Species composition on the dock at Hakai Beach Institute: Does dock age and dock substrate influence composition?

by

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Abstract

The dock at the Hakai Beach Institute on Calvert Island, British Columbia, is home to many sub- and intertidal species. We surveyed the dock and compiled a list of found species. We compared the community structure of the different ages and substrates that compose the dock. We used an in-water quadrat sampling method, whereby relative abundance of sessile species was estimated using percent cover classes. Motile species were accounted for through repeated observations and counts. We ran an ANOSIM, a multivariate community structure analysis tool to determine what variables had an impact on the species composition of the dock. We found that age was the dominant factor in determining community structure. Substrate had an effect on the older well-established dock sections but not on the new sections.

Introduction:

The Hakai Beach Institute is a non-profit organization aimed at teaching and research on the Central Coast of British Columbia. Since its inception in 2009, the Hakai Beach Institute has made many improvements to the grounds including dock improvements (Hakai Beach Institute, n.d). To expand upon knowledge of intertidal and subtidal ecosystems, a species survey of the new and old docks was conducted. It is hoped this baseline information will aid the Hakai Beach Institute and other parties in future research about species abundance and presence on the dock.

The Hakai Beach Institute is located on the northwest of Calvert Island, located in the Hakai Luxvbalis Conservancy area. The Hakai Luxvbalis Conservancy is the largest marine park in British Columbia (British Columbia.com, 1998). The area has a rich history of Indigenous use which the Hakai Beach Institute has acknowledged and is attempting to foster in an attempt to better understand and appreciate the biodiversity of this immense region (British Columbia Parks, 2010). Calvert Island is an unlogged and pristine area.

Calvert Island is part of the Great Bear Rainforest. It is an ecologically, culturally, and economically important area in coastal British Columbia. The Spirit Bear, grizzly bears, coastal wolves, and untouched portions of the coastal temperate rainforest are found here. The Great

Bear Rainforest is a BC coastal area where conservation, traditional First Nations management and use, and ecologically based management practices meet. Diverse stakeholders created an agreement to legally protect two million hectares of the Great Bear Rainforest from logging in 2006 (Sierra Club of BC, n.d). However, parts of the Great Bear Rainforest still face biodiversity threats from development. New biodiversity information is important and could be applied to climate change, pollution, increased human activity, and invasive species (Sierra Club of BC, n.d).

The history of the dock was determined through discussions in June 2011 with Eric Peterson. The new dock was built in Surrey in December 2010, in freshwater. In April it was towed by a tug-boat to Hakai Beach Institute, though it spent a considerable amount of time stationary while the tug-boat had to wait for calmer water. Only a portion of the old dock was kept. According to information Eric Peterson obtained about the old dock, the previous owners would disassemble the dock in the winter months and keep them anchored in Pruth Bay. The dock was assembled only in the summer months.

The dock at Hakai is composed of different substrates and ages (Figure 1). There are two old sections. One is constructed of wood and rubber tires. The other was constructed of concrete. The old dock sections are approximately 18 years old. There are two new dock sections that are seven months old. These sections have been at Hakai for two months. One of the new sections is constructed of concrete while the other is constructed of concrete and rubber tires.

