New York Harbor School HARBOR SEALs Citizen Science: Monitoring the Water Quality of the Upper New York Bay around Governors Island and Lower Manhattan

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Abstract

Industrial and domestic waste is the primary cause of poor water quality in the Upper New York Harbor, part of the Hudson River Estuary. The continuous discharge of pollutants into the Harbor over many years adversely affects commercially and ecosystemically valuable organisms that live in the Harbor and consequently the quality of life of the inhabitants of this geographically diverse area. Despite improvement of the water quality due to the Clean Water Act (1972) and the consequent waste reduction, there is still concern that contamination may threaten marine life in the Harbor (Revkin, 1995). In the present study we measured water quality parameters at 4 locations around the Battery in lower Manhattan to determine its suitability for eel grass and eastern oyster restoration as well as for recreational use. The parameters were dissolved oxygen, pH, temperature, phosphates, ammonia, salinity, nitrates, water currents, rain, and *Enterococcus* bacteria. We also addressed whether rain fall affects the levels of bacteria and ammonia in the water as well as the effects of currents on the parameters measured. Public outreach and environmental education efforts were also a key element to the project to promote environmental awareness.

By the conclusion of this study it was determined that rain fall was not enough of a predictor of *Enterococcus* and ammonia levels. However, *Enterococcus* levels were found to be three times larger during ebb tide (ebb= 23.7 MPN and flood= 8.3 MPN) and ammonia was one and a half times larger (ebb= 0.75 ppm and flood= 0.49 ppm). Average ammonia was found to be above the tolerance level for striped bass around Manhattan and Governors Island (Manhattan= 0.39 ppm and Governors Island= 1.08 ppm). Average dissolved oxygen readings

were found to be higher during colder months (9.2 ppm) than warmer months (7.6 ppm). Average salinity between ebb and flood were found to be nearly identical (ebb= 22.07 ppt and flood= 22.21 ppt). Average pH levels fell around 7.5. Temperature ranged from 1.0 to 24.3 Celsius. Nutrient levels (nitrate and phosphate) were low to moderately high.

Several public outreach events were held to present some of the project's results and promote environmental awareness. We had over 40 long term student volunteers work on the project over its duration. It is estimated that almost 20,000 people have been directly or indirectly reached through our work. On the winter of 2014-2015 several sightings of Harbor Seals were recorded which indicates that the water quality, food web, and general health of the Harbor is improving.

Introduction

Industrial waste in the Upper New York Harbor, part of the Hudson-Raritan Estuary, is the primary cause of poor water quality. The continuous discharge of pollutants into the Harbor over many years has adversely affected many of the organisms that live in the Harbor (Revkin, 1995). The Clean Water Act of 1972 was enacted to regulate the contamination of waterways by industrial waste and led to the significant improvement of the quality of American waterways such as the Upper New York Harbor. Despite improvement of the water quality due to waste reduction, there is still concern that contamination may threaten marine life in the Harbor (Revkin, 1995).

We responded to these considerations by creating a citizen science program to monitor these waters, keep track of the Harbor's improvement, and determine its viability as a habitat for the organisms living there for a period of approximately three years. Specifically, the objective of this project was to measure several parameters of water quality at four locations around Governor's Island and lower Manhattan. The measurements included standard water quality parameters (*e.g.* dissolved oxygen, pH, temperature, phosphates, ammonia, salinity, and nitrates); water currents; effect of rain on *Enterococcus* (fecal) bacteria; and the suitability of water for recreational use. We documented the water quality to give an account of potential improvement as the region expands its industry, technology, transportation and recreational opportunities. It was proposed that the amount of Enterococcus bacteria will be at dangerous levels after it rains because of the CSO pipes overflowing. We further hypothesized that the tides affect the quality

of the water. Once we obtained results, we initiated a series of public outreach events to promote our efforts and disseminate information on the state of the Upper New York Bay.

Background

Water quality data of the New York Harbor has been collected by New York City since 1909, slightly over 100 years (NYC DEP, 2007). The data have served to help monitor the ecological health of the New York Harbor over the years. Revkin (1995) determined that one of the main sources of contamination to the Harbor was untreated raw sewage, solid waste, and wastewater that was released in the Harbor without treatment, leading to the environmental degradation of the Harbor. Currently, the waters sampled in this project are affected by at least ten Tier 1 Combined Sewage Overflows (CSOs) that carry discharge water during ebb tide and only one during flood (NYC DEP, 2014). Needless to say, this adversely affects aquatic life and impacts human health. Data from 1909 shows that the levels of dissolved oxygen read as low as 2ppm, with fluctuations between 3ppm and 4ppm, which is unsustainable for marine life. These readings remained constant until 1968. There were many dead zones in the Harbor with dissolved oxygen readings as low as 2ppm. By 1952 eleven waste water treatment plants were in operation helping increase the oxygen levels to 4ppm. The readings gradually increased after the Clean Water Act was implemented in 1972, but it wasn't until the 1990's that the oxygen levels in the Harbor began to reach healthier levels of 7ppm (NYC DEP, 2014). During the period preceding the Clean Water Act, not surprisingly, bacteria levels were at an all time high with readings over 1000 (Counts/100mL). This allowed the fish population to begin to recover (NYC DEP, 2007). Environmental efforts, water monitoring programs, protective laws, and

stewardship of concerned citizens in this past century have led to the significant improvement and comeback of marine and wildlife to the Harbor. Despite these important gains, however, New York Harbor remains among the 20 most toxic estuaries in the country (NYC DEP, 2007). Its seabed is tainted with many heavy metals and other hazardous substances.

Crassostrea virginica, also known as the eastern oyster, is a native species to the New York Harbor. Oysters were once one of the most common food sources for New Yorkers (Nigro, 2011). However, by the beginning of the 20th century, the eastern oyster had all but disappeared from the region, and the few that remained were, and still remain, contaminated (Nigro, 2011). Oysters are considered a keystone species since they filter pollutants from the water, stabilizing the aquatic habitat for millions of other marine species. In fact, they can filter upwards of 50 gallons of water and pollutants found in it per day (Nigro, 2011). One such pollutant is excess nitrogen (Chesapeake Bay Foundation, 2014), which can cause destructive algae blooms that in turn cause fish kills. This makes oysters indispensable in our efforts to improve the quality of New York Harbor.

Oyster larvae and adults have two different sets of environmental tolerances. In general, larvae are more susceptible to changes in environmental levels. The optimal salinity for oyster larvae is 10-27 ppt and about 5-40 ppt for adults (Calabrese, 1970 in NOAA, 2007). The optimal temperature range for oysters to grow in is 20-30 degrees Celsius (Stanley, 1986 in NOAA, 2007). Oyster larvae need a pH of 6.75-8.75 to settle (Calabrese, 1996 in NOAA, 2007).

Eelgrass is a type of marine vegetation that has been nearly wiped off of North America, Europe, and Japan (Martinez, 2015). This is due to unnaturally high temperatures, over harvesting, and human activity such as dredging. Because of the unnaturally high temperatures,

eelgrass is susceptible to a marine slime mold called *Labyrinthula zostera* (Martinez, 2015). Like oysters, eelgrass is a potential keystone species that can help improve the water of the Hudson River. Eelgrass also creates food and shelter for other organisms. Because eelgrass has not been successfully bred in captivity, a quality that makes it even more vulnerable to extirpation than oysters, the only way to repopulate these sea grasses is to remediate its natural habitat by improving water quality.

Materials

Table 01- Materials list- Materials used in both the field and the lab.

Item	Function	Quantity
Dissolved Oxygen kit	Measure water quality with Winkler method	6
Reusable gloves	Used as Personal Protective Equipment in field	15
Test strips: pH, and nitrate (Aquachek)	Measure the respective parameters	10
Ammonia strips (Aquachek)	Measure ammonia	10
Phosphate strips (Aquachek)	Measure phosphate	10
Lens paper	Help clean sensitive materials	5
pH Storage solution	To store Hanna combo safely	1
Refractometer (Vital Sine-SR-6)	To measure salinity	6
Beta bottle	To receive water sample	3
Buckets	Used to receive surface water sample	2

Waterproof data tables	To record data	-
Thermometers	Used to measure water temperature	4
Hanna combo sensor	To read accurate pH and temperature	4
Stop watch	Time the test strip measurements	4
Incubator	Grow *Enterococcus*	1
YSI (Pro-Plus, Quatro 4)	Measure water parameters -pH -Dissolved Oxygen -Temperature -Salinity	4
pH standard solutions	Calibrate YSI and Hanna Combo	_
Waste containers	Dispose hazardous waste from field	4
Walkie-talkie (Motorola)	For communication	4
Turbidity Tube	Measures turbidity of the water	4
Enterolert	Used to measure	-

	Enterococcus bacteria	
Coolers	Used to carry materials to and from the field, including water samples	4
Photometer (YSI, 9500)	Used to measure water parameters such as ammonia and nitrites.	2

Procedures

Table 02- Project Design Chart.

Category	Entry
Scientific Problem:	What is the water quality of four sampling stations off of Governors Island and Lower Manhattan?
Hypothesis 01:	The salinity will be affected by the current direction.
Hypothesis 02:	Rain will affect the measurements of *Enterococcus* bacteria
Objective 01:	Collect water quality parameters at four stations off of Governors Island and Lower Manhattan.
Objective 02:	Determine the suitability of the water quality at the four sampling stations to sustain Atlantic oyster reefs and eel grass beds.
Objective 03:	Determine how tidal dynamics affect water quality parameters at the four sites.
Objective 04:	Educate community stakeholders and students about the water resources of the Hudson River Estuary and empower them to directly contribute to its study.

Locality-

Two sites were chosen at Governors Island and two on the southern tip of Manhattan. Station M1 (40.704738, -74.018953) on Lower Manhattan is located by Battery Park. This site is characterized by having a cement seawall and fast currents. Station M2 (40.704903, -74.003790), also on Lower Manhattan, is located on the East River off of Pier 15. This station is characterized by having busy ferry docks with boats that maintain full engine throttle while docked as opposed to tying up. Station G1 (40.690948, -74.021423) is located on the northwest side of Governors Island and is characterized with sea wall, rip rap and having strong water currents. Station G2 (40.691094, -74.012190) is located on the east of Governors Island off of

Pier 101. It is characterized by sea wall and docks with less boats docking and rip rap but vulnerable to large wakes from commercial and private vessels that pass along Buttermilk Channel. This station is also close to the Governors Island Oyster Reef. The following physical-chemical and biological water quality parameters were sampled on a monthly basis: pH, dissolved oxygen, temperature, salinity, nutrients, *Enterococcus* bacteria, and currents. These were chosen because they are proposed sites for restoration efforts (*e.g.* oyster bed and sea grass restoration) and in order to determine the dynamics and influence of the Hudson and East Rivers on the surrounding waters of Governors Island.

Figure 1- Locations of testing sites (M1, M2, G1, G2) in the Upper New York Bay. (Source: Google Earth,2013)

Measuring *Enterococcus*:

1. Collect sample using microbiological uncontaminated sampling equipment, Personal Protective Equipment (PPE) must be worn at all time. Periodically collect samples of sterile water
2. Dilute sample 1:10 with sterile water
3. Add premeasured media from Enterolert kit and dissolve
4. Pour sample into open end of enterolert tray, into waffle grid and seal tray
5. Incubate at 41°C for 24 hours
6. Examine wells using UV light, while wearing PPE
7. Look up Most Probable Number (MPN) on chart and multiply by dilution factor to get final MPN

Disinfecting after *Enterococcus* Sampling:

1. While wearing PPE, put Enterolert Quantitrays into special Biohazard Container with a solution of water and Clorox with a ratio of 6:1(i.e. 600 mL of water and 100mL of Clorox)
2. Using a skewer poke holes into wells on quanti trays and draining them out into water Clorox solution
3. Properly dispose of empty Quantitrays in their own bio-hazardous waste bag

Measuring Salinity with Refractometer:

1. Open daylight plate, and with pipette put drops of sample on the surface of the prism
2. Gently close daylight plate, hold the prism towards the light
3. Look though eyepiece

4. When the refractometer scale is leveled through the eye piece the reading will be taken when the point of the boundary between the blue and white field crosses the scale
5. Clean using Ro/Di water and lens paper

Measuring Temperature with Calibrated Thermometer:

1. Using a calibrated thermometer, temperature in Degrees Celsius will be measured
2. Once the sample is brought up, place thermometer with protective cylinder in bucket
3. Wait approximately 1 minute before taking the thermometer out of the water
4. Unscrew the cylinder and take reading
5. Add data to data table
6. Rinse off the thermometer completely with RO/DI water and re-screw the cylinder

Measuring Dissolved Oxygen, Winkler Method:

1. Rinse sample bottle
2. Tightly cap bottle outside of water
3. Place water sampling bottle under water and remove cap
4. Remove any air bubbles, and cap bottle while it is in water; remove bottle from water
5. Remove cap from bottle, add 8 drops of manganese sulfates
6. Add 8 drops of alkaline potassium iodine
7. Cap bottle and mix by inverting several times, a precipitate will form
8. Allow precipitate to settle
9. Add 8 drops of sulfuric acid
10. Fill titration tube to 20 mL line, cap tube
11. Add sodium Thiosulfate into plunger until the large ring reaches 0 on the scale

12. Insert tip of plunger into titration tube, slowly depress the plunger until solution turns pale yellow
13. Carefully remove plunger and cap, and add 8 drops of starch indicator
14. Cap the titration tube, titrate until blue color disappears
15. Read the test results where the large ring in the titrator meets the titrator barrel

Measuring pH and Nitrate using Pond Test Strips (Aquachek):

1. Remove one strip from the bottle and close bottle tightly
2. Dip test strip in water for 1 second
3. Hold strip for 30 seconds
4. Compare the color of the end of strip to pH color on bottle
5. After 60 seconds compare the pad nearest the handle to the nitrate color chart on the bottle

Measuring Ammonia with Pond Test Strips (Aquachek):

1. Remove a test strip from the ammonia test strip bottle and close bottle tightly
2. Fill sample vile to top line with water
3. Dip test strip into sample vile and move strip vigorously up and down for 30 seconds, make sure both pads are completely submerged
4. Remove test strips and shake off access water hold strip level pad side up
5. To read results, turn strip over so that both pads are facing away from you; compare the color of the pad to the ammonia color chart on bottle

Measuring Phosphate with Pond Test Strips (Aquachek):

1. Dip strip into water for 5 seconds and remove

2. Hold strip level, pad side up, for 45 seconds. Do not shake excess water from the test strips
3. Compare the phosphate test pas to the color pad on the color chart on bottle

Determining Data Reconciliation:

Precision - Duplicate samples of all physical and chemical samples were taken in the field at all four sampling stations during each sampling event. A subset of parameters were measured *in situ* and another subset that could not be measured *in situ* were taken to the lab for processing. Biological samples (*i.e. Enterococcus*) were not duplicated due to the less than favorable trade-off between reproducibility and cost effectiveness of this method.

In order for the data to be considered for analysis, each parameter had to be measured twice on a given sampling event, and the readings would need to agree with a given value of precision. Those values can be found in Table 03.

Table 03- Parameter precision table to determine data reconciliation.

PARAMETER	PRECISION	PARAMETER	PRECISION
Salinity (YSI Pro Plus + 600 OMS)	± 0.1 ppt	Salinity (Refractometer)	± 1.0 ppt
Temperature (YSI Pro Plus + 600 OMS)	± 0.1 °C	Temperature (Thermometer)	± 1.0 °C
Dissolved Oxygen (YSI Pro Plus + 600 OMS)	± 0.5 ppm	Dissolved Oxygen (Mod. Winkler)	± 1.0 ppm
pH (YSI Pro Plus)	± 0.1 units	pH (Test strips)	± 0.6 units
Ammonia (YSI 9500)	± 0.25 ppm	Ammonia (Test strips)	± 0.5 ppm
Phosphate (YSI 9500)	± 0.25 ppm	Phosphate (Test strips)	± 1.0 ppm
Nitrate (YSI 9500)	± 0.25 ppm	Nitrate (Test strips)	± 1.0 ppm

Procedure for Data Analysis:

After determining the data reconciliation, the data were separated by parameters and the average, range, and standard deviation were calculated. Spearman correlations were calculated for various parameters (*i.e.* temperature and dissolved oxygen, rain fall and ammonia levels, and rain fall and *Enterococcus* levels). Parameters were also compared based on tidal dynamics, ebb tides and flood tides were compared, as well as cold months and warm months. Sampling stations were grouped to compare larger geographic regions (*i.e.* Manhattan and Governors Island, and East and West of the Battery) as well as cold and warm months.

Using Existing Data:

Existing data were used from the National Weather Service - Central Park Location for regional precipitation to determine if there's a relationship between *Enterococcus* levels and precipitation.

Safety-

Biological Safety Level II guidelines were adhered to for *Enterococcus* bacteria which was measured in the lab. Personal Protective Equipment was used in the field and the lab. Corrosive material such as sulfuric acid was used in dissolved oxygen kit.

Results

There was a strong negative correlation between dissolved oxygen and temperature (fig. 01; Spearman -0.604). As temperature increases dissolved oxygen decreases. Ammonia and rain fall had a weak correlation (fig. 02; Spearman 0.134). The graph of Figure 03 shows a weak correlation (Spearman 0.279) between *Enterococcus* bacteria and rain fall during the sampling events. There was no significant difference between the pH of Governors Island and Manhattan (table 04; fig. 04). The average pH recorded was a pH of 7.36 for Governors Island and a pH of 7.39 in Manhattan. The average yearly water temperature was taken for the two sets: Manhattan vs. Governors Island (table 04; fig. 05) and East vs. West (table 04; fig. 07). There was little to no difference in the temperature for both sets of data. The ammonia level from Governors Island was lower than that of Manhattan (table 04; fig.8).

Table 04- Mean and Range of Specific Parameters Measured in the Upper New York Bay, 2012 - 2015.

	Mean (Range)					
Parameter	**Battery West**	**Battery East**	**Manhattan**	**Governors Island**	**Cold Months**	**Warm Months**
pH	7.6 (6.8 – 8.19)	7.6 (6.4 – 8.3)	7.4 (6.2 – 8.3)	7.5 (6.2 – 9.6)	n/a	n/a
Dissolved Oxygen (ppm)	9.5 (6.6 – 14.0)	8.3 (5.0 – 12.5)	9.1 (6.6 – 12.0)	8.6 (5.0 – 14.0)	9.2 (5.0 – 14.0)	7.6 (5.0 – 10.0)
Temperature (°C)	8.7 (1.9 – 24.3)	9.4 (1.0 – 22.8)	7.3 (1.0 – 19.2)	6.3 (1.8 – 19.0)	n/a	n/a
Salinity (ppt)	18 (5 – 28)	21 (10 – 28)	21 (9 – 28)	19 (10 – 27)	n/a	n/a
Ammonia (ppm)	0.71 (0.25 – 5.00)	0.61 (0.00 – 3.00)	1.08 (0.00 – 3.00)	0.39 (0.00 – 0.50)	n/a	n/a
Nitrate (ppm)	2 (0 – 20)	5 (0 – 20)	2 (0 – 20)	5 (0 – 20)	n/a	n/a
Phosphate (ppm)	7 (5 – 30)	8 (5 – 30)	9 (5 – 30)	7 (5 – 30)	n/a	n/a

There was no significant difference in average ammonia readings between the East and West (table 04; fig.9). There was no significant difference between the salinity of the four different sampling sites (fig.13 and fig.14). Furthermore, salinity of ebb tide was nearly the same as flood tide (avg. of 23 and 22 ppt respectively; table 05). *Enterococcus* was found to be three times greater during ebb tide (table 05). Also, ammonia levels were found to be one and a half times higher during ebb tide (table 05).

Table 05- Mean and range of Specific Parameters during Ebb and Flood Tide Measured in the Upper New York Bay, 2012 - 2015.

	Mean (Range)	
Parameter	**Ebb**	**Flood**
Salinity (ppt)	23 (10 – 30)	22 (5 – 28)
Enterococcus (MPN)	23.7 (0.0 – 94.5)	8.3 (0.0 – 45.3)
Ammonia (ppm)	0.75 (0.00 – 5.00)	0.49 (0.00 – 1.00)

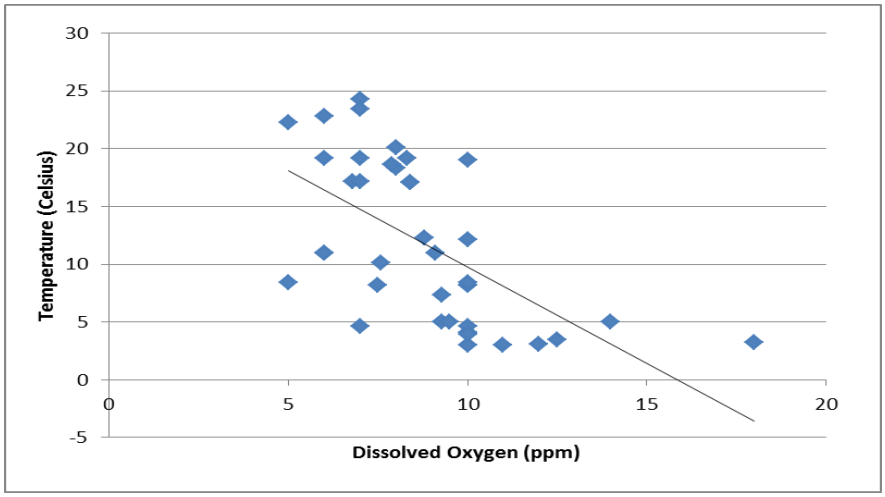

Figure 01- Correlation between temperature and dissolved oxygen in the Upper New York Bay of subsurface water from February 2013 to June 2014- Graph shows the correlation between dissolved oxygen and temperature. Spearman, R, is equivalent to -0.604.

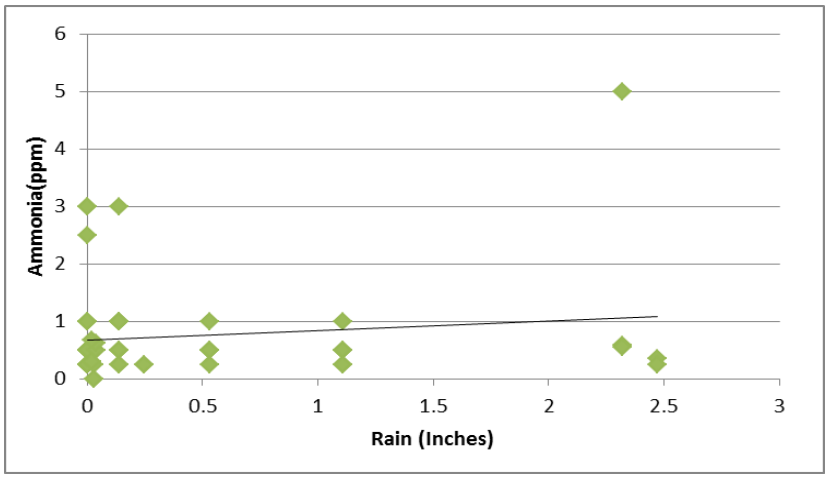

Figure 02- Correlation between ammonia and rainfall in the Upper New York Bay of subsurface water from February 2013 to June 2014- this graph shows the correlation between ammonia and rain. Spearman, R, equals, 0.134, which is very low.

