Living Oyster Reef Shorelines Using Shell and Alternative Structures in the Lynnhaven River System of Lower Chesapeake Bay

RP Burke* and RN Lipcius

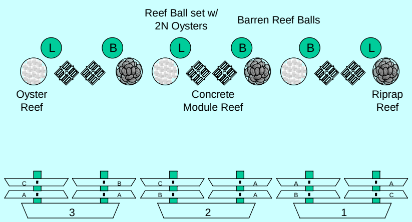
Virginia Institute of Marine Science, The College of William and Mary

Introduction

Ecological restoration of the Eastern oyster in Chesapeake Bay has been a long-term multi-agency effort. The use of living shorelines to restore oyster populations in the Lynnhaven River system (LRS) has been a strategy of Lynnhaven River Now (LRNow; a local community group geared toward rehabilitating the watershed and its waters), the Virginia Institute of Marine Science (VIMS), the Chesapeake Bay Foundation (CBF), and the U.S. Army Corps of Engineers (USACE; Norfolk District). The USACE has adopted a plan to restore >100 acres of oyster bottom in the LRS (30+ acres constructed in December 2007), which represents an unique opportunity to link community-wide efforts with state and federal interests. In summer 2006, we constructed three oyster shell, riprap and concrete modular reefs at two subtidal sites in the LRS. In addition, we placed six reef balls at each site, half of which had been seeded with oysters in controlled tank settings pre-deployment. The primary goal of this construction was the development of healthy oyster reef habitat as a living shoreline in the subtidal zone adjoining natural marshes. We assessed the comparative success of the reef types with respect to oyster recruitment, growth, and survival, and reef structural integrity.

Photo 1. Lynnhaven River, Chesapeake Bay

Living Shoreline Deployment (Summer 2006)



A = Bare (deployed 7-24-06; zero cable ties)

B = Triploid (3N) larvae set (deployed 8-7-06; one cable tie)

C = Bare (deployed Late August 2006; two cable ties)

Figure 1. The Living Shoreline Experiment as drawn in the permit application, the explicit layout of the concrete modular reefs, and a post-deployment photo at the Handeland Site.

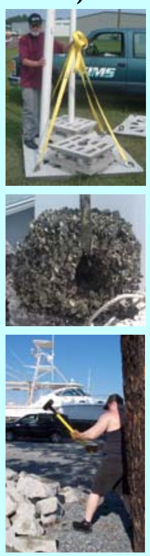


Photo 2. Top: Captain Robert Jensen and his new concrete module prototype; Middle: A seeded reefball suspended prior to deployment; Bottom: Dave Schulte (USACE/VIMS) splits granite that was delivered two classes too large.

Materials and Methods

Upon obtaining homeowner consent to construct the general reef configuration, scale drawings were constructed and submitted within two joint permit applications with CBF as our co-applicant. The official permits were issued on July 24, 2006; we deployed the granite riprap and oyster shell reefs that same day. The next day, eighteen of the twenty-four miniature concrete modular structures were deployed. Due to construction delays, the last six modules were deployed a few weeks later. A permit addendum was sought and granted for the addition of six reefballs to each living shoreline. Half of the reefballs were conditioned and seeded with diploid oysters; the other half were barren of oysters and unconditioned. The reefballs are called Mini-Bay Balls (dimensions: Base diameter – 28", Top diameter – 20", Height – 20", and estimated surface area of 29.5 ft^2). The reefballs were deployed on Sept. 26, 2006 and are assumed to have missed the 2006 oyster larval recruitment window.

Sampling of the reefs has been conducted in July 2007, Jan./Feb. 2008, and Sept./Oct. 2008 (sample processing is ongoing). Oyster shell height (SH) of live and dead oysters and mud crab counts were recorded from one of four quadrants of each reef. One quarter of the granite riprap and oyster reefs were non-destructively sampled *in situ* (except for Fall 2008), recording the percent of substrate present below the sediment line. Care was taken to return reef material in its original orientation (i.e. rocks at the reef base were returned to the base position of the reef; oyster clusters from shell reefs were placed on top of the empty, anoxic shell). One-quarter of each concrete module layer was also non-destructively sampled noting its position (upper/lower), condition, and locations of oysters measured (top, sides, holes or bottom). Reefballs were photographed and notes taken regarding oyster reef progression (estimated growth, density, and presence/absence of oyster recruits). At the close of the experiment (Fall 2008), one quarter of each reefball was destructively sampled. For all reef types, a fixed number of oysters throughout the range of oyster SHs were retained for disease (Dermo/MSX), biomass, and condition index analysis. Note, the presenter may discuss these preliminary findings, but only the July 2007 and Jan./Feb. 2008 data are present on this poster.

Table 1. Comparison of Site-Sampling Period for oyster count, biomass and proportion live.

