Coral Cover and Diversity of the GBR

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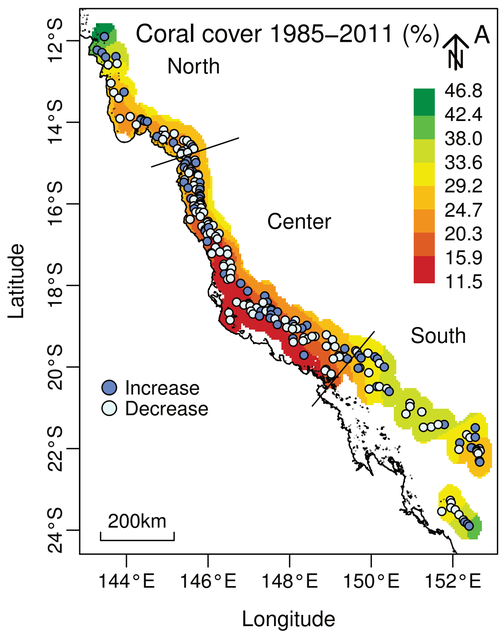
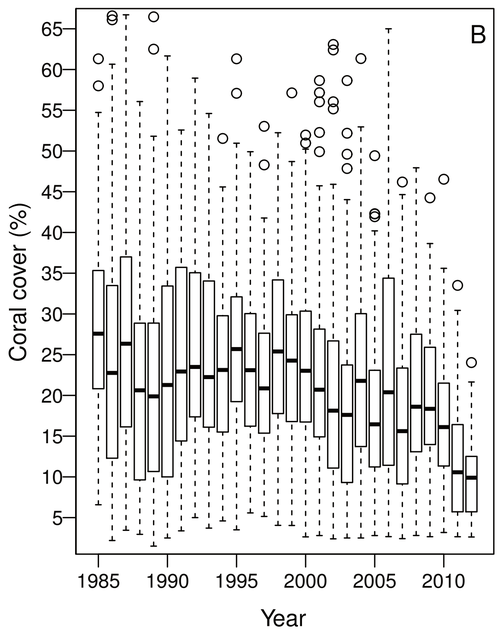
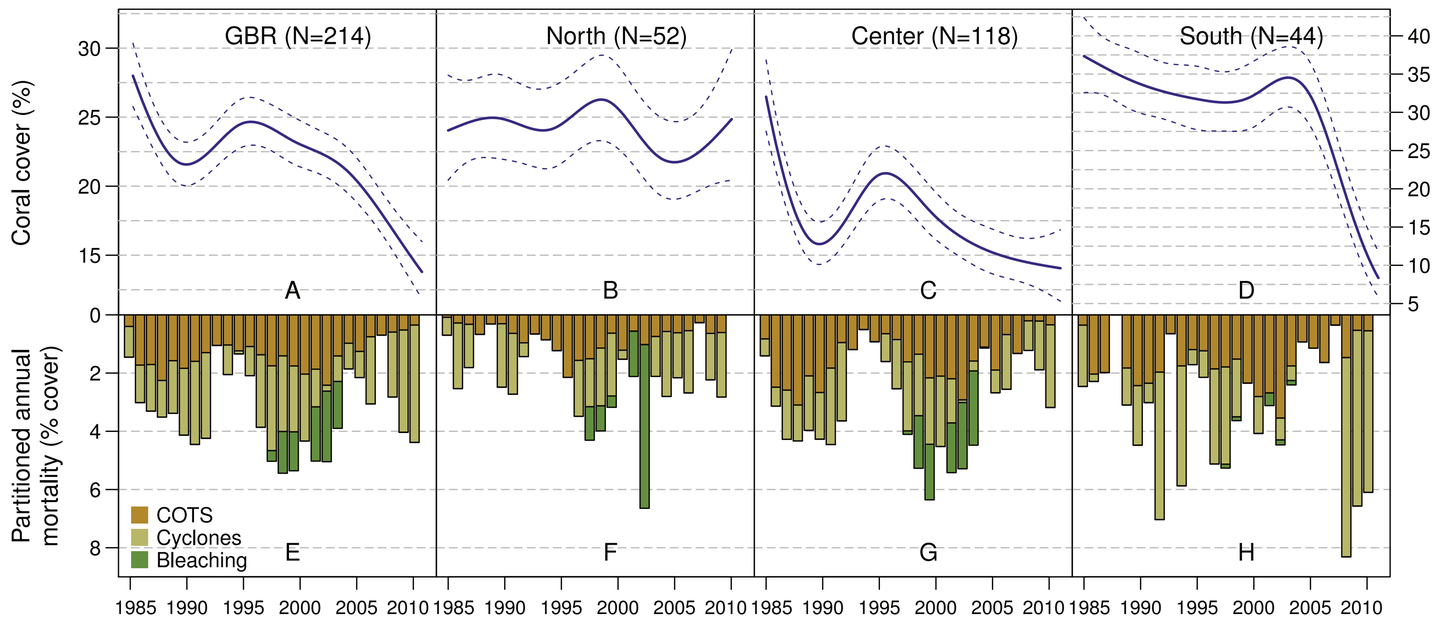
The Decline in Coral Cover and its Causes

