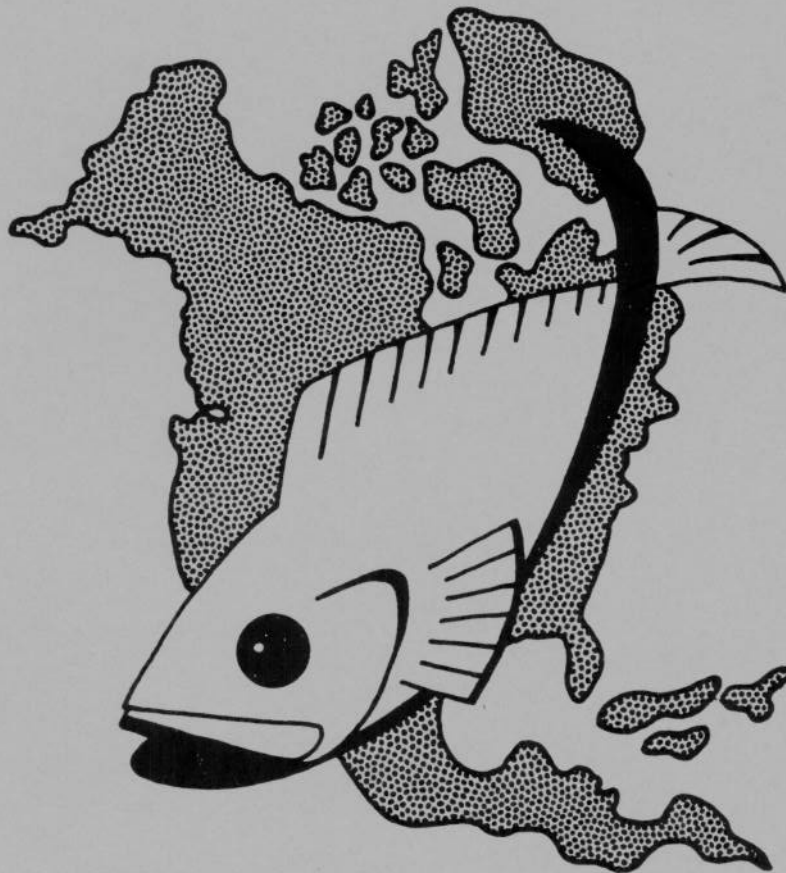


ANNUAL PROCEEDINGS
of the
TEXAS CHAPTER
AMERICAN FISHERIES SOCIETY



Galveston, Texas
October, 13-14, 1991

VOLUME 14

KURZAWSKI

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

October 13 and 14, 1991

Galveston, Texas

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Texas Chapter, American Fisheries Society
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4200 Smith School Road
Austin, Texas 78744

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ISSN 1060-2224

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CONTRIBUTORS

The following companies made contributions of money or services, or exhibited products and/or services at the annual meeting in 1991.

CONTRIBUTORS	PRODUCT OR SERVICE
ADPI ENTERPRISES, INC. 3621 B Street Philadelphia, Pennsylvania 19134 800-621-0275	Manufacturer of plastic netting and fences
ARGENT CHEMICAL LABORATORIES 8702 152 nd Avenue NE Redmond, Washington 98052 800-426-6258	Aquaculture products and chemicals
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CEDAR CREEK PUBLISHERS 2712 Mallard Court Columbia, Missouri 65201 314-442-8694	Wildlife art
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GUNDLE LIVING SYSTEMS, INC. 19103 Gundle Road Houston, Texas 77073 800-435-2008	Pond liners

CONTRIBUTORS	PRODUCT OR SERVICE
HALLPRINT PARTY LTD. 27 Jacobson Crescent Holden Hill, South Australia 5088 Australia	Fish tags
JPS ELASTOMERICS CORPORATION Environmental Products Division 395 Pleasant St. Northampton, Maine 01060 413-582-1031	Pond liners
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ZEBCO CORPORATION P.O. Box 270 Tulsa, Oklahoma 74101 918-936-5581	Fishing tackle

1991 TEXAS CHAPTER AWARDS

Outstanding Fisheries Worker of the Year

The award for Fisheries Administration went to **Pat Hudson** (TPWD). Pat was recognized for his administrative accomplishments as Texas Parks and Wildlife Department program leader for largemouth bass, rainbow trout, paddlefish and smallmouth bass. Under Pat's direction, record numbers of largemouth bass fingerlings were produced this year (7 million). In addition to the record numbers produced, Pat was also recognized because of his concern for the quality of fish produced by TPWD. He has been instrumental in the establishment of genetic criteria that will help assure the quality of bass produced at state hatcheries. As program leader for rainbow trout, Pat was described as the key player that made everything work. Pat procured the fish, set up delivery dates and statewide stocking schedules. He was also recognized for his work with "Access to Rainbows". From this program's inception, Pat worked with community leaders across the state to provide fishing opportunities to special people. Under Pat's direction as program leader for paddlefish, Texas now leads the nation on intensive culture of this species.

The award in the category of Culture went to **Jake Isaac, Jr.** (TPWD). Jake was recognized for his successes with raceway spawning of largemouth bass. Jake found the preferred spawning material to best accomplish mass spawning and developed the stocking density necessary to best utilize facilities and broodfish. His work in Texas has had a major impact on largemouth bass production all over the country. Jake has also been a principal leader in development of techniques for intensive culture of paddlefish. He has been the leader in development of a new technique for incubation of catfish eggs which allows for use of jars and yields increased hatching success. Jake was also instrumental in a controlled, indoor mat spawning technique for goldfish and koi carp which doubled production of these forage fishes.

The Fisheries Management award went to **Mark Webb** (TPWD). Mark was recognized for his fisheries management work in the Houston metropolitan area, particularly with the promotion and development of urban fishing programs there. Mark was also recognized for work with the management of white crappie. He was the principle investigator on a study which evaluated the effects of an experimental 10-inch minimum length limit on three reservoirs. Results of the study were published in the proceedings of the Crappie Biology and Management Symposium and were recently used to initiate a statewide length limit for this species.

The award for Fisheries Research went to **Ronnie Pitman** (TPWD). Ronnie was recognized for her work on the paddlefish restoration program. As coordinator of this program, Ronnie wrote two TPWD publications: "Texas paddlefish recovery plan" and "A synopsis of paddlefish biology". Ronnie also wrote "History of paddlefish occurrences in Texas" published in the Texas Journal of Science. She also presented the results of her research at numerous professional meetings. Since writing the initial recovery plan, Ronnie has been active in all aspects of the plan, including the culture, restocking and radio tracking of this species. Ronnie was also recognized for her work on the recently completed study on initial stocking survival of hatchery fishes. Results of this study were presented at the annual meeting of the American Fisheries Society.

An award for Special Recognition in Fisheries Work went to **The Wetland Habitat Alliance of Texas**. This non-profit corporation is committed to the maintenance, preservation, enhancement and creation of wetland habitat. They focus on drawing government, business and conservation groups together to achieve their goals in habitat enhancement. Particular support is extended to cooperative projects among these diverse sponsors for enhancement of wetland resources. In 1991, Wetland Habitat Alliance of Texas gave the Texas Chapter of the American Fisheries Society \$1,000 for student scholarships. They believe that providing financial support to help educate future resource managers is one of the most worthwhile investments they can make toward the future of Texas fisheries.

Scholarship Recipients

Two students were presented with scholarship awards from the Texas Chapter of the American Fisheries Society, **Jim Tolan** and **Michelle Badough**. Jim is pursuing his bachelor's degree at Corpus Christi State University and plans to continue his education by pursuing a master's degree in Marine Sciences. Michelle is completing work on her bachelor's degree at Southwest Texas State University and plans to continue on with a master's degree in Aquatic Biology.

Outstanding Presentation

Mark Stacell of the Texas Parks and Wildlife Department received the award for Outstanding Presentation at the 1991 Annual Meeting for his paper entitled "Photosensitivity of Channel Catfish to Oxytetracycline", by Mark Stacell and David Huffman.

A RARE GENETIC MARK IN FLORIDA BASS
FROM THE HOMOSASSA RIVER, FLORIDA

by

Lorraine T. Fries
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San Marcos, Texas 78667

Abstract - Genetic marks may become important for post-stocking identification of hatchery produced fishes. Genetically marked stocks of Florida bass Micropterus salmoides floridanus were developed by Texas Parks and Wildlife Department fish hatcheries by fixing broodstock for certain allele combinations. Fish produced from these stocks could be used to estimate stocking impacts by observing shifts in allele frequencies following stocking. However, individuals produced from this stock were not always recognizable as hatchery produced fish. Recent acquisition of Florida bass from the Homosassa River, Florida, has allowed Texas Parks and Wildlife to develop broodstock possessing a unique allele at the IDHP-1* locus. Fish produced from this stock will allow fishery managers to positively identify hatchery produced individuals for a variety of post-stocking investigations.

