LONG-TERM GROWTH OF HATCHERY STOCKS OF TEXAS AND SOUTH CAROLINA RED DRUM 1986 - 1989

by

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ABSTRACT

Texas and South Carolina red drum (Sciaenops ocellatus) were compared to evaluate long-term growth characteristics of the two hatchery stocks; this paper summarizes the first 3 years of growth. Red drum from each group were spawned in spring 1986, and fry were held in either outdoor earthen ponds or indoor recirculating tanks through March 1989. No consistent difference in growth was found between the two groups over the 3-year test period.

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INTRODUCTION

Red drum (Sciaenops ocellatus) occur along the Atlantic coast from Massachusetts to southern Florida, and along coastal Gulf of Mexico from Florida to northern Mexico (Simmons and Breuer 1962). State record red drum from the Gulf of Mexico range in weight from 19.5 kg in Alabama to 25.6 kg in Louisiana; the state record red drum in Texas weighs 23.4 kg (Matlock 1987). In contrast, state record red drum from the Atlantic coast range from 34.0 kg in South Carolina to 42.7 kg in North Carolina.

Populations of some marine fishes, such as butterfish (Poronotus triacanthus), harvest fish (Peprilus paru) and spadefish (Chaetodipterus faber) have been observed to exhibit disparate growth between the Atlantic and Gulf regions (Gunter 1950). Delayed sexual maturity, longer life, slower growth and greater final size are characteristics of animals in colder seas. Geographic variations in growth have also been found in some members of the sciaenid family, including Atlantic croaker (Micropogonias undulatus) and sand seatrout (Cynoscion arenarius) (White and Chittenden 1977, Shlossman and Chittenden 1981).

The Texas Parks and Wildlife Department (TPWD) maintains hatchery stocks of adult red drum from the Gulf of Mexico (Texas) and Atlantic (South Carolina) coasts in controlled tank systems at the Gulf Coast Conservation Association/Central Power and Light Marine Development Center (MDC) in Corpus Christi, Texas. In 1985, efforts were initiated by TPWD to identify potentially cold-tolerant red drum which could contribute to stocking programs used for population enhancement in Texas coastal waters. Red drum inhabiting the Texas coast experience periodic winter kills (Gunter 1941, Moore 1976, McEachron 1984); the more northerly distributed Atlantic red drum may be more tolerant of low water temperatures (Bearden 1967). However, a possible impact of non-native red drum stocking could be increased growth of Texas fish if growth of Atlantic fish was dissimilar.

The specific objective of this study was to evaluate and compare long-term growth between hatchery stocks of red drum from Texas and South Carolina; this paper summarizes the first 3 years of growth.

MATERIALS AND METHODS

Red drum used in this study were spawned at MDC 2 May 1986 (South Carolina fish), and 28 April to 1 May 1986 (Texas fish). Fish were reared in outdoor earthen ponds and indoor fiberglass tanks from May 1986 to March 1989 (Figures 1 and 2) at either the TPWD Marine Fisheries Research Station (MFRS), Palacios, or the MDC. Due to space limitations, progressively fewer fish were overwintered as they grew larger, therefore, selection was required (see below) at the beginning of each overwintering period.

Texas red drum fry were stocked 1 - 3 May 1986 in a 1.6-ha pond at 1,250,000 fry/ha. South Carolina fry were stocked 4 May in a 0.2-ha pond at 1,500,000 fry/ha. Pond culture techniques for both groups during this phase of the study followed the general methods of McCarty et al. (1986). Pond

salinity, water temperature and dissolved oxygen were recorded once daily between sunrise and 0900 h in this and all pond phases of the study.

South Carolina fish were harvested after 37 days (10 June 1986), Texas fish were harvested after 34 days (5 June 1986), and 2,000 randomly selected fish from each group were retained. Total length (TL) and weight (W) were obtained from 100 fish of each group. Unless otherwise noted, a sample of 100 fish from each pond or all surviving fish (whichever was less) were measured and weighed after each period of residence. The total number of fish recovered from each pond at harvest was estimated by dividing the total weight of all fish harvested by the mean weight of 100 measured fish. Survival and production (kg/ha/day) were also determined for each pond.

