A REVIEW OF SPOTTED SEATROUT CULTURE AT THE PERRY R. BASS MARINE FISHERIES RESEARCH STATION: 1983-1985

by

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ABSTRACT

Spotted seatrout spawning and culture trials were conducted from 1983 through 1985. Spotted seatrout were spawned by human chorionic gonadotropin (HCG) induced tank-spawning (1983) and HCG induced strip-spawning (1984 and 1985). Hormone-induced tank-spawning yielded 600,000 larvae for pond stocking. Strip-spawning efforts yielded 562,600 and 1,531,000 larvae for stocking in 1984 and 1985, respectively. Thirty-one spotted seatrout pond trials were conducted between 1983 and 1985. Included in the overall database were separate experiments designed to determine: 1) feasibility of increasing pond forage by mysid shrimp inoculation; 2) whether a 10-, 18-, or 28-day interval between pond preparation and stocking provides the best zooplankton forage base for fingerling production; and 3) a preliminary evaluation of stocking rates on fingerling production. All ponds were stocked with 2-day old larvae. Stocking rates were dependent on larvae availability and specific study objectives. Overall mean ± SD recovery from the 31 pond culture trials was 32 ± 26%. However, returns and production were highly variable. Production variability was influenced by water quality and zooplankton densities but only salinity demonstrated a qualitative relationship to fingerling survival. Pond culture trials exhibiting mean salinities < 16 o/oo had mean ± SD survival of 7.13 ± 3.83% (n=12); whereas, average ± SD yield from culture trials conducted at mean salinities > 16 o/oo was 47.0 ± 20.1% (n=19). Although mysid shrimp populations were established by stocking approximately 17,000 mysids/pond into three, 0.1-ha ponds, mean ± SD yield, (44.1 ± 26.9%), and weight/area/day produced (2.32 ± 0.92 kg/ha/day), were not significantly different than yield, (37.9 ± 15.79%) and weight/area/day production, (2.84 ± 0.37 kg/ha/day) from three, 0.1-ha uninoculated control ponds. The time interval between pond preparation and larvae stocking affected mean survival, with ponds stocked 18 days after initial filling exhibiting a significantly greater mean percent yield (64.0 ± 1.4%) than ponds stocked at 10 (47.5 ± 2.1%) or 26 (33.0 ± 12.7%) days after filling. Production results for the variable stocking rate experiment were atypically low with percent fingerling yield averaging ± SD 5.9 ± 4.8%. Overall returns (32%) of spotted seatrout culture pond trials are similar to striped bass fingerling returns suggesting spotted seatrout culture methods are sufficiently advanced to allow hatchery scale culture of fingerlings.

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INTRODUCTION

Experimental pond culture of spotted seatrout (Cynoscion nebulosus) has been conducted for more than a decade (Colura et al. 1976, Colura and Hysmith 1976, Heath et al. 1981). Early results were sporadic; however, with fingerling returns and weight/area/day production values ranging 0-3% and 0.0-0.2 kg/ha/day, respectively. Porter and Maciorowski (1984) produced more than 50,000 spotted seatrout fingerlings in six experimental ponds with an average recovery of 8.4% and mean weight/area/day produced of 2.13 kg/ha/day. Improved yields were attributed to pond management strategies designed to increase zooplankton forage (Geiger 1983 a, b). Nevertheless, the 30% larvae-to-fingerling returns generally considered minimal for routine hatchery production (Kerby et al. 1982) have not been reported for spotted seatrout. Hatchery production of spotted seatrout has been hampered by unpredictable spawning and poor survival in culture ponds (Colura et al. 1976, Porter and Maciorowski 1984). Problems associated with spawning and broodfish selection of spotted seatrout have received attention (Colura et al. 1988, Colura et al. In Press), but larviculture and fingerling production data remain scant. Since 1983, the Texas Parks and Wildlife Department (TPWD) has had an ongoing experimental culture program to develop hatchery methods for spotted seatrout. Although experimental culture trials have been conducted for different specific objectives, general procedures have been similar. Further, the collective data represent 31 separate pond culture trials and provide a unique opportunity to evaluate spotted seatrout as a candidate for hatchery-scale fingerling production.

The present report summarizes results of spawning, larviculture, and pond culture trials of spotted seatrout conducted at the TPWD Perry R. Bass Marine Fisheries Research Station (MFRS) between 1983 and 1985. Included in the data base are separate experiments designed to determine: 1) the feasibility of inoculating culture ponds with mysid shrimp as forage for spotted seatrout; 2) whether a 10-, 18-, or 28-day time interval between pond preparation and stocking of larvae provides the best zooplankton forage base for fingerling production; and 3) a preliminary evaluation of stocking rates on fingerling production.

MATERIALS AND METHODS

Spotted seatrout used for spawning were sexually mature specimens captured by hook and line from Matagorda Bay, Texas. All fish were transported to the MFRS near Palacios, Texas, on the day of capture. However, transport, handling and spawning procedures differed between years. In 1983, fish were transported in a 140-l recirculating seawater tanks, and transferred to a 9,500-l recirculating seawater tank equipped with a rotating biodisc filtration system. On the day of capture, five females were injected with 550 IU/kg human chorionic gonadotropin (HCG) and released into the brood tank with seven uninjected males. Fertilized eggs were collected approximately 36 h post-injection (Porter and Maciorowski 1984). In 1984 and 1985, spotted seatrout were transported to the MFRS in 140-l live wells receiving compressed oxygen. Upon arrival, spotted seatrout were anesthetized with a commercial

fish calmer (Hypno^{R}, Jungle Laboratories, Redmond, Washington), examined, measured (total length mm), weighed (nearest 10 g), and biopsied (females) or abdominally massaged (males) to determine gonadal condition as described by Colura (1974).

Females eligible for spawning (mean ova diameter > 0.4 mm) and all males were intramuscularly injected with 50 mg oxytetracycline hydrochloride to minimize bacterial lesions from handling. Fish were subsequently transferred into a partitioned recirculating seawater system consisting of three 1,850-l tanks equipped with a gravel, sand and shell biofilter. Female spotted seatrout were intramuscularly injected with 1,100 IU/kg HCG the morning following capture to induce ovulation. Males received no hormones. Females were maintained in holding tanks until ovulation (26-32 h) when they were strip-spawned by the dry method (Davis 1953).

