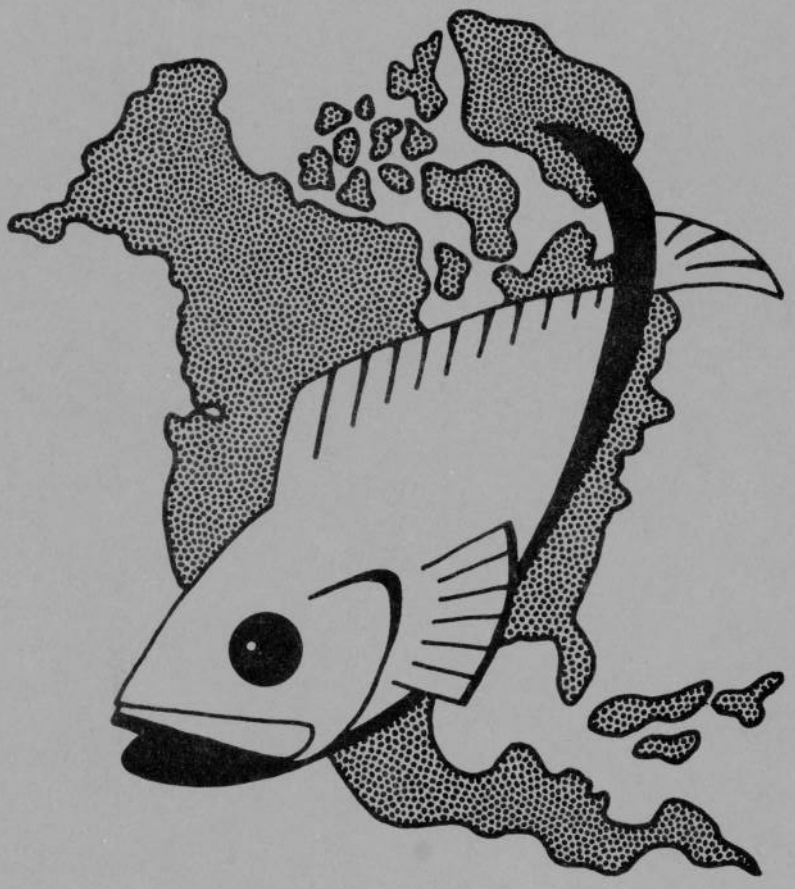
ANNUAL PROCEEDINGS of the TEXAS CHAPTER AMERICAN FISHERIES SOCIETY



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TEXAS CHAPTER

OF THE

AMERICAN FISHERIES SOCIETY

The Texas Chapter of the 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 by 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 the Secretary-Treasurer, Valerie Morrill at 1102 S. 7th St., Copperas Cove, TX 76522. Annual membership dues are $8 for Active Members and $5 for Student Members.

ANNUAL PROCEEDINGS OF THE TEXAS CHAPTER

AMERICAN FISHERIES SOCIETY

October 31 and November 1, 1986

Southwest Texas State University
San Marcos, Texas

1987

TABLE OF CONTENTS

CONTRIBUTORS

The following companies made contributions to the Texas Chapter, American Fisheries Society in 1986:

CONTRIBUTORS	PRODUCT OR SERVICE
ADPI ENTERPRISES, INC. 3621 "B" Street Philadelphia, Pennsylvania 19134 800-621-0275 (215)425-8866	Manufacturer of plastic netting
AQUACULTURE ENTERPRISES Rt. 2, Box 234B Seguin, Texas 78155	Catfish, bass fingerlings
BASS'N GALS, INC. P. O. Box 13925 Arlington, Texas 76013 (817)265-6214	Nonprofit professional fishing organization for women
BOATCYCLE MANUFACTURING CO. Box 494'Henderson, Texas 75652 (214)657-3791	Fish farming supplies
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COMMON SENSING, INC. 7595 Finch Road, N.E. Bainbridge Island, Washington 98110 (206)842-4873	Total dissolved gas and oxygen meters, water quality consulting, analytical gas chemistry, marine and lacustrine science
FISH FARMERS OF TEXAS P. O. Box 2948 College Station, Texas 77841 (409)845-1261	Nonprofit professional trade organization
FLOY TAG & MANUFACTURING, INC. 4616 Union Bay Place, N.E. Seattle, Washington 98105 (206)524-2700	Manufacturer of fisheries research tags and equipment

CONTRIBUTORS	PRODUCT OR SERVICE
THE HERSHEY CORPUS CHRISTI HOTEL 900 North Shoreline Blvd. Corpus Christi, Texas 78401 800-533-3131 (512)887-1600	Hotel, convention, resort and restaurant facilities
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AGCHEM PENWALT 3 Parkway, Rm. 619 Philadelphia, Pennsylvania 19102	Manufacturer of aquatic herbicides Aquathol K and Hydrothol 191
RON THE GUIDE 6011 S. Staples Corpus Christi, Texas 78413 (512)993-2062	Hunting and fishing expeditions
ROWLAND FIBERGLASS, INC. 560 6th Street P. O. box 971 Ingleside, Texas 78362 (512)776-7753	Manufacturer of aquaculture tanks, round-sloping bottom, cone bottom, rectangular raceways, fish hauling and custom manufacturing
SMITH-ROOT, INC. 14014 N.E. Salmon Creek Ave. Vancouver, Washington 98665 (206)573-0202	Electronics for fisheries: electrofishers, electro-fishing boat systems, radio and sonic tracking and micro-tagging equipment
SPORTSMEN'S CLUBS OF TEXAS (SCOT) 311 Vaughn Building 807 Brazos Street Austin, Texas 78701 (512)472-2267	Nonprofit conservation organization
SURF COURT MOTEL 1204 Market Rockport, Texas 78382 (512)729-3249	Motel, kitchenettes, TV, swimming pool, pier
SWEENEY ENTERPRISES, INC. Rt. 2, Box 2452 Boerne, Texas 78006	Automatic feeders

CONTRIBUTORS	PRODUCT OR SERVICE
TEXAS SHRIMP ASSOCIATION Vaughn Building, Room 402 807 Brazos Street Austin, Texas 78701 (512)476-8446	Nonprofit professional organization
VILLAGE INN 503 North Austin Rockport, Texas 78382 (512)729-6370	Motel, kitchenettes, TV, swimming pool
WILDLIFE SUPPLY CO. 301 Cass Street Saginaw, Michigan 48602	Biological sampling equipment

In addition, personal contributions was made by the following individual:

ROBERT NITSCH
Ballinger, Texas

1986 OUTSTANDING FISHERY WORKER AWARDS

There were two recipients of the 1986 Outstanding Fishery Worker Award from the Texas Chapter. The recipient in the Research Category was:

Mr. Robert L. Colura
Texas Parks and Wildlife Department
Perry R. Bass Marine Fisheries Research Station
Palacios, Texas

Robert Colura received his BS in Zoology from Texas A&M University in 1966. From 1966 to 1967 he worked for Shell Chemical in Houston, Texas. He began working as a biologist for Texas Parks and Wildlife Department in 1967 and continues until today. He pioneered work in red drum spawning and pond production techniques as early as 1974. More recently he has been instrumental in the development of production techniques for spotted seatrout and orangemouth corvina. For his outstanding accomplishments in marine fish culture, the Texas Chapter presented this award.

