TEXAS
PARKS AND WILDLIFE DEPARTMENT
~~4200 Smith School Road · Austin, Texas 78744~~

CHARLES D. TRAVIS
Executive Director

Heart of the Hills Fisheries Research Station
Junction Star Route, Box 62
Ingram, Texas 78025

April 22,1985

Mr. Bob Behnke
Colorado State University
Dept. of Fishery and Wildlife Biology
Fort Collins, Colorado 80523

Dear Mr. Behnke:

Regarding your March 25 letter to Al Sonski requesting information on redband trout, please be advised that Al no longer works for us. He is now working in Connecticutt and his address is as follows:

Albin J. Sonski
Quinnebaug State Fish Hatchery
P.O. Box 941
Central Village, Connecticutt 06336

I have taken the liberty of sending you copies of three of Al's publications related to redband trout, "Heat Tolerance of Redband Trout", "Culture of Redband Trout at a Warm-Water Hatchery" and "Comparison of Heat Tolerances of Redband Trout, Firehole River Rainbow Trout and Wytheville Rainbow Trout". Furthermore, in reference to your inquiry regarding stocking of redbands in Texas, no, none have been stocked yet. We were hoping to stock some below Canyon Dam on the Guadalupe River this past winter but were unable to obtain the fish. If you desire any more specific information on that matter I would suggest you contact our Fish Hatcheries Branch Chief, Bill Rutledge at (512)479-4859.

I will forward your letter on to Al. Perhaps he has some additional information.

Sincerely,

Dick Luebke

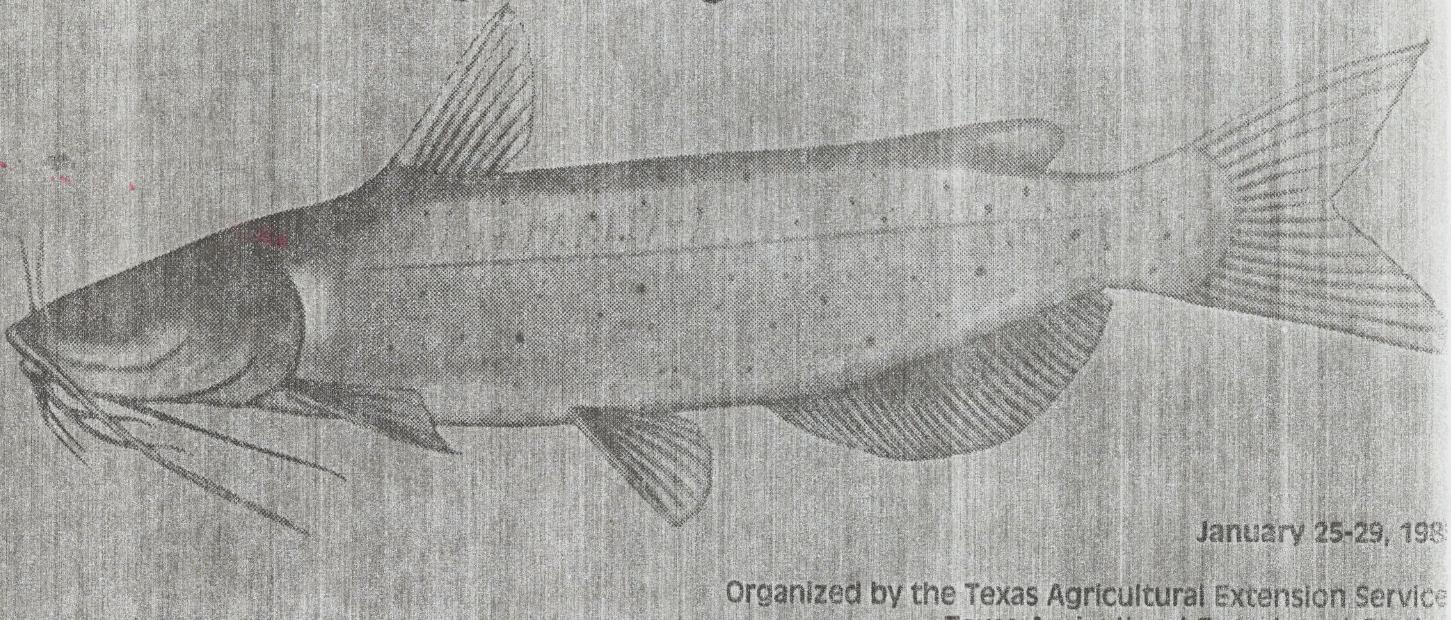
Richard W. Luebke, Director
ks
encl.
cc: Al Sonski
    Bill Rutledge

FFT

MEMBER
*Fish Farmers
of Texas*

Proceedings...

1983 Fish Farming Conference and Annual Convention
Fish Farmers of Texas



January 25-29, 198

Organized by the Texas Agricultural Extension Servic
Texas Agricultural Experiment Statio
College of Agricultur
The Texas A&M University Syste

CULTURE OF REDBAND TROUT AT A WARM-WATER HATCHERY

Albin J. Sonski*

ABSTRACT

Fingerling redband trout (Salmo sp.) were reared in earthen ponds during a winter and indoor tanks the following summer at a hatchery in central Texas to produce broodstock. Mean daily surface temperatures ranged between 49 and 80°F in ponds and between 67 and 75°F in tanks. While in ponds, fish grew from a mean total length of 5.9 in and a mean weight of 0.08 lb to 12.3 in and 0.74 lb. After over-summering in indoor tanks mean fish length was 15.2 in and mean weight 1.55 lb. Mean daily growth rates during pond and tank culture were 0.04 in and 0.004 lb and 0.02 in and 0.004 lb, respectively. Mean condition factors were 3774.02×10^{-7} for fish reared in ponds and 3823.90×10^{-7} for fish reared in tanks. Survival averaged 65.1% in ponds and 90.4% in tanks. There were no disease problems in ponds; diseases were minimal in tanks.

INTRODUCTION

Texas trout fisheries are dependent upon winter stocking of rainbow trout (Salmo gairdneri) from northern sources. These trout are stocked primarily in cold tailraces. Over-summer survival to enhance quality fishing is very limited. Warm-adapted trout would

---

*Texas Parks and Wildlife Department, Heart of the Hills Fisheries Research Station, Ingram, Texas 78025.

extend fishing into spring and summer months and additional waters could be stocked. Redband trout (Salmo sp.) are native to a few rivers in northern California and desert basin regions of Oregon (Behnke 1970; Schreck and Behnke 1971; Legendre et al. 1972; Hoopaugh 1974; Wilmot 1974; Behnke 1979). Upper lethal limits for redband trout, 80.2 to 81.3°F, indicate this species would over-summer in traditional tailrace fisheries and could enhance trout fishing in Texas (Sonski 1982).

Trout culture in the southern United States has primarily been restricted to winter because of water temperature requirements for survival (Hill et al. 1972; Rutledge 1973a; Newton et al. 1977; Jensen 1979; Flynn 1980). Nevertheless, Rutledge (1973b) cultured rainbow trout in water at temperatures up to 84°F.

Redband trout are cultured by a few state agencies (Behnke 1979) and at one federal hatchery (W. Orr, National Fish Hatchery, Ennis Montana, personal communication). Conceivably, redband trout for stocking in Texas could result from artificial spawning and production by a Texas state hatchery. Success of this program would be limited by over-summering of broodstock.

This study describes culture of redband trout for 1 year at a central Texas hatchery.

MATERIALS AND METHODS

Redband trout were obtained from the Fish Cultural Development Center, Bozeman, Montana, in August, 1981. Their eggs were spawned (May, 1980) from wild fish captured in Parsnip Reservoir, southeastern

Oregon (W. Hosford, Oregon Department of Fish and Wildlife, Hines Oregon, personal communication). Live fish (average total length = 5.4 in, average weight = 0.03 lb) were air-freighted (8 h) in plastic bags (1.5 - 2.0 lb/2.50 gal at 47°F) packed in styrofoam boxes (18 x 18 x 9 in) to Heart of the Hills Research Station, Ingram, Texas. They were maintained for the first 13 wk in circular 250 - or 500-gal fiberglass tanks at 58 to 68°F. During this period all fish were fed a sinking commercial trout pellet (38% crude protein, 5% fat) at 3 to 4% body weight per day.

In November, 1981 fish were graded into two size groups, 4.0 to 5.4 in and 5.5 to 7.5 in (total length), and stocked into separate earthen ponds (Table 1). Water was added periodically to ponds to maintain a constant level until draining. Ponds were drained the following spring and the fish transferred to indoor circular tanks (Table 1). Fish from Pond A were placed into a cement tank with a conical-shaped bottom; this tank was situated in a building enclosed with screens. Fish from Pond B were put in a fiberglass tank with a flat bottom, in a plastic-covered greenhouse equipped with exhaust fans to circulate air. Fresh spring water (pH = 7.7, total dissolved solids - 360 ppm) was continuously flowed through each tank (Table 1). Sleeve tubes with bottom notches were placed around center stand-pipes to remove water and large waste material from tank bottoms. The inside tank walls were scrubbed clean approximately every 2 to 4 weeks. During July to October filamentous algae became overabundant and was removed from the greenhouse tank weekly to prevent sleeve tube clogging.

Pond fish were sampled at approximate 2-wk intervals (Table 2, 3) to monitor growth and alter feeding rates. Sampling methods including angling and electrofishing. On three sampling dates no fish were collected in Pond B (Table 3) and average weight was estimated from weight gain in Pond A fish during the same growth period. At pond draining, fish were dipped from the drain box and two samples of fish taken. Tanks were also sampled at approximate 2-wk intervals; however, to reduce stress during periods of high water temperature (May to November) intervals were changed to 3 to 4 weeks. During sampling, tanks were partially drained and a sample (Table 2, 3) was randomly captured with a dip net. Sample fish were anesthetized in a quinaldine solution, measured for total length (in) and weight (lb), and then placed into a tub containing a 3% salt dip for 1 minute before returning them to the water.

Pond fish were fed a commercial production trout pellet (38% crude protein, 5% fat) according to a standard table (Sterling H. Nelson and Sons, Murray, Utah). Feed rates were calculated for the number of fish stocked until April, then the number of fish in Pond A was visually estimated to be 100. During periods of cold weather they were fed only to satiation if less than the prescribed rate. Fish in the fiberglass tank were fed similarly except they were fed maintenance diets (Table 3) during June to November. Fish in the cement tank were fed maintenance diets (Table 2) throughout the culture period. Their food was the commercial production trout pellet during May - July but was changed to a commerical broodstock trout pellet (45% crude protein, 8% fat) during August to October. During a 14-day period in July, tank feeding rates were increased from 0.75 to 1.4% to administer a prescribed level of medication in the diet. All fish were fed half the daily ration each morning and afternoon. Feeding was discontinued the afternoon before and on sampling dates.

Growth rates expressed as increase in weight and length per day were calculated for fish in each pond and tank from total gain in length and weight divided by the number of culture days (Haskell 1959; Haskell et al. 1960; Piper et al. 1982). Feed conversions were calculated as net gain weight divided by weight of feed fed. Standard deviation (Snedecor and Cochran 1978) was calculated for mean fish length and weight at stocking and draining. Condition factors (K) were calculated from mean fish weight (W) and length (L) as each sampling as $K = W/L^3$ (Haskell 1959; Piper et al. 1982).

Surface water temperature (Table 2,3) was recorded in the morning only, November, 1981 to January, 1982, and thereafter in the morning and afternoon. Mean morning and afternoon temperatures were calculated as the average of measurements collected during a growth period.

Fish in tanks were treated weekly for 3 h with a mixture of 0.1 ppm malachite green and 50.0 ppm formalin (Leteux and Meyer 1972) as prophylaxis from external protozoan parasites and fungus.

RESULTS AND DISSCUSSION

Growth and Condition

Growth rates between ponds were similar (Table 4). Growth rate in weight was similar between tanks but the rate of increase in length was less in the cement tank than in the fiberglass tank. Fish grown in the cement tank were large when stocked; the feeding rate and type of feed maintained broodstock without increasing length considerably. Partial weight gain resulted from gonadal maturation evidenced in dissection of several fish at draining. Mean weight of redband trout at 2 years of age (June 9 in Table 2,3) was less than Kincaid (1981) reported for same aged domesticated rainbow trout.

Haskell et at. (1956), Haskell (1959) and Spence (1973) indicate trout growth rate increases as temperature increases but do not give data for water temperatures greater than 65°F. Growth rates obtained from the present study were similar to those achieved (0.001 to 0.006 lb/day) by redband trout reared at a cold-water hatchery at 54°F during the same time period (W. Orr, personal communication). For redband trout, increases in growth with increased temperature may be limited up to 75°F. Above this temperature heat stress may occur; Sonski (1982) noted redband trout ceased feeding at 78°F.

Redband trout fingerlings (mean weight = 0.013 lb) grow faster at 66°F than at cooler temperatures (P. Dwyer, Fish Cultural Development Center, Bozeman, Montana, personal communication) and Sonski (1982) found redband trout (mean weight = 0.064 lb) gained more weight when held at 68°F than at 59 or 73°F. Although temperatures in this study fluctuated 2 to 5°F daily, the upper levels experienced were apparently not harmful as long as temperature decreased to 69 to 71°F at night. This water temperature regime was apparently conducive to good growth.

Condition factors of fish were similar between ponds and tanks (Table 5). They were lower than those (4055×10^{-7}) given for rainbow trout by Piper et al. (1982) but higher than those (3082×10^{-7}) of redband trout broodstock grown on a cold-water hatchery (W. Orr, personal communication). Differences in redband trout condition between hatcheries may result from differences in feeding rates. Fish grown at the cold-water hatchery were fed 0.5 to 0.7% body weight per day, while redband trout reared in the present study were fed 0.75 to 4.00% (Table 2, 3).

Mortality

Natural mortalities were not observed in either pond; however, at draining, mortality was greater than 30% (Table 4). Most mortality was probably due to bird predation. Rutledge (1973a) reported mortality of 27 to 72% for brown (*Salmo trutta*) and rainbow trout respectively, reared in the winter ponds at this hatchery . He attributed part of the mortality to great blue heron (*Ardea herodias*) predation. Substantial harvest mortality (22.4%) occurred when Pond A was drained on May 25. The primary cause was fish became trapped in aquatic vegetation and were unable to swim to the drain box. Water temperature at draining was 75°F; this probably increased stress of trapped fish.

There was no harvest mortality for Pond B fish drained the previous March when the temperature was 65°F.

Over-summering redband trout in shallow earthen ponds in central Texas would probably be impossible. Pond temperatures often reach 85°F which exceeds lethal limits for redband trout. Maximum daily afternoon temperatures in tanks (approximately 75°F) were probably stressful to trout; however, each night water temperatures cooled to 69 to 71°F, decreasing stress. Sonski (unpublished data) showed 54% mortality of a sample of 50 redband trout (mean weight = 0.055 lb) held at 73°F for 70 days and a 50% mortality of 10 similar redband trout held at 77°F for 26 days.

Feeding and Feed Conversion

Feed conversions were lower (Table 4) than Rutledge (1973b) obtained (0.26) for rainbow trout cultured in winter in similar ponds at this hatchery (Rutledge 1973a). Flynn (1980) reported feed conversions of 0.11 to 0.43 in winter rainbow trout production in earthen ponds in Alabama. For sibling redband trout broodstock cultured at a cold-water hatchery in raceways, the conversion was 0.77 (W. Orr, personal communication).

Feed conversion for redband trout cultured in ponds probably could be improved if the number of fish was known when feed rates were calculated; this would prevent overfeeding and waste. Stocking larger fish at a higher density (Table 4) was important to feeding activity. Fish in Pond A fed very readily while those in Pond B were cautious and easily scared at feedings. Good feeding activity was conducive to less feed waste. In raceway culture of redband trout feed utilization can be increased if fish are fed by a demand feeder (W. Orr, personal communication).

Broodstock held in cold-water (48 to 54°F) hatcheries are fed 0.7 to 1.0% body weight per day to maintain growth and good condition (Piper et al. 1982). Feed recommendations for trout broodstock cultured in warm-water hatcheries apparently are not available. For trout production, Rutledge (1973b) suggested a feed rate of 1.0% for fish greater than 0.25 lb reared in 65 to 75°F water. In this study, feed rates as low as 0.75% were effective for maintaining broodstock in good condition in water less than 75°F.

Water Quality

The water at this hatchery originates from a large spring and historically has been of high quality with dissolved oxygen concentration at saturation or above. In all culture units, water quality was sufficient and crowding minimum to provide healthy rearing conditions as evidenced in good growth and high survival at warm water temperatures. Spence (1973) showed if the density remains constant as size of fish increases, water flow-through rate required to limit ammonia (NH_4-N) to 0.5 ppm decreases but required flow rates increase with temperature. His data indicate that a 60°F, 100 lb of 15-in fish required a flow rate of about 6.0 gal/min (gpm) to limit ammonia to 0.5 ppm. Data were not given for higher water temperatures. In the present study, maximum loads in tanks (Table 1) approached levels recommended by

Rutldege (1973b) of 1.0 gpm per 1.5 to 2.5 lb of fish cultured in water greater than 60°F.

As a general rule, Piper et al. (1982) indicates to avoid crowding, trout should be held at densities in pounds per cubic foot no greater than 0.5 their length. As an example, the cement tank had a volume of 502 ft^3 and the average fish length was 15.5 inches. This would allow 7.25 lb/ft^3 to be reared in the cement tank. Maximum density in this study was 0.17 lb/ft^3.

