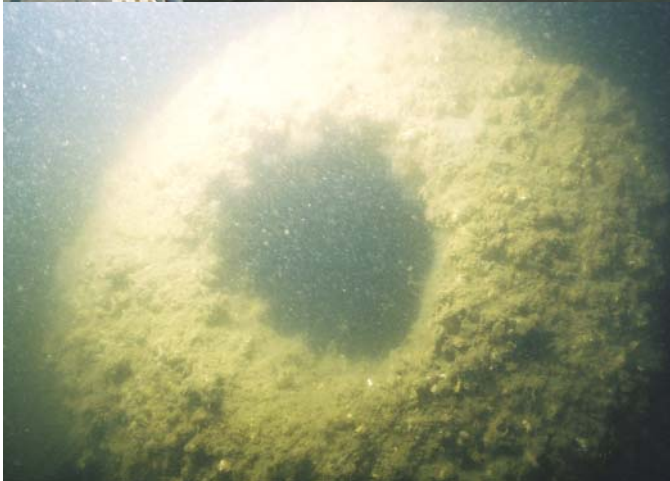


Reef Ball Monitoring and Qualitative Assessment Report

August 2006



Prepared by
Maryland Environmental Service
259 Najoles Road
Millersville, Md. 21108

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Reef Ball Monitoring and Qualitative Assessment Report August 2006

Introduction

This monitoring and qualitative assessment study was performed by the Maryland Environmental Service (MES) to determine and document the success of Reef Balls in improving benthic and fish habitat at reef sites in the Maryland portion of the Chesapeake Bay. The findings are based on video monitoring and other sources. The majority of the monitoring performed did not include quantitative assessments of the benthic and fisheries growth related to reef balls due to funding constraints. However, one study provides fisheries catch per unit effort for a “reef ball site” in comparison with a “non-reef ball” site. The monitoring includes underwater video footage captured by MES using an Atlantis underwater video camera system at six Reef Ball sites monitored in 2005 and four sites monitored (to date) in 2006. Due to equipment limitations, limited underwater visibility, currents, and the presence of “marine snow” at most of the locations, video quality is limited at some of the sites, but MES believes that the video footage does demonstrate use of the Reef Balls as benthic and fish habitat. The DVDs of the 2004-5 and 2006 monitoring are included with the report.

Also included in this report are other sources of information and documentation assessing the habitat improvement of Reef Balls in the Maryland portion of the Chesapeake Bay.

Findings at individual reef sites are presented on the following pages.

2004-5 Reef Ball Monitoring Video, MES

St. Mary's Oyster Sanctuary (Figure 1), St Mary's County: MES placed twenty-five (25) Reef Balls in June 2003 at this site for the Maryland Department of Natural Resources (DNR). The Reef Balls were placed in 12-15 feet of water.

The video is baseline monitoring performed the same day as Reef Ball deployment. The video depicts the vertical relief and structure provided by the Reef Balls as compared to a flat shell bottom in the vicinity.

This site was monitored by DNR in November 2003. Six months after deployment, the Reef Balls were covered with anemones and barnacles and a juvenile sea bass was observed (Attachment C).

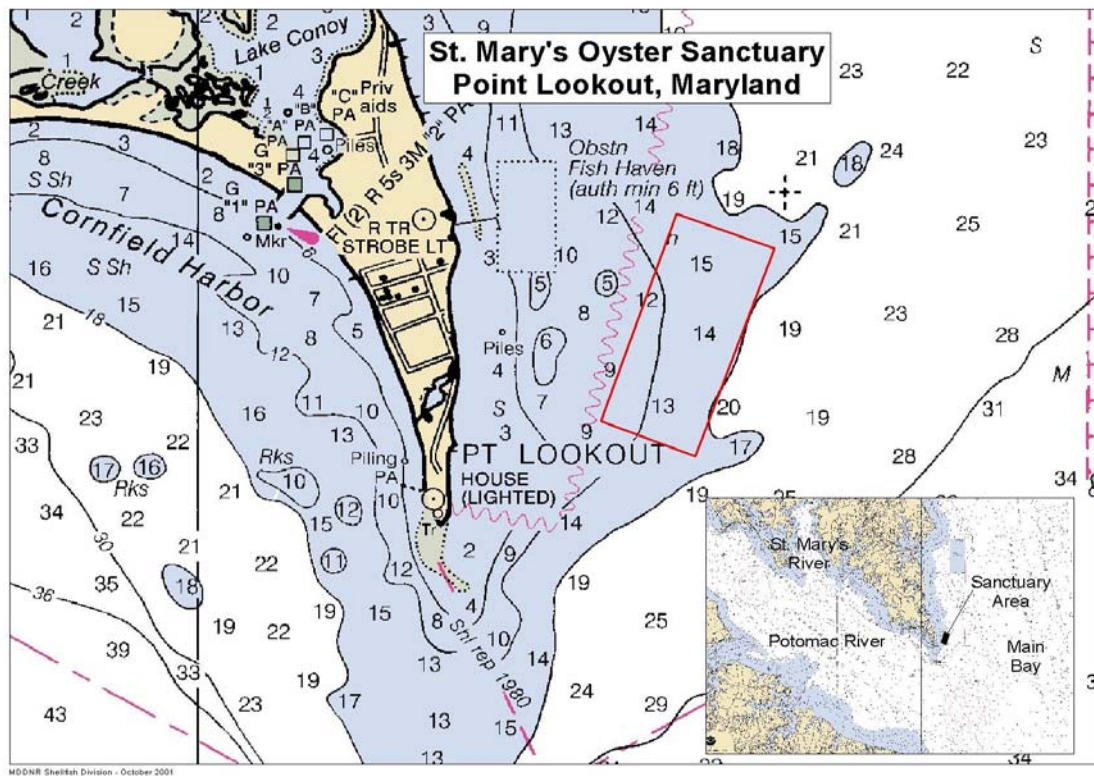


Figure 1: St. Mary's Oyster Sanctuary

2004-5 Reef Ball Monitoring Video, MES

Memorial Stadium Reef Oyster Sanctuary (Figure 2), Kent County: Ninety (90) Reef Balls were placed at this oyster sanctuary in the Upper Bay by MES in October 2002 for MDNR. The water depth in the site was 12-15 ft.

The video is from monitoring done in June 2004, one year and eight months after deployment. This video shows good epibenthic growth covering the entire Reef Ball surface after 20 months in the water. The benthic organisms consist mainly of mussels, with some barnacles, anemones and hydroids also observed. A single croaker and schools of croakers can be observed in the video in addition to catfish.

This site was also monitored by DNR in 2003, which found massive numbers of mussels (Attachment B).

