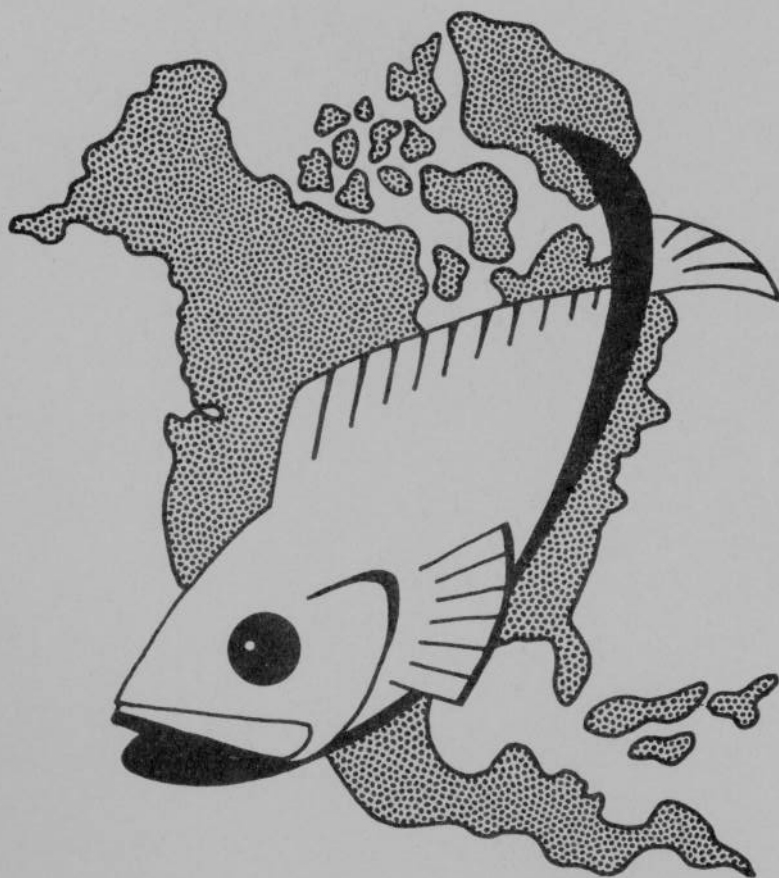


ANNUAL PROCEEDINGS
of the
TEXAS CHAPTER
AMERICAN FISHERIES SOCIETY



SEPTEMBER 26, 1981
AUSTIN, TEXAS

VOLUME 4

KURZAWSKI

ANNUAL PROCEEDINGS OF THE TEXAS CHAPTER OF THE
AMERICAN FISHERIES SOCIETY

September 26, 1981

Austin, Texas

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1982

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PROGRAM
Annual Meeting of
TEXAS CHAPTER
AMERICAN FISHERIES SOCIETY

A.M.

- 7:45-8:30 Registration, Texas Parks and Wildlife Department Building
8:30-8:40 Welcome, Charles Travis, Executive Director, TPWD
8:40-9:30 Business Meeting

SESSION I, 9:30-11:30
Mike Zeman, Moderator

- 9:30-9:45 Bryan Murphy
Aquatic Research at Texas Tech University
9:45-10:00 Charles Mulford
The Surgical Skin Stapler as a Means to Close Incisions in Fish
10:00-10:15 Barry Lyons
Survival Rates of Three Sunfish X Largemouth Bass Hybrids
10:15-10:30 Break
10:30-10:45 Gary Carmichael, B. A. Simco, J. R. Tomasso
Effects of Formalin on Survival and Plasma Corticosteroid
Levels in Channel Catfish
10:45-11:00 Maury Osborn
An Overview of the Coastal Fisheries Branch of the Texas Parks
and Wildlife Department
11:00-11:15 Albin Sonski
Heat Tolerance of Brook Trout
11:15-11:30 Henry Day
Food Habits Study of the Largemouth Bass, Guadalupe Bass, and
White Bass X Striped Bass Hybrid in a Central Texas Reservoir
Receiving Heated Effluent
11:30-12:45 Lunch

SESSION II, 12:45-2:15
Joe Tomasso, Moderator

P.M.

- 12:45-1:00 Phillip Bettoli
Analysis of Cove Rotenone Data Collected in Lake Conroe, Texas
- 1:00-1:15 Ed Schwille
Beneficial Fish and Wildlife Features in Floodwater Retarding Structures
- 1:15-1:30 Dennis Parmley
A Comparison of Three Pond Management Programs Utilized to Produce Striped Bass During the 1981 Rearing Season at the Possum Kingdom State Fish Hatchery
- 1:30-1:45 William Harvey, R. L. Noble, W. H. Neill
A Biopsy Technique for Genetic Evaluation of Largemouth Bass
- 1:45-2:00 John Wakeman, D. E. Wohlschlag
Swimming Capabilities and Size-Performance Relationships of Spotted Seatrout
- 2:00-2:15 Holt Williamson
Comparing Training Success Between Two Strains of Largemouth Bass
- 2:15-2:30 Break

SESSION III, 2:30-4:15
Jerry Turrentine, Moderator

- 2:30-2:45 Bobby Farquhar
Evaluation of Striped Bass X White Bass Hybrids in Small Impoundments
- 2:45-3:00 Joe Tomasso, B. A. Simco, K. B. Davis
Circulating Corticosteroid and Leucocyte Dynamics in Channel Catfish During Net Confinement
- 3:00-3:15 Lee Green
Sharks in Texas Bays
- 3:15-3:30 Blair Brenner, R. L. Noble
Seining and Electrofishing as Indices of Largemouth Bass Abundance
- 3:30-3:45 Gene Gilliland, C. W. Kleinholz, M. D. Clady
Further Evaluations of the Efficiency of Removing Food Items from Live Fish with Glass Tubes

- 3:45-4:00 John Prentice, P. P. Durocher
Average Growth Rates for Striped, White and Striped X
White Hybrid Bass in Texas
- 4:00-4:15 Nadine Hall, J. K. Andreasen
Toxaphene Resistance in Mosquitofish from the Rio Grande
Valley of Texas
- 4:15- New Business/Open Discussion

LIST OF ATTENDEES

15 organizations; 85 people

- | | |
|---|---|
| <p>(1) <u>Fort Hood Fish & Wildlife Section</u>
Valerie Drysdale</p> | <p>(7) con't
Bill Harvey
Jeff Isely
Ken Johnson
Steven Kelsch
Joe Morris
William Neill
Rich Noble
Alan Rudd
Don Steinbach
Kirk Strawn</p> |
| <p>(2) <u>Hydrolab</u>
Jim Flynn</p> | |
| <p>(3) <u>Louisiana Tech</u>
John Wakeman</p> | |
| <p>(4) <u>Oklahoma State University</u>
Gene Gilliland</p> | <p>(8) <u>Texas Agricultural Ext. Service</u>
Billy Higginbotham</p> |
| <p>(5) <u>Soil Conservation Service</u>
Ed Schwille
Jerry Turrentine
Gary Valentine
Michael Zeman</p> | <p>(9) <u>Texas Dept. of Water Resources</u>
Henry P. Day
Robert Phillips
Gary Powell</p> |
| <p>(6) <u>Southwest Texas State University</u>
Mike Bira
Gary Carmichael
Russell Kiefer
Ralph Manns
Donald Mitchell
Victor Palma
Tony Spinelli
Joe Tomasso
Sharon Wallace
Bobby Whiteside</p> | <p>(10) <u>Texas Parks & Wildlife Department</u>
Bob Bounds
C. E. Bryan
David Campbell
Nick Carter
Philip Durocher
Ted Englehardt
Bobby Farquhar
Allen Forshage
Albert Green
Lee Green
Clell Guest
Pat Hutson
C. R. Inman
Pat Johansen
Kathryn Kulzer
Dick Luebke
Gary Matlock
Roger McCabe
Gene McCarty
John Means
Steve Miranda
John Mitchell
Tom Moore
Charles Mulford</p> |
| <p>(7) <u>Texas A&M University</u>
Robert K. Betsill
Phillip W. Bettoli
Blair Brenner
Colleen Caldwell
Kris Chenicer</p> | |

(10) con't

Richard O'Keefe
Maury Osborn
Dennis Parmley
Floyd Potter
John Prentice
William Rutledge
Ken Sellers

Charles Shaw
Albin Sonski
Catherine Wakefield
Joe Warren
Alan Wenger
Billy White

(11) Texas Tech

Brian Murphy
Alan Temple

(12) University of Texas

Gary P. Garrett
Donald Wohlschlag

(13) University of Texas at Arlington

Don Whitmore

(14) U.S. Fish & Wildlife Service

Jim Andreason
Thomas Brandt
Denwood Butler
Nadine Hall (also TAMU)
Holt Williamson

(15) Wildlife Mgt. Inst.

Murray Walton

CONTRIBUTORS

HYDROLAB - JIM FLINN
P. O. Box 9406
Austin, TX 78766

Tel: (512) 255-8841
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Water quality instrumentation

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LIST OF REVIEWERS OF PUBLISHED PAPERS

A hearty thank you is extended to the following reviewers who contributed their time and efforts to improving the quality of the papers published in the 1981 proceedings:

Dr. Clark Hubbs

Dr. Joan Holt

Dr. Andy Landry

Mr. Bob Colura

Mr. Dick Luebke

Dr. Rus Miget

Dr. Kirk Strawn

Mr. Holt Williamson

Mr. E. Smith

Mr. Al Green

Mr. Ed Hegen

Dr. Fred Rainwater

Dr. T. Hellier

Dr. Brian Murphy

AQUATIC RESEARCH AT TEXAS TECH UNIVERSITY

by

Brian R. Murphy

Department of Range and Wildlife Management
Texas Tech University

ABSTRACT

The relative scarcity of aquatic resources in West Texas makes the efficient use and management of these resources imperative. Aquatic research underway within the Range and Wildlife Management Department at Texas Tech University is aimed at improving the efficiency of the management of these resources.

The control of phreatophytes (water-wasting plants) is critical to water conservation in West Texas. Researchers at Texas Tech University are investigating the impacts of herbicides on the ecology of West Texas streams infested with saltcedar (Tamarix sp).

Reservoir walleye (Stizostedion v. vitreum) populations in the Panhandle provide one of the major sport fisheries in West Texas, and are also the major source of walleye fry for stocking in reservoirs across the state. Electrophoretic investigations of the population genetics of this species, soon to be underway at Texas Tech University, will lead to a better understanding of the population dynamics and management requirements of this important sportfish. In particular, these investigations should help to improve the effectiveness of the state's extensive walleye stocking program.

Playa lakes and the Yellowhouse Canyon Lakes project, the only surface waters within the city, receive heavy recreational fishing pressure from Lubbock residents. Although sportfish are provided for stocking by Texas

Parks and Wildlife, the Lubbock Parks and Recreation Department (LPRD) has no comprehensive management plan for the city lakes. Texas Tech has undertaken a survey of surface waters within the city with the aim of assisting LPRD in the development of a management plan for this much-needed urban fishery. As these lakes receive heavy street runoff during storms, future research plans include an investigation of the trace metal contamination of these urban waterways.

THE SURGICAL SKIN STAPLER AS A MEANS TO CLOSE INCISIONS IN FISH

by

Charles J. Mulford

Texas Parks and Wildlife Department
Ft. Worth Research Station
Ft. Worth, Texas 76114

ABSTRACT

Sham ultrasonic transmitters were implanted in four adult striped bass to evaluate surgical procedures and the feasibility of using disposable surgical staplers as a means of closing incisions. After surgery, these fish and one control were held in a 0.4-ha hatchery pond for approximately 1 month. The control and two implanted fish died within 10 days, most likely due to handling stress. However, when the pond was drained, two striped bass in good condition were retrieved. The incisions had healed with no signs of infection. It appears the skin stapler is a suitable means for quick closure of incisions in fish if handling stress is minimal.

3

4

SURVIVAL RATES OF THREE SUNFISH X LARGEMOUTH BASS HYBRIDS

by

Barry W. Lyons

Texas Parks and Wildlife Department
Ingram, Texas 78025

ABSTRACT

Male redbreast sunfish (Lepomis auritus), redear sunfish (L. microlophus) and coppernose bluegill (L. macrochirus purpureus) were crossed with largemouth bass (Micropterus salmoides). These sunfish were selected for their adult size. All crosses were artificially produced by hand-stripping the sex products into petri dishes. Survival to 60-mm fingerlings ranged from 0.00 to 3.13%. Many of the resulting hybrids were deformed. Based on low survival rates, none of the hybrids studied appear to be feasible for hatchery production.

EFFECTS OF FORMALIN ON SURVIVAL AND PLASMA CORTICOSTERIOD
LEVELS IN CHANNEL CATFISH

by

G. J. Carmichael, B. A. Simco
Memphis State University

J. R. Tomasso
Southwest Texas State University

ABSTRACT

The median lethal concentrations of formalin to channel catfish fingerlings ranged from 605 ppm after 2 h of exposure to 137 ppm after 72 h of exposure in aerated, dechlorinated tap water (40 mg/liter total hardness, 47 mg/liter alkalinity, 4 mg/liter chloride, pH 6.6-7.1, 21-22 C). All mortalities occurred within the first 24 h of exposure. Only one fish of 40 exposed to 100 ppm formalin died during the course of the experiment.

Plasma corticosteriod levels were measured in fish exposed to 25, 50, and 100 ppm formalin for 24 h, and in fish treated with 100 ppm for 3, 6, and 12 h. The relationship between treatment levels of formalin and elevated levels of corticosteriod will be discussed with respect to possible applications in disease control.

AN OVERVIEW OF THE COASTAL FISHERIES BRANCH OF THE
TEXAS PARKS AND WILDLIFE DEPARTMENT

by

Maury F. Osborn

Coastal Fisheries Branch
Texas Parks and Wildlife Department
4200 Smith School Road
Austin, Texas 78744

ABSTRACT

The purpose of the Coastal Fisheries Branch of the TPWD is to manage the coastal fishery resources in Texas bays and territorial seas out to 9 nautical miles, in order to provide for an optimum sustained harvest by sport and commercial fishermen. This resource has a direct and indirect economic impact of over 400 million dollars in Texas, and is used by over 800,000 commercial and recreational fishermen. In order to manage these resources, the Branch has set up four broad objectives:

1. To provide, through research, information necessary for the conservation of the principle marine species,
2. To enhance opportunities in the harvest of marine life,
3. To permit the taking of shell and fill material in a manner not detrimental to marine habitat and
4. To provide the consumer with high quality, wholesome seafood products.

The Coastal Fisheries Branch had a budget of \$1.6 million dollars in FY 81 and a staff of 76. The staff collects, analyzes, interprets and reports data from 9 major projects and other minor projects and short-term studies which are described in this paper. The results of these research projects are used to report to the Texas Parks and Wildlife Commission for their use

in the promulgation of regulations for management and are also used to report to the Governor and the Legislature for use in creation of legislation.

HEAT TOLERANCE OF BROOK TROUT

by

Albin J. Sonski
Texas Parks & Wildlife Department
Ingram, Texas 78025

ABSTRACT

Laboratory testing determined the ultimate upper lethal temperature (LT₅₀) for brook trout, Salvelinus fontinalis. In two replicate trials, trout (\bar{x} TL = 18.6 cm) acclimated at 18 C and 23 C were exposed to temperature increases of 0.5 C/day until death. Lethal temperatures were significantly different ($\alpha = 0.05$) between acclimation temperatures. Temperatures at death ranged from 23.3 C to 26.6 C. The LT₅₀ for fish acclimated at 18 C and 23 C was 25.3 and 25.1 C, respectively. There was a 90.4% mortality of 23 C control fish; no mortality occurred in the 18 C control.

INTRODUCTION

The Texas Parks and Wildlife Department has been stocking rainbow (Salmo gairdneri) and brown (S. trutta) trout since 1964 to provide substantial put-and-take fisheries in selected Texas waters (White 1968; personal communication, B. Bounds, Texas Parks and Wildlife Dept., Austin, Tx.). Brook trout (Salvelinus fontinalis) have not been stocked, even though they are reported easier to catch than rainbow and brown trout (Thorpe et al. 1947; Cooper 1953). Brook trout stocking could provide additional angler benefits. Magnitude of these benefits would undoubtedly be dependent upon the ability of this species to withstand maximum summer water temperatures in Texas.

McCormick et al. (1972) determined thermal tolerance limits for newly hatched and swim-up alevin brook trout. Fry et al. (1946) determined thermal limits of juvenile brook trout (2-25 g). No tests of heat tolerance in harvestable-size brook trout have been conducted. The objective of this experiment was to determine the heat tolerance of harvestable-size brook trout in order to evaluate their suitability for introduction in selected Texas waters.

MATERIALS AND METHODS

Brook trout were obtained from the Norfolk National Fish Hatchery, Mountain Home, Arkansas. They were maintained indoors at 14 C for 3 months prior to the temperature acclimation period. The trout averaged 17.4 cm total length (TL) and were acclimated at a rate of 1 C/day to constant temperatures of 18 C and 23 C. Circular 830-1 fiberglass tanks served as control and test tanks. Fish were held at acclimation temperatures for a minimum of 21 days before testing began. Temperature in control tanks was regulated by thermostatically controlled cooling or heating units accurate to ± 0.1 C. Air was bubbled into all tanks to insure mixing of heated or cooled water. Each control tank contained 41 fish at the beginning of acclimation. Fish in both control and test tanks were fed a pelleted feed (40.0% crude protein) at 5.0% body weight/day. Control tanks were treated alike with nitrofurazone (2 treatments, 100 ppm, interval of 48 h) during a disease outbreak, but no fish in test tanks received treatment.

Testing took place in two tanks. Each tank was divided into two equal sections to assure testing fish from both acclimation temperatures in the event of equipment failure in one of the tanks. Two trials were completed (total of 40 fish, 20/trial). For each trial a random sample of five fish was taken from the 18 C control tank and placed into one

section of each test tank. Temperatures were increased 0.5 C/day until water reached 23 C, then five fish from the 23 C control tank were placed into the vacant section of each tank. A timing device controlled a thermostat which regulated the rate of increase in test tanks. Water temperature was increased until all fish died. Temperature when each fish stopped feeding and temperature at death was recorded. Criteria used to determine death were lack of respiratory movement and response to touch (Otto and Rice 1977).

The procedure to determine ultimate upper lethal temperature was modified from Otto and Rice (1977) and Guest et al. (1979). The temperature at which 50% of the fish died was considered to be the ultimate upper lethal temperature (LT_{50}). The LT_{50} was calculated from the regression of percentage cumulative mortality (arcsin transformation) on lethal temperature. Analysis of covariance (Snedecor and Cochran 1978) was used to evaluate differences in slope between regression lines for each acclimation temperature.

RESULTS AND DISCUSSION

The analysis of covariance showed a significant difference ($OC = 0.05$) between regressions of cumulative mortality (arcsin) on lethal temperature for each acclimation temperature. The LT_{50} for the 18 C and 23 C acclimation temperatures was 25.3 C and 25.1 C, respectively. This is in close agreement with results from previous experiments. Fry et al. (1946) determined a lethal temperature of 25.3 C for juvenile brook trout weighing 2.0 - 25.9 g. The method used in this paper to determine the LT_{50} (Otto and Rice 1977) provided seemingly reliable data with limited number of specimens and time available. Temperature tolerances of brook and rainbow trout are similar, however, rainbow trout are considered to withstand warmer water

temperatures than brook trout. Upper incipient lethal temperatures for fingerling Great Lakes rainbow trout acclimated to 15 C fell between 25 C and 26 C (Bidgood and Berst 1969). Kaya (1978) investigated thermal tolerance of rainbow trout fingerlings and juveniles from a permanently heated stream and two hatchery strains. Upper incipient lethal temperatures ranged from 23.2 C to 26.2 C for fish acclimated to several temperatures (5 C - 24.5 C).

Fish held at 18 C fed more readily and were highly active compared to 23 C fish. Fish from both acclimation temperatures stopped feeding between 23.3 C and 24.3 C.

Mortality in 23 C controls was 90.4% (19 of 21 fish) while no mortality was recorded in 18 C controls. During acclimation there was no mortality in either control. Heavy mortality in 23 C control fish may invalidate lethal temperature data for this acclimation temperature. Fish in the 23 C acclimation tank were probably in a stressful condition before testing; whether lethal temperatures determined were a product of the testing procedure alone, or strongly influenced by pre-test stress remains unknown. Mortality of 18 C-acclimated fish during testing probably resulted from the test procedure alone as these fish were held within the range of optimum temperatures (11-19 C) reported by Baldwin (1951) and Mullan (1958).

There was no mortality in the 23 C control until the sixth week after acclimation, after which heavy mortality occurred. Exact cause of death is unclear because isolates of bacteria from diseased fish were identified (personal communication, D. Jezek, Fish Disease Diagnostic Laboratory, Auburn Univ., Al.) as organisms which are not considered serious fish pathogens (Escherichia coli and Enterobacter sp.). Nevertheless, constant exposure of brook trout to 23 C was devastating.

This study indicates brook trout will thrive in water 18 C or below. Above this temperature, survival is uncertain even though natural populations have been reported to exist for prolonged periods of time at 24 C (LaRivers 1962). Henderson (1963) reported that brook trout are not found in lentic or lotic areas with temperature above 20 C if cooler water is available. Successful establishment of brook trout fisheries in Texas would be dependent upon thermal regime of the stocked waters. If temperatures are 23 C for prolonged periods fish will become stressed and their ability to recover will depend on availability of cool water. Hokanson et al. (1973) determined mean summer temperature should not exceed 19 C for functional maturity. They promoted findings of Fry et al. (1946) that maximum summer temperature should not exceed the upper incipient lethal temperature of 25 C. Above this temperature brook trout have little opportunity to recover.

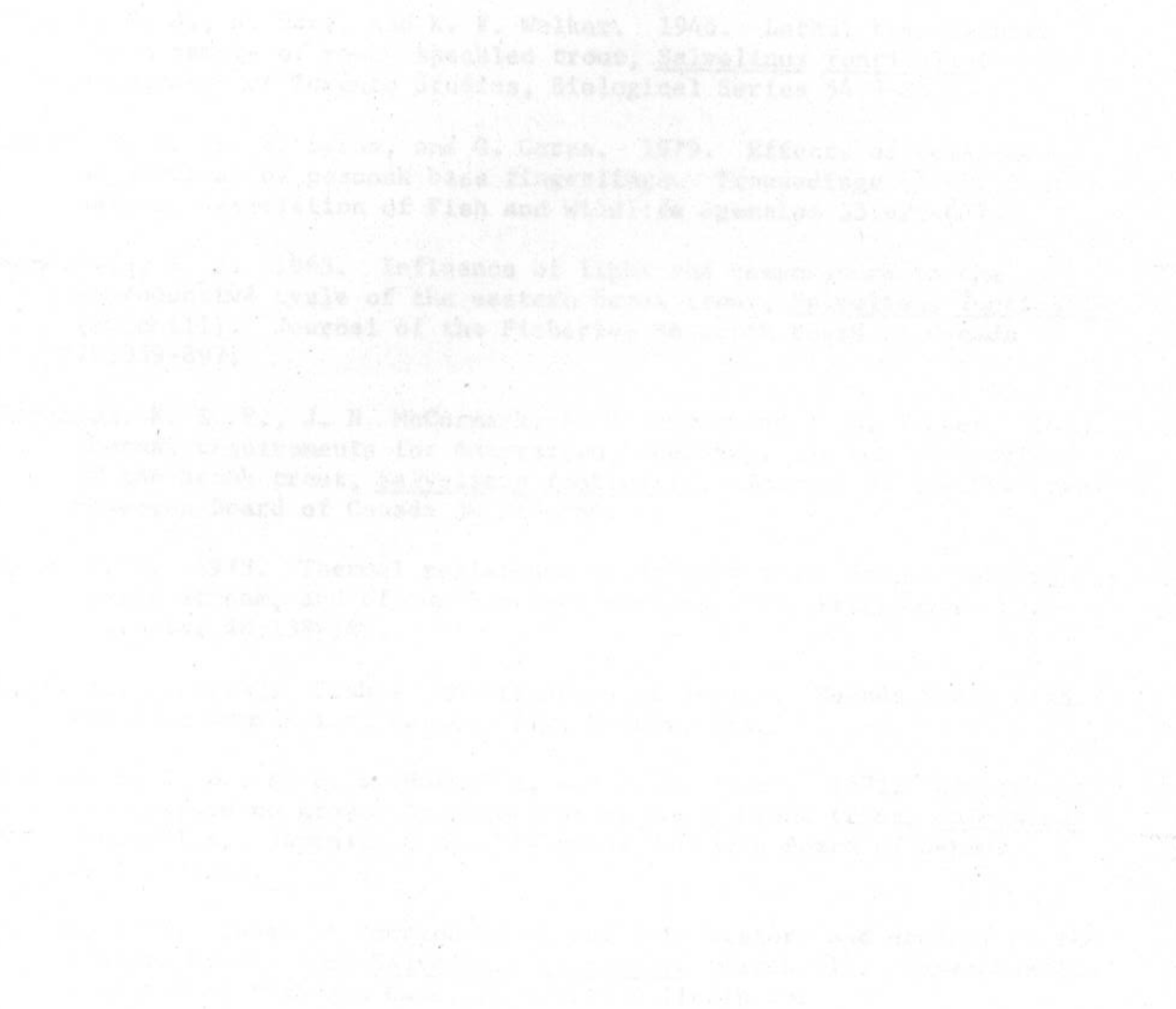
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Figure 1. Arcsin transformation of cumulative mortality (CM) vs lethal temperature (LT) for brook trout acclimated at 18 C and 23 C and exposed to temperature increases of 0.5 C/day. Equations for 18 C and 23 C regressions are indicated by CM-18 and CM-23, respectively. Points referring to 18 C are indicated by o, 23 C by ●. The LT₅₀ is indicated by the intersection of regression lines and the broken line.

