
FRIDAY HARBOR LABS
UNIVERSITY of WASHINGTON

# FHL Tide Bites

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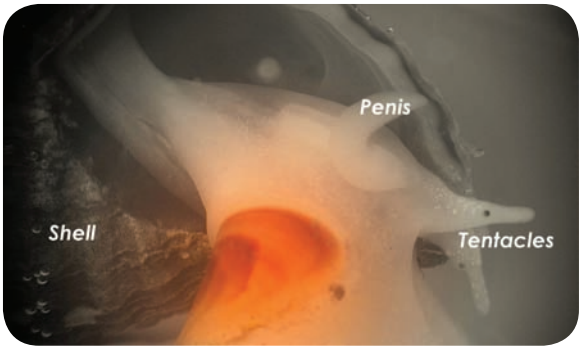
## Will global warming affect males and females differently?

Life on a rocky shore is challenging. With each passing tide, the animals and plants of this land-sea interface are emerged in seawater one minute and exposed to air and the hot, drying effects of the sun the next. Yet, a diversity of organisms including snails, barnacles, crabs, sea anemones and sea stars thrive in this environment of extremes. Marine in origin, and not well adapted to life on land, many intertidal organisms must mount physiological defenses to cope with even small fluctuations in climatic conditions. Over the next century, global temperatures are predicted to rise by as much as 5.8° C. How will nature respond to this rapid change in climate? What makes this question difficult is that climate change does not affect all organisms in the same way. For instance, organisms that cannot move, such as barnacles, will just have to "take the heat", but mobile organisms like snails might avoid the heat by taking refuge under rocks or within crevices. Even individuals of the same species can differ in their potential exposure and responses to global warming depending on demographics like age and sex.




A male snail shown belly up. Photo by D. Vaughn

As a postdoctoral researcher in Dr. Emily Carrington's lab, Dr. Dawn Vaughn was interested in the potential significance of sex-specific responses to elevated temperatures. Vaughn wondered, given differences in reproductive physiology between sexes, might increased thermal stress affect the males and females of a species differently? In the first of her studies, recently published in the journal Marine Biology, Vaughn designed an experiment testing for sex-specific effects of increasing temperatures on the foraging behavior and growth of a snail commonly found on the shores of San Juan Island. From previous research in the Carrington lab, Vaughn knew that her focal snails eat in rhythm with the tides, feeding in hoards when low tide exposure is at night and the risk of thermal stress is low. With help from Olivia Turnross, an undergraduate supported by the National Science Foundation's Research Experiences for Undergraduates at the Friday Harbor Labs, Vaughn set up an experiment to test if snails would alter their behavior if she "turned up the heat". They collected snails from Deadman Bay and determined their sex prior to placing them in outdoor tanks at the Friday Harbor Labs that simulated the natural tidal cycle. Above each tank Vaughn mounted heat lamps that warmed the air during each

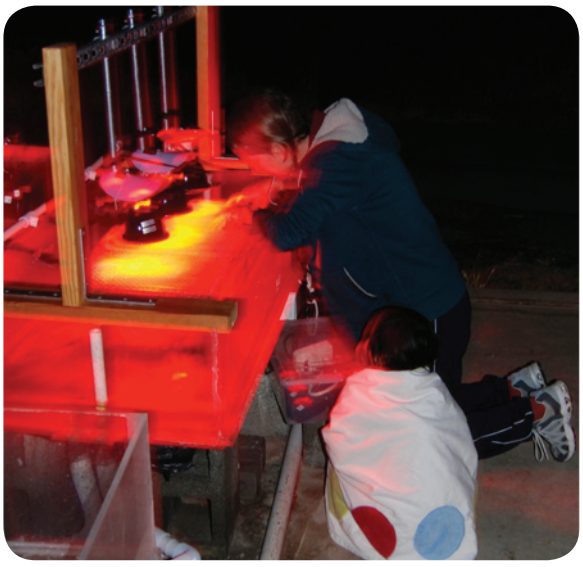
Olivia Turnross, Dr. Dawn Vaughn and Dr. Emily Carrington at Deadman Bay, San Juan Island.

low tide; as the tide receded, the heat lamps powered on. During early morning low tides, the infrared heat bulbs glowed red, and could be seen across the water from the Port of Friday Harbor – beautiful!

Vaughn and Turnross then closely monitored snail foraging activity at each low tide, predicting that the snails would notice it was too hot during their favorite feeding times and change their behavior accordingly. Much to their surprise, many snails just kept feeding in the heat ... the behavior seemed to be hard-wired. Notably, they found that the most active foragers were females, feeding more often than males, even when the threat of thermal stress was high. However, this risky female foraging behavior came at a cost. Despite an increased foraging effort, most females were unable to satisfy their growing energetic needs with exposure to higher temperatures. The result? – A significant loss of weight for the majority of females over the month-long experiment.

**The tidal tanks at Friday Harbor Labs illuminated by the glow of the heat lamps during an early morning low tide. Beyond the tanks and across the water lies the town of Friday Harbor. Photo by K. Vaughn.**

But why would females engage in such risky foraging? Vaughn believes that the answer may lie in the "cost of motherhood". In most organisms with separate sexes, males and females differ dramatically in their reproductive roles, physiology and degree of parental investment. Throughout the animal kingdom there are many examples of mothers investing a great deal to ensure the success of their offspring, and Vaughn's snails are no exception. These snail mothers provide their young with protection in tough egg capsules that are secured tightly to rocks and include all the nutrition that the baby snails require for their development. Providing for offspring in this way is energetically costly, above and beyond what a female needs to maintain her health. Vaughn's study was conducted in mid June, shortly after the snails had finished an extended breeding cycle -- from October to early May. So the female snails were potentially drained of energy by recent reproductive activity and in need of a few good meals to recover and to ramp up reserves for the next round of reproduction. In following an extended reproductive season that is more energetically costly to females than males, Vaughn's initial experiment likely capitalized on differential (and perhaps seasonal) vulnerability of male and female snails to thermal stress. These results suggest that the consequences of a warming climate in the short-term may be different for males and females, but also imply longer-term costs of reduced reproductive output. Although a slightly warmer climate might not kill snails outright, it could lead to the demise of the population over time if the adult snails cannot reproduce effectively.



**Vaughn monitoring snails accompanied by one of her own offspring, daughter Quinn. Photo K. Vaughn**

In a follow-up experiment, Vaughn explicitly tested the effects of prolonged exposure to elevated temperatures on reproductive output in snails from the same population at Deadman Bay. The results, which Vaughn presented at the annual Western Society of Naturalists meeting in November, paint a somewhat grim picture. Regardless of whether the male, female or both the male and female of a pair were previously heat stressed, prolonged exposure to elevated temperatures significantly reduced the number egg capsules and thus offspring produced by the pair. The mechanism underlying the reduced number of offspring produced by unstressed females mated to thermally stressed males is unknown but may be decreased sperm viability, or...perhaps nothing more than a diminished sex drive with stressed male snails choosing to take refuge and recover rather than copulate. Vaughn's work with the snails on

San Juan Island is providing some of the first evidence of sex-specific responses to elevated temperatures in the rocky intertidal. Other examples of differential vulnerability of males and females to increased temperatures are reported in butterflies, wasps and even trees. Taken together, these studies each point to the potential significance of sex-specific responses in an increasingly warm world.

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