Based on the world's most extensive time series data on reef condition (2258 surveys of 214 reefs over 1985–2012), we have shown a major decline in coral cover from 28.0% to 13.8% (0.53% yr^{-1}), a loss of 50.7% of initial coral cover on the GBR. Tropical cyclones, coral predation by crown-of-thorns starfish (COTS), and coral bleaching accounted for 48%, 42% and 10% of the respective estimated losses, amounting to 3.38% yr^{-1} mortality. The relatively pristine northern region showed no overall decline. The estimated rate of increase in coral cover in the absence of cyclones, COTS and bleaching was 2.85% yr^{-1}, demonstrating substantial capacity for recovery of reefs. In the absence of COTS, coral cover would increase at 0.89% yr^{-1}, despite ongoing losses due to cyclones and bleaching. Thus, reducing COTS populations, by improving water quality and developing alternative control measures, could prevent further coral decline and improve the outlook for the GBR.





Above: Coral cover on the Great Barrier Reef (GBR). A: Map of the GBR with colour shading indicating mean coral cover averaged over 1985–2012. Points show the locations of the 214 survey reefs in the northern, central and southern regions, and their color indicates the direction of change in cover over time. B: Boxplots indicate the percentiles (25%, 50% and 75%) of the coral cover distributions within each year and suggests a substantial decline in coral cover over the 27 years.



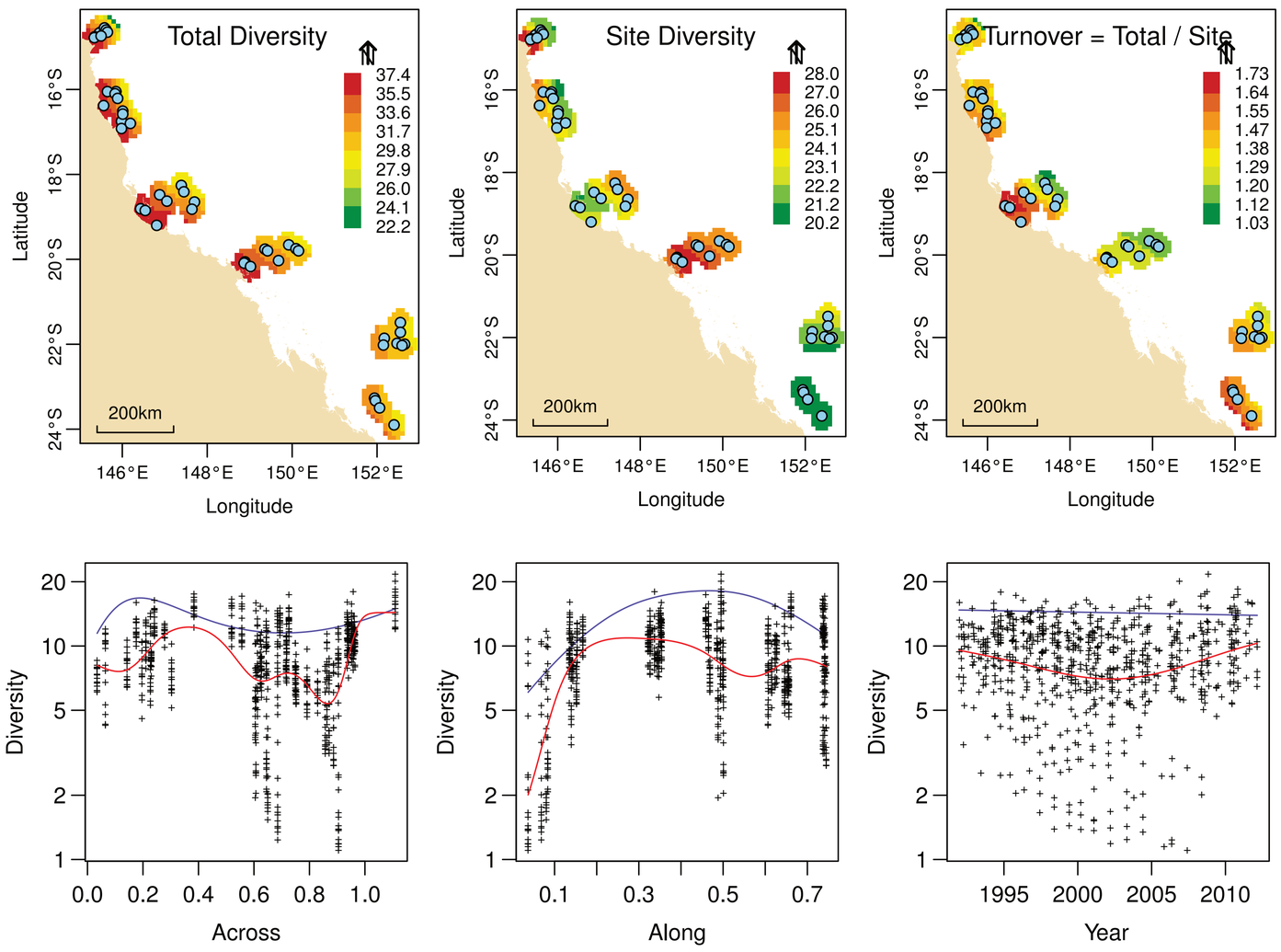
Above: The observed coral cover profiles (A-D) and estimates of growth and mortality due to COTS, cyclones and bleaching. If mean coral cover of the GBR continues to decline from the current 13.8% at its mean rate of 0.53% yr^{-1} for 1985–2012, then cover will be 10.0% (SE = 1.7%) by 2022. This assumption may be over-optimistic since the rate of decline from 2006–2012 has consistently been substantially higher at ~1.45% yr^{-1} (A), and based on that rate, estimated coral cover would be only 5.1% (1.2%) by 2022. For the northern, central and southern regions, the mean rates of coral cover decline are -0.19%, 0.47% and 1.12% yr^{-1} respectively.

