PUBLIC NOTICE

US Army Corps
of Engineers
New York District
Jacob K. Javits Federal Building
New York, N.Y. 10278-0090
ATTN: Regulatory Branch

In replying refer to:
Public Notice Number: NAN-2019-00193-ESW
Issue Date: January 21, 2020
Expiration Date: February 20, 2020

To Whom It May Concern:

The New York District, Corps of Engineers has received an application for a Department of the Army permit pursuant to Section 10 of the Rivers and Harbors Act of 1899 (33 U.S.C. 403) and Section 404 of the Clean Water Act (33 U.S.C. 1344).

APPLICANT: New York Harbor Foundation, Inc.
Attn: Peter Malinownski
10 South Street, Slip 7
Battery Maritime Building
New York, New York 10004

ACTIVITY: Construction of oyster reefs for the Billion Oyster Project

WATERWAY: Bronx River

LOCATION: Soundview Park, Borough of Bronx, Bronx County, City of New York, New York

A detailed description and plans of the applicant's activity are enclosed to assist in your review.

The decision whether to issue a permit will be based on an evaluation of the probable impact including cumulative impacts of the proposed activity on the public interest. That decision will reflect the national concern for both protection and utilization of important resources. The benefit which reasonably may be expected to accrue from the proposal must be balanced against its reasonably foreseeable detriments. All factors which may be relevant to the proposal will be considered including the cumulative effects thereof; among those are conservation, economics, aesthetics, general environmental concerns, wetlands, historic properties, fish and wildlife values, flood hazards, floodplain values, land use, navigation, shoreline erosion and accretion, recreation, water supply and conservation, water quality, energy needs, safety, food and fiber production, mineral needs, considerations of property ownership and, in general, the needs and welfare of the people.

The Corps of Engineers is soliciting comments from the public; Federal, state, and local agencies and officials; Indian Tribes; and other interested parties in order to consider and evaluate the impacts of this proposed activity. Any comments received will be considered by the Corps of Engineers to determine whether to issue, modify, condition or deny a permit for this proposal. To make this decision, comments are used to assess impacts on endangered species, historic properties, water quality, general environmental effects, and the other public interest factors listed above. Comments are used in preparation of an Environmental Assessment and/or an Environmental Impact Statement pursuant to the National Environmental Policy Act. Comments are also used to determine the need for a public hearing and to determine the overall public interest of the proposed activity.

ALL COMMENTS REGARDING THE PERMIT APPLICATION MUST BE PREPARED IN WRITING AND MAILED TO REACH THIS OFFICE BEFORE THE EXPIRATION DATE OF THIS NOTICE, otherwise, it will be presumed that there are no objections to the activity.

Comments submitted in response to this notice will be fully considered during the public interest review for this permit application. Comments provided will become part of the public record for this permit application. All written comments, including contact information, will be made a part of the administrative record, available to the public under the Freedom of Information Act. The Administrative Record, or portions thereof, may also be posted on a Corps of Engineers internet web site. Due to resource limitations, this office will normally not acknowledge the receipt of comments or respond to individual letters of comment.

Any person may request, in writing, before this public notice expires, that a public hearing be held to collect information necessary to consider this application. Requests for public hearings shall state, with particularity, the reasons why a public hearing should be held. It should be noted that information submitted by mail is considered just as carefully in the permit decision process and bears the same weight as that furnished at a public hearing.

Our preliminary determination is that the activity for which authorization is sought herein is not likely to affect any Federally endangered or threatened species or their critical habitat. However, pursuant to Section 7 of the Endangered Species Act (16 U.S.C. 1531), the District Engineer is consulting with the appropriate Federal agency to determine the presence of and potential impacts to listed species in the project area or their critical habitat.

The Magnuson-Stevens Fishery Conservation and Management Act, as amended by the Sustainable Fisheries Act (Public Law 104-267), requires all Federal agencies to consult with the National Oceanic and Atmospheric Administration Fisheries Service (NOAA/FS) on all actions, or proposed actions, permitted, funded, or undertaken by the agency, that may adversely affect Essential Fish Habitat (EFH). The proposed work, fully described in the attached work description, could cause the disruption of habitat for various lifestages of some EFH-designated species as a result of a temporary increase in turbidity during construction. However, the New York District has made the preliminary determination that the site-specific adverse effects are not likely to be substantial because it is expected that fish populations would avoid the small area of disturbance. Further consultation with NOAA/FS regarding EFH impacts and conservation recommendations is being conducted and will be concluded prior to the final decision.

Based upon a review of the latest published version of the National Register of Historic Places, there are no known sites eligible for, or included in, the Register within the permit area. Presently unknown archeological, scientific, prehistorical, or historical data may be lost by work accomplished under the required permit.

Reviews of activities pursuant to Section 404 of the Clean Water Act will include application of the guidelines promulgated by the Administrator, U.S. Environmental Protection Agency, under authority of Section 404 (b) of the Clean Water Act and the applicant will obtain a water quality certificate or waiver from the appropriate state agency in accordance with Section 401 of the Clean Water Act prior to a permit decision.

Pursuant to Section 307 (c) of the Coastal Zone Management Act of 1972 as amended [16 U.S.C. 1456 (c)], for activities under consideration that are located within the coastal zone of a state which has a federally approved coastal zone management program, the applicant has certified in the permit application that the activity complies with, and will be conducted in a manner that is consistent

with, the approved state coastal zone management program. By this public notice, we are requesting the state's concurrence with, objection to, or waiver of the applicant's certification. No permit decision will be made until one of these actions occur. For activities within the coastal zone of New York State, the applicant's certification and accompanying information is available from the Consistency Coordinator, New York State Department of State, Division of Coastal Resources and Waterfront Revitalization, Coastal Zone Management Program, One Commerce Plaza, 99 Washington Avenue, Albany, New York 12231, Telephone (518) 474-6000. Comments regarding the applicant's certification, and copies of any letters to this office commenting upon this proposal, should be so addressed.

In addition to any required water quality certificate and coastal zone management program concurrence, the applicant has obtained or requested the following governmental authorization for the activity under consideration:

- New York State Department of Environmental Conservation

It is requested that you communicate the foregoing information concerning the activity to any persons known by you to be interested and who did not receive a copy of this notice. If you have any questions concerning this application, you may contact this office at (917) 790-8521 and ask for Seika Robinson.

In order for us to better serve you, please complete our Customer Service Survey located at http://www.nan.usace.army.mil/Missions/Regulatory/CustomerSurvey.aspx.

For more information on New York District Corps of Engineers programs, visit our website at http://www.nan.usace.army.mil.

For and In behalf of
Stephan A. Ryba
Chief, Regulatory Branch

Enclosures

WORK DESCRIPTION

The permit applicant, the New York Harbor Foundation, Inc. (also known as the Billion Oyster Project), has requested Department of the Army authorization for construction of oyster reefs at the confluence of the Bronx and East Rivers adjacent to Soundview Park in the Borough of Bronx, Bronx County, City of New York, New York.

The proposed work would involve construction of various oyster cultivation structures within an approximate five-acre footprint. The applicant proposes 250 units over approximately 0.05 acres of gabion structures filled with live oysters and shells. Each structure will measure two-foot-wide by 4.25-foot-long by two-foot-high. The applicant would discharge approximately 1,309 cubic yards of loose shell in mounds within an approximate 0.90 acre footprint.

Each gabion structure weighs approximately 350 pounds and is not proposed to be anchored to the riverbed. The applicant stated that the proposed gabions will not move because of the weight of the structures, the predominant mud substrate, and the flat bathymetry of the project area. The applicant stated that the gabion structures would degrade over time, allowing for the newly formed reef (the live oysters which have developed within the gabions) to remain in place. The applicant stated that the corrosion rate of the steel is estimated to be 0.23 mm/year, with the applicant's assumption that the gabions will remain fully submerged in the subtidal zone. The applicant has stated that the full functionality of the steel gabions will remain for at least 25 years.

The applicant would utilize a barge to transport gabion structures, loose shell, and a hydraulic crane to place shell and gabion structures in the waterway. The gabion structures and loose shell will be transported to the project site by tug and spud barges and will secure position during high tide. The loose shell mounds will be installed by utilizing high-volume, low-pressure hoses, cranes or other means to install the loose shell within predetermined boundaries and at desired heights.

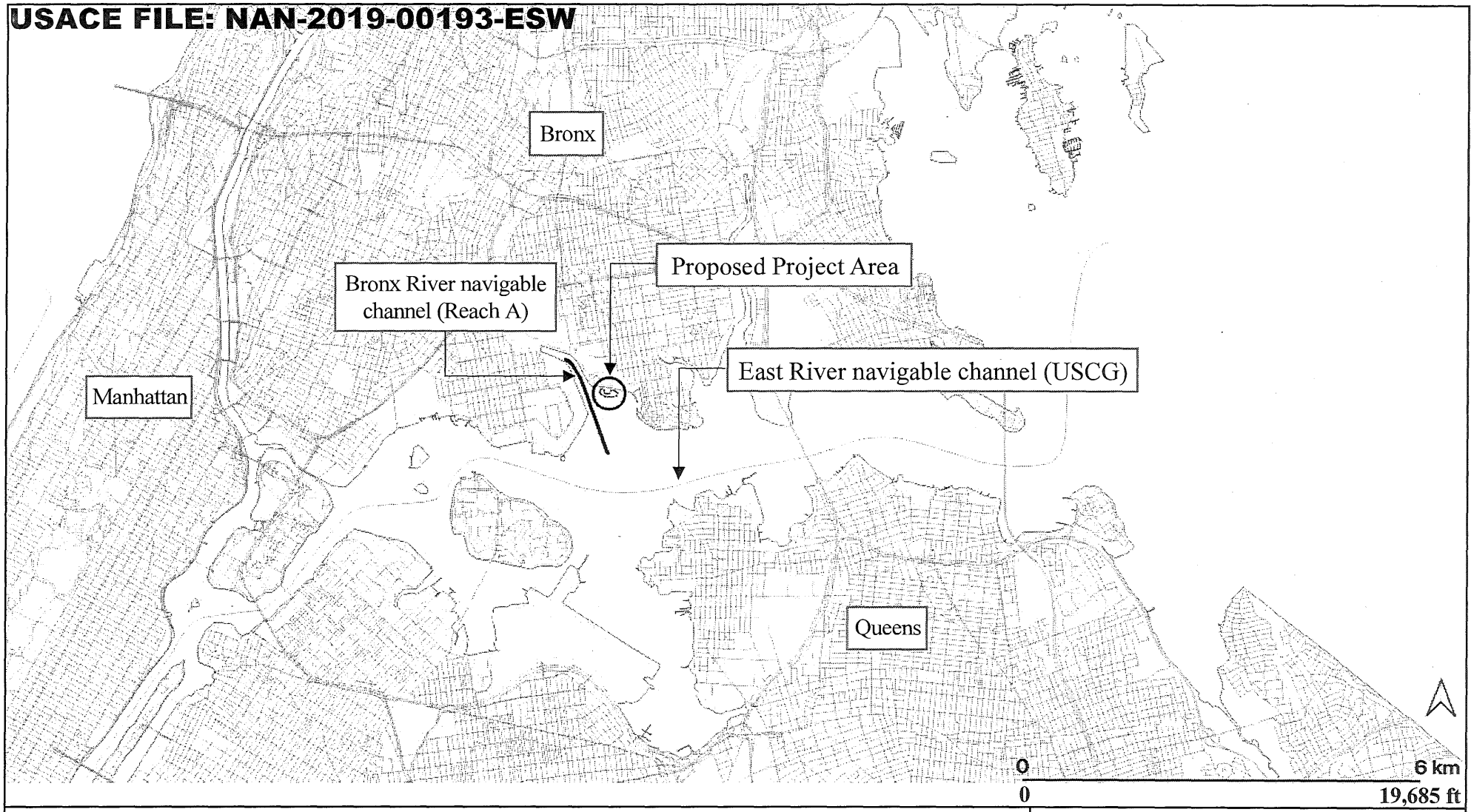
The attached monitoring plan is proposed by the applicant to address the oyster restoration activities and potential adaptive management, as needed, to ensure the integrity of the oyster restoration structures. The monitoring and adaptive management would ensure the reef structures would not move closer to the navigation channels or become a hazard to navigation.

The proposed oyster reef construction activities would be installed a maximum of 475 linear feet into the waterway from the plane of Mean Low Water. The waterward extent of the oyster structures would be located approximately 650 linear feet from the edge of the Bronx River Federal navigation project.

The applicant has stated that they have avoided, minimized and mitigated for impacts by installing the proposed gabions and loose shell on the ebb tide at the convergence of the Bronx and East Rivers to reduce suspended sediment in the waterway with a limited benthic footprint because it includes vertical habitat. The live oysters contained within the gabion structures and seeded onto a portion of the loose shell will filter water and will create additional marine habitat. Additionally, the applicant would implement adaptive management and monitoring in accordance with the enclosed plans, which would be required in special conditions of any Department of the Army permit authorization.

The stated purpose of this project is to conduct additional oyster restoration to expand research and restoration activities that improve the water quality of the Bronx and East Rivers.

USACE FILE: NAN-2019-00193-ESW



Soundview Oyster Habitat Restoration Project Vicinity Map - Zoomed Out

Submitted By: Billion Oyster Project on 12/12/2019

LEGEND

- Project Footprint ~5 acres
- Streets
- Soundview Park (land)
- Bronx River navigable channel (Reach A)

Bronx and East Rivers
Clason Point and Hunts Point, Bronx
County of Bronx, State of New York

Digital Tax Map: Block 3463 Lot 1

Datum N.A.V.D 88

Project Site Coordinates: 40.809453; -73.865549

Data Source for Bronx River navigable channel (Reach A): NOAA's Ocean Service, Office of Coast Survey (OCS) (2015) "Coastal Maintained Channels in US waters" Retrieved from:https://nauticalcharts.noaa.gov/data/gis-data-and-services.html#enc-direct-to-gis

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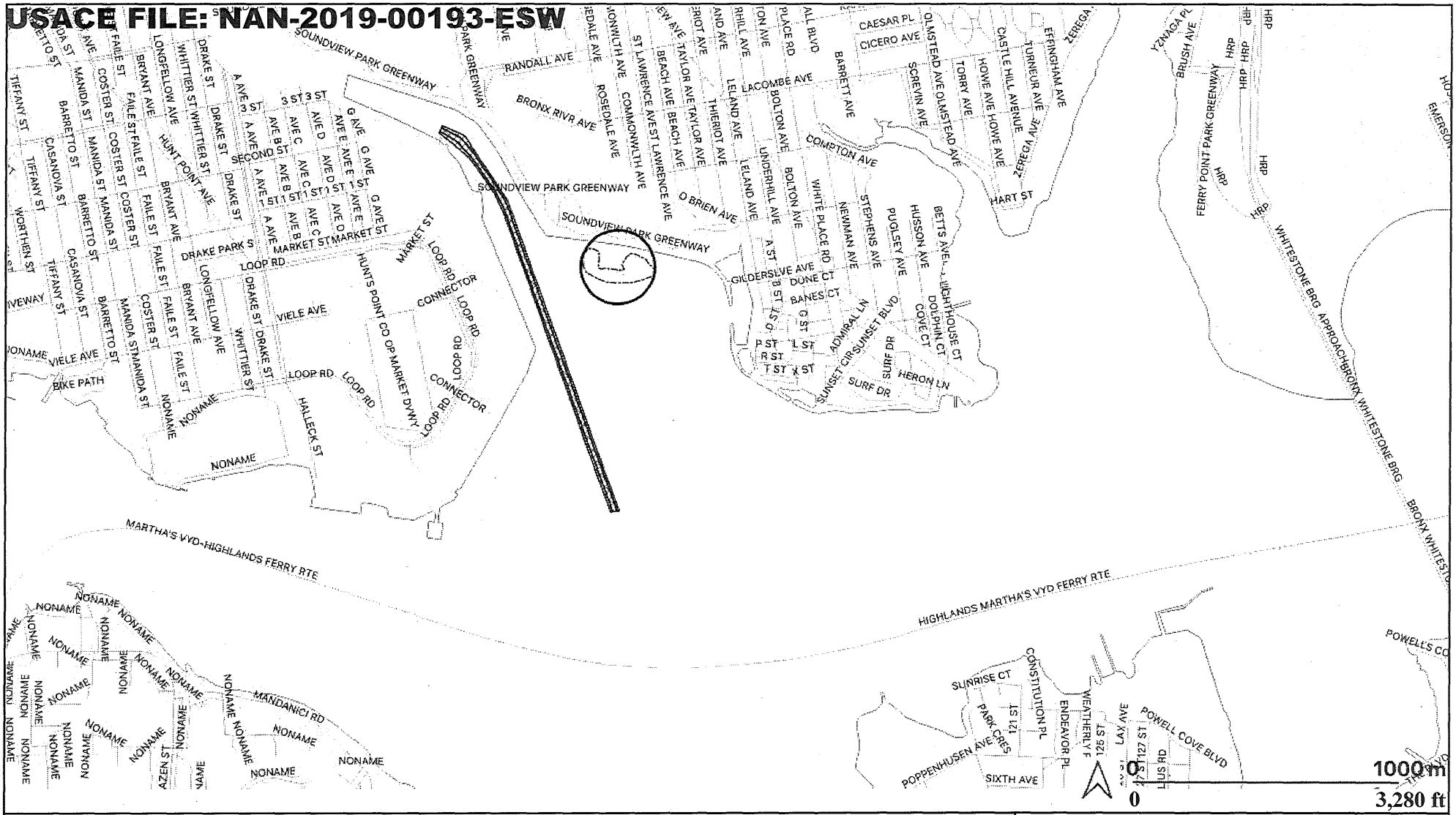

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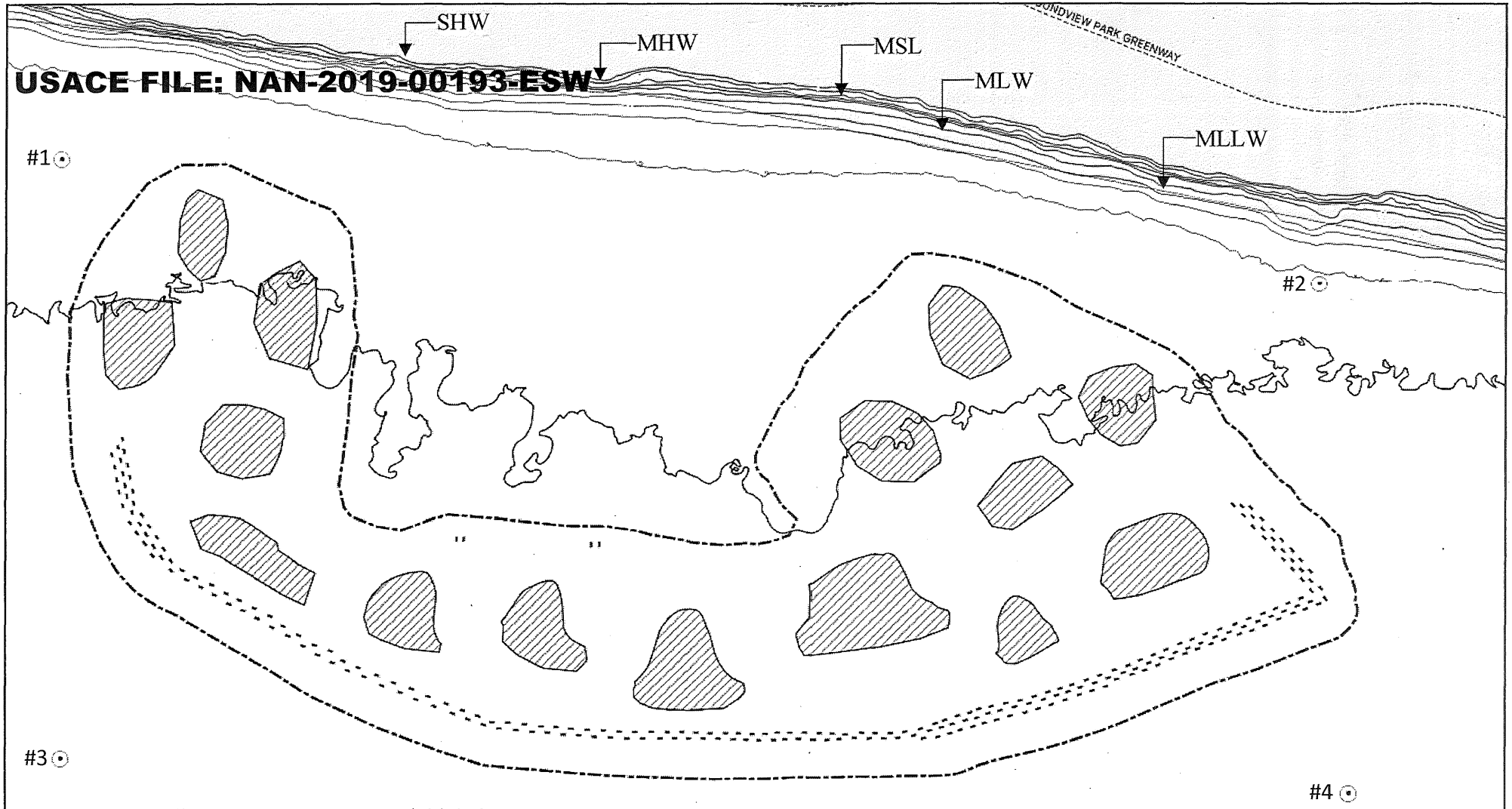

Submitted By: Billion Oyster Project on 12/12/2019

Soundview Oyster Habitat Restoration Project Plan View

Project Site Coordinates
40.809453; -73.865549

0 164 ft
0 50 m

LEGEND
- Proposed Reef Area: Gabions (250 units) ~0.05 acres
- Proposed Reef Area: Loose Shell (Blank: 695 CY, Spat on Shell: 5 CY) ~0.90 acres
- Project Footprint ~5 acres
- City Centerline (road within park)
- Soundview Park (land)
- Coordinate (#1-4: latitude; longitude)
- Contour line (1 ft. between each line)

Coordinates #1-4
#1: 40.8101695; -73.8660210
#2: 40.8099231; -73.8628460
#3: 40.8090069; -73.8660240
#4: 40.8089323; -73.8627730

SHW: 3.33 ft.
MHW: 2.98 ft.
MSL: -0.14 ft.
MLW: -3.26 ft.
MLLW: - 3.52 ft.

Bronx and East Rivers
Clason Point and Hunts Point, Bronx
County of Bronx, State of New York

Digital Tax Map: Block 3463
Lot 1
Datum N.A.V.D 88

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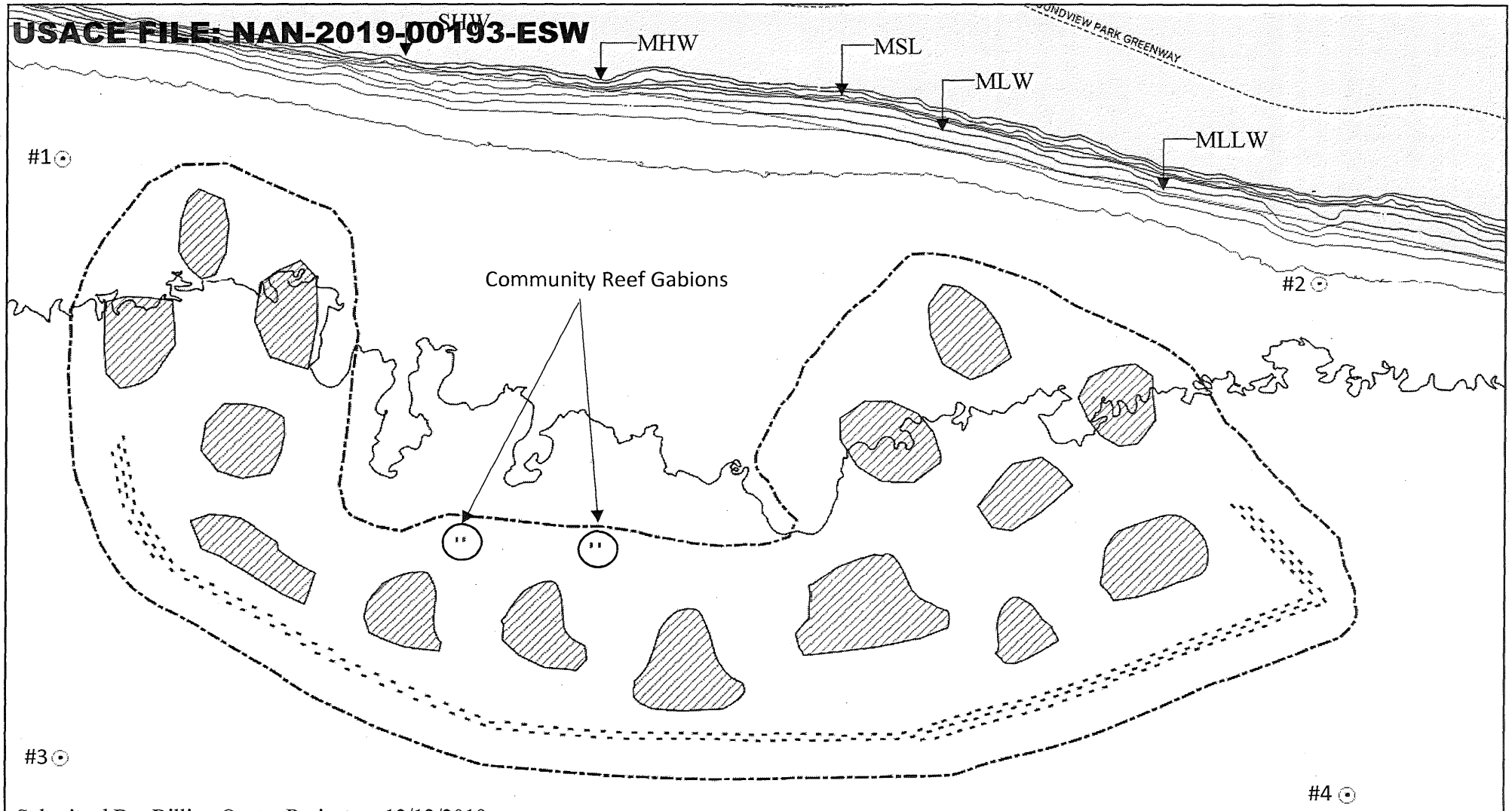

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Soundview Oyster Habitat Restoration Project Plan View

