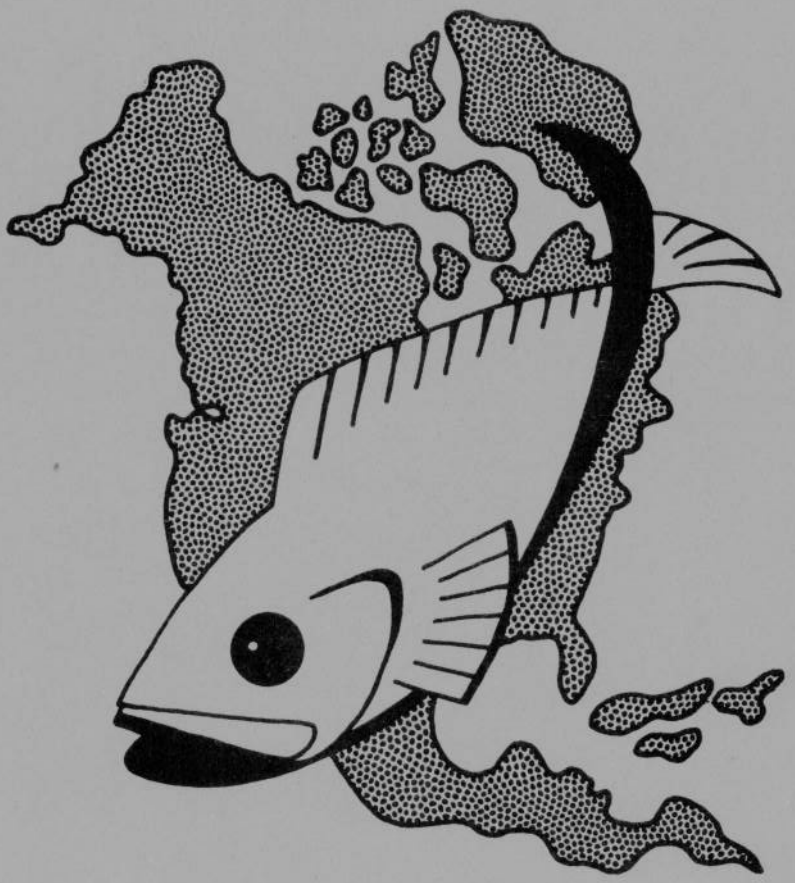
ANNUAL PROCEEDINGS of the TEXAS CHAPTER AMERICAN FISHERIES SOCIETY



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KURZANSKI

TEXAS CHAPTER

OF THE

AMERICAN FISHERIES SOCIETY

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

MEMBERSHIP

Persons interested in the Texas Chapter and its objectives are eligible for membership and should apply to the Secretary-Treasurer, Gene McCarty at 24 Winn Wood, Wimberly, Texas 78676. Annual membership dues are $8 for Active Members and $5 for Student Members.

ANNUAL PROCEEDINGS OF THE TEXAS CHAPTER

AMERICAN FISHERIES SOCIETY

October 7 and 8, 1988

Abilene, Texas

1989

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The following individuals, companies, or organizations made contributions of money or services, or exhibited products and/or services at the Annual meeting in 1988:

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ARGENT CHEMICAL LABORATORIES Dr. Eliot Lieberman, President 8702 152nd Avenue NE Redmond, Washington 98052 601-335-0295	Aquaculture products and chemicals
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Jim Flynn, Marketing Vice President
12921 Burnet Road
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Austin, Texas 78763-0116
512-255-8841

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Houston, Texas 77043
713-465-2571

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SMITH-ROOT, INC. David V. Smith 14014 NE Salmon Creek Avenue Vancouver, Washington 98686 206-573-0202	Manufacturer of electrofishing and radio tracking equipment
SONOTRONICS Don Brumbaugh 1150 East Pennsylvania Street Suite 601 Tucson, Arizona 85714 602-792-1696	Manufacturer of sonar tracking equipment
SPORTMEN CONSERVATIONISTS OF TEXAS Alan Allen 311 Vaughn Building 807 Brazos Austin, Texas 78701 512-472-2267	Non-profit conservation organization
TACKLE BOX Jim and Barbara Dunkle Route 2, Box 258 C-4 Pottsboro, Texas 75076 214-786-9010	Fishing tackle

1988 TEXAS CHAPTER AWARDS

Special Recognition in Fisheries Work

The recipient in the Special Recognition Category was Dr. Kirk Strawn. Dr. Strawn is on the faculty of Texas A&M University. He has made major contributions to the advancement of fisheries science and as a superior educator and advisor of numerous graduate students during his long and productive career. A large proportion of his students hold important positions in fisheries and related fields.

Outstanding Fisheries Worker of the Year

The recipient in the Research category was Dr. Gary Garrett. Dr. Garrett works for the Texas Parks and Wildlife Department at the Heart of the Hills Research Station. Gary received his PhD under Dr. Clark Hubbs at the University of Texas in Austin. He has long been interested in endemic, often non-game species. Recently, he developed and is continuing to work on a recovery plan for the Guadalupe bass Micropterus treculi.

Receiving Honorable Mention for the Fisheries Worker of the Year in the Culture category was Loraine Fries. Loraine works for the Texas Parks and Wildlife Department at the A. E. Wood Fish Hatchery in San Marcos. She attended University of Texas-El Paso where she received her Master's degree. Loraine's accomplishments include publications describing lab techniques and findings that benefitted hatchery broodstock evaluation and development. Also, she was instrumental in the forensic lab analysis of tissue and blood samples from fish and game to determine species identification and in the identification of a genetic marker in channel catfish.

Outstanding Presentation

The outstanding presentation was by Joe Fries entitled, "Effects of several feeding methods on growth, survival, and condition of striped bass." Joe works for the U.S. Fish and Wildlife Service at the National Fish Hatchery and Technology Center in San Marcos. Joe received his Master's degree from the University of Texas-El Paso. The presentation was coauthored by Thomas Brandt of the USFWS and Bobby G. Whiteside of Southwest Texas State University.

Receiving Honorable Mention for outstanding presentation was Catherine Dryden for her presentation, "Genetic characteristics of walleye from Dale Hollow Reservoir, Tennessee, with implications for southern strain restoration." Catherine did this work while a student at Texas A&M University. She presently works for Texas Parks and Wildlife Department at the A. E. Wood

Fish Hatchery in San Marcos. The paper that the presentation was based on was coauthored by Dr. Brian Murphy of Texas A&M University and Dr. Phillip Bettoli of Tennessee Tech University.

FUTURE WATER DEVELOPMENT AND WILDLIFE IN TEXAS

by

Larry D. McKinney
and
Susan Rieff
Texas Parks and Wildlife Department
Resource Protection Division
4200 Smith School Road
Austin, Texas 78744

Abstract

New legislation amending both the Texas Parks and Wildlife Code and the Texas Water code are reviewed. These changes enhance the consideration of fish and wildlife resources during the state water permitting process. Texas Parks and Wildlife, through its Resource Protection Division, will be in a position to better protect these resources through interaction with project sponsors and the Texas Water Commission. Such early consideration of terrestrial and aquatic mitigative action can only be of benefit to bottomland hardwood habitats and efforts to preserve this valuable resource.

PRISTINE OR POLLUTED IN THE 90'S?

by

Dave Buzan
Water Quality Monitoring Unit
Water Quality Division
Texas Water Commission
510 South Congress
Austin, Texas 78711

Abstract

Will the 1990's bring more polluted water? More fish kills? Reduced amounts of water? Will nutrient limitations be required in wastewater discharges? Will it be okay to eat fish? The Texas Water Commission (TWC) is beginning new initiatives on water quality that will bear fruit in the 1990's and attempt to address these questions. Resources that are currently available to fishery biologists and aquaculturists include the Water Quality Data Base, Fish Kill Report file, Interim Return Flow file, TWC library, etc. Future water quality monitoring directions include sampling and analysis of non-point source pollution, assessments of native biological communities for toxic impact, establishment of water quality standards for small streams, and analysis of impact of reductions of freshwater flows to bays. The TWC will also begin establishing Water Master Offices in different river basins in order to improve the management of water rights and uses. Other areas of emphasis will include increased monitoring of toxics in fish tissue, increased monitoring by cities and river authorities, and increased consolidation and analysis of water quality data.

WATER QUALITY PROTECTION IN AGRICULTURE

by

John M. Sweeten
Texas Agricultural Extension Service
College Station, Texas 77843

Abstract

Research has confirmed that unconfined livestock production is an environmentally sound water quality management practice. However, cattle feedlots require systems that prevent discharge of pollutants. Non-point source pollutants from both unconfined and confined cattle operations are generally controlled through Best Management Practices (BMPs) rather than wastewater treatment methods. Sediment loads at unconfined, high-impact cattle feeding and watering sites can be minimized by: 1) protecting fragile stream banks: 2) maintaining vegetative cover; 3) stocking fewer cattle; 4) distributing salt and water; and 5) providing feed, salt and water away from streams. In 1984, the Environmental Protection Agency recommended to Congress that states should be responsible for management of non-point source pollution control. Barriers that prevent adoption of BMPs by ranchers and farmers are economic, educational and institutional.

IMPORTANCE OF COASTAL FISHERIES

by

Robin K. Riechers
and
C. E. Bryan
Texas Parks and Wildlife Department
Coastal Fisheries Branch
4200 Smith School Road
Austin, Texas 78701

ABSTRACT

The Coastal Fisheries Branch of Texas Parks and Wildlife Department plays an important role in the managing and monitoring of Texas marine fisheries resources. Hydrological data are routinely collected while gathering both fishery dependent and independent data (20,000 samples/year). Fishing pressure on the limited resource has continued to increase throughout the 1980's, and this trend is expected to remain in the future. Direct sportfishing expenditures in 1986 were around $350 million, and over 5 million fishing visits were made to the coast of Texas. This in addition to commercial fishing has an enormous impact on the Texas economy ($1.7 billion annually). Management efforts in the future should focus on the effects of freshwater inflows as they relate to trends and abundances of finfish and shellfish, while considering both the direct economic effects of fishing, aesthetic values, and other inherent social values in the coastal region.

WATER USE IN THE 90'S - AN IMPACT
ON FISHERIES PANEL DISCUSSION

Participants: Dave Buzan, Texas Water Commission
Sam Chapman, Environmental Protection Agency
Robin Riechers, Texas Parks and Wildlife Department
John Sweeten, Texas Agricultural Extension Service
Moderator - Hal Schramm, Jr., Texas Tech University

QUESTION: CAN INFRARED PHOTOGRAPHY BE USED MORE EFFECTIVELY IDENTIFYING SOURCES AND TYPES OF POLLUTION?

ANSWER: (BUZAN) I'm not familiar enough with the use of infrared photography and pollution detection. That's something that's done primarily by the Texas Water Development Board (TWDB). We don't use it much at the Texas Water Commission (TWC) because we work in smaller scales than aerial photography can provide. I believe the smallest resolution of LANDSAT imagery is approximately 90 acres. That's too large for monitoring of sewage treatment plants that discharge 10,000 gallons per day. Also, we have to buy the imagery. We have high altitude imagery which is a relatively new area that's developed over the last 10 years. David Brock of the TWDB uses it to do statewide lake classification. He is looking at seeing differences in chlorophyll concentrations and ranking the lakes accordingly. (CHAPMAN) The Tennessee Valley Authority has a program doing work for the Army Corps of Engineers monitoring large drainage areas looking for nutrient inputs. They can get resolution down to 9 meters.

Q: HOW MANY ENVIRONMENTAL PROTECTION AGENCY (EPA) EMPLOYEES ARE IN TEXAS, AND WHY ARE SO FEW INVOLVED IN THE TEXAS AFS CHAPTER?

A: (CHAPMAN) I don't know how many EPA employees are in Texas or if there is a fishery person on staff. The Dallas office has 835 employees and covers a five state area.

Q: WHAT HAS BASIC WATER QUALITY IN THE TEXAS BAY SYSTEM BEEN DOING WHILE THE FINFISH LANDINGS HAVE BEEN DECLINING?

A: (RIECHERS) As far as I know, we have not seen any drastic changes in the bays. Other than some specific occurrences, we haven't seen any relations to long term trends.
(BUZAN) We haven't spent adequate effort evaluating the physical, chemical, and biological data available to assess declines or increases. In general, quality of waste discharges has improved. Assuming everything else is the same (may not be a valid assumption), water quality has improved to a certain degree. That doesn't mean quality of the flow to bays has

improved. There is more dredging, thermal inputs, and increased shrimping activities on bays. The situation is very complex. I think we're lucky, with regards to the national survey on toxic contaminants, as the Texas system does have some hot spots but not as many as other U.S. coastal areas. We as agencies, particularly the TWC, perhaps have been negligent in not standing back and looking at the data and seeing what it is telling us. I feel like our field offices are more aware of the need to do that. We have tons of data there, but what can we really say about water quality trends in Galveston Bay for instance? And who has sat down and looked at it over the last 10 years? There was a project done in the early 70's to look at Galveston Bay. In reality, we have not spent a lot of time looking at data. Our unit's direction has been to collect and make sure data are available. We are getting to the point where are capabilities to collect data are outstripping our capacity to analyze it. We need to spend more resources analyzing data and stop worrying about going out and getting tons of data.
(AUDIENCE COMMENT) Is this where universities can come in and tap into your data base?
(BUZAN) I would love to have any university students who can work for free to come in and do a research project or a problems course study. We only have funds to hire one student intern, and we have more problems than that.

Q: ARE STRICTER REGULATIONS GOING TO KEEP UP WITH INCREASED DISCHARGE VOLUMES IN THE FUTURE?

A: (BUZAN) I think so; 10 years ago we were looking at a major battle to get sewage treatment plants to go to any more stringent treatment than a 30-day average of 20 mg/L Biological Oxygen Demand (BOD) and 20 mg/L Total Suspended Solids (TSS). Now we are seeing situations like the City of Kerrville; rather than spending time fighting a controversial water quality issue, they went to 5 mg/L BOD, 5 mg/l TSS, and 1 mg/L total phosphorus for their discharge. Ten years ago people would have fought that. In the Mesquite hearings in 1977 with regards to the Trinity River, all sorts of technical experts said it was impossible to meet 5 mg/L BOD as a monthly average. Now people are accepting these limitations. Rather than 20-20, we are seeing 10-15 as a common level plus the addition of dissolved oxygen (DO) and ammonia-nitrogen limits. We are seeing a trend towards much more stringent treatment statewide. We have been negligent in assessing our natural resources and using those to indicate how we should orient treatment, and that is a direction we should be emphasizing.
(CHAPMAN) Point sources are under control in most states. In Oklahoma and Louisiana, 65% of their problems now are non-point. In Texas, a good job has been done on monitoring point sources. Waste load dedicated to a stream or lake will have to consider non-point sources. It could be our achilles heel.

(AUDIENCE COMMENT) Clarify how you determine what portion of the problem is non-point?
(CHAPMAN) In Louisiana, they've taken all point waste load allocations, compared it with data, and the difference is non-point. You do run into problems with sampling during high flow periods when non-point pollution is occurring.