Fertilized eggs were placed into a known volume of seawater and the total volume of eggs and water determined. Three 1-ml aliquots from the individual spawns were removed with a Hensen-Stemple pipet and enumerated using a plankton counting wheel and a stereomicroscope. The average number of eggs/spawn was determined by volumetric estimation (Bayless 1972). At least 2 h after spawning, three samples of approximately 100 eggs from each spawn were microscopically examined for mitotic division to estimate the average percent fertilization.

Fertilized eggs from individual females spawned on the same date were mixed and incubated in a 1,900-l cone-bottomed fiberglass tank at 28-31 o/oo salinity and 24-29 C through hatching. Incubation medium consisted of Matagorda Bay water supplemented with a synthetic sea salt mixture (Super Salt^{R}, Fritz Chemical Company, Dallas, Texas or Instant Ocean^{R}, Aquarium Systems, Eastlake, Ohio). After hatching, incubators received a continuous flow of Matagorda Bay water at ambient salinity (17-28 o/oo). Alimentary development for all larvae was completed approximately 2 days post hatch. Two-day old larvae were concentrated, enumerated by volumetric estimation (Bayless 1972), and stocked into prepared ponds. Stocking rates varied throughout the study period, and were dependent on larvae availability and specific objectives of individual experiments (Table 1). Specific experiments included brine shrimp (trials 1-6) and mysid shrimp (trials 7-12) inoculation to improve zooplankton forage; variable time intervals between pond preparation and stocking of larvae (trials 13-18); comparison of spotted seatrout fingerling production to that of other sciaenids (trials 19-22, 29-31), and variable stocking rates (trials 23-28). Results of the brine shrimp inoculation experiments (trials 1-6) and the growth comparison of spotted seatrout to other sciaenids (trials 19-24, 29-31) are presented elsewhere (Porter and Maciorowski 1984, Bumguardner et al. In Review) and only spotted seatrout production data are discussed herein.

General pond culture procedures were similar for all trials. Ponds were filled with saran sock-filtered (0.5 mm) Matagorda Bay water using the puddle technique (Bonn et al. 1976) and stocked 10-28 days after initial filling. All ponds were fertilized with cottonseed meal, phosphoric acid and urea, but specific fertilization rates differed (Table 1). Half of the cottonseed meal was initially applied to dry pond bottoms. Ponds were filled to 1.5-1.7 m,

and the remaining cottonseed meal was broadcast from pond levees in 32 kg/ha applications three times weekly. The different cottonseed meal application rates (Table 1) reflect different time intervals between initial filling and larvae stocking, number of days in production, and adjustments necessary to maintain adequate water quality. Increased urea and phosphoric acid applications in 1984 reflect the decision to increase total inorganic fertilizer applications.

Zooplankton in each pond were sampled twice weekly in 1983 and 1984, and three times weekly in 1985. Zooplankton samples consisted of 25 liters of water pumped from the pond drain box and passed through a 64-mμ Wisconsin plankton net (Farquhar and Geiger 1984). All samples were preserved in 4% buffered formalin. Preserved samples were subsampled (Weber 1973, APHA et al. 1985), and major faunal groups identified and enumerated using a plankton counting wheel and stereomicroscopy.

Water quality determinations were performed daily at each pond drain box between sunrise and 0730. Dissolved oxygen and temperature were determined by the membrane electrode method (YSI Model 57, Yellow Springs, Ohio) and a thermometer, respectively. Salinity was measured by a refractometer (AO Scientific Instruments, Buffalo, New York) or salinity meter (YSI Model 33, Yellow Springs, Ohio).

Ponds were drained 22-30 days post stocking, and 100 fingerlings from each pond were preserved in 4% buffered formalin. Total length (TL), standard length (SL), and weight were determined for each specimen. Remaining fish from each pond were mass weighed at harvest with a dairy scale (Model 600, Hanson Co., Shubuta, Mississippi). The total number of fish recovered was determined by extrapolating mean individual weight of 100 fish from each pond to its respective total harvest biomass.

Mysid shrimp (Mysidopsis bahia and M. elmyra) were collected from Matagorda Bay in 1984 using an epibenthic sled with a 52 X 18-cm opening and a 0.5 mm mesh bag. Mysids were enumerated using standard subsampling and counting techniques (Weber 1973). Three randomly selected 0.1-ha ponds were subsequently stocked with mysid shrimp 10, 15, 16, and 17 days post filling for an estimated inoculation of 17,000 mysids/pond. Three 0.1-ha ponds served as uninoculated controls. Benthic samples were collected from each pond twice weekly beginning 27 days post filling and continuing until the day before harvest. Samples were obtained by pulling the previously described epibenthic sled across the width of each pond. Samples were collected across the width of each pond at the middle and each end on each sampling day and preserved in a 10% formalin. Preserved samples were washed in a 1.5-mm sieve and major faunal groups identified and enumerated.

Ponds with the same initial date of filling and size were grouped into six experimental units (Table 1). Calculated means of water quality characteristics, TL, weight, and numerical return for the mysid inoculation, time of stocking, and stocking density experiments were compared by single classification ANOVA and the T-method for equal sample sizes or the GT-2 method for unequal samples sizes. All statistical analyses followed Sokal and Rohlf (1981) and were performed at the 0.05 level of significance.

RESULTS

Percent ovulation of hormone injected spotted seatrout, percent fertilization of spawned eggs, and larval survival at 2.5 days was highly variable (Table 2). Despite the underestimation of tank-spawned eggs in 1983, the best larvae recoveries (number of larvae/female) were obtained by the hormone-induced tank-spawning method. The high strip-spawning variability in 1984 and 1985 was presumably due to using spotted seatrout which were ineligible for HCG induced strip spawning. Larvae recoveries at 2.5 days ranged 11.4-43.6% and averaged (± SD) 33.4 ± 14.5% and 20.1 ± 14.8% in 1984 and 1985, respectively.