The recipient in the Management Category was:

Mr. William Higginbotham
Cooperative Extension Program
Texas Agricultural Extension Service
Overton, Texas

William Higginbotham received his BS in Fisheries Ecology in 1977 from Texas A&M University. While working for the Tennessee Cooperative Fisheries Research Unit he also received his MS in 1979 from Tennessee Technological University. He was employed as a biologist from 1979-81 by the Florida Fish and Game Commission until joining the Texas Agricultural Extension Service as a fisheries specialist. His duties as a fisheries specialist include advising individuals on private water management and commercial aquaculture. For his contribution to the revised "Stocking and Management Recommendations for Texas Farm Ponds", the Texas Chapter presented this award.

HISTORY OF RED DRUM CULTURE IN TEXAS

by

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Perry R. Bass Marine Fisheries Research Station
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ABSTRACT

Red drum (Sciaenops ocellatus) culture in Texas began in 1970 when Texas Parks and Wildlife Department (TPWD) biologists began field studies of red drum spawning. Laboratory spawning of red drum was first observed at the Perry R. Bass Marine Fisheries Research Station (MFRS) in 1974 when a single wild caught female unexpectedly spawned one week after being placed in a tank with 2 males that had been reared from juveniles to adults in ponds. Controlled spawning was first accomplished by the U. S. National Marine Fisheries Service Port Aransas Laboratory in 1975 using photoperiod and temperature conditioning. The latter has since become the spawning method of choice for routine red drum culture. Fry from the 1975 Port Aransas spawns were stocked into ponds at the MFRS for the first demonstrated pond culture of red drum fingerlings. The initial study yielded approximately 250,000 fingerlings of 35-40 mm TL. Large scale evaluation of red drum culture and bay stocking programs were started by TPWD in 1978. By 1979 TPWD personnel were producing more than 1 million fingerlings per year in saltwater ponds but fry to fingerling survival was 20%. Implementation of pond management strategies to increase zooplankton forage raised survival to approximately 40% by 1983. The same year, the John Wilson Marine Fish Hatchery at Flour Bluff,Texas opened as the first large scale hatchery dedicated to a saltwater gamefish. Funded by the Gulf Coast Conservation Association and located on land provided by Central Power and Light Company, the TPWD operated facility currently produces 7-10 million red drum fingerlings annually. Although research emphasis on red drum culture has focused on spawning and fingerling production, Texas A&M University (TAMU) researchers demonstrated wild juvenile red drum could be reared to marketable size as early as 1972. Over a 373 day period in 1984-85 TAMU personnel using extensive culture methods obtained 4 g/day growth but only 1% yield (357 fish) from a 13.4 ha saltwater reservoir. However, growth rates in two adjacent 0.4 ha ponds each stocked with 3,690 0.3 g red drum were 0.6 and 0.7 g/day over 183 and 149 days, respectively with approximately 68% survival. Similarly, TPWD biologists obtained growth rates of 0.6 g/day, 63% survival and a 1.5 food conversion over 235 days from two 0.2 ha ponds stocked with 3,000 0.6 g red drum suggesting good potential for commercial red drum culture.

Management of Red Drum in Coastal Waters

by

Ms. Maury Ferguson
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ABSTRACT

Texas Parks and Wildlife Department has a broad scale management program for red drum in coastal waters. The program goal is to perpetuate their populations at levels where when fished on the basis of optimum yield will generate the greatest possible benefit to the state.

To achieve this goal two objectives must be met:

1) prevent recruitment overfishing by

   a) offsetting environmental impacts to the population,
   b) ensuring adequate spawning stock, and
   c) ensuring maximum utilization of the environmental potential, and

2) attain optimum yield that

   a) generates maximum economic benefits to the state, and
   b) reduces user conflicts by providing maximum distribution of fishery participation.

The management program combines long-term standardized monitoring and short-term special studies. The long-term monitoring programs are divided into resource monitoring or fishery independent surveys and harvest monitoring or fishery dependent surveys. A variety of conventional collecting gear is used to collect trend data on species and size composition and relative abundance. Fishing mortality is determined through a harvest monitoring program; sport harvest is estimated from creel surveys and commercial harvest from a dealers' self-reporting system. Based on these data allocations of red drum stocks are made.

In the finfish monitoring program bag seines and gill nets are the primary gears used. Bay seines are currently collected year-round but November through March is the period of generally high catch rates for red drum. Bag seines provide data on red drum before they are recruited to the sport fishery. Gill net sampling is concentrated in the fall and spring to provide the most precise estimates for sub-adult and adult finfish.

The sport harvest monitoring survey has collected data on boat fishing--private, party and bay headboats--since 1974. Shore based fishing was surveyed only in 1974-76 and 1979-80. From 1974-75 half the bay systems

were surveyed and half in 1975-76, so these two years were combined as one coastwide annual estimate.

Commercial landings are monitored through monthly reports from commercial dealers. Currently a sampling program designed to give better and more complete information on the commercial fishery is being tested.

In addition to long-term continuous monitoring of the resource and its users, special studies to fill specific data needs are conducted. Special studies have included projects to estimate or determine growth, movement and mortality through tagging, reporting rates, survival of released fish, stocking success, catch rates and mortality from various troutline baits and setting methods, and to verify self-reported data collected in the sport fishing survey. Studies are conducted of emergency environmental events such as the 1983-84 freeze and the red tide outbreak that is presently occurring. In addition, cooperative studies with the Water Development Board to study the effects of freshwater inflow, and with Texas A&M University Department of Parks and Recreation to conduct a public attitude/opinion survey have been undertaken. An economist has been hired to broaden the agency's research base.

These research programs provide the rationale for implementing management strategies to maintain and enhance red drum populations. This also allows for prediction of impacts of proposed strategies to be made and actual results monitored.

Based upon analysis of those data obtained through these various monitoring programs and special studies programs, population trends in red drum in the coastal waters of Texas are as follows:

a) the relative abundance of red drum juveniles declined from a high of 55 per hectare in 1981-82 to about 11 per hectare in 1985-86,
b) fall gill net samples showed a 50 percent decline in sub-adult red drum from 1979 to 1983 followed by an increase to historically high levels in 1984 and 1985,
c) private-boat fishing pressure has increased since 1976-77 while red drum landings in 1985-86 were half of the landings in 1974-76,
d) private-boat fishing catch rates declined from 1974-76 to 1978-79 and then remained stable except for a drop after the 1983-84 freeze and fish kill,
e) mean weight almost doubled due to size regulations so that private-boat fishermen are landing almost as much weight as they did 11 years ago,
f) commercial red drum landings peaked from 1969 to 1976 and then dropped rapidly,
g) annual survival rates of only 15% were estimated from November 1975 to April 1979 and are as low or lower than any published rate for other exploited fish populations.

Management actions to increase recruitment and prevent overfishing include the ban on the sale of red drum in September 1981, setting of size limits, regulation of the means and methods of harvesting red drum, stocking

of hatchery reared fish in the natural environment, and promoting mariculture development and habitat protection. Actions taken to achieve optimum yield include setting bag and possession limits, requiring licensing of user groups, imposing penalties for noncompliance with the regulations and stocking hatchery reared fish to enhance natural populations.

The TPWD produces over 30 scientific reports each year to communicate findings to user groups and other agencies. A state red drum management plan is near completion that summarizes known data, and makes both management and research recommendations. The Gulf of Mexico Fishery Management Council is also preparing a management plan for red drum and TPWD is intensely involved in that effort. Based upon the state of knowledge regarding red drum in the coastal waters of Texas the following are the major research needs that the Texas Parks and Wildlife Department feels are critical to successful management of red drum in the future:

1) Life history details

   a) stock boundaries,
   b) specific identification of spawning areas,
   c) egg and larval transport mechanisms,
   d) movement patterns of juveniles and adults,
   e) habitat requirements,
   f) parasite composition and infection rates,

2) Life history parameter estimates

   a) fecundity of wild fish,
   b) sex ratios of fish recruited to spawning population,
   c) size at sexual maturity is unclear,
   d) age determination,
   e) growth estimates for adults,
   f) maximum age and length,
   g) estimate of mortality and parameters needed for yield assessments are incomplete,
   h) longer-term trends in size composition and abundance,
   i) spawner-recruit relationship,

3) Population dynamics of fish in the Gulf,

4) Inaccurate and incomplete commercial landings data prevent determining if MSY is being reached,

5) Total number of recreational anglers and total landings are unknown,

6) Causes of fluctuations in landings have not been clearly identified,

7) Current and accurate sociologic and economic data is needed for equitable allocation,

8) Economic and sociologic factors influencing fishing effort are poorly understood,

9) Life history information on a bay system basis is needed to allow for management by bay systems, and

10) Impacts of regulations and other management actions on red drum are not fully understood.

Over-Wintering and Grow-Out of Red drum at Coastal Sites

by

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ABSTRACT

An overview of redfish growout trials conducted during 1984 through 1986 in brackish water ponds near Palacios, Texas is presented. Trial one was begun on 1 June 1985. Two 0.4 ha ponds were each stocked with 3500 redfish fingerlings (25 mm mean TL, 0.33 mean weight). Fish in both ponds were started on trout feed (48% protein). After two months the feeding regime was changed; one pond was kept on trout feed (38% protein) and the other switched to catfish feed (32% protein). Both ponds were harvested after month 5. Fish fed trout feed averaged 226 mm TL and 101 g. Mortality over the five months was estimated to be 3%. A number of fish were kept in each pond over the winter. Average size of surviving fish after month 11 was 295 mm TL and 313 g.

Trial two was begun in November 1984 and consisted of stocking 33,000 fingerlings (25 mm TL, 0.3 g) in a 13.4 ha reservoir. No supplemental feed was provided during the 12 month growout. In November 1985, 357 fish averaging 488 mm TL and 1500 g were harvested.

A third trial, begun on 5 June 1986, utilized three 0.6 ha ponds which were stocked with fingerlings (25 mm TL, 0.21 g) at rates estimated to be 25,000, 65,000, and 125,000 per pond. Fish were fed trout feed (38-48% protein) for the duration of the trial. All ponds were harvested after month 3; the pond stocked at 25,000 yielded 4,000 fish (150 mm TL, 36.8 g), the pond stocked at 65,000 yielded 7,000 fish (101 mm TL, 13.1 g) and the pond stocked at 125,000 yielded 25,700 fish (118 mm Tl, 17.8 g).

PRODUCTION OF RED DRUM IN INLAND SALTWATER PONDS IN WESTERN TEXAS

by

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ABSTRACT

Larval Rearing

Red drum, Sciaenops ocellatus, larvae were stocked into a pond near Stanton, Texas. The fish were procured from the John Wilson Hatchery of Texas Parks and Wildlife approximately 30 hours after spawning. The fish were placed in plastic bags containing about 40,000 larvae and 2 gallons of 25 ppt salinity seawater. The bags were transported by automobile and commercial aircraft. The entire trip required 8 hours and one hour was required for tempering the fish upon delivery.

On arrival the fish were inspected visually and survival was estimated at 99%. Temperature of the water in the hauling bags was 23 degrees and surface water temperature was 27 degrees. The receiving ponds has been treated with fertilizer as has been discussed by an earlier speaker. The lone exception to the recommended regime was the fish arrived after water had been in the pond 45 days rather than the recommended 15 days after filling.

Harvest of the fish was attempted on May 22 after the fish had been in the ponds 23 days. The equipment available was of too large a mesh size to capture the animals. On June 5 test seining of the pond revealed that many fish had survived but field personnel were unable to determine the actual survival percentage. They did report a very dense insect population.

Fingerling Rearing

Fingerlings were secured from the Perry R. Bass Marine Fisheries Research Station of Texas Parks and Wildlife and transported in truck-mounted hauling tanks by Texas Parks and Wildlife personnel. Seven ponds were stocked in the vicinity of Stanton and three ponds in the vicinity of Grand Falls. Fish were transported in water with 25 ppt salinity and about 25 C. Survival on the truck was reported to be fair to good.

One series of ponds, (4 near Stanton) were cutoff from the road by high water. This required the fish be moved to different hauling tanks and moved on a trailer towed by a farm tractor to the pond site. This extra handling apparently stressed the fish considerably and mortalities were reported as high at the pond. The insect problem at this location was extremely high and they began to prey on the fingerlings immediately. In addition, the

recent high waters had allowed sheepshead minnows Cyprinodon variegatus to spread into each of the ponds. These fish also began to prey on the red drum fingerlings. Water quality data was kept on the ponds and test seining conducted at 2 week intervals. Survival was very low and at final harvest less than 50 fish were harvested from the 3 acres of ponds.

At a second site near Stanton, 3 ponds were stocked. Mortalities noticed at the time of stocking were minimal. Data on water temperature and quality was maintained and test seining was conducted on a monthly basis. Insects were also a problem at this location but not in the numbers found at the first location. One of the ponds was plagued with hypersaline water during the first 3 weeks and no fish were found in the pond at the end of 6 weeks. A second pond developed very low dissolved oxygen and though fish survived for at least 12 weeks, the survival rate was less than 1 percent. The third pond was stocked with 2,000 fingerlings and survival was good for the majority of the season. Low dissolved oxygens occurred on one occasion in late August and again in late September. When the ponds were completely seined in early October approximately 300 of the fish had survived and reached an average length of 20 cm.

All 15,000 of the fish delivered to the Grand Falls location arrived in very poor condition due to a malfunction of the hauling equipment. Nonetheless, survival was considered adequate. Growth was very poor due to faulty feed used for the first 90 days. Subsequently the fish grew rapidly and reached an average length of 15 centimeters by the harvest date of October 8. Fish will be left in these ponds for over-wintering.

This year's demonstrations indicated the red drum will survive in the above ground ponds supplied with saline water in Western Texas. The economic feasibility remains to be determined. Because the fingerling fish stocked on June 5 did not achieve a marketable size and other data indicates they will not live over winter at these locations due to cold temperatures, the feasibility of commercial production is very unlikely.

Genetics

by

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ABSTRACT

Considerable progress has been made in characterizing the molecular structure of the red drum genome. Nuclear DNAs from individuals of two stocks have been isolated, purified, and stored for DNA base composition and melting rate profile analyses, and the red drum mitochondrial DNA molecule has been isolated, purified, and partially mapped using restriction endonuclease analysis. The products of 20-25 presumptive structural gene loci have been resolved from red drum tissues using gel electrophoresis, and the total quantity of clear DNA per cell has been determined using flow cytometry. Finally, cell cultures using red drum leukocytes have been initiated for the chromosome studies.

