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FINAL REPORT

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Prepared by: John W.S. Foster, III

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UPPER CHESAPEAKE BAY OYSTER REEF RESTORATION PROJECT

Final Report
1994 Grant
Award No. NA46FU0262

Maryland Department of Natural Resources
Fisheries Service
Tawes State Office Building
Annapolis, Maryland 21401

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Upper Chesapeake Bay Oyster Reef Restoration

Objective

The objective of the Oyster Reef Restoration project was:

- to restore hard substrate, vertical profile and bottom roughness of historic oyster reefs to continue to provide suitable surfaces for the attachment and growth of the oyster reef community and associated fish assemblages.

Background

The economic significance of the oyster harvest in the Chesapeake Bay has long been recognized (Kennedy and Breisch 1981). What is only now becoming widely appreciated is the importance of the oyster in the natural functioning of the complex ecosystem that is the Chesapeake Bay. Historically, oysters may have been important in maintaining water quality by removing algae and silt from suspension. Furthermore, the hard bottom substrate formed by natural oyster reefs is essential to the existence of many other benthic organisms, and beneficial to many finfish (Newell and Breitburg 1991). Although soft mud bottom benthic communities predominate within the Bay today (Holland et al. 1987), only 140 years ago oyster reef communities were extensive (Newell 1988). It is estimated that there has been a 25 to 38 fold decline in oyster stocks in the Bay (Newell 1988, Rothchild et al. 1991). These oyster reefs provide habitat and food resources for a number of mobile species that are ecologically important to the Chesapeake Bay ecosystem (Newell and Breitburg 1991). It was primarily the fishing gear, especially patent tongs and dredges,that spread the shell reduced the physical profile of the oyster reef to the characteristically flat bars found in the bay today (Rothchild et al. 1991, Winslow 1884).

The benefits of re-establishing the historic oyster reef communities to the Chesapeake Bay have been well documented in recent literature and management reports (Myatt and Myatt 1990, Newell 1988, Rothchild et al. 1991, Newell and Breitburg 1991, Chesapeake Bay Program Action Agenda, 1991). The rebuilding of these reefs will take more than just waiting for the oyster communities to naturally re-establish. Several restoration techniques to create siltfree bottom topography and suitable surface substrate will be constructed and evaluated.

The reconstruction of Chesapeake Bay oyster reefs is based on historic descriptions of Bay reefs. Winslow (1884) described a natural oyster rock as a well defined area where "oysters are crowded together so closely that they cannot lie flat but grow vertically upwards, side by side. They are long and narrow, are fastened together in clusters..." This description of subtidal oyster reefs in the Chesapeake is similar to oyster reefs in North Carolina (Grave 1905) and to intertidal oyster reefs observed today along the South Atlantic and Gulf coasts.

Based upon these historic characterizations and the recommendations of a 1990 review of Maryland's Chesapeake Bay artificial reef program (Myatt and Myatt 1990), Maryland Fisheries Division proposed to re-create the oyster reef complex by placing clusters of hard substrate for the attachment of a 'oyster reef community'. The initial requirements of such structure and area are:

height	- 0.5 - 2.0 m
slope	- 1:1 or greater
material	- suitable for the attachment of fouling community - interstitial spaces similar to oyster clusters
bottom	- bearing strength to artificial structures
location	- historical oyster growing area outside existing live bottom.

Habitat management has been on-going on the Chesapeake Bay since at least the 1880's. Winslow (1884) reported that oyster shell was placed on barren areas near natural oyster reefs to increase the harvestable quantity of oysters. Additionally, these new oysters were a more desirable flat product for the market than the traditional Bay oyster, due to less competition for space. Since the 1960's, Maryland's Oyster Repletion Program has been spreading fossil shell over depleted bars to provide new substrate for spat settlement. This program was not designed to restore historic oyster bars but to supplement the commercial oyster fishery with a harvestable product.

Maryland's Artificial Reef Program built a series of 'state of the art' reefs (fiberglass, preformed concrete and quarry rock) to determine an appropriate Bay reef design for estuarine species. This work indicated the effectiveness of low profile (0.5 - 2m) hard substrate reefs to simulate oyster reefs. It also became evident that traditional marine reefs built strictly for sport fish harvest were not economically justified due to the behavioral characteristics of estuarine fish species, though oyster reef restoration is justifiable when based on environmental enhancement of the predominating benthic habitat structures which have been lost (Myatt and Myatt 1990).

In 1968 Maryland DNR built a series of fish reefs from concrete pipe and concrete ballasted tire units. The concrete pipe survived about 10 years before it began to sink into the mud substrate. At least one tire reef survives and is still functioning in Eastern Bay. After 24 years the units are intact, in their original location and are covered with oysters(102 on an eight tire unit) and associated fouling organisms. Additionally, oyster shells that have fallen off the units have provided substrate for the development of a reef community up to 2 meters outward from each unit.

Approach

The approach to this project was divided into two parts:

1. construction and placement of structures on reef sites, and
2. evaluation and monitoring of materials used in the construction of reefs.

The former included predeployment surveys of each site and the construction and deployment of the reef structures. The latter part was the biological evaluation of community development on materials used in the construction of reefs.

