Conservation practice insights from a comparative case study of two shoreline stabilization projects in Boston Harbor, MA

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Abstract
As sea levels rise and the frequency of flooding events increases, so do efforts to stabilize coastal shorelines. Nature-based solutions to shoreline stabilization (“green” solutions, as opposed to traditional “grey” shoreline hardening) have been increasingly adopted in the Gulf of Mexico and mid-Atlantic regions of the United States, but they are only beginning to be implemented, documented, and understood in the northeastern United States. This case study contrasts two shoreline stabilization projects directly across from each other on the banks of the Mystic River, Boston Harbor, MA. These two projects, one private and one public, employ a spectrum of green-grey shoreline stabilization techniques. Originally planned as traditional grey shoreline stabilizations, both projects shifted toward greener solutions due to local environmental group advocacy, highlighting the influence of outside groups as advocates for nature-based solutions. This study documents the evolution of both projects, highlighting common challenges in permitting and vegetation maintenance, as well as critical differences in project goals, funding sources, and biodiversity impacts.

KEYWORDS
Boston Harbor, living shorelines, nature-based solutions, shoreline stabilization

1 | INTRODUCTION

Stone seawalls were built in the Boston Harbor as early as 1784 (Rosen & Vine, 1995) and by 2013, almost 60% of the shoreline in the Boston Harbor was protected by hard structures (Fontenault, Vinhateiro, & Knee, 2013). Hardened structures (“grey” infrastructure), while effective for coastal protection from storm events and bolstered by centuries of construction expertise, have limited lifespans, do not adapt to changing conditions, and contribute to habitat, biodiversity, and sediment transport losses (Sutton-Grier, Wowk, & Bamford, 2015). Nature-based solutions (NBS) are relatively newer practices that incorporate or work in conjunction with natural features and vegetation and/or are designed to mimic natural features or processes that provide protective value. Living shorelines are a gradient of NBS, including hybrid “green-grey” solutions that combine innovative NBS with
traditional hardened approaches, increasingly have been used to stabilize shorelines while generating various co-benefits, including habitat enhancement, increased carbon sequestration, and improved water quality (Sutton-Grier et al., 2015). NBS also have the potential to adapt to rising sea levels and other effects of climate change, vastly extending the lifespans of these solutions over grey solutions. NBS for shoreline stabilization have been more widely adopted along the Mid-Atlantic and Gulf coasts of the United States, but their implementation has been slower in New England due to both regulatory and ecological suitability concerns (O’Donnell, 2017).

This case study, compiled through project site visits, policy document reviews, and informal interviews with key informants (e.g., environmental groups, regulatory agencies, landscape architects, design firms, restoration practitioners) documents the processes, challenges, and adaptive management of two different living shoreline stabilization approaches directly across from each other on the Mystic River, which opens to the Boston Harbor. Our study design was reviewed by Northeastern University’s Institutional Review Board, which determined that the project-focused interviews with key informants did not require approval as human subjects research.

Located just below the Amelia Earhart Dam, the portion of the lower Mystic River on which the projects are situated is brackish to saline. The bathymetry between the two sites is gently sloping, with a maximum water depth of 3.3 m. Water quality is considered good, but the area has a history of contaminated sediments from centuries of heavy industrialization. The projects, one privately-funded and one publicly-funded, exist along a green-grey spectrum, providing valuable insight into both policy and practice-related components of the NBS process, as well as a unique opportunity to compare different NBS approaches to shoreline stabilization in close proximity.

![Site map of the two case studies, located along the Mystic River, less than 8 km from the mouth of the Boston Harbor.](image)

(Figure 1) Site map of the two case studies, located along the Mystic River, less than 8 km from the mouth of the Boston Harbor. 
(a) Located on the main map in orange, the living shoreline at Encore Boston Harbor Resort and Casino, including the planted vegetation and coir-wrapped rock roll. The living shoreline at the bottom of the frame overlooks the reinforced flood wall of the Charlestown Massachusetts Bay Transportation Authority (MBTA) Bus Facility across the water. (b) Located on the main map in red, the shoreline stabilization project at the MBTA Bus Facility, including the vegetation plugs and riprap revetment.
2  |  CASE STUDY PROJECTS

