A Comparison of Species Biodiversity at Cattle Point, San Juan Island: 1971 - 2018

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Abstract

Algal species at Cattle Point on San Juan Island, WA have been monitored and surveyed by Friday Harbor Labs since 1971. This resource of data presented the opportunity to examine Cattle Point's algal species diversification over 47 years. The goal of this research was to examine the changing diversity as well as the zonation of the area over time. Through this paper, we examine differences in percent cover from 2006, 2008, 2013, and 2018 using the program PRIMER. A dendrogram and MDS plot of the Bray Curtis Similarity of the percent cover data was used to visually represent the data. According to the dendrogram, a group of zone 4 transects dominated by kelps were less than 10% similar to all the other transects. The percent cover data was then tested using ANISOM statistical methods. Zone 1 was found to be the most differentiated from all four zones. This result matched the data from the dendrogram and MDS plot. No conclusions could be drawn from the ANISOM results on comparing the years due to different sampling methods. Using data from 1971-3, 2008, 2013, and 2018, presence/absence data of 49 species were examined. The number of species present increased and peaked in 1973 and 2008 and declined moving forward to 2018. Lastly, the change in percent cover of *Fucus distichus* was examined and found to be in overall decline. From all of these results, a lowering level of *Fucus distichus* as well as biodiversity was seen over time.

Introduction

The NE Pacific Ocean is home to a diverse community of marine algae ranging from the 30 m long bull kelp, *Nereocystis,* to microscopic diatoms. From Southeast Alaska to Oregon, there are currently 671 species in the marine macrophyte flora (Gabrielson 2018.) With this amazing diversity, it is important to monitor how biodiversity of different species in this area changes over time and how these species interact together.

The intertidal community can be complicated to study because of the seasonal variability and daily flux of Washington's mixed semidiurnal tides. The intertidal covers the low tide zone (fully submerged except for low tides) up to the spray zone (never fully submerged in water). This large variability in environmental and tidal conditions creates zonation in the intertidal community. Some of the many environmental stressors that impact the zones are sunlight, UV radiation (Johansson and Snoeijs 2002), herbivory, changes in salinity, and changes in temperature (Sanford 2002).

Studies of intertidal zonation began in the 1940s as Maxwell S. Doty examined the tidal factors that affected the vegetation cover and the breaks that were created. While this focused on Oregon and California, Doty concentrated on the differences in zones while seeing a pattern within the tide patterns throughout the year. However, this paper does not take into account changes in the environment; instead just noting them as a significant factor to research later (Doty 1946). However, accurately sampling data in a way that would consider environmental factors is still a challenge today as researchers must account for the variability from one site to another (Dethier 1992). Going forward, this topic began gaining interest as these intertidal zones were seen as a potential to measure pollution in the area and its effects on the algae diversity. At the same time, Borowitzka (1972) observed that algal diversity decreased as they surveyed higher up in the intertidal zone. Surveying the intertidal zones continued as researchers began to identify not only the visibility of the zonation, but also the impacts that various environmental factors have on the zones themselves. In order to understand how the intertidal zones are being affected by time, pollution, tidal levels, and other environmental factors, research has continued to go deeper into recognizing these factors as well as the overall rate of biodiversity change over the surveyed area (Smith 1992). Multiple transects across the northwest coast have been set up in a variety of habitats in order to examine the biodiversity changes over time as well as with the changing climate (Dethier 1992). However, past studies allow for current research to observe how the algae have changed as well as how the changes in the tides and water body itself have affected these areas.

Starting in 1971, Dr. Tom Mumford periodically surveyed four locations at Cattle Point on San Juan Island. This older data creates a perfect opportunity to examine how the biodiversity and zonation of algae in this area has changed in both the short and long term. For this research, the main objective is to understand the changes of biodiversity over time/height over a transect of the intertidal zone and the zonation that occurs. With this objective in mind, we will use transect data to evaluate if biodiversity in the transects have declined over time and if biodiversity declines going higher up the intertidal zone.

Methods

A survey previously completed multiple times by Dr. Tom Mumford, Katie Dobkowski, and many students throughout the years at Cattle Point, San Juan Island, Washington was repeated on Saturday, June 16th, 2018. The head of the transect is marked by a brass plaque placed in 1971, marked Transect "C" and is referred to in earlier studies as a "protected rocky" habitat. A meter tape was used to measure the distances between each 0.25 m^2quadrat area. Data was collected every meter down from 0 (top, brass marker) to 22 meters at low tide. Notecards and plastic ziplock bags helped to keep track of different specimens from each quadrant. The notecards had the specific description of the specimens as well as which quadrant the specimen was taken from. For the first three quadrants, the percent cover of each species in each square (25 total squares) was counted. For the rest of the quadrants, a simplified approach was taken by estimating the percent cover of the total quadrant instead of each individual square. Each species was recorded with a number between 1 and 5 to represent the percent cover in the quadrant. The number 5 represented a 50-100% cover, 4 represented 25-50%, 3 represented 12.5-25%, 2 represented 5-12.5%, and 1 represented less than 5% cover. This numbering system was from Dr. Mumford's original surveys from which he used the method of indexing species percent coverage originally from the Braun-Blanquet system (Poore 1955). This was done in order to not confuse similar specimens. The tide inhibited the ability to complete the transects in order. The first half was completed with one quadrat and in the last half when pressed for time, both quadrats were used (two quadrats total were brought to the site). The slope at each quadrat was also recorded using the iPhone Compass app. Pictures were taken at each quadrant as well to help with the identification process back at the lab (see appendix C). Specimens were brought to the lab for identification using Gabrielson 2018.

After identifying the samples, analysis began in order to assess the biodiversity of the transect line. In doing so, we examined the species composition of each quadrat of our transect line to see overall change in biodiversity throughout the intertidal zones. At the same time, we used this data in order assess the change in biodiversity of this transect line over time. With this, we compared species diversity over time of each study done during 1971, 1972, 1973, 2008, 2013, and present (2018) (Graham et al. 1973). These years were used due to the range of years in each century to get an overall view of the species diversity. This inquiry has allowed us to see the differences of biodiversity both over time as well as across the intertidal zones. However, the data from the 1970s did not include percent cover over quadrats, and therefore was only used in analysing presence/absence across the available data. Due to the fact that names of some algae have changed over the years, adjustments were made to account for this by taking the data from the 1970s and reassessing it with the modern names. At the same time, this factor has also been taken into account when looking at the results with the potential of human error through misidentification of the various algae.

All the data for percent cover from 2006, 2008, 2013, and 2018 was compiled into one Excel© sheet with the transect and year as a column and genus/species as rows. This data was entered into Primer-7 (PRIMER-E (Quest Research Limited), Gate 5, Oaklands Rd Massey University, Albany Auckland 0632, New Zealand; http://www.primer-e.com/) and analyzed using the Bray Curtis Similarity. The Bray Curtis statistical method as described in Clark and Green paper in 1988 and was used by Clark in his paper on nonmetric multivariate analysis. This is the method our analysis is based from. Following Clarke's methodology, we created a dendrogram of the Bray Curtis similarity examining the similarity of species between the different intertidal zones. The transect data was split into four different zones: zone 1 (0-5 m along the transect line), zone 2 (6-10 m), zone 3 (11-15 m), and zone 4 (16 m to the end of the transect). The data from different years is not uniform with the depth of the final transects, resulting in an ending range from 21-24 m. The meters on the transect line can also be represented by tidal height. A table converting the meters used in the Cattle Point data to the tidal height from the 2013 survey can be found in Appendix D. Tidal height, measured in feet, starts at mean lower low tide (0 ft) and increases to mean high water and above. In this transect, there is negative tidal height since the tide is below the lower low tide. Next, continuing with Clarke's methods, we created a MDS (nonmetric multidimensional scaling ordination) of the Bray Curtis similarity with different zones and years of our data. Lastly with this data set, two ANOSIM tests (Clarke 1999) were used to test for differences between years and for differences between zones. The ANOSIM test gives back an R statistic which ranges from a value of 0-1: 0 meaning treatments are identical and 1 meaning there is a high differentiation (Clarke 1999). Along with the R statistic outputted in the ANOSIM test is the significance level, possible and actual permutations, and the number observed.

