PROPOSALS FOR AQUATIC HABITAT RESTORATION & COMMUNITY ENGAGEMENT

AT WAGNER PARK AND PIER A COVE

JUNE 4, 2020

Hudson River Foundation /
NY-NJ Harbor & Estuary Program

Consultant to Nautilus International
Development Consulting, Inc.

NEW YORK STATE OF OPPORTUNITY. | Battery Park City Authority | AECOM | Nautilus | HUDSON RIVER FOUNDATION | NY/NJ HARBOR & ESTUARY PROGRAM

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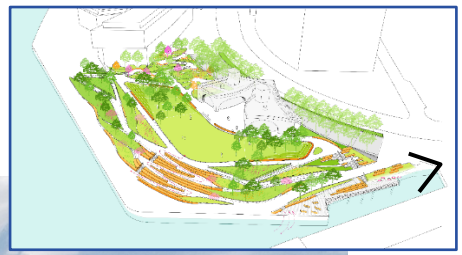
EXECUTIVE SUMMARY

These proposals for aquatic habitat restoration and community engagement at Wagner Park and Pier A Cove are based on discussions between the Battery Park City Authority, the AECOM design team for the South Battery Park City Resiliency Project, and a scientific Aquatic Ecology Advisory Group led by the NY-NJ Harbor & Estuary Program/Hudson River Foundation and managed by Nautilus International Development Consulting, Inc. For each of the six aquatic habitat types, the report describes their existing conditions, conservation and restoration goals, ecological reference sites, preferred and potential options, and monitoring methods. It also identifies opportunities for enhancing community engagement through formal and passive educational programs.

Proposed Design of Pier A Cove, Overlook and Esplanade. (Inset) Overview Showing Vantage Point. (Source: AECOM, January 15, 2020)

The Hudson-Raritan Estuary, where the Atlantic Ocean's salt water mixes with fresh river water flowing from the watershed, harbors an abundant diversity of life. Of the more than 200 species of fish, some of the best known are striped bass, bluefish and giant sturgeon. Feasting on that bounty are many birds, like eagles, osprey and herons. Blue crabs and a variety of shellfish abound along its shorelines.



The Estuary's location, right at the heart of the nation's largest metropolitan area, poses significant challenges to this complex ecosystem. The past half century has seen concerted bistate efforts to improve water quality and significant progress in restoring its health. Today there is a comprehensive plan for ongoing restoration of the Estuary. Battery Park City (BPC), located right at the confluence of the Upper New York Bay and mouth of the Hudson River, has an opportunity to play a significant role in the Estuary's environmental recovery.

The shorelines surrounding Wagner Park, like many others in the Estuary, have had their ecological value compromised by engineered structures and landfill. However, the massive tidal flux in this area can help support high densities and a rich diversity of organisms, particularly when vegetated. These littoral zones provide opportunities to support populations of

small fish and crustaceans, and critical nursery habitat for transient species. Meanwhile, larger fish enjoy adjacent deeper water habitat where they feed on invertebrates and small fishes carried outward by tidal currents.

Restoring ecological functions in urban areas is still an evolving field, made more compelling by the coastal effects of climate change. Battery Park City Authority (BPCA) can contribute to expanding this knowledge base by advancing pilot projects based on best available science with defined monitoring plans.

Some of those pilot projects might include:

- **Ledges & Tidepools** - Rebuilding the riprap slope near Pier A to include a series of ledges and tidepools to increase complexity and provide additional intertidal habitat.
- **Coastal Vegetation** - Planting high marsh wetland species and/or coastal shrubs above the riprap ledges to increase the abundance of fish, birds and other species.
- **Artificial Reefs** - Creating artificial reefs at the entrance to Pier A cove and outside the seawall to provide surfaces attractive to oysters and other invertebrates and reduce wave energy to encourage shallow water habitat for spawning areas, nursery zones and refuge for juvenile and small fish.
- **Oyster and Shellfish Restoration** - Working with Billion Oyster Project to add additional Oyster Research Stations with small cages. Explore options for adding ecologically beneficial surfaces to enhance growth of shellfish, including wrapping the wooden piles at Pier A with ECOncrete or similar material and placing u-shaped oyster gabions at the base of the concrete piles under the BPC Esplanade.
- **Riparian Zone** - Planting the upland areas of Wagner Park using a palette of native coastal meadows, coastal shrubs and maritime forests to increase the habitat for birds and pollinators and support a functional riparian zone.

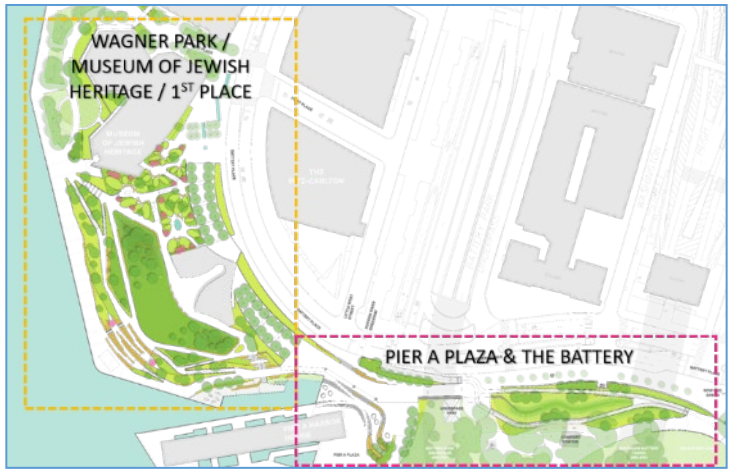
Wagner Park offers numerous opportunities for engaging Battery Park City's community and visitors in a range of active learning experiences about its aquatic habitats, the progress of these pilot projects and other BPCA work to address climate change, as well as for passive unstructured exploration of estuary ecology.

To move forward, BPCA should consider how to incorporate these pilots and proposals into the design of the South Battery Park City Resiliency Project, initiate preliminary discussion with both regulatory authorities and potential partners, and begin follow-up studies and assessments of current baseline conditions.

A. BACKGROUND & INTRODUCTION

All across the Hudson River Estuary, communities and landowners are developing coastal resiliency plans and advancing capital projects to address sea level rise and the growing risk of coastal flooding. With the states of New York and New Jersey anticipating an increase of one to two feet in the mean high tide by 2050, the risk of regular tidal and storm-based flooding will increase dramatically. For many of these stakeholders, the damage wrought by Hurricane Sandy is a fresh memory.

These coastal resiliency projects present an opportunity to enhance the ecological performance of shorelines and shallow waters, a Target Ecosystem Characteristic (TEC) of the Hudson Raritan Estuary Comprehensive Restoration Plan and the Action Agenda of the NY-NJ Harbor & Estuary Program. By offering new opportunities for estuary education and community engagement, these projects can also improve the quality of public access.



The advancement of such natural and nature-based resiliency features, and the opportunity to realize valuable co-benefits in an integrated and cost-effective manner, should be an important consideration for permitting of proposed shoreline projects throughout the region.

The Battery Park City Authority (BPCA) in Lower Manhattan is currently advancing many such projects along their shoreline. The projects are divided into a series of phases all along their property. The shoreline adjacent to Wagner Park, including in and around Pier A cove, is part of one of these phases and lies within the South Battery Park City Resiliency Project.

The NY-NJ Harbor & Estuary Program (HEP), the federal bistate collaboration managed at the Hudson River Foundation (HRF), was asked by Nautilus International Development Consulting, Inc. to help them consider how best to conserve and enhance the ecological function of shallow water, intertidal and adjacent upland habitat and provide opportunities for related environmental programs and community engagement. Nautilus is a member of the AECOM team serving as consultants to BPCA for the South Battery Park City Resiliency Project. The possible conservation and restoration work is intended to complement BPCA's proposal to build an integrated flood risk reduction system, not necessarily to provide any direct flood protection.

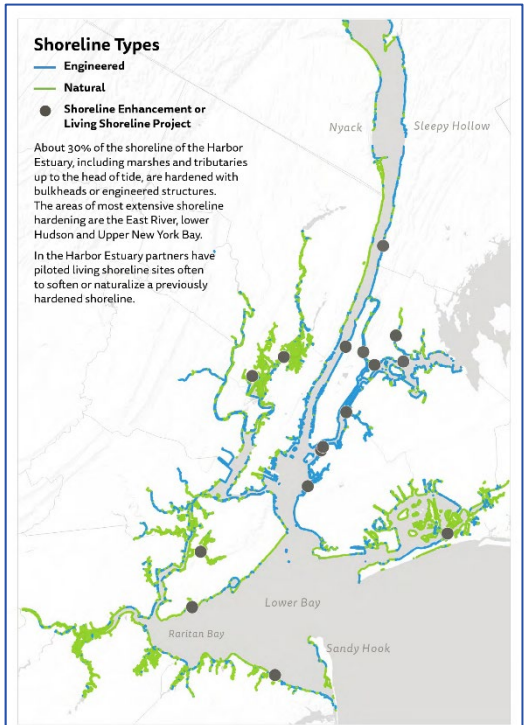
Hudson Raritan Estuary Comprehensive Restoration Plan [www.hudsonriver.org/article/hrecrp]

Action Agenda of the NY-NJ Harbor & Estuary Program [www.hudsonriver.org/NYNJHEP ActionAgenda.pdf]

Upper right: Overall South Battery Park City Resiliency Site (Source: AECOM, 2019)

Lower left: Battery Park City Resiliency Projects (Source: AECOM, January 15, 2020)

A. BACKGROUND & INTRODUCTION



Natural and Engineered Shorelines in the Harbor Estuary (Source: NYNJHEP)

Site Walk, January 30, 2020 (Source: Nautilus International)

HEP was specifically tasked with developing initial conceptual proposals as well as making recommendations for assessing current site conditions, monitoring the outcomes over time, and engaging the public in estuarine restoration.

The expectation is that the AECOM team will refine and incorporate these proposals into their design and construction plans for BPCA's South Battery Park City Resiliency Project, and the work will be advanced as the project moves forward over the next several years. This report will be shared with HEP's partners, notably the public and private sector experts in its Restoration Work Group, one of the collaborative committees formed under the auspices of HEP.