On 5 and 10 June 1986, respectively, the 2,000 Texas and South Carolina fish were transferred to separate 1.6-ha ponds. Fish were not fed a supplemental feed; natural forage was the only available food source. Ponds were harvested 18 and 19 November 1986, and 65 fish (of each group) were retained.

The 65 Texas and 65 South Carolina red drum were transferred to separate 9,500-liter fiberglass tanks (for overwintering) and held from 18-19 November 1986 to 7 April 1987. Tanks were maintained under similar temperature and photoperiod conditions, and were equipped with a rotating contact biological filter, an ultraviolet water sterilization unit and a diatomaceous earth filter. Fish were fed 7% body weight (BW) of frozen shrimp, frozen chopped fish and floating pellets (35% protein Lone Star Feeds, Nacagdoches, Texas) daily from 18 November to 12 December 1986; feeding rate was reduced to 3% BW from 13 December 1986 to 2 April 1987 as fish failed to consume the entire offered portion. Salinity and water temperature were measured once daily, ammonia and pH were measured three times weekly in this and all tank phases of the study. Total weight of fish held in tanks was determined monthly and feeding amounts adjusted accordingly. Surviving fish were sampled as previously described and tagged abdominally with internal anchor tags on 23 March 1987.

The fish were transferred to separate 1.6-ha ponds on 7 April 1987. Fish were not fed a supplemental feed while held in ponds. Fish were harvested 9 and 10 November 1987 for laboratory overwintering. Twenty-five randomly selected fish of each group were placed in separate 4,000-liter fiberglass tanks at MFRS; remaining fish (28 Texas and 32 South Carolina) were transferred to separate tanks at MDC. MFRS fish were fed 1% BW frozen shrimp, 1% BW chopped fish, and 0.5% BW floating pellets daily, and were measured and weighed monthly through April 1988. MDC fish were fed 2.5% BW frozen shrimp 3 - 4 times weekly.

In April 1988, the MFRS and MDC fish were recombined at the MFRS. MFRS fish were individually measured, weighed, tagged with a Passive Integrated Transponder (PIT) tag, and moved to a single unfiltered 1.6-ha pond 13 April 1988. Fish that had been overwintered at the MDC were returned to the MFRS on 20 April, PIT tagged, and placed in the same 1.6-ha pond as the MFRS fish. Fish fed on natural forage pumped into the pond from April through September, after which chopped fish, shrimp and floating pelleted fish food were offered

from October 1988 until harvest.

Fish were harvested 9 November 1988; survival and production (kg/ha/day) were determined. Ten Texas fish were selected (in conjunction with a separate study) for large size, superior condition, and good health (i.e., lack of obvious external aberrations), and moved to a 4,000-l indoor recirculating tank; the 25 remaining Texas fish were transferred to an unfiltered 1.6-ha pond. All South Carolina fish, however, were moved indoors and examined for a genetic "mark" present in blood protein fractions. Examination for the mark was completed 23 January 1989; no genetic mark was found. Ten South Carolina fish were then selected (as described previously) and transferred to a single 10,000-l indoor recirculating tank; the remaining 18 South Carolina fish were moved to the 1.6-ha pond that contained the 25 Texas red drum. The ten previously selected Texas fish were also sampled on 23 January. While held in tanks, fish were fed shrimp, chopped fish and floating pellets at approximately 2.0% of body weight (BW). All fish were sampled 21 March 1989; feed was adjusted accordingly.

The 43 red drum overwintered in the 1.6-ha pond were fed 1.1 kg floating pellets 5 days/week when water temperatures were > 14.0 C. Fish were measured and weighed as mortalities were observed. The pond was harvested 20 March 1989 (however, complete mortality had occurred during a freeze in February; see results).

