BOP Field Science Manual

Restoration Station Protocols and Data Sheets

(9/25/2015 Draft)

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Getting Started

Welcome and thank you for taking part in BOP Field Science and Restoration Station monitoring!

These protocols are designed for teachers, citizen scientists and anyone else interested in being responsible for the care and monitoring on an oyster restoration station. There are five protocols outlined in this manual: site conditions, oyster measurement, mobile trap, settlement tiles and water quality. Each protocol includes an explanation of how to carry out the necessary monitoring and the equipment involved.

BOP asks that all five protocols be carried out at each monitoring session. We have provided recommended measurement methods and tests for each protocol. Please adhere to these suggestions as closely as possible.

Notes:

- The Restoration Stations need to be monitored *at least* 4 to 6 times per year. Our recommended way to achieve this minimum to do the monitoring once per month during April–June and Sept–Nov.
- Protocols are designed for a group size of up to 34 individuals; if a student group, an additional three adults – one teacher, two chaperones, with chaperones trained in advance – are required
- Protocols can also be carried out by individuals (citizen scientists) or a small group.
- All waterfront sites have a place of the installation of the Restoration Station and have shoreline space for groups to carry out the monitoring.
- All supplies and equipment must be carried to and from the site.
- All field data will be collected using a tablet/smartphone app that does not require cellular or wifi connectivity. Data will be saved on the tablet's internal memory then uploaded whenever an internet connection is available.
- Be sure to rinse all equipment with fresh water after each use. Salt will corrode equipment and cause inaccurate readings on certain devices.

Group leaders: Use your discretion to split your group into 5 monitoring teams according to individuals' abilities, interests, group size, time available, and other constraints. Each monitoring team will be responsible for one or more of the following:

Protocol 1. Site Conditions

Protocol 2. Oyster Measurements

Protocol 3. Mobile Trap

Protocol 4. Settlement Tiles

Protocol 5. Water Quality

Equipment and Supplies Checklist

Supplies provided by BOP

(Highlighted items are provided as part of the Restoration Station kit.)

Item	Purpose	Check
Thermometer	Air and water temperature	
Anemometer	Wind speed	
Sling psychrometer	Humidity	
Tape measure reel 30m	Site measurement	
Nitrile gloves (medium)	Sampling work	
Boat hook	Restoration station retrieval	
Large plastic tub with lid	Submerging mobile trap	
Shallow plastic tub with lid	Submerging settlement tiles	
Calipers	Measuring oysters	
0.5-3.0 mm sieve set	Sorting organisms	
E-book - Peterson Field Guide to the Mid Atlantic	Species identification	
Van Dorn Bottle	Collect water samples at specified depths	
CHEMets Colorimetric	Dissolved Oxygen	
Refractometer	Salinity	
Hydrometer	Salinity	
pH meter	pH	
Calibration solution	Calibration of pH meter	
Aquacheck test strips	Ammonia, nitrates	
Turbidity tube	Turbidity	

Plankton net	Plankton sampling	
Wash bottles (3)	Cleaning equipment in Protocol 2, 3 and 5	
Scrub brush	Cleaning/defouling mesh	
Outdoor cable ties (11” pack of 100)	Reattaching/repairing cage and tiles	
Sample collection jars	Transporting species back to the lab/classroom	
Rolling cooler bag	Transporting species back to the lab/classroom	

Supplies NOT provided by BOP:

Item	**Purpose**	**Check**
Lifejacket	Working near the water’s edge with the Restoration Station	
3-gallon Bucket (2)	Collecting surface water sample & mobile trap monitoring	
Rope	To tie onto the buckets	
Pocket knife	In case lines or zip ties need to be cut	
Waste container (with secure cap)	Collecting used sample water, chemicals and disposable test equipment	
Funnel	Pouring water at top of turbidity tube	
Winkler DO kit	Dissolved Oxygen (advanced method)	
Bunsen burner stand	Photographing the settlement tiles at a consistent distance	
Hand lenses	Identifying small organisms	
Field microscope	Identifying small organisms and plankton	
Tweezers and/or pipettes	Sorting through organisms in the mobile trap	
Cloth or towel	Drying pH meter	
Umbrella or towel	Shading the glare when photographing the settlement tiles	

On-site Timetable for Field Procedures

1. Arrive on site and direct the group to set up **basecamp** – basecamp is a central meeting place for storage of backpacks and supplies. (5 min)
2. Meanwhile, **conduct a quick visual inspection** of the site to ascertain how to keep all group members safe and to check that the Restoration Station is in place. **NOTE:** If possible, the group leader should check the site the day before the trip to ensure the Station is still intact. (5 min)
3. **Gather the group** at the shoreline and orient them to the site. Distribute data sheets and/or tablets. (5 min)
4. **Deliver a short introduction** to the field monitoring, as needed, to the group. Review the schedule for the field work. (10–15 min)
5. As a group, make the initial **field monitoring observations**. (5 min)
6. Divide individuals into their **assigned "monitoring teams"** and make sure all participants understand their monitoring task. (5 min)
7. **Retrieve the Restoration Station**. This task should be led by a trained adult with the help of one or two other individuals. (5 min)
8. Meanwhile, assign a couple of individuals to **prepare two tubs of water** in which to immerse the trap components.
9. **Disassemble the Restoration Station** and distribute components to appropriate monitoring team. (5 min)
10. Carry out **monitoring** work. (45–60 min)
11. Announce the **end of the monitoring period** 5 minutes prior and ensure all data has been properly recorded on the data sheets and/or entered into the BOP Input app.
12. **Pack up equipment and reassemble Restoration Station**. Restoration station is restocked with oysters, mesh, oyster shells and tiles and then reassembled. Monitoring equipment is returned and packed up. Any samples to be brought to the lab/classroom are packaged for transport. (10 min)
13. **Reinstall Restoration Station** in the water. This task should be led by a trained adult with the help of one or two other individuals. (10 min)
14. Meanwhile, monitoring teams do **final cleanup** of their work area. Make sure to wash down the area where the oyster cage was scrubbed, so mud and dead organisms are not left behind.
15. Assemble the whole class and **debrief** experience. Group makes any **final site observations.** Monitoring teams can **report back the results** of their group's monitoring activities. (15 min)
16. **Depart**.
17. Back in the classroom, connect each tablet to an internet connection and **upload data**.