Q: WHAT DO YOU WANT TEXAS AFS CHAPTER MEMBERS TO DO, AND HOW CAN MEMBERS FIND OUT ABOUT ACTIVITIES THAT ARE GOING ON?

A: (CHAPMAN) The only ways I know are by public notices from the TWC or by reading notices in the newspaper. If you do have a concern or know of a problem, write it up, and send it to the TWC or the EPA's non-point source group. We have only one person working non-point sources on the federal level for 5 states and only one on the state level. If you have concerns, put them into the process.
(SWEETEN) I would like to reiterate that 90% of the country considers sediment their number one pollutant. It's not controversial. I'm an agricultural engineer and don't know the effects of sediments on aquatic species. I think our non-point source program was hung up on what extent silt is a problem. That controversy must be resolved before the application of technology can address the problem.
(CHAPMAN) TWC is the lead agency on issues, but in Texas, the Soil Conservation Service is responsible for agriculture, non-point source identification of problems, and silviculture. They give the TWC the information.
(BUZAN) We already have the data that would tell us what the suspended sediment load is in most of the state's waters because TSS is one of the parameters we routinely monitor. We have a good indication of what values might be appropriate as far as criteria. We do have a general criterion that says no discharge will cause the turbidity of the water to be adversely affected or changed from normal. The only time that was applied was when an industry in the Freeport area added a chemical that caused all the sediment in the Brazos River to flocculate. The criterion was enforced even though they were clearing up the river. We should be concerned on the entire scale; are we preserving the native turbidity, nutrient, DO, and temperature regimes of the stream? We should focus on what natural conditions are.
(CHAPMAN) Somewhere in Texas law it says sediment is not a pollutant.
(BUZAN) Most of the standards were written to control point sources. We have fairly good control over point sources. In the future, standards will probably address non-point sources.
(CHAPMAN) The biggest fear of people out there is that they are not even sure of what they are now discharging. If standards are set, they don't know if it will put them out of business. For someone causing non-point problems, they don't even know if they're violating the standard on a daily basis.

(SWEETEN) The flip side is that if you spend a lot of money on corrective measures are you doing the fish and wildlife any good, or is it just some other bureaucratic number that is pulled out that doesn't have an impact on the organisms downstream? Suppose you cut the sediments in half; will you increase catfish production, for instance? That linkage has to be made and brought out in a public forum.
(CHAPMAN) Some states have standards. New Mexico has one. They actually closed down a National Forest timber operation on a cold-water stream because they couldn't meet the criterion. Some standards can have an adverse effects on economics.

Q: TO WHAT EXTENT ARE INDICATOR SPECIES USED BY THE TWC TO ASSESS WATER QUALITY, AND IF SO, WHAT INDICATOR SPECIES ARE MONITORED?

A: (BUZAN) We don't typically monitor for specific water quality indicators. We do monitor for Prymnesium parvum in the Pecos River. When you have too many of them, you have fish kills. We use biological organisms, like nuisance algae (Microcystis, Anabaena, and Oscillatoria) and certain benthic macroinvertebrates, particularly the absence of certain species or genera as indicators of water quality conditions. We use fish presence or absence, not necessarily a particular organism. We are not currently putting much emphasis on monitoring specific indicator organisms.

Q: DOES THE EPA CONSIDER SALT IN THE RED RIVER BASIN A POLLUTANT?

A: (CHAPMAN) Salinity is a pollutant. The level is what's important.

Q: AT THE INSTREAM FLOW WORKSHOP, GARY POWELL OF THE TWDB STATED THAT UNCLASSIFIED SEGMENTS IN TEXAS ARE MOSTLY DRY ARROYOS. DO YOU AGREE WITH THAT STATEMENT?

A: (BUZAN) No, I didn't. His statement was a broad generalization. I have seen figures that list 80,000 stream miles within Texas. We have standards for approximately 13,000-14,000 stream miles, but I know some of the rivers that are classified waters are dry arroyos at least part of the year. We have standards for places that are dry creek beds some of the time. Our ecosystem study shows hundreds of streams that are more than dry arroyos and that flow year round. That's why we are trying to take the ecoregion approach because these aren't classified waters, and they need to be protected. There are undoubtedly lots of stream miles that don't flow during parts of the year; we need to find out which of those stream miles have perennial pools that need to be protected. Our Waco office called to tell us that we had a fish kill in the Leon River. It wasn't really in the river but in pools on a farmer's property

that were in the river bed. The river was dry, so we have dry streambed between perennial pools, and we need to think about those habitats as well.
(AUDIENCE COMMENT) Does EPA have any plans to look at non-classified waters?
(CHAPMAN) I heard a figure used that EPA looked at assessments turned in, and I don't think all navigable streams are in EPA classification. There was data for less than 50% of the streams in Texas.
(BUZAN) I think the EPA wished we had put specific criteria and designated a lot more streams than we did. That was an issue in the standards suit filed by the Sierra Club and Sportmen Conservationists of Texas against EPA. Our response was we don't have data to set standards on a lot of unclassified waters. Again, that brings us to the ecosystem approach. We don't have the resources to set standards for every stream, but if we could go to an ecoregion and know what the habitat and water quality are, we could use the standards to protect other unclassified waters.

Q: WHAT DOES THE EPA PLAN TO DO TO REGULATE STORMWATER DISCHARGES, PARTICULARLY IN LIGHT OF MUNICIPALITIES CHANNELIZING FLOW?

A: (CHAPMAN) That should be coming under state regulations. It will set standards.
(BUZAN) Agencies prefer to consider stormwater outfalls as non-point discharges because it's a diffuse source.
(SWEETEN) The only area in Texas that was designated as agricultural non-point source was the upper North Bosque River valley, north of Stephenville down to Meridian in Erath and Bosque counties. The cause of that was given as dairies. That was the only one discussed. A long list other problems was discussed.

GROWTH DIFFERENCES BETWEEN GENETICALLY TAGGED ARKANSAS AND IOWA STRAIN WALLEYE IN A TEXAS RESERVOIR

by

David R. Terre
Texas Parks and Wildlife Department
Inland Fisheries Branch
P.O. Box 947
San Marcos, Texas 78667
Brian R. Murphy
Department of Wildlife and Fisheries Sciences
Texas A&M University
College Station, Texas 77843
and
William C. Provine
Texas Parks and Wildlife Department
Inland Fisheries Branch
3407 South Chadbourne
San Angelo, Texas 76904

Abstract

Genetically tagged walleye Stizostedion vitreum originating from broodstock collected in Greers Ferry Lake, Arkansas (Arkansas strain) and Lake Meredith, Texas (Iowa strain) were stocked during 1985 into Canyon Reservoir, Texas for growth comparisons. In February 1988, 26 walleye from the 1985 stocking were captured and their genetic origin determined by vertical acrylamide gel electrophoresis. Arkansas strain walleye comprised 54% of the sample. Arkansas strain females were significantly ($P \leq 0.05$) larger by weight (18%) and length (6%) than Iowa females. Arkansas strain males were significantly larger by weight (18%) than Iowa males, but lengths were similar.

TEXAS PADDLEFISH RECOVERY PLAN: SPECIES DISTRIBUTION AND RECOVERY AREA

by

Veronica Pitman
Texas Parks and Wildlife Department
Heart of the Hills Research Station
Junction Star Route Box 62
Ingram, Texas 78025

Abstract

The historic and present distribution of paddlefish Polyodon spathula in East Texas was determined. River systems which once supported paddlefish populations were identified and evaluated for both present day paddlefish spawning habitat and water quality conditions necessary to maintain the species. Preferred spawning habitat is clean gravel substrate (15-100 mm diameter particle size) submerged at least 1 m deep. Suitable water quality conditions include dissolved oxygen level $\geq$5.0 mg/L, spring spawning temperatures 10-17°C and increased river flow in spring. Potential stocking sites were identified. Information was obtained through scientific literature, federal and state documents and reports, data files from the U.S. Geological Survey and the Resource Protection Division of the Texas Parks and Wildlife Department, and personal telephone communications with professionals in the scientific community. Five river systems (Red, Sabine, Neches, Trinity and San Jacinto) had supported paddlefish populations in varying degrees during the last 100 years. Four river systems (Red, Sabine, Neches and Trinity) meet criteria for potential maintenance of paddlefish populations.

USE OF A 15.0-20.9 INCH SLOT LENGTH LIMIT TO PREVENT OVERHARVEST AND MAINTAIN A LARGEMOUTH BASS POPULATION IN A NEWLY-OPENED, HEATED RESERVOIR

by

Kenneth F. Kurzawski
Texas Parks and Wildlife Department
Inland Fisheries Branch
1004 East 26th Street
Bryan, Texas 77803

Abstract

The largemouth bass Micropterus salmoides population in a newly-opened heated reservoir, Gibbons Creek, was studied from March 1985 to March 1988 to determine if a 15.0-20.9 inch slot length limit would prevent initial overharvest and maintain or increase abundance of largemouth bass ≥15.0 inches. Angler catch and harvest were monitored in 1985, 1986, and 1988 by a March through May creel survey. Largemouth bass population structure and abundance were monitored by electrofishing in fall (November 1985, 1986, and 1987) and spring (February 1986/March 1987 and 1988). Initial overharvest was prevented and population structure maintained after angling commencement. Catch and release rates exceeded harvest rates by 25 to 1 during the first 2.7 months of angling. Most largemouth bass caught and released (95%) were within the slot limit. Harvest rate was similar for all 3 years. The RSD 15-21 values from electrofishing ranged from 29 to 32 in fall and from 44 to 49 in spring. Electrofishing catch rate (fish per hour) for slot-sized largemouth bass increased in fall from 6.0 in 1985 to 18.2 in 1987 and in spring from 18.6 in 1986 to 36.4 in 1988. Catch rate of largemouth bass ≥21.0 inches was low (0.3 to 3.0 fish per hour). Catch rate for largemouth bass <15.0 inches increased indicative of recruitment of successive year classes.

COMPARATIVE MORPHOLOGY OF WHITE BASS, STRIPED BASS, AND STRIPED BASS X WHITE BASS HYBRIDS

by

Maurice I. Muoneke[1] and O. Eugene Maughan[2]
Oklahoma Cooperative Fish and Wildlife Research Unit
Oklahoma State University
Stillwater, Oklahoma 74078

Abstract

Striped bass Morone saxatilis x white bass M. chrysops hybrids are stocked in reservoirs with resident populations of white bass and/or striped bass. Morphometric and meristic characters used to separate the three groups in the southeastern United States are inadequate for use in Oklahoma. A multivariate approach using linear discriminant analysis and sheared principal component analysis was employed for identification of characteristics for separating the three groups. Seven of the 52 morphometric variables contributed significantly to the separation of the three groups. The discriminating characters were: caudal peduncle length, snout length, base length of first dorsal fin, base length of pelvic fin, distance from pectoral fin to second dorsal fin, pectoral fin height, and internasal distance. Caudal peduncle length and snout length were the most important. Hybrid morphometrics are intermediate between those of the parental species. Striped bass can be separated from the other two groups easier than white bass can be separated from the hybrid. Separation of the three groups can be accomplished using linear discriminant classification function coefficients.

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[1]Present address: Texas Parks and Wildlife Department, Heart of the Hills Research Station, Junction Star Route Box 62, Ingram, Texas 78025

[2]Present address: Arizona Cooperative Fish and Wildlife Research Unit, 210 Biological Science Building E, University of Arizona, Tucson, Arizona.

THE EFFECTS OF SEVERAL FEEDING METHODS ON GROWTH, SURVIVAL, AND CONDITION OF STRIPED BASS

by

Joe N. Fries and Thomas M. Brandt
U.S. Fish and Wildlife Service
National Fish Hatchery and Technology Center
Box 159-D
San Marcos, Texas 78666
and
Bobby G. Whiteside
Aquatic Station
Southwest Texas State University
San Marcos, Texas 78666

Abstract

Juvenile striped bass Morone saxatilis were cultured for 14 weeks in circular tanks and fed pelleted feed by hand, automatic timer, and an electronic demand system. No significant differences in mean total length were detected although fish fed by the demand system generally were longer. Mean weight of fish fed by hand was significantly lower at study termination than fish fed by either automated method. Relative condition was highest for fish fed by the demand system and lowest for those fed by hand. Hand-fed fish had a significantly higher cumulative mortality than fish fed by automated methods. Time required for the hand feeding method was four to ten times that required for mechanized methods.

STANDARD-WEIGHT (Ws) DEVELOPMENT FOR WALLEYE, HYBRID STRIPED BASS, AND STRIPED BASS

by

Michael L. Brown, Brian R. Murphy,
David J. Lee, and Carolyn J. Rose
Department of Wildlife and Fisheries Sciences
Texas A&M University
College Station, Texas 77843

Abstract

Standard weight-length relationships have been defined in the literature for nine species. Development of these equations was dependent upon extensive weight-length data summaries. We examined the feasibility of a technique whereby a standard weight-length relation is derived by regression through the 75th percentile of predicted weights and extracted for each cm-class from weight-length regressions of representative populations of the species. As a preliminary test, the technique was applied to largemouth bass Micropterus salmoides and bluegill Lepomis macrochirus weight-length regressions obtained from the literature. Results from this technique were compared to accepted 75th percentile equations (below, largemouth bass and bluegill, respectively).

Original equation	Regression extraction
log Ws = -5.313 + 3.196 log TL	log Ws = -5.379 + 3.221 log TL
log Ws = -5.374 + 3.316 log TL	log Ws = -5.385 + 3.318 log TL

A comparison of index values derived from both techniques indicated no functional differences. The technique was then applied to three fishes for which comprehensive weight-length data sets were obtained. Results from the regression extraction were:

Walleye Stizostedion vitreum	log Ws = -5.453 + 3.180 log TL
White bass Morone chrysops x striped bass M. saxatilis hybrid	log Ws = -5.201 + 3.139 log TL
Striped bass	log Ws = -4.924 + 3.007 log TL

Equations developed from the regression-extraction technique appear to model optimal growth forms and prevent sample bias associated with the original method. Analysis of index distributions obtained from 50th-percentile regressions indicates inflation of index values that would invoke ambiguous management goals. The 75th percentile produced index values with reasonable target distributions.

GENETIC CHARACTERISTICS OF WALLEYE FROM DALE HOLLOW RESERVOIR, TENNESSEE WITH IMPLICATIONS FOR SOUTHERN STRAIN RESTORATION

by

Catherine J. Dryden[1] and Brian R. Murphy
Department of Wildlife and Fisheries Sciences
Texas A&M University
College Station, Texas 77843
and
Phillip W. Bettoli
Tennessee Cooperative Fishery Research Unit
Tennessee Tech University
Cookeville, Tennessee 38505

Abstract

Walleye Stizostedion vitreum vitreum have been widely stocked both within and outside their native range. The stocking of northern walleye and possible loss of specific river-spawning habitats due to impoundment have led to the possibility that native walleye populations in many southern reservoirs have been replaced by northern fish. We investigated genetic differentiation of walleye at three spawning sites in Dale Hollow Reservoir, Tennessee, and compared the genetic traits of these fish to walleye from northern states. We found no segregation between spawning populations of walleye in the reservoir, and we found that Dale Hollow Reservoir walleye were very similar to New York walleye that previously had been stocked in the reservoir. Because of possible existence of southern strain walleye in the Appalachian region and the potential importance of this strain, we recommend genetic analyses of all river/reservoir systems that may contain southern walleye.

