1999

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Oyster Reef Habitat Restoration: A Synopsis and Synthesis of Approaches

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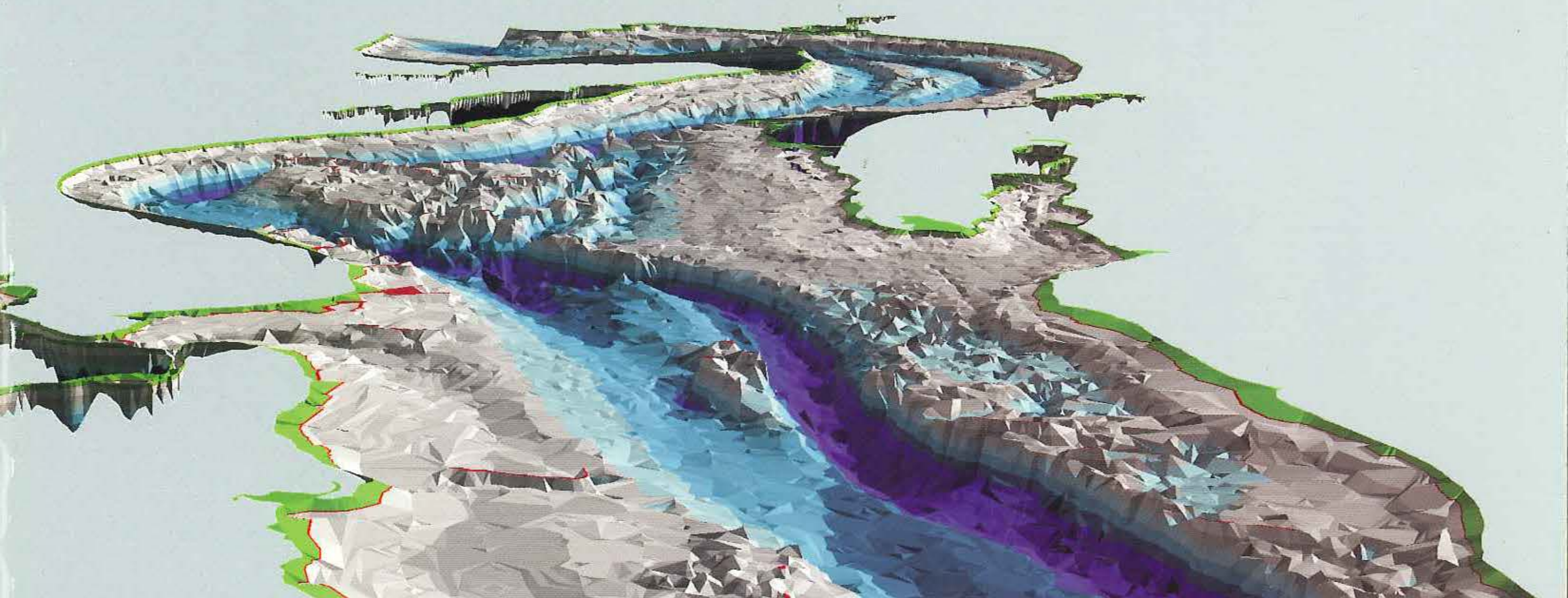

Proceedings from the Symposium • Williamsburg, Virginia • April 1995

Chapter 19

Use of Dredged Material for Oyster Habitat Creation in Coastal Virginia

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Abstract

Dredging can have a beneficial effect on oyster habitat when the placement of the dredged material is effectively managed to help provide the bottom structure necessary to develop an oyster reef. Construction and maintenance of the Waterway on the Coast of Virginia (WCV) by the U. S. Army Corps of Engineers (Corps) has provided a number of examples of this process, both serendipitous and deliberate. The historical development of reefs that evolved from the random overboard placement of dredged material and the subsequent leasing of these areas for oyster cultivation is reviewed. A monitoring plan for the development of a reef in Swash Bay using maintenance dredging material is also described including pre- and post-dredging hydrographic surveys, surface sediment distributions, and shellfish surveys.

After one year, the benthic communities at the recently used placement site, the historical placement site and an unimpacted area in Swash Bay were compared using the Benthic Assessment Method (BAM) to determine short-term impacts. The historical and unimpacted sites had very similar values while the recently used site was somewhat lower. Consequences of continued success in developing oyster reefs in close proximity to a dredged channel are addressed with a suggested management plan that involves rotating the placement among a number of sites. This would allow for the continued maintenance of both the channel and the adjacent oyster reefs.

Introduction

Properly managed, dredged material has the potential to be an important resource in the management and enhancement of oyster fisheries by providing the foundation material for the construction of new or the restoration of old reefs. This can be particularly important in areas like the Seaside of the Eastern Shore of Virginia (Figure 1) where natural oyster reefs in the back barrier bays are primarily intertidal and raised one to two feet above the surrounding flats (Haven et al. 1981). Higher elevations are necessary for oyster production on the Seaside. Intertidal exposure appears to improve survival of the oysters by minimizing their exposure to disease and predators (M. Luckenbach, personal communication). In fact, intertidal oyster reefs have developed serendipitously on dredged material placement sites on the WCV (Priest, 1994). Dredged material has also been used in Maryland for the construction of a subtidal reef that was subsequently planted with oyster shell cultch to initiate development of the reef (Earhart et al, 1988 and Clarke et al. 1999, Chapter 21, this volume).

