

Nature-Based Solutions in Boston's Harbor: Policy Insights for Coastal Cities

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Introduction

Coastal cities face many challenges—including vulnerable water infrastructure, and the escalating impacts of climate change—which require innovative and forward-thinking solutions. Traditional gray infrastructure approaches, like seawalls and other shoreline hardening, can aggravate erosion and cause coasts to be more vulnerable in the long term. At the same time as the need for climate adaptation intensifies, much of the previously obligated federal climate funding is being cut, delayed, or revoked by the Trump Administration. Nature-based solutions (NBS) offer a necessary and cost-effective approach for securing water availability, enhancing water quality, and fortifying the safety of coastal communities, all while absorbing tons of carbon.¹ Despite these benefits to community and local ecosystems, NBS are often subject to extensive regulatory and permitting requirements, leading to outsized regulatory delays in comparison to traditional gray-infrastructure development projects. As cities work with implementers to upgrade existing infrastructure and plan for future coastal development, adapting policy and regulations to encourage integration of NBS will be essential to foster climate-resilient coastal communities and ecosystems in a cost efficient manner.²

Several organizations and municipalities in Greater Boston are working towards advancing NBS along the waterfront, and experiences there offer valuable lessons for other coastal cities nationwide. Created in partnership by Urban Ocean Lab and Boston Harbor Now, this memo was informed by discussions with community organizations, nonprofits, and private developers in Boston, and presents key recommendations for U.S. coastal cities to increase the use of NBS in urban harbor and waterfront projects.

Benefits of Coastal Nature-Based Solutions

According to the most recent Census figures, over 47 million people live in U.S. coastal cities. As cities prepare for projected population growth, they must not only adapt existing infrastructure but also develop new housing, transportation, and other necessities. NBS offer a wealth of community and environmental benefits by enhancing the natural services provided by coastal ecosystems—including wetlands, dunes, barrier islands, seagrasses, coral and oyster reefs, and mangroves—that build climate resilience while providing key social and economic benefits. NBS can:

- Reduce risks from flooding, erosion, and sea level rise. Existing coastal ecosystems protect people and properties most exposed to storms and reduce the risk of coastal climate impacts along U.S. coastlines by 50%. Coral reefs can buffer wave energy by 97%, cutting annual flood damage costs by nearly half, while wetlands and seagrasses trap sediments and build soils, protecting against erosion and preventing saltwater intrusion.
- Serve as cost-effective alternatives to concrete seawalls and jetties often used to protect shorelines. Nature-based infrastructure can be 50% cheaper than gray infrastructure, while providing 28% more value. As well as lower initial costs, NBS are often cheaper to maintain than these hardened structures and can increase climate resiliency.
- Support ecosystem services by maintaining critical habitat for economically and ecologically important fish and marine plants, improving water quality through groundwater filtration, reducing surface water runoff, and enhancing carbon sequestration. For example, a seagrass restoration project in Virginia was found to increase local fish populations by over sixfold.³
- Create economic activity and generate jobs in aquaculture, landscaping, restoration and maintenance, and outdoor recreation and tourism, as well as boost related industries like food and hospitality. For example, in the Florida Keys National Marine Sanctuary, tourism associated with mangroves and seagrass contributed \$4.4 billion to the state's economy annually in 2019. While marshes and living shorelines in Virginia generate over \$6.4 million from recreational fishing each year.

Cover: *Habitat panels installed along an urban shoreline mimic natural features, supporting marine life.*

