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Oyster Restoration Efforts in Virginia

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Oyster Reef Habitat Restoration: A Synopsis and Synthesis of Approaches

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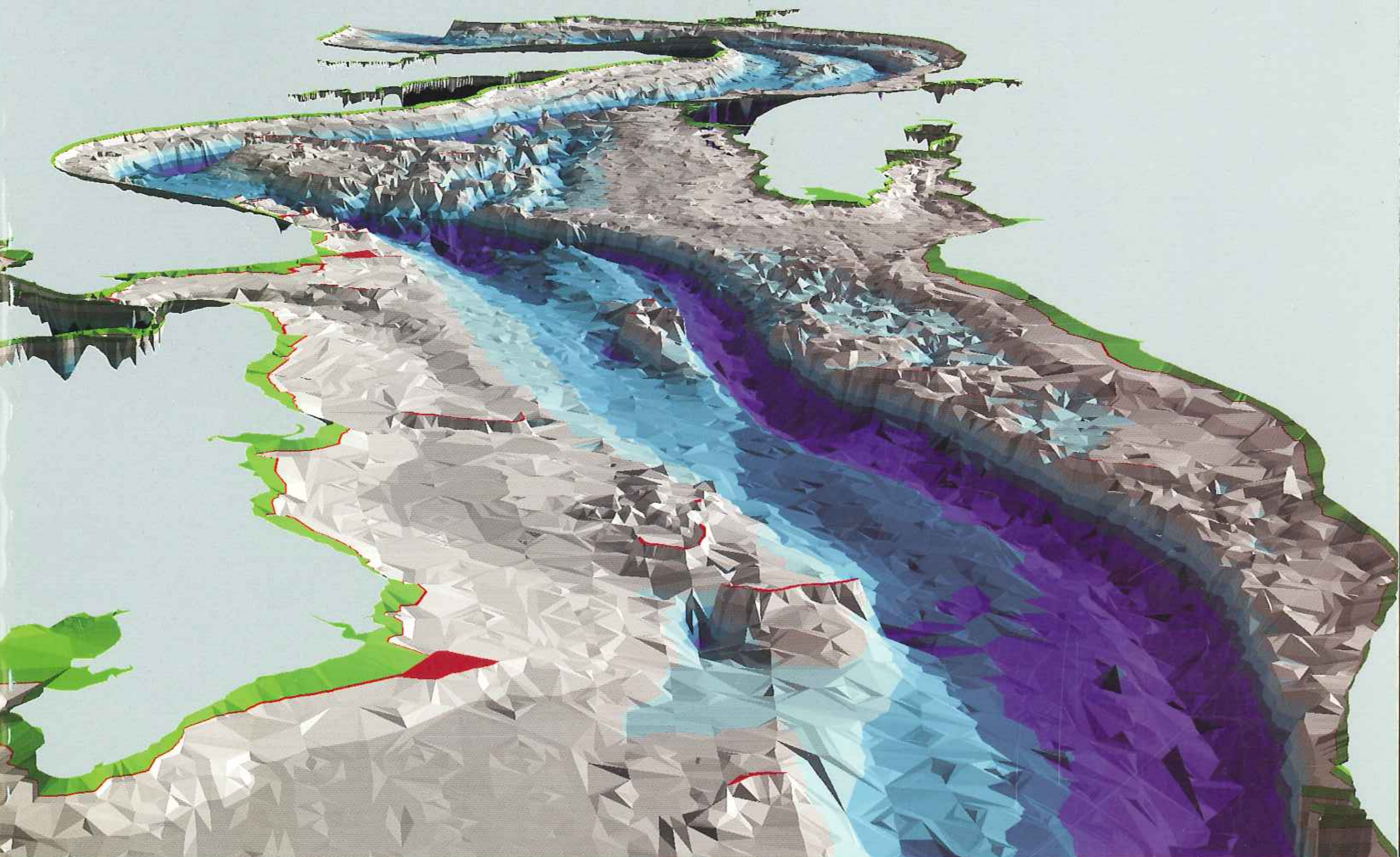

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Abstract

Long-term restoration of the Virginia Oyster resource has been assisted by a series of governmental and regulatory initiatives. Following the 1990 Blue Ribbon Panel the Virginia Marine Resources Commission set as goals that the oyster resources and oyster fishery would be so managed as to achieve (a) no net loss of existing standing stock of the native oyster over the next five years, and (b) a doubling of the existing standing stock of the native oyster over the next ten years. The 1994 Chesapeake Bay Aquatic Reef Plan and Oyster Fishery Management Plan both recommended the creation of 5,000 acres (2024 hectares) of oyster reef habitat during the 1995-2000 period. Practical progress toward this goal has been made through the development of several programs including direct application of substrate (cultch) to extant oyster reefs to facilitate settlement and recruitment, enhancement of reefs of the Seaside of the Eastern Shore by exhumation of buried shell, and construction of elevated reef structures in the Virginia subestuaries of the Chesapeake Bay. Efforts in the James River have included subtidal berm type structures capped with shell and a reef constructed entirely of shell. A shell reef has been constructed in the Piankatank River, and construction of several more is planned. All reefs remain as broodstock sanctuaries. Continuing management is supported by quantitative stock assessment.

Overview of Blue Ribbon Oyster Panel Recommendations

Years of intensive harvesting, habitat destruction, pollution, and disease related mortalities have reduced Virginia's oyster population to less than 1% of that of only 35 years ago (Table 1, Fig. 1, also see Hargis 1999, Chapter 1, this volume). Many attempts have been made to limit harvest and to facilitate restoration projects; however, industry and political objections have reduced most efforts to insignificance. In 1990, the Governor, Lawrence Douglas Wilder, convened a Blue Ribbon Oyster Panel, staffed by the Virginia Marine Resources Commission (VMRC), to develop plans to restore the oyster resource and the oyster industry. This panel, composed of commercial fishermen (watermen), seafood processors, politicians, economists, and scientists developed a plan and presented it to VMRC in November 1991. The Plan (Appendix 1), with the exception of a recommendation for the introduction of non-native oysters in Virginia waters, was adopted in May, 1992. In addition, two long range goals developed by the Commission itself were adopted to guide oyster management and restoration in Virginia for the next ten years.

These goals were:

1) The Commonwealth's resources and oyster fishery shall be so managed as to achieve no net loss of existing standing stock of the native oyster over the next five years.
2) The Commonwealth's resources and oyster fishery shall be so managed as to achieve a doubling of the existing standing stock of the native oyster over the next ten years.

