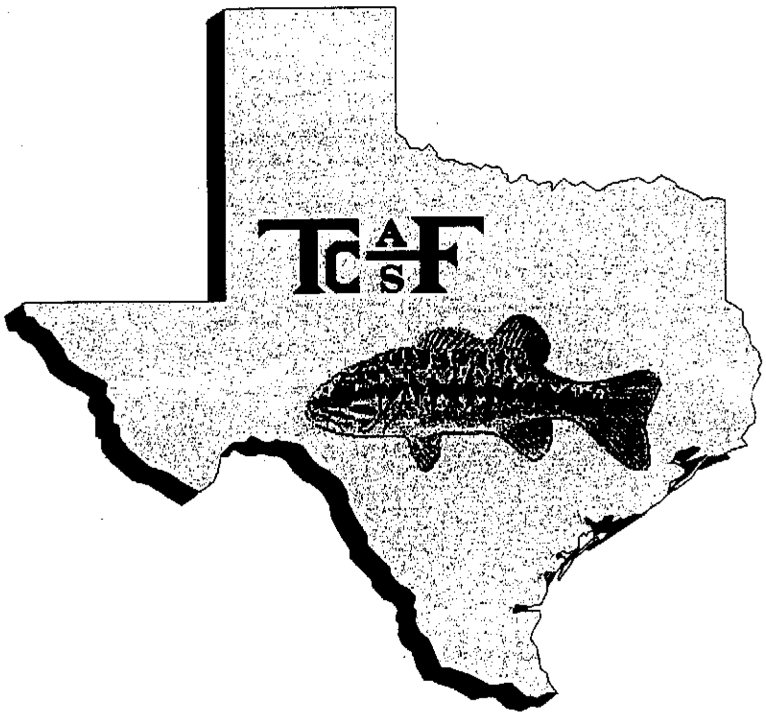
ANNUAL PROCEEDINGS
of the
TEXAS CHAPTER
AMERICAN FISHERIES SOCIETY



Corpus Christi, Texas
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TEXAS CHAPTER

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 use of recreational and commercial fisheries, promotion of all branches of fisheries science and practice, and exchange and dissemination of knowledge about fishes, fisheries, and related subjects. A principal goal is to encourage the exchange of information among members of the Society residing within 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

Annual Meeting
24-26 January 1999
Corpus Christi, Texas

1999 - 2000 Officers

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2000

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Abstracts of Posters Given at the Annual Meeting but not Published in the Proceedings

PAST TEXAS CHAPTER PRESIDENTS AND MEETING LOCATIONS

DATE	PRESIDENT	LOCATION
1976		College Station
1976	Ed Bonn	Lake Brownwood
1977	Jim Davis	San Antonio
1978	Bill Rutledge	San Marcos
1979	Bobby Whiteside	College Station
1980	Richard Noble	Arlington
1981	Charles Inman	Austin
1982	Gary Valentine	Kerrville
1983	Don Steinbach	Lake Texoma, OK
1984	Gary Matlock	Port Aransas
1985	Maury Ferguson	Junction
1986	Brian Murphy	San Marcos
1987	Joe Tomasso	Kerrville
1988	Dick Luebke	Abilene
1989	Mac McCune	San Antonio
1990	Bobby Farquhar	Lake Texoma, OK
1991	Gene McCarty	Galveston
1992	Bill Provine	Kerrville
1993	Barbara Gregg	Port Aransas
1994	Loraine Fries	Lake Travis
1995	Pat Hutson	College Station
1996	Mark Webb	Pottsboro
1998	Katherine Ramos	Athens
1999	John Prentice	Corpus Christi
2000	Paul Hammerschmidt	Bossier City, LA

TEXAS CHAPTER AWARDS

Eight awards may be presented annually. 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. If multiple nominations are received and more than one nominee is considered outstanding, multiple recipients are permissible. The awards and their associated criteria are:

Outstanding Fisheries Worker of the Year - The nominees must be Chapter members in good standing. There are six specialization categories: Administration, Culture, Education, Management, Research, and Technical Support. 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. Members of the current Awards Committee shall be ineligible.

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

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

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

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

a. Academic excellence
b. Professional activities
c. Promise of future professional involvement and significant contribution to the field of fisheries science.

TEXAS CHAPTER AWARDS RECIPIENTS

1977 Fish Culture - Don Steinbach (TAMU)
Fisheries Management - Edward Bonn (TPWD)
Fisheries Administration - David Pritchard (TPWD)
Fisheries Research - John Prentice and Richard Clark (TPWD)

1978 Fish Culture - Pat Hutson (TPWD)
Fisheries Education - Clark Hubbs (UT)
Fisheries Research - Clark Hubbs (UT)
Special Recognition - Edward Lyles (USFWS)

1979 Fish Culture - Robert Stickney (TAMU)
Fisheries Education - Richard Noble (TAMU)
Fisheries Management - Gary Valentine (SCS)
Fisheries Research - Phil Durocher (TPWD)
Special Recognition - Charles Inman (TPWD)

1980 None

1981 Fish Culture - Billy White (TPWD)
Fisheries Education - Bobby Whiteside (SWTSU)
Fisheries Management - Steve Smith (TUGC)
Fisheries Research - Al Green (TPWD)
Special Recognition - Jim Davis (TAMU)

1982 Fish Culture - Roger McCabe (TPWD)
Fisheries Research - Clell Guest (TPWD)
Special Recognition - Bob Hofstetter (TPWD)

1983 Special Recognition - Robert Kemp (TPWD)

1984 None

1985 Fisheries Education - Donald Wohlschlag (UTMSI)
Fisheries Research - Connie Arnold (UTMSI)

1986 Fisheries Management - Billy Higginbotham (TAES)
Fisheries Research - Robert Colura (TPWD)

1987 Fish Culture - Kerry Graves (USFWS)
Special Recognition - The Sportsmen's Club of Texas
Best Presentation - Kerry Graves (USFWS)

1988 Honorable Mention (culture) - Loraine Fries (TPWD)
Fisheries Research - Gary Garrett (TPWD)
Special Recognition - Kirk Strawn (TAMU)
Best Presentation - Joe Fries (USFWS)
Honorable Mention (presentation) - Catherine Dryden (TAMU)

1989 Fish Culture - Robert Vega (TPWD)
Fisheries Management - Joe Kraai (TPWD)
Fisheries Administration - Gary Matlock (TPWD)
Fisheries Research - Roy Kleinsasser and Gordon Linam (TPWD)
Honorable Mention (research) - Bob Edwards (UTPA)
Best Presentation - Robert Smith (TAMU)

1990 Fish Culture - Glen Alexander and David Campbell (TPWD)
Fisheries Management - Dave Terre (TPWD)
Fisheries Administration - Gene McCarty (TPWD)
Best Presentation - Joe Kraai (TPWD)
Scholarships - Tommy Bates (TAMU:1989), Michael Brice (TTU)

1991 Fish Culture - Jake Isaac (TPWD)
Fisheries Management - Mark Webb (TPWD)
Fisheries Administration - Pat Hutson (TPWD)
Fisheries Research - Ronnie Pitman (TPWD)
Special Recognition - The Wetland Habitat Alliance of Texas
Best Presentation - Mark Stacell (TPWD)
Scholarships - Jim Tolan (CCSU), Michelle Badough (SWTSU)

1992 Fish Culture - Camilo Chavez (TPWD)
Fisheries Education - Brian Murphy (TAMU)
Fisheries Management - Ken Sellers (TPWD)
Fisheries Research - Bob Colura (TPWD)
Special Recognition - Bobby Farquhar, Andy Sansom, and Rudy Rosen (TPWD)
Best Presentation - Maurice Muoneke (TPWD)

1993 Fisheries Management - Bruce Hysmith (TPWD)
Special Recognition - Joe Martin and Steve Gutreuter (TPWD)
Best Presentation - Jay Rooker (UTMSI)
Scholarships -Erica Schlickeisen (SWTSU), Brian Blackwell and Nancy McFarlen (TAMU)

1994 Fish Culture - Ted Engelhardt (TPWD)
Fisheries Management - Steve Magnelia (TPWD)
Fisheries Administration - Dick Luebke (TPWD)
Special Recognition - Bob Howells (TPWD)
Best Presentation - Travis Kelsey (SWTSU)
Scholarships - Kathyrn Cauble (SWTSU), Howard Elder and Kim Jefferson (TAMU)

1995 Fish Culture - Robert Adami (TPWD)
Fisheries Education - Bill Neill (TAMU)
Fisheries Management - Spencer Dumont (TPWD)
Fisheries Administration - Roger McCabe (TPWD)
Fisheries Research - Maurice Muoneke (TPWD)
Special Recognition - Tom Heffernan and Robin Reichers (TPWD)
S. Ken Johnson (TAMU)
Best Presentation (s) - Robert Weller (TTU), Robert D. Doyle (ACE)
Scholarships - Jay Rooker (UTMSI), Robert Weller (TTU), Gil Rosenthal (UT),
John Findiesen and Karen Quinonez (SWTSU)

1996 Fisheries Education - Billy Higginbothan (TAMU)
Fisheries Management - Gary Garrett (TPWD)
Fisheries Administration - Gene McCarty (TPWD)
Fisheries Research - Ivonne Blandon (TPWD)
Special Recognition - Reeves County Water Improvement Board
Best Presentation (s) - Craig Paukert (OSU), Gene Guilliland (ODWC)
Scholarships - Chad Thomas (SWTSU), Anna-Claire Fernandez (UTMSI),
Kenneth Ostrand, Dawn Lee Johnson
Technical Support - Jimmy Gonzales (TPWD)
Honorable Mention (technical support) - Eric Young (TPWD)

1997/1998 Fish Culture - Tom Dorzak (TPWD)
Fisheries Education - Robert Ditton (TAMU)
Special Recognition - Fred Janssen, Chris Cummings, Dan Lewis, Dan Strickland, and Gary Graham (TPWD), Jim Davis (TAMU)
Best Presentation (s) -Timothy Bonner (TTU) and Gene Wilde (TTU)
Scholarships - Tony Baker and Allison Anderson (TAMU), Patrick Rice (TAMU-Galveston), Laurie Dries (UT)

