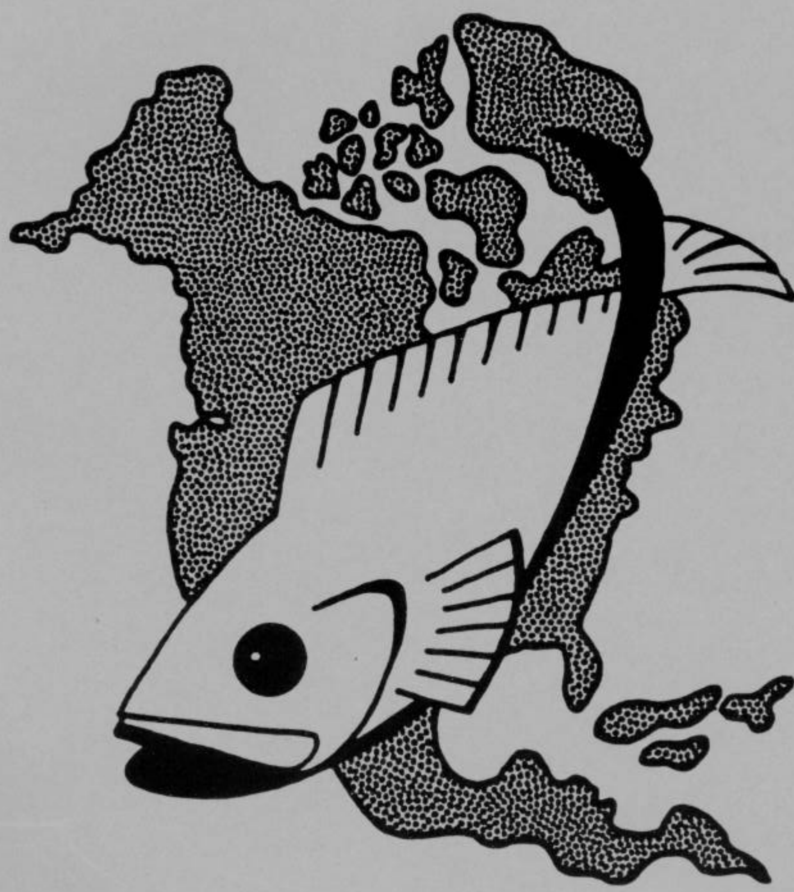
ANNUAL PROCEEDINGS of the TEXAS CHAPTER

AMERICAN FISHERIES SOCIETY



Port Aransas, Texas
September 16-17, 1993

VOLUME 16

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TEXAS CHAPTER

AMERICAN FISHERIES SOCIETY

The Texas Chapter, American Fisheries Society was organized in 1975. Its objectives are those of the parent Society -- conservation, development and wise utilization of recreational and commercial fisheries, promotion of all branches of fisheries science and practice, and exchange and dissemination of knowledge about fish, fisheries and related subjects. A principal goal is to encourage the exchange of information among members of the Society residing within the State of Texas. The Chapter holds at least one meeting annually at a time and place designated by the Executive Committee.

MEMBERSHIP

Persons interested in the Texas Chapter and its objectives are eligible for membership and should apply to:

Texas Chapter, American Fisheries Society
Secretary - Treasurer
Texas Parks and Wildlife Department
4200 Smith School Road
Austin, Texas 78744

Annual membership dues are $8 for Active Members and $5 for Student Members.

ANNUAL PROCEEDINGS OF THE TEXAS CHAPTER

AMERICAN FISHERIES SOCIETY

September 16 and 17, 1993

Port Aransas, Texas

1993-1994 Officers

Loraine T. Fries, President
Texas Parks and Wildlife Department

Pat L. Hutson, President-Elect
Texas Parks and Wildlife Department

Katherine T. Ramos, Secretary - Treasurer
Texas Parks and Wildlife Department

Brian G. Blackwell, Editor
Texas A&M University

1994

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c/o Texas Parks and Wildlife Department
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Austin, Texas 78744

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PAST TEXAS CHAPTER PRESIDENTS AND MEETING LOCATIONS

DATE	PRESIDENT	LOCATION
1976		College Station
1976	Ed Bonn	Lake Brownwood
1977	Jim Davis	San Antonio
1978	Bill Rutledge	San Marcos
1979	Bobby Whiteside	College Station
1980	Richard Noble	Arlington
1981	Charles Inman	Austin
1982	Gary Valentine	Kerrville
1983	Don Steinbach	Lake Texoma
1984	Gary Matlock	Port Aransas
1985	Maury Ferguson	Junction
1986	Brian Murphy	San Marcos
1987	Joe Tomasso	Kerrville
1988	Dick Luebke	Abilene
1989	Mac McCune	San Antonio
1990	Bobby Farquhar	Lake Texoma
1991	Gene McCarty	Galveston
1992	Bill Provine	Kerrville
1993	Barbara Gregg	Port Aransas
1994	Loraine Fries	Lake Travis

TEXAS CHAPTER AWARDS

A total of seven awards may be presented on an annual basis, assuming nominations are received. Only members in good standing may make nominations. If nominations reviewed by the Awards Committee are found to be inadequate in one or all categories, awards need not be given in any or all areas. If multiple nominations are received and more than one nominee is considered outstanding, multiple recipients are permissible. The awards and their associated criteria are:

Outstanding Fisheries Worker of the Year - The nominees must be Chapter members in good standing. There are five specialization categories: Administration, Culture, Education, Management, and Research. An award may be presented in each area of specialization. All nominations must be accompanied by supporting data on contributions to <u>one</u> particular area of focus.

Special Recognition in Fisheries Work - The nominees do not have to be Chapter members. They may be individuals or organizations that have made substantial contributions to fisheries in Texas.

Outstanding Presentation at the Annual Meeting - The basic requirements are:

a. The presentation must be made by one of the authors.
b. At least one of the authors must be a Chapter member in good standing.
d. Members of the current Awards Committee shall be ineligible.

The award is for the presentation, not a manuscript or paper. Criteria for evaluation, made by the Awards Committee, and their relative values are:

a. Introduction - 10 points
b. Methods - 10 points
c. Organization - 10 points
d. Originality - 15 points
e. Technical Merit - 20 points
f. Delivery - 15 points
g. Visual Aids - 15 points
h. Other considerations - 5 points

Judges will evaluate each presentation immediately after it is given. They will not confer until after the last presentation. The decision will be made based on relative rankings assigned by the judges.

Scholarship Selection - Selection of scholarship recipients is made by members of the Scholarship Selection Committee. University representatives nominate students from their institution for scholarship consideration. Selection is based on the following criteria:

a. academic excellence
b. professional activities
c. promise of future professional involvement and significant contribution to the field of fisheries science

1993 TEXAS CHAPTER AWARDS

Bruce Hysmith was recognized as the **Outstanding Fisheries Worker of the year for Management**. Bruce was recognized for his many educational activities with youth and civic groups and his continued dedication to the fisheries resource. He has been instrumental in working with the U. S. Army Corps of Engineers to benefit fisheries in his district. Bruce also has been active with striped bass management and during the past year presented several papers of ongoing research at scientific meetings. The Texas Chapter of the American Fisheries Society has benefitted from Bruce's involvement in chapter activities.

Two awards were presented for **Special Recognition in Fisheries Work**. The awards were presented to **Joe Martin** and **Steve Gutreuter**.

Joe Martin has been employed by Texas Parks and Wildlife as the upper Laguna Madre Resource Biologist since January 1991. Over the years, Joe has conducted several biological sampling projects and sport and commercial harvest surveys along the Texas Coast. During the past 12.5 years the upper Laguna Madre Resource team under Joe's direction has never missed a sample and have done >60% of the weekend harvest surveys. Joe also has lent extensive assistance to resource teams in the Aransas and Corpus Christi bay systems.

Steve Gutreuter was employed by the Inland Fisheries Branch of Texas Parks and Wildlife from 1983 through 1991. During that time he designed and managed the development of statewide databases for Inland Fisheries' standardized fishery surveys. Steve also oversaw the development of statistical (SAS) programs that could access the newly developed databases. These databases and subsequent statistical analysis programs have led to a high level of technical proficiency in fisheries management throughout Texas.

Jay Rooker gave the **Outstanding Presentation** at the 1993 Annual Meeting. The paper presented by Jay was entitled, "Ontogenetic Shifts in Diet, Habitat, and Diel Feeding Periodicity of Schoolmaster Snapper.

Three $500 scholarships were presented at the 1993 Annuaul Meeting. Scholarships were presented to Erica Schlickeisen (SWTSU), Brian Blackwell (TAMU), and Nancy McFarlan (TAMU).

PAST TEXAS CHAPTER AWARDS RECIPIENTS

1977	Fisheries Research - John A. Prentice and Richard D. Clark, Jr. (TPWD)
1978	Fisheries Education and Research - Clark Hubbs (UT) Fish Culture - Pat L. Hutson (TPWD) Special Recognition - Edward R. Lyles (FWS)
1979	Fish Culture - Robert Stickney (TAMU) Fisheries Education - Richard Noble (TAMU) Fisheries Management - Gary Valentine (SCS) Fisheries Research - Phil Durocher (TPWD) Special Recognition - Charles Inman (TPWD)
1980	none
1981	Fisheries Education - Bobby Whiteside (SWTSU)
1982	Fish Culture - Roger L. McCabe Fisheries Research - William C. Guest (TPWD) Special Recognition - Robert P. Hofstetter (TPWD)
1983	Special Recognition - Robert J. Kemp (TPWD)
1984	none
1985	Fisheries Education - Donald E. Wohlschlag (UTMSI) Fisheries Research - Connie R. Arnold (UTMSI)
1986	Fisheries Management - William Higginbotham (TAES) Fisheries Research - Robert L. Colura (TPWD)
1987	Fish Culture - Kerry Graves (FWS) Special Recognition - The Sportsmen's Club of Texas
1988	Fisheries Research - Gary P. Garrett (TPWD) Special Recognition - Kirk Strawn (TAMU)
1989	Fisheries Administration - Gary C. Matlock (TPWD) Fish Culture - Robert R. Vega (TPWD) Fisheries Management - Joseph E. Kraai (TPWD) Fisheries Research - Roy J. Kleinsasser and Gordon W. Linam (TPWD)
1990	Fisheries Administration - C. Gene McCarty (TPWD) Fish Culture - Glen A. Alexander and David L. Campbell (TPWD) Fisheries Management - David R. Terre (TPWD)
1991	Fisheries Administration - Pat L. Hutson (TPWD) Fish Culture - Jake Isaac, Jr. (TPWD) Fisheries Management - Mark Webb (TPWD) Fisheries Research - Ronnie M. Pitman (TPWD) Special Recognition - The Wetland Habitat Alliance of Texas
1992	Fish Culture - Camilo Chavez, Jr. (TPWD) Fisheries Education - Brian R. Murphy (TPWD) Fisheries Management - Ken Sellers (TPWD) Fisheries Research - Bob Colura (TPWD) Special Recognition - Bobby Farquhar (TPWD) Texas

CONTRIBUTORS

The following individuals or companies made contributions of money, products or services, or exhibited products and/or services at the annual meeting in 1993.

CONTRIBUTORS	PRODUCT OR SERVICE
ADAMI, ROBERT Star Route, Box 535 Palacios, TX 77565	Whitetail deer hunting trip
A&V INC N62 W22632 Village Dr. Sussex, WI 53089	Chemicals
ADPI ENTERPRISES, INC. P.O. Box 64 Milano, TX 76556	Plastic netting
BARTLETT MOTOR COMPANY 111 Oyster Creek Drive Lake Jackson, TX 77566	Boat and motor supplier
BASKET CREATIONS 1596 Padre Staples Mall Corpus Christi, TX 78411	Gift baskets
BEACH BAIT AND TACKLE P.O. Box 2025 Freeport, TX 77541	Fishing bait and tackle
BRUSH COUNTRY CHAPTER, GCCA Route 2, Box 320 Q Kingsvillle, TX 78363	Nonprofit conservation organization
CENTRAL POWER AND LIGHT CO. 539 N. Carancahua Corpus Christi, TX 78403	Electrical power company
DOW CHEMICAL Texas Operations AP Beutel Building Freeport, TX 77541	Chemical manufacturer

CONTRIBUTORS	PRODUCT OR SERVICE
FRIES, LORAINE A.E. Wood Fish Hatchery P.O. Box 947 San Marcos TX 78667	Stained glass
GCCA/CPL MARINE DEVELOPMENT CENTER STAFF 4300 Waldon Road Corpus Christi, TX 78418	Nonprofit conservation organization
GULF COAST CONSERVATION ASSOCIATION 4801 Woodway, Suite 220-W Houston, TX 77056	Nonprofit conservation organization
HOLT, JOAN The University of Texas Marine Science Institute Port Aransas, TX 78373	Clothing
HUTSON, PAT A.E. Wood Fish Hatchery P.O. Box 947 San Marcos, TX 78667	Metal art
ISLANDER P.O. Box 696 Port Aransas, TX 78373	Gift shop
JENNINGS & CO. 3455 South Alameda Corpus Christi, TX 78411	Medical equipment distributor
JOHNSON LAKE MANAGEMENT SERVICES 310 Deerwood Drive San Marcos, TX 78666	Consulting, fisheries management
LAKE MANAGEMENT SERVICES, INC. P.O. Box 923 Richmond, TX 77469	Lake and pond design construction and management
MASTER PUMPS & EQUIPMENT 4414 North Baldwin Corpus Christi, TX 78408	Pump distributor and manufacturer

CONTRIBUTORS	PRODUCT OR SERVICE
OLDHAM LURE Route 1, Box 94 Wimberly, TX 78676	Fishing Tackle
ORION RESEARCH, INC. 2506 Elmhurst Rowlett, TX 75088	Aquaculture equipment
POLY PIPE INDUSTRIES P.O. Box 390 Gainesville, TX 78216	Fiberglass pipe distributor
PORTIS, KIP 134 Braniff San Antonio, TX 78216	Barbeque pit
RED EWALD, INC. P.O. Box 519 Karnes City, TX 76241	Aquaculture tanks
REDFISH UNLIMITED 5015 Larch Avenue consulting Missoula, MT 59802	Fish farm and
ROWLAND FIBERGLASS P.O. Box 971 Ingleside, TX 78362	Aquaculture tanks
ROYCE INSTRUMENT 13555 Gentilly Road New Orleans, LA 70129	Aquaculture equipment
RYAN INSTRUMENTS P.O. Box 599 Redmond, WA 98073	Aquaculture equipment
SPORTSMEN CONSERVATIONISTS OF TEXAS 807 Brazos, Suite 311 Austin, TX 78701	Nonprofit conservation organization
SURE GROW SOLUTIONS P.O. Box 476 Taft, TX 78390	Agriculture supplies

CONTRIBUTORS	PRODUCT OR SERVICE
TYLER FISH FARMS Route 3, Box 3286 Ben Wheeler, TX 75754	Fish farm
WADE BUTLER FINE ART 601 Franklin Drive San Marcos, TX 78666	Fine art
WALKER, DENVER P.O. Box 686 Uvalde, TX 78802	Bow hunting trip
WALLACE, ROBERT Suite 1800 American Bank Plaza Corpus Christi, TX 78475	Attorney
WILLIAMS DISTRIBUTING 601 North 19th Street Corpus Christi, TX 78408	Beverages
WOODY'S SPORTS CENTER P.O. Box 1438 Port Aransas, TX 78373	Sporting goods

Pre- and Post-Spawning Blood Chemistries of Florida Largemouth Bass: Preliminary Results

Katherine T. Ramos, Loraine T. Fries and Steven C. Hamby (Texas Parks and Wildlife Department, San Marcos, Texas 78667)

Intensive spawning is a recent advance in largemouth bass *Micropterus salmoides* culture. Fish spawned intensively are likely subjected to different stressors than fish spawned extensively: however, the effects of the stressors on the broodfish are relatively unknown. The objectives of this study were to 1) establish baseline data on blood chemistry variables of hatchery reared Florida largemouth bass *M.s. floridanus* as they relate to pre- and post-spawning situations, 2) compare blood chemistry between intensively and extensively spawned fish and 3) develop management strategies that lessen stress without affecting production. Blood samples were collected pre- and post-spawning from 34 pairs of largemouth bass spawned extensively in outdoor ponds and 40 pairs spawned intensively in indoor raceways. Samples were analyzed for glucose, cholesterol and chloride levels, hematocrit, and total blood protein. There were significant differences between glucose, cholesterol and chloride levels in the two spawning methods. These results indicate that intensively spawned fish are exposed to lower levels of stress and are likely less affected by these stressors.

