THE INFLUENCE OF CORAL DEGRADATION ON TROPICAL FISH COMMUNITY STRUCTURE

Thesis submitted by

David A. Feary (B.Sc, M.Sc)

in March 2007

For the degree of Doctor of Philosophy

In the School of Marine and Tropical Biology

James Cook University

STATEMENT OF ACCESS

I, the undersigned, author of this work, understand that James Cook University will make this thesis available for use within the University library, and via the Australian Digital Thesis network, for use elsewhere.

I understand that as an unpublished work, a thesis has significant protection under the Copyright Act, and I do not wish to place further restriction on access to this work.

	25/6/08
Signature	Date

ABSTRACT

Coral reefs harbour a spectacular diversity of fishes that derive food and shelter from the habitat provided by living corals. Unfortunately, both natural and anthropogenic disturbances are intensifying the global alteration and loss of live coral cover. The likely impacts of this loss on reef associated fish communities have yet to be fully assessed. The broad aim of this thesis was to examine the processes and mechanisms underlying the effects of live coral reductions on coral-associated reef fish communities. A combination of surveys and experimental manipulations were used to explore this relationship for both the fish community as a whole, and key components that represented species with differing associations with live coral.

To examine the role of coral disturbance in structuring diverse coral reef fish communities, I surveyed and compared assemblages associated with 2 coral species (*Seriatopora hystrix* and *Pocillopora damicornis*) in 3 health states (live, degraded and dead colonies with algal cover) (Chapter 2). This study showed that despite differences in the structure of assemblages associated with live and degraded colonies between coral species, there were similar patterns in reef fish community change with coral death. Assemblages associated with dead, algal-covered colonies of both coral species held virtually no coral obligates, while coral-specific differences in obligate abundance were apparent between live and degraded colonies. There was a shift in the diversity of reef fish communities between health states, within both coral species. Live and degraded colonies were numerically dominated by coral-associated fishes while dead, algal-covered colonies were numerically dominated by fishes closely

associated with non live-coral habitats. The total abundance of species was lowest in algal-covered colonies of both coral species, largely due to the low number of small size classes (new recruits and juveniles) associated with the habitat. Overall, this study has shown that coral health will play a substantial role in structuring reef associated fish assemblages, though the effects of coral loss on fish communities will be dependent on coral species and the taxonomic and functional composition of its associated fish assemblage

Within Chapter 2 I found that dead, algal-covered colonies held substantially lower abundances of fishes in small size classes (i.e. new settlers and recruits) than live or degraded colonies. Historically, disparity in coral reef fish community composition has been attributed to ecological factors affecting patterns of reef fish larval settlement. However, the mechanisms that determine how new settlers will respond to coral stress and the repercussions of coral loss in structuring reef fish communities are poorly understood. In Chapter 3, therefore, I examined the role of coral degradation in structuring patterns of coral reef fish settlement. Within aquaria choice experiments, reef associated damselfishes (both coral and non-coral associated) avoided dead, algal-covered colonies, preferentially settling into either live or partially degraded colonies. Using a habitat-limited recruitment model, such avoidance of algal-covered habitats at settlement was predicted to substantially alter patterns of reef fish settlement. I hypothesised that settlement of coral-associated fishes would become habitat-limited within degraded reef landscapes, with new settlers unable to find suitable settlement habitat. Consequently, an extensive field experiment showed that live coral colonies formed important settlement substratum for a range of reef associated fishes. *In situ* experimental live coral degradation on

small coral colonies led to rapid reductions in the abundance of coral-associated fishes settling into the colonies (2 - 4 weeks after disturbance), replaced by extremely low abundances of species closely associated with the algal biomass. From these experiments, I argued that the abundance and diversity of new settlers apparent within coral habitats would reflect the health of the ecosystem; live coral alteration and loss leading to reduced new settler abundance and a phase shift in new settler diversity within the degraded habitat.

The response of reef fish communities to coral degradation and algal overgrowth was species and functional group specific (Chapter 2). However, there were higher than expected levels of resistance to coral degradation within a range of coral-associated fishes (Chapter 2). Applying terrestrial-based theory, I hypothesised that such differences in resistance were potentially influenced by species habitat specialisation (Chapter 4). Habitat specialists were more likely to remain within degraded coral colonies than generalists, due to their lowered ability to successfully migrate between habitats. Within Chapter 4, I compared the resistance and migration ability of both habitat generalist and specialist coral-dwelling goby species (Gobiidae). At low levels of coral loss specialists exhibited a higher propensity to remain in colonies than generalists, though there was no difference in resistance at both medium and high levels of coral loss. Over the majority of distances examined, specialists also showed substantially lower levels of successful migration. These results suggest that specialists are more likely to become isolated in degraded habitats than generalists, increasing the probability of their decline with habitat degradation. I argue that if this pattern holds true for the array of coral-associated reef fish species, such disparity in response to live coral disturbance between specialists and generalists

may result in disproportionate reductions in the population abundance of habitat specialists in degraded habitats.