Total time required on site: 125-145 minutes.

Field Monitoring Initial Observations

Initial observations are conducted before any other monitoring work is completed and are entered at the beginning of the "Protocol 1. Site Conditions" section of the BOP Input app. These observations are made by the whole group to ensure that all participants are oriented to the site. Initial observations include: location, date, time, weather conditions, air temperature, and tidal stage.

Retrieving the Restoration Station

Use a bucket on a rope to collect seawater from the site with which to fill the tubs. Remember to tie the end of the rope to a fixed structure so you don't lose it. **Be careful** not to slip when throwing the bucket into the water.

Prepare the following:

- The lid of the large tub: Have ready to receive the restoration station as soon as it comes out of the water.
- One large tub (>25"x12"x12"): Fill with approximately 6" of water in order to submerge the mobile trap.
- One shallow tub (>20"x12"x6"): Fill with approximately 3" of water in order to fully submerge the settlement tiles panels.

A trained adult and one or two helpers should carefully retrieve the restoration station by hauling it out by the attached rope/cable. Be mindful of leaning over railings or the water's edge and wear a lifejacket when appropriate. Use a boat hook to grab the lines of cage if unable to access the edge of the dock or pier safely.

1. Place the whole restoration station directly onto the lid of the large tub or **as soon as possible** after removing it from the water.
2. Check the area around the lid and restoration station for any organisms that might have fallen off during retrieval (e.g. crabs, fish, shrimp, etc.)
3. With one person holding the restoration station upright, the other should remove the settlement tile panels and separate them from each other. Place the two panels in the shallow tub, side-by-side. Make sure the tiles are face-up.
4. Remove the mobile trap and place it directly into the large tub. Make sure the oyster shell and mesh within the trap are submerged in water.
5. Place the oyster cage on the ground. (Note: The oyster cage does not need to be submerged because the oyster spat and juvenile oysters can remain out of the water for 3 - 4 hours.)
6. Take the lid and carefully pour any water into the large tub with the mobile trap.
7. If monitoring with a group, move the components apart from each other so each monitoring team has room to work. If monitoring alone, process the mobile trap first, so organisms may be counted and returned to the harbor in a timely manner. It is best to set the oyster cage and settlement tiles in the shade until possessed.

Protocol 1. Site Conditions

The Site Conditions subgroup is responsible for observations about the land, water and air including: weather, a recent rainfall, tide and current, as well as describing the conditions of the land and the water.

Instructions

As a group, carefully and quietly observe the entire research area including the water, the shoreline and the upland areas. Record observations for about three minutes.

1. **Meteorological conditions**

   Record the current weather conditions, temperature, wind speed (method: anemometer), wind direction (method: wind sock), and humidity (method: sling psychrometer).

2. **Recent rainfall**

   Record whether it has rained in the past 24 hours, 72 hours, or 7 days.

3. **Tides**

   Estimate the tide level by noting the high tide mark or the low tide mark. Then use a tide table such as NOAA Tides and Currents to confirm tides at the southernmost tip of Manhattan (the Battery). Tide charts are available on several mobile apps, or at:

   http://co-ops.nos.noaa.gov/stationhome.html?id=8518750

   If you are using the BOP Input App, you can access the data from NOAA Tides and Currents by clicking on the "Tide Tables" button, and it will show the tides for 7 days from the day the device was last connected to wifi.

4. **Current Speed**

   Estimate current speed by throwing a stick, orange, or other natural floating object into the water at a set point on the shoreline. Measure a set distance (100m) of the shoreline and record the amount of time it takes for the orange to travel that distance. Distance/time=speed

5. **Current Direction**

   State the direction/stage of the tidal current: flood (incoming tide), slack, or ebb (outgoing tide).

6. **Water conditions**

   Record appearance and characteristics of water at point where the Restoration Station was deployed.

7. **Land conditions**

   Record appearance and characteristics of nearby on-shore areas.

Protocol 2. Oyster Measurements

The oyster subgroup is responsible for measuring growth and recording mortality of oysters in the oyster cage.

The oyster cage contains up to 50 recycled oyster shells (substrate shells) with anywhere from one to 50 individual oysters growing on each. Individual oysters will start as one to three month old juveniles (sometimes called spat) and range in size from 2 to 30cm. Monitoring oyster growth includes measuring ***all*** live oysters on ***each*** of the ten tagged substrate shells. Tagged shells have a pre-drilled hole with a white plastic tag attached by zip tie. Each tag contains a unique tag number (1-10), oyster date of birth/set date, and source/broodstock. All tag info is shown by hole-punch. Monitoring also includes counting all dead oysters at each monitoring event except for the first (baseline mortality is zero).

Note: in addition to the 10 tagged shells, oyster cages will include up to 20 additional substrate shells with several hundred additional oysters growing on them. The purpose of these additional oysters is simply to create a bigger breading colony. Schools and citizen scientists can use these additional non-tagged oysters to run their own experiments or transfer them to indoor tanks for a set period of time.