Deliverables

The deliverables presented in the project proposal included:

1. a description of habitat structure construction,
2. locations of reef construction,
3. monitoring activities for structure construction and placement, epibenthic substrate growth study, and reef site survey.

The criteria for Chesapeake Bay artificial oyster reef structures was previously noted.

The structure designs used in the project, which best met this criteria at a reasonable cost, were: 1. a 24 inch open concrete cube design, Figure 1, which had proven successful in the Chesapeake Bay and Japan in providing the physical structure similar to that of historic oyster reef for the development of an attached benthic oyster fouling community and the physical habitat to promote fish community development; and 2. oyster shell piles designed to maximize slope and surface area for added habitat diversity.

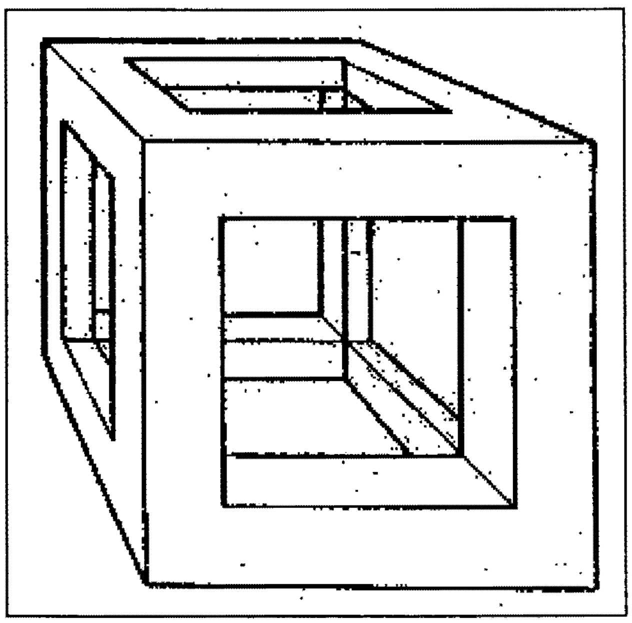

Figure 1 Concrete cube for oyster reef restoration.

Concrete Cubes

The concrete cubes were constructed using 100 steel forms procured under a previous grant (EPA _____). A scope of work to construct between 5,000 and 10,000 cubes was advertised for bid in February 1995 in accordance with State of Maryland guidelines. Ten companies bid on the work. A contract was awarded to the low bidder, Power Dynamics Co. of Baltimore, Md., in June with construction commencing July 1. In August, 1995, the contract with Power Dynamics was terminated for non-performance and the remaining work was awarded to C.J. Langenfelder and Son, Inc. of Stevensville, Md., the next lowest available bidder. Power Dynamics constructed and were paid for 500 acceptable cubes. Langenfelder successfully constructed 6,000 cube units by the end of the grant period at an average cost of $38.83 per unit, approximately half of the proposal estimate.

The conditions of the bid request were intentionally kept simple, i.e. no performance bond was required. Payment was made only on accepted units delivered to a Fisheries barge. This was done as the scope of work was relatively simple in spite of the total value of the contract and to permit small businesses to bid. The low bidder was one such company.

The cubes were loaded onto a barge by the contractors. The barge and 1995 towing services were donated by the U.S. Army Reserve, 949th Transportation Company headquartered in Baltimore, Md. Additional towing was provided by Fisheries in 1996. The cubes were placed on two reef sites:

Hollicutts Snooze	- 1,000 units, 10 acres
Plum Point	- 5,500 units, 88 acres.

Cube placement was made in random drops of clusters of four to eight units over a marked area on the reef site. The drops were monitored with differential GPS for location. Figures 2 and 3 indicate the areas the cubes were placed at the Hollicutts and Plum Point sites and there relation to the shell piles. Where the areas overlap, the cubes were placed on top of the shell.

A total of 98 acres of sport fish habitat was enhanced with an average of 66 units and a cost of $2,575 per acre.

Shell

Maryland has dredged fossil oyster shell for use as cultch in the Oyster Repletion Program since the 1960's. The state has a negotiated contract with C. J. Langenfelder and Son, Inc. of Stevensville, Md. to dredge shell from deposits in the upper Chesapeake Bay, haul and plant the shell onto oyster seed areas. The following year part of this shell and attached spat are transplanted to more favorable growing areas. It was determined that utilizing this contract would be the more cost effective means of having oyster shell structures constructed on reef sites. In a contract modification, the contractor agreed to place mounds of oyster shell at several reef sites in the Bay. The specifications called for fossil shell piles of 'normal planting quality' to have:

slope	1:1 or greater
height	> 3 ft., < 6 ft.
base	less than 3 X height
shape	conical
distribution	20 to 30 piles per acre, random placement.

The volume of each pile was to be 8 to 10 cubic yards and would have affected structure restoration on 200 to 300 acres of barren Bay bottom. A cost adjustment within the contract limits was made for the increased effort necessary to meet the specifications.

