Overwintering of South Carolina and Texas Stocks of Fingerling Red Drum

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Abstract: South Carolina and Texas red drum (*Sciaenops ocellatus*) fingerlings were compared to evaluate pond overwintering characteristics. Red drum from each hatchery stock were spawned in September 1987 and fry were reared in outdoor earthen ponds. Red drum fingerlings (mean ± SD total length (TL) South Carolina fish 50.5 ± 4.9 mm; Texas fish 48.3 ± 4.4 mm) were transferred to 6 0.2-ha saltwater ponds in November 1987, and ponds were harvested in March 1988. The lowest water temperature encountered was 3.0° C on 10 January 1988. Survival was similar between Texas (91.7% ± 13.9%) and South Carolina (83.5% ± 6.6%) fingerlings. Production (kg/ha/day) was also similar between the 2 stocks. Fish grew at equal rates over the production period; at harvest, mean TL of South Carolina fish was 87.7 ± 11.9 mm, TL of Texas fish was 83.7 ± 11.2 mm.

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Red drum are important sport fish along the Gulf of Mexico and Atlantic coasts of the United States (Matlock 1984). Development of controlled spawning techniques (Arnold et al. 1977), hatchery-scale fingerling production (Colura et al. 1976, McCarty et al. 1986), and overfishing of Texas red drum populations (Matlock 1983) have resulted in the implementation of red drum stocking programs in Texas (Dailey and Matlock 1987).

Red drum populations from different geographic locations may possess different traits that make them more or less suited to the goals of a specific stocking program. In particular, Gulf coast red drum suffer periodic winter kills due to low water temperatures (Gunter 1941, Gunter and Hildebrand 1951, McEachron et al. 1984); the more northerly distributed Atlantic coast red drum may be less susceptible to low water temperatures (Bearden 1967). Identification of a potentially cold-tolerant red drum could increase the survival of stocked fish used for population enhancement in Texas.

The Texas Parks and Wildlife Department (TPWD) maintains hatchery stocks of adult red drum from the Atlantic (South Carolina) and Gulf (Texas) coasts in controlled tank systems at the Gulf Coast Conservation Association/Central Power

and Light Marine Development Center (MDC), Corpus Christi, Texas. In 1985, TPWD initiated a series of studies to compare thermal tolerance between the 2 stocks. The specific objective of this study was to evaluate survival, growth, and production of South Carolina and Texas red drum fingerlings overwintered in marine culture ponds. This study was conducted with partial funding from the U.S. Department of the Interior, Fish and Wildlife Service under DJ 15.605 (Project F-36-R).

Methods

The study was conducted at the TPWD Perry R. Bass Marine Fisheries Research Station (MFRS), Palacios, Texas, from September 1987 to March 1988. South Carolina broodstock was obtained from a saltwater impoundment near North Island, held at the Waddell Mariculture Center in Bluffton for approximately 1 year, and transported to MDC in October 1985. Texas broodstock was obtained from Matagorda and Corpus Christi bays and transported to MDC. Adults from the 2 geographic populations were held in separate recirculating tanks. Each hatchery stock spawned 19–20 September 1987, and fry were transported to MFRS and cultured in separate 0.1-ha ponds from 22 September to 18 November following the general methods of McCarty et al. (1986). Commercial salmon starter (Silver Cup, Murray Elevators, Murray, Utah) was offered daily at 6.0 kg/ha, beginning 2 weeks post-stocking.

The 0.1-ha ponds were harvested 18 November, and 2,000 randomly selected Texas red drum (mean ± SD total length (TL) 48.3 ± 4.4 mm) were stocked in each of 3 0.2-ha ponds (10,000/ha). Three additional 0.2-ha ponds were each stocked with 2,000 randomly selected South Carolina red drum (mean TL 50.5 ± 4.9 mm). Fish were stocked by weight, and the number of fish was estimated by dividing the mean individual weight of 100 measured fish into the total harvest biomass. Fish were fed 5.0 kg/ha trout feed 5 days/week when afternoon water temperatures were >14.0° C. Two 4 × 30-m sections of 1.9-cm mesh floating plastic netting were placed on each pond to discourage piscivorous birds. Twenty fish were obtained from each pond on 20 January 1988 to estimate growth. Ponds were harvested 17 March 1988; TL and weight (W) of 100 fish from each pond were recorded. The total number of fish recovered from each pond was estimated as previously described.

