Impacts of Climate Change on the Foundational Species *Eudistylia vancouveri*

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Introduction

Some of the most substantial consequences of climate change for coastal marine communities include rising sea temperatures and increases in the frequency and intensity of storms (Harley et al., 2006). Dramatic shifts in precipitation levels can be devastating for intertidal invertebrate species whose tolerances to decreased salinity are often ill-equipped for the rapid onset of climate change (Beadle, 1931). Foundational species have intrinsic value in structuring the biodiversity of the ecosystems in which they inhabit (Ellison, 2019). It is critical to understand how foundational species may be impacted in the face of anthropogenic climate change in order to get an idea of how other coastal organisms will be affected. As a result of their immense ecological value, they are critical to understand and monitor in the face of anthropogenic climate change.

*Eudistylia vancouveri*, more commonly known as the Northern Feather Duster Worm is a foundational species found in low intertidal regions from Alaska to central California (Hiebert et al., 2016). *E.vancouveri* forms distinctive non-calcareous tube networks known as “hummocks'' that provide habitat for algae and marine invertebrates (Hiebert et al., 2016). Its hardy parchment tube is made of cemented mucus and sediment obtained from filter feeding (Hiebert et al., 2016). Tube worm species of the family *Sabellidae* have advanced regenerative capacities allowing them to quickly regrow their tubes after disturbances (Vinn et al., 2018). This regenerative ability can provide a unique framework for understanding the fitness of a species under the intensifying conditions of climate change. Additionally, *E. vancouveri’*s role as a foundational species makes them of valued interest to monitor and study in the context of climate change.

Literature shows that the intricate tube networks made by *E.vancouveri* provide a hardy substrate for kelps in soft, sandy, silty, or muddy sedimentary habitats where settlement is difficult (Bracken, 2018). Knowing the significant role that kelp play in providing three-dimensional habitat, food, and substrate for fish and invertebrates, *E.vancouveri* can resultantly play an integral role in facilitation cascades that support greater biodiversity of an ecosystem (Teagle et al., 2017). Additional research by Thomsen & McGlathery (2005) found that the sedimentary tube forming organism *Diopatra cuprea* aids in the settlement of primary producing macroalgae in the mudflats of Virginia USA. Further, a study examining the colonization of the genus *Ulva* in high disturbance boulder fields found that tubeworms provided a near-absolute habitat requirement for algal settlement (Liversage, 2017).

In addition to its role as kelp substrate facilitators, *E.vancouveri* is an invertebrate species that have often been found colonizing intertidal areas that experience high levels of anthropogenic disturbances such as wharves and harbors (Hiebert et al., 2016). These disturbances may include boat traffic, fuel pollution, and habitat loss due to development. These disturbances may inhibit the biodiversity found in that area. Additionally, as filter feeders, *E. vancouveri* aids in detoxifying the water column from anthropogenic activities. (CITE). As a result, the presence of *E. vancouveri* as a foundational species is significant to the long-term stability of those otherwise vulnerable ecosystems.

Despite their important ecological role, little is known about how parchment tube worms like *E. vancouveri* are impacted by climate change. Additionally, in the literature on climate change, there is a large concentration of research on calcified organisms for marine invertebrate studies and less known about the implications of non-calcified species (Prather et al., 2012).

This study aims to understand how *E. vancouveri* tube growth rates will be impacted by climate change given their significant ecological role as a foundational species. Specifically, this research will measure how tube growth rates are impacted by increases in temperature, decreases in salinity and the combinatorial effect of both increased temperature and decreased salinity. We hypothesize that *E. vancouveri* tube growth rates will be impacted by temperature and salinity since these environmental conditions will affect the worm’s overall fitness. We predict that the isolated treatment of increasing temperature will decrease tube growth rates. Additionally, we predict that the isolated treatment of decreasing salinity will decrease tube growth rates. Finally, we predict that when treated in combination, increased temperature and decreased salinity will show the largest decline in tube growth rates.

Methods

Collection

*E. vancouveri* samples were collected from rope lines hanging off the (South) Bamfield Marine Science Center (BMSC) docks located in Bamfield, BC in October of 2021. To reduce stress, individuals or small groups were collected by cutting out segments of the rope line to which their tubes were attached rather than attempting to untangle the tubes from the lines. A total of 120 *E. vancouveri,* either as individuals or in small clusters, were collected. Samples of *E. vancouveri* were transported back to the lab in buckets where marine invertebrates living on the tubes were then removed. Specimens were placed into 55-gallon aquarium tanks and suspended in their natural orientation with lines attached to metal rods that lay across the top of the treatment tanks. The worms were left for 24 hours to acclimatize to lab conditions with constant seawater flow.

Experimental Setup

The experiment measured four treatment groups: (1) normal temperature- normal salinity (control), (2) normal temperature- low salinity, (3) high temperature- normal salinity, and (4) high temperature- low salinity. “Normal” was defined as the temperature and salinity found at our samples collection site on the day of collection. These were measured as a temperature of 11°C and a salinity of 33 ppt. The high treatment temperature was 17 °C which was based on the IPCC predictions for sea surface temperature for the sample area in November 2100 given a global temperature increase of 4°C (CITE). The low salinity of 24 ppt was obtained from research on predicted future ocean conditions and the effects on phytoplankton in the Arctic Ocean (Sugie et al. 2020).

Researchers baffled four 55-gallon aquariums to create three 18-gallon replicates per aquarium. Two 55-gallon aquariums contained the high temperature treatments and the other two contained normal temperature treatments. High temperature treatments were conducted within the same aquariums using a separate heater for each section to reduce pseudo replication effects or the transfer of heat to control treatments. In all aquariums, low and normal salinity treatments were alternated between baffled replicates to ensure water columns were isolated.

Samples of *E. vancouveri*, both individuals and small clusters, were randomly assigned to one of the 12 replicates so that each replicate had a total of 10 organisms. Each temperature replicate was heated with a 50W heater and the water temperature was raised gradually by 1.5 °C per day over the four days of acclimatization to avoid shock. Once acclimatized, temperature was then held stable at 17 °C for the entirety of the fifteen-day experiment.

Similarly, the salinity of the low salinity treatments was lowered by 2 ppt per day over the four-day acclimatization period then held stable at 24 ppt for the remainder of the experiment. Salinity was lowered using reverse osmosis water (RO) at 0 ppt and c1/v1=c2/v2 calculations of known volumes and a desired concentration of 24 ppt. .

Growth Measurements

Growth measurements were modeled after Katzan and Paterson study on *E. vancouveri* tube growth rate from stimulated predation (2018). After the four days of acclimatization to temperature and salinity treatments, the circumference of each tube of *E. vancouveri* was sewn 2.5 cm from the anterior of the tube and the tubes were cut horizontally across 2 cm down from the anterior end of the tube. Tube growth was measured on the day of tube cutting then every three days for a total of 15 days. Tube growth was measured from the sewn line to the anterior end of the tube with digital calipers, considering the original 0.5 cm to determine how much the tube had grown.

Animal Care

A siphon was used every other day to clean organic matter from the bottom of the aquariums. Air stones were added to all replicates to promote water movement and to cycle oxygen. To replenish water in our closed system, water was heated and diluted to the appropriate treatment conditions in separate buckets prior to replacing the old water. This was done so that temperature and salinity would remain constant throughout the entire experiment. Supplemental food was given every three days from plankton tows.

Data Analysis

Prior to the 15-day experiment, we conducted a power analysis using effect size from the literature to determine the power of our experimental results given the anticipated sample size (n = 120) (CITE). Following the experiment, data was analyzed using linear regression models for each treatment. Statistical analyses were done through R studio software. A Shapiro-Wilk test was used to test for the normality of the data. Assuming normality based on the P-value of the Shapiro-Wilk test, an ANOVA analysis was used to assess differences in the continuous variable (tube growth) between treatment types (Shapiro & Wilk, 1965) (Anova citation).

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