Habitat Selection by Immigrating Larval Fish in a South Texas Estuary

Scott A. Holt and Jim Tolan (Department of Marine Science, University of Texas at Austin, Port Aransas, Texas 78373-1267)

Ichthyoplankton were collected on two cruises within the lower Laguna Madre February-May 1993 to study habitat selection of immigrating larval fishes. Collections were made in shallow, seagrass covered (shoalgrass *Halodule wrightii* and manateegrass *Syringodium filliforme*) areas and adjacent bare bottom habitats at six locations within the lagoon. A total of 31 species representing 15 families were collected. The gulf menhaden *Brevoortia patronus* made up 57.1% of the total catch, followed by larval anchovies *Anchoa* sp. and pinfish *Lagodon rhomboides*, 21.9% and 9.2% respectively. Habitat utilization patterns for gulf menhaden and pinfish from the February sampling period were investigated by comparing the density and size of fish found among different habitats and locations in the study area. For gulf menhaden only habitat type was significant ($P<0.0001$, $r^2=0.523$). Pinfish densities were significant for both habitat type and location in the estuary ($P<0.0001$, $r^2=0.929$). Preliminary analysis of the results to date indicate habitat selection by immigrating fish to be a combination of larval supply and complex settlement patterns.

An Attempt to Demonstrate Solunar Influence on Angling Results

Ralph E. Manns (Fishing Information Services, Austin, TX 78759)

Analysis of big fish catches reported to the In-Fisherman magazine from 1987 through 1990 failed to show an statistical differences between catches of sport fish on supposedly better or poorer angling days or during specific moon phases. Comparisons of catch rates for black bass taken by anglers on all hours of the solunar cycle were close, but failed to meet 95% significance criteria. Nevertheless, profiles of the catch rates show distinct peaks in catches centered on major solunar forces did effect daily catches, but that the forces are only one of several factors that influence angling success. The influence of solunar periods appeared to vary when they coincide with dawn, dusk, and other times anglers typically believe fish are more likely to bite. I postulate that major solunar alignments act as precise zeitgebars, stimulating activity by a portion of the black bass community. Activity near minors appears to be stimulated by imprecise biological timing. As a result, the total angler catch near minors was greater than that near majors, a reversal of popular angling doctrine concerning the relative length and strength of solunar fishing periods.

An Evaluation of Low-Density Triploid Grass Carp Stocking in Small Sportfishing Impoundments to Control Submersed Vegetation

Brian G. Blackwell and Brian R. Murphy (Department of Wildlife and Fisheries Sciences, Texas A&M University, 210 Nagle Hall, College Station, TX 77843)

Texas legalized the use of triploid grass carp *Ctenopharyngodon idella* for private waters in January, 1992. Current regulations allow for stocking a maximum of 7 triploid grass carp per surface acre. Baseline results of grass carp stocking in small Texas impoundments are limited. The objective of this study was to evaluate low densities of triploid grass carp for controlling submersed vegetation in small impoundments and any subsequent affects on established sportfish communities. We attempted to reduce, but not completely remove, submersed vegetation in four small Texas impoundments. Submersed aquatic vegetation was monitored through three growing seasons and fish communities were monitored seasonally. Results were variable, but tended to indicate that low-density stockings of triploid grass carp can provide control of nuisance submersed vegetation. No changes in fish community structure were noted. Vegetation type and density need to be considered when making stocking recommendations.

Improved Hatch of Koi Carp Eggs After Treatment With Formalin

Susan L. Froelich and Loraine T. Fries (Texas Parks and Wildlife Department, San Marcos, Texas 78667)

Formalin treatments to control mycotic infestation during koi carp *Cyprinus carpio* egg incubation were evaluated. Static treatments of 15 min with formalin concentrations of 0 mg/L, 250 mg/L, and 1000 mg/L were compared in each of 5 trials. Treatment efficacy was inferred using percent hatch. Analysis of variance showed a statistically significant difference in the hatch rates of the different treatments. Tukey's honest significant difference indicated there was no difference between 0 mg/L and 250 mg/L, however, the hatch rate was significantly improved between either of these rates and 1000 mg/L formalin.

Lined vs. Unlined Ponds in Striped Bass Production

Joe N. Fries (U.S. Fish and Wildlife Service, San Marcos, Texas 78666), Loraine T. Fries and Steve C. Hamby (Texas Parks and Wildlife Department, San Marcos, Texas 78667)

Twenty-five thousand 5-d-old striped bass *Morone saxatilis* were placed in each of 10 0.04-ha ponds. Five of these ponds were earthen (unlined) and the other five had black polyethylene plastic liners (lined). The fish were cultured for 27-28 d and then harvested. Dissolved oxygen usually was lower ($P \leq 0.01$) in the unlined ponds than in the lined ponds (morning mean, 6.6 vs. 8.1 mg/L, respectively). The pH generally was lower ($P<0.001$) and more constant in the unlined ponds (afternoon mean, 8.3 vs. 8.9; afternoon CV, 0.03 vs. 0.05). Carbon dioxide was higher ($P<0.001$) in the unlined ponds (mean, 12.3 vs. 1.8 mg/L). Unionized ammonia was lower ($P<0.001$) and less variable in the unlined ponds (mean, 0.02 vs. 0.08 mg/L; afternoon CV, 0.56 vs. 0.72). Ionized ammonia patterns were similar in both pond types and averaged about 0.35 mg/L. Nitrite usually was lower ($P < 0.05$) in the unlined ponds (mean, 0.09 vs 0.24 mg/L). Mean orthophosphate in both pond types decreased from about 0.9 mg/L on day 1 to about 0.04 mg/L on day 32. Chlorophyll *a* generally was lower ($P<0.001$) in the unlined ponds (mean, 6.8 vs. 15.6 mg/L). Rotifer densities were lower ($P<0.001$) in the unlined ponds, especially for the first 7 days that fish ere in the pond (7-d mean, 6 vs. 297 rotifers/L of sample) ($P<0.01$). Overall zooplankton densities also were lower ($P \leq 0.005$) in the unlined ponds (mean, 356 vs. 520 zooplankters/L sample). Fish in the unlined ponds grew faster (mean, 1.27 vs. 1.17 mm/d) ($P<0.05$) but harvest biomass was lower (mean 960 vs. 2440 g) ($P \leq 0.005$). Average survival also was lower ($P \leq 0.005$) in the unlined ponds (5%) than in the lined ponds (19%). Water quality problems did not appear to account for the poor fish production in the unlined ponds (data extremes were not excessive). It is possible that too few appropriately-sized food item (e.g., rotifers) were available to the striped bass during the critical early days.

Ethics of Biodiversity Conservation

Phil Pister (Desert Fishes Council, P.O. Box 337, Bishop, CA 93515)

Habitat disruption and species endangerment have accelerated to a point where complacency by fishery scientists is neither realistic nor ethically acceptable if we are to pass on to future generations a biota which reflects our professional competence and obligation. Aldo Leopold observed in A Sand County Almanac that: "Conservationists are notorious for their dissensions...In each field one group (A) regards the land as soil, and its function as commodity production; another group (B) regards the land as a biota and its function as something broader." In management of biological resources, Group A persists in favoring politically popular consumptive harvest programs to the relative exclusion of the biotic community, and to the increasing chagrin of Group B. Schooled primarily in utilitarian philosophy and technology, Group A biologists generally fail to extend their vision to higher and more enduring goals, and to recognize that their obligation to an increasingly sophisticated public (and to the organisms themselves) may likely be fulfilled more appropriately from stocks of native species within secure habitats. Dramatic decreases in hunting and fishing license sales in key areas of the nation support this thesis. Group A counterparts within academe are biological research scientists who, seemingly oblivious to deteriorating ecosystems and to meet tenure track and academic advancement criteria, often subordinate quality to quantity in research endeavors.

Improvement in breadth and quality of curriculum structure and undergraduate instruction provides perhaps the best approach to producing the deep thinkers and values needed to lead us into an uncertain but generally predictable future. An unacceptable alternative is continued production of technologically well trained but philosophically shallow specialists who, in order to satisfy supervisors and immediate demands of agency and society, soon become missiles without guidance systems who primary target becomes undeviating devotion to an obsolescent status quo.

Observations of Abnormalities in Largemouth Bass Fry Exposed to Arsenic Contaminated Water

R. Carrier, Mark Stacell, (Texas Parks and Wildlife Department, San Marcos, Texas) and Mark Webb (Texas Parks and Wildlife Department, Inland Fisheries, Bryan, Texas 77802)

Pelvic and pectoral fin abnormalities were observed in largemouth bass collected from an urban reservoir contaminated with arsenic. Based on these observations, a preliminary study was conducted to gather qualitative information on the effects of the exposure to arsenic contaminated lake water on the development of largemouth bass fry. Adult fish were collected in late February from the arsenic contaminated reservoir, Finfeather Lake, and a control reservoir, Lake Madisonville, and placed in 0.25-acre ponds for spawning. Four spawns from Finfeather Lake fish and two spawns from the Lake Madisonville fish were collected. Approximately half of each spawn was transferred to water from Finfeather Lake (mean arsenic concentration, 420 ppb) and the other half placed in control water (mean arsenic concentration, <10 ppb). Fry hatched between 72 and 120 hours, and were examined daily for five days. Developmental abnormalities included eye, head, jaw and trunk/spinal deformities, and cardiac and abdominal edema. In both lake Madisonville spawns, fry exhibited few deformities when raised in control water. However, the number of deformities increased approximately two to three times when fry were held in the arsenic contaminated water. In two of the Finfeather Lake spawns low numbers of live fry were observed regardless of exposure water, suggesting possible decreases in survival of fry. In another Finfeather Lake spawn, high numbers of deformities were noted in fry from both control and arsenic contaminated water.

The Fish Collection of the Texas Natural History Collection and its Availability Online to the General Public

Dean Hendrickson (The University of Texas at Austin, Texas Memorial Museum, Austin, Texas 78705)

The fish collection of the University of Texas at Austin originated over 40 years ago with collections made by faculty in the Zoology Department, and has grown to include an estimated 400,000 specimens of nearly 1,400 species. The total number of lots (jars) has surpassed 23,000, with slightly over 60% of these being from Texas (mostly freshwater), but 19 other U.S. states are represented, and significant collections from 15 other countries are also available (e.g., Mexico, 1,268 lots from 17 states; Venezuela, 215 lots, Costa Rica 140 lots, Zambia 89 lots). Central and West Texas are especially well represented. Other features include a sizable collection of natural and artificially produced hybrid freshwater fishes (mostly Poeciliid, Cyprinodontids, and Percids) and paratypes of 41 taxa. The collection is important for its comprehensive collections of many endangered taxa and documentation of historic changes in distribution, largely through the many years of collecting efforts by Dr. Clark Hubbs and his students. Extensive ecological data can be extracted from this large specimen database, and new techniques in molecular systematics are beginning to utilize preserved material as well, thus further increasing the utility of this collection in addressing questions regarding now-vanished populations and taxa. Field notes associated with many collections are available, and association of the specimens to literature based on them is improving.

The catalog of the collection has been fully computerized, running on a MS-DOS-based system in Xtrieve, using the MUSE interface widely employed in other fish collections. Output is available in almost any electronic format, as well as hard copy. Recently, a copy of the entire database was made available online directly to anyone with access to the Internet and Gopher. Such access is available through most universities (often very inexpensively) and private electronic communications services such as CompuServe and others. The Gopher interface is extremely user-friendly, flexible, quick, and allows Boolean keyword searches to allow users to extract records by taxonomic categories, drainage, political units, collector, collection dates, etc.

The objective of the collection is to serve as a broad-based historical archive and a multi-faceted resource for the research community. Toward this goal, the Texas Natural History Collection solicits fish collectors from throughout the state to contribute to this readily available electronic and specimen database by depositing voucher material from their studies in the collection, along with associated data and notes. The collection's move to a new, improved facility at the end of this year promises to improve curation and expansion capacity. A full-time, permanent Collections Manager will be hired in September to better serve the users and continue improvements. Future development plans are to extend the database to interface with a Geographic Information System and to add automated links to catalogs of many other regional and international collections of fishes.

Observations of Movement/Feeding Patterns of Extra-Large Largemouth Bass

John Hope (Palestine, TX 75801) and Ralph E. Manns (Fishing Information Services, Austin, TX 78759)

Long-lived ultrasonic transmitters were surgically inserted in 11 largemouth bass weighing more than 6 pounds between 1986 and 1990. Seven bass were tracked in Houston County Lake, three in Lake Fork, and one in Lake Sam Rayburn, all Texas reservoirs. One bass shifted in stages from spawning in the shallows in spring to water about 25 ft deep in fall and winter. The others held offshore, suspending about 10-ft deep over substrate 15- to 25-ft when inactive and moved to cruise parallel to shorelines at 5- to 10-ft depths when active and apparently feeding. From October to May, the large bass were active during two, 5-h periods, one starting about an hour before sunset and the second an hour before sunrise. During the remainder of the year the bass moved continually at night with only brief pauses, starting just before sunset and stopping shortly after sunrise. Several of the large bass were repeatedly caught and released, suggesting they were not particularly resistant to angling and that their behavior patterns gave them a greater chance to survive, avoid anglers, and grow to larger sizes than bass with other behaviors.

Ontogenetic Shifts in Diet, Habitat, and Diel Feeding Periodicity of Schoolmaster Snapper

Jay R. Rooker (Department of Marine Science, University of Texas at Austin, Port Aransas, Texas 78373-1267)

Stomach contents from 449 schoolmaster snapper *Lutjanus apodus* from southwestern Puerto Rico were examined. Ontogenetic patterns in diet were investigated using hierarchical cluster analysis. Cluster analysis identified two primary trophic groups: ≤ 70 mm FL and > 70 mm FL. Small juvenile *L. apodus* (≤ 70 mm FL) fed almost exclusively on crustaceans (89% composition by weight), particularly amphipods and crabs. By contrast, large juvenile to adult sized *L. apodus* (> 70 mm FL) were primarily piscivores (57% composition by weight and complimented their diets with crabs, stomatopods and shrimp. Spatial and temporal variations were sized related and appeared to play some role in structuring the diet of *L. apodus*. Small juveniles (≤ 70 mm FL) were found only in mangrove prop-root habitats and showed peak feeding at 1200 h. Intermediate to adult sized *L. apodus* (> 70 mm FL) were present in both mangrove and coral reef habitats and showed little variation in diurnal feeding periodicity. Seasonal trends in prey consumption by *L. apodus* were evident and influenced by ontogenetic stage and habitat.