Larval Rearing and Grow-Out of Red Drum in Recirculating Systems

by

Ms. Joan Holt
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Port Aransas, Texas 78373

ABSTRACT

The Mariculture Program of the University of Texas at Austin Marine Science Institute is a team approach to the study of marine finfish native to Texas coastal waters. Scientists are conducting research in the areas of maturation and spawning, reproductive and stress physiology, nutrition, ecology, larval fish biology, and grow-out. Our approach to marine fish culture is based on first determining the underlying processes which control reproduction, survival and growth, and secondly on applying this knowledge to culture and eventually mass production of fish. Thus, the results from basic research on the ecology, physiology and biochemistry of a species will provide the technical framework for mariculture of that species.

This discussion will include results of current research projects under the direction of C. R. Arnold (spawning and grow-out), Peter Thomas (reproductive biology and stress physiology), Scott Holt (ecology and field biology), and Joan Holt (larval fish biology, ecology and culture).

Ongoing field studies (primarily centered on red drum, but also including spotted seatrout, black drum and other species) are designed to: 1) elucidate mechanisms of migration and recruitment of larvae and post larvae, 2) provide data on the relative importance of fresh water dominated nursery areas of Texas bays compared to more marine dominated areas, and 3) identify changes in "nursery habitat" in Mesquite Bay due to the reopening of Cedar Bayou. Ecological information from these research studies is invaluable for understanding life history strategies of warm water marine fishes.

Current laboratory research includes: 1) an investigation of the salinity requirements for reproduction and larval development in important marine fishes in Texas, 2) elaboration of more reliable methods for inducing spawning in marine finfish, including the use of gonadotropin releasing hormone and the dopamine blocker pimozide, 3) development of an artificial or non-living diet for larval fish using micro-capsulation techniques, 4) progressing toward the development of a vaccine for Oodinium using recent advances in fish immunology, and 5) refinement of grow-out techniques using high density rearing systems and hormonal enhancement of growth.

RED DRUM IN FRESH WATERS

by

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ABSTRACT[1]

A summary of findings of research conducted relative to red drum Sciaenops ocellatus in freshwater environments was presented. Laboratory bioassays demonstrated red drum should survive in fresh waters with at least 130 mg/liter chloride ion concentration and a minimum water temperature of 9 C. Sampling of red drum populations in Braunig Lake, a freshwater reservoir in Bexar County, Texas showed red drum stocked as 30-mm fingerlings grew to approximately 320, 525, and 750 mm TL 1, 2 and 3 years after stocking, respectively. Examination of 464 red drum stomachs from Braunig Lake from 1981 to 1984 showed red drum ate 81-91% fish, the primary species being gizzard and threadfin shad Dorosoma cepedianum and D. petenense and blue tilapia Tilapia aurea. Seasonally, red drum diet was most diverse during the warmer months. According to creel figures obtained from the San Antonio River Authority, Braunig Lake anglers harvested increasing biomass of red drum each year from 1981 through 1985; the annual harvest in 1985 was 13,249 kg (24.3 kg/hectare). During 1985, 46.7% of the total fishing pressure on Braunig Lake was attributed to red drum angling (45.78 hours/hectare). During that year, harvest rates were 0.078 red drum/hour and 0.316 kg/hour; the mean weight of red drum harvested was 4.10 kg.

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1 Results reported here were obtained during research funded by the Federal Aid in Sport Fish Restoration Act under Project F-31-R of the Texas Parks and Wildlife Department. The majority of the findings have been reported in the following:

Dolman, W. B. 1985. Red drum freshwater stocking evaluation. Dingell-Johnson Federal Aid Project F-31-R-11, Objective XLII, Final Report. Texas Parks and Wildlife Department, Austin, Texas USA.

Thyroid Gland Function in Red Drum

by

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ABSTRACT

Hormones secreted by the thyroid gland have been shown to be of fundamental importance in teleost fishes in the regulation of metabolically-demanding physiological processes. Although it is now recognized that thyroid hormones influence larval growth, osmoregulation, intermediary metabolism, and reproduction in teleost fish, little information is available on thyroid function in any teleost group other than salmonids. Salmonid studies have shown that the potential exists for use of thyroid hormones as agents for enhancing growth, nutrient utilization, and reproductive success or as indicators of metabolic activation in cultured species. Such use must be based, however, on a thorough knowledge of normal thyroid function in the species under consideration. Work in my laboratory is therefore currently directed towards characterizing normal thyroid function in captive red drum. Studies are currently underway to measure the levels of the two primary teleost thyroid hormones, thyroxine (T_4) and triiodothyronine (T_3) in juvenile red drum held in recirculating full strength salt water systems and to identify thyroid hormone targets using radioreceptor assay techniques. These studies will provide background information on the normal levels of secretion of these hormones as a function of age in captive animals and will identify possible targets subject to thyroid hormone modulation. In addition, we are also examining the response of the thyroid to acute salinity transfer as might happen during a stocking or shipping of juvenile fish. Thyroid hormone levels are being measured after transfer of animals to higher or lower salinities to determine the possible effects of environmental salinity on endocrine regulatory systems. In addition, thyroid function is being related to blood osmolarity and specific ion levels as well as the activity of a major gill osmoregulatory enzyme, NA^+/K^+ ATPase to examine the possible correlations between these variables and as a means for elucidating the mechanism of action of thyroid hormones. Because of interest in fresh water as a potential habitat for red drum, it is important to understand the long term effects of low salinity habitats on red drum physiology. Knowledge of the endogenous processes regulating growth and reproduction in red drum may provide us with the ability to optimize these processes in cultured animals through endocrine or environmental manipulation. Knowledge of the mechanisms of salinity adaptation and physiological responses to salinity transfer will enable aquaculturists and fisheries management personnel to make more informed decisions about appropriate habitats for stocking or release of fingerlings. Finally, these studies will provide new basic information on the physiological regulation of salinity adaptation and the role of the thyroid gland in a euryhaline teleost species.

Hatchery Techniques, Transporting, and Larval Rearing in Open Systems

by

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John R. Wilson Marine Fish Hatchery
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ABSTRACT

The John Wilson Marine Fish Hatchery located in Corpus Christi, Texas, is the first saltwater production fish hatchery on the Gulf coast. This facility is the result of the cooperative efforts between Texas Parks and Wildlife Department, Gulf Coast Conservation Association, and the Central Power and Light Company. The hatchery is truly unique because of its pioneering role in the enhancement of red drum (Sciaenops ocellatus) populations.

The physical plant consists of a main laboratory-culture building and twenty acres of pond area. The hatchery utilizes a combination of closed system technology and temperature/photoperiod control for broodstock maturation and spawning, and possesses an extensive fingerling grow-out capability in earthen ponds. The primary mission of the hatchery is to produce up to 10 million red drum fingerlings yearly for stocking Texas coastal waters.

Broodstock are subjected to a 150-day maturation cycle and resulting spawns are incubated in 1900-L conical bottom tanks. Thirty-six hour post-hatch survival has averaged 62.3%. Ponds are stocked at an average rate of 740,000 "first feeding" larvae per hectare. Pond recoveries have averaged 44.2% survival after 35 days in production. After 4 years in operation, more than 30 million fingerlings have been reared and stocked.

This highly successful pond production of red drum fingerlings was the result of a pond management program using a combination of organic fertilizer (cottonseed meal) and liquid inorganic fertilizers (phosphoric acid, and urea or ammonium nitrate). Zooplankton populations were routinely monitored and fry were stocked when zooplankton densities were optimum. This program provides larval fish with suitable food items to not only meet their metabolic demands but also provides for growth.