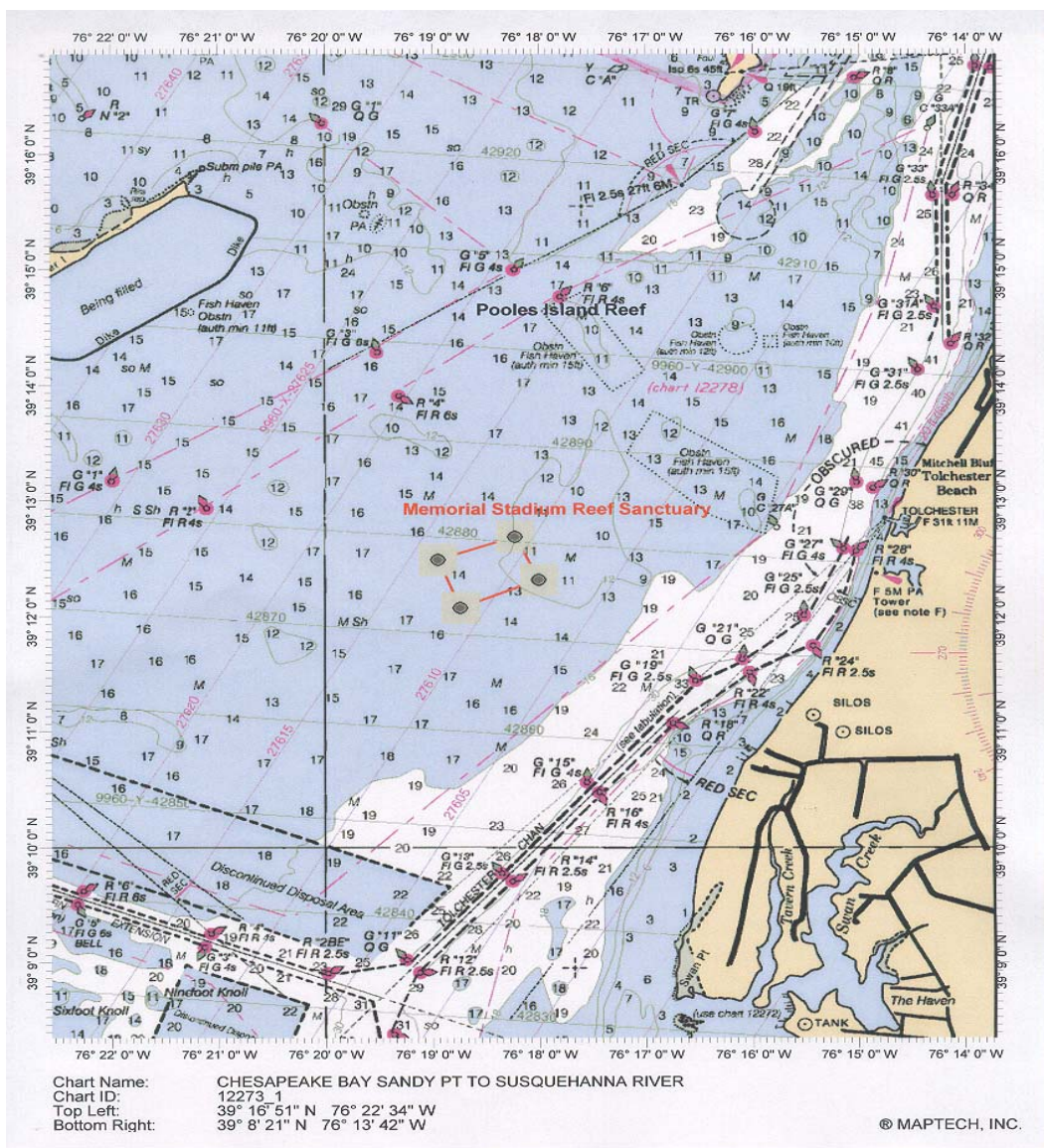


Figure 2: Memorial Stadium Reef Sanctuary

2004-5 Reef Ball Monitoring Video, MES

Prospect Bay Oyster Sanctuary (Figure 3), Chesapeake Bay Environmental Center (CBEC), Queen Anne's County: One hundred and forty Reef Balls were placed in March 2005 at this newly created oyster sanctuary in 3-6 ft of water. This project was primarily funded by a Chesapeake Bay Trust grant to CBEC with partial funding by the Abell and Exxon Foundations. Monitoring of the site was partially funded by the Abell Foundation.

Monitoring occurred in October 2005, and video footage shows moderate epibenthic growth after just 6 months, consisting mainly of barnacles, with some anemones and hydroids, and what appears to be algae. Numerous fish can be seen in and around the Reef Balls, including white perch, bream, and blennies. In addition, what appears to be fish fry can be observed inside one Reef Ball.