The goals and recommendations of the plan were well conceived, significant, and reasonable, but success in oyster restoration remains uncertain. The depleted state of the extant oyster stocks dictate that any recovery will be extremely slow in rate and limited to those areas where stocks remain in sufficient numbers to be reproductively active. For example, the James

Table 1. Oyster Ground Production.

Year	Public Landings (Bushels)	Private Landings (Bushels)	Total
58	586,304	2,926,750	3,513,054
59	703,915	3,347,170	4,051,085
60	699,420	2,553,275	3,252,695
61	781,783	2,237,736	3,019,519
62	227,921	1,815,001	2,042,922
63	278,830	1,652,880	1,931,710
64	576,857	1,223,549	1,800,406
65	615,864	1,605,759	2,221,623
66	605,982	1,188,633	1,794,615
67	226,855	587,105	813,960
68	262,996	790,483	1,053,479
69	227,577	621,463	849,040
70	192,187	818,943	1,011,130
71	281,001	836,014	1,117,015
72	260,241	928,404	1,188,645
73	157,890	394,121	552,011
74	374,522	424,277	798,799
75	403,737	491,860	895,597
76	397,209	475,159	872,368
77	312,539	320,711	633,250
78	512,687	394,692	907,379
79	590,533	441,082	1,031,615
80	608,880	465,896	1,074,776
81	704,848	472,465	1,177,313
83	329,492	361,792	691,284
84	334,749	247,525	582,274
85	308,392	318,660	627,052
86	328,338	386,665	715,003
87	501,075	279,872	780,947
88	325,527	194,654	520,181
89	165,061	107,612	272,673
90	88,635	73,983	162,618
91	59,883	52,109	111,992
93	34,355	30,182	64,537
94	7,401	28,134	35,535

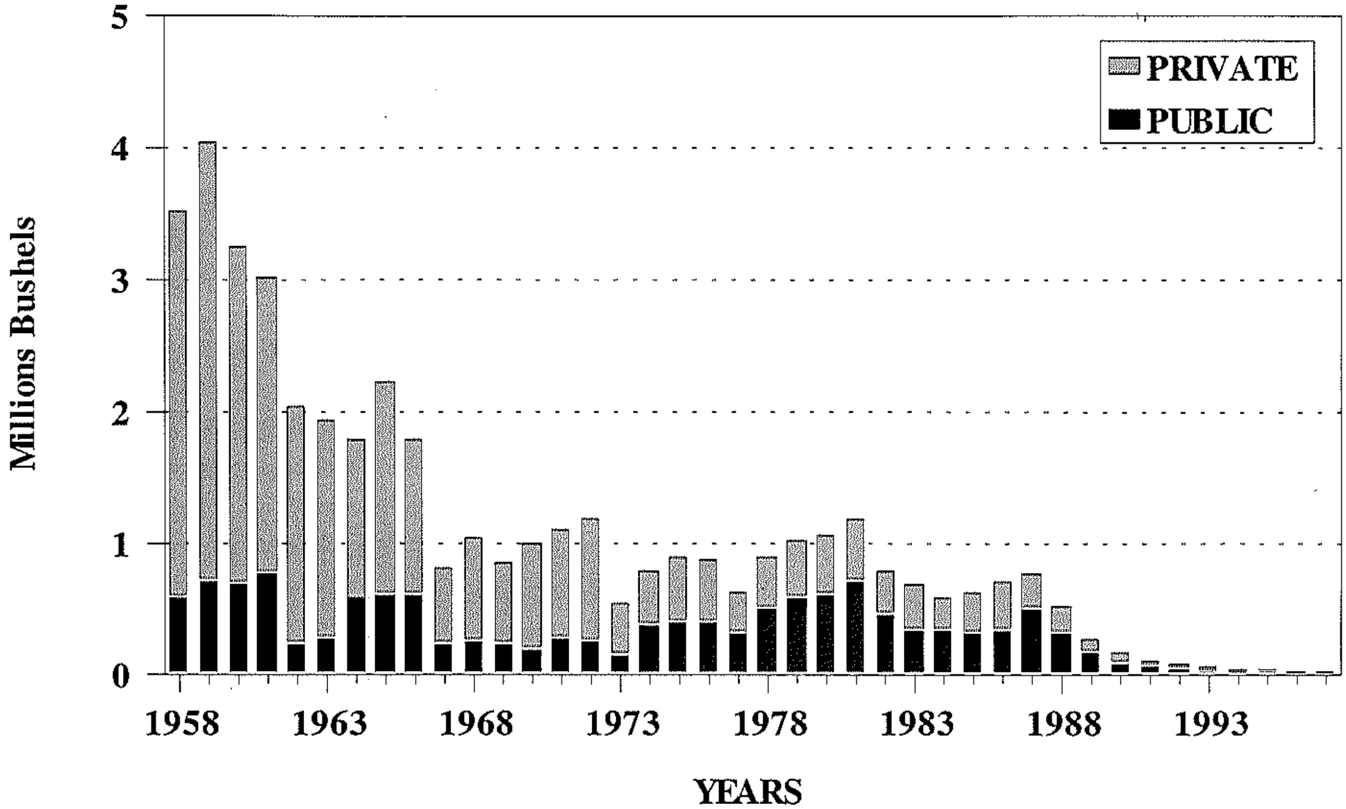

Figure 1. *Oyster ground production, public and private.*

River continues to exhibit limited annual recruitment, but that in the lower Rappahannock River is sparse to absent. We lack current knowledge of brood stock genetic diversity, and must contend with the possibility that this may have been reduced by the major decrease in population size over the past three decades. Successful spawning may be limited by low extant densities of reproductive oysters in many locations. Disease prevalence and intensity remains weather driven and unpredictable. Political pressures impeding scientific and long-term management are still strong. All of these factors combine to make the substantial ten year recovery goal extremely difficult to achieve.

Stock Assessment

The first recommendation of the Blue Ribbon Oyster Panel called for the establishment of a computer database system and fishery independent stock assessment methods to monitor both population trends and the success of replenishment efforts. Both VMRC and the Virginia Institute of Marine Science (VIMS) have monitored Virginia's oyster resources for many years with dredge surveys. These surveys provided qualitative information that Virginia's oyster population levels were closely reflected by landing records. In 1993, a patent tong based stock assessment project was funded by the Chesapeake Bay Stock Assessment Committee (CBSAC) and was begun in the James and Rappahannock Rivers. The project was repeated in 1994 for the James and Rappahannock Rivers with the addition of areas on the Seaside of the Eastern Shore. Standing stock estimates are now available for all of these areas. As we have suspected from dredge surveys, except for a small area of the upper James River, standing stocks of oysters in Virginia's portion of the Chesapeake Bay are at low levels. In the small area of the upper James, several oyster bars are still relatively healthy, and exhibited a small increase in the standing stocks from 1993 - 1994 in this area. Fishery independent quantitative stock assessment of the historically important

Table 2. Changes in Virginia Harvesting Regulations, 5/3/95.

	1992	1993	1994
Chesapeake Bay			
Daily Time Limit	None	12:00 noon	CLOSED
Season Limits	Oct 1 - Mar 31	Oct 15 - Dec 31	
Tong Limits	None	18'	
Cull Law	3" mkt, 4 qts shell	3" mkt, 4 qts shell	
Quota	None	None	
James River			
Daily Time Limit	None	12:00 noon	12:00 noon
Season Limit	Oct 1 - May 31	Oct 15 - Apr 30	Oct 1 - Apr 30
Tong Limit	None	18'	18'
Cull Law	mkt 2-1/2", 4 qts shell seed no size, 10 qts shell	mkt 3", 4 qts shell seed no size, 6 qts shell	mkt 3", 4 qts shell seed no size, 6 qts shell
Quota	None	mkt 6,000 bu. seed 80,000 bu.	*seed 120,000 bu.
Seaside, Eastern Shore			
Daily Time limit	None	None	None
Season Limit	Oct 1 - Mar 31	Oct 15 - Mar 31	Oct 1 - Dec 31
Cull Law	No size, 6 qts shell	mkt 3", 4 qts shell seed no size, 6 qts shell	mkt 3", 4 qts shell seed no size, 6 qts shell
Summer Harvest - Private Grounds	Allowed	Allowed, permit required	Allowed, permit required

* Originally 80,000 bu, raised to 120,000 bu when quota completed in February

oyster bars throughout Virginia's Bay and tributaries is now effected on an annual basis as a joint VMRC-VIMS program. This stock assessment method is invaluable for making rational management decisions; however, employing the resultant data in the management process has required a significant continuing effort to explain the employed methods and their statistical basis to both the oyster industry and the regulatory body, the VMRC itself.

Harvest Restrictions

The most dramatic and potentially most productive restoration activity in Virginia has been the closure of most the Chesapeake Bay to harvest and the restriction of harvesting in the remaining areas. Many of these restrictions were implemented directly in response to recommendations of the Blue Ribbon Oyster Panel; however, others were added due to the low natural recruitment in 1993 and 1994, and the low standing stocks observed in the patent tong survey. Prior to the 1993 oyster harvest season, harvesting regulations were promulgated that implemented a 12:00 noon daily time limit, 18 ft (5.45 m) hand tong limit, an increase in the minimum size for market oysters from 2.5 inches (62.5 mm) to 3 inches (76 mm) maximum dimension, reduction in shell tolerance for harvests, shortened seasons, and harvest quotas (Table 2). The most significant conservation measure was the 12:00 noon daily time limit along with a reduction by half of the season length (October 15 - December 31) for the Chesapeake Bay. Season length remained from October through April in the James River; however, a 6,000 bushel market oyster and 80,000 bushel seed oyster quota was set. On the Seaside of the Eastern Shore, a 3 inch (76 mm) cull limit was implemented for the first time on market oysters, in addition to some controls on the summer harvests of oysters.

At the completion of the 1993 - 1994 oyster season, neither market nor seed quotas were reached in the James River, only 361 bushels of oysters were harvested in all other areas of Virginia's Chesapeake Bay, and less than 1600 bushels of oysters were harvested on all of the Seaside of the Eastern Shore. Harvest restrictions were, therefore, tightened further for 1994-1995. Quotas were maintained in the James River. The harvest season length on Seaside was shortened and ended on December 31 instead of March 31. For the first time, market harvest on all other public grounds in the Chesapeake Bay were closed. There was very little natural spat set (recruitment) in 1993 and 1994. Greater than normal rainfall levels in 1993 and 1994 reduced disease related mortality and allowed excellent survival of the 1992 year class of recruits. The 1994-1995 harvest closure protected this critically important component of the population so that it was available to spawn in the summer of 1995. Had this timely closure not occurred the size of the spawning stock would have been depleted with negative implications for the ability of the resource to recover in a timely manner. Long-term rehabilitation is and probably will continue to be challenged by industry and its political supporters to open the harvest season to take advantage of a single, large years classes when they occur. Such pressure must be resisted when there remains no evidence of significant recovery in all year classes towards the previously described long term goal.

Re-evaluating Shell Placement and Seed Transplanting

The Blue Ribbon Oyster Panel recommended reexamination of past replenishment strategies and evaluation of the cost-benefit ratio of future projects. Replenishment programs in Virginia over the past 35 years have focused on moving shell and transplanting seed oysters to enhance harvest. Watermen have always been employed in Virginia to harvest and transplant seed oysters. The transplanted oysters were usually available for harvest the same year. The program had notable deficiencies. Little attention was directed to the probability of disease transfer with transplant of seed oysters. Such transfers undoubtedly occurred because the best seed producing areas were the higher salinity areas which had the highest disease incidence. In addition, almost all of the shell planting efforts have been directed towards the questionable practice of creating new oyster bars rather than towards the maintenance of the natural oyster bars of the state. Most natural oyster bars are maintained by the hydrodynamic and bottom characteristics of their unique location (see Hargis 1999, Kennedy and Sanford, 1999, Chapters 1 and 2, this volume). By contrast it is usually very difficult and expensive to build and maintain new bars in areas where oysters are not naturally present.

The movement of seed oysters is expensive and has a high financial risk caused by fluctuating disease prevalence and unpredictable freshwater events. Seed oyster movement is very complicated in that oysters produce the greatest and most dependable spat sets in moderate to