Diseases

Trout cultured in ponds had no disease problems; temperatures were low and water quality was good. In June, an outbreak of "ich" (*Ichthyophthirius* sp.) occurred in the cement tank. Three fish died before the parasite was brought under control with four daily treatments (4 h each) of 0.1 ppm malachite green and 50.0 ppm formalin. Later the same month about 20% of the fish in this tank developed small lesions on their sides. *Aeromonas hydrophila* was diagnosed as the causative agent; the bacteria was sensitive to terramycin (R. Jones, United States Fish and Wildlife Service, Pinetop, Arizona, personal communication). A few fish in the fiberglass tank also had similar symptoms. Fish in both tanks were fed a medicated feed diet (oxytetracycline, 0.09 oz/100 lbs fish/day) for 14 days. Effectiveness of the treatment was undetermined, however, increased feeding activity was noticed after treatment completion. The disease remained chronic until fall, when water temperatures decreased to 68°F. Two fish died from the bacteria.

Approximately 20% of the trout in the cement tank developed symptoms of gas-bubble disease (bubbles in the eyes) in August. This is known to occur where there is a supersaturation of nitrogen or other dissolved gases (Weitkamp and Katz 1980). This saturation can be decreased by baffeling or agitating the water to increase circulation (P. Dwyer and C. Smith, Fish Cultural Development Center, Bozeman, Montana, personal communication). A portable surface aerator was run in the cement tank during the day and an air-lift pump was installed in the fiberglass tank. By the fall there were no symptoms of gas-bubble disease. One fish died, apparently due to this disease.

Sampling Concerns

Angling with artificial lures yielded large samples for the first four sampling periods (Table 2, 3). Thereafter, fish would not accept lures and had, no doubt, become "conditioned". Boat-mounted electrofishing equipment was employed but was time consuming and did not collect an adequate sample; trout avoided the boat. Angling with live forage fish proved to be the most efficient sampling method although hooking mortalities occurred. Piper et al. (1982) suggested sampling ponds with a seine or lift nets. Although not attempted in this study, these methods may have proved useful.

Although 16 to 25% of the fish in indoor tanks were easily captured during routine collections, there apparently was considerable sampling variation. This was evident in three samples, which fish had lower mean lengths and weights than previously (Table 2, 3). Sampling variation was probably compounded by the fact that broodstock segregate by size (W. Orr, personal communication). Fish should have been more crowded before collection to assure a more representative sample.

RECOMMENDATIONS

Based on results of this study redband trout can be reared at a warm-water hatchery and grown from fingerling to broodstock size in a period of 1 year. Caution should be applied in situations where water temperatures and quality, and type of rearing facilities differ.

In good water quality at 65 to 75°F, growth of redband trout fed 1 to 3% body weight per day will be sufficient to produce broodstock and a feeding rate of 1% will maintain them in good condition.

Weed control should be practiced to reduce harvest mortality in ponds and trout should be transferred to over-summering facilities before afternoon pond temperatures exceed 65°F. Over-summering in stagnant earthen ponds would probably result in mortality of redband trout if morning and afternoon water temperatures exceed 70 and 75°F, respectively.

In ponds wild-spawn juvenile redband trout should be stocked at densities of at least 200 fish/acre to encourage aggregate feeding activity. Mortality in ponds should be estimated to determine accurate feed rates.

Diseases should be diagnosed and may be treated with medicated feed, however, bacterial diseases may remain chronic as long as temperatures exceed 68°F.

Sampling broodstock greater than 1.0 lb should be conducted at least every 4 weeks to adjust feed rates. Angling with natural baits may be used to sample ponds. Fish in tanks should be crowded before samples are taken to reduce sampling variation.

ACKNOWLEDGMENTS

I wish to express my appreciation to Ronald Major, United States Fish and Wildlife Service, Pinetop, Arizona, for assistance in diagnosing diseases; to the staff of the Fish Cultural Development Center, United States Fish and Wildlife Service, Bozeman, Montana, for their suggestions on trout culture; and Wesley Orr, United States Fish and Wildlife Service, Ennis, Montana, and William Hosford, Oregon Department of Fish and Wildlife, Hines, Oregon, for providing data on redband trout.

REFERENCES

Behnke, R.J. 1970. The application of cytogenetic and biochemical systematics to phylogenetic problems in the family Salmonidae. Trans. Am. Fish. Soc. 99:237-248.

______. 1979. Monograph of the native trouts of the genus Salmo of western North America. U.S. Fish. Wildl. Serv. Region 6.

Calderon, E.G. 1965. The raising of brown trout and rainbow trout in water at high temperatures. Stud. Rev. Gen. Fish. Coun. Medit. (30).

Flynn, J.B. 1989. The effect of stocking density, diet form, and partial harvest on winter production of rainbow trout in static water Alabama ponds. M.S. Thesis, Auburn University, Auburn, Alabama.

Haskell, D.C. 1959. Trout growth in hatcheries. N.Y. Fish Game J. 6:204-237.

_______, L.E. Wolf and L. Bouchard. 1956. The effect of temperature on the growth of brook trout. N.Y. Fish Game J. 3:108-113.

_______, R. Davies and F. Reckahn. 1960. Effect of sorting brown trout on sex ratio and growth. N.Y. Fish Game J. 7:39-45.

Hill, T.K., J.L. Chesness and E.E. Brown. 1972. Utilization of rainbow trout (Salmo gairdneri) in a double-crop fish culture system in south Georgia. Proc. Ann. Conf. S.E. Assoc. Fish Game Comm. 26:366-376.

Hoopaugh, D.A. 1974. Status of the redband trout (Salmo sp.) in California. State of California Resources Agency, Dept. Fish Game. Inland Fish. Admin. Rep. No. 74-7.

Jensen, J.W. 1979. Winter culture of rainbow trout (Salmo gairdneri) in earthen ponds and floating cages at Auburn, Alabama. Doctoral dissertation. Auburn University, Auburn, Alabama.

Kincaid, H.L. 1981. Trout strain registry. Nat. Fish. Cent.-Leetown, W. Va., FWS/NFC-1/81-1.

Lengendre, P., C.B. Schreck and R.J. Behnke. 1972. Taximetric analysis of selected groups of western North American Salmo with respect to phylogenetic divergences. Syst. Zoo 24:292-307.

Leteux, F. and F.P. Meyer. 1972. Mixtures of malachite green and formalin for controlling Ichthyophthirius and other protozoan parasites of fish. Prog. Fish-Cult. 34:21-26.

Newton, S.H., A.J. Handcock and A.J. Merkowsky. 1977. Rainbow trout production in southern Arkansas. Ark. Farm. Res. J. 26:6.

Piper, R.G., I.B. McElwain, L.E. Orme, J.P. McCraren, L.G. Fowler and J.R. Loenard. 1982. Fish hatchery management. U.S. Dept. Int. Fish Wildl. Serv., Washington, D.C.

Rutledge, W.P. 1973a. Winter trout rearing experiment. Unpublished report, Tx. Parks Wildl. Dept., Austin, Texas.

________. 1973b. Rainbow trout rearing experiment. Unpublished report, Tx. Parks Wildl. Dept., Austin, Texas.

Schreck, C.B. and R.J. Behnke. 1971. Trouts of the Upper Kern River basin, California, with reference to systematics and evolution of western North American Salmo. J. Fish. Res. Board Can 28:987-998.

Snedecor, G.W. and W.G. Cochran. 1978. Statistical methods. Iowa State University Press, Ames, Iowa.

Sonski, A.J. 1982. Heat tolerance of redband trout. Ann. Proc. Tx. Chap. Am. Fish. Soc. 5:(in press).

Spence, R.E. 1973. Trout metabolism characteristics and the rational design of nitrification facilities for water reuse in hatcheries. Trans. Am. Fish Soc. 102:323-334.

Weitkamp, D.E. and M. Katz. 1980. A review of dissolved gas supersaturation literature. Trans. Am. Fish. Soc. 109:659-702.

Wilmot, R.L. 1974. A genetic study of the redband trout. Doctoral dissertation. Oregon State University, Corvallis, Oregon.

Table 1. Culture unit specifications and loading parameters for redband trout reared at Heart of the Hills Research Station, Ingram, Texas, November, 1981 - November 1982.

Culture unit	Area (a)	Volume (ft^3)	Diameter (ft)	Flow rate (gal/min)	Maximum density (lb/ft^3)	Maximum loading (lb/gal/min)
Pond A	0.72	79,074	-	-	0.0013	-
Pond B	0.62	72,963	-	-	0.0003	-
Cement tank	-	502	20.7	50	0.17	1.73
Fiberglass tank	-	455	12.0	30	0.16	2.45

Table 2. Sampling dates, sample size, mean total length (in), mean weight (lb), mean surface water temperature (^{o}F) and feeding rate (% body weight/day) for redband trout cultured in an earthen pond and an indoor circular cement tank at Heart of the Hills Research Station, Ingram, Texas, November, 1981 - November, 1982.

Sampling date	Sample size	Fish length	Fish weight	Surface temperature AM	Surface temperature PM	Feed rate
			POND A			
Nov 6	10	6.77	0.11			
				63.3	-	4.00
23	15	7.11	0.13			
				60.4	-	4.00
Dec 8	15	8.29	0.21			
				60.1	-	3.00
23	8	9.23	0.31			
				54.5	-	2.50
Jan 5	14	10.08	0.40			
				48.7	-	2.00
21	5	10.10	0.42			
				58.8	-	1.40
27	16	10.20	0.45			
				52.3	-	1.50
Feb 11	12	11.78	0.62			
				59.7	61.5	1.50
25	10	11.85	0.65			
				56.8	62.2	1.30
Mar 8	12	12.38	0.73			
				67.3	68.9	1.70
23	8	13.58	0.95			
				63.3	75.5	1.50
Apr 6	10	13.62	0.99			
				66.6	71.4	1.25
20	8	13.91	0.99			
				66.0	71.8	1.25
May 11	8	13.87	1.01			
				73.6	81.0	1.25
25	26	14.09	1.07			
			CEMENT TANK			
				68.9	71.8	0.75
Jun 9	10	13.94	0.87			
				68.5	71.6	0.75
Jul 14	11	14.63	1.09			
				68.9	72.1	1.00
Aug 9	12	13.81	0.93			
				69.1	71.4	1.00
Sept 8	12	14.44	1.16			
				68.0	70.3	1.00
Oct 7	11	14.39	1.25			
				66.9	69.3	1.00
25	48	15.48	1.63			

Table 3. Sampling dates, sample size, mean total length (in), mean weight (lb), mean surface water temperature (^{o}F) and feeding rate (% body weight/day) for redband trout cultured in an earthen pond and an indoor circular fiberglass tank at Heart of the Hills Research Station, Ingram, Texas, November, 1981 - November, 1982.

Sampling date	Sample size	Fish length	Fish weight	Surface temperature		Feed rate
				AM	PM	
			POND B			
Nov 6	10	5.00	0.05			
				62.8	-	4.00
24	6	6.03	0.08			
				61.2	-	4.00
Dec 8	0	-	0.11*			
				58.1	-	3.00
23	0	-	0.23*			
				53.2	-	2.50
Jan 5	9	8.13	0.21			
				50.4	-	2.25
21	9	8.45	0.22			
				54.1	51.6	1.50
Feb 11	0	-	0.33*			
				59.7	60.1	1.50
25	5	9.77	0.34			
				56.7	61.5	1.40
Mar 8	20	10.43	0.40			
			FIBERGLASS TANK			
				68.0	69.6	1.80
Mar 23	10	10.10	0.37			
				66.7	69.1	1.80
Apr 7	12	10.89	0.48			
				66.9	70.7	1.70
19	11	10.89	0.48			
				67.1	69.8	2.00
May 11	12	11.60	0.62			
				68.2	71.6	2.00
25	16	11.56	0.57			
				69.1	73.2	1.00
Jun 9	16	11.97	0.64			
				69.1	73.2	1.00
Jul 15	13	12.52	0.75			
				69.8	74.5	1.00
Aug 9	12	13.08	0.85			
				69.4	73.8	1.00
Sep 7	12	13.66	0.99			
				68.5	72.7	1.00
Oct 6	12	13.81	1.14			
				66.7	69.8	1.00
Nov 15	18	14.96	1.47			

*indicates weight was estimated from growth of similar fish cultured in another pond during the same period.

Table 4. Summary of information on culture of redband trout reared in earthen ponds and circular tanks at Heart of the Hills Research Station, Ingram, Texas, November, 1981 - November, 1982.

Parameter	Pond A	Cement tank	Pond B	Fiberglass tank
Stocking				
date	Nov 6, 1982	May 25, 1982	Nov6, 1981	Mar 8, 1981
no. fish stocked	146	64	75	52
mean length-in (SD)*	6.77(0.03)	14.09(1.22)	5.00(0.59)	10.43(0.98)
mean weight-lb (SD)*	0.11(0.03)	1.07(0.34)	0.05(0.02)	0.40(0.14)
Draining				
date	May 25, 1981	Oct 25, 1982	Mar 8, 1982	Nov 15, 1982
no. fish recovered	89	53	52	50
mean length-in (SD)*	14.09(0.22)	15.48(1.65)	10.43(0.14)	14.96(1.22)
mean weight-lb (SD)*	1.07(0.34)	1.63(0.55)	0.40(0.14)	1.47(0.39)
Culture days	201	153	123	252
Mortality %	39.1	17.2	30.7	2.0
Growth rate				
in/day	0.036	0.009	0.044	0.018
lb/day	0.005	0.004	0.003	0.004
Feed conversion				
lb gain/lb fed	0.38	0.27 1	0.41	0.59

* SD = standard deviation

Table 5. Mean condition factors, and ranges for redband trout cultured in earthen ponds and indoor circular tanks at Heart of the Hills Research Station, Ingram, Texas, November, 1981 - November, 1982.

Culture Unit	Condition Factor (x 10^{-7})	Range
Pond A	3854.49	3685.26 - 4227.21
Cement tank	3776.00	3205.08 - 4394.69
Pond B	3693.55	3539.66 - 3898.07
Fiberglass tank	3871.80	3569.06 - 4387.02

Reprinted from
~~Presented at the~~ Annual Proceedings of the
Texas Chapter, American Fisheries Society 5 : 66-76 1982

Texas Parks and Wildlife Department
Fisheries Research Section

HEAT TOLERANCE OF REDBAND TROUT

by

Albin J. Sonski

Heart of the Hills Research Station
Ingram, Texas 78025

Austin, Texas

HEAT TOLERANCE OF REDBAND TROUT

by

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

ABSTRACT

Upper lethal temperatures (LT_{50}) were determined for redband trout (Salmo sp.) that had been acclimated to 15, 20 and 23 C and exposed to temperature increases of 0.5 C/day until death. Temperatures at time of death ranged from 25.5 to 27.7 C. The LT_{50} for fish acclimated to 20 C (27.4) was significantly higher ($\alpha = 0.05$) from those of 15- (27.1) and 23-C (26.8) acclimated fish.

INTRODUCTION

Trout fisheries in Texas depend entirely on stocking harvestable size rainbow trout (Salmo gairdneri) for put-and-take fisheries. Usually fishing is restricted to cooler months (November - March) when water temperatures are favorable for trout survival and stockers are available. Because of poor over-summer survival of stocked trout only limited year round fishing is provided. Fishery biologists in Texas are currently experimenting with trouts reportedly to be tolerant of warm water in an effort to expand the existing fisheries and fishing season. One of these fish is the redband trout (Salmo sp.).

Redband trout are native to the upper Pit and McCloud Rivers in northern California and to desert basins of southeastern Oregon (Behnke 1970; Schreck and Behnke 1971; Legendre et al. 1972; Hoopaugh 1974; Wilmot

1974; and Behnke 1979). Redband trout are known to thrive at elevated temperatures in harsh environments unfavorable for hatchery produced rainbow trout. They can be found in stagnant pools of intermittent streams and water with high alkalinity at 28.0 - 29.5 C (W. Hosford, Oregon Department of Fish and Wildlife, Hines, Oregon, personal communication; Behnke 1980).

Taxonomic classification precludes redband trout as a distinct species (Behnke 1970; Hoopaugh 1974; Robins et al. 1980). R.J. Behnke, Cooperative Fisheries Unit, Fort Collins, Colorado, (personal communication) acknowledges it is a subspecies of rainbow trout based on Jordan and Evermann's (1896) description of an inland form of rainbow trout (S. g. gairdneri) with type characteristics of redband trout. The redband possesses some characteristics of rainbow, cutthroat (S. clarki) and golden (S. aquabonita) trout (Behnke, 1970), however, it is distinguished by coloration, spotting and meristic counts (Schreck and Behnke 1971; Legendre et al. 1972; Behnke 1979).

Behnke (1979) denotes Kamploops trout of British Columbia are redband trout. Black (1953) determined the upper lethal temperature for Kamploops fingerlings to be 24.0 C when acclimated to 11.0 C. Although this provides some guidance in regard to the temperature tolerance of this species complex, lethal temperatures for desert basin redband trout have not been determined. This information is needed to evaluate their potential as a sport fish in Texas. To provide this more definitive information a laboratory study was conducted to describe and evaluate from a fishery management perspective the upper lethal temperature (LT_{50}) of redband trout originating from a desert region.

MATERIALS AND METHODS

Redband trout were obtained from the Fish Cultural Development Center, Bozeman, Montana in August, 1981. Eggs originated from fish spawned in

Parsnip Reservoir in southeastern Oregon (Behnke 1982; W. Hosford, personal communication). Fish were air-freighted to Heart of the Hills Research Station, Ingram, Texas where they were maintained indoors at 14 - 16 C for 4 months prior to temperature acclimation.

