ASSOCIATIONS AMONG SPECIES RICHNESS AND PHYSICAL VARIABLES IN NAHANT, MA TIDE POOLS

Kristen Cullity

Department of Biology, Clark University, Worcester, MA 01610 USA

(kcullity@clarku.edu)

Abstract Tide pools along the high, middle, and low intertidal zones of Nahant, MA were investigated for associations among pH, temperature, salinity, area, and species richness. The primary purpose of this study is to assess whether a correlation exists between various physical factors and species richness within tide pools. Later analyses will investigate whether there are significant differences among the three different zonation levels of the rocky intertidal shore, whether the physical factors significantly affect each other, and if notable short-term variations reflecting the date of the measurement exist. Measurements were taken on three different dates: September 15th, October 26th, and November 18th, 2012. Correlation coefficients were found between variables, which were then used to calculate p-values. When the data was segregated by date, varying significant relationships were found on each date. When the data from the three dates was analyzed together, significant relationships were found between temperature and species richness and temperature and pH. A two-way ANOVA test determined that there were significant relationships between date and temperature, date and pH, date and species richness, elevation and species richness, and elevation and pH.

Key Words: species richness, tide pools, zonation

Introduction

Tide pools found on rocky intertidal shores present a vast amount of research regarding variations in physical and chemical properties and their consequential effects on biota due to the peculiar temperamental habitats they create for intertidal organisms. When intertidal organisms, such as *Littorina littorea* (common periwinkle) and *Mytilus edulis* (blue mussel), settle into a specific tide pool, they are essentially determining their own ultimate survival rates. Choosing a tide pool in the low intertidal zone may present more competition and stronger wave forces, yet choosing a tide pool in the high intertidal zone may present resource scarcity, stronger sunlight exposure, and avian predation. Furthermore, the physical and chemical properties of tide pools need to be within a healthy range for organisms to even persist within them.

Past studies on these variables are largely outdated and, in most cases, brief. Klugh (1924) measured temperature and salinity in six tide pools throughout a single day but did not find significant correlations among any of the parameters. Huggett and Griffiths (1986) similarly looked at diurnal fluctuations in temperature and salinity, among other factors, in tide pools. They found temperature and salinity to be significant factors in determining high intertidal and middle intertidal species composition. Morris and Taylor (1983) measured diurnal variations for a year and found both significant diurnal and seasonal variations in temperature, pH, and salinity. Additionally, they found local variation among the tide pools.

The purpose of this study was to assess whether there is a relationship between pH levels, salinity, or temperature and species richness within tide pool, and whether these relationships significantly vary among the three intertidal zones. The results of this observational study should build upon previous results and ultimately present a modern, more in-depth collection of factors contributing to tide pool function and composition.

Materials and Methods

The study site consisted of tide pools designated by zonation level (high, middle, low) along the rocky intertidal shore surrounding the Northeastern University Marine Science Center in Nahant, MA (42.42730°N, -70.92244°W). Zonation levels were determined by species composition; the low zonation level was determined by the presence of *Ascophyllum nodosum* (knotted wrack) and the middle zonation level was determined by the presence of *Semibalanus balanoides* (barnacle). Research was performed on three different occasions. On September 15th, 2012, three tide pools for each of the three zones were analyzed, as well as one open ocean sample. On October 26th, 2012, four tide pools in each of the three zones were analyzed, as well as two open ocean samples. On November 18th, 2012, two tide pools for each of the three zones were analyzed, as well as two open ocean samples. Among the three visits, twenty-six tide pool samples and five open ocean samples were successfully measured.

The pH levels, salinity, temperature, and species richness were measured in each tide pool. Tide pool area was measured October 26th, 2012. pH was measured using pH strips (pHydrion). Salinity was measured using a salinity refractometer (Lumen Optical Instrument Co). Water temperature was measured with a standard thermometer. Species richness was determined as the number of species in each tide pool; while tide pools were being sampled, species types were recorded. To determine approximate area size, the tide pools were either video-recorded or photographed containing a meter stick, similar to Daniel and Boyden (1975), and analyzed via ImageJ software. These videos were also used to confirm the species richness data obtained in the field.

Correlation analyses were used to examine interactions among variables. A two-way ANOVA test was implemented to assess interactions between the variables in regards to measurement date and elevation. The p-value significance level was 0.05.

Results and Discussion

The primary variables analyzed in this study were pH (*Figure 1*), temperature (*Figure 2*), salinity (*Figure 3*), and species richness (*Figure 4*).