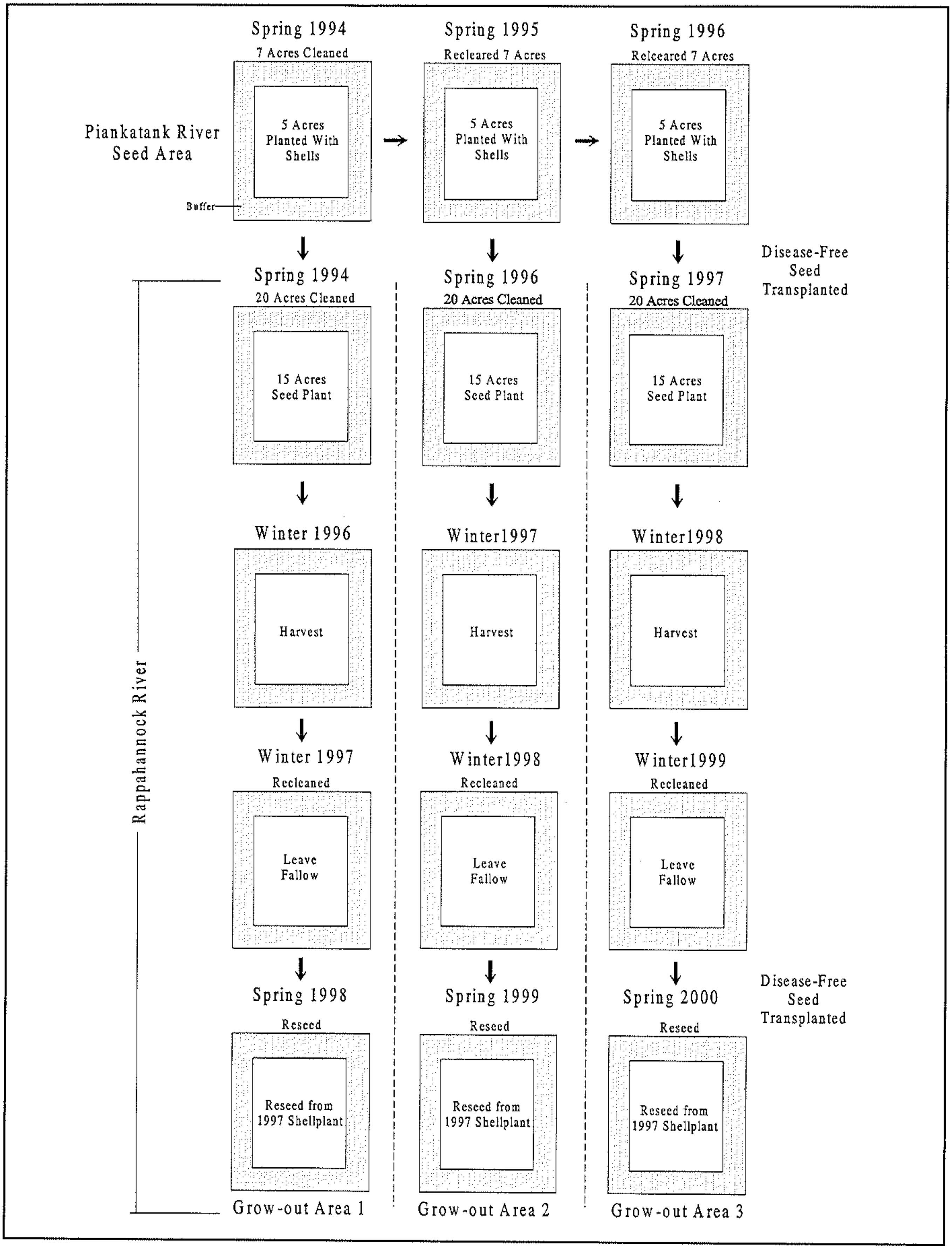

Figure 2. *Protocols and design for seed planting and harvest schedule for Piankatank and Rappahannock Rivers.*

high salinity waters but disease inhibits these oysters from reaching market size. If such seed is moved from the high salinity areas to lower salinity areas with attending lower disease pressure, the seed grows very slowly and is vulnerable to freshwater related mortality. In 1994 and 1995, the replenishment program in Virginia received two Oyster Disease Research Grants from the National Oceanic and Atmospheric Administration (NOAA) Office of Sea Grant to develop and test protocols that can use the advantages of higher salinity for spat set and oyster growth, while at the same time reducing the impacts of the oyster disease environment. These protocols have adapted past recommendations from oyster disease scientists by cleaning shell and seed beds prior to any replenishment activity as a method to reduce the impact of resident endemic disease (Fig. 2). The studies are continuing; however, current information demonstrates that removing live oysters and shell from a shell plant area prior to shell planting has resulted in disease-free seed that can be transplanted in the winter of the first year. Seed oysters are subsequently transplanted to other grow-out bed areas that again have been cleaned prior to the seed being placed on the bottom.

Reconstructing Reefs

Researchers have stressed for years the importance of maintaining cultch and reef height on the natural oyster rocks in Virginia (Haven et al. 1978; Hargis and Haven 1999, Chapter 23, this volume); however, their advice was, until recently, never heeded. Two new shell application projects have been directed towards restoring cultch on natural oyster rocks by two strategies. The first project was to lightly sprinkle shells at a rate of 500 - 1000 bushels/acre on the natural oyster rocks in the upper James River. This project began with 250,000 bushels of surf clam (*Spisula solidissima*) shells in 1994. The procedure was controversial with watermen who feared this would result in burial of living oysters; however, results demonstrating greatly improved spat sets (recruitment) on the lightly shelled natural rocks impressed almost all of the antagonists. The cultch on the critically important seed-oyster-producing bars in the James River is extremely thin, generally less than 10 L m^{-2} or a mean shell layer thickness of 2.5 cm when shells were evenly distributed (Wesson and Mann, unpublished data), and the addition of clean cultch more than doubled the natural spat set on almost all of the areas that were subjected to shell application.

The second project was carried out on the Seaside of the Eastern Shore, where cultch on many of the natural intertidal oyster bars is at low density or absent. The reef footprint and contour still exists; however, the bottom is barren of shell. In 1993, the replenishment program began concentrating shell restoration efforts on areas with almost no cultch or live oysters on bars which appeared to have the correct bottom contour. Concurrently, a hydraulic excavating machine was adapted to turnover and exhume shell of former oyster reefs when a layer of sand or sediment had covered the shells. Results of shell planting and hydraulic excavation have been very successful when proper elevation in relation to tidal height is achieved. Most disturbingly, it appears that many, if not all of the natural reefs on Seaside have been harvested to such an extent that they are now below an optimal tidal elevation for natural recruitment and survival. If the reef profiles are too low, neither cultch restoration method will be successful unless the entire reef elevation is raised.

Reef restoration was a major recommendation of Virginia's Blue Ribbon Oyster Panel. In 1994 the Governor of Virginia, George F. Allen, signed the Chesapeake Bay Aquatic Reef Plan and Oyster Fishery Management Plan, both of which call for the creation of 5,000 acres (2,024 hectares) of oyster reef habitat during the next five years. Historical accounts indicate that during colonial times many oyster rocks in Virginia were exposed at low tide, but after years of harvesting most reefs are just "footprints" of former elevations in excess of 1m below mean low water (MLW) (see Hargis 1999, Chapter 1 this volume). Any level of significant reef restoration will therefore be a very substantial reconstruction effort and is likely to be extremely expensive.