2.1  |  Encore Boston Harbor living shoreline

Encore Boston Harbor, a luxury resort hotel and casino run by Wynn Resorts, opened in 2019 in Everett, MA, after a four-year permitting, site remediation, and construction process. The 183-m living shoreline was constructed along a portion of the harborwalk, a walking and biking trail designed to reconnect the city of Everett to public-access waterfront (Figure 1a). Initially planned as a traditional grey infrastructure shoreline stabilization project, the plan for a living shoreline was developed after advocacy from the Mystic River Watershed Association (MyRWA, 2018). The living shoreline, located at the southwestern edge of the Encore property along the Mystic River, expanded on existing salt marsh. The project created 918 m² of salt marsh and 1,236 m² of higher-elevation coastal bank, protected by a coir-wrapped rock roll of 11–45 kg cobbles and salt marsh soil wrapped in a biodegradable fabric. More than 10,000 native coastal plants were planted in the salt marsh and coastal bank portions of the living shoreline, with the salt marsh portion predominantly Spartina alterniflora in the low marsh and Spartina patens and Distichlis spicata in the high marsh. Landward of the living shoreline, the Encore Boston Harbor is protected by an extensive vertical bulkhead that is typically above the mean higher high water (MHHW) mark. The living shoreline was funded alongside inlet dredging and sediment remediation (including capping of ~3 ha of contaminated sediment) that totaled $68 million in private funds, $38 million above budget (MyRWA, 2018).

2.2  |  Charlestown bus facility shoreline stabilization

Directly across the river from Encore Boston Harbor’s living shoreline sits the Massachusetts Bay Transportation Authority (MBTA)’s Charlestown Bus Facility. In 2017, public-funded work began on a $38.9 million project to repair a deteriorating steel sheet-pile bulkhead to correct resultant sinkholes and better protect the municipal bus facility from flooding, storm events, and sea-level rise. The project aimed to stabilize 570 m of coastal bank through the use of piling and stone rip rap, as well as a shore-parallel 4.5 m flood wall. The project also included dredging of ~1,600 m³ of sediment to establish stable grades. After advocacy from regulatory agencies and the Mystic River Watershed Association, the decision was made to add a bioengineered slope planted with native vegetation. The relatively steep slope (2:1), held with geogrid fabric, was planted with more than 125,000 native plants above the MHHW mark, including S. patens and D. spicata in the lower zones, and native upland plants in the higher zones. Below the MHHW mark, the shoreline is protected with a riprap revetment (Figure 1b).

3  |  PROJECT CHALLENGES

Both projects experienced challenges with vegetation. Encore Boston Harbor experienced a fair amount of loss after the first round of planting in the fall of 2017 from both challenges in watering and goose grazing, and the area was replanted in the fall of 2018 and the spring of 2019. Goose grazing was discouraged through the use of canine bird control. The project also made a critical pivot from vegetation appearance to function. While plants were originally arranged with an eye for aesthetics, replanting efforts focused more on species best suited to hardiness and sediment retention. The steep slope of the MBTA project, combined with ~3 m tidal fluctuations, required the use of three distinct planting zones. Similar to the Encore Boston Harbor project, geese grazing of newly planted plugs was problematic; an exclusion fence was developed as part of the project. Unique to this project, the planting schedule at the MBTA site was delayed due to the onset of the COVID-19 pandemic. Plugs were planted later in the season, requiring more frequent watering due to summer heat. Additional months of growing in the nursery also meant that plugs were larger than requested by the time they were planted, resulting in additional labor on site at a time when labor was difficult to acquire.

Permitting also proved difficult for both projects. When their living shoreline experienced erosion along the edge of the coir-wrapped rock roll, Encore Boston Harbor needed to acquire permits to repair both the dredge cap and coir-wrapped rock roll. The permitting process, including for secondary corrective modifications, required 10 separate permits from five different issuing agencies spanning federal (US Army Corps of Engineers), state (MA Department of Environmental Protection, MA Executive Office of Energy and Environmental Affairs), and municipal (Everett Conservation Commission, Boston Conservation Commission) governments from 2015 to 2017. Permitting for the MBTA project was also identified as complicated, requiring permits from five different agencies (US Army Corps of Engineers, US Environmental Protection Agency, MA Department of Environmental Protection, Boston Conservation Commission, Somerville Conservation Commission) in several jurisdictions, each
with different requirements regarding the implementation of infrastructure along the green-grey spectrum.

4 | IMPLICATIONS FOR ADVANCING NATURE-BASED SOLUTIONS

Despite the above challenges, both projects have been generally well-received. In 2018, Encore Boston Harbor was awarded an Environmental Merit Award from the United States Environmental Protection Agency in recognition of the living shoreline and other efforts to protect and remediate the local environment. Public support for the MBTA project remains high, particularly as the project has been within budget thus far and will also incorporate a shared-use path for public use, connecting the town of Charlestown to major subway and bus transportation hubs.