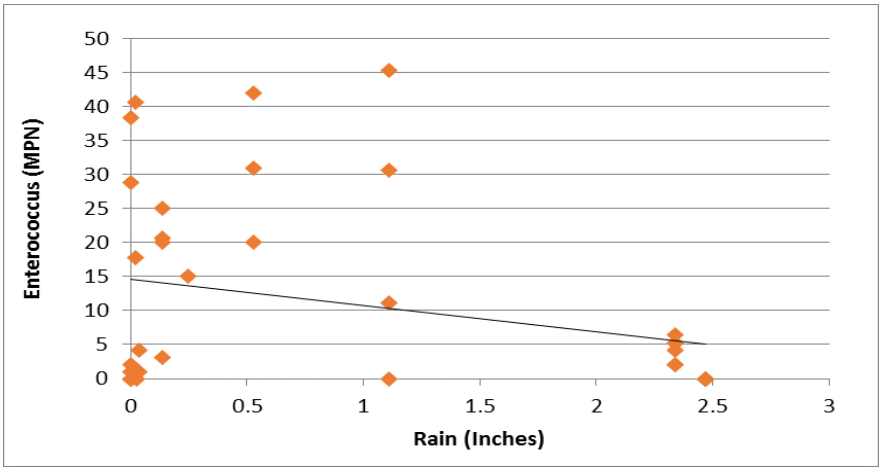

Figure 03- Correlation between *Enterococcus* and rain in the Upper New York Bay of subsurface water from February 2013 to June 2014- The relationship between rain data and *Enterococcus* bacteria (MPN) is shown in the above scatterplot. Spearman, R, is equal to 0.279

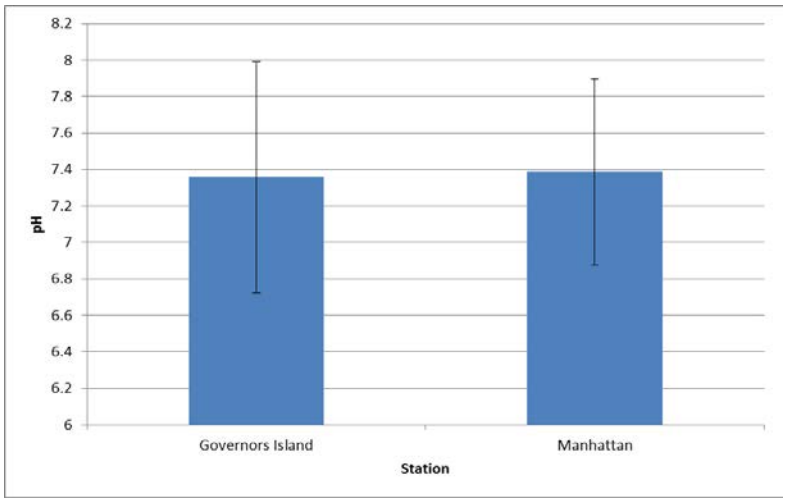

Figure 04- Compared average pH of Governors Island and Manhattan in the Upper New York Bay of subsurface water from February 2013 to March 2015- Compared average pH data of Governors Island and Manhattan. The pH of Governors Island is 7.4 with a standard deviation of 0.633 and the pH of Manhattan has pH 7.4 with a standard deviation of 0.509.

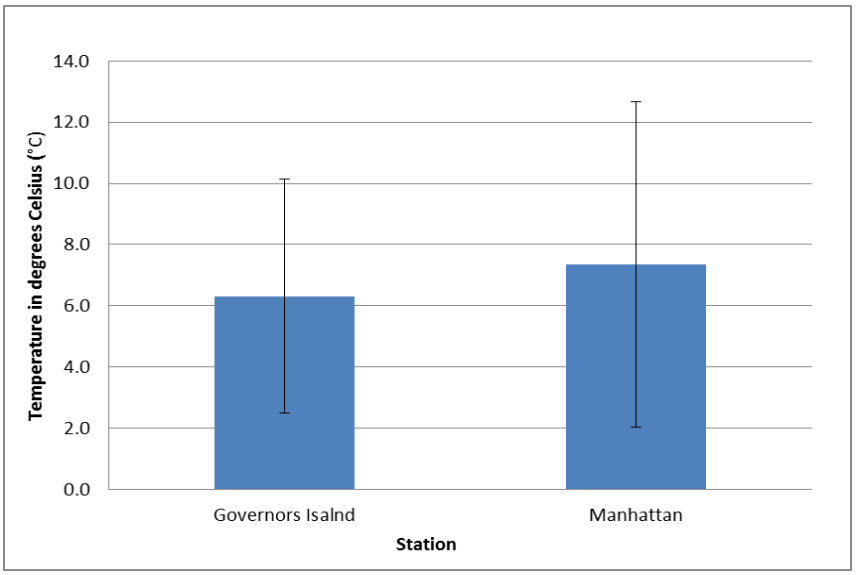

Figure 05- Compared average temperature of Governors Island and Manhattan in the Upper New York Bay of subsurface water from February 2013 to March 2015- The average temperature of Governors Island and Manhattan are shown above. Governors Island has an average yearly temperature 6.3° Celsius with a standard deviation of 3.825. Manhattan has an average water temperature of 7.3° Celsius with a standard deviation of 5.312.

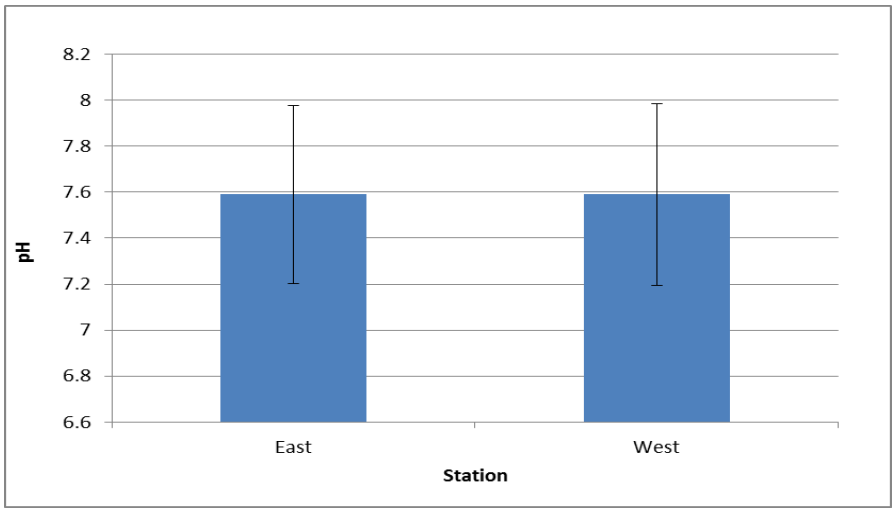

Figure 06 – Compared average pH of East and West in the Upper New York Bay of subsurface water from February 2013 to March 2015- The bar graph compares the average pH between the east sites and the west sites. The error bars show plus or minus one standard deviation. The pH of East and West are 7.590 and 7.590, respectfully. The standard deviation is 0.387

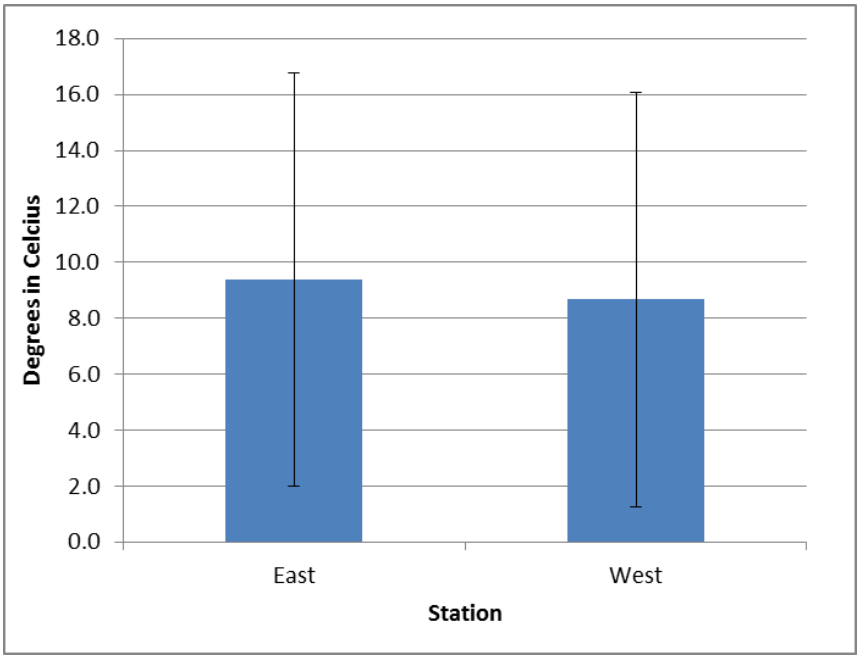

Figure 07- Compared average temperature of the East and West of the Upper New York Bay of subsurface water from February 2013 to March 2015- The graph shows the temperature of the two Western sites and the two eastern sites.

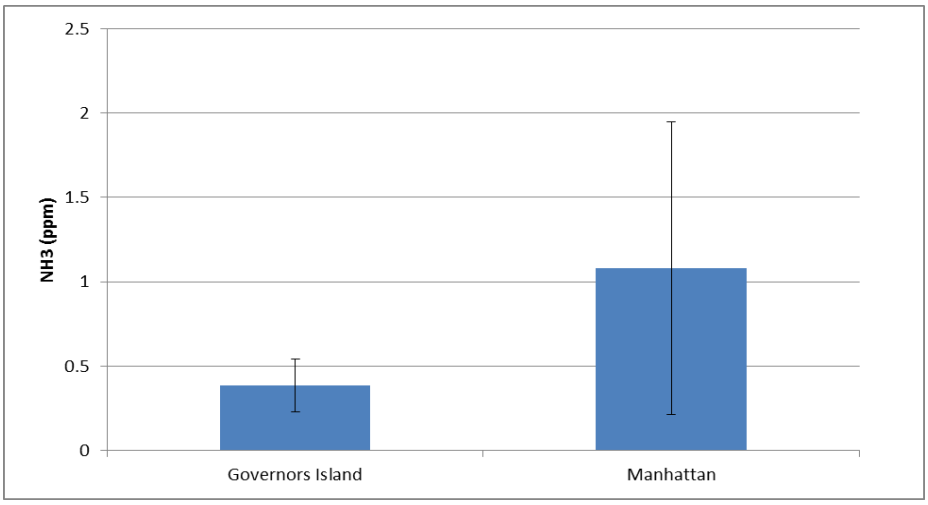

Figure 08- Compared average ammonia in the Upper New York Bay of Governors Island and Manhattan of subsurface water from February 2013 to March 2015 - The graph shows the average ammonia in Governors Island (0.387) compared to that of Manhattan (1.08). The standard deviation for GI is 0.156 and the standard deviation for Manhattan is 0.865.

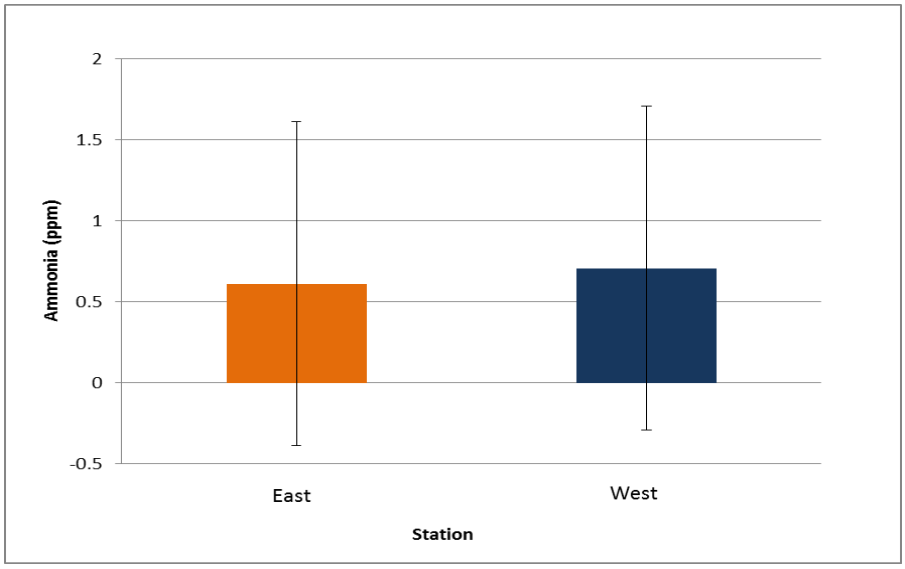

Figure 09- Compared average ammonia of East and West in the Upper New York Bay of subsurface water from February 2013 to March 2015- The graph shows the average ammonia of the two eastern sites compared with the average ammonia of the two western sites. The average ammonia of the east was 0.613 ppm with a standard deviation of 0.656. The average ammonnia of the west was 0.708 with a standard deviation of 0.867.