In 1993, the VMRC Oyster Replenishment Program began two projects to investigate both the value of reef structures for the survival of the oyster as well as methods by which reefs could be constructed. The first project was in the Piankatank River (Figures 3 and 4), a small coastal plain estuary classified as a "trap-type" estuary (Andrews and Ray 1988) because setting is more intensive and localized due to a circular closed water movement pattern (this is in contrast to the large flushing type rivers like the Rappahannock.). In the "trap type" estuaries, spat settlement has remained relatively high even with the decline in the population of oysters. The 1993 project began with construction of an intertidal oyster reef made entirely from shucked oyster shells. Shells were loaded on barges at shucking houses, moved by tugboat to the Piankatank River, and deployed by water cannon. The reef was constructed parallel with the direction of tidal movement on the footprint of an old oyster reef. Water depths were approximately 2 m at high tide and oyster shells were deployed until visible on the surface. Approximately 207,000 bushels of oyster and clam shells were deployed in a 300 m long by 30 m wide high reef structure in 1.8 - 2.0 m depth that consisted initially of 22 individual intertidal mounds. The Piankatank typically has an 0.5 m tidal range. All 22 mounds were covered at high tide and exposed to some degree at low tide. This reef project had a total cost of $137,908 or $460 per linear meter of reef structure.

Since building reefs with shells which are transported from land

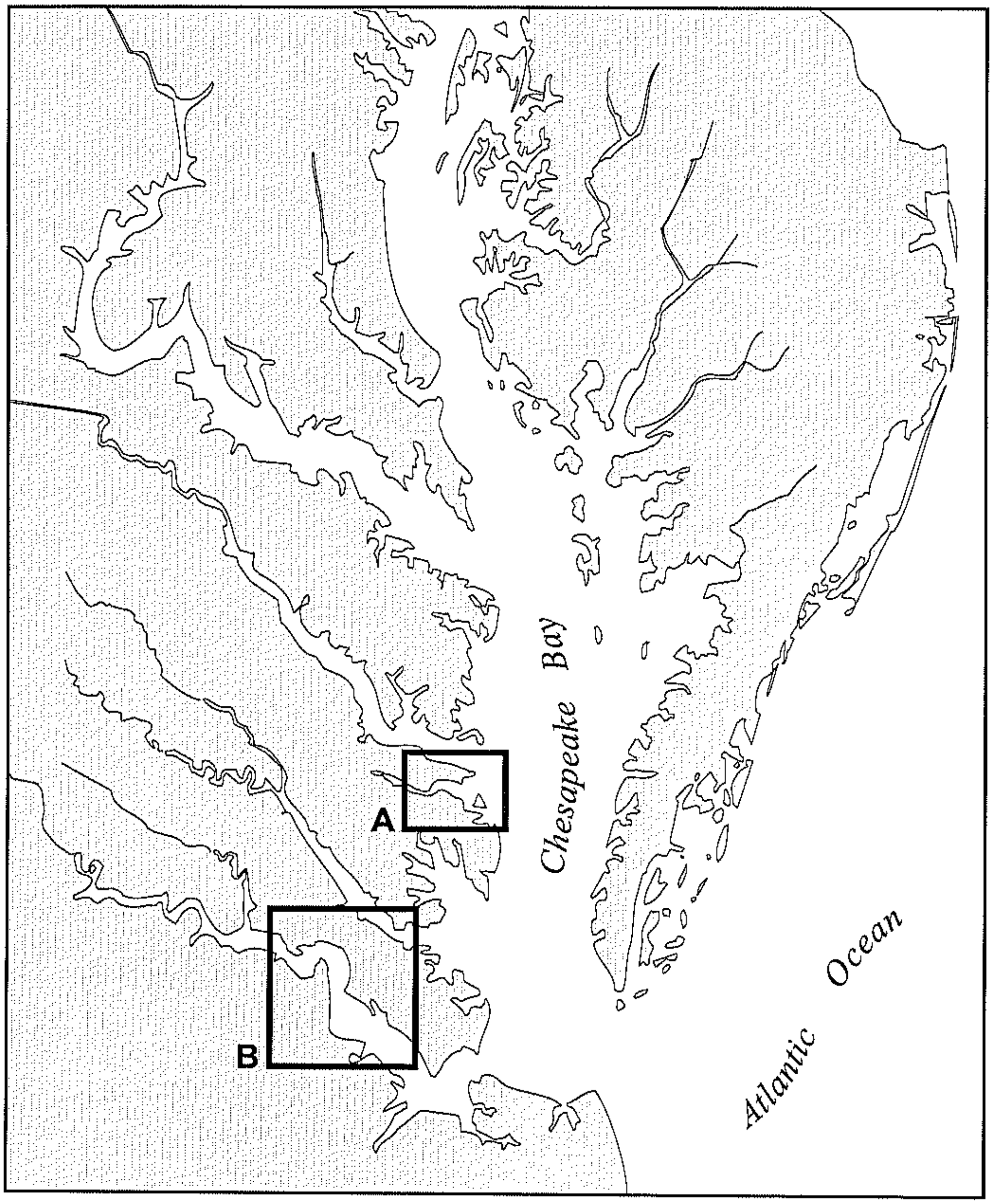

Figure 3. Chesapeake Bay with regions of the Piankatank (A) and James (B) Rivers, indicating reef restoration sites.

appears very expensive for significant restoration efforts, a second construction technique was tested at Wreck Shoals in the James River (Figure 5). At Wreck Shoals, historical bathymetric and oyster survey information was examined to select an area that would have both firm bottom and high buried shell content. Marine construction proposals were then solicited to build, using the bottom substrate, 7,575 linear m (25, 000 linear feet) of 1.2 - 2.0 m tall reef structures in water depths of approximately 3.0 m. Specifications limited the depth that contractors could dig when building the reef structures. Several methods were proposed, and the successful bidder used a clam shell dredge on a barge. Thirteen parallel berms were constructed in a pattern similar to field furrows. The cost for this project was $251,887 or approximately $33/linear meter. After construction, 80,000 bushels of clam shell cultch were spread on the reef area, which covered a total of approximately 50 acres. This increased the final cost to approximately $39/linear meter of reef. This appears to be the most cost effective method of constructing significant amounts of reef structures.

