THE IMPORTANCE OF LIVE CORAL HABITAT FOR REEF FISHES AND ITS ROLE IN KEY ECOLOGICAL PROCESSES

Thesis submitted by

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Statement on the contribution of others

This thesis included some collaborative work with Prof. Morgan Pratchett, Prof. Philip Munday, Dr. Nick Graham, Dr. Shaun Wilson, Dr. Aaron McNeil and Dr. Stefan Walker. While conducting these collaborative projects, experimental design, data collection, technical analysis and ecological interpretation were primarily conducted by me. My collaborators provided intellectual guidance, financial support, and assistance with fieldwork, technical instruction and editorial assistance. Aside from standardised formatting for the thesis, chapters three, four and six have been presented as published.

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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 Practise* (2001).

This project was approved by James Cook University Animal Ethics review committee. Research was conducted under animal ethics: A1682, A1594, A1272, and A1185.

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Abstract

Climate change is having major impacts in all the world's ecosystems. On coral reefs, the most conspicuous and devastating effects of climate change relate to widespread bleaching and resulting mortality of key habitat-forming corals. This, in turn, has affects on reef fishes that recruit, feed and shelter on live corals. Bleaching events often cause declines in abundance and diversity of coral associated fishes, but the proximate causes of these declines remain largely unknown. Specifically, it is unclear why coral-dwelling fishes disappear from bleached coral hosts, even though these corals continue to provide a physical habitat structure. The purpose of this research is to document the importance of live coral habitat for reef fishes, in order to understand the likely effects of coral loss caused by current and ongoing climate change.

Critical first steps to understanding the effects of coral depletion on reef fishes is to establish the range of fishes that associate with live coral habitats, and to determine which species of corals are most important as habitat. Chapter 2 combines a comprehensive literature review with independent field surveys to directly record fishes that use live coral habitats. A total of 320 different fish species, representing approximately 8% of reef fishes globally, were recorded to use live coral habitats. These fishes, from 39 different families, used a wide range (93 species) of different corals. However, reef fishes mainly used branching corals from Acroporidae and Pocilloporidae families. This study shows that many species of reef fish will be affected by extensive coral loss, especially considering that the corals most important in providing habitat are among the most susceptible corals to both biological and physical disturbances.

Coral bleaching initiates a sequence of changes in the biological and physical structure of habitat-forming corals, although the degradation of physical habitat structure can take several years. Yet well before major structural degradation transpires, coral-dwelling fishes often decline in abundance on bleached or dead corals even though they would still be expected to offer protection from predators. The aim of Chapter 3 was to test for changes in predation risk among i) healthy coral colonies, ii) bleached, but living coral colonies, iii) recently dead coral colonies, and iv) dead coral colonies that had been colonised by algae. *Psedochromis fuscus*, a common predatory reef fish, was found to avoid bleached and recently dead habitats, but targeted prey fishes on habitats with degraded pigmentation more than fishes on healthy coral habitats. This suggests that fish are visually more vulnerable to predators when associated with bleached and recently dead coral habitats. Direct measures of predation showed a decline in prey fish survivorship with declines in habitat condition from healthy through to algal covered habitats (75-58% respectively). This shows that bleached and algal covered habitats provide reduced protection for coral-dwelling fishes from predators. Moreover, the growth of algae, sponges and other invertebrates that colonise dead coral skeletons reduce access to the valuable refuge spaces and limit their ability to effectively avoid predators and explains why these habitats are often devoid of coral-dwelling fishes.

While coral-dwelling fishes typically associate with a single host colony, changes in habitat structure and increased exposure to predators following coral bleaching may provide strong motivation for fishes to vacate degraded habitats and relocate to alternative healthy habitats. Chapter 4 investigated the response of a common coral-dwelling fish (*Dascyllus aruanus*) to host coral bleaching and the loss of their coral habitat. Following host coral bleaching there was no movement of fish from corals that bleached but retained their live tissue cover. In contrast, 67% of fish vacated dead but structurally intact corals and migrated

to neighbouring healthy coral colonies. Manipulative experiments revealed that selection of new habitats by relocating fishes was largely influenced by the presence of conspecifics. These results suggest that coral-dwelling fishes have the capacity to move between habitats and therefore the ability to withstand moderate levels of host coral depletion. However, with disturbances predicted to become more severe and widespread, the availability of alternative habitats becomes reduced and the distance between healthy habitats increases. This may further reduce the potential to relocate and therefore mediate habitat loss.

Many coral-dwelling fishes live in stable and hierarchically organised social groups. Therefore, it is likely that intra-specific competition will have a strong influence on the success of displaced fishes in colonising new habitats. Chapter 5 used manipulative experiments to explore intra-specific competition and colonisation of new habitats by the coral-dwelling damselfish, *D. aruanus*. Relatively few individuals (11%) were able to successfully join existing groups of conspecifics, with neither group-size nor body-size distribution predicting their success. Resident individuals similar and slightly larger in size than the intruding fish displayed the greatest levels of aggression, possibly because these individuals have the most to lose if the intruder gains entry. Competition between displaced individuals and group members will substantially reduce population resilience through relocation among coral-dwelling fishes following habitat degradation.

The recovery of fish communities following biological and physical disturbance is important in order to maintain key ecological functions. Many studies have independently investigated the effects of live coral cover and structural complexity on fish recruitment, but little is known about the combined effects these two factors. Chapter 6 involved manipulation of patch reefs to investigate the combined effect of high, medium and low live coral cover and high and low structural complexity on reef fish recruitment. In the first month following establishment of patch reefs, there were significant differences in abundance and diversity of

recruiting fishes among the six treatments, but there was no consistent difference through time. However, species composition showed significant differences among the different habitat treatments. Overall, live coral cover drove the differences, with coral-dependent species recruiting to high coral and high complexity reefs, and rubble-associated species recruiting to degraded reefs. SIMPER analysis revealed that some species of fish with no obvious dependence on live corals, still recruit preferentially to patch reefs with high coral cover. This suggests that some non-coral dependent species depend on live coral at recruitment and emphasizes that healthy live coral habitat can also be important for fishes that have no obvious dependence on live coral in their adult stage for recruitment.

This thesis elucidates the importance of live coral for reef fishes. It demonstrates that many reef fish species currently rely on live coral as a habitat. Among these coral-dependent fishes, it identifies key ecological processes that are affected once the coral habitat becomes degraded. Taken together, the findings of this thesis suggest that a degraded biological and physical structure of reef habitat may significantly affect a wide range of reef fishes, potentially undermining the success of key ecological functions. Such a scenario has far reaching implications towards the biodiversity and productivity of coral reef ecosystems, and therefore the goods and services they provide.

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