OYSTER GARDENING MANUAL

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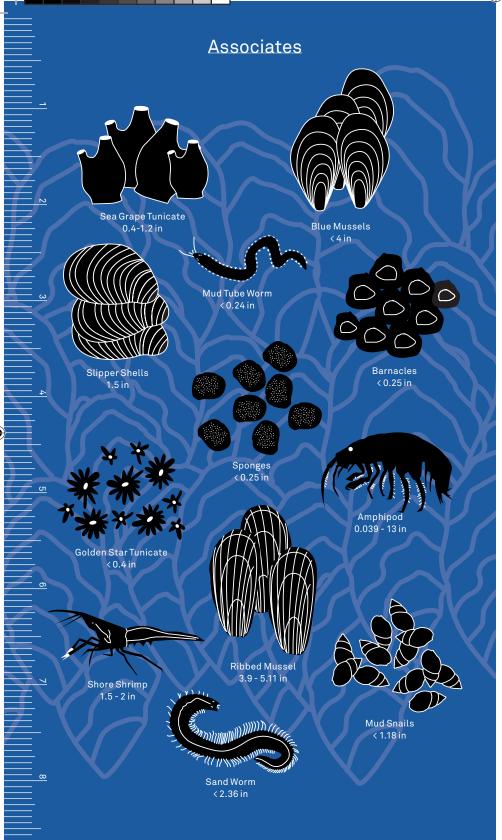
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OYSTER GARDENING MANUAL

BILLION OYSTER PROJECT OYSTER GARDENING PROGRAM FOR MIDDLE SCHOOLS

STATEN ISLAND EDITION



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Published by

New York Harbor School and New York Harbor Foundation Battery Maritime Building, Slip 7 10 South Street New York, NY 10004

Graphic Design

MTWTF, NY: Glen Cummings, Boyeon Choi, Ravena Hengst, Virginia Chow

"Oyster Gardening Manual" is a guidebook produced by New York Harbor School and Foundation in collaboration with SCAPE as part of the Rebuild by Design initiative.

The Urban Assembly New York Harbor School is located in the heart of New York Harbor, and is accessible only by ferry, Harbor School offers a unique, on-water learning experience for all its students. Students learn to build and operate boats; spawn and harvest millions of oysters; design submersible, remotely-operated vehicles; conduct real-life research; and dive underwater. Students go on trips, tour colleges, hear and learn from experts in science and industry, and participate in the school's on-going oyster restoration research program. Harbor Foundation is a 502(c)3 non-profit based on Governors Island, whose missions is to prepare New York City students for careers in marine science and technology through the restoration of New York Harbor.

Rebuild by Design, an initiative of the Hurricane Sandy Rebuilding Task Force and HUD, is aimed at addressing structural and environmental vulnerabilities that Hurricane Sandy exposed in communities throughout the region and developing fundable solutions to better protect residents from future climate events. Because of the enormity of this challenge, the Rebuild by Design process was developed to find better ways of implementing designs and informing policy. http://www.rebuildbydesign.org/

NY/NJ Baykeeper is an independent 501©3 non-profit with a mission to protect, preserve, and restore the NY/NJ Harbor Estuary. Since 1989, Baykeeper has served as the citizen advocate for the bays, streams and shores of the Hudson-Raritan Estuary – stopping polluters, championing public access, influencing land use decisions, educating the public and preserving and restoring habitat. Baykeeper works to pursue a healthy harbor through three core programs: Conservation, Oyster Restoration, and Clean Water Campaign.

SCAPE/LANDSCAPE ARCHITECTURE PLLC is a design-driven landscape architecture and urban design studio based in New York. SCAPE is a certified WBE with LEEDaccredited professionals on staff. SCAPE shares a commitment to innovative design and construction of the urban landscape. Living, Growing Breakwaters is the SCAPE team proposal for the Rebuild By Design initiative. This project proposes the restoration of living reef ecosystems to the South Shore of Staten Island for risk reduction, enhanced waterfront recreation, and increased shoreline education and stewardship.

MTWTF is a graphic design studio specializing in publications, environmental graphics and identity systems. MTWTF engages in collaborative projects with partners in other disciplines, such as architecture, industrial design, and urban planning. MTWTF was founded in 2008 and is located in Long Island City, New York.

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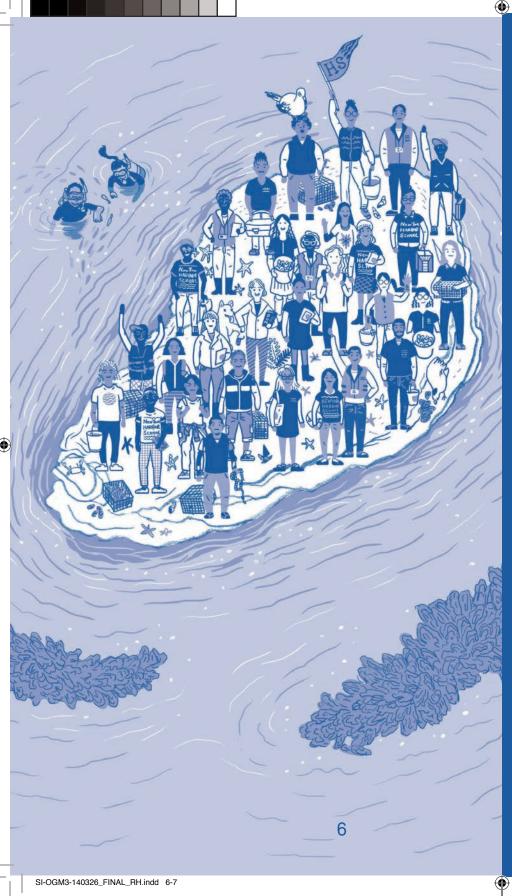
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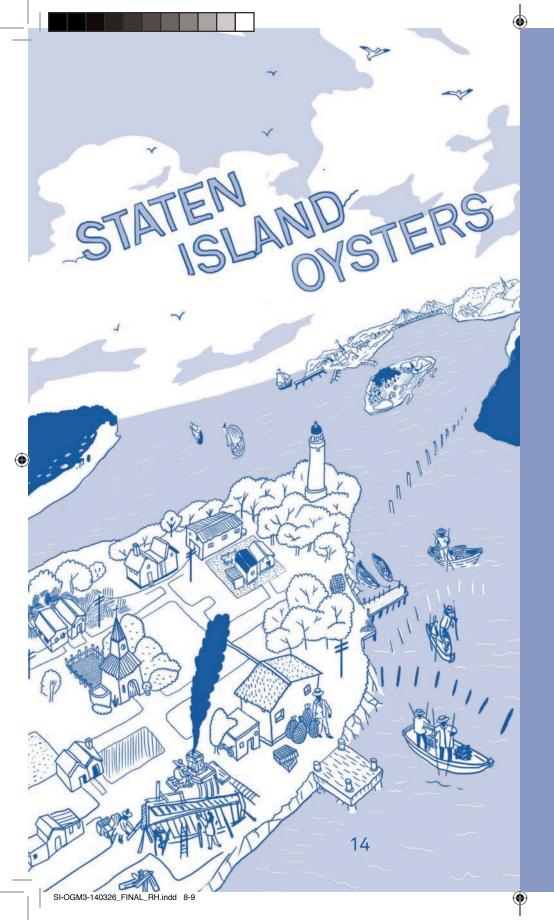
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INTRODUCTION

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<u>Staten Island Oyster:</u> New York's Abundant Food Source

When Europeans first arrived on the Island of Manhattan in the early 17th century, Oysters were literally everywhere. Oyster reefs, or massive conglomerates of individual oysters growing on top of one another, covered more than 260.000 acres of our shoreline. This mean that oysters covered the vast majority of the estuary and formed the basis of its ecology and economy. Oysters were the first commodities that the native Lenape exchanged with the Europeans. They were easy to harvest and a cheap source of food for all. The oyster economy of New York lasted for more than 300 years feeding the rich and poor alike. By its peak in 1860 more than 12 million oysters were sold in city markets and exported annually, making NYC the oyster trading capital of the world.

Throughout the 18th century oysters harvested from the South Shore of Staten Island (Prince's Bay and Tottenville) were a staple of all New Yorkers' diets and exported across the country. By 1820 however, after more than a century of continuous harvest, Staten Island's native oyster beds had become exhausted. After the abolition of slavery in 1827. free blacks from the Chesapeake came to settle the South Shore and brought in their seed oysters to replant the local beds. John Jackson was the first to purchase land in the Rossville area and led the establishment of Sandy Ground, the oldest community of free blacks in the United States.

Because of the efforts of the men and women of Sandy Ground, by the mid 1830s, the oyster industry in Staten Island was once again thriving. Along with it, the shipbuilding and ship repair industry of Tottenville also began to flourish. Throughout the 1800's, Tottenville was home to more than half a dozen shipyards. Unfortunately, by 1890 the oyster industry was once again in decline, due primarily to industrial pollutants and sewage. In 1916, the New York Department of Health declared clamming and oystering in the waters around Staten Island unsafe. Coupled with the closure of ovster and clam beds, the advent of steel hulled ships finally brought about the end of the local shipbuilding industry of Tottenville. Today the clamming industry of Staten Island is once again alive and well (thanks to the clammers of the Staten Island Baymen's Association), however prohibited and restoration, not consumption, is the priority.

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Since the passing of the Clean Water Act in 1972, which limits the amount of pollution and sewage permissible in the harbor, water quality has

Staten Island Oyster 9

improved dramatically within the Hudson Raritan Estuary. In fact NYC's waters are the cleanest they have been in the past 100 years. In the last decade scientists and naturalists alike have watched in awe as many aquatic species, once thought to be lost for good, are returning to our local waters.

<u>1850s-1900</u>

1895

in Raritan Bay, where seed oysters were brought in from Long Island and grown in the Bay's shallow waters. Native beds declined due to overharvesting and water quality. Oysters were stored in "drinking" creeks prior to final sale until the late 1890s. Soft and hard clam harvest limited to wading depths and intertidal shorelines.

OYSTERS: Oyster leases were created

CLAMS: Clamming areas expanded with the invention of the long handle rake and the sailing dredge.

10

I remember,

10 years ago, it

was way eas-

ier to harvest these oysters.

<u>1900–1950s</u>

1925

 $(\mathbf{0})$

OYSTERS: In 1900 mechanized dredge boats enabled more efficient harvesting of oysters. Oyster aquaculture declined due to pollution and sedimentation. The oyster industry collapsed by 1925 due to human health hazard and population decline.

CLAMS: Clamming was impacted by water quality concerns but returned to the harbor by 1950. The rocking chair dredge enabled more efficient harvesting.

I wonder what

to be here?

happened to the

ovsters that used

History of Oysters in Raritan Bay and Staten Island

1950s–Today

OYSTERS: Oyster culture is not a viable industry due to population decline and water quality. Restoration reefs have been constructed at limited sites within the bay and a larger area has been identified by the US ARMY Corps of Engineers Comprehensive Restoration Plan for Hudson-Raritan Estuary as suitable oyster habitat. Water quality has significantly imporved since the 1970s but wastewater effluent and industrial contamination from Arthur Kill are still concerns.

CLAMS: The clamming industry was closed due to disease concerns in the 1960s. Today, NJ clam areas are closed for the foreseeable future, while NY clam beds remain open; however, staten Island clammers must transplant their harvests to cleaner waters (on Long Island) for a minimum of three weeks for purification.

> Maps of Staten Island Oyster & Clam Beds on p.98!

> > 2014

See the Historic

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Staten Island Oyster

back in the day, there used to be so many oysters...

We're growing oysters in my school!

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1800s-1850s

1825

OYSTERS: Eastern oysters were harvested from native beds, primarily Great Beds and Chingarora beds in Raritan Bay. Oysters were tonged and dredged by hand. By the 1800s native oyster beds were already in decline.

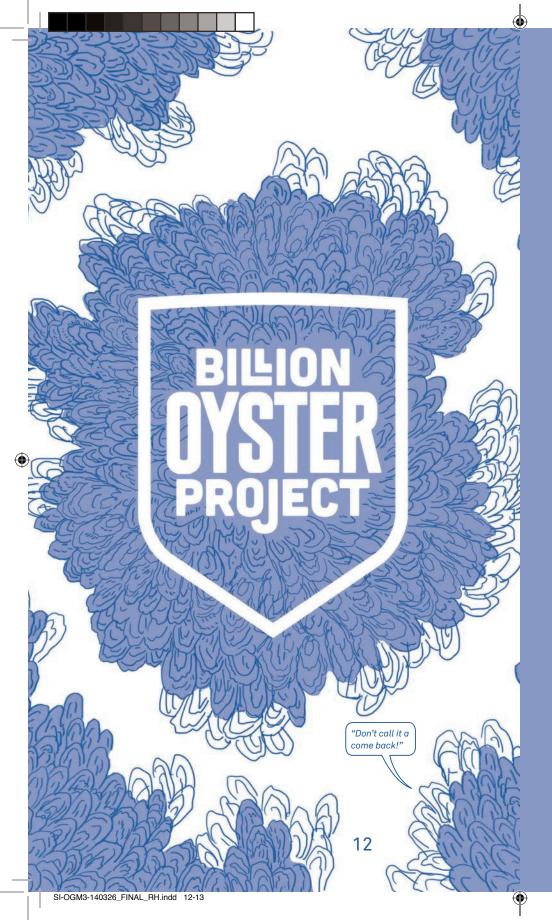
CLAMS: Soft and hard clam harvest was limited to wading depths and intertidal shorelines.

I'm making

my living

pulling up

ovsters



Billion Oyster Project (BOP)

BOP is Harbor School's longterm, large-scale plan to restore one billion live oysters to New York Harbor over the next twenty years and in the process train thousands of young people in New York City to restore the ecology and economy of their local marine environment. BOP is a partnership of schools, businesses, nonprofits, and individuals all working together to grow oysters and make our city a healthier and more resilient place to live. This partnership also includes local, state, and federal regulatory agencies with whom we work closely to certify and monitor our aquaculture methodology and ongoing habitat restoration projects.

School based oyster gardening is an integral component of the **Billion Oyster Project. Students** as restoration scientists contribute to BOP in two main ways. Students help BOP to answer key scientific questions about urban estuary restoration. They do this by growing and monitoring oysters in diverse locations and micro-niches around the Harbor. Student scientists try to answer questions such as: where do native oysters grow best in a highly urbanized estuary; what site conditions (maare commonly associated with oyster growth; what organisms (predators and associates) are commonly found in and around oyster restoration sites; what

ence oyster growth. These questions require long term research and professional commitment from students, teachers, and schools.

The second major contribution of school based oyster gardening is simply to increase the total number of breeding adult oysters in the ecosystem. While 500 oysters in cage may seem insignificant when compared to the project's goal of one billion, each breeding female is capable of producing up to 25 million eggs every time she spawns (two or three times per summer). In a semi-enclosed embayment with one or two gardens this can lead to tens of millions of fertilized larvae swimming about looking for a place to call home. The more gardens we install the more likely the larvae will successfully find substrate and metamorphose into oysters.

