ANNUAL PROCEEDINGS
of the
TEXAS CHAPTER

AMERICAN FISHERIES SOCIETY

Lake Jackson, Texas

2 – 4 March 2007

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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.

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ANNUAL PROCEEDINGS OF THE TEXAS CHAPTER AMERICAN FISHERIES SOCIETY

Annual Meeting
2-4 March 2007
Lake Jackson, Texas

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Date	President	Location
1976		College Station
1976	Ed Bonn	Lake Brownwood
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1979	Bobby Whiteside	College Station
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2004	Gary Garrett	College Station
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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)
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1981	Fish Culture - Billy White (TPWD) Fisheries Education - Bobby Whiteside (TXSTATE) 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 (TAMUCC), Michelle Badough (TXSTATE)

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 (TXSTATE), 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 (TXSTATE)
Scholarships - Kathyrn Cauble (TXSTATE), 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 (TXSTATE)

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 (TXSTATE), Anna-Claire Fernandez (UTMSI), Kenneth Ostrand (TTU), Dawn Lee Johnson
Technical Support - Jimmy Gonzales (TPWD)
Honorable Mention (technical support) - Eric Young (TPWD)

1997/8 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) - Gene R. Wilde and Kenneth G. Ostrand (TTU)
Scholarships - Scott Hollingsworth and William Granberry (TTU), Brian Bohnsack and Michael Morgan (TAMU)

2000 Fisheries Research - Gene R. Wilde (TTU)
Best Presentation - J. Warren Schlechte, coauthors - Richard Luebke, and T.O. Smith (TPWD)
Best Student Presentation - Scott Hollingsworth, coauthors - Kevin L. Pope and Gene R. Wilde (TTU)
Special Recognition - Emily Harber, Joe L.Hernandez, Robert W. Wienecke, and John Moczygemba (TPWD), Joe N. Fries (USFWS)
Scholarships - Mandy Cunningham and Calub Shavlik (TTU), Laurieanne Lancaster(SHSU)

2001 Fisheries Administration - Ken Kurzawski (TPWD)
Fisheries Education - Kevin Pope (TTU)
Fisheries Management - Brian Van Zee (TPWD)
Fisheries Research - Reynaldo Patino (TTU)
Fisheries Student - Timothy Bonner (TTU)
Technical Support - David DeLeon (TPWD)
Special Recognition - Rhandy Helton, Rosie Roegner, and Walter D. Dalquest (TPWD)
Best Presentation – Jason Turner, coauthors – Jay Rooker and Graham Worthy (TAMUG), and Scott Holt (UTMSI)
Scholarships, Undergraduate - Mandy Cunningham, and Cody Winfrey (TTU)
Scholarship, Graduate - Abrey Arrington (TAMU), and Laurianne Dent (SHSU)

2002 Fisheries Administration – Leroy Kleinsasser (TPWD)
Fisheries Management – Gordon Linam (TPWD)
Special Recognition – Raymond Mathews, Jr. (TWDB), Austin Bass Club of the Deaf
Best Presentation – Jay Rooker, coauthors – Bert Geary, Richard Kraus, and David Secor (TAMUG)
Best Student Presentation – J. P. Turner, coauthor – Jay Rooker (TAMUG)
Best Poster Presentation – Michael Lowe, Gregory Stunz, and Thomas Minello (NMFS)
Scholarships, Undergraduate – Felix Martinez, Jr. (TTU), Stuart Willis (TAMU)
Scholarships, Graduate – Mathew Chumchal (TCU), Michael Morgan (TAMU)

2003 Fisheries Culture – Dennis Smith (TPWD)
Fisheries Education – Gene Wilde (TTU)
Fisheries Student – Christine Burgess (TAMU)
Special Recognition – Larry McEachron (TPWD)
Best Presentation – Gregory Stunz (TAMUCC), coauthors Thomas Minello and Phillip Levin (NMFS)
Best Student Presentation – Monte Brown, coauthors Felix Martinez Jr., Kevin Pope, and Gene Wilde (TTU)
Best Poster Presentation – Suraida Nanez-James (TAMUG) and Thomas Minello (NMFS)

2004 Fisheries Culture - Lisa Griggs (TPWD)
Fisheries Education - Timothy Bonner (TXSTATE)
Fisheries Research - Dave Buckmeier (TPWD)
Fisheries Student - Casey Williams (TXSTATE)
Special Recognition - Deborah Wade (TPWD)

Best Presentation - Richard Kraus and David Secor (TAMUG)
Best Student Presentation - Tracy Leavy, coauthor Timothy Bonner (TXSTATE)
Best Poster Presentation - Brian Scott and Gary Aron (TXSTATE)

2005 Fisheries Administration – Roger McCabe (TPWD)
Fisheries Management – Todd Driscoll (TPWD)
Fisheries Student – Bart Durham (TTU)
Special Recognition – Jimmie Green (TPWD) and Kirk Green
Special Recognition – The Patsy B. Hollandsworth Family Foundation
Best Presentation – Gregory Stunz (TAMUCC), and coauthors Jay Rooker (TAMUG), Joan Holt and Scott Holt (UT)
Best Student Presentation – Julie Hulbert, and coauthors Timothy Bonner and David Pendagrass (TXSTATE), and Joe Fries (National Fish Hatchery – San Marcos)
Best Poster Presentation – Michael Baird (TPWD)
Scholarships, Undergraduate – Brian Bartram (TAMUCC), John Putegnat (TAMU)
Scholarships, Graduate – Megan Fencil (UTMSI), Casey Williams (TXSTATE)

2006 Fisheries Education – Kevin Pope (TTU)
Fisheries Management – Dave Terre (TPWD)
Fisheries Research – Loraine Fries (TPWD)
Technical Support – Todd Robinson (TPWD)
Special Recognition – Bruce Hysmith (TPWD)
Special Recognition – Joan Glass (TPWD)
Best Presentation - Richard Kraus and David Secor (TAMUG)
Best Student Presentation - Tracy Leavy, coauthor Timothy Bonner (TXSTATE)
Best Poster Presentation - Brian Scott and Gary Aron (TXSTATE)
Scholarships, Undergraduate – Chris Arredondo (TAMUCC), Josh Perkin (TXSTATE)
Scholarships, Graduate – Bart Dunham (TTU), Casey Williams (TXSTATE)

2007 Fisheries Administration – Larry McKinney (TPWD)
Fisheries Culture – Gary Garrett (TPWD)
Fisheries Management – Charlie Munger (TPWD)
Fisheries Research – Gary Garrett (TPWD) and Bob Edwards (UTPA)
Fisheries Student – Chris Chizinski (TTU)
Honorable Mention (Fisheries Student) – Brad Littrell (TXSTATE)
Technical Support – Reynaldo Cardona (TPWD)
Special Recognition – Robert Howells (TPWD)
Special Recognition – Fred Janssen (TPWD)
Special Recognition – Craig Scofield (TPWD)
Special Recognition – Sandy Henry (Science Spectrum, Lubbock)
Best Presentation – Craig Bonds, coauthors John Taylor and Jeremy Leitz (TPWD)
Best Student Presentation – Matthew Chumchal (OU), coauthors Michael Slattery, Ray Drenner, Matthew Drenner and Leo Newland (TCU)
Best Poster Presentation – Richard Ott and Timothy Bister (TPWD)
Scholarships, Graduate (M.S.) – Brian Bartram (Baylor)
Scholarships, Graduate (PhD.) – John Froeschke (TAMUCC)

Abbreviations:

ACE - Army Corps of Engineers
NMFS - National Marine Fisheries Service
ODWC - Oklahoma Department of Wildlife Conservation
OSU - Oklahoma State University
SCS - Soil Conservation Service
SHSU - Sam Houston State University
TAES - Texas Agricultural Extension Service
TAMU - Texas A&M University
TAMUCC – Texas A&M University-Corpus Christi
TPWD - Texas Parks and Wildlife Department
TTU - Texas Tech University
TUGC - Texas Utilities Generating Company
TXSTATE - Texas State University-San Marcos
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

TECHNICAL SESSION ABSTRACTS

Assessing Ecosystem Health in Tidally Influenced Coastal Streams

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Tidal streams are highly productive transitional areas between the freshwater of rivers and the saltwater of bays. These dynamic areas serve as nurseries for many fish and shellfish, including many commercially and recreationally important species. Numerous tidal streams are currently included on the State's list of impaired waters. Inclusion on this list initiates the Total Maximum Daily Load (TMDL) process. As a first step in the TMDL, it is necessary to assess the water body and determine if the impairment is genuine, and if so, whether or not it is caused by pollutants. This task is more difficult with respect to tidally influenced portions, as there is no accepted methodology for performing this assessment. A new assessment methodology, which relies heavily on multivariate ordination techniques, integrates the many disparate physical, chemical, and biological components of ecosystem health and allows for robust comparisons of tidal systems. Data collected from two tidal streams (Tres Palacios, currently listed as impaired; and West Carancahua, used as a reference) will be presented as an example of this methodology. The results of this study will ultimately be used to help make recommendations regarding the appropriate aquatic life uses currently identified for classified as well as the numerous unclassified tidal streams.

Reproductive Characteristics of Three Obligate Riverine Species from the Lower Brazos River

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Historic and current declines in native riverine fishes are often associated with long-term anthropogenic disturbances such as reservoir construction and flow regulation. Changes in fish assemblages vary among impacted streams with the degree of change related largely to fish life history traits, especially reproduction. For example, obligate riverine species are often more susceptible to flow alterations and often the first taxa to exhibit population declines following stream modifications. The purpose of this study was to describe the reproductive characteristics of three obligate riverine species from the lower Brazos River. *Notropis shumardi*, *N. buchanani*, and *M. hyostoma* were collected monthly from January 2004 through December 2005. Various aspects of reproduction (reproductive season, fecundity, clutch characteristics, reproductive length) were determined and yearly variation of these characteristics was compared to assess relationships between spawning success and flow.

Conservation Status and Life History of the Chub Shiner in the Lower Brazos River

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Anthropogenic regulation is a major source of disturbance in fluvial systems and has been linked to the decline in occurrence and abundance of several obligate riverine fishes. Large-scale regulation of the main stem Brazos River began in 1941 with construction of Possum Kingdom Reservoir. To date, 17 dams impound water in the Brazos River drainage. The purpose of this study was to assess conservation status, habitat selection,

reproduction, and diet of the fluvial specialist chub shiner collected from multiple sites on the Brazos River November 2003 to December 2005. Historical surveys compared to recent collections suggest that the chub shiner has declined in abundance since the 1940s (>15% to <1% in relative abundance), corresponding in part to the anthropogenic regulation of the river. Chub shiners were found in relatively shallow, low current velocity runs with predominately sand substrate. Patterns in ovarian development and gonadosomatic indices indicate chub shiner spawns multiple cohorts of eggs from spring to late summer. Gut tract contents contained primarily aquatic insects and fish. Range of chub shiner has been disputed since its description in 1951; however, new evidence suggests that chub shiners are native to the Red River basin. With localized extirpation in the Red River and abundance declines in the lower Brazos River, the long term viability of this fish is a concern.

Habitat Associations of the Fish Assemblage within the Big Bend Reach of the Rio Grande (Rio Bravo del Norte)

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The establishment of habitat associations for obligate riverine species in the Rio Grande has important implications for future conservation and reintroduction programs. Anthropogenic activities along the Rio Grande have significantly impacted biotic and abiotic conditions within this system. The Big Bend reach of the Rio Grande, between the confluence of the Rio Conchos and the Pecos River, maintains a relatively healthy fish assemblage when compared to other reaches of this river. Species such as the Rio Grande shiner (*Notropis jemezanus*) and the Rio Grande speckled chub (*Macrhybopsis aestivalis*), which have been extirpated from much of there historic range, still occur within the Big Bend reach. Habitat associations were analyzed from data collected monthly from January 2006 to December 2006. Abiotic habitat measurements and species sampling were conducted simultaneously along transects spaced 20 meters apart in areas that contained a diverse collection of geomorphic units. Seven study sites were established over roughly 190 river kilometers between Contrabando Creek, near Lajitas, and Maravillas Canyon in Black Gap Wildlife Management Area. This study provided detailed information necessary for the conservation and possible reintroduction of obligate riverine species in a highly impacted system.