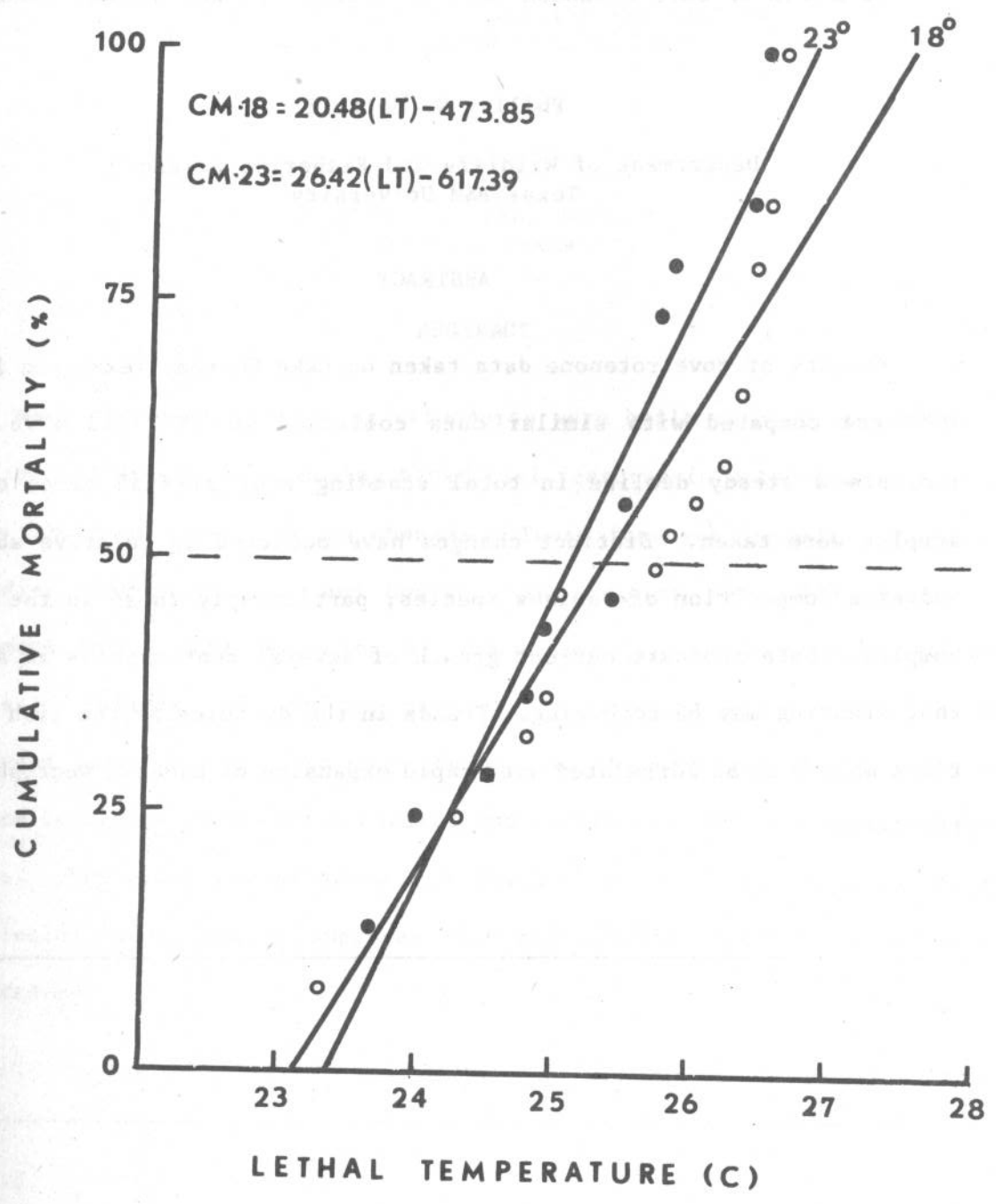


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W. F. Waikar, and G. L. Gorman, 1979. Effects of temperature on growth and survival of brook trout, *Salvelinus fontinalis* (Mills). *Journal of the Fisheries Research Board of Canada*, 36: 1119-1124.

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W. F. Waikar, 1984. Thermal requirements of brook trout, *Salvelinus fontinalis* (Mills). *Journal of the Fisheries Research Board of Canada*, 41: 1119-1124.



ANALYSIS OF COVE ROTENONE DATA COLLECTED IN LAKE CONROE, TEXAS

by

Phillip W. Bettoli

Department of Wildlife and Fisheries Sciences
Texas A&M University

ABSTRACT

Results of cove rotenone data taken on Lake Conroe, Texas, in 1980 and 1981 are compared with similar data collected in 1974 and 1976. Data indicate a steady decline in total standing crop of fish since original samples were taken. Distinct changes have occurred in relative abundance and size composition of various species, particularly those in the Lepomis complex. Data indicate current growth of several centrarchids is slow and that stunting may be occurring. Trends in the dynamics of the fish populations appear to be correlated with rapid expansion of aquatic macrophytes in the lake.

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BENEFICIAL FISH AND WILDLIFE FEATURES IN
FLOODWATER RETARDING STRUCTURES

by

Ed M. Schwille

Soil Conservation Service
Terrell, Texas

ABSTRACT

Many floodwater retarding structures were built without consideration to fish and wildlife. Planning beneficial features in watershed activities is a result of recent policy changes. These features include (1) leaving standing timber or rocks and boulders in sediment pool, (2) fencing of sediment pools, (3) deepening of shoreline, (4) development of earthen piers or islands, (5) porting primary spillways at lower elevations to decrease water area of sediment pools, and (6) limiting borrow areas to reduce losses of terrestrial habitat and create smaller or deeper sediment pools. Procedures, evaluation and layout for the basis of planning to completion, resulting in improved fish and wildlife habitat in watershed structures.

A Comparison of Three Pond Management Programs Utilized to
Produce Striped Bass

Dennis Parmley

Texas Parks and Wildlife Department

Possum Kingdom Fish Hatchery

Graford, Texas 76045

ABSTRACT

During the 1981 striped bass (Morone saxatilis) production season (April-June), the percent survival of fish under three types of pond management programs was investigated at the Possum Kingdom Fish Hatchery to determine the most effective technique for artificially rearing striped bass. The three management programs utilized were: ponds that received supplementary fertilizer and feed, ponds that received fertilizer but no feed, and ponds that received feed but no fertilizer. There were no significant differences ($p=0.05$) among percentage survival for fish in ponds fed only, fertilized only or fed and fertilized. However, the actual values of percentage survival were consistently higher in ponds fed and fertilized than in ponds fed only or fertilized only. The water quality parameters tested for each pond (pH, temperature, dissolved oxygen, hardness, and salinity) varied only slightly among ponds. The pond that received feed but no fertilizer maintained the largest zooplankton population. Ponds that received fertilizer and feed maintained the next largest zooplankton populations, and ponds that received fertilizer but no feed maintained the lowest zooplankton populations. Apparently, the combination of fertilizer and feed was needed to maintain zooplankton populations at a level required to obtain a high percent survival of pond-reared striped bass.

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INTRODUCTION

Since about 1960 the Texas Parks and Wildlife Department has been actively involved with various types of management and natural history studies of the striped bass (Morone saxatilis). Originally, this anadromous fish inhabited the Atlantic seaboard and Gulf of Mexico of North America. Successful introduction of the species into freshwater impoundments has generated a great amount of interest among Texas biologists and fishermen. As a result, many of the state's impoundments have been stocked with striped bass and it has become a much sought-after freshwater game fish.

Because sizeable self-sustaining populations of striped bass are (as presently known) restricted to a few of the larger reservoirs, hatchery reared striped bass are the major source of stockable size fish. During the 1981 striped bass production season at the Texas Parks and Wildlife Possum Kingdom fish hatchery three types of pond rearing management programs were examined to determine the most productive method of artificially rearing striped bass to a desired stocking size (approximately 30 mm).

MATERIALS AND METHODS

The initial design of this project was to test and compare three striped bass rearing techniques in 10 earthen ponds. However, because of an excessive seepage problem in one pond and errors in stocking rates in two ponds, insufficient reliable data were collected from these three ponds. They were not included in the analysis.

A total of 3.12 ha of water were utilized and the average pond size was 0.31 ha. Water quality parameters of each pond were monitored throughout the production season. Three different types of pond management programs were set up, including: (1) ponds that received supplementary applications of organic fertilizer and feed (FF); (2) ponds that received feed but no

fertilizer (FN); and (3) ponds that received fertilizer but no feed (NF).

On 15 April 1981, 10 days prior to fry stocking, 10 ponds were fertilized with 448 kg/ha of ground peanut hay and filled with water. Filter devices were placed over the incoming water pipe to prevent the introduction of undesirable fishes via the water supply. Filter devices remained in place until 10 days after fry stocking. Fry were stocked into ponds 5 days after hatching (when mouth parts appeared functional and muscle development had advanced enough to facilitate coordinated swimming) at the rate of 494,200 fry/ha. They were transported from an incubator facility to the ponds in sealed plastic bags that were injected with oxygen. Stocking was accomplished by a direct release tempering procedure (American Fisheries Society 1976). The number of fry stocked into a pond was calculated by random volumetric sampling as outlined in American Fisheries Society (1976). The number of fish harvested from a pond was calculated by weighing a random sample of 300 fish from each pond, calculating an average number of fish per unit of weight and dividing into the total weight harvested.

Ponds receiving supplementary treatments of fertilizer were treated bi-weekly with cottonseed meal (41% protein) at the rate of 9.31 kg/ha/week. Ponds receiving feed were treated with 1.8 kg/day of Silver Cup Salmon starter fish food. Feedings began 10 days after stocking and were conducted in the morning and in the evening, 7 days a week.

Plankton samples were collected twice weekly using a Wisconsin style plankton net (80 μ mesh size). Sampling was conducted at approximately the same time (in the morning) each sampling day. Samples were collected by either a verticle tow method or an oblique tow method (Geiger 1981) depending on the depth of water to be sampled. They were measured on a quantitative basis only with results recorded as a total volumetric yield. No attempt was

made to determine major taxons represented. Samples were preserved in a 4% buffered formalin solution with 40 g of sucrose added per liter.

Water temperatures and dissolved oxygen amounts were monitored with a Garcia oxygen-temperature probe. Readings were taken at the time zooplankton samples were collected. The total hardness (as Mg/l CaCO₃), chloride (as Mg/l NaCl), and pH of each test pond were tested using HACH testing equipment and procedures. Tests were conducted at the time fry were stocked, at approximately the middle of the rearing period, and just prior to harvest. Significant ($p=0.05$) differences in percent survival for fish subjected to the three treatments were determined using analyses of variance (Sokal and Rohlf 1969). Data were transformed to arcsine prior to analysis.

RESULTS

The water quality parameters tested for each pond (ph, temperature, dissolved oxygen, hardness, and salinity) varied only slightly throughout the sampling period and remained within tolerance levels of striped bass. The pH remained 7.0 throughout the rearing season. The mean values of the other parameters tested were as follows: temperature, 22°C; dissolved oxygen, 6.5 ppm; hardness, 380 mg/l CaCO₃; and salinity 812 mg/k NaCl (Table 1).

Percent survival of fry stocked ranged from 1 to 35%. An analysis of variance of survival percentages for the three types of management techniques indicated no significant differences (Table 2). However, the raw values of percent survival were consistently higher in ponds fed and fertilized than in ponds fed only or fertilized only (Table 1).

Zooplankton populations varied from pond to pond and between management techniques (Figs. 1, 2, and 3). Samples appeared to consist mostly of zooplankton, but small amounts of algal and detrital materials were also noted. The pond that received treatments of feed only appeared to maintain the largest

amounts of zooplankters. Ponds that received treatments of fertilizer and feed maintained the next largest zooplankton populations, and ponds that received treatments of fertilizer only maintained the lowest zooplankton populations.

DISCUSSION

A cursory examination of the raw data compiled in the course of this investigation points to the conclusion that a pond feeding and fertilizing program is the most successful (in terms of percentage survival of fish) technique for artificially rearing striped bass at the Possum Kingdom hatchery. But, since there is no statistical correlation of data to one best type of management technique, factors that may have influenced results must be considered.

For the first 10 days of their pond life the striped bass were totally dependent on available food-zooplankton. Geiger (1981) suggested that an adequate zooplankton forage base in striped bass rearing ponds is essential to insure high survival. He also suggested that the quality of zooplankton is equally important. If an adequate zooplankton forage base is not available, many of the fry starve to death or become weak and die from complications brought about by stress. The remaining fish usually diverge into an atypical balance of size that results in further depletion of the population via cannibalism or an unequal balance of food utilization. It was observed that fish harvested from ponds that had received treatments of feed and fertilizer exhibited a more uniform size than fish harvested from ponds that had received treatments of feed only or fertilizer only. This indicated that zooplankton populations in feed-only or fertilizer-only ponds were insufficient to support the striped bass populations. However, the pond that received feed only maintained the largest zooplankton population. This discrepancy may be explained by a larger stocking mortality in the feed-only pond resulting in a

23 very small population of fish to prey upon the zooplankters. But, until a better method of calculating hatchery stocking mortalities in striped bass is reported, this idea must remain speculative.

A problem with water seepage was encountered in all test ponds. This resulted in high rates of water exchange and fluctuations in water depth. On the average, ponds lost 215,745 liters of water per day. It is likely that fluctuations in pond depths lessened the effectiveness of the fertilizer to act as a zooplankton precursor. An undetermined percentage of nutrients supplied by the fertilizer, and nutrients occurring naturally (Boyd 1979) were probably drained from the ponds. Thus, a less than desirable nutrient base was probably available for zooplankton communities to draw from. Some researchers have suggested that ponds having high rates of water exchange should not be fertilized (Snow et al. 1964).

to In summation, the results of this research suggest a bipartible conclusion. First, of the three types of pond management programs tested, the feed and fertilizer program produced the greatest percent survival of striped bass artificially reared at the Possum Kingdom hatchery during the 1981 season. This conclusion is not supported statistically, but is supported by actual values of percent survival. In addition, the results indicate that further research is needed at the Possum Kingdom hatchery to determine a more successful technique to promote adequate zooplankton populations in striped bass rearing ponds.

ACKNOWLEDGMENTS

I wish to thank especially Gary Matlock for helpful criticism of the manuscript. Bill Rutledge offered valuable comments on the manuscript and on striped bass culture in general. Bobby Palmer, Edward Nunez, and Armando Rincones provided help with field work. Mrs. Faye Dell Clements typed the manuscript.

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Table 1. Striped bass pond production, and influencing factors, for three different types of pond management programs, Possum Kingdom hatchery, 1981.

Table 1. Striped bass pond production, and influencing factors, for three different types of pond management programs, Possum Kingdom hatchery, 1981.

Management regime ^a	Pond Size (ha)	Days to Harvest	No. stocked	No. harvested	% survival	Mean dissolved Oxygen (ppm)	Mean temperature (c) ±1SE	Mean hardness (mg/l CaCO ₃)	Mean salinity (mg/l NaCl)
FF	0.33	37	164,000	45,356	28	6.1	22±0.9	387	847
FF	0.35	45	172,000	25,706	15	6.5	23±0.8	390	843
FF	0.36	31	178,000	62,137	35	6.8	22±0.1	393	875
NF	0.35	45	172,000	18,768	11	6.4	23±0.9	370	800
NF	0.34	45	170,000	14,768	8	6.4	22±0.9	383	828
NF	0.38	38	186,000	1,791	1	6.7	22±0.9	357	666
FN	0.24	45	118,000	2,000	2	6.7	21±0.8	380	825

a. FF = Fed and fertilized; NF = fertilized, not fed; FN = fed, not fertilized.

Table 2. Results of analysis of variance of survival percentages in one pond fed only, three ponds fertilized only, and three ponds fed and fertilized.

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square	F-statistic
Total	6	772.62		
Treatments	2	574.96	287.48	5.817 NS
Error	4	197.66	49.42	

NS at $p=0.05$

Figur

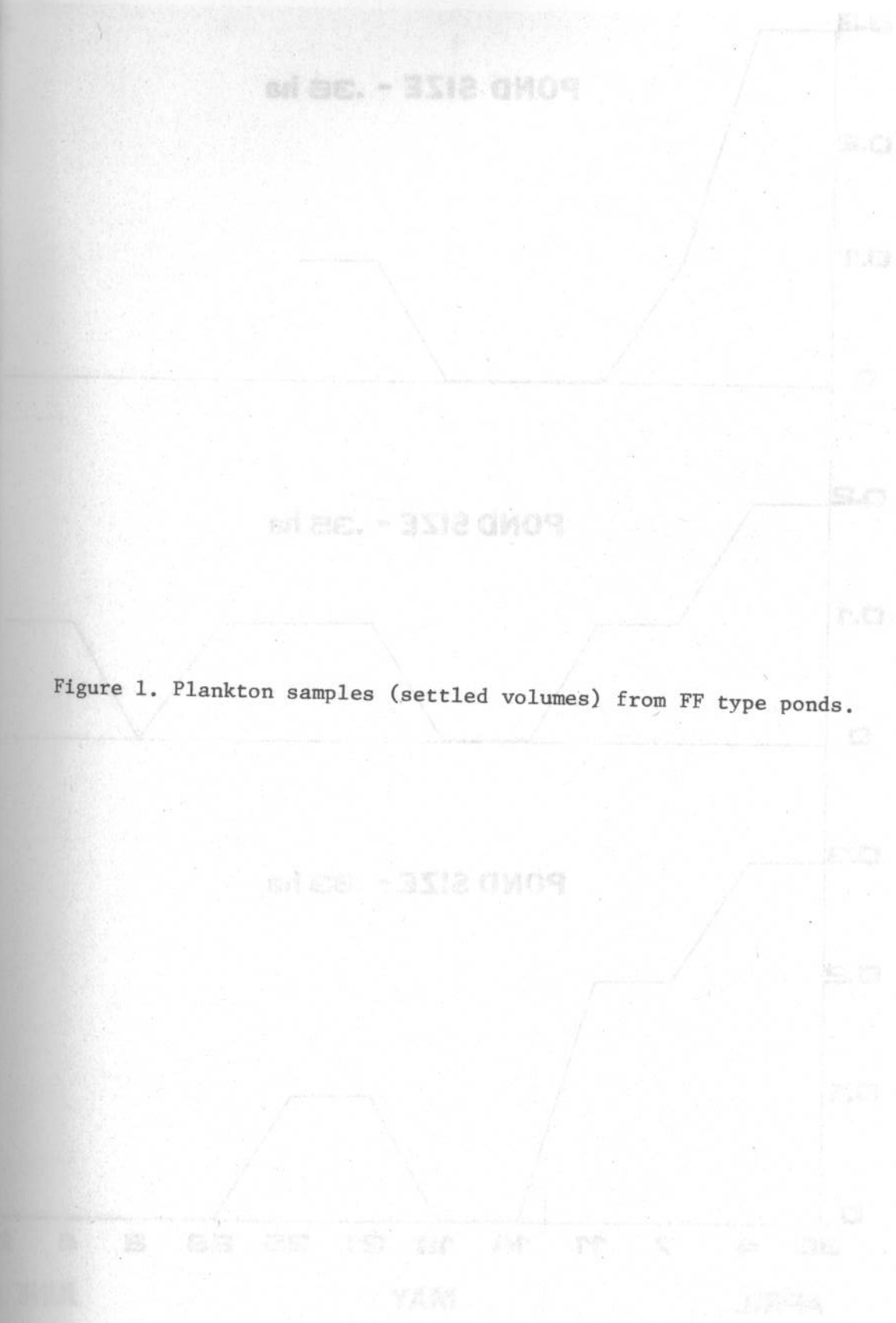
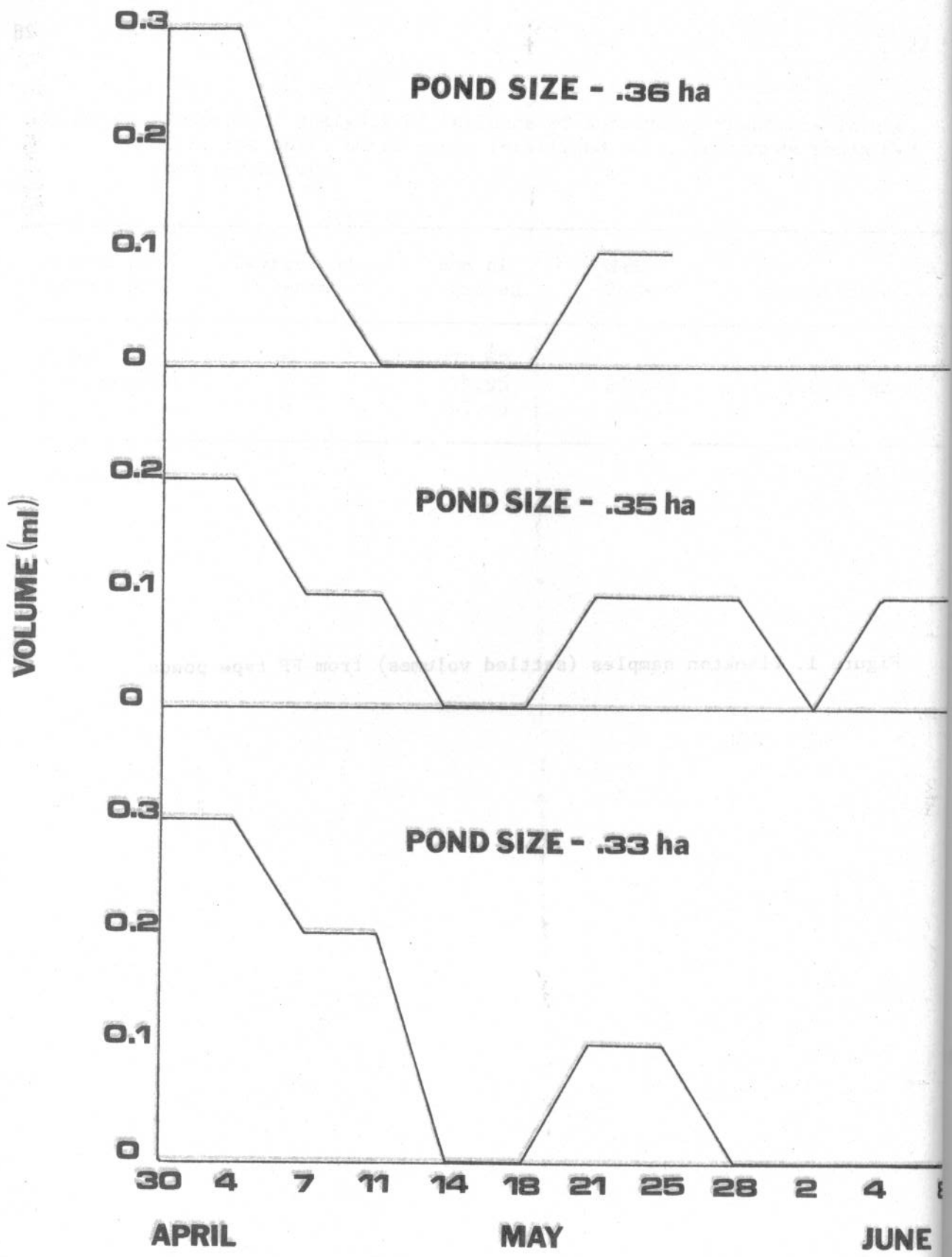


Figure 1. Plankton samples (settled volumes) from FF type ponds.