Analysis of Fisheries Data Using Classification and Regression Trees

Gene R. Wilde (Texas Parks and Wildlife Department, 4200 Smith School Road, Austin, TX 78744)

Classification and regression trees provide alternatives to the linear regression models commonly used to analyze fisheries data. Tree-based models are fit by binary recursive partitioning whereby a dataset is successively divided into increasingly homogeneous subsets. These models are, essentially, collections of rules that allow classification of new observations based on one or more predictor variables. When the dependent variable is categorical or binary, a classification tree is developed; for continuous dependent variables, regression trees are developed. Although tree-based models are primarily used for exploratory analyses, they are useful when rapid development of a predictive model is required and they facilitate presentation and interpretation of complex relationships among predictor variables.

Assessment of Selective Neutrality for Three Esterase D* Phenotypes in Selectively Bred F_1 Red Drum

Ivonne R. Blandon, Rocky Ward (Texas Parks and Wildlife Department, Perry R. Bass Marine Fisheries Research Station HC 2, P.O. Box 385 Palacios, TX 77465) and Tim L. King (U.S. Fish and Wildlife Service National Fisheries Research Laboratory, Box 700 Leetown, Kearneysville, West Virginia 25430)

The assumption of selective neutrality was tested for three Esterase D* phenotypes in selectively bred F_1 red drum *Sciaenops ocellatus*. Phenotypes were determined for 1,400 individuals using starch gel electrophoresis after a 30 day culture period and 66 individuals after 10 months. No significant deviations from the predicted Mendelian ratio were observed. Differences in weight and total length were not significantly different between individuals possessing the three phenotypes. For the factors examined in this study, we conclude that phenotypic variation in Esterase D* is selectively neutral.

A Comparison of Two Phosphorus Concentrations for Fertilization of Florida Largemouth Bass Spawning Ponds

Gerald Kurten (Jasper Fish Hatchery, Texas Parks and Wildlife Department, Route 2 Box 535, Jasper, Texas 75951)

Two concentrations of soluble reactive phosphorous (SRP) (0.5 mg/L P and 1.0 mg/L P) were compared for fertilizing Florida largemouth bass *Micropterus salmoides floridanus* spawning ponds. Follow up applications of inorganic nutrients were made when water quality analysis indicated SRP and nitrogen levels fell below target concentrations.

No difference was found in total length, weight, or number of fingerlings harvested between the two SRP levels tested. Zooplankton densities were similar except for higher and longer sustained numbers of copepod adults and nauplii in the low SRP treatments. Chlorophyll and nutrient levels did not differ except for higher levels of nitrate nitrogen in the low SRP treatments. Stepwise regression analysis indicated that ammonia nitrogen may have limited phytoplankton productivity under the two SRP concentrations tested. Filamentous algae problems were substantially reduced from previous years, probably due to the reduction of phosphorous inputs.

Free Amino Acids and Salinity Stress in Red Drum Larvae

Liz Young-Abel and G. Joan Holt (University of Texas at Austin, Marine Science Institute, Port Aransas, Texas 78373)

Problems associated with larval fish enhancement could be due to ecological incompatibility. We studied one such incompatibility, salinity stress and its effect on larval red drum *Sciaenops ocellatus*. It was found that though red drum larvae were competent osmoregulators the capability to osmoregulate varied with age. An apparent reduction in osmoregulatory ability was found on day 3 but was overcome by day 5. By sampling fish reared at 30 and 15 ppt on days 1, 3 and 7 it was found that the concentration of free amino acids, known to be osmoeffectors, followed the pattern of osmotic adaptability, i.e., being at the lowest concentration on day 3 (with yolk-sac absorption) and at a significantly higher concentration on day 7 (with exogenous feeding). Both chronic salinity tests (rearing larvae at 30 and 15 ppt) and acute salinity tests (exposing larvae to 10 and 35 ppt) indicated that it was not the total free amino acid pool that responded to changes in salinity but certain specific free amino acids (serine, isoleucine, leucine, phenylalanine, valine, asparagine and glutamic acid). These results indicate that larvae should be released before yolk-sac absorption or after several days of exogenous feeding.

Genetic Implications of Stocking Florida Bass

David P. Philipp
Center for Aquatic Ecology
Illinois Natural History Survey
Champaign, IL 61820

More states culture largemouth bass for introductions into their waters than any other single sportfish species. Although some of these programs involve introducing the largemouth bass into waters outside of its native range, many others involve stocking hatchery-reared individuals into waters well within its native range. The broodstocks used in many of these culture/introduction programs are composed of individuals collected from waters close to the hatchery. The broodstocks used in many others; however, originate from a quite distant part of the country (e.g., Florida), in some attempt to "improve" native fisheries. Evolutionary theory predicts that through natural selection, populations will have become genetically tailored to their local environments, maximizing their fitness traits through local adaptation. Thus, a species becomes composed of a number of genetically divergent stocks, and for truly effective management, it is the stock, not the species as a whole, that must be considered the operational unit for management concern. Unfortunately, many management programs currently fail to recognize this fact and continue to indiscriminately stock fish without knowing what the long-term impacts of that activity will be. Since interbreeding between the resident and introduced populations is not only likely but expected, this activity has the potential for significantly adverse impacts on the resident population by destroying genetic diversity among populations. Unfortunately, few empirical studies have attempted to quantify the performance and/or fitness trait differences between discrete stocks, and even fewer have attempted to assess the impacts of stock transfer on these traits. Our long-term studies on the largemouth bass have documented the genetic and physiological differences that exist among stocks of this highly managed sportfish species. In addition, we have recently demonstrated that introduced stocks exhibit poorer fitness and performance traits than native stocks, indicating that supplemental fish introductions that involve stock transfer will not accomplish the management goal of improving a fishery, but instead will negatively impact an optimally-adapted local stock. As a consequence, natural resource agencies must reassess their various stocking practices for largemouth bass, as well as for all sportfish species, and institute new programs based on biological principles rather than political expediency.

Marine Fish Enhancement

G. Joan Holt
The University of Texas at Austin
Marine Science Institute
Port Aransas, Texas 78373-1267

The history of marine fish enhancement began in the U.S. in the later part of the 18th century with the development of techniques for stripping commercially caught cod, artificially fertilizing them and hatching out the larvae (summarized by J. E. Shelbourne, 1964, Advances in Marine Biology 2:1-83). In 1885 the first commercial marine hatchery was built at Woods Hole, Massachusetts, soon the techniques for artificial propagation of cod were applied to other marine species, and by 1917 the output of cod, pollack, haddock, and flounder larvae exceeded 3 billion per year. The newly hatched larvae were released into local waters or taken out to sea to enhance commercial catches, or even introduced into areas of the Gulf of Mexico in an attempt to develop new fisheries. European countries followed suit and hatcheries were built in Norway, Newfoundland, and Great Britain for artificial propagation of cod and plaice, and in France for common sole and turbot. High levels of fry production and stocking did not improve the commercial catches and the American effort was discontinued in 1950. The basis for the artificial propagation was that the year class strength of a species is directly related to the number of eggs produced by the spawning stock, and since there was heavy fishing on the spawning aggregations, stocking could deflect major reductions in the fishery. We now know that there is not a direct relationship between egg production and year class strength in marine fish possessing high fecundity and pelagic larvae, but instead the year class strength is established during the early life history stages.

A revival of stocking in the 1960s followed the development of techniques for mass culture of juvenile plaice and turbot, but experimental releases were not successful. It was calculated that 20 million juveniles per year needed to be released for a 5% increase in fisheries catch. Such massive production was not possible at the time so the effort was discontinued. Successful mass culture of cod was developed in Norway in 1983, with the rearing of juveniles 4-6 months in large outdoor enclosures. Since then, massive field experiments have been carried out in land locked fjords to evaluate possible biological, genetic, and behavioral differences between reared and wild juveniles. In Japan an immense number of fish and shellfish have been released since the 1960s, in response to fishery declines. Stocked juvenile salmon, shrimp fry, red sea bream fingerings, and many other species have contributed to the fishery landings. Variability in success, monitored by tagging, is related to hatcheries, location of release, and movement of released fish. In the U.S., Texas has stocked red drum fingerings since 1983 following a 10 year decline in the fishery. Red drum stocks have since rebounded but it is not certain if stocking or a combination of management strategies used during this period were responsible.

In order to evaluate marine fish enhancement programs and to determine whether a stocking approach will contribute to an increase in fish stocks, the following are needed: 1) data on the cause for the observed decline in the natural stocks to be enhanced, i.e. over-fishing, loss of critical habitat, climatic fluctuations, 2) genetic characterization to determine broodstock selection, 3) tags for evaluating survival and contribution to the fishery, and heritable markers for monitoring impact on natural populations, 4) habitat evaluations for ecological impacts on other species and life stages, and 5) field experiments to test whether large scale releases would be effective.

Finally the decision as to how long a stocking program will be continued is important. Juveniles can be used on a short term basis to increase a depleted natural stock, and discontinued once it has recovered. On the other hand releases may be needed indefinitely if critical conditions for the larvae are missing and cannot be restored.

Fish Stocking: Pros and Cons

Gary J. Carmichael
United States Fish and Wildlife Service
South West Regional Office
500 Gold Avenue SW, Room 308
Albuquerque, New Mexico 87102

This panel was convened and asked to address fish stocking pros and cons: 1) benefits; 2) mistakes; 3) future gains; 4) impending problems; and 5) potential solutions. I greatly appreciate the honor of participating, it is good to return to Texas. Thank you for having me on the panel.

As immediate past President of the Fish Culture Section of the AFS, I expect that I am here on the pro side of the issue. However, I am an active member of the Fisheries Management Section. So, hopefully, I can represent diverse viewpoints with some balance and a logical approach.

I would like to address the above 5 issues keeping in mind that fish hatcheries are but a tool of fisheries management. Fisheries managers have three main tools to use in addressing resource issues: 1) habitat alteration or improvement; 2) regulations development and use; and 3) fish hatchery products. Fisheries management is a tool of natural resource administrators. Administrators answer to the public in their jurisdiction, or "society" if you will. It is evident that society uses tools. Administration, fisheries management, and fish stocking are all tools. Opponents (Con speakers) of any issue often select the easiest target -- it is part of human nature. Hatcheries, or more correctly fish hatchery products of stocking, are the easiest targets in this case because they are visible. But, the issue at hand is really not fish stocking, rather it is the wants and needs of society -- appropriate and wise use or abuse of the resources.

I will address the stocking of fish asking that you keep in mind that tools can be used properly or can be abuse. Also, keep in mind the other tools; habitat alteration and regulations. If a society is diverse, as ours is, one tool cannot be a panacea nor an armageddon. Habitats or resources that have to be managed are extremely diverse all over our country, and they are especially diverse in a state as large as Texas. Habitats and the included resources in Texas range from open gulf salt waters to inland saline lakes, from copious freshwater springs to desert pools.

I believe that there is room to fill many, if not all, of the wants and needs of society. If managers were to partition the resources to different human use levels many diverse societal goals could be reached. Managers could designate heavy use, moderate use, and non-use areas. Sensitive areas could be protected while altered habitats such as reservoirs could be used for recreation, sport fishing, and food gathering.

1) Benefits

Fish hatcheries were designed to produce fishes for stocking or placing in resource areas that are perceived by fishery managers to have a need. This need historically came from gaps in the life cycles of fishes. Hatcheries were created to fill life cycle gaps by stocking fish. This is the most obvious benefit of stocking fishes, it puts them where they can't otherwise exist on their own, anymore.

Recreation and commercial opportunities are increased using fish stocking. There often are considerable economic gains associated with fish stocking and related industries. Fish stocking and aquaculture can lead to availability of high quality alternate food products and consumption of fish is increasing in our society. Fish stocking and aquaculture, if used wisely, can reduce over harvest of commercial species by changing emphasis to individual food gathering rather than high technology commercial harvest. Similarly, bycatch problems in commercial fisheries can be reduced, if harvest is reduced.

Appropriate fish stocking can increase fishing pressure in altered habitats, such as impoundments. Fish stocking can be used to repopulate degraded habitats and contaminated habitats. Fish stocking has been used to protect threatened and endangered species. Fish stocking can be a part of an excellent educational tool to teach environmental and natural resource awareness. Finally, used appropriately, fish stocking can successfully increase biodiversity -- especially in watersheds or ecosystems that are highly modified by society, and many have been so modified.

2) Mistakes

I think that many of the so called "mistakes" that we made were due only to using the best available information that we had at the time. It is easy to use hindsight, look back, and place blame -- but that activity gains us nothing. Society dictates what we did, do, and will do in the future. Johnny Appleseed (John Chapman) was a folk hero in our earlier civilization, not a dastardly villain bent on spreading "exotics" about the land. Humans of western America civilization are exotics to North America. We brought to North America what we missed from our ancestral homelands. Can anyone claim to eat solely native North American staple crops? I think not. Can anyone here even name 5 native North American food staples? It would be difficult.

Humans are exotic to North America. Even Native Americans in New Mexico, for instance, are exotic to North America. They are exotic and simply arrived earlier that those of us of European or African descent. We are all "naturalized". My point is that humans are a migrating and colonizing species and we carry our baggage with us where we go. That is not "bad", rather it is our history, the way we are. As humans have become more reflective on their place in the environment, we have recognized a need to learn more about our impacts as we advance our civilization. Stocking mistakes, as it were, must become learning tools. There are many diverse viewpoints on our natural resources and how we should manage them. Those viewpoints obviously change over time and all are part of our society and should be learned from, even if not adopted.

I believe that if there were errors using the stocking of fishes they were usually due to using the tool inappropriately -- as a short term quick-fix to a perceived problem.

Two cases of "mistakes" that I can think of that are well documented resulted in Guadalupe bass hybridization (smallmouth bass stocked) and Apache trout hybridization (rainbow trout and cutthroat trout stocked). Once we, as mangers, learned of these problems, steps were taken to prevent further errors. Resource areas are now set aside for Guadalupe bass to protect them and keep them from further damage. The smallmouth bass stocking program was modified but still creates a viable fishery. Apache trout, damaged mainly be stocking of rainbow trout, are being "recovered" using the same tool that damaged them, the stocking of fish -- except now Apache trout are the fish stocked rather than rainbow trout. In addition, habitat degradation is also recognized as being a major factor in the decline of both species. So, "mistakes" are not necessarily forever, we need to learn from the past and not repeat past errors. We also need not look back to place blame, rather we need to move forward.

3) Future gains

One major problem in our society is ever-increasing human overpopulation. That likely will not change in the near future. Fisheries management tools, including the stocking of fishes and restricted uses of habitats, will be needed to adapt to an increasing demand on resources. Society should reap tremendous benefits from appropriate fisheries management tool use, including the stocking of fishes. I believe that fish stocking will help address human impacts and will be used to counteract deleterious habitat alterations of the past and the future. I believe that fish stocking will be used as a tool that will play a central role in conservation and biodiversity. Fish stocking will continue to play a central role in recreation and food production. We need more fish hatcheries and more modern fish hatchery products in order to address societal needs.