Using *Fucus distichus* as a marker, zoneage was assessed in a comparison of the average percent cover for each zone over the years. This analysis allows for a chance to see if the overall zoneage has changed throughout 2006, 2008, 2013, and 2018 due to a variety of environmental factors that shift this transect. This alga is generally found in the midrange of the transect, allowing it to be used to examine changes from the top as well as from the bottom.

Results

With a total of 49 species or functional groups found at some point throughout 1971, 1972, 1973, 2008, 2013, and 2018, there has been a wide variety of diversity found at this site, seen in Figure 1. Species that have been found in all of these years include *Acrosiphonia sp., Corallina vancouveriensis, Endocladia muricata, Fucus distichus, Mastocarpus crust ("Petrocelis"), Mastocarpus sp., Phyllospadix scouleri,* and *Ulva sp*. At the same time, *Analipus japonicus, Bossiella plumosa, Ralfsia sp.,* and *Saccharina sessilis* were found in 1971, but not present in 2018. On the other side, *Odonthalia washingtoniensis, Alaria marginata,* and *Halosaccion glandiforme* were recorded being present in 2018, but not throughout the 1970s data. Overall in 1971, 16 different algal species were sampled, while in 1972 and 1973 there were 23 and 28 algal species respectively. Then going into the 21st century, there were also 28 species found in 2008, however after that, the number of species dropped to 20 in 2013 and 21 in 2018.

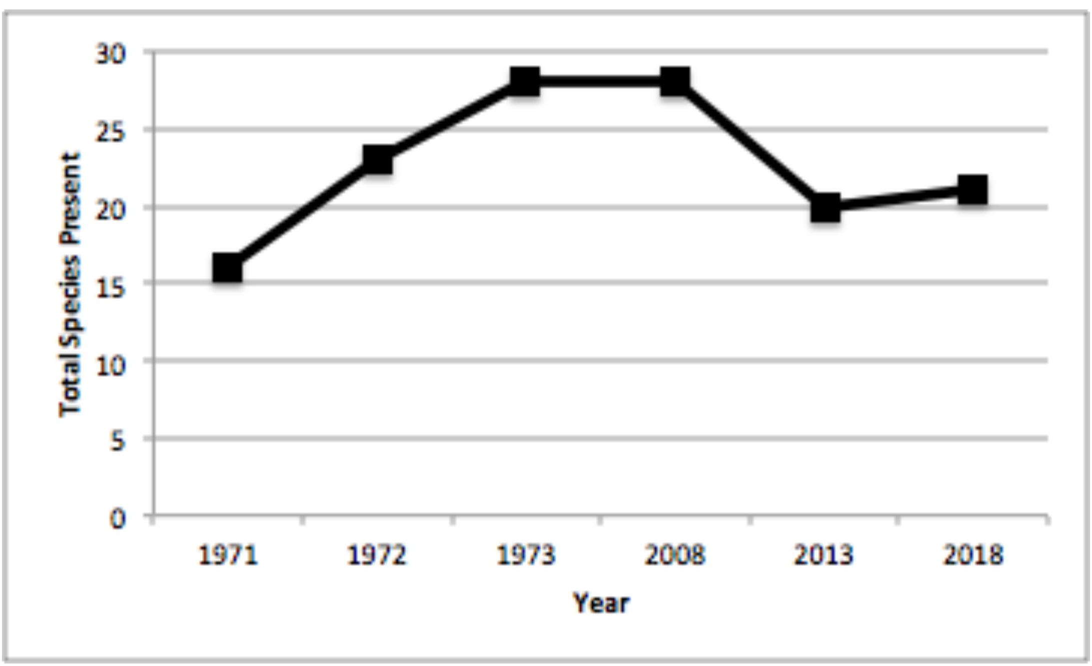

Figure 1: Comparison of total number of species present over time.

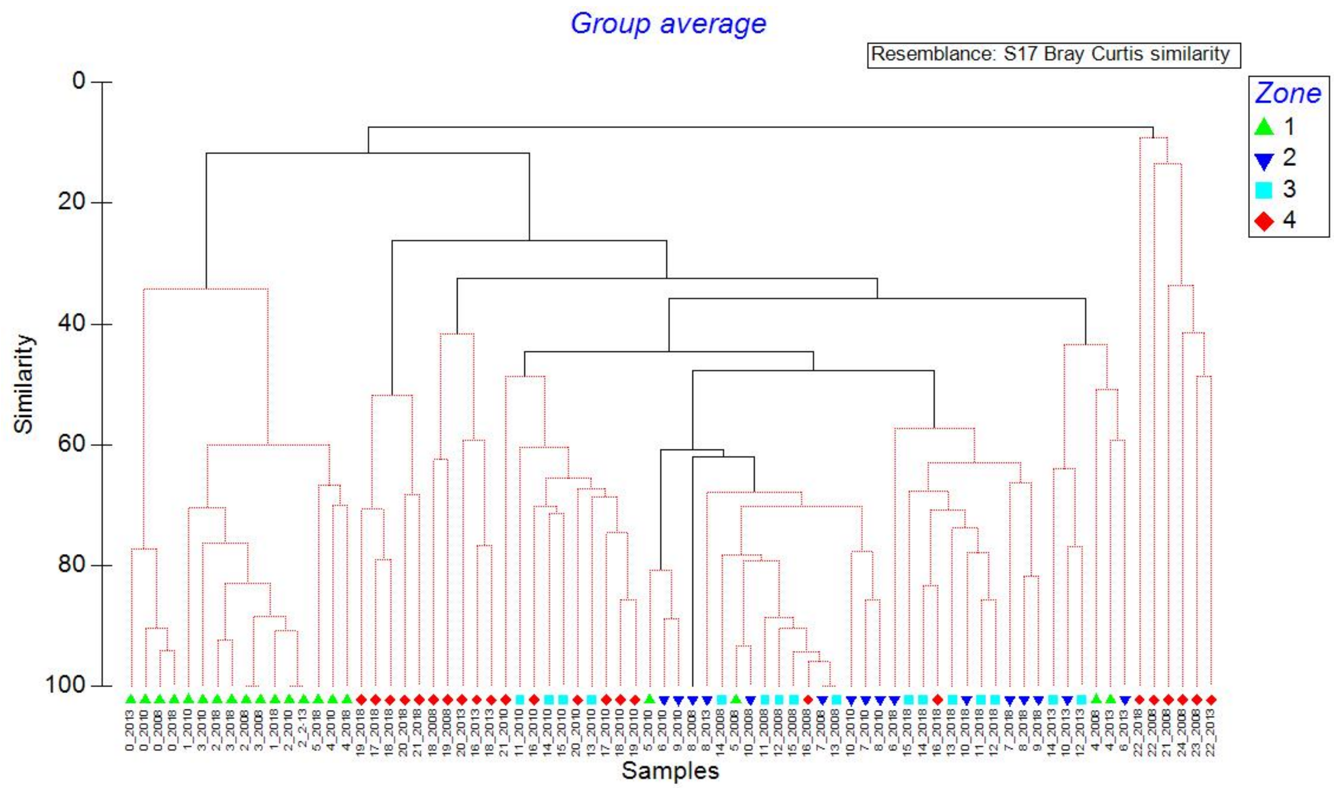

Figure 2: A dendrogram of the Bray Curtis Similarity represented by different zones.

The dendrogram in Figure 2 showed both similarities and differences in the zones throughout the different years. Zone 1 showed the most similarity with 16 quadrats from different years being aligned next to each other in the dendrogram. Zone 4 also showed similarity in the dendrogram. There are two separate groups of similarities in this zone which are very dissimilar from each other. The zone 4 group on the left side of the dendrogram is a group of 11 quadrats from different years. The zone 4 group on the right side of the dendrogram, a group of 6, has the least similarity to any other grouping. This group consists of the quadrats with depth ranging from 21-24 m. Zone 2 and 3 don't form any large groupings (no more than four in a row) and are mixed together with the outliers from zone 1 and 4.

