Australian Government
Department of the Environment, Water, Heritage and the Arts

Marine and Tropical Sciences Research Facility Milestone Report, June 2009

Program 1: **Status and trends of species and ecosystems in the Great Barrier Reef**

Project 1.1.1: **Identification of indicators and thresholds of concern for ecosystem health on a bioregional scale for the Great Barrier Reef**

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Summary

Here we report statistical models of rates of recovery of coral cover for three of the four main types of benthic communities recorded in intensive surveys by the AIMS Long-term Monitoring Program. This is the most sophisticated analysis of recovery rates on coral reefs to date and will be the basis of an important paper. A manuscript is in preparation.

Agreed Project Outputs / Milestones

Targeted Activity
• Report on evidence for changes in disturbance regimes and rates of recovery on GBR reefs.
• Delivery of finalised products for integration into the e-Atlas (Project 1.1.5)

Project Results

Description of the results achieved for this milestone

Introduction

In their 2008 paper[1], Wakeford and others compared detailed information on the dynamics of the coral community from photographs of 32m^2 of reef front at Lizard Island from 1981 to 2003 with the predicted trajectories from a model of spatial dynamics of a coral community (C. R. Johnson's *Compete* model). In that time, the coral community suffered three acute disturbances (from bleaching, an outbreak of *Acanthaster planci* and a storm) and the study spanned three periods of recovery. The model could be fitted to the observed trajectory of coral cover and community composition by varying the model growth-rates, mortality and effects of interactions among corals. For the period 1981-1996, which included the first two cycles of disturbance and recovery, the best fits were obtained by varying model coral growth rates (reflecting size dependent growth and annual variability in growth rates), but in the later part of the study, the coral community recovered much more slowly and additional

[1] Wakeford, M., Done, T. and Johnson, C. (2008) Decadal trends in a coral community and evidence of changed disturbance regime. *Coral Reefs* 27: 113.

background mortality had to be included to obtain a satisfactory fit between the observed and the modelled trajectories. On this basis, the authors suggested that the disturbance regime at Lizard Island, and probably elsewhere on the Great Barrier Reef, had changed from infrequent, intense disturbances to include additional frequent, low intensity disturbances as well (adding background mortality).

The AIMS Long-term Monitoring Program (LTMP) has made intensive surveys of 47 reefs since 1993. In that time, the average reef in the data set has suffered one or two discernable disturbance events, and only ten of the 47 reefs were subject to more than two discernable disturbances, which means that the sample is too small to assess **changes** in frequency of disturbance, which was the original objective of the study. The data do allow estimates of coral recovery following disturbances of varying intensity. This is a subject of increasing relevance given the broad interest in 'resilience', which is usually defined in terms of the capacity of a system to recover, and the prediction that disturbances such as bleaching will become much more frequent in coming decades and storms will become more intense.

Methods

Using surveys of the fixed sites on LTMP reefs, 26 of the 47 core reefs had periods of increasing coral cover spanning more than five years. Past analyses (e.g. Ninio *et al.* 2000[2]) have used cluster analyses to distinguish groups of reefs that support different types of benthic community; the first four groups are (1) reefs dominated by *Acropora* spp, (2) reefs with a high proportion of soft corals, (3) reefs supporting mixed coral communities and (4) inshore reefs. Sustained recovery was only recorded on one inshore reef (Langford – Bird Island in the Whitsundays), so this reef was included with the 'Mixed coral' reefs.

Recovery was modelled using a Bayesian approach. The model involved logistic population growth based on the level of hard coral cover immediately following the disturbance (coded as Year 1), the maximum hard coral cover at a reef (K) and the rate of increase of coral cover (r). The last two components of the model were adjusted for reefs supporting each of the three benthic community types. Distributions of expected recovery times for each group of reefs were then generated using the modelled distributions of the growth parameters.

