REBUILD BY DESIGN

LIVING BREAKWATERS

IP EDITION
STATEN ISLAND AND RARITAN BAY

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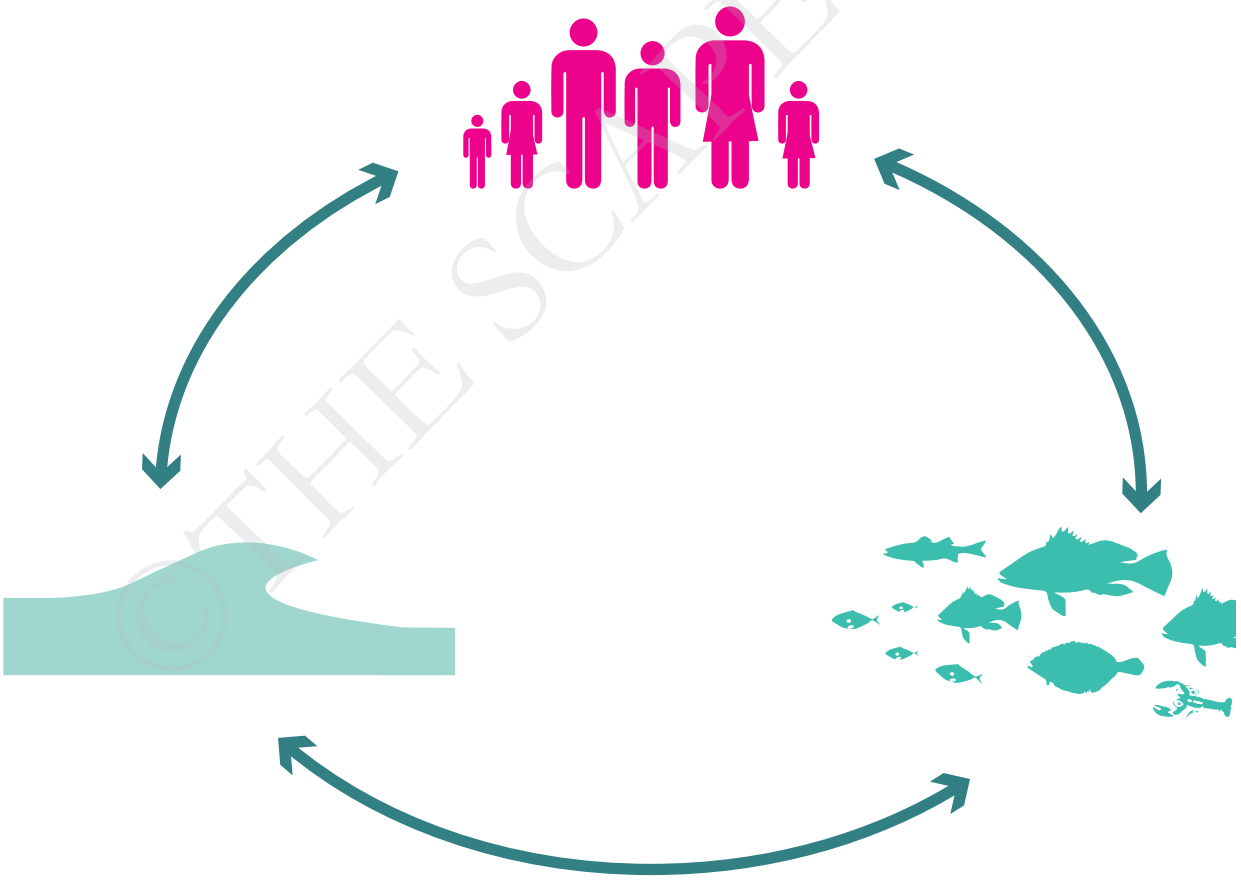
The SCAPE team has developed a science-driven methodology that pairs layered eco-infrastructural systems sited for risk-reduction with social and educational networks, rebuilding water based infrastructures in tandem with surrounding communities.



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LIVING BREAKWATERS ON STATEN ISLAND

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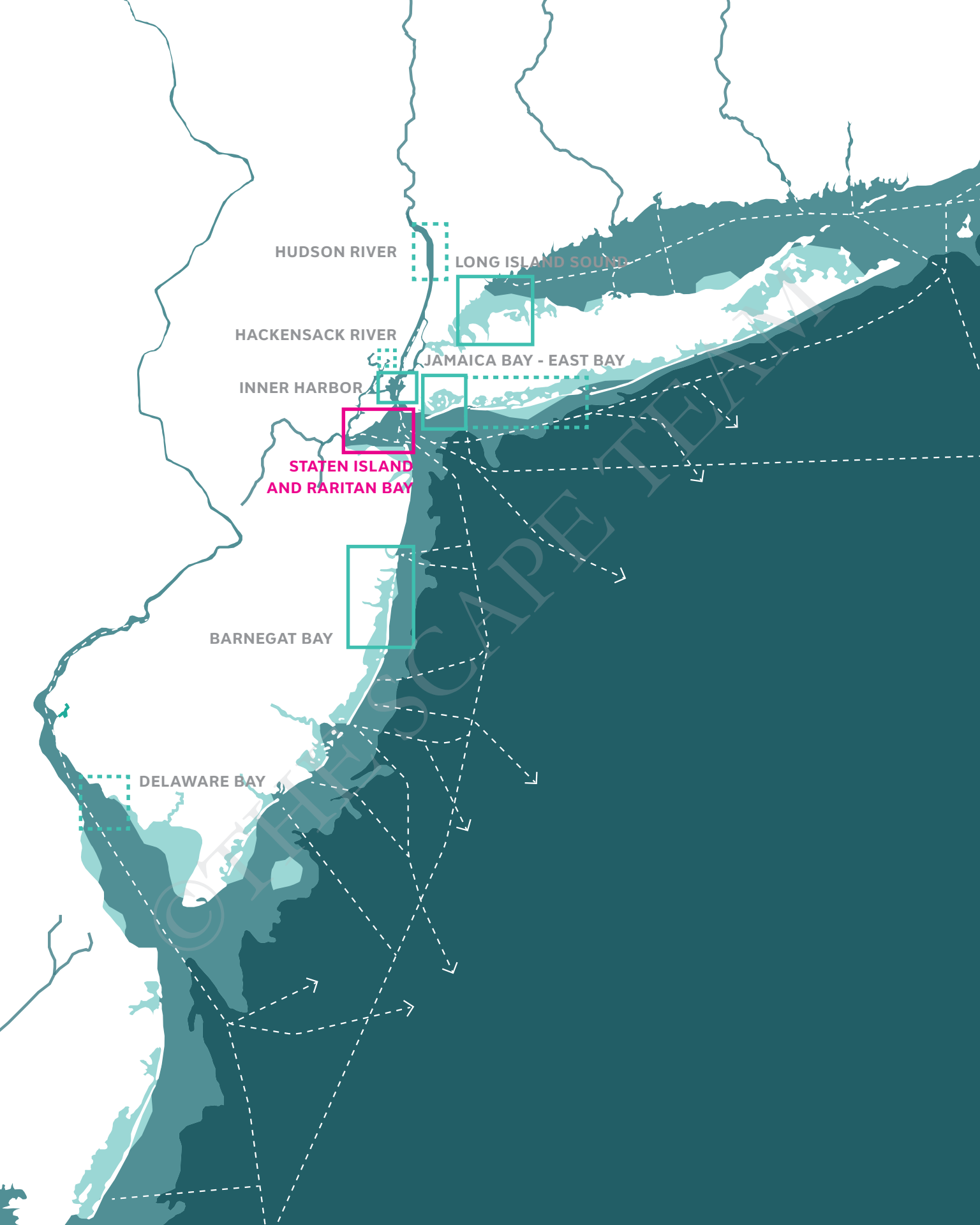
HUDSON RIVER
LONG ISLAND SOUND
HACKENSACK RIVER
JAMAICA BAY - EAST BAY
INNER HARBOR
STATEN ISLAND
AND RARITAN BAY
BARNEGAT BAY
DELAWARE BAY
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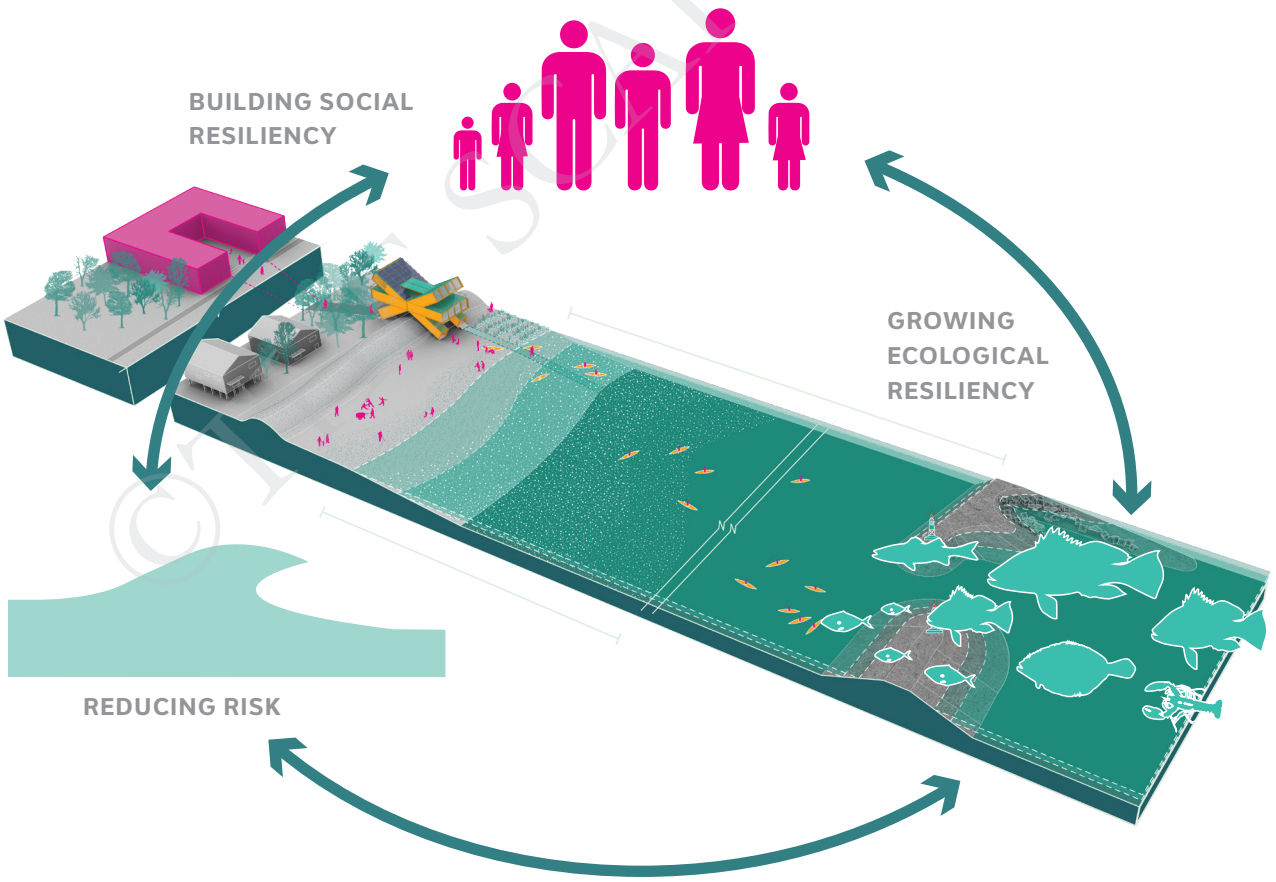
INTRODUCTION

THE LIVING BREAKWATERS PROJECT REDUCES RISK, REVIVES ECOLOGIES, AND CONNECTS EDUCATORS TO THE SHORELINE, inspiring a new generation of harbor stewards and a more resilient region over time. Staten Island sits at the mouth of the New York Bight and is vulnerable to wave action and erosion. Rather than create a wall between people and water, our project embraces the water, increases awareness of risk, and steps down that risk with a necklace of breakwaters to buffer against wave damage, flooding, and erosion. We have designed "reef street" micro-pockets of habitat complexity to host finfish, shellfish, and lobsters, and also modeled the breakwater system at a macro scale to understand how and where they can most effectively protect communities. This living infrastructure will be paired with social resiliency frameworks in adjacent neighborhoods. Through the Billion Oyster Project and an associated network of programmed Water Hubs, local schools will be empowered with science, recreation, education, and access. Our approach is especially suited to Staten Island's South Shore, but it is also replicable in other waterfront communities faced with the similar duality of risk and opportunity presented by their connection to the water. Tottenville, the site of our proposed Phase One pilot, was once known as "the Town the Oyster Built." During Sandy, lives were tragically lost, and homes and parks were severely damaged. Moving forward, we can foster a vibrant water-based culture, invest in our students, shoreline ecologies and economies, and Tottenville can claim the mantle as the Town the reef re-built.



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THE PROTECTIVE SHALLOWS

Staten Island's South Shore was once buffered by a wide shallow bathymetric shelf known as the "West Bank." Oysters and clams once played a major role in the Raritan Bay ecosystem and economy. Reefs and leased oyster beds extended across the shallow water flats of Raritan Bay, reducing storm impacts and filtering water. Over time, dredging and the collapse of oyster populations diminished its capacity to protect the shore. Staten Island can also look back at a rich history of recreational facilities along the shoreline that Staten Islanders started populating in the early 19th century.

"RAKING FOR OYSTERS" AT PRINCE'S BAY, 1869

CRESCENT BEACH, AROUND 1900

BATHERS AT THE BLUFF OF TOTTENVILLE

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SHALLOW BATHYMETRY AND HISTORIC OYSTER BED LOCATIONS IN THE NEW YORK HARBOR

SOURCE: USACE and Clyde MacKenzie.

BAYS AS ECOLOGICAL INFRASTRUCTURE

Beyond Raritan Bay, the Northeast region hosts many bay landscapes that were directly affected by Hurricane Sandy and face continued risks from urbanization, contamination, sediment starvation, and sea level rise. In stage II of the Rebuild by Design competition, our team mapped potential enhancements to endangered bay landscapes and communities including Barnegat Bay, Raritan Bay, the Inner Harbor, Jamaica Bay, the Great South Bay, and others along the Upper Hudson. We developed a range of design ideas to nourish this bay system to not only help protect us from extreme storm events but also to improve the quality of our everyday lives.

The shallow bay landscape of Raritan Bay - the focus of our RBD stage III focus and this report - is a complex and critical area of topography, maritime economic activity, and recreation, and hosts historic ecosystems which are under threat of disappearing. In addition, this landscape bears the immense potential for educational engagement and community participation in their safekeeping. Interconnected systems by their very nature are more resilient - they are not dependent upon one element to succeed or fail but rather offer networked opportunities for change and continual recalibration. To us, this is the definition of resiliency.

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REGIONAL APPROACH

The Northeastern Seaboard contains several shallow water bay landscapes with shoreline communities at risk. These endangered bays are key test sites for the layered approach described on the following page.

THE LAYERED APPROACH

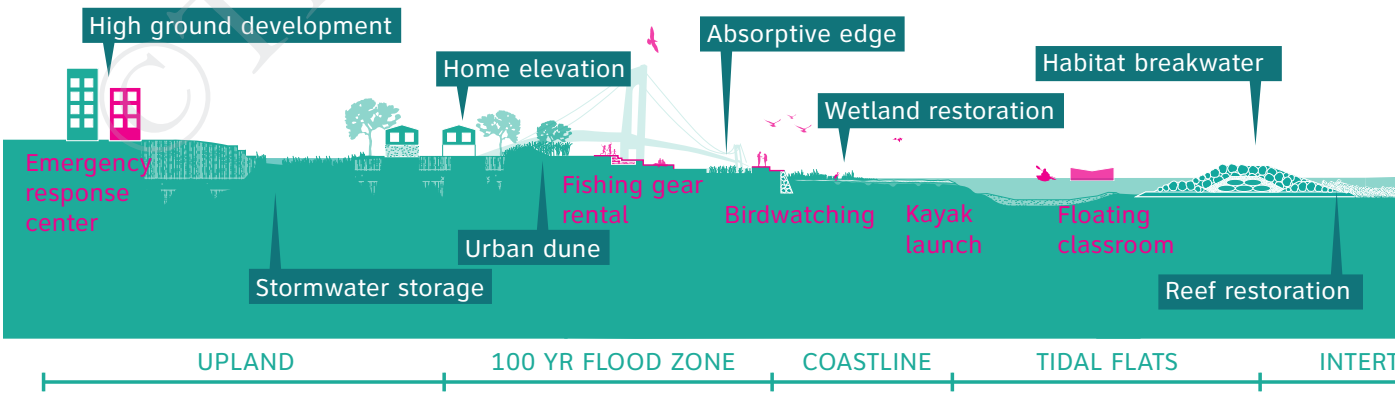
Our project combines **COASTAL RESILIENCY** infrastructure with **HABITAT ENHANCEMENT** techniques and **COMMUNITY ENGAGEMENT** models, deploying a layered strategy that links in-water protective forms to on-shore interventions. We aim to advance ideas that help protect us from periodic weather extremes while improving the quality of our everyday lives.

New York City faces a high degree of potential risk. Rather than cut communities off from the water with a levee or wall, we need to embrace the water and its economic and recreational opportunities, using shallow water landscapes to stabilize the shore. Ecosystems can be restored to step down risk faced by coastal communities and to rebuild diverse habitats. The **LAYERED APPROACH** extends across a thick section, creating multiple lines of defense that will not fail singularly and catastrophically.

People are a critical component of any ecosystem. Thus we have developed a framework to link people with the shoreline and with the water through education, engagement, and the expansion of a water-based recreational economy. Shallow, slow, and safe water opens up a variety of in-water programming opportunities, from sport diving to charter fishing to kayaking to citizen stewardship, all enabled by the layered approach to risk reduction.

FLOATING CLASSROOM
SCIENCE BARGE
KAYAK LAUNCH
FISH CLEANING STATION
FISHING GEAR RENTAL
BIRDING POINT
SEASONAL FOOD
EMERGENCY RESPONSE
COMMUNICATION HOT SPOT
ESCAPE ROUTE
TRAIL HEAD
OVERLOOK TOWER

WATER BASED COMMUNITIES



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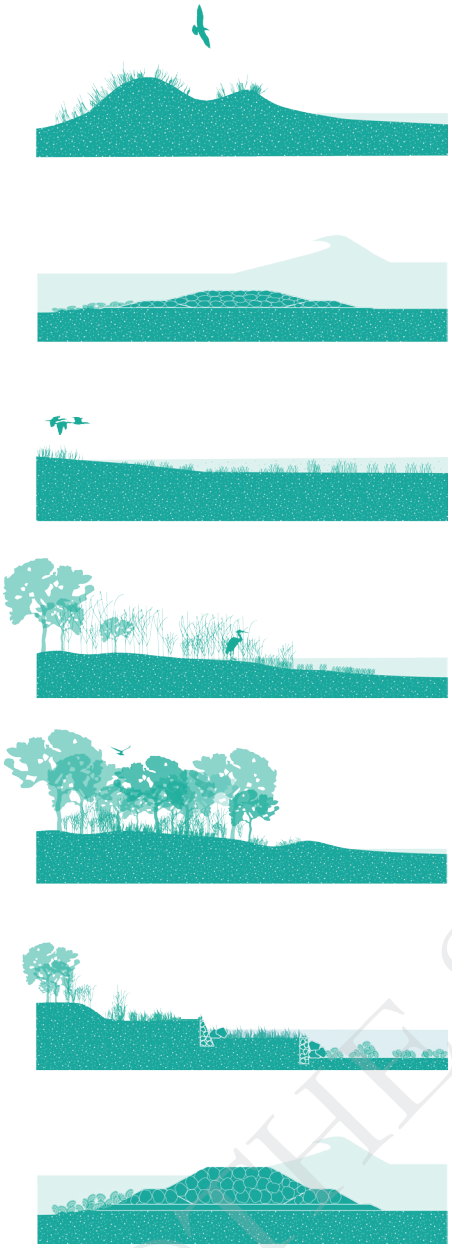
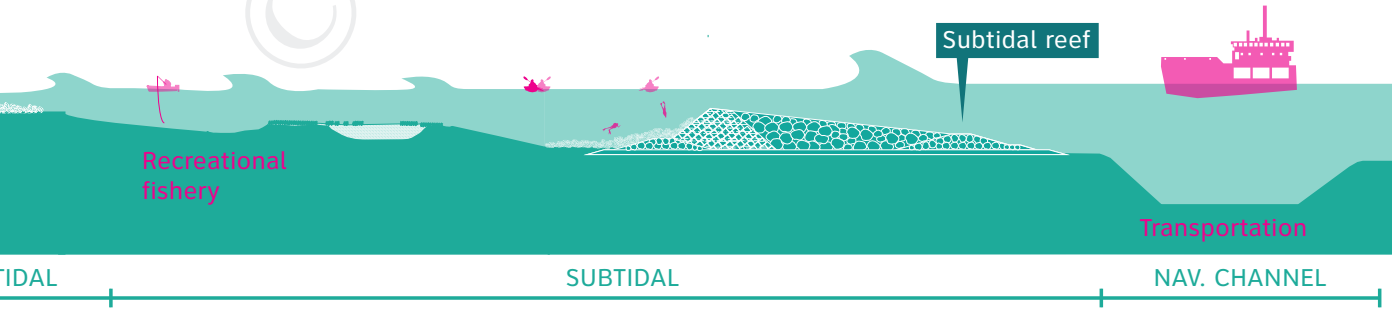


LOW SALT MARSH
HIGH SALT MARSH
MARITIME SHRUBLAND
MARITIME FOREST
MARITIME MUD FLAT
BEACH
DUNE
SALT PANNE
SALT SHRUBLAND
DUNE SLACK
SUBTIDAL REEF
BARRIER ISLAND



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LIVING BREAKWATERS PROPOSAL

STATEN ISLAND'S SOUTH SHORE

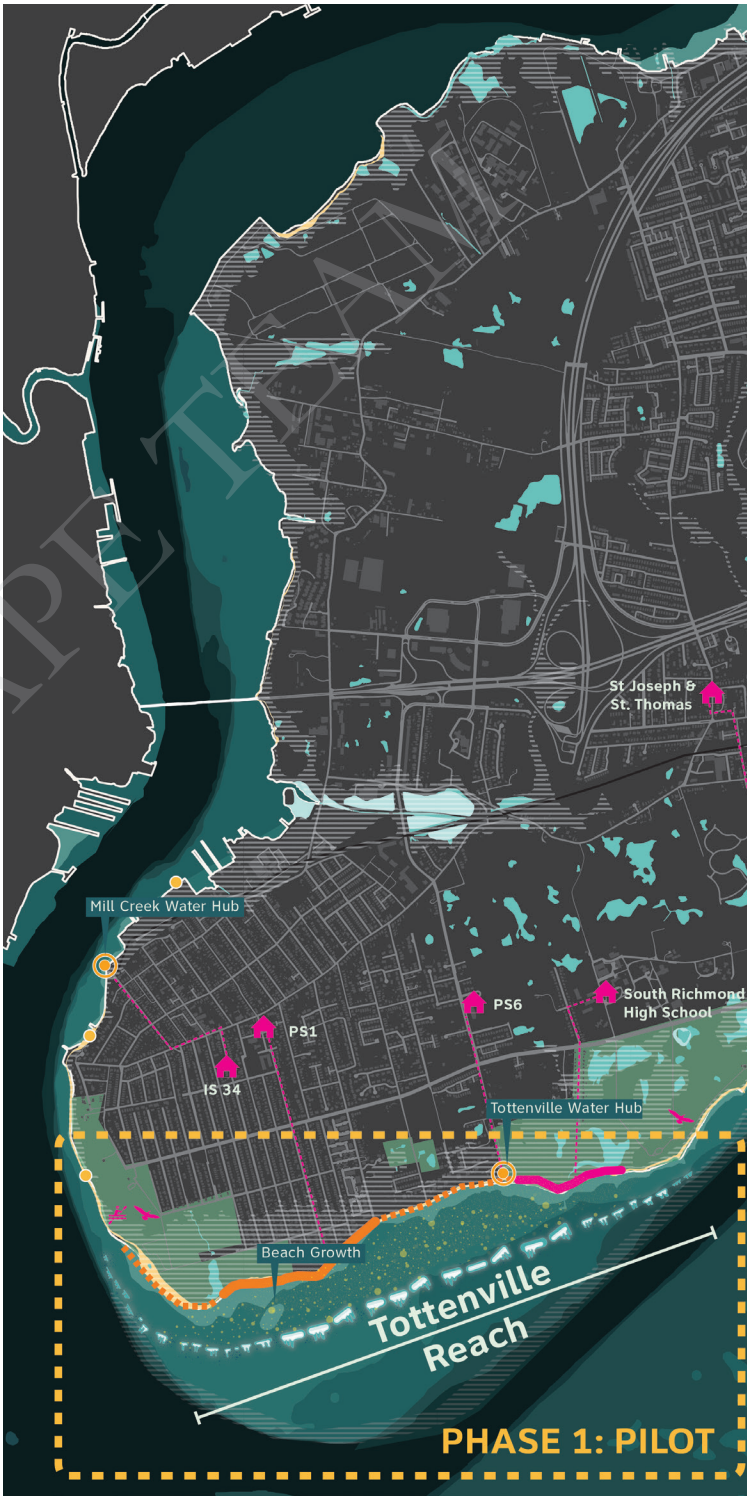
Living Breakwaters are strategically sited relative to the South Shore of Staten Island to reduce risk for coastal communities, build reef habitat for juvenile fish and shellfish, and enhance waterfront recreation and stewardship. In areas of high land loss and risk to infrastructure, they are located to encourage sedimentation and help build back the beach. In more ecologically or economically sensitive zones, such as hard clam habitat areas, their footprint is minimized or realigned.

The project strengthens ongoing shoreline improvements and creates opportunities for rethinking the coastal edge. For example, new dune systems created by the NYC Department of Parks and Recreation will be protected from erosion by the offshore system, and new seawall constructions can incorporate living marsh elements due to lower wave velocity. Structures called Water Hubs are located at critical points along the shore and serve as places of gathering for classes, orientation, kayak & equipment storage, data monitoring, and emergency response. Combined, the system creates a crucial link between communities, schools, and the water's edge.

PHASE 1
The TOTTENVILLE REACH
This approximately 13,000 LF stretch protects the Tottenville community and valuable parklands at Conference House Park.

PHASE 2
CRESCENT BEACH AND ANNADALE REACH
This 6000-7000 LF stretch protects communities from Crescent Beach to the mouth of Great Kills Harbor.

PHASE 3
LEMON CREEK & WOLFES POND REACH
Protects Lemon Creek, Prince's Bay, and valuable State Parklands.



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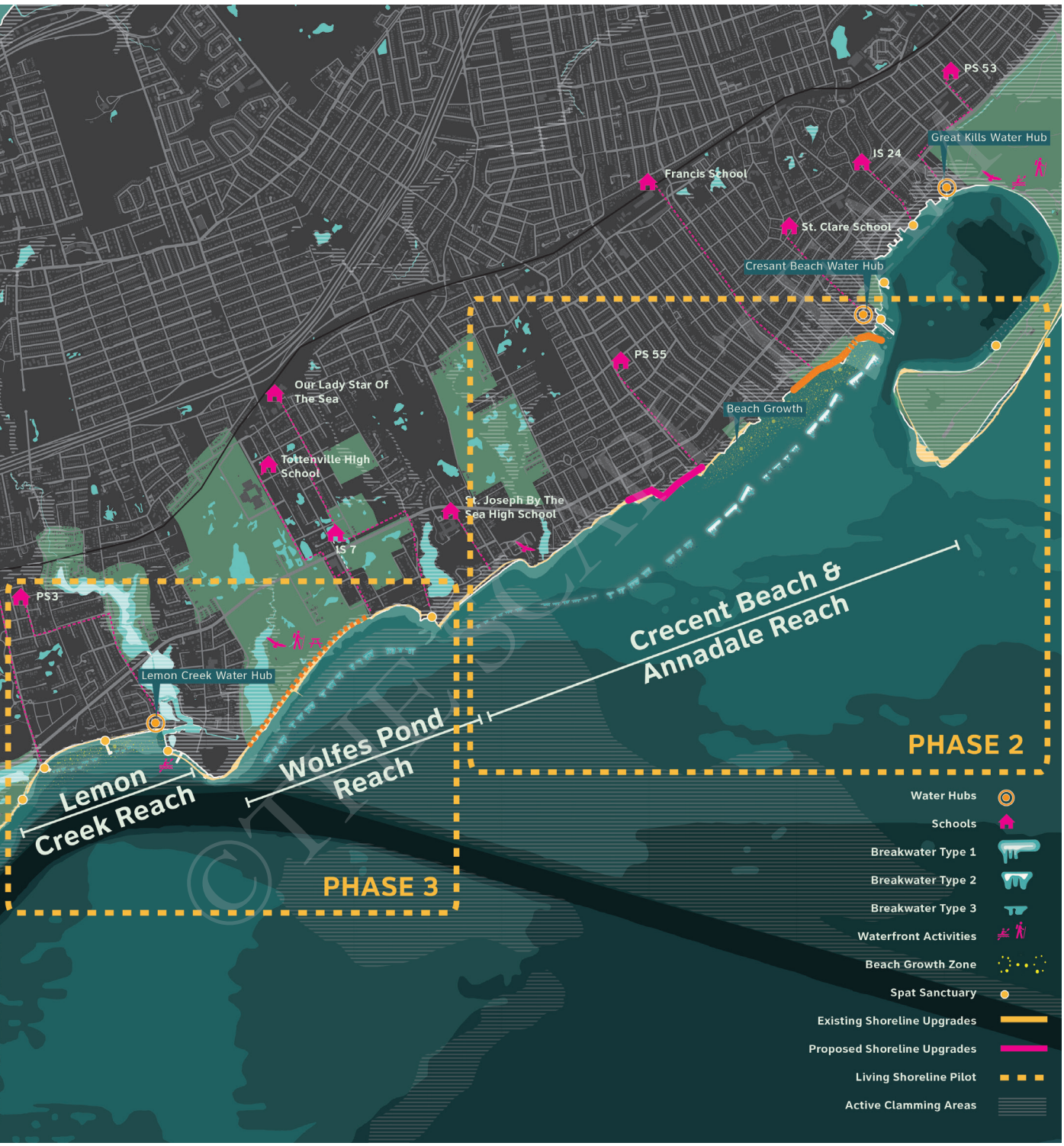
PS 53
Great Kills Water Hub
IS 24
Francis School
St. Clare School
Cresant Beach Water Hub
PS 55
Our Lady Star Of The Sea
Beach Growth
Tottenville High School
St. Joseph By The Sea High School
IS 7
PS 3
Lemon Creek Water Hub
Crecent Beach & Annadale Reach
Wolfes Pond Reach
Lemon Creek Reach
PHASE 2
PHASE 3
Water Hubs
Schools
Breakwater Type 1
Breakwater Type 2
Breakwater Type 3
Waterfront Activities
Beach Growth Zone
Spat Sanctuary
Existing Shoreline Upgrades
Proposed Shoreline Upgrades
Living Shoreline Pilot
Active Clamming Areas

COASTAL EROSION ALONG STATEN ISLAND'S SHORE

REDUCING RISK

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DESIGN TO REDUCE FRAGILITY

Risk is embedded in all coastal resiliency strategies. Our approach aims to step down risk with each investment, redefine scales of harm, and move beyond the impossible scenario of enclosing “dry” from “wet” to address larger issues of ecosystem collapse, cycles of regional decline, and managed, calmer, and non-disastrous inundation events. We build up resiliency by strengthening networks, incrementally decreasing the overall risk embedded in the system. Our strategies mitigate the impacts of flooding without eliminating it altogether and re-focus the region on ecologically driven improvements that make flooding slower, cleaner, and safer, and less prone to catastrophic failure. We aim to make risk legible and part of everyday life, while building ecological and social resiliency through new stewardship programs on the waterfront.

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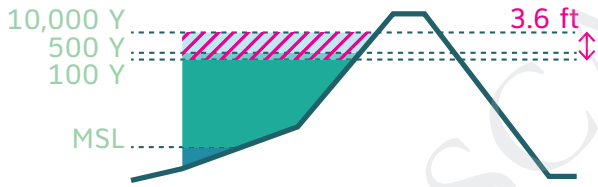
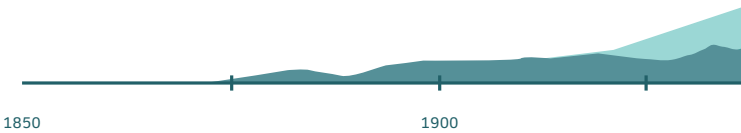
NETHERLANDS



NEW YORK CITY

COMMUNITY FRAGILITY New York City faces high degrees of uncertainty when planning for risk, mostly due to the variable nature of hurricanes. We propose to move beyond single-use flood infrastructure, focusing instead on the LAYERED APPROACH.



Climate change is bringing new challenges to the eastern seaboard of the United States. Its predicted effects include a rise in mean temperature and precipitation, accelerated sea level rise, and more frequent, extreme flooding and storm events like Hurricane Sandy. These phenomena, coupled with the excess nitrogen levels in our waters from treated wastewater and fertilizers put our critical estuaries and bays at risk of disappearing within decades, if not years. With their shallow bathymetry and delicate balance of vulnerable marine life, a loss of these endangered waters would threaten not only the places we live, work, and play in but also our cultural connection to the water. We know that in addition to being beloved fishing and recreational grounds, bay landscapes are crucial absorptive ecological infrastructure that help reduce risk for communities located along the water's edge.

