STRENGTH OF SEA URCHIN HERBIVORY AND CONDITION FROM BIOGEOGRAPHIC TO ORGANISMAL SCALES

JUAN PABLO LIVORE

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Dedicated to Maria Eugenia and Mya with all my love.

Cover image: *Heliocidaris erythrogramma* in South Australia on a limestone reef that supports high local densities. Photo in cover image: Nicholas Payne

DECLARATION OF AUTHORSHIP

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List of published works:

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- Livore, J.P. & Connell, S.D. 2012. Fine-scale effects of sedentary urchins on canopy and understory algae. J Experimental Marine Biology and Ecology **411**: 66-69

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ABSTRACT

Amongst the many ecological processes that can have an influence on community structure within marine ecosystems, herbivory is recognised as having an important role. Algae are not only living components of the community, they often provide a physical structure, food and protection indispensable for many other species. Therefore, understanding herbivore behaviour and their effects on the surrounding habitat is vital to further comprehend benthic marine ecosystem dynamics. Strength of herbivory is often determined by simple numbers of individual herbivores. There are however, other factors that may influence herbivore feeding behaviour such as food quantity and quality. Changes in food availability can have a strong influence on the dynamics of consumers that rely on allochthonous sources as their main supply of energy. I tested the hypothesis that a decrease in *per capita* food supply to a sedentary herbivore has a negative effect on herbivore condition and also affects the surrounding habitat through changes herbivore feeding behaviour. The reduction in food supply had a negative influence on herbivore gonad condition, whilst concomitant increases in consumer density caused greater foraging of the surrounding habitat. Poor consumer condition can be the result of food limitation and in some cases can lead to stronger herbivory. This process could help explain barrens creation across many subtidal rocky coasts.

Ecological traits may have a stronger influence on population and community dynamics than currently acknowledged; particularly sedentary herbivores that may be incapable of migrating to alternate environments. I assessed the effects of origin of food and its frequency of delivery on sea urchin behaviour and condition. Higher consumption rates and poorer condition were associated with food originating from sheltered coasts; coinciding with observations of urchin over-grazing in this type of environment. Whilst algae derived from exposed coasts caused lower consumption rates and better condition; coinciding with no urchin over-grazing on exposed reefs. Understanding such trait-mediated responses to allochthonous food may assist the

development of more comprehensive models that account for variation in strength of herbivory.

Many studies have focussed on foraging of canopy-forming algae by sea urchins associated with barrens, however, foraging effects of urchins not associated with barrens is less clear. I tested the hypothesis that the sedentary (largely site attached) sea urchin *Heliocidaris erythrogramma* has detectable effects on the canopy-forming and understory algae. In a location where densities were at the upper limits of their range of a region that lacks sea urchin barrens, algal cover was estimated beneath and immediately around sea urchins. The area under the urchins was consistently bare rock. Sea urchin removal experiments showed that canopy-forming algae were able to develop in greater covers after 16 months and approached those in areas that naturally lacked urchins. In the area immediately surrounding the sea urchins, turf-forming algae dominated the first 5-6 cm, whilst at 8 cm canopy-forming algal cover matched areas without urchins. Cover of canopy-forming algal can be reduced in the presence of non-barren forming urchins, albeit only within a few centimetres of individual urchins. This suggests that such organismal-scale effects may have an influence on the ecology of rocky coasts with dense populations of these urchins (e.g. sheltered coasts).

In conclusion, strength of herbivory can depend on many factors that vary across a broad range of scales. In this thesis, I provide knowledge on some of the factors associated with herbivory by the purple sea urchin, *Heliocidaris erythrogramma*. I show that herbivore abundance and condition which can directly affect strength of herbivory vary at regional (i.e. Eastern Australian Current v. Leeuwin Current) and local scales (i.e. sheltered v. exposed coasts). I also demonstrate that drift-algal quantity and origin can have a strong influence on sea urchin condition and feeding behaviour. Finally, the organismal scale effects (i.e. centimetres) may not only be detectable but also influential at some places and scales. Together, these results suggest that populations of herbivores, their condition and impact, may have predictable effects from local through regional scales. The integration of such dependencies to general models may contribute to a more comprehensive understanding of rocky subtidal ecosystems.

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