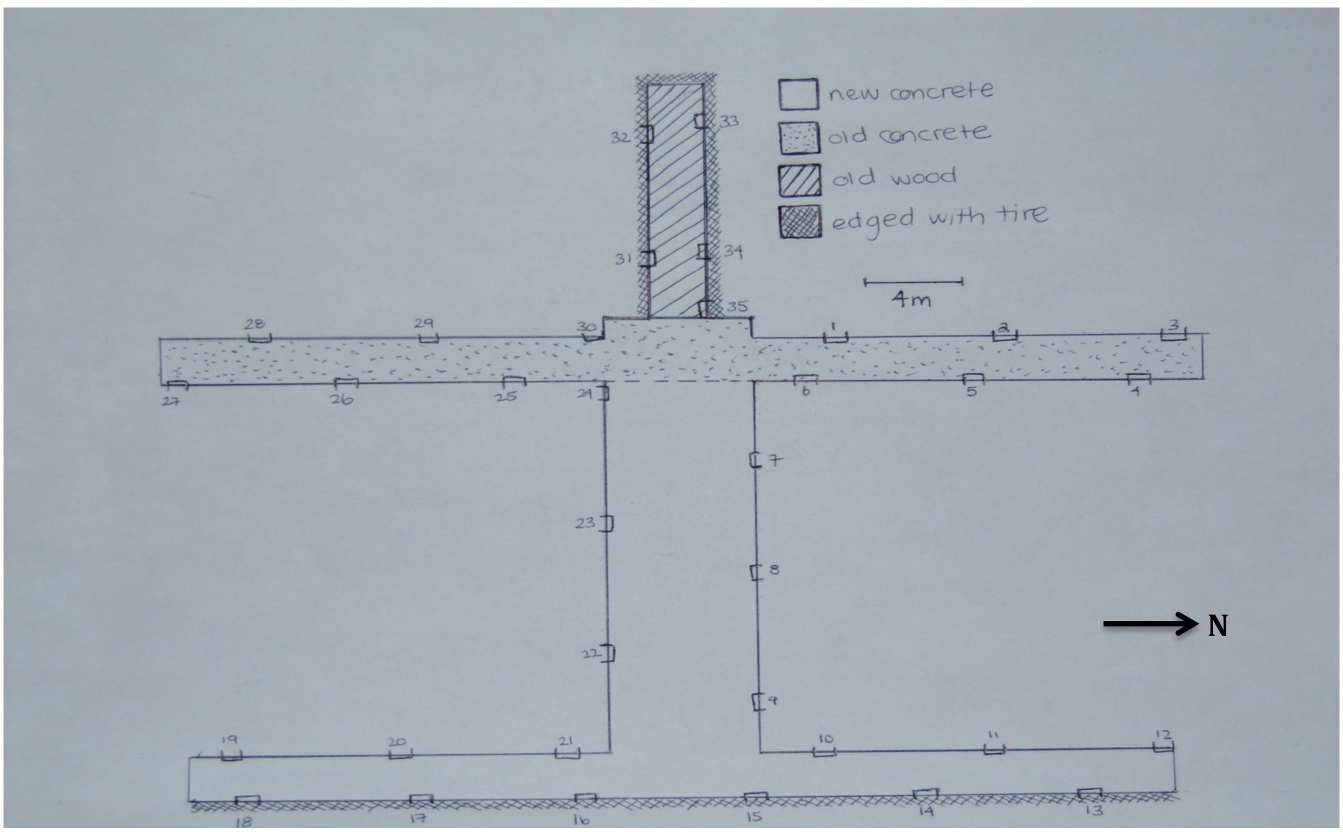
Determining the species present on the dock, as well as their relative abundances, according to age and substrate will offer some important information for the Hakai Beach Institute. Boulinier et al (1998) conducted a study in which the importance of species richness in an area was determined. What was concluded is that the information gleaned from surveys and estimates of species richness are of crucial concern “when dealing with the conservation and management of biodiversity” (Boulinier et al, 1998, 1018). The hopes in conducting a species survey and a species abundance survey on the Hakai Beach Institute dock were to create a baseline of data that could be used in future studies or research. With the addition of a new dock it will be especially interesting to note the rate in which it is colonized, with what it is colonized, and upon which substrate is preferred by different species, as the new dock includes both concrete and rubber tire.

Another concern with the biodiversity on the dock is invasive species. Conducting regular dock surveys have been recommended to detect the introduction and growth rate of exotic and potentially invasive species (Grey, 2009, 82). This will be important for the Hakai Beach Institute in that it receives visitors from all across the west coast, and is in the center of an important ecological area in British Columbia. Expanded tourism in coastal regions can result in an increase of man-made structures, which can act as “habitat islands” which if built in a traffic heavy area could result in a high influx of alien organisms (Bax et al, 26, 2002). Invasive exotic species could do immeasurable harm to the biodiversity on the Hakai Beach Institute dock, as invasive species tend to do well as r-selected organisms, and can easily outcompete native species (Leppakoski et al, 2, 2002). An introduction of a particularly dominating invasive species that spreads quickly could spread across the coast with boat traffic, and could have a considerable impact on the intertidal species (Leppakoski et al, 2, 2002).

Creating a baseline species and abundance survey may also be beneficial to future studies of the effects of climate change on the sub- and intertidal ecosystems. Raising sea temperatures, sea levels, increased freshwater runoff, or increased levels of carbonic acid in the ocean could have potentially harmful effects on the organisms living in the intertidal and on docks. Helmulth et al believe that climate change may cause localized extinctions in the intertidal of the northern west coast (2002). If this should occur in the Pacific Northwest the biodiversity of the intertidal could be threatened, with potentially harmful effects to other ecosystems and species through cross-boundary linkages. This baseline data could help determine and track any changes that may occur.