Introduction

Walleye Stizostedion vitreum vitreum have been widely stocked in areas within and outside of their range to the extent that stocks have been intermixed (Colby and Nepszy 1981). Poor records and indiscriminate stocking procedures have led to concern about the genetic integrity of some stocked areas. Walleye are distributed naturally from New Brunswick to Virginia on the Atlantic coast, through the Great Lakes region and upper Mississippi Valley westward to the Saskatchewan Valley, northward to the Mackenzie River region and Hudson Bay drainage, and southward to the Gulf of Mexico in the Tennessee River and

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[1]Present address: Texas Parks and Wildlife Department, A. E. Wood Fish Hatchery, P.O. Box 947, San Marcos, Texas 78666.

Mississippi River drainages (Radforth 1944; Hubbs and Lagler 1947). There is evidence for the existence of northern and southern strains of walleyes, with each strain possibly possessing distinctive characteristics of reproduction and growth. Northern stocks apparently spawn in both rivers and lakes; southern stocks may be obligate river spawners, perhaps even having specific well-defined spawning grounds (Hackney and Holbrook 1978). Alteration of spawning grounds, as by impoundment, may result in degradation or total extinction of river-spawning populations. For example, native walleye in Center Hill Reservoir, Tennessee, declined after impoundment in 1949 and were replaced with walleye from a New York source in the 1950's (Hackney and Holbrook 1978). Dale Hollow Reservoir, Tennessee, exhibited a similar pattern after impoundment; stocks were restored there in 1954-1964 with walleye fry from a New York source (Tennessee Wildlife Resources Agency records).

Until recently, there has been little concern about mixing walleye from different regions. Northern fish have been widely stocked leading to the possibility that most southeast reservoir walleye fisheries are now composed primarily of northern fish. Also, southern walleye may have more-specific spawning requirements. Southern strain walleye need to be identified and protected where they exist to allow fisheries managers the option of using these fish for fisheries restoration in southern impoundments. The purpose of this study was to determine the present stock identity of walleye in Dale Hollow Reservoir, Tennessee, thereby determining whether native southern strain walleye exist there.

Methods

Adult walleye were collected from two disjunct regions in Dale Hollow Reservoir and from a tributary stream (East Fork of the Obey River) by electrofishing during the spring spawning season of 1988. Fish were packed on ice immediately upon capture and returned to the Tennessee Cooperative Fishery Research Unit Laboratory. Liver and white muscle tissue samples were excised from each sample and were shipped on dry ice to the Fisheries Genetics Laboratory at Texas A&M University. Samples were then stored at -90°C pending electrophoretic analysis.

Subsamples of white skeletal muscle were thawed and homogenized in 0.5-1.0 mL grinding buffer (0.01M Tris-0.001M EDTA pH 6.8), and centrifuged (800x gravity) at room temperature for 5 minutes. Liver samples were thawed but not ground or centrifuged. Muscle and liver supernatants were subjected to starch gel electrophoresis (Selander et al. 1971) using N-(3-aminopropyl) morpholine-citrate buffer pH 6.1 (Clayton and

Tretiak 1972). Alcohol dehydrogenase (ADH, ISN[2] 1.1.1.1), malate dehydrogenase (MDH, ISN 1.1.1.37) and isocitrate dehydrogenase (IDH, ISN 1.1.1.42) were stained with specific enzyme stains from Selander et al. (1971) and Harris and Hopkinson (1976).

Vertical-slab polyacrylamide-gel electrophoresis (Hoefer Scientific Instruments 1980), with gel formulations from Davis (1964), was utilized to visualize muscle myogen (MYO) proteins (Uthe and Ryder 1970). Muscle supernatant was mixed with an equal volume of layering solution (60% sucrose in distilled water), applied to a 12% acrylamide gel in 10-µL aliquots, and subjected to electrophoresis for 3,000 volt-hours at 40 mA per gel. General proteins were stained with a 0.04% Coomassie Brilliant-Blue-Green/5% perchloric-acid solution and destained with a 15% ethanol/10% acetic acid solution. Observed genotypic ratios were tested against expected Hardy-Weinberg distributions and for between-site variations using the chi-square test.

Results and Discussion

ADH was monomorphic and all other loci were polymorphic (Table 1). Observed genotypic frequencies did not differ significantly from expected Hardy-Weinberg distributions. Allele frequencies were similar for all locations sampled, indicating that panmixia probably occurs throughout the reservoir and the tributary stream sampled. These results are similar to those of Terre (1985) who found similarities between spawning areas in Lake Meredith, Texas.

The high frequency of the MDH-B2 allele in the Tennessee walleye was similar to frequencies observed previously in New York, Pennsylvania and North Carolina (which has been stocked with northern walleye)(Table 2). This high MDH-B2 frequency may be indicative of the continued existence of northern stocks in Dale Hollow Reservoir as a result of the stocking of New York walleye; conversely, native southern walleye seem to have a high frequency of the MDH-B3 allele, as evidenced in Mississippi samples (Table 2). Similarly, in a previous study, Murphy et al. (1983) found evidence of stocked northern walleye becoming established in a southern reservoir that also contained native walleye.

Results for IDH were similar to MDH; Tennessee walleye (Table 1) displayed allele frequencies similar to frequencies for walleye from New York and North Carolina (Table 2). Native southern walleye seem to have a high frequency of IDH-A2, similar to Mississippi samples (B. Murphy, Texas A&M University, unpublished data). Muscle myogen results also showed no significant differences between sites in Dale Hollow Reservoir, with the slow allele (MYO-A2) existing at a high frequency (Table 1) similar to frequencies of northern populations (Table 2).

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[2]International standard number (IUBNC 1984).

Again, this is in contrast to native southern walleye in Mississippi that were fixed for the fast (MYO-A1) allele (B. Murphy, unpublished data).

Previous studies have demonstrated genetic differences between walleye from different watersheds. Significant differences between Kansas and Pennsylvania stocks were found for muscle myogen (Murphy et al. 1983). Uthe and Ryder (1970) found that populations in Lake Winnipeg and Great Slave Lake differed in muscle myogen from Great Lakes populations. Clayton et al. (1974) noted differences in MDH allele frequencies between populations from several lakes in western Canada. Not surprisingly, genetic differentiation is less-clearly defined within individual lacustrine systems. Terre (1985) found moderate differentiation between spawning areas in Lake Meredith, Texas in some years, but the differentiation was not evident in other years. Murphy et al. (1983) found significant variation between lacustrine and riverine spawning areas in Claytor Lake, Virginia; these differences probably arose from the stocking of northern walleye over an already-existing native population.

In contrast to Murphy et al. (1983), the present study noted no differences between spawning areas in Dale Hollow Reservoir. Based on lack of spawning-area differentiation and the genetic similarity of Dale Hollow walleye to walleye in northern states, the Dale Hollow Reservoir walleye population is most likely of northern descent.

The present study was preliminary in nature and based on small sample sizes. Further sample collections are presently underway to verify results described here. Because of possible existence of southern strain walleye in the Appalachian region and the potential importance of this strain, we recommend genetic analysis of all river/reservoir systems that may contain southern walleye. Present stock structure of walleye in all watersheds should be determined so that future stocking programs can be aimed at preserving important stocks and protecting them from genetic dilution.

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Table 1. Allele frequencies for three genetic loci in walleye collected from three sites in Dale Hollow Reservoir, Tennessee. Sample sizes are indicated in parentheses below site names. MDH = malate dehydrogenase; IDH = isocitrate dehydrogenase; MYO = muscle myogen.

Protein	Allele	Collection site: Lower reservoir (30)	Obey River (16)	Upper reservoir (6)
MDH-B	1	0.06	0.00	0.00
	2	0.75	0.92	0.84
	3	0.19	0.08	0.16
IDH-A	1	0.44	0.50	0.38
	2	0.56	0.50	0.62
MYO-A	1	0.44	0.33	0.50
	2	0.56	0.67	0.50

Table 2. Allele frequencies for three genetic loci in walleye from various sites in the United States (from B. Murphy, Texas A&M University,unpublished data). MDH = malate dehydrogenase; IDH = isocitrate dehydrogenase; MYO = muscle myogen; NY = New York; PA = Pennsylvania; NC = North Carolina; MS = Mississippi; VA = Virginia; ND = no data.

		Collection				
Protein	Allele	NY	PA	NC	MS	VA
MDH-B	1	0.06	0.00	0.00	0.00	0.00
	2	0.76	0.78	0.90	0.00	0.65
	3	0.18	0.32	0.10	1.00	0.35
IDH-A	1	0.38	ND	0.50	0.00	ND
	2	0.62	ND	0.50	1.00	ND
MYO-A	1	0.35	0.65	0.78	0.00	0.65
	2	0.65	0.35	0.22	1.00	0.35

BEHAVIOR VARIATIONS ASSOCIATED WITH ULTRASONIC TAGGING OF GUADALUPE BASS

by

Ralph E. Manns Jr.
Fishing Information Services
8800 Silver Arrow Court
Austin, Texas 78759
and
B. G. Whiteside
Aquatic Station
Southwest Texas State University
San Marcos, Texas 78666

Abstract

Fourteen adult Guadalupe bass Micropterus treculi from Lake Travis, Texas, were tagged with ultrasonic transmitters and tracked intermittently until they died from natural causes and/or stress associated with tagging. Underwater and surface sightings of wild Guadalupe bass provided control data. Some behaviors of tagged bass changed significantly as the fish progressed through a post-operative recovery period, into a period of apparent good health, and then into a pre-mortality period. Differences were found in depth selection, body temperature, amount of apparent feeding, home-range and nomadic activity, pelagic activity, habitat and cover selections, and responses to divers and boats. Differences were also found between the depth and habitat selections of apparently healthy tagged Guadalupe bass and wild (untagged) Guadalupe bass. The assumption of behavioral normality for electronically-tagged black bass Micropterus spp. should not be made until any behavioral changes associated with the recovery-mortality sequence are identified. Comparisons with untagged fish are desirable.

Introduction

Since Trefethen (1956) pioneered the application of electronic tracking to the study of fish behavior, ultrasonic and radio tracking devices have been increasingly used to gain knowledge of black bass Micropterus spp. behavior. Most researchers asserted implantation or external attachment of devices did not modify behavior significantly. Normality was assumed because surgery healed and tagged fish "appeared" normal, seemed to feed, maintained hydrostatic balance, and survived in aquaria (Hasler et al. 1969; Clugston 1973; Ziebell 1973; Smith 1974; Coutant 1975; Merriner 1975; Peterson 1975; Stasko et al. 1976; Winter 1976; Stasko and Pincock 1977).

Few trackers reported attempts to verify the assumption of normality. Ager (1978) analyzed movement data for tagged walleye but found no correlation between fish activity and time after release. Prince and Maughan (1979) detected gradual changes in largemouth bass Micropterus salmoides activity over a 30 d period but included all but the first 2 d of tracking in their report of fish behavior.

Numerous studies have, nevertheless, shown tagged and environmentally stressed fish to have modified behavior. McCleave and Stred (1975) and Gray and Haynes (1977) found tagged salmon had reduced swimming performance, and Gallepp and Magnuson (1972) demonstrated that small weights interfered with the buoyancy of sunfish. Ross and McCormick (1981) demonstrated that externally-attached, dummy radio tags adversely effected the mortality, feeding, and growth of yellow perch Perca flavescens and largemouth bass. Carlander (1977) and Heidinger (1976) cited numerous studies in which apparently minor injuries and light-weight objects, like fin clips and jaw tags, significantly increased mortality or decreased growth of black bass. Woltering et al. (1978) showed that the effectiveness of largemouth bass as predators was greatly reduced by sub-lethal levels of ammonia, and Coutant et al. (1979) cited studies where environmental stress caused increased vulnerability of prey fishes. Reynolds (1977) noted that the precision of thermoregulatory responses of fishes appeared to be increased by stress. Baker and Modde (1977) found significant differences between the vulnerability of chemically-dyed and untreated shiners up to 7 h after exposure, and noted visual estimates of the normality of treated fish had led other experimenters to assume recovery within a few hours.

These findings suggest surgical procedures and/or attachment of weights will affect tagged fish. If the effects are not obvious, we believe they may be revealed by statistical analysis.

We published a preliminary report to warn trackers of possible abnormalities (Manns and Whiteside 1979). Later, Knopf (1982) also reported surgical transmitter implants significantly influenced largemouth bass behavior. Since these warnings were published; however, bass trackers continue to assume normality without reporting efforts to statistically review their data (Doerzbacher 1980; Savitz and Fish 1982; Crumpton 1983; Zimmerman 1983; Kraai 1986; Pearson 1987).

The original intent of this research was to document the behaviors of tagged and wild (untagged) Guadalupe bass Micropterus treculi in a reservoir. Instead, we report impacts of tracking procedures and equipment on natural behaviors and show that changes in behavior over time can be detected with simple statistical comparisons. We wished to study the movement patterns of Guadalupe bass in more detail than the daily or weekly spot locations and estimates of home ranges reported by previous black bass trackers and hoped to collect control data (on untagged fish) with observers.

Methods

The study site, Lake Travis, was selected because it contained Guadalupe bass, a relatively unstudied black bass species, and is usually clear enough to allow underwater observation of fish. Lake Travis is a large and moderately fertile, bottom-draining, deep storage reservoir built in 1942. The reservoir is located 19 km northwest of Austin, Texas on the Colorado River. The study was made within 10 km of the dam where water is clearest. Hydrology, limnology, and biota are detailed in Manns (1981).

Between 1 June and 3 November 1977, Guadalupe bass for tagging were collected by angling, tagged, and released. Fish were caught at various depths and times of day and night.

Long-range (1,400 m), long-lived (12-14 months) ultrasonic transmitters were purchased from Sonotronics, Tuscon, Arizona. Units were 16 mm in diameter, 60 mm long, and weighed 20 g in air and 8 g in water. They broadcasted on discrete frequencies, and varied beep frequency as fish body temperature changed. To assure accuracy of fish body temperature data and depth computations, transmitters were calibrated and equivalent-temperature curves prepared before use. Whenever possible, units were recalibrated after use to correct small temperature shifts.

Transmitters were surgically implanted in the coelom of each Guadalupe bass by using a modified version of procedures described by Peterson (1975). After laboratory pre-tests (Manns 1981), we elected to make incisions 2 cm to the side of the linea alba to reduce stress on sutures and improve healing. When practical, surgery was performed immediately after capture, but some fish were held in a live well or floating wire box for several hours before surgery. Surgical equipment and transmitters were sterilized with ethanol, and transmitters were dusted with nitro-furazone (Furacin) prior to insertion. Fish were anesthetized with a 15 mg/L quinaldine solution immediately before surgery. Surgery and exposure to quinaldine lasted 12-14 min. Fish were then held 5-30 min in a 10-20 mg/L solution of nitro-furazone prior to release. Sutures and wounds from external tags and any skin lesions were treated with direct application of 100 mg/L malachite green (Kirkland 1962).

Fish to be tagged were sexed by inspection through incisions (Manns and Whiteside 1980). All but the last two fish tagged were also identified with numbered disks (25 mm diameter) pinned just below the spiny dorsal fin.

Throughout June, trackers maintained a 24 h/d observation schedule whenever possible. From 1 July through mid-September, tagged fish were monitored 8-10 h/d, Monday through Friday, with observations normally starting at sunrise or near noon. To collect nighttime data in this period, observers arrived earlier or stayed until midnight. From mid-September through 6 January, fish were tracked two or three times per week. Seven additional spot checks were made until the last tagged fish was obviously dead in September 1978. Death was confirmed by recovery of fish

and/or transmitters, or was assumed when transmitters in deep water ceased all movement.

Locations of tagged fish were determined by triangulation and receiver angle. Fish depth ranges were determined by comparison of fish body temperature with water temperatures. Sonar images of fish and substrate and visual sightings provided specific depths. Observers used checklists to record data as sightings were made. Data were collected on 108 variables; data relevant to this report are cruise swimming speed, body temperature deviations, mean depth, substrate depth, depth shifts, apparent feeding activity, type and direction of movement, nomadic and home range behaviors, aggregation and schooling, reactions to divers and boats, horizontal and vertical relationship to cover, lake locations, and substrate, habitat, and cover usages.

Data were recorded each time a tagged fish entered a new habitat or changed a behavior or depth. Tagged fish moving in a constant direction were followed until they stopped. If specific starting and stopping points were identified and the track could be measured, average swimming speeds in body-lengths per second (BL/s) were computed. If a fish remained stationary or merely moved back and forth a few meters without changing habitat, the observer would record data and move to another fish if one was available. When two fish were reasonably close together, the tracker moved back and forth to collect nearly continuous data on both fish. Whenever an observer left a fish, he would attempt to move the boat over the tagged fish and record its depth with a sonar chart recorder.

SCUBA divers and surface observers refined depth information and obtained data not available from tracking alone during daylight hours. When water was fairly clear and lighting adequate, divers periodically attempted to visually contact tagged fish, surveyed the immediate area by swimming vertical and horizontal transects, and identified other fishes in the vicinity. Observations of wild Guadalupe bass by divers and surface observers provided control data.

Each sighting of a tagged Guadalupe bass, of single wild Guadalupe bass, or of two or more wild Guadalupe bass of similar size and behavior, plus associated data on behavior and habitat, formed one case. The length of time assigned to each case was dependent upon continuous observation of a Guadalupe bass or group of similar Guadalupe bass without a change of any of the variables measured in this study. If, for example, a tagged fish or group of similar wild fish changed swimming speed or direction, started to feed, or moved to a different depth or habitat, a new case was initiated.

Aggregated or schooled, wild Guadalupe bass were considered of similar size if they appeared to be within ± 25 mm of the same total length (TL). Fish of different lengths were logged as separate cases. Because the number of fish and length of observation periods varied from case to case, case data were weighted by the number of fish and length of the observation to

provide "fish-minute" data for comparison. Our ability to monitor tagged fish for up to 14 months allowed us to detect the apparent death of each fish. When field observations suggested behaviors changed as fish recovered from surgery and changed again as they neared death, we decided to separate our data into categories for analysis based upon the dates of tagging and evident mortality.

The tagged Guadalupe bass were arbitrarily separated into a "healthy" period and four ill-health periods:

1. Immediate Post-operative Recovery Period (PO) = the first 4 d after surgical implantation;
2. Extended Post-operative Recovery Period (EPO) = The 5-14 d period after tagging;
3. "Healthy" Period (H) = All time between extended post-operative and extended mortality periods;
4. Extended Mortality Period (EM) = the 14-5 d period before death;
5. Imminent Mortality Period (IM) = the 4 d period before death.

Data for the four ill-health categories were compared statistically with data for the "healthy" group, and data for the "Healthy" Period were compared with observations of wild Guadalupe bass.

These arbitrary periods did not always match our assessments of the actual health status of individual Guadalupe bass. They were used to avoid bias that would have resulted if observers had used subjective criteria to assign individual fish to various ill-health periods. They also allow comparison of 4 and 14 day periods as potential cut-off criteria to separate post-release and pre-mortality data from data on apparently healthy and normal tagged fish.

Each data analysis was made with simple case data, data weighted by the number of fish in each case, and data weighted by both the number of fish and length of the observation period (fish-minute data). Fish-minute data provided the most valid descriptions of comparative behaviors but exaggerated sample sizes and the significance of differences. Whenever appropriate, the statistical test results presented in this report reference case data to provide the most rigorous tests.

Because unequal collection methods and an uneven tracking schedule created many confounding factors, data for each variable collected were reviewed to identify factors that biased the results. Variables for which data appeared overly confounded are not reported here but were discussed in Manns (1981).

Nominal data were compared in contingency tables using Chi-square statistics, the Statistical Package for the Social Sciences (SPSS)(Nie et al. 1970), and a DEC-10 computer (Digital Equipment Co.). Analysis of variance (ANOVA), Dunnett's multiple comparison tests, and two-sample *t*-tests were hand calculated as described by Zar (1974) to analyze ratio and interval scale data. Two-tailed criteria were used and probabilities of less than 0.05

and 0.01 were considered significant and highly-significant, respectively.

The 4-day ill-health periods (PO and EM) were compared individually with the "Healthy" (H) Period data. To achieve minimum numbers of cases for cross-tabulation tests of nominal variables, data were combined into PO+EPO and EM+IM groupings. These combined groups were statistically compared with data for "Healthy" (H) fish. See Manns (1981) for methods and procedures in greater detail.

Results

Seven of 14 adult Guadalupe bass tagged with ultrasonic transmitters and released in Lake Travis between 1 June and 3 November 1977 survived implantation and were tracked intermittently until their evident deaths 5 d to 331 d after surgery. They provide 94% of the tracking data referenced in this report, are primary data sources, and provide all of the data on "Healthy" (H) tagged Guadalupe bass (Table 1).

The seven other tagged Guadalupe bass died within 4 d of tagging and release. These fish provided only 6% of the tracking data and are secondary data sources. They provide data only on the Immediate Post-operative (PO) and/or Immediate Mortality (IM) Periods (Table 2).

Field observations suggested some behaviors changed as fish recovered from surgery and others changed with declining health and approaching mortality. Data analysis indicated many of the behaviors of recovering and dying fish were significantly different from those of H Period Guadalupe bass. Analysis also revealed significant differences between the behaviors of H Period and wild Guadalupe bass.

The deviations of the mean body temperatures of tagged Guadalupe bass above the temperature of ambient water (Figure 1) increased from 0.38°C in the PO Period to 0.72°C in the Extended Post-operative (EPO) and H Periods, then dropped to 0.20°C and 0.29°C in the Extended and Imminent Mortality (EM and IM) Periods, respectively. The PO, IM, and EM averages were different from the H value at highly-significant levels. Healthy fish were warmer, even when data on sedentary and moving fish were separated (Manns 1981).

Profiles are used to present most of the remaining data (Figures 2-9). Although profiles reveal numbers less precisely and give less statistical information than complete data presentations (Figure 1), profiles make the sequence of changes more obvious and require less space.

Average cruise swimming speed (Figure 2A) was 0.25 BL/s in the PO Period, increased to about 0.40 BL/s in the EPO, H, and EM Periods, and then dropped again to about 0.25 BL/s in IM Period. However, sample sizes are too small to detect significant differences.

The mean depths (Figure 2B) used by tagged fish in the PO, EPO, and EM Periods were deeper than that of fish in the H Period. The mean depth of wild Guadalupe bass (3.8 m), was deeper than that of H Period fish (2.7 m). All differences were highly-significant, but the comparison with wild fish may be confounded to an unknown degree by the small sample size for tagged fish.

The profile depicting the percent of time spent in direct light (away from shade) (Figure 2C) shows tagged Guadalupe bass were in shaded areas more often when they were fully recovered from surgery, but then exposed themselves to more direct light in the EM Period. The latter change was associated with increased open-water activity. Wild Guadalupe bass moved away from shade slightly more than H tagged Guadalupe bass, but case data are not significantly different. More detailed tables are available in Manns (1981) for all nominal data mentioned in this report.

Major depth shifts, as indicated by body temperature changes >0.2°C, were most frequent in the PO and EM Periods (Figure 3A). An almost identical profile describes the frequency of depth changes >1 m confirmed by sonar imagery and/or direct observation (Figure 3B).

The position of tagged Guadalupe bass relative to the bottom (Figure 3C) and their position relative to cover (Figure 3D) changed significantly, with the most distinct shifts occurring in the EM and IM Periods. Imminent mortality was associated with both increased resting behavior near the bottom and more use of water away from cover. Wild Guadalupe bass positions were significantly different from those of H Period Guadalupe bass.

Divers approached H Period Guadalupe bass to an average distance of 1.4 ± 0.9 m, wild Guadalupe bass to 1.2 ± 0.6 m, and Guadalupe bass in the ill-health categories (lumped together) to 1.6 ± 0.6 m. These distances are not significantly different for case data but significantly different for appropriately weighted fish-minute data. Divers noted that wild Guadalupe bass were less likely to flee (22%) when approached by divers than tagged Guadalupe bass in all health periods (52-56%). This difference was significant for case data. H Period Guadalupe bass (28%) were also more likely to eventually become agitated and flee if a diver remained nearby than wild Guadalupe bass (5%) at a highly-significant level. H Period Guadalupe bass reacted to approaching boats with electric motors more frequently than tagged Guadalupe bass in any of the ill-health categories (Figure 4A). The responses by PO+EPO and IM Period Guadalupe bass were significantly different from those of H Period Guadalupe bass.

Stress associated with carrying transmitters evidently made reasonably healthy tagged Guadalupe bass feel less secure and act more warily. But recent surgery and/or imminent death apparently made tagged fish less sensitive to stimuli in general.

Stress induced by transmitter drag may also have modified relationships with other fishes. When case data was used, shifts in amounts of solitary, aggregated, and schooling behavior by tagged Guadalupe bass were insignificant (Figure 4B). However,

when aggregation and schooling are combined, wild Guadalupe bass were grouped twice as often as tagged fish, a highly-significant difference. The profiles for schooled and aggregated fish are misleading because of the tendency of tagged fish, healthy and otherwise, to aggregate with large (too big to swallow) sunfishes Lepomis spp. rather than with other black bass.

The relationship of tagged fish to forage fish also changed with health status (Figure 4C). Tagged Guadalupe bass in the EM period were more frequently seen with shad Dorsoma spp. nearby. This finding was associated with increased movement into open water areas. Small shad and sunfish were seen less often near PO and EPO Period tagged Guadalupe bass, but larger fish of various species remained nearby. The H and EM Period Guadalupe bass were more active. Divers noted potential prey were more likely to try to avoid H and EM Period fish than ailing tagged Guadalupe bass. The H and EM Period Guadalupe bass were, however, better able to move to areas occupied by small preyfish. The ability of EM Period Guadalupe bass to move nearer shad at times when sunfish generally avoided them may explain the increased interest of these stressed, but still mobile, fish in offshore movements. The types of movements made by tagged Guadalupe bass (Figure 5A) varied with health category at a highly-significant level. Random movement decreased slightly with recovery but became dominant with approaching morbidity. Dying fish made more random moves and were stationary less, possibly in attempts to find more satisfactory conditions. Movements to avoid divers, boats and other potential threats were greatest by EPO and H Period Guadalupe bass.

Movements of PO Period tagged Guadalupe bass relative to wind direction were highly significantly different from those of H Period Guadalupe bass (Figure 5B). Recovering and weakening Guadalupe bass appeared to opt for easy swimming and tended to avoid upwind (presumably upcurrent) directions, while more healthy and actively feeding fish preferred upwind swimming.

Neither recovering (PO) nor dying (IM) tagged fish appeared to feed as frequently as the healthier (EPO, H, and EM) tagged fish (Figure 5C). However, even the least healthy fish made moves that appeared to be attempts to feed 25% of the time.

The most obvious change in behavior of tagged Guadalupe bass was the shift from home range, local movements to nomadic behavior (Figure 5D). All differences were highly-significant. Recovering and healthy tagged Guadalupe bass stayed in local areas. Guadalupe bass stressed by impending death moved more frequently into new habitats, particularly into the open water habitat. Because nomadic fish had completely recovered from surgery and environmental conditions and food availability had not measurably changed at the times these individuals began nomadic behavior, we postulated they were stressed by inability to capture prey. Deaths resulted when they exhausted bodily reserves and/or weakened enough to become prey themselves. We attribute some losses to illegal spearfishing, a giant catfish, and local ospreys (Tables 1 and 2), but starvation was likely a

major contributing factor in the eventual deaths of most of our primary data sources.

Transmitter weight evidently was sufficient to prevent prey capture. Tagged fish No. 41, for example, was monitored in apparent feeding activity several times, including the day prior to her death and recovery. A necropsy revealed she was disease and parasite free. Her sutures had completely healed and the transmitter was encapsulated, but visceral tissue was degenerate. Lagler et al. (1962) notes such non-functional tissue results in fishes from severe starvation.

H Period Guadalupe bass were less likely than wild Guadalupe bass to hold in main lake areas, but EM Period Guadalupe bass moved out of coves into the main lake (Figure 6A). A comparable increase in offshore activity by EM Period Guadalupe bass was also noted (Figures 6B). As tagged fish recovered, they tended to move away from soft and small-rock substrates with shallow to moderate slopes to steeper, rockier habitats (Figures 6C and 6D). But as tagged fish became moribund, they moved over the detritus and silt of deep, open water and then to the backs of coves with flatter and softer substrates. Tagged fish in all health periods were more likely at highly significantly levels to use places with soft substrates than wild Guadalupe bass (Figure 7).

Most habitat choices of tagged and wild Guadalupe bass were different at highly significant levels, and major shifts in habitat use occurred in the EM Period (Figure 8). Imminent mortality changed habitat use patterns. Ailing tagged fish first became more mobile and searched new habitats, apparently trying to reduce hunger or other physical discomforts. As death became more imminent, they eventually wandered aimlessly, apparently unable to discriminate between favorable and unfavorable sites. Dying fish displayed obviously abnormal behaviors.

Discussion

The study of behavior in natural environments is difficult because a host of uncontrolled variables modify behavior and behavioral responses vary according to the experience and learning of individual subjects. Problems in the field prevented uniform data collection, and sample sizes were limited by the availability of time and funds. Our data are partially confounded by these and other limitations. But analysis of sub-samples based on the month, season, and method of data collection (scuba data only, for example) provided results similar to those obtained from the overall data base (Manns 1981).

We believe our data are reliable enough to support three conclusions: (1) tagged Guadalupe bass changed behavior as they recovered from surgical implantation; (2) tagged Guadalupe bass changed behavior again as they were stressed by inability to capture prey and neared death; and (3) healthy tagged Guadalupe bass behaved somewhat differently from wild Guadalupe bass swimming in similar areas.

Our preliminary report (Manns and Whiteside 1979) was discounted because we reported a high death rate (Doerzbacher 1980), but our findings should not be ignored merely because we identify our losses. The deaths let us identify behavioral changes associated with imminent mortality and long-term stress as well as behaviors associated with recovery from surgery. In any case, six of our seven primary data sources were monitored as long or longer than black bass in most prior tracking studies.

Our death rate within 4 days of surgery might have been reduced by improving surgical procedures or different chemical treatments. Crumpton (1983) indicated changes in treatments helped survival. Mike Lembeck (San Diego County, personal communication) said the death rate in his tracking study of 200 largemouth bass in California was about 1% in winter but 50% in midsummer. The latter figure matches our loss rate, suggesting we might have increased survival by avoiding surgery while surface water was warm.

Deaths after recovery might have been postponed by studying bass in another lake or by tagging larger fish. Lake Travis Guadalupe bass are often diseased and apparently have a high natural mortality rate (Drew and Tilton 1970; Manns 1981). The small Guadalupe bass apparently had a marginal ability to carry 8 g (in-water) transmitters. Excess weight and drag evidently stressed tagged fish, limited successful feeding, contributed to early death, and made obvious the changes in behavior over time.

Only the most obviously diseased and dying tagged fish failed to move about or try to feed. Had we evaluated the feeding movements of tagged fish uncritically, we could have falsely concluded most were healthy and "normal" just before they died.

We postulate increased searching movements are normal and predictable responses by bass and other active predators under environmental stress. Increased feeding attempts are a logical response to hunger resulting from failure to catch prey, as long as fish sense the effort may be rewarded. Vertical and/or horizontal searching moves are likely options whenever local water conditions become unfavorable, even if an obvious gradient toward better conditions is not detectable. We suggest that tracking data on the amount of movement and home-ranges sizes are most meaningful as indicators of relative health and stress associated with environments. Home ranges and amounts of movement likely vary between lakes, as environmental conditions change in specific areas, with food availability and type, and with the learning experiences of individual fish. There likely is no typical home-range size or universal movement pattern for black bass species, which appear flexible in their responses to different habitats.

Many black bass waters contain both relatively well fed, unstressed fish with relatively small home ranges and mobile, more highly stressed, bass at any given time. This duality may explain reports that there appear to be two separate bass

populations in some waters (Fetterolf 1952; Funk 1957; Miller 1975; Manns 1981).

Researchers using tracking techniques might use shifts in behavior as clues to changes in fish health or environmental quality. But, to do so they must exclude changes in behaviors induced by the tagging process. We found significant behavioral differences within 14 d after tagging and 14 d before death. In the absence of data analyses showing no significant differences between the behavior of recently-tagged and long-tracked fish, we suggest at least the first 2 weeks after surgery be excluded from studies of "normal" behavior using implantation techniques. The normality of long-tracked fish should also not be assumed unless fish are tracked long enough after a data cut-off point to assure they were not sick or dying when last monitored. Moreover, any obvious shift in behavior should be investigated to determine probable cause(s). Had we classified all data up to the moment of transmitter loss as "normal", we would have reached invalid conclusions about the typical behavior of Guadalupe bass.

This study does not prove that similar differences will exist in other tagged fish or that differences will be as overt and easily measured. The use of larger specimens and/or smaller transmitters in healthier environments likely masks, and may eliminate, many behavioral changes.

This study does demonstrate the desirability of observation of untagged fish as controls and that simple statistical analysis can identify and separate periods of changed behavior, even when controls cannot be used. The assumption of normality should not be made, nor should tracking data be considered a single package, without serious attempts to identify behavioral changes associated with recovery from capture and tagging, temporary sickness or unusual hunger, approaching death, or major environmental shifts that force subjects to change behaviors.

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Table 1. Data summary for 7 Guadalupe bass that survived surgery and were electronically tagged, released, and tracked in Lake Travis, Texas. These primary data sources provided 94% of the tracking information referenced in this study.

Fish no.	TL (mm)	Date tagged 1977	Date last contact	Percent of total case data	Days observed in each Health Category[a]					Remarks
					PO	EPO	H	EM	IM	
11	335	1 Jun	22 Jun 77	6.6	4	2	0	8	2	Nomadic, moved offshore, possibly eaten by catfish
41	290	1 Jun	9 Jul 77	10.7	3	7	4	2	2	Nomadic along shore, obviously starved
12	370	3 Aug	26 Dec 77	35.4	4	7	48	5	1	Home range then offshore nomadic
42	350	16 Aug	19 Aug 77	1.0	4	0	0	0	0	Local recovery, killed by spear-fisherman
51	300	16 Aug	1 Sep 77	3.9	4	5	1	0	0	Local recovery, then nomadic, contact lost, caught by angler?
81	360	18 Oct	14 Sep 78	19.1	2	2	27	0	1	Home range, then extended home range
61	340	3 Nov	1 Feb 78	13.1	2	4	15	0	1	Local recovery, large home range, then nomadic

[a] PO = Immediate Post-operative Recovery Period (0-4 d after surgery)
EPO = Extended Post-Operative Recovery Period (5-14 d after surgery)
H = "Healthy" Period (period between the EPO and EM Periods)
EM = Extended Mortality Period (14-5 d before death)
IM = Immediate Mortality Period (4-0 d before death)

Table 2. Data summary for 7 Guadalupe bass that died within 4 d of surgical implantation of transmitters. These secondary data sources provided 6% of the data on behavior of Guadalupe bass immediately after release and prior to death.

Fish no.	TL (mm)	Date tagged 1977	Date last contact 1977	Percent of total case data	Days observed in each Health Category[a]					Remarks
					PO	EPO	H	EM	IM	
21	330	2 Jun	2 Jun	0.2	0	0	0	0	1	Body recovered
22	340	30 Jun	4 Jul	1.1	0	0	0	0	3	Lived in and near cave, transmitter recovered
31	375	30 Jun	2 Jul	0.9	0	0	0	0	2	Body recovered
32	330	6 Jul	6 Jul	0.0	0	0	0	0	0	Gas bladder problem, lost at release, unit not recovered
43	360	11 Sep	15 Sep	0.8	1	0	0	0	1	Body recovered
44	365	20 Sep	22 Sep	1.3	1	0	0	0	1	Disappeared
71	325	6 Oct	9 Oct	1.5	1	0	0	0	2	Sick near surface, disappeared by osprey?

[a] PO = Immediate Post-operative Recovery Period (0-4 d after surgery)
EPO = Extended Post-Operative Recovery Period (5-14 d after surgery)
H = "Healthy" Period (period between the EPO and EM Periods)
EM = Extended Mortality Period (14-5 d before death)
IM = Immediate Mortality Period (4-0 d before death)

Figure 1. Mean deviations of body temperatures of electronically-tagged Guadalupe bass above the ambient water temperature. Double asterisks (**) indicate a mean deviation temperature is different from the mean of the "healthy" tagged Guadalupe bass at the 0.01 level (Dunnett's multiple comparison test). Mean values are indicated by horizontal lines, ranges by vertical lines, standard deviations by rectangles, 95% confidence limits by dots, and sample sizes by numbers. Health periods (X-axis) are:

PO = Immediate Post-operative Recovery Period (0-4 d after surgery);
EPO = Extended Post-Operative Recovery Period (5-14 d after surgery);
H = "Healthy" Period (period between the EPO and EM Periods);
EM = Extended Mortality Period (14-5 d before death);
IM = Immediate Mortality Period (4-0 d before death).

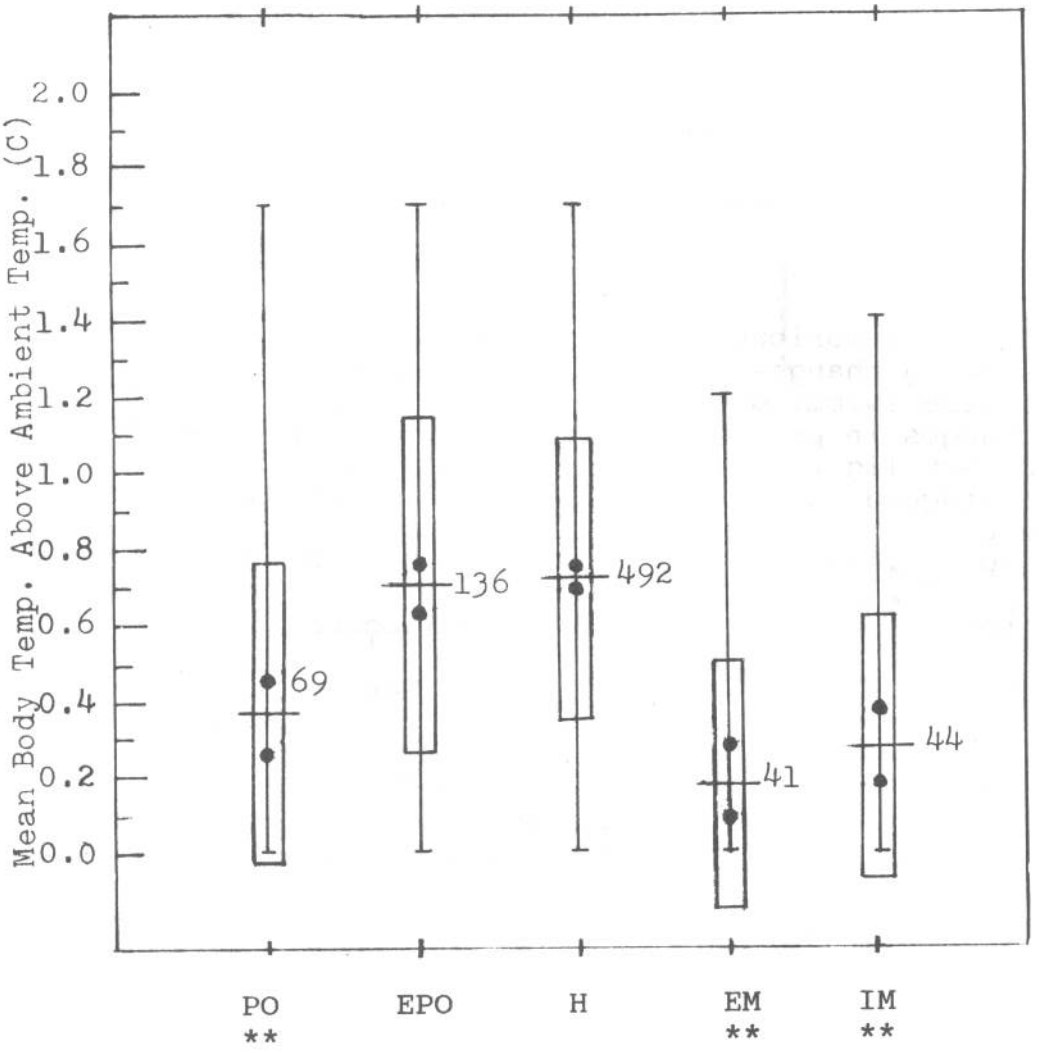
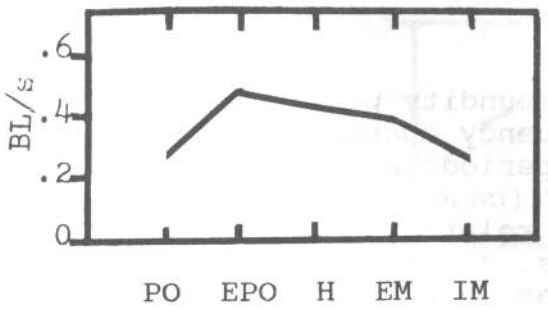

Mean Body Temp. Above Ambient Temp. (C)
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
69
136
492
41
44
PO
**
EPO
H
EM
**
IM
**

Figure 2. Recovery-moribundity profiles of tagged Guadalupe bass showing changes during five health periods in (A) cruise swimming speeds, (B) mean depths, and (C) changes in percent of time spent away from shade. The direct light profile also displays data points for wild (untagged) Guadalupe bass. Health periods (X-axis) are:

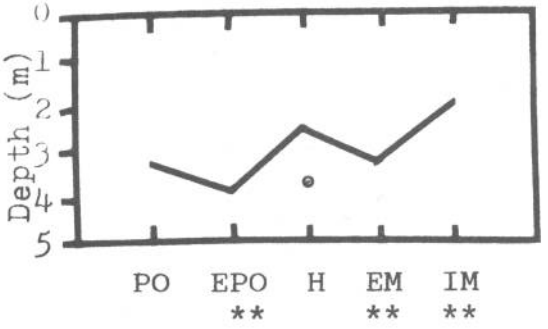
PO = Immediate Post-Operative Recovery Period (0-4 d after surgery);
EPO = Extended Post-Operative Recovery Period (5-14 d after surgery);
H = "Healthy" Period (period between the EPO and EM Periods);
EM = Extended Mortality Period (14-5 d before death);
IM = Immediate Mortality Period (4-0 d before death).

An (*) indicates significance at the 0.05 level, and (**) indicate significance at the 0.01 level.

A. Mean cruise swimming speed



B. Mean depth



C. Percent of time spent in direct light

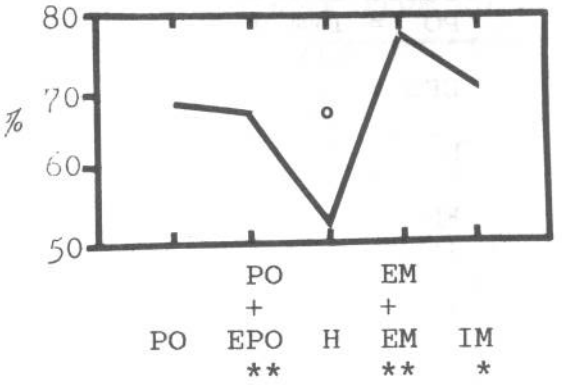
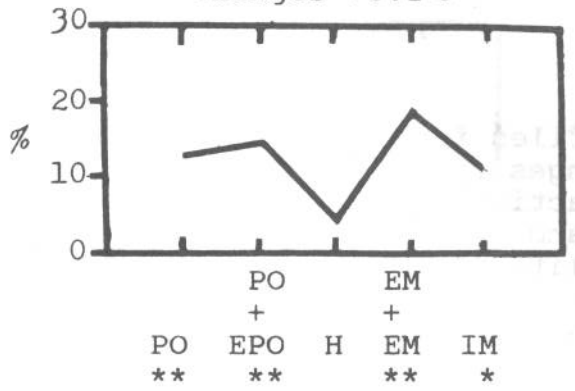


Figure 3. Recovery-moribundity profiles for tagged Guadalupe bass showing frequency changes (percent) in depth during five health periods as revealed by (A) temperature shifts >0.2°C (cases), (B) confirmed depth changes >1 m (cases), (C) relationship to the bottom (1 = on bottom, 2 = ambiguous, 3 = suspended, and 4 = near surface), and (D) distance to cover (1 = in cover, 2 = ambiguous, 3 = near cover, and 4 = open water). Numbers in the middle of Figures 3C and 3D identify equivalent data points for wild Guadalupe bass for comparison with H Period frequencies. Health periods (X-axis) are:

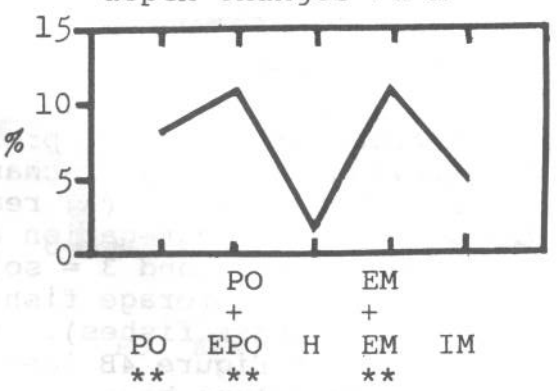
PO = Immediate Post-Operative Recovery Period (0-4 d after surgery);
EPO = Extended Post-Operative Recovery Period (5-14 d after surgery);
H = "Healthy" Period (period between the EPO and EM Periods);
EM = Extended Mortality Period (14-5 d before death);
IM = Immediate Mortality Period (4-0 d before death).

