CHARACTERIZATION OF ENVIRONMENTAL PARAMETERS AND SPECIES RICHNESS IN TIDEPOOLS Jason Silva Moreira Biology Department, Clark University, 950 Main Street, Worcester, Ma 01610 Jmoreira@clarku.edu

Abstract The rocky intertidal is full of tide pools at different elevations. These elevations are the high, middle, and low intertidal zone. The higher elevated tide pools would have more exposure time than pools in the middle and lower intertidal. This allows more time for the physical environmental factors to affect the water chemistry. The lower the elevation of the tide pools, the less exposure occurs minimizing the affect of the physical environmental factors on water chemistry. The high intertidal zone would have less species richness because of the increased variation in water chemistry. We investigated whether variation in water chemistry correlated with species richness by measuring salinity, pH, temperature, and species richness at three different zones in the rocky intertidal.

Key Words: Salinity, elevation, species richness

Introduction

The rocky intertidal has an array of species found in the different zones. The intertidal is typically broken up into three parts: high, middle and low. The zones can be differentiated by either measuring the physical height from mean low water level or by identifying the key species (typically algae) of each zone (Doty 1946). During low tide organisms in the higher intertidal are emerged in air for a longer duration than organisms lower in the intertidal. Therefore in high intertidal zones it would be expected to find a community of hardy organisms that could tolerate the fluctuations of these physical factors.

A couple physical environmental factors that may affect intertidal communities are outside temperature, rock temperature, wind speed, sunlight intensity (shaded or nonshaded), and rainfall. Each of these factors can increase or decrease the salinity, pH, and temperature of the tide pools. Salinity is a factor highly susceptible to variation due to sun exposure, rain or cloudy weather. The sun intensity causes evaporation, which would lead to a higher concentration of salt in the water increasing the salinity. Also during rainstorms the salinity would be lowered because of the rain water diluting the tide pool water.

The focus of this study is to determine observationally whether tide pool exposure to the physical environmental factors would affect the salinity, pH, and temperature of the water and therefore the species richness in the tide pool.

Materials and Methods

Study Site: The study took place at the rocky shores surrounding the Northeastern University Marine Science Center, Nahant MA. Water analysis was conducted on twenty-seven randomly selected tide pools and five open ocean samples. Nine tide pools were identified in three zones of the intertidal (high, middle, and low). The zones were identified by using key species. This means we used species only found in the certain zone to identify it. Data were collected during three low tides (September 15th, October 26th, and November 18th, 2012).

Temperature, pH, salinity, and species richness were measured in each of the tidal pools. A submerged underwater thermometer was used for temperature. The pH was measured using pH strips that were placed in the tidal pool and left there for 5 minutes or until color changes had stopped. The color on the strip was compared to the color/pH chart that ranged from 6>0 - 10.0 on the pH strip container. To determine the salinity a refractometer was used to read it. A drop of water from the tide pool was placed on the lens and the salinity was read. Species richness was measured by video recording each tide pool and later counting the different species observed. The entire pools were sampled and the video length varied depending on size of tide pool.

The different variables were tested for relationships between them using the correlation test. The p values of the correlation were used to test for significant relationships among variables.

Results and Discussion

Temperature

The temperature in the tide pools ranged between 6-20 °C. The temperature decreased significantly between September and November. The temperature at high tide varied most from the open water temperature (Figure 1).

Temperature was affected by the solar radiation, air temperature and rock temperature. Based on figure 1 in earlier trips (September and October) solar radiation had the greatest effect on the water temperature. The higher average temperature of the water showed this. The higher temperature was discovered in the longer exposed zones (high and middle zones). The later trip (November) the rock temperature and air temperature had a greatest effect observed by the low temperatures in the longer exposed tide pools (figure 1). The air temperature and rock temperature was cooled as the months passed. Therefore the air temperature and colder rocks cooled the water in the longer exposed zones. If the study were to continue the rock temperature will note as well. In the correlation tests it was found that temperature had a significant correlation with pH (pvalue of 0.021) and species richness (p-value of 0.032)(Table 1).



Figure 1. **Temperature Variation in Tide Pools Located throughout the Intertidal.** *The average temperature of the four zones for the three different trips in 2012. The temperature dropped every month. The general temperature pattern was that the greatest differences are at high zones and it gradually moves towards the ocean temperature the lower it moves in the intertidal. The error bars show the standard error for each of the averages. Each point signifies the average species found for each of the zones during each trip in 2012*

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The pH was lower in the low intertidal and increased in the tide pools higher in the intertidal on the September and November trips (Figure 2). The October trip showed a slight drop of pH in the lower intertidal zone and then a increase in the ocean pH. After using testing for correlation and correlation significance using excel it was found that pH had significant correlation with temperature. This indicates sun exposure could have an affect on pH. Klugh (1924) showed states that the pH was not affected by elevation of the tide pool but by the proportion of vegetation to animals in the tide pools. Future research could be done on the organism's metabolic rate and its affect on water pH. Metabolic rate is slowed in colder temperature (Johnston et al. 2001) and the pH was lower during the colder water temperature trip.



