Survey of Seaweeds Along Vancouver's Coastline

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Abstract

Seaweeds play a crucial and diverse role in Vancouver's coastal ecosystems. Seaweeds provide habitats for smaller organisms; they help counteract climate change and play a role in preventing ocean acidification and deoxygenation via photosynthesis. The goal of this study is to determine differences in species richness across three different coastal locations through an observational survey. To achieve this, we used line-transect quadrat sampling to estimate species biodiversity at Tower Beach, Kitsilano Beach, and Stanley Park Lighthouse. At each location, we documented the species of seaweed present, water temperature, water salinity, and oxygen concentration of water. We also documented the collection time, invertebrate species present, weather and water conditions, site direction, and substrate conditions to assess possible relationships between seaweed biodiversity and the various abiotic and biotic conditions. We found that Tower Beach had the fewest species compared to Kitsilano Beach and Stanley Park Lighthouse. These results can be explained by variations in the substrata, predation and competition, as well as zonation. However, our conclusions are limited due to our small sample size. Overall, our study demonstrates how various abiotic and biotic factors can affect the distribution and biodiversity of seaweed and provides information on their optimal growth conditions, such that we can better improve seaweed conservation methods in the future.

Introduction

Seaweeds, or macroalgae, are an important primary producer for the coastal ecosystem of Vancouver. The Northeast Pacific waters are home to approximately 650 macroalgal species, making British Columbia one of the most notable hotspots for seaweed biodiversity (Bates, 2008). Seaweeds can be classified into three major groups based on pigmentations: brown (*Phaeophyceae*), green (*Chlorophyceae*), and red (*Rhodophyceae*). In the intertidal and upper subtidal zones in British Columbia, brown seaweeds are found to be the most abundant among the three groups (Bates, 2008). They play an extensive ecological role from providing habitats for small organisms to being a reliable food source for higher trophic levels (Bringloe et al., 2020).

As global warming increases due to anthropogenic factors, seaweeds are essential to counteracting climate change. Plants, including seaweeds, are key players in sequestering carbon because they use carbon dioxide to create organic matter and oxygen. In a 2016 study, macroalgae have been found to sequester approximately 200 tetragrams of carbon per year (Krause-Jensen & Duarte, 2016). In addition to climate change mitigation, seaweeds also protect the ecosystem by controlling ocean acidification and ocean deoxygenation through photosynthesis.

During low tide, seaweeds are exposed to solar irradiance and are susceptible to desiccation. Since light is the basis of photosynthesis, the quality of light that seaweeds receive is crucial to their survival. Changes in irradiance and light quality, such as an increase in ultraviolet radiation, may either encourage or impede various biological processes if radiation prolongs (Bischof et al., 2006). Extreme ultraviolet radiation can negatively impact seaweeds by altering gene replication and destroying photosynthetic pigments, resulting in a decrease in nutrient uptake and photosynthesis (Bischof et al., 2006). As the ozone depletes due to the rise of anthropogenic emissions, the marine ecosystem is under major threats of losing one of its important primary producers.

Nevertheless, intertidal ecosystem balance can only occur if there are healthy amounts of both seaweeds and invertebrates. Macroalgal studies often only look through a one-way lens when observing the importance of seaweeds in the intertidal zone. A study found that the removal of invertebrates leads to a nutrient-limited intertidal pool following the lack of local-scale nitrogen excreted by invertebrate taxa (Bracken et al., 2007). However, a different study found that invertebrate species richness and abundance are independent of seaweed biodiversity and vice-versa (Bates & DeWreede, 2007). Therefore, the current knowledge is that intertidal ecosystem balance revolves around the diverse assemblage of invertebrates rather than the interspecific interactions that exist between them.

In this study, we investigate seaweed biodiversity in three Vancouver coastal ecosystems to evaluate the impact of the local-scale environment and to understand what makes certain locations more desirable than others.

Methods

We applied the following methods at the three sampling locations: Tower Beach (outermost coastline), Kitsilano Beach (intermediate coastline between Tower Beach and Stanley Park Lighthouse), and Stanley Park Lighthouse (innermost coastline). All locations were sampled on the same day during low tide in March 2022.

At each site, we looked for a location that had a good distribution of seaweed to lay down our 15m transect line. We used a random number generator to pick a number between 1 and 15 to determine where to place the quadrat, and then to pick a number between 1 and 2 to determine what side of the line the quadrat will be placed. This was repeated three times at each site. Seaweed species were identified within the quadrat using the Seaweed Sorter App and the Gabrielson et al. dichotomous key (2012).

We also recorded general observations at each site, including the time of collection, invertebrate species present, weather and water conditions, substrate conditions, and direction of site. Water temperature and oxygen concentration were measured via an oxygen probe, and water salinity was measured using a refractometer. We ran a one-way ANOVA test and Tukey Test using the GraphPad Prism 9.0.0 program.