Figure

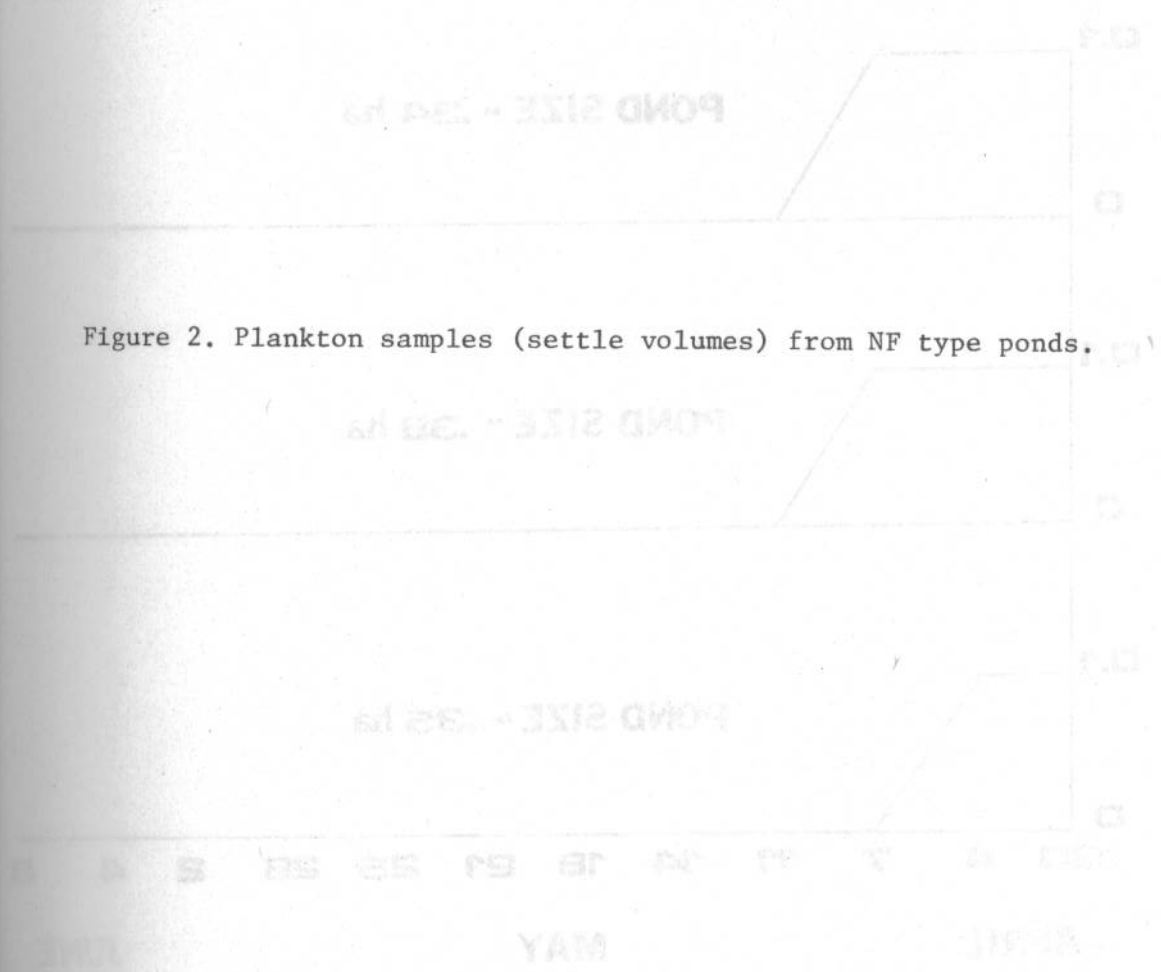
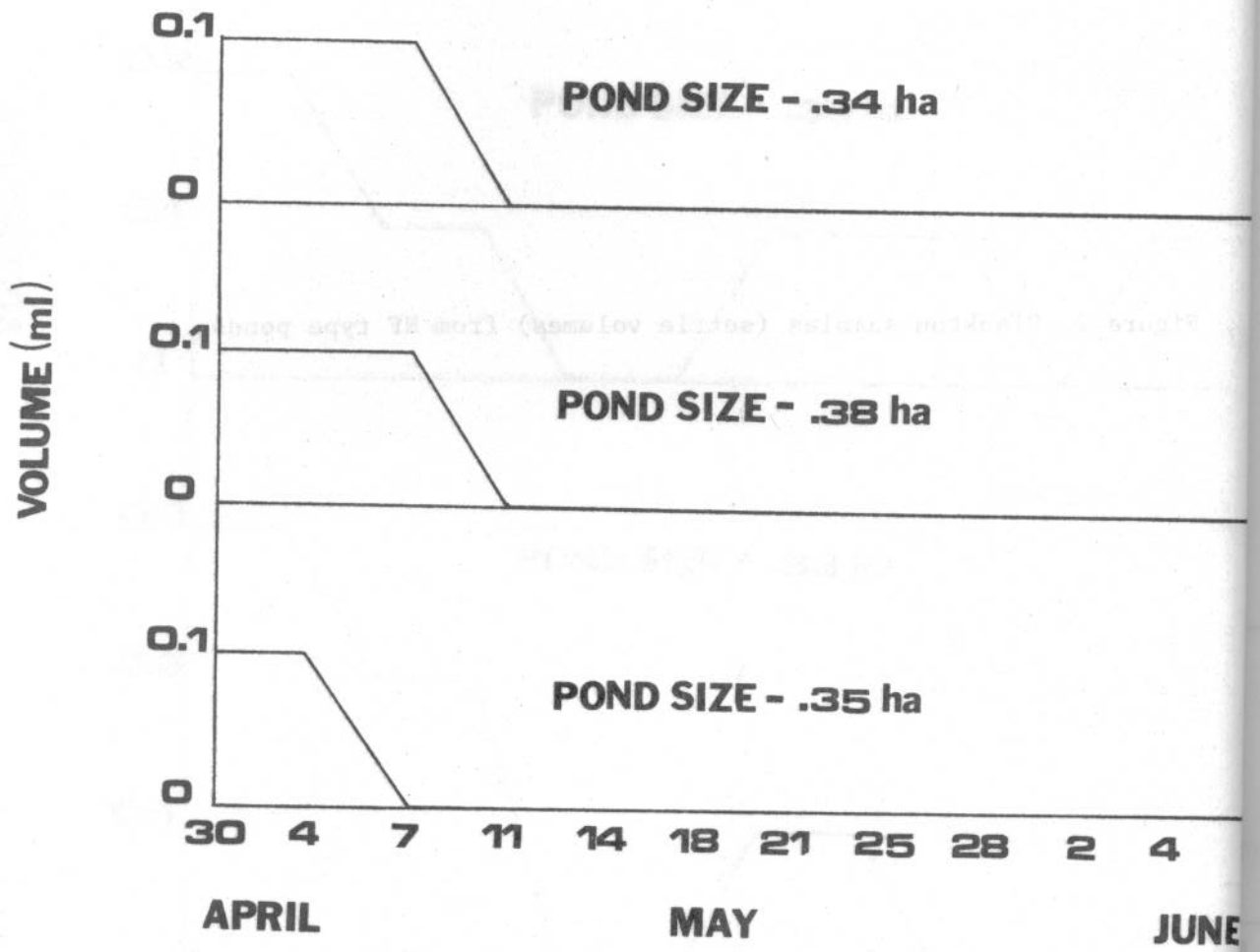


Figure 2. Plankton samples (settle volumes) from NF type ponds.



Figure

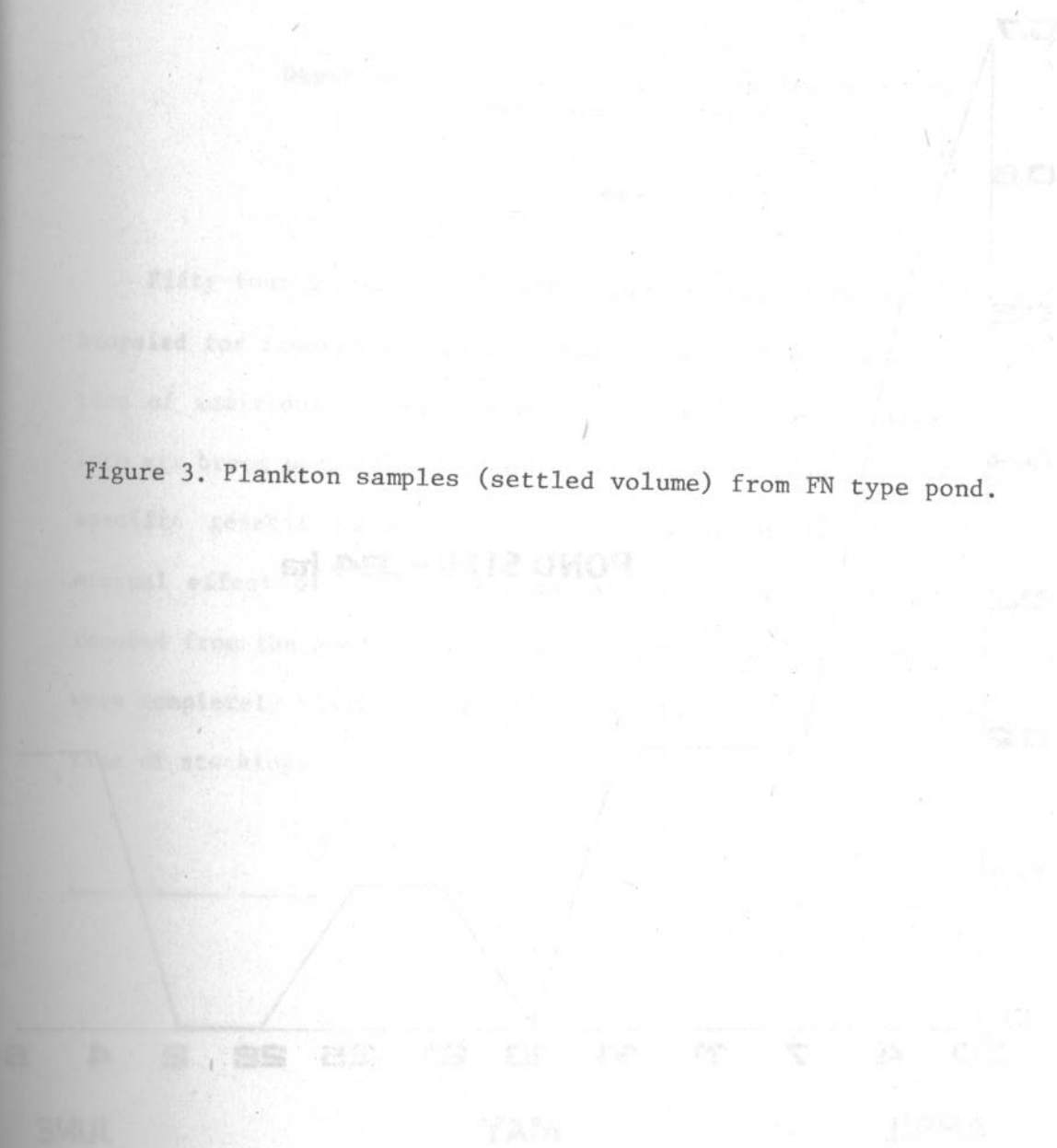
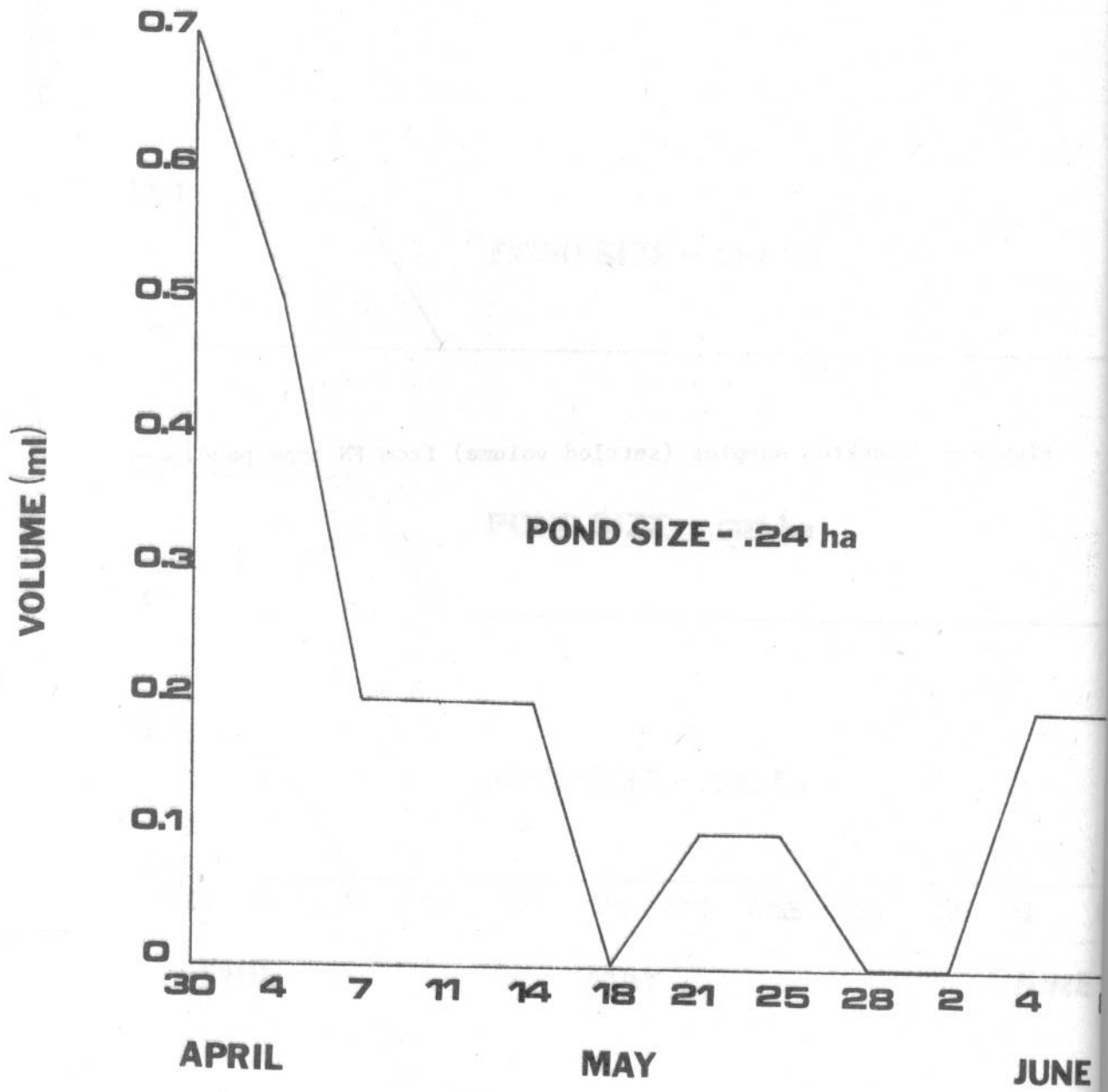


Figure 3. Plankton samples (settled volume) from FN type pond.



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A BIOPSY TECHNIQUE FOR GENETIC EVALUATION
OF LARGEMOUTH BASS

by

William D. Harvey, Richard L. Noble,
and William H. Neill

Department of Wildlife and Fisheries Sciences
Texas A&M University

ABSTRACT

Fifty-four brood size (greater than 250 mm) largemouth bass were live biopsied for removal of liver tissue to be used in electrophoretic evaluation of individual genetic status. These fish were subsequently stocked into six brood ponds for production of known intrasubspecific and intersubspecific genetic crosses. Spawning occurred in each pond indicating minimal effect of biopsy on spawning physiology. Forty-four fish were removed from the ponds at the termination of the experiment. All incisions were completely healed and condition of fish had improved over condition at time of stocking.

SWIMMING CAPABILITIES OF SPOTTED SEATROUT

By

John M. Wakeman
Department of Zoology
Louisiana Tech University
Ruston, Louisiana 71272

and

D. E. Wohlschlag
University of Texas
Marine Science Institute
Port Aransas, Texas 78373

ABSTRACT

The relationship between body size and swimming capability in spotted seatrout was analyzed. Both maximum sustained speeds and intermediate levels of swimming performance were found to be proportional to the square root of body length ($L^{0.5}$). Simple linear regression analysis of maximum sustained swimming speed as a function of body length indicated that only speed expressed in terms of $L^{0.5} \text{ sec}^{-1}$ was independent of body length. Similarly, multiple regression analysis of O_2 consumption as a function of body weight and swimming performance level yielded a partial regression coefficient on weight similar to those reported

in the literature only when swimming performance was expressed in terms of $L^{0.5} \cdot \text{sec}^{-1}$. These findings agree with theoretical considerations of size-performance relationships among swimming fishes indicating that swimming performance should be proportional to body length raised to a power ranging from 0.4 to 0.7 depending on boundary layer conditions around the body of the swimming fish.

INTRODUCTION

Variations in swimming capabilities of fish may be used to assess their psychological well-being or to evaluate effects of sublethal stresses (Wakeman and Wohlschlag 1979). The literature dealing with the swimming capabilities of fishes has been reviewed by Nursall (1962), Blaxter (1969), and Beamish (1978). In spite of the extent of this literature, it often proves difficult to compare reported swimming capabilities of various species because the fishes which have been studied vary greatly in size. Size is an important biological constraint on the swimming capabilities of fish (Beamish 1978).

Bainbridge (1958) attempted to negate the size-performance effect by dividing swimming speed by body length, expressing performance as specific speed in terms of

lengths per second ($L \cdot \text{sec}^{-1}$). He found maximum sprint speeds for a number of species of fishes to be about $10 L \cdot \text{sec}^{-1}$, and the concept of specific speed has since been widely used in reports of fish swimming capabilities. While this concept may be adequate for comparisons of sprint capabilities over limited size ranges, it is less useful for comparisons of sustained swimming capabilities of different sized fish (Webb 1975, Beamish 1978). For fish swimming at sustained speeds, maximum specific speed usually decreases as body size increases (Brett 1965, Webb 1975), indicating that this standardization procedure over-compensates for the performance-size relationship in fish.

More precise standardization procedures based on experimental observations have been used by some authors to adjust the swimming speeds of fish relative to body size (Blaxter and Dickson 1959, Bainbridge 1962, Dahlberg et al. 1968, Hunter and Zwiemel 1971). Such adjustments indicate that swimming capabilities in many fishes may be proportional to length raised to some power less than 1.0. Thus, Bainbridge (1962) effectively compared swimming capabilities of different sized salmonids by dividing velocity by length raised to the 0.58 power, and Brett (1965) found performance of salmonid fishes to be proportional to length raised to the 0.5 to 0.6 power. In most such studies, however, no

attempts were made to justify the validity of the standardization procedures on theoretical grounds.

In cases where it is impractical to determine precise size-performance relationships, a standardization procedure based on theoretical considerations may be required for the comparison of performance capabilities of different sized fish. In this paper, a simple theoretical model is derived to predict relationships between body length and swimming performance. Predictions of the model are compared with some experimental observations of the swimming performance of adult and sub-adult spotted seatrout (Cynoscion nebulosus). Support for this study by the Texas Department of Water Resources is gratefully acknowledged.

MATERIALS AND METHODS

Theoretical Model Derivation

According to the Lambert-Teissier theory of biological similarity (Gunther 1975), power generated by muscular effort is related to body length in organisms of similar shape, but different size by:

$$P \propto L^{2.2} \quad (1)$$

where P is power and L is body length.

From Prandtl's formula for hydrodynamic drag (Prandtl and Tietjens 1934), the hydrodynamic drag force acting on a submerged body is also related to body length by:

$$F \propto C \cdot L^2 \quad (2)$$

where F is drag force and C is a drag coefficient. The value of C is affected by a number of factors including boundary layer conditions and body size (Webb 1975) and is related to body length by:

$$C \propto L^{-0.2} \quad (3)$$

for turbulent boundary layers, and

$$C \propto L^{-0.5} \quad (4)$$

for laminar boundary layers.

Combining equations (3) and (2) and equations (4) and (2) yields:

$$F \propto L^{1.8} \quad (5)$$

for turbulent boundary layer conditions, and

$$F \propto L^{1.5} \quad (6)$$

for laminar boundary layer conditions.

Velocity (U) can be expressed as:

$$U = P/F \quad (7)$$

Inserting equation (1) and equations (5) and (6) respectively into equation (7) yields:

$$U \propto L^{0.4} \quad (8)$$

under conditions where turbulent boundary layers predominate, or

$$U \propto L^{0.7} \quad (9)$$

under conditions where laminary boundary layers predominate.

Equations (8) and (9) indicate that swimming performance should be proportional to length raised to a fractional power between 0.4 and 0.7 depending on boundary layer conditions around the body of the swimming fish. Assuming that boundary layer conditions for swimming fishes are generally intermediate between turbulent and laminar (Smit 1965), swimming performance should be approximately proportional to the square root of body length ($L^{0.5}$).

Experimental Observations

Sixteen adult and sub-adult spotted seatrout ranging in length from 23.3 to 45.5 cm, were collected by hook-and-line near Port Aransas, Texas, and held in circular tanks through which ambient seawater was pumped continuously. After a recovery period of 1 - 2 weeks, the fish were fasted and acclimated to the experimental temperature (28 C) for 48 hours, and their oxygen consumption rates at various swimming speeds were measured in a Blazka-type swimming chamber respirometer (Blazka et al. 1960) as described by Wohlschlag and Wakeman (1978). Experimental salinities ranged from 15 - 25 ‰.

The maximum sustained swimming speed of each fish was determined by gradually increasing the velocity of the water flow through the swimming chamber until a "critical" velocity was reached at which the tail-beat of the swimming fish abruptly changed from a smooth regular frequency to an erra-

tic, irregular motion. Preliminary observations with this species showed that swimming speeds below the "critical" velocity could be maintained for periods longer than 200 minutes without evidence of fatigue, while water flow velocities about the "critical" velocity quickly resulted in exhaustion of the fish (Wakeman and Wohlschlag 1979).

Oxygen consumption rates were determined for each fish swimming at its maximum sustained speed and at lower velocities. A total of 48 such oxygen consumption determinations were made with the 16 fish (4 each) at swimming speeds ranging from 46 - 116 $\text{cm}\cdot\text{sec}^{-1}$. Each fish was rested between experimental observations at different speeds, so each determination was treated as a separate measurement for statistical analysis of the data. Swimming speeds were held constant during each of the 48 experiments and were expressed in three different terms: absolute speed ($\text{cm}\cdot\text{sec}^{-1}$), specific speed ($\text{L}\cdot\text{sec}^{-1}$), and standardized speed ($\text{L}^{0.5}\cdot\text{sec}^{-1}$) which was calculated by dividing absolute speed by the square root of body length. The rationale for the last term was based on the theoretical considerations discussed above.

