Murrells Inlet Special Area Management Plan

Contract M-3-959

Final Report from SCDNR

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Introduction

The American oyster *Crassostrea virginica*, once a dominant feature of most Atlantic and Gulf coast estuaries, has drastically declined in many areas across the U.S. due to a variety of causes (over-harvesting, oyster pathogens, impacts of coastal development and habitat disturbance, see for example Rothschild et al. 1994, Luckenbach et al. 1999, Coen and Luckenbach 2000 and ref. therein). Once valued primarily as a resource, oysters are now recognized as key elements of many estuarine ecosystems (reviewed in Coen et al. 1999b, Lenihan 1999, Luckenbach et al. 1999, Coen and Luckenbach 2000, Luckenbach et al. in press). Oysters create complex habitats utilized by fish, crustaceans, bivalves, numerous other invertebrates, birds, and mammals (e.g., Zimmerman et al. 1989, Wenner et al. 1996, Coen et al. 1999b, Coen and Luckenbach 2000, Meyer and Townsend 2000). They improve water clarity and quality by filtering large quantities of water in conjunction with feeding and transfer nutrients from the water column to the benthos (e.g., Coen and Luckenbach 2000, Dame et al. 2001). Declines in oyster populations are associated with adverse effects to other species, reduced water quality and ecosystem shifts (Rothschild et al. 1994). In the southeastern U.S. (southern NC, SC, GA, large areas of FL), oysters are predominantly intertidal, often forming a protective breakwater that retards shoreline erosion (Coen and Fischer 2002, Coen et al. in prep.).

Large and small-scale restoration of oyster habitat is now being attempted in many Atlantic (New England, New York, New Jersey, MD, VA, NC, SC, GA, FL) and Gulf coast (FL, AL, TX) waters (Luckenbach et al. in press). Most oyster restoration is based on the principal of substrate enhancement, assuming that is a limiting factor (Brumbaugh et al. 2000a,b). Oyster larvae require a hard, stable substrate for attachment. Alternatives to shucked oyster shell cultch have included *Spisula* shell, whelk shell, coal ash byproducts, fossil shell, midden shell, old porcelain material and $CaCO_3$, to name but a few (Luckenbach et al., 1997, 1999), but fresh oyster shell remains the best material (Coen and Luckenbach 1999b and citations therein). Other areas may be larval limited requiring significant investments in hatcheries and remote setting (Luckenbach et al. in press).

Throughout most of its range, oysters occur predominantly subtidally (rarely if ever exposed, even at low tide), but in SC, GA, and parts of NC, VA, TX and FL oysters occur almost exclusively intertidally, exposed to air for up to six hours at a time (Grizzle 1990, O'Beirn et al. 2000, Grizzle et al. 2002, Coen et al. 1999a, Coen and Luckenbach 2000). Many restoration projects therefore have focused on subtidal habitats (reviewed in Luckenbach et al. 1999, Coen and Luckenbach 2000). Unlike subtidal oysters, intertidal populations protect fringing marshes and are vulnerable to boat wakes (especially at low to mid tides) which can undermine reefs, particularly in areas with softer substrates, resulting in the loss of marsh and oyster habitat, (Coen and Fischer 2002; Grizzle et al. 2002). When the oyster reefs which fringe the saltmarsh are damaged by harvesting and/or boat wakes, the marsh is left unprotected and can erode at a rapid pace (Chose 1999, Anderson 2002; Meyer et al.1997, Coen and Fischer 2002, Coen and Bolton-Warberg 2003, work in progress). We have documented erosion rates of more than 5 cm/month (averaged over nearly 30 months) at some SC sites (Coen et al. unpublished data). Hence, restoration efforts must also take into account the vulnerability of the restored areas to boat wakes (Coen and Bolton-Warberg, 2003, Coen et al., work in progress).

Although oysters in SC have not been as extensively exploited as populations in mid-Atlantic states, the rapid pace of coastal development has created numerous threats to tidal creek habitats, with impacts inevitable. Some of the most salient problems include: (1) increased runoff due to upland clearing, (2) increased contaminants which are particularly detrimental to larval stages, (3) increased water quality closures which result in concentrated harvest pressure on open beds, (4) increased harvesting, particularly recreational harvesting and (5) increased boat wake impacts (e.g., Van Dolah et al. 2000, Chose 1999).

Historically, state oyster resources were leased and managed by companies that operated canneries and shucking houses. These companies replanted shucked shell on the shorelines, providing essential substrate for the next generation of oysters. With the demise of the last cannery in Beaufort County in 1986, the industry has transformed to predominantly shell stock businesses that sell intertidal product for oyster roasts. At the same time, legislative changes in the leasing system resulted in the genesis of State Shellfish Grounds—common property areas available to independent commercial harvesters and recreational gathering. However, no funding was allocated by the legislature to maintain and cultivate these and there is a shortage of shell to use for replanting, as it is often diverted to other uses such as driveways and decorative walls. Thus these common grounds may not be receiving adequate shell replenishment to compensate for increased harvest pressure.

SCDNR has taken a number of steps in the last five years to increase oyster enhancement efforts. SCDNR has developed a statewide oyster shell recycling program, designed to recover shell from oyster roasts, restaurants and household consumption, to generate the shell needed for adequate husbandry. Currently there are sixteen shell recycling drop-off sites in the coastal counties that provide depositories for shell that is transferred to holding areas and then replanted on oyster beds. SCDNR has also created a community-based restoration program (SCORE) to involve the public in hands-on restoration, monitoring and shell recycling. This successful program has constructed reefs at 28 sites along the SC coast since its inception in 2001 (see http://www3.csc.noaa.gov/scoysters). Volunteers monitor water quality weekly at twenty sites and participate in other monitoring activities.

Murrell's Inlet historically had extensive oyster reefs, but these have suffered in recent years from adverse affects of rapid coastal development, increased siltation due to local dredging operations, non-point source runoff and lack of husbandry in areas closed to shellfish harvesting. As part of the Murrell's Inlet SAMP, SCDNR proposed to:

1. Expand shell recycling efforts in the Murrells Inlet region
2. Evaluate the status of oyster beds in Murrells Inlet and prioritize areas most suitable for habitat restoration

3. Use recycled shell to establish large scale restoration sites, particularly targeting areas chronically closed to shellfish harvesting, to create habitat
4. Monitor the success of restored areas
5. Utilize the SCORE program to involve citizens in hands-on activities including construction of small reefs and water monitoring

Summary of Accomplishments

1. Expand shell recycling efforts in the Murrells Inlet region

SAMP funds were used to purchase two hydraulic dump trailers for recycling oyster shells, which were transferred to Murrells Inlet 2007. These trailers served as additional drop-off sites for donated shells and are also used to collect shells from participating restaurants. Promotional materials were distributed to restaurants and seafood dealers. The Murrells Inlet area recycles more shells each year than any other single area of the state.

2. Evaluate the status of oyster beds in Murrells Inlet and prioritize areas most suitable for habitat restoration

Staff surveyed oyster resources in Murrells Inlet and compared current status to historical data. Additional survey and status information will be available in the future from an ongoing project to resurvey SC shellfish grounds using remote sensing. Survey results were used to recommend areas for shell replenishment in 2004 and 2005.