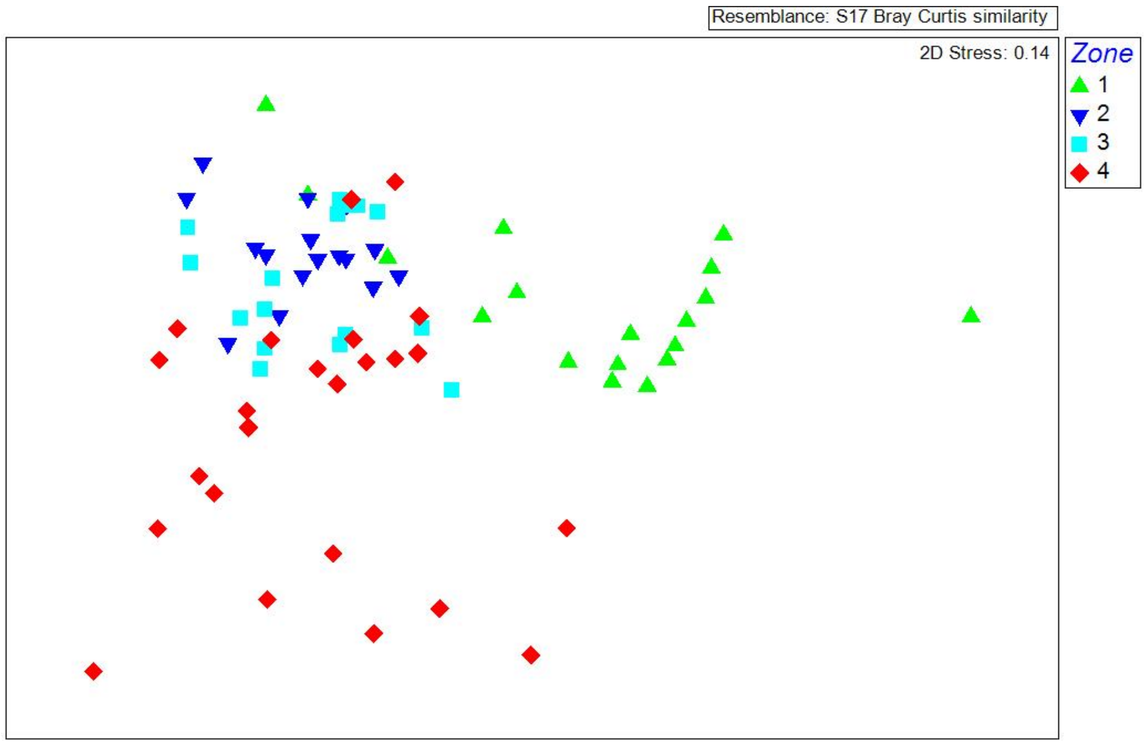

Figure 3: An MDS plot of the Bray Curtis Similarity represented by different zones.

As seen in Figure 3, zone 1 and 4 are unique clusters dissimilar to the other zones. Zone 2 and 3 are mostly indistinguishable from each other with the clusters occupying the same area. The 2D stress of the graph is 0.14. Outliers of zone 1 and 4 are also clustered with zone 2 and 3. The graph is being pulled in three directions. The kelps of the lower zone 4 (21-24 m) are pulling in the negative x and y directions with the leading quadrat 22 m from 2018. This leading point is dominated by *Saccharina nigripes.* Zone 1 is pulling the graph in the positive x direction. The four leading quadrats are the 0 m from all four years which are dominated by *Prasiola meridionalis* and bare rock. Lastly, zone 2 and 3 are collectively pulling in the positive y and negative x direction. The leading quadrants, 6 m and 10 m from 2013, are dominated by *Fucus distichus*.

Two ANISOM tests were completed with the percent cover data: tests for differences between the years and between the different zones (see appendix A). Comparing the years, there is a global R value of 0.459 with a p-value of 0.001. Comparing the years to each other, 2008 and 2013 has the lowest R value of 0.204 and 2006, 2013 have the largest R value of 0.672. Comparing differences in the zones, the global R value is 0.479 also with a p-value of 0.001. The lowest R value is 0.272 looking at zone 3, 4. The highest R value is 0.673 from zone 1,3. The R values from zone 1 to 2 and zone 1 to 4 are both high as well with R values of 0.63 and 0.663. All p-values for both ANOSIM tests are under 0.05, and therefore can be considered statistically significant.

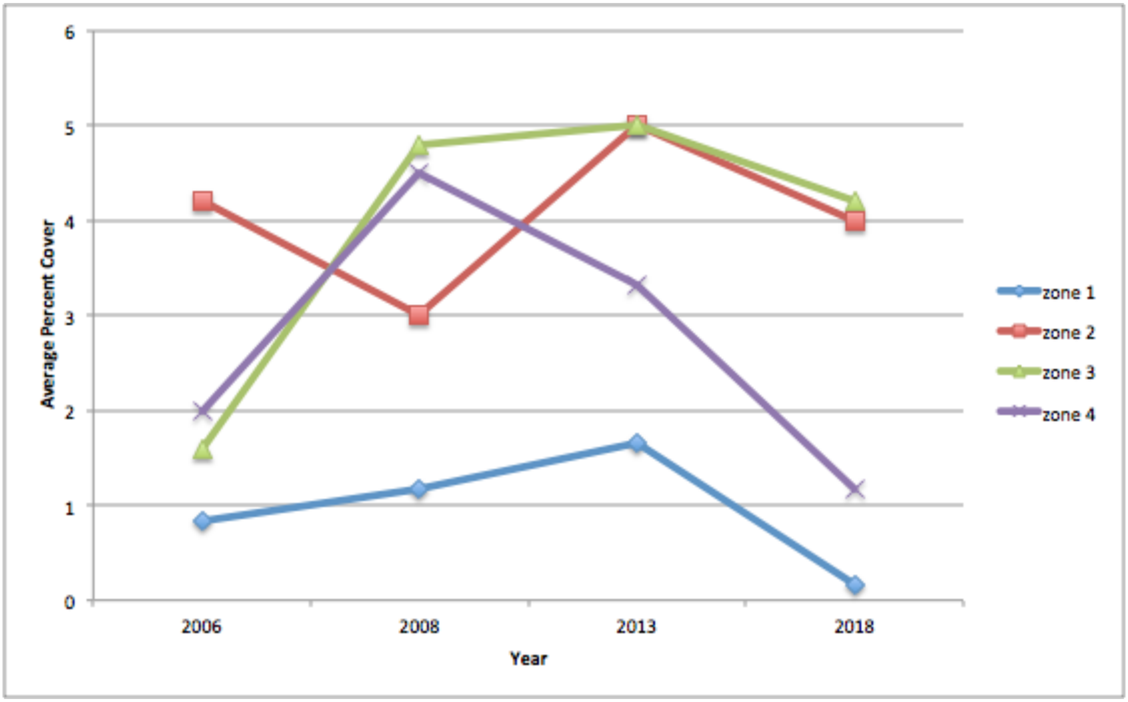

Figure 4: Examining the *Fucus distichus* in each zone over time using average percent cover.

Fucus distichus has significantly shifted over the years assessed in not only its location on the transect, but also how much is present over time, shown in Figure 4. Within the four zones assigned, in 2006, the average percent cover (using the aforementioned numbering system) was 0.83 for zone 1, 4.2 for zone 2, 1.6 for zone 3, and 2 for zone 4. Then in 2008, it was 1.17 in zone 1, 3 in zone 2, 4.8 in zone 3, and 4.5 for zone 4. For 2013, the average percent cover was 1.67, 5, 5, and 3.3 for each zone respectively. Finally, in 2018, zone 1 was 0.17, zone 2 was 4, zone 3 was 4.2, and zone 4 was 1.17.

Discussion

Since 1971, this transect has been used in order to assess the species diversity found across a clearly zoned intertidal area. While there is not any data for the quadrants themselves, the comprehensive presence to absence data shows how the changes in the environment are affecting overall species diversity. From 1971 to 1973, the total species diversity increased to the highest point of the data set at 28 species. This trend may be due to the difference in sampling methods as others were able to learn from past studies. At the same time, this peak amount of 28 species was also found in the 2008 dataset, showing that over the 35 year difference, there was not a significant decrease. However, the diversity found in each showed there was 10 unique species that were only found in 2008 or 1973. While these differences may be due to misidentification or the continuous changes of species classification, the environmental factors would have shifted significantly over the years, causing the habitat to potentially no longer support the earlier species. Beyond 2008, there was a consequential drop, going from 28 species in 2008 to 20 species found in 2013 with 21 species in 2018. With this drop, both of the winters of 2008-2009 and 2011-2012 were substantially drier than previous years (Di Liberto 2017). This environmental factor would impact the species diversity overtime, while also displaying that regardless of all of the various components that may come from the changing environment. At the same time, there is not a significant difference between 2013 and 2018, however there is one more species found in 2018. This is also accounted when examining the species that are newly present as well as the various ones that are no longer found in the area. For the most part, the species that are unique to 1971 or 2018 are fairly obvious and thus leading to the idea that these were not found again or previously.