Food Habits of the Non-Indigenous Suckermouth Catfish in the San Marcos River, Texas: A Concern for Spring Endemics?

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The South American catfishes of the family Loricariidae, also known as suckermouth catfish, have been widely introduced in North America due to their popularity in the aquarium trade. These fishes have currently established viable populations in Hawaii, Florida, Nevada, Texas, and Mexico. In Texas, suckermouth catfish (*Hypostomus* sp.) are established in San Marcos and Comal River, but their impacts on these unique spring-fed ecosystems and native biota are unknown. The purpose of this study was to assess the feeding habits of the suckermouth catfish in the San Marcos River and to determine dietary overlap with a native herbivorous fish, Guadalupe roundnose minnow *Dionda nigrotaeniata*. Among 27 catfishes collected from January through December 2005, gut contents consisted of algal detritus (mean relative abundance = 81.3%), picoplankton (7.7%), red algae (*Sirodotia;* 6.4 %) and diatoms and other filamentous algal taxa (5.0 %). Fish eggs, macroinvertebrates, and macrophyte material were notably absent from catfish guts. These results suggest that suckermouth catfish may have the strongest potential effects on native algivorous and detritivorous fishes through competition for food resources. Impacts of these catfishes on benthic spawning fishes, macroinvertebrates, and macrophytes is less likely to be a concern in the San Marcos River ecosystem.

Associations between Hydrological Connectivity and Resource Partitioning among Sympatric Gar Species (*Lepisosteidae*) in a Texas River and Associated Oxbows

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Patterns of resource use among sympatric gar species (*Lepisosteus oculatus*, *L. osseus*, and *Atractosteus spatula*) associated with river-floodplain connectivity in the Brazos River was studied for a period of two years (May 2003 to May 2005). Flood dynamics of the Brazos River are aseasonal and connections may be months or years apart. The first year of the study was relatively dry (few lateral connections) and the second year was relatively wet (more frequent lateral connections). Overall, 684 gars were collected with experimental gillnets: 19 *A. spatula* (alligator gar), 374 *L. oculatus* (spotted gar), and 291 *L. osseus* (longnose gar). There was strong partitioning of habitat between spotted and longnose gars, in which 98% of spotted gars were captured in oxbow habitats and 84% of longnose gars were captured in the river channel. Hydrology did not appear to affect habitat partitioning, although longnose gar abundance significantly increased in oxbows during the wet year. Diet overlap was high between the two most abundant gar species, spotted and longnose gars. Temporal variation in diet was significantly influenced by flood pulses that connected oxbows with the river channel, and which allowed predators and their prey to move between habitats.

Occurrence of the Asian Fish Tapeworm in the Rio Grande: Implications for Fishes of Conservation Concern

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Timothy H. Bonner *(Texas State University – San Marcos, Department of Biology, Freeman Aquatic Biology Building, 601 University Drive, San Marcos, Texas 78666, tbonner@txstate.edu)*

Bothriocephalus acheilognathi (Cestoda: Pseudophyllidea), the exotic Asian fish tapeworm, was reported recently in fishes from the Rio Grande in the vicinity of Big Bend National Park (BBNP). The purpose of this study was to determine distribution, prevalence, and intensity of the tapeworm in fishes of the Rio Grande, and to assess impact of the tapeworm on fish reproduction. Red shiners *Cyprinella lutrensis* were collected from four sites on the Rio Grande (three sites in BBNP, one site on Texas Parks and Wildlife Department's Black Gap Wildlife Management Area) from January through December 2006. *Bothriocephalus acheilognathi* were found at all four sites with the greatest prevalence (27%) and intensity (1-5 tapeworms per fish) during January through August. Red shiners with the parasite (N = 62) had lower condition factors (mean = 0.655) than those without the parasite (N = 302; mean condition factor = 0.764). Biomass of the tapeworm in the fish ranged from 0.02% to 14.71% of fish weight. Impact on red shiner reproduction suggests that populations of other fishes in the Rio Grande might be impacted by *B. acheilognathi* including the state-threatened Chihuahua shiner *Notropis chihuahua* and Rio Grande endemics Tamaulipas shiner *N. braytoni* (a new host record) and Rio Grande shiner *N. jemezanus*.

Historical Fish Assemblage Change in Three Western Gulf Slope Rivers

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Timothy H. Bonner *(Texas State University – San Marcos, Department of Biology, Freeman Aquatic Biology Building, 601 University Drive, San Marcos, Texas 78666, tbonner@txstate.edu)*

Monitoring fish assemblage change is an effective way to establish the level of anthropogenic impact a river has sustained. Fish assemblage data for the lower reaches of the Brazos, Sabine, and San Antonio Rivers was agglomerated and combined with hydrologic data to determine the status of fish species populations and determine the extent to which they have changed. Habitat changes have resulted in proliferation of native invader species;

habitat generalist fishes have increased in abundance while native riverine fauna have decreased. Relative abundance of many species shows little change while few show substantial increase or decline. This change is further indicated in by a shift in reproductive guilds away from obligate riverine fishes and species replacements within trophic guilds. Ultimately, these alterations are a result of flow regime and hydraulic changes commonly associated with impoundment, dewatering, and diversion of rivers.

Lake Amistad Bass Release Tube related to Increased Post-Tournament Mortality in Summer

Mandy K. Scott (*Texas Parks and Wildlife Department, Inland Fisheries Management District 1-C, 3407-A S. Chadbourne, San Angelo, Texas 76904, mandy.scott@tpwd.state.tx.us*)
John A. Dennis (*Texas Parks and Wildlife Department, Inland Fisheries Management District 1-D, 134 Braniff, San Antonio, TX 78216, john.dennis@tpwd.state.tx.us*)
Randall A. Myers (*Texas Parks and Wildlife Department, Inland Fisheries Management District 1-D, 134 Braniff, San Antonio, TX 78216, randy.myers@tpwd.state.tx.us*)

Because largemouth bass tournament angling is an important component of the recreational fishery at Lake Amistad, the National Park Service built a 46-m water-slide style tube to facilitate the rapid return to the lake of weighed-in bass. The hope was that decreased handling time might decrease post-tournament mortality, but until this study there had been no comparison of tube-released bass and conventionally-released bass. We used a mock bass tournament to compare delayed (6-d) tournament-associated mortality between tube-released bass and bass carried to the lake in water-filled bags. Twenty-three teams fished for eight hours and weighed in their fish as in a typical tournament. The fish were released by randomly-assigned method into temporary holding nets, fin-clipped according to treatment, and transferred < 1 km by boat tanks into 3 holding pens (5.5 m across x 9.1 m deep) in an 11.3-m deep cove. Overall mortality of both treatments combined was 54%. Delayed mortality of tube-released fish was 64%, double the proportion of hand-released fish (32%), even after correcting for control fish mortality. Our results suggest that fish-release tubes like this one may not be a good option for tournaments, especially in the summer when fish stress is high.

Results of a Volunteer Angler Survey Conducted at Fayette County Reservoir, Texas

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Stephan J. Magnelia (*Texas Parks and Wildlife Department, Inland Fisheries Management District 2-C, 505 Staples Rd., San Marcos, Texas 78666, stephan.magnelia@tpwd.state.tx.us*)
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A volunteer angler survey was conducted at Fayette County Reservoir, Texas, to help determine availability of trophy size largemouth bass *Micropterus salmoides* (≥534 mm in length). The upper length of the slot length limit regulation was increased from 534 mm to 610 mm in 1995. Effects of the regulation change based on standard electrofishing and creel survey data were unclear. Volunteer survey boxes were placed at the two access points where anglers voluntarily entered reports of trophy size largemouth bass catches. One hundred seventy-seven bass which exceeded 534 mm in length were voluntarily reported between October 2004 and May 2006. Data were compared to a concurrent Texas Parks and Wildlife Department (TPWD) roving creel survey to validate data gathered from volunteer responders. A chi-square test compared distributions of fish reported caught by 25.4 mm-group exceeding 534 mm during both surveys. No significant differences ($P > 0.05$) were found between the length distributions validating voluntary catch reports. Voluntary survey results supplemented electrofishing and creel data confirming availability of bass exceeding 534 mm in length to anglers and were a reliable compliment for helping determine effectiveness of the slot length limit regulation modification.

The Human Dimension of Fisheries Management Using Slot Length Limits: a Survey of Texas Anglers

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Rates of voluntary release of legally harvestable largemouth bass have increased over the last few decades, causing managers concern that this behavior is reducing the effectiveness of harvest restriction regulations. We conducted an angler survey to assess the degree to which Texas anglers practice voluntary release, their attitudes towards harvest and slot-length regulations, and factors that influence these attitudes and actions. Our sampling frame consisted of a random sample of general fishing license holders and anglers intercepted by creel surveys on reservoirs managed with a slot-length limit for bass. Seventy-one percent of bass anglers reported they rarely or never harvest bass smaller than the slot. Concerns with contaminants, value of fish as food, or the influence of peers were not reported to be strong factors in their decision to release fish. Increases to the minimum size of the protected slot range or an increase in the daily bag were not effective incentives for harvest of small bass. Anglers intercepted on slot lakes appeared to have a better understanding of the rationale for slot-length limits, and are more likely to harvest bass smaller than the slot. The propensity for general fishing license holders to release small bass appears to be motivated by a perceived conservation ethic against harvesting small bass. More anglers rely on friends, magazines, television, and websites than other informational sources. We believe these results can be used to enhance effectiveness of educational efforts to encourage angler harvest of bass smaller than protected slot-length ranges.

A Comparison of Two Texas Hatchery Management Plans on the Control of *Prymnesium parvum* during the 2006 Striped Bass Production

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Two management plans, using ammonia sulfate, were used to control *Prymnesium parvum*. Treatment 1 seeks to maintain a range of unionized ammonia, 0.16 – 0.25 mg/L, throughout production. Treatment 2 uses unionized ammonia, in the range of 0.16 – 0.25 mg/L, but only when *P. parvum* are observed. No significant differences occurred between the two treatments for production indices stocking density, harvest density, percent return, fish weight and length. Total ammonia sulfate used in treatment 1 was higher although not significant. Significant differences were found in treatment rates, which corresponded to significantly higher levels of ammonia and unionized ammonia in treatment 1 water chemistry. Daily temperature, dissolved oxygen, and pH reflect significant differences over time. No significant differences were found in zooplankton data. The results do not identify a best choice for a specific management plan which may be dependent upon conditions related to golden algae prevalence. In instances of low exposure to golden algae and no toxicity it may be beneficial to minimize ammonia additions to production ponds reducing exposure to fish and effluent. This will reduce cost and labor. In situations of consistent exposure to golden algae or identification of toxicity, a consistent continuous treatment would be recommended.

Effect of Dietary Lipids on Neutral and Polarlipids during Cold Acclimation of Fingerling Channel Catfish

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The production of channel catfish *Ictalurus punctatus* represents the largest sector of the U.S. aquaculture industry, currently accounting for nearly 50% of all sales of cultured aquatic animals. Common production strategies typically employed by catfish farmers is the multiple-crop system. However, fish held in ponds throughout the winter months are subject to sudden reductions in water temperature, which has been shown to cause mortality in warm water fish. A 12-week growth trial was conducted to determine the effects of dietary lipids (beef tallow, catfish oil, and menhaden oil) on cold tolerance of channel catfish. At the termination of the trial, catfish were exposed to two distinct temperature challenges (gradual decrease and rapid decrease). In both temperature challenges, no mortalities were observed when catfish were exposed to gradual or rapid temperature regime, suggesting that channel catfish can effectively alter their tissue fatty acid content using either dietary lipid source to successfully acclimate to cooler water temperatures. However, results from the present study indicate that fingerling channel catfish utilize two distinct methods to increase overall unsaturation content within their tissues: 1) increasing monounsaturated fatty acids when water temperatures decrease gradually; or 2) increasing *n*-3 HUFA content when water temperature decrease rapidly.