Nutrition and Physiology - Environmental Requirements

by

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ABSTRACT

Proposed research on lower-lethal temperature tolerance of juvenile red drum has been completed; preparations for a respirometric study of osmoregulatory costs are under way.

Ultimate lower-lethal temperatures were estimated for fish living at various combinations of salinity (0, 5, 10, 20, and 35 ppt total dissolved solids) and water hardness (10, 100, 400 ppm CA^{++}). Fish at intermediate salinities (5, 10 ppt) and moderate or high hardness (100 or 400 ppm Ca^{++}) tended to have greatest cold tolerance; median lower-lethal temperatures for these treatments were 7.6-10.6 C. In contrast, fish in "soft" water (0 ppm Ca^{++}) with either low (0 ppt) or high (20, 35 ppt) salinity had median lower-lethal temperatures above 16 C.

Update on Immunoidentification of Red Drum

by

Dr. B. C. Robinson
and
Prof. F. M. Fisher, Jr.
Wetland Studies Program
Rice University
Houston, Texas

ABSTRACT

A simple, accurate and reliable field test for the on-site identification of fish species than can be performed by non-technical personnel would be of invaluable service to game-fish law enforcement by state agencies.

The theoretical basis for such a test has now been established in the laboratories of the Wetland Studies Program. This test for the identification of fish species, employing only a small portion of muscle tissue, is an immunochemical test based on the species-specific calcium binding protein known as parvalbumin.

This protein is present in substantial quantities in white muscle fish; it has, in our laboratories, been isolated in a highly purified form from the spotted seatrout and the red drum. Antiserum (mammalian blood serum containing antibodies specific against a given protein) has been produced in New Zealand rabbits.

This anti-serum has then been tested versus both proteins by means of the interfacial ring test, the double immunodiffusion test, and the enzyme-linked immunoabsorbent assay. A measurable difference has been demonstrated between the cross-reactivity of each protein with the red drum antiserum, thereby establishing the feasibility of an immuno-diagnostic test based on the presence of these proteins in fish muscle.

To complete this project, further work is necessary to remove all cross-reactivity from the red drum anti-serum. This can be accomplished by a procedure known as affinity chromatography. This biochemical technique removes antibodies that cross-react with spotted seatrout, or any other species of fish from whom parvalbumin has been isolated, from the red drum antiserum. The resulting antiserum is then highly specific for red drum, rendering its use in the field identification of red drum feasible.

Nutrition and Physiology - Dietary Requirements

by

Dr. Edwin G. Robinson
Mississippi State University
Starkville, Mississippi

ABSTRACT

Several studies to determine critical nutrient requirements of red drum are complete and others are in progress. Thus far, we have determined that 5-30 g fish, living at 2-26 C in water with 5-6 ppt salinity, require a diet with 1) 35% protein (gross energy, 3.6 kcal/g feed), 2) 6% of the protein as lysine, 3) not more than 7% fat, and 4) 0.8% available phosphorous.

An Electrophoretic Analysis of Texas Gulf Coast Red Drum (Sciaenops ocellata): Identification of Possible Stocks and Implications for Fisheries Management

by

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ABSTRACT

Red drum (Sciaenops ocellata) from seven of the nine major embayments of the Texas Gulf Coast were electrophoretically analyzed for genetic variability. Indices of genetic similarity and distance were derived, as well as estimates of genetic divergence between bays. Cluster analysis phenograms were developed, and possible causes for population structure were addressed.

Forty presumptive loci were screened, of which 30 proved to be of value for genetic population analysis. Percent polymorphic loci and heterozygosity/locus/individual ranged from 6.7%-13.3% and 0.025-0.042, respectively. These values were lower than those reported in similar studies, including some dealing specifically with Sciaenidae, but remained within the range reported for teleosts in general.

A total of thirteen tests of genetic similarity/distance were performed. Of these tests, no segregation below a genetic identity of 0.95 was detected in those samples large enough to statistically satisfy the analysis. Upon exclusion of the small samples, no differentiation below 0.97 was demonstrated.

Contingency chi-square tests and F-Statistics found only extremely low levels of divergence. Indeed, none of the divergence indicated was significant in terms of distinction of subpopulations among bays. This lack of differentiation in spite of apparently low levels of interbay migration was explained as a function of the dichotomus life stages. While juveniles are geographically isolated, adults occupy the open waters of the Gulf of Mexico, and have yet to be thoroughly described from either a life history or reproductive strategy viewpoint.

The indicated single stock of reproductively active red drum in the Gulf requires further investigation, in order to accurately determine migrational habits as well as breeding success. The implications for management of the fishery at present are to regulate the resource as a single stock; as well as institute a comprehensive physical and biochemical study for future policy formulation.

ABUNDANCE VS. AVAILABILITY: IMPACTS OF VEGETATION CONTROL IN LAKE CONROE, TEXAS

by

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and

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ABSTRACT

Grass carp introduced into an 8,000-hectare reservoir reduced submergent vegetation infestation from 45% area to essentially 0%. Fish populations were monitored for 6 years, including 2 years prior to grass carp stocking and 2 years following submergent macrophyte control. Annual rotenone samples from 6 coves were used to calculate AP:P ratios. Conclusions regarding prey availability were complicated by changes in biomass and species composition of both prey and predators as well as by potential density-dependent effects of piscivore populations. Examination of prey selection by largemouth bass revealed that after vegetation control piscivory began at smaller predator sizes and a closer relationship between predator length and prey length occurred. These relationships suggested that prey availability increased, even though prey abundance decreased.

SALTWATER POND CULTURE OF SPOTTED SEATORUT, ORANGEMOUTH CORVINA, AND THEIR RECIPROCAL HYBRIDS

by

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ABSTRACT

Spotted seatrout (Cynoscion nebulosus) provide an important recreational fishery along the Southeastern Atlantic and Gulf coasts. Similarly, the orangemouth corvina (Cynoscion xanthulus) is a valued gamefish in the Gulf of California and the Salton Sea. Ongoing artificial propagation research with both fishes prompted interest in intrageneric hybrids between the two species. Accordingly, a study was undertaken to determine if spotted seatrout and orangemouth corvina could be hybridized and pond cultured. Spotted seatrout and the hybrids were strip spawned following HCG injection to provide fry. Orangemouth corvina fry were obtained from hormone (LHRHa and pimozide) or photoperiod and temperature induced tank spawns. A total of 22 pond trials were conducted from 1984 to 1986. Fry stocking rates were based solely on availability and ranged 36,500 to 1,365,000 fry/hectare for orangemouth corvina; 45,000 to 129,000 fry/hectare for spotted seatrout and the spotted seatrout X orangemouth corvina hybrid; and 4,700 to 71,500 fry/hectare for the reciprocal hybrid. Fingerling recoveries for spotted seatrout, orangemouth corvina, spotted seatrout X orangemouth corvina, and orangemouth corvina X spotted seatrout hybrids averaged (± SD) 51 ± 25.1% (n=7), 44 ± 39.7% (n=8), 36 ± 7.0% (n=5), and 109 ± 80.6% (n=2), respectively. Respective average production for the four fishes was 1.1, 2.9, 1.1, and 0.7 kg/hectare/day. Average standard length and weight for the four fishes was 36 mm and 0.81 g for spotted seatrout; 26 mm and 0.41 g for orangemouth corvina; 39 mm and 1.03 g for spotted seatrout X orangemouth corvina hybrids; and 37 mm and 1.43 g for orangemouth corvina X spotted seatrout hybrids. Results indicate spotted seatrout, orangemouth corvina, and the two hybrids can be pond reared on a hatchery scale.