Production and fingerling characteristics (Tables 3, 4), water quality characteristics (Table 5), and zooplankton densities (Table 6), for the data base were also highly variable (Table 7), and reflect differences in spawning methods, fertilizer application rates, larval stocking rates, specific experimental objectives, and seasonal differences in temperature and salinity. Production variability was influenced by differences in water quality and zooplankton densities. However, only salinity demonstrated a qualitative relationship to fingerling survival (Figure 1, Tables 3, 5). Pond culture trials exhibiting mean salinities < 16 o/oo (trials 1-6, 23-28) had a mean ± SD percent yield of 7.1 ± 3.8% (n=12); whereas, culture trials conducted at mean salinities > 16 o/oo (remaining trials) had a mean percent yield of 47.0 ± 20.1% (n=19). The marked reduction in survival at salinities < 16 o/oo was not as apparent for weight/area/day produced which averaged ± SD 1.39 ± 0.91 kg/ha/day in low salinity ponds. In contrast, pond trials with > 16 o/oo salinity averaged ± SD 1.85 ± 0.93 kg/ha/day.

Inoculating ponds with mysid shrimp did not affect spotted seatrout growth or production. Mean ± SD spotted seatrout fingerling yields and weight/area/day produced in mysid inoculated ponds (trials 7-9) was 44.1 ± 26.9% and 2.32 ± 0.92 kg/hg/day, in contrast to 37.9 ± 15.79% and 2.84 and 0.37 kg/ha/day for uninoculated controls (trials 10-12). Individual spotted seatrout fingerlings averaged ± SD 0.24 ± 0.12 g and 30 ± 5.3 mm TL from mysid inoculated ponds, and 0.24 ± 0.08 g and 31 ± 4.0 mm TL from uninoculated control ponds. No significant differences were evident in mean yield ($F_{1,4}$ = 0.010), weight/area/day produced ($F_{1,4}$ = 0.03), or fingerling length ($F_{1,4}$ = 0.068) and weight ($F_{1,4}$ = 0.001) between inoculated and control ponds. Similarly, there were no significant differences in mean salinity ($F_{1,4}$ = 1.010) or dissolved oxygen concentrations ($F_{1,4}$ = 0.001) between ponds. The mean water temperature of the six culture ponds was identical (Table 5). Mysid shrimp were established in inoculated ponds prior to stocking spotted seatrout larvae (Table 8). However, no mysid shrimp were recovered from culture ponds at fingerling harvest.

The time interval between pond preparation and the introduction of spotted seatrout larvae (trials 13-18) affected mean survival. Mean spotted seatrout survival in ponds stocked 18 days after initial filling was a significantly greater than survival in ponds stocked 10 or 26 days after filling (Table 9). Mean total lengths ($F_{5,594}$ = 269.43) and weights ($F_{5,594}$ =

85.70) of individual fingerlings were significantly different between ponds (Table 4). Fingerlings from ponds stocked 10 days after filling were smaller in TL than fingerlings obtained from ponds stocked at 18 or 26 days. However, the different time intervals had no significant effect on weight/area/day produced which averaged ± SD 2.23 ± 0.57 kg/ha/day for the six culture trials. Peak zooplankton densities occurred in the first week after filling for ponds stocked at 10 and 18 days, and in the second week for the 26-day treatment group (Figure 2, Table 6). Temperature ($F_{F,211}$ = 0.828) and salinity ($F_{5,211}$ = 1.732) were not significantly different between the 10-, 18-, and 26-day time interval treatment ponds. However, mean dissolved oxygen concentrations ($F_{5,211}$ = 5.16) were significantly different between treatments (Table 5). Lowest percent yield (24%) was obtained from the pond (Trial 17) with lowest mean ± SD dissolved oxygen concentration (3.3 ± 1.0).

Production results for the variable stocking rate experiment (trials 23-28) were atypically low (Table 3), with percent fingerling yields and weight/area/day produced averaging ± SD 5.9 ± 4.8% and 0.66 ± 0.65 kg/ha/day. In contrast, mean percent survival and weight/area/day produced for the remaining 1985 pond culture trials (n=13) averaged 49.8 ± 20.3% and 1.60 ± 0.77 kg/ha/day. Temperature averaged 29 C in all ponds, whereas salinities ranged 15-16 o/oo and dissolved oxygen concentrations ranged 3.5-4.6 mg/l (Table 5). Although salinity was not significantly different ($F_{5,234}$ = 1.01), dissolved oxygen concentrations differed significantly ($F_{5,234}$ = 8.48) among ponds.

DISCUSSION

Spotted seatrout spawning success was variable in 1984 and 1985. Variability may have been due to the use of fish ineligible for HCG induced strip-spawning. Spotted seatrout spawned in 1984 were randomly selected as part of a spawning study (Colura et al. 1988), whereas only broodfish exhibiting vitellogenic ova averaging > 0.4 mm in diameter were used in 1985. Colura et al. (1988) found successfully spawned spotted seatrout females had mean ova diameters > 0.45 mm. The use of fish with ova diameter < 0.45 mm during both 1984 and 1985 presumably reduced the ovulation and fertilization rates. Tank spawning methods in 1983 provide better fertilization and larvae survival rates than strip-spawning. However, multiple attempts to duplicate the spotted seatrout tank spawning methods used in 1983 have proven unsuccessful (TPWD unpublished data).

Mean survival of spotted seatrout larvae produced by strip-spawning in 1984 and 1985 was 21 and 25%, respectively. The low larval survival may be related to the use of broodfish exhibiting a mean oocyte maturation size < 0.45 mm in hormone induced strip-spawning. Such fish may have had ova with insufficient yolk to allow larvae to survive through mouthpart development. As with egg fertilization, larvae survival may be improved by limiting hormone-induced strip-spawning to broodfish exhibiting a mean oocyte maturation size > 0.45 mm.