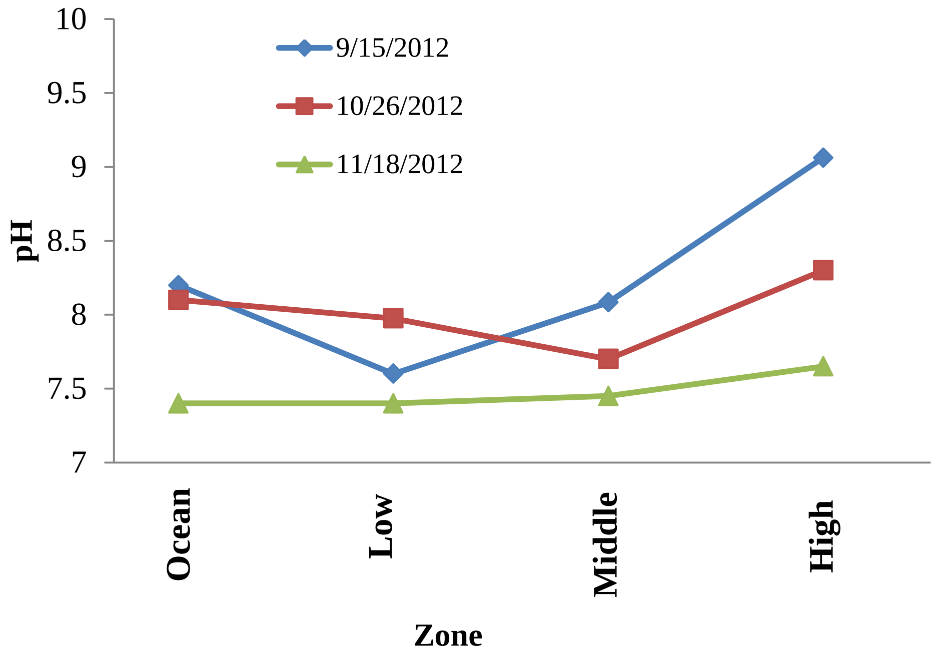

Figure 1*; Average pH values for the ocean and high, middle, and low intertidal zones for the three research dates.*

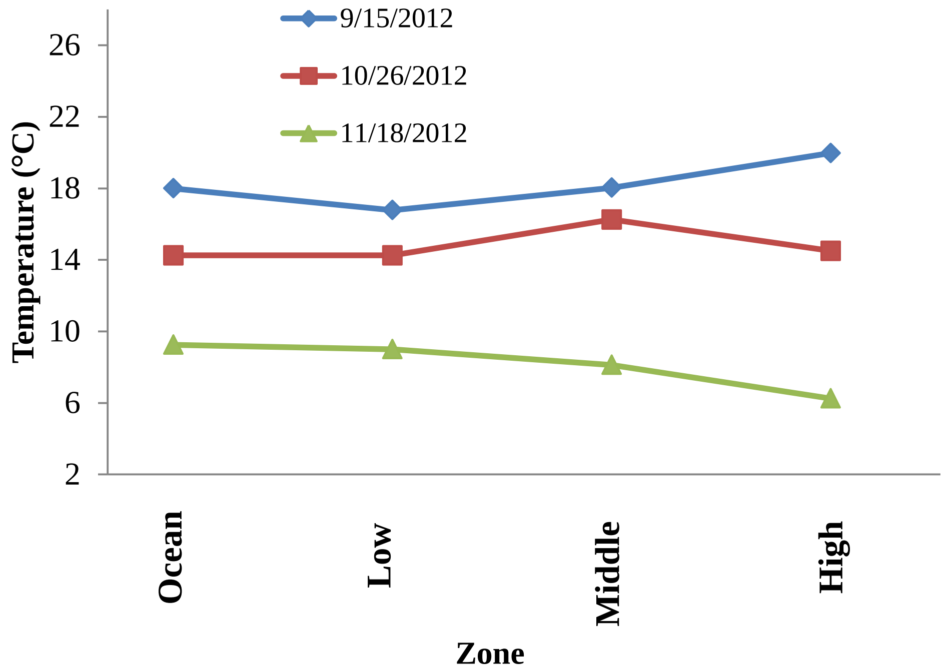

Figure 2*; Average temperatures (°C) for the ocean and high, middle, and low intertidal zones for the three research dates.*