Results

The following graphs represent the distributions of recovery trajectories for reefs supporting the three types of benthic community. The X axis represents the time post-disturbance, the Y-axis represents the coral cover as a percent of the maximum cover recorded on that reef but starting at a fixed value of 10% absolute coral cover (note that the; thus if the maximum recorded coral cover was 35%, then 40% recovery on the Y-axis = 14% absolute coral cover.

Application of such results

Rates of recovery are of great interest to managers, for instance LTMP surveys of outer reefs of the Whitsunday sector following severe Tropical Cyclone *Hamish* in March 2009 found that reef-wide coral cover on Slate Reef had dropped from the highest recorded coral cover for that reef of 42% to 14% (33% of the maximum). Survey sites on this reef had benthic communities with a high proportion of soft corals, so Figure 2 shows the appropriate recovery trajectory. Fourteen percent absolute cover is 33% of maximum cover, corresponding to about post-disturbance Year 4 on Figure 2. Using the lower 95% confidence limit, we estimate there is 95% probability that total coral cover on the northeast face of Slate Reef will sixty percent of the pre-disturbance value after (13-4 =) 9 years.

[2] Ninio, R., Meekan, M. G., Done, T. J. and Sweatman, H. (2000) Temporal patterns in coral assemblages on the Great Barrier Reef from local to large spatial scales. *Marine Ecology Progress Series* 194: 65.