Mean values $\pm$ SD were calculated for each variable tested. Students' t-test was used to compare TL and W of South Carolina and Texas red drum after each period of residence; pond water temperature, salinity, and dissolved oxygen were compared after each pond phase. Growth of both Texas and South Carolina fish was fit to a quadratic model through 2.5 years of age (May 1986 to November 1988; fish from the two populations were handled differently after this time) and compared for heterogeneity of slopes (SAS Institute 1985). Growth data from April 1988 through November 1988 were analyzed separately for MFRS and MDC fish, as different feeding and handling procedures had been used at the two locations from November 1987 to April 1988. Growth data after November, however, was recombined for analysis. All statistical tests were performed using the Statistical Analysis System (SAS Institute 1985) at the 0.05 level of significance.

RESULTS

No consistent difference in growth or survival were seen between Texas and South Carolina red drum during pond and tank phases of the study. Following the initial summer of pond culture (harvested November 1986) and after the first tank overwintering (March 1987), the two groups were similar in length and weight (Table 1). After the second summer in ponds (November 1987), South Carolina fish were significantly longer and heavier than Texas fish. Following the second overwintering period (April 1988), South Carolina fish that had been held at MFRS and those that had been held at MDC were significantly longer than Texas fish. However, fish overwintered at both locations were similar in weight. Neither Texas nor South Carolina fish increased in weight in the 1.6-ha pond (April 1988 through November 1988). At

harvest (November 1988), Texas and South Carolina fish that had been overwintered at the MFRS (November 1987 to April 1988) were similar in length and weight. MDC-overwintered South Carolina fish were significantly longer and heavier than Texas fish.

While held in indoor tanks (November 1988 through March 1989), Texas fish (N = 10) were significantly heavier than South Carolina fish (N = 28) at the 23 January 1989 tank sample (Table 1). At the 21 March tank sample, the ten selected fish of each group were similar in length and weight.

While held in the 1.6-ha pond for overwintering (beginning November 1988), a severe cold front in early February 1989 caused total fish mortality. Water temperature declined from 19.7 C on 2 February to -0.1 C on 7 February. Within two weeks, 40 of the 43 stocked fish had been found dead (22 Texas fish, 18 South Carolina fish). Analysis of growth indicated that South Carolina fish were significantly longer and heavier than Texas fish (Table 1). Final pond harvest occurred on 20 March 1989; the three remaining fish were not found.

May 1986 through November 1988 growth (TL) was fit to a quadratic model; r^2 values of 0.919 and 0.930 were obtained for Texas and South Carolina fish, respectively. Covariance analysis revealed that growth was similar ($F_{6,714}$ = 2.42, $p > 0.120$) between Texas and South Carolina fish. Growth of individually PIT tagged fish (April 1988 to March 1989) is presented in Appendix 1.

Total weight harvested, production (kg/ha/day) and survival for the pond trials showed results consistent with the growth data (Table 2). Survival was comparable in ponds which were stocked at equal rates (harvested November 1986, 1987, and 1988). Production was also similar in these ponds at the November 1986 harvest. However, production appeared higher in the South Carolina-stocked pond at the November 1987 harvest. Water quality was similar between South Carolina and Texas stocked ponds in all trials, with the exception of the 1986 fry culture ponds; salinity was significantly greater (but only by 1 o/oo) in ponds containing Texas fish (Table 3).

DISCUSSION

No clear advantage in long-term growth characteristics was found between Texas or South Carolina stocks of red drum. Based on mean weights of fish after the second summer pond trial (harvested November 1987), South Carolina red drum may grow faster in ponds than Texas red drum. Although bay water was pumped to the ponds simultaneously, shrimp and crabs were found in the Texas pond following the November 1987 harvest and no individuals of either group were found in the South Carolina pond, suggesting that South Carolina fish feed more readily on the natural forage available. The cause of this disparate growth pattern between the two groups is unknown.