With this in mind, the species diversity has been shifting over the years, not only overall biodiversity, but also throughout the variety of different species found in each year.

The dendrogram from PRIMER showed similarities and differences of quadrats between and within the zones. First of all, zone 1 was similar between the years and throughout the zonal depth. This observation makes sense as zone 1 is generally a sparsely populated and uniform area occupied mostly by *Prasiola meridionalis*. Delving into zones 2 and 3, there are few similarities in the individual zones. There is no defined zonation between the two middle zones, but instead they are completely mixed in the dendrogram and MDS plot. The dominant species in both zone 2 and 3 is *Fucus distichus* which ranges from 4-21 m depending on the year. This dominance creates almost indistinguishable middle zones. The final zone showed two distinct groupings of similarity. These two groups were separated by depth: 16-20m and 21-24 m. The higher part of zone 4 has a diverse community including *Ulva sp., Fucus distichus, Corallina vancouveriensis, Pyropia sp.* and *Mastocarpus sp.* The lower part of zone 4 according to the dendrogram is the least similar to all other quadrats with less than 10% similarity and is home to the kelps and eelgrass. One of the reasons these three groups are appearing this way is from environmental stressors. Zone 1 has the most exposure to the sun (dessication and thermal stress) and UV radiation and therefore is always limited in diversity. Zone 4 is always submerged unless it is low tide and so has species particularly suited to that environment. Zone 2 and 3 share similar stressors and aren't under the same particular stressors of zone 1 and 4 and therefore are merged together in the dendrogram. Overall the dendrogram shows how different zones and the species within them relate to one another.

The MDS plot confirms what was seen in the dendrogram with the three different grouping. One observation of this plot is that the mixed cluster entirely encompasses the *Fucus distichus* zone. The three clusters can be split up by major species, zone 1: *Prasiola meridionalis,* zone 2, 3, and the first half of 4: *Fucus distichus,* and second half of zone 4: kelps and *Phyllospadix scouleri.*

It was hard to decipher the ANISOM data looking at similarities in the years. The years 2008 and 2013 were the most similar to each other out of 2006, 2008, 2013, and 2018. The most differentiated years are 2006 and 2013. The data from 2006 and 2008 came from one source, while the 2013 data came from a separate source. Also, the 2013 sheet has about half the data as the other years because only the even numbered quadrats were examined in this survey. Since the data came from different sources, there is a significant difference in the amount and quality of data between the years. Looking at the ANISOM data on the similarities between zones, zone 3 and 4 were shown to be most similar to each other (lowest R value) and zone 1 and 3 had the most differences (highest R value). This is different than the results from the dendrogram and MDS plot which showed most similarity between zone 2 and 3. Zone 4 in the dendrogram was the most differentiated, yet in the ANOSIM result, it is the most similar to zone 3. A possible explanation to why zone 4 shows different similarities could be from the size and species diversity of the zone. All four years had different ending quadrats depending on the daily tide which created ending points ranging from 21-24 m. If zone 4 had been split into two zones: 16-20 m (containing diverse community of filamentous red algae such as *Odonthalia floccosa)* and 21-24 m (mostly kelps and eelgrass), there would have been different results that could possibly explain the conflicting outcome with zone 4. The range of *Fucus distichus* could also be a major contributor to the zone 4 split. *Fucus distichus* was found all the way up to 21 m, splitting zone 4 into two groups: with and without *Fucus distichus.* This also coincides with the split in the dendrogram of zone 4. The result that zone 1 and 3 are most differentiated from each other does coincide with the dendrogram and MDS plot as these two groups are in different clusters. The zone 1 to 3 R value is only slightly higher than the 1 to 2 and 1 to 4 tests. All tests with zone 1 showed high differentiation, meaning that zone 1 is not particularly similar to any other zone. This result aligns with the particular environmental conditions/stressors present in this zone. Also, only *Prasiola meridionalis* is abundant in the top of zone 1 and it does not appear in lower zones, making it unique and differentiated from the rest of the intertidal. In looking at the PRIMER data and results in total, there are both important similarities and differences of the transect data that show the structure and composition of the intertidal zonation.

In examining *Fucus distichus*, it is clear that the overall zones of this transect line has changed since 2006. Using the zones previously mentioned, the average percent cover generally increased from 2006 to 2008 (other than zone 2). After 2013, however, they all are steadily decreasing, with the highest drops coming from zone 1 and zone 4. These decreases in the general average percent cover illustrates the minimization of the *Fucus distichus* habitat range. Overall, the habitat is shrinking mostly from a decrease in percent cover from zone 4, which has the highest drop off, however, the habitat also appears to be decreasing from the top down as well with a fairly significant drop coming from zone 1. With this, the impacts of climate change are a significant factor in the overall decrease of the average percent cover of *Fucus distichus.* These impacts are creating hotter and drier summers which allow for this species to dry out considerably faster during the low tides with extended exposure. At the same time, these summers lead into increasingly harsher winters, forcing this species to adapt to the increased chance of storms and the wind and waves that come with it (Future Climate 2014). In conclusion, the *Fucus distichus* has faced a significant decrease of percent cover from 2006 to 2018, showing that there has not only been an overall change in biodiversity at this site, but also the zonation itself has shifted.

Within the data used for this study, there appear to be a variety of sampling techniques used to collect the data as well as identify the samples. With this, it was difficult to compare the data year to year as these methods appeared to be entirely different within each study. Comparing the zones were possible due to the fact that the major species were recorded correctly, however, many of the smaller species were difficult to compare due to the poor sampling techniques, identification, and lack of holdfast assemblage data. At the same time, in only having percent cover for the datasets in the 2000s, the data from the 1970s were only able to be used to compare presence/absence overall rather than being able to look at each quadrants. In doing so, there had to be multiple comparisons in order to try and understand all of the data that were made available. With that, there have not been consistent methods in sampling and therefore the potential for significant human error is high and very abundant throughout these datasets. This analysis has been done regardless of these issues, but instead being aware of this throughout in order to use this wide range of data to get the best understanding of how the zoneage and biodiversity of this transect has changed over time. In order to get a better understanding of zoneage, the sampling and identification techniques need to become standard and better organized in the future.

Conclusion

The overall goal of this study was to examine the changes in biodiversity over a transect to see the impacts of climate change and other various environmental factors. In doing so, presence to absence was assessed, showing a decrease in biodiversity since 1971. At the same time, the dendrogram from PRIMER displays the differences of the zones created with MDS being used as a visual representation whereas zone 1 was the most dissimilar from the other zones. In this same dendrogram, zone 4 appears to be separated into two separate categories while zones 2 and 3 are the most similar. Then with the ANISOM data, zones 1 and 3 were the most different with *Fucus distichus* present in of half of zone 4. Even so, it appears that there are in fact 5 zones in order to separate the kelp areas from the *Fucus distichus.* However, the overall *Fucus distichus* found at this site has shown a decrease in the overall percent cover. With this, *Fucus distichus* has the highest average percent cover in zone 3, however all of the zones have decreased since 2006, demonstrating the impact of various environmental factors affecting the habitats of the algae. In the end, there have been essential changes in the biodiversity of the algae over this transect, which show a general decrease in these various results. Moving forward, this study should continue to occur to monitor this area as well as have a better understanding of the biodiversity shifts.

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Statement of Contributions

For this project, Bailey Armos and Veronica Owen worked together to go along the transect in quadrants for data collection and again with identification of the samples and transcribing the previous years' data. In writing the paper, they worked on the methods and introduction together. In analyzing the results, Bailey wrote the the PRIMER results while Veronica wrote the presence/absence and *Fucus distichus* results, while working overall on the general analytical process together. Finally, Bailey wrote the abstract while Veronica wrote the conclusion.