An (*) indicates significance at the 0.05 level, and (**) indicate significance at the 0.01 level.

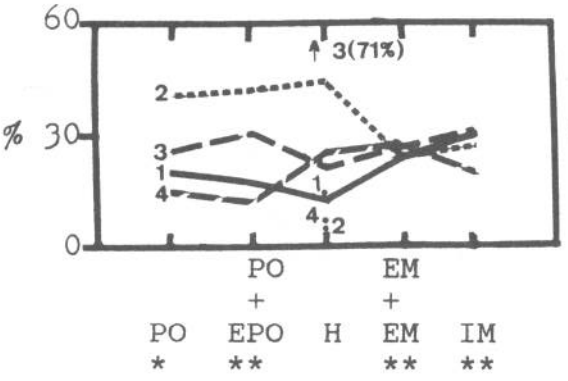
A. Frequency of temperature changes >0.2°C



B. Frequency of confirmed depth changes >1 m



C. Relationship to the bottom



D. Distance from cover

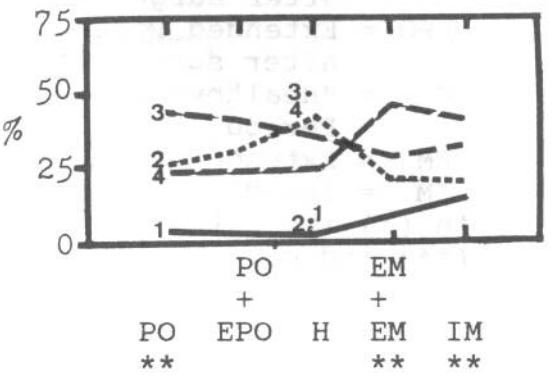


Figure 4. Recovery-moribundity profiles for tagged Guadalupe bass showing frequency of changes (percent) during five health periods in (A) reactions to boats with electric motors, (B) aggregation and schooling (1 = schooled, 2 = aggregated, and 3 = solitary or paired), and (C) proximity to forage fishes (1 = shad, 2 = sunfishes, and 3 = other fishes). Numbers and circles in the middle of Figure 4B identify equivalent data points for wild Guadalupe bass. Health periods (X-axis) are:

PO = Immediate Post-Operative Recovery Period (0-4 d after surgery);

EPO = Extended Post-Operative Recovery Period (5-14 d after surgery);

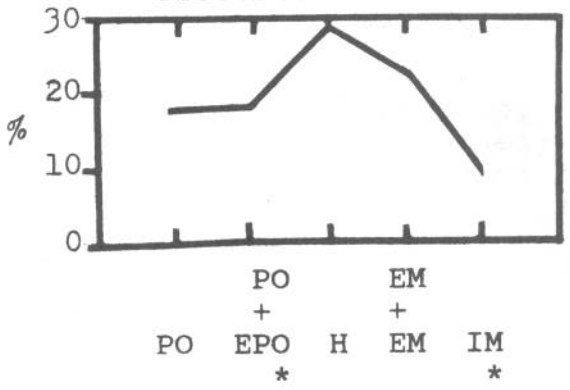
H = "Healthy" Period (period between the EPO and EM Periods);

EM = Extended Mortality Period (14-5 d before death);

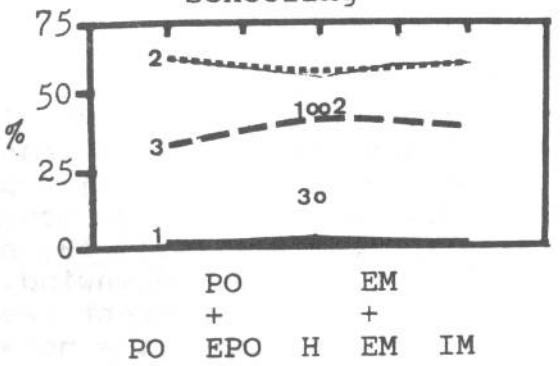
IM = Immediate Mortality Period (4-0 d before death).

An (*) indicates significance at the 0.05 level, and (**) indicate significance at the 0.01 level.

A. Reactions to boats with electric motors



B. Aggregation and schooling



C. Proximity to forage fishes

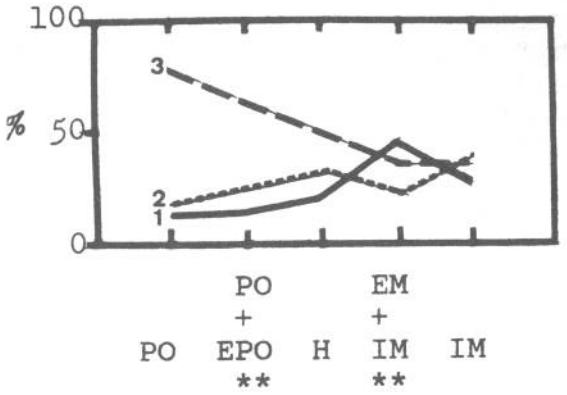
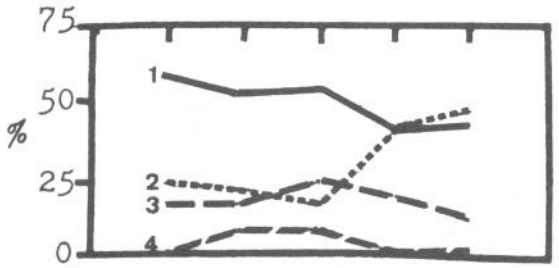


Figure 5. Recovery-moribundity profiles for tagged Guadalupe bass showing frequency of changes (percent) during five health periods in (A) type of movement (1 = no movement, 2 = random movement, 3 = one-way moves, and 4 = avoidance moves), (B) movement relative to wind directions (1 = downwind, 2 = crosswind, and 3 = upwind), (C) apparent feeding, and (D) nomadic and home range behaviors (1 = nomadic, 2 = shifting range, and 3 = home range). Health periods (X-axis) are:

PO = Immediate Post-Operative Recovery Period (0-4 d after surgery);
EPO = Extended Post-Operative Recovery Period (5-14 d after surgery);
H = "Healthy" Period (period between the EPO and EM Periods);
EM = Extended Mortality Period (14-5 d before death);
IM = Immediate Mortality Period (4-0 d before death).

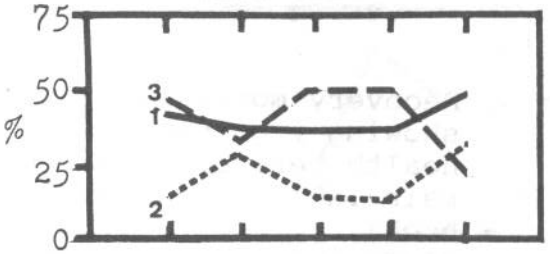
An (*) indicates significance at the 0.05 level, and (**) indicate significance at the 0.01 level.

A. Movement categories



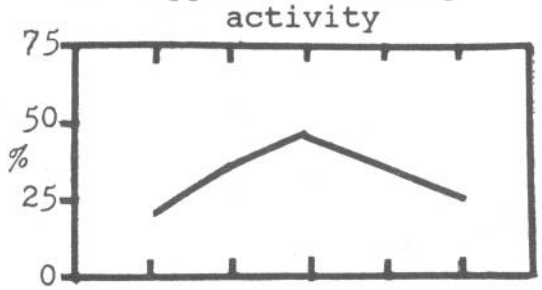
PO	PO + EPO	H	EM + EM	IM
**	**		**	**

B. Movement relative to wind directions



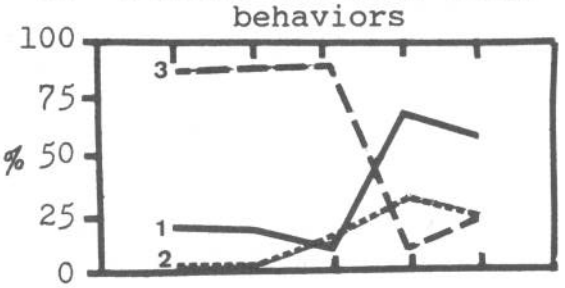
PO	PO + EPO	H	EM + EM	IM
	**			

C. Apparent feeding activity



PO	PO + EPO	H	EM + EM	IM
**	**		*	**

D. Nomadic and home range behaviors



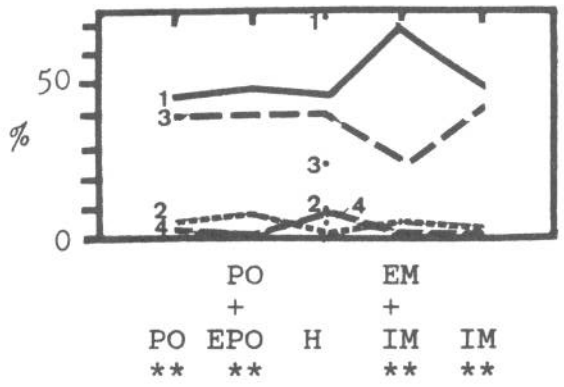
PO	PO + EPO	H	EM + EM	IM
**	**		**	**

Figure 6. Recovery-moribundity profiles of tagged Guadalupe bass showing frequency of changes (percent) during five health periods in use of (A) reservoir locations (1 = main lake, 2 = cove mouth, 3 = mid-cove, and 4 = cove back), (B) offshore habitat, and substrates of different (C) compositions (1 = detritus, 2 = sand, 3 = small rock, 4 = large rock, and 5 = boulders) and (D) gradients (1 = 0-10°, 2 = 11-30°, 3 = 31-75°, and 4 = 76-90°). Numbers and dots in the middle of each profile identify comparable data points for wild Guadalupe bass. Health periods (X-axis) are:

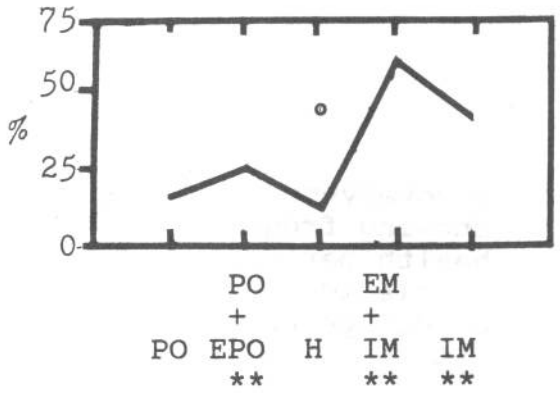
PO = Immediate Post-Operative Recovery Period (0-4 d after surgery);
EPO = Extended Post-Operative Recovery Period (5-14 d after surgery);
H = "Healthy" Period (period between the EPO and EM Periods);
EM = Extended Mortality Period (14-5 d before death);
IM = Immediate Mortality Period (4-0 d before death).

A (**) indicate significance at the 0.01 level.

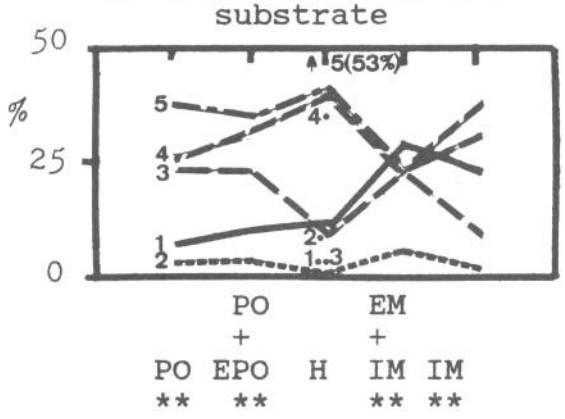
A. Location within the reservoir



B. Offshore activity



C. Composition of the substrate



D. Gradient of the substrate

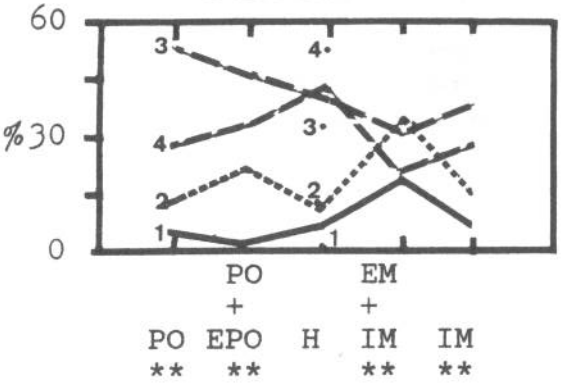


Figure 7. Recovery-moribundity profile of tagged Guadalupe bass showing frequency of changes (percent) during five health periods in use of soft substrates. A small circle identifies the comparable data point for wild Guadalupe bass. Health periods (X-axis) are:
PO = Immediate Post-Operative Recovery Period (0-4 d after surgery);
EPO = Extended Post-Operative Recovery Period (5-14 d after surgery);
H = "Healthy" Period (period between the EPO and EM Periods);
EM = Extended Mortality Period (14-5 d before death);
IM = Immediate Mortality Period (4-0 d before death).
A (**) indicate significance at the 0.01 level.