Site - Sampling Period	Total No. Oysters	Total Biomass AFDM (g)	Proportion Live
Chalmers (July 2007)	162	24.41	0.81
Handeland (July 2007)	1040	335.75	0.80
Chalmers (Jan./Feb. 2008)	2342	346.82	0.85
Handeland (Jan./Feb. 2008)	2099	546.68	0.81

Results and Discussion

In 2006, the large-scale recruitment that was measured on oyster shell (OS) reefs (and on seeded shell/alternative structures – part of another experiment) was not recorded on granite riprap (RR) reefs and concrete module (CM) reefs. This delay was likely due to a protracted substrate conditioning period. However, RR and CM reefs did recruit some oysters in 2006 (Figures 2A, 4B) followed by a successful summer/fall 2007 recruitment (Figures 2B, 4B). Besides the disparity between substrates in the first year, one site (Handeland – HD) seemed to be outperforming the other site (Chalmers – CH) by one order of magnitude (Table 1). Despite the recruitment differential, general survival was the same (~80%). Notably, survival did vary between reef types (Table 2) with CM>OS>RR. The small number of oysters on CM reefs in 2006 made this observation less impressive; furthermore, OS and RR reefs showed similar survivorship by Jan./Feb 2008 (Table 2). On all reef types, the oyster growth rate was high; a few oysters had shell heights (SH) >100.0 mm (~4 inches) within one year. Nearly half were on the verge of market size (75.1 mm) by July 2007. At the HD site, the OS reefs were already beginning to cohere. Overall, the July 2007 results for oyster recruitment, growth and survival were encouraging. The big question still remaining after one year was whether the RR and CM reefs would receive the same 'jumpstart' in 2007 as the OS reefs experienced in 2006. We were encouraged by other contemporaneous alternative substrate research being conducted in the LRS (Figure 5), and had already witnessed major spurts of reef development on shell and non-shell substrates.

By Jan./Feb. 2008, both sites had experienced another good recruitment event (Figure 4B), but the greater visible changes occurred at the CH site (Table 1); there were actually more oysters at the CH site than at the HD site (Figure 2B). An important detail not to overlook is a telling metric called oyster biomass. We used ash-free dry mass (AFDM in grams) of oyster tissue as one means to determine the reef status and found that the HD site was still likely outperforming (filtration rate) the CH site with the presence of more large oysters and associated biomass advantage of ~35%. Also, the OS reefs at the HD site were really beginning to stabilize (cohesion) and accrete (grow out), a critical aspect of oyster survival in this particularly muddy tributary. One surprising find was that OR and RR reefs at the HD site maintained 44% and 29% of their oysters on other living or recently dead oysters, respectively; 17% and 13% of those reef's oysters, respectively, were serving as base substrate for other oysters (Table 2). The importance of this discovery is that other successful Chesapeake Bay oyster reef restoration projects have shown that accretion occurs at a much faster rate with this type of recruitment and growth.

The final sampling this fall has been a bitter sweet experience. We are pleased to see the project thrive, but left yearning to spend more time with the reefs to watch the initial temporal gaps in reef development close and see the thriving reefs surpass the metrics of success set by the USACE's Lynnhaven River Oyster Restoration Planning Document. By 1.5 years post-deployment, the OS reefs had reached the prescribed levels of success projected for five years post-construction, and it appears that both the RR and CM reefs are doing the same at 2 years of age. Please feel free to contact us about this or other projects; working effectively in oyster restoration is one of our great joys and we love sharing in the adventure!

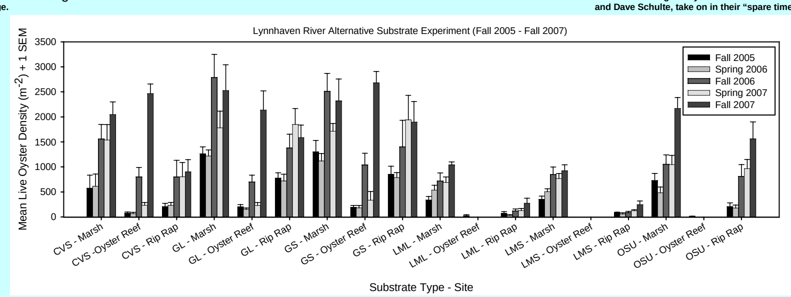


Figure 5. Oyster density results from the Lynnhaven River Alternative Substrate Experiment (Fall 2005 – Fall 2007) may forecast the potential of the living shoreline substrates to accrete and grow into fully restored reefs (Burke et al., *unpublished data*). CVS = Recycled Concrete; GL/GS: Granite Lg/Sm; LML/LMS = Limestone Marl Lg/Sm; OSU = Oyster Shell

Photo 7. Large oysters from one of the oyster shell reefs at the Handeland site.

