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Resilience and Recovery of Coral Communities on an Isolated Reef System in Western Australia Following a Catastrophic Mortality Event

Thesis submitted by

Luke Darren SMITH B.Sc. (Hons) JCU

In December 2005

For the Degree of Doctor of Philosophy

In the School of Marine Biology and Aquaculture at

James Cook University

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Statement of the contribution of others

During my postgraduate studies, overall supervision was provided by Professor Terry Hughes (TPH) and Dr Andrew Heyward (AJH). This research was primarily funded by Australian Institute of Marine Science.

Other collaborations: Numerous people have assisted with my PhD research over the years; many by providing simulating intellectual input (see Acknowledgements). However, some have co-authored research papers that resulted from my postdoctoral research.

Chapter 3: James Bird undertook the modelling to hindcast the water temperatures at Scott Reef in 1998. Steve Delean provided assistance with statistics. TPH, and AJH provided editorial and research input. Currently, a paper is in preparation (see Appendix 1, research paper #13).

Chapter 4: TPH and AJH and James Gilmour provided editorial assistance and intellectual input. Currently a paper is in review (see Appendix 1, paper #11).

Chapter 5: Max Rees and AJH and James Gilmour provided input into this chapter and are co-authors in the resultant research paper (Appendix 1, paper #9).

Chapter 6: Steve Delean assisted with the statistical analysis. My supervisors contributed to the intellectual work. This chapter forms part of a research paper that is in review (see Appendix 1, paper #12).

Chapter 7: Richard Brinkman assisted in downloading and representing the drogue track data.

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Abstract

Coral reefs are increasingly exposed to disturbances acting over a range of spatial scales. At a global scale, there is growing concern that a changing climate will affect the long-term health and resilience of coral reefs. Climate change is predicted to increase seawater temperatures and cause extensive and recurrent mass bleaching of corals. In 1998, seawater temperature anomalies in the world's oceans affected a large proportion of coral reefs, many of which suffered catastrophic levels of mortality. This thesis provides quantitative data on the direct impacts of a severe bleaching event at an isolated reef system, Scott Reef in northwest Australia, during the actual period of elevated seawater temperatures and in the months and years following it. I assess the recovery of coral communities in the five years following the disturbance, including the changes in recruitment, benthic cover and population size-structures. Overall, this thesis provides a key dataset to further our understanding of the impacts of severe bleaching events on coral communities and the processes of replenishment and recovery.

While many studies have documented the patterns of bleaching among species of corals at the time of elevated sea-water temperatures few have shown how these patterns of bleaching vary during the period of elevated sea-water temperatures and directly following it. To determine the short- and longer-term effects of bleaching on the community structure of corals, I quantified the changes in the percentage cover of different taxa, three and six months after a mass-bleaching event, at the Scott Reef system. The overall result of the mass bleaching event at Scott Reef was a major shift in community structure from one dominated by a diverse range of scleractinian and alcyonarian corals to one dominated by turf and coralline algae. It resulted in the death of the majority of zooxanthallae corals at all of the study locations at Scott Reef, with relative decreases in the mean cover of hard corals of between 75% and 89%, depending on the reef habitat and depth. In addition, major differences were seen in the timing of mortality between different genera of corals.

In addition, I investigate how the severe bleaching event at the Scott Reef affected recruitment rates of corals, and consequently, the resilience of the resident coral communities. Coral cover and rates of sexual recruitment were quantified from two years before to five years after the bleaching event. The mass mortality of hard corals in 1998 caused a 97% decrease in recruitment rates at the Scott Reef system decreasing from a mean of 39.1 (± 12.6 *s.e.*) recruits yr^{-1} prior to the beaching to a mean of 1.3 (± 0.2 *s.e.*) after it. I attribute this decline in coral recruitment to both the extent and severity of the bleaching and the loss of reproductive corals on Scott Reef, and the isolation (> 240 km) of the reef system. Satellite-tracked drogues released in the region showed larval transport times to the Scott Reef system are likely to be greater than 25 days, longer than the optimal competency period for most coral larvae.

To understand changes in percent coral cover I measured the changes in the number of colonies of different size and/or stage classes of three common groups of corals at the Scott Reef system. The data showed that the bleaching event affected all life stages (ie juvenile, small adults and large adults) of each coral group surveyed. In addition, the number of juvenile corals in the families Acroporidae and Pocilloporidae five years after the bleaching was unexpectedly high, given the very low rates of recruitment.

To elucidate the recovery of the reef communities at Scott Reef I quantified the changes in their structure over nine years; four years before and five years after the catastrophic bleaching event. Almost six years after the bleaching, percentage cover of hard corals had returned to approximately 40% of their pre-bleaching cover and the community was returning to its previous percent cover, with evidence of an increasing rate of recovery in the later years. In fact, coral communities at some monitoring sites had almost returned to their pre-bleaching precent cover by 2003. It is likely that the survival and growth rates of corals at the Scott Reef system are relatively high. As a consequence, the coral communities are recovering, and at a faster rate than would be predicted, based in the severity of the bleaching event and the reduction in coral recruitment rates. In part, I attribute this recovery to the lack of many anthropogenic stressors that reduce the population growth rates of corals and promote the growth of competitors. These results suggest the resilience of coral communities to extreme, but infrequent (decadal) disturbances, and highlight the potential extent to which human activities may be compromising this resilience elsewhere.

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