The Species Specific Arthropod Colonization of Three Species of Beach-Cast Wrack

Fucus, Macrocystis and Nereocystis

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Abstract:

Sandy beaches on British Columbia's central coast are home to various intertidal and supralittoral species who depend upon beach cast marine algae to supply necessary nutrients and habitat. Beach wrack occurs in a variation of patch sizes, species , decomposition levels and location along the vertical beach gradient. The detritivore communities who utilize this resource are an important trophic foundation for other marine and terrestrial organisms. Our study focused on the "upstream" effects of beach cast algae and their role in ecosystem function of coastal and terrestrial environments on Calvert Island. We conducted an experiment to investigate consumption preference of detritivores in the supralittoral zone by observing colonization on three common species of marine algae. Through this process we set out to answer three questions regarding this community of species which utilize this resource. We analyzed the differences in community structure between the three different species of beach cast wrack, the differences in abundance and species richness between them and the proportion of marine versus terrestrial colonizing individuals. Our results proved statistically insignificant, but our data provided insights into species assemblages as well as the relatively high proportion of terrestrial arthropods within the supralittoral zone.

1. Introduction:

Sandy beaches along the central coast of British Columbia support vast communities of supralittoral and intertidal fauna but lack the primary producers characteristic of their surrounding marine and terrestrial ecosystems (Pelletier e*t al.* 2009). The species diversity found within these ecosystems, the structure of trophic levels, and ecosystem processes are dependent upon external nutrient subsidies arriving in the form of beach cast algae (Dugan et al. 2011)**.** Amphipods, isopods and dipterans are the major primary consumers of beach cast wrack and provide the trophic foundation for many intertidal predators including shorebirds, crabs, bears and several species of terrestrial coleoptera (Pelletier *et al.* 2009). Population dynamics surrounding the colonization of beach cast algae in the supralittoral have been researched, but little data exists surrounding detritivore preference between specific species of algae, trophic assemblages or the differences of abundance between marine and terrestrial arthropods in the supralittoral zone.

1.1 Marine Subsidies and Their Implications

Cross boundary ecosystem dynamics such as beach wrack inputs are often poorly understood. The overlapping boundary of marine and terrestrial environments often produce unique diversity, productivity and ecosystem functions which the individual ecosystems may lack (Mellbrand *et. al.* 2011). The interactions of cross boundary ecosystem linkages have often focused on “downstream “ energy and nutrient flows, while the impact of “upstream“ cycles is often overlooked (Darimont *et al.* 2010). Marine subsidies such as beach wrack, affect terrestrial ecosystem diversity and have been observed to be an integral aspect of ecosystem diversity on the central coast of BC (Darimont e*t al.* 2010). An increased understanding of these nutrient subsidies has highlighted the necessity of looking at marine and terrestrial protected areas as open ecological systems (Stoms e*t al.* 2005).

1.2 Beach Wrack

Beach wrack is derived from seasonal nearshore marine productivity and the subsequent growth and decay of marine algaes. Beach wrack is a matrix of decomposing algae washed in from offshore reefs, and forms patches of wrack which can vary in size and species composition (Dugan e*t al.* 2011). The abundance of standing wrack on coastal beaches is correlated to the proximity and productivity of intertidal reefs and kelp forests (Dugan *et al.* 2003) . In marine environments wrack is deposited throughout the tidal range and is subject to fragmentation, dehydration, burial in sand and decomposition (Olabarria, Lastra, and Garrido 2007). Sandy intertidal beaches are often characterized by distinct horizontal gradients in factors such as: physical disturbance, species diversity, and density patterns (Malinga *et al.* 2008). Beaches can be divided into three broad zones: (a)The littoral zone is the area of marine shore which is exposed to air during low-tide, it is synonymous with the intertidal (b)The sublittoral zone is below the littoral and is permanently covered by water. (c)The area above the intertidal zone is known as the supralittoral zone (Lindberg e*t al. 2*010; Gale 2011). The spatial distribution of wrack between gradients of the beach plays an important role in arthropod colonization, macrofaunal diversity, trophic structure, and the ecological processes between the three different zones (Rodill, 2008; Pelletier *et al.* 2009). The heterogeneity of these wrack patches might influence the species assemblage structure and taxonomic composition, with variations between the different marine gradients (Olabarria, Lastra, and Garrido 2007). A study into the feeding preferences of supralittoral crustaceans found that selections were based upon general algal traits rather than detrivore adaptation to specific species of algae (Prennings e*t al. 2*000).

1.3 Ecosystems of the Central Coast

The Pacific Coast of Canada lies along an active edge of continental margin, the central coast is backed by steep mountains modified by glacial action and is dominated by deep fjords, inlets and islands (Clague 2010) .The location of our study area is on Calvert Island (Figure 1), 5-10 km from the mainland and is a part of the coastal western hemlock biogeoclimatic zone (Pojar 1991). The marine environments off the coast of Calvert Island are home to an abundance of marine species which thrive upon the temperate water conditions, geographic diversity and the upwelling at the edge of the continental shelf (Harbo 1999). A large portion of Calvert Island is located within the Hakai Luxvbalis Conservancy (120,000 hectares) which is the largest marine protected area on the British Columbia coast. This park provides a unique contrast between marine and terrestrial ecosystems within the Provincial Park system (BC Parks 2012).

<u>Figure 1</u>: Location Map of Calvert Island in British Columbia.

1.4. Three common algae of West Beach

Macrocystis integrifolia, Giant perennial kelp.

Giant perennial kelp exists in large marine forests in nearshore coastal ecosystems, ranging from Alaska to Monterey (Lamb *et al.* 2005) It is only found where surf is strong and has a black-brown colour. Each individual may have as many as 300 blades (Kozloff 1993). Each individual can grow upwards of 30 meters, and provides habitat for a multitude of marine organisms. Its importance as a source of food and shelter also occurs once it has washed up on the beach as wrack (Druehl 2000).

Nereocystis luetkeana, Bull kelp.

Bull kelp can reach to 30 meters, growing 15 cm a day during summer months in the Pacific North West. Holdfasts support a single cylindrical whip like stipe, terminating in a pneumatocyst float with two clusters of blades from the top of the bulb (Mondragon 2003). It ranges from Alaska to central California, and grows from March to September, in certain cases it has been know to survive the winter. Spores drop from the blades to the ocean floor to ensure survival in the same area (Druehl 200).