Each BOP garden is both a research experiment and a tangible contribution to restoration. Every BOP school extends the message and the practice of stewardship. It our hope that BOP fosters a lifelong appreciation in all students for the principles and practice of environmental stewardship.

Billion Oyster Project 13

Become a BOP SCHOOL



New York Harbor together with School and Foundation the NY/ NJ Baykeeper present the BOP Oyster Gardening and Harbor Restoration Curriculum for Schools.

Through a series of interdisciplinary lesson plans incorporating NYS Common Core standards, BOP Curriculum is designed to give students a place-based education and build their enthusiasm for marine restoration science and technology. The Curriculum provides teachers an adaptable instructional resource that aligns with Common Core math and science scope and sequence. BOP Curriculum is leveled for middle school but can be readily adapted by both elementary and high school teachers as well. The Oyster story of New York is also a rich and varied theme that exposes students to the history of their city, marine ecology, statistics, environmental policy and real life scientific research.

The Oyster Gardening program in New York City was initially begun by NY/NJ Baykeeper in 1999 to establish a database for documenting native oyster restoration and local conditions for survivability in the NY/NJ Harbor Estuary. By enlisting the help of Harbor residents Baykeeper was able to establish an extensive and ongoing database that has been useful in informing local oyster resto-

Become a BOP School! 15

ration activities. Over the years the program has enjoyed widespread participation attracting private individuals and families, community and civic groups.

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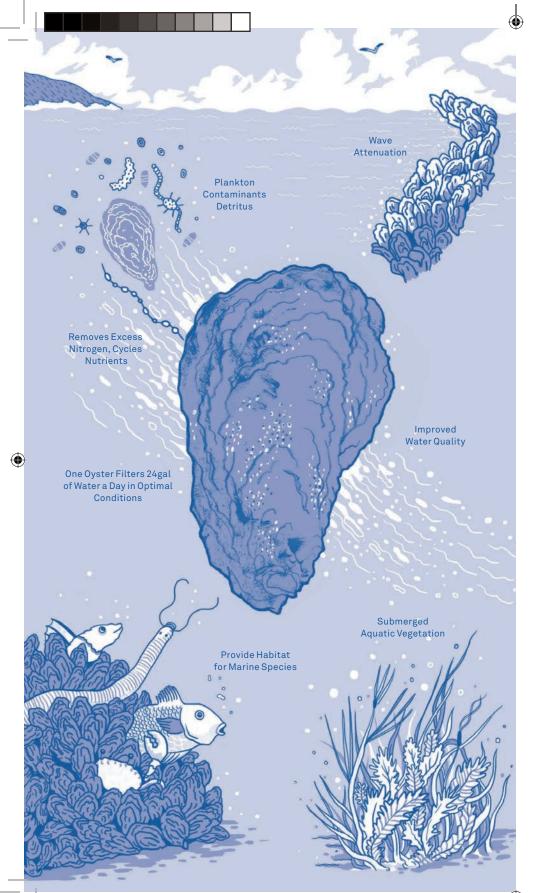
Hello!



<u>Students as Restoration</u> <u>Scientists</u>

The basis of this curriculum is to enable middle school students to maintain and care for a small cage of approximately 300 baby oysters (called "spat-onshell") for one to two years. By continuous monitoring students observe and record oyster growth, mortality and note aggregating species. Relevant water quality parameters are also be collected. Through this research project, students develop critical thinking and problem solving skills. They learn to formulate their own hypotheses and search for answers using the data they collect, and they present their conclusions to their peer group at a school wide symposium. Optionally, teachers can use the symposium to create a grade 8 exit project which enables students to research other aspects of marine environmental science and technology, in addition to restoration of native oysters in New York Harbor.

This hands-on teaching approach allows students to gain direct experience with scientific procedures and career fields pertaining directly to the biology, technology, policy, and economics of the estuary. By bringing this program to middle school students BOP hopes to inspire and equip them to become the next generation of policy makers, scientists, stewards and advocates of the Harbor.

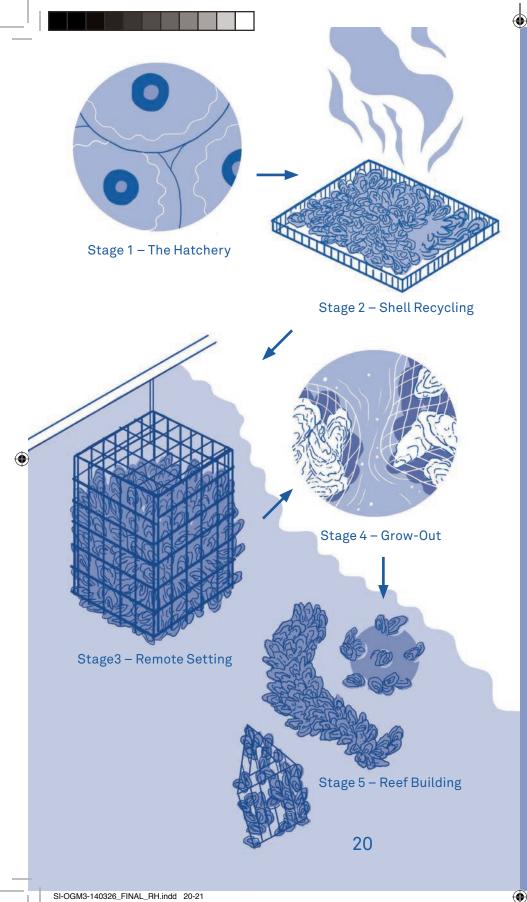


Oysters as Ecosystem Engineers

The eastern oyster or American oyster (Crassostrea virginica) is the only species of oyster found along the U.S. East coast. Crassostrea virginica ranges from St. Lawrence Bay in Canada south to the Gulf of Mexico, Yucatan Peninsula, and can be found as far afield as the West Indies and Brazil. The species most commonly occurs in coastal (estuary and bay) waters and is well known for forming extensive reef systems both intertidally and subtidally. These three-dimensional oyster reef structures provide habitat for a variety of marine species and play an important role in shoreline stabilization. As filter feeding organisms, oysters help improve local water quality by removing suspended sediments and algae, and in so doing they also play a crucial role in nutrient cycling by removing excess nitrogen out of the system.

Oysters once formed the dominant habitat type in the Hudson Raritan Estuary (HRE) providing shelter, food and spawning grounds to over 200 species of aquatic organisms. The HRE encompasses all waters around New York City and northern New Jersey and is home to one of the greatest natural harbors in the world, and now also one of the busiest ports in the entire United States.

Become a BOP School! 19



BOP Lifecycle

Five Stages in the Life Cycle of BOP

The following pages depict the five stages of the life cycle of BOP. These are illustrated technical diagrams. They show almost all the activities involved in the project, from production to education to restoration. Each of the five phases takes place in unique location(s) around Governors Island and New York Harbor. BOP offers guided tours of the hatchery and other facilities on GI to motivated school groups. Contact us if you and your students are interested in setting up an educational workshop and tour of BOP facilities (restore@nyharbor.org).

BOP breeds and spawns wild oysters in the lab to produce hundreds of millions of larvae for the remote-setting process. (@ Harbor School MAST Center)

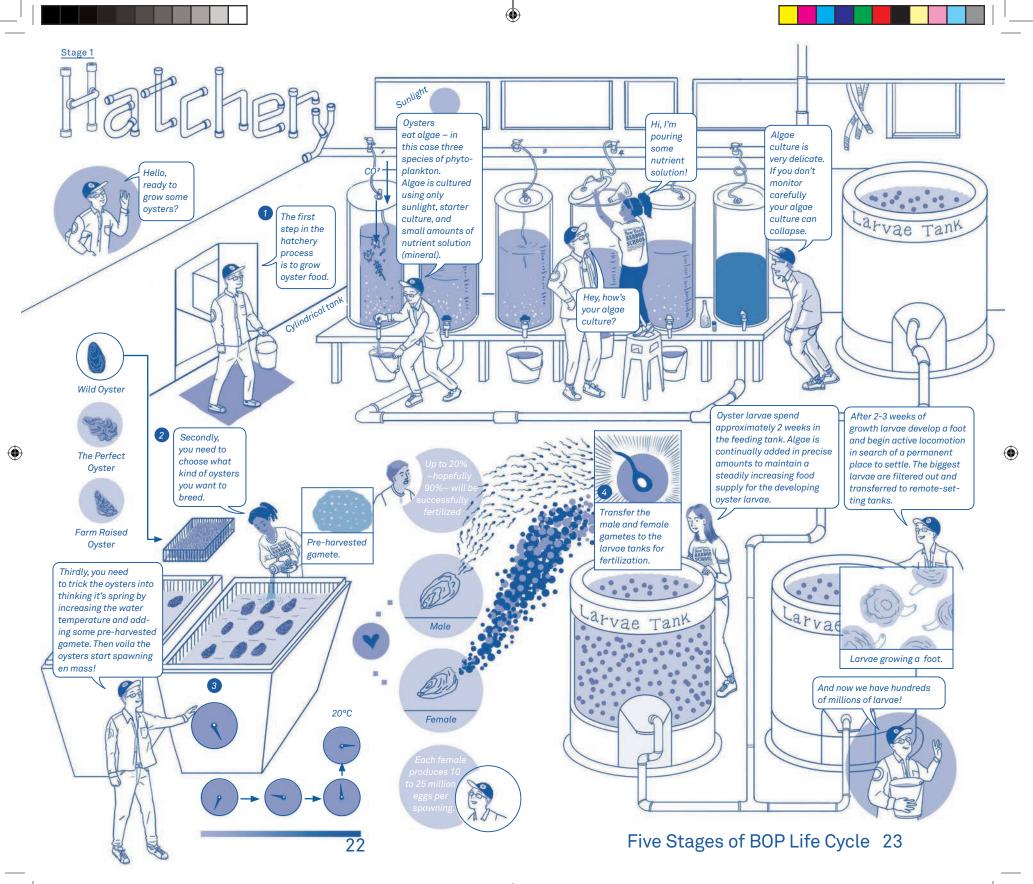
Stage 2 – Shell Recycling BOP collects thousands of pounds of shell per week from local restaurants to use as growing medium for new oysters. (@ restaurants and GI/ Earth Matter)

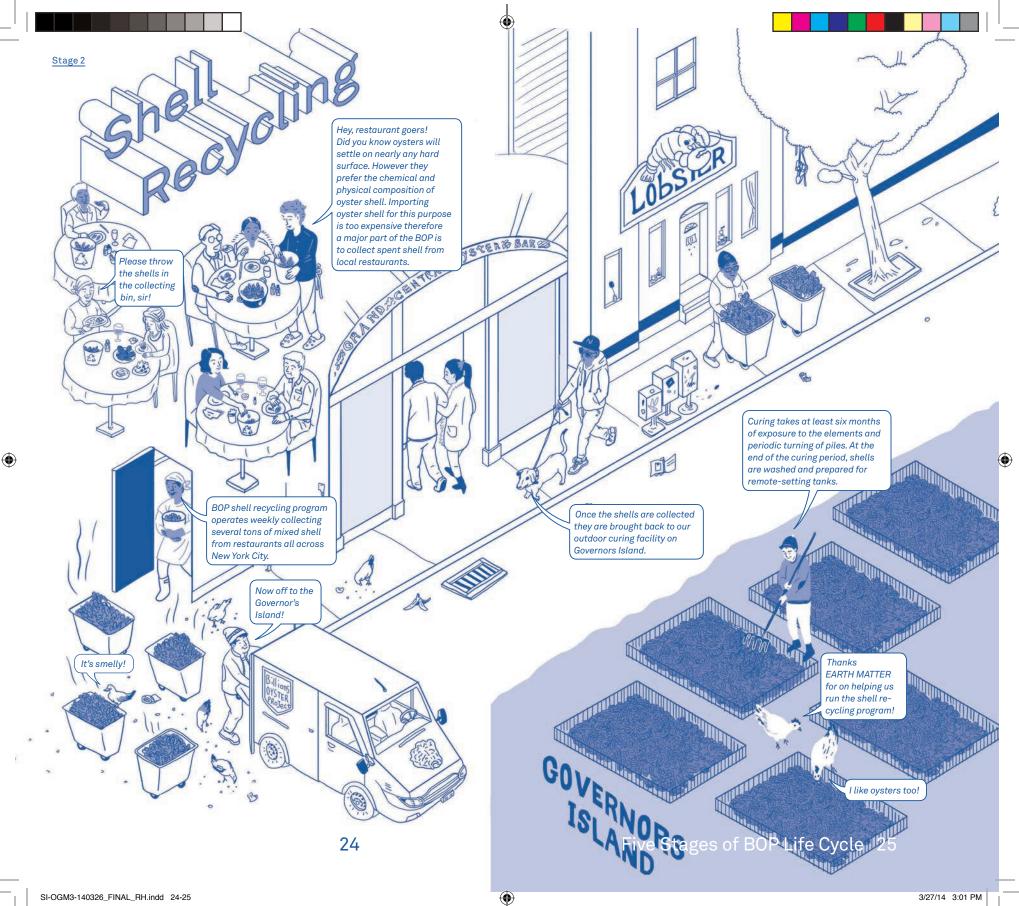
Stage 3 – Remote Setting The process of "seeding" recycled shell with millions of lab grown oyster larvae in large seawater filled tanks. (@ GI Pier 101)