Swimming speeds were tabulated with \log_{10} body weight (in grams) and \log_{10} oxygen consumption rate ($\text{mg O}_2\cdot\text{hr}^{-1}$). Multiple regression procedures were then used to relate \log_{10} oxygen consumption rate (\underline{M}) to the independent

variables, \log_{10} weight (\underline{W}) and swimming speed (\underline{S}), such that

$$\underline{M} = a + b_w \underline{W} + b_s \underline{S}$$

where a is a constant, and b_w and b_s are regression coefficients for \log_{10} weight and swimming speed respectively. Since swimming speed was expressed in three different ways, coefficients for the equation were calculated three times, with swimming speed expressed in terms of $\text{cm}\cdot\text{sec}^{-1}$, $\text{L}\cdot\text{sec}^{-1}$, and $\text{L}^{0.5}\cdot\text{sec}^{-1}$ alternatively.

Because the multiple regression analysis included data for fish swimming at both intermediate and maximum sustained speeds, we felt it would also be informative to analyze only maximum sustained speed data. For this purpose, the maximum sustained swimming speed of each fish was plotted against total body length in three separate graphs (one for each swimming speed term) and a simple least-squares linear regression was fitted to each plot.

RESULTS AND DISCUSSION

Multiple Regression Analysis

The three multiple regression equations relating \log_{10} $\text{mg O}_2\cdot\text{hr}^{-1}$ (\underline{M}) to \log_{10} body weight (\underline{W}) and swimming performance (\underline{S}) in Table 1 show that the value of the partial regression coefficient on \underline{W} , (b_w), varies depending on how swimming performance is expressed. Although the same data

were evaluated in all three equations, the value of b_w was 0.68 when swimming performance was expressed in $\text{cm}\cdot\text{sec}^{-1}$, 1.02 when expressed in terms of $\text{L}\cdot\text{sec}^{-1}$, and 0.86 when expressed in terms of $\text{L}^{0.5}\cdot\text{sec}^{-1}$.

Standard metabolic rates have been determined for many species of fish and reviews of such data indicate that for resting fishes in general, the value of b_w is 0.8 - 0.9 when $\log_{10} \text{O}_2$ consumption is regressed against \log_{10} body weight (Winberg 1956, Glass 1969). This relationship has been shown to hold true for spotted seatrout (Vetter 1977).

If swimming performance is effectively standardized, the relative effort of individual fish should be independent of weight, and the energetic cost of equal levels of standardized performance should represent approximately the same multiple of standard metabolism. Therefore, for a given level of standardized swimming performance, the slope of \underline{M} on \underline{W} might be expected to parallel that of standard metabolism (McMahon 1973). Thus Muir and Niimi (1972) found b_w values for both resting and swimming aholehols to be 0.78, although a number of experimental studies have suggested that the value of b_w may gradually increase with increased activity in certain fishes, and may approach 1.0 at maximum velocities (Brett 1965, Rao 1968, Farmer and Beamish 1968).

In any case, because the majority of the experiments in this analysis involved intermediate speeds rather than maximum sustained speeds, it is reasonable to expect that the regression coefficient on weight (b_w), independent of swimming performance, should lie between 0.8 and 0.9. From these considerations, the b_w obtained when swimming speed was expressed in terms of $\text{cm}\cdot\text{sec}^{-1}$ was low, while the b_w value obtained when speed was expressed in terms of $\text{L}\cdot\text{sec}^{-1}$ was high (Table 1). Thus, although the squared multiple correlation coefficient was equally high for all three equations in Table 1, the regression coefficient on body weight independent of swimming speed appears to be realistic only when swimming speeds were expressed in terms of $\text{L}^{0.5}\cdot\text{sec}^{-1}$.

Analysis of Maximum Speed vs Body Length

The concept of swimming performance of spotted seatrout being approximately proportional to the square root of body length was further supported by the elimination of a size dependent trend when maximum swimming speed was expressed as $\text{L}^{0.5}\cdot\text{sec}^{-1}$ (Figure 1) and analyzed by simple linear regression. Maximum sustained swimming speed expressed in $\text{cm}\cdot\text{sec}^{-1}$ increased with increased body length, and the slope of this increase (1.29) was significantly different from zero ($r=.83, P<0.01$). Maximum specific speed ($\text{L}\cdot\text{sec}^{-1}$) decreased with increased body length and the slope of this

decrease (-0.07) was differed significantly from zero ($r=.91, P<0.01$). However, the slope of standardized speed ($L^{0.5} \cdot \text{sec}^{-1}$) did not differ significantly from zero ($r=.4$), indicating that maximum standardized speeds were independent of body length over the size range used in this study (Figure 1).

Theoretical Considerations

According to the theoretical model presented in this paper, the performance-length relationship for swimming in fish can be defined in the form of the allometric relationship, $Y = aL^b$ where Y is swimming speed, a is constant, and b is the exponent on length which may vary between 0.4 and 0.7 depending on boundary layer conditions around the body of the swimming fish. Active or passive mechanisms which help maintain laminar boundary layers may enable certain species to reduce frictional drag (Webb 1975) and in such species, the model predicts that performance will be proportional to $L^{0.7}$. However, turbulent boundary layers are likely to be generated when fish are swimming in currents such as exist in streams and in experimental flumes (Webb 1975). Moreover, it has been hypothesized that surface protuberances in many fishes and exhalent water from the gills may serve to promote turbulence in the boundary layer and thus reduce pressure drag by delaying boundary layer separation (Blaxter 1969). For totally turbulent

boundary layers, the model predicts that swimming performance will be proportional to $L^{0.4}$.

If intermediate boundary layers are assumed to persist for swimming fishes in general (Smit 1965), the model predicts that swimming performance will be approximately proportional to the square root of body length. This prediction, which is clearly supported by the results of the present study with spotted seatrout, is in agreement with similar conclusions based on studies of the swimming capabilities of goldfish (Smit et al. 1971) and rainbow trout (Fry and Cox 1970). That this size-performance relationship can be clearly shown over even the relatively small size range used in this study, serves to emphasize the importance of standardizing swimming speeds in studies involving comparisons of the performance capabilities of different sized fish.

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Table

Perfor

cm/

L/s

L^{0.5}

Table 1. Coefficients for the multiple regression equation

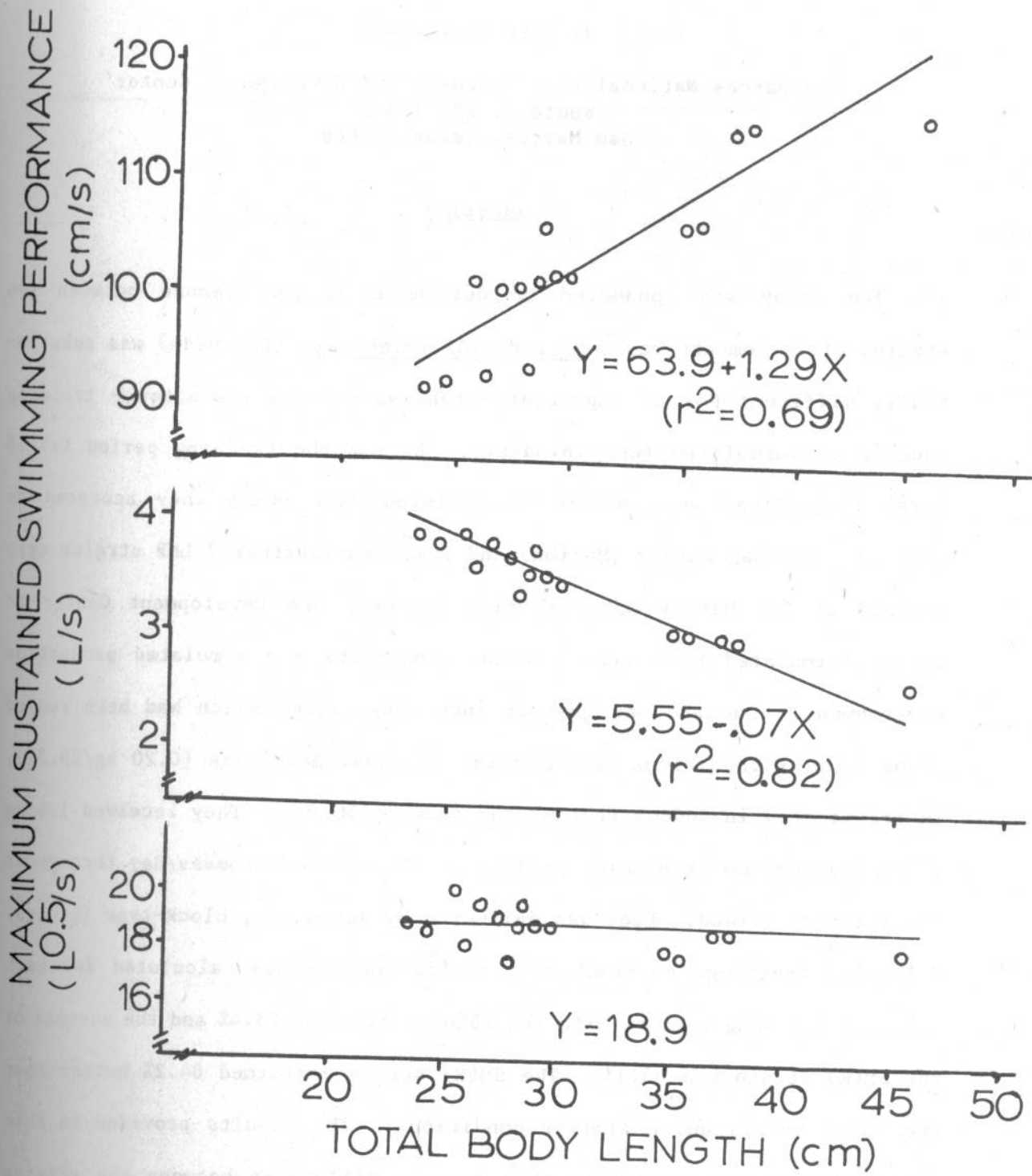
$\underline{M} = a + b_w \underline{W} + b_s \underline{S}$, relating \log_{10} mg $O_2 \cdot \text{hr}^{-1}$ (\underline{M}) to \log_{10} weight in g (\underline{W}) and to swimming performance (\underline{S}) where performance is expressed in terms of $\text{cm} \cdot \text{sec}^{-1}$, $\text{L} \cdot \text{sec}^{-1}$ and $\text{L}^{0.5} \cdot \text{sec}^{-1/2}$ alternatively.

Performance Term	a	b_w	b_s	N	R^2
cm/s	-0.0238	0.6776	0.0058	48	0.94
L/s	-0.8043	1.0204	0.1629	48	0.94
$\text{L}^{0.5}/\text{s}$	-0.4456	0.8603	0.0313	48	0.94

Figure 1

Maximum sustained swimming speeds of spotted seatrout as a function of total body length, with swimming speeds expressed alternatively in terms of $\text{cm}\cdot\text{sec}^{-1}$, $\text{L}\cdot\text{sec}^{-1}$, and $\text{L}^{0.5}\cdot\text{sec}^{-1}$. Curves for $\text{cm}\cdot\text{sec}^{-1}$ and $\text{L}^0\cdot\text{sec}^{-1}$ were fitted by simple linear regression and were significant ($P < 0.01$). The curve for $\text{L}^{0.5}\cdot\text{sec}^{-1}$ represents the mean, because of the absence of any significant correlation at the 0.5 level (see text).

MAXIMUM SUSTAINED SWIMMING PERFORMANCE
($\text{L}^{0.5}/\text{s}$) (L/s) (cm/s)



COMPARING TRAINING SUCCESS BETWEEN TWO STRAINS OF LARGEMOUTH BASS

by

J. Holt Williamson

San Marcos National Fish Hatchery and Development Center
Route 1, Box 159-D
San Marcos, Texas 78666

ABSTRACT

The study was conducted to determine if performance between two strains of largemouth bass, Micropterus salmoides, (Lacepede) was substantially different for an important intensive culture character - training success on formulated feed (Biodiet). During the training period (17-18 days) fingerlings were offered a pelleted diet which they accepted or starved. The San Marcos (Marion) and Inks Dam (northern) LMB strains were trained at San Marcos National Fish Hatchery and Development Center to accept formulated feed under similar conditions - a simulated production environment. One and one quarter inch fingerlings which had been reared using similar conditions were stocked at equal densities (0.20 kg/28.31), in triplicate, in indoor rectangular tanks (230.01). They received 1.6 mm (1/16 in) semi-moist Biodiet pellets at 15% stocked biomass/day throughout the training period. Feed was delivered by automatic, clock-type feeders. Following training, survival or training success was calculated for each strain. Training success with the ID(n) strain was 23.4% and the success of the SM(M) strain was 43.1%. The SM(M) strain performed 84.2% better than the ID(n) strain under similar conditions. The results provided in this study support the contention that genetic difference between the strains explains to a measurable extent the training success difference between the strains. This data as well as previous experience with both strains suggest

significant gains in production and management are possible by exploiting the genetic potential of different strains of largemouth bass.

These gains were achieved by using a hybrid vigor program that involved crossing two different strains of largemouth bass.

ABSTRACT

A study was conducted to evaluate the genetic potential of largemouth bass (Micropterus dolomieu) raised in small impoundments.

The study was conducted in small impoundments in the state of Mississippi. The study was conducted in small impoundments in the state of Mississippi.

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EVALUATION OF STRIPED BASS X WHITE BASS HYBRIDS IN SMALL IMPOUNDMENTS

by

Bobby W. Farquhar
Texas Parks and Wildlife Department
6200 Hatchery Road
Fort Worth, Texas 76114

ABSTRACT

A study was conducted to evaluate the effects of striped bass (Morone saxatilis) x white bass (M. chrysops) hybrids on existing fish populations and sport fish harvest in small impoundments. Two lakes (40 and 42 ha) were initially stocked with 50 hybrids/ha (30 mm TL), followed by two years of supplemental stocking (25-50/ha). Growth rates of hybrids and selected centrarchids were monitored, and creel surveys conducted to determine effects of the hybrid introductions. Over the study period hybrids failed to reach sufficient size in adequate numbers in either lake to significantly impact existing fish populations or sport fishery. Hybrid growth was consistently lower in both lakes than those of hybrids found in larger reservoirs, and survival in one lake was apparently poor. The unsuccessful hybrid introduction could probably be attributed to competition with overabundant crappies (Pomoxis spp.) for available forage.

INTRODUCTION

There are numerous state park, city, and privately owned small impoundments in Texas which constitute an important recreational fisheries resource. However, many of these lakes are characterized by overabundant stunted sunfishes and poor fishing. This situation often occurs in waters with insufficient predation (Bennett 1970) resulting from overharvest of available predators (Novinger and Legler 1978). Introduction of an additional

predator sport fish to control overabundant fishes is an accepted management practice (Bennett 1970; Lagler 1972). This practice should increase sport fish diversity by adding an additional species to the creel while also creating a more balanced system, thus producing a more satisfactory sustained yield of other sport fishes (Anderson 1973).

Studies indicate that the female striped bass (Morone saxatilis) x male white bass (M. chrysops) hybrid could be a desirable predator sport fish for stocking in small impoundments. In larger reservoirs, this hybrid is reported to be a highly desirable sport fish (Bishop 1967; Ware 1978) which feeds on sunfishes and shad (Williams 1970; Crandall 1978) and exhibits rapid growth when compared to parent species (Ware 1974). This study was conducted to determine the effects of striped bass x white bass hybrids on existing fish populations and sport fishery in small impoundments.

METHODS

Study Sites

Lake Anson, located in Jones County approximately 3.2 km south of Anson, Texas, has a surface area of 40 ha and a mean depth of 1.5 m. The lake is owned by the City of Anson and is open to the public for fishing on a fee basis. Lake Eanes, located in Comanche County approximately 8 km southwest of Comanche, Texas, covers 42 ha with a mean depth of 3.4 m. The lake is owned by the City of Comanche and is open to free public fishing.

These lakes are located in the Brazos River watershed and were impounded approximately 50 years ago by constructing earthen dams across intermittent streams. Both lakes depend primarily on rainwater runoff to maintain their pool elevations and are subject to extreme water level fluctuations. Used originally as municipal water supplies, primary use of both lakes is now recreational. Each lake has one boat ramp as the only

access point.

Hybrid Stocking

Striped bass x white bass hybrids were initially stocked in each study lake at a rate of 50/ha in June 1978. Creel survey catch rates, and gill net and electrofishing sampling were used to determine supplemental stocking needs. Consequently, Lakes Anson and Eanes were restocked in 1979 with 50 and 25 hybrids/ha, respectively. Each lake received an additional stocking of 25 hybrids/ha in 1980. All hybrids were approximately 30 mm mean total length (TL) when stocked.

Fish Populations

Growth rate trends of selected centrarchids were used to measure possible effects of hybrids on the existing fish populations. Fishes were collected in October each year using experimental gill nets measuring 53.3 m long and 2.4 m deep with bar mesh sizes varying from 25.4 mm to 101.6 mm in 12.7-mm increments. Fish were also collected during this period with electrofishing gear. Hybrids were also sampled annually in May and in November and December 1980 using gill nets and electrofishing gear.

Scale samples for age and growth determinations were taken from hybrids, largemouth bass (Micropterus salmoides), bluegill (Lepomis macrochirus), white crappie (Pomoxis annularis), and black crappie (P. nigromaculatus). Justification for the use of scales to determine age was based on validation criteria presented by Hile (1941). Age determinations followed methods presented by Carlander (1961). Growth was determined when possible by the Lee method of back calculation (Lagler 1972).

Sport Fishery

Creel surveys were conducted annually to determine effects of the hybrid introductions on the sport fishery. Fishing pressure, harvest, and

types of fishes sought were determined for 30 randomly selected days each year. The surveys were done March through November from 0900 hours till 1500 hours. Creel clerks were concerned with completed fishing trips and recorded the following information: (1) number of fishermen; (2) number and bulk weight of each species caught; (3) hours fished; (4) species sought. Data were compiled and submitted to the Texas Parks and Wildlife Department Data Processing Branch for analysis following procedures outlined in the Texas Parks and Wildlife Department's Management Manual (1975).

RESULTS AND DISCUSSION

Fish Populations

Hybrid survival apparently was low in both lakes. Of the 57 hybrids collected, 52 were captured in Lake Eanes indicating higher survival in that lake. The majority of those from Lake Eanes (45) were collected with electrofishing gear. Few hybrids were collected in either lake with gill nets.

Growth rates of hybrids in both lakes (Table 1) were extremely low compared with growth of fish in larger reservoirs. Total lengths ranged from 137 to 188 mm for Age I hybrids from Lakes Anson and Eanes; whereas Bishop (1967) found Age I hybrids in Cherokee Reservoir, Tennessee, ranged from 281 to 358 mm TL, and hybrids in Lake Bastrop, Texas were 308 mm TL at first annulus formation (Crandall 1978). Total lengths of hybrids in two South Carolina lakes ranged from 451 to 533 mm TL and weighed from 1.4 to 2.6 kg at 30 months of age (Williams 1970), while similar age hybrids from Lakes Anson and Eanes were much smaller (Table 1).

According to Bayless (1972) striped bass x white bass hybrids may be dependent on shad forage. Lakes Anson and Eanes support large populations of gizzard shad (Dorosoma cepedianum); however, most hybrids did not attain

an adequate size to utilize them. Threadfin shad (D. petenense) were introduced into Lake Eanes in May 1980 to increase hybrid survival and growth. The 1980 year class of hybrids grew more in 8 months (179 - 208 mm TL) than the previous year classes grew in 12 months (137 - 188 mm TL). However, growth was still slow compared with those from larger reservoirs.

The addition of hybrids had no measurable effects on the growth of centrarchids in either Lake Anson or Lake Eanes (Tables 2, 3, 4 and 5). Inadequate numbers of largemouth bass collected from Lake Anson and of redear sunfish collected from Lake Eanes made growth analyses impossible in those cases. Most crappies collected from both lakes were II+ years old and averaged 157 mm TL; therefore, due to uniformity in TL, back calculations were not possible. This situation persisted throughout the study period indicating crappie growth was poor both before and after the introduction of hybrids.

The dominance of small crappies in both lakes offers a possible explanation of poor survival and growth of hybrids. The crappies could have not only competed with the hybrids for forage, but probably preyed directly on the hybrid fingerlings when first introduced.

Because the hybrids did not survive in enough numbers or grow large enough to significantly impact the growth of the other fishes in the lakes, any effects they might have had were slight and masked by normal environmental influences and population fluctuations. Few hybrids grew large enough to begin preying on the small sunfishes or crappies and thus the reduction in numbers which was expected to benefit growth never occurred.

Sport Fishery

The addition of hybrids to Lakes Anson and Eanes had no measurable effects on the sport fishery. Few hybrids reached a size sought by fisher-

men and the ones that were caught were often released, so they did not enter the creel harvest estimates. Hybrids were sought by few fishermen and efforts expended seeking them were less than 2% of the total fishing effort. Estimated harvest rates of hybrids were also low with only 0.5% of the fishermen catching a hybrid.

The introduction of hybrids under conditions similar to those found in the two lakes during the present study would have no practical management application. In small lakes, hybrids are apparently unable to compete with existing fish populations, especially when they are dominated by stunted crappies. Further research under conditions more favorable to hybrid success would be necessary before the potential of hybrid introductions as a management practice in small impoundments could be determined.

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Table 1. Mean total lengths (TL) and weights (WT) with ranges in parentheses for striped bass x white bass hybrids collected from Lakes Anson and Eanes, Texas, 1978-1980.

Table 1. Mean total lengths (TL) and weights (WT) with ranges in parentheses for striped bass x white bass hybrids collected from Lakes Anson and Eanes, Texas, 1978-1980.

Age (Months)	Number	TL (mm)	WT (g)
6	6	165 (135-199)	50 (24-82)
12	27	166 (137-188)	43 (30-70)
18	14	238 (142-390)	174 (25-776)
30	8	424 (192-520)	1320 (66-2088)

Table 2. Largemouth bass age and growth data, Lake Eanes, Texas, 1980.

Age group	Year class	No.	Mean total length (mm) at annulus							
			1	2	3	4	5	6	7	
1	1979	2	118.3							
3	1977	1	112.5	178.2	309.6					
4	1976	2	116.1	264.5	393.6	442.7				
5	1975	4	134.4	188.7	307.3	418.5	471.9			
7	1973	1	76.5	144.8	212.6	269.4	401.8	462.3	501.9	
Grand average-weighted			10	119.58	200.89	317.37	404.17	457.89	462.34	501.97
Average increment				119.58	81.31	116.48	86.80	53.72	4.45	39.63
Average annual increment				119.58	81.00	116.47	85.69	69.17	60.48	39.63

Table 3. Bluegill age and growth data, Lake Eanes, Texas, 1980.

Table 3. Bluegill age and growth data, Lake Eanes, Texas, 1980.

Age group	Year class	No.	Mean total length (mm) at annulus			
			1	2	3	4
1	1979	1	69.1			
2	1978	13	88.3	123.5		
3	1977	18	76.7	107.5	126.0	
4	1976	1	79.9	86.4	101.4	114.3
Grand average-weighted			81.17	113.36	123.80	114.3
Average increment			81.17	32.19	11.44	-10.49
Average annual increment			81.17	31.80	18.37	12.83

Table 4. Bluegill age and growth data, Lake Anson, Texas, 1980.

Age group	Year class	No.	Mean total length (mm) at annulus				
			1	2	3	4	5
1	1979	7	61.3				
2	1978	7	76.6	115.2			
3	1977	14	76.8	108.3	127.0		
4	1976	12	71.0	105.0	126.0	138.3	
5	1975	2	72.9	105.0	119.2	129.8	136.6
Grand average-weighted			72.40	108.41	126.06	137.11	136.62
Average increment			72.40	36.01	17.65	11.05	-0.49
Average annual increment			72.40	33.80	19.36	12.06	6.77

Table 5. Redear sunfish age and growth data, Lake Anson, Texas, 1980.

Table 5. Redear sunfish age and growth data, Lake Anson, Texas, 1980.

