

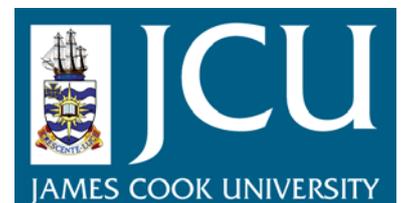
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Disturbance effects on tropical reef fish assemblages at large spatial
and temporal scales

Thesis submitted by

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In February 2010

For the degree of Doctor of Philosophy

In the School of Marine and Tropical Biology

James Cook University



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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

Chapter 1: General Introduction	1
Thesis Structure	4
Chapter 2: Resilience to large-scale disturbance in coral and fish assemblages on the Great Barrier Reef	7
Abstract	7
Introduction	8
Methods	12
Results	16
Discussion	27
Chapter 3: Towards an understanding of resilience in isolated coral reefs	34
Abstract	34
Introduction	35
Methods	38
Results	44
Discussion	54
Chapter 4: Shedding light on the detail: Species-specific responses to large-scale bleaching at Scott Reef	65
Abstract	65
Introduction	66
Methods	69
Results	71
Discussion	90

Chapter 5: Patterns of recovery in catastrophically disturbed reef fish assemblages	97
Abstract	97
Introduction	98
Methods	101
Results	105
Discussion	114
Chapter 6: General Discussion	123

List of Tables

Table 2.1 Methods used to collect benthic and fish data over the 14-year time span of this study. <i>Benthos</i> : LI - line intercept, MT- manta tow, VT- video transects <i>Fish</i> : Log ₅ -timed swims using an abundance scale, LTM – absolute transect counts. See text for references on each method.....	14
Table 2.2 Comparisons between pre- and post-impact fish abundance levels for the Capricorn Bunker reefs (impact) and the Swains reefs (reference). Significance is at $p \leq 0.05$. ns: not significant, —: no data available, ↓↑: direction of significant change...21	21
Table 2.3 Relative abundance of those species accounting for 90% of total abundance of chaetodontids and pomacentrids for 1984 (pre-impact), 1992 (immediate post-impact) and 1998 (9 years post-impact). Data is for Lady Musgrave (LM) and One Tree (OT) Island reefs. — : no individuals counted.....	25
Table 2.4 Percentage of variation in the abundances of dominant families and genera of reef fishes, accounted for by benthic cover and temporal trends in the multiple regression model. ns: not significant.....	26
Table 3.1 Correlations (Spearman's Rho) between fish and benthic assemblages at various taxonomic, temporal, and spatial scales of resolution. Benthic matrices were sqrt transformed and fish matrices were $\ln(x+1)$ transformed prior to any calculations. NB. 97-97 denotes the 1997 fish assemblage matrix correlated with the 1997 benthic matrix, 98-97 denotes the 1998 fish assemblage matrix correlated with the 1997 benthic matrix, etc. ns – non-significant Acan – Acanthuridae, Chaet – Chaetodontidae, Scar – Scaridae, Poma – Pomacentridae.....	51

Table 3.2. Index of Multivariate Dispersion (IMD) between pre-and post-bleaching surveys, for benthic, and fish assemblages at various taxonomic and spatial scales.....	53
Table 4.1 Results of the Linear Mixed Model analysis for species within the families Acanthuridae, Chaetodontidae, Scaridae and Pomacentridae. Planned contrasts for each post-impact year were against the mean and variance of all pre-impact years combined. The complete model contains 4 lagoon locations and 3 slope locations. L – Lagoon, S – Slope, WR – Whole Reef. Significance Levels - $p < 0.05$ (*), $p < 0.001$ (**), $p < 0.0001$ (***). NS – non-significant.....	75
Table 4.2 The first 3 eigenvectors (components) extracted from the Factor analysis of 15 Benthic variables, and the amount of variance they explain. These components were subsequently used as independent variables in hierarchical regressions with individual fish species abundance. Only vectors with an eigenvalue of >1 were chosen.....	79
Table 4.3 Loadings of individual benthic variables on the 3 extracted Factors. Only loadings > 0.6 were tabulated.....	80
Table 4.4 Results of Hierarchical Multiple Regressions of individual species abundance against the first 3 extracted factors from a PCA of 15 benthic variables. Results are interpreted in the context of loadings in Table 6. The amount of variance accounted for by each individual factor is expressed as an absolute percentage of the total explained variance, not a proportion. Negative percentages refer to the direction of the relationship between that factor and the dependent species. NS – No significant relationship at the $p < 0.05$ level of significance.....	81

Table 5.1 Relative abundance (%), by Treatment and Year, for all species within the families Acanthuridae, Chaetodontidae, Scaridae and Pomacentridae.....109

Table 5.2 Results of the Linear Mixed Modelling for the dependent variables of Hard Coral, Species Richness and Abundance of the 4 main fish families, and Abundance of selected species. Significant results are indicated by * $p < 0.05$, ** $p < 0.001$, *** $p < 0.0001$. Planned comparisons were made between years for each Treatment x Location combination with significant results annotated to the relevant graphics.....115

List of Figures

- Fig. 2.1** Location of the seven reefs surveyed at the southern end of the Great Barrier Reef, Australia..... 13
- Fig. 2.2** (a) Percentage cover of hard coral, soft coral and turf algae on 5 reefs in the Capricorn Bunker sector. Values are estimated means and 95% CI's calculated from the mixed linear models. (b) The relative contribution of the main hard coral morphologies to total coral cover in the Capricorn Bunker sector. Coral codes: M – massive, AT – *Acropora* tabulates, AS – *Acropora* submassives, B – branching, E – corals encrusting. (c) Percentage cover of hard coral from 3 reefs in the central Great Barrier Reef subject to a crown-of-thorns outbreak in 1983-84 (Williams D. McB, unpublished). Arrows indicate the timing of the disturbance..... 17
- Fig. 2.3** Video frames of the beginning of Site 1 at One Tree Reef in the Capricorn Bunker sector from (a) 1992 (b) 1996 and (c) 1998. This reef was one of the most badly damaged during the disturbance and this sequence illustrates the rapid regrowth of corals. 18
- Fig. 2.4** Species richness of Acanthuridae, Chaetodontidae, Scaridae and Pomacentridae in the Capricorn Bunker and Swains sectors between 1983 and 1998. No data were available between 1984-91. Values are estimated means and standard errors calculated from the mixed linear models. Arrows indicate the timing of the disturbance. 19
- Fig. 2.5** Abundance of selected fish species from reefs in the Capricorn Bunker and Swains sectors between 1983 and 1998. No data were available during 1984-91. Values are estimated means and standard errors as calculated by the mixed linear

models. Horizontal lines along the X-axis link years where the rate of change was significantly > 0 (at $p < 0.05$), in the Capricorn Bunker sector. Arrows indicate the timing of the disturbance.....23

Fig. 3.1 Location of Scott and Seringapatam Reefs off the NW coast of Australia and the position of the fixed monitoring sites at those reefs. The dashed line represents the edge of the continental shelf.39

Fig. 3.2 Dendrogram of the benthic assemblages for all location x year combinations sampled at Scott Reef. Clustering was hierarchical using group-average linking and based on Bray-Curtis derived similarity matrices. Sites are coded in the cluster analysis according to their habitat (L = lagoon, S = slope), followed by the location number nested within habitat (first digit), and sampling year (last two digits). The symbols represent the two habitat types and are individually shaded for each location within habitats (Δ - Lagoon locations, \circ - Slope Locations)44

Fig. 3.3 Percentage cover of a) Hard Corals and b) Turfing Algae between 1994 and 2003, within the lagoon and slope habitats. Vertical dashed line indicates time of bleaching. Error bars are one standard error of the mean46

Fig. 3.4 Non-metric MDS ordinations of the benthic assemblages at Scott Reef, from all location x year combinations. The ordinations used the same similarity matrices used for the clustering. The ordinations are plotted separately for lagoon (a) and slope (b) habitats for easier interpretation. Symbols and color coding pattern are as outlined in the dendrogram of Fig. 3.2. Arrows indicate the direction of change of these communities in multi-dimensional space.....47

Fig. 3.5 Rugosity of the benthic communities at Scott Reef. Data presented are from (a) 1997, immediately before the bleaching event, and (b) 2003, five years after the

bleaching event (***) ($p < 0.0001$). Groups of locations not sharing an overscore differed with the indicated probability. Location S3 was not surveyed in 2003 due to bad weather. See text for further details of methods used.48

Fig. 3.6 Cluster analysis of the fish assemblages from all location by year combinations sampled at Scott Reef. Clustering was hierarchical using group-average linking and based on Bray-Curtis derived similarity matrices. Sites are coded in the cluster analysis according to their habitat (L = lagoon, S = slope), followed by the location number nested within habitat (first digit), and sampling year (last two digits). The symbols are the same as for Fig. 3.2.....49

Fig. 3.7 Non-metric MDS ordinations of the fish assemblages at Scott Reef from (a) all location by year combinations, (b) the inner lagoon location L2 only, and (c) all location by year combinations except L2. Sizes of bubbles are proportional to the amount of hard coral cover in each location by year combination. The percentage coral cover present at each location in 1997, just prior to bleaching, is noted in the bubble for that year. L2 is presented separately to aid interpretation of relationships of the fish communities at the other locations. Arrows indicate the temporal progression of sampling, with the full sequence of sampling years depicted for L1.50