The contract called for the work to occur immediately following the 1995 Repletion Program's shell planting in August 1995. The contractor delayed the work until June 1996 requiring an additional grant extension. When the work was started, the mechanism the contractor designed to construct the specified pile design was not effective and it bacame necessary to modify the design specifications so that the construction could be completed in a timely manner. This modification permitted the contractor to anchor the barges and use a front end loader to dump shell directly overboard and to wash a quarter of the shell overboard to create large piles. The piles created varied in size, and averaged about 300 ft. long, 100 - 500 ft. wide and had elevations of 4 to 12 ft. off the bottom. Up to 3,500 cy was used to create a pile.

The primary design objective of the steep slope and high surface area to volume ratio was not met as a result of the alteration in off loading methods. The high slope was specified to reduce sediment buildup and maximize the life expectancy of the structures.

A total of 36,251 cubic yards (cy) was placed at four locations creating 135.5 acres of potential oyster reef and sport fish habitat:

Hollicuts Snooze	9157 cy	32.5 acres
Cedar Point	1896 cy	21 acres
Little Cove Point	2486 cy	12 acres
Plum Point	22712 cy	70 acres

Figures 2, 3, and 4 indicate the areas of habitat enhancement on each reef site.

Reef personnel directed the placement and monitored the results of the shell placement. The area of placement for each barge load of shell was marked with buoys. The location of the barges was monitored with GPS during off loading activities and the elevations of the piles were recorded after construction.

The cost of the shell placement was $227,306, or $1,678 and 268 cy per acre.

<u>Monitoring</u>

The monitoring was broken into three activities:

1. Monitoring of concrete cube construction by contractor;
2. A evaluation study of epibenthic growth on various substrates considered for reef structures; and
3. A survey of the reef sites for state and federal permitting.

All monitoring activities were performed as matching activities by the Maryland Reef Program staff.

Cube Construction Monitoring

Construction monitoring or inspection was necessary to assure contractor compliance. Reef personnel made unannounced site visits two to three times a week to the cube contractors to monitor construction, quality control and handling of the forms. Concrete construction is weather dependent and occurred from July through November and April to June. Reef personnel directed and unloaded the cubes from the barge at the reef sites.

Epibethic Substrate Growth

The monitoring evaluation of the initial epibenthic community growth on various substrates considered for use as oyster reef habitat structures was completed. The study was designed to evaluate the suitability of the several test substrates, including tires, which were part of the project's original proposal, for use in the construction of oyster reef habitats. The various substrates were tested over two growing seasons at several locations in the middle and lower Maryland Chesapeake Bay. The study report is presented in Appendix A.

Reef Site Survey

A survey of reef sites on the Chesapeake Bay was performed as part of the permit process for Corps of Engineers and Maryland Wetland permit renewals. The 23 separate reef permits for the Bay were combined into single permits with similar conditions and expirations. The work performed surveyed the reef locations, depths, and noted bottom type. Locations were confirmed using calibrated differential GPS navigational equipment. The sediment classifications were per the Maryland Geological Survey's data and classifications of bottom type. Sediment at each site was ground truthed by divers. The charted depths were confirmed by on site measurements and corrected to low water values. A summary of the reef site data appears in Table 1.

Budget

The table of expenditures are attached in Table 2.

Table 2. Oyster Reef Restoration Project fund expenditures for 1994 grant, NA46FU0262.

	Federal	State
Cube construction		
Power Dynamics	$ 7,500	$ 7,500
C.J. Langenfelder	115,651	115,651
Cleanup of Power Dynamics default		11,105
Shell		
C.J. Langenfelder	150,000	40,843
Monitoring and administration salaries		
J. Foster		48,443
D. Myatt		32,926
K. Holder		13,919
S. Alspach		2,764
Total	$273,151	$273,151

Citations

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Winslow, F. 1884. Report to the Oyster Commission of the State of Maryland. Annapolis, MD pp183.

