and Virginia, where aquaculture is a newly emerging industry, the most significant fish disease problems differ from those found in the larger catfish-producing states in the deep south (e.g. Mississippi and Alabama). Enteric septicemia of catfish (ESC) and winter saprolegniosis (also called winter kill) are the fish disease problems that have the most economic impact on the aquaculture industry in the major catfish production states. In Kentucky and Virginia, ESC and winter saprolegniosis are diagnosed only about 2 or 3 times a year from an annual caseload of approximately 60, while *Aeromonas*-complex and external columnaris bacterial problems occur about 25 times. Differences in frequency of occurrence of particular disease problems also exist between Kentucky and Virginia. Bacterial infections are involved in 49% (average over the past five years) of all cases in Kentucky, while they occur in only 27% of the cases examined in Virginia. Parasite problems played a larger role in Virginia's fish health problems, comprising about 40% of cases; and were less significant in Kentucky at 30% of the caseload. *Trichodina* sp. caused the most number of parasite-related problems in Virginia, while gill flukes, *Ichthyophthirius multifiliis*, and *Trichophrya* sp. were the leading parasites in Kentucky. Catfish are the most frequently submitted species in both the Kentucky and Virginia laboratories.

THE EFFECT OF TEMPERATURE ON THE GROWTH OF THE YELLOW PERCH (*PERCA FLAVESCENS*)

J. W. Evans, J. H. Tidwell, S. D. Coyle, C. Weibel, K. D. Dodson, and J. McKinney, Aquaculture Research Center, Kentucky State University, Frankfort, KY 40601

Abstract. Juvenile yellow perch (*Perca flavescens*) were evaluated under controlled conditions in tanks for 12 weeks to determine the effect of temperature on growth to advanced sizes under intensive culture conditions. Yellow perch weighing 6.6 g were stocked into nine 1.83 m x 3.66 m x 0.71 m tanks at 131.4 fish/m³. There were three replicate tanks per temperature (20°, 24°, and 28°C). Perch were fed to apparent satiation twice daily using a 45% crude protein diet with 16% crude fat. After 77 days the perch in the 24° treatment were significantly larger ($P < 0.05$) than those in the 20° and 28° treatments which were not significantly different ($P < 0.05$) from each other. Apparent feed conversion ratios (FCR) after 77 days were 0.80 (20°), 0.78 (24°), and 1.03 (28°), specific growth rates (%) were 2.03 (20°), 2.21 (24°), and 1.83 (28°).

PRODUCTION OF 12-INCH LARGEMOUTH BASS AT THE MINOR E. CLARK HATCHERY (KENTUCKY)

Mike Hearn, Minor Clark Fish Hatchery, Kentucky Department of Fish and Wildlife Resources, 120 Fish Hatchery Road, Morehead, KY 40351

Abstract. Largemouth bass, exceeding eight inches in length, were requested for a four-year stocking study at Carr Fork Lake (Kentucky). The fish were primarily produced on a pelleted diet and averaged 12 inches in length after a 17 to 23-month production period. Surplus forage fish were added to the ponds during the winter and increased the cost of production. Survival of the fish from <2.0 to 12 inches was better than anticipated and exceeded 50% for three of the four years.

CLUPEIDS: SO MUCH MORE THAN BAIT

INTERACTIONS BETWEEN AGE-0 GIZZARD SHAD AND SUNFISH FOLLOWING A SELECTIVE SHAD REMOVAL: AN ALTERNATIVE HYPOTHESIS (TO COMPETITION)

Gene W. Kim and Dennis R. DeVries, Department of Fisheries and Allied Aquacultures, 203 Swingle Hall, Auburn University, AL 36849

Abstract. We used a selective rotenone on gizzard shad (*Dorosoma cepedianum*) from a 63-ha lake to test hypotheses of cascading trophic interactions and competition between shad and sunfish (*Lepomis* sp.) larvae. During the second year after shad reduction, we found higher larval sunfish and larval shad densities, lower zooplankton density, and higher algal biomass relative to year one, suggesting cascading trophic interactions. Larval sunfish survival was higher in the second year than the first year, contrary to expectations given the higher shad densities. We tested an alternative hypothesis of larval sunfish mortality due to predation by planktivorous fishes via an enclosure/exclosure experiment using gizzard shad, bluegill (*Lepomis macrochirus*), and white crappie (*Pomoxis annularis*) as predators and zooplankton as alternative prey. Relative to fishless controls, larval sunfish mortality was higher in bluegill and crappie treatments while the shad treatment did not differ from fishless controls. Predation by crappie appeared to be size-specific, as indicated by small larvae (3-7 mmSL) having higher mortality than large larvae (8-18 mmSL). In contrast, for bluegill predators large larvae suffered higher mortality than small larvae. Given these results, we suggest that recruitment in freshwater systems is likely influenced by both competition and predation, similar to results from marine systems.

AMERICAN SHAD (*ALOSA SAPIDISSIMA*) PASSAGE AND MOVEMENT AT EMPORIA DAM, VIRGINIA

Robert L. Simmonds, Jr. and Mitchell D. Norman, Virginia Department of Game and Inland Fisheries, 5268-B Godwin Blvd, Suffolk, VA 23434

Abstract. Emporia Dam has blocked anadromous fish migration up the Meherrin River for over 90 years. A fish lift was constructed to allow passage of the American shad (*Alosa sapidissima*) that migrated to the dam each spring. Our objective was to identify ideal conditions (e.g., turbine discharge, time of day) for fish passage by monitoring American shad passage through the lift and their movements below the dam using radio telemetry. Because we only observed 7 American shad in the lift, we were unable to correlate passage with the above variables. Also, many of our radio tagged American shad died or regurgitated tags, or they moved downstream after tagging and never returned. Only 1 fish returned to the dam after tagging. For 3 days, this fish approached the dam at sunrise then moved downstream after sunset. It then stayed at the dam continuously for an additional 28 hours. We concluded that 1) fish lift entrance tunnel head must be automatically maintained, 2) repairs to the fish lift must be completed more rapidly (the lift only operated during 44% of the American shad run) and 3) fish approached the dam throughout the day/night and not just during a narrow time span.

TALES OF PREDATOR DEMAND IN A VIRGINIA RESERVOIR

M. J. Cytreski and J. J. Ney, Department of Fisheries and Wildlife, Virginia Polytechnic Institute and State University, 100 Cheatham Hall, Blacksburg, VA 24060-0321

Abstract. In Smith Mountain Lake, Virginia, the two most popular and abundant game fishes, the indigenous largemouth bass *Micropterus salmoides* and the non-native striped bass *Morone saxatilis*, rely heavily upon introduced alewife *Alosa pseudoharengus* and gizzard shad *Dorsoma cepedianum* as forage. Motivated by angler desire to increase striped bass stocking levels, this ongoing study was undertaken to determine the annual demand of predators for clupeids and the yearly production of these critical prey species. The demand problem is being handled using bioenergetics modeling. The two primary inputs for deriving individual consumption are diet composition of predators by percent weight and predator growth rates. Extrapolation to population consumption requires abundance estimates for both predator species. Data requirements have been satisfied using a variety of sampling methods, including electrofishing, gillnetting, and rotenone surveys. It was found that largemouth bass annually consume 3.6 kilograms/ha of alewife and 5.2 kilograms/ha of shad, while striped bass utilize 33.1 and 15.2 kilograms/ha, respectively. Over 80 percent of largemouth population consumption is attributed to fish age four and younger. For striped bass, these cohorts are responsible for over 90 percent of population consumption. Average annual conversion efficiencies for largemouth bass range from 8 to 41 percent, and 6 to 23 percent for striped bass.

