Invertebrate Growth On Porcelain Tiles

Ecological Succesion

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2015

Abstract

Porcelain is a common building material and is often thrown away, forgotten, and sent to landfills. Instead of wasting the porcelain, it can be used as a valuable resource for marine invertebrates to settle on. The experiment tests if light penetration will affect the growth of sessile invertebrates in the Hudson River Estuary. Porcelain tiles are placed at 5 different depths and light measurements are monitored by a sensor. It is hypothesized that the tile receiving the most light will experience the most growth and biodiversity of species at the end of the study. After measuring percent cover and finding the calculating biodiversity using Hill's index, it was determined it was determined that there is a correlation between light intensity and biodiversity. Tiles receiving more light have generally had more biodiversity than tiles experiencing less light penetration

Introduction:

In NYC alone, large amounts of porcelain are thrown into landfills every year where they remain for time to come (NYC DEP, 2012). This porcelain comes from old building being demolished around the city. Instead of being wasted, these porcelain tiles may be used as ecosystems for sessile invertebrates living in the harbor. The study tests how light penetration affects the growth of sessile invertebrates settling on porcelain plates in the Hudson River Estuary. In the past, there have been very few studies concerning invertebrate growth in the New York Harbor. This project is one of the few. In it, tiles are suspended in the water and attached to an above-water platform. The platform keeps the tiles at a constant depth throughout the experiment. It is extremely crucial to monitor estuaries, especially in the New York Harbor. By constantly observing patterns of sessile invertebrates, the health of the estuary can also be monitored. In the future, porcelain tiles might become more used for such experiments due to their high availability. Also, recycled tiles might have environmental uses such as a hard substrate for recruitment and settlement.It is hypothesized that if the tiles are immersed into the water at the depths of 1.5, 2.5, 3.5, and 5 meters, then the tiles receiving the most light (1.5 meters deep) will experience the most growth and ecological succession. Also, on the tile at 1.5 meters there will be the most percent cover out of all of them. The presumption is that the tile will have 100 percent cover after one year has elapsed from the start of the project. On the other hand, the tile at 5 meters deep will most likely have only a 90% cover after a year due to the fact that it will experience a lot less light. The biodiversity of plates will probably increase as you go

closer to the surface of the water. The tiles towards the top will have a lot more biodiversity while the lower tiles will most likely be dominated by a certain species, such as colonial ascidians.

Background Information:

Porcelain is a common ceramic material which is often found in the everyday household. It is seen many times in the form of toilets and even bathroom tiles. In NYC, an unknown amount of porcelain is thrown out each year, but it is presumably a very large number. The city of New York plans to replace 800,000 toilets in total within the next few years (NYC DEP, 2012). Instead of wasting all of this porcelain, it can be used as a valuable resource. Recycling them is one option, but they can also be used as a substrate for sessile invertebrates to settle on. A lack of hard substrate accounts for the loss of many aquatic sessile organisms. The amount of suitable substrate has declined due to sedimentation and reef extirpation. Reef building sessile invertebrates, such as oysters, have also declined because of habitat destruction, poor water quality, and disease (Columbia, 2006).

Porcelain plates in the water can be used to test ecological succession. Other experiments in the past have tested succession on similar materials such as black perplex panels (Schmidt, 1982). Flat panels used are often the size of 25cm by 25cm. These porcelain plates immersed in the water can be used as a valuable resource. If invertebrates prove to grow on porcelain well, then it can be used as settlement sites by piers and in estuaries.

The design of the project is similar to that of ecological successions in the past (Hirata, 1987). In it panels are placed into the water at different depths to test for the growth of invertebrates over time. During these studies, the immersed tiles are taken out of the water at a set time interval and then tested using percent cover (Nandukumark, 1993). Percent cover is the most common way of measuring invertebrate growth on panels. It is often done using a grid composed of 1 cm boxes. Studies have shown that in the past, different species have dominated the tiles/plates over time. The colonial ascidians have frequently dominated the entirety of plates (Schmit, 1982). Though the colonial ascidians dominated the tiles in many of the studies, they percent cover fluctuated with seasons. Often times, in the warmer months there were less of them

than usual Colonial ascidians belong to a group of organisms known as sea squirts. Other classes of organisms include animals such as bivalves which are solitary organisms. Much often they take up less percent cover than colonial organisms (Hirata, 1987).

Project Design:

Project Design Chart	
Category	**Entry**
Scientific Problem:	**How does light penetration and depth affect the biodiversity and growth of sessile invertebrates on porcelain tiles in the Hudson River Estuary?**
Hypothesis 01:	**If the tiles are immersed into the water at the depths of .5, 1.0, 1.5, 2.0, and 2.5 meters, then the tiles receiving the most light (1.5 meters deep) will experience the most growth and ecological succession. On the tile at .5 meters there will be the most percent cover out of all of them. The presumption is that the tile will have 100 percent cover after one year has elapsed from the start of the project. On the other hand, the tile at 2.5 meters deep will most likely have only a 90% cover after a year due to the fact that it will experience a lot less light. The biodiversity of plates will probably increase as you go closer to the surface of the water. The tiles towards the top will have a lot more biodiversity while the lower tiles will most likely be dominated by colonial ascidians.**
Objective 01:	**Determine which tile is at the most suitable depth for invertebrate growth**
Objective 02:	**Determine which species grows best on porcelain tiles overtime**
Objective 03:	**Determine which tile(s) have the most biodiversity**