3. Use recycled shell to establish large scale restoration sites, particularly targeting areas chronically closed to shellfish harvesting, to create habitat

SCDNR planted oyster shell on Murrells Inlet grounds in 2002 (pre-SAMP), 2003, 2004 and 2005. A total of 27,797 bushels have been planted on 51,064 square feet (~1.25 acres) of shoreline since 2002. Sites where shell planting has occurred are S354, R351, Parsonage Creek, Allston Creek, Horseshoe Creek (S358) and Drunken Jack Island (S357).

4. Monitor the success of restored areas

SCDNR surveyed restoration sites shortly after shell planting to document their original size and depth of the shell layer. Later surveys allowed us to determine whether shell was being lost from the site (generally due to boat wakes or wave action), covered over (siltation), or lost due to sinking in soft substrates. Sites were sampled 1 to 2 years after shell planting to evaluate recruitment and early growth. Annual evaluations of oyster recruitment were conducted in conjunction with our statewide recruitment program to evaluate the potential for restoration success and replenishment of natural populations.

5. Utilize the SCORE program to involve citizens in hands-on activities including construction of small reefs and water monitoring

Volunteers assisted in bagging oyster shells to build five small reefs in two locations in the Inlet. Additional volunteers were trained and equipped to monitor water quality weekly at restoration sites.

Materials and Methods

1. Expand shell recycling efforts in the Murrells Inlet region

SCDNR had previously established a shell drop-off station at Huntington Beach State Park, which proved to be the most productive drop-off site in the state. Expansion of the Murrells Inlet recycling program included the capability to pick up shells from nine participating local restaurants by using two hydraulic dump trailers as drop-off stations. SCDNR purchased the two trailers and transferred ownership to Murrells Inlet 2007, a nonprofit community revitalization group. One trailer was stationed at Cedar Hill landing and the other at the Garden City/Murrells Inlet Fire Station (both on Highway 17, Business, Murrells Inlet). Using the dump trailers, a Murrells Inlet 2007 volunteer collected discarded shells from restaurants participating in the shell recycling program. The restaurants are: The Admiral's Flagship, Capt. Dave's Dockside Restaurant, Bovine's/Divine Fish House, Drunken Jack's Restaurant and Lounge, Inlet Crab House, Seafare Seafood Restaurant, Russell's Seafood Grille, Dead Dog Saloon and Flo's Place. Fifteen 20 gallon Herculiner® coated galvanized containers were distributed to the participating restaurants for shell collection and loading into the hydraulic dump trailers. The restaurants also received window decals with the oyster recycle logo and "We Participate in SCDNR's Oyster Shell Recycling Program—You should too!" and the telephone number of Murrells Inlet 2007. Murrells Inlet certified shellfish dealers and seafood retail outlets were provided with 1,200 oyster bags with printed shell recycling logo and "Complete the Cycle—Recycle Your Shells". The recycling program was featured in a MI 2007 newsletter, in local newspapers and on local television. SCDNR has made a commitment to use shells collected by town volunteers for oyster restoration and enhancement projects in the Murrells Inlet estuary.

Figure 1. Murrell's Inlet 2007 volunteers receive dump trailers from SCDNR (left). Shell recycling drop-off center at Huntington Beach State Park (right).

2. Evaluate the status of oyster beds in Murrells Inlet and prioritize areas most suitable for habitat restoration

In early 2004, waterways in the BROOKGREEN NE Quarter Quad were surveyed to evaluate location, size and general condition of oyster beds (Figure 2). Existing oyster beds were compared to those identified in the most recent survey conducted in 1984. A total of 249 oyster beds were identified, of which 145 were 'new' compared to the previous survey. Many of these new beds are probably the result of one oyster reef becoming fragmented into multiple smaller reefs. Some of the differences may also be due to increased accuracy/resolution available when using GPS survey equipment. Approximately half of the identified beds were surveyed with GPS equipment that is accurate to less than a meter to quantify location, size and shape of the beds. The remainder of the beds were qualitatively assessed using the strata system developed by OFM for the previous survey. Assessments were augmented with video footage of some banks as part of a ground-truthing effort related to mapping state oyster resources with remote sensing.

Figure 2. Survey areas in Murrell's Inlet.

Figure 3. DNR equipment loads shell aboard a contractor's barge (left). High pressure water is used to blow the shells onto the shoreline (right).

3. **Use recycled shell to establish large scale restoration sites, particularly targeting areas chronically closed to shellfish harvesting, to create habitat**

Although updated survey information was not yet available, two areas of the Inlet were planted in late summer 2003 based on previous determinations of need. These included State Shellfish ground S-354 (Brookgreen), which is under administrative closure, and Public Shellfish Ground R-351 (Clam Bank Flats), which is classified as conditional by SCDHEC. In 2004, planting locations were based on survey results (see previous section) and logistical considerations. Planting sites were in Oaks Creek (S-354), Woodland Creek (S358), Parsonage Creek (undesignated SSG classified as Conditional) and Allston Creek (undesignated SSG classified as Restricted). In 2005, shell was planted at Drunken Jack Island (S357) and Woodland Creek (S358). These plantings were conducted by private contractor under SCDNR supervision with SCDNR equipment being used to move the shell from storage areas and load the barge.

Figure 4. Shoreline in Parsonage Creek before and after shell planting.

4. Monitor the success of restored areas

Shortly after shell planting was completed, we measured shell depths at the sites and took samples to determine the mean shell counts. The sites were monitored for the next year to document changes in footprint and shell depth over time and to make observations of siltation, shell migration, etc. This will help us to improve our site selection and shell deployment techniques.

Shell-planting sites established in 2002 and 2003 (pre-SAMP) were sampled in Fall 2004 to evaluate density and size of oysters. A total of twenty 0.25 m^2 samples were collected and processed to count and measure all live oysters. We evaluated differences between plots that had been covered with mesh vs. uncovered plots and differences in settlement on different shell types. Sites that were planted in 2004 will be assessed in Fall 2005 to evaluate density and size of recruited oyster populations. We will continue to monitor the success of restoration sites beyond the funded project period to determine long-term success.

The six SCORE reefs constructed in Oaks Creek in 2001 and 2003 were sampled in Fall 2004, at 3 and 1 years of age, respectively. Prior to sampling, the reefs were photographed with a novel overhead camera system to determine relative proportions of mud and oysters. Five bags were removed from each of the six reefs and processed to evaluate oyster population parameters and associated crabs and mussels.

SCDNR monitors oyster recruitment and early growth statewide each year. Recruitment and early growth are useful indicators of the potential for successful restoration and the degree to which natural populations are being replenished. Oyster recruitment was monitored in Murrells Inlet in 2003-04 and 2004-05 by deploying trays filled with local oyster shell in early spring and retrieving them approximately 10-11 months later. In 2003, recruitment trays (n=3 per site) were deployed at five Murrells Inlet sites: Oaks Creek (S354), Oaks Creek (R355), Oaks Creek (R351), Main Creek, and Whale Creek (C370). In 2004, shell trays (n=3 per site) were deployed at four Inlet sites: Woodland Creek, Parsonage Creek and Oaks Creek (S354 and R355).

