Stock Enhancement Research with Anadromous and Marine Fishes in South Carolina

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Abstract

South Carolina's Marine Resources Research Institute (Department of Natural Resources) has been active in stock enhancement research since 1985. Initial efforts focused on a semi-anadromous endangered species, shortnose sturgeon *Acipenser brevirostrum*. Spawning, hatchery, and rearing techniques were developed using broodstock acquired from the Savannah River (the boundary river between South Carolina and Georgia), and over an 8-year period nearly 100,000 progeny (18.7% of which were tagged) were released back into that river. Stocking site, season, and fish sizes were varied in order to develop an optimal stocking protocol, and a number of studies were conducted to determine the best tagging method(s). A recent study designed to evaluate the success of the stocking program indicated that 38.7% of the adult population in the Savannah River is now comprised of stocked fish, and that the stocked fish have matured and are participating in spawning migrations. However, while wild fish generally do not leave their natal river, identifiable stocked fish have been captured in several other systems up to 278 km away from the mouth of the Savannah River. Data indicate that these wandering fish were almost exclusively individuals stocked at advanced ages and thus they may not have imprinted on the target river.

Since 1988, stock enhancement research has been conducted on a recreationally important and overfished sciaenid species, red drum *Sciaenops ocellatus.* Photothermal conditioning permits precise control of tank spawning in any season. Stocking studies, which are ongoing, have been conducted in a number of estuaries. It has been verified that fish stocked at a size >100 mm TL do appear in angler creels when they achieve the minimum legal size, but that they are relatively expensive to produce. Less expensive early age 0 (~2 mo, 20-55 mm TL) fish are now being stocked. They can be effectively marked, stocked, and their dispersal pattern determined. They also appear in angler creels in large numbers. Optimal stocking density has been estimated, and up to 78% of the legal fish in study areas have been identified as stocked fish. Controlled stocking in certain index areas has produced strong evidence that wild fish are supplemented rather than replaced by stocked fish.

A recent (2001) stock enhancement research program has been initiated for cobia *Rachycentron canadum*. About 1,500 tagged juveniles (~5 months old) were released into Port Royal Sound, SC, the estuary from which the broodfish were obtained. These were the first cobia stocked on the east coast of the U.S. This program has generated a great deal of interest from local angling clubs and fishing guides, and a number of these groups have provided labor and/or funds to assist the project. Near-term plans for research on this species include refinement of spawning methodology and growout techniques, as well as additional stocking activities. to elucidate early life history characteristics.

Introduction

South Carolina (SC) has been a pioneer in marine and estuarine stock enhancement research. Significant regional involvement dates to the mid-1960's and was focused on production of striped bass *Morone saxatilis* and its hybrids (especially white bass *M. chrysops* hybrids). The work was performed by staff of the Wildlife and Freshwater Fisheries Division of the South Carolina Department of Natural Resources (SCDNR). Development of a hormone based technique for spawning striped bass was a major breakthrough (Stevens, 1967) and formed the foundation for expansion of production activities. Although originally stocked to control gizzard shad *Dorosoma cepedianum*, the striped bass has become a premier freshwater game species. Based on the early work in South Carolina and neighboring states, striped bass and its hybrids are now stocked in estuaries, rivers, lakes and reservoirs throughout the United States (Bailey, 1975; Axon and Whitehurst, 1985).

Interest in stocking coastal rivers and estuaries began in 1985 with the establishment of a cooperative program between SCDNR and the United States Fish & Wildlife Service (USFWS). This program, conducted by the Marine Resources Research Institute (MRRI), Marine Resources Division, was broad based and examined the life history, ecology and potential for stock enhancement of the endangered shortnose sturgeon *Acipenser brevirostrum.* Stocking of this amphidromous fish occurred during the period 1984-1992, but funding for sampling to evaluate the success of the stocking program occurred only from 1990 to early 1993, and then again in 1997-2000. Fortunately, in the interim, other monitoring projects have provided substantial information on the occurrence and impacts of the stocked fish.

