Spawning and Grow-out Trials with Red Drum in South Carolina

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Abstract: Increasing interest in the farming of red drum (*Sciaenops ocellatus*) has resulted in research and development activities with this species at the Waddell Mariculture Center in South Carolina. Red drum adults were captured from tidal impoundments and held in ponds until being moved to tanks for spawning during their natural reproductive season. Three females averaging 11 kg spawned 9 million eggs, 50% of which hatched. The fry were reared to fingerlings in fertilized ponds. Survival of fry to fingerlings was 24%. Survival of fingerlings through their first winter was 57%. Simultaneously, fingerlings from another hatchery were grown to marketable size at commercial densities in a 0.10- and later in a 0.25-ha pond. Survival of fingerlings stocked in grow-out ponds in the spring was 98% during the first 9 months. During this time, fish grew to 304 grams. Survival was again very high (e.g., 97%) during the second year of grow-out. Fish averaging 1,540 g were produced in 22 months. A total of 783 kg of marketable fish were harvested from a 0.25-ha pond (3,127 kg/ha). Red drum appear to be a viable candidate for commercial cultivation in the Southeastern United States.

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Over the past several years there has been a growing interest in the cultivation of red drum. Increased interest in their cultivation is the result of several interacting factors. In some states, it is felt that wild stocks of *Sciaenops* sp. are declining due to intensified recreational and commercial fisheries and environmental modifications (Van Chau 1982). As a result, fishery management for the species has intensified and stock enhancement programs initiated. Stock enhancement programs have provided the technology for controlled fingerling production and demonstrated the hardiness of the species in captivity. Reduced wild stocks and commercial fishing restrictions have increased the demand for red drum in the market place. Simultaneously, specialty dishes using red drum have become popular in restaurants. The fish commands moderate prices at present ($1.55 to $1.90/kg live weight), but there is speculation that the price may increase dramatically as a result of the factors outlined above. At the same time, the warmwater fish farming industry is seeking alternative species with which to diversify. This report summarizes the initial trials conducted on spawning, fingerling production and grow-out of the species at the James M. Waddell Jr. Mariculture Research and Development Center in South Carolina.

The earliest studies on culturing red drum were conducted by Lunz (1951, 1956) at Bears Bluff Laboratories near Charleston, South Carolina. This work and subsequent work in South Carolina by Bearden (1967) and Theiling and Loyacano (1976) demonstrated the rapid growth rates of red drum in impounded water where wild fish are often recruited. Arnold et al. (1977) and Roberts et al. (1978) developed techniques for controlled spawning of red drum using temperature and photoperiod manipulation. Colura et al. (1976) demonstrated large scale fingerling production in fertilized ponds. Luebke and Strawn (1973) grew wild-caught juveniles in the heated effluent of a power plant. Trimble (1979) grew captive-spawned red drum up to a size of 407 g in managed ponds. Van Chau (1982) and Smith et al. (1985) discussed the current status of redfish culture in Texas and South Carolina respectively.

This report summarizes South Carolina's initial spawning, fingerling production and red drum grow-out oriented toward commercial production of the species and assessment of the potential for stock enhancement. The technique used in the first East Coast spawning of captive red drum broodstock is described and survival of these fingerlings during their first winter is reported. Also described is an initial grow-out trial in which red drum were cultivated to marketable size in a pond at densities comparable to those used for catfish production in the Southeastern United States. The grow-out trial was conducted concurrently with the collection of local broodstock, spawning and fingerling production.

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Methods

Water was drawn from the adjacent high salinity estuarine embayment off Port Royal Sound near its entrance to the Atlantic Ocean. Ponds were lined with 40-mm high density polyethylene. Pond levees had a 3 to 1 slope and a mean depth of 1.3 meters. Pond bottoms were covered with a 26-cm deep layer of sand which served as a natural substrate. Submerged pond levees had a layer of silt deposited on the liner surface and were partially encrusted with barnacles, oysters, tube worms, and benthic algae. Ponds were fertilized with 45 kg/ha of 20-20-5 granular fertilizer and 160 kg/ha Bermuda grass pellets to induce a plankton bloom before stocking fry.

Spawning

Broodstock used in this project had been recruited into brackish impounded water as either fry or fingerlings where they grew to adulthood. Adult red drum were captured with gill nets in a tidal impoundment near Georgetown, South Carolina, during 1984. Additional adults were caught with hook and line during early 1985 in an impounded tidal lagoon on Hilton Head Island, South Carolina, as part of a reward program utilizing recreational fishermen. All adult fish were placed in an 0.25-ha outdoor pond and fed a variety or natural and compounded foods.