Spotted seatrout larval-to-fingerling recoveries have steadily increased over the earliest saltwater pond culture attempts (Colura et al. 1976) when

yields averaged < 3%. Porter and Maciorowski (1984) achieved mean survival to 8.4% by increasing fertilization and stocking after zooplankton population densities had peaked in the culture ponds. Pond management strategies designed to improve zooplankton forage (Geiger 1983 a, b) may have reduced mortality and increased fingerling yields. Continued reliance on similar strategies in 1984 and 1985 provided mean survivals of 41 and 36% of the 2 respective years. Presumably, the fertilization strategy provided sufficient forage for spotted seatrout survival in all ponds. Salinities < 16 o/oo appeared to reduce survival.

Inoculating ponds with a suitable crustacean forage has successfully increased striped bass fingerling production in freshwater ponds (Geiger 1983 a, b). However, attempts to inoculate spotted seatrout culture ponds with saltwater crustaceans have been unsuccessful. Porter and Maciorowski (1984) failed to establish brine shrimp populations in spotted seatrout culture ponds. Mysid shrimp were established in ponds in this study, however, populations were apparently insufficient to affect spotted seatrout fingerling production. Mysid shrimp have a 14-28 day life cycle (Nimmo et al. 1978) relative to a 30-45 day period necessary for spotted seatrout fingerling production. Accordingly, inoculation densities and the time interval between inoculation and larvae introduction were insufficient for mysid shrimp population growth prior to predation by fingerlings. Indeed, establishing reproducing populations of wild caught mysids in production ponds may be impractical. Establishment of a forage pond from which mysids or other suitable crustacean forage may be cultured and used to inoculate spotted seatrout culture ponds may provide a better method of increasing forage.

Significantly greater fingerling yields of spotted seatrout from ponds stocked 18 days post filling was consistent with observations from the entire pond culture data base. Ponds with mean salinities > 16 o/oo and stocked approximately 20 days after preparation yielded fingerling returns of 13-67% (Tables 3 and 5). Reasons for better fingerling yields in ponds stocked at 18, rather than 10 or 26 days are unclear. Previous studies have demonstrated peak zooplankton densities occur approximately 10 days post filling and fertilization (Colura and Matlock 1984). Therefore, ponds stocked 10 days after filling should have provided the best fingerling yields and growth. Failure to achieve greatest yields from ponds stocked 10 days after preparation suggests spotted seatrout fingerling yields are only partially related to available forage.

In general, higher stocking rates resulted in the greatest yields of spotted seatrout at harvest. Similarly, McCarty et al. (1986) obtained greater red drum fingerling yields from ponds stocked at 750,000 and 1,025,000 larvae/ha than from those stocked 500,000 larvae/ha. However, interpretation of the spotted seatrout stocking density experiment was complicated by poor survival.

In conclusion, spotted seatrout culture methods are sufficiently advanced to allow hatchery scale culture of fingerlings. Although spawning success, egg fertilization rates, and larval survival at 2 days remains fairly low, concentrating production effort during peak spawning activity and using only fish with a mean oocyte diameter > 0.45 mm should improve hatchery

returns (Colura et al. 1988). Average fingerlings returns from spotted seatrout culture ponds in 1983-1985 (32%) were lower than the 40-53% fingerling yields reported for red drum (McCarty et al. 1986). However, spotted seatrout fingerling returns are similar to the 30% fingerling recovery rate reported for striped bass (Kerby et al. 1983). Further, 12 of 31 pond culture trials yielded fingerling returns > 40%, suggesting greater production potential than achieved in the overall database. Limiting pond culture of spotted seatrout to periods when salinity exceeds 16 o/oo, and identifying optimum stocking rates should provide overall fingerling yields and production values comparable to those for red drum.

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Table 1. Summary of fertilizer application and larvae stocking rates for 31 spotted seatrout pond culture trials conducted from 1983-1985 at the Texas Parks and Wildlife Department's Perry R. Bass Marine Fisheries Research Station.

Experiment		Trial number	Pond size (ha)	Date of initial filling	Fertilizer			Stocking date	Number of larvae stocked
					CSM (kg/ha)	Phosphoric acid (l/ha)	Urea (kg/ha)		
Brine shrimp inoculation	Treatment	1-3	0.1	14 Jun 1983	568	3.8	1.8	10 Jul 1983	100,000
	Control	4-6	0.1	14 Jun 1983	568	3.8	1.8	10 Jul 1983	100,000
Mysid shrimp inoculation	Treatment	7-9	0.1	27 Jun 1984	598	9.8	4.5	21 Jul 1984	87,500
	Control	10-12	0.1	27 Jun 1984	598	9.8	4.5	21 Jul 1984	87,500
Variable stocking date	10-Day	13-14	0.1	01 May 1985	570	3.8	1.8	11 May 1985	69,000
	18-Day	15-16	0.1	01 May 1985	698	3.8	1.8	19 May 1985	69,000
	26-Day	17-18	0.1	01 May 1985	825	3.8	1.8	27 May 1985	69,000
Seatrout production		19-20	0.2	06 May 1985	506	3.8	1.8	27 May 1985	9,000
		21-22	0.2	06 May 1985	475	3.8	1.8	19 May 1985	14,000
Variable larvae stocking rate		23	0.1	09 Jul 1985	666	3.8	1.8	27 Jul 1985	25,000
		24	0.1	09 Jul 1985	666	3.8	1.8	27 Jul 1985	33,750
		25	0.1	09 Jul 1985	666	3.8	1.8	27 Jul 1985	45,000
		26	0.1	09 Jul 1985	666	3.8	1.8	27 Jul 1985	60,000
		27	0.1	09 Jul 1985	666	3.8	1.8	27 Jul 1985	80,000
		28	0.1	09 Jul 1985	666	3.8	1.8	27 Jul 1985	105,000
Seatrout production		29-31	0.2	12 Jul 1985	697	3.8	1.8	27 Jul 1985	25,800

Table 2. Summary of spawning data and larvae yields for spotted seatrout production from 1983-1985.