The WCV is an 85 mile long portion of the Intracoastal Waterway that extends north to south through the barrier bays and channels along the Seaside of Virginia's Eastern Shore (Figure 1). Maintenance of this waterway involves the regular dredging of approximately nineteen shoals and several ancillary channels with an average annual volume of over 300,000 yd^3 (VIMS and VMRC 1994). While many different placement options are used for dredging these shoals, the most commonly used option is overboard hydraulic discharge in open water adjacent and parallel to the channels. With repeated usage these sites can begin to emerge in a series of intertidal sand and shell hummocks that are often colonized by oysters naturally.

Local watermen soon realize the value of these areas for the cultivation of oysters and start leasing them from the State. By comparing the locations of previously used placement areas shown on the Corps project maps and the oyster lease records maintained by the Virginia Marine

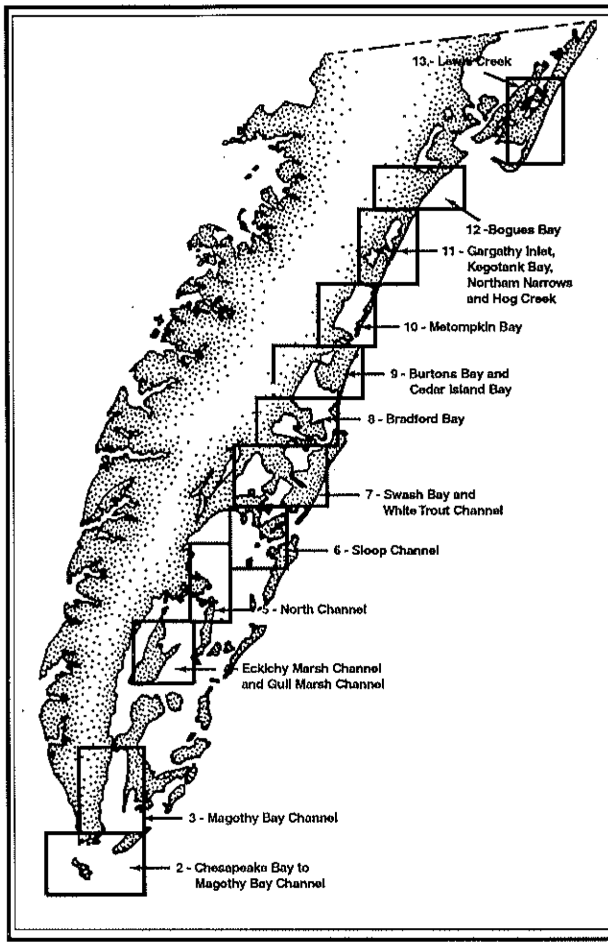

Figure 1. Waterway on the coast of Virginia showing segments maintained by Corps dredging.

Resources Commission (VMRC), we have been able to determine that at least thirteen different sites have been leased subsequent to their use as placement areas for the WCV and its ancillary channels. This leasing can present a serious management problem because it usually eliminates that area as a future placement site. Consequently, new sites have to developed and approved which can become problematic due to engineering considerations or adverse environmental impacts. This situation actually occurred in Swash Bay where the placement area that had been used since 1957 was leased in 1985 and was no longer available as a placement area. As a part of the approval process for a new placement site, a management plan for the Swash Bay channel was developed with three goals in mind, 1) to use the dredged material to build an oyster reef, 2) monitor its development as a model for other channels and 3) to plan for the future placement needs.

A major concern in this approval process is the tradeoff that inevitably occurs when one type of habitat, shallow subtidal soft-bottom, is converted to another, intertidal mud/sand flat. Both are still part of the marine ecosystem, but their ecological roles can be completely different. The question of whether these changes are good, bad or indifferent always begs to be answered.

The circumstances in Swash Bay presented a unique opportunity to address the resource tradeoff question in addition to monitoring the evolution of the dredged material placement area. Swash Bay has all of the components that might be used to evaluate both the short and long term effects of the dredged material placement on benthic communities. It contains an area of recently deposited material, old reef areas greater than ten years old that have developed on dredged material, and previously undisturbed bottom.

Since the existing reefs developed from dredged material have evolved over a number dredging episodes and involved varied sediment characteristics and placement methods, their ontogeny cannot be reconstructed with any certainty. Hence this study was designed to begin the process of documenting the intentional development of an oyster rock using the dredged material from Swash Bay. This will be accomplished by continuing to place the material in the same area until such time as a substantial portion of the area becomes intertidal (the initial threshold has been proposed at approximately ten acres). Once the intertidal elevations have been reached the Corps will endeavor to plant the dredged material with shell cultch to stimulate the development of an oyster reef on the site. During the interim VMRC has agreed not to lease the bottom as long as it is an active placement area for the channel. The Virginia Institute of Marine Science (VIMS) and the Corps are monitoring conditions at the placement site before, six and eighteen months after the first dredging episode as a part of the management plan. VIMS is to document changes in the shellfish community and surface sediment conditions, while the Corps is to provide periodic bathymetric surveys of the placement area to describe changes in the physiography of the sediment mound.