Age group	Year class	No.	Mean total length (mm) at annulus			
			1	2	3	4
1	1979	18	77.6			
2	1978	17	86.2	135.0		
3	1977	19	81.9	138.0	153.6	
4	1976	15	83.9	129.2	152.4	165.8
Grand average-weighted			82.33	134.47	153.11	165.83
Average increments			82.33	52.14	18.64	12.72
Average annual increments			82.33	50.46	151.72	165.07

CIRCULATING CORTICOSTEROID AND LEUCOCYTE DYNAMICS
IN CHANNEL CATFISH DURING NET CONFINEMENT

by

J. R. Tomasso
Southwest Texas State University

and

B. A. Simco and K. B. Davis
Memphis State University

ABSTRACT

Plasma corticosteroid concentrations of channel catfish increased significantly in response to a 24 h net confinement. Leucocrits of net confined fish decreased after 6 h of confinement. Blood cell differential counts indicated that, during the stress, lymphocyte counts decreased by 6 h of confinement and granulocyte counts increased by 12 h of confinement. The decrease in leucocrit at 6 h was attributed to the decrease in lymphocyte number and the increase in leucocrit at 12 h was attributed to the increase in granulocyte number.

SHARKS IN TEXAS BAYS

by

Lee M. Green
Coastal Fisheries Branch
Texas Parks and Wildlife Department
P. O. Box 1707
Rockport, Texas 78382

ABSTRACT

During routine sampling by Texas Parks and Wildlife Department personnel with 184-m gill nets, 742 sharks representing 10 species were caught in the seven major bay systems of Texas from November 1975 to October 1980. Sharks accounted for less than 1% of the total catch. Bull shark (Carcharhinus leucas), blacktip shark (C. limbatus) and bonnethead (Sphyrna tiburo) comprised 88% of the total shark catch. Catch rate of sharks varied between bay systems, ranging from 94.7 to 1.4 sharks per 1000 hours in Matagorda Bay and upper Laguna Madre systems, respectively. Sharks were most abundant during summer (June-August) with a catch rate of 149.6 sharks per 1000 hours and least abundant in winter (December-February) with a catch rate of 0.4 shark per 1000 hours. Influences of water temperature, salinity and distance from nearest Gulf-to-bay pass on availability of sharks were considered.

INTRODUCTION

Little is known of the occurrence, distribution and relative abundance of sharks in Texas bays. Studies conducted over the years in various Texas bays have occasionally mentioned sharks but no study based on coastwide data collection has been made.

The Coastal Fisheries Branch of Texas Parks and Wildlife Department, using a variety of gear, has conducted an extensive sampling program to monitor fish

populations in Texas bays since November 1975 (Matlock et al. 1978, Matlock and Weaver 1979, Hegen and Matlock 1980, Hegen 1981). Primary emphasis of this program has been directed towards those fishes of sport and commercial value; however, data on all fishes encountered have been recorded.

Sharks were caught primarily in gill nets and data obtained with this gear were the only data included in this study. Examination of these data offered an opportunity to delimit occurrence, distribution and relative abundance of sharks in Texas bays.

Recognition is due those members of the Bay Finfish Monitoring Program who collected the data. Thanks are extended to Patricia Johansen, Gary Matlock, Helmut Hegen, Tom Heffernan and Roy Johnson for reviewing the manuscript and to Nancy Ziegler for typing it. Bill Mercer assisted in preparation of maps and figures.

MATERIALS AND METHODS

From November 1975 through October 1980 overnight gill net samples were collected in seven major bay systems of Texas (Galveston, Matagorda, San Antonio, Aransas and Corpus Christi Bays and the upper Laguna Madre and lower Laguna Madre).

Gill nets were constructed of monofilament nylon webbing hung in a single layer on a one-half basis to a float line with uniformly spaced plastic floats and to a sink line with a solid lead core. Nets were 1.2 m deep and 184 m long consisting of separate 46-m sections of 76-, 102-, 127- and 152-mm stretched mesh webbing attached together in order of increasing mesh size to form a single net.

Sampling stations in each bay system were selected randomly on a monthly basis from a list of ≤ 40 stations (except ≤ 80 stations in Galveston Bay system) from November 1975 through September 1977 and from a list of ≤ 100

stations from October 1977 through October 1980. Each station was at least 1.6 km of continuous shoreline from any other station. Half the stations selected each month were sampled during the first two weeks of the month; the other half were sampled during the last two weeks of the month. Some months were not sampled in all years (April and May 1976, July and September 1977 and June-September 1978).

Nets were set perpendicular to the shoreline and anchored at each end with the smallest mesh end on shore. Nets were set within 1 hour before sunset and retrieved within 1 hour after sunrise. Number of hours (to nearest 0.1 hour) between set and retrieval times was recorded as a measurement of effort.

All fish caught in each mesh size were identified to species and measured (total length to nearest 1 mm).

Water temperature (to nearest 0.5 C) and salinity (to nearest 0.5 ‰) were taken at net retrieval.

Distances from stations to nearest Gulf-to-bay passes in each bay system were determined in nmi from NOAA nautical charts dated 1976-1979 and converted to nearest km.

Scientific and common names follow those of Robins et al. (1980).

RESULTS

During this study, 1550 gill net samples were collected in which 742 sharks, representing 10 species, were caught. Effort totaled 20,848.7 hours. Sharks accounted for only 0.88% of the total fish catch during the 5-year study. Shark percentage of the total catch varied seasonally with 0.01% in winter (December-February), 0.55% in spring (March-May), 3.19% in summer (June-August) and 0.83% in fall (September-November).

Bull sharks (Carcharhinus leucas) were caught in 10% of the samples and

represented 65% of the total shark catch. Other sharks caught in order of decreasing abundance included blacktip shark (C. limbatus), bonnethead (Sphyrna tiburo), scalloped hammerhead (S. lewini), Atlantic sharpnose shark (Rhizoprionodon terraenovae), lemon shark (Negaprion brevirostris), finetooth shark (C. isodon), spinner shark (C. brevipinna), sandbar shark (C. plumbeus) and smalltail shark (C. porosus). Only bull shark and bonnethead were caught in all bay systems. Sharks were widely distributed in all bay systems except the Laguna Madre (Figs. 1-4).

Sharks were most abundant in the Matagorda Bay system with a catch of 94.7 sharks per 1000 hours and least abundant in the upper Laguna Madre system with 1.4 sharks per 1000 hours (Table 1).

Monthly catches of sharks per 1000 hours ranged from 195.8 in July to 0.0 in January (Table 2). Sharks were most abundant in summer (149.6 per 1000 hours), followed by fall (40.5 per 1000 hours), spring (23.3 per 1000 hours) and winter (0.4 per 1000 hours) (Table 2). Year to year differences in catch rates were not considered since some months, especially peak shark months (June, July, August and September), were not sampled in all years.

Sharks were caught over wide ranges of water temperature (13.0-32.0 C), salinity (0.0-39.0 ‰) and distance from nearest Gulf-to-bay pass (5-51 km) (Table 3). There was little difference among most species with respect to catches at different water temperatures; 79% of the sharks were caught between 24 and 30 C. Differences between species were evident for salinity and distance. Bull and blacktip sharks were caught over wide ranges of salinity (0.0-37.0 ‰ and 0.0-36.0 ‰, respectively) and distance (5-51 km and 7-49 km, respectively). Scalloped hammerhead and Atlantic sharpnose sharks were caught over narrower ranges of salinity (23.0-37.0 ‰ and 23.0-39.0 ‰, respectively) and

distance (5-25 km and 6-15 km, respectively).

The largest shark caught was a 1850-mm bull shark; the smallest was a 370-mm Atlantic sharpnose shark (Table 4). On the average, bull sharks were the largest caught. Length frequencies for each species are shown in Figure 5.

Number and size of sharks increased with ascending gill net mesh size; 57% of the sharks (949 mm average) were caught in the 152-mm mesh section, 30% (884 mm average) in the 127-mm mesh section, 11% (685 mm average) in the 102-mm mesh section and 2% (628 mm average) in the 76-mm mesh section.

DISCUSSION

Sharks are quite abundant in waters over the continental shelf. They frequent inshore coastal waters and occasionally enter estuaries especially during warmer months. Of the 22-32 shark species (Order Squaliformes) found in Texas coastal waters (Baughman 1950, Baughman and Springer 1950, Hoese 1958, Parker 1972, Walls 1975, Hoese and Moore 1977), only 10 were represented in Texas bays during this study, 8 of which have been reported previously from one or more Texas bays.

Differences in species composition and especially number of sharks caught were evident among bay systems. Reasons for these differences are not entirely clear for all species. Bay systems differ in physical configuration, proximity of Gulf-to-bay passes and freshwater inflow. Water temperature had the greatest apparent influence on availability of sharks, as evidenced by observed differences in monthly and seasonal catch rates. It is unknown whether bay shark populations seek deeper bay waters or migrate to the Gulf in winter.

Sharks encountered during this study were generally small (903 mm average overall). This is probably a function of one or more of the following: gear limitations including mesh size and strength of webbing, possible differential distribution of small and large sharks between Gulf and bay waters and between shallow and deep bay waters, and sampling limitations of setting nets only in relatively shallow bay margins.

Bull shark, blacktip shark and bonnethead were the most commonly caught species during this study. Parker (1972) listed the distribution of these sharks as marine and estuarine along the Texas coast. Remaining species were infrequently caught during this study and were listed by Parker (1972) only as marine in their distributions along the Texas coast.

The bull shark was the most abundant shark caught in this study; however, its predominance was limited to Galveston, Matagorda, San Antonio and Aransas Bay systems. Young bull sharks appear to have a high tolerance and perhaps an affinity for less saline waters (10-20 ‰). Catch rates of this species were low in Corpus Christi Bay, upper Laguna Madre and lower Laguna Madre systems where freshwater inflows are comparatively low. Hoese and Moore (1977) noted that the bull shark is the only shark in low salinity estuaries and that it even penetrates fresh water. Gunter (1938) reported the capture of a bull shark in the Atchafalaya River at Simmesport, Louisiana which is over 99 km, by river, from the Gulf of Mexico. Gunter (1956) listed the bull shark as a euryhaline marine fish.

The blacktip shark, less abundant but almost as widespread as the bull shark, was caught in all bay systems except upper Laguna Madre; however, Simmons (1957) reported blacktip sharks to be occasionally plentiful in upper Laguna Madre system during less saline periods. Hoese (1958) noted that this species

occasionally enters bays. Walls (1975) stated that young blacktip shark are often common in brackish water, but are seldom found in fresh water. One blacktip shark was caught at 0.0 ‰ salinity in this study.

The bonnethead was as abundant as the blacktip shark, but was limited in its penetration of low salinity areas. It was caught in all bay systems, but was most abundant in lower Laguna Madre and Corpus Christi Bay systems where it was the predominant shark taken. Both bay systems have direct Gulf accesses and higher salinities. Bonnetheads often stay close inshore and venture into saltier bays (Hoese and Moore 1977).

The scalloped hammerhead was caught only in lower Laguna Madre and Galveston Bay systems; however, it has been reported from Aransas Bay system by Simmons (1951). Scalloped hammerheads generally were caught at higher salinities and shorter distances from Gulf-to-bay passes than other species taken during this study. The scalloped hammerhead is the common hammerhead of the Texas Coast (Hoese and Moore 1977) and is apparently the most common hammerhead in shallow inshore Gulf waters (Walls 1975).

The Atlantic sharpnose shark was caught in all but two bay systems, San Antonio and Aransas. They were caught over similar ranges of salinity and distance from nearest Gulf-to-bay pass as the scalloped hammerhead. The 22 Atlantic sharpnose sharks taken during this study seems surprisingly small after a review of the literature. According to Cody et al. (1981) this species represented about 78% of the number of fish caught on bottom longlines in inshore Gulf waters of the central Texas coast. Hoese and Moore (1977) stated that the Atlantic sharpnose shark is one of the most common inshore species along the Texas coast, with young appearing in the surf and saltier estuaries during summer. Briggs (1958) classified this species as euryhaline in Florida.

The lemon shark was caught only in Galveston, Matagorda and San Antonio

Bay systems. It has been reported once previously from a Texas bay system, Aransas (Gunter 1945). The lemon shark is an inshore species which appears sporadically in summer along the northern Gulf (Walls 1975). Hoese and Moore (1977) noted that the young of this species are often caught in marsh channels during summer.

The finetooth shark was caught in all but three bay systems: Aransas and Corpus Christi Bays and upper Laguna Madre. However, it has been reported from Aransas Bay system by Simmons (1951) and from upper Laguna Madre system by Simmons (1957). The finetooth shark is common along the northern Gulf coast but uncommon in estuaries (Walls 1975). Its young are common in the surf zone, except during winter (Hoese and Moore 1977).

The spinner shark was caught only in San Antonio Bay system on four occasions. It has not been reported previously from a Texas bay system in any of the literature reviewed. The spinner shark is apparently common inshore (Hoese and Moore 1977) and moderately common in offshore waters of the northern Gulf (Walls 1975). Cody et al. (1981) reported this species from inshore Gulf waters along the central Texas coast.

The sandbar shark was caught only in San Antonio Bay system on two occasions during November 1975. It has not been reported previously from a Texas bay system in any of the literature reviewed. This species is listed as being present in Texas waters by Baughman and Springer (1950) and Hoese (1958) without annotation. The sandbar shark is uncommon in the Gulf (Hoese and Moore 1977), but common along the Atlantic coast of the United States (Casey 1964).

One smalltail shark was taken in Corpus Christi Bay system in November 1979. It has been reported once previously from a Texas bay system, lower Laguna Madre (Baughman and Springer 1950). This shark is poorly known in the northern Gulf, with the few records coming from offshore waters (Walls 1975);

however, it has been reported from inshore Gulf waters along the central Texas coast by Hildebrand (1954) and Cody et al. (1981). Hoese (1958) listed this species from Gulf waters off Port Aransas, Texas.

The 10 species caught during this study do not necessarily represent the only sharks that enter Texas bays. Any species that occurs inshore in Gulf coastal waters of Texas has the potential for entering Texas bays, especially in the vicinity of Gulf-to-bay passes, when conditions (water temperature, salinity and tides) are favorable.

Significance of sharks in Texas bays is difficult to assess from results of this study; however, it is clear that their significance is variable between bay systems and seasons and between localities within bay systems for certain species. By number caught, sharks represented <1% of the total catch during this study, but >3% in summer. The number of sharks caught in this study is probably an underestimate, judging from extensive net damage occasionally incurred.

Although in small numbers compared to other fishes, sharks are caught and retained by sport fishermen in Texas bays (McEachron et al. 1981). Discarded specimens of Carcharhinus and Sphyrna from sport catches were observed by Johnson (1977) near the mouths of the San Bernard and Brazos Rivers of Texas.

Retention of sharks by commercial fishermen in Texas bays has probably been minimal over the years since little or no market for shark meat has existed in Texas. However, future market potentials for shark may be favorable. Whether or not Texas bays could support a limited shark fishery is unknown.

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Table 1. Gill net catch rates (No./1000 hours) of sharks in Texas bay systems during November
1975-October 1980 with number of samples in which sharks were caught (in parenthesis).

Table 1. Gill net catch rates (No./1000 hours) of sharks in Texas bay systems during November 1975-October 1980 with number of samples in which sharks were caught (in parenthesis).

Species	Bay system						
	Galveston	Matagorda	San Antonio	Aransas	Corpus Christi	Upper Laguna Madre	Lower Laguna Madre
Bull	12.4 (15)	76.8 (61)	45.8 (44)	27.9 (35)	1.4 (2)	0.4 (1)	0.3 (1)
Blacktip	9.2 (11)	9.3 (12)	1.7 (4)	0.7 (2)	5.4 (4)	0.0 (0)	2.4 (4)
Bonnethead	0.3 (1)	3.6 (4)	3.7 (7)	1.4 (3)	6.4 (5)	0.4 (1)	14.0 (12)
Scalloped hammerhead	6.3 (5)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	2.0 (5)
Atlantic sharpnose	1.7 (3)	2.1 (1)	0.0 (0)	0.0 (0)	0.3 (1)	0.7 (2)	2.4 (2)
Lemon	0.6 (1)	1.4 (3)	1.4 (4)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)
Finetooth	0.3 (1)	1.4 (3)	0.3 (1)	0.0 (0)	0.0 (0)	0.0 (0)	1.0 (1)
Spinner	0.0 (0)	0.0 (0)	3.1 (4)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)
Sandbar	0.0 (0)	0.0 (0)	2.7 (2)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)
Smalltail	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.3 (1)	0.0 (0)	0.0 (0)
All species	30.8	94.7	58.8	29.9	13.9	1.4	22.1

Table 2. Monthly and seasonal gill net catch rates (No./1000 hours) of sharks in Texas bays during November 1975-October 1980.

Species	Winter			Spring			Summer			Fall			
	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Season
Bull	0.4	0.0	0.0	1.3	19.2	37.9	15.5	29.4	124.0	104.9	58.1	41.2	29.1
Blacktip	0.0	0.0	0.4	1.7	5.2	3.9	3.2	10.7	17.4	25.7	7.7	0.9	3.9
Bonnethead	0.0	0.0	0.0	2.1	3.0	3.2	2.6	2.7	26.1	33.9	12.1	0.9	2.7
Scalloped hammerhead	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.3	20.7	3.1	4.4	0.0	0.9
Atlantic sharpnose	0.4	0.0	0.0	0.0	0.0	2.4	0.6	0.0	4.4	8.2	5.5	0.5	1.1
Lemon	0.0	0.0	0.0	0.4	0.0	1.6	0.6	1.3	1.1	5.1	0.0	0.0	0.0
Finetooth	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.3	2.2	1.0	1.1	0.5	0.4
Spinner	0.0	0.0	0.0	0.0	0.7	2.4	0.8	0.0	0.0	0.0	0.0	2.3	0.9
Sandbar	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.4
Smalltail	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2
All species	0.8	0.0	0.4	5.5	28.0	51.3	23.3	50.8	195.8	182.0	88.8	46.3	40.5

Table 3. Means, standard deviations and ranges for water temperature and salinity as measured at gill net retrieval and distance of catch from nearest Gulf-to-bay pass for each shark

Table 3. Means, standard deviations and ranges for water temperature and salinity as measured at gill net retrieval and distance of catch from nearest Gulf-to-bay pass for each shark species caught in Texas bays during November 1975-October 1980.

Species	No. Obsvs.	Temperature (C)			Salinity (‰)			Distance (km) ^a		
		Mean	SD	Range	Mean	SD	Range	Mean	SD	Range
Bull	480	26.0	2.9	13.0-30.0	15.6	9.1	0.0-37.0	26	11	5-51
Blacktip	88	25.8	3.8	15.0-31.0	20.8	9.4	0.0-36.0	25	14	7-49
Bonnethead	87 ^b	26.8	3.1	16.5-32.0	29.6	5.1	20.0-38.5	15	8	6-49
Scalloped hammerhead	28 ^b	27.6	2.6	17.5-29.5	33.9	3.5	23.0-37.0	10	5	5-25
Atlantic sharpnose	22	26.7	2.7	19.0-29.5	29.4	3.8	23.0-39.0	11	3	6-15
Lemon	10	26.4	2.1	22.0-28.0	26.6	5.4	13.5-31.5	17	9	7-32
Finetooth	9	27.1	2.0	23.0-30.0	24.2	9.7	5.0-33.0	19	7	7-26
Spinner	9	24.3	3.4	16.5-27.0	26.4	2.9	23.5-30.0	15	11	12-28
Sandbar	8	21.1	0.4	21.0-22.0	16.6	4.4	15.0-27.5	31	5	18-33
Smalltail	1	17.0			28.0			18		
All Species	742	26.1	3.1	13.0-32.0	19.3	10.2	0.0-39.0	23	12	5-51

^a On average there was <1 station per bay system located <5 km from a Gulf-to-bay pass.
^b Salinity not measured on one occasion.

Table 4. Total length (mm) means, standard deviations and ranges for sharks caught with gill nets in Texas bays during November 1975-October 1980, with birth and maximum total lengths from the literature.

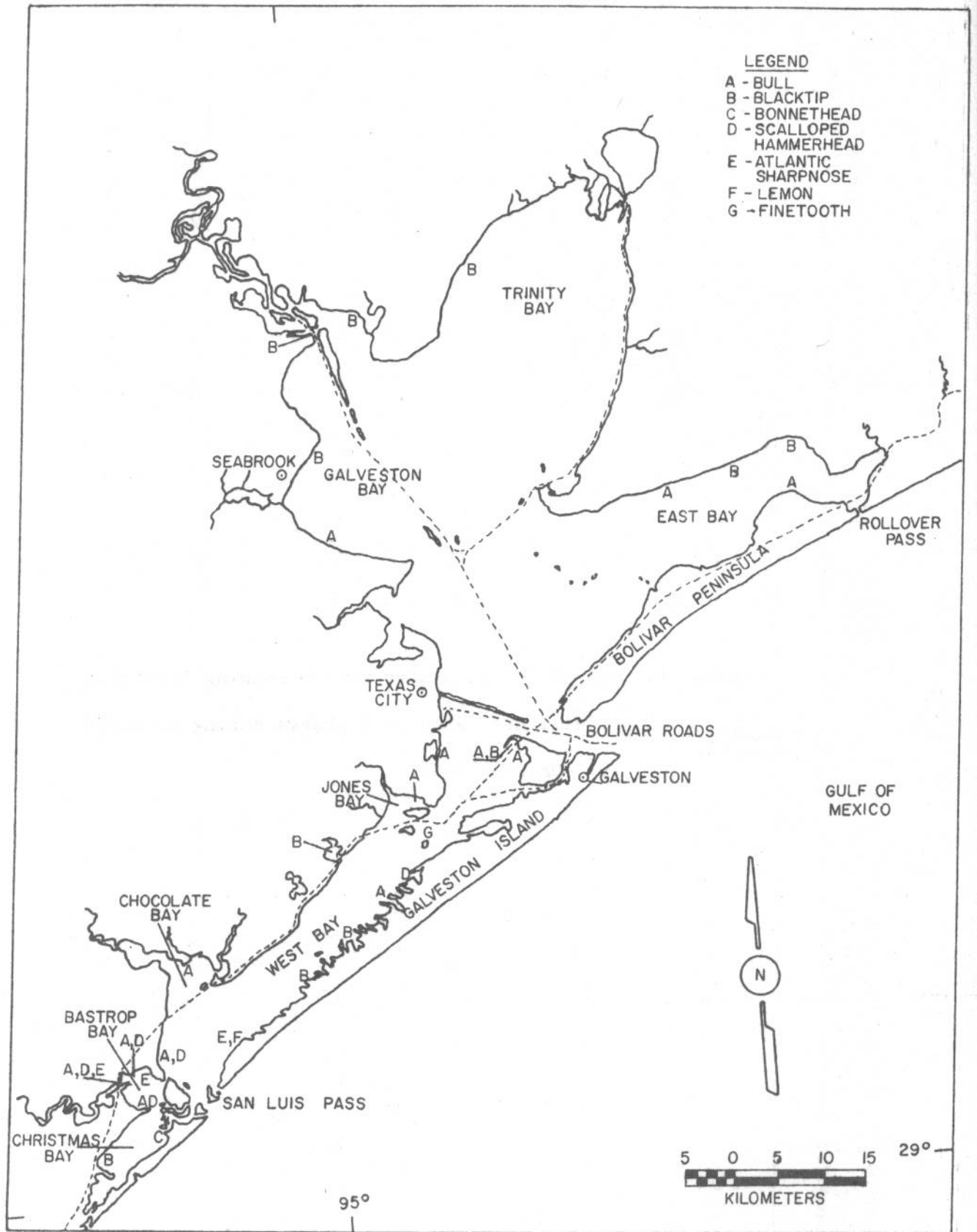
Species	No. Measured	Mean	SD	Range	Sizes ^a from literature	
					Birth	Maximum
Bull	463	998	203	644-1850	620-750	3658
Blacktip	85	874	194	396-1465	580-660	2438
Bonnethead	85	722	146	485-1470	278-369	1829
Scalloped hammerhead	28	580	84	489-695	245-450	3962
Atlantic sharpnose	21	838	396	370-1530	267-406	1200
Lemon	10	706	122	455-884	550-660	3353
Finetooth	9	651	78	550-790	≤ 451	1524
Spinner	9	979	362	670-1497		2438
Sandbar	8	902	50	840-970	432-660	2438
Smalltail	1	690				1235

^a Assembled from the following sources: Bigelow and Schroeder (1948); Springer (1950, 1960), Hildebrand (1954), Reid (1954), Hoese and Moore (1958), Pullen (1960), Casey (1964), Clark and von Schmidt (1965), Swingle (1971), Moffett (1975) and Hoese and Moore (1977).