Project Site Coordinates
40.809453; -73.865549

0 164 ft
0 50 m

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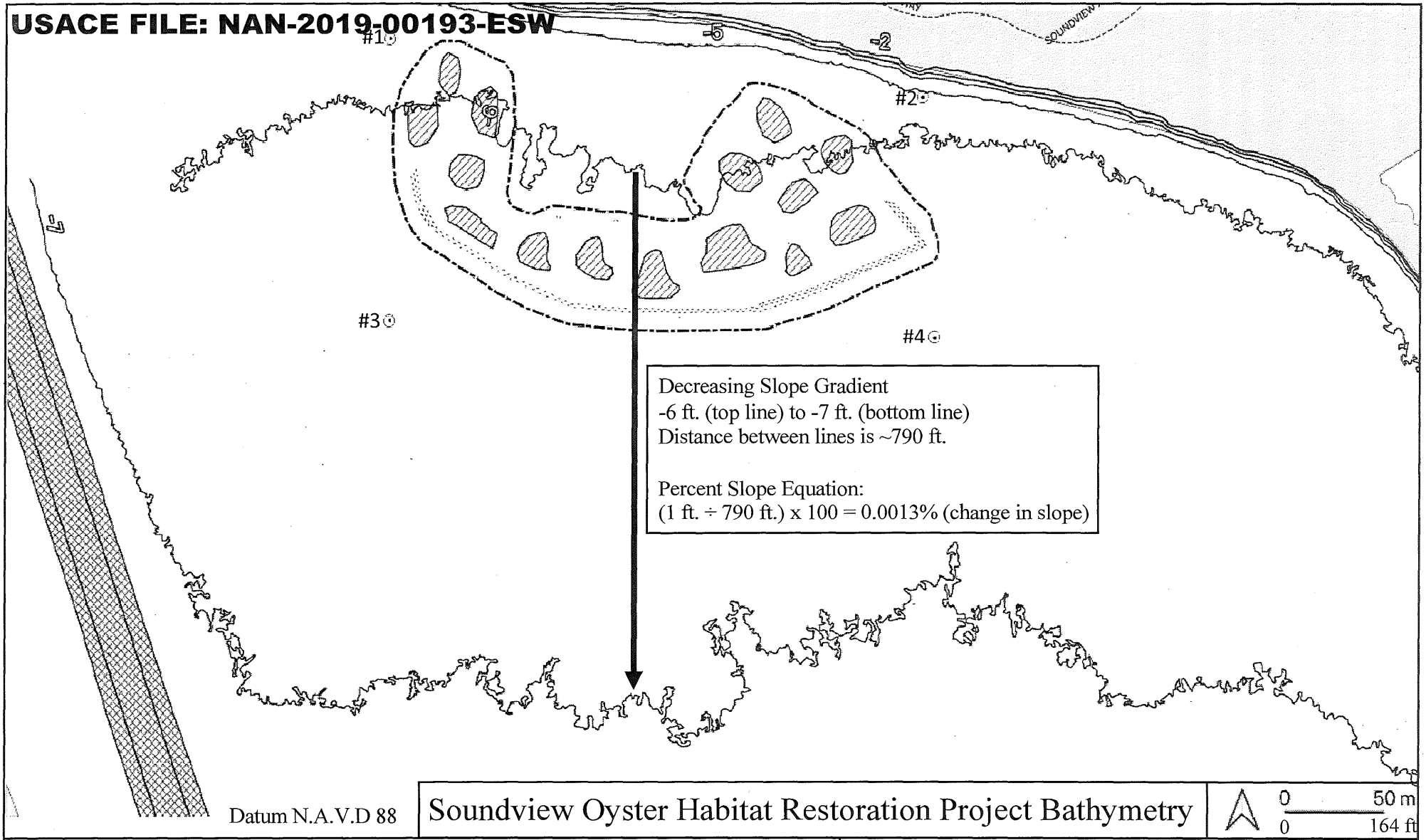


Datum N.A.V.D 88

Soundview Oyster Habitat Restoration Project Bathymetry

0 50 m
0 164 ft

LEGEND

- Proposed Reef Area: Gabions (250 units) ~0.05 acres
- Proposed Reef Area: Loose Shell (Blank: 695 CY, Spat on Shell: 5 CY) ~0.90 acres
- Project Footprint ~5 acres
- City Centerline (road within park)
- Soundview Park (land)
- Coordinate (#1-4: latitude; longitude)
- Contour line (1 ft. between each line)
- Bronx River navigable channel (Reach A)

Project Site Coordinates: 40.809453; -73.865549

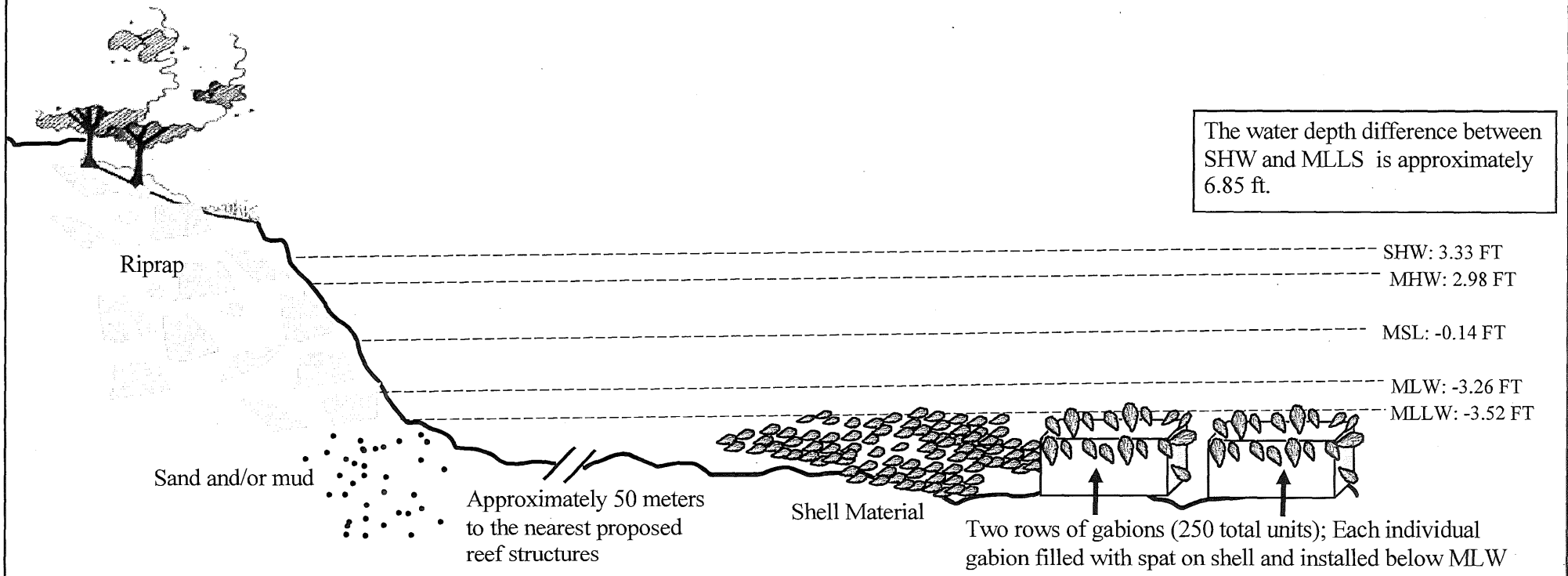
Data Source: NOAA's Ocean Service, Office of Coast Survey (OCS) (2015) "Coastal Maintained Channels in US waters" Retrieved from:https://nauticalcharts.noaa.gov/data/gis-data-and-services.html#enc-direct-to-gis

Submitted By: Billion Oyster Project on 12/1[illegible]

USACE FILE: NAN-2019-00193-ESW

Soundview Oyster Habitat Restoration Project Section View of Proposed Oyster Installations

Submitted By: Billion Oyster Project on 12/12/2019



Project Site Coordinates: 40.809453; -73.865549

Confluence of Bronx and East River

Property Owner is NYC Department of Parks and Recreation

Datum N.A.V.D 88

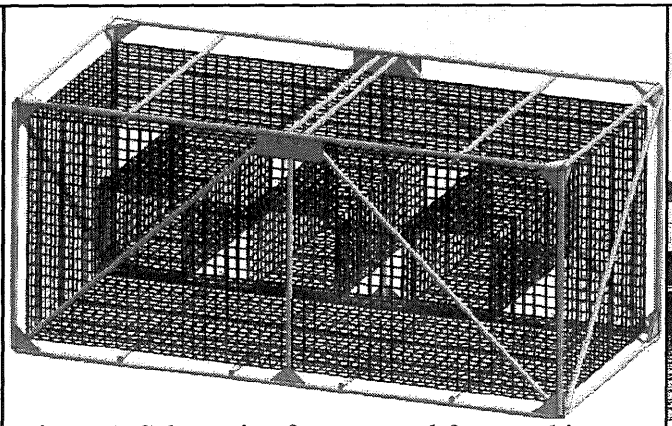


Figure 1: Schematic of empty steel frame gabion structure (4'x2'x2'), all gabions will be filled with spat on shell.

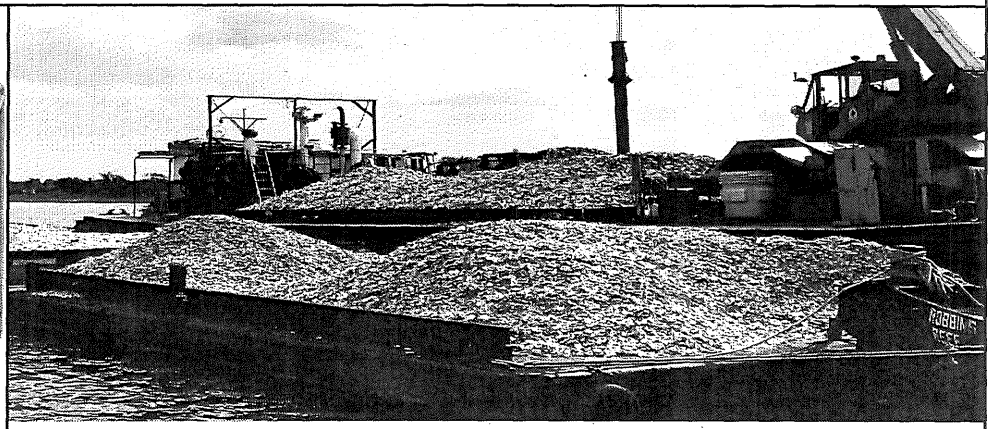
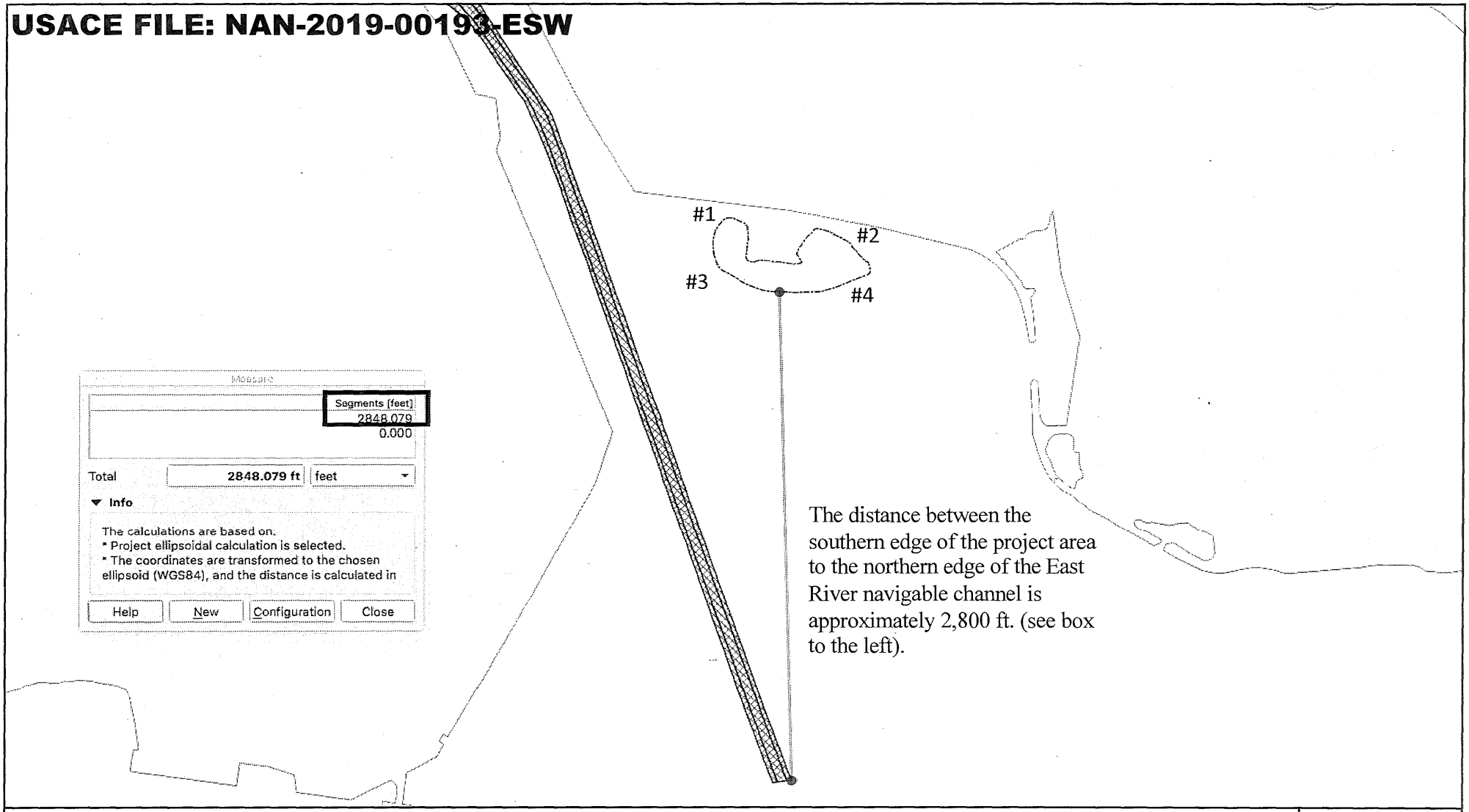


Figure 2: Example of loose shell deployment in Jamaica Bay, Queens, NY

USACE FILE: NAN-2019-00193-ESW



Soundview Oyster Habitat Restoration Project Distance from Project Area to East River Navigable Channel

0 50 m
0 164 ft

LEGEND

- Project Footprint ~5 acres
- Land
- Bronx River navigable channel (Reach A)
- Distance between project area and the East River navigable channel