Length and/or weight differences between stocks in January and February 1989 were probably due to selection and handling differences. Length and weight of Texas fish were greater than that of South Carolina fish at the

January 1989 tank sample; however, the 10 Texas fish had already been selected for weight. Following the early February pond fish kill, mean length and weight of South Carolina fish were greater than that of Texas fish. For the 3 months prior to the freeze conditions, South Carolina fish had been held indoors at a constant temperature and were being fed fish, shrimp, and dry pellets daily. Texas fish, however, were being held in the 1.6-ha pond and were fed pellets only (when water temperature was > 14.0 C).

Red drum TL at 3 years (which is most comparable to our 2.8-year fish at the March 1989 tank sample) for wild fish in Texas was estimated to range from 548 - 760 mm TL (Pearson 1929, Simmons and Breuer 1962, Wakefield and Colura 1982); Texas fish at the MFRS averaged 610 mm. Sub-adult red drum along the Texas coast can reach total lengths of 548 - 602 mm in 26 months (Matlock 1984). Three-year growth estimates from North and South Carolina red drum ranged from 660 - 731 mm (Bearden 1967, Theiling and Loyacano 1976); South Carolina fish at the MFRS averaged 616 mm TL. Extremely high salinities due to summer 1988 drought conditions most likely contributed to the low third-year growth of our pond-raised fish compared to wild stocks.

As neither hatchery stock exhibited a clear advantage in growth, production or survival, no recommendation to stock one group in preference to the other can be made at this time.

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TABLE 1. Lengths and weights of South Carolina and Texas red drum during long-term growth trial. Dates listed are either pond harvest dates or dates at which fish held in indoor tanks were last sampled.

Harvest or sample date	Age (days)	Group	No.	Total length (mm) mean	Total length (mm) t-statistic	Weight (g) mean	Weight (g) t-statistic
05 Jun 1986[a]	34	Texas	100	29 ± 2.2		0.24 ± 0.05	
					11.681**		8.296**
10 Jun[a]	37	South Carolina	100	32 ± 1.5		0.30 ± 0.05	
19 Nov[a]	207	Texas	100	241 ± 38.6		157 ± 69.4	
					0.086		0.414
18 Nov[a]	204	South Carolina	100	240 ± 52.9		161 ± 89.6	
23 Mar 1987[b]	338	Texas	64	355 ± 41.9		483 ± 145.0	
					0.673		0.001
23 Mar[b]	336	South Carolina	65	360 ± 44.5		482 ± 157.9	
09 Nov[a]	569	Texas	53	408 ± 43.4		688 ± 253.1	
					3.708**		2.623*
10 Nov[a]	568	South Carolina	57	441 ± 47.9		828 ± 300.2	
13 Apr 1988[bc]	680	Texas	20	509 ± 28.9		1,612 ± 237.8	
					2.183*		0.347
13 Apr[bc]	682	South Carolina	22	530 ± 32.8		1,641 ± 311.1	
20 Apr[bd]	687	Texas	26	473 ± 37.3		1,103 ± 266.6	
					2.143*		1.906
20 Apr[bd]	689	South Carolina	23	505 ± 44.6		1,274 ± 357.5	

Table 1. (Cont'd.)

Harvest or sample date	Age (days)	Group	No.	Total length (mm) mean	Total length (mm) t-statistic	Weight (g) mean	Weight (g) t-statistic
09 Nov[ac]	890	Texas	19	541 ± 30.9		1,587 ± 215.2	
					1.611		0.182
09 Nov[ac]	892	South Carolina	21	557 ± 32.7		1,602 ± 310.8	
09 Nov[ad]	890	Texas	16	494 ± 30.3		1,080 ± 268.0	
					3.462*		2.104*
09 Nov[ad]	892	South Carolina	10	534 ± 25.4		1,270 ± 115.0	
23 Jan 1989[b]	964	Texas	10	592 ± 16.8		2,584 ± 226.9	
					1.787		4.806**
23 Jan[b]	966	South Carolina	28	574 ± 30.0		1,996 ± 360.1	
21 Feb[a]	993	Texas	22	498 ± 26.7		1,375 ± 259.2	
					5.673**		4.587**
21 Feb[a]	995	South Carolina	18	545 ± 25.5		1,754 ± 251.7	
21 Mar[b]	1,021	Texas	10	610 ± 15.8		3,037 ± 216.9	
					0.706		1.106
21 Mar[b]	1,023	South Carolina	10	616 ± 19.5		2,917 ± 265.8	

