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Marine Invertebrate Zoology Summer A 2025

Behavioral responses to heat stress in a North Pacific bivalve (*Macoma nasuta*)

Abstract: To assess the effects of heat stress on bent-nosed clams (*Macoma nasuta*) I measure relative siphon length as a behavioral response for individual bivalves kept at their preferred temperatures and for those placed in a heated tank, over a period of five hours. The results of this study provide no evidence to support a link between water temperature and siphon extension; however, bivalves placed in a heated tank do appear to show a reduced or entirely absent siphon retraction response when threatened, though further study is needed to provide definitive support for this trend and the mechanism behind it.

Key Words: Bivalvia, heat stress, energetics

Energy is the currency with which organisms invest in survival, growth, and reproduction. It follows, then, that the rates at which organisms obtain and use energy, and how they vary across space and time, has major consequences for evolutionary success. Energy expenditure also has many implications in the face of anthropogenic climate warming. Temperature, dissolved oxygen, and metabolic rate are closely linked; as temperatures increase, the energetic and aerobic demands placed on organisms increase, while oxygen supply decreases. Warming and hypoxia resulting from anthropogenic climate change thus place physiological constraints on marine organisms that threaten their survival. Our ability to predict the effects of anthropogenic climate change on marine organisms and ecosystems is therefore predicated on a strong understanding of organismal metabolism and energetics, particularly within the context of rising temperatures in a rapidly changing world.

Bivalves are useful model systems for studying responses to heat stress—understanding how they will be affected by climate change remains ever relevant. For the purposes of this study, the bent-nosed clam (*Macoma nasuta*) was chosen due to its distinctly separated siphons, which can be extended quite far beyond the mantle, and provides a concrete behavioral response to heat stress that can be measured and recorded. *M. nasuta* uses its siphons for both filtration and respiration; as such, siphon length could potentially serve as a proxy for energy expenditure. I hypothesize that because filtration, assessed as siphon extension length, is energetically costly, *M. nasuta* placed in a heated tank will extend their siphons far less than individuals kept at their preferred water temperatures.

Specimens of *M. nasuta* were collected from False Bay on June 25th, 2025, and were assigned randomly to either the control or experimental condition. Specimens were placed individually in cups filled with 200 ml of seawater. Those in the control group were placed in the sea table to keep the temperature constant. Those in the experimental group were placed in an aquarium with a heater set to 20 °C. The bivalves were allowed to acclimate to their assigned condition for one hour before the heater in the experimental tank was turned on and the experiment commenced. I took pictures of and measured the surrounding water temperature of each setup at ten-minute intervals over a period of five hours. Siphon length was measured from these pictures using the image processing program ImageJ. Because siphon length can vary based on shell size, it was standardized for each individual bivalve by dividing the siphon length by the distance between the umbo and base of the incurrent siphon.

Water temperatures in the control condition remained relatively constant at around 11 °C for the duration of the experiment. Water temperatures in the experimental condition increased rapidly over the first two hours, then leveled off around 23 °C (Figure 1). Relative siphon length in the experimental condition did appear to vary more widely during this initial period. However, overall, there does not appear to be a clear difference in relative siphon length over time between the control and experimental conditions (Figure 2). These results do not provide any evidence to support my initial hypothesis, that water temperature and heat stress would affect siphon extension length.

However, this is not to say that no behavioral response to heat stress is observed—something potentially just as interesting may be happening here. At the end of the experiment, I poked each individual bivalve's siphons with a probe in order to confirm that they were still alive. Several of the individuals in the experimental group, and only the experimental group, had their siphons extended, but did not retract them when irritated. This could indicate that they were either dead or dying; however, after having been eased back into their preferred seawater temperature, these bivalves all became fully responsive again. It appears heat stress may impact the ability of *M. nasuta* to retract its siphons, for one of several reasons. Siphon retraction is likely to be energetically costly. It's possible that the energetic constraints placed on *M. nasuta* during heat stress may make siphon retraction unsustainable. Alternatively, the increased demand for oxygen to supply aerobic respiration in warmer temperatures may force continued filtration through the siphon, at the cost of safety and defense. Either of these could explain the lack of siphon retraction response in members of the experimental group, though further study is necessary to confirm (1) whether this trend is real, and (2) if so, the mechanisms behind it.