Groups of 30 fish were acclimated to constant temperatures of 15, 20 and 23 C at a rate of 1 C/day. Mean total length and weight of test fish were 130 mm (SD = 18) and 29 g (SD = 12), respectively. All fish were held at acclimation temperatures for a minimum of 14 days before testing. Cylindrical 800-1 fiberglass tanks (diameter = 91.4 cm) served as control and test tanks. Temperatures in all tanks were 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. Water passed through gravel and rock filters and larger waste material that accumulated on the bottoms of the tanks was siphoned daily. Fish in all tanks were fed a sinking pelleted feed (38% crude protein) at 4.0% body weight/day.

Testing took place in two tanks. Each tank was divided with netted frames into three compartments. Fish were randomly assigned to tanks and compartments. The electrical system used to produce temperature increases consisted of timing devices which controlled thermostatically regulated heating elements. When the water temperature in test tanks was 15 C, 10 fish acclimated to 15 C were placed in a compartment in each tank. Temperature was increased 0.5 C/day until it reached 20 C. Ten fish acclimated to 20 C were then placed in a second compartment in each of the two tanks. Temperature was again increased 0.5 C/day until it reached 23 C. Ten fish acclimated to 23 C were then placed in the third compartment in each test tank. The 10 remaining fish in each acclimation tank served as controls. Water temperature in the test tanks was then increased 0.5 C/day until all fish died.

Temperatures were recorded when fish stopped feeding and when individual deaths occurred. Fish were considered dead when they lacked opercular movement and did not respond to touch (Otto and Rice 1977). Data was combined by acclimation temperature. LT_{50}'s were calculated as defined by Otto and Rice (1977) as the point at which 50% of the fish died from the regression of percentage cumulative mortality (arcsin transformation) on lethal temperature. Analysis of covariance (Sendecor and Cochran 1978) was used to evaluate differences in slope between regression lines for each acclimation temperature. The Newman-Kuels multiple range test (Zar 1974) was employed to designate inter-slope differences.

RESULTS AND DISCUSSION

One mortality occurred in 23-C controls. Fish acclimated to 15 and 20 C ceased feeding at 27.0 C and fish acclimated to 23 C stopped feeding at 25.5 C. Lethal temperatures ranged from 25.5 to 27.7 C (Table 1).

Analysis of covariance showed a significant difference in slopes between regression lines ($\alpha = 0.05$). The Newman-Kuels test indicated the slope from the regression for fish acclimated to 20 C was different from the slopes obtained from other acclimation temperatures because fish acclimated to 20 C died at a higher rate (Figure 1). The slopes of regression lines for 15 and 23 C were found similar. The LT_{50} for fish acclimated to 15, 20 and 23 C was 27.1, 27.4 and 26.8 C, respectively (Table 1).

Although LT_{50} differences were not large there were differences in death temperatures (Table 1). There were no deaths in fish acclimated to 20 C until 27.2 C, but mortalities began at 25.5 C for 15- and 23-C acclimated fish. Higher heat tolerance of fish held at 20 C is not clearly understood, however, fish may have been in better initial condition than fish held at other temperatures. Weight gain in 20-C controls was 5.5 and

8.8 g more than in 15- and 23-C controls, respectively. Redband trout fingerlings (2-12 g) were shown to gain more weight when held at 19 C than at 4 - 16 C (P. Dwyer, Fish Cultural Development Center, Bozeman, Montana, personal communication), whereas, rainbow trout fingerlings gained more weight at 16 C than at 19 C (Dwyer et al. 1981). Redband trout, adapted to desert heat, would seemingly optimize at warm temperatures. Therefore, redband trout reared at 18 C to 20 C would perhaps have the best chance of enduring summertime water temperatures.

Most importantly, heat tolerance of redband trout should be compared to rainbow trout, the species currently stocked in Texas. Upper incipient lethal temperatures for rainbow trout have been reported to be 24.0 - 27.0 C (Craige 1963; Bidgood and Berst 1969; Bidgood 1980). Vancil et al. (1979) determined the ultimate upper lethal temperature for Lake McConaughy (Nebraska) rainbow trout to be $>$ 26.0 C but $<$ 28.0 C. Results of this experiment show redband trout apparently have upper lethal temperatures comparable to Lake McConaughy rainbow trout. Kaya (1978) determined rainbow trout originating from a permanently heated stream did not have higher upper incipient lethal temperatures (25.0 C - 26.2 C) than hatchery rainbows (23.2 C - 26.2 C) although the former reputedly thrive in natural habitat up to 28.8 C (Kaya 1977).

Although redband trout are reported to survive up to 29.5 C, LT_{50} values ranged only from 26.8 to 27.4 C. Inherent thermal resistance of redband trout may be daily temperature extremes tolerated rather than upper lethal temperatures (R.J. Behnke, personal communication). Redband trout survive diurnal temperature ranges of 13.0 to 29.0 C (W. Hosford, personal communication). Standard temperature tolerance testing does not examine this information. An alternative may be long-term experiments approximating the natural cyclic thermal regime (i.e., heating during the day, cooling at night) of candidate waters. This type of testing may show differences in species by their ability to recover from, rather than withstand high temperatures as would occur naturally. The critical thermal maximum, CT_{max} (Huntsman and Sparks 1924) appears to be a good test where fish would be exposed to quickly changing temperatures, for example in power plant cooling lakes, but is impractical for most natural settings where trout are considered. Lee and Rinne (1980) showed no differences in CT_{max} for five species of trout.

Behnke (1979) noted, "For warm-adapted trout, the genetic resources available in the arid lands would appear promising." Considering the thermal regime in Texas rivers, for example, availability of cool springs and cooler temperature at night, redband trout are good candidates to enhance trout fishing in Texas.

REFERENCES

Behnke, R.J. 1970. The application of cytogenetic and biochemical systematics to phylogenetic problems in the family Salmonidae. Transactions of the American Fisheries Society 99:237-248.

Behnke, R.J. 1979. Monograph of the native trouts of the genus Salmo of western North America. United States Fish and Wildlife Service, Region 6.

Behnke, R.J. 1980. Rainbow trout. Page 106 in D.S. Lee, C.S. Gilbert, C. Hocutt, R.E. Jenkins, D. McAllister, and J.R. Stauffer, Jr. editors. Atlas of North American Freshwater Fishes. North Carolina State Museum of Natural History, Raleigh, North Carolina, USA.

Behnke, R.J. 1982. Evaluation of redband trout collections from Malheur River drainage, Malheur County, Oregon. Unpublished report, Bureau of Land Management, Vale, Oregon, District.

Bidgood, B.F. 1980. Temperature tolerance of hatchery reared rainbow trout Salmo gairdneri Richardson. Fish and Wildlife Division, Alberta Energy and Natural Resources. Fisheries Research Report No. 14. Alberta, Canada.

Bidgood, B.F. and A.H. Berst. 1969. Lethal temperature for Great Lakes rainbow trout. Journal of Fisheries Research Board of Canada 26:456-459.

Black, E.C. 1953. Upper lethal temperatures of some British Columbia freshwater fishes. Journal of Fisheries Research Board of Canada 10:196-210.

Craige, D.E. 1963. An effect of water hardness in the thermal resistance of the rainbow trout, Salmo gairdneri Richardson. Canadian Journal of Zoology, 41:825-831.

Dwyer, W.P.,C.E. Smith and R.G. Piper. 1981. Rainbow trout growth efficiency as affected by temperature. United States Fish and Wildlife Service, Bozeman Information Leaflet Number 18, Bozeman, Montana.

Hoopaugh, D.A. 1974. Status of the redband trout (Salmo sp.) in California. State of California Resources Agency, Department of Fish and Game. Inland Fisheries Administrative Report No. 74-7.

Huntsman, A.G. and M.I. Sparks. 1924. Limiting factors for marine animals 3. Relative resistance to high temperatures. Journal of Fisheries Research Board of Canada 2:97-114.

Jordan, D.S. and B.W. Everman. 1896. The fishes of North and Middle America. Bulletin of the United States Natural Museum 27, Part 1.

Kaya, C.M. 1977. Reproductive biology of rainbow and brown trout in a geothermally heated stream: the Firehole River of Yellowstone National Park. Transactions of the American Fisheries Society 106:354-361.

Kaya, C.M. 1978. Thermal resistance of rainbow trout from a permanently heated stream, and of two hatchery strains. The Progressive Fish-Culturist 40:138-142.

Legendre, P., C.B. Schreck and R.J. Behnke. 1972. Taximetric analysis of selected groups of western North American Salmo with respect to phylogenetic divergences. Systematic Zoology 24:292-307.

Lee, R.M. and J.N. Rinne. 1980. Critical thermal maxima of five trout species in the southwestern United States. Transactions of the American Fisheries Society 109:632-635.

Otto, R.G. and J.O. Rice. 1977. Responses of a freshwater sculpin (Cottus cognatus gracilis) to temperatures. Transactions of the American Fisheries Society 106:89-94.

Robins, C.R., R.M. Bailey, C.E. Bond, J.R. Brooker, E.A. Lachner, R.N. Lea and W.B. Scott. 1980. A list of common and scientific names of fishes from the United States and Canada. American Fisheries Society Special Publication No. 12.

Schreck, C.B. and R.J. Behnke. 1971. Trouts of the Upper Kern River basin, California, with reference to systematics and evolution of western North American Salmo. Journal of Fisheries Research Board of Canada 28:987-998.

Snedecor, G.W. and W.G. Cochran. 1978. Statistical methods, Iowa State University Press, Ames, Iowa, USA.

Vancil, R., G. Zuerlein and L. Hess. 1979. Lethal and preferred temperatures of Lake McConaughy rainbow trout versus domestic strain rainbow trout. Nebraska Game and Parks Commission, Nebraska Technical Series No. 7. Lincoln, Nebraska, USA.

Wilmot, R.L. 1974. A genetic study of the red-band trout. Doctoral thesis. Oregon State University, Corvallis, Oregon.

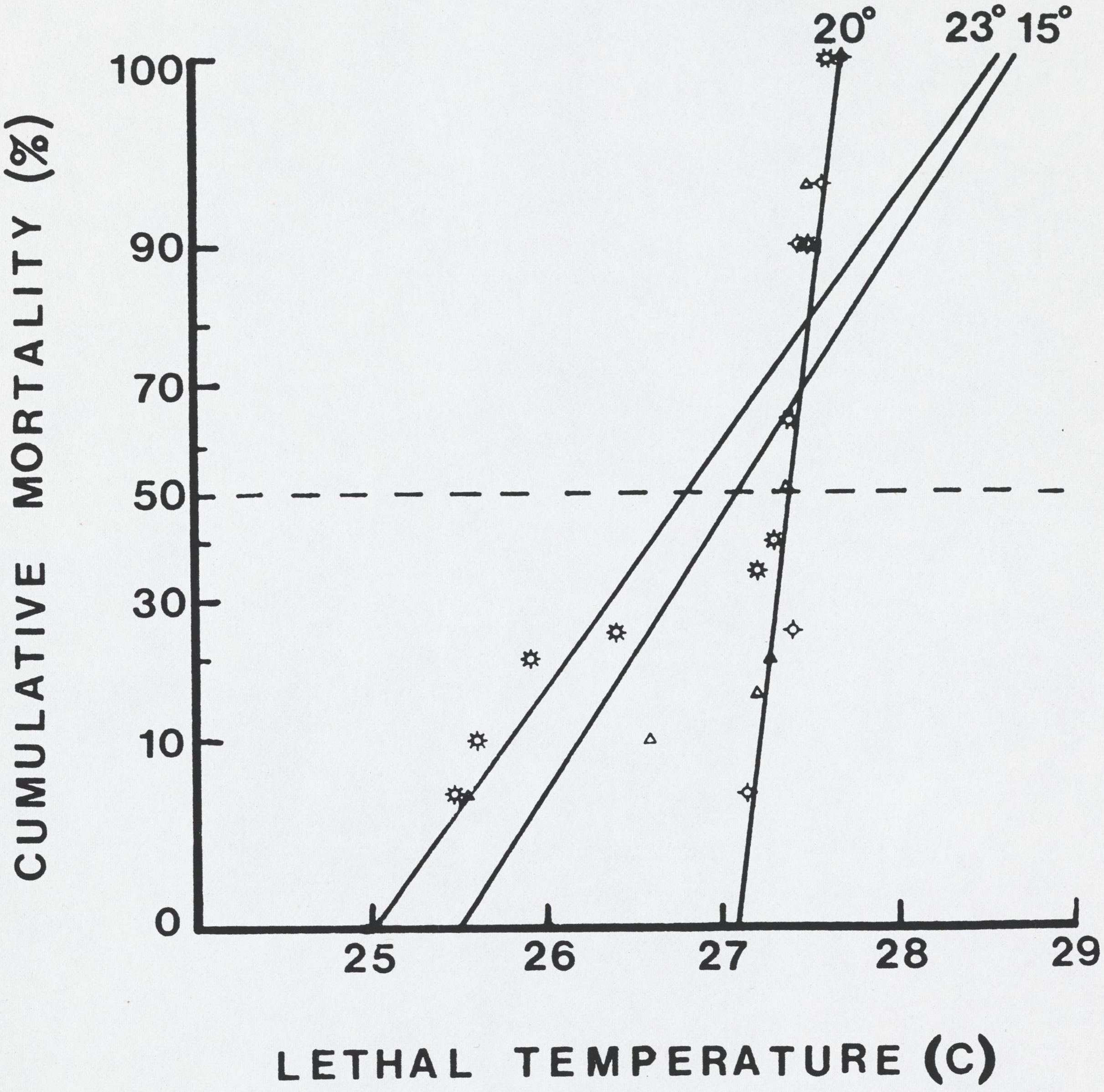
Zar, J.H. 1974. Biostatistical analysis. Prentice-Hall, Incorporated, Englewood Cliffs, New Jersey, USA.

Table 1. Upper lethal temperatures for redband trout acclimated to three temperatures and exposed to temperature increases of 0.5 C/day.

Acclimation temperature (C)	n	Lethal temperature range (C)	LT_{50} (C)	Regression[a] equation (arcsin Y=a+bX)	r^2
15	20	25.5-27.7	27.1	Y=-720.09+28.23(X)	0.492
20	20	27.2-27.7	27.4	Y=-4485.0+165.30(X)	0.942
23	20	25.5-27.6	26.8	Y=-621.36+24.85(X)	0.712

[a] Y = percent cumulative mortality, a = Y-intercept at X = 0, b = slope, and X = lethal temperature.

Figure 1. Cumulative mortality (plotted with the arcsin transformation) vs. lethal temperature for redband trout acclimated at 15, 20 and 23 C and exposed to temperature increases of 0.5 C/day until death. Data points referring to 15 C are indicated by △ , 20 C by ⌖ , and 23 C by ☼ . LT_{50}'s are indicated by the intersection of regression lines and the 50% cumulative mortality line.


20°
23°
15°
CUMULATIVE MORTALITY (%)
100
90
70
50
30
10
0
25
26
27
28
29
LETHAL TEMPERATURE (C)

ANNUAL PROCEEDINGS
of the
TEXAS CHAPTER
AMERICAN FISHERIES SOCIETY

SEPTEMBER 26, 1981
AUSTIN, TEXAS

VOLUME 4

ANNUAL PROCEEDINGS OF THE TEXAS CHAPTER OF THE AMERICAN FISHERIES SOCIETY

September 26, 1981

Austin, Texas

1981-82 Officers

Gary Valentine, President
Soil Conservation Service

Don Steinbach, President-Elect
Texas A & M University

Maury Osborn, Secretary-Treasurer
Texas Parks and Wildlife Department

Editorial Committee: Gary C. Matlock, Chairman
Gary P. Garrett

1982

TABLE OF CONTENTS

PROGRAM

Annual Meeting of

TEXAS CHAPTER

AMERICAN FISHERIES SOCIETY

<u>A.M.</u>

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 Largemough 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

(1) Fort Hood Fish & Wildlife Section

Valerie Drysdale

(2) Hydrolab

Jim Flynn

(3) Louisiana Tech

John Wakeman

(4) Oklahoma State University

Gene Gilliland

(5) Soil Conservation Service

Ed Schwille
Jerry Turrentine
Gary Valentine
Michael Zeman

(6) Southwest Texas State University

Mike Bira
Gary Carmichael
Russell Kiefer
Ralph Manns
Donald Mitchell
Victor Palma
Tony Spinelli
Joe Tomasso
Sharon Wallace
Bobby Whiteside

(7) Texas A&M University

Robert K. Betsill
Phillip W. Bettoli
Blair Brenner
Colleen Caldwell
Kris Chenicer

(7) con't

Bill Harvey
Jeff Isely
Ken Johnson
Steven Kelsch
Joe Morris
William Neill
Rich Noble
Alan Rudd
Don Steinbach
Kirk Strawn

(8) Texas Agricultural Ext. Service

Billy Higginbotham

(9) Texas Dept. of Water Resources

Henry P. Day
Robert Phillips
Gary Powell

(10) Texas Parks & Wildlife Department

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

(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
TWX: (910) 874-1335

Water quality instrumentation

R. R. REEVES ENTERPRISES
Rt. 3, Box 580
Orange, TX 77630

(713) 745-3948

Consultants in aquatic management and bio-aquatic systems.

GEORGE L. VAUGHT, ASSOCIATE
ESPEY, HUSTON & ASSOCIATES, INC.
916 Capital of Texas Hwy South
P. O. Box 519
Austin, TX 78767

(512) 327-6840

Engineering and environmental consultants providing civil design and multi-disciplinary environmental support services for Federal and State permitting.

FRIGID UNITS, INC. DEXTON McCLOUGHAM
3214 Sylvania Avenue
Toledo, OH 43613

(419) 474-6971

Controlled environment aquatic systems including living stream, fiberglass tanks, and Min-O-Cool.

TEXAS INSTRUMENTS LYNDA COUMELIS
P. O. Box 22605
Dallas, TX 75266

(214) 995-2011

Scientific equipment supplies.