1999 Fisheries Administration - Lorraine Fries (TPWD)
Special Recognition - Pat Hutson (TPWD, retired)
Best Presentation (s) - to be announced at 2000 Annual Meeting
Scholarships - Scott Hollingsworth and William Granberry (TTU), Brian Bohnsack and Michael Morgan (TAMU)

Abbreviations:
ACE - Army Corps of Engineers
CCSU - Corpus Christi State University
ODWC - Oklahoma Department of Wildlife Conservation
OSU - Oklahoma State University
SCS - Soil Conservation Service
TAES - Texas Agricultural Extension Service
TAMU - Texas A&M University
TPWD - Texas Parks and Wildlife Department
SWTSU - Southwest Texas State University
TTU - Texas Tech University
TUGC - Texas Utilities Generating Company
USFWS - US Fish and Wildlife Service
UT - University of Texas at Austin
UTMSI - University of Texas Marine Science Institute
UTPA - University of Texas/Pan American

PANEL DISCUSSION - "WATER USE ISSUES IN TEXAS--A 21ST CENTURY CHALLENGE FOR FISHERIES MANAGERS"

PAUL HAMMERSCHMIDT, *Moderator*

Overview of Senate Bill 1

CINDY LOEFFLER *(Water Resources Team Leader, Resource Protection Division, Texas Parks and Wildlife Department, 3000 I.H. 35 South, Suite 320, Austin, Texas 78744)*

Politics of Water

LARRY MCKINNEY *(Senior Director of Aquatic Resources, Texas Parks and Wildlife Department, 4200 Smith School Road, Austin, Texas 78744)*

Reservoirs

KEN RICE *(Regional Biologist, Resource Protection Division, Texas Parks and Wildlife Department, 6300 Ocean Drive, Suite 2501, Corpus Christi, Texas 78412)*

Instream Flows

RANDY MOSS *(River Studies Program Leader, Resource Protection Division, Texas Parks and Wildlife Department, P.O. Box 1685, San Marcos, Texas 78666)*

Freshwater Flows to Bays and Estuaries

WARREN PULICH *(Coastal Studies Program Leader, Resource Protection Divison, Texas Parks and Wildlife Department, 3000 I.H. 35 South, Suite 320, Austin, Texas 78704)*

Wetlands

ROLLIN MACRAE *(Wetlands Conservation Team Leader, Resource Protection Division, Texas Parks and Wildlife Department, 4200 Smith School Road, Austin, Texas 78744)*

TECHNICAL SESSION ABSTRACTS

Lake Balmorhea Renovation Project

BOBBY FARQUHAR *(Texas Parks and Wildlife Department, 4002 North Chadbourne, San Angelo, Texas 76903)*
GARY GARRETT *(Texas Parks and Wildlife Department, HCO 7, Box 62, Ingram, Texas 78025)*

A project to renovate a 232 hectare irrigation reservoir in the Trans-Pecos area of West Texas was undertaken in summer 1998. The purpose of the project was to remove a source of non-native sheepshead minnows *Cyprinodon variegatus* that have been posing a threat to at least three species of native pupfish, and to improve the sportfish population in the reservoir through the removal of rough fish and re-stocking with sportfish. Two federally endangered fishes, the Commanche Springs pupfish *C. elegans* and the Leon Springs pupfish *C. bovinus*, and one that is currently proposed for listing, the Pecos pupfish *C. pecosensis*, are threatened by hybridization with the sheepshead minnow. Through a memorandum of agreement with the local water improvement district the water level in the reservoir was lowered to reduce the surface area to approximately 61 hectares with an average depth of 0.3-0.6 m. Rotenone was applied on August 24 by aerial spraying using a crop duster, backpack sprayers, and pumps to distribute rotenone into the deeper areas of the reservoir. Dead fish were collected for three days following the kill and disposed of in trenches dug in the dry lake bottom. Estimates of the kill indicated 7,879,597 total fish were killed of which 5,310,000 were sheepshead minnows. Three weeks after the kill no fish were collected in the reservoir or the inflow canal using seines. Seven weeks after the kill the presence of more than 70,000 sheepshead minnows was confirmed. Rotenone was re-applied to the inflow canal and an estimated 3,500 adult sheepshead minnows were killed. Estimated densities ranged from 2 per square meter in the reservoir to 200 per square meter in the inflow pool. Possible explanations include a source of genetic contamination upstream, sabotage, or survival in the lake of either adults or eggs. The restocking phase has begun with over 33,000 adult channel catfish *Ictalurus punctatus* stocked in fall 1998. Additional stocking plans include native and triploid Florida largemouth bass *Micropterus salmoides*, sunfish, and crappie. Habitat improvement projects to benefit both fish and wildlife have also been undertaken.

The Influence of Flow on Gonadal Maturation and Egg Release in Prairie Stream Fishes

TIMOTHY H. BONNER AND GENE R. WILDE *(Department of Range, Wildlife, and Fisheries Management, Texas Tech University, Lubbock, Texas 79409-2125)*

The decrease in timing, magnitude, and duration of flows is hypothesized to reduce or eliminate reproduction in native prairie stream fishes. Therefore, we tested the hypothesis that gonadal maturation and egg release is independent of stream flow in two prairie stream fishes, the Arkansas River shiner *Notropis girardi* and the speckled chub *Macrhybopsis aestivalis*. We collected approximately 25 individuals of each species per month for two years (twice a month during the summer) from the Canadian River in New Mexico and Texas. In both years, gonadal maturation was initiated in April; however, asynchronous maturation was observed throughout the summer. Gonadal maturation was independent of flow, but, in general, appeared to be dependent on photoperiod. Females contained mature ova from May through August and spent ovaries were observed only in August and September. This suggests that individual females of both species were multiple spawners. Two peaks in the gonadosomatic index were observed each year in both species and significantly decreaed following an increase in flow. This suggests that egg release occurred with an increase in flow. However, a few individuals released eggs independent of increased flow, which was determined by length-frequency and daily otolith analyses. In general, our results suggest that egg release was dependent upon flow for both the Arkansas River shiner and the speckled chub; however, under extreme low-flow conditions, few individuals from both species may release eggs. Future management of these species may require maintaining minimum flow in prairie streams during the reproductive season.

The Effects of Temporal Variation in Abiotic Factors on Stream Fish Assemblages within Isolated Pools of Ephemeral Streams

KENNETH G. OSTRAND AND GENE R. WILDE *(Department of Range, Wildlife, and Fisheries Management, Texas Tech University, Lubbock, Texas 79409-2125)*

The Brazos River upstream from Possum Kingdom Reservoir is largely intermittent. During summer dry spells, the river consists of a series of isolated pools with varying physical and chemical characteristics. We examined fish assemblage patterns in dry-season pools to determine how species composition and abundance respond to changing environmental factors. We found that species assemblages within dry-season pools were structured by maximum depth, turbidity, salinity, dissolved oxygen and ammonia concentrations ($P<0.05$). Cyprinids (i.e. plains minnow *Hybognathus placitus*, smalleye shiner *Notropis buccula*, and sharpnose shiner *N. oxyrhynchus*) were more abundant within alkaline, turbid, deeper pools. Shallower pools had higher salt and ammonia concentrations and higher relative abundance of cyprinodonts (i.e. Red River pupfish *Cyprinodon rubrofluviatilis* and plains killifish *Fundulus zebrinus*). Within pools maximum temperatures and salinity increased through time whereas pH and depth decreased. As these environmental factors changed cyprinid relative abundance decreased while cyprinodonts increased in relative abundance. Changes in individual pools parallel those observed among pools on a larger geographic range.

Biotic and Abiotic Factors Influencing Fish Assemblagte Structure in a Naturally Saline River System

NIKKOAL J. DICTSON AND FRANCES P. GELWICK *(Department of Wildlife and Fishery Sciences, 210 Nagle Hall, Texas A&M University, College Station, Texas 77843-2258)*

The purpose of this study was to document fish populations that could potentially be affected by the proposed Red River Chloride Control Project on the Wichita River. Thirty-six sites were sampled on the Wichita River and its tributaries. Additionally, 31 sites were sampled on the Red River's tributaries in Texas and Oklahoma between the Wichita River and Lake Texoma. The Wichita River consists of north, middle, and south forks that merge into the Red River. The south fork contains an inflatable dam that is currently diverting water, the middle fork has an inactive dam, and the north fork does not have a dam. The Wichita River is a prairie stream that provides a harsh summer environment for fish due to high temperatures, high natural salinities, and low flows. We hypothesized that during periods of high stress these abiotic factors should be strongly related to fish assemblage structure and their distributions. Furthermore, species less tolerant to such harsh abiotic conditions should be absent from the fish assemblage, while highly tolerant species should be present. We further hypothesized that if highly tolerant species are absent in the presence of intolerant species, then additional biotic interactions may be influencing fish assemblages.

Fishes of the Sulphur River

MICHAEL N. MORGAN AND FRANCES P. GELWICK *(Department of Wildlife and Fishery Sciences, 210 Nagle Hall, Texas A&M University, College Station, Texas 77843-2258)*

As part of an in-stream flow study, fish were collected in the downstream reaches of two proposed reservoir sites on the Sulphur River. Previous collections of fish from this river were made in the early 1950's prior to inundation of Wright Patman Lake and in the early 1970's on upstream tributaries. However, no collections have been made in the middle reaches of the mainstem Sulphur River where deep water due to upstream channelization occurs. Electrofisher, seines, and gillnets were used to sample fish from a variety of complex habitats. Samples to date indicate similar species richness and relative abundances within upstream or downstream river reaches. However, comparison of assemblage composition between river reaches showed smallmouth buffalo *Ictiobus bubalus* were most abundant in upstream sites, and red shiners *Cyprinella lutrensis* were most abundant in downstream sites. Periodic fish collections are necessary to determine expected background variation in fish community structure so that changes due to anthropogenic alterations can be detected.

An Overview of the Proposed Designation of the 7 ½ Fathom Reef as a Coastal Preserve

PAUL CHOUCAIR *(Texas Parks & Wildlife Department,702 Navigation Circle, Rockport Texas 78382)*

The Texas Parks & Wildlife Department (TPWD) and the Texas General Land Office (GLO) implemented the Coastal Preserve System to develop a system of Coastal Preserve Leases which, through joint cooperation of the GLO and TPWD and supportive help from private and public organizations, would protect unique coastal biological communities, and preserve natural resources. The unique ecology and biology of 7 ½ Fathom Reef is discussed, along with the potential benefits of its designation as a Coastal Preserve.