The purpose of this study is primarily to determine the existing shellfish resources, i.e. the molluscan fauna, the amount of surficial shell, and the nature of the surface sediments in the placement area and document the changes that occur after the initial dredged material placement. Additionally, an effort was made to evaluate the short- and long-term impacts of the placement on the benthic communities in Swash Bay.

Methods

The new dredged material placement area is a 1000 ft^2 (93 m^3) square centered 1500 ft (457 m) east of the southern portion of the project channel (Figure 2). The area was surveyed by the Corps in March 1992 to established the pre-dredging bathymetry at the site. The channel was dredged during March and April of 1993. Post-dredging surveys were

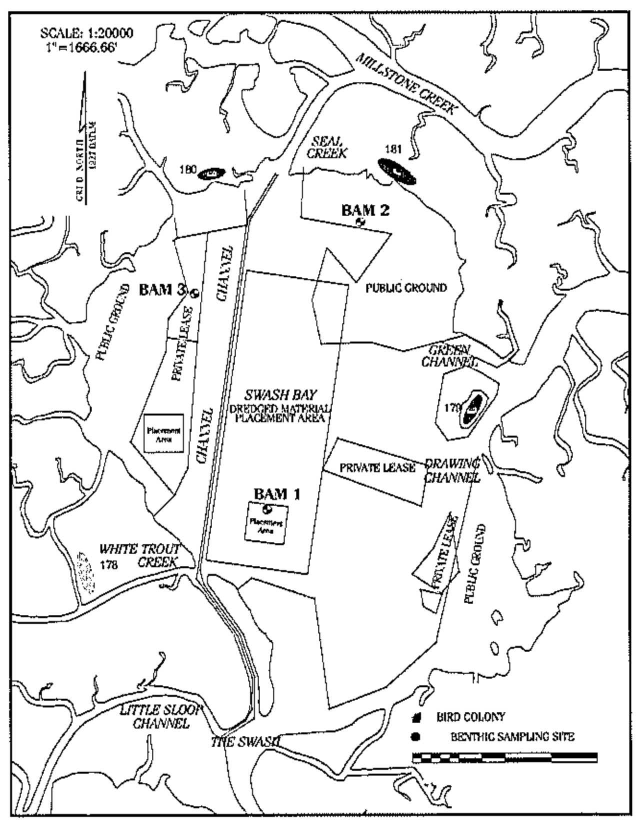

Figure 2. Swash Bay Vacinity.

conducted in July 1993 and September 1994 to document changes that have occurred in the bathymetry of the placement area. These surveys were conducted with a vessel mounted recording fathometer linked to a differential Global Positioning System (G.P.S.) to determine location.

A sampling grid was established on the placement area with 25 stations on 250 ft. centers forming a 5 x 5 grid. In addition, a short transect with four stations 250 ft. apart was established extending east from the middle of the eastern side of the placement area (Figure 3). Each station was located by a Corps survey crew in both 1992 and 1993.

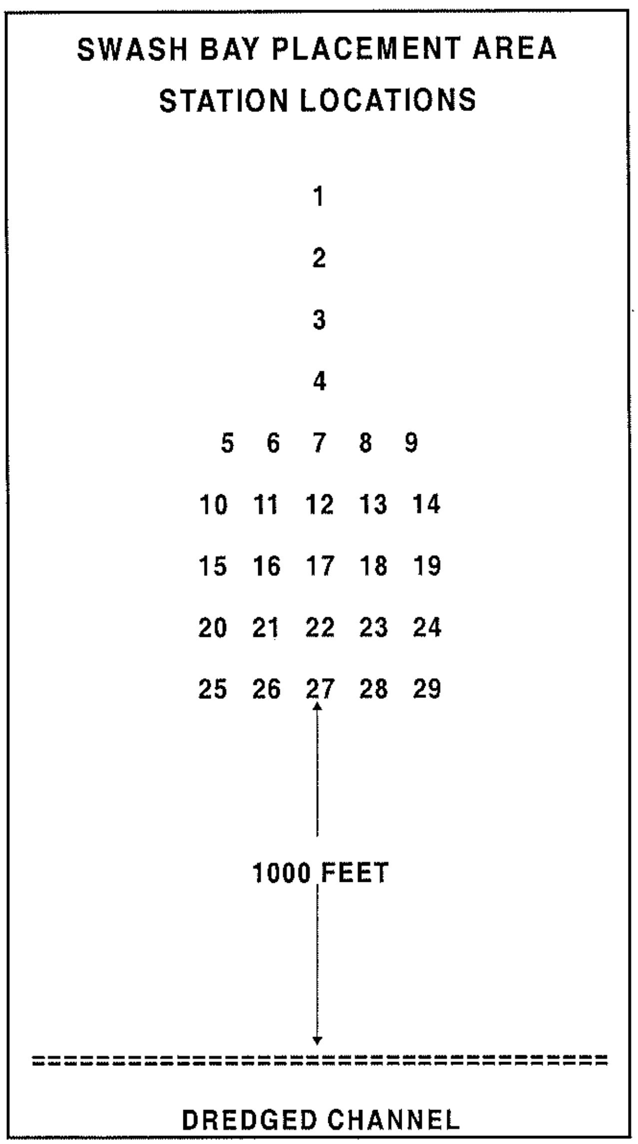

Figure 3. Schematic of station locations for Swash Bay placement area

Each of the 29 stations was sampled using randomly placed 0.25 m^2 circular quadrat deployed by divers. All of the material to a depth of 15 cm was removed with a 76 mm diameter suction dredge fitted with a 5 mm mesh bag over the discharge. Each bag was labeled, secured, placed on ice, and returned to the lab for live-sorting for benthic fauna. The material in each bag was sieved through a 5 mm mesh screen. All mollusks and other large fauna retained on the screen were preserved in 10% formalin for later identification. The shell material retained on the screen was placed in a graduated jar and its volume in cubic centimeters was estimated.