Analyzing the Significance of Chemical versus Visual Cues for Species Recognition in Male Sailfin Mollies *Poecilia latipinna*

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Animal communication involves numerous sensory modalities. Receivers can benefit from signalers using a multiple sensory modalities or they may rely primarily on one sensory modality in some circumstances. Previous work with male sailfin mollies *Poecilia latipinna* has shown that males produce more sperm when presented with both visual and chemical cues of conspecific females than when no females are present. However, there is not evidence on whether males rely on a combination of cues or if they assess only one. This study examines both the individual effects of chemical and visual cues of female sailfin mollies on male sperm production and whether male sailfin mollies prefer conspecific over heterospecific chemical cues. Male sailfin mollies are "sexually parasitized" by the gynogenetic Amazon molly. Gynogens require sperm of one of their parental species to induce embryogenesis, however, none of the male's genetic information is inherited by the offspring. My results show that males preferred chemical cues of conspecifics over visual cues, however, they did not exhibit a preference for either conspecific female chemical cues or heterospecific female chemical cues. This suggests that males may need more than one cue to assess species recognition and that the two species may secrete similar pheromonal cues.

Efforts to Recover an Endangered Catostomid *Chasmistes liorus* in Western North America

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Utah Lake, located in central Utah, is a large (96,600 surface acres) freshwater remnant of prehistoric Lake Bonneville. Historically the native fish assemblage was comprised of thirteen species, dominated by salmonids and catostomids. As early as 1847, concurrent with Anglo settlement, commercial overfishing and nonnative introductions began, resulting in decline, extirpation, and extinction of native fishes. Currently only two native species, *Chasmistes liorus* June sucker and *Catostomus ardens* Utah sucker, are found in low abundance in Utah Lake. *Cyprinus carpio* common carp (relative abundance: >90%) dominate the fish assemblage. In 1986, with <1,000 wild individuals, *C. liorus* was federally listed as endangered with critical habitat. Finalization of the June Sucker Recovery Plan occurred in 1999 and the June Sucker Recovery Implementation Program (JSRIP) in 2002. JSRIP is a multi-agency cooperative effort designed to coordinate and implement recovery actions for June sucker. The program works to balance water resource needs of the human population with June sucker recovery efforts. Current recovery efforts include refuge June sucker populations, stocking of hatchery-reared June sucker, carp removal, and habitat enhancement. Urbanization, nonnatives, and managing for angling opportunities are among a suite of obstacles hindering June sucker recovery.

Utilization of Microsatellite Markers for a Preliminary Analysis of Southern Flounder *Paralichthys lethostigma* Genetic Resources on the Texas Coast: Applications for Stock Enhancement

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The southern flounder *Paralichthys lethostigma,* an important commercial and recreational species on the Texas Coast, has recently been characterized by coastwide declines in population size. Texas Parks & Wildlife Department (TPWD) initiated an effort to hatchery-rear juvenile southern flounder for purposes of stock enhancement. Protocols to spawn captive flounder broodstock and rear juveniles in grow-out ponds are currently being tested at TPWD hatcheries. The primary goal of this effort is to develop hatchery techniques to culture this species on a large-scale basis, allowing a flexible response to changing management needs (e.g., stocking to compensate for year class failures owing to catastrophic events). In preparation for this intensive enhancement effort, research is ongoing at the TPWD/CCA-CPL Marine Development Center to conduct a preliminary survey of genetic variability among southern flounder collected along the Texas coast. Variation in allele frequencies of five polymorphic microsatellite loci was determined for 350 southern flounder obtained from 8 Texas bay systems. Samples from northern Mexico and North Carolina were also included for comparison. The information obtained in this study will be used to design comprehensive management strategies (e.g., broodfish collection, husbandry, larval rearing protocols, and hatchery juvenile release strategies) focused on the conservation of the genetic resources of this species in Texas waters.

How Will New Coal Burning Power Plants in Texas Affect Mercury Contamination in Fish?

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Emissions from coal-burning power plants are the largest anthropogenic source of environmental mercury; and mercury contamination of aquatic food webs is one of the most important environmental problems facing humans and wildlife. Utility companies have proposed building 17 new coal-powered electric generating units (EGUs), mostly in central and east Texas. In this presentation, we discuss what the potential impact of these 17 EGUs is likely to be on ecosystem quality in Texas and surrounding states, specifically in terms of mercury contamination in fish. Using data collected from fish in several reservoirs in Texas, coupled with atmospheric modeling of pollutant plumes under ambient wind flow, we show that: (i) there is currently cause for concern with respect to mercury contamination in fish in Texas and surrounding areas, (ii) emissions from the proposed EGUs in central Texas will be directly in the path of the dominant transport winds and will compromise air quality in DFW and surrounding areas, and (iii) that mercury contamination of the region's ecosystems and fisheries may increase further as a result of the proposed increased coal combustion.

Measuring Predators' Response to Stocking Larger Largemouth Bass

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For stocked fish to be utilized efficiently, they must survive the stocking. One proposed method for increasing the survival of the stocked cohort is to stock a larger fish. Previous studies have suggested that the primary regulator of stocking success in largemouth bass in Texas has been predation shortly after stocking. Hence, we investigated whether 2-inch (46-70 mm), 4-inch (90-117mm) or 6-inch (140-164 mm) fingerling largemouth bass survived longer in the presence of predators. We stocked groups of fingerling largemouth bass of various sizes into large open-water tanks (~3,000 L) with two largemouth bass (231-514 mm) per tank as predators. During the first 2 minutes, predator-prey interactions were monitored. After 1 hour, surviving fish were recaptured and measured. While it is often assumed a larger fish will survive through reduced predation, our results suggest that larger fish may also suffer high predation. Further, our results mimicked those predicted by optimal foraging theory, wherein fish preferentially choose larger prey if they can do so while expending the same amount of energy. These results suggest that simply stocking larger fish may not improve overall survival of stocked fish; that regardless of size, disorientation associated with stocking is an issue that increases vulnerability.

Why TCEQ's Nutrient Criteria Are Important to Fisheries

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The United States Environmental Protection Agency (EPA) has mandated that states develop numeric nutrient criteria for reservoirs. Under the EPA, these criteria are based on using the currently pristine waters

within a state and having all waters conform to those waters' values. This approach assumes that all developed waters were once equivalent to those waters that have remained pristine. This is a tenuous assumption, especially in Texas where all reservoirs are man-made. Fortunately, the EPA has allowed the states to develop alternative approaches in the development of these criteria. Three approaches have been forwarded in Texas, a use-based approach, a parametric approach based on "minimally-impacted" regions, and a nonparametric approach that considers each reservoir as unique. We will discuss the various approaches that have been forwarded to develop nutrient criteria and discuss why our involvement in the development of nutrient criteria within Texas' waters could be critical for future fisheries management activities.

A Nonparametric, Multivariate Approach to Comparing Length and Weight Distributions

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For many experiments and for many fisheries management actions, the final outcome of interest is whether a length or weight frequency was altered. Frequently, comparison of length frequencies is done using either a chi-square test or a Kolmogorov-Smirnov test. Other frequent ways to compare length and weight changes are to look at Wr or PSDs. We present a nonparametric, multivariate method for comparing and visualizing changes in length and weight frequency distributions. This new method uses replicate samples of the distributions to estimate within-sample variance versus between-sample variance, and utilizes a permutation test for comparing the ranked similarities of the multiple distributions. We will present two examples illustrating how this technique can be used to compare length frequencies following a regulation change or some similar perturbation to a system.

Distribution and Potential Impacts of Invasive Fishes within Wadeable Streams of the Clear Lake Watershed

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During September 2004 through October 2006 we conducted studies of selected wadeable tributaries of the Clear Lake watershed in upper Galveston Bay. Fish community data were collected using backpack electroshocking gear and seines. In addition, limited trawling and gillnetting was conducted in one of the larger bayous. Examination of preliminary results of these surveys and comparisons with past data suggest that native "exotics" such as the Rio Grande Cichlid, *Cichlasoma cyanoguttatum*, have invaded and extended their range within the watershed,and have become dominant in some water bodies. Native sunfish and overall diversity have declined in many water bodies invaded by Rio Grande Cichlids. Other exotic species including, tilapia *Oreochromis niloticus* and suckermouth catfish *Pterygoplichthys* spp. were collected and appear to be extending their ranges and increasing in density in recent years. Possible sources of invasive species include ongoing introductions by tropical fish hobbyists and downstream invasion through low salinity bay systems during flood events. The probability is high for widespread invasion of these species into other coastal streams, due to their tolerance to low salinity water.

Lake Conroe: A Case History of Integrated Plant Management for Hydrilla Control

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Lake Conroe has long been synonymous with the controversy surrounding control of the exotic plant hydrilla. By the time hydrilla was first identified in Lake Conroe in 1975, (only two years after impoundment) it already occupied 470 acres. By 1979, hydrilla had increased to over 4,500 acres and was causing significant problems for boaters, skiers, and swimmers. As a result of efforts by the Lake Conroe Association and its supporters and despite objections by Texas Parks and Wildlife Department (TPWD) staff, the Texas Legislature directed the Texas Agricultural Experiment Station and TPWD to conduct a study to determine the ability of grass carp to control hydrilla and the ecosystem effects. Between September 1981 and September 1982, 270,000 non-sterile diploid grass carp were introduced into Lake Conroe. By October 1983 hydrilla and all other vegetation had been removed from the reservoir. No significant hydrilla growth was detected in Lake Conroe for the next 13 years; however, in 1996, 3.2 acres of hydrilla were discovered. For the next nine years, herbicide treatments funded primarily by the San Jacinto River Authority (SJRA) and conducted by SJRA and TPWD were able to successfully limit the expansion of hydrilla. But by 2005 herbicide treatments alone were unable to control hydrilla expansion. As a result, TPWD and SJRA determined the need to develop a comprehensive hydrilla management plan for Lake Conroe, based on the principles of Integrated Pest Management (IPM). This plan was developed with the cooperation of angler, homeowner, other user groups, and local businesses. The plan calls for the integrated use of ecological, biological, chemical, and mechanical strategies for control of hydrilla. The goal of the plan is to reduce the surface coverage of hydrilla at Lake Conroe to < 40 acres by spring of 2008 while preserving the reservoir's native aquatic plant community.

Pollution Response: Involvement of TPWD Kills and Spills Team

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Pollution has been defined as the introduction of harmful substances or products into unprotected environments. The Texas Parks and Wildlife Department's Kills and Spills Team (KAST) was formed to investigate kills and pollution events that impact or threaten biotic resources of the state. Pollution comes from a variety of sources, such as industrial and municipal facilities, the transportation industry, and oil exploration/pipeline activities. While sources are highly variable, causes are generally limited to natural phenomena, human error, or unlawful discharge. Due to the wide variability in source and cause, investigators have the potential of working with other local, state, and federal agencies as well as other TPWD divisions. This may lead KAST staff to assuming a variety of different roles at an event ranging from consultantion, to being an independent investigator, to collecting data and functioning as an expert witness for a criminal investigation. Typically, when authorized, any legal action initiated against a responsible party by KAST will result from civil law. If restitution funds are collected, their use is regulated by agency guidelines and typically funds a wide variety of actions such as aquatic restoration, water quality projects/surveys, or educational events.