Fiberglass tanks were used to facilitate egg collection, enumeration, and hatching. At the onset of the natural spawning season, a group of fish were transferred to a 3.7-m diameter, 1.0-m deep fiberglass tank. The tank received a constant flow of high salinity estuarine water with ambient temperature and an artificial light cycle from fluorescent lighting which simulated natural day length. Tank effluent passed through an egg collector before being discharged. Contents of the egg collector were emptied daily. Eggs were hatched in 1,000-liter fiberglass tanks with conical bottoms. After hatching, ambient sand filtered seawater was used to exchange the tank water. Eggs hatched 24 hours after spawning and 48 hours later, fry appeared ready to feed.

Fingerling Production

Fingerling production methods were very similar to those used by stock enhancement hatcheries. When fry were ready to begin feeding, number of fry was estimated from aliquot samples and they were transferred to fingerling production ponds. Fingerling ponds were stocked at a rate of one-million per ha. Survival of fry to fingerling was determined by harvesting 1 pond prior to the onset of cold weather.

Fingerling Overwintering

A group of fingerlings were restocked in a total of 8 ponds at densities of 9,000, 18,000 and 36,000 /ha for the winter (December 1985 through March 1986). After 4 months, ponds were drained and survival determined.

Grow-Out

The pond grow-out trial was conducted in 2 phases. The first phase was initiated in May 1984. Fingerlings were air-shipped from the TPWD Marine Fishery Research Station near Palacios, Texas, and held in circular fiberglass tanks until they recovered from the stress of shipping. Five hundred fingerlings with a mean size of 32 mm total length, TL and 0.33 g were then stocked into a 0.1-ha pond. In March 1985 (day 280) the 0.01-ha Phase I grow-out pond was drained and the fish harvested. Fish were counted and 17% were individually weighed to determine mean size and production.

In Phase II, a 0.25-ha pond was used. In March 1985, 366 fish from the Phase I grow-out were restocked into the 0.25 ha pond. In July 1985, 367 fish from another age group were added to this same 0.25 ha pond. The second group of fish had been received from the John Wilson Marine Fish Hatchery (TPWD) near Corpus Christi, Texas, and used in tank studies for 6 months before being stocked in the pond. The 0.25-ha pond was harvested in March 1986 and all fish were individually weighed and measured.

Environmental conditions were regularly monitored throughout the study. Surface and bottom temperatures and dissolved oxygen levels were recorded daily at sunrise during the summer and 3 times per week during winter months. Salinity, pH, chlorophyll a, and secchi disc measurements were recorded 3 times per week. Densities of the major zooplankton taxa (rotifers, copepods, polychaete larvae) were determined in fingerling ponds. No water was added the first 28 days. Subsequently, an exchange rate of 50 to 100 liters/minute was established and mechanical aeration was used as needed to control temperature stratification and low dissolved oxygen levels.

Fish were fed 7 days per week with a 32% protein floating fish pellet at a rate which declined over the course of the grow-out period from 100% to 3% of the estimated biomass per day. The pond was fed on a regimented schedule regardless of the presence or absence of feeding activity in an effort to maximize the growth rate.

The processing yields were determined using standard AOAC methods at the Southeast Fisheries Center. Fillet yields and proximate analysis of the raw fillets were evaluated.

Results

Spawning

Spawning was achieved during the natural spawning season using broodstock which had been held in outdoor ponds for 6 to 18 months. On 23 September 1985, fish were swimming on the surface and following one another which is characteristic of the spawning ritual for this species. On 25 September 1985, 7 of the larger fish were captured, weighed, checked for sex and maturation stage, and placed in the spawning tank. On the evening of 28 September and on many evenings thereafter drumming, a courtship ritual (Guest 1978), was heard. On the morning of 29 September 1985 eggs were found in the egg collectors. Spawning continued intermittently for several weeks. Eggs were collected each morning and their numbers estimated before placing them in 1,000 liter conical bottom hatchery tanks. Three female brood fish averaging 11 kg spawned a total of 9 million eggs with 4.5 million viable fry being produced. Water temperatures averaged 24.3° C and salinity averaged 28 ppt during the spawning period.

Fingerling Production

When fry developed mouthparts and were ready to begin feeding, they were transferred to outdoor ponds which had previously been fertilized to induce a plankton bloom. Since more fry were produced than fingerling ponds could accommodate, 1.5 million fry were stocked in the adjacent estuary and 2.0 million into brackish water lagoon systems on Hilton Head Island. Brood fish were returned to the outdoor pond in excellent condition.

Fingerling production in ponds appeared to be good but only 1 pond was harvested before the onset of cold weather. The 0.5-ha pond harvested in the fall had 24% survival yielding 95,200 fingerlings with a mean size of 0.48 g.