A surface sediment sample was collected at each of the 29 stations and analyzed for percent sand in 1992 and percent sand, silt and clay in 1993 using standard sieve and pipette procedures.

Numerous rapid bioassessment methods have been developed to evaluate and detect anthropogenic stress, disturbance and change in benthic communities. The Benthic Assessment Method (BAM), was recently developed at VIMS by Diaz and Maxemchuck-Daly (in prep) for use in soft-bottom estuarine habitats. This index is based on the premise that healthy areas contain diverse well-developed communities dominated by large deep-dwelling organisms. The benthic community is evaluated and given a score based on the functional lifestyle, size, depth of occurrence and biomass of the fauna present. In general, low scores reflect disturbed or stressed habitats and high scores indicate productive established habitats. BAM scores for Virginia estuaries typically range from 0 to 8 (Diaz and Maxemchuck-Daly, in prep).

The BAM method was used to compare the benthic communities at the recently used placement site (BAM 1), one that was over ten years old (BAM 2), and a previously undisturbed site (BAM 3) (Figure 2). Each of these habitats was sampled in June 1994 approximately one year after the most recent dredging episode. Three replicate samples were taken at each site to assess the average condition.

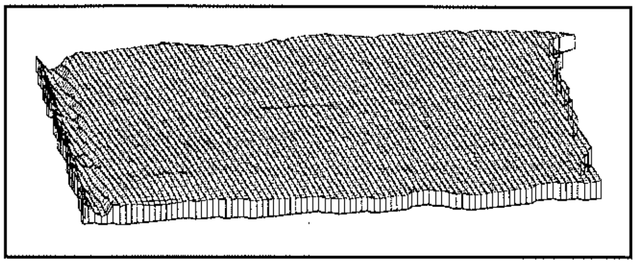

Figure 4. Topography of Swash Bay Placement Area, March 1992.

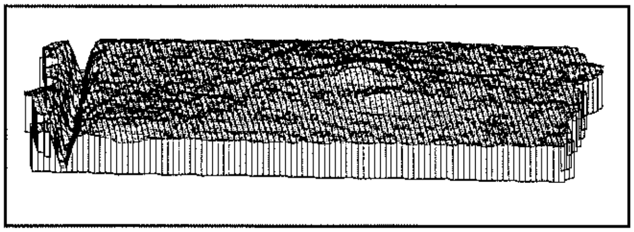

Figure 5. Topography of Swash Bay Placement Area, July 1993.

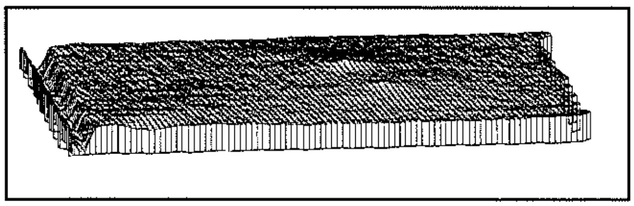

Figure 6. Topography of Swash Bay Placement Area, September 1994

The benthic macrofaunal samples were obtained using a Wildco 15 cm x 15 cm x 30 cm box core (225 cm^2 surface area) which penetrated the sediment to a depth of at least 15 cm. In the field, the box core sample was divided into 0-5 cm and >5 cm fractions. Both fractions of the box core sample were sieved separately on a 500 μm Nitex mesh screen. Material retained was fixed in 10% buffered formalin with a rose bengal stain. In the laboratory, samples were washed in fresh water and organisms were removed from the sediment and detritus and sorted into major taxonomic groups using a binocular dissecting microscope. The formalin preserved wet weight was determined to the nearest 0.1 mg.

Results

The most recent dredging of Swash Bay occurred in April 1993 when 111,000 yd^3 of maintenance material was removed from the channel and placed in a 1000 ft^2 area centered 1500 feet east of the southern end of the channel (Figures 2 and 3). Pre-dredging sediment sampling indicated the material averaged approximately 6% sand (Century Engineering, 1983). The pre-dredging bathymetric survey (Figure 4) depicts a relatively flat shallow subtidal area that was approximately 1.5 ft. (45.7 cm.) deep at mean low water. The mean tide range at the site is approximately 4 ft. (1.2 m). When the area was bathymetrically surveyed three months after the dredging in July 1993, two small mounds of material are noticeable above a much larger mound of lower relief (Figure 5). Based on this survey, the Corps calculated that the volume of the dredged material mound was approximately 82,000 yd^3 which represented 74% of the material dredged. The placement area was surveyed again in September 1994 approximately 17

Table 1. Summary of monitoring parameters for the Swash Bay Dredged Material Placement and Reference Areas.

