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**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

James Cook University



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**2011**

# STATEMENT OF SOURCES

## 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 Information derived from the published or unpublished work of others has been acknowledged in the text and a list of references is given.

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*Tom Bridge*

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*2011*

## STATEMENT OF CONTRIBUTION OF OTHERS

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## **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.

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## 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 km<sup>2</sup>, 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<sup>2</sup> 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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