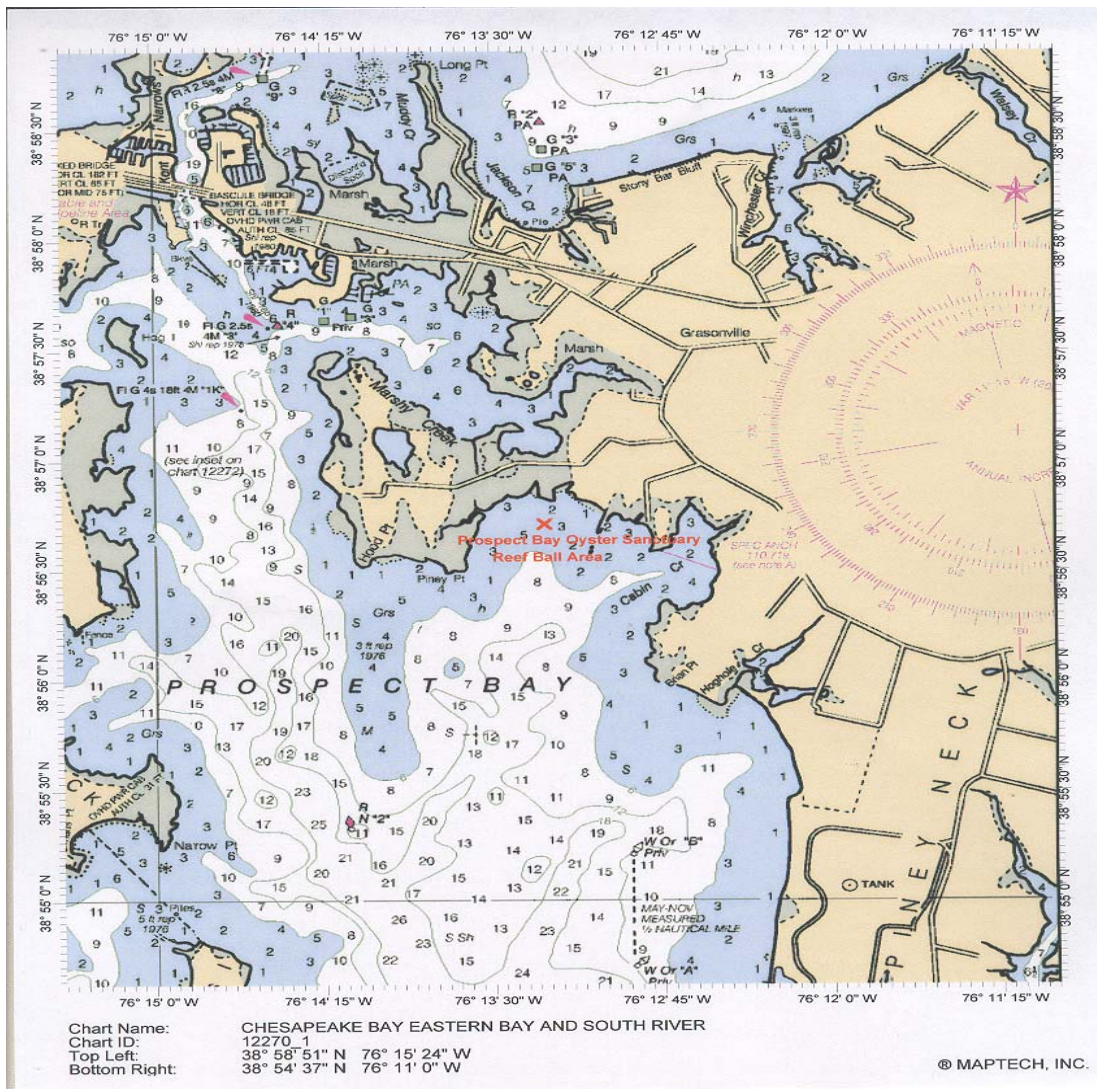


Figure 3: Prospect Bay Oyster Sanctuary

2004-5 Reef Ball Monitoring Video, MES

Hollicutts Noose Artificial Reef Site (Figure 4), Queen Anne's County: This deployment of thirty two (32) Reef Balls occurred in October 2004 in 25 ft of water and was funded by grants from Constellation Energy, The Abell Foundation, and Exxon-Mobil, as well as MES.

The baseline video was taken the same day as Reef Ball deployment and shows a striped bass observing the newly placed Reef Balls.

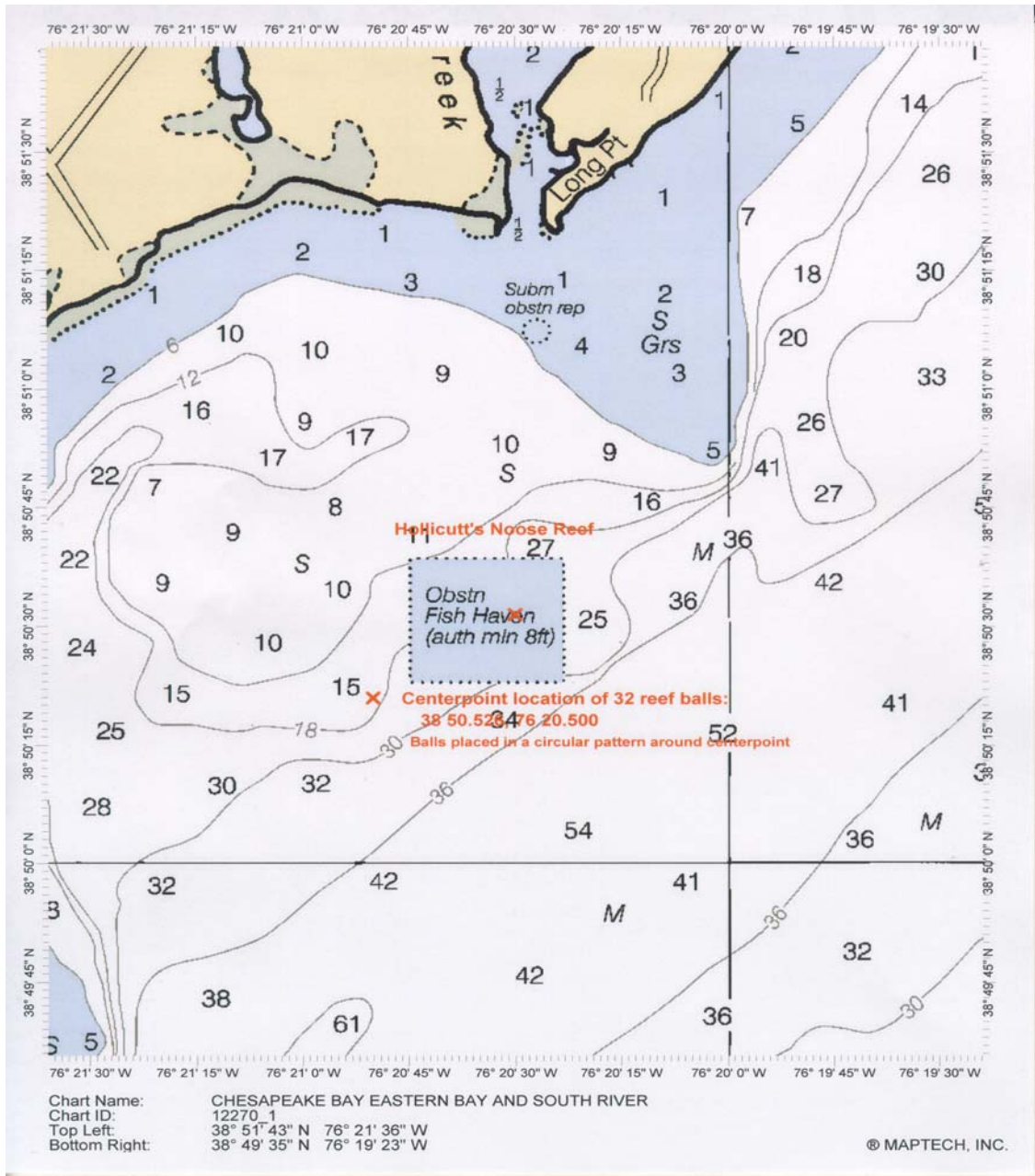


Figure 4: Hollicutts Noose Artificial Reef

2004-5 Reef Ball Monitoring Video, MES

Mill Hill Oyster Sanctuary (Figure 5), Queen Anne's County: DNR funded placement of sixty (60) Reef Balls in August 2002 at this site. The water depth ranged between 12-15ft.