RESTORATION, CREATION AND RECOVERY OF WETLANDS SYMPOSIUM ABSTRACTS

Goose Island Shoreline Stabilization and Marsh Restoration Project – Phase One

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Goose Island, located at the northern end of Aransas Bay in Aransas County, consists of estuarine intertidal and high marsh. Adjacent aquatic habitats include seagrass beds and oyster reefs. Texas Parks and Wildlife Department (TPWD) GIS staff compared aerial photography from 1969 and 1995 and determined that 17.1 acres of Goose Island eroded from the southern shoreline during that time period. Continued erosion and submergence of Goose Island threatened to convert the remaining emergent marsh on the island into open water with resulting degradation of adjacent aquatic habitats. Phase One of the Goose Island Shoreline Stabilization and Marsh Restoration Project, implemented by TPWD and federal, state and local partners, provides immediate and long-term protection and enhancement of valuable wetland habitats that are integral to the Texas Gulf Coast and Mission-Aransas estuarine ecosystems. A 4,400-foot-long offshore rock breakwater protects a 40-acre lagoon south of Goose Island while two containment levees outline a 24-acre marsh creation site north of the island. In Phase Two, beneficial use of dredged material from two nearby boat channels will raise the bay bottom within the created marsh cells to an elevation that will support smooth cordgrass marsh. Community volunteers and school groups will plant the marsh.

An Overview of Wetland Restoration Projects in West Bay

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Relative sea level rise has increased the rate of erosion on the Northwestern shoreline of Galveston Island resulting in significant losses of intertidal wetlands and high marsh habitats. Texas Parks and Wildlife staff have worked with Galveston Bay conservation partners to plan projects and acquire funding to address these losses. Different techniques were used to address site specific issues and that incorporated knowledge from previous experiences. Further efforts are needed to address not only needs on Galveston Island but other parts of the Texas Coast.

Water and Wetlands for the Future: a Water Conservation Model at Richland Creek Wildlife Management Area

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POSTER SESSION ABSTRACTS

Temporal Variation in Mean Weight and Body Condition of Trophy Largemouth Bass in Lake Fork Reservoir, Texas

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Lake Fork Reservoir is an established trophy largemouth bass *Micropterus salmoides* fishery and has been managed under a protective slot limit since 1985. We sought to characterize the Lake Fork trophy bass fishery using voluntary reporting of trophy fish catches. Initiated in March 2003, this ongoing survey targets bass weighing ≥ 7 lbs and/or measuring ≥ 24 inches. As of October 2006, we obtained information on nearly 6,500 trophy largemouth bass. We examined whether mean weight and body condition (Wr) varied as a function of year and season. Our results suggest a significant decrease in mean weight ($P = 0.004$) and decreasing body condition ($P = 0.074$) of trophy bass since the beginning of the survey. Additionally, mean weight and body condition of trophy bass during winter (December – February) were significantly higher than during all other seasons, while trophy bass mean weight and body condition during summer (June – August) were significantly lower than during all other seasons. The number of trophy bass reported during a sampling quarter was positively correlated with directed angler effort as estimated by access creel surveys ($P < 0.001$). Using trophy bass survey data in conjunction with angler access creel surveys, we conclude that the slot limit on Lake Fork is effectively sustaining the trophy bass fishery.

Post-Larval Settlement Dynamics and Habitat Preference of Young-of-the-Year Tarpon in Texas Embayments

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Despite well-developed recreational tarpon fisheries in the northwestern Gulf of Mexico, little is known regarding their population dynamics in Texas and Louisiana. Monthly bag seine surveys for YOY tarpon conducted at three estuarine sites in Galveston, Matagorda and Jackson Counties, Texas, from August 2004 through January 2005, yielded peak abundance in November with the capture of 37 age-0 tarpon. Arrival and departure of YOY were observed in September and January, respectively. The 91 YOY captured during this interval were comprised of three length-frequency cohorts providing evidence of multiple recruitment phases. Their standard length ranged from 40 to 146 mm and averaged 67.9 mm. Approximately two-thirds of these YOY sorted to six 5-mm bins ranging from 40 to 75 mm. Monthly mean abundance differed significantly between collection sites; Matagorda (13.5 ± 5.61) (number of tarpon ± SE), Jackson (1.67 ± 0.92) and Galveston (0.0 ± 0.0). Matagorda and Jackson sites were characterized as *Spartina*-dominated low mesohaline tidal creeks distal to estuary mouth. The Galveston site was characterized as *Spartina*-*Sporobolus*-dominated ephemeral polyhaline saltmarsh pond proximal to an estuary mouth. Monthly water temperature, salinity and dissolved oxygen parameters for these sites ranged from 11.5-31.2 C, 5-24 ppt, and 3.1-8.6 mg/L, respectively.

Using Creel Surveys and a Geographic Information System to Access Marketing and Demographics Data in Support of an Urban Fishing Program

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Texas Parks and Wildlife Department (TPWD) has implemented an urban fishing program with a goal of introducing angling to demographic groups less likely to participate in angling. One challenge is finding marketing methods that effectively identify and recruit target demographic groups to the program. In winter 2005-2006, TPWD began year-round biweekly stockings of adult rainbow trout (winter) and channel catfish (other seasons) in eight major metropolitan area lakes throughout Texas. On-site angler surveys were conducted to determine the number of different people fishing at the lakes, the degree to which they had previously participated in fishing, and their zip code of residence. We used a Geographic Information System (GIS) supported by ESRI's ArcView software, including ESRI's Business Analyst (BA) extension, to geocode each interviewee's zip code of residence. This allowed us to examine geographic distribution patterns of anglers. The software's databases of census and marketing survey data allowed us to learn about the characteristics of people residing near the lakes, as well as in the interviewees' zip codes. We were able to obtain insight on sensitive demographic information, evaluate our success in targeting the desired groups, and develop marketing strategies that would help us more effectively reach the desired groups.

Can Barley Straw or the Probiotic, Liquid Live Micro-Organisms System Control *Prymnesium parvum* and Its Ichthyotoxicity?

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Since 2001, the ichthyotoxic microalga *Prymnesium parvum* has caused major fish kills in 13 US states including Texas, raising concerns about impacts on hatchery fish production, sport fisheries, and local economies. *P. parvum* can be controlled in hatchery ponds with ammonium sulfate or copper sulfate. While generally useful, several undesirable issues exist when using these chemicals. For example, (a) these chemicals provide short-term improvements, requiring frequent applications, (b) environmental conditions, such as temperature and pH, influence success, (c) concentrations of ammonium sulfate required to control *P. parvum* may harm fish, and (d) copper sulfate kills desirable algae along with *P. parvum* and significantly reduces zooplankton densities. To counter these problems, we investigated two natural products, barley straw and the probiotic, Liquid Live Micro-Organisms System (LLMO®) for their efficacy in controlling *P. parvum* and its ichthyotoxicity. We also evaluated the effects of barley straw and LLMO® on nutrients and phytoplankton biomass (chlorophyll *a*). Barley straw and LLMO® were individually tested in summer and fall 2004 in hatchery ponds for 140 days. Four ponds were treated with barley straw applied once at the beginning of the study at 252 kg/ha and four ponds received

LLMO® at a rate of 1L/56,718 L of pond water at 2-week intervals throughout the study. Another four ponds were untreated and served as control. Barley straw was further tested in winter 2005 for 93 days at 280 kg/ha. These barley straw treatment rates were similar to those used in other studies, and the LLMO® rate was provided by the manufacturer. In both experiments *P. parvum* blooms did occur. Neither barley straw nor LLMO®, at the rate used in this study, had any significant ($P > 0.05$) effect on *P. parvum* density, toxin levels, or ichthyotoxicity. Similarly, barley straw or LLMO® did not affect nitrogen and phosphorus levels and phytoplankton biomass. Our results did not support reports that barley straw or LLMO® can control planktonic algae.

Largemouth Bass Population Recovery following Hydrilla Control in Lake Bellwood, Texas

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Prior to establishment of hydrilla *Hydrilla verticillata* at Lake Bellwood, Texas in the mid 1990s, the reservoir contained a high quality largemouth bass *Micropterus salmoides* population with a proportional stock density (PSD) in the desired range of 40 - 70. By 1998, hydrilla occupied 80% of the reservoir and largemouth bass PSD had fallen to 28 in the spring and 16 in the fall; fish <305 mm dominated the population. Relative weight (Wr) was poor for most size classes. Following herbicide treatment of hydrilla in summer 1998, the size structure of the largemouth bass population changed significantly. By spring 1999 the relative density of small fish had decreased (presumably a result of increased predation by large fish) and the size distribution had improved greatly. Largemouth bass PSD in spring 1999 was 42, within the desired range for fisheries management objectives. This improved size distribution was also apparent in fall 1999 and continued through spring and fall 2000 and 2001. Wr of sub-stock sized largemouth bass improved over 1998 level as forage accessibility improved. However, no difference in Wr of larger individuals or in overall growth rate was detected.

Mercury Concentrations in Largemouth Bass from Six North Texas Reservoirs

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Largemouth bass *Micropterus salmoides* is the most important recreational fish species in Texas reservoirs. Because largemouth bass feed at high trophic levels and grow to large sizes, they can have high levels of mercury and therefore pose a risk to human consumers. During 2004 and 2005, largemouth bass were collected from six reservoirs in the Dallas/Ft. Worth area using nighttime electrofishing with assistance from Texas Parks and Wildlife Department biologists. Biologists released trophy-sized largemouth bass and they were not included in this study. Dorsal muscle tissues of 428 largemouth bass were analyzed for concentrations of total mercury. Mercury concentrations in largemouth bass ranged from 13 to 984 ppb weight wet (ww) and increased as exponential functions of fish age and total length. Less than 1% and 6% of largemouth bass collected exceeded the Texas Department of State Health Services' and the United States Environmental Protection Agency's screening values of 700 and 300 ppb ww respectively. Therefore, most largemouth bass from the six reservoirs do not pose a health risk to consumers.

Use of Preserved Museum Fish to Evaluate Mercury Contamination in Two Oklahoma Rivers

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Due to human alteration of the global mercury cycle by the burning of fossil fuels, waste incineration, and other industrial activities, mercury contamination in the environment has changed through time. To evaluate how mercury contamination of two rivers in southeastern Oklahoma may have changed through time, we determined mercury concentrations in 188 preserved longear sunfish *Lepomis megalotis* from the Sam Noble Oklahoma Museum of Natural History. Longear sunfish had been collected over 41- and 79-year periods from Glover and Mountain Fork Rivers, respectively. Glover River is unimpounded, whereas Mountain Fork River was impounded upstream from the sampling sites in 1968. Mercury concentrations in longear sunfish from Glover River showed no temporal trend from 1963 to 2004. Mercury concentrations in longear sunfish from Mountain Fork River showed no temporal trend from 1925 to 1993 but then declined to 2003. Mercury concentrations in longear sunfish from the museum were a good predictor of mercury concentrations found in un-preserved longear sunfish collected from the two rivers in 2006. These results suggest that museum collections of preserved fish may be a valuable resource for evaluating mercury contamination in fish.

Florida Largemouth Bass Introgression Following Annual Supplemental Stockings in Caddo Lake, Texas

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Abstract.—Florida largemouth bass (FLMB) *Micropterus salmoides floridanus* were successfully introduced into Caddo Lake, Texas, in 1981 and 1982. A trophy largemouth bass fishery developed in the late 1980s and the lake record was broken several times between 1989 and 1992. In an effort to maintain or increase the genetic influence of FLMB in the population, annual supplemental stockings of the subspecies were initiated in 1994 and continued through 2000 at rates ranging from 24 to 79 fish/ha. Age-0 largemouth bass were examined to assess effects of stocking. The genetic composition of age-0 largemouth bass collected using pulsed-DC electrofishing was assessed using starch gel electrophoresis in 1992, 1995 through 2003, and 2005. Percent FLMB alleles (range= 33.1 to 45.0) and percent FLMB genotypes (range = 0 to17.3) did not change significantly following additional annual stockings. Our results suggest that after establishing FLMB genetic influence in a population, additional annual stocking efforts will not necessarily continue to increase percent FLMB alleles and genotypes. However, annual stockings may help maintain levels of alleles and genotypes. Our results support the Texas Parks and Wildlife Department's current strategy of stocking FLMB in qualifying waters for two consecutive years and then reassessing genetic structure 3 years following stocking.

Supplemental stocking programs have been successful in either establishing or increasing the Florida largemouth bass (FLMB) *Micropterus salmoides floridanus* influence in new or existing largemouth bass populations (Kulzer et al. 1985; Maceina 1987; Gilliland and Whitaker 1991; Brown and Murphy 1994). Successful stockings of FLMB in communities that have existing northern largemouth bass populations have reduced high exploitation rates, increased mean size of catch, and in some instances created trophy fisheries (Pelzman 1980; Forshage et al. 1989; Kleinsasser et al. 1990).

Florida largemouth bass were successfully introduced into Caddo Lake by the Texas Parks and Wildlife Department (TPWD) in 1981 (37 fish/ha) and 1982 (45 fish/ha). A trophy largemouth bass fishery developed in the late 1980s and the lake record was broken several times between 1989 and 1992. In 1992, Florida largemouth bass allele influence at Caddo Lake was estimated at 35%, however, no pure Florida largemouth bass were sampled and F_1 and F_x genotypes totaled 20% and 56.7%, respectively (TPWD, unpublished data). In an effort to maintain and/or improve the trophy largemouth bass potential in Caddo Lake, an aggressive supplemental stocking program of FLMB was implemented in 1994. Our objective was to examine the genetic composition of the largemouth bass population following annual supplemental stocking efforts.

Methods

Caddo Lake is located in northeast Texas on the Texas-Louisiana border. It is the largest natural lake in Texas (surface area = 108.5 km^2) with a mean depth of 1.5 m. An abundance of habitat in the form of bald cypress trees *Taxodium distichum* and aquatic macrophytes contribute to quality largemouth bass *Microterus salmoides*, crappie and sunfish *Lepomis spp.* fisheries.

From 1994 to 2000, FLMB fingerlings (mean total length = 32 mm; range = 18 to 55 mm) were stocked annually in Caddo Lake at rates ranging from 24 to 79 fish/ha (Table 1). Fish were produced and stocked by Texas Parks and Wildlife Department hatcheries. Fish were transported in aerated hauling trailers and stocked at various public access locations around Caddo Lake.

Age-0 largemouth bass were collected annually in 1992, 1995 through 2003, and 2005 during fall (October or November) pulsed-DC (60 pps, 6-8 amps) electrofishing surveys. Eight fixed stations were sampled for 15 minutes each during each annual survey. Sampling locations were at least 1.5 km from stocking sites to avoid sampling stocked fish (Noble et al. 1994; Buckmeier et al. 2003). A minimum of 30 age-0 largemouth bass were collected during each electrofishing survey and attempts were made to gather an equal number of age-0 fish from each sampling location. Liver tissue was extracted from each fish and starch gel electrophoresis was conducted to determine allele frequencies and genotypes (Philipp et al. 1983). Electrophoretic analysis was conducted for loci that code for the enzymes isocitrate dehydrogenase and aspartate aminotransferase. Sagittal otoliths were removed from each fish for age verification.

Our hypothesis was that multiple annual stockings may significantly change the percent alleles and/or genotypes in a FLMB population. Comparisons among FLMB alleles and FLMB genotypes from 1992 to 2005 were accomplished using linear regression analyses. Statistics and Forecasting Software (Wessa 2007) was used to test for significant ($\alpha = 0.05$) changes in percent alleles and genotypes over years.

Results and Discussion

From 1994 to 2000, over 4 million FLMB were stocked into Caddo Lake at 24 to 79 fish/ha. The range of stocking rates was the result of varying availability of surplus hatchery fish from year to year. This aggressive supplemental stocking strategy did not significantly change the percent FLMB alleles or percent FLMB genotypes in Caddo Lake. Linear regression analyses indicated that there was no significant change in percent FLMB alleles ($F = 0.004$; df = 1,9; $P = 0.95$) or percent FLMB genotypes ($F = 0.013$; df = 1,9; $P = 0.91$) in Caddo Lake from 1992 to 2005. Percent FLMB alleles ranged from 33.1 (2005) to 45 (2004) and percent FLMB genotypes ranged from 0 (1992 and 1998) to 17.3 (1997). From 1992 to 2005 both alleles and genotypes fluctuated slightly, but essentially remained stable indicating that multiple annual stockings of FLMB did not result in continued introgression (Table 2). However, these results do indicate that annual stockings of FLMB may maintain levels of alleles and genotypes in a population.

Our results suggest that after the FLMB gene is established into a population, multiple annual stockings do not continue to increase FLMB introgression. However, additional annual stocking efforts may aid in maintaining established levels of alleles and genotypes. Because annual stockings are not always practical, periodic stockings may be a more efficient use of hatchery-produced fish. Currently, the TPWD stocks FLMB fingerlings in qualifying waters for two consecutive years followed by genetic assessment 3 years post stocking. Our research supports this stocking frequency strategy because both the percent FLMB alleles and percent FLMB genotypes in our study remained stable following supplemental stockings.

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Table 1.—Florida largemouth bass stocking history at Caddo Lake, Texas.

Year	Number of fish	Number of fish/ha
1981	411,215	37
1982	500,550	45
1994	878,048	79
1995	766,534	68.9
1996	287,218	25.8
1997	268,000	24.1
1998	673,167	60.5
1999	670,925	60.3
2000	683,264	61.5

Table 2.—Summary of starch gell electrophoretic analyses of age-0 largemouth bass collected using pulsed-DC electrofishing in Caddo Lake, Texas, in 1992, 1995 through2003, and 2005. The acronym "FLMB" refers to Florida largemouth bass, "NLMB" refers to northern largemouth bass, "F1" refers to first generation hybrid, and "Fx" refers to non-first generation hybrid.

Year	% FLMB alleles	% FLMB genotypes	% F1 genotypes	% Fx genotypes	% NLMB genotypes	Total sample size
1992	35	0	20	56.7	23.3	30
1995	44.1	6.9	24.1	62.1	6.9	30
1996	36.7	10	26.7	36.7	26.7	30
1997	44.7	17.3	15.4	53.8	13.4	52
1998	34.7	0	20	63.3	16.7	30
1999	42.5	6.7	20	50	23.3	30
2000	41.7	10	30	46.7	13.3	30
2001	41.1	3.2	35.5	41.9	19.4	31
2002	38.9	9.7	35.5	45.2	9.7	35
2003	45	5.2	21.6	60.8	11.8	60
2005	33.1	2	2	84	12	62

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Changes in Aquatic Life Use in Texas Streams from 1953 to 1986

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Abstract.— Fish were collected from a diversity of freshwater habitats throughout Texas by C. Hubbs and colleagues in 1953. Sampling was replicated 33 years later. A regionalized index of biotic integrity was applied to the fish assemblage data from 110 of these streams to examine changes in aquatic life use. Overall, aquatic life use did not change in most of the streams. Seventy-one percent of the streams yielded the same aquatic life use in 1986 as they did in 1953, suggesting that water quality and stream habitat may have remained relatively unchanged in streams across the state. The Western Gulf Coastal Plain showed the highest percentage of streams with an improved aquatic life use (50%), while the South Central and Southern Humid Mixed Land Use Region yielded the highest percentage of streams with decreased aquatic life use (14%).

Anderson et al. (1995) and Hubbs et al. (1997) previously reported on changes in fish assemblages based upon two data collections from a diversity of streams throughout Texas over a 33-year period. Their analyses examined trends at the fish family and species level using Mantel tests and detrended correspondence analysis, respectively. The most notable statewide trend reported was a reduction in lotic-adapted habitat specialists and an increase in habitat generalists (Anderson et al. 1995). In addition, Hubbs et al. (1997) reported that the relatively distinct fish assemblages in the five eastern-most river basins in the 1950s exhibited complete overlap in species composition by the 1980s. These authors suggested that this increased overlap was the result of increased variation in assemblage structure within each river basin.

This manuscript examines the aforementioned fish assemblage data from a different perspective. The index of biotic integrity (IBI) is applied to both data sets to evaluate the fish assemblage over the three decades from a water quality and habitat perspective. The IBI was originally developed by Karr et al. (1986) as a means of assessing fish assemblage degradation in streams located in the midwestern United States. Linam et al. (2002) modified IBI scoring criteria and metrics specifically for the various aquatic ecoregions described for Texas. The index is comprised of metrics specifically selected to reflect degradation of water quality and habitat. For example, sunfish species are particularly responsive to the degradation of pool habitats. If minimal numbers of sunfish species are collected, pool habitats may be degraded. Other metrics such as those associated with trophic structure provide insight into energy dynamics and can reflect the overall health of the stream. For example, the presence of a high percentage of invertivores and piscivores suggest a concurrent abundance of macroinvertebrates and forage fish, respectively. Omnivores typically become dominant in degraded systems where they are able to take advantage of a variety of energy sources. The U.S. Environmental Protection Agency has identified the IBI as a suitable technique for conducting biological monitoring (Plafkin et al. 1989). It is routinely applied in regulatory water quality assessments in Texas.

Methods

Data used in this study were collected by Hubbs and colleagues during 1953 and 1986 in a manner consistent with employing the IBI with the exception that fish were not examined for disease and other physical abnormalities and the number of seine hauls was not recorded. Fishes were collected by seining all habitat types, with the goal of collecting all species that were present in proportion to their true abundance. Seine hauls were repeated at each site until no new species were captured.

The sampling sites selected were located within four of the eight aquatic ecoregion aggregrates as described by Omernik and Gallant (1989) for Texas, including the Western Gulf Coastal Plain, the South Central and Southern Humid Mixed Land Use Region, the Subhumid Agricultural Plain, and the Central Texas Plateau (Figure 1). The IBI developed for each respective aquatic ecoregion aggregrate by Linam et al. (2002) was applied. Aquatic life use was assigned to each stream based upon the IBI score. For regulatory purposes associated with state water quality standards, streams in Texas may be classified as having limited, intermediate, high, or exceptional aquatic life use. The ecological characteristics of these uses are defined qualitatively in Texas surface water quality standards (Texas Natural Resource Conservation Commission 1995). Based upon unpublished research regarding the natural variability associated with IBI values derived from repeated sampling efforts from over 200 Texas stream stations (G. Linam, unpublished data), standard deviations ranging from 3 to 13% were applied to the calculated IBI values as a means of determining which sample stations had a significant aquatic life use change. These values are similar to those computed in a Maryland case study where the average coefficient of variation for replicates sampled within one year was 8% (Roth et al. 2001). A sampling station was considered to have had a significant change if the confidence intervals around the IBI scores did not overlap across common aquatic life use ranges.

Since fish disease data were not available, all collections were assumed to have no diseased fish and were consequently assigned the highest metric score (5). In order to determine the possible effects of assuming the absence of disease and anomalies, IBIs were recalculated using three different scoring scenarios. One iteration assigned all sampling stations the lowest possible metric score (1) with the assumption that a large percentage of diseased individuals were present during both collection events. Another iteration assigned the 1953 collections a score of 5 and the 1986 collections a score of 1. This iteration was repeated with the scores reversed for the respective collection dates. It was assumed that at least 10 seine hauls were conducted at each site. Since care was taken to match original sampling effort, time of day, and date, the difference in number of individuals collected between the sampling dates should be reflective of true changes in the fish assemblage. Data from 110 of the 129 revisited sites were used. Marine and lentic sites were omitted for the purposes of this study as assessment tools for assigning an aquatic life use to the fish assemblages in these locations have not been developed for Texas.