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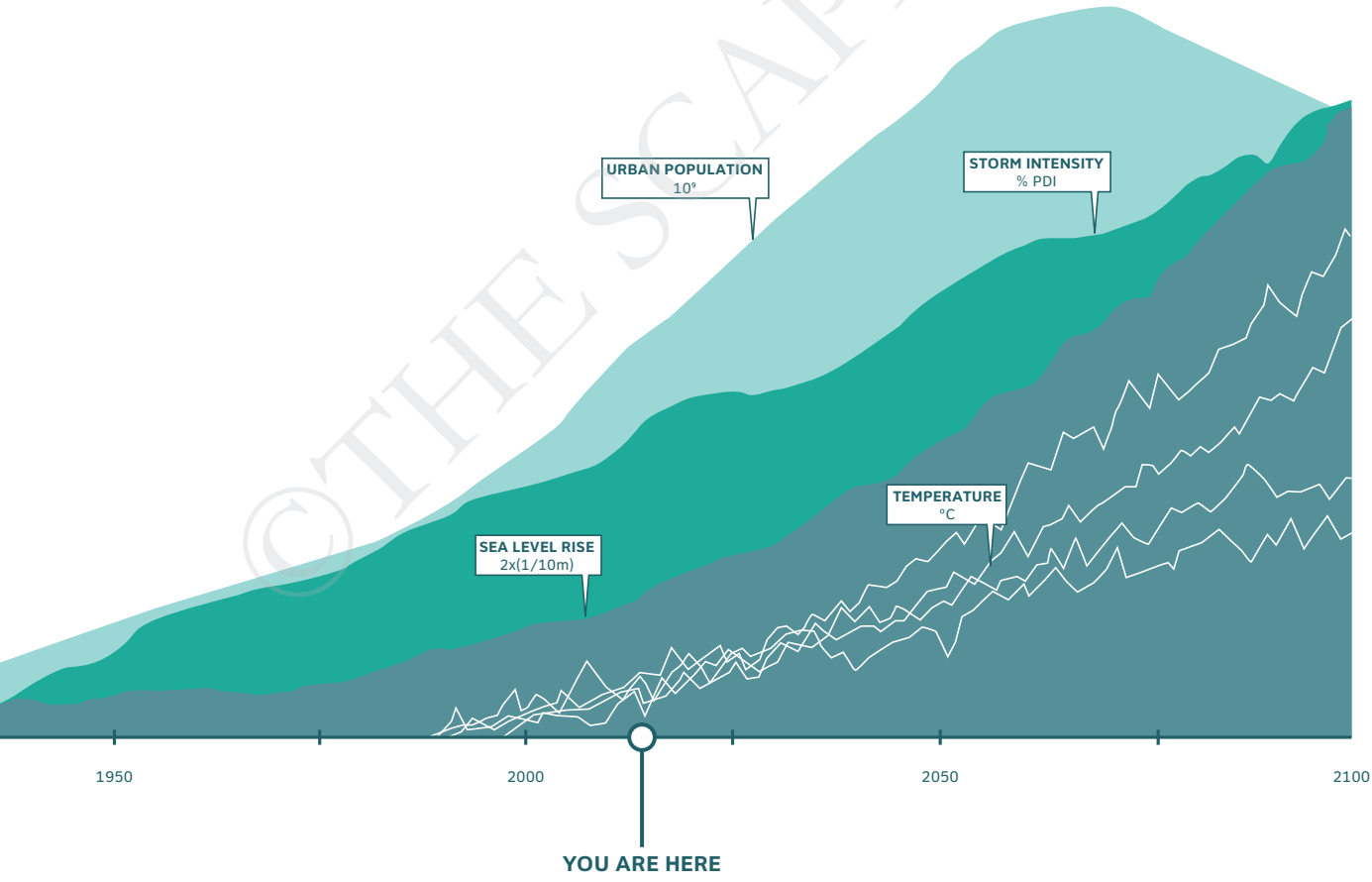

SHORELINE LOSS + INUNDATION

STATEN ISLAND AND RARITAN BAY

Staten Island is exposed to extreme wave action and storm surge during hurricane events due to its location directly at the mouth of the New York Bight. Within Staten Island, however, the impacts of Hurricane Sandy were highly localized – the East Shore was impacted differently than the North Shore or South Shore. Each condition requires a localized response, but in all instances, can be paired with ecological and recreational systems for greater public benefit and longevity.

Living Breakwaters proposes layered strategies for risk reduction in these neighborhoods closely connected to the water. Our project helps to preserve a cultural, lived relationship with the water by protecting water based economies such as sport and charter fishing, marinas, and small waterfront structures such as restaurants.

WATER-BASED ECONOMIES

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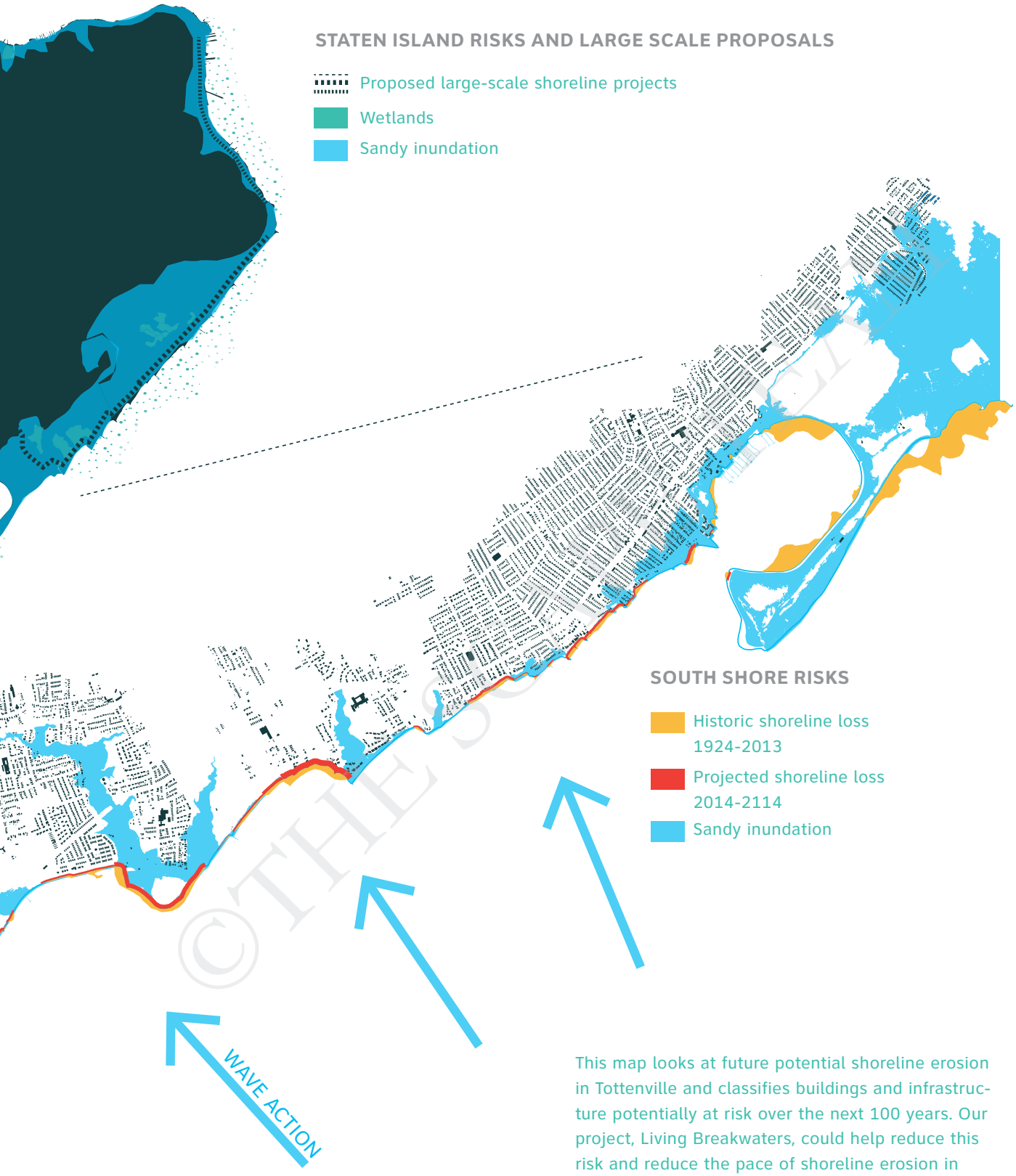

This map looks at future potential shoreline erosion in Tottenville and classifies buildings and infrastructure potentially at risk over the next 100 years. Our project, Living Breakwaters, could help reduce this risk and reduce the pace of shoreline erosion in Tottenville.

VULNERABLE SHORELINE COMMUNITIES

On the South Shore, coastal erosion and land loss combine with wave action for catastrophic effect. The area has lost acres of land over the last 100 years. Over time, beaches become narrower and less public, communities become more exposed. Infrastructure crumbles into open water, parklands are lost, and critical ecosystems are destroyed. Without action, the shoreline will continue to erode and threaten the communities of Tottenville, Prince's Bay, Lemon Creek, Great Kills, Crescent Beach, and Annadale.

"Kids don't use our beaches because they are cut off."
- S.i. Resident

TOTTENVILLE WATER ACCESS CONFLICT

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TOTTENVILLE EMERGENCY DUNE

"Sandy damaged and eroded a lot of the beaches I used to take walks on."
- S.I. Resident

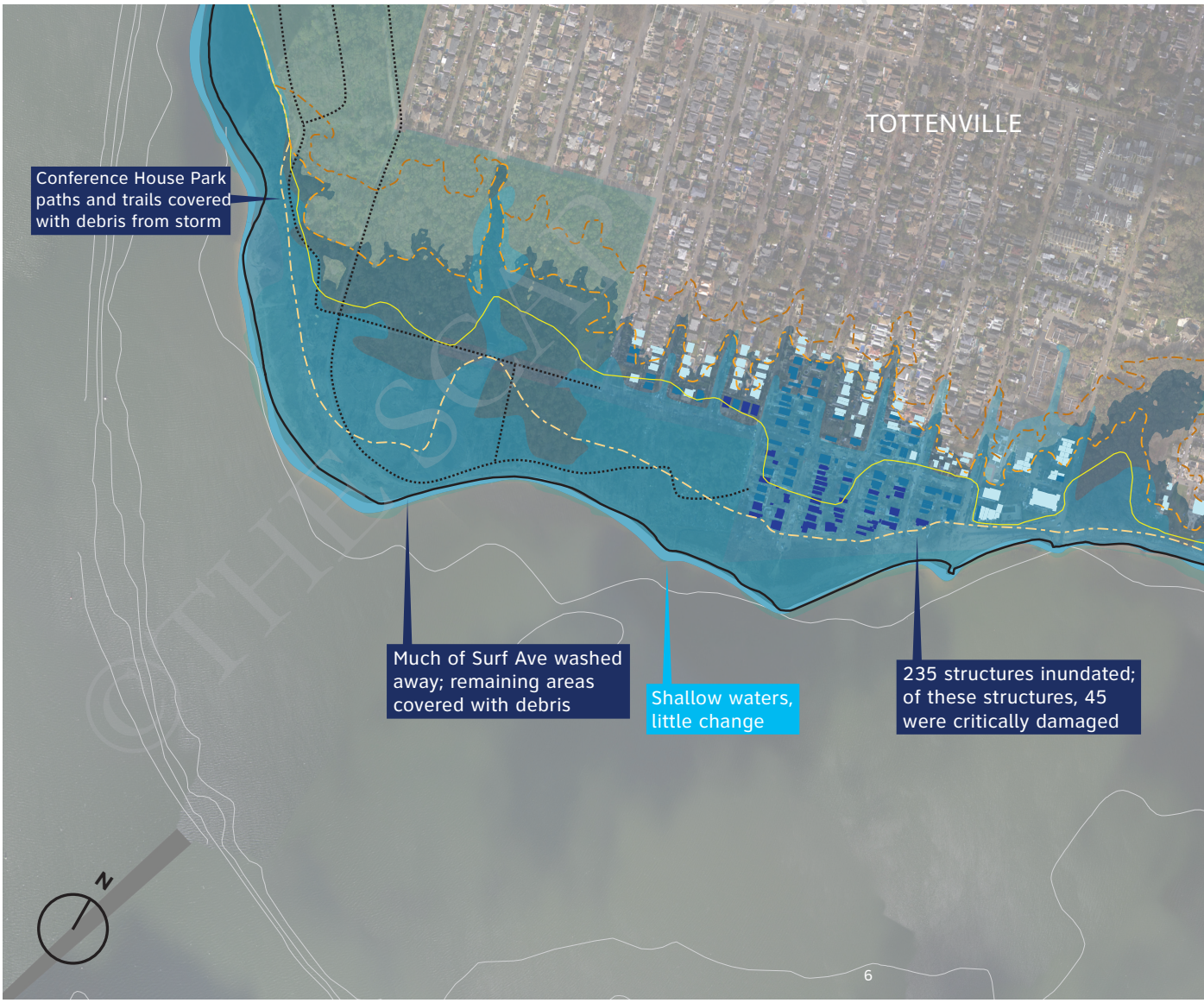
LEMON CREEK CLIFF EROSION

PREVIEW

SANDY DAMAGE ASSESSMENT

This map - one of a sequence along the entire coast - integrates flooding extents with anecdotal data or damage, debris, and water flow provided by the community to describe and assess damages experienced due to Superstorm Sandy.

- Wetlands Trail (Mt Loretto)
- Beach Trail (Mt Loretto)
- Conference House Park Trails
- Major land erosion
- Minor land erosion
- Erosion along the beaches
- Sedimentation along the beaches



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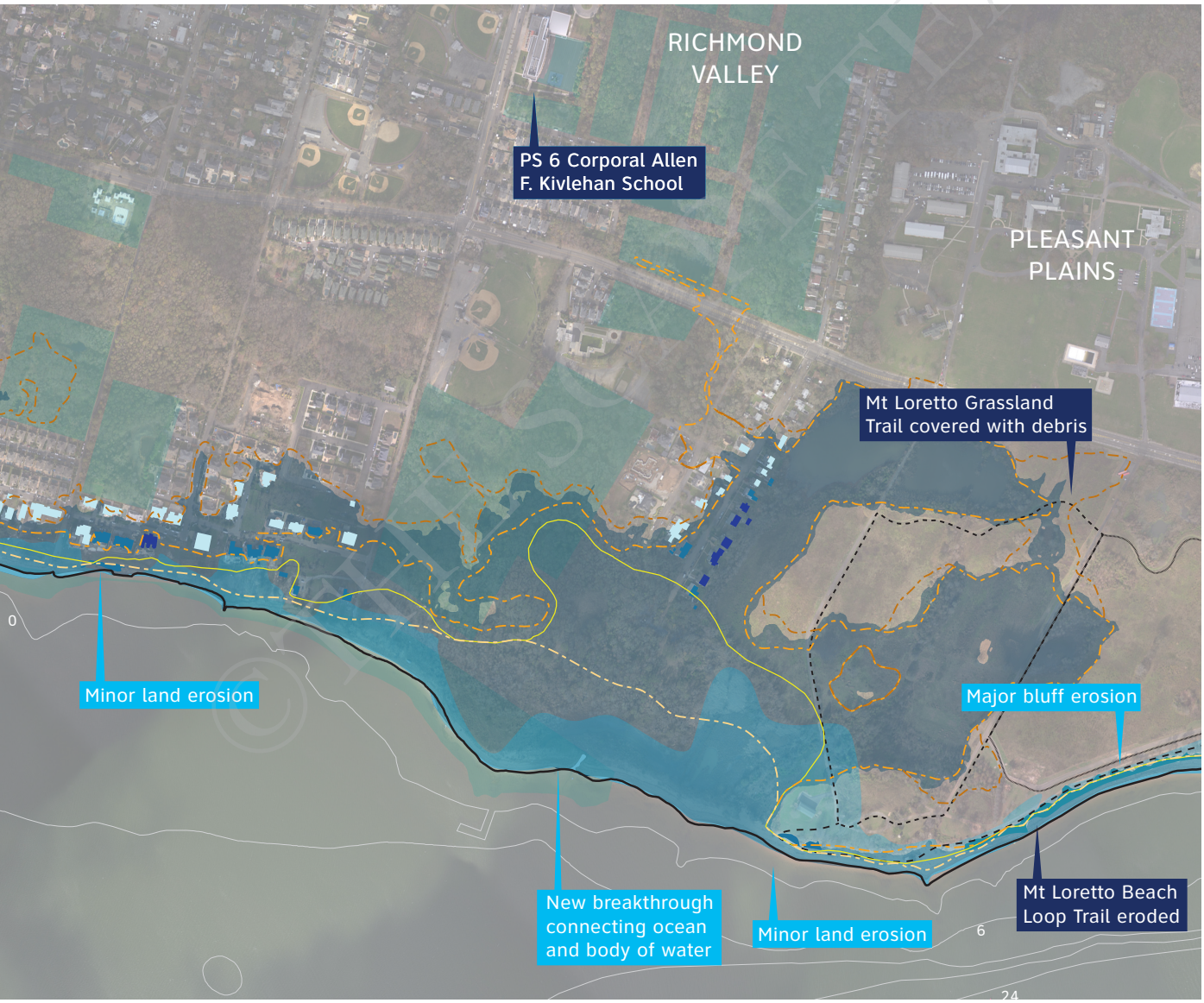
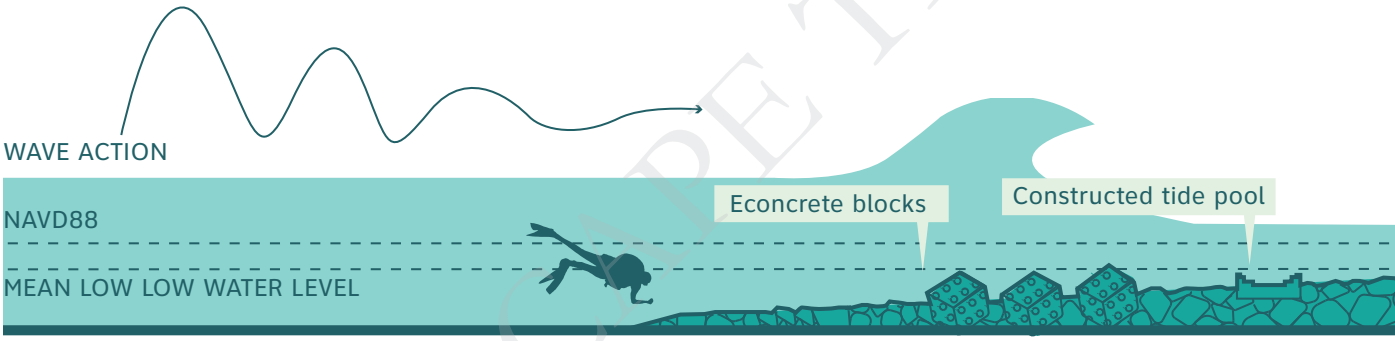
- Parksland
- Inundation from Sandy storm surge
- Major debris on land from Sandy
- Buildings Inundated, 6-18 ft standing water
- Buildings Inundated, 3-6 ft standing water
- Buildings Inundated, 0-3 ft standing water
- Bodies of water on land
- 500-year flood line
- 100-year flood line
- Coastal High Hazard Area
- LiMWA
- Maritime locations damaged



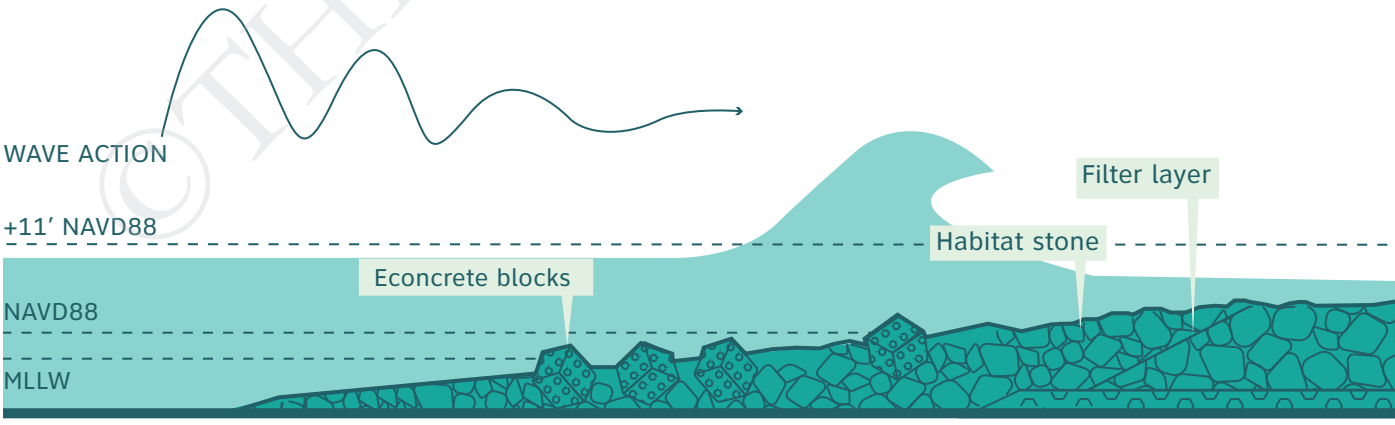
REDUCING RISK WITH BREAKWATERS

Conventional techniques that "protect" us by erecting a barrier between people and water ultimately sever our visual and physical relationship to the water. We want to reduce risk while increasing our perception of risk by building a landscape scale intervention that integrates aquatic habitat and community access.

Breakwaters do not keep the water out, however, they have the ability to calm water, reduce wave heights, and prevent shoreline erosion. High velocity water - such as when a levee is overtopped - can be fatal.



SUBTIDAL BREAKWATER



EXPOSED BREAKWATER

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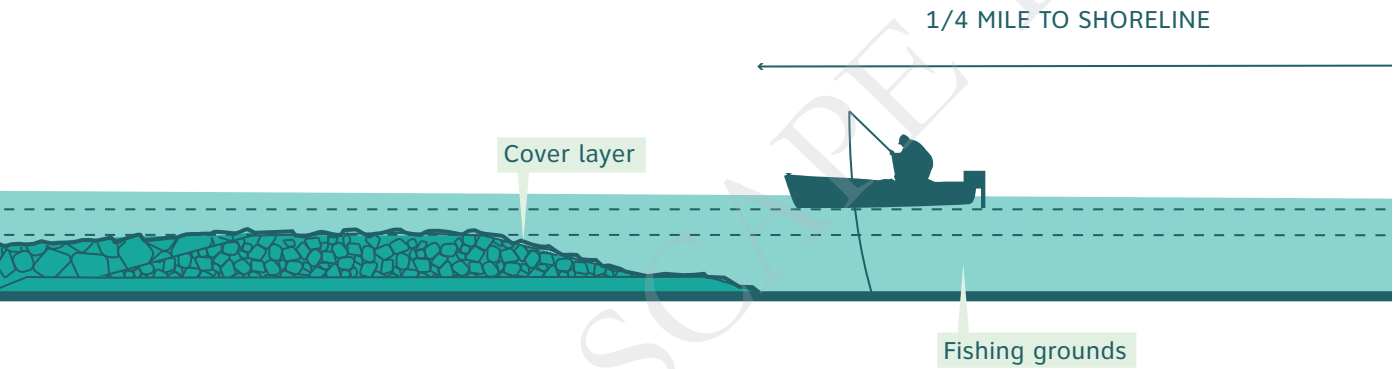
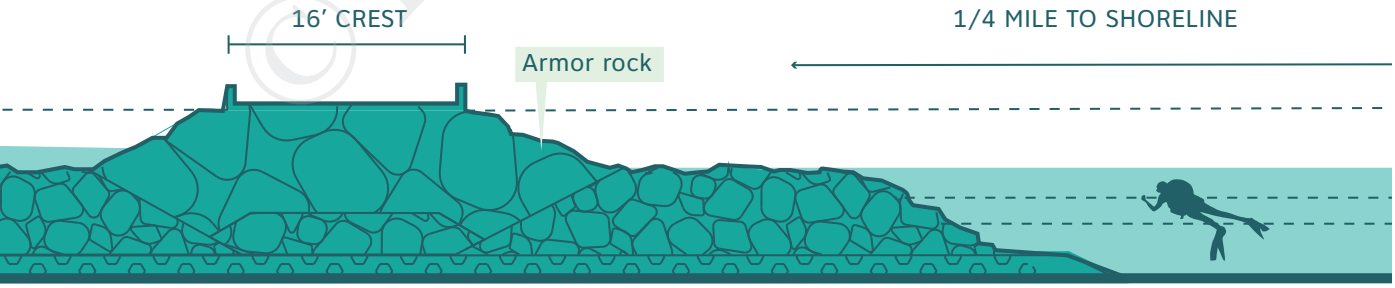
Breakwaters absorb wave energy and create slow moving water, which can save lives, reduce damage to structures, and reduce floodwater elevations. Calm water in turn encourages sedimentation, which replenishes protective beaches. Designed with attention to materiality, scale, and location, these breakwaters will enhance maritime ecosystems and link risk reduction with a renewed stewardship of a biodiverse and activated Raritan Bay shoreline. Designed as living systems, they build up biogenically in parallel with future sea level rise





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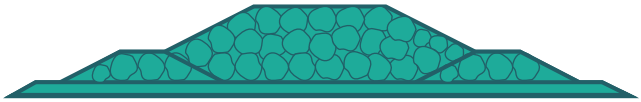
HABITAT BREAKWATERS

Breakwaters reduce risk at the shoreline by reducing wave velocity and reducing shoreline loss - they do not keep out flood water.



DO

REDUCE EROSION

LESSEN WAVE IMPACTS

PROVIDE HABITAT

ENCOURAGE RECREATIONAL FISHERIES

DO NOT

KEEP OUT FLOOD WATER

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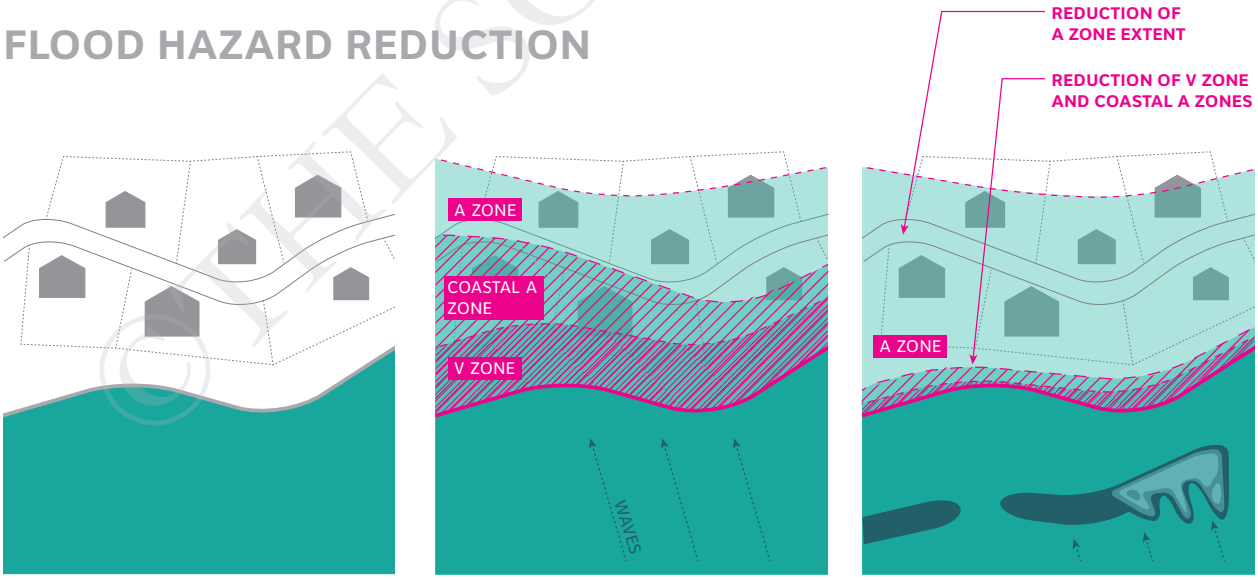
FLOOD HAZARD REDUCTION



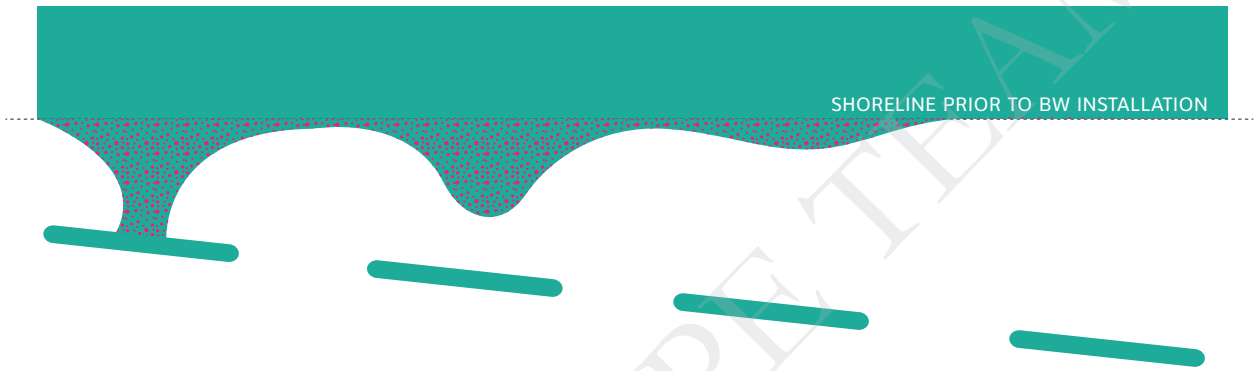
EVERYDAY

FLOOD EVENT

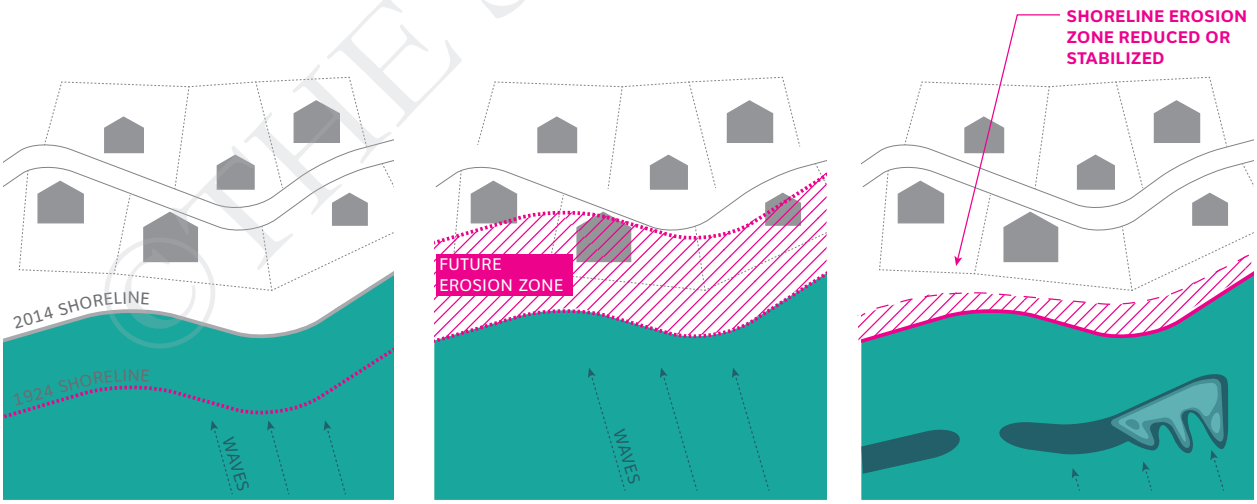
FLOOD EVENT + BREAKWATER

SEDIMENTATION STUDIES

Breakwaters can be designed and located to encourage or discourage sedimentation along the shoreline. Sedimentation can help to extend the beach, useful in areas of high erosion. Sedimentation is not desirable close to critical habitat or navigation channels.



COASTAL EROSION REDUCTION



HISTORIC SHORELINE LOSS

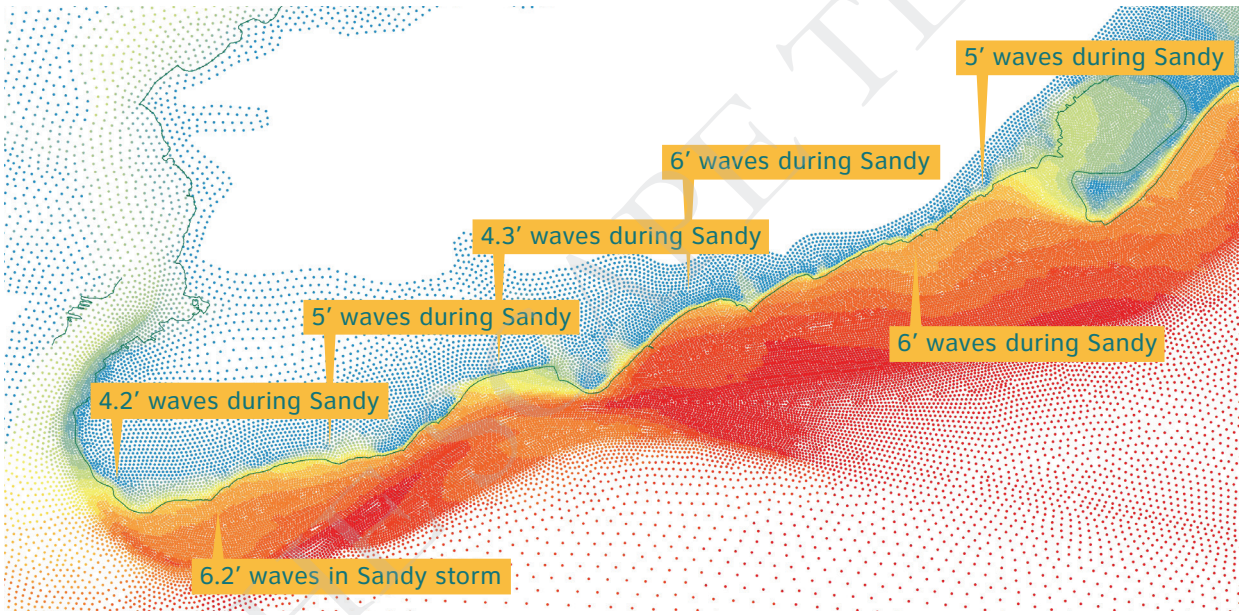
PROJECTED SHORELINE LOSS WITH NO INTERVENTION

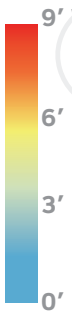
SHORELINE STABILIZATION WITH INTERVENTION

©THE SCAPE TEAM

TEST RISK-REDUCTION SCENARIOS

Communities that were flooded by Sandy face complex decisions about the future, and a quantification of flood and wave risk-reduction is a useful tool to understand these direct physical benefits of ecological infrastructure. Having developed a suite of strategies that could be applicable for coastal protection against storm surges, it was imperative that the team tested their performance using the latest scientific tools.





WAVE HEIGHT DURING SANDY - NO INTERVENTION
Hydrodynamic model: Base Run
During Sandy, the South Shore was exposed to waves 4 feet to 6 feet in height. During typical nor’easters, the shoreline also faces wave damage.

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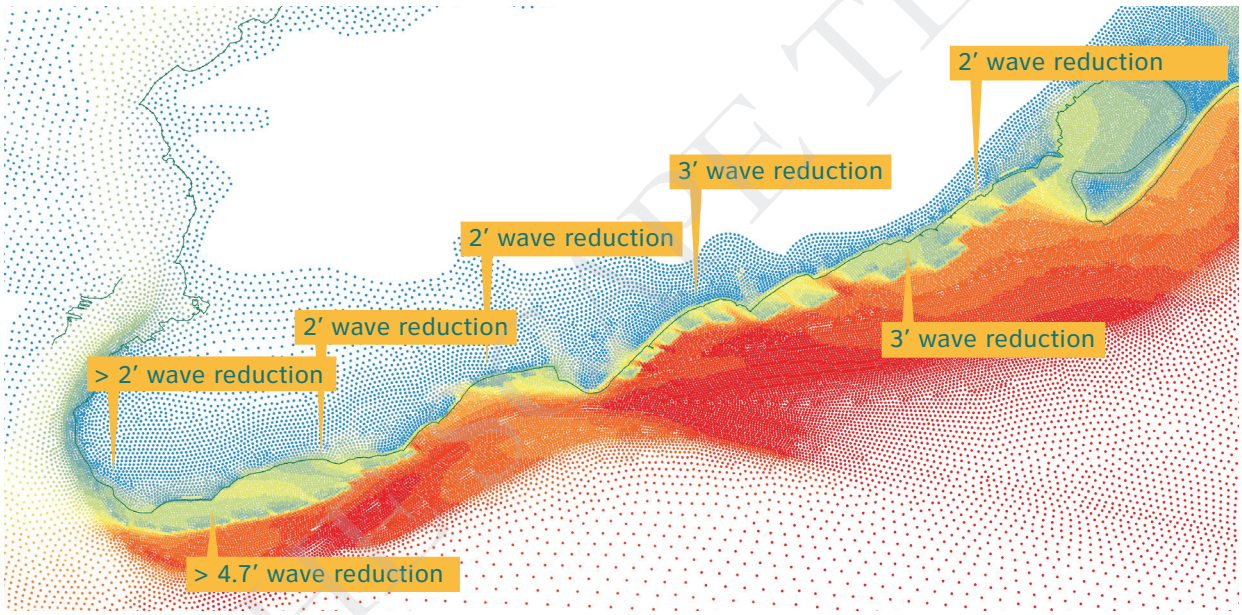
With Dr. Philip Orton of the Stevens Institute of Technology, we have evaluated the proposed strategies using a computerized model – the ADCIRC/SWAN storm surge and wave modeling system. The model results show that having exposed breakwaters for Hurricane Sandy led to wave height decreases of 4.0 feet and base flood elevation reductions of 4.5 feet at Staten Island’s South Shore, by causing partial breaking and a reduction in wave heights as they passed over the breakwater.