Results

The abiotic conditions were similar across the three sites (Table 1), although the Stanley Park Lighthouse location had slightly choppier waters, was facing more north, and had a colder ocean temperature reading compared to the other sites. Furthermore, the substrate and number of invertebrate species differed across the three sites. Tower Beach had a rocky substrate with most of the algae growing on the east side of the largest rocks, Kitsilano Beach was sandy with a few larger rocks where the algae were present, and Stanley Park was comprised of all flat rocks with a few smaller rocks here and there (Figure 1). The Stanley Park location had the highest diversity of invertebrate species as seen in Figure 2, compared to the other sites, which only had barnacles and mussels.

Table 1. General abiotic and biotic observations recorded from each site.

Site	Time (PST)	Weather Conditions	Substrate	Shade Coverage	Water Conditions	Direction (N/S)	Water Temperature (°C)	Water Oxygen Concentration (%)	Water Salinity Level (‰)	Invertebrates Present
Tower Beach	11:44	Rain	Rocky	Overcast	Calm	326°NW	8.7	19.6	25	Barnacles, *Mytilus spp.* (mussels)
Kitsilano Beach	13:34	Rain	Sand, minimal rocks	Overcast	Calm	333°NW	8.7	19.7	28	Barnacles, *Mytilus spp.* (mussels), Limpets
Stanley Park Beach	14:31	Rain	Flat rock	Overcast	Choppy	10°N	7.9	17.7	25	Barnacles, *Mytilus spp.* (mussels), *Littorina spp.,* Limpets

There was a significant difference between species richness at Tower Beach and Kitsilano Beach (P<0.05) and Tower Beach and Stanley Park Lighthouse (P<0.001). There was no statistical difference between Kitsilano Beach and Stanley Park (Figure 3). Overall, Tower Beach had the lowest species richness of all sampled sites. We also observed certain trends in the location of certain seaweed species that were growing at each site. At Tower Beach, *Fucus* sp. was seen to only be growing on mussels and a similar trend was observed at Kitsilano Beach where *Fucus* sp.

(Figure 3).

Figure 1. Substrates from each site. Left: Tower Beach, Middle: Kitsilano Beach, Right: Stanley Park Lighthouse.

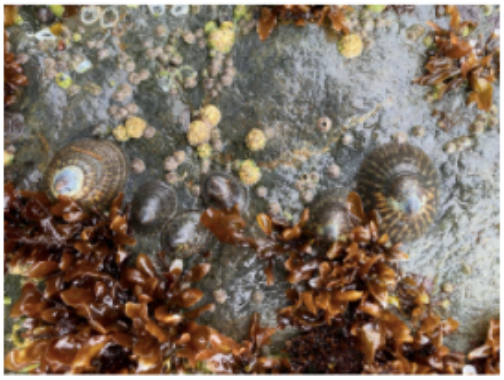

Figure 2. Example of invertebrate species (limpets and barnacles) seen at Stanley Park Lighthouse.

was growing on barnacles and near mussels. *Pyropia* sp. was seen exclusively on bare rocks, *Ulva* sp. was near the bottom of the rocks, and *Mastocarpus* sp. and *Polysiphonia* sp. were growing next to each other. At Stanley Park Lighthouse, *Ulva* sp. was also growing near the bottom of the rocks.

Discussion

Through an observational survey of Tower Beach, Kitsilano Beach, and Stanley Park Lighthouse, we found that there is a significant difference in macroalgal species richness between Tower Beach and the others, while the difference between Kitsilano Beach and Stanley Park Lighthouse is not significant. Specifically, our results found that Tower Beach has the lowest macroalgal species richness compared to both Kitsilano Beach and Stanley Park Lighthouse (Figure 3).

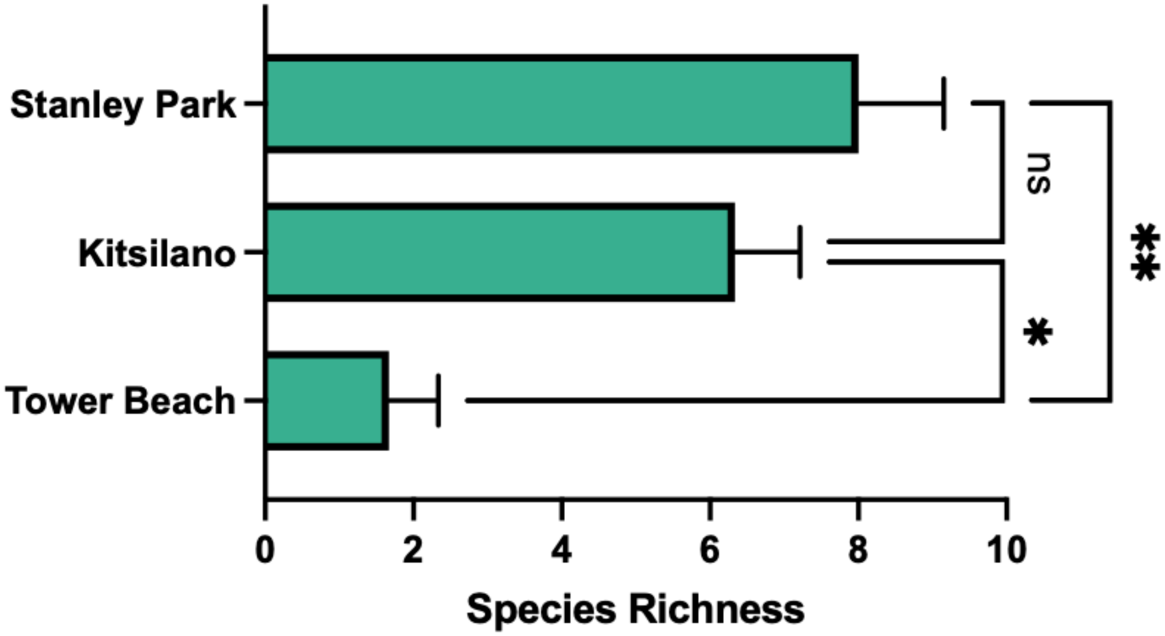

Figure 3. Comparison of macroalgal species richness at each site surveyed: Tower Beach (n=3), Kitsilano Beach (n=3), and Stanley Park Lighthouse (n=3); statistical test (one-way ANOVA), ns (no significance), * (*P*<0.05), ** (*P*<0.001) to indicate statistical significance.

A potential explanation for this distribution of species richness is the types of substrata present at each site. Substrata are important abiotic factors that can impact species richness as they affect the difficulty of attachment (Nybakken & Bertness, 2005). While all sites surveyed were rocky surfaces, the area that we surveyed at Tower Beach was extremely non-uniform in surface evenness due to variable rock sizes which were very smooth, whereas the areas surveyed at Kitsilano Beach and Stanley Park Lighthouse, were both relatively flat and rough in texture (Table 1). Flat surfaces allow sessile organisms to better attach themselves to the substrate compared to more complex surfaces because the organism is able to fully press their body against the surface; thus, providing more surface to hold onto. Also, having a rough-textured substratum compared to a smooth one allows for better algal attachment because it provides more grip to strengthen the attachment (Cao et al., 2009).

Furthermore, biotic factors such as predation and competition can influence the species richness of algae. Short-term competition actively reduces species richness by limiting the ability of similar species to occupy the same niche; however, long-term competition can drive specialization and divergence (Purves et al., 1995). Contrastingly, predation can either limit or promote species richness depending on the type and number of predators in the area, as well as impact species distribution and composition (Smee, 2010). During the survey, there appeared to be a lot of substrata available and fewer invertebrates present at Tower Beach compared to the other two sites which were very dense with algae and invertebrates, suggesting that in addition to less predation, there is also less competition (Table 1). Although herbivory reduces photosynthetic area and decreases habitat availability, it opens up space for other competitors which can result in having a higher species richness (Crowe et al., 2011; Cubit, 1984). According to the intermediate disturbance hypothesis, intermediate disturbance allows for the most diverse and complex algal communities, whereas algal species diversity decreases with low disturbance such as predation due to single species that are fast-growing to dominate, like *Ulva* sp.; however, low predation will also result in low algal species diversity because of the high grazing rate causing crust species like *Hildenbrandia sp.* to dominate (Roxburgh et al., 2004).

Zonation is another factor that can impact species richness. There are three zones: supratidal zone, intertidal zone, and subtidal zone. The intertidal zone can be further split up into three different zones: high, mid, and low. Intertidal organisms often create distinctive bands that are parallel to the shore due to abiotic and biotic stressors that restrict their distribution (Göltenboth et al., 2006). In our study, the intertidal zone, as a whole, at Stanley Park had the highest species richness; however, we did not look at each subsection of the intertidal zone individually, which could result in bias. Different algae have different characteristics that are better suited for different conditions. Algae, like *Fucus distichus,* which are more intolerant to desiccation are more likely to be found in higher zones that are dominated by barnacles and mussels since mussels and barnacles can hinder the impact of herbivores like limpets (Wangkulangkul et al., 2016). However, algae-like *Pyropia sp.* which are less intolerant to desiccation are more likely to be found lower in the intertidal zone and attached to bare rock to avoid herbivores (Nelson, 2013).

Since our sample size was relatively small it could lead to bias in our results. In the future, ecologists can increase the sample size to obtain a power of 80% or higher and observe how the algae composition and richness change with seasons. Also, in our study we only looked at marine sites in Vancouver, other studies could investigate how species richness changes between freshwater and marine water sites, as well as look at the relative abundance by analyzing the percent coverage of algae. Additionally, since we did not distinguish between the different zones within the intertidal zone, a possible study could observe how species richness and composition change across intertidal zones. Finally, researchers could observe other abiotic and biotic factors such as light intensity, wave action, desiccation, rugosity, and types of invertebrates present to investigate how they affect species richness, distribution, and abundance.

Conclusion

Overall, our data suggests that seaweed biodiversity and distribution vary based on the types of substrate present, the different forms of competition and predation, as well as which section of the intertidal zone they are found in. Seaweed has the lowest species richness at the smooth and uneven substrate of Tower Beach, and the highest diversity at the flatter and gravelly substrates of Kitsilano Beach and Stanley Park Lighthouse. Seaweeds are an important member of Vancouver’s coastal ecosystems and understanding more about their optimal growing conditions can help us conserve their habitats moving forward.

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