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Appendix A

ANOSIM
Analysis of Similarities

Two-Way Crossed Analysis

Resemblance worksheet
Name: Resem1
Data type: Similarity
Selection: All

Factor Values
Factor: Year
2008
2006
2013
2018
Factor: Zone
1
2
3
4

Factor Groups

SampleYear	Zone	
0_2008	2008	1
2_2008	2008	1

3_2008	2008	1
4_2008	2008	1
5_2008	2008	1
7_2008	2008	2
8_2008	2008	2
10_2008	2008	2
11_2008	2008	3
12_2008	2008	3
13_2008	2008	3
14_2008	2008	3
15_2008	2008	3
16_2008	2008	4
18_2008	2008	4
19_2008	2008	4
21_2008	2008	4
22_2008	2008	4
23_2008	2008	4
24_2008	2008	4
0_2010	2006	1
1_2010	2006	1
2_2010	2006	1
3_2010	2006	1
4_2010	2006	1
5_2010	2006	1
6_2010	2006	2
7_2010	2006	2
8_2010	2006	2
9_2010	2006	2
10_2010	2006	2
11_2010	2006	3
13_2010	2006	3
14_2010	2006	3
15_2010	2006	3
16_2010	2006	4
17_2010	2006	4
18_2010	2006	4
19_2010	2006	4
20_2010	2006	4
21_2010	2006	4
0_2013	2013	1

2_2-13 2013	1	
4_2013	2013	1
6_2013	2013	2
8_2013	2013	2
10_2013	2013	2
12_2013	2013	3
14_2013	2013	3
16_2013	2013	4
18_2013	2013	4
20_2013	2013	4
22_2013	2013	4
0_2018	2018	1
1_2018	2018	1
2_2018	2018	1
3_2018	2018	1
4_2018	2018	1
5_2018	2018	1
6_2018	2018	2
7_2018	2018	2
8_2018	2018	2
9_2018	2018	2
10_2018	2018	2
11_2018	2018	3
12_2018	2018	3
13_2018	2018	3
14_2018	2018	3
15_2018	2018	3
16_2018	2018	4
17_2018	2018	4
18_2018	2018	4
19_2018	2018	4
20_2018	2018	4
21_2018	2018	4
22_2018	2018	4

TESTS FOR DIFFERENCES BETWEEN Year GROUPS
(across all Zone groups)
Global Test
Sample statistic (Global R): 0.459
Significance level of sample statistic: 0.1%

Number of permutations: 999 (Random sample from a large number)
Number of permuted statistics greater than or equal to Global R: 0

Pairwise Tests

Groups	R Statistic	Significance Level %	Possible Permutations	Actual Permutations	Number >= Observed
2008, 2006	0.379	0.1	Very large	999	0
2008, 2013	0.204	4.1	3880800	999	40
2008, 2018	0.531	0.1	Very large	999	0
2006, 2013	0.672	0.1	14817600	999	0
2006, 2018	0.465	0.1	Very large	999	0
2013, 2018	0.609	0.1	32598720	999	0

TESTS FOR DIFFERENCES BETWEEN Zone GROUPS
(across all Year groups)
Global Test
Sample statistic (Global R): 0.479
Significance level of sample statistic: 0.1%
Number of permutations: 999 (Random sample from a large number)
Number of permuted statistics greater than or equal to Global R: 0

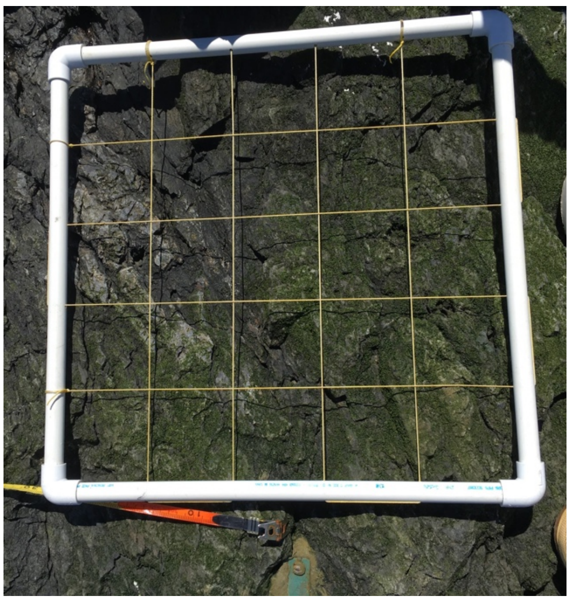
Pairwise Tests

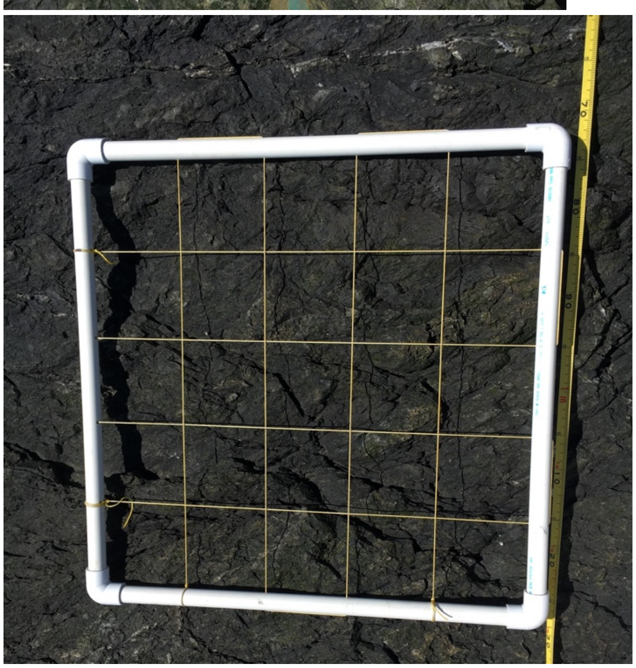
Groups	R Statistic	Significance Level %	Possible Permutations	Actual Permutations	Number >= Observed
1, 2	0.63	0.1	119528640	999	0
1, 3	0.673	0.1	122245200	999	0
1, 4	0.663	0.1	Very large	999	0
2, 3	0.383	0.1	8890560	999	0
2, 4	0.448	0.1	Very large	999	0
3, 4	0.272	0.6	Very large	999	5

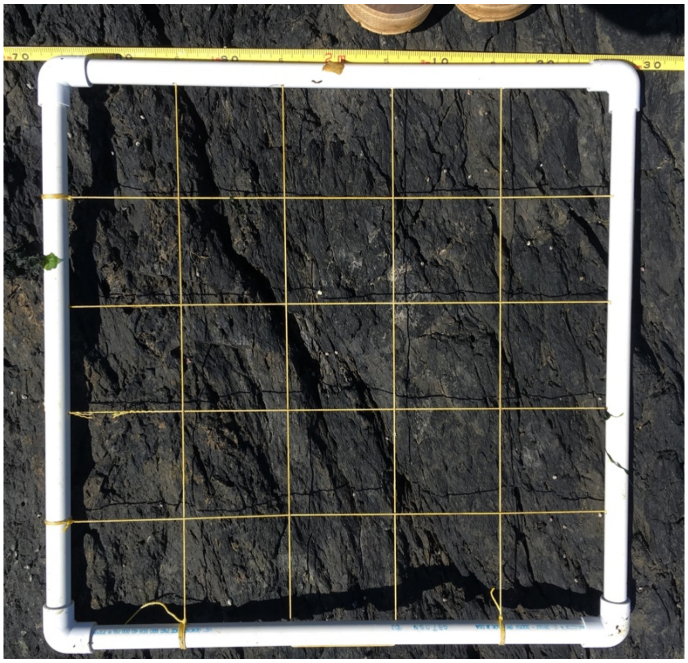
Outputs
Plot: Graph3
Plot: Graph4

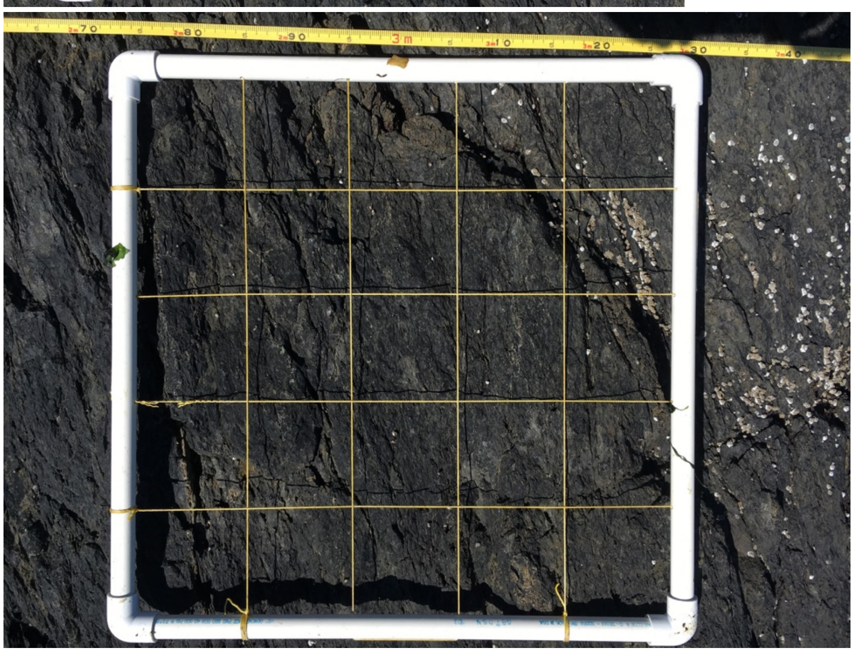
Appendix B
See “Cattle Point Transect C 2018” Excel