UTILIZATION OF A NEWLY ESTABLISHED GIZZARD SHAD POPULATION BY RESERVOIR SPORTFISHES

C. C. Bonds and J. J. Ney, Department of Fisheries and Wildlife Sciences, Virginia Polytechnic Institute and State University, Blacksburg, VA 24061-0321

Abstract. Gizzard shad, illegally introduced into Claytor Lake, Virginia, in the late 1980's, have expanded to comprise more than one-third of fish biomass, but their benefit as a prey resource has not been determined. We collected piscivores (stocked striped and hybrid striped bass, walleye, and three black bass species) by electrofishing and gillnetting over a 1-year period to describe their seasonal diets. The moronid species and walleye fed heavily on gizzard shad in spring and fall; shad constituted as much as 85% by weight of stomach contents of these pelagic piscivores on a seasonal basis. The largemouth bass diet included 40% shad in spring and fall, but <10% on gizzard shad during summer months. Only age-0 gizzard shad were eaten by even the largest sportfish. The seasonal pattern of shad consumption thus reflects the morphological and distributional availability of young-of-year gizzard shad. Shad seasonally supplanted alewife in the diets of pelagic piscivores and largemouth bass. The effect of this dietary shift on sportfish growth remains to be determined.

ANALYSIS OF COMPETITIVE INTERACTIONS AMONG LARVAL GIZZARD SHAD AND YOUNG-OF-YEAR FISHES IN CLAYTOR LAKE, VIRGINIA

R. J. Small, Jr. and J. J. Ney, Department of Fisheries and Wildlife Sciences, Virginia Polytechnic Institute and State University, Blacksburg, VA 24061-0321

Abstract. Gizzard shad *Dorosoma cepedianum* may negatively affect zooplanktivorous forage-fish and young-of-year sport fish through trophic competition. By influencing zooplankton density and composition, larval shad may alter prey availability to other young-of-year fishes. The intensity of this impact will depend on interspecific overlap in timing of zooplanktivory, diet composition, and zooplankton availability. We are currently examining the temporal distribution, abundance, and diet of young-of-year fishes in addition to the abundance and composition of zooplankton in mesotrophic Claytor Lake, Virginia. Extensive ichthyoplankton sampling in 1997 indicated that larval shad are present from late May to mid-July, overlapping in time with larval alewives *Alosa pseudoharengus* and black basses *Micropterus* spp.; abundance of larval sunfish peaked in late July. Larval shad and larval alewives primarily consumed cyclopoid copepods and cladocerans, yet alewives selected larger individuals than shad. Young-of-year black bass consumed littoral cladocerans before switching to benthos. Density and composition of limnetic zooplankton showed no relationship to density of larval shad. In Claytor Lake, trophic competition between larval shad and other zooplanktivores appears to be minimized by moderate temporal overlap, abundant zooplankton, and low similarities in diet.

EFFECT OF THREADFIN SHAD DENSITY ON LARVAL PRODUCTION OF THREADFIN SHAD AND GIZZARD SHAD IN A TENNESSEE RESERVOIR

Steve M. Sammons and Phillip W. Bettoli, Tennessee Cooperative Fishery Research Unit, Tennessee Technological University, Box 5114, Cookeville, TN 38505

Abstract. Larval production by threadfin shad *Dorosoma petenense* and gizzard shad *D. cepedianum* varied over two orders of magnitude and was regulated by adult threadfin shad abundance over five years in Normandy Reservoir, Tennessee. Significantly more larvae of both species were produced in years following winterkills of threadfin shad (repeated-measures ANOVA, $df = 4, 75$; $F > 21.44$, $P = 0.0001$). Peak geometric mean catch of larval threadfin shad in neuston samples was inversely related to biomass of adult (>70 mm total length) threadfin shad in mid-summer cove samples ($r = -0.91$; $P = 0.031$). Peak geometric mean catch of larval gizzard shad was also inversely related to adult threadfin shad biomass in cove samples ($r = -0.93$; $P = 0.022$). Winterkills of threadfin shad were size selective, killing all fish under 60 mm total length but allowing some unknown percentage of larger fish to survive. When threadfin shad populations were reduced by winterkills, gizzard shad and surviving threadfin shad may have taken advantage of less competition for food resources in early spring and increased condition enough to spawn successfully.

RECAPTURE OF OXYTETRACYCLINE (OTC) MARKED JUVENILE AMERICAN SHAD (*ALOSA SAPIDISSIMA*) IN THE PAMUNKEY RIVER, VIRGINIA: 1995-1997

Douglas A. Dixon, Electric Power Research Institute, 2000 L Street, NW, Suite 805, Washington, D.C., James D. Goins, John E. Olney, and Joseph G. Loesch, Virginia Institute of Marine Science, College of William and Mary, Gloucester Point, VA

Abstract. Annual (1995-1997) stocking of oxytetracycline (OTC) marked larval American shad in the Pamunkey River and subsequent monitoring of juvenile abundance afforded the opportunity to assess the relative contribution of hatchery fish to wild stocks and to investigate the movement of hatchery fish in the nursery zone. Each year, between late March and early May, larval fish (4-7 days age) were stocked at river kilometer 100. Stocked larvae totaled 2.7, 2.0, and 1.3 million for the years 1995 through 1997, respectively. Juvenile relative abundance sampling began the first week of June and continued through mid-August. Excised sagittae were examined with epifluorescent microscopy to detect OTC marks. The number of recaptures each year was nearly proportional to juvenile relative abundance. Recaptures were 14, 147, and 26 fish for 1995 through 1997, respectively. As a percentage of the wild stock, between year variation in the annual recapture frequency was minor (4.7, 7.5, and 3.8%, respectively), suggesting that hatchery fish experienced approximately the same annual natural mortality as wild fish. By early June of each year and throughout the sampling season, the recapture of hatchery fish indicated upstream movement of at least 28-km from the stocking location. The mean size of recaptured and wild fish decreased with upstream distance. Observed behavior suggests that movement upstream is a size-dependent process. Furthermore, because potential swimming speeds may not account for the distance traveled through a strong diurnal tide environment, upstream movement synchronized with flood tide is theorized. Results imply new information on early life history and nursery zone dynamics of larval and juvenile American shad. Recapture information also provides results on American shad restoration efforts and information that can be used to modify stocking practices by the Virginia Department of Game and Inland Fishes.

EVALUATION OF THREADFIN STOCKING IN FOUR SMALL IMPOUNDMENTS IN CENTRAL KENTUCKY

Jeff Crosby, Kentucky Department of Fish and Wildlife Resources, 1 Game Farm Road, Frankfort, KY 40601

Abstract. This study was conducted to determine if the stocking of high densities of threadfin shad in small impoundments could increase the availability of late season forage for largemouth bass and result in improvements in bass growth rates and population structure. Four small impoundments (<120 hectares) located in central and northern Kentucky were sampled for largemouth bass *Micropterus salmoides*, gizzard shad *Dorosoma cepedianum*, and threadfin shad *D. Petenense* from 1995-1997. Following one year of preliminary data collection in 1995, threadfin shad were stocked into each lake in 1996 at a rate of 250 fish/hectare. Data were collected, following the stockings, to determine the contribution of threadfin shad to the forage base, utilization of the shad by largemouth bass, changes in growth of largemouth bass, and any negative interactions occurred between age-0 largemouth bass and threadfin shad. The specific study goals were to 1) produce a ratio of peak threadfin shad to peak gizzard shad abundance greater than 80%, 2) produce a catch rate of threadfin shad greater than 0.2 fish/m³ from June through September, 3) increase ($P \leq 0.10$) shad consumption by largemouth bass during the fall, 4) increase ($P \leq 0.10$) annual growth of age 1-4 largemouth bass, 5) improve condition of 10-45 cm largemouth bass, and 6) result in no significant decreases in growth of age-0 largemouth bass.