We set out to determine what factors on the dock influenced species composition in the top 75 centimeters of water. We looked at the age of the dock and the material of the dock. We hypothesized that both dock age and dock construction material would influence species composition.

Figure 1. Map of the dock at Hakai.



Methodology:

A systematic sampling design was chosen to ensure a representative sample was collected from each dock section. The location of the first sampling site was chosen by using a random number generator. The random number determined the distance from the north-western corner of the dock to the beginning of the site. This included a degree of randomness in our methodology. Float and marine surveys often sample every 10- 15 meters (Cohen *et al*., 2005). Our sampling sites were tapped off every six meters. This resulted in 35 sampling sites spread over the entire dock. One site was rejected as a boat obscured sightlines and prevented proper data collection. Thirty-four sites were fully sampled. Though time was a constraining factor when deciding the number of sample plots to survey, our design is sufficiently detailed to capture species composition data from the dock.

The old dock sections were 50 cm deep and had large amounts of biomass extending below the bottom of the dock. Sections of the new dock ranged from 50-90 cm. A quadrat size of 75 cm^2 was chosen to represent and account for as much as the variation as possible. Small scale dock studies aimed at monitoring invasive species used quadrats as small as 25 cm^2 (Grey, 2009). Our quadrat was larger to account for a greater amount of biodiversity. There are several established methodologies for surveying port environments. Our approach closely followed the guidelines of the rapid assessment as organisms on the dock were not removed or disturbed while sampling (Campbell *et al*., 2007).

Species residing on the dock were divided into two broad categories based on movement patterns. Different methodologies were used to survey the sessile and motile species. Sessile species were sampled using a modified classification. The cover classes and corresponding percentages are shown in Table 1. The quadrat was placed in the water and held at the water line. It was kept ten centimeters (cm) away from the dock to minimize organism disturbances. A swimmer in the water estimated and relayed the present cover class of each present species. Percent cover class estimations were simultaneously observed from on the dock. Estimating percent covers from both locations helped ensure a degree of consistency throughout the experiment. Data was collected over two consecutive days that had fair weather and relatively low tides. The similar conditions reduced potential variance in visibility and experimenter perception. In the water and from on the dock surveying methods can both result in similar data (Grey, 2009)

Table 1. Class Covers and Related Percentages.

Class	1	2	3	4	5	6
Percent Cover	1-5	5-15	15-25	25-50	50-75	75-100

The motile species were sampled by preforming repeated counts of each individual species in the sample area. Counts were conducted twice a day over four consecutive days. Each quadrat was observed for 5 minutes to reduce observation bias and to ensure an equal effort was applied to all dock sections. Observations occurred between 7:30-9:00 in the morning and between 7:30-9:00 in the evening. As *Hermissenda crassicornis* exhibits diurnal tendencies, (Lederhendler, 1980) sampling in the morning and evening increased the opportunity to see individuals.

Several types of organisms with limited mobility were placed in the sessile category for the purposes of our study. The suspension feeding *Cucumaria miniata* was considered sessile. It has suctioned tube feet for minor position adjustments, but does not travel distances (Lambert, 1997). Chitons were similarly treated as sessile species. Both *Katharina tunicate* and *Tonicella spp* move, but do so within a limited range. The literature is inconclusive, but suggests that both genera have homing instincts and live within an approximate one meter square area (Jett & Konar, 2001). Individual counts of chitons of were conducted to see if population abundances differed throughout our sample sites.

A list of the species living primarily on the dock was compiled. This list included species regardless of their positions in the sampling areas. The data was analyzed was the multivariate statistical package Primer.