We have been monitoring erosion at the SCORE reefs in Oaks Creek since 2001. When reefs were built in Woodland Creek, we began monitoring erosion there also.

5. Utilize the SCORE program to involve citizens in hands-on activities including construction of small reefs and water monitoring

We worked through Murrells Inlet 2007 and the Friends of Huntington Beach State Park to develop public interest in oyster restoration activities and solicit volunteers. We also distributed informational brochures through local fishing clubs, seafood outlets, environmental groups, civic clubs, and the state park to heighten public awareness.

During July and August 2003, volunteers assisted DNR staff in constructing five small-scale oyster reefs in Murrells Inlet. SCORE reefs are constructed of mesh bags filled with oyster shells. A reef typically has 100 bags, each holding ¾ bushel of shell. DNR typically constructs three reefs at a site, allowing scientific replication. Approximately 30 volunteers filled shell bags at Huntington Beach State, including a group from Georgetown Marine Institute and many from Friends of Huntington Beach State Park. The bags were used to build three reefs in Oaks Creek and two reefs adjacent to the educational pier at Huntington Beach State Park (see Figure 5, right). At the State Park, uncontained shell was used to create two reference areas for comparison. Approximately 20 volunteers assisted with the reef construction in the park. In

Oaks Creek the three reefs were positioned adjacent to reefs constructed by the SCORE program in 2001 to provide more information on reef development over time and among years (Figure 5, left). The Oaks Creek project required transporting the bags in boats, which were provided by volunteers. Approximately ten volunteers with two boats assisted in the reef building in Oaks Creek.

Working through the Friends of Huntington Beach State Park and the HBSP Education Center, we conducted a water quality information and training session. Ten volunteers were trained to monitor temperature, pH, salinity, water clarity, and dissolved oxygen. Two full sets of measuring equipment are housed at the park. Equipment includes thermometers, pH probes, refractometers, Secchi disk, and dissolved oxygen kit. Volunteers monitored water quality weekly at two locations, Huntington Beach State Park and Oyster Landing, until fall 2004 when the pier at the Park was damaged in a storm. Monitoring at Oyster Landing has continued. Volunteers enter data online at our existing website (http://www3.csc.noaa.gov/scoysters) where it is available for viewing at any time. The Park has integrated water quality lessons into their school programs.

Figure 5. SCORE reefs in Oaks Creek (top) and at Huntington Beach State Park (bottom).

Results

1. Expand shell recycling in Murrells Inlet

Murrells Inlet recycling stations produced 2,150 bushels of shell in 2003-04 and 1,460 bushels in 2004-05. Although recycled shell volume was lower in 2004-05 than the previous year, Murrells Inlet continued to be the most productive drop-off/recycling area in coastal South Carolina. SCDNR has committed to using the shell recycled in this area for resource restoration in Murrell's Inlet.

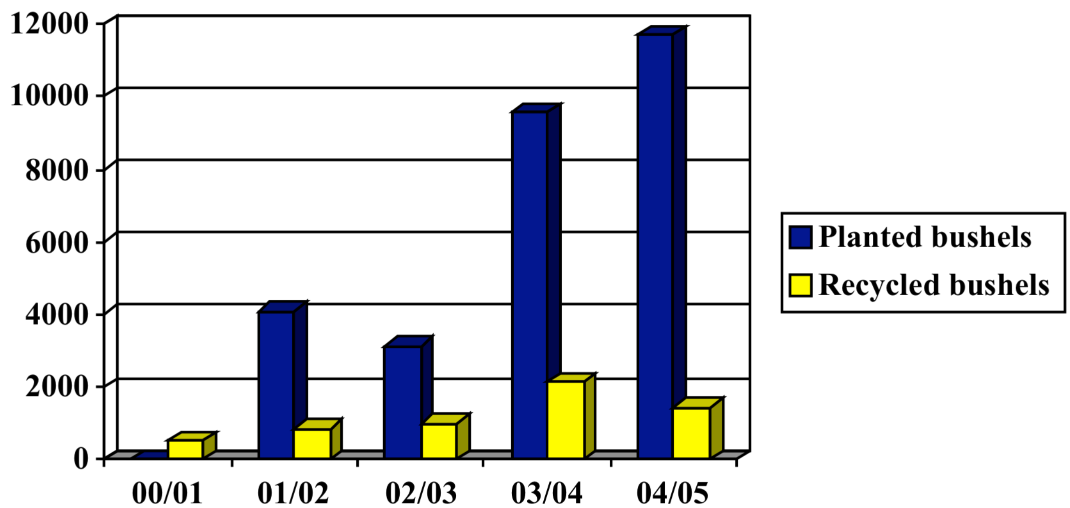


Figure 6. Shell recycling and DNR shell planting in Murrells Inlet over last five years.

2. Evaluate the current state of shellfish beds in Murrells inlet and recommend areas for restoration

Of the 180 beds for which prior survey data existed, 99 (55%) showed no change, 54 (30%) showed improvement either in bed condition or bed size, and 27 (15%) had declined in condition. The beds that had declined were primarily in the areas of the inlet that are subjected to heavy boat traffic. Complete survey data is included in Appendix A.

Based on the survey data, as well as the general desire to plant in closed areas in order to minimize human interference, we recommended that 2004 shell planting be conducted in:

- Portions of Parsonage and lower Allston Creeks, based on presence of suitable intertidal bottom (not too soft, gentle slope) and physical protection from wave/wake energy (Undesignated grounds);
- Woodland Creek (at the "horseshoe") which had little boat traffic and suitable bottoms (S358);

- Oaks Creek adjacent to "Clambank Flats", where a sandbar provides some protection from boat wakes and previous plantings had received good recruitment (S354).

3. **Use recycled shell to establish large scale restoration sites, particularly targeting areas chronically closed to shellfish harvesting, to create habitat**

In 2002 (pre-SAMP), 2003, 2004 and 2005, a total of 27,797 bushels of shells were planted in six areas of the Inlet, covering a total of 51,064 square feet (4,834 m^2) (See Table 1). Most of this shell was planted in areas that are closed to harvesting by SCDNR (R355, S354) or DHEC (R351, Allston, Parsonage). Shell planting was funded not only by SAMP but also by Saltwater Stamp Funds. The 2004 planting represents the major SAMP-funded effort and targeted areas recommended by the SAMP-funded resource survey mentioned above (Figure 7).