AGE AND GROWTH ANALYSIS OF SPOTTED SEATROUT FROM GALVESTON BAY, TEXAS, USING SECTIONED OTOLITHS

by

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ABSTRACT

Age and growth was estimated from sectioned otoliths for 426 spotted seatrout Cynoscion nebulosus collected from Galveston Bay, Texas, between October 1981 and September 1982. Marginal increment measurements demonstrated a single annulus on the otolith was formed once a year during March and April. Complete agreement for annular counts was made by two independent readers, suggesting age interpretation from sectioned otoliths was precise. After age 1, back-calculated length-at-age estimates were much greater for females than males. The maximum age observed was twelve years, which was considerably greater than the maximum age of six to eight years reported by previous workers using scales. Spotted seatrout from Galveston Bay generally grew faster than fish collected from other areas. Gonadosomatic index values reflected a prolonged six month spawning period, which may have accounted for a four-fold difference in back-calculated lengths at age 1. The length advantage gained by larger individuals at age 1 was maintained as they grew older. Regression analysis indicated length and corrected body weight were better predictors of female gonad weight than age. Weight-to-length regression equations differed significantly between males and females.

TEXAS VOLUNTEER ANGLER PROGRAM

by

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ABSTRACT

The Texas Parks and Wildlife Department is currently developing a program utilizing volunteer anglers to collect data on catch and population structure of sport fishes in Texas Reservoirs. The objective is to provide a cost-effective way to monitor sportfish populations in years when regular management data are not collected. The volunteer angler data will be corroborated with regular management data, and criteria will be established to invoke sampling when volunteer angler data suggest sudden changes in a population.

Initial recruiting efforts for anglers is directed toward licensed fishing guides and members of fishing clubs. Volunteers are supplied diaries and rulers and asked to record information about location of fishing trip, date, time spent fishing, species caught, total length, and whether fish were kept or released. Space is provided in the diary for optional information on weather and water conditions, bait type and color, time of catch , and weight of fish. Completed diaries are mailed postpaid to the Department for analyses, and then returned to volunteers for their records. Reservoir summary reports and newsletters are provided to participants in the program.

Approximately 300 anglers have thus far been recruited and trained, and about 200 more have expressed an interest in the program.

GROWTH PERFORMANCE OF THREE AND SIX-YEAR OLD NORTHERN FLORIDA, AND INTERGRADE LARGEMOUTH BASS STOCKS

by

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ABSTRACT

The largemouth bass Micropterus salmoides is an important fish in North America and is cultured and managed extensively. Both described subspecies and intergrades are stocked by private, state, and federal agencies. This study was conducted to detect strain effects on long-term growth among M. s. salmoides, M. s. floridanus, and intergrades. Purity of strains was verified electrophoretically before the study was conducted. Comparative growth was monitored over a 3 and a 6-year period in 0.04-ha earthern ponds. All fish were fed pelleted food supplemented with live food-fishes. The northern largemouth bass grew faster than the Florida and intergrade strains for at least 3 years.

EFFECTS OF GIZZARD AND THREADFIN SHAD ON ZOOPLANKTON COMMUNITIES AND WHITE CRAPPIE RECRUITMENT IN PONDS

by

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and

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ABSTRACT

The effect of gizzard and threadfin shad on zooplankton communities and white crappie recruitment were studied at the Lewisville State Fish Hatchery, March through July, 1986.

Twenty 0.3-ha ponds were stocked with adult white crappie. A 2x2 factorial design was used to allocate adult shad to ponds in four treatment combinations (no shad, gizzard shad, threadfin shad, gizzard shad and threadfin shad). Zooplankton and larval fish counts were made at 2-week intervals. At the end of the study all ponds were drained and fish recovered.

Gizzard and threadfin shad suppressed some zooplankton taxa, and total number and weight of young-of-the-year crappie. Food competition appeared to be one mechanism responsible for the lowered crappie recruitment.

MANAGING LARGEMOUTH BASS EXPLOITATION WITH BASS TOURNAMENTS

by

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ABSTRACT

Eleven live-release largemouth bass (Micropterus salmoides floridanus) fishing tournaments held on two Florida lakes during July 1984-June 1985 were sampled to quantify tournament angler and total mortality (pre-release plus post-release mortality) of tournament-caught fish statistics. The average statistics from this investigation were applied to creel census data from Orange Lake, Florida, and Pomme de Terre and Truman Lakes, Missouri, to assess the effects of tournament harvest on total largemouth bass sportfishing harvest. On all three lakes, frequent live-release bass tournaments resulted in decreased largemouth bass harvest compared to the harvest that would result from non-competetive sportfishing. Therefore, competetive fishing events can be used as a mangement tool for reducing the exploitation of largemouth bass. Furthermore, reduction of harvest by competetive fishing events may have more desirable effects on largemouth bass populations than those effects resulting from size-limit or number-limit regulations typically used by regulatory agencies.

TOLERANCE OF SOUTHERN FLOUNDER TO LOW TEMPERATURE

by

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ABSTRACT

Young and adult southern flounder (Paralichthys lethostigma) were subjected to decreasing temperature (1 C/24 hours) in fresh and salt water to bioassay their lower temperature tolerance. Adult flounder overwinter survival in fresh and salt water ponds was also observed. Comparison of laboratory and pond results indicated lower temperature tolerance limits for young in freshwater, adults in freshwater, and adults in saltwater are 4.1, 6.4, and 7.3 C, respectively. Young flounder in saltwater were most tolerant of cold since 90% survived exposure to 2 C.

ANGLER USE AND ATTITUDES FOR AN URBAN FISHERY IN LUBBOCK, TEXAS

by

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ABSTRACT

We conducted an angler survey on 14 lakes located in park environments in Lubbock, Texas during June-September 1986 to evaluate angler use and attitudes. Lakes ranged in size from 0.3 to 33.2 ha and averaged 8.5 ha. The average fisherman density was 5.7 anglers per lake per survey period. Fish preferred by anglers included catfishes (Ictaluridae, 35%), largemouth bass (Micropterus salmoides, 27%), and white crappie (Pomoxis annularis, 17%). In contrast to preferred species, most anglers fished for catfishes and "any species", and fish most commonly caught were sunfishes (Lepomis spp.) and catfishes. Average number of fish caught was 2.2 per angler-trip. The mean number of trips to the lakes per angler per month was 6.9 (range 1-30). Expenditures per month per angler averaged $14 (range $0-150). Seventy-one percent of the anglers were satisfied with the fishing. Sixty-six percent of the anglers surveyed had an understanding of fishing regulations, and 85% of these anglers thought regulations could be used to improve the fishery. Only 18% of the anglers who did not understand regulations thought regulations could be used to improve the fishery. Thirty-seven percent of the anglers were aware that a no-cost permit was required to fish in the Lubbock lakes. These statistics should be considered in the implementation of an urban fisheries program for Lubbock lakes.

INTRODUCTION

Development of fishery management objectives should consider the desires and perceptions of the angling community. As part of an urban fishing program for Lubbock, Texas, we conducted an angler survey on existing city lakes to determine present use and catch statistics and to determine angler preferences and perceptions useful to a fishery management program. This paper reports some of the findings of this angler survey.

METHODS

Angler interviews were conducted on 14 lakes within the city limits of Lubbock, Texas. Lakes were located in city parks and ranged in size from 0.3-33.2 ha with a mean size of 8.5 ha. Anglers were surveyed on weekdays and weekends during morning (sunrise to 1100 hours), midday (1100-1600 hours), and evening (1600 hours to sunset). All lakes were sampled during

each time period on at least one weekday and one weekend day. Anglers were surveyed individually and surveys were not time-limited. The survey was comprised of questions designed to determine (i) fish species preferred, fished for and caught; (ii) angler use and expenditures; (iii) demographic information (age, race, sex, distance travelled); (iv) satisfaction with the fisheries, and (v) awareness and understanding of fishing regulations.

RESULTS

A total of 194 anglers were interviewed during 113 weekday and 21 weekend survey periods among the different lakes during June-September 1986. Based on instantaneous counts, an average of 5.7 anglers were fishing in each lake during each period (range 0-26, standard error 0.5).

Fishermen surveyed were 4-77 years of age and averaged 32 years of age (standard error 1.4). Individuals younger than 16 years old were the most frequent age group of anglers (29%), followed by 26-45 (23%), 16-25 (21%), 46-60 (16%), and 60 (12%) year old anglers. The fishing population was 86% males and 14% females. Racial composition of the anglers was 54% white, 35% black, and 10% hispanic.

Fishes preferred by the anglers included catfishes (Ictaluridae), largemouth bass (Micropterus salmoides), white crappie (Pomoxis annularis), sunfishes (Lepomis spp.), and carp (Cyprinus carpio) (Table 1). When asked what they were fishing for (fish species sought), the most frequent responses were catfish and "any species". Other fish frequently sought included sunfishes and largemouth bass. Sunfishes and catfishes were most frequently caught.

For purposes of our survey, the number of fish caught by an angler prior to the interview was considered the catch per trip. Average number of fish caught was 2.2 per angler per trip (range 0-91, standard error 0.4). Fifty-six percent of the anglers caught one or more fish.

Most anglers (51%) travelled less than two miles to fish in the lake where they were interviewed. Nineteen percent of the anglers travelled 2-5 miles (3-8 km), 23% travelled 5-15 miles (8-24 km), and 7% travelled more than 15 miles (24 km) to fish in the city lakes. Among age groups, short distance travelled was most frequent for individuals less than 16 years old (Figure 1). Although most anglers travelled short distances to fish, 82% fished in different city lakes during the preceding month, and 49% fished in lakes other than the city lakes.

Anglers fished an average of 6.9 times per month (range 1-31, standard error 0.6) in the Lubbock city lakes. Thirty-one percent made only one fishing trip to the city lakes during the month prior to the interview. Sixty-six percent fished in the city lakes five or fewer times during the preceding month, and 12%, 7%, 5%, and 2% and 7% fished 6-10, 11-15, 16-20, 21-25, and greater than 25 times, respectively, in the city lakes during the preceding month. In general, older age groups of anglers fished more frequently in the city lakes than did the younger age groups (Figure 2).

The anglers who fished most frequently were also the anglers who travelled the least distance to fish in the city lakes (Figure 3). Of the anglers who fished 11 or more times during the previous month, few travelled more than six miles to fish.

Exclusive of travelling expenses, the average expenditure per fisherman for fishing in the city lakes during the preceding month was $14.50 (Table 2). The amount spent during the preceding month increased with the frequency of fishing during the preceding month. Regardless of the frequency of fishing, some anglers reported zero expenditure for fishing.

Seventy-one percent of all anglers surveyed were satisfied with the fishing in the city lakes. Regardless of whether anglers were satisfied or dissatisfied with fishing in the city lakes, the anglers were asked a series of "preference" questions. When asked their preference for "more fish" or "larger fish", 35% of the anglers preferred more fish and 64% preferred larger fish. When asked if they preferred "better fish" or "a better place to fish", 71% of the anglers preferred better fish and 27% preferred a better place to fish. Given a preference between "better access" or "a cleaner park", 28% wanted better access and 63% preferred a cleaner park. When asked their preference for "a cleaner park" or "cleaner water", 20% wanted a cleaner park and 76% wanted cleaner water. In all choices, a few anglers had no preference.

Sixty-six percent of the anglers had an understanding of fishing regulations. Of these, 85% felt that regulations could be used to improve the fishing in the city lakes. Of those who did not understand fishing regulations, only 18% felt that regulations could be used to improve fishing in the city lakes. Among all anglers, 37% were aware that a no-cost permit, issued by the Lubbock Parks and Recreation Department, was required to fish in the city lakes. Of the 63% that were unaware that a no-cost permit was required to fish in the city lakes, 61% felt that regulations could be used to improve the fishing.

DISCUSSION

The population of anglers fishing in the Lubbock city lakes can be characterized as primarily male, comprised of diverse age groups, and anglers who travel short distances to fish. This characterization is very similar to the angler profile for New York City ponds stocked with bullheads (Lange 1984). Although most anglers interviewed at the Lubbock lakes fished infrequently, some fished more than 15 days each month and several fished every day.

Anglers were, in general, satisfied with the fishery even though many fished for species other than those they preferred to catch and, furthermore, caught fish other than the species they preferred or sought. Although the anglers interviewed were generally satisfied with the fishing, we consider the angler use of the Lubbock city lakes to be low. Unfortunately, comparable angler use statistics are not available for other urban fisheries. We consider angler use to be low because only 0.04% of the

Lubbock population (5.7 anglers per lake per creel period times 14 lakes divided by 187,000 population of Lubbock) fished in the city lakes on any day. Furthermore, our survey was conducted during the summer months when youths were out of school and many adults had vacations.

We suggest that the low angler density may be due to the perceptions or previous experiences of anglers who were not interviewed; i.e., anglers who do not fish in the Lubbock lakes. If this is the case, a measure of angler satisfaction alone is not necessarily indicative of the adequacy of a fisheries management program. Based on the low angler density, low catch rate, and the fact that the catch was primarily composed of small sunfish and black bullheads, we feel the fishery in the Lubbock city lakes can be improved. Information obtained in this angler survey will provide useful guidelines for improving the fishing. Unfortunately, preferences of potential anglers are not known and, therefore, can not be considered in the development of fishery management plans. The information obtained in this survey will be useful for evaluating future improvements in the fishery.

Regulations (size limits, creel limits, closed seasons) are frequently employed to reduce the harvest of fish. High harvests of fish are to be expected in urban waters, and, therefore, regulations may appear to be a potentially useful management tool. Regulations, however, can be effective only if anglers comply with the regulations. Many anglers in our survey had a poor awareness and no understanding of fishing regulations. Compliance by these anglers would likely be poor. Therefore, use of fishing regulations in the Lubbock city lakes may not have the desired effect without an extensive public information program and strict enforcement.