RIVER/STREAM - BIOLOGY AND MANAGEMENT

CHARACTERISTICS OF BROWN TROUT *SALMO TRUTTA* AND RAINBOW TROUT *ONCORHYNCHUS MYKISS* GROWTH IN THE SOUTH FORK OF THE HOLSTON RIVER, TENNESSEE

Stephen J. Owens and Phillip W. Bettoli, Tennessee Cooperative Fishery Research Unit, Tennessee Technological University, Box 5114, Cookeville, TN 38505

Abstract. The South Fork of the Holston River, Tennessee, has been managed by the Tennessee Wildlife Resources Agency as a tailwater trout fishery since 1952, but the growth of salmonids in that system has not been studied. Four cohorts of about 6,000 rainbow trout *Oncorhynchus mykiss* and 16,000 brown trout *Salmo trutta* were microtagged and stocked at different times in 1997. Monthly electrofishing samples were collected between March and November 1997; each trout was measured, weighed, and checked for the presence of a microtag. Growth rates for the different cohorts of microtagged trout were calculated and compared. Mean growth of the four rainbow trout cohorts averaged 13 - 22 mm/month and 25-51 g/month, and growth rates varied among cohorts ($P \leq 0.05$). Hatchery-reared brown trout grew 11 mm/month and 20 g/month; wild brown trout grew 11 mm/month and 18 g/month. Hatchery brown trout grew at similar rates to resident wild brown trout. Hatchery trout grew faster in this system than trout studied in other Tennessee tailwaters. Rainbow trout stocked later in the season showed a trend for faster growth in weight than earlier stocked trout. Except for rainbow trout stocked in July, the relative weight of stocked fish declined consistently over time.

EFFECTS OF PHYSICOCHEMICAL HABITAT CHARACTERISTICS ON ZOOPLANKTON ASSEMBLAGES WITHIN MACROPHYTE BEDS

Laura E. Townley and William E. Kelso, School of Forestry, Wildlife, and Fisheries, Louisiana State University Agricultural Center, Baton Rouge, LA 70803-6202

Abstract. We examined the species composition of zooplankton assemblages within hydrilla *Hydrilla verticillata* and water hyacinth *Eichornia crassipes* beds in the Atchafalaya River Basin. Our objectives were to compare zooplankton assemblages between: 1) depths and water qualities within plant types; 2) edge habitat and middle habitat within plant types, and 3) diurnal and nocturnal periods within plant beds. Zooplankton samples were taken at the edge (<1.5 m from open water) and in the middle (>4 m from open water) of the plant beds with a 2-L whole-water sampler. Diurnal and nocturnal samples were collected at 25-cm intervals from surface to bottom. Water quality, total organic carbon, and selected cations and anions were measured at each sampling point, and cladocerans and loricate rotifers were counted and identified to species. Preliminary results indicate rotifers were more abundant than cladocerans at all sampling sites, and densities of both taxa were highest at the surface, decreasing with depth. Species composition was similar in edge and middle habitats in both plant types, during the day, but edge habitats contained different species than middle habitats, at night. These differences could be due to diel horizontal migration of zooplankton which may be as important as vertical migration to vegetation dwelling microcrustaceans.

POPULATION STRUCTURE OF LONGNOSE GAR BELOW JORDAN DAM, COOSA RIVER, ALABAMA

Allyse M. Ferrara and Elise R. Irwin, USGS Biological Resources Division, Alabama Cooperative Fish and Wildlife Research Unit, 103 Swingle Hall, Auburn University, AL 36849

Abstract. Longnose gar *Lepiososteus osseus* commonly occur in many habitats in the southeastern United States, however, little is known about life history and population characteristics of the species. Age structure, size structure, and sex ratio were determined from longnose gar downstream of Jordan Dam, (Coosa River, Alabama). Thus far, 68 longnose gar were collected using a boat electrofisher, where sampling effort was approximately equal, on two sampling dates; May and September 1997. Whole view branchiostegal rays were used to age fish. Males were more abundant than females (2:1). Female longnose gar were significantly older (\bar{x} female = 6.5 yrs.; \bar{x} male = 3.4 yrs.) and larger (10.4% TL) than male longnose gar. In addition, we are evaluating the use of sagittal otoliths for aging and hypothesize increased accuracy using this technique. Sampling will continue to increase our understanding of longnose gar population characteristics and to aid in management of the species.

EFFECTS OF FLOW REGIME ON RECRUITMENT AND GROWTH OF JUVENILE BASS (*MICROPTERUS* SPP.) IN FLOW-REGULATED RIVERS

Elise R. Irwin, USGS, Biological Resources Division, Alabama Cooperative Fish and Wildlife Research Unit, 119 Swingle Hall, Auburn University, AL 36849; Mary C. Freeman, USGS, Biological Resources Division, Patuxent Wildlife Research Center, Athens, GA 30602; and J. Jeffery Isely, USGS, Biological Resources Division, South Carolina Cooperative Fish and Wildlife Research Unit, Clemson, SC 29634

Abstract. Flow alteration effects on recruitment of juvenile sportfishes in riverine systems poses a major issue in licensing and management of hydropower facilities. Suppressing hydropeaking operations for specified periods may be an option for enhancement of juvenile recruitment. We used *Micropterus* spp. as models to test the hypothesis that flow stability enhances recruitment of juveniles. We compared abundance and growth of age-0 black bass between river systems differentially affected by flow regulation and assessed the importance of stable flow periods to recruitment in a system subjected to daily flow fluctuations. We collected and aged 386 age-0 *Micropterus* spp. from three regulated and three unregulated sites. Catch-per-unit-effort was lower, fish were smaller and mean hatch dates were later from highly regulated sites. Forty percent of the black bass collected from the highly regulated site exhibited abnormal growth as indicated by irregularities in otolith ring formation. Black bass from unregulated and moderately regulated sites had fewer growth abnormalities (3-20%). Flow and hatch date data indicated that more fish hatched during non-generation periods. These data indicate that recruitment and growth are impacted by flow regulation. Therefore, mitigation schemes that include provision of optimal flows during periods critical to recruitment may enhance sport fisheries.

SEASONAL AND SPATIAL DISTRIBUTIONAL PATTERNS OF LARVAL FISHES IN THE ALABAMA RIVER

David L. Buckmeier, Timothy M. Wetzel, and Elise R. Irwin, USGS Biological Resources Division, Alabama Cooperative Fish and Wildlife Research Unit, 103 Swingle Hall, Auburn University, AL 36849

Abstract. Differences in distributional patterns of larval fishes in large rivers are apparent and may reflect longitudinal changes in habitat and/or managed flow regimes. Upper and lower reaches of the Alabama River were sampled between March and September 1996 and 1997. Within reaches, main channel and tributaries were sampled during day and night with push-nets (N=2006) and tributary margins were sampled at night with light traps (N=645). Initial results (1915 samples processed) indicate that ichthyoplankton in the Alabama River exhibited two distinct peaks in abundance at all sites, including both tributaries and main channel areas within each site. In addition to seasonal patterns, spatial differences in abundance between upper and lower reaches were apparent. Larval abundance was higher at the lower sites during the first season (March through May), whereas abundance during the second season (June through September) did not differ. Initial results reflect our hypothesis that larval abundance will be higher in river reaches where the floodplain is intact and reaches where the natural periodicity of the flood-pulse regime has not been altered. Potential exists for recovery of systems downstream of navigational structures and we intend to test this hypothesis in an unregulated system.