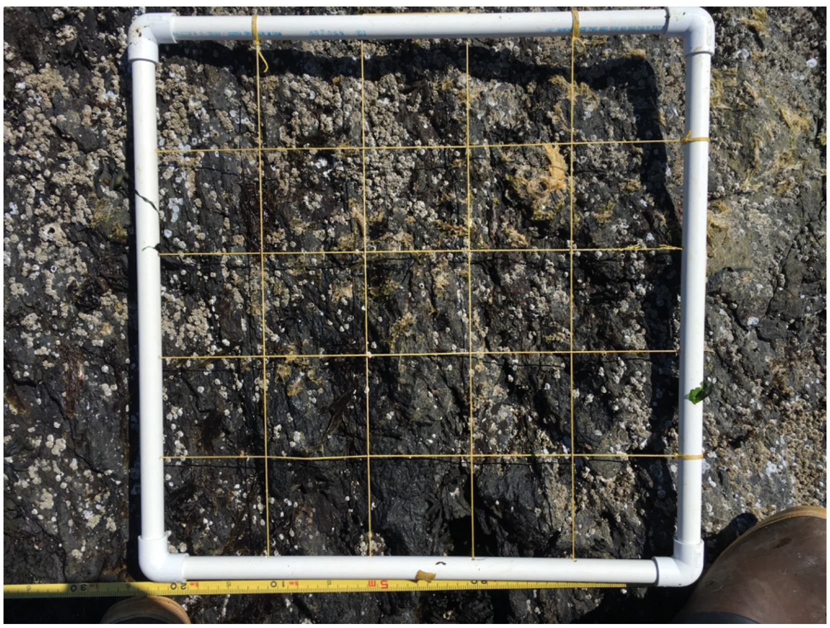
Appendix C Photographs of the 0.5m x 0.5m quadrats. The position of the quadrats are seen in the meter tape on one side of the photo

