

# **Digestion of algae by red urchins leads to increased green shore crab consumption rate**

Tessa Putz<sup>1,2</sup>

Nearshore Ecology Research Experience 2013  
Spring 2013

<sup>1</sup>Friday Harbor Laboratories, University of Washington, Friday Harbor, WA 98250

<sup>2</sup>School of Environmental and Forest Sciences, University of Washington, Seattle, WA 98195

## Contact Information:

Tessa Putz

School of Environmental and Forest Sciences

University of Washington

Box 352100

Seattle, WA 98195-2100

tessap2@uw.edu

*Keywords:* Spatial subsidy, *Strongylocentrotus franciscanus*, detrital kelp, feces, *Hemigrapsus oregonensis*, *Nereocystis luetkeana*, *Mazzaella splendens*, *Ulva spp.*

## **Abstract**

Spatial subsidies play a significant role in nearshore ecosystems. In the form of drift algae, these subsidies are not only important to larger herbivores but also smaller invertebrates as a food source. The goal of this study is to test red sea urchin (*Strongylocentrotus franciscanus*) feces as acceptable food items and see if there is a preference of algal type. Feeding the green shore crab (*Hemigrapsus oregonensis*) fecal pellets from red sea urchins that have consumed *Nereocystis luetkeana*, *Mazzaella splendens*, and *Ulva spp*, there was no preference of species in fecal matter. Using a control of feeding the green shore crabs blades of the algae types, there was a preference of *Nereocystis*, but more importantly a preference of fecal pellets over undigested algae was seen.

## **Introduction**

Many marine systems benefit from resources, such as detritus and nutrients that arrive from outside their boundaries. These resources are called spatial subsidies; as they move from one habitat to another they may increase the productivity of a recipient population, as well as change consumer resource dynamics (Polis et al. 1997). One of these important subsidies is carbon produced by algae that enters subtidal, intertidal, and pelagic regions as detritus. This detritus ranges in size from dissolved organic material to detached whole plants that float in the water column, also known as drift algae. Many types of algal tissues contain high nitrogen content and are easily available for consumers (Duggins and Eckman 1997). In local temperate waters light is limiting, with primary productivity occurring only in shallow nearshore habitats. This concentrated productivity from drift algae is an important spatial subsidy for herbivores in the different zones (Britton-Simmons et al. 2009).

In the San Juan Archipelago, Washington, USA, the red sea urchin, *Strongylocentrotus franciscanus*, benefits from spatial subsidies. In deep subtidal habitats, *S. franciscanus* consumes drift algae transported from the photic zone (Britton-Simmons et al. 2009). Urchins are important to subtidal ecosystems by altering nutrients through grazing and drift algal capture. This is seen in the increased densities of detritivores underneath *S. franciscanus* in the subtidal (Lowe et al. In review). Scavengers in particular benefit from spatial subsidies through detritus (Duggins and Eckman 1997).

Sea urchins do not digest efficiently, with fecal pellets consisting mostly of drift algae particles (Sauchyn et al. 2011). It is not known if the increased amount of fauna beneath urchins because the organisms are consuming the urchin feces. *Hemigrapsus oregonensis*, or the green shore crab, is an herbivore that lives in high to low intertidal zones, and is known to eat diatoms and green algae (Morris et al. 1980). While in nature it might not encounter *S. franciscanus* fecal pellets, the green shore crab is an excellent model organism for testing edibility of this resource.

My goal is to determine if scavengers can benefit from spatial subsidies from drift algae indirectly, via fecal pellets of *S. franciscanus*. If drift algae are beneficial to consumers, are they still beneficial after they have been digested by urchins? If so, is there a preference for different fecal matter depending on whether the urchin has eaten red, green, or brown algae? Is there a preference between algae and fecal pellets? I will test these questions by feeding the urchin fecal pellets to *H. oregonensis* after the urchin has consumed different types of algae, as well as feeding the crab these different types of algae. I hypothesize that *H. oregonensis* will prefer the resource that is easiest to

consume, the fecal pellets. As for preference of type, I hypothesize that *Nereocystis* will be preferred in both trials due to its low phenolic content, or antigrazing compounds (Chenelot & Konar, 2007).