ACKNOWLEDGMENTS

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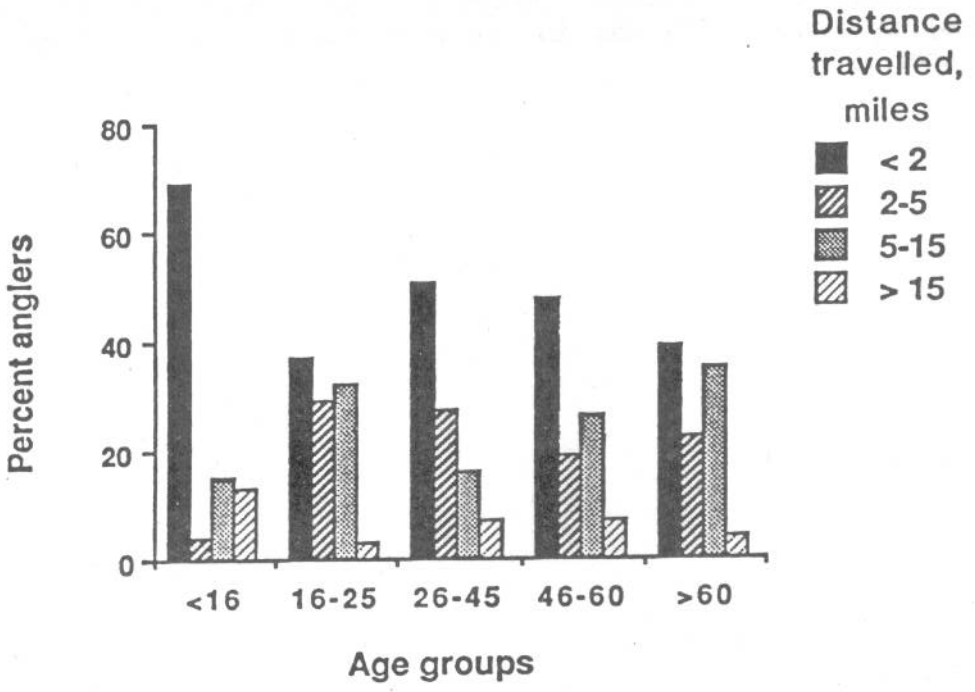
Table 1. Fishes preferred, fished for (sought), and caught by anglers fishing in city lakes, Lubbock, Texas, June-September 1986.

Fish	Preferred (% of anglers)	Sought (% of anglers)	Caught (% of anglers)
Anything	1	31	
Catfishes	46	38	34
Bullhead	1	1	12
Channel catfish	10	5	3
Largemouth bass	32	11	7
Sunfishes	8	14	45
White crappie	10	2	2
Carp	3	4	12

Table 2. Expenditures (dollars) per month by anglers fishing in the city lakes, Lubbock, Texas, June-September 1986.

	Fishing trips per month					
	1-5	6-10	11-15	16-20	21-25	26-31
Mean	$9.55	13.21	16.82	15.55	110.00	30.00
Standard error	$1.29	2.36	4.38	6.89	18.37	10.73
Range	$0-75	0-40	0-40	0-50	55-130	0-150
Sample size	119	19	11	9	4	13

LIST OF FIGURES


Distance travelled, miles
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2-5
5-15
> 15
Percent anglers
80
60
40
20
0
<16
16-25
26-45
46-60
>60
Age groups

Figure 1

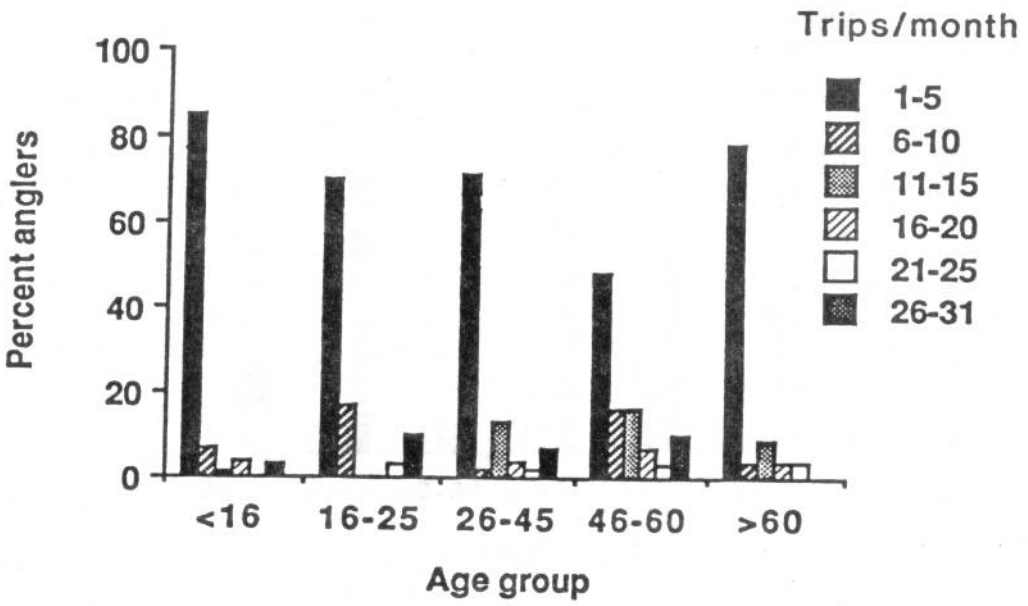
Trips/month
1-5
6-10
11-15
16-20
21-25
26-31
Percent anglers
100
80
60
40
20
0
<16
16-25
26-45
46-60
>60
Age group

Figure 2

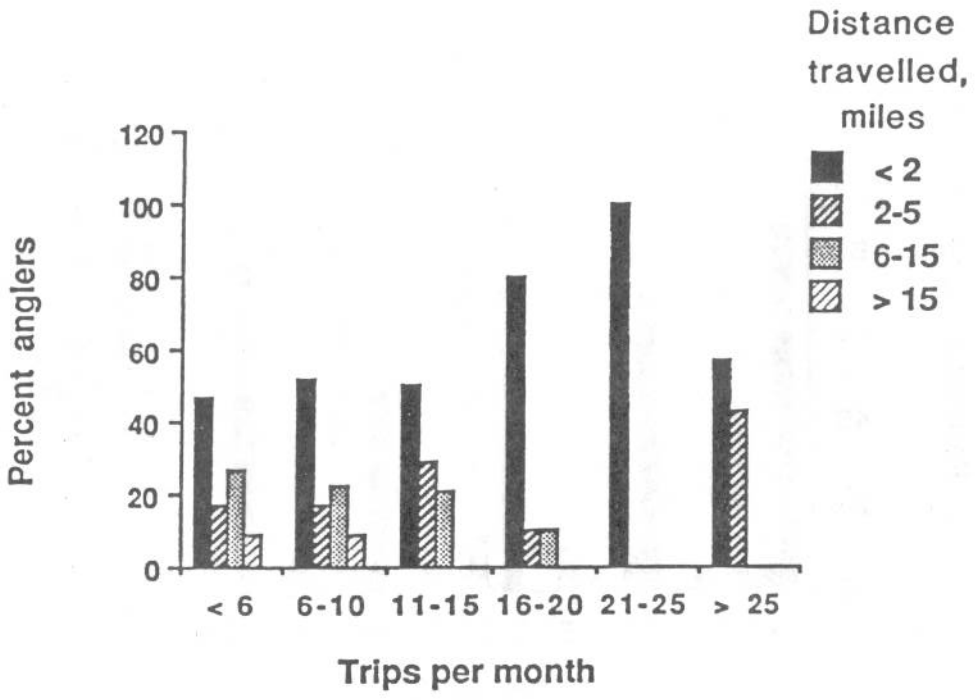
Distance travelled, miles
< 2
2-5
6-15
> 15
120
100
80
60
40
20
0
Percent anglers
< 6
6-10
11-15
16-20
21-25
> 25
Trips per month

Figure 3

ACKNOWLEDGEMENTS

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