Five Stages of BOP Life Cycle 21

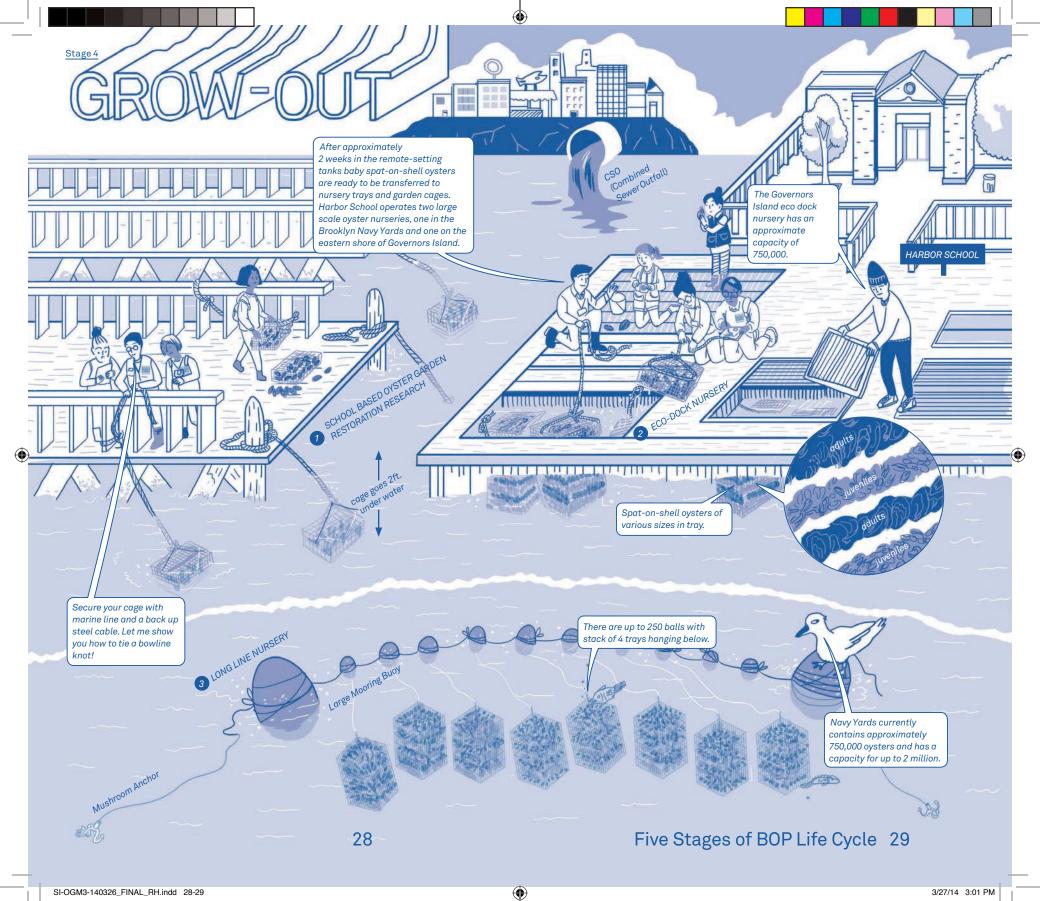
Stage 4 – Grow-Out Baby, spat-on-shell oysters are grown out in floating trays or school gardens for 1-2 years before being transferred to reefs. (@ BOP school gardens and floating nurseries)

Stage 5 – Reef Building The final stage in the restoration process, mature oysters are "planted" on reef restoration sites around the Harbor using various structures and techniques. (@ multiple restoration sites)









Stage 5



Now, the most

Reet

substratem, usually rock and/ro clam shell, and seeded oyster shell (spat on shell) to recreate the effect of naturally occurring oyster bed. This approach works well in low energy environments where the wave and tidal forces are not strong enough to knock the spat-on-shell (SOS)

off into the surround-

ing muck.

waterlevel

SPAT-ON-SHELL SUBSTRATE MOUNDS

Using a combi-

nation of unseeded

Reef balls are artificial reef structures made of poured concrete. The specially compounded reef ball cement has pH closer to seawater (~8.0) and therefore serves a good habitat for ovsters and other marine life. Reef balls can be artificially seeded in tanks with oyster larvae and then placed on the bottom as "instant

GOVERNORS ISLAND

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reefs."

30

Hatchery grown spat on shell are placed as a top layer in hopes they will remain in place on the rock and shell base. Stay firm on the shell!

most of NY Harbor is characterized by conditions of high energy and high sedimentation. Another approach to overcome the probem to use remotely set artificial reef structures known as "Reef balls".

Unfortunately

CUNSTRUCTED REEF BALLS CONSTRUCTED REEF

DINUCIUMEDINEE

3-4 knot curre

Oyster condos are large

metal frames built from

welded rebar and wire mesh

sleeves or plastic trays that

can contain thousands of

spat-on-shell.

Another approach to ensuring oysters remain in place on the bottom in high energy environments is to build large metal frames (called "oyster condos") that can contain thousands of spat-on-shell and are themselves habitat. generating structures.

Restoration Site

Eelgrass Restoration Site

FUTURE SITES

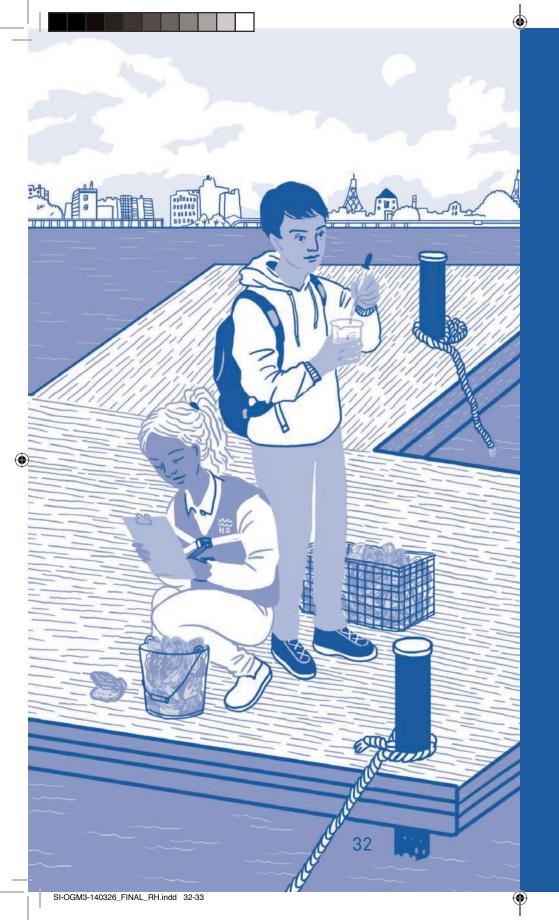
Tidal Lagoon A tidal lagoon is a Marsh Grass

man-made enclosure created in a tidal area. It looks like a harbor or marina, and acts to separate a body of water away from the natural ebb and flow of the tides.

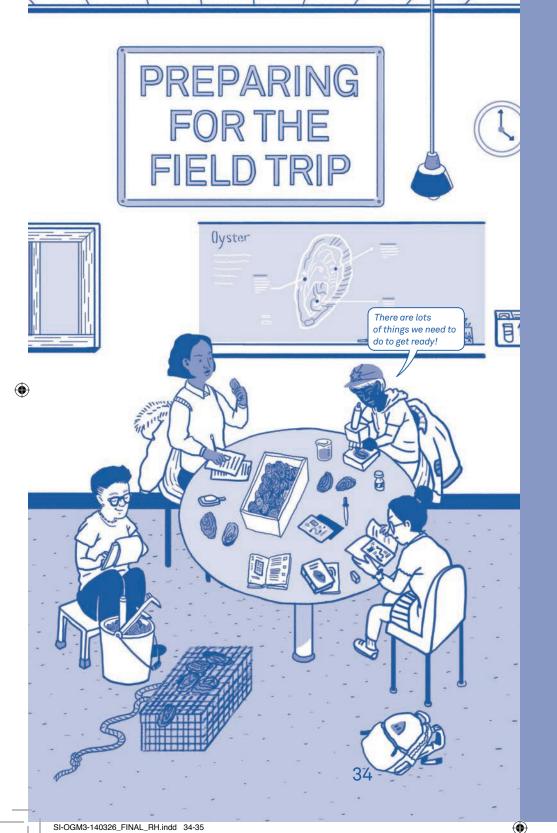
The GI Reef Science Platform is our underwater base station for collecting scientific data on the impacts of reef restoration. The platform has three separate instruments: a water auality sonde that measures parameters like pH, salinity, dissolved oxygen, and chlorophyll; a current profiler that measures the speed and direction of the water column; and a live streaming webcam that anyone can drive from the internet.

Reef castles are artificial reef structures using large concrete forms including hollow blocks and spheres. They are placed inside remote setting tanks (see 'Remote setting'), seeded with lab grown larvae, then placed directly onto the bottom to serve as habitat and wave attenuating structure.

Five Stages of BOP Life Cycle 31



B.O.P. OYSTER GARDENING MANUAL



What is Oyster Gardening?

BOP oyster gardening is a platform for teaching students environmental science research and fostering a personal connection to our local marine environment. The goal of the curriculum is to grow more oysters and to engage students in marine science and steward-

BOP oyster gardening is not just about taking field trips to the waterfront. At least one week of in-class preparation and training in scientific monitoring is required before the first trip takes place. There are also dozens of related lessons in history, mathematics, and ELA plus extension activities and research projects that can be utilized in concert with oyster gardening. The BOP oyster gardening contract requires that teachers care for and monitor oysters with their students on a monthly basis. However, these are just the minimum requirements. It is our hope that all participating teachers go beyond the minimum to develop their own specialized Harbor Literacy curriculum based in marine science, policy, mathematics, ELA, or other subject areas.

New York Harbor Foundation and Harbor School have worked in partnership with 15 schools and environmental organizations across the region to develop the oyster gardening manual you have here and

the online BOP curriculum. We hope the resources developed through this network make it easy and exciting for students and teachers to access the Harbor and become empowered as stewards of their own marine backyard. BOP oyster gardening is not an end in itself, but a point of departure for a integrating New York Harbor into New York City Schools. It is up to teachers and students to take it from here.

The rest of this manual covers how to prepare, install, and monitor oyster gardens in the field with students.

The manual is designed as a guide for teachers AND as a visual/technical resource for students. Teachers can cut and paste anything from the manual directly into their lesson plans or worksheets. Teachers can also adapt the monitoring procedures as needed, as long as the final data collected remain consistent and scientifically valid. We encourage teachers to communicate with BOP on a regular basis to share feedback and discuss the procedures. Contact info can be found on the first and last page of the

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Review Data Sheet



Make Weather Observations



Make Water Surface Observations



Measure Oysters



<u>What Each Student Should</u> <u>Know</u>

Before going into the field all students should be familiar with the principles and practices of scientific monitoring. Teachers can use BOP monitoring lessons to teach the protocols required for oyster garden monitoring and water quality testing. Teachers should prepare students using these lessons for at least one week prior to the trip. All students should be proficient in the following aspects of field monitoring:

Overview of the Data Sheet small group responsibilities, supplies and equipment, deliverables.

Making Weather Observations in the Field (without the use of instruments).

<u>Understanding the Significance</u> of Tides and How to Read a Tide <u>Chart.</u>

<u>Making Water Surface</u> <u>Observations</u> wave height, debris, pollution, observed visibility, etc.

<u>Measuring Oysters</u> use of the caliper; millimeters and cetimeters; how to find the umbo to bill length; 50 oysters per sample; obtaining the average, minimum, maximum of the sample.

Identifying Mortality students should be familiar



Identify Reef Associates



Test Water Quality Testing

with the tap test.

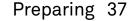
Identifying Reef Associates review the species ID card with students; if possible obtain live samples of some common species (tunicates, grass shrimp, shore crabs)

and examine in class under microscopes. See Reef Associates LP.

Water Quality Testing

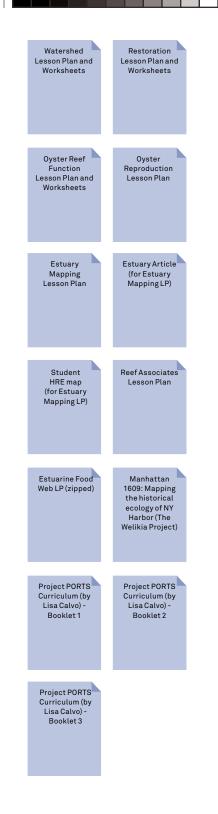
All students should be familiar with the LaMotte water quality test kit and ecological significance of each parameter (see BOP lessons: Water Quality LP and worksheets and Water Quality Data Plotting and worksheets).

The teacher should identify students who demonstrate strong understanding and dexterity for water quality testing in class and designate these students as group leaders for water quality testing in the field.



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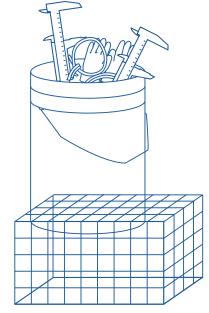
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Background Lessons

Students should be engaged in background lessons – ecological history of NY Harbor, the role of oysters in the estuary, ecology of oyster reefs, etc – for at least one week prior to the first monitoring trip. Students should be engaged for at least one additional week in field monitoring training and the protocols for completing the oyster gardening field data sheet.

Teachers can download background and training lesson plans on the BOP website or create their own. Regardless of whether teachers create their own lessons or use BOP related curriculum, NY Harbor Foundation will provide free in-class support and assist teachers in developing resources for oyster gardening. For support and questions, teachers should contact New York Harbor Foundation Restoration Program Manager. Contact information can be found on the last page of this manual.

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Oyster Gardening Kit (5x)

You Bring - writing utensils

- camera (if available)
- pocket calculator
- water (for rinsing equipment)
- towels or paper towels
- knife (for cutting lines)
- garbage bags (for collecting marine debris)



BOP Oyster Gardening Kit

- oyster cage
- lines and cable
- installation hardware
- caliper
- thermometer
- latex gloves
- dump bottle
- scrub brush
- laminated species ID card
- clipboard
- 5-gallon bucket + lid + 25' deployment rope



Oyster Gardening Kit

Oyster Cage

security.

Lines and Cables

attachment.

clamps.

W80150).

Thermometer_

Used for water and air

temperature testing.

Calipers (6 pair)

Installation Hardware

Vinyl coated wire mesh

or galvanized aluminum

rectangular cage; enclosure

comprised of bungee cord and

hook; use zip ties and bungee

One 25 ft marine braided poly

line for primary attachment to pier; one 30 ft vinyl coated ¼ in

steel cable as back-up/security

20 zip-ties for cage closure; 4

galvanized steel cable clamps

for security line; one half-inch

wrench for tightening cable

Used for measuring oyster

to each group of up to five

students; each group must

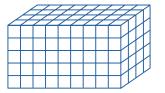
measure at least 50 oysters;

plastic sliding model (Wilmar

growth; one caliper is assigned

as enclosure for additional

Please carefully inventory the contents of your BOP oyster gardening kit. These materials are your responsibility. Each item has a specific purpose for monitoring and/or maintenance of your oyster garden.



Oyster Cage



Lines and Cables



Installation Hardware



Calipers



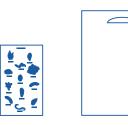
Thermometer







Dump Bottle



Species ID Card Clipboard



5 Gallon Bucket, Lid and Rope



Water Quality Test Kit

Latex Gloves For water quality testing and

species handling.

Distilled Water Required for salinity test.

Dump Bottle

Small plastic bottle with lid used for storing waste solutions from water quality test kit.

Scrub Brush

For cleaning/defouling of the oyster cage.

Laminated Species ID Card (6): For identification of other species found in and around the oyster garden; one card per group of five students.

Clipboard

For field data sheet.

5 Gallon Bucket + Lid + 25 ft Deployment Rope For carrying other items in kit and water quality sample extraction; attach rope to bucket handle with bowline knot and deploy from pier.

Oyster Gardening Manual Weather proof bound copy of this manual for use in the field.

Water Quality Test Kit (1) LaMotte Scientific Estuary and Marine Monitoring kit; includes chemical test tabs for up to 10 tests of pH, dissolved oxygen, nitrate, phosphate, salinity, fecal coliform, turbidity, and temperature; can be operated by 2 to 5 students.