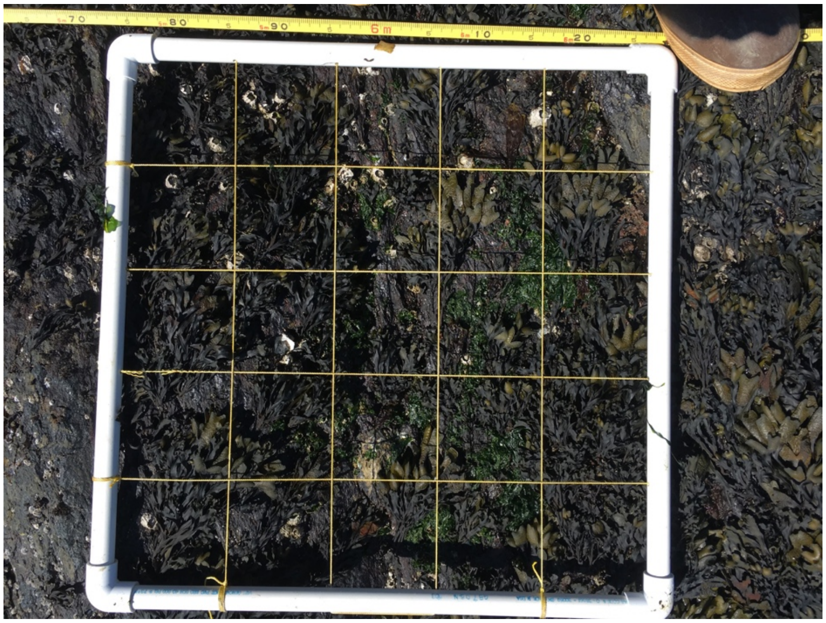


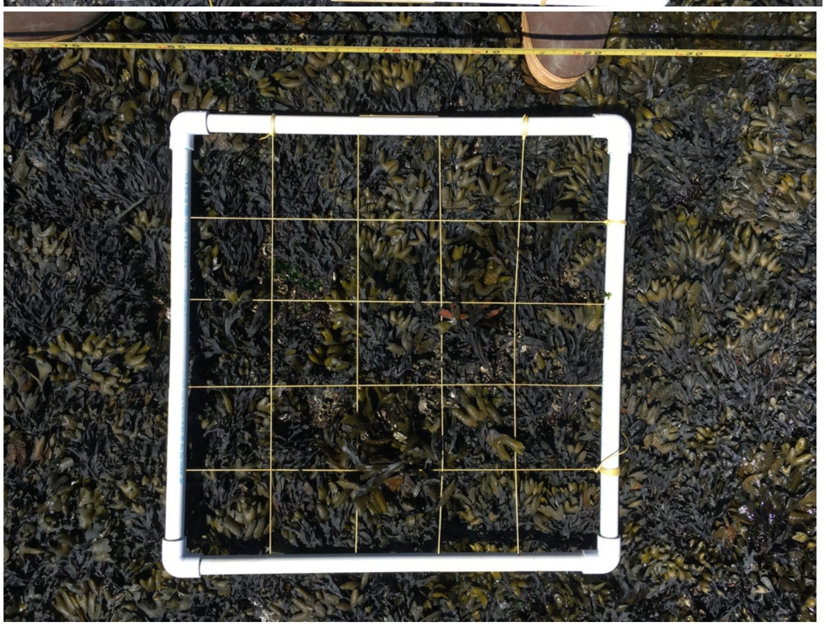


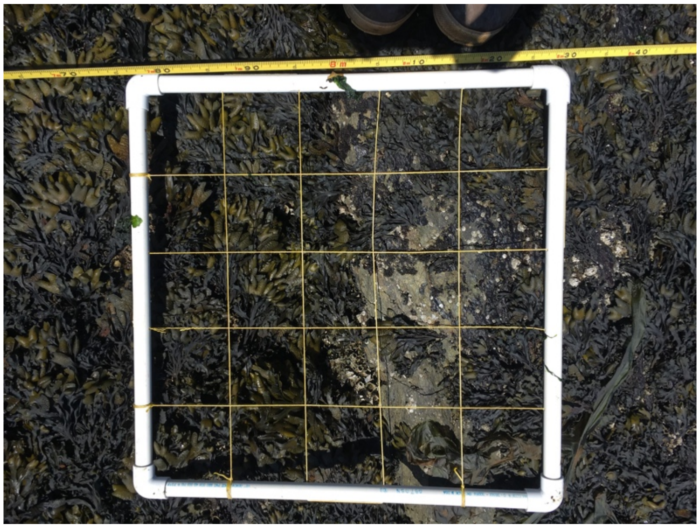


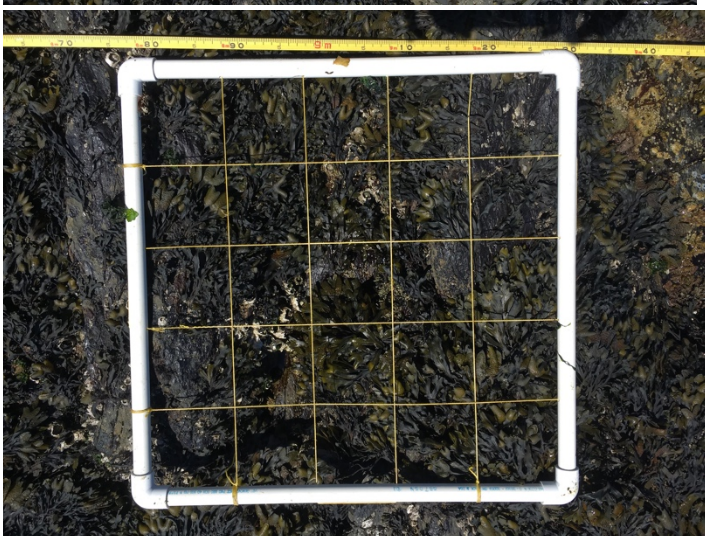


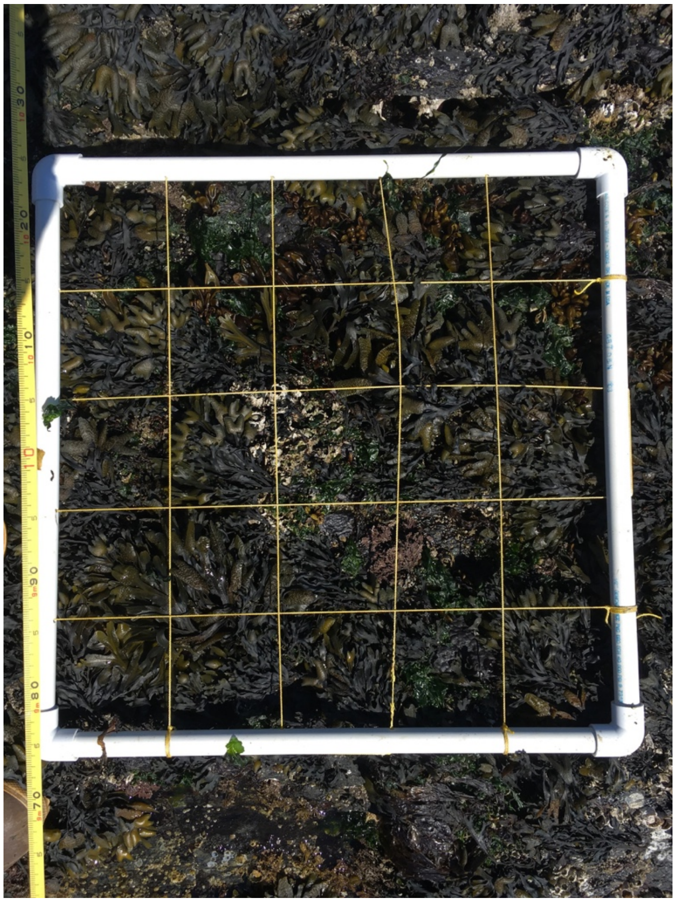


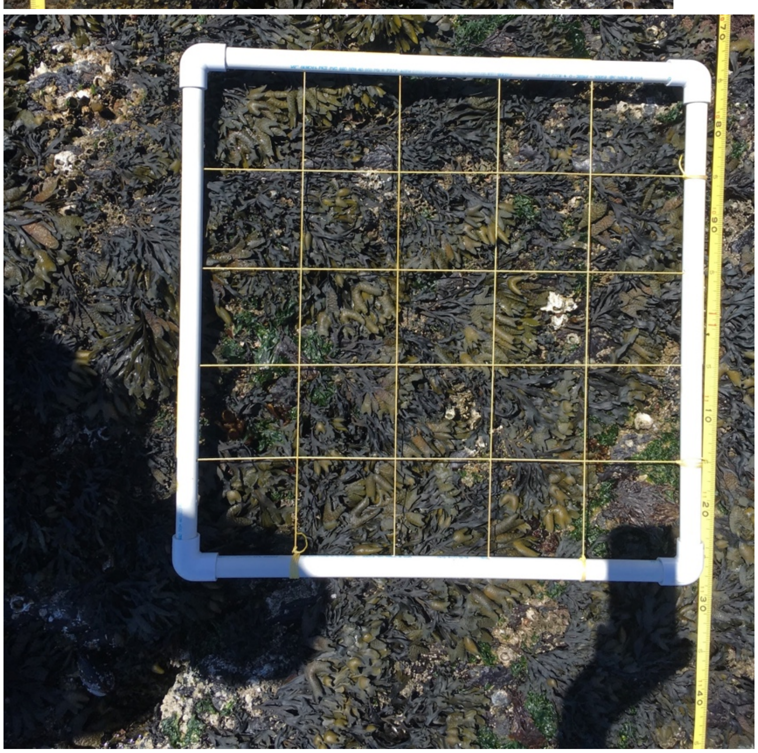


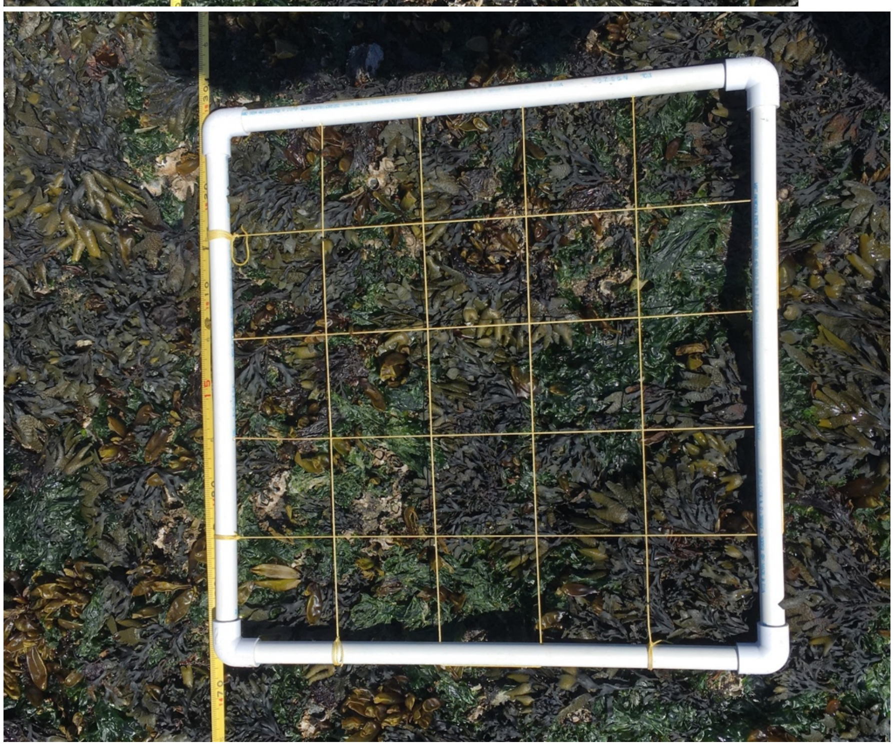


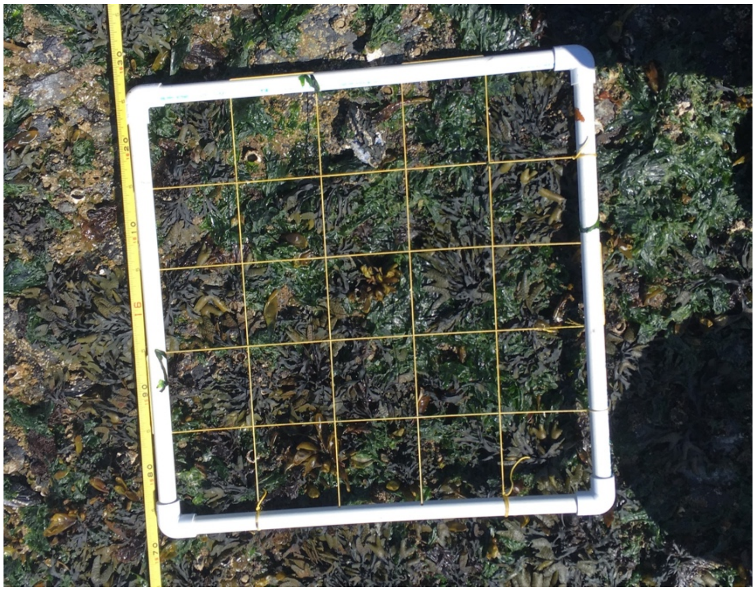