Another obvious example of fish stocking benefits that can offer lessons for the future is the Texas redfish stocking program. Following a devastating freeze and high commercial and sport fishing harvest in the early 1980's populations of redfish crashed in the western Gulf of Mexico. Regulation changes combined with fish stocking led to a much faster recovery than would have otherwise been predicted. Fish stocking helped fill a life cycle gap in the redfish populations. Many more such instances will occur in the future. We, as fisheries managers need to have our tools at the ready, including fish hatcheries.

4) Impending problems

Unfortunately, I perceive the greatest impending problem to the stocking of fish to be a portion of our society guided by **"partial knowledge and good intentions"**. Right now the loudest voices heard in our society are those of the "purist or preservationist" bent that are guided by the combined mind set of "nature and wildness" and human non-use of our resources. Some opponents (Con speakers) of the stocking of fish seem willing to "throw out the baby with the bath water". Increasing human overpopulation and demands on the environment for recreation and industry are unlikely to cease. They combine fir devastating effects. Addressing these will be more difficult without the use of fish stocking as a tool. If we shut down hatcheries we will lose much flexibility in fisheries management tools. If we limit hatchery fish production, fisheries management needs will be unmet and pressure will increase on extant fisheries resources. We will be less able to expedite our reactions to natural and man-made resource disasters.

5) Potential solutions

I offer a potential solution for fisheries managers that includes the use of fish stocking, habitat restoration, and regulations. It is but one generalized solution of many such potential solutions. This one is not my own, rather I synthesized concepts from managers in the northwestern Provinces of Canada and several eastern States of the USA. This solution is most suitable for situations where habitats are already altered and degraded. Unfortunately, much of our resource may be described as degraded and altered.

1) Partition fisheries resources (habitats) for human use: into heavy-use; supplemented; naturalized (already modified); and non-use areas.

2) Develop regulations that help define and enforce the human use partitions.

3) Use fish stocking as a tool in the heavy-use areas regularly, in the supplemented areas as needed, only rarely in the naturalized areas, and not at all (except in emergencies) in the non-use areas.

4) Focus habitat restoration in the non-use and naturalized areas and create gene pool refuges for sensitive aquatic organisms in the non-use and naturalized areas.

5) Formalize the habitat partitioning, advertize the concept, and listen to, educate, and inform society.

6) Evaluate the program and adapt and change according to successes and failures.

Important, I believe, is the need for administrators, managers and fish culturists to listen to different factions of society. We should recognize that fisheries management is dynamic and complex. Fisheries management should be society driven; from an informed or learned society, not just from an impassioned faction of society. As fish stocking is a tool of management, the tool can be refined and adapted to offer as much flexibility and opportunity as possible. We can adapt and plan for the future.

To me, it is important for us to train and educate fisheries managers, administrators, and fish culturists in modern fisheries management as well as ecological and agricultural and population genetic principles.

I would suggest that we develop and use the best available tools to evaluate hatchery products. Regular evaluation of fish stocking products should be part of fisheries management. We should be obliged to search to improve and tailor the hatchery products for specific uses in resource management. I recommend that fisheries administrators, fisheries managers, and fish culturists embrace both agricultural and population genetic theories -- that are proven and appropriate. Similarly, embrace proven ecosystem and watershed driven ecological tenets. Discard the unproven and conjectural models and theories.

A great danger and tendency exists to jump on the bandwagon of unproven theories or theories that are expanding to areas in which they are unproven. Humans are a large part of and have great impacts on our ecosystem. To me, humans must be included in any formula for the future of our resources and that human presence includes the consumption, catching, and stocking of fishes.

Fish Stockings - Pros and Cons: A Far West Perspective

Phil Pister
Desert Fishes Council
P.O. Box 337
Bishop, California 93515

We tend to be victims of our own generation, and probably nowhere is this concept more evident than in the way society views its biological resources. Highly utilitarian attitudes, especially at the turn of the 20th century, presumed that the highest and best use of a body of water was to maximize fish production for human advantage. Introduction of alien fishes and other organisms resulted in major disruption of natural systems to a point where, throughout the western United States, it is now exceedingly difficult to find a water sufficiently pristine to satisfy either research or aesthetic needs. In many cases native invertebrate populations have been totally eradicated. Added to this are recently discovered impacts of hatchery stocks on wild fish populations. Irrespective of the obvious damage wrought to natural systems, there are still those who steadfastly defend past practices and, in so doing, totally ignore our obligation to future generations.

Our posterity will almost unquestionably view fishery resources very differently from the perspective we have developed during the 20th century, yet many of their options will have been removed by our errors and shortsightedness. A reasonable question might well be posed here: "Which of the following will aquatic scientists (and society) be most likely to judge our competence by: the general level of angler satisfaction in 1993, or the integrity of habits and natural aquatic biota that we pass on to them?" In responding to shallow demands of the consumptive user, we seldom think of the evolutionary history (in progress for billions of years) and precision of the biota that we are influencing, often irreversibly and for all practical purposes, forever. The future requires that fish and wildlife agency personnel become keenly aware of these concepts. Their power to alter and destroy is awesome, if not properly directed. Proper direction can result in satisfaction of both goals, but extreme prudence and caution must be used!

A Bass Angler Perspective on Fish Stocking[a]

Wayne Boyd
Texas Association of Bass Clubs
Nacogdoches, Texas 75963

I have been a fisherman all of my life and for the past 30 years I primarily have been a bass fisherman. Because of my long fishing history I have heard a number of comments from fishermen and I believe I understand today's fishermen. In the mind of fishermen the pros of fish stocking outweigh the cons. Most fisherman view stocking as being beneficial to the state's sportfisheries. Humans are the greatest enemy to fish stocks. The reintroduction of paddlefish by stocking is an important step towards overcoming human destruction. Stocking provides urban fishing and allows for small-time fishing tournaments. Both of these can be used as incubators of tomorrow's fishermen. In today's society it is far to easy for kids to go down to the corner store and play video games. Thus, if urban fishing opportunities are provided we may instill a sense of value in today's youth.

Today more people are fishing because they have more leisure time and the economy is so much better than 30 years ago. The fishing in Texas is much better than it was 20-30 years ago. Several record size fish have been caught in the past 10 years as a result of management efforts. Yes, fishing equipment and techniques have led to improved catches, but proper fisheries management has provided the fish. In the eyes of fishermen fisheries management consists of three tools: 1) bag limits, 2) size limits, and 3) stocking. Fishermen judge a biologist or the state agency by what they catch and if they do not catch anything they want Texas Parks and Wildlife to stock the lake. Stocking is often used as a crutch by anglers. Whether stocking is beneficial or not, it serves as excellent public relations.

The mention of stocking exotic fish in Texas' waters raises a red flag for most fishermen. What you will here from fishermen when you mention stocking an exotic is: How big does it get?, What does it eat?, How long does it live?, and Will it reproduce? However, the stocking of Florida bass has been the greatest thing to happen to bass fishing in Texas and you would be hard pressed to sell otherwise to fishermen.

I am against stocking grass carp for vegetation control. You can not tell a fish to eat from point A to point B and then stop. Vegetation control is misleading; vegetation is not controlled it is eradicated. Eradication occurs whether it is by grass carp or chemical use. The continued use of chemical must stop because we do not know what happens to the chemical after the vegetation is gone.

Today's fishermen are interested in what the biologists are doing and have a greater appreciation for what has been done. Stocking aids in correcting catastrophes caused by humans and mother natures own mishaps. There is nothing wrong with giving mother nature a boost. Fishing is better today because of stocking and most fishermen hope stocking will continue into the future.

[a]Mr. Boyd's presentation was summarized by the editor.

A Comprehensive Approach to Planning and Evaluating Stocking Programs

Brian R. Murphy
Wildlife and Fisheries Sciences
210 Nagle Hall
Texas A&M University
College Station, Texas 77843

Stocking is one of the oldest and most used fisheries management tools, but it is also one of the most abused. Well-planned stocking programs enhance fisheries management efforts and simplify the achievement of management goals. Poorly planned stocking is a waste of money, at best; at its worse, improper stocking can lead to management failures and ecological disturbances. Comprehensive planning by conservation agencies can improve the potential for success of stocking and management programs. Pre- and post-stocking evaluations must consider: (1) biological parameters of target fish populations, such as survival, growth, and reproduction; (2) social and economic characteristics of the angling public; (3) program benefit:cost ratios; and (4) additional factors that may limit beneficial results of stocking programs, such as genetic mixing of stocks, competition, movement, disease introduction, habitat modification by stocked species, and predator-prey interactions (see Figure 1). These latter factors frequently receive little attention due to agency constraints, but ultimately they may control program success. A greater emphasis on planning and evaluation will allow the channeling of limited agency resources to those programs that maximize benefit:cost ratios. Failure to do so will result in wasted time and money, and may influence the future integrity and productivity of fisheries resources.

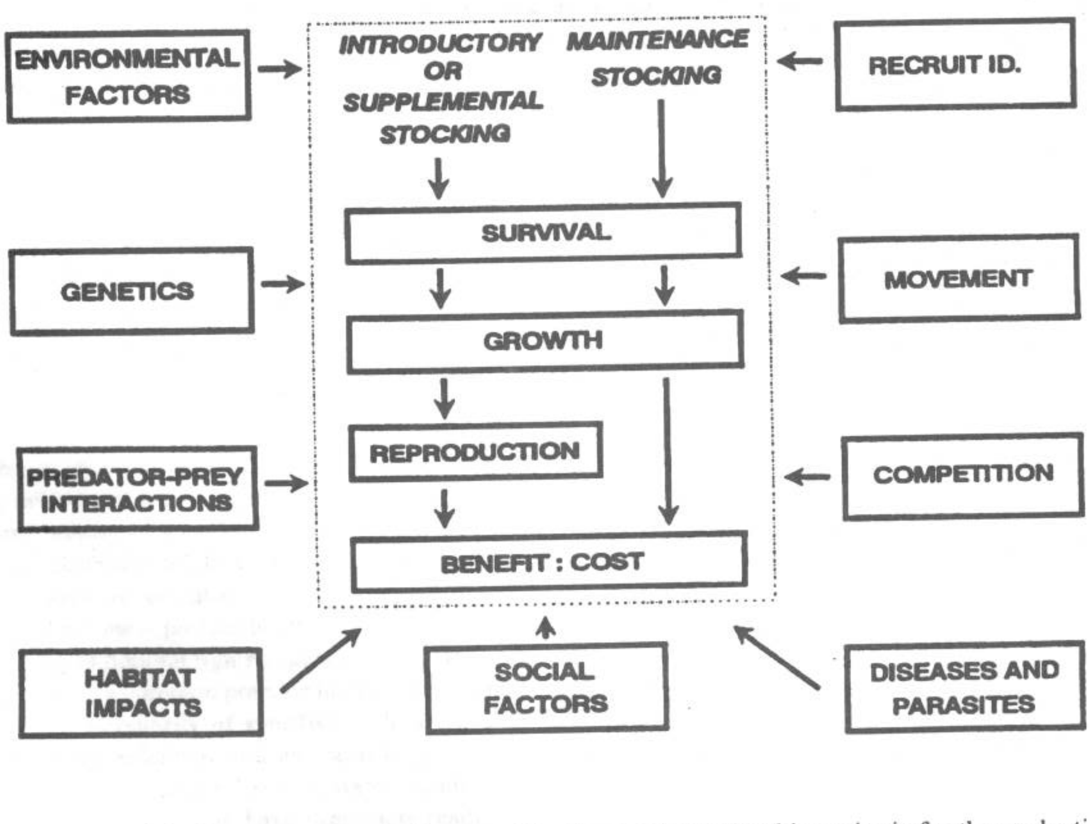

Figure 1.-A model of important pre-stocking considerations and post-stocking criteria for the evaluation of three types of stocking programs. Rectangles inside the dotted line represent criteria of program success; other rectangles represent factors that may affect program advisability or success.

Fish Stocking - From a Texas Parks and Wildlife Department Viewpoint

Roger L. McCabe
Texas Parks and Wildlife Department
Director of Programs Inland Fisheries, Region 2
1601 East Crest Drive
Waco, Texas 76705

Dealing with the biological, physical, and social variables involved with fish stocking as a form of fishery management requires both science and art. Throughout history, fish stocking was performed to meet specific food or recreational needs, and was generally the result of using the best information available at the time. The Texas Parks and Wildlife Department's (TPWD) philosophy of fisheries management and fish stocking is generally pragmatic; waters are managed as they are, altered to some degree. However, when rare, threatened, or endangered species, or pristine waters are involved, a purist philosophy usually prevails. TPWD's stocking goal is to pursue a stocking program, including the taking, transporting, and release of fish, in its management effort to insure an ample supply of these resources for public enjoyment, and to maintain the natural heritage of Texas. Twenty different species, subspecies, or hybrids are currently being used to stock Texas' public inland waters. Our stocking program utilizes warm-water, cool-water, cold-water, anadramous, and marine fishes, both indigenous and nonindigenous. Goals, objectives, criteria, and stocking rates for these fishes are provided in the Department's "Fish Stocking Philosophy". In 1992, approximately 40 million fish (27 million fry and 13 million fingerlings) were stocked into public inland waters. In addition to meeting annual management needs, these fish were utilized for providing urban fishing opportunities and restoring threatened and endangered species. Fish stocking is not a cure for all of our management problems; we are aware of the many advantages and disadvantages of stocking. Much of our success in providing outstanding recreational fishing is due to stocking.

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Private Sportfish Leasing Opportunities: Determining Profitability

Billy J. Higginbotham

Department of Wildlife and Fisheries Science
Texas A&M University, Agricultural Research and Extension Center
Overton, Texas 75684

Greg M. Clary

Department of Agricultural Economics
Texas A&M University, Agricultural Research and Extension Center
Overton, Texas 75684

Abstract.-The popularity of developing sportfish leases is increasing rapidly in the South, much as development of hunting leases has done over the past three decades. This trend is occurring because an increasing number of: (1) landowners realize that their ponds and reservoirs are valuable resources capable of generating additional profits and (2) anglers desire a level of exclusivity not normally available on public waters. A sound economic evaluation of sportfish leasing opportunities is essential if landowners are to identify their most profitable alternatives. Net present value analysis is suggested as a method for evaluating the comparative profitability of selected investment and leasing strategies. Case studies are presented to illustrate analyses where sportfish leasing is the sole recreational lease and where sportfish leasing is viewed as a value-added activity when combined with a hunting lease. Key economic values directly affecting the profitability of sportfish leasing alternatives include investment costs, lease rate, annual operating costs, interest rates and desired rate of return on investment.

Leasing rights to fish in private waters generally has been limited to fish-out enterprises, where channel catfish, rainbow trout, or other species are stocked in specially designed (aquaculture) ponds (Higginbotham and Legg 1989). Other sportfish leasing arrangements observed include short-term (day or multi-day) and long-term (annual) leasing of ponds and reservoirs.

This paper discusses and provides examples of using net present value (NPV) analysis to evaluate the profitability of sportfish leasing opportunities. A sound economic evaluation of sportfish leasing opportunities is essential if landowners are to identify their most profitable alternatives.

Leasing of hunting rights to generate income for landowners is a common practice in many southern states. The popularity of sportfishing leases as a farm or ranch enterprise has not been as great as hunting leases, generally because water resources held in the public domain have been more readily available compared to state and federal land for sporthunting. However, interest in developing sportfishing leases is increasing rapidly across the South. Many landowners expressing this interest are those who already lease hunting rights because of the realization that ponds and reservoirs are valuable resources which offer additional profit opportunities.