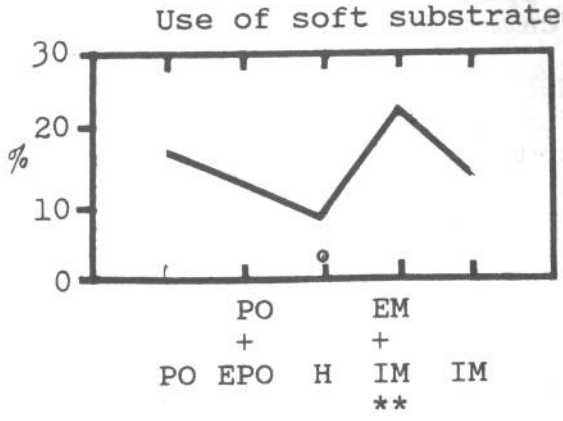
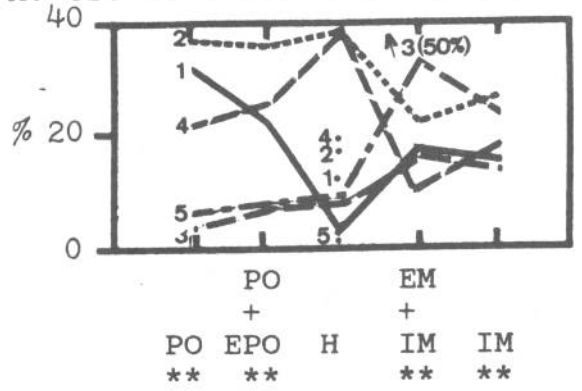

Use of soft substrates
30
20
10
0
%
PO
+
PO
EPO
H
EM
+
IM
**
IM

Figure 8. Recovery-moribundity profiles of tagged Guadalupe bass showing changing usage (percent) during five health periods of (A) structural habitats (1 = points, 2 = shoreline, 3 = underwater structure, 4 = floats, and 5 = offshore), (B) man-made objects, and specific cover types (C - 1 = open water, 2 = underwater dropoffs, 3 = man-made, 4 = caves/holes, and 5 = rocks and D - 6 = smooth bottom, 7 = brush, 8 = timber/stumps, 9 = underwater ledge, and 10 = floats). Statistical significance for specific cover was determined by simultaneous comparison of all 10 cover types shown in profiles C and D. Numbers and dots in the middle of each profile are data points for wild Guadalupe bass. Figures C and D include only data points that differ by >5% from those of H Period Guadalupe bass. Health periods (X-axis) are:

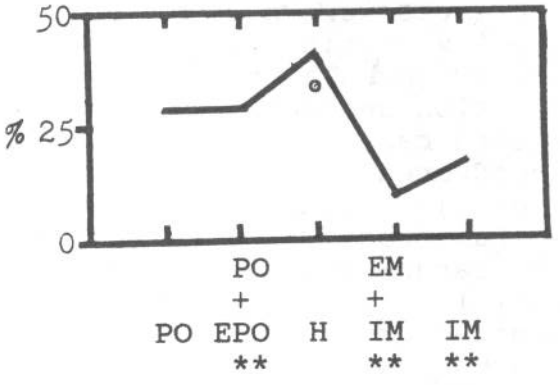
PO = Immediate Post-Operative Recovery Period (0-4 d after surgery);
EPO = Extended Post-Operative Recovery Period (5-14 d after surgery);
H = "Healthy" Period (period between the EPO and EM Periods);
EM = Extended Mortality Period (14-5 d before death);
IM = Immediate Mortality Period (4-0 d before death).

A (**) indicate significance at the 0.01 level.

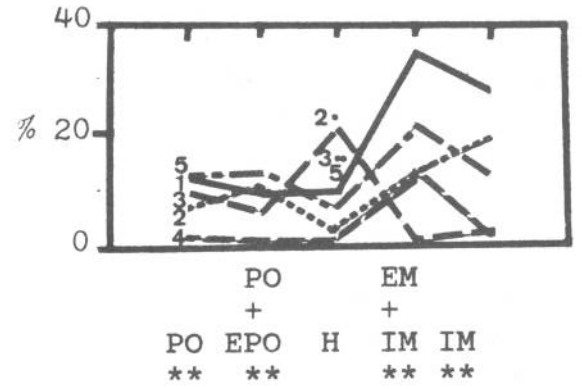
A. Use of structural habitats

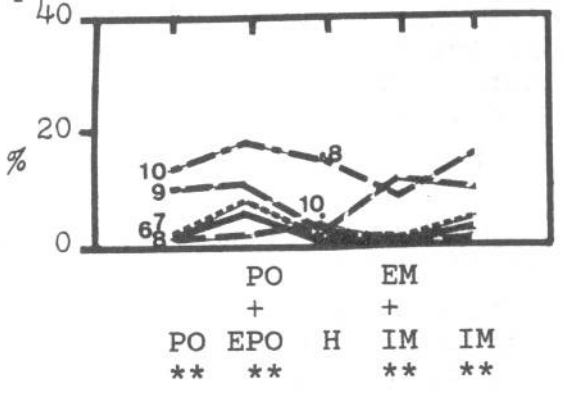


B. Use of man-made objects



C. and D. Use of specific cover types





PRODUCTION AND SPORTFISH CHARACTERISTICS OF SMALLMOUTH BASS X FLORIDA LARGEMOUTH BASS HYBRIDS

by

John A. Prentice
Texas Parks and Wildlife Department
Junction Star Route, Box 62
Ingram, Texas 78025

Abstract

Attempts were made to produce smallmouth bass Micropterus dolomieui x Florida largemouth bass M. salmoides floridanus hybrids (F_1 and F_2) and to compare their survival, growth, reproduction and catchability to that of parentals and northern largemouth bass M. s. salmoides. F_1 hybrid production efforts were conducted in hatchery ponds (natural) and in the laboratory (stripping); F_2 production was conducted only in ponds. The only successful cross produced was male smallmouth bass x female Florida largemouth bass. No increase in survival, growth or catchability could be attributed to hybrid performances over that of parental or northern largemouth bass. Reproductive abilities of F_2 and F_1 hybrids also were poor, especially the F_2 hybrid. Although F_2 hybrids were produced more easily in ponds, F_1 hybrid bass production was difficult and time consuming. Because of lack of fishery management benefits when compared to parental or northern largemouth bass and culture difficulties, male smallmouth bass x female Florida largemouth bass hybrids would not be desirable for stocking under most fishery management strategies.

Introduction

Fishing pressure on black basses Micropterus spp. has increased dramatically during recent years. Black basses are extremely popular game fishes throughout the United States (Beaty and Childers 1980) and the most popular in Texas (Whitworth 1984, 1987). Since fishing pressure on black bass resources is predicted to continue increasing (Branton et al. 1975; United States Fish and Wildlife Service 1980; Whitworth 1984, 1987), information is needed to increase or maintain quality fishing through planned fishery management programs.

Hybridization experiments have shown various black bass hybrids can be produced (Childers 1975). The hybrid between male smallmouth bass M. dolomieui and female northern largemouth bass M. salmoides salmoides has exhibited valuable traits such as fast growth rate, aggressive behavior, strong fighting ability when caught on hook and line, and reproductive maturity at a young age (Childers 1975; Beaty and Childers 1980). More recent study

found that growth rates of largemouth bass were greater than those of F_1 hybrids (male smallmouth bass x female northern largemouth bass), but no comparison was made between F_1 hybrids and smallmouth bass (Buck and Hooe 1986).

This study was conducted to determine the fishery management values of smallmouth bass and Florida largemouth bass M. s. floridanus hybrids (F_1 and F_2). Production, survival, growth, reproduction and catchability of hybrids were compared to those of parentals and northern largemouth bass.

Methods

This study was conducted from 1977-1983. Production of F_1 hybrids needed for F_2 hybrid production was conducted in 1977. In spring 1978, F_2 hybrid, parental and northern largemouth basses were produced and stocked as fingerlings into ponds and subsequently evaluated during 1979 through 1982. In spring 1980, F_1 hybrids were produced and stocked as fingerlings into ponds and subsequently evaluated 1981-1983.

Black basses used in this study were obtained from electrophoretically verified pure broodstock at the A. E. Wood State Fish Hatchery, San Marcos, Texas. Attempts were made to produce male smallmouth bass x female Florida largemouth bass F_1 hybrids by two methods. The first (1977-1979) involved natural hybridization by stocking one pair of fish in each of two 0.05-ha ponds. The second (1979-1981) involved manual stripping of sex products from ripe individuals, incubating eggs and rearing young in the laboratory following procedures of Beaty and Childers (1980). Identical procedures were followed to produce the reciprocal hybrid except laboratory methods were attempted only in 1981 because of lack of broodfish. F_2 hybrids were produced (1978-1983) by holding F_1 hybrid broodfish in a hatchery pond and allowing natural reproduction.

Experiments comparing hybrid crosses to other black basses were conducted at Heart of the Hills Research Station, Ingram, Texas. Ponds used for stocking were adjacent to each other, of similar morphometry (approximately 0.2 ha; 2-m maximum depth), and had a common spring water supply. Pond bottoms were plowed and repacked, and ponds were filled with water each year at least 1 month before black basses were stocked. Water was screened before entering each pond. Equal amounts and types of forage (goldfish Carassius auratus, inland silversides Menidia beryllina, and fathead minnows, Pimephales promelas) were stocked in each pond each year. All ponds contained equal numbers of similarly placed gravel beds to provide spawning substrate.

Each year upon filling, ponds were fertilized at equal rates (56 kg/ha; 16-20-0 granular fertilizer) to promote plankton blooms in an effort to control macrophyte growth. Additional fertilizer was applied as needed to maintain blooms. All ponds were treated with granular 2,4-D herbicide and/or copper sulfate as needed to further control macrophyte growth. Approximately 2-

4 weeks before catchability experiments and pond draining each year most remaining macrophytes were mechanically removed from all ponds.

Black basses were stocked each year in as close to equal numbers as possible, one species or hybrid per pond (Table 1). Black bass species and hybrids were randomly assigned to each pond the first year and rotated to a different pond each year thereafter to reduce potential for pond-effect bias. At pond draining each year, original stocks were separated from offspring, and original fishes were used to restock ponds for the next year of study. Black basses were stocked at higher than recommended rates (Anonymous 1980) to help ensure adequate numbers for restocking in subsequent years and to keep experimental fish in a crowded condition. According to Childers and Bennett (1961) and Childers (1975), crowding increases differences between performance of hybrids and their parental species. Due to difficulties in producing F_1 hybrids, insufficient numbers were available to stock until 1980, which allowed only 3 years of study for this cross. Only 3 years of study were available for smallmouth bass because insufficient numbers were available for restocking in year IV due to an apparent overnight drop in dissolved oxygen level at the end of year III that killed all but one fish.

Individual total lengths and weights were measured for a maximum of 30 black bass adults per pond (all other adults were only counted) at pond draining each year. Offspring were counted each year. Adults were held in 1,700- or 24,250-L indoor holding tanks for approximately 1.5 months while ponds were prepared for restocking. Adult hybrids (surplus from restocking each year and all individuals at study termination) were dissected to determine sex ratios.

Survival was determined by comparing numbers of each species or hybrid at pond draining to the number that had been stocked at the beginning of that year. Survival data were converted to proportions, transformed (arcsine of square root), and tested for differences among years (age) and species using two-way analysis of variance (ANOVA; Dixon et al. 1981).

Growth data (length and weight) were obtained by actual measurements of the known age black basses each year and transformed ($\log_{10}$) for analyses. Growth data were analyzed by two-way ANOVA (Dixon et al. 1981) to test for differences among years (age) and species. Bonferroni multiple pairwise comparisons (Wasserman 1974) were made to test for differences in growth increments among hybrids (F_1 and F_2) and parentals. Length-weight relationships were calculated by least-squares regression (Dixon et al. 1981).

The measure of reproduction used in this study was the number of offspring divided by the number of adults found in each pond at draining each year and, therefore, was an indirect measure. Variability of survival factors caused by differences in study ponds (such as predation on and food for young black basses) were assumed to be minimal, and reproductive ability was

considered the major variable affecting numbers of young at pond draining. Reproduction data were transformed (arcsine of square root) and tested by two-way ANOVA to test for differences among years (age of adults) and species or hybrids. Duncan's multiple-range test (Steel and Torrie 1960) was used to analyze differences in reproduction between species and hybrids.

Catchability experiments were conducted in late June or early July of each study year. Each pond was fished a total of 2 hours (1 hour in morning and 1 hour in afternoon) in 0.5 hour increments over 2 days. All ponds were fished simultaneously by one fisherman per pond during increments. During the first fishing period each year, fishermen were randomly assigned to ponds, and each fisherman rotated to a new pond in each succeeding increment such that over the 2 days of fishing each fisherman fished each pond in morning and afternoon hours equally. All fishermen used identical baits. During the first 3 years, only artificial baits (spinners) were used to reduce mortality related to fishes swallowing baits. Artificial and natural (live goldfish) baits were used during the last year. Fish caught were immediately returned to the pond from which they were caught. Catch was recorded as number of fish caught in each angling period. Each pond was drained the following week and all fishes were collected and counted to determine numbers present.

Catches were converted to proportions (number caught/2 hours/number present) and transformed (arcsine of square root), then tested for differences among years (age) and species or hybrids by two-way ANOVA. Differences in catch by bait type were tested with one-way ANOVA (Dixon et al. 1981).

Level of significance was set at $P = 0.05$ for all ANOVA tests.

Results and Discussion

Hybrid Production

Natural production of F_1 hybrids between smallmouth bass and Florida largemouth bass in hatchery ponds was very low. In 1977, nesting activity was observed in each pond containing male smallmouth bass and female Florida largemouth bass, and at draining, 72 F_1 fingerlings were obtained from one of these two ponds. No nesting activity was noted and no young were obtained from two ponds containing the reciprocal cross. Repeated attempts in 1978 and 1979 produced no young from any ponds even though some nesting activity again was observed in ponds containing male smallmouth bass and female Florida largemouth bass. Similar attempts at hybridization between northern largemouth bass and smallmouth bass in Illinois ponds were unsuccessful (Beaty and Childers 1980), and hybridization between these species in nature is very rare (Childers 1975). The Florida subspecies of largemouth bass may be more closely related genetically to smallmouth bass (D. P. Philipp, Illinois Natural History Survey, Urbana, personal communication).

Laboratory production of F_1 hybrids was somewhat more successful than natural hybridization in ponds. Sexually ripe males of both species were easily obtained from limited numbers of hatchery broodstock each year; however, naturally flowing ripe ova were not obtained. This necessitated monitoring egg maturity by catheterization and administration of human chorionic gonadotropin (HCG) to promote ovulation. During 1979, females did not respond well to HCG injections, possibly because expertise in judging egg maturity was limited. Approximately 750 eggs were obtained in 1980 from four of eight Florida largemouth bass 30 hours after HCG injection. After fertilization with milt from two smallmouth bass, they produced 288 F_1 fingerlings. During 1981, eight of 18 Florida largemouth bass yielded approximately 5,600 eggs that resulted in approximately 3,000 F_1 fingerlings after fertilization with smallmouth bass milt. Laboratory production of male Florida largemouth bass x female smallmouth bass F_1 hybrids was unsuccessful. No development was observed in approximately 200 smallmouth bass eggs fertilized with Florida largemouth bass milt. Normal development and hatching was observed when samples of the same smallmouth bass eggs and Florida largemouth bass milt were mixed with appropriate sex products of their own species. Similarly, Beaty and Childers (1980) found male northern largemouth bass x female smallmouth bass F_1 hybrids very difficult to produce and frequency of deformities in the few produced very high. They concluded this F_1 hybrid cross was almost totally lethal.

F_2 hybrids were produced in a pond after F_1 brood fish were stocked each year. Approximately 300 F_2 fingerlings were collected each spring to confirm F_2 production, but total production was not determined.

Survival

Differences in survival (Table 2) as fish aged or among species or hybrids were not found to be significant (Table 3). Survival was similar to findings of Beaty and Childers (1980), who found no difference in survival of F_1 hybrids and northern largemouth bass. Unlike this study, they observed low survival of smallmouth bass. Buck and Hooe (1986) found no difference in survival of F_1 hybrids and northern largemouth bass.

Growth

Analyses of growth data (Table 4) indicated that the reduction in length increments as fishes aged as well as differences among species and hybrids were significant (Table 3). Growth over all years of F_1 and F_2 hybrids was not statistically different from that of Florida largemouth bass and significantly less than that of smallmouth bass or northern largemouth bass (Table 5). Hybrid black bass have been noted for improved growth rate over parental species (Childers 1975; Inman et al. 1977; Wright and Wigtil 1980). Beaty and Childers (1980) reported hybrid black bass growth was intermediate to parentals at low population densities (48 fish/ha) but superior at high densities

(168 fish/ha). Population densities in this study were almost always higher than 168 fish/ha (Table 1), but improved hybrid growth was not observed. Buck and Hooe (1986) also found growth of F_1 hybrid bass was less than parental largemouth bass. Length-weight relationships (Figure 1) indicate greatest weight gain for increase in length occurred in F_2 hybrids followed by smallmouth bass and F_1 hybrids. A heavy-bodied appearance for F_2 hybrids was noted during this study.