Figure 1. Map of Galveston Bay system showing locations of gill net catches of sharks during November 1975-October 1980.





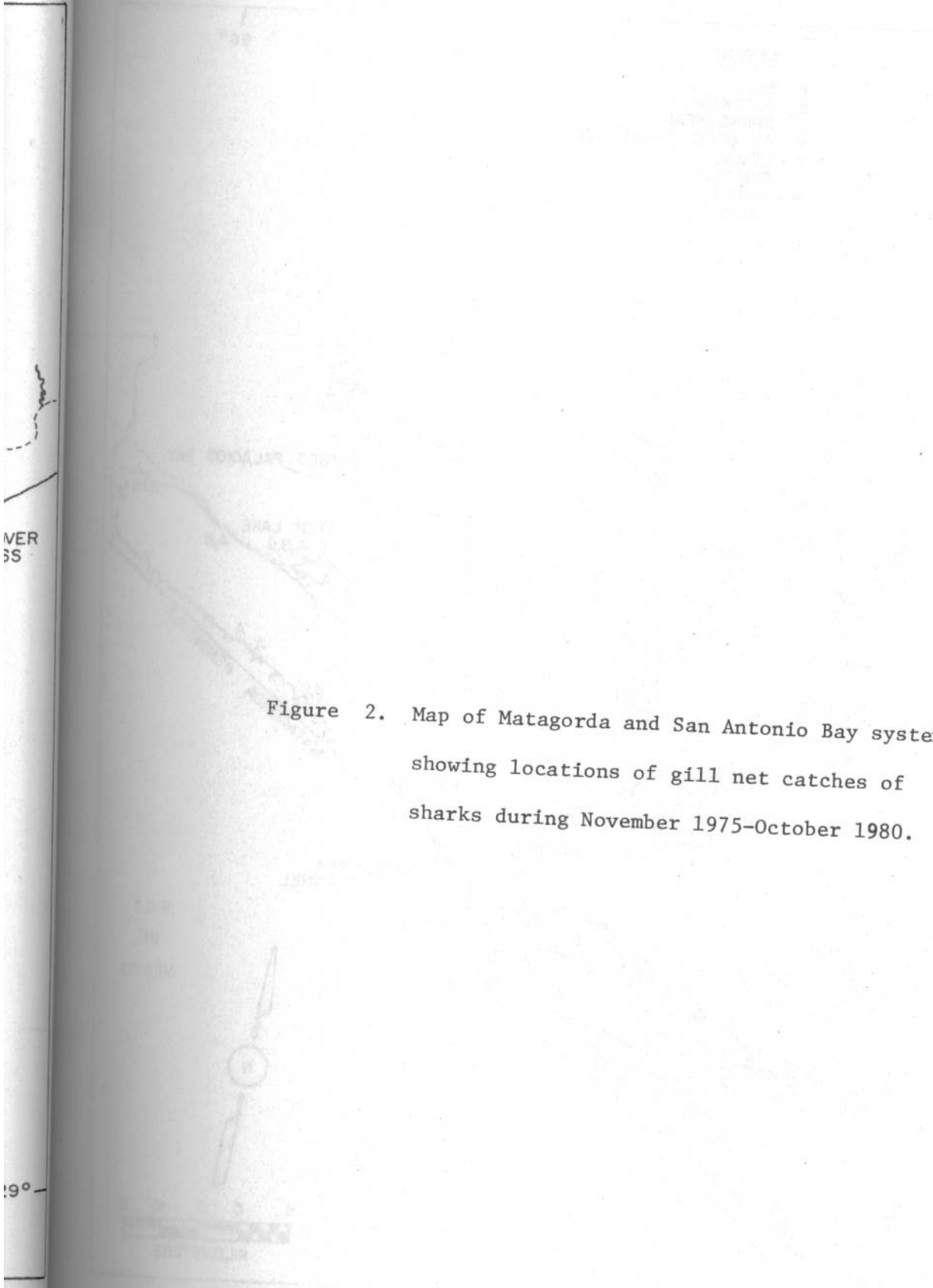
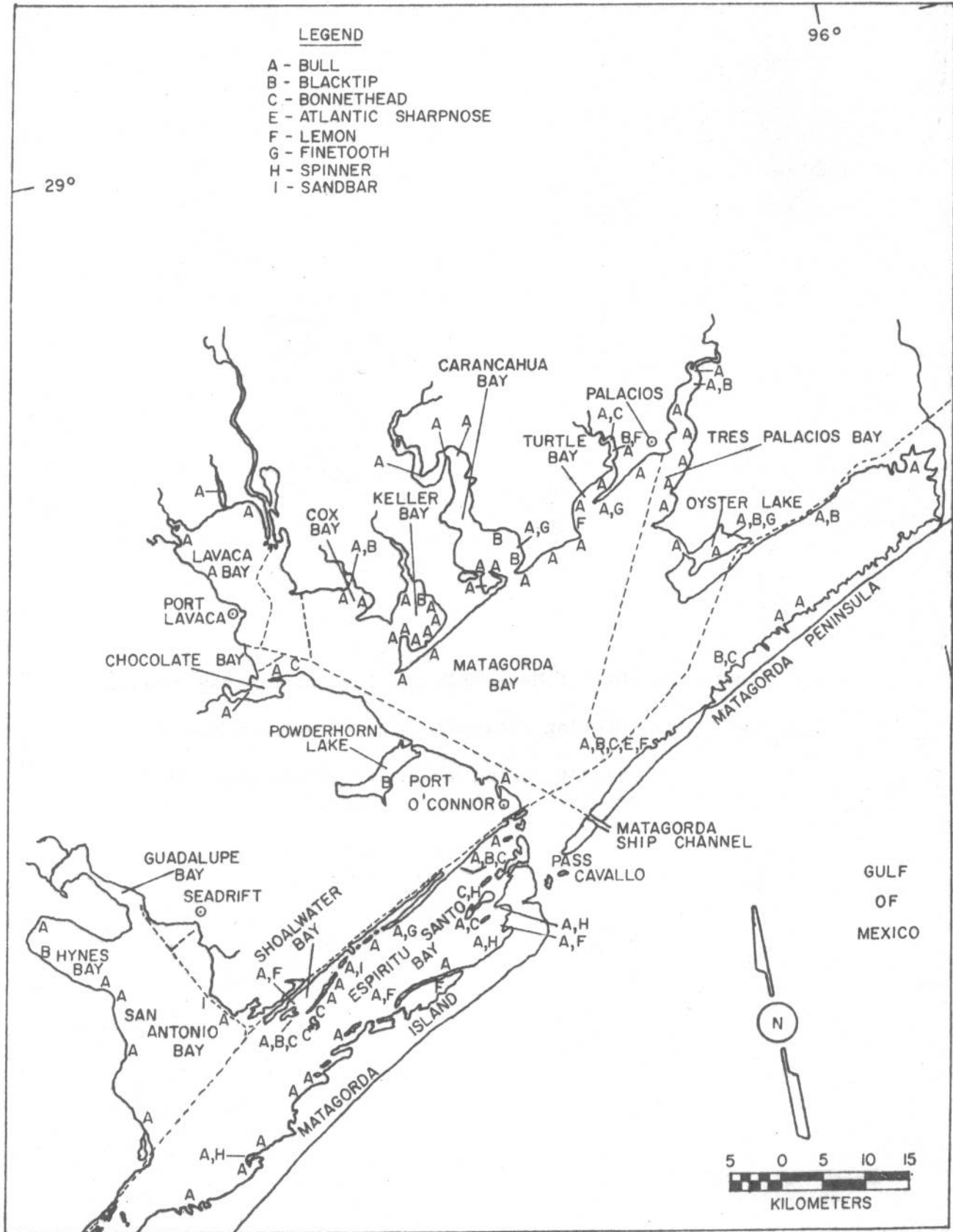


Figure 2. Map of Matagorda and San Antonio Bay systems showing locations of gill net catches of sharks during November 1975-October 1980.

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LEGEND

- A - BULL
- B - BLACKTIP
- C - BONNETHEAD
- E - ATLANTIC SHARPNOSE
- F - LEMON
- G - FINETOOTH
- H - SPINNER
- I - SANDBAR

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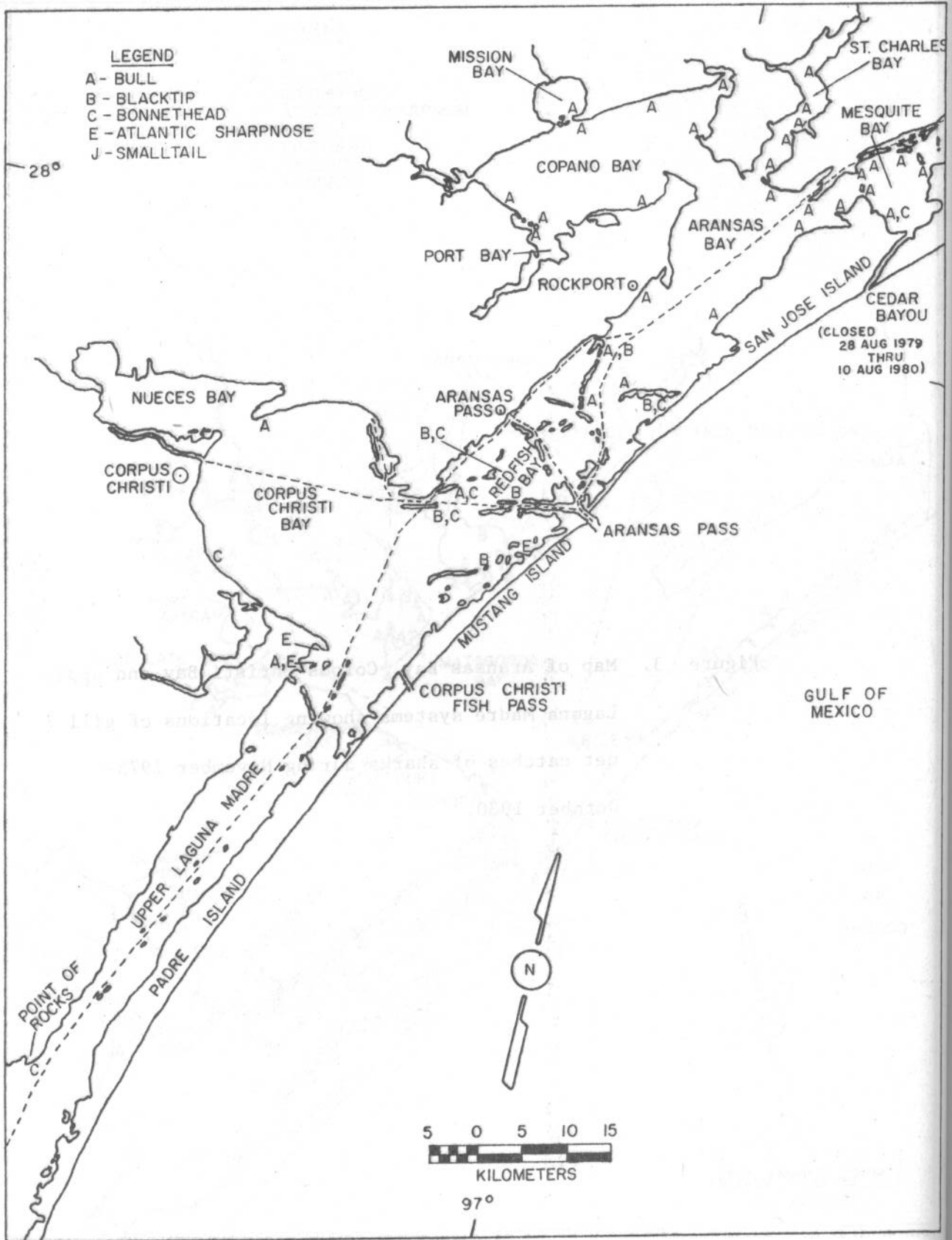
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Figure 3. Map of Aransas Bay, Corpus Christi Bay and upper Laguna Madre systems showing locations of gill net catches of sharks during November 1975-October 1980.



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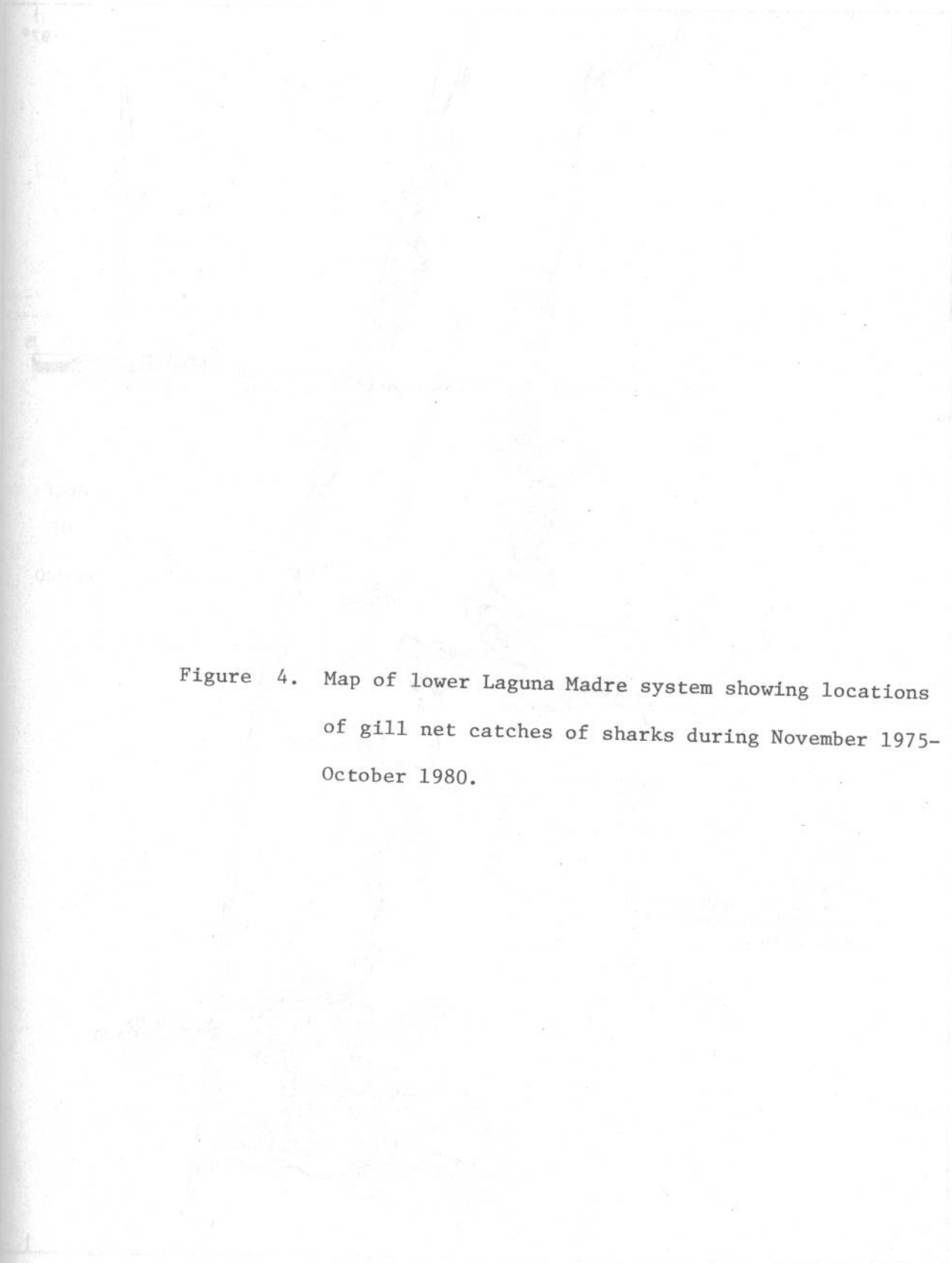
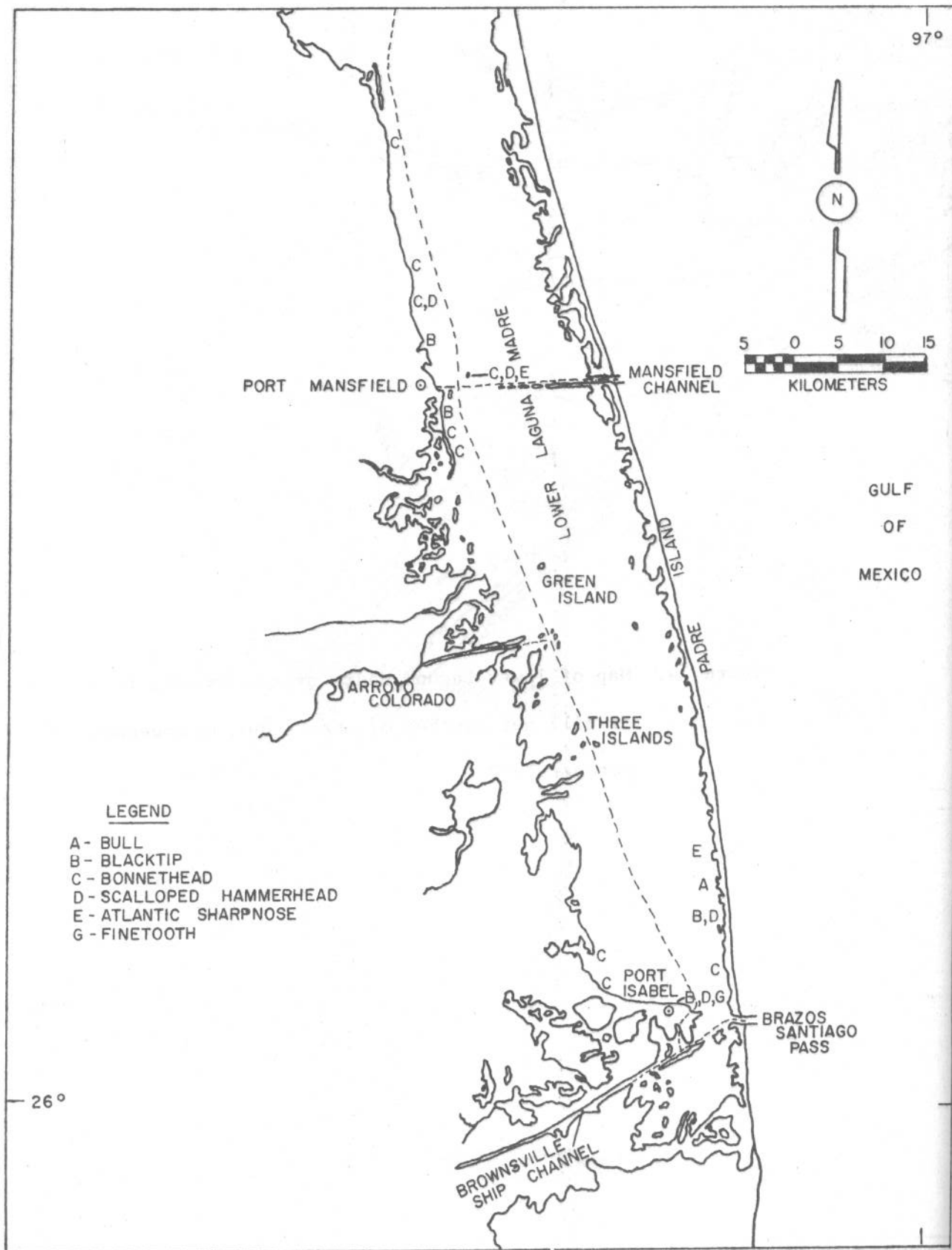


Figure 4. Map of lower Laguna Madre system showing locations of gill net catches of sharks during November 1975-October 1980.



- LEGEND**
- A - BULL
 - B - BLACKTIP
 - C - BONNETHEAD
 - D - SCALLOPED HAMMERHEAD
 - E - ATLANTIC SHARPNOSE
 - G - FINETOOTH

26°

97°

5 0 5 10 15
KILOMETERS

GULF OF MEXICO

BRAZOS SANTIAGO PASS

BROWNSVILLE SHIP CHANNEL

PORT ISABEL

THREE ISLANDS

GREEN ISLAND

ARROYO COLORADO

PORT MANSFIELD

MANSFIELD CHANNEL

MADRE

LAGUNA LOWER

ISLAND PADRE

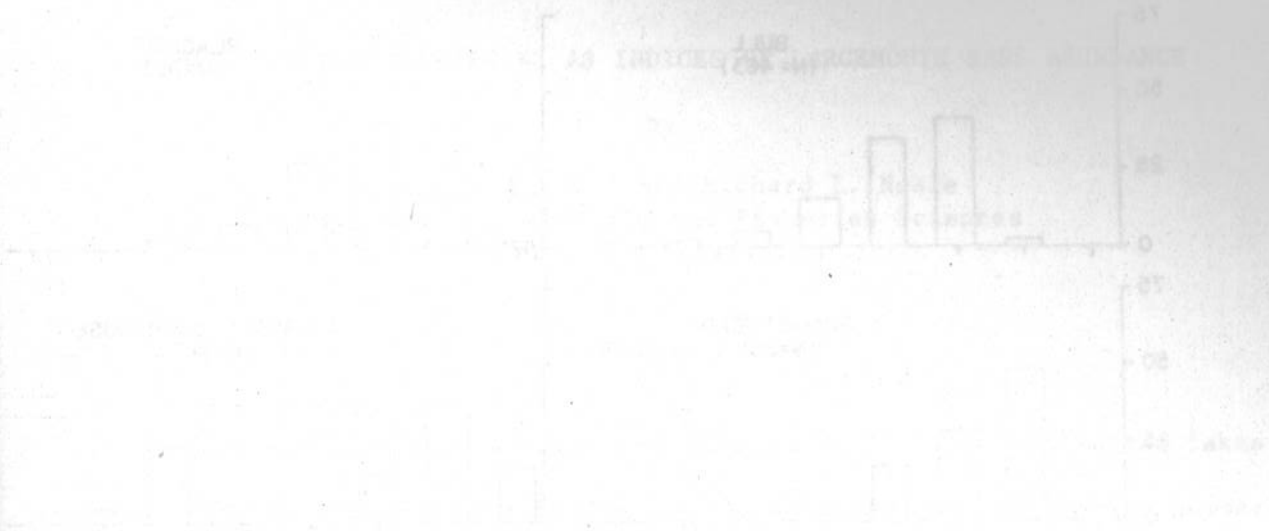
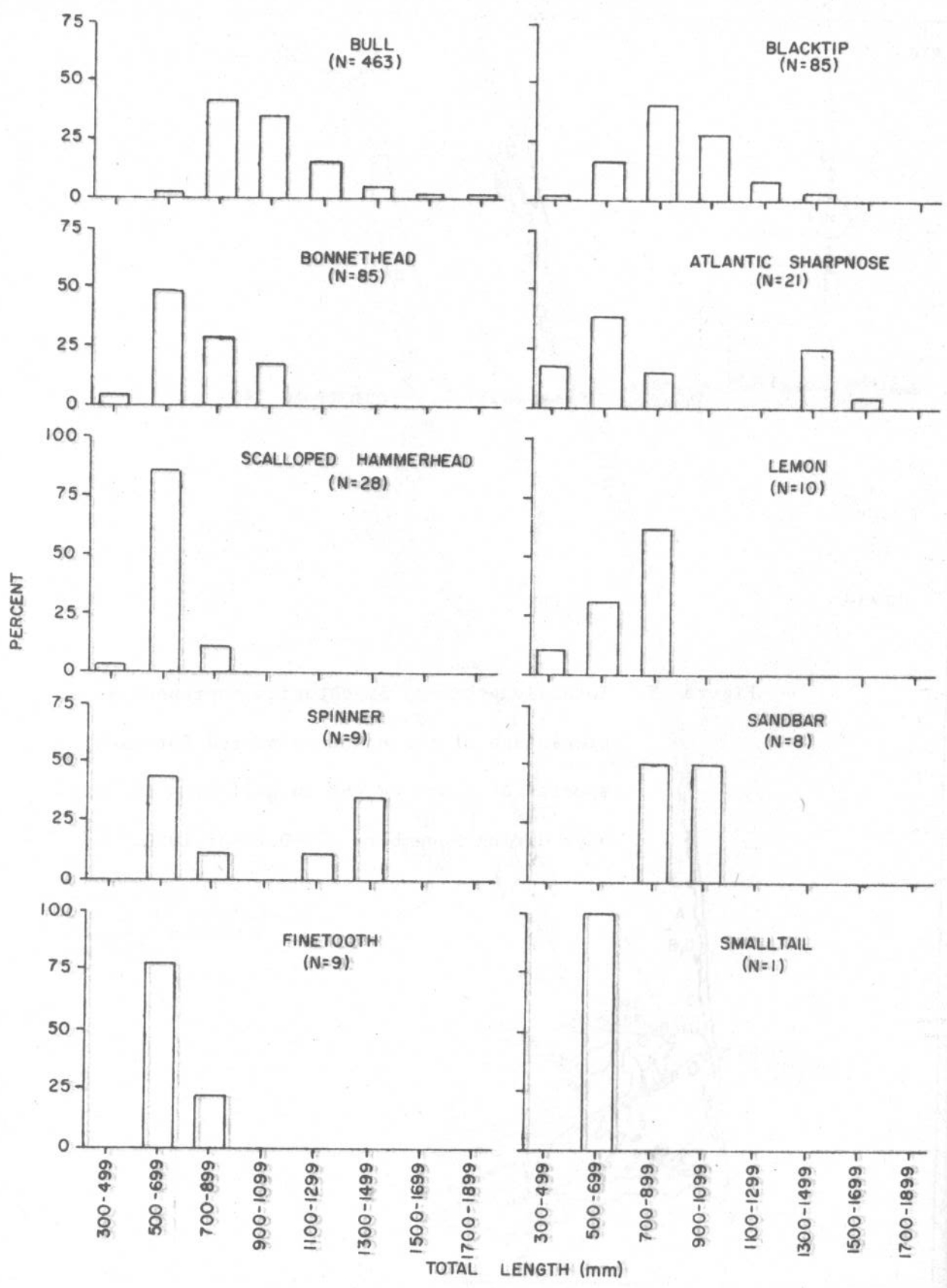


Figure 5. Total length (mm) frequencies expressed as a percentage of the number measured for each species of shark caught in gill nets in Texas bays during November 1975–October 1980.