Instructions

Remove all ten tagged substrate shells and leave the rest of the untagged substrate shells in the cage, being careful not to damage the oyster spat on each shell. Place each substrate shell on the ground in numerical order, 1 through 10. Note: multiple shells can be monitored simultaneously however it is simplest to go in numerical order, one at a time, following these steps

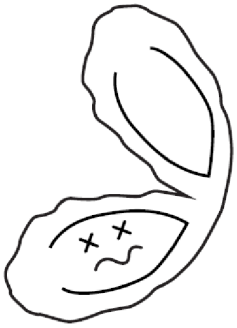
1. **Photograph both sides of each tagged shell**
   Make sure that the tag is visible in each photograph.
2. **Count the number of live oysters on both sides of the tagged shell**

   Record the total number of live oysters.
3. **Measure live oyster spat**
   Measure and record the size of all live oysters on each tagged substrate shell, using the instructions below. If you realize that you miscounted in #2 above, adjust your total number so that is it accurate and equals the number of live oysters you took measurements for.

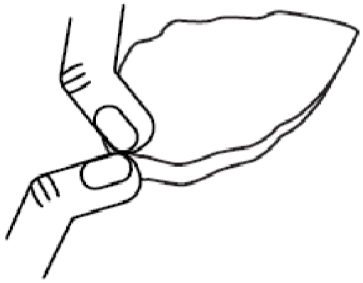
Identifying live versus dead oyster spat

Dead oyster spat can be identified with a light tap on the top shell. If the shell is visibly gaping open, if there is softness or movement in the shell, or if bubbles are discharged when the shell is lightly pressed, this means the oyster is dead.

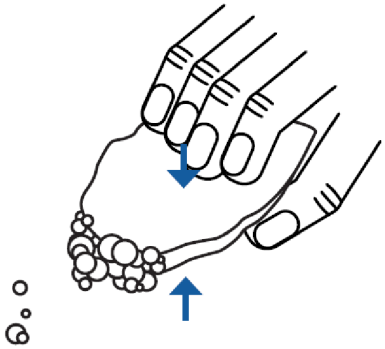
Dead oyster spat will also sound hollow when lightly tapped. To double check that an oyster is dead gently try to pry them open with your fingernail. A dead oyster will generally open very easily. Often a dead oyster is filled with mud and therefore can be mistaken for being alive. The 'fingernail check'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



A Dead Oyster Is Gaping Open



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



Dead Oyster Will Discharge Bubbles When Lightly Squeezed

Dead Oysters Sound Hollow When Lightly Tapped

Measure all live spat on the tagged substrate shell

Always measure oyster spat on their longest side, from the top (bill) to the bottom (umbo) – see diagram. 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. Be careful not to damage the oyster spat while measuring.

How to measure multiple spat-on-shell:

a. Start with the exterior (rough) side. Move from the umbo (pointed) end to bill (rounded) end of the substrate shell, measuring all oyster spat systematically. Make sure not to miss or repeat any.

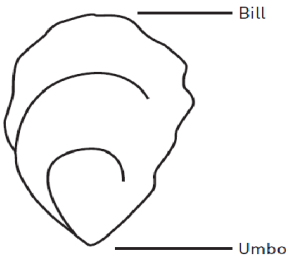
b. One person should measure while another person writes the measurements on the data sheet or enters data using the BOP Input App.

c. Hold the caliper in one hand and slide the jaws open gradually with the thumb. Use the other hand to hold the substrate shell.

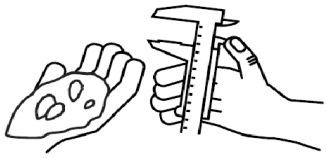
d. Place the jaws of the caliper just above but not touching the spat. Slide the caliper open or closed until it is precisely aligned to the length of the oyster spat (bill to umbo).

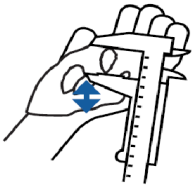
e. Note the measurement for each oyster spat and record on the data sheet or in the BOP Input app.

f. Measure all oyster spat on the exterior side, then move to the interior (smooth side).



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

Protocol 3. Mobile Trap

The Mobile group records all organisms found in the Restoration Station compartments that hold mesh netting and a small number of oysters. These materials provide different environments within which the mobile organisms live.

Instructions

Note: It is best to monitor the mobile trap near the water's edge so that organisms may be returned to the harbor as soon as they are processed.

1. Keep the mobile trap in the large tub with the mesh and oyster shell submerged until the monitoring begins. The water in the tub will serve to catch all the organisms from the mobile trap for counting and recording.
2. Gently **swish the entire mobile trap** in the tub in order to shake off larger organisms.
3. Remove the mobile trap from the large tub and place on the lid of the large tub.
4. **Remove the mesh** from the mobile trap and place in the tub. Gently open the mesh underwater and swish around to further dislodge organisms. Hold the mesh just above the water for a visual inspection. Carefully remove any other organisms clinging to the mesh (particularly caprellid amphipods) and place them in the large tub. Return the mesh to the mobile trap.
5. **Remove the oyster shells** from the mobile trap a handful at a time and gently swish around in the tub. Hold the oyster shells just above the water for a visual inspection. Carefully remove any other organisms clinging to the shell and place them in the large tub. Return all shells to the mobile trap.
6. **Identify, count and record all large organisms**. Return organisms to the harbor as they are recorded. If any fish have been captured in the mobile trap take a picture, then return them to the water alive. Next, count other large, highly mobile groups (e.g. crabs) and then count the other organisms.
7. **Filter the water from the large tub** to capture smaller organisms, invertebrates and plankton. Pour the water in the tub through a sieve (recommended mesh size **500-µm**). Remove large particles of debris, rocks or plastic.
8. **Replace the mobile trap in the large tub** and cover with water once again to keep any attached sessile organisms from drying out.
9. **Identify, count and record smaller organisms.** Use tweezers, a pipette or similar instrument to remove organisms from the mesh. Hand lenses or field microscopes amy aid in identification of these organisms.
10. **Identify, count and record plankton.** (optional – see Field Science Extensions)
11. **Preserve an organism sample** (optional)