License Limitation for the Texas Blue Crab Fishery

TOM WAGNER *(Texas Parks & Wildlife Department,702 Navigation Circle, Rockport, Texas 78382)*

House Bill 2542, signed into law by Governor George Bush on June 20, 1997, authorized the Texas Parks and Wildlife Commission to create a new license and license limitation plan for the Texas commercial crab fishery. The goal of this plan was to improve the economic stability of the commercial crab fishery while providing long-term conservation for crab stocks. Extensive outreach activities were conducted prior to and during plan development to educate, solicit input, and ensure an industry-generated plan. The Texas Parks and Wildlife Commission adopted the new commercial crab license and license limitation plan in April 1997, which became effective September 1, 1998. Major plan elements include eligibility, license renewal and transferability, antimonopoly feature, license revocation, license buyback, review board and program review. Proactive cooperation between Department staff, industry and other interested individuals on this license limitation plan should provide long-term benefits to both commercial crab fishermen and the resource.

Evaluation of Three Bycatch Reduction Devices in Aransas Bay during the 1997 Spring and Fall Commercial Bay Shrimp Seasons

BILLY E. FULS AND LAWRENCE W. MCEACHRON *(Texas Parks & Wildlife Department, 702 Navigation Circle, Rockport Texas 78382)*

The Texas Seafood Producers Association in conjunction with Texas Parks and Wildlife Department and Texas A&M Sea Grant researchers conducted a Coastal Bend Bays and Estuaries Program funded Bycatch Reduction Device (BRD) Demonstration Project during the 1997 spring (15 May - 15 Jul) and fall (15 Aug - 15 Dec) commercial bay shrimp seasons. Three BRDs (Fish Eye [FE],

5.1 cm Space Bar Turtle Excluder Device [5.1 cm TED], and Large Mesh Extended Funnel [LMEF]) were evaluated for their effectiveness to reduce bycatch and limit shrimp loss. One-hour comparative trawl tows were conducted in Aransas Bay using 9.7 m trawls during the spring season and 13.6 m trawls during the fall season. Bycatch varied between seasons and among BRDs, but indicated BRDs have potential for reducing bycatch organisms while at the same time limiting shrimp loss. The LMEF had the highest total bycatch reduction rate in weight and the second highest reduction rate in number, with no significant overall shrimp loss during spring. The 5.1 cm TED was first in total bycatch reduction in number during spring, but had significant loss in shrimp weight. This shrimp loss was greater than the total bycatch reduction rate. Weight reduction rates for total bycatch and total other invertebrates were significant during spring with the LMEF. Overall, the LMEF significantly reduced bycatch in number and weight at higher rates than the other two BRDs during fall. However, high significant shrimp loss with the LMEF is a concern during fall. Both the FE and 5.1 cm TED reduction rates varied among groups in fall. Spot *Leiostomus xanthurus*, the most abundant bycatch species, was reduced best by the LMEF during spring and fall. During spring, economically important species of management concern had greatest reduction rates with the 5.1 cm TED and FE for Atlantic croaker *Micropogonias undulatus*, 5.1 cm TED for sand seatrout *Cynoscion arenarius*, LMEF for blue crab *Callinectes sapidus*, and FE for southern flounder *Paralichthys lethostigma*. During fall, Atlantic croaker and sand seatrout had greatest reduction rates with the LMEF; whereas, blue crab had highest reduction rates with the 5.1 cm TED. Differences in bycatch reduction among studies and BRDs can be affected by many factors such as variations in bottom substrate, water depth, and temporal and spatial biodiversity in size and population of shrimp and other organisms within commercial trawling areas. Other variables are size and placement of BRDs, size and type of trawl, length of trawl bag used, and speed and duration of tow. All these factors working independently or in concert affect bycatch reduction and shrimp loss. Low reduction rates in spring compared to fall are a concern because major bycatch organisms are, overall, smaller in size and found in greater abundance and weight in spring than in fall. Future development of BRDs for use in bays should be directed at reducing smaller bycatch organisms during the spring season, as well as maintaining equal or greater reduction rates during fall, with minimal shrimp .loss. It is recommended that further studies are conducted on the three BRDs tested in this demonstration project, and on other configurations that may hold promise at reducing bycatch. More BRD research is needed before specific recommendations for BRD use in Texas waters can be proposed. Although BRD reduction rates in this demonstration project are promising, differences between BRDs and control nets were not significant for many groups and species, probably due to small sample sizes. Continued proactive participation of the bay shrimp industry in research and development of BRDs will help speed resolution of the bycatch issue. This cooperative process will benefit Texas ecosystems as well as the Texas bay shrimping industry. It is recommended that the bay shrimp industry, through a responsible proactive approach to fisheries management (conservation, stewardship?), adopt and support the voluntary use of BRDs.

The 1996 Red Tide Event in Texas Coastal Waters

DENNIS PRIDGEN *(Texas Parks and Wildlife Department, 702 Navigation Circle, Rockport, Texas 78382)*

A toxic red tide algal bloom *Gymnodinium breve* was first identified in the Gulf of Mexico off the lower Texas coast on September 11, 1996, and persisted for eight weeks. Inshore and nearshore Gulf waters were affected. Approximately three million fish were killed and shellfish harvest was closed in affected areas. Twelve thousand mature red drum *Sciaenops ocellatus* were killed immediately prior to their annual spawning run, and recruitment was 65% below average in two major embayments. Texas Parks and Wildlife responded with increased stock enhancement the following year to compensate for lost recruitment in Aransas and Corpus Christi bays.

Monitoring of Fisheries Resources of the Gulf of Mexico Surf Zone Along the Texas Coast, 1987-95

PERRY F. TRIAL AND DAVID R. BLANKINSHIP *(Texas Parks and Wildlife Department, 95 Fish Hatchery Road, Brownsville, Texas 78520)*

The surf zone of the Gulf of Mexico was sampled in five areas from Sabine Lake to the Rio Grande using bag seines and beach seines from 1987-95. Bag seines were 18.3 m long X 1.8 m deep and constructed of multifilament nylon. The wings and the bag of the seine were 19 mm and 13 mm stretched mesh respectively. Beach seines were 60.9 m long X 1.8 m deep and constructed of monofilament with 76 mm stretched mesh. Sampling occurred throughout the year from 1987-90 and from May-November from 1991-95. Each gear was used to collect three samples twice a month per sampling area. All organisms ≥5 mm were collected and counted, and a subsample of 19 individuals of each species was measured. Hydrological data were also collected at each sampling station. Coast-wide relative abundance and size of organisms will be reported for selected species.

Potential for Aquaculture in Effluents from Cattle Feedlots

NICK C. PARKER, CLIFFORD B. FEDLER, AND T.J. COX *(U.S. Geological Survey - Biological Resources Division, Texas Cooperative Fish and Wildlife Research Unit, Texas Tech University, Lubbock, Texas 79409-2120)*

The 5.3 million head of cattle produced annually from feedlots on the High Plains of Texas generate 27.7 million mg (wet weight) of manure annually. In a demonstration project at Texas Tech University nutrients were extracted in a series of constructed wetlands receiving anaerobically digested cattle waste originating as the runoff from a cattle feedlot. Effluent from the constructed wetlands was passed through a series of tanks to evaluate quality of water for culture of selected freshwater fishes. Bioassays with eight species of freshwater fish were used to evaluate quality of effluents originating from a cattle feedlot. The fish species chosen represent fish of interest to anglers (bluegill *Lepomis macrochirus*), a standard used by regulatory agencies such as the

Environmental Protection Agency in bioassays (fathead minnow *Pimephales promelas*), baitfish (redfin shiner *Lythrurus umbratilis*), globally important aquaculture species (blue tilapia *Tilapia aurea*), and commercially valuable aquarium fish (common carp *Cyprinus carpio*, guppies *Poecilia reticulata*, swordtails *Xiphophorus helleri*, and sailfin mollies *Poecilia latipinna*). These species were chosen in concert with the Texas Parks and Wildlife Department to provide a wide scale evaluation of constructed wetland effluent. Effluent from six constructed wetlands loaded with anaerobically digested cattle waste and from one control system with dechlorinated tap water (seven treatments total) was directed to 28 fiberglass tanks 3 m long x 0.3 m x 0.3 m. The 28 tanks were arranged four per series per treatment. Ten bioassay trials (replications) were conducted with 8 species of fish randomly assigned to one of each of the 4 tanks in each series. Each tank was partitioned into two compartments with each compartment containing 10 fish of one species per 2-week trial. Water was aerated to provide oxygen, and fish were monitored daily to determine survival. Average survival of all species combined was 93% in the controls with a COD of 10.6 mg/L; 63.7% at a COD of 29 mg/L; 67.3% at a COD of 55 mg/L; 66.3% at a COD of 65 mg/L; and, 0% at a COD of 616 mg/L. At a COD of 65 mg/L survival by species was 90.9% for blue tilapia, 93.9% for common carp, 63.6% for fathead minnows, 100% for sailfin mollies, 0% for redfin shiners, 27.2% for guppies, 100% for bluegill, and 54.5% for swordtails. These preliminary data indicate that constructed wetlands can be used to process effluents from cattle feedlots and yield water suitable for survival of some economically valuable freshwater finfishes.