Another group of landowners finding sportfish leasing attractive as a source of income in addition to those with hunting leases are those with properties that are not capable of supporting large-scale hunting activities. Leasing opportunities for members of this group often are limited by tract size, urbanization, capital, management or other factors.

Properties offering both hunting and fishing opportunities should be more valuable than those leased only for hunting. A survey of Texas hunting leases reported that ponds were present on nearly a third of the ranches and that fishing was considered a popular recreational activity on 18% of these leases (Thomas et al. 1990). Officials of the U.S. Fish and Wildlife Service indicated that while nearly 16.7 million adult Americans hunt, over 2.5 times that number (46.6 million) fish (USFWS 1988).

Demand for sportfish leasing opportunities is expected to increase as recreational demand on public waters increases. Much of the demand to lease fishing rights results from increased fishing pressure on public waters, decreased construction of new reservoirs, desire for exclusive fishing rights and reasonable expectations of catching fish. Reports indicate that the demand for fishing is more than twice the demand for hunting among Texans (Thomas and Adams 1989). Anglers state they are willing to take five trips at an average of 200 km/trip, while hunters are willing to take three trips at 405 km/trip.

Proper management of fish populations is a key ingredient to successfully leasing private waters for sportfishing. It is important that lessees experience reasonable catch rates to insure continued demand for the lease. The popularity of catch and release fishing enhances the opportunities for more anglers to share the available fisheries resources.

Lease Development

Marketing is an important management function in the operation of successful fishing leases, as it is for all successful agricultural enterprises. Landowners successfully leasing private waters for fishing must offer unique experiences at reasonable prices. These experiences will not be readily available or accessible at public fishing areas. Careful evaluation of direct competition from other leasing operations, of alternate public fishing areas and of the number of potential lessees is necessary.

Additional service-related amenities often provided to clientele include boats and motors, fishing tackle, guide services, meals and lodging. These value-added items are often desired by clientele, but increase the cost of the lease. Landowners establishing a profitable leasing enterprise must determine in advance how much potential customers are willing to pay for these value-added amenities. It is important to insure that revenues exceed costs of establishment and operation for the enterprise to be profitable.

Management strategies critical to developing fisheries on private lands are appropriate fish stocking rates and species balance, control of noxious aquatic vegetation and fertilization to increase carrying capacity. Other important operational activities include water quality maintenance, fish attractor construction and maintenance, and fish population surveys conducted by a professional biologist. Additional expenses may include security, liability insurance and ad valorem taxes.

Methods

Potential profitability of sportfish leasing alternatives should be evaluated prior to start-up in much the same way as any investment that is expected to generate a return over a future time period. Net present value analysis is an appropriate economic analysis tool for evaluating the profitability of establishing a sportfish leasing enterprise while accounting for the long-term nature of the investment. Similarly, it is a tool that facilitates establishing a lease fee to cover investment costs, operating expenses and return on investment.

Calculation of NPV is accomplished by deducting current investment requirements from future net earnings, expressed in terms of current dollars, generated by the investment. Expressing future net earnings in current dollars involves accounting for expected inflation and anticipated interest earnings foregone by not putting an equivalent amount of money in the next best alternative investment. In other words, NPV accounts for the time value of money or the earning potential money would have if placed in an interest paying account.

The present value of a nonuniform series of future payments (in this case net incomes or losses after an initial investment) is given by (Hopkin et al. 1973):

$$V_o = \sum_{n=0}^{N} P_n (1 + i)^{-n}$$

where:

V_o= present value of a future payment(s)
n = a conversion period (n=0..N)
P_n= payment at other conversion periods
i = interest (discount) rate per conversion period

For example, the current value of a contract promising to pay $100 at the end of five years is $68.05 (assuming money would earn a real rate of 8% interest in the next best alternative investment). On the other hand, a $68.05 investment today at

Table 1.-Example of net present value (NPV) calculation of a leasing arrangement for an existing 4-ha lake.

	Beginning of:				
Income and Expenses	Year 1	Year 2	Year 3	Year 4	Year 5
INCOME					
Lease fees (actual \$)	1250	1250	1250	1250	1250
Lease fees (current \$)	1250	1157	1072	992	919
EXPENSES					
Bass[a] fingerlings (actual \$)	200				
Catfish[b] fingerlings (actual \$)	500				
Fertilizer (actual \$)	150	150	150	150	
Lime (actual \$)	400		400		
Herbicide (actual \$)	200	200	200	200	200
Labor (actual \$)	250	250	250	250	250
Taxes (actual \$)	30	30	30	30	30
Insurance & Misc. (actual \$)	250	250	250	250	250
Total (actual \$)	1980	880	1280	880	880
Total (actual \$)	1980	880	1100	700	650

[a]largemouth bass *Micropterus salmoides*.
[b]channel catfish *Ictalurus punctatus*.

8% (real rate compounded annually) interest, would grow to \$100 at the end of 5 years. In other words, a person would be indifferent between having \$68.05 today and \$100 five years in the future with the opportunity to earn an 8% real rate of interest.

The interest (discount) rate used in estimating NPV reflects several factors, including the landowner's expected return on this and other alternative investments, the level of risk involved and the prevailing inflation rate. Foregone investments should be considered costs in economic evaluations and in establishing the rate at which future earnings are discounted to current values.

An example of a detailed NPV calculation is presented in Table 1 to illustrate using this methodology to evaluate the profitability of initiating a leasing agreement on an existing 4-ha lake. This 5-year project is evaluated using a discount rate of 8%. An annual lease fee is set arbitrarily at \$1,250 as one that might be considered reasonable for rights to fish a managed 4-ha lake.

Each of the actual total lease fee and total cost values in Table 1 which the manager expects to face in the future are expressed in current values after making the appropriate NPV calculation. If the aggregate current value of income (lease fees) is greater than the aggregate current value of total costs, this investment is considered profitable given the assumed discount rate. In this example, current value of lease fees totals \$5,390, while current value of total costs is \$5,240. The positive difference of \$150 means that the owner of this lake would realize a greater rate of return than the 8% assumed in the NPV calculation.

The NPV formula will be transposed in subsequent cases to determine at what level a lease fee should be set to cover costs of establishing and maintaining a sportfish lease and to provide the owners a reasonable rate of return on their investment. In such cases, a reasonable rate of return is implicit in the selection of a discount rate, NPV is set equal to zero and an estimated lease rate results from the calculation. Setting NPV equal to zero eliminates the returns in excess of those included in the assumed discount rate.

Results

Two case studies are presented as examples of using NPV to estimate the lease fee which must be charged to cover the costs of establishing and

Table 2.-Using net present value (NPV) to estimate a lease fee for a 85-ha lake in Southeast Texas.

		Start-up	Years 1 through 10
Construction and stocking		$54,200	
Revenue - Lease fee			$17,795
Costs	Item		
	Fertilizer		3,200
	Weed Control		500
	Labor		500
	Taxes		600
	Management		2,500
	Advertising		2,500
	Insurance		200
	Return on investment		1,626
Total costs			$11,626
Net income			$6,169
Lease rate/ha		$209.35	
Lease rate/person (party of 15)		$1,186	

operating selected sportfish leases. The first case is an economic analysis of a sportfish lease developed exclusive of a hunting lease on a Southeast Texas farm. The second case involves a sportfish lease developed to enhance the value of a hunting lease.

The first scenario shown in Table 2 involves a farmer with an 85-ha lake in Southeast Texas. The farmer determines that $54,200 has been spent to develop the lake (levees, fish, herbicides, drainage system and erosion control) to the point where it offers potential as a sportfish leasing enterprise. He/she would like to establish a 10-year-annual lease fee, to be paid at the beginning of each year, that provides a reasonable rate of return on investment and annual operating capital while repaying investment capital. He/she decides that 3% is a reasonable discount rate for NPV analysis given current alternative investments, inflation trends and risk associated with the lease enterprise.

The objective in this case is to establish an annual lease fee such that the NPV of the net income generated each year by the lease just equals zero when the initial investment is $54,200. This result would imply that net revenues are generated over the 10-year-period to cover, yet not exceed, investment costs. The farmer estimates that annual operating costs (fertilizer, weed control, labor, taxes, management, advertising and a return on initial investment capital of 3%) total $11,626.

Net present value calculations indicate that an annual lease fee of $17,795 for a 10-year lease creates sufficient annual net income to offset the current initial expenditure of $54,200 (Table 2). This is equivalent to a fee of $209.35/ha of lake or $1,186/angler, assuming 15 people equally divide fees.

The second application of NPV analysis concerns an East Texas rancher that is providing a 405-ha hunting lease with year-round access to a group of hunters. The group wishes access to fish a 4-ha lake that is part of the 405-ha tract over 5 years. The rancher agrees to provide this to the group provided they are willing to pay an increased lease that covers initial investment and annual operating costs and provides a reasonable return to capital and management. Estimated costs of preparing the lake for fishing during the first year total $2,650 (Table 3). A discount rate of 3% is used for NPV calculations as the rancher thinks this is a reasonable rate given alternative investment opportunities.

Annual expenditures over the 5-year lease agreement differ due to production activities to maintain an excellent fishery for lessees (Table 3). Lime is applied every 2 years and fish are stocked

Table 3.-Example of net present value analysis of a sportfish lease on a 4-ha lake as part of a hunting lease[1].

Item	Years					
	1	2	3	4	5	6
Revenue-Lease	$0	$2,278	$2,278	$2,278	$2,278	$2,278
Fish	1,000			1,000		
Fertilizer	200	200	200	200	200	200
Lime	250		250		250	
Management	500	500	500	500	500	500
Labor		500				
Weed Control	200	200	200	200	200	200
Total operating cost	2,600	1,400	1,650	2,400	1,650	1,400
Net Income	(2,650)	878	628	(122)	628	878

[1]Assumptions used in creating this example include: (1) lease fees collected at the start of each year to eliminate borrowing operating capitol, (2) start-up costs are assumed to be owner capital contributions, (3) operating costs are incurred at the beginning at each year, 4) NPV calculated using a 3% real rate of return and (5) lake contains fish populations but supplemental stocking of Florida largemouth bass *M. s. floridanus* and channel catfish fingerlings is required.

every 3rd year once the fishery is established.

An annual lease fee for the 4-ha lake is estimated by equating NPV to zero and completing appropriate calculations is $2,278 (Table 3). This could be considered a breakeven lease fee to cover all designated costs and provide a desired rate of return. One method of charging for the sportfishing lease would be to add $5.62/ha to the original amount being charged for the hunting lease. This amount represents the added value of having a managed lake with sportfishing opportunities on this tract of land.

Discussion

Net Present Value analysis is one economic tool that landowners and managers can use to estimate revenues necessary to cover investment and operating costs of sportfish leasing opportunities. These enterprises may be operated strictly as a sportfish lease or as a value-added amenity to an existing recreational operation such as a hunting lease. Landowners and managers should expect sportfish leases to be profitable, just as they would any other farm or ranch enterprise.

Although sportfish leasing opportunities are relatively new enterprises compared to hunting leases, management and marketing concepts are similar. Landowners interested in marketing sportfishing recreation must wear two hats: that of a fisheries manager to maintain suitable fish populations and that of a successful business manager to maintain positive cash flows and profitability while working with clientele.

Many individuals are accomplished and comfortable in one of these roles, but lack the skills or interest to be attentive to the other. The success of sport-fishing operators depends upon well thought out, detailed and written management and marketing plans. The intense competition that exists today for the publics' recreation dollar almost ensures that those depending on blind luck will not succeed. The availability of quality fishing is an important component of sportfish recreation enterprises. However, it is only one part of the entire recreational experience.

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Gizzard Shad Spawning Period in Central Meredith Reservoir, Texas

Charles R. Munger

Texas Parks and Wildlife Department
5325 North 3rd Street
Abilene, Texas 79603

Abstract.-Adult and larval gizzard shad *Dorosoma cepedianum* were collected during spring over a 2-year period to determine spawning season in Meredith Reservoir, Texas. Gonadosomatic index was used to determine spawning period in adults; presence of larvae corroborated spawning period identification. Spawning, in 1992, began around 27 April at a water temperature of about 13°C and lasted through mid-June when water temperatures were around 22°C. Total catch of larval gizzard shad appeared to follow a trimodal pattern with modes every other week. The final mode was the largest and resulted from spawning that occurred at about 19°C. The pattern of small modes followed by one large mode was opposite of what has been reported in the literature. Numbers of larvae <9 mm total length also were trimodally distributed but there was no increase in magnitude as with total catch, indicating possible surges in spawning activity.

Gizzard shad *Dorosoma cepedianum* population dynamics differ in various parts of their range (Willis 1987). In general, fish will spawn within specific temperatures with later spawns at higher latitudes (Conover 1990). Timing of spawning may also be locally influenced by annual changes in the rate of water warming (Amundrud, et al. 1974). Conrow et al. (1990) suggest that duration of larval presence and latitude are inversely correlated.

Gizzard shad spawning is variable with spawning activity occurring from February through late June (Baglin and Kilambi 1968; Houser and Netsch 1971; Netsch et al. 1971a; Gallagher and Conner 1980; Downey and Toetz 1983; Willis 1985; Miranda and Muncy 1987; Conrow et al. 1990; Guest et al. 1990). Spawning has been documented at temperatures ranging from 10 - 29°C (Miller 1960; Jester and Jensen 1972; Mayhew 1977; Shelton and Stephens 1980; Storck et al. 1982; Downey and Toetz 1983; Heidinger 1983; Miranda and Muncy 1987). Gizzard shad spawning period can vary within a single water body (Baglin and Kilambi 1968; Netsch et al. 1971a). Willis (1985) suggested that a gizzard shad population dominated by large fish may have a brief spawn while a population with smaller individuals may have a more extended spawn.

Largemouth bass *Micropterus salmoides*, smallmouth bass *M. dolomieu*, walleye *Stizostedion vitreum*, white bass *Morone chrysops*, and white crappie *Pomoxis annularis* are all important game fish species in Meredith Reservoir, Texas. Gizzard shad can be an important forage item for most sportfish species (Lewis 1953; Miller 1960; Netsch et al. 1971a; Ruelle 1971; Jester and Jensen 1972; Storck et al. 1982; Mosher 1983; Willis 1985; Storck 1986; Miranda and Muncy 1987). Growth and condition of game fish can be directly affected by the timing and abundance of age-0 gizzard shad (Ruelle 1971; Miranda and Muncy 1987) and can greatly affect the survival of age-0 game species (Timmons et al. 1980). Knowledge of temporal distribution of larval and juvenile fishes is essential for effective fisheries management (Conrow et al. 1990). The purpose of this study was to determine the spawning period of gizzard shad in Meredith Reservoir.

Methods

Collection of Adults

Sexually mature (>180 mm total length (TL), Heidinger 1983) female gizzard shad were collected by daytime electrofishing. A Smith Root GPP 5.0 electrofishing unit powered by a 5,000-watt generator provided pulsed DC current (60 pulses/s, 8-14 amps) for all electrofishing.

The boat hull served as the cathode. Electrofishing samples were collected between Cedar Canyon and Fritch Fortress areas of Meredith Reservoir between 1000 and 1400 hours. Collections were made every 2 weeks from 16 May - 25 June 1991 and weekly from 6 April - 22 June 1992. The fish were individually weighed (g) and measured TL (mm). Whole ovaries were removed and weighed to the nearest gram. Ovary weight was divided by the total weight of the fish, then multiplied by 100 to derive the gonadosomatic index (GSI). Surface water temperature was recorded for each collection. Adults were collected from a central area of the reservoir since spawning can occur several weeks earlier in upper than lower portions of a reservoir (Netsch et al. 1971a) especially when experiencing water level rises (Storck et al. 1978, Storck et al. 1982). The central sampling location was selected as likely to yield a median spawning period since Meredith Reservoir experienced no water level rises during the sample period and it is relatively small compared to reservoirs showing differential spawning.