SPATIAL AND TEMPORAL DISTRIBUTION OF FISHES IN THE NEW RIVER BASIN, TENNESSEE, A WATERSHED HISTORICALLY AFFECTED BY COAL MINE DRAINAGE

R. Brian Evans, Department of Ecology and Evolutionary Biology, University of Tennessee, Knoxville, TN 38916

Abstract. An ichthyofaunal survey was undertaken during the summer and fall of 1996 to determine the distribution of fishes in the New River basin, Tennessee, a tributary system of the Big South Fork of the Cumberland River. *Etheostoma cinereum*, a threatened species in Tennessee, was collected for the first time in New River system and found to be widely distributed. *Moxostoma macrolepidotum breviceps* was also captured for the first time in the New River, and specimens of *Moxostoma carinatum* represent the first records from the Big South Fork system south of Kentucky. Many other species, particularly percids and the apparently introduced *Luxilus chrysocephalus*, have recently expanded their distribution in the river system. Collection of *Noturus exilis* from Brimstone Creek substantiated the persistence of a relict population previously represented by only 3 individuals collected in the same creek in 1953.

Using samples from this and previous surveys, analyses of fish assemblages were performed to detect spatial and temporal differences relative to mining and reclamation. Results indicate that negative changes in fish communities occurred after the onset of surface coal mining. Fish populations have improved over the past twenty years, coinciding with reclamation mandated by the Surface Mining Act.

SPATIAL AND TEMPORAL PATTERNS OF FISH ASSEMBLAGE USE IN EMBAYMENTS ALONG THE OHIO RIVER

David C. Cray and Deanna J. Stouder, Ohio Cooperative Fish and Wildlife Research Unit, The Ohio State University, 1735 Neil Avenue, Columbus, OH 43210

Abstract. The completion of the lock and dam system on the Ohio River in 1929 turned a once free-flowing river into a series of pools, flooded tributary mouths, and created the current set of embayments. Currently, 124 embayments exist along the Ohio side of the Ohio river however, few remain relatively unaltered. Between Parkersburg, WV and Cincinnati, OH, we only found six embayments in this condition. Because these habitats are extremely rare and imperiled, it is essential to understand the role these habitats play in supporting riverine fish assemblages. From April through October 1997, we sampled fishes (using electroshocking and gill nets) in up-, mid-, and downstream locations within each embayment to evaluate spatial and temporal patterns of fish assemblage structure. Fish density increases over time. For example, most young *Micropterus* spp. recruited to our sites in August. At the same time *Dorosoma cepedianum* densities increased dramatically. Up- and mid-stream fish assemblages appeared most similar. Shallow versus deep embayments harbored slightly different fishes. GIS coverages allowed us to assess the influences of physical characteristics on biological components of these habitats. This information will provide managers with the tools to evaluate the importance of this resource to fishes along the Ohio River.

OHIO RIVER RECREATIONAL USE SURVEY

Scott A. Schell, David J. Bright, James A. Marshall and Michael A. Greenlee, Ohio Division of Wildlife, 360 East State Street, Athens, OH 45701

Abstract. A recreational use survey funded by Ohio, West Virginia, Kentucky, and Indiana was conducted on 491 miles of the Ohio River during 1991 and 1992. The objectives were to provide direction and prioritization in developing fisheries strategies by determining catch statistics and economic benefits of the sport fishery. A total of 28,683 interviews representing 50,596 anglers were conducted. Fishing pressure was estimated at 2.5 million angler hours which translates to an estimated economic value of \$34 million. Comparisons of the 1992 data with a 1981 West Virginia survey demonstrate that recreational use and angler success have both increased significantly. Total fishing pressure increased by 225% from 1981 to 1992 for the Ohio River bordering West Virginia. Fishing boats comprised 25% of all pleasure craft in 1981 but increased to 40% in 1992. Total catch for all gamefish species increased from 316,679 in 1981 to 2,827,228 in 1992, suggesting that this resource is in a state of recovery. Mean trip length also increased from 2.2 hours in 1981 to 3 hours in 1992 as anglers took advantage of expanded fishing opportunities. Despite these increases, the fishery still exhibits classic symptoms of underutilization with low fishing pressure and high catch rates accompanied by low harvest rates.

SPATIAL AND TEMPORAL VARIATION IN FISH DISTRIBUTIONS AND ASSEMBLAGE STRUCTURE IN THE UPPER SAN JACINTO RIVER SYSTEM

M.E. Herbert and F.P. Gelwick, Department of Wildlife and Fisheries Sciences, Texas A&M University, College Station, TX 77843

Abstract. Fishes were collected seasonally (Feb, May, Aug, Dec) for one year in tributaries of the West Fork (13 sites) and East Fork (9 sites) of the San Jacinto River. All sites were within or bordering the Sam Houston National Forest. West Fork tributaries were isolated from each other by Lake Conroe. Fishes were collected in a 100-m stream reach by seining and backpack electrofishing. A total of 42 species were collected. Species distributions and assemblage structure were related to the seasonal variation in discharge and other instream habitat conditions and physico-chemical water conditions. Species richness decreased across sites with increasing seasonal variation in discharge in both forks. Preliminary analyses show that Spearman's Rank correlation and Morisita's index decrease with increasing seasonal variation in flow in the unimpounded East Fork system. West Fork sites above Lake Conroe show either no relationship or show increases with increasing variation in discharge. The coefficient of variation of population abundance estimates between seasons declined with variation in discharge in both forks, but showed a much stronger relationship in the East Fork streams. This suggests that patterns of seasonal assemblage stability and persistence have been influenced by the presence of Lake Conroe. Lake Conroe may buffer seasonal changes in assemblage structure in tributary streams through a stable source of potential colonizing fishes. Other results also indicate that the presence of Lake Conroe influences some species' presence or absence and relative abundance in tributary streams.

EVALUATING FISHERIES TECHNIQUES

THE COSTS OF SAMPLING LOTIC HABITATS IN THE LOWER MISSISSIPPI RIVER

Harold L. Schramm, Jr., Mississippi Cooperative Fish and Wildlife Research Unit, Mississippi State, MS 39762. Lawrence L. Pugh, Department of Wildlife and Fisheries, Mississippi State University, Mississippi State, MS 39762

Abstract. We compared sampling costs exclusive of personnel costs of two types of hoop nets and two types of pulsed DC electrofishing in lotic habitats in main and secondary channels of the Lower Mississippi River. Sampling costs were based on completing 241 samples with 61-cm diameter hoop nets, 233 samples with 122-cm diameter hoop nets, 155 samples with low-frequency pulsed DC electrofishing, and 165 samples with high-frequency pulsed DC electrofishing. Hoop net sampling cost less (\$4.15-11.20 per net night) than electrofishing (\$15.26-16.42 per 5-minute sample). Standardizing sampling effort to personnel-hour, hoop net sampling cost \$13.83-37.33 per unit effort and electrofishing cost \$25.44-27.06 per unit effort. Cost per fish was \$3.04-8.97 for hoop net sampling and \$0.68-1.33 for electrofishing. Replacement of lost and unretrievable hoop nets substantially increased the cost of hoop net sampling.

EVALUATION OF THE NEED FOR A CHASE BOAT WHILE CONDUCTING FLATHEAD CATFISH ELECTROFISHING SURVEYS

Kenneth K. Cunningham, Oklahoma Fishery Research Lab, 500 East Constellation, Norman, Oklahoma 73072

Abstract. Fisheries personnel with the Oklahoma Department of Wildlife Conservation began using electrofishing in 1991 to assess flathead catfish *Pylodictis olivaris* populations in reservoirs. While this type of sampling is highly effective, it is also labor intensive because of the perceived need for a chase boat to facilitate the capture of stunned individuals. During summer 1997, I compared electrofishing with and without a chase boat on three Oklahoma reservoirs to assess the benefit of using a chase boat while conducting flathead catfish electrofishing surveys. I detected no significant differences between the two methods when comparing capture efficiency, mean C/f (numbers of stunned flathead catfish per 3 min of electrofishing) or length frequency distribution. I recommend chase boats no longer be used while sampling for flathead catfish in reservoirs. This recommendation would result in a 33-50% decrease in labor and a 50% decrease in sampling equipment needed when conducting these types of surveys in Oklahoma.