Results and Discussion

The Western Gulf Coastal Plain exhibited the highest percentage of streams (50%) with a significantly improved aquatic life use (Figure 2; Table 1); however, it also contained the highest percentage of streams with limited aquatic life use. No streams in this region exhibited significant declines in aquatic life use. In 1953, 67% of the streams sampled in this region (highest of all regions) harbored non-native species, albeit in low numbers. Non-native species are often capable of hybridizing or competing with native species and represent a deviation from natural conditions as they disrupt the original, highly structured fish assemblage (Echelle and Connor 1989; Miller et al. 1989; Williams et al. 1989; Garrett 1991). They can also serve as an indicator of human influence and activity. Early perturbations to streams in this region associated with the discovery of oil in the early 1900s contributed to the high incidence of limited aquatic life use found in 1953. For example, Harrel and Smith (2002) address the history of exploitation, navigational improvements, and pollution of the Neches River estuary since the 1901 discovery of the Spindletop oil field. As was the case for the Neches River (Harrel and

Smith 2002), passage of the Clean Water Act by the United States Congress in 1972 was likely the major reason for the high percentage of improved conditions found in this study. Nationwide, the percentage of waterways deemed unsafe for fishing or swimming has fallen from 66 to 33% since the passage of the act (Texas Clean Water Action 2000).

Common to all three water bodies where aquatic life use significantly increased (Lone Oak Bayou, Santa Gertrudis Creek, and Spindletop Bayou), was a decline in the percentage of omnivores (75 to 10%, 10 to 0%, and 21 to 2%, respectively). In addition, the percentage of invertivores increased (24 to 88%) and the percentage of the population comprised of individuals considered tolerant to organic enrichment declined (38 to 1%) in Lone Oak Bayou (Chambers County), which improved in aquatic life use from limited to intermediate. These differences likely reflect improved water quality as does the increase in the number of intolerant species and benthic invertivores (which could signal improved habitat conditions as well) collected in Spindletop Bayou (Chambers County), which increased from intermediate to exceptional. Santa Gerturdis Creek (Kleberg County) improved from limited to intermediate. By 1986, the percentage of streams within this region harboring non-native species had declined to 17%.

Streams in the Subhumid Agricultural Plains demonstrated the next highest percentage of streams (17%) with significantly improved aquatic life use. This region also had two streams (9%) with significantly lower aquatic life uses (Figure 3; Table 2). Sample locations that rated significantly higher in 1986 included the Brazos River (McLennan County), Childress Creek (Bosque County), Sister Grove and Pilot Grove creeks (Collin County), and the Paluxy River (Erath County). Common to all four of these streams was an increase in the number of sunfish species which increased from 3 to 5 in the Brazos River and from 2 to 4 in the remaining systems. This may indicate improved pool habitat including instream cover (Gammon et al. 1981; Angermeier 1983). Three of these streams showed a decrease in the percentage of omnivores and tolerant species and an increase in fish abundance. A decrease in omnivores typically occurs as specific components of the food base become more reliable, facilitating the support of more specialized foragers. Increased abundance is typically an indication of improved conditions as the stream exhibits increased carrying capacity (Karr et al. 1986). The concurrent decrease in tolerant species further supports improved conditions as the observed increase in fish abundance is not attributable to an influx of resilient invasive species. Two streams exhibited an increased number of benthic invertivore species and a higher percentage of the population comprised of piscivores and invertivores. An increase in benthic invertivore species (e.g., darters, madtoms, and invertivorous suckers) indicates improved water quality, greater energy sources, and increased instream habitat (Karr et al. 1986). The change in the percentage of the population comprised of piscivores and invertivores reflects a more balanced trophic structure. Increased species richness in Sister and Pilot Grove creeks provides further support for improved stream conditions.

The two stations in the Subhumid Agricultural Plains that significantly declined in aquatic life use were the North Fork of the Bosque River (McLennan County) and the Medina River (Bexar County). Both stations declined from high to limited aquatic life use. The number of native cyprinid species declined at both sites (4 to 2 in the North Fork of the Bosque River and 4 to 3 in the Medina River) while the percentage of omnivores increased (1 to 41% in the North Fork of the Bosque River and 4 to 15% in the Medina River). The Medina River also exhibited a decline in species richness (15 to 8) including the loss of all four previously collected sunfish species. The North Fork of the Bosque River exhibited a significant decline in invertivores relative abundance (96 to 53%) as well as a complete loss of benthic invertivore species. The percentage of the fish assemblage comprised of tolerant species also increased (45 to 55%) and this system exhibited the greatest increase (0 to 40%) in non-native species of any of the 110 streams analyzed. These changes point to degradation of water quality and instream habitat, which has been documented in the North Fork of the Bosque River due to pollutant contributions from confined animal feeding operations as well as municipal wastewater discharge from the City of Stephenville prior to completion of a new treatment facility (Texas Water Commission 1988, 1992). Similar to the relationship between sunfish and pool habitats, the decline in cyprinids and benthic invertivores may signal deteriorating habitat in riffle and run habitat types.

Seventy-two percent of the streams analyzed in the South Central and Southern Humid Mixed Land Use Region showed no significant change in aquatic life use, an additional 14% improved, whereas the remaining 14% received a lower rating (Figure 4; Table 3). No streams were rated as limited in 1986 even though 11% of the streams scored as such in 1953. Of the streams significantly increasing in aquatic life use, two improved from high to exceptional, one from intermediate to high, one from limited to high, and one from limited to intermediate. Each of these streams had a greater number of sunfish species (reflecting improved pool habitat) and four streams exhibited an increased abundance of individuals (typically associated with improved conditions as the stream exhibits the capacity to support more individuals) in 1986. Three sites also rated higher in the percentage of piscivores present, which is likely linked to the increase in fish abundance that provides a more reliable prey base. In addition, Barnhardt Creek (Rusk County) and Jones Creek (Upshur County) exhibited increases in the number of intolerant species (3 to 5 and 0 to 2, respectively) and decreases in the percentage of omnivores (from 14 and 9 to 1%, respectively). Omnivores in Murvaul Creek (Panola County) declined from 23 to 15%. Bassetts Creek tributary (Anderson County) doubled in species richness (6 to 12) and decreased in the percentage of individuals considered tolerant to organic enrichment (54 to 18%). Black Cypress Creek (Cass County) increased in native cyprinid richness (2 to 5) whereas Jones and Murvaul creeks increased in benthic invertivore species richness (2 to 3 and 1 to 3, respectively), providing further support for improved water quality and habitat.

The South Central and Southern Humid Mixed Land Use Region had the highest percentage of streams with a significant decrease in aquatic life use between 1953 and 1986. The Sulphur River (Bowie County) declined in aquatic life use from exceptional to intermediate. Aiken Creek (Bowie County) declined from exceptional to high, whereas Cow Bayou (Orange County), McFaddin Creek (Shelby County), and Threemile Branch (Newton County) declined from high to intermediate. All of these streams yielded fewer fish species in 1986. Four of the streams declined in native cyprinid species and benthic invertivores and no longer yielded intolerant species in their collections. Three streams also declined in the number of sunfish species and two exhibited lower percentages of piscivores. Threemile Branch changed from having no tolerant species to 28% of the individuals considered tolerant of organic enrichment. The Sulphur River also exhibited a significant decline in invertebrate feeders (78 to 59%) and increased in the relative abundance of omnivores (9 to 30%). Lower aquatic life use ratings are likely linked to deteriorating water quality and instream habitat. Kirkpatrick (1985) reported low dissolved oxygen concentrations in the upper reaches of Cow Bayou as well as a lack of flow. This bayou has been the focus of a number of water quality studies since the 1980s. Lake Wright Patman was constructed at the Sulphur River sampling site, thus drastically altering instream habitat. Sampling in 1986 was conducted in the swimming area near the spillway about 400 m from the outlet mouth. Howells (1997) attributed the concurrent decline of freshwater mussel populations in East Texas to aquatic and terrestrial habitat modification and degradation, historical and current pollution, and wide-ranging human development. Habitat notes taken during the collections at Aiken Creek indicated a change in riparian structure from hardwoods in the 1950s to grasses in 1986. Pronounced losses of bottomland hardwood forests documented over this time period by Leipnik et al. (1997) illustrate the extent of riparian modification.

Two streams (6%) in the Central Texas Plateau received a significantly higher aquatic life use rating in 1986 than in 1953, resulting in the lowest increase of all the regions tested (Figure 5; Table 4). However, this region also had the highest percentage of streams showing no significant change in aquatic life use rating (92%), the highest percentage of streams rating as high or better in 1953, and was the only region that did not have a stream rated as limited in either year. Streams in this region appear to have been unaffected by many of the anthropogenic perturbations already experienced in other regions by 1953. United States census data for 1950 support this claim, with an estimated 8 individuals per square mile of land area within the sampled counties from this region. This density is 5-10 times less than those found in the other regions reported in this study (Kingston 1991). Selected biological community status indicators of stream quality nationwide show that stream quality is more likely to be degraded in watersheds dominated by urban and agricultural activities than those that are predominantly undeveloped (Bush et al. 2000).

The sites that significantly increased in aquatic life use rating (intermediate to high) were the Medina River (Medina County) and the South Conchos River (Tom Green County). One additional site from each of these rivers was also sampled and received a high rating during both sampling periods. Both rivers had an increase in species richness, the number of native cyprinid species, and the number of sunfish species. In addition, the Medina River also exhibited an increased number of intolerant species and the percentage of individuals comprised of invertivores, and a decrease in the percentage of individuals comprised of tolerant species and omnivores. The percentage of non-native species significantly declined in the South Conchos River (3 to 0.9%). Changes in these metric scores suggest that improved stream conditions including water quality (two intolerant species opposed to none in 1953, five versus one native cyprinid species, 12 versus 47% of the individuals being tolerant species, and no omnivores compared to 41% in the Medina River), habitat (increase in native cyprinid and sunfish species), and increased benthic invertebrate densities (increase from 51 to 96% of the individuals being invertivores in the Medina River) may have occurred.

The East Frio River (Real County) declined from high to intermediate aquatic life use. A decline from nine to four fish species, an increase from 0 to 15% of the individuals being omnivores, and the elimination of benthic invertivore, sunfish, piscivore, and intolerant species from the sample suggest a deterioration in water quality. Two other sites on the East Frio River (one several kilometers upstream and the other several kilometers downstream) were also sampled during this study but did not show a change in aquatic life use over the 33-year period (i.e., remained intermediate).

Aquatic life use did not change in most of the 110 streams evaluated in this study. Seventy-one percent of the streams yielded the same aquatic life use in 1986 as they did in 1953. Thirty-one percent of the streams received an IBI score within two points of their score based on the 1953 data (13% were identical). Likewise, Anderson et al. (1995) found reductions in biological diversity on a local scale, but relative stability in statewide and regional ichthyofaunas over this 33-year period. The Subhumid Agricultural Plains, Western Gulf Coastal Plain, and Central Texas Plateau had more streams that significantly improved in aquatic life use than declined. The South Central and Southern Humid Mixed Land Use Region had equal numbers of streams that improved as declined in aquatic life use. Overall, more streams significantly improved than declined. This may indicate that water quality and stream habitat have remained fairly unchanged and, in more cases than not, even improved. The South Central and Southern Humid Mixed Land Use Region and Subhumid Agricultural Plains had the greatest percentages of streams with a lower aquatic life use in 1986 than 1953. This coincides with the findings of Anderson et al. (1995) who reported the eastern half of the state exhibited a higher percentage of change than the western half in species diversity and regional assemblage structure.

Results based upon the three other assumption possibilities concerning the percentage of fish with disease deviated very little from what is reported here based upon the assumption of no disease or anomalies during either sampling event. Streamflow conditions at the time of and preceding sampling could have influenced some of the aquatic life use changes observed. The National Oceanic and Amospheric Association palmer drought index illustrates that Texas experienced severe to extreme drought during the 1950s. Such a drought would most likely result in deteriorated water quality associated with reduced stream discharges, which may have resulted in lower aquatic life uses. According to the drought index, no portion of Texas was experiencing drought in 1986. However, roughly one-half of the state was reported as experiencing such conditions in 1985.

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Table 1.—Texas streams sampled in the Western Gulf Coastal Plain during 1953 and 1986.