Coordinates #1-4

#1 (Northwest): 40.8101695; -73.8660210

#2 (Northeast): 40.8099231; -73.8628460

#3 (Southwest): 40.8090069; -73.8660240

#4 (Southeast): 40.8089323; -73.8627730

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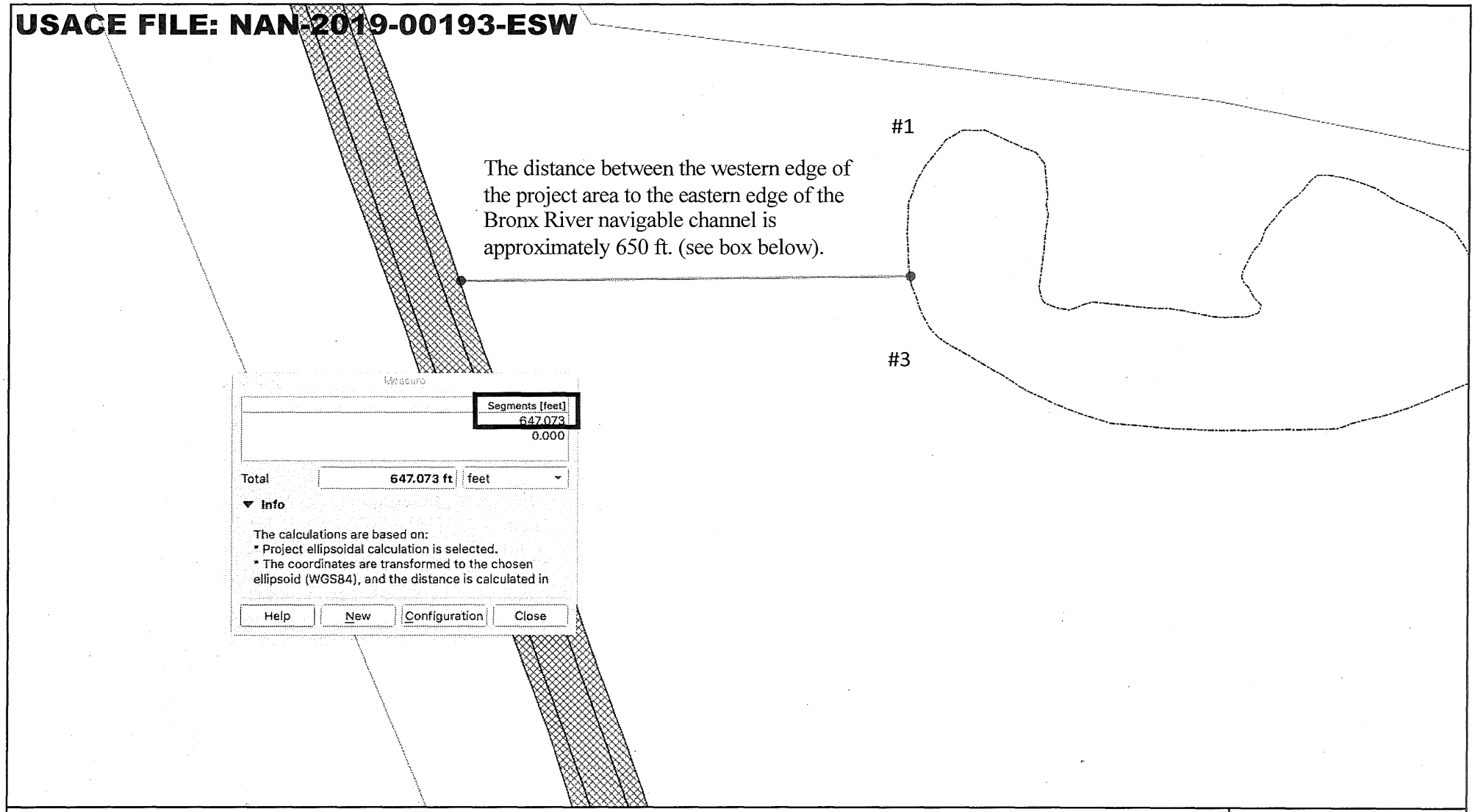

Soundview Oyster Habitat Restoration Project Distance from Project Area to Bronx River Navigable Channel

0 50 m
0 164 ft

LEGEND

- Project Footprint ~5 acres
- Land
- Bronx River navigable channel (Reach A)
- Distance between project area and the Bronx River navigable channel

Coordinates #1-4

#1 (Northwest): 40.8101695; -73.8660210

#3 (Southwest): 40.8090069; -73.8660240

Project Site Coordinates: 40.809453; -73.865549

Data Source: NOAA's Ocean Service, Office of Coast Survey (OCS) (2015) "Coastal Maintained Channels in US waters" Retrieved from:https://nauticalcharts.noaa.gov/data/gis-data-and-services.html#enc-direct-to-gis

Submitted By: Billion Oyster Project on 12/12/19

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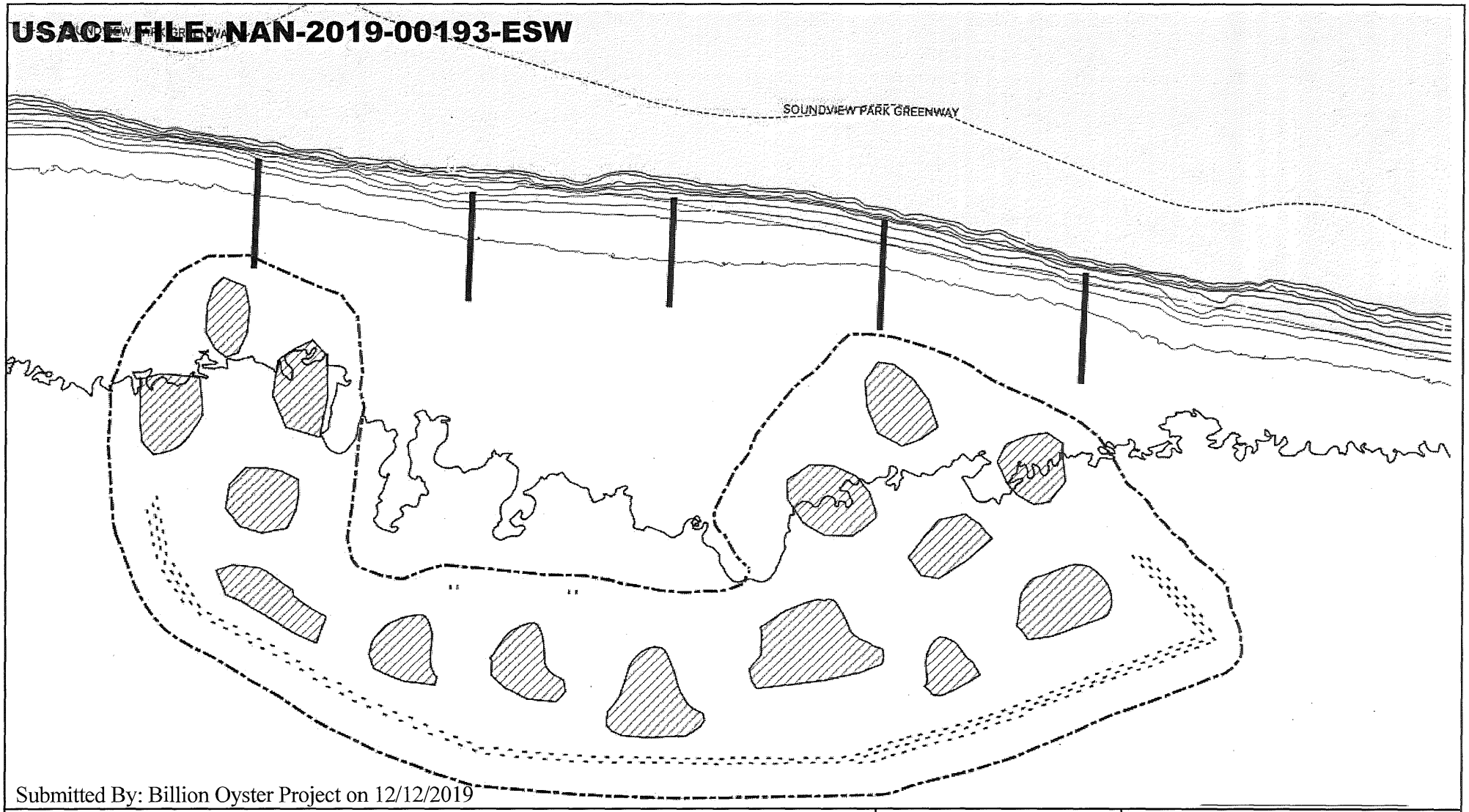

Submitted By: Billion Oyster Project on 12/12/2019

Soundview Oyster Habitat Restoration Project Shoreline Transects

Project Site Coordinates
40.809453; -73.865549

0 164 ft
0 50 m

LEGEND
- Proposed Reef Area: Gabions (250 units) ~0.05 acres
- Proposed Reef Area: Loose Shell (Blank: 695 CY, Spat on Shell: 5 CY) ~0.90 acres
- Project Footprint ~5 acres
- City Centerline (road within park)
- Soundview Park (land)
- Contour line (1 ft. between each line)
- Shoreline Transects

Shoreline Transect Details	
- Transects are 25 meters long	SHW: 3.33 ft.
- 50 meters between each transect	MHW: 2.98 ft.
- Measurements taken every 5 meters on each transect	MSL: -0.14 ft.
	MLW: -3.26 ft.
	MLLW: - 3.52 ft.
Bronx and East Rivers Clason Point and Hunts Point, Bronx County of Bronx, State of New York	Digital Tax Map: Block 3463 Lot 1 Datum N.A.V.D 88

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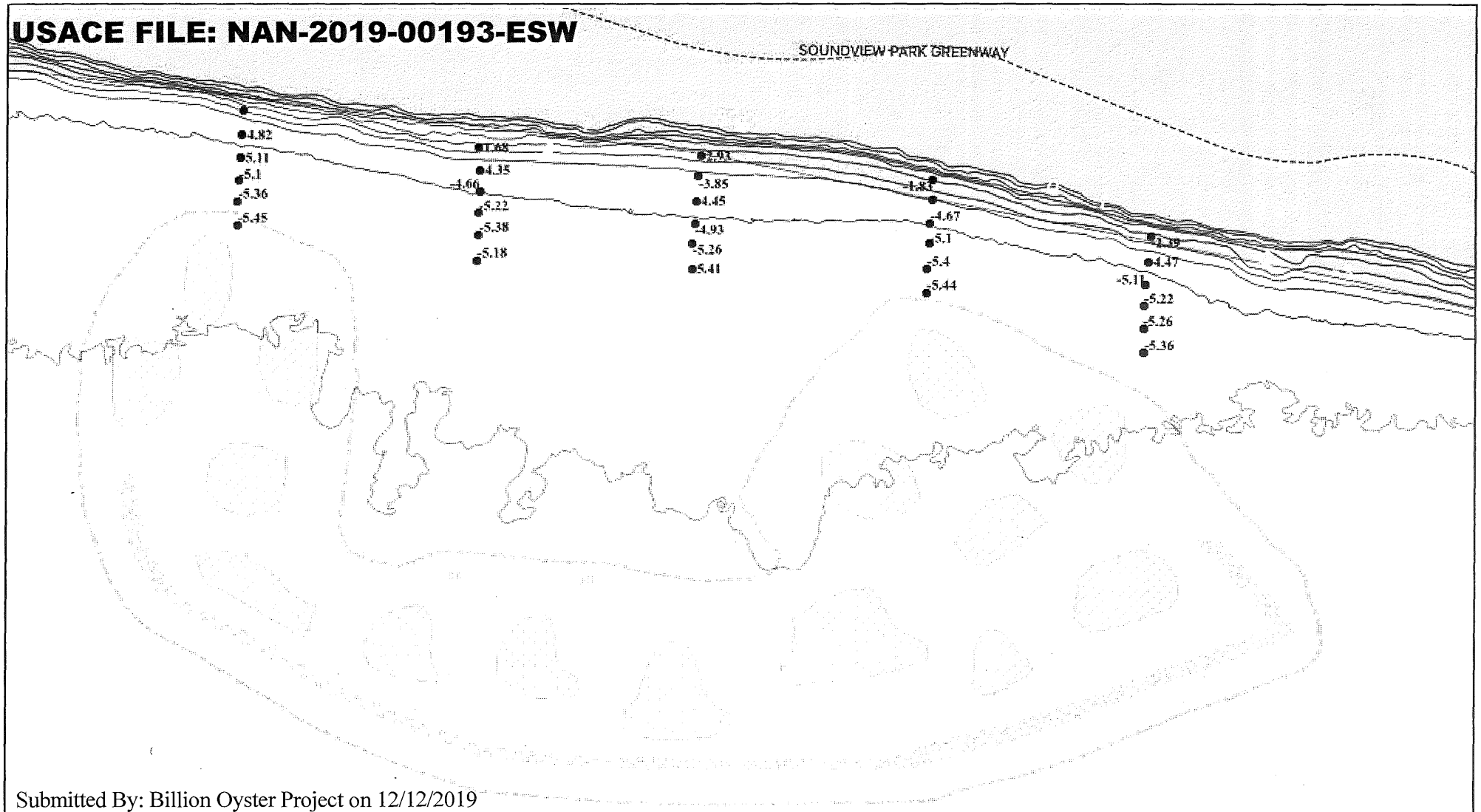

Submitted By: Billion Oyster Project on 12/12/2019

Soundview Oyster Habitat Restoration Project Shoreline Measurements	Project Site Coordinates 40.809453; -73.865549	0 164 ft 0 50 m

LEGEND

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- Proposed Reef Area: Loose Shell (Blank: 695 CY, Spat on Shell: 5 CY) ~0.90 acres
- Project Footprint ~5 acres
- City Centerline (road within park)
- Soundview Park (land)
- Contour line (1 ft. between each line)
- Shoreline Transects

Shoreline Transect Details - Transects are 25 meters long - 50 meters between each transect - Measurements taken every 5 meters on each transect	SHW: 3.33 ft. MHW: 2.98 ft. MSL: -0.14 ft. MLW: -3.26 ft. MLLW: - 3.52 ft.
Bronx and East Rivers Clason Point and Hunts Point, Bronx County of Bronx, State of New York	Digital Tax Map: Block 3463 Lot 1 Datum N.A.V.D 88