## **Methods**

### *Feces Production*

Six *S. franciscanus* were collected by divers from the San Juan Islands and placed into six separate “urchin outhouses”. These “outhouses” are 5 gallon buckets with holes drilled in the sides for water flow and grates placed a few inches below the bottom to allow for undisturbed accumulation of fecal pellets. Buckets are placed in dark seawater tanks with good flow, bricks on top to prevent floating and escaping animals, and a lid on the tank to prevent diatom growth. Two urchins were fed *Nereocystis luetkeana*, two *Mazzaella splendens*, and the other two *Ulva spp.*, all freshly collected off the Friday Harbor Labs docks. Two urchins per algal species allowed for maximized fecal production. After a week of feeding a regular diet of the respective algal type to each urchin, fecal pellets do not contain any other algal source, having enough time for other species to pass through their system.

### *Feces Preparation*

Feces were collected with a turkey baster without disturbing the urchins. Fecal pellets were concentrated under vacuum using a Millipore vacuum filter and a 140  $\mu\text{m}$  mesh pre-filter placed over a 0.22  $\mu\text{m}$  filter. Resultant damp feces were scraped off the filter and weighed.

### *Feces Preference Trial*

Three *H. oregonensis* of similar sizes were collected from the Friday Harbor Labs shoreline and starved for 24 hours (Table 1). Carapaces were measured at the widest point and crabs were placed in 400 mL plastic containers. Containers were filled with filtered seawater and each of the three types of feces was added to a separate container. Crabs were allowed to feed for 24 hours. Using a pointed dissecting tool, clumped feces were separated into pellet form or smaller particles. Containers were placed in a temperature controlled room with an aerator positioned to prevent escaping animals. Five trials were completed, each one with all three species.

#### *Algae Preference Trial*

*Nereocystis*, *Mazzaella*, and *Ulva* were collected fresh off the dock, patted dry with kimwipes and weighed. Pieces of each type were cut to the same weights. Experimental set-up and duration was the same as in the feces preference trial. Each alga was added to a corresponding container, with *Mazzaella* cut into two pieces, *Ulva* three, and *Nereocystis* remaining in one.

These trials test the hypothesis that there is preference of algal type in both feces and undigested algae. An analysis of variance (ANOVA) was used to compare consumption rates of the three types of feces, as well as species of algae. Welch's t-test was used to compare consumption rate of fecal pellets and the corresponding algae.

## **Results**

#### *Feces Trial*

In comparing feces consumed per algal type, there is a small difference between the treatments (Fig. 1). *Nereocystis* was the most consumed, with *Ulva* the next most, and

*Mazzaella* the least, however, the difference was insignificant between the treatments (ANOVA,  $p=0.86$ ).

#### *Algae Trial*

In trials of undigested algae, there was a large difference of algae consumed between the species (Fig. 2). A significantly greater amount of *Nereocystis* was consumed than *Ulva* or *Mazzaella* (ANOVA,  $p = 0.0147$ ). Significantly more *Nereocystis* was consumed than *Ulva* (pair-wise comparison,  $p = 0.0094$ ). A similar pattern was observed for *Nereocystis* versus *Mazzaella* (pair-wise comparison,  $p = 0.0109$ ), but no difference was observed between *Ulva* and *Mazzaella* (pair-wise comparison,  $p = 0.929$ ).

#### *Feces Versus Algae Trial*

Significantly greater amount of feces was consumed compared to algae (Fig. 3). It is significant in comparing *Mazzaella* feces versus algae (t-test,  $p = 0.0023$ ), and *Ulva* feces versus algae (t-test,  $p = 0.0075$ ). The next significant were *Nereocystis* feces versus algae (t-test,  $p = 0.045$ ).