Preparing 41

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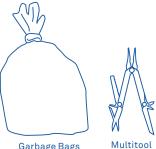
Calculator



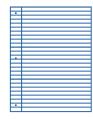
Camera (if available)



Water Paper Towels



Garbage Bags



Field Notebook

You Bring

Writing Utensils

In order to note your test results and sizes of your oysters, please bring writing utensils

Calculator

While measuring your oysters, you will have to calculate an average of their size

Camera

If you are not sure about a predator or associate, while identifying aggregating species, you can take a picture and send it to restore@nyharbor.org

Water

Used for washing and cleaning

Paper Towels Used for cleaning

Garbage Bags

Used for cleaning before leaving the site

Multitool

If you have one bring a multitool with needle-nose pliers in case you have to make repairs in the field

Field Notebook

All students should have their own field notebook for taking notes and observations (additional to the data sheet)

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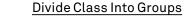
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Before the trip, divide your class into six groups of 3 to 5 students each.

Each group should be heterogeneous, with a range of skills appropriate for each of the monitoring tasks. Five of the six groups will carry out oyster garden monitoring tasks, while one of the six groups will be dedicated specifically to water quality testing. If there are additional WQ test kits available then other groups can also carry out water quality monitoring.



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It is recommended that the teacher assign each student a specific role/function in monitoring and data collection. Below are five roles for each group:

Scribe

Responsible for careful (legible) annotation of all data on the field data sheet.

Verifier

Responsible for final check and approval of all data; submits the field data sheet to the teacher; may also be asked to upload field data on the BOP website.

Oyster Measurer

Trained in the use of calipers and oyster measurements; measures and states measurements for scribe.

Species Identifier Identifies and counts all associated species.

Organizer

Ensures that all field supplies and equipment are kept in a neat and orderly fashion constantly.

Water Quality Tester

responsible for water quality testing using the Lamotte estuary kit or other resources provided; the teacher will assign water quality testing to one group of three to four students who will then conduct all tests before doing any additional oyster monitoring.

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Recruit Chaperones

Teachers should follow their school's standard regulations for field trips (Chancellors Regulations A-670 for NYC Schools). As a waterfront activity, a minimum of three adults, including the teacher, are required for each group of up to 30 students. Because the class will be broken up into at least five small groups for oyster garden monitoring, it is recommended that the teacher have at least 3 additional adult chaperones on the trip. for a total of 6 adults. Each adult should be assigned to one small group, while the teacher should rotate between groups to answer questions and ensure proper data collection.





Teacher



Student Groups

Preparing 45





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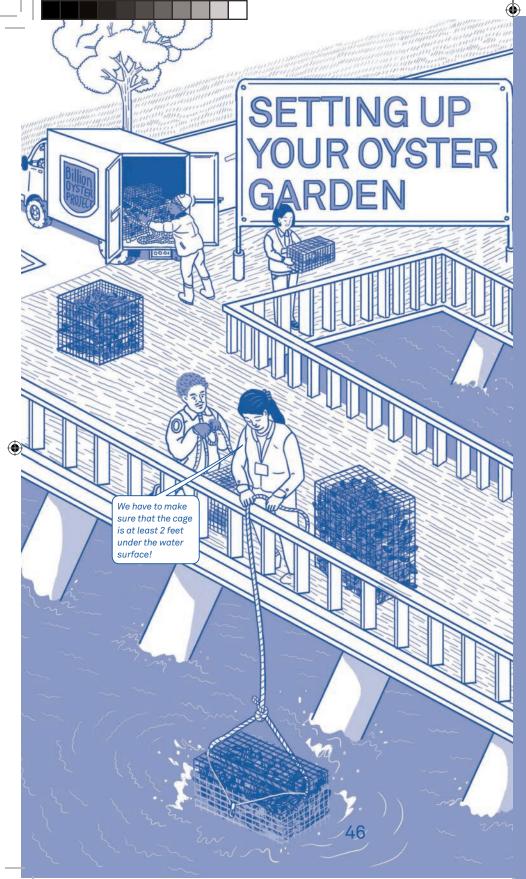
Water Quality Tester





Species Identifier

Oyster Measurer



Setting Up Your Oyster Garden

The next step is to measure the oysters in the garden in order

to obtain a baseline for growth

rate. The most accurate way

the oysters in your cage im-

to do this is to measure ALL of

mediately after receiving them.

Measuring 300 oysters takes

less than 30 minutes with one

person measuring and one per-

son writing. If for some reason vou are not able to measure all

of your oysters at that time then

you can take a large representative sample (>30%) and find

the averages.

Your oyster garden will be stocked with 300, 500, or 1000 spat-on-shell oysters, depending on the size of the cage and age/size of your oysters. You will receive spat-on-shell oysters produced by the Harbor School hatchery and set in tanks of New York Harbor water.

The oysters may be anywhere from two weeks to two months old when you receive them. One-month oysters will range in size from 2 mm to 20 mm. Typically each shell substrate will contain 10 to 50 individual oyster spat, depending on the size and shape of the shell and the setting rate of the particular batch. The first step is to count out the total number of live oysters. Identifying oyster spat smaller than 1 cm can be tricky. It is possible to confuse oyster spat with barnacle spat.

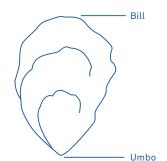


Oyster shells have a distinctly round bulging shape while barnacles are sharper and taller. Use the tip of your finger to sense the shape of the shell.

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Setting Up Your Oyster Graden 47

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Always Measure Oysters on Their Longest Side



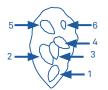
Hold the Caliper in One Hand, Use the Other Hand to Hold the Oyster



Place the Jaws of the Caliper above but Not Touching the Spat



Note Your Measurement



Measure All Individual Oysters, Start with the Exterior, Move from the Umbo to Bill

Measuring Your Oysters

Always measure oysters on their longest side (from the top to the bottom, also called the bill to the umbo). When in doubt simply measure the longest side of the oyster. When measuring multiple spat clustered together on one shell it can be difficult to position the caliper. BABY OYSTERS ARE VERY FRAGILE. Do not damage the oyster while measuring. How to measure multiple spat on shell:

A. One Person Should Measure While One Person Writes the Measurements on the Data Sheet

B. Hold the Caliper in One Hand and Slide the Jaws Open Gradually with the Thumb. Use the other hand to hold the oyster

<u>C. Place the Jaws of the Caliper</u> Just above but Not Touching the Spat.

Slide the caliper open or closed until it is precisely aligned to length of the oyster (bill to umbo).

D. Note the Measurement for Each Oyster and Record.

E. Measure All Individual Oysters on the Substrate Shell.

Start with the exterior (rough) side. Move from the umbo (pointed) end to bill (rounded) end, measuring all oysters systematically. Make sure not to miss or repeat any. After

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Identify Dead Oysters (see p. 63)



Record the Number of Dead Oysters

all exterior side oysters are counted, move to the interior (smooth) side and repeat.

<u>F. Note and Tally the Number of</u> Dead Oysters.

There will be few if any dead oysters at the time of stocking; however oyster mortality will occur over the next three to four months as spat compete for space on the shell and students must be familiar with identifying dead oysters. Dead oysters can be identified with a light tap on the top shell. If the shell is visibly open or there is softness or movement in the shell this means the oyster is dead.

Setting Up Your Oyster Graden 49

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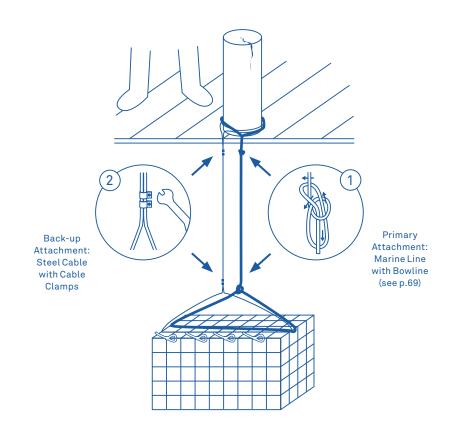
Where to Put Your Cage

Oysters prefer brackish water and wide tidal range to ensure good flow of food and nutrients. The ideal location to install your oyster garden is a protected embayment with good exposure to tides and moderate to high flow rate to deliver food and nutrients to the filtering oysters.

Siting

The ideal siting to install your cage is a dock, pier, or bulkhead (seawall) surrounded by waters more than 5 feet deep at low tide. If possible, choose a specific location in the embayment that is most protected and least exposed to waves or boat wakes.

Access for Student Groups The shoreline adjacent to your oyster garden should be easily accessible for your student group and their needs. If possible choose an area of the shoreline where students can comfortably split into small groups and monitor the oyster garden. For some sites this may include grassy areas, shade trees, or benches. The teacher/site coordinator should be able to raise the cage from behind the railing then bring it to rest safely and securely on the shore side of the railing. Ideally the oyster garden should NOT need to be disconnected from the railing or other point of attachment.



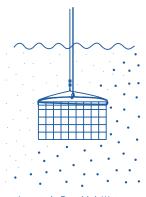
Goal Is to Attach Securely and Make It Inaccessible and Invisible from the Public

Attaching the Lines

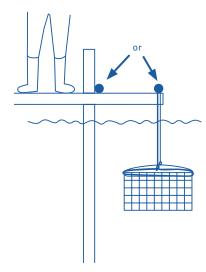
The cage is secured with two separate lines: a braided polyester marine line and ¼ inch steel cable. These two lines will come pre-attached to the cage before installation. At the time of installation, the first step is to tie the long end of the marine line to the pier or bulkhead on a railing, cleat, or metal eyelet. Make sure the cage is secured on the shoreline while tying the bowline knot. After the bowline knot is tied correctly, lower the cage into the water to check the water level. To adjust the water level, raise the cage then retie the

bowline knot. Once the correct height has been established, attach the steel cable with plenty of slack to serve as a back up to the marine line. The steel cable should be attached with at least two cable clamps. If possible, choose a point of attachment which is well away from public access (behind a railing) or even better, out of public view. No matter where the cage is attached, retrieving the cage should not endanger the teacher/site coordinator! For some sites, use of a **boat hook** (hook on a telescoping pole) will be helpful to retrieve the line from behind the railing.

Setting Up Your Oyster Graden 51



Locate in Brackish Water

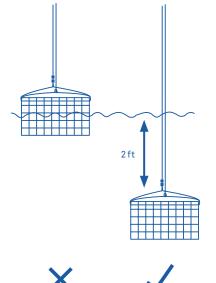


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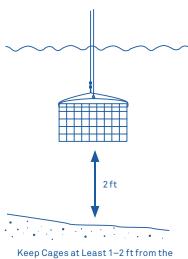
Best Attachment Point Is Set Back or Invisible from Railing

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Keep cages submerged to reduce vandalism and protect oysters from cold air



Sediment

How Deep to Put Your Cage

Very important! The ideal water level for an oyster cage is two feet below the surface at low tide. If possible cage installation should take place during maximum low tide. If installation does not occur at low tide. account for an additional 1 to 5 feet of depth depending on specific tides. For example if the cage is installed at max high tide, then it should be suspended 7 feet below the surface. The minimum total depth at any oyster gardening site should not fall below 5 feet except during extreme low tides.

Regardless of depth below the surface, the cage should be always be suspended at least two feet from the bottom. Much of New York Harbor bottom is composed of thick mucky sediment. This sediment can inhibit oyster feeding and oxygenation, slowing growth and eventually suffocating oysters. The sediment is also home to the oyster drill, one of the most destructive oyster predators (see p.112).

In summary the oyster garden should be suspended somewhere in the middle of the water column; closer to the surface (where there is more oxygen) but never exposed to the air especially in the winter (extreme cold temperatures can kill oysters in a matter of an hour). It is recommended that all oyster gardeners measure

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In Case Excessive of Abrasion Place Your Marine Poly Line in a Conduit of Old Garden Hose

the total depth of their site before installation. When in doubt, you can always return to the site at an extreme low tide to make sure the cage is not exposed to the air (or touching the sediment).

Securing Your Cage

Please read and follow all of these points extremely carefully.

The forces of waves and tides causes the oyster garden to move continuously. In higher energy locations, lines and cables attached to the oyster garden will continuously scrape against the edge of the dock or pier. This slow steady friction will cut through lines and cables in surprisingly short order. To avoid losing your oyster cage to the bottom, check your lines regularly, making sure both are in good condition. Especially after stormy weather it's a good idea to go check on your oyster cage.

In case of excessive abrasion, the marine poly line can be placed in a conduit of old garden hose or replaced altogether. The vinyl coated steel cable should not wear down unless the coating is torn, in which case the cable will rust over time.

Setting Up Your Oyster Graden 53

Cage Security

Unfortunately, oyster cages

are occasionally tampered

with in New York City. The

most common reason for

tampering is usually not

malicious: maintenance staff or others working for the

property owner, not aware of the program, attempt to the remove or destroy the cage. It is the responsibility of all oyster gardening property owners/ site managers to inform their

staff and train them as needed in oyster gardening protocol. Some sites may also choose to display signage that explains BOP and restoration; however this is not required and in some case may draw undue attention or nuisance to the garden.

In very rare instances oyster

cages have been tampered with or destroyed intentionally by people with malicious intent. The best protection against

creating this sort of attractive

nuisance is simply to make the

cages invisible to the public, either by installing them on a secured waterfront property or by attach the lines out of public view (behind and set back from a railing). While BOP has experimented with tamper proof installation mechanisms,

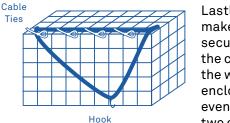


Some Sites May Also Choose to Display Signage That Explains BOP



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Oysters Are NOT for Consumption NYC Waters Closed to Shellfishing by Order of NYS DEC



Make Sure Hatch Is Shut, Use Cable Ties for Extra Security

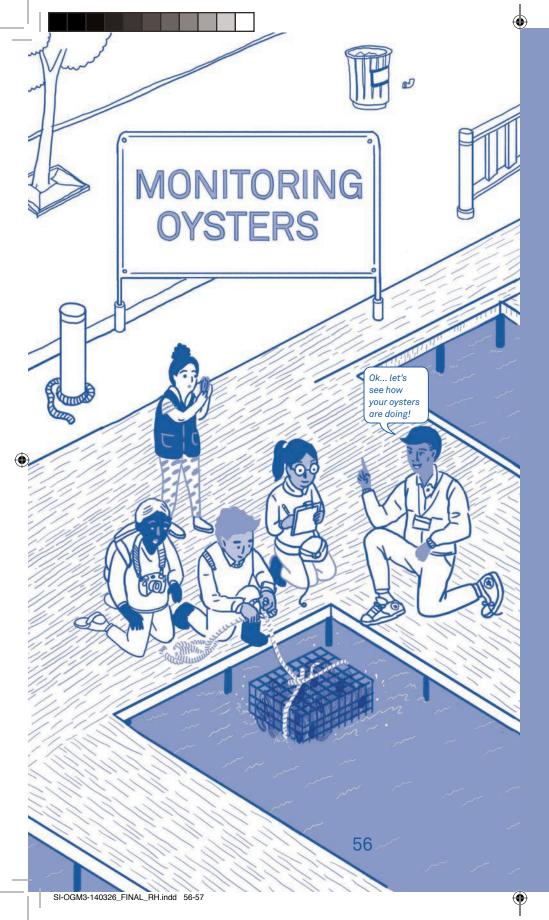
Lastly, and most importantly, make sure the hatch is always securely clipped shut whenever the cage is lowered back in the water. The bungee cord enclosure can stretch out and eventually break. If need be use two cable ties as the enclosure for extra security.