WAVE HEIGHT DURING SANDY - WITH INTERVENTION
(all breakwaters modeled as exposed)
With a system of entirely exposed breakwaters, wave damage risk during a Sandy storm reduces greatly, up to 3 feet- 4.5 feet in select zones. During typical nor’easters wave damage may be entirely avoided.

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RISK REDUCTION ANALYSIS: TOTTENVILLE PILOT IMPACTS WITHOUT PROJECT (100 YEAR)

The "baseline scenario" - what would happen in the future without the project? - took a number of factors into consideration: Tottenville's shoreline is eroding. If historic rates continue, we predict approximately 20 acres of land lost to erosion, mostly parkland. This will decrease the distance between homes, businesses, and critical infrastructure, and the shoreline, in some cases causing these assets to be lost to erosion. Even if not directly impacted by erosion, the loss of shoreline will increase exposure to waves during a storm event as long as there is not limiting topography, effectively increasing the extent of V and Coastal A zones and associated increases in Base Flood Elevations. Exposure to intense wave action and higher water velocities will continue to put people's lives and safety at risk. The baseline scenario did not consider the added risk of sea level rise in this impact analysis.

Projected land loss due to erosion
Land lost to erosion (next 100 years)^

Future Storm Risk
500 year floodplain
Other A Zone (100 year floodplain)
*Projected Expanded Coastal A Zone**
Coastal A Zone
Projected Expanded V Zone*
Current V Zone

Anticipated Damage: Buildings & Roads
Total Loss / Reconstruction (erosion)^
Severe (V zone)
Moderate - Heavy (Coastal A Zone)
Water damage only (A zone)

^ Erosion is independent of storm event.
** Wave zones are anticipated to increase proportionaly with the receeding shoreline as long as the elevation excedes the current BFE in the exisisting V and Coastal A zones.*

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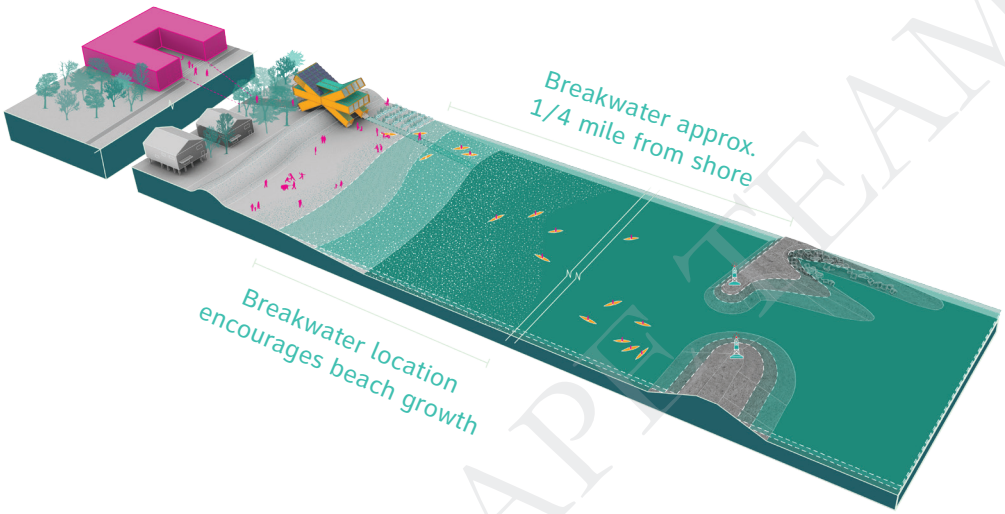
Increased V and Coastal A zones
due to erosion of shoreline

A SUITE OF REPLICABLE TYPOLOGIES

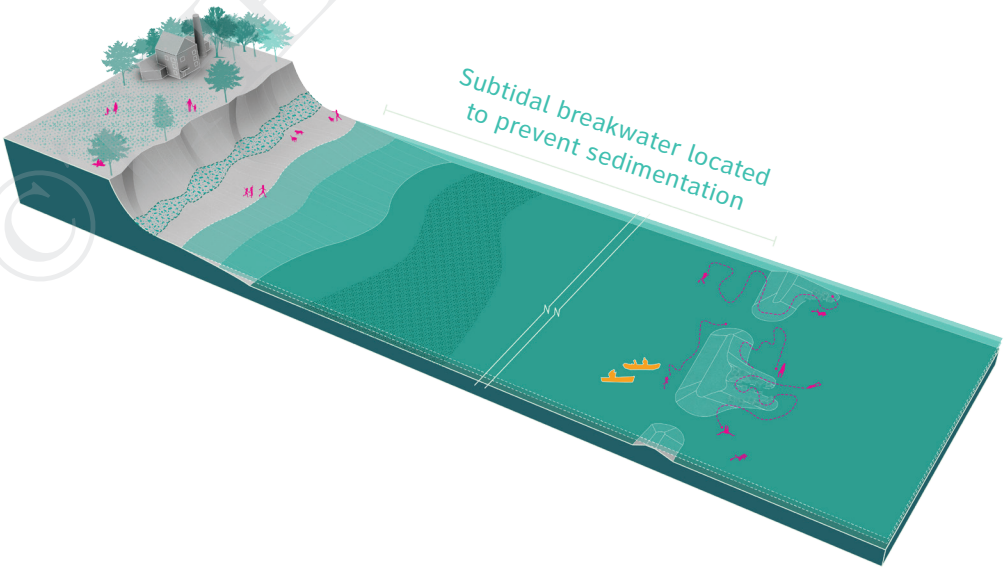
REVIVE RECREATIONAL ECONOMIES

CASE STUDY SITE: TOTTENVILLE, STATEN ISLAND



PROTECT SENSITIVE ECOSYSTEMS

CASE STUDY SITE: MT. LORETTO STATE PARK, STATEN ISLAND



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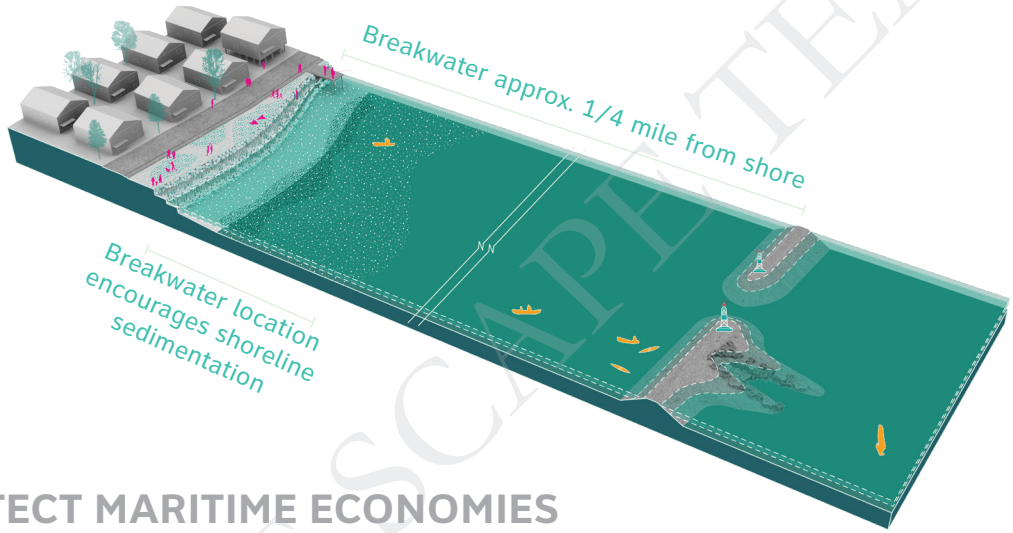
The **LAYERED APPROACH** takes distinct configurations along multiple stretches of shoreline. The concept is replicable yet highly contextual, as the combination of breakwaters and living shoreline techniques is applicable over a broad range of conditions. In addition to helping reduce erosion and wave heights at the shoreline, breakwaters can be designed to catalyze new forms of waterfront occupation, grow beaches, protect sensitive ecosystems, and enable more ecologically and aesthetically sensitive methods of shoreline construction. Design considerations include breakwater design height, width, distance to shoreline, and length. Each condition shown here uses these design parameters differently to propose a new relationship between Staten Islanders and the shore.

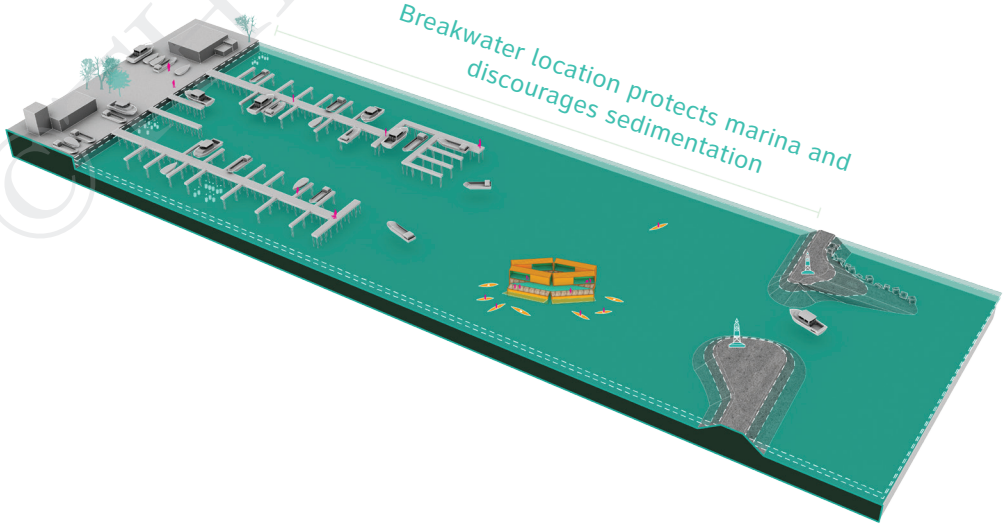
ENABLE NEW EDGES

CASE STUDY SITE: ANNADALE AND CRESCENT BEACH, STATEN ISLAND



PROTECT MARITIME ECONOMIES

CASE STUDY SITE: GREAT KILLS HARBOR, STATEN ISLAND



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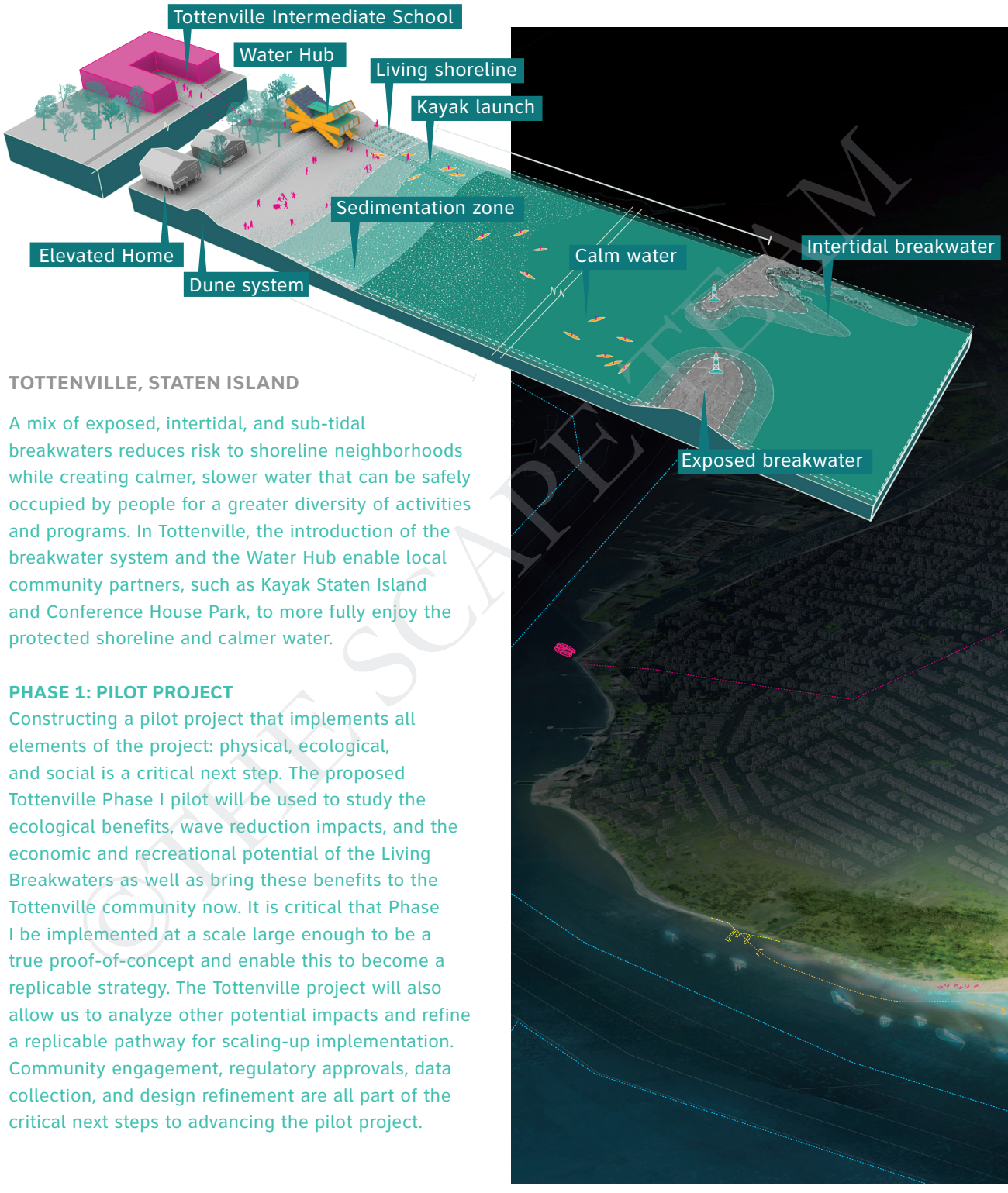
REVIVE RECREATIONAL ECONOMIES



TOTTENVILLE, STATEN ISLAND

A mix of exposed, intertidal, and sub-tidal breakwaters reduces risk to shoreline neighborhoods while creating calmer, slower water that can be safely occupied by people for a greater diversity of activities and programs. In Tottenville, the introduction of the breakwater system and the Water Hub enable local community partners, such as Kayak Staten Island and Conference House Park, to more fully enjoy the protected shoreline and calmer water.

PHASE 1: PILOT PROJECT

Constructing a pilot project that implements all elements of the project: physical, ecological, and social is a critical next step. The proposed Tottenville Phase I pilot will be used to study the ecological benefits, wave reduction impacts, and the economic and recreational potential of the Living Breakwaters as well as bring these benefits to the Tottenville community now. It is critical that Phase I be implemented at a scale large enough to be a true proof-of-concept and enable this to become a replicable strategy. The Tottenville project will also allow us to analyze other potential impacts and refine a replicable pathway for scaling-up implementation. Community engagement, regulatory approvals, data collection, and design refinement are all part of the critical next steps to advancing the pilot project.

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TOTTENVILLE PHASE I PILOT:

COSTS

$51 M physical infrastructure costs

$2.7 M ecological infrastructure costs

$4 M social infrastructure costs

$12 M maintenance costs

BENEFITS

$263 M of damages avoided

52 acres of habitat created

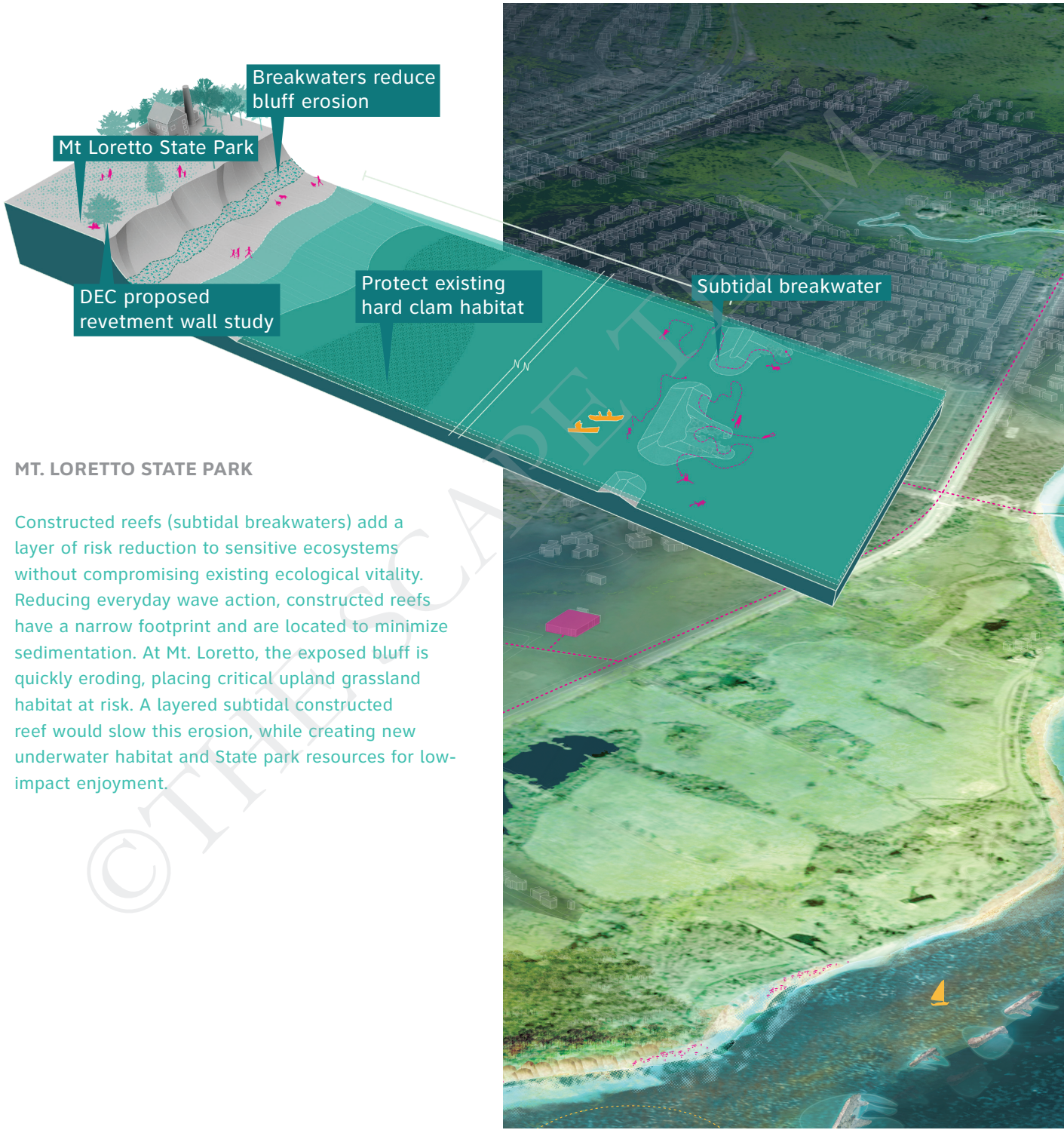
32+ species supported by the breakwaters

$15 M of potential economic generation annually

550 students engaged directly annually

23,500 students engaged island-wide annually

PROTECT SENSITIVE ECOSYSTEMS



MT. LORETTO STATE PARK

Constructed reefs (subtidal breakwaters) add a layer of risk reduction to sensitive ecosystems without compromising existing ecological vitality. Reducing everyday wave action, constructed reefs have a narrow footprint and are located to minimize sedimentation. At Mt. Loretto, the exposed bluff is quickly eroding, placing critical upland grassland habitat at risk. A layered subtidal constructed reef would slow this erosion, while creating new underwater habitat and State park resources for low-impact enjoyment.

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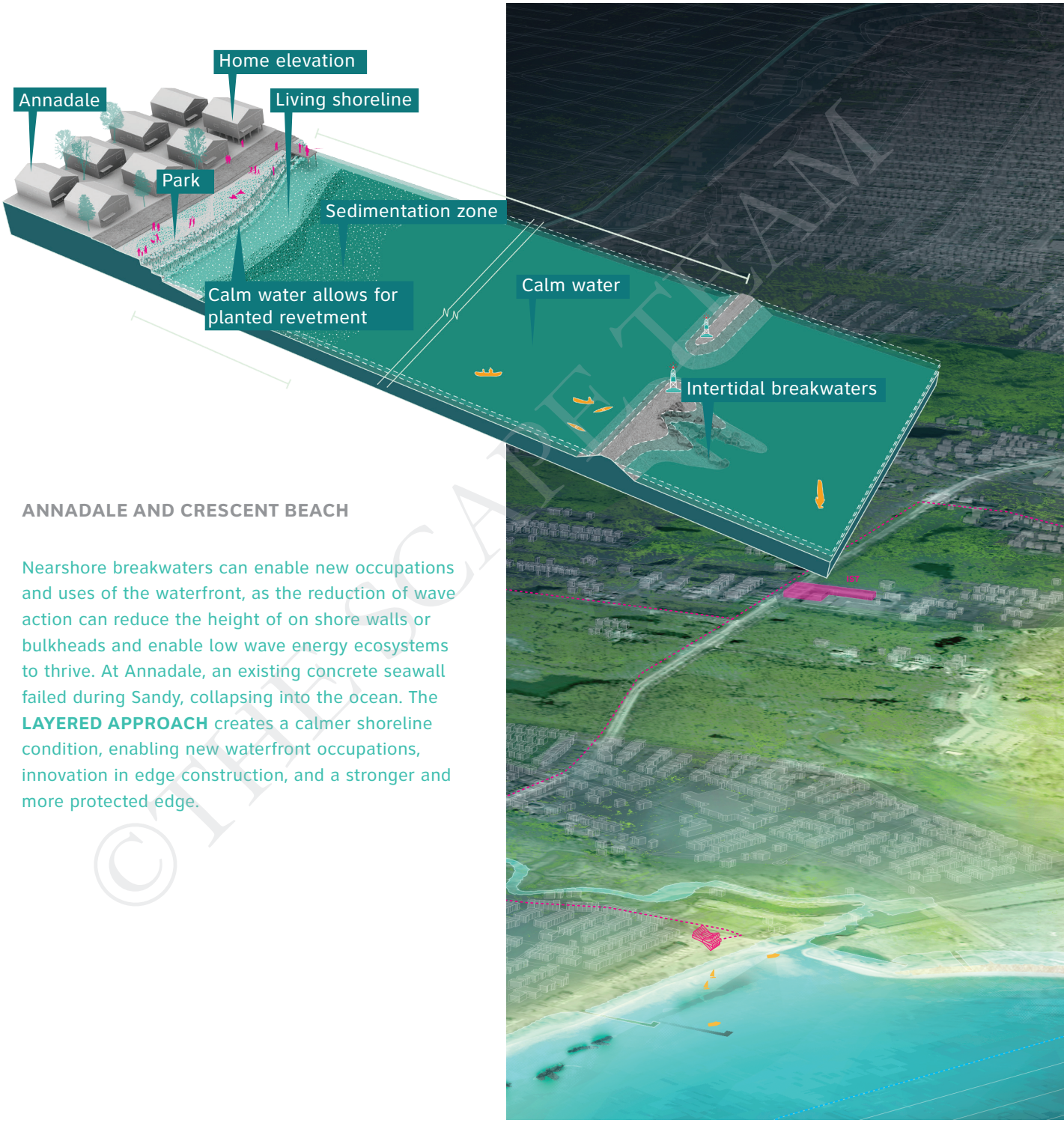
ENABLE NEW EDGES



ANNADALE AND CRESCENT BEACH

Nearshore breakwaters can enable new occupations and uses of the waterfront, as the reduction of wave action can reduce the height of on shore walls or bulkheads and enable low wave energy ecosystems to thrive. At Annadale, an existing concrete seawall failed during Sandy, collapsing into the ocean. The **LAYERED APPROACH** creates a calmer shoreline condition, enabling new waterfront occupations, innovation in edge construction, and a stronger and more protected edge.

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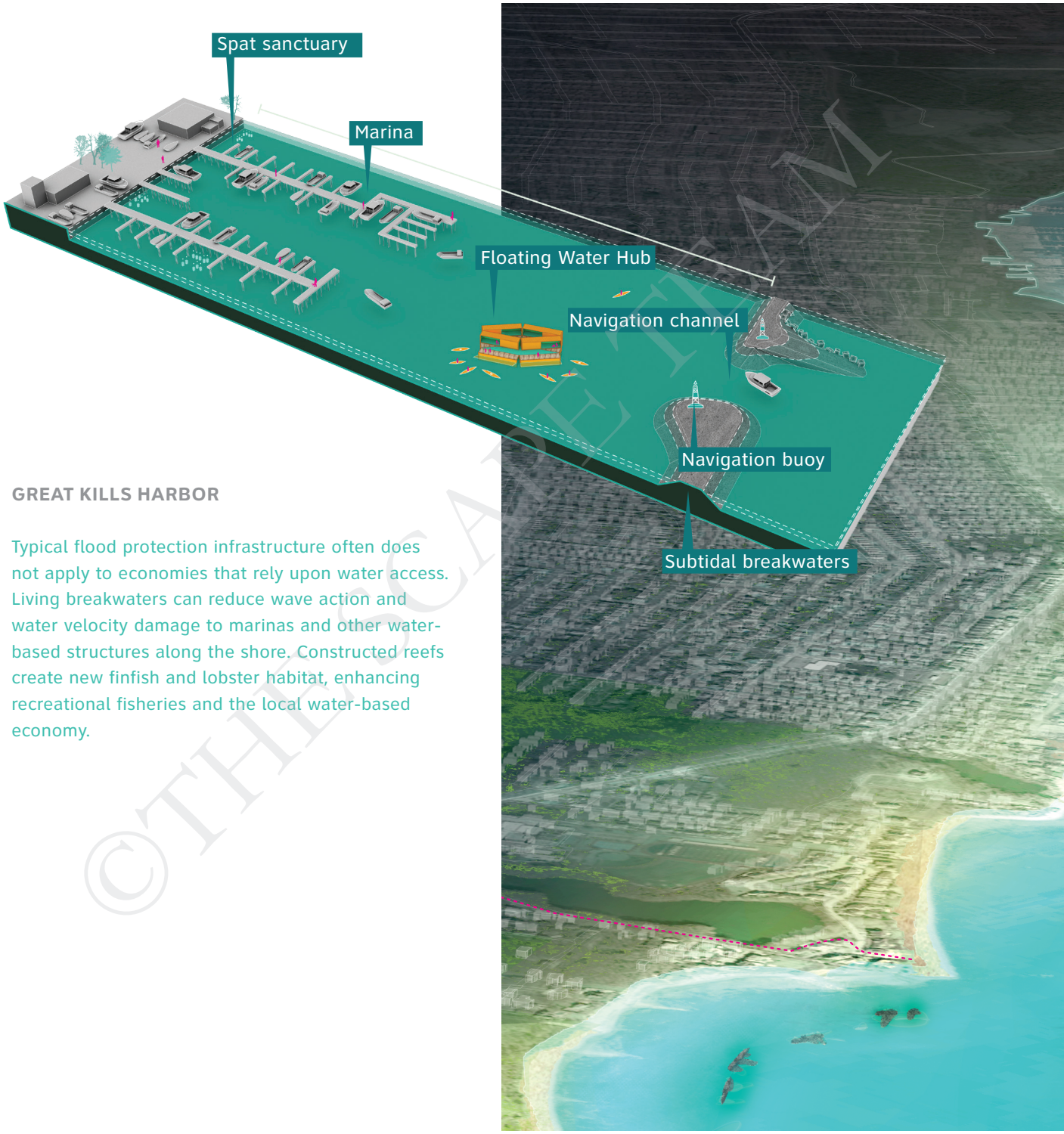
" Oysters are an attractive nuisance and pose significant human health threats. Restoration sites need to be carefully monitored.
- DEC Employee "

PROTECT MARITIME ECONOMIES



GREAT KILLS HARBOR

Typical flood protection infrastructure often does not apply to economies that rely upon water access. Living breakwaters can reduce wave action and water velocity damage to marinas and other water-based structures along the shore. Constructed reefs create new finfish and lobster habitat, enhancing recreational fisheries and the local water-based economy.

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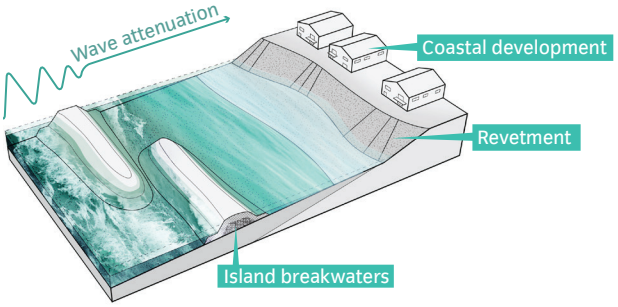
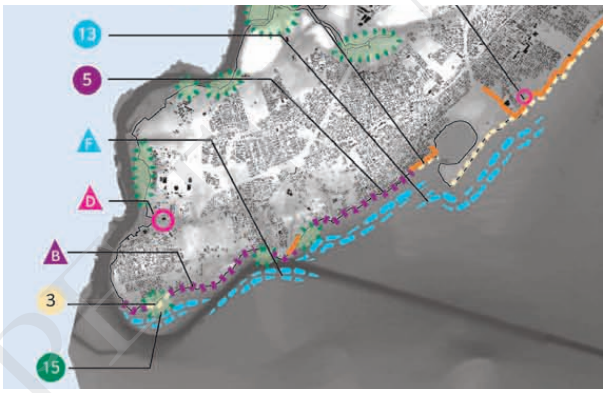
BUILDING ON EXISTING INITIATIVES

The Living Breakwaters project is coordinated with City and State rebuilding initiatives and harbor-wide restoration frameworks and adds a layer of protection that compliments and enhances on-shore upgrades



SIRR REPORT



HTTP://WWW.NYC.GOV/HTML/SIRR/HTML/REPORT/REPORT.SHTML

Comprehensive Coastal Protection Plan | Full-Build Recommendations

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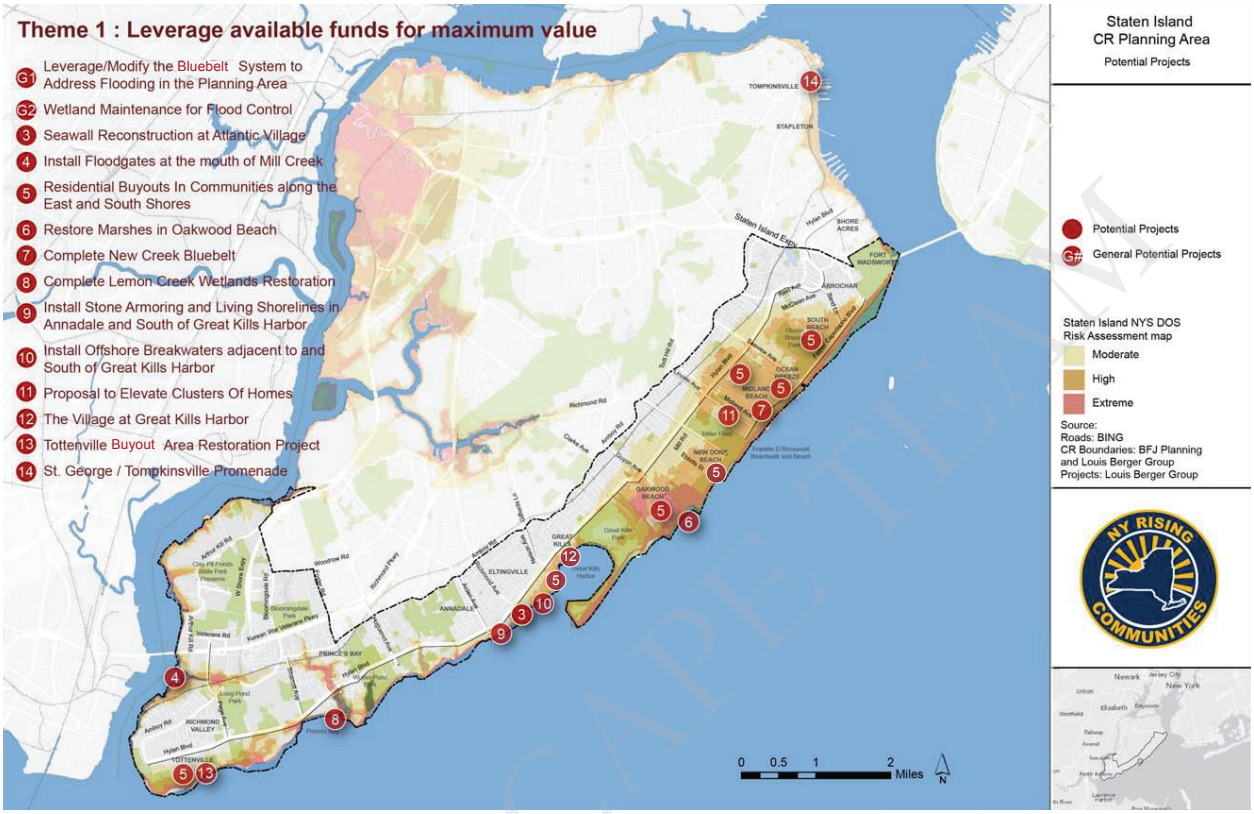
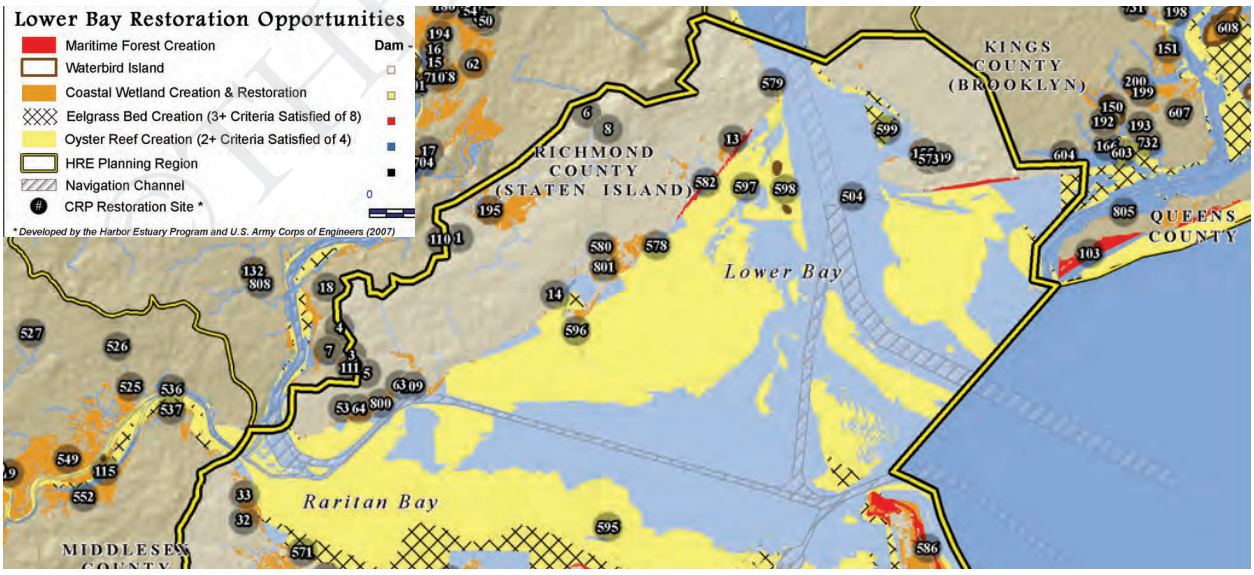
NY RISING STATEN ISLAND CONCEPT PLAN



