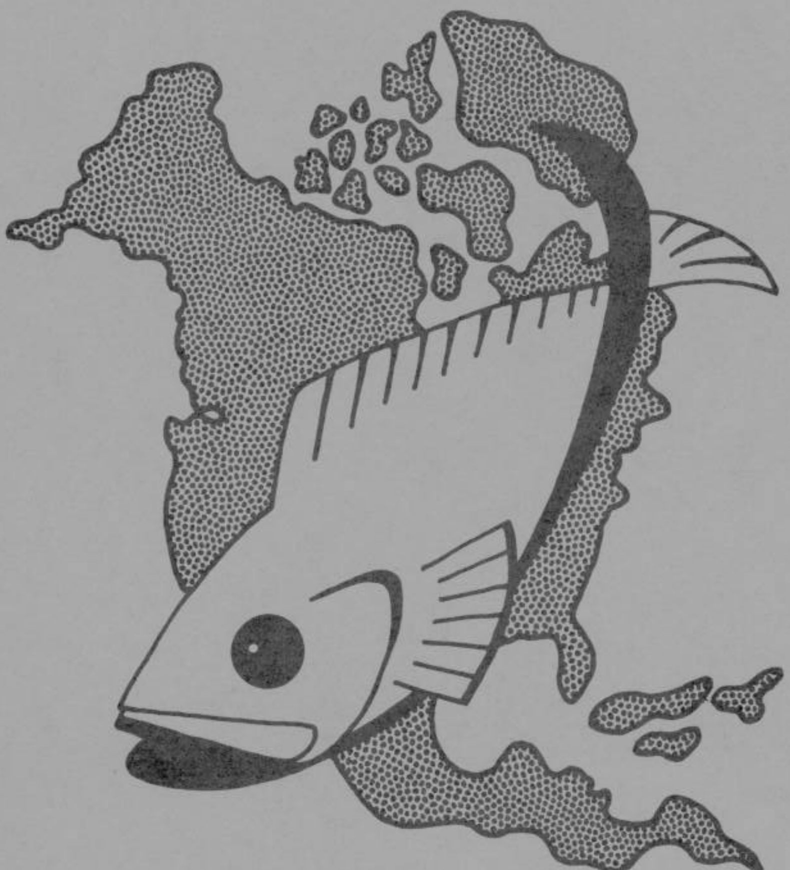
ANNUAL PROCEEDINGS of the TEXAS CHAPTER AMERICAN FISHERIES SOCIETY



SEPTEMBER 30, 1978
SAN MARCOS, TEXAS

VOLUME I

KURZANSKI

ANNUAL PROCEEDINGS
OF THE
TEXAS CHAPTER

September 30, 1978
San Marcos, Texas

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PROGRAM

Friday Evening,	September 29, 1978
7:30 - 9:00 PM	Social Meeting and Registration
Saturday Morning,	September 30, 1978
7:30 - 8:00 AM	Registration
8:00 - 9:05	Business Meeting
* 9:15 - 9:25	John M. Wakeman and Donald E. Wohlschlag University of Texas Marine Science Institute "An Apparatus to Study the Energetics of Swimming Fishes"
9:25 - 9:35	Travis R. Phillips National Fish Hatchery & Development Center U.S. Fish and Wildlife Service "Mass Culture of Zooplankton and Its Applicability to Intensive Fish Fry Culture"
9:35 - 9:50	H. H. Hannan, Teresa Savage, Fred Werkenthin, Charles Wiedenfeld, and Tom Cole Aquatic Station Southwest Texas State University "Limnology of Canyon Reservoir"
9:50 - 10:05	Ralph E. Manns, Jr. and B. G. Whiteside Aquatic Station Southwest Texas State University "Movement of the Guadalupe Bass in Travis Lake"
10:05 - 10:20	Discussion
*10:30 - 10:40	Eugene B. Henderson Texas Parks and Wildlife Department, now with the Lower Colorado River Authority "Cost:Benefit Evaluation of Stocking Harvestable Sized Catfishes"
*10:40 - 10:55	Bill Bailey Texas Parks and Wildlife Department "Predator-Prey Relationships in Select Texas Reservoirs"
10:55 - 11:05	Clell Guest and Barry Lyons Texas Parks and Wildlife Department "Temperature Tolerance of Peacock Bass"

11:05 - 11:15	Paul S. Crandall Texas Parks and Wildlife Department "Evaluation of Striped Bass x White Bass Hybrids in a Heated Texas Reservoir"
11:15 - 11:25	David J. Morris and Billy J. Follis Texas Parks and Wildlife Department "Effects of Striped Bass Predation Upon Shad in Lake E. V. Spence"
11:25 - 11:40	Discussion
11:40 - 1:10	Lunch Break
1:10 - 1:20	Richard L. Noble Department of Wildlife and Fisheries Science Texas A&M University "Some Preliminary Results of the Use of Advanced Fingerling Largemouth Bass Supplementally Stocked into Stunted Sunfish Populations"
* 1:20 - 1:30	Albert E. Bivings, IV, Richard L. Noble, and Raphael E. Quinn Department of Wildlife and Fisheries Science Texas A&M University "Growth of Largemouth Bass Following Vegetation Control and Threadfin Shad Introduction"
* 1:30 - 1:35	John A. Prentice and Philip P. Durocher Texas Parks and Wildlife Department "Average Growth Rates for Largemouth Bass in Texas"
* 1:35 - 1:45	Don W. Steinbach and Richard L. Noble Department of Wildlife and Fisheries Science Texas A&M University "First-Year Growth of Northern and Florida Largemouth Bass in a Central Texas Pond"
1:45 - 1:55	Charles Cichra Department of Wildlife and Fisheries Science Texas A&M University "Comparison of Low Temperature Stock Exhibited by Northern and Florida Largemouth Bass"
1:55 - 2:05	Discussion
2:15 - 2:30	Allen Forshage Texas Parks and Wildlife Department "The Florida Largemouth Bass Program in Texas"
2:30 - 2:45	Dick Luebke Texas Parks and Wildlife Department "Bass Management in Texas"

2:45 - 3:00	Gary Valentine Biologist, Soil Conservation Service "Fisheries Activities of the Soil Conservation Service in Texas"
3:00 - 3:10	Bill Provine Texas Parks and Wildlife Department "White Amur (Grass Carp)"
3:10 - 3:25	Discussion
3:35 - 5:00	Discussion of fisheries management-research questions of statewide interest (e.g., grass carp; stocking policy for Florida bass, Nile perch, peacock bass, striped bass, and others).

Dr. Bobby Gene Whiteside, Program Chairman

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*Submitted for Publication

1978 OUTSTANDING FISHERY WORKER AWARDS

Research and Education

CLARK HUBBS, Ph.D.
University of Texas
Austin, Texas

This honor is awarded to Dr. Clark Hubbs for his continuous and productive service in the fields of education and fishery research. His contributions to an understanding of Texas fishery resources are highly regarded by cohorts.

Dr. Hubbs received a A.B. from the University of Michigan in 1942 and, after serving 3½ years in the U.S. Army, entered Stanford University where he earned his Ph.D. in 1951. His academic career began in 1948 as an instructor in biology at Hopkins Marine Station and full time teaching started in 1949 at the University of Texas. Presently, Dr. Hubbs is the Chairman of the Department of Zoology. In addition to administrative assignments, he serves as Professor at the University of Texas, visiting Professor at the University of Oklahoma, member of the Graduate Faculty at Texas A&M University, and a member of the Graduate Studies Committee of Marine Sciences at University of Texas at Austin.

He began collecting fishes for scientific purposes with his father, Dr. Carl L. Hubbs, at the ripe age of six. His first paper, co-authored with his father, was published in 1941. Over 170 publications on a variety of subjects relating primarily to freshwater fishes have since been written. The main emphasis of his work has dealt with why fishes are able to live in their environments and the adaptation processes involved.

An active professional Society and Committee worker, Dr. Hubbs has been able to apply his talents on a national and international basis. Of particular interest to Texans is his work as President of the Texas Academy of Science, 1972-73; Editor of the Texas Journal of Science, 1957-61; Ecology Panel Director for the Texas Water Conservation Association, 1971-80; Chairman of the Governor's Inland Task Force for Power Plant Siting Committee, 1971-72; Chairman of the Conservation Committee for the Texas Academy of Science, 1974-75; President of the Texas Organization of Endangered Species, 1978-79; and Leader of the Rio Grande Fishes Recovery Team for the United States Department of Interior, 1977. He is an active member of the American Fisheries Society and its Texas Chapter.

Fish Culture

PAT L. HUTSON
Texas Parks and Wildlife Department
San Marcos State Fish Hatchery

Mr. Hutson graduated from New Mexico State University in 1970 with a degree in Wildlife Management. He was employed by the Texas Parks and Wildlife Department and first worked as a technician at both San Angelo and Jasper State Fish Hatcheries. Since 1974, he has served as Fish Hatchery Superintendent of the San Marcos Fish Hatchery where a diversity of fish species (striped bass, rainbow trout, smallmouth bass, Florida bass, hybrid sunfish, and catfishes) are cultured to meet fishery management program needs.

This award is given to Mr. Hutson for his developmental refinement of smallmouth bass culture. Within a 4-year period, he has taken a smallmouth culture program from its inception to the point where it is a major supplier of fish for public water stocking.

Special Non-Member or Member

EDWARD R. LYLES
Fish and Wildlife Service
Fort Worth, Texas

Mr. Lyles is a longtime veteran in the Fish and Wildlife Service, and brings to his work in our state a great amount of experience in fish and wildlife planning and protection. His previous experience was obtained during service with both state and federal agencies in Tennessee, Pennsylvania, Delaware, West Virginia, New Jersey, New York, Virginia, and North Carolina.

Over the past 5 years in Texas, he has assessed and implemented planning in numerous projects impacting the state's fish and wildlife resources. His instrumental work in obtaining the first mitigation measures to be implemented in Texas under the Fish and Wildlife Coordination Act deserves special attention. This mitigation was obtained for the Brazos River Salt Pollution Control Project of the Corps of Engineers.

PREDATOR-PREY RELATIONSHIPS IN SELECTED TEXAS RESERVOIRS

By

William H. Bailey
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ABSTRACT

Prey-predator ratios (AP/P) determined in this study compared standing crops of available prey to predators in 29 Texas reservoirs. Forty-one percent of these reservoirs had balanced prey-predator populations while 21 percent did not. Thirty-eight percent of the reservoirs were in the midrange of balance. With modifications, an actual AP/P ratio with %NUF and %PD provided three diagnostic tools for Texas fishery managers.

INTRODUCTION

Instantaneous estimates of fish species standing crops in reservoirs can be made with cove rotenone techniques (Hayne et al., 1968). However, a comparison of standing crop results between reservoirs, evaluation of the effects of a management technique on those standing crops in different reservoirs, or explanation of annual or longer term trends in a reservoir's standing crop has been difficult.

Two theories that may explain differences in standing crops have emerged. First, workers have attempted to relate changes in differences in standing crops to fluctuations in reservoir physicochemical or hydraulic conditions (Jenkins, 1975). A second theory to explain standing crops is based upon relationships between fish species populations (Swingle and Swingle, 1968). Swingle (1950) in pond studies described the relationship of prey and predator biomasses and populations with a Y/C ratio. This ratio was found by dividing the total weight consumable of prey (Y) by the total weight of all predators (C) that could consume these prey. A ratio of 0.5-4.8 denoted an instantaneous balance and predators had sufficient food. This Y/C ratio may be applied to reservoirs if an "over-winter" reserve is considered. Jenkins and Morais (1978) state a prey-predator ratio of 1.0 ($Y/C \cong 1.0$) in August must be present for predators to over-winter successfully. These authors have developed a method to interrelate available prey (AP) and predators (P) fish species feeding types with an AP/P ratio.

This paper will demonstrate the prey-predator ratio (AP/P) as it applies to 29 Texas reservoirs. Results could aid Texas fishery managers in predicting and explaining differences in standing crops.

METHODS AND MATERIALS

Cove data from 29 Texas reservoirs (Texas Parks and Wildlife Department 1975, 1976, 1977) were used to determine the AP/P ratio. Standing crop estimates were determined in July and August and data recorded by inch group as described in the Texas Parks and Wildlife Department's Inland Fisheries Management Handbook (1974). Texas reservoirs in the sample ranged in size from 641-181,600 surface acres and had a mean impoundment age of 23.5 years. Reservoirs were classified as water storage, power, flood control, and municipal or industrial use.

Jenkins and Morais (1978), using as a base the calculations of Lawrence (1958) on the relation between mouth size of largemouth bass and the maximum body depth of various prey species they could swallow, developed a set of factors to convert inch group sizes of major predators to largemouth total length equivalents. For example, a 13-in white bass (conversion factor 1.3) can swallow the same size prey fish as a 10-in largemouth bass. I used one exception to these factors: smallmouth and spotted bass were given a conversion factor of 1.1. Once the format for the worksheet (Table 1) was completed, the standing crop for each inch group of each predator species was listed in the appropriate columns. A worksheet was made for all 29 lakes. In Tables 1, 2, and 3, Houston County Lake standing crop data was used as an example. The cutoff point in Table 1 was at the 24-in group since no largemouth bass longer than 23-in total length occurred in cove rotenone samples. A column total by weight for all predators by inch group of equivalent largemouth bass lengths is recorded in Predator Total at the bottom of Table 1. Below this row, a Cumulative Predator Total weight for all predators in equivalent largemouth bass lengths is indicated.

A Maximum Predator Length (MxP) for each reservoir was designated as that inch group in equivalent largemouth bass lengths where the last continuous inch grouping of predators was present. In some cases predators were found above the MxP inch group; but if these larger inch groups were more than two-inch groups above the original MxP and did not constitute more than 3% of the cumulative total predator weight, they were not considered as the MxP. At MxP effective predation in a reservoir would cease.

Prey species were placed into seven categories by body depth and form in Table 2. Inch groups of the species in each of the seven food categories were positioned beneath the equivalent largemouth bass inch group column listed at the top of the prey worksheet. Once the format for the prey worksheet was completed, the standing crop for each prey species by categories was listed under the appropriate column. A prey worksheet was made for all 29 lakes. Prey above MxP and above the 24-in equivalent largemouth bass cutoff length were entered on the worksheet immediately past the 24-in equivalent largemouth bass length. A Total Prey weight was calculated for each column and listed at the bottom of Table 2. Below this a Cumulative weight for all prey species in equivalent largemouth bass lengths is indicated.

These Cumulative weights were transcribed to the bottom of Table 1 below the appropriate equivalent largemouth bass inch groups. The Cumulative Prey Totals were divided by the Cumulative Predator Totals to find an AP/P ratio for each equivalent largemouth bass inch group. If the final AP/P ratio recorded at MxP was >1.0, the reservoir was in balance according to Jenkins and Morais (1978). The AP/P at the MxP is the Actual AP/P.

Prey above MxP and above the 24-in cutoff point were not subject to predation but bind up production in a nonusable form. If the Cumulative Total Prey weight for inch groups above MxP was divided by the Cumulative Predator Total at MxP, an Ideal AP/P was found. This Ideal AP/P demonstrated a prey-predator balance if all prey were subject to predation. When the Cumulative Total Prey weight at MxP was subtracted from the Cumulative Total Prey weight at the Ideal AP/P and then divided by this latter weight, the percent of nonusable forage (%NUF) was found.

MxP was used to determine percentage of predator inch classes that were prey deficient (%PD) and was determined by dividing the number of inch groups with AP/P <1.0 by the MxP inch group. For example, %PD in a reservoir, where six of the total inch groups were below AP/P 1.0 and with an 18-in MxP, would be 33% (6/18). A log-log plot of cumulative AP/P versus inch group demonstrated where %PD occurred and its magnitude.

Conversion factors used by Jenkins and Morais (1978) to extend cove samples to open water situations and adjustment for partial species recoveries were not used in this paper since these conversions have not been determined for Texas reservoirs.

RESULTS

Mean Actual AP/P for the 29 reservoirs was 6.182 with all reservoirs at Actual AP/P >1.0. However, log plots of the AP/P at each inch group versus the log plots of the Cumulative Predator Total weight at each inch group (Jenkins and Morais, 1978) revealed that the 29 reservoirs had an average of 41% of the equivalent largemouth bass inch groups at AP/P <1.0. Reservoirs in this sample could not be classed in prey-predator balance if a majority of the equivalent largemouth bass inch groups had AP/P <1.0.

