Overview of Finfish Aquaculture Research at South Carolina's Marine Resources Research Institute

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ABSTRACT

The State of South Carolina is committed to the development, demonstration and promotion of aquaculture. This is evidenced by the recent construction and staffing of the James M. Waddell, Jr. Mariculture Research and Development Center in Bluffton, and the continuing activities at the Charleston Laboratory. Aquaculture emphasis with finfish is primarily focused on the identification and demonstration of culture species and systems which can utilize native species and enhance the state's economy. In particular, current activities are focused on: (1) species which can be farm-reared as an aquafood product; (2) species which may be used to increase both public and private recreational fishing opportunities; and (3) species which may be used for stock enhancement or rehabilitation purposes. This paper provides: 1) a brief description of the MRRI aquaculture facilities and capabilities; and 2) an overview of the various finfish aquaculture programs.

INTRODUCTION

The State of South Carolina is fully aware of the potential impact that aquaculture development could have on the state's economy. This awareness was manifested recently by the construction of the James M. Waddell, Jr. Mariculture Research and Development Center in Bluffton, South Carolina. The mission of this facility, under the direction of the Marine Resources Research Institute (MRRI), South Carolina Wildlife and Marine Resources Department, is to develop and demonstrate aquaculture in its broadest sense. The resources of this facility in conjunction with those of MRRI's Charleston Laboratory are focusing on finfish, crustaceans and molluscs of present and potential economic and recreational value.

Aquaculture research with marine and anadromous finfish species are underway for a variety of purposes. These range from providing basic culture and life history data for an endangered species, to development of marketable seafood products. The remainder of this manuscript identifies finfish species of current development interest, provides rationale for their selection, and discusses research progress.

SOUTH CAROLINA MRRI AQUACULTURE FACILITIES AND PERSONNEL

Charleston Laboratory

Located in Charleston, South Carolina (Fig. 1) the Charleston Laboratory has identified aquaculture as a major focus for research and development activities. Facilities consist of two major wet laboratories (total area approximately 555 m^2) as well as several dry support laboratories and staff offices. Tanks housed in these laboratories range in size from 80 l aquaria to 20,000 l rectangular raceway tanks (Fig. 2). For the most part, independent and/or interconnected recirculated water systems are utilized and salinity can be regulated from freshwater to full strength seawater. Additionally, plastic covered and exposed outdoor tanks, varying in size from 4,000 l rectangular concrete tanks to 40,000 l cylindrical fiberglass tanks, are used to supplement the indoor facilities. These tanks can be supplied with freshwater or saltwater (or a mixture) and operate in a partial flow-through or fully recirculated mode. Operation of the Charleston Laboratory is under the direction of MRRI's scientific staff.

James M. Waddell, Jr. Mariculture Research and Development Center

The primary mission of this facility is to encourage, develop and demonstrate aquaculture of native and non-indigenous aquatic species of importance to South Carolina. Cooperative activities in research and education are conducted in conjunction with various state agencies and institutions including the Department of Agriculture, Clemson University, University of South Carolina and the South Carolina Sea Grant Consortium. Provisions for hands-on training in aquaculture techniques for both the private sector as well as students are available. Additionally, extension services provided at this facility are used to supplement those from other state programs.

The Center is located on a 486 ha state managed site along the Colleton River in Bluffton (3 miles from Hilton Head Island) (Fig. 1). Current facilities encompass 20 ha with 41 ha available for future expansion. The facilities of the Waddell Mariculture Center (WMC) include: 1) a 930 m^2 research building which provides indoor hatchery and laboratory space and houses staff personnel; 2) a 2,508 m^2 outdoor pad which contains a variety of large tanks for outdoor research; 3) a 243 m^2 controlled environment building for maturation studies; 4) a series of ponds consisting of 12 ponds 0.10 ha in size, 9 at 0.24 ha, and 3 at 0.51 ha (Fig. 3); 5) a conference/dormatory building capable of providing sleeping accommodations for 17 persons; and 6) a 81 m long pier which allows direct access to the Colleton River for launching of small boats and for <u>in situ</u> research studies. Both freshwater and seawater are available to all culture systems. Continuous management and security of the facilities is provided by a resident manager who lives in an