To launch this process, HEP and Nautilus hosted a site walk and information exchange on January 30, 2020 and online workshops on March 18 and April 8, 2020. Leading scientific experts in fisheries, benthic and wetland ecology; oyster / shellfish restoration; and community education / engagement were invited to join BPCA and the AECOM team to identify opportunities, discuss challenges and consider options. The list of participants is included in Acknowledgements.

The goals for these workshops and this report are to:

- Identify opportunities and challenges for conserving and enhancing the ecological value of the shallows and shoreline adjacent to Wagner Park, including in and around Pier A cove.
- Develop concepts and preliminary proposals for assessing Ensure best available science is brought to bear on this issue.

Based on the workshop discussions and additional research, the HEP team developed a series of conceptual proposals. These are organized by six habitat types: Riprap / Sloped Shoreline, Subtidal & Intertidal, Shallow Water, Piles & Platforms, Seawall, and Upland Vegetation.

Recommendations for community engagement practices are also included. Next steps in terms of additional engineering work, preliminary discussions with regulatory authorities, and baseline monitoring are identified.

These proposals will assist BPCA and the AECOM team in preparing their work for certification under the Waterfront Edge Design Guidelines (WEDG®), a voluntary rating system administered by Waterfront Alliance. Some considerations for that process are also included.

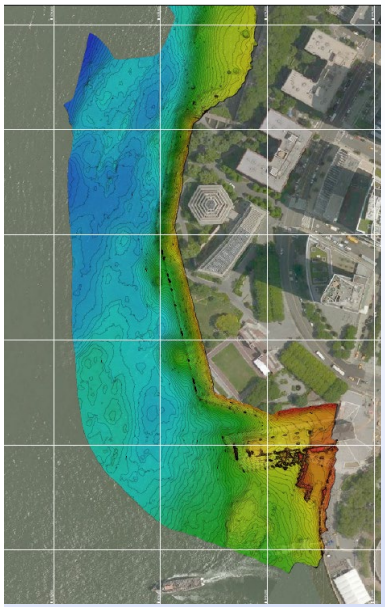
Restoring Shallows & Shorelines in the Hudson River Estuary

The shoreline and adjacent shallow waters of the Hudson River and its Estuary are a critical habitat resource, identified as a Target Ecosystem Characteristic in Hudson Raritan Estuary Comprehensive Restoration Plan and the Action Agenda of the NY-NJ Harbor & Estuary Program. Their ecological value is compromised as they have been extensively modified for a variety of uses. Fill has replaced shoals and other shallow water habitat. About 30% of the shoreline of the Estuary north to the Mario Cuomo (Tappan Zee) Bridge, including marshes and tributaries up to the head of tide, is hardened with bulkheads or engineered structures.

Advancing conservation and connectivity of these habitats is of critical concern. Shallow and shoreline habitat is defined in the Comprehensive Restoration Plan as the near-shore waters less than 13 feet deep, intertidal areas regularly inundated during high tides, and the riparian zones that experience occasional flooding. The tidal flux helps support high densities and a rich diversity of organisms, particularly when vegetated. Due to high densities of invertebrates, slower current velocities and available refuge, shallow and shoreline habitat supports resident populations of small fish and crustaceans, and provides critical nursery habitat areas for transient species. Larger fish enjoy adjacent deeper water habitat where they feed on invertebrates and small fishes carried outward by tidal currents.

While there is broad general agreement as to the value of shorelines and shallow waters, better understanding of ecological function in urbanized locations and the study of how to enhance that value is an evolving field.

A. BACKGROUND & INTRODUCTION



Bathymetric Survey (Source: Rogers Surveying, PLLC, September 10, 2019)

The imperative to adapt shorelines for sea level rise and the projected increases in severity and frequency of coastal flooding are making this issue especially timely. Advancing pilot projects that are based on best available science with a defined monitoring plan will help current and future applicants and regulators to be more effective in meeting permit requirements for modifying shorelines and building piers and other maritime infrastructure.

Clarifying how best to provide ecological uplift through restoration has been a focus of the Hudson River Foundation. This includes a series of Hudson River Fund grants to Drs. Kenneth W. Able and Thomas M. Grothues to develop and test new methodologies to assess the impacts of piers, pilings, and other maritime infrastructure on the fishes of the Hudson River. HEP developed and funded an effort with its partners led by Columbia University to establish a standardized and ecologically meaningful assessment of the relative habitat values of urban shorelines varying in physical habitat complexity across New York – New Jersey Harbor in 2015.

Working with a large team of researchers, HEP compiled a standard set of metrics and monitoring protocols for shorelines across New York State, advancing best practices for measuring ecological, social, and structural benefits. Staff have also been active participants in developing and undertaking restoration and monitoring projects for shallow water and shoreline habitats, including numerous oyster restoration efforts and advancing the Estuarine Sanctuary Management Plan for Hudson River Park.

Context for the Project

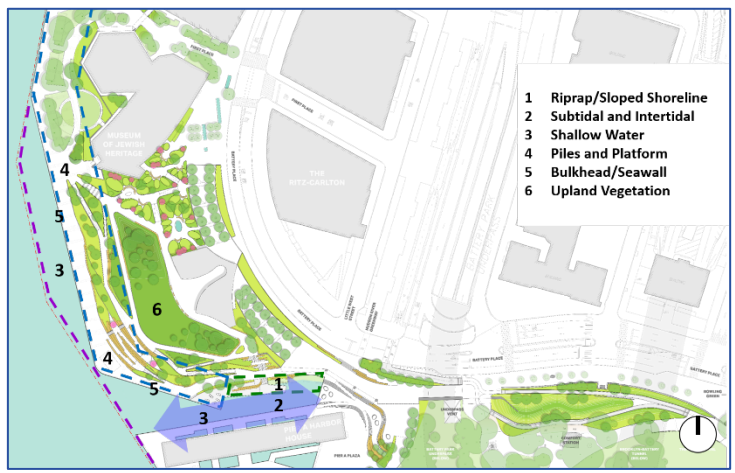
Across the estuary, communities and responsible landowners are evaluating options and taking steps to address risk from coastal flooding and anticipated sea level rise. This imperative to address these dangers was brought into sharp focus by Superstorm Sandy in 2012. During Sandy, coastal surge inundated Lower Manhattan on its western side through low elevation points such as Pier A, impacting some of Lower Manhattan's critical and civic infrastructure. At Battery Park City itself, while the seawall was overtopped flooding parts of the Esplanade and some adjacent open spaces, the majority of the buildings were built at higher elevations and did not flood. According to *A Stronger, More Resilient New York*, the buildings at Battery Park City "for the most part emerged from Sandy unscathed" (page 374). Looking forward, however, BPCA has chosen to be proactive about projected increases in intensity and frequency of rainfall, coastal surge and sea level rise.

BPCA is currently developing plans for four interrelated resiliency projects to protect all of Battery Park City. Its work is being coordinated with other projects anticipated for Lower Manhattan. The South Battery Park City Resiliency Project consists of a continuous upland risk reduction system and associated improvements from the Museum of Jewish Heritage through Wagner Park, Pier A Plaza and Battery Place. As part of that work, BPCA is assessing possible aquatic habitat restoration and community engagement work In Wagner Park.

Conservation & Restoration of Wagner Park Shoreline and Pier A Cove

The study area includes the shoreline and adjacent shallow waters around Wagner Park and Pier A. The cove, created by the historic Pier A and the southern edge of the Battery Park City landfill, is a unique sheltered shallow water environment.

To help facilitate the consideration of some alternative concepts, the study area was divided into six habitat types: 1) Riprap / Sloped Shoreline, 2) Subtidal & Intertidal Vegetation, 3) Shallow Water, 4) Piles & Platforms, 5) Seawall, and 6) Upland Vegetation. Community engagement practices are also considered.

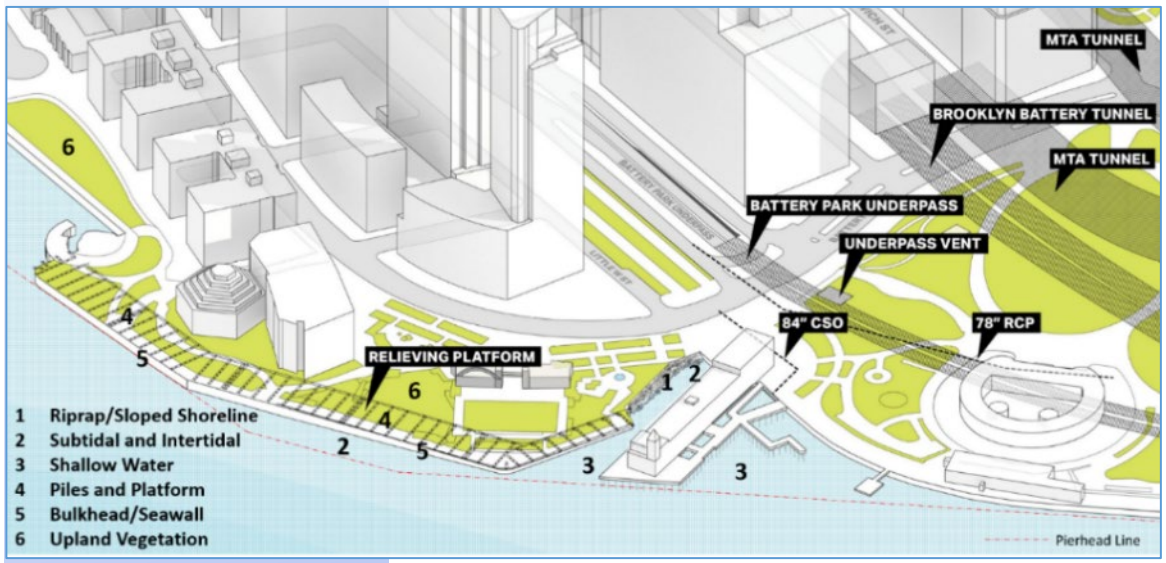


Right: Project Design with Aquatic Habitat Types (Source: AECOM and Nautilus International Development Consulting, Inc., 2019)

A. BACKGROUND & INTRODUCTION

For each habitat type, the following are identified and discussed:

- Existing Conditions;
- Restoration Techniques & Goals;
- Ecological Reference Sites;
- Preferred/Potential Options; and
- Monitoring Purpose & Proposed Techniques.