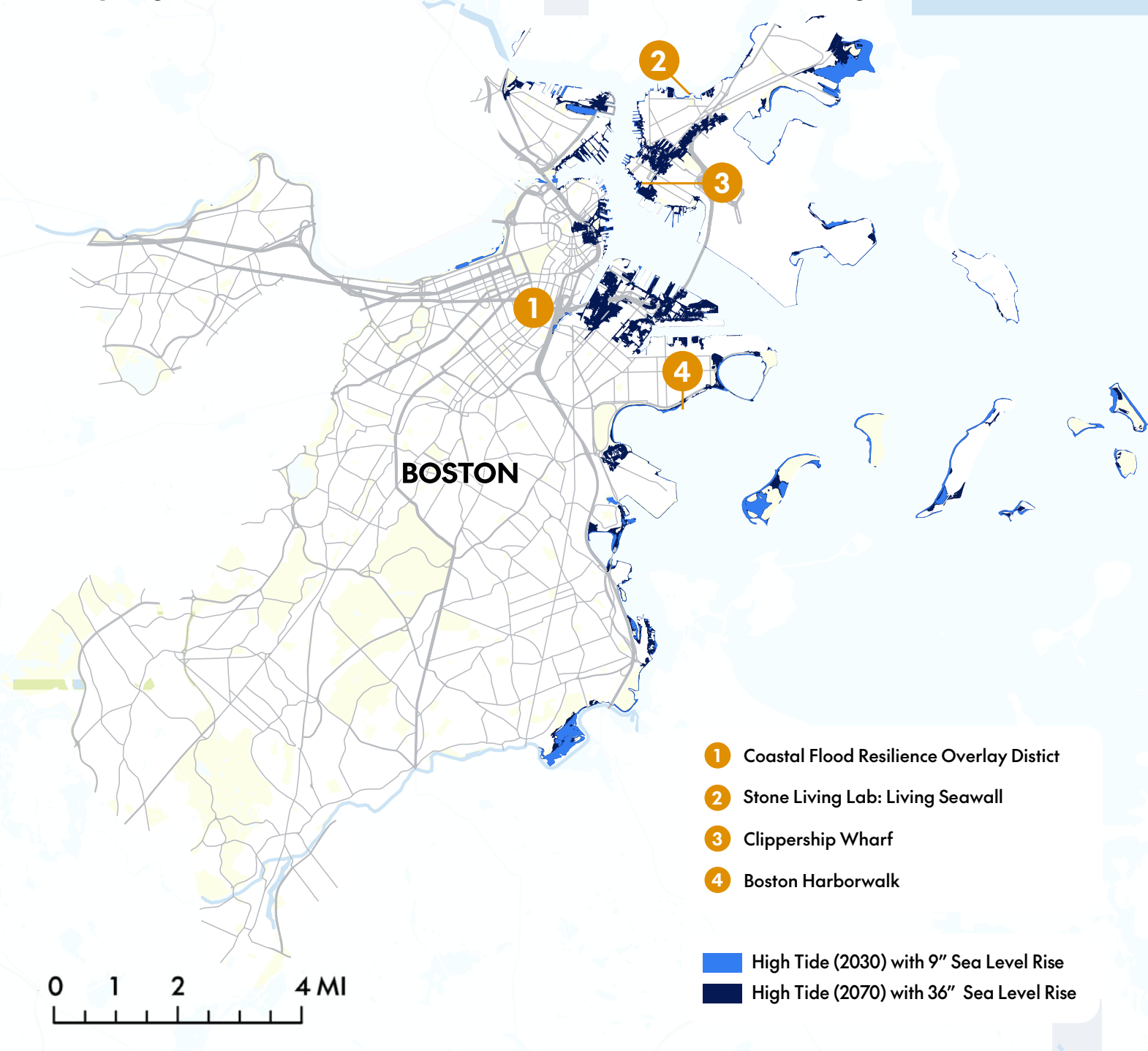
Photo © Living Seawalls

1 Nature-based solutions are projects that use nature—conservation, restoration and sustainable management of ecosystems—to help people adapt to climate change. NBS approaches include the restoration of floodplains and wetlands and the protection of natural infrastructure, such as barrier beaches, mangroves, coral reefs, or oyster beds, to shield communities from sea level rise, and lessen storm and wave impacts.

2 NBS implementers in this memo refers to entities, including public and private developers, that apply for permits for NBS approaches and build projects that include NBS.

3 Ecosystem services are the benefits people obtain from ecosystems. These include provisioning services such as food and water; regulating services such as regulation of floods, drought, land degradation, and disease; supporting services such as soil formation and nutrient cycling; and cultural services such as recreational, spiritual, religious and other nonmaterial benefits.

Adapting Boston's Coastline: Nature-Based Solutions for a Rising Tide



As sea levels rise, Boston's high tides reach further inland, putting the city's bustling downtown and waterfront at risk of severe flooding. In response, public and private actors have adopted nature-based approaches to development. Improvements to Boston Harborwalk and spaces such as the Clippership Wharf integrate natural defenses to flooding like living shorelines and rain gardens. Meanwhile, planning policies like the Coastal Flood Resilience Overlay District guide development away from flood-vulnerable areas and promote green infrastructure.