If %PD and %NUF were considered with the Actual AP/P then balance in prey-predator populations could be determined accurately. Ideally, a reservoir in balance should have an AP/P >1.0 (Jenkins and Morais, 1978) and %PD and %NUF equal to zero. The AP/P mean %PD of (41) and mean %NUF of (42.7) were used in conjunction to divide the 29 reservoirs into 4 groups (Table 3). Reservoirs were placed into two %PD categories: those with %PD of >41 or <41. %NUF was also used to further subdivide the 29 reservoirs into 4 final groups: reservoirs with %NUF of >42.7 and <42.7.

Twelve reservoirs (41.4%) in the first group had %PD <41 and %NUF <42.7 and AP/P >1.0. These reservoirs were considered to have balanced prey-predator populations. Winnsboro was perhaps the most balanced of this first group.

Seven reservoirs in the second group had %PD <41, %NUF >42.7, and >1.0 AP/P. These reservoirs could have benefited by additions of larger individuals of a predator species to control the %NUF. Perhaps physical removal (netting) of larger roughfish would provide some benefit to the fishery manager. These seven lakes were in the midrange of balance.

Four reservoirs in the third group had %PD >41, %NUF <42.7, and >1.0 AP/P. These reservoirs needed "seed stocks" of smaller prey species added to build a larger base of food at the smaller equivalent largemouth bass inch groups. The four reservoirs were also in the midrange of balance.

Six reservoirs in the last group had %PD >41, %NUF >42.7 and >1.0 AP/P. These reservoirs had unbalanced prey-predator populations. To correct this condition, "seed stocks" of smaller prey species and also large individuals of a predator species should be added. These two techniques of fishery management need to be implemented and monitored annually with cove rotenone samples, and AP/P analysis, to record the effectiveness of each technique.

Another benefit of AP/P analysis is the detection of overabundant (stunted) prey populations. Nine reservoirs had Actual AP/P >4.5 (Table 3) and were by Swingle's (1950) Y/C in an unbalanced, overabundant prey situation. Stunting could be found if the intermediate equivalent largemouth bass inch groups (7-12) weights were unusually large. Twin Buttes was an example with >531 lb/acre in the 7-12 in groups.

AP/P, %NUF, and %PD has been used in these 29 reservoirs to detect balance in and to compare predator-prey population in reservoirs independent of such factors as differences in reservoir locations, impoundment ages, surface acreages, standing crops, species compositions, and hydraulic or physicochemical changes.

A single reservoir may be subjected to AP/P analysis over extended periods to demonstrate prey-predator trends and to evaluate a management technique. Bastrop Reservoir was selected as an example since striped x white bass hybrids were stocked at 10 fish/acre from 1973 to 1975 (Crandall, 1978). Standing crop data was collected from 1972-1977.

After hybrid introduction in Bastrop Reservoir, the effects of predators on prey species can be noted by a %PD increase from 33 in 1972 to 83 and 50 in 1974 and 1975, respectively (Table 4). The %PD was due to a decrease in bullhead, warmouth, and bluegill standing crops in 1973 and 1974 and to a decrease in shad crops from 1975 to 1977. A %NUF increase of 29 to 62 in 1972 to 1975 demonstrated that a prey was nonutilized and grew beyond the range of predation. The %NUF increase was due to carp.

If AP/P analysis of cove rotenone data had been possible in 1974 and the Actual AP/P of 0.98 was noted with increased %PD and %NUF, the

1975 hybrid stocking could have been reduced or eliminated. Large scale depletion of shad after 1975 in all probability would have been eliminated. Prey-predator balance with hybrid introductions in Bastrop Reservoir could have been maintained by using these three diagnostic tools.

The effects of a predator stocking or other technique of management in one or more reservoirs can be monitored and evaluated annually with AP/P and %PD and %NUF analyses.

CONCLUSIONS

Standing crops in different reservoirs may be compared and prey-predator relationships identified using Jenkins and Morais (1978) method with %NUF and %PD modifications. These three analytical tools can be used to explain annual or longer term trends in one or more reservoirs where a management technique is being evaluated. This predator-prey technique also can provide a springboard for the development of a more powerful set of analytical tools that can fully explain standing crop trends.

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TABLE 1. Predator species inch groups converted to equivalent largemouth bass inch groups. Conversion factors listed for each species. Houston County Reservoir standing crops are used for an example.

SPECIES																TOTAL
Largemouth bass (1.0)	1	10 9.58	11 8.84	12 1.60	13	14	15 1.07	16	17	18 2.07	19 5.40	20	21 6.54	22	23	
Spotted bass (1.1)	1	11	12	13	14	15	16–17	18	19	20	21	22	23	24	25	
Crappies (1.5)	1–2 0.11	15	16–17	18	19–20	21	22–23									
Flathead catfish (1.0)	1	10	11	12	13	14	15	16	17	18	19	20	21			
Channel catfish (1.5)		15 3.76	16–17 3.06	18 2.71	19–20 1.94	21 2.54	22–23	24	25–26	27	28–29	30	31–32	33	34–35	
Spotted gar (2.3)	1–3	22–24	25–26	27–28	29–30 0.70	31–33	34–35	36–37	38–40	41–42	43–44	45–47	48–49	50–51	52–53	
Predator Total	0.11	13.34	11.90	4.31	2.64	2.54	1.07			2.07	5.40		6.54			
Cumulative Predator	0.11	47.41	59.31	63.62	66.26	68.80	69.87	69.87	69.87	71.94	77.34	77.34	83.88			83.88
Cumulative Prey		85.39	99.31	100.36	105.88	114.56	125.25	140.58	150.46	159.88	170.85	187.12	199.82	204.54	207.31	207.31
Cumulative AP/P		1.801	1.674	1.577	1.598	1.665	1.793	2.012	2.153	2.222	2.209	2.419	2.382			2.472

TABLE 2. Prey species inch groups converted to equivalent largemouth bass inch groups. Houston County Reservoir standing crops used for an example.

GROUPS	1	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	TOTAL
#1 I.C.			5		6		7	8		9	10	11	12	13			
yellow bullhead			0.11		0.95		0.97	1.22		0.30	0.35						
flathead			0.02		0.04		0.09	0.11									
gar											0.13	0.10	0.13				
chub sucker								0.18			0.64						
golden shiner					0.06		0.74	2.78		2.14							
grass pickerel																	
#1 TOTAL			0.13		1.05		1.80	4.29		2.44	1.12	0.10	0.13				
#2 I.C.		4			5		6	7		8		9	10	11	12	13	
gizzard shad										0.96		4.02	11.53	4.52	2.77		
#2 TOTAL										0.96		4.02	11.53	4.52	2.77		
#4 I.C.			3			4		5		6		7		8	9	10	
bluegill			3.68			3.01		3.00		1.63		0.79					
warmouth			7.19			5.31		7.98		4.39		1.41		0.20			
rio grande			0.18			0.36		0.06									
#4 TOTAL			11.05			8.68		11.04		6.02		2.20		0.20			
#5 I.C.		3			4		5		6		7		8	9		10	
green sunfish		0.60			0.27		0.22		0.18		0.28						
#5 TOTAL		0.60			0.27		0.22		0.18		0.28						
#6 I.C.			3		4		5		6		7	8	9	10			
redear			0.75		2.80		7.80		9.70		9.57	9.95	1.04				
longear			1.98		1.40		0.87										
#6 TOTAL			2.74		4.20		8.67		9.70		9.57	9.95	1.04				
#7 I.C.		5		6													
largemouth bass		1.56		1.05													
crappie		0.18															
spotted bass		0.11															
#7 TOTAL		1.85		1.05													
Prey Total		2.45	13.79	1.05	4.47	8.68	8.89	11.04	9.88	6.02	9.85	12.15	1.04	0.20			
Cum. Prey Total		2.45	13.92	1.05	5.52	8.68	10.69	15.33	9.88	9.42	10.97	16.27	12.70	4.72	2.77		

TABLE 3. Reservoir and cove rotenone sample information from 29 Texas Lakes with various AP/P, MxP, %PD, and %NUF relationships.

GROUP	LAKE/YEAR OF SAMPLE	USE TYPE	LAKE AGE	SURFACE ACRES	STANDINC CROP (lb/acre)	CUMULATIVE PREDATORS (lb/acre) @ (MxP)	MAXIMUM PREDATOR LENGTH (MxP)	ACTUAL AP/P	IDEAL AP/P	PERCENT PREY DEFICIT (%PD) INCH CLASSES	PERCENT NON-USABLE FORAGE (%NUF)
I.	FAIRFIELD-76	power	7	2,350	490	41.21	17	6.628	10.903	35	39.2
	MEDINA-75	storage	62	5,575	124	16.87	17	3.883	6.642	6	41.4
	CANYON-76	flood	21	8,240	166	17.72	17	4.591	6.495	24	29.3
	FT. PHANTOM HILL-75	storage	37	4,246	581	78.36	19	3.911	6.702	37	41.7
	STILLHOUSE-75	flood	7	6,430	141	26.43	19	3.111	4.495	32	30.8
	LAKE O'PINES-75	storage	14	18,700	427	94.20	21	3.031	3.797	14	20.2
	HOUSTON COUNTY-75	municipal	9	1,282	303	83.88	21	2.382	2.472	29	3.8
	TRAVIS-75	power	33	18,930	290	48.25	21	2.016	4.495	29	10.3
	BELTON-76	flood	22	12,300	245	48.85	22	3.056	4.511	18	30.9
	WINNSBORO-75	municipal	9	806	228	41.03	22	4.419	4.350	18	3.7
	TOLEDO BEND-75	flood	7	181,600	373	55.51	22	6.289	6.280	27	10.6
	STEINHAGEN-77	flood	16	13,700	256	63.68	23	1.987	2.375	30	18.0
II.	TWIN BUTTES-75	storage	12	9,080	1,644	58.67	14	11.568	27.287	29	57.6
	BENBROOK-75	municipal	25	3,770	609	32.93	16	3.804	17.152	38	78.5
	SAM RAYBURN-75	flood	10	113,400	188	14.47	17	5.180	8.842	12	55.7
	BASTROP-77	power	13	906	120	29.78	18	1.510	2.945	39	44.7
	FALCON-75	irrigation	22	87,210	234	32.07	19	3.123	6.309	37	49.5
	ABILENE-75	municipal	54	641	208	33.97	20	2.580	2.494	35	46.0
	LBJ-76	power	25	6,375	172	23.18	22	3.362	6.452	23	47.9
III.	BRAUNIG-77	power	15	1,350	346	10.81	14	20.884	32.044	43	34.8
	COLEMAN-75	municipal	9	2,000	314	22.26	19	7.671	12.596	42	39.1
	WICHITA-75	municipal	74	2,200	645	57.52	19	6.081	8.790	47	41.1
	LIVINGSTON-75	flood	6	82,600	817	178.17	21	2.206	3.677	67	40.0
IV.	ALCOA-75	power	23	950	728	85.68	15	1.144	6.677	80	82.5
	BUCHANAN-75	power	37	23,060	346	33.04	17	2.857	9.490	65	70.0
	DIVERSION-75	municipal	51	3,419	285	32.60	20	1.014	7.985	95	87.3
	J.B. THOMAS-75	storage	23	7,820	163	21.68	20	2.263	5.836	45	61.2
	POSSUM KINGDOM-74	flood	33	19,800	160	29.84	21	1.692	6.495	91	71.2
	AMISTAD-75	irrigation	6	64,900	866	76.54	21	5.065	10.033	62	51.0
MEAN			23.5	24,263	396	47.90	19.8	6.182	8.224	41	42.7

TABLE 4. Reservoir and cove rotenone sample information from Bastrop Reservoir (1972-77) with various AP/P, MxP, %PD, and %NUF relationships before and after striped x white hybrid bass introductions.

YEARS	STANDING CROP (lb/acre)	CUMULATIVE PREDATORS (lb/acre) at MxP	MAXIMUM PREDATOR LENGTH (MxP)	ACTUAL AP/P	IDEAL AP/P	PERCENT PREY DEFICIT (%PD)	PERCENT NON-USED FORAGE (%NUF)
1972	155	37.35	21	2.16	3.072	33	29.4
1973*	153	43.12	18	1.71	2.528	28	32.4
1974*	196	57.49	18	0.98	2.265	83	58.0
1975*	124	25.57	16	1.46	3.827	50	61.9
1976	164	33.64	17	1.55	3.886	35	60.0
1977	120	29.78	18	1.51	.945	39	48.8
MEAN	152	37.83	18.0	1.56	3.087	44.7	48.4

*Striped x white hybrid bass stockings at 10 fish/acre.

GROWTH OF LARGEMOUTH BASS FOLLOWING VEGETATION CONTROL AND THREADFIN SHAD INTRODUCTION

By

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ABSTRACT

A 15-ha pond in northeast Texas was treated with an herbicide to control aquatic vegetation and was subsequently stocked with threadfin shad. Total lengths back-calculated from scales of largemouth bass indicated that first-year growth of the three year classes following initiation of management was significantly greater than that of previous year classes. No significant differences in length were observed at annulus II. The management practices had the primary effect of reducing the time required for bass to reach catchable size. Because of similarities in growth increments among years, effects of vegetation control and threadfin shad introduction could not be differentiated.

INTRODUCTION

Many studies have shown that growth rates of largemouth bass, *Micropterus salmoides* (Lacépède), vary with availability and abundance of prey. Availability of prey to predators has been generally increased by drawdown or vegetation control. Heman et al. (1969) reported that increased growth of predatory species after vegetation control was due to elimination of cover. The introduction of threadfin shad, *Dorosoma petenense* (Gunther), as an additional forage species in southern reservoirs has become a widespread management technique (Jenkins 1970); however, such introductions have produced variable results throughout the United States (von Geldern and Mitchell 1975). Although these introductions have generally resulted in increased growth of largemouth bass, in some cases the shad populations were not maintained (Swingle 1969) or no significant effects on bass growth were observed (Range 1972). The objective of this study was to compare growth rates of largemouth bass prior to and after the initiation of vegetation control and subsequent introduction of threadfin shad. First- and second-year growth increments were back-calculated from scales collected two years after shad introduction and three years after the initiation of vegetation control.

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MATERIALS AND METHODS

This study was conducted on a 15-ha reservoir located 6.1 km southeast of Grand Saline, Van Zandt County, Texas. Maximum and mean depth of the lake are 7 and 3 m, respectively. The lake received runoff from fertilized pastures. Dense stands of emergent and submerged vegetation including rushes (*Juncus* spp.), Water Leaf (*Hydrolea affinis*), Smartweed (*Polygonum* sp.), sedges (*Carex* spp.), Needle Rush (*Eleocharis acicularis*), Stonewart (*Chara* sp.), Water Primrose (*Jussiaea diffusa*), and Coontail (*Ceratophyllum demeasum*) occurred in the littoral region. In May 1973 chemical control virtually eliminated all submergent vegetation.

The landowner applied diuron to approximately one-fourth of the lake at a time without apparent adverse effects on fish populations. Vegetation control was continued in 1974 and 1975 around the entire shoreline. In April 1974, approximately 10,000 adult threadfin shad were stocked to provide additional forage. A fish survey in 1975 indicated that the threadfin shad population was established and that the forage community was diverse, including six species of minnows and seven species of sunfishes (Bivings 1976).

From October 1975 through April 1976, 139 bass were collected by hook-and-line, gill nets, and electrofishing. Total length to the nearest 1.0 mm and weight to the nearest 28 g (1 oz) were recorded for each fish. Scales were removed from below the lateral line and age-growth analysis was done after examination of magnified scale impressions in cellulose acetate. Lack of agreement between independent agings of age III and older fish indicated that errors in aging became greater as fish got older. Since the sample sizes for these year classes were small and the study did not require separate categorization of these fish, they were combined into a large group referred to as the 1972 and older year class for analyses (Figure 1). Annual growth increments during the first two years of life were estimated by back-calculation using the Lee equation (Lagler 1952). An intercept of 42 mm based on the body-scale relationship (Bivings 1976) was used in the Lee equation. Differences among mean back-calculated lengths and increments were tested using analysis of variance and Tukey's multiple range test at the 0.05 level of significance.

To facilitate comparisons of growth increments in relation to management techniques applied, the year classes were grouped in an attempt to best represent the management history of the lake. The 1974 and 1975 year classes had their first year growth after the introduction of threadfin shad. The 1973 year class had its first-year growth after the vegetation control was initiated but prior to the introduction of the shad. The 1972 and older group represented the average first year growth prior to the implementation of these management techniques.