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. Andy Landry
Mr. Dick Luebke
Dr. Kirk Strawn
Mr. E. Smith
Mr. Ed Hegen
Dr. T. Hellier

Dr. Joan Holt
Mr. Bob Colura
Dr. Rus Miget
Mr. Holt Williamson
Mr. Al Green
Dr. Fred Rainwater
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 Unversity 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 retreived. 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.

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 (<u>Lepomis</u> <u>auritus</u>), redear sunfish (<u>L</u>. <u>microlophus</u>) and coppernose bluegill (<u>L</u>. <u>macrochirus</u> <u>purpurescens</u>) were crossed with largemouth bass (<u>Micropterus</u> <u>salmoides</u>). These sunfish were selected for their adult size. All crosses were artifically 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 aklalinity, 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 (LT_{50}) 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 (OC = 0.05) between acclimation temperatures. Temperatures at death ranged from 23.3 C to 26.6 C. The LT_{50} 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 Norfork 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-l 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.

LITERATURE CITED

Baldwin, N. S. 1951. A preliminary study of brook trout food consumption and growth at different temperatures. Research Council of Ontario, 5th Technical Session.

Bidgood, B. F. and A. H. Berst. 1969. Lethal temperatures for Great Lakes rainbow trout. Journal of the Fisheries Research Board of Canada 26:456-459.

Cooper, E. L. 1953. Returns from plantings of legal-sized brook, brown and rainbow trout in the Pigeon River, Otsego County, Michigan. Transactions of the American Fisheries Society 82:265-280.

Fry, R. E. J., S. Hart, and K. F. Walker. 1946. Lethal temperatures for a sample of young speckled trout, Salvelinus fontinalis. University of Toronto Studies, Biological Series 54:9-35.

Guest, W. C., B. W. Lyons, and G. Garza. 1979. Effects of temperature on survival of peacock bass fingerlings. Proceedings of the Southeastern Association of Fish and Wildlife Agencies 33:620-627.

Henderson, N. E. 1963. Influence of light and temperature on the reproductive cycle of the eastern brook trout, Salvelinus fontinalis (Mitchill). Journal of the Fisheries Research Board of Canada 20:859-897.

Hokanson, K. E. F., J. H. McCormick, B. R. Jones and J. H. Tucker. 1973. Thermal requirements for maturation, spawning, and embryo survival of the brook trout, Salvelinus fontinalis. Journal of the Fisheries Research Board of Canada 30:975-984.

Kaya, C. M. 1978. Thermal resistance of rainbow trout from a permanently heated stream, and of two hatchery strains. The Progressive Fish-Culturist 40:138-142.

LaRivers, I. 1962. Fishes and fisheries of Nevada. Nevada State Fish and Game Commission, Carson City, Nevada, USA.

McCormick, J. H., K. E. F. Hokanson, and B. R. Jones. 1972. Effects of temperature on growth and survival of young brook trout, Salveninus fontinalis. Journal of the Fisheries Research Board of Canada 29:1107-1112.

Mullan, J. W. 1958. A compendium of the life history and ecology of the eastern brook trout Salvelinus fontinalis (Mitchill). Massachusetts Division of Fish and Game, Fisheries Bulletin 23.

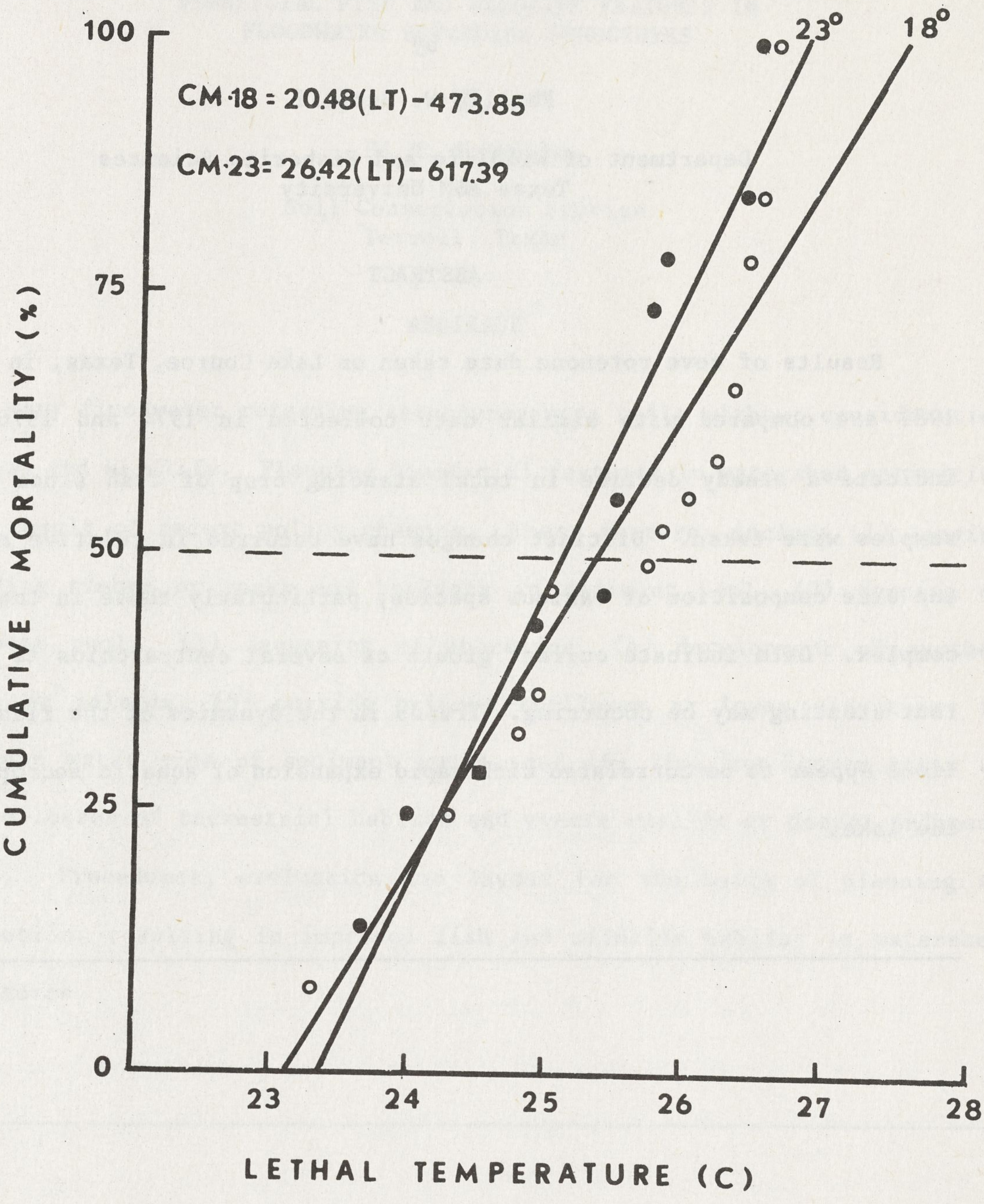
Otto, R. G. and J. O. Rice. 1977. Responses of a freshwater sculpin (Cottus cognatus gracilis) to temperature. Transactions of the American Fisheries Society 106:89-94.

Snedecor, G. W. and W. G. Cochran. 1978. Statistical methods. Iowa State University Press, Ames, Iowa, USA.

Thorpe, L. M., J. Rayner and D. A. Webster, 1947. Population depletion in brook, brown and rainbow trout stocked in the Blackledge River, Connecticut, in 1942. Transactions of the American Fisheries Society 74:166-187.

White, R. L. 1968. Evaluation of catchable rainbow trout fishery. Texas Parks & Wildlife Department, Job Progress Report, Dingell-Johnson Federal Aid, Project F-2-15, Job E9, Austin, Texas, USA.

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 LT_{50} is indicated by the intersection of regression lines and the broken line.


CM·18 = 20.48(LT)−473.85
CM·23= 26.42(LT)−617.39
23°
18°
100
75
50
25
0
23
24
25
26
27
28
CUMULATIVE MORTALITY (%)
LETHAL TEMPERATURE (C)

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.

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.

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 biweekly 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 u 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 $CaCO_3$), 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 $CaCO_3$; 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 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).

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.

LITERATURE CITED

Boyd, C. E. 1979. Water quality in warmwater fish ponds. Auburn Univ., Agricultural experiment station. 359 pp.

Geiger, J. G. 1981. Zooplankton sampling procedures. U.S.F.W.S., Southeastern Fish Cultural Lab., Marion, Al. 9 pp.

American Fisheries Society. 1976. Guidelines for striped bass culture. Striped bass Committee of the Southern Division. 103 pp.

Snow, J. R., R. O. Jones and W. A. Rogers. 1964. Training manual for warm-water fish culture. Bureau of Sport Fisheries and Wildlife. Marion, Al. 460 pp.

Sokal, R. R. and F. J. Rohlf. 1969. Biometry, W. H. Freeman and Co., San Francisco, Ca. 776 pp.

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

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

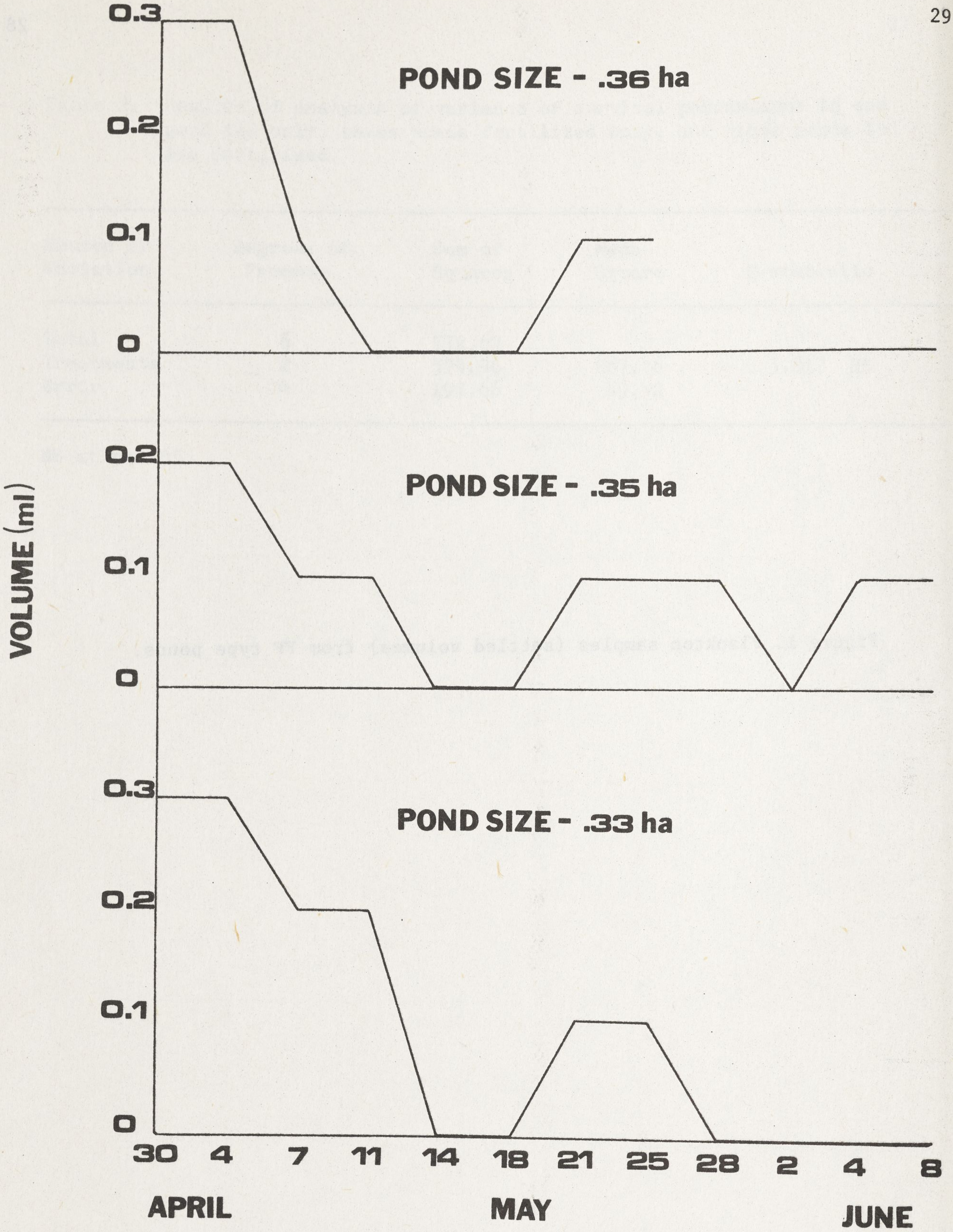

POND SIZE - .36 ha
POND SIZE - .35 ha
POND SIZE - .33 ha
VOLUME (ml)
0.3
0.2
0.1
0
0.2
0.1
0
0.3
0.2
0.1
0
30
4
7
11
14
18
21
25
28
2
4
8
APRIL
MAY
JUNE

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

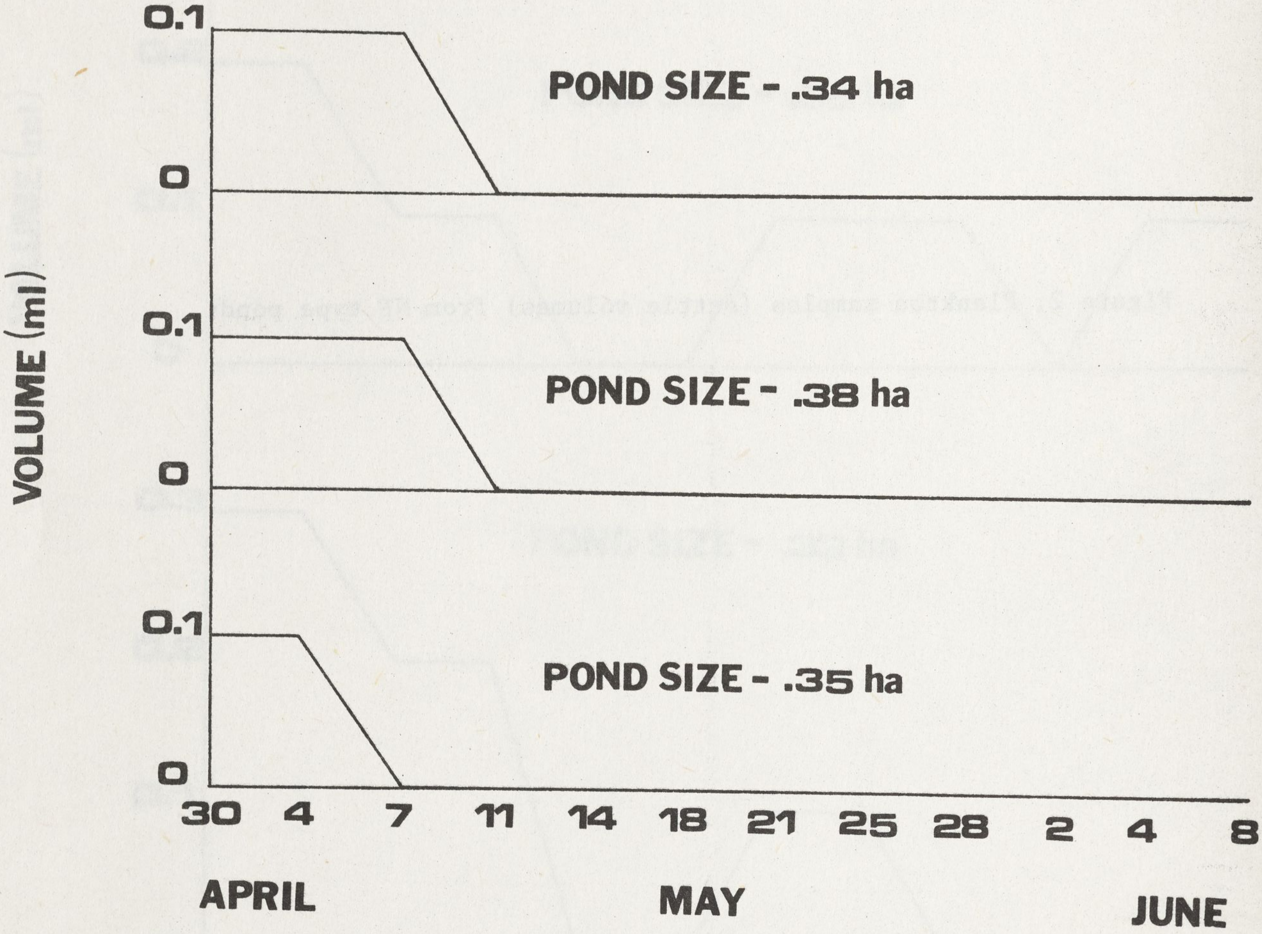
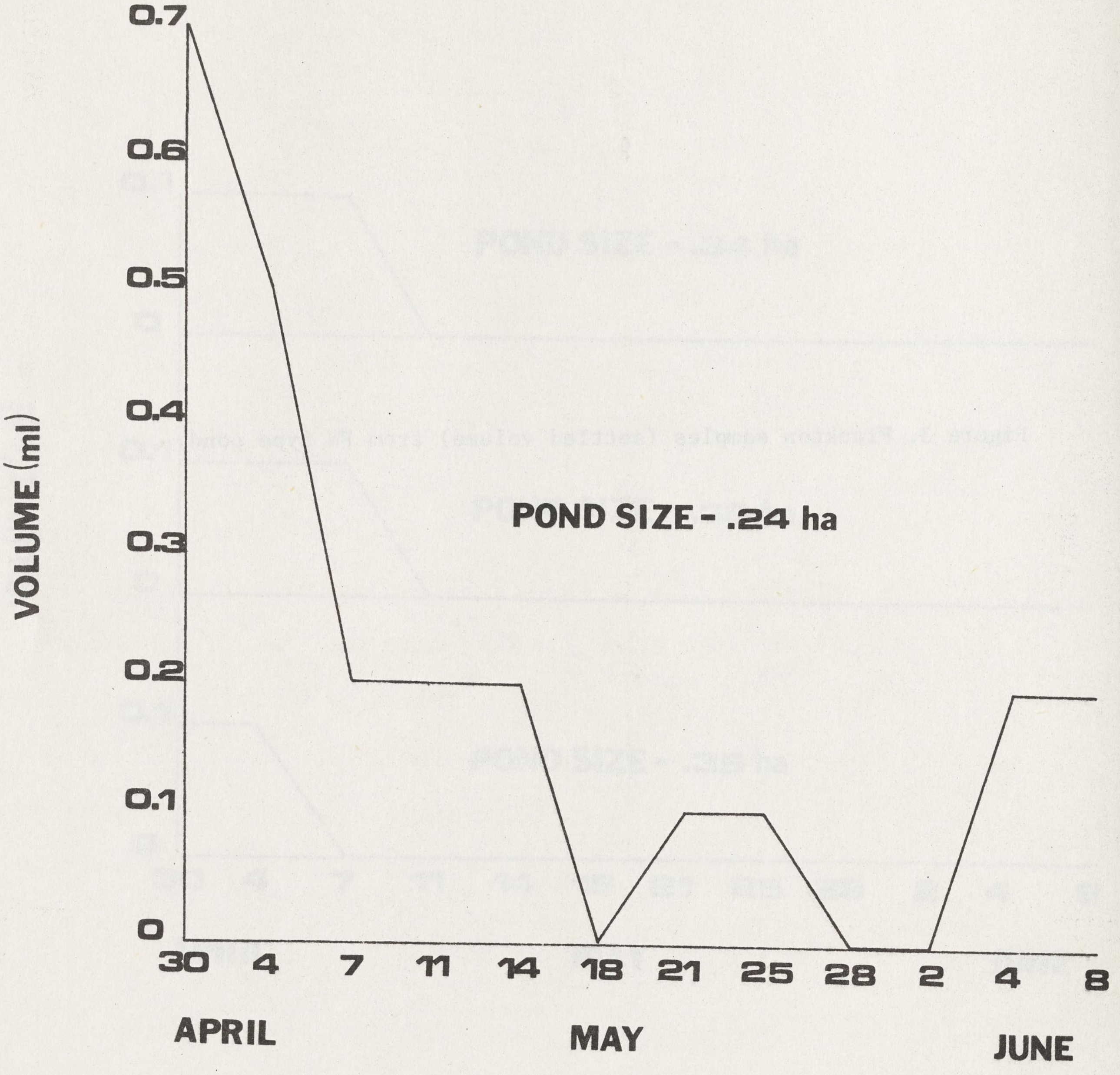