Map Data: 9" Sea Level Rise High Tide Scenario: [Boston Maps](#), 36" Sea Level Rise High Tide Scenario: [Boston Maps](#), Hydrography: [MassDEP](#), Municipal Boundaries: [Boston Maps](#), Open Space: [MassGIS](#), Roads: [MassDOT](#).

Nature-Based Solutions in Boston

Boston serves as a strong case study for understanding the opportunities and barriers to implementing NBS projects. Coastal adaptation is critical in Boston—the city, with a population of over 600,000, can expect nine inches of sea level rise by 2030 relative to the 2000 base year, and up to three feet by the 2070s. Currently, Boston experiences more sunny-day flooding from high tides than any other city in the Northeast. Boston’s coastal neighborhoods are increasingly at risk, particularly because one sixth of the city was built on filled land and 30% lies within eight feet of today’s high tide. As tideland was filled, salt marsh and oyster beds were removed or degraded, also eliminating their ability to buffer the city from storms and erosion.

In the face of these climate risks, Boston has emerged as a leader in coastal resilience, integrating nature-based approaches in a variety of impactful initiatives:

- Boston’s Harborwalk, established in 1984, creates extensive waterfront access. This network of waterfront paths and parks spans over 40 miles, incorporating nearly all of Boston’s shoreline across public and private property. Efforts are underway to further prepare the walkway for climate change while supporting healthy coastal ecosystems, including living shorelines and climate-resilient parks.
- Coastal resilience planning figures into a comprehensive strategy for the city’s 47-mile shoreline. In 2016, the City launched the Climate Ready Boston initiative to guide projects that address coastal and inland flooding, along with Coastal Resilience Solutions plans for each of Boston’s five coastal neighborhoods. These plans, created with engagement from communities, highlight the importance of utilizing shore-based solutions along the Harborwalk, restoring salt marshes, enhancing dune ecosystems, and implementing living shorelines to protect the city.
- Zoning and design guidelines account for sea level rise and encourage nature-based approaches. To ensure new buildings can withstand future storm events, Boston created a Coastal Flood Resilience Overlay District for areas projected to be at risk of flooding by 2070. Projects in this zone are subject to the city’s Coastal Flood Resilience Design Guidelines, which promote district-scale resilience strategies like preserving open space along the waterfront and creating vegetated levee systems.
- Private development is actively contributing to coastal resilience. The Clippership Wharf project, for example, is a mixed-use development project that integrates ecosystem restoration and resilience to sea level rise by incorporating wetland restoration, rain gardens, bioswales, and a living shoreline that allows natural tidal flow.

Despite progress in the city, gaps remain in implementing NBS for climate resilience. While Boston’s history and coastal ecosystems are unique in many respects, the challenges that public and private implementers face in implementing NBS are shared by many coastal communities.

Barriers to NBS

Across the country, complex permitting processes, outdated regulations, and research gaps remain significant barriers for implementers to include NBS in projects. Current environmental and regulatory policies, originally designed to prevent harmful development, are largely inflexible, are not prepared to confront the compounding challenges of the climate crisis, and have not adapted to account for changing coastal conditions or the needs of resilience and restoration projects. Furthermore, municipal engineers can be wary of NBS due to perceived uncertainty regarding performance compared to gray infrastructure. Similarly, finance professionals are typically more comfortable underwriting gray infrastructure than NBS projects, which can have greater maintenance and operational requirements (although they are often less capital intensive).

NBS projects in Boston and other coastal cities are currently facing the following major barriers:

Permitting

Permitting is a significant challenge for NBS projects, adding time, cost, and complexity. Coastal NBS projects often require construction in the water across multiple jurisdictional boundaries, triggering regulatory oversight from federal, state, and local agencies. Moving

sediment in tidal waters, for example, falls under the Clean Water Act and requires approval from federal agencies such as the Army Corps of Engineers, the Environmental Protection Agency, the National Marine Fisheries Service, the U.S. Fish and Wildlife Service, in addition to state agencies under the Massachusetts Wetlands Protection Act.

The involvement of multiple agencies, each with different requirements and timelines, makes the permitting process complicated and costly. Permitting NBS projects often takes years and the process demands specialized knowledge of site-specific regulations –often pertaining to different aspects of the project including wetland regulations, development permitting, coastal zone management, and others–increasing costs for implementers. Adding to the complexity, development projects that incorporate NBS often require separate permits for both coastal resilience activities and construction, discouraging the use of NBS and diverting funds that could otherwise support resilience efforts. This regulatory complexity puts NBS projects at a disadvantage compared to traditional hard structures like sea walls, which are easier to build above the jurisdictional boundary without requiring additional federal review.