A COMPARISON OF TRAPNETS TO ROTENONE FOR CRAPPIE SAMPLING ON A SMALL IMPOUNDMENT

Ralph A. Fourt, Ronald D. Moore, and Carolyn Fielder, Arkansas Game and Fish Commission, 2805 West Oak, Rogers, AR 72756

Abstract. Routine trapnet sampling from 1991 to 1995 and rotenone sampling from 1988 through 1993 on 80-hectare Bob Kidd Lake were evaluated. Trapnet estimates of recruitment ranged from 0 to 0.8 age 0 fish per net night. Trapnet estimates of density ranged from 1.82 to 7.2 (age 1 and over) per net-night. Rotenone sampling demonstrated massive spawns in 1989, 91, and 93, when numbers per hectare were 2,375, 1,920, and 4,797, respectively. These spawns were shown by rotenone sampling to have recruited to strong intermediate densities the following year, and to strong adult populations in subsequent years. Trapnet densities actually declined in the years following the big spawns. We conclude that neither sampling technique gave a complete picture of the crappie *Pomoxis* spp. population in Bob Kidd lake. Trapnets severely underestimated recruitment and density, whereas rotenone showed both to be quite high. Conversely, rotenone underestimated the proportion of fish over 250 mm in length while trapnets showed they comprised a relatively large portion of the population. Rotenone sampling proved to be more efficient in the capture of crappie at 50 per man hour compared to 1.5 per man hour for trap nets.

CRAPPIE CATCH RATE COMPARISON USING 13 MM AND 19 MM BAR MESH TRAP NETS ON TWO NORTH CAROLINA RESERVOIRS

Douglas A. Besler, Shari L. Bryant, and Scott L. Van Horn, North Carolina Wildlife Resources Commission, 512 N. Salisbury Street, Raleigh, NC 27604-1118

Abstract. Catch rates of crappie (*Pomoxis* spp.) in piedmont North Carolina reservoirs have declined from approximately 11 to <1 fish/net night during the last decade in North Carolina Wildlife Resources Commission trap net samples. The nets employed are 0.9 x 1.5 m frame trap nets with 13 mm bar mesh netting. The mesh size was chosen to enhance the vulnerability of juvenile crappie as well as capture adult fish. The nets have not provided useful indices of juvenile crappie abundance and at current catch rates for adult fish are too effort intensive to be an effective sampling tool. The North Carolina Wildlife Resources Commission and Duke Power Company sampled crappie at Lake Norman, NC, in October 1997. Duke Power Company deployed trap nets with a similar frame size but 19 mm bar mesh. Catch rates were much higher in the larger (4.0 fish/net night) than smaller (0.1 fish/trap net night) mesh trap nets (262 net nights total effort); however, sample location considerations did not allow direct comparisons of the two gear types. We subsequently made a more rigorous comparison of the two mesh sizes by fishing 10-15 nets of the two net types at alternating sites for 40-60 net/nights at each of two piedmont reservoirs. Catch rates for crappie were 3-10 times higher in the 19 mm bar mesh nets ($P = 0.05$). Mean catch rates in the 13 mm bar mesh nets ranged from 0.3-1.0 crappie/net night; crappie catch rates in the 19 mm bar mesh ranged from 1.0-21.9 crappie/net night. Similar size and age ranges were observed for fish collected by the two meshes but the low number of fish caught in the 13 mm bar mesh nets prevented statistical comparisons. Our results suggest there may be important tradeoffs in sampling efficiency for juvenile crappie and stock-sized crappie when choosing between 13 and 19 mm bar mesh trap nets.

EFFECTS OF SUTURE TYPE AND IMPLANT METHOD ON TAG RETENTION AND SURVIVAL IN SUNSHINE BASS

K. A. Bjorgo, M. G. Walsh, and J. Jeffery Isely, South Carolina Cooperative Fish and Wildlife Research Unit, Clemson University, Clemson, SC 29634

Abstract. The use of radio telemetry in fisheries research is common. However, methods of transmitter implantation and incision closure vary and may affect survival and tag retention. Two common implantation techniques; the shielded needle and the non-shielded needle technique, were evaluated in conjunction with two incision closure materials; absorbable or non-absorbable sutures to determine the combined effects on survival and tag retention in sunshine bass *Morone saxatilis* x *M. chrysops*. Fifty sunshine bass were stocked into each of 3 - 1,500 l circular flow-through fiberglass tanks and held indoors at 17°C. Twenty fish in each replicate were implanted using the shielded needle, and 20 fish were implanted using the non-shielded needle technique. Half of each implant group were then sutured with absorbable, and half were sutured with non-absorbable sutures. An additional 10 fish in each replicate served as mortality controls. Preliminary data suggest no significant implant techniques or suture type effects on survival or tag retention.

THE CALIBRATION OF A SEMI-QUANTITATIVE APPROACH TO JUVENILE SALMONID STOCK ASSESSMENT

Mukhtar Farooqi, Virginia Department of Game and Inland Fisheries, 5806 Mooretown Road, Williamsburg, VA 23188 and Miran Aprahamian, Environmental Agency, Richard Fairclough House, Knutsford Road, Warrington WA4 1HG, United Kingdom

Abstract. The acquisition of quantitative data for juvenile salmonid stock assessment can be a time consuming and labor intensive procedure particularly when contemplating a large number of sites. The removal method of population estimation is a commonly used approach, but an alternative strategy might be to conduct a single fishing without the use of stop nets. This would enable a larger number of sites to be sampled within given time and resource constraints. For such results to be of value, it is necessary to equate the findings of this less accurate method with those that would have been obtained from a quantitative survey at the same site. The aim of this study is to determine the relationship between the two sampling techniques to assess whether the semi-quantitative technique can be used as a reliable means of stock assessment. A significant relationship was found to exist between the semi-quantitative and quantitative population estimates for 0+ and 1+ salmon (*Salmo salar* L.), and 0+ and >0+ brown trout (*S. Trutta* L.). The R^2 ranged from 83.4% to 96.1%, $p < 0.0001$. Thus the semi-quantitative sampling technique can be used as an effective and rapid means of routine stock assessment of juvenile salmonids.

SHOOTING FISH IN A BARREL: HYDROACOUSTIC COMPARISON WITH OHIO RIVER LOCK ROTENONE SURVEYS

K. J. Hartman, T. Bassista, B. Nagy, R. C. Tipton. Wildlife & Fisheries Program, Division of Forestry, West Virginia University, PO Box 6125, Morgantown, WV 26506-6125 and F. Jernejcic, West Virginia Division of Natural Resources, Wildlife Resources Section, 1304 Goose Run Road, Fairmont, WV 26554-1392, and S. Morrison, West Virginia Division of Natural Resources, 2311 Ohio Avenue, Parkersburg, WV 26101

Abstract. On September 16-18, 1997, we conducted a hydroacoustic survey of 3 locks along the West Virginia border of the Ohio River in conjunction with annual lock rotenone sampling. After lock doors were closed, but before rotenone was applied, we used a 120 kHz split beam hydroacoustic system to estimate the abundance and sizes of fish trapped in the Pike Island, Willows Island, and Racine locks of the Ohio River. Subsequent processing of rotenoned fish provided estimates of the species composition, abundance, and size of fish in the lock for comparison with the hydroacoustics estimates. Relative fish abundance from both sampling techniques were in agreement. Highest fish densities were in the Pike Island lock due to high abundances of age-0 gizzard shad *Dorsoma cepedianum* and skipjack herring *Alosa chrysochloris*. Lower densities of these clupeids in the other 2 locks resulted in much lower estimates of fish densities. Size estimates from the acoustics and direct measurements also agreed closely. This study represents the first of its kind in which near total measurements of fish in an area have been made for validation of hydroacoustic techniques. The success of this study suggests that mobile hydroacoustic surveys of the Ohio River will also likely be successful in estimating seasonal and annual changes in fish abundance and distribution.