Fig. 3.8 (i) Relative abundance per species, (ii) Total family abundance and (iii) Species richness, for the Acanthuridae, Chaetodontidae Scaridae, and Pomacentridae in (a) lagoon and (b) slope habitats. (i) Relative Abundance: the shaded area delineates the $\pm 95\%$ confidence interval of the pre-bleaching abundances. Immediate ● - 1998 and longer-term ○ - 2003. post-bleaching abundances are overlaid on this confidence interval. (ii) Total Abundance: Abundance summed across species. The horizontal dashed lines delineate the 95% CI of pre-impact abundance. (iii) Species

Richness: a rarefaction curve with 95% CI, based on the mean abundance of species over the four years pre-impact is presented with the observed total abundance and species richness values for the 1998 and 2003 censuses plotted. Species abbreviations – see Appendix55-58

Fig. 4.1 Change in coral cover between 1997, 1998 and 2003, at all seven surveyed locations at Scott Reef71

Fig. 4.2 Pie charts indicating the percentage cover of 6 composite benthic categories, for the Lagoon (a) and Slope (b) habitats, immediately before the bleaching event (1997), 6 months after (1998) and 5 years after (2003). NB. CB – Branching corals, CE/CS – Encrusting and sub-massive corals, CM – Massive corals, CF – Foliose corals, TA – Turfing algae, SC – Soft corals. Percentage cover values have been rounded to the nearest whole percent.....72

Fig. 4.3 Three screen shots taken from video footage of the inner lagoon site of L2 from the years 1997, 1998 and 2001. The gradual breakdown in structure can clearly be seen.73

Fig. 4.4 Changes in abundance from pre- to post-bleaching for those species from the (a) Acanthuridae (b) Chaetodontidae (c) Scaridae and (d) Pomacentridae, identified as significant by the Linear Mixed Models. Abundance values are square root transformed estimated means (± 1 S.E.) as calculated by the linear mixed models.89

Fig. 5.1 (a) Location map of Coral Bay, Western Australia (b) Decomposing remains of fish and other organisms from the March 1989 coral spawning event in Bill’s Bay. (c) Recently killed fish from the April 2002 coral spawning event in the inner Control Bay.

The fish are parrotfishes and damselfishes. The reddish scum is coral spawn, with its colour indicative of how recent the mortality event was at the time the picture was taken. (d) The position of the survey sites within Bill's Bay and the Control Bay - the dashed lines indicate the outer extent of mortality caused by the two disturbances. The numbering of the survey sites in the Control Bay is the same as shown for Bill's Bay100

Fig. 5.2 (a) Hard coral cover by Treatment and Location, as estimated by the Linear Mixed Effects model. If transformation was necessary for the LME model analysis then transformed data was plotted. Significant differences between years for any given Treatment x Location are indicated thus * $p < 0.05$, ** $p < 0.001$, *** $p < 0.0001$; ● 1995; ○ 2002 (b) Spatial contour plots of hard coral cover within the Control bay and BILL's bay, for 1995 and 2002. The shading scale represents the percentage cover of hard coral. The dots indicate the positions of the survey sites within each bay..... 106

Fig. 5.3 Change in hard coral cover between 1995 and 2002, on the nine transects constituting the INNER Location within the Control bay (see methods for more details). The spatially patchy mortality effects of the 2002 coral spawn disturbance are evident..... 107

Fig. 5.4 Dendrogram illustrating the spatio-temporal relationships between the fish assemblages recorded at each site in 1995 and 2002. The abundance data matrix of 44 fish species was $\ln(x+1)$ transformed prior to calculation of Bray-Curtis similarities. Clustering was performed using UPGMA. The horizontal dashed line indicates four main groupings at 55% similarity. Colored symbols allow for easier comparison with the ordination of Fig. 5.5 111

Fig. 5.5 Non-metric Multidimensional Scaling ordination of all Site x Year combinations. The similarity matrix underlying the analysis was the same one used for clustering. The four main groupings identified from the dendrogram are encircled. Biplots of the eight

fish species most responsible for the observed patterns are superimposed – species were identified through the SIMPER routine in PRIMER (see methods for more detail).
 Das.arua – *Dascyllus aruanus*, Pgy.lacr – *Plectroglyphidodon lacrymatus*, Pom.molu – *Pomacentrus moluccensis*, Sca.micr – *Scarus microrhinos*, Sca.schl – *Scarus schlegeli*, Sca.sord – *Scarus sordidus*, Ste.livi – *Stegastes lividus*, Ste.obre – *Stegastes obreptus*. Symbol colours follow that of Fig.5.4. Numbers 1-9 represent site locations as identified in Fig. 5.1b 112

Fig. 5.6 Species richness of the families Acanthuridae, Chaetodontidae, Scaridae and Pomacentridae by Treatment and Location, as estimated by the Linear Mixed Effects Model. Legend is same as described in Fig. 5.2a 113

Fig. 5.7 (a) Abundance of fish species by Treatment and Location, as estimated by the Linear Mixed Effects model. Legend is the same as described in Fig. 2a. Only those species showing significant disturbance effects were plotted. 117