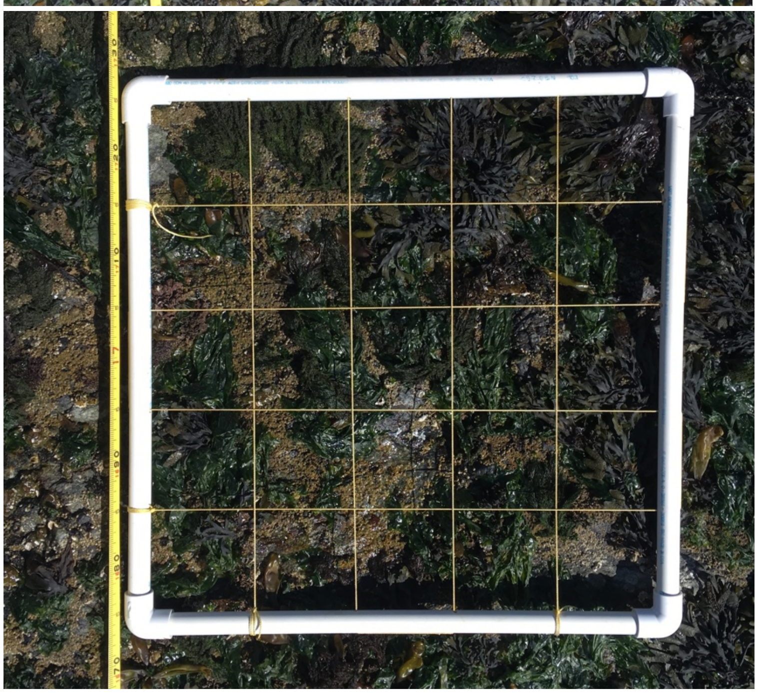


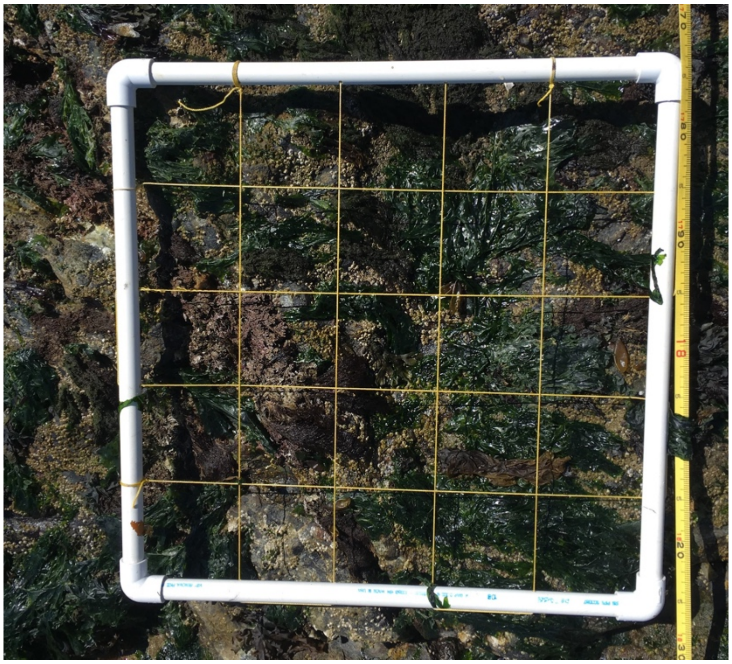


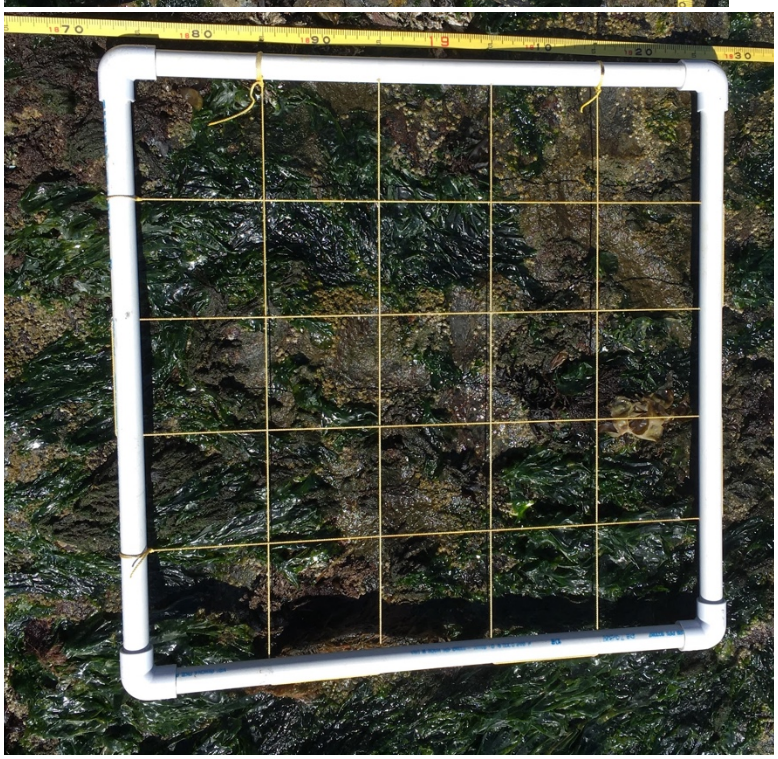


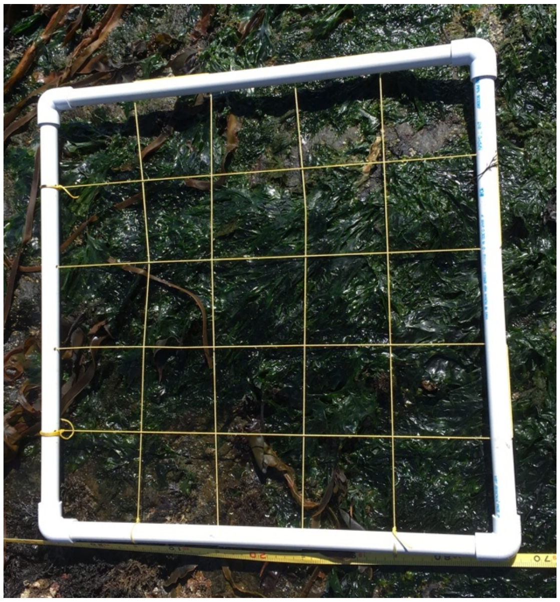


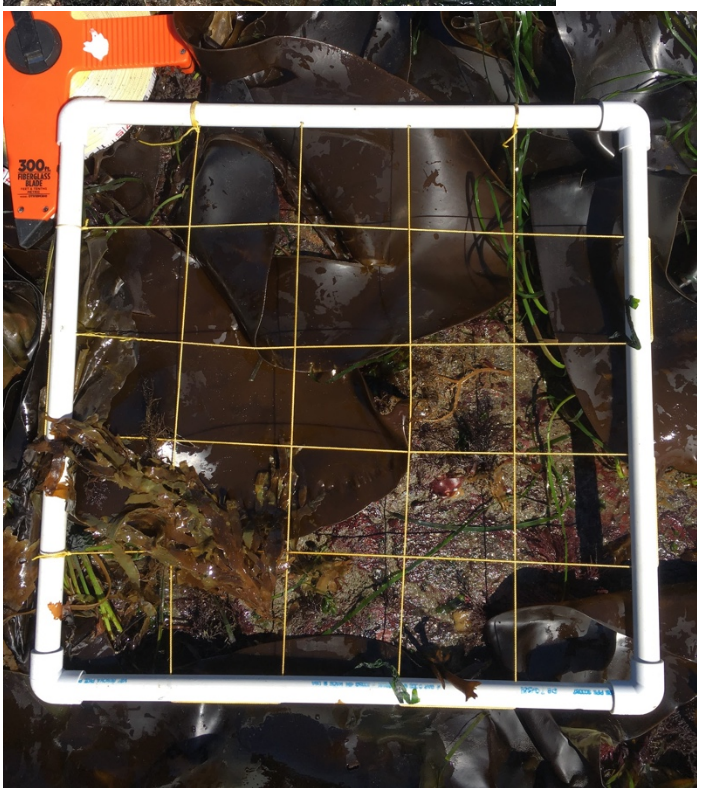












Appendix D

0 m	2 m	4 m	6 m	8 m	10 m	12 m	14 m	16 m	18 m	20 m	22 m	24 m

7.72	4.8	2.76	2.54	2.42	2.38	1.44	1.34	1.24	0.9	-0.68	-2.64	-3.1