Biodiversity and Species Richness of Invertebrates in the New York Harbor (2018)

Nailea Rodriguez

Mentor: Nikos Konstantinides, NYU Post-doctoral Fellow, Ph.D.

Advisors: Mauricio Gonzalez, M.Sc. NYHS

Liz Burmester, Ph.D., Billion Oyster Project

Abstract Habitat complexity is reduced when natural estuarine shorelines are replaced with concrete seawalls in highly urbanized regions (Reid *et. al.*, 2015). In order to determine if spatial complexity increases the biodiversity of invertebrates inhabiting the New York Harbor different cage set-ups were deployed: 01) the experimental cages had eastern oysters and blue stone rock and 02) the control cages were empty. The invertebrates found in the control cages were barnacles, amphipods, sponge colonies, and tunicate colonies. The invertebrates found in the experimental cages were barnacles, tunicate colonies, amphipods, sponge colonies, oyster drills, mud crabs, glass shrimp, sea squirts, and slipper shells. There was a higher biodiversity in control cages due to more species evenness but a higher species richness and abundance on the experimental cages. These results support the hypothesis that the presence of spatial complexity in the form of oysters and blue stone rock in an environment promotes a higher species richness of invertebrates.

Introduction

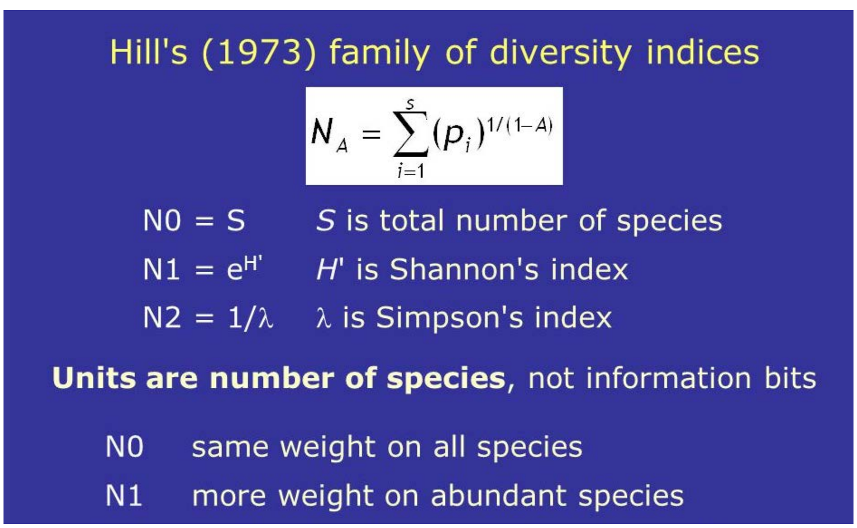
Currently the seawall on the East-River Esplanade is cracking; the pieces of concrete are falling into the water, further damaging the state of the biodiversity within the East-River's ecosystem. It's important to test for changes in biodiversity. Biodiversity can be used as an indicator to identify the health and productivity of an ecosystem. Using different construction materials, that add spatial complexity, can help increase the biodiversity within an ecosystem thereby making a healthier and more productive ecosystem. Re-building the East-River Esplanade would not only benefit the environment but also allow for the boardwalk to be opened for recreational activity- to all of NYC and its visitors.

Biodiversity is the variability among living organisms from all sources, including terrestrial, marine, and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species**,** between species, and of ecosystems (Kiester, 1997). Biodiversity is a measure of the variety of organisms present in different ecosystems. This can refer to genetic variation, ecosystem variation, or variation within a species (McGrath, 1999).

Biodiversity is important, because greater species diversity ensures natural sustainability of the life forms within an ecosystem (Shah, 2014).