NEW APPROACHES TO MANAGEMENT OF
FERTILIZED HATCHERY PONDS

by

Richard O. Anderson
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San Marcos, Texas 78666

Abstract - Several new approaches were tested in 1991 to solve or prevent problems in the production of phase-1 striped bass Morone saxatilis in fertilized hatchery ponds. Successful techniques included: (1) an early treatment with anhydrous ammonia to kill viable filamentous algae and the initial hatch of fairy shrimp and clam shrimp; (2) stocking aquatic plants; (3) stocking larvae at an age of 4 days to avoid lack of inflation of the swim bladder; (4) stocking ponds that were half full; and (5) the addition of urea as a source of nitrogen and phosphoric acid as a source of phosphorus in amounts to make available each week 600 $\mu\text{g/L}$ N and 30 $\mu\text{g/L}$ P. The moderate rate of fertilization with these nutrients avoided problems of high pH and un-ionized ammonia, resulted in similar zooplankton abundance and fish production as in ponds fertilized with either alfalfa meal or a combination of organic and inorganic nutrients at a cost for fertilizers that was less than 10% of treatment with alfalfa meal.

THE DEVELOPMENT OF RED DRUM FATTY ACID
PROFILES AS A FORENSIC TOOL TO
DISTINGUISH WILD FROM CULTURED FISH

by

Beverly Winkler Villarreal and Paul M. Rosenblum
Southwest Texas State University
San Marcos, Texas 78666

Lorraine T. Fries
Texas Parks and Wildlife Department
San Marcos, Texas 78667

Abstract - Law enforcement officials lack effective methods for discriminating between wild (poached) and cultured (farm-raised) red drum Sciaenops ocellatus. Fatty acid profiles of red drum were investigated to determine if significant differences existed between wild and cultured fish. Over 200 fish were sampled over seasons and from four bay systems (Matagorda, Corpus Christi, Aransas, and Upper Laguna Madre). Cultured fish were collected from an indoor recirculating facility and an outdoor pond operation, both commercial aquaculture ventures. Arachidonic acid (20:4n-6) exhibited low levels (1 - 2.5%) in cultured fish and high levels (6 - 12%) in wild fish, with some seasonal variation observed. Linoleic acid (18:2n-6) exhibited low levels (1 - 2%) in wild fish and high levels (9 - 11%) in cultured fish.

Fatty acid profiles for red drum is an effective method for distinguishing wild from cultured fish, and should be a powerful forensic tool to aid law enforcement in protecting the red drum fishery.

SELECTIVE DIP-NETTING OF LARGEMOUTH BASS
DURING ELECTROFISHING

by

Daniel J. Twedt
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W. Clell Guest and Bobby W. Farquhar
Texas Parks and Wildlife Department
Fort Worth, Texas 76114

Abstract - We electrofished ten north-central Texas reservoirs from 1987 through 1990 by either dip-netting all electroshocked fishes (intensive dip-netting) or selectively dip-netting only fishes visually identified as largemouth bass Micropterus salmoides. We compared selected indices of population structure (PSD, RSD-38, and YAR) and abundance (CPUE) for largemouth bass derived from data obtained using these two dip-netting techniques. No significant differences ($P > 0.17$) were detected between intensive dip-netting and selective dip-netting for any of these indices of population structure. Similarly, neither the total number of bass collected per h nor the number of small bass (< 20 cm total length) collected per h differed significantly ($P > 0.31$) between dip-netting techniques.

SHORT-TERM WATER QUALITY IN A FISH-HAULING TANK

by

Joe N. Fries, Casey S. Berkhouse and Jacob C. Morrow
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San Marcos, Texas 78666

Abstract - Approximately 900 kg of 229 mm channel catfish Ictalurus punctatus were loaded into a 2,650 L fish-hauling tank (0.34 kg/L of water) at Inks Dam National Fish Hatchery. Tank water was aerated using three 12-volt Fresh-Flo® units and supplied with oxygen at 10 L/min from two 610 mm Wilfley-Weber® diffusers. Water quality was monitored during the 21 min fish were being loaded into the tank and for 4 h after loading. Salinity, conductivity, and total alkalinity remained essentially constant at about 5.5 ppt, 9,000 μ mhos, and 90 mg/L (as CaCO₃), respectively. Temperature rose from 21.7 to 23.5 °C during the test. Dissolved oxygen dropped from about 20 mg/L to 4.6 mg/L while fish were loaded and then down to 2.2 mg/L about 20 min later. By the end of the test, dissolved oxygen had risen to saturation (8.0 mg/L). The pH dropped from 7.70 to 6.70 during the test. Total ammonia nitrogen (NH₃-N) rose to 12.8 mg/L during the test but was predominantly ionized (NH₄⁺). Un-ionized ammonia (NH₃) peaked at 0.025 mg/L within 1 h, and then gradually rose to 0.032 mg/L by the end of the test. Fish were returned to a raceway following the test and showed no excessive mortality after 3 days. Increasing the loading period, reducing the loading density, and increasing oxygen transfer efficiency should help alleviate exposure to the observed low dissolved oxygen.

OBSERVATIONS ON APPARENT SUNBURN IN JUVENILE PADDLEFISH

by

Katherine T. Ramos and Loraine T. Fries
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Casey S. Berkhouse and Joe N. Fries
U. S. Fish and Wildlife Service
San Marcos, Texas 78666

Abstract - Paddlefish Polyodon spathula are being cultured intensively in raceways and extensively in ponds in efforts to restore their populations within the state of Texas. Intensive culture of this species outdoors has proven to be difficult. Efforts by the San Marcos National Fish Hatchery and Technology Center to rear paddlefish fingerlings in outdoor raceways have had limited success. It appeared that some fish had been exposed to sunlight of such an intensity that normal skin growth was affected. Juvenile paddlefish (average total length = 180 mm, average weight = 20 g) were exposed to full sunlight for 1 week followed by exposure to partial sunlight (50% overhead reduction) for several weeks. Fish were assigned three groups with respect to body condition. An equal number of fish from each of these groups were stocked into one raceway in two treatments at a density of 1 fish/7L. One treatment was exposed to full overhead sunlight and the second to partial sunlight (100% overhead reduction). Over a period of 7 weeks mortalities were recorded for each treatment and external effects documented by photography. At the end of the study period, length-weight data for both were collected and body condition evaluated. Percent survival for fish fully exposed and partially exposed was 55% and 87%, respectively. Fish exposed to full overhead sunlight had a greater number of mortalities and exhibited a range of skin abnormalities.

EXAMPLE PREVIEW OF A PREPARED TEXAS PARKS AND WILDLIFE DEPARTMENT
FISHERIES PRESENTATION

by

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Abilene, Texas 79603

Joyce Johnson
Texas Parks and Wildlife Department
Austin, Texas 78744

Steve Magnelia
Texas Parks and Wildlife Department
San Marcos, Texas 78667

Kevin Storey
Texas Parks and Wildlife Department
Tyler, Texas 75707

Abstract - An example of a Texas Parks and Wildlife Department slide presentation is being shown to illustrate what is in the planning stages for information and education exchange to various public groups (such as school classes, fishing clubs, civic groups, etc.). This presentation, "Fish Species Management in Texas," is one of more than 10 topics in preparation. Comments will be appreciated from this peer exposure to aid in the final version that will be distributed to Department staff and available to fisheries biologists in the state.

PHOTOSENSITIVITY OF CHANNEL CATFISH TO OXYTETRACYCLINE

by

Mark Stacell
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San Marcos, Texas 78667

David G. Huffman
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San Marcos, Texas 78666

Abstract - Channel catfish Ictalurus punctatus were injected with oxytetracycline and subjected to sunlight to determine if a synergistic reaction between the two factors would cause lethal photosensitivity of ocular and epidermal tissue. Twenty-six fish were injected with 0.55 mg/kg oxytetracycline while 26 fish from a control group were injected with physiological saline. Half of each group was then exposed to direct sunlight in a shallow lined culture pond while the remaining fish were held in indoor troughs protected from ultraviolet radiation. Within 5 days, all individuals injected with oxytetracycline and exposed to direct sunlight exhibited necrotic ocular and dorsal epidermal tissue. All individuals from this group died within 8 days. Catfish did not exhibit any irregular symptoms. No saline injected catfish from either group exhibited photosensitivity. These results suggest oxytetracycline may cause mortalities if treated fish are held in direct sunlight.

SPATIAL AND TEMPORAL VARIATION IN GENETIC STRUCTURE OF
HYBRID PUFFISH POPULATIONS IN THE PECOS RIVER, TEXAS

by

Gene R. Wilde
Texas Parks and Wildlife Department
Austin, Texas 78744

Abstract - Pecos pupfish Cyprinodon pecosensis is endemic to the Pecos River of eastern New Mexico and southwest Texas. Between 1980 and 1984, sheepshead minnow C. variegatus was introduced into the Pecos River. In 1984, hybrids between the two species were widespread in the river. By 1986, hybrids were present throughout Texas portions of the Pecos River, from Red Bluff Reservoir to Pandale, Texas. Spatial variation in frequencies of alleles diagnostic of sheepshead minnow suggest Pecos, Texas as the most probable site of introduction of that species. Temporal variation in allele frequencies show a general increase in the proportion of alleles diagnostic of sheepshead minnow and a rapid approach to linkage equilibrium among loci.