	Ovulation and fertilization					Larvae	
Spawning date	Number fish used	Fish ovulated %	Total eggs	Viable eggs	Fertilization %	Number larvae at 2 days	Survival %
08 Jul 1983	5	--	595,000	499,800	84	600,000	>100
28 Jul 1984	7	86	464,000	92,800	20	41,000	44
18 Jul 1984	26	42	3,275,000	2,259,800	69	521,600	23
05 May 1985	16	56	2,496,000	1,577,000	63	137,000	11
16 May 1985	9	78	4,445,000	3,150,000	71	784,000	25
12 May 1985	10	80	1,860,000	517,000	28	200,000	39
Total	35	68	8,801,000	5,244,000	60	1,121,000	21
17 Jul 1985	11	73	866,000	34,000	4	0	0
25 Jul 1985	28	43	3,302,000	1,600,000	48	410,600	26
Total	39	51	4,168,000	1,634,000	39	410,600	25

Table 3. Summary of stocking and harvest data from 31 spotted seatrout pond culture trials conducted at the Texas Parks and Wildlife Department's Perry R. Bass Marine Fisheries Research Station.

Experiment		Trial numbers	Stocking date	Harvest date	Stocking rate (larvae/ha)	Fingerlings harvested	Yield (%)	Production (kg/ha/day)
Brine shrimp inoculation	Treatment	1	10 Jul 1983	01 Aug 1983	1,000,000	9,016	9.0	2.35
		2	10 Jul 1983	01 Aug 1983	1,000,000	8,985	9.0	2.53
		3	10 Jul 1983	01 Aug 1983	1,000,000	5,869	5.8	1.58
	Control	4	10 Jul 1983	01 Aug 1983	1,000,000	9,678	9.7	2.12
		5	10 Jul 1983	01 Aug 1983	1,000,000	11,292	11.3	2.22
		6	10 Jul 1983	01 Aug 1983	1,000,000	5,616	5.6	1.97
Mysid shrimp inoculation	Treatment	7	21 Jul 1984	14 Aug 1984	875,000	12,100	13.8	1.41
		8	21 Jul 1984	14 Aug 1984	875,000	57,000	65.1	3.26
		9	21 Jul 1984	14 Aug 1984	875,000	24,900	53.4	2.29
	Control	10	21 Jul 1984	14 Aug 1984	875,000	49,100	56.1	2.55
		11	21 Jul 1984	14 Aug 1984	875,000	25,400	29.0	2.73
		12	21 Jul 1984	14 Aug 1984	875,000	24,900	28.5	3.26
Variable stocking date	10-day	13	11 May 1985	08 Jun 1985	690,000	32,000	46.4	1.50
		14	11 May 1985	08 Jun 1985	690,000	34,000	49.3	1.85
	18-day	15	19 May 1985	16 Jun 1985	690,000	24,000	63.8	2.55
		16	19 May 1985	16 Jun 1985	690,000	45,000	65.2	3.08
	26-day	17	27 May 1985	25 Jun 1985	690,000	17,000	24.0	1.94
		18	27 May 1985	25 Jun 1985	690,000	29,000	42.0	2.46
Seatrout production		19	27 May 1985	26 Jun 1985	45,000	3,200	35.6	0.79
		20	27 May 1985	26 Jun 1985	45,000	3,800	41.8	0.63
		21	19 May 1985	18 Jun 1985	70,000	17,700	>100.0	1.68
		22	27 May 1985	26 Jun 1985	70,000	3,700	26.4	0.66
Variable larvae stocking rate		23	27 Jul 1985	21 Aug 1985	250,000	1,341	5.4	0.31
		24	27 Jul 1985	21 Aug 1985	337,500	25	--	--
		25	27 Jul 1985	21 Aug 1985	450,000	1,671	5.0	0.44

Table 3. (Cont'd)

	26	27 Jul 1985	21 Aug 1985	600,000	5,910	9.8	0.91
	27	27 Jul 1985	21 Aug 1985	800,000	10,376	13.0	1.84
	28	27 Jul 1985	21 Aug 1985	1,050,000	2,065	2.0	0.44
Seatrout production	29	27 Jul 1985	26 Aug 1985	129,000	11,500	44.6	1.28
	30	27 Jul 1985	26 Aug 1985	129,000	17,300	67.1	1.51
	31	27 Jul 1985	26 Aug 1985	129,000	10,800	41.9	0.87

Table 4. Fingerling characteristics of spotted seatrout from 31 pond culture trials Conducted at the Texas Parks and Wildlife Department's Perry R. Bass Marine Fisheries Research Station 1983-1985. Means followed by the same capital letter represent non-significant ($P > 0.05$) subsets within the designated experiment.

Experiment		Trial numbers	WT (g)	TL (mm)	SL (mm)	Condition factora	Number fingerlings/kg
Brine shrimp inoculation	Treatment	1	0.54 ± 0.07	38 ± 1.9	31 ± 1.7	1.81	1,744
		2	0.67 ± 0.08	40 ± 2.2	33 ± 2.1	1.86	1,613
		3	0.61 ± 0.05	39 ± 1.2	31 ± 1.4	2.05	1,675
	Control	4	0.57 ± 0.06	39 ± 1.8	31 ± 1.6	1.91	2,072
		5	0.43 ± 0.04	35 ± 1.3	28 ± 1.6	1.96	2,309
		6	0.69 ± 0.05	41 ± 1.4	33 ± 1.2	1.92	1,291
Mysid shrimp inoculation	Treatment	7	0.37 ± 0.04	36 ± 1.2	28 ± 1.1	1.68	2,702
		8	0.18 ± 0.02	28 ± 1.2	22 ± 1.0	1.69	5,556
		9	0.16 ± 0.03	26 ± 1.5	21 ± 1.2	1.73	6,250
	Control	10	0.16 ± 0.02	27 ± 0.9	22 ± 0.9	1.50	6,250
		11	0.33 ± 0.04	35 ± 1.4	27 ± 1.1	1.68	3,030
		12	0.24 ± 0.03	31 ± 1.2	25 ± 1.0	1.54	4,167
Variable stocking date	10-day	13	0.16 ± 0.04 A	27 ± 2.7 A	21 ± 2.0	1.73	6,250
		14	0.17 ± 0.04 A	28 ± 2.3 A	21 ± 2.0	1.84	5,882
	18-day	15	0.21 ± 0.04 AB	30 ± 2.2 B	24 ± 2.0	1.52	4,762
		16	0.25 ± 0.05 AB	31 ± 2.2 C	24 ± 2.0	1.81	4,000
	26-day	17	0.44 ± 0.07 B	37 ± 2.4 D	30 ± 2.0	1.63	2,273
		18	0.32 ± 0.04 AB	33 ± 1.5 E	26 ± 2.0	1.82	3,125
Seatrout production		19	1.27 ± 0.21	53 ± 5.7	43 ± 1.5	1.72	729
		20	0.94 ± 0.16	47 ± 5.2	38 ± 2.5	1.71	1,003
		21	0.59 ± 0.07	41 ± 2.2	33 ± 1.7	1.64	1,694
		22	0.53 ± 0.07	40 ± 1.8	32 ± 1.6	1.62	1,887
Variable larvae stocking rate		23	0.61 ± 0.07	42 ± 2.2 I	34 ± 1.8	1.55	1,639
		24	0.68 ± 0.82	43 ± 2.2 I	34 ± 1.8	1.73	1,471
		25	0.68 ± 0.11	43 ± 2.7 I	34 ± 2.2	1.73	1,471
		26	0.40 ± 0.06	37 ± 1.8 H	29 ± 1.6	1.64	2,500