Decline in abundance of red drum *Sciaenops ocellatus* has been a major concern among fishery managers from the mid-Atlantic to the Gulf of Mexico for almost two decades. This species formerly supported substantial commercial and recreational fisheries from North Carolina (NC) through Texas (TX), and now all commercial fisheries have either been closed or severely restricted (Mercer, 1984; Matlock *et al.*, 1987; Goodyear, 1991; Wenner, 1992). Recreational anglers have also been impacted as evident by the increasingly restrictive size and creel limits that have evolved [1 fish/day in Florida (FL) and NC; 2 fish/day in SC]. In the most recent red drum virtual population analysis (VPA) the estimated escapement to spawning stock was 17% (Vaughan and Carmichael, 2000). This is an improvement over the previous estimate of 10% escapement in the 1993 VPA. However, even though escapement is slowly increasing, abundance of the population segment available to anglers (primarily subadults) appears to be declining, at least in SC (C. Wenner, SCDNR, Charleston, SC, personal communication). The current fisheries recruitment model suggests that a target escapement level of 40% is needed for a healthy population. Thus, it appears that full recovery of stocks through conventional management approaches will require a long time frame.

In 1988, MRRI initiated its first stock enhancement program with a marine species, red drum, to evaluate the use of hatchery fish as an additional management option. Initial stocking studies focused on use of larger juveniles which could be externally tagged. Results indicated that these fish survived and entered the creel of anglers as well as the adult population. Efforts then shifted to the use of smaller (~20-55 mm TL) juveniles that could be produced in larger numbers and at lower cost. These fish were marked with oxytetracycline-HCL (OTC) as well as genetically tagged. Using these smaller fish, it is now possible to stock 1–1.5 million/year as part of the research program, as compared to tens of thousands of larger fish.

During 2001, success in spawning and culturing cobia *Rachycentron canadum* has provided the opportunity to begin work with this highly migratory coastal species. This species, which has been reported to grow to a size of about 47 kg, inhabits most tropical, subtropical and warm temperate waters throughout the world (Shaffer and Nakamura, 1989). It is a prized game and valuable commercial species throughout its range. In spite of its high value as a seafood, landings are typically low and consist primarily of incidental captures. In the U.S. during 1998, combined landings from the Atlantic coast and Gulf of Mexico was approximately 150 mt with a value of about US $600,000 (Mills, 2000). Cobia inhabit SC waters during May to September (Bearden, 1961), but are absent during winter months. When here, they are the focus of specialty fishing, especially when aggregated for spawning. In conjunction with the local angling community, ~4-month old juveniles were tagged and stocked during fall 2001, around the time of their natural southern migration.

This manuscript provides a summary of the findings from the coastal stocking programs involving shortnose sturgeon, red drum and cobia.

Materials and Methods

General

The stocking programs were conducted under the auspices of MRRI. Stocking efforts were controlled as possible and performed in a fashion that has been described as the "responsible approach" by Blankenship and Leber (1995). In the case of the shortnose sturgeon, spawning activities took place at the Orangeburg National Fish Hatchery, SC (Smith, 1990; Smith and Jenkins, 1991; Smith *et al.*, 1993). Production of juveniles occurred at several USFWS hatcheries as well as MRRI's Charleston facilities and at the Waddell Mariculture Center (WMC), Bluffton, SC (Smith *et al.*, 1995). Red drum were spawned in Charleston and the juveniles produced in ponds at WMC (Smith *et al.*, 1999; 2001). Cobia spawning and production of juveniles occurred at WMC (Dodd, 2001).

Wild broodstock were used in all studies and were replaced during successive years of study. Released fish were marked and performance of marks/tags was documented. General health of fish was visually assessed before release. As possible, fish were held for several days to a week after marking to allow recovery before release into the wild. Samples from stocking groups were retained to assess tag retention or to validate biological marks, and to provide an estimate of post-stocking mortality. Tag recovery typically involved fishery independent as well as fishery dependent techniques. When external tags were used, tags contained reporting information as well as the offer of a reward.

Shortnose Sturgeon

The stocking research with shortnose sturgeon represents the first major effort in the U.S. with an acipenserid since the turn of the century. During 1984-1992, a state/federal program was conducted to evaluate the potential of enhancing/restoring populations of shortnose sturgeon through releases of hatchery reared fish (Smith and Jenkins, 1991; Smith *et al.*, 1995; Collins *et al.*, 1999). The Savannah River (Fig. 1) was chosen because ripe broodstock were obtainable but abundance of juveniles appeared low. A total of 97,483 sturgeon were stocked in the Savannah River. Of the fish released, 79,270 (81.3%) were untagged small juveniles (age 2-10 weeks, mean 41 mm TL, range 17-70 mm). They were stocked during 1984-1990 (except 1986). These fish were in excess of hatchery holding capabilities and were stocked in response to federal

directives. In addition, 18,213 juveniles were marked and released during 1986-1992 (except 1987). These fish varied substantially in size (mean lengths of different groups ranged from 76 to 762 mm TL) and ages (2.5 months to 3 years old). The largest and oldest fish were extras to a program focused on development of domesticated breeding stock. The types of marks used varied as did the longevity of retention and detection (Collins *et al.*, 1994; Smith *et al.*, 1990; Smith *et al.*, 2002a).