Figure 2. **pH variation in the intertidal**. *Tide pools in three intertidal zones were identified and tested for pH on three different dates in 2012. Each point signifies the average pH of one of the four zones for the three different trips. The pH was higher in the high intertidal zones and decreased in the lower zones. The different symbols represent the different trips. The error bars show the standard error for each of the averages.*

Species Richness

Generally there as low species richness in the high intertidal, high in the middle, and again low species richness in the low intertidal. Species richness also was found to have a significant positive correlation with temperature (Table1). This means the higher the temperature the higher the species richness. Salinity and pH were also tested for correlation with species richness. Salinity and species richness were both slightly negatively correlated, but these results were not significant. This indicates that the hypothesis was correct in that temperature affects species richness. In this study it was found that species richness was not significantly correlated with pH and salinity. Further analysis with a larger sample sizes is needed to ascertain what, if any, relationship exists between pH, salinity, and species richness.

The same species were typically found throughout each of the zones. This demonstrates that there are limitations to the species in the intertidal zone. In the rocky intertidal organisms are limited by physical factors in the upper intertidal zone and biological factors limits organisms in the lower intertidal (Foster 1971, Underwood et al.1983).



Figure 3. **Species Richness across the Rocky Intertidal Zone.** Tide pools in the three intertidal zones were identified and recorded to count the different species. Each point signifies the average species found for each of the zones during each trip in 2012. The error bars show the standard error for each of the averages. Species richness was at its peak during middle tide. In high and low tide it drops with high having the lowest numbers.

Salinity

The salinity of tide pools in the middle and low intertidal was similar to that measured in the ocean water. However, the salinity in the high intertidal tide pools varied from 30.0 to 37.2 ppt. For example, in September, one tide pool had salinity reading of 25. The other tide pool in that zone that day was 34.5, more consistent with other days sampled. The 25 ppt reading of salinity alters the average, which explains the low point on the graph. The low salinity levels have resulted from rainwater entering the pool earlier in the day.

The elevated salinity in the October and November trips showed that evaporation had occurred in the tide pools longer exposed to the solar radiation. The correlation test found that the data didn't significantly demonstrate that salinity can effected species richness. A better correlation might be found if the data were collected within a period of a month, especially during a month of high solar radiation intensity (summer). The study took place during a seasonal change from summer to winter therefore the cooling temperature could have affected salinity(Doty 1946). The correlation table shows a negative correlation between temperature and salinity. The correlation was found to almost significant with a p value of 0.082.



Figure 4. Salinity levels in selected tide pools and the ocean during fall 2012. Tide pools in three intertidal zones were identified and analyzed for salinity on three different dates in 2012. Salinity was measured using the refractometer. High tide had a higher salinity and it dropped to around ocean salinity for mid and low zones. The error bars show the standard error for each of the averages. Species richness was at its peak during middle tide.

Summary

Table 1. **Correlation Table**. The correlation between the different variables and the significance of those correlations. The bolded Temperature/pH and Temperature/Species richness were found to be significant with values of 0.021 and 0.032. The variables were averaged for all three trips.

	Correlation	Standard Error	p value
Species Richness/pH	-0.21	-1.08	0.29
Temperature/pH	0.41	2.44	0.02
Salinity/pH	-0.20	-1.10	0.28
Temperature/Species Richness	0.42	2.27	0.03
Temperature/Salinity	-0.32	-1.80	0.08
Salinity/Species richness	-0.16	-0.78	0.44

Zonal species richness distribution may be correlated with daily, monthly, or annual variation. Keeping this in mind it is possible that the main factors effecting zonation may

shift throughout the seasons. This can be seen through the changes between the different trips (Figure 1-4). The species richness for middle and low tide for the two later trips (October and November) decreased substantially (figure3). It was also noted that the species found during those visits were primarily vegetation and snails. From the analysis conducted temperature is a limiting factor of species richness in the middle intertidal. The analysis of the factors involved correlations between species richness, pH, salinity and temperature. The results showed that the factors correlated with each other therefore in order to get more definite answers to the hypothesis the experiment would have to be brought into the lab where the other variables can be controlled and monitored. Temperature and pH and Temperature and species richness had a significant correlation.

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