RESULTS

The average observed and back-calculated total lengths at annulus I, which were identical to the first-year growth increments, ranged from 170.9 mm for the 1972 and older year class bass to 217.2 mm for the 1973 year class (Table 1). A comparison of the mean total lengths at annulus I of the 1973, 1974, and 1975 year classes indicated that they could not be considered significantly different from one another. Growth of these year classes was considered to represent the average first-year growth increments following the initiation of management practices. The first-year increment for the 1972 and older year class, which represented the average estimated first-year growth increment prior to pond management, was significantly smaller than that of each of the other year classes.

At annulus II, the average total lengths ranged from 311.2 mm for the 1974 year class to 315.6 mm for the 1972 and older year class (Table 1). A comparison of total lengths for all three year classes indicated that the differences between average total lengths for all three year classes at annulus II were not significant. The increment of second-year growth ranged from 144.8 mm for the 1972 and older year class to 97.0 mm for the 1973 year class (Table 2). The difference between increments of the 1973 and 1974 year classes was not significant. However, the differences between the 1972 and older year class and each of the other two year classes were significant. Thus, there was a significant reduction in second-year increment after the initiation of management practices, even though lengths at the annulus II were essentially the same for these year classes.

DISCUSSION

This study suggests that the immediate effects of the management practices initiated were beneficial. There was a significant increase in the average estimated total length at annulus I which began with vegetation control and continued during threadfin shad introduction. Casual examinations of food habits of age I and older bass revealed that shad were serving as a primary forage for the adult fish. In an attempt to quantify the vigor and plumpness of the bass which was observed in this study, the coefficient of condition, K (TL), was computed (Carlander 1969). The mean values ranged from 1.3 for the 1975 year class to 1.6 for the 1972 and older year class with a weighted mean of 1.5 which is above average for the species according to Carlander (1977).

Lee's phenomenon was considered as one possible explanation for the significant increase in first-year growth observed in the younger fish, however this hypothesis was not supported by the data (Table 1). The largest first-year increment was in the 1973 year class. Since the first-year increments did not increase from smallest to largest in chronological order, the first-year data do not support Lee's phenomenon. Since there were no significant differences in the total lengths at annulus II, there was no support for Lee's phenomenon in second-year growth. Thus, it appeared that Lee's phenomenon was not a major factor in this study.

It was difficult to elucidate the principal factors involved in the fluctuations in the first-year growth rates. The major factor in the dramatic increase in growth rates in 1973 appeared to be the removal of the cover for the forage species. Similar results were reported by Bennett (1948) and Heman et al. (1969). It was more difficult to explain the drop in the first-year growth rates of the 1974 year class and subsequent rise of the 1975 year class. Perhaps a change in age structure of the forage populations was also initiated by the vegetation control. It appeared that the bass population was still seeking an equilibrium with the forage population following the reduction of cover. It was plausible that 1973 was very strong for the bass and very weak for the forage. Thus, a drop in growth rates for the next year class of bass could have been expected. The length-frequency data on the adult bass did not indicate that this had occurred. However, the samples in this study may not have been adequate to represent the true strength of each year class. The introduction of shad as an alternate forage species which is suited to open waters and limited amounts of cover may have minimized the instability in other prey populations produced by vegetation control. However, no additional prey population data existed for any of these years.

The significant increase in first-year growth was a substantial benefit. The most apparent benefit was the reduction in time required for individual fish to grow to a catchable size of approximately 250 mm. At the end of the study, average fish were entering the fishery approximately 13 to 15 months after being spawned. Although few fish this size were being kept, their presence improved the recreational fishing in the lake which the landowner reports to be very good. Another possible benefit may have been increased survivorship of the first-year fish. An increase in the average total length of young bass to over 200 mm should reduce the young-of-the-year mortality over the first winter. Bivings (1976) reported that in the years following vegetation control there was limited survivorship over winter of young-of-the-year which were less than 150 mm in total length.

There were no observed beneficial effects of threadfin shad introduction or vegetation control on the second year of growth, but rather a decrease in the second-year increment. Strong year classes of the young-of-the-year bass could have produced a larger total population of adult bass; however, unless the total amount of available forage also increased, there would have been a reduction in the available food per adult bass. This would probably have resulted in a reduction of growth increments for all year classes of adult bass and smaller average size bass for a given age. This result would not be desirable if large bass were the principal management objective.

Although the short-term effects of the management practices were generally favorable, the long-term effects of these management procedures are unclear. Unless the bass and forage populations had reached equilibrium, the response of high first-year growth and reduced second-year growth may not persist. Effects on growth in the third and subsequent years may also occur.

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Table 1. Mean calculated total length (TL), annual increment of growth (INCR), and confidence intervals (CI) of largemouth bass for annulus I and annulus II.

Year Class		Annulus I (CI)	Annulus II (CI)
1975	TL	214.4 (197.8, 231.0)	
1974	TL	196.1 (183.5, 208.6)	311.2 (303.3, 319.2)
	INCR		115.2 (105.6, 124.7)
1973	TL	217.2 (203.6, 230.8)	314.2 (305.2, 323.2)
	INCR		97.0 (86.9, 107.2)
1972 and older	TL	170.9 (161.1, 180.6)	315.6 (305.5, 328.7)
	INCR		144.8 (134.1, 155.5)

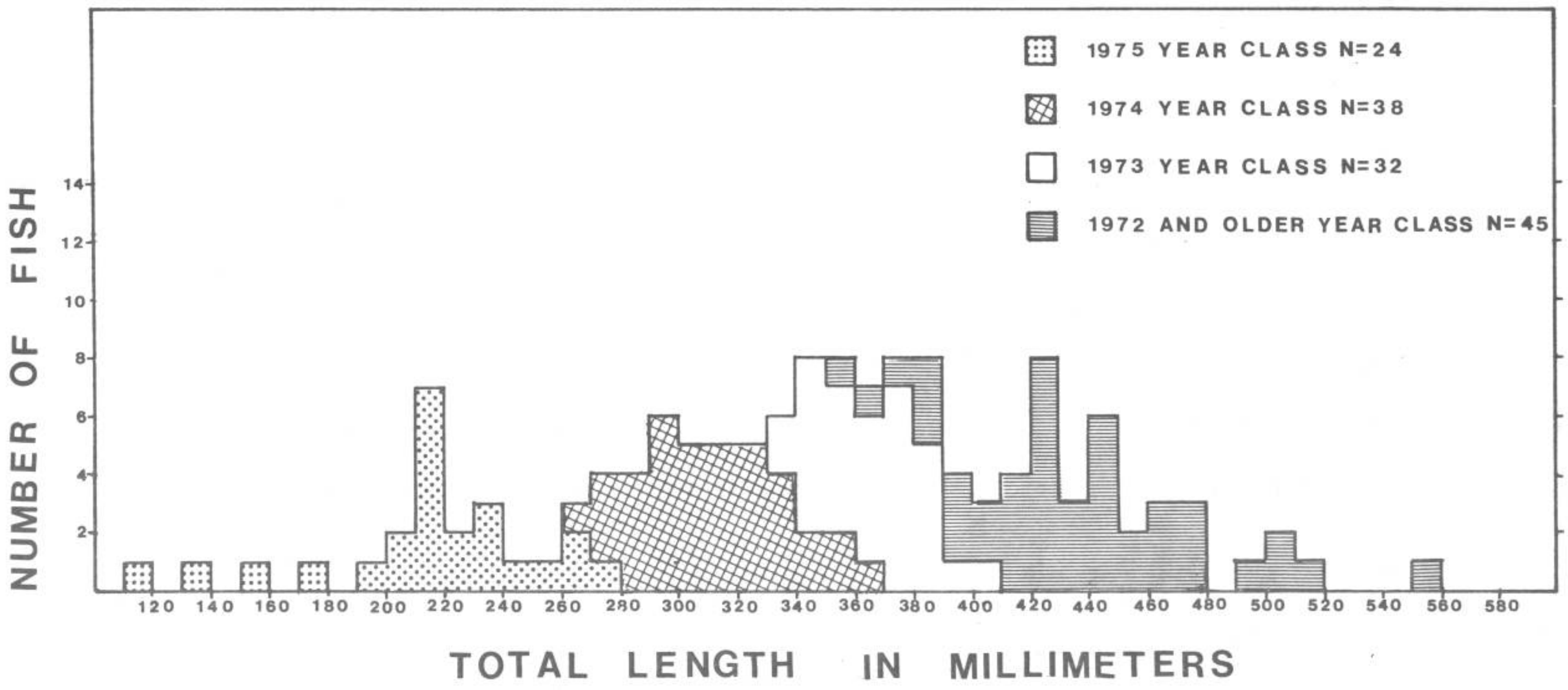

Figure 1. Length-frequency distribution of northern largemouth bass, October 1975-April 1976.

COST:BENEFIT EVALUATION OF STOCKING HARVESTABLE-SIZED CATFISHES

By

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ABSTRACT

A 7-yr study (1968-74) to determine the cost:benefit ratio of stocking harvestable-sized blue and channel catfishes was conducted on Lake Bastrop, Texas; a 906-acre heated reservoir with a catfish recruitment problem. Combinations of these catfishes (7-16 in. TL) were stocked from 1969 through 1971 at an annual rate of approximately 10 per acre. At the end of the study, total harvest of stocked blue and channel catfish was 17 and 26% respectively. Cumulative fishermen benefit 3 yr after the last stocking was $2.05 for each $1.00 spent to rear and stock the fishes. The cost:benefit ratio for the blue and channel catfish stocking program at the end of 1974 was 1:2.03 and 1:2.08 respectively.

INTRODUCTION

Sport fishing in Texas reservoirs generally exhibits a pattern of good fishing for the first few years after impoundment followed by a decline as the reservoir ages. An early management technique used to improve fishing in older reservoirs involved mass stocking of fry or fingerling fishes. However, this practice was usually ineffective because of low returns to the fishermen (Broach, 1967). A stocking program utilizing catchable-sized catfish has been

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suggested for increasing harvest from lakes with an established fish community (Calhoun et al., 1963). Although more expensive, these fish would be less vulnerable to predation than fry or fingerlings and create an immediate fishery. The objective of this study was to determine the cost:benefit ratio of stocking harvestable-sized blue and channel catfishes into an established fish community.

Appreciation is expressed to the Federal Aid in Fish Restoration Act under Project F-12-R of the Texas Parks and Wildlife Department for financial support; to the Lower Colorado River Authority and concessionaires of Lake Bastrop for their cooperation; to Calvin Wyatt and Steve Boehm, Texas Parks and Wildlife Department, for collection of field data; and to Neil Carter and Dr. Bobby Whiteside for review of the manuscript.

MATERIALS AND METHODS

Lake Bastrop, a 906-acre power plant lake, is located 3 miles northeast of Bastrop, Texas. Since it is built on an intermittent stream with a watershed of only 9 square miles, water is pumped from the Colorado River to maintain a constant lake level. Submerged tree cover is limited to a few cove areas, but aquatic macrophytes provide abundant seasonal cover to depths of 15 ft. A well-defined thermocline occurs at approximately 22 ft from June through September. Temperatures of the discharge water from the 605-megawatt power plant range from a monthly average of 58 F in winter to 102 F in summer.

Multifilament experimental gill nets were used to measure the abundance of harvestable-sized catfishes in the reservoir prior to the catfish stocking program. Eight permanent stations were sampled biweekly from March, 1968 through August, 1973 and monthly from September, 1973 through November, 1974.

Night seining collections were made at eight permanent stations for an indication of catfish spawning success before the introduction of the sub-adult catfishes. A 24-ft long, 1/4-in. mesh bag seine was fished monthly from March through November, 1968.

A creel survey, stratified into weekdays and weekend days, was conducted during 1968 to categorize the sport fishing in Lake Bastrop prior to the catfish introductions. Approximately 38 weekdays and 40 weekend days were sampled. Survey stations were manned at the two lake exits during daylight hours on survey days from March through November. The winter period was not sampled because of limited fishing activity.

Combinations of blue and channel catfishes (approximately 10/acre) were stocked each year from 1969 through 1971 (Table 1). Stocked fishes were 7-16 in. TL with the mode in the 8- to 8.9-inch group. Catfishes were reared at State fish hatcheries for one growing season and fed a commercial catfish ration. Before stocking, fishes were tagged with Floy anchor tags (Dill, 1968) coded according to stocking size and year.

From 1969 through 1974 netting, seining and creel surveys were continued to determine the effects of the stocking program on the lake's catfish angling potential, spawning success, fishing pressure, harvest, and to determine the benefits which resulted from the stocking program. Benefits provided by stocking the harvestable-sized blue and channel catfishes were compared with the cost of the introductions and estimated value of the fishery which would have been provided without stocking. Commercial live weight catch-out values for central Texas from 1968 through 1974 ($0.575, $0.575, $0.575, $0.672, $0.723, $0.750, and $0.925/lb respectively) were used in calculating fisherman benefit estimates (J. T. Davis, Texas A&M Extension Service, College Station, Texas, personal communication). This is a minimum measure of benefits since values received by establishing a reproducing population and increasing fisherman recreation are not included. Cost estimates were based on Texas State fish hatchery rearing and stocking costs for catfishes ($0.45/lb) from 1969 through 1971 (W. H. Henderson, Texas Parks and Wildlife Department, San Marcos, Texas, personal communication).

RESULTS AND DISCUSSION

The number of blue and channel catfishes captured by gill nets was low in 1968 before the stocking program began, but catches increased substantially in 1969 after stocking (Figure 1). The gill net catch of blue catfish peaked in 1970 and then decreased markedly each successive year. This decrease occurred even though introductions were made in 1970 and 1971. This decrease did not necessarily indicate a decline in the blue catfish angling potential since fisherman harvest of these fish increased in the same years (Figure 2). Total catch of channel catfish by fishermen and gill nets showed an annual increase through 1973 but decreased in 1974 (Figures 1 and 2).

Night seining produced no channel catfish fingerlings in 1968 or 1969, but fingerlings were caught from 1970 through 1974. The spawning success of the channel catfish evidently improved each year after stocking, especially in 1974. This may have been the result of stocking subadults. An absence of fingerling blue catfish throughout the study indicated that recruitment for this species in Lake Bastrop was not changed by introductions of harvestable-sized individuals.

The first introduction of catfishes was made in 1969, but fishing pressure decreased substantially that year (Table 2). This decrease was mostly attributed to the greater appeal of newly impounded waters near Lake Bastrop. Rod and reel fishing pressure increased, however, from 1970 through 1973. Set line fishing was initiated in 1970 and peaked in 1972; it declined in 1973 after most large resident flathead and blue catfish had been removed. Set line fishing increased after the 1973 decline, and most of the catch was composed of stocked catfishes. Without the catfish stocking program, set line fishing may have disappeared after depletion of large resident catfishes.

Catfishes with tag scars began appearing in the first stocking year and became increasingly abundant in the fishermen's creel (Figure 2). Unmarked catfishes (those without tags or scars) also became increasingly abundant in the fishermen's creel. Creel and netting data indicated a very low resident catfish population, and since seining data indicated limited spawning success, most unmarked fishes were probably stocked fishes which had lost their tags and whose scars had become indistinct.

The total number of blue and channel catfishes caught by fishermen in 1968 was low, but showed an overall increase through 1973 (Figure 2). In 1974, 3 years after the last stocking, there was a decrease in total harvest.

The percent harvest of introduced catfishes increased with stocking size and time lapse after stocking (Figure 3). Miller and Bottroff's (1968) study had similar results concerning the relationship of stocking size to catfish harvest by fishermen. Their study indicated (1) smaller fish may be less vulnerable to the angler, (2) tagging and/or natural mortality is higher for smaller fish, or (3) tag shedding rate is inversely related to size.