Pond salinity, temperature, and dissolved oxygen were recorded daily between sunrise and 0900 hours. Salinity was measured with a salinity meter, water temperature and dissolved oxygen were measured with a dissolved oxygen meter.

All statistical tests were performed with the Statistical Analysis System (SAS Inst. Inc. 1985) at the 0.05 level of significance. Mean values ± SD were calculated for each variable tested. Student's *t*-test was used to compare production (kg/ha/day) and survival between stocks at harvest. As South Carolina fingerlings were slightly larger than Texas fingerlings at study initiation, growth (TL and W) was compared between stocks and ponds (within stocks) with a nested analysis of covariance. Water temperature, salinity, and dissolved oxygen over the production period were similarly compared with a nested analysis of variance (ANOVA).

Table 1. Mean ± SD total length, weight, survival and production of South Carolina (N = 300) and Texas (N = 300) red drum fingerlings following overwintering (18 Nov 1987–17 Mar 1988). Mean ± SD temperature, salinity and dissolved oxygen over the culture period. Means with a letter in common are not significantly different.

	South Carolina	Texas
Total length (mm)	87.7 ± 11.9 A	83.7 ± 11.2 B
Weight (g)	6.4 ± 2.7 A	5.8 ± 2.2 B
Survival (%)	83.5 ± 6.6 A	91.7 ± 13.9 A
Production (kg/ha/day)	0.42 ± 0.06 A	0.43 ± 0.05 A
Temperature (°C)	13.3 ± 4.09 A	13.3 ± 4.04 A
Salinity (ppt)	25 ± 1.1 A	25 ± 1.1 A
Dissolved oxygen (mg/liter)	8.9 ± 1.22 A	8.7 ± 1.22 A

Results

Overwinter survival was not significantly different ($P > 0.392$) between South Carolina and Texas red drum (Table 1). As 107% survival was calculated for 1 pond (possibly because of the procedure used to estimate stocking rates; there was no access between ponds), this survival percentage was considered to be 100% in all calculations. Production was not significantly different ($P > 0.944$) between the 2 stocks. Analysis of covariance indicated that South Carolina fingerlings were significantly ($P < 0.001$) larger and heavier than Texas fingerlings from stocking through pond harvest (Table 1), but that both stocks grew at equal rates.

Mean pond temperature and dissolved oxygen did not differ between stocks or individual ponds within stocks during the production period (Table 1). Pond water temperatures fluctuated between 3.0° C on 10 January and 20.6° C on 25 November 1987 (Fig. 1). Dissolved oxygen ranged from 4.1 to 12.0 mg/liter. Salinity was not significantly different between Texas and South Carolina ponds ($P > 0.339$), but was significantly different ($P < 0.001$) between individual ponds within stocks (0.7 ppt maximum difference).

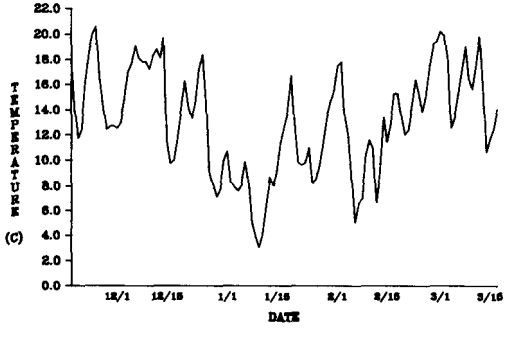

Figure 1. Mean daily water temperature (°C) of 6 0.2-ha saltwater culture ponds stocked with South Carolina or Texas red drum from 18 November 1987 to 17 March 1988.

Discussion

Red drum population enhancement depends on the ability of the species to tolerate low temperatures in production ponds and shallow estuarine bays. In addition to genetic control of thermal tolerance, the response of a fish to low temperature is influenced in part by its previous thermal history, the rate of temperature decline, and the length of time exposed to the low temperature (Fry 1971). Water quality characteristics such as salinity, water hardness, and chloride levels also can influence thermal tolerance.

Both South Carolina and Texas red drum exhibited high survival rates when overwintered in 0.2-ha ponds along the mid-Texas coast. Although the lowest pond water temperature encountered was 3.0° C, water temperature over the previous 14-day period ranged from 4.8° to 10.9° C. The gradual rate of temperature decline combined with the lengthy exposure to low temperatures before experiencing 3.0° C may have afforded fish time to acclimate sufficiently to the cold January temperatures. Similarly, Hopkins et al. (1988) reported 80.7% survival of red drum (0.5 g) overwintered in South Carolina culture ponds under temperature conditions comparable to those of this study. In late January, water temperature declined to 4° C, and temperatures over the previous 28-day period ranged from approximately 6° to 12° C. In contrast, a February 1989 cold front in which water temperature declined from 19.7° to −0.1° C over a 5-day period caused total fish mortality in a MFRS pond stocked with 43 sub-adult (mean TL 522 mm) South Carolina and Texas red drum (Procarione 1990).

These results agree with experimentally determined lower lethal temperatures of red drum. Procarione and King (1989) found the median lower lethal temperature (LT_{50}) of 18.0° C acclimated red drum to be 4.6° and 4.3° C for South Carolina and Texas fish, respectively. However, the LT_{50} of 12.0° C acclimated red drum (the treatment most comparable to the current study) could not be determined; most fish survived the direct transfer to low temperatures.

Fish kills caused by low bay water temperatures have been reported periodically along the Texas coast (Simmons and Breuer 1962, McEachron et al. 1984), but the estimated temperatures at which red drum have been killed vary. Mass mortality of Texas red drum was observed along the Gulf coast during an early winter cold front in 1940 in which water temperatures dropped to 3.8° C (Gunter 1941). An equally severe cold front in 1951 had less effect on sciaenid populations, possibly due to its being the third front of the season as opposed to the first (Gunter and Hildebrand 1951). Moore (1976) reported the lower lethal temperature of red drum to be between 4° and 7° C from observations along the Texas coast. In December 1983, an estimated 90,000 red drum were killed in Texas bays (McEachron et al. 1984) when water temperatures remained below 2.8° C for 13 consecutive days (Corpus Christi bay). Bay temperatures had been warm prior to the cold front, and fish had little time to acclimate or move into deeper waters. On the Atlantic coast, however, Bearden (1967) reported complete red drum survival in saltwater impoundments after water temperatures fell to approximately 0.8° C over a 3-day period. The previous thermal history of the fish was not stated.

A laboratory experiment that simulated temperature conditions in Texas bays during an overwinter freeze resulted in average ± SD survival rates of 76.0% ± 32.8% and 52.0% ± 32.4% for South Carolina and Texas fingerlings, respectively (Procarione 1989). Water temperature was lowered from 18.0° to 2.8° C over a period of 11 days and then remained below 4.8° C for 5 consecutive days. Most mortalities occurred 3–10 days after low temperatures were encountered, suggesting a delayed response to low temperature conditions or an inability to withstand low temperatures for an extended time period. In the current study, however, water temperature increased steadily (approximately 1.2° C/day) and reached 12.5° C within 1 week of the low temperature experience.

Neither South Carolina nor Texas red drum exhibited superior survival, production, or growth during the low temperature conditions of this pond study. However, the effects of acclimation state, rate of temperature decline, and temperature/salinity interactions on pond overwintering of red drum remain poorly defined; further pond and laboratory studies may help clarify these relationships. No recommendation to stock 1 group in preference to the other can be made at this time.

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