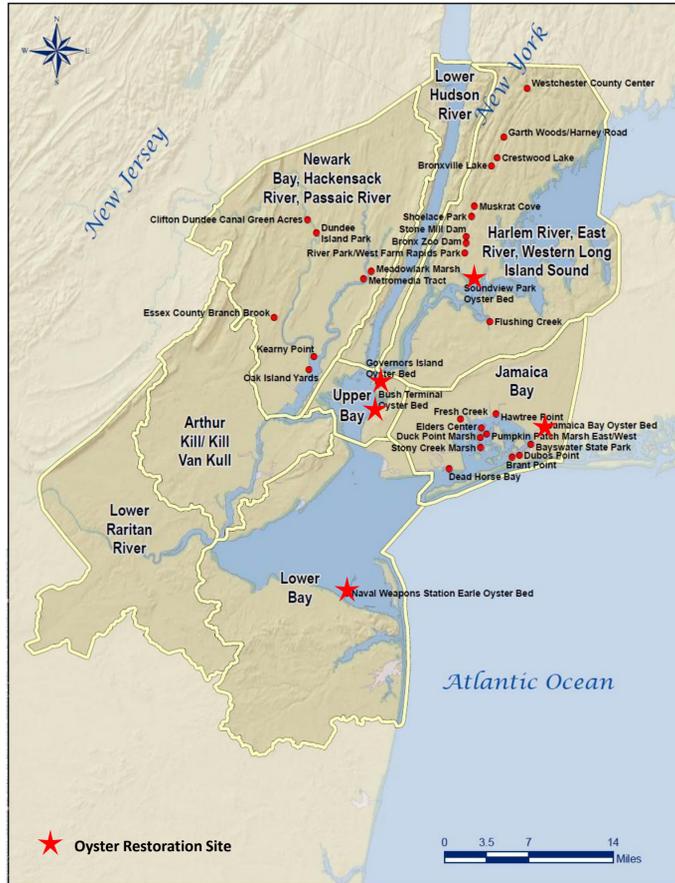


OYSTER RESTORATION



Prior to European colonization, oysters and oyster reefs were key components of the estuarine habitat in HRE. It is believed that approximately 350 square miles of oyster beds were present in the HRE. Principal concentrations occurred along the Brooklyn, Manhattan, and Queens shorelines, Jamaica Bay, and Hudson and East Rivers.

Due to **overharvesting, pollution and habitat disturbances, oysters became practically non-existent** by the mid 20th Century. However, with the passage of the Clean Water Act and other environmental legislation, water quality has improved and limited isolated populations do exist in a few areas of the HRE. Initial pilot programs to restore oysters began in the early 2000s, such as the Oyster Restoration Research Project (ORRP), a partnership of over 30 not-for-profit organizations, federal, state and city agencies, scientists and citizens. ORRP initial programs, along with the NYCDEP, NY/NJ Baykeeper, NY Harbor School, etc. have determined that restored oysters and created oyster beds can survive in the HRE. However, oysters are sessile organisms and offspring are often dispersed into the current with little chance of resettlement. Thus, a more targeted oyster restoration effort, as proposed, in the HRE would promote and enhance the oyster recovery to attain the TEC goal of 20+ acres of oyster beds by the year 2020, as well as provide critical scientific information on how to restore oysters more efficiently in the future.

As part of the HRE, five sites were selected for oyster restoration throughout the estuary based on past successes and/or to work in concert with other ecological improvements. The sites are generally along the shoreline in depths of water that range from 3-12 feet.



Significance of Oyster Restoration in the Region and at Each Site

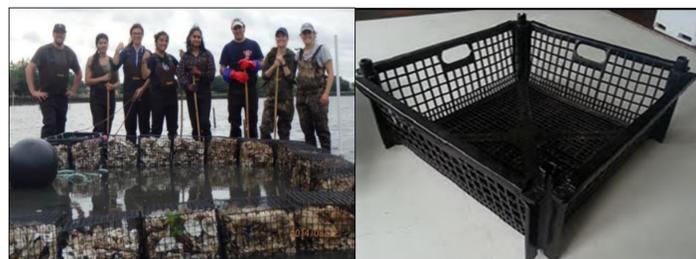
- Builds/expands on previous successful oyster restoration in the HRE.
- Achieves the HRE regional goal of establishing 20 acres of reef habitat across several sites by 2020 and advances the BOP to restore one billion live oysters to New York Harbor over the next twenty years.
- Ecological uplift includes:
 - ✓ Improve habitat quality for invertebrates, fish and vegetation;
 - ✓ Increase biomass of fish and large motile crustaceans by over 1,000 kg/acre;
 - ✓ Improve ecosystem function;
 - ✓ Improve water quality through filtration of nutrients, water turbidity, nitrogen, phosphorous, organic carbon (141,570,000 gallons of water filtered daily per acre of functional reef);
 - ✓ Carbon sequestration;
 - ✓ Stabilize the shoreline to prevent erosion; and
 - ✓ Wave attenuation.
- Innovative solution to reutilizing derelict shorelines and piers.
- Restores an important estuarine species in Harbor.
- Provides unique opportunity to work with Harbor School for construction and maintenance of reefs.

Restoration Opportunities/Measures

- Habitat creation and improvement
- Shoreline stabilization
- Public education/access
- Water Quality Improvement



Spat on Shell

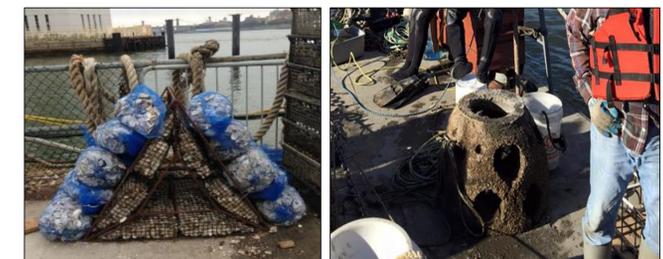


Gabion Blocks

Hanging Trays

Tentatively Selected Plan for Oyster Restoration Sites

| Restoration Site | Measures/Target Ecosystem Characteristic | First Level Costs | | | Non-Federal Sponsors (Congressional Representatives) |
|---|--|---------------------|---------------------|---------------------|--|
| | | Federal | Non-Federal | Total | |
| Jamaica Bay Head of Bay | Oyster beds (1.5 ac); Hanging trays (>0.5 ac) | \$533,000 | \$287,000 | \$820,000 | NYCDEP (Meeks) |
| Bronx River Soundview Park | Spat on shell (0.83 ac); Gabion blocks (0.14 ac) | \$494,000 | \$266,000 | \$760,000 | NY/NJ Baykeeper, Hudson River Foundation (Serrano) |
| Upper Bay Bush Terminal | Spat on shell (31.65 ac); Gabion blocks (8.48 ac); Oyster condos (3.49 ac); Hanging trays (0.1 ac) | \$21,417,500 | \$11,532,500 | \$32,950,000 | NY Harbor Foundation/School (Nadler, NY-10) |
| Upper Bay Governors Island | Gabion blocks 1.66 ac); Oyster condos (1.79 ac); Hanging trays (0.68 ac) | \$3,172,000 | \$1,708,000 | \$4,880,000 | |
| Lower Bay Naval Weapons Station Earle | Spat on shell (3.1 ac); Gabion blocks (3.2 ac); Reef balls (1.3 ac) | \$4,823,000 | \$2,597,000 | \$7,420,000 | NY/NJ Baykeeper (Pallone, NJ-6) |
| Total | | \$30,439,500 | \$16,390,500 | \$46,830,000 | |



Oyster Condos

Reef Balls

OYSTER RESTORATION SITES

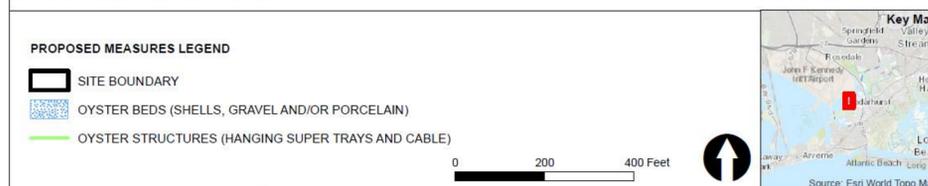
Jamaica Bay Tentatively Selected Plan Design:

- Oyster Beds (shells, gravel, porcelain). (1.5 ac).
- Hanging Trays/Super Trays. 200 trays (1ft x 5ft). Oysters placed vertically in the water column. Immediate benefits to water quality as oysters filter the water and can disperse veliger (larvae) to nearby constructed reefs, beds (>0.5 ac), or other hard substrate as receiver site.
- Builds on past success of NYCDEP and provides valuable information on substrates (e.g., shells, gravel, etc.), recruitment, and settlement patterns of oysters spawned from the hanging tray stocks.