Site Number	Site	County	Location
1	Lone Oak Creek	Chambers	18 km south of Anahuac
2	Santa Gertrudis Creek	Kleberg	8 km west of Kingsville
3	Spindletop Bayou	Chambers	5 km south of Stowell
4	roadside ditch	Chambers	14.5 km south-southwest of Stowell
5	Elm Bayou	Chambers	13 km south of Stowell
6	South Fork Taylor Bayou	Jefferson	7 km southeast of Fannet

Table 2.—Texas streams sampled in the Subhumid Agricultural Plains during 1953 and 1986.

Site Number	Site	County	Location
1	Medina River	Bexar	1.5 km north of Macdona
2	Bee Creek	Bosque	11 km south of Meridian
3	Sister Grove-Pilot Grove Creeks	Collin	6.5 km west of Farmersville
4	Childress Creek	Bosque	11 km northeast of Valley Mills
5	Paluxy River	Erath	Bluff Dale
6	Brazos River	McLennan	19 km northwest of Waco
7	North Fork Bosque River	Erath	2.5 km northwest of Stephenville
8	White Rock Creek	McLennan	7 km north of Waco
9	East Fork Trinity River	Kaufman	4 km east of Forney
10	East Fork Trinity River	Collin	6.5 km east-northeast of Wylie
11	Colorado River	Bastrop	Utley
12	Gualalupe River	Dewitt	5 km southwest of Cuero
13	Brazos River	Bosque	8 km southeast of Whitney Dam
14	South Fork Bosque River	McLennan	1 km southwest of South Bosque
15	Brazos River	Bosque	8 kn west of Hempstead
16	Nolans River	Johnson	10.5 km south of Cleburne
17	West Fork Trinity River	Wise	13 km south-southwest of Decatur
18	Clear Fork Trinity River	Parker	5 km south of Aledo
19	Meridian Creek	Bosque	13 km south-southwest of Meridian
20	Meridian Creek	Bosque	5 km northwest of Clifton
21	East Fork Trinity River	Collin	5 km north of McKinney
22	North Fork Bosque River	McLennan	17.5 km west of Waco
23	Medina River	Bexar	Von Ormy

Table 3.—Texas streams sampled in the South Central and Southern Humid Mixed Land Use Region during 1953 and 1986.

Site Number	Site	County	Location
1	Little Quicksand Creek	Newton	13 km north-northeast of Newton
2	Thickety Creek	Newton	1.5 km north of Bleakwood
3	Yellow Bayou	Newton	5 km south of Burkeville
4	Flat Fork Creek	Shelby	6.5 km south-southeast of Tenaha
5	Sabine River	Harrison	7 km north-northeast of Tatum
6	Flat Creek	Cass	9.5 km west of Linden
7	Murvaul Creek	Panola	10.5 km south of Carthage
8	Bassetts Creek tributary	Anderson	9.5 km southwest of Palestine
9	Jones Creek	Upshur	25.5 km northeast of Gilmer
10	Black Cypress Creek	Cass	10.5 km west of Hughes Springs
11	Barnhardt Creek	Rusk	14.5 km south of Henderson
12	roadside ditch	Newton	6.5 km southwest of Deweyville
13	Piney Creek	Bastrop	2.5 km north of Bastrop
14	Nichols Creek	Newton	25.5 km south of Bleakwood
15	Cedar Creek	Bastrop	17 km west of Bastrop
16	Striker Creek	Cherokee	10.5 km west of New Summerfield
17	Indian Creek tributary	Nacogdoches	4 km east of Cushing
18	Cedar Creek	Bastrop	7 km west of Bastrop
19	Big Sandy Creek	Bastrop	Sayerville
20	Colorado Creek	Sabine	1.5 km southeast of Sexton
21	Frazier Creek	Cass	17.5 km east-southeast of Linden
22	Little Cow Creek	Newton	1.5 km south of Burkeville
23	Jones Creek	Upshur	24 km northeast of Gilmer
24	unnamed creek	Shelby	5 km north-northwest of Center
25	Reeves Creek	Sabine	21 km north of Hemphill
26	Sulphur River (side pools)	Cass	7 km north of Douglassville
27	Big Cow Creek	Newton	4 km southwest of Newton
28	Jims Bayou	Cass	21.5 km soutwest of Linden
29	Black Bayou	Cass	1.5 km southwest of Atlanta
30	Caney Creek	Bowie	4 km west-wouthwest of Redwater
31	McFaddin Creek	Shelby	Panola County line
32	Cow Bayou	Orange	5 km west-southwest of Mauriceville
33	Threemile Creek	Newton	5.5 km northeast of Newton
34	Aiken Creek	Bowie	11 km west of Texarkana
35	Sulphur River	Bowie	Texarkana Dam

Table 4.—Texas streams sampled in the Central Texas Plateau during 1953 and 1986.

Site Number	Site	County	Location
1	Live Oak Creek	Kinney	Headsprings
2	Guadalupe River	Kendall	Comfort
3	Mill Creek	Bandera	9.5 km east of Vanderpool
4	Cypress Creek	Real	At mouth
5	Guadalupe River	Kerr	0.5 km west of Center Point
6	Guadalupe River	Kendall	5 km east of Comfort
7	South Fork Guadalupe River	Kerr	13 km southwest of Hunt
8	Medina River	Medina	4 km southeast of Castroville
9	South Conchos River	Tom Green	Christoval
10	West Sabinal River	Real	Bandera County line
11	Kent Creek	Real	Headsprings
12	Montell Creek	Uvalde	6.5 km northwest of Montell
13	Guadalupe River	Kerr	0.5 km east of Kerrville
14	Guadalupe River	Kerr	Center Point
15	Dove Creek	Irion	8 km southwest of Knickerbocker
16	Guadalupe River	Kerr	5 km east of Ingram
17	Guadalupe River	Kerr	3 km west of Ingram
18	San Saba River	Menard	14.5 km west of Menard
19	Spring Branch	Real	4 km west of Leakey
20	Medina River	Medina	1.5 km west of Rio Medina
21	South Fork Guadalupe River	Kerr	14.5 km southwest of Hunt
22	Guadalupe River	Kerr	8 km east of Center Point
23	Frio River	Uvalde	32 km northwest of Sabinal
24	Guadalupe River	Kerr	Guadalupe River State Park
25	South Conchos River	Tom Green	6.5 km south of Christoval
26	Spring to East Frio River	Real	16 km northeast of Leakey
27	Clear Creek	Menard	Headsprings
28	Live Oak Creek	Kinney	48 km northeast of Brackettville
29	East Frio River	Real	19.5 km northeast of Leakey
30	East Frio River	Real	3 km northeast of Leakey
31	Celery Creek	Menard	6.5 km north-northwest of Menard
32	Guadalupe River	Kerr	3 km northwest of Kerrville
33	Sabinal River	Bandera	Vanderpool
34	West Frio River	Real	Downstream of Kent Creek
35	Dove Creek	Irion	8 km southwest of Knickerbocker
36	East Frio River	Real	13 km northeast of Leakey

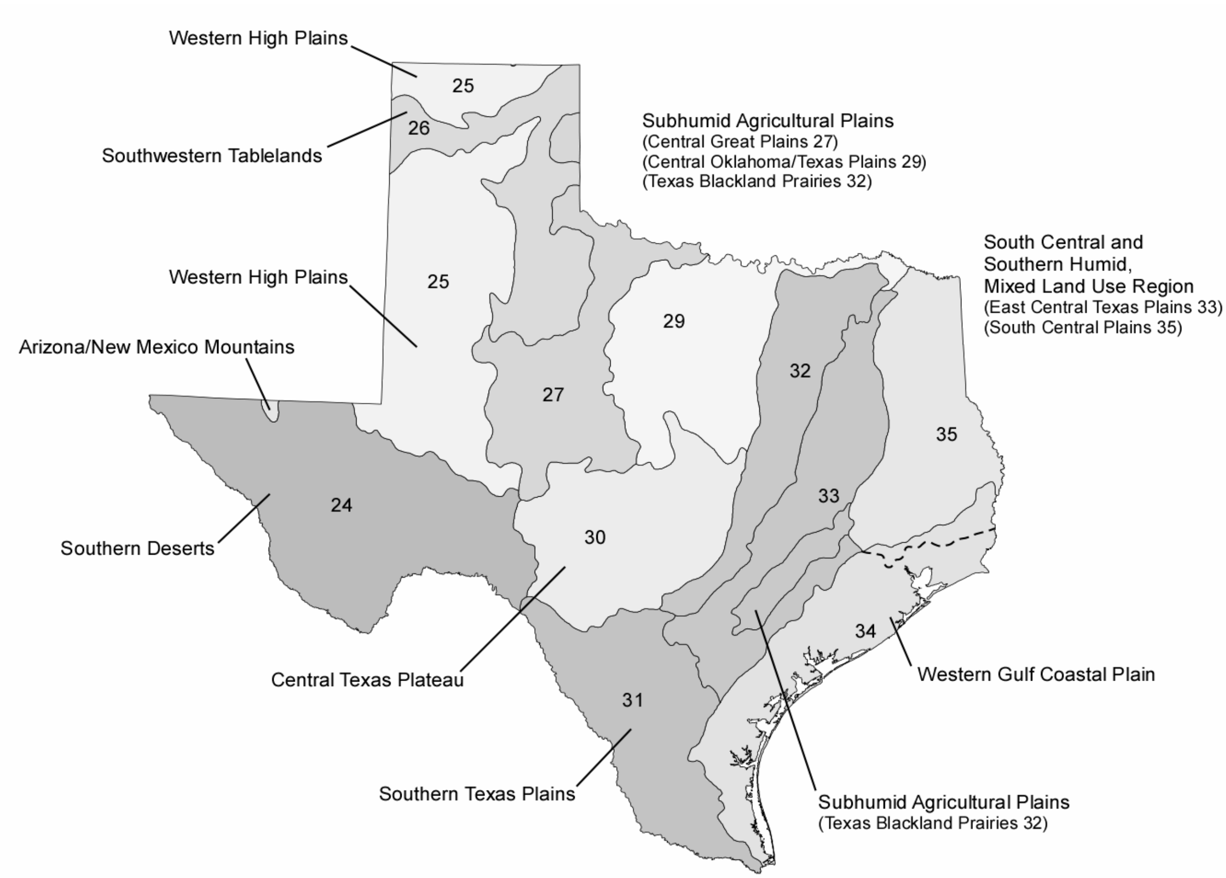

Figure 1.—Map of the ecoregion aggregates defined for the state of Texas modified from Omernik (1987) and Omernik and Gallant (1989). The dashed line represents a boundary that was subsequently modified, enlarging ecoregion 35 (U.S. Environmental Protection Agency 1997).