Collection of Larvae

Gizzard shad larvae were collected with a 129-cm trawl with a 0.88-m^2 opening and consisting of two mesh sizes. The larger mesh was 91 cm and constructed of 0.50-mm bar mesh nylon screen positioned proximal to the mouth of the gear; the smaller mesh was 38 cm and constructed of 0.25-mm bar mesh nylon screen and proximal to the terminal end (Tomljanovich and Heuer 1986).

Trawl collections were made on 30 May and 14 June 1991 and weekly from 6 April through 13 July 1992. Surface water temperature was recorded prior to the first trawl collection each day. Samples were collected in open water (Netsch, et al. 1971b; Conrow et al. 1990) at least 15 m off shore, at a constant depth of approximately 1 m (Storck et al. 1978; Graser 1979; Van Den Avyle and Fox 1980; Storck et al. 1982; Matthews 1984) a constant speed, and away from the propwash (Netsch et al. 1971b). Four, 5-min trawl collections were made each day. Samples were preserved in 75% ethanol. Trawl samples were sorted by species and all gizzard shad larvae were measured to the nearest mm TL.

Data Analysis

Gonadosomatic indices were plotted against the date of sample collection to determine the spawning time period. It is believed that the period when GSI values are highest indicate the spawning period has begun (Miranda and Muncy 1987). The date at which all collected female gizzard shad were spent (eggs fully discharged) indicated the end of the spawning period. Number of larvae was plotted against the date of sample collection to determine the time and duration of larval appearance.

Results and Discussion

Adult Gizzard Shad

Four samples of adult females were collected in 1991 and 12 samples were collected in 1992. The number of females collected in each sample ranged from 5 to 30 in 1991 and 0 to 42 in 1992. In 1991, mean GSI decreased from 7.21 on 16 May at 16°C to 0.66 on 25 June at 22°C (Figure 1). Examination of shad collected on 25 June indicated all females were spent and spawning was complete. In 1992, mean GSI increased from 2.53 at 12°C to 5.91 at 16°C, and then decreased to 1.29 at 22°C by 22 June indicating the end of spawning (Figure 1).

Willis (1987) used GSI values to indicate when gizzard shad spawning occurred and its duration in Melvern Reservoir, Kansas. He found gizzard shad GSI values began to rise in April, peaked in mid-May, then declined through June. Gonadosomatic index values in Meredith Reservoir followed a similar pattern of rising to a peak then gradually declining through the spawning period. This indicates one continuous spawn beginning around the second week in May and lasting until the third week in June.

Larval Gizzard Shad

In 1991, only two trawl samples were collected, too few for analysis. Sample design was modified in 1992 allowing for collection of 15 weekly samples. Number of gizzard shad larvae collected in trawl samples ranged from 0 to 543 (4 - 25 mm TL). The first large group of larvae was collected on 11 May at 17°C. The highest catch of larvae occurred on 8 June 1992 at 19°C, 5 weeks after the first larva was collected (Figure 2). Most of these fish (69%) were 11 mm TL or less indicating the high catch was not a result of accumulated previous spawns. This was similar to what was found in Beaver Reservoir, Arkansas (Netsch et al. 1971a), and Lake Carl Blackwell, Oklahoma (Downey and Toetz 1983).

Netsch et al. (1971a) reported the general pattern of gizzard shad abundance reaches a peak

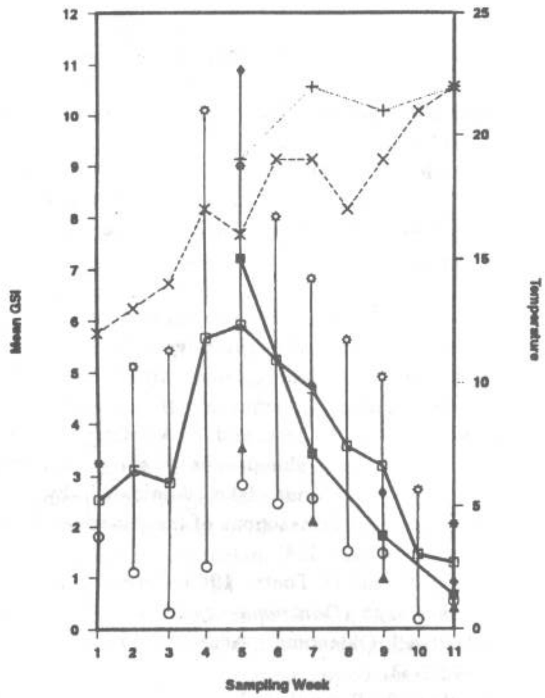

Figure 1.-Surface water temperature (°C) and gonadosomatic index (GSI) values for female gizzard shad, Meredith Reservoir, Texas, 15 May through 25 June 1991 and 13 April through 22 June 1992. Broken lines indicate temperature with 1991 indicated by the dotted line and 1992 by the dashed line. Solid lines indicate GSI with 1991 represented by filled squares and 1992 by open squares. Standard error limits are indicated by vertical lines with 1991 indicated by filled diamonds and triangles and 1992 by open sunbursts and circles.

approximately 4 - 8 weeks after the start of the spawning period. This would place the start of the spawn in central Meredith Reservoir between 13 April and 17 May. Shelton and Stephens (1980) reported gizzard shad incubation lasts from about 80 to 120 h at 15°C with 50% hatching between 100 and 110 h. Miller (1960) indicated 4.5-5.5 mm TL gizzard shad larvae are 1-2 d old. The first larva was collected on 4 May in 17°C water. Two d of growth plus 4.5 d incubation at 15°C, would place the beginning of the 1992 spawning on 27 April. Larval gizzard shad catch information indicates the 1992 spawning period in Meredith Reservoir began around 27 April and lasted to 22 June. Total catch of larval gizzard shad in 1992 had modes occurring on a 2-week cycle except during the week immediately following the peak catch.

Gonadosomatic index data indicated spawning began around 11 May while trawl data indicate spawning around 27 April. This 2-week disparity may be due to a low initial spawning effort. It appears that spawning began early but was not strong enough to lower mean GSI. Early fry collections at Meredith Reservoir yielded relatively few larval shad. This suggests limited spawning at cooler water temperatures. Mean GSI did not begin to drop until a larger portion of the population had begun to spawn. Photoperiod may have more of an impact on time of spawn than temperature. Photoperiod may have prompted the initial spawning effort, but that effort may have been tempered by temperature. The wide variation in reported spawning temperatures may be due to a response to the effects of photoperiod, rather than to just water temperature.

Declining GSI values and rising total catch of gizzard shad larvae indicate one extended spawning period in Meredith Reservoir. This agrees with what has been reported by other researchers (Taber 1969; Netsch et al. 1971a; Willis 1987), however, the Meredith Reservoir spawning period was longer than that reported for Lake Carl Blackwell, Oklahoma (Downey and Toetz 1983), and, only Miller (1960) reported lower spawning temperatures. The catch of larval shad <9 mm followed the same pattern as total larval catch except the peaks were uniform in distribution and magnitude. This regular cycle may indicate that, within the extended spawn, there are distinct surges in reproductive activity.

The overall pattern of larval gizzard shad abundance in Meredith Reservoir shows some unique tendencies. Total catch of larval gizzard shad was trimodally distributed (Figure 2). There was a pattern of two small peaks followed by a major peak each occurring every other week. Total catch dropped rapidly after the major peak indicating the end of spawning. Netsch et al. (1971a) showed larval abundance reached a peak early and then had a few minor peaks later.

Management Implications

Knowledge of the spawning period and timing of the first appearance of gizzard shad larvae can aid managers in timing the stocking of predators to maximize survival. If predator species can be stocked at a time and size that would best allow utilization of forage, stocking survival and growth of age-0 game fish could be greatly improved. Recent advancements in temperature and

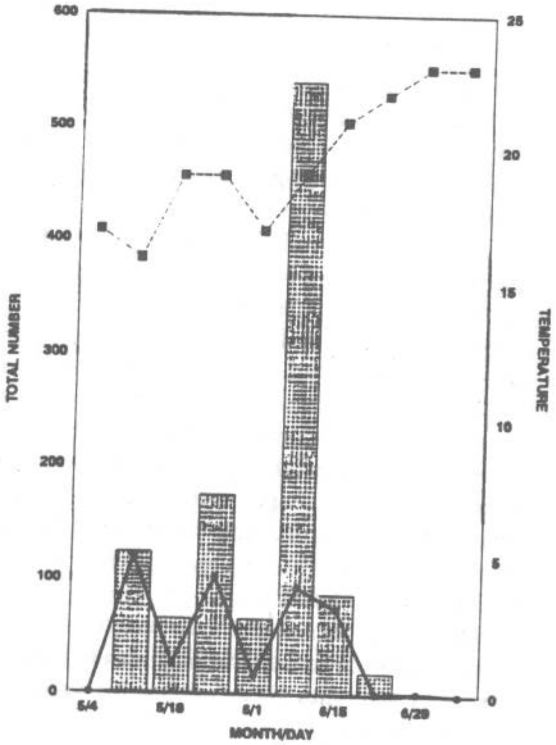

Figure 2.-Total number of gizzard shad larvae collected in four trawl samples per sample day, Meredith Reservoir, Texas, 1992. Bars are total number collected per sample day, the solid line is the total number of larvae <9 mm TL collected per sample day, and temperature (dashed line) is surface water temperature in °C.

photoperiod technology allow hatchery managers greater control of gamefish spawning period. Fisheries managers, therefore, should be able to request a specific size fish to stock within specific time periods. Fine-tuned stocking, based on availability of forage, should benefit the angler and the manager. Anglers would benefit through increased survival and growth of stocked game species. Managers would benefit from the need for lower production. If stocking survival is increased, then the number of fish to be stocked can be decreased. Decreased demand for fish would save hatchery space, labor, and money.

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Identification of Easily Misidentified Sharks of the Texas Coast Using Isoelectric Focusing

Rocky Ward and Ivonne Blandon

Perry R. Bass Marine Fisheries Research Station
Texas Parks and Wildlife Department
HC-2 Box 385, Palacios, Texas 77465

Tim L. King

National Fisheries Research Lab, U. S. Fish and Wildlife Service
Leetown Box 700, Kearneysville, West Virginia 25430

Abstract.-Several sharks occurring on the Texas coast are difficult to identify because of morphological similarity to closely related species. As an aid in identification we utilized isoelectric focusing to obtain protein banding patterns, characteristic of several commonly misidentified taxa. Densitometric tracings of banding patterns presented in this study may be used to confirm identification of these species as well as to identify processed shark parts.

During the latter half of this century a significant decrease in the populations of most large coastal and pelagic sharks has been noted (National Marine Fisheries Service 1993). The decline is not localized and has been documented in the southern Pacific (Campbell et al. 1992; Pepperell 1992) North Atlantic (Casey et al. 1978), and Gulf of Mexico (Casey and Hoey 1985). The cause of these declines has been attributed to recent changes in fishery practices such as "finning" sharks to supply Asian markets. Additionally, sharks generally are long-lived with low reproductive rates and are adversely impacted by high exploitation rates (National Marine Fisheries Service 1993).

During the spring of 1993 a shark management plan was implemented that established guidelines and controls over the shark fishery in U. S. waters of the Atlantic, Caribbean, and Gulf of Mexico. The plan mandates the monitoring and regulating of 39 species of coastal and pelagic sharks found in these waters and recommends increased shark research by both federal and state agencies.

Efforts aimed at monitoring, regulating, and researching shark populations is hampered by difficulty in identifying species of sharks (Castro 1983). Identification has usually relied on dichotomous keys (Compagno 1984a; Compagno 1984b). However, identification using morphological characters is made difficult by high levels of intraspecific variability and by occurrence of sibling and near-sibling species (Brannstetter 1982).

Recent advances in biochemical techniques have proven useful in identification of morphologically similar organisms. Martin (1991) used mitochondrial DNA to identify sharks to species level. This technique, while powerful, has the disadvantage of being labor and time consumptive making its application to identification of large numbers of samples difficult. Another biochemical technique, isoelectric focusing (IEF), has been used to identify a variety of morphologically similar organisms (Balboa et al. 1991; King et al. 1991; Martin and King 1991). This technique has the advantage of being easily, accurately, and inexpensively used to determine the taxonomic affinity of large numbers of samples.

The purpose of the current study was to determine if IEF can be used to identify species of commonly misidentified sharks in Texas. Species chosen for the present study were three members of the genus *Sphyrna* (the bonnethead *S. tiburo*, the great hammerhead *S. mokarran*, and the smooth hammerhead *S. lewini*) which are commonly collected in open waters and bays of the northwestern Gulf of Mexico, and two members of the genus *Carcharhinus*, (the blacktip shark *C. limbatus* and the spinner shark *C. brevipinna*).

The great hammerhead and the smooth hammerhead are difficult to differentiate in the field. The most useful key character is the shape of the teeth; these are sometimes difficult to closely examine, especially if the shark is alive. The bonnethead is also occasionally confused with its larger congenerics, especially the smooth hammerhead. Juveniles of the smooth hammerhead have a head which is similar in shape to that of an adult bonnethead, which results in frequent confusion during identification. The blacktip shark and the spinner shark are similar in morphology, coloration, and behavior making them among the most commonly misidentified sharks in Texas waters.

Methods

Tissue samples were obtained from a variety of sources and geographical locations both in the Gulf of Mexico and other waters. Muscle samples were maintained at the coldest temperature practicable until arrival at the laboratory where they were stored at -85 °C until processed. Tissues were homogenized in an equal volume of distilled water and centrifuged at 10,000 rpm for 10 min at 4 °C. The resulting supernatant was retained for analysis and maintained at -85°C.

All individuals tentatively assigned to a species were screened in low-resolution (pH gradient 3-10) gels which contained a known member of that species. This initial screening allowed culling of misidentified individuals and assessment of intraspecific variability. Additional screenings using higher resolution gels were conducted in gels with a narrower pH gradient (pH 4-5 and 9-11 or 8-10).

Isoelectric focusing procedures and staining protocols followed those of King et al. (1988). Following staining, gels were scanned to determine protein migration and absorbance (intensity) utilizing an ultrascan XL Laser Densitometer interfaced with LKB Gelscan 2.0 software (Pharmacia LKB Instruments, Gaithersburg, MD). Isoelectric points (pIs) were assigned to bands based on comparisons with pI values of bands produced by commercial protein markers (Sigma Biochemicals, Saint Louis, MO).