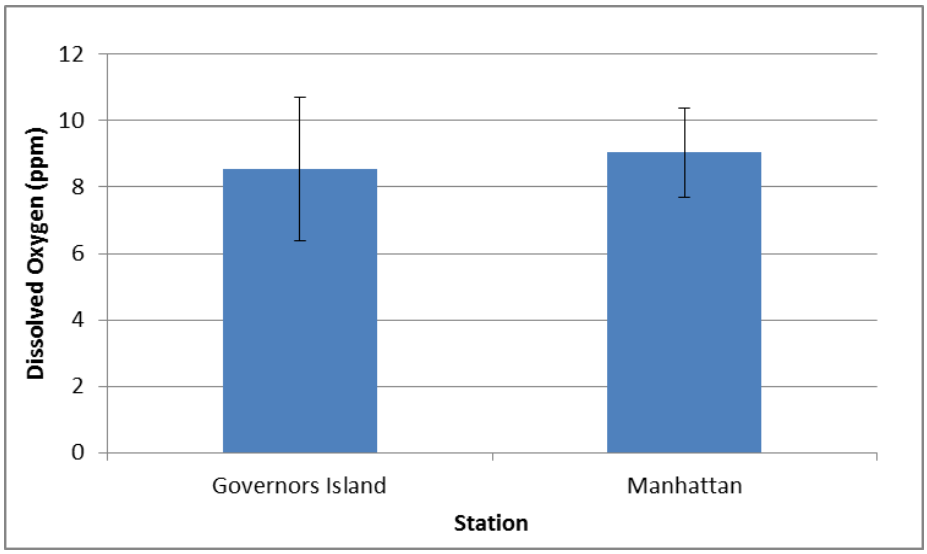

Figure 10- Compared average dissolved oxygen of Governors Island and Manhattan in the Upper New York Bay of subsurface water from February 2013 to March 2015- The graph shows the average dissolved oxygen within 2 sets measured in PPM. The average DO of Governors Island is 8.6 with a standard deviation of 2.162. The DO of Manhattan is 9.1 with a standard deviation of 1.344.

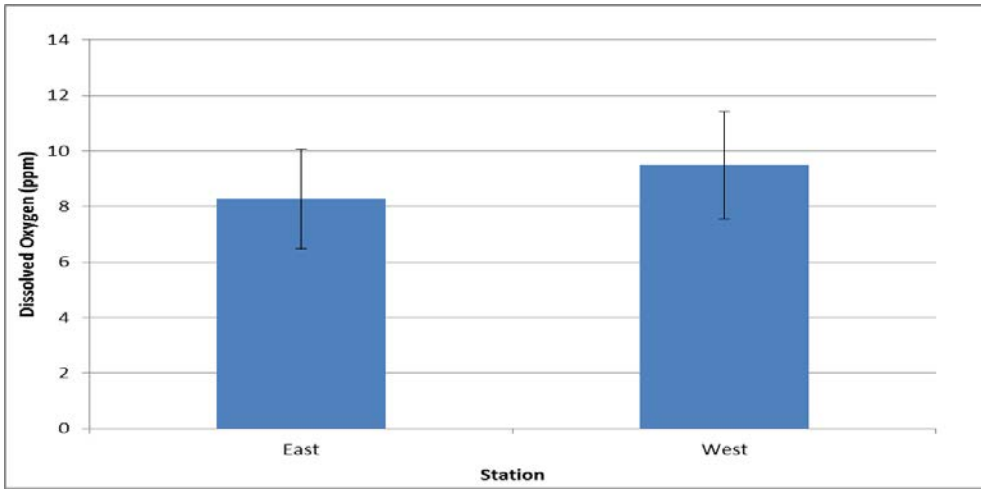

Figure 11- Compared average dissolved oxygen of East and West in the Upper New York Bay of subsurface water from February 2013 to March 2015- The graph shows the average Dissolved Oxygen of East and West. The DO of the east was 8.3 with a standard deviation of 1.800. The DO of the west was 9.5 with a standard deviation of 1.939.

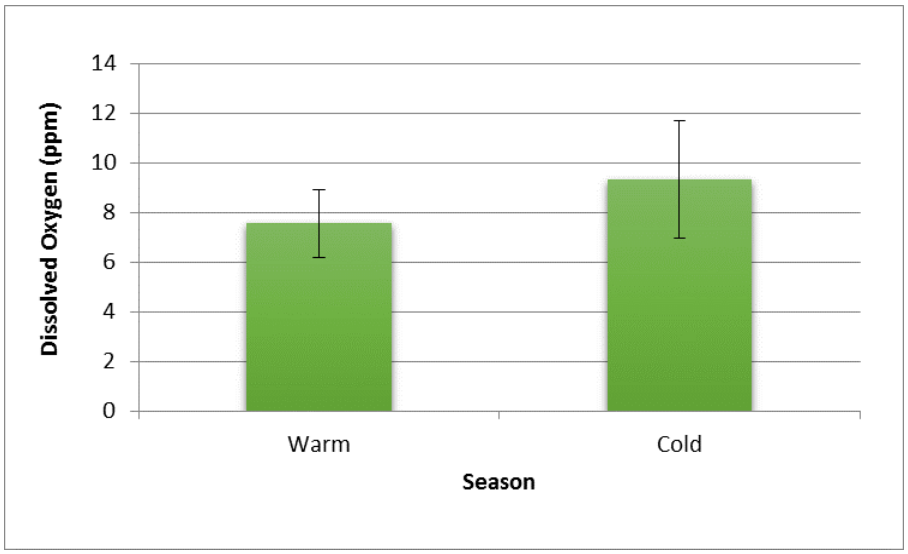

Figure 12- Compared average dissolved oxygen of cold moths and warm months in the Upper New York Bay of subsurface water from February 2013 to March 2015- The DO was compared between warmer months (7.6 ppm) which we defined as being from June to October and colder months (9.2 ppm) which we defined as being from December to May.

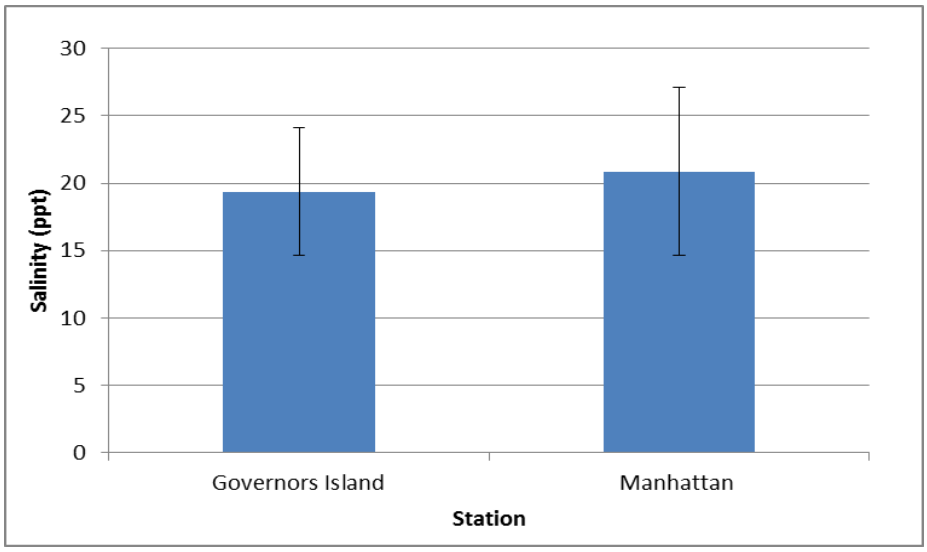

Figure 13- Compared average salinity of Governors Island and Manhattan in the Upper New York Bay of subsurface water from February 2013 to March 2015- The graph shows the salinity of Governors Island and Mannhattan. Manhattan has a salinity of 20.857 ppt with a standard deviation of 6.228. Governors Island has a salinity of 19.366 ppt with a standard deviation of 4.718.

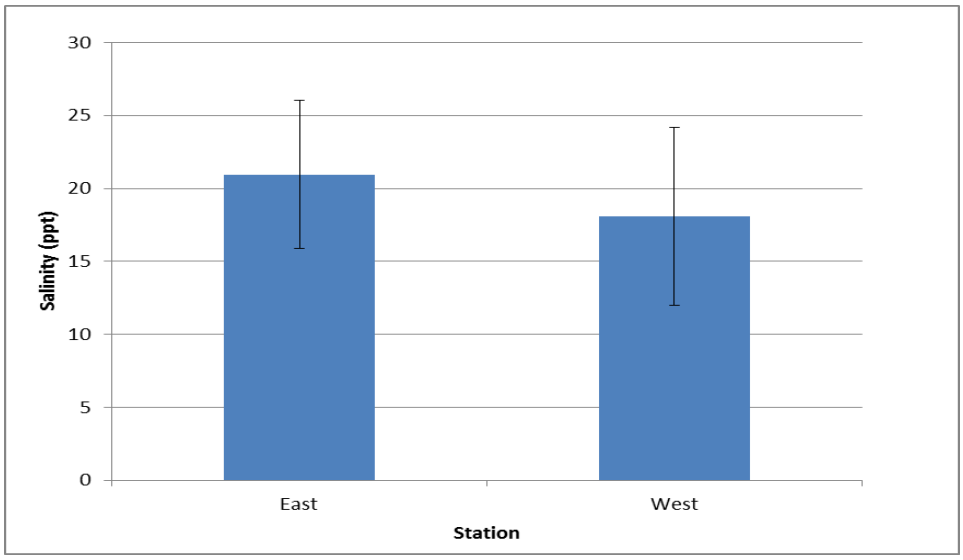

Figure 14- Compared averae salinity (ppt) of East and West in the Upper New York Bay of subsurface water from February 2013 to March 2015- the bar graph shows differences in salinity between the two eastern sites and the two western sites. The east had a salinity of 20.966 ppt with a standard deviation of 5.084. The west had a salinity of 18.071 ppt with a standard deviation of 6.103.

Figure 15- The sighting of a Harbor Seal. This shows the improvement of the water quality of the Hudson River**.** This seal which was spotted in Pier 101 is a sign that our efforts of restoration are paying off. Fish are coming back to harbor which can support these great predators of the estuary. Credit: Katelyn Fong, 2015

Analysis

Dissolved Oxygen:

In figures 01 and 12, it can be seen that the colder months have higher levels of DO than the warmer months. For pure water, a negative correlation between dissolved oxygen (DO) and temperature occurs because lower temperatures hold higher amounts of dissolved oxygen (Wetzel, 2001). The DO for Manhattan and GI as well as for the east and west sides of the Battery show no significant difference and fall within acceptable levels for oysters and eel grass.

Ammonia:

Because rain makes CSOs overflow it was hypothesized that ammonia would be higher after it rained. Ammonia remained above 0.25 ppm no matter the rain fall. Unfortunately, anything measurement higher than 0.25 ppm is considered toxic and is not healthy for organisms (Environmental Test Systems Inc., 1998). Because test strips were used and in order to determine whether there was a limitation to the precision and accuracy of our data, a YSI photometer was also used. Unfortunately again, the ammonia levels were still slightly above 0.25 ppm.

Our data suggest that rainfall does not affect ammonia levels, but that instead, tidal stages do. The average ammonia during ebb tide was 0.8 ppm and flood tide was 0.5 ppm. Ammonia levels below 0.25 ppm were only recorded once. On sampling day 19, M2 recorded ammonia levels of 0.00 for two replicates. The ammonia from Governors Island is significantly lower than that of Manhattan. This might be due to CSOs discharging into the area of the sample sites. The average ammonia was in toxic levels as they were higher than 0.25 ppm for both Governors

Island and Manhattan. Average ammonia compared between east (0.61 ppm) and west (0.71 ppm) of the Battery was similar.

***Enterococcus*:**

Even without rain prior to the sampling day, *Enterococcus* bacteria were still present in the water. It was expected that *Enterococcus* bacteria would be higher after it rained because CSOs overflow and raw sewage is released into the water which, should have made *Enterococcus* bacteria levels much higher. Our data show that *Enterococcus* may not be affected by rain. This is supported by Citizen Testing Data (Riverkeeper, 2015). Rather, our data suggests that *Enterococcus* is affected by current. The average *Enterococcus* MPN during ebb was 23.7 and flood was 8.3. This may be due to most CSOs being located north of our sampling sites, and during ebb the river may be carrying discharge water from them. Ammonia was higher during ebb tide as stated above, which further supports this assertion.

pH:

After calculating standard deviation, the data show that there is no significant difference in the pH of the water between Manhattan and Governors Island. Both sites have a suitable pH for oyster and eel grass growth and recruitment. Oyster larvae need a pH between 6.75-8.75 (Calabrese, 1996 in NOAA, 2007). However, adult oysters are less sensitive to changes in the pH. Additionally, figure 06 show that the pH on the two western sites has no significant difference with sites on the eastern sites. This data also falls in the optimal pH range for oyster larvae.