		% Sand		**Shell Volume (cc/quadrat)**		**Total Mollusks (#/quadrat)**	
		1992	**1993**	**1992**	**1993**	**1992**	**1993**
Placement Area (Stations 5-29)	Mean	13.7	11.4	49.9	9.2	7.7	4
	Range	22-5	49-2	300-5	25-1	101-0	21-1
Reference Transect (Stations 1-4)	Mean	35	32.3	57.5	47.5	6	5.5
	Range	54-20	51-3	125-5	150-5	13-0	9-2
Combined Value (Stations 1-29)	Mean	16.7	14.3	51	14.4	7.5	4.2
	Range	54-5	51-2	300-5	150-1	101-0	21-1

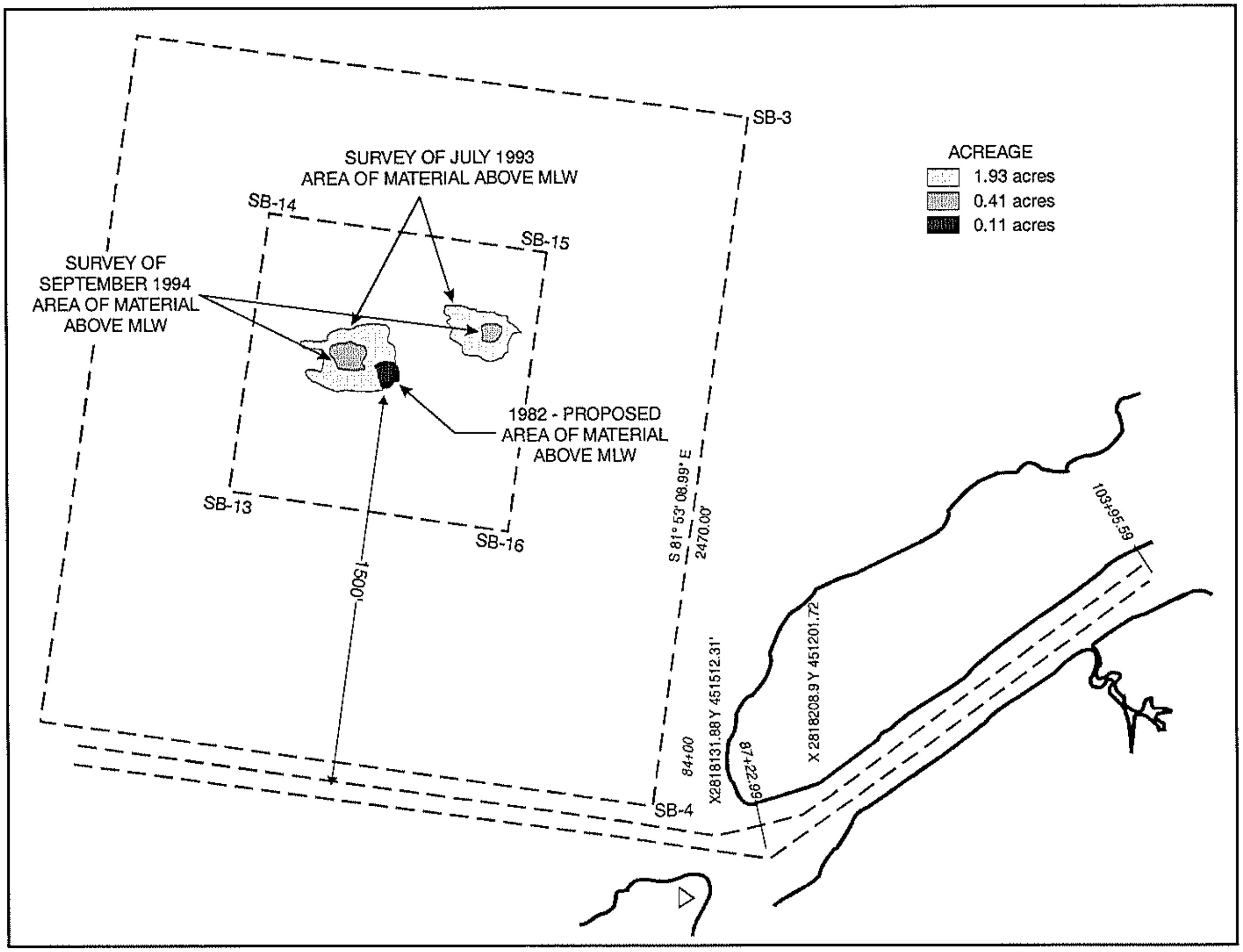

Figure 7. Bathymetric survey results for Swash Bay Reef showing intertidal portion.

Table 2. Mollusks identified from the Swash Bay Dredged Material.

Species	1992	1993
Andara ovalis	1	3
Crepidula fornicata	2	1
Cylichna sp.	0	10
Eupleura caudata	0	1
Ilyanassa obseleta	177	38
Mecoma balthica	8	20
Macoma tenta	10	38
Mercenaria mercenaria	3	0
Tagelus plebius	15	11
unid mussel	0	1

months after the dredging (Figure 6). The two small mounds were still evident and the volume was calculated to be 75,000 yd^3 which represents 68% of the original material dredged.

The Corps originally estimated in the Swash Bay Management Plan that approximately 0.11 acres (445 m^2) of the placement area would become intertidal after the first dredging cycle. According to the July 1993 bathymetric survey, the intertidal area was approximately 1.93 acres (7811 m^2). Fourteen months later when the area was resurveyed in September 1994, the intertidal area had been reduced to 0.41 acres (1660 m^2) (see Figure 7).