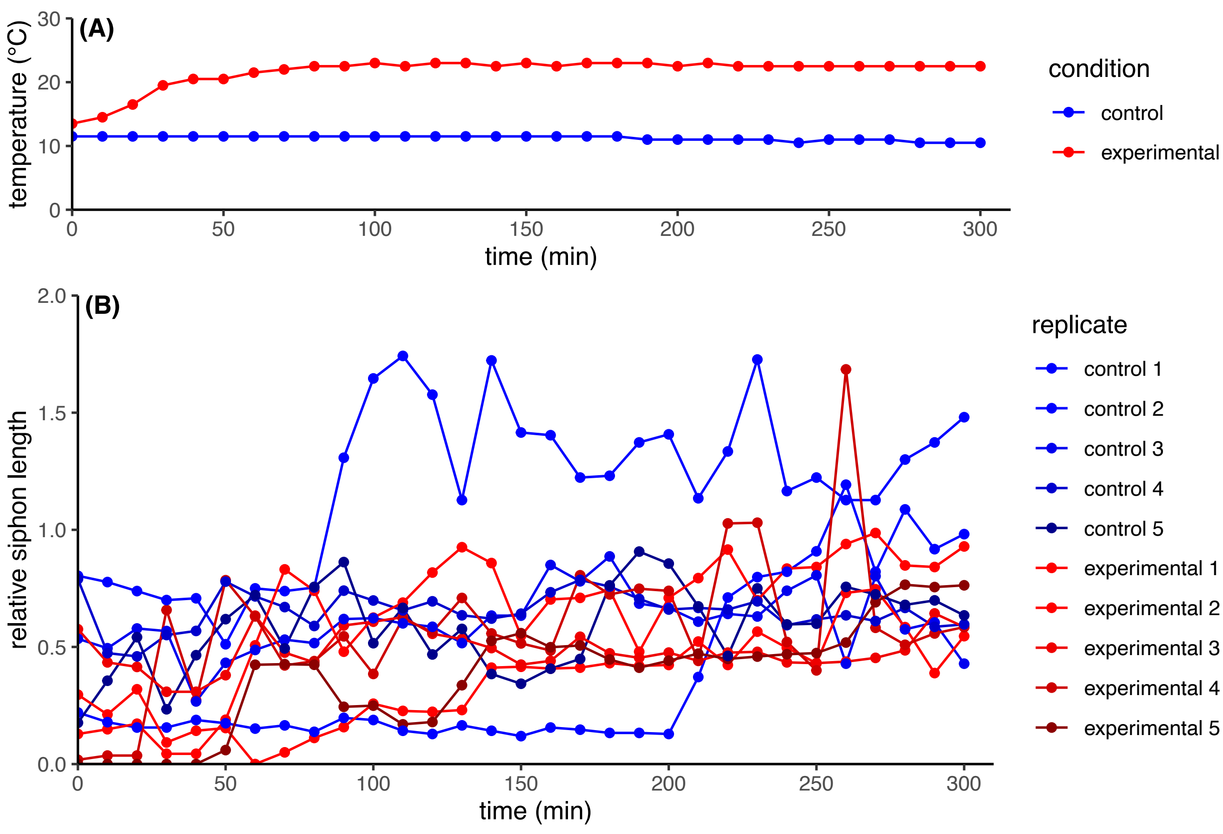

Figure 1: (A) Changes in water temperature over time in the control and experimental conditions. (B) Changes in relative siphon length. Water temperature does not appear to affect relative siphon length between the control and experimental conditions

Steamed Clams

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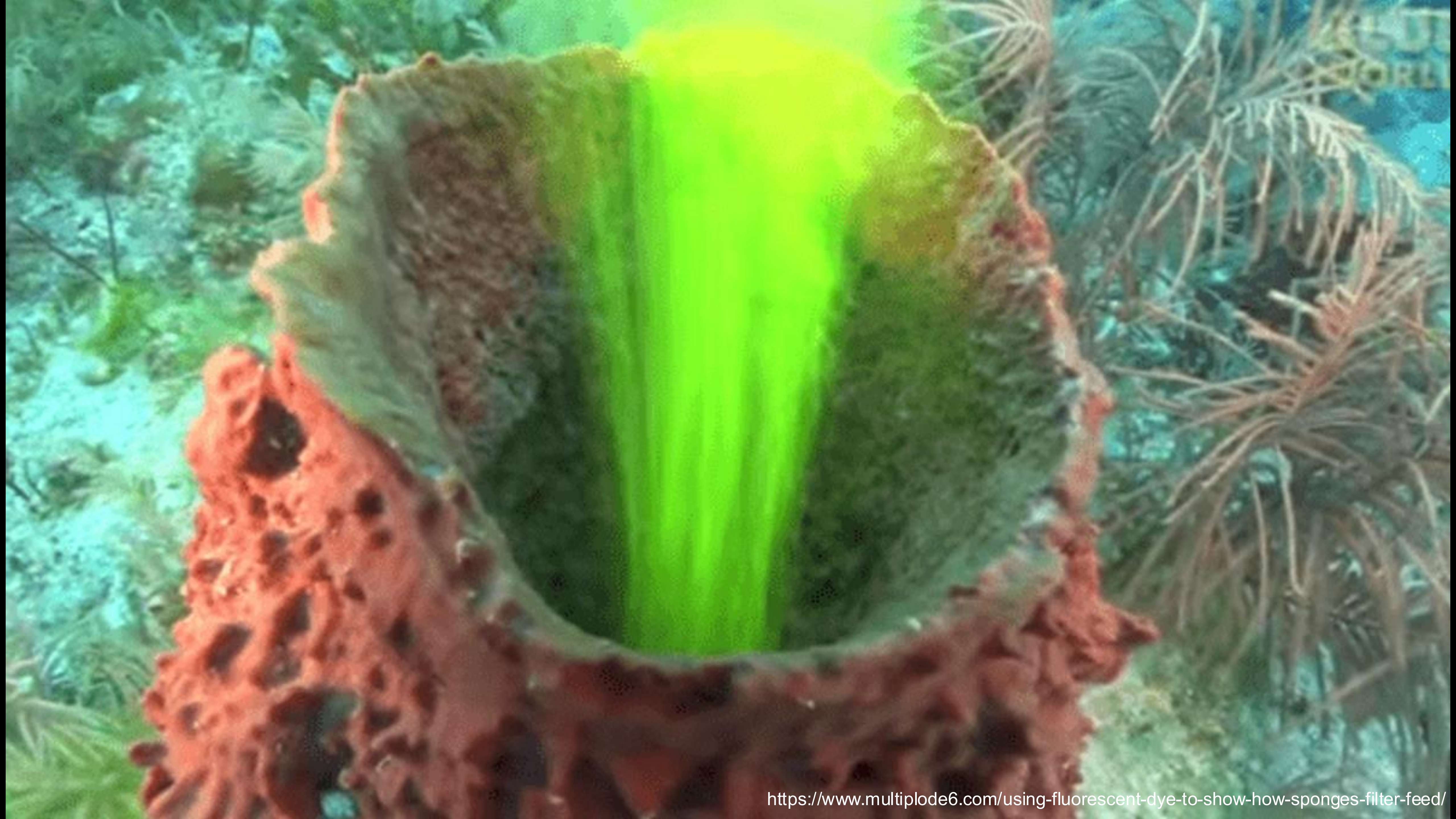
FHL 432: Marine Invertebrate Zoology

https://gravelbeach.blogspot.com/2006/03/san-juan-island.html

Energy is the currency that organisms invest in survival, growth, and reproduction



https://www.multiplode6.com/using-fluorescent-dye-to-show-how-sponges-filter-feed/

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https://storymaps.arcgis.com/stories/839b3a82ad1845d785b13b789d730b38

https://barnegatshellfish.org/blue_crab_molting.htm https://www.horniman.ac.uk/story/coral-spawning-season-at-the-horniman-aquarium/

How organisms obtain and use energy has major implications for their evolutionary success

Also, the climate is changing

- Metabolic rate is linked with temperature and dissolved oxygen
- Climate change places physiological constraints on organisms that affect their survival
- Understanding organismal responses to heat stress can provide insight into how anthropogenic climate change will affect biodiversity

How does heat stress affect patterns of energy use in marine organisms?

Why study bivalves?

- Diverse and abundant
  - ~9,200 living species
- Major components of marine ecosystems
- Economically important
- Provide many valuable ecosystem services

https://www.researchgate.net/figure/Bivalve-species-associated-with-rocky-intertidal-zone-of-MPR-32-Acapulco-Mexico_fig1_268746037

Macoma nasuta, the bent-nosed clam

- Infaunal bivalve
- Order Cardiidae, Family Tellinidae
- Native to Pacific coast of North America
- Inhabits intertidal and subtidal zones

https://commons.wikimedia.org/wiki/File:FMIB_34796_Shell_of_Macoma_nasuta.jpeg

Experimental design

- Use siphon length as a proxy for filtration rate
- Account for size differences by dividing siphon length by shell size

Hypothesis: Individuals of *M. nasuta* placed in a heated tank will extend their siphons less far than clams kept in normal seawater conditions

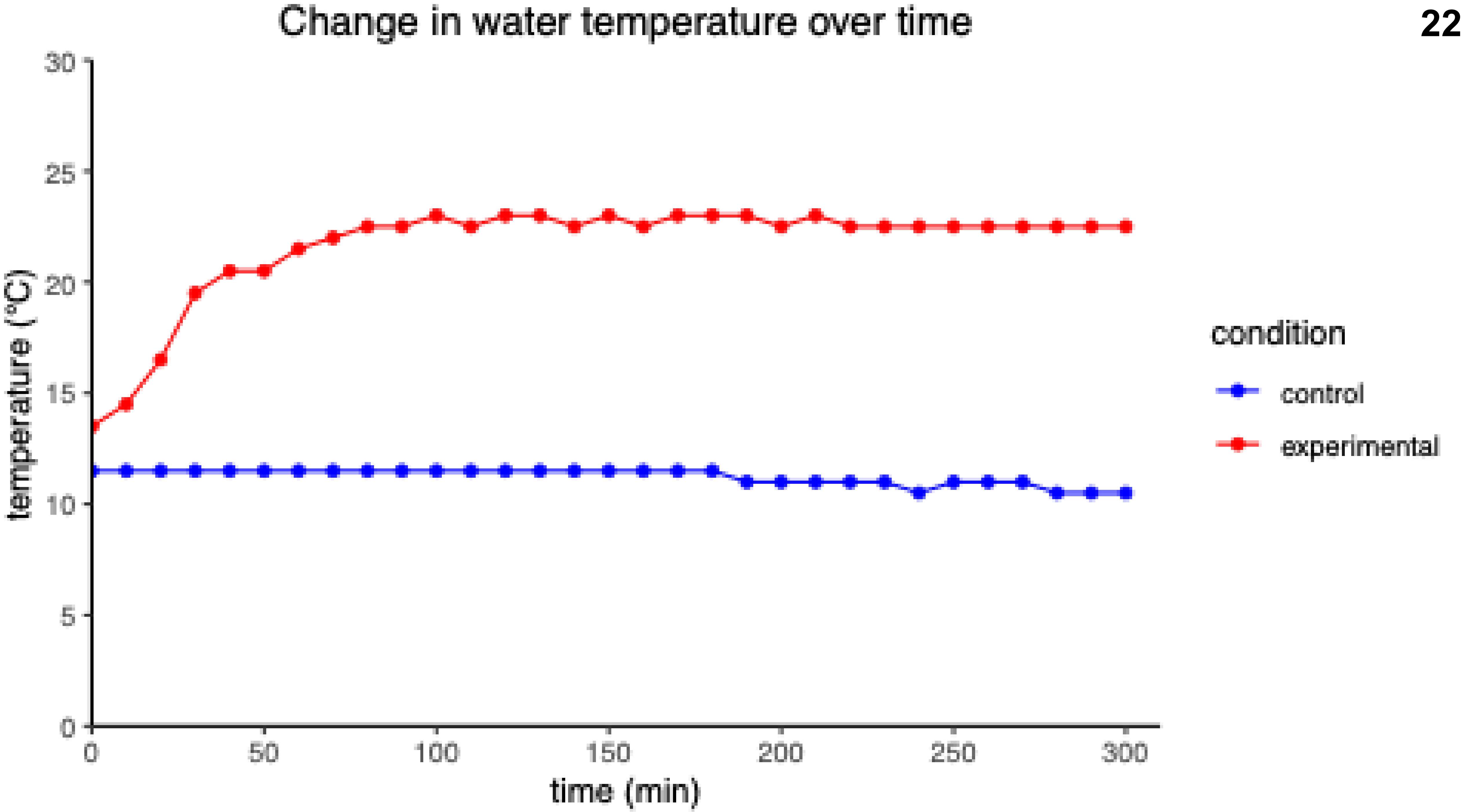

Shell length measured
as distance from umbo
to incurrent siphon

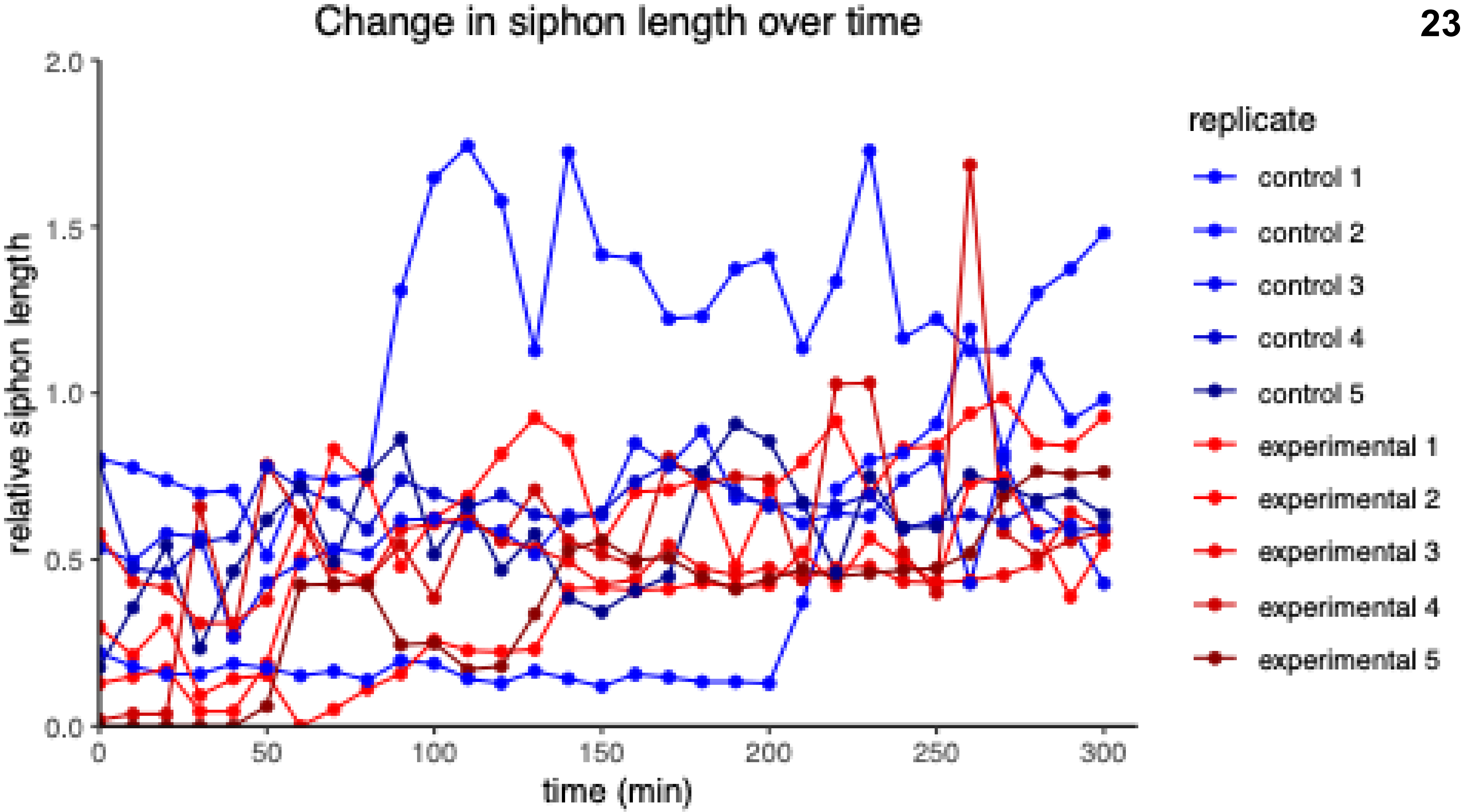
Experimental setup

- Collected from False Bay, 6/25/25 (and 7/12/25)
- Assigned randomly to control/experimental
- Placed individually in 200 ml cups of water
  - Control: cups placed in sea table (kept at ~11 °C)
  - Experimental: cups placed in heated tank (heater set to 20 °C)
- Bivalves allowed to acclimate for one hour

Experimental setup

- Water heater turned on after one hour, tank warmed up gradually
- Pictures taken and temperature recorded at ten-minute intervals over the course of five hours
- Shell size and siphon length measured from pictures using ImageJ


Change in water temperature over time
temperature (°C)
30
25
20
15
10
5
0
0
50
100
150
200
250
300
time (min)
condition
control
experimental


Change in siphon length over time
relative siphon length
2.0
1.5
1.0
0.5
0.0
0
50
100
150
200
250
300
time (min)
replicate
control 1
control 2
control 3
control 4
control 5
experimental 1
experimental 2
experimental 3
experimental 4
experimental 5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Discussion

- Increasing water temperature does not appear to affect **siphon length**
- However, temperature may affect **siphon retraction rate**, though further study is needed
- Could indicate either of two options:
  - Energetic cost of siphon retraction
  - Increased importance of respiration during heat stress, at expense of safety

Acknowledgements

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Questions?

https://gravelbeach.blogspot.com/2006/03/san-juan-island.html