Tidal variation in nitrogen cycling in Oregon sponges

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ABSTRACT

As filter feeders, marine sponges are closely integrated with their environment. Sponges also host many diverse species of bacteria that carry out a gamut of metabolic processes, including several nitrogen transformations. The variable nature of tidal exchanges can influence the biogeochemicals available for the sponge and its associated microbes to obtain from the environment. As ambient nutrient concentrations change, it is suggested that the pumping rates of the sponge will change, thus altering the activity of the symbionts. To explore these hypotheses, ambient and exhalent water samples were collected at both high tide and low tide in Netarts Bay, Oregon. To assess pumping rates, transect images between tides were analyzed for changes in oscula diameter within species. Nitrate, ammonia, and total nitrogen concentrations were analyzed via spectroscopy. Transect results demonstrated decreased oscula diameter and therefore decreased pumping rates during high tide and inverse results at low tide. Significant variation was found between inhalant and exhalent nitrate, ammonia, and total nitrogen values between species and between tides. This suggests that ambient nitrogen concentrations influence internal nitrogen cycling, but varies between species. These results suggest that sponges and their associated microbial communities adjust their metabolism based on tidal influences.

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BACKGROUND

- Netarts Bay is a small estuary that is minimally impacted, located on the Oregon Coast.
- Its watershed covers 13 square miles
- It was observed that there is a marked difference in ambient particulate matter at Netarts between slack high and slack low tides (Fig. 1)
- Coastal upwelling from northerly winds in April to September may contribute to increased particulate matter when the tides rise (high tide) which then settle at low tide
- Sponges host microbes that perform nitrogen transformations during metabolism (Fig. 2)

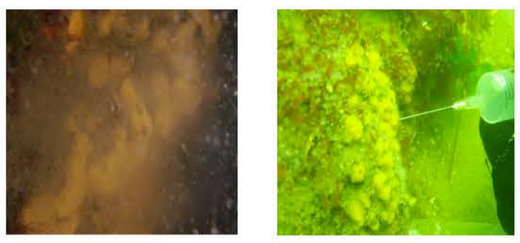

Figure 1. Both images captured during the daytime, demonstrates the difference in ambient particulate matter between high tide (left) and low tide (right).

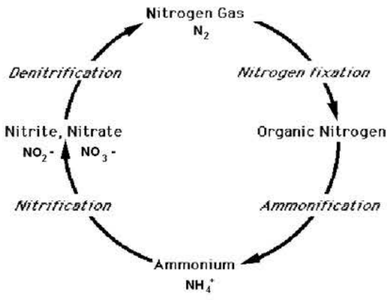

Figure 2. The nitrogen cycle. Measuring flux of nitrate indicates ongoing nitrification. Measuring flux of ammonia indicates ammonification. Measuring flux of organic nitrogen suggests nitrogen fixation.

QUESTIONS

1. Do sponges alter pumping rates between tides to account for the changing environment?
2. What metabolic changes, in respect to nitrogen cycling, do the sponge and its associated microbes undergo in response to tidally influenced ambient nutrient changes?

METHODS AND MATERIALS

Assessment of Relative Pumping Rates via Oscula Dilation

- Image transects recorded at high and low tides at Netarts
- Average oscula diameter within species were analyzed using Image J software

Assessment of Nitrogen Transformation

- Ambient and exhalent water samples collected *in situ* from three different sponge species at slack (high/low) tides
- Water samples analyzed for concentrations of nitrate, ammonia and total nitrogen using Hach DR 2800 spectrometer and low-range reagent kits

RESULTS

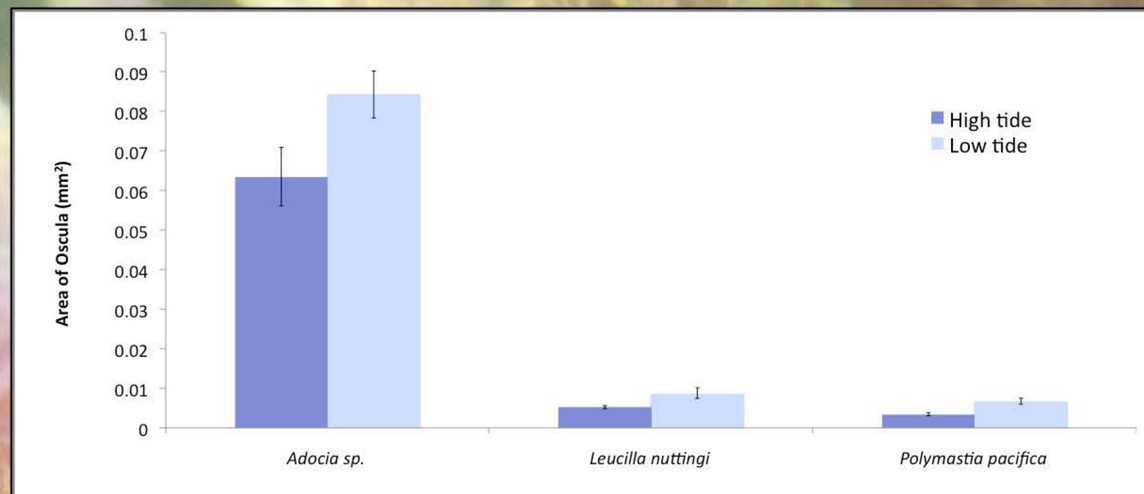

Figure 3. Tidal comparison of mean (± SD) oscula size by species. Asterisks indicate a statistically significant difference ($p<0.05$). Closed oscula have been correlated to lower pumping rates, suggesting slower pumping at high tides.

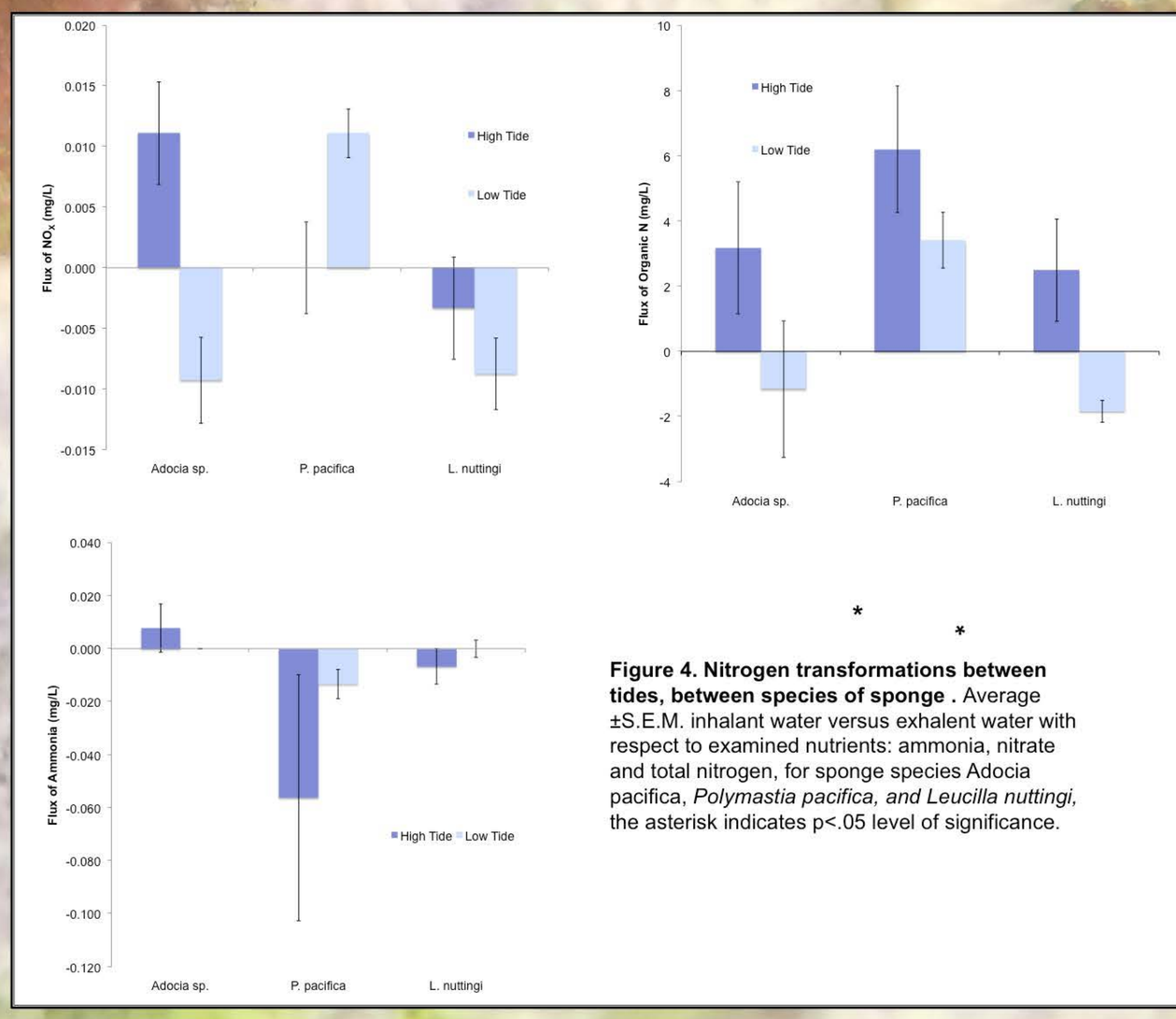

Figure 4. Nitrogen transformations between tides, between species of sponge . Average ±S.E.M. inhalant water versus exhalent water with respect to examined nutrients: ammonia, nitrate and total nitrogen, for sponge species Adocia pacifica, *Polymastia pacifica, and Leucilla nuttingi,* the asterisk indicates $p<.05$ level of significance.

DISCUSSION

- Pumping rates were found to differ in sponges in response to their environment. The oscula appeared to significantly contract during high tides and dilate during low tides.
- A significant difference was demonstrated between many inhalant/exhalant biogeochemicals important in nitrogen cycling in response to a tidally altered environment.

FUTURE DIRECTIONS

- Determine variation in activity of sponge-associated microbes undergoing nitrogen cycling.
- Determine in which regions of the sponge these transformations are taking place, the magnitude to which they occur, and the impact of nitrogen transformation on the sponge.

ACKNOWLEDGEMENTS

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