Cumulative fishermen benefit for each species did not exceed cumulative costs of stocking until 1973, the fourth year after the first introduction (Figure 4). Cumulative fishermen benefit for both catfishes combined at the end of the study was $7,570. Total cost of the three introductions was $3,566. Thus, for each $1.00 spent to rear and stock the catfishes, $2.05 of fisherman benefit was received. The cost:benefit ratio of the blue catfish introductions at the end of each of the years 1971 through 1974 was 1:0.18, 1:0.74, 1:1.41 and 1:2.03 respectively, while the cost:benefit ratio of the channel catfish introductions during the same years was 1:0.20, 1:0.84, 1:1.63 and 1:2.08 respectively. These benefits are probably conservative because of the marked decrease in fishing pressure after the introductions. Even with this decrease, harvest of catfishes increased substantially. Therefore, if fishing pressure had remained at its normal level, benefits could have been much larger. Although there was a greater percent harvest of stocked channel catfish than blue catfish (26 and 17% respectively), the average weight of blue catfish was greater. The channel catfish is desirable for a stocking program in Texas because of its greater returns to the fisherman. However, anglers might be more attracted to blue catfish because of the fish's ability to reach a larger size.

This study indicates fisherman benefit should be substantially higher than the cost of rearing and stocking catfishes. Stocking of harvestable-sized catfishes appears to be a worthwhile management practice whenever a small reservoir with potential angling pressure has limited recruitment and small standing crops of catfishes.

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TABLE 1. STOCKING RECORD OF CATFISHES, LAKE BASTROP, 1969-1971.

		STOCKING RECORD							
		1969		1970		1971		Total	
Species	Size Group (Inches)	Number	Pounds	Number	Pounds	Number	Pounds	Number	Pounds
Blue Catfish									
	7.0-7.9	1,467	249	1,975	336	1,284	218	4,726	803
	8.0-8.9	1,478	362	1,946	477	1,563	383	4,987	1,222
	9.0-9.9	990	336	557	189	980	332	2,527	857
	10.0-10.9	410	187	119	54	578	264	1,107	505
	11.0-11.9	72	43	14	8	194	116	280	167
	12.0-	8	6	4	3	45	34	57	43
Total		4,425	1,183	4,615	1,067	4,644	1,347	13,684	3,597
Channel Catfish									
	7.0-7.9	1,904	314	660	112	1,773	301	4,337	737
	8.0-8.9	1,586	389	1,926	472	1,277	313	4,789	1,174
	9.0-9.9	940	319	1,199	406	873	296	3,012	1,021
	10.0-10.9	732	334	548	250	472	215	1,752	799
	11.0-11.9	188	112	253	151	199	119	640	382
	12.0-	167	128	97	74	16	12	280	214
Total		5,517	1,606	4,683	1,465	4,610	1,256	14,810	4,327

Table 2. Estimated Fishing Pressure, Lake Bastrop, 1968-74.

	Annual Fishing Pressure						
	1968	1969	1970	1971	1972	1973	1974
Rod and Reel Fishing							
Total Man-hours	88,473	34,034	22,865	31,259	46,544	51,039	33,444
Man-hours/Acre	97.65	37.56	25.25	34.50	51.37	56.37	36.91
Set Line Fishing							
Total Hooks	0	0	1,743	2,746	7,379	2,226	3,822
Hooks/Acre	0	0	1.92	3.03	8.14	2.46	4.22

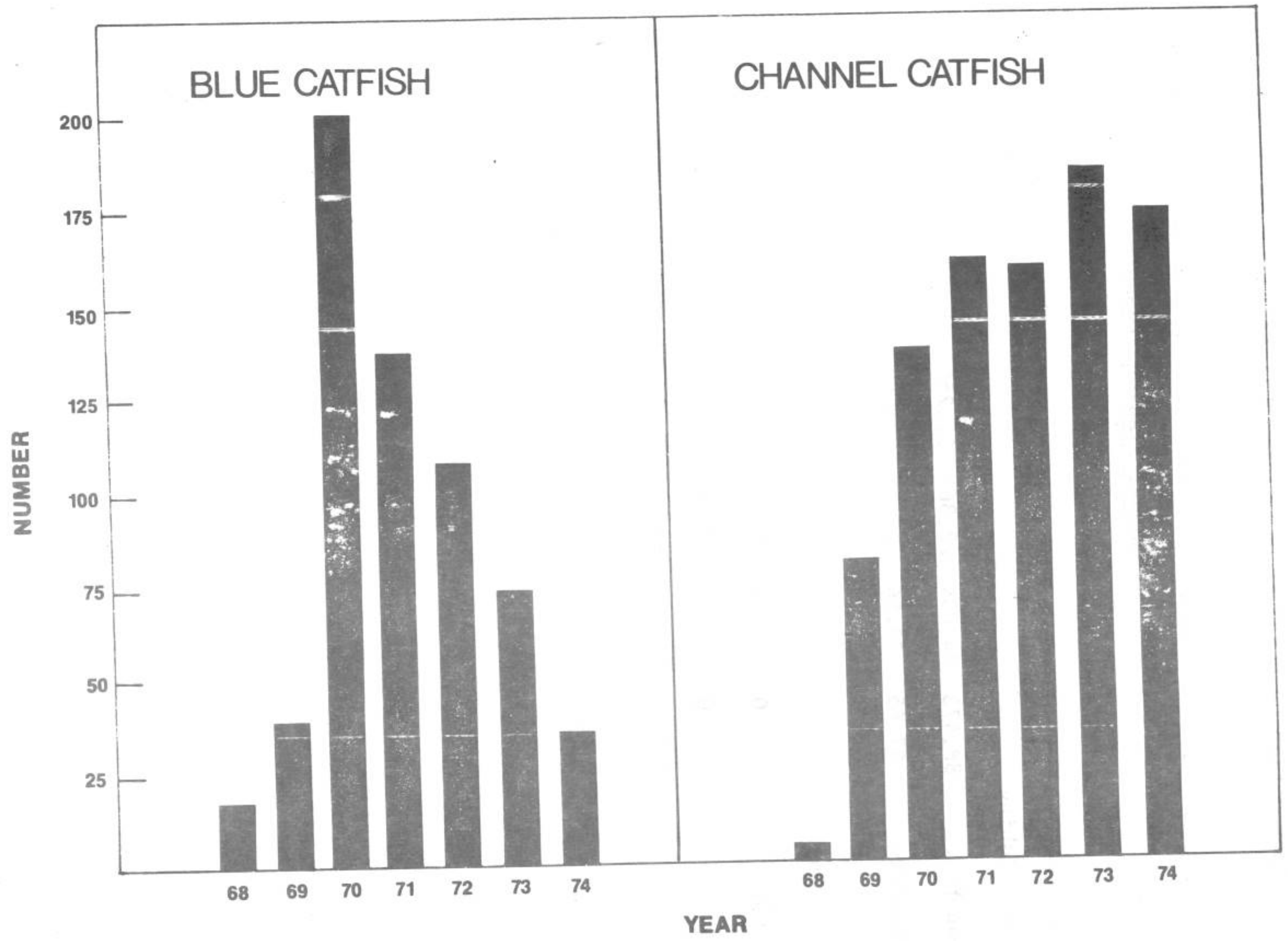

Figure 1. Harvest of catfishes by experimental gill nets, Lake Bastrop, 1968-74 (based on 19 overnight samples with eight 300-ft gill nets at permanent stations, March-November).

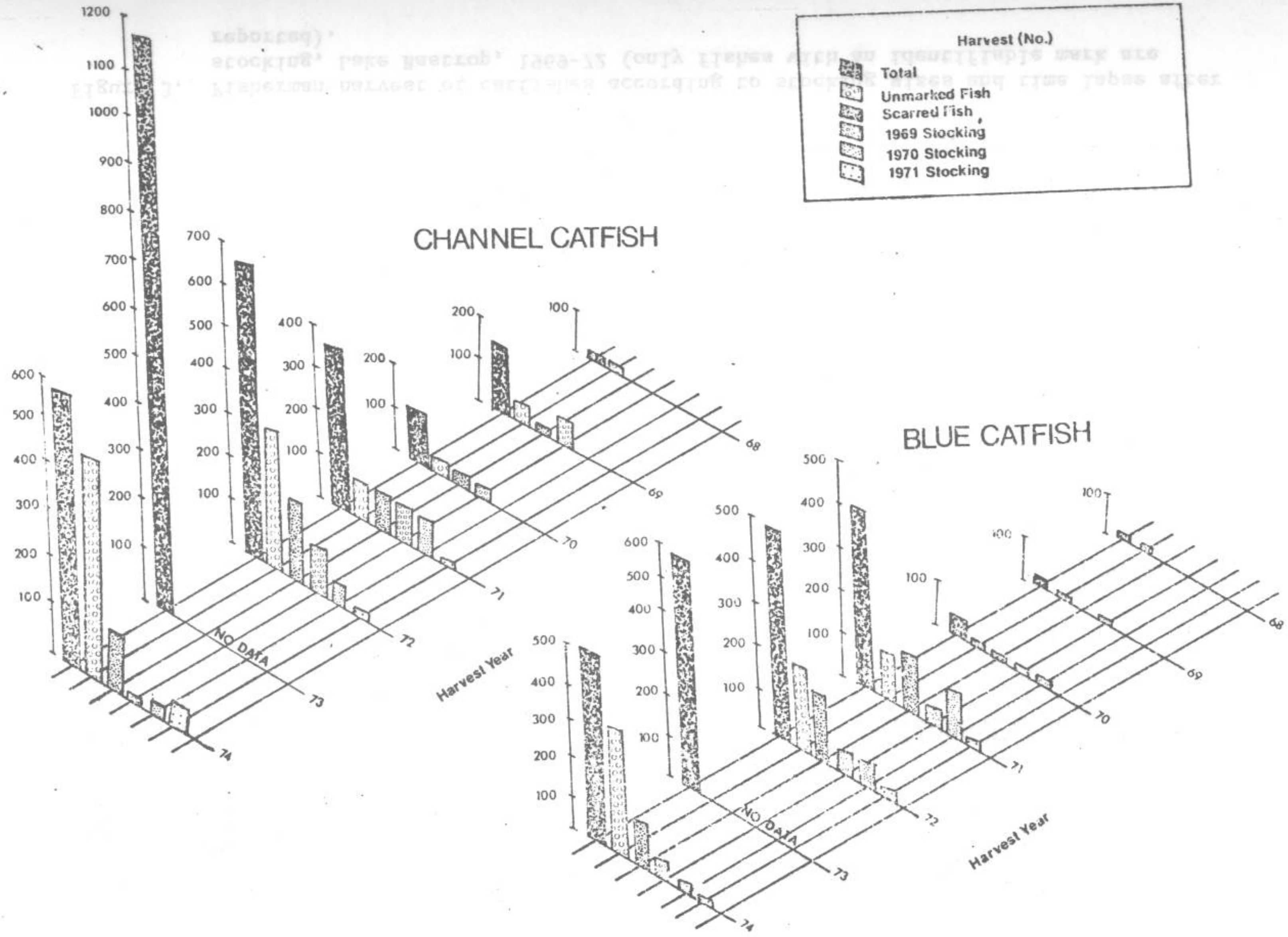

Figure 2. Annual estimates (no.) of catfishes harvested by fishermen, Lake Bastrop, 1968-74.

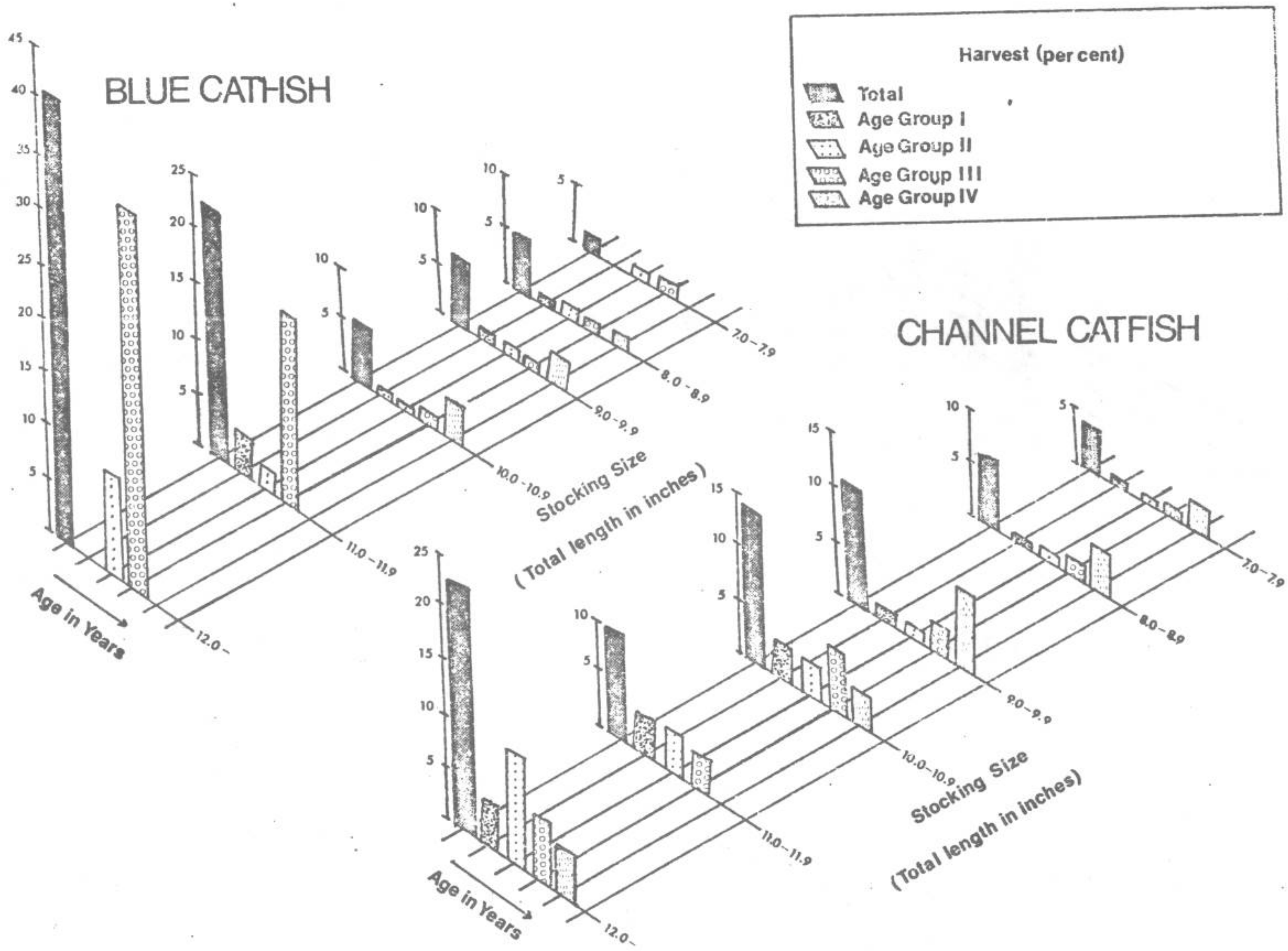

Figure 3. Fisherman harvest of catfishes according to stocking sizes and time lapse after stocking, Lake Bastrop, 1969-72 (only fishes with an identifiable mark are reported).

