

Growth and Mortality of the Barnacle *Chthalamus fissus* in the Context of Climate Change

Elizabeth Bushnell & Nathalie Reyns
Department of Environmental and Ocean Sciences



Introduction

Barnacles are sessile (attached) organisms that live in the rocky intertidal, where they structure the community by creating important habitats and serving as prey for other species. There is increasing concern that rising sea surface temperatures due to climate change might negatively impact barnacles. *Chthalamus fissus* is the most prominent barnacle species in Southern California and ranges from San Francisco, CA to Baja, MX¹. Not much is known about the growth and mortality rates or temperature preferences of this barnacle species. In Southern CA, rocky intertidal temperatures range from 14.7 to 24.1° C². In previous studies with other barnacle species, mortality is typically highest in the early post-settlement period, and that vulnerability decreases with increasing size as metamorphs get larger³. Therefore, high mortality right after settlement can cause barnacle populations to fluctuate and can have ecological consequences on rocky intertidal communities.

Objective

To evaluate the impacts of temperature on growth and mortality of the barnacle *Chthalamus fissus*

Methods

- PVC settlement plates were deployed in the rocky intertidal to collect barnacle metamorphs (Fig. 1).

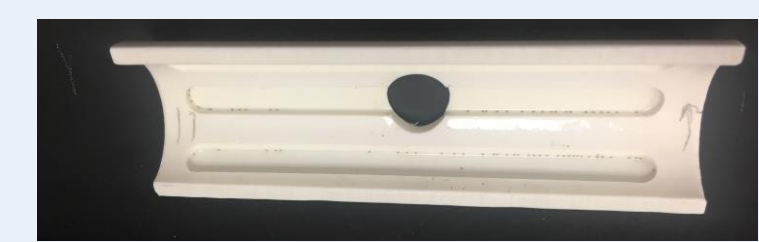


Figure 1 PVC settlement plate

- Metamorphs were cultivated at 14°C, 22°C and 28°C with 33 salinity, in 1L containers with air stones (Fig. 2).



Figure 2 Lab setup used to rear barnacles (far left), and treatments at 22°C (left) 14°C (center), and 28°C (right)

- Barnacles were photographed weekly, and basal diameter and operculum length measured using a Leica S9i microscope and Leica Microsystems software at 50x magnification (Fig. 3).

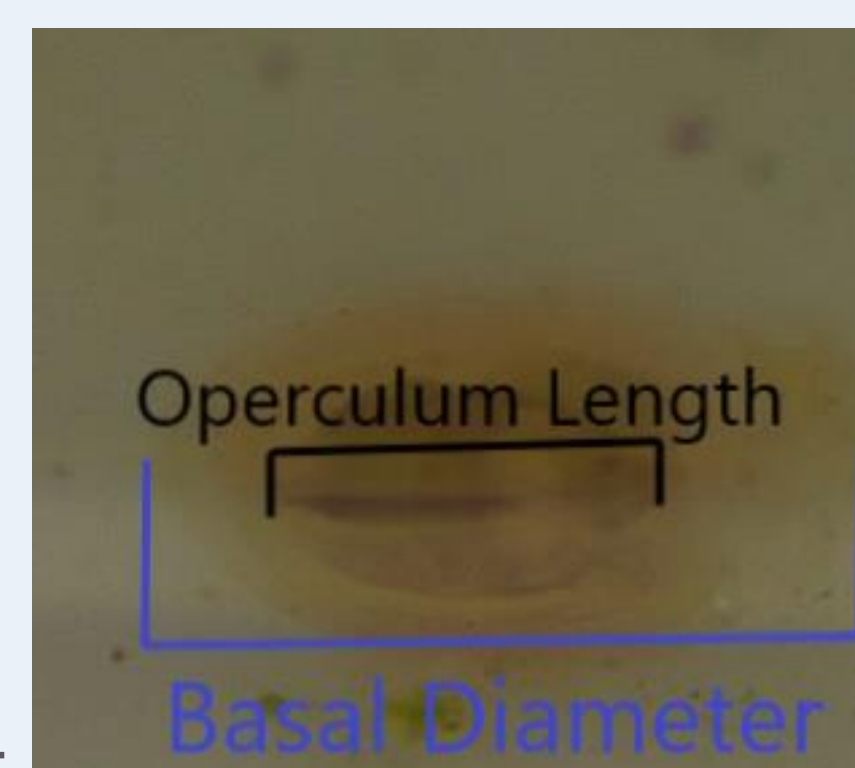


Figure 3 Example of measurements collected, shown on a 7 week old barnacle, photographed at 50x magnification

- Barnacles were counted daily to track mortality.

- Kruskal-Wallis statistical tests were used to detect significant differences between treatments.

Results

- **Increasing mortality of metamorphs with increasing temperature:** Results suggest a short-term tolerance to warm temperatures, as metamorph survivorship at 28°C begins to decline after 3 weeks, and metamorph survivorship at 22 °C begins to decline after 5 weeks.

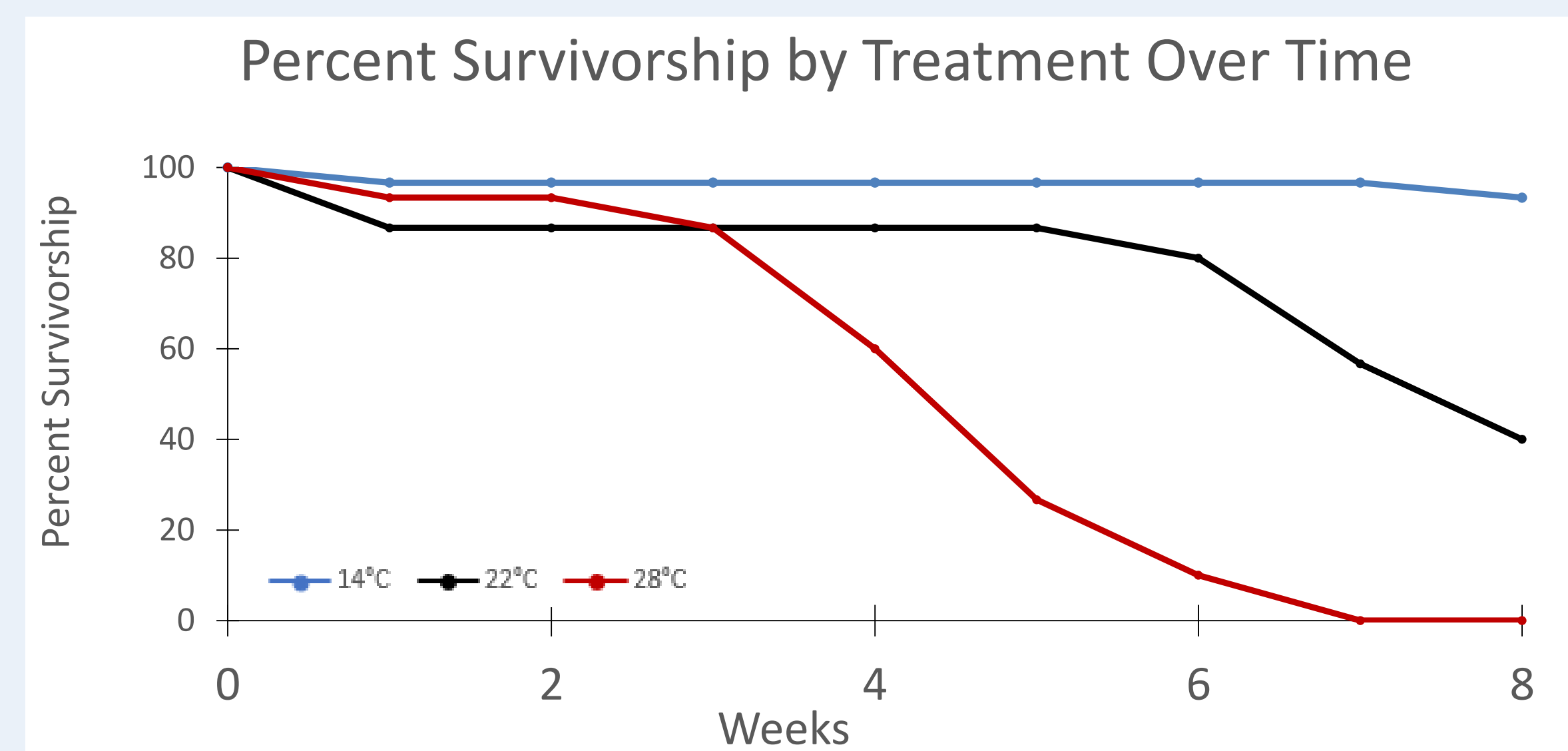


Figure 4 Weekly percent survivorship in each treatment.

- **No difference in operculum size at 8 weeks between 14°C and 22°C:** Operculum size appears to decrease as health declines, as visible at 4 weeks in 28°C.

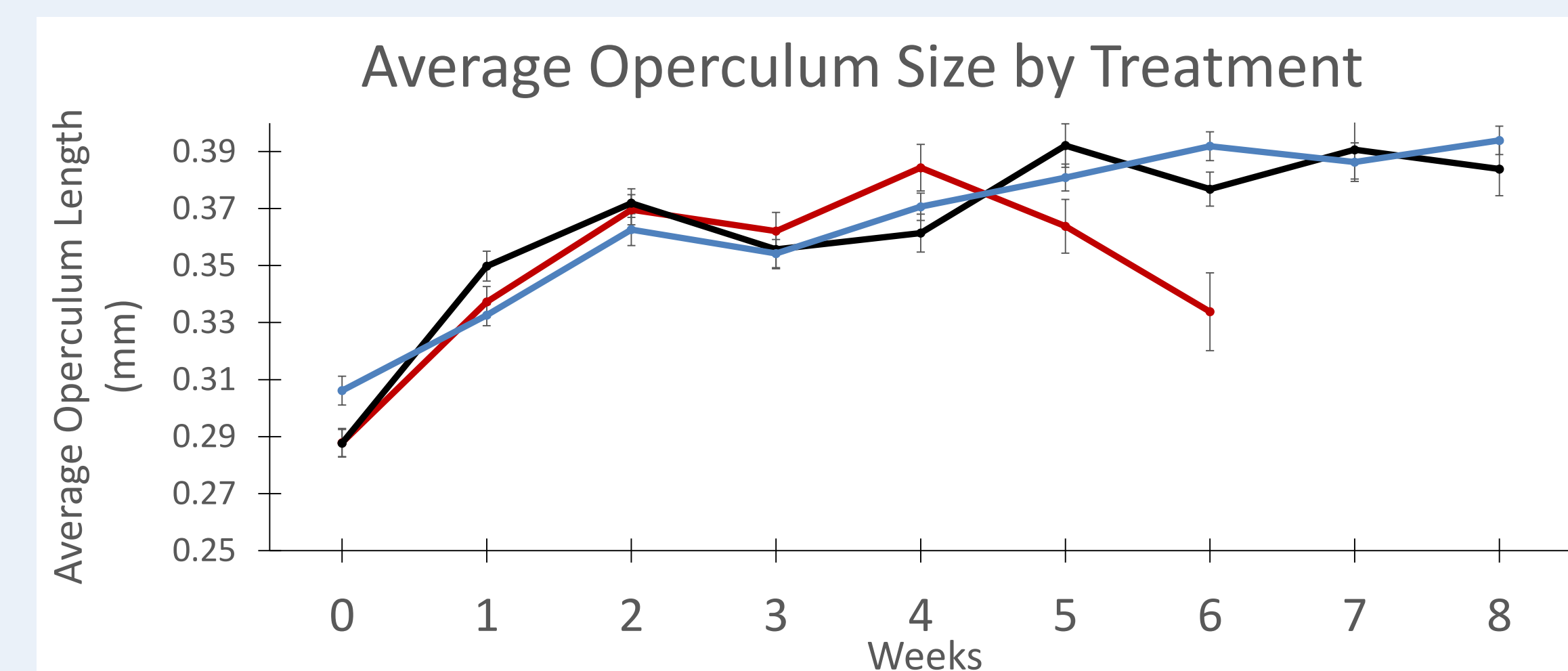


Figure 5 Average operculum length \pm SE by treatment. Initially, a Kruskal-Wallis Test indicated a difference in operculum length between groups ($p=0.02$) but by the end of the experiment, there was no difference between 14°C and 22°C ($p=0.24$).

- **Barnacles grow larger in warmer water at week 1. At 8 weeks, barnacles reared in intermediate temperatures were largest.**

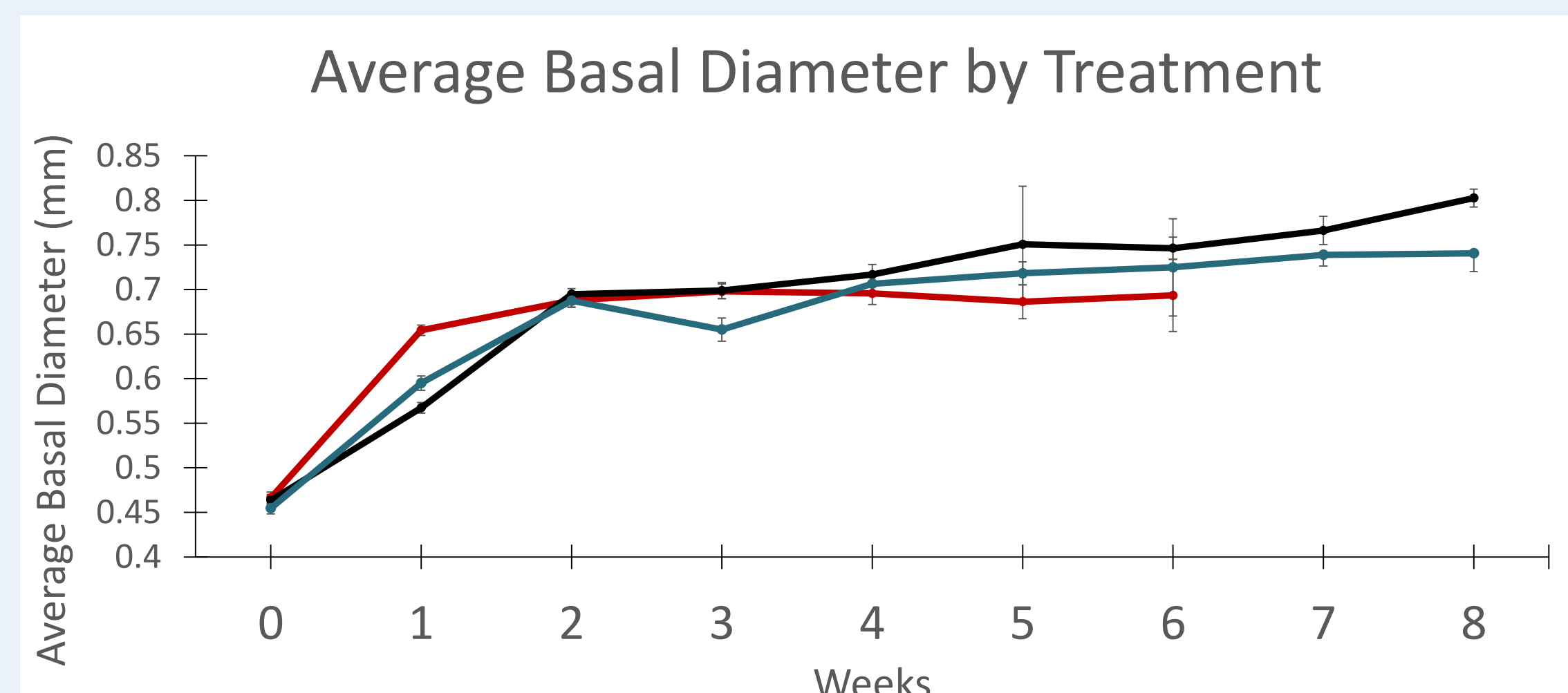


Figure 6 Average basal diameter \pm SE by treatment. Initially, a Kruskal-Wallis Test indicated no difference between groups ($p=0.161$) but by the end of the experiment, barnacles in 14 °C were significantly smaller than barnacles in 22 °C ($p=0.002$).

Conclusions

- Barnacle metamorphs reared at 28°C had the highest initial growth rate. Such accelerated growth suggests a link between temperature and metabolism, as visible in other barnacle species⁴. However, barnacles maintained in elevated temperatures (22°C or greater) suffered high mortality.
- In our study, optimal temperature for growth of *Chthalamus fissus* was 14°C.
- A field study in San Diego (April-December 2014, 2015, and April-November 2016) indicated that barnacles experienced sub-optimal temperatures in excess of 21°C 23% of the time².
- Intertidal organisms have greater thermal tolerances than subtidal organisms⁵. However, *Chthalamus fissus* in San Diego live in the southern range of their distributions, and may not tolerate increased sea surface temperature due to climate change as effectively as barnacles in the northern limit of its range^{1, 5}.
- Other studies examining climate change impacts on coastal marine systems have noted displacement of cold water species by warm water species, and severe declines in 27% of invertebrate populations analyzed⁶.

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