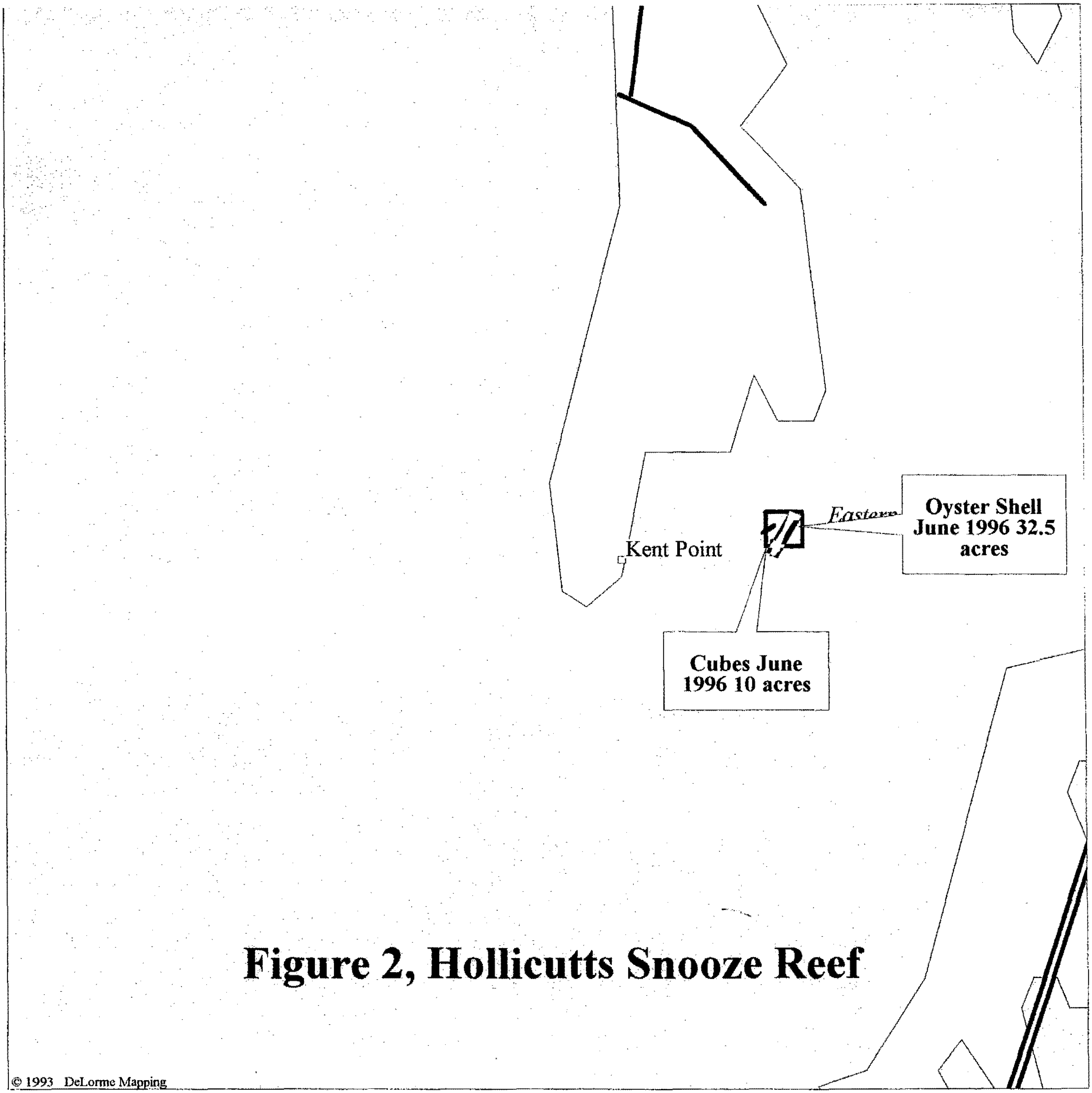


Figure 2, Hollicutts Snooze Reef