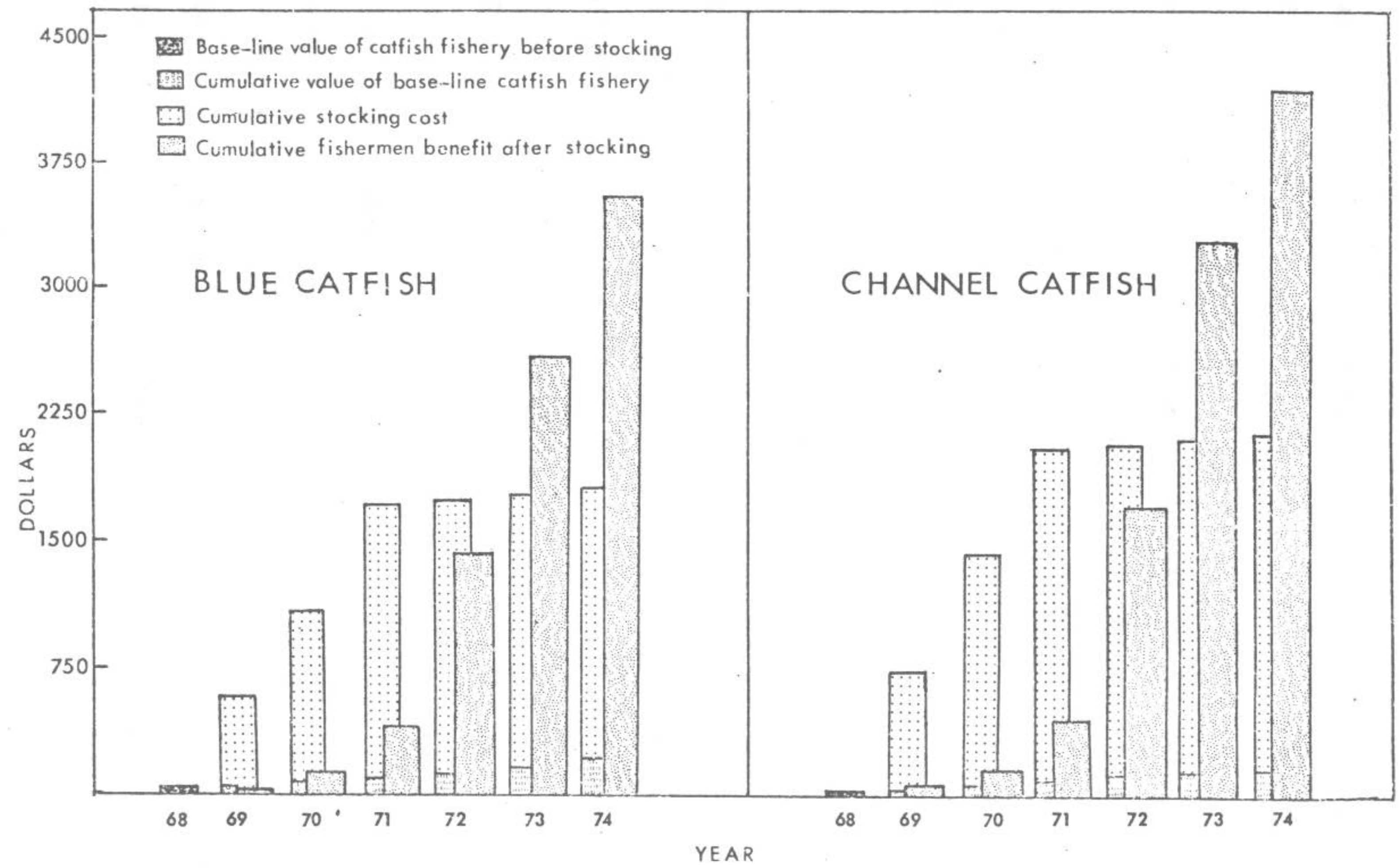

Figure 4. Base-line value of catfish fishery before stocking, 1968, and cumulative stocking costs and fishermen benefit after stocking, 1969-74, Lake Bastrop.

AVERAGE GROWTH RATES FOR LARGEMOUTH BASS IN TEXAS

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ABSTRACT

Average growth rates, length-weight relationship, and condition factors were calculated for largemouth bass (*Micropterus salmoides*) in Texas using 2,631 specimens representing 58 reservoirs. Results are presented statewide, by river system and by ecological regions within the state.

Bass in the Sabine-Sulphur-Cypress-Neches river system which fall primarily within the pineywoods ecological region exhibited the best growth. Those from the Canadian-Red river system (High and Rolling Plains) exhibited the slowest growth.

INTRODUCTION

Fishery management decision making has become increasingly more crucial in recent years as demands for recreation increased. Fishing pressure increases are projected to continue (Branton et al. 1975; U.S. Fish and Wildlife Service 1977) and fishery managers will be required to make concentrated efforts to 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 use of the scale method of fish aging has been shown for waters of the southern United States (Brown 1960; Houser and Bross 1963; Prather 1967; Prentice and Whiteside 1975; and Kolb and Whiteside 1977), and growth rate data could therefore be used in Texas to improve fishery management decision making.

This study was conducted to provide and consolidate growth rate information for largemouth bass (*Micropterus salmoides*) in Texas waters on statewide, river system and ecological region bases.

MATERIALS AND METHODS

A total of 2,631 largemouth bass were collected from 58 reservoirs between 1974 and 1977 for use in this study. Collections were part of the fish population sampling conducted throughout Texas by biologists of the Parks and Wildlife Department. Total length, weight, sex and scale samples were taken from each fish. Age determination followed methods similar to those presented by Carlander (1961), Carlander and Whitney (1961) and Prentice and Whiteside (1975).

Growth rates and condition were calculated statewide, by river system (Figure 1), and by ecological regions (Figure 2) of Texas. Fish collected in reservoirs falling within each division were used to determine these values.

Growth was determined by the Lee method of back calculating lengths of fish (Lagler 1952). Growth trends were studied using the Von Bertalanffy growth model (Rafail 1973).

Length-weight relationships (Everhart et al. 1975) and condition factors (Lagler 1952) using total length were used to determine condition of the fish.

RESULTS AND DISCUSSION

Apparent differences across the state were observed by comparison of growth rates in different river systems (Figure 3). Bass in the Canadian-Red and Guadalupe-Lavaca-San Antonio river systems exhibited slower growth, while bass in the Sabine-Sulphur-Cypress-Neches, Brazos and Colorado river systems exhibited faster growth. Growth rates observed by ecological regions (Figure 4) were more uniform across the state than those observed by river systems. However, bass growth in the High and Rolling Plains (Region 7) appeared to decline very rapidly, being above average for the first two years of growth and below average for ages III, IV and V.

No effort was made to explain growth rates. However, this study should supply fishery managers with a reference for largemouth bass growth rates on a statewide basis or in a smaller region within the state.

Analysis of covariance revealed no differences (0.05 level) between the length-weight relationships for females and males on statewide, river system or ecological region bases. Therefore a single regression for both sexes was calculated for each river system, region and statewide (Table 1). Similarity was found between length-weight relationships calculated in this study and those listed by Carlander (1977) for other locations.

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Table 1. Length-weight relationships and condition factors of largemouth bass (sexes combined) in Texas waters on statewide, river system and ecological region bases where W = weight (g) and L = total length (mm).

Sample location	Sample size	Length-weight relationship	Condition factor
Statewide	2,631	Log W = -4.8 + 3.0 Log L	2.02
River systems			
1) Sabine-Sulphur-Cypress-Neches	794	Log W = -5.0 + 3.0 Log L	1.81
2) Trinity-San Jacinto	545	Log W = -4.8 + 2.9 Log L	2.39
3) Brazos	362	Log W = -4.9 + 3.0 Log L	2.02
4) Colorado	532	Log W = -4.9 + 3.0 Log L	1.74
5) Guadalupe-Lavaca-San Antonio	42	Log W = -5.5 + 3.2 Log L	1.56
6) Rio Grande-Pecos-Nueces	263	Log W = -5.3 + 3.1 Log L	1.74
7) Canadian-Red	93	Log W = -5.4 + 3.2 Log L	2.61
Ecological regions			
1) Pineywoods	559	Log W = -5.1 + 3.1 Log L	1.80
2) Gulf prairies	44	Log W = -5.5 + 3.2 Log L	1.99
3) South Texas plains	141	Log W = -5.4 + 3.2 Log L	1.71
4) Post oak savannah, blackland prairies	458	Log W = -4.7 + 2.9 Log L	1.87
5) Cross timbers and prairies	692	Log W = -4.8 + 3.0 Log L	2.38
6) Edwards plateau, trans-Pecos and mountains and basins	470	Log W = -5.0 + 3.0 Log L	1.70
7) High and rolling plains	267	Log W = -5.0 + 3.0 Log L	1.89

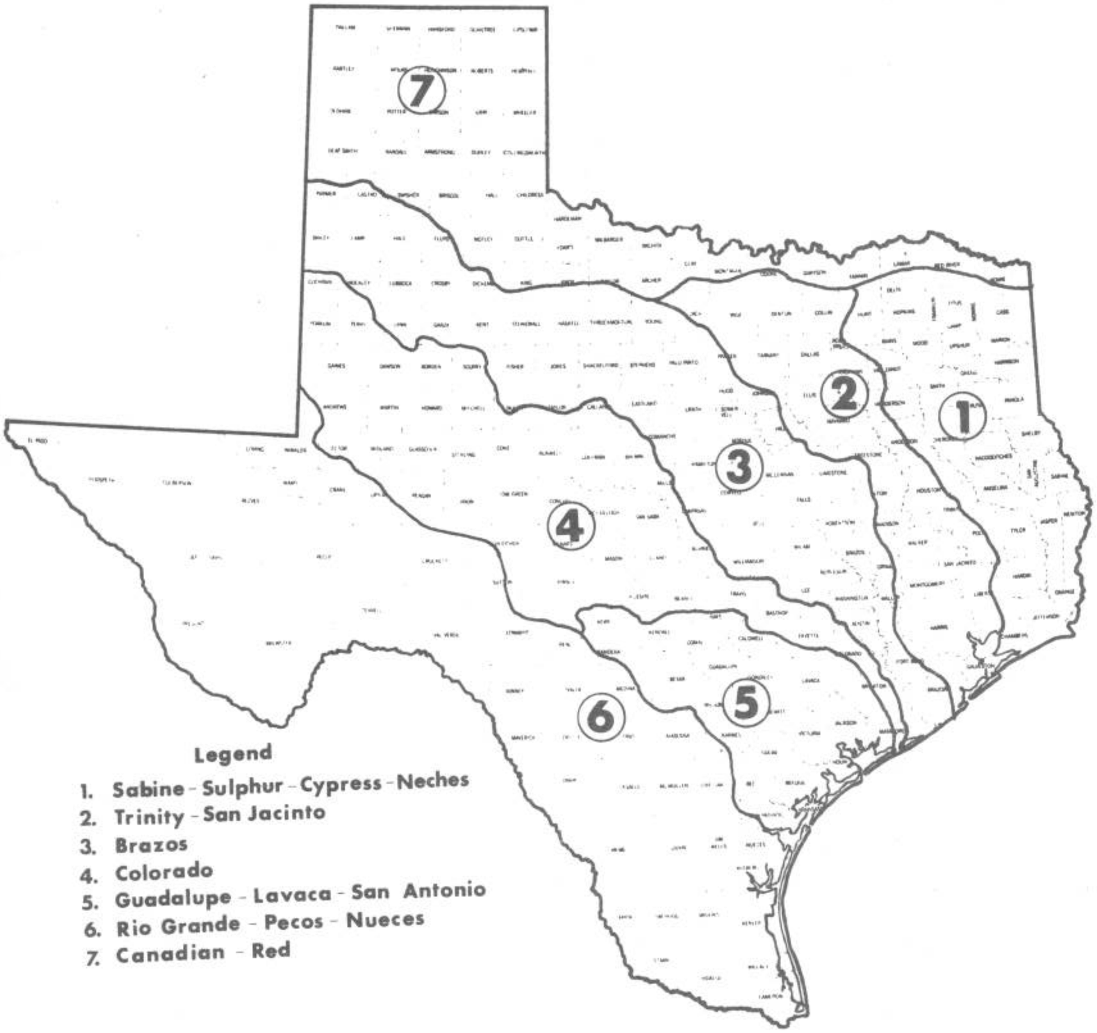

Figure 1. Major river systems of Texas.

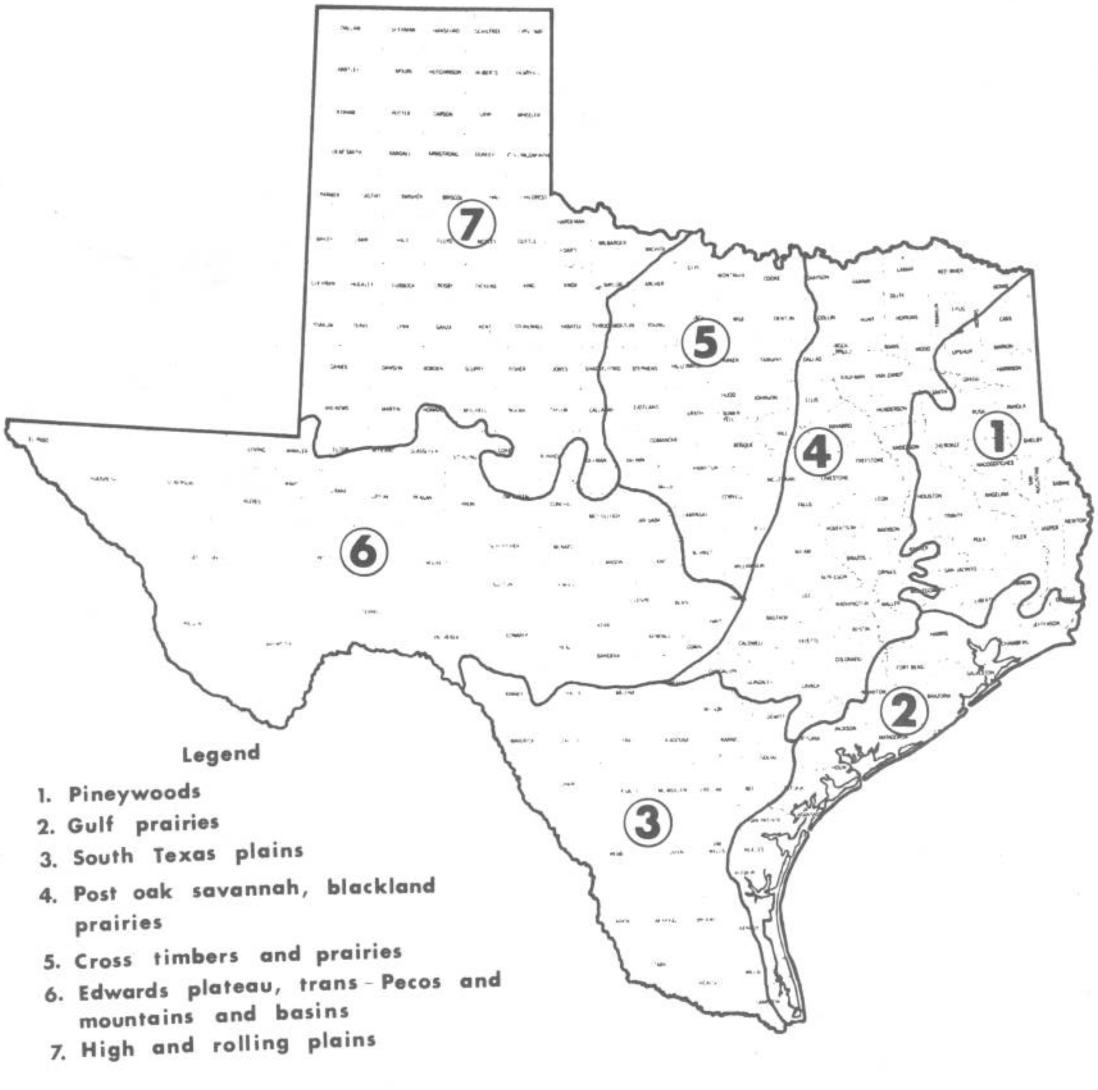

Figure 2. Ecological regions of Texas.