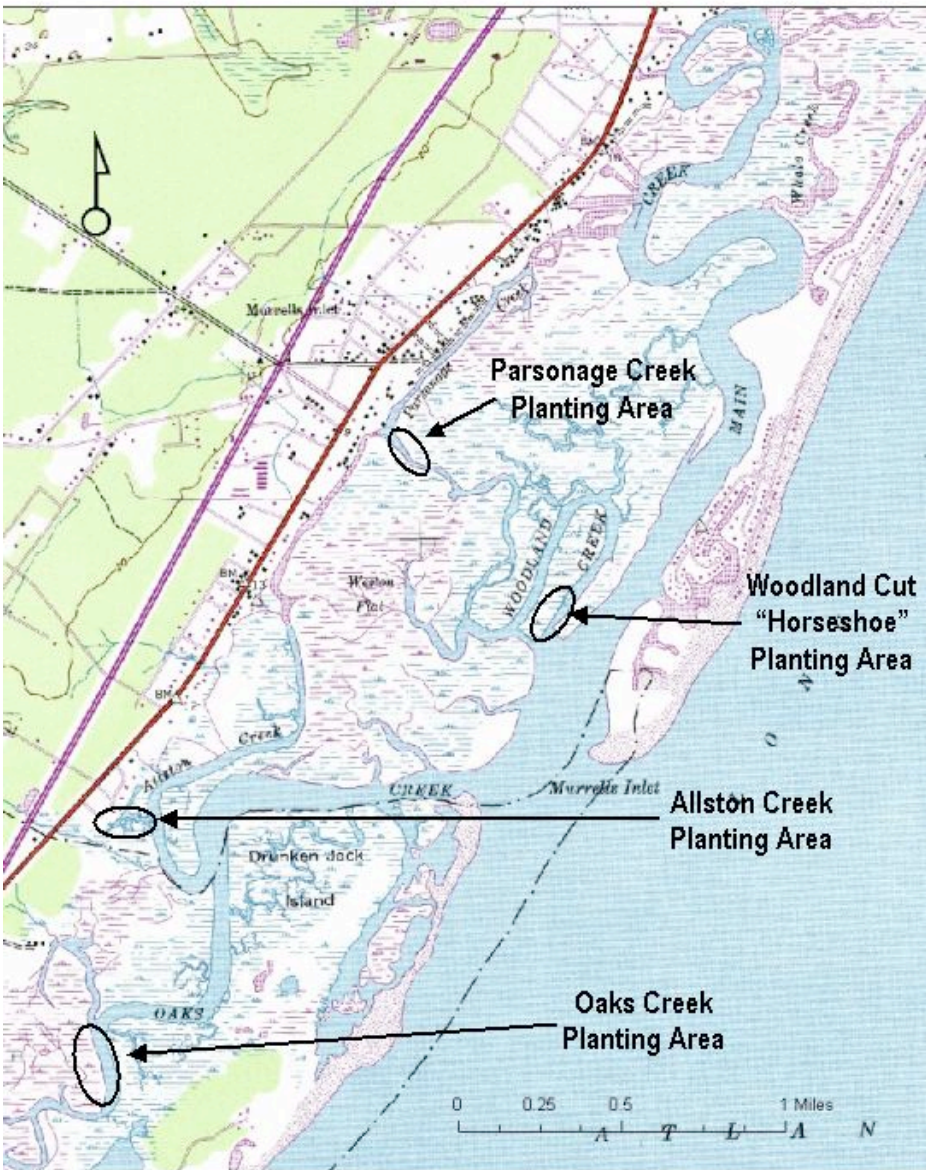


Figure 7. Four areas in Murrell's Inlet where oyster shells were planted in 2004 to restore habitat.

Table 1. Shell Planting in Murrell's Inlet 2002-2005

Site		Clambank	Oaks Creek	Woodland	Parsonage	Allston	Drunken Jack	Total
Mgmt Area		S354, R351	S354, R351	S358	Undesig-nated	Undesig-nated	S357	
Harvest status		Closed-SCDNR	Restricted	Approved	Conditional	Restricted	Approved	
2002	bushels	2,080	2,020					4,100
	area (ft^2)	5,028	4,880					9,908
2003	bushels	815	2,465					2,465
	area (ft^2)	2,007	4,341					4,341
2004	bushels		3,787	2,325	1,499	1,941		9,552
	area(ft^2)		5,693	7,045	2,588	4,827		20,153
2005	bushels			3,577			8,103	11,680
	area (ft^2)			6,544			10,118	16,662
Total	bushels	4,545	6,622	5,902	1,499	1,941	8,103	27,797
	area (ft^2)	9,369	12,580	13,589	2,588	4,827	10,118	51,064

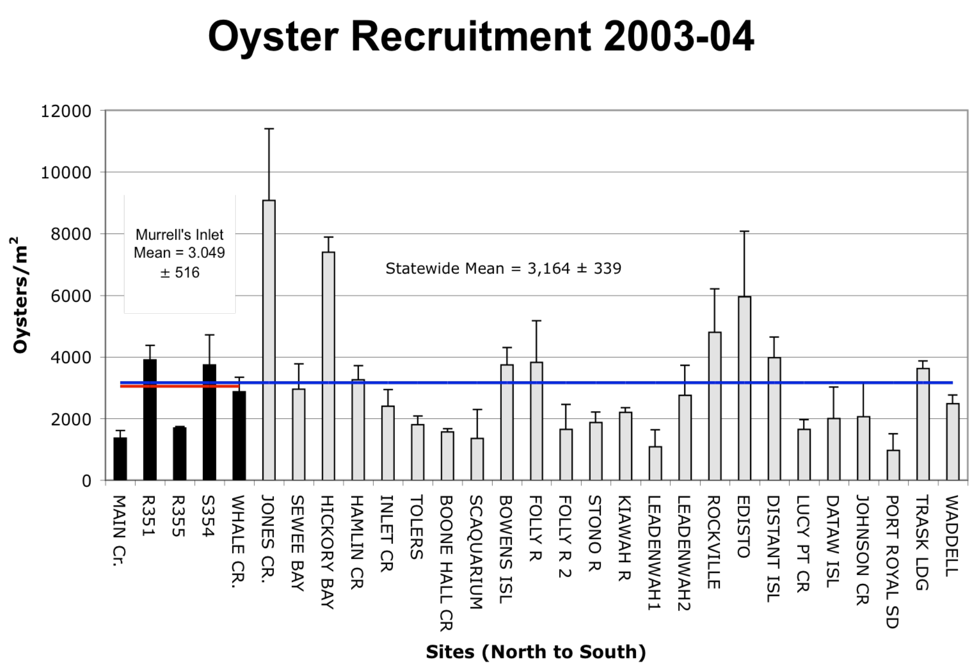
4. **Monitor success of restoration efforts**

Recruitment

Oyster recruitment at a number of sites in Murrell's Inlet was compared with other sites statewide in 2003-04 and 2004-05. This recruitment analysis using shell trays helps SCDNR evaluate relative replenishment and/or restoration potential of oyster grounds to assist in management decisions. In 2003-04, the average recruitment at five Murrell's Inlet sites was 3,049 oysters/m^2 (289 oysters/ft^2) compared with a statewide (31 sites) mean of 3,164 oysters/m^2 (300 oysters/ft^2). Three Murrells Inlet sites had recruitment equal to or greater than the statewide average, but the other two sites (Main Creek and Oaks Creek R355) had lower than average recruitment (Figure 8, top). The 2004-05 statewide recruitment average was the highest we have observed since adopting the shell tray method in 1998. The mean recruitment from 30 sites statewide was 6,194 oysters/m^2 (586 oysters/ft^2). The average recruitment at the four Murrells Inlet sites was slightly higher than the state average at 6,454 oysters/m^2 (611 oysters/ft^2) but, as in the previous year, the recruitment at Oaks Creek R355 (Clambank Landing) was less than the statewide average (Figure 8, bottom). Overall, recruitment in Murrell's Inlet appears to be high enough to adequately populate newly planted shell.