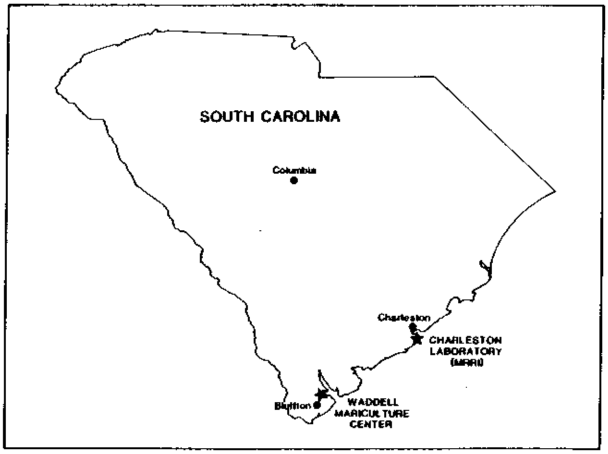

Figure 1. Map of South Carolina showing location of the Marine Resources Research Institute's Charleston Laboratory and the James M. Waddell, Jr., Mariculture Research and Development Center.

Figure 2. View of culture tanks in one of the wet labs at the Marine Resources Research Institute's Charleston Laboratory.

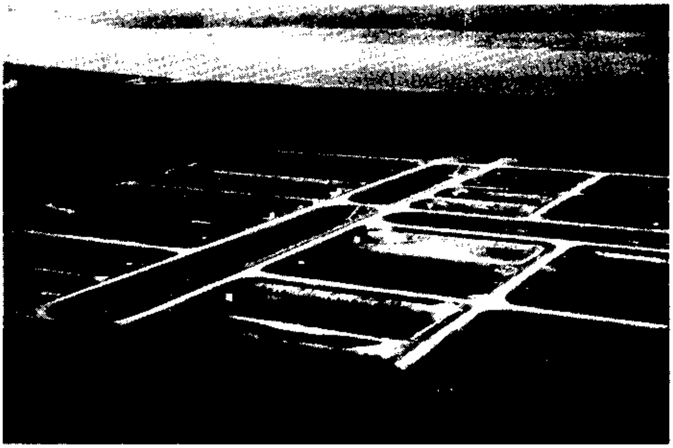

Figure 3. Ponds used for aquaculture research at the James M. Waddell, Jr. Mariculture Research and Development Center in Bluffton, S.C.

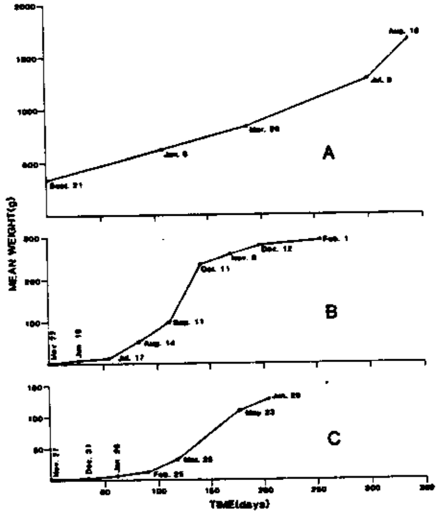

Figure 4. Growth curves for captive red drum, Sciaenops ocellatus. A - growth of wild-caught juveniles in an indoor tank which utilized recirculated water; B - growth in an outdoor pond which used small juveniles from hatchery-produced fry; C - growth of cultured juveniles in an indoor tank trial which used flow-through ambient temperature brackish water. Note decreased growth rates in B and C during cooler months.

on-site residence.

Personnel

Guidance and direction for aquaculture activities are provided by MRRI Ph.D. level scientists in conjunction with investigators from associated institutions. Personnel expertise are quite varied and include: finfish, crustacean and molluscan aquaculture; fisheries management; phytoplankton ecology; marine chemistry; statistics; systems design; information and education services; genetics; economics; product processing and marketing, etc. Thus, the State of South Carolina, through its inter-coordinated multi-disciplinary approach, has the facilities and personnel to develop aquaculture to its fullest potential.