Results

Densitometric tracings of the low-resolution (pH

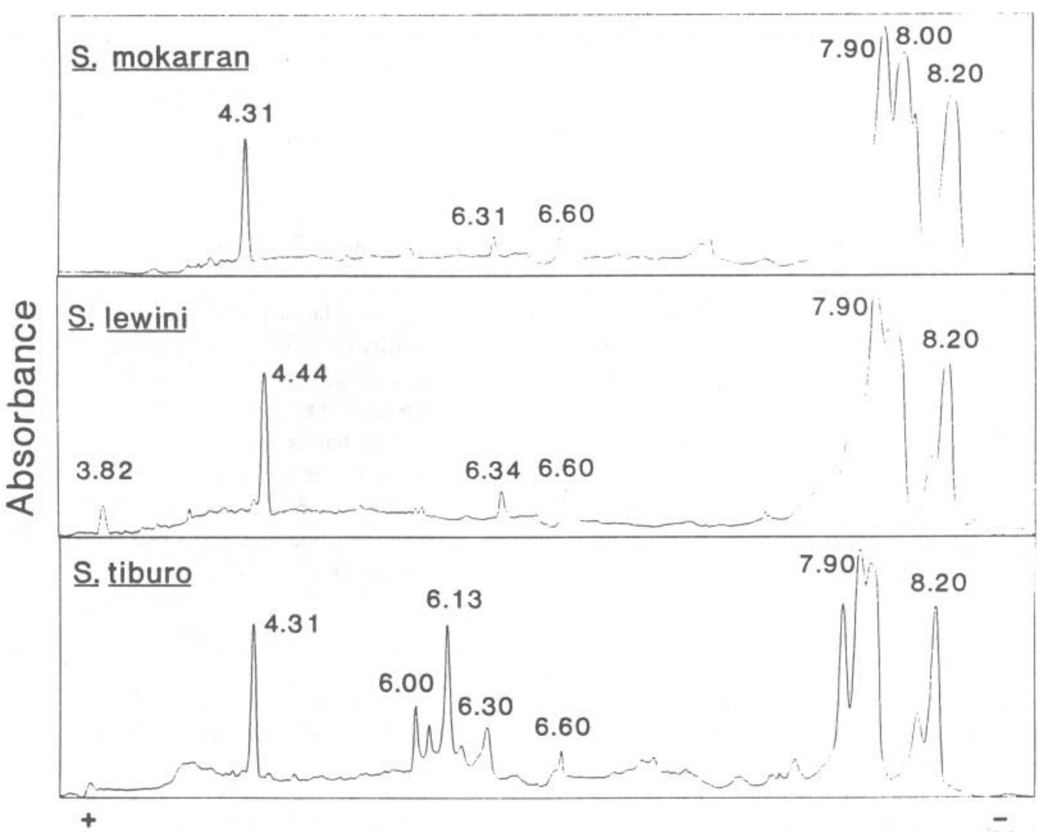

Figure 1.-Densitometric tracings of IEF low-resolution gels for three members of the genus *Sphyrna*.

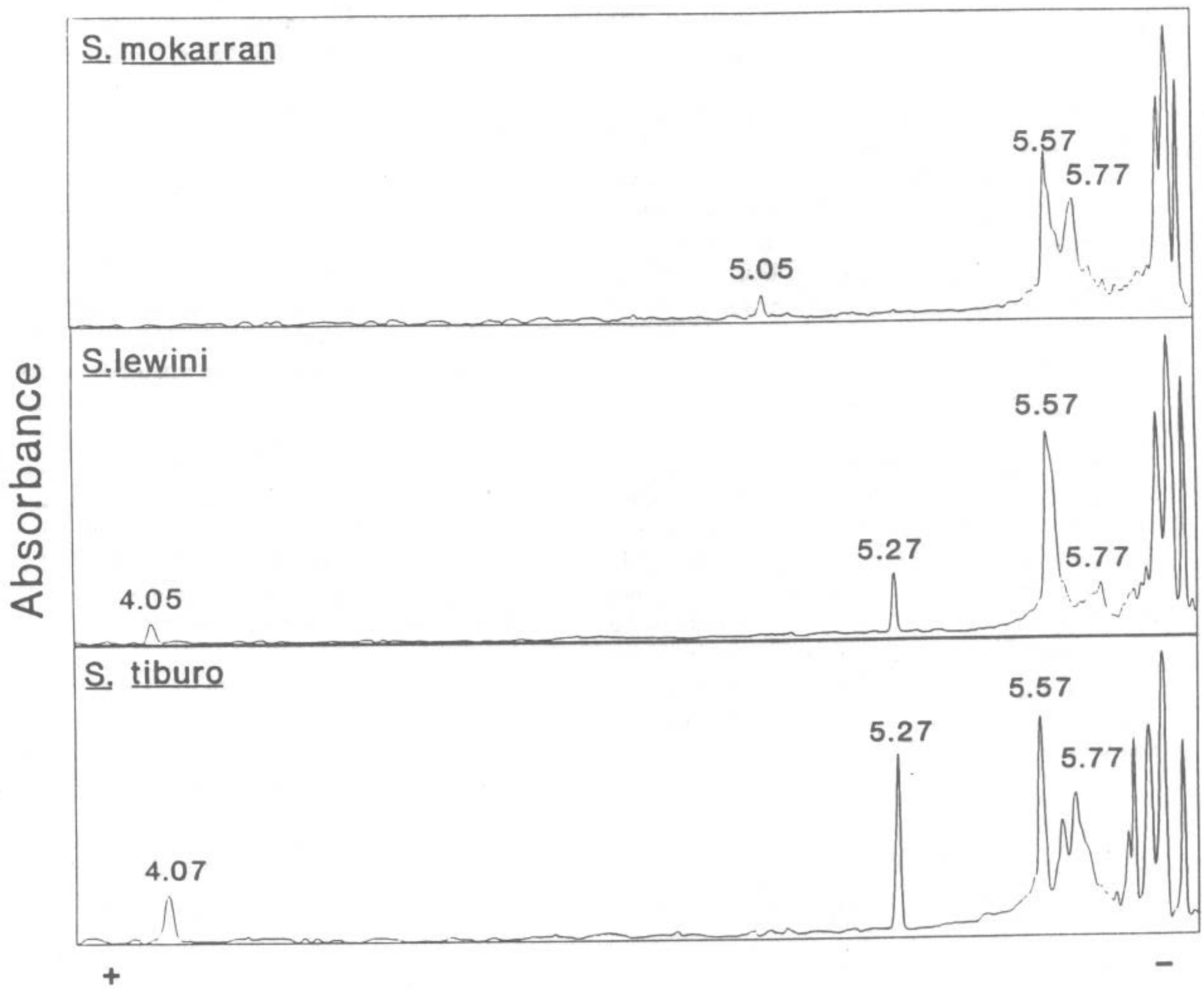

Figure 2.-Densitometric tracings of IEF high-resolution gels for three members of the genus *Sphyrna*.

3-10) gels for the three members of the genus *Sphyrna* (Figure 1) identified major differences between the bonnethead and the two larger species. All three species have major bands at pI 7.9 and pI 8.2, and all have a distinct band at or near pI 4.31. However, the bonnethead has a series of relatively low-absorbance bands between pI 6.00 and pI 6.60, with the most intense band at pI 6.13. The great hammerhead and smooth hammerhead have relatively low-intensity bands at pI 6.60 and at or near pI 6.31. Differences between the great hammerhead and the smooth hammerhead on the low-resolution gels ar minor; however, the two species are easily distinguished on high-resolution gels (pH 4-5, Figure 2). These species are similar in the upper pH ranges, but the great hammerhead possesses a band at pI 5.05; whereas, the smooth hammerhead has a band at pI 5.27.

The blacktip shark and the spinner shark are readily distinguished on the basis of low-resolution gels (Figure 3). The blacktip shark has a high-intensity band at pI 3.92 and three increasingly intense bands at pI 6.15, pI 6.30, and pI 6.55. The spinner shark lacks these bands but has low-intensity bands at pI 5.47 and in a series ending at pI 8.09. The two species have similar patterns in the upper pH ranges.

Discussion

Commonly misidentified sharks of the genera *Sphyrna* and *Carcharhinus* are readily differentiated using IEF. This technique is useful in confirming field identification of individuals. Another important use of IEF is the identification of processed shark products. Sharks are often "finned

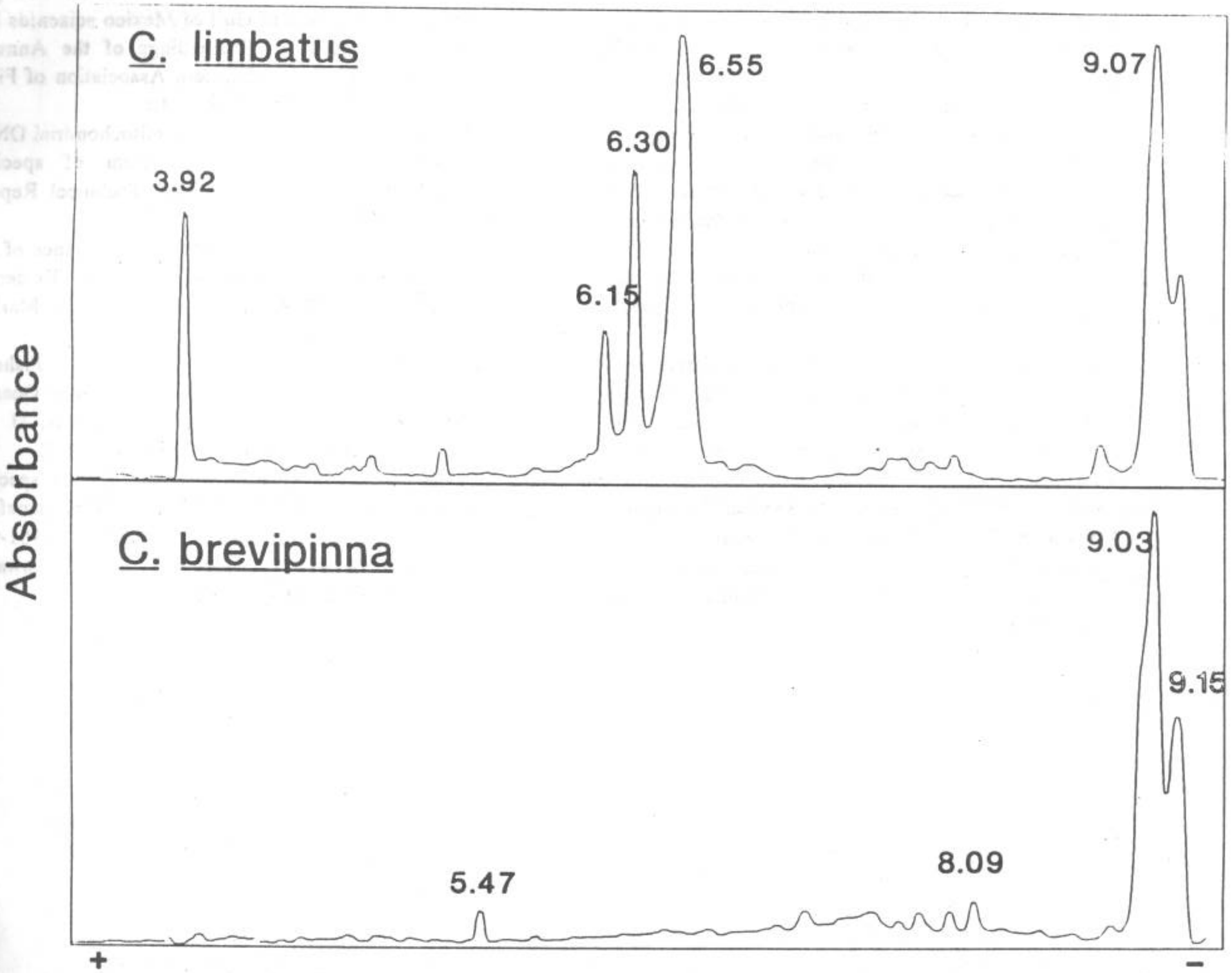

Figure 3.-Densitometric tracings of IEF low-resolution gels for blacktip shark *Carcharhinus limbatus* and spinner shark *C. brevipinna*.

and headed" at sea leaving a carcass lacking key identification characters. The ability to identify processed sharks is important to the implementation of the shark fishery management plan.

Sharks, like all fishery-targeted organisms, should be managed on a species-specific basis. Isoelectric focusing makes this possible. Large numbers of individuals can be screened easily, quickly, inexpensively, and accurately. Tissue used for IEF can also be in a relatively degraded condition allowing identification of individuals which have been kept of ice at sea for several days or even weeks.

Isolelectric focusing is a robust and useful technique for both fishery managers and research biologists. Its use will aid in the monitoring of shark populations and harvest, and in the enforcement of conservation regulations designed to preserve this group of organisms.

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Evaluation of Larval Red Drum Releases for Stock Enhancement

Scott A. Holt, Cameron M. Pratt and Connie R. Arnold

The University of Texas at Austin, Marine Science Institute
Port Aransas, Texas 78373

Abstract.-The ability of yolk-sac larvae to survive introduction to the wild (as part of a stock enhancement program) was evaluated through a release and recapture project using 2-d-old hatchery spawned red drum *Sciaenops ocellatus* in Aransas Bay, Texas. Fourteen million larvae were released throughout the summer of 1991. We attempted to collect these larvae by ichthyoplankton sampling at 2 week intervals with an epibenthic sled. No released larvae were captured during the study. Differences in salinity and temperature of hatchery and stocked waters were potential sources of high mortality. The absence of larvae could also have resulted from our inability to locate larvae because of dispersion patterns or transport from the study area by tidal influences. It was concluded, however, that most of the larval fish did not survive their introduction to the wild. Extreme changes in salinity and temperature during the introduction process, and possibly other factors related to introducing the larvae at a time of year when they do not naturally occur may have added to the typically high natural mortality of larval fish.

The culture of marine fishes for stock development or enhancement has a long history (see Richards and Edwards 1986 for a review). Initial attempts focused on releasing eggs and larvae of oceanic species (i.e., cod *Gadus morhua* and haddock *Melanogrammus aeglefinus*), but those efforts generally ceased by the mid 1900's when there was little evidence that these expensive endeavors were successful (Shelbourne 1964). Since that time, most enhancement programs have involved releases of mass-reared juveniles, but there has been only limited assessment of the success of these programs (Richards and Edwards 1986; Svasand et al. 1990; Wells et al. 1991).

The red drum *Sciaenops ocellatus* is a popular and economically important game fish native to the Texas Gulf coast and has therefore been the subject of much attention by management agencies. This species has recently been the focus of an expanding hatchery and stock enhancement program along the Texas Gulf coast. Red drum are estuarine dependent marine fish of the family Sciaenidae. They have a life span of 40 plus years and spend the first 3-5 years in the estuarine environment after which they move offshore and become members of a pelagic community of breeding adults. Adult red drum return inshore to the passes during the fall spawning period, an approximate 8 week time span from mid-August through mid-October (Simmons and Breuer 1962; Beckman et al. 1988). The eggs and larvae are carried through the passes into bays and estuaries where they develop into juvenile fish (Holt et al. 1989). This short and predictable spawning period makes it easy to release hatchery-produced larvae so they can be reliably identified during the early phases of life by their relative size, negating the need for any marking techniques.