Limits on fill and NBS

Projects that discharge dredged or fill material into waters and wetlands require water quality permits from both the Army Corps of Engineers and the Massachusetts Department of Environmental Protection. Under the Massachusetts Public Waterfront Act, broad limits on fill create significant restrictions on NBS. While these regulations were originally designed to protect the public by preventing harmful development, in the case of coastal adaptation projects like living shorelines or cobble berms, the movement of sediment can be necessary to raise elevation and support nature-based elements such as tidal plants.

Inter-agency coordination

Coastal NBS projects require approval from multiple agencies, but communication and alignment between them are often lacking. Inadequate coordination between agencies can lead to inconsistent interpretation and application of regulations. As a result, NBS implementers must invest significant resources into navigating the varied timelines and requirements of each agency, particularly when those requirements conflict.

Within agencies, regulatory and coastal resilience staff are frequently siloed. The novelty of some NBS approaches, compared to traditional gray infrastructure, adds to the lack of consistency and familiarity in the permitting process, further complicating project development.

Research needs

Despite increased investment and awareness of the benefits of NBS, significant research gaps remain regarding the long-term performance and cost-effectiveness of various techniques in local environments. Gaps in site-specific research on NBS techniques can hinder their adoption and long-term success.

Pilot projects play a crucial role in addressing these gaps. However, opportunities to test and refine NBS techniques are constrained by permitting processes. NBS pilot projects are often subject to the same rigorous permitting requirements as larger-scale development, making it challenging to test new techniques or adapt them over time based on how they perform in the environment. The current system remains focused on traditional flood prevention techniques, and there is a shortage of site-specific examples that demonstrate the performance of NBS. This lack of flexibility limits the ability to learn from pilot projects and gather the data needed to build confidence in NBS within the regulatory system.



Clippership Wharf. Photo © Ed Wonsek

Recommendations

By leveraging policy and regulatory tools, the City of Boston and the Commonwealth of Massachusetts can accelerate the implementation of NBS while serving as a model for other coastal cities. The following recommendations serve not only to strengthen Boston’s climate resilience, but also offer replicable approaches that other coastal cities and states can enact to increase the use of NBS nationwide.

1 Issue efficient approvals

State regulatory agencies should create a consolidated, efficient process for NBS projects and ensure permitting is completed in a timely and cost-effective way.

To address permitting challenges, states should create a separate permitting pathway for NBS projects that improve coastal restoration and resilience. Developing dedicated approvals processes for these projects would shorten permitting timelines, lower costs, and promote better coastal resilience outcomes.

There are a few initiatives at the state and federal levels that aim to simplify the permitting process for NBS projects and could serve as valuable models. Florida’s Living Shoreline Permit Exemption removes the burden of a lengthy regulatory process for small-scale living shoreline projects and California’s Habitat Restoration and Enhancement Act expedites permits for voluntary small-scale habitat restoration efforts. At the federal level, the Army Corps of Engineers created a permit specifically for living shorelines, streamlining the review process. Meanwhile, the proposed

AQUAA Act recommends implementing a unified application process for permitting aquaculture farms, creating collaboration across federal agencies, with each agency designating specialized aquaculture staff.