Biodiversity is affected by pollution, substrate, climate, etc…The rising effects of pollution have affected the biodiversity of all invertebrates in the Hudson Estuary (Dugan *et al*., 2011). To see what effects substrates have on the growth of invertebrates, two (2) types of set-ups were placed at two (2) different locations along the East/Harlem River. There two types of set-ups were (1) the treatment cages and (2) the control cages. The experimental cages had thirty (30) live eastern oysters and blue stone rock. The control cages have no Oysters (*Crassostrea virginica)* or rocks. The cages provide habitat for the organisms in the Harlem River. This allows for the ability to count the different species of invertebrates growing in a definite area of the Harlem River.

The diversity of species in an ecosystem can help to determine the overall health of the area. The simplest way to measure biodiversity is to count the number of species; the result is termed the species richness (McIntosh, 1967). There are, however, many limitations to this index. The most important limitation comes from the failure to include all species from the community in a sample, but this error decreases as the proportion of species represented in samples increases (McIntosh, 1967).



Hill's Index Formula (Birks, H.J.B., 2018)

Hill numbers show the relation between the species-richness indices, a measure of the number of species found in a sample, and the evenness-indices, how close in numbers each species in an environment is. To determine species richness Hill numbers will be used.

Oysters historically were a keystone species in the Harbor Estuary; they can help sustain good water quality as they not only consume things like free-floating algae and organic matter, but they will also take in things like nitrogen and phosphorous (Smayda & Mann, 1982). As the ecological and economic importance of oyster reefs have become more widely acknowledged, creation of oyster reef habitat through restoration efforts have become more important-often with the goal of restoring multiple ecosystem services associated with natural oyster reefs (Jud & Layman, 2011).

Table 1 Project design chart identifying the objectives and problem associated with the growth and biodiversity of invertebrates in the Hudson Estuary.

Category	**Entry**
Scientific Problem	Does the introduction of natural substrate (oysters and blue stone rocks) promote biodiversity and species richness of sessile invertebrates in the Harlem River?
Hypothesis	The presence of oysters and blue stone rock in an environment promotes a higher diversity and species richness of sessile invertebrates because it provides more surface area for organisms to colonize.
Null Hypothesis	The presence of oysters and blue stone rock has no impact on the biodiversity of sessile invertebrates; the diversity of invertebrates is the same in the experimental cages as in the control cages.
Objectives	**1.**Measure the biodiversity of sessile invertebrates on deployments with or without natural substrate in the Harlem River using Hill numbers **2.**Identify the species richness of sessile invertebrates using Hill Numbers **3.**Determine the species evenness of sessile invertebrates in the Harlem River

Table 2 Shows a summary of each step needed to identify the growth and biodiversity of invertebrates in the Hudson Estuary As well as assumptions, limitations, and safety

Independent Variables	**Dependent Variables**	**Controlled Variables**	**Constant Variables**
1.Oysters and blue stone **2.**Location a. Under Warden/Randall Island walking Bridge b. E 116th St. across Jefferson park **3.** Survivability of the oysters	**1**. Biodiversity (Hill numbers) **2.** Species evenness **3**. Species richness **4.** Survivability of the oysters	**1.** Control cage **2.** Number of oysters **3.** Location of blue stone rocks (below the oysters)	**1.**Size of cages **2.**10ft wooden pole holding up the cages **3**.Location of set-up **4.** Number of cages per set-up **5**. Number of oysters per cage **6.**Depth- 2ft above benthic layer

<u>Table 3</u> The assumptions, risks for volunteers, limitations, and safety requirements of this project.

Assumptions	**Limitations and Risks**	**Safety**
1.The invertebrates that are found on the experimental cage will be found on the control cage **2.**The oysters will increase the population of invertebrates	**1.** The experiment should only be checked up on once before the 1 year mark is up, in order to not disturb the settlement of organism **2.** The experiment can only be deployed for 1 year **3.** Vandalism is a risk, the wire rope is exposed on the sidewalk because it's wrapped around the fences, due to this they might be cut, however the buoys will allow us to find them if they are cut or fall. **5.** The depth of the platform must be 2ft above the benthic layer	**1.** Type 1 and 3 personal flotation device (PFD) **2**. Working gloves **3.** Protective eyewear **4.** First Aid kit