Experimental design		
PROPOSED VARIABLES		**PROPOSED CONSTANTS**
INDEPENDENT	**DEPENDANT**	- **Depth of tiles for each replicate** - **General area the tiles are deployed** - **The type of tiles** - **The size of the tiles**
Amount of Light Received/ Depth of the tiles.	**The growths of Invertebrates in percent cover. The amount of each type of Solitary Invertebrates**	

Project Scope			
ASSUMPTIONS		**LIMITATIONS**	**RISKs**
All of the tiles are of the same composition.	**There will be an equal amount of predation on each set of replicates**	**Pier 101 cannot be constantly monitored**	**There is a possibility of falling into the water when removing the tiles. Life rings are used for safety.**

Locality:

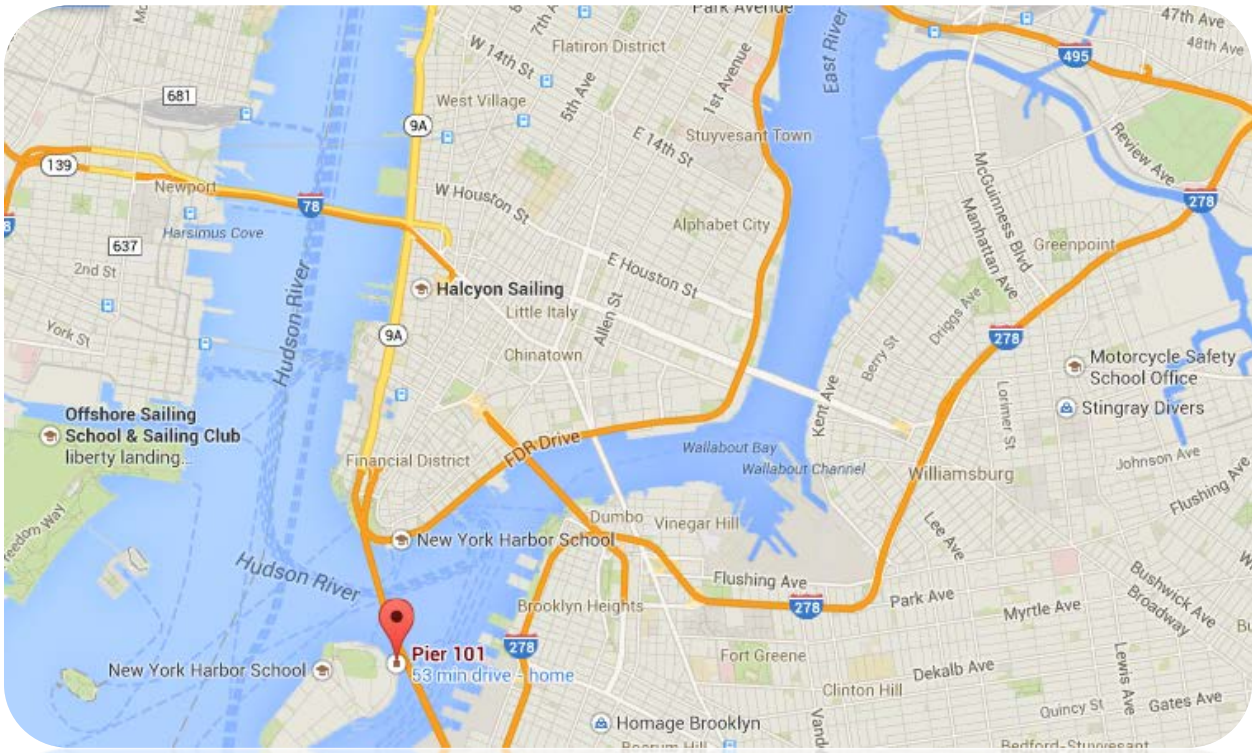

Figure 0.1- The project takes place at pier 101, located on Governors Island

Latitude: 40.691412

Longitude: -74.012106

Materials:

Item	Quantity	use
Life Jacket	1	Safety
Carbineer	4	Attach rope to dock
Cart	1	to move equipment
Rope	-	to secure bottles/platform/tiles
Bottles	4	add support / floatation
porcelain tiles (15cm x 15cm)	10	a structure for recruitment
Electric tape	-	to mark the different ropes
Sample Unit (1 cm grid)	1	Data Collection
Duct tape	-	extra support on the platforms
Life Ring	1	Safety
Drill	1	to drill the tiles

Procedures:

1) Attaching the Porcelain Tiles- For each replicate there are to be 5 ceramic porcelain bathroom tiles hung from a rope.

A hole is to be drilled through the center of each 15x15cm porcelain plate.

A rope is put through the hole and an overhand knot is tied above and below it.

The tiles are to be placed at depths of .5, 1, 1.5, 2, and 2.5m meters deep

They are placed at these depths to ensure the tiles don't touch the benthic zone or the surface

A weight is tied with a bowline to the bottom of the rope to ensure the tiles sink.

2) Securing tiles to Pier 101- The tiles are secured using carbineers off of a floating dock.

At several points, a carabineer is attached to the dock

A bowline is tied and secured to the platform

The tiles are slowly lowered into the water

3) Attaching the temperature/light Sensor- A HOBO data logger is placed in the water

- Next to the tiles, two data loggers are placed in the water
- This is at the depths of .5 and 2.5 meters
- They can log for months at a time

4) Collecting Data- Data from the tiles is collected periodically.