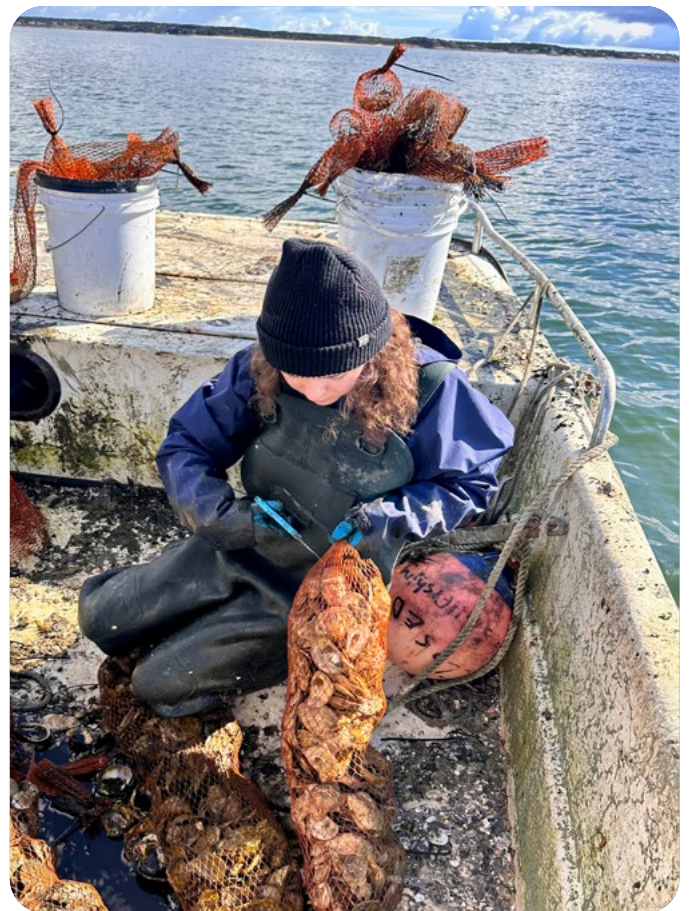


Photo © Massachusetts Oyster Project

2 Dedicate staff and capacity to improve coordination

Local and state regulatory agencies involved with permitting in coastal areas should hire climate resilience specialists who can work closely with implementers throughout the NBS project planning process. These staff should answer permitting questions and identify projects suited for an expedited regulatory process. With dedicated staff, agencies can also improve inter-agency coordination, ensuring NBS projects receive the necessary support and guidance to navigate regulatory requirements efficiently.

These specialists should also play a role in updating regulations to better accommodate NBS projects. Their expertise would help bridge the knowledge gap between traditional regulatory frameworks and innovative coastal resilience approaches, reduce uncertainties in the permitting process, resolve inconsistencies in agency processes, and encourage more implementers to pursue NBS.

On the first full day of her administration, Massachusetts Governor Maura Healey signed an Executive Order establishing the position of Climate Chief and creating an Office of Climate Innovation and Resilience within the Governor's Office. Melissa Hoffer was appointed as Massachusetts' first Climate Chief. Massachusetts is the first state in the nation to establish such a position at the cabinet level. The City of Boston has also made strides toward increasing coordination

by hiring its first Chief Climate Officer, who will oversee climate adaptation and resilience efforts across city departments, and launched its Office of Climate Resilience, which is leading resilience implementation along the Boston waterfront. Building on this leadership, Massachusetts could take additional steps to enhance coordination at the state level, by designating a single state agency to coordinate and review NBS applications; improving communication systems between local and federal permitting agencies to better understand overlapping or divergent requirements; creating a joint agency permit review team; and developing state-specific permitting portals, similar to the Alaska Aquaculture Permitting portal.

Initiatives like the San Francisco Bay Restoration Regulatory Integration Team (BRRIT), comprised of representatives from multiple federal and state agencies, demonstrates how aligning agencies during the application phase can lead to more efficient and cohesive project approvals. In the first five years of the initiative, San Francisco's BRRIT created three new permitting tools for restoration efforts and permitted 10 projects that, once constructed, will restore or enhance 3,500 acres of tidal habitat and provide increased sea level rise resiliency. Notably, for the first 10 projects, BRRIT representatives met all their agency-specific timelines for permits and consultations and issued all permits in time to meet construction schedules.

3 Update regulations

Coastal cities, states, and the federal government should update regulations to encourage regionally appropriate and specific NBS projects, such as wetland protection, living seawalls, artificial tidepool installation, and other activities with long-term ecological and climate resiliency benefits to be more easily implemented than traditional gray infrastructure. Restoration practitioners, coastal developers, and permitting agencies should collaborate to identify appropriate NBS subject to unnecessary regulatory barriers, such as Massachusetts' shellfish planting regulations that effectively prohibit oyster restoration in Boston Harbor. Regulating agencies and governments should change policies to ensure NBS can be used to maximize ecosystem benefits while addressing public health, navigation, and other concerns.

In Massachusetts, the Commonwealth has launched its ResilientCoasts Initiative to update regulations, establish protections

for areas most vulnerable to climate change impacts, and implement incentives for NBS. A Massachusetts proposed bill would also create a program to encourage improved understanding and expand construction of NBS projects by shortening permitting timelines for NBS research and demonstration projects that provide ecosystem benefits.

Other states have implemented successful programs that allow for and encourage oyster restoration projects for their climate resilience benefits. Georgia supports the restoration of oyster reefs in historically overharvested waters through the Generating Enhanced Oyster Reefs in Georgia's Inshore Areas program. New York City's Billion Oyster Project has successfully restored millions of oysters to New York Harbor, adding natural water filtration across five boroughs, providing habitat for hundreds of species, and demonstrating the viability of oyster restoration even in high-use environments.