These projects, located less than 250 m apart on opposite shores of the Mystic River, represent two different approaches along the green-grey spectrum of shoreline stabilization infrastructure. While both projects rely on grey components, both include green, nature-based components, after advocacy from regulatory and environmental groups. This highlights the influence of outside groups as advocates for NBS for shoreline stabilization.

The degree to which each project was able to implement NBS is indicative of the type of infrastructure being protected by the shoreline stabilization project and when NBS were introduced. Encore Boston Harbor privately funded their mostly green living shoreline to stabilize a portion of the public harborwalk, whereas the MBTA, a public-funded entity, implemented a green-grey hybrid flood wall with vegetated slope to protect their largest bus maintenance facility, which serves 99,000 bus passengers daily. While the project at Encore Boston Harbor was largely completed before the opening of the hotel and casino, the MBTA had to keep their bus facility fully operational throughout the construction process. Since both projects were initially planned as traditional grey approaches to shoreline stabilization and later shifted due to local advocacy, the timing of a project’s shift to a greener design influenced the extent to which it could incorporate a blend of grey and green approaches. With a larger budget, potentially fewer spending restrictions, an earlier shift to greener design, and less critical infrastructure to protect, Encore Boston Harbor was better able to implement a greener solution that incorporated a gentler slope and likely greater ecological function.

It is also important to weigh the project goals with their impacts on ecosystem services. While largely developed for shoreline stabilization and coastal protection during storms and flooding events, each project will influence ecosystem services differently based on where it falls on the green-grey spectrum. While both the Encore Boston Harbor and MBTA projects involve grey infrastructure to maximize coastal flooding protection, the Encore living shoreline’s location and design may provide more flexibility to adapt over time in response to sea-level rise. The Encore project provides an essential nursery habitat for juvenile nekton and a sill for bivalve colonization, which in turn will provide food and refuge to nekton, whereas the above-water planting at the MBTA project has little ecological value for aquatic species, but may have greater value for coastal birds (Gittman et al., 2016). Whereas a traditional hardening approach to shoreline stabilization has little or no benefit (and often pose a potential detriment) to local biodiversity, projects at the greener end of the green-grey spectrum may provide a “win-win” solution for increasing both coastal biodiversity and protection. To maximize these benefits, however, it is essential to consider them as primary project goals and early enough in the project timeline to be effectively incorporated.

Accelerating the implementation of NBS in Massachusetts will require overcoming ecological, socioeconomical, and regulatory obstacles. As a relatively new approach to engineered shoreline stabilization, NBS may be more complicated to implement than traditional grey approaches, especially given the natural variability in working with NBS. Funding and permitting restrictions, especially related to protecting critical infrastructure, combined with relatively short growing seasons and colder winters, make implementation of NBS challenging in the northeastern United States. With a mind toward innovation, however, this case study is an important contribution to advancing the practice of NBS, illustrating the importance of adaptive management in maintenance, as well as the importance of regulatory agencies and environmental organizations willing to advocate for a shift “from grey to green.” Efficient permitting processes, continued monitoring, adaptive management, and, especially, knowledge sharing are necessary to continue to build a strong foundation, knowledge base, and support for future nature-based solutions to shoreline stabilization in Massachusetts. Continued research on the efficacy of these solutions, particularly in the case of increasing storminess and sea-level rise, will be imperative for building coastal resilience.

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CONFLICT OF INTEREST
The authors declare no conflicts of interest.

AUTHOR CONTRIBUTIONS
Katherine A. Castagno and Steven B. Scyphers conceived the manuscript. Katherine A. Castagno wrote the first draft of the manuscript. Alison A. Bowden, Eric J. Roberts, Sara E. Burns, Sharon L. Harlan, Laura Senier, and Steven B. Scyphers offered critical insight and edits to the manuscript. Field photos were taken by Katherine A. Castagno and Steven B. Scyphers.

ETHICS STATEMENT
Northeastern University’s Institutional Review Board determined that the project-focused interviews with key informants did not require approval as human subjects research.

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ENDNOTE
1 Public documents related to the Encore Boston Harbor project can be found online at https://www.encorebostonharbor.com/about-us/public-documents. Documents and permits related to the MBTA project can be found on the Massachusetts Energy & Environmental Affairs Data Portal (EEA#15487, DEP File No. 006-1501 and 287-0058. http://eeaonline.eea.state.ma.us/portal/).