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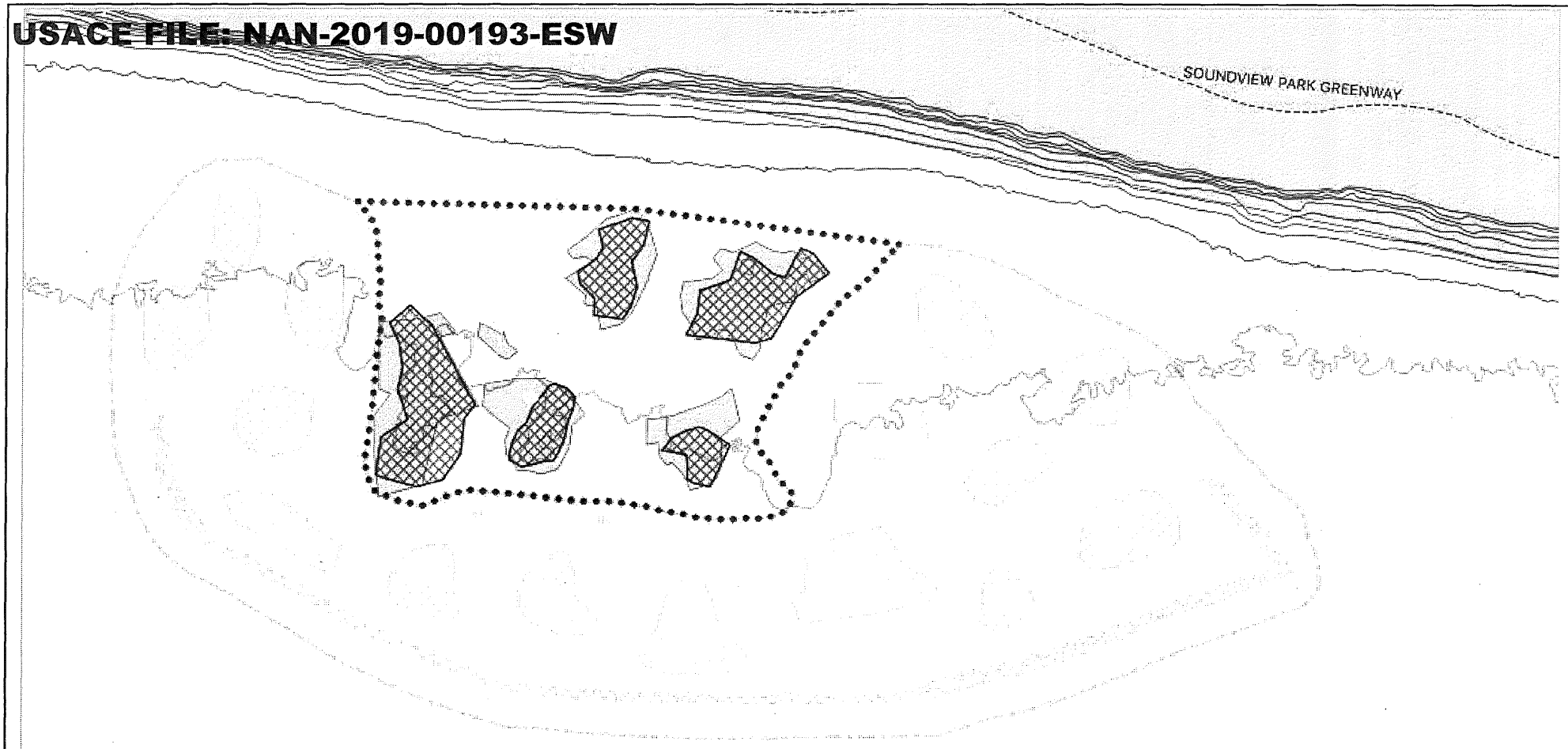

Submitted By: Billion Oyster Project on 12/12/2019

0 50 m

0 164 ft

Movement of Pre-Existing Oyster Reef Mounds

Project Site Coordinates
40.809453; -73.865549

LEGEND

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- Project Footprint ~5 acres
- City Centerline (road within park)
- Soundview Park (land)
- Contour line (1 ft. between each line)
- Existing reef mapped in 2013
- Existing reef mapped in 2019
- Existing reef perimeter

The existing oyster reefs are authorized by permit # NAN-2012-01130-EOF.

SHW: 3.33 ft.
MHW: 2.98 ft.
MSL: -0.14 ft.
MLW: -3.26 ft.
MLLW: - 3.52 ft.

Bronx and East Rivers
Clason Point and Hunts Point, Bronx
County of Bronx, State of New York

Digital Tax Map: Block 3463
Lot 1

Datum N.A.V.D 88

Appendix E: Monitoring Plans and Protocols

Table of Contents

Monitoring and Adaptive Management Plan

Summary of Proposed Installations and Monitoring Protocols

The project team proposes to restore 5-acres of oyster reef habitat to the mouth of the Bronx River, adjacent to the shoreline of Soundview Park, Bronx, NY. The proposed installations include (a) 250 steel-framed gabion structures, (b) 500,000 lbs. of loose shell (or 695 cubic yards), and (c) 25 million oysters. Tables 1 and 2, below, provide information regarding the monitoring protocols and timeline.

Table 1: Monitoring Protocols

Protocol	Parameter	Substrate	Frequency	Deliverables
Oyster Reef Development	Oyster Demography	Loose Shell and Gabion	Once a year	Database for density, size demography and percent mortality (via boat). Oyster abundance data will be analyzed to develop size-frequency distributions.
Ecosystem Services and Habitat Substitution	Associated Benthic Macrofauna/ Epifauna	N/A	Once before project construction and at least once more at the end of the last installation season	Database of the benthic/epifaunal community associated with the oyster bed based on composition, size demography (where applicable), abundance, biomass, and species richness
Oyster Reef Habitat Footprint and Elevation Monitoring	Mapping of Installed Oyster Reef Habitat Footprint and Shoreline	N/A	Once a year post installation	Maps will be produced using a handheld GPS device in the field and ArcGIS software to map installed reef perimeters and subsequent changes
Water Quality (Data loggers)	Database of Water Quality Parameters	N/A	Every 30 minutes throughout the summer and fall	Database of water quality parameters including, Temperature (°C), Dissolved oxygen (mg/L), Salinity (ppt) and Conductivity (mS/cm)
Oyster Disease and Conditions Index (C.I.)	Oyster Health	Community Gabion	Beginning 2020 MSX (May and Sept) and Dermo (May and Sept)	Mean C.I. for adult oysters and evaluation and analysis of Oyster C.I. through time Infection rates and intensity of MSX and Dermo Sex ratios for the population and both reproductive stages and shell height (mm) for all oysters sampled
Oyster Growth and Survival - Quadrats	Oyster Demography	Community Gabion	Once a month to once a year	Database for density, size demography and percent mortality

Table 2: Post Installation Monitoring Timeline

Protocol	Parameter Monitored	Frequency	Active Project												Post Project							
			2020				2021				2022				2023				2024			
			Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Water Quality (Data Loggers)	Water Quality	Summer and spring months																				
Oyster Disease & Conditions Index (C.I.)	Oyster Health	Monthly (May - Sept.)																				
Oyster Growth & Disease - quadrats	Oyster Demography	Once a month to once a year																				
Oyster Reef Habitat Footprint Monitoring and Elevation Monitoring	Mapping of Installed Oyster Reef Habitat Footprint	Yearly																				
Oyster Reef Development	Oyster Demography	Yearly																				
Ecosystem Services & Habitat Substitution	Associated Benthic Macrofauna/ Epifauna	Once post construction																				
*Q1 = Jan - March; Q2 = April - June; Q3 = July - September; Q4 = October - December																						

Project Design and Implementation

After each installation, the project team will share and review information about the installation methods and will convene to evaluate potential modifications prior to planning for subsequent installations.

- Potential Adaptive Action: The project team will revise installation methods for gabion structures and loose shell if post-installation surveys reveal a discrepancy between target spatial coverage or loose shell mound height.

Gabion Structures

The gabion structures will degrade over time, allowing for the newly formed reef (the live oysters which have developed within the gabions) to remain in place. The corrosion rate of fully submerged steel is estimated to be 0.23 mm/yr^2.[1] The steel is expected to have a 40% reduction in diameter in 25 years and will maintain functionality for several decades thereafter. Therefore, it is highly unlikely that the structural integrity of the gabions will be compromised.

- Potential Adaptive Action: BOP will map each gabion annually via GPS and/or sonar technology and will monitor a set of gabions to collect data on oyster health and mortality. During this monitoring activity, BOP will conduct a Gabion Visual Assessment as a preventative measure to confirm the structural integrity of the gabions is intact. If the gabion fails the assessment, BOP will (1) remove all oysters and shells within the unit, (2) place the removed oysters and shells on top of the existing shell mounds within the project boundary, and (3) return the degraded gabion to Governors Island.

[1] Farro, N.W., Veleva, L., Aguilar, P. (2009) Mild Steel Marine Corrosion: Corrosion Rates in Atmospheric and Seawater Environments of a Peruvian Port. The Electrochemical Society.

During the two gabion deployments, the project team will map the coordinates of each gabion via GPS technology. The project area has a very moderate slope (0.0013%) and is predominantly composed of a soft mud bottom. BOP will monitor the location of each gabion, annually via GPS and/or sonar technology, to confirm the gabions have not moved. In the event of any movement of the installed gabion structures outside of the project boundary, the following action will be implemented.

- Potential Adaptive Action – General Movement (no storm): If any gabions move outside of the project boundary, the project team will (1) located and return the gabion units, (2) cable groups of 50 gabions together, and (3) anchor the ends of each group of gabions.

- Potential Adaptive Action - Large storm event: After a Category 1 Hurricane (classified as a storm event with sustained winds of 75 mph or more[2]) the project team will visit the project site during weather that is deemed safe for staff to confirm that each gabion structure has maintained its original position. If the position of a gabion has moved out of the project boundary, the project team will locate and return the gabion(s) and cable groups of approximately 50 gabions together. The end of each group will be anchored to prevent further movement.

Loose Shell

After the installation of loose blank and seeded shell, the project team will map the perimeter of the loose shell mounds with a GPS device. The project team will use this data to monitor the placement of the loose shell mounds over time. The project area has a very moderate slope (0.0013%) and is predominantly composed of a soft mud bottom. In the event of any movement of the installed loose shell ends up out of the project boundary the following action will be implemented.

- Potential Adaptive Action: The post-construction mapping of the reefs installed in 2013 indicate that there has been very little to no movement occurring on-site when compared to the most recent data collected in the summer of 2019. However, if the shell mounds move outside of the project boundary, BOP will retrieve the loose shell and return it to Governors Island.

Oyster Monitoring

The project team will conduct five years of post-installation monitoring, starting in 2020 and ending in 2024. The project team will collect data to satisfy project deliverables for habitat creation and enhancement. The project team has established oyster monitoring protocols that will be used for (1) gabion structures, (2) community gabion structures and (3) loose shell mounds.[3] The project team will monitor the loose shell mounds via a Van Veen grab following Standard sampling methods used in previous studies in the region. The project team will monitor the gabion structures using quadrats to determine oyster growth and density within a known area because the units are welded closed and oysters are expected to grow and aggregate (i.e. form a "reef") through the gabion structure. On community reef gabion structures, oyster growth and survival will be determined using one of two methods depending on the intensity of oyster accretion through the files: (1) by employing the same quadrat protocol used on gabions to determine oyster shell height and density or (2) by emptying files and monitoring individual oyster clumps. See Table 1 below for information regarding success metrics, which will inform adaptive management decisions.

- Potential Adaptive Action for Monitoring Gabion Structures: If the project team observes high oyster mortality in the lower sections of the gabion structures then the project team will consider reducing the oyster density at the bottom of the units and/or revising the design of the gabion to

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[2] Saffir-Simpson Hurricane Wind Scale (2012) *National Hurricane Center and Central Pacific Hurricane Center*. National Oceanic and Atmospheric Administration. Retrieved from: https://www.nhc.noaa.gov/aboutsshws.php

[3] "Community gabion structures" are of a different design than the "gabion structure". The community gabion structure will have removable files that will be monitored by community groups.

contain more blank shell at the bottom of the unit.

- Potential Adaptive Action for Monitoring Community Gabion Structures: Based on oyster growth, the project team will use one of the two monitoring protocols mentioned above to accurately monitor the community gabion structures.

Table 3: Summary of Performance Metrics for Assessing Success at BOP Restoration Sites

Metric Type	Success Criteria	Explanation	Caveats
Growth	Change in shell height in first year as spat on shell	Young spat on shell oysters should increase their shell height rapidly in the first year of planting.	Not all restoration activities use spat on shell. In these cases, this success metric will not apply.
	Continued increase in shell height after year 1	Growth rates typically slow down in year 2+, but oysters should continue to increase their shell height.	
	Oysters "reefing" or cementing to each other or gear forming clumps of 2 or more oysters	As oysters increase in size they should "reef" or cement to each other and gear.	In some cases, oysters will not cement because 1) they are handled to prevent cementing as dictated by the gear type, or 2) the site is a high energy environment (i.e., lots of wave action or current).
Survival	Oyster density stabilizes after initial mortality	As spat, oysters naturally have a high mortality rate. After an initial period of high mortality, survival increases and density of oysters (i.e., number of oysters per clump or number of oysters per m2) should stabilize.	At some sites, as oysters transition from loose clumps to cemented or "reefed" density measurements will transition from "oysters to clump" to "oysters per m2." This will make density comparisons over this period difficult.
Disease	Disease prevalence & intensity is low	Prevalence and intensity of oyster disease (Dermo, MSX) should be low.	Disease testing is not carried out at all sites because 1) disease testing is costly, 2) disease loads are expected to be low in small/young (<1 year old) oysters, and 3) disease testing requires sacrificing oysters (n=30) at each sampling point.
Reproduction	Gonads conditioned	Qualitative or quantitative assessments of gonad condition should show gonads that are ripe and ready to spawn.	Assessing gonad condition requires sacrificing oysters (n=30) at each sampling point, therefore this may not be done at small restoration sites. Small or young oysters also should not have conditioned gonads.
	Sex ratios near 50:50	Oysters switch sexes, with smaller and younger oysters typically being males. Even sex ratios will increase the odds of successful reproduction.	See caveats for Performance Metric 5, related to disease testing.
	>1 size class of oysters present	After 3 or more years, more than one size class of oysters should be present.	Reproduction and recruitment are not expected in the first 1-2 years of restoration at a site. Some sites may have reproduction but due to their hydrodynamic context they may be "source" sites that export larvae elsewhere.
	Juvenile oysters present on off-reef structures	Once oysters become reproductive they may seed nearby structures. The presence of wildly-occurring oysters even from other sources may indicate suitable conditions for larval survival and transport at that site.	Wildly-occurring oysters on nearby substrate may be the offspring of oysters from beyond the site that are transported there.