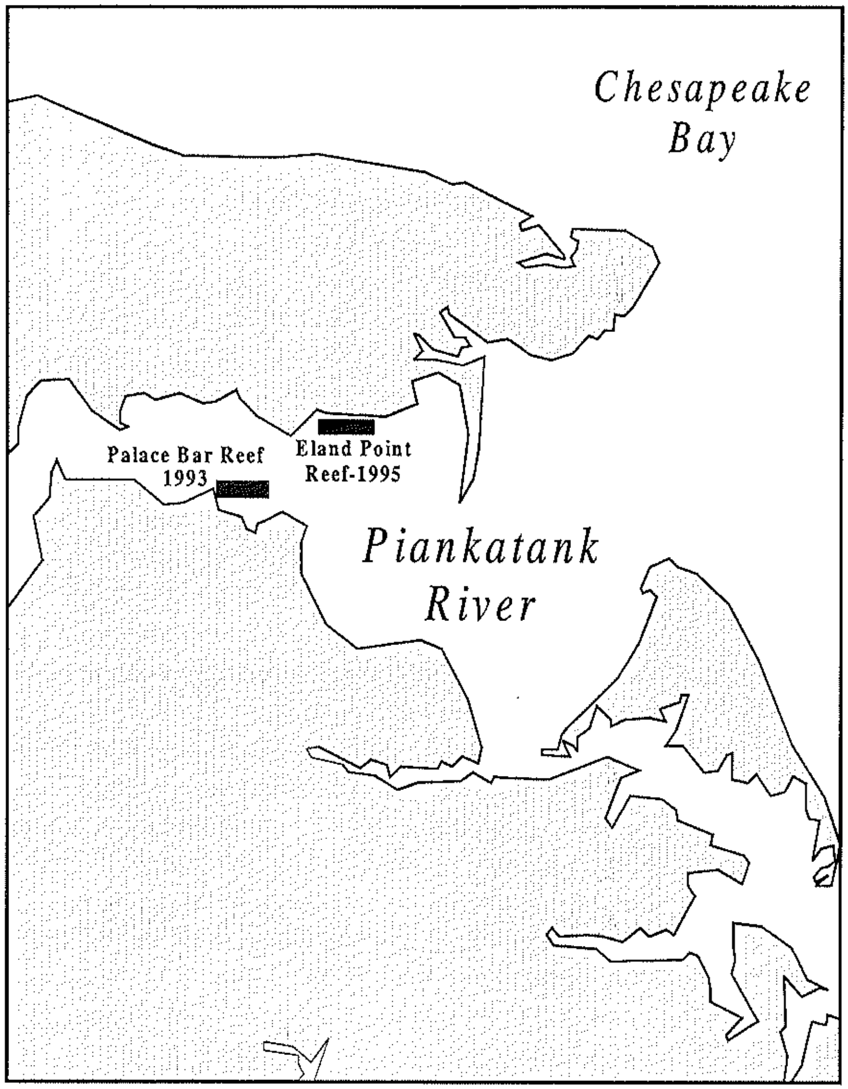

Figure 4. Reef restroation sites in the Piankatank River, Virginia.

Both of the 1993 reef projects were in historic oyster habitat with moderate salinity (15-20 ppt), where modest settlement and recruitment potential still exists, both oyster diseases are present and should give long-term information on disease mortality. Oyster spat sets were light in both areas in the summer of 1993 and 1994; however, small and market oysters are now apparent on both sites. In the fall of 1994 mean oyster density on the Piankatank Reef was five times higher than on the Wreck Shoals Reef. The larger population of oysters on the Piankatank River Reef may have resulted from the greater thickness of oyster cultch which may have increased the survival of the young oysters; however, many differences in the reef sites may have contributed to these differences, including but not limited to reef configuration, substrate material, geographic location, brood stock abundance and water depths. Intensive monitoring continues at both of these sites.

A third reef structure in Virginia was proposed and funded by the Environmental Protection Agency (EPA) Chesapeake Bay Program in 1994. As proposed, the reef would have been constructed on historic oyster bottom in the James River slightly upstream from the Wreck Shoals reef (Figure 5). The method as originally proposed and funded was to use marine construction equipment to build 9,100 linear m (30,000 liner ft) of subtidal oyster reef using bottom substrate. As proposed, the project would have examined the orientation of the reef structure in relation to tidal flow direction by building the reef in a pattern similar to the "spokes of a wheel" radiating from a hub. The project had been through scientific peer review and a successful construction bidding process; however, in May, the approved site and methodology were challenged by local watermen.

As a consequence of this challenge, the project was delayed and a committee of watermen and fisheries managers was appointed to choose a new site and review the methodology. After examining several sites in the James River, the committee chose a site on barren, shifting, sandy bottom, on the public (Baylor) oyster grounds inshore of Rocklanding Channel near Mulberry Point (Figures 3, 5 and 6). In many ways, the committee decision stood in opposition to the principles of the funded project. There were no living oysters on the construction site, although oyster beds were upriver and downriver of the site. The annual records for salinity on the site varied from a minimum of 0 ppt to a maximum of around 12 ppt, but averaged 5 - 10 ppt. Neither Dermo (*Perkinsus marinus*) nor MSX (*Haplosporidium nelsoni*) were suspected to cause mortality in this area; however, oysters were subject to freshets. Tidal currents in the area were high on both ebb and flow. It is not known why the oysters did not exist on this site; but a majority of the committee believed that if substrate was placed at this site in a reef structure, oysters would colonize the reef. The committee also decided to change the construction method. As originally proposed, marine construction equipment would mound bottom materials on site to create the reefs and then cap the structure with shell veneer. The committee recommended the