- Every month the tiles are pulled out of the water; preferably the 1st Tuesday of the month
- Using 15 by 15cm grid the tiles are tested for biodiversity and percent cover.
- Each grid covered by a specific species is 1% of the cover.
- Also, every specific organism on the tile is to be tallied.

5) Analyzing the Results- The information collected above will be analyzed for relationships between species and overtime.

- A line graph for each species is constructed when new data is obtained.
- Biodiversity is to be calculated using Hill's Index
- The tiles at different depths will also be compared to show which tile has the most growth.
- Finally relationships between tiles and organism growth will be analyzed

Results:

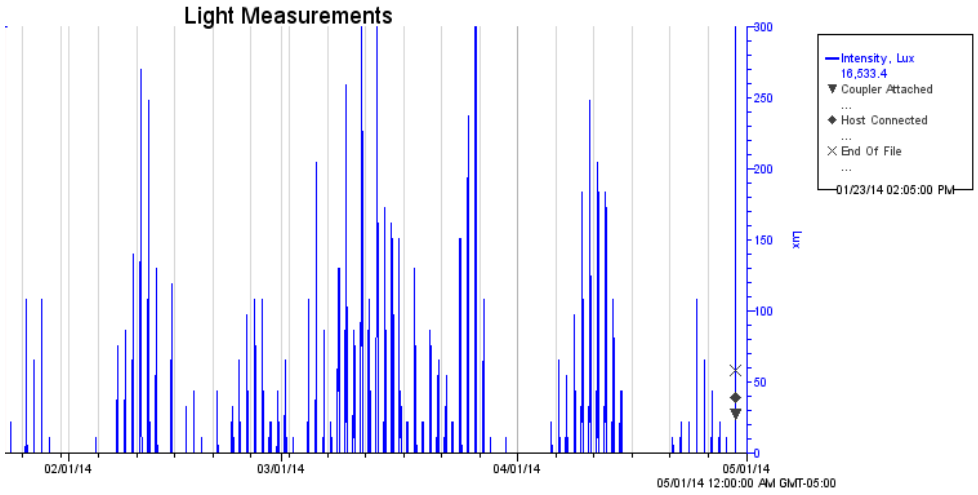

Figure 0.2 – The Graph above shows light intensity measured in lux. There are fluxuations between days and nights

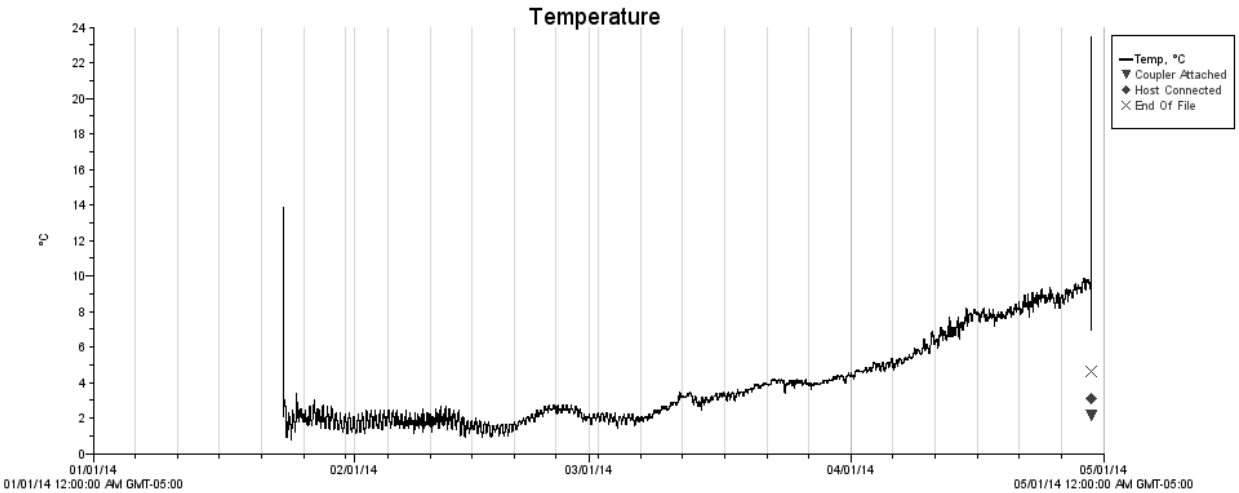

Figure 0.3- This graph shows temperature over time. As time increases, so does the temperature of the water.

Table 0.1- Percent Cover, April 10, 2014. The first sample shows that turf algae were the first organism to settle on the tiles. The replicates are the numbers 1, 2, 3 and 4 while the depths are a, b, c, d, and e. The letters represent the depths .5m, 1.0m, 1.5m, 2.0m, and 2.5m, respectfully.