    Note: If you plan to preserve organisms to take back to the classroom solitary ascidians (e.g., sea squirts *Molgula manhattensis*) that are attached to the netting should ***not*** be added to the samples; they retain seawater in their bodies and make preservation of the sample difficult.

a. Return the organisms to a sample bag labeled with the trap identifier, location, time and date.

b. Add local seawater (⅓) and 90% ethanol (⅔) to approximate a 70% ethanol solution for preservation.

c. Add a few drops of Rose Bengal stain to color the animals if necessary.

Protocol 4. Settlement Tiles

The Settlement Tile group will record the invertebrates and algae colonizing the tiles. Four tiles are included with each Restoration Station. Ceramic tiles provide a suitable colonization surface for many types of algae and invertebrates found within the harbor. Two panels of wire mesh hang from the Restoration Station with two tiles each.

Instructions

1. **Set up the settlement tiles in the shallow tray of water**

   Remove the settlement tile panels from the Restoration Station and lay both of them, side-by-side with **the tiles placed 'face up'** (the 'face' is the surface facing outwards from the mesh panel and should show most growth) in the shallow tub. **Add enough water (approx. 3") to the tub** to just cover all organisms on the tiles.

2. **Describe the tile condition**, noting any damage to the tile, and sedimentation.

3. **Set up the tiles and camera**

   Position the camera at a consistent distance from the tiles, preferably using a camera stand or tripod to minimize camera shake. As an easy solution, we recommend Bunsen burner stands. Rest the camera or smartphone on the stand, making sure there is enough distance between the surface of the water and the camera to avoid the camera getting wet. Make sure the whole set-up is level and that the tile takes up as much of the camera's field of view as possible.

4. **Photograph the tile surfaces**

   Photograph the front surface of each tile at high resolution. ***Note*:** The sessile communities on the tiles should remain just below the water surface when photographed, to minimize refraction and glare. Shading the settlement plate surface from sunlight using an umbrella or towel may also be required to reduce glare. **Carefully note tile and photograph numbers** in the field sheet as an additional backup to avoid errors in sampling.

5. **Lay the sampling grid on the tile**

   Line up the edges of the 9-square sampling grid with the edges of the tile.

6. **Closely observe the organisms present within each of the 9 total squares**

   Use the field guide (hard copy or app) to identify the **dominant** cover – the species/cover type that occupies the most space within the square – of each of the sample squares. (e.g., commonly red or green algae, colonial ascidians, solitary ascidians, bare space or sediment). If **two cover types occupy** roughly equal amounts of space, **record these as co-dominants**.

7. **Record the dominant cover (and co-dominant, if present) cover** for each of the 9 sample squares. Note any other prominent species on the tiles that were not recorded as dominant(s).

8. **More detailed analysis** of the digital images can be done back in class (see Extensions B).

9. **Reattach the tile panels to the Restoration Station.**

Protocol 5. Water Quality

The Water Quality (WQ) group is responsible for measuring a number of parameters using a water sample extracted on site.

Instructions

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. Complete the temperature and dissolved oxygen tests first, as these parameters can change quickly once the sample is extracted from the Harbor.

***Notes**:*

- *The BOP Input app is designed to record the test results of a single sample of surface water. If a Van Dorn bottle is used to take a sample at depth, print out an additional Water Quality Data Sheet on which to record results about this second sample.*
- *The turbidity test requires a lot of water. Pull a second bucket of surface water from the same location you got the first bucket, in order to complete three turbidity tests.*
- *If you are concerned about running out of time to complete all the water quality tests, do them in the order listed below. At least complete tests 1 through 5.*

Water quality measurements

1. **Water Temperature**
   The temperature of the water has a lot to do with which plants and animals feel comfortable and will grow there—and oysters really care about the temperature! Water temperature also affects how much dissolved gas is in the water, for example, cold water will hold a lot more oxygen than warm water. Finally, water temperature is one of two things that determine how dense the water is: warm water is lighter than cold water, and in most of the ocean, there is a layer of warm water over a thicker layer of cold water.

   Recommended method: alcohol thermometer
   The BOP oyster gardening kit includes an alcohol thermometer encased in a durable plastic cover. Immerse the thermometer in the water being sampled, ideally directly into the water, or into a bucket of the water if direct measurement is not practical. If working from a bucket, be sure to measure the temperature right away. The thermometer should sit in the water for about a minute before it is withdrawn and read.

2. **Dissolved Oxygen (DO)**

   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 (which produce oxygen as long as there is sunlight), and wind conditions. DO measurements are given in mg/L and as percent saturation. 100% saturation is the amount of oxygen that water will hold when there is no biology at work and no air bubbles mixed in. Note: mg/L is approximately the same as parts per million (ppm). A healthy range for our estuary is 5.0 – 11.0 mg/L or ppm.