Aquaculture and Confined Animal Operations: An Integrated Approach to Recycle Resources

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Freshwater constitutes only about 3% of the earth's total water volume and two-thirds of that is locked up in polar ice caps and glaciers. The global per capita water availability based on data from 96 countries in the 1970s was 17 m^3/year. With a global population of about 4 billion in 1975 and a population of 5.9 billion in 1998 the per capita water supply is now only 12 m^3/day. The United States used 544,320 m^3 of recycled sewage per day in 1985 and cities from Florida to California are now considering additional treatment of sewage effluent and recycling to augment freshwater supplies. Freshwater for livestock is also becoming more expensive as freshwater supplies become more limited and production of cattle, swine, and poultry increase. The global cattle industry had about 1.28 billion head in 1989, of which 100 million were in the Unites States. The manure produced by these cattle averages about 10 billion mg of wet manure worldwide annually and contains 58 million mg of nitrogen. On the Texas High Plains, 5.3 million head of cattle are fed annually in feedlots and at any one time have about 3.5 million head on feed. The animals each consume about 31 L of water per day (11.6 m^3/year) or about 40 million m^3/year, and produce about 27.7 million mg (wet weight) of manure containing about 158,000 mg of nitrogen. The nitrogen-rich effluents from confined animal feeding operation (CAFOs) containing cattle, swine, and poultry are major sources of nutrients released into the environment. The aquaculture production of both plants and animals (fish and shellfish) is one way to capture and recycle nutrient resources from CAFOs. In a demonstration project at Texas Tech University we have extracted nutrients by producing duckweed *Lemna* sp. and other plants in a series of constructed wetlands receiving anaerobically digested cattle manure. The effluent from these constructed wetlands was used to culture freshwater fishes. Up to 79.5% of the total nitrogen was removed in a constructed wetland loaded daily with nitrogen at 2.3 kg/ha. However, in wetlands loaded daily with 15.5 kg/ha , 50% of the nitrogen or 7.7 kg/ha was removed. The removal of ammonia-nitrogen ranged from 64.0% at a loading rate of 3.11 kg/ha to 86.9% at a daily loading rate of 1.24 kg total nitrogen per hectare. We calculated that 1.39 kg (dry weight)/day of duckweed (27% protein) could be produced from the daily manure from one 454 kg steer. Therefore, a 50,000 head feedlot at 80% capacity could produce 22,000 metric tons (dry weight) of duckweed annually, or 11% of the plant protein needed for cattle in the feedlot. Were effluent from constructed wetlands used for production of fish, we have calculated that a feedlot of 50,000 head of cattle would yield nutrients to support 15,000 kg of baitfish or 30,000 to 75,000 kg of fish harvested as protein. The integration of aquaculture production facilities with existing CAFOs provides an attractive alternative to reduce environmental pollution, to produce aquatic products, and to recycle freshwater.

Performance of Wild Stock and Imperial Stock Channel Catfish Fingerlings in Hatchery Ponds

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Fingerlings from two channel catfish *Ictalurus punctatus* stocks, a domesticated stock (Imperial) and a "wild" stock from Texas reservoirs, were compared for hatchery performance. Four ponds of each group were stocked at 0.03 fish/L and fed the same regimen. The ponds were lowered and sampled at 55 to 63 days post stocking to obtain length and weight estimates, at which time feeding rates were adjusted. Fingerlings were harvested 111 to 116 days after stocking. Growth rates, food conversion, and survival were compared between stocks. Fingerlings from Imperial stock out performed those from "wild" stock. Growth rate (mm/d and kg/d) was significantly greater ($P<0.05$) and food conversion was significantly less ($P<0.05$) for the Imperial stock fingerlings. No significant difference was found in percent survival ($P>0.05$) between the two stocks. Fingerlings from the Imperial brood stock were observed to be much more aggressive feeders, which may have contributed to their better performance in this study.

Movement of Triploid Grass Carp Among Small Hydropower Impoundments of the Guadalupe River, Texas

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Triploid grass carp *Ctenopharyngodon idella* (N=125, 50.8 - 98.6 cm total length) were implanted with radio tags and released into five reservoirs (25 fish each in Dunlap, McQueeney, Placid, H4, and H5) on the Guadalupe River, Texas. These fish were located periodically to determine specific movement patterns in and among the series of riverine reservoirs and the Guadalupe River system to provide an evaluation of their efficacy and safety as an aquatic vegetation control tool. All grass carp survived tag placement surgery and stocking into assigned reservoirs. However, beginning six months after release, stationary (no longer implanted in a fish and laying on the bottom) radio tags, due to tag loss and fish mortality, were located. Ultimately, 60 stationary radio tags were recovered and placed into other grass carp for release where each tag was found. Grass carp emigration from home reservoirs occurred throughout the study. Emigration was always observed in a downstream direction. Grass carp emigrated from these reservoirs at a rate of approximately 3.5% each six months during the first 18 months of study, which had low river flow conditions. During high river flow conditions, grass carp emigrated from these reservoirs at a rate of approximately 59% in six months. Seventy grass carp moved by from one to 10 dams, emigrating a maximum one way distance of 325 km. Due to observed grass carp emigration, they are not recommended for vegetation control efforts in similar riverine aquatic systems.

The Lake Jacksonville Integrated Approach to Managing Aquatic Plants

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Hydrilla *Hydrilla verticillata* is an invasive exotic plant, which has become a serious pest in clear East Texas reservoirs where diverse native plant communities do not exist. Traditional plant management tools such as her bicides and grass carp *Ctenopharyngodon idella* have been used successfully in Hydrilla management. However, herbicides are expensive, their use is limited by label restrictions, and Hydrilla frequently recolonizes treated areas. Grass carp can control Hydrilla but can also have adverse impacts on desirable plant communities (important as fish habitat) when used at rates high enough to control problematic plant species. Lake Jacksonville is a clear (Secchi visibility ≥ 2 m), 547 ha municipal water supply reservoir in East Texas with abundant shoreline housing and limited littoral area. Hydrilla was problematic at Lake Jacksonville in the early 1980s infesting about 48 ha. Following complaints from shoreline residents Hydrilla was treated with herbicide and subsequently disappeared completely for over 10 years. During the ensuing period, aquatic vegetation was sparse, limited primarily to rooted algae (*Nitella* sp.), and the fishery declined. To improve primary productivity and the fishery, the Texas Parks and Wildlife Department (TPWD) initiated a fertilization program on two arms of the reservoir (120 ha) from 1993-1995. Fertilization was discontinued in 1995 when Hydrilla was rediscovered in the reservoir. By fall of 1995 Hydrilla occupied 8 ha; by fall 1996 it had expanded to occupy the same areas occupied in the early 1980s. Early in 1997 a management plan was developed that combined the goals of the City of Jacksonville and TPWD. The City's goals were to: (1) minimize complaints from shoreline residents, recreational boaters, and swimmers; (2) maintain or enhance the fishery; and (3) minimize long-term costs. TPWD's goals were to: (1) minimize the occurrence of exotic plant species; (2) increase habitat stability by diversifying the aquatic plant community; and (3) increase coverage of native aquatic plants to improve fish habitat. The plan called for initial reduction in Hydrilla biomass with aquatic herbicide followed by introduction of a minimal number of grass carp (to control resprouting) and introduction of a diverse native plant community to occupy the growing space. The Hydrilla was treated with herbicide in May 1997 followed by stocking of 75 grass carp in June and 25 grass carp in fall 1997. Native aquatic plants were planted in protective cages in late summer 1997. A total of 21 species were planted representing floating, emergent, and submergent ecotypes. Plants were established in the littoral zone in five areas of the reservoir where shoreline housing was minimal. Actively growing Hydrilla was still present in fall 1997, primarily in shallow water where low reservoir levels had exposed the substrate in 1996 and herbicide treatment had not occured. Herbicide treatment of Hydrilla was conducted in these shallow water areas in June 1998 followed by additional stocking of 100 grass carp and planting of native vegetation. Although low water conditions in late summer 1998 limited growth and survival of some of the introduced plant species, many recovered following inundation as a result of early fall rains. By late fall, many of the plants introduced in 1997 and 1998 had survived and were beginning to colonize areas outside of the protective cages. Although Hydrilla was still present in some of the protective cages where native plant survival was low, predation outside the cages appeared to be controlling the resprouting of Hydrilla. In areas where Hydrilla had been present in mixed colonies with native species during the summer of 1998, it was not apparent by the fall possibly as a result of selective predation. Although the cost to the City of Jacksonville for grass carp was the same for 1997 and 1998 herbicide costs were reduced to less than half. No additional grass carp stockings are anticipated for 1999. Herbicide applications are expected to be spot treatments only if necessary with minimal cost to the City. Continued native plant introductions are scheduled for 1999 in additional areas and on an experimental basis where Hydrilla has been controlled. Preliminary results indicate that the integrated treatment approach has the potential to meet the goals of both the City and TPWD. Assessment of the integrated plan will continue.

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

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Because many Texas reservoirs are either sparsely vegetated or contain an overabundance of non-native plant species such as hydrilla *Hydrilla verticillata*, the Texas Parks and Wildlife Department, Inland Fisheries Division began a new initiative to develop procedures for establishing diverse native aquatic plant communities in reservoirs. The objective of the first phase of the initiative is to determine survival of 21 species of native aquatic vegetation planted in 11 different exclosure types (to protect against herbivory) in seven reservoirs representing a variety of ecological conditions. Two-month survival for vegetation protected by two levels of exclosures (individual "tomato cages" within cove or shoreline fences) for emergent species was 90%, followed by 76% for floating-leaved species, and 69% for submersed species. Survival was considerably lower without protection from herbivory: 67% for emergent species, 35% for floating-leaved species, and 19% for submersed species.

Survival and Vulnerability to Angling of Channel Catfish and Blue Catfish Produced for Texas Parks and Wildlife Department's Community Fishing Lake Program.

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We compared survival and catchability of channel catfish *Ictalurus punctatus* and blue catfish *I. furcatus* produced for the Texas Parks and Wildlife Department's statewide small impoundment stocking program. Transporting fish from the producing hatchery to the research facility simulated standard transport procedures for the statewide stocking program. Fish of each species were stocked into laboratory tanks to assess short-term (12 h, 24 h, 48 h, and 72 h) stocking survival. Other fish were stocked into four, 0.20 - 1.01 ha ponds to assess medium-term stocking survival (21 d), and into three, 0.24 ha ponds for comparison of vulnerability to angling. Survival at 80 d poststocking was also assessed for fish stocked into three 0.24 ha ponds. We observed 100% survival of both species for the first 72 h poststocking. Survival averaged 97% for each species for fish held 21 d in ponds. At 80 d poststocking, survival of channel catfish (96%) was considerably better than survival of blue catfish (70%). During a 4 week period, angling returned an average of 50% of the initial stocking of blue catfish and 28% of stocked channel catfish. Based on observed rates of survival and vulnerability to angling, stocked blue catfish yielded a short-term return of 35% (percentage surviving and being caught within 6 months after stocking) versus 27% for channel catfish. Our findings suggest two management alternatives: blue catfish can provide a greater short-term benefit in community fishing lakes due to greater vulnerability to angling, whereas channel catfish may provide a reduced benefit spread over a longer time period due to greater long-term survival.

Mortality in Texas Black Bass Fishing Tournaments

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We studied self-reported measurements of initial tournament-associated mortality in Texas black bass *Micropterus* spp. fishing tournaments that varied in size and rules of conduct. Self-reported measurements of initial mortality varied by a factor of 30 among tournaments according to rules and format. The lowest initial mortality was reported for paper tournaments (1.1%), in which fish are captured, measured, and immediately released. Initial mortality estimates ranged between 4.7 and 5.4% for big fish, team, and total weight tournaments. The greatest initial mortality (31.8%) was observed in road runner tournaments, in which fish are captured from various lakes, transported overland to a central weigh-in site, and then weighed and released. For total weight tournaments, we also compared self-reported measurments of mortality with those derived from a regression model that predicts initial mortality based on water temperature. Self-reported measurements of initial mortality averaged 5.8% and predicted initial mortality averaged 3.9%. The greatest differences between these estimates occurred in March through June when self-reported mortality was 3 - 4% greater than predicted mortality. The general agreement between self-reported and predicted estimates of initial mortality suggests that most black bass fishing clubs and tournament sponsors reliably report tournament-associated mortality. A lower rate of mortality (1.8%) was reported for large tournaments, those with greater than 50 participants, than for smaller tournaments (5.7%). Larger tournaments may be conducted with rules and procedures that reduce initial mortality, or sponsors of these tournaments may be less willing to accurately report tournament-associated mortality. Using a regression model that predicts total mortality based on water temperature, we estimated total mortality to be 18.0%. We added the difference between self-reported and predicted estimates of initial mortality (1.9%) to this value, yielding a final estimate of approximately 20% for total mortality in Texas black bass fishing tournaments.

POSTER SESSION ABSTRACTS

1997 Texas Red Tide Fish Kill Estimates

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The third major red tide event in 11 years was first identified offshore the middle Texas coast, near Pass Cavallo and Sargent's Beach, on 18 September 1997. The bloom moved southward into Mexico during October, with the majority of the bloom occurring in the Gulf of Mexico waters off from Padre Island. The offshore bloom endured through 23 November 1997. On 21 November, red tide was reported inside bay waters near Corpus Christi and Port Aransas. The duration of this bloom lasted through 10 December with areas of high cell counts lasting until 19 January 1998. The Texas Parks and Wildlife Department used ground truth, airplane flights, and shoreline counts to estimate species and number of animals killed. A minimum estimate of mortality was 21.8 million aquatic organisms (16.5 from the surf and 5.3 from the bays). The species most affected (in the millions) were anchovies *Anchoa* sp., Gulf menhaden *Brevoortia patronus*, Atlantic bumper *Chloroscombrus chrysurus*, beach ghost shrimp *Callichirus islagrande*, scaled sardines *Harengula jaguana*, and striped mullet *Mugil cephalus*. The species composition and red tide distributions are compared for the 1986 and 1997 red tide events.

Underwater Video Techniques for Assessing Relative Abundance of Reef Fish

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Since 1995, the Texas Parks and Wildlife Department (TPWD) has participated in a pilot study to determine if trap/video techniques can be used off the Texas coast to assess relative abundance and compute population estimates of reef fish. The program complements a SEAMAP sponsored Reef Fish Survey conducted by the National Marine Fisheries Service and other Gulf states using similar techniques. Methods used by TPWD to sample offshore oil and gas platforms and artificial reefs will be presented. Preliminary results and comparisons with other underwater techniques will be discussed.

Genetic Identification of Texas' First Record Largemouth Bass

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The first record largemouth bass *Micropterus salmoides* for Texas, caught in 1943 from Medina Lake, was larger than normally expected for the native subspecies, according to the local fisheries biologist. Speculation suggested it may have had genetic input from an early introduction of the Florida subspecies. Using the random amplified polymorphic DNA technique, I investigated it's genetic heritage with DNA extracted from scales. I found that this fish, as well as another old Medina Lake largemouth bass, were intergrades between the Florida and northern subspecies. Historical background was also researched to gain perspective on the role this early reservoir and it's anglers played in the fisheries legacy of Texas.

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Select Life History Information for Yellow Perch in Greenbelt Reservoir, Texas

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stract.— Select life history parameters were monitored for yellow perch Perca flavescens in Greenbelt Reservoir, Texas, from 1995 to 1998 to compile baseline information for this species. Female yellow perch matured by age 2 with some maturing as small as 116 mm TL and 18 g. Spawning occurred during the first 2 weeks of April at water temperatures of 10.0 - 12.9° C. Fecundity estimates ranged from 2,487 eggs/fish at age 2 to 9,427 eggs/fish at age 4. Diet of yellow perch was almost exclusively invertebrates, primarily Amphipoda, Copepoda, and Cladocera. The diet changed with fish size: fish ≤110 mm fed primarily on Copepoda and fish >110 mm fed primarily on Amphipoda. Yellow perch comprised approximately 8% (numerically and by volume) of the largemouth bass Micropterus salmoides diet, 19% numerically and 42% by volume of the white crappie Pomoxis annularis diet, and 7% numerically and 23% by volume of the walleye Stizostedion vitreum diet. No yellow perch were found in white bass Morone chrysops stomachs. Electrofishing catch rates for yellow perch ranged from 29 to 217 fish/h and proportional stock density from 14 to 25. Yellow perch young-to-adult ratio ranged from 2.0 to 27.5. Mean relative weight of yellow perch was poor (range 77.1 – 90.2). Creel surveys indicated limited use of yellow perch by anglers. Only 2.3% of anglers indicated they were seeking yellow perch in 1995 and no anglers indicated they were seeking this species from 1996-1998.

Yellow perch Perca flavescens were first stocked in northwest Texas reservoirs during the 1980's and 1990's to increase prey diversity and to provide an additional panfish for sport harvest. Reproducing populations developed in three reservoirs and several urban lakes. Very little was known of their life history in Texas waters. Yellow perch populations in reservoirs of the southern United States, although self-sustaining, are reported to be small and insignificant from a fisheries standpoint (Hackney and Holbrook 1978; Clugston et al. 1978). Except for some initial work by Kraai (1993), we found no published information regarding yellow perch populations in reservoirs in the southwestern United States. Much of the life history information for yellow perch has been published from midwestern and northern regions of the country (Pycha and Smith 1955; Maloney and Johnson 1957; Herman et al. 1959; Muncy 1962; Weber and Les 1982; Whiteside et al. 1985).

During initial investigations in Texas waters, Kraai (1993) found that winter water temperatures and spawning habitat appeared to control yellow perch recruitment in Greenbelt and Meredith reservoirs. Harvest rates were low for the first 5 years after the species was introduced. Growth was similar to that of other yellow perch populations across their native range. Population structure indices and sampling catch rates revealed that strong year classes were just starting to be produced in Greenbelt Reservoir at the conclusion of that study.

Life history information is necessary for sound biological management of fish species. The objectives of this study were to determine: age and size at maturity, spawning season, fecundity, food habits, importance as prey, population structure indices and abundance, and contribution to the fishery for yellow perch in Greenbelt Reservoir, Texas.

Methods

Greenbelt Reservoir is an 806-hectare impoundment located on the Salt Fork of the Red River 74 km east of Amarillo, Texas. The reservoir was impounded in 1967. Rooted aquatic vegetation is present in low densities. The reservoir has a water temperature regime suitable for developing self-sustaining populations of yellow perch (Hokenson 1977; Kraai 1993). The primary sport fish species found in Greenbelt Reservoir are white bass Morone chrysops, largemouth bass Micropterus salmoides, white crappie Pomoxis annularis, and walleye Stizostedion vitreum. Primary prey species are gizzard shad Dorosoma cepedianum and inland silverside Menidia beryllina. The reservoir was stocked with yellow perch in 1983 (7,500 25-mm fingerlings), 1985 (1,145 38-mm fingerlings) and 1986 (300 127-mm fingerlings).

Trap netting was conducted from late January through mid-April, 1995, 1996 and 1997 to collect yellow perch to determine age and size at maturity, spawning period, and fecundity. Frame nets had 0.9-m high x 1.8-m wide frames, a 0.9-m deep x 20-m long lead net, and 1.3-cm square knotless nylon webbing throughout. Four to six samples were collected each year with five overnight net sets for each sample. Total length (mm) and weight (g) of each female yellow perch were recorded and scale samples were collected.

Age was determined by placing a scale in a black-bottomed dish under a dissecting microscope, illuminating it from above, and counting annuli. The gonadosomatic index (GSI) of females was used to determine spawning period. The GSI was determined by removing and weighing whole ovaries to the nearest gram. Ovary weight was divided by total weight and then multiplied by 100 to derive the GSI. A peak in GSI followed by a rapid decline indicates the start of the spawning period. The end of the spawning period is indicated when no further decline in GSI is noted or no more egg bearing females are captured. Fecundity was assessed by determining the total volume of both ovaries through volumetric water displacement. Six percent of total ovarian volume was subtracted to account for outer ovarian tissue cover. Eggs were counted in two separate 0.5-ml aliquats randomly selected from the ovaries and counts were expanded to the total volume (Brazo et al. 1975).

Daytime electrofishing (between 1100 and 1600 hours) was used to collect food habit information for yellow perch. Five 15-min stations were sampled in June and August 1995, June 1996, and August 1997. All fish were measured to the nearest millimeter, stomachs removed at the esophageal junction, and cut longitudinally with a scalpel. Whole stomachs were excised and preserved in a 10% formalin solution in the field and returned to the laboratory where stomach contents were flushed with water into a petri dish with a 10- x 10-mm grid. Food items were identified to the lowest practical taxonomic level and quantified numerically.

Use of yellow perch as prey was determined by collecting food habit information from white bass, white crappie, largemouth bass and walleye. These predators were collected by summer daytime and fall nighttime electrofishing; winter, spring, and fall trap netting; and gill netting (five overnight sets; May 1995). Fall trap netting, fall electrofishing, and May gill netting were conducted in accordance with procedures detailed in TPWD (1993). Whole stomachs of up to 30 adults of each species were excised and preserved in 10% formalin in the field and returned to the laboratory. Food items were identified to species when practical and quantified numerically and through volumetric displacement.