Tile	percent cover	c. ascidian %	Sponge %	Byrozoan %	Algae	Polychate %	Bivaleves #	Tunicates #	Anemone #	Other
1a	40%	_	_	_	40%	_	_	_	_	_
1b	_	_	_	_	_	_	_	_	_	_
1c	2%	_	_	_	2%	_	_	_	_	_
1d	5%	_	_	_	5%	_	_	_	_	_
1e	98%	_	_	_	98%	_	_	_	_	_
2a	96%	_	_	_	96%	_	_	_	_	_
2b	89%	_	_	_	89%	_	_	_	_	_
2c	88%	_	_	_	88%	_	_	_	_	_
2d	_	_	_	_	_	_	_	_	_	_
2e	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3a	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3b	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3c	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3d	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3e	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
4a	95%	_	_	_	95%	_	_	_	_	_
4b	75%	_	_	_	75%	_	_	_	_	_
4c	5%	_	_	_	5%	_	_	_	_	_
4d	70%	_	_	_	70%	_	_	_	_	_
4e	30%	_	_	_	30%	_	_	_	_	_

Table 0.2- Percent Cover, September 17, 2014. This shows the cover data for the tiles on September 17th. The acronyms are: BA-Brown Algae, L- Limpet, B- Barnacle. 2 of the tile sets were lost over the summer. The Tunicates were counted individually.

Tile	percent cover	c. ascidian %	Sponge %	Byrozoan %	Algae %	Polychate %	Bivaleves #	Tunicates #	Hydrozoan %	Other
1a	95%	10%	60%	_	5%	5%	_	20+	10%	_
1b	90%	40%	50%	_	25%	10%	B3	15+	_	_
1c	90%	5%	40%	_	_	_	L1	70%*	_	_
1d	80%	7%	70%	_	_	_	B7	12	_	_
1e	70%	5%	70%	_	_	5%	B6	30	_	_
4a	100%	5%	20%	_	100% BA	_	2L	20+	_	_
4b	100%	_	30%	_	5%	_	_	80+	_	_
4c	85%	50%	10%	_	_	_	5B	20+	_	_
4d	90%	20%	90%	_	_	_	_	15	_	_
4e	90%	10%	70%	_	_	5%	1L	10	_	_

Table 0.3- Percent Cover, October 24. As of October 24th, tunicates were measured in both percentage and counted individually. This was done in order to accurately measure biodiversity.

Tile	percent cover	c. ascidian %	Sponge %	Byrozoan %	Algae R/G %	Polychate %	Bivaleves #	Tunicates #	Tunicates %	Hydrozoan %
1a	95%	8%	60%	_	_	_	_	18	30%	40%
1b	90%	10%	70%	_	_	10%	1 L 1S	15	25%	5%
1c	70%	3%	60%	_	_	5%	2L	10	10%	2%
1d	85%	15%	70%	_	_	3%	_	30	25%	10%
1e	70%	5%	70%	_	_	4%	_	10	10%	2%
4a	85%	25%	80%	_	_	2%	1 M(mussel)	25	50%	_
4b	90%	15%	60%	_	_	1%	1L	9	10%	_
4c	85%	10%	70%	_	_	5%	_	5	10%	25%
4d	90%	35%	60%	_	_	5%	_	5	5%	25%
4e	70%	25%	30%	_	_	_	_	20	30%	10%

Table 0.4 Biodiversity indexes 1a, October 24. The calculations for biodiversity were completed through an excel spreadsheet. Credit to: K. Goepel, Creative Commons Attribution-Noncommercial. In column 0, the hill number represents species richness (amoun of different organism types) while 1 represents biodiversity.

Order *q*:	**0**	**1**	**2**	**3**	**4**	**∞**
Generalized Mean:	harm	geom	avg	rms	-	Inf
Hill Numbers -True Diversity ^{q}D:	**4.00**	**3.38**	**3.09**	**2.92**	**2.81**	**2.30**
Renyi Entropy ^{q}H:	**1.39**	**1.22**	**1.13**	**1.07**	**1.03**	**0.83**

Table 0.5 Biodiversity indexes 1b, October 24.The calculations for biodiversity were completed through an excel spreadsheet. Credit to: K. Goepel, Creative Commons Attribution-Noncommercial.

Order *q*:	**0**	**1**	**2**	**3**	**4**	**∞**
Generalized Mean:	harm	geom	avg	rms	-	Inf
Hill Numbers -True Diversity ^{q}D:	**6.00**	**3.93**	**2.89**	**2.46**	**2.27**	**1.86**
Renyi Entropy ^{q}H:	**1.79**	**1.37**	**1.06**	**0.90**	**0.82**	**0.62**

Table 0.6 Biodiversity indexes 1c, October 24. The calculations for biodiversity were completed through an excel spreadsheet. Credit to: K. Goepel, Creative Commons Attribution-Noncommercial.

Order q:	0	1	2	3	4	∞
Generalized Mean:	harm	geom	avg	rms	-	Inf
Hill Numbers -True Diversity ^{q}D:	5.00	2.37	1.71	1.54	1.47	1.33
Renyi Entropy ^{q}H:	1.61	0.86	0.54	0.43	0.38	0.29

Table 0.7 Biodiversity Index 1d, October 24. The calculations for biodiversity were completed through an excel spreadsheet. Credit to: K. Goepel, Creative Commons Attribution-Noncommercial.

Order q:	0	1	2	3	4	∞
Generalized Mean:	harm	geom	avg	rms	-	Inf
Hill Numbers -True Diversity ^{q}D:	5.00	3.31	2.58	2.26	2.11	1.76
Renyi Entropy ^{q}H:	1.61	1.20	0.95	0.82	0.75	0.56

Table 0.8 Biodiversity Index 1e, October 24. The calculations for biodiversity were completed through an excel spreadsheet. Credit to: K. Goepel, Creative Commons Attribution-Noncommercial.