Temperature:

The average temperature for Governors Island, Manhattan, East Sites, and the west sites are 6.3, 7.3, 9.4, and 8,7; respectively. The optimal temperature for the growth of adult oysters is 20° - 30° Celsius (Stanley, 1986 in NOAA, 2007). The four mean values were all much lower than this. Although most of the data was collected in the colder months of the year when school is in full session, the summer temperatures fall within the optimal temperature.

Salinity:

In Manhattan and Governors Island, the average salinities are suitable for both the larvae of oysters and adult oysters. The tolerance levels for larvae 10 ppt – 27 ppt while the tolerance level for adults is about 5 ppt to 40 ppt (Davis, 1970 in NOAA, 2007). The salinity in the Hudson River Estuary can support healthy oyster and eel grass growth.

Public Outreach, Harbor Seals, and the Improving New York Harbor

The Harbor Sea, Estuary, Air, and Land (SEALs) have participated in public outreach through City of Water Day for two years. At these event, our volunteers had exposure to roughly 750 people. Volunteers were able to talk to people about the health of the Harbor, their efforts to monitor the water quality, and the importance of its restoration. During the Harbor School Marine Science Symposium, volunteers were also able to talk to the public about the school's research program as well as the health of the Harbor. Additionally, volunteers were invited to present their work at Omega Center's "Where Do We Go from Here?" annual conference in Rhinebeck, New York, and at the North Eastern Aquaculture Conference in Portland, Maine.

These opportunities were valuable efforts in further educating the public about the Harbor SEAL's research results, the Harbor's natural resources, and its restoration. In total, it is estimated that over 1000 people were directly engaged. Volunteers also created a website (www.harborseals.org) where results are posted and a blog of their work is maintained. As of June 30, 2015 over 13,720 hits have been recorded. Additionally, we had over 40 long term student volunteers work on the project over its duration. In total, we estimate that we have reached almost 20,000 people directly and indirectly.

During the winter of 2014-2015 several sightings of Harbor Seals were recorded which indirectly indicates that the water quality, food web, and general health of the Harbor is improving, as these are top level consumers.

Conclusions

The original hypothesis of the research study was not supported, as rain did not increase the measurements of *Enterococcus* bacteria. Based on the data collected, the amount of *Enterococcus* bacteria is lower when it rains (but not significant). A stronger relationship between *Enterococcus* and rain might have existed, however, because the Enterolert that was used for measuring the *Enterococcus* was expired, and thus accurate data could not be guaranteed. Also, sometimes expired test strips were used, which could have affected ammonia data.

Salinity did not appear to be affected by the current direction. Average salinity during ebb and flood were found to be nearly identical (ebb= 22.07 ppt and flood= 22.21 ppt). If there was more data available, perhaps a correlation between salinity and current might have been noticed, but for the time being no correlation has been detected.

For oysters and seagrasses, the water quality data obtained show that the water parameters were within tolerance levels except for ammonia. The average ammonia was found to be higher than tolerance levels for striped bass. The average ammonia levels in Manhattan were abnormally high at 1.08 ppm, while Governors Island average is 0.39 ppm. Tidal dynamics seem to affect ammonia and *Enterococcus* levels, not salinity, as was originally hypothesized. *Enterococcus* levels were found to be three times larger during ebb tide (ebb= 23.7 MPN and flood= 8.3 MPN) and ammonia was one and a half times larger (ebb= 0.75 ppm and flood= 0.49 ppm). Rain fall was not a strong predictor of *Enterococcus* and ammonia levels.

Dissolved oxygen appeared to not vary depending on location as much as it did depending on the season. The average dissolved oxygen around Manhattan (9.1 ppm) and Governors Island (8.6 ppm) and east (8.3 ppm) and west (9.5 ppm) was relatively the same. Average dissolved oxygen readings were found to be higher during colder months (9.2 ppm) than warmer months (7.6 ppm).

Water quality parameters were measured in three stations instead of four for approximately eight months due to construction on Governors Island. The fourth station that was not included for this period of time was Governors Island station (G1). However, for the final few sampling events, we were able to sample there as construction had ceased. Toward the end of the project, the Harbor SEALs were able to train new student volunteers more thoroughly, and as a result data measurements became more accurate and precise.

The Harbor SEALs were able to reach out to the public through City of Water Day, the Harbor School Marine Science Symposium, the Omega Conference in Rhinebeck, New York, the North Eastern Aquaculture Conference in Portland, Maine, our Website (www.harborseals.org) and other venues (See Annex B below). We estimate that we have reached almost 20,000 people directly and indirectly.

During the winter of 2014-2015 several sightings of Harbor Seals were recorded, which indirectly indicates that the water quality, food web, and general health of the Harbor is improving as these are top level consumers.

Suggestion for Future Research

1. Do currents affect *Enterococcus* and ammonia levels more than rain events at the Battery?

2. What are the glyphosate levels in the Upper New York Bay and how does it affect eelgrass and oyster populations?

3. Do CSOs along the Hudson River bring down waste during ebb tide and affect *Enterococcus* levels at the Battery?

4. What are the specific sources of nitrates detected at Buttermilk Channel?

5. What are the specific sources of ammonia coming from the Hudson down to the battery?

6. How does the strength of currents, boat traffic, and rainfall affect turbidity levels?

7. What is the difference between subsurface water quality and deep water?

Suggestion for Improvement

The experiment could be improved if there were more student volunteers that consistently showed up every week and participated in gathering data precisely and accurately. Because of time constraints, some of the data gathered was not accurate or precise. Also, if more time had been dedicated to training student volunteers thoroughly, data collection and analysis could have gone more smoothly. Another improvement would be to sample rain and *Enterococcus* on different parts of the Hudson River to better understand if there is a correlation between them. Furthermore, more historical data should be collected to compare with data gathered during the study. Also, instruments should have been calibrated before every sampling day. Materials should have been checked more regularly to prevent using them past expiration. A person should have been assigned to take inventory every month to avoid this issue. Wind speed and wind direction should have been recorded to see how they affect the current. Lastly, in order to work on a project with volunteers, they must be taught the importance of accuracy and precision.

Acknowledgements

I would like to express the deepest appreciation to all the student volunteers that helped with this project. I would like to personally thank Rachel Anderson for organizing all of our activities and helping organize all the newer volunteers. I would also like to thank Averille Ramos for stepping up during the last year of the Harbor SEALs as our data quality assurance officer. I am grateful to Tahirah Abdo for stepping up and being a leader that everyone can look up to. I would like to thank Andrew Sommer for helping me organize the data we collected and helping to complete the final report. I would also like to thank Jade Gonzalez for all her help, she stepped up and helped whenever she was needed and was a very important team member. I would also like to personally thank all the younger and newer student volunteers; they had to learn a lot, as well as go out into the field when it was freezing cold or raining. This project would not have been able to be completed without them. I would also like to personally thank the lab techs Kieron Achee and Jelani Wiltshire for calibrating our instruments and preparing our gear so we could sample both in the field and in the lab. I would like to thank Mauricio Gonzalez and Dr. Michael Judge for giving us the knowledge we needed to pass onto the newer student volunteers. In particular, I would like to thank Mr. Gonzalez for guiding me these last three year, I have learned a lot from him and he provided proper guidance for completing this project. I thank Anita Morawski for editing the final version of this report. Lastly, I would like to thank the New York Harbor School and the New York Harbor Foundation for all their help and support getting this project off the ground.

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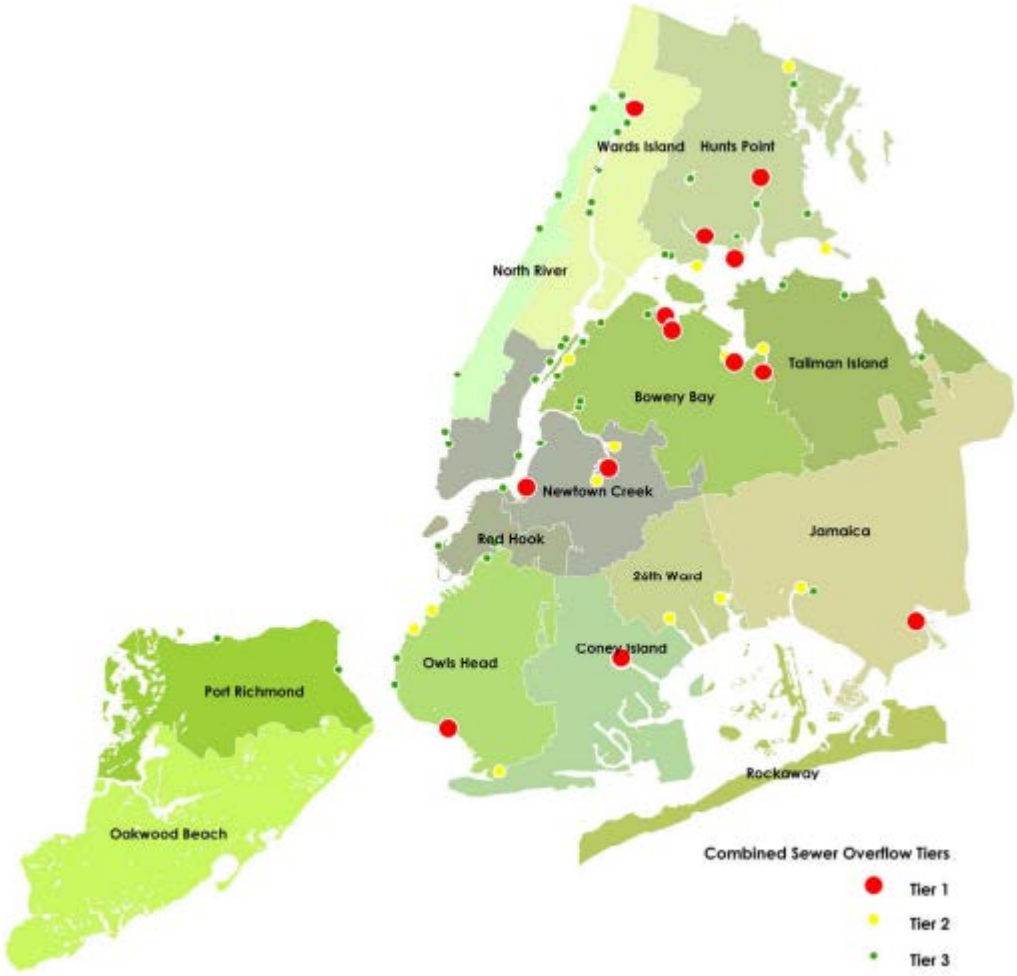
Appendices

Appendix A: Combined Sewer Overflows (CSOs) in New York City



Annex A- Combined Sewer Overflows (CSOs) in New York City Area (NYC DEP, 2014)

Appendix B: Public Outreach

There have been various venues at which the Harbor SEALs have been able to reach large numbers of people. SEALs reached out to the New York City public at City of Water Day two years in a row. At these events our volunteers were able to reach over 750 people. SEALs presented their research to visitors at the Harbor School Science Symposiums, which included a group of over 30 visitors from Denmark. SEALs also presented their work to over 300 people in attendance at the Omega Institute's "Where Do We Go from Here" conference in October 2014, and were workshop presenters at the North Eastern Aquaculture Conference in Portland, Maine in January 2015. Finally, the SEALs volunteer data manager, Violeta Gonzalez, was invited to present her research at a national conference in Washington DC hosted by the AFL-CIO, at which Vice President Joe Biden and other prominent government officials were in attendance. The content of these workshops and presentations was primarily the health of the Harbor as indicated by the data collected during the course of the research study. Flyers and posters available for viewing, as well as hands-on water quality testing.