The results of the surface sediment, shell volume and total mollusks sampling over the grid established on the placement area are

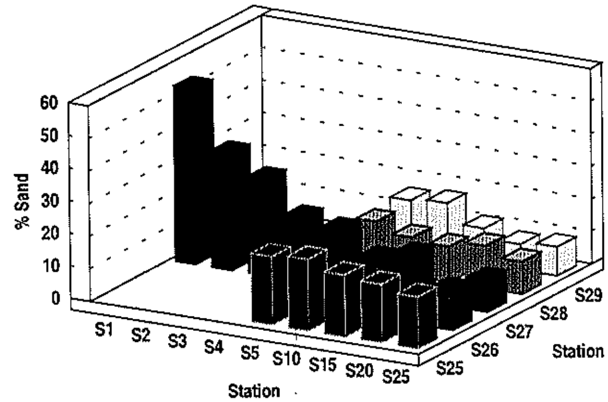

Figure 8. Sand composition by station before dredging, 1992.

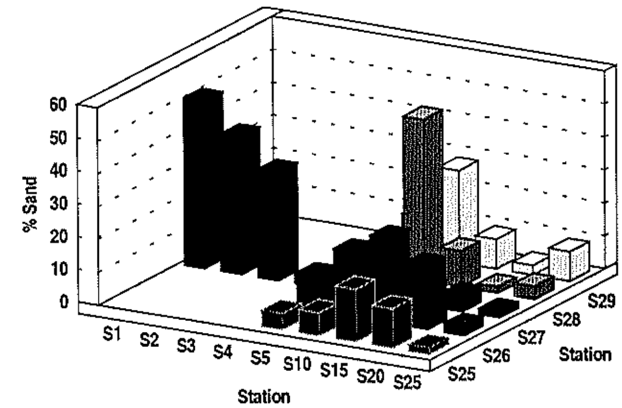

Figure 9. Sand composition by station after dredging, 1993.

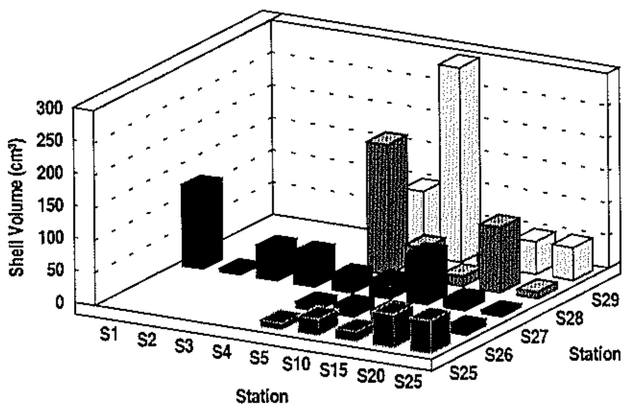

Figure 10. Shell volume by station before dredging, 1992.

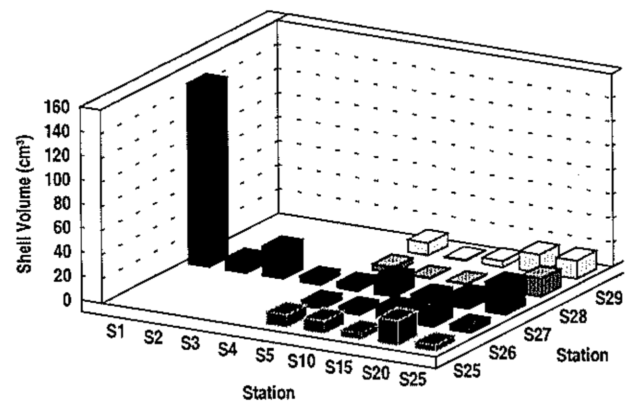

Figure 11. Shell volume by station after dredging, 1993.

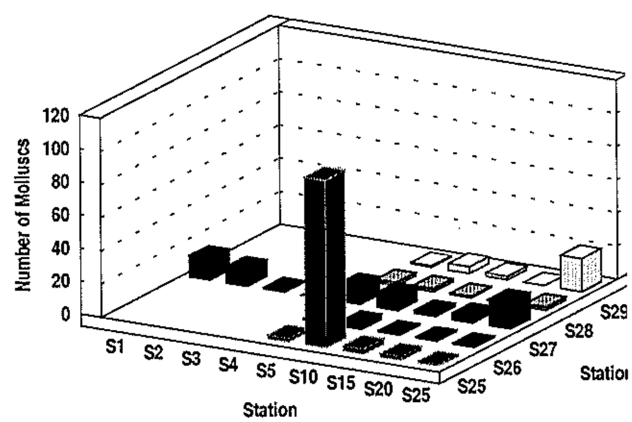

Figure 12. Number of molluscs by station before dredging, 1992.