Setting Up Your Oyster Graden 55

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these are prohibitively expensive and not justifiable given the infrequency of

vandalism.



Variables and Oyster Growth

One of the main research questions in oyster gardening is what variables affect oyster growth rates and how do these variables change across locations in the Harbor.

In this experiment, oyster growth is our dependent variable and everything else is considered an independent variable. We can compare oyster growth rates at one site across different times of the year OR across multiple sites over the full year. For example, if we are looking at oyster growth rates at one site over an entire year and growth rates increase in the warmest months, then we can hypothesize that temperature or seasonal water quality changes are the main factors affecting oyster growth. If on the other hand, we are comparing oyster growth rates across multiple sites and some are demonstrating higher growth rates then others, then we can hypothesize that site specific water quality parameters (e.g., higher nitrogen content) are the primary variables of concern. Regardless of how we design the experiment, to ensure the validity of our data and any conextremely important to monitor and record all variables consistently and accurately.

The data sheet begins with students making (qualitative) observations on weather, water surface conditions, conditions

Monitoring 57

of the oyster cage, and conditions of the shoreline. Following that students measure oyster growth, identify and count associated species, and test water quality.

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Arriving at the Site



Observe and Record = 5 mins

As the class arrives at the site. gather them closely around the oyster garden installation site but do not pull up the oyster garden. Ask them to carefully and quietly observe the entire research area including the water, the shoreline, and the upland areas. Ask students to record their initial observations (in journals) for about five minutes. These can also be open ended and subjective; how they are feeling, their impressions of the place, what they notice around them (on the ground, water, air), their expectations or fears for the day, what they think they will learn, and any other creative prompts.

After the initial observations are completed, briefly review the plan for the day with them. Explain that all small groups will be responsible for answering all questions on the data sheet. Explain that the final data submission will be an average of all the groups. Explain that redundancy is a good thing in statistics because it allows us to find errors and increase accuracy.



Observe Weather Conditions



Observe Water Surface Conditions



Answer #1-6 on Data Sheet



Raise the Cage from the Water

Observe the Independent Variables

Break students into small groups and ask them to answer Section I questions 1 to 6 on the field data sheet. What are the current weather conditions? What are the surface water conditions? Is the site well maintained or not? What is the condition of the water? Does the water look dirty? Is there an oily sheen? How was the weather three days before leading up to the monitoring? Did it rain? Could that be why there is litter in the water? For question 3, the teacher should provide a copy of a tide chart or be prepared to look up tides in the field using a website such as: http://tidesandcurrents. noaa.gov/stationhome. html?id=8518750

After all students have completed questions I.1-6, the teacher should gather all students in one group around the site of the oyster cage and prepare to raise the cage. Raising the cage is one of the most exciting and scientifically important moments of the field monitoring trip. Students should carefully observe what if anything falls or drips from the cage as it is being raised. This may include hungry blue crabs clinging to the outside of the cage, oyster toad fish and other finfish stuck in the mesh openings, algae, sponges, and possibly oily sediment if the cage has accidentally touched the bottom.

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Observe and Record Organisms in the Cage



Answer #7 on Data Sheet and Document Cage Conditions

During the process of raising the cage the teacher should also explain how to estimate water level or depth of the cage. This can be done by tying a colorful piece of string or plastic onto the marine line at the approximate level of the surface when the cage is fully extended. The cage should then be re-lowered to see where the piece of string falls relative to the surface. The teacher should ask students to make their own estimates of the depth of the cage based on this process.

Once the cage has been retrieved from the water and placed securely on the shoreline, carefully open the cage and ask all students to observe the contents but do not touch. There will most likely be various small organisms moving around; grass shrimp, shore crabs, sand worms and others. Ask students to give a description of the condition of the cage and answer the final question 7. Is the cage covered over by algae and/or sediment? (Fouling organisms can prevent water flowing through the cage ultimately affecting the oyster's ability to feed.) Is the cage damaged?



Identify Reef Associates and Predators



Reef Species ID (see p.110)



Record and Note the Presence of Predators and Associates

Identify Reef Associates and Predators

Now split the students back into their groups (see p. 43/44). The Oyster Measurers will measure oysters while the Species Identifiers begin identifying and recording reef associates and predators. If there are not enough students in the group for both roles, Species ID should happen first. Otherwise the associated organisms will dry out, escape, or die before there is time to observe them. Students should use the Organism Identification Sheet to help with species identification. When an organism is unknown, the teacher should be consulted. If the teacher cannot identify the organism take a picture of the organism and send it directly to restore@nyharbor.org.

Student scientists must record and note the presence of oyster predators and reef associates living amongst their subset of oysters. Knowing the prevalence and quantities of these species over time can help us better understand the variables affecting oyster growth, both positive (mutualistic or communistic organisms) and negative (predator organisms). Students should note the presence and number of these marine organisms. Record data on the data sheet.

Measuring 300 Oysters

Each oyster gardening cage has a total of 300 to 1000 oysters. At least 300 of the total number of oysters in the cage should be measured. To do this all student groups will need to measure a set of 60 oysters.

After the cage is opened and associated species have been observed, the instructor will divide the total number of oysters into 6 subsets, one for each group (50 to 200 oysters will given to each group). Make sure the students handle the oysters extremely carefully. Spat on shell clusters are fragile when young.

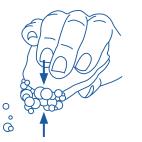
Each group should receive at least 2 calipers. Students should only measure LIVE oysters. Each group should measure a maximum of 50 LIVE oysters. The spat on shell clusters for measuring should be chosen at random from the group subset. The remaining spat on shell clusters should be counted and the number of dead oysters on each cluster should be tallied.

Randomly choose 50 LIVE oysters to measure. Make sure that after each oyster is measured it is separated from the subset pile to ensure that each oyster is measured only once. Live oysters have both valves intact and are firmly shut. Record oyster length in mm on the data sheet provided. Oyster shell length is measured

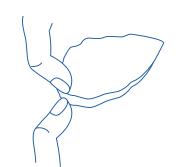
62



A Dead Oyster Is Gaping Open



Dead Oyster Will Discharge Bubbles When Lightly Squeezed



To Check If Oyster Is Dead, Gently Try to Pry It Open



Dead Oysters Sound Hollow When Lightly Tapped

from the umbo to the bill. And all measurements are to be recorded in the metric system! All students must record at least 50 oyster measurements on their data sheet (see p.48).

Mortality Monitoring

ALL dead oysters within each subset are to be tallied and the total number of dead oysters should be recorded on each group's data sheet.

Students should inspect their entire subset of oysters to determine the number of dead and living oysters.

Count all dead oysters in the subset – DO NOT discard dead oysters or detach from clumps. KEEP ALL DEAD OYSTERS in the sample and return to the population.

Identifying Tips for Dead Oysters

Dead oysters will be gaping open or will discharge bubbles at the rim when lightly squeezed. Dead oysters will also sound hollow when lightly tapped. To double check that an oyster is dead gently try to pry them open with your fingernail. A dead oyster will generally open very easily. Often a dead ovster is filled with mud and therefore can be mistaken for being alive. The 'fingernail check' is especially useful to make sure that the oyster is truly dead.

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Bill

Calipers

Oyster Shell Length Is Measured from the Umbo to the Bill. All Measurements Are to Be Recorded in the Metric System!

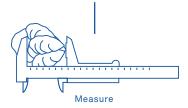
Umbo

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Each Group Gets 50-200 Oysters







Record Length in mm



Compile and Return to Cage

Monitor Living Oysters

Each group gets a subset of the garden; 50 to 200 oysters

Make sure the oysters are kept out of direct sunlight; splash water on the oysters to keep them from drying out; baby oysters are very fragile; be careful not to damage their shells.

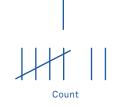
Carefully measure each individual oyster on the cluster using the caliper. Do not measure the larger shell substrate, measure only individual live oysters; be careful not to damage the oysters with the caliper jaws. The measurer should call out each oyster measurement.

The scribe should record each measurement on the data sheet. The measurer should measure at least 50 oysters in the sample.

Once all of the oysters on a shell cluster have been measured that cluster should be placed in pile of measured oysters; Be very careful to keep the pile of measured and un-measured oysters separate so as not to measure any oysters twice.









Record Number of Dead Oysters



Compile and Return to Cage

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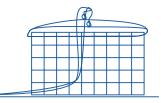
Monitor Dead Oysters

When an oyster is dead its shell begins to open. The shell can also feel flexible or soft to the touch. If the oyster has been dead for more than a few days, its shells will be wide open.

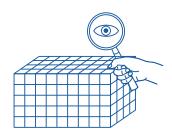
Whenever a dead oyster is found amongst the living, do not remove it. Simply add one to the running tally. Keep a tally of the total number of dead oysters. During each monitoring trip you will need to repeat the count of dead oysters.

Monitoring 65

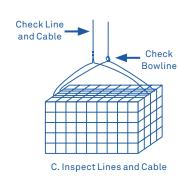
Maintaining Your Cage



A. Haul Cage out of Water



B. Inspect Cage for Damage or Weakness





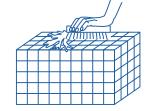
Cages should be maintained in person by an adult at least once every four weeks from May 1 through October 31 and once every eight weeks from Nov 1 through April 30. Maintenance routine includes the following items:

A. Haul the cage fully out of the water and on to the shoreline for inspection

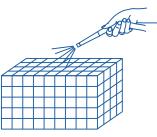
B. Inspect the cage thoroughly for any damage or weakness.

C. Inspect the lines and cable for damage or abrasion. Replace or reinforce lines as needed.

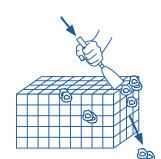
D. Clean and de-foul the cage



Scrub with a Hard Bristle Brush to Remove Algae and Sediment



Flush off Scrubbed Cages with the Hard Spray of a Garden Hose



Remove Barnacles with a Harder Tool





De-fouling Your Cage

In our estuary, an abundance of marine organisms will colonize your cage, similar to what happens on the bottom of a boat or pilings on a pier. During the summer months, when water temperatures are warmest, fouling will be at its peak. It is important to clean the cage periodically as fouling as can impede water flowing through the cage, ultimately starving your oysters. The most common fouling organisms that will grow on your float are algae, barnacles, and sea squirts/ tunicates.

Scrubbing with a hard bristle brush (provided in the BOP oyster garden kit) will also remove algae and sediment; barnacles may need a harder tool. The hard spray of a garden hose is sufficient to flush off the scrubbed cage.

Be sure to thoroughly wash down the area around your cage after de-fouling. Most property owners do not appreciate a pile of dead sea squirts and slimy algae littering their waterfront. If you don't clean up, somebody else will have to!

Desiccation or air drying can help to reduce fouling; you may leave your oyster cage out of the water for a few hours (up to 6 in cool/wet weather, and 2-4 in warm/dry weather) on monitoring days. This will dry out and kill many organisms that have attached.

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Winterizing Your Cage

Shallow waters of the Hudson-Raritan Estuary generally freeze in late December -February. Oysters are tolerant of the cold water, but not cold air. Make sure your oyster cage remains in the water even at the lowest tides during the winter. Keep the cage closer to (but not on) the bottom, so as to avoid damage from any potential ice floats on the surface.

It is very important to protect the lines that are tied to the cage during winter, as icing on the shoreline can further accelerate wear and tear of the lines. If need be, tie extra lines to the cage during winter to lower the chance of the ice cutting the cage free. If you need additional lines or cable please contact BOP immediately.

Tie Your Line to a Post or an Eyehole



Monitoring 69



The Rabbit Runs Around the Tree

Make a

Rabbit Hole



The Rabbit Runs Back Down Its Hole

Tying Proper Knots

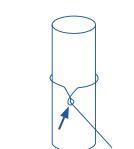
Tying strong and resilient knots (correctly) will ensure that your oyster cage does not come untied. A great knot for this purpose is the bowline; this knot will never slip, and holds especially well under tension. The bowline should be used for all oyster garden attachments; line to the cage, and cage to the dock.

Tie a Bowline when:

A. You need to secure a line to your cage.

B. You need to tie your line to a post or through an eyehole.

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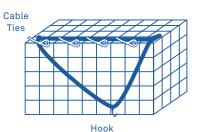






Water Even at the Lowest Tides During the

Winter



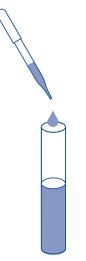
Make Sure Hatch Is Shut, Use Cable Ties for Extra Security



Gently Lower the Cage Back Into the Water

Returning Your Cage to the Water

Once the class has measured and recorded all the data. place all oysters back into the cage and be sure to close the hatch and fasten properly! (Use cable ties for added security). If necessary, reinstall the cage by securely tying the marine line to the railing with a bowline knot and use the wire clamp provided. Gently lower the cage back into the water. Make sure the cage, is continually free of debris and fouling organisms. These may need to be cleared off so as not to impede water flow over the cage and create excess tension on the rope. Before re-suspending your cage, make sure that your rope is still in a good condition. If necessary, replace your rope or add a second line if your cage is heavy.



Students Will Test Physical Properties of Water and Water Chemistry

Testing Water Quality

See Water Qualitiy Testing procedures on p.76

Students will test PHYSICAL properties of water and water CHEMISTRY using the Lamotte estuary and Marine Water Quality Monitoring Kit.

Monitoring instructions for the specified parameters are in the Appendix. You can also refer to the kit manual when out in the field.

All students should be instructed in water quality monitoring in the classroom; however, when in the field we suggest having only one student group (3 to 5 students) conduct the sampling and tests. The water quality test group can rotate during each of the six trips or the group can remain the same for all trips (greater consistency/accuracy of results).

Using a bucket suspended from a rope, collect a sample of water from an area close to where your oyster cage is suspended. The same water sample should be used for all 8 tests as instructed below.

Conduct the temperature and Dissolved Oxygen tests first, as these parameters can change quickly once the sample is extracted from the Harbor.

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Other Noteworthy Observations

Ask students to make any final observations about the garden or the site as a whole which were not recorded in the previous questions on the field data sheet. Ask them to take note of any social or environmental conditions that were not recorded previously. For example, this might include: flocks of birds nearby, school of fish swimming around oyster garden, oyster cage is damaged, public visitors asking questions about oyster gardening, construction on site, etc.