The video is from monitoring that occurred in August 2005, three years after deployment. It shows heavy epibenthic growth including barnacles, mussels, and anemones. No fish were observed during this monitoring event.

This site was also monitored for DNR in 2003 by UMCES. Barnacles, mussels, and anemones were observed in massive numbers, covering the Reef Balls inside and out.

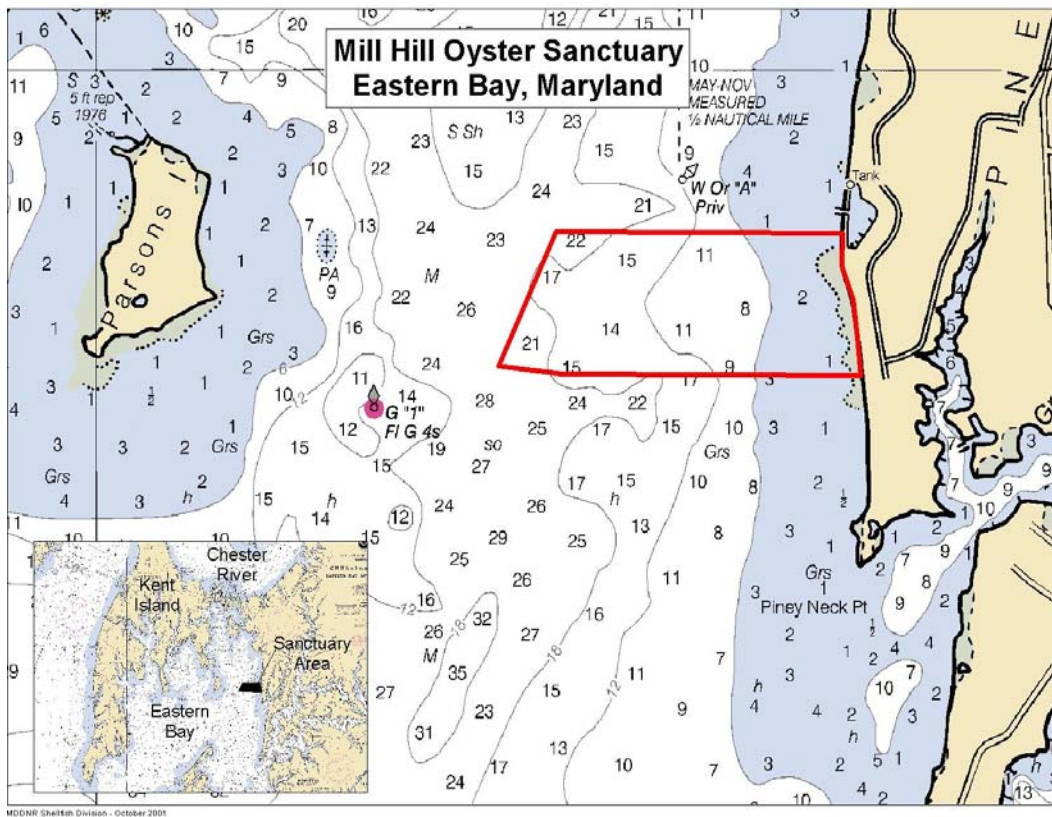


Figure 5: Mill Hill Oyster Sanctuary

2004-5 Reef Ball Monitoring Video, MES

Tilghman Island Artificial Reef (Figure 6), Talbot County: Fourteen (14) Reef Balls were placed at this site in November 2004 at a depth of 20-25 ft. Grants from The Abell Foundation and Constellation Energy funded this project.

This site was monitored June 2005, seven months after deployment. It shows some benthic growth in that short period, although it is hard to determine what species are observed due to the grainy nature of the video. A tautog and a couple of striped bass can be observed around the Reef Balls.