Restoration Footprints

In 2004, we assessed reef footprints at the four restoration sites shortly after the shells were planted. In Woodland Creek, two footprints were planted: a 340 m^2 (3,590 ft^2) footprint with an average of 944 shells or 1.6 bushels/m^2 and a 327 m^2 (3,454 ft^2) footprint with an average of 588 shells/m^2 (~ 1 bu/m^2). In Oaks Creek, a 539 m^2 footprint had an average of 2,968 shells/m^2 (5.2 bushels/m^2). In Parsonage Creek footprints of 122 and 123 m^2 (~1,289 ft^2) were created and had an average of 416 shells/m^2. In Allston Creek footprints of 190 and 267 m^2 had 1,800 shell/m^2. The footprints were reassessed approximately one year later to evaluate shell retention and other changes to the bed configurations. Sites planted at the "Undesignated" shellfish areas in Allston and Parsonage Creeks had significant siltation issues, with footprints decreasing by 58 and 36% at Parsonage Creek and 62 and 82% at Allston Creek, due apparently to covering of the shell by fine sediments. The two sites in Woodland Creek had decreased by 28 and 27% in the same time period, while the footprint in Oaks Creek decreased by 49%. We have observed good recruitment at Woodland Creek and Oaks Creek although these will not be



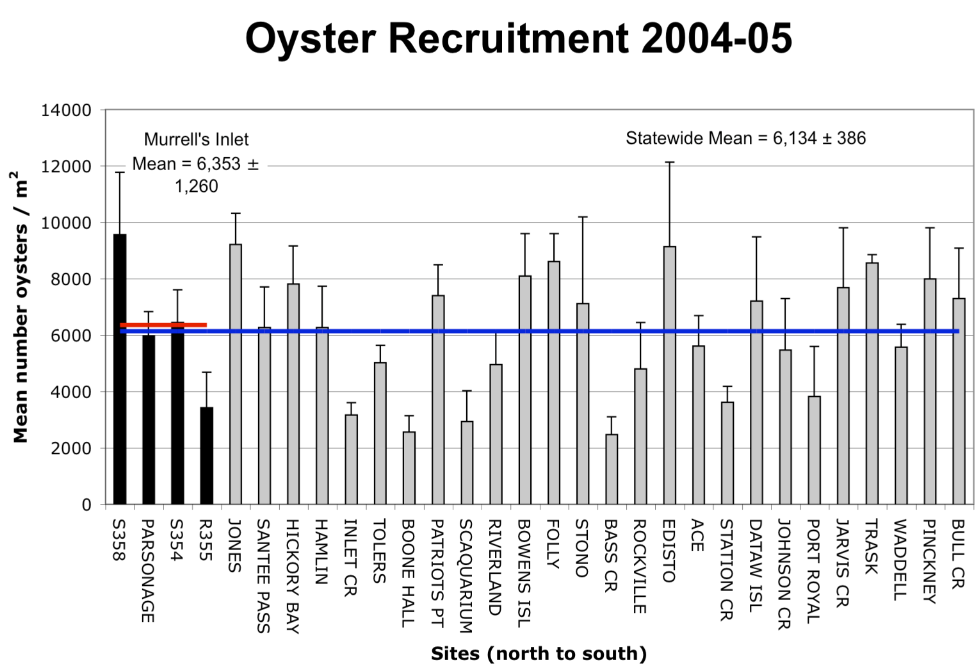


Figure 8. Statewide oyster recruitment for 2003-04 and 2004-05. Darker columns are Murrell's Inlet sites.

quantitatively assessed until fall 2005. We will continue to monitor the progress of these reefs beyond the project period to evaluate reef development.

Reef Development

In November 2004 we sampled both large-scale reefs constructed in previous years in Oaks Creek. The large-scale site planted in 2002 in Oaks Creek included shell treatments (Gulf and Whelk) and mesh treatments (mesh and no mesh). In Fall 2004 the average oyster density in 20 samples was 987 oysters/m^2 (93 oysters/sq. ft.). The mean size of the oysters in all samples was 42.8 mm. When sampled, plots that had been designed to be planted with whelk shell had as much as 50% Gulf shell and vice versa. The abundance of oysters on unmeshed plots was twice as high as that on meshed plots. Average recruitment on unmeshed plots was 1,213/m^2 (115/sq. ft.) vs. only 564/m^2 (53/sq. ft.) on meshed plots (Figure 9). This is probably attributable to the fact that meshed areas, while effective at stabilizing shell, were associated with increased siltation. The mesh may be actually trapping sediment, or the reduction in shell movement may allow more silt to settle from the water column.

The six SCORE reefs constructed in Oaks Creek in 2001 and 2003 were also sampled in Fall 2004. These reefs are immediately adjacent to the large scale site mentioned above. Mean oyster densities were 1,514 and 1,298 oysters/m^2 (143 and 123 oysters/sq. ft.) for three-year-old and one-year-old reefs, respectively. This is considerably higher than the 987/m^2 (93/sq. ft.) on