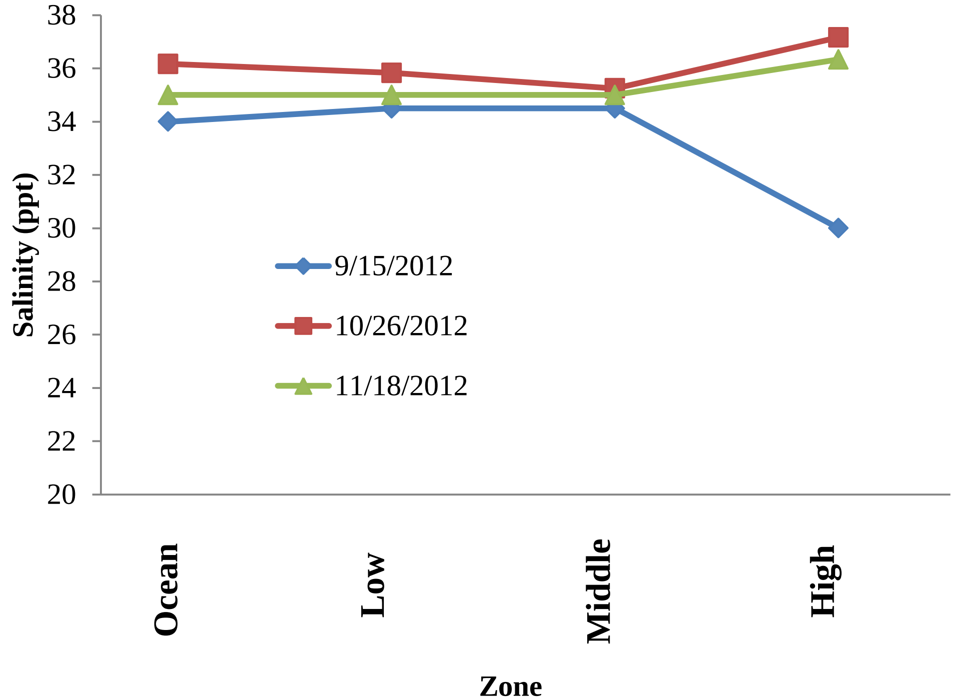

***Figure 3**; Average salinity (ppt) for the ocean and high, middle, and low intertidal zones for the three research dates.*

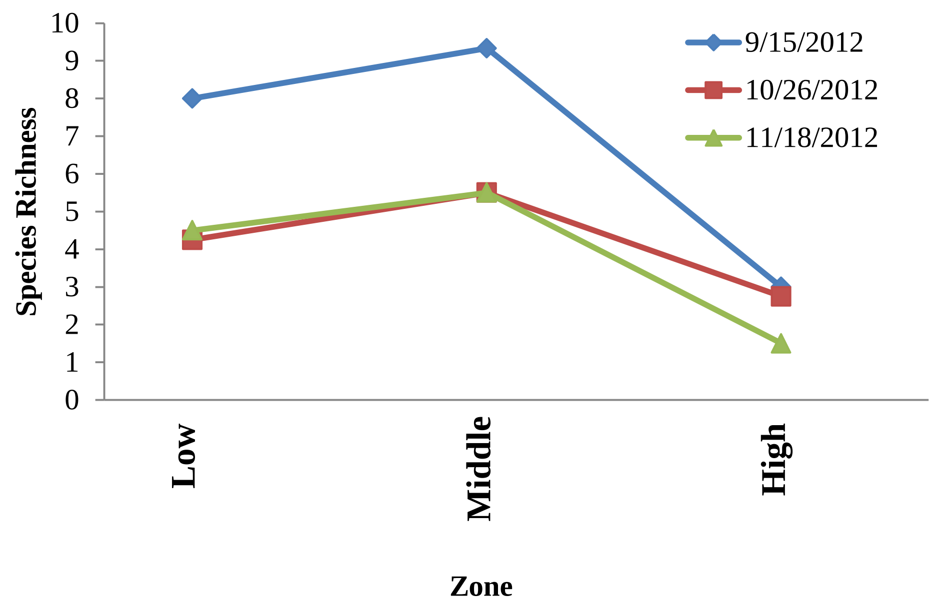

Figure 4*; Species richness for the ocean and high, middle, and low intertidal zones for the three research dates.*

Area was looked at only on October 26th, but was found to have nonsignificant impacts on all other variables. It is important to note one of the high intertidal pools from the September measurement date was ultimately determined to be an inaccurate measurement due to its skewed results, and was therefore excluded from the analyses. The pool was believed to be predominantly composed of rainwater from precipitation earlier that day and so, produced outlier results.

Temperature decreased when moving from the ocean to the high intertidal for the latter two measurement dates (October 26th and November 18th) but increased for the earliest measurement date (September 15th). This could be because both ocean and land temperatures were warmest on the earliest measurement date. On the latter two dates, temperature of both the water and land was cooler. The pH values became more basic when moving from the ocean to the high intertidal. Salinity measurements increase from the ocean to the high intertidal on the two latter dates (October 26th and November 18th) but decrease for the earliest date (September 15th). Increases in salinity are expected in higher tide pools due to evaporation throughout the day. The cause for decreased salinity in the high intertidal on September 15th is most likely due to precipitation that occurred the morning of sampling.

Significant associations between pH, temperature, salinity, area, and species richness varied among the three data-collection dates. On September 15th, there were significant relationships between pH and species richness ($p = 0.048$), pH and salinity ($p = 0.018$), and salinity and species richness ($p = 0.033$). On October 26th, there were significant relationships between pH and salinity ($p = 0.014$) and temperature and species richness (p = 0.004). On November 18th, there were significant relationships between pH and species richness 0.026), pH and temperature (p = 0.006), and temperature and salinity (p = 0.003). However, when the data from the three dates was combined for an overall analysis, only pH and temperature (p = 0.017) and temperature and species richness (p = 0.027) had significant relationships (*Table 1*).

Table 1*; P-values for correlations among five variables: pH, species richness, temperature, salinity, and area. Significant p-values (p-value < 0.05) are shown in red. Tide pool area was only measured on 10/26/2012.*

	P-Value			
Possible Correlations	**9/15/2012**	**10/26/2012**	**11/18/2012**	**All data**
pH and Species Richness	0.048	0.377	0.026	0.274
pH and Temperature	0.201	0.591	0.006	0.017
pH and Salinity	0.018	0.014	0.111	0.263
Temperature and Species Richness	0.081	0.004	0.078	0.027
Temperature and Salinity	0.591	0.178	0.003	0.073
Salinity and Species Richness	0.033	0.104	0.119	0.427
Area and Species Richness		0.364		
Area and pH		0.901		
Area and Temperature		0.933		
Area and Salinity		0.936		

Date of measurement and zonation level both had significant effects on pH, temperature, and species richness. When analyzed against the date of measurement, significant relationships were found with pH (p = 0.023), temperature (p < 0.0001), and species richness (p = 0.0003). When analyzed against elevation, significant relationships were found with pH (p = 0.040) and species richness (p < 0.0001) (*Table 2*).

Table 2*; Two-way ANOVA p-value results determining statistically significant relationships with the date of measurement and elevation (zonation level). P-values shown in red are significant (p-value < 0.05).*

	ANOVA P-Value	
Variable	**Date**	**Elevation**
pH	0.023	0.040
Temperature	< 0.0001	0.693
Salinity	0.052	0.546
Species Diversity	0.0003	<0.0001

The significant differences shown among the three measurement dates suggest that there is seasonal variation in the physical and biological properties of tide pools. The impacts of zonation level on pH and species richness confirm that elevation and distance from the ocean also affect tide pools (regardless of date). Among the physical variables (pH, temperature, salinity), only pH and temperature displayed an overall significant relationship to each other.

Future work could investigate more variables that might affect species richness in tide pools along the rocky intertidal shore. Variables of interest could include light intensity/exposure, wave exposure, water depth, oxygen content, and alkalinity. The data regarding area in this study is not extensive enough to show a significant relationship between tide pool composition and area, so future work could investigate tide pool area further.

Acknowledgements

I would like to say thank you to Deb Robertson and Todd Livdahl for giving me the opportunity to pursue an independent project in Nahant, MA. I would also like to say thank you to the other students in the class for their support and help with my project and paper revision.

Literature Cited

Daniel, M.J. and C. R. Boyden. 1975. Diurnal variations in physico-chemical conditions with intertidal rock pools. Field Studies 4, 161-176.

Huggett, J. and C. L. Griffiths. 1986. Some relationships between elevation, physico-chemical variables and biota of intertidal rock pools. Marine Ecology Progress Series 29, 189-197.

Klugh, A. Brooker. 1924. Factors controlling the biota of tide-pools. Ecological Society of America, 192-196.

Morris, S. and A. C. Taylor. 1983. Diurnal and seasonal variation in physico-chemical conditions within intertidal rock pools. Estuarine, Coastal, and Shelf Science 17, 339-355.