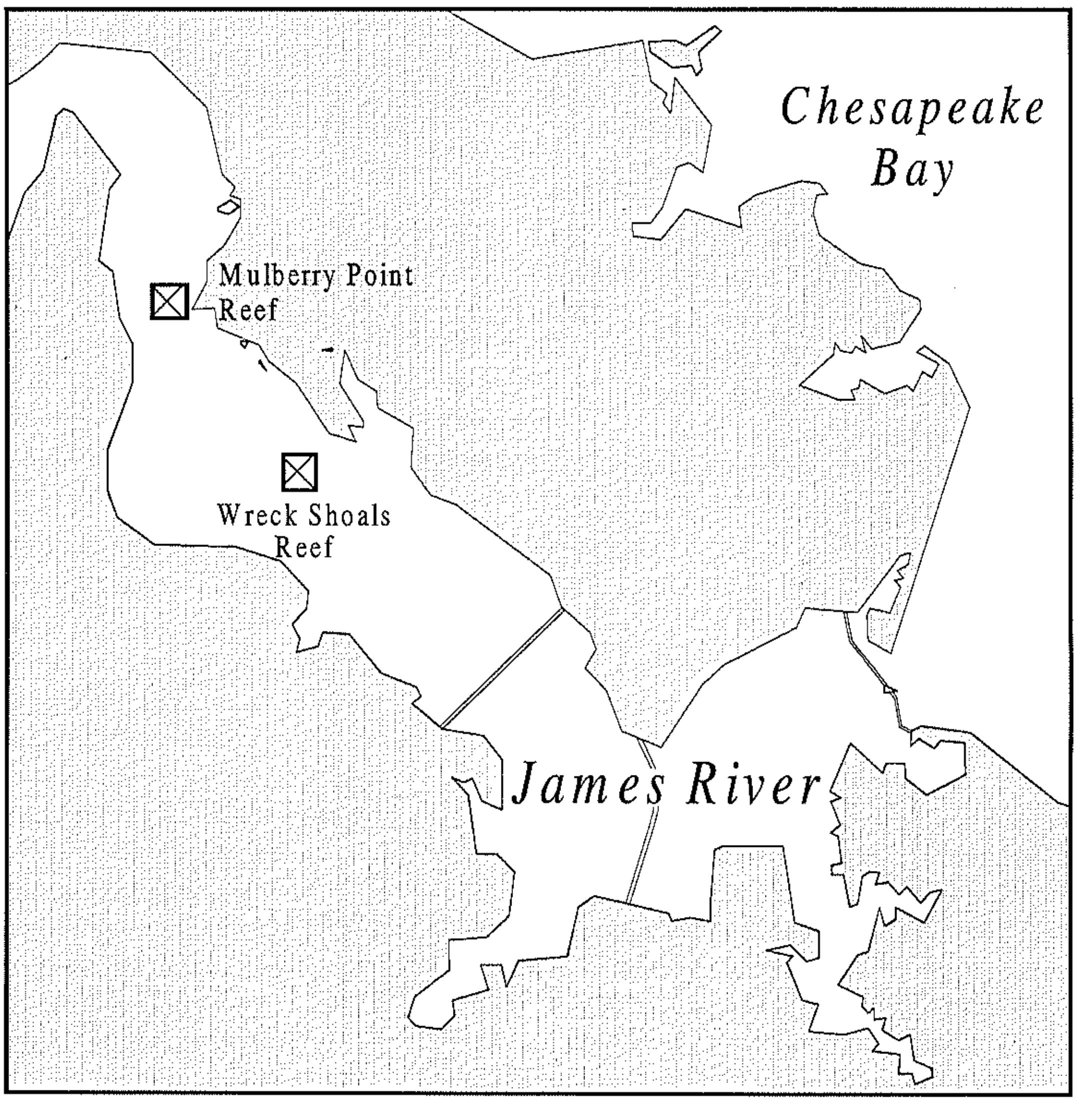

Figure 5. *Reef restoration sites in the James River, Virginia.*

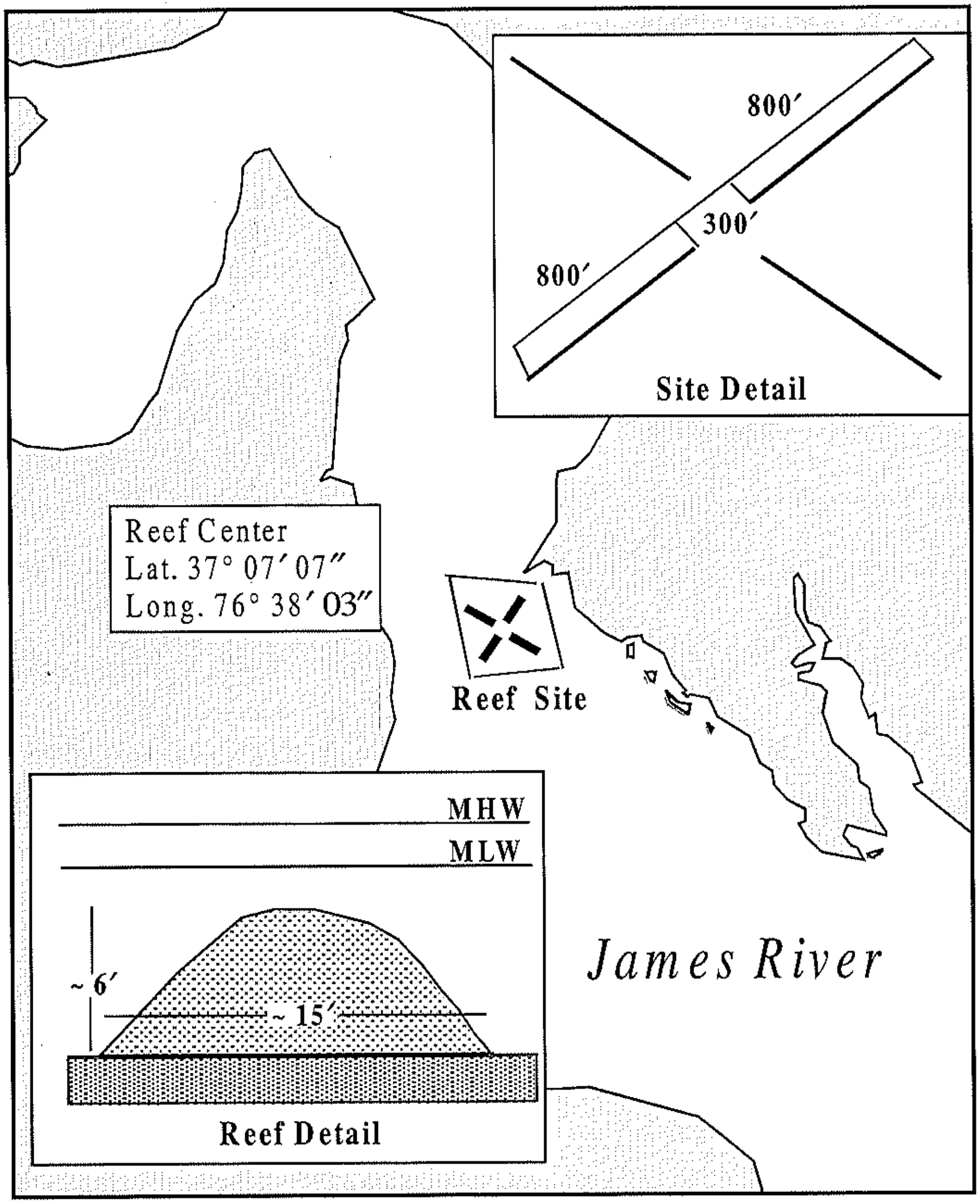

Figure 6. Mulberry Point Reef in the James River, Virginia.

construction of the reef from deployed shell material. Shells would be purchased from oyster and clam houses and come by barge to the site. Since the costs of the shell method was much more than the bottom construction method that was originally proposed, the design of the reef was simplified. Only four lines of reef structure were surveyed and marked for deployment in an orientation where two lines were approximately parallel with the tidal flow and two lines were approximately perpendicular to the tidal flow (Figure 6). Water depths at the site varied from 1.6 - 3.5 m MLW.