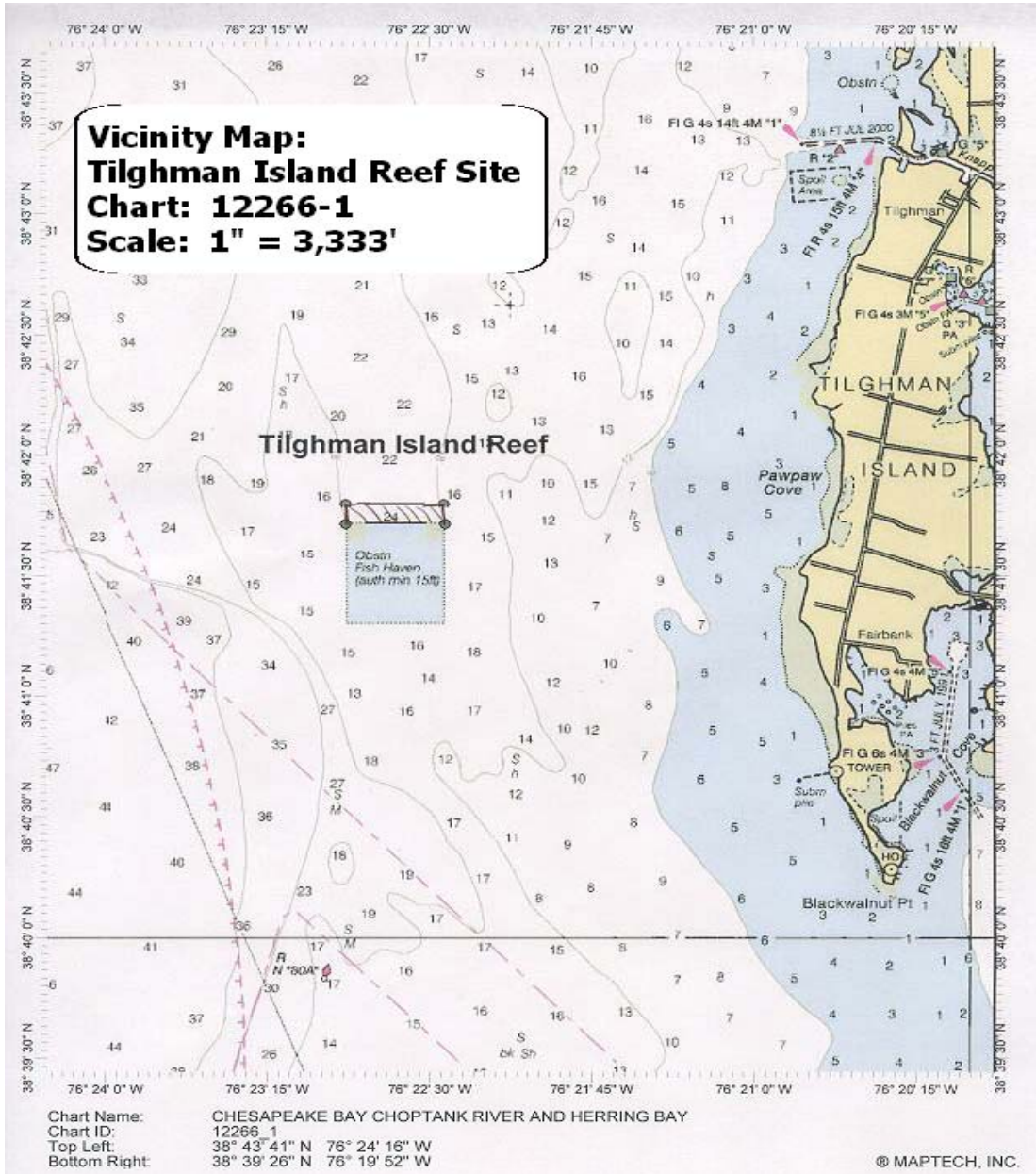


Figure 6: Tilghman Island Artificial Reef

2006 Reef Ball Monitoring Video, MES

Little Cove Point Reef Artificial Reef Site (Figure 7), Calvert County: One hundred and sixty (160) Reef Balls were placed at the artificial reef site in October 2004 in 20-25 ft of water. Funding was primarily through a grant from the Chesapeake Bay Trust and Fish America Foundation (#6716) and partial funding from Constellation Energy.

Monitoring was performed in May 2006, one year, 7 months after placement. Captain Rick Younger, a private diving contractor, scuba dived on the Reef Balls and took still pictures as well as video. The still pictures are included in Attachment A.

Both pictures and video depict heavy and diverse epibenthic growth consisting of barnacles, sea squirts/grapes, clamworms, limey tubeworms, hydroids, anemones, mussels and amphipods. In addition, Mr. Younger observed blue crabs in and around the Reef Ball as well as a natural oyster spat set.

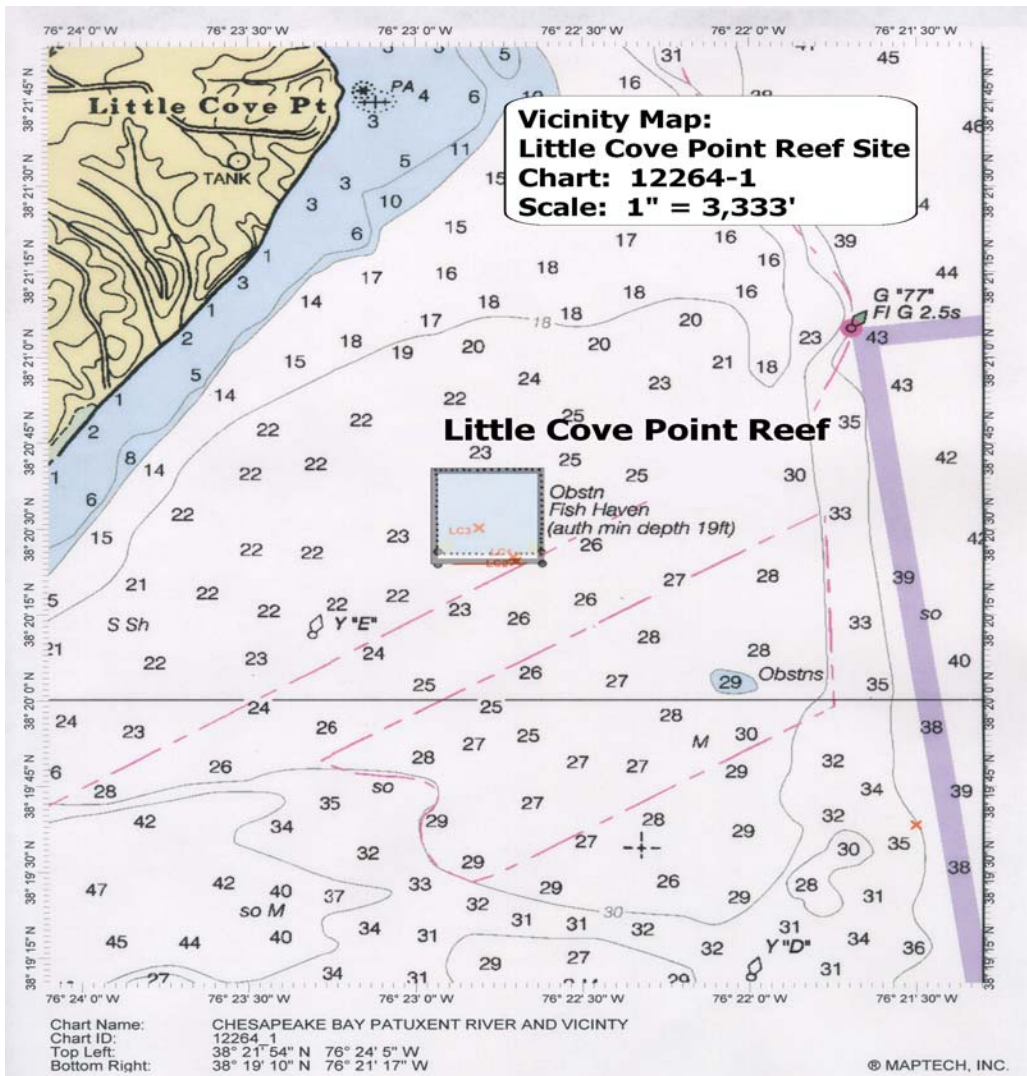


Figure 7: Little Cove Point Artificial Reef

2006 Reef Ball Monitoring Video, MES

Dobbins Island Oyster Sanctuary (Figure 8), Magothy River: Fifty (50) Reef Balls were placed by MES in 9-12 ft of water at this oyster sanctuary in October 2004. Primary funding was a grant from the Chesapeake Bay Trust to the Magothy River Association (MRA) with partial funding from The Abell Foundation.

Video monitoring was performed in June 2006, one year, eight months after placement. This video depicts abundant epibenthic growth including of mussels, barnacles and hydroids. Bream and white perch can also be observed in proximity to the Reef Balls.