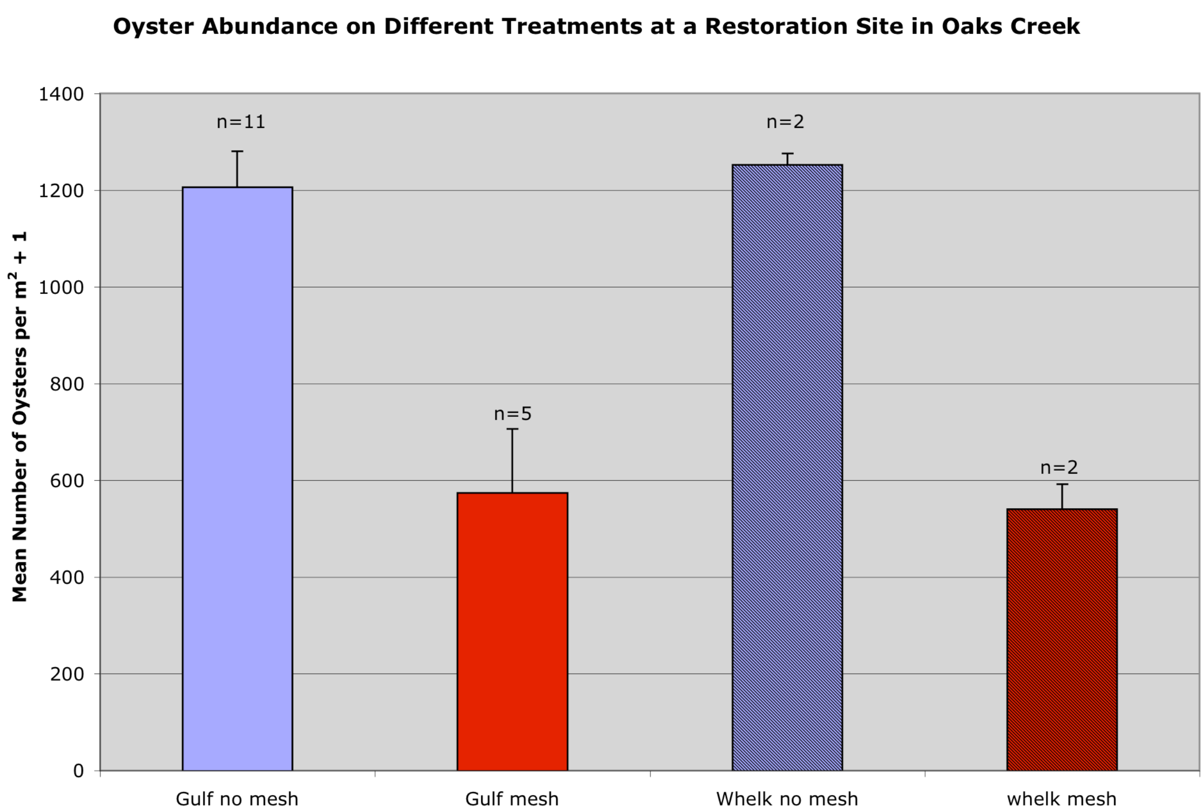


Figure 9. Oyster density at 2002 Oaks Creek large-scale restoration site when sampled in Fall 2004.

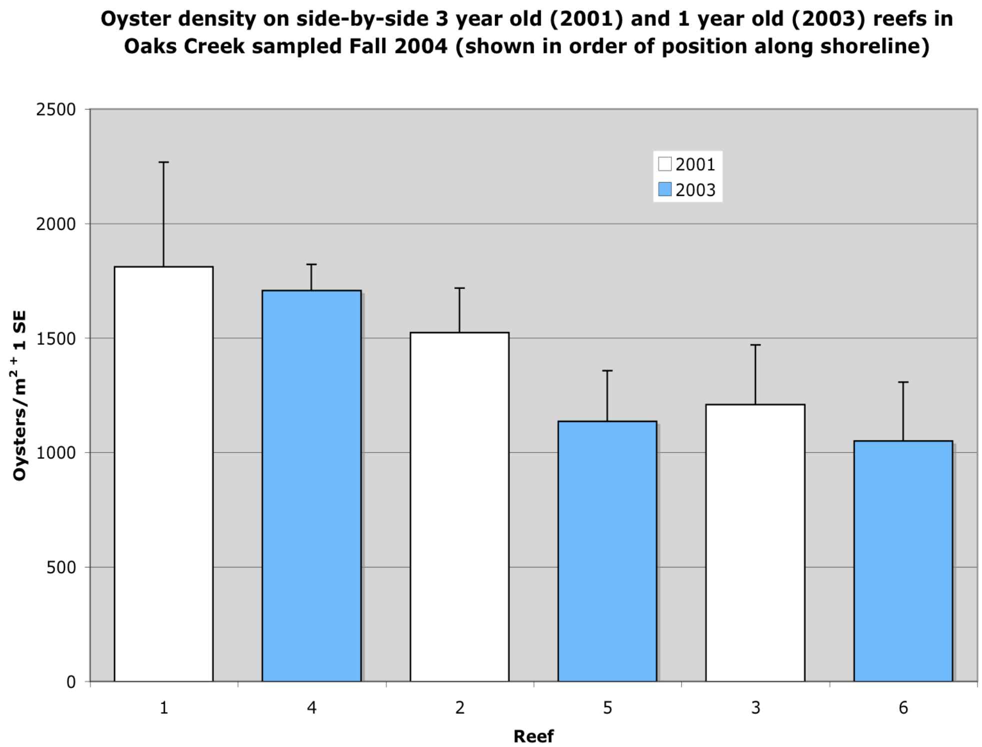


Figure 10. Mean oyster density on one year old and three year old reefs in Oaks Creek.

the adjacent large-scale planting, which was intermediate in age. The mean density of oysters was not different among the six reefs or the two construction years but there appeared to be an effect of location, with density decreasing from the upstream (towards State Park) to downstream (towards Murrells Inlet) end of the shoreline (Figure 10). Of five SCORE sites sampled in Fall 2004, Murrell's Inlet had the second lowest density on both three year old and one year old reefs (Table 2).

Table 2. Comparison of Oyster Density (#/m^2) and Size among SCORE Reefs of Different Ages Sampled Fall 2004

3 year old reefs						
	Bowens	Dataw	**Murrells**	Pinckney	Palmetto	Mean
Density	2341	2127	**1512**	1458	2882	2064
Size	23.9	22.5	**42.2**	21	28.2	27.6
1 year old reefs						
	Bowens	Dataw	**Murrells**	Pinckney	Palmetto*	
Density	2269	1458	**1295**	2206	1093	1663
Size	18.4	22.7	**28.3**	20.6	31.9	24.4

The mean size of oysters on the SCORE reefs was 41.5 mm (1.6") and 28.0 mm (1.1") on three year old and two year old reefs, respectively (Figure 11). This is the largest mean size observed on three year old reefs at five SCORE sites sampled Fall 2004 and the second largest mean size observed on 1 year old reefs (Table 2). The mean size on three year old reefs (41.5 mm = 1.6") is similar to that on the adjacent large-scale two year old reefs (42.8 mm = 1.7"). We have observed at other sites that the mean size on two year old reefs is similar to that on older reefs. We interpret this to indicate that the older reefs are continuing to recruit smaller oysters as well as retaining the larger size classes. This is confirmed by evaluation of the size frequency distribution on the 1 year old and 3 year old reefs, which indicates good survival as evidenced by the larger size classes on the older reefs (Figure 12). There are substantially more oysters in the larger size classes on the three year old (2001) reefs than on the one year old (2003) reefs. There is demonstrable evidence of multiple year classes on the older reefs, a major criterion for sustainability.