Fucus distichus subsp. *evanescens.* Rockweed

One of the most common algae's along sheltered intertidal shorelines of the Pacific Northwest (Kozloff 1993). Its flattened straplike blades are dichotomously branching to swollen air bladers which are the site of its reproductive structure. Fucus is very tolerant to fresh water and freezing (Lindeberg, Lindstrom 2010). The life cycle of Fucus is unique in the plant world as it follows animal reproduction, such that the vegetative body directly produces eggs and sperm (Druehl 2000).

2. Methods:

2.1. Materials:

-Bucket (Diameter 26 cm)

-Wooden Slab

-Ziploc bags for collection of samples

-Sieves created from PBC piping and mesh

-Totes

-Tweezers

-Small squares of netting used for closer examination of specimens

-Microscopes

-Wooden stakes to mark plots

-Flagging tape

-Tape measure

-ProScout Scale (up to 600.0g)

-Masks and Snorkels

-Paring Knife

2.2. Site Selection

West Beach, Calvert Island was observed through silent observation to examine complex interactions that resulted from the deposition of beach wrack at various heights and locations on the sandy beach. After thorough examination of various levels of beach wrack deposition found along the shore we also observed differing heights of sand being pushed up the beach resulting in the covering of logs and beach debris. This variation was likely due to differing levels of wave action and width from the water line to the back of the beach, which at some locations appeared right up to the tree line and sand dunes. After careful examination of the entire length of West Beach on multiple days, we decided to use the southern end of the beach (51°39'15.74"N and 128° 8'20.98"W). Sites were chosen in the supralittoral zone, 3 m from the vegetation line which allowed for consistency in plot positioning. This allowed the samples to remain above water line to avoid loss of samples due to changing tides and wave action (Pelletier 2011). At the time of observation, there was a considerable amount of swell combined with large spring tides with max high tide of 4.4 m on June 18, 2012 at Striker Island (FAO 2012). There was beach wrack deposited throughout the entire range of the beach including the supralittoral zone.

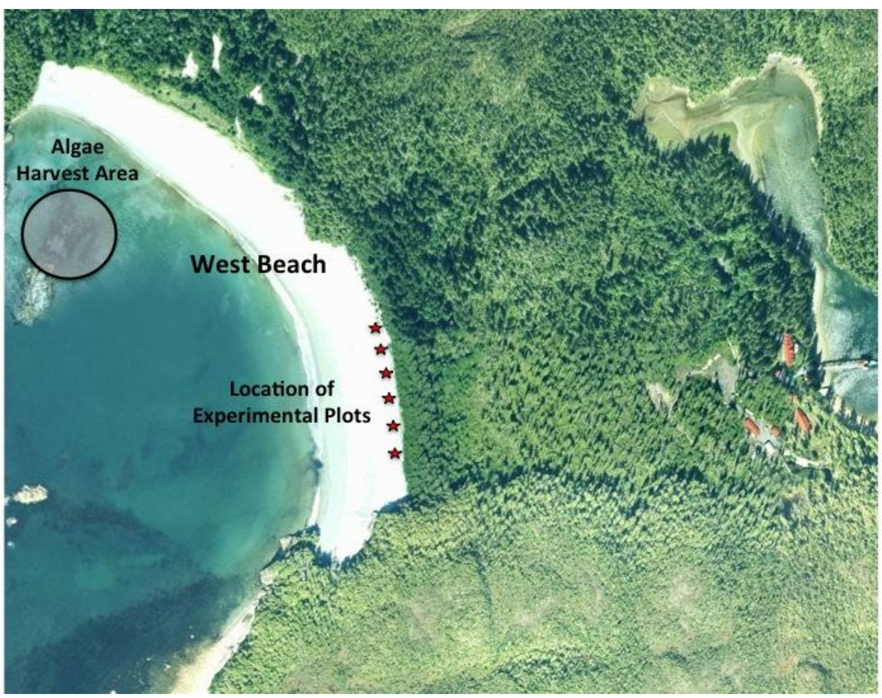


Figure 2: Location of experiment on Calvert Island, including algae harvest area and position of treatments on West beach.

2.3. Collection

Samples of the three different types of seaweed (*Macrocystis integrifolia, Nereocystis luetkeana,* and *Fucus distichus* subsp. *evanescens*) were collected on June 18, 2012. The samples of *Macrocystis,* and *Nereocystis* were harvested directly from kelp beds located off the northern end of West Beach, Calvert Island using mask, snorkels and mesh bags at 51°39'21.07"N and 128° 8'47.20"W. *Fucus* samples were collected from the intertidal rocks also at the northern end of West Beach, located at 51°39'29.03"N and 128° 8'47.11"W. The *Fucus* was removed directly off the rocks on low tide and careful attention was made to ensure specimens of all sizes. To ensure equal levels of decomposition between samples, fresh algae was collected. They were then thoroughly washed in salt water to rid them of any species that may have been already present. The most common species found were Kelp Isopods (*Idotea wosnesenskii*) which were abundant and very determined not to let go of the algaes. Samples of 450.0g were weighed out using a Scout Pro scale (measures up to 600.0g) to allow for sufficient patch size (Pelletier *et al.* 2011).

2.4. Site Preparation

Each replicate consisted of four treatments positioned 2m apart to minimize the possibility of transient individuals between the treatments. Six replicate sets were positioned along the beach in accordance with availability of sufficient open space clear of logs and other large debris. Replicate sites were prepared by clearing and raking any previously deposited wrack and left overnight to allow for the dispersal of any species that may have been present. In each replicate there was one treatment consisting exclusively of *Macrocystis*, one exclusively of *Nereocystis*, one exclusively of *Fucu*s and one which consisted of a mixture of the three which contained equal parts (150.0g) of each of the algae. Within each replicate, the positioning of the 4 treatments were rotated to avoid the possibility of the results being confounded by relative positioning to the other treatments. Treatments were positioned and named 1ABCD, 2BCDA, 3CDAB, 4DABC, 5ABCD and 6ACBD. Each sample was marked with a cedar stake with a ribbon of flagging tape to ensure that they were visible. The treatments were left for four days to allow sufficient time for colonization by insects and intertidal species which has been shown to typically be a rapid process (Olabarria, Lastra, and Garrido, 2007). Sites were observed daily from a distance to avoid human disturbance but allow for weather conditions and activity around sites to be observed.