Table 4. (Cont'd)

	27	0.46 ± 0.05	39 ± 1.8 G	31 ± 1.8	1.54	2,174
	28	0.55 ± 0.11	40 ± 2.7 F	32 ± 3.6	1.68	1,818
Seatrout	29	0.69 ± 0.08	45 ± 2.3	37 ± 2.0	1.36	1,449
production	30	0.54 ± 0.08	42 ± 2.9	34 ± 1.7	1.37	1,852
	31	0.50 ± 0.07	41 ± 2.1	33 ± 1.8	1.39	2,000

[a] Condition factor = 105W/SL3 where: W = weight (g) and SL = standard length (mm).

Table 5. Water quality characteristics of 31 spotted seatrout pond culture trials conducted at the Texas Parks and Wildlife Department's Perry R. Bass Marine Fisheries Research Station, 1983-1985. Means followed by the same capital letter represent non-significant ($P > 0.05$) subsets within the designated experiment.

Experiment		Trial numbers	n	Temperature (C) Mean (± SD)	Range	Dissolved oxygen (mg/l) Mean (± SD)	Range	Salinity (o/oo) Mean (± SD)	Range
Brine shrimp inoculation	Treatment	1	23	28 ± 1.3	25-29	4.4 ± 0.72	0.2-5.1	15 ± 5.3	10-26
		2	23	28 ± 1.3	25-28	3.9 ± 0.85	0.2-5.2	15 ± 5.2	10-26
		3	23	28 ± 1.3	25-29	4.3 ± 0.79	0.4-5.8	15 ± 5.0	10-25
	Control	4	23	28 ± 1.3	25-29	4.0 ± 0.92	0.3-5.3	14 ± 5.0	10-26
		5	23	28 ± 1.3	25-29	4.8 ± 0.65	0.2-5.8	14 ± 4.8	10-25
		6	23	28 ± 1.2	25-29	4.0 ± 0.91	0.2-5.5	14 ± 5.0	10-25
Mysid shrimp inoculation	Treatment	7	29	28 ± 0.7	27-29	3.5 ± 1.0	1.4-5.6	34 ± 0.9	32-36
		8	29	28 ± 0.6	27-29	3.5 ± 1.0	1.5-5.6	34 ± 0.9	32-35
		9	29	28 ± 1.0	26-30	3.5 ± 1.2	1.0-6.0	34 ± 1.2	32-35
	Control	10	29	28 ± 0.7	27-29	3.4 ± 1.3	1.7-5.9	34 ± 0.9	32-36
		11	29	28 ± 0.6	27-29	3.4 ± 1.2	1.0-5.9	34 ± 0.8	32-35
		12	29	28 ± 1.0	26-30	3.6 ± 1.2	1.6-4.9	33 ± 1.5	27-35
Variable stocking date	10-day	13	28	26 ± 1.4	23-30	3.8 ± 0.8 AB	1.7-5.3	20 ± 1.1	19-22
		14	28	26 ± 1.3	24-29	4.2 ± 1.0 A	2.6-5.7	19 1.1	18-21
		15	36	26 ± 1.5	23-29	3.6 ± 0.9 AB	1.8-5.4	20 ± 1.3	19-23
		16	36	26 ± 1.5	23-29	3.4 ± 1.0 BC	1.2-5.3	20 ± 1.3	18-22
	26-day	17	44	27 ± 1.5	23-29	3.3 ± 1.0 BC	1.5-5.0	20 ± 3.2	19-22
		18	44	26 ± 1.5	24-29	3.6 ± 0.8 AB	1.4-5.1	20 ± 2.3	17-22
Seatrout production		19	46	27 ± 1.4	24-29	4.4 ± 1.0	2.2-6.2	19 ± 1.0	18-22
		20	46	26 ± 1.4	24-29	5.0 ± 0.7	3.0-6.5	18 ± 5.0	17-21
		21	37	27 ± 1.5	24-29	4.7 ± 1.0	3.0-7.3	19 ± 1.5	17-22
		22	46	26 ± 1.4	24-29	4.8 ± 0.5	3.7-5.9	19 ± 1.4	17-22

Table 5. (Cont'd)

Variable larvae stocking rate	23	40	29 ± 0.8	27-32	4.3 ± 1.2	DF	1.2-6.4	15 ± 3.0	10-20
	24	40	29 ± 0.8	27-31	3.5 ± 0.9	D	1.8-5.6	16 ± 3.3	12-22
	25	40	29 ± 0.9	27-32	3.8 ± 1.0	DE	1.6-5.3	16 ± 3.3	11-22
	26	40	29 ± 0.7	28-31	3.8 ± 1.3	F	2.8-6.4	15 ± 3.0	12-20
	27	40	29 ± 0.8	27-31	3.9 ± 0.8	DE	2.1-5.4	16 ± 3.2	11-22
	28	40	29 ± 0.7	27-30	3.5 ± 0.9	D	1.4-4.4	16 ± 3.6	11-22
Seatrout production	29	31	29 ± 0.5	28-30	4.1 ± 0.6		3.0-5.4	18 ± 2.7	14-22
	30	31	29 ± 0.5	28-30	4.2 ± 0.6		3.2-5.4	18 ± 3.0	14-22
	31	31	29 ± 0.5	28-30	4.3 ± 0.4		3.5-6.0	18 ± 2.9	14-22

Table 6. Grand mean of the weekly mean (± SD) zooplankton for 31 spotted seatrout pond culture trials conducted at the Texas Parks and Wildlife Department's Perry R. Bass Marine Fisheries Research Station, 1983-1985.