Recommended method: CHEMets Colorimetric
Fill up the plastic sample cup to the 25 mL mark. Take a glass ampoule and place it in the sample cup at a diagonal angle with the tip of the ampoule at the bottom of the cup. Carefully pull the ampoule toward the edge of the cup so that the tip of the ampoule snaps off. Remove the ampoule from the cup and invert it 10 times allowing the air bubble to travel from one end of the ampoule to the other with each inversion. Compare the ampoule to the comparator and record the result. Place the ampoule, and all contents of 25mL sample cup into the waste container.

3. **Salinity**

Salinity is a measure of the amount of salt present in the water. Most of this salt is sodium chloride, just like table salt, but there are many other dissolved minerals in trace amounts. Variable salinity is the most characteristic feature of water in estuaries, with salty water from the ocean confronting fresh water running off from the land. In estuaries salinity can change daily, with the tides and tidal excursions, and with the seasons. In our area, the Atlantic salinity range is from about 33–35 parts per thousand (ppt); freshwater ranges from 0–3 ppt; and the estuary salinity range is from about 5–28 ppt. Oysters prefer estuarine (brackish) salinity conditions.

Recommended method: Refractometer
Use a pipette to place 2-3 drops of water on the prism of the refractometer and close the plastic plate on the drops. Hold the refractometer up to your eye and look through the eyepiece. Take the reading where the boundary line of blue and white cross the graduated scale. Be sure to frequently calibrate the refractometer with distilled water (salinity = 0 ppt).

4. **pH**

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. Natural waters tend to be basic, and a water pH below 7 is often a sign of pollution. Seawater typically has a pH near 8 and clean river water is normally near 7. Estuarine waters are typically between those two values, with higher values correlating with saltier water and vice versa. pH is a ratio of "free" hydrogen atoms to water molecules, so there are NO UNITS used with pH.

Recommended Method: pH meter
Follow manufacture's instructions.

5. **Turbidity**

Turbidity describes the cloudiness or murkiness of the water. It is measured by gauging how much light can pass through the water. Estuaries are often quite turbid, either because there is a lot of dirt washing in from the coast or because there is a lot of plankton, or both. In the Hudson Raritan Estuary turbidity is made up of small plankton, pieces of detritus or decomposing plant and animal matter, and suspended grains of sediment.

Recommended Method: Turbidity tube
Make sure the nozzle of the turbidity tube is locked. Place a funnel at the top of the turbidity tube. Fill up the turbidity tube with water. Designate one person to look down into the tube.

Another person controls the nozzle lock and begins to slowly let out water. The person looking into the tube says "stop" when he/she sees the secchi disk symbol at the bottom of the tube. Measure the depth of the water in cm using the ruler on the side of the tube.

6. **Nitrates**

   Nitrate (NO3) and phosphate (PO4) are two of the major nutrients. Along with many micro-nutrients, these are necessary for plants to grow, and the conversion of these nutrients into living plants is known as "primary production." It is the process that supports the entire ecosystem, including oysters. In a natural system, nitrate is "fixed" from nitrogen in the atmosphere by bacteria that have evolved to play that role. Over the past 100 years, however, human economy has become the dominant source, especially in coastal areas. In the New York Harbor, these nutrients enter the estuary as runoff from fertilized lawns and farms, as effluents from sewage treatment plants, and through aerial deposition as a result of fossil fuel combustion. In addition, after heavy rainfall, organic matter flows into the estuary from combined sewage overflows and septic systems. Over the next several days, much of that organic matter is processed by bacteria into high concentrations of inorganic nutrients.

   Recommended Method: Test strips
   See manufacturer's instructions. Units = parts per million (ppm) or micromoles per kilogram.
   Place used test strips in the waste container.

7. **Phosphates**

   In most natural environments, the main phosphate source is dissolution from mineral grains, for example from sand and clay at the bottom of an estuary. However, the main phosphate source in populated coastal areas is now from fertilizer runoff and sewage treatment. Phosphate detergents are a source that has largely been eliminated in the New York area. As with nitrate, the decomposition of organic matter after heavy rains will also lead to a "spike" in phosphate levels.

   Recommended Method: Test strips
   See manufacturer's instructions. Units = parts per million (ppm) or micromoles per kilogram.
   Place used test strips in the waste container.

8. **Ammonia**
   Ammonia is produced by bacteria in the process of cycling organic material into inorganic chemicals. In populated estuaries, high ammonia concentrations are a typical indication of sewage outflows.

   Recommended Method: Test strips
   See manufacturer's instructions. Units = parts per million (ppm) or micromoles per kilogram.
   Place used test strips in the waste container.

Sediment Trap observations (required)

The WQ group is also responsible for describing the sediment that has accumulated in the sediment trap. Enter your observations into the data sheet or the BOP Input app.

Returning the Restoration Station to the Water

Once all the organisms within the three components of the restoration station (oyster cage, mobile trap, settlement tiles) have been processed, it is time to clean up, put the restoration station back together and return it to the water.

De-foul the Restoration Station – Lightly scrub the outer wire mesh of the trap components using a wire brush. Scrub with enough force to dislodge the larger, bulkier fouling organisms (such as solitary ascidians, mussels). **Be careful not to disturb or scrape the tiles**. Closely attached algae, small barnacles and serpulid worm casings may not come off easily – this is ok. It is not necessary to remove these.

Mobile Trap – Return the mesh and shell substrates to the mobile trap.

Settlement Tiles – Replace any removed or damaged tiles with cable ties to each side of the prism. Reconnect each tile panel to the outer edges of the Restoration Station then clip together at the base to form a prism shape.

Oyster Cage – Replace all substrate shells into the cage, being careful not to damage any spat-on-shell. Secure the lid.

Re-connect all components of the restoration station.

Reattach (if needed) and carefully lower the restoration station into the water wearing a lifejacket if necessary.

Protocol 1. Site Conditions Data Sheet

Field monitoring Initial Observations	
Name of site or water body:	
Coordinates:	
Date of monitoring:	
Time of monitoring:	
Name of monitor(s): (names of all group members)	
School or organization name: (if applicable)	

1. Meteorological conditions:
Weather Conditions (circle one): Sunny | Partly cloudy | Cloudy | Rain | Fog | Snow | Hail | Thunderstorm
Air Temperature (°C):
Wind speed (mph): *Method = Anemometer*
Wind direction (circle one): N | NW | W | SW | S | SE | E | NE *Method = Wind sock*
Humidity (%): *Method = Sling Psychrometer*

2. Recent Rainfall
Has it rained in the past 24 hours? Y / N
Has it rained in the past 72 hours? Y / N
Has it rained in the past 7 days? Y / N

3. Tide conditions
Tide level: Low | Medium low | Mid | Medium high | High
Today's PM high tide: Time: Height: *Method = NOAA tides and current, Tides app, or published Tide Table*
Current speed: Distance (meters): Time (seconds): *Method = estimate by throwing a stick or cracker and observing time/distance*
Current direction: Flood current (incoming tide) | Slack water | Ebb current (outgoing tide)

4. Water Conditions
Take a photograph of the water with your camera in landscape orientation.
Describe the water color: Light Blue | Dark Blue | Light Green | Dark Green | Light Brown | Dark Brown
Oil sheen present? Y / N
Is there any garbage in the water? Y / N

Record type and extent of garbage in the water:

Type	Extent			
	None	Sporadic	Common	Extensive
Hard Plastic				
Soft Plastic				
Metal				
Paper				
Glass				
Organic				
Other _____				

Notes:_____

_____

_____

Are there any sewer or outfall pipes? Y / N

If Y, what is the diameter of the pipe (cm)?

If Y, is there any flow through the pipe? Y / N

How much?

Trickle | Light Stream | Steady Stream | Full Flow

5. Land conditions:

Take a photograph of the land with your camera in landscape orientation.

Choose shoreline type:

bulkhead/wall | fixed pier | floating dock | riprap/rocky shoreline | dirt or sand | other

Estimate percent surface cover for the adjacent shoreline (about 500 x 500 feet)

_____% Impervious Surface (concrete/asphalt paths, roads, buildings etc.)

_____% Pervious Surface (dirt, gravel etc.)

_____% Vegetated surface (grass, shrubs, trees)

=_____% Sum should equal 100%.

Is there any garbage on the adjacent shoreline? Y / N

Record type and extent of garbage on the adjacent shoreline:

Type	**Extent**			
	None	**Sporadic**	**Common**	**Extensive**
Hard Plastic				
Soft Plastic				
Metal				
Paper				
Glass				
Organic				
Other _____				

Notes:_____

_____

_____

Protocol 2. Oyster Measurements Data Sheet

Instructions: This datasheet is used to record field metadata (location, time and group information) as well as the condition of the oyster cage and oyster measurements.	
Name of site or water body	
Coordinates:	
Date of monitoring:	
Time of monitoring:	
Name of monitor(s): (names of all group members)	
School or organization name: (if applicable)	

2. Depth of oyster cage
Submerged depth of cage (meters): *Method = record length of wet line from surface to cage*

3. Condition of oyster cage
Take a photograph of the oyster cage.
Bioaccumulation on cage: None/clean | Light | Medium | Heavy *None/clean – No macroalgae or animals present* *Light – Macroalgae or minimal animals present that do not encroach on mesh openings* *Medium – Some encrusting macroalgae/animals reducing size of mesh opening up to 25%* *Heavy – Encrusting macroalgae/animals reducing mesh opening by over 50%*
Note any damage to cage:

4. Measuring Oyster Growth
Directions: *Ten substrate shells in a cage will be tagged with engraved plastic number tags (1–10). Each tagged substrate shell will have multiple live oysters growing on it; over time these will begin to die in increasing numbers. Only live oysters on tagged shells should be measured, whereas dead oysters found on tagged shells should be simply counted.* ***Measure all live oysters on each tagged substrate shell****, starting at the umbo end and working towards the bill.*

Substrate Shell #1			*Check if the oyster is dead or alive. Measure and record the size (in mm) of each live oyster below.*				
	DEAD	ALIVE	MEASUREMENT (mm)		DEAD	ALIVE	MEASUREMENT (mm)
1.				16.			
2.				17.			
3.				18.			
4.				19.			
5.				20.			
6.				21.			
7.				22.			
8.				23.			
9.				24.			
10.				25.			
11.				26.			
12.				27.			
13.				28.			
14.				29.			
15.				30.			

Substrate Shell #1 oyster size (mm)	**Min:**	**Max:**	**Avg:**
Substrate Shell #1 mortality	**#Live:**	**#Dead:**	

Substrate Shell #2			*Check if the oyster is dead or alive. Measure and record the size (in mm) of each live oyster below.*				
	DEAD	ALIVE	MEASUREMENT (mm)		DEAD	ALIVE	MEASUREMENT (mm)
1.				16.			
2.				17.			
3.				18.			
4.				19.			
5.				20.			
6.				21.			
7.				22.			
8.				23.			
9.				24.			
10.				25.			
11.				26.			
12.				27.			
13.				28.			
14.				29.			
15.				30.			