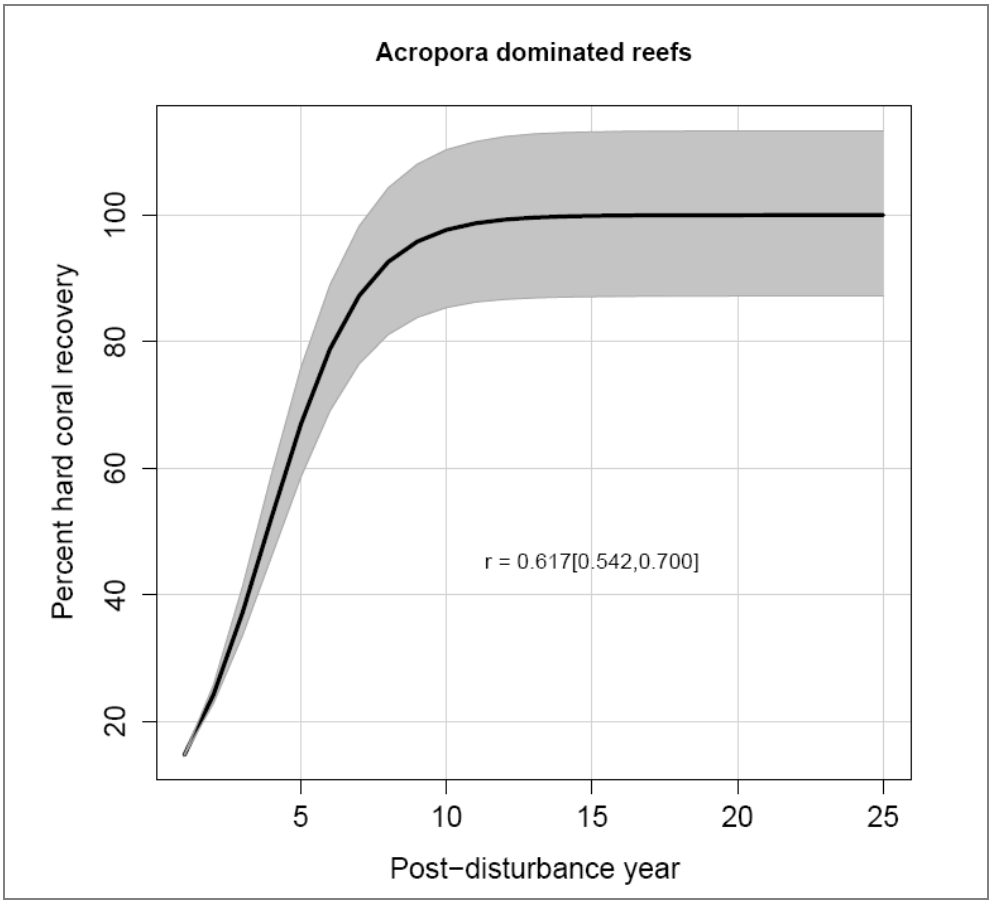

Figure 1: Predicted post-disturbance recovery of total hard coral cover through time for reefs with benthic communities including a lot of *Acropora* spp. Black line is Bayesian hierarchical fits from a logistic population growth model for reefs with this type of benthic community; shaded area represents the 95% credible trajectory for average hard coral cover through time. Note original data were from a maximum of fifteen years.

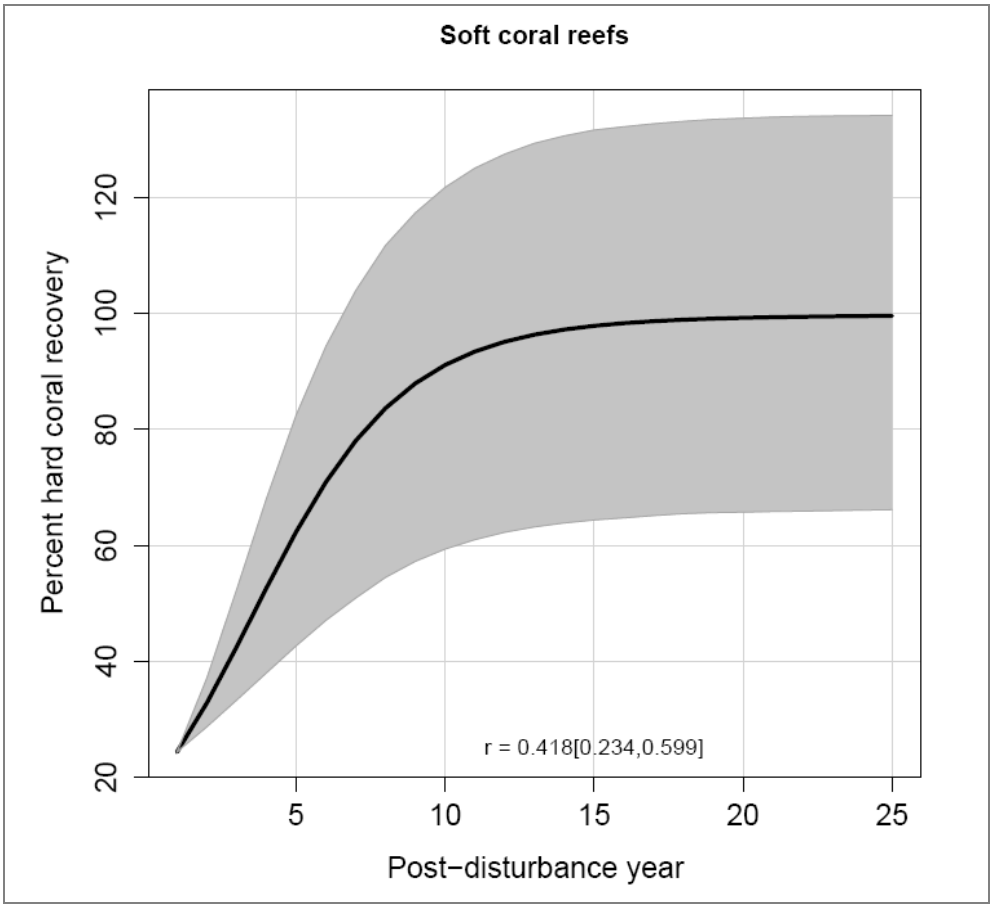

Figure 2: Predicted post-disturbance recovery of total hard coral cover through time for reefs with benthic communities with a high proportion of soft coral. Black line is Bayesian hierarchical fits from a logistic population growth model for reefs with this type of benthic community; shaded area represents the 95% credible trajectory for average hard coral cover through time. Note original data were from a maximum of fifteen years.