Results:

We had three main questions to answer when interpreting the data. The first asked if there was a difference in species composition on the old and the new dock sections. A Bray-Curtis similarity matrix and a nonmetric multidimensional scaling (NMDS) plot were created to visually represent data similarities between age samples. The NMDS plot is shown in Figure 2. An ANOSIM (analysis of similarities) was conducted to quantify the similarities. We found a significant difference between the old and new dock sections (Global R = 0.936, P value= 0.001). SIMPER (similarity percent) analysis showed the average dissimilarity to be 76.15 percent between the old and new sections. *Metridium giganteum* and *Eudistylia vancouveri* combined to create 30 percent of the differences. A second ANOSIM was performed to assess if species composition differed based on the material of the dock. Different materials of the same age were compared. An NMDS plot was created (Figure 3) and an ANOSIM was run. The Global R value and related p values are shown in Table 2. There was not a significant difference between new concrete and the concrete and rubber sections of the new dock (global R = 0.161, p value 0.082). There was, however, a significant difference between the old concrete and the old wooden and rubber dock (global R= 0.9, p value= 0.001). SIMPER analysis showed the two sections to be an average of 44.38% dissimilar. The lack of *Serpula vermicularis* on the old dock played a large role in the dissimilarity.

Table 2. Pairwise comparisons of different dock substrates.

Groups	Global R	P value
Old Concrete vs Old Wood & Rubber	0.9	0.001
New Concrete vs New Concrete & Rubber	0.161	0.082
Old Concrete vs New Concrete	0.924	0.001

The Global R value ranges from 1 to -1. One indicates that the community compositions greatly differ from each other. 0 indicates that there is no difference between the groups. The p value is the probability of the Global R being false.

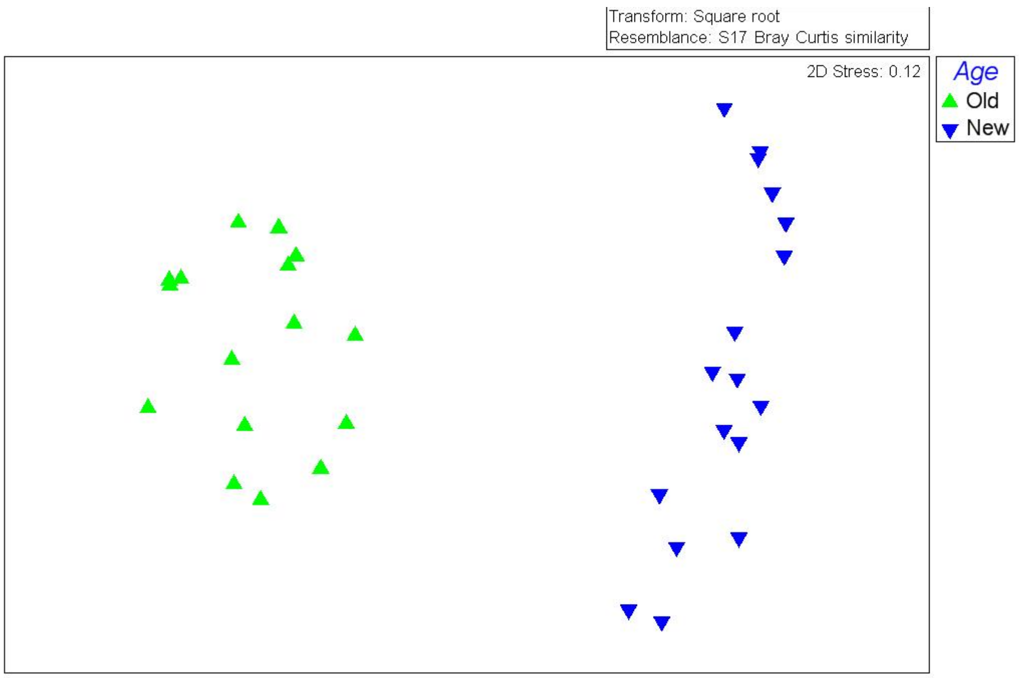


Figure 2. Nonmetric Multidimensional Scale (NMDS) plot showing the relative similarities of species composition between the old and the new dock sections.