Photo 8. Oysters covering >90% of a concrete module at the Chalmers site.

Photo 9. A seeded reefball with oysters thriving in every nook and cranny.

Photo 3. An oyster cluster from one of the oyster shell reefs

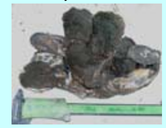
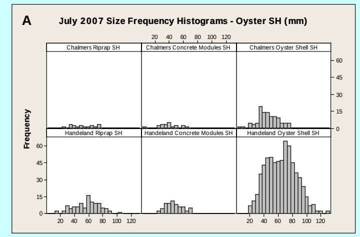


Photo 4. Oysters (2.5 yrs old) from a seeded reefball with shell heights >7 inches

Photo 5. Granite riprap with oysters

Photo 6. Submerged concrete modules



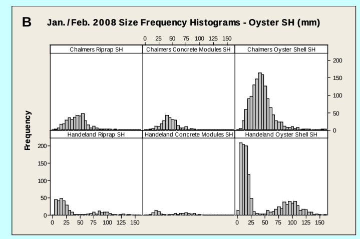


Figure 4. Oyster size frequency histograms (SH – mm) on the living shoreline reefs sampled in July 2007 (above - A) and Jan./Feb 2008 (below - B)

Photo 10: Ecological Oyster Reef Restoration is what scientists, Russell Burke and Dave Schulte, take on in their "spare time"

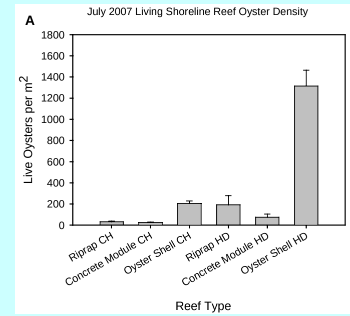
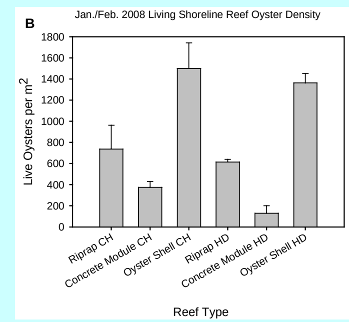


Figure 2. Oyster Density on the living shoreline reefs sampled in July 2007 (above - A) and Jan./Feb 2008 (below - B); CH = Chalmers Site, HD = Handeland Site



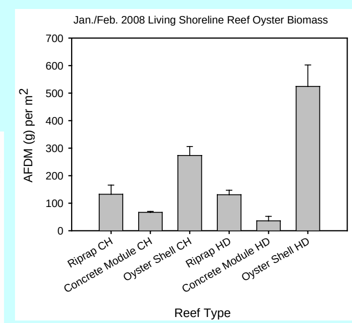


Figure 3. Oyster Biomass (Ash-Free Dry Mass –AFDM (g)) on the living shoreline reefs sampled in Jan./Feb 2008; CH = Chalmers Site, HD = Handeland Site

Table 2. General comparisons made across site and reef type between the July 2007 and Jan./Feb. 2008 sampling events; CH = Chalmers Site, HD = Handeland Site; RR = Riprap Reef, CM = Concrete Module Reef, OS = Oyster Shell Reef

Site - Reef Type	July 2007 Total No. Oysters	Jan./Feb. 2008 Total No. Oysters	July 2007 Total Biomass AFDM (g)	Jan./Feb. 2008 Total Biomass AFDM (g)	July 2007 Proportion Live	Jan./Feb. 2008 Proportion Live	Jan./Feb. 2008 Proportion of Oysters Set On Live/Dead Oyster Shell	Jan./Feb. 2008 Proportion of Oysters Serving as a Spat Base
CH -RR	27	455	4.31	65.25	0.59	0.82	0.04	0.02
CH - CM	21	251	2.46	41.97	0.95	0.93	0.01	0.01
CH - OS	114	1636	17.64	239.60	0.89	0.80	0.03	0.03
HD - RR	131	421	30.87	64.50	0.73	0.72	0.29	0.13
HD - CM	69	90	11.39	22.69	0.90	0.95	0.09	0.06
HD - OS	840	1588	293.49	459.49	0.77	0.76	0.44	0.17

Acknowledgments:

Lynnhaven River Now, with special thanks to Hap Chalmers and Wally Handeland

VIMS Marine Conservation Biology Lab for all their helpful assistance

Dave Schulte for his support at the US Army Corps of Engineers and at VIMS

Chesapeake Bay Foundation for assistance in joint permitting and reef deployment

Sea Search, Inc. for the construction, seeding and transportation of the reefballs

US Army Corps of Engineers
Norfolk District