Order q:	0	1	2	3	4	∞
Generalized Mean:	harm	geom	avg	rms	-	Inf
Hill Numbers -True Diversity ^{q}D:	5.00	2.28	1.64	1.48	1.42	1.30
Renyi Entropy ^{q}H:	1.61	0.83	0.50	0.39	0.35	0.26

Table 0.9 Biodiversity Index 4a, October 24. The calculations for biodiversity were completed through an excel spreadsheet. Credit to: K. Goepel, Creative Commons Attribution-Noncommercial.

Order q:	0	1	2	3	4	∞
Generalized Mean:	harm	geom	avg	rms	-	Inf
Hill Numbers -True Diversity ^{q}D:	5.00	3.19	2.75	2.55	2.44	2.03
Renyi Entropy ^{q}H:	1.61	1.16	1.01	0.94	0.89	0.71

Table1.0 Biodiversity Index 4b, October 24. The calculations for biodiversity were completed through an excel spreadsheet. Credit to: K. Goepel, Creative Commons Attribution-Noncommercial.

Order *q*:	**0**	**1**	**2**	**3**	**4**	**∞**
Generalized Mean:	harm	geom	avg	rms	-	Inf
Hill Numbers -True Diversity ^{q}D:	**5.00**	**2.78**	**2.10**	**1.85**	**1.74**	**1.52**
Renyi Entropy ^{q}H:	**1.61**	**1.02**	**0.74**	**0.61**	**0.55**	**0.42**

Table 1.1 Biodiversity Index 4c, October 24. The calculations for biodiversity were completed through an excel spreadsheet. Credit to: K. Goepel, Creative Commons Attribution-Noncommercial.

Order *q*:	**0**	**1**	**2**	**3**	**4**	**∞**
Generalized Mean:	harm	geom	avg	rms	-	Inf
Hill Numbers -True Diversity ^{q}D:	**5.00**	**3.34**	**1.74**	**1.66**	**1.60**	**1.43**
Renyi Entropy ^{q}H:	**1.61**	**1.21**	**0.55**	**0.51**	**0.47**	**0.36**

Table 1.2 Biodiversity Index 4d, October 24. The calculations for biodiversity were completed through an excel spreadsheet. Credit to: K. Goepel, Creative Commons Attribution-Noncommercial.

Order *q*:	**0**	**1**	**2**	**3**	**4**	**∞**
Generalized Mean:	harm	geom	avg	rms	-	Inf
Hill Numbers -True Diversity ^{q}D:	**5.00**	**3.59**	**3.07**	**2.83**	**2.68**	**2.17**
Renyi Entropy ^{q}H:	**1.61**	**1.28**	**1.12**	**1.04**	**0.99**	**0.77**

Table 1.3 Biodiversity Index 4e, October 24. The calculations for biodiversity were completed through an excel spreadsheet. Credit to: K. Goepel, Creative Commons Attribution-Noncommercial.

Order *q*:	**0**	**1**	**2**	**3**	**4**	**∞**
Generalized Mean:	harm	geom	avg	rms	-	Inf
Hill Numbers -True Diversity ^{q}D:	**4.00**	**2.36**	**1.95**	**1.70**	**1.61**	**1.43**
Renyi Entropy ^{q}H:	**1.39**	**0.86**	**0.67**	**0.53**	**0.48**	**0.36**

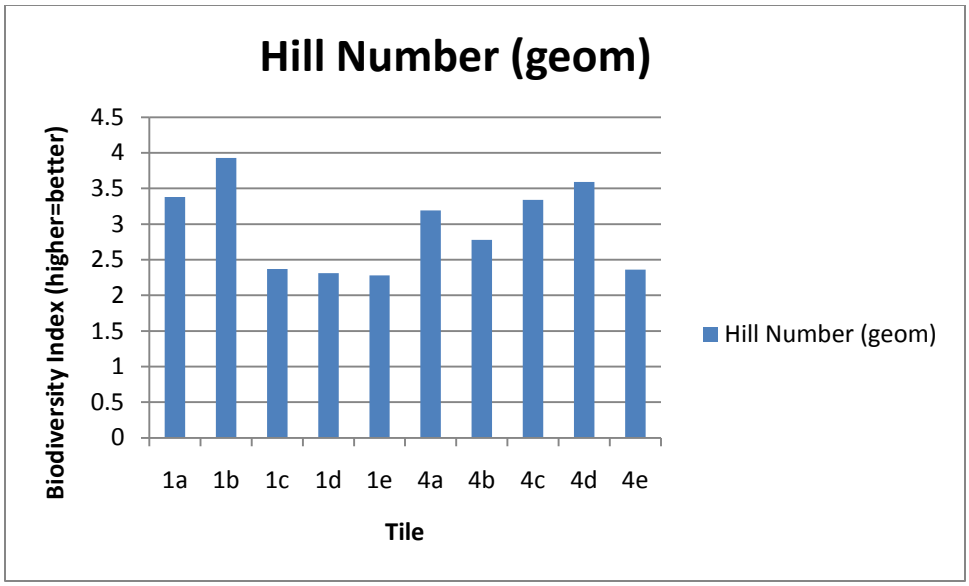

Figure 0.4 The Biodiversity index (Hill) is shown on the graph above. The tiles 1a,1b,4a, and 4d have the highest biodiversity level.