SEINING AND ELECTROFISHING AS INDICES OF LARGEMOUTH BASS ABUNDANCE

by

Blair C. Brenner and Richard L. Noble
Department of Wildlife and Fisheries Sciences
Texas A&M University

ABSTRACT

Largemouth bass populations were sampled in 12 flood prevention lakes during 1979-80 and 11 during 1980-81. Data were analyzed to compare number and size composition of bass captured in common seine and bag seines, and electrofishing samples. Fall and spring samples were compared to Petersen population estimates. Reliability of seining and electrofishing samples as indicators of length distribution and of population size will be discussed.

THE EFFICIENCY OF REMOVING FOOD ITEMS
FROM FISH WITH GLASS TUBES

By

Eugene R. Gilliland, Conrad W. Kleinholz, and Michael D. Clady
Oklahoma Cooperative Fishery Research Unit
Oklahoma State University
Stillwater, Oklahoma 74078

ABSTRACT

The stomach contents of live striped bass (Morone saxatilis), white bass (M. chrysops), striped bass x white bass hybrids, largemouth bass (Micropterus salmoides), and white crappie (Pomoxis annularis) were examined and removed using glass tubes. This technique removed more than 90% of the food by weight or volume from all species except white crappie. We removed shad (Dorosoma spp.), sunfishes (Lepomis spp.), inland silversides (Menidia beryllina), crayfish, benthic invertebrates, zooplankton, and adult and larval insects from the species studied. This technique is fast, efficient, and usually does not require sacrificing the fish.

INTRODUCTION

Many methods such as gastroscopes (Dubets 1954), stomach flushing devices (Seaburg 1957; Foster 1977), and emetics (Jernejcic 1969), have been used for sampling the stomach contents of live fish. White (1930) first used glass tubes to remove the stomach contents of brook trout (Salvelinus fontinalis). They were later used for large walleye (Stizostedion vitreum), yellow perch (Perca flavescens), largemouth bass (Micropterus salmoides), smallmouth bass

(M. dolomieu), spotted bass (M. punctulatus), and young-of-the-year largemouth and spotted bass (Forney 1974; Neiman 1978; Clady 1980; Van Den Avyle and Roussel 1980). However, the only quantitative evaluation of the technique was made by Van Den Avyle and Roussel (1980). We further evaluated the method using essentially pelagic fishes--striped bass (Morone saxatilis), white bass (M. chrysops), striped bass x white bass hybrids, and white crappie (Pomoxis annularis). Largemouth bass were also examined.

MATERIALS AND METHOD

Fish were collected from Sooner Lake, a 2185-hectare power plant cooling water reservoir in north-central Oklahoma, from April 1980 through April 1981 with gill nets, trap and hoop nets, seines, electrofishing gear, and hook and line sampling. The technique used was similar to that outlined by Van Den Avyle and Roussel (1980) and briefly is as follows: an appropriately sized glass tube, ranging in diameter from 4 to 50 mm, is selected and inserted through the fish's mouth and esophagus and into the stomach. A visual inspection is made through the tube to determine if food is present and the end of the tube is sealed with the thumb or palm of the hand. As the tube is withdrawn a slight vacuum is created which aids in removing the food items. After examination with the tube, selected fish were dissected and their stomachs removed and emptied into separate sample containers. All samples were labeled and preserved in 70% ethanol. Samples were returned to the lab for determination of weights (g) and volumes (ml).

RESULTS

Using the glass tubes, we examined 798 fish of the following ranges in total length: striped bass and hybrids, 180 to 600 mm; largemouth bass, 100

to 460 mm; white bass, 120 to 350 mm; and white crappie, 90 to 250 mm. We removed the stomachs from 82 hybrids, 4 striped bass, 5 largemouth bass, 48 white bass, and 16 white crappie (Table 1). Use of the tubes resulted in the removal of the entire stomach contents from 100% of the striped bass and largemouth bass, 95% of the hybrids, 90% of the white bass, and 75% of the white crappie (Table 1). Percentages by weight and volume were about equal; slight variations (< 2%) seemed to be a result of inaccuracy in measurement. We removed more than 90% of the food by weight and volume from all species except white crappie. The poorer results with this species were probably due to the presence of a small down-turned pouch at the posterior end of the stomach. Another source of error occurred in the examination of three hybrids that had eaten large gizzard shad (Dorosoma cepedianum). The shad could be seen through the tube but could not be removed because the largest tube that would fit through the predator's mouth would not fit over the prey. In one other hybrid, two large gizzard shad were seen but their orientation in the stomach prevented the tube from passing over either of them.

DISCUSSION

We removed Dorosoma spp., Lepomis spp., Menidia beryllina, crayfish, benthic macroinvertebrates, zooplankton, and adult and larval insects from the species studied. We did not estimate survival of the fish after they had been examined with the tubes and released; however, in another study by Clady and Luker (1980) almost 100% of the young-of-the-year largemouth and spotted bass examined by this method were later recovered alive in seines. We concur with Van Den Avyle and Roussel (1980) on the high efficiency of the technique for use with largemouth bass. In addition, we have shown that the use of glass tubes for the removal of stomach contents of several important pelagic game

fish is fast, efficient, and usually does not require sacrificing the fish. We, like Van Den Avyle and Roussel (1980) also conclude that the technique is limited only by unusual stomach anatomy or by the large size of certain prey items.

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Table 1. Species of fish collected from Sooner Lake, Oklahoma, April 1980 through April 1981, number examined with glass tubes, number dissected, number and percent from which tubes removed all food, and the range and mean of percent (by weight or volume) of food removed.

	Number examined	Number dissected	All food removed		% food removed	
			No.	%	Range	Mean
Striped bass x white bass hybrid	224	82	78	95	0-100	95
Striped bass	7	4	4	100	100	100
Largemouth bass	122	5	5	100	100	100
White bass	317	48	43	90	20-100	90
White crappie	128	16	12	75	0-100	75
All species	798	155	141	91	0-100	92

LENGTH-WEIGHT RELATIONSHIPS AND
AVERAGE GROWTH RATES FOR STRIPED, WHITE
AND STRIPED x WHITE HYBRID BASS IN TEXAS

by

John A. Prentice
Texas Parks and Wildlife Department
Ingram, Texas 78025

and

Philip P. Durocher
Texas Parks and Wildlife Department
Austin, Texas 78744

ABSTRACT

Total length-weight relationships and average growth rates were calculated for 835 striped bass (Morone saxatilis) from 16 reservoirs, 594 white bass (M. chrysops) from 18 reservoirs and 866 striped x white hybrid bass from 23 reservoirs in Texas. Results are presented statewide, by river systems and by ecological regions within the State. Hybrid bass exhibited the fastest growth rate for the first 2 yr of life and were intermediate in growth rate in later years. Striped bass attained the greatest size in the second through sixth years of life. White bass exhibited the slowest growth rate. Growth rates in different river systems or ecological regions for each of the fishes were similar.

INTRODUCTION

Continued and projected increases in fishing pressure (Branton et al. 1975; U. S. Fish and Wildlife Service 1977) are requiring fishery managers to make concentrated efforts to manage fisheries resources and maintain acceptable fishing. Fish age and growth information has become a major part of most work directed to rational fishery management (Lagler 1952;

Chugunova 1963; Houser and Bross 1963; and Bagenal 1974). Validity of the use of fish ageing techniques has been shown for waters of the southern United States (Brown 1960; Houser and Bross 1963; Prather 1967; and Prentice and Whiteside 1975), and growth rate data could therefore be used in Texas to improve fishery management decision making.

This study was conducted to provide and consolidate length-weight relationship and growth rate information for striped bass (Morone saxatilis), white bass (M. chrysops) and striped x white hybrid bass in Texas waters on statewide, river system and ecological region bases. This information can therefore aid fisheries managers as a quick reference to improve fishery management decision making.

MATERIALS AND METHODS

A total of 835 striped bass (from 16 reservoirs), 594 white bass (from 18 reservoirs) and 866 striped x white hybrid bass (from 23 reservoirs) were collected between 1973 and 1980 for use in this study. Collections were part of fish population sampling conducted throughout Texas by biologists of the Texas Parks and Wildlife Department. Total length, weight, sex and scale samples were taken from each fish. Age determinations followed methods similar to those presented by Carlander (1961), Carlander and Whitney (1961) and Prentice and Whiteside (1975).

Length-weight relationships using total length were calculated as described by Everhart et al. (1975). Growth was determined by the Lee method of back calculating lengths of fishes (Lagler 1952). Growth trends were plotted using the Von Bertalanffy growth model fitted to growth increment data for statewide collections only (Rafail 1973). The model describes growth by the relationship:

$$l_t = L_{\infty} (1 - e^{-K(t-t_0)})$$

where l_t = length at age t

L_{∞} = the maximum (predicted) length for the population

e = base of the natural log (2.7183)

K = growth coefficient

t_0 = time when length would theoretically be 0.

Growth statistics were calculated statewide and for river systems and/or ecological regions of Texas within which three or more samples were made. River system and ecological region division boundaries followed those used by Prentice and Durocher (1978). Fishes collected in reservoirs falling within each division were used to determine these values.

RESULTS AND DISCUSSION

Analyses of covariance revealed no differences in slopes between length-weight relationships for female and male striped ($F_{0.05(1,445)} = 0.08$) and striped x white hybrid ($F_{0.05(1,430)} = 2.56$) bass statewide. But a significant difference ($F_{0.05(1,341)} = 5.76$) between slopes for female and male white bass length-weight relationships was found. Therefore a single regression (sexes combined) was calculated statewide, for each river system and each ecological region for striped (Table 1) and striped x white hybrid bass (Table 2). A regression for each sex and sexes combined was calculated for white bass on statewide basis but only a single regression (sexes combined) was calculated for river systems and ecological regions (Table 3).

Striped x white hybrid bass exhibited the fastest growth rate of the three fishes during the first 2 yr of life, then striped bass grew fastest (Figure 1). Bishop (1967) reported similarly that striped bass grew

slower than hybrid bass until age 27 months. White bass exhibited slowest growth rate and smallest size attainment throughout this study.

Annual growth increments of true basses studied in Texas waters (Tables 4, 5 and 6) revealed growth in Texas was generally faster than reported in areas outside the State (Lewis 1950; Tompkins and Peters 1951; Jenkins and Elkin 1957; Stevens 1958; Forney and Taylor 1963; Fritz 1963; Bishop 1967; Mensinger 1970; Williams 1970; Ware 1974; and Wigfall and Barkuloo 1975).

No effort was made to explain length-weight relationships or growth rates. However, this study should supply fishery managers with a reference for striped bass, white bass and striped x white hybrid bass length-weight and growth rate data in Texas.

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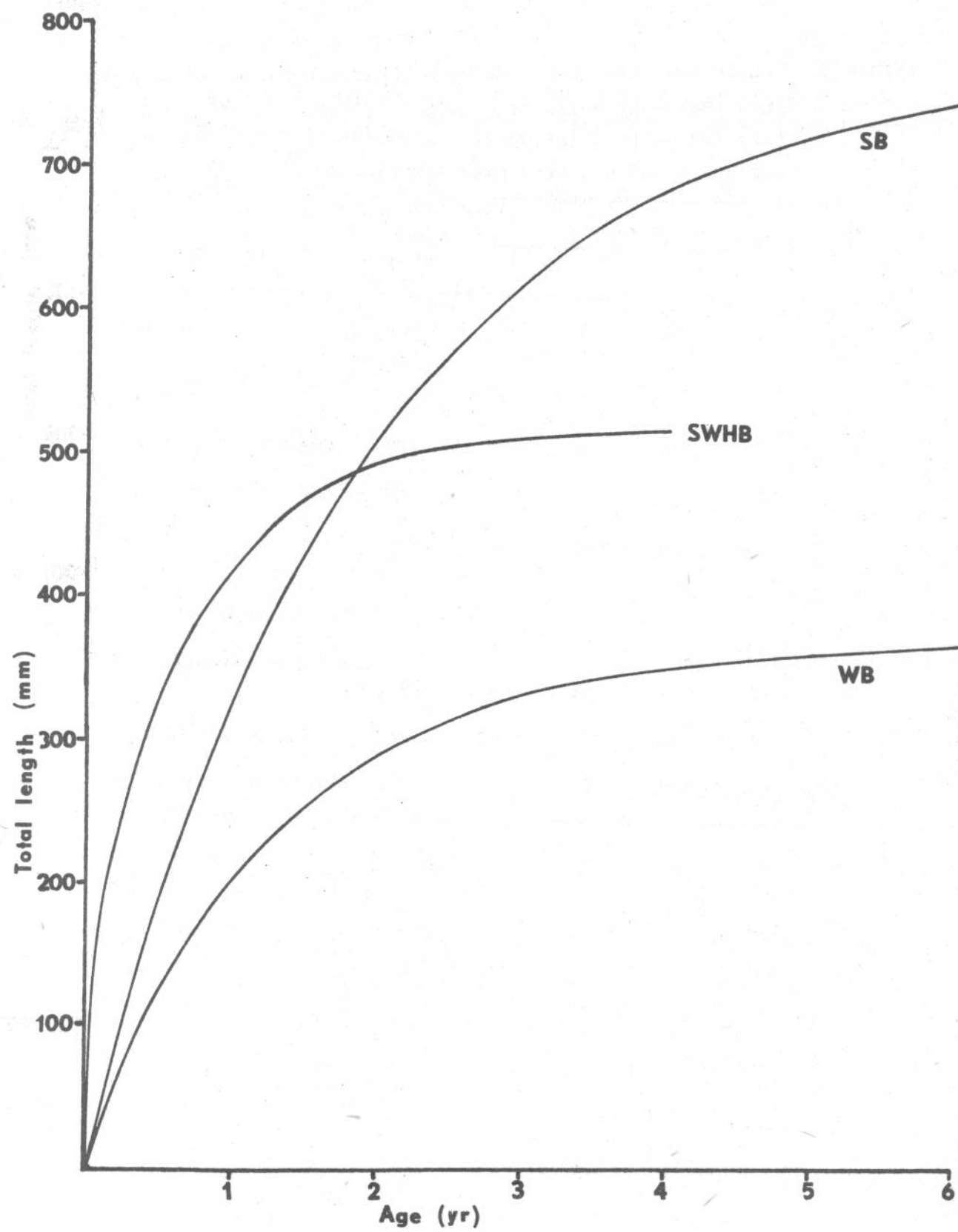
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Table 5. Annual growth increments of white bass (sexes combined) in Texas waters on statewide, river system and ecological region bases, 1973-1980.

Sample location	Sample size	Total length (mm) at year					
		1	2	3	4	5	6
Statewide	498	235	293	323	342	359	363
River system							
Trinity-San Jacinto	107	254	313	347			
Brazos	137	265	325	363	379		
Colorado	66	262	321	348	346		
Ecological region							
Cross Timbers & Prairies	156	258	330	359	378		
Edwards Plateau	90	203	286	330	345	357	
High & Rolling Plains	103	200	263	302	329	360	

Figure 1. Von Bertalanffy statewide average growth curves of striped bass (SB) — $L_t = 739.89 (1 - e^{-0.4316(t + 0.0168)})$, white bass (WB) — $L_t = 365.93 (1 - e^{-0.7747(t + 0.0213)})$, and striped x white hybrid bass (SWHB) — $L_t = 523.57 (1 - e^{-1.2920(t + 0.0012)})$, 1973-1980.



TOXAPHENE RESISTANCE IN MOSQUITOFISH
FROM THE RIO GRANDE VALLEY OF TEXAS

by

James K. Andreasen and Nadine E. Hall

U. S. Fish and Wildlife Service
Columbia National Fisheries Research Lab
Victoria Field Station
P.O. Box 2087
Victoria, Texas 77902

ABSTRACT

Mosquitofish collected from an agricultural area of the Rio Grande Valley showed a 30-fold increased tolerance to toxaphene over mosquitofish not normally exposed to agricultural pesticides from the Aransas National Wildlife Refuge. The results show that the resistant fish, by bioaccumulation of toxaphene, may pose a hazard to predatory species of fish and wildlife.

TEXAS FISHERIES WORKERS
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TEXAS CHAPTER
AMERICAN FISHERIES SOCIETY

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TEXAS FISHERIES WORKERS DIRECTORY
1981

Abilene 79603: Texas Parks and Wildlife Department. 5325 North Third. (915)
692-0921

Bamberg, R., District Management Biologist. Reservoir management in northwest Texas.

Amarillo 79109: Bureau of Reclamation, Southwest Region. (806) 378-5463

Ratteree, J. H., Environmental Specialist. Aquatic and wetland ecology.
Hill, A. W., Regional Affairs Officer. Fisheries biology and environmental analysis.

Anahuac 77514: Texas Agricultural Extension Service. P. O. Box 699. (713) 267-3185

Buckner, J., Marine County Agent. Marine Fisheries Extension

Angleton 77515: Texas Agricultural Extension Service. Rt. 2 Armory. (713) 849-5711

Graham, G., Marine Fisheries Specialist. Commercial Marine Fishes.
Holcomb, H., Mariculturist Specialist. Shrimp.
Harrell, J., Mariculturist Specialist. Shrimp.
Moss, C., Marine County Agent. Marine Fisheries Extension.

Arlington 76019: The University of Texas at Arlington, Department of Biology,
(817) 273-2871

Arnott, H., Ph.D., Dean of Science and Professor. Cellular basis of eyeshine in fishes.
Hellier, T., Ph.D., Professor. Aquatic pollution abatement. The structure and dynamics of natural fish populations.
Whitmore, D., Ph.D., Associate Professor. Biochemical genetics of fish. Fish physiology.
McMahon, R., Ph.D., Associate Professor. Physiological Ecology of Mollusks.
Sandgren, C., Ph.D., Assistant Professor. Phycology.
Bible, D., Graduate Student. Thermal effects on macrophytic degradation of vegetation.
Ibarra, J., Graduate Student. Population structure and dynamics of snails.
Williams, C., Graduate Student. Physiology ecology of Corbicula.
Looney, L., Graduate Student. Heavy metals in fish.

Austin 78712: The University of Texas at Austin, Department of Zoology and Botany. (512) 471-7131

Cameron, J., Ph.D., Associate Professor. Physiology of Marine organisms.
Hubbs, C., Professor. Fishes.
Kitting, C., Ph.D., Associate Professor. Plankton.
Bittner, G., Ph.D., Associate Professor. Neurophysiology.
Larimer, J., Ph.D., Professor. Neurophysiology.
Maguire, B., Ph.D., Professor. Limnology.
Reeder, W., Ph.D., Professor. Galapagos.
Cole, G., Ph.D., Associate Professor. Marine Fungi.
McMillan, C., Ph.D., Professor. Marine Grasses.
Starr, R., Ph.D., Professor. Algae.
Bold, H., Ph.D., Professor. Algae.

VanBalen, A., PH.D. Professor. Marine Plant Physiology.
 Armstrong, N. PH.D. Professor. Marine Ecosystems.

Austin 78744: Texas Parks and Wildlife Department. 4200 Smith School Road
 (512) 479-4800

Adams, G., Fish and Wildlife Permit Program Leader. Scientific Permits.
 Bounds, R., Management Coordinator. Administration of Inland Fisheries
 Management Programs.
 Bryan, C., Shellfish Program Director. Administration of Shellfish
 Management Programs.
 Carter, N., Research Coordinator. Administration of Inland Fisheries
 Research Program.
 Durocher, P. Research Analyst. Inland Fisheries Research and Management.
 Green, A., Research Analyst. Coastal Fisheries Research and Management.
 Kemp, R., Director of Fisheries. Administration of Coastal, Inland,
 Noxious Vegetation and Resource Protection Programs.
 Leigon, C., Fisheries Staff Services. Fisheries Administration.
 Matlock, G., Finfish Program Director. Administration of Finfish Programs.
 (Marine Fish Population Director.)
 Moore, T., Chief of Coastal Fisheries. Administration of Branch Programs.
 Osborn, M., Fishery Biologist. Coastal Recreational Creel Survey Analyst.
 Palafox, S., Pollution Surveillance Program Leader. Water Pollution.
 Potter, F., Wildlife Biologist. Non-game and Endangered Fishes.
 Roberts, J., Environmental Assessment Program Leader. Environmental
 Documents.
 Roberts, L., Chief of Resource Protection. Administration of Branch
 Programs.
 Rutledge, W., Hatchery Coordinator. Administration of Fish Hatchery
 Program.
 Simmons, E., Chief of Inland Fisheries. Administration of Branch Programs.
 (Life History Study of Aquatic Organisms.)

Austin 78701: United States Fish and Wildlife Service. Area Office. 300 East
 Eighth, Room G-155. (512) 397-5433

Elkin, R., Assistant Area Manager. Fisheries Resources, Hatchery.
 Bentley, J., Assistant Area Manager. Endangered Species, Animal damage
 control.
 Funizelli, N., Contract Management Team Leader. Marine Fishes.
 King, B., Project Officer. Marine Biology.
 Cole, W., Assistant Area Manager. Environment, Marine Biology.
 Rogers, H., Fish and Wildlife Biologist. Project Planning in Fisheries
 resources.

Austin 78766: Hydrolab P.O. Box 9406 (512) 255-8841

Flynn, J., Vice President Marketing. Water Quality Monitoring Equipment.

Austin 78711: Texas Department of Water Resources. P.O. Box 13087, Capitol
 Station. (512) 475-4344.

Powell, G.L., Hydrologist. Ichthyology, Aquatic Ecology.
 Brock, D.A., Hydrologist Assistant. Ichthyology, Estuarine Ecology.

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Bay City 77414: Texas Agricultural Extension Service. 326 Courthouse. (713) 245-8415

Younger, W., Marine County Agent. Marine Fisheries Extension.