[a] Pond harvest
[b] Tank sample
[c] Fish overwintered at MFRS.
[d] Fish overwintered at MDC.
* $P < 0.05$
** $P < 0.01$

TABLE 2. Production and survival of South Carolina and Texas red drum at the end of each pond culture period.

Pond production period	Days in pond	Group	No. stocked	Weight stocked (kg)	Weight harvested (kg)	Production (kg/ha/day)	Survival (%)
May-Jun 1986	33	Texas	2,000,000	fry[a]	180.6	3.4	43.5
	37	South Carolina	300,000	fry[a]	66.0	8.7	75.3
Jun-Nov 1986	167	Texas	2,000	0.4	228.1	0.85	72.9
	161	South Carolina	2,000	0.6	221.3	0.86	68.6
Apr-Nov 1987	216	Texas	64	30.9	36.5	0.02	83.0
	217	South Carolina	64	31.4	47.2	0.05	89.0
Apr-Nov 1988	208	Texas	46	60.9	47.4	ND[b]	76.1
	208	South Carolina	45	65.4	46.4	ND[b]	68.9

[a]Not weighed
[b]No production

TABLE 3. Mean (± SD) temperature, salinity, and dissolved oxygen values for the pond production periods of the red drum long-term growth study.

Dates	Group	Temperature (C) mean	Temperature (C) t-statistic	Salinity (o/oo) mean	Salinity (o/oo) t-statistic	Dissolved oxygen (mg/l) mean	Dissolved oxygen (mg/l) t-statistic
May-Jun 1986	Texas	24.8 ± 2.00	1.406	27 ± 0.83	-3.283**	4.0 ± 1.27	1.702
	South Carolina	25.5 ± 2.10		26 ± 1.21		4.6 ± 1.17	
Jun-Nov 1986	Texas	26.0 ± 3.98	0.978	30 ± 4.57	0.698	4.1 ± 1.43	1.055
	South Carolina	26.0 ± 3.97		30 ± 4.26		4.3 ± 1.26	
Apr-Nov 1987	Texas	25.1 ± 3.35	0.764	25 ± 4.84	-1.144	4.7 ± 1.22	0.454
	South Carolina	25.4 ± 3.49		25 ± 3.94		4.8 ± 1.22	
Apr-Nov[a] 1988		25.5 ± 3.04		42 ± 9.94		5.4 ± 1.31	
Nov 1988-[a] Mar 1989		14.5 ± 5.00		40 ± 4.60		7.8 ± 1.80	

** $P<0.01$
[a]Fish held in same pond.

Figure 1. Flow-chart depicting dates of transfer from ponds to tanks for Texas red drum.

