Habitats and Sessile Benthic Megafaunal Communities in the Mesophotic Zone of the Great Barrier Reef World Heritage Area, Australia

Thesis submitted by

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B.Sc. (Hons) University of Sydney

In June 2011

For the degree of Doctor of Philosophy

In the School of Earth and Environmental Sciences

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Declaration

I declare that this thesis is my own work and has not been submitted in any form for another degree or diploma at any university or other institution of tertiary education. Information derived from the published or unpublished work of others has been acknowledged in the text and la list of references is given.

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STATEMENT OF CONTRIBUTION OF OTHERS

Stipend Support:	School of Earth and Environmental Sciences and James Cook University co-funded scholarship
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Editorial Assistance:	Dr Terry Done Dr Robin Beaman Dr Jody Webster Dr Stefan Williams Dr Oscar Pizarro Mr Ariell Friedman Dr Katharina Fabricius Dr Carden Wallace Dr Paul Muir
Financial Support:	JCU School of Earth and Environmental Sciences JCU Graduate Research School Great Barrier Reef Marine Park Authority
Statistical Support:	Dr Yvette Everingham JCU School of Mathematical and Physical Sciences

STATEMENT OF CONTENT

The body of this thesis is presented as four separate, self-contained works. Each chapter has been published, submitted, or will soon be submitted to journals of international significance in a similar format. Due to the completeness of each section, a small amount of repetition is unavoidable. The four data chapters are followed by a discussion of the findings of the research that places this work in reference to both the research aims outlined in the introduction and its place in the broader scheme of the scientific body of knowledge.

ACKNOWLEDGEMENTS

Through the course of my PhD research I received assistance and advice from many people in many different places. In particular, I am indebted to my supervisory team, which grew and changed as my research progressed. Professor Peter Davies of Sydney University initially put me into contact with Dr Jody Webster, who initiated the project. These two men planned, organised and coordinated the 2007 research expedition on which my entire PhD project was based. I am very grateful to both of them for allowing me the opportunity to be part of such an interesting and innovative research project. Dr Robin Beaman passed on his extensive knowledge of marine remote sensing which proved extremely valuable throughout my PhD, and also provided detailed and insightful editorial comments on all my manuscripts. Finally, I am particularly grateful for Dr Terry Done. I was put it contact with Terry about a year into my PhD, and he immediately set me on a clear path. His knowledge of coral reef ecology is unrivalled and I am thankful to him for taking time out of his retirement so pass on some of his wisdom to me. Finally, I would like to thank Dr Scott Smithers, who took me on when Jody accepted a new position at Sydney University. Despite an incredibly busy schedule, Scott always made time to answer any supervisory questions I had or to comment on papers or presentations.

I am also very appreciative of the academic and administrative assistance provided by the School of Earth and Environmental Sciences, especially James Moloney, Adella Edwards, Raphael Wust, Kevin Parnell, Clive Grant, Rob Scott, Blake Hudson, Glenn Connolly, Melissa Crawford, Vivian Doherty and Beth Moore.

I would like to thank the following people and organizations who assisted me during my candidature: Katharina Fabricius, Chris Battershill, Andrew Heyward (AIMS), Carden Wallace, Paul Muir (Museum of Tropical Queensland), Stefan Williams, Oscar Pizarro, Ariell Friedman (Australian Centre for Field Robotics,

University of Sydney), John Guinotte (Marine Conservation Biology Institute), Dave Wachenfeld, Laurence McCook (Great Barrier Reef Marine Park Authority), Ari Stypel, Scott Hansen, Alex Brazenor and Michael Kramer (JCU student volunteers), Pim Bongaerts for his enthusiasm and ideas regarding mesophotic coral reefs, the captain and crew of the RV *Southern Surveyor* for their outstanding work in the field, and Erika Woolsey for her help processing all the samples while on board the ship. I am particularly thankful to the JCU School of Earth and Environmental Sciences, the JCU Graduate Research School, and the Great Barrier Reef Marine Park Authority for financial support.

Thank you to my student colleagues at JCU who made my PhD a (mostly) enjoyable experience; Alana Grech, Iain Faichney, Marissa Land, Liz Abbey, Deane Ludman, Olivier Bittar, Jim Austin, Damien Keys, Nick George, Nikki Browne, Jessica Stella and Ben Gordon. Thanks must also go to my non-student friends who have made my time in Townsville thoroughly enjoyable, particularly Ed Roberts, Simon and Heather, Greg Fenn, Amos Maplestone, and Steve Sutton who introduced me to freshwater fishing in the tropics and with whom I have shared some amazing adventures. Of course, I also thank the University Hawks football club; it was always therapeutic to be able to get out of the office for Tuesday and Thursday evening training and of course Saturday game-day and to run around and kick the footy. In particular, thanks to Febes, Irish, Cheese, Spanner, Clarkey, Flash, Jay, Dom, Mods, Stabs, B-rad, Ads Connell, Dodzy, Dingo, Gus, Jimmy, Joey Shaw, Juzzy, Crumpy, Philly and everyone else who made living in Townsville so much fun.

