Composition and Spatial Relationships of Algal Wrack on a Mixed Substrate Beach Exposed to Moderate Wave Action: Cattle Point, WA

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Abstract

Algal wrack serves as an integral component of the high intertidal zone. As a primary producer it contributes organic matter that may be utilized as a habitat and/or food source for a variety of wildlife. A vital resource in marine environments, it connects marine and terrestrial ecosystems and serves a variety of anthropological usages. Much of the research that investigates the ecological significance of algal wrack focuses on its prominence on sandy beaches, however there is little inquiry regarding other substrate categories. Moreover, composition and spatial distribution of the wrack have rarely been described. To address these deficits, we conducted a survey at Cattle Point, WA, on a small sand-and-gravel beach exposed to moderate wave action. Our aim was to gain a better understanding of the composition and spatial relationships of composition and individual blade size. We employed two sampling methods and then compared them in order to determine which method was most effective in describing characteristics of the wrack. Our results indicated that composition was consistent between sampling methods. Kelps were the most frequent algal group in the wrack, followed in descending abundance by filamentous reds, red blades, sea grasses, and greens. Additionally, we found no significant relationship between algal type or algal scrap size and position on the beach. When comparing sampling methods, we found that the two methods returned fairly consistent results regarding algal composition as well as similarly variable results regarding spatial relationships attributed to algal type/scrap size. We believe that more data and broader sample areas may address these shortcomings and give a more comprehensive picture as to algal wrack and its ecological significance on underrepresented sand-and-gravel beaches with moderate wave exposure. Nevertheless, our survey provides context for ecological relationships on the San Juan Islands.

Introduction

Foundational species influence species composition and are integral players in the stabilization, condition and biodiversity of environments (Lamy et al., 2020). Marine algae serve as foundational species in the environments in which they are found, converting light energy into organic matter and providing habitat and food for a variety of organisms (Metzger et al., 2019). While marine algae inhabit aquatic ecosystems, the impacts of these primary producers are not limited to these environments. Algal wrack, which refers to the drift seaweed that assembles on coastal shorelines, is found globally and is an important component of coastal ecosystems (Rodil et al., 2008). This beachcast organic matter serves as a link connecting marine and terrestrial environments. Accumulating along the high tide line, algal wrack serves as an important resource on these shores, providing a habitat and/or food source for invertebrates, which, in turn, serve as a food source for intertidal organisms such as shore birds (Schlacher et al., 2017). Studies show that algal wrack may be utilized to stabilize environments in a variety of conservation and restoration efforts (Biel et al., 2018; Chapman & Roberts, 2004; Schlacher, et al., 2017; Toft et al., 2021). Additionally, there is potential for algal wrack to serve as a valuable natural resource demonstrating its anthropological significance (Chubarenko et al., 2021).

Much of the research regarding the ecological importance of algal wrack focuses on sandy beach habitats, however, little attention has been given to the role and influence of algal wrack in marine environments in which sand is not the prevailing sediment (Heerhartz et al., 2014). Gravel beaches dominate the Pacific Northwest and serve as an underrepresented habitat for algal wrack research. This survey was conducted on a moderately wave exposed sand-and-gravel beach with large algal wrack deposits residing at the southeast tip of San Juan Island, WA. The aim of this survey is to gain a better understanding of the composition of algal wrack that is found in these habitats. We performed our survey with the following questions in mind: (1) What is the composition of the wrack?, (2) Are there detectable spatial relationships among algal types?, (3) Which of two sampling methods we employed is the most appropriate and/or effective?, and (4) Is there a spatial association relating to algae size and distribution? We anticipated that kelps, filamentous reds, and/or red blades would dominate composition and that there would be no spatial distinction between algal types. Additionally, we predicted that our second sampling method would yield more complete data and that there would be no spatial distinction in algal size across our sample area.