Beaumont 77701: Soil Conservation Service. 855 I-H 10 South. Room 135. (713) 839-2675

Zeman, M., Biologist. Aquaculture.

Brownsville 78520: Texas Parks and Wildlife Department. Route 2, Box 537 (512) 350-4490

Rice, K., Area Biologist. Finfish Abundance in Bays.

Breuer, J., Area Biologist. Finfish harvest in Bays.

Burnet 78611: Inks Dam National Fish Hatchery. Route 2. (512) 793-2474

Young, C., Hatchery Manager. Culture of Largemouth Bass, Channel Cat and Rainbow Trout.

Cole, G., Assistant Hatchery Manager. Culture of Largemouth Bass, Channel Cat and Rainbow Trout.

Canyon 79015: Texas Parks and Wildlife Department. Box 835. (806) 655-4341

Kraai, J., District Management Biologist. Reservoir and Walleye Management in Panhandle.

Parks, J., Assistant Management Biologist. Reservoir and Walleye Management in Panhandle.

College Station 77843: Texas Agricultural Extension Service. 110 Nagel Hall (913) 845-7471

Davis, J., Fish Specialist. Fisheries Management and Aquaculture.

Steinbach, D., Fish Specialist. Fisheries Management.

Johnson, S., Fish Disease Specialist. Fish Diseases.

Nichelson, R., Seafood Technologist. Commercial Marine Fisheries.

Rowland, B., Seafood Consumer Education Specialist. Seafood Nutrition.

Lang, M., Seafood Marketing Specialist. Marketing.

Swartz, N., Marine Economist. Economist.

College Station 77843: Texas A & M University. Department of Wildlife and Fisheries Sciences. (713) 845-6751

Klussman, W., Ph.D., Professor. Fisheries Administration.

Noble, R., Ph.D., Professor. Management of Small Impoundments.

Neill, W., Ph.D., Associate Professor. Thermal Ecology.

Stickney, R., Ph. D., Associate Professor. Aquaculture.

Chittenden, M., Ph. D., Associate Professor. Marine Fisheries.

Clark, W., Ph. D., Associate Professor. Limnology.

Betioli, P., M.S., Resident Associate. Biological Vegetation Control.

Kosinski, R., Ph.D., Assistant Professor. Stream and Pond Ecology.

Robinson, E., Ph. D., Assistant Professor. Fish Physiology and Nutrition.

Linton, P., Ph.D., Associate Professor. Marine Fisheries.

McGeachin, P., Ph. D., Instructor. Aquaculture.

Strawn, K., Ph. D., Professor. Mariculture.

Corpus Christi 78411: United States Fish and Wildlife Services Ecological Services Field Office, Suite 24, Commerce One. 4455 South Padre Island Drive. (512) 888-3346

Perez, R., Field Supervisor. Environmental Impact and Mitigation.
 French, J., Fish and Wildlife Biologist. Environmental Impact and Mitigation.
 Lazarine, P., Fish and Wildlife Biologist. Environmental Impact and Mitigation.
 Spiller, S., Fish and Wildlife Biologist. Environmental Impact and Mitigation.
 Meineke, D., Fish and Wildlife Biologist. Environmental Impact and Mitigation.
 Ramirez, P., Fish and Wildlife Biologist. Environmental Impact and Mitigation.

Corpus Christi 78410: Texas Agricultural Extension Service. Route 2 Box 589 (512) 265-9201

Miget, R., Marine Fish Specialist. Commercial Marine Fishes.
 Lawrence, A., Mariculturist Specialist. Shrimp.
 Chamberlian, G., Mariculturist Specialist. Shrimp.
 Hegen, A., Seafood Consumer Education. Nutrition.

Corpus Christi 78418: Texas Parks and Wildlife Department. 4121 Laguna Shores Drive. (512) 937-2931

Martin, J., Area Biologist. Finfish Abundance in Bays.
 Spiller, K., Area Biologist. Finfish Harvest in Bays.
 Harrington, R., Environmental Biologist. Habitat Protection.

Dallas 75201: Texas Utilities Company. 2001 Bryan Tower. (214) 653-4794

Michel, L., Biologist. Environmental Impact Studies.

Denison 75020: Texas Parks and Wildlife Department. Route 4 Box 157 (214) 786-2389

Hysmith, B., District Management Biologist. Reservoir Management in North Central Texas.
 Moczygemba, J., Assistant Management Biologist. Reservoir Management in North Central Texas.

Dickinson 77539: Texas Agricultural Extension Service. 5115 Highway 3 (713) 337-2595

Read, J., Marine County Agent. Marine Fisheries Extension.

Electra 76360: Texas Parks and Wildlife Department. Route 1. (817) 586-1576

Warren, J., Hatchery Superintendent. Culture of Striped Bass, Forage and Striper Hybrids.

Fort Hood 76544: Department of the Army. Ft. Hood Fish and Wildlife Section. Building 1938 (817) 685-3114

Herbert, D., Chief, F & W Section. Lake and Pond Management.

Fort I

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Oja,

Kewl

Jones, B., Bio-technician. Stocking; survey and control.
 Drysdale, V., Bio-technician. Stocking; survey and control.
 Walsh, P., Bio-technician. Stocking; survey and control.

Fort Worth 76135: Texas Parks and Wildlife Department. Route 10 Box 626
 (817) 237-3536

Boyd, H., Hatchery Superintendent. Culture of Smallmouth Bass and Forage.

Fort Worth 76114: Texas Parks and Wildlife Department. 6200 Hatchery Road
 (817) 732-0761

Guest, C., Research Unit Leader. Temperature Tolerance, Sunfish Hybridization, Forage Introductions.

Gray, C., Regional Fish Culturist. Striped Bass Culture Leader.

Mulford, C., Research Biologist. Florida Bass Evaluation, Striped Bass Behavior.

Farquhar, B., Research Biologist. Pond Fertilization, Forage Introduction.

Fort Worth 76101: Texas Electric Service Company. 115 West Seventh Street (817)
 336-9411

Nawrocki, S., Environmental Specialist. Temperature Tolerance, Aquaculture.

Fort Worth 76115: South Technical Service Center. P.O. Box 6567 (817) 334-5287

Smith, E., Biologist. Aquaculture (Catfish, Trout, and Crawfish), Farm Pond Management, Water Quality, Aquatic Weed, Their Identification and Control.

Fort Worth 76102: United States Fish and Wildlife Services Field Office. Fritz
 Lanham Building, 819 Taylor Street. (817) 334-2961

Johnson, J., Field Supervisor. Environmental Impact and Mitigation.

Cloud, T., Fish and Wildlife Biologist. Coal Coordinator.

Curtis, D., Fish and Wildlife Biologist. Environmental Impact and Mitigation.

Bierman, H., Fish and Wildlife Biologist. Environmental Impact and Mitigation.

Butler, D., Fish and Wildlife Biologist. Instream Flow Specialist.

Davis, C., Fish and Wildlife Biologist. Environmental Impact and Mitigation.

McCollum, M., Fish and Wildlife Biologist. Environmental Impact and Mitigation.

Colbert, B., Fish and Wildlife Biologist. Environmental Impact and Mitigation.

Lyles, E., Fish and Wildlife Biologist. Environmental Impact and Mitigation.

Galveston 77550: United States Fish and Wildlife Ecological Services Field Office
 United States Post Office and Courthouse Building Room 229, 601
 Rosenberg Street. (713) 763-1211 Extension 586

Mendoza, C., Fish and Wildlife Biologist. Environmental Impact and Mitigation.

Halstead, B., Fish and Wildlife Biologist. Environmental Impact and Mitigation.

Werner, F., Fish and Wildlife Biologist. Environmental Impact and Mitigation.

Mueller, A., Fish and Wildlife Biologist. Environmental Impact and Mitigation.

Oja, R., Fish and Wildlife Biologist. Environmental Impact and Mitigation.

Kewley, W., Fish and Wildlife Biologist. Environmental Impact and Mitigation.

Graford 76045: Texas Parks and Wildlife Department. Box 13 (817) 779-2301

Palmer, B., Hatchery Superintendent. Culture of Striped Bass, Forage and Trout.

Houston 77028: Texas Parks and Wildlife Department. Route 5 Box 563-A. (713) 456-9350

Menn, C., District Management Biologist. Reservoir Management in South East Texas.

Houston 77028: Bob Hambric, 9129 Chatwood. (713) 633-9492

Hambric, B., Fisheries Management Consultant. Management of Private Waters.

Huntsville 77340: Texas Parks and Wildlife Department. Route 5 Box 89. (713) 295-7216

McCarty, G., Hatchery Superintendent. Culture of Florida Bass, Forage and Catfish.

Ingram 78025: Texas Parks and Wildlife Department. Junction Star Route Box 62. (512) 866-3356

Luebke, R., Regional Director. Nile Perch and Peacock Bass Research.

Prentice, J., Research Unit Leader. Electrophoresis, Age and Growth, and Hybridization.

Sonski, A., Research Biologist. Temperature Tolerance, Electrophoresis.

Kulzer, K., Research Biologist. Length Limit Regulations, Flathead Catfish Reproduction.

Miranda, S., Research Biologist. Reservoir Categorization, Stocking Evaluation.

Lee, A., Hatchery Superintendent. Culture of Exotic Fishes.

Jasper 75951: Texas Parks and Wildlife Department. Fish Hatchery. (713) 384-2221

Bowling, B., Hatchery Superintendent. Culture of Florida Bass and Forage.

Jasper 75951: Texas Parks and Wildlife Department. 638 East Crockett. (713) 384-9572

Seidensticker, P., District Management Biologist. Reservoir Management in South East Texas.

Helton, R., Assistant Management Biologist. Reservoir Management in South East Texas.

La Porte 77571: Texas Parks and Wildlife Department. 105 San Jacinto. (713) 471-3200

Wenger, A., Regional Director. Inland Fisheries Field Administration.

Johnson, R., Regional Director. Coastal Fisheries Field Administration.

Lewisville 75067: Texas Parks and Wildlife Department. Box 68 (214) 434-1468

Engelhardt, T., Hatchery Superintendent. Culture of Catfish, Sunfish and Forage.

Lubbock 79409: Texas Tech University, Department of Range and Wildlife Management. (806) 742-2843

Murphy, B., Ph. D. Assistant Professor. Reservoir Fisheries Management.
Biochemical Genetics of Fish. Aquatic Pollution Ecology.
Temple, A., Graduate Student. Aquatic Ecology of Pesticides.

Marshall 75670: Texas Parks and Wildlife Department. 205 Martindale Drive East (214) 938-1007

Toole, J., District Management Biologist. Reservoir Management in North East Texas.
Ryan, J., Assistant Management Biologist. Reservoir Management in North East Texas.

Nacogdoches 75962: Stephen F. Austin State University, Department of Biology (713) 569-3601

Rainwater, F., Ph. D. Associate Professor. Ichthyology.
McCullough, J., Ph. D. Professor. Limnology.
VanDover, B., Ph. D. Associate Professor. Phycology.
Taylor, R., Graduate Student. Invertebrate Zoology.
McCulloch, D., Graduate Student. Limnology.
Pickrell, W., Graduate Student. Limnology.
Reat, V., Graduate Student. Aquatic Biology.
Jones, J., Graduate Student. Aquatic Biology.
Reed, C., Graduate Student. Limnology.
Wilson, V., Graduate Student. Limnology.
Sidnell, J., Graduate Student. Limnology.
Sturm, G., Graduate Student. Limnology.

Overton 75684: Texas Agricultural Extension Service. Box 38 (214) 834-6191

Higginbotham, B., Fish Specialist. Fish Specialist.

Palacios 77465: Texas Parks and Wildlife Department. Star Route Box 385. (512) 972-5483

Colura, B., Project Leader. Red Drum Reproduction and Pond Culture.
Wakefield, C., Culture Biologist. Red Drum Reproduction and Pond Culture.
Dailey, J., Area Biologist. Finfish Abundance in Bays.
Weixelman, M., Area Biologist. Finfish Harvest in Bays.

Port Aransas 78373: University of Texas Marine Science Institute. Port Aransas Laboratory. (512) 749-6739

Wohlschlag, D., Ph. D. Professor. Metabolism, Dynamics.
Arnold, C., Ph. D., Research Scientist. Finfish Mariculture.
Holt, J., Ph. D., Resident Associate. Early Life History of Marine organisms.
Thomas, P., Ph. D., Resident Associate. Comparative Endocrinology.
Lin, H., Ph. D., Resident Associate. Fish Biochemical Nutrition.
Checldey, D., Ph. D., Assistant Professor. Larval Fish Ecology.
Kitting, C., Ph. D., Assistant Professor. Foraging Ecology of Marine Organisms.
Bird, J., Graduate Student. Plankton Interactions.
Holt, S., Resident Associate. Early Life History of Fishes.

Rabalias, N., Graduate Student. Physioecology, Decopod Crustaceans.
 Rabalias, S., Resident Assistant. Benthic Ecology and Invertebrate
 Systematics. Sea Turtle Ecology.

Kalke, R., Resident Associate. Estuarine Zooplankton and Peracaridean
 Ecology, Systematics.

Flint, R., Ph. D., Resident Associate. Benthic Ecology.

Pulich, W., Ph. D., Resident Associate. Physiological Ecology of Seagrasses

Rosson, R., Ph. D., Assistant Professor. Marine Microbiology.

Port Lavaca 77979: Texas Agricultural Extension Service. P.O. Box 86 (512)
552-9747

Surovik, J., Marine County Agent. Marine Fisheries Extension.

Rockport 78382: Texas Parks and Wildlife Department. P.O. Box 1707 (512)
729-2328

Heffernan, T., Regional Director. Coastal Fisheries Field Administration.

Johansen, P., Editor. Editorial Review of Scientific Reports.

McEacheron, L., Project Leader. Recreational and Commercial Finfish
 Harvest.

Hagen, E., Project Leader. Finfish Abundance in Bays.

Cody, T., Project Leader. Monitoring of Gulf Waters.

Green, L. Area Biologist. Finfish Abundance in Bays.

Osburn, H., Area Biologist. Finfish Abundance in Bays.

Hostettler, P., Area Biologist. Finfish Harvest in Bays.

Fuls, B., Gulf Biologist. Monitoring of Gulf Waters.

Spears, R., Chemist. Water Pollution.

Rockport 78382: Texas Agricultural Extension Service. Courthouse (512) 729-1211

Messinger, J., Marine County Agent. Marine Fisheries Extension.

San Angelo 76904: Texas Parks and Wildlife Department. 3407 South Chadbourne
(915) 655-1528

Provine, B., Regional Director. Smallmouth Bass Program Leader.

Campbell, L., Regional Fish Culturist. Walleye Culture Leader.

Wagner, W., Hatchery Superintendent. Culture of Smallmouth Bass, Catfish,
 Walleye, Striped Bass, and Hybrid Striped Bass.

Ralph, J., Chemist. Water Pollution.

San Angelo 76901: Texas Parks and Wildlife Department. Route 4 Box 472 (915)
944-1711

Clary, W., Hatchery Superintendent. Culture of Striped Bass and Catfish.

San Angelo 76901: Texas Parks and Wildlife Department. 4002 North Chadbourne
(915) 655-9413

Follis, B., District Management Biologist. Reservoir and Striped Bass
 Management in West Texas.

San Antonio 78216: Texas Parks and Wildlife Department. 134 Braniff (512)
349-2174

Guerra, L., Noxious Vegetation Leader. Control of Aquatic Weeds.

- Dean, J., District Management Biologist. Reservoir Management in South Texas.
- Zerr, B., Assistant Management Biologist. Reservoir Management in South Texas.
- Gholson, K., District Management Biologist. Artificial Reef Leader.

San Benito 78586: Texas Agricultural Extension Service. County Building (512) 399-2448

Rickner, J., Marine County Agent. Marine Fisheries Extension.

San Marcos 78666: Texas Parks and Wildlife Department. Box 947 (512) 392-3072

- Lowman, F., Regional Fish Culturist. Native Fishes Culture Leader.
- Hutson, P., Hatchery Superintendent. Culture of Smallmouth Bass, Trout, Florida Bass and Forage.
- Butler, W., District Management Biologist. Reservoir and Smallmouth Bass Management in South Central Texas.

San Marcos 78666: Southwest Texas State University. Aquatic Station (512) 245-2284

- Short, R., Ph. D., Assistant Professor. Invertebrate Stream Ecology.
- Whiteside, B., Ph. D., Professor. Fisheries Management.
- Huffman, D., Ph. D., Associate Professor. Fish Parasitology.
- Longley, G., Ph. D., Professor. Pollution and Cave Fishes.
- Hannan, H., Ph. D., Professor. Liminology of Reservoirs.
- Young, W., Ph. D., Professor. Invertebrates.
- Bira, M.R., Graduate Student. Fisheries.
- Bynum, M. P., Graduate Student. Limnology.
- Caldwell, B.D., Graduate Student. Limnology.
- Cole, T.M., Graduate Student. Reservoir Modeling.
- Douglas, D.J., Graduate Student. Aquatic Biology.
- Guthrie, D.W., Graduate Student. Aquatic Biology.
- Hall, R.D., Graduate Student. Limnology.
- Keifer, R.B., Graduate Student. Fisheries.
- Palma, V., Graduate Student. Fisheries.
- Spinelli, A., Graduate Student. Fisheries.

San Marcos 78666: United States Fish and Wildlife Service, National Fish Hatchery and Development Center (512) 392-1214

- Bishop, H., Director. Administration, Post Stocking Evaluations.
- Brandt, T., Supervisor of Technical Activities. Fish Nutrition, Feed Processing and Feed Storage.
- Williamson, J., Fishery Biologist. Intensive Production of Largemouth Bass, Strain Evaluation of Largemouth Bass.
- Carmichael, G., Biolab Fisheries Technician. Stress Physiology of Largemouth Bass, Weed and Pest Control, Treatment Toxicology.

Seabrook 77586: Texas Parks and Wildlife Department. P.O. Box 8 (713) 474-2811

- Benefield, R., Project Leader. Shrimp Biology.
- Hofstetter, B., Project Leader. Oyster Biology.
- Barrington, L., Area Biologist. Finfish Harvest in Bays.
- Baker, B., Area Biologist. Finfish Abundance in Bays.
- Moffett, A., Environmental Biologist. Habitat Protection.
- Barry, R., Chemist. Water Pollution.

Seadrift 77983: Texas Parks and Wildlife Department. Route 1 Box 368 (512) 785-3521

Hammerschmidt, P., Project Leader. Crab Biology.
Crowe, A., Project Leader. Shell Dredge Monitoring.
Marwitz, S., Area Biologist. Finfish Abundance in Bays.

Temple 76501: Soil Conservation Service. (817) 774-1291

Valentine, G., Biologist. Farm Pond Management, Stream Habitat Improvement, Exotic Fish.

Temple 76501: Soil Conservation Service. (817) 774-1255

Goins, D., Biologist. Watershed Stream Investigations.

Terrell 75160: Soil Conservation Service, P.O. Box 430 (214) 563-6431

Schwille, E., Biologist. Private and Public Pond Evaluation and Management. This Includes Construction, Stocking, Pondweed Control and Fertilization.

Tyler 75707: Texas Parks and Wildlife Department. Route 10 Box 1043 (214) 566-2161

Forshage, A., Regional Director. Florida Bass Program Leader.
Inman, C., District Management Biologist. Reservoir Management in North East Texas; Farm Pond Specialist.
Means, J., Assistant Management Biologist. Reservoir Management in North East Texas.
White, B., Regional Fish Culturist. Florida Bass Culture Leader.
Green, M., Regional Chemist. Water Pollution.

Tyler 75701: Texas Parks and Wildlife Department. Route 11 Box 311 (214) 592-7570

Campbell, D., Hatchery Superintendent. Culture of Future Florida Brood Bass, Forage Program Leader.

Tyler 75701: Texas Parks and Wildlife Department. 2122 Old Henderson Highway (214) 593-5077

Lyons, B., District Management Biologist. Reservoir Management in North East Texas.

Uvalde 78801: United States Fish and Wildlife Service, National Fish Hatchery P.O. Box 708 (512) 278-2419

Davenport, K., Hatchery Manager. Culture of Largemouth Bass, Florida Bass, and Rainbow Trout.
Freeman, J., Assistant Hatchery Manager. Culture of Largemouth Bass, Florida Bass, and Rainbow Trout.

Victoria 77901: United States Fish and Wildlife Service. Columbia National Fisheries Research Lab Field Station, P.O. Box 2087 (512) 575-7306

Andreasen, J.K., Ph.D. Station Leader. Contaminants, Toxicology, Aquatic Ecology, Reproduction.

Hall, N., Cooperative Education Student. Contaminants, Toxicology.

Waco 76705: Texas Parks and Wildlife Department. 1601 East Crest Drive (817) 799-2446

McCabe, R., Regional Director. Striped Bass Program Leader.

Waco 76705: Texas Parks and Wildlife Department. 4110 New Corsicana Highway (817) 799-5190

Sellers, K., District Management Biologist. Reservoir Management in Central Texas.

Mitchell, J., Assistant Management Biologist. Reservoir Management in Central Texas.

FISHERIES WORKERS INDEX

<u>NAME</u>	<u>LOCATION</u>	<u>NAME</u>	<u>LOCATION</u>	
Adams	Austin	Colura	Palacios	N
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Armstrong	Austin	Curtis	Fort Worth	Hi
Arnold	Port Aransas			He
Arnott	Arlington			Hi
		Dailey	Palacios	Hi
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Bowling	Fort Worth	Follis	San Angelo	Joh
Boyd	Fort Worth	Forshage	Tyler	Joh
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Cole G.	Burnett	Harrell	Angleton	Lin
Cole T.	San Marcos	Harrington	Corpus Christi	Linto
Cole W.	Austin	Heffernan	Rockport	Langl
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<u>NAME</u>	<u>LOCATION</u>	<u>NAME</u>	<u>LOCATION</u>
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Ibarra	Arlington	McMahon	Arlington
Inman	Tyler	McMillam	Austin
		Means	Tyler
Johansen	Rockport	Meineke	Corpus Christi
Johnson J.	Fort Worth	Mendoza	Galveston
Johnson R.	La Porte	Menn	Houston
Johnson S.	College Station	Messinger	Rockport
Jones B.	Fort Hood	Michel	Dallas
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Kitting C.	Port Aransas		
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Linton	College Station	Palafox	Austin
Langley	San Marcos	Palma	San Marcos
Looney	Arlington	Palmer	Graford
		Parks	Canyon

<u>NAME</u>	<u>LOCATION</u>	<u>NAME</u>	<u>LOCATION</u>
Perez	Corpus Christi	Taylor	Nacogdoches
Pickrell	Nacogdoches	Temple	Lubbock
Potter	Austin	Thomas	Port Aransas
Powell	Austin	Toole	Marshall
Provine	San Agnelo		
Pulich	Port Aransas		
		Valentine	Temple
Rabalias N.	Port Aransas	Vanbalen	Austin
Rabalias S.	Port Aransas	VanDover	Nacogdoches
Rainwater	Nacogdoches		
Ralph	San Angelo	Wagner	San Angelo
Ramirez	Corpus Christi	Wakefield	Palacios
Ratteree	Amarillo	Walsh	Fort Hood
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Reeder	Austin	Werner	Galveston
Rice	Brownsville	White	Tyler
Rickner	San Benito	Whiteside	San Marcos
Rlussman	College Station	Whitmore	Arlington
Roberts J.	Austin	Williams	Arlington
Roberts L.	Austin	Williamson	San Marcos
Robinson	College Station	Wilson	Nacogdoches
Rogers	Austin	Wohlschlag	Port Aransas
Rosson	Port Aransas		
Rowland	College Station	Young C.	Burnet
Rutledge	Austin	Young W.	San Marcos
Ryan	Marshall	Younger	Bay City
Sandgren	Arlington	Zeman	Beaumont
Schulle	Temple	Zerr	San Antonio
Seidensticker	Jasper		
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Shrot	San Marcos		
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Simmons	Austin		
Smith	Fort Worth		
Sonskis	Ingram		
Spears	Rockport		
Spiller K.	Corpus Christi		
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Surovik	Port Lavaca		
Starr	Austin		
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5. Materials and methods (including description of study area)
6. Results
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9. Tables
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