THE EFFECTS OF VARIOUS CONCENTRATIONS OF
MS-222 AS AN ANESTHETIC FOR PADDLEFISH

by

Chris Caudle and Dennis Smith
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Joe N. Fries
U. S. Fish and Wildlife Service
San Marcos, Texas 78666

Abstract - Tricaine Methane Sulfonate (MS-222) is widely used as an anesthetic for many species of fish. Levels of MS-222 necessary to anesthetize paddlefish Polyodon spathula were unknown. An experiment was conducted which subjected samples of ten paddlefish (mean length = 181 mm, mean weight = 15.8g) to 20, 40, 60, 80 or 100 ppm MS-222 for ten minutes. The time required for 50% of the fish to recover was noted. Weight and total length were also recorded. The fish were then observed each day for 7 days for mortalities. The experiment was run in triplicate. Treatment levels of 40 ppm or less took too long (over 8 minutes) to produce anesthesia to be of practical use in handling fish. Treatment at 100 ppm produces rapid anesthesia but recovery time is very long (over 6 minutes). Though it did not show a significant increase in the number of mortalities, treatment at 100 ppm is not recommended. Treatment levels of 60 and 80 ppm produced fairly rapid anesthesia (2 to 4 minutes) with short recovery times (same range) and appear to be the best concentrations to use in most hatchery situations. However, no differences in mortality were found between the treatments and, barring subtle stress-related effects, the use of MS-222 on paddlefish may be more for the benefit of the culturist than for the fish.

LOSS OF FLOY ANCHOR TAGS FROM WHITE BASS

by

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Texas Parks and Wildlife Department
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Abstract - This study was conducted to estimate tag shedding rates for white bass Morone chrysops in the Brazos River and Whitney Reservoir, Texas and provide information on tag retention and a correction for shedding. Four hundred and eighty-seven white bass were double tagged in 1989 and 215 in 1990 with Floy FD-68BC anchor tags. The mean total lengths of the fish were 342 mm (range = 230-429 mm; SE = 2 mm) in 1989 and 312 mm (range = 123-553 mm; SE = 4 mm) in 1990. Tagged fish were at liberty for up to 560 days and tags were returned by anglers for rewards of \$5, \$10, \$20, \$50, or \$100 for each tagged fish. One hundred and three fish tagged in 1989 were caught (85 in 1989 and 18 in 1990) and 62 fish tagged in 1990 were caught (59 in 1990 and 3 in 1991). Sixteen percent of the returns from the 1989 tagging and 13% from the 1990 tagging consisted of single tags. The shedding rates (= return rates) were not significantly different between tags during both years ($Z = 0.92$; $P > 0.05$). Immediate post-tagging shedding (Type-I), usually resulting from mortality, improper tag placement, and non-reporting by anglers, was negligible. On the other hand, long-term shedding (Type-II) rate, estimated from the slope of a weighted least squares regression of \log_e (proportion of tags retained) versus time up to 560 days, was significantly different from zero ($P < 0.05$), and occurred at a rate of 0.078% per day, or 28.47% per year. This study demonstrated that failure to adjust for Floy FD-68BC tag shedding could seriously bias white bass population parameter estimates.

FLORIDA LARGEMOUTH BASS
RACEWAY SPAWNING MEDIA EVALUATION

by

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Abstract - Florida largemouth bass Micropterus salmoides floridanus traditionally have been spawned in hatchery ponds. Facilities with raceways could potentially intensify largemouth bass production through raceway spawning and artificial incubation of spawns. However, a major factor inhibiting raceway spawning has been finding a suitable nest substrate. This study evaluated six different nest types, including combinations of rock, gravel and artificial Spanish moss, as substrates for raceway spawning of Florida largemouth bass. Each nest type was evenly distributed in two 24 x 2.4 m indoor raceways at the A. E. Wood fish hatchery in San Marcos, Texas. Raceways were stocked with either seventeen or sixteen pairs of five-year-old Florida largemouth bass. Ninety-three percent of the 74 spawns were on nests of artificial Spanish moss. Spawns occurred in all but one location where the artificial Spanish moss mats were placed in the raceways. Successful spawning on artificial Spanish moss nests enabled the intensification of Florida largemouth bass culture through the use of raceways.

AQUACULTURE: BIOREMEDIATION FOR AGRICULTURE AND INDUSTRY¹

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Abstract - The expanding human population throughout the world places people in competition with fish and wildlife for land, water, and air. Because the urban centers of industrialized nations are dependent on extraction of natural resources from less populated rural areas, habitat loss is a recognized threat to a stable environment. Many natural resources, including marine and freshwater fisheries stocks, are being rapidly depleted, which is stimulating the development of aquaculture. Current agricultural and industrial processes produce or concentrate discharges that degrade the environment. Regulations developed to protect the environment require reduction or total elimination of discharges. To comply with these regulations, aquaculture integrated with agricultural and industrial processes can recycle some waste by-products into valuable products while minimizing environmental degradation. Specifically, the marine microalgae Spirulina can be grown in water too saline for traditional agriculture. In addition, Spirulina can also utilize discarded nutrients from cattle feedlots, CO₂ from power plants, and organics from textile mills to produce protein and fine chemicals for use in pharmaceuticals and research. The integration of agriculture, industry, and aquaculture offers the opportunity to build a new environmentally sound agribusiness in Texas.

¹Publication No. T-9-647 of the College of Agriculture, Texas Tech University.

²Jointly supported by Texas Parks and Wildlife Department, Texas Tech University, The Wildlife Management Institute and the U.S. Fish and Wildlife Service.

Over \$9.6 billion worth of fish and fishery products were imported into the United States in 1989 (National Marine Fisheries Service 1990). However, the global catch of 98.4 million tonnes of fish in 1988 was not adequate to meet current and projected demands (National Marine Fisheries Service 1990). The Food and Agricultural Organization estimates that industrialized nations will need an additional 22.5 million tonnes of fish and fisheries products and non-industrialized nations will need 5.9 million tonnes by the year 2000 (Ratafia and Purinton 1989). Depending on regional fertility rates and other factors, the United Nations estimates the global human population to be from 8.5 to 28 billion by the year 2150. At the current rate of expansion the world's population of 5.2 billion is expected to double by the year 2038 (Ratafia and Purinton 1989). Although aquaculture has been expanding globally, present aquacultural production will not satisfy the projected demands of even the most modest population expansion.

Increasing salinization of freshwater supplies limits traditional agricultural production in many arid and semi-arid regions. Saline water unsuitable for traditional crops can be used to culture marine or brackish water algae and fish. These aquaculture products may be marketed as food, bait, or recreational species or may serve as the source for high value pharmaceutical and other biochemical products. Specifically, production of algae and fish using animal wastes from livestock and poultry production systems, saline water from oil production, and CO₂ from power plants can not only provide bioremediation of environmental problems, but also can be the basis for a new agribusiness. In arid and semi-arid regions where intensive solar radiation is conducive to high primary production and other natural resources are available, marine algae has the potential to develop as a new agricultural crop.

Locations in the southwest and especially in the Texas Southern High Plains have the natural resources required to develop efficient, commercial-scale systems for culture of algae and fish using the plentiful livestock waste from feedlots as a nutrient base and saltwater as a culture medium (Parker et. al 1991). Because aquaculture is a form of agriculture, the High Plains area has much of the infrastructure needed to support aquaculture. Potential aquaculture products in such a system include algal protein for direct consumption by fish or zooplankton that are important food organisms for larval fish and several species of adult fish. Other possible products include food fish (Tilapia spp. and red drum Sciaenops ocellatus), caviar from paddlefish Polyodon spathula, and harvested algae. The harvested algae provides products such as animal feeds, health food, and a variety of high value extractable compounds.

The increased demand and declining supply of seafood products worldwide has prompted investors to identify aquaculture as a growing industry. The commercial value of some products (fish and caviar) is known, but the value and identity of other potential products remains unknown. As a food source for livestock and

poultry, algal protein will be more expensive than soya protein (Henson 1990). The cost of algal protein would be lowered by the scale of the production system and the high value of products extracted from the algae (e.g., pigments, pharmaceuticals, reagents).

Algal lipids containing omega-3 fatty acids should be more valuable than fish oils; however, if consumer concern about contaminants in marine fish increases, algal-derived fatty acids could command a higher price. Engineering improvements in the development of water reuse systems to conserve fresh water and development of aquaculture production systems to use saline waters would be a marketable technology of increasing value worldwide.