Reproduction

Florida largemouth bass and northern largemouth bass produced numerous offspring throughout the study (Table 6). Offspring production from F_1 and F_2 hybrids was much less and smallmouth bass produced none. There were no differences as broodfish aged, but significant differences did occur between species and hybrids (Table 3). There were no significant differences in offspring production between F_1 and F_2 hybrids or between hybrids and smallmouth bass. Offspring production of hybrids was lower than that of F_1 male smallmouth bass x female northern largemouth bass hybrids reported by Beaty and Childers (1980). They noted similar reproduction from hybrids and parentals in their study ponds. Low offspring production reduces the value of F_1 and F_2 male smallmouth bass x female Florida largemouth bass hybrids as predators because continued restocking would be necessary.

Lack of offspring production in smallmouth bass ponds may have been because of improper spawning habitat. Preferred smallmouth bass spawning substrate is rock or gravel free of silt, which may smother eggs and fry (Hutson 1983). Silting was observed in gravel beds in all ponds during this study since considerable time elapsed between gravel bed placement and spawning. Low offspring production in F_1 and F_2 hybrid bass ponds also may have been related to silting and may indicate substrate preference of hybrids is similar to that of smallmouth bass.

Sexual predominance of bass hybrids was different than that reported for sunfish hybrids. A sample of 66 F_1 hybrids was 53.0% males, and a sample of 41 F_2 hybrids was 9.8% males. However, sex ratios in sunfish hybrids have often been noted to be dominated by males (Ricker 1948; Childers 1967; Laarman 1973; Lewis and Heidinger 1973; Henderson and Whiteside 1975; Crandall and Durocher 1980).

Catchability

Catch rates (Table 7) decreased significantly as fishes aged, but no significant differences were observed among species (Table 3). Catch differences between artificial and natural baits were not significant (Table 3).

Childers (1975) noted aggressive behavior in F_1 male smallmouth bass x female northern largemouth bass hybrids which implies this hybrid would be vulnerable to angling. However, Beaty and Childers (1980) concluded there was no significant difference in catchabilities of F_1 male smallmouth bass x female

northern largemouth bass and parental species. Results of hybrid (F_1 and F_2) catchability in this study agree with their findings. Childers (1965) and Childers and Bennett (1967) studied catchability of hybrid sunfishes and concluded hybrids generally were more aggressive, less wary, and less able to learn to avoid being caught than their parental species.

Conclusions

Hybridization of (F_1 and F_2) male smallmouth bass x female Florida largemouth bass provided no increase in survival, growth or catchability over that of parental or northern largemouth bass. Reproductive abilities of F_1 and F_2 hybrids also were poor, especially the F_2 hybrid. Although F_2 hybrids could be produced in ponds, F_1 hybrid production was difficult and time consuming. Therefore, these hybrids would not be desirable for stocking under most fishery management strategies. However, the F_2 hybrid might be considered when a predator with reduced reproduction is desired.

Acknowledgments

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Table 1. F_1 and F_2 male smallmouth bass x female Florida largemouth bass hybrid, smallmouth bass (SMB), Florida largemouth bass (FLA) and northern largemouth bass (LMB) stocked in separate ponds, Heart of the Hills Research Station, Ingram, Texas, 1979-1983. ND = no data.

Year of study	F_1 hybrid		F_2 hybrid		SMB		FLA		LMB	
	N	Number/hectare	N	Number/hectare	N	Number/hectare	N	Number/hectare	N	Number/hectare
1	168	780	200	870	200	1,176	200	1,111	200	870
2	80	348	120	706	114	633	120	522	120	522
3	14	140	40	222	40	174	40	174	40	235
4	ND	ND	30	130	ND	ND	30	176	30	166

Table 2. Number recovered at pond draining and percent survival (%) of F_1 and F_2 male smallmouth bass x female Florida largemouth bass hybrid, smallmouth bass (SMB), Florida largemouth bass (FLA) and northern largemouth bass (LMB), by age group, determined at annual pond draining, Heart of the Hills Research Station, Ingram, Texas, 1979-1983. ND = no data.

	F_1 hybrid		F_2 hybrid		SMB		FLA		LMB	
Age	Number recovered	Percent survival	Number recovered	Percent survival	Number recovered	Percent survival	Number recovered	Percent survival	Number recovered	Percent survival
I	89	53.0	172	86.0	59	29.5	199	99.5	170	85.0
II	56	70.0	64	53.3	103	89.6	113	94.2	111	92.5
III	11	78.6	33	82.5	28	70.0	38	95.0	37	92.5
IV	ND	ND	27	90.0	ND	ND	28	93.3	26	86.7

Table 3. Summary of analysis of variance of survival, growth, reproduction, catchability and catch on artificial compared to natural baits of F_1 and F_2 male smallmouth bass x female Florida largemouth bass hybrid, smallmouth bass (SMB), Florida largemouth bass (FLA) and northern largemouth bass (LMB) evaluated in hatchery ponds, Heart of the Hills Research Station, Ingram, Texas, 1979-1983.

Parameter	Source of variation	df	F-ratio	P(>F)
Survival	Age	2	0.46	0.64
	Species	4	2.76	0.10
	Error	8		
Growth	Age	2	414.09	0.01
	Species	4	49.36	0.01
	Error	447		
Reproduction	Age	2	0.93	0.45
	Species	4	10.34	0.00
	Error	8		
Catchability	Age	2	6.27	0.02
	Species	4	3.11	0.08
	Error	8		
Catch	Bait type	1	3.30	0.13
	Error	5		

Table 4. Mean length ± SE (mm), weight ± SE (g) and increments of F_1 and F_2 male smallmouth bass x female Florida largemouth bass hybrid, smallmouth bass (SMB), Florida largemouth bass (FLA), and northern largemouth bass (LMB) evaluated in hatchery ponds, Heart of the Hills Research Station, Ingram, Texas, 1979-1983. ND = no data.

	F_1 hybrid		F_2 hybrid		SMB		FLA		LMB	
	Length	Weight	Length	Weight	Length	Weight	Length	Weight	Length	Weight
Age I	222±5.6	140±19.4	213±2.3	122±3.8	261±4.1	237±11.1	197±3.1	87±2.9	228±1.6	144±3.7
Increment	222	140	213	122	261	237	197	87	228	144
Age II	252±3.8	182±11.4	231±5.3	160±7.8	283±3.5	236±9.8	240±2.1	257±4.5	256±1.8	198±5.1
Increment	30	42	18	38	22	-1	43	170	28	54
Age III	314±4.5	438±29.5	290±4.6	322±17.7	313±3.3	370±14.8	307±3.9	372±15.5	305±3.2	344±13.3
Increment	62	256	59	162	30	134	67	115	49	146
Age IV	ND	ND	336±5.6	518±27.4	ND	ND	316±6.2	386±15.7	342±3.9	515±19.3
Increment	ND	ND	46	196	ND	ND	9	14	37	171

Table 5. Bonferroni $\pm_{(0.005;447)}$ values and growth (length) comparisons (in parentheses) of F_1 and F_2 male smallmouth bass x female Florida largemouth bass hybrids to smallmouth bass (SMB), Florida largemouth bass (FLA) and northern largemouth bass (LMB), Heart of the Hills Research Station, Ingram, Texas, 1979-1983.

Hybrid	SMB	FLA	LMB
F_1	13.47	1.67	3.23
	(SMB > F_1 hybrid)	(FLA = F_1 hybrid)	(LMB > F_1 hybrid)
F_2	16.88	1.58	5.60
	(SMB > F_2 hybrid)	(FLA = F_2 hybrid)	(LMB > F_2 hybrid)

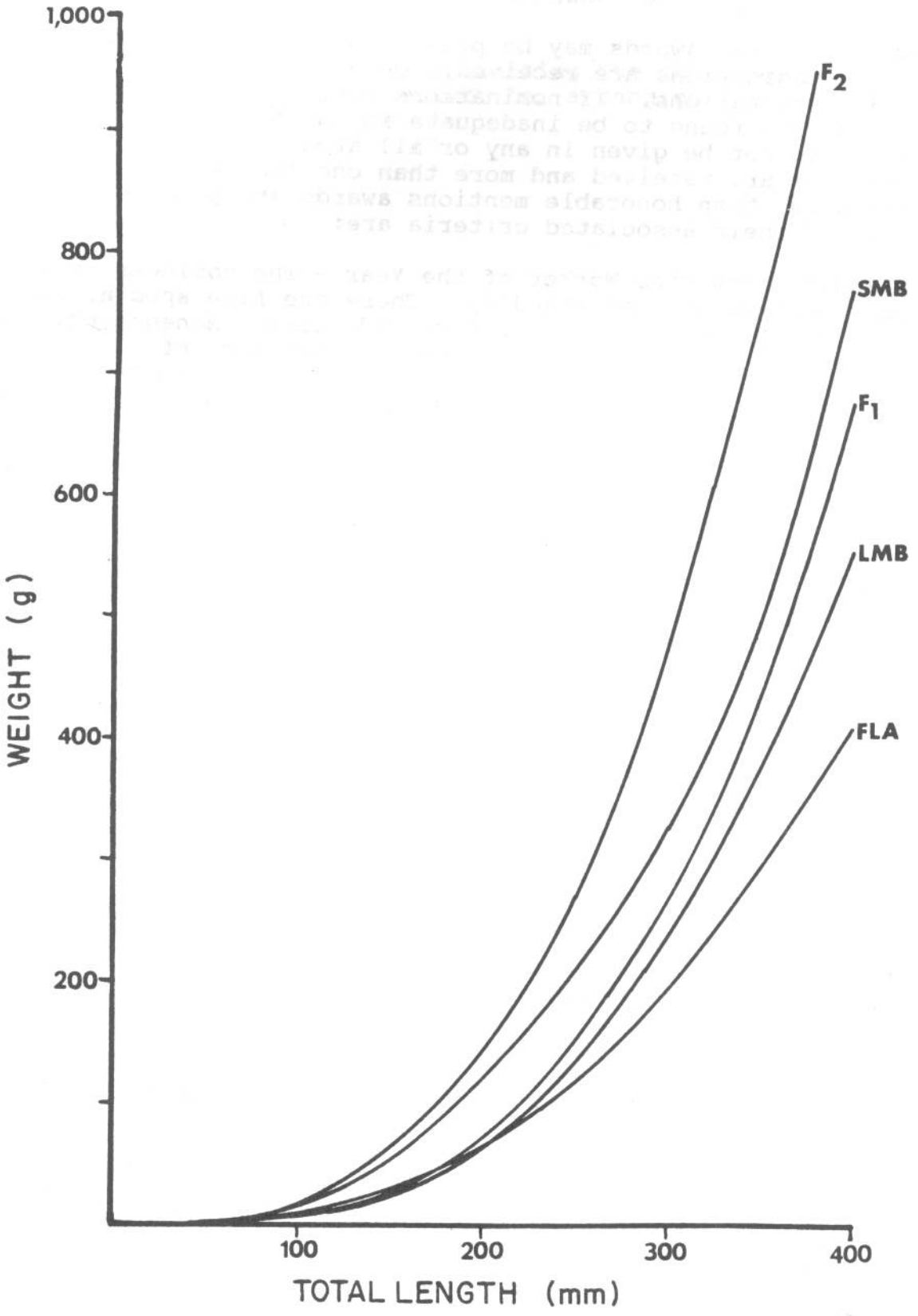
Table 6. Number of offspring produced per adult found at each pond draining each year for F_1 and F_2 male smallmouth bass x female Florida largemouth bass hybrids, smallmouth bass (SMB), Florida largemouth bass (FLA) and northern largemouth bass (LMB) held in separate hatchery ponds, Heart of the Hills Research Station, Ingram, Texas, 1979-1983. ND = no data.

Age of brooders	Number of offspring				
	F_1 hybrid	F_2 hybrid	SMB	FLA	LMB
I	5.22	0.12	0	4.04	10.85
II	2.80	0	0	8.41	1.30
III	0.09	0	0	32.63	74.76
IV	ND	0.07	ND	74.89	58.73

Table 7. Angling data summary for F_1 and F_2 male smallmouth bass x female Florida largemouth bass hybrids, smallmouth bass (SMB), Florida largemouth (FLA) and northern largemouth bass (LMB), Heart of the Hills Research Station, Ingram, Texas, 1979-1983. Angling utilized artificial (A) and natural (N) baits and equivalent effort for each species. N at oldest age only. ND = no data.

		F_1 hybrid			F_2 hybrid			SMB			FLA			LMB		
Age of fish	Bait type	Number caught	Number present	Percent caught	Number caught	Number present	Percent caught	Number caught	Number present	Percent caught	Number caught	Number present	Percent caught	Number caught	Number present	Percent caught
I	A	29	89	32.58	53	172	30.81	23	59	38.98	43	199	21.61	61	170	40.59
II	A	12	56	21.43	15	64	23.44	12	103	11.65	12	113	10.62	30	111	27.03
III	A	1	11	9.09	5	33	15.15	0	1	0.00	0	38	0.00	16	37	43.24
IV	A	ND	ND	ND	1	27	3.70	ND	ND	ND	6	28	21.43	6	26	23.08
	N	4	11	36.36	4	27	14.81	ND	ND	ND	22	28	78.57	24	26	92.31

Figure 1. Length (L) - weight (W) relationships of F_1 and F_2 male smallmouth bass x female Florida largemouth bass hybrids, smallmouth bass (SMB), Florida largemouth bass (FLA) and northern largemouth bass (LMB), Heart of the Hills Research Station, Ingram, Texas, 1979-1983. Curves are defined by the following equations: F_1 hybrid, Log W = -5.5258 + (3.2478) Log L; F_2 hybrid, Log W = -4.511 + (2.8557) Log L; SMB, Log W = -3.9142 + (2.5840) Log L; FLA, Log W = -4.4476 + (2.7994) Log L; LMB, Log W = -5.2752 + (3.1458) Log L.


1,000
800
600
400
200
WEIGHT (g)
100
200
300
400
TOTAL LENGTH (mm)
F2
SMB
F1
LMB
FLA

TEXAS CHAPTER CRITERIA AWARDS

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

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

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

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

a. The presentation must be made by one of the authors;
b. At least one of the authors must be a Chapter member in good standing;
c. The presentation must not be on data presented elsewhere; and
d. Members of the current Awards Committee shall be ineligible.

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

a. Scientific and research value - 20 points;
b. Management value - 15 points;
c. Scope - 10 points;
d. Verbal presentation - 20 points;
e. Audio-visual presentation - 15 points;
f. Conciseness and clarity - 10 points;
g. Intelligent discussion stimulated - 5 points; and
h. Other considerations - 5 points.

Judges will evaluate each presentation immediately after it is given. They will not confer until after the last presentation. The decision will be made based either on cumulative point totals or relative rankings.

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