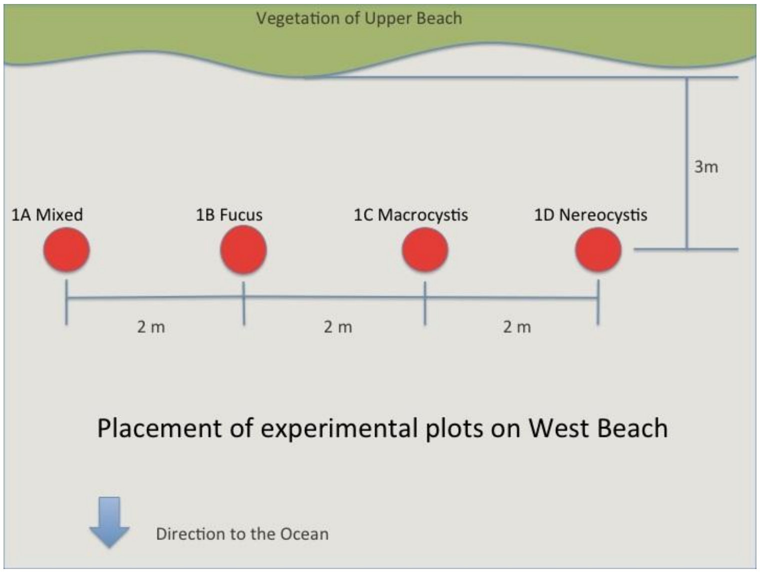


Figure 3: Example of treatment placement and spacing at each replicate site.

2.5. Collection

Samples were collected on day 4 (June 22, 2012) using an ice cream bucket with a diameter of 26 cm and a square piece of plywood. The bucket was placed over top of the treatment and pressed down in the sand to a depth of 3 cm. The sand surrounding the sample was scraped away, then the wooden square was then slid underneath to collect the sample. This sample consisted of the algae treatment as well the sand beneath. The sand was collected in an attempt to capture any burrowing species that may have burrowed beneath the samples. Six control treatments were also collected consisting of the sand along the sampling transect located 3m from the tree line in areas void of seaweed. This was done to ensure any species found in the sand were there as a result of the presence of the seaweed treatments and thus used to control for ambient arthropod density (Pelletier *et al.* 2011). Collected samples were placed in Ziploc bags and placed in the freezer for 5 hours to immobilise specimens to allow for ease of manipulation and collection (Pelletier *et al.* 2011). Samples were then sieved and examined thoroughly. The sieves that were used to do this were created with large PBC piping and window screening (+/- 5 mm). Treatments were placed in the sieves in large totes of water which allowed the sand to sink to the bottom while the algae remained trapped by the mesh as the specimens floated to the top. Each seaweed treatment was thoroughly examined by hand to check for species that had failed to float and remained attached to the algae. Totes, sieves, and water were all cleaned between each treatment to reduce the possibility of residual specimens from previous samples. All specimens found were collected, dried, and placed in petri dishes. We later examined the specimens under the microscope and different species found were identified to family. Because of the enormous arthropod diversity and lack of resources at our disposal, identifying specimens to species was slightly beyond the scope of this project.

2.6. Analysis:

. Data was entered into PRIMER-E Multivariate Statistics for Ecologists. Sample similarities, ordination, and site differences were examined. Nonmetric multidimensional scaling (nMDS), Analysis of Similarities (ANOSIM) including Global and Pairwise Tests, and Similarity Percentages were calculated/performed for species contribution. As well as these tests, further analysis was conducted through Excell, including species abundance and richness analysis. For all averaged results, calculations of Standard Error, Standard Deviation and 95% confidence intervals were generated.

3. Results:

3.1. Difference in Community Structure with Different Algae Treatments

The results of a multivariate analysis of community structure on Primer® showed that there isn't a significant difference between the different species of algae (Figure 4). The overall Global R value for the sample statistic is 0.254 with a significance level of 0.5% (Table 1). Although this analysis provided

Table 1: Results from ANOSIM Analysis of Similarities from Primer®

Groups	R Significance Statistic	Significance Level %
Mixed, Perennial	0.284	2.8
Mixed, Fucus	0.381	0.9
Mixed, Bull	0.527	0.6
Perennial, Fucus	0.169	12.1
Perennial, Bull	-0.111	83.8
Fucus, Bull	0.227	5.4
Global Test	0.254	0.5

evidence for significant differences between the samples, the only statistically significant relationships existed between the three algae species and the mixture. When comparing the Mixed sample with *Macrocystis*, there was an R value of 0.284 with a level of 2.8%. The Mixed sample versus *Fucus* had an R value of 0.381 at a level of 0.9%. The Mixed sample and *Nereocystis* had an R value of 0.527 at a level

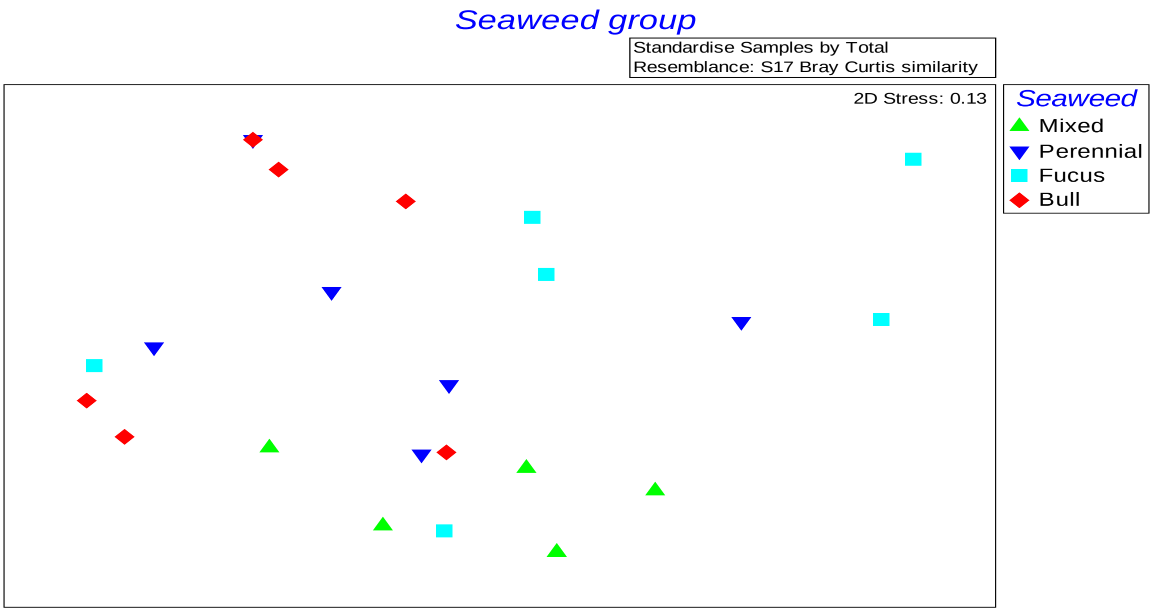


Figure 4: Nonmetric multidimensional scaling (nMDS) Ordination Map of all 4 algae treatments

of 0.6%. These results prove a significant difference between these samples. In contrast with the comparisons with the algae mixture, all three pairwise tests between *Nereocystis*, *Macrocystis* and *Fucus* prove insignificant. The test comparing *Fucus and Macrocystis* had a R value of 0.169 at a level of 12.1%. *Macrocystis* versus *Nereocystis* had an R value of -0.111 at a level of 83.8. Finally, *Fucus* versus *Nereocystis* had an R value of 0.227 at a level of 5.4%. The results of these multivariate tests are summarized in Table 1. Although our results provide evidence for significant differences in community structure of colonizing species, an outlier caused by an abundance of Ceratopogonidae in Mixed sample 4C appears to have driven a large portion of the relationships observed. Through removal of this outlier and other random samples, the Global R value no longer displays as significant of relationship.

3.2. Total Species Richness

A combined total of 12 terrestrial and marine morphospecies have been identified in all of the samples from collection. A great deal of variation in richness of species was observed through experimentation (Table 2. Appendix I). *Nereocystis* samples 3B and 4A had the greatest species richness with 5 species present (Figure 5). Results of species richness across treatments are presented in Figure 1.

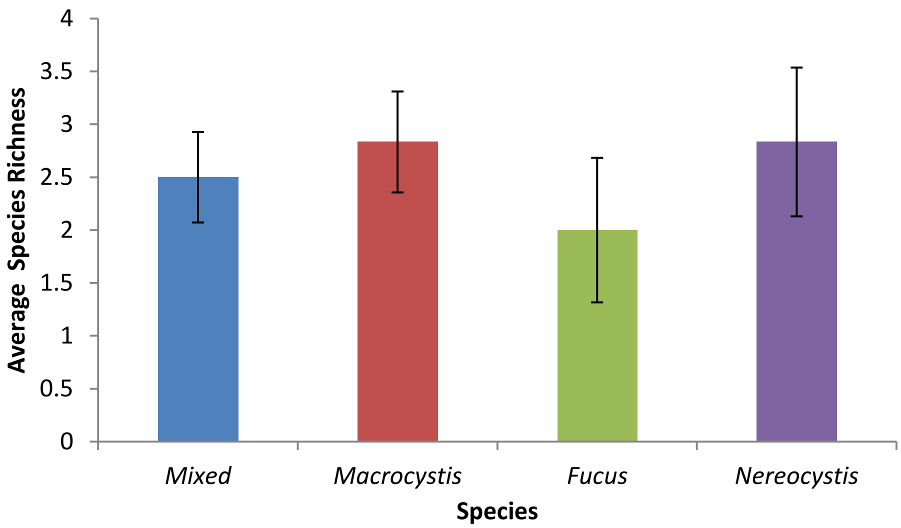
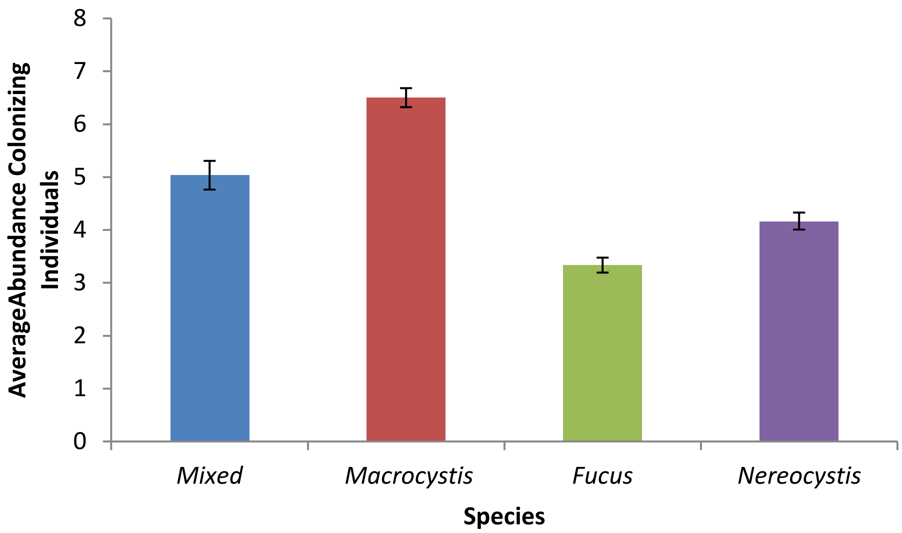


Figure 5: Average species richness of colonizing individuals on Mixed, *Macrocystis*, *Fucus* and *Nereocystis* samples. Error bars indicate Standard Error and are ± 0.428, 0.477, 0.683 and 0.703 respectively

The highest calculated average species richness was found in *Macrocystis* and *Nereocystis* which was 2.833 with a SE of ± 0.428 and ± 0.703 respectively. The Mixed sample had an average of 2.5 with a SE of ± 0.477. *Fucus* had the lowest observed species richness with an average of 2 with a SE of ± 0.638.

3.3. Total Species Abundance

As with species richness, there was a considerable amount of variation in the abundance of individuals found in each sample (Figure 6). Ceratopogonidae (noseeums) were the most common species throughout all samples with a total count of 42 individuals. In contrast, individuals of both the Coccinellidae (lady bug) and Curculionidae (beetle) only occurred once. Within samples, 4C had the



<u>Figure 6</u>: Average abundance of colonizing individuals found on Mixed, *Macrocystis, Fucus* and *Nereocystis*. Error bars indicate Standard Error and are ± 0.271, 0.180, 0.141 and 0.161 respectively.

greatest number of individuals present with a total of 15. Average species abundances can be found in Figure 2. *Macrocystis* had the highest average species abundance, 6.5 with a SE of ± 0.271. The next most abundant was the Mixed sample with an average of 5.333 with a SE of ± 0.180. Followed by *Nereocystis* with 4.167 with a SE of ± 0.142, then *Fucus* with 3.333 with a SE of ± 0.161.

3.4. Proportion of Marine Versus Terrestrial Colonizers

Since this test occurred in the supralittoral zone of the beach, we were interested in the proportion of marine versus terrestrial animals colonizing the samples. The total count of marine animals was 6, and 109 for terrestrial. The calculated ratio is 1:18.17 (marine vs. terrestrial).