Procedures

A. Choosing the Oysters

1. Using a caliper, measure 360 oysters all measuring between 2.5in and 3.5in

2. Store oysters in a cage and hang off the side of the boat, until they're ready to be placed in the experimental cage

3. Once at the deployment location, place 30 oysters in all 12 of the experimental cage

B. Constructing the cages

1. Using wire cutters cute 10 main box panels (8" high x 18" long x 4" deep)

2. Cut 10 center divider panels (18" x 4")

3. Cut 10 back panels (18" x 16")

4. Cut 20 side panels (8" x 4")

5. Fold the cages as shown by the dashed lines in figure 1 'main box'

6. Align the edges of the main box and the back panel; using cable ties attach the (already folded) main box onto the back panel

7. Using hog rings attach the center divider halfway on the (already folded) main box

8. Using hog rings attach the sidepieces onto the sides of the cage

9. Repeat steps 5-8, 10 times

C. Deploying the set-ups

1. Label north "N" and south "S" on the wooden platform

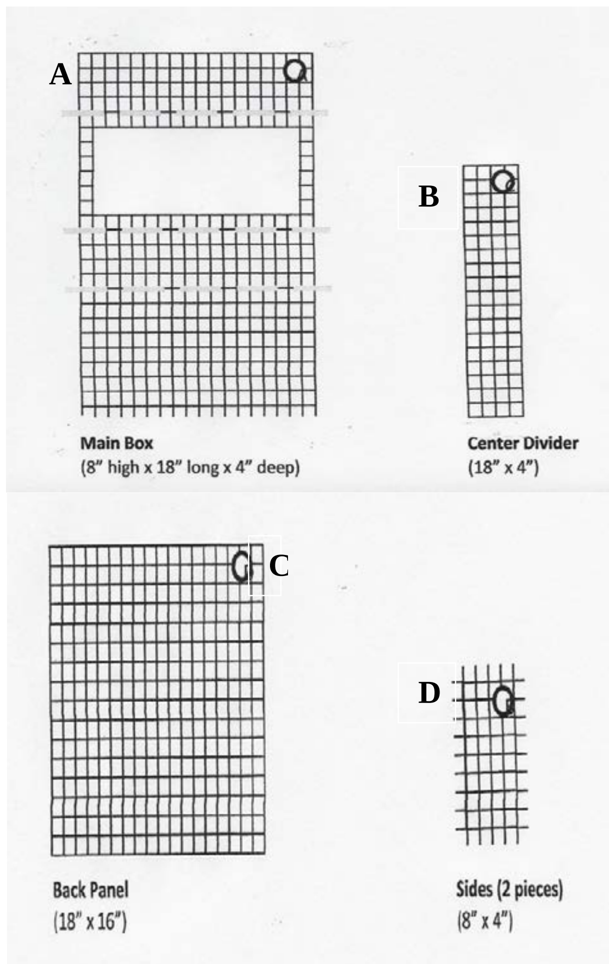


Figure 1: To scale measurements of the cage model; a) main box: 8" high x long x 4" deep b) center divider: 18" high x 4" long c) back panel: 18" high x 16: long d) 8" high x 4" long.

2. Measure 10 in from the edge of the platform (on both sides) and drill a hole smaller than ¼ in width through the platform (on both sides) and insert a 1/4th in eyehook

3. Measure the distance from the edge of the seawall to the bottom of the river; double that distance and cut that amount in feet of vinyl covered wire (cut this twice, one for each side of the platform)

4. Look the vinyl covered wire through the drilled hole and the cinder block; place a washer through the wire and place it under the drilled hole to hold the wire in place (do this to both sides, only 1 cinder block)

a) The cages should be 4 inches from the edge if the platform, on both sides

5. Using heavy-duty steel clamps attach the bottom of both wires together and loop the wires on the bottom of the fence to hold the platform up

6. Repeat steps above for every platform

D. Collecting Samples

1. Have 2 plastic tubs, one with water and one without water on the side of the boat

2. Dismount cages from the mobile platform; gently swish the entire cage in the tub with water in order to shake of larger mobile organisms

3. (If it's an experimental cage) remove oyster shells from the cage a handful at a time and gently swish around in the tub; visually inspect the cage and carefully remove any other organisms clinging to the shell and place them in the tub with water- return all shells to the cage and set aside

4. Begin collecting samples from the tub with water

a) Any known organisms should be logged by species name and amount found

b) Any unknown species should be cataloged with picture and an identification number as well as number found

Materials

Table 4 Materials needed to build the oyster cages, cage platforms, taking samples, and the upkeep of the set ups.