Experiment		Trial numbers	Rotifers	Copepod nauplii	Copepod adults and copepodites	Polychaete larvae	Total zooplankton
Brine shrimp inoculation	Treatment	1	160 ± 43	93 ± 35	124 ± 131	9 ± 11	386 ± 183
		2	189 ± 95	121 ± 64	158 ± 107	11 ± 12	463 ± 209
		3	189 ± 50	121 ± 79	151 ± 120	4 ± 4	474 ± 218
	Control	4	154 ± 111	173 ± 130	182 ± 219	4 ± 3	510 ± 303
		5	220 ± 149	208 ± 147	82 ± 87	100 ± 105	606 ± 360
		6	199 ± 88	81 ± 38	75 ± 53	53 ± 43	409 ± 122
Mysid shrimp inoculation	Treatment	7	1096 ± 2296	237 ± 252	304 ± 360	423 ± 466	2038 ± 2222
		8	3802 ± 5649	394 ± 668	308 ± 355	870 ± 1217	5403 ± 593
		9	1419 ± 319	271 ± 338	512 ± 648	1065 ± 2060	3269 ± 3712
	Control	10	2059 ± 5151	510 ± 964	337 ± 420	313 ± 448	3197 ± 5283
		11	1272 ± 2825	286 ± 277	272 ± 343	417 ± 564	2247 ± 2897
		12	1296 ± 3239	217 ± 261	234 ± 268	434 ± 596	2181 ± 3210
Variable stocking date	10-day	13	519 ± 839	132 ± 95	93 ± 125	125 ± 116	872 ± 965
		14	242 ± 399	210 ± 162	77 ± 99	266 ± 522	800 ± 557
		15	275 ± 390	140 ± 109	97 ± 104	240 ± 270	758 ± 457
		16	289 ± 387	142 ± 46	98 ± 117	223 ± 237	754 ± 422
	26-day	17	220 ± 250	157 ± 104	95 ± 99	205 ± 213	679 ± 319
		18	510 ± 1284	145 ± 77	62 ± 45	105 ± 40	824 ± 1291
Spotted production		19	1594 ± 3201	234 ± 141	136 ± 187	243 ± 296	1928 ± 3026
		20	3143 ± 7223	318 ± 373	75 ± 8	112 ± 97	667 ± 554
		21	870 ± 1649	201 ± 175	131 ± 134	30 ± 36	997 ± 1609
		22	2962 ± 7151	295 ± 399	61 ± 90	51 ± 41	3344 ± 7442
Variable larvae stocking rate		23	2207 ± 1778	415 ± 415	300 ± 230	240 ± 278	3165 ± 1768
		24	1129 ± 1278	314 ± 250	913 ± 614	93 ± 99	2454 ± 1810
		25	1969 ± 34812	298 ± 197	824 ± 549	121 ± 126	3219 ± 3626
		26	1934 ± 1729	406 ± 417	276 ± 387	344 ± 211	2961 ± 1609

Table 6. (Cont'd)

	27	1491 ± 2528	236 ± 176	633 ± 602	103 ± 87	2465 ± 2690
	28	2171 ± 2298	311 ± 295	578 ± 460	19 ± 12	3118 ± 2629
Seatrout	29	1302 ± 1277	252 ± 148	104 ± 104	468 ± 437	2137 ± 1412
production	30	1102 ± 1106	290 ± 73	140 ± 209	623 ± 603	2327 ± 1129
	31	1547 ± 1432	307 ± 117	153 ± 136	463 ± 373	2446 ± 1405

Table 7. Grand mean and coefficients of variation (CV) for fingerling production data from 31 spotted seatrout pond culture trials conducted at the Texas Parks and Wildlife Department's Perry R. Bass Marine Fisheries Research Station 1983-1985.

	Percent Yield	Production (kg/ha/day)	Weight (g)	Length (mm)		Condition factor[a]	Fingerlings/kg
				TL	SL		
Mean (± SD)	31.6 ± 25.2	1.69 ± 0.93	0.48 ± 0.25	37 ± 6.5	28 ± 5.5	1.69 ± 0.17	1794 ± 1698
CV	79.95%	55.22%	51.63%	17.52%	19.50%	9.98%	60.76%

[a] Condition factor = $10^5 W/SL^3$ where: W = weight(g) and SL = standard length (mm).

