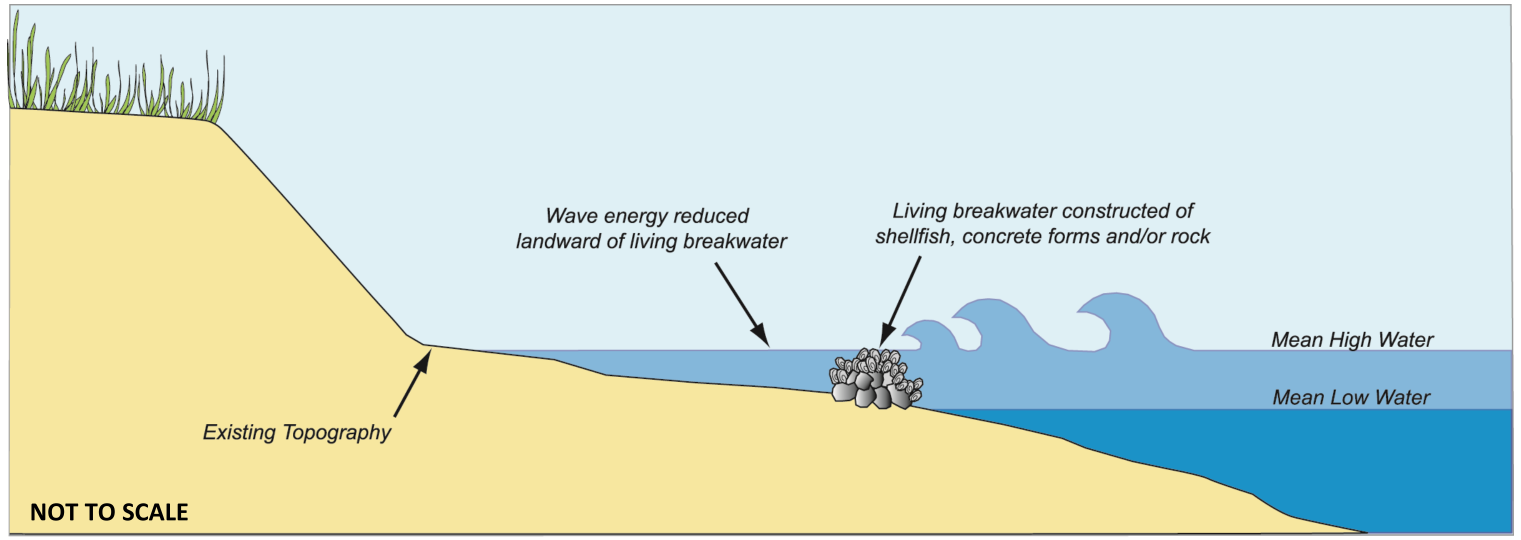
Living Breakwater

Living breakwaters are constructed nearshore to break waves on the structure rather than on the shoreline to reduce erosion and promote accumulation of sand and gravel landward of the structure. They are typically larger than sills and constructed in deeper water in more energetic wave climates, and have the potential to enhance habitat.

Objectives: break waves, dissipates wave energy, erosion control, habitat creation

Design Schematics



Design Overview

Materials	Living reef materials (oysters/mussels). Shellfish reefs can be constructed with bagged or loose shell to provide the same erosion control as rock sills but with additional ecosystem benefits.[11] Precast concrete forms or stone.
Habitat Components	Shellfish reef. Complex structure for fisheries habitat.
Durability and Maintenance	Concrete reefs or living resources (e.g. shell bags) will break down over time, while precast concrete forms and stone will last longer. The degradation of the shell bags over time is often a desired characteristic if they are being used to temporarily break waves while a system behind it is reestablishing or a natural living system is establishing itself on this substrate.
Design Life	Shell bags, concrete forms, and stone provide the foundation for living breakwaters; concrete forms and stone provide more time for natural recruitment of shellfish and marine algae.
Ecological Services Provided	Can become valuable substrate for marine organisms, as well as provide shelter and habitat for many fish, crab and other mobile species.[14] Can dampen wave energies and increase sediment retention.[10] Because shellfish are filter feeders, oyster/mussel reefs can improve water quality.[11] As the living breakwaters become colonized with marine species, they provide recreational benefits such as fishing and snorkeling.[11]
Unique Adaptations to NE Challenges (e.g. ice, winter storms, cold temps)	Reef Balls installed in Stratford, CT withstood significant icing during the 2014-2015 winter.[14] Need to consider where in the tidal range shellfish will be placed if they're used: too high in the intertidal area may result in freezing and loss of shellfish.

Case Study

Stratford, CT Reef Balls

Beginning in 2010, the Stratford Point project has focused on restoring and managing 28 acres of coastal upland and 12 acres of intertidal habitat using an integrated whole ecosystem approach. The creation of a 1,000-foot living shoreline started with the construction of an artificial reef, using pre-cast reef balls, at mean tide elevation (~ 75 ft. offshore), in conjunction with restoration of low and high marshes and dune shoreward of the artificial reef. In addition, upland shrub, coastal forest and meadow mosaic is being restored to improve bird and pollinator habitat.

Reef Ball Breakwater, Stratford, CT
Photo courtesy of Jennifer Mattei

Project Proponents	Sacred Heart Uni.(Project Lead), Audubon Society (Site Manager); DuPont Company (Site Owner)
Status	In Progress (Reef construction: Complete; Marsh & Dune Restoration and Upland work: Continuing
Permitting Insights	DABA had concerns about 'wild' oysters settling on the reef and possibly harboring diseases that might affect the aquaculture industry of Long Island Sound. So far, this has not been a problem.
Construction Notes	A restoration team of land managers, restoration ecologists and environmental engineers is key for designing and deploying a living shoreline. The study of local bathymetry, storm wind and wave trajectory, sediment loads and causes of erosion are imperative for proper placement of artificial reefs used to protect newly restored saltmarshes.
Maintenance Issues	Previous attempts of dune restoration prior to artificial reef construction highlight the importance of comprehensive restoration planning, and construction sequencing.
Final Cost	To be determined
Challenges	Initial dune installation (2012) was eroded by storms before the artificial reef and saltmarsh were installed. Slight field modifications to reef ball placement due to natural rock outcroppings.

Reef Ball Breakwater, Stratford, CT
Photo courtesy of Jennifer Mattei

Living Breakwater

Although breakwaters are often considered coastal engineering structures, a gapped living breakwater allows habitat connectivity and greater tidal exchange and can be used in combination with other living shorelines practices to reduce the wave energy allowing the establishment of a beach or vegetated (typically marsh) shoreline in its lee.

Oyster bags for a living reef at Gandy's Beach NJ
Photo courtesy of Mary Conti, TNC NJ

Oyster castles for a living reef at Gandy's Beach NJ
Photo courtesy of Mary Conti, TNC NJ

Regulatory and Review Agencies

Maine	Municipal Shoreland Zoning, Municipal Floodplain, ME Dept. of Environmental Protection, ME Land Use Planning Commission, ME Coastal Program, ME Department of Marine Resources, ME Department of Inland Fisheries and Wildlife, ME Geological Survey, and ME Submerged Lands Program.
New Hampshire	Local Conservation Commission, NH Natural Heritage Bureau, NH Department of Environmental Services (Wetlands Bureau, Shoreland Program, and Coastal Program), and NH Fish & Game Department.
Massachusetts	Local Conservation Commission, MA Dept. of Environmental Protection (Waterways and Water Quality), MA Division of Fisheries and Wildlife (Natural Heritage and Endangered Species Program), MA Environmental Policy Act, and MA Office of Coastal Zone Management.
Rhode Island	Coastal Resources Management Program, and RI Dept. of Environmental Management.
Connecticut	Local Planning and Zoning Commission, and CT Department of Energy and Environmental Protection.
Federal (for all states)	U.S. Army Corps of Engineers, National Marine Fisheries Service, U.S. Environmental Protection Agency, and U.S. Fish and Wildlife Service.

Siting Characteristics and Design Considerations

Selection Characteristics	Detail
ES Energy State	Moderate to high. Suitable for most areas, except those in the highest wave energy environments.[2] Concrete forms are generally stable under most wave conditions due to the size and weight of the units, and have been shown to attenuate wave energy and reduce erosion in a low to moderate wave energy locations; one study found that Reef Balls could reduce wave heights by 60%.[7] Using additional rows of Reef Balls can decrease this even more.[7]
EE Existing Environmental Resources	Coastal beach; mud flat; subtidal
SR Nearby Sensitive Resources	Endangered and threatened species. If the project is proposed in or adjacent to habitat for protected wildlife species or horseshoe crab spawning areas, there may be limitations on the time of year for construction. Shellfish beds, submerged aquatic vegetation, and essential fish habitats will restrict where a living breakwater can be constructed.
TR Tidal Range	Low to middle. In areas with a large tidal range, these structures would have to be extremely large to continue to provide protection functions,[2] or could be sited closer to shore. Best suited for low to medium tidal range areas.
EL Elevation	MLW to MHW; subtidal. Located intertidally or subtidally, but typically designed with crest elevation at MHHW, therefore quickly overtopped during storms; not effective at dealing with storm surge events.[10]
IS Intertidal Slope	Flat to steep. The breakwater itself will not be impacted by the intertidal slope[7], but other project components, such as a marsh planted behind the breakwater, may have specific slope requirements.
BS Bathymetric Slope	Flat to steep. The bathymetric slope will influence the size and type of waves that impact the structure, and thus should be considered in the wave analysis.[7]
ER Erosion	High to low. Assuming wave energy is the primary driver of coastal erosion at the site, an appropriately sized and placed breakwater should be capable of mitigating the erosional problem under most conditions.[7]
Other Characteristics	**Detail**
Ice Sensitivity	Current guidance suggests sizing stone so that the median stone diameter is two to three times the maximum expected ice thickness.[7] In colder climates, oysters/mussels should be submerged (below MLW) to prevent them from freezing during the winter months.[7]
Climate Vulnerability	The effectiveness of a breakwater will be reduced over time as sea level rise gradually reduces the freeboard of the structure. Living reef breakwaters have some capacity to adapt to changing conditions, as long as sea level rise is relatively slow.[7]
Surrounding Land Use	Projects need to be planned alongside other competing water uses such as boating, fishing, shellfishing, and aquaculture. Consideration should be given to potential conflicts with existing navigable waters.