Daytime electrofishing (five, 15-min stations) was conducted during August, 1995 -1998 to collect yellow perch for assessing population structure, relative weight indices (Wr), and relative density. All fish collected were measured (mm total length, TL) and weighed (g). Catch per unit effort (CPUE) for electrofishing was recorded as the number of fish caught per hour of actual electrofishing. Sampling statistics (CPUE for various length categories) and structural indices [proportional stock density (PSD)] were calculated for yellow perch according to length categories specified in Anderson and Neumann (1996). The young-to-adult ratio (YAR) was calculated by dividing the number of fish 77-127 mm TL by the number of fish ≥208 mm TL. Relative weight indices were calculated using standard equations from Murphy et al. (1991).

A creel survey (five weekend days and four weekdays each year, April - June 1995 - 1998) was conducted to determine directed fishing effort, catch rates, and harvest of yellow perch. The survey was conducted in accordance with TPWD (1993).

Results

Age and Size at Maturity

Female yellow perch matured by age 2 (Table 1). Individual fish as small as 116 mm and weighing 18 g had fully developed gonads with eggs. Adequate samples of mature females for GSI determination were collected only in 1995. Mean GSI increased monthly from January until the second week in April. Spawning appeared to be of very short duration, occurring the first or second week of April when water temperatures were 10.0 - 12.9° C. Each year during this period extruded egg masses were observed on trap net leads and subsequent sampling produced no additional female yellow perch or egg masses.

Fecundity

Fecundity estimates were based on a sample of 13 female yellow perch collected during the pre-spawning periods in 1995 - 1997 (Table 2). Mean number of eggs per fish ranged from 2,487 for age 2 fish (mean TL = 134 mm) to 9,427 for age 4 fish (mean TL = 184 mm).

Food Habits

Yellow perch gut contents revealed 13 different categories of food items (Table 3). Amphipoda were the most abundant food item (33.4% by number) followed by Copepoda (31.9%), Cladocera (12.1%), and Zygoptera (8.9%). Mean number of food items per stomach was 24.2. Diet of yellow perch between 66 and 110 mm TL primarily consisted of Copepoda (41.5%), Amphipoda (27.8%), Cladocera (15.7%), and Zygoptera (5.5%) (Table 3). The mean number of food items per stomach for this size group was 148.3. The most abundant food items found in yellow perch 111 - 129 mm TL were Amphipoda (54.5%), Zygoptera (18.7%), Trichoptera (12.3%), and Anisoptera (11.0%). The mean number of food items per stomach for this size range was 26.0. Diet of yellow perch 131-250 mm TL was primarily Amphipoda (47.9%), Zygoptera (22.0%), Anisoptera (10.8%), and Trichoptera (8.7%). The mean number of items per stomach was 19.0.

Yellow Perch as Prey

Yellow perch were the most important single food item by volume at 41.5% in the 47 white crappie stomachs examined. Yellow perch comprised 18.8% of the white crappie diet numerically. Diet of the 50 walleye (mean TL 405 mm, range 253 – 710 mm) examined was 22.7% yellow perch by volume and 7.3% by number. A total of 106 largemouth bass (mean TL 254 mm, range 95 – 436 mm) stomachs were also examined. Yellow perch comprised 7.7% of their diet numerically and 8.2% by volume. No yellow perch were found in any of the 60 white bass (mean TL 308 mm, range 100 – 400 mm) stomachs examined.

Population Characteristics and Contribution to the Fishery

Daytime electrofishing each August 1995 - 1998 yielded yellow perch catch rates ranging from 29 to 217 fish/h. Proportional stock density values ranged from 14 to 25, YAR values ranged from 2.0 to 27.5, and relative weight values ranged from 77.1 to 90.2 (Table 4).

Spring creel survey results from 1995 through 1998

TABLE 1.—Yellow perch gonadosomatic index (GSI), Greenbelt Reservoir, Texas, 1995 - 1997. Mean GSI is the mean value for the week the data were collected. Spawn indicates no female yellow perch were collected but egg masses were found on trap nets. An entry of NC indicates the data was not collected and NF indicates no female yellow perch were collected.

Date	Water temperature (°C)	Age	Total length (mm)	Total weight (g)	Ovary weight (g)	GSI value	Mean GSI
20-Jan-95	7.0	2	143	24	2.3	9.4	
20-Jan-95		4	192	82	10.2	12.4	10.9
21-Feb-95	NC	3	147	30	5.0	16.7	
21-Feb-95		4	179	61	10.0	16.4	16.6
22-Mar-95	NC	4	212	114	22.0	19.3	
22-Mar-95		3	188	94	13.0	13.8	16.6
31-Mar-95	NC	3	186	73	18.5	25.3	
31-Mar-95		4	192	83	21.0	25.3	25.3
5-Apr-95	NC	4	187	72	19.0	26.4	
5-Apr-95		4	196	82	Spent		26.4
12-Apr-95	12.2	NF	Spawn				
1-Mar-96	6.9	2	116	18	5.0	27.8	
1-Mar-96		2	142	29	8.0	27.6	27.7
5-Apr-96	10.0	NF	Spawn				
18-Mar-97	10.7	3	135	24	4.0	16.7	16.7
26-Mar-97	12.0	4	144	39	9.0	23.1	23.1
1-Apr-97	12.9	NF	Spawn				

TABLE 2.— Yellow perch fecundity estimates, Greenbelt Reservoir, Texas, 1995 - 1997. Numbers in parentheses are the standard deviation from the mean.

Age	N	Mean TL (mm)	Mean weight (g)	Mean number of eggs	Number of eggs per gram
2	3	134 (15)	24 (6)	2,487 (440)	108 (25)
3	4	164 (27)	55 (34)	5,567 (2,535)	111 (26)
4	6	184 (23)	75 (25)	9,427 (5,360)	128 (63)

TABLE 3.—Composition of diet (percent by number) of food items for size groups of yellow perch collected from Greenbelt Reservoir, Texas, 1995-1997. Mean total length for all sizes combined was 110 mm.

		Yellow Perch Size Groups		
Food Item	All fish N=120	66 -110 mm N=74	111 - 129 mm N=22	131 - 250 mm N=24
Amphipoda	33.4	27.8	54.5	47.9
Anisoptera	4.4	2.4	11.0	10.8
Cladocera	12.1	15.7	0.5	0.0
Coleoptera	0.1	0.1	0.0	0.0
Copepoda	31.9	41.5	0.5	0.0
Decapoda	0.4	0.0	0.0	3.8
Diptera	2.3	3.0	0.0	0.0
Ephemeroptera	1.5	1.8	1.0	0.0
Fish egg	<0.1	<0.1	0.0	0.0
Gastropoda	0.9	0.1	1.5	6.3
Hydracarina	0.1	<0.1	0.0	0.4
Trichoptera	4.0	1.9	12.3	8.7
Zygoptera	8.9	5.5	18.7	22.0

TABLE 4.— Number per hour (CPUE), proportional stock density (PSD), mean relative weight (Wr), and young-to-adult ratios (YAR) for yellow perch collected by electrofishing, Greenbelt Reservoir, Texas, 1995-1998. Young-to-adult ratios were calculated by dividing the number of fish 77-127 mm total length (TL) by the number of fish ≥208 mm TL. The number in parentheses is the number of fish used to calculate the mean.

	1995	1996	1997	1998
Total CPUE	79	217	29	112
PSD	14	23	25	15
Mean Wr*	90.2 (56)	78.1 (25)	77.1 (11)	81.1 (73)
YAR	27.5	26.7	2.0	23.7

*Mean for all fish greater than or equal to102-mm total length.

revealed few anglers seeking yellow perch. In 1995, only 2.3% of anglers indicated they were seeking yellow perch. The catch rate for these anglers was 1.58 fish/h. No anglers indicated they were seeking yellow perch in surveys during 1996-1998. All yellow perch observed during the creel surveys from 1996-1998 were incidental catches and were caught at rates of 0.001 – 0.026 fish/h.

Discussion

Reproduction

Optimal conditions for maturation of yellow perch gonads are 185 consecutive days with water temperatures at or below 6° C (Craig 1987). These conditions are frequently met in Greenbelt Reservoir but are less frequently met in other areas of the state. In Greenbelt Reservoir, spawning duration appeared to be limited to a short period within the first 2 weeks in April when water temperatures ranged from 10 to 13°C. Craig (1987) indicated spawning duration could vary from 2 weeks, as seen in southeastern Lake Michigan, to 8 weeks, as seen in Slapton Ley, England. The spawning period in Greenbelt Reservoir appeared to be much shorter than the 2-week period in Lake Michigan. We suspect there may be a negative relation between spawning duration and the rate of water body warming in the spring, but determination of this relationship is beyond the scope of this study. Fecundity estimates and GSI values for Greenbelt Reservoir were similar to those reported for waters in the southeastern United States (Clugston et al. 1978).

Food Habits

Yellow perch are opportunistic feeders that are most active during daylight hours (Craig 1987). Since they feed during daylight hours, their stomachs generally are empty in the morning. The fish then actively feed, with stomachs being fullest from 1200 to 1600 hours (Craig 1987). Yellow perch generally turn piscivorous when they reach 150 mm, but gape width limits food selection (Craig 1987). There was no evidence of piscivory by yellow perch in Greenbelt Reservoir. Analysis of diet by size group revealed a shift in food selection as size increased (Table 3). For yellow perch 66-110 mm TL, the most abundant food item was Copepoda, while the primary food item for yellow perch 111-250 mm TL was Amphipoda. This apparent shift from planktivory to feeding on macroinvertebrates appeared to occur at lengths around 110 mm. Craig (1978) documented a similar shift in the occurrence of food items in a closely related species, the Eurasian perch Perca fluviatilis, from plankton to macroinvertebrates between 90 and 112 mm. He indicated that this shift was less a function of size of fish and more a function of seasonal vulnerability of prey. Further work on seasonal prey availability in Greenbelt Reservoir would need to be conducted to determine if the shift is due to prey availability or size selection.

