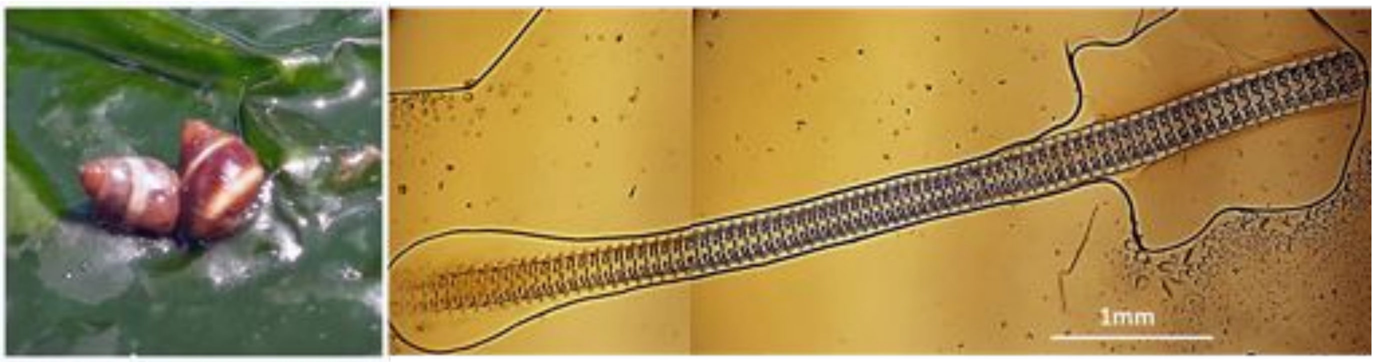
The following article is by one of our 2018 Scholarship Recipients, Sasha Seroy, of the University of Washington.

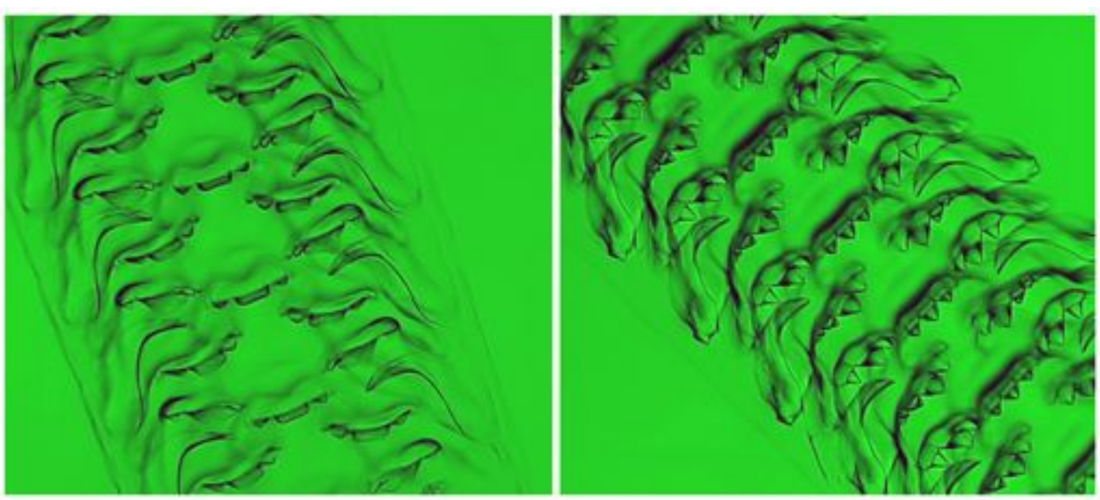
The snail dentist is in: Studying how tooth shape affects snail responses to a warming ocean
By Sasha Seroy, PhD Candidate, University of Washington

Marine snails are common in kelp and eelgrass beds of the Pacific Northwest. The snail, *Lacuna vincta*, plays an important ecological role in the shallow subtidal zone, munching heavily on kelp and eelgrass-associated diatoms with its conveyor belt like teeth, called a radula. New rows of teeth are continuously made at the back of the mouth and old used teeth are shed at the front of their mouth. *L. vincta* also exhibits plastic tooth morphology, meaning that they can change the shape of their teeth depending on their diet. *L. vincta* produces flat teeth in eelgrass habitats, which are advantageous for scraping nutritious diatoms off eelgrass blades, and sharp teeth in kelp habitats, for tearing kelp and consuming it directly. *L. vincta* disperse between habitats using mucus parachutes to drift on currents which enables them to avoid predation. But this behavior can result in the arrival to a habitat that does not match tooth morphology. Therefore, *L. vincta* radula tell a story, they can tell us where a snail has been, when it was there, and for how long. As a graduate student at University of Washington's Friday Harbor Labs, I set out to find out how often snails were actually mismatched with their habitat and how this affected their responses to changing ocean conditions.



Left: The marine snail *Lacuna vincta* consuming kelp. Right: A radula dissected out of a snail collected from a field survey. New rows of teeth are on the left end of the radula and old worn rows teeth are on the right end of the radula. On average, three rows of teeth are produced per day.

I conducted field surveys around San Juan Island, WA to understand how frequently snails were mismatched with their habitat in various locations. I collected 20 snails from four sites, two eelgrass and two kelp sites, during several summer low tide series. I dissected these snails, then extracted and imaged their radulae under the microscope. Snails were classified as (1) completely matched: all teeth shapes matched the habitat they were collected from and these snails were

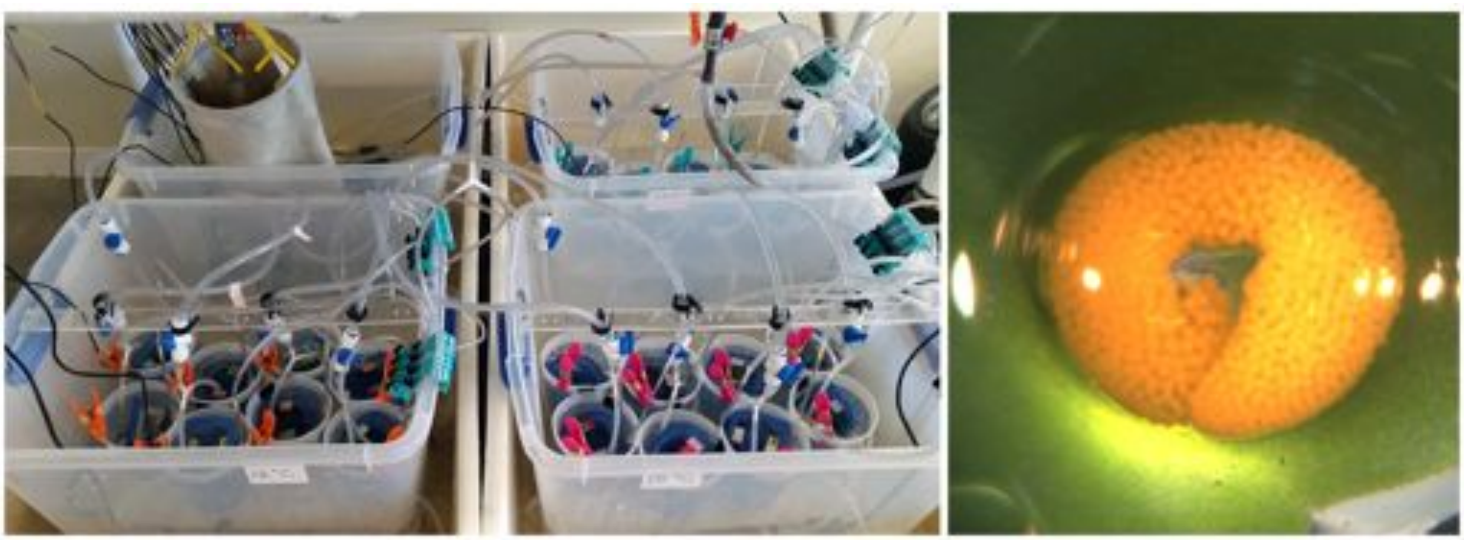


Microscope views of *Lacuna* radulae with flat teeth produced from consuming eelgrass-associated diatoms (left) and pointed teeth produced from consuming kelp (right) assumed residents of that site, (2) transitioning: newly-formed teeth matched the habitat they were collected from but old teeth did not, signifying the snail was a recent arrival to the site, or completely mismatched: all teeth were the wrong shape for the habitat they were collected from, signifying the snail was a new arrival to the habitat. In eelgrass beds, the amount of matched snails increased throughout the summer, potentially indicating immigration to these habitats to take advantage of eelgrass-associated diatoms which only grow in the summer. In kelp beds, the proportion of matched snails decreased over the summer, potentially indicating dispersal away from these sites.

I also designed, constructed and deployed current speed sensors to investigate how the snail dispersal patterns I uncovered with radulae imaging might be affected by water flow. I measured current speeds at each site to see if there was a relationship between flow speed and the proportions of snails whose radula did not match the habitat. Faster current speeds corresponded with more mismatched snails at kelp sites but not at eelgrass sites. This suggests that snails may have stayed at eelgrass sites even when flow speeds were high, potentially to take advantage of the high quality food in these habitats.

Because field surveys showed that snails commonly had a radula that was mismatched with their habitats, I wanted to know how radula morphology might affect snails' responses to warming ocean temperatures. I conducted lab experiments to measure reproductive output of snails whose radula was matched and mismatched with their food source over a range of temperatures. Over the range of 12°C-20°C, snail reproductive output was not very sensitive to temperature. But tooth shape and diet were important! Snails that consumed eelgrass-associated diatoms with matched teeth produced nearly 3 times more eggs than those with matched teeth on kelp! Snails that were matched on eelgrass also produced more eggs than those that were mismatched on eelgrass.

Left - A microcontroller-based current speed sensor deployed in the field. Top view of the sensor. Right - The current sensor suspended in a flow tank at Friday Harbor Labs for calibration. Bottom view of the sensor. Propeller mechanism was constructed from 3D printed components.



Left - The experimental setup with chambers containing snails at different water temperatures with matched or mismatched radulae. Egg production was monitored throughout the experiment. Right - A picture of an egg mass laid by *Lacuna vincta*, approximately 2mm in diameter.

These experiments help contextualize the field survey patterns and demonstrate the advantage of staying in eelgrass habitats once snails arrive there. Dispersal to and retention in eelgrass environments can increase the amount of eggs that are laid. I didn't observe a significant effect of temperature, which suggests that *Lacuna vincta* may be tolerant of a wide range of temperatures and well-positioned to persist under changing ocean conditions. Studying snail teeth can give us a glimpse into the day in the life of snail!

Below is a comic inspired by my research on *Lacuna vincta* from my weekly comic strip called "interviews with invertebrates".

Yes, snails actually have teeth! Snails have a 'conveyor belt' of teeth called the radula in which old, worn out, teeth are continuously being replaced by new teeth. Marine snails of the genus *Lacuna* can change the shape of their teeth to better consume the type of food that is available in the habitat where they live. Pointy teeth are more effective for eating kelp but rounded teeth are produced when diatoms, single-celled algae, are the dominant food source. Often times *Lacuna* move between these habitats to avoid predators but have to wait for their teeth to catch up in order to get the most out of their food. This is one example of how animals can deal with changes in their environment. interviewswithinvertebrates.com