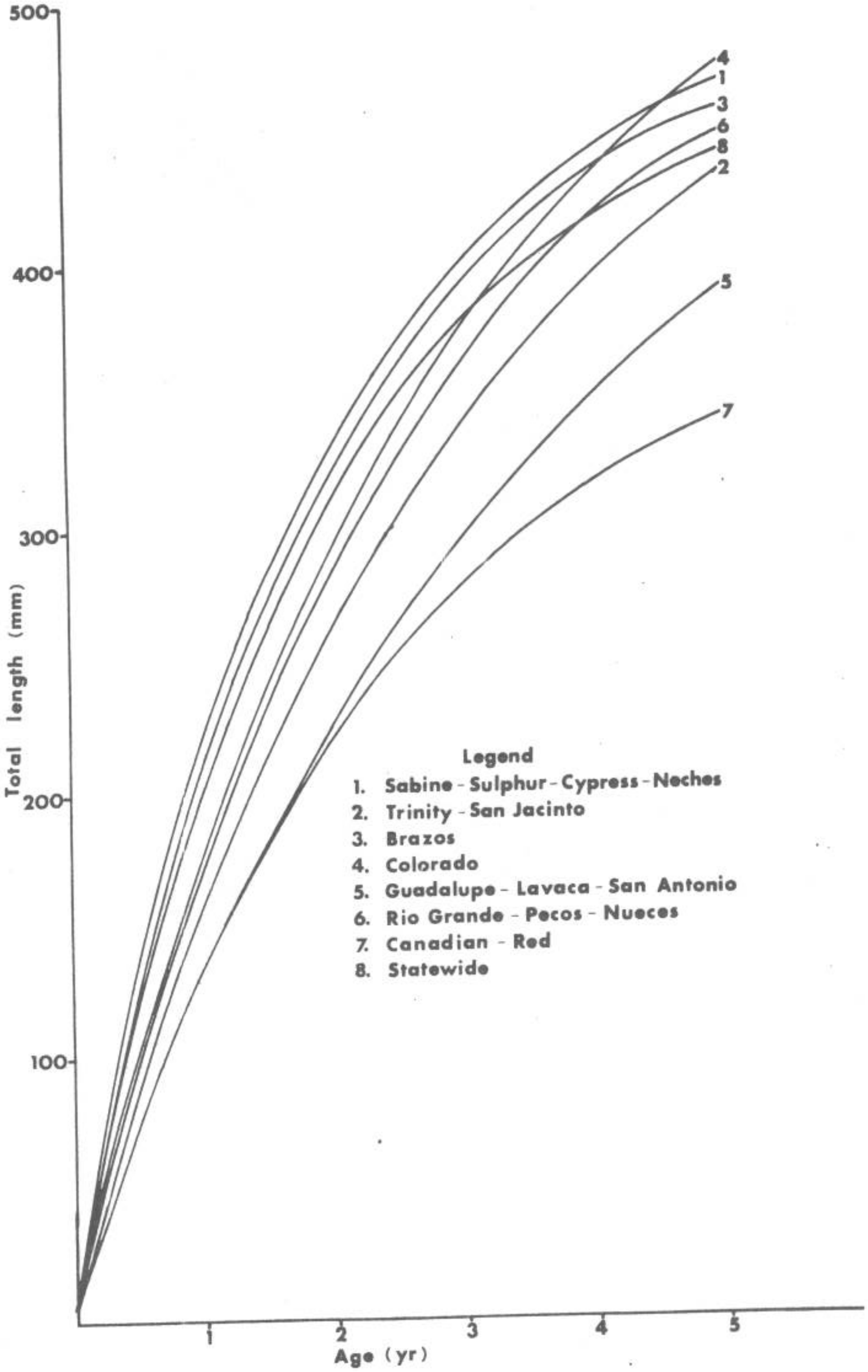

Figure 3. Von Bertalanffy growth curves of largemouth bass by river systems of Texas and statewide.

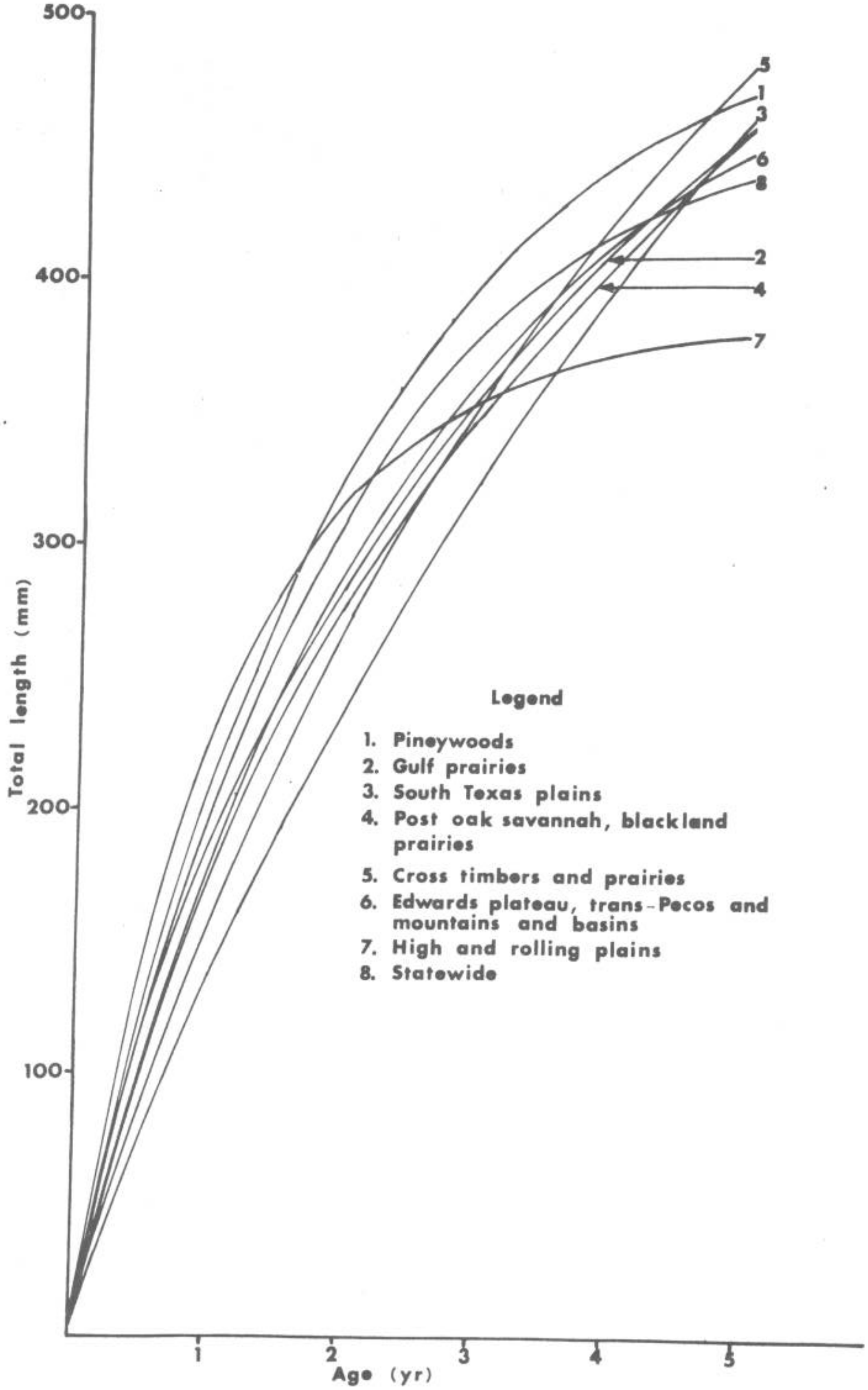

Figure 4. Von Bertalanffy growth curves of largemouth bass by ecological regions of Texas and statewide.

FIRST-YEAR GROWTH OF NORTHERN AND FLORIDA LARGEMOUTH BASS IN A CENTRAL TEXAS POND

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ABSTRACT

An evaluation of the growth rate of Florida (*Micropterus salmoides floridanus*) and northern largemouth bass (*Micropterus salmoides salmoides*) was made in a 0.44 ha pond. In May 1975, 100 fingerlings of each subspecies were stocked. The pond was periodically sampled by electrofishing and was retononed in September 1976, to determine final growth attained. The northern largemouth consistently exceeded the Florida largemouth bass in size. At the end of the study, the northern largemouth bass exceeded the Florida bass by 42 mm in length and 313 g in weight. The northern bass spawned, but no evidence of Florida bass spawning was found.

INTRODUCTION

Two subspecies of largemouth bass (*Micropterus salmoides*) were described by Bailey and Hubbs (1949). Studies comparing growth rates of the two subspecies in various areas have yielded inconsistent results. In Florida, Clugston (1964) reported differences in growth rates of northern largemouth bass (*M. s. salmoides*) from Iowa and Florida largemouth bass (*M. s. floridanus*), but the variations could not be attributed to genetic differences. In California, Sasaki (1961) found virtually no differences in first-year growth between the subspecies and Miller (1965) did not find significant differences in growth of the two subspecies stocked together in a 10-acre reservoir. In Alabama, Zolczynski and Davies (1976) reported that at age 0 northern largemouth bass were significantly larger than Florida largemouth, but Addison and Spencer (1971) reported that Florida bass were noticeably larger than northern largemouth at 22 and 27 months of age. Studies in Texas by Inman et al. (1976) indicated that northern largemouth initially were larger than Florida bass, but from age I to age II, sizes were approximately equal. However, the Florida bass surpassed the northern bass after age II.

The purpose of this study was to evaluate the growth rates of the Florida and northern largemouth bass stocked together.

MATERIALS AND METHODS

A 0.44 ha pond located on the Stiles Farm in Williamson County, Texas, was selected for the study site. The pond receives run-off from row crop farming and coastal bermuda pasture land. The pond could be classified as very fertile with a dense bloom of phytoplankton produced by run-off from the fertilized watershed.

The pond was treated with rotenone in the summer of 1974 and subsequently was stocked with approximately 100 fingerling channel catfish (*Ictalurus punctatus*). Bluegill (*Lepomis macrochirus*) were stocked later and a reproducing population was established.

In May 1975, 100 northern and 100 Florida largemouth bass were stocked in the pond as fingerlings. The northern largemouth averaged 64 mm and the Florida largemouth averaged 51 mm in total length at stocking.

The fish were sampled in October 1975 and in February and May 1976 with electrofishing gear. Length and weight were recorded and lateral line scales counted. All fish having less than 68 lateral line scales were classified as northern largemouth and fish with a greater number of scales classified as Florida largemouth bass. The fish sampled were returned to the pond. In September 1976, the pond was electrofished and again poisoned with rotenone. All fish were collected, weighed and measured. The lateral line scales were counted on all age I fish and on a subsample of the age 0 fish.

RESULTS AND DISCUSSION

The northern largemouth consistently exceeded Florida bass in size and attained a significantly greater length by September 1976 (Table 1). The total lengths of the northern largemouth and the Florida largemouth were 334 mm and 292 mm respectively ($t=5.52$, $p< 0.05$). Disparities in length and weight between the two subspecies gradually increased during the study. By September 1976, northern largemouth exceeded Florida bass by 42 mm in length and 313 g in weight.

The Florida largemouth did not appear in the electrofishing samples taken in October, February and May in as great a frequency as did the northern largemouth (Figure 1). This low relative occurrence could not be attributed to differential survival or differential susceptibility to electrofishing. Lack of close agreement between composition of the electrofishing sample and the rotenone sample in September 1976 suggests, however, that electrofishing may have underestimated relative abundance of Florida bass. In contrast to the results obtained by electrofishing earlier, the total sample in September 1976 had a greater occurrence of the Florida largemouth bass. This change in composition could have been due to removal of northern largemouth bass by unsanctioned angling which was initiated during the summer of 1976. Such angling pressure probably differentially removed the northern largemouth due to their larger size. No catch data were taken, but anglers did indicate that fish of the average size of the northern largemouth bass were creeled. Catch data could have provided valuable information on the relative susceptibility of the two subspecies to angling and possibly confirmed the cause of the change in composition between May and September.

Reproduction of largemouth bass was noted in the sample taken in May 1976 and again in September 1976. Based on lateral line scale counts, the bass reproduction noted in September 1976 consisted entirely of northern largemouth bass (Figure 2). Mean scale count of bass reproduction (63.5) was not significantly different (t=1.30) from that of age I northern largemouth (64.2) (Table 1). Absence of young bass with lateral line scale counts greater than 68 indicated that Florida bass reproduction had not been successful.

If the electrofishing samples can be considered representative, this study indicates that Florida largemouth bass will not adequately compete with northern largemouth when stocked together as fingerlings. Lack of Florida bass spawning at age I, perhaps related to their smaller size, delayed the possibility of the production of Florida hybrid bass at least one additional year. Young northern largemouth bass were successfully produced in the spring of 1976, but due to their small size (60.7 mm mean total length) as of September, they were not likely to the following year. The establishment of this strong first-year class would give the northern largemouth bass a long-term advantage. Unless some relative advantage at larger sizes or older ages characterizes the Florida bass, they would seem to be eventually destined to be outcompeted and have minimal impact on the total population of largemouth bass in the pond.

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Table 1. Mean total lengths and weights of largemouth bass in Stiles Farm experimental pond, 1975-1976.

		Northern Largemouth Bass				Florida Largemouth Bass			
Date	Total Fish	Number	%Sample	Length(mm)	Weight(g)	Number	%Sample	Length(mm)	Weight(g)
May 1975[a]	200	100	50%	65	3.0	100	50%	51	2.6
Oct. 1975	9	7	77%	249	269	2	22%	202	167
Feb. 1976	18	12	67%	246	211	6	33%	215	124
May 1976	11	9	82%	274	291	2	18%	233	107
Sept. 1976*	25	8	33%	334	673	17	67%	292	360
Sept. 1976[b]	380	380	100%	60.7	2.9				

[a] At stocking
[b] Reproduction
*Rotenone and electrofishing

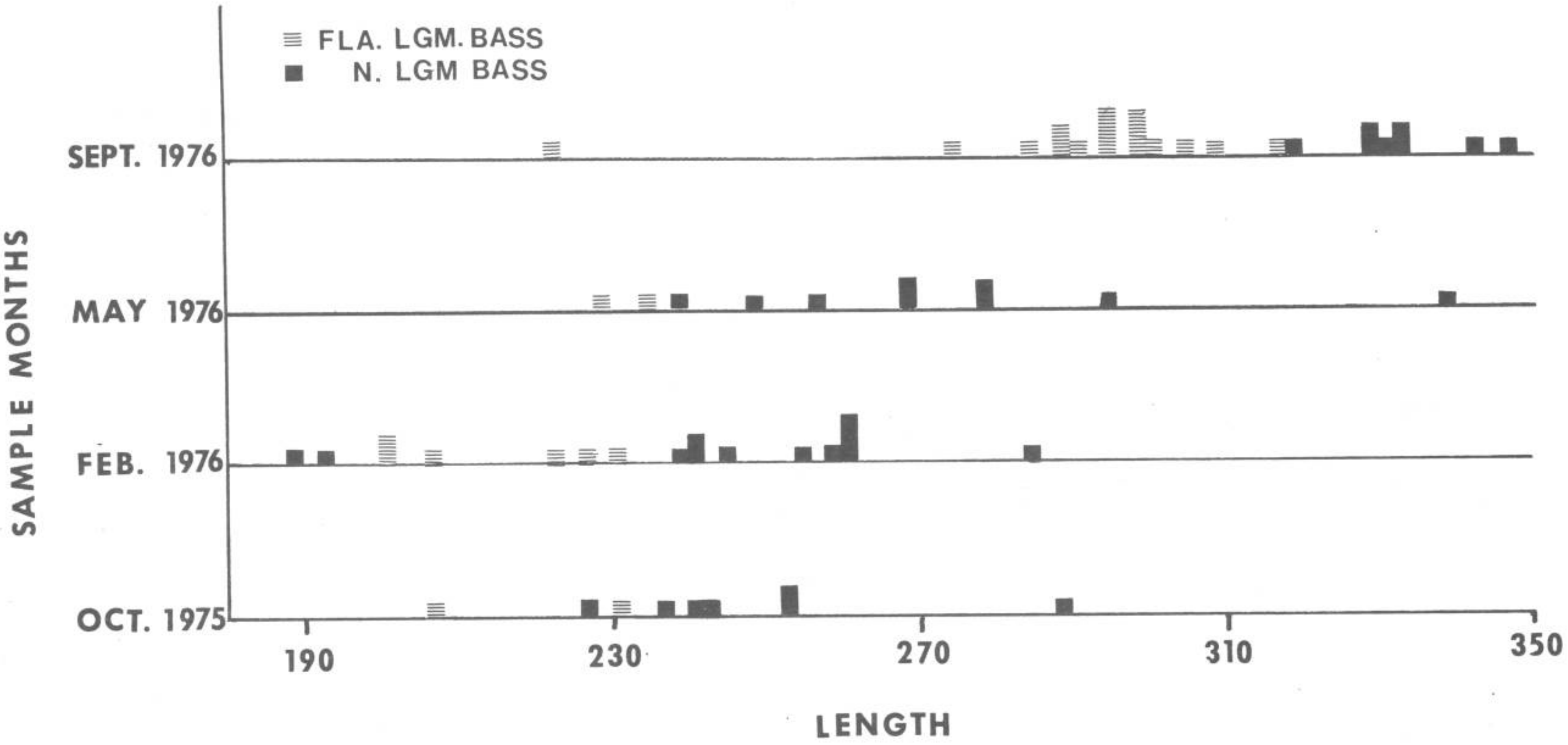

Figure 1. Length frequency of Florida and Northern largemouth bass (≣▌=one fish) at the four sample months.