NY / NJ HARBOR COMPREHENSIVE RESTORATION PLAN



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BIOGENIC BUILDUP

GROWING ECOLOGICAL RESILIENCY

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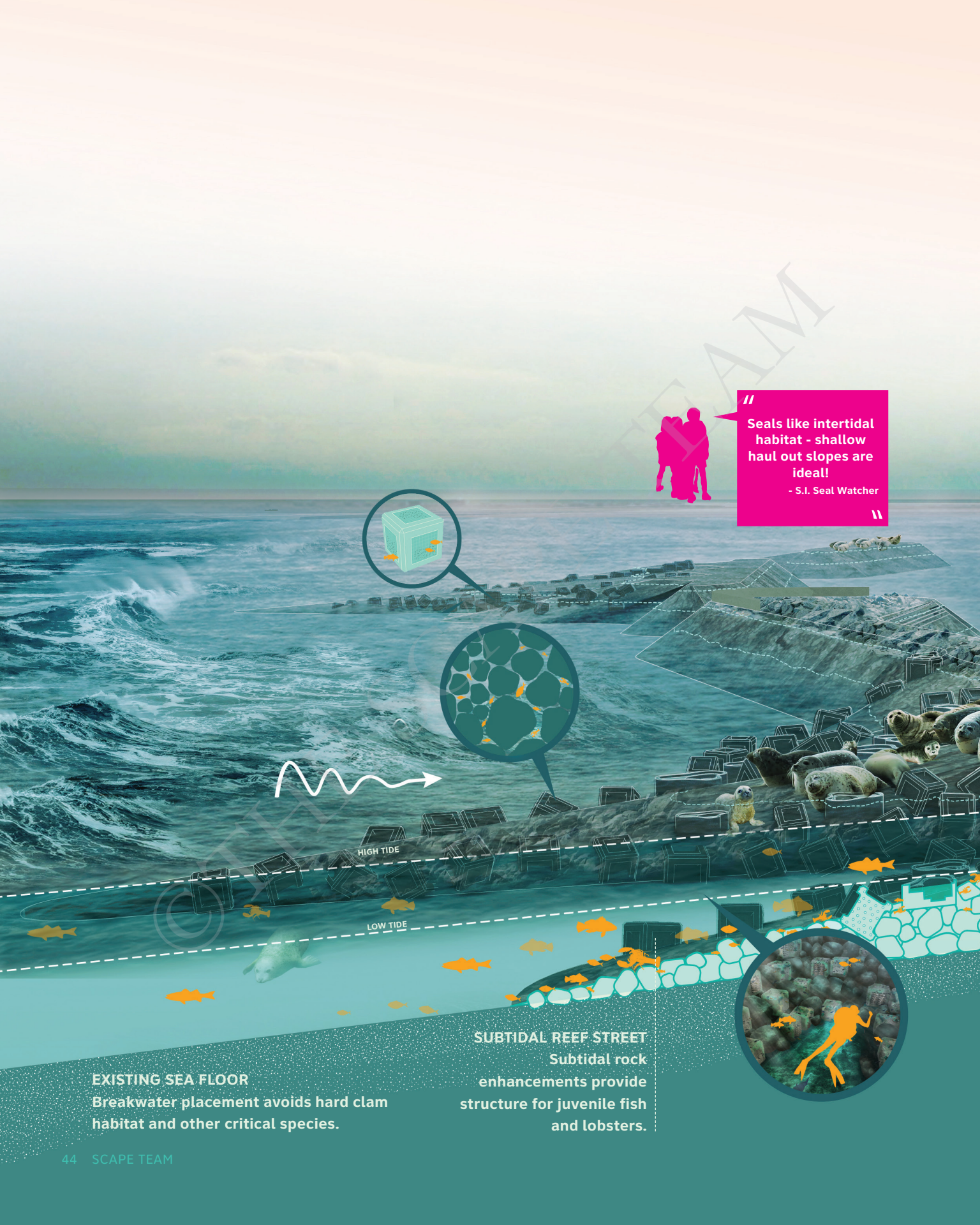
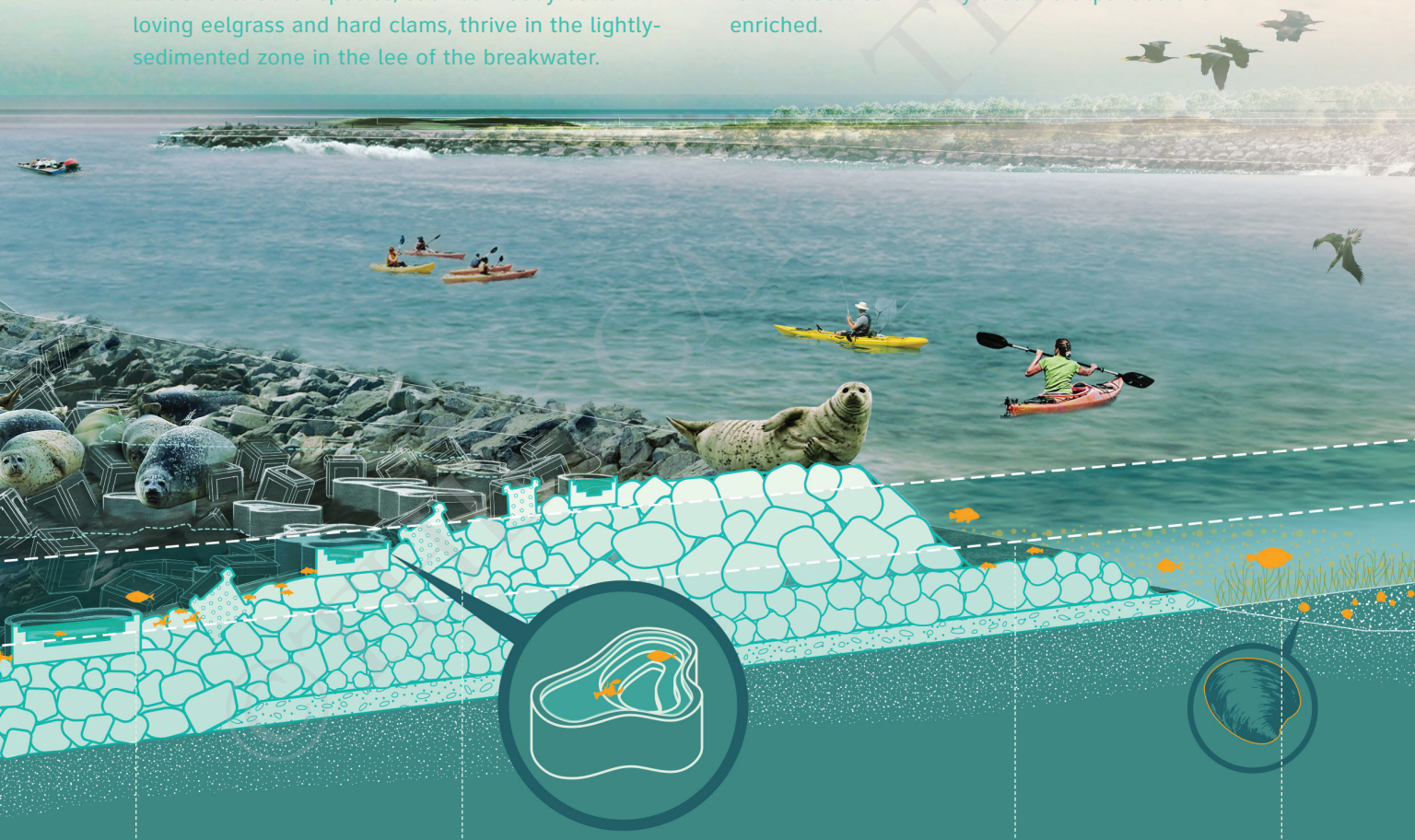

"Seals like intertidal habitat - shallow haul out slopes are ideal!
- S.I. Seal Watcher"
HIGH TIDE
LOW TIDE
EXISTING SEA FLOOR
Breakwater placement avoids hard clam habitat and other critical species.
SUBTIDAL REEF STREET
Subtidal rock enhancements provide structure for juvenile fish and lobsters.

GROWING ECOLOGICAL RESILIENCY

Raritan Bay is prime habitat for juvenile fish that shelter in the bay before venturing out into the Atlantic Ocean as adults. Many of these fish species require rocky habitat and tiny pore spaces for shelter during this crucial phase of life. The breakwaters are designed to maximize complexity and habitat for a diversity of species, including finfish, lobsters, and shellfish. Pockets of maximum complexity, known as "reef streets" mimic the historic reef habitats of Raritan Bay while serving as fishing and recreational attractions. Other species, such as muddy bottom-loving eelgrass and hard clams, thrive in the lightly-sedimented zone in the lee of the breakwater.

Harbor seals and birds use the exposed uplands for basking and perching. Econcrete, an innovative low pH concrete mix for maritime construction, is formed into special units that line the reef streets. Their composition of micro- and macro-surface textures is proven to increase biological recruitment and shelter filter-feeding organisms. Ultimately, biogenic buildup will protect the structures from damage and prolong their operational life span. At the same time, water based economies and wildlife viewing opportunities for the local community area are expanded and enriched.



INTERTIDAL REEF STREET
Intertidal shallow water rock enhancements for juvenile fish, lobsters, and mussels.

UPLAND ISLAND
Exposed island habitat free from predators. Used by seals, people, and birds.

SUBTIDAL ROCKY SUBSTRATE
Subtidal shallow water rock enhancements for juvenile finfish, lobsters, and shellfish.

MUDFLATS
Zones of moderate sedimentation create habitat for hard clams, benthic fish, and eelgrass.

DESIGN FOR JUVENILES

Artificial reefs exist offshore of NY and NJ, creating habitat for adult fish. Inside the Raritan Bay, juvenile finfish are a target species group for habitat creation, as they use the bay as a protective living and feeding grounds before venturing into the Atlantic as adults. Our project aims to create subtidal and intertidal reef habitat for juvenile finfish and lobsters in the protective Raritan Bay. Juvenile fish need small holes and crevices to protect them from larger fish. The breakwater is designed with a range of small crevice spaces found in the piling up of natural stone. These niches are complimented by specific holes formed in econcrete units that line the reef streets.

BLACK SEA BASS

SUMMER / SPRING

ESTUARIES WITH ROUGH BOTTOMS, SHELLFISH AND ELGRASS BEDS, MAN -MADE STUCTURES SANDY/ SHELLY AREAS, OFFSHORE CLAM BEDS AND SHALL PATCHES FOR WINTERING . OYSTER REEFS

3- 19 CM

SCUP

SUMMER/ SPRING

ESTUARIES WITH SANDS, MUD, MUSSEL AND EELGRASS BEDS

STRUCTURE SIZE DEPENDANT ON BODY SIZE - SEEK OUT HOLES THAT FIT BODY. 5 CM - 13 CM AS JUV.

BLUEFISH

5-7 MM AS JUVENILES
4-22 MM AS ADULTS

JUVENILES: SANDY BOTTOM HABITATS. ALSO SEA LETTUCE, EELGRASS, AND SPARTINA MARSHES

BUTTERFISH
1.6 - 12 CM JUVENILES

LIVE IN SHELTER OF JELLYFISH

SHALLOW FLATS, SHELTERED BAYS OVER SAND MUD AND ROCK SUBSTRATES

TAUTOG

NEWLY SETTLED TAUTOG INHABITAT SHALOW AREAS LESS THAN 1M DEPTH INCLUDING TIDE POOLS.

YOUNG TAUTOG- LESS THAN 10 CM JUVENILE - LESS THAN 25 CM

COVER AND VERTICAL RELEIF IMPORTANT - EELGRASS BEDS OYSTER AND CLAM SHELLS USED AS HABITAT FOR YOY AND SMALL BOULDERS.

STRIPED BASS

CLEAN, SANDY BOTTOM SHALLOW WATER. GRAVEL BEACHES. SHALLOW WATER NEARSHORE AREAS

ATLANTIC STURGEON

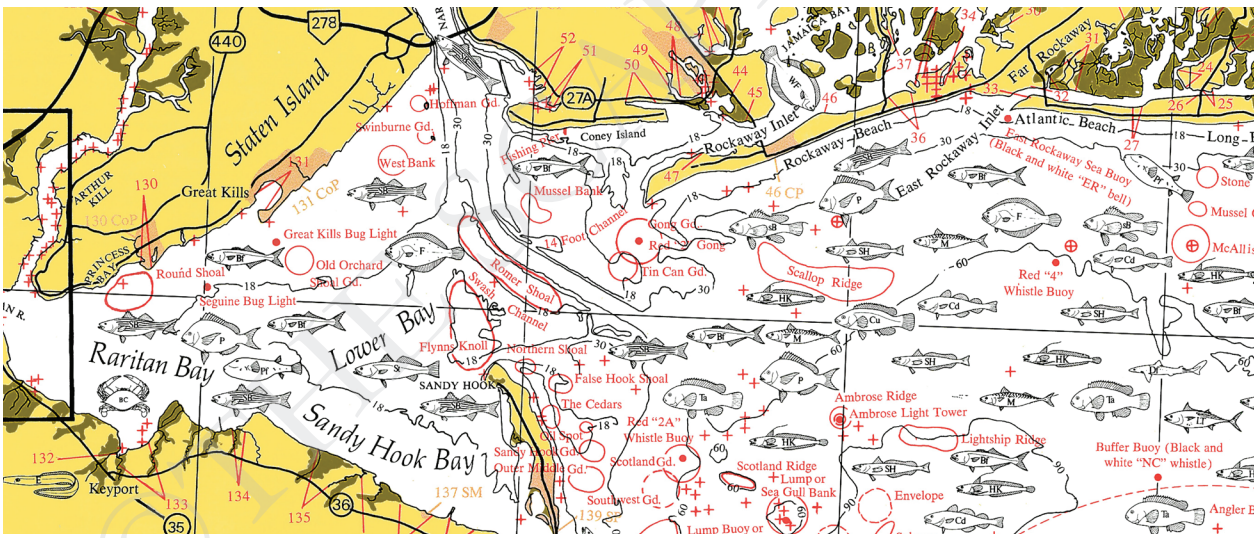
LOBSTER

(SIM REQ AS BLACK SEA BASS AND TAUTOG)

JUV - SHALLOW COBBLE SUBSTRATA. 25 MM SIZE WHEN VENTURE FROM SHELTER.

COBBLE OR SMALL ROCK - 3-10 CM IN DIAMETER.

LARGER ROCK/ BOULDERS 20-40 CM IN DIAMETER.



CONSTRUCT AROUND THE FISH LIFE CYCLE

SUMMER FLOUNDER

16 CM - 30 CM

SALT MARSH CREEKS, SEAGRASS BEDS, MUDFLATS, OPEN BAY AREAS

WINTER FLOUNDER

BOTTOM HABITATS WITH MUD OR FINE GRAINED SAND

ATLANTIC STURGEON

BOTTOM FEEDERS. SPAWN IN HUDSON, SPEND MOST OF LIFE IN OCEAN

AVOID FLOUNDER MATING SEASON!

JAN	FEB	MAR	APR	MAY	JUN
JUL	AUG	SEP	OCT	NOV	DEC

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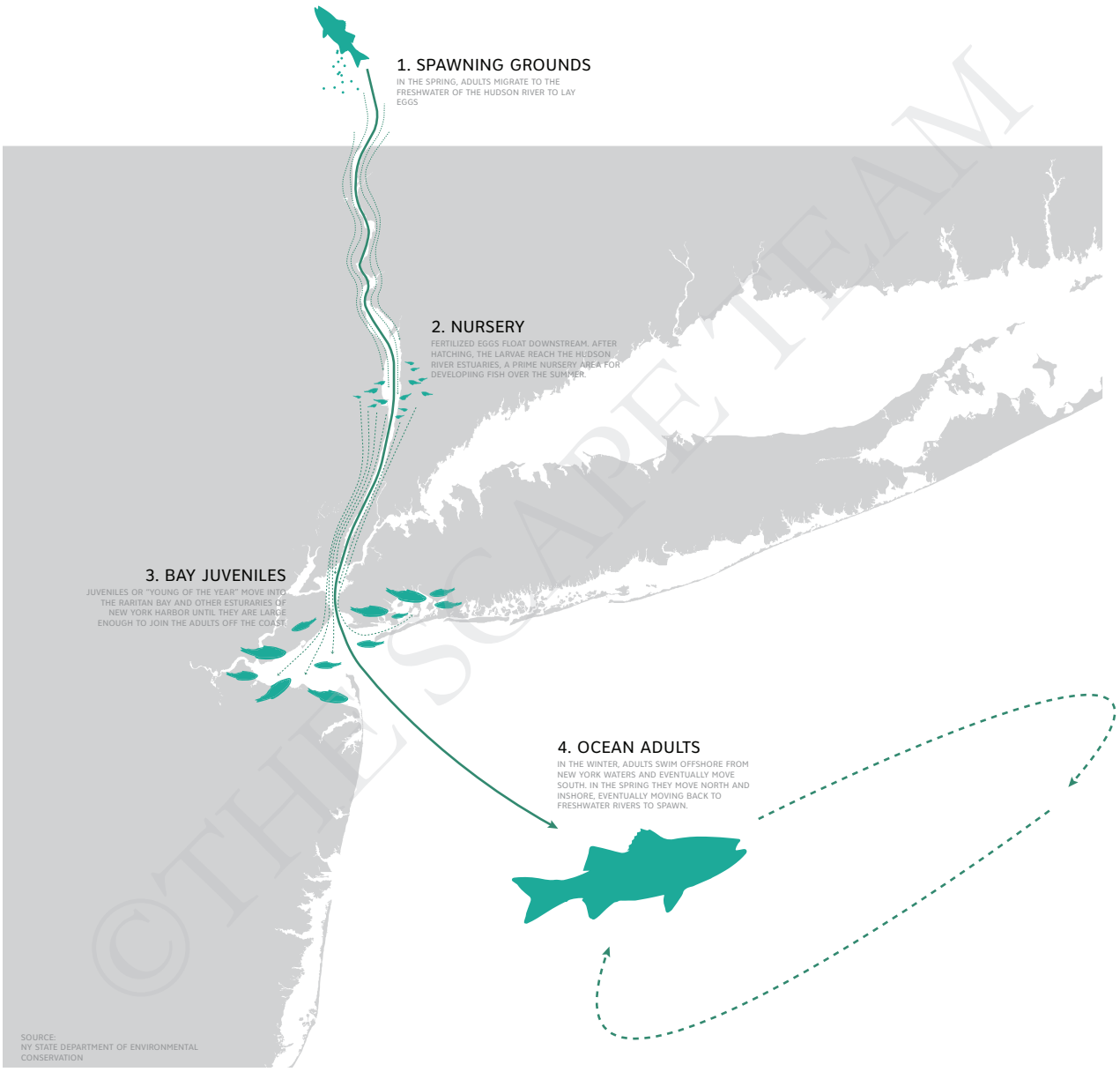
HABITAT LIFE CYCLE
NY/NJ HARBOR



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BREAKWATER DESIGN EVOLUTION

Breakwaters are designed to avoid critical habitat and integrate micro-complexity for a diversity of species. The living breakwaters provide habitat throughout the water column, from subtidal structure to upland islands. Underwater, small scale pockets, or reef streets, are incorporated into the breakwater and provide foraging and shelter for juvenile fish. Above water, the breakwaters can host harbor seals and nesting birds, providing habitat free from predators.

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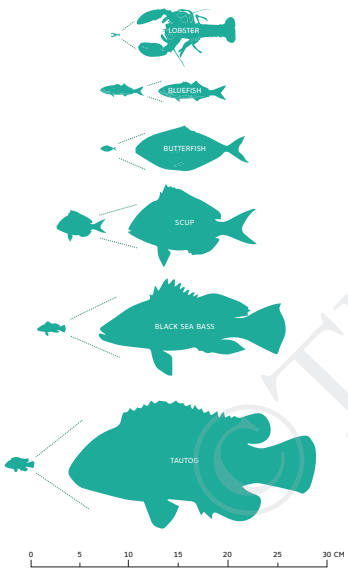
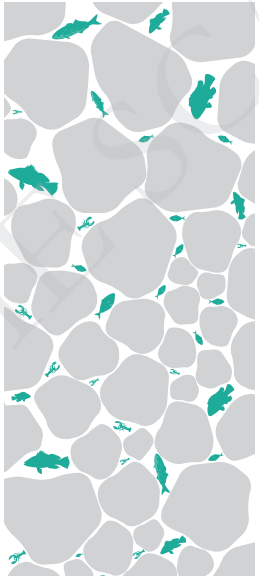
JUVENILE SIZE

FISH AND SHELLFISH SPECIES OF RARITAN BAY WITH PREFERENCE FOR STRUCTURED HABITAT



3 CM - 10 CM ROCK

SMALLER ROCK PROVIDES HABITAT FOR YOUNGER AND SMALLER JUVENILE SPECIES MOST PRONE TO PREDATION.

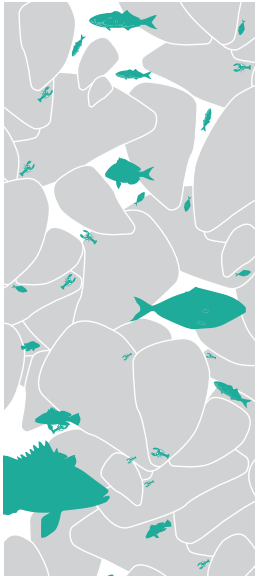


20 CM - 40 CM ROCK

LARGER HOLE SPACES PROVIDE HABITAT FOR JUVENILES AS THEY GROW AND EXAPND THEIR FORAGING RANGE.

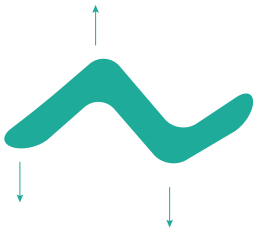
OYSTER REEF

BIOLOGICAL STRUCTURES PROVIDE COMPLEX GEOMETRIES ACCOMMODATING A RANGE OF SPECIES AND AGES.



TYPICAL BREAKWATER

X



MACRO-LEVEL COMPLEXITY

ECOLOGICAL VALUE- LOW

X

MODIFY FORM TO AVOID CRITICAL HABITAT

ECOLOGICAL VALUE- HIGH

✓

MODIFY FORM FOR LOCALIZED, MICRO-SCALE COMPLEXITY

ECOLOGICAL VALUE- HIGH

✓

SOME COMPLEXITY OVER ENTIRE STRUCTURE

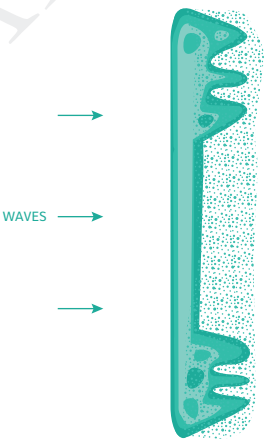
ECOLOGICAL VALUE- LOW

X

POCKETS OF MAXIMUM COMPLEXITY

ECOLOGICAL VALUE- HIGHER

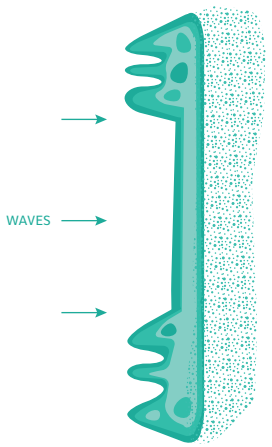
✓



HARD STRUCTURE COMPLEXITY ON LEE SIDE

PORE SPACE FILLS WITH SEDIMENT

X



HARD STRUCTURE COMPLEXITY ON WAVE-WARD SIDE

PORE SPACE REMAINS OPEN

✓

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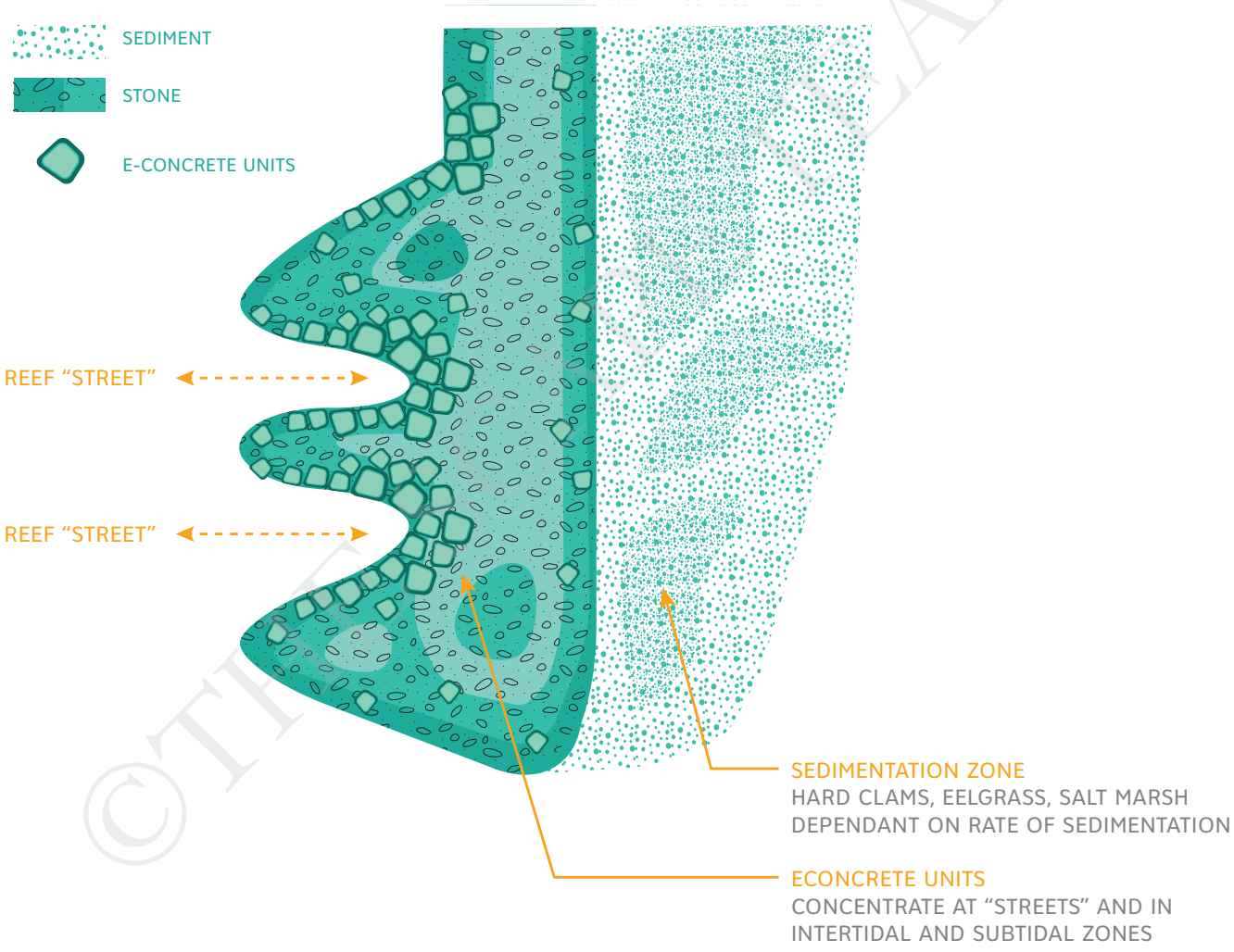
THE REEF "STREET"

Juvenile fish hide from predators in the matrix of econcrete and stone and feed in the narrow waters of the reef streets. This constructed habitat will attract fish of all ages, and in turn, fishermen looking for that perfect secret fishing hole.



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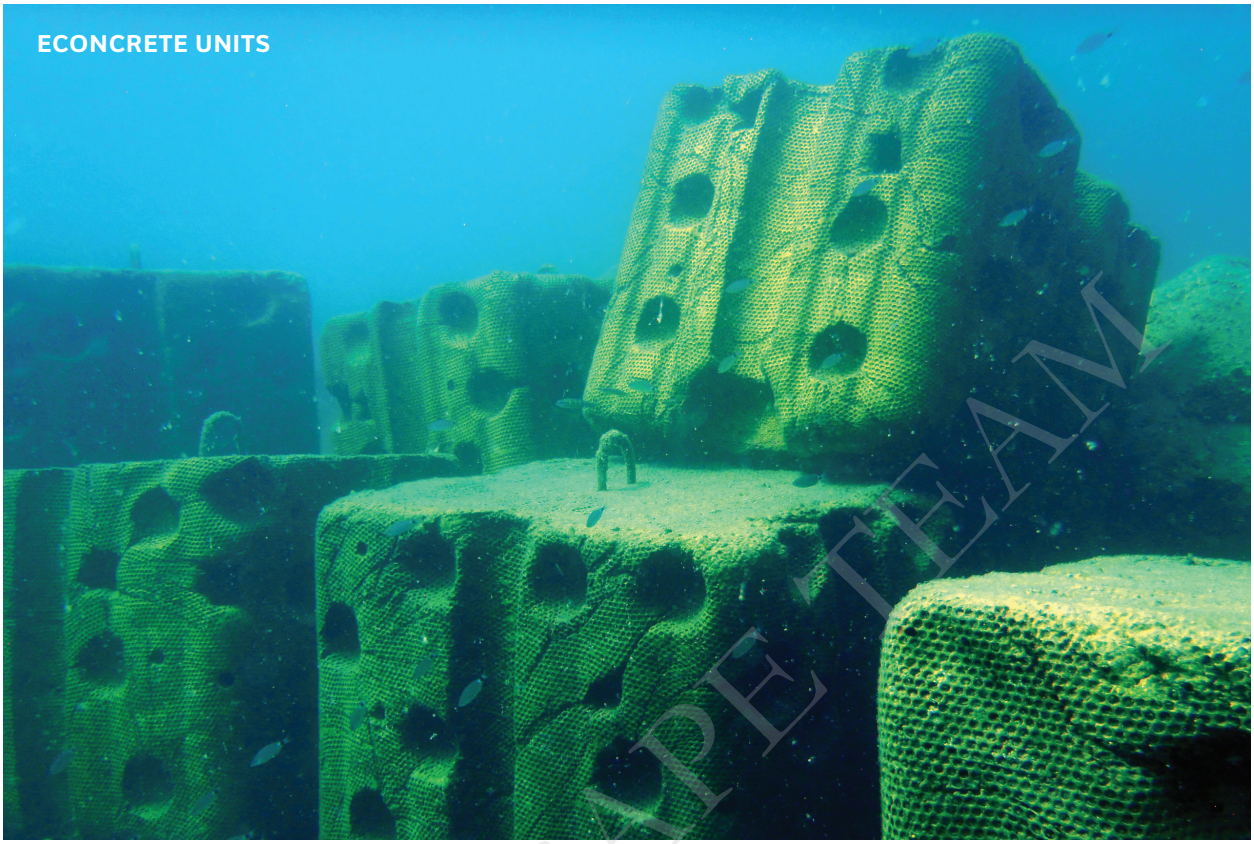

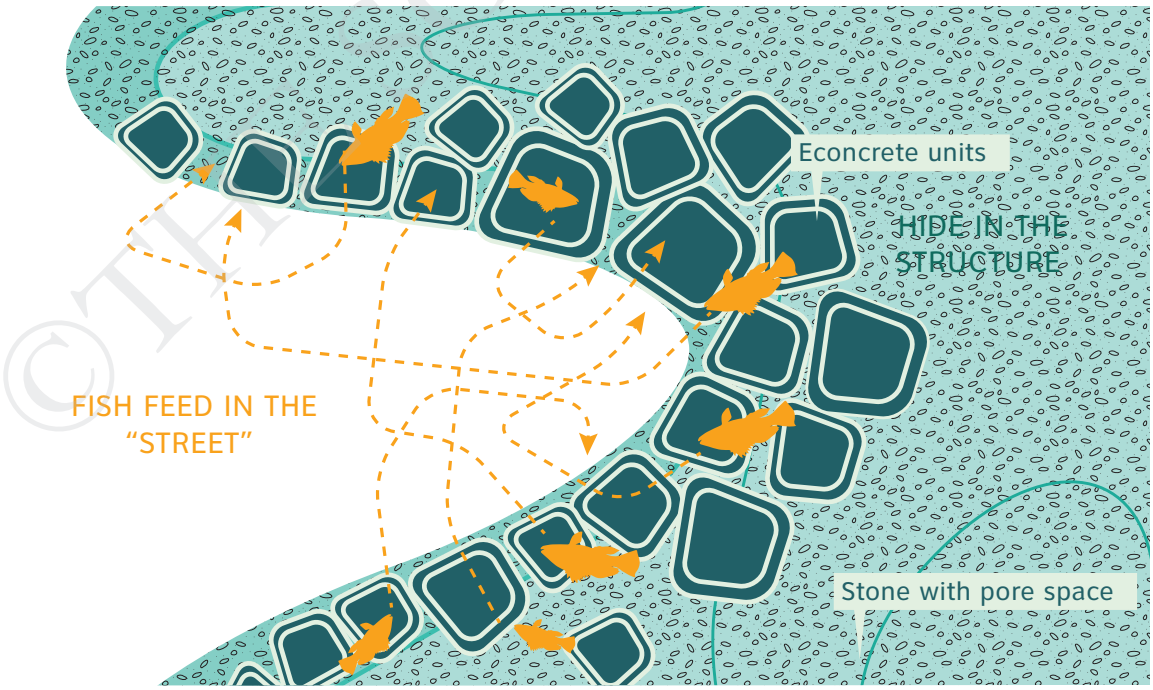

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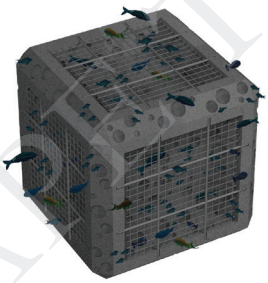
ECONCRETE UNITS

Econcrete units will be set with oyster spat (juveniles) and placed in the breakwater reef. Oyster gabions will be tested as part of the living shoreline and breakwater strategy. Tankless setting, an experimental method that releases spat into the water column, can be tested along the reef streets. Spat sanctuaries will be placed in local marinas and parks with the permission of project partners and will increase the likelihood of natural oyster recruitment throughout the harbor.