Finally, a special thanks to my family. Firstly, for giving me the opportunity to experience coral reefs and other wild places growing up and set me on my current career path. Secondly, for supporting me throughout my University study – both emotionally and financially!

ABSTRACT

The Great Barrier Reef (GBR) is the world's largest coral reef ecosystem, extending for over 2300 km along Australia's north-east coast. The Great Barrier Reef World Heritage Area (GBRWHA), one of the world's largest Marine Protected Areas, covers a total area of ~348 000 km2, approximately 7% of which is currently classified as coral reef habitat. The vast majority of this habitat occurs in shallow waters <30 m depth. These iconic shallow-water reefs are well known, however a lesser-known but extensive series of submerged reefs also occurs on the shoulder of the continental shelf to depths of ~130 m. These reefs provide a vast potential habitat for mesophotic coral reef ecosystems (MCEs), tropical coral reef communities that occur in the middle to lower photic zone. Although there has been a significant increase in research interest on MCEs in recent years, very few studies have focused on the Indo-west Pacific region, the epicentre of coral reef biodiversity, and the ecology of MCEs in the GBR remains virtually unknown. This thesis provides the first quantitative analysis of the ecology of mesophotic coral reef ecosystems in the GBRWHA.

Data were collected on a 3-week expedition on board the RV *Southern Surveyor* in September-October 2007 at four sites along the GBR outer-shelf: the Ribbon Reefs (approximately 15˚S), Noggin Pass (17˚S), Viper Reef (19˚S) and Hydrographers Passage (20˚S). The surveys combined high-resolution multibeam bathymetry with over 57 000 Autonomous Underwater Vehicle (AUV) images, and samples collected by dredging from 50 to 150 m water depth. The specific scientific objectives of the study are to (1) examine the diversity of sessile benthic megafauna (SBM) occurring on MCEs in the GBRWHA and compare them to adjacent shallow-water reefs; (2) identify how SBM communities change along a depth gradient and to identify geophysical variables which explain the observed variation; (3) identify how SBM communities change along the length of the GBR outer-shelf in response to a range of environmental variables; and (4) to develop models to predict the distribution of SBM taxa and

communities and use them to estimate the total amount of mesophotic reef habitat in the GBRWHA.

In general, the diversity of phototrophic (zooxanthellate) taxa is highest in shallower waters <70 m depth, and diverse communities of heterotrophic taxa (particularly octocorals) occurs on deeper reef habitats from 90-120 m. Although some Scleractinia represent species only occurring in deep water, many species are also common inhabitants of shallow-water reef habitats. In contrast, many of the heterotrophic octocoral taxa occurring on mesophotic reefs are rare or absent from shallow-water habitats. Several Scleractinia and Octocoral taxa recovered during the expedition represent the first records from the GBR.

Vertical zonation of reef communities was clearly evident, with shallow areas (50-60 m depth) inhabited by a community comprised predominantly of phototrophic taxa, including zooxanthellate Scleractinia and Octocorallia and the phototrophic sponge *Carteriospongia*. Benthic communities below 75 m depth were comprised largely of heterotrophic suspension-feeders, primarily azooxanthellate octocorals but also containing sponges and black corals (order Antipatharia). There was also a transitional community comprising both phototrophic and heterotrophic taxa occurring in 60-75 m depth. The distribution of sessile benthic megafauna was strongly correlated to reef habitat, with sandy non-reef habitats exhibiting low abundance and diversity of megafauna.

Random sampling of images at a standardised depth (50-65 m) from Noggin Pass, Viper Reef and Hydrographers Passage revealed diverse communities of sessile benthic megafauna at all sites but significant variation in community composition both within and between each site. However, there were consistent patterns in the functional ecological groups occupying different finer-scale habitat types; in general, phototrophic taxa occupied the flatter tops of reefs while heterotrophic suspension-feeders occurred on steep walls of submerged reefs.

Reduced light irradiance on steeper slopes combined with low ambient light levels at mesophotic depths probably excludes phototrophic taxa from reef walls.

Predictive habitat suitability models indicate the GBR shelf contains over 10 000 km^2 of habitat which may potentially be inhabited by MCE communities. Habitat for phototrophic communities occur both on the submerged reefs of the outer-shelf and also on the deeper flanks of reefs inside the GBR lagoon, while heterotrophic communities are more confined to deeper reefs (90-120 m depth) along the outer-shelf. The models indicate that the outer-shelf of the GBR may be inhabited by extensive MCEs, and so including MCEs as “reef” habitats may increase the amount of reef habitat within the GBRWHA by ~40%.

This thesis provides the first quantitative study of MCEs in the GBR, indicates that MCEs in the GBR warrant further study, not only on their SBM but also on their fish and mobile invertebrate communities. In addition to containing unique ecological communities, MCEs may also provide important ecosystem services including sites for fish spawning aggregations and also by acting as refugia for corals and associated species from environmental stress, such as warm-water bleaching events and severe tropical storms. With shallow-water coral reefs predicted to be strongly affected by climate change in coming decades, MCEs should be given greater attention by both scientists and managers.

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