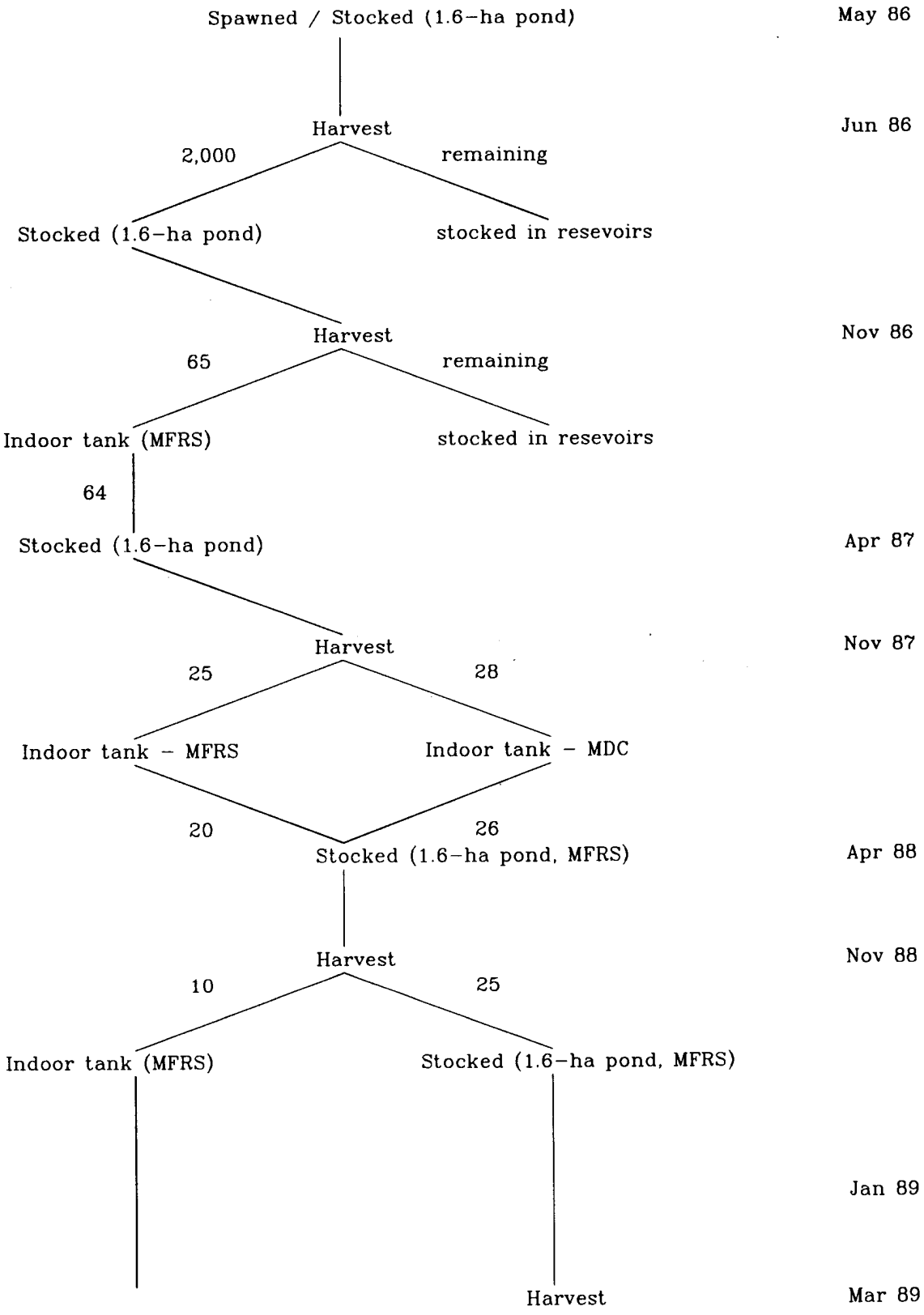
