Tropical cyclone impacts on coral reef communities: Modelling the disturbance regime in the Great Barrier Reef region, 1969-2003

Thesis submitted by

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ABSTRACT

Principal objective

Tropical cyclones periodically cross the Great Barrier Reef (GBR), generating large waves that cause structural damage to reef communities, ranging from broken corals to removal of entire sections of substrate. Over time, repeated impacts can significantly alter coral reef community structure. Thus, effective management of the GBR requires an understanding of the cyclone disturbance regime (which reefs are likely to be affected and how often). The primary objective of this study was to characterise the tropical cyclone disturbance regime in the GBR over the past three and one-half decades (1969-2003).

Methods

The spatial distribution of cyclone damage over time across even single reefs for most of the GBR is poorly known. Though cyclone disturbance patterns operate over century time scales and 100s of km space scales, most studies have examined single storm events across a few reefs or many storm events for a single reef. Further, detailed observations of cyclone damage to reefs in the GBR are rare. Examining the impacts of cyclones over time thus required reconstructing a likely disturbance history from what information was available. Meteorological models were used to hindