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GROWTH AND SURVIVAL OF *LEIOSTOMUS XANTHURUS* (SPOT) IN MAN-MADE AND NATURAL WETLANDS

Report to

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by

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

SUMMARY

Growth and survival of the benthic feeding fish *Leiostomus xanthurus* ("spot") was compared in man-made (Project Area 2) and natural oligohaline subtributaries of the Pamlico River Estuary. Experiments during 1984 defined a viable protocol for collecting and individually marking fish, and for employing enclosures to assess growth (increase in weight) and survival of the fish. Spot were collected by short (30 second) otter trawls, and individually marked by clipping all or part of specific fins. Growth and survival of spot in man-made and natural areas was compared by holding a predetermined number of fish for two weeks within circular enclosures placed in both areas.

Growth and survival of spot were similar in the Project Area and the natural creeks. These experiments imply that the Project Area is capable of functioning effectively as a nursery area for spot and other benthic predators with similar feeding habits.

INTRODUCTION

The overall goal of this research is to determine if man-made estuarine wetlands can play a role equivalent to that of natural wetlands within the estuarine ecosystem. Structural features of the faunal communities of man-made and natural marshes have been studied over time with the objectives of: (1) defining the faunal communities of natural and man-made wetlands; (2) determining the rate of development of the faunal community in man-made wetlands, and (3) identifying major factors controlling the rate of faunal community development in man-made wetlands. Structural features of the community consist of the distribution and abundance of the resident species, and their pattern of change over time.

Functional features of faunal communities are those relationships between members of the community (eg., competition and predation) which act collectively to influence species composition and relative abundance. A critical functional aspect of a man-made marsh is its ability to support commercially and recreationally important species of finfish and shell fish. The diverse diets typical of some of these species imply that man-made and natural estuarine wetlands may differ structurally, but not functionally. An understanding of both sets of features is needed in order to identify key factors governing wetland maturation, and to permit estimates to be made of the rate of convergence of the man-made and natural wetland communities.

This report compares growth and survival of the benthic feeding fish *Leiostomus xanthurus* ("spot") held within experimental enclosures in natural and man-made oligohaline creeks. Spot are among the most abundant benthic predators which recruit into the tributaries and subtributaries of the Pamlico River Estuary each spring (Ross and Epperly 1985; Rulifson 1985).

METHODS AND MATERIALS

Fish were contained within circular enclosures constructed of black plastic netting (Vexar; 6-mm bar mesh), supported on a frame of stainless steel and concrete reinforcing bar. Each enclosure was 120 cm high and covered with a vexar top. Enclosures of two different diameters (0.9 m and 1.8 m) were used in order to estimate the effect of the enclosure on fish growth and survival.

Five pairs of cages, each pair consisting of one large and one small cage, were placed in Project Area 2 and two natural creeks, Drinkwater Creek and Jacobs Creek (Figures 1,2). Sites within each location were selected at random, but were unavoidably subject to some bias owing to space limitations in Project Area 2, and the desire to maintain a minimal (about 25 m) distance between pairs of cages to eliminate the possibility of cage-pair influences on the physical and biological environment within a cage. The potential caging area within each location was divided into five zones. The actual position of each pair of cages was determined by randomly selecting a site within each of the five zones. In practice, cages resided within the shallow water area (40-80 cm deep) near the marsh surface. Each cage was shoved into the sediment to a depth of 20-30 cm to prevent the fish from escaping and to deter entry into the cage by unwanted predators.

The first growth experiment was started during June 25-28, 1984. Spot were collected with a 30-ft 1/4 -inch mesh seine and held in a 30-gallon insulated cooler. Each fish was measured (total length), weighed, and individually marked by attaching a single colored bead to the fish near the base of its dorsal fin. The bead was attached to the fish by first tying the bead to a length of four pound test nylon monofilament, threading the monofilament onto a beading needle, and passing the monofilament through the body of the fish just below the dorsal fin until the bead laid snugly against the body of the fish. A short length of 0.004-inch diameter tubular metal leader was threaded over the monofilament on the side of the fish opposite the bead, and crimped tightly around the monofilament with wire cutters. The crimped piece of metal tubing

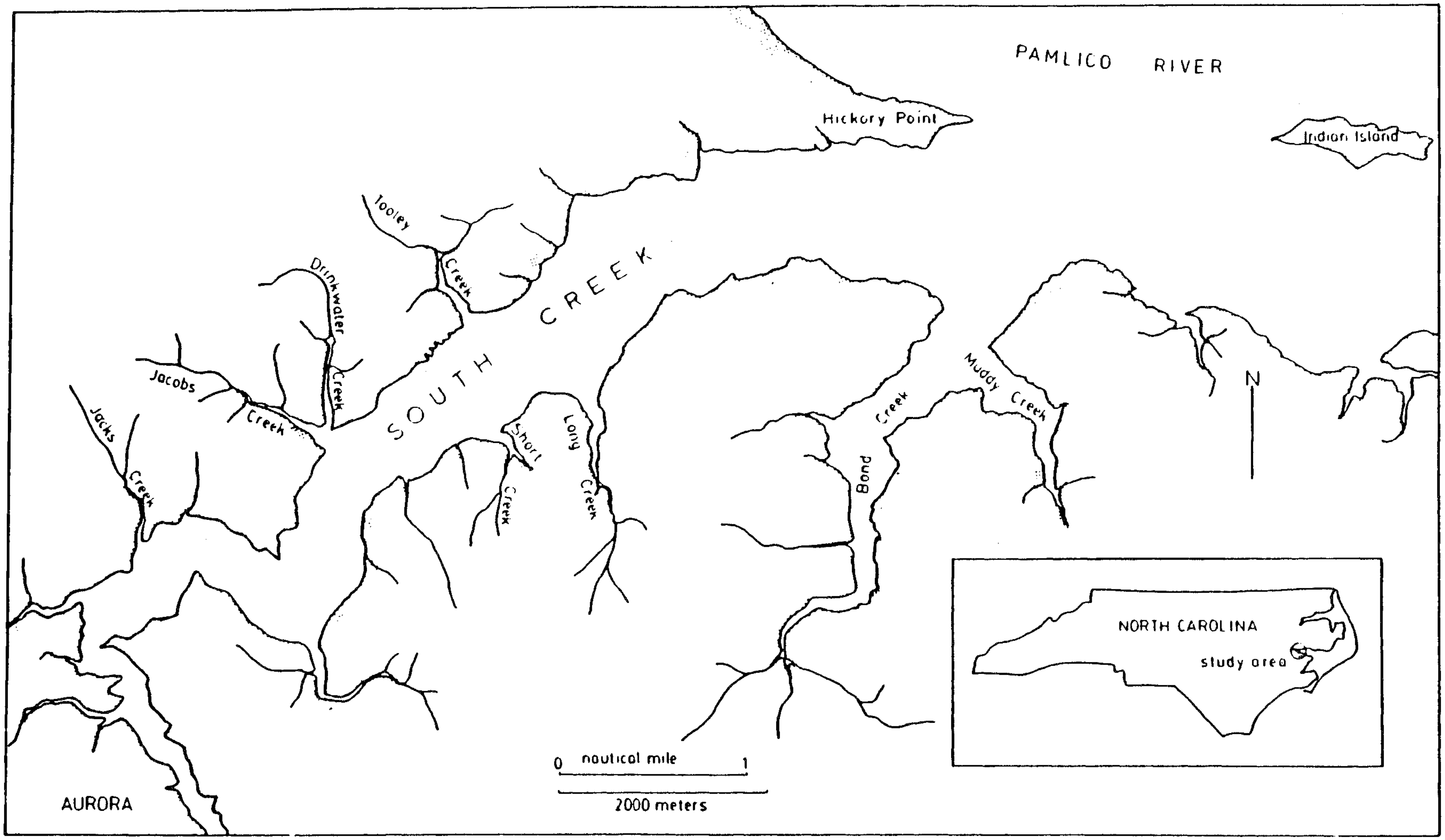

Figure 1. Location of the natural creeks used in the study. The man-made area (Project Area 2) is not shown, but opens into Drinkwater Creek near the junction of Drinkwater Creek and Jacobs Creek.

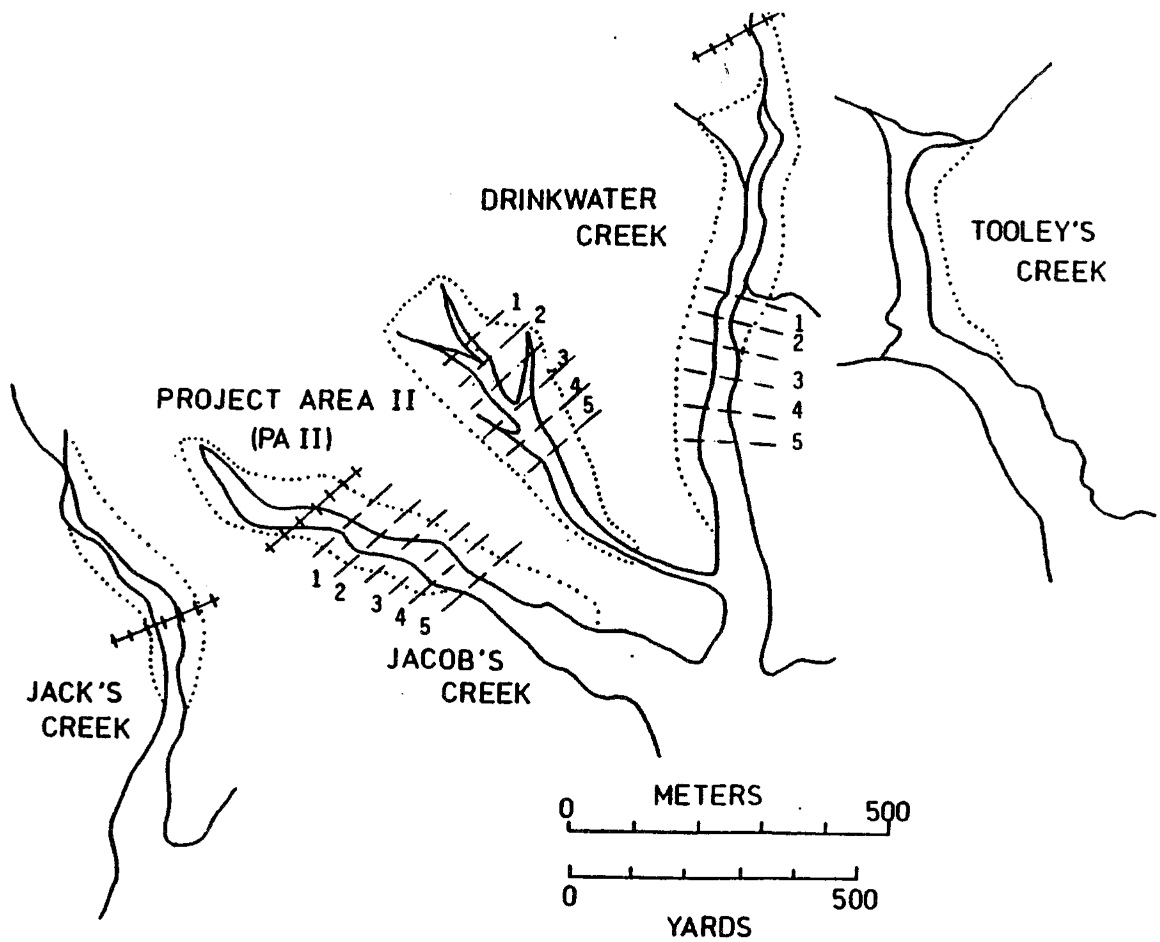

Figure 2. Placement areas for the enclosures used in the spot (*Leiostomus xanthurus*) growth and survival experiments.

served to prevent the monofilament from being pulled through the body of the fish. Fish could be identified by the color of the attached bead.

In the second and third experiments in 1984, fish were collected using an otter trawl, and held overnight in 0.9 m enclosures. Fish were individually marked by clipping single fins, or by clipping discrete sections of single fins (Figure 3). In 1985, total lengths were not taken, and fish growth was determined by just the gain in weight.

The cages were first seined to remove fish captured inadvertently during their installation. Eight fish were then added to each large cage, and two fish were added to each small cage. The cages were censused by seining fourteen days later. Survivors were placed in 10% formalin, and were later measured (total length) and weighed in the lab.

One way analyses of variance (ANOVA) were done to test the effect of cage size on fish growth and survival within each creek. The survival ANOVAs were done on arc sine transformations of the percent survival data.

Nested one-way analyses of variance were done to compare growth of fish in the natural and man-made creeks. The nested ANOVAs were confined to the data pertaining to the large cages. Data from the small cages were excluded because any mortality in these cages precluded an estimate of variance. Survival of fish in man-made and natural areas was compared by a one-way ANOVA. Analyses were also limited to data pertaining to the large cages in order to be consistent with the comparisons of growth.

RESULTS

Survival of fish held in large cages was low during the first growth experiment, ranging from 0-50% in Drinkwater Creek and Project Area 2, and 0-62.5% in Jacobs Creek (Table 1). Nevertheless, these results are comparable to those obtained using unmarked fish during a set of pilot studies in 1983 on growth and survival of caged spot. (NCPC SEIR).

Survival in the small cages was more erratic than in the large cages. Fish were recovered from three of the five large cages, but from only one of the five small cages, in both Drinkwater and Jacob's Creeks. Surviving fish were found in a single large and small cage in Project Area 2 (Table 1).