Existing Conditions with Aquatic Habitat Types (Source: AECOM and Nautilus International Development Consulting, Inc., 2019)

These parameters are also identified for community engagement. The habitat descriptions necessarily overlap but are presented in this format to facilitate integration into the project and increase the report's utility for other sites. The ecological reference sites cited include urbanized shorelines that have been modified to provide ecological value, or research studies that provide important data. As the project planning advances, additional sites that better provide a measure of natural site biodiversity, cover, and function should be identified to help determine which species are missing, allowing identification of areas for future improvement.

The monitoring section suggests some specific techniques that would be useful for documenting current conditions and helping ensure success at this and similar urban shorelines in the future. Enhancing ecological conditions in such environments is very much a learning process, and pilot projects being proposed for Wagner Park and Pier A cove are a critical part of that process. Toward that end, data collection should be done in conformance with the metrics and monitoring protocols proposed by New York State in the Measuring Success project advanced by the Department of State and NYSERDA *(Source: Measuring Success: Monitoring Natural and Nature-Based Shoreline Features in New York State,* Science and Resiliency Institute at Jamaica Bay*)*. If possible, baseline assessments should be done prior to demolition or pile maintenance work. Ideally these would extend for multiple seasons, especially for fish, in order to capture the presence of different species. Seasonal baselines for vegetation should be conducted for three seasons (spring, summer, and fall) or spring/late summer.

Given the scale of the site and current understanding of the potential ecological benefits, any of these possible interventions should be considered as pilot projects. For that reason, considerable attention is paid to the proposed monitoring methods as well as the potential for involving the public in this work.

B.1 RIPRAP/SLOPING HABITAT

Above: Pier A Cove - Existing conditions looking northeast (Source: NYNJHEP, 2019)

At right: Pier A Cove - Existing conditions looking west (Source: Nautilus International, August 2019)

NYC DEP Newtown Creek Nature Walk (Source: Newtown Creek Alliance)

Photos on right:

Near right: Roberto Clemente State Park (Source: NYNJHEP)

Far right: Pier 35 Mussel Beach (Source: NYNJHEP)

Existing Conditions

An area of steeply sloping riprap revetment exists along the northwestern side of Pier A cove, consisting of stone blocks extending up from the shallow waters of the cove to the upland edge.

Goals

Maximize interstitial space of various sizes and add complexity; minimize slope; and provide structures, such as tide pools, that mimic natural habitat features to:

- Provide and improve habitat utilization (abundance, richness, composition) for fish, shellfish, crabs, birds and possibly seals; and
- Showcase key habitat types that are representative of a healthy estuary.

Ecological Reference Sites

Brooklyn Bridge Park, Pier 4

Roberto Clemente State Park Tide Pools

Randall's Island Park, Living Shoreline

Pier 35 Mussel Beach

Hudson River Park, Gansevoort Peninsula (in design)

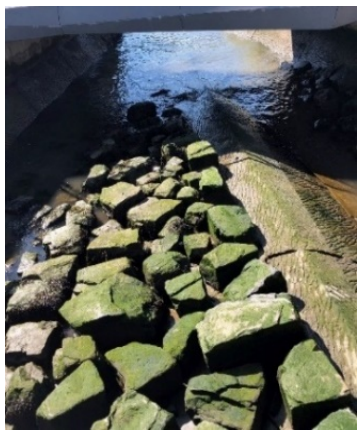
NYC DEP Newtown Creek Nature Walk

Preferred/Potential Option(s)

Rebuild Riprap Slope: Rebuild the riprap slope to include a series of ledges and tidepools to increase the physical complexity of the site and provide additional intertidal habitat. Modifying the revetment in this way would create beneficial shallow slopes while also providing the stability needed to contain the fill that underlies Wagner Park. While desirable in terms of potential habitat benefits, shallowing the angle of the riprap slope would require extending the riprap further into the Park, or preferably, shoaling the in-water slope in the cove.

The ledges should be a series of broad steps and include lips to slow drainage and allow tidewater to pool. It would be beneficial to cut channels into the ledge surfaces to add texture. These ledges should be at different elevations to zone them differently in terms of slope and tide; ideally there would be three staggered elevations in roughly 1 foot increments from -4 feet Mean High Water (MHW) to -1 foot (MHW). The ledges should be as big as possible.

Addition of ledges would slow down water, cut turbulence, allow warming and trap sediment that in turn would harbor invertebrate infauna as food. It is anticipated the additional structures will provide structure and cover to enhance fish usage. At the right elevation, structures could recruit sessile marine organisms (e.g., mussels) and flora. Together, we anticipate these enhancements will increase species diversity and provide a net ecological uplift to the Pier A inlet.



Three-dimensional applications will be better than two-dimensional for enhancing abundance and, perhaps more importantly, species diversity, by creating additional habitat complexity. Layers of stone would provide more complexity and prey refuges and small gabion structures with oyster shells could add visual/educational/research interest. Likewise, using rough-hewn stone and/or having the supplier carve "bird baths" at the top of the stones would also create texture. Two feet^3 boulders with "bird baths" of 1.5 feet diameter are being used by Hudson River Park at Pier 26.

B.1 RIPRAP/SLOPING HABITAT

Wrack in Pier A Cove (Source: Nautilus International, August, 2019)

Maximize Sunlight: Minimizing shading imposed by the proposed new overlook on this sloped intertidal habitat would be beneficial. Our understanding is that the deck will allow 50% of available light to pass through. Reducing the size of the overlook and/or adding open light wells would maximize the sunlight that reaches the water and sloped habitat.

Consider Maintenance: The proposed ledges may retain wrack, including floating trash and large debris deposited by the tides, so an important provision is safe access to the area for regular removal of this material and possibly ecological monitoring. Riprap at Hudson River Park is accessed via locked gates. At some locations adjoining shallow water, such as the currently configured north side of the Gansevoort Peninsula, the Hudson River Park Trust has allowed organized community shoreline cleanups, where volunteers are allowed on the riprap with protocols such as waivers, life vests and safety rules.

Rendering of Gansevoort Peninsula - view from NE looking down the Hudson River (Source: Hudson River Park Trust, 2019)

Monitoring

Purpose: Characterize the organisms that utilize the restoration structures with a focus on fish, sessile organisms and vegetation. The aim would be to quantitatively characterize communities focusing on habitat provision (estimated by biodiversity and cover), structural changes (e.g. sediment buildup) and resilience to boat wakes, tidal energy and storm events.

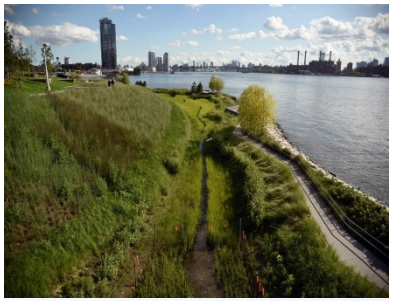
Techniques: Sampling for species coverage of quadrats along a transect perpendicular to the shore. Nearshore seining or trapping for fish biodiversity. Record observations of any other species utilization (e.g. marine mammals, birds or crustaceans) and for target species such as oysters, measure a subset for growth and density.

Metric: Taxonomic richness (at the species level when practical) and percent cover by the major taxa.

Frequency: Sampling should occur in spring, summer and fall. Throughout this period, sondes should be deployed to record water temperature, salinity, depth and dissolved oxygen, every thirty minutes.

Baseline Assessment: Same as seasonal monitoring.

B.2 SUBTIDAL & INTERTIDAL VEGETATION



Hunters Point South Park (Source: Nathan Kensinger)

Brooklyn Bridge Park (Source: NYNJHEP)

Rendering of Gansevoort Peninsula – North edge from Esplanade (Source: Hudson River Park Trust, 2019)

Existing Conditions

This habitat consists of vegetation within the near-shore waters less than 13 feet deep, as well as intertidal and riparian areas that are regularly inundated during high tides or seasonal flooding.

Goals

Create structures and planting areas that will enable the presence of key species, such as *Spartina alterniflora*, that will:

- Improve abundance, richness, composition of fish, birds and other species; and
- Showcase key habitat types that are representative of a healthy estuary.

Ecological Reference Sites

Pocket marshes:

Hunters Point South Park

Brooklyn Bridge Park, Pier 2

Hudson River Park, Gansevoort Peninsula (in design)

Subtidal:

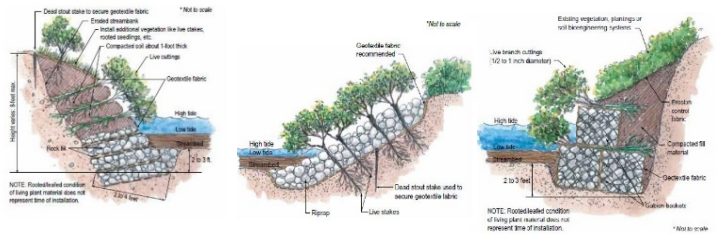
Bush Terminals Pier Park (Bart Chezar)

Jamaica Bay Floating Wetlands (NYCDEP and Biohabitats)

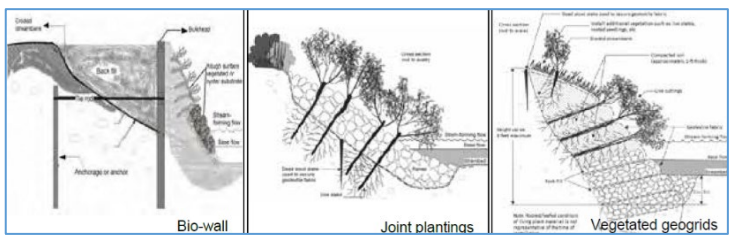
Preferred/Potential Option(s)

Plant High Marsh Grasses and Coastal Shrubs: Above the proposed riprap ledges, space should be allocated for planting high marsh wetland species and/or coastal shrubs. This could be achieved by creating structured planting beds and/or by planting in the joints between riprap blocks.