Oyster Reef Development and Ecosystem Services and Habitat Substitution Protocols[4]

Post-Construction Monitoring and Assessment

Oyster Reef Development

Development of the constructed oyster reefs and oyster gabions will be assessed by measuring changes in: (1) oyster size (to estimate recruitment and growth), (2) population density, (3) bottom area of the restoration site covered by live oyster reef, and (4) vertical extent of the oysters growing on the gabions. These represent the four "universal metrics" recommended by Baggett et al. (2015) for assessing oyster reef restoration success.

For the gabions, individual oyster size and oyster population density and biomass will be measured by sampling the gabions (4' x 2' x 2' welded steel cages). The wire mesh contained within the gabion frame will be opened using wire cutters and oyster shell (cultch) will be excavated from the upper 2 cm (approximately 2 cultch depth) of the cage. The shell height (calipers to nearest mm) from the first 50 live oysters will be measured. These methods will yield data on oyster size-frequency, total (live and dead) oyster biomass, and mean oyster size.

For the newly developed reef bases and the planted spat-on-shell reefs, individual oyster size and oyster population density and biomass will be measured. At approximately 20 haphazardly selected sampling points per acre, the surface of the shell bases will be sampled with patent tongs that extract a quantitative (0.1 m2) bottom sample containing reef base material and live oysters that have recruited to the reefs. All live oysters encountered will be measured (shell height to the nearest mm) with calipers or a ruler. These methods will yield data on oyster size-frequency, total (live and dead) oyster biomass, and mean oyster size.

Ecosystem Services

Quantification of ecosystem services provided by the constructed reefs will focus on habitat provision, which will be characterized by measuring taxonomic richness and density of macroalgae, invertebrates, and fish that colonize the gabions. The overall aim will be to characterize habitat provision for resident flora and fauna.

All organisms encountered while processing the gabions (see above) will be identified to the lowest practical taxonomic level and counted in the field. Some voucher specimens may be returned to the laboratory for positive identification, but others will be returned to the water after processing.

Habitat Substitution

The objective of habitat substitution is to determine how the constructed reefs (habitats) compare to what they replaced. This will be accomplished by comparing the metrics for oysters and resident flora and fauna with comparable data from the van Veen grab samples collected before project construction. These comparisons will be made on an overall (5-acre restoration area) basis as well as by the relative amounts (areal cover) of each of the five bottom types mapped in the pre-construction sampling.

[4] Prepared by: Hudson River Foundation & University of New Hampshire 1/2019, Updated 9/2019

Data Analysis

Differences in each of the above metrics will be compared among the three treatments (unplanted shell reef, spat-on-shell reefs, gabions) using ANOVA models (followed by Tukey t-tests when appropriate) to determine the relative effects of each treatment on reef development and resilience to storms.

Sampling Schedule

- Oyster reef development: At least once a year at the end of the summer season
- Ecosystem services: This will occur once prior to construction and at least once more after all materials are installed.
- Habitat substitution: This will occur once prior to construction and at least once more after all materials are installed.

Metrics for Assessing Restoration Success

Table 4: Metrics for Assessing Restoration Success

Performance Metric	Criteria for Success	Unit
Oyster reef development (oyster size and density; reef area and vertical extension)	As monitoring progresses, there should be a trend of increasing oyster density, with the ultimate goal of having statistically greater oyster densities than those present pre-construction, and a density that is roughly equal to or exceeds that of a natural reference site. It should be noted that the reference site for this project is a previous oyster restoration pilot project.	Mean total density (individuals/m^2) Mean shell height of oysters (mm) Percentage (%) and/or the number of measured oysters per size class
Ecosystem services (habitat provision; species richness, density, and biomass)	As monitoring progresses, there should be a trend of increasing biodiversity (species richness and biomass), with the ultimate goal of having statistically greater densities than those present pre-construction, and a density that is roughly equal to or exceeds that of a natural reference site.	Density of each species (or lowest taxonomic grouping possible) (individuals/m^2)
Habitat substitution	The post-construction assessment for habitat substitution should indicate an increase in habitat compared to those present pre-construction.	Unit = Major sediment types throughout the project area (sediment type/grab sample).

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Oyster Reef Habitat Footprint and Elevation Monitoring Protocol[5]

Purpose

New York Harbor Foundation, Inc. (also known as the Billion Oyster Project - BOP) in partnership with Hudson River Foundation, NY/NJ Baykeeper, NYC Parks, Rocking the Boat, and Bronx River Alliance, is expanding on previously restored oyster reef habitat in Soundview Park, at the mouth of the Bronx River, in the Bronx, NY. From 2019 to 2020, BOP will install up to 500,000 lbs of loose shell and 250 gabion structures to promote oyster settlement and growth. To track changes in oyster reef habitat created by the Soundview Oyster Habitat Restoration Project, NYC Parks will map the perimeter, or "footprint," as well as elevations of the oyster reef and its various components (i.e. shell piles and gabion structures), both before and after construction. This will allow NYC Parks and project partners to track how the installed structures may move, grow or subside over time. This can help us track the stability and success of the various reef structures installed during this project and inform future restoration design.

Monitoring Design

Using real-time kinematic (RTK) satellite positioning on a handheld Trimble GPS and controller, spatial location and elevation will be measured with centimeter-level accuracy. The RTK equipment will be used to map both the perimeters of installed reef structures and elevations across the project area annually, as follows:

1. Reef Footprint
    a. Objective – Reef footprint monitoring will be used to track how structures may move after installation. Tracking movement over time can help to understand how wave energy and other site-specific conditions impact the gabions and shell piles installed during the project and can help to inform future placement of new materials. Long-term monitoring, if possible, can also determine if the oyster reef habitat expands on its own after the lifetime of this project.
    b. Monitoring – The perimeter of each reef structure installed (individual shell piles and gabion arrangements) will be mapped during construction. Mapping will consist of recording GPS points using the RTK equipment at regular points along the perimeters of the individual structures. After construction, the perimeters will be mapped again at the end of each monitoring season to track any transport. The reef footprint will be mapped twice during the first and second year of the project (as structures are installed and again at the end of that season) and once each year following for the duration of the project.
    c. Data analysis – The data recorded by the RTK will be saved to an ArcGIS database and viewed on a desktop computer in ArcMap. The points will be converted into polygons outlining the structures and then compared over time to track potential transport or shifting of structures.
    d. *Note: The reef footprint mapping can be completed with an alternative handheld GPS device if RTK equipment is unavailable since elevation data is not necessary for this monitoring; however, other units will have a lower level of accuracy than the RTK device.*

2. Reef Elevation
    a. Objective – Elevations will be monitored at predetermined points throughout the oyster reef restoration area, both on and surrounding installed structures, to track whether the

[5] Prepared by: NYC Parks 1/2019, Updated 9/2019

installed structures subside into the sediment at all. Additionally, identifying elevation changes throughout the project area can help predict sediment loss or accretion on site.

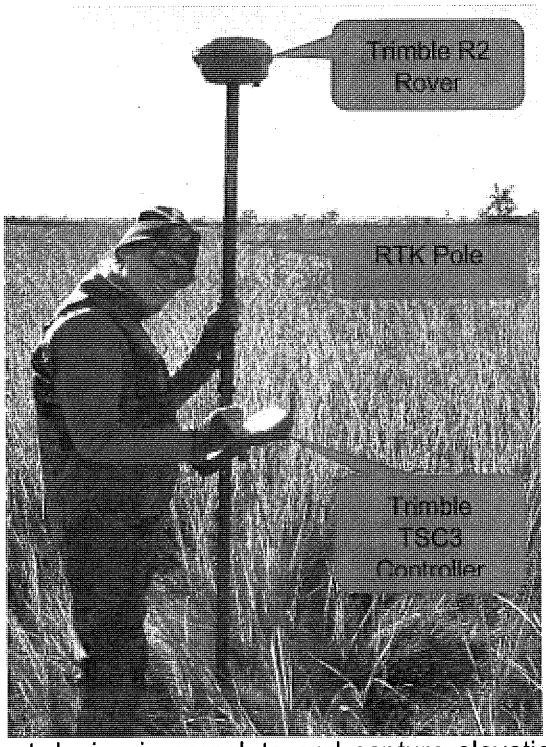
b. Monitoring – Points will be assigned at random within the installation area, plus a 10-foot buffer. The selected points will capture areas both on the installed reef structures and in the surrounding mudflat areas, and elevations will be measured at the same points each time to track changes. The GPS locations and elevations will be recorded using the RTK at each monitoring point, just before construction (after the project design has been finalized and sampling points determined) and at the end of each monitoring season. This mapping will be conducted twice during the first year of the project (before and after construction) and once each year.
c. Data analysis – Elevation data points will be saved to an ArcGIS database and viewed on a desktop computer in ArcMap. Elevation tables will also be exported into an excel document to plot changes. Changes in elevation on the installed structures can help to inform whether structures are subsiding into the sediment and if action needs to be taken to remove them. Elevation changes across the mudflat may also be able to help determine whether the site is gaining or losing sediment overall. This information can help strategize future materials and placement of structures, both during the final installation year of this project and during future projects. Additional opportunities exist to compare elevation data collected with available Lidar elevation data to determine the accuracy and applicability of using NYC Lidar data to track changes at this site remotely.

3. Shoreline Elevation
    a. Objective – Monitoring the shoreline will help define accretion and erosion of sediment over time. This shoreline assessment will not be able to define or provide a robust analysis of the impact that the reef may have on the shoreline due to the absence of long-term baseline data within the area. There will be one season of pre-installation shoreline monitoring that will not be able to capture any long-term trends that may be taking place along this shoreline. Due to the predominant mud composition of the area, variations in elevation readings may occur as a result of walking within the project area.
    b. Monitoring – Five transects will be identified: one perpendicular to the western edge of the reef, one perpendicular to the eastern edge of the reef, and one in the center with the possibility of having extra if needed. The shoreline transects will be monitored once during each monitoring season.
    c. Data analysis – Elevation data points will be saved to an ArcGIS database and viewed on a desktop computer in ArcMap. Elevation tables will also be exported into an excel document to plot changes. Plots will be made to show the changes in elevation over time of each transect, to highlight whether accretion or erosion is occurring in particular locations along the reef installation.

Equipment

The following equipment is needed to properly monitor the reef footprint, reef elevation, and shoreline elevation:

- An RTK device (see image, right), consisting of:
  - Trimble R2 Rover GPS with Bluetooth compatibility
  - RTK Pole with bracket to mount controller and rover, with wide-base topo shoe
  - Trimble TSC3 Controller with access to GNSS and Bluetooth connection to rover
- A trimble handheld GPS device (for location mapping only, as backup to RTK)
- ArcGIS desktop software
- Chest-high waders (plus additional weather-appropriate gear)



Field Monitoring Preparation

1. Prior to construction, determine sampling points to monitor for elevation in ArcGIS. These points should be selected after the project design is complete and capture elevations both on the installed reef structures as well as in the surrounding mudflat
2. Load the sampling points determined by step 1, as well as any other existing GPS points of the reef structures, onto the Trimble TSC3 Controller prior to mapping in the field, for easier navigation to these points in the field using the Stakeout feature on the controller.
3. Load shoreline transect monitoring points to repeat the same transect line.
4. Before going out into the field to collect data, check the NYSNet CORS/RTN Twitter feed to check that the GNSS network is functional (you will need to connect to this network to collect data points).
5. Mapping should be conducted at low tide (and at spring low tides, if possible) when the water level is lowest and it is possible to access the entire project area on foot in waders.

Field Monitoring

1. Reef Footprint
   a. If mapping a pre-existing structure, navigate to the point(s) using the Trimble Stakeout feature on the Trimble TSC3 Controller. If a newly installed structure is being mapped for the first time, you will have to navigate to the structure manually.
   b. Walk out to each structure (i.e. individual shell piles, gabions, etc.) and locate the perimeter of each using your vision, if water visibility is clear enough, and feeling the substrate with your feet.
   c. Collect several points along the perimeter at each vertex of the structure using the Trimble TSC3 Controller and R2 Rover GPS.
   d. This mapping should be done at the start of the project, as the structures are installed, and then at the end of each monitoring season throughout the project period.

2. Reef Elevation
   a. Navigate to your predetermined elevation monitoring points using the Trimble Stakeout feature on the Trimble TSC3 Controller.

b. At each elevation monitoring point, gently rest the RTK pole on top of the sediment or reef structure. The wide-base topo shoe on the bottom of the pole will help prevent it from sinking into soft sediment, but you want to double check that it is resting on top for an accurate reading. Use the level on the equipment to ensure that the pole is straight and hold it steady.
c. At each monitoring point, collect a new point to capture the location and current elevation.
d. This mapping should be done at the start of the project, prior to construction, and then at the end of each monitoring season throughout the project, in conjunction with the reef footprint mapping.

3. Shoreline Elevation
    a. Navigate to your predetermined transect monitoring points using the Trimble Stakeout feature on the Trimble TSC3 Controller.
    b. At each elevation monitoring point, gently rest the RTK pole on top of the sediment or reef structure. The wide-base topo shoe on the bottom of the pole will help prevent it from sinking into soft sediment, but you want to double-check that it is resting on top for an accurate reading. Use the level on the equipment to ensure that the pole is straight and hold it steady.
    c. At each monitoring point, collect a new point to capture the location and current elevation.
    d. Take elevation points at every change in slope, in order to characterize the main geomorphological features. Points should be taken at least every 5 meters.
    e. Take photos of breaks in slope, where possible, and record relevant information in the "Field Data Form – Coastal Topography Survey" datasheet.

Water Quality Protocol (Data Loggers)[6]

Rationale
The *Water quality (Data loggers)* protocol provides high temporal resolution data on the environmental conditions at oyster restoration sites. These data may help explain the performance of restored oysters. High temporal resolution data may be important because extreme events (e.g., rare low dissolved oxygen levels) may be more important than the mean or any single point in time.