As a result of the low survival obtained from fish marked with beads, an experiment was done to evaluate the effects of an alternative marking method--fin clipping-- on growth and survival of spot. An otter trawl was employed to collect the spot used in this experiment because repeated seining failed to yield enough fish. The effect of trawling on spot survival was estimated by examining trawl-collected spot held in 10 gallon aquaria in the laboratory at 24 and 72 hour intervals (Table 2). The fish were fed immediately after being placed in the aquarium. Mortality within the aquaria was substantial, varying from 75% (3 of 4 fish) to 25% (1/4). However, all mortality occurred within the first 24 hours after capture. These results indicated that the otter trawl could be employed to collect spot for the growth experiments, provided that the fish were first held for 24 hours prior to use.

In marking the experiment, two sets (A and B) of five large cages were placed at 75-m intervals along the length of the lower half of Jacobs Creek. Each "A" cage contained four clipped fish and four unclipped fish. Each of these fish had been measured and weighed; thus, the unclipped fish served as a marking control for the clipped fish. Each "B" cage also contained four clipped fish and four unclipped fish; however, only the clipped fish had been measured and weighed. Hence the unclipped fish in cage B served as a control for handling stress. An "A" cage and a "B" cage was censused at 1, 3, 6, 9, and 12 days after the beginning of the experiment. The order in which fish were added to cages, and the order in which the cages were censused, was random.

Survival was high among fish in all three experimental treatments (marked, unmarked, unhandled) (Table 3), and unrelated to residence time within the cages. Only marked fish

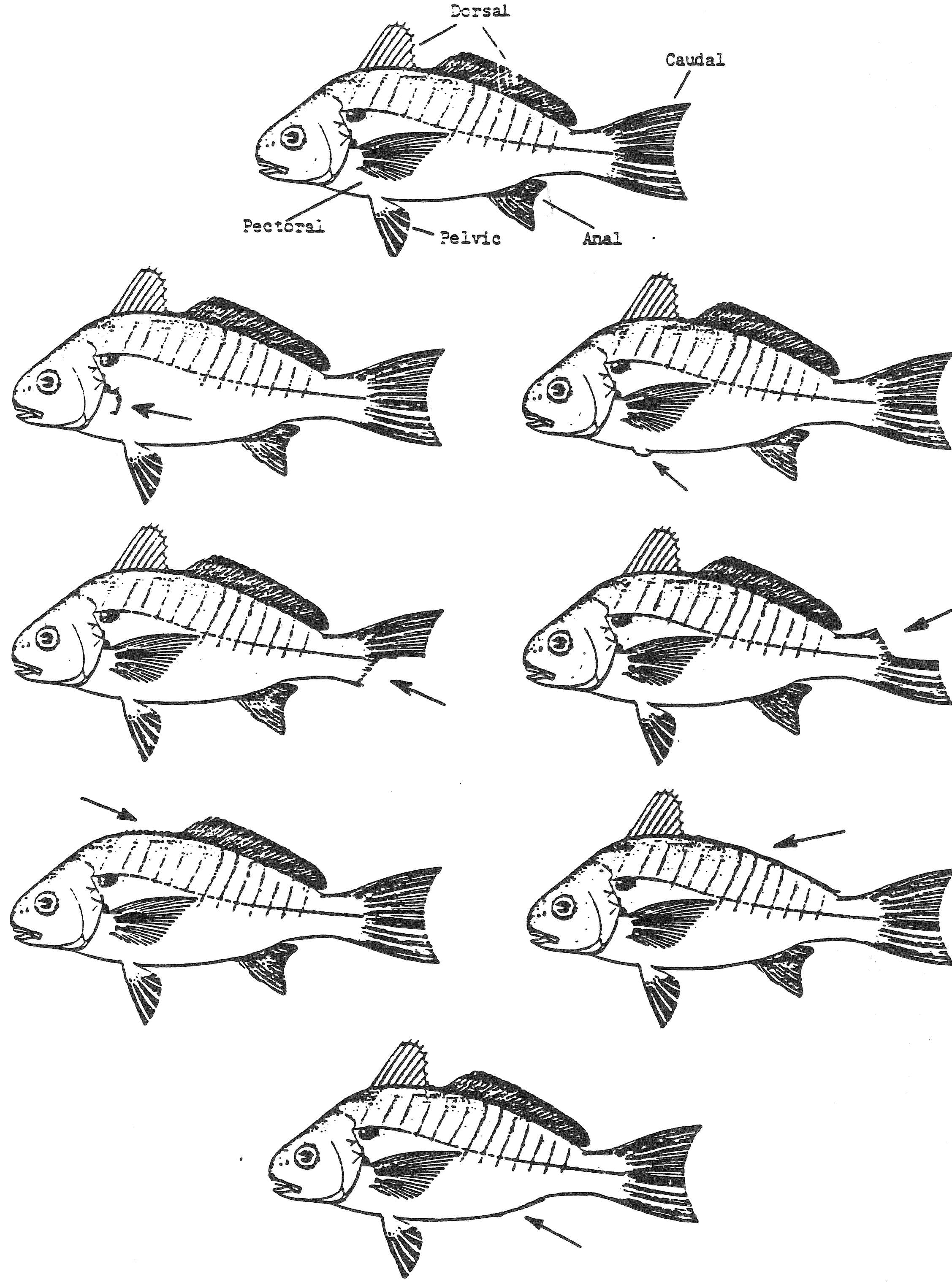

Figure 3. Fin clipping scheme used to identify individual spot (L. xanthurus) placed within the experimental enclosures. The arrows point to the clipped region of the fin.

TABLE 1. Survival of caged spot (*Leiostomus xanthurus*) in Drinkwater Creek (DW), Jacob's Creek (JB), and Project Area 2 (PA 2) during 25 June - 10 July, 1984. The cages with the lowest roman numeral values were placed farthest upstream.

Location	Cage No.	Cage Diameter (meters)	Duration of Experiment	Survival
DW	I-L	1.8	14 Days	12.5% (1/8)
	I-S	0.9	14 Days	100% (2/2)
	II-L	1.8	14 Days	50% (4/8)
	II-S	0.9	14 Days	0% (0/2)
	III-L	1.8	14 Days	0% (0/8)
	III-S	0.9	14 Days	0% (0/2)
	IV-L	1.8	14 Days	0% (0/8)
	IV-S	0.9	14 Days	0% (0/2)
	V-L	1.8	14 Days	(3/8)
	V-S	0.9	14 Days	0% (0/2)
JB	I-L	1.8	14 Days	62.5% (5/8)
	I-S	0.9	14 Days	50% (1/2)
	II-L	1.8	14 Days	0% (0/8)
	II-S	0.9	14 Days	0% (0/2)
	III-L	1.8	14 Days	0% (0/8)
	III-S	0.9	14 Days	0% (0/2)
	IV-L	1.8	14 Days	12.5% (1/8)
	IV-S	0.9	14 Days	0% (0/2)
	V-L	1.8	14 Days	25% (2/8)
	V-S	0.9	14 Days	0% (0/2)

TABLE 1 (Cont.). Survival of caged spot (*Leiostomus xanthurus*) in Drinkwater Creek (DW), Jacob's Creek (JB), and Project Area 2 (PA 2) during 25 June - 10 July, 1984. The cages with the lowest roman numeral values were placed farthest upstream.

Location	Cage No.	Cage Diameter (meters)	Duration of Experiment	Survival
PA 2	I-L	1.8	14 Days	25% (2/8)
	I-S	0.9	14 Days	50% (1/8)
	II-L	1.8	14 Days	0% (0/8)
	II-S	0.9	14 Days	0% (0/2)
	III-L	1.8	14 Days	0% (0/8)
	III-S	0.9	14 Days	0% (0/2)
	IV-L	1.8	14 Days	0% (0/8)
	IV-S	0.9	14 Days	0% (0/2)
	V-L	1.8	14 Days	0% (0/8)
	V-S	0.9	14 Days	0% (0/2)

TABLE 2. Short-term survival of spot *(Leiostomus xanthurus)* collected with a modified otter trawl.

Duration of Experiment	Aquarium 1	Aquarium 2	Aquarium 3
24 hrs.	25% (1/4)	50% (2/4)	75% (3/4)
72 hrs.	25% (1/4)	50% (2/4)	75% (3/4)

showed any mortality; thus stress associated only with measuring and weighing the fish was not sufficient to lower survival.

The temporal pattern of growth in length and weight was similar among all three treatments. No net positive increase occurred in both length and weight until Days 9 and 12, when both parameters increased sharply (Tables 4-6). Prior to day 9, weight loss and reduction in total length were common in all treatments. The peculiar delay in the onset of growth cannot be attributed to fin clipping, since both marked and unmarked fish showed similar growth patterns. Some acclimation to the cage environment may be necessary before normal growth is resumed. Reductions in total length are probably the result of limited precision in the original measurements and to interactions with resident fish while in the cage. Several of the censused fish clearly had been bitten on the caudal fin during the growth period, and in one case, the caudal fin was completely missing. Thus, the negative changes in length are probably more artifactual than real. The negative weight changes are also probably an artifact since the precision of the scale used (+0.1 gram) is comparable to the weight losses recorded. After 12 days, virtually all of the clipped fins had completely regenerated. However, regenerated fins could still be distinguished from natural fins owing to the presence of deformed fin rays in the regenerated fins. There was no apparent relationship between which fin was removed, and the subsequent incremental weight change, among fish held for 6, 9, and 12 days (Table 7).

The design of the marking experiment restricted the flexibility for statistical analyses, especially for comparisons between marked and unmarked groups of fish. Because members of the unmarked group could not be identified individually at the beginning and end of the experiment, comparisons of growth between unmarked and marked groups relied upon comparison of the mean sizes of both groups before and after the experiment. In this case, the sensitivity of the statistical analyses is dependent upon the similarity of the initial mean values and their corresponding variance. Thus, an analysis of variance failed to reveal significant differences in the initial and final mean lengths among the marked fish in Cage A, the unmarked fish in Cage A, and the marked fish in Cage B after nine days of growth (Table 8) in spite of the fact that the difference between the initial and final length of fish in Cage B was one-fourth that of the marked and unmarked fish in Cage A (Tables 4-6). Initial mean lengths and weights were not significantly different among all three groups of fish held for 12 days, but differences in both final length and weight were highly significant (Table 9). In this case, the analysis of variance corroborated the large gain in mean length and weight of the unmarked fish in Cage A relative to that of the marked fish in Cages A and B (Tables 4-6). If the growth data from the marked fish at 9 and 12 days are used to estimate their growth over a 30-day period, these projected values compare well with the increases in the mean length and weight of spot collected monthly in nearby creeks during 1983 (Table 10).

The second growth experiment in 1984 was initiated during August 28-30. Two problems were encountered with this experiment. First, spot were scarce and four days of repeated trawling produced sufficient numbers of healthy fish for only three out of a possible five replicates at each locality. Second, the approach of hurricane Dianna forced a premature census of the cages. Given these circumstances, the data from this experiment have not been included in this report. (see Rulifson and West 1985 for a description of these data).

Growth and survival experiments were carried out during May and July 1985. Weight gain was substantial in both experiments compared to the previous year (Table 11) (Figures 4,5). The effect of cage size on growth was significant in Jacobs Creek during the May experiment, and in Drinkwater Creek during the July experiment (Tables 12,13). However, the cage effects were not consistent among the two experiments; mean weight gain was significantly greater in the small cages in Jacobs Creek, but significantly less in the small cages in Drinkwater Creek. Survival was not affected by cage size in either experiment (Tables 14,15).

Growth and survival of caged spot were similar in the natural and man-made creeks (Tables 16,17). Significant variations in growth were limited to within creek (among cages) occurrences (Table 16).

TABLE 3. Effect of marking and handling on survival of caged spot (*Leiostomus xanthurus*) during 7-19 August, 1984. Fin clipping was used to individually mark fish in each pair of cages (A and B). Unmarked fish were not fin clipped, but were handled (i.e. weighed and measured) like marked fish. Unhandled fish were neither marked nor weighed or measured. The pair of cages with the lowest roman numeral value was located farthest upstream.

		SURVIVAL			
	DURATION OF	CAGE A		CAGE B	
CAGE #	EXPERIMENT	MARKED	UNMARKED	MARKED	UNHANDLED
II	1 DAY	100% (4/4)	100% (4/4)	100% (4/4)	100% (4/4)
IV	3 DAYS	100% (4/4)	100% (4/4)	75% (3/4)	100% (4/4)
V	6 DAYS	100% (4/4)	100% (4/4)	100% (4/4)	100% (4/4)
III	9 DAYS	75% (3/4)	100% (4/4)	75% (3/4)	100% (4/4)
I	12 DAYS	100% (4/4)	100% (4/4)	100% (4/4)	100% (4/4)

TABLE 4. Effect of marking and handling on the growth of caged spot (*Leiostomus xanthurus*) during 7-19 August, 1984. Fin clipping was used to individually mark fish. The mean (x) and standard deviation (s) are derived from the initial and final measurements of those fish (n) surviving the experiment. All data pertain to marked fish placed in Cage A of each cage pair.

MARKED: CAGE A

DURATION OF EXPERIMENT

	1 DAY			3 DAYS			6 DAYS			9 DAYS			12 DAYS		
	x	s	n	x	s	n	x	s	n	x	s	n	x	s	n
LENGTH															
INITIAL	74.3	13.8	4	74.3	7.5	4	68.3	4.3	4	73.3	1.2	3	63.8	2.5	4
FINAL	74.3	14.5	4	74.3	9.3	4	66.8	5.4	4	77.7	0.6	3	65.8	4.5	4
CHANGE	0.0			0.0			-1.5			+4.4			+2.0		
WEIGHT															
INITIAL	6.1	4.1	4	5.8	2.6	4	3.9	0.9	4	4.9	0.4	3	3.1	0.5	4
FINAL	6.0	4.0	4	5.9	2.6	4	3.8	0.7	4	5.7	0.1	3	4.1	0.5	4
CHANGE	-0.1			+0.1			-0.1			+0.8			+1.0		

TABLE 5. Effect of marking and handling on the growth of caged spot (*Leiostomus xanthurus*) during 7-19 August, 1984. Unmarked fish were not fin clipped, but were handled (i.e., weighed and measured) like marked fish. The mean (x) and standard deviation (s) are derived from the initial and final measurements of those fish (n) surviving the experiment. All data pertain to fish placed in Cage A of each cage pair.