The focus should be on high marsh bushes, such as *Iva frutescens* and *Baccaris halimifolia*, or grasses, such as *Spartina patens* or *Distichlis spicata*. These should be located above the intertidal area and thus not subjected to tidal wave action and scour. However, the elevation of the planting of these species would have to be precise on such a steep slope; planting them too high, beyond regular tide inundation, would also lead to planting failure. The *Iva frutescens* could be planted in riprap above the high tide line, inundated only on very high tides and storm tides, where the water drains rather than pooling. Planting *Spartina alterniflora* would help green the cove itself but might be a bit more challenging. It could be attempted in pieces of coir logs wedged into the riprap at elevations where it is inundated twice a day.



The sample sections above show how vegetation could be designed into the intertidal shoreline. Examples from Scenic Hudson include vegetated geogrids, joint planting and rock gabions, and were based on an analysis of Hudson River shoreline stabilization by the NYSDEC Hudson River Estuary Program *(Image Source: Revitalizing Hudson Riverfronts, Scenic Hudson).* The sections below from Arcadis include joint plantings and vegetated geogrids and were done as part of a study on green infrastructure for New York City *(Image Source: Coastal Green Infrastructure Research, Arcadis).*



Consider Intertidal and Subtidal Species: Plantings of low marsh *Spartina alterniflora* are being planted in plastic polyethylene terephthalate (PET) media installed above riprap in Hudson River Park on Pier 26. However, the size of the site and tidal wave action make this a challenging location and any installation should be considered experimental.

B.2 SUBTIDAL & INTERTIDAL VEGETATION

Similarly, a pilot project to restore eelgrass and other subtidal vegetation could be undertaken in the sheltered waters of the cove where sunlight can reach into the water column and currents are calm. Experiments using a variety of techniques have been undertaken in the Estuary, with mixed results. Certain site conditions, including depth (2>5 feet preferred) and the high organic content in the sediment, will likely rule this site out as a seagrass restoration opportunity, but that can be determined upon baseline monitoring.

Monitoring

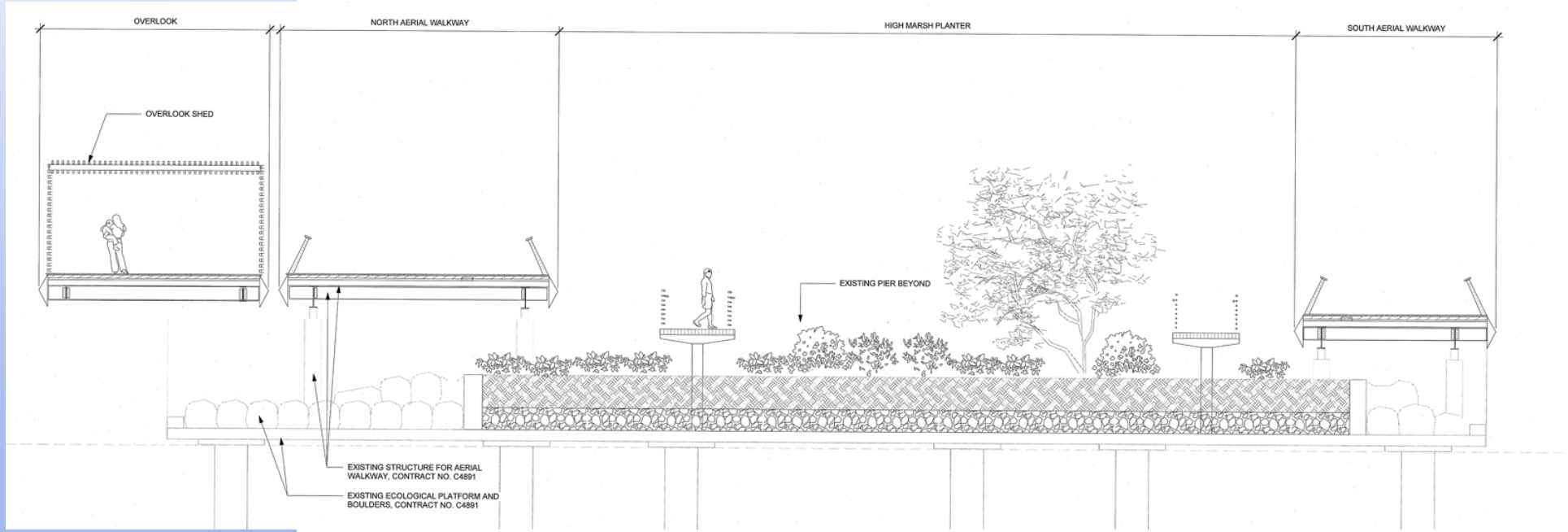
Purpose: Characterize the potential for the site to support a sustainable high marsh vegetation habitat. The aim would be to quantitatively characterize the plant and animal communities focusing on growth and survivorship, habitat provision (estimated by biodiversity and cover) and resilience to boat wakes, tidal energy and storm events.

Techniques: Plant density counts with a quadrat, coverage and height. Record observations of any other species utilization.

Metric: Taxonomic richness (at the species level when practical) and percent cover by the major taxa.

Frequency: Sampling should occur annually in summer.

Baseline Assessment: The issue of 'habitat substitution' will be documented by assessing the upper slope area for any vegetation or signs of faunal utilization.



Cross Section of Pier 26 (Source: Hudson River Park Trust, 2019)

B.3 SHALLOW WATER HABITAT

Reef Balls and Gabion Cages Filled with Oyster Shell (Source: Hudson River Foundation)

Upper right: Suggested Placement of Gabion Structures (Source: Hudson River Foundation)

Lower left: Conceptual Design for Tappan Zee Oyster Reef (Source: Hudson River Foundation)

Existing Conditions

This habitat includes the substrate of the near-shore waters of less than 13 feet deep, including mud and other soft deposits as well as the rock and other hard surfaces that are inundated.

Goals

Create shallow structured benthic invertebrate habitat that provides spawning areas, nursery areas and refuge for cover-seeking fish to:

- Enhance recruitment of juvenile and small fish species;
- Increase the diversity and abundance of reef-associated benthic, sessile, and mobile species, including infauna of soft-bottom habitats;
- Increase in the size of the local bivalve population; and
- Add source of oyster larvae

Ecological Reference Sites and Comparable Data

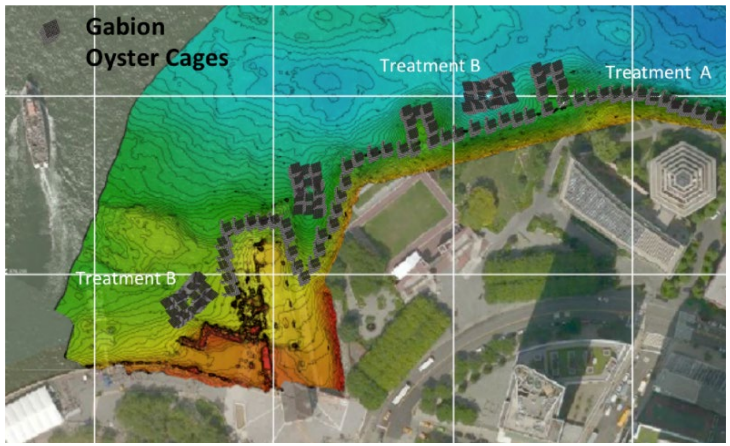
Soundview Park Oyster Reef (*Grizzle et al. 2013; Lodge et al. 2015*)

Tappan Zee Bridge Mitigation (*AKRF 2020; Lodge et al. 2017*)

Hudson River Park (*Taghon et al. 2018; Bain et al. 2006*)

West Harlem Piers Reef Balls (*NYCEDC, 2008*)

Hoboken and Jersey City commercial inlets (*Able and Grothues, 2018*)



Preferred/Potential Option(s)

Create Oyster Reefs: Artificial reefs made from gabion blocks should be placed outside of the seawall and at the entrance to Pier A cove. These reefs can provide the surface area attractive to oysters and other invertebrates. The structures will help create calm and shallow shoals similar to the coves created by piers and fill in Bayonne and Jersey City, New Jersey where Rutgers researchers are finding fish in great numbers.

Modular gabion reef blocks should be used to create these subtidal reef structures in a staggered line / shape. The placement of the gabions could mimic and perhaps enhance the two rock outcroppings possibly created by rocks at the historic pier ends, alongside the seawall just northwest of Pier A cove along Wagner Park's Esplanade.

While the waters deepen rapidly, these structures could break up the wave energy. Two conceptual treatments are envisioned for the area between the seawall and pierhead line. Possible depths are indicated, but any refinement will need to wait for detailed bathymetry and assessment of the slope in front of the seawall:

A. Gabion cages designed to create a sloping shallow water habitat in front of the seawall (-30 feet to -3 feet). Alternatively, a staggered single line parallel to BPC seawall. This may provide a near-shore zone of reduced waves from vessel traffic, and

Placement of Gabion Cages at Tappan Zee (Source: Hudson River Foundation)

possibly eddies of lower tidal energy. Gabions located at the mouth of Pier A cove itself would beneficially calm the waters there.

B. Rectangular (20 feet x 10 feet) clusters of gabions arranged in close proximity to each other, at 3 feet to -30 feet water depth.

Gabion blocks themselves can be constructed and configured in any desired shape. Rough / complex surfaces are important for oyster settlement. A mix of larger and smaller holes are important to different fish species. Smaller holes provide refuge habitat for small fish to avoid predation; however, larger holes are better for predators like black sea bass that are targeted by anglers. The size and shape would also have address final location, including the slope in front of the seawall.

All of the subtidal reef structures can be seeded with live oysters in aquaculture tanks prior to field placement. If possible, the oyster larvae should be spawned from oysters collected from either the lower Hudson River or upper NY Harbor.

Be Cautious with Floating Structures: The possibility of floating wetland islands planted with *Spartina alterniflora* was discussed. The frame could be modified to allow ribbed mussel attachment on the outside edges. Such devices have been tried in both Jamaica Bay and Newtown Creek with limited success. The wave and storm energy in this section of the Hudson River may be too great to support construction and anchoring of these structures.

