Abiotic effects on an Invasive Clam in the Pacific Northwest

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Introduction

Fish stocks globally are at risk due to human impacts such as overfishing, climate change, pollution, declining biodiversity, and invasive species1. Invasive species that affect British Columbian fisheries have been introduced both intentionally and unintentionally in recent decades2. While many may pose threats to native species and ecosystems, some can become commercially fished species2. For example, during the 1930’s Manila clams (*Venerupis philippinarum*) were introduced, and shortly after the first observation in Barkley Sound, a fishery developed and is still active today, although little research has been conducted that studies their ecological impacts on native species3,4. In contrast, a 2001 Department of Fisheries and Oceans (DFO) survey found that the invasive varnish clam (*Nuttallia obscurata*) could not sustain a viable commercial fishery5. 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 Northwest6. This species has been reported in the Pacific Northwest since the early 1990s, but were not noted in Howe Sound until 20106,7. 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 predation8. 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 surface8. 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 20psu9,10. 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 densities6,8. Preliminary observations suggest they are very abundant in Porteau Cove Provincial Park (PCPP) on the east side of Howe Sound9,11. 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 park7.

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;5 Dr. James Byers investigated the impacts of sediment types and predation12; and Dr. Sarah Dudas and colleagues have investigated the species’ geographic locations, life history traits, and preliminary susceptibility to predation 6,8,10. 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 studied10,12. 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 Keystone11, and a preliminary survey I conducted on July 13, 2019. Experiment methods follow those used by Byers 200212.

Visual surveys were conducted along the center of the streams on both of the beaches on either side of the ferry pier. The center of the stream was walked down and the number of clam valves within 50 cm of the stream center.

Survey:

On the south 20 cm diameter holes were dug 20 cm deep were dug 2 meters from the streams edge every 10 m. Because no clams alive or fragments of any clam species were found, no further surveying was conducted south of the ferry pier.

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 were taken using a transit and stadia rod, following Gerstle’s method11. Additionally, a 20 cm long core sample was taken with a 6 cm steel pipe. Each sample was then characterized using the methods used in other studies of varnish clams8.

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. The sediment data is first reduced to one variable from seven proportional categories. To do this the data is normalized using a ln-ratio transformation, to rescale the proportion of each sediment type in each sample to the geometric metric mean13.**\*** The strengths of the correlations between the explanatory variables as well as the two response variables (presence/absence and density) are then investigated.

The data is 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 categorical variable, whether the size of clams and density are normally distributed between each distance from the stream, each burial depth, and each side of the stream is considered. (show the numerical test statistics will be calculated, and the results visualized.) Once this is completed, the ANCOVA tests were conducted. The abiotic variables have significant effects on clam distribution or size have been found (or not if the null is not rejected), those variables are analyzed further though linear regression and then Shapiro-Wilks tests.

Results:

The key results from each step will be shown here. This will include an PCA plot, ANCOVA output tables, regression plots of key variables, and a density box plot between the north and south beach

Reflection:

Normalizing the data and running the PCA has taken much more time than expected and has put me very behind schedule, as I am only just getting to running my initial regression tests to check for compounding variables. This is predominately because I have tried multiple approaches to condense the sediment to one variable each leaving me stranded at dead ends for a while. Once I settled on normalizing the data and then using the PCA it was then a matter of extracting the PCA1 value and putting that new data column in with the other data for my ANCOVA test. This is where I have made it so far.

The next steps are to run the regression tests

Run the ANCOVAs

And then run any appropriate follow up tests

Sources

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