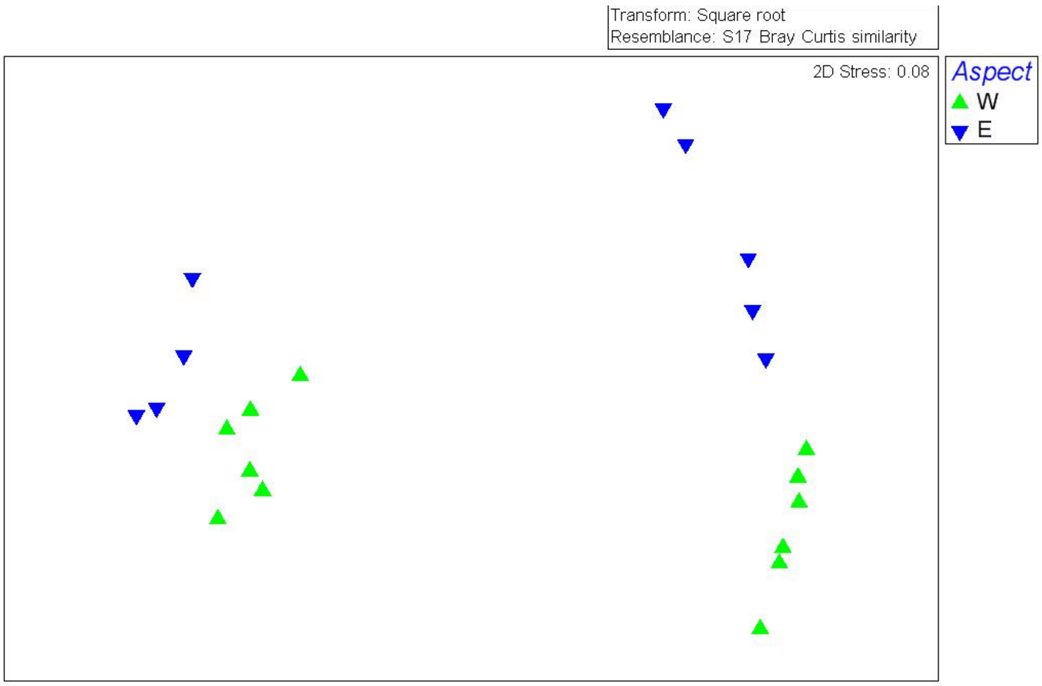


Figure 3. NMDS plot showing the how similar the species composition is on the east and west aspects of the dock.

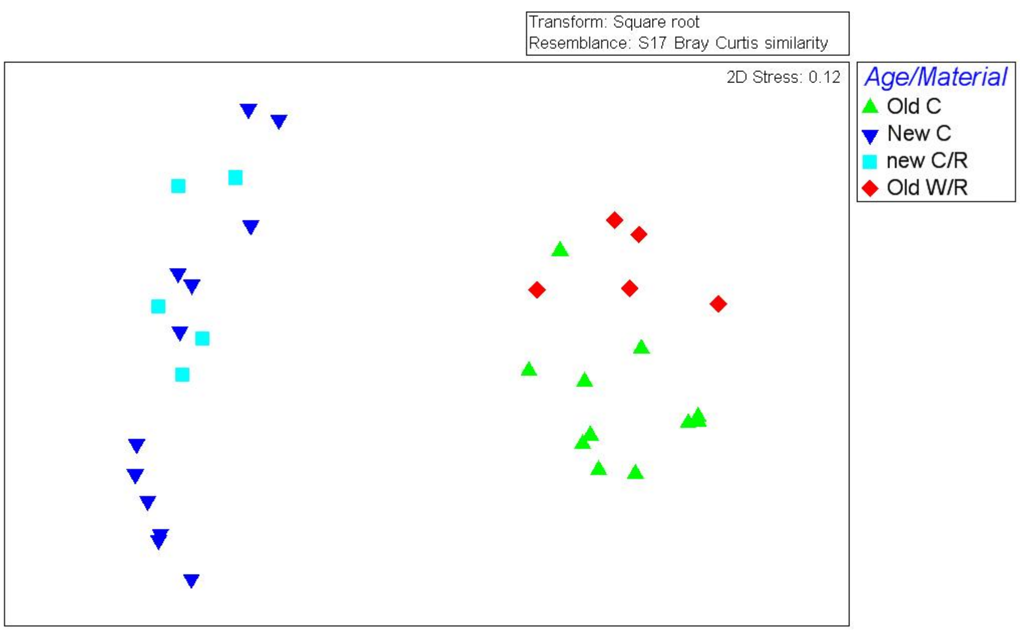


Figure 4. NMDS plot showing the relative similarities and differences of species composition based on the dock substrate.

A third ANOSIM was performed to determine if an east or west aspect impacted the species composition. The NMDS plot is shown in Figure 4. Aspect did not have a significant effect on species composition (global R= 0.12, p value= 0.067).

The number of quadrats where Nudibranch species were found is shown in Table 3. This data can be used to determine which sections of the dock provide habitat for each observed nudibranch species.