Variables measured
- Temperature (°C)
- Dissolved oxygen (mg/L)
- Salinity (ppt)
- Conductivity(mS/cm)

Data sheet(s): link

Key equipment list
- HOBO Dissolved Oxygen Logger (U26)
- HOBO Conductivity Logger (U24)
- HOBO Waterproof Shuttle
- Horiba U-52 Multiparameter Water Quality Meter (or other brand multiparameter meter)
- HOBOware software

Equipment calibration/maintenance
- Calibrate dissolved oxygen logger with sodium sulfite solution prior to deployment
- Loggers are deployed for 6 month intervals
- Every site visit, fouling should be removed from the loggers (soft scouring pad)

Sampling frequency
Data logging frequency is specified by the user. A frequency of 30 minutes is recommended.

Sample transport/handling
No physical samples are collected. Data will be retrieved from the loggers with the HOBO Waterproof Shuttle, offloaded to a computer, and uploaded to data folders (e.g., Google Drive).

Field Methods
- Loggers are mounted to fixed points at the site. Use coated wire rope and secure hardware.
- Loggers are typically deployed as close as possible to the oyster installation. Therefore, at sites were oysters are in floating nurseries, loggers may remain at the surface of the water, moving up and down with the tide. At other sites, where oysters are in benthic structures (e.g., cages), the logger remains at a fixed point in the water column.
- Although the deployment lasts six months, data should be retrieved more frequently using the HOBO Waterproof Shuttle.

Data Processing & QA/QC
- Data processing is conducted in Onset's HOBOware Pro software.
- Use HOBOware's Conductivity Assistant to calculate salinity values based on conductivity values.

[6] Prepared by: M McCann (TNC) 3/2017, Updated 8/2018

- Use HOBOware's Dissolved Oxygen Data Assistant to adjust dissolved oxygen values for varying conductivity/salinity.
- In some cases, portions of the time series were excluded if values appear to be influenced by an apparent instrument failure. For example, a conductivity/salinity time series that abruptly dropped and remained at 0 ms/cm (0 ppt) without any bio-physical reason to believe conductivity/salinity actually dropped.
- In some cases, conductivity/salinity values were not available for a portion of the time series. In these cases, dissolved oxygen values could not be adjusted for varying conductivity/salinity. Although unadjusted dissolved oxygen values are presented graphically, they should be used with caution.

References

- HOBO Dissolved Oxygen Logger User Manual
- HOBO Conductivity Logger User Manual
- HOBO Waterproof Shuttle User Manual
- Baggett, Powers, Brumbaugh, Coen, DeAngelis, Greene, Hancock, and Morlock. 2014 Oyster Habitat Restoration and Monitoring Assessment Handbook. The Nature Conservancy. Arlington, VA, USA. p. 26-27

Photo Examples

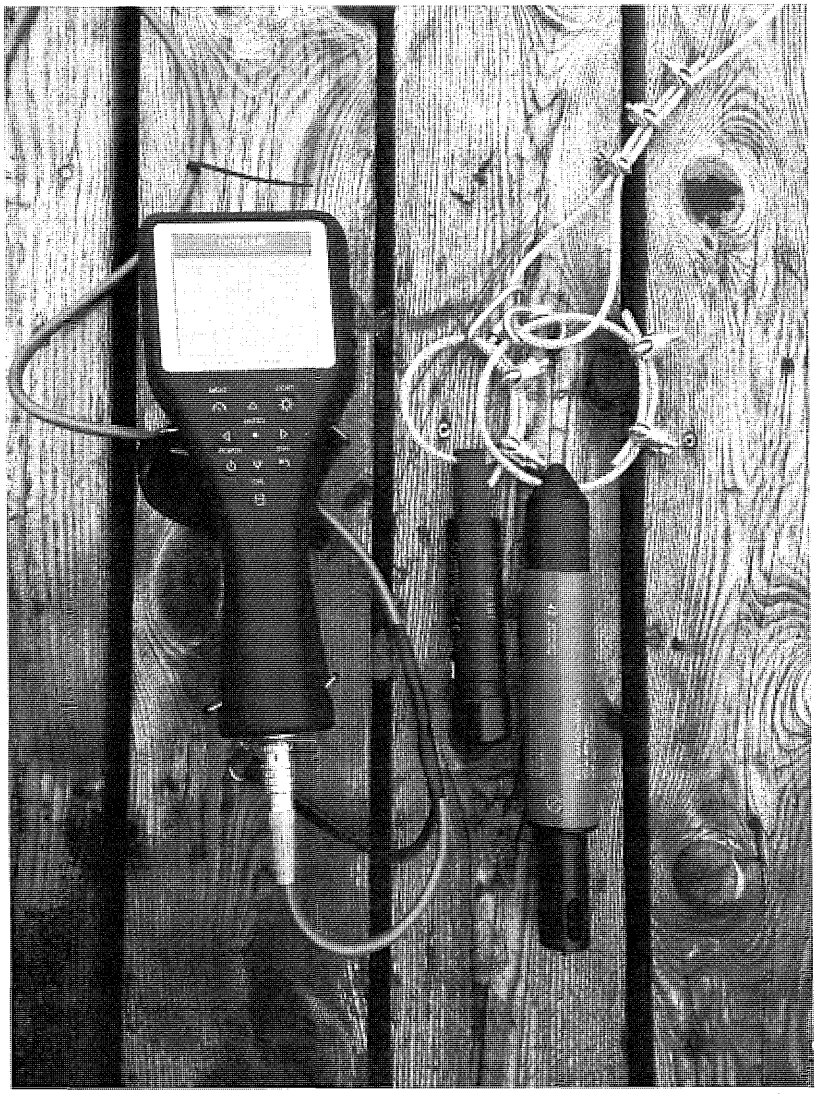


Figure 1: Horiba U-52 Multiparameter Water Quality Meter (LEFT), Onset HOBO Conductivity Logger (U24) (CENTER), and Onset HOBO Dissolved Oxygen Logger (U26) (RIGHT). Coated-wire rope and hardware for mounting water quality loggers is visible (Photo: M. McCann, The Nature Conservancy).

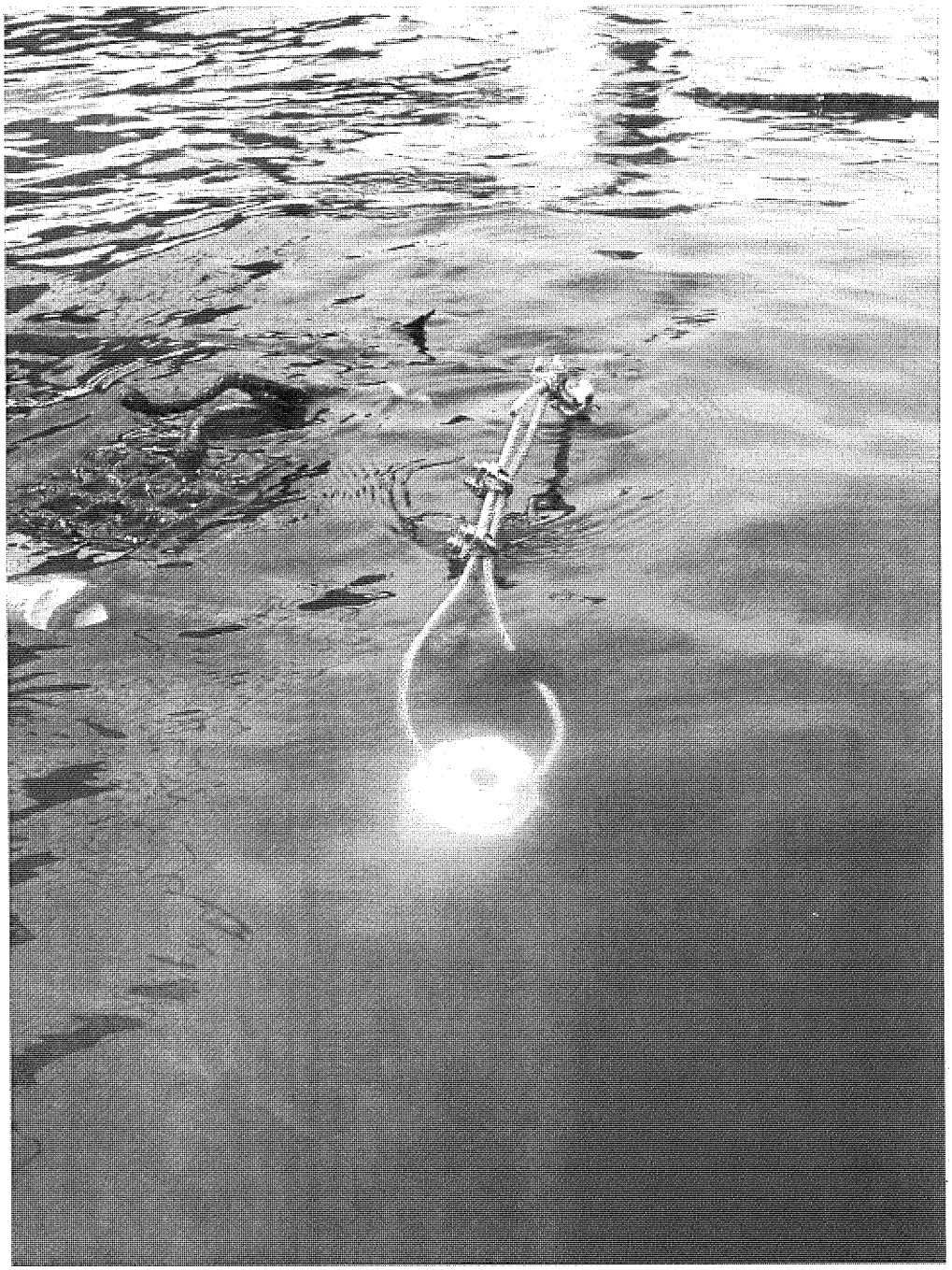


Figure 2: Onset HOBO Conductivity Logger (U24) (FRONT) in white, PVC case and Onset HOBO Dissolved Oxygen Logger (U26) (back) attached to the Community Reef at Brooklyn Bridge Park in the East River in summer 2017 (Photo: M. McCann, The Nature Conservancy).

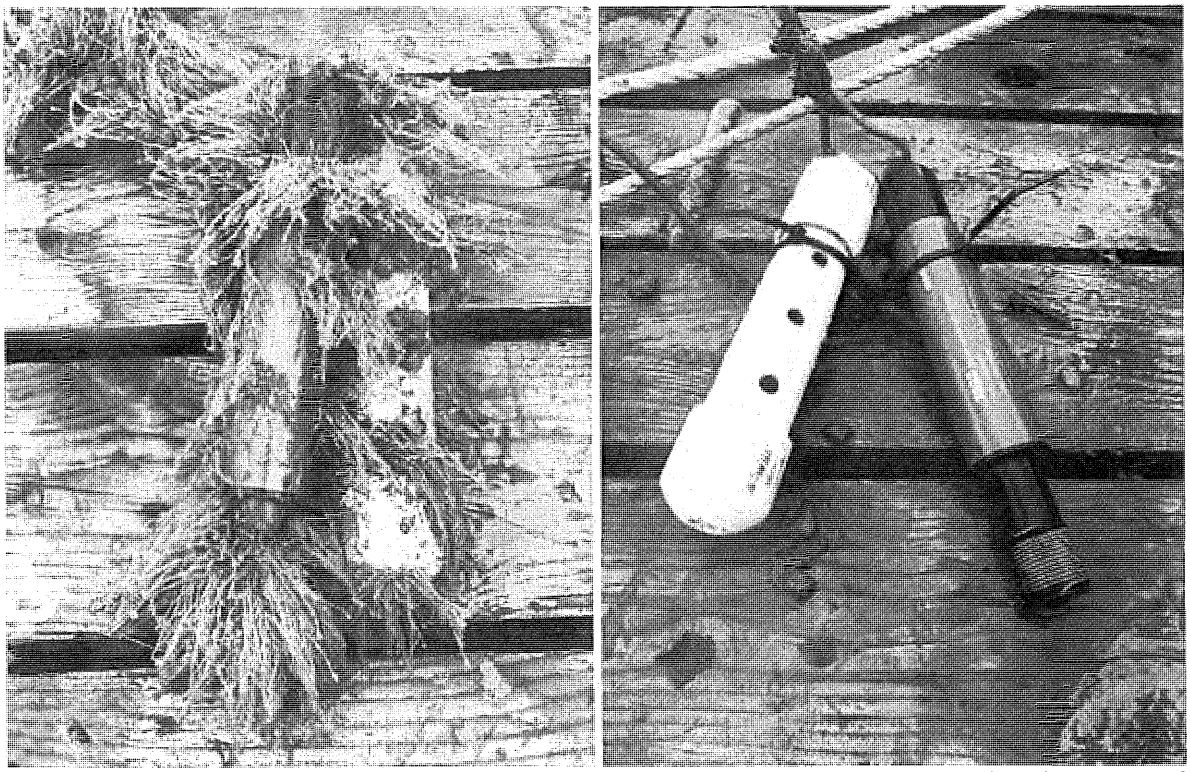


Figure 3: Water quality loggers on Governors Island EcoDock before (*left*) and after (*right*) removal of fouling organisms, offloading of data and recalibration. (Photos: Mike McCann, The Nature Conservancy).

Datasheet

Water Quality - Onset HOBO Data Logger Maintenance

Site	Date

Instrument Parameter: DO | Salinity	Instrument Parameter: DO | Salinity
Serial Number	Serial Number
Describe condition & actions performed	Describe condition & actions performed
Data offloaded: Yes | No	Data offloaded: Yes | No

Current water quality conditions [measure at least 3 times for replication]

Time					
DO (mg/L)					
Temp (°C)					
pH					
Sal (ppt)					
Cond (mS/cm)					
Turbidity (NTU)					
TDS (g/L)					

Water quality measured with:

Prepared by M. McCann (TNC) 8/2017; updated 5/2018

Scanned: ____
Entered: ____

Oyster Disease and Conditions Index Protocol (C.I.)[7]

Rationale
The *Disease* protocol provides data on of the potential impediments to successful oyster restoration.

Variables measured
- Dermo (*Perkinsus marinus*) prevalence and intensity
- MSX (*Haplosporidium nelsoni*) prevalence and intensity
- In addition to disease testing, condition index, sex determination, and reproductive stage can be determined simultaneously by most laboratories.