Also discussed was the possible installation of a floating barge that could potentially attract seals looking for haul-outs. This is not recommended. It may put seals in harm's way, given the amount of ferry and other vessel traffic in the area. Attracting seals may increase predation and reduce the benefits of the restored area for fish. If included, such a system would need to be very low in the water and modified to have a sloping thwart; a landing platform very close to water level and a ramp up to an elevation where seals could avoid the wakes that would likely continuously wash up.

Submerged and floating structures require approval by the Army Corps of Engineers with U.S. Coast Guard review. The area does see considerable ferry and police boat traffic. To understand the requisite proximity to the shore, the draft of these vessels needs to be investigated to determine if there would be interference.

Monitoring

The monitoring regimen for assessing fish in the Riprap / Sloping Habitat should also be deployed here. Below is a monitoring system specific to the artificial reefs themselves.

Purpose: Characterize the organisms that develop on the artificial reefs and other restoration structures, with a focus on oysters but also include other invertebrates and plants. The aim would be to quantitatively characterize the plant and animal communities focusing on habitat provision (estimated by biodiversity and cover) and resilience to boat wakes, tidal energy and storm events.

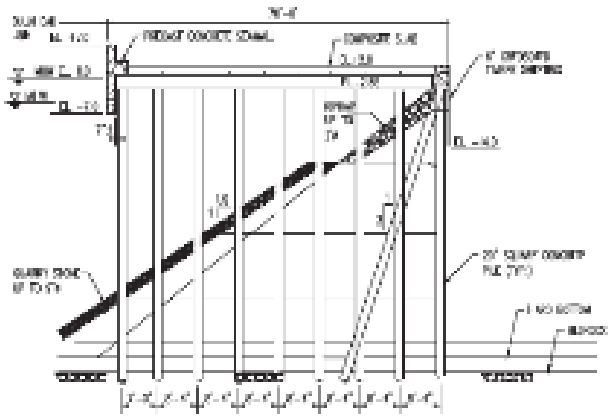
Techniques: Photographic imaging (Replicate photo quadrats - 0.1 m^2 surface area) would be the major monitoring technique, but some extractive sampling would be used to confirm identification of some taxa and to monitor the oyster population for disease load and reproductive health.

Metric: Taxonomic richness (at the species level when practical) and percent cover by the major taxa. Oysters would be counted, and shell height measured on the gabions.

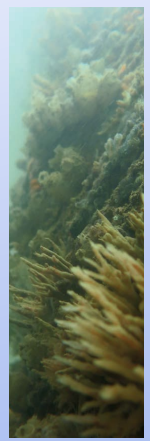
Frequency: Sampling should occur in spring, summer and fall. Throughout this period, sondes should be deployed to record water temperature, salinity, depth and dissolved oxygen every thirty minutes.

Baseline Assessment: The issue of 'habitat substitution' will be assessed by taking replicate van Veen grab (0.04 m^2 sampling area) samples from the soft sediments before the gabions and other restoration activities occur. The resulting data will be compared to the data from the photo quadrats to determine how the biotic communities on the constructed habitats differ from the soft-sediment habitat they replaced.

B.4 PILES & PLATFORMS HABITAT



Section of relieving platform and piles (Source: Marine Services, August 2019)



Invertebrate colonization of pier pilings in the Hudson River (Source: Fitzgerald)

Images on right from top: Pier 42 Design, Hanging Mesh Cages and Experimental Pile Wrap (Source: Hudson River Park Trust and Billion Oyster Project)

Existing Conditions

The relieving platform that forms the Battery Park City Esplanade is supported by a series of concrete piles. These are located in and alongside sloped riprap shoreline underneath the Esplanade. A dense array of wooden piles as well as a solid foundation support historic Pier A, creating a fairly solid southern edge to the site. Based on the National Register of Historic Places nomination for Pier A, the foundations beneath Harbor House were constructed on bedrock, which lay about ten feet below MLW, and consist of cribbing filled with concrete in bags with mass concrete placed over them and leveled off to support the subpiers and girders.

Goals

Create new and enhanced surfaces to encourage establishment of a diverse and resilient ecological community, including:

- Increase recruitment of bivalves including ribbed mussels, blue mussels and oysters;
- Increase the diversity and abundance of sessile and mobile species on and near piles; and
- Provide new sources of oyster larvae.

Ecological Reference Sites and Comparable Data

Hudson River Park, Invertebrate colonization of pier pilings in the Hudson River *(Fitzgerald et al. 2020)*

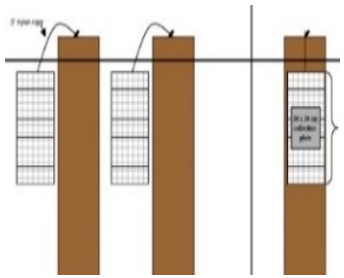
Hudson River Park, Pier 32 Oyster Wraps, Estuary Lab Community Oyster Project 2018

Brooklyn Bridge Park, tide pools and pile enhancements *(ECOncrete case study 2018)*

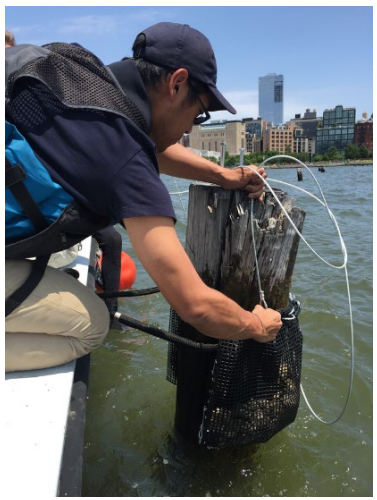
NY-NJ HEP Habitat Value of Urban Shorelines Study *(Reid et al., 2015)*

Preferred/Potential Option(s)

Add Additional Oyster Research Stations: The Billion Oyster Project (BOP) currently has two Oyster Research Stations (ORS) hanging from Pier A. These small waterfront cages, filled with oysters raised at BOP's aquaculture nursery, are attached by rope to the pier so they can be periodically hauled out. BOP students, participants, and volunteers use similar stations, located throughout the Estuary, to collect data on oyster growth and mortality, local biodiversity and water quality.



Adding six to eight additional stations will increase and diversify the sources of oyster larvae in the vicinity of the restoration pilots and enhance recruitment of bivalves. Configuring the new railing on the Esplanade and overlook to hang additional stations safely will help build community engagement. These should be added in Pier A cove, as the western Esplanade is less appropriate for the Stations, given wave and wake energy.



Add Ecologically Beneficial Surfaces: Wrapping the pilings at Pier A and under the Battery Park City relieving platform in ECOncrete (or similar forms) or ringing pilings in wire mesh cages filled with seeded oyster spat-on-shell would also improve habitat. However, BPCA is currently starting some maintenance work on the piles under the relieving platform and the opportunity to get ahead of this important effort is unclear. Typical BPCA construction would involve putting plastic sleeves around the piles and filling cracks with epoxy above the slab. Ideally this infrastructure work could provide an opportunity for ecological improvement. The dive teams could also be asked to provide baseline information on bivalve growth on and near the piles.

Even if ringing the pilings is not feasible, u-shaped oyster gabions could be placed around the bottom of pilings after the needed maintenance work is done.

Consider Light Under the Esplanade: Despite being shaded, the sloping habitat and piles under the Battery Park City relieving platform still offer important habitat to invertebrates, eels, and other organisms that are chemosensitive or olfactory (rather than light) stimulated. Adding light would improve the area for some fish, although it has also been shown to increase predation. However, there will be five to 15 feet of fill on top of these platforms and adding any light wells would be a challenge. One possibility would be to place reflective light tubes close to the waterside of the Esplanade in one bay to test its efficacy. Similar structures, called “remote skylights,” were proposed in the designs for the Lowline Park. Such a structure could also be a way to engage the public.

Monitoring

The monitoring regimen for assessing success of the Riprap/Sloping Habitat should also be deployed here. Below is a monitoring system specific to the ORS.

Purpose: To gather growth and mortality data about oysters in the ORSs, biodiversity data about organisms that come up with the ORS and water quality. There are 30 oyster clumps placed in each ORS at installation.

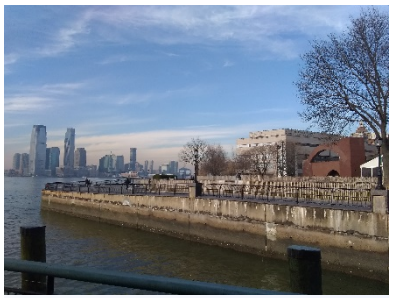
Techniques: All live oysters are counted. A random sampling of oyster clumps is taken from within the ORS. Live oysters are measured with calipers and oyster measurements are recorded in millimeters. Participants measure at least 30 live oysters (or as many that are alive if it is less than 30).

Metrics: Oyster growth and mortality.

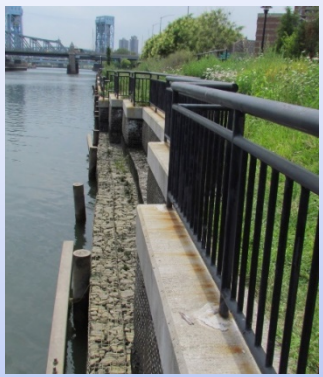
Frequency: Minimum - Once at beginning of oyster growing season (spring) and once at end of oyster growing season (fall).

Baseline Assessment: Baseline of oyster size (shell height) and number of live oysters is taken at the ORS installation or as soon as possible after ORS installation.

B.5 SEAWALL HABITAT



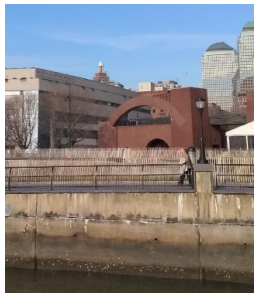
Pier A Cove - Existing conditions looking west, January 2020 (above) and Seawall panel at Wagner Park, January 2020 (at right) (Source: Nautilus International)



Harlem River Park Enhanced Seawall (Source: New York City Parks and Waterfront Alliance)

Right: Newtown Creek Bulkhead Enhancement (Source: Riverkeeper and Newtown Creek Alliance)

Existing Conditions



The seawall on the Hudson River side of the Battery Park City Esplanade consists of vertical concrete seawall, 1'-8" thick, connected to the pile caps and extending from the relieving platform down to below MLW. The seawall reduces wave and wake impact under the platform.