Agricultural and Industrial Problems

A large portion of the earth has an arid or semi-arid climate. In the United States, irrigation technology and development of drought-tolerant crops have resulted in agricultural development of arid and semi-arid lands. Irrigation has been a tremendous boon to our agricultural production and economy, but it is not without drawbacks. Water used for irrigation on U.S. farms was only 269 billion liters annually in 1940 but peaked at 568 billion liters in 1980 (U.S. Bureau of Census 1990). Analysis of these data indicate this increase was not due to population growth alone; daily per capita consumption of water increased from 3,887 liters in 1940 to 7,392 liters in 1989 -- an increase of 90% in 40 years. Withdrawal of ground water from the Ogallala Aquifer, estimated to contain $0.5 \times 10^{12} \text{ m}^3$ of drainable water (Weeks and Gutentag 1984), has increased in the High Plains to support population growth and extensive agricultural production (Nativ 1992). In many areas, withdrawal of water for irrigation has been blamed for alarming declines in the level of the Ogallala Aquifer. Due to concern for the increased cost of pumping water, some farmers have ceased irrigation. Irrigated agriculture is responsible for salinization of soils and water (Camp 1963). Some areas of the arid southwest that formally produced agricultural crops are now fallow because of the presence of subsurface saline water and an accumulation of salts at the surface. The relation between these changes and water withdrawal from the Ogallala Aquifer is unclear.

Natural sources of salt water are a liability to traditional agricultural development. Because brine springs are found throughout much of the arid western United States, several retention dams have been built to contain the salt water and protect downstream freshwater supplies. Several other containment dams have been authorized but not yet funded by Congress. The oil industry in Texas, valued at \$17 billion in 1988 (Kingston 1989), produces considerable quantities of oil-contaminated brine -- in some cases, one barrel of brine is produced for each barrel of petroleum pumped to the surface. Brine water must be re-injected into deep wells or contained on the surface. Bioremediation to

remove the hydrocarbon from the brine (Sims 1991) could condition it for use in aquaculture.

In addition to water consumption by crops, large cattle feedlots that require relatively large amounts of fresh water exist in Texas. Cattle are typically maintained in feedlot pens for 120-150 days while they gain weight from an initial 200-400 kg to about 500 kg at time of slaughter (Bush 1992). In 1989, over five million head of cattle were shipped from feedlots in the Southern High Plains (Texas Agricultural Statistics Service 1989). Recent trends have been to develop large feedlots; in 1989, 198 feedlots accounted for 51% of the nation's output of fed cattle. A typical feedlot will have 50,000 to 100,000 head of cattle at one time. Each feedlot steer annually excretes approximately 10 tonnes of waste (88.2% moisture) per 454 kg of live weight (Midwest Plan Service 1975). The concentration of waste resulting from these and other intensive agricultural operations such as swine, poultry, and dairy creates severe waste management problems. In addition to potential environmental damage, there are economic aspects associated with disposal of this waste. The Environmental Protection Agency has recently fined dairy farmers for groundwater pollution. Several fines have been in the \$10,000 range, and at least one fine was \$85,000.

Interaction with Migratory Waterfowl

Individual feedlots are frequently sited on sloping land to provide adequate drainage. On the High Plains, much of the surface drainage flows into one of the 20,000 playa lakes. These typically shallow, and often ephemeral, basins are believed to be the predominant recharge zones for the underlying Ogallala Aquifer and exchange rates greater than 30 mm/yr have been reported (Nativ 1992). Playas receiving runoff from cattle feedlots typically contain water throughout the year and often contain open water during the winter when other bodies are covered with ice. During harsh weather, waterfowl actively feed on grain spread throughout the feedlots and occasionally feed directly from cattle feed troughs. Under damp conditions much of this grain may mold and contain levels of aflatoxin or other mycotoxins at levels high enough to stress waterfowl. The population of migratory waterfowl on feedlot playas has been as high as 40,000 geese and 40,000 ducks on an approximately 18-hectare playa in Castro County, Texas (Personal communications, H. Miller, U. S. Fish and Wildlife Service, Lubbock, Texas). This high concentration of birds increases the likelihood of disease; however, avian cholera is not restricted to feedlot playas. Avian cholera is frequently found in birds on playas not associated with feedlots.

The potential effects of waterfowl ingesting organic and inorganic contaminants associated with runoff from cattle feedlots have not been fully explored; however, contaminants are expected in waterfowl. The occurrence of avian cholera has been linked to presence of mycotoxins on moldy waste grains and may be the cause

of epizootics (Higgins et. al 1992). Water analyses from sites receiving feedlot runoff were reported to have elevated concentrations of ammonia, calcium, chemical oxygen demand, chlorophyll a, coliform bacteria, conductivity, magnesium, total Kjeldahl nitrogen, sulfates, and volatile suspended solids (Irwin and Dodson 1991).

Playas receiving effluent from feedlots can be protected by incorporating them as the final stage in a wastewater treatment facility. Waste treatment systems for cattle feedlots can be designed to include a series of anaerobic and aerobic oxidation lagoons with either (1) no discharge or (2) discharge of water of quality much greater than that now found in playas associated with feedlots. Adoption of these techniques would allow economical screening of the small, anaerobic, first-stage ponds if exclusion of migratory waterfowl from these ponds were desirable. The second- and third-phase ponds can provide a healthy habitat for migratory waterfowl and the production of economically important fish species, including fish for bait, recreation, and food.

Organic wastes from cattle feedlots provide an untapped nutrient base to support aquacultural operations. Specifically, anaerobically digested nutrients from feedlot wastes can be converted through aquaculture to algal protein for inclusion in animal feeds, including fish feed. A pilot project has been developed to produce freshwater microalgae such as Chlorella and Scenedesmus or to produce marine algae such as Spirulina (Parker et al. 1991; Parker et al. 1992), when using saline water. Manure collected from cattle feedlots and anaerobically digested and combined in a 50:50 ratio with synthetic sea salts (Instant Ocean) supported daily growth of Spirulina up to 785 mg/L (Table 1; Bates 1992). This level of production is far greater than the 60 mg/L considered acceptable on commercial Spirulina farms (Richmond 1986). The microalgae may (1) be harvested and fed without drying to livestock, swine, and fish, (2) be dried to produce a protein rich (65-70%) powder for formulated rations, (3) be harvested directly by phytoplanktivorous fish and molluscs, or (4) serve as the base stock for extraction of pharmaceuticals, fine chemicals, and other bioextracts.

Aquaculture: A Bioremediation Alternative

Fish production in ponds is based on surface area and is greatly regulated by ambient temperature. Natural ecological processes in ponds are used to convert waste products to nontoxic forms. To attain high production in limited water volumes in temperate climates, fish can be cultured indoors, where temperature can be controlled to speed up fish growth and degradation of waste metabolites. Control of temperature allows continuous production, thereby increasing total annual production, and allows the culture of warmwater fishes in locations that would otherwise be unsuitable. Environmental control in water reuse systems allows great flexibility in the types of fish that can be produced.

However, there are two constraints: (1) the products must be sufficiently high in value to compensate for the additional costs of construction and operation of the facility, and (2) the animals reared must tolerate high-density crowding. In arid regions of the world, it may be prudent to rear and sell fry and fingerlings to other fish farmers with more abundant water supplies. Other species could be produced to meet specialty markets such as hobby fish, molluscs, shrimp, bait fish, and aquatic plants. Markets for aquatic plants include sale of cultured plants not only as a protein source, but also as ornamentals, as nursery stock to restore degraded wetlands, as stock to construct wetlands, and as bioaccumulators of toxic metals (Dunbabin and Bowmer 1992; Lan et al. 1992).

Summary

Locations in the southwest, and especially in the Texas Southern High Plains, have the natural resources to develop efficient, commercial-scale systems for culture of algae and fish using livestock waste from feedlots as a nutrient base, saltwater as a culture medium, the intense solar irradiation and other associated components. These natural resources, the abundance of level farm land easily modified to support raceways for algae and fish, the presence of farm equipment, labor, natural gas and CO₂, and the high production rate of Spirulina grown on a cattle waste medium provide encouragement for development of a new agribusiness in the Southwestern United States. Aquaculture provides an attractive method for bioremediation of feedlot runoff into playa lakes.

Hydrocarbon degrading microorganisms can detoxify petroleum spills. Phytoplankton can use the degraded petroleum as a source of carbon and, when provided a nitrogen source, grow at a rapid rate. On-site bioremediation of aquatic environments can be combined with aquaculture to improve water quality, not only for fish and wildlife, but also before recharge to underlying aquifers.

The potential of aquaculture seems to be unmatched by any other sector in the agricultural community in Texas. Semi-arid and arid regions can support significant aquacultural operations if approaches are taken to use natural resources available locally, to produce products of special interest and high value, and to develop the infrastructure to become an integral part of agriculture and other industries.

Acknowledgments

We thank R. Patino, U.S. Fish and Wildlife Service, Lubbock, Texas, L. Smith, J. Winter, Texas Tech University, Lubbock, Texas and two anonymous reviewers for constructive criticism of the manuscript.