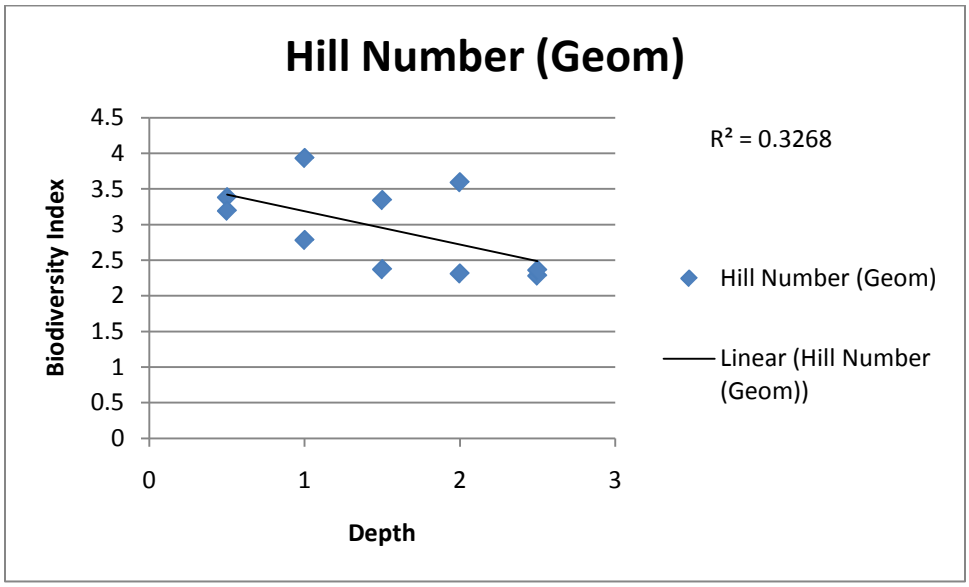

Figure 0.5- The biodiversity index for Hill is shown again. As seen on the scatterplot, biodiversity decreases as depth increases.

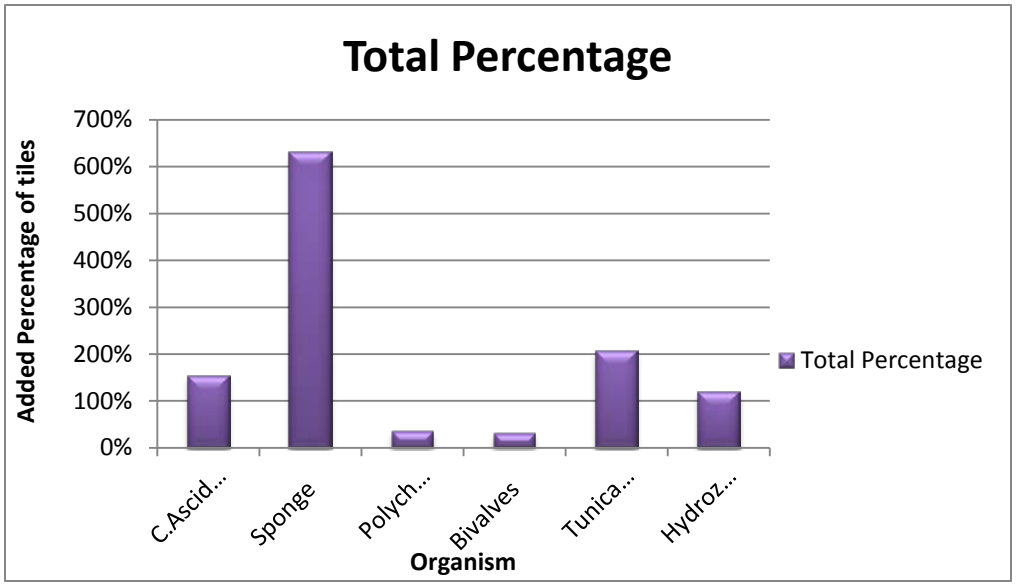

Figure 0.6 the percentages of each organism on every tile were added up for the date October 24th, 2014. This represents the total space each organism is taking up on all the tiles.

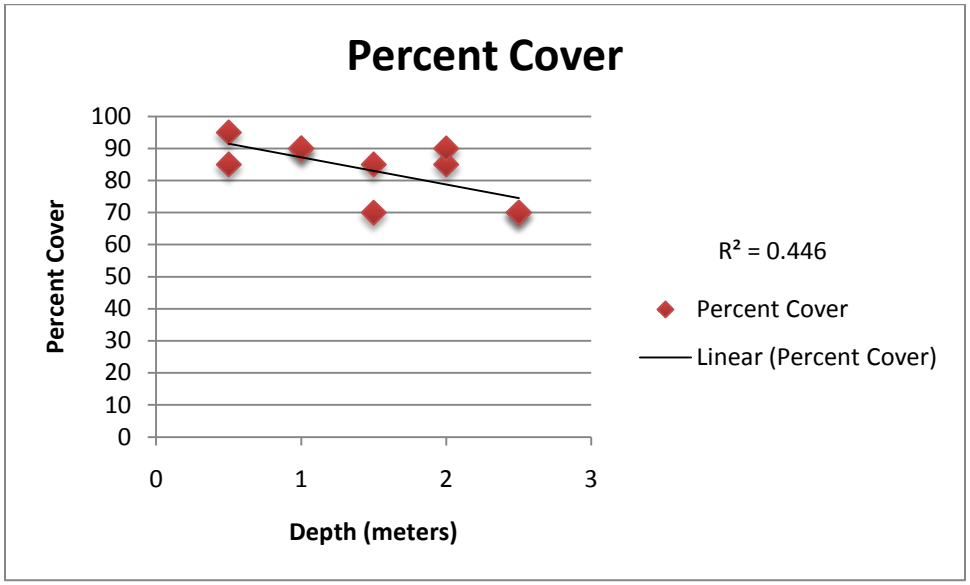

Figure 0.7 The scatterplot of percent cover. The x-axis shows depth (in meters) while the y-axis shows the percent cover. There is a negative correlation of .669 between percent cover and depth