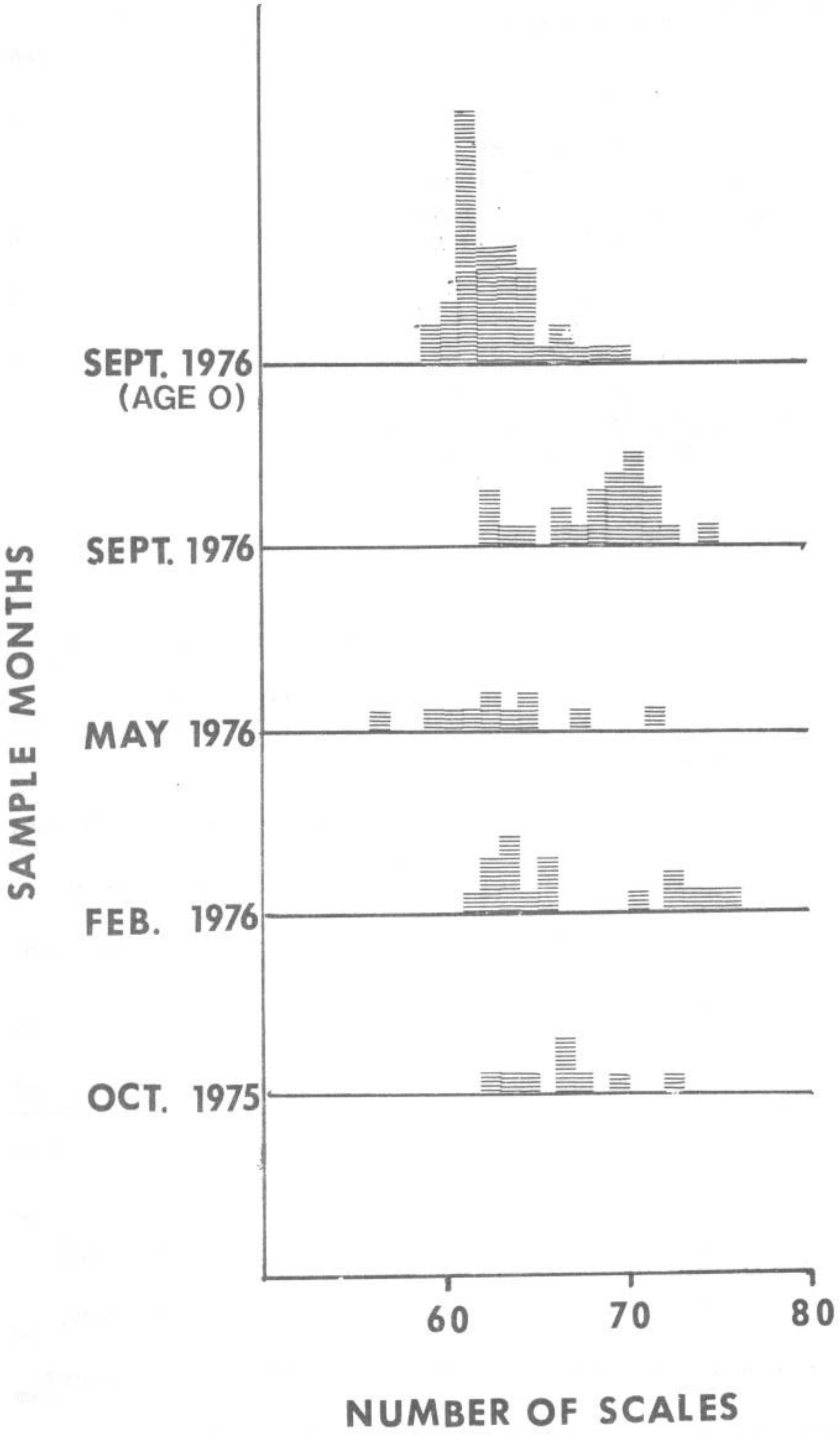

Figure 2. Lateral line scale counts of all age I and age 0 bass (≡ =one fish) at each sample month.

AN APPARATUS TO STUDY THE ENERGETICS OF SWIMMING FISHES

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ABSTRACT

A Blazka-type respirometer for swimming fishes was recently designed and constructed at the Port Aransas Marine Laboratory. Initial hydrodynamic tests indicated that flow velocity profiles within the respirometer swimming tunnel were approximately rectilinear at pertinent velocities, while macro-turbulence in the flow was effectively eliminated. Fish were easily induced to swim in the chamber. Preliminary metabolic determinations indicated that their oxygen consumption rates increased exponentially with swimming speed.

INTRODUCTION

The study of swimming in fishes is important from both biological and hydromechanical viewpoints (Webb, 1975). From a biological point of view, energy requirements for swimming have long elicited a considerable interest in applied and theoretical aspects of fisheries biology, ecology, and related disciplines.

A variety of types of swimming chambers have been used to study various aspects of swimming in fishes. Some authors have used rotating annular (toroid) chambers with transparent walls through which the fish visually orient to stationary markers outside the chamber, and hold their position against the rotation of the chamber (Fry, 1957; Wohlschlag, 1957; Bainbridge, 1958). Others have stimulated fish to swim around a circular track, either by training fish to follow a rotating pool of projected light (Pitcher _et al_., 1976) or by inducing them to swim against a flume of water pumped around the track (MacLeod, 1967; Hettler, 1978).

A disadvantage of the above methods is that the animal is compelled to swim in a circular path, while paths followed by swimming fishes are more often linear. Although the hydrodynamics of flow within toroid chambers is poorly known, such circular paths presumably cause the fish to swim in their own turbulence. To overcome this problem, an apparatus was devised by Blazka _et al_. (1960) in which water was pumped in a linear flow through a swimming tunnel in such a way that the fish remained stationary with respect to the observer. Modifications of the Blazka apparatus have been used by a number of investigators (Brett, 1964; Smit, 1965; Farmer and Beamish, 1969; Smith and Newcomb, 1970; Griffiths and Alderdice, 1972). In many of these studies, the water was recirculated and the rate of oxygen uptake from the water by the organism was measured.

There are some basic hydrodynamic problems inherent in all such swimming chambers, especially when the chamber is also used as a respirometer. The cross sectional area of the swimming tunnel should be at least ten times greater than the widest cross sectional area of the fish, in order to avoid blocking effects in the water flow through the swimming chamber (Webb, 1975), but small volume is also advantageous for sensitive oxygen uptake determinations. To simplify calculation of the mean swimming speed, it is desirable that the velocity profile of the water flow in the swimming tunnel be maintained as flat as possible. At the same time, the effect of turbulence in the flow needs to be minimized. In general, turbulent flow velocity profiles tend to be flat (rectilinear) while laminar flows tend to yield curved (parabolic) velocity profiles (Bell and Terhune, 1970). It is therefore necessary to devise a means of introducing micro-turbulence into the flow, so that a rectilinear flow profile is maintained without the presence of macro-turbulence which might unduly affect the swimming performance of the organism being studied.

In spite of problems such as those mentioned above, this type of apparatus, which is analagous to the treadmills used with terrestrial animals, has proved to be very useful in studies of the behavior or energetics of swimming fishes.

A Blazka-type respirometer incorporating some modifications from previous chambers of this type was recently designed by the junior author and constructed under his supervision at the University of Texas Marine Science Institute at Port Aransas. At present, this apparatus is being utilized in investigations involving fish energetics. Although some results from these investigations have already been reported elsewhere (Wohlschlag and Wakeman, 1978; Wakeman and Wohlschlag, 1978) this paper describes the respirometer in detail, and the initial tests which were conducted to determine the hydrodynamic capabilities of the apparatus and its suitability for the study of the respiratory metabolism of swimming fishes. The study was supported by the Texas Department of Water Resources.

RESPIROMETER DESCRIPTION

The apparatus (Figure 1) was a closed recirculating system containing 207 liters of water. The swimming tunnel portion consisted of a transparent acrylic cylinder, 63 cm in length, with an inside diameter of 19 cm. This cylinder was centered within a similar but larger cylinder with an inside diameter of 29 cm. Water was drawn through the inner cylinder by an impeller which was powered by a constant torque, 10 hp variable speed motor. A cone-and-dome device behind the impeller served to redirect the water flow back down the space between the inner and outer cylinders towards the front of the chamber where another cone-and-dome device returned it to the swimming tunnel.

Before entering the swimming tunnel, the water flow passed through two baffles set at 45° angle to each other. This baffle set and a 4 mm screen were positioned directly before the entrance into the swimming tunnel, and were designed to create linearized, microturbulent flow through the swimming chamber (Mar, 1959; Bell and Terhune, 1970). Another 4 mm screen at the posterior end of the swimming tunnel prevented fish from being sucked back into the impeller.

The entire apparatus was suspended from an overhead trolley in a temperature controlled aquarium. A shaft through a stuffing box in the aquarium wall connected the impeller to the motor. For addition or removal of fish, the portion of the apparatus forward from the rear cone-and-dome was detachable by means of leverage clamps and could be moved forward on the overhead trolley. Foam-neoprene gaskets provided sealing between these sections when the clamps were locked in place.

Access into the swimming area of the sealed respiratory chamber were available by means of two 30 mm diameter tubes positioned near the front and back ends of the swimming tunnel. Either of these access ports could be used for the purpose of withdrawing water samples from the chamber, or the insertion of a flow-meter into the chamber while the apparatus was in operation. During metabolic determinations, plugs in these access ports completely sealed the chamber.

During swimming experiments, a black plastic sheet was draped over the central area of the swimming tunnel, which was otherwise illuminated by a flood-light directed downwards from the overhead trolley. This served to provide a shadowed region in the center of swimming tunnel in which fish, because of their natural tendency to seek cover, were encouraged to swim.

MATERIALS AND METHODS

Two different visual methods were used to observe the degree of turbulence within the swimming tunnel. In the first, the water in the chamber was supersaturated with a fine stream of air bubbles from an airstone inserted through the rear access port while the impeller was turning. These bubbles were drawn through the rotating impeller and were distributed throughout the water in the chamber. Impeller speed was then varied from 40 to 400 rpm and the flow pattern of these bubbles at various speeds was visually observed. The second method used to observe flow turbulence involved the attachment of 20 evenly distributed strands of fine yellow sewing thread to the face of the forward screen (Blazka et al., 1960). Each of these strands was about 30 cm in length and extended about halfway back into the swimming tunnel. The orientation of these threads was observed in water flows with impeller speeds ranging from 100 to 400 rpm.

Direct velocity measurements of the water flow within the cylindrical swimming tunnel were made by means of a paddle-wheel speedometer inserted into the rear access port. Initial flow velocity determinations were made with the impeller rotation rate set at 150 rpm. The rotation rate was then increased in step-wise increments of 50 rpm, and the concurrent increase in flow velocity with each increase in impeller rotation rate was measured.

Velocity profiles across the vertical diameter of the swimming tunnel were determined by inserting the flow-meter to various levels within the the chamber. For each rmp setting, a total of 17 such flow velocity measurements were made at 1 cm intervals across the vertical axis of the tunnel. These velocity measurements were plotted diagrammatically to illustrate the velocity profile across the swimming tunnel. Velocity profiles were determined for temperatures of 12^{o} and 22^{o} at salinities of 30 and 10 ppt. An additional velocity profile was determined at 28^{o} at a salinity of 25 ppt.

Preliminary observations were required as to the ability of fish to orient themselves and swim in the chamber. For this purpose, ten spotted seatrout (*Cynoscion nebulosus*) and two sand seatrout (*Cynoscion arenarius*) were used. The behavior of these fishes, which ranged in body length from

16 to 28 cm, was observed at water flow velocities ranging from zero to about 90 cm sec^{-1}. Metabolic rates at various speeds were calculated from differences in oxygen tensions in water samples withdrawn from the chamber at the beginning and end of a period of continuous swimming at a given velocity. Oxygen tensions were determined using a Radiometer oxygen electrode.

RESULTS AND DISCUSSION

The flow pattern of the fine air bubbles in the supersaturated water was difficult to observe because it was somewhat obscured by the bubbles passing along the outside of the swimming tunnel in the opposite direction. Nevertheless, careful visual observations indicated linear flow along the length of the swimming tunnel at impeller speeds ranging from 50 to 400 rpm. The only exception to this observation was a small region of turbulence directly behind the forward screen where bubbles tended to swirl and were often trapped for a few moments. This region of turbulence, which was observed to extend for a distance of 4 - 5 cm from the forward screen in a region about 2 cm thick adjacent to the sides of the tunnel, was attributed to an interference in flow caused by the edges of the baffle set and the forward screen.

The streaming patterns of the fine sewing threads also indicated a linearized flow through the swimming tunnel with very little macroturbulence at impeller speeds ranging from 100 - 400 rpm. Each strand tended to stream directly back along the tunnel with very little side motion and no crossing over. The area of turbulence which had been observed at the forward end of the tunnel with the supersaturated water had little effect on the streaming patterns of the strands, adding further support to the assumption that this region of turbulence was restricted to a relatively small cross sectional area of the swimming tunnel.

Quantitative methods of flow visualization such as detecting changes in the refractive index of the fluid or using holographic laser techniques to delineate the flow were not available for this study, but the qualitative turbulence observations described above indicated that the baffles at the forward end of the swimming tunnel effectively eliminated macro-turbulence and adequately linearized the water flow through the tunnel.

Flow velocity profiles at various temperatures and salinities are shown in Figure 2. Velocity profiles were approximately rectilinear, particularly at impeller speeds less than 300 rpm (about 150 cm sec^{-1}). Velocities tended to be slightly higher in the lower half of the chamber, and to have somewhat flatter profiles in this region. This was considered to be due to increased turbulence in this region, caused by the flow meter itself as it was inserted deeper into the tunnel, or from the permanent effects induced by the non-streamlined access tubes.

At a given temperature, salinity variations seemed to have no significant effect on the flow velocities at various impeller rpm settings (Figure 2), but decreases in water temperature caused noticeable decreases in flow velocities at a given impeller rotation speed. This was probably due to the fact that water viscosity increases significantly with decreased tempeature, but is very little affected by changes in salinity (Sverdrup *et al.*, 1942).

Fishes which were observed in this study tended to avoid the edges of the tunnel and swam in the central area, positioning themselves so that their caudal fins were about 3 - 5 cm from the rear screen. For this reason, the flow velocity measurements were taken through the rear access port, and velocity at the center of the tunnel was used as the mean swimming speed.

For a given temperature, a linear relationship between water flow velocity (mean swimming speed) and impeller shaft rpm was apparent (Figure 3). Because such a relationship should logically pass through the origin, lines extending to the origin were visually fitted to the points in Figure 3 (a, b, c), yielding simple equations which could be used to express the relationship between water flow velocity (U) in cm sec^{-1} and impeller revolution speed (I) in rpm. These equations took the form; $U = bI$, where b is velocity-rpm coefficient for a given temperature. The value of the coefficient (b) increased linearly with water temperature (Figure 3 d), so values for b could be interpolated for various temperatures and used to convert direct measurements of impeller shaft rpm to mean swimming speeds without the necessity of inserting the flow-meter into the swimming chamber during experiments with fish.

As soon as water flow was initiated in the swimming tunnel, each fish was observed to orient itself against the flow of the water. However, after a few minutes of swimming, both spotted seatrout and sand seatrout tended to drift back in the swimming tunnel until their caudal fins touched the rear screen. In this position, these fishes usually began to rest with stiffened tails against the rear screen, thus avoiding swimming against the water flow. Such behavior was discouraged by inserting a piece of stiff wire through the rear access port and lightly touching the caudal peduncle of the fish. This stimulus caused the fish to move forward and position itself in the shadowed area in the center of the tunnel under the black plastic sheet that was draped over the outer cylinder of the chamber. After this procedure had been repeated a number of times (usually 10 - 20 times), the fish "learned" to avoid the rear screen, and tended to remain swimming steadily in the shadowed area.

A second method of avoiding swimming at the full velocity of the water flow was also observed in four of the spotted seatrout and in both of the sand seatrout. Each of these fish showed a tendency to move forward in the swimming tunnel until its nose touched the anterior screen. In this position a blocking effect (Webb, 1975) was apparently created, and it was visually obvious from the reduced tail-beat frequency that actual swimming velocity was less than the water velocity in the chamber as a whole. This behavior was discouraged by gently tapping the snout of the fish with a piece of stiff wire inserted through the forward access port. Upon being touched on the snout, the fish would drift back into the shadowed region of the tunnel and resume normal swimming behavior. It was usually necessary to repeat this procedure 10 - 20 times before the fish was "trained" to swim consistently in the shadowed region.

Metabolic rates of actively swimming fish increased exponentially with swimming velocity. A "typical" example (Figure 4) shows oxygen uptake rates of 220 g sand seatrout (total length, 28.4 cm) at rest and at intermediate swimming speeds. The exponential relationship between oxygen uptake rate and swimming speed agrees both with theoretical predictions for power required to overcome drag as a function of velocity

(Webb, 1975) and with published reports of the metabolic rate - swimming speed relationship in other species (Brett, 1964; Aleyev, 1977).

The results of these initial tests indicated that the hydrodynamic capabilities of this swimming respirometer made it an effective apparatus for the study of the swimming behavior, performance and energetics of many fishes. Large scale turbulence appeared to be adequately eliminated, and relatively flat velocity profiles were maintained at velocities within the sustained capabilities of most fishes of the size suitable for study in this apparatus.

The swimming tunnel had a cross-sectional area of 283.5 cm^2. Wake-blocking effects on the water flow from experimental animals within such a swimming tunnel are inconsequential if their widest cross-sectional area is less than 10% of the cross-sectional area of the tunnel (Webb, 1975). Thus, this chamber would accommodate a hypothetical fish of circular cross-sectional shape with a circumference of 19 cm at its widest girth. Since the cross-sectional shape of most fishes is more often elliptical, the girth of the typical fish used for study in this chamber could be somewhat greater than 19 cm without causing significant wake-blocking effects.

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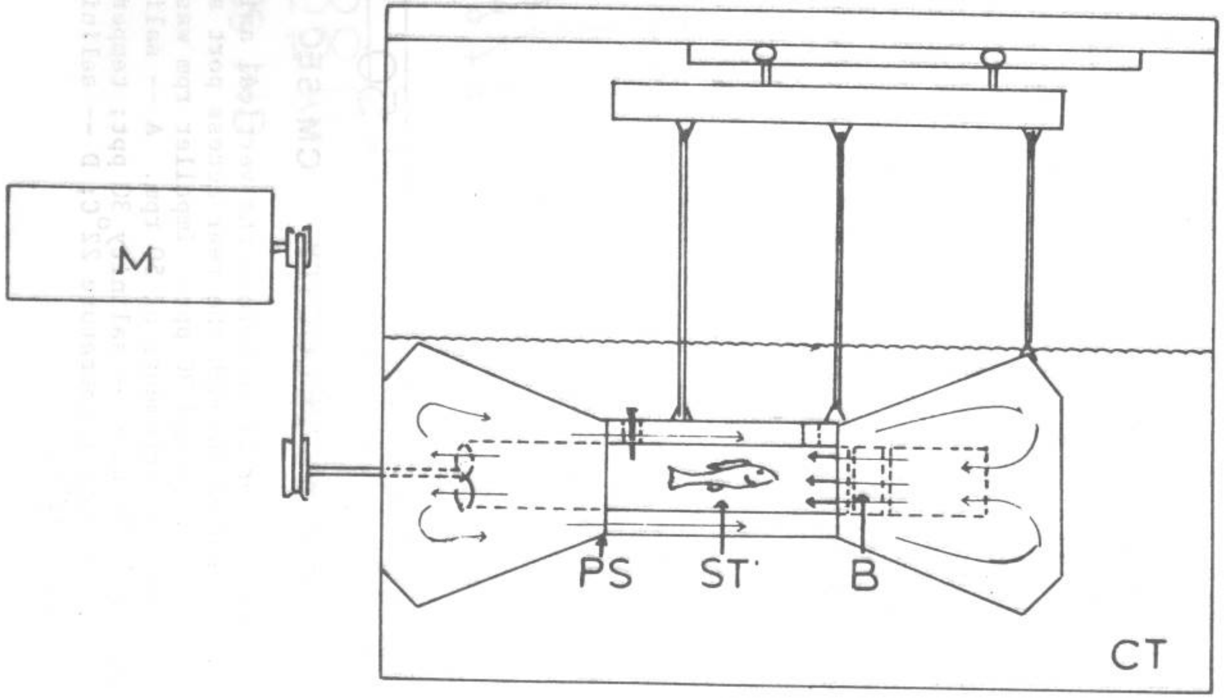

Figure 1. Diagram of the 207 l modified Blazka respirometer. M -- variable speed motor; B -- flow linearizing baffles; ST -- transparent acrylic swimming tunnel; PS -- posterior screen; CT -- constant temperature water bath (Adapted from Wakeman and Wohlschlag, 1978).

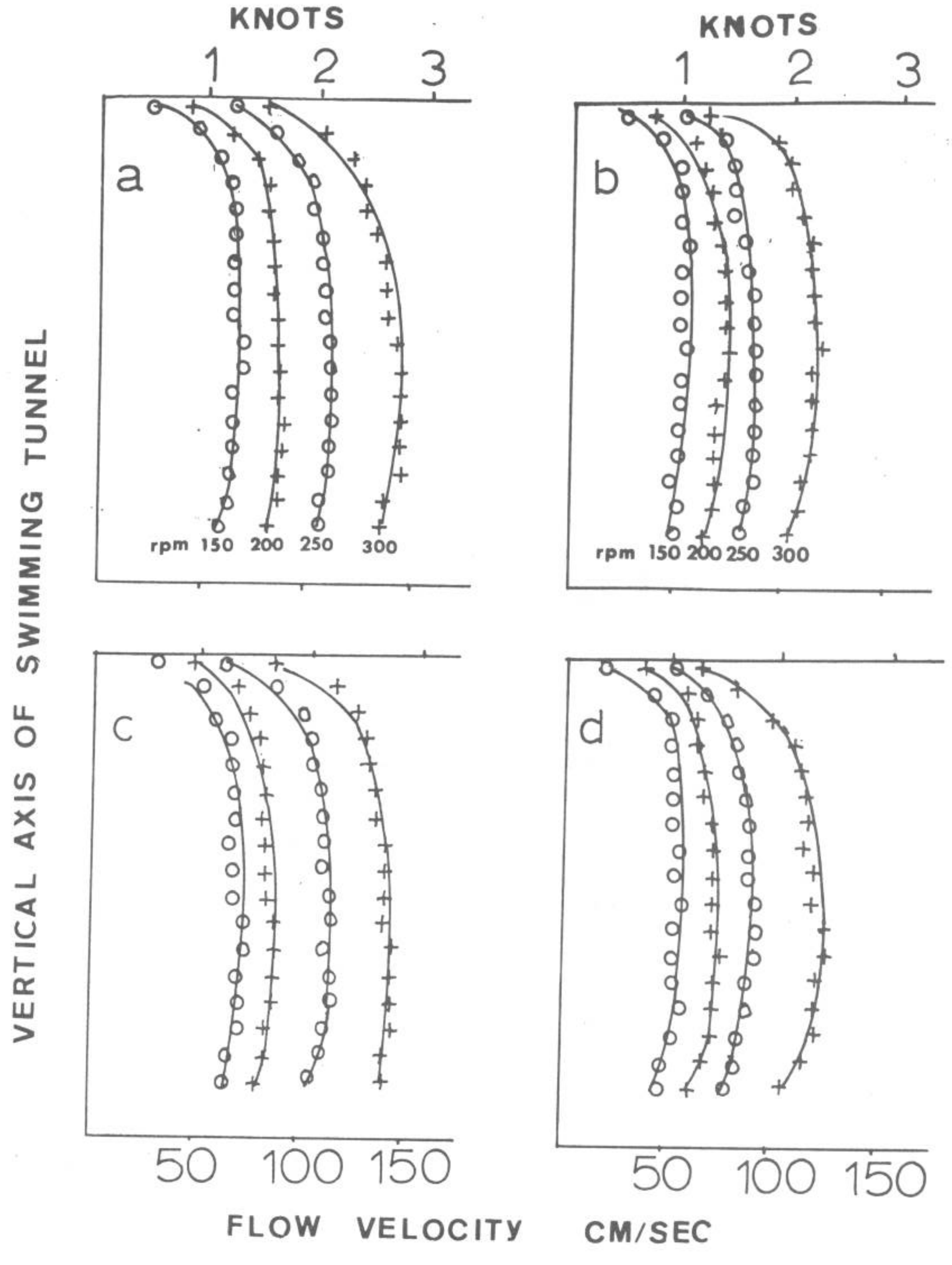

Figure 2. Flow velocity profiles across the vertical axis of the swimming tunnel measured through the rear access port at 12° and 22°C at salinities of 10 and 30 ppt. Impeller rpm was varied from 150 to 300 rpm in increments of 50 rpm. A -- salinity 30 ppt; temperature 22°C; B -- salinity 30 ppt; temperature 12°C; C -- salinity 10 ppt; temperature 22°C; D -- salinity 10 ppt; temperature 12°C.

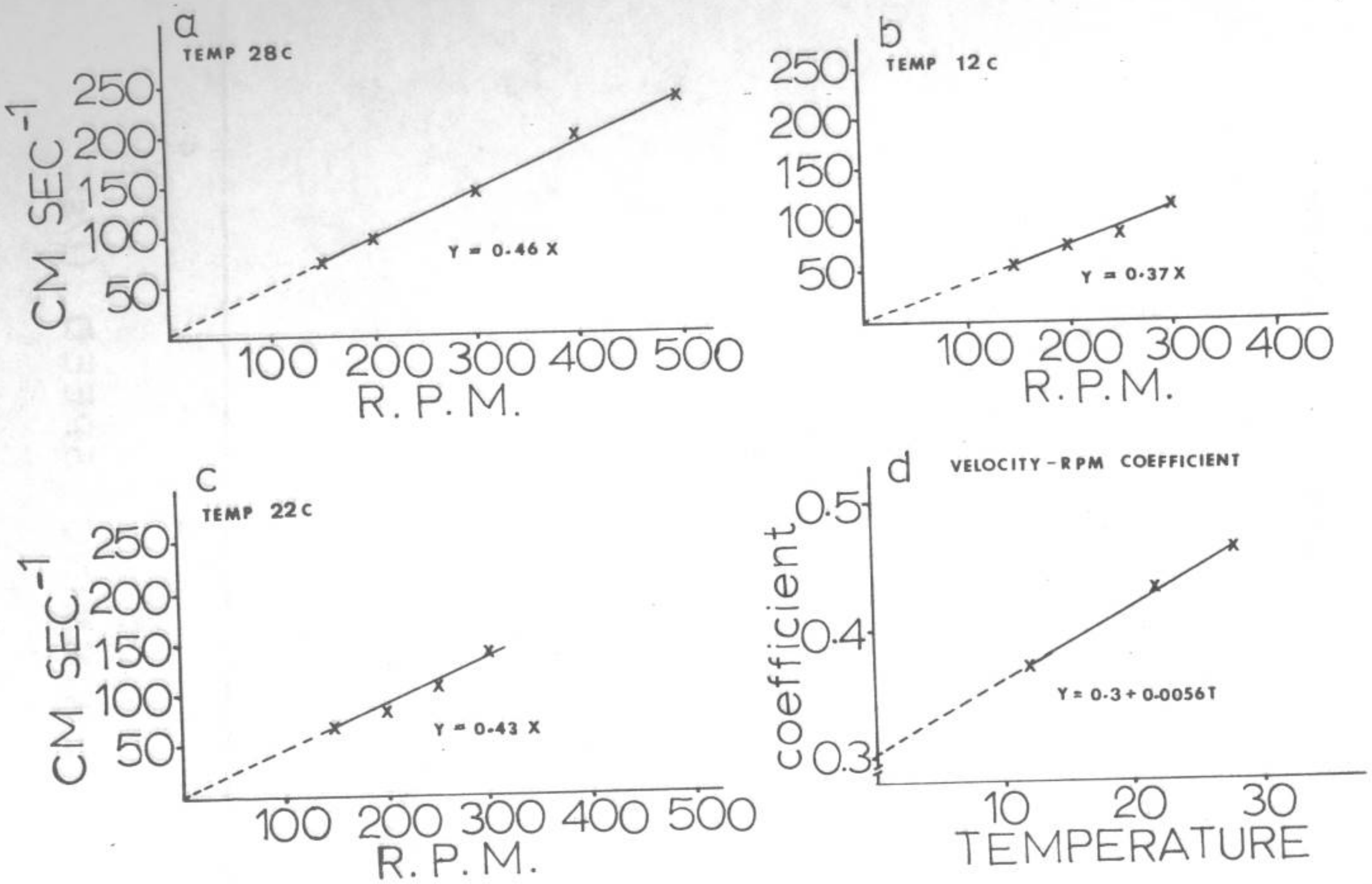

Figure 3. Plots showing linear relationship between mean swimming velocity (flow velocity at mid point across vertical axis of tunnel) and impeller rpm at various temperatures (plots A, B, and C). The relationship between temperature and the slops of plots A, B, and C is shown in plot D.

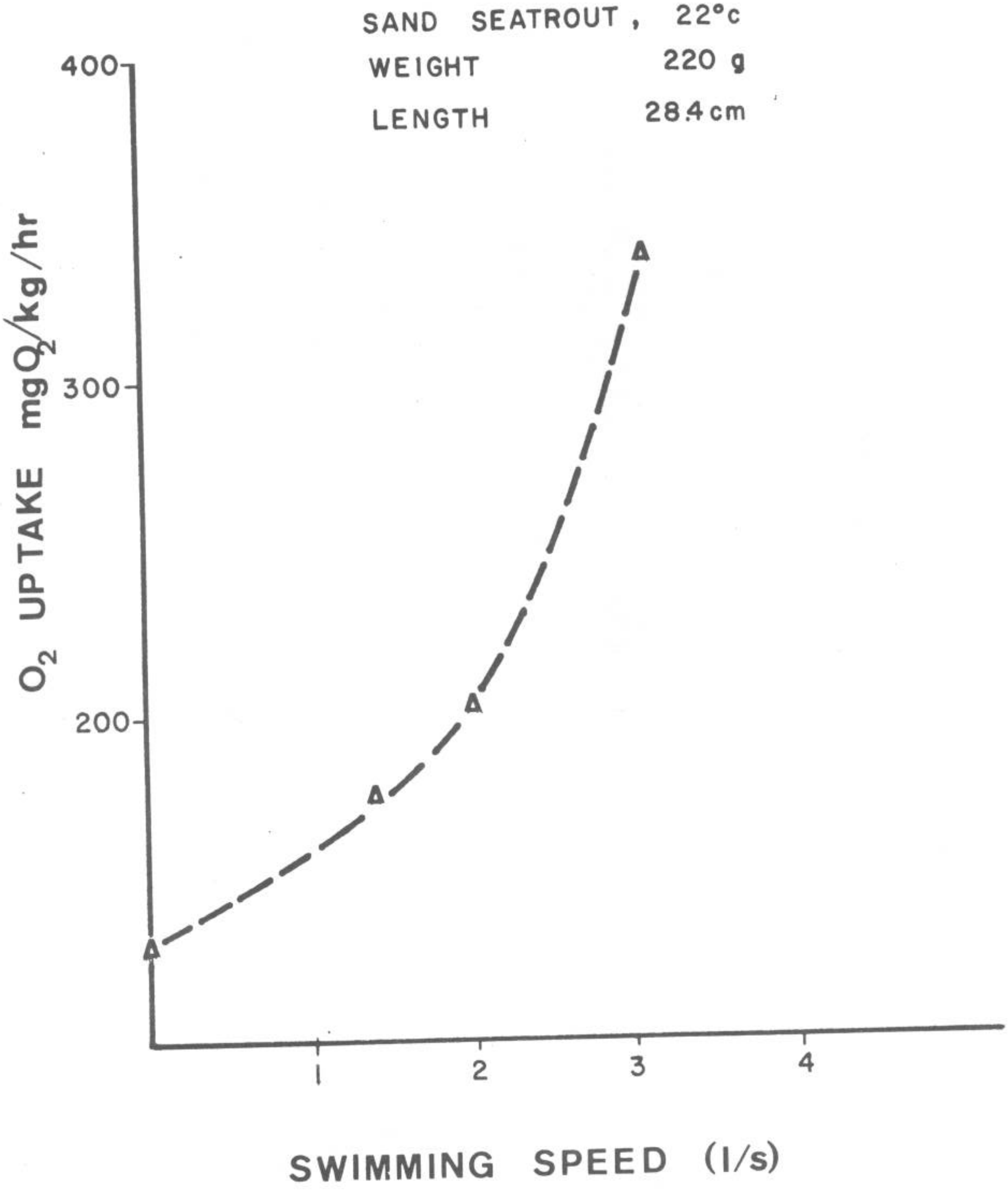

Figure 4. Metabolic rates of a 220 g sand seatrout at various swimming speeds at 22°C.

TEXAS CHAPTER

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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.

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