Data sheet(s): Link

Key equipment list
- Cooler and ice packs for transporting samples

Conditions Index
- Sampling frequency: Once a month (May - Sept); July and August ideally twice.
- Sampling intensity: 10 adult oysters per site
- Sample transport/handling: See "Methods"
- Equipment calibration/maintenance: NA. Analysis done by a third-party.

Dermo and MSX
- Sampling frequency: Once a year, October
- Sampling intensity: 10 adult oysters per site
- Sample transport/handling: See "Methods"
- Equipment calibration/maintenance: NA. Analysis done by a third-party.

Methods
- During each sampling event, haphazardly collect 10 adult oysters and immediately place them in a cooler with gel/ice packs so that the oysters are not directly in contact with the coolant. If there are several cohorts at a site, 10 oysters should be sampled from a single cohort.
- Within 24 hours, the oysters need to be delivered to the disease testing laboratory (i.e., ship overnight via FedEx)
    - Package oysters dry, in unclosed ziplock bags
    - Place oysters with ice packs and insulation (e.g., newspaper, bubble wrap) to avoid direct contact between oysters and ice packs
    - Ship in an insulated cooler box
- Disease testing laboratory will use industry standard protocols. Ray's fluid thioglycollate medium (RFTM) will be used on mantle and rectal tissues for Dermo diagnosis. The remaining tissues will be fixed in a buffered formalin solution for histopathology with one slide from each paraffin block. Hematoxylin and eosin (H&E) staining will be used for MSX diagnosis

Potential Analysis Laboratories

Marine Animal Disease Laboratory
155 Dana Hall, Stony Brook University
Stony Brook, NY 11794
Contact: Bassem Allam, Ph.D.

[7] Prepared by: M McCann (TNC) 3/2017, Updated 8/2018

* This lab has been used by the Head of Bay project and other testing in 2017

Haskin Shellfish Research Laboratory
Rutgers University
6959 Miller Avenue
Port Norris, NJ 08349
Contact: Dave Bushek

References

- Baggett, Powers, Brumbaugh, Coen, DeAngelis, Greene, Hancock, and Morlock. 2014 Oyster Habitat Restoration and Monitoring Assessment Handbook. The Nature Conservancy. Arlington, VA, USA. p. 28-30

Datasheet

Disease Testing

Site:
Date:
Time:

Collect 30 adult oysters and transeft to cooler with ice packs.

Deliver oysters ASAP to disease testing lab

Collected by:
Collected from: *describe location where oysters were collected (e.g., tray, cabinet, etc)*

Disease testing lab:
Delivery method & time:

Notes:

Prepared by M McCann (TNC) March 2017

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Oyster Growth and Survival Protocol - Quadrats[8]

Rationale
The *Oyster Growth & Survival* protocol provides data on the performance of restored oysters. This is one of the main protocols for assessing the success of restored oysters.

Applications
This protocol should be used when oysters are cemented to structures (e.g., to each other or set onto structures like Reef Balls). This protocol can be used to monitor files in BOP Community Gabions. This protocol is not typically used if oyster clumps are loose or if oysters can be handled individually. This protocol has been used at Bush Terminal Park, Coney Island Creek, and the Tappan Zee Bridge project.

Variables measured
- Oyster shell height - used to determine growth rate
- Oyster density - used to determine mortality/survival

Data sheet(s): link

Equipment Needed
- Calipers
- Quadrat
- Datasheet & clipboard
- Hand counters (optional)

Equipment calibration/maintenance: NA

Sampling frequency
Once a month after installation of the gabions between May to early October. For new projects, conduct this protocol within a month of installations.

Sampling intensity
The number of units (e.g., cages, trays) to sample depends on the restoration design at the site. Sampling should consider any covariates (e.g., depth, position in a stack of cages, distance to shore) and sample units that capture any variability due to these variables. A minimum of three samples is necessary to calculate the mean and variance.

Sample transport/handling
NA. No physical samples are collected.

[8] Prepared by: M McCann (TNC) 3/2017, Updated 8/2018

Methods

Retrieve The Oysters

- Logistics will depend on the conditions at the site. See your BOP Site Manager for best practices for getting your oysters on shore.

Divide Into Groups

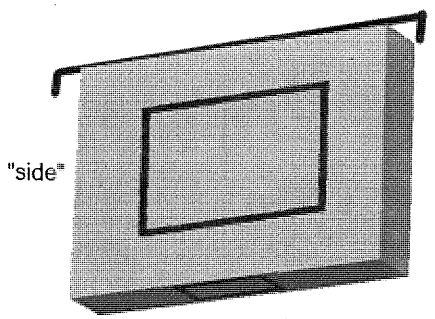
- Designate one person to write down the information
- And one or two people to measure the oysters
- If you have retrieved several structures or cages, you can split into multiple groups.

Fill Out Your Data Sheet

- At the top of your datasheet fill out:
  - Site
  - Names of people making measurements and recording (i.e., "Observers")
  - Today's date ("Date")
  - Describe the structure("Cabinet/File/Tray")
- The datasheet now has room to record data from three quadrats
- Use a new datasheet for each new cage or structure that you are observing

Quadrat Placement

- Since there are several sides to most cages or structures, you can do one or more quadrats per cage
- Record your quadrat size on your data sheet. Most quadrats are labelled with their size (e.g., 0.1 m^2).
- Record the location where the quadrat is placed on the structure.
  - For Community Reefs, quadrats are typically placed on the center of the broad side (i.e., "side") or in the center of the bottom (i.e., "bottom") of the file (i.e., oyster cage) (see image on right).

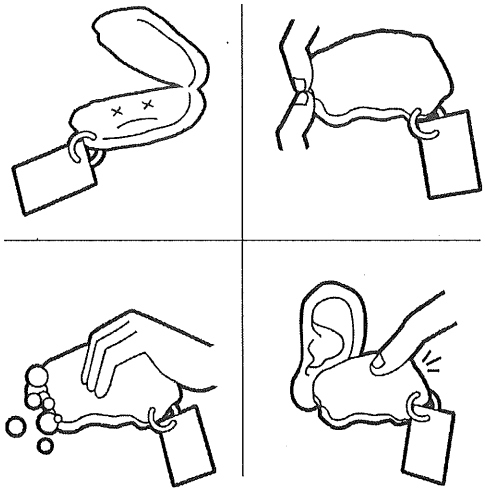


Counting and Measuring Oysters

- Count and measure the shell height of all live oysters and dead box oysters (i.e., oysters that are dead but still have both valves).
  - If it is too difficult to fit the "jaws" of the caliper to the base of the oyster shell, the thin, metal portion that sticks out of the caliper when it is open can be slid into tighter spaces. The measurement that is displayed on the open calipers is the same distance as the amount of the metal wire that is exposed from the back of the calipers.
- Work systematically across your quadrat so you do not skip any oysters.
- Once you have measured 30 live or dead oysters, continue counting the remaining live and dead oysters to get a total count in your quadrat. You can optionally use the hand clicker to count larger numbers.
- Photo documentation of quadrats may also supplement in-the-field measurements.

Identifying Dead Oysters

- Dead oysters can be identified with a light tap on the top shell. Dead oysters will also sound hollow when lightly tapped (see *bottom right*).
- If the shell is visibly gaping open (see *top left*), if there is softness or movement in the shell, or if bubbles are discharged when the shell is lightly pressed (see *bottom left*), this means the oyster is dead.
- To double check that an oyster is dead gently try to pry them open with your fingernail (see *top right*). A dead oyster will generally open very easily. Often a dead oyster is filled with mud and therefore can be mistaken for being alive.



Additional Quadrats

- If you have completed your first quadrat and you still have more time, you can reposition the cage and find another location to place your qudrat and repeat this protocol.

Review Your Data Sheet

- Are there any pieces of information that are missing from your data sheet that you should record now before you forget them?

References

- New York Harbor Foundation. 2016. Field Science Manual: Oyster Restoration Station
- Tier 3 Tappan Zee Bridge Oyster Restoration Pilot Study: TZB Monitoring Protocol - October 7, 2015

Photo Examples

Figure 1: Jim Lodge and Ray Grizzle using a quadrat (1/10 m^2) on top of gabion block at Tappan Zee Bridge restoration site, October 2016.

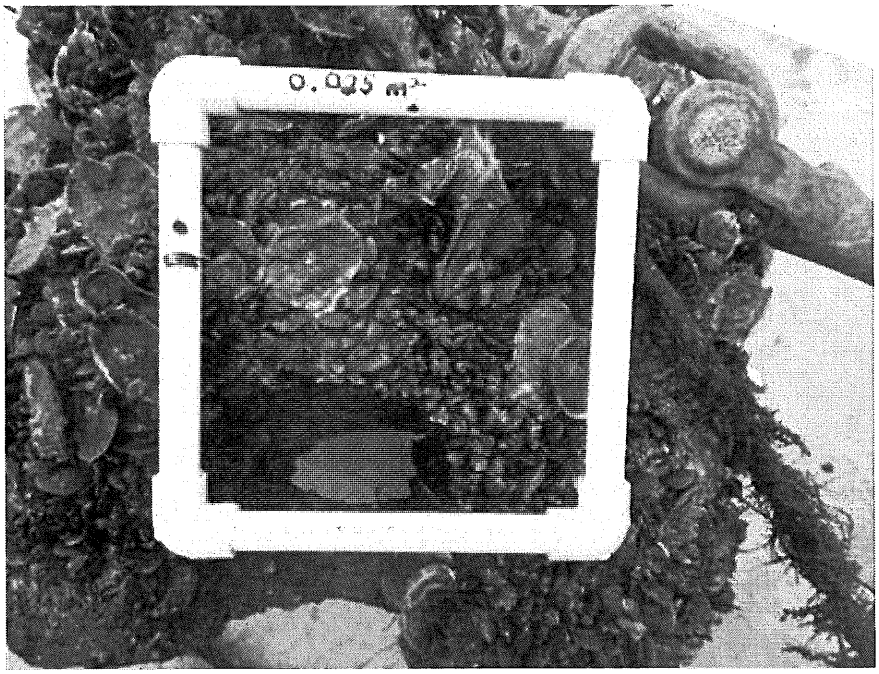


Figure 2: Quadrat sampling (0.025 m^2) on Reef Balls at Tappan Zee Bridge restoration site.

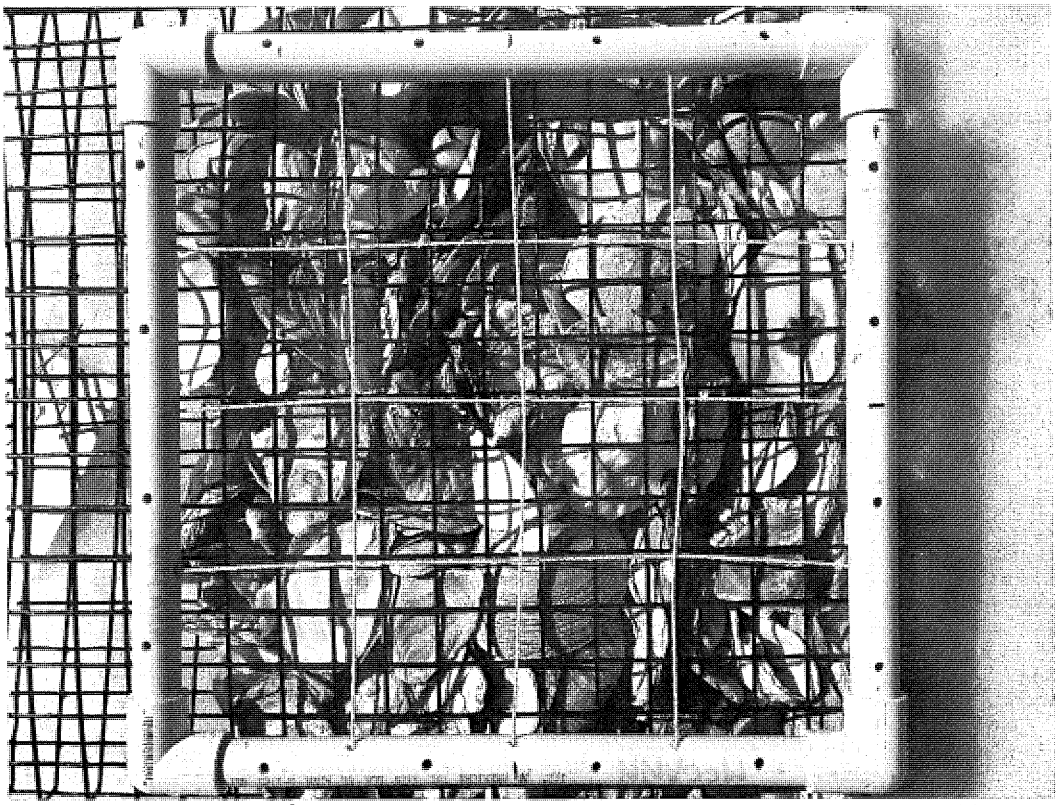


Figure 3: Quadrat (1/8 m^2) BOP oyster "files" from Community Reefs. String, sub-dividers are optional, but allow for quantifying smaller areas of the quadrat. Yes, that's snow in the background.

Figure 4: Example of Tanasia Swift using the "bottom" placement of quadrat on the bottom of a community reef file at Bush Terminal Park in summer 2017 (Photo credit: Mike McCann).

Datasheet

Oyster Measurments: Quadrats

Site:	Date:	Observers:
Cabinet/File/Tray:		

Measure up to 30 oysters per quadrat and count the total number of live/dead in each quadrat

	Quadrat 1		Quadrat 2		Quadrat 3	
Quadrat size:						
Quadrat placement on structure:						
	Shell height (mm)	Live or Dead (box only)	Shell height (mm)	Live or Dead (box only)	Shell height (mm)	Live or Dead (box only)
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						
14						
15						
16						
17						
18						
19						
20						
21						
22						
23						
24						
25						
26						
27						
28						
29						
30						
Total number live & dead	Live: Dead:		Live: Dead:		Live: Dead:	

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