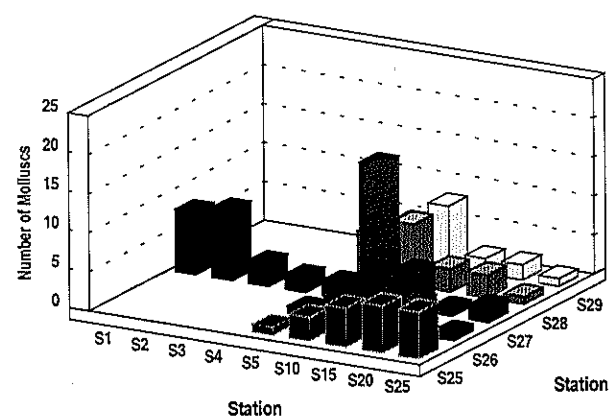

Figure 13. Number of Molluscs by station after dredging, 1993.

summarized in Table 1. These data are also graphically compared by station for both before dredging, 1992, and after dredging, 1993 in Figures 8-13. The specific data on the mollusks recovered are presented in Table 2.

The surface sediments in the placement area prior to the dredging ranged from 5-22% sand with an average of 13.7% in 1992. After dredging in 1993, the average percent sand was only slightly lower at 11.4%. The range, however, had increased considerably to 2-49%. The reference transect (stations 1-4) sand percentages changed very little from 35% in 1992 to 32.3% in 1993. The range increased slightly from 20-54% in 1992 to 3-51% in 1993. The highest percentages of sand after the dredging were located in two areas near where the pipeline discharge occurred, and the lowest percentages were found around the perimeter.

The average shell volume in the placement area dropped substantially between 1992 and 1993 from 50 cm³/quadrat to 9.2 cm³/quadrat. The range of shell volumes was also reduced from 5-300 cm³/quadrat to 1-25 cm³/quadrat. The reference transect average shell volume stayed virtually the same 57.5 cm³/quadrat vs. 47.5 cm³/quadrat and maintained similar ranges.

The only commercially important shellfish that were found in the placement area during the quadrat sampling were three hard clams, *Mercenaria*. None were found in the placement area after the dredging. Overall, the number of

Table 3. Swash Bay B.A.M. Results - June 1994.

Site	Replicate	Core Section	Is fauna present in >5cm section?	Is fauna in >5cm section large?	Fauna lifestyle	Section biomass (g)	Total biomass (g)	% biomass in >5cm section	Total BAM score*	Comments
New Displacement Area	1	0-5cm	yes (1)	yes (1)	Small burrowers (1)	1.330	2.0137	34% (2)	(5)	
		>5cm				0.6807				
	2	0-5cm	yes (1)	yes (1)	Long-lived large fauna (2)	0.5582	1.9984	72% (3)	(7)	Large Nereis
		>5cm				1.4402				
	3	0-5cm	yes (1)	yes (1)	Small burrowers (1)	0.5613	1.0661	47% (2)	(5)	
		>5cm				0.5048				
Undisturbed Area	1	0-5cm	yes (1)	yes (1)	Long-lived large fauna (2)	0.4827	7.0717	93% (4)	(8)	Large Nereis
		>5cm				6.5890				
	2	0-5cm	yes (1)	yes (1)	Long-lived large fauna (2)	0.6338	3.9136	83% (4)	(8)	Large Nereis
		>5cm				3.2798				
	3	0-5cm	yes (1)	yes (1)	Small burrowers (1)	0.2770	2.1408	87% (4)	(7)	
		>5cm				1.8638				
Old Placement Area	1	0-5cm	yes (1)	yes (1)	Small burrowers (1)	0.6379	4.2831	85% (4)	(7)	
		>5cm				3.6452				
	2	0-5cm	yes (1)	yes (1)	Long-lived large fauna (2)	10.5559	14.7868	29% (2)	(6)	Large Nereis holothuroidea
		>5cm				4.2309				
	3	0-5cm	yes (1)	yes (1)	Long-lived large fauna (2)	0.4273	13.1988	97% (4)	(8)	Large Nereis small Mercenaria
		>5cm				12.7715				

Total BAM Score interpretation:
- 0-1 Poor habitat, seriously disturbed
- 2-3 Moderately disturbed or stresses habitat
- 4-5 Slightly disturbed to moderately disturbed habitat
- 6-8 Good habitat

Table 4. Surface sediment characteristics at the Benthic Assessment Method sites in Swash Bay.

		% Gravel	% Sand	% Silt	% Clay
BAM1	New Placement Site (n=3)	-0-	9.5	53.7	36.7
BAM2	Undisturbed Site (n=1)	-0-	9.6	57.5	32.9
BAM3	Old Placement Site (n=2)	0.2	24.6	43.1	32.2

mollusks in the placement area appears to have decreased from an average of 7.7/quadrat in 1992 to 4/quadrat in 1993. These data are somewhat skewed by one quadrat that had 101 snails, *Ilyanassa obseleta*. If this quadrat is eliminated from the analysis the numbers per quadrat become 4.0 and 3.8 for 1992 and 1993, respectively. A summary of the species and numbers found in the quadrats is given in Table 2. The relationship between the number of mollusks and the percent sand at each station after the dredging is depicted in Figure 14.

The results of the BAM sampling at the new placement area, undisturbed site and the old placement areas in Swash Bay are provided in Table 3. The averages of the BAM scores for the three replicate samples at each site are as follows: the new site, 5.7, the old site, 7.0, and the undisturbed site, 7.7. The grain size analyses of the surface sediments at each of the BAM sampling sites are given in Table 4.