PROJECT FIRST COST (Oct 2016): \$820,000



Hudson-Raritan Estuary (HRE) Feasibility Study
Jamaica Bay, Queens, New York
Source: NYS GIS Clearinghouse 2013 & 2014 Orthoimagery



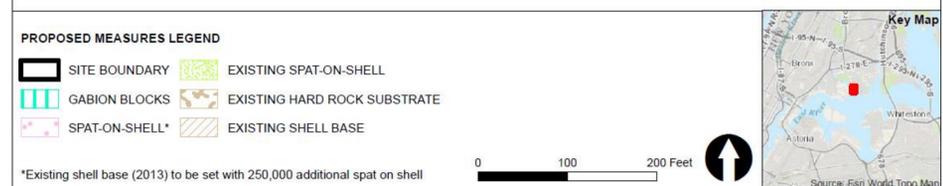
Soundview Park Tentatively Selected Plan Design:

- Spat on Shell (SoS). Produced by the Harbor School using local broodstock, with a veneer layer of mollusk shell on a base of rock/rubble. Suited to lower energy environments with firm substrate, or in combination with other techniques that shelter the SoS from strong currents and smothering by sediments, and prevent sinking into loose substrate. (0.83 ac).
- Gabion Blocks. (0.14 ac).
- Designed to build on past successes. Restoration will occur in an area with subtidal rock outcrops to form a ~2.75 ac reef/bed complex. The design would continue to provide excellent research opportunities.

PROJECT FIRST COST (Oct 2016): \$760,000



Hudson-Raritan Estuary (HRE) Feasibility Study
Soundview Park, Bronx, New York
Source: NYS GIS Clearinghouse 2014 Orthoimagery