### **Discussion**

My results show that shore crabs don't have a strong preference for algal type after it has been passed through the digestion of the red sea urchin, which implies that if given fecal pellets a shore crabs will consume it no matter what type, compared to algae prior to consumption, where the crabs have a strong preference for *Nereocystis*. This combined with the results of far greater consumption of *Nereocystis*, *Mazzaella*, and *Ulva* as fecal pellets over the undigested algae reveals that the shore crabs significantly prefer red sea urchin feces to algal blades. This implies that algae are a better food source for the crabs once digested by an urchin. Crabs with delicate tipped chelae have a preference

for filamentous forms of food rather than foliose (Kennish and Williams, 1997), which could be a factor in the green shore crab diet. Scavengers or even particular herbivores are more likely to benefit from algae as a spatial subsidy if transported into their habitat as feces. In Nova Scotia it is seen that sea urchin feces represent a significant source of organic matter for benthic populations in rocky subtidal zone and nearby sedimentary habitats (Sauchyn et al. 2011).

As a spatial subsidy, drift algae have a significant affect on marine ecosystems, both subtidal and intertidal (Britton-Simmons et al. 2009). This development of fecal pellet preference is important in the studying of spatial subsidies, showing that whether or not red sea urchin feces are spatial subsidies on their own, they are at least a link to the spatial subsidy of drift algae through the digestive system with 40% to 80% of macronutrients in algae remaining in feces (Mamelona and Pelletier, 2004). In a similar habitat as the red, the green sea urchin has been shown to have a significant role in the production of particulate organic matter within nearshore benthic ecosystems, and it is a potentially nutritious food source for detritivores (Mamelona and Pelletier, 2004).

In conclusion, this study exhibits how spatial subsidies that begin as drift algae, are caught by herbivores to then continue through their digestive systems and on to creating a potentially important food source for other organisms. Though not quite a spatial subsidy on their own, feces are a link in spatial subsidy energy flow from macrophytes to smaller invertebrates in subtidal, and possibly intertidal, zones.

### **Acknowledgements**

I would like to thank my mentor, Dr. Megan Dethier, for all the guidance and inspiration in intertidal ecology she gave me through out this project. Thank you to Alex

Lowe and Morgan Eisenlord for their knowledge and assistance with a variety of methods with animals. The Nearshore Ecological Research Experience advisors also deserve recognition for support and helpful suggestions throughout the quarter: Dr. David Duggins, Hilary Hayford, and Katie Dobkowski. Thank you to the University of Washington Provost and Friday Harbor Labs for the beneficial facilities in a valuable location for this study. And finally, thank you to the Mary Gates Endowment for the generous contribution to my education.

### **Literature Cited**

Britton-Simmons, K. H., G. Foley, and D. Okamoto. 2009. Spatial subsidy in the subtidal zone: Utilization of drift algae by a deep subtidal sea urchin. *Aquatic Biology* 5:233-243.

Chenelot, H. and B. Konar. 2007. *Lacuna vincta* (Mollusca, Neotaenioglossa) herbivory on juvenile and adult *Nereocystis luetkeana* (Heterokontophyta, Laminariales). *Hydrobiologia* 583:107-118.

Duggins, D. O. and J. E. Eckman. 1997. Is kelp detritus a good food for suspension feeders? Effects of kelp species, age and secondary metabolites. *Marine Biology* 128(3):489-495.

Kennish, R., and Williams, G.A. 1997. Feeding Preferences of the Herbivorous Crab *Grapsus Albolineatus*: the Differential Influence of Algal Nutrient Content and Morphology. *Marine Ecology Progress Series* 147: 87-95. Print.

Lowe, A. T., Whippo R., Galloway, A.W.E., Britton-Simmons, K. H. and Dethier, M. N. Sedentary urchins influence benthic community composition below the macroalgal zone. *Marine Ecology*. In Review.