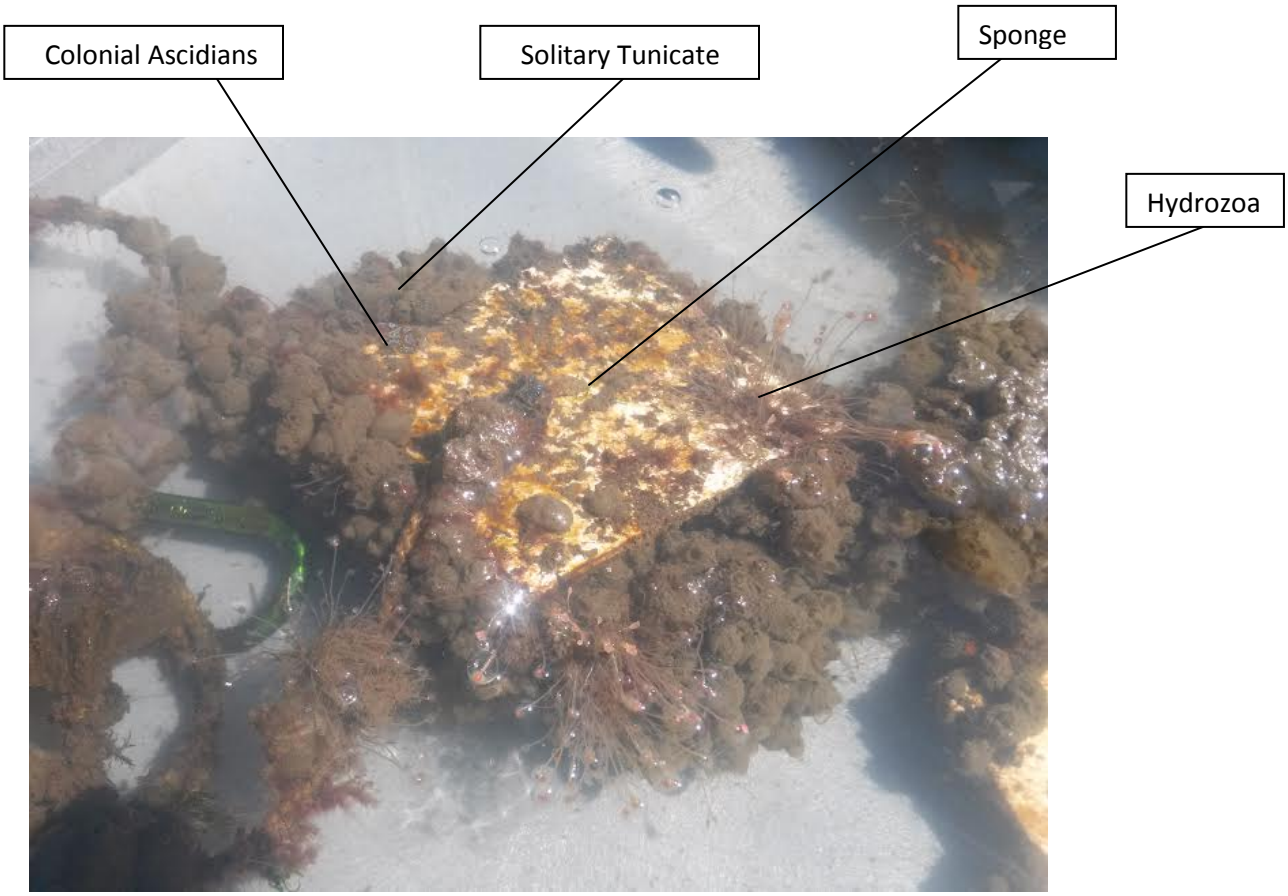

Figure 0.8-Tile 1A, September 17, 2014. This shows tile number 1A at the time of sampling. Some of the different organisms are marked.

Analysis:

The original design of the Project did not work properly. In the start of the project, the tiles were attached to a platform (figure 0.9). This platform was constructed out of wood and Styrofoam and held together by duct tape. Shortly after placing them in the water the lines snapped. The logical explanation for this is the tides. The measurements for the tides at Pier 101 might not have been completely accurate. If the tide was too long and the line too short, the platform would have been suspending above the water. The solution to this was to attach the tiles directly to the eco-dock at Pier 101. This is a much simpler design.

The two graphs, figure 0.1 and 0.2, above shows basic trends that would be expected. Figure 0.2 shows light intensity. The light intensity changes between the night and the day. This is because there is light coming from the sun during the day while there is little to none at night. The HOBO light sensor was placed in the water so that its depth changed with the tide. That also accounts for the differences in the amount of lux the sensor received. This data shows how the tiles at each of the different depths receive different intensities of light. The second graph, figure 0.3 shows temperature increasing over time. The temperature gradually changes over time. This is due to the warming of the outside air temperature in the transition from winter to spring. It

does not change as much as the outside air because of waters high specific heat. In the winter, the temperature is around 3 degrees Celsius and then rises to 8 degrees.