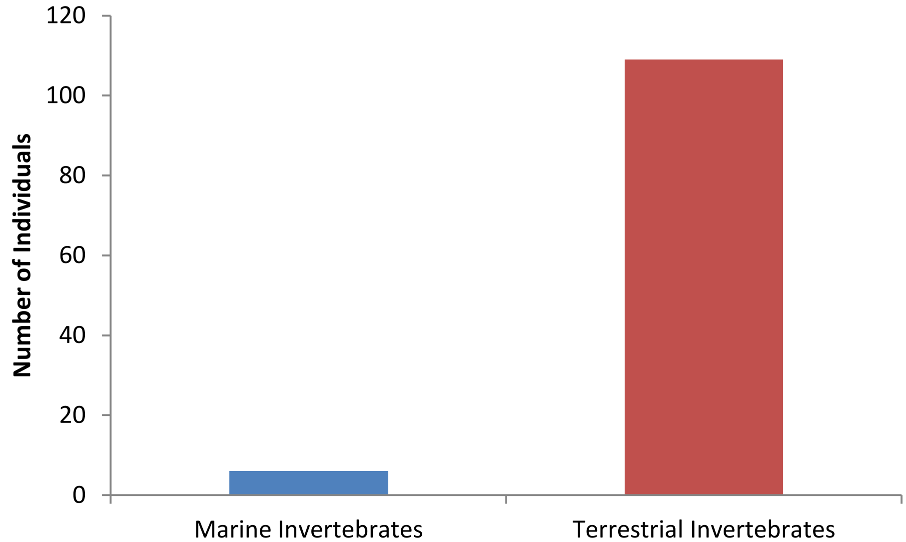


Figure 7: Proportion of marine vs. terrestrial individuals: Total marine= 6 Total terrestrial= 109. Ratio= 1: 18.17

4. Discussion:

Although similar experiments have been conducted within British Columbia, this is the first of its kind on the Central Coast, adding great value to our findings. As well as being a new study area, our plots were placed higher on the beach profile than most other experiments we have found. Although our results concerning community structure between the algae treatments were not statistically significant, there are interesting trends in species richness and abundance between treatments. We have also observed a significant ratio of marine versus terrestrial invertebrates which show a dominance of terrestrial organisms.

4.1. Difference in Community Structure with Different Algae Treatments

Through analysis using a multivariate analysis of community structure, we have concluded that there is no statistically significant difference between treatments. A Global R value of 0.254 with a significance sample statistic of 0.5% was calculated for analysis of the entire community structure within the experiment (Table 1). Evaluation of the similarities between treatments can be observed through a S17

Bray Curtis Similarity model (Figure 4). These values are statistically significant, although through further investigation we realized that there was an outlier which appeared to have driven this result. Pairwise tests have shown significant R values for all mixed versus other algae species while the individual algae types compared to each other are not significant (Table 1). Through analysing the results of the SIMPER Similarity Percentages species contributions One-Way Analysis it becomes evident of the influence of the test sample 4C. In this sample it is clear that the Ceratopogonidae (Noseeums) contribute 97.48% of the comparative analysis of community structure in the Mixed group. Through manipulative analysis we have discovered that without this significant outlier, the difference between samples is no longer statistically viable. To do this we randomly selected and removed samples 4C, 2A, 6A and 3B and input the data back into the ANOSIM Analysis of Similarities One-Way Analysis. The results of this test did not produce R values of any significance so we cannot claim there to be any difference in community structure between the different treatment types. There appears to be a great deal of variation in community structure between the samples, this can be observed through the rank abundance plots in Figures 8-13 (Appendix II). There are a few possible reasons for this lack of significant differences between the samples. The first and most obvious is the fact that our observed abundances in each group were much lower than were expected, this small data set was very susceptible to skewing by an outlier. These low abundances may be a result of the lack of amphipods as observed in other similar experiments conducted within the tidal range, like those completed by Pellitier *et al.* 2011. Small sample size must have also contributed to these low values.

4.2. Total Species Richness

Since the data set collected in this experiment was so unexpectedly small, statistical analysis of the total species richness and abundance between treatments wasn't possible. Besides this fact, we have observed some interesting trends with which further research could reveal some significant findings. By averaging the number of species observed in each treatment type, *Macrocystis* and *Nereocystis* had the highest number of species present (Figure 5). The mixed sample was the intermediate and *Fucus* had the lowest average. The standard error for these samples was 0.477, 0.428, 0.703 and 0.683 respectively. Because of the small variation between samples and the large standard error observed in each, we have not seen a trend in the species richness between the different Algae treatments.

4.3. Total Abundance of Individuals

In contrast with the total species richness, the total abundance of individuals of all species of colonizers displayed a more obvious trend. *Macrocystis* had the highest total abundance of individuals with an average of 6.5 across all treatments, followed by the Mixed 5.33, *Nereocystis* 4.17 then *Fucus* 3.33 (Figure 6). The standard errors for the averages were: 0.18, 0.27, 0.16 and 0.14 respectively. These observations of food preference are constant with the results found by Mews, Zimmer and Jelinski (2006) who also observed *Macrocystis* to have the highest rates of Amphipod consumption.

There are a few possible factors that may have lead to these trends in algae preference in detritivores. The chemical composition of the individual algaes have been observed to play a role in the feeding preference (Carefoot *et al*. 2000; Mews, Zimmer and Jelinski 2006). Carefoot *et al*. 2000 identified specific algal characteristics which play a role in feeding preference of supralittoral isopods and amphipods. The presence of defensive phenolic compounds in *Fucus* greatly reduced the colonization of consumers. Their studies also showed that over time, there was an increase in colonization over time in *Fucus*, which they have identified to be the result of the breakdown of these defensive compounds. They also identified the role that temporal differences play in algae colonization. All three colonizing species identified preferred wrack over fresh algae, which they believe is the result of increasing nutrient concentrations over time. As observed in our experiment, *Macrocystis* and *Nereocystis* become saturated in mucus soon after deposition (Mews, Zimmer and Jelinski 2006). This mucus is composed mostly of alginate which is a major component of brown algae cell walls (Mews, Zimmer and Jelinski 2006). The leaching of alginate rapidly promotes mass loss in these two algaes, whereas *Fucus* barely decayed over time (Mews, Zimmer and Jelinski 2006). This loss in mass effectively concentrates the nutrients in aged wrack, and is believed to be another factor influencing the preference of aged wrack over fresh (Carefoot *et al.* 2000). Aged wrack also has significantly higher abundances of fungi and bacteria, which may be more edible than the algae themselves (Carefoot *et al.* 2000). The samples we used appeared to decay at surprising rates and must have developed colonizations of bacteria and fungi by the end of the experiment, although we did not sample for this factor. Factors such as pH, toughness, nitrogen content, carbon: nitrogen ratio and water content differ between algae species, they have not been directly linked to food preference (Carefoot *et al.* 2000). There are clearly many factors which affect the colonization of the different algae types used in this experiment, although further investigation is necessary to pinpoint what is specifically causing this relationship.