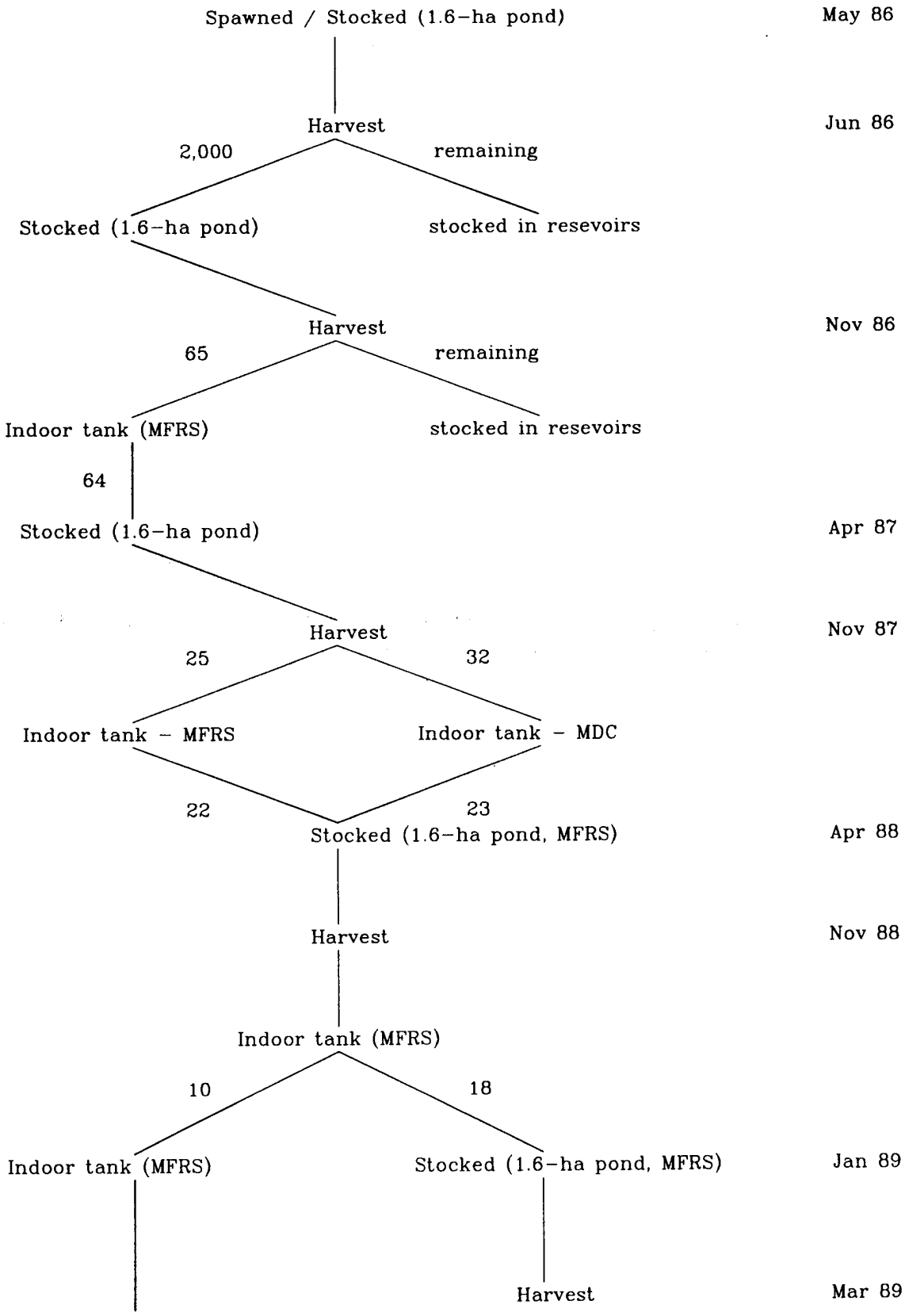

Spawned / Stocked (1.6-ha pond)
May 86
Harvest
Jun 86
2,000
remaining
Stocked (1.6-ha pond)
stocked in resevoirs
Harvest
Nov 86
65
remaining
Indoor tank (MFRS)
stocked in resevoirs
64
Stocked (1.6-ha pond)
Apr 87
Harvest
Nov 87
25
28
Indoor tank - MFRS
Indoor tank - MDC
20
26
Stocked (1.6-ha pond, MFRS)
Apr 88
Harvest
Nov 88
10
25
Indoor tank (MFRS)
Stocked (1.6-ha pond, MFRS)
Jan 89
Harvest
Mar 89

Figure 2. Flow chart depicting dates of transfer from ponds to tanks for South Carolina red drum.


Spawned / Stocked (1.6-ha pond)
May 86
Harvest
Jun 86
2,000
remaining
Stocked (1.6-ha pond)
stocked in resevoirs
Harvest
Nov 86
65
remaining
Indoor tank (MFRS)
stocked in resevoirs
64
Stocked (1.6-ha pond)
Apr 87
Harvest
Nov 87
25
32
Indoor tank - MFRS
Indoor tank - MDC
22
23
Stocked (1.6-ha pond, MFRS)
Apr 88
Harvest
Nov 88
Indoor tank (MFRS)
10
18
Indoor tank (MFRS)
Stocked (1.6-ha pond, MFRS)
Jan 89
Harvest
Mar 89

Appendix A. Total lengths of Texas and South Carolina red drum tagged with PIT tags (April 1988 - March 1989).

A.1. Total lengths of Texas red drum tagged with PIT tags (April 1988 - March 1989).

	Date				
Fish Number	Apr 1988	Nov 1988	Jan 1989	Feb 1989	Mar 1989
315 C1D	545	570	601		623
316 D58	492	534	577		598
316 F72	507	534	572		591
320 A0D	505	535	567		581
321 257	533	563	601		617
321 C02	549	583	610		626
332 A0E	546	576	613		627
332 33B	525	556	589		609
2C2 461	546	570	608		621
317 271	542	544	582		608
315 77A	473	507		500	
315 909	515	529			
316 A19	491				
316 24D	491	522		508	
316 031	443	540		543	
330 41F	443	486		490	
332 F57	539	604			
332 97D	481	506			
332 922	484	515		510	
2C2 636	509	541		540	
2C3 E63	489	508		492	
315 D2C	473	465		460	
315 D4A	500	511		515	
315 C4C	431				
316 87F	516	515		510	
316 D16	481	484		490	
316 23C	463	483		490	
316 E26	480	491		497	
316 E4E	467	488			
316 419	515	526		520	

A.1. (Cont'd.)

Fish Number	Date				
	Apr 1988	Nov 1988	Jan 1989	Feb 1989	Mar 1989
316 026	519				
317 25B	419				
320 E0F	517	526		525	
321 736	500	500		495	
321 D05	394				
327 414	486	497		500	
330 22A	448	446		435	
330 65D	429				
330 25F	468				
332 420	420	424		440	
333 004	430				
2C1 F0F	489	506		510	
2C2 132	447				
2C2 746	485				
2C2 046	483				
2C3 C06	507	497		485	

A.2. Total lengths of South Carolina red drum tagged with PIT tags (April 1988 - March 1989).

Fish Number	Date				
	Apr 1988	Nov 1988	Jan 1989	Feb 1989	Mar 1989
315 966	588	600	623		638
317 20A	548	578	598		611
321 418	543	560	585		606
321 E67	576	605	632		646
327 510	546	579	600		606
331 C3B	546	569	584		607
332 F36	570	598	621		643
2C4 31D	543	576	600		612
316 22F	507	510	559		590
332 230	525	531	571		598
315 753	521	555			
316 001	464	476	516	495	
316 E2C	486	496	519	500	
316 209	497	525	561	540	
317 06E	495	520	527	515	
317 52C	542	570	595	577	
321 03E	521	534	554	538	
321 B22	544	563	577	560	
330 217	524	543	547	540	
332 F59	503	525	553	ND	
2C1 E3B	548	564	588	575	
2C1 A0A	531	541	569	550	
2C2 241	469				
2C2 658	551	575			
315 83C	554	556	580	552	
315 811	478				
316 607	541	536	575	561	
316 F09	465	511			
316 313	489	501	535	520	
316 72E	458				

A.2. (Cont'd.)

Fish Number	Date				
	Apr 1988	Nov 1988	Jan 1989	Feb 1989	Mar 1989
317 568	532	536	556	550	
317 036	595	588	605	591	
320 A54	477				
320 649	414				
321 75E	511				
321 02F	539	544	577	560	
321 717	459				
321 002	523				
322 36	492				
322 16	482				
331 F36	462				
2C1 760	469				
2C1 655	600				
2C3 A76	514	525	566	549	
2C3 A70	527				

PWD-RP-3400-318-2/90