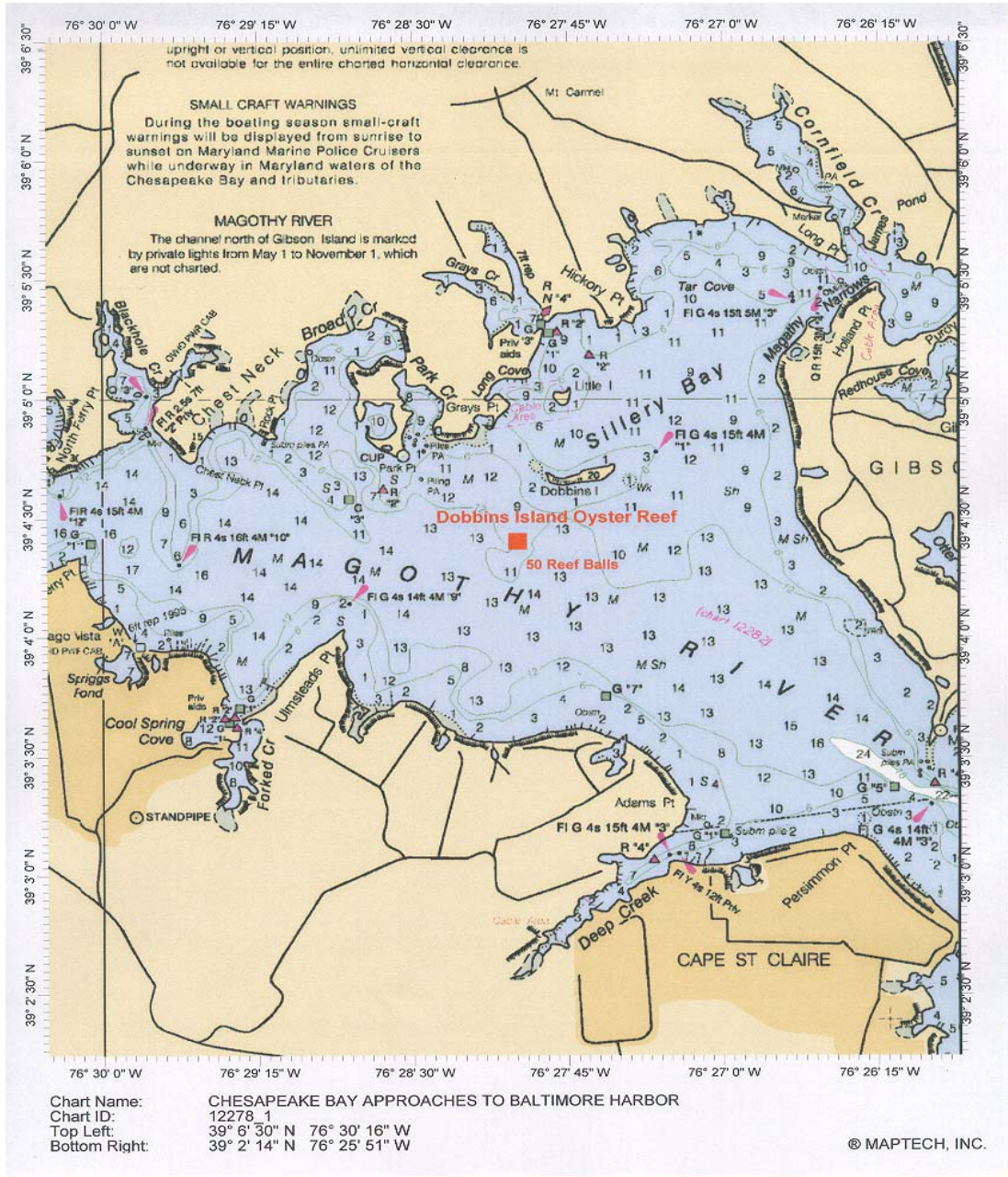


Figure 8: Dobbins Island Oyster Sanctuary

2006 Reef Ball Monitoring Video, MES

Prospect Bay Oyster Sanctuary (Figure 3), CBEC: The 2006 monitoring occurred in April 2006, one year after placement. (The same site monitored in 2005.)

The moderate epibenthic growth observed is similar to what was found in 2005, most likely due to early season cold-water temperatures. Barnacles, anemones, mussels, hydroids and algae can be seen. Numerous fish were observed using the Reef Balls as structure or habitat. The fish species included blennies, goby, bream, and white perch.

Tilghman Island Artificial Reef (Figure 6), Talbot County: Monitoring occurred in June 2006. (The same site monitored in 2005.)

Due to a strong tides running during filming, a Reef Ball is only visible in this video for a brief time. However, it does appear to be covered with epibenthic growth. It can be compared with the surrounding relatively bare bottom of sand and scattered shell in the area.

Reef Ball Extraction, Hollicutts Noose, August 2006

On August 1, 2006, MES, the Chesapeake Bay Program Office of the U.S. National Oceanic and Atmospheric Administration (NOAA), and the Chesapeake Bay Foundation (CBF), lifted four Reef Balls from the bottom of the Hollicutts Noose Reef site (Figure 4, page 5) using the NOAA vessel *RV Bay Commitment*.

The Reef Balls were part of 29 that had oyster spat set on them in CBF's spat settling tanks at Shady Side, Md. in July 2005 and then placed in Parrish Creek to grow out till September 2005, when they were placed at the Hollicutts Noose reef site. All the Reef Balls set with oysters showed good growth and survival both outside and inside of the Reef Ball.

Photos of the oyster covered Reef Balls are included in Attachment D. Numerous gobies, small crabs, and worms were also observed using the oysters-covered Reef Balls as habitat. The Reef Balls were returned to the water once photographed and data recorded.

Findings: Oyster density of the Reef Balls was 44 per sq. ft. with 90 % coverage. The average size of the oyster had increased from an average of 13 mm when placed in September 2005 to 53 mm when measured in August 2006. See Attachment E, quantitative Data Summary for details.

Additional Sources Used for the Ecological Assessment of Reef Balls as Habitat

Draft Monitoring Report for Gales Lump (Memorial Stadium Reef), Mill Hill, Dorchester, Somerset, and St. Mary's Oyster Sanctuaries, DNR 2005

This was a DNR funded monitoring program of substrate (including Reef Balls) by Ken Paynter, *et. al.*, of University of Maryland Center for Environmental Science (UMCES) placed at oyster sanctuaries in 2002-3. Limited monitoring of the Reef Balls were performed by UMCES. However, the report concludes that while few oysters were found growing on the Reef Balls, barnacles, anemones, and mussels were found in massive numbers covering the Reef Balls inside and out and fish were also observed using the balls as structure or habitat. Photo documentation is included showing mussels were dominant at Memorial Stadium oyster sanctuary (Attachment B), while anemones dominated at St. Mary's sanctuary (Attachment C).

MRA Letter

A letter dated March 7, 2006 was sent from Paul Spadaro, president of Magothy River Association (MRA) to MDNR reporting on the Pasadena Fishing Club's success in fishing the Dobbins Island and Rock Point Reef Ball sites in the Magothy River. The letter also mentions that scuba divers have reported good marine growth on the Reef Balls, with small fish and crabs found in and around the Reef Balls. The MRA thinks that Reef Balls are a valuable addition to the habitat of the Magothy River.