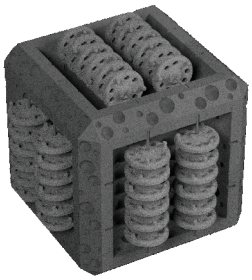
OYSTER HATCHERY UNIT

FISH HUB

TIDAL PLANTER



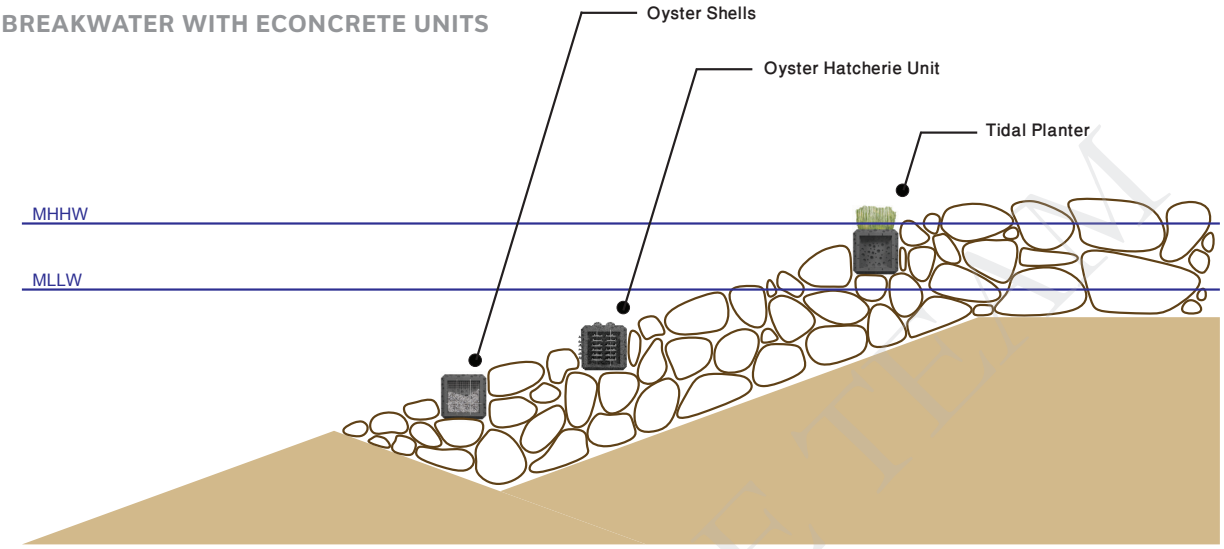
OYSTER SHELLS



ECONCRETE MATERIAL SAMPLE WITH RECYCLED GLASS AGGREGATE

SCAPE TEAM

BREAKWATER WITH ECONCRETE UNITS



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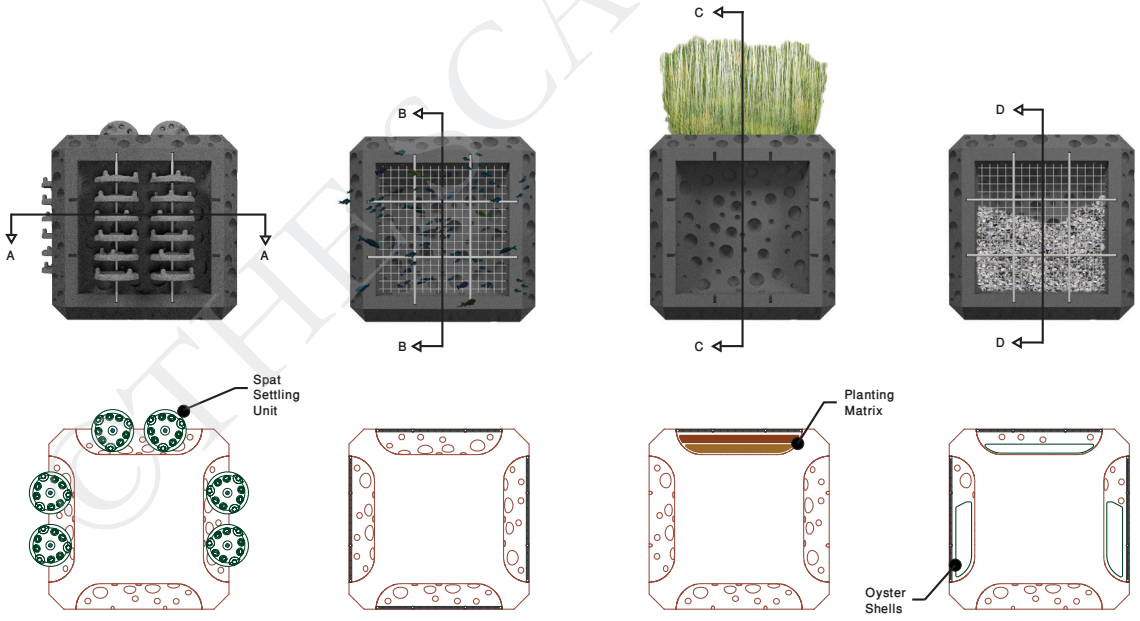
Oyster Hatcherie Unit: Fish Hub: Tidal Planter: Oyster Shells:



5	Project Name: Breakwater Unit	Sketch Name: Section View			
	Part:	Version: 1	Scale: 1:20	Page Size: A3	
			Updated: 13-12-2013	Drawn by: Adi Neuman	
		File Name: ECOncrete_BreakwaterUnits_13_12_2013		Approved by: Ido Sella	
		For Review: ☒	For Approval: ☐	For Tender: ☐	For Execution: ☐

Comments:

- All dimentons are in millimeters.

- The sketches on this page are general product plans and are not for production. Engineering and development as well as shop drawings of the products are the sole responsibility of the manufacturer under the supervision of ECOncrete.
- The final dimentions of the product will be determined at the final planning stage.
- The maufacturer will provide construction and load calculations as well as detailed production drawings for ECOncrete's approval.

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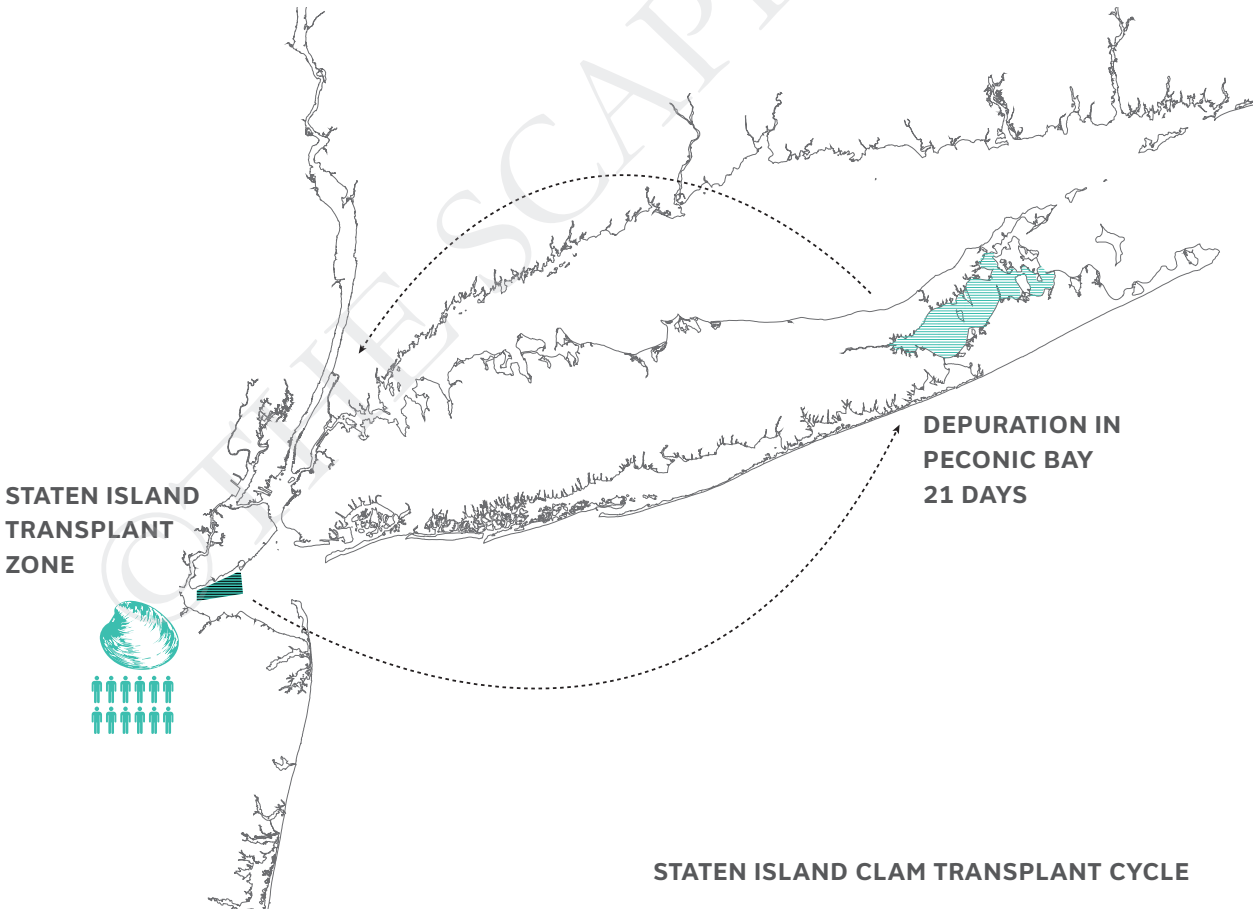
AVOID CLAM HABITAT DISPLACEMENT

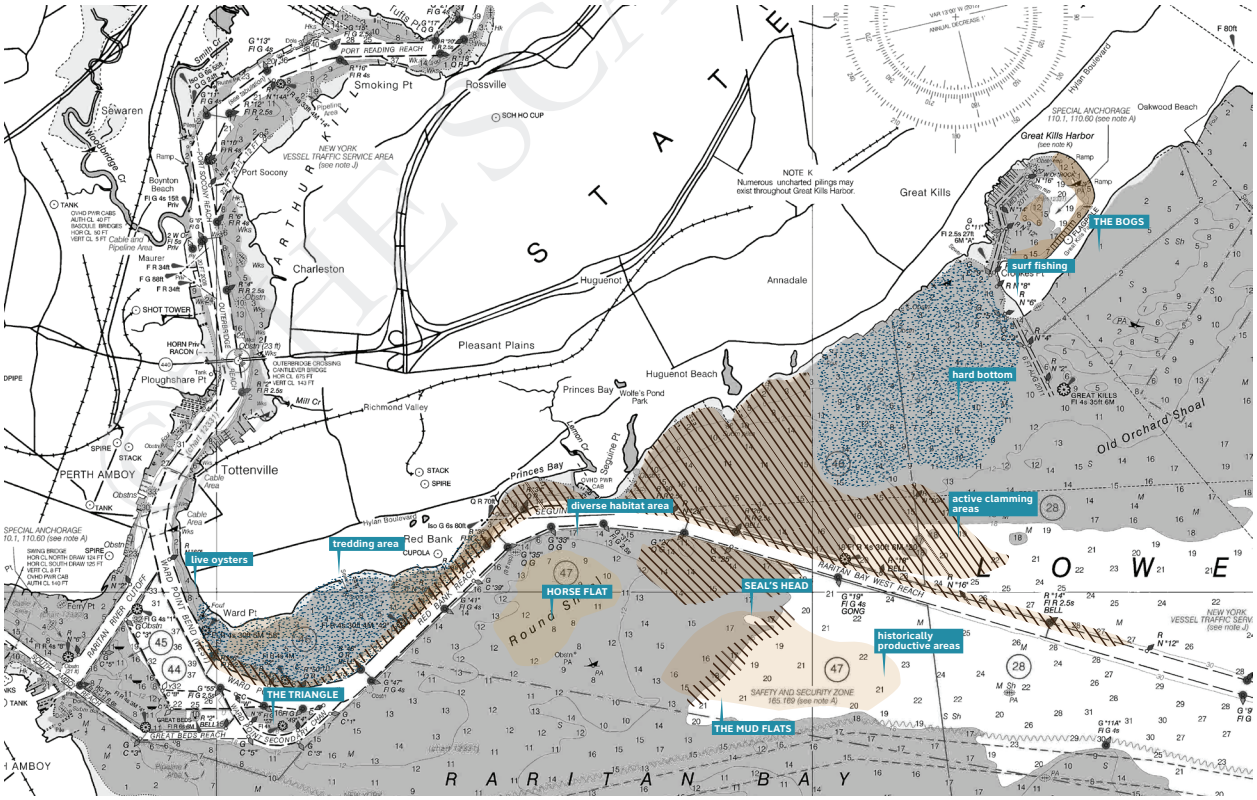
Protecting aquatic habitat and the maritime economy is critical to our proposal. Our team met with a local group of Staten Island clammers to learn more about the link between ecosystems and economies in the active South Shore hard clam transplant zone. The clammers helped us map out zones of hard clam abundance and benthic sediment conditions, helping us align the breakwaters to avoid disturbing this ecosystem. As the project advances, further benthic habitat studies will be needed to avoid damage to the Staten Island clamming economy.



STATEN ISLAND CLAM TRANSPLANT CYCLE

©THE SCAPE TEAM

HARD CLAM ABUNDANCE MAPPING, 2014


THE BOGS
surf fishing
hard bottom
active clamming areas
diverse habitat area
tredding area
live oysters
HORSE FLAT
SEAL'S HEAD
historically productive areas
THE TRIANGLE
THE MUD FLATS
Old Orchard Shoal
Great Kills Harbor
Great Kills
Oakwood Beach
Sewaren
Port Reading Beach
Smoking Pt
Rossville
Port Socony
Boynton Beach
Maurer
Charleston
Huguenot
Annadale
Pleasant Plains
Huguenot Beach
Princes Bay
Wolfe's Pond Park
Richmond Valley
Ploughshare Pt
SHOT TOWER
PERTH AMBOY
Tottenville
Red Bank
Ward Pt
Round Shoal
Raritan River Cutoff
Arthur Kill
Raritan Bay West Reach
Raritan Bay
NOTE K
Numerous uncharted pilings may exist throughout Great Kills Harbor.
SPECIAL ANCHORAGE 110.1, 110.60 (see note A)
NEW YORK VESSEL TRAFFIC SERVICE AREA (see note J)
SAFETY AND SECURITY ZONE 165.169 (see note A)
STATEN ISLAND
RARITAN BAY

FREE SAMPLE

WHAT ABOUT OYSTERS?

Reefs and leased oyster beds once extended across the shallow water flats of Raritan Bay, reducing storm impacts and filtering water. Our project incorporates oyster restoration as one of many critical habitats of the breakwater design. We propose the use of multiple techniques - from oyster gardens to spat on econcrete units - to restore oysters to the Raritan Bay in a measured and monitored way. Along with filtering the water, oysters biogenically build along with the threat of climate change to increase the strength of the protective breakwater system.

OPPORTUNITIES

ADVANCE RESTORATION OF HISTORIC AND CULTURALLY RELEVANT ECOSYSTEMS

GROW ALONG WITH THE THREAT OF CLIMATE CHANGE

ADVANCE THE COMPREHENSIVE RESTORATION PLAN GOALS

IMPROVE WATER QUALITY

EDUCATIONAL TEACHING TOOL

KEYSTONE SPECIES - BUILD DIVERSITY

ADVANCE RESTORATION SCIENCE

CONCERNS

ATTRACTIVE NUISANCE AND THREAT TO HUMAN HEALTH AND SAFETY

POTENTIAL DISPLACEMENT OF EXISTING HABITAT

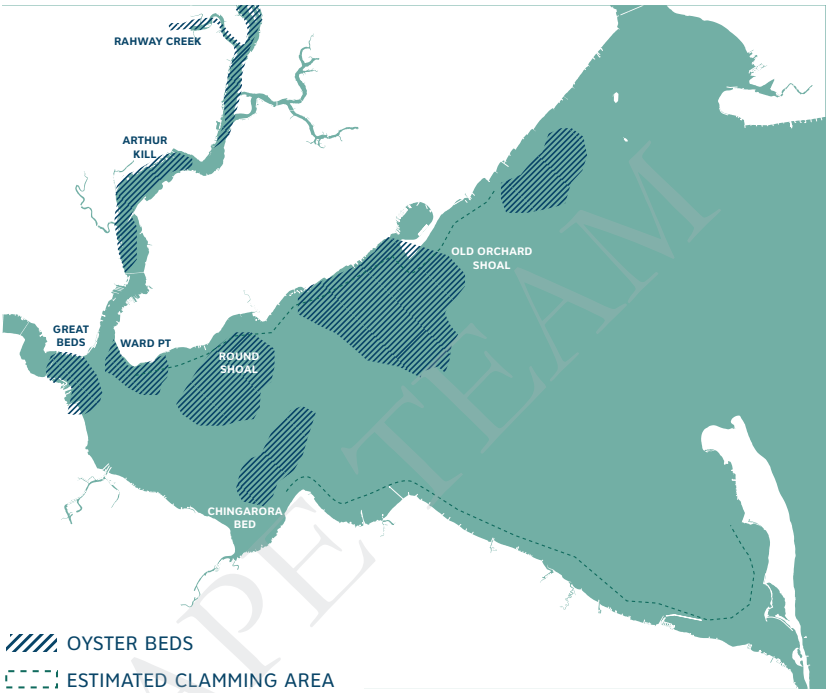
LONG TERM VIABILITY

©THE SCAPE TEAM

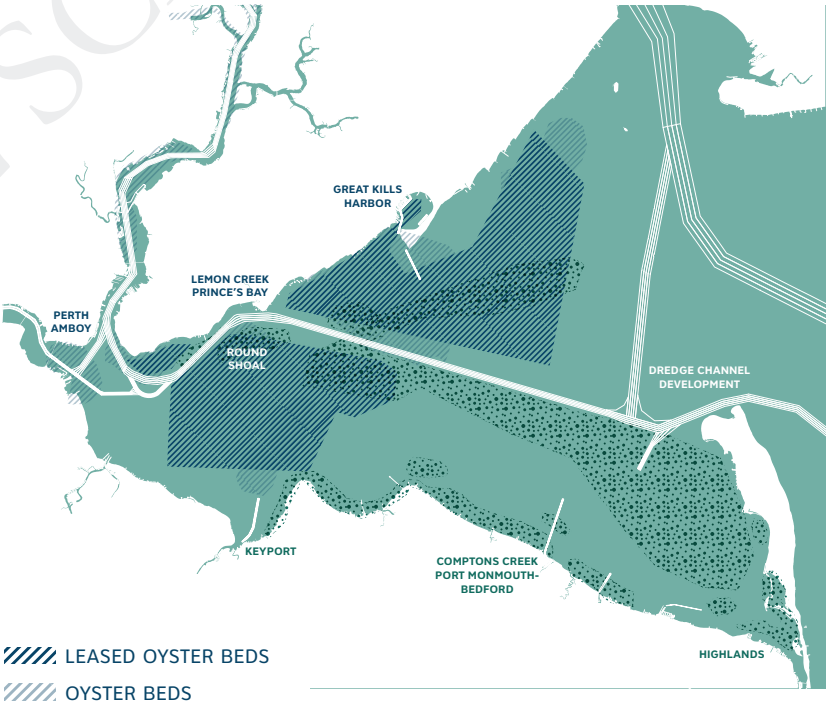
OYSTER REEF INCORPORATED INTO LIVING BREAKWATER
OYSTER REEF
EASTERN OYSTER
CLEAN WATER
EXCESS NUTRIENTS
+ ONE EASTERN OYSTER (CRASSOSTREA VIRGINICA) FILTERS 50 GALLONS OF WATER A DAY. OYSTER REEFS ACCRETE INTO GROWING, ADAPTIVE COASTAL STRUCTURES THAT CAN BE HARNESSED FOR RESILIENCY AND GROW TO ADAPT TO SEA LEVEL RISE.
+ OYSTERCATCHERS

THE HISTORY OF THE OYSTER AND CLAM INDUSTRY IN RARITAN BAY

1800-1850S



1850s-1900



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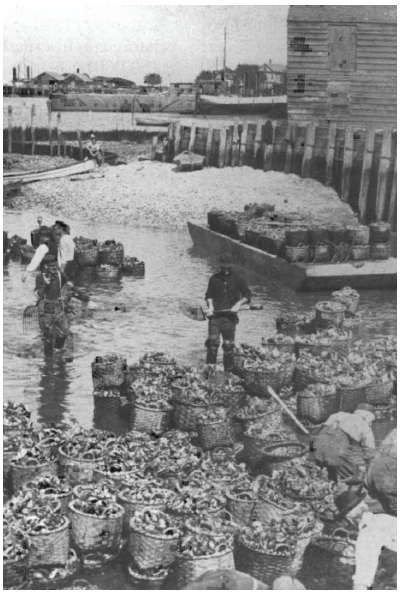
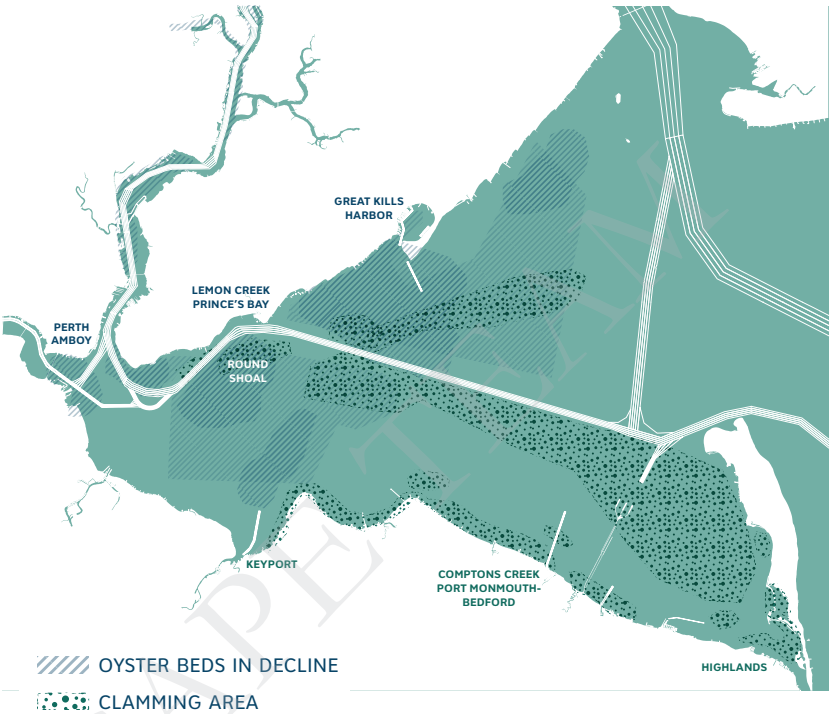
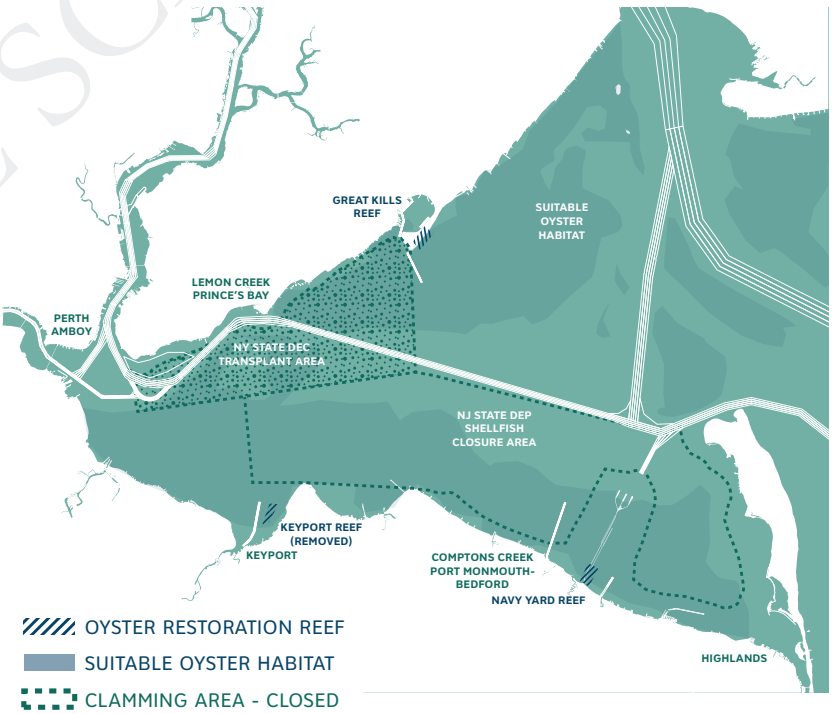


1900S-1950s



1950s-TODAY



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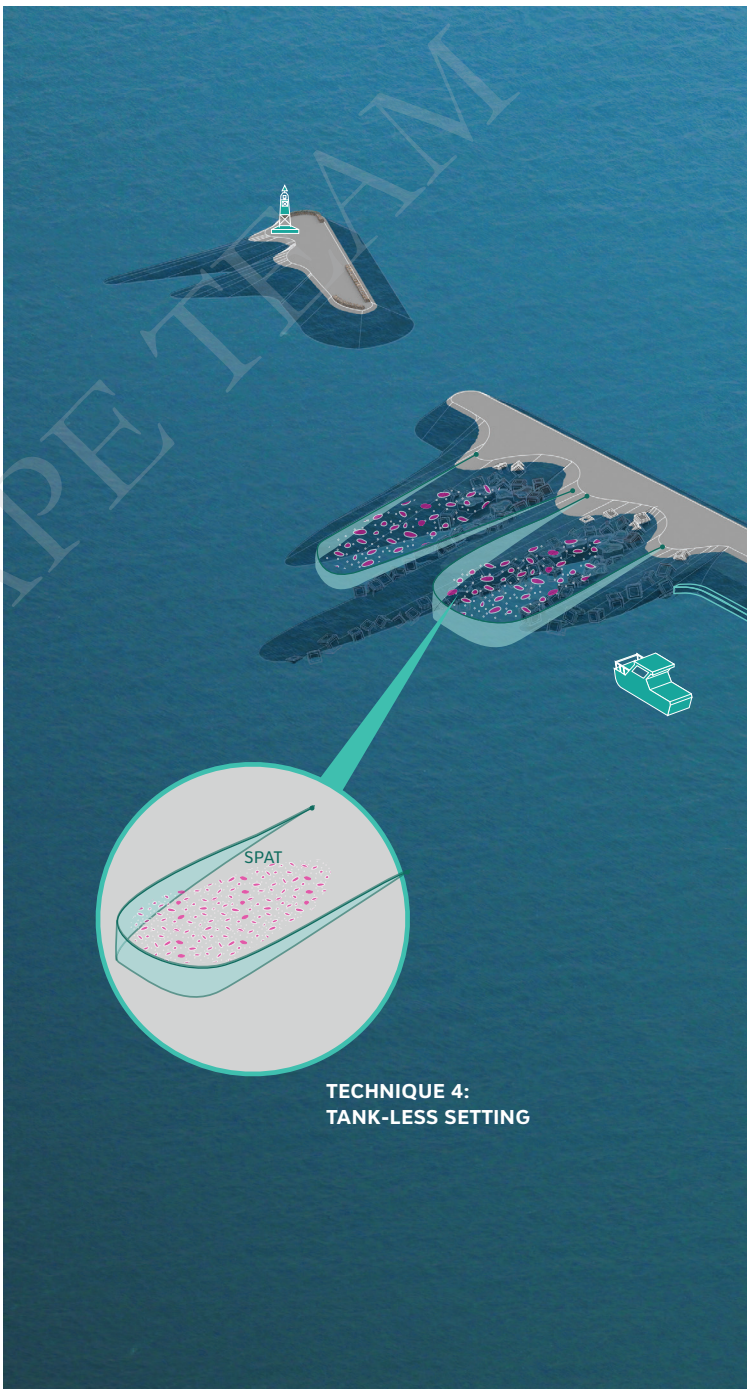
OYSTER RESTORATION TECHNIQUES

We propose to integrate shellfish restoration into the design using multiple techniques – some previously tested in the Harbor, some experimental. The suggested restoration techniques range from oyster gardens to spat on econcrete units and help to restore oysters to the Raritan Bay in a measured and monitored way.

Econcrete units will be set with oyster spat (juveniles) and placed in the breakwater reef. Oyster gabions will be tested as part of the living shoreline and breakwater strategy. Tankless setting, an experimental method that releases spat into the water column, can be tested along the reef streets. Spat sanctuaries will be placed in local marinas and parks with the permission of project partners and will increase the likelihood of natural oyster recruitment throughout the harbor.

SPAT SANCTUARY WITH FLOATS MOORED TO MARINA PIERS.



**TECHNIQUE 4:
TANK-LESS SETTING**

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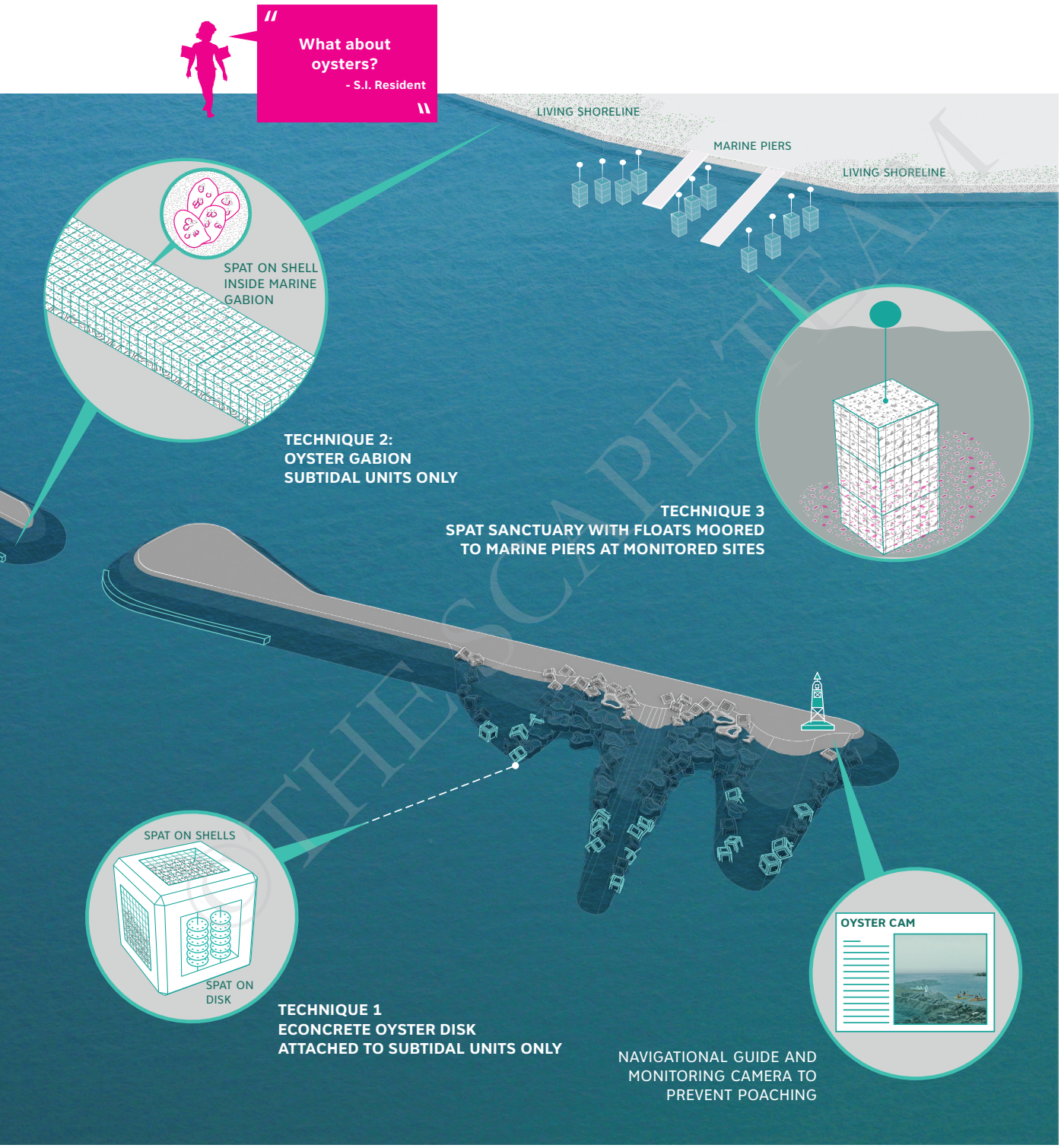

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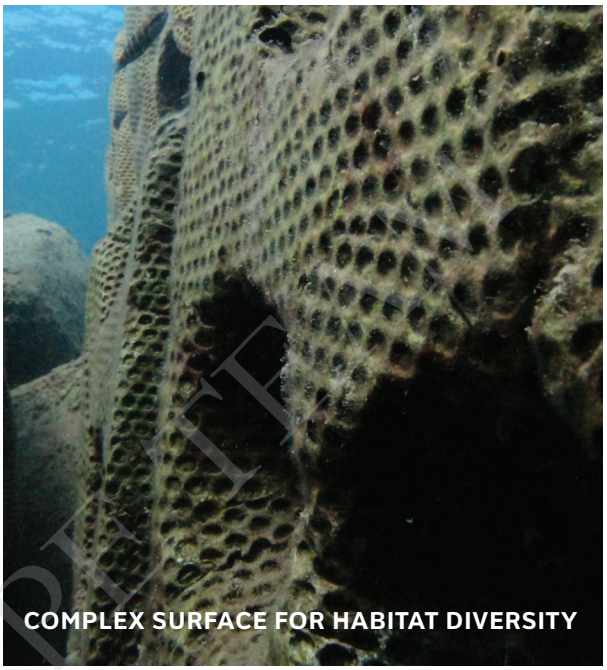
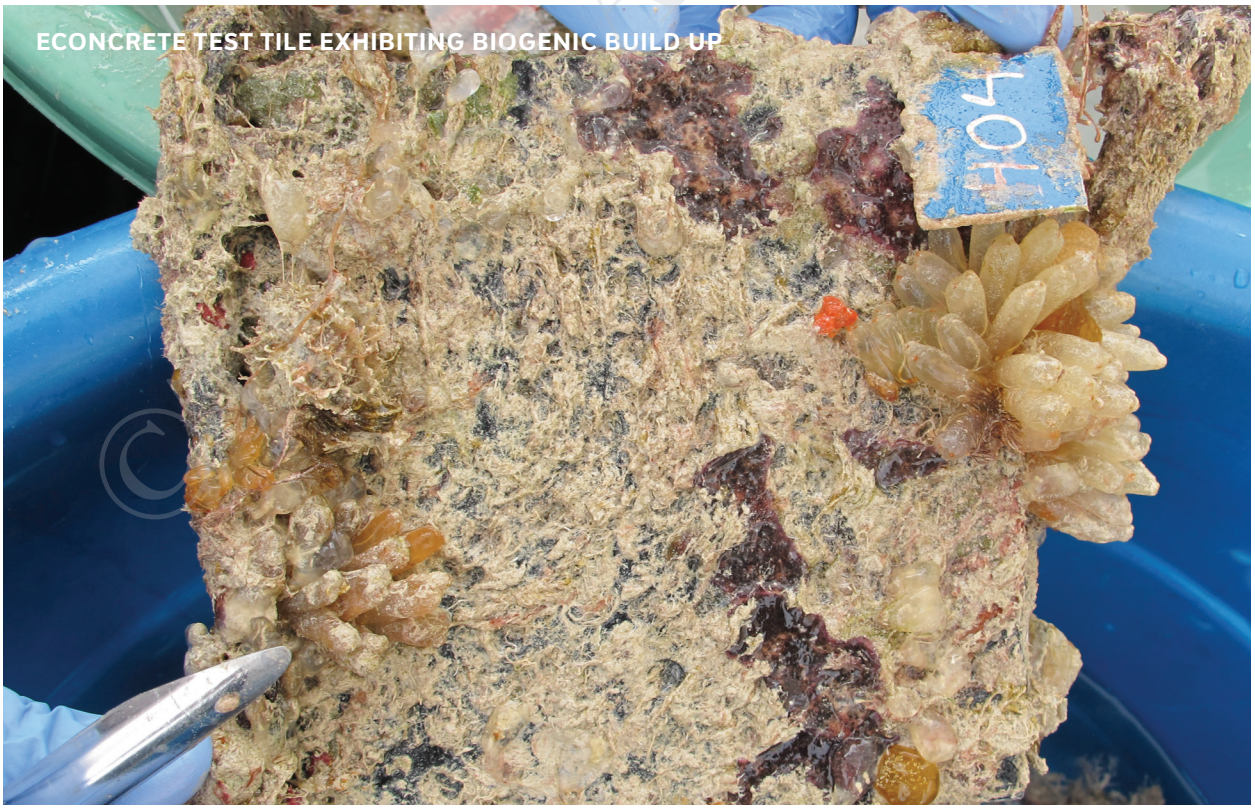
BIOGENIC BUILD UP

It is critical to explore the restoration of oysters and other species that biogenically build reef systems, as these species can grow along with the threat of climate change, while increasing the strength of the protective breakwater system. Biogenic buildup is the agglomeration of multiple marine species on the face of an underwater structure. The shells of these organisms not only create a thriving ecosystem, but layer over time to create a calcified natural surface over top the man-made structure below. Marine growth can contribute to enhanced strength, stability, and longevity of breakwaters - thus reducing the need for maintenance



COMPLEX SURFACE FOR HABITAT DIVERSITY



ECONCRETE TEST TILE EXHIBITING BIOGENIC BUILD UP

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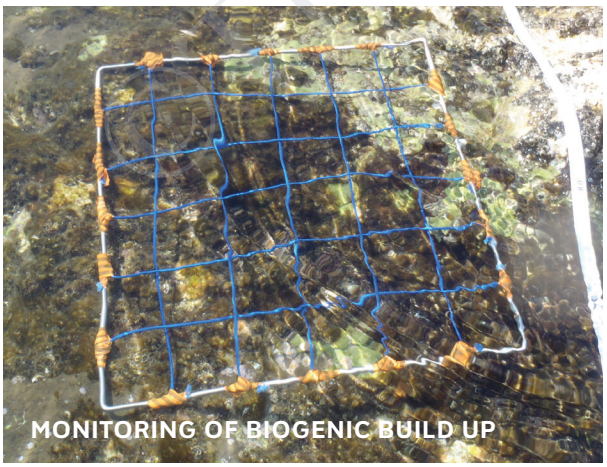
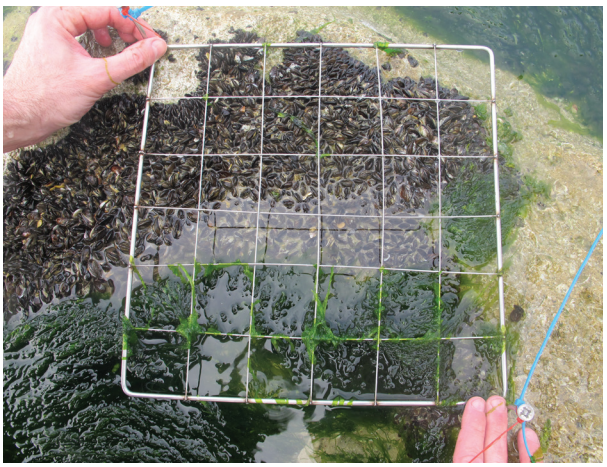
SOUND VIEW REEF RESTORATION, BRONX

Monitoring of the ecosystem can be conducted in concert between scientists, students, and citizen scientists within the community.