VOLUME (ml)
0.1
0
POND SIZE - .34 ha
0.1
0
POND SIZE - .38 ha
0.1
0
POND SIZE - .35 ha
30
4
7
11
14
18
21
25
28
2
4
8
APRIL
MAY
JUNE

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


0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
VOLUME (ml)
POND SIZE - .24 ha
30
4
7
11
14
18
21
25
28
2
4
8
APRIL
MAY
JUNE

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. Fourty-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 condtion 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 $L^{0.5} \cdot sec^{-1}$ 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 $L^{0.5} \cdot sec^{-1}$. 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 <u>specific</u> <u>speed</u> in terms of lengths per second ($L \cdot sec^{-1}$). He found maximum sprint speeds for a number of species of fishes to be about 10 $L \cdot sec^{-1}$, 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 Zwiefel 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:

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

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:

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

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:

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

for turbulent boundary layers, and

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

for laminar boundary layers.

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

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

for turbulent boundary layer conditions, and

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

for laminar boundary layer conditions.

Velocity (U) can be expressed as:

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

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

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

under conditions where turbulent boundary layers predominate, or

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

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 erratic, 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 $cm \cdot sec^{-1}$. 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: <u>absolute</u> <u>speed</u> ($cm \cdot sec^{-1}$), <u>specific</u> <u>speed</u> ($L \cdot sec^{-1}$), and <u>standardized</u> <u>speed</u> ($L^{0.5} \cdot sec^{-1}$) 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 ($mg\ O_2 \cdot hr^{-1}$). 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 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 $cm \cdot sec^{-1}$, 1.02 when expressed in terms of $L \cdot sec^{-1}$, and 0.86 when expressed in terms of $L^{0.5} \cdot sec^{-1}$.

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 $\log_{10}$ 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 M on 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 $cm \cdot sec^{-1}$ was low, while the b_w value obtained when speed was expressed in terms of $L \cdot sec^{-1}$ 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 $L^{0.5} \cdot sec^{-1}$.

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 $L^{0.5} \cdot sec^{-1}$ (Figure 1) and analyzed by simple linear regression. Maximum sustained swimming speed expressed in $cm \cdot sec^{-1}$ 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 ($L \cdot sec^{-1}$) 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 ($L^{0.5} \cdot sec^{-1}$) 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.

LITERATURE CITED

Bainbridge, R. 1958. The speed of swimming of fish as related to size and to the frequency and the amplitude of the tailbeat. J. Exp. Biol. 35:109-133.

Bainbridge, R. 1969. Speed and stamina in three fish. J. Exp. Biol. 37:129-153.

Bainbridge, R. 1962. Training, speed and stamina in trout. J. Exp. Biol. 39:537-555.

Beamish, F. W. H. 1978. Swimming capacity. In W. S. Hoar and D. J. Randall (Eds.), Fish physiology. Vol. 7 Academic Press. N.Y.

Blaxter, J. H. S. 1969. Swimming speeds of fish. FAO Fish. Rep 62(2):69-100.

Blaxter, J. H. S., and W. Dickson. 1959. Observations on the swimming speeds of fish. J. Cons, Int. Explor. Mer. 24:472-479.

Blazka, P., M. Volf, and M. Cepela. 1960. A new type of respirometer for the determination of metabolism of fish in an active state. Physiol. Bohemoslov. 9:553-58.

Brett, J. R. 1965. The relation of size to the rate of oxygen consumption and sustained swimming speeds of sockeye salmon (<u>Oncorhynchus nerka</u>). J. Fish Res. Bd. Canada 22:1491-1501.

Dahlberg, M. L., D. L. Shumway, and P. Dondoroff. 1968. Influence of dissolved oxygen and carbon dioxide on swimming performance of largemouth bass and coho salmon. J. Fish. Res. Bd. Canada 25:49-70.

Farmer, G. J. and F. W. H. Beamish. 1968. Oxygen consumption of <u>Tilapia nilotica</u> in relation to swimming speed and salinity. J. Fish. Res. Bd. Canada 26:2807-2821.

Fry, F. J. and E. T. Cox 1970. A relation to size to swimming speed in rainbow trout. J. Fish Res. Bd. Canada 27:976-978.

Glass, N. R. 1969. Discussion of calculation of power function with special reference to respiratory metabolism in fish. J. Fish. Res. Bd. Canada 26:2643-2650.

Gunther, B. 1975. Dimensional analysis and theory of biological similarity. Physiol. Rev. 55(4):659-699.

Hunter, J. R. and J. R. Zwiefel. 1971. Swimming speed, tail-beat frequency, tail-beat amplitude and size in jack mackeral, *Trachurus symmetricus*, and other fishes. Fish. Bull. 69:253-266.

McMahon, T. 1973. Size and shape in biology. Science 179: 1201-1204.

Muir, B. S. and A. J. Niimi. 1972. Oxygen consumption of the euryhaline fish aholehole (*Kukhia sandvicensis*) with reference to salinity, swimming and food consumption. J. Fish. Res. Bd. Canada 29:67-77.

Nursall, J. R. 1962. Swimming and the origin of paired appendages. Amer. Zoologist 2:217-141.

Prandtl, L. and O. G. Tietjens. 1934. Fundamentals of hydro and aeromechanics. Dover Books, N.Y.

Rao, G. M. 1968. Oxygen consumption of rainbow trout (*Salmo gairdneri*) in relation to activity and salinity. Can. J. Zoology 46:781-786.

Smit, H. 1965. Some experiments on the oxygen consumption of goldfish (*Carassius auratus* L.) in relation to swimming speed. Can. J. Zoology 43:623-633.

Smit, H., J. M. Amelink-Kontstaal, J. Vijverberg and J. Von Vaupel-Klein. 1971. Oxygen consumption and efficiency of swimming goldfish. Comp. Biochem. Physiol. 39A:1-28.

Vetter, R. D. 1977. Respiratory metabolism of, and niche separation between two co-occurring congeneric species, *Cynoscion nebulosus* and *Cynoscion arenarius*, in a south Texas estuary. M. A. Thesis. Univ. of Texas at Austin, Austin, Texas.

Wakeman, J. M. and D. E. Wohlschlag. 1978. An apparatus to study the energetics of swimming fishes. Ann. Proceed. Texas Chapt. Amer. Fish. Soc., Vol. 1:67-83.

Wakeman, J. M. and D. E. Wohlschlag. 1979. Salinity stress and swimming performance of spotted seatrout. Proc. 31st Ann. Conf. Southeast Assoc. Game and Fish Comm.

Webb, P. J. 1975. Hydrodynamics and energetics of fish propulsion. Fish. Res. Bd. Canada, Bull. 190.

Winberg, G. G. 1956. Rate of metabolism and food requirements of fishes. Fish. Res. Bd. Canada Transl. Ser. 194 (1960).

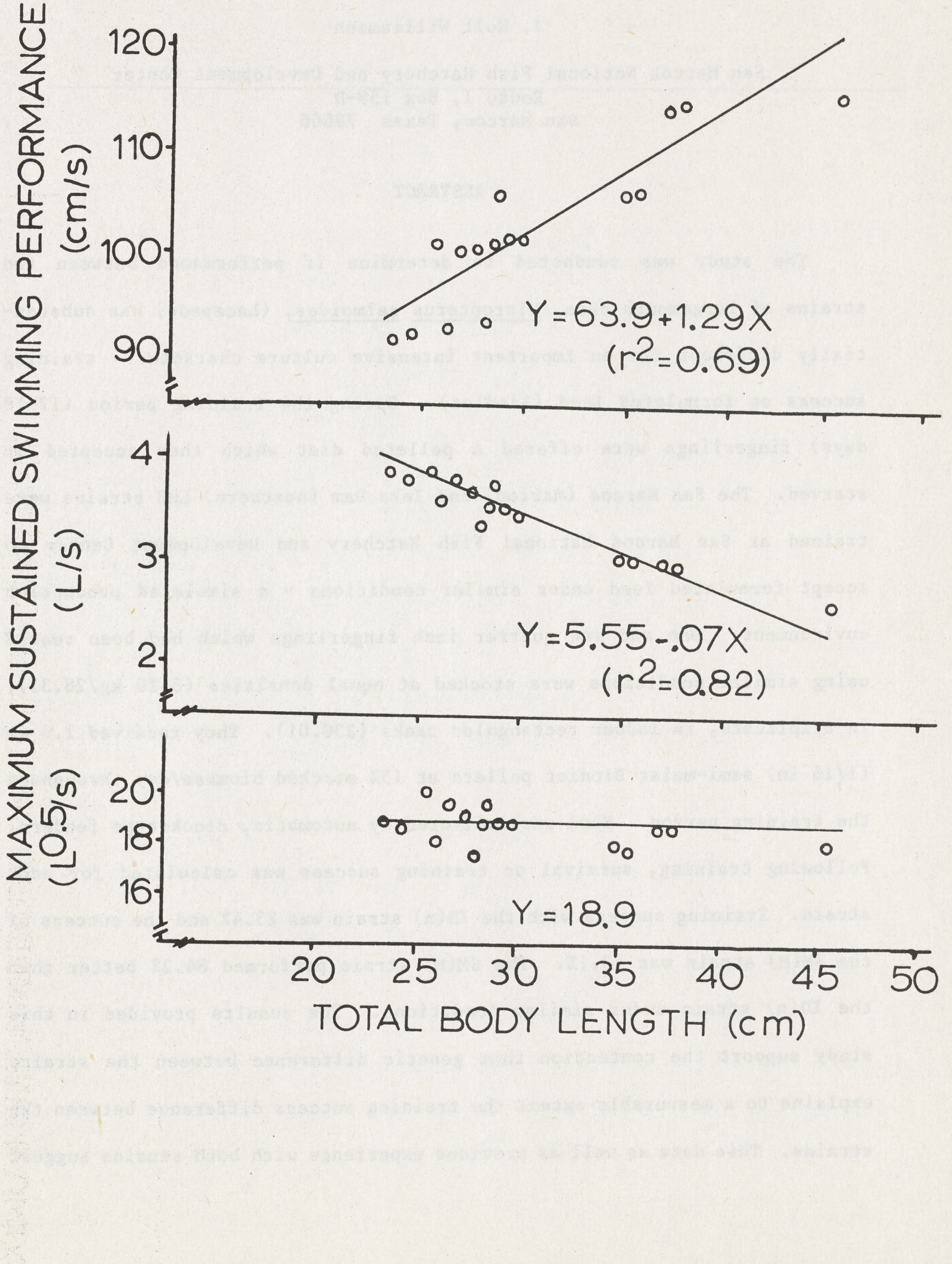
Wohlschlag, D. E. and J. M. Wakeman. 1978. Salinity stresses, metabolic responses and distribution of the coastal spotted seatrout, Cynoscion nebulosus. Contr. Mar. Sci., Univ. Texas. 21:171-185.

Table 1. Coefficients for the multiple regression equation $\underline{M} = a + b_w\underline{W} + b_s\underline{S}$, relating $\log_{10}$ mg $O_2 \cdot hr^{-1}$ ($\underline{M}$) to $\log_{10}$ weight in g ($\underline{W}$) and to swimming performance ($\underline{S}$) where performance is expressed in terms of $cm \cdot sec^{-1}$, $L \cdot sec^{-1}$ and $L^{0.5} \cdot sec^{-12}$ 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
$L^{0.5}$/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 $cm \cdot sec^{-1}$, $L \cdot sec^{-1}$, and $L^{0.5} \cdot sec^{-1}$. Curves for $cm \cdot sec^{-1}$ and $L^{0} \cdot sec^{-1}$ were fitted by simple linear regression and were significant ($P < 0.01$). The curve for $L^{0.5} \cdot sec^{-1}$ represents the mean, because of the absence of any significant correlation at the 0.5 level (see text).


MAXIMUM SUSTAINED SWIMMING PERFORMANCE
(cm/s)
120
110
100
90
Y=63.9+1.29X
(r^2=0.69)
(L/s)
4
3
2
Y=5.55-.07X
(r^2=0.82)
(L0.5/s)
20
18
16
Y=18.9
20
25
30
35
40
45
50
TOTAL BODY LENGTH (cm)

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) wsa 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 producion and management are possible by exploiting the genetic potential of different strains of largemouth bass.

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 over-abundant 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 fishermen 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.

LITERATURE CITED

Anderson, R. O. 1973. Application of theory and research to management of warmwater fish populations. Transactions of the American Fisheries Society 102:164-171.

Bayless, J. D. 1972. Artificial propagation and hybridization of striped bass, Morone saxatilis (Walbaum). Special Report, South Carolina Wildlife Department, Columbia, South Carolina, USA.

Bennett, G. W. 1970. Management of lakes and ponds. Van Nostrand Reinhold Company, New York, New York, USA.

Bishop, R. D. 1967. Evaluation of the striped (Roccus saxatilis) and white bass (R. chrysops) hybrids after two years. Proceedings of the Southeastern Association of Game and Fish Commissioners 21:245-254.

Carlander, K. D. 1961. Variations on rereading walleye scales. Transactions of the American Fisheries Society 90:230-231.

Crandall, P.S. 1978. Evaluation of striped bass x white bass hybrids in a heated Texas reservoir. Proceedings of the Southeastern Association of Fish and Wildlife Agencies 32:588-598.

Hile, R. 1941. Growth of the rock bass, Ambloplites rupestris (Rafinesque) in Nebish Lake, Wisconsin. Transactions of the Wisconsin Academy of Science, Arts, and Letters 33:189-337.

Lagler, K. F. 1972. Freshwater fishery biology. William C. Brown Company, Dubuque, Iowa, USA.

Novinger, G. D., and R. E. Legler. 1978. Bluegill population structure and dynamics. Pages 37-49 in G. D. Novinger and J. G. Dillard, editors. New approaches to the management of small impoundments. North Central Division American Fisheries Society, Special Publication Number 5, Bethesda, Maryland, USA.

Texas Parks and Wildlife Department. 1975. A manual of survey and management techniques for reservoir and stream management. Looseleaf publication, Austin, Texas, USA.

Ware, F. J. 1974. Progress with Morone hybrids in freshwater. Proceedings of the Southeastern Association of Game and Fish Commissioners 28:48-54.

Williams, H. M. 1970. Preliminary studies of certain aspects of the life history of the hybrid (striped bass x white bass) in two South Carolina reservoirs. Proceedings of the Southeastern Association of Game and Fish Commissioners 24:424-431.

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.

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		33	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		42	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.

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		69	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 CORTICOSTERIOD 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 Unversity

ABSTRACT

Plasma corticosteriod 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 $\leq$ 40 stations (except $\leq$ 80 stations in Galveston Bay system) from November 1975 through September 1977 and from a list of $\leq$ 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 $^{o}/oo$) 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 (<u>Carcharhinus</u> <u>leucas</u>) 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 ^{o}/oo) 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 ^{o}/oo and 0.0-36.0 ^{o}/oo, 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 ^{o}/oo and 23.0-39.0 ^{o}/oo, 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 ^{o}/oo). 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 ^{o}/oo 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.