Chesapeake Bay Memories (CBM) Fishing Surveys

Chesapeake Bay Memories, an environmental education organization, conducted fishing surveys in 2005 at the Man O' War Shoals (an area without Reef Balls) and at the Reef Ball area within the Memorial Stadium oyster sanctuary. Two trips were made to the Memorial Stadium site, as compared to eight to Man O' War shoals. The CBM fishing data shows catch per unit effort rates of 4 fish/angler/hour at the Reef Ball site at Memorial Reef as compared to 0.52 fish/angler/hour at Man O' War Shoals. The species caught were primarily white perch and spot, with some croakers and toadfish also being taken.

UMCES/EA Literature Search

This report, "*Quantifying Artificial Reef Habitat Benefits*" by Jane Boraczek, fisheries biologist with EA, Inc. and Elizabeth Price research assistant of University of Maryland Center for Environmental Science (UMCES) was prepared for the Maryland Port Administration Harbor Study Team investigating habitat improvement associated with the installation of Reef Balls as mitigation for loss of shallow water habitat at dredged material containment facilities in the Baltimore Harbor. While no quantitative data was available for Reef Balls themselves in temperate estuarine environments, the literature search and review found that in Delaware Bay on reef structures, productivity of the reef epifaunal (organisms growing on a structure) community per unit area was generally 20 times greater than the nearby infaunal (organisms living in the substrate) community. The report concluded that studies from Delaware Bay suggest that Reef Balls may result in secondary production that is 10 times greater than the existing soft bottom habitat.

Organisms Observed Using Reef Balls as Habitat and/or Structure:

The following species have been observed by MES or others during the monitoring of Reef Balls at oyster sanctuaries and reef sites in the Maryland portion of the Chesapeake Bay:

Benthic Species (13):

Barnacles (*Balanus sp.*)
American oyster (*Crassostrea virginica*)
Blue crab (*Callinectes sapidus*)
Mussels (*sp. unknown*)
Sea squirts (*sp. unknown*)
Sea grapes (*sp. unknown*)
Anemones (*sp. unknown*)
Hydroids (*sp. unknown*)
Bryozoans (*sp. unknown*)
Amphipod (*sp. unknown*)
Limey tubeworms (*sp. unknown*)
Clamworms (*sp. unknown*)
Mud crabs (*sp. unknown*)

Fish Species (11):

Catfish (*sp. unknown*)
Atlantic Croaker (*Micropogonias undulatus*)
White perch (*Morone Americana*)
Bream (*sp. unknown*)
Striped bass (*Morone saxatilis*)
Blenny (*sp. unknown*)
Tautog (*Tautoga onitis*)
Sea bass (*Centropristis striata*)
Spot (*Leiostomus xanthurus*)
Goby (*sp. unknown*)
Toadfish (*Opsanus tau*)

Findings

Based on the findings of the 2005 and 2006 video monitoring events performed by MES and other sources of information and data, Reef Balls appear to be successful in improving benthic and fish habitat at reef sites in the Maryland portion of the Chesapeake Bay. Video monitoring shows epibenthic growth of encrusting organisms to be moderate (even after only six months in the water) to heavy. This was true for both oyster sanctuaries and artificial reef locations. To date, thirteen species of benthic organisms cited above have been observed using the Reef Balls as habitat and substrate.

On many of the videos, the benthic communities growing on the Reef Ball surface can be compared to the relatively barren Bay bottom in the vicinity of the Reef Balls. Based on the EA/UMCES study, this would indicate an increase in biological biomass and productivity compared to the soft bottom habitat existing previously. Mussels appear to be the most dominant species in the Upper Bay using the Reef Balls as substrate, with anemones, hydroids, and barnacles becoming more prevalent in the Mid and Lower Bays. A few oysters were observed growing on Reef Balls at Memorial Reef and the St. Mary's oyster sanctuaries, and a natural set oyster was observed on one of the Reef Balls at the Little Cove Point artificial reef site.

The oyster-covered Reef Balls extracted from the Hollicutts Noose reef site on August 1, 2006 showed they can provide excellent substrate for oyster spat attachment, growth and survivability and provide habitat for associated oyster reef communities. In addition, by providing more vertical substrate above the bottom, oyster set on Reef Balls are less likely to be adversely effected by sedimentation and anoxic/hypoxic conditions.

In addition to increased productivity, increased populations of benthic organisms on the Reef Balls (as compared to soft bottom habitat) would lead to an increase in the biological filtration rate of the overlying waters. This would have a positive ecological effect in terms of water quality removing algae and nutrients, as well as decreasing turbidity in the overlying waters.

Eleven species of fish cited above have been observed using Reef Balls as habitat and structure in the videos, the DNR report and from the fishing surveys at Memorial Reef. Although baseline studies were not performed prior to placement of the Reef Balls, simple observation indicates an increase in fish diversity and biomass, due to increased structure and habitat area, as compared to the flat bottom habitat previously existing at and surrounding the sites. Most of the fish found at the Reef Ball sites appear to be juveniles, which may indicate that the Reef Balls are providing nursery habitat for some species.

MES plans to continue monitoring the Reef Ball sites in the future as funds permit. At least yearly reports will be forwarded to grantors as required and interested parties as the reports are completed. Efforts will be undertaken to begin to quantify data for assessment of the value of Reef Balls as estuarine habitat in the Chesapeake Bay.

Literature Cited

Boraczek, J., Price, E., *Quantifying Artificial Reef Habitat Benefits*, report to the Harbor Projects Delivery Team, December 2005.

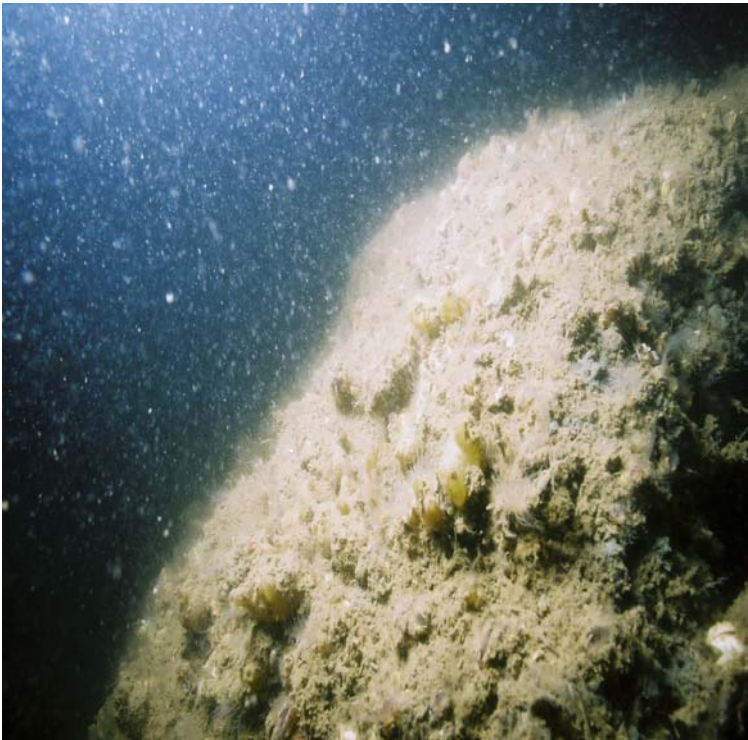
Chesapeake Bay Memories, 2005 fishing survey.

