Abiotic effects on an Invasive Clam in the Pacific Northwest

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Introduction

Varnish clams traveled in ship ballast water and were released unintentionally into Vancouver waters and today can often be found in high densities throughout the Pacific Northwest1. This species has been reported in the Pacific Northwest since the early 1990s, but were not noted in Howe Sound until 20101,2. Varnish clams are successful invaders in this region for several likely reasons. They tend to be found deeper than similar native species allowing them to escape predation3. Although clams that bury deep in shoreline sediment usually grow slower than surface species, varnish clams mature at the same rate as the native species closer to the surface3. Varnish clams also have an unusually high tolerance to a wide range of temperatures and salinities, with their highest fecundity levels at 20°C and 20psu4,5. Due to a longer planktonic phase this invader is able to disperse more effectively, and with their relative short maturation period and long (six-year) lifespan, they can quickly populate new areas and reach high densities1,3. Preliminary observations suggest they are very abundant in Porteau Cove Provincial Park (PCPP) on the east side of Howe Sound4,6. Curiously, they are found in large numbers on the sand and gravel beach on the north side of a infrequently used ferry pier at the PCPP, but are essentially absent from the pebble and rock beach on the south side of the park2.

Little research has been conducted on varnish clams in the Pacific Northwest to date: a 2001 DFO report explored the viability of a varnish clam fishery;7 Dr. James Byers investigated the impacts of sediment types and predation8; and Dr. Sarah Dudas and colleagues have investigated the species’ geographic locations, life history traits, and preliminary susceptibility to predation 1,3,5. Only Byers’ study focuses on impacts of the abiotic environment on varnish clam population dynamics. However, only two tidal elevations and sediment types (sand and mud + cobble) were considered, and the proximity to freshwater, a factor deemed significant by Dudas et al., was not studied5,8. The primary goal of this study was to determine the relationship between abiotic factors and the varnish clam density and size in PCPP. This research aimed to meet these goals by studying population density and individual size as a function of four abiotic variables: sediment type, burial depth, intertidal elevation, and proximity to freshwater in order to test the null hypothesis that abiotic factors do not have a significant effect on varnish clam distribution.

Methods

This empirical field study was conducted during low tide periods (<2m Lowest Low Water Large Tide (LLWLT)) from October 2019 through December 2019 at Porteau Cove Provincial Park (PCPP). The survey methods were designed based on the course Biodiversity of British Columbia, methods piloted in Catherine Gerstle’s Keystone6, and a preliminary survey I conducted on July 13, 2019. Experiment methods follow those used by Byers 20028.

On the north beach 20 cm diameter holes were dug 20 cm deep every 10 m, 2 m, 5m, and 10 m from the streams edge, a set were dug in the center of the stream. Each of these transects began as far up the beach as possible. Each hole was dug in four 5 cm increments. The number of live clams and valves were counted in every increment. Live clams were measured and returned to the hole when digging was completed. For each hole tidal elevations and core sample was.

Data Analysis:

The data consists of seven explanatory variables and two response variables. The explanatory variables consist of clam burial depth (counted in each 4 5 cm intervals), distance from freshwater, tidal elevation, side stream, distance downstream, and sediment type. The response variables are number of clams live or dead at each burial depth in each hole and clam size (measured in mm).

Because the response variables consist of both categorical and continuous data and there may be a relationship between the response variables, two separate ANCOVA tests are used to for clam size and clam density. In order to ensure that there are no significantly compounding variables that may skew the results the explanatory variables are analyzed for relationships. In plotting the sediment data it became clear that it would be there was not a singular raw sediment variable that would work to represent the entirety of the sediment characteristics To reduce the sediment data to one variable from seven proportional categories it was normalized using a ln-ratio transformation, to rescale the proportion of each sediment type in each sample to the geometric metric mean9. This normalized data was then used to perform a PCA and the first principal component was used then to represent the sediment data in the remainder of the data analysis.

With a working data frame, I tested for normality and homogeneity of the variances for the categorical and continuous variables. For the continuous variables by looking at whether or not the residuals are normally distributed, which is an assumption for linear regression. In testing the assumptions of normal distribution for stream side I decided to remove it, thus removing the only categorical variable. With the final data set to be analyzed, a linear model was used to test the correlation between both response variables and each of the response variables.

Results:

Varnish Clams were found solely on the beach north of the pier while conducting visual surveys as well as while digging sample holes. On the north beach clams were typically found further away from the stream and at lower tidal elevations (Figure 1.) The most clams were found about 2.5 LLWLT and 10 meters away from the stream. However, these findings were not significant enough to provide any strong correlations. Additionally, clams seem to have been more prevalent in the second bin depth, from 5 to 10 cm. The highest concentrations of clams were found between 5 and 10 cm deep (n=53) and the least were found in the top 5 cm of the sediment (n=25). The live clams had the largest correlation coefficient (0.146) with the sediment Principle Component 1, but this correlation had weak significance (r = 0.183). The correlations for live clams in each bin and tidal elevation and depth bin were both subtle and had very low significances (tidal elevation r=0.031, depth bin r= 0.055). The hole with the largest the most clams (n=26) was at a tidal elevation of 2.65 and was 10 meters from the stream. The bin with the most clams (n=13) was also 10 meters from the stream, had a tidal elevation of 2.30. The bin that had the most clams differed the mist from the hole with most clams in the PC1 values (-0.936 and 3.652 respectively. There were 475 depth bins where no clams were found, and no clams were found higher than 3.5 LLWLT.



**Figure 1. Number of Live Clam ~ Explanatory Variable Correlations.** This figure shows the different correlations between the number of live clams per depth bin for each explanatory variable; Distance from Stream (far left), Tidal Elevation (middle left), Depth Bin (middle right), and Sediment Principle Component 1

The largest correlation found in this study was between clam size and bin depth (r= 0.152) (Figure 2). There was also a very noticeable correlation between clam size and distance from stream (r= 0.125). Although there were visually detectable correlations between clam size and tidal elevation (r= 0.068) and sediment type (r= 0.056) the slopes of both regression lines were noticeably closer to 0. The largest clam (64.79 mm) was found in the bin from 15-20 cm deep and was 5 meters away from the stream. The highest concentrations of clams were found between 5 and 10 cm deep (n=53) and the least were found in the top 5 cm of the sediment (n=25). Clam size was more concentrated towards the upper limit of their tidal range (~3.5 LLWLT) and more dispersed around the lower limits (1.5 LLWLT).



**Figure 2. Clam Size (mm) ~ Explanatory Variable Correlations.** This figure shows the different correlations between the length of live clams (in mm) per hole for each explanatory variable; Distance from Stream (far left), Tidal Elevation (middle left), Depth Bin (middle right), and Sediment Principle Component 1

Because no significant correlations were found between either of the response variables and any of the explanatory variables, no further analytical testing was conducted.

Discussion:

Because there were no significant correlations for density or clam size, I did not conduct any multiple regression models. These findings differ from what Byers (2002) found during his study conducted in the San Juan Islands, particularly in tidal elevation preference. However, there is a definitive upper limit to their tidal range which seems to be just under 3.5 LLWLT. Varnish clams did seem to prefer the lower end of their distribution. The lower tidal elevations also had the most variance in size distribution. This could be due to predation and/or cold temperatures (when placed on the ground clams seemed to only naturally bury when covered in water or in during warmer data collection times, this would be something for further testing).

The slight positive correlation with distance from freshwater also suggests that Dudas’s alternative hypothesis that varnish clams may have an affinity for freshwater has an effect on varnish clam distribution to be false. Although the variance was too great for a significant r value, my results suggest that higher densities of clams are found further away from the stream.

The highest concentrations of clams were found between 5 and 15 cm most likely due to predation and food availability. Clams on the surface are more likely to be prey for different species including crabs and birds8. Due to their feeding habits being closer to the surface increases nutrient availability3. I did tend to find clams lower in the sediment than both Dudas and Byer’s, who both conducted their studies during warmer months, which could be due to the often-sub-freezing temperatures during my data collection. This would be an area for future study.

Reflection:

This process was full of roadblocks and much more frustrating than expected. In particular, testing the assumptions of for ANCOVAs kept on presenting new challenged. Perhaps the hardest technical part was understanding how to conduct and extract the important information from the PCA used to characterize sediment data. Frustrating would be the overall descriptor for this project, partially because there were no significant conclusions that I found during my data analysis. For future studies I would suggest focusing more on an experimental design testing specific sediment types as that seems to be the likely difference between the north and south beaches at Porteau Cove Provincial Park. Conducting a similar study may also prove to be more telling if more clams were found, one way of achieving this would be to increase the hole size. Repeating this experiment in both the summer and winter could also shed light on possible seasonal sediment depth distributions.

Sources

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Report

In incorporating feedback, I focused on including everything that needed to be included with nothing else. For the introduction this primarily consisted of thinning out the details that were not directly related to the study itself. In the methods section I cut out some of the more detailed data collection methods and tried to add more of a narrative to the data analysis section. A key part of trying to create more of a narrative was making sure that I was not missing any key steps. I struggled to find how to naturally fit data visualization as a step in the narrative, maybe this is because I do not tend to give it much credence while reading papers. I tried the best I could to incorporate the relatively few comments in the time that I had.