LITERATURE CITED

Baughman, J. L. 1950. Random notes on Texas fishes, part I. Tex. J. Sci. 2(1):117-138.

Baughman, J. L. and S. Springer. 1950. Biological and economic notes on the sharks of the Gulf of Mexico, with special reference to those of Texas, and with a key for their identification. Am. Midl. Nat. 44(1):96-152.

Bigelow, H. B. and W. C. Schroeder. 1948. Sharks. In: Fishes of the western North Atlantic. Mem. Sears Found. Mar. Res. 1(1):59-546.

Briggs, J. C. 1958. A list of Florida fishes and their distribution. Bull. Fla. State Mus. Biol. Sci. 2(8):223-318.

Casey, J. G. 1964. Angler's guide to sharks of the northeastern United States, Maine to Chesapeake Bay. U. S. Fish Wildl.Serv., Bur. Sport Fish. Wildl. Circ. No. 179. 32 p.

Clark, E. and K. von Schmidt. 1965. Sharks of the central Gulf coast of Florida. Bull. Mar. Sci. 15(1):13-83.

Cody, T. J., B. E. Fuls, G. C. Matlock and C. E.Bryan. 1981. Assessment of bottom longline fishing off the central Texas coast, a completion report. Tx. Pks. Wildl. Dept., Coastal Fish. Br. Mgmt. Data Ser. No. 22. 51 p.

Gunter, G. 1938. Notes on invasion of fresh waters by fishes of the Gulf of Mexico, with special reference to the Mississippi-Atchafalaya River system. Copeia 1938(2):69-72.

_________. 1945. Studies on marine fishes of Texas. Publ. Inst. Mar. Sci. Univ. Tx. 1(1):1-190.

_________. 1956. A revised list of euryhaline fishes of North and Middle America. Am. Midl. Nat. 56(2):345-354.

Hegen, H. E. 1981. Monitoring of coastal finfish resources for sport fish management, October 1979-September 1980. Tx. Pks. Wildl. Dept., Coastal Fish. Br. Mgmt. Data Ser. No. 28. 228 p.

__________. and G. C. Matlock. 1980. Monitoring of coastal finfish resources for sport fish management, October 1978-September 1979. Tx. Pks. Wildl. Dept., Coastal Fish. Br. Mgmt. Data Ser. No. 17. 245 p.

Hildebrand, H. H. 1954. A study of the fauna of the brown shrimp (Penaeus aztecus Ives) grounds in the western Gulf of Mexico. Publ. Inst. Mar. Sci. Univ. Tx. 3(2):233-366.

Hoese, H. D. 1958. A partially annotated checklist of the marine fishes of Texas. Publ. Inst. Mar. Sci. Univ. Tx. 5:312-352.

Hoese, H. D. and R. B. Moore 1958. Notes on the life history of the bonnetnose shark, Sphyrna tiburo. Tx. J. Sci. 1(1):69-72.

____________. and R. H. Moore. 1977. Fishes of the Gulf of Mexico-Texas, Louisiana, and adjacent waters. Tex. A&M Univ. Press, College Station. 327 p.

Johnson, R. B. 1977. Fishery survey of Cedar Lakes and the Brazos and San Bernard River estuaries. Tx. Pks. Wildl. Dept. Tech. Ser. No. 23. 65 p.

Matlock, G. C. and J. E. Weaver. 1979. Assessment and monitoring of Texas coastal finfish resources. Tx. Pks. Wildl. Dept., Coastal Fish. Br. Rept. No. 3000-66. 241 p.

____________. and J. E. Weaver, L. W. McEachron, J. A. Dailey, P. C. Hammerschmidt, H. E. Hegen, R. A. Harrington, and G. M. Stokes. 1978. Trends in finfish abundance in Texas estuaries as indicated by gill nets. Tx. Pks. Wildl. Dept., Coastal Fish. Br. Rept. No. 3000-42. 271 p.

McEachron, L. W., A. W. Green, L. Z. Barrington, M. G. Weixelman, P. Campbell-Hostettler, R. A. Spaw, K. W. Spiller, and J. P. Breuer. 1981. Survey of finfish harvest by sport fishermen in selected Texas bays, September-August 1974-76 and 1979-80. Tx. Pks. Wildl. Dept., Coastal Fish. Br. Mgmt. Data Ser. No. 24. 221 p.

Moffett, A. W. 1975. The hydrography and macro-biota of the Chocolate Bayou estuary, Brazoria county, Texas (1969-1971). Tx. Pks. Wildl. Dept. Tech. Ser. No. 14. 72 p.

Parker, J. C., ed. 1972. Key to the estuarine and marine fishes of Texas. Tx. Agri. Ext. Serv., Tx. A&M Univ., Sea Grant Publ. No. 72-402. 177 p.

Pullen, E. J. 1960. Collection and identification of vertebrate forms present in area M-2 and determination their relative seasonal abundance. Tx. Game Fish Comm., Mar. Fish. Div. Proj. Rept. 1959-1960. 11 p.

Reid, G. K. 1954. An ecological study of Gulf of Mexico fishes in the vicinity of Cedar Key, Florida. Bull. Mar. Sci. Gulf Caribb. 4(1):1-94.

Robins, C. R., R. M. Bailey, C. E. Bond, J. R. Brooker, E. A. Lachner, R. N. Lea and W. B. Scott. 1980. A list of common and scientific names of fishes from the United States and Canada. 4th. ed. Am. Fish. Soc. Spec. Publ. No. 12. 174 p.

Simmons, E. G. 1951. The Cedar Bayou fish trap. Tx. Game Fish Comm., Mar. Lab. Ann. Rept. 1950-1951. 35 p.

____________. 1957. An ecological survey of the upper Laguna Madre of Texas. Publ. Inst. Mar. Sci. Univ. Tex. 4(2):156-200.

Springer, S. 1950. Natural history notes on the lemon shark, Negaprion brevirostris. Tx. J. Sci. 2(3):349-359.

Springer, S. 1960. Natural history of the sandbar shark, Eulamia milberti. U. S. Fish Wildl. Serv., Fish. Bull. 61(178). 38 p.

Swingle, H. A. 1971. Biology of Alabama estuarine areas-cooperative Gulf of Mexico estuarine inventory. Ala. Mar. Res. Bull. 5:1-123.

Walls, J. G. 1975. Fishes of the northern Gulf of Mexico. T. F. H. Publ., Inc., Ltd. Neptune City, N. J. 432 p.

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	Season	Mar	Apr	May	Season	Jun	Jul	Aug	Season	Sep	Oct	Nov	Season
Bull	0.4	0.0	0.0	0.1	1.3	19.2	37.9	15.5	29.4	124.0	104.9	90.1	58.1	41.2	8.6	29.1
Blacktip	0.0	0.0	0.4	0.1	1.7	5.2	3.9	3.2	10.7	17.4	25.7	18.6	7.7	0.9	5.1	3.9
Bonnethead	0.0	0.0	0.0	0.0	2.1	3.0	3.2	2.6	2.7	26.1	33.9	22.3	12.1	0.9	0.8	2.7
Scalloped hammerhead	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.3	20.7	3.1	8.7	4.4	0.0	0.4	0.9
Atlantic sharpnose	0.4	0.0	0.0	0.1	0.0	0.0	2.4	0.6	0.0	4.4	8.2	4.5	5.5	0.5	0.0	1.1
Lemon	0.0	0.0	0.0	0.0	0.4	0.0	1.6	0.6	1.3	1.1	5.1	2.7	0.0	0.0	0.0	0.0
Finetooth	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.3	2.2	1.0	2.7	1.1	0.5	0.0	0.4
Spinner	0.0	0.0	0.0	0.0	0.0	0.7	2.4	0.8	0.0	0.0	0.0	0.0	0.0	2.3	0.0	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	0.0	0.0	3.1	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	0.0	0.0	0.4	0.2
All species	0.8	0.0	0.4	0.4	5.5	28.0	51.3	23.3	50.8	195.8	182.0	149.6	88.8	46.3	18.4	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 species caught in Texas bays during November 1975-October 1980.

		Temperature (C)			Salinity (°/oo)			Distance (km)[a]		
Species	No. Obvs.	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	Sizes[a] from literature 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.

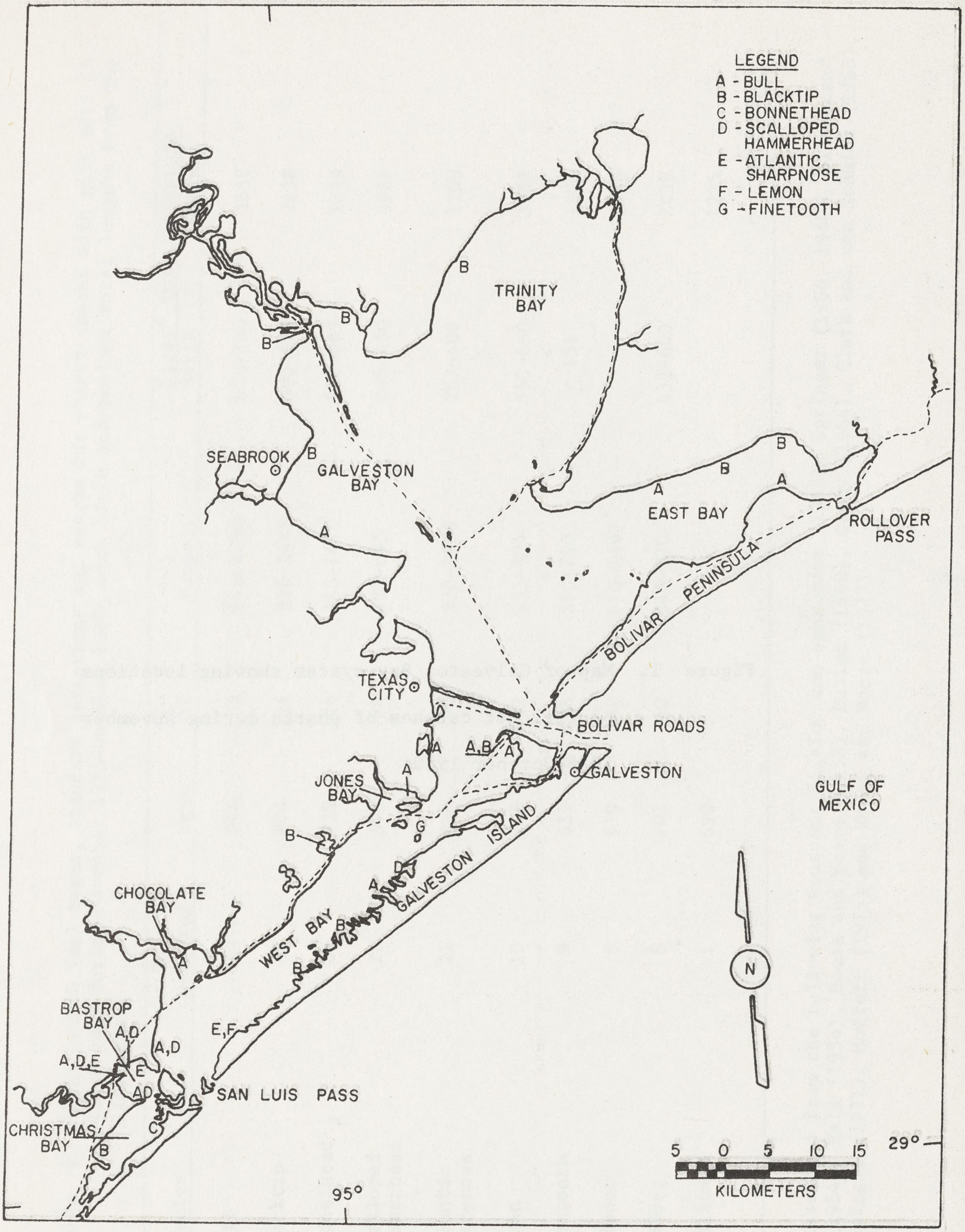

LEGEND
A - BULL
B - BLACKTIP
C - BONNETHEAD
D - SCALLOPED HAMMERHEAD
E - ATLANTIC SHARPNOSE
F - LEMON
G - FINETOOTH
TRINITY BAY
GALVESTON BAY
SEABROOK
EAST BAY
ROLLOVER PASS
BOLIVAR PENINSULA
TEXAS CITY
BOLIVAR ROADS
GALVESTON
GULF OF MEXICO
JONES BAY
CHOCOLATE BAY
WEST BAY
GALVESTON ISLAND
BASTROP BAY
SAN LUIS PASS
CHRISTMAS BAY
N
5 0 5 10 15
KILOMETERS
95°
29°
A,B
A,D
A,D,E
E,F
E
AD
C
G
D
A
B

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

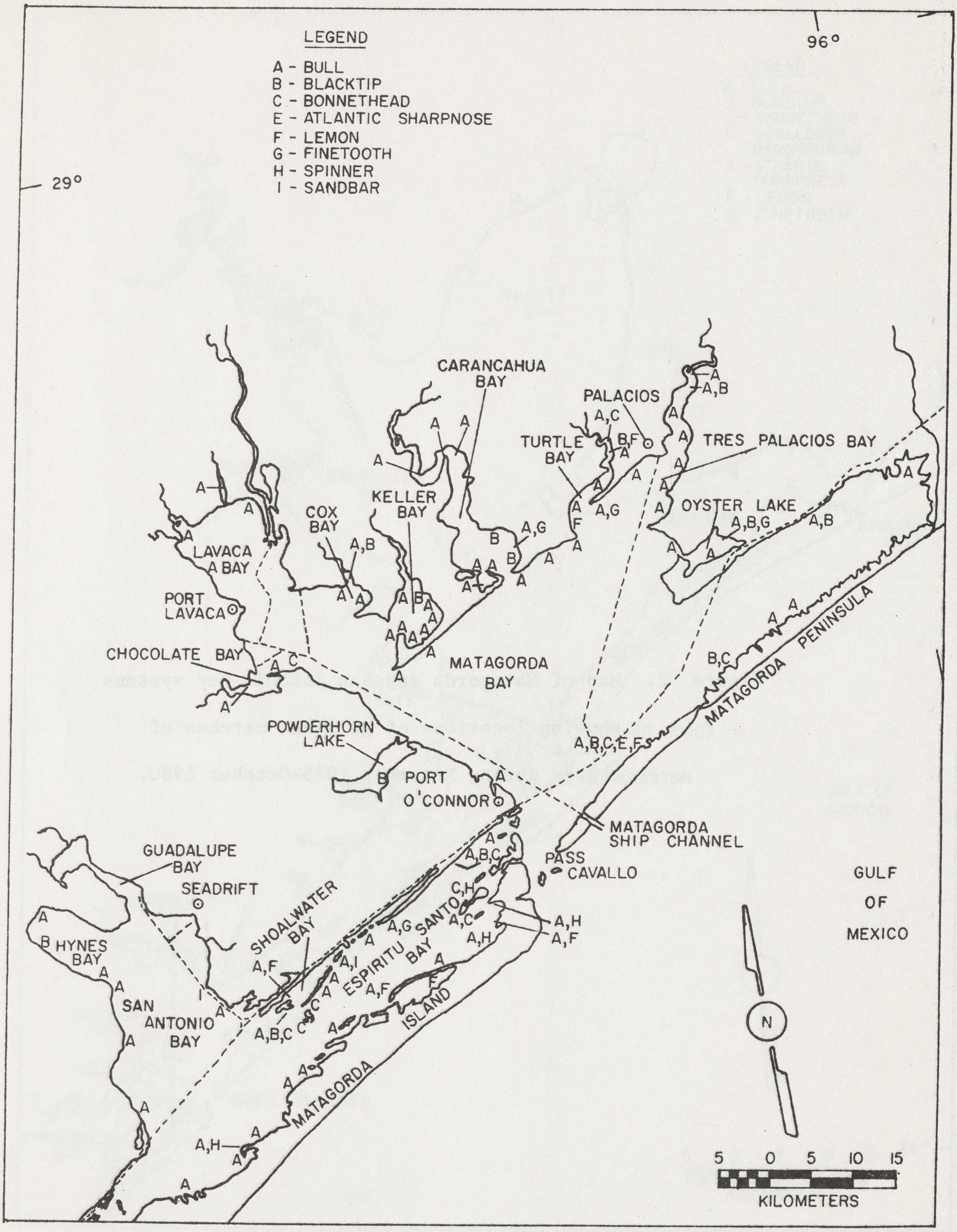

LEGEND
A - BULL
B - BLACKTIP
C - BONNETHEAD
E - ATLANTIC SHARPNOSE
F - LEMON
G - FINETOOTH
H - SPINNER
I - SANDBAR
29°
96°
CARANCAHUA BAY
PALACIOS
TURTLE BAY
TRES PALACIOS BAY
KELLER BAY
COX BAY
LAVACA BAY
PORT LAVACA
OYSTER LAKE
CHOCOLATE BAY
MATAGORDA BAY
POWDERHORN LAKE
PORT O'CONNOR
MATAGORDA PENINSULA
MATAGORDA SHIP CHANNEL
PASS CAVALLO
GUADALUPE BAY
SEADRIFT
HYNES BAY
SAN ANTONIO BAY
SHOALWATER BAY
ESPIRITU SANTO BAY
MATAGORDA ISLAND
GULF OF MEXICO
N
A,B,C,E,F
5 0 5 10 15
KILOMETERS

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.