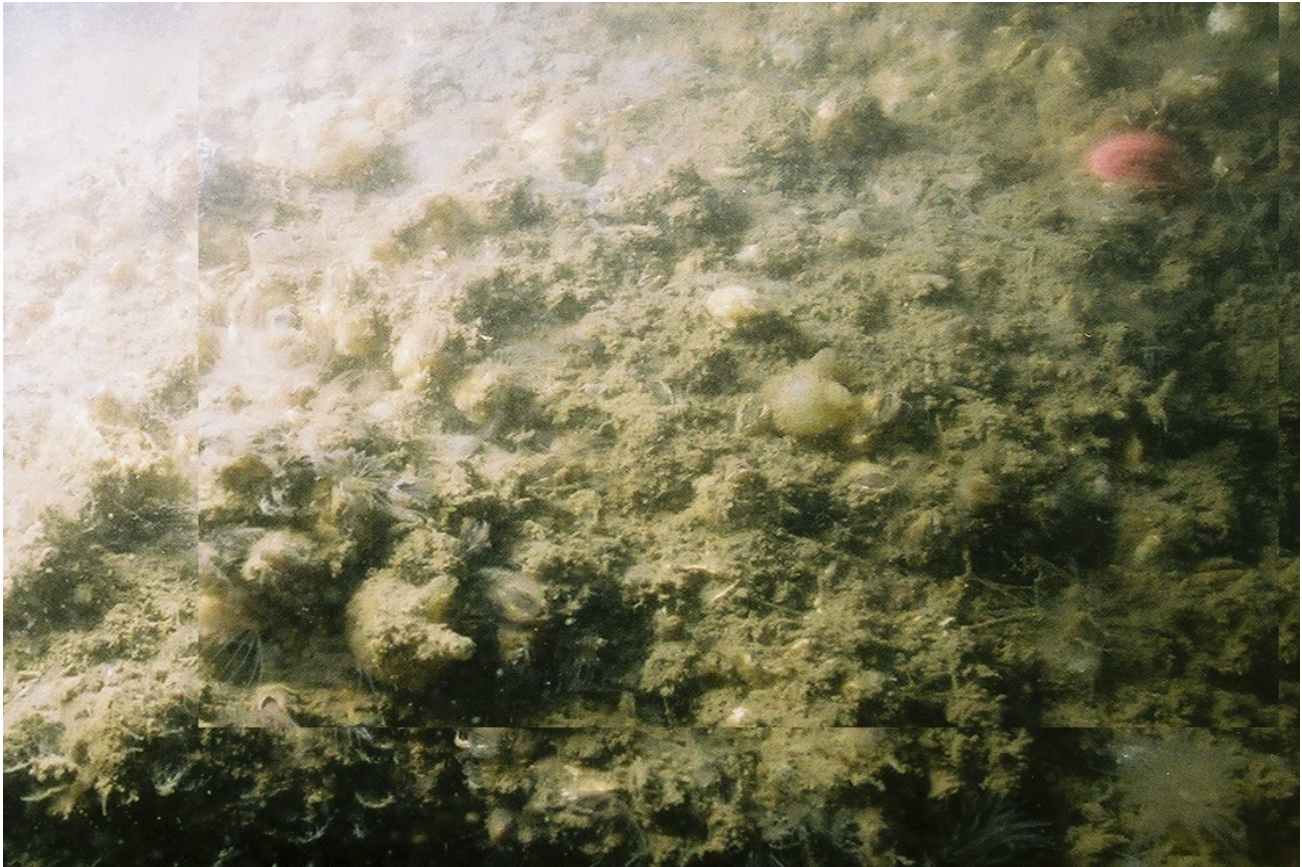
Paynter, K., et. al., UMCES, *Monitoring Report for Gales Lump, Strong Bay, Mill Hill, Dorchester, Somerset and St. Mary's Oyster Sanctuaries*, draft report to DNR, 2004

Spadaro, P., written communication, March 2006.

Attachment A
Little Cove Point Reef Balls
May 2006
Photos by Rick Younger







Attachment B
Reef Ball from Gales Lump (Memorial Stadium Reef) with Copious
Mussel Coverage, 2003



Attachment C
Anemone Covered Reef Balls with Juvenile Sea Bass, St. Mary's
Oyster Sanctuary, 2004



Attachment D
Oyster Covered Reef Balls Extracted from the Hollicutts Noose Reef
Site, August 2006







Attachment E

Data Summary from the Hollicutts Noose Set with Oysters, August 2006

Initial Planting information:

9/22/05 and 9/23/05: Site was shelled with 200 tons whole shell by Doug West aboard the Robert Lee

9/23/05: Site was planted with 27 set reef balls (see chart below) and 42 unset reef balls by Patricia Campbell

Set reef balls were from CBF's oyster restoration center in Shady Side, MD

9/23/05: Site was planted by Patricia Campbell with 1003100 spat-on-shell from CBF's oyster restoration center.

These were planted otop of the set and unset reef balls.

Reef Ball Type	Square Footage	Spat/ Sq. Foot	# Balls	Total Spat
oyster	7.25	120.8	1	876
low pro	16.6	120.8	4	8,021
mini-bay ball	29.5	120.8	14	49,891
bay ball	30	120.8	6	21,744
pallet ball	75	120.8	2	18,120
			TOTAL:	98652

The following reflects data collected on 8/1/2006 from of the three set reef balls.

% Coverage with live oysters:

90%

Size:

Starting average size (9/23/2005): 12.99 mm

Average size on 8/1/2006: 53 mm

Survival:*

Start density (9/23/2005): 120.8 oysters/ sq ft x 16.6 sq. ft = 2005

Density on 8/1/2006: 44 oysters/ sq. ft. x 16.6 sq. ft. = 730

% Survival: 36.40%

* Note that this is an extremely high initial density, amounting to 15.11 spat per shell for comparison, so a high mortality would be expected.