**Halford, Andrew Robert (2010)** ***Disturbance effects on tropical reef fish assemblages at large spatial and temporal scales.*** **PhD thesis, James Cook University.**

# Disturbance effects on tropical reef fish assemblages at large spatial and temporal scales

Thesis submitted by

Andrew Robert Halford (B.Sc.) JCU, Qld.

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## Statement on the Contribution of Others

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# General Abstract

Since the early eighties, when non-equilibrium dynamics became accepted as an intrinsic part of ecological systems, considerable research effort has been invested towards understanding the effects of disturbance on community dynamics. Coral reefs, being one of the most diverse environments on the planet and subject to many varied disturbances are a particularly appropriate system for investigating disturbance effects. Current models of community dynamics incorporate emergent properties of ecosystems, with smaller-scale, non-equilibrium dynamics fitting into a larger framework of hierarchical patch dynamics, metapopulation dynamics, landscape ecology and macroecology. To more fully understand how meta-communities function however, requires a combination of empirical and theoretical studies that bridge the gap between smaller scale field experiments and larger scale phenomena that are presently explored mostly by theory. The need to fill the knowledge gaps at these "in-between" scales was highlighted by the extent of the circum-global bleaching in 1998. A renewed focus on landscape scale dynamics is required to try and understand how, and ultimately whether, entire reef systems are likely to survive such large scale disturbances. This thesis is one of the first examples to use such an approach on coral reefs.

Using a consistent protocol I monitored fixed sites annually, for a period of 10 years, on three reef systems that were fundamentally different from each other in size, location and structure. What these systems did have in common however, was that they all suffered an extreme disturbance event at some time during their monitoring. Reefs in the Capricorn Bunker Sector of the southern Great Barrier Reef suffered extreme storm damage to their north-east flanks which effectively removed the benthic communities back to bedrock. Scott Reef off the north-west shelf of Australia suffered catastrophic levels of coral mortality from the bleaching event of 1998; while Coral Bay,

part of a fringing reef system on the mid-west coast of Australia, suffered severe mortality of many organisms as a result of coral spawn induced anoxia.

The coral and fish assemblages of the Capricorn Bunkers recovered to their pre-impact levels after a period of approximately 10 years. Their recovery was coherent among numerous reefs spread over 80 km, providing evidence of stability at large scales of space and time. This result was one of the first empirical tests of the resilience of meta-reef systems to natural disturbance. In comparison, given its relative isolation it was predicted that the Scott Reef system would struggle to recover from the bleaching event of 1998. It has however, displayed a similar level of resilience to catastrophic disturbance as the reefs in the southern GBR. These results are some of the first to provide evidence of the efficacy of the metapopulation model to explain dynamics on isolated reef systems. Moreover, these results also provide a comprehensive set of baseline conditions with which to compare other such isolated reef systems in the future. In contrast to the other two systems the recovery at Coral Bay has been somewhat slower with the coral and fish assemblages remaining considerably changed from their pre-impact structure some 13 years after the disturbance.

The resilience displayed by reefs in the southern GBR and Scott Reef off the northwest coast was underpinned by the availability of healthy coral and fish assemblages adjacent to the disturbed areas. The availability of these healthy areas was a consequence of firstly, the inherent patchiness of disturbance effects and secondly, the presence of significant reef areas below those depths usually subject to disturbance. This contrasts strongly with other reef systems like the Seychelles which lack significant reef areas at depth and have not recovered from the 1998 bleaching event. On the other hand, the coral reef community at Coral Bay had not recovered over the same time frame despite the availability of healthy reef communities in adjacent areas. This delayed recovery was the result of a recruitment bottleneck to the affected areas which is, in turn, the result of a raised ridge of live and dead coral running across the middle of the bay which impedes water flow.

The lack of recovery in Coral Bay highlights the significance of 'local' conditions in the population dynamics of coral reef communities. These local conditions are prevalent at all reef systems and are not just confined to physical differences in the shape and structure of reefs but may also include differences in the population dynamics of individual species. Localised upwelling effects at Scott Reef played a significant part in conferring resilience to the 1998 bleaching, allowing cooler water to moderate the effects of the warm water mass sitting over the reef. There were also a number of species that responded to the bleaching in the opposite direction to what had been recorded from other reef systems. For example, the territorial, herbivorous damselfish *Plectroglyphidodon lacrymatus* responded positively to the bleaching at Scott Reef whereas it was found to have declined across numerous other similarly disturbed systems. While the reasons for these differences are not clear they nevertheless highlight the fact that there is no single set of predictions applicable to the response of coral reef communities to disturbance with species-, reef-, region- and ocean-specific patterns prevalent. In the search for general principles of coral reef dynamics this can often be overlooked.

The work contained within this thesis reinforces the role of monitoring programs as an essential tool for gathering the long-term and large-scale datasets required to validate current models of community dynamics. Such programs provide a level of detail that periodic assessments can not and in doing so offer considerable insights into the processes driving the observed patterns. The 1998 bleaching event and the scale of predicted disturbance scenarios have highlighted the significant knowledge gaps that exist at intermediate scales. These gaps need to be filled to enable more rigorous testing and validation of metapopulation models. Such models will be vital for troubleshooting and understanding future climate change effects on entire reef systems

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