The data collected for this project can be viewed by the public and is found in the following link: http://tinyurl.com/om28rml

This report can be found online in the following link: http://harborseals.org/seals/

Appendix C: Data Reconciliation Results and Associated Recommendations/Limitations

Over the course of three years, the Harbor SEALs met at least once a week to collect water samples from the field and measure parameters in the lab. Unfortunately the program has had some setbacks such as:

1. Not having enough student volunteers that consistently show up every week.
2. The precision of the data was not always of the highest quality.
3. Training new recruits was challenging because not all the volunteer members understood the importance of precision.
4. Time constraints created by the school and ferry schedules made field sampling and lab measurements challenging.
5. Due to school events, some sampling days had to be cancelled.

Some solutions to these problems are:

1. The SEALs will have 30 minutes longer to sample which should make more of our data usable.
2. This year more time has been spent training new recruits than previously, which should improve the acquisition of quality data.
3. This year the veteran volunteers created a volunteer recruitment criteria list to help pick students that will be more dedicated to the program. This should increase the likelihood that they will show up every Wednesday.

4. The new student volunteers will be given extra training in precision to learn its importance.
5. Finally, SEALs will discuss the data we get and review it to see how precise it is before putting it on the website.

Appendix D: Calibration Records

Table 04- This table shows the calibration of instruments on a given day as well as the parameters being calibrated and the initials of those who calibrated the instruments.

Date	Instrument Model	Reference Number	Parameter	Initials
131018	H.C.S HI98129	A1	pH	V.G
131008	H.C.S HI98129	A2	pH	V.G
131022	H.C.S HI98129	A1	pH	K.A
131022	H.C.S HI98129	A2	pH	K.A
140204	YSI Model 556	G2	D.O./pH	K.A
140204	YSI Model 556	M1	D.O./pH	A.R
140204	YSI Model 556	M2	D.O./pH	J.W
140304	YSI Model 556	M2	pH	G.C
140304	H.C.S HI98129	A1	pH	T.A
140317	YSI Model 556	G2	pH	K.A
140317	YSI Model 556	M2	pH	K.A
140317	YSI Model 556	M1	pH	J.W
140517	YSI Model 556	M1	D.O./pH/E.C.	J.G
140517	YSI Model 556	M2	D.O./pH/E.C.	T.A
140517	YSI Model 556	G2	D.O./pH/E.C.	V.G
140520	H.C.S HI98129	A1	pH	V.G
140520	H.C.S HI98129	M1	pH	J.G

140520	H.C.S HI98129	M2	pH	J.G
141008	H.C.S HI98129	A1	pH	J.G
141008	H.C.S HI98129	M2	pH	J.G
141008	H.C.S HI98129	G2	pH	J.G
141008	H.C.S HI98129	G1	pH	J.G
141203	H.C.S HI98129	M1	D.O./pH	J.W
141203	H.C.S HI98129	M2	D.O./pH	J.W
141203	H.C.S HI98129	G1	D.O./pH	J.W
150114	H.C.S HI98129	M1	D.O./pH	J.W
150114	H.C.S HI98129	M2	D.O./pH	J.W
150114	H.C.S HI98129	G1	D.O./pH	J.W
150204	H.C.S HI98129	M1	D.O./pH	J.W
150204	H.C.S HI98129	M2	D.O./pH	J.W
150204	H.C.S HI98129	G1	D.O./pH	J.W
150304	H.C.S HI98129	M1	D.O./pH	J.W
150304	H.C.S HI98129	M2	D.O./pH	J.W
150304	H.C.S HI98129	G1	D.O./pH	J.W
150325	H.C.S HI98129	M1	D.O./pH	J.W
150325	H.C.S HI98129	M2	D.O./pH	J.W
150325	H.C.S HI98129	G1	D.O./pH	J.W

Appendix E: Quality Control Sample Records

Blanks were only possible for *Enterococcus* until June of 2014 when we ran out of IDEXX Enterolert test kits. Nutrient blanks were started during November of 2014 because it wasn't until then that we had the capacity to train a quality assurance volunteer. All of our blanks always tested negative for *Enterococcus* and all nutrients.

Table 05- Quality control table for nutrients and *Enterococcus*.

Date (yymmdd)	Vile Number	Notes:	Initial
130206	None	*Enterococcus* blank.	V.G
130220	None	*Enterococcus* blank.	V.G
130320	None	*Enterococcus* blank.	V.G
131008	None	*Enterococcus* blank.	V.G
131022	None	*Enterococcus* blank.	V.G
131114	None	*Enterococcus* blank.	V.G
140304	None	*Enterococcus* blank.	V.G
140318	None	*Enterococcus* blank.	V.G
140401	None	*Enterococcus* blank.	V.G
140506	None	*Enterococcus* blank.	V.G
140610	None	*Enterococcus* blank.	V.G

140612	None	*Enterococcus* blank.	V.G
141119	N/A	One Sample Vial full of RO/DI water has been switch for teams M1, M2, G1, and G2.	A.R
141217	1418E	M1 has been switched with a decoy of RO/DI water	A.R
150113	1429E	Blank 1429E has been placed with group G2. Three bottles placed in box just in case; one is the blank.	A.R
150204	1481E	Blank 1481E has been switched with G2	A.R

Appendix F: Sample Collection Records

Project name _EPA Citizen Science Water Quality Monitoring of Governors Island and Lower Manhattan_ **page** 1 **of** ___

Initial date __02/06/2013__ **Final Date** _____ **Location** East side

Station GI 2

Sampling Day #	Date (mmddyy)	Time	Sample Vial #	T °C	D.O. mg/L	pH units	NO_3 ppm	NO_2 ppm	NH_3 ppm	pH* units	T* °C	Sal ppt	Current (ebb or flood)	Entero. MPN	Rain Same day (in)	Rain (Prior day)	Rain (2 days prior)	Rain (3 days prior)	Rain (5 days prior)	Air T °C	Wind Direction (use GPS)
DAY 1	2/6/13	4:25	1321A	5	14	6.8	0	0	0.05	7.62		23	Ebb	20							
	Initials			SM	SM	SM	AF	AF	AF	SM		SR	SM	V.G							
			1324A																		
DAY 1	Initials																				
			1328A																		
DAY 1	Initials																				
DAY 2	Initials																				
2/6/13		4:25	1304A	32	11	7.4	5	0	1.0	7.43		14	Ebb	3.1							
DAY 2	Initials			SR	JM	AF	SR	SR	SR	SR		AF	AF								
			1330A			7.2	5	0	1.0	7.48		14									
	Initials					BS	SR	BS	ELD	BS		BS									
			1333A			7.8	SR	0	1.0	7.55		15		3.1							
	Initials					SR	SR	SR	SR	SR		BS									

Use pencil only please. Make sure all required cells are completed including time + initials.

*pH and Temperature with Hanna Combo Sensor

General Comments:

FOR30L PO4 5 GS

1 B.C: 80

2 B.C: 80 ELD, B.S, SR

3 B.C: 80 S.R

Ask your group leader if you have any questions.

Project name _EPA Citizen Science Water Quality Monitoring of Governors Island and Lower Manhattan_ **page** 1 **of** ____

Initial date __02/06/2013___ **Final Date** _____ **Location** West Side

Station M1

Sampling Day #	Date (mmddyy)	Time	Sample Vial #	T °C	D.O. mg/L	pH units	~~NO_2~~ PO_4 ppm	NO_3 ppm	NH_3 ppm	pH* units	T* °C	Sal ppt	Current (ebb or flood)	Entero. MPN	Rain Same day (in)	Rain (Prior day)	Rain (2 days prior)	Rain (3 days prior)	Rain (5 days prior)	Air T °C	Wind Direction (use GPS)
DAY 1	02/06/13	4:40	1302A		10	7.2	0	0	0.50	6.88	4.1	28	ebb	31							
	Initials				NM	V.G	V.G	V.G	SK	V.G	V.G	KA		V.G							
			1303A																		
	Initials																				
	02/13/13	4:25	1301A			1.2	0	0	0.30			27									
	Initials					VG	VG	VG	SK			KA									
DAY 2	2/20/13	4:19	1317A	2	12	N/A	N/A	N/A	N/A	7.94	3.1	N/A	ebb								
	Initials			KA	NM					V.G	V.G	/	SK								
			1315A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2.0							
	Initials																				
			1316A	N/A	N/A	7.6	0.5	0	0.5	N/A	N/A	10	N/A								
	Initials																				
			1317A	N/A	N/A	7.2	N/A	0	0.5	N/A	N/A	13	N/A								
	Initials																				

Use pencil only please. Make sure all required cells are completed including time + initials.

*pH and Temperature with Hanna Combo Sensor

General Comments:

- Bring Waste bottle squirt bottle

2/13/13 phosphate 5ppm-AR B.C: 80 - VG (1301A) 1303A lent to M2

1302A 2/13/13 phosphate 5ppm-AR BC: 80 - VG

3/13/13 - Salinity between vials 1316A and 1317A are close. Everything else is also the same or similar

1316A BC: 80 1317A BC: 80

Ask your group leader if you have any questions.

NY Harbor SEALs
Revision Number: 04
August 9, 2015

Ameena, Raees, Kimberly, Alyston Velasquez

Project name _EPA Citizen Science Water Quality Monitoring of Governors Island and Lower Manhattan_ **page** _1_ **of** _____

Initial date __02/06/2013___ **Final Date** _____ **Location** West Side

Station GI 1

Sampling Day #	Date (mmddyy)	Time	Sample Vial #	T °C	D.O. mg/L	pH units	~~NO_2~~ ppm PO_4	NO_3 ppm	NH_3 ppm	pH* units	T* °C	Sal ppt	Current (ebb or flood)	Entero. MPN	Rain Same day (in)	Rain (Prior day)	Rain (2 days prior)	Rain (3 days prior)	Rain (5 days prior)	Air T °C	Wind Direction (use GPS)
DAY 1	2/6/13	4:25	1308A	4	12.5	7	.5	10	1		3.5	16	Flood	42							
	Initials	A.P.		KM	AP/RM	AV	AV	AV	km			R.AM	A.V	V.G							
	2/13/13		1306A		12.5	7	0	0	.5			15			[redacted]						
	Initials				AP/RAM	AV	AV	AV	km			R.AM									
			1328A																		
	Initials																				
DAY 2			1340A	3	18	[illegible]				8.46	8.2			20.7							
	Initials			KM	AP/NM					A.V	AP			V.G							
			1307A			7.6	5	10	3.0						[redacted]						
	Initials					K.M	K.M	K.M	S.V												
			1326A			7.4	5	10	0.5												
	Initials					K.M	S.V	K.M	S.V												
			1340A			7.2	5	10	1.0												
	Initials					K.M	K.M	K.M	S.V												

Use pencil only please. Make sure all required cells are completed including time + initials.

*pH and Temperature with Hanna Combo Sensor

General Comments:

An orange was used to determine the current
forgot to add phosphate Phosphate 5ppm A.P. Phosphate 5ppm A.P.
A lot of wind might effect direction of orange, icy sea wall
orange 5ppm

Ask your group leader if you have any questions.

NY Harbor SEALs
Revision Number: 04
August 9, 2015

Project name _EPA Citizen Science Water Quality Monitoring of Governors Island and Lower Manhattan_ **page** 2 **of** _____

Initial date __02/06/2013___ **Final Date** _____ **Location** East Side

Station G 2

Sampling Day #	Date (mmddyy)	Time	Sample Vial #	T °C	D.O. mg/L	pH units	~~NO_2~~ ppm PO_4	NO_3 ppm	NH_3 ppm	pH* units	T* °C	Sal ppt	Current (ebb or flood)	Entero. MPN	Rain Same day (in)	Rain (Prior day)	Rain (2 days prior)	Rain (3 days prior)	Rain (5 days prior)	Air T °C	Wind Direction (use GPS)
DAY 3	3/20/13	4:25pm		7	14	6.8	5	0	0.0	6.9	4.8	10	ebb	30.6							
	Initials	E.O		6.0	1pr	6.0	B.J	SR	E.O	JM	C.H	S.R	A.F								
			1315A												[redacted]						
	Initials																				
			1315A	8		6.8	5	0.1	0.37	6.8	8	10									
	Initials			A.L		JM	JM	JM	8.0	A.L	A.L	A.L									
DAY ~~1~~			1312A	7		7.2	5	0	1	7.2	7	10									
	Initials			A.L		C.L	C.B	CL	CL	C.L	A.L	[illegible]									
															[redacted]						
	Initials																				
	Initials																				
	Initials																				

Use pencil only please. Make sure all required cells are completed including time + initials.