UNMARKED: CAGE A

	DURATION OF EXPERIMENT														
	1 DAY			3 DAYS			6 DAYS			9 DAYS			12 DAYS		
	x	s	n	x	s	n	x	s	n	x	s	n	x	s	n
LENGTH															
INITIAL	70.5	7.9	4	70.5	2.9	4	66.0	4.7	4	68.8	3.0	4	72.8	9.5	4
FINAL	69.5	8.4	4	69.0	2.2	4	65.3	4.2	4	74.5	5.9	4	78.9	7.4	4
CHANGE	-1.0			-1.5			-0.8			+5.7			+6.1		
WEIGHT															
INITIAL	4.3	1.6	4	4.3	0.6	4	3.4	0.6	4	3.8	0.5	4	5.0	2.1	4
FINAL	4.3	1.8	4	4.1	0.5	4	3.6	0.5	4	4.9	1.3	4	6.8	2.3	4
CHANGE	0.0			-0.2			+0.2			+1.1			+2.8		

TABLE 6. Effect of marking and handling on the growth of caged spot (*Leiostomus xanthurus*) during 7-19 August, 1984. Fin clipping was used to individually mark fish. The mean (x) and standard deviation (s) are derived from the initial and final measurement of those fish (n) surviving the experiment. All data pertain to marked fish placed in Cage B of each cage pair.

MARKED: CAGE B

DURATION OF EXPERIMENT

	1 DAY			3 DAYS			6 DAYS			9 DAYS			12 DAYS		
	x	s	n	x	s	n	x	s	n	x	s	n	x	s	n
LENGTH															
INITIAL	70.8	8.6	4	75.3	0.6	3	73.8	10.0	4	72.0	6.6	3	71.0	4.5	4
FINAL	69.8	7.9	4	73.0	1.0	3	72.3	9.3	4	73.0	6.6	3	71.8	5.1	4
CHANGE	-1.0			-2.3			-1.5			+1.0			+0.8		
WEIGHT															
INITIAL	4.4	1.7	4	5.2	0.4	3	5.0	1.9	4	4.5	1.2	3	4.1	1.1	4
FINAL	4.3	1.6	4	5.0	0.3	3	5.0	1.9	4	4.9	1.4	3	5.0	1.0	4
CHANGE	-0.1			-0.2			0.0			+0.4			+0.9		

TABLE 7. Weight increment of caged spot (*Leiostomus xanthurus*) according to fin clipped.

DURATION OF EXPERIMENT	CAGE	FIN CLIPPED DORSAL	PELVIC	ANAL	CAUDAL
6 Days	A	0.2	0.1	0.1	-0.05
	B	0.1	-0.2	0.1	0.0
9 Days	A	0.8	-	0.5	1.1
	B	-	0.1	0.5	0.6
12 Days	A	0.3	1.0	2.0	1.0
	B	1.7	0.2	0.7	1.1

TABLE 8. Effect of fin clipping on the growth of caged spot (*Leiostomus xanthurus*). An analysis of variance was due to test for differences in length and weight among clipped and unclipped fish, before (0 days) and after 9 days of growth. ns = not significant.

Time	Growth Parameter	Analysis of Variance: Source of Variation	df	MS	F
0 Days	Length	Among Groups	2	30.3	1.8 ns
		Within Groups	7	16.4	
		Total	9		
		0.10 < P < 0.25			
9 Days	Length	Among Groups	2	17.7	0.66 ns
		Within Groups	7	27.1	
		Total	9		
		0.50 < P < 0.75			
0 Days	Weight	Among Groups	2	1.23	2.30 ns
		Within Groups	7	0.53	
		Total	9		
		0.10 < P < 0.25			
9 Days	Weight	Among Groups	2	0.75	0.58 ns
		Within Groups	7	1.33	
		Total	9		
		0.50 < P < 0.75			

TABLE 9. Effect of fin clipping on the growth of caged spot (*Leiostomus xanthurus*). An analysis of variance was done to test for differences in length and weight among clipped and unclipped fish before (0 days) and after 12 days of growth. ns = not significant; * = statistically significant.

Time	Growth Paramater	Analysis of Variance			
		Source of Variation	df	MS	F
0 Days	Length	Among Groups	2	94.6	2.9 ns
		Within Groups	11	32.6	
		Total	13		
			0.10 < P < 0.25		
12 Days	Length	Among Groups	2	169.3	6.2 *
		Within Groups	11	27.5	
		Total	13		
			0.01 < P < 0.025		
0 Days	Weight	Among Groups	2	3.3	2.0 ns
		Within Groups	11	1.7	
		Total	13		
			0.10 < P < 0.25		
12 Days	Weight	Among Groups	2	7.4	4.2 *
		Within Groups	11	1.8	
		Total	13		
			0.025 < P < 0.05		

TABLE 10. Mean length and weight of spot (*Leiostomus xanthurus*) collected monthly in Bond, Long, and Short Creeks during March - October, 1983 (West, unpublished data).

Date of Collection	Length (mm) x	s	n	Change in Length	Weight (gm) x	s	n	Change in Weight
3-23	28.1	4.0	38	-	0.26	0.12	38	-
4-26	37.1	13.4	125	+9.0	0.95	3.09	125	+0.69
5-21	44.5	7.2	125	+7.4	1.23	1.80	125	+0.28
6-15	54.9	20.4	125	+10.4	3.59	9.36	125	+1.96
7-15	66.0	16.9	122	+11.1	4.79	6.81	122	+1.20
8-19	73.9	11.7	73	+7.9	6.86	10.77	73	+2.07
9-25	89.4	10.6	75	+5.5	9.89	3.98	75	+3.98
10-28	98.8	8.3	49	+9.4	12.29	3.21	49	+2.40

DISCUSSION

Work during 1984 served to establish a viable protocol for the growth experiments. Marking individual fish using beads attached by monofilament was not particularly effective. Many of the fish lost their markers, and the marking device probably contributed to mortality by acting to maintain an open wound, or by causing additional injury as it worked itself out of the fish. Fin clipping was quicker, easier, and resulted in better growth and survival. It was also clear that the handling involved in obtaining the length and weight of the fish constituted a significant stress. The superior growth performance obtained in the 1985 experiments may in part be explained by the fact that handling of the fish was kept to a minimum by weighing the fish in water, and by not attempting to obtain length measurements.

The purpose of using cages of unequal size was to control for the effect of the cage itself on the outcome of the growth experiment. The presence of an enclosure alters the physical environment by reducing current flow and by trapping sediment (Virnstein 1978). The cage can also act as an attachment site for fouling organisms, and as a refuge for small crustacean predators (Peterson 1979). The enclosure could therefore influence the growth and survival of fish by its potential impact on benthic food sources, development of alternative food sources (i.e., the fouling community), and alteration of the physical environment within the cage.

The magnitude of the cage effect should be proportional to some aspect of its size (e.g. bottom surface area enclosed; surface area of the cage, volume of the cage). The four-fold difference in the initial fish densities between the small and large cages was therefore a function of the four-fold difference in the bottom surface area enclosed by two sizes of cages. The absence of a consistent quantitative relationship between cage size and the growth and survival of the resident fish argues against a strong cage effect.

Both of the 1985 experiments demonstrated that growth and survival of spot was similar in the natural and man-made creeks. Hence the Project Area appears capable of functioning effectively as a nursery area for predatory finfish like *L. xanthurus*. The higher average weight increase observed in all areas during May could be the result of the seasonal differences in temperature and density of benthic invertebrate prey (cf. West 1985,1990).

Growth and survival of spot in the natural and man-made areas were similar despite differences in benthic invertebrate community structure among these areas (West 1990). These results imply some measure of independence between estuarine community structure and function. This independence is related to the diverse diet of this species of fish (Table 18). Croaker (*Micropogonias undulatus*) also evinces a varied diet (Table 18). However, it is presently unclear if dietary diversity is a general feature of the abundant species of finfish which reside in these creeks.

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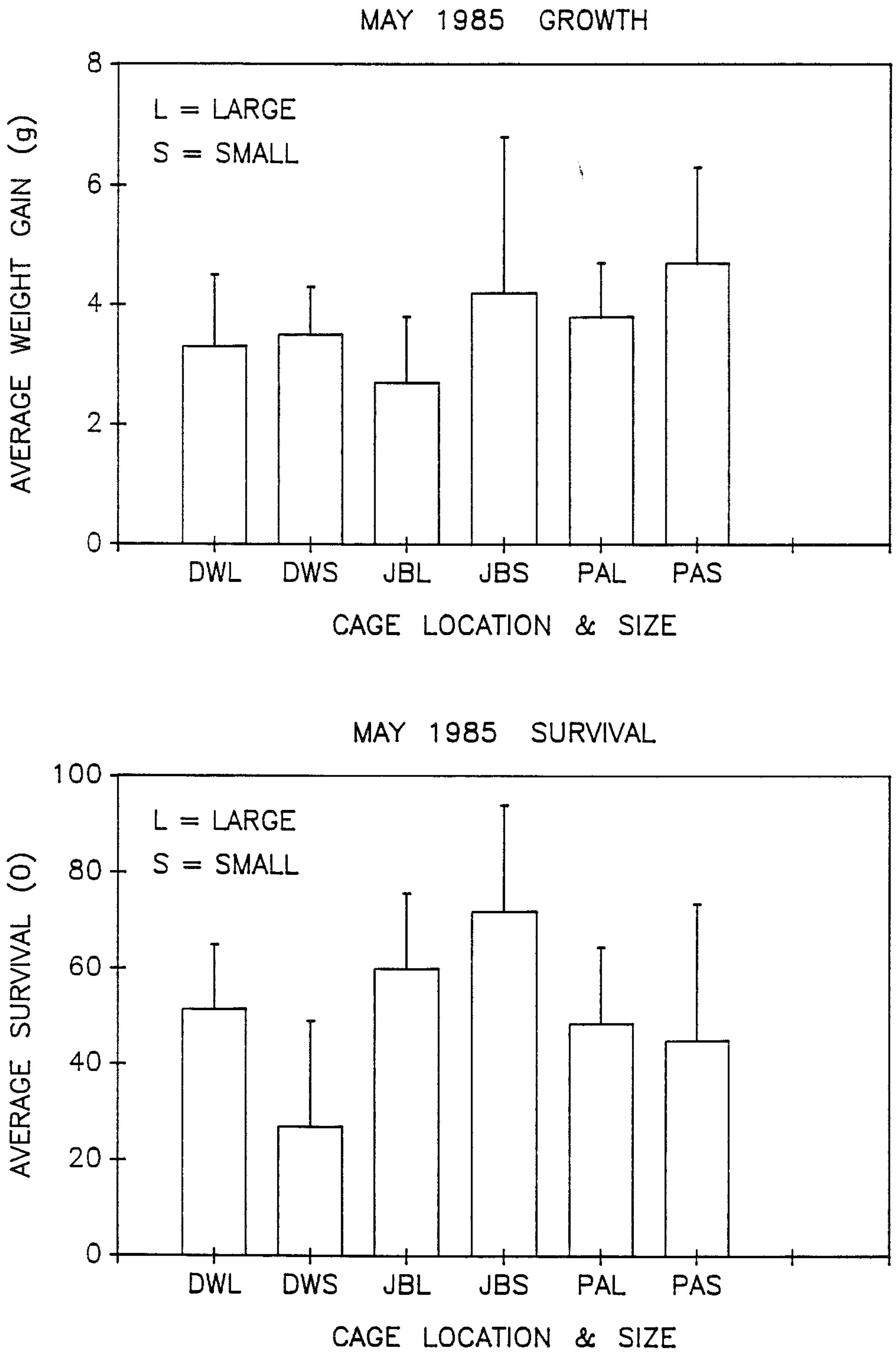
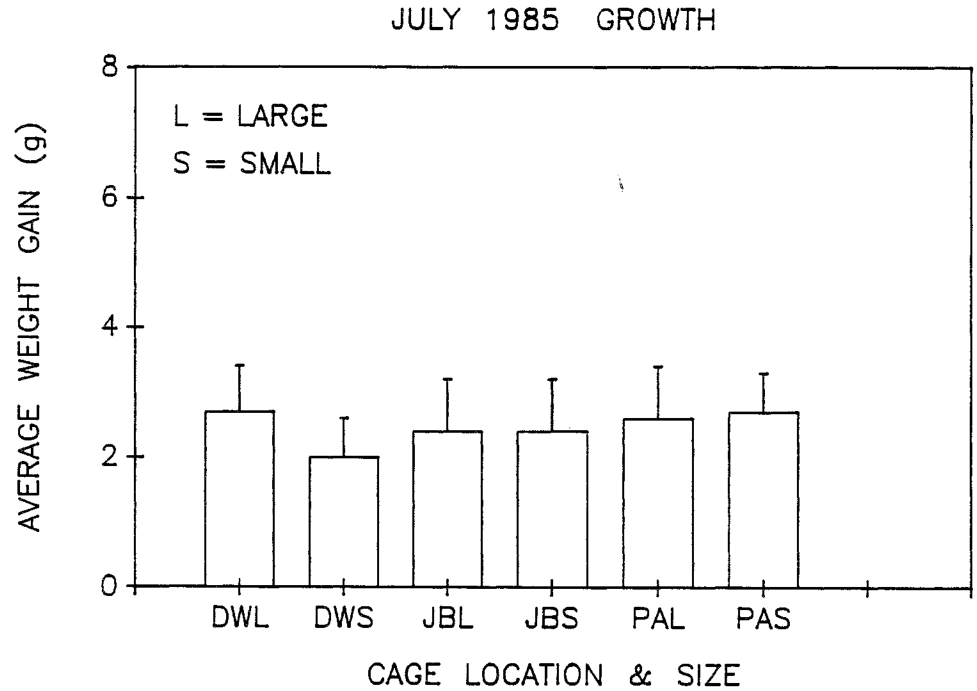


Figure 4. Effects of enclosure size on growth (average weight gain) and survival of spot in the Project Area and the natural creeks during the 29 May-13 July 1985 experiments. Survival is presented as the arc sine (angle 0) transforms of the orginal percentage values.