FINFISH RESEARCH

Besides aquaculture education and information services which are provided by MRRI, a number of finfish species have been selected for development activities. Rationale for the selection of these species and a summary of current research activities are provided below:

Family Acipensereidae

The two indigenous species of sturgeon in South Carolina were once commercially harvested in this State. Currently, the smaller (maximum size ~1.1 m in total length) shortnose sturgeon (Acipenser brevirostrum) is listed as an endangered species in the United States (Miller, 1972) and considered rare and possibly threatened in Canada (McAllister, 1970). The larger (adult size range ≥ 2-3 m in length) Atlantic sturgeon, A. oxyrhynchus, is prized for its eggs ("caviar") and flesh and is still harvested in several Atlantic coast states and in Canada (Smith, 1985). However, this species has been severely depleted over its entire range and many states have enacted legislation to protect remaining stocks (Smith, 1985). Similarly, South Carolina which had been the major producer of this species in recent years (Smith et al., 1984) has recorded greatly depressed landings, and beginning in 1986 the commercial fishery will be closed until further notice.

Efforts to culture sturgeons began in the late 1800's and early 1900's in an effort to replenish diminishing stocks (Ryder, 1890; Cobb, 1900; Stone, 1900). Unfortunately, such efforts were of only limited success as early workers had great difficulty in obtaining simultaneously ripe male and female sturgeon (Dean, 1894; Leach, 1920; Smith and Dingley, 1984). The use of pituitary glands and hormones to induce final ripening of fish has, to some degree, alleviated this problem, but obtaining ripe brood stock is still a major constraint for both shortnose and Atlantic sturgeon.

Shortnose sturgeon, which inhabit major river systems, are often a serious concern in evaluating site selection for various industrial purposes. Further, little is known of their life history, ecology and abundance in the southeastern U.S. The purpose of our research is to provide such information as well as to develop culture systems for use in mitigation and stock enhancement programs. In South Carolina, mature shortnose sturgeon, which range in weight from 1.1 to 5.1 kg (61 to 83 cm TL), are obtained from commercial shad (Alosa sapidissima) fishermen who catch sturgeon incidentally in their gill nets. During 1984 and 1985 substantial progress was achieved in spawning and rearing this species (Smith, Dingley, Lindsey, Van Sant, Smiley and Stokes, 1985) and approximately 6,000 fingerlings were released for stock enhancement purposes. Current research is continuing development of suitable culture techniques and identification of acceptable environmental parameters. These data, coupled with our field studies, are providing basic information on the ecological requirements and habitats of South Carolina's only federally listed endangered fish species.

Research on Atlantic sturgeon is aimed at development of culture techniques for use in stock enhancement and restoration programs. The average size of spawning female Atlantic sturgeon in South Carolina during 1978-1982 was 85 kg (200 cm FL; 17.2 years of age) while males were 41 kg (157 cm FL; 12.1 years of age) (Smith et al., 1984). Mature fish are now difficult to obtain as commercial landings are depressed in neighboring states and the fishery is closed in South Carolina. This species was successfully spawned in 1979 using injection of sturgeon pituitary glands (Smith et al., 1980), but since then the lack of ripe fish has slowed hatchery development activities. Collection efforts for brood stock are being expanded and wild-caught juveniles are being reared in captivity to determine if they can be grown to a mature size.

Family Sciaenidae

Two indigenous species are of current interest: red drum Sciaenops ocellatus (= spottail bass, channel bass, redfish); and spotted seatrout, Cynoscion nebulosus (= speckled trout, winter trout, spotted weakfish). Of these, the red drum is more attractive for development purposes. The red drum is a highly popular recreational species throughout the South Atlantic and Gulf of Mexico and historically it has been of substantial commercial importance particularly in Florida (primarily west coast), Louisiana and Texas (Mercer, 1984a). Average total U.S. commercial landings during 1980-1982 were 1,336 metric tons. Recreational landings far exceed the commercial harvest and during 1980-1982 the recreational catch was estimated at 5,984 metric tons (Mercer, 1984a). In the Gulf of Mexico a sports fishermen group (the Gulf Coast Conservation Association) continues to lobby for regulations on the commercial harvesting of red drum. Thus far, this group has succeeded in establishing a commercial harvesting ban in Texas since 1981 and in Alabama in 1985. These restrictions have resulted in increased market demand and higher prices for red drum which is highly prized by restaurants (Barnett, 1985).