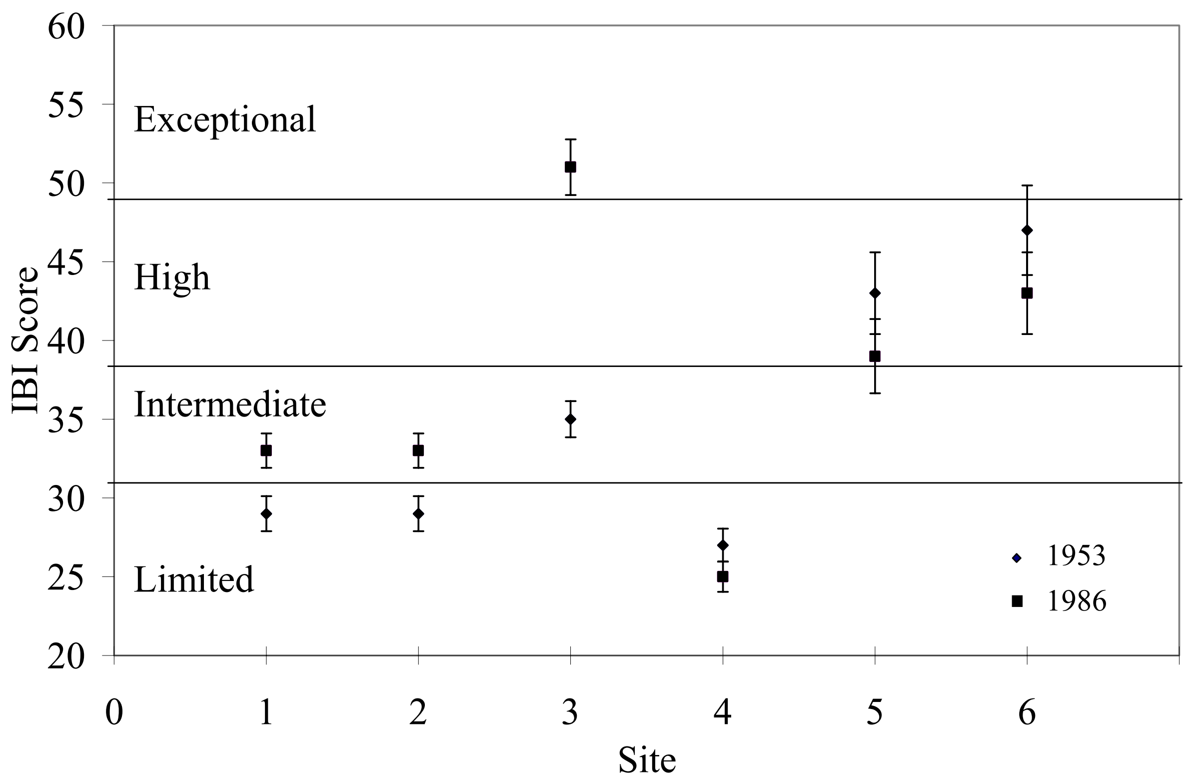

Figure 2.—Comparison of aquatic life uses in streams sampled in 1953 and 1986 in the Western Gulf Coastal Plain of Texas. Stream names and locations corresponding to the site numbers are reported in Table 1.

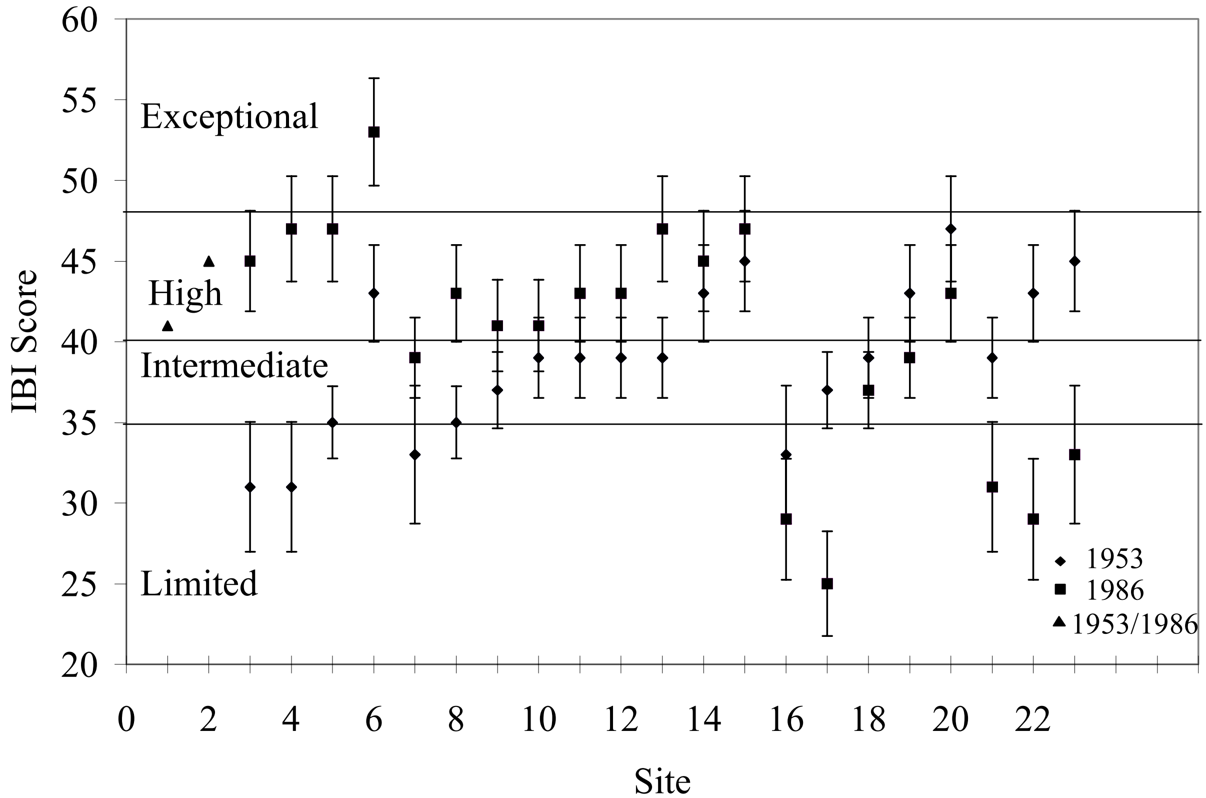

Figure 3.—Comparison of aquatic life uses in streams sampled in 1953 and 1986 in the Subhumid Agricultural Plains of Texas. Stream names and locations corresponding to the site numbers are reported in Table 2.

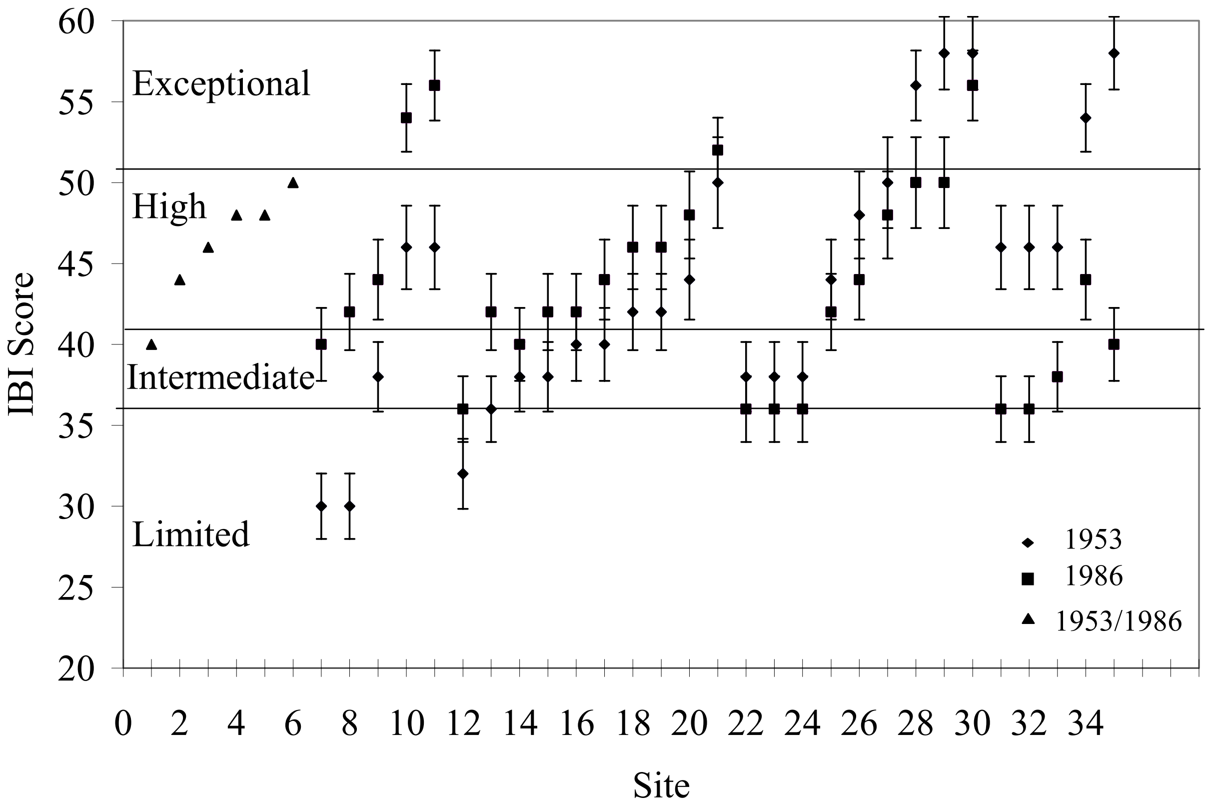

Figure 4.—Comparison of aquatic life uses in streams sampled in 1953 and 1986 in the South Central and Southern Humid Mixed Land Use Region of Texas. Stream names and locations corresponding to the site numbers are reported in Table 3.

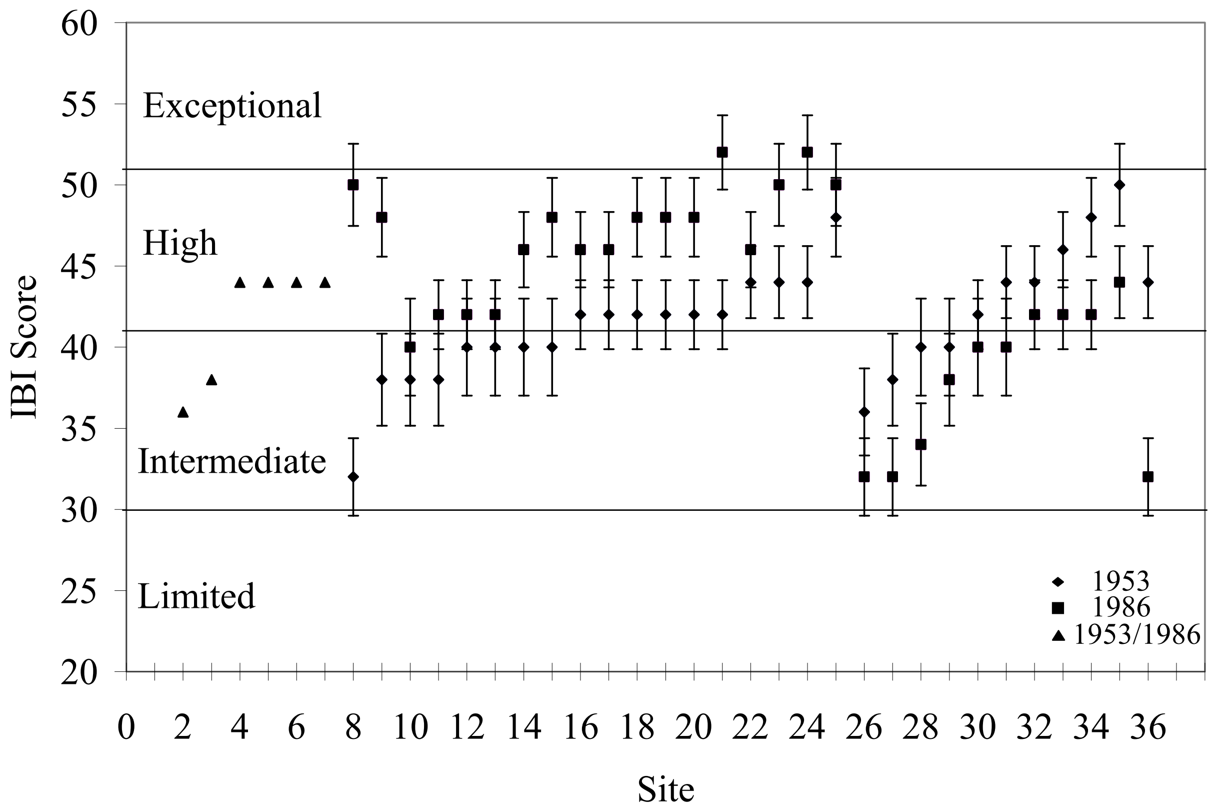

Figure 5.—Comparison of aquatic life uses in streams sampled in 1953 and 1986 in the Central Texas Plateau. Stream names and locations corresponding to the site numbers are reported in Table 4.

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