HYDROACOUSTIC COMPARISON OF FISH DENSITY BETWEEN A POWER PLANT INTAKE LAGOON AND THE ADJACENT HUDSON RIVER

R. C. Tipton and K. J. Hartman, Wildlife & Fisheries Program, Division of Forestry, West Virginia University, P.O. Box 6125, Morgantown, WV 26506-6125

Abstract. Diel hydroacoustic assessment of relative fish densities were performed within the intake lagoon of Bowline power plant, at Stoney Point, New York, and the Hudson River adjacent to the lagoon during July, 1996. We compared fish densities between the two sites to evaluate habitat preferences by fish in the power plant near-field waters vs nearby areas. Information on fish density and distribution near water intakes is important baseline information related to possible impingement and entrainment of fish at plants. A 120 kHz split-beam sounder was used to detect fish every two hours over a 24-h period at four transects running from near-shore to the Hudson River channel and three transects within the lagoon. Midwater trawling was used to partition acoustic targets among fish species. Trawl catch consisted of tom cod, *Microgadus tomcod*, (67.7%), bay anchovy, *Anchoa mitchilli*, (20.3%), weakfish, *Cynoscion regalis* (4.5%), bluefish (*Pomatomus saltatrix*, (2.3%), white perch, *Morone americana*, (2.3%), alosids, *Alosa sp.*, (2.3%), and hogchokers, *Trinectes maculatus*, (0.8%). Relative fish densities were higher within the power plant lagoon. The increased fish densities are believed to be due to the unique and complex habitat found in the lagoon. Although preliminary, these data suggest care should be exercised in siting of future plants in the Hudson River and elsewhere.

ESTIMATING GILL NET SELECTIVITY USING NONLINEAR RESPONSE SURFACE REGRESSION

Thomas E. Helser, Wildlife and Fisheries, College of Agriculture and Forestry, West Virginia University, PO Box 6125, Morgantown, WV 26506-6125; James P. Geaghan, Department of Experimental Statistics, Louisiana State University, Baton Rouge, LA 70803; and Richard E. Condrey, Coastal Fisheries Institute, Wetland Resources Building, Louisiana State University, Baton Rouge, LA 70803.

Abstract. Gill nets are widely used as research tools to sample fish populations and as commercial fishing gears. Size selectivity of gill nets must be estimated to correct for sampling bias and to manage the commercial fishery. While myriads of methods have been proposed to estimate the selectivity of gill nets, few have been developed within a statistical framework. We present a method of estimating the selectivity of experimental gill nets in which type A and type B curves are solved simultaneously as a response surface using nonlinear regression. The modeling approach provides a general statistical framework for estimating selectivity parameters, evaluating different functional forms of the selectivity model, and testing for differences between models. We applied this approach to the gill net catches of Louisiana spotted seatrout in a five-panel experimental net from data collected from 1988-1995. The selectivity of the experimental gill nets for female and male spotted seatrout could be described by a common response surface that was based on a 4-parameter normal probability density function ($r^2 = 0.95$). By estimating type A and type B curves simultaneously, the model explained 74% more variation in the data than compared to methods which estimate type B curves for each size-class individually. Statistical comparisons of annual response surfaces were not significantly different ($p > 0.05$) and suggest that the estimation approach was insensitive to annual variation in population size composition.

APPLICATION OF BASINWIDE VISUAL ESTIMATION TECHNIQUE FOR INVENTORYING BLACKSIDE DACE IN CLEAR STREAMS

Kevin N. Leftwich, C. Andrew Dolloff, and Martin K. Underwood, U.S. Department of Agriculture Forest Service Center for Aquatic Technology Transfer, Department of Fisheries and Wildlife Sciences, Virginia Polytechnic Institute and State University, Blacksburg, VA 24061-0321; and Victoria R. Bishop, U.S. Department of Agriculture Forest Service, Daniel Boone National Forest, 1700 By-Pass Road, Winchester, KY 40391

Abstract. We used Basinwide Visual Estimation Techniques (BVET) to determine the distribution and abundance of the Federally Threatened blackside dace *Phoxinus phoxinus* in Middle Fork Beaver Creek, Kentucky during 1995. Blackside dace were found in over 75 percent of the pools and nearly 25 percent of the riffles in the 10 km study section. We estimated $3,284 \pm 651$ blackside dace in pools. Immediate mortality from electrofishing was less than 0.1 percent and delayed mortality less than two percent of the estimated population. The BVET is a safe, reliable method for determining distribution and abundance of blackside dace.

A COMPARISON OF TWO ICHTHYOPLANKTON SAMPLE METHODS

Charles R. Drumright, Christopher J. O'Bara, and Michael A. Eggleton, Center for the Management, Utilization and Protection of Water Resources, Tennessee Technological University, PO Box 5033, Cookeville, TN 38505

Abstract. Recent studies of aquatic systems often include a larval fish component. There are several types of gear that can be used in larval fish evaluations. These gear types fall into two general categories; passive, such as light traps and drift nets, and active, larval tows (Gregory and Powles 1988). Each gear type has inherent advantages and disadvantages associated with its application. Light traps are devices that use either a chemical or electric light source to attract larval fish. Designs for light traps vary, but usually consist of a central light source surrounded by plexiglass with slits wide enough to allow passage of zooplankton and larval fish. Larval tow samples typically use a plankton net towed or pushed by a specially fitted boat to sample larval fish in open water. Larval tow and light trap samples were taken concurrently for three years from Chickamauga Reservoir, Tennessee. Data obtained by each method were compared. The utilization of these sample gears to ascertain key features of larval fish dynamics, such as first appearance and peak abundance of target species, was evaluated over the three-year period. A community analysis was performed on the data to highlight differences in the communities sampled. Light trap data proved much more variable over the course of the study, possibly due in part to the smaller sample size. Larval tows, while more labor intensive, provided less variability and consistency in data points. Community assemblages between gears was similar.

POSTER PRESENTATIONS

EVALUATION OF CULTURE TECHNIQUES FOR JUVENILE FRESHWATER MUSSELS (BIVALVIA: UNIONIDAE)

Michelle B. Steg and Richard J. Neves, Virginia Cooperative Fish and Wildlife Research Unit, Department of Fisheries and Wildlife Sciences, Virginia Polytechnic Institute and State University, Blacksburg, VA 24061-0321

Abstract. Growth and survival of juveniles of the wavy-rayed lampmussel (*Lampsilis fasciola*) were compared in two recirculating culture systems, and with two levels of water hardness and organic content of the substrate. The first experiment compared the growth and survival of 4,000 *L. fasciola* juveniles in two culture systems of different design, one with juveniles held in dishes and one with them free in sediment beds. After four months, the mussels in the dish system had significantly higher survival ($P < 0.01$) than in the bed system. The mussels in the bed system had significantly greater growth (height, $P < 0.01$; width, $P < 0.01$), partially attributable to higher water temperature. The second experiment compared growth and survival of 4,800 juvenile mussels in containers with two levels of substrate organic content and two levels of water hardness. The experiment continued for four months, with subsamples taken every three weeks. At six weeks, mussels in the high water hardness treatment exhibited significantly greater growth (height, $P < 0.01$; width, $P < 0.05$) and survival ($P < 0.01$). There is no significant difference in mussel growth or survival between the two levels of organic content, and no interaction effect between organic content of sediment and water hardness.