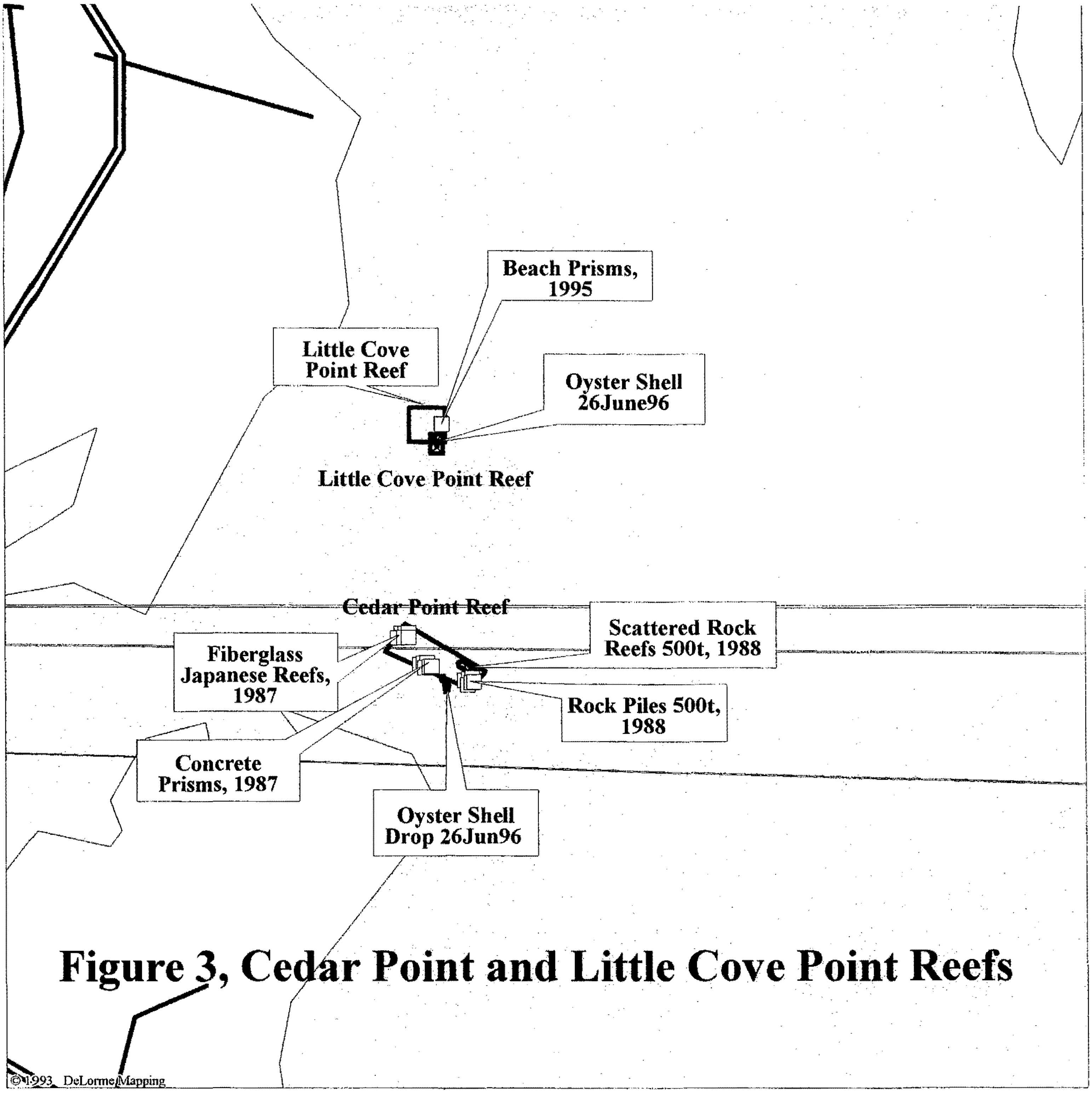
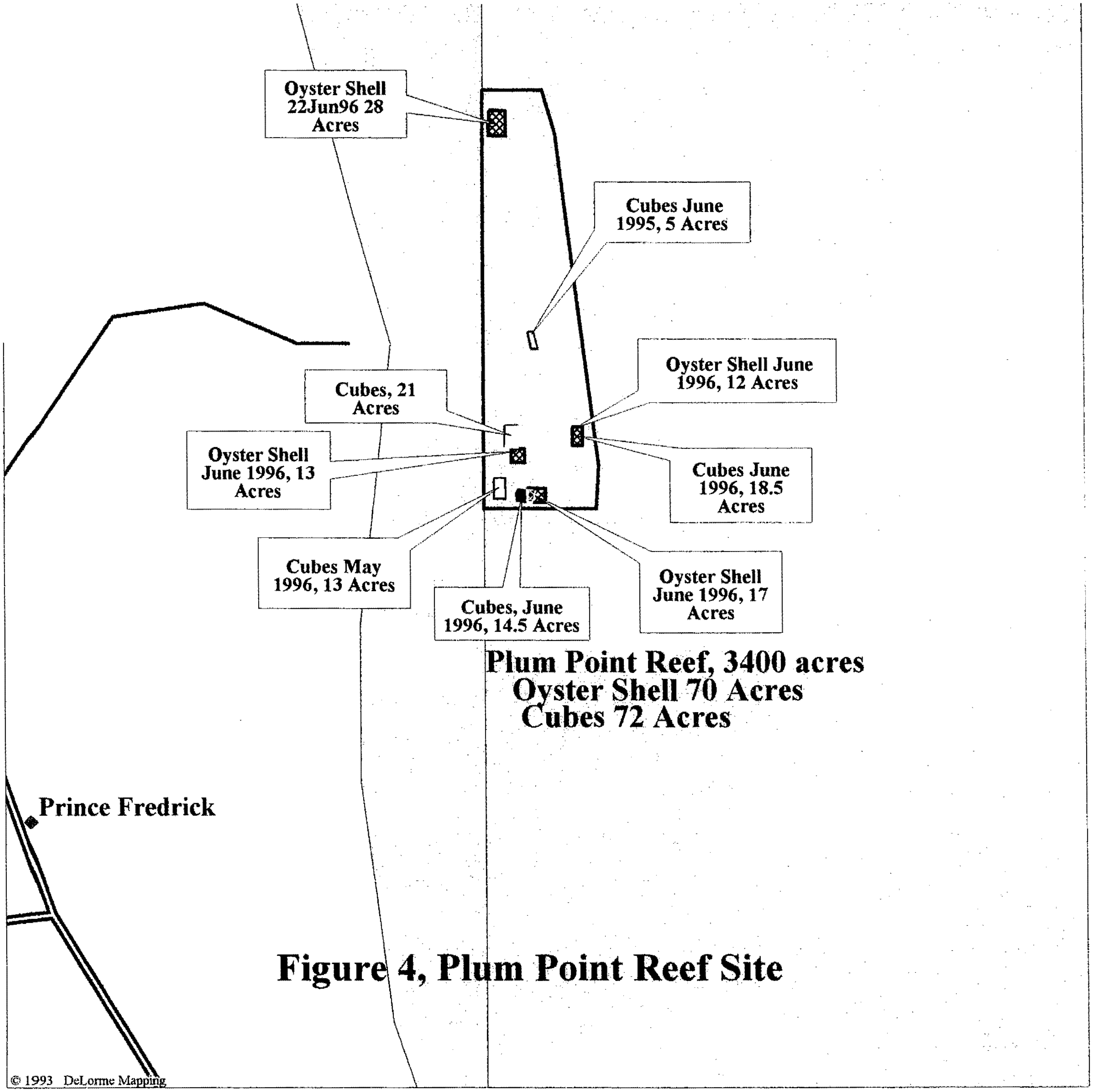


