Prionitis and herbivore interactions of Oregon’s rocky intertidal tidepools

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Abstract:

The study related the density of herbivores to the length and density of *Prionitis spp.* in Oregon's coastal tidepools. Oregon's coastal rocky intertidal tidepools contain a variety of species interactions, including algal grazing by herbivores. The red branched algae *Prionitis spp.* is found throughout the rocky intertidal in the low and high zones. In the intertidal, *Prionitis spp.* has many herbivores that graze on it; chitons, limpets, sea urchins, and snails being the most common in tidepools. An observational study was conducted throughout the rocky intertidal and the data was analyzed using excel. Herbivore density was significantly different between the high and low zone tidepools, while *Prionitis spp.* size and density were similar. The density of herbivores described a little bit of the variation in *Prionitis spp.* size and so did *Prionitis spp.* density for herbivore density. Herbivores do not strongly influence the size and density of *Prionitis spp.* in rocky intertidal tidepools.

Introduction:

The objective of the study was to examine the interaction between *Prionitis spp.* and the herbivores that feed on it. The study related the abundance of herbivores to the length and abundance of *Prionitis spp.* in Oregon coastal tidepools, and considers the intertidal vertical gradient.

Oregon's coastal rocky intertidal tidepools contain a variety of species interactions, including algal grazing by herbivores. The red branched algae *Prionitis spp.* is found throughout the rocky intertidal in the low and high zones. In the intertidal, *Prionitis spp.* has many herbivores that graze on it; chitons, limpets, sea urchins, and snails being the most common in tidepools. Limpets have been found to decrease algal abundance throughout the intertidal (Burgos-Rubio et al. 2015), while sea urchins are voracious herbivores as well (Nielson 2001).

Low zone tidepools in the intertidal are more frequently hit by waves than high zone tidepools. The increased wave action at the low zone will sweep smaller herbivores out of the tidepools, reducing the grazing pressure on *Prionitis spp.* Findings by Raffaelli (1979) show that grazer biomass decreases more towards the lower shore (Raffaelli 1979). Disparity between high and low zone grazing pressure can be distinct and noticeable. High zone tidepools, which tend to be protected from wave action, show low fleshy algae density (Tamelen 1996). Tamelen's findings in conjunction with Raffaelli's findings points towards a higher *Prionitis spp.* density in the low zone than the high zone.

Tidepool algae are not defenseless against their herbivore attackers. *Prionitis spp.* has a means of chemical defense like many other intertidal algae do. Halogenated compounds given off by the algae may show an antibiotic activity that may deter invertebrate grazers (Deathier 1981). The exact chemical defense is not agreed upon, but none the less *Prionitis spp.* possess a chemical defense to herbivores.

While doing an observational study of what species are found in tidepools with *Prionitis spp.* earlier I noticed differing sizes of the algae in the tidepools. I want to explore more of why this size difference occurred and studies involving algal interactions with other species is sparse compared to invertebrate interactions. Based on a top down ecological model, I hypothesized that herbivores feed on *Prionitis spp.* reducing the size and density of the *Prionitis spp.* in the tidepools. I also hypothesized that low zone tidepools will have a lower density of herbivores than high zone tidepools.

Methods:

The sites this study happened at was Strawberry Hill and Tokatee Klootchman of Cape Perpetua. Cape Perpetua has a broad continental shelf offshore that keeps water on-shore with retentive waves. Located closer to California than other more northerly capes of Oregon's coast, these sites will have stronger upwelling than further up north on the coast (Checkly and Barth 2009).

At each site, I surveyed both low and high zone tidepools along the intertidal. I measured the size of the tidepools by assuming a circle shape, then measuring diameter and depth in centimeters to later calculate the volume of the tidepool. The count of *Prionitis spp.* was taken by counting the number of holdfasts, and I randomly measured five of the *Prionitis spp.* The longest frond of the five *Prionitis spp.* was measured in millimeters, where those five lengths were then averaged. I counted the number of chitons, limpets, sea urchins and snails present in the tidepools as well. Lastly, the blades and holdfasts were checked for any sign of feeding by herbivores.

I ran two-sided t-tests for my statistical analysis of the data. A two-sided t-test testing for significant differences was ran for *Prionitis spp.* size, *Prionitis spp.* density, and herbivore density between the high and low zone tidepools. I also analyzed the relationship between herbivore density and *Prionitis* density, along with *Prionitis* size and herbivore density using a scatter plot. A simple linear regression was ran to test how much of the variation in herbivore density was described by *Prionitis spp.* density, also the variation in *Prionitis spp.* length described by herbivore density. When testing the relationship between herbivore density and *Prionitis spp.* length the herbivore density was log transformed plus one, and *Prionitis spp.* length was just log transformed.