Table 3. Number of Quadrats By Dock Section Where Nudibranchs Were Observed

	Old Concrete	Old Wood and Rubber	New Concrete	New Concrete and Rubber
Op	9	1	1	1
White	2	0	0	0
Bushy	0	0	2	0

Discussion:

Comparative survey

As expected, the comparison between the old and new docks yielded significant differences in community structure. This was the dominant factor in determining overall community composition on the dock, although substrate did have an impact on the old section. Conversely, substrate did not have a significant impact on composition on the new dock.

The large differences between age classes are likely due to the differences in life history between species in each community, particularly in the context of *r*- and *K*-selected species. *R*-selected species tend to be better colonizers, poor competitors, reproduce frequently, and are found at a lower density. *K*-selected species do not colonize as well, but have the advantage of inter- and intraspecific competitive and defense abilities; therefore an empty habitat would initially be dominated by *r*-selection, but with time *K*-selection would characterize the overall population (Krebs, 2001). The most abundant species found on the new dock are typically more *r*-selected; neither algae nor barnacles have particularly effective defence or competition mechanisms, and both are prolific reproducers and colonizers (Harbo, 1999; Druehl, 2000). In comparison, the species on the old dock are generally more *K*-selected as they are larger, longer-lived, and take longer to reach a full mature size. *Metridium giganteum*, which contributed to the significant difference between the dock ages, is particularly large and territorial. It can reach up to 1 m in length, grow in dense colonies, and will attack other colonies and anemone species with special tentacles and far-reaching stinging capsules (Harbo 1999). *Eudistylia vancouveri*, which also was a significant factor in the difference between the dock age classes, is a particularly hardy animal; once it is attached to a substrate its long tube is very difficult to remove, and damage to the tube does not result in the removal of the animals – rather the worm repairs it (Sept, 1999). The painted anemone has been known to reach 80 years of age; it was not abundant on the dock but when present its size was significant (Sept, 1999).

A particularly interesting finding of this study was that substrate was a significant factor in community composition on the older dock, but not on the newer dock; this may indicate that those initial colonizing species are generalists and therefore settle on a substrate as long as there is space. A select few species on the old dock do appear have more of a preference relating to substrate; the main species of note here is *Serpula vermicularis* which was only present on the old concrete dock. This species' preference for attaching to harder and likely more textured surfaces is indicated in its usual appearance on rocks, pilings, and floats (Harbo, 1999).

<u>Overall Survey</u>

Our general survey of the species that inhabit the Hakai Beach Institute dock found a clearly defined group of species that dominates the dock space, such as *M. giganteum*, *Serpula vermicularis*, and *E. vancouveri* on the old dock, a handful of algal species on the new dock, and barnacles on both. Despite this, there is also large variety of species that are present in smaller numbers and therefore increase the species abundance in the dock community: the total count of species along the approximately 220 m perimeter was 45. Most of the species observed on the dock are quite sessile, most notably *M. giganteum*, *U. crassicornis*, *E. vancouveri*, *Serpula vermicularis*, *Strongylocentrotus droebachiensis*, *Pododesmus macrochisma*, algae species, and barnacle species. The other species were largely sessile; *Cucumaria miniata*, chitons, and limpets do move, but very slowly. Nudibranchs were the most notable motile species, while sea snails, small *Pisaster ochraceus*, and other tiny unidentified sea stars were occasionally observed. On the last two days of our motile species survey we observed multiple clusters of nudibranch eggs on the old concrete dock; this likely contributed to the prevalence of these animals during our counts, particularly of the most frequently observed species *Dirona albolineata* and *Hermissenda crassicornis*. Overall the species abundance of the dock is largely accounted for by sessile or barely motile species, with relatively few freely motile species.

In order to create a more comprehensive list of species, we also recorded any species we observed anywhere on the dock that we had not observed in our relative abundance estimates. This resulted in a significant increase in the species count, as we were able to record species that we observed only once or twice, such as *Cnemidocarpa finkariensis*, *Membranipora membrancea*, *Nucella laminosa*, *Pugettia gracilis*, and *Oregonia gracilis*. One particularly interesting find was a cryptic 1.5 cm long *Dendronotus frondosus* specimen, unexpectedly discovered while identifying algae species on the new concrete section of the dock. This further indicates that other such species may have gone unobserved, even on the relatively bare new dock. There were other species that we were unable to confidently identify, which would have further increased the recorded species abundance.