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Table 1 - Mean daily growth rate (mg/L) of *Spirulina platensis* cultures after 144 hours of culture in growth media formulated with Instant Ocean and five concentrations of cattle waste (either feedlot lagoon water (lagoon water), anaerobically digested cattle waste (digested effluent) or simple cattle waste leachate (leachate)) and fresh water (Bates 1992).

Treatment no.	Concentration (cattle waste: fresh water)	Final daily growth rate (mg/L*)		
		Lagoon water	Digested effluent	Leachate
1(control)	0:100	61 ± 41 ^{ab}	235 ± 74 ^{ab}	157 ± 11 ^{abAB}
2	12.5:87.5	225 ± 41 ^{ba}	384 ± 70 ^{ab}	184 ± 16 ^{ba}
3	25:75	228 ± 37 ^{ba}	637 ± 129 ^{bb}	128 ± 14 ^{ba}
4	50:50	363 ± 41 ^{ca}	785 ± 28 ^{bb}	128 ± 21 ^{aba}
5	100:0	213 ± 14 ^{ba}	381 ± 73 ^{ab}	149 ± 20 ^{aba}

*All reported values are treatment means ± standard error (n = 4). Any two means in a column not followed by a common lowercase superscript are significantly different (P < 0.05) as determined by a CRD ANOVA and Fishers protected LSD means separation test. Any two means in a row not followed by a common uppercase superscript are significantly different (P < 0.05) as determined by a CRD ANOVA and Fishers protected LSD means separation test.

PREVENTION OF A RECURRING VEGETATION PROBLEM
BY TRIPLOID GRASS CARP

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Abstract - In July 1990, triploid grass carp Ctenopharyngodon idella were stocked at a rate of 2.5 per hectare in Weatherford Reservoir (445 hectares) to control aquatic vegetation. Weatherford Reservoir had serious vegetation problems during years prior to stocking; however, during 1990, floods and high turbidity had virtually eliminated all macrophytes with the exception of bulrush Scirpus sp. To determine grass carp effectiveness during the study period, August 1990 to July 1991, eight enclosure cages were sampled, transects were established and a grappling hook was used to sample vegetation along transect lines, and stomach samples from eight grass carp captured during the study were analyzed. Enclosures were devoid of vegetation until July 1991, when significant growths of Potamogeton sp. and Nelumbo lutea were found. Throughout the study no vegetation was found along transect lines. Bulrush comprised nearly 100% of the plant material in grass carp stomachs. Only one specimen, captured in July 1991, had a measurable amount of Potamogeton in its gut. Our results support a hypothesis that when vegetation has been reduced, control may be achieved by stocking grass carp at a low density. This could be an effective management tool in certain situations by reducing the number of grass carp needed for vegetative control, therefore reducing the cost of control and the risk of escapement.

Excessive amounts of aquatic vegetation may create problems in aquatic systems. Recreational activities such as boating, fishing, and swimming can be impeded. The use of the system as a water supply can also be hindered. Excessive vegetation has also been associated with reduction in standing crops of some fish species (Maceina and Shireman 1982). Techniques for controlling aquatic vegetation (physical and chemical) are usually expensive, ineffective over long periods of time, and can be ecologically detrimental (Shireman 1982; Allen and Wattendorf 1987). Biological

controls are relatively cost-efficient, but questions remain about their safety and effectiveness.

The effectiveness of grass carp Ctenopharyngodon idella at controlling aquatic vegetation has been documented frequently since their introduction into the United States (Leslie et al. 1983; Klussman et al. 1988; Tanner et al. 1990). However, apprehension exists that grass carp could begin natural reproduction and range expansion after introduction. This apprehension has been compounded by documentation of grass carp spawning in North America (Conner et al. 1980; Zimpfer et al. 1987; Brown and Coon 1991). To eliminate the possibility of unchecked natural reproduction, functionally sterile triploid grass carp (triploids) have been developed (Allen et al. 1986; Allen and Wattendorf 1987; Van Eenennaam et al. 1990). This study was part of a larger study funded by the Texas Parks and Wildlife Department (TPWD) to determine if the use of triploids could be a safe and effective method for controlling noxious aquatic vegetation in the waters of Texas. Specifically, the objective of this study was to determine if triploid grass carp, stocked at low rates, would prevent the recurrence of vegetation problems after vegetation reduction by other means.

Study Area

Weatherford Reservoir is a 445-hectare impoundment on the Clear Fork of the West Fork of the Trinity River. Mean and maximum depths are 4.6 m and 12.5 m, respectively. The reservoir is located in Parker County, Texas about 50 km west of the Dallas-Fort Worth metroplex and is used extensively for recreational activities and as a water supply for the city of Weatherford. In years prior to stocking, Weatherford Reservoir had experienced nuisance levels of aquatic vegetation, primarily Eurasian watermilfoil Myriophyllum spicatum. During the summer of 1988, surface coverage of aquatic macrophytes was estimated at over 50%. The excessive growth of vegetation began interfering with reservoir usage and vegetation control was deemed necessary. However, as a result of flooding and high turbidity in the spring, by summer 1990 the reservoir was virtually devoid of vegetation, with the exception of bulrush Scirpus sp. stands. This presented the opportunity to determine if the grass carp could be used to prevent the recurrence of the vegetation problem.

Methods

During July 1990, 1,100 triploids were stocked at a rate of 2.5 per surface hectare into Weatherford Reservoir. Three methods were used from August 1990 to July 1991 to evaluate the effectiveness of triploids at preventing the recurrence of vegetation in Weatherford Reservoir. The study period was dictated

by the time frame established by the parent TPWD study and sampling after July 1991 was not possible.

Exclosure cages were used to determine if macrophytes would return or grow differently in areas protected from triploids. The cages were 2m x 3m x 2.5m high and were constructed of iron pipe and coated mesh screen. Four cages were placed at each of two sites in the reservoir (Figure 1). Two T-bar posts were used to mark an equal and corresponding area directly to one side of each cage. The inside and outside areas of the cages were each divided into 24 equal grids of 0.25m² each. Corresponding grids, from inside to outside and from cage to cage, were assigned identical alphanumeric labels (Figure 2). Exclosure cages were sampled in August and November 1990, and in July 1991. On each sampling date, three grid labels were randomly selected and sampled inside and outside of each cage. The grids were sampled by placing a metal, bottomless trash can onto the grid and removing all vegetation found within the trash can. Vegetation was then sorted, identified and weighed. Non-sampling visual observations were made every other month during the study, both in and near the cages and in other areas of the reservoir.

For analysis, plant weights from inside all cages at each site were pooled and compared to weights pooled from outside all cages at each site for each sampling period. Data were compared using a Wilcoxon nonparametric test.

In order to document vegetation growth, thirteen transects were established representing different areas of the reservoir (Figure 1). The transects were sampled using a metal grappling hook attached to a 10-m section of rope. Working from the shore outward, the grappling hook was tossed approximately 10 m from a boat toward the shore and parallel to the transect line at 0.3 m depth intervals. Samples were not taken in depths in excess of 4 m. The hook was dragged along the bottom of the reservoir while being retrieved. As with cage samples, any vegetation retrieved was sorted, identified and weighed. Transect lines were sampled bimonthly from August 1990 through December 1990. For the duration of the study, transects were sampled with random grappling hook tosses at approximately bimonthly intervals. Described techniques were discontinued due to lack of vegetation growth. Random tosses were used as an indicator. Had any vegetation been retrieved using random tosses, the original sampling regime would have been resumed.

Bimonthly electrofishing and gillnetting surveys conducted as part of the larger study to monitor fish populations resulted in the capture of eight triploids. To determine food habits, captured triploids were placed on ice and returned to the lab for analysis. The entire stomach was removed and contents were sorted and identified by species. A dissecting microscope and aquatic macrophyte taxonomic keys were used to identify vegetation types found. Volume was measured by displacement for each type of food item found in each fish. Percent volume and percent occurrence were calculated.

Results

No vegetation, with the exception of bulrush (which was never found inside exclosure cages), was observed anywhere in the reservoir until July 1991. During the July 1991 sample period, vegetation appeared inside all cages. At site 1, a total of 8,399 g of pondweed Potamogeton sp. and 4 g of coontail Ceratophyllum demersum were found in samples inside the cages, while only 1 g of pondweed, and no coontail, was found in the outside samples. Dense mats of pondweed were visible inside all four cages at site 1. At site 2, 1,452 g of American lotus Nelumbo lutea were weighed from the inside samples, while no vegetation was found in the outside samples. American lotus was observed inside of all four cages at site 2, but was found nowhere else in the reservoir. Using the Wilcoxon test, weights of vegetation inside cages were significantly greater ($P < 0.05$) than weights outside cages at both sites during the July 1991 sample.

Transect sampling continued through July 1991; however, no vegetation was retrieved using the grappling hook. No vegetation, with the exception of bulrush, was visible along or near the transect lines.