*pH and Temperature with Hanna Combo Sensor

General Comments:

B.C. = 0
B.C = 60
B.C = 80

Ask your group leader if you have any questions.

NY Harbor SEALs
Revision Number: 04
August 9, 2015

Project name _EPA Citizen Science Water Quality Monitoring of Governors Island and Lower Manhattan_ **page** _2_ **of** _____

Initial date __02/06/2013___ **Final Date** _____ **Location** West Side

Station M1

Sampling Day #	Date (mmddyy)	Time	Sample Vial #	T °C	D.O. mg/L	pH units	~~NO_2 ppm~~ PO_4	NO_3 ppm	NH_3 ppm	pH* units	T* °C	Sal ppt	Current (ebb or flood)	Entero. MPN	Rain Same day (in)	Rain (Prior day)	Rain (2 days prior)	Rain (3 days prior)	Rain (5 days prior)	Air T °C	Wind Direction (use GPS)
	3/20/13	4:29	1322A	3.5	10		5			8.49	11.6	5	flood	0		.51	.31				
	Initials																				
DAY 3			1310A			6.8	5	0	.5			10									
	Initials					S.R	S.R	S.R	SU			DG									
			1323A			6.8	5	0	.5			9									
	Initials					AD	A.R	A.R	AR			JA									
DAY 4	04/24/13		1327A	10	10	6.5		0		7.42	12.1	16	EB.B								
	Initials																				
			1332A			6.2	5	0	.30			25									
	Initials					A.R	J.W.	A.D.	K.A			KA									
			1330A			6.1	10	0	.30			15									
	Initials					A.R	J.W.	AD	KA			KA									
	Initials																				

Use pencil only please. Make sure all required cells are completed including time + initials.

*pH and Temperature with Hanna Combo Sensor

General Comments:

Bc: 60
Day 4 1332A: BC 0
Day 4 1330A: BC 0

Ask your group leader if you have any questions.

NY Harbor SEALs
Revision Number: 04
August 9, 2015

Project name _EPA Citizen Science Water Quality Monitoring of Governors Island and Lower Manhattan_ **page** 2 **of** ____

Initial date __02/06/2013___ **Final Date** _____ **Location** West Side

Station GI 1

Sampling Day #	Date (mmddyy)	Time	Sample Vial #	T °C	D.O. mg/L	pH units	PO_4 ppm	NO_3 ppm	NH_3 ppm	pH* units	T* °C	Sal ppt	Current (ebb or flood)	Entero. MPN	Rain Same day (in)	Rain (Prior day)	Rain (2 days prior)	Rain (3 days prior)	Rain (5 days prior)	Air T °C	Wind Direction (use GPS)
DAY 3	3/2/13	4:25	1331A	5	9	7.2	5	0	0.25			6	flood	45.3							
	Initials		1320A	AP	RM KM	K.M	A.P	K.M	J.M			TM	AV KM								
	1331		1339A	5	9.5	7.6	5	0	0.25			7	flood		[redacted]						
	Initials			AP	RMKM	K.M	A.P	K.M	J.M			TM	AV KM								
	13																				
	Initials																				
DAY 4	4/24/13		1315B			6.8	5	0	1			7									
	Initials					K.M	A.P	K.M	S.G			A.F									
			1331B												[redacted]						
	Initials																				
	4/24/13	4-25	1302B		9	6.8	3	0	1			16	flood								
	Initials				R.M	K.M	A.P	K.M	S.G			A.F									
					8								flood								
	Initials				R.M																

Use pencil only please. Make sure all required cells are completed including time + initials.

*pH and Temperature with Hanna Combo Sensor

General Comments:

It's real windy and cold.

Ask your group leader if you have any questions.

NY Harbor SEALs
Revision Number: 04
August 9, 2015

Project name _EPA Citizen Science Water Quality Monitoring of Governors Island and Lower Manhattan_ **page** ____ **of** _____

Initial date __02/06/2013___ **Final Date** _____ **Location** East Side Pier 101

Station G2

Sampling Day #	Date (mmddyy)	Time	Sample Vial #	T °C	D.O. mg/L	pH units	PO_4 ppm	NO_3 ppm	NH_3 ppm	pH* units	T* °C	Sal ppt	Current (ebb or flood)	Entero. MPN	Rain Same day (in)	Rain (Prior day)	Rain (2 days prior)	Rain (3 days prior)	Rain (5 days prior)	Air T °C	Wind Direction (use GPS)
DAY 9	12/3/13	4:10	13083	8	10	6.5	5	20	.25	NV	8.2	23	Flood		0	0				43	NE
	Initials			8	9	6.5	5	20	.25	NV	8.2	23									
			13358	9	5	6.8	5	20	.25	NV	8.4	24	Flood								
	Initials			9	10	6.2	5	20	.25	NV	8.4	24									
			13243	NV	10	6.5	5	25	.50	NV	NV	17	Flood								
	Initials			NV	10	6.2	5	20	.50	NV	NV	18									
DAY ___																					
	Initials																				
	Initials																				
	Initials																				
	Initials			V.G	0.8	5.5	5.6	5.5	5.5		5.6	V.G									

Use pencil only please. Make sure all required cells are completed including time + initials.

*pH and Temperature with Hanna Combo Sensor

General Comments:

Hanna Combo Not Calibrated Correctly - or it is broken.

Ask your group leader if you have any questions.

NY Harbor SEALs
Revision Number: 04
August 9, 2015

Project name _EPA Citizen Science Water Quality Monitoring of Governors Island and Lower Manhattan_ **page** ____ **of** _____

Initial date __02/06/2013___ **Final Date** _____ **Location** Pier 101

Station G2

Sampling Day #	Date (mmddyy)	Time	Sample Vial #	Current (ebb or flood)	Air T°C	Wind Direction (use GPS)	T °C	D.O. mg/L	pH* units	T* °C	T** °C	D.O. ** mg/L	pH** units	Sal** ppt	Turbidity inches	Chl ppm	pH units	NO_2 ppm	NO_3 ppm	NH_3 ppm	Sal ppt	Entero. MPN
DAY 10	03.04.14	16:09	1318C	Flood			18		8.23	3							6.8	0	0	0.624	20	4.2
	Initials																		0.493			
			1313C				3		9.14	1.8							6.8	0	0	0	19	
	Initials																					
			1301C																			3.1
	Initials																M.J	M.J	M.J		V.G	K.A

Use pencil only please. Make sure all required cells are completed including time + initials. * Hanna Combo Sensor **YSI Pro Series

Sampling Day #	Date (mmddyy)	Time	Sample Vial #	Current (ebb or flood)	Air T°C	Wind Direction (use GPS)	T °C	D.O. mg/L	pH* units	T* °C	T** °C	D.O. ** mg/L	pH** units	Sal** ppt	Turbidity inches	Chl ppm	pH units	NO_2 ppm	NO_3 ppm	NH_3 ppm	Sal ppt	Entero. MPN
DAY 11	03.18.14		1329C	Flood				8	8.74	3.5	3.9	12.6	8.15	25	61.2							<1.0
	Initials																					
			1317C					9														
	Initials																					
			1324C																			<1.0
	Initials																					

Use pencil only please. Make sure all required cells are completed including time + initials. * Hanna Combo Sensor **YSI Pro Series

Sampling Day #	Date (mmddyy)	Time	Sample Vial #	Current (ebb or flood)	Air T°C	Wind Direction (use GPS)	T °C	D.O. mg/L	pH* units	T* °C	T** °C	D.O. ** mg/L	pH** units	Sal** ppt	Turbidity inches	Chl ppm	pH units	NO_2 ppm	NO_3 ppm	NH_3 ppm	Sal ppt	Entero. MPN
DAY 12	04.1.14		1330C					7			4.52	12.7	7.75		35.2		6.9	0	0.582	0.58	19	5.3
	Initials												7.80									
			1327C								4.51	12.4	7.92						0.552	0.552	18	2.0
	Initials																					
			1328C																3.5			
	Initials																					

Use pencil only please. Make sure all required cells are completed including time + initials. * Hanna Combo Sensor **YSI Pro Series

Ask your group leader if you have any questions.

Project name _EPA Citizen Science Water Quality Monitoring of Governors Island and Lower Manhattan_ **page** ____ **of** _____

Initial date __02/06/2013___ **Final Date** _____ **Location** West side

Station M1

Sampling Day #	Date (mmddyy)	Time	Sample Vial #	Current (ebb or flood)	Air T°C	Wind Direction (use GPS)	T °C	D.O. mg/L	pH* units	T* °C	T** °C	D.O. ** mg/L	pH** units	Sal** ppt	Turbidity inches	Chl ppm	pH units	NO_2 ppm	NO_3 ppm	NH_3 ppm	Sal ppt	Entero. MPN
DAY 10	03.04.14	11:20PM	1303C	ebb	0°C						1.9	11.64	7.59	27						77		<1.0
	Initials			I.C.							E.T.		E.T.	11						P.S.		
		1:30PM	1307C						7.8			11.47			38					77		2.0
	Initials																			P		
			1312C						7.9			10.68								77		
	Initials																			P		

Use pencil only please. Make sure all required cells are completed including time + initials. * Hanna Combo Sensor **YSI Pro Series

Sampling Day #	Date (mmddyy)	Time	Sample Vial #	Current (ebb or flood)	Air T°C	Wind Direction (use GPS)	T °C	D.O. mg/L	pH* units	T* °C	T** °C	D.O. ** mg/L	pH** units	Sal** ppt	Turbidity inches	Chl ppm	pH units	NO_2 ppm	NO_3 ppm	NH_3 ppm	Sal ppt	Entero. MPN
DAY 11	03.18.14		1311C	EBB							5.6	11.63	8.01	0	51.2							28.8
	Initials			AR							E.O	E.O	E.O	E.O	L.G.							
			1315C																			38.4
	Initials																					
			1305C																			
	Initials																					

Use pencil only please. Make sure all required cells are completed including time + initials. * Hanna Combo Sensor **YSI Pro Series

Sampling Day #	Date (mmddyy)	Time	Sample Vial #	Current (ebb or flood)	Air T°C	Wind Direction (use GPS)	T °C	D.O. mg/L	pH* units	T* °C	T** °C	D.O. ** mg/L	pH** units	Sal** ppt	Turbidity inches	Chl ppm	pH units	NO_2 ppm	NO_3 ppm	NH_3 ppm	Sal ppt	Entero. MPN	BC
DAY 12	04.1.14	4:25	1309C	EBB							6.7	11.47	7.8		14.96 58		7.5	0	5			2.0	90
	Initials			AR								L.G			I.C								
			1320C								6.7	10.63	7.4		13.982	5.5	7.5	0	5			6.4	40
	Initials										L.G	L.G.			I.C								
			1324C														7.0	0	5	77			0
	Initials																						

Use pencil only please. Make sure all required cells are completed including time + initials. * Hanna Combo Sensor **YSI Pro Series

Ask your group leader if you have any questions.

Appendix G: Semi-Annual Assessment Reports

Semi-Annual Report – April 11th, 2013 Re: EPA Agreement No. X5-96298212-0 / Citizen Science New York Harbor Foundation and New York Harbor School "Harbor SEALS"

Background: Students of New York Harbor School's "Harbor SEALS" after-school science program are participating in a U.S. EPA funded Citizen Science initiative. The objectives of this initiative are to:

• Train and deploy in New York City a minimum of 24 high school youth as volunteer citizen scientists to monitor water quality throughout New York Harbor.

• Facilitate twice monthly field trips of youth and adult volunteers to collect water quality data at up to five monitoring stations in New York Harbor; monitor up to eight water quality parameters using a range of increasingly advanced tools and techniques; train youth volunteers in SOPs emphasizing reliability and accuracy within a consistent range.

• Conduct four major public outreach events to educate up to 400 members of the general public on the needs for youth citizen science and water quality monitoring in particular.

• Disseminate the data collected for analysis and use by pertinent stake holders, mainly the New York Harbor School and members of the Oyster Restoration Research Project.