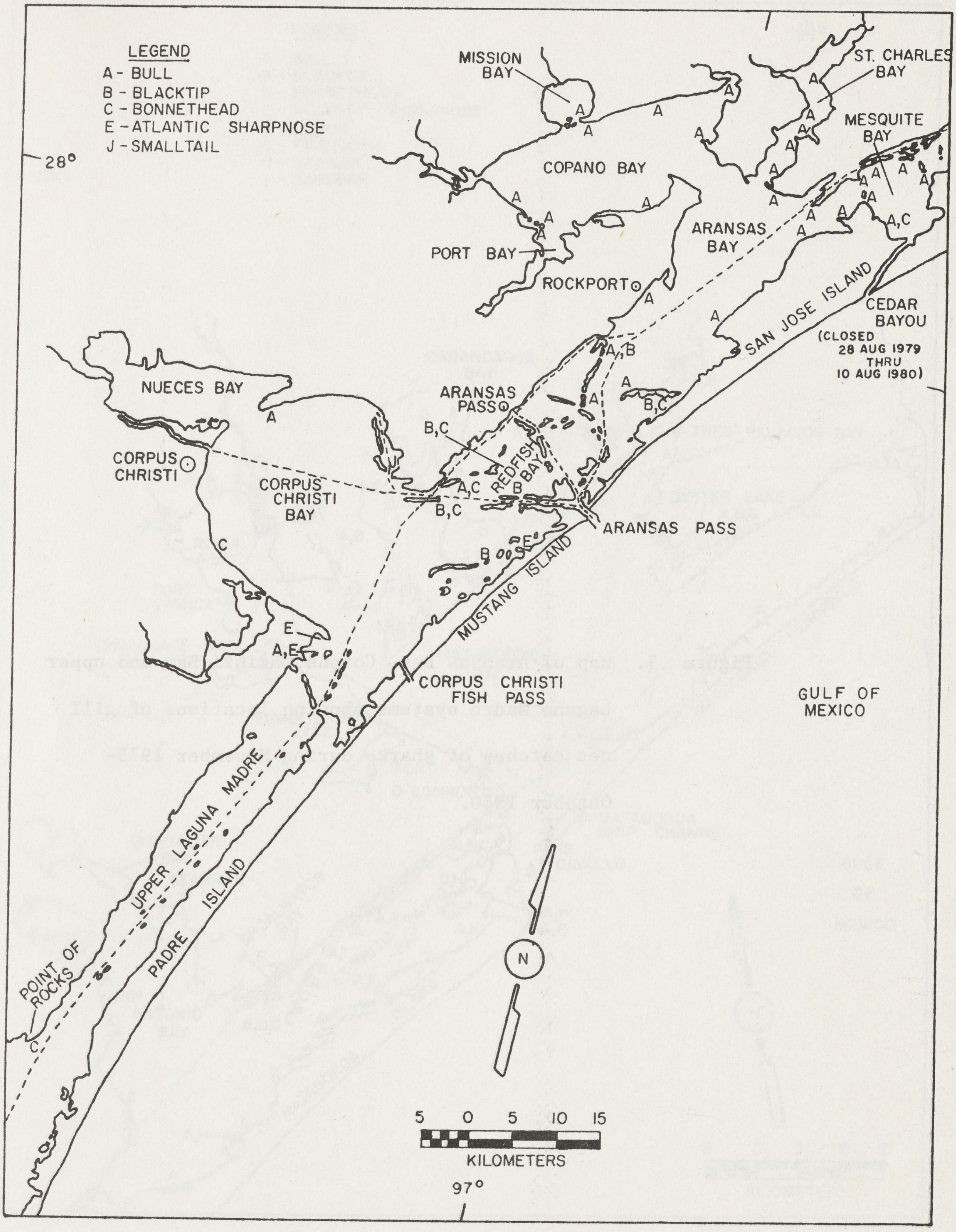

LEGEND
A - BULL
B - BLACKTIP
C - BONNETHEAD
E - ATLANTIC SHARPNOSE
J - SMALLTAIL
28°
MISSION BAY
ST. CHARLES BAY
MESQUITE BAY
COPANO BAY
PORT BAY
ROCKPORT
ARANSAS BAY
SAN JOSE ISLAND
CEDAR BAYOU
(CLOSED 28 AUG 1979 THRU 10 AUG 1980)
NUECES BAY
ARANSAS PASS
CORPUS CHRISTI
CORPUS CHRISTI BAY
REDFISH BAY
ARANSAS PASS
MUSTANG ISLAND
CORPUS CHRISTI FISH PASS
GULF OF MEXICO
UPPER LAGUNA MADRE
PADRE ISLAND
POINT OF ROCKS
N
5 0 5 10 15
KILOMETERS
97°

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

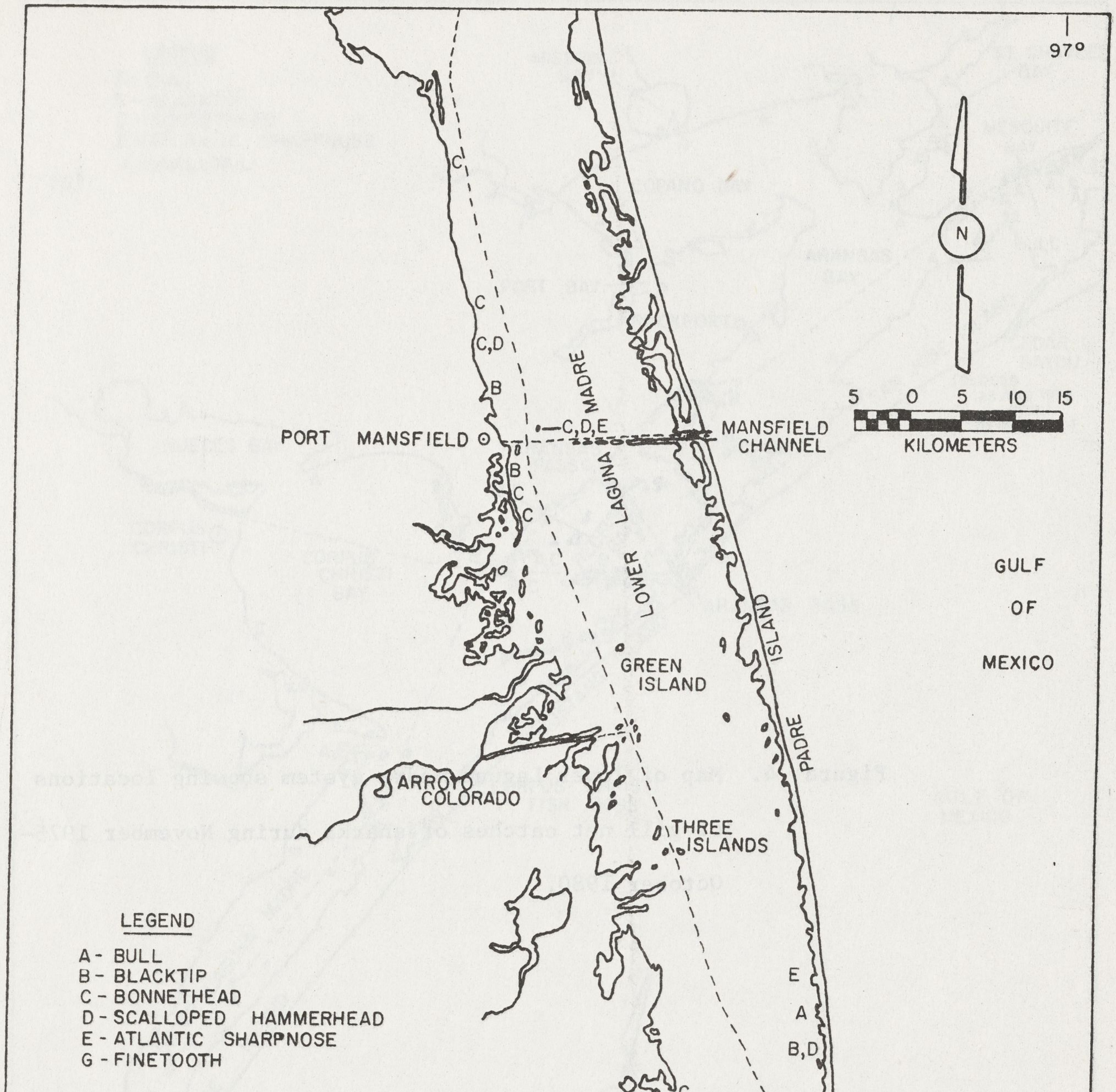
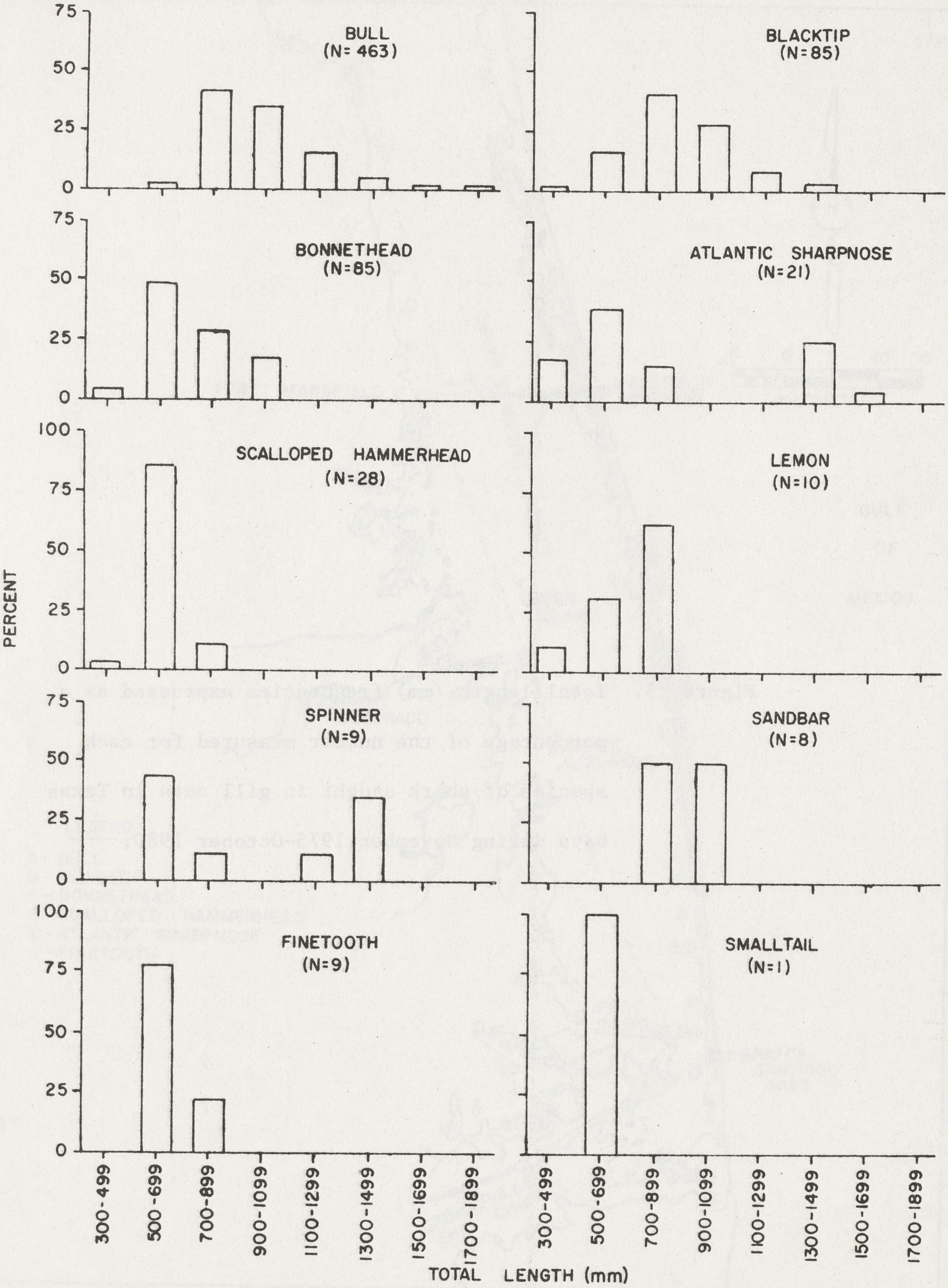

97°
N
5 0 5 10 15
KILOMETERS
C
C
C,D
B
PORT MANSFIELD
C,D,E
MADRE
LAGUNA
LOWER
MANSFIELD CHANNEL
B
C
C
GULF OF MEXICO
GREEN ISLAND
ISLAND
PADRE
ARROYO COLORADO
THREE ISLANDS
LEGEND
A - BULL
B - BLACKTIP
C - BONNETHEAD
D - SCALLOPED HAMMERHEAD
E - ATLANTIC SHARPNOSE
G - FINETOOTH
E
A
B,D
C
C
C
PORT ISABEL
B,D,G
BRAZOS SANTIAGO PASS
26°
BROWNSVILLE SHIP CHANNEL

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.


BULL
(N= 463)
BLACKTIP
(N= 85)
BONNETHEAD
(N=85)
ATLANTIC SHARPNOSE
(N=21)
SCALLOPED HAMMERHEAD
(N=28)
LEMON
(N=10)
SPINNER
(N=9)
SANDBAR
(N=8)
FINETOOTH
(N=9)
SMALLTAIL
(N=1)
PERCENT
0
25
50
75
100
300-499
500-699
700-899
900-1099
1100-1299
1300-1499
1500-1699
1700-1899
TOTAL LENGTH (mm)

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 sense 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 (Jernejicic 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. dolomieui), 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 vaccuum 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.

LITERATURE CITED

Clady, M. D. 1980. Results of stocking young largemouth bass and spotted bass in several ratios in Oklahoma ponds. Proc. Okla. Acad. Sci. 60:18-25.

Clady, M. D., and G. Luker. 1980. Assessing benefits from polytypic *Micropterus* species populations in large reservoirs. Okla. Dept. Wildl. Cons. D-J Final Rep. No. F-36-R, Job No. 2. 25 pp.

Dubets, H. A. 1954. Feeding habits of the largemouth bass as revealed by a gastroscope. Prog. Fish-Cult. 16:134-136.

Forney, J. L. 1974. Interactions between yellow perch abundance, walleye predation, and survival of alternate prey in Oneida Lake, New York. Trans. Am. Fish. Soc. 103:15-24.

Foster, J. R. 1977. Pulsed gastric lavage: an efficient method of removing the stomach contents of live fish. Prog. Fish-Cult. 39:166-169.

Jernejicic, F. 1969. Use of emetics to collect stomach contents of walleye and largemouth bass. Trans. Am. Fish. Soc. 98:698-702.

Neiman, D. A. 1978. Some aspects of the ecology of Florida and northern largemouth bass in a thermally enriched reservoir. M.S. Thesis, Okla. State Univ., Stillwater. 120 pp.

Seaburg, K. G. 1957. A stomach sampler for live fish. Prog. Fish-Cult. 19: 137-139.

Van Den Avyle, M. J., and J. E. Roussel. 1980. Evaluation of a simple method for removing food items from live back bass. Prog. Fish-Cult. 42:222-223.

White, H. C. 1930. Some observations on eastern brook trout (*Salvelinus fontinalis*) of Prince Edward Island. Trans. Am. Fish. Soc. 60:101-105.

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:

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

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_o = 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 hybird 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.

LITERATURE CITED

Bagenal, T. B. 1974. Introduction. Page V *in* T. B. Bagenal, ed., Ageing of fish, Gresham Press, Old Woking, Surrey, England.

Bishop, R. D. 1967. Evaluation of the striped bass (*Roccus saxatilis*) and white bass (*R. chrysops*) hybrids after two years. Proceedings of the Southeastern Association of Game and Fish Commissioners 21:245-254.

Branton, C. L., J. C. Riggs, J. S. Seffel, J. T. Ruben, J. A. Deloney, R. H. McGinn, and J. F. Moran, Jr. 1975. Texas outdoor recreation plan: Volume I. Texas Parks and Wildlife Department, Austin, Texas, USA.

Brown, R. S. 1960. An investigation to determine the adequacy of the scale method in revealing the age of the bluegill sunfish, *Lepomis macrochirus* (Rafinesque) from Lake Austin, Texas. Unpublished Master's Thesis, Cornell University, Ithaca, New York, USA.

Carlander, K. D. 1961. Variations on rereading walleye scales. Transactions of the American Fisheries Society 90: 230-231.

__________, and R. R. Whitney. 1961. Age and growth of walleye in Clear Lake, Iowa, 1935-1957. Transactions of the American Fisheries Society 90:130-138.

Chugunova, N. I. 1963. Age and growth studies. Academy of Sciences of the USSR., Department of Biological Sciences, USSR.

Everhart, W. H., A. W. Eipper, and W. D. Youngs. 1975. Principles of fishery science. Cornell University Press, Ithaca, New York, USA.

Forney, J. L. and C. B. Taylor. 1963. Age and growth of white bass in Oneida Lake, New York. New York Fish and Game Journal 10:194-200.

Fritz, A. W. 1963. The true basses of Illinois. Illinois Department of Conservation and Fish Management Mimeograph 27.

Houser, A. and M. G. Bross. 1963. Average growth rates and length-weight relationships for fifteen species of fish in Oklahoma waters. Oklahoma Fishery Research Lab Report 85.

Jenkins, R. M. and R. E. Elkin. 1957. Growth of white bass in Oklahoma. Oklahoma Fishery Research Lab Report 60.

Lagler, K. F. 1952. Freshwater fishery biology. William C. Brown Co., Dubuque, Iowa, USA.

Lewis, W. M. 1950. Growth of the white bass, *Lepibema chrysops* (Rafinesque), in Clear Lake, Iowa. Iowa State College Journal of Science 24: 273-278.