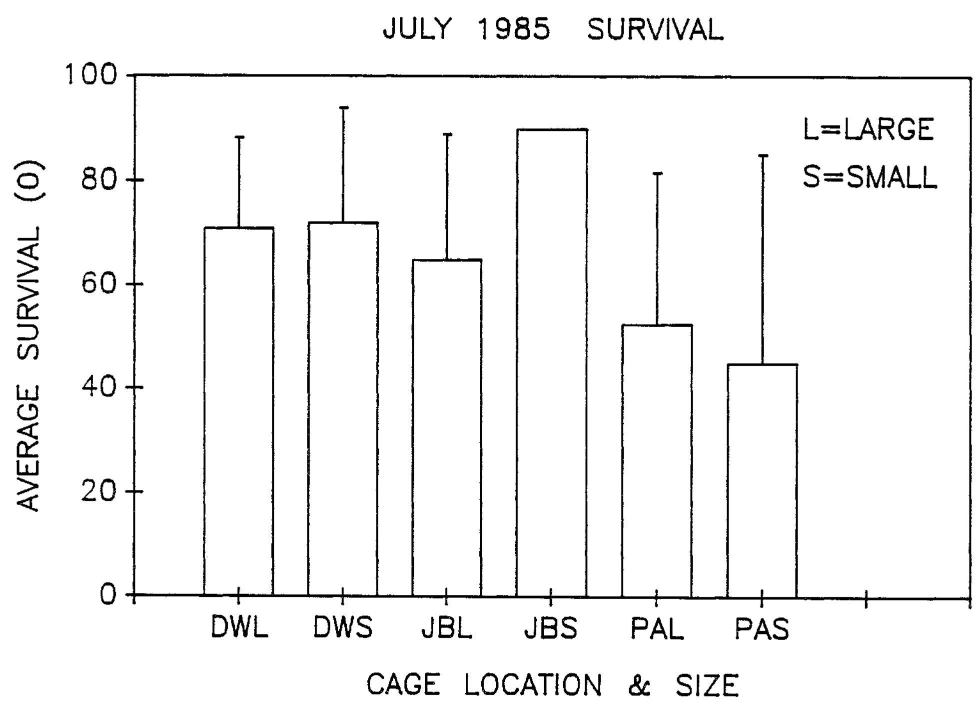


Figure 5. Effects of enclosure size on growth (average weight gain) and survival of spot in the Project Area and the natural creeks during the 24July-9 August 1985 experiments. Survival is presented as the arc sine (angle 0) transforms of the orginal percentage values.

TABLE 11. Growth (weight gain) and survival of spot (*Leiostomus xanthurus*) held for 14 days in 1.8m diameter (Large) and 0.9m diameter (Small) enclosures during 29 May - 13 June, and 24 July - 9 August 1985, in Drinkwater Creek (DW), Jacobs Creek (JB), and Project Area 2 (PA 2). N=8 and n=2, respectively, for large and small cages. std=standard deviation.

		WEIGHT GAIN (g)				PERCENT SURVIVAL	
		Large Cage		Small Cage		Large	Small
Creek	Cage No.	Mean	STD	Mean	STD	Cage	Cage
			May 1985				
DW	1	3.2	0.8	--	--	75	0
	2	3.0	0.7	3.3		50	50
	3	1.9	1.1	4.6	--	63	50
	4	3.0	0.1	--	--	25	0
	5	4.6	0.7	2.6	--	88	50
JB	1	2.3	1.3	2.6	0.4	50	100
	2	2.1	1.2	2.1	--	75	50
	3	2.9	1.0	3.0	--	50	50
	4	3.2	1.1	8.5	1.1	63	100
	5	3.1	0.9	5.0	0.8	63	100
PA 2	1	2.8	1.3	--	--	25	0
	2	4.4	1.0	3.7	1.7	88	100
	3	3.4	0.8	7.0	--	63	50
	4	3.6	0.6	4.3	--	25	50
	5	3.9	0.9	4.7	--	75	50
			JULY 1985				
DW	1	2.9	0.7	1.6	--	88	50
	2	2.7	0.7	2.6	0.6	100	100
	3	2.7	0.6	1.2	--	75	50
	4	2.5	0.6	1.8	0.1	50	100
	5	2.5	1.0	2.3	0.1	100	100
JB	1	2.1	1.0	1.5	0.3	100	100
	2	1.4	0.6	3.2	0.5	25	100
	3	2.5	0.7	1.9	0.2	100	100
	4	2.3	0.4	2.1	0.6	50	100
	5	3.0	0.5	3.1	0.2	88	100
PA 2	1	1.9	0.7	--	--	63	0
	2			2.9	--	0	50
	3	3.1	0.9	--	--	75	0
	4	2.8	0.5	2.1	0.4	100	100
	5	3.2	0.4	3.3	0.4	75	100

TABLE 12. Effect of cage size on growth of spot (*Leiostomus xanthurus*); 29 May - 13 June 1985 experiments. Significant probability levels (P < 0.05) are indicated by an asterisk. ns=not significant.

DRINKWATER CREEK

ANALYSIS OF VARIANCE

SOURCE	SUM-OF-SQUARES	DF	MEAN-SQUARE	F-RATIO	P
CAGE	0.125	1	0.125	0.085	0.773 ns
ERROR	36.853	25	1.474		

JACOBS CREEK

ANALYSIS OF VARIANCE

SOURCE	SUM-OF-SQUARES	DF	MEAN-SQUARE	F-RATIO	P
CAGE	14.030	1	14.030	5.073	0.032 *
ERROR	82.965	30	2.765		

PROJECT AREA 2

ANALYSIS OF VARIANCE

SOURCE	SUM-OF-SQUARES	DF	MEAN-SQUARE	F-RATIO	P
CAGE	2.962	1	2.962	2.165	0.154 ns
ERROR	34.212	25	1.368		

TABLE 13. Effect of cage size on growth of spot (*Leiostomus xanthurus*); 24 July - 9 August 1985 experiments. Significant probalility levels ($P < 0.05$) are indicated by an asterisk. ns=not significant.

DRINKWATER CREEK

ANALYSIS OF VARIANCE

SOURCE	SUM-OF-SQUARES	DF	MEAN-SQUARE	F-RATIO	P
CAGE	2.676	1	2.676	5.249	0.027 *
ERROR	19.885	39	0.510		

JACOBS CREEK

ANALYSIS OF VARIANCE

SOURCE	SUM-OF-SQUARES	DF	MEAN-SQUARE	F-RATIO	P
CAGE	0.010	1	0.010	0.015	0.902
ERROR	24.280	37	0.656		

PROJECT AREA 2

ANALYSIS OF VARIANCE

SOURCE	SUM-OF-SQUARES	DF	MEAN-SQUARE	F-RATIO	P
CAGE	0.036	1	0.036	0.064	0.802 ns
ERROR	16.519	29	0.570		

TABLE 14. Effect of cage size on survival of spot (*Leiostomus xanthurus*); May 1985 experiment. Significant probability levels ($P < 0.05$) are indicated by an asterisk. ns=not significant

DRINKWATER CREEK

ANALYSIS OF VARIANCE

SOURCE	SUM-OF-SQUARES	DF	MEAN-SQUARE	F-RATIO	P
CAGE	1493.284	1	1493.284	3.578	0.095 ns
ERROR	3338.972	8	417.372		

JACOBS CREEK

ANALYSIS OF VARIANCE

SOURCE	SUM-OF-SQUARES	DF	MEAN-SQUARE	F-RATIO	P
CAGE	360.000	1	360.000	0.785	0.401 ns
ERROR	3667.500	8	458.438		

PROJECT AREA 2

ANALYSIS OF VARIANCE

SOURCE	SUM-OF-SQUARES	DF	MEAN-SQUARE	F-RATIO	P
CAGE	29.584	1	29.584	0.044	0.838 ns
ERROR	5332.172	8	666.522		

TABLE 15. Effect of cage size on survival of spot (*Leiostomus xanthurus*); 24 July - 9 August 1985 experiment. Significant probability levels ($P < 0.05$) are indicated by an asterisk. ns=not significant

DRINKWATER CREEK

ANALYSIS OF VARIANCE

SOURCE	SUM-OF-SQUARES	DF	MEAN-SQUARE	F-RATIO	P
CAGE	2.809	1	2.809	0.006	0.942 ns
ERROR	3950.672	8	493.834		

JACOBS CREEK

ANALYSIS OF VARIANCE

SOURCE	SUM-OF-SQUARES	DF	MEAN-SQUARE	F-RATIO	P
CAGE	1570.009	1	1570.009	4.335	0.071 ns
ERROR	2897.072	8	362.134		

PROJECT AREA 2

ANALYSIS OF VARIANCE

SOURCE	SUM-OF-SQUARES	DF	MEAN-SQUARE	F-RATIO	P
CAGE	140.625	1	140.625	0.091	0.771 ns
ERROR	12375.000	8	1546.875		

TABLE 16. Effect of location (creek) on growth of caged spot (*Leiostomus xanthurus*) during May and July 1985. A nested analysis of variance was using data from the large cages, in which cages were nested within creeks. Significant probability levels ($P < 0.05$) are indicated by an asterisk. DW=Drinkwater Creek; JB=Jacobs Creek; PA=Project Area 2.

MAY 1985

ANALYSIS OF VARIANCE

SOURCE	SUM-OF-SQUARES	DF	MEAN-SQUARE	F-RATIO	P
AMONG CREEKS	10.822	2	5.411	5.644	0.005 *
AMONG CAGES (DW)	22.225	4	5.556	5.795	0.000 *
AMONG CAGES (JB)	10.944	4	2.736	2.854	0.029 *
AMONG CAGES (PA)	5.565	4	1.391	1.451	0.225
ERROR	75.743	79	0.959		

JULY 1985

ANALYSIS OF VARIANCE

SOURCE	SUM-OF-SQUARES	DF	MEAN-SQUARE	F-RATIO	P
AMONG CREEKS	2.271	2	1.136	2.180	0.120
AMONG CAGES (DW)	0.703	4	0.176	0.337	0.852
AMONG CAGES (JB)	5.534	4	1.383	2.655	0.040 *
AMONG CAGES (PA)	6.069	4	1.517	2.912	0.027 *
ERROR	38.034	73	0.521		

TABLE 17. Effect of location (creek) on survival of spot (*Leiostomus xanthurus*). One-way analyses of variance were done using data pertaining to the large cages. ns=not significant.

MAY 1985

ANALYSIS OF VARIANCE

SOURCE	SUM-OF-SQUARES	DF	MEAN-SQUARE	F-RATIO	P
CREEK	359.845	2	179.923	0.630	0.549 ns
ERROR	3428.644	12	285.720		

JULY 1985

ANALYSIS OF VARIANCE

SOURCE	SUM-OF-SQUARES	DF	MEAN-SQUARE	F-RATIO	P
CREEK	884.645	2	442.323	0.611	0.559 ns
ERROR	8692.744	12	724.395		

TABLE 18. Absolute and relative abundance of dietary items of the benthic feeding fish spot (*Leiostomus xanthurus*) and croaker (*Micropogonias undulatus*) during March to May, 1985. All items were recovered from examining the gut contents of formalin preserved individuals. The table is a compilation of pooled size class data (20 -100 mm, total length) of 1400 spot and 400 croaker. The fish were caught in Tooley, Long, and Bond Creeks, all tributaries of South Creek.

Leiostomus xanthurus			*Micropogonius undulatus*		
Taxon	Number	%	Taxon	Number	%
Copepoda	24946	51.6	Copepoda	1080	36.6
Chironomidae	5814	12.0	Chironomidae	931	31.6
Ostracoda	4639	9.6	*Neomysis americanus*	263	8.9
Nematoda	3304	6.8	*Leptocheirus plumulosus*	180	6.1
foraminifera	2523	5.2	clam siphon	133	4.5
Gammarus tigrinus	1714	3.5	Ostracoda	111	3.8
Oligochaeta	1655	3.4	*Gammarus tigrinus*	94	3.2
clam siphon	1439	3.0	Insect	53	1.8
Leptocheirus plumulosus	1159	2.4	*Corophium lacustre*	38	1.3
Hobsonia florida	261	0.5	*Scolecolepides viridis*	18	0.6
Insect	249	0.5	foraminifera	15	0.5
Corophium lacustre	207	0.4	Nematoda	8	0.3
Laeonereis culveri	142	0.3	Ceratopogonidae	6	0.2
Neomysis americanus	100	0.2	*Gammarus mucronatus*	2	0.1
Scolecolepides viridis	38	0.1	*Eteone heteropoda*	2	0.1
Ceratopogonidae	25	0.1	*Hobsonia florida*	1	0.0
Eteone heteropoda	17	0.0	*Laeonereis culveri*	1	0.0
Gammarus mucronatus	8	0.0			
Polydora ligni	8	0.0			
Streblospio benedicti	4	0.0			
Neanthes succinea	2	0.0			

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