Although species-specific differences in live coral dependence were likely to influence how fish assemblages responded to live coral loss, within Chapter 2 I showed that the abundance of a diverse range of coral-associated fishes were not substantially lower in degraded than live coral colonies. Recent evidence suggested that even with no observable change in abundance, however, reduced resource availability in degraded habitats may have negative effects on resident fishes physiological condition. Therefore, within Chapter 5, I compared the growth, condition and persistence of 2 planktivorous damselfish species (Pomacentridae) over 29 days, translocated onto coral colonies in 3 experimental treatments: live, partially and fully degraded colonies. This research showed that both species growth rates were directly related to live coral cover; populations associated with fully degraded colonies showed the lowest growth while those associated with live colonies the highest. There was no significant change in the condition or persistence of populations, between treatments. These results suggested that the short-term response of coral-associated reef fishes to low live coral were reductions in growth rather than condition or absolute abundance. I argued that such bottlenecks in the growth rate of fish species associated with degraded habitats may negatively influence their time to maturity, fitness and lifetime fecundity.

The results of this thesis have fundamental implications in understanding the response of coral reef fish communities to increasing levels of live coral degradation. Fluctuations in species replenishment, differences in the resistance of individuals

dependent on their habitat specialisation, and reductions in the growth of individuals remaining in degraded habitats will significantly affect the structure of the reef associated fish community within degraded reef systems. Ultimately, the alteration and loss of the living coral tissue will play a substantial role in structuring tropical reef fish community structure.

INDEX

ACKNOWLEDGEMENTS

I would like to thank my supervisors, Geoffrey Jones, Mark McCormick and Glenn Almany for their patience and perseverance in developing this project and seeing it through from (many convoluted) ideas to publication. I would also like to thank Phil Munday for his many insightful discussions along the way.

I am indebted to the staff of Mahonia Na Dari Research and Conservation Centre, Kimbe Bay for their enthusiasm and support of my research in Papua New Guinea. I especially would like to thank Anaseini Ban for keeping me guessing every day of the week, Lorna Romaso for her help and enthusiasm for my (what must have seemed bizarre) experimental ideas and especially my dive site finder and all round great boat driver, Blazius Ponde. I would also like to wholeheartedly thank Max and Cecile Benjamin at Walindi Dive Resort, Kimbe Bay for their support and generosity. At Lizard Island, I thank Lyle and Ann for their hospitality.

I am deeply grateful to the many field assistants that have worked with me during my doctorate. I was very fortunate to have both Lisa Peacock and Tina Knight work with me at Lizard Island, while my work in Papua New Guinea greatly benefited from having Chris Denny, Dan Godoy, Jenny Pickering and Schannel van Dijken with me along the way.

This research would not have been possible without the financial support from the Australian Coral Reef Society, the Great Barrier Reef Marine Park Authority,

Mahonia Na Dari Research and Conservation Centre, Walindi Plantation Resort and The Nature Conservancy.

I have been extremely lucky to have had such an amazing group of friends during my time in Townsville. I am indebted to both James Moloney and Joshua Cinner, my first two flatmates and the purveyors of many excellent parties at 40 Stokes Street. Thanks also to Matt Fraser, Alana Grech, Dean Miller, James Sheppard, Vanessa Ramirez and many others that have made my time in Townsville so exciting. My heartfelt thanks also to Di for being such an important part of my life in Australia.

Lastly, for their moral, psychological and financial support I would like to sincerely thank my family for backing my decision to remain within the University system for another 4 years. The many phone calls, e-mails, packages of chocolates and presents in Townsville and the enthusiasm and tears at seeing me on my (unfortunately too frequent) flying visits through Auckland, have kept me going throughout my time.

STATEMENT OF SOURCES

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 institutions 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.

25/6/08

Signature Date

STATEMENT OF CONTRIBUTION OF OTHERS

I declare that this thesis is my own work, and has been supported by the following organisations and people. The field budget was funded by the Australian Coral Reef Society, Great Barrier Reef Marine Park Authority, Mahonia Na Dari Research and Conservation Centre, Walindi Plantation Resort and The Nature Conservancy. Additional support for the project was provided by a James Cook University Merit Research Grant to Dr M.I. McCormick and an Australian Research Council Discovery grant to Professor G.P. Jones.

Financial support for university fees and living expenses were funded through a James Cook University Postgraduate Research Scholarship (JCUPRS) and by departmental scholarships from the School of Marine and Tropical Biology, James Cook University.

Editorial contributions to this thesis were provided by my supervisors, Geoffrey Jones, Mark McCormick and Glenn Almany.

25/6/08

Signature Date

DECLARATION OF ETHICS

The research presented and reported in this thesis was conducted within the guidelines for research ethics outlined in the *James Cook University Policy on Experimentation Ethics, Standard Practices and Guidelines* (2001), and the *James Cook University Statement and Guidelines on Research Practice* (2001).

	25/6/08
Signature	Date

ELECTRONIC COPY OF THESIS FOR LIBRARY DEPOSIT

I, the undersigned, the author of this work, declare that the electronic copy of this thesis provided to the James Cook University Library is an accurate copy of the print thesis submitted, within the limits of the technology available.

_____	25/6/08
Signature	Date

TABLES

FIGURES