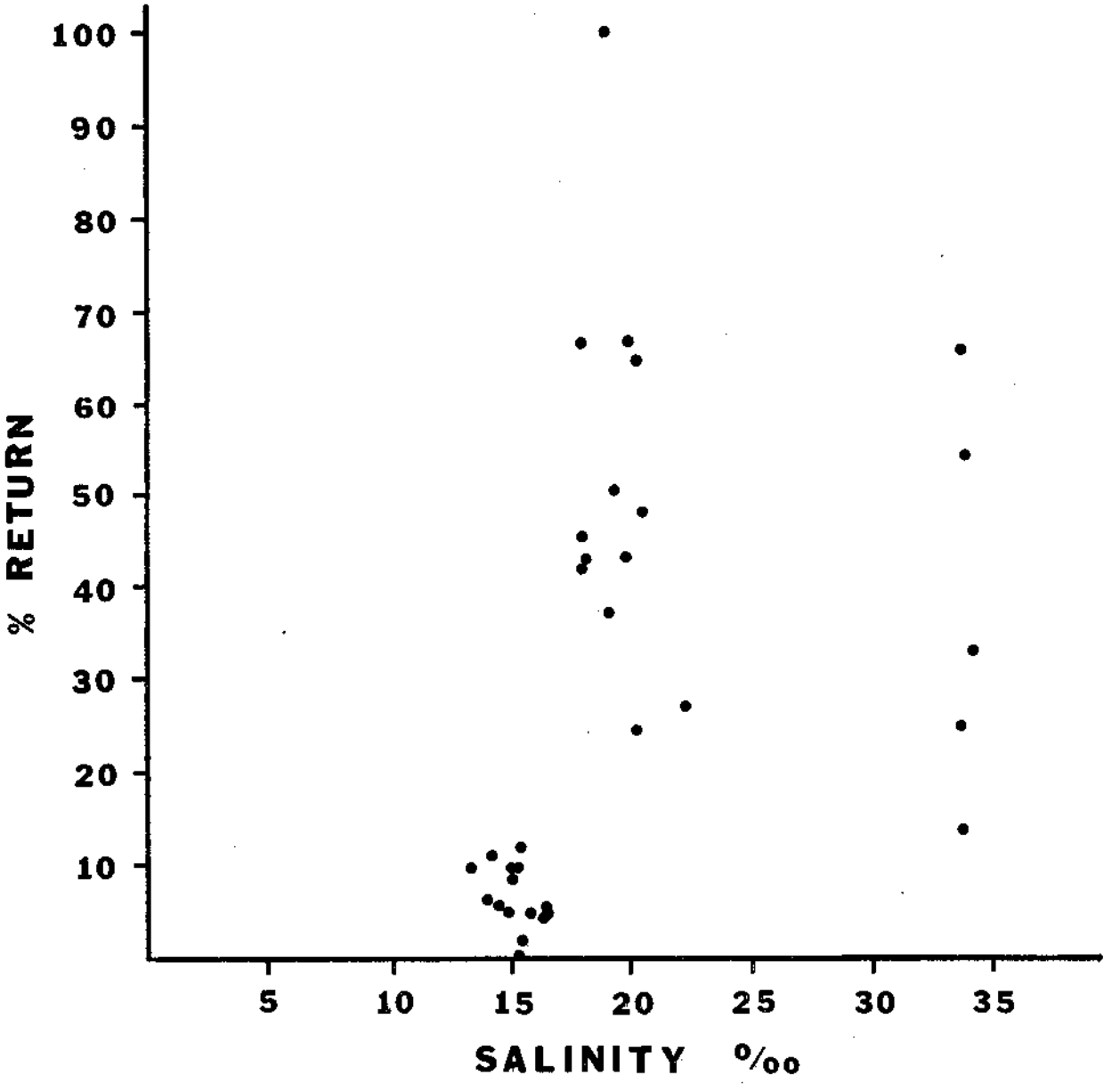
Table 8. Mean (± SD) densities (No./m) of mysid shrimp and common epibenthic organisms in mysid inoculated and control (uninoculated) spotted seatrout culture ponds near the date of larvae introduction (21 Jul 1984) and fingerling harvest (14 Aug 1984).

Treatment	Trial numbers	Sample date	Mysid shrimp	Polychaete larvae	Insects (corixids)	Amphipods
Mysid inoculated	7	23 Jul 1984	3.23 ± 4.26	34.98 ± 33.06	493.09 ± 213.20	1.72 ± 1.29
	8	23 Jul 1984	11.31 ± 16.32	16.59 ± 9.82	472.05 ± 227.59	0.49 ± 0.21
	9	24 Jul 1984	2.83 ± 2.67	12.26 ± 9.90	409.72 ± 124.58	0.31 ± 0.76
			5.79 ± 4.78	21.28 ± 12.06	458.29 ± 43.36	0.84 ± 0.77
Uninoculated	10	23 Jul 1984	0.00 ± 0.00	19.45 ± 11.42	546.20 ± 431.53	0.00 ± 0.00
	11	23 Jul 1984	0.17 ± 0.30	23.52 ± 31.98	559.79 ± 373.84	0.09 ± 0.15
	12	24 Jul 1984	0.00 ± 0.00	47.78 ± 52.80	985.50 ± 712.69	0.13 ± 0.13
			0.6 ± 0.10	30.25 ± 15.32	597.20 ± 249.80	0.04 ± 0.08
Mysid inoculated	7	13 Aug 1984	0	26.56 ± 14.98	6.59 ± 2.03	3.83 ± 2.59
	8	13 Aug 1984	0	95.42 ± 58.28	3.61 ± 1.16	3.65 ± 3.38
	9	13 Aug 1984	0	35.91 ± 17.58	15.67 ± 4.88	16.07 ± 20.78
			0	52.63 ± 37.35	8.62 ± 6.28	7.85 ± 7.12
Uninoculated	10	13 Aug 198	0	72.48 ± 20.80	17.72 ± 16.25	0.00 ± 0.00
	11	13 Aug 1984	0	131.74 ± 36.50	5.95 ± 1.32	1.05 ± 0.13
	12	13 Aug 1984	0	52.38 ± 17.24	3.88 ± 2.70	0.51 ± 0.33
			0	85.53 ± 41.26	9.18 ± 7.46	0.52 ± 0.53

Table 9. Comparison by the T method of mean percent survival and production of ponds stocked at 10, 18, and 26 days after filling.

Days post filling larvae were stocked	Variable	Mean (± SD)	Lower 95% comparison limit	Upper 95% comparison limit
10	Percent	47.5 ± 2.1	42.9	52.1
18	Survival	64.0 ± 1.4	59.4	68.6
26		33.0 ± 12.7	28.4	37.6
10	Production	1.6 ± 0.7	1.3	2.5
18	kg/ha/day	3.2 ± 0.4	2.9	3.8
26		2.5 ± 0.4	1.9	3.1

Figure 1. Percent return and mean salinity from 31 spotted seatrout pond culture trials, Perry R. Bass Marine Fisheries Research Station.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