Diversity of the GBR in Space and Time

Diversity is a key concept for understanding and managing global and local ecosystems. These systems are under severe pressure from growing human populations and increasing demands on the environment, and we need to understand how ecosystem diversity is changing in response to these pressures. This requires both a clear mathematical definition of diversity, and a modeling system that can relate spatial and temporal change of diversity to complex environmental drivers. The theory of ecological diversity has for many years been problematic and bedeviled by a multitude of definitions of β diversity, with analyses limited to hierarchies of α, β and γ diversities, and species turnover. The widespread use of diversity indices (e.g. richness, Shannon, Simpson) can be misleading and there have been no statistical models to directly relate diversity to environmental drivers.

The Multinomial Diversity Model (MDM; De'ath 2012) is a solution to this problem. It is based on a parametric formulation of entropy and diversity that extends the definition of diversity, and a novel link between entropy and the log-likelihood of the multinomial model. This enables the MDM to model change in diversity due to complex environmental drivers through the established theory of generalized linear models.

We have applied the MDM to coral cover data of 73 taxa (AIMS LTMP) and show how diversity varies over time in six zones of the GBR. In the final year of this project the MDM toolbox will be applied to several GBR biotic data sets and a comprehensive report on the current state of diversity on the GBR will be delivered. It will show how the GBR has evolved in space and time due to the effects of tropical cyclones, coral predation by crown-of-thorns starfish (COTS), and coral bleaching.



Top left: Spatial distribution of total, site and turnover diversities of reef benthos from the AIMS LTMP along the GBR averaged over 1992–2013. The three forms of diversity are related by the equation:

Total Diversity = Site Diversity x Turnover

We see higher total diversity on the inshore (central and north), highest site diversity in the Whitsundays, and highest turnover in the inshore central GBR.

Botttom left: Variation in diversities across (0 = coast, 1 = outer reef), along (0 = South, 1 = North) and years (1992–2012). The solid lines show the modelled local site diversity (red) and total diversity (blue), and the vertical distance between them indicates the turnover of taxa. The points (black) indicate the observed site diversities and are extremely variable (range = 1–22).

References:

[1] De'ath G.
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[2] De'ath G, Fabricius K, Sweatman, H & Puotinen, M.
(2012) The 27-year decline in coral cover on the Great Barrier Reef and its causes
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