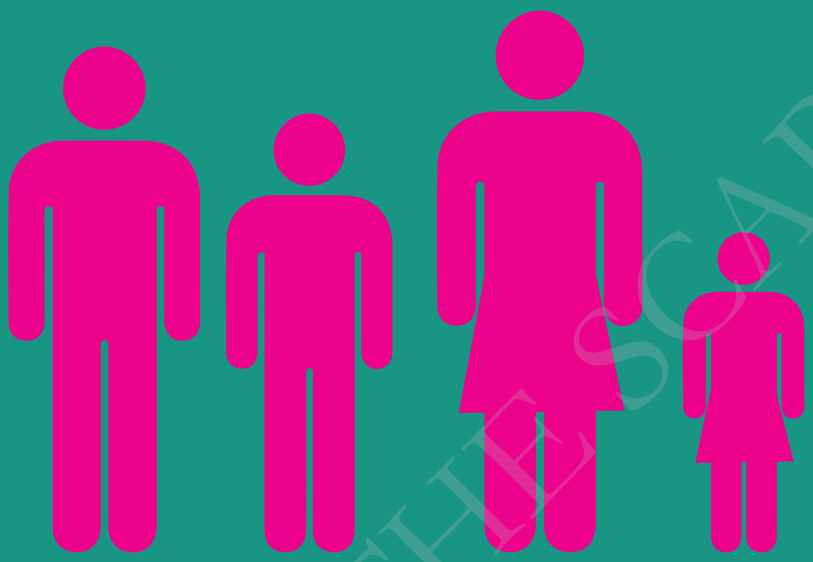
MONITORING OF BIOGENIC BUILD UP



REEF MODEL BUILDING WORKSHOP

THE SOLE TEAM

BUILDING SOCIAL RESILIENCY



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BUILDING SOCIAL RESILIENCY

Staten Islanders can reconnect to the coast through a network of highly visible and programmed Water Hubs which will become places that foster social cohesion and provide orientation, information, storage space, and group gathering spaces. The hubs are to be designed through community design charrettes where programs and needs are identified and incorporated into the structures. Each site condition and community need creates a different type of hub – embedded, floating, cantilevered, or elevated. At Tottenville, pictured here at right, potential water-hub programs include community kayak storage suggested by Kayak Staten Island, wet-lab science tools for use by Tottenville High School, and bird-and-seal-watching platforms replacing those lost at Conference House Park during the storm. These programs, combined with amenities such as bathrooms and water fountains, vastly expand the age range and experience level for water-based activities available to residents. The Water Hub acts as a "lighthouse," a beacon of orientation, and bridges the layered dune system below.

POTENTIAL WATER HUB LOCATIONS

The site selection for the Water Hubs is driven by multiple factors: First and foremost, the Water Hub is the on-land component of the Living Breakwaters, therefore it must be located on places where the breakwaters are required, namely flooding prone areas with potential for marine habitat, places where access to the waterfront can be created for the community, and sites where public transportation is within reach. Great Kills, Lemon Creek, Mill Creek and Tottenville in the South of Staten Island were selected for these reasons. Sites will be more rigorously assessed during the following phases addressing questions about the CEHA zone sensitivity and coastal construction permitting.

©THE SCAPE TEAM

Great Kills Water Hub
IS 24
Francis School
Crescent Beach Water Hub
PS 55
Our Lady Star Of The Sea
Beach Growth
Tottenville High School
St. Joseph By The Sea High School
IS 7
PS3
Lemon Creek Water Hub
Crecent Beach & Annadale Reach
Wolfes Pond Reach
Lemon Creek Reach
Water Hubs
Schools
Breakwater Type 1
Breakwater Type 2
Breakwater Type 3
Waterfront Activities
Beach Growth Zone
Spat Sanctuary
Existing Shoreline Upgrades
Proposed Shoreline Upgrades
Living Shoreline Pilot
Active Clamming Areas

COMMUNITY WATER HUBS

Staten Islanders can reconnect to the coast through a network of highly visible and programmed Water Hubs, which provide places for access, orientation, information, storage, and gathering. The hubs are to be designed through community design charrettes, where programs and needs are identified and incorporated into the structures. Each site condition and community need creates a different type of hub: embedded, floating, cantilevered or elevated.

Floating Water Hubs work as platforms for observation of the Living Breakwaters also function as fishing stations and offer spaces for educational workshops and field trips for oyster gardening by local schools. On-land Water Hubs rise above the base flood elevation without losing contact with the ground floor and embracing the co-existence with water. The lower structure contains the circulation and safe spaces with floodable program, integrated with the dune system creating a second layer of protection from wave action and flooding. The second level, designed as an open plan, is a flexible space for the main program such as ADA accessible classrooms, gathering spaces and services, and the third level for commercial and recreational program with access to bird watching stations. Designed and built with prefabricated modular systems, sustainable materials, and energy efficient equipment, the Water Hubs are replicable models with iconic presence.

©THESCAPE

MARITIME FRICTION FOREST
DUNE CONSTRUCTION
Forest
Reef
View

> “Being able to show our students that these ecological systems are a way of protecting ourselves is absolutely tremendous.”
>
> - S.I. Teacher

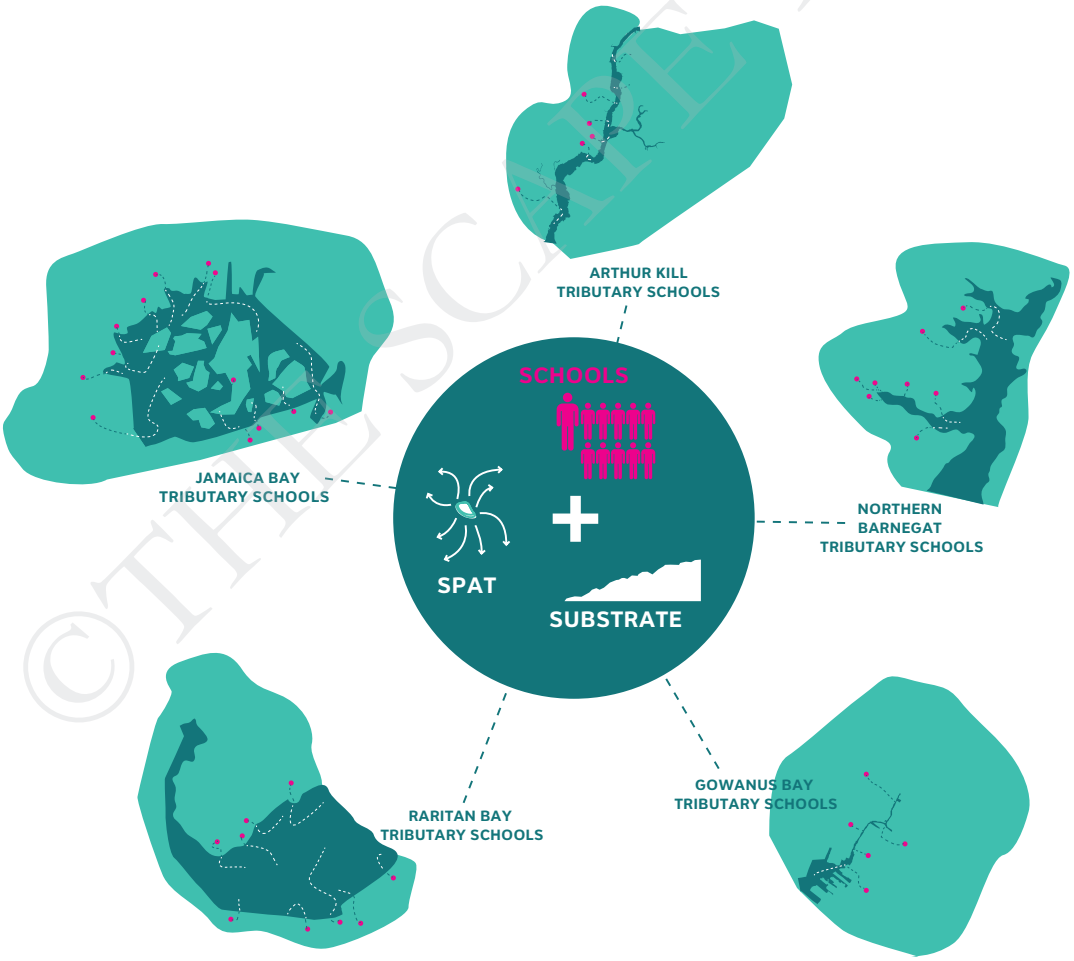
IMAGE: CARTER CRAFT

SCAPE PREVIEW

BUILDING COMMUNITY AROUND WATER

The project aims to engage Staten Island schools in waterfront education, restoration, and reef building. Local schools close to the waterfront can use the Water Hub gathering spaces for outdoor classes, hands-on education, and interactive maritime stewardship.

Schools offer additional opportunities for cultivating long term estuary stewardship. Our partner, The New York Harbor School, has advanced models for engaging middle and high school students in the active restoration and management of the New York Harbor, from biological inventory to maritime job training. All strategies offer opportunities to engage local schools in building resiliency within a community. We will work with The Harbor School to integrate scalable activities into the local curriculum - from oyster gardening to reef building, that build maritime knowledge and preparedness at the neighborhood scale.



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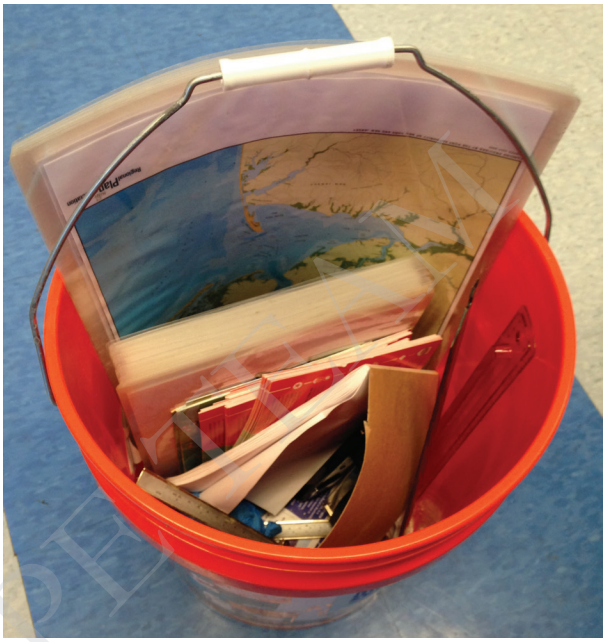
HARBOR AS A CLASSROOM

Living Breakwaters will engage Staten Island schools in waterfront education, restoration, and reef restoration. Local schools can use the Water Hubs for outdoor classes, hands-on science based education, and maritime skill building. The Billion Oyster Project (BOP) is a long-term initiative linked to this proposal to restore one billion live oysters to New York Harbor over the next twenty years and in the process, train thousands of young people to restore the ecology and economy of their local marine environment.



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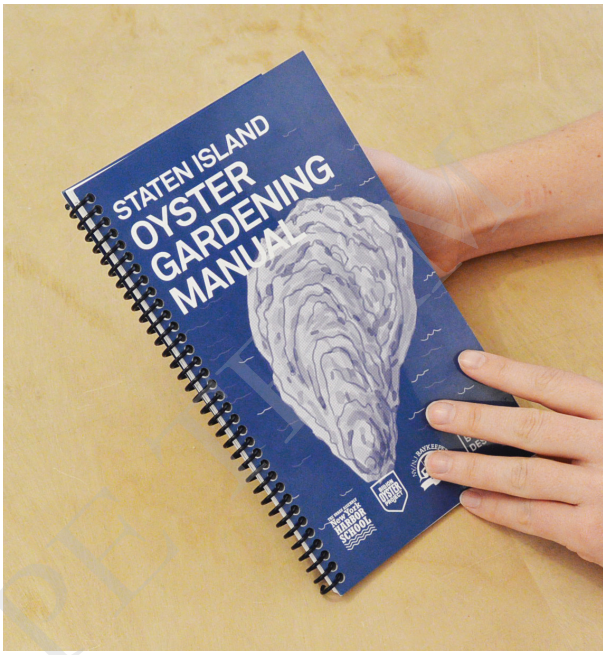
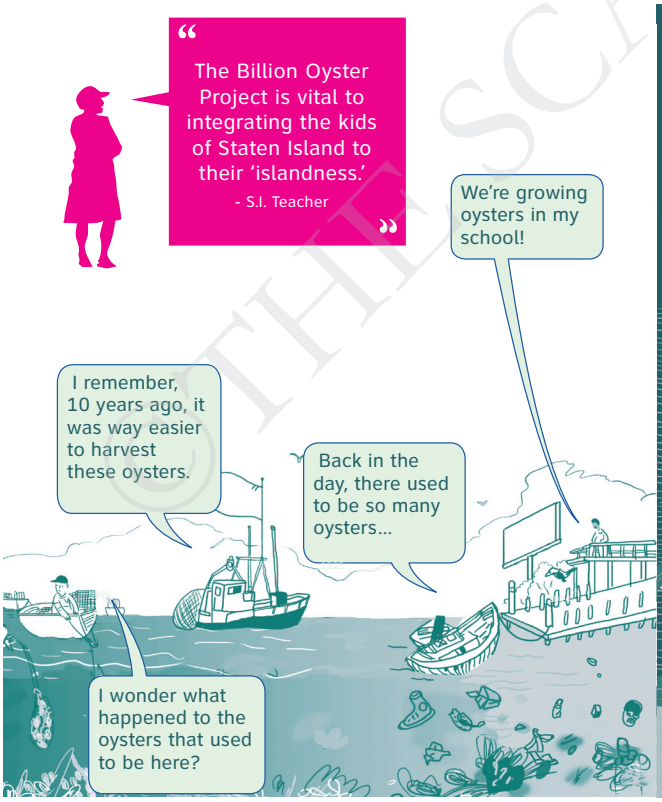
THE OYSTER GARDENING MANUAL

As advanced through Rebuild by Design, together we created the BOP Staten Island Oyster Gardening Manual and held public workshops where teachers signed up to become BOP schools. Individual classrooms can reconnect with the waterfront using oyster gardening techniques and referencing the BOP manual and associated curriculum guide. This strategy is one of many opportunities to bring our schools and the next generation of Staten Islanders into the design, management, and stewardship of bay ecosystems.





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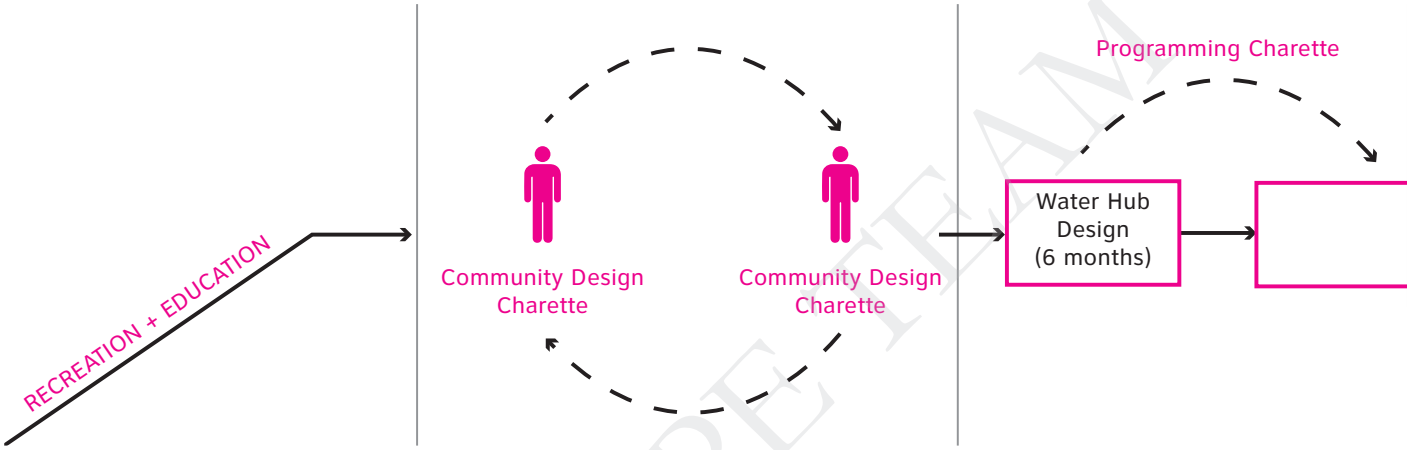
COMMUNITY LED DESIGN PROCESS



Community input is critical to the design process. At this stage of the design process, we have met with community members and stakeholders to collectively brainstorm on how to best program and occupy the Water Hubs. Input from Kayak Staten Island, the New York Rising Committee, and Conference House Park was especially useful for the Tottenville Water Hub concept. Moving forward, these constituents and the broader community will continue to shape the design process. While part of a larger resilient shoreline, the Water Hubs can be advanced as a more immediate step of Rebuild by Design, showcasing positive change on the shoreline in a measureable and quick way.

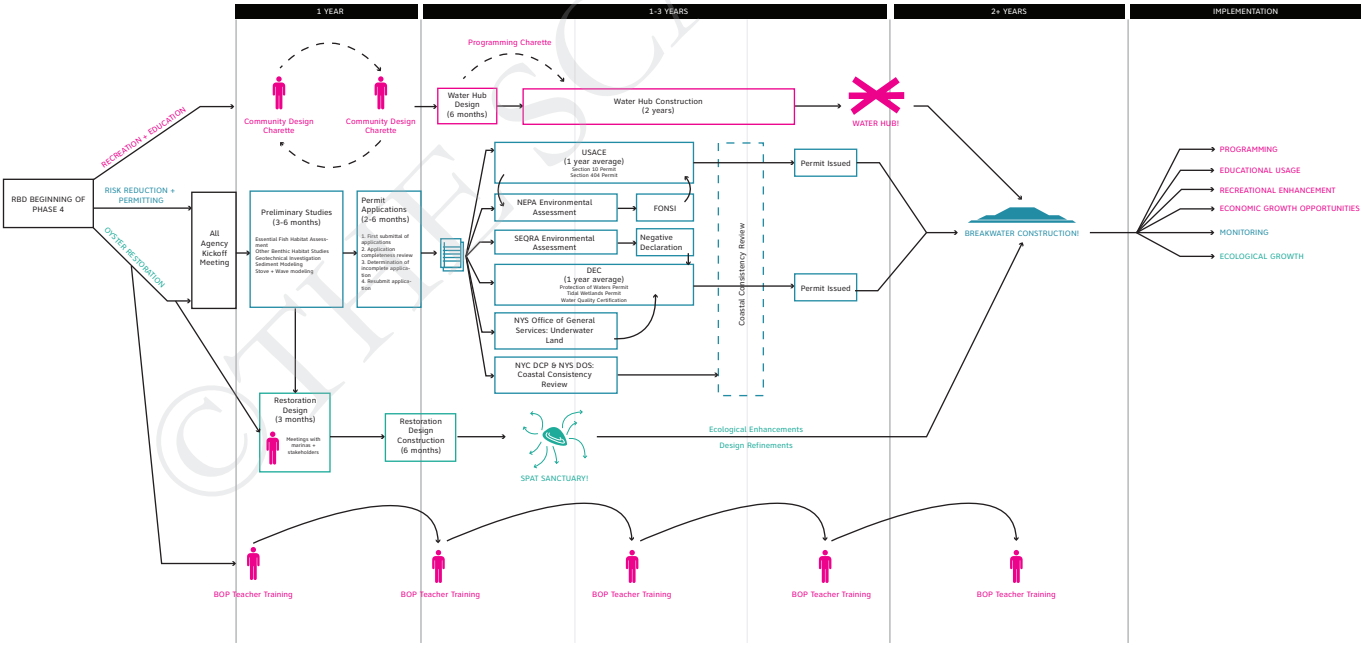
©SCAPE TEAM

Water Hub Construction (2 years)

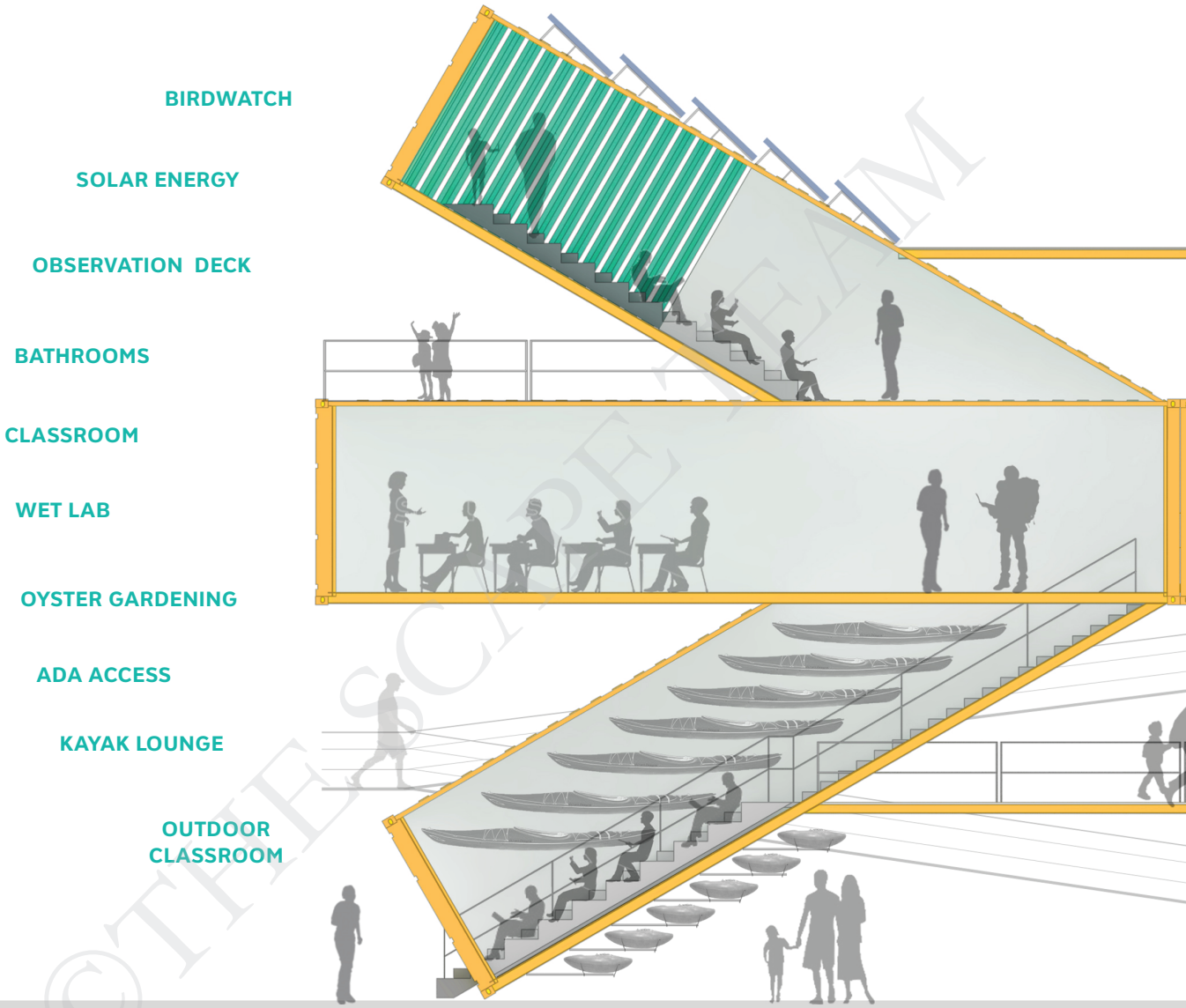
WATER HUB!

BREAKWATER CONSTRUCTION!

©THE SCAPE TEAM



WATER HUB PROGRAMMING



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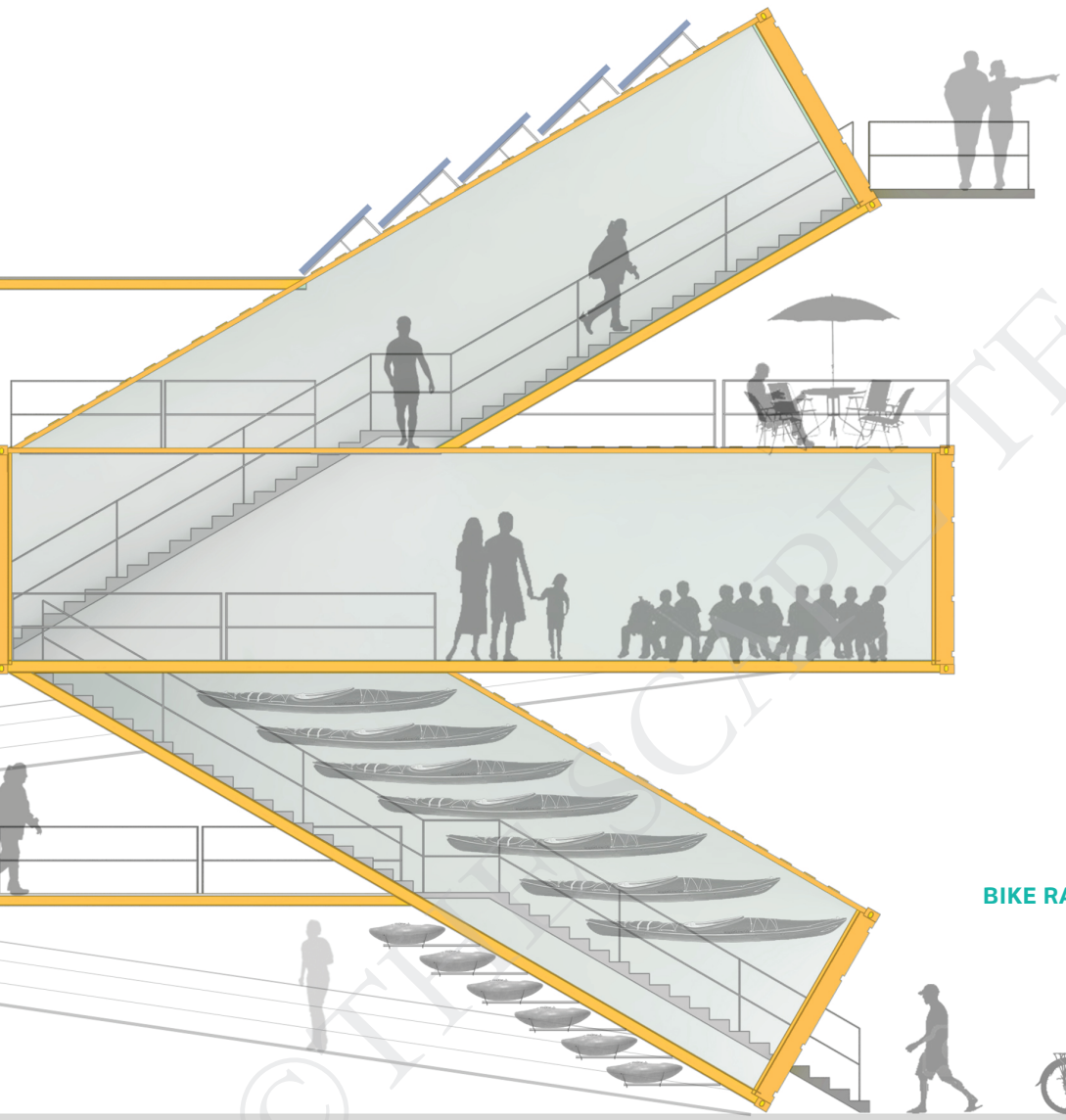
The programming for each Water Hub is shaped by its particular location, context, and the community needs and aspirations. At its core, the purpose of the Water Hub is to connect people to the water, encourage water-based activities, provide infrastructure for recreation and education, and create a platform for the community to meet and learn. Besides of offering basic services such as bathrooms and water fountains, the Water Hubs include a kayak lounge, community kayak storage, classrooms for local schools, wet-lab for The Harbor School, flexible space for community workshops, gatherings and exhibitions, local restaurant, bird watching stations and nature observation decks.