Gut analysis was conducted on eight triploids captured from Weatherford Reservoir. Dates of capture ranged from November 1990 through July 1991. Bulrush was the only food item detected in six fish captured before July 1991. Of the remaining two fish caught in July 1991, one contained bulrush and pondweed, and the other was empty. Volumes of bulrush content ranged from 5 ml to 520 ml, with a mean of 176.4 ml. Volume of pondweed was 30 ml. Percent volume of bulrush and pondweed was 98% and 2%, respectively. Percent occurrence for bulrush and pondweed for the eight fish captured was 87.5% and 12.5%, respectively (Figure 4).

Discussion

Exclosure cage data from Weatherford Reservoir indicates that triploids were effective in preventing the recurrence of vegetation. The fact that little or no vegetation was sampled from the outside areas of the cages while vegetation was found inside all of the cages (July 1991) suggests that triploids were controlling vegetation growth in the reservoir in 1991. In addition, the transect data revealed no vegetation, again suggesting that triploids were preventing the growth of aquatic macrophytes.

Throughout most of the study, the only vegetation found in either the reservoir, or in gut analysis of triploids was bulrush. Pondweed only appeared in one fish captured in July 1991, corresponding to the growth of pondweed in the cages at site 1. However the volume of pondweed only comprised 5.4% of the content of that gut, while bulrush made up the rest. Apparently, pondweed was growing outside the cages and was being cropped off by triploids, therefore preventing the formation of dense mats. This

could have also been true for other types of vegetation. Triploids probably foraged on tender shoots of American lotus as they sprouted from the bottom. Consequently, the only established stands of American lotus were located inside enclosure cages. The amount of other vegetation available (none found during transect surveys) to triploids was so low compared to bulrush, it is not surprising that other plant species did not show up in gut analyses, especially with a sample size as low as eight fish (only two of which were sampled from the period when vegetation was observed in the enclosure cages).

The effectiveness of both diploid and triploid grass carp at controlling aquatic vegetation is well established, however, in most instances they were stocked at high densities into waters experiencing severe vegetation problems. Vegetation coverage was approximately 45% in Lake Conroe Reservoir when grass carp were stocked at a rate of 33 per surface hectare (Klussman et al. 1988). Eradication of vegetation was achieved within two years. Greater than 99% reduction of aquatic macrophytes was documented when grass carp were stocked at 30 per surface hectare in Lake Parkinson, New Zealand (Tanner et al. 1990). Similarly, Van Dyke et al. (1984) reported that grass carp stocked at 50 per surface hectare totally eliminated hydrilla Hydrilla verticillata from three central Florida reservoirs. Triploids are nearly as efficient as diploids in feeding, and at controlling aquatic vegetation (Wattendorf and Anderson 1984; Wiley and Wike 1986).

The combined advantages of high efficiency and virtually no reproductive potential associated with triploids have led 24 states in the U.S. to allow their use for vegetation control, however some questions still remain. One concern is that unregulated and extensive stocking of large numbers of triploids could result in a situation similar to a reproducing population if escapement and subsequent restocking occurred frequently. Grass carp have been noted for their ability to escape whenever possible (Noble et al. 1986). Trimm et al. (1989) suggested that several verified reports of grass carp found in Texas were the result of escapement. There are two methods which could be used in conjunction to alleviate this problem. The first is a strict regulatory process which would reduce the numbers of triploids stocked and restrict stocking to low risk areas. The other is to determine methods that allow the use of triploids at lower stocking rates while still achieving the desired amount of vegetation control.

Apparently, triploids can be stocked at reduced rates in certain situations and produce desirable results. In this study, a reservoir that had experienced a severe vegetation problem was stocked with triploids at a time when vegetation levels had been reduced by floods and high turbidity. Although the stocking rate of 2.5 per surface hectare was considerably less than rates used in other studies (30 per hectare, Tanner et al. 1990; 33 per hectare, Klussman et al. 1988; 50 per hectare, Van Dyke et al. 1984), triploids prevented the recurrence of the vegetation problem during the study period. The project ended too soon to justify firm conclusions. However, the data support a hypothesis that nuisance

aquatic vegetation, once depleted by catastrophic or other means, can be controlled by stocking triploid grass carp at low densities. The advantages include reductions in the costs associated with stocking the fish, and a reduction in the chance of escapement and the associated risks. While we realize this may not be feasible in all situations, especially where natural reductions have not occurred and chemical or mechanical methods of reduction are not possible, or are impractical, triploids may be an effective management tool in certain situations. Therefore, further studies to rigorously test this hypothesis are warranted.

Acknowledgements

This study was supported through the Texas Parks and Wildlife Department. Funds were allocated by 1989 Texas State Legislative action Appropriation Rider No. 39. We thank Richard Luebke and John Prentice for support and suggestions during the course of the study, and Todd Viola, John Chamberlin, Leo Garcia, and David Wilson for technical support.

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Figure 1. Map of Weatherford Reservoir indicating the locations of vegetation sampling transects (lines) and sites of the enclosure cages (rectangles) used in the triploid grass carp study.

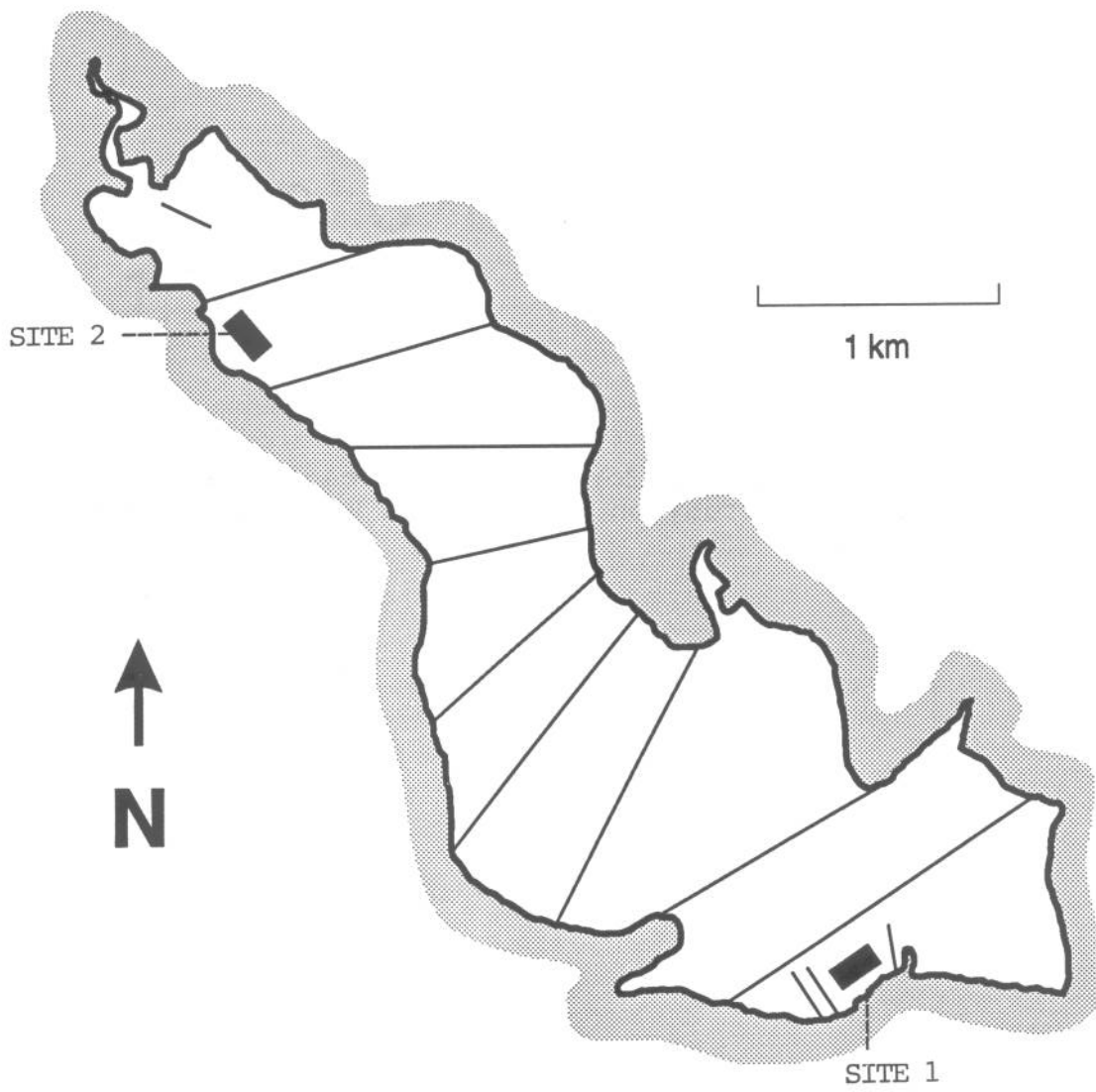




Figure 2. Labeling scheme for exclosure cages used in triploid grass carp study on Weatherford Reservoir, August 1990 - July 1991.

	A	B	C	D	A	B	C	D
1								
2								
3								
4								
5								
6								
	OUTSIDE				INSIDE			

Figure 3. Total weights of vegetation sampled inside and outside of exclosure cages during triploid grass carp study on Weatherford Reservoir, August 1990 - July 1991.