<u>Results:</u>

The average *Prionitis spp.* Density was lower in the low zone (3.81E-04 (holdfast per cm^3) ± 1.75E-04) than the high zone was (7.99E-04 (holdfast per cm^3) ± 2.48E-04); however these differences were not significant (figure 1). Average *Prionitis spp.* size was higher in the low zone (132.58mm ± 9.42) than in the high zone (127.31mm ± 9.88). The differences in high and low zone *Prionitis spp.* size were not significant (figure 2). Figure 3 shows a higher density of herbivores are found in high zone tidepools compared to low zone tidepools (p-value=0.003, two-sided t-test, n=40). The average low zone herbivore density was 6.34E-06 (herbivores per cm^3) ± 2.84E-06, while it was 4.47E-04 (herbivores per cm^3) ± 1.30E-04 in the high zone.

Figure 1

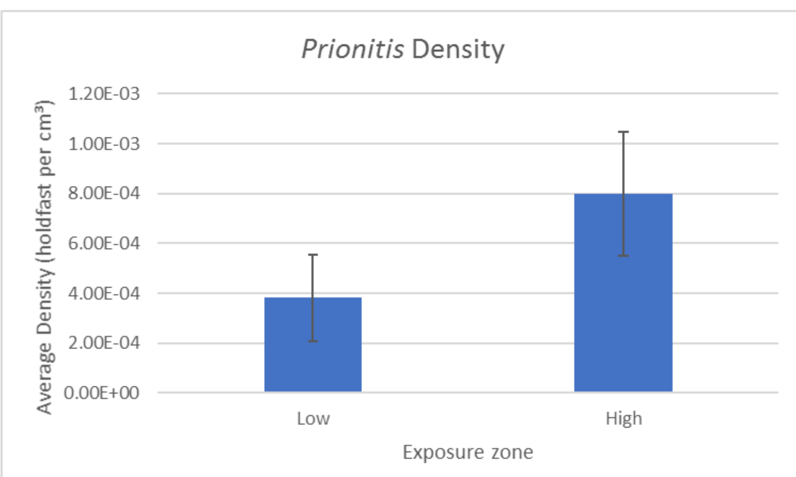

Figure 1: Average *Prionitis spp.* density in the low and high zone tidepools. No significant difference along the vertical gradient (p-value= 0.18, two-sided t-test, n=40).

Figure 2

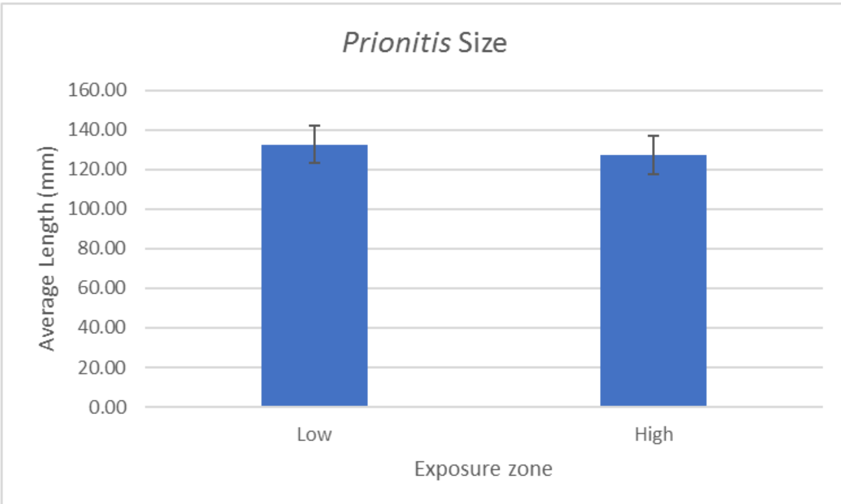

Figure 2: Average *Prionitis spp.* size in the low and high zone tidepools. No significant difference along the vertical gradient (p-value=0.70, two-sided t-test, n=40).