OVERLOOK

TOURS

CAFE

RESTAURANT

GATHERING SPACE

EXHIBITION SPACE

EVENTS

LECTURES

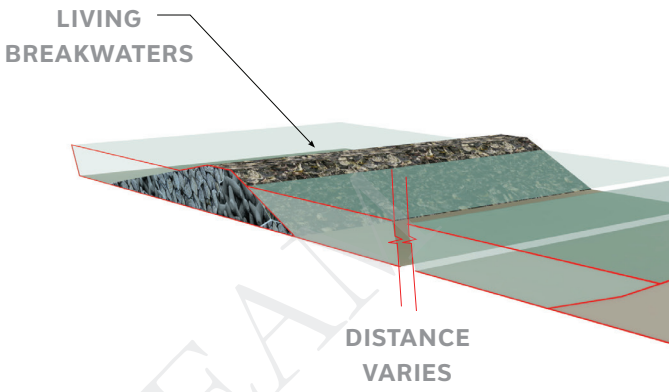
COMMUNITY
KAYAK STORAGE

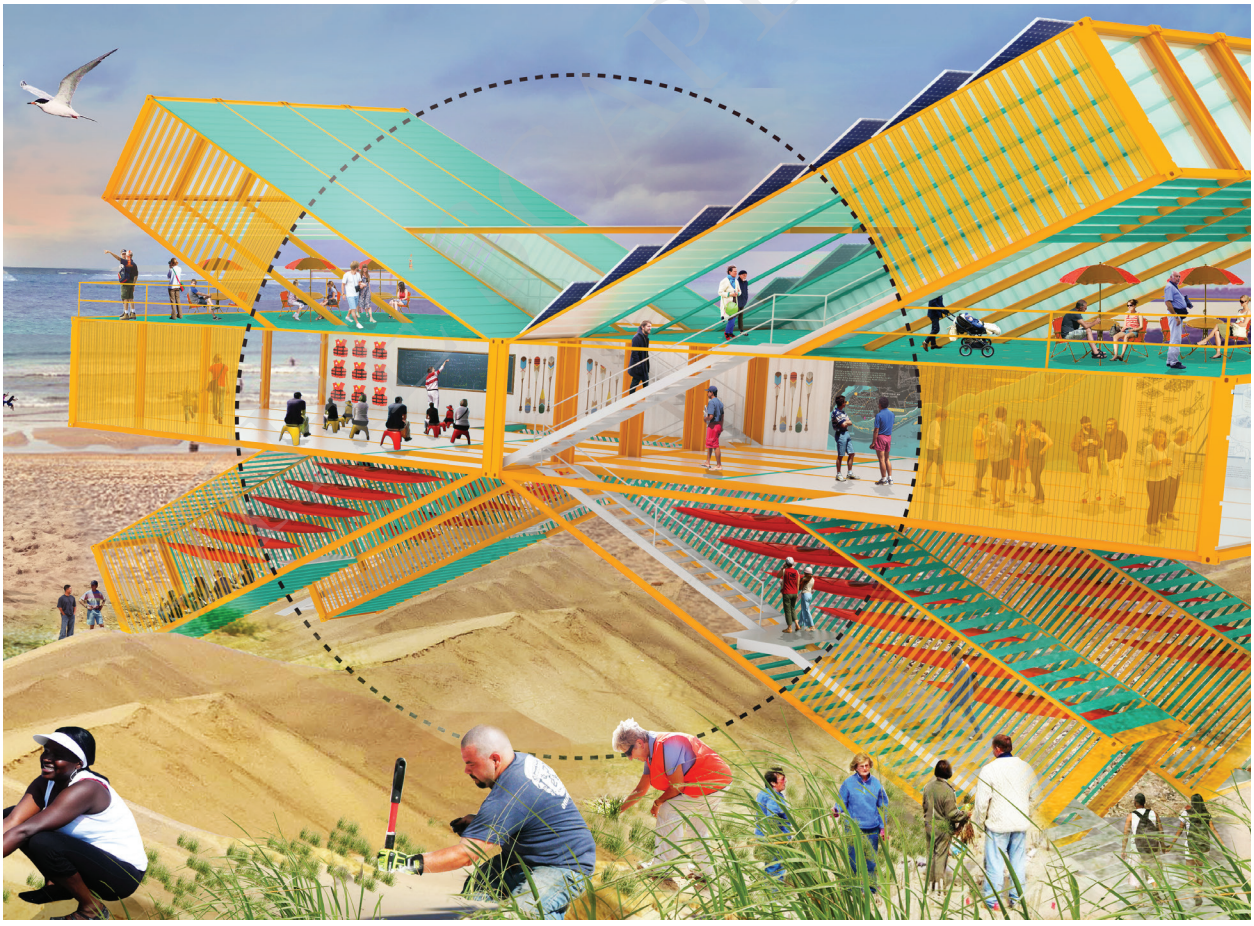
BIKE RACK / RENTAL

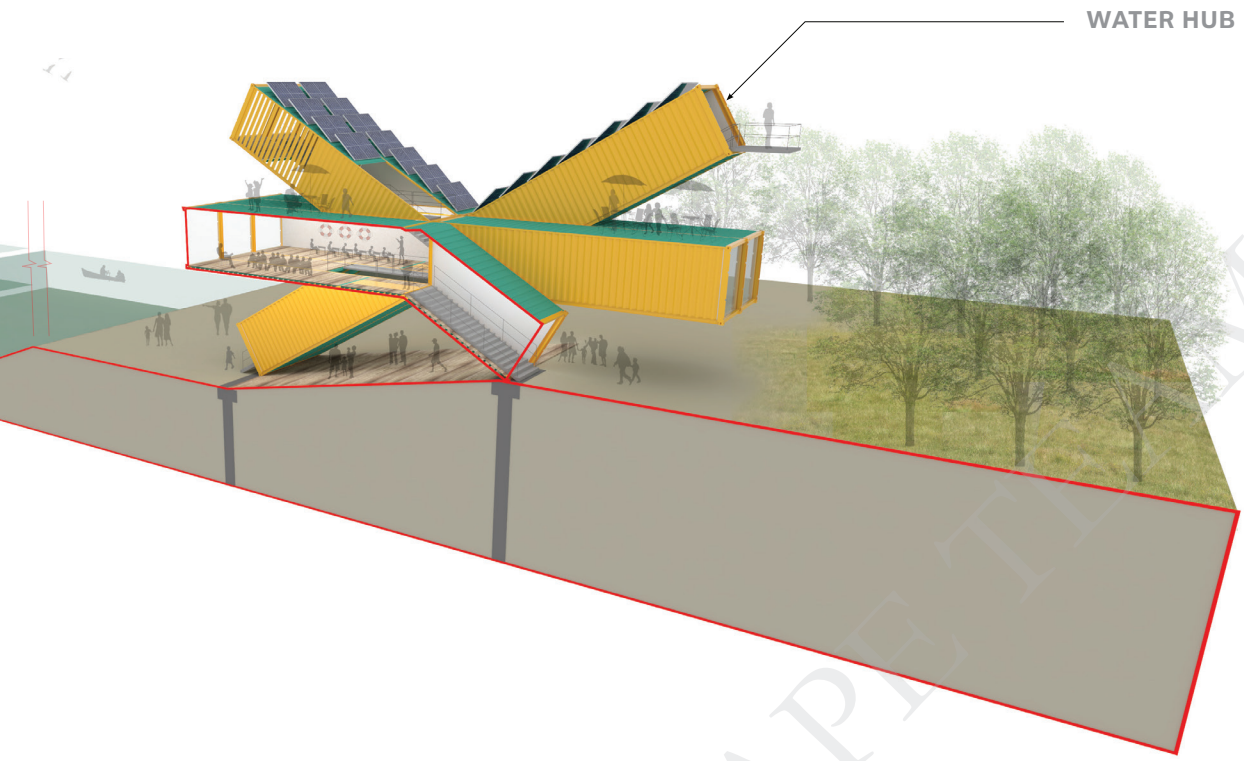
©THE SCAPE TEAM

TOTTENVILLE WATER HUB

The end of Page Avenue at Tottenville Conference House Park was identified as a pilot site for Water Hub construction, due to its proximity to a residential district, PS 6 Corporal Allan F. Kivlehan School and public transportation. Community members identified program for the Tottenville Water Hub, including a kayak Lounge, kayak storage facility, public services, classroom space and wet lab for local schools, flexible space for exhibitions, workshops and community gathering, plus restaurant and birdwatching deck and birdblind tower at the top level.





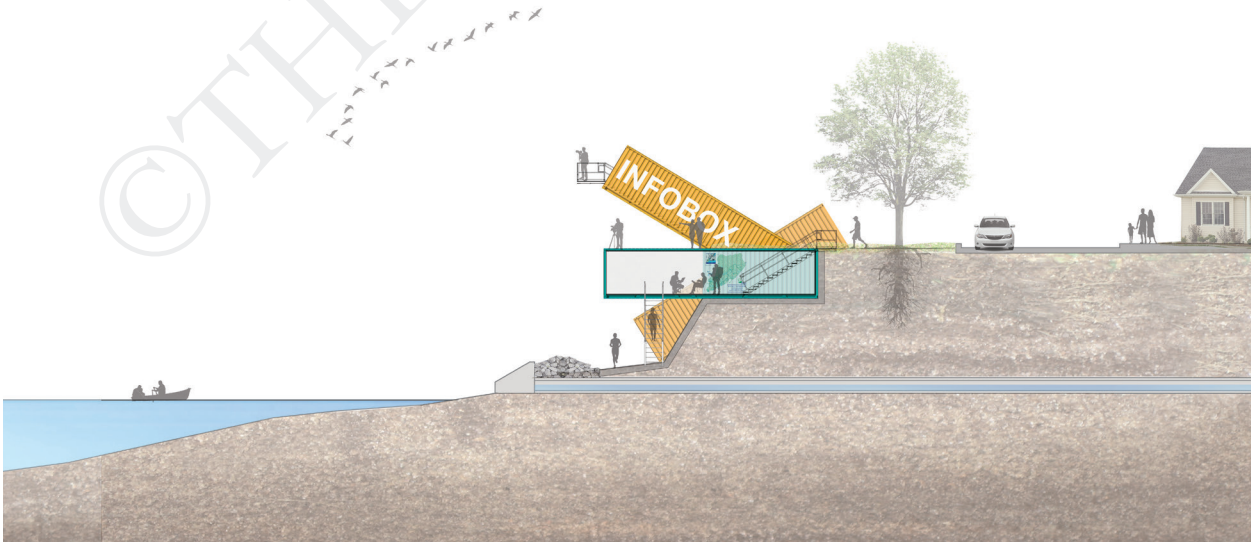

WATER HUB

WATER HUB LOCATION IN TOTTENVILLE
PAGE AVENUE
1.6 MI TO SIR STATION
Walk 27 min
Bus 18 min
Drive 5 min
1.3 MI TO IS 34
Walk 24 min
Bus 15 min
Drive 4 min
1.4 MI TO PS1
Walk 26 min
Bus 15 min
Drive 4 min
0.5 MI TO PS6
Walk 9 min
1.0 MI TO SOUTH RICHMOND HIGH SCHOOL
Walk 20 min
Bus 9 min
Drive 3 min
0.4 MI TO BUS STOP
Walk 8 min
TOTTENVILLE WATER HUB
0.85 MI TO CONFERENCE PARK TRA
Walk 20 min
1.7 MI TO LEMON CREEK WATER HU
Walk 30 min
0.2 MI TO LIVING BREAKWATERS
Kayak 6 min

LEMON CREEK WATER HUB

Located at Prince's bay shore, mediating between Brighton street residential development and Lemon Creek's marina, the Lemon Creek Water Hub performs at multiple levels. From the ground up, the structure's base is intended to act as a retention wall for the highly erosion prone condition of the site while framing the Bluebelt culvert running underneath.

The building is meant to bridge the street level with the beach level, allowing direct access to the water. Given the active Birdwatching culture at the site, Lemon Creek's Water Hub offers viewing decks and a birdblind tower for local residents and aficionados plus a visitor's center for tourists alike.



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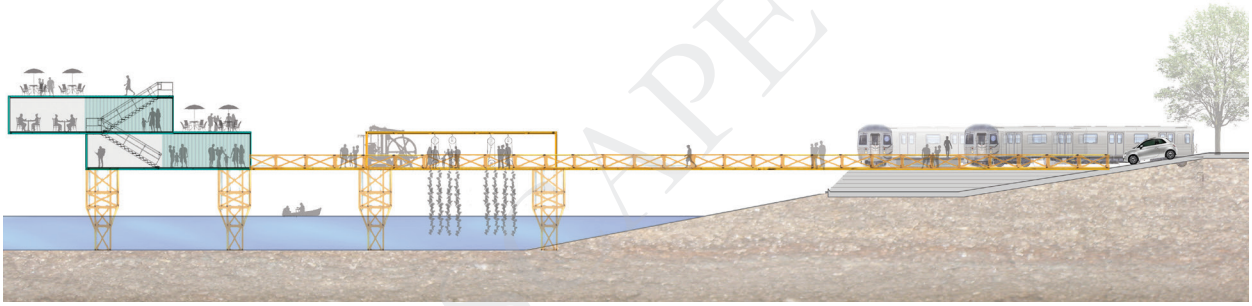
MILL CREEK/TOTTENVILLE STATION WATER HUB

Located in the southernmost point of New York State, Tottenville Station is the southern terminus of the main rail line. Taking advantage of the direct public transportation access, for this site we envision a bifurcated pier structure that extends over the Arthur Kill Channel, resembling the Bentley Street Ferry Terminal that used to operate on this location until the mid 1900's. A pier structure integrates sheltered areas, and a "head house" for commercial activity such as an Oyster bar, educational space for Oyster gardening, and a cultural space for potential showcases and events by the Tottenville Historical Society.

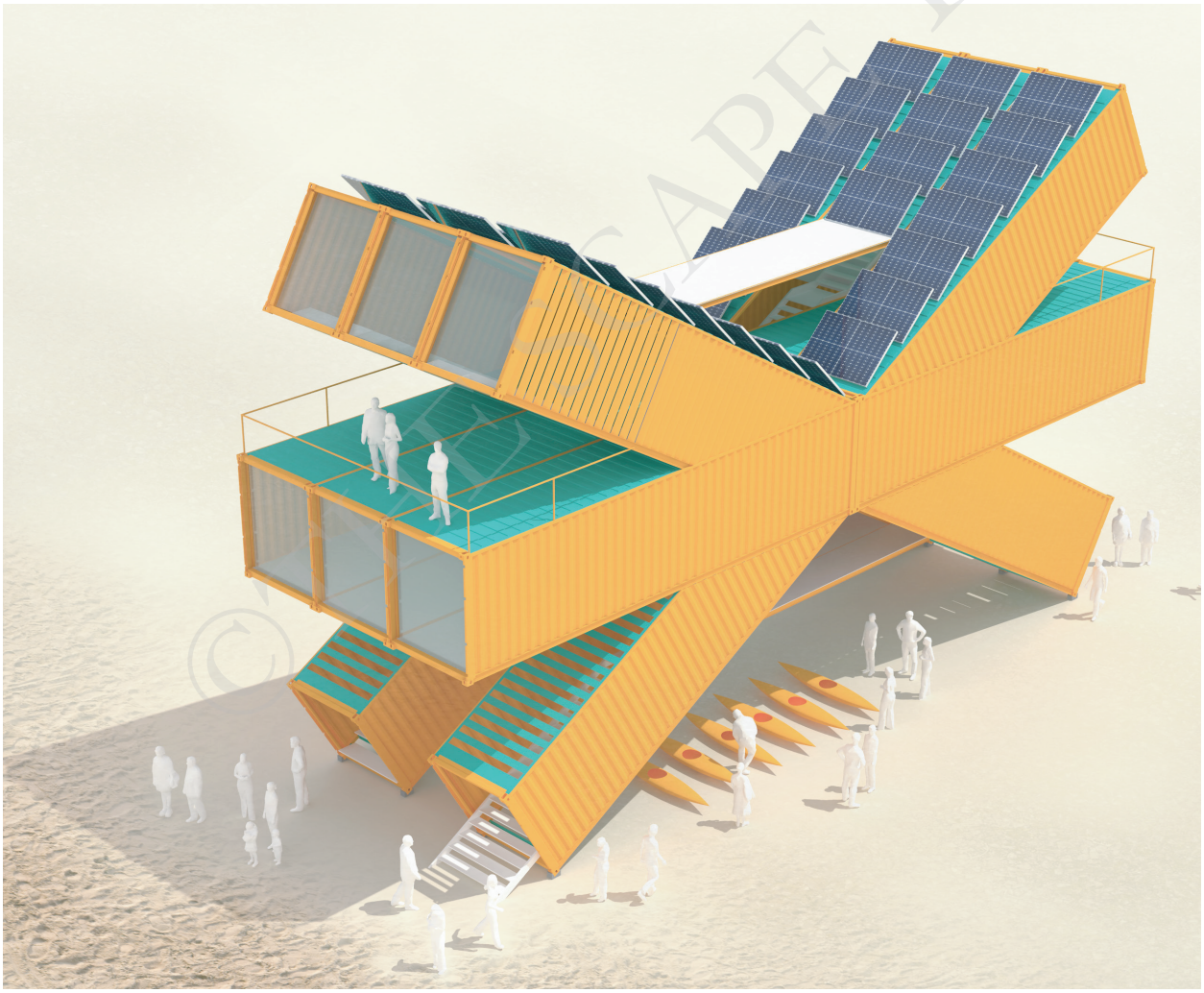
VIEW OF THE HISTORIC TOTTENVILLE FERRY TERMINAL, 1898



SCAPE

CRESCENT BEACH WATER HUB

Located at Crescent Beach, an area that was highly flooded and damaged during Superstorm Sandy, the Water Hub rises above the Base flood elevation, containing floodable program below the Design flood elevation such as kayak launch and kayak storage. The hub, conveniently located on NYC Parks and Recreation property, has a close proximity to many of the local schools, offering them space for education and summer activities as well as for boating training.



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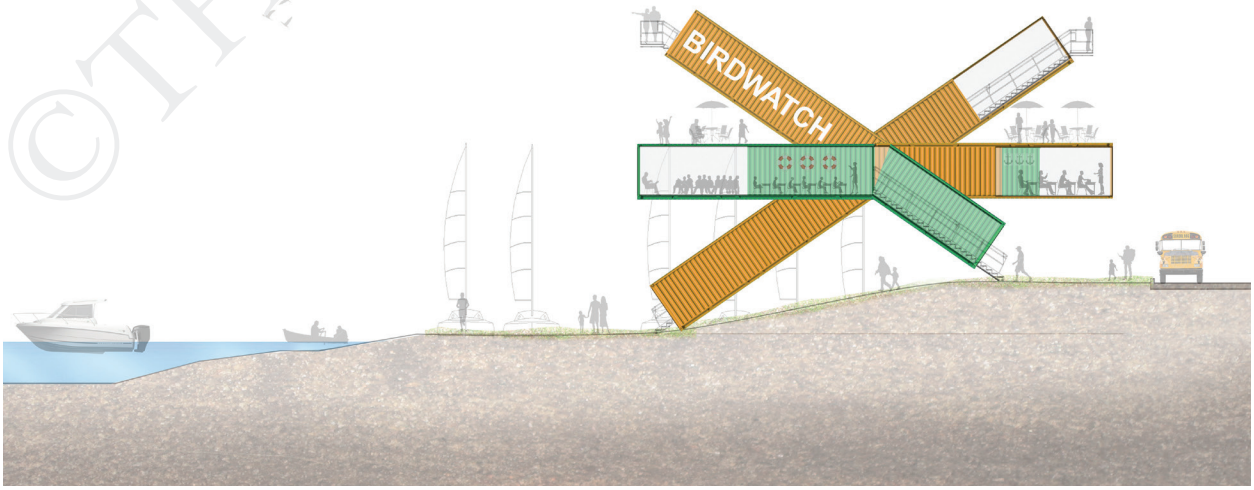

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PARTNERING & IMPLEMENTATION

COMMUNITY & AGENCY INPUT
COALITION BUILDING
A ROBUST REGULATORY STRATEGY
STRONG FUNDING JUSTIFICATION

©THE SCAPE TEAM

***THE SEPARATE DOCUMENT "TECHNICAL APPENDIX" INCLUDES DETAILED DOCUMENTATION OF THE FOLLOWING:**

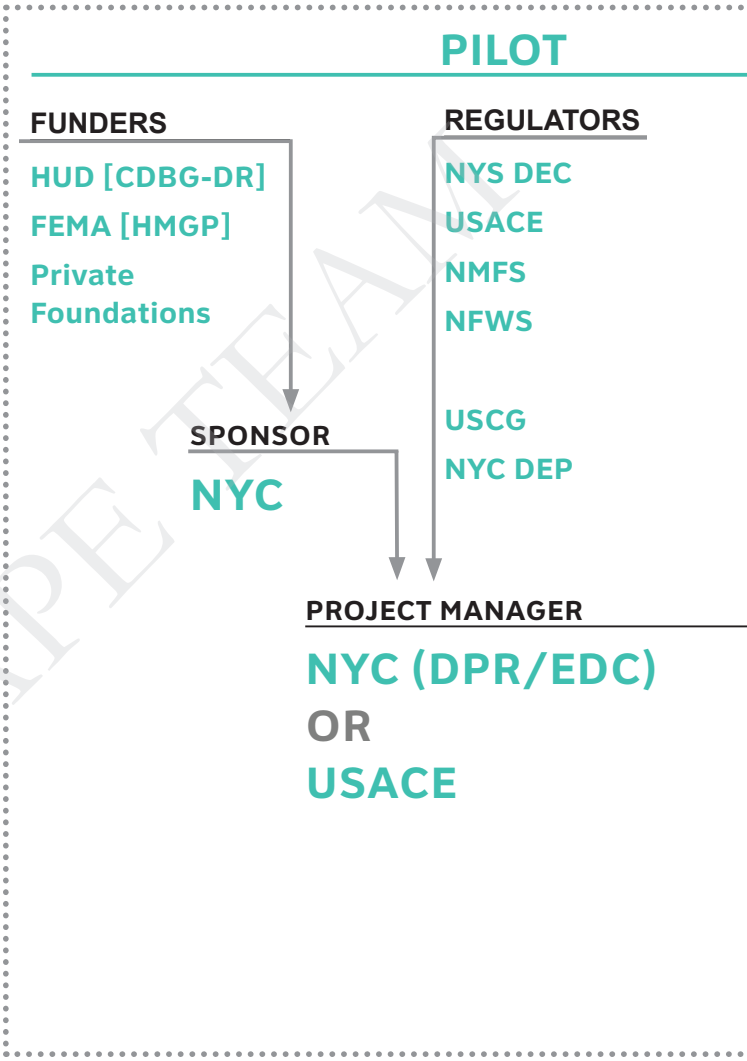
LETTERS OF SUPPORT
COST BENEFIT ANALYSIS
PILOT REGULATORY PATHWAY
MODEL RESULTS
FINANCING PLAN
MONITORING

IMPLEMENTATION

Implementation of the project will happen in two key phases: (A) implementing a large-scale Living Breakwater pilot project at Tottenville, (B) expanding the living breakwater strategy to the remainder of the Staten Island South Shore, and other appropriate locations in the region and even nationally.

While we believe that the justification and need for this project is clear through the benefits that it brings in the form of **REDUCING RISK, GROWING ECOLOGICAL RESILIENCY** and **BUILDING SOCIAL RESILIENCY**, we understand that in order to realize its benefits this project needs to be implementable. Implementation will require a strategy that addresses not only the constructability of the project, but the permitability and fundability of Living Breakwaters in the physical, political, and regulatory context of New York Harbor. Successful implementation will require four key elements:

(1) COMMUNITY AND AGENCY INPUT
(2) COALITION BUILDING
(3) A ROBUST REGULATORY STRATEGY
(4) STRONG FUNDING JUSTIFICATION



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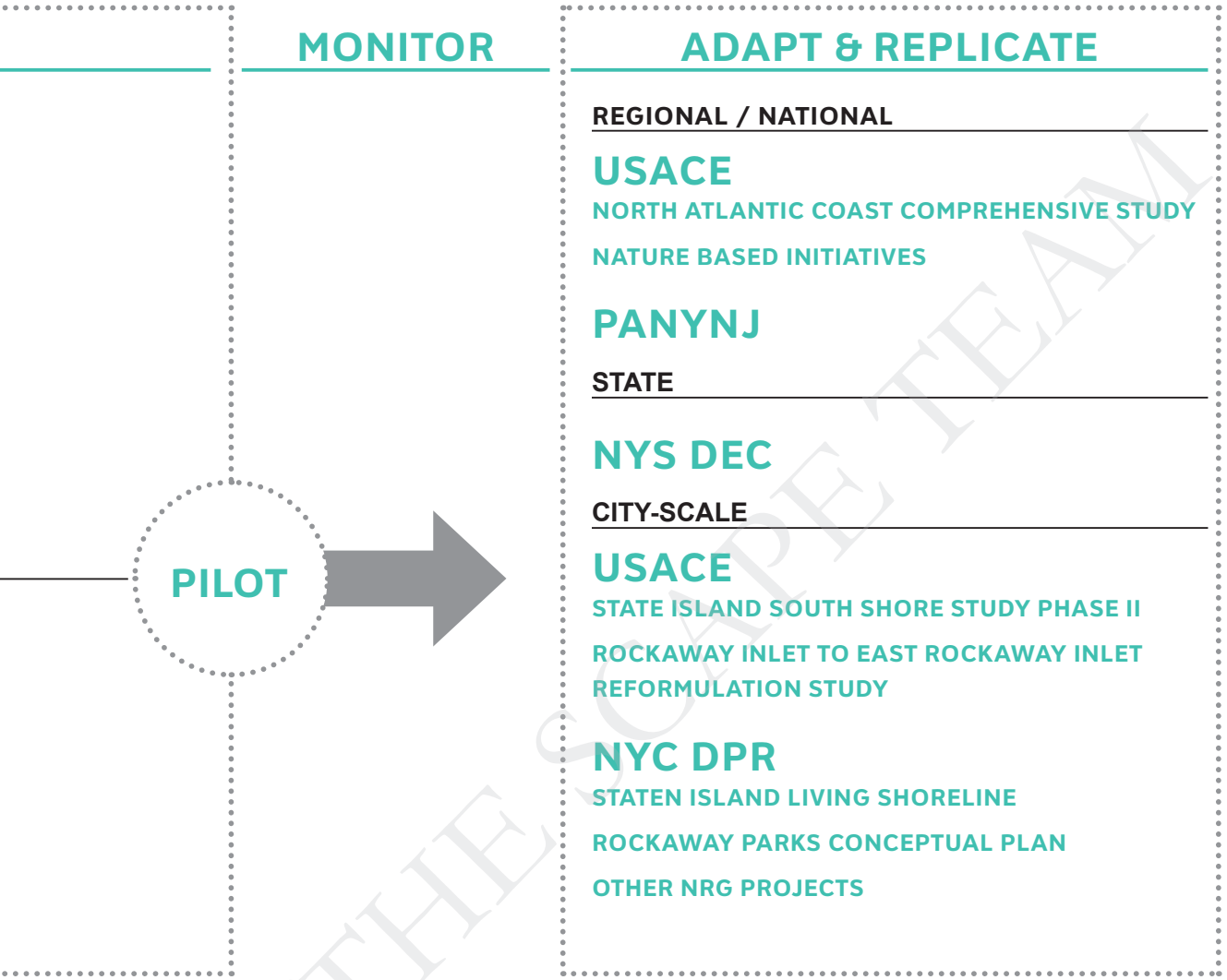

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COMMUNITY & AGENCY INPUT TIMELINE

Our team benefitted from diverse input from a range of stakeholders. A series of community meetings in Mt. Loretto crafted our approach and helped us determine the physical extents of our proposed pilot. Regular meetings with regulators and habitat specialists at The Army Corps, NYS DEC, US WFS, Marine Fisheries, and others helped to craft our approach to the design. In addition, we met with Clammers in Staten Island to map clam beds and held an "Oyster Summit" of restoration experts to develop a range of techniques that would help advance restoration science, monitoring, and maintenance practices within the scope of our pilot project. We conducted several teacher outreach workshops and heard first hand from secondary and high school science teachers about the need for and great interest in this project and the range of programming strategies and facilities embedded.

NOV 2013

NOV 6
HUD RBD STAGE III KICK-OFF

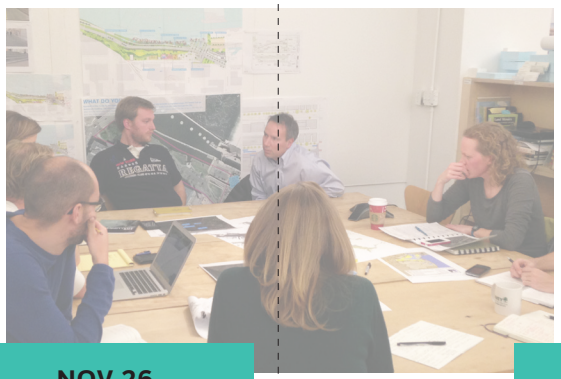
NOV 12
GUIDED SHORELINE BOAT TOUR
STATEN ISLAND/ RARITAN BAY

> "The next step is to conduct studies to determine environmental impact outside the breakwater footprint."
> - DEC employee

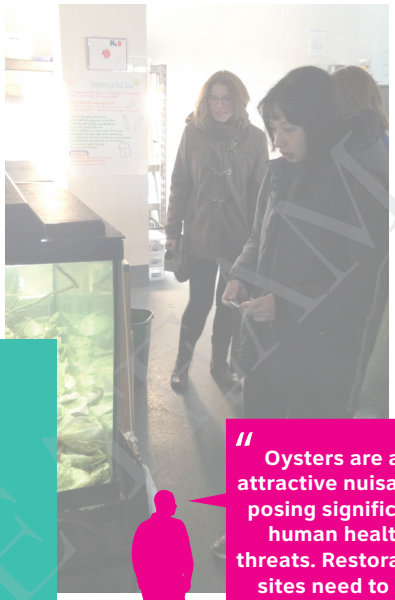
DEC 19
NYC AGENCIES MEETING

©THE SCAPE TEAM

DEC



NOV 26
BAYKEEPERS + HUDSON RIVER FOUNDATION MEETING



DEC 13
HARBOR SCHOOL VISIT
GOVERNORS ISLAND

> "Oysters are an attractive nuisance, posing significant human health threats. Restoration sites need to be carefully monitored."
> - DEC Employee

DEC 20
DEC/TNC MEETINGS

DEC 4
USACE MEETING

DEC 9-13
NYC DPR/ SI ELECTEDS NPS/ MEETINGS

> "A continuum of protection is absolutely essential along the South Shore."
> - Parks employee

LIFESCAPE

JAN 2014

FEB

JAN 23
NY RISING STATEN ISLAND COMITTEE MTG
JCC STATEN ISLAND

FEB 4
STATEN ISLAND COMMUNITY MTG #1
MT LORETTO

This project could be the catalyst for other planning processes around the island.
- NY Rising committee member

JAN 13
PS 57 SCHOOL OUTREACH MEETING

JAN 16
TOTTENVILLE CIVIC ASS. + FISHERMENS CONSERVATION ASS. MTGS

FEB 26
TEACHER OUTREACH WORKSHOP
NEW DORP HIGH SCHOOL

JAN 14-16
DEC/ NYC OLTPS/ SI BOROUGH PRESIDENT MTGS

JAN 28-31
USACE EDC/DOS CC/ NOAA MEETINGS

FEB 20
OLTPS MEETING
NYC

JAN 23-24
DEC/ NYC DPR/SI CLAMMERS/NY RISING MEETINGS

SCAPE TEAM

MAR

APR

MAR 11
STATEN ISLAND COMMUNITY MTG #2
MT LORETTO

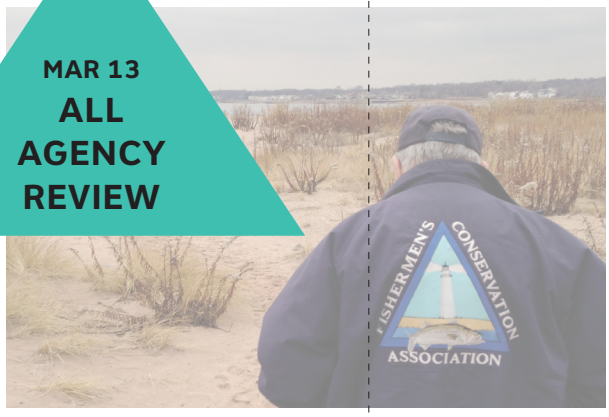
MAR 23
SCALE IT UP!
STATEN ISLAND MUSEUM

MAR 4
COAST GUARD MEETING

MAR 15
REEF BUILDING WORKSHOP
STATEN ISLAND MAKER SPACE

APR 3
STAGE III PUBLIC PRESENTATION
JERSEY CITY & MANHATTAN

MAR 13
ALL AGENCY REVIEW



MAR 13
DEC FINAL REVIEW

Keep going!
- DEC employee

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COALITION BUILDING

The Rebuild by Design competition itself illustrates the level of commitment at the federal level and specifically by the Department of Housing and Urban Development (HUD) to the development and implementation of innovative solutions such as Living Breakwaters. Support from HUD and the competition's project partners have helped spur commitment to this design. Support for Living Breakwaters goes well beyond the competition as national, state, and local leaders have voiced their support for this project, not to mention the many individuals and local, city, and harbor-wide organizations whose support is illustrated through the many letters of support submitted for this project. In New York City, resiliency is also high on the City's agenda - The Special Initiative for Rebuilding and Resiliency lays out the City's agenda regarding resiliency and specifically identifies breakwaters for the South Shore of Staten Island.

It would make science class even more fun. I already want to go there!
- S.I. Eighth Grader

From left to right: Staten Island Borough President James Oddo (R), New York State Senator Andrew Lanza (R), U.S. Senator Charles Schumer (D), New York State Assemblyman Joseph Borelli (R), New York City Councilmember Vincent Ignizio (R), New York City First Deputy Commissioner of Parks & Recreation Liam Kavanagh

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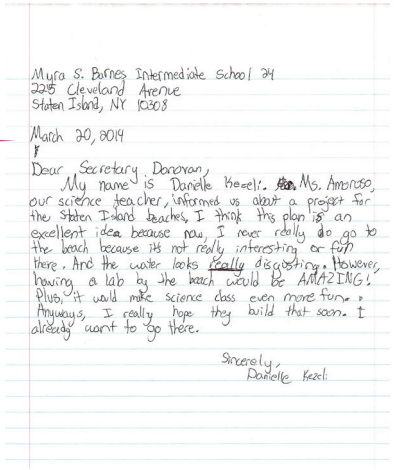
LETTERS OF SUPPORT

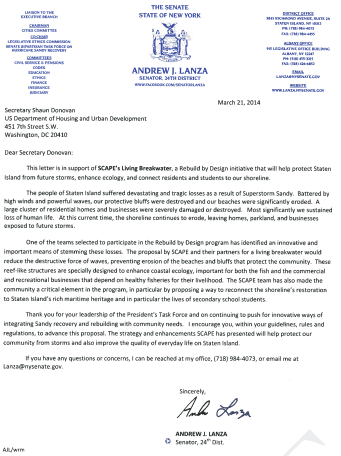


Myra S. Barnes Intermediate School 24
225 Cleveland Avenue
Staten Island, NY 10308

March 20, 2014

Dear Secretary Donovan,
My name is Danielle Kezeli. Ms. Amoroso, our science teacher, informed us about a project for the Staten Island beaches, I think this plan is an excellent idea because now, I never really do go to the beach because its not really interesting or fun there. And the water looks really disgusting. However, having a lab by the beach would be AMAZING! Plus, it would make science class even more fun. Anyways, I really hope they build that soon. I already want to go there.

Sincerely,
Danielle Kezeli



THE SENATE
STATE OF NEW YORK

ANDREW J. LANZA
SENATOR, 24TH DISTRICT

March 21, 2014

Secretary Shaun Donovan
US Department of Housing and Urban Development
451 7th Street S.W.
Washington, DC 20410

Dear Secretary Donovan:

This letter is in support of **SCAPE's Living Breakwater**, a Rebuild by Design initiative that will help protect Staten Island from future storms, enhance ecology, and connect residents and students to our shoreline.

The people of Staten Island suffered devastating and tragic losses as a result of Superstorm Sandy. Battered by high winds and powerful waves, our protective bluffs were destroyed and our beaches were significantly eroded. A large cluster of residential homes and businesses were severely damaged or destroyed. Most significantly we sustained loss of human life. At this current time, the shoreline continues to erode, leaving homes, parkland, and businesses exposed to future storms.

One of the teams selected to participate in the Rebuild by Design program has identified an innovative and important means of stemming these losses. The proposal by SCAPE and their partners for a living breakwater would reduce the destructive force of waves, preventing erosion of the beaches and bluffs that protect the community. These reef-like structures are specially designed to enhance coastal ecology, important for both the fish and the commercial and recreational businesses that depend on healthy fisheries for their livelihood. The SCAPE team has also made the community a critical element in the program, in particular by proposing a way to reconnect the shoreline's restoration to Staten Island's rich maritime heritage and in particular the lives of secondary school students.

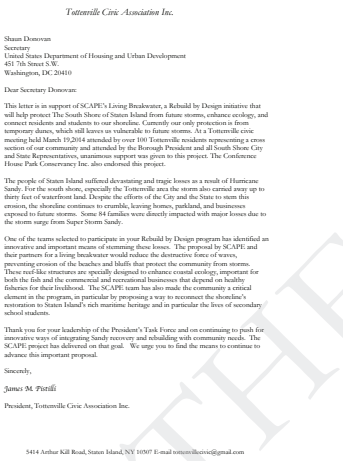
Thank you for your leadership of the President's Task Force and on continuing to push for innovative ways of integrating Sandy recovery and rebuilding with community needs. I encourage you, within your guidelines, rules and regulations, to advance this proposal. The strategy and enhancements SCAPE has presented will help protect our community from storms and also improve the quality of everyday life on Staten Island.