Goals

Create new and enhanced surfaces to encourage establishment of a diverse and resilient ecological community, including:

- Enhance recruitment of bivalves including ribbed mussels, blue mussels and oysters; and
- Increase the diversity and abundance of sessile and mobile species on and near the seawall.

Ecological Reference Sites and Comparable Data

Newtown Creek *(Riverkeeper and Newtown Creek Alliance, 2019)*

Harlem River Park *(Johnson et al, 2010)*

Elliot Bay Seawall *(in Bilkovic et al, 2017)*

Decision tool for adaptive management of marine infrastructure, Sydney, Australia *(in Morris et al, 2018)*

Rutgers University and Pratt Institute proposals for improved bulkhead design *(Kaunzinger, 2020 personal communication)*

Preferred/Potential Option(s)

Add Additional Oyster Research Stations: The Billion Oyster Project (BOP) currently has Oyster Research Stations (ORS) hanging from Pier A. These small waterfront cages, filled with oysters raised at BOP's aquaculture nursery, are attached by rope to the pier so they can be periodically hauled out. BOP students and volunteers use these stations, located throughout the Estuary, to collect data on oyster growth and mortality, local biodiversity, and water quality.

Adding additional lightweight stations and configuring the new railing on the Esplanade and overlook to hang the stations safely would help create additional opportunities to add a source of oyster larvae, enhance recruitment of bivalves, and support community engagement. However, given wave energy, these would likely have to be located in or near Pier A cove. Six to eight ORS could be located in the Cove, spaced and hung from the bottom of the railing stanchions, focused around the proposed overlook. This would be in addition to two currently located on Pier A.

Add Ecologically Beneficial Surfaces: Adding structural complexity, both in terms of texture and features, and modifying the chemical composition of the seawall would improve its ability to support marine fauna and flora. Sloping the seawall might also be a possibility. Including removable panels as part of the seawall would assist in monitoring and assessment of the viability of these techniques. A team led by Rutgers University and Pratt Institute have developed examples of such work, and there have been development of innovative techniques in Australia and elsewhere.

Monitoring

The monitoring regimen for assessing the success of the Riprap/Sloping Habitat could also be deployed here. Below is a monitoring system specific to the ORS.

Purpose: To gather oyster growth and mortality data about oysters in the ORSs, biodiversity data about organisms that come up with the ORS, and water quality. There are 30 oyster clumps placed in each ORS at installation.

Techniques: All live oysters are counted. A random sampling of oyster clumps is taken from within the ORS. Live oysters are measured with calipers and oyster measurements are recorded in mm. Participants measure at least 30 live oysters (or as many that are alive if it is less than 30).

Metrics: Oyster growth and mortality.

Frequency: Minimum - Once at beginning of oyster growing season (spring) and once at end of oyster growing season (fall).

Baseline Assessment: Baseline of oyster size (shell height) and number of live oysters is taken at the ORS installation or as soon as possible after ORS installation.

B.6 UPLAND VEGETATION

Randall's Island Park, Living Shoreline (Source: NYNJHEP)

Existing Conditions

The proposed plan includes a series of planting areas extending from the Esplanade to the top of Wagner Park. These areas support a range of annual and perennial plants, shrubs and trees.

Goals

- Create planting areas and a functional riparian zone with appropriate native plants: and
- Improve abundance, richness, composition of upland plants, pollinators and birds.

Ecological Reference Sites

Randall's Island Park, Living Shoreline

Hudson River Park, Pier 26 (in design)

Preferred/Potential Option(s)

Plant Riparian Species: Utilizing salt tolerant species from the planting palette for native coastal meadows, coastal shrubs and maritime forest throughout Wagner Park will provide habitat for plants, birds and insects in the upland portions of the site. This approach should be followed as much as feasible, given other priorities. The New York Natural Heritage Program *Ecological Communities* document is a good resource for appropriate plant species. These can be planted in an ecological gradient to mimic those that naturally occur together (and may have co-benefits) in maritime ecosystems. *(Edinger et al., 2014*)

BPCA Parks has considerable expertise and experience in this approach and successfully manages its native plantings despite heavy use by residents and visitors. The New York Natural Heritage Program provides information on habitat types that might be useful. Procuring the plants from local expert nurseries, such as the Greenbelt Native Plant Center in Staten Island, can also ensure that local genotypes are utilized. Such nurseries often need considerable lead time to grow project-specific plants.

Monitoring

Purpose: Characterize the organisms that utilize the restored maritime ecosystem. The aim would be to quantitatively characterize the plant and animal communities focusing on habitat provision (estimated by biodiversity), planting success and resilience.

Techniques: Biodiversity sampling may be able to be accomplished using citizen science. There is already a rich data source tracking birds and pollinators in interactive apps such as ibird and inaturalist. Community bioblitzes may also be a good tool.

Metric: Taxonomic richness (at the species level when practical and differentializing native and invasive species) and percent cover by the major taxa. Planting success should also be monitored for the first five years.

Frequency: Biodiversity sampling should occur in spring, summer, fall or spring/late summer as well as during migration periods for any key species identified in earlier surveys.

Baseline Assessment: Spring and summer bioblitzes in the study area, including a current species list from BCPA Parks horticulture maintenance, as well as a mining of citizen science data over the past five years for this location.

C. COMMUNITY ENGAGEMENT

Students at The River Project (Source: The River Project)

Existing Programs

BPCA's Parks Programming team creates hundreds of educational and creative events throughout the year. Some of the ones at Wagner Park that engage the community and visitors in the life of the Estuary are:

Go Fish! BPC's Celebration of Life in the Hudson Estuary – This three-hour series of programs includes anglers, both experienced and new, learning about the Hudson River through catch-and-release fishing; a multi-lingual, live concert for families; a creative art project; and invited educators conducting a nature walk, such as Volunteers for Wildlife presenting an up-close look at raptors.

Marine Education Classroom Visits – An experiential program for school groups from grades three and up to learn about the geographic and ecological history of the Hudson River and try catch-and-release fishing.

Drawing in the Park – At this two-hour event, an artist/educator supports participants at all levels of expertise to capture some the ever-changing seasonal landscapes of the park or the spectacular views of the Hudson River and harbor.

Goals

- Enhance shoreline and provide infrastructure to enable waterfront education and monitoring activities;
- Engage BPCA community and visitors in passive and active activities that reference habitat values, and support restoration and ongoing environmental stewardship, including monitoring.

Reference Programs

Billion Oyster Project Research Stations (ORS), including existing program at Pier A, Lower East Side Ecology center and Baylander
Billion Oyster Project MAST Center, Governors Island
Billion Oyster Project Field Stations, including Coney Island Creek and Paerdegat Basin
Brooklyn Bridge Park Conservancy Environmental Educational Center
Hudson River Park Trust Estuary Lab/Pier 26 (under construction) and Pier 84
The River Project (Pier 40)

Preferred/Potential Option(s)

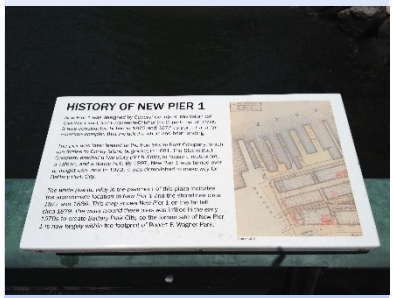
Plan for a Range of Programs: The project site is spacious enough to accommodate a range of active learning opportunities as well as passive, unstructured exploration of estuary ecology. The proposed project, most notably the community room in the new pavilion, terraced walkways and seating areas, outdoor classroom and enhancements to the Esplanade and railing will greatly increase these opportunities. Additional considerations, inspired in part by the suggested habitat restoration discussed above, will further improve the use of the site by BPC residents and visitors. New themes could include seasonal changes in fish populations and estuary restoration and resiliency efforts.

In terms of active learning, the community room in the new pavilion and park areas should accommodate the needs of smaller and larger gathering of school groups and informal educational experiences. This could range from small groups of 12-15 students, typical New York City classrooms of 30-35 people, or larger festivals such as the annual Day in the Life of the Hudson and Harbor sponsored by New York State DEC that attract upwards of 180 participants. We understand that this range of audiences is in keeping with current BPCA programs and aspirations. Additional target audiences could include researchers and citizen scientists.

Provide Flexible Infrastructure for Learning: The community room in the new pavilion should ideally include dry and refrigerated storage, be generous with sinks and counters, provide space for small informal displays of living aquatic creatures, and include equipment for projecting educational presentations. Both indoor and outdoor classrooms should be easily cleanable, reconfigurable, and user friendly. Nearby storage should allow for easy access to tables and portable equipment (tables, tanks, scientific equipment) by electric carts or similar vehicles for transport to the water's edge. There should be running water available near the outdoor classroom and other learning stations on the Esplanade. We understand that hose bibs and faucets are in keeping with current BPCA plans for Wagner Park.

Make Data Collection Part of the Experience: Locating a sonde in the water and/or providing a monitor display with data collected on tides, temperature, dissolved oxygen and other parameters through the Hudson River Ecological Conditions Observing System

Passive educational feature at Pier A Cove, January, 2020 (Source: Nautilus International)



Close up of passive educational Sign at Pier A Cove, January, 2020 (Source: Nautilus International)

could be an additional educational tool. This data could be shown on an outdoor monitoring display in real-time.

Provide a Range of Formal and Passive Learning Spaces: Three formal learning areas are envisioned. These could be used individually or as an ensemble depending on the scope and size of the program being offered:

- The overlook and Esplanade north of Pier A will allow students and teachers to see the enhancements to the riprap and to investigate the proposed Oyster Research Stations. Bringing temporary tables to this space would enhance this learning experience. While the area is constrained, access all around the tables would be ideal. Utilizing the area at the eastern head of the cove might be less constrained. It is also possible that the riprap ledges would provide an opportunity for qualified staff to directly monitor shellfish and/or assess the nature of the floatables (e.g. plastics);
- The seating area being built into the upland terraces will allow larger groups of students/visitors to comfortably enjoy presentations. This area will ideally be shaded as needed to allow for year-round use;
- The Esplanade outside of the cove area is the best site for the existing Go Fish! festivals (as well as informal fishing). The railing in this area should be articulated to allow for placement of fishing poles in a way that minimizes visual and physical obstructions for pedestrians.