Figure 3

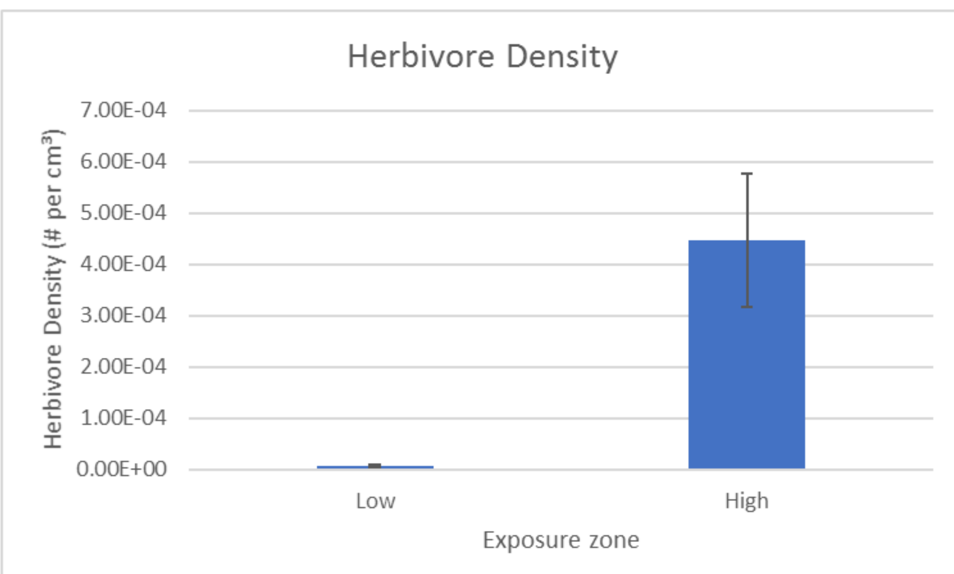

Figure 3: Average herbivore density in the high and low zone tidepools. A significant difference between the two zones was present (p-value=0.003, two-sided t-test, n=40).

The intertidal zone along a vertical gradient was found to be affecting herbivore densities as a function of *Prionitis spp.* density (figure 4). In the low zone, herbivore density did not change with changing *Prionitis spp.* density. On the other hand, the herbivore density in the high zone tidepools increased as *Prionitis spp.* density increased. One percent of the low zones herbivore density was described by *Prionitis spp.* density and thirteen percent in the high zone. *Prionitis spp.* size and herbivore density showed a weak positive relationship (figure 5). Three percent of the variation in *Prionitis spp.* size was described by the density of herbivores in the tidepools. The high zone had considerably more limpets and snails present than the low zone (figure 6).

Figure 4

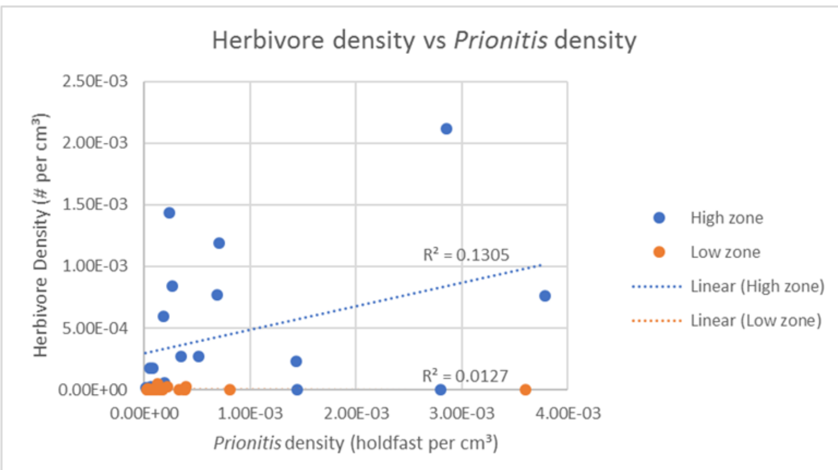

Figure 4: Herbivore density as a function of *Prionitis spp.* density for the low and high zone tidepools. In the high zone, herbivore density increases as *Prionitis spp.* density increases. The low zone density of herbivore did not change with *Prion its spp.* density. The R^2 values describe how much of the variation in the data is described by *Prionitis spp.* density. Only one percent of the variation in herbivore density is described by *Prionitis spp.* density in low zone and thirteen percent in the high zone.

Figure 5

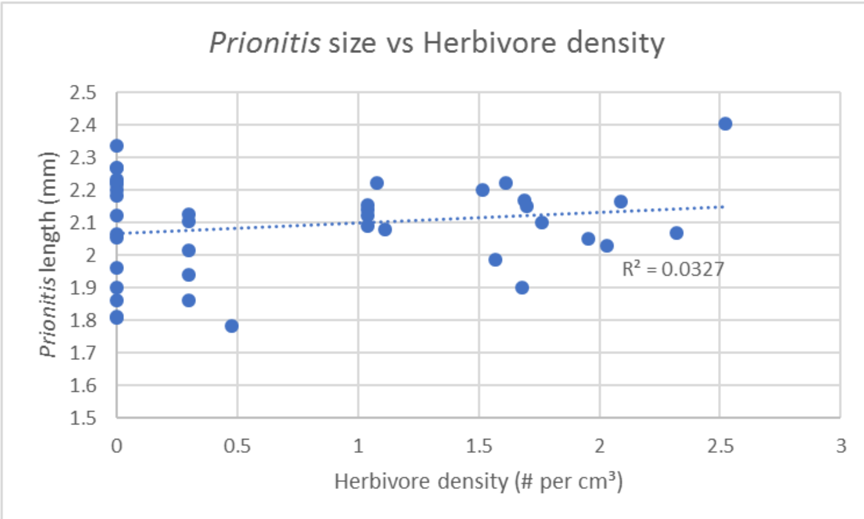

Figure 5: The variables has been log transformed, where herbivore density was log +1 transformed. *Prionitis spp.* size, measured by length, as a function of herbivore abundance. A weak positive relationship is shown by the trendline between *Prionitis spp.* and herbivore abundance. Three percent of the variation in *Prionitis spp.* length is described by the density of herbivores in the tidepools.