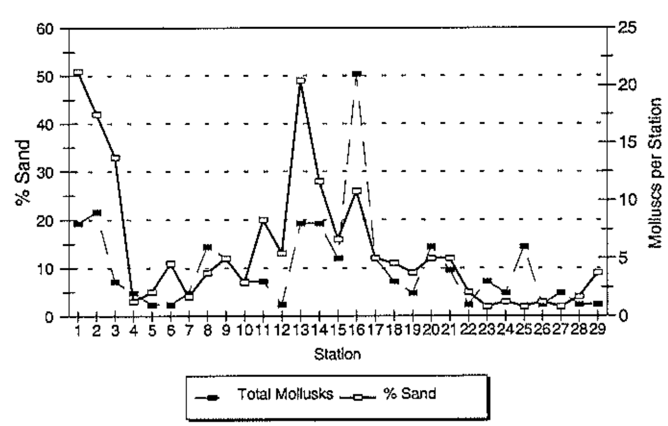

Figure 14. Sand composition and mollusc abundance by station.

Discussion

Little is known of the intermediate behavior of dredged material mounds resulting from repetitive overboard placement in shallow subtidal areas along the WCV. This behavior is greatly influenced by the volumetric increases and the bulk density reductions that occur in the dredged sediments as a result of the hydraulic dredging process. The subsequent volumetric reductions resulted from consolidation of the sediments and losses due to erosion from wave action and tidal currents (Halka et al. 1991; Panageotou and Halka 1994). Compaction of the underlying fine-grained sediment may also be a factor in the bathymetric changes observed.

When the Swash Bay channel was last dredged in April, 1993, approximately 111,000 yd^3 of material that averaged approximately 6% fine sand was pumped into the placement area (Century Engineering 1983; VIMS and VMRC 1995). Similar fine-grained sediments were reported to increase in volume by a bulking factor of 1.7 when hydraulically deposited in depths from 3-17m in the upper Chesapeake Bay (Halka et al. 1994). Three months later, the after dredging survey at the Swash Bay Placement Site indicated there was approximately 82,000 yd^3 of material in the area or approximately 74% of the original volume of material dredged. The survey in September, 1994 indicated 75,000 yd^3 remained; an additional loss of 8% for a total of 66% remaining after 17 months. Halka et al. (1991) reported losses from 39-63% of the material deposited after 18 months. At depths greater than 3m, Halka et al. (1994) attributed ½ to ⅔ of the losses to erosion and a ⅓ to ½ to consolidation.

The distribution of sand in the surface sediments corresponds with the location of the discharge pipe, the movement of which was intentionally constrained to maximize the accumulation of the limited amount of sand available in the dredged material. The amount of sand away from the immediate vicinity of the discharge was lower than the original levels and was suggestive of the sediment sorting that occurs around the discharge point. This process will be repeated in the future to manage the placement of the sand in an attempt to develop a reasonably stable foundation for the placement of cultch to initiate the development of an oyster reef.

The amount of surface shell in the placement area was extremely low and indicative of the existing soft-bottom community. The amount of shell was even less after the dredged material was deposited. The only exceptions are two small shell areas at the discharge points that were so small that neither was included within any of the sampling locations.

The original purpose of this study was to determine the extent of any oyster or hard clam resources located within the placement area. The reasons were twofold. First, if there was any significant shellfish resource, it would have been prudent to relocate the placement area to avoid displacing the existing resource. Second was the need to establish baseline information on the existing resources in the placement area so that future changes could be recognized and logically attributed to the dredged material placement and subsequent management efforts.

Since no oysters and only a very limited number of clams were found, and the sampling protocol was aimed only at very large organisms, it was decided that all of the mollusks retained would be used to compare the benthic community between sampling periods. The similarity of the molluscan communities before and six months after the dredging appears to indicate a fairly rapid recovery from the dredged material placement. The reasons for this rapid recovery are not specifically known but could be attributed to factors such as the lack of predators on the new site, the structure or "edge effect" provided by this mound of material on an otherwise flat bottom and the introduction of the relatively coarse-grained material into a area dominated by soft-bottom communities. The contribution by the vertical migration of the pre-dredging benthos is not known, but it was probably only a factor on the perimeter of the mound because the center was so thick and the change in sediment type so dramatic as to preclude most vertical migration (Hirsh et al. 1978). The relationship between the numbers of mollusks and the percent sand would appear to indicate that recolonization was an important factor because the deposit was thickest in the high sand areas.

The BAM analysis also appears to indicate a fast short-term recovery rate for the benthos in the placement area with an average score of 5.7. This would put the community in the mildly disturbed category just six months after eliminating virtually the entire benthic community at the site. The old site that has not been used in over ten years had an average score of 7.0 which ranked it among the more valuable communities. This would seem to connote that the prognosis for long-term recovery at the impacted site is also good. The undisturbed site scored 7.7 out of a possible 8.0 and served as reference for the other sites.

Conclusions

1. The intertidal area created by the dredged material placement decreased from 1.93 acres three months after dredging to 0.41 acres seventeen months after dredging.
2. The molluscan fauna displayed very little change six months after dredging as compared to pre-dredging conditions.
3. The amount of surficial shell decreased over the majority of the placement area, exclusive of the small shell pile at the discharge locations.
4. The distribution of sand in the surface sediments changed dramatically after dredging reflecting the hydraulic sorting process from the pipeline discharge.

5. The benthic community in the placement area appears to have had a good short-term recovery as reflected in the BAM values. The long-term prognosis is also good as indicated by the BAM values obtained at the historical placement site.

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