FISH HOST IDENTIFICATION FOR ENDANGERED FRESHWATER MUSSELS (BIVALVIA: UNIONIDAE) IN THE UPPER TENNESSEE RIVER DRAINAGE

Brian T. Watson, Michelle B. Steg, and Richard J. Neves, Virginia Cooperative Fish and Wildlife Research Unit, Department of Fisheries and Wildlife Sciences, Virginia Polytechnic Institute and State University, Blacksburg, VA 24061-0321

Abstract. Fish host identifications were completed in 1996 and 1997 for two Virginia state listed freshwater mussel species, the black sandshell (*Ligumia recta*) and Tennessee heelsplitter (*Lasmigona holstonia*), and four federally endangered freshwater mussel species, the tan riffleshell (*Epioblasma florentina walkeri*), purple bean (*Villosa perpurpurea*), dromedary pearl mussel (*Dromus dromas*), and birdwing pearl mussel (*Lemiox rimosus*). Both state-listed species exhibited low degrees of host specificity in laboratory tests. Host fish for *L. recta* include largemouth bass, green sunfish, redbreast sunfish, rockbass, white perch, yellow perch, platy, and convict chichlids. The banded sculpin was the only host fish identified for *L. holstonia* but rockbass, stoneroller, striped and warpaint shiners were identified as potential hosts. Conversely, the federally endangered species exhibited high degrees of host specificity. Host fish for *E. f. walkeri* were limited to the banded and/or mottled sculpin and several percids; greenside, redline, fantail, and snubnose darters. Fish hosts identified for *V. perpurpurea* were also the banded and/or mottle sculpin and two percids; greenside and redline darters. The fantail darter was the only fish host identified for *D. dromas*, with the gilt darter, tangerine darter, and Ohio logperch identified as potential hosts. Additionally, a second darter (snubnose) was identified as a host for *L. rimosus*.

A THESIS PROPOSAL: THE DEVELOPMENT OF HOLDING AND REARING SYSTEMS FOR THE AMERICAN EEL

Marion L. Moss and Steven G. Hughes, Maryland Cooperative Fish and Wildlife Research Unit, 1120 Trigg Hall, University of Maryland Eastern Shore, Princess Anne, MD 21853

Abstract. The American eel *Anguilla rostrata* is an important economic resource for the Chesapeake Bay region. There is increasing concern over current harvesting and holding methods employed within the fishery. This proposed research will have two stages with the main goals being the enhancement of the Chesapeake Bay eel fishery and the marketable husbandry of eels. Two prototype low-cost recirculating systems are being developed. The short-term holding system will be capable of successfully containing eels in a captive environment while reducing the threat of disease and mortality. This system will be stocked with eels harvested in local waters which will be purged, graded, and held a minimum of two weeks under close observation for signs of stress and induced infection. Evaluation of the system will be based on maintenance of high water quality, successful containment, and survival of the eels. Within the long-term rearing system, growth parameters, survival, and adaptability to artificial feed will be compared between yellow eels (23-30 cm) stocked in circular and rectangular tanks and reared a minimum of twelve weeks. We hope to offer a practical system approach for the profitable rearing of eels.

TARGET STRENGTH ANALYSIS OF STRIPED BASS (*MORONE SAXATILIS*) AND WHITE PERCH (*MORONE AMERICANA*) OF VARYING SIZES

B. W. Nagy and K. J. Hartman, West Virginia University Division of Forestry, Wildlife and Fisheries, PO Box 6125, Morgantown, WV 26505

Abstract. The use of hydroacoustics in fisheries research, while not entirely new, is relatively undocumented for most fish species and most waterways. It was therefore necessary to determine species-specific target strengths (TS) for both striped bass *Morone saxatilis* and white perch *M. americana* while performing abundance estimates on the Hudson River estuary. The TS measurements were taken through the use of a fish cage constructed of plastic mesh and aluminum supports, and a Simrad EY500 with a ES120 split beam transducer. A number of individuals and sizes for each species were caught using both mid-water trawls and hook and line. These fish were then placed, one at a time, in the enclosure and it was lowered to an appropriate depth to capture the entire fish in the acoustic beam. After each fish was held in the beam for several seconds and data for that fish was logged, the enclosure was retrieved and the process was repeated. On return to the lab, the data was analyzed using custom made programs written in the IDL programming format. Analysis showed, as expected, that the larger fish produced a larger TS, while smaller fish produced a smaller TS. The main portion of a fish responsible for the TS is the swim bladder, therefore the larger the fish the larger the swim bladder and the larger the TS.

INLAND FISH POPULATIONS OF THE BAHAMAS: BIOLOGY OF *CYPRINODON LACINIATUS* AND RELATED SPECIES

Chris Anderson and Michael Barton, Division of Science and Mathematics, Centre College, 600 W. Walnut Street, Danville, KY 40422

Abstract. Pupfishes of the genus *Cyprinodon* are common inhabitants of coastal and inland waters along the Atlantic coast as well as throughout the Bahamian archipelago and the Caribbean. These fishes present a unique opportunity to address fundamental questions concerning the ecology and adaptations of organisms to unusual environmental circumstances. The insularity afforded by the inland waters of the Bahamas provides a remarkable natural laboratory to assess speciation phenomena. Two species of pupfishes of the genus *Cyprinodon* have been provisionally identified as inhabiting the inland waters of New Providence Island. One species, *C. laciniatus*, was first described in 1942, as an endemic known only from two lakes in New Providence. To date, no comprehensive life history investigations have been done on this species. A visual census of *C. laciniatus* was conducted in one of the lakes to determine population density, depth, and microhabitat preferences. Sampling from several inland bodies of water revealed variation in length-weight relationships and fecundity suggesting the existence of a species complex in New Providence consisting of *C. laciniatus*, *C. variegatus*, as well as several intermediate forms. Preliminary biochemical analysis (DNA fingerprinting) of the sampled populations support this claim.

SMALLMOUTH BASS SPAWNING BENCH EVALUATION IN DALE HOLLOW RESERVOIR

Andre Paul Christian Heil and Frankl J. Bulow, Department of Biology, Tennessee Technological University, Cookeville, TN 38505

Abstract. Spawning smallmouth bass (*Micropterus dolomieu*) have demonstrated a preference for the proximity of logs, boulders, stumps, and similar cover as nesting sites. Such cover affords the spawning male bass protection while guarding the nest, and fry seek adjacent cover as they disperse from the nest. Spawning benches have been used to enhance spawning habitat in areas that are deficient of natural structure. The purpose of this study was to evaluate the effectiveness of these structures in Dale Hollow Reservoir, TN. In Fall of 1995, young-of-year density was estimated using a hand-held electrofishing unit in Dale Hollow Cove (study cover) and Horse Creek (control cove), just prior to installation of the spawning benches. In February of 1996, 50 spawning benches were installed in Dale Hollow cove. SCUBA gear was used to monitor the nesting activity of bass on 34 benches during the 1996 spawning season. Electrofishing was conducted again in Fall of 1996 and 1997, and benches were observed again during the spawning season of 1997. Smallmouth bass utilized 38% of the benches for spawning. Bass preferred benches at 4-8 ft (1.2-2.4 m) depths, location on points. Although there were no relationships between bench success and substrate, slope of shoreline, and position of bench (parallel vs. perpendicular to the shoreline), observation in the control cove indicated that spawning bass preferred a rock or gravel substrate over mud or sand. During the 1997 spawning season, there was no difference in nest density between the study and control cove; however, young-of-year density (#/100m) did increase after benches were installed ($p = 0.05$).

USING SOCIAL SCIENCE IN THE MANAGEMENT OF THE SOUTH ATLANTIC ROCK SHRIMP FISHERY

Michael Jepson, South Atlantic Fishery Management Council, One Southpark Circle, Suite 306, Charleston, SC 29407.