From October 1975 through December 1990 Texas Parks and Wildlife Department (TP&WD) released over 68 million pond-raised red drum (20-30 mm total length (TL)) into Texas bays and estuaries (Dailey 1991). This is an expensive endeavor in terms of both space and food required to grow individuals to a releasable size, as well as the cost of personnel to handle the operations (Matlock 1988). As an alternative to raising and releasing juvenile fish, TP&WD released approximately 361 million yolk-sac larvae (2.5-3.0 mm notochord length) into coastal bays from 1975-1990 (Dailey 1991). Yolk-sac larvae are maintained for only 2 d and require no food; thus the production costs of their stocking program could be greatly reduced if this method was deemed successful. This approach differs from the unsuccessful earlier egg and larval stocking in that these larvae would be released into estuarine nursery areas rather than open ocean; however, natural mortality rates may be relatively high even in protected estuarine environments (Houde and Zastrow 1993). Larvae have poor locomotor abilities, are highly sensitive to environmental

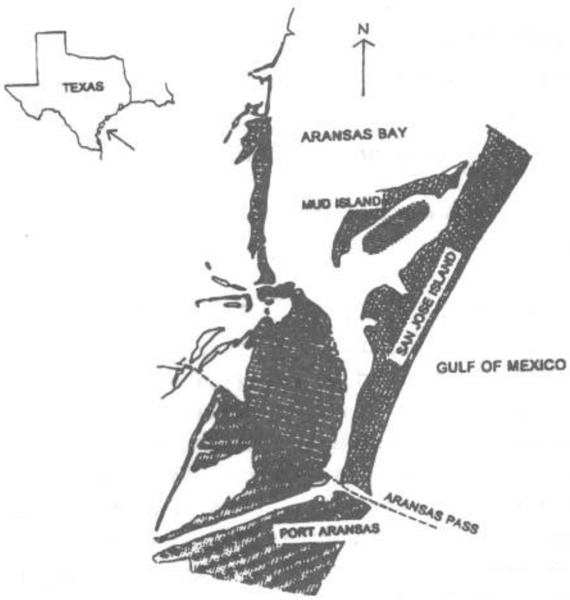

Figure 1.-Location of red drum release and sampling site in Aransas Bay, Texas.

changes (e.g., salinity and temperature shifts), and are subjected to intense predation (Leak and Houde 1987). In an earlier evaluation of larval stocking, Matlock (1988) recovered no released fish with bag seine collections during a four month period following the release of 4.8 million red drum larvae in Christmas Bay, Texas. The purpose of our study was to assess short-term (1 d to 2 week) survival of hatchery-spawned red drum yolk-sac larvae released into the wild using methods employed by TP&WD in their stocking program (Colura et al. 1990).

Methods

This release and recapture project took place from 20 May 1991 through 5 September 1991 along the middle Texas coast in Aransas Bay, approximately 10 km north of Port Aransas, adjacent to the south side of Mud Island and the west side of the barrier island San Jose at 27.56N, 97.01W (Figure 1). Red drum larvae naturally occur here during this species's spawning period when incoming tides carry both eggs and larvae from Aransas Pass into the surrounding bay systems.

A total of 14,054,000 hatchery-produced red drum larvae, supplied by TP&WD from the Gulf Coast Conservation Association/Central Power and Light Company/Marine Development Center in Flour Bluff, Texas, were released from 20 May through 7 August, with 8,186,000 of these released

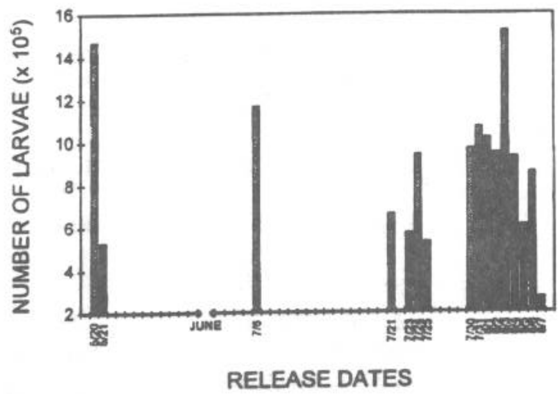

Figure 2- Larval red drum release dates and number released into Aransas Bay, Texas.

from 30 July through 7 August (266,000 to 1,516,200/d) (Figure 2). Larvae were transported to the study site in large plastic bags (approximately 100,000 larvae/bag) and released into open water over a bare muddy-sand bottom with an average water depth of 2 m. Guidelines developed by TP&WD were followed for tempering larvae at the release site (Colura et al. 1990). The bags were floated in the water to be stocked until the temperature within the bag reached equilibrium with the ambient water. If the salinities of transport water and stocking water differed by >5‰, stocking water was slowly added to the bag for 15-30 min until the salinities between transport water and ambient water were within 5‰.

One bag of larvae was taken to the lab after one release to test the effect handling had on survivability. Larvae were placed into rearing tanks with water conditions identical to the hauling units and kept under typical laboratory rearing conditions for 14 d.

Larva sampling was conducted within 1 km of the release site using standard ichthyoplankton sampling procedures. The sampling period of the project extended from 20 May to 5 September with collections made during daylight hours on an average of every 2 weeks. Sampling was planned to occur within several hours of releasing larvae, at the end of nine consecutive days of releases, and up to 2 weeks later. During each sampling trip, five replicate ichthyoplankton tows were taken using a 1-m net (500 μm mesh) attached to an epibenthic sled pulled through the lower 1 m of the water column. The volume of water filtered for each tow was measured with a mechanical flowmeter. Samples were preserved in 5%

formalin or 70% ethanol. All sciaenids in the samples were identified to species (except *Menticirrhus sp.*), enumerated, and measured. Larval densities are expressed as number per 1000 m^3 of water.

Water temperature and salinity were measured at the hatchery source, and in the hauling units before leaving the hatchery and upon reaching the study site. Atmospheric conditions (air temperature, cloud cover, wind direction, and wind speed) and water conditions (clarity, depth, temperature, and salinity) were recorded at the study site during each release and collection. Current speed and direction were also measured during each release. Salinity and temperature profiles of the water column were taken using either a Beckman salinometer or Seabird CTD during ichthyoplankton sampling.

Results and Discussion

No released red drum larvae were captured during this project, yet other sciaenids were consistently caught at the study site at densities ranging from <1 to >400 larvae per 1000 m^3 of bay water (Table 1). Two red drum larvae (2.16 and 2.98 mm) were caught on 5 September but they were much smaller than the expected size of the last hatchery released larvae based on growth rates from Comyns et al. (1989) and were clearly naturally spawned larvae. Any released larvae should have been at least 12 mm long at this time. The presence of these naturally-spawned red drum at the study site reinforces the premise that the area represented suitable habitat for this species. Salinities and temperatures recorded during releases (Table 2) also indicate that the site satisfied these criteria for suitable stocking habitat. Throughout most of the project, salinities and temperatures were close to or within the range considered optimal (25-35‰ and 25-30°C) for red drum larval development (Holt 1990), and were within the range of these parameters measured when naturally spawned red drum larvae have been collected in South Texas (Holt et al. 1988). Further, the presence of other sciaenids commonly found in association with red drum larvae (S. Holt unpubished. data), which are of a similar body shape and size as red drum larvae, reinforces the assumption that if there were red drum larvae in the area, they could have been caught with this sampling technique.

The lack of stocked red drum captures could be the result of natural factors inherent in the pelagic environment of larval fish. Mortality is very high at day one, and remains high during the first few weeks while the larvae are members of the pelagic community (Houde and Zastrow 1993). Comyns et al. (1991) estimated the natural mortality rate of red drum larvae (3.0-5.4 mm notochord length) in the eastern Gulf of Mexico to be 40.6% per day. Assuming similar mortality rates for released red drum larvae, the number of viable 2-d-old larvae would have rapidly decreased from 1,516,000 (largest daily release) to about 600 fish by the end of 2 weeks (Figure 3). After the nine consecutive days of releases, from 30 July through 7 August, the cumulative number of larvae surviving would have been reduced to 1,530,000, or 19% of the eight million larvae released (Figure 4). This mortality model does not take into account additional sources of mortality that hatchery-produced larvae might be subjected to, and thus gives a conservative estimate of survival of hatchery-produced larvae.

The likelihood of finding larvae after the initial release into the open bay may have been reduced due to the hydrodynamics of the basin itself. The study site contained an estimated 18 million m^3 of water. During a typical sampling trip approximately 1500 m^3 of water was filtered

Table 1.-Sciaenid larvae caught throughout project with range of dates when caught, mean density, maximum density, average length, and range of lengths.

Species	Range of Dates	Mean Density #/1000 m^3	Maximum Density #/1000 m^3	Average Length (mm)	Range of Lengths (mm)
Sciaenops ocellatus	5 Sep	0.2	1.5	2.57	2.16 - 2.98
Bairdiella chrysoura	20 May - 7 Aug	3.6	15.6	3.08	1.49 - 5.44
Cynoscion Arenarius	20 May - 5 Sep	9.4	26.1	4.98	2.75- 19.34
Cynoscion nebulosus	20 May - 5 Sep	68.9	444.1	2.54	1.14 - 6.00
Menticirrhus sp.	20 May - 5 Sep	3.0	19.2	3.13	1.45 - 4.64
Stellifer lanceolatus	20 May - 23 May	0.9	4.5	4.94	3.28 - 7.76

Table 2.-Salinity and temperature of transport water and water at the release site.

Date	Transport Salinty (‰)	Bay Salinity (‰)	Salinity Difference (‰)	Transport Temperature (°C)	Bay Temperature (°C)	Temperature Difference (°C)
20 May	36.0	18.0	18.0	27.0	25.0	2.0
21 May	38.0	20.0	18.0	27.7	25.9	1.8
6 Jul	34.0	23.0	11.0	29.0	31.0	2.0
21 Jul	34.0	26.0	8.0	32.0	34.0	2.0
23 Jul	34.0	27.0	7.0	29.0	29.0	0.0
24 Jul	34.0	27.0	7.0	29.0	30.0	1.0
25 Jul	38.0	32.0	6.0	28.5	29.5	1.0
30 Jul	39.0	34.0	5.0	28.0	31.0	3.0
31 Jul	38.0	34.0	4.0	27.5	32.0	4.5
1 Aug	38.0	34.0	4.0	30.0	31.5	1.5
2 Aug	38.5	35.5	3.0	29.0	31.0	2.0
3 Aug	38.0	35.5	2.5	29.0	30.8	1.8
4 Aug	38.0	35.5	2.5	29.5	30.5	1.0
5 Aug	38.0	35.0	3.0	28.0	30.0	2.0
6 Aug	38.0	35.0	3.0	28.0	30.0	2.0
7 Aug	38.5	35.0	3.5	29.0	31.0	2.0

through the net, implying that there would have to be 12,000 evenly-distributed larval red drum in the bay for one to be recaptured per trip. If the 1.5 million larvae, estimated by the mortality model to be remaining in the bay after the 9 d of consecutive releases, were evenly distributed in the study area, about 125 red drum larvae should have been captured on 7 August; yet none were caught. This suggests that the larval distribution was patchy rather than even, thus it is possible that none of the released larvae were captured due to their pattern of distribution within the study area. It is likely that any surviving larvae did not stay in one place after being released but were dispersed throughout the basin by diffusion and weak advection due to tidal exchanges. It is also possible that they were carried not only out of the immediate release area, but out of the bay altogether.

Variables associated with implementing the study need to be considered when addressing the absence of released red drum larvae in our samples. The amount of time elapsing between releases and sampling could have been a factor, but a variety of regimens were used to offset that possibility. The long time intervals between sampling events should have increased the possibility of capturing older red drum from previous releases. Although we restricted our sampling to the lower 1 m of the water column we do not feel that this would have had a negative impact on our catch data. Our previous research on estuarine larval distribution shows that most sciaenid larvae, including red drum, are caught in higher concentrations in bottom samples compared to surface samples during daytime sampling (S. Holt unpublished data).

The results of the laboratory study showed physiological stress due to transport from the hatchery to stocking site (and back to the laboratory) was minimal. After 3 d the fish were in good condition and after 14 d they exhibited a survival rate consistent with the 40% expected for typical laboratory-reared larvae (Holt 1993).

It is possible that even after tempering, the transfer of the larvae into waters of different temperatures and salinity concentrations could have been stressful. Acclimating the larvae from

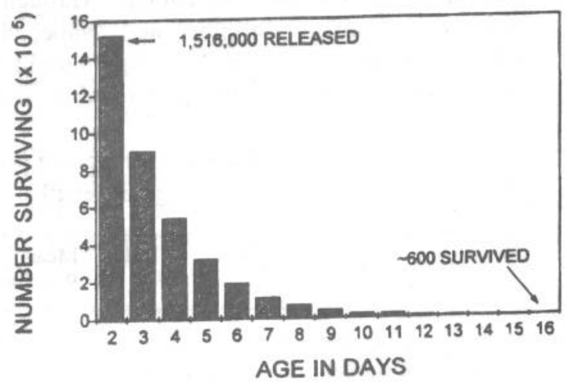

Figure 3- Predicted number of 2-d-old red drum larvae surviving on each day for 2 weeks following an initial release of 1,516,000 larvae in Aransas Bay, Texas. [Modeled after Comyns et al. (1991)].

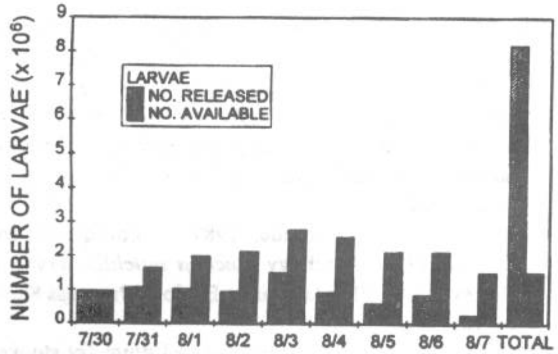

Figure 4.-Relationship between the total number of red drum larvae released over a 9 day period and the predicted number of surviving larvae based on the model $N_t=N_o\exp^{-zt}$, where z=-0.521 (Comyns et al. 1991).

hatchery water to bay water was accomplished in approximately 1-2 h. The average salinity change was a reduction of 6.6‰ (range 2.5-18.0‰) (Table 2). Average temperature change was 1.9°C (range 0-4.5°C) (Table 2). The total tempering time of 1-2 h for both salinity and temperature may still not have been sufficient to adequately insure that the osmoregulatory functions of the larvae were not stressed beyond their capabilities. Acclimating larval red drum from one salinity concentration to another should be accomplished at a rate no greater than 5‰ per hour (G. J. Holt, University of Texas, Marine Science Institute, personal communication). Similarly, research by Fuiman and Ottey (1993) indicates that a minimum adjustment period of 2-5 h is advisable when moving young red drum between waters of different temperatures. Larvae that did not die upon release may have used energy adjusting to changes in temperature and salinity rather than other bioenergetic functions (Holt and Banks 1989), and thus become more susceptible to starvation and predation.

These results are similar to those obtained by Matlock (1988) who failed to recover any fish out of 4.8 million larvae released in Christmas Bay, Texas. That study attempted to collect post-settlement juveniles from near the release area over a 4 month period. The reason(s) for lack of recoveries were unknown but potential explanations included inadequate stocking densities, high handling mortality or unsuitable environmental conditions at the release site, or movement into unsampled adjacent areas.

Although it is possible that we did not retrieve any of the released red drum larvae due to advective or dispersal mechanisms within the study site, it is our conclusion that few of the released larvae survived their introduction to the wild. The high rate of natural mortality in the wild suggests that the number of larvae stocked must be very high to result in a measurable increase of red drum larvae in even a relatively small estuarine area. This mortality rate may be higher for hatchery-spawned yolk-sac larvae introduced into the bay when red drum larvae do not naturally occur. Although conditions we measured in the bay during releases and sampling did not differ greatly from those during the annual red drum spawning period (Holt et al. 1985), important components may be missing that we did not measure which are necessary for larval survival. Another critical factor potentially affecting survival was the stress caused by changes in salinity and temperature over a relatively short period of time during the acclimation process. Greater attention should be given to this process if the use of larval red drum is to be part of a stocking program.

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