Materials	**Amount**	**Uses**
10ft wooden pole	10	To serve as the platform
Sharpie	2	To write north and south
Wire Cutters	2	To cut wire mesh
Vinyl covered wire mesh		To build cages
Wire rope 250 ft. spool-quarter in	5	To hang the structure
Cinder blocks	20	To hold platform above benthic layer
Heavy duty wire cutters	2	To cut wire rope
Wire clips-half inch	60	To support the structure
Ratchet	1	To tighten the wire clips
Ratchet head- Half inch	2	To tighten the wire clips
Drill bit- half inch	1	To secure grid to plank
Drill bit- quarter inch	1	To drill hole though the platform
Drill battery	2	To power drill
WD40	2	To clean tools
Gloves	1 pair per person	To protect hands from harm
Flat had screws-quarter inch	80	To secure grid to plank
Washers-quarter inch	80	To secure grid to plank
Calipers	3	To measure oyster size
Hog gun and clips	1	To put together cage panels
8” cable ties	1	To put together cage panels
¼ in eye hooks	40	To hang platform
Buckets	5	To use as waste bucket and bring water on board vessel
WD40	2	To clean tools

Results

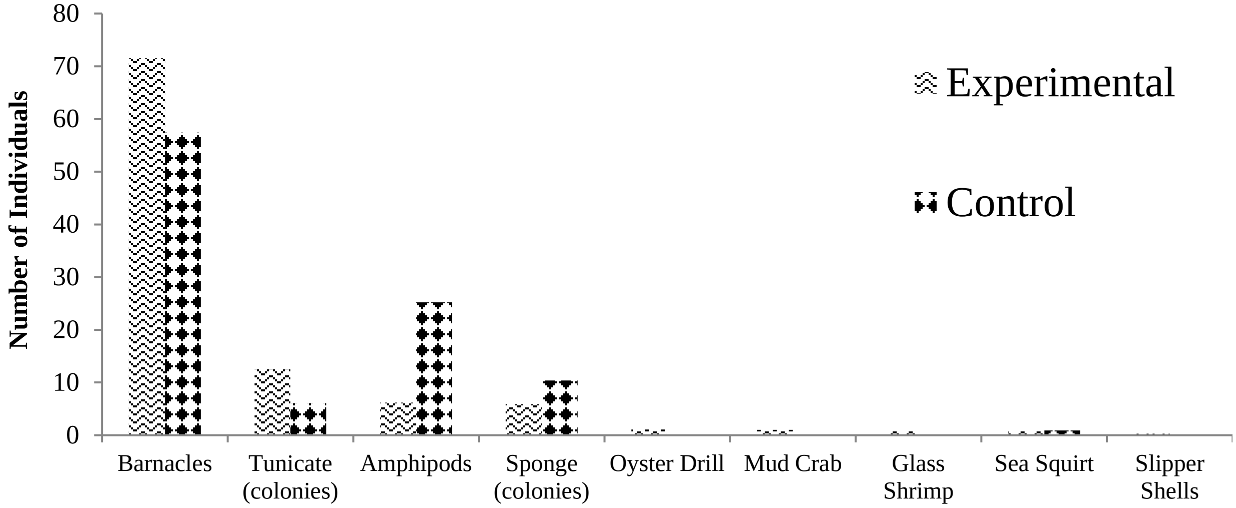


Figure 2 *Side by side results of the experimental cages and the control cages. Where the experimental cages have a higher species richness than the control cages*