Abstract. In 1992, the South Atlantic Fishery Management Council began public scoping on management issues within the Florida east coast rock shrimp fishery at the request of the commercial fishing industry. The industry was concerned about the decline in landings of rock shrimp despite increased effort in the fishery and the harvesting of smaller sized shrimp. The council decided to proceed with an amendment to the Shrimp Fishery Management Plan to manage rock shrimp in June of 1994 to address those concerns. However, in October 1994, the council voted to defer license limitation, co-management and other measures to another amendment and chose to focus on protecting habitat from rock shrimp trawling by closing harvest areas. The poster session demonstrates how, with the use of social science to enlist industry input into the fisheries management process, it was revealed that through normal reporting channels landings were underestimated. Therefore the economic impacts of council actions were also underestimated. Also, the makeup of the fleet had changed with more harvesters from the Gulf of Mexico changing the dynamics of the fishery. Once primarily a Florida east coast fishery with harvesters from Florida and Georgia, harvesters were now from as far away as Texas. In addition, harvesting area had expanded to areas previously not fished which dramatically affected the councils final decision regarding area closures. The use of social science helped foster better relations with the industry which removed some of the antagonism that often comes with council actions, thereby enhancing the process of managing rock shrimp.

PREVALENCE OF PROTOZOANS PARASITIZING AGE-0 CLUPEIDS IN KENTUCKY LAKE, KENTUCKY

Kevin J. Frey, Kentucky Department of Fish and Wildlife Resources, 1 Game Farm Road, Frankfort, KY 40601, and Leon F. Duobinis-Gray, Department of Biological Sciences, PO Box 9, Murray State University, Murray, KY 42071-0009

Abstract. Age-0 skipjack herring *Alosa chrysochloris*, gizzard shad *Dorosoma cepedianum*, and threadfin shad *D. petenense* in Kentucky Lake were examined for *Apiosoma piscicolum*, *Myxobolus petenensis* and *Trichodina discoidea* May 6 through July 7, 1994 and August 9, 1995. *A. piscicolum* and *T. discoidea* infested all three species of clupeids, while *M. petenensis* infected only threadfin shad. During 1994 prevalence of *A. piscicolum* on age-0 hosts ranged from 3.5% on May 6 to 65.4% on June 22, *M. petenensis* ranged from 0.0% on May 6 to 12.4% on July 7, and *T. discoidea* ranged from 0.0% on May 6 to 83.1% on June 22. Data from 1994 and 1995 indicated that the total lengths of *A. piscicolum*-infected clupeids ranged from 5-88 mm, *M. petenensis*-infected threadfin shad 17-78 mm, and *T. discoidea*-infested clupeids 11-99 millimeters. This is the first record of *A. piscicolum* infesting freshwater fish in the United States, and the first report of *Myxobolus* infecting fish of the genus *Dorosoma*.

RETENTION AND DETECTION OF CODED WIRE TAGS AND ELASTOMER TAGS IN TROUT

R. Scott Hale, Inland Fisheries Research Unit, Ohio Division of Wildlife, 10517 Canal Road, SE, Hebron, OH 43025, and James H. Gray, Wolf Creek National Fish Hatchery, 50 Kendall Road, Jamestown, KY 42629

Abstract. Tag retention >95% and easy tag detection were possible with blank coded wire tags and elastomer tags implanted in a variety of body locations of adult trout (*Salmo* and *Oncorhynchus* spp.). These tags were used in a generic way to differentiate 32 groups of brown trout *Salmo trutta* (142-254 mm TL) and rainbow trout *Oncorhynchus mykiss* (80-314 mm TL) that were stocked at different times and locations in the Cumberland River, Kentucky. Retention rates (19-30 d) ranged from 92 to 100% for coded wire tags implanted in the snout, left cheek, and muscle near the left pectoral, pelvic, dorsal, adipose, and caudal fins. Retention rates (24-30 d) ranged from 94 to 99% for elastomer tags placed in the left and right adipose eyelids and the caudal fin rays. Loss of coded wire tags by trout did not increase with the number of days tagged fish were held in raceways, which suggested that most tag loss was complete prior to stocking. By contrast, loss of elastomer tags increased with holding time and may have continued after stocking; therefore, we recommend further investigation of elastomer retention. Two inexperienced creel clerks successfully detected the body locations of coded wire tags 91 and 98% of the time following only 1 h of training. Detection of the presence or absence of coded wire tags was easy and precise. However, accurate determination of tag location could become a source of error if adjacent tags are too close due to the selection of tag locations or fish size. Visual detection of elastomer tags was enhanced by a black light but detection was obvious and required minimal training.

THE ABUNDANCE AND RIFFLE HABITAT PREFERENCE OF FRESHWATER MUSSELS IN THE SULPHUR FORK CREEK WATERSHED, ROBERTSON COUNTY, TENNESSEE

R. Adam Ray, Steven W. Hamilton, and Joseph Schiller, PO Box 4718 Austin Peay State University, Department of Biology, Clarksville, TN

Abstract. Freshwater mussel populations have declined significantly in Tennessee's waterways. The Sulphur Fork Creek (SFC) watershed is a typical Tennessee watershed, creating the potential for constructing a model applicable to other mussel studies in the state. This is the inaugural freshwater mussel survey of SFC watershed. The Tennessee Department of Fish and Wildlife has recently completed a fish survey of SFC watershed. In November of 1997, mussels were collected by clam net along transects from both the head and foot of four riffles located in the northern portion of the watershed. Temperature, dissolved oxygen (D.O.), pH, stream velocity, and turbidity, measurements were taken approximately 20 meters upstream of the first riffle. The Asiatic clam (*Corbicula fluminea*) was the most predominant species. Remnant shells of Sphaeriid (i.e. fingernail) and the Unionid clams were also observed. Freshwater mussels appear to prefer riffle headwaters to riffle tailwaters. The chi square goodness of fit test indicates that observed and expected frequencies were significantly different ($p < 0.001$) in all four riffles. High siltation rates in the SFC watershed are a likely factor depressing abundance and diversity of freshwater mussels by reducing recruitment of young mussels.

JUVENILE RIVER HERRING INDEXES: RELATIONSHIPS BETWEEN SPECIES, RIVERS, NURSERY ZONE SIZE, AND RECRUITMENT

Joseph G. Loesch and Douglas A. Dixon, The College of William and Mary, School of Marine Science, Gloucester Point, VA 23062-1346

Abstract. A juvenile index of abundance was developed for the alewife and the blueback herring in the Mattaponi and Pamunkey rivers, Virginia. The objectives were to: develop juvenile *Alosa* indexes sensitive to varying degrees of reproductive success; determine if the two species-specific indexes exhibited a common pattern of change in a river system; determine if index changes are common to both rivers; and determine if the index is related to nursery zone size. Sampling was conducted at night with a bow-mounted pushnet. The maximal CPUE for a series of weekly sampling was chosen as the index of abundance. Species indexes were strongly correlated within the Mattaponi and Pamunkey rivers ($r = 0.89$ and 0.85). Blueback herring and alewife indexes between rivers were also reasonably strong ($r = 0.69$ and 0.74). There was a strong correlation between the maximal CPUE and the seasonal CPUE (>0.90 for both species), but the CV for the maximal CPUE was always lower. The linear relationship of index values to nursery zone sizes was direct and significant ($P > 0.001$), indicating no crowding effect. For the combined species data, the recruitment correlations for the Pamunkey and Mattaponi rivers were strong (0.78 and 0.87). When data were also combined for rivers, as in landings reports, the correlation between the maximal CPUE and year class recruitment was $r = 0.86$, indicating the index is determined after year-class strength is established.