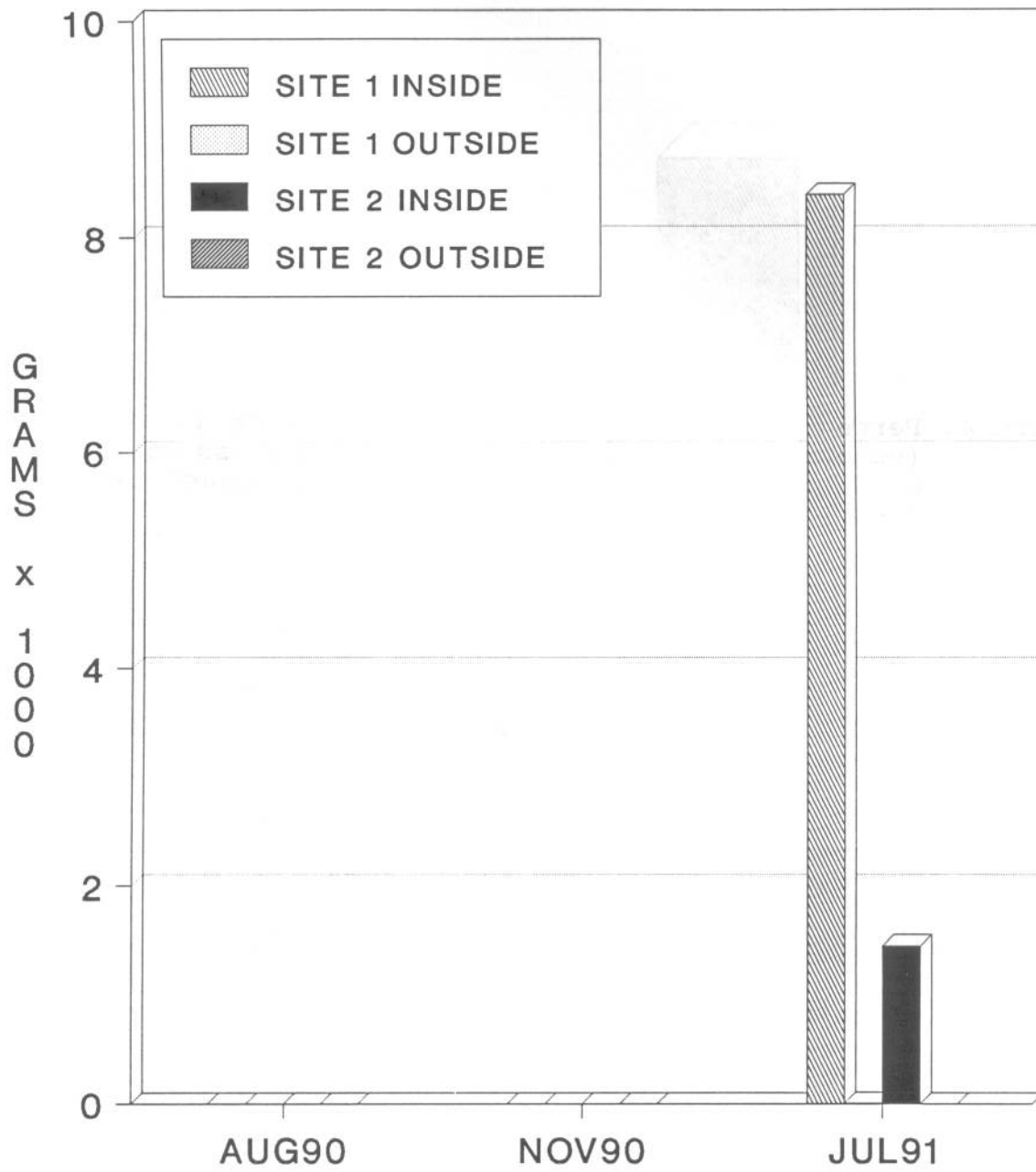
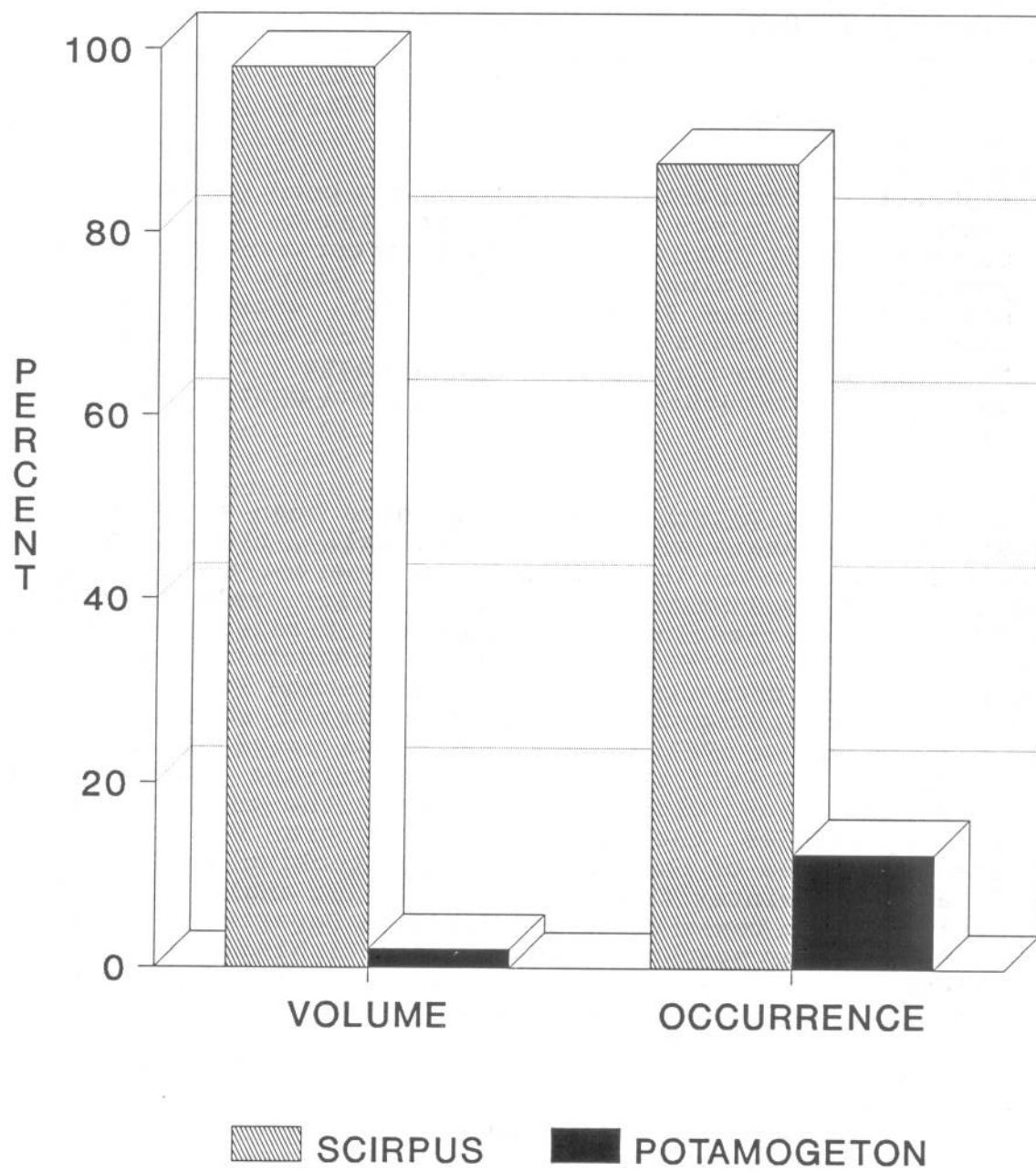




Figure 4. Percent volume and percent occurrence of food types (vegetation) found in eight triploid grass carp stomachs examined from Weatherford Reservoir, August 1990 - July 1991.



ECONOMICS OF THE TEXAS FRESHWATER TROUT PROGRAM

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Abstract - A freshwater trout stamp has been required for Texas trout anglers since 1986 to finance the state's trout stocking program. The cost effectiveness of this program was evaluated for fiscal years 1986-1990. Revenues from the \$5 trout stamp fell short of total costs in all 5 years. Most of the deficit was attributed to increased trout prices and labor costs. From FY 1986 to FY 1990 revenues increased by 95% and costs increased by 165%.

Rainbow trout Oncorhynchus mykiss have been stocked annually in Texas public waters since 1966. Initially, trout were stocked in tailrace areas below large mainstream reservoirs where low water temperatures allowed summer survival. Earlier evaluation of these put-and-take fisheries indicated stocking of rainbow trout was an effective and economically justified management technique to increased fishing pressure and harvest (Forshage 1976). Due to the popularity of the program, winter stocking of small, state-park reservoirs began in 1983. These fisheries provided recreational and economical benefits similar to tailrace fisheries plus increased visitation (Ott 1985). Based on the success documented in the early studies, the rainbow trout program was expanded.

The objectives of the rainbow trout stocking expansion was to provide a unique winter fishery to more Texas anglers, to increase park visitation at Texas Parks and Wildlife Department (TPWD) state parks during winter months and to increase fishing opportunities in urban areas, particularly for young, non-experienced anglers and/or physically challenged. Water body stocking criteria included all TPWD-owned reservoirs and reservoirs and streams in urban areas (populations > 75,000). Reservoirs stocked had to be < 40 hectares, open to the public and have good bank fishing access. The number of trout stocked annually in public waters increased from 10,000 in 1966 to over 290,000 in 1990.

On 1 January 1986 the 69th Texas legislature passed the Texas Freshwater Trout Stamp Act. This law requires a \$5 freshwater trout stamp for any person (over 17 or under 65 years of age) taking or attempting to take trout (any species of the family

Salmonidae) from public waters. This stamp is required in addition to a valid fishing license. Justification for this additional license requirement was to achieve economic efficiency by applying a user fee to participants of the fishery.

At least 25 other states require trout anglers to purchase a stamp permit in addition to a general fishing license (Radonski, 1986). However, there is a lack of documentation regarding the net economic effect of these programs. Peery (1967) reported a \$1 daily fee on a Virginia trout stream was accepted by anglers and sufficient money was generated to pay for most of the expenses. He indicated normal revenues from sales of fishing licenses would not support this fishery. Gilliland (1989) reported income sales of a special trout license exceeded trout stocking costs at Roman Nose State Park and Resort in Oklahoma. The objective of this study was to compare costs of the Texas trout program with revenues generated by freshwater trout stamp sales.

Methods

The number of rainbow trout stocked in public waters and cost of the trout program to the TPWD were compiled for fiscal years 1986 through 1990. Fiscal years (FY) were from 1 September, to 31 August. Hatchery costs (trout purchase price, transportation, feed and labor) and administrative costs (trout stamp printing costs and license vendor cost, a \$.50 fee for each stamp sold by private vendors) were compiled. Information on hatchery costs, administrative fees and license and stamp sales were obtained from TPWD records. Mean hatchery cost per trout stocked was determined by dividing total hatchery cost by the number of trout stocked in public waters.

The number of trout stamps sold each fiscal year was multiplied by \$5 to determine total revenue and total program cost was subtracted from total revenue to determine net income or loss for each fiscal year.

Results and Discussion

The number of rainbow trout stocked increased 29% from FY 1986 to FY 1990 (Table 1). The number of reservoirs stocked during this same time increased 409%. Stocking philosophy was to increase the number of rainbow trout fisheries, primarily in urban areas and state parks, to increase public participation and trout stamp sales.

The total cost of the trout program increased 165% from FY 1986 to FY 1990. Most of the increases were due to higher trout purchase prices and increased transportation and labor costs (Table 2). All trout were obtained from out-of-state sources and transported to Texas hatcheries or directly to stocking sites. As the trout program expanded, many of the new sites were farther from the hatcheries supplying trout. The sharp cost increase in FY 1988

coincided with a doubling in number of reservoirs stocked. Hatchery cost per stocked trout increased from \$0.33 in FY 1986 and FY 1987 to \$0.66 in FY 1988 with labor and transportation costs accounting for 81% of the increase. Hatchery cost per trout further increased to \$0.70 in FY 1990. Increases in trout purchase price plus transportation and labor costs account for this increase.

Administrative cost increased by 86% from FY 1986 to FY 1990. Most of this increase was related to the vendor fee for the sale of stamps since private vendors sell 94% of all stamps.

Trout stamp sales climbed steadily from FY 1986 through FY 1989, but declined in 1990 (Table 2). Trout stamp sales and revenues increased by 95% during the 5-year period. Revenues generated from trout stamp sales never exceeded costs of the trout program; a \$279 deficit in FY 1986 increased to \$58,689 by FY 1990.

The trout stocking program generated revenues external to its own budget, such as greater visitation receipts in state parks where trout stocking occurs (Anderson 1972, Ott 1985, Gilliland 1989). In addition the value of recreation provided, value of fish harvested and revenue provided to local economies has been a significant component in economic assessments (Forshage 1970; Ott 1985). We did not conduct a full economic impact analysis of this program. Therefore, we cannot determine at this time whether or not the program's deficit budget is offset by associated economic benefits.

Evaluating the effectiveness of the trout program solely on the basis of revenue to TPWD misses some very important components of the economic impact of the stocking program. Intangible benefits also have to be considered. One of the objectives of the trout program is to increase fishing opportunities for young anglers. Because formative childhood years exert a major influence on an individual's choice of recreational activity (McBride 1978), angling by youngsters will have the added benefit of introducing this form of recreation to persons who may enjoy it throughout life. For example, Bevin et al. (1968) reported 93% of all northeastern fishermen had participated in fishing during their youth.

Although the program is beneficial to Texas anglers it is not self-sustaining, in spite of the trout stamp. To reduce cost, careful scrutiny of the program should be made. Cost containment efforts for stocking, such as route-optimization algorithms for stocking trips and buying trout through competitive bids have been implemented. Stocking frequency, number and location of stocking sites, and angler use of existing sites need to be evaluated to insure cost efficiency.

If budget restrictions limit program expansion or subsidy, alternate revenue sources or cost cutting measures may be necessary. For example, all users could be required to purchase trout stamps like the Texas archery, waterfowl and white-wing dove stamps. Several states require a trout stamp for minors and senior citizens but provide it at a discounted price. To eliminate vendor costs, vendors could charge an extra \$0.50 for trout stamps to

allow the TPWD the full \$5 from each stamp sold. Cities that have trout fisheries could also be asked to contribute funds to keep or expand stocking programs. Another alternative is to increase the price of the trout stamp. An increase to \$7 would provide sufficient revenue to cover the cost of the program, based on FY 90 figures.

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Table 1. Texas Parks and Wildlife Department rainbow trout stocking history by fishery type (state park reservoirs, tailrace areas, or urban reservoirs), for fiscal years (FY) 1986 through 1990.

Description	FY 1986	FY 1987	FY 1988	FY 1989	FY 1990
Number of trout stocked	226,540	281,629	231,818	287,040	291,602
Number of State Parks	6	6	7	16	19
Number of Tailrace Areas	2	2	2	3	3
Number of Urban Reservoirs	3	7	17	26	34

Table 2. Cost, revenue and net income associated with the Texas Parks and Wildlife Department rainbow trout program for fiscal years (FY) 1986 through 1990.

Description	FY 1986	FY 1987	FY 1988	FY 1989	FY 1990
Hatchery Cost					
Transportation	\$22,349	\$21,489	\$25,000	\$25,000	\$30,000
Feed	\$1,200	\$1,200	\$1,500	\$1,500	\$1,500
Trout	\$26,451	\$27,311	\$30,500	\$50,000	\$60,000
Labor	\$24,177	\$42,938	\$96,000	\$98,594	\$112,621
Sub Total	\$74,177	\$92,938	\$153,000	\$175,094	\$204,121
Administrative Cost					
Stamp Printing	\$1,957	\$4,045	\$2,569	\$2,949	\$2,853
Vendors	\$7,870	\$8,742	\$12,639	\$15,619	\$15,385
Sub Total	\$9,827	\$12,787	\$15,208	\$18,568	\$18,238
Total Cost	\$84,004	\$105,725	\$168,208	\$193,662	\$222,359
Revenue					
Number Stamps Sold	16,745	18,599	26,892	33,232	32,734
Total Revenue	\$83,725	\$92,995	\$134,460	\$166,160	\$163,670
Net Income	-\$279	-\$12,730	-\$33,748	-\$27,502	-\$58,689

TEXAS CHAPTER AWARDS CRITERIA

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, then honorable mention awards 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 one 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;
- c. The presentation must not be on data presented elsewhere; and
- 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. Scientific and research value - 20 points;
- b. Management value - 15 points;
- c. Scope - 10 points;
- d. Verbal presentation - 20 points;
- e. Audio-visual presentation - 15 points;
- f. Conciseness and clarity - 10 points;
- g. Intelligent discussion stimulated - 5 points; and
- 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 either on cumulative point totals or relative rankings.

ACKNOWLEDGMENTS

Reviewers for the technical papers in the 1991 Annual Proceedings of the Texas Chapter of the American Fisheries Society were: Dr. Robert Edwards, Bobby Farquhar, Loraine Fries, Dr. Clark Hubbs, Dr. Maurice Muoneke and Dr. Bobby Whiteside. Their efforts are greatly appreciated.

Thanks to Annette M. Sudyka, Texas Parks and Wildlife Department, for her assistance in putting the Proceedings together and to Dr. James Davis and Lee Bartlett, Texas Agricultural Extension Service for their assistance in arranging reproduction and binding of the Proceedings.

Citation:

Author. 1992. Title. Annual Proceedings of the Texas Chapter,
American Fisheries Society 14:pages.