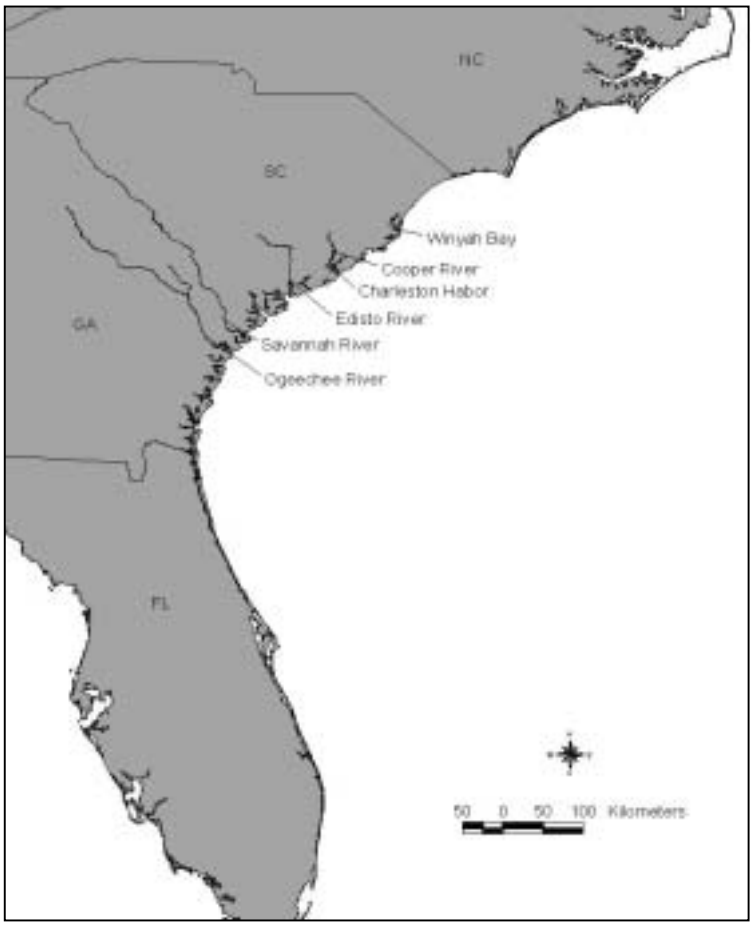

Figure 1. Map of Southeast United States showing locations where stocked shortnose sturgeon were captured.

Program components included examination of various stocking issues including: season of stocking; area of stocking; size of fish at stocking; retention and impacts of various marks; and movement of stocked fish (Smith *et al.*, 1995; Smith and Collins, 1996). Broodstock were obtained from the bycatch of the commercial American shad *Alosa sapidissima* gill net fishery and from directed sampling with gill nets and trammel nets. Directed sampling for stocked fish ended in January 1993, shortly after the stocking activities were concluded. Directed sampling in the Savannah River resumed during 1997-2000 using gill and trammel nets. In the interim, bycatch data collected from the commercial American shad fishery was used to monitor the population.

During 1994-2000, gill net collections targeting sturgeons and American shad were conducted in the Edisto River, SC (Smith *et al.*, 2002b) (Fig. 1). Sampling was limited to river kilometer (rkm) 23 to 36, but due to the limitations of the gear (drifting gill net with varying mesh sizes), rkm 28 was the primary sampling area. The area of rkm 28 typically coincided with the vicinity of the saltwater/freshwater interface. Besides this directed effort, commercial American shad fishers in the Edisto River had been keeping records of incidental captures of sturgeons since 1979. Shad fishers reporting sturgeon captures in the Edisto and other SC river systems typically used gill nets with 13.3 cm stretch mesh webbing, which effectively captured adult shortnose sturgeon. Bycatch information was also provided by participants in other fisheries (e.g., commercial shrimp *Penaeus* spp. trawl fishery). Directed sampling for sturgeons was also conducted in the Ogeechee River, Georgia (GA) (Fig. 1). During 1993-1998 (excluding 1996), 46 m long trammel nets (7.6 cm stretch inner and 38.1 stretch outer mesh) were used, while in 1999-2000, 27 m long anchored gillnets of varying mesh sizes (1.9 to 8.9 cm stretch mesh) were fished.