If you have any questions or concerns, I can be reached at my office, (718) 984-4073, or email me at Lanza@nysenate.gov.

Sincerely,

ANDREW J. LANZA
Senator, 24th Dist.

AJL/wrm



Totterville Civic Association Inc.

Shaun Donovan
Secretary
United States Department of Housing and Urban Development
451 7th Street S.W.
Washington, DC 20410

Dear Secretary Donovan:

This letter is in support of SCAPE's Living Breakwater, a Rebuild by Design initiative that will help protect The South Shore of Staten Island from future storms, enhance ecology, and connect residents and students to our shoreline. Currently our only protection is from temporary dunes, which still leaves us vulnerable to future storms. At a Totterville civic meeting held March 19,2014 attended by over 100 Totterville residents representing a cross section of our community and attended by the Borough President and all South Shore City and State Representatives, unanimous support was given to this project. The Conference House Park Conservancy Inc. also endorsed this project.

The people of Staten Island suffered devastating and tragic losses as a result of Hurricane Sandy. For the south shore, especially the Totterville area the storm also carried away up to thirty feet of waterfront land. Despite the efforts of the City and the State to stem this erosion, the shoreline continues to crumble, leaving homes, parkland, and businesses exposed to future storms. Some 84 families were directly impacted with major losses due to the storm surge from Super Storm Sandy.

One of the teams selected to participate in your Rebuild by Design program has identified an innovative and important means of stemming these losses. The proposal by SCAPE and their partners for a living breakwater would reduce the destructive force of waves, preventing erosion of the beaches and bluffs that protect the community from storms. These reef-like structures are specially designed to enhance coastal ecology, important for both the fish and the commercial and recreational businesses that depend on healthy fisheries for their livelihood. The SCAPE team has also made the community a critical element in the program, in particular by proposing a way to reconnect the shoreline's restoration to Staten Island's rich maritime heritage and in particular the lives of secondary school students.

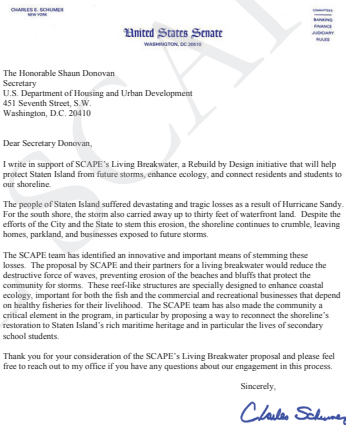
Thank you for your leadership of the President's Task Force and on continuing to push for innovative ways of integrating Sandy recovery and rebuilding with community needs. The SCAPE project has delivered on that goal. We urge you to find the means to continue to advance this important proposal.

Sincerely,

James M. Pistilli

President, Totterville Civic Association Inc.

5414 Arthur Kill Road, Staten Island, NY 10307 E-mail tottervillecivic@gmail.com



CHARLES E. SCHUMER
NEW YORK

United States Senate
WASHINGTON, DC 20510

COMMITTEES
BANKING
FINANCE
JUDICIARY
RULES

The Honorable Shaun Donovan
Secretary
U.S. Department of Housing and Urban Development
451 Seventh Street, S.W.
Washington, D.C. 20410

Dear Secretary Donovan,

I write in support of SCAPE's Living Breakwater, a Rebuild by Design initiative that will help protect Staten Island from future storms, enhance ecology, and connect residents and students to our shoreline.

The people of Staten Island suffered devastating and tragic losses as a result of Hurricane Sandy. For the south shore, the storm also carried away up to thirty feet of waterfront land. Despite the efforts of the City and the State to stem this erosion, the shoreline continues to crumble, leaving homes, parkland, and businesses exposed to future storms.

The SCAPE team has identified an innovative and important means of stemming these losses. The proposal by SCAPE and their partners for a living breakwater would reduce the destructive force of waves, preventing erosion of the beaches and bluffs that protect the community for storms. These reef-like structures are specially designed to enhance coastal ecology, important for both the fish and the commercial and recreational businesses that depend on healthy fisheries for their livelihood. The SCAPE team has also made the community a critical element in the program, in particular by proposing a way to reconnect the shoreline's restoration to Staten Island's rich maritime heritage and in particular the lives of secondary school students.

Thank you for your consideration of the SCAPE's Living Breakwater proposal and please feel free to reach out to my office if you have any questions about our engagement in this process.

Sincerely,

Charles E. Schumer
United States Senate

James S. Oddo, President of the Borough of Staten Island, City of New York

Vincent M. Ignizio, Minority Leader, The Council of New York City Hall

Andrew J. Lanza, New York State Senate, 24th District

Charles E. Schumer, United States Senate, New York

Rev. Terry Troia, President, Staten Island Longterm Recovery Organization

Meredith Comi, Oyster Restoration Project Director, NY/NJ Baykeeper

James M. Pistilli, Tottenville Civic Association

Community Board 3, NYC

NY Rising Community Reconstruction Program, Staten Island Planning Comittee

Debra A. Amoroso, Myra S. Barnes Intermediate School 24

Samantha Shakhvorostova, Salvatore Bonamassa, Carmela, Danielle Kezel, Izabela Rak, Maria, Madison Matteo, Luke Peteley, Bernadette Mustacchio, Ryan Gough, Jonathan Colella, Gianna M., Isaak Dorvin, Jillian O'Brien, Shane DeSilva, Kelly Nickel, Gerta Cako, Samantha Sette, Michelle Grishchenko; students of Intermediate School 24 in Staten Island

Brett F. Branco, Ph.D. Department of Earth and Environmental Sciences, Brooklyn College, The City University of New York

Katina Johnstone, Co-founder, Kayak Staten Island

Alan I. Benimoff, Ph.D.,College of Staten Island

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Myra S. Barnes Intermediate School 24
225 Cleveland Avenue
Staten Island, NY 10308

March 20, 2014

Dear Secretary Donovan:

As a student of the 9th grade, im heading off to high school. My favorite subject and the feild I want my career in to be in the future, is science. Science is my passion and I enjoy learning as much as I can about it. Having this project in Staten Island would mean a lot to me and all the residents. This plan would bring everyone closer to nature and let them learn more about it. This would inspire people like me to take interest. Bringing people closer to nature will hopefully make them care more for the environment. This project will show us the potential that our Island has. As for all the buroughs, we dont have many attractions and all those skyscrapers. We are surrounded by water, so why not use that to attract audiences to us and show why we are unique. We are often forgotten about and don't get much attention brought to us, even after hurricane Sandy. So many people were devistated; as for myself, I had no power for a week. Bringing this project here would give Staten Island something to attract people and make people more interested in us. I really hope to have this here because I have shores very close to where I live and I love being by the water. Having it would make me get out even more and enjoy the water so much more.

From,
Samantha Shakhvorostova 833

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Myra S. Barnes Intermidicte School 24
225 Cleveland Avenue
Staten Island, NY 10308

March 20, 2014

Dear Secretary Donovan,

My name is Maria. I am 14 years old and attend I.S.24 as an eigth grader. Staten Island can get a bit ~~dull~~ boring sometimes. The only two things to do at Staten Island is its mall and the movie theaters. The beaches aren't like the one's in Long Island or any other borough. I would appreciate it, if you fund us to build hubs on the beaches, to make Staten Island a bit more fun. The other boroughs are all known for things such as Manhatten - its building, Brooklyn - the environent, Queens - the apartments, ~~and~~ and the Bronx - its zoo. We are known as the boring borough, but we wouldn't if we had nice beaches and various activities to do there. Even if we aren't recognized as the borough with nice beaches, at least my peers, classmates, and all the students will be able to go to the beach and learn about ~~marine~~ and marine biology and observe the water.

From,
Maria

©THESCIENTEAM

Madison Matteo

Myra S. Barnes Intermediate School 24
225 Cleveland Avenue
Staten Island, NY, 10308
March 20, 2014

Dear Secretary Donovan:

My name is Madison Matteo. My classmates and I are 8th grade students at Myra S. Barnes Intermediate School. Our school is considerably close to Staten Island's waterfront, and our teacher has informed us about a plan to grow oysters and free them into the water. I think that this would be a great idea. The project would be an educational and memorable experience in our last year of I.S.24, and it would also contribute well to the environment. Oysters are naturally filters, and would clean the water while preventing something as devestating as Super-Storm Sandy from happening again. Please take all of this into consideration. We would be very grateful if you could make this project happen.

Sincerely,
Madison Matteo

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Myra S. Barnes Intermediate School 24
225 Cleveland Avenue
Staten Island, NY 10308

March 20, 2014
Dear Secretary Donovan:

My name is Bernadette Mustacchio and I'm an 8th grade student at I.S. 24. Mrs. Amoroso, my science teacher, recently informed us about a project that would help the waterFront on Staten Island. They would build reefs that would protect us from another storm like Sandy and community hubs. Our island would benefit so much from this. Sandy, unfortunately, devasted families all across the island. Some people were left homeless. This would help prevent another tragedy. We will also be growing oysters and set them free to clean our water. Staten Islanders would benefit greatly from this. We would actually be able utilize our beach. We would also attract many tourists which would help our economy. There will be many labs and activities, as well, that could provide us will educational school trips. I hope you consider this.

Sincerly,
Bernadette Mustacchio.

©THE OCEAN TEAM

Myra S. Barnes Intermediate School 24
225 Cleveland Avenue
Staten Island, NY 10308

March 20, 2014

Dear Secretary Donovan:

I am a child, a friend, a ~~neighbor~~ neighbor, but most importantly I am part of a community. My name is Luke Petrey and it is true I may just be an eighth grader at I.S. 24 but I have an opinion revolving around the construction of the reefs and the community has establishments. My neighborhood has been devastated, places of memory shattered, people introduced to a dark man that is called death. Never throughout my young life have I seen such a catastrophic event since 9/11. My home I consider one of the lucky ones this is due to the fact that even though I live in a one floor ranch and water had risen up into our dwelling our home was at least in tact. Homes had been engulfed in flames or even flattened by the monsterous like waves. Innocent lives were taken and Staten Island was scarred for eternity, or so I thought. As a community we rose to the challenge we rebuilt, we fought, we survived, we as a community became sturdy strong. We are torn, we are ravaged, but best of all we proud to be called a Staten Islander. New York needed aid, America answered, food was donated, clothes donated, comfort distributed, like channels. As they say what doesn't kill you makes you stronger. Yet in order to prevent another devastation such as this we must be provided with funds to construct this grand project. Lives are on the line if another one comes, kids could become educated

© SCAPE TEAM

from the labs, the reefs could prevent another storm, the hubs could help the community come together.

That is why I am pleading you not as a teacher or a student but as a fellow New Yorker. Thank you for reading this letter and taking your time to understand my cause for creating this piece, thank you.

Sincerely, your fellow Islander,
Luke Peterey

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Myra S Barnes Intermediate School 24
225 Cleveland Ave.
Staten Island, NY, 10308

March 20, 2014

Secretary Donovan,

I haven't lived on Staten Island for very long. My father is in the military, so I have only lived here for 2 years. However, in the short time I've been here, I have realized that Staten Island has very little in comparison to the rest of New York. You might not live here, but I have learned to call this place home, and I want my home to be better than it is now. A program was recently proposed that would provide benifits for our home. Education would be provided for the children of New York through the growing of oysters, and the reefs built would lessen the damages of another Sandy. I don't know about you, but that sounds like a pretty good deal. Staten Island isn't the most flashy or the most populated borough, but it has gotten the short end of the stick for too long. I am a voice in a million, but my name is Isaac Davan, and I think you should support this project.

Support our Borough,

Isaac Davan

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Myra S. Barnes Intermidate School 24
225 Cleveland Avenue
Staten Island, NY 10308

March 20, 2014

Dear Secretary Donovan,

AS a resident of Staten Island and a Kid in the local community I feel Staten Island has very little for anyone to do anything. Theres very few places for Kids and adults to hangout. I would be more than happy to be able to experience your project in my home town. It seems to feel like Staten Island is always the left out borough, we have nothing hereand it would feel good knowing people might actually like Staten Island and get some torrist over here other than Minhattan all the time. Mr. Donovan please pick Staten Island as your project place. My name is Kelly Nickel and I go to Myra S. Barnes Intermidate School 24 and I would love to see Staten Island as a place people want to live and visit in.

Sincerly,
Kelly Nickel

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Myra S. Barnes Intermediate School 24
225 Cleveland Avenue
Staten Island, NY 10308

March 20, 2014

Dear Secretary Donovan:

My name is Samantha Sette and I'm an 8th grade student at Myra S. Barnes Intermediate School 24. My teacher recently informed my class about to build reefs in our water. Several days in the summer, my family and many others want to go out onto the beach. However, the water now is uncomfortably dirty. This plan would hopefully cleanse our waters and provide our borough with enjoyable beaches. Along with this, my family and several others were severely affected by Hurricane Sandy. In the event of a similiar accurance in the future, any possibility of lessening the destruction would be a huge help to our community. Growing oysters would sincerely benefit our Island and community.

Sincerely,
Samantha Sette

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Brooklyn College The City University of New York

March 24, 2014

Shaun Donovan, Secretary
United States Department of Housing and Urban Development
451 7th Street S.W.
Washington, DC 20410

Dear Secretary Donovan:

I am writing to express my support of SCAPE's Living Breakwater, a Rebuild by Design initiative that will help protect Staten Island from future storms, enhance ecology, and connect residents and students to our shoreline. The people of Staten Island suffered devastating and tragic losses as a result of Hurricane Sandy. For the south shore, the storm also carried away up to thirty feet of waterfront land. Despite the efforts of the City and the State to stem this erosion, the shoreline continues to crumble, leaving homes, parkland, and businesses exposed to future storms.

The Rebuild by Design proposal by SCAPE and partners identifies an innovative and important means of stemming these losses. Their living breakwaters would reduce the destructive force of waves, preventing erosion of the beaches and bluffs that protect the community for storms. These reef-like structures are specially designed to enhance coastal ecology, important for both the fish and the commercial and recreational businesses that depend on healthy fisheries for their livelihood. The SCAPE team has also made the community a critical element in the program, in particular by proposing a way to reconnect the shoreline's restoration to Staten Island's rich maritime heritage and in particular the lives of secondary school students.

As a marine scientist and active member of the new Science and Resilience Institute at Jamaica Bay, I am particularly excited to see such innovative solutions to coastal resiliency being proposed. If SCAPE's project is selected, it would present a unique opportunity to advance our understanding of how to protect our coastal communities in an era of sea level rise. Not only would this project protect communities, but it would also attract researchers and graduate students from around the region interested in advancing the science of resilience.

Thank you for your leadership of the President's Task Force and on continuing to push for innovative ways of integrating Sandy recovery and rebuilding with community needs. The SCAPE project has delivered on that goal. We urge you to find the means to continue to advance this important proposal.

Sincerely,

Brett F. Branco, Ph.D.

Department of Earth and Environmental Sciences

Brooklyn College of The City University of New York
2900 Bedford Avenue · Brooklyn, New York 11210-2889 · Telephone (718) 951-5631

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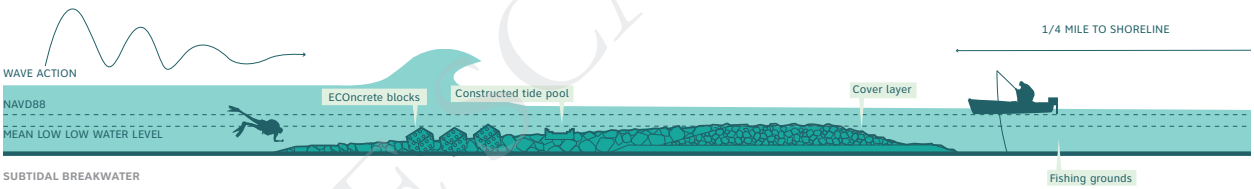
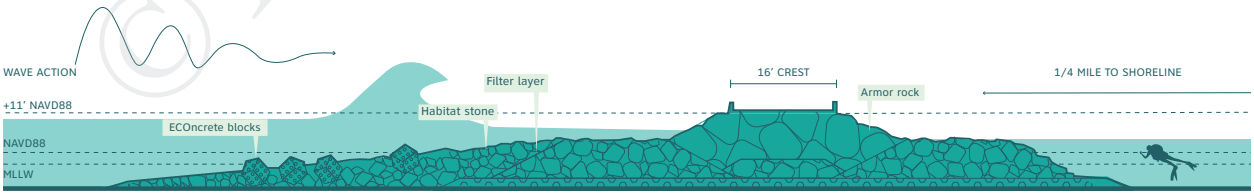
A TECHNICAL SOLUTION

The team has crafted an innovative and yet feasible solution to address a threefold need to reduce risk, grow ecological resiliency, and build social resiliency. The design has been informed by technical experts including engineers and ecologists, and the input and analysis from these experts is reflected in the level of technical detail presented in the design. The team has undertaken extensive analysis, including hydrologic modeling, in order to craft a design that maximizes the positive risk reduction and ecological and social impacts of the design. The team has also identified those areas where more information is needed and outlined the specific additional studies and modeling needed to develop and adapt the design to be ready for construction.



SUBTIDAL BREAKWATER



EXPOSED BREAKWATER

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A ROBUST REGULATORY STRATEGY

The team has met multiple times throughout this process with potential project implementation partners and regulatory agencies. The input from these potential regulators has informed both the project design and approach to implementation. The team has mapped out a regulatory pathway that will advance the project from the culmination of the RBD Phase III to construction and has identified the reviews, approvals, and permits that will be required for the implementation of this project. In addition, we have identified potential hurdles to implementation and specific strategies to overcome them.

1. **AVOID BARRIERS** Identify the barriers to implementation and avoid them as much as possible, either by changing location or minimizing temporary impacts with actions like seasonal work windows.

2. **EARLY AND FREQUENT COORDINATION WITH REGULATORY AGENCIES AND STAKEHOLDER ORGANIZATIONS** to educate them about the project, understand their concerns, and learn how to avoid or minimize impacts that are important to these groups. This action also includes getting commitments from senior leadership in these groups.

3. **LINK THE PROJECT INTO AN APPROVED REGIONAL FRAMEWORK,** either using regional shore protection plans and/or ecosystem improvement plans such as The Hudson Raritan Estuary Comprehensive Restoration Plan (HRE CRP).

4. **CLOSE DATA GAPS** Regulatory and advisory agencies lack the resources to obtain all the data that is important for their review processes; without sufficient data they are more inclined to delay projects with additional data requests. For this reason filling data gaps (within reason) early in the permit process and/or making commitments for follow-on studies will avoid delay.

5. **ENSURE THAT THE PROJECT IS CONSISTENT WITH AGENCY REVIEW STANDARDS FOR ISSUING A PERMIT** (these standards are generally applicable for all the regulatory agencies):
   a. the proposal is reasonable and necessary (this is achieved by demonstrating the benefits of the project)
   b. the proposal will not endanger the health, safety and welfare of the people of the State of New York
   c. the proposal will not cause unreasonable, uncontrolled, or unnecessary damage to the natural resources of the state including soil, forests, water, fish, and aquatic and related environment (in other words the project must be compatible with the preservation, protection, and enhancement of the present and potential values of the water resources).

6. **CONTINUE TO STRESS THE PROJECT BENEFITS OF PROTECTING THE PUBLIC HEALTH AND WELFARE** by noting the loss of life and property/infrastructure damage from past storms and showing what the project will do to avoid/reduce this damage.

7. **USE CASE STUDIES** Avoid unnecessary or duplicative work by utilizing applicable case studies like the USACE's Plumb Beach Beneficial Use of Dredge Materials for Shoreline Protection and others.

8. **CONTINUE COMMUNITY OUTREACH** Outreach is important for early identification of community issues and ways to address those issues as well as garnering public support (both public support – as indicated by positive comments from community groups and representatives – and a lack of public objections will avoid regulatory delays).

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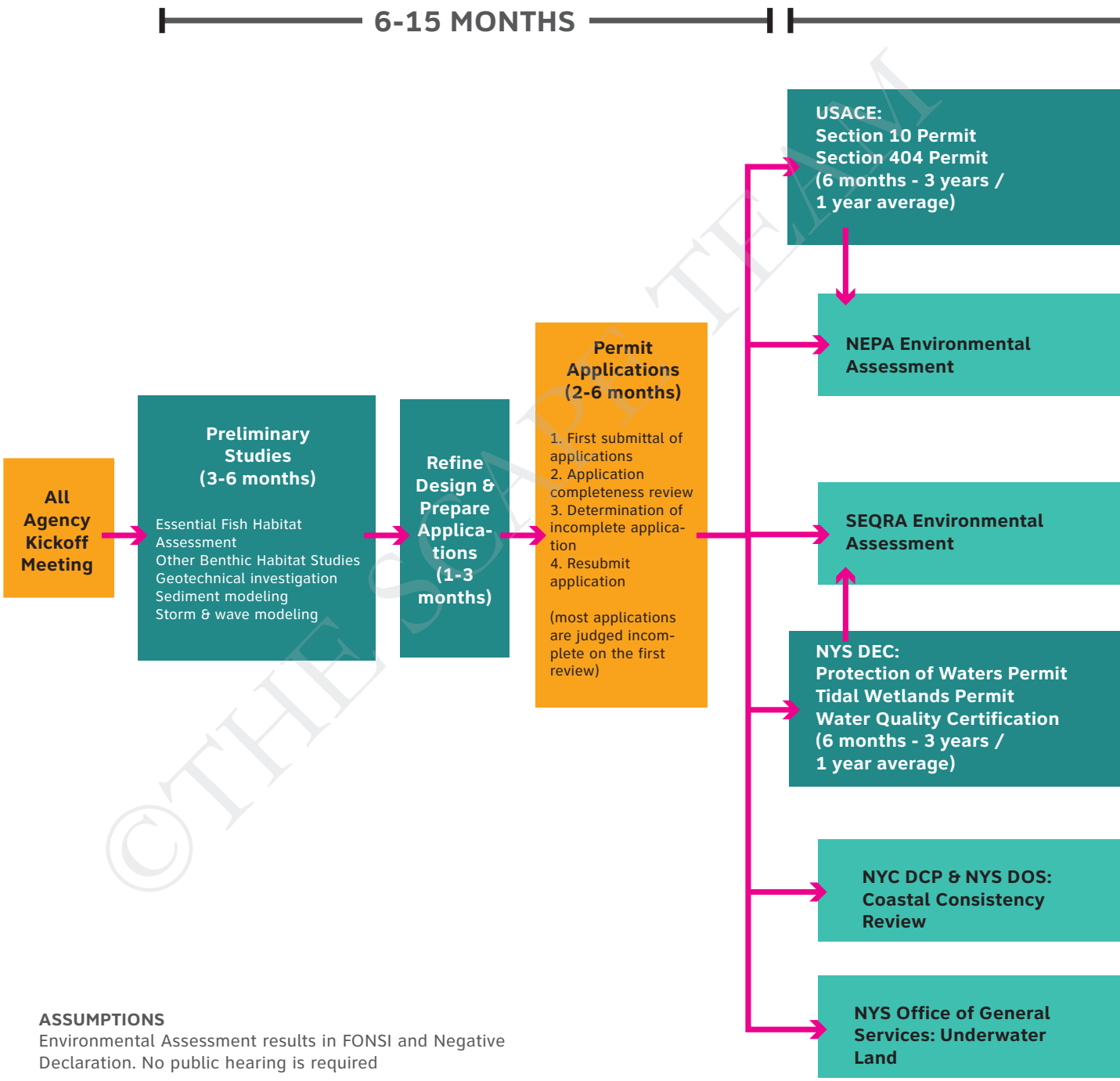
PILOT PROJECT
REGULATORY PATHWAY



ASSUMPTIONS
Environmental Assessment results in FONSI and Negative Declaration. No public hearing is required

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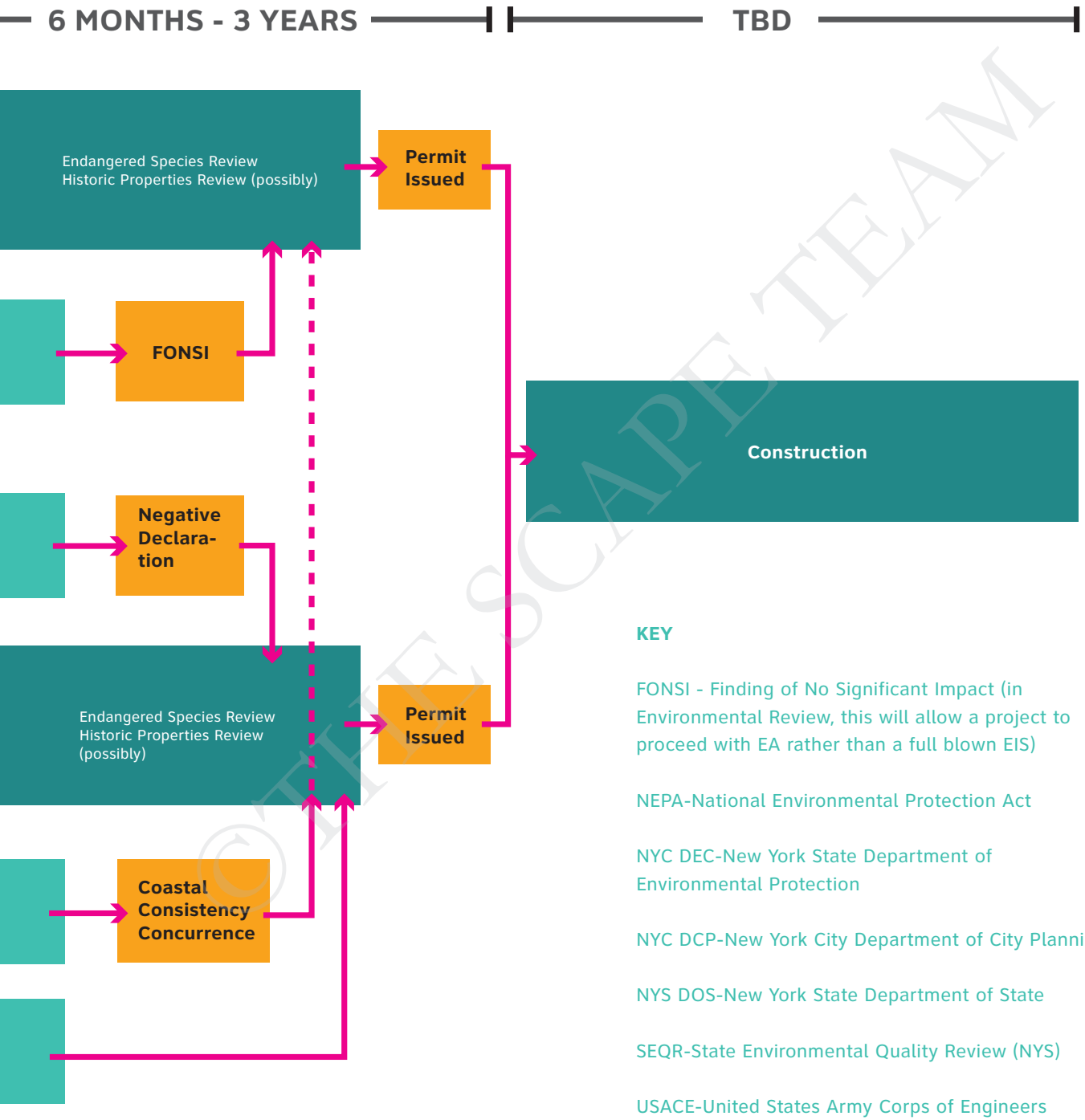

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KEY

FONSI - Finding of No Significant Impact (in Environmental Review, this will allow a project to proceed with EA rather than a full blown EIS)

NEPA-National Environmental Protection Act

NYC DEC-New York State Department of Environmental Protection

NYC DCP-New York City Department of City Planning

NYS DOS-New York State Department of State

SEQR-State Environmental Quality Review (NYS)

USACE-United States Army Corps of Engineers

STRONG FUNDING JUSTIFICATION

Identifying funding sources is key, but in order to access these sources, clear justification for the expense of funds expressed in terms of the goals and objectives of the particular funding source are required. The team has developed and applied a method for estimating the impacts of the project on reducing land loss to erosion, damage to property, and loss of life. For the proposed pilot phase at Tottenville, these risk reduction benefits considering a 100 year storm event were monetized and compared against the cost of the project yielding a benefit cost ration greater than 1 and indicating that even without consideration of the additional ecological, social, and economic benefits offered by the project, the benefits to risk reduction outweigh the cost of implementing the Tottenville pilot.

TOTTENVILLE PILOT: RISK REDUCTION*

RISK REDUCTION BENEFITS (Loss/Damage Avoided)

COSTS

	Loss/damages Without Project	Loss/damages With Project	Benefits (difference)
Residential			
Reconstruction	$52,073,000	$19,405,750	$32,667,250
Relocation	$26,151,984	$0	$26,151,984
Commercial			
Reconstruction	$1,248,000	$166,250	$1,081,750
Revenue	$20,000,000	$0	$20,000,000
Roads			
Reconstruction	$5,815,007	$3,251,829	$2,563,178
Parks & Beaches			
Reconstruction	$266,764,016	$127,316,309	$139,447,707
Safety			
Loss of Life	$13,063,484	$0	$13,063,484
Property Values			
Value Lost	$2,772,608	$0	$2,772,608
Erosion Control Costs	**$17,062,500**	**$0**	**$17,062,500**
Storm Year Impacts	**$387,888,100**	**$150,140,138**	**$237,747,961**
Effective Annual Impact	$4,049,506	$1,501,401	**$2,548,105**

Assumptions:

Effective Life of Project	100 years
Discount Rate	5%

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Escalation rates revised based on USACE ratios provided by Scott Davis at HUD. The assumption made for cost escalation was: escalation over a four year permitting and construction period from 3QFY2014 to 3QFY2018. The escalation rate used for capital construction and equipment was 8%. No escalation was applied to programming, monitoring, or maintenance and operations costs. As these will be pilot projects/the first of their type, the soft costs may require additional iterations of design and modeling. These are approximately 5% of the total breakwater costs.

Living Breakwaters is part of a greater strategy of resiliency along the South Shore of Staten Island, a layered approach which builds on the ongoing planning and construction of other organizations, including the State NY Rising program. While none of these costs are included in the cost analysis of for Living Breakwaters, the coordinated implementation of these measures is key to a successful project.

TOTAL COST TOTTENVILLE REACH	
Total Capital Construction Costs	$58,473,000
Total Equipment Costs	$632,000
Total Programming costs (period varies)	$1,902,000
Total Maintenance Costs (period varies)	$11,697,000
Total Monitoring costs (period varies)	$1,200,000
TOTAL COSTS (undiscounted)	**$73,904,000**

BENEFIT-COST ANALYSIS

Discounted Analysis (@ 5%)	
Total Benefits	$81,862,645
Total Costs	$51,373,952
BC Ratio	1.59
NPV	$30,488,693

Sensitivity Analysis (@ 5%)	
15% Increase in Benefits	
Benefits	$94,142,041
BC Ratio	**1.83**
NPV	$42,768,090
15% Decrease in Benefits	
Benefits	$69,583,248
BC Ratio	**1.35**
NPV	$18,209,296
15% Increase in Costs	
Costs	$59,080,044
BC Ratio	**1.39**
NPV	$22,782,600
15% Decrease in Costs	
Costs	$43,667,859
BC Ratio	**1.87**
NPV	$38,194,786

*** THIS BENEFIT-COST ANALYSIS REFLECTS RISK REDUCTION BENEFITS ONLY AND DOES NOT INCORPORATE ECOLOGICAL OR SOCIAL BENEFITS. SEE TECHNICAL APPENDIX FOR DETAILS.**

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LIVING BREAKWATERS

SOUTH SHORE OF STATEN ISLAND

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Public School 3

South Richmond High School

BOP's Oyster Gardening Manual will provide information how to actively engage students with oyster restoration in Raritan Bay.

PS6

Tottenville—"The town the oyster built"—was founded on a thriving oyster economy and a rich maritime industry.

Public School 1

Intermediate School 34

Tottenville

Linking initiatives underway at Conference House Park to the larger breakwater system is key for efficient coastal protection in the future.

Historically, the South Shore had a vibrant shoreline culture. Encouraging recreation and education will help to rekindle this historical linkage to the water.

Kayak fishing zone

Protective dune

Coastal maritime forest restoration

Intertidal breakwaters

Subtidal constructed reefs

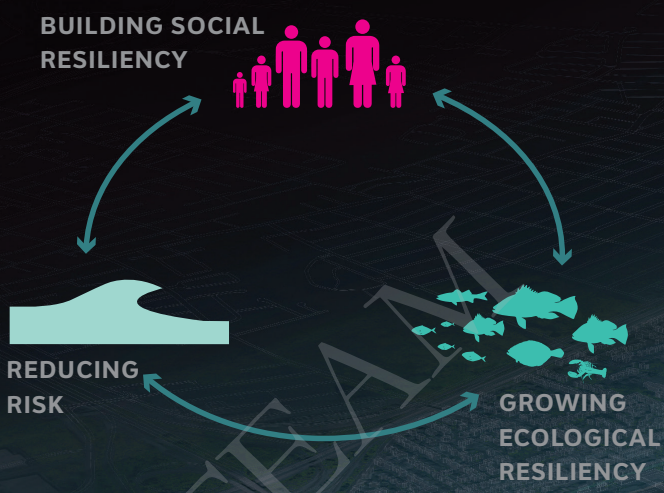
Active oyster restoration and monitoring

Underwater scuba trail

Marinas hold the potential to cultivate educational opportunities as well as economic gains for the South Shore as valuable water access points.
Great Kills Harbor
Eltingville
Crescent Beach water hub
Huguenot
Tottenville High School
INFOBOX
Annadale
Prince's Bay
Spat sanctuary
Recreational and charter fishing have the potential to benefit hugely from these breakwaters, strengthening shoreline economies.
Lemon Creek water hub
Sharrott's Pier
Hylan Blvd.
Our community outreach events engaged the entire island. Here, Staten Islanders built an interactive oyster reef for future educational events, and teachers discussed the potentials of the Billion Oyster Project curriculum.
Staten Island clammers actively helped to shape and inform the placement of the breakwaters to avoid critical shellfish habitat.
Tottenville water hub
Living shoreline
Exposed breakwaters
Enhanced fishing grounds
Navigation channel
Biogenic buildup of marine species creates a thriving ecosystem and serves to structurally reinforce the breakwaters.
Eastern oysters were harvested by hand from native beds in Raritan Bay. Oyster leases were created and farmed until the late 1890s.

The SCAPE team has developed a science-driven methodology that pairs layered eco-infrastructural systems sited for risk-reduction with social and educational networks, rebuilding water based infrastructures in tandem with surrounding communities.

Our project for Staten Island, NY - called Living Breakwaters **REDUCES RISK, REVIVES ECOLOGIES, AND CONNECTS EDUCATORS TO THE SHORELINE**, inspiring a new generation of harbor stewards and a more resilient region over time.



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