Having such a baseline survey is important for the purposes of monitoring the health of the surrounding marine ecosystem, particularly because docks and ports are the most common source for the immigration of exotic species (Orensanz *et al*., 2002; Grey, 2009). Our survey did not identify any obvious exotic or invasive species; this is an important piece of information for the Hakai Beach Institute to know as once these species are introduced they are nearly impossible to extirpate (Orensanz *et al*. 2002). The likelihood of such transmissions at this location is not a major concern due to the smaller size of the dock as well as the boats that moor at it and offshore in the bay, but an increasing interest in eco-tourism, and the natural beauty Great Bear Rainforest in particular, could result in a rise in interested tourists to the area, and therefore an increase in boat and float plane traffic. This would further increase the likelihood of accidentally introducing exotic species.

At the present time most of the boat and float plane traffic appears to be relatively local, with the most frequent traffic coming from the nearby areas of the Mainland or Vancouver Island, and most other traffic coming from and going to other areas along the Pacific Northwest coast. As all the species identified in our survey have a broad range across this area, the introduction of exotic species is not of particular concern. An influx in float planes and tour and private pleasure boats could change this. Regular surveys of the area would, therefore, be beneficial in monitoring the status of the dock and preventing such introductions. Such prevention should be a key concern given the ecological sensitivity and importance of the Hakai Luxvbalis Conservancy and the Great Bear Rainforest, as well as of coastal marine ecosystems in general. From intertidal zones to the continental shelf, coastal marine systems are some of most socio-economically and ecologically important and productive on the planet (Harley *et al*., 2006).

Factors affecting survey and sampling

One possible way that bias could have entered into our sampling is that our method of sampling was largely based on one person in the water estimating percent cover; while this does not have the benefit of being completely unbiased within each quadrat, it is beneficial in that it maintains consistency between quadrats, which therefore gives an accurate representation of the relative abundance between quadrats. In addition, this sampling technique and the counts of motile species do not allow for the inclusion of rare or inconspicuous species; we attempted to account for these species through general observations of species encountered on all areas of the dock, but doubtless there are species present in small numbers which were not accounted for.

In addition, there were restrictions with identifying algae, both in the water and on land. The species that were identified in the water as distinct species could not necessarily be narrowed down to a certain species or genus name, due to a lack of equipment required for closer microscopic observation and genetic testing. At the same time, the species that were distinguished in the water may not have encompassed the entire algal community due to often low water clarity and to the small amount of growth that some of the species had undergone since colonization. A longer period of study or a more intensive study – which would possibly result in damage to some species on the dock – would be required to create a fully comprehensive species list that includes all algae and rare or inconspicuous species.

Future Studies

This study offers up a baseline survey of the species present on the Hakai Beach Institute dock, as well as a basic comparison of community structures within the dock. As such, it opens up many possibilities for future studies. One such study could investigate the variables of aspect and exposure. The analysis of similarities between the east and west facing sides did not statistically reveal any significant differences. These were not variables examined directly in this study, however; with this in mind, and the fact that the sample statistic was near the threshold of significance, it is possible that these factors do have an influence on community structure. In addition, during our sampling we observed that species of green algae grew more readily on areas of the dock that had more consistent access to sun, such as areas where boats were never or rarely moored. Further studies could also monitor the effects of boat activity on the dock community structure, particularly as it relates to invasive species. A more intensive, detailed survey for invasive species is recommended, both on the dock and in Pruth Bay in which pleasure boats anchor.

Conclusion:

Our study found that age is the most significant factor in determining community structure on the dock, and that substrate is also a significant factor on the older, well-established dock but not the new dock.

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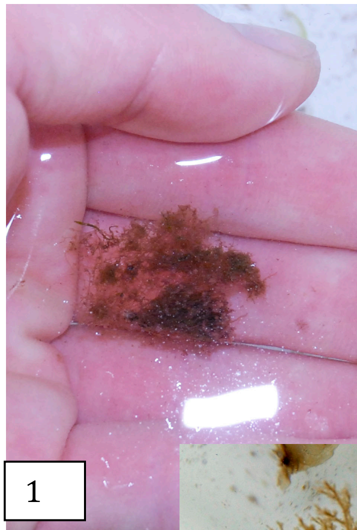
Appendices:

Appendix 1: Species List

Genus	**Species**	**Species Common Name**	**Old Wood**	**Old Conc**	**New Conc**
Metridium giganteum	*giganteum*	Giant Plumose Anemones	✓	✓	
Metridium senile	*senile*	Short Plumose Anemones	✓	✓	
Urticina crassicornis	*crassicornis*	Painted Anemones	✓	✓	
Eudistylia vancouveri	*vancouveri*	Northern Feather Duster Worms	✓	✓	
Serpula vermicularis	*vermicularis*	Calcareous Tube Worms	✓	✓	
Balanus	*glandula*	Common Acorn Barnacle	✓	✓	✓
Mytilus	*edulis*	Pacific Blue Mussel	✓	✓	
Lottia	*pelta*	Shield Limpet		✓	
Tectura	*scutum*	Plate Limpet		✓	
Tectura	*persona*	Mask Limpet		✓	
Archidoris	*montereyensis*	Monteray Sea Lemon		✓	
Onchidoris	*bilamellata*	Barnacle Nudibranch		✓	
Dirona	*albolineata*	White-Lined Dirona		✓	
Hermissenda	*crassicornis*	Opalescent (aeolid) Nudibranch		✓	
Dendronotus	*frondosus*	Bushy Backed Nudibranch			✓
Tonicella	*lineata*	Lined Chiton	✓	✓	
Tonicella	*undocaeruea*	Blue-Line Chiton		✓	
Mopalia	*ciliata*	Hairy Chiton		✓	
Mopalia	*muscosa*	Mossy Chiton		✓	
Katharina	*tunicata*	Black Katy Chiton	✓	✓	
Evasterias	*troschelii*	Mottled Star		✓	
Pisaster	*ochraceus*	Ochre Star		✓	
Leptasteras	*hexactis*	Six Ray Star		✓	

Pycnopodia	*helianthoides*	Sunflower Star			
Cucumaria	*miniata*	Orange Sea Cucumber		✓	
Halecium	*beani*	Candelabrum Hydroid			✓
Strongylocentrotus	*droebachiensis*	Green Sea Urchin		✓	
Pododesmus	*macrochisma*	Green False-Jingle		✓	
Cnemidocarpa	*finmarkiensis*	Shiny Orange Sea Squirt		✓	
Chthamalus	*dalli*	Small Acorn Barnacle	✓	✓	✓
Nucella	*osterina*	Northern Striped Dogwinkle		✓	
Membranipora	*membracea*	Kelp Lace Bryzoan		✓	
Seaweed					
Haplogloia	*andersonii*	Hariy Brown		✓	✓
Ulva	*linza*	Flat tube sea lettuce		?	✓
Ralfsia	*fungiformis*	Fungiform tar spot alga		✓	
Other Species					
Aurelia	*labiata*	Moon Jellyfish			
Cyanea	*capillata*	Sea Blubber/Lion's Mane	✓		
Pugettia	*gracilis*	Slender Kelp Crab			
Oregonia	*gracilis*	Slender Decorator Crab			
Traskorchestia	*traskiana*	Kelp Isopod			
Oligocttus	*maculosus*	Tidepool Sculpin			
Nereis	*brandti/virens*	Giant Oiling Sea-Nymph/Clam Worm			
Sygnathus	*leptorhynchus*	Bay Pipefish			
Sebastes	*unknown*	Various rockfish (species unknown			

Appendix 2: Unidentified Algae Species



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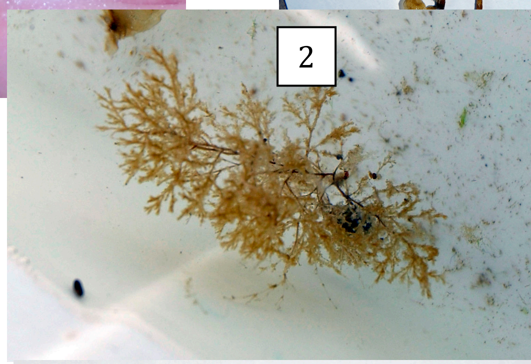

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1) Red algae species A: small, tufted, red-brown, found between barnacles
2) Brown algae species A: almond brown, long and string-like, growing in small patches.
3) Brown algae species B: almond brown, usually growing in large quantities, thin and translucent, rubbery, gel-like texture.
4) Brown algae species C: almond brown, insubstantial out of water, very branched and tree-like.
5) Green algae species C: grassy-green, thick and felt-like in texture, growing in small to medium-sized tufts.