*Existing shell base (2013) to be set with 250,000 additional spat on shell

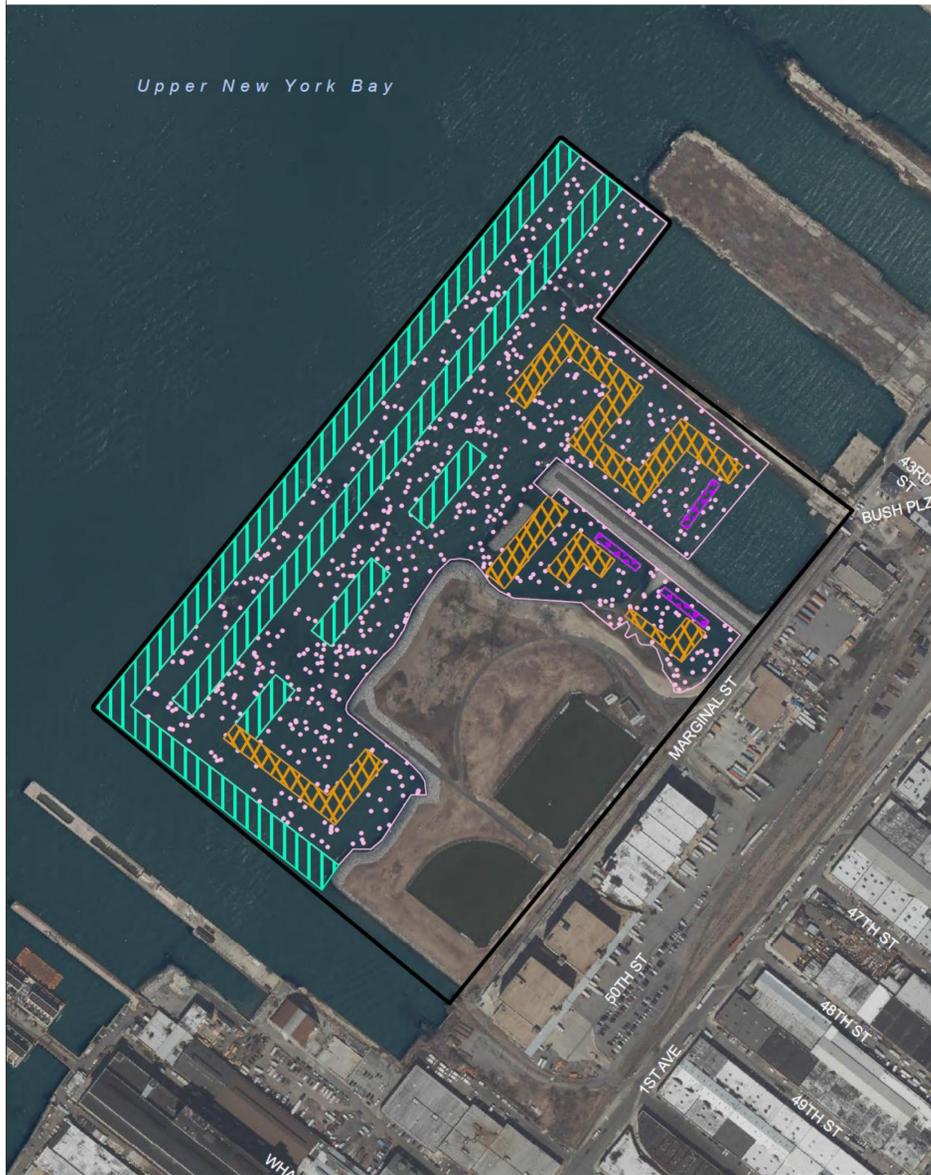


OYSTER RESTORATION SITES

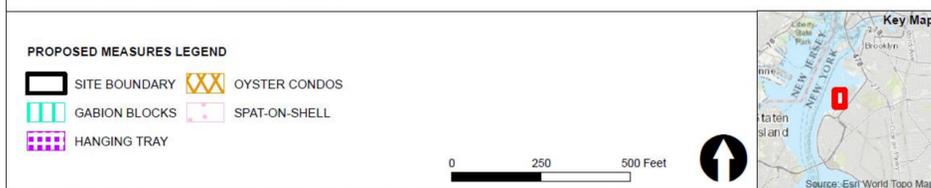
Bush Terminal Tentatively Selected Plan Design:

- Spat on Shell (SoS) (31.65 ac).
- Gabion Blocks (8.48 ac). Provides protection for adjacent spat on shell habitat.
- Oyster Condos (3.49 ac).
- Hanging Trays/Super Trays (0.1 ac).
- Would serve as a model for the re-utilization of derelict portions of the harbor shoreline and has positive synergistic effect with adjacent park development. The derelict piers provide wave attenuation and depth variability provide habitat diversity. Site is close to Harbor School resulting in reduced transport costs for future placement of oysters. Provides excellent public access, stewardship and future study.

PROJECT FIRST COST (Oct 2016): \$32,950,000



Hudson-Raritan Estuary (HRE) Feasibility Study
Bush Terminal Park, Brooklyn, New York
Source: NYS GIS Clearinghouse 2014 Orthoimagery



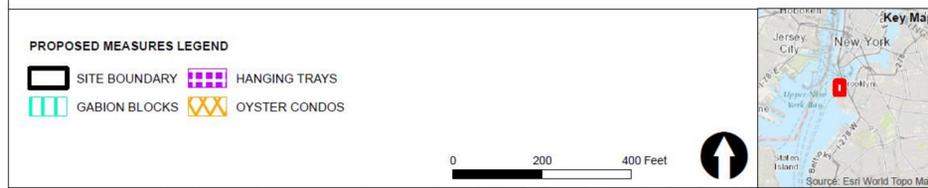
Governors Island Tentatively Selected Plan Design:

- Gabion Blocks. The blocks are 12x3x3 ft. wire cages filled with oyster shells pre-seeded with spat. (1.66 ac).
- Oyster Condos. Triangular structures; mimics the rugosity (three dimensionality) of an oyster reef. (1.79 ac).
- Hanging Trays/Super Trays. The trays are submerged and suspended from a float or pier to serve as larval source for adjacent habitat. (0.68 ac).
- Restoration designed to place reproductive stock (hanging trays) in close proximity to suitable hard substrate (condos and gabion blocks) for settlement. The use of Governors Island, in concert with the Harbor School, provides facilities, technical experts and a cost-effective means for construction and maintenance, as well as an excellent teaching/research opportunities for future generations of scientists.

PROJECT FIRST COST (Oct 2016): \$4,880,000



Hudson-Raritan Estuary (HRE) Feasibility Study
Governors Island, New York City, New York
Source: NYS GIS Clearinghouse 2014 Orthoimagery



Naval Weapons Station Earle Tentatively Selected Plan Design:

- Spat on Shell (SoS) (3.10 ac).
- Gabion Blocks (3.20 ac).
- Reef Balls. Reef balls are half-dome, concrete structures, with holes that allow water to flow through, and fish and other aquatic creatures to inhabit the interior. Although used successfully to construct intertidal reefs, reef balls are better suited to subtidal areas to avoid damage from waves and currents. (1.30 ac).
- Builds on past success of NY/NJ Baykeeper. Security provided by Naval forces would eliminate any potential poaching.

PROJECT FIRST COST (Oct 2016): \$7,420,000



Hudson-Raritan Estuary (HRE) Feasibility Study
Naval Weapons Station Earle, Middletown, New Jersey
Source: NJGIN 2015 Orthoimagery