Mamelona J., Pelletier E. 2004. Green urchin as a significant source of fecal pellet organic matter within nearshore benthic ecosystems. *Journal of Experimental Marine Biology and Ecology*, **314**, 163-174.

Morris, R. H., Abbott, D. P., and Haderlie, E. C. 1980. *Intertidal Invertebrates of California*. Stanford, CA: Stanford UP. Print.

Polis GA, Anderson WB, Holt RD. 1977. Toward an integration of landscape and food web ecology: The dynamics of spatially subsidized food webs. *Annual Review of Ecology and Systematics*;28:289-316.

Sauchyn L.K., Lauzon-Guay J.-S., Scheibling R.E. 2011. Sea urchin fecal production and accumulation in a rocky subtidal ecosystem. *Aquatic Biology*, **13**, 215-223.

Vadas RL. 1977. Preferential feeding – optimization strategy in sea-urchins. *Ecological Monographs*;47(4):337-371.

Van Alstyne, K.L., J.J. McCarthy III, C.L. Hustead, and L.J. Kearns. 1999. Geographic variation in polyphenolic levels of Northeastern Pacific kelps and rockweeds. *Marine Biology* 133:37

Figure 1.

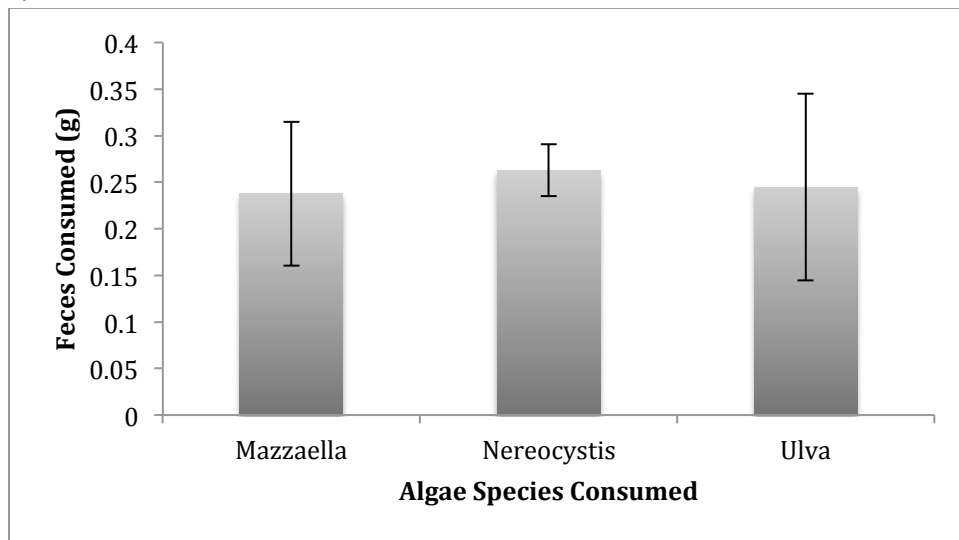


Figure 1. shows amount of fecal pellets consumed in grams per algae species. Insignificant difference between treatments (ANOVA,  $p=0.086$ )

Figure 2.

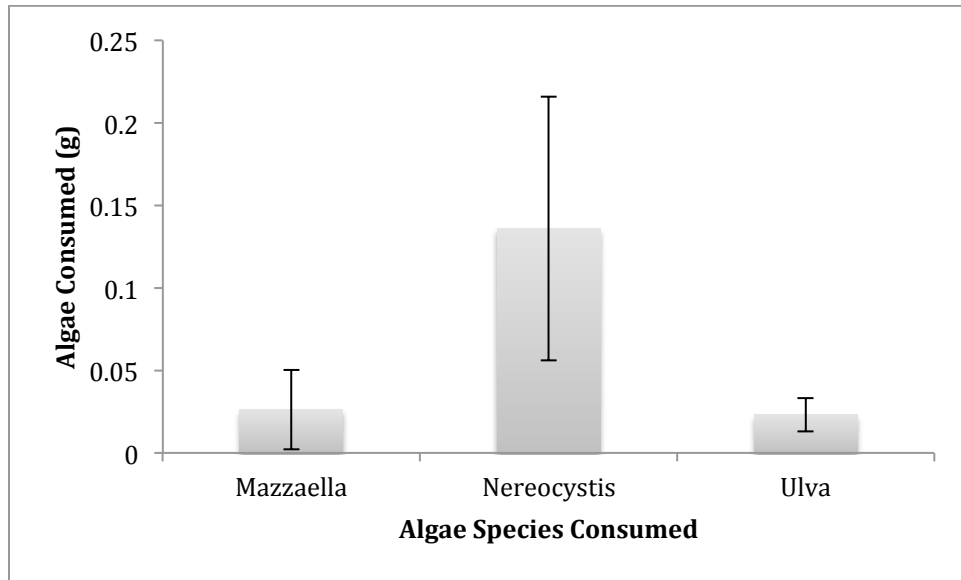


Figure 2. shows algae consumed in grams per algae species. Significant difference between treatments (ANOVA,  $p=0.0147$ ).

Figure 3.

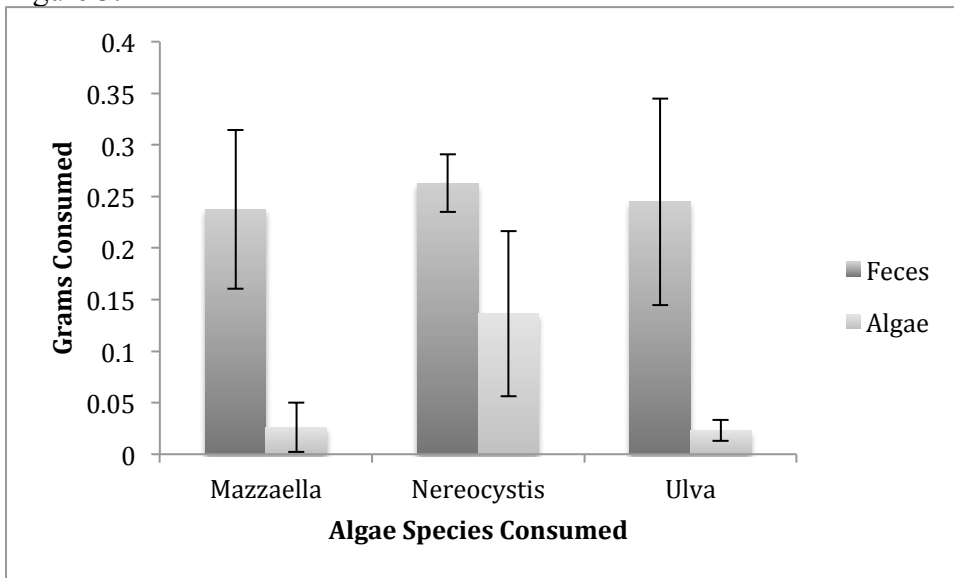


Figure 3. shows comparison of feces consumed versus algae consumed. Significant difference between treatments (t-test,  $p = 0.0023$  *Mazzaella*,  $0.0075$  *Nereocystis*,  $0.045$  *Ulva*).

Table 1.

Trial Type	Trial Number	Average Width (n=3)	Standard Deviation
Feces	1	1.38	0.0235
Feces	2	1.4	0
Feces	3	1.33	0.0125
Feces	4	1.45	0.0707
Feces	5	1.68	0.0236
Algae	1	1.42	0.0236
Algae	2	1.4	0.0408
Algae	3	1.46	0.0471
Algae	4	1.65	0.0707

Table 1. shows average width and standard deviation of green shore crab per trial type and trial number.