Figure 6

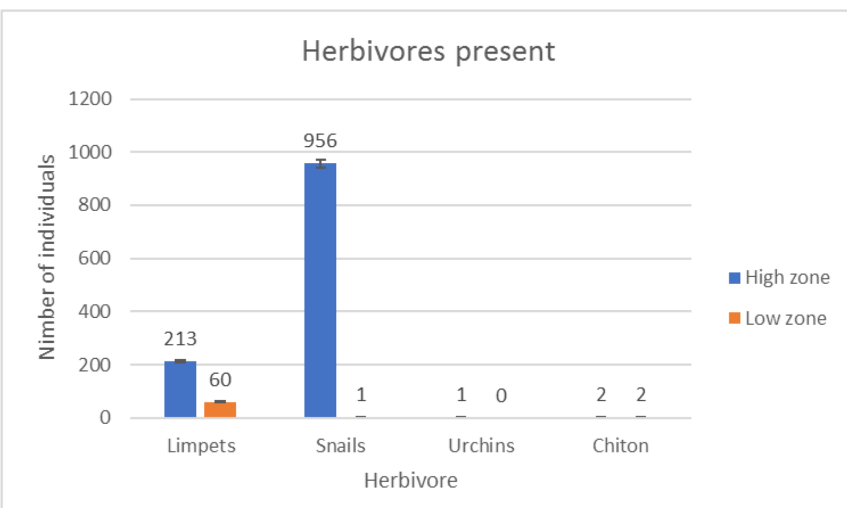

Figure 6: Limpet, snail, urchin, and chiton abundance in the high and low zone tidepools. Limpets and snails were noticeably more present in the high zone tidepools than the low zone tidepools.

Discussion:

The lack of a difference in *Prionitis spp.* size and density between the high and low zone tidepools does not fit with prior finding of previous intertidal studies. At the same time though, the significant difference in herbivore abundance does support prior findings. A top down predation model where herbivores have a strong effect on algae that declines more towards exposed sites (Nielson 2001) is not fully supported by the data. Herbivore densities are significantly higher in the high zone, but does not seem to effect *Prionitis spp.* differently than in the low zone.

Low zone tidepools experience a more dynamic environment than high zone tidepools, where waves constantly beat down on them. Constant water flow through the low zone tidepools decreases an herbivores ability to stay in the tidepool. The exposed intertidal has less herbivores present than the protected intertidal (Tamelen 1996). The increased cycling of water through low zone tidepools also introduces more predators of the herbivores, which could negatively affect herbivore densities.

The effect of herbivores on algal communities has been found to be dependent on herbivore densities (Aquilino et al. 2012), yet this does not seem so in Oregon's rocky intertidal tidepools. Impactful herbivores such as limpets and snails are commonly found in tidepools along with *Prionitis spp.* Limpets are key herbivores in determine macroalgae abundances in the intertidal (Coleman et al. 2006). Specifically, in Strawberry Hill macroalgae densities were inversely related to *Tegula* snail densities (Bracken and Nielson 2004). Based on the role of the herbivores, they should have an increasing impact as their densities increase. Considerable impacts were not associated with an herbivore density increase between zones. Herbivore density described little of the variation in *Prionitis spp.* size, as did *Prionitis spp.* density for herbivore density. Herbivores might be reluctant to eat the Prionitis spp. in the tidepools. Brominated compounds given off by red algae act as a defense against herbivores (Paul and Bohnert 2010). When compared to algae without a chemical defense, Prionitis spp. showed better defense towards herbivore grazing (Paul and Bohnert 2010). *Prionitis spp.* and herbivores interact weakly with each other in rocky intertidal tidepools.

This was an observational study and by that token is subject to human error in measurements. Measurements of *Prionitis spp.* size taken by length of longest frond may not reflect the most accurate size of the whole algae, but is a good estimate. Also, not all tidepool closely resemble a circle in shape and may not have an accurate volume recorded because of this. The results support hypothesis two but not hypothesis one. The top down predation model does not seem to be an accurate model to describe the interaction between herbivores and *Prionitis spp.* in tidepools.

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