A living sea wall is installed at Condor Street Urban Wild in East Boston. Photo © Sindayiganza Photography

The Unique Benefits of Oysters

In recent decades, there have been significant efforts to reverse the global decline of oysters, whose populations have declined by 85%, through oyster reef restoration. Initiatives are underway around the world—from the Chesapeake Bay in the U.S. to the Solent in the U.K. and New South Wales in Australia.

Oysters are a cornerstone of coastal ecosystems and fisheries, providing structural protection to the coast as well as improving water quality. Oyster reefs reduce wave energy, preventing flooding and reducing shoreline erosion by up to 54%. A single oyster can filter up to 50 gallons of water each day, which also boosts local biodiversity, and mitigates algal blooms, dead zones, and local ocean acidification. Oysters are also adaptive to environmental changes. For instance, oyster reefs can recover quickly from major storm events and grow vertically at a rate faster than sea level rise. Artificial structures, in contrast, must be rebuilt, upgraded, and maintained in response to a changing climate.

Oysters were once plentiful in the waters around Boston, but by the early 20th century, over-harvesting, industrialization and landfill decimated populations. The Massachusetts Oyster Project is working to restore native populations through oyster cultivation, shell recycling, and education. After working with the state government to find areas suitable for reintroduction, they have released over 200,000 oysters and currently maintain seven upwellers, a device used to grow young oysters in a protected environment, across Massachusetts. These oysters are not harvested

for food, but instead demonstrate the viability and benefits of restoring shellfish populations around Boston.

However, oyster restoration faces significant constraints due to strict permitting requirements. In Massachusetts, an aquaculture permit is required to release oysters, and these permits are only issued for clean, harvestable waters. Following decades of remediation, Boston Harbor is now much cleaner than it was 50 years ago. However, it remains closed to oyster restoration due to public health concerns of illegal oyster harvesting from potentially contaminated waters. As a result, Boston, and other areas across the state where restoration could be beneficial, are left out of these efforts.



Oyster seed grown for restoration projects in Massachusetts. Photo © Massachusetts Oyster Project

4 Invest in monitoring

Monitoring and evaluating the progress of NBS projects is crucial for shaping a comprehensive coastal resilience strategy. Establishing a public tracking system will allow practitioners and regulators to document and share successful practices, identify and address barriers, and plan future initiatives. Collecting and analyzing data on various aspects of NBS projects—such as ecological outcomes, community impact, and cost-effectiveness—ensures that initiatives are achieving their intended goals.

In parallel, research and pilot projects provide critical site-specific data to improve NBS design and efficacy. Boston's Stone Living Lab— a partnership between a non-profit, a research university, an Indigenous tribe, and federal, state, and local government—is leading efforts to test, monitor, and refine NBS strategies through real-world applications, generating valuable insights for Boston and other coastal cities.

Key projects include:

→ **Real Time Monitoring in Boston Harbor:**

Stone Living Lab maintains a network of flood sensors, tide gauges, and weather stations in and around Boston Harbor, offering a continuous stream of information on water levels, wave conditions, storm events, and climate change impacts. This information will help the City of Boston anticipate and plan for the impacts of climate change and sea level rise on their beaches and coastal habitats.