Methods

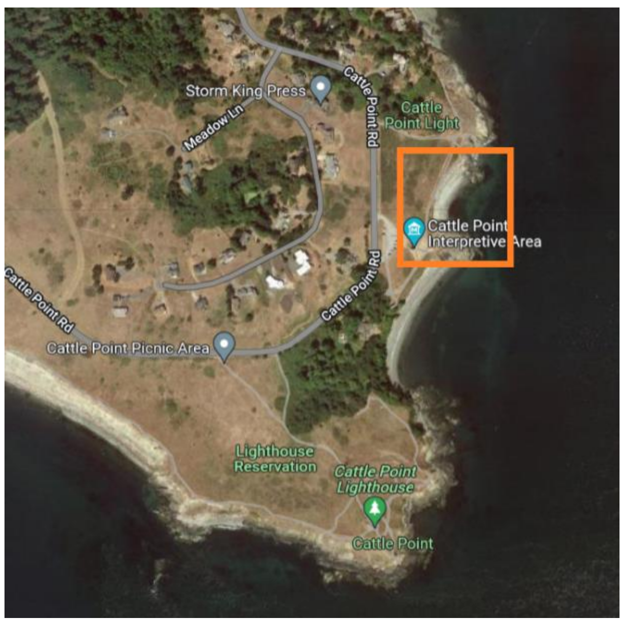

Figure 1 – Google maps image of sample area on San Juan Island, as defined within the borders of the orange box.

We conducted two surveys of algal wrack on a sand-and-gravel beach at Cattle Point, WA, located on the southeast end of San Juan Island. For each survey we established our survey area at the high tide line, along the seaweed drift that localized within this region, known as the wrack zone. We laid down a 60 meter transect, positioning it so that as much of the transect went through the center patch of any seaweed within the survey area. Our transect was divided into four sections with S1 (0m- 14.5m), S2 (15m- 29.5m) and S3 (30m- 44.5m) measuring 15 meters, and S4 (45m- 60m) measuring 15.5 meters. For our first survey we performed a point-contact survey method in which we sampled points along the seaward side of the transect tape, at 0.5-meter intervals, and removed the first layer of seaweed it came into contact with, followed by repeating this selection method with the second layer and collecting this as our sample. We did this to avoid the dry and brittle top layer of seaweed and instead collect a fresh and less degraded sample. Patches in which algal wrack were absent were skipped. We repeated this sampling along the beach. We held the samples in buckets and covered samples with sea water-soaked paper towels and placed them in a cold room (10 °C) for holding while we performed our second sampling method.

Figure 2 – Northward view of sample area (0m - 60m) on the day of sampling, May 19, 2022.

Figure 3 – Southward view of sample area on the day of sampling. The yellow line indicates the length of the sample area (0m - 60m) and the red lines indicate an

approximation of section divisions.

The second survey method involved using a 10-centimeter clam gun at intervals of 5-meters to collect a total of 3 samples from each section. Adjustments were made at 25m, moved to 26m, and 30m, moved to 31m, in order to avoid bare patches and we omitted sampling at 60 meters so as to consistently collect 3 samples from each section. Samples were collected by placing the clam gun on the seaward side of the transect tape at designated intervals, and cutting around the perimeter of the clam gun with a knife to extract a 10cm seaweed disk which would serve as our sample. This sampling method took into account the bulk of seaweed that encompassed the 10cm diameter, sampling the full depth of wrack at this location. We dubbed this method the “cookie-cutter” method. We placed each sample in its designated container to maintain spatial distinction between sections. Containers were then placed in a cold room (10 °C) while we worked to organize our first set of samples into algal type and section.

We separated the point-contact samples into algal groups by segment and measure each piece. Pieces less than 5cm and more than 1m in length were accounted for, but not measured for exact length. Pieces longer than 1 m were recorded but left on the beach. We did the same for the cookie-cutter samples, but did not measure size. Using R, we created bar charts to visualize composition and distribution and a box plot to visualize length and distribution. Lastly, using R, a PERMANOVA test was performed to determine the significance of the results. In order to standardize data for this analysis we converted compositional data to proportion rather than quantity.

Results

Kelps were the most frequent algal type in our samples, followed in descending abundance by other browns, filamentous reds, red blades, seagrasses, and greens. Both sampling methods generated similar results regarding the composition of algal type abundance (Figure 4). The overall frequency was higher in our cookie-cutter sampling method compared with the point contact method. All algal types were observed in the point-contact method while greens were the only algal type not observed in samples from the cookie-cutter method.

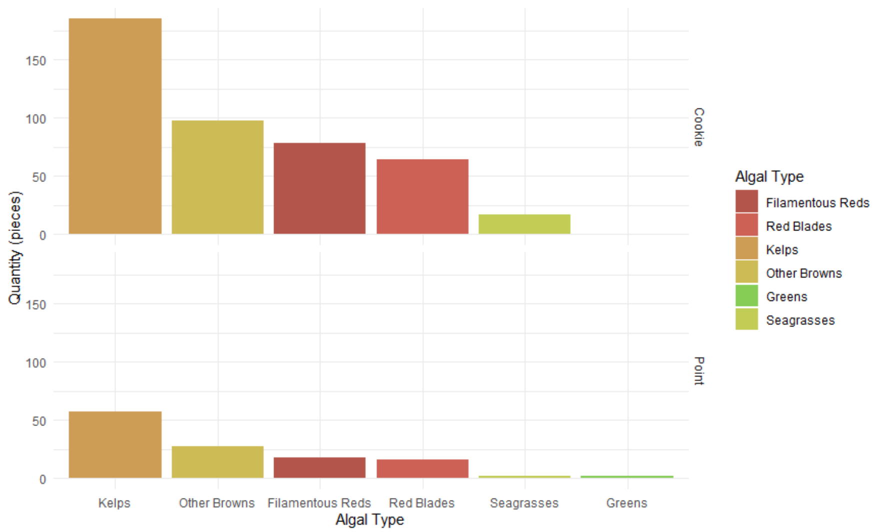

Figure 4 –Bar graph of algal wrack composition as determined by each sampling method, Cookie-Cutter and Point-Contact. Both sampling methods demonstrate similar proportions for overall algal type across our survey area.

We found that kelps represent the majority in both spatial distribution and abundance while seagrasses and greens share in the minority in both spatial distribution and abundance. There was no discernable spatial relationship between algal type and section (Figure 5). Additionally, we detected no statistical significance in spatial distribution of algal groups among sections (PERMANOVA, p=0.184). We determined that both sampling methods were comparable (PERMANOVA, p=0.492).

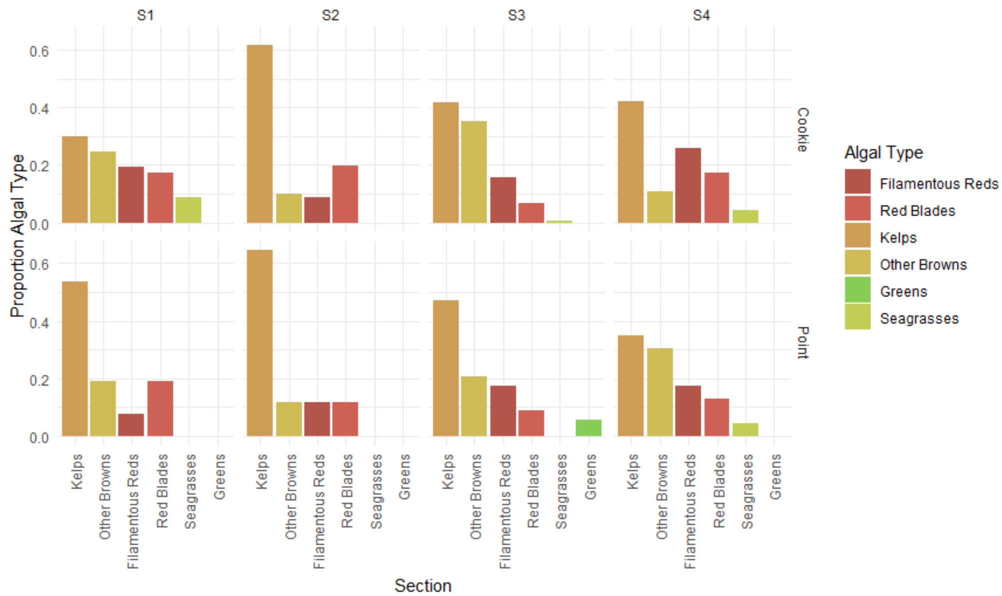

Figure 5 –Bar graph depicting algal wrack composition for both sampling methods, Cookie-Cutter and Point Contact, relative to proportion of each algal type and where within the sample area algal types were observed.

We recorded maximum length for algal blades sampled in our point-contact method. Mean values are similar across all sections and average length ranges from approximately 10cm – 50cm. Section 1 shows the most restricted length range. Our data show that there is no discernable spatial relationship between algal length and location on beach (Figure 6).

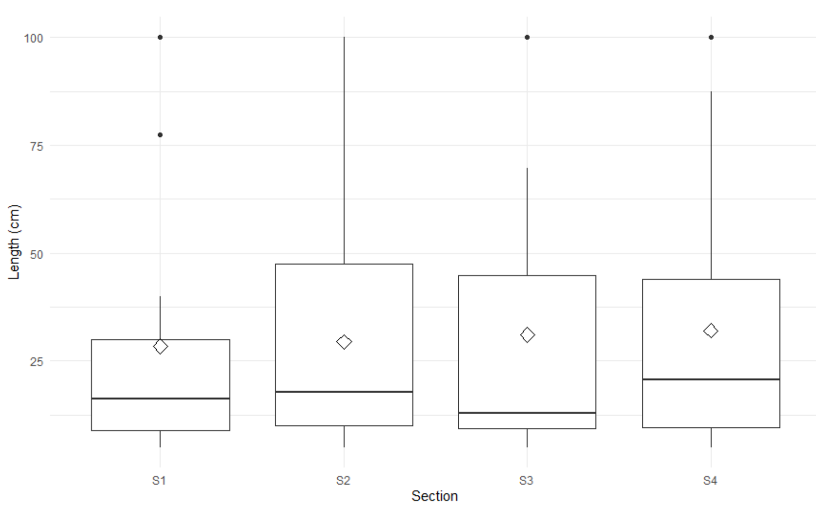

Figure 3 – Box and whisker plot showing the relationship between wrack length and spatial distribution. Mean values are represented by diamonds, medians are represented by horizontal lines and outliers are represented by singular points.

Discussion

Our results are consistent with prior studies that identify kelps and other brown algae as dominant on gravel beaches, which may be attributed to the buoyant physical properties of these algal types. As our study was conducted on a sand-and-gravel moderately wave exposed beach the few observations of seagrasses and green algae are also consistent with prior research that states that these algal types are more common in the algal wrack of sandy beaches (Orr et al., 2005).

We observed no detectable spatial relationships among algal types or algal lengths along the transect, which is consistent with our initial expectations. These results may be attributed to the slope of the beach and the manner in which rocky high intertidal zones tend to be dominated by algal species with buoyant properties without demonstrating spatial preference (Barreiro et al., 2011; Gómez et al., 2014). There is no literature that describes the length of individual algae specimens within wrack, therefore it is difficult to determine how these data contribute to the larger body of work regarding the ecological importance of algal wrack. We believe that this gap in knowledge is attributed to the difficulty involved in determining factors that contribute to the desiccation of algae once it is beachast. This is to say that algal size is not directly related to the manner in which it is cast onto shore Considering these factors may add context to the relevance of measuring individual algal wrack specimens.

Algal composition was consistent across both sampling methods demonstrating the effectiveness of these methods in measuring composition. Results generated by data sets pertaining to spatial relationships among algal types do not show discernible relationships. Nevertheless, a statistical analysis comparing both sampling methods under these parameters revealed the comparable nature of these methods. Many studies regarding algal wrack are carried out over annual timeframes, which take into account seasonal, temporal, and life cycle changes in the environment and in algal and marine organisms that utilize wrack. Our study was carried out over the course of one day at one site, therefore it is difficult to speak to local wrack characteristics between sites and overtime. These additional considerations are valuable in gaining a more comprehensive picture regarding the ecological significance of algal wrack.

Algal wrack serves a variety of important roles that extend beyond its high intertidal environment. From serving as a vital habitat and food source for wildlife, stabilizing and influencing ecosystems, and its potential for anthropological uses, algal wrack is a vital resource. Concentrating on the high intertidal wrack zone gives context to this prominent habitat that serves as a connection between terrestrial and marine ecosystems and can contribute to the overall understanding of these ecosystems as they pertain to San Juan Island. This survey contributes to the greater body of knowledge regarding algal wrack, giving attention to gravel beaches, which are an underrepresented substrate in this area of study.

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