Bannister, Raymond (2008) ***The ecology and feeding biology of the sponge Rhopaloeides odorabile.*** **PhD thesis, James Cook University.**

The ecology and feeding biology of the sponge *Rhopaloeides odorabile*

Thesis submitted by

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July 2008

for the degree of Doctor of Philosophy
in the School of Marine and Tropical Biology
James Cook University

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Research funding for this PhD study was provided through the Australian Institute of Marine Science, James Cook University Research Advancement Program – Finfish and Emerging Aquaculture, CRC Reef. A James Cook University Postgraduate Award provided stipend support.

Acknowledgements

First and foremost, I would like to acknowledge both of my supervisors, Professor Rocky de Nys and Dr Chris Battershill. Throughout the duration of my candidature, Rocky has been an excellent supervisor, providing enthusiasm, endless support and an open attitude, which has resulted in a remarkable student-mentor relationship. Thank you for your encouragement and high motivation, without which the completion of this PhD thesis would not have been possible. Chris, thank you for many delightful discussions on sponge ecology and providing me with a greater understanding of experimental design and statistical analysis. Your support and assistance with underwater field surveys and sample collection whilst at sea was also invaluable. Also, thank you to Dr Raphael Wust. He always had his door open for me when I needed advice. He also provided interesting discussions on marine sediments and their impacts on benthic habitats, sparking future research ideas and topics.

I would also like to thank all members of the de Nys lab over the past four years, especially Steve Whalan, Nick Paul, Piers Ettinger-Epstein, Andrew Scardino and Michael Horne, who have provided in-depth scientific discussions and an enjoyable working environment. Thank you to the many volunteers that have helped me in the field and the laboratory. I would especially like to thank all my diving volunteers that have spent countless hours underwater with me and many more putting up with my fading sense of humour during extended periods of time isolated at Orpheus Island Research Station. These volunteers included Rod Hidlebaugh, May-Helen Holme, Adam Mills, Steve Whalan, David Bourne, Rebecca Fox, Dommie Loong, Andy Cole, Daniel Louden, Chris Ryen, Kate Markey, Carsten Wolff and Alan Duckworth.

Thank you to several researchers at James Cook University and other institutions, who have provided me with technical assistance or access to scientific equipment to collect and analyse my data. These people included Dr Raphael Wust, Dr Heiner Korner, Dr Kirsten Heimann, Dr Joe Holtum, Dr Adele Pile, Dr Ken Anthony, Dr Mia Hoogenboom, Professor Mike Kingsford and the Advanced Analytical Center (AAC) at James Cook University. Thank you to all the staff at Orpheus Island Research Stations, especially, Anna, Ollie and Pete who would literally bend over backwards to fulfil my field trip requirements. I would also like to thank all the crew onboard the research vessels Cape Ferguson, and the recently decommissioned Lady Basten, who provided assistance throughout the duration of each cruise.

I would also like to thank Dr Nick Paul and Dr Jana Guenther for their assistance with statistical analysis, which was very much appreciated.

A special thank you to Rod Hidlebaugh, Rocky de Nys, Nick Paul, Andrew Scardino and Chris Glasson for the weekly competitive golf games. These games provided some comic relief from the stresses of being a PhD student.

Finally, I would like to thank my family. My beautiful fiancé Jana Guenther has supported me whole heartily throughout my candidature, despite my frequent 12-day trips away in the field. She has provided me with much love and support and an enormous amount of encouragement over the last four years, and without her by my side this thesis would have been an even greater uphill battle. I would also like to thank my parents, Steve and Rhonda, for their support and encouragement throughout my studies.

Abstract

On large coral reef systems like the Great Barrier Reef, with a significant cross shelf component throughout most of its length, sponges inhabit a broad range of benthic habitats, from shallow water turbid coastal reefs to clear water oceanic reef systems. The structure of sponge assemblages differs taxonomically and morphologically across these varied benthic habitats, responding to environmental conditions and reflecting the prevailing biophysical character. Despite these differences sponges as a group constitute a critical component of the benthos across all these habitats, providing structural rigour, and contributing to benthic-pelagic nutrient fluxes. Sponges also provide a substrate for the settlement and refuge of other benthic organisms and are a host to a large diversity and biomass of symbiotic microorganisms. Despite the importance of sponges within these habitats our understanding of population distributions and the key environmental parameters that influence and maintain them is in its infancy. This knowledge is fundamental to conservation and management of marine benthic environments.

The abundance, size and depth distribution of the sponge *Rhopaloeides odorabile* was quantified within inner-, mid- and outer-shelf reef locations across the continental shelf of the central Great Barrier Reef (GBR), Australia using belt transects. There was a clear gradient in the abundance, size and depth distribution of *R. odorabile* across all reefs sampled, with mean abundances on mid- (20.3 ± 2.2 individuals.250 m^{-2}) and outer-shelf reefs (22.6 ± 6.4 individuals.250 m^{-2}) being more than three times greater than inner-shelf reefs (6.2 ± 2.4 individuals.250 m^{-2}). In addition, although not statistically different, the mean size of *R. odorabile* on outer-shelf reef locations (4236.3 ± 941.9 cm^3) were larger than *R. odorabile* on inner- (3096.3 ± 1394.2 cm^3) and mid-shelf reef locations (2323.8 ± 548.3 cm^3), with *R. odorabile* preferring to inhabit deeper habitats on mid- and

outer-shelf reef locations (8 to 12 m) than inner-shelf reef locations (<8 m). These distinct differences between shelf locations may be driven by differences in environmental gradients across shelf locations, in particular light availability, sedimentation and food availability.