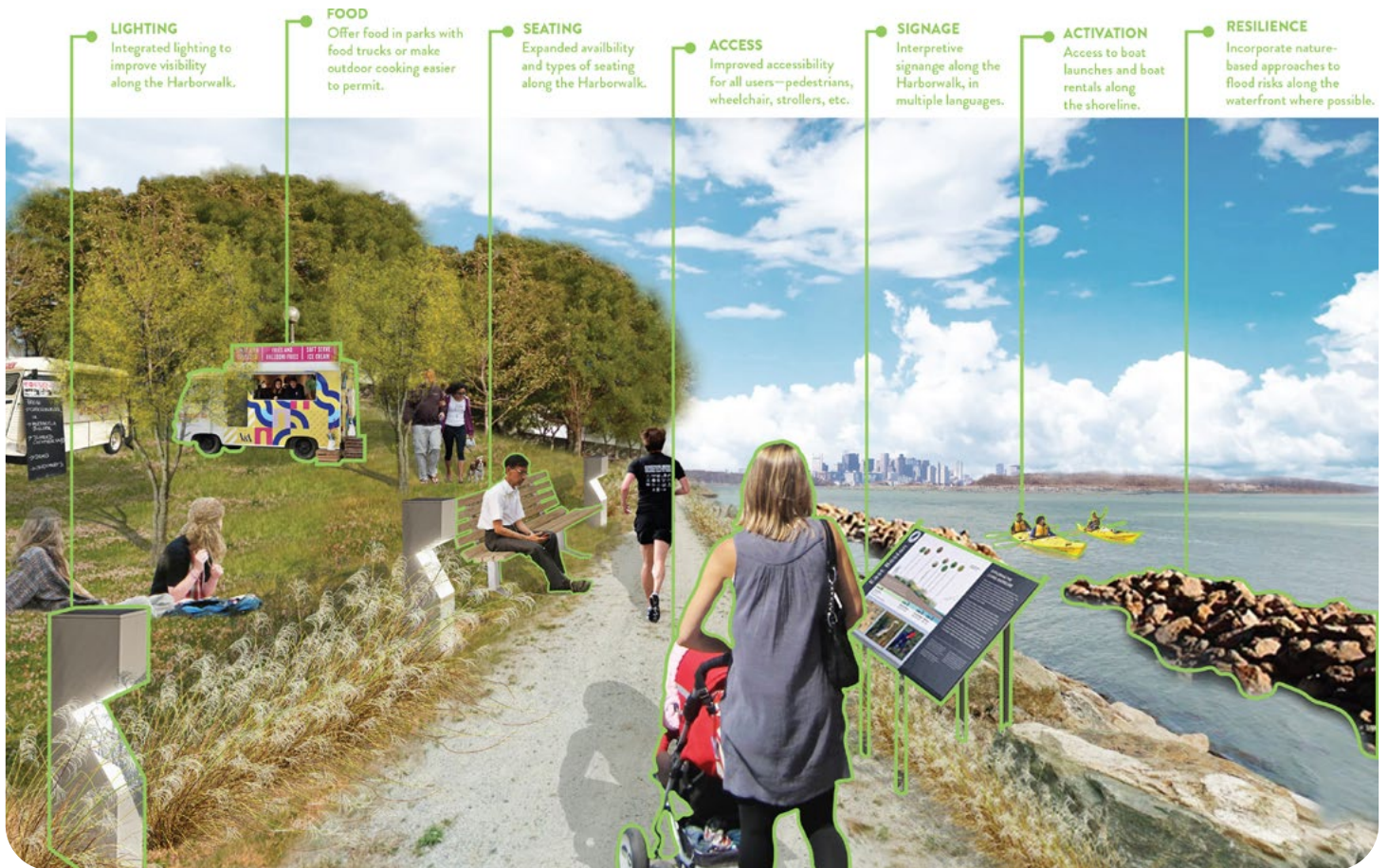
→ **Research and Education on Cobble**

Berms: In 2023, Stone Living Lab launched an initiative to assess the performance of cobble berms across Massachusetts. The project also created an educational platform for local stakeholders, offering insights into monitoring techniques, maintenance requirements, and permitting processes for this type of project. Demonstration and pilot projects play a vital role in knowledge sharing and collaboration among coastal practitioners and regulators. These initiatives enable cities to identify effective design strategies, refine successful approaches, develop management models, and translate local successes into policy.

→ **Installing Living Seawalls:** As of 2024, Stone Living Lab has installed two living seawalls in Boston Harbor, designed to create hotspots for biodiversity, education, and research. Site-specific research can help practitioners design NBS projects tailored to specific local needs, such as dissipating wave energy or trapping sediment; documenting the effectiveness of projects during storm events; and understanding the social and ecological benefits of the approach.

Conclusion

Nature-based solutions provide vital benefits for coastal cities. Despite the success of many NBS projects, current regulations still favor hardened, gray infrastructure. To better safeguard coastal communities, it is critical that more coastal cities follow Boston's lead in exploring and implementing numerous available NBS opportunities. Resolving governance challenges, particularly in streamlining the permitting process, should be a top priority to ensure these solutions are implemented efficiently and at scale.



Boston's waterfront—especially in East Boston and Dorchester—offers space to model nature-based solutions such as living breakwaters and vegetated berms, while also integrating elevated paths and shaded gathering spots. Image created by Rocio Alonoso for Boston Harbor Now.

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