Photos

Take photos of the oyster garden: oysters, cage, reef associates, site conditions, water conditions, weather etc.

Data Upload

The last component of the oyster garden monitoring field trip is to verify and upload the data. Data can be uploaded to the BOP website either back at school or in the field using the mobile version of the website. BOP is currently working on mobile app for uploading oyster restoration data in the field.

The teacher has two options for data upload:

A. Designate a Qualified

<u>Uploader</u>

from each student group to upload their own data sheet while in the field, or;

B.Aggregate All Groups' Sheets into One Master and Upload It to the Website Back in the

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It to the Website Back in the Classroom.

If each student group has reliable data and a capable uploader, then option A is better.

Regardless of which option the teacher chooses, one student per group is assigned to verifying and submitting their data. The verifier can be the same as the scribe. At the end of the monitoring period, this student will submit the data sheet to the teacher and if possible upload the data to the BOP website via http:// billionoysterproject.org/shareyour-research/

Congratulations!

You have finished the oyster garden monitoring and data collection regime. You are welcome to conduct additional data collection - for example benthic studies and sediment analysis - then upload these to the online database as supplementary material. You can also upload special research conducted by your students. Remember you are required to upload the complete monitoring dataset at least four times per year. Ideally your oyster garden should be monitoring once per month from April to November.

The following appendix pages contain detailed information on water quality testing, BOP lesson plans, and other supplementary material.

Take Observations About the Site Which Were Not Recorded in the Previous

Questions

Verify And Upload the Data

Monitoring 73

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APPENDIX

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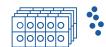


Kit Container

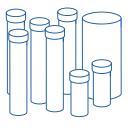
14 16 18 20 22 24 26 28 30 32 34 36 38 40

High Temp Thermometer

Low Temp Thermometer



Test Tablets



Test Tubes

WATER QUALITY TEST KIT

The following is a detailed explanation of the LaMotte Estuary and Marine Monitoring Kit; content and how-to. You can also refer to the manual provided in the kit for additional information.

Kit Container

This big white jar is not only to carry the kit, but also needed for the Turbidity Test.

High Temp Thermometer

Use this thermometer for high range temperatures (>14 °C) *If you have your own digital thermometer you may wish to use it here; as the test strip thermometers are less accurate.

Low Temp Thermometer

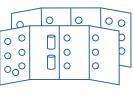
Use this thermometer for low range temperatures (<14 °C).

Tablets

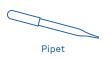
The Kit provides 6 types of Test Tablets to test the different properties of the water. 10 tabs are provided for each test; when you run out order more from Lamotte.com.

Test Tubes

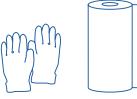
Your Kit contains different sized Test Tubes you will need for your tests.



Color Charts







Rubber Gloves Paper Towels



Distilled Water Dump Bottle



Household Chlorine Bleach

Color Charts

Use the two-sided chart to INTERPRET the results of your water quality test; match the color of your test result with the range shown on the chart and record the number.

Pipet

You will need a pipet for the disposing procedure of your Coliform Test Tube. You will also need it for the Salinity Test.

Secchi Disk Sticker

You will use these stickers for the Turbidity Test.

Items Not Included in the Kit

The water quality test kit does not include bulk supplies such as rubber gloves, paper towels, bleach, or a dump bottle. You will also need to purchase a gallon jug of distilled water for salinity tests.

Distilled Water

You will need destilled or deionized water to fill up your tube during the salinity test. This can be purchased at a supermarket.

Household Chlorine Bleach You will need the Household chlorine bleach to dispose your Coliform Test Tube.

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Household

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WATER TEMP TEST Physical Properties of Water

Parameter

Water temperature affects the amount of dissolved oxygen the water can hold, which directly affects aquatic life dependent on oxygen. Students will better understand Fahrenheit temperatures, but in science it is important to become familiar with Celsius. The Lamotte testing kit only records temperature in Celsius. Students can use the formula below to convert °C to °F.

 $^{\circ}F = (^{\circ}C \times 9/5) + 32$

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Note: Alternatively, use the electronic thermometer provided in the BOP oyster gardening kit for both air and water temperature testing.



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DISSOLVED OXYGEN (DO) TEST Chemical Properties of Water

Parameter

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The amount of dissolved oxygen in the water is one of the most important factors in telling how healthy an ecosystem is. All aquatic animals need oxygen to survive. Many variables affect DO, including temperature (cold water can hold more oxygen than warm water), time of day, presence of plants, and wind conditions, DO measurements are given in mg/l and as percent saturation. 100% saturation means that the water cannot hold any more oxygen at that temperature. If more oxygen is added (such as by a high wind or a waterfall) saturation may temporarily exceed 100%, but in this case oxygen will diffuse from the water into the air. Saturation levels below 100% are not necessarily the result of pollution. At night, when plants aren't producing oxygen through photosynthesis, saturation may fall below 100% as living things use up the available DO.

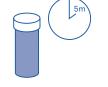
Note: ppm is the same as mg/l. A healthy range for our estuary is 5.0 – 11.0 mg/l or ppm.



1 Submerge the small 1 inch tube (0125) into your water sample. Fill the tube with water to the top.



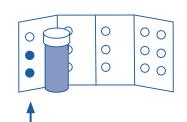
2 Drop two dissolved oxygen TesTabs into the tube and screw the cap on tight. Water will overflow as you do this. Make sure there are NO AIR BUBBLES in the sample. 3 Give the tube a good mix until the tablets have disintegrated. This should take about 4 minutes.



4 Wait another 5 minutes for the color to develop.

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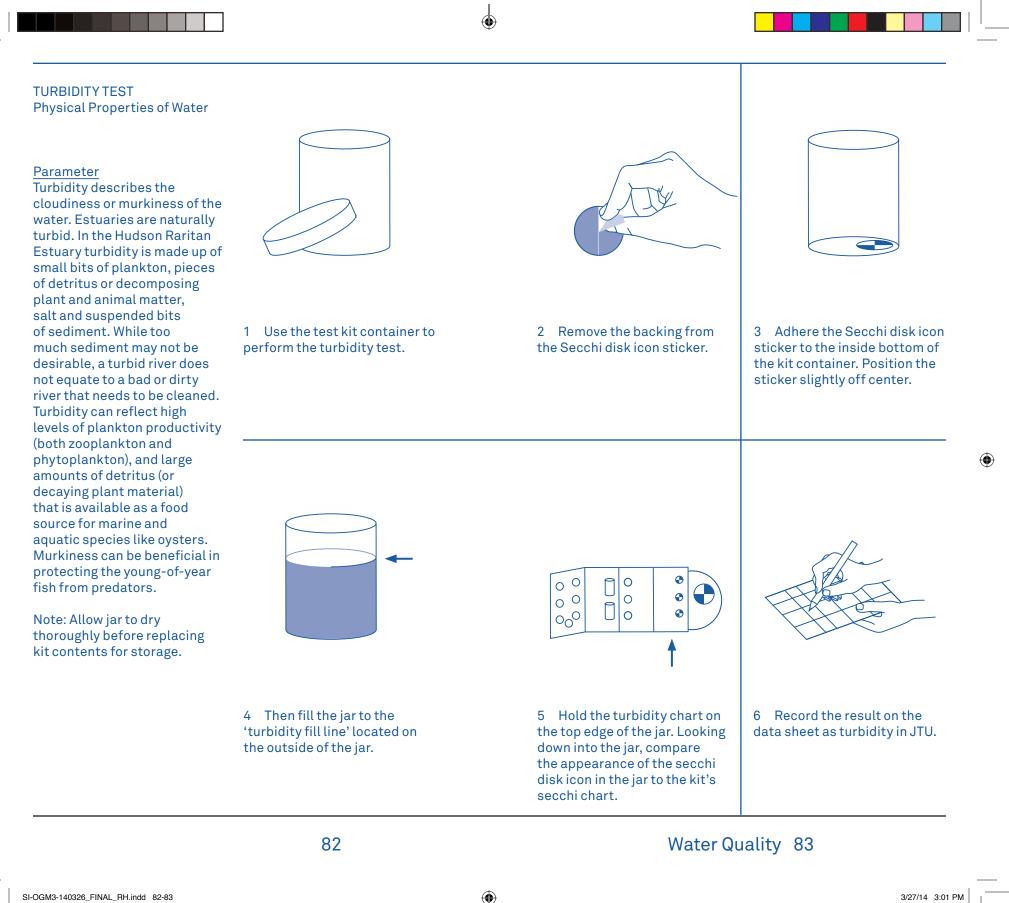


5 Compare the color of the water sample to the DO color chart.



6 Record the result as ppm dissolved oxygen.

Water Quality 81



FECAL COLIFORM TEST Physical Properties of Water

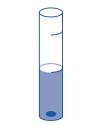
Parameter

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Fecal coliform bacteria are naturally present in the human digestive tract but are rare or absent in unpolluted waters. Coliform bacteria should not be found in well water or other sources of drinking water. Their presence in water serves as a reliable indication of sewage or fecal contamination. Although coliform bacteria themselves are not pathogenic, they occur with intestinal pathogens that are dangerous to human health. This presence or absence i.e. positive or negative total coliform tests detects all coliform bacteria strains and may indicate fecal contamination. The coliform test in the kit will indicate if you have above or below 20 coliform colonies per 100mL of water.

As this test is sensitive to movement, it may be best to take a sample of the water back to the classroom and complete the test there.

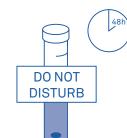
Note: This test requires 48hrs for results to be obtained!



1 Fill the larger test tube containing the tablet with your water sample until it its filled to the 10ml line. 2 Cap the tube and let the tube stand upright, with the tablet flat on the bottom of the tube.

3 Incubate the tube in the upright position, out of direct sunlight for 48 hours. The rooms temperature should be fairly constant (70-80°F).

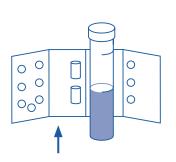
70°-80°F



4 DO NOT disturb, handle or shake tube during the incubation period.

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5 After incubation period compare the appearance of the tube to the picture on the coliform color chart.



6 Record the result as positive or negative.

Water Quality 85

Fecal Coliform TEST 2 Physical Properties of Water

Reactions_

Negative:

a. Liquid above gel is clear b. Gel remains at the bottom of the tube c. Indicator remains red or turns yellow with no gas bubbles d. Indicates < 20 total coliform colonies per 100 ml of water

Positive:

a. Many gas bubbles present b. Gel rises to the surface c. Liquid below gel is cloudy d. Indicator turns yellow e. Indicates > 20 total coliform colonies per 100 ml of water

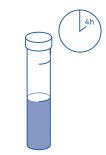
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Note: This test must be disposed of appropriately. Please refer to Test Manual Kit pg. 20 for details.

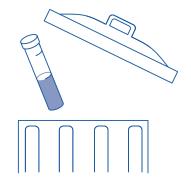


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1 One tube at a time, remove the cap and add approximately 1 ml (1/3 teaspoon or 20 drops) of household chlorine bleach and immediately recap.



2 Let the tube stand upright for about 4 hours.



3 Dispose of the closed tubes in the trash. Do not open tubes. NEVER re-use tubes after coliform bacteria testing.

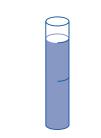
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PH TEST Chemical Properties of Water

Parameter

pH measures how acidic or basic (alkaline) a solution is. pH is measured on a scale from 0 to 14. The middle of the scale, 7.0, is neutral, below 7.0 is acidic and above 7.0 is basic. Seawater tends to be more of a base than neutral, so the higher your salinity the higher your pH may be. There are NO UNITS used with pH.

Most aquatic organisms are adapted to a specific pH level and may die if the pH of the water changes even slightly. Most fish prefer a pH range of 6.5 to 8.5 pH.



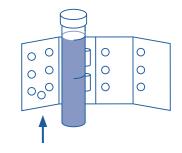
1 Fill the larger test tube to the 10ml line with water from your water sample.

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2 Add 1 pH Wide Range Test Tab.

3 Cap and mix until tablet has disintegrated. Bits of material may remain in the sample.



4 Compare color of water sample to the pH color chart.



5 Record the pH result on the data sheet.

Water Quality 89



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right-hand column of the black circles on the salinity chart. Compare the appearance of the circles through the tube to the circles, record the result.

Water Quality 91

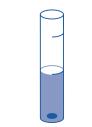
NITRATES TEST Chemical Properties of Water

Parameter

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Nitrates (NO3-), measured in mg/L, are a form of nitrogen. They occur naturally as a part of plant and animal growth and decay. They are also abundant in human sewage. Nitrates are essential nutrients used by plants and animals for maintenance and growth (building protein), but normally occur in small levels of <1 mg/L. Excess nitrates in the form of sewage, fertilizer and agricultural runoff can trigger sharp increases in plant growth causing problems for aquatic animals, and if high enough, for humans as well. Drinking water with high level of nitrates can affect the ability of our blood to carry oxygen.

NOTE: The protective sleeve will protect the reaction from UV light – if testing indoors it is not necessary to use the sleeve.



1 Fill the test tube with sample water to the 5mL line.

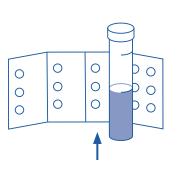
2 Add 1 Nitrate Wide Range CTA TestTab, and immediately slide the test tube into the Protective Sleeve.



3 Cap the tube and mix for 2 minutes until tab dissolves.



4 Wait another 5 minutes to remove the sleeve



5 Compare the color of sample to nitrate color chart.

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6 Record the result on the datasheet as ppm nitrate.

Water Quality 93

PHOSPHATE TEST Chemical Properties of Water

Parameter

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Phosphate (PO4-3) is the second nutrient needed for plant and animal growth and is also a fundamental element in metabolic reactions. High levels of this nutrient can lead to overgrowth of plants, increased bacterial activity, and decreased dissolved oxygen levels. Phosphate comes from several sources including human and animal waste, industrial pollution, and agricultural runoff.

In saltwater ecosystems nitrates/nitrogen is generally the nutrient in shortest supply (called the limiting nutrient) although it can fluctuate.

In freshwater ecosystems phosphorous is the nutrient in shortest supply.

1 Fill the test tube to the 2 Add 1 Phosphorus TesTab. 10mL line with water from your sample.

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4 Wait 5 minutes for color to develop.

Note: If no color develops after 5 minutes, record the result as 0 ppm.

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5 Compare the color of the

sample to the phosphate color

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chart.

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3 Cap and mix until tablet

has dissolved.

6 Record the result on the datasheet as ppm.

Water Quality 95

RANKING TEST RESULTS

While standards of healthy water vary by location and conditions, ranking the results can often give you a good introduction to water quality monitoring and indicate relative quality of the water.