Use as Prey

In the central and northern areas of walleye distribution, yellow perch are the most common prey item found in walleye stomachs (Craig 1987). Yellow perch were a large portion of the walleye diet in Greenbelt Reservoir, but were not as important as inland silversides and gizzard shad. Yellow perch made up almost 23% of the walleye diet by volume, but only 7% by number. This may be due to the relative abundance of prey species in the reservoir as gizzard shad and inland silversides are more abundant than yellow perch.

Although yellow perch were not found in the diet of white bass in Greenbelt Reservoir, they have been documented as a white bass prey item by Nelson and Walburg (1977) and Germann and Bunch (1985). Small yellow perch occupied areas of dense aquatic vegetation during collections at Greenbelt Reservoir. White bass are generally an open water species and are therefore less likely to feed in yellow perch habitat which could explain the absence of yellow perch in the diet. We did not collect white bass for food analysis during June and July, when age-0 yellow perch were more likely to be found further offshore. A summer collection might show that yellow perch seasonally contribute to the white bass diet.

Yellow perch also have been listed as prey for largemouth bass (Seaburg and Moyle 1964; Starostka et al. 1996; Pierce and Tomcko 1998), but they were found only in limited numbers in largemouth bass stomachs in Greenbelt Reservoir. Yellow perch were an important prey item for white crappie in Greenbelt Reservoir. This was unexpected since we found little documentation of use as white crappie prey in the literature (Seaburg and Moyle 1964).

Population Characteristics and Contribution to the Fishery

Electrofishing catch rates for yellow perch were variable with catch rates ranging from 29 fish/h to 217 fish/h with young-of-the-year (<129 mm TL) being the majority of fish collected. According to growth data presented by Anderson and Weithman (1978), growth of yellow perch in Greenbelt Reservoir was slow to moderate for age 2 to 4 fish. Fish condition, as indicated by Wr, was low with population averages below 85.

Analysis of PSD and YAR values from this study indicated this population of yellow perch was out of balance. Proportional stock density values were lower than the suggested range of 30-60% presented by Anderson and Weithman (1978). Anderson and Weithman (1978) also indicated that populations with PSD's below 25% should have a YAR between 7.0 and 13.3. The YAR values for Greenbelt Reservoir were much higher than this range for 3 of the 4 years studied. Both the low PSD values and high YAR values indicate a low density of quality size (204 mm TL) fish in the population. Anderson and Weithman (1978) stated that low PSD values for yellow perch are either a result of too few predators preying on small yellow perch or too many large predators feeding on adult yellow perch. Both of these scenarios may be occurring in Greenbelt Reservoir. Estimated aquatic vegetation coverage in 1996, primarily Eurasian water milfoil Myriophyllum aquaticum, was approximately 2.5% of the total area of the reservoir (Altena 1997), but the stands of vegetation that occur are often very dense. Predator avoidance behavior by stock-size (130 mm TL) and smaller yellow perch may result in concentrations of fish in these localized areas of dense vegetation where they are less susceptible to predation. Greenbelt Reservoir is managed with restrictive minimum length limits for white bass, largemouth bass, white crappie, and walleye. These minimum length limits ensure a continued presence of large numbers of predators able to feed on stock (127 mm TL) and quality (204 mm TL) size yellow perch. This situation is not expected to improve, as significant areal expansion of aquatic vegetation is unlikely due to fluctuating water levels and minimum length limits for game species will not be reduced to manage for yellow perch. This fishery is expected to remain static, with a few incidental catches of yellow perch taken by anglers seeking other species, similar to fisheries reported for southeastern waters of the United States (Clugston et al. 1978).

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Comparison of Bait Type Use by Sport-boat Anglers in Texas Bays and Passes, 1987-1997

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Abstract.—On-site recreational harvest survey data were examined to determine bait type usage, landings by bait type, and angler success by bait type in Texas bay and pass waters. Sixteen bait types and eight sport fish species were examined. The success of angling parties landing at least one fish was evaluated using percentage of successful anglers by bait type and fish species. Live shrimp was the most often used bait type, followed by worm jigs and live fish. Angling parties using artificial baits were more successful at catching at least one fish of all species studied. However, most fish were landed on natural baits. Usage of live shrimp has changed little since the late 1970's. The most noticeable change in bait type use was in the use of live fish which increased 333% from 1983-1987.

Sport fishing in Texas coastal waters contributes more than $1.9 billion each year to the state economy (Maharaj and Carpenter 1997). During 1996, more than 860,000 anglers spent over 13 million days fishing in Texas coastal waters (United States Fish and Wildlife Service 1996). To maintain this industry, fisheries managers have needed to provide a quality product and useful information on the product.

According to Weixelman and Chai (1991), making more information available to the angling public on the use and relative effectiveness of bait types may increase angler success. Ditton et al. (1990) reported the most important aspect of a memorable saltwater fishing trip was catch related. When fisheries managers provide information that help anglers be more successful at catching fish, one may assume that the angler is more satisfied with his angling experience.

Catch related statistics on use and effectiveness of baits for recreational anglers have been documented for the Texas coastal recreational fishery. Heffernan et al. (1976), Breuer et al. (1977), Heffernan and Green (1977), McEachron et al. (1981) and Weixelman and Chai (1991) were the only studies found that reported on use and effectiveness of baits in Texas. Since 1974, the Texas Parks and Wildlife (TPW) Coastal Fisheries Division has collected data from coastal anglers for its ongoing harvest monitoring program. These surveys target sport boat anglers at boat access sites as they return from fishing trips (Heffernan et al. 1976, Green et al. 1978, Osburn and Ferguson 1987). Information on bait use from these surveys is helpful in describing trends in bait use so fisheries managers can better manage fishery resources.

This study had two objectives: (1) to determine the types (and relative frequencies) of baits used by bay and pass anglers using a documented bait-type classification; and (2) to determine the effectiveness of various bait types at catching eight of the most often landed coastal sport fishes.

Methods

Data used in this study came from TPW harvest surveys targeting bay and pass sport-boat anglers from 15 May 1987 through 14 May 1997 on randomly selected week days and weekend days. Surveys were conducted at boat access sites in all eight major Texas bay systems as angling parties completed their fishing trip. Data collection methods are described in Heffernan et al. (1976), Green et al. (1978), and Osburn and Ferguson (1987).

Sixteen different bait types were compared: 12 single and four combination bait types (Table 1). Whenever a fishing party (entire party = one observation) estimated landing 85% or more of their catch on one bait type or used a particular bait type 85% or more of the time, then that was the bait type recorded. If two or more baits were recorded, then they were categorized as one of four combination bait types. All fish landed were observed by the interviewers. If the angling party released all fish prior to termination of the fishing trip, then the interview was classified as unsuccessful for these compilations.

Percent fishing parties use of each bait type was calculated by dividing those fishing parties by the total number of fishing parties. Similarly, the percentage of each fish landed by bait type was calculated by dividing the number of those fish by the total number of fish for each respective species. Success of bait use was calculated by dividing the number of observations of those angling parties using a bait that landed at least one fish by the total number of angling parties that used that bait type.

The eight most often landed sport fish in Texas bays and passes (Warren et al. 1994) were used in the analyses: Atlantic croaker *Micropogon undulatus*, black drum *Pogonias cromis*, gafftopsail catfish *Bagre marinus*, red drum *Sciaenops ocellatus*, sand seatrout *Cynoscion arenarius*, sheepshead *Archosargus probatocephalus*, southern flounder *Paralichthys lethostigma*, and spotted seatrout *Cynoscion nebulosus*.

TABLE 1.—Descriptions of bait types used in Texas Parks and Wildlife harvest program surveys.

Bait Type	Description
Dead shrimp	Non-living decapod crustaceans of the family Penaeidae, either fresh dead or previously iced or frozen
Live shrimp	Living decapod crustaceans of the Family Penaeidae
Spoons	Curved or flattened, chrome plated or painted metal of different colors with one hook, either single or treble, attached
Worm jigs	Soft, flexible and rubbery tails of various lengths, colors and shapes (worm-like, shrimp-like or fish-like) threaded onto a weighted or non-weighted hook
Other jigs	Natural (e.g., feathers, horse hair, etc.) or artificial (e.g., nylon, plastic, rubber, etc.) materials of various colors attached in a skirt-like manner to a weighted or non-weighted hook
Fish-like plugs	Artificial fish-like baits of various materials, shapes and colors that usually have multiple treble hooks attached
Squid	Cephalopods of the Order Teuthoidea
Live fish	Any living finfish
Dead fish	Any non-living finfish, either salted, fresh dead or previously iced or frozen, whole or in pieces
Crabs	Crustaceans of the Order Decapoda which are non-shrimp like (dead or alive)
Sea lice	Crustaceans of the Order Stomatopoda
Artificial combination	Two artificial lures were used, no one bait used >85% of the time
Natural combination	Two natural baits were used, no one bait used >85% of the time
Natural + Artificial combination	One natural bait and one artificial bait type were used, no one bait used >85% of the time
Combination 3+	Three or more bait types were used interchangeably
Unknown	Bait type unknown or bait type used did not fit into above categories

Results

A total of 98,400 individual angling party interviews from eight different bay systems were used. Coastwide, live shrimp was the most popular bait type used, with 30% of all angling parties using this bait. Worm jigs (17%), live fish (11%), and dead shrimp (10%) ranked second, third and fourth, respectively. The remaining 12 bait types represented about 32% of the usage. Live shrimp was the most often used bait type in all bay systems, with the exception of Sabine Lake (dead shrimp) and lower Laguna Madre (worm jigs) (Table 2).

Coastwide, 62% of all fishing parties interviewed were successful in landing at least one fish when using one of the bait types studied. Angling parties that were most successful used worm jigs (70%), followed by other jigs (69%), spoons (67%) and live shrimp (66%). The least effective bait type was a combination of ≥3 baits (40%). The most effective bait types by sport fish were: Atlantic croaker/dead shrimp (24%), black drum/dead shrimp (20%), gafftopsail catfish/squid (25%), red drum/spoons (45%), sand seatrout/squid (14%), sheepshead/crabs (30%), southern flounder/live fish (20%), and spotted seatrout/worm jigs (57%) (Table 3).