Mensinger, G. C. 1970. Observations on the striped bass, Morone saxatilis, in Keystone Reservoir, Oklahoma. Proceedings of the Southeastern Association of Game and Fish Commissioners 24:447-463.

Prather, E. E. 1967. A note on the accuracy of the scale method in determining the ages of largemouth bass and bluegill from Alabama waters. Proceedings of the Southeastern Association of Game and Fish Commissioners 20:483-486.

Prentice, J. A. and P. P. Durocher. 1978. Average growth rates for largemouth bass in Texas. Annual Proceedings of the Texas Chapter, American Fisheries Society 1:49-57.

________, and B. G. Whiteside. 1975. Validation of techniques for largemouth bass and channel catfish in central Texas farm ponds. Proceedings of the Southeastern Association of Game and Fish Commissioners 28:414-428.

Rafail, S. Z. 1973. A simple and precise method for fitting a Von Bertalanffy growth curve. Marine Biology 19:354-358.

Stevens, R. E. 1958. The striped bass of the Santee-Cooper reservoir. South Carolina Wildlife Resources Department Mimeograph.

Tompkins, W. A. and M. M. Peters. 1951. The age and growth of the white bass, Lepibema chrysops, of Herrington Lake, Kentucky. Kentucky Division of Game and Fish, Fisheries Bulletin 8.

United States Fish and Wildlife Service. 1977. 1975 national survey of hunting, fishing and wildlife-associated recreation. United States Department of the Interior, Washington, D. C., USA.

Ware, F. J. 1974. Progress with Morone hybrids in fresh water. Proceedings of the Southeastern Association of Game and Fish Commissioners 28:48-54.

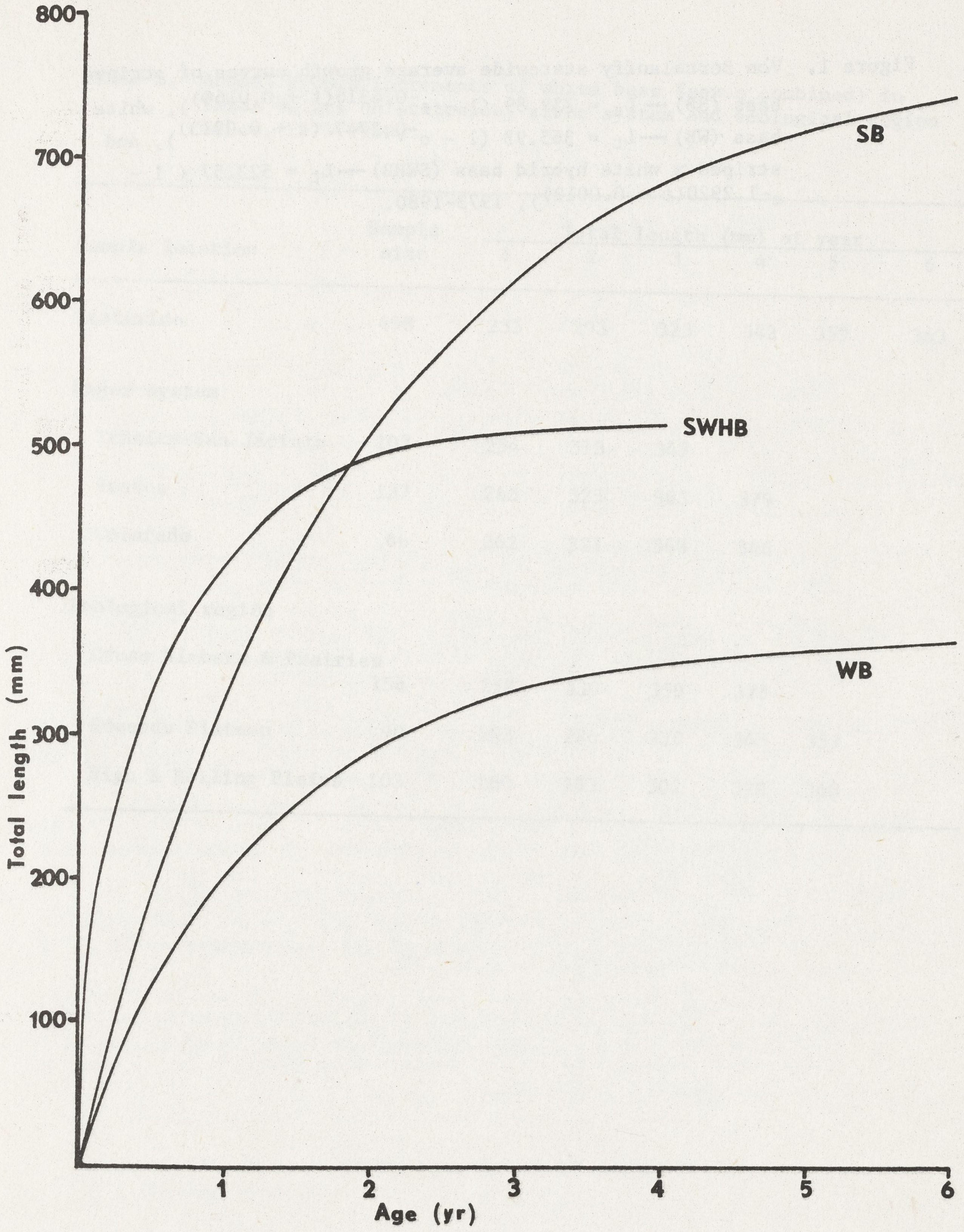
Wigfall, M. and J. M. Barkuloo. 1975. A preliminary report on the abundance and biology of stocked striped bass in the Choctawhatchee River System, Florida. Proceedings of the Southeastern Association of Game and Fish Commissioners 29:152-161.

Williams, H. M. 1970. Preliminary studies of certain aspects of the life history of the hybrid (striped bass x white bass) in two South Carolina reservoirs. Proceedings of the Southeastern Association of Game and Fish Commissioners 24:424-431.

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.


800
700
600
500
400
300
200
100
Total length (mm)
1
2
3
4
5
6
Age (yr)
SB
SWHB
WB

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
DIRECTORY
1981

Prepared
by
TEXAS CHAPTER
AMERICAN FISHERIES SOCIETY

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 macropytic 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.

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.
Lawerence, 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 Couty 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.

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 Wildlfie 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 Bilogist. 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. Larvel 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. Coastsl Fisheries Field Administration.
Johansen, P., Editor. Editoral 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. Monitroing 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 Extenstion 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

NAME	LOCATION
Adams	Austin
Andreasen	Victoria
Armstrong	Austin
Arnold	Port Aransas
Arnott	Arlington
Baker	Seabrook
Bamberg	Abilene
Barrington	Seabrook
Barry	Seabrook
Benefield	College Station
Bentley	Austin
Betioli	College Station
Bible	Arlington
Bierman	Fort Worth
Bira	San Marcos
Bird	Port Aransas
Bishop	San Marcos
Bittner	Austin
Bold	Austin
Bounds	Austin
Bowling	Fort Worth
Boyd	Fort Worth
Brandt	San Marcos
Breuer	Brownsville
Brock	Austin
Bryan	Austin
Buckner	Anahuac
Butler D.	Fort Worth
Butler W.	San Marcos
Bynum	San Marcos
Caldwell	San Marcos
Cameron	Austin
Campbell D.	Tyler
Campbell L.	San Angelo
Carmichael	San Marcos
Carter	Austin
Chamberlain	Corpus Christi
Checldey	Port Aransas
Chittenden	College Station
Clark	College Station
Clary	San Angelo
Cloud	Fort Worth
Cody	Rockport
Colbert	Fort Worth
Cole G.	Austin
Cole G.	Burnett
Cole T.	San Marcos
Cole W.	Austin

NAME	LOCATION
Colura	Palacios
Crowe	Seadrift
Curtis	Fort Worth
Dailey	Palacios
Davenport	Uvalde
Davis C.	Fort Worth
Davis J.	College Station
Dean	San Antonio
Douglas	San Marcos
Drysdale	Fort Hood
Durocher	Austin
Elkin	Austin
Englehardt	Lewisville
Farquhar	Fort Worth
Flint	Port Aransas
Flynn	Austin
Follis	San Angleo
Forshage	Tyler
Freeman	Uvalde
French	Corpus Christi
Fuls	Rockport
Funizelli	Austin
Gholson	San Antonio
Goins	Temple
Graham	Angleton
Gray	Fort Worth
Green A.	Austin
Green L.	Rockport
Green M.	Tyler
Guerra	San Antonio
Guest	Fort Worth
Gutherie	San Marcos
Hagen	Rockport
Hall N.	Victoria
Hall R.	San Marcos
Halstead	Galveston
Hambric	Houston
Hammerschmidt	Seadrift
Hannan	San Marcos
Harrell	Angleton
Harrington	Corpus Christi
Heffernan	Rockport

FISHERIES WORKERS INDEX

NAME	LOCATION
Hegen	Corpus Christi
Hellier	Arlington
Helton	Jasper
Herbert	Fort Hood
Higginbotham	Overton
Hill	Amarillo
Hofstetter	Seabrook
Holcomb	Angleton
Holt J.	Port Aransas
Holt S.	Port Aransas
Hostettler	Rockport
Hubbs	Austin
Huffman	San Marcos
Hutson	San Marcos
Hysmith	Denison
Ibarra	Arlington
Inman	Tyler
Johansen	Rockport
Johnson J.	Fort Worth
Johnson R.	La Porte
Johnson S.	College Station
Jones B.	Fort Hood
Jones J.	Nacogdoches
Kalke	Port Aransas
Keifer	San Marcos
Kemp	Austin
Kewley	Galveston
King	Austin
Kitting C.	Austin
Kitting C.	Port Aransas
Klussman	College Station
Kosinski	College Station
Kraai	Canyon
Kulzer	Ingram
Lang	College Station
Larimer	Austin
Lawerence	Corpus Christi
Lazarine	Corpus Christi
Lee	Ingram
Leigon	Austin
Lin	Port Aransas
Linton	College Station
Langley	San Marcos
Looney	Arlington
Lowman	San Marcos
Luebke	Ingram
Lyles	Fort Worth
Lyons	Tyler
Maguire	Austin
Martin	Corpus Christi
arwitz	Seadrift
Matlock	Austin
McCabe	Waco
McCarty	Huntsville
McCollum	Fort Worth
McCulloch D.	Nacogdoches
McCulloch J.	Nacogdoches
McEacheron	Rockport
McGeachin	College Station
McMahon	Arlington
McMillam	Austin
Means	Tyler
Meineke	Corpus Christi
Mendosa	Galveston
Menn	Houston
Messinger	Rockport
Michel	Dallas
Miget	Corpus Christi
Miranda	Ingram
Mitchell	Waco
Moczygemba	Denison
Moffett	Seabrook
Moore	Austin
Moss	Angleton
Mueller	Galveston
Mulford	Fort Worth
Murphy	Lubbock
Nawrocki	Fort Worth
Neill	College Station
Nichelson	College Station
Noble	College Station
Ojo	Galveston
Osborn	Austin
Osburn	Rockport
Palafox	Austin
Palma	San Marcos
Palmer	Graford
Parks	Canyon

NAME	LOCATION
Perez	Corpus Christi
Pickrell	Nacogdoches
Potter	Austin
Powell	Austin
Provine	San Agnelo
Pulich	Port Aransas
Rabalias N.	Port Aransas
Rabalias S.	Port Aransas
Rainwater	Nacogdoches
Ralph	San Angelo
Ramirez	Corpus Christi
Ratteree	Amarillo
Read	Dickinson
Reat	Nacogdoches
Reed	Nacogdoches
Reeder	Austin
Rice	Brownsville
Rickner	San Benito
Rlussman	College Station
Roberts J.	Austin
Roberts L.	Austin
Robinson	College Station
Rogers	Austin
Rosson	Port Aransas
Rowland	College Station
Rutledge	Austin
Ryan	Marshall
Sandgren	Arlington
Schwille	Temple
Seidensticker	Jasper
Sellers	Waco
Shrot	San Marcos
Sidnell	
Simmons	Austin
Smith	Fort Worth
Sonskis	Ingram
Spears	Rockport
Spiller K.	Corpus Christi
Spiller S.	Corpus Christi
Surovik	Port Lavaca
Starr	Austin
Steinbach	College Station
Stickney	College Station
Sturm	Nacogdoches
Strawn	College Station
Swartz	College Station
Taylor	Nacogdoches
Temple	Lubbock
Thomas	Port Aransas
Toole	Marshall
Valentine	Temple
Vanbalen	Austin
VanDover	Nacogdoches
Wagner	San Angelo
Wakefield	Palacios
Walsh	Fort Hood
Warren	Electra
Weixelman	Palacios
Wenger	La Porte
Werner	Galveston
White	Tyler
Whiteside	San Marcos
Whitmore	Arlington
Williams	Arlington
Williamson	San Marcos
Wilson	Nacogdoches
Wohlschlag	Port Aransas
Young C.	Burnet
Young W.	San Marcos
Younger	Bay City
Zeman	Beaumont
Zerr	San Antonio

INSTRUCTIONS FOR MANUSCRIPT PREPARATION

General Procedures. Manuscripts should be typed double-spaced on good quality of white bond paper (8½ x 11 inches or 8 x 10½ inches) with margins at least one inch all around. Number all pages in upper right corner and do not staple or bind the copies required for the publisher.

Length of Manuscripts. Manuscripts should not exceed 25 typewritten pages in length including tables and figures. Papers of excessive length will be rejected.

Sequence of Contents. Contents should appear in the following sequence except non-research papers which may deviate on points 5 through 7.

1. Title
2. Author(s) and name(s)
3. Abstract
4. Introduction (including acknowledgments - Do not footnote acknowledgemnets)
5. Materials and methods (including description of study area)
6. Results
7. Discussion (may be combined with results if appropriate)
8. Literature cited
9. Tables
10. Figure legends
11. Figures

Style. General rules for preparation of copy (capitalization, abbreviation, punctuation, literature citation) are presented in *Council of Biology Editors Style Manual for Biological Journals* (American Institute of Biological Sciences, 3900 Wisconsin Ave., N.W., Washington, D. C. 20036). A recent issue of the Journal of Wildlife Management (after volume 36) or the Transactions of the American Fisheries Scoiety will provide adequate examples of appropriate style.

Title. The title generally should be 10 words or less and descriptive. Avoid scientific names in the title.

Author. The name(s) of author(s) should be below the title at the top of the first page with organizational connection and city of residence following. Organizations should be identified by the title which most specifically identifies them, e.g., Department of Forestry, The University of Tennessee, Knoxville; Refuge Division, Bureau of Sport Fisheries and Wildlife, Atlanta, GA; Game Management, Florida Game and Fresh Water Fish Commission, Tallahassee. Indicate on title page which author should receive the galley proof.

Abstract. An abstract emphasizing major results or conclusions (no more than 100 words or three percent of the article) should be written as a single paragraph preceding the introductory paragraph of the article and separated from it by a single line across the page.

References. References are grouped alphabetically by author's last names under "Literature Cited." Follow a current issue of the Journal of Wildlife Mangement or the Transactions of the American Fisheries Scoiety. Avoid citing unpublished reports or, if essential, cite parenthetically in the text. All references listed are to be cited in the text.

Tables. Tables should be understandable without references to the text and should not contain data shown in illustrations. Tables should be numbered consecutively (order of first mention) with Arabic numerals. Titles and box headings should be clear but concise. Type each table on a separate sheet 8½ x 11 inches or 8 x 10½ inches. Put long tables on as many sheets as needed. Double space all lines, leaving at least one-inch margins. Omit vertical lines. Keep tables simple. Indicate on margin in text where tables should be placed.

Illustrations. Photographs must be black and white glossy prints, at least 4 x 5 inches in size. Charts should be neatly drafted in black ink on white paper. Typing and freehand lettering on a figure are not acceptable. Identify each drawing or photograph on the back lightly with soft pencil (Smith, Turkey management in Florida, Fig. 1). Do not attach photographs to cards or sheets. Type figure legends on a separate sheet in paragraph form, double spaced, in sequence. Indicate on margin of text where figures should be placed.

Number of copies. The program chairman shall notify authors of the necessary number of copies of papers needed. Copies for the program committee and awards committee are usually mailed to the program committee chairman. Two copies (the original for the publisher and an extra for the editor) are given to the program chairman at the technical session. Glossy prints should be included in the original copy.

THE PROGRAM COMMITTEES MAY REJECT MANUSCRIPTS THAT DO NOT CONFORM TO THESE INSTRUCTIONS.

TEXAS CHAPTER

OF THE

AMERICAN FISHERIES SOCIETY

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

MEMBERSHIP

Persons interested in the Texas Chapter and its objectives are eligible for membership and should apply to the existing Secretary-Treasurer, Maury Osborn, 4200 Smith School Road, Austin 78744. Annual membership dues are $3 for Active Members and $2 for students.

Texas Parks & Wildlife Department
Heart of the Hills Research Sta.
Junction Star Route, Box 62
Ingram, Texas 78025

TEXAS
PARKS AND WILDLIFE DEPARTMENT
4200 SMITH SCHOOL ROAD
AUSTIN, TEXAS 78744

RETURN REQUESTED

Texas Parks & Wildlife Department
Heart of the Hills Research Sta.
Junction Star Route, Box 62
Ingram, Texas 78025

SAN ANTONIO, TX
APR 23
P.M.
1985
782

USA 20c
Igor Stravinsky USA 2c
Rachel Carson USA 17c
Rachel Carson USA 17c

42

82-83 Texas redband repts
- Al Sonski moved to Conn.

BOB BEHNKE
COLORADO STATE UNIVERSITY
DEPT OF FISHERY & WILDLIFE BIOLOGY
FORT COLLINS, COLORADO 80523