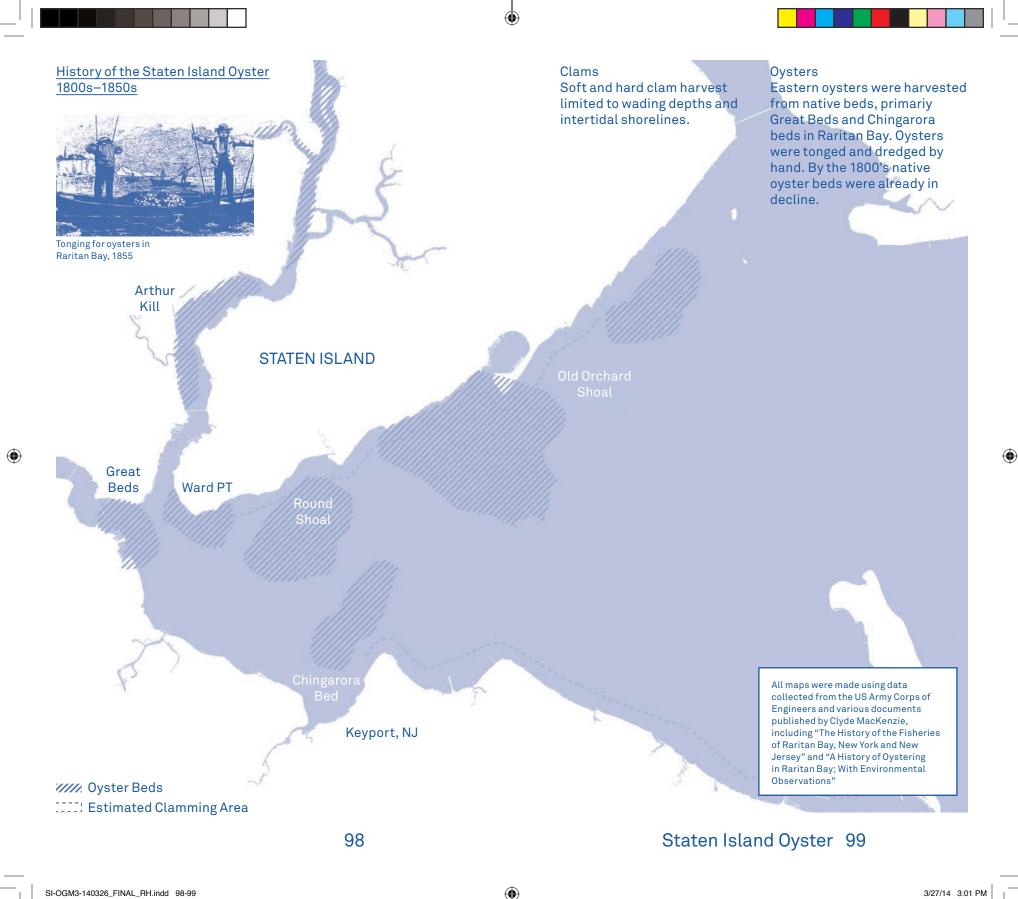
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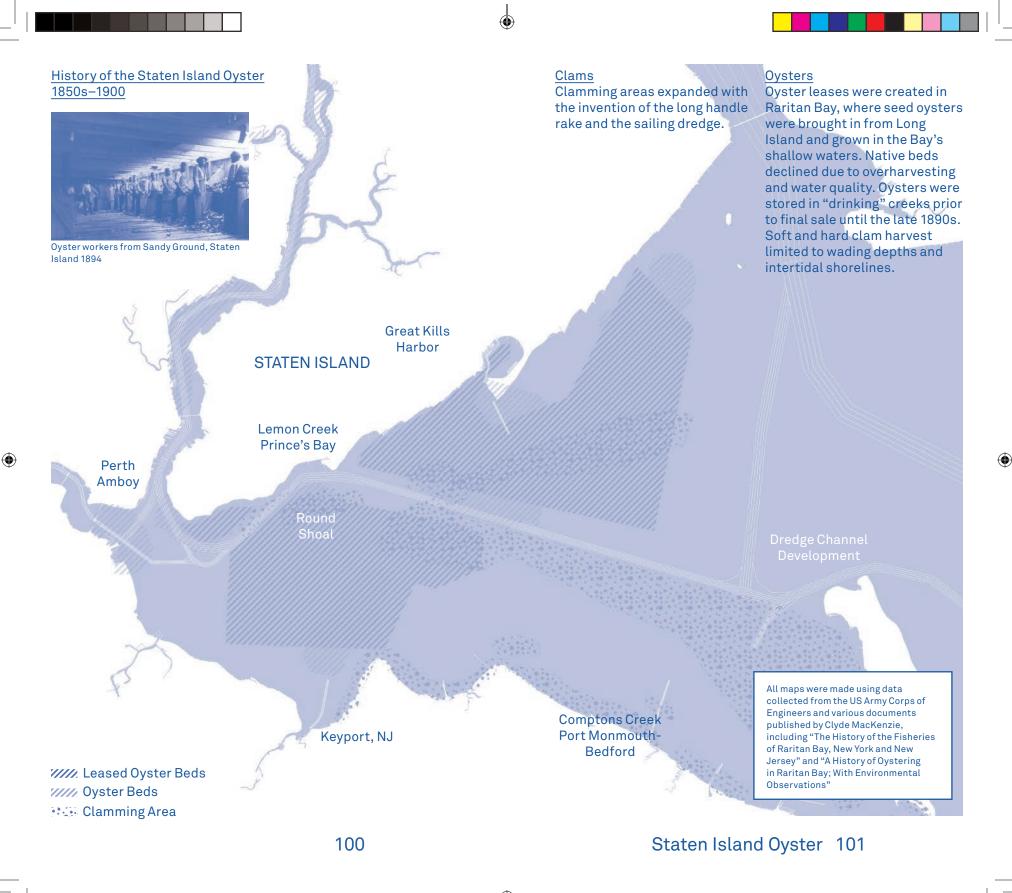
Test Factor	<u>Result</u>	Ranking	<u>Score</u> (from ranking)
Colform Bacteria	Negative Positive	3 (good) 1 (poor)	
Dissolved Oxygen Saturaion	91–110% Saturation 71–90% Saturation 51–70% Saturation <50% Saturation	4 (excellent) 3 (good) 2 (fair) 1 (poor)	
Biochemical Oxygen Demand	0 ppm 4 ppm 8 ppm	4 (excellent) 3 (good) 2 (fair)	
Nitrate	5 ppm 20 ppm 40 ppm	2 (fair) 1 (poor) 1 (poor)	
рН	4 5 6 7 8 9 10	1 (poor) 2 (poor) 3 (good) 4 (excellent) 3 (good) 2 (poor) 1 (poor)	
Phosphate	1 ppm 2 ppm 4 ppm	4 (excellent) 3 (good) 2 (fair)	
Salinity	0 ppt 14 ppt 35 ppt	3 (good) 3 (good) 3 (good)	
Temperature Change	0-2°C 3-5°C 6-10°C 10°C	4 (excellent) 3 (good) 2 (fair) 1 (poor)	
Turbidity	0 Between 0 & 40 JTU Between 40 & 100 JTU > 100 JTU	4 (excellent) 3 (good) 2 (fair) 1 (poor)	

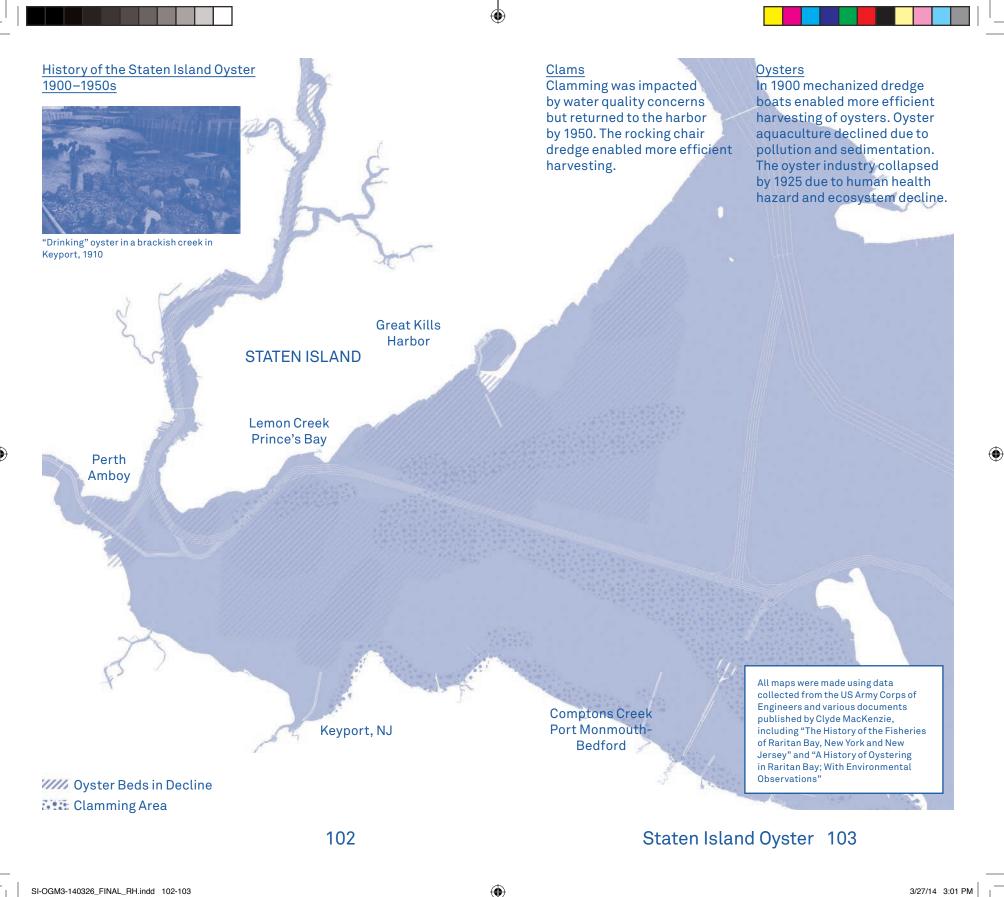
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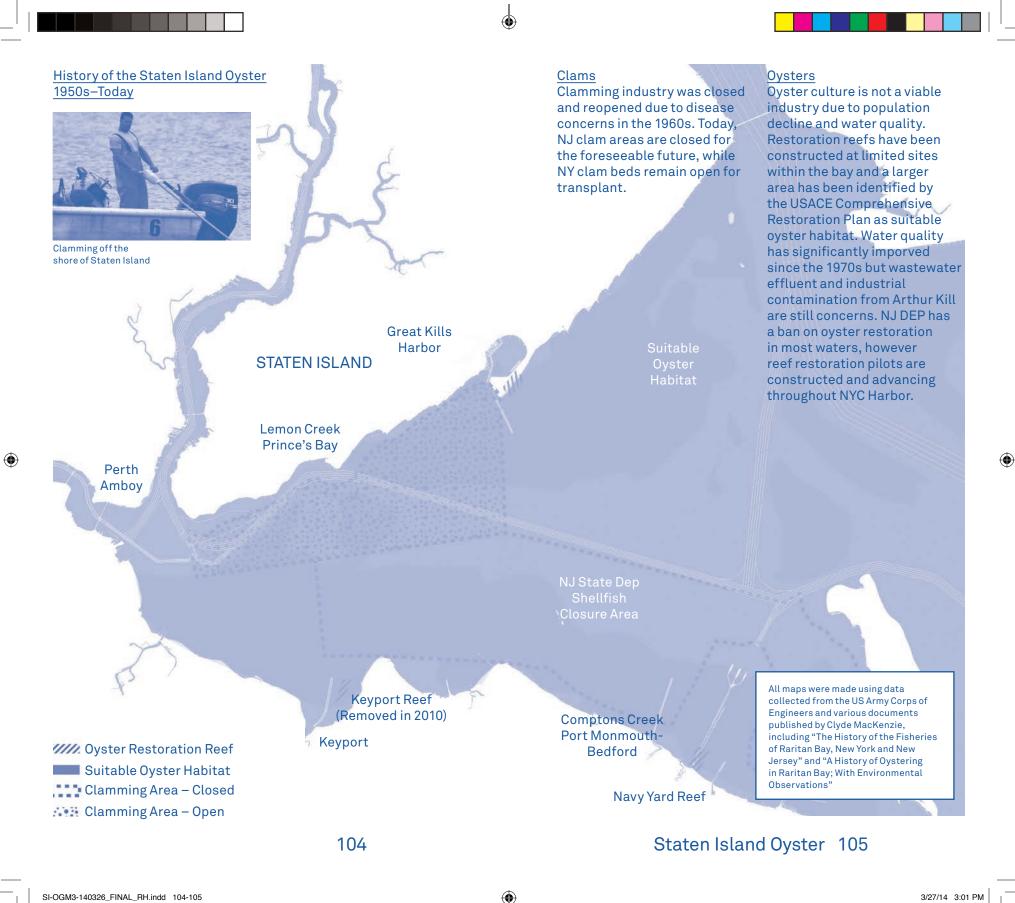
Water Quality 97

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Grade Level:	Oyster Anatomy
6-8	Advand form Design PODTC Description Orabe Destantion Through
Subject Areas:	Adapted from Project PORTS: Promoting Oyster Restoration Through
Science	Schools Curriculum Guide copyrighted 2007 by L. Calvo & Rutgers
Sector	University
Duration:	Charting the course:
One 40-minute class session	Students will examine the morphology and anatomy of an oyster through
Setting:	a dissection exercise.
Classroom	
	Objectives/Students will be able to:
Skills:	-examine and describe the external features of an oyster
Identifying, describing	-dissect an oyster and identify main body parts
Correlation with NY Core	-understand how an oyster carries out basic life functions -Identify key features of a bivalve mollusk
Correlation with NY Core Curriculum Standards:	-identity key realtines of a bivalve monusk
Living environment skills: identify	
structure and function relationships	Background
in organisms	
Key idea 5 performance indicator	How do oysters feed? How do they breathe? How do oysters sense the
5.1	world around them?
New Vocabulary:	The survival of an organism depends on its ability to sense and respond to
Anatomy: the bodily structure of an	its external environment. To understand how oysters are able to perform
organism	basic life functions, scientists perform dissections to familiarize themselves with the structural make-up or the anatomy of an oyster. By
Bivalve: an aquatic mollusk that has	learning how an oyster functions scientists can gain a better
a compressed body enclosed within	understanding of how oysters contribute to maintaining ecological
two hinged shells	balance within their environment, and how threats like water quality concerns can impact oyster functioning.
Invertebrate: Animals lacking a	a construction of the first of the second second second second
backbone	Oysters are taxonomically classified as mollusks which is one of the most diverse groups of animals on the planet. Mollusks are soft bodied animals
Mollusk: soft bodied animals	and include familiar organisms like snails, octopuses, squids, and clams There are thought to be at least 50,000 species in the world that are
Taxonomy: classification of	classified as mollusks. Oysters are further classified as bivalves, which
something	describes the two external shells that form the outer, protective layer of
0	an oyster. The scientific name for the eastern oyster is Crassostree
Materials needed:	virginica.
- Dissection trays (plastic plates will work)	Procedure/Warm Up
	Discuss why it is useful to know the anatomy of an organism. Introduce
 Shucked oysters (will be supplied 	the ovster in terms of important taxonomic concepts (i.e. ovsters are
by NY Harbor School aquaculture	invertebrates which are soft bodied animals lacking an endoskeleton, that
department)	they fall under the phylum Mollusca and are bivalves. Oyster anatomy is
O de la contra di contra	very different to human anatomy. Let's see how oysters are structurally
 Oyster anatomy diagram 	organized.