A total of 445,187 fish were observed landed. Spotted seatrout was the most numerous species landed (215,076), followed by red drum (63,267), Atlantic croaker (50,642) and sand seatrout (49,914). Overall, angling parties using live shrimp landed the most fish (29%), followed by worm jigs (17%), dead shrimp (13%), and live fish (11%). Angling parties using live shrimp landed the most red drum (22%), spotted seatrout (34%), black drum (40%), and sheepshead (65%). Dead shrimp accounted for most of the gafftopsail catfish (22%), Atlantic croaker (58%), and sand seatrout (26%) landed. Angling parties using live fish landed the most southern flounder (26%) (Table 4).

Discussion

Results from this study indicate Texas bay and pass sport-boat anglers use a wide variety of bait types. Although there are differences in percent of bait types used among bay systems, Texas anglers generally follow the same bait use patterns coastwide. With the exception of Sabine Lake and the lower Laguna Madre, live shrimp was the number one bait type used coastwide. McEachron et al. (1981) reported live shrimp as the second most popular bait type used on the Texas coast behind dead shrimp in the late 1970's. Weixelman and Chai (1991) reported that from 1983-1987, live shrimp was the most common bait type used coastwide. Regarding live shrimp use, very little change has occurred since the late 1970's.

Nevertheless, changes were observed in other bait type usage. Overall artificial lure use has increased since 1983-1987. This may be a reflection of angler perceptions that it is more sporting to use artificial baits or that they catch more or bigger fish. This was not reflected in the landings data. With the exception of worm jigs, most fish were landed when some type of natural bait was used. Yet in terms of successfulness, artificial baits generally ranked higher for all species combined. Conversely, decreases in use of the natural bait types were observed. It is unclear why natural bait use has declined. However, in some areas of the Texas coast live bait dealers have commented to TPW Coastal Fisheries Division staff that they can not supply demand.

The most noticeable change in bait use that occurred since 1983-1987 is the use of live fish has increased 333% coastwide, ranking third in overall use. Weixelman and Chai (1991) reported that live fish ranked 10th in use from 1983-1987. Popular media and for-hire sportfishing guides often report the effectiveness of live fish, particularly live Atlantic croaker for spotted seatrout, the most frequently landed sportfish in Texas bays. In response to requests from the sportfishing public and the bait dealer industry for increased availability of live finfish for bait and to better utilize bycatch more efficiently in the bait shrimp fishery, TPW removed certain restrictions within the shrimping industry to allow for a limited harvest of finfish in 1995. This regulatory change provided the potential for greater availability of finfish baits, particularly Atlantic croaker. This may be partly responsible for the increase in use of this bait type. Additionally, anglers may overrate the effectiveness of using live fish thinking that they catch more or bigger fish.

Angler preferences and sampling methodology may have influenced the findings of this study documenting success of baits. For example, a low success rate for a particular species may indicate that those anglers interviewed may or may not have been targeting a particular species, i.e. anglers that used live shrimp may have not sought a particular species. Also when an angling party landed multiple species, no effort was made to separate each species by bait type. To alleviate these biases, it would be necessary to separate all species by bait and gear type when the surveyor conducts the interview and species sought information correlated to bait type use. However, this is impractical when surveying numerous angling parties in succession.

In this study, when an angling party chose to release fish, rather than land them, that interview was categorized as unsuccessful. Little research has been done to determine the extent of catch and release fishing by Texas saltwater anglers. Ditton et al. (1998) surveyed a portion of the licensed resident anglers in Texas who fished in saltwater in 1993-1994 and reported that 19% of the respondents practiced catch and release fishing, as defined as releasing all fish caught. If this is indicative of the anglers interviewed in this study, then these results are minimum estimates of success and in reality may be much higher.

Results from this study should prove useful for fisheries managers and sport anglers alike. Fisheries managers may be able to predict how management decisions on regulated natural bait types, such as shrimp or finfish, will affect sportfish landings. Anglers can use the information to compare bait type effectiveness to help them decide which bait to use for a targeted species. Future studies should be conducted to determine if there are differences in bait type use on size of fish landed, species sought, and fishing history.

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TABLE 2.—Percent angling party use of bait types by bay system along the Texas coast, 1987-1997. See Table 1 for bait type descriptions.

Bait type	Sabine Lake	Galveston Bay	Matagorda Bay	San Antonio Bay	Aransas Bay	Corpus Christi Bay	Lower Laguna Madre	Upper Laguna Madre	Coastwide
Live shrimp	2.6	48.2	31.4	22.6	29.5	38.6	42.0	21.0	30.3
Worm jigs	13.9	9.2	20.7	20.5	17.2	10.3	18.0	28.4	17.4
Live fish	26.9	7.1	7.0	8.9	22.7	15.1	3.6	1.0	11.3
Dead shrimp	30.1	10.7	11.6	7.0	4.2	8.4	9.9	3.4	10.0
Natural combination	9.9	9.1	6.5	8.7	6.4	8.0	3.6	5.2	7.0
Natural + Artificial combination	4.6	3.7	5.7	7.4	4.4	4.4	5.3	10.2	5.7
Artificial combination	1.4	1.4	3.8	7.4	2.8	2.4	4.7	7.7	4.1
Spoons	2.3	1.8	4.1	6.0	3.6	2.8	3.8	3.1	3.5
Dead fish	1.9	3.1	2.4	2.8	2.2	2.9	0.8	10.0	3.3
Fish-like plugs	1.3	2.0	2.9	3.3	3.9	3.3	3.5	1.1	2.7
Combination 3+	3.0	1.5	1.4	2.2	1.9	1.7	3.5	2.4	2.2
Other jigs	1.2	0.9	1.1	0.9	0.4	0.4	1.1	5.9	1.5
Squid	0.2	0.4	1.1	1.0	0.3	0.5	0.0	0.2	0.4
Unknown	0.4	0.6	0.2	0.8	0.2	0.6	0.2	0.3	0.4
Crabs	0.1	0.5	0.2	0.3	0.3	0.5	<0.1	<0.1	0.2
Sea lice	0.0	0.0	0.0	<0.1	0.0	<0.1	0.0	0.0	<0.1
Total number angling parties	10,055	11,220	9,777	11,360	14,358	12,903	15,344	13,383	98,400

TABLE 3.—Percent angling party success (landing at least one fish) per bait type and sportfish species in Texas bays and passes, 1987-1997. See Table 1 for bait type descriptions.

Bait type	Number using bait type	Spotted seatrout	Red drum	Black drum	Southern flounder	Sheepshead	Atlantic croaker	Sand seatrout	Gafftopsail catfish	% Success for all species
Worm jigs	17,151	57.1	27.9	1.6	14.3	0.4	0.8	3.0	0.2	69.6
Other jigs	1,493	56.3	29.7	1.9	11.9	0.4	1.1	2.9	0.1	69.3
Spoons	3,397	34.5	45.2	1.5	6.0	0.4	0.9	1.6	2.3	66.8
Live shrimp	29,782	47.8	19.9	11.0	11.2	7.3	5.9	7.1	1.0	65.9
Crabs	223	1.3	25.1	16.6	0.4	29.6	0.9	0.4	1.3	65.5
Fish-like plugs	2,683	52.0	39.1	0.7	7.8	0.1	0.4	0.9	0.1	65.2
Live fish	11,081	36.8	31.9	1.7	20.0	0.4	2.1	2.3	1.3	65.1
Dead fish	3,244	27.7	34.9	5.2	7.8	0.6	6.5	9.8	2.7	60.1
Natural + Artificial combination	5,649	46.6	22.0	5.2	14.4	2.5	3.4	4.0	1.1	57.3
Artificial combination	3,997	47.6	31.9	1.1	10.7	0.3	0.6	0.9	0.1	56.9
Dead shrimp	9,831	11.2	11.6	20.3	8.1	5.4	24.3	12.6	3.0	52.7
Natural combination	6,845	24.6	16.3	10.0	14.0	4.3	13.2	10.9	4.0	52.3
Squid	436	1.6	4.3	1.6	1.2	0.0	6.6	13.7	25.4	45.7
Unknown	384	15.4	14.8	4.9	6.3	13.8	2.6	4.9	1.8	45.3
Combination 3+	2,199	27.4	14.2	3.7	9.8	2.2	5.0	4.1	1.3	40.2

TABLE 4.—Percentage of fish landed by species and bait type from Texas bays and passes, 1987-1997. See Table 1 for bait type descriptions.

Bait type	Spotted seatrout	Red drum	Black drum	Southern flounder	Sheepshead	Atlantic croaker	Sand seatrout	Gafftopsail catfish	All species
Live shrimp	33.9	21.7	40.5	21.9	65.3	15.2	25.1	16.3	29.3
Worm jigs	25.8	18.9	2.6	20.4	1.0	0.5	5.7	1.6	17.3
Dead shrimp	1.2	3.9	36.7	4.4	12.8	58.5	26.3	22.2	13.4
Live fish	13.2	19.3	1.9	26.2	0.7	1.8	2.8	7.0	11.4
Natural combination	3.0	4.8	10.3	7.8	6.7	16.2	17.6	22.0	7.4
Natural + Artificial combination	7.4	5.3	3.3	7.2	2.9	1.5	2.6	3.3	5.5
Dead fish	1.3	6.0	1.5	2.1	0.2	3.6	13.4	6.9	3.7
Artificial combination	4.7	5.9	0.4	2.8	0.1	0.1	0.2	0.1	3.3
Spoons	1.9	7.4	0.6	2.4	0.1	<0.1	0.1	0.5	2.2
Fish-like plugs	3.1	2.9	0.1	1.5	0.1	0.1	0.3	0.4	2.1
Combination 3+	1.8	1.3	1.2	1.9	2.3	1.4	2.6	2.1	1.8
Other jigs	2.5	2.0	0.2	1.4	0.1	0.1	0.3	<0.1	1.6
Squid	0.0	<0.1	0.1	<0.1	<0.1	0.7	2.4	16.0	0.5
Unknown	0.2	0.2	0.2	0.2	4.0	0.3	0.8	1.4	0.4
Crabs	<0.1	0.3	0.5	<0.1	3.5	0.0	<0.1	0.2	0.2
Total number	215,076	63,267	21,172	28,029	12,428	50,642	49,914	4,659	445,187

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