Figure 3, Cedar Point and Little Cove Point Reefs



Oyster Shell 22Jun96 28 Acres
Cubes June 1995, 5 Acres
Oyster Shell June 1996, 12 Acres
Cubes, 21 Acres
Oyster Shell June 1996, 13 Acres
Cubes June 1996, 18.5 Acres
Cubes May 1996, 13 Acres
Oyster Shell June 1996, 17 Acres
Cubes, June 1996, 14.5 Acres
Plum Point Reef, 3400 acres
Oyster Shell 70 Acres
Cubes 72 Acres
Prince Fredrick
Figure 4, Plum Point Reef Site
© 1993 DeLorme Mapping

Table 1. Chesapeake Bay Oyster Reef Restoration Sites

	REEF	CORNER COORDINATES		CENTER POINT		DEPTH	BOTTOM TYPE
	Name, acres	Latitude	Longitude	Latitude	Longitude	Feet	
1	Cedar Point	38*18.82	076*23.22	38*18.43	076*22.43	20'-27'	sand
	155 acres	38*19.03	076*23.03				
		38*18.53	076*22.40				
		38*18.67	076*22.25				
2	Cedarhurst	38*50.53	076*27.90	38*50.40	076*27.72	15'-25'	sand, sand with cultch
	50 acres	38*50.53	076*27.54				clay
		35*50.27	076*27.90				
		38*50.27	076*27.54				
3	Chesapeake Beach	38*43.08	076*30.36	38*42.95	076*30.18	12'-26'	sand, silty sand
	50 acres	38*43.08	076*30.00				
		38*42.82	076*30.36				
		38*42.82	076*30.00				
4	Choptank River Bridge						
5	Hackett Point	38*59.53	076*24.35	38*59.40	076*24.17	20'-30'	clay, clay with cultch
	50 acres	38*59.53	076*23.99				
		38*59.27	076*24.35				
		38*59.27	076*23.99				
6	Holland Point	38*45.00	076*29.20	38*44.60	076*29.07	33'-36'	clay, clay with cultch
	50 acres	38*45.00	076*29.02				
		38*44.35	076*29.20				
		38*44.35	072*29.02				

7 Hollicutt's Noose	38*50.64	076*20.75	38*50.51	076*20.57	20'-30'	sand, sand with cultch
50 acres	38*50.64	076*20.39				
	35*50.38	076*20.75				
	38*50.38	076*20.39				
8 Jane's Island	37*57.13	075*55.18	37*57.00	075*55.00	12'-18'	sand, sand with cultch
50 acres	37*57.13	075*54.82				
	37*56.87	075*55.18				
	37*56.87	075*54.82				
9 Little Cove Point	38*20.66	076*22.98	38*20.53	076*22.80	20'-25'	silty sand, silty sand
74.6 acres	38*20.66	076*22.63				with cultch
	38*20.40	076*22.98				
	38*20.40	076*22.63				
10 Love Point	39*04.21	076*17.63	39*04.08	076*17.45	20'-25'	silty clay
50 acres	39*04.21	076*17.27				
	39*03.95	076*17.63				
	39*03.95	076*17.27				
11 Plum Point	38*39.03	076*30.00	38*37.19	076*29.36	25'-35'	sand, silty sand,
3443.5 acres	38*39.03	076*29.32				clay, clayey sand
	38*38.65	076*29.18				
	38*35.73	076*28.70				
	38*35.35	076*28.73				
	38*35.35	076*30.00				
12 Point No Point	38*07.71	076*18.30	38*06.85	076*17.85	30'-35'	sand, silty sand
1059 acres	38*07.71	076*17.40				
	38*06.00	076*18.30				
	38*06.00	076*17.40				
13 Point Lookout	38*03.13	076*18.97	38*02.80	076*18.63	10'-15'	sand, clayey sand
50 acres	38*02.87	076*18.97				
	38*03.13	076*19.26				
	38*02.87	076*19.26				

14 Pooles Island	39*14.65	076*17.97	39*14.37	076*17.48	10'-16'	silty sand
230 acres	39*14.80	076*17.60				
	39*13.95	076.17.31				
	39*14.13	076*17.00				
15 Severn River	38*59.62	076*29.12	38*59.63	076*29.07	15'-30'	sand, clay, silt
	38*59.65	076*29.07				
	38*59.63	076*29.06				
	38*59.59	076*29.07				
	38*59.58	076*29.09				
16 Sharp's Island	38*34.27	076*24.52	38*33.95	076*24.42	36'	sand, silty sand
50 acres	38*34.27	076*24.32				
	38*33.62	076*24.52				
	38*33.62	076*24.32				
17 Tangier Sound	37*55.22	075*56.67	37*55.22	075*56.67	30'-36'	sand
86 acres	37*55.08	075*56.90				
	37*55.08	075*56.35				
18 Tilghman Island	38*41.72	076*22.88	38*41.51	076*22.65	20'-25'	sand, sand with cultch
50 acres	38*41.72	076*22.43				
	38*41.30	076*22.88				
	38*41.30	076*22.43				
19 Tolchester			39*14.38	076*16.13	15'-20'	silty clay
50 acres						

Appendix A

PROJECT REPORT TO THE DEPARTMENT OF NATURAL RESOURCES

Evaluation of Substrates for Settlement of Fouling Organisms Typical of the Oyster Reef Climax Community

Sam Alspach
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Introduction

Although soft mud and sand communities currently predominate the Chesapeake Bay, only a hundred years ago, oyster reef communities were extensive throughout the mesohaline Bay. These reefs form a complex community that includes many species that are important food items for finish. Within the past century, oyster production has fluctuated (ca.1 to 10 million bushels), however, over the past 30 years production has dramatically declined. Several reasons account for this decrease: over harvesting (Newell, 1988), and disease. Beginning in the 1960's, oysters in higher salinity areas (in excess of 12 0/00) of the bay have been ravaged by the parasitic diseases of MSX (Haplosporidium nelsoni) and dermo (Perkinsus marinus). All time low harvests occurred within 4 years (1992-1995).