Activity

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-Divide the class into 2-3 students. Provide each group with a live oyster on a tray. -Have the students examine and describe the ovster

-Identify the two shells or valves and compare them. One is more cupped and rough, the other smooth and flat; note – in nature the deeper valve is the one that is cemented down, the flatter valve acts as a lid. Are the two shells the same size? Is one thicker than the other?

-What is the shape of the oyster? Identify the hinge or umbo area, the narrow point where the two shells come together. This is the oldest part of the shell, as oysters grow shell is laid down at the opposite end. It is also a point at which the shells are attached to one another. The other end is referred to as the bill (the ventral margin) is free to open.

-Look for other organisms on the outside of the shell, or 'scars' of organisms that were once there (sponges leave holes on the shell surface; barnacles leave an oval round mark; oyster drills leave a single hole, limey tube worms leave a network of calciferous tubes).

Have students draw the exoskeleton, or shell of the oyster and label the umbo and bill. Discuss with students the function of the shell.

Anatomy of an Oyster:

Referring to the Oyster Anatomy Diagram point out the following organs to the students

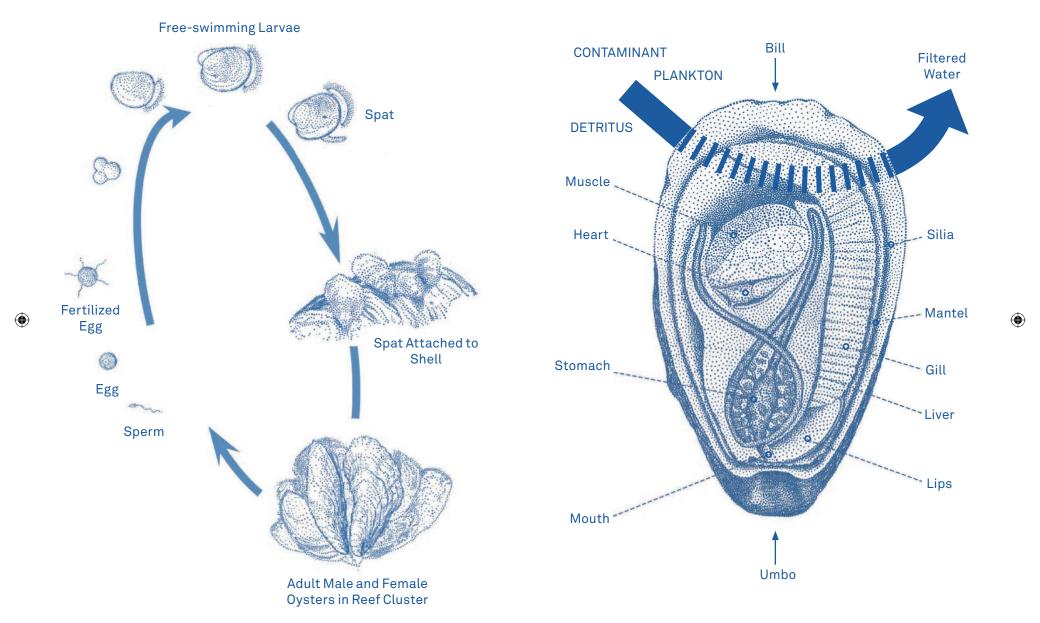
- a. Adductor muscle this is a notably different type of tissue, generally shaped like an oval. The muscle controls the opening and closing of the shells. The adductor muscle leaves a scar on the shell at the point where it is attached. Have students find the muscle scar.
- b. Mantle this is the loose outer tissue that covers the entire body of the oyster. The mantle is always in contact with the shell but is not attached to it. The primary function of the mantle is to produce the oyster shell.
- c. Gills are the oyster's largest organ and consist of 4 folds of tissue that are located under the mantle edge. Gills are the main respiratory organ but also play a role in feeding. By beating thy hairs called cilia, the gills are able to create a current pumping water over the gills. By this method the gills are able to collect food particles (phytoplankton) and move them onto the labial palps for further sorting.
- d. Labial palps and mouth follow the gills toward the umbo area. There will be a slit followed by two thicker layers of tissue these are the palps. The mouth is the U-shaped slit that is located between the palps. The labial palps are specialized organs that control the total amount of food that is passed along to the mouth.

Sample Lesson Plan 107

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Oyster Life Cycle

Oyster Anatomy



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Oyster Life Cycle & Anatomy 109

<u>Associates</u>



1.5 in

0.039 - 13 in

< 4 in

<0.24 in

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Mud Snails (Ilyanassa Obsolete)

Small (up to 3 cm) gastropod snail with a whorled, cone shaped shell. Opening to the shell is oval and large (1/2 the height of the shell).Dark black or brown in color.Often the shell is covered in mud, algae, and encrusting bryozoans. Extremely abundant in Mid Atlantic intertidal estuaries. Crawls along surface of the mud. Eats algae, worms, and detritus (dead and decaying matter) in the mud; eaten by birds.

Slipper Shells (Crepidula fornicata)

A small gastropod with a one-valved shell, which is found attached to the underside of hard substrates (including other shells and live organisms). The underside of the shell has a platform extending about ½ way across the shell opening. Usually white-beige in color. Often considered a "nuisance species" in oyster gardens and beds because they compete with oysters for food and space, and can inhibit oyster spat from setting to a bed. Species seen in NY/NJ: Eastern slipper shell (Crepidula plana): flattened, pure white, and small (up to 1 inch. Common/ Atlantic slipper shell (Crepidula fornicata): has a more rounded/arched shell, with brown markings and a slightly crooked axis (tip is bent to one side); small size (1.5 inches).

<u>Amphipod (Gammarus Spp.)</u>

Small crustaceans (like crabs, shrimp, and lobsters) that are laterally flattened. Large eyes on either side of the head. Multiple pairs of legs on the thorax.

Blue Mussel (Mytilus Edulis)

Small bivalve (up to 4 inches) with 2 shells (hinged together) that occurs attached to hard substrates (rocks, pilings, ropes, etc) and usually found in clumps. Shells are smooth on the outside, blue black in color and often glossy/shiny. Mussels attach themselves using tough byssal threads which glue the bivalve to the surface.

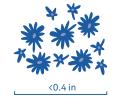
Mud Tube Worm (Spionidae Family, Especially Streblospio Benedicti)

Polychaete (marine segmented worms) with one pair of parapodia per segment (paddle like appendages). Head is cone shaped, with 4 eyes, a pair of tentacles, and 2 pairs of gills. Reddish brown coloring with dark green around gills. Small size (up to 6 mm). Lives in fine sandy, and silty sediments that are easy to ingest. Make tubes out of sediment and mucus and live inside the tubes, right below the surface.

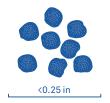


Sea Grape Tunicate (Molgula Manhattensis)

Small, round, jelly like animal that can occur in large numbers on oyster gardens. Rounded, with 2 siphons on the top side. "Sea grapes" (Molgula and Bostrichobranchus spp.) have uneven siphons; most other species of sea squirt have even siphons. Most species live attached to hard substrates, such as ropes and oyster nets. Squeezing the sea grape can cause the siphon to shoot water out at you (hence the name, sea squirt!) Outer surfaces often covered in debris and encrusting algae. Sea squirts are the most prolific oyster reef associate in NY Harbor, sometimes covering an entire cage with a thick layer of slimy mass. Sea Squirts have mysteriously unique anatomy including an enlarged kidney with no outflow ducts and two levels of symbiotic bacteria that consume its crystalline "stones."



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Golden Star Tunicate (Botryllus Schlosseri)

This species can be distinguished from Botrylloides sp. by the pattern of zooid growth. B. schlosseri zooids emanate from a center in the manner of the arms of a star. Also, there usually are fewer zooids per cluster (5-8 in B. schlosseri and 10 or more in Botrylloides). There are many colors in which this species can be found, ranging from orange, blue and grey.

Sponges

The simplest of all true 'animals', sponges look like a plant but are really living animals. Sponges can be free standing, encrusting, and boring (becoming intertwined with their substrate). Species found in NY/NJ: Red beard sponge (Microciona prolifera): a reddish orange brown sponge that encrusts on a substrate, grow up to 8 inches; in shallow subtidal estuaries. Boring sponges (Cliona spp.): very small (less than 1/4 inch), yellowish in color; bore into mollusk shells (especially oysters!).Doesn't eat the oyster, but can weaken the shell enough for another parasite or predator to kill the oyster.

Sand Worm (Nereis Spp.: Commonly Called Clam Worms) Polychaete worm, with a set of setae (bristled, spiny like projections) and parapodia (appendages) on each segment. Head has a pair of sickle shaped jaws, and short blunt palps near the eyes.

Barnacles (Class: Thecostraca; Common species: Chthamalus stellatus)

Small organism, sometimes found cemented along the ropes and mesh of oyster gardens and on the oysters themselves. Usually white to beige in color, and have a pyramid like shape, with plates forming a cone. The outer surface of the barnacle is hard, due to calcium carbonate shell plates. Main type of barnacles found in NYC nets is the acorn barnacles. Common species seen in NY/NJ: Northern rock barnacle which is found in more saline waters, and the lvory barnacle which is found in lower salinity water.

Ribbed Mussel (Geukensia Demissa; Previously Known as Modiolus Demissa)

Long, thin bivalve with 2 hinged shells that have ribs running lengthwise; brownish, green brown coloring. Found in salt marshes and other estuarine areas, usually attached to the base of marsh grass and half buried in the sediment. Usually occur in clumps. Attaches to plants and each other using tough byssal threads. During low tides, shells are usually closed to prevent dehydration, but the bivalves sometimes open to take in air.

Shore Shrimps (Palaemonetes Spp., Especially P. Pugio) Small (1.5-2 inches); often clear with dark streaks; with numerous legs and antennae. First and second legs have claws, others with hairlike projections for swimming. The rostrum (piece over the head) extends outward beyond the antennae. Likes to hide out in eelgrass or other seagrass beds, or congregate around pilings. Known as "grass shrimp" but are not true Grass shrimp (Hippolyte spp.)

Aggregating Species ID 111

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Predators



< 1 in

<u>Green Crab (Carcinus Maenas)</u>

Shell has 5 'teeth' (small pieces sticking out) behind each eye; shell is about 90 mm wide. Usually a darker green color on top, with a yellowish underbelly; during molting the color can become orange and blotched with white spots. Known to eat bivalves, especially juvenile oysters (the crab is limited by the oyster's size, it can't eat larger oysters.

Flatworm (Stylochus ellipitcus)

These flattened, wider worms are usually found as parasites (an animal that lives off of another, causing harm or death to the host) on larger organisms, such as oysters. Thin, translucent body. Feed on oysters and barnacles by slipping under the shell and eating the animal from within. Species found in NY/NJ: Oyster flatworm :pale colored with eyspecks along front margin and tiny tentacles on top of body.

<u>Sea Robin (Prionotus Carolinus)</u>

A small fish (usually smaller than 1m long as adults) that lives its life near the bottom of the intertidal area. It has a bony head, and larger pectoral fins (located towards the head of the fish, under the gills). The fins almost resemble stubby 'arms' as they are very fleshy. Three spines come off of each fin and are used as feelers. Grey reddish brown coloring, with some paler spots and stripes on the back and sides; white coloring on belly; yellowish brown fins. Feeds on bivalves, worms, crustaceans, and other smaller fish.

11.8 - 14.9 in

< 3.2 ft

<u>Oyster Toadfish (Opsanus Tau)</u>

Also known as the ugly toad, oyster cracker, super bick and "bar dog," is a fish of the family Batrachoididae. The maximum length of the toadfish is about 38 cm; the most common recorded length of an oyster toadfish is about 30 cm. They are generally yellowish with a pattern of brown oblique bars.



Blue Crabs (Callinectes sapidus)

Has a wider shell than mud crabs, and larger size (up to 9 inches for adults). Last pair of legs is modified into swimmerettes. Spiny projections off the sides of the carapace (body). Olive green bluish coloring, with brighter blue color under claws and a whiter underbelly. Picture shows a juvenile.



<u>Mud Crabs (Panopeus herbstii)</u>

Small crabs (less than 1") with 10 legs; front legs have claws (one bigger than the other).Claws can be colored differently; the rest of the body is a lighter brown. Prey on juvenile oysters and crabs; can crush the shells of up to 1/2 inch bivalves!

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Blackfish/Tautog(Tautoga)

Has very prominent 'lips' with teeth jutting outward. Usually less than 2m long as an adult. Often associated with reefs (mussel and oyster). Feeds on bivalves, snails, and crustaceans.

Oyster Drills (Urosalpinx cinerea)

A small gastropod (snail) with a single shell. One end is open and flared out. Oyster drills prey on oysters by using their long, rough radula (tongue like appendage) to bore a hole in the shell of the oyster and suck the meat out. The oyster drill also secretes sulfuric acid to aid in the decomposition of the shell!

Japanese Shore Crab (Hemigrapsus sanguineus)

An invasive species, it first appeared on the NJ coast in 1988 and quickly spread north. Occurs in the intertidal zone, using rocks as places to hide and forage for food; also seen on oyster reefs and mussel beds. Small size (adults are usually up to 1.5 inches) with a more square shaped carapace (the part of the shell that covers the main body) than other crabs. Usually dark brown green black in color; walking legs usually banded in color. Eats blue mussels, soft shell clams, and oysters mainly; can have a large effect on these populations. Note the colored leg bands and square shaped carapace.

Aggregating Species ID 113

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Oyster Gardening and Human **Health Advisory** The New York State **Department of Environmental Conservation (NYSDEC)** designate their state's waters based on samples analyzed for bacterial contaminants. Due to NYC's outdated sewer system raw sewage and other pollutants are still being discharged into the harbor. For this reason the waters in NYC are closed to commercial shellfish harvesting. Filter feeding organisms, such as oysters, concentrate harmful bacteria and pollutants within their body tissue posing a threat to people eating them. Therefore:

Sources

Hudson River Snapshot Day Water Quality Monitoring Guide http://www.ldeo.columbia. edu/edu/k12/snapshotday/

Lamotte WQ Test Kit manual code 5911

NY/NJ BAYKEEPER Oyster **Gardening Manual**

Credits

Billion Oyster Project New York Harbor Foundation Urban Assembly New York Harbor School, **Governors Island, NY**

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