<u>Associated Fauna</u>

When SCORE reefs were sampled in Fall 2004 we collected crabs and mussels for identification and measurement. This provides an indicator of habitat functioning. One year old reefs averaged 150 crabs/m^2 (14/sq. ft.) while three year old reefs had 158 crabs per m^2 (15/sq. ft.). One year old reefs were dominated by the black-clawed mud crab *Panopeus herbstii* while three year old reefs had equal numbers of *P. herbstii* and the flat-backed mud crab *Eurypanopeus depressus*. *E. depressus* has been reported to favor high vertical profile, which would be expected on an older reef. Compared with four other sites sampled in Fall 2004, Murrell's Inlet had the lowest crab density and was the only site where the non-native green

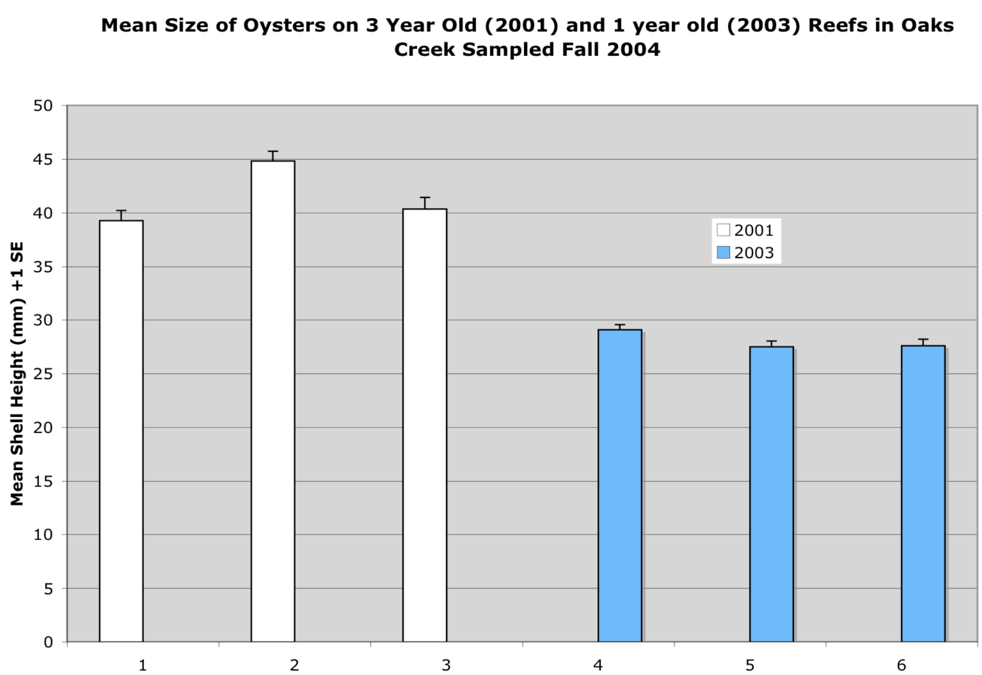


Figure 11. Mean size of oysters on 1 year old and three year old SCORE reefs at Murrell's Inlet.

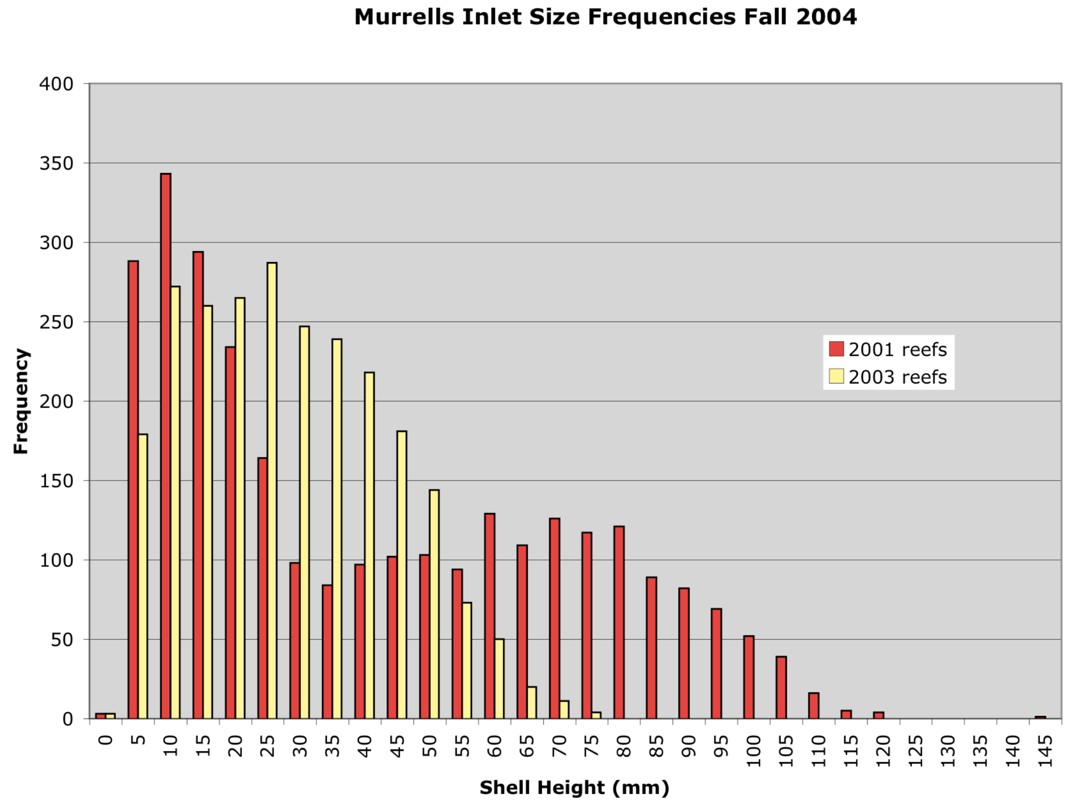


Figure 12. Size distribution of oysters on reefs constructed in 2001 and 2003 in Oaks Creek.

porcelain crab *Petrolisthes armatus* was not observed. The reefs had an average of 950 mussels/m^2 (90/sq. ft.), heavily dominated by the scorched mussel *Brachidontes exustus*. This is typical for SC oyster reefs in high salinity areas.

In some cases, a goal of oyster restoration is to stabilize adjacent shorelines. Many of the waterways in Murrell's Inlet appear to have eroding shorelines, possible due to increased boat traffic. Therefore, we have been attempting to document shoreline changes behind the SCORE reefs in Oaks Creek and the 2004 reefs in Woodland Creek. The shoreline behind the SCORE reefs has lost an average of 86 cm (34") since 2001 when we began monitoring. The average rate of loss is 1.8 cm/month (0.7"/mo). We do not have a long enough data series (and no "before" data) to be able to demonstrate whether the rate of loss is changing. The Woodland Creek site has had an average loss of 13.13 cm (5.2") over one year (rate=1.1 cm/mo).

5. Utilize the SCORE program to involve citizens in hands-on activities including construction of small reefs and water monitoring

We worked with the educational staff at the Huntington Beach State Park to develop activities related to oysters, biodiversity and habitat for incorporation in their regular school programs. Two informational signs were mounted on the boardwalk at the park. The Park used these reefs as living classrooms until the boardwalk was damaged in Fall 2004.

As mentioned above, the SCORE reefs constructed by volunteers in 2001 and 2003 were sampled last fall. The size and density of oysters, as well as the size distribution on the older reefs, were encouraging. Based on the success of the reefs in Oaks Creek, especially relative to the adjacent larger scale plantings, we constructed small footprint reefs using shell bags adjacent to larger-scale reefs in Woodland Creek in the summer of 2004. The small reefs were sampled in spring 2005 to determine recruitment and early growth. Mean recruitment at this site was 5,325/m^2 (504/sq. ft.). This was higher than the mean recruitment of 4,408/m^2 (417/sq. ft.) for 7 sites constructed at various locations statewide in summer 2004. It is also higher than the early recruitment in 2001 and 2003 on the bag reefs in Oaks Creek. The adjacent large-scale planting in Woodland Creek will be sampled Fall 2005 which will provide a comparison of the two restoration methods (bagged, not bagged).