Substrate Shell #2 oyster size (mm)	**Min:**	**Max:**	**Avg:**
Substrate Shell #2 mortality	**#Live:**	**#Dead:**	

Substrate Shell #3			*Check if the oyster is dead or alive. Measure and record the size (in mm) of each live oyster below.*				
	DEAD	ALIVE	MEASUREMENT (mm)		DEAD	ALIVE	MEASUREMENT (mm)
1.				16.			
2.				17.			
3.				18.			
4.				19.			
5.				20.			
6.				21.			
7.				22.			
8.				23.			
9.				24.			
10.				25.			
11.				26.			
12.				27.			
13.				28.			
14.				29.			
15.				30.			

Substrate Shell #3 oyster size (mm)	**Min:**	**Max:**	**Avg:**
Substrate Shell #3 mortality	**#Live:**	**#Dead:**	

Substrate Shell #4			*Check if the oyster is dead or alive. Measure and record the size (in mm) of each live oyster below.*				
	DEAD	ALIVE	MEASUREMENT (mm)		DEAD	ALIVE	MEASUREMENT (mm)
1.				16.			
2.				17.			
3.				18.			
4.				19.			
5.				20.			
6.				21.			
7.				22.			
8.				23.			
9.				24.			
10.				25.			
11.				26.			
12.				27.			
13.				28.			
14.				29.			
15.				30.			

Substrate Shell #4 oyster size (mm)	**Min:**	**Max:**	**Avg:**
Substrate Shell #4 mortality	**#Live:**	**#Dead:**	

Substrate Shell #5			*Check if the oyster is dead or alive. Measure and record the size (in mm) of each live oyster below.*				
	DEAD	ALIVE	MEASUREMENT (mm)		DEAD	ALIVE	MEASUREMENT (mm)
1.				16.			
2.				17.			
3.				18.			
4.				19.			
5.				20.			
6.				21.			
7.				22.			
8.				23.			
9.				24.			
10.				25.			
11.				26.			
12.				27.			
13.				28.			
14.				29.			
15.				30.			

Substrate Shell #5 oyster size (mm)	**Min:**	**Max:**	**Avg:**
Substrate Shell #5 mortality	**#Live:**	**#Dead:**	

Substrate Shell #6			*Check if the oyster is dead or alive. Measure and record the size (in mm) of each live oyster below.*				
	DEAD	ALIVE	MEASUREMENT (mm)		DEAD	ALIVE	MEASUREMENT (mm)
1.				16.			
2.				17.			
3.				18.			
4.				19.			
5.				20.			
6.				21.			
7.				22.			
8.				23.			
9.				24.			
10.				25.			
11.				26.			
12.				27.			
13.				28.			
14.				29.			
15.				30.			

Substrate Shell #6 oyster size (mm)	**Min:**	**Max:**	**Avg:**
Substrate Shell #6 mortality	**#Live:**	**#Dead:**	

Substrate Shell #7			*Check if the oyster is dead or alive. Measure and record the size (in mm) of each live oyster below.*				
	DEAD	ALIVE	MEASUREMENT (mm)		DEAD	ALIVE	MEASUREMENT (mm)
1.				16.			
2.				17.			
3.				18.			
4.				19.			
5.				20.			
6.				21.			
7.				22.			
8.				23.			
9.				24.			
10.				25.			
11.				26.			
12.				27.			
13.				28.			
14.				29.			
15.				30.			

Substrate Shell #7 oyster size (mm)	**Min:**	**Max:**	**Avg:**
Substrate Shell #7 mortality	**#Live:**	**#Dead:**	

Substrate Shell #8			*Check if the oyster is dead or alive. Measure and record the size (in mm) of each live oyster below.*				
	DEAD	ALIVE	MEASUREMENT (mm)		DEAD	ALIVE	MEASUREMENT (mm)
1.				16.			
2.				17.			
3.				18.			
4.				19.			
5.				20.			
6.				21.			
7.				22.			
8.				23.			
9.				24.			
10.				25.			
11.				26.			
12.				27.			
13.				28.			
14.				29.			
15.				30.			

Substrate Shell #8 oyster size (mm)	**Min:**	**Max:**	**Avg:**
Substrate Shell #8 mortality	**#Live:**	**#Dead:**	

Substrate Shell #9			*Check if the oyster is dead or alive. Measure and record the size (in mm) of each live oyster below.*				
	DEAD	ALIVE	MEASUREMENT (mm)		DEAD	ALIVE	MEASUREMENT (mm)
1.				16.			
2.				17.			
3.				18.			
4.				19.			
5.				20.			
6.				21.			
7.				22.			
8.				23.			
9.				24.			
10.				25.			
11.				26.			
12.				27.			
13.				28.			
14.				29.			
15.				30.			

Substrate Shell #9 oyster size (mm)	**Min:**	**Max:**	**Avg:**
Substrate Shell #9 mortality	**#Live:**	**#Dead:**	

Substrate Shell #10			*Check if the oyster is dead or alive. Measure and record the size (in mm) of each live oyster below.*				
	DEAD	ALIVE	MEASUREMENT (mm)		DEAD	ALIVE	MEASUREMENT (mm)
1.				16.			
2.				17.			
3.				18.			
4.				19.			
5.				20.			
6.				21.			
7.				22.			
8.				23.			
9.				24.			
10.				25.			
11.				26.			
12.				27.			
13.				28.			
14.				29.			
15.				30.			

Substrate Shell #10 oyster size (mm)	**Min:**	**Max:**	**Avg:**
Substrate Shell #10 mortality	**#Live:**	**#Dead:**	

Population total: oyster size (mm)	**Min:**	**Max:**	**Avg:**	**Population total: mortality**	**#Live:**	**#Dead:**

Protocol 3. Mobile Trap Data Sheet

Instructions: This data sheet is used to record field metadata and the types and quantities of mobile animals found within the small compartments containing mesh and oysters.	
Name of site or water body	
Coordinates:	
Date of monitoring:	
Time of monitoring:	
Name of monitor(s): (names of all group members)	
School or organization name: (if applicable)	

Mobile Trap				
Mobile Organisms observed: *Use hard copy field guides or the guide included in the app to identify all mobile species found within the mobile trap.* ***Note:*** *We recommend first sorting animals by type into separate petri dishes or containers, and then counting. Where quantities are very large, used a combination of a timed sort and subsampling. First, take 20 min to sort organisms according to their type as well as possible, then count, counting a subsample of the groups that have very high numbers. For those numerous groups, split the remaining organisms within each group into subsamples approximating the first subsample, then multiply by the number of subsamples to tally the estimated total number of individuals for each group.*				
Common Name	**Latin Name**	**Quantity**	**Sketch**	**Notes or questions**

Protocol 4. Settlement Tiles Data Sheet

Instructions: This datasheet is used to record both field metadata and the types and quantities of sessile organisms found on the settlement tiles attached to the sessile trap.	
Name of site or water body	
Coordinates:	
Date of monitoring:	
Time of monitoring:	
Name of monitor(s): (names of group members)	
School or organization: (if applicable)	

Settlement Tiles
1. General tile description (condition, damage, sedimentation): _____ _____ _____ _____ _____ ***2. Sessile organisms observed:*** *Take a picture of the front surface of the tile as described in the protocol instructions. Overlay the tile with the sample grid. Use the app field guide within the app or other field guides to identify the dominant species within each of the sample squares. Record the dominant and co-dominant cover (if present) in each of these squares on the datasheet below. Record any additional species found within these squares as notes.*

Tile 1 – Sampling sheet

Overlay the tile with the sample grid. Identify the dominant species within each of the sample squares. Record the dominant cover in each of these squares on the datasheet below. Record any additional species found within these squares as notes. Tally up the number of squares (each equating to 4% of area) that each species or cover type occupies on the tile and list them in the second table.

Sample square	Dominant cover – common name	Dominant cover – Latin name (if applicable	Co-Dominant cover – common name	Co-dominant cover – Latin name (if applicable)	Notes
1					
2					
3					
4					
5					
6					
7					
8					
9					

General comments on Tile 1:

_____

_____

Tile 2 – Sampling sheet

Overlay the tile with the sample grid. Identify the dominant species within each of the sample squares. Record the dominant cover in each of these squares on the datasheet below. Record any additional species found within these squares as notes. Tally up the number of squares (each equating to 4% of area) that each species or cover type occupies on the tile and list them in the second table.

Sample square	Dominant cover – common name	Dominant cover – Latin name (if applicable	Co-Dominant cover – common name	Co-dominant cover – Latin name (if applicable)	Notes
1					
2					
3					
4					
5					
6					
7					
8					
9					

General comments on Tile 2:

_____

_____

Tile 3 – Sampling sheet

Overlay the tile with the sample grid. Identify the dominant species within each of the sample squares. Record the dominant cover in each of these squares on the datasheet below. Record any additional species found within these squares as notes. Tally up the number of squares (each equating to 4% of area) that each species or cover type occupies on the tile and list them in the second table.

Sample square	Dominant cover – common name	Dominant cover – Latin name (if applicable	Co-Dominant cover – common name	Co-dominant cover – Latin name (if applicable)	Notes
1					
2					
3					
4					
5					
6					
7					
8					
9					

General comments on Tile 3:

_____

_____

Tile 4 – Sampling sheet

Overlay the tile with the sample grid. Identify the dominant species within each of the sample squares. Record the dominant cover in each of these squares on the datasheet below. Record any additional species found within these squares as notes. Tally up the number of squares (each equating to 4% of area) that each species or cover type occupies on the tile and list them in the second table.

Sample square	Dominant cover – common name	Dominant cover – Latin name (if applicable	Co-Dominant cover – common name	Co-dominant cover – Latin name (if applicable)	Notes
1					
2					
3					
4					
5					
6					
7					
8					
9					

General comments on Tile 4:

_____

_____

Protocol 5. Water Quality Data Sheet

Instructions: This datasheet is used to record field metadata, water quality parameters and amount of sediment collected by the sediment trap attached to the Restoration Station.	
Name of site or water body	
Coordinates:	
Date of monitoring:	
Time of monitoring:	
Name of monitor(s): (names of group members)	
School or organization: (if applicable)	

1. Water Quality Parameters	*Take 3 measurements for each parameter. In the app, the drop-down menu will list the recommended method first.*				
Depth of Sample: _____					
Parameter	**Method**	**Results**			**Units**
Water Temperature					
Dissolved Oxygen					
Salinity					
pH					
Turbidity					
Nitrates					
Phosphates					
Ammonia					

2. Sediment Tube
Describe the appearance of the accumulated sediment on the outside of the sediment tube.
Smell (pick one): Earthy | Briny | Seaweed | Rotten Eggs | Dead Fish | Oil/Petroleum
Color (pick one): Light Brown/Sandy | Chocolate Brown | Chocolate Brown/Green | Brown/Black
Thickness (pick one): Grainy | Sticky | Runny | Claylike | Clumpy | Muddy
Organisms (circle all that apply): Crustaceans | Fish | Molluscs | Sponges | Tunicates | Worms | Other
Notes: