The ecology of the grazing urchin *Echinometra mathaei* at Ningaloo Marine Park.

PhD Thesis: Mark W Langdon BSc (Hons)

Murdoch University

May 2012

Declaration

I declare that this thesis is a record of my own research and contains work that has not been presented for the award of any degree at another tertiary institution.

.....

Mark W Langdon

May 2012

Abstract

Sea urchins can have a significant influence upon the ecological structure of coral reefs through both bioerosion of substrata and by affecting competition for space. Loss of reef structure can limit space for algal and coral recruitment which further alters the balance between reef growth and reef destruction. Urchins are important grazers in many marine systems and can cause major ecosystem changes when their numbers reach high levels (generally after a decline in the numbers of their fish predators). However, the relative importance of the role of urchins in influencing the composition and structure of coral reef habitats has rarely been explored.

This thesis investigated the habitat preferences, distribution, grazing, bioerosion, and behaviour of the grazing urchin *Echinometra mathaei* at Ningaloo Marine Park (NMP), Western Australia. Coral reef habitats of the NMP were characterised using field surveys and validations of broad-scale hyper-spectral benthic habitat maps; the effects of habitat type and different closure regimes (e.g. Sanctuary zones) on urchin distribution and abundance were then examined and compared. This thesis represents the first study to quantify the grazing and consequent bioerosion rates of *E. mathaei* at Ningaloo Reef and the first to study their animistic behaviour and diurnal movement patterns.

Data were collected from over 100 sites within the Marine Park, focussing on near shore, lagoonal and back reef areas within Sanctuary zones and adjacent Recreation zones. Data analyses indicated that the distribution of urchins was variable and appears not to be affected by the management zones of the park (i.e. no significant evidence has been found of indirect effects from fishing of known urchin predators).

However, habitat type had a major influence on urchin distribution; urchin abundances were higher on nearshore intertidal and sub-tidal reef platforms, lagoonal patch reefs and shallow backreef platforms than in other habitats. Data analysis showed strong positive correlations between urchin densities and habitats that contained turf algae, and a combination of limestone pavement and turf algae.

Grazing and bioerosion studies demonstrated that although *E. mathaei* grazing plays an important ecological role, concomitant bioerosion may play a more central role in influencing the structure of coral reef communities than grazing at the NMP. Urchin, morphometrics and gut content analyses from different habitats in four regions of the NMP indicated higher mean urchin densities, size and subsequent bioerosion rates in southern regions than in the north of the park. Bioerosion rates from Ningaloo Reef (1.0 - 4.5 kg m^{-2} $year^{-1}$ of $CaCO_3$) were found to be comparable to degraded (overfished) reef systems in other parts of the world, but without accurate estimates of $CaCO_3$ accretion rates it is difficult to determine the degree to which bioerosion is affecting reef growth at the NMP or if it is any more or less significant than in other parts of the world. Results from this study suggest that habitats at Ningaloo with high *E. mathaei* densities are more likely to be niche habitats that co-exist with other coral reef habitats as part of a healthy ecosystem.

Video footage of diurnal movement revealed that *E. mathaei* did not leave their burrows to graze but were systematically “gardening’ turf within longitudinal burrows at night and sheltering from predators during the day. Observations of animistic behaviour experiments showed that they would also defend their burrows when threatened by intruding conspecifics but the majority of interactions would result in

urchins coexisting in the same longitudinal burrow. This type of territorial grazing behaviour within long, tube-like burrows has been documented for other urchin species (e.g. the northern Atlantic echinoid, *E. lucunter*) but never for *E. mathaei.* Defence of (and sharing of) longitudinal burrows may also be associated with other predation avoidance behaviour.

Acknowledgements

Firstly my heartfelt thanks go to my supervisors, Dr Mike van Keulen and Dr Erik Paling. Their combined wealth of knowledge and experience was an invaluable source of advice, encouragement and support throughout the past four years. As director of Coral Bay Research Station, Mike provided the materials and means to conduct my field research at Ningaloo. Between field trips his door was always open at Murdoch to answer my never ending questions. Many thanks to Erik for "going in to bat' for me during the initial developmental stages of my thesis and ensuring funding to complete the project and for ongoing support. Thanks also to both Mike and Erik for valuable feedback and editing of this thesis. I value your advice and your friendship.

Special thanks to Kimberly Marrs-Ekamper for her assistance in the field surveys on numerous trips in 2008. Thanks to Frazer McGregor at CBRS for field operations support as well. Thanks also to Dr Halina Kobryn and Dr Nicole Pinnel for providing charts and images for the mapping validation work. To my friend Steve Cossington, thank you for your hard work and assistance with the cage experiments. Special thanks to my dear friend and colleague, Natalie Toon for her guidance and assistance with the underwater video system and for her help with data analysis. I also wish to thank my good friend and research assistant Fionna Cosgrove for her support, expertise and her smiley face on the many field trips that she participated in during this project.

To Taryn Foster, Matt Belsar, Hannah Rice, James Raeside, Courtney Wood, Jane Melvin, Abby Mitchell, Chloe Bird and the many other volunteers and technical staff that assisted with the field and laboratory work; thank you all very much for your

support. I also wish to acknowledge Professor Neil Loneragan, co-ordinator of the Ningaloo Collaboration Cluster for his guidance in the initial phases of the project and CSIRO's Wealth from Oceans Flagship, for partly funding this project.

Lastly, I wish to give special thanks to my best friend, my wife Pam. Her enduring patience, understanding and support in the field and at home over the past four years has been amazing. It has been another challenging and rewarding journey for both of us.

Table of Contents

List of Tables

List of Figures