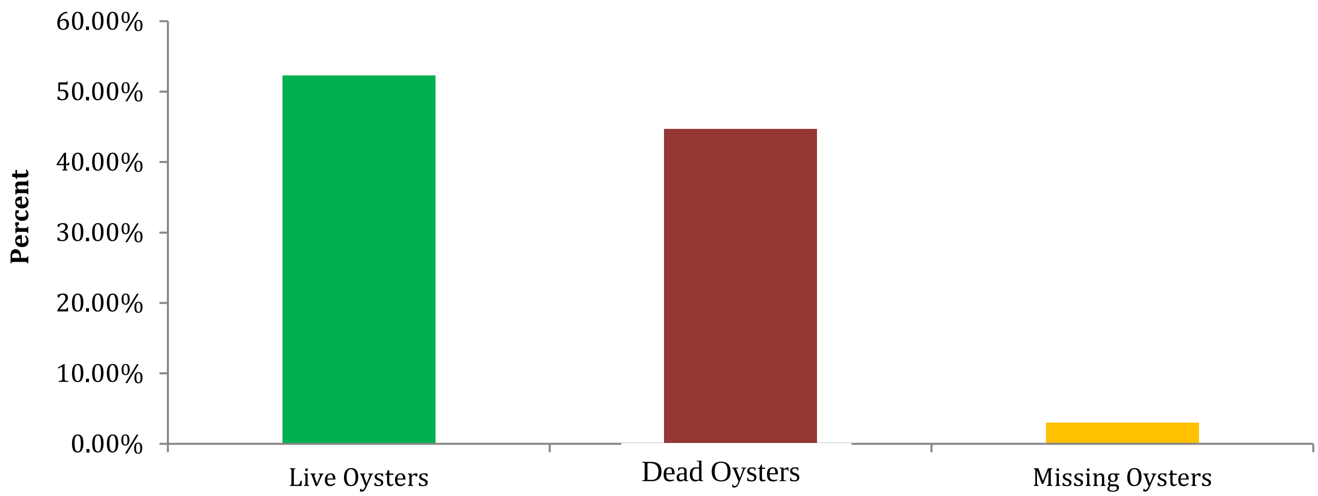


Figure 3 *Percent survival of the live eastern oysters that were incorporated in the experimental cages.*

Table 5 *Hill numbers Index: species diversity, species richness, and species evenness of the consolidated data of the control and experimental cages, control cages, and experimental cages.*

	Consolidated	**Control**	**Experimental**
Species Diversity	3.05	3.05	2.78
Species Richness	11	5	9
Species Evenness	1.96	2.45	1.87

Table 6 The sessile and motile invertebrates found in the experiment as a whole. Only sessile invertebrates were being taken into consideration for diversity indexes; the deployment attracted both sessile and motile invertebrates.

Sessile	**Motile**
Barnacles	Polychaetas
Tunicate (colonies)	Oyster Drills
Sponge (colonies)	Slipper shells
Sea squirts	Glass Shrimps
Ribbed Mussels	Mud Crabs

Discussion

This experiment was deployed to identify the biodiversity and species richness of invertebrates in the Harlem River Esplanade and to test whether introducing natural substrate increases the diversity within that area. The results showed that the cages with natural substrate, the experimental cages, have a higher Hill (H0) richness and abundance than control cages, supporting the hypothesis that introducing spatial complexity with natural substrate increases diversity. The experimental cages not only have a higher species richness and species abundance, but also more sessile and motile organisms as shown in *Table 6*, and an increased diversity of motile invertebrates makes for a more complex food web (Brose & Dunne 2009). However, the control cages have a higher species diversity than the experimental cages. This is only because the control cages have a more even distribution of abundance. The experimental cages were dominated by barnacles which decreased the species evenness. The hill index algorithm works in a way that biodiversity is a direct correlation of species evenness and species diversity. The difference in species richness can’t be denied: the experimental cages had a species richness of 9 while the control cages had a species richness of 5. Which partially supports the hypothesis that the introduction of natural substrate increases the species richness.