Volunteers have been monitoring water quality at Clambank landing since 2002. The education dock at Huntington Beach State Park was added as a monitoring site in 2003 but had to be discontinued in winter 2004 when the dock was damaged in a storm.

Summary, Recommendations and Future Work

- SCDNR provided SCDHEC, Shellfish Sanitation Program with three priority areas that are classified conditionally approved and restricted in Murrells Inlet for water quality upgrades. These are Clam Bank Flats, currently a Public Shellfish Ground (R-351), North Main Creek and flats, a shellfish culture permit (Nance's Creekfront Restaurant, C-372) and Garden City Canal and flats (an undesignated State Shellfish Ground). All three have viable oyster and clam resources.

- Survey results found that many oyster beds recorded in a 1984 survey had fragmented into two or more beds. The qualitative condition of Murrells Inlet oyster beds was largely unchanged. Beds in heavily traveled creeks were more likely to have declined in condition than those in smaller, less traveled creeks.

- Restoration efforts have had mixed success. Some sites experienced heavy siltation, possibly due to nearby dredging activities. However, in sites where siltation did not smother the shell and juvenile oysters, recruitment and growth were good. Growth on both large and small-scale sites in Oaks Creek has been particularly high. Monitoring needs to be continued for several more years, as two years is not long enough to evaluate long-term success or failure.

- SCDNR should continue to plant shell during spring and summer months, targeting lower traffic creeks with gentle slopes.

- Restoration efforts should recognize the ecosystem benefits of oyster reefs and not be confined to harvestable areas.

- SCDNR should continue regular assessment of bed condition and close heavily harvested areas as needed to protect the resource. Prior to reopening any closed areas, quantitative analysis of the resource should be conducted.

- It may be prudent to consider establishing no-wake zones in some areas of the Inlet for the protection of the shoreline and oyster reefs.
- A SC coastal remote sensing survey of oyster resources is being conducted at this time. When completed and verified with ground-truthing, this will update the previous surveys competed in the 1980s.

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Appendix. Survey Results

S-358

Main Creek (Site #1): Although there is regular heavy boat traffic (main route to Inlet), beds are showing some recent improvement in the more protected areas. Out of the 6 beds with prior data, one reef improved to a better density strata classification, and five stayed within the same strata type, none declined. This area all falls within the 'Approved' DHEC status. Area behind spit by NE boundary may be plantable for Murrells Inlet SAMP (see SAMP map).

Woodland Cr: At the "Horseshoe " and slightly past, there was little success from previous plantings by local culture permit holders. None of the 5 beds with prior data show any improvement. The main problem in the area seems to be siltation and shifting of shell. This area falls within the 'Approved' DHEC status.

Just past Horseshoe: From this Area well into Oaks Cr is where the most activity and wave energy are found. None of the 2 beds with prior data show any improvement.

Main Creek Tributary: Washed shell in this area is indicative of high-energy area. Out of the 11 beds with prior data, 2 reefs improved to a better density strata classification, and 9 stayed within the same strata type, none declined. It should be noted, however the change from an "F" to an "E" is not necessarily an improvement (higher, denser, smaller oysters) other than as an erosion barrier.

Bend into Oaks Creek: Likewise, a high energy area. Of the 2 beds with prior data, 1 improved, and 1 remained the same.

Oaks Creek Tributary: Sandy bottoms with swift tidal currents, these constantly shifting and scouring. Of the 11 reefs with prior data, 3 have declined (2 of which have declined to the less dense, single oyster "D" classification), 1 has shown improvement, and 7 have remained the same. Parts of this tributary lying in C-359 exhibited the same characteristics.

Oaks Creek North Bank: Previous shell plantings along this stretch by culture permit holders planting on SSG's for double credit have accomplished nothing other than to provide more protection for resident clam populations. The change from "F1" to "C" indicated settlement of mud and silt on the previously exposed shell matrix, leaving vertical clusters still visible. Of the 9 reefs with prior data, 3 have declined and 6 have remained the same. If shell planting were attempted on thisbank, some stabilization would be required.

Oaks Creek South Bank: As indicated by surveying reefs, a poor stretch except in the lower intertidal zone ("B" strata) and would need stabilization. Of the 8 reefs with prior data, one has declined and 7 have remained the same.

Oaks Creek Flat: Some improvement as indicated by the presence of "C" strata on old "D" strata reef. Of the 5 reefs with previous data, 2 have improved and 3 have remained the same. Not part of an SSG or PSG.

Undesignated SSG

Parsonage Creek Marsh Island: Original survey data not available for Parsonage Creek at time of resurvey, but included now with its subsequent addition. Soft and muddy banks predominate in tributaries. Overall condition of oysters improves further SW of public landing (clusters standing up on bank with good growth). SE bank generally comparable in firmness to the Oaks Cr. restoration site established 2002, and portions from the first tributary SW of marsh island to confluence of Parsonage and Allston Creeks behind Nance's Restaurant may be good future planting sites. Only small boat traffic can use this channel near low tides. The primary question concerning planting on any portion of Parsonage Creek is accessibility with a barge. Narrow and lined with docks on the opposite bank, maneuvering a barge of any size along this creek would be a challenge.

Parsonage Creek NW Bank: Softer and muddier than seaward bank in many portions, with numerous docks as noted.

Parsonage Creek SE Bank: As noted above, stretches of this bank along the length of the creek SW of the first tributary past the marsh island may be good future planting sites (with previously noted caveat regarding maneuverability using a shell barge).

Start into Woodland Cut: Very healthy-looking oysters in this area. Good size with new growth on all blades. "C" reefs appear to be increasing in density and progressing well enough to leave to nature. Planting in this area may not be necessary at this time.

Woodland Cut: Soft mud and many docks. Probably not a good site for shell planting.

Lower Parsonage Creek SE Bank: Noted above as portions being suitable for planting if navigable with a barge - or smaller vessels may be used for shell transport.

Allston Creek NW Bank: Populations of "C" strata possibly increasing in density to "G" on their own. Planting on some thin spots may be helpful, but overall looks encouraging as it is.

Allston Creek "T" Tributary, NW Bank: Some portions may be suitable for planting, but creek is narrow. Navigability with a barge is questionable here as well.

C-359

Upper Allston Creek C-359 West Bank: Despite silt load, new clusters are standing up on covered shell of old "D" strata. Oysters look healthy with good new growth. Of the 4 reefs with prior data, 3 have improved and 1 has remained the same. This stretch falls within a culture permit, and is not open to harvesting without written permission from the culture permit holder.

Upper Allston Creek C-359 East Bank: One dense "F" strata reef not indicated in 1980s survey. Otherwise unchanged. All of the 4 reefs with prior data have remained the same. As on the West bank, reefs improving on their own.

S-357

Lower Allston Creek: Shell base present, but few live oysters for years – boat traffic increases in this stretch of the creek. Portions may be suitable for planting, but shell may need robust stabilization, especially outer (South) bank. Current stabilization methods might raise complaints from fishermen and clam harvesters