One additional area being considered for presentations is a floating dock. This would be located on the western shore of the site, outside of the cove. A floating dock would provide a way for visitors to be near the water. Placement of the dock would require a controlled gangway from a locked gate on the Esplanade and, possibly, structures to secure the dock in the current. If such a structure is pursued, there are options for minimizing its impacts and enhancing its ecological value. However, the mooring of any such structure would have to be configured to be stable in the strong current, waves and wakes in the area. Permits for the floating dock would also be required.

Passive educational features should be innovative and flexible, maximizing opportunities for visitors to learn about estuary ecology and the site in an engaging manner. Using art, such as temporary fish pavers and changeable sculpture, as a means to convey information about ongoing ecological restoration projects is encouraged. These displays could also provide a means of communicating BPCA's work to address sustainability and climate change.

Monitoring

Our understanding is that BPCA currently collects data on the numbers and origin points of people served by their program, for example, whether participants are BPCA residents or not. Recommending additional steps to monitor the success of expanded community engagement requires additional information on current practices. In any case, monitoring and evaluating informal education programs should include a complement of quantitative and qualitative measures. Possible options to enhance current information gathering could include identifying origin by zip code, age or user group (this may already be the case); tallying the number of partners and partnership events hosted.

While is it important to understand the audiences participating at BPCA, it is equally important to assess the value of their experience. Qualitative methods can include:

- short 2-minute 'snapshot interviews' that include clear, concise questions of participants and;
- online questionnaires following an event;
- direct participant observations; posted 'graffiti or feedback walls' seeded with prompts or questions;
- suggestion boxes with feedback cards provided to participants with short prompts;
- social media traffic; and
- for more organized events, pre and post responses can be used to collect and assess learning or satisfaction.

All of these can be used at both events or with informal use using in-house staff or partnering with a college or external evaluator. Comparisons could be made to other peer parks and managers.

D. NEXT STEPS

Moving forward on the proposals recommended in this report would involve the following next steps:

- **Incorporation of proposals into the design/engineering documentation for the project**

  As a result of the workshop and follow up discussions, AECOM and its team are advancing some of these proposals in their project work. The scientists and restoration experts involved in this study are prepared to continue their consultative role with Nautilus going forward. In particular, additional fieldwork and engineering assessments are required to advance proposals for shallow water and seawall habitats.

- **Preliminary discussion of proposals with regulatory authorities and potential partners**

  Some of the proposals included here may require permits from city, state and federal agencies. These restoration actions should be considered pilot projects, in keeping with similar work being proposed in Hudson River Park and elsewhere in the Estuary. Through careful assessment of baseline conditions and on-going monitoring, the work being undertaken at Pier A can inform restoration efforts elsewhere, helping advance knowledge of these urban shorelines and the ecological lift that these innovative practices are likely to provide. As appropriate, Hudson River Foundation/HEP staff are willing to help with these pre-proposal briefings along with the AECOM team.

- **Assessment of baseline conditions and other follow up studies**

  Key to understanding the success of any proposed restoration project is an accurate portrayal of pre-project conditions. Specific recommended techniques are identified in the monitoring sections above. Ideally these studies would begin (subject to lifting of the quarantine) this upcoming summer and fall season so that there are as many sampling seasons as possible before construction begins. Hudson River Foundation/HEP staff would be willing to discuss possible collaborations for such sampling.

E. WEDG® CERTIFICATION

These proposals will assist BPCA and the AECOM team in preparing their proposal for certification under the Waterfront Edge Design Guidelines (WEDG®), a voluntary rating system administered by Waterfront Alliance. More information about WEDG® can be found here: http://wedg.waterfrontalliance.org.

If incorporated into the project and its planning, the restoration, scientific study and community engagement actions proposed above may enable the team to secure points towards WEDG® credits. Final determination will be based on the submission, implementation and review by the Waterfront Alliance. The following WEDG® credits could be considered for inclusion in the application:

Credit 0.2: Assess site-wide social and ecological context and vulnerabilities

In addition to the assessment of site conditions provided by AECOM, analysis of the site has benefited from the consultation provided by the scientists involved in this workshop. In particular this includes identifying opportunities and challenges for conserving and enhancing the ecological value of the shallows and shoreline adjacent to Wagner Park, including in and around Pier A cove as well as the development and discussion of preliminary proposals for assessing sites, enhancing ecological value, and monitoring results.

Credit 0.4: Create a maintenance and adaptive management plan

This report provides a basis for providing maintenance and adaptive management over time. In particular, it proposes an ongoing partnership between the AECOM team, Foundation / HEP and other partners to "strengthen the team's ability to track, monitor, and learn from changes."

Credit 1.2: Site with ecological sensitivity

Some of the restoration proposals could provide a buffer between water and the upland parkland, and if incorporated into the final design, may reduce shadowing under the Esplanade's relieving platform.

Credit 2.1: Provide quality public access areas on the waterfront

The community engagement section provides several considerations, such as support for community science and informal educators, that will further augment the overall intent of the project to create "high quality public access areas on the waterfront that maximize interaction with the water."

Credit 2.7: Provide direct connections to the water for people and boats

The restoration proposals and the community engagement section are intended to be specifically supportive of public fishing on a catch-and-release basis and engagement of the community and students in understanding the marine life in the area. However, these proposals do not suggest any direct access for the public or boats to enter the water.

Credit 3.1: Choose an appropriate edge strategy for the context and intended use

While a hardened shoreline is required at the site to continue to contain the landfill, the proposed restoration techniques are considered "nature-based" or "ecologically-enhanced" shoreline strategies that will minimize/mitigate the impacts of the riprap, relieving platform and seawall.

Credit 3.2: Maintain or emulate natural shoreline shape

While softer edges are not feasible at this currently hardened shoreline, the proposed restoration of the riprap and the placement of the gabions in shallow water will increase the sinuosity of the shoreline and reduce the slope.

Credit 3.4: Ecologically enhance structural components

While stabilization is required, the proposed alterations to the riprap, and potentially the seawall and pilings, incorporate complexity and living material into these structures to improve their habitat value.

Credit 4.1: Maintain and restore biodiversity and ecosystem services

Because the project is "retrofitting an existing property in a highly urban area, with no current existing habitat and limited space or feasibility for more expanded restoration activities," it is possible that the project will not qualify for these credits (but should seek credit through credit 3.4). However, if the AECOM team can make a case that the project meets the first condition by maintaining "intact and significant habitats and ecosystem services" then, depending on the scale and scope of the shallow water habitat restoration, credits are available for restoring more than one acre of habitat and contributing to regional or local restoration plans and priorities.

Credit 4.2: Restore/increase ecosystem connectivity

Qualifying for this credit requires meeting the conditions for Credit 4.1. If the project does qualify per above, then the proposed design and scope of the shallow water habitat restoration will provide a "net increase in restored contiguous inwater habitats."

Credit 4.3: Support native habitat complexity and biodiversity

The planting plan for upland vegetation habitat should qualify for credits, with total planned coverage consisting of plants tolerant of shoreline conditions and no plants listed on state invasive species lists.

Credit 4.13: Partner with academic and scientific institutions to study or monitor the site

A monitoring partnership with the Hudson River Foundation/HEP, Billion Oyster Project and/or the academic institutions participating in this report would qualify for this credit.

A C K N O W L E D G E M E N T S

The Hudson River Foundation and NY-NJ Harbor & Estuary Program are grateful for the enthusiastic participation of the invited scientists who contributed their time and expertise, Battery Park City Authority, and the AECOM consulting team in the success of this project and many contributions during the workshops. Special thanks to Nautilus International Development Consulting, Inc. for advancing this project and their contributions to this report.

Aquatic Ecology Advisory Group & Invited Scientists

NY-NJ Harbor & Estuary Program / Hudson River Foundation
Consultant to Nautilus International Development Consulting, Inc.
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G L O S S A R Y

Benthic The ecological zone beneath the water column, including the sediment surface and sub-surface layers.
USGS Waterwords-Benthic Zone 2020. Retrieved from https://www.usgs.gov/news/waterwords-benthic-zone?qt-news_science_products=4#qt-news_science_products

Biodiversity In its most general sense, biodiversity refers to all aspects of variety in the living world. Specifically, the term may be used to describe the number of species, the amount of genetic variation or the number of community types present in an area.
Glossary. (2005, May 05). Western Michigan University.
Retrieved from http://homepages.wmich.edu/~malcolm/BIOS3010-ecology/Begon-etal-Ecology-Glossary.pdf

Bivalve Broadly speaking, any animal with a shell in two parts hinged together e.g. oyster, clam, mussel.
Wetland Terminology. 2020. The Mediterranean Wetlands Initiative.
Retrieved from https://medwet.org/aboutwetlands/wetland-terminology/

Bulkhead A structure or partition to retain or prevent sliding of the land. A secondary purpose is to protect the upland against damage from wave action.
Engineer Manuals. (2003). USACE Publications. Retrieved from
https://www.publications.usace.army.mil/Portals/76/Publications/EngineerManuals/EM_1110-2-1100_App_A.pdf

Chemosensitive Sensitive to chemical stimuli, the sensory nerve endings that mediate taste and smell.
Chemosensory. (2020). https://www.dictionary.com/browse/chemosensory

Dissolved oxygen Oxygen present in water and available to fish and other marine creatures.
USGS Water Science School - Dissolved Oxygen and Water. 2020. Retrieved from
https://www.usgs.gov/special-topic/water-science-school/science/dissolved-oxygen-and-water?qt-science_center_objects=0#qt-science_center_objects

Gabions (1) Steel wire-mesh basket to hold stones or crushed rock to protect a bank or bottom from erosion. (2) Structures composed of masses of rocks, rubble or masonry held tightly together usually by wire mesh so as to form blocks or walls. Sometimes used on heavy erosion areas to retard wave action or as a foundation for breakwaters or jetties.
Engineer Manuals. (2003). USACE Publications. Retrieved from
https://www.publications.usace.army.mil/Portals/76/Publications/EngineerManuals/EM_1110-2-1100_App_A.pdf