• Develop a set of best practices and SOPs that will be used by future citizen science and environmental monitoring activities at New York Harbor School and in other similar educational programs around the city.

Report: The Harbor SEALS Citizen Science program officially commenced on Wednesday February 6th, 2013, as Harbor SEALS students, led by program manager Mauricio Gonzalez, were trained in water quality sampling procedures and carried out a practice sampling run at four designated sites. 24 students participated in the training, with each group of 6 students sampling one of the four designated sites. Each group tested for nine chemical and hydrological parameters including water temperature (°C), Dissolved Oxygen (ppm), pH (Units), PO4 (ppm), NO3 (ppm), NH3 (ppm), Salinity (ppt), Current (kts), and *Enterococcus* (MPN). Prior to the sampling run students were trained in the use of all required sampling and testing equipment. Students were also trained in data collection SOPs and input methods. One team leader was selected from each group to be responsible for submission of finalized field data sheets. Field data sheets were collected and verified by both the project manager and the advisor to the project manager. Verified data sheets were then given to the student data input manager who is

responsible for uploading all finalized data to the Harbor SEALS website and online database (at: http://harborseals.org/data/harbor-seals-water-quality/)

Harbor SEALS water quality sampling works on an alternate weekly schedule: the first and third Wednesday of each month student teams sample and test from their designated field sites and the second and fourth Wednesday all student teams return to the classroom-lab for additional testing (*Enterococcus*), data cleaning and analysis. Following this alternative weekly schedule Harbor SEALS Citizen Science student teams have now completed three sampling runs followed by three analysis days.

The sampling schedule was interrupted once by an extreme weather event (on February 27, 2013), which required closure of the Governors Island ferry and subsequently an early dismissal from School. Since that time, all 24 Harbor SEALS students have continued to follow the pre-set schedule, and carry out sampling and analysis according to the grant's proposed timeline and work plan.

Two adult volunteers have also been trained to support and work alongside Harbor SEALS water quality sampling teams. These volunteers attend Harbor SEALS activities every Wednesday and support deployment of sampling teams around the Island. The project manager also recently convened (on March 6 and April 10) two leading scientists in the field of environmental monitoring to attend Harbor SEALS after-school meetings and present their research to students. These presentations have served as valuable supplemental enrichment to the research framework and curriculum proposed by the Harbor SEALS EPA Citizen Science grant agreement.

Harbor SEALS will continue to conduct sampling runs and analysis on alternating Wednesdays until June 5th. On June 12th students will meet to finalize data and begin preparing research presentations. A culminating event will then be held on June 19th in which students will present their results to date to a professional audience consisting of Harbor School faculty, research scientists, the students' peers and their family members. The Harbor SEALS program will then break for summer recess and return to its scheduled sampling protocols in early September 2013.

Semi-Annual Report – September 30, 2013
Re: EPA Agreement No. X5-96298212-0/Citizen Science

New York Harbor Foundation and New York Harbor School
"Harbor SEALs"

Background

Students of New York Harbor School's "Harbor SEALS" after---school science program are participating in a U.S. EPA funded Citizen Science initiative. The objectives of this initiative are to:

- Train and deploy in New York City a minimum of 24 high school youth as volunteer citizen scientists to monitor water quality throughout New York Harbor
- Facilitate twice monthly field trips of youth and adult volunteers to collect water quality data at up to five monitoring stations in New York Harbor; monitor up to eight water quality parameters using a range of increasingly advanced tools and techniques; train youth volunteers in SOPs emphasizing reliability and accuracy within a consistent range.
- Conduct four major public outreach events to educate up to 400 members of the general public on the needs for youth citizen science and water quality monitoring in particular.
- Disseminate the data collected for analysis and use by pertinent stake holders, mainly the New York Harbor School and members of the Oyster Restoration Research Project.
- Develop a set of best practices and SOPs that will be used by future citizen science and environmental monitoring activities at New York Harbor School and in other similar educational programs around the city.

Over the course of the Harbor SEALs project, four groups of volunteers have been monitoring water quality in lower Manhattan on both East and West sides, and on Governors Island on East and West sides. Among the parameters sampled are dissolved oxygen, ammonia, phosphate, pH, temperature, nitrate, nitrite and current.

Report.

01. Comparison of actual accomplishments with anticipated outputs/outcomes specified in the QAPP:

No.	Anticipated Outcomes	Accomplished	Not Accomplished
1	Create and revise Quality Assurance Project Plan (QAPP) by the proposed date of April 2013.	X	
2	Volunteers will be trained during the months of February and October 2013 for phase 01.	X (ahead of schedule)	
3	Official sampling starting in April 2013 and continuing uninterrupted through September 2013.		X
4	Web page built for public data access: www.harborseals.org	X	
5	All water quality parameters and replicates collected during each sampling event.		X
6	Acquisition of all phase 01 materials has been completed.	X	
7	Data is up on web page. https://docs.google.com/a/newyorkharborschool.org/spreadsheet/pub?key=0AjkpjB8fZIOIdGZYRFRtRGl3M01fSUM0b2UxejJULXc&output=html	X	
8	Harbor SEALS conduct public outreach to peers - accomplished through their participation in a summer enrichment program for middle school students called Camp RESTORE. Harbor SEALS –taught middle school students to conduct water quality testing on 8 parameters using chemical test strips and tabs.	X	

02. Explain why anticipated outcomes were not met:

Anticipated Outcome 03: Sampling events ran on Wednesdays. April sampling went according to schedule. May sampling was not completed due to pressing school events. June – August sampling was discontinued due to an accident suffered by Mauricio Gonzalez, the project manager. Although efforts were made to gather volunteers by Sam Janis, project advisor, it proved impossible to do so. Sampling has resumed in September with the Project Manager's return.

Anticipated Outcome 05: Most physical-chemical parameters have been collected but it has proven challenging to acquire all with our citizen volunteers. Replication for each station per sampling event has been performed during most sampling events except for 2 stations on two events.

03. Include, when appropriate, an analysis and explanation of cost overruns or high unit costs:

None

04. Preliminary Volunteer Data Analysis:

In the Harbor Seals website there are graphs for Dissolved oxygen and temperature. These graphs show how the levels of the DO and the temperature changed throughout the days that we sampled. For the temperature it shows that the closer it gets to the warmer months the water Temperature raises. For the Dissolved Oxygen it shows that when the temperature gets higher the Dissolved oxygen levels get lower. This is because warmer water holds less dissolved oxygen than colder water.

Semi-Annual Report – November 26, 2014
Re: EPA Agreement No. X5-96298212-0/Citizen Science

New York Harbor Foundation and New York Harbor School
"Harbor SEALs"

Status Update

Students of the New York Harbor School's "Harbor SEALs" program have been able to accomplish certain goals, but have had difficulties with others.

GOAL 1. Train and deploy in New York City a minimum of 24 high school youth as volunteer citizen scientists to monitor water quality throughout New York Harbor.

The Harbor SEALs has been able to train approximately more than 50 high school students however, as new recruits come in, they need to be trained. Inconsistent members have made it difficult to properly train enough interns that know how to sample properly out in the field. This Fall we've been able to increase the number of trainings than in the past to ensure that the volunteers are ready for sampling.

GOAL 2. Facilitate twice monthly field trips of youth and adult volunteers to collect water quality data at up to four monitoring stations in New York Harbor; monitor up to eight water quality parameters using a range of increasingly advanced tools and techniques; train youth volunteers in SOPs emphasizing precision and accuracy within a consistent range.

Due to construction on Governors Island, the SEALs have had difficulty sampling all 4 stations continuously. For example, Station G1 at the westernmost side of GI was blocked off for approximately 8 months. Notwithstanding, most of the water quality parameters were sampled on days and stations we were able to sample. Table 01 has the calculation of the 5 of data that is precise.

GOAL 3. Conduct four major public outreach events to educate up to 400 member of the general public on the needs for youth citizen science and water quality monitoring in particular.

There have been various venues at which the Harbor SEALs have been able to reach large numbers of people. First, the SEALs reached out to the public at City of Water Day two years in a row. At these events our volunteers have been able to reach over 750 people. Second, during the Harbor School Symposium volunteers were also able to reach visitors. Among those that were there was a group of over 30 visitors from Denmark. Third, the SEALs presented at the over 300 people at the Omega Institute during their Commons Conference back in October.

Lastly, one of our SEALs volunteers and data manager, Violeta Gonzalez, was invited to present her research at a National Conference hosted by the AFL-CIO. There were prominent government officials in attendance such as Vice President Joe Biden. At most of these events, the SEALs talked about the health of the Harbor as indicated by the data collected and had flyers and posters available for viewing.

GOAL 4. Disseminate the data collected for analysis and use by pertinent stake holders, mainly the New York Harbor School and members of the Oyster Restoration Research Project.

The Harbor SEALs data are posted and updated on-line for public viewing and use. At the end of this year, a research report will be generated with the analysis of all data collected to date. By the end of sampling cycle, another report will be generated including the rest of the data collected up to that point.

Assessment Report

Since the Harbor SEALs was started, our volunteers have been able to accomplish things such as:

1. Calibrating instruments regularly,
2. Sampling done accurately,
3. Website populated with data,
4. Volunteers receive leadership experience,
5. Volunteers more aware of the estuary and its health,
6. Volunteers develop new skills,
7. Disseminate data to the public at conferences, public events, and science symposia,
8. Collect data for over a year.

Over the course of three years the Harbor SEALs have been meeting at least once a week to sample out in the field as well as measure parameters in the lab from water samples taken from the field. Unfortunately the program has had some setbacks such as:

6. Not having enough student volunteers that consistently show up every week.
7. The precision of the data has been poor.
8. Training new recruits has been difficult because not all the members know how to measure certain parameters or don’t understand how important precision is.
9. There are time constraints, especially when it comes to sampling out in the field.
10. Due to school events sampling days had to be cancelled.

Some solutions to these problems are:

6. The SEALs will be able to have around 30 minutes longer to sample which should make more of our data usable.
7. This year more days have been spent training new recruits than before which should help acquire better data.
8. This year the veteran volunteers made criteria to help pick students that will be more dedicated to the program and are sure they will show up every Wednesday.
9. The new student volunteers will sit in on a precision lesson to learn its importance.
10. In addition to that, we are going to talk about the data we get and review it to see how precise it is before putting it on the website.

Precision Table- Table 1. This table shows the estimate of how precise Harbor SEALs data is as well as an estimate of how much usable data the SEALs will have by the end of the school year.

Parameters	Precision Percentage (estimate)	Projected Estimate
Temperature	20%	30%
Temperature*	20%	35%
Dissolved Oxygen	30%	35%
pH*	20%	35%
PO4	35%	45%
NO3	26%	30%
NH3	30%	40%
Salinity	26%	30%

Equipment Calibration Records

Calibration Records- Table 2. This table shows the calibration of instruments on a given day as well as the parameters being calibrated and the initials of those who calibrated the instruments.

Date	Instrument Model	Instrument Ref. Number	Parameter	Initials
10.08.13	H.C.S HI 98129	A1	pH	V.G
	H.C.S HI 98129	A2	pH	V.G
10.22.13	H.C.S HI 98129	A1	pH	K.A
	H.C.S HI 98129	A2	pH	K.A
2.4.14	YSI Model1556	G2	D.O/pH	K.A
	YSI Model1556	M1	D.O/pH	A.R
	YSI Model1556	M2	D.O/pH	J.W
3.4.14	YSI Model1556	M2	pH	G.C
	H.C.S HI 98129	A1	pH	T.A
3.17.14	YSI Model1556	G2	pH	K.A
	YSI Model1556	M2	pH	K.A
	YSI Model1556	M1	pH	J.W
5.17.14	YSI Model1556	M1	pH/D.O/E.C	J.G
	YSI Model1556	M2	pH/D.O/E.C	T.A
	YSI Model1556	G2	pH/D.O/E.C	V.G
5.20.14	H.C.S HI 98129	A1	pH	V.G
	H.C.S HI 98129	M1	pH	J.G

	H.C.S HI 98129	M2	pH	J.G
10.8.14	H.C.S HI 98129	A1	pH	J.G
	H.C.S HI 98129	M2	pH	J.G
	H.C.S HI 98129	G2	pH	J.G
	H.C.S HI 98129	G1	pH	J.G