Culture emphasis with this species in South Carolina is two fold: 1) to produce small fingerlings for enhancement of recreational fishing in coastal impoundments and inshore waters; and 2) to determine the aquaculture potential of rearing red drum as a food fish. Such objectives parallel those of the State of Texas which has focused on this species for a number of years. The stocking of a marine finfish species to enhance wild stocks has not been attempted in South Carolina. However, red drum have been stocked in coastal waters in Texas by the Texas Parks and Wildlife Department (TP&WD) for the past ten years. During 1975-1982 there was a combined stocking of approximately 56 million red drum as eggs (15%), fry (80%), and fingerlings (5%) (Mercer, 1984a). In 1983, the John Wilson Marine Fish Hatchery (TP&WD) produced over 6.1 million fingerlings in three rearing cycles and in 1984 a similar number were produced from two rearing cycles (McCarty et al., 1985). These fish were used for stocking purposes and a recent news release (in May, 1985) from TP&WD indicated that the catch rates of recreational fishermen in some stocked bays were several times higher than those in nonstocked areas along the coast. Thus, it appears that hatchery-produced fingerlings may contribute to a sport fishery. Although the results of this stocking program are not conclusive, the success in Texas is being watched by a number of coastal states, including South Carolina, which may also consider large-scale stock enhancement programs in the future. Limited stocking programs with this species in South Carolina were initiated in 1985. In time, depending on results of in-state activities and ongoing studies in Texas, the South Carolina stocking program may be expanded to include coastal impoundments, bays, sounds and other coastal waters.

Studies on the grow-out of red drum were begun in 1947 in South Carolina with tidally stocked wild fish (Lunz, 1951). Similar studies continued through 1967 (Lunz, 1956; Bearden, 1967) and in 1976, Theiling and Loyacano indicated that red drum could grow rapdily in coastal impoundments at low density. Based on a small sample size and using otolith aging techniques, they estimated that 1 year old impounded fish in South Carolina averaged 950 g (range 800-1,070 g). At about this time, mass spawning techniques were demonstrated for red drum in Texas and Florida using manipulation of temperature and photoperiod (Colura, 1974a; Arnold et al., 1977; Roberts et al., 1978a). Concurrent with the controlled reproductive studies, Colura et al., (1976) showed that fingerlings could be produced from fertilized earthen ponds. Since then, there have been additional reports on the production of fingerlings and food fish under various conditions (Roberts et al., 1978b; Trimble, 1979; Crocker et al., 1981; Hysmith et al., 1982; Van Chau, 1982; Chamberlain, 1984; Lee et al., 1984). However, substantial research and development efforts are still required to demonstrate the commercial feasibility of farming this species.

In 1974 and 1976, spawning trials were initiated with this species at MRRI, but limited facilities at that time prevented success. In 1982, wild red drum (mean weight 344 g) were gill-netted and stocked in an indoor tank to examine growth and survival of these captive fish. Of the 31 fish captured, ~17% suffered substantial damage to the fins and body due to blue crab (Callinectes sapidus) predation while the fish were in the gill nets. These fish were stocked in a 3.7 m diameter x 0.7 m deep fiberglass tank connected to a recirculated brackish water system. Fish were initially fed a choppped squid and fish diet and then weaned to a commercial trout ration (38% protein) over a two month period. Fish were irregularly sampled over a 340-day period to obtain growth and survival data. During this time temperature averaged ~22°C (range 19-26°C) and salinity averaged ~25 ppt (range 14-30 ppt). Fish grew rapidly and attained a mean size of 1.66 kg by day 340 (Fig. 4A). All mortalities occurred prior to the first sample (day 107) and were primarily the result of the original capture damage and/or due to the inability of some fish to transfer to a pelleted ration. At termination of this 340-day trial biomass was 5.4 kg/m^3 and survival was 83.9%.

More recently, several rearing experiments have been conducted at the Waddell Mariculture Center using fish originating from the Texas Parks and Wildlife Department. On May 22, 1984, small red drum (mean size 0.3 g) were stocked in a 0.1 ha pond at a density of 5,594 fish/ha (2,264/a) and fed a trout ration. On day 142 (October 11) mean fish weight had increased to 237 g and the estimated standing crop was 1,309 kg/ha. Fish were reared for an additional 119 days, but due to the decreased water temperatures during October to February, mean size increased to only 287 g (Fig. 4B) and biomass increased to 1,584 kg/ha (1,411 lb/a). Survival during this 261-day study was 98.6%. Several tank studies have been conducted using small fingerlings (mean size 0.3 to 1.7 g) stocked at densities ranging from 90-120 fish/m^3. In these studies growth was rapid and approximated that observed in the pond trial (Fig. 4C). In contrast to the pond trial, however, survival of the small fingerling was poor (range 20-55%) and such fish appeared susceptible to disease, especially after sampling. Standing crops of 5.1 to 8.5 kg/m^3 were obtained during these 7 month studies which included about 3.5 months of cold water temperatures.

Spawning trials are underway in South Carolina using wild-caught adults which have been held in ponds for 3-14 months. On September 25, 1985 three females (mean size 11.0 kg, range 9.4-12.8 kg) and four males (mean size 7.9, range 6.3-7.4 kg) were stocked in an indoor 3.7 m diameter x 1.4 m deep tank supplied with flow-through seawater (salinity 30-31 ppt). Between September 28 - October 17 these fish produced a total of 8.6 million eggs (mean 537,011 eggs/spawning day) and spawned on 16 days of the 20-day period. Water temperature on successful spawning days ranged from 23.5°C to 25.0°C. Sac-fry have been stocked in fertilized ponds and the resulting fingerlings will be used in a variety of grow-out trials in spring, 1986.

Work in South Carolina and elsewhere suggests that S. ocellatus is an excellent species for aquaculture. Red drum can be spawned throughout the year using environmental manipulation and fingerlings can be produced in managed ponds. Also, substantial progress is being made in development of intensive nursery systems. These fish are hardy and can grow under a broad range of environmental conditions including nearly freshwater and very high salinity water (50 ppt). They can tolerate temperatures of 2-36°C, although the lower lethal temperature may be higher (7°C) when the fish are reared in freshwater (Chamberlain, 1984). Fish can be reared to a market size of about 454 g in one year at reasonably high population densities and market demand is high. Value of the fish has increased substantially in recent years and is expected to continue as commercial landings are restricted (Barnett, 1985). Thus, this species appears to possess many of the qualities of a desirable aquaculture species. Culture research needs to be focused on demonstration of production levels under different culture conditions and the identification of nutritional requirements of this species.

The spotted seatrout, Cynoscion nebulosus, is an important recreational and commercial species from Maryland to Texas. In 1980 U.S. commercial landings were 1,966 metric tons as compared to 9,448 metric tons for the recreational catch (Mercer, 1984b). Major producing states are Florida (west and east coasts), Texas, Louisiana, and to a much lesser degree, North Carolina. Commercial harvesting of this essentially non-migratory estuarine species has been banned in Texas (since 1981) and in Alabama (beginning in 1985). Of the sciaenid landings, total value of spotted seatrout landings has ranked third behind croaker and weakfish since 1977. Value of landings in 1982 was $3 million.

Researchers in Texas have successfully induced spotted seatrout to spawn and have developed techniques for repeated spawning of adults and production of juveniles (Colura, 1974b; Arnold et al., 1976). More recently, laboratory studies have examined growth of larvae in relationship to temperature, prey species and concentration, and stocking densities (Taniguchi, 1979; Houde and Taniguchi, 1982). Limited data on pond rearing of seatrout is available (Colura et al., 1976; Sackett et al., 1979).

Although no programs are presently planned, South Carolina has some interest in this species for possible stocking programs. Limited research on the spawning of wild-caught fish and the production of juveniles in tank and pond nursery systems was begun in June, 1985. Captured wild-fish, which had been tank and pond held for several months, were used in the spawning trials. Females with ripe gonads were injected with human chorionic gonadotropin (HCG) at a rate of 1,100 IU/kg body weight and held separate from ripe males. However, attempts to strip these females after 27 and 33 hours post-injection were unsuccessful. An additional group of females were similarly injected with HCG and stocked in a tank with ripe males. Approximately 36 hours later eggs were observed and screened from the discharge water and hatching began 49 hours post-injection. Approximately 400,000 sac-fry hatched of which 200,000 were stocked in a 0.24 ha pond which had been fertilized to induce a zooplankton bloom. The remainder of the hatch was stocked into natural waters and also placed in indoor nursery tanks which received either a culture of rotifers or concentrated natural zooplankton. The number of fry in the indoor tanks declined rapidly and by day 16 less than 5% survival was noted. The zooplankton in the ponds exhibited peaks and declines and the number of observed larvae steadily declined. During the second to third week salmon starter meal was added as a supplemental feed, but the fish appeared not to accept it. The pond was drained on day 116 and only 1,200 fish were recovered. These fish ranged in weight from 1.7 to 37.7 g and stomach analyses of the larger fish indicated that cannibalism was occurring.

At present this species has a lower priority as an aquaculture candidate as it is highly cannibalistic, susceptible to handling stress, and less tolerant of broad environmental conditions. However, research with this species will be continued on a limited scale.

Family Percichthyidae

The striped bass, Morone saxatilis, and its white bass (M. chrysops) hybrids are being examined as aquaculture farm-reared food products. The striped bass and its white bass hybrids are of major recreational importance in the United States and have been stocked into various lakes and coastal areas including 57% by area of the nation's reservoirs (Stevens, 1984). Striped bass is also a major commercial species from North Carolina to Massachusetts, but landings have drastically declined to less than 15% of their 1973 level. In an effort to preserve and enhance existing stocks various regulations have been established which include closed areas and seasons, and even total fishing moratoriums (Atlantic States Marine Fisheries Commission, 1981, 1984). Striped bass command a high price and live cultured fish have been sold for $13.20/kg in speciality markets in California and New York (Swartz, 1984). This high market demand coupled with wild product unavailability offers a strong incentive for the development of aquaculture. Research in South Carolina and elsewhere has shown that the striped bass/white bass hybrids exhibit hybrid vigor (Ware, 1975; Kerby et al., 1983a; Smith, Jenkins and Snevel, 1985) and that they can be reared under a broad range of environmental conditions. Further, these hybrids appear to serve as a market substitute for striped bass.

Studies at MRRI are focused on development of controlled maturation systems for spawning cultured striped bass and white bass, demonstration of intensive nursery systems for rearing juveniles, comparison of culture characteristics of various striped bass hybrids, and identification of hybrid production levels in ponds under various stocking and salinity regimes. The controlled maturation studies are intended to allow production of fry before they could normally be produced from wild-caught ripe fish. Currently, wild spawning stocks are used to support U.S. hatchery operations which are generally owned by state and federal governments. These government hatcheries have difficulty meeting their fish requirements and do not provide fish to the private sector (American Fisheries Society, 1983). This lack of seed stock was identified by the Joint subcommittee on Aquaculture of the Federal Government (1983) as a major constraint to the development of commercial striped bass aquaculture.

Substantial progress has been achieved in demonstrating that striped bass and white bass can be cultured in recirculating water systems and that manipulation of photoperiod and temperature in indoor systems can be used to induce maturation of striped bass before the natural spawning season (Smith and Jenkins, 1985; in press). Trials conducted during 1985 resulted in the tank spawning of hormone-injected (HCG) striped bass and production of reciprocal cross striped bass/white bass hybrids (female white bass x male striped bass) through manual stripping techniques. Expanded research efforts are planned during 1986 and 1987 as more of the cultured striped bass reach sexual maturity (~4-5 years of age for females, ~2-3 years of age for males).

Development and demonstration of indoor intensive nursery systems for bass is underway so that fry from domesticated brood stock can be reared to a small fingerling size early in the season when outdoor temperatures are not suitable for pond nursery systems. In this manner, the natural growing season could be more fully utilized as fingerlings would be available to stock grow-out systems at the onset of suitable outdoor rearing temperatures. Research to date in our laboratory and elsewhere indicates that such systems show high potential and can result in survival rates comparable to those obtained in pond nursery systems (Lewis and Heidinger, 1981; Carlberg et al., 1984; Smith and Jenkins, 1985). MRRI nursery systems are characterized by stocking of high population densities, feeding of dry and soft-moist diets at frequent intervals (5-7 minutes), use of recirculated brackish water (5-10 ppt salinity), and daily tank maintenance. Initially, *Artemia* nauplii are fed at a concentration of about 10/ml and various natural foods (clams, squid) and dry and soft-moist rations are used to supplement the *Artemia*. Over the first three weeks the concentration of *Artemia* is decreased and the supplementation with other foods is increased. By the fourth/fifth week small juveniles are feeding on strictly prepared rations and are ready for stocking grow-out systems. In the nursery systems, cannibalism can be a major problem and result in substantial mortality (Braid and Shell, 1981; Smith and Jenkins, 1984). Frequent feeding of acceptable and nutritious feeds coupled with grading and good water quality can help reduce losses due to cannibalism.

Comparable indoor tank studies with striped bass and striped bass hybrids have shown that striped bass/white bass hybrids (original and reciprocal crosses) are well suited for aquaculture development (Table 1) (Smith, Jenkins and Snevel, 1985; Smith and Jenkins, in press). These hybrids grow rapidly, have high survival rates, tolerate wide environmental conditions, and can be grown in various systems ranging from net-pens to ponds (Williams et al., 1981; Kerby et al., 1983a, b; Woods et al., 1983; Collins et al., 1984). These fish can be grown on available trout rations with feed conversions of approximately 2.0-2.5 and controlled tank studies have demonstrated standing crop levels up to 43.1 kg/m^3 (Table 1) (Smith, Jenkins and Snevel, 1985). Current efforts are continuing on the controlled spawning of domesticated broodstock, development of intensive nursery systems, and the documentation of pond production levels of striped bass/white bass hybrids when reared at different population densities and salinities. Economic feasibility studies will be coupled with these research and development activities to assess the commercial potential of hybrid bass aquaculture in the southeastern United States.

SUMMARY

The State of South Carolina has undertaken an active role in the development of finfish aquaculture. Increased commercial and recreational fishing pressures coupled with alterations and degradation of natural ecosystems has resulted in lower abundance of many native stocks of fishes. As a result, commercial landings are depressed and various future management regulations may place further restrictions on landings. Consequently, more fishery products are imported to satisfy U.S. consumers and the national trade deficit becomes further unbalanced. Similarly, the increased popularity of fishing coupled with an ever-increasing number of recreational fishermen has resulted in substantial harvests of fish. In most cases, such increased fishing pressure translates into more restrictive fishing regulations and lower catch rates for recreational anglers.

At present, South Carolina aquaculture programs are focused on: 1) food fish production either directly, through the culture of a farm-reared product or indirectly, through native stock enhancement programs, and 2) increasing the opportunity for and the quality of coastal recreational fishing. Fish species currently selected for aquaculture development in South Carolina fit these objectives.

The State of South Carolina is primarily an agriculture state and thus an excellent site for development of aquaculture. Here, there is an abundance of upland and coastal areas for location of facilities and the numerous rivers and reservoirs provide an abundance of water resources. Further, due to recent economic problems with agriculture there is a large available work force. Finally, the state has demonstrated a commitment to aquaculture development by the establishment of various research and development facilities and the staffing of such facilities with highly qualified personnel.

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Table 1. Stocking and harvest data for controlled grow-out trials in tanks with striped bass and its hybrids (SB=striped bass, *Morone saxatilis*; WB=white bass, *M. chrysops*; WP=white perch, *M. americana*).

	Stocking Data			Harvest Data			
	Density Fish/m^3	Mean weight (g)	Duration (days)	Survival (%)	Mean weight (g)	Density (kg/m^3)	Feed conversion
Study I							
Striped bass	35.3	30.0	219	74.6	592.9	15.6	
F_1 hybrid bass (SB X WB)	65.8	46.6	302	78.4	835.4	43.1	
Study II							
Striped bass	31.6	4.4	287	95.9	289.3	8.8	2.32
F_1 hybrid bass (WB X SB)	31.6	6.4	287	100.0	506.6	16.0	2.21
F_2 hybrid bass (SB/WB X SB/WB)	31.6	12.8	287	84.2	346.7	9.2	2.67
Study III							
F_1 hybrid bass (SB X WB)	31.6	23.3	140	99.1	262.5	8.3	1.95
F_1 hybrid bass (SB X WP)	31.6	21.5	140	99.1	175.6	5.5	2.50

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