Variation in light, sediment and food are key factors structuring the distribution, abundance and physiology of many sessile marine invertebrates in benthic habitats, particularly those harbouring symbiotic (possibly phototrophic) microbial symbionts. Photophysiology results for *R. odorabile* individuals from inner-, mid-, and outer-shelf reef locations, demonstrate that light availability does not physiologically regulate the size and depth distributions of *R. odorabile* across shelf locations. Photophysiology experiments identified that regardless of their origin, *R. odorabile* individuals collected across inner-, mid-, and outer-shelf reef locations did not photosynthesise or possess any photopigments. Therefore, *R. odorabile* does not acquire energy requirements by way of photosynthesis, showing that in terms of energy acquisition light availability does not influence size and/or the depth distribution of *R. odorabile* across shelf locations.

To quantitatively determine the impact of sedimentation and the role of sediment grain size and mineralogy on the ecology and physiology of *R. odorabile*, suspended sediment was sampled monthly across winter (Austral tropical dry season) and summer (Austral tropical wet season) at different locations including Pelorus Island (inner-shelf reef), Rib Reef (mid-shelf reef), and Pith Reef (outer-shelf reef). Regardless of month sampled, up to 32% of the volume of sediment on inner-shelf reefs was dominated by fine clay sediments (mean grain size 24.4 ± 5.7 μm), in contrast to mid and outer shelf reefs where less than 3% of the volume of sediments were fine clay sediments and instead sediments are dominated by coarse biogenic materials (mean grain sizes of 126.6 ± 30.5 μm and 214.3 ± 33.4 μm, respectively) (carbonate sediments). Decreasing sediment grain size and increasing clay content of suspended sediments towards the coast corresponded with the decreasing abundance, size and reduced depth distribution of *R. odorabile* towards the coast.

Food availability and the retention efficiency of ultraplankton cell types <3 μm were quantified for *R. odorabile* across inner-, mid- and outer-shelf locations. Across these shelf locations, *R. odorabile* was exposed to a broad range of ultraplankton cell types, including heterotrophic bacteria, *Prochlorococcus* spp., *Synechococcus* – type cyanobacteria and picoeukaryotes <3 μm. Food availability was more abundant on inner-shelf locations than outer-shelf locations, including picoeukaryotes <3 μm, the main planktonic food source for *R. odorabile*. Picoeukaryotes were retained preferentially with high efficiencies and these efficiencies are consistent across shelf locations (inner-shelf, 95%; mid-shelf, 87%; outer-shelf, 92%). Given the higher abundance of picoeukaryotes <3 μm on inner-shelf reefs, *R. odorabile* at these reefs assimilated 1.5 times more carbon (8.38 ± 0.10 μg $C.l^{-1}$) and nitrogen (1.34 ± 0.02 μg $N.l^{-1}$) than on mid-shelf reefs (5.23 ± 0.84 μg $C.l^{-1}$, 0.84 ± 0.13 μg $N.l^{-1}$), and 3 times more carbon and nitrogen than outer-shelf reefs (2.71 ± 0.90 μg $C.l^{-1}$, 0.44 ± 0.15 μg $N.l^{-1}$). Paradoxically, *R. odorabile* retains significantly more carbon and nitrogen in the form of picoeukaryotes on inner-shelf reefs than mid- and outer-shelf reefs, however, *R. odorabile* are not larger or more abundant on inner-shelf reefs. This may be explained by a metabolic 'trade-off' from increased energetic costs for *R.odorabile* living in high sediment inshore environments exposed to fine clay sediments.

Experimental manipulation of sediment grain size and mineralogy on the respiration rate of *R. odorabile* demonstrated unequivocally that fine clay sediments (mean grain size 3.1 ± 0.1 μm) increase the respiration activity from baseline respiration rates by 35% during short-term exposure (7 hours) and up to 43% during long-term exposure (4 days). Visual observations also identified that exposure to fine clay sediments induce the production of mucus on the external surfaces of *R. odorabile*, whilst the shutdown of sponge oscula was also evident. Therefore, exposure of *R. odorabile* on inner-shelf reefs to fine clay suspended sediments that are absent on mid- and outer-shelf reefs increases their metabolic costs, which may be responsible for reduced abundance and sizes of *R. odorabile* on inner-shelf reefs. This suggests that inner-shelf reefs provide sub-optimal habitat conditions for *R. odorabile*. These higher energetic drains in inshore environments may result in energy normally utilised for growth and reproduction being diverted to maintenance and survival, resulting in lower reproductive output, smaller individuals and subsequently lower abundance. These findings highlight the importance of identifying the key environmental parameters linked with anthropogenic change on the dynamics and structure of an important component of the benthic community.

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