4.4. Marine Vs. Terrestrial Species

The results of this experiment came to a surprise to our team as we were expecting to observe a much larger proportion of marine invertebrates to colonize our wrack samples. Instead, a ratio of 1 : 18.17 in favour of terrestrial organisms was observed through analysis. (Figure 7). Our predictions differed from our findings in respect to the abundance and diversity of marine T*raskorchestia traskiana* (Pale Beach Hoppers) which have been observed to compose up to 90% of the macrofauna within their habitat (Pelltier *et al*. 2011). These crustaceans support a vast array of animals of various trophic levels which forage on beaches (Griffiths et. al. 1983). The lack of *T. traskiana* within the upper supralittoral zone may play a role in the trophic composition of foragers as well as reducing competition between other detritivores. There appeared to be a distinct line in the sand roughly 3-4 m down from our sample site which had a much greater abundance of *T. traskiana.* The sand within the upper supralittoral zone was significantly dryer in contrast with that in the upper high tide mark. With warm temperatures and high UV radiation on 2 days of our sampling procedure, the sand surrounding our samples became extremely dry. As a primarily nocturnal species, *T. traskiana* burrows beneath the sand during the day under patches of wrack , although our observations saw a large abundance during the daytime (Pelletier *et al* 2011). The dryness of the sand in this zone may have not had the cohesive properties necessary for burrowing. Our results may have differed if the weather had been more moist throughout the entire experiment, keeping the sand cohesive up to the back beach. Also, the fact that we did our sampling at around 10 am may have reduced the amount of *T. traskiana* present.

The most abundant species found throughout the sampling procedure was *Ceratopogonidae* (Noseeum) with a total of 42. Their great abundance may have been the result of a localised breeding event as it was mostly concentrated to a few significant treatments. Staphylinidae (Rove Beetles) were the second most abundant species throughout, with high numbers of both adult specimens as well as larval forms. Although these beetles are primarily terrestrial, they have the ability to survive submersion in sea water through a process of reducing their metabolic rate which aids them in taking advantage of both marine and terrestrial food sources (Topp and Ring 1988). Both the adult and larval forms are predatory, feeding on intertidal invertebrates (Knopf 1980). In the preparation of this experiment we collected one species of the most common individuals we could find on west beach. These were individuals of *T. traskiana*, Ceratopogonidae and Staphylinidae, which we brought back to our lab to analyse and identify. During the time of our observation we observed the adult Staphylinidae eat both the *T. traskiana* and Ceratopogonidae. It is possible that because of the predatory nature of the Staphylinidae, the *T. traskiana* have identified the high risk in this region and avoid it. This observation leads us to the hypothesis that both the Staphylinidae adults and larvae had colonized our wrack samples primarily to feed on other colonizing insects.

4.5. Methodological Review

By evaluating the entire procedure of this experiment, we have formulated possible alterations to our methodology that could enhance the accuracy of our data. One factor that became obvious from the beginning of our field experiment was the alginate released from our *Nereocystis* and *Macrocystis* treatments. These two treatments released an enormous amounts of alginate slime, which caused rapid decay in contrast with the *Fucus*. This substantial decay lead to samples with only a portion of the size that they were at the beginning of our experiment. The process of alginate release is unpreventable, so increasing the sample size and taking measurements of dry weight would help to calculate the actual amount of organic material and water content. Increasing sample size combined with an increase in the amount of replicates would gather a much larger data set and would help to assure that the Analysis of Similarities (ANOSIM) tests would not be disrupted to the same extent by outlier samples . The comparison of average abundance of colonizing individuals as observed in Figure 4. is an obvious trend although, the small data set was insufficient for a Kruskal-Wallis statistical analysis. This analysis would have allowed us to confidently answer the question that was asked. Through intensive research, we discovered other abiotic factors which may have affected our results such as the tide high, seasonal and temporal differences which should be taken into account through the sampling process.

5. Conclusion:

In conclusion, we found that there was no significant relationship between community structures found on the differing algae types. We observed trends in the highest average abundances among the species, but due to small sample size we cannot make statistically significant conclusions about this trend. There was an apparent relationship between community structure of marine versus terrestrial individuals, which is likely due to the distance of the sample plots in the supralittoral zone from the high tide line. Provided that sufficient time and resources were available it would be interesting to explore this research to a greater depth. Investigating the dynamics of species richness and abundance of marine and terrestrial arthropods along the entirety of the beach gradient at various tidal zones would give more insight into why these trends were observed. Studying the effects of arthropods on higher trophic levels would help explore the depth to which marine and terrestrial organisms have upon these cross-boundary coastal ecosystems. Isotope analysis of the chemical components such N15 and C13 content of the various types of marine algae could provide more insight into what, if any, factors might influence preference by colonizing species, as well as the influence that these marine derived nutrients from beach wrack might have throughout terrestrial ecosystems. There are many abiotic factors that can influence the abundance and difference in species found on West beach and it would also be interesting to conduct collection and analysis for a variety of these such as various tidal heights, differences in rising versus ebbing tide, time of day, as well as seasonal factors. Studying the effects that marine derived primary producers have on terrestrial ecosystems along various trophic levels could be of great importance when it comes to creating, designing, and revamping protection areas and as well when considering ecosystem based management.

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Appendix I:

Table 2: Raw data

Date	Seaweed	Sample	Talitridae	Arachnid	Staphylinidae	Coccinellidae	Curculionidae	Staphylinidae	Coelopidae Larvae	Ceratopogonidae	Entomobryidae	Coelopidae	Centeped	Oribatoidea
24-Jun-12	Mixed	1A	0	0	1	0	0	0	1	3	3	0	0	0
24-Jun-12	Mixed	2C	0	0	0	0	0	0	0	1	0	0	0	0
24-Jun-12	Mixed	3D	0	0	0	0	0	0	0	3	0	0	0	0
24-Jun-12	Mixed	4C	1	0	0	0	0	1	0	13	0	0	0	0
24-Jun-12	Mixed	5A	1	0	0	0	0	0	0	1	0	0	0	0
24-Jun-12	Mixed	6C	0	0	2	0	0	0	0	1	0	0	0	0
24-Jun-12	*Macrocystis*	1B	0	0	3	0	0	1	0	0	0	0	0	0
24-Jun-12	*Macrocystis*	2A	0	0	1	0	0	3	0	1	0	0	0	0
24-Jun-12	*Macrocystis*	3C	0	0	0	0	0	3	0	0	0	0	0	0
24-Jun-12	*Macrocystis*	4D	0	1	2	0	0	0	1	5	0	0	0	0
24-Jun-12	*Macrocystis*	5D	0	2	0	0	0	0	0	1	0	2	0	0
24-Jun-12	*Macrocystis*	6B	0	0	0	0	0	4	2	6	0	0	1	0
24-Jun-12	*Fucus*	1C	0	0	0	0	0	0	0	0	0	2	0	0
24-Jun-12	*Fucus*	2D	0	0	1	1	0	0	0	3	0	0	0	1
24-Jun-12	*Fucus*	3A	0	0	1	0	0	0	0	0	0	0	0	0
24-Jun-12	*Fucus*	4B	2	2	2	0	1	0	0	0	0	0	0	0
24-Jun-12	*Fucus*	5C	2	0	0	0	0	0	0	0	0	2	0	0
24-Jun-12	*Fucus*	6A	0	0	0	0	0	0	0	0	0	0	0	0
24-Jun-12	*Nereocystis*	1D	0	0	0	0	0	1	0	0	0	0	0	0
24-Jun-12	*Nereocystis*	2B	0	0	1	0	0	0	1	0	0	0	0	0
24-Jun-12	*Nereocystis*	3B	0	0	1	0	0	1	0	4	0	0	0	0
24-Jun-12	*Nereocystis*	4A	0	1	1	0	0	4	0	0	0	1	0	1
24-Jun-12	*Nereocystis*	5B	0	0	0	0	0	4	1	0	0	0	0	0
24-Jun-12	*Nereocystis*	6D	0	0	1	0	0	0	0	0	0	0	0	0

Appendix II:

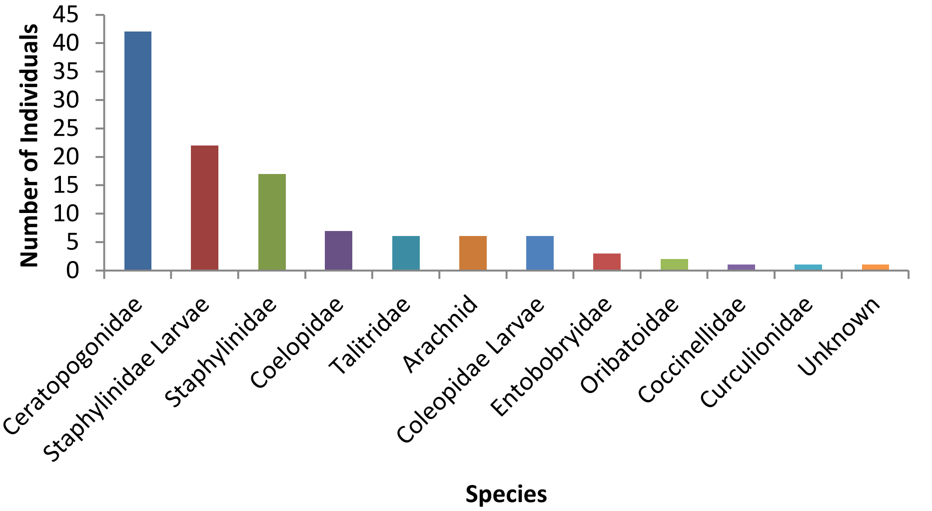


Figure 8: Total rank abundance plot for all samples.

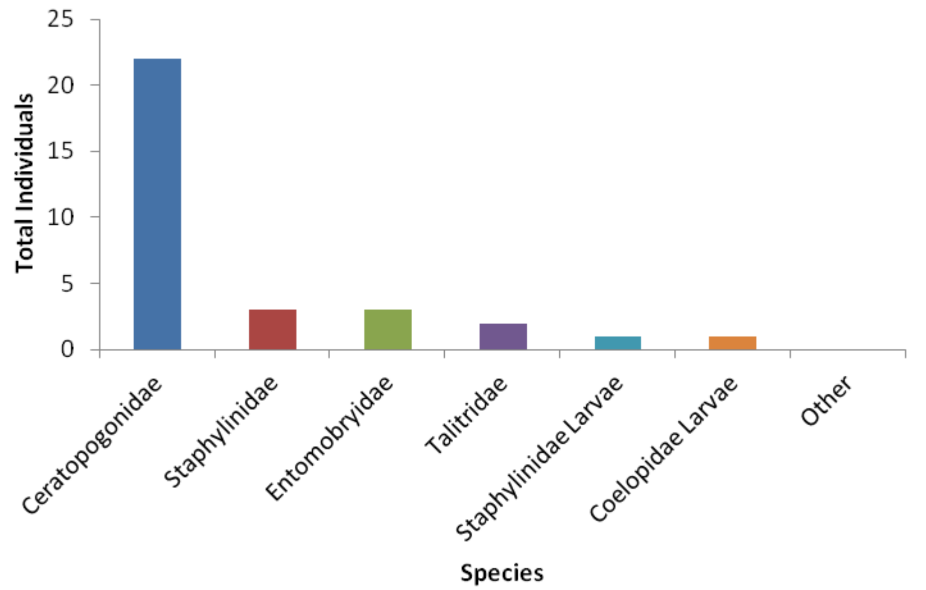
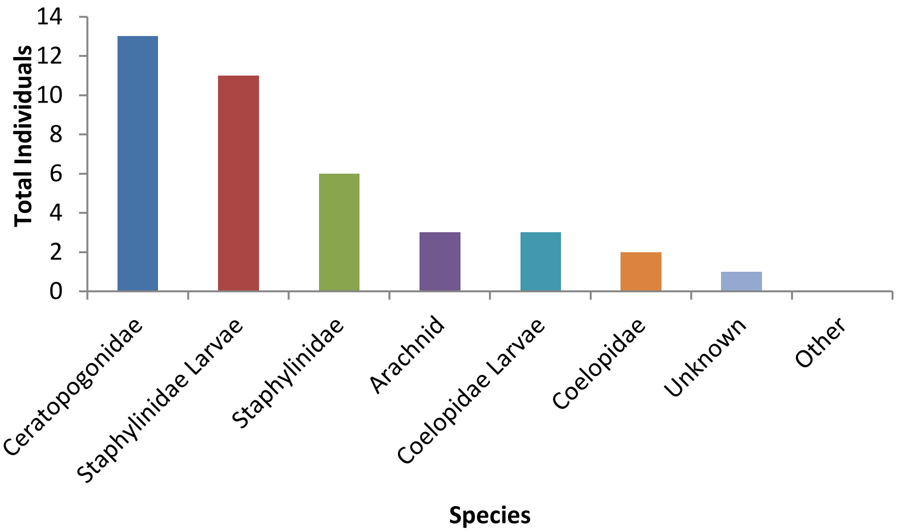
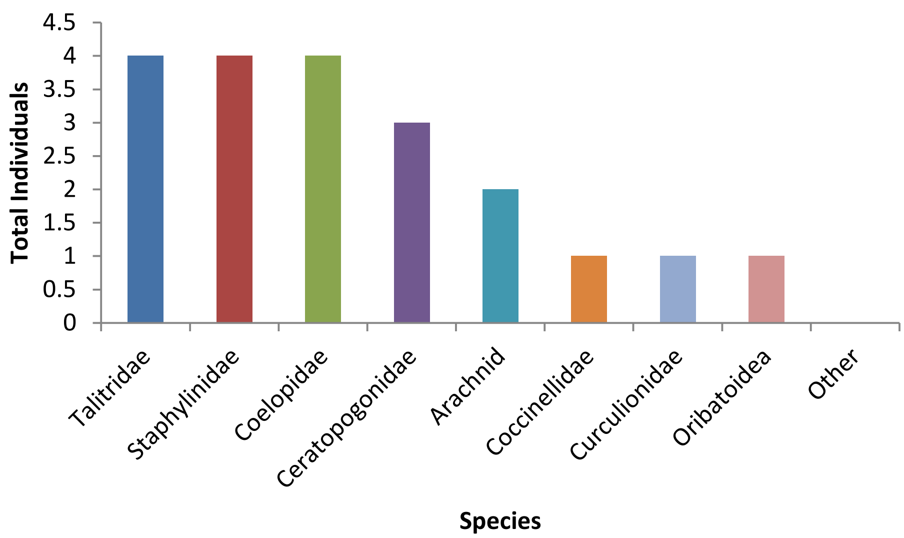


Figure 9: Rank abundance plot for species found on the Mixed algae sample. Other includes: Arachnid, Coccinellidae, Curculionidae, Coelopida, Centeped, , Oribatoidea.



<u>Figure 10:</u> Rank abundance plot for species found on *Macrocystis* sample. Others includes: Talitridae, Coccinellidae, Curculionidae, Entomobrydae, Oribatoidea.



<u>Figure 11:</u> Rank abundance plot for species found on *Fucus* sample. Others include: Staphylinidae Larvae, Coelopida Larvae, Entomobryidae and Centeped.

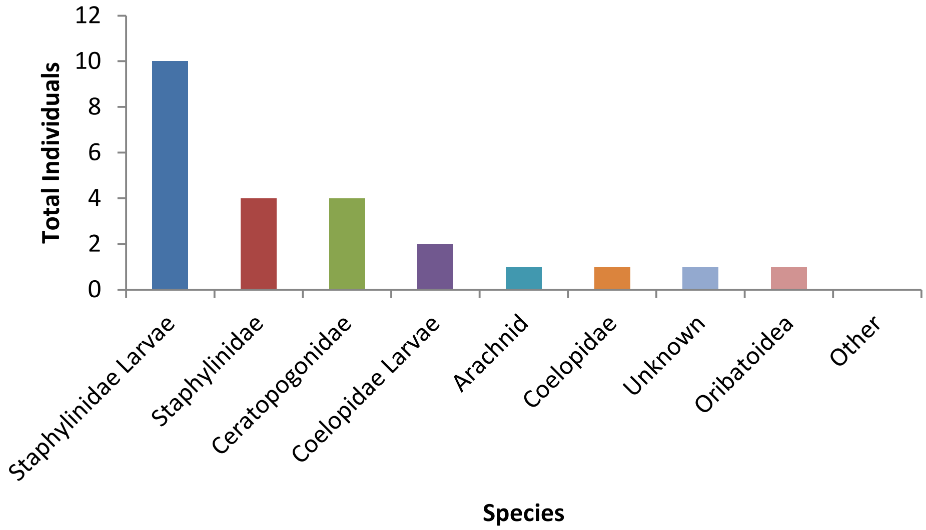


Figure 12: Rank abundance plot for species found on *Nereocystis* sample. Talitridae, Coccinellidae, Curculionidae, Entomobryidae, Centeped

Appendix III:

Four common species of Arthropods of West Beach

Rove beetles (*Staphylinidae)*:

Rove beetles have 2,900 species in North America and prey upon mites, other insects and small worms (Knopf 1980). Eleven species of Rove beetle inhabit coastal british columbia, they prefer fine grained sand beaches and feed upon intertidal invertebrates (Topp and Ring, 1988). Both the adults and larvae are predatory (Borror and White, 1970) and during our experiment an adult was observed eating a dead beach hopper in one of our collection samples. Some Rove beetles are able to survive submersion in sea water by reducing their metabolic rate (Topp and Ring, 1988) allowing them to survive and capitalize upon the cross boundary communities associated around beach wrack.

Pale Beach hopper *(Traskorchestia traskiana)*:

Talitrid Amphipods are among the primary consumers of beach wrack consuming up to 60% of their mass a day, they are among the first to colonize fresh arrivals of marine algae and can represent up to 90% of the macrofauna within their habitat (Pelletier et. al, 2011). These crustaceans form an important food supply for many different foragers of the intertidal zone and are important aspect of the coastal trophic web (Griffiths et. al. 1983)

Kelp Flies *(Coleopidae):*

Kelp flies, also called seaweed flies, are small black-brown flies with hairy legs and bodies and are abundant along the intertidal. Adults are common on and around flowers near the seashore and use decomposing seaweed above the high tide line as the location to lay their eggs (Borror and White, 1970). Both the adult and larvae feed on decomposing seaweed and are an important food supply for shorebirds (Knopf. 1980).

Springtail *(Entomobryidae)*:

Springtails are widely distributed across the globe and can survive in many inhospitable environments ranging from Mount Everest to the shores of Antarctica (Leslie 2004). Springtails feed on mold, decaying vegetation and algae (Knopf 1980).

Noseeum *(Ceratopogonidae)*:

Noseeums are minute flies 1 - 3 mm long that ressemble tiny, short legged mosquitos. Females from a few species are known to prey upon humans, but most feed upon flowers (Knopf 1980). Larvae are slender and snake-like and are both scavengers and predators in water and wet soil environments (Borror and White, 1970).