The first organisms to settle on the Porcelain tiles were turf Algae. They could be considered the pioneer species. As seen in table 0.1, turf algae were the only organisms on the tiles. Over the summer, the turf algae became dominated by organisms such as sponges or colonial ascidians.

The October 24th sampling date showed an influx in hydrozoa that settled on the tiles. Over the course of one month, the percent of hydrozoa increased across the board; mostly, in tile 1A, 4C, and 4D. Although not measured, hydrozoans seem to settle on the rope which connects the tiles.

When Invertebrates settle, they sometimes settle on top of each other. This is showed especially well in Figure 0.8 (Annex). A colony of colonial ascidians settled over solitary tunicates. This shows how sessile invertebrates do not necessarily need to settle on a hard substrate. This also explains how reefs are formed. Species settle and grow on top of each other.

Competition is a major factor in the growth of sessile invertebrates on porcelain plates. Table 0.6 shows the total amount of each type organism growing on the tiles on October 24th. As seen there, sponges are the most abundant organisms. They have the most coverage than any other organism. This data is consistent with each and every individual tile as well. Colonial Organisms cover the largest percentage of the tiles. This is because they grow in groups. Solitary organisms, with the exception of the tunicate, are much less abundant.

At different depths, the tiles have different diversity. In this study, biodiversity is measured using the Hill Index. Figure 0.5 implies that light intensity affects biodiversity. There is a negative correlation between Depth and biodiversity. This means that if light intensity increases so will biodiversity. Generally speaking, the tiles closer to the surface receiving more light have a higher diversity. There are some irregularities. One example of this is tile 4d. Tile 4d had a high biodiversity because there was a more equal distribution of organisms on the plates. Tile 1e had the lowest biodiversity with an index of only 2.28. This is because a large percentage of the tile is taken up by sponges. Although species richness is important to biodiversity, species evenness is just as crucial to the calculations. Tile 1e had a very high richness of 5, but it lacked quantity of most organisms. Only sponges were able to successfully and fully colonize on that plate. Other tiles, such as 1a, have a high biodiversity index, but have a slightly lower richness level. Its biodiversity was still high as there was a more even distribution. The tile with the highest biodiversity was 1b. This was because the tile had both an even distribution and the highest species richness. If a tile has a high biodiversity level, it is a much healthier ecosystem as it is much more balanced.

There is a strong negative correlation between depth and percent cover. This means that the tiles lower in the harbor experience less growth while tiles toward the surface experience

more. Figure 0.7 shows the correlation where r= -.667. Since there is less light reaching the deeper tiles, it can be assumed that light intensity and percent cover are also directly correlated.

Conclusion:

So far, there were several conclusions drawn from the experiment. The first deals with the original procedures plan. In the beginning of the project, the porcelain tiles were suspended from a platform constructed out of both wood and Styrofoam. This method proved to be ineffective as some of the tiles and even the platform was lost at sea due to the high wave action. Now, the tiles are hung from a floating dock which gives the tiles the same effect of constant depth as the platform did. Because currents and other factors do not affect the experiment as much; this method may seem to be more useful. By having the tiles suspended right from the dock, there is less of a chance of losing them.

Currently, the data supports the hypothesis in the fact that the tiles receiving the most light experience the most growth in terms of the total coverage. However, the hypothesis can't be definitively supported as one year has not elapsed yet. It can be said that the biodiversity does increase in tiles close to the surface of the water. This is due to increased light intensity. The data does not support the part of the hypothesis that states that colonial ascidians will dominate the lower two tiles (1d, 4d, 1e, 4e). Instead of colonial ascidians dominating those tiles, sponges did. Colonial ascidians did not make as much of a presence as expected.

According to the data, the most suitable depth for invertebrates to grow on is tiles situated .5-1.0 meters under the surface (a&b). This is because there is both a high biodiversity and a high percent cover. Biodiversity and percent cover both have a negative correlation. This means that as the depth increases the y-variable decreases. The data proves that there is also a correlation between the growth of sessile organisms on porcelain plates and light penetration. In order to achieve the best results, porcelain tiles should be placed close it the surface. It is important that the tiles are constantly under the water so tides do not affect them.

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Suggestions for Future Research:

In order to maintain quality and accuracy, the tiles should continue to be immersed in the harbor and should be monitored. Since succession is not a fast process, the data changes over time. By continuing to measure in the future, new conclusions can be drawn as well as a reassurance of old conclusions. Since ecological succession takes an elongated time, the climax community has not been found. Past studies have shown that a climax community is not found till about 37 months. These communities are usually dominated by sponges, colonial ascidians, or bryozoans (Hirata, 1987).

Annex:

Figure 0.9- The Original design of the project platform

Figure 1.0- Close up of Tile 1B, October 24th. The tentative identification of the organism is an Oyster Drill.

Figure 1.1- Close up of tile 1c, October 24. A limpet is pointed to.

Figure 1.2- Close up on tile 4a, October 24. A blue mussel is shown on the tile.

Figure 1.3- The rope. Many Hydrozoa settled on the rope

Figure 1.4- Settlement of Colonial Ascidians. A colony of Colonial Ascidians settled on solitary tunicates.