Construction began on August 17 and was completed on September 23, 1994. During each deployment of shells, a barge was placed in a parallel position adjacent to one at the lines which had been marked by flags. A spud barge with a crane held the shell barge in place. A water cannon on the shell barge was maneuvered with a "bobcat" loader and shells were washed off one side for the entire 45 m length. Each barge completed 45 - 60 m of mound approximately 2 m tall and 5 - 6 m wide. A total of 920 linear m of structure was completed with lines 1 (255 m) and 4 (255 m) being partially intertidal and line 2 (240 m) and 3 (170 m) being entirely subtidal. A total of 302,390 bushels of shells was placed in reef structures at an average cost of $0.95/bushel or $312.67/linear meter of reef. In recent years, spatfall has occurred in the James River between late July and mid-September. Delay in the site selection process of the new reef resulted in the construction late in the oyster setting season. Thus it was not surprising that very little oyster settlement was observed during the year of construction.

The success of the 1993 effort in the Piankatank River reef encouraged a more supportive political attitude towards reefs in that

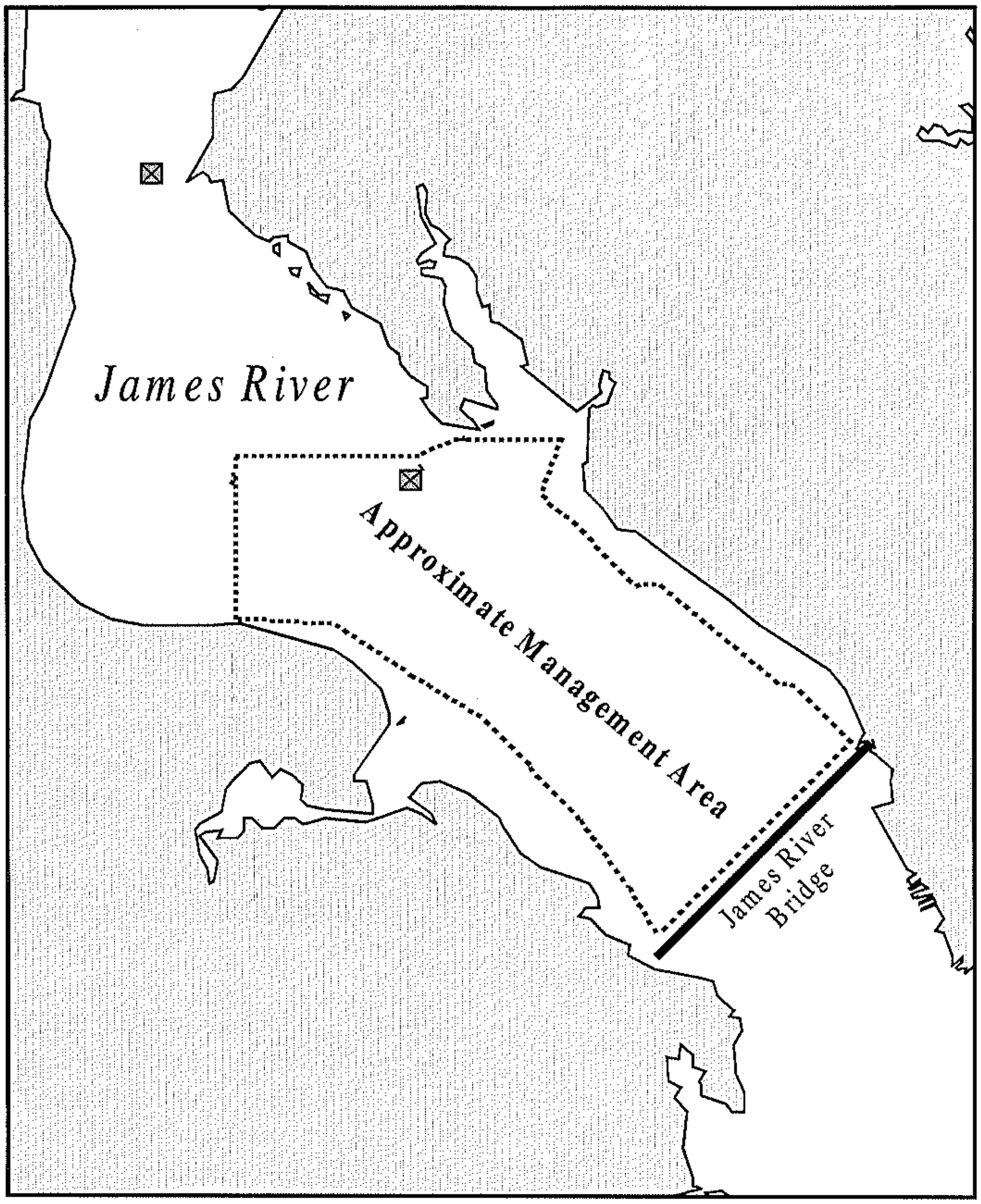

Figure 7. Oyster sanctuary area in the James river, Virginia.

area, and in 1995 another EPA Chesapeake Bay Program Grant project was funded to continue the investigation of created reef habitat in that location. The 1995 grant was for $245,907 for further reef construction using oyster shells. Three reef construction locations (Figure 4) were chosen for the bottom consistency (old shell and hard bottom), and for depths that are 2 - 2.5 m MLW so that the reefs can be mounded to an intertidal height. The recorded oyster spat set in the Piankatank River in 1993 and 1994 were the lowest in the 1977-1994 period. It is possible that broodstock density has reached such a low level that reproductive success in even this type of estuary has been compromised. The objective of the multiple reef project is to investigate the possibility that several thriving reef populations of oysters could, in aggregate, rebuild the spawning capacity of the entire river system.

All reef structures built in Virginia are closed to oyster harvesting and will remain sanctuaries for broodstock restoration. In addition, the Blue Ribbon Oyster Panel recommended setting aside oyster sanctuaries in several river systems throughout the Bay. To date, one large sanctuary in the James River has been designated (Figure 7). Currently, this area has very limited oyster population, and was therefore unimportant to the oyster industry. Restoration of the oyster resource in Virginia, which has been invigorated by the joint efforts of the Blue Ribbon Oyster Plan and by achievable long-term goals set by the Marine Resources Commission, is slowly progressing in a positive direction. Oyster recovery will only be accomplished by the combination of a commitment to long-term management, protection of a stable and growing broodstock population, and by controlling harvest limits to only the small surplus production of a precariously small oyster resource.

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