Red Drum

Research on red drum stock enhancement spans over a decade in SC. Initial work during 1988-1992 focused on identification of predictable spawning and juvenile production techniques and development of stocking protocols for juveniles (Smith *et al.*, 1992). Of substantial importance during this period was identification of tagging techniques for advanced juveniles and an evaluation of tag retention and reporting of tagged fish by anglers (Smith *et al.*, 1997; Jenkins *et al.*, 2000; Denson *et al.*, 2002). Evaluation of impacts was based on fishery independent (trammel netting) data coupled with fishery dependent (angler tag returns) data. During the mid-1990's, studies began to examine the impacts of stocking small red drum, as was being done in TX (Matlock, 1990; McEachron and Daniels, 1995; McEachron *et al.*, 1995; 1998). At this time, a chemical mark (OTC) was approved for use with red drum under an investigational new animal drug (INAD) permit issued by the U.S. Food and Drug Administration (FDA). Small fish could be more cheaply produced and thus more fish could be used in the stocking studies. Refinement of the marking technique was done and the retention of marks validated (Jenkins *et al.*, 2002). Small juveniles (20-45 mm TL) were produced in ponds out of season (May- June) and during the normal spawning season (August-October) and marked with OTC. After marking, fish were returned to a recovery pond for a week before stocking in Callawassie Creek, a tributary of the Colleton River and part of the Port Royal Sound estuary. This creek was located near the production facility. During 1995-1997, 1.7 million fish were released. Data on movements, contribution, growth, and sex composition were determined primarily from samples collected with trammel nets. Information obtained from trials conducted during spring 1995 are not included as marking, stocking, and sampling protocols were being developed during this period.

Current activities are examining the critical issue – "do stocked fish supplement a population or displace native fish." The Charleston Harbor estuary was selected for this study as there is an 8-year historical data base on red drum abundance based on a stratified random trammel net survey. Data were summarized for red drum less than 450 mm TL for nets set in 1 m depth or less water for the period July - December. Mean catch per unit effort (CPUE) for the Ashley River ranged from 0.3 to 1.4 fish/net set while the mean CPUE for the Wando River ranged from 1.2 to 8.4 fish/net set (Fig. 2).

These data support the hypothesis that the Ashley River has a much smaller population of age 1 red drum than does the Wando River. Due to the wide differences in the CPUE data, these two rivers were selected to examine the question of supplementation or displacement of wild fish by hatchery produced fish in a "degraded habitat" (Ashley River) and in a "healthy habitat" (Wando River). Fish were stocked over a 15 km reach of the river. The maximum potential nursery area was calculated over this distance using GIS technology. This calculation was made by adding the total coverage of *Spartina alterniflora* and the area of tributaries within the marsh while excluding the area covered by main river channel. Using this technique the stocked area of the Ashley River was estimated to contain a maximum of 980 ha of potential nursery area while the stocked area of the Wando River contained 2,903 ha. The Ashley River has been stocked for three years (1999-2001) with 617-687 fish/ha while the Wando River was stocked at a lower density of 118 and 177 fish/ha in 2001 and 2000, respectively (Table 1). Impacts are being evaluated based on recruitment of age 1 fish (~350 mm TL). Only results from the first year's stocking in the Ashley River are available.

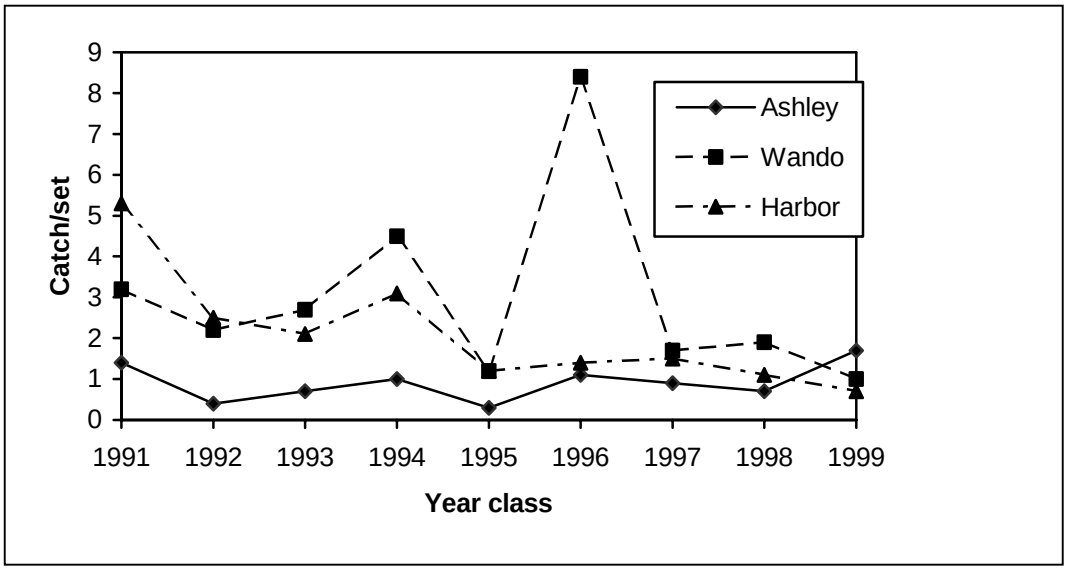

Figure 2. Random catch/unit effort data for age 11-16 month red drum collected in three areas of the Charleston Harbor estuary from each year class between 1991 and 1999. Hatchery fish (30 mm TL) were stocked in the Ashley River in the 1999 year class.

Table 1. Number released, mean total length and stocking density for red drum marked released each fall (Sept.- Nov.) in the Ashley and Wando Rivers between 1999 and 2001.

	Ashley River			Wando River		
Year	Number	Mean length (mm TL)	Density (n/ha)	Number	Mean length (mm TL)	Density (n/ha)
1999	617,190	30.0	630	-	-	-
2000	604,884	23.5	617	513,920	23.5	177
2001	673,751	20.8	687	344,949	20.4	118

Cobia

In the US, research with cobia has relied on field capture of wild fish as it has only been very recently that this species has been spawned in captivity and progeny produced (Sea Grant Virginia, 2000; Dodd, 2001; Arnold *et al.*, 2002). The spawning and culture successes in SC during 2001 produced advanced juveniles for research purposes. Interest in this species is three-fold: 1 – gain initial insights into the potential for stock enhancement; 2 – obtain basic

information on the movements, growth, recruitment, and homing instincts of the species; and, 3 – examine its potential for commercial aquaculture. Work in all these areas is underway. During fall 2001, a total of 1,523 fish were tagged and released in four locations in Port Royal Sound through the combined efforts of local angling clubs (Hilton Head Island Sportfishing Club; Beaufort Sportfishing and Dive Club) and project staff. The fish were tagged with a dart tag and stocked on October 9 and 24 at which time they were 130-144 days old (Table 2). Overall, fish had a mean size of 347 mm TL and weighed 331 g. These pond-reared juveniles were produced during the normal spawning season and were similar in size to wild juveniles. Due to the high level of interest and involvement of recreational anglers and fishing guides, this program has been publicized along the south Atlantic coast (e.g. Florida Sportsman, Hilton Head Island Packet).

Table 2. Mean size (range) of 1,523, ~4 month old cobia juveniles tagged (dart tag) and released in Port Royal Sound, SC in 2001.

Release date (mth/da/yr)	Mean length (mm TL)	Mean weight (g)	Released (#)
10/09/2001	341 (235-390)	309 (178-443)	881
10/24/2001	356 (294-402)	362 (193-533)	642

Results and Discussion

Shortnose Sturgeon

This federal/state program was the first effort to evaluate the use of hatchery produced shortnose sturgeon as a potential management tool for supplementation or restoration of this endangered species. Information collected during the stocking efforts in the Savannah River and shortly thereafter indicated that stocked juveniles comprised a minimum of 35.4% of the juvenile population in the lower river nursery area (Smith and Collins, 1996). Based on recovery of marked fish after a mean time out of 7.2 ± 1.9 years (range 5.9-10.4) and results from double tagging studies, it is estimated that at least 38.7% of the adult population in the Savannah River during 1997-2000 was made up of stocked fish (Smith *et al.*, 2002a) (Table 3).

Table 3. Contribution of hatchery produced shortnose sturgeon to the adult populations of three coastal rivers between 1990 and 2000. Tag loss/non-detection factor of 3.72 not applied to the known hatchery origin data (fish contained marks). Data are means with range shown in parenthesis.

River (state)	Years data collected	Known hatchery origin (%)	Time at large (yrs)	Mean size (TL cm)
Savannah (GA)	1997-2000	10.4	7.2 (5.9-7.9)	77 (63-96)
Edisto (SC)	1995-2000	10.6	6.7 (4.1-10.2)	78 (58-98)
Ogeechee (GA)	1997-2000	8.4	7.4 (5.4-9.7)	80 (75-95)

Further, it was documented that stocked fish contained mature gametes and participated in spawning migrations (Smith *et al.*, 2002a). Population estimates and CPUE data from 1997-2000 suggest that the adult population is now larger than 10 years ago, but juveniles are still rare. This suggests that a recruitment bottleneck exists during the early life stages. From field sampling data, water quality degredation in the nursery habitat is believed to be at least partially responsible for the poor recruitment in the Savannah River (Smith *et al.*, 2002a).

Data on capture of tagged fish obtained from directed sampling and from commercial fisheries bycatch in other river systems have provided additional information on the fate of the fish stocked in the Savannah River. Beginning in 1995, hatchery fish began to be captured in non-target rivers, especially the Ogeechee River, GA, and Edisto River, SC, the two large rivers closest to the Savannah River (Figure 1, Table 3). From 1997-2000, identifiable stocked fish comprised 8.4% of the adult population in the Ogeechee River, while from 1995-2000, 10.6% of the adults in the Edisto River were identifiable as stocked fish (Smith *et al.*, 2002b) (Table 3). These values, as well as that for the Savannah River, can also be expanded (multiplied by 3.72) based on tag loss data from double tagging studies. In the Edisto River there was a historical Atlantic sturgeon fishery and shad fishery, the latter of which continues today. However, no shortnose sturgeon had been reported from the Edisto River prior to 1994. It appears that fish stocked into the Savannah River emigrated and colonized the Edisto River, and in 1998 the first age 1 juvenile was captured. In the Ogeechee River it appears that substantial supplementation of the population has occurred from the fish stocked in the Savannah River. Other stocked fish have been detected in the Cooper River, SC and in Winyah Bay, SC, a maximum of 278 km from the mouth of the Savannah River (Smith *et al.*, in press b) (Figure 1).

This stocking research identified issues associated with long term marking of stocked fish and showed that marking of small juvenile sturgeon for later recapture as adults was especially problematic. Improvement in tagging technologies, including use of genetic markers, should help resolve this issue. Stocking protocols approximated current recommendations developed by the

Atlantic States Marine Fisheries Commission (ASMFC) for Atlantic sturgeon (ASMFC, 1996) and were used in part to help develop these recommendations. However, stocking similar numbers of progeny per mating was not well controlled. This, coupled with assumed differential survival of different size groups of stocked animals, may have genetic implications relative to other river systems (Quattro *et al.*, 2002). Future stocking efforts need to strive for balanced numbers of progeny per broodstock mating and similar survival rates. As straying of some stocked fish into non-target rivers was noted, future shortnose sturgeon (and perhaps other species) stocking programs should address the issue of imprinting. Perhaps straying into non-target areas can be reduced by raising fish in target river water or by stocking very young (assumed pre-imprinting) fish.

Red Drum

With the apparent limited success of conventional fishery management regulations in maintaining healthy red drum populations, SC and other states are implementing or examining the use of hatchery release programs as an additional management tool. Texas has developed a large scale program which it feels is highly effective, and stocks approximately 40 million small juveniles per year (McEachron *et al.*, 1998). South Carolina and FL (Willis *et al.*, 1995) are conducting controlled studies to evaluate this approach, while other states (e.g. NC – Copeland *et al.*, 1998; GA – Woodward, 2000) have an interest but are evaluating the success of neighboring states.

Studies conducted to date in SC have identified suitable protocols for release (size, season, habitat, etc.) and have documented the survival and growth of stocked fish for periods up to 4 years post-release (Smith *et al.*, 1997). Chemical treatments for batch marking large numbers of small fish, as well as the use of external tags (abdominal T anchor) for individually marking larger fish, have been shown to be suitable for use in large scale field programs. However, both tagging methods have limitations; OTC requires sacrifice of the fish while external tags require use of large fish. Although stocking of large fish in Charleston Harbor, SC has resulted in a contribution to the local population of up to 4.1% (Table 4), production and stocking costs are major considerations (Smith *et al.*, 1997).

Table 4. Annual contribution of externally marked hatchery fish to the wild red drum population in the Wando River, SC between 1989 and 1994 (size at release ranged from 100–300 mm TL). Samples were collected randomly using a trammel net and include all ages and sizes of red drum captured each year.

Year	Stocked (#)	Fish sampled (#)	Hatchery contribution (%)
1989	4,145	897	0.8
1990	5,961	784	3.8
1991	11,279	1,209	0.3
1992	15,409	2,265	4.1
1993	14,957	2,496	1.3
1994	0	2,246	1.0

A total of 1,574,862 red drum juveniles (mean length 22 - 56 mm TL) were marked with OTC and released in Callawassie Creek, Port Royal Sound estuary, from fall 1995 to spring

1997. Using various gear types, 1,687 fish from target size groups were captured and sacrificed. In addition, 1,722 larger fish were captured, measured and released. Controlled studies with captive marked fish indicated that the OTC marks were visible for at least 52 months (Jenkins *et al.*, 2002). Results of analyses of otoliths indicated that there were no differences in growth rates of wild fish before or during the years that stocking occurred. Hatchery fish released in the fall grew at a rate similar to wild fish of the same year class (Smith *et al.*, 1999). Impacts of the stocked fish were evaluated over a 30 km distance from the stocking site. Sampling in the Port Royal Sound estuary of age 0 - 3 fish from the 1995 and 1996 year classes indicated that overall, hatchery fish comprised 19.4% (n=252) of the 1,316 fish collected from these year classes. Contribution to the local population at the release site increased as stocking number increased, with a maximum of 77.3% hatchery contribution recorded for the 1996 year class at Callawassie Creek, the stocking site (Fig. 3). However, in the estuary as a whole this proportional increase was not sustained, as the intermediate stocking number of 346,926 fish (1995) provided an overall contribution of 19.0%, which is similar to that recorded (19.7%) for the highest release number (1.2 million). Hatchery contribution decreased as fish aged, and fall hatchery fish (natural spawning time) appeared to make a larger proportional contribution than fish released out of season in the spring (Smith *et al.*, 1999). Hatchery and wild fish of various ages occupied similar habitats and were frequently captured in the same net sets. In addition, wild and hatchery-produced fish exhibited similar sex ratios (Smith *et al.*, 1999).

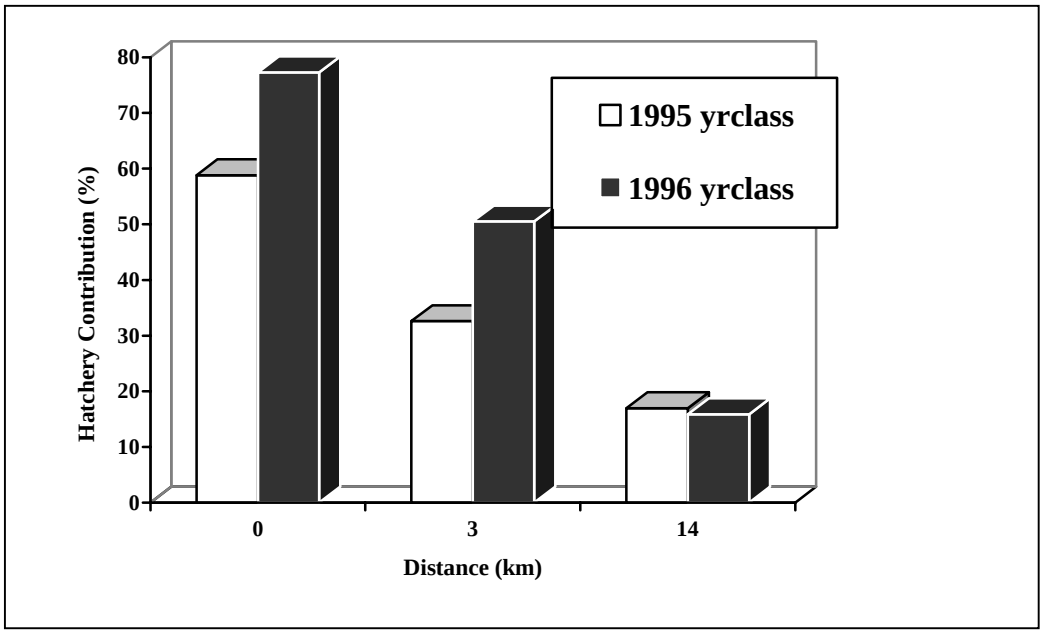

Figure 3. Percentage of all fish captured from each year class at each site between Summer 1996 and Spring 1999 which were of hatchery origin. The primary sample sites were the release site (0 km) Callawassie Creek; Rose Hill flats (3 km from release site) and the Chechessee River (14 km from release site).

The current phase of research is focused on the critical issue of supplementation vs. displacement. Stocked fish begin to recruit to the trammel nets used to sample the population at

about 10 months of age, so only results from the 1999 stocking in the Ashley river are available. During December 2000 - February 2001, fish were taken (sacrificed) from the Ashley River to determine the percent contribution of stocked fish, as well as from Charleston Harbor and the Wando River to see if any movement had occurred. Based on OTC marked otoliths, stocking has had a significant supplemental impact on the Ashley River population (78% contribution) (Table 5) with the CPUE exceeding the highest level on record for this river (Table 6; Fig. 2). In fact, the Ashley River CPUE was the highest reported from any sampling site in the entire state, further demonstrating the depressed level of red drum stocks (Table 6). Besides the substantial impact on fish abundance in the Ashley River, a substantial portion of the fish in the Charleston Harbor estuary and a smaller portion of the fish in the Wando River were identified as originating from fish stocked in the Ashley River (Table 5).

Table 5. Hatchery contribution (%) to the 1999 year class of red drum as determined by both fishery independent and dependent sampling in the Ashley and Wando Rivers and Charleston Harbor. A total of 617,190 juvenile red drum were stocked in the Ashley River only.

	Fishery Independent		Fishery Dependent	
Site	**Number sampled**	**Hatchery (%)**	**Number Sampled**	**Hatchery (%)**
Ashley River	41	78	20	70
Wando River	51	12	3	0
Charleston Harbor	20	15	25	52

Table 6. Catch per unit effort in descending order for young of year red drum collected during random trammel net sampling along the coast of SC between July and December 2000.

Site	**Effort (net sets)**	**Mean CPUE**	**Standard Deviation**
Ashley River	41	1.73	3.7
Ace Basin	41	1.34	3.6
Muddy Bay	45	1.07	1.7
Wando River	32	1.00	2.4
Charleston Harbor	38	0.74	1.0
Romaine Harbor	46	0.63	1.3

These findings are quite dramatic and could have far reaching implications for SC and other states exploring the possibility of hatchery releases as a fishery management tool. However, data are from only the first year of this multi-year project and thus should be considered as preliminary. Additional annual stocking and data collection efforts in the Ashley and Wando Rivers will allow a time sequence of replication over which impacts can be assessed. This issue of supplementation vs. displacement has been identified as a priority concern and needs to be quantitatively addressed (Hilborn, 1999).

Cobia

There is limited information on the impacts of the stocked cobia in this new program. However, within a week of both stockings, there were anecdotal reports of a captured fish within the general release area. One fish was reported by an angler who was fishing in a tournament. He caught a tagged juvenile by hook and line but the fish was lost overboard before the tag details could be obtained. The second report came from a recreational shrimp baiter. While cast netting for shrimp at night he caught a cobia of the general size that had been stocked. No tag was noted before the fish was released. Both reports came from Port Royal Sound. A third fish was reported as being captured on October 27, 2001 in the surf at Cocoa Beach FL. This fish was from the October 9th release and had traveled approximately 480 km south during 18 days at large (26.7 km/day).

It is anticipated that during winter 2002 additional captures will be reported, as there is a suspected north-south movement pattern during fall along the southeastern U.S. (Hardy, 1978). In spring, fishermen have tracked the movement of adult cobia in the opposite direction (McNally, 1985). There is also a report of a wild cobia tagged off Charleston in June 1984 being recaptured off Biloxi, Mississippi in April 1986 (Shaffer and Nakamura, 1989). In SC, there have also been several reports of juveniles being captured in offshore waters during winter months suggesting an offshore movement (D. Hammond, SCDNR, Charleston, SC).

Little information exists on the population abundance of cobia. Recent VPA's on fish abundance in the Gulf of Mexico and along the Atlantic coast have been inconclusive due to a lack of sound modeling data (D. Hammond, SCDNR, Charleston, SC, personal communication 2001). However, it is felt that populations in the Gulf and along the south Atlantic have increased since the early 1980's. Information obtained from the stocking effort will provide new insights into the movements, growth, and potential for stock enhancement of this species.

Conclusions

South Carolina has made substantial progress in evaluating the utility of stock enhancement as a management tool. Although additional information is needed, the results to date suggest that release of hatchery fish may benefit depleted stocks. However, all efforts should be conducted in a responsible manner and stocking of hatchery fish should not be viewed as a substitute for strict habitat protection. Further, stock supplementation efforts should be coupled with conventional conservation/management actions to maintain the long term health of the populations.

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