Genotypes The genetic makeup of an organism, with respect to a given genetic locus, the alleles it carries.
Levinton, J. (n.d.) Marine Biology: Function, Biodiversity, Ecology. Oxford University Press: New York, NY.
Retrieved from https://life.bio.sunysb.edu/marinebio/glossary.ghijk.html

High/low marsh High marsh is a tidal marsh zone located above the Mean Highwater Mark (MHW), which is inundated infrequently during periods of extreme high tide and storm surge associated with coastal storms. The high marsh is distinguished from the low marsh by its sandy soil and higher elevation. It is characterized as being flooded daily.
High Marsh. (2017 June 18). In Wikipedia. https://en.wikipedia.org/wiki/High_marsh

The water of the **low marsh** is shallow, silt laden, salty, and warm. These factors decrease the water's capacity to hold dissolved oxygen. Some areas of the low marsh are covered by the tides for most of the day. The mud that makes up the soil in the low marsh has high levels of salinity.
Low Marsh. (2017 June 18). In Wikipedia. https://en.wikipedia.org/wiki/Low_marsh

G L O S S A R Y

Infauna Living within a soft sediment and being large enough to displace sedimentary grains.
Levinton, J. (n.d.) Marine Biology: Function, Biodiversity, Ecology. Oxford University Press: New York, NY. Retrieved from https://life.bio.sunysb.edu/marinebio/glossary.ghijk.html

Interstitial spaces Living in the pore spaces among sedimentary grains in a soft sediment.
Levinton, J. (n.d.) Marine Biology: Function, Biodiversity, Ecology. Oxford University Press: New York, NY. Retrieved from https://life.bio.sunysb.edu/marinebio/glossary.ghijk.html

Key species A species whose removal would produce a significant effect in the community of which it is part, changing its fundamental nature.
Glossary. (2005, May 05). Western Michigan University. Retrieved from http://homepages.wmich.edu/~malcolm/BIOS3010-ecology/Begon-etal-Ecology-Glossary.pdf

Natural and Nature-based resiliency features Landscape features that are used to provide engineering functions relevant to flood risk management, while producing additional economic, environmental, and/or social benefits such as beaches and dunes; vegetated environments such as maritime forests, salt marshes, freshwater wetlands and fluvial flood plains, and seagrass beds; coral and oyster reefs, barrier islands, among others. These features may occur naturally in landscapes or be engineered, constructed and/or restored to mimic natural conditions.
Natural and Nature Based Features. (n.d.). Engineering with Nature. https://ewn.el.erdc.dren.mil/nnbf.html

Oyster spat When oysters reproduce, they spawn tiny larvae that freely navigate the water column until they find an appropriate habitat with a structure to settle on. Once the larvae permanently attach to a surface, they are known as spat.
What is Spat? (2018). NOAA. Retrieved from https://oceanservice.noaa.gov/facts/spat.html

Pocket marshes Constructed shallow marsh systems designed and placed to control stormwater volume and facilitate pollutant removal. As engineered constructed facilities, pocket wetlands have less biodiversity than natural wetlands, but still require a base flow to support the aquatic vegetation present.
Pocket Wetlands. (2009). Water Environment Research Foundation. https://www.werf.org/liveablecommunities/toolbox/pocket.htm

Quadrat A classic tool for the study of ecology, especially biodiversity. In general, a series of squares (quadrats) of a set size are placed in a habitat of interest and the species within those quadrats are identified and recorded.
Investigating Marine Life. (2009). Census of Marine Life. Retrieved from http://www.coml.org/investigating/observing/quadrat_sampling.html

Relieving platform Typically, a deck on the landside of a retaining wall to transfer loads vertically down to the wall. In this location at Battery Park City, the Esplanade along the Hudson River rests on a thick concrete deck known as a relieving platform that is supported on concrete piles extending through a riprap revetment containing the inboard landfill.
Relieving platform. (2020). https://encyclopedia2.thefreedictionary.com/relieving+platform

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Revetment (1) A facing of stone, concrete, etc., to protect an embankment, or shore structure, against erosion by wave action or currents. (2) A retaining wall. (3) Facing of stone, concrete, etc., built to protect a scarp, embankment or shore structure against erosion by waves or currents.
Engineer Manuals. (2003). USACE Publications. Retrieved from https://www.publications.usace.army.mil/Portals/76/Publications/EngineerManuals/EM_1110-2-1100_App_A.pdf

Riprap Man-placed rock or other material used to armor shorelines, streambeds, bridge abutments, pilings and other shoreline structures against scour and water, wave, or ice erosion.
Riprap. (2020 April 13). In Wikipedia. https://en.wikipedia.org/wiki/riprap

Riparian zone The border or banks of a stream. Although this term is sometimes used interchangeably with floodplain, the riparian zone is generally regarded as relatively narrow compared to a floodplain. The duration of flooding in a riparian zone is generally much shorter, and the timing less predictable than in a river floodplain.
Wetland Terminology. 2020. The Mediterranean Wetlands Initiative.
Retrieved from https://medwet.org/aboutwetlands/wetland-terminology/

Seawall An earth, concrete, stone, or metal wall or embankment constructed along a shore to reduce wave erosion and encroachment by the sea.
Wetland Terminology. 2020. The Mediterranean Wetlands Initiative.
Retrieved from https://medwet.org/aboutwetlands/wetland-terminology/

Sessile Animals attached to the substratum.
Costello MJ, Harris P, Pearce B, Fiorentino A, Bourillet J-F, Hamylton S (Editors) 2019. A glossary of terminology used in marine biology, ecology, and geology. Version 2.0.
Retrieved from https://www.oceansofbiodiversity.auckland.ac.nz/2019/05/16/a-glossary-of-terminology-used-in-marine-biology-ecology-and-geology/

Shoals A normally submerged bank rising from the bed of a shallow body of water and consisting of, or covered by, unconsolidated material which may be exposed at low water.
Wetland Terminology. 2020. The Mediterranean Wetlands Initiative.
Retrieved from https://medwet.org/aboutwetlands/wetland-terminology/

Sloping habitat Ecosystems upon a surface that slants up or down, these areas can be prone to shallow landslides that can displace the topsoil and vegetation downwards.
Gonzalez-Ollauri, A. and S.B. Mickovski. Shallowlandslides as drivers for slope ecosystem evolution and biophysical diversity. Landslides. 14: 1699-1714. Retrieved from https://link.springer.com/article/10.1007/s10346-017-0822-y

Sondes Sondes collect data for temperature, specific conductivity, salinity, pH, dissolved oxygen (% saturation and mg/L), turbidity, water level and battery voltage. These sensors provide the data necessary to monitor the health of the ecosystem and to track the impacts of natural or man-made events.
YSI Environmental. (2015). Using Real-Time Telemetry for Ecological Monitoring of Coastal Wetlands Environmental.
Retrieved from https://www.ysi.com/File%20Library/Documents/Application%20Notes/A578-Using-Real-time-Telemetry-for-Ecological-Monitoring-of-Coastal-Wetlands.pdf

G L O S S A R Y

Subtidal/intertidal The subtidal or sublittoral zone is permanently covered with seawater. In physical oceanography, the sublittoral zone refers to coastal regions with significant tidal flows and energy dissipation, including non-linear flows, internal waves, river outflows and oceanic fronts. In marine biology, it refers to the areas where sunlight reaches the ocean floor. This results in high primary production and makes the sublittoral zone the location of the majority of sea life.
Littoral Zone. (2020 March 29). In Wikipedia. https://en.wikipedia.org/wiki/Littoral_zone

The intertidal zone, also known as the foreshore or seashore, is the area that is above water level at low tide and underwater at high tide. This area can include several types of habitats with various species of life, such as seastars, sea urchins, and many species of coral.
Intertidal zone. (2020 April 30). In Wikipedia. https://en.wikipedia.org/wiki/Intertidal_zone

Taxonomic richness Taxa richness or species richness Species richness is the number of different species represented in an ecological community, landscape, or region. Species richness is simply a count of species, and it does not take into account the abundances of the species or their relative abundance distributions.
Glossary of Ecological Terms. (n.d.). Bureau of Ocean Energy Management. Retrieved from https://www.boem.gov/sites/default/files/boem-newsroom/Technical-Announcements/2016/Chapter-7-Glossary-of-Ecological-Terms.pdf

Upland Dry land area above and landward of the ORDINARY HIGH WATER MARK (OHWM). Often used as a general term to mean high land far from the COAST and in the interior of the country.
Engineer Manuals. (2003). USACE Publications. Retrieved from https://www.publications.usace.army.mil/Portals/76/Publications/EngineerManuals/EM_1110-2-1100_App_A.pdf

Van Veen grab An instrument to sample sediment in water environments. Usually it is a clamshell bucket made of stainless steel.
Van Veen Grab Sampler. (2020 April 25). In Wikipedia. https://en.wikipedia.org/wiki/Van_Veen_Grab_Sampler

Wrack Dead floating plant material often deposited on salt marshes or beaches by high spring tides. Wracks can be quite large—up to hundreds of square meters, and up to 30 centimeters thick. If these wracks are deposited in the high marsh, they often become stranded smothering all of the plant life beneath them.
Natural Disturbances to Estuaries. (2020). NOAA. Retrieved from https://oceanservice.noaa.gov/education/kits/estuaries/media/supp_estuar08b.html

A C R O N Y M S

AECOM	An American multinational planning, design, and engineering firm serving as prime consultant to Battery Park City Authority on the South Battery Park City Resiliency Project
BPC	Battery Park City
BPCA	The Battery Park City Authority
BOP	The Billion Oyster Project
DEC	New York State Department of Environmental Conservation
HEP	New York – New Jersey Harbor & Estuary Program
HRF	Hudson River Foundation
MLW	Mean Low Water
MHW	Mean High Water
NYSERDA	New York State Energy Research and Development Authority,
ORS	Billion Oyster Project Oyster Research Stations
PET	Polyethylene terephthalate
WEDG®	Waterfront Edge Design Guidelines

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Kaunzinger, 2020 Personal Communication. See https://issuu.com/penndesign/docs/pressingmattersiv_102315_final/129 for examples of the ecological bulkhead improvements being advanced by a team from Rutgers University and Pratt Institute.

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