Based on a report to the Maryland Department of Natural Resources in 1990 (International Weighmasters, Inc.), the feasibility to construct artificial reefs as habitat resources in the bay was proposed. Artificial reefs offer increased substrate surface for the recruitment of those estuarine species that prefer a hard substrate for attachment, for example the American oyster, Crassostrrea virginica. Consequently, a monitoring project to study artificial reefs began in the summer of 1992 and continued through 1994.

The purpose of this project is to monitor the short term and long term community development on artificial hard substrates, with special attention focused on the recruitment of oyster spat and development of the oyster reef community assemblage. A particular advantage of artificial reef structures is that their shape, size and site of deployment can be controlled. The latter is of particular importance relevant to the salinity regimes where both MSX and Dermo are most frequently, ca. > 12//co. In contrast to Osman et al, (1989), we choose to examine natural field recruitment of all species in both the short term and long term study, whereas we choose to study the influence of a single species on oyster recruitment. Thus, multiple species recruitment and succession was observed in our study, however we did note, as previously documented by Osman that species composition and abundance have a profound effect on the recruitment of oyster spat.

Methods and Materials

Field sample plates of three different materials were deployed into the Chesapeake Bay attached to a pedestal unit placed overboard to stand upright on the existing bottom material(s).

1. Pedestal Design

   Each pedestal consists of an automobile tire as a base unit and a top ring. A base unit is constructed of a 15" automobile tire filled with an aggregate concrete mixture. Into the center of each base tire ring and held by the concrete is a 30" high standpipe of 2" galvanized pipe surrounded by a 3" diameter PVC pipe of equal length. The purpose of the Latter is to present no exposed metal surfaces that might have variable effects on our experimental and control plates. To stabilize the standpipe and reinforce the base, 3/8" rebar is cross linked through the PVC and galvanized pipe and placed under the rim of the tire ring within the cement.

   Two types of top rings were constructed: one of a 14" automobile tire or an equal diameter plastic barrel hoop. A top ring is affixed to the 3" PVC pipe via a toilet flange attached to a 2" x 6" plastic lumber cross member. To each type ring, the sample plates are attached with plastic tie wraps through predrilled holes into the tire or plastic barrel hoop ring.

   Three sample plate types were used: PVC, slate and tire segments. Each was approximately 4 to 6 square inches. Tire segments were sliced from bead to bead to give three equal surfaces: a top, vertical or horizontal, and a bottom.

2. Deployment

   Three sites within the mosohaline Chesapeake Bay were chosen based on information regarding the incidence of disease and salinity regime. In Tangier

Sound off Crisfield, Maryland, salinities range between 12 and 18 ppt, while the incidence of disease is high. The other sites used were: off the southern tip of Tilghman Island, and off the southern tip of Kent Island (Hollicutt's Noose oyster reef/bar). Salinities at these sites range between 5 and 13 ppt. Diseases are present, however the incidence is lower. Each are chosen is a known oyster bar that is currently productive or was productive at one time in the Bay.

Deployment as facilitated by the captain and crew of the H. J. Elser.

3. Plate Sample Collections

Sample collections were made every two weeks from June through September 1992 for the Hollicutt's Noose and Tilghman sites. Deployment to Tangier Sound occurred in late July 1992 with sampling following the similar two week regime. Plates were also collected monthly during the fall and again in the spring.

At each site divers retrieved previously deployed plates and attached new replacement plates. For each (pedestal, a top and a bottom plate of each type was retrieved and replaced. Tire segments offer a multi-surface area, consequently each segment provided a top, vertical and bottom surface and were replaced according to the above protocol. Plates recovered every two weeks were designed "NEW" whereas plates that were held over a long time course of a month or more were designed "OLD". Thus, such "OLD" plates reflect longer term changes in community structure development while "NEW" plates illustrated short-term (two week) changes in the fauna. It was desired that the short term plates would indicate oyster spat recruitment int he immediate area of deployment as well as the initial colonization states of organisms potentially common to the oyster reef community or opportunistic species which might compete with oyster spat recruitment under field conditions.

4. Plate Analysis

Each plate was treated identically, and examined in two ways: one "macro" and the other "micro". These terms reflect a method. A "macro" identification consists of placing an acetate sheet with a 100 cm^2 grid on top of the live material on the plate. The number and types of organisms occupying the 1 cm squares is recorded. Percent area of cover of some species, e.g. bryozoans was recorded. No organisms were removed.

A "micro" examination consisted of scrapping a 20 cm^2 randomly selected section off the surface of the plate. These samples were transferred to a buffered preservative solution containing rose bengal. Both macro and microscopic identification and quantification of each species present in this area was made.