Fingerling Overwintering

Dead fish were noted in the unharvested fingerling ponds and density experiment ponds during the coldest portions of the winter. Growth during the colder months was minimal. Fish had concave abdomens and appeared to be starving. Zooplankton was scarce during this time. Some fish were seen consuming the salmon starter ration being provided but the poor condition of the fish indicated that most were not eating. Survival of fingerlings during the 4 winter months averaged 57.4%. Statistical analysis indicated that overwintering survival was inversely related to stocking density (Table 1).

Grow-Out

In Phase I, growth was rapid during most of the year but nearly ceased during the coldest months. Survival was excellent as 98.2% were recovered at harvest.

Table 1. Overwinter survival and growth of 0.5-g red drum fingerlings stocked in ponds for four months at several densities.

Pond size (ha)	Density (*N*/ha)	Stocked (*N*)	Harvest (*N*)	Weight (g)	Survival (%)
0.1	9,000	900	747	1.9	83.0
0.1	9,000	900	768	3.0	85.3
0.5	9,000	4,500	3,315	4.3	73.7
0.1	18,000	1,800	1,187	2.1	65.4
0.1	18,000	1,800	830	1.6	46.1
0.1	36,000	3,600	1,567	1.9	43.5
0.1	36,000	3,600	817	3.4	22.7
0.5	36,000	18,000	10,921	7.4	60.7

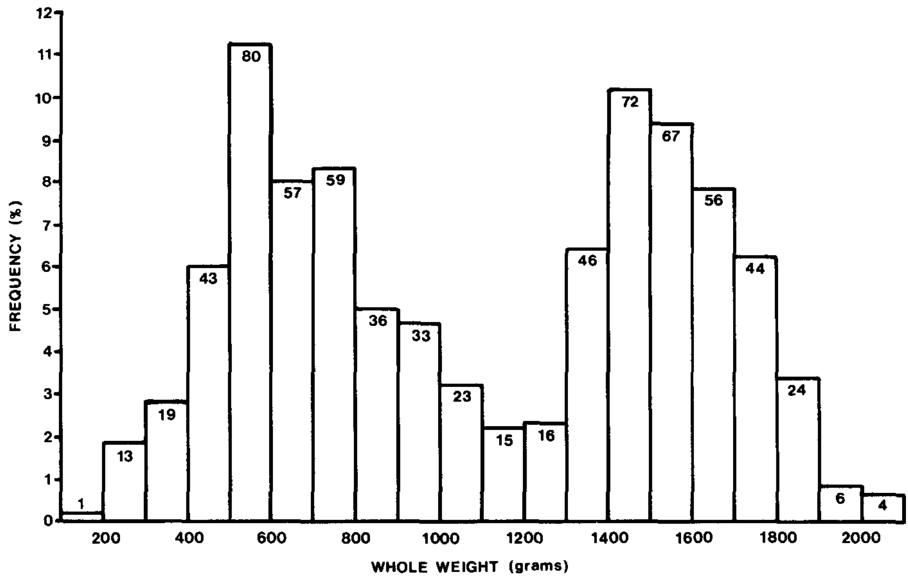

Figure 1. Frequency distribution of red drum at end of Phase II pond grow-out trial including number in each size category.

Table 2. Summary of growth, survival, and production of red drum in Phase I (0.1 ha pond) and Phase II (0.25 ha pond) of grow-out trial.

Date stocked (m/d/y)	Number stocked (*N*)	Mean wt. stocked (g)	Date harvest (%)	Percent survival (%)	Mean wt. harvest (g)	Pond production (kg/ha)
			Phase I			
05/23/84	500	0.3	03/01/85	98.2	304	1,492
			Phase II			
03/01/85	366	303	03/24/86		1,540[a]	
07/24/85	367	116	03/24/86		652[a]	
				97.4[b]	1,095[b]	3,127[b]

[a]Estimated values from length frequency distribution.
[b]Actual total for both groups.

Mean size increased from 0.33 to 304 g during the 9-month period. At harvest, the standing crop was 149.2 kg for a production yield of 1,492 kg/ha in the 0.1-ha pond.

Growth and survival during Phase II was again very encouraging. Survival during Phase II was 97.4%. Mean weight for all fish in the pond was 1,095 g. The 2 groups of fish form prominent nodes in the size frequency distribution (Fig. 1). If we assume similar survival and minimal overlapping of sizes within the 2 groups, the mean size for the 2 populations would be 652 and 1,540 g. Thus, the older group of fish grew from 303 to 1,540 g in 11 months and the younger group grew from 116 to 652 g in 8 months. Standing crop at harvest was 781.8 kg in the 0.25 ha pond or 3,127 kg/ha (Table 2).