Eastern oysters are a key stone species in the Harbor Estuary. The removal of a key stone species often decreases overall diversity. Introducing live eastern oysters in this experiment would, hypothetically, increase the diversity of invertebrates. Of the 360 oysters that were deployed in this experiment, more than half of them survived the year in the Harbor. So not only would using natural substrate increase the biodiversity in an area, but also re-introducing a key stone species to the area would increase the diversity.

Suggestion for Future Research

This experiment supports the hypothesis that introducing natural substrate to an area increases the biodiversity of the area. However, this experiment had 2 different natural substrates in the same cage. For future research I suggest there are four (4) different types of cage. (1) The control cage with no natural substrate (2) a cage only with oysters (3) a cage only with blue stone rock and (4) a cage with both blue stone rock and oysters. This way you’re able to test for: what invertebrates oysters attract? What invertebrates do rocks attract?

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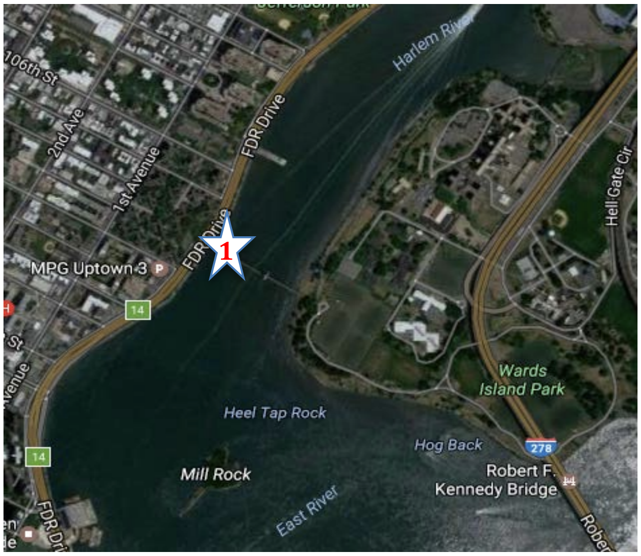
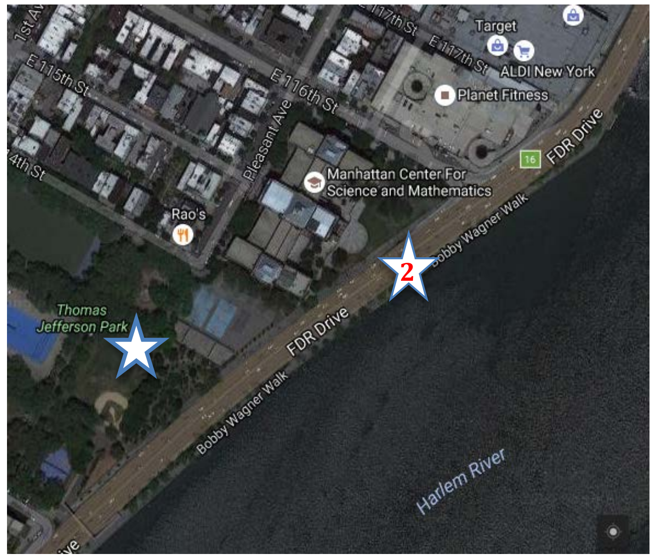
Annexes