RESULTS AND DISCUSSION

No oyster recruitment was observed on any of our substrates (pvc, tire, slate) for the entire duration
of both the 1992-1993 and 1993-1994 summer season. Furthermore, this observation applies to all
three sites selected: Hollicutt's Noose in Eastern Bay, Tilghman Island, and Tangier Sound. Confirmation of these results is found in the Department of Natural Resources fall spat surveys for these years where little to no new spat were recorded for the Bay (Roy Scott, pers. comm.). Adult oysters of reproductive age do exist at all three sites. Possible explanations include: poor substrate choices, lack of available space on our test substrates, poor larval survival under natural field conditions, high predation of oyster larvae or juveniles, or dynamics of larval transport at each site.
Previous studies of oyster recruitment conducted by Kennedy and Newel with slate and PVC plates show these substrates to attract and permit larval settlement in the field. Consequently, we have good reason to believe these substrates have demonstrated their application for oyster spat recruitment.

Data analyses were made of initial colonizers on these substrates. As will be shown later in this paper, the availability of space for settlement may be the most important factor for the lack of oyster spat recruitment. Other reasons sited above may also play a dynamic role int he lack of oyster recruitment we observed but were not studied.

TABLE 1 HOLICUT'S NOOSE - EASTERN BAY RANK ORDER			
SPECIES	1	2	3
POLYDORA	SLATE/T SLATE/H	TIRE	PVC/T PVCC/H
BARNACLES	SLATE/T PVC/H		
MEMBRANIPORA	PVC/H TIRE	SLATE/T	PVC/T SLATE/H
HYDROIDS	SLATE/T TIRE	PVC/T PVC/H SLATE/H	
AMPHIPODS	SLATE/T SLATE/H PVC/H	PVC/T	TIRE

H = PVC HOOP
T = TIRE RING

TABLE 2 TILGHMAN ISLAND RANK ORDER				
SPECIES	1	2	3	4
POLYDORA	PVC/T*	PVC/H SLATE/H SLATE/T		
BARNACLES	TIRE*	PVC/T SLATE/H	PVC/H	SLATE/T

TABLE 2 TILGHMAN ISLAND RANK ORDER				
SPECIES	**1**	**2**	**3**	**4**
MEMBRANIPORA	**TIRE PVC/H SLATE/H**	**PVC/T SLATE/T**		
HYDROIDS	**TIRE PVC/H SLATE/H**	**PVC/T SLATE/T**		
AMPHIPODS	**PVC/T**			
ROUNDWORMS	**SLATE/H**	**PVC/H SLATE/T**	**TIRE PVC/T**	

Colonization by invertebrate species occurs on all substrates tested. Statistical analysis of our results tested three parameters. One, is there a difference in settlement between the three substrates used in the study. Two is there a difference between tire units and non-tire material (plastic hoop) for any substrate. Thirdly, is there any difference between sites in the initial invertebrate settlement in contrast to the longer term settlement pattern over the course of one year.

The principal species found on the substrates are:

Polydera	Phylum Annelida	mud tube worm
Neanthus		red clam worm
Balanus	Phylum Arthropoda	barnacle
Corophium		amphipod
Membranipora	Phylum Ectoprocta	bryozoan
Sagartia	Phylum Cnideria	anemone, hydroid

To establish statistical differences, an ANOVA program with rank order was used. Tables 1 and 2 shows the rank orders by species for each site.

For Hollicutt's Noose in Eastern bay, the five major species show a preferential initial colonization to substrates on the tire ring. Of the three substrates tested, slate and tire segments outranked the PVC plates. At the Tilghman site, the tire ring ranked number one for three of the five major species. In comparison to Eastern Bay, however, t he PVC substrate outranked slate as a preferred surface.

Between site analysis by species shows the following contrasts: Polydora settlement on slate tiles is greater in Eastern Bay than for Tilghman. Membranipora, on the other hand, how equal numbers settling on all substrates for both sites, but barnacles settle in grater numbers at Tilghman where four times as many individuals were observed per 100 cm^2. Finally, the amphipod, Corophium and roundworms are found in larger number at Hollicutt's Noose (Eastern Bay) than at Tilghman. Long term study using 'OLD' plates did not show a substantial difference in species diversity from the 'NEW' plates. Of all species studied, bryozoans did show the greatest percentage cover on all surfaces (92.3%). Barnacles represented the second
largest percentage cover (57.1%). Both of these changes reflect long term exposure which reflects increased growth in size and numbers of colonies rather than an increase in recruitment. Furthermore, both species were initial colonizers as well as long term community members. Some benthic ecologists, Mullineaux (1989) have suggested that initial larval settlement does not reflect that adult community composition, largely due to changes in adult food habitat selection.

Comparison of our data with that of Shaw (1968) who followed setlement for a two year period in Broad Creek (Choptank River), our results show similar species diversiity with the exception of oyster spat. Since we found no settlement of oysters, this simply reflects a lack of brood stock and larvae in the water column.

Furthermore, our data shows that tire segments do recruit and establish all major species inhabiting hard substrates. Tires do have the potential to establish climax benthic communities.

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