Temperatures ranged from 4° to 30° C over the course of the trial with an overall mean of 22° C. Salinities ranged from 20 to 34 ppt with an overall mean of 29 ppt. Dissolved oxygen levels ranged from 0.1 to 10.4 ppm with an overall mean of 5.5 ppm. The pH range was 7.5 to 8.9 with a mean of 8.1. Secchi disc visibility ranged from 1.6 to 0.3 m with a mean of 0.8 m. Chlorophyll-a ranged from 2 to 390 ppm with a mean of 30 ppm.

Little effort was made to maximize feed efficiency during the grow-out trial. Overall feed conversion during Phase I was 5.2:1. A heavy accumulation of anaerobic organic material was noted on the pond bottom at harvest. This fact, coupled with the high feed conversion rates indicated the fish were grossly overfed much of the time. During Phase II, slightly improved feed management and use of a paddlewheel instead of fountain-type aerator to mix the water prevented the accumulation of excessive organic material on the pond bottom. Feed conversion during Phase II was 3.3:1.

Discussion

Spawning

Although the technology of controlled maturation and spawning of red drum in tanks has been developed and refined by others (Arnold et al. 1977, Roberts et al. 1978), pond maintenance and conditioning of brood stock has not been previously reported. While the approach presented here is fairly simple, it does not accommodate out-of-season spawning or the option of completing more than one spawning cycle per year.

Fingerling Production

Fingerlings red drum were readily produced in fertilized ponds stocked with newly hatched fry. Colura et al. (1976) reported survival rates ranging from 2% to 65% with a mean of 20% during 1-month fingerling production trials. In the present study, fingerlings harvested here after 2 months had a survival rate of 24%.

Fingerling Overwintering

The presence of dying fish in the ponds through the winter when zooplankton levels were low indicated that fingerlings which were not weaned onto dry rations may suffer mortalities through starvation or intolerance of low temperatures. The relationship between stocking density and overwinter survival may have indicated that food availability was a major factor.

The high rate of survival of weaned juveniles through the winter when water temperatures were as low as 4° C indicates that winter-kill is not a problem for slightly larger fish. Lunz (1951) noted that a pond fish kill at 4.4° C included one red drum. However, Bearden (1967) noted that red drum were moribund but none died in a fish kill involving several other species at 0.8° C. Trimble (1979) reported overwintering survival rates of 82% for 11.5 g juveniles exposed to temperatures as low as 2° C at 6 ppt salinity. Van Chau (1982) cites unpublished data indicating red drum will die at 6° C and below in salinities of 12 to 14 ppt.

Grow-Out

Although fish used in this grow-out trial had been spawned out of season, yearly growth rate was similar to that reported for wild fish by Pearson (1929). Growth rates of these fish were considerably below that reported by Theiling and Loyacano (1976) using otolith annuli of impounded red drum. Luebke and Strawn (1973) also reported much faster growth rates in the heated discharge of power plants. Smith et al. (1985) reported a growth rate for a group of wild-caught fish held in a heated tank which was very similar to the Phase II grow-out reported here. However, the Phase I grow-out had faster growth and higher survival than a corresponding tank grow-out trial reported by Smith et al. (1985). At 1 year of age, these fish were smaller than those described by Bearden (1967) but were of similar size at nearly 2 years of age. Growth rates in this study were very similar to those reported by Trimble (1979).

The 3,127 kg/ha pond production in this grow-out trial was higher than any previously reported and similar to catfish production rates at similar management intensities. Lunz (1951, 1956) and Bearden (1967), working with fish recruited into tidal impoundments had low total production of red drum. Trimble (1979) reported standing crops as high as 2,292 kg/ha. Absence of severe water quality deterioration during this trial indicated that maximum carrying capacity of the pond had not been approached.

At harvest the fish appeared very healthy. All had heavy fat deposits along the abdominal wall. No annelid or crustacean parasites were observed in any harvested fish. Bearden (1967) also noted similar fat deposits and the absence of parasites in pond raised red drum. Fish in this trial were not checked for the various bacteria, dinoflagellates, protozoans, and fungi reported by Trimble (1979) but the high survival rate indicated that disease was not a serious problem.

Conclusions

There is much work to be done before red drum farming can become a commercial reality. However, trials presented here demonstrated several important factors relative to the prospects for this species: 1) broodstock were maintained and conditioned to spawn during their natural reproductive season in outdoor ponds, 2) unweaned fingerlings, while readily cultured throughout most of the year, were subject to winter kill in saltwater ponds as the result of lower temperature tolerance and/or starvation, 3) juvenile fish weaned to pelleted rations were not subject to winter kill through disease or temperature intolerance, 4) red drum reached a marketable size (454 g) in slightly more than one year and 1,540 g fish were produced in 22 months, and 5) pond production as high as 3,127 kg/ha was demonstrated. The absence of disease problems or severe water quality deterioration in the pond trial suggested that higher production levels may be possible.

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