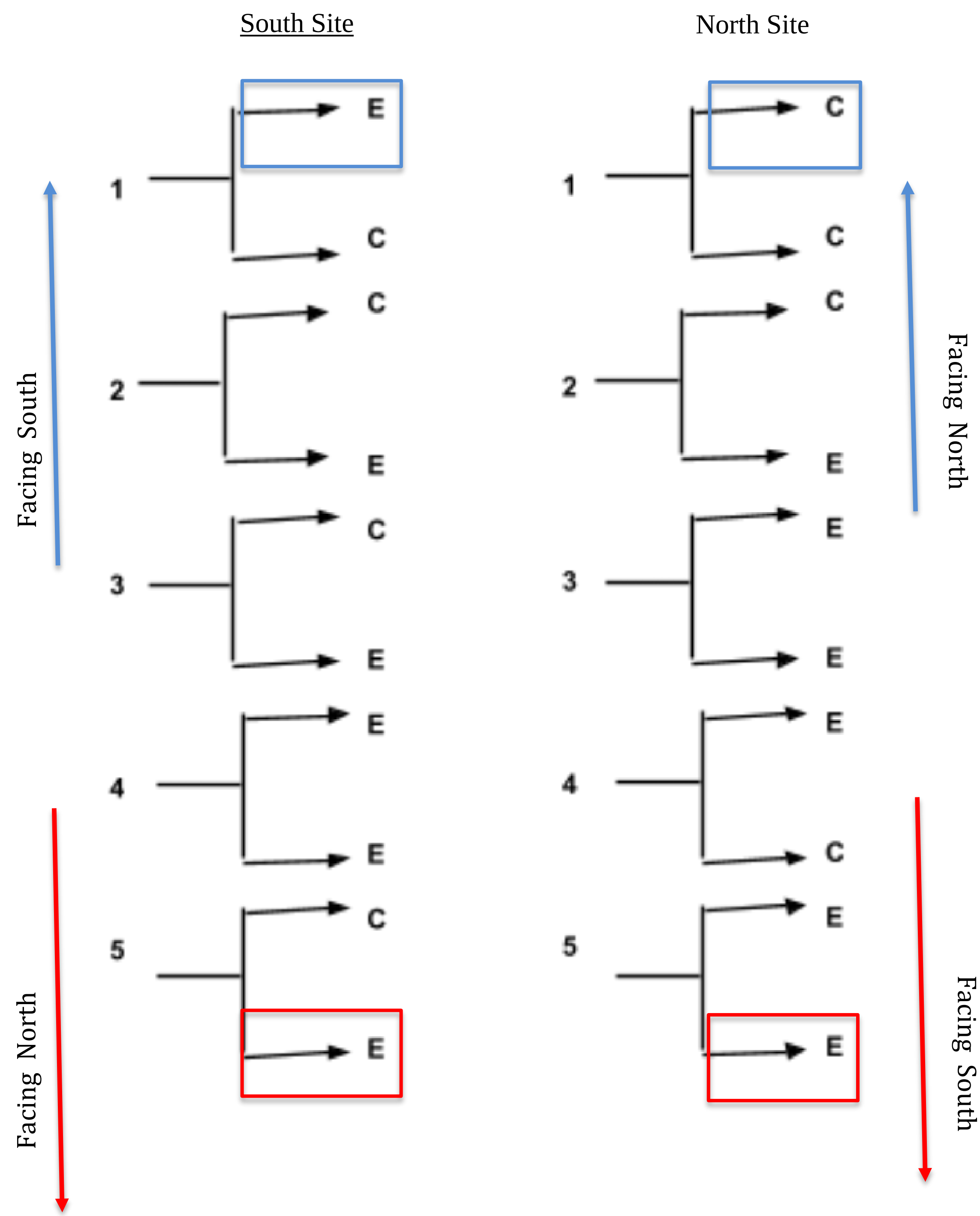
Locality:





Annex 1: *(1) South Site (40°786594'N, -73.938472'W-Under the Wordens Island bridge) and the (2) North Site (40°47.641665'N, 73°55.863572'W-E116st on FDR drive).*

Annex 2 *Bird's eye map of NYC, showing the location of where the experiment deployment is located in relation to the rest of NYC. (1) South site (40°786594'N, -73.938472'W) and the (2) north site (40°47.641665'N, 73°55.863572'W)*



<u>Annex 3</u> *The orientation of the wooden platforms and the cages against the sea wall. While facing the deployment, your left is north, and your right is south; the left cage is the northern cage and the right cage is the southern cage. There is a total of twenty (20) cages deployed: twelve (12) experimental cages and eight (8) control cages.*