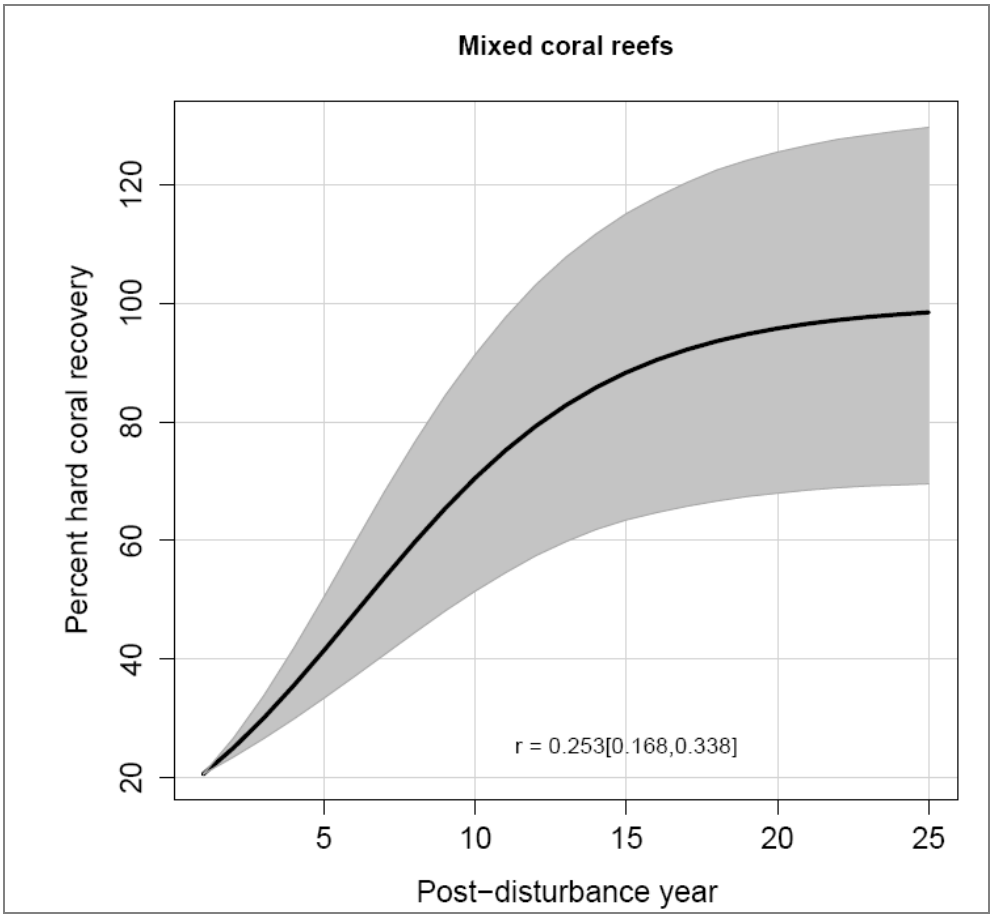

Figure 3: Predicted post-disturbance recovery of total hard coral cover through time for reefs with benthic communities made up of a mixture of coral species. Black line is Bayesian hierarchical fits from a logistic population growth model for reefs with this type of benthic community; shaded area represents the 95% credible trajectory for average hard coral cover through time. Note original data were from a maximum of fifteen years.

Explanation of activity changes

As described above, the focus of the study switched from looking for evidence for changes in disturbance rates (for which even the extensive LTMP data set is inadequate) to estimating recovery rates.

Problems and opportunities

This analysis of rates of recovery of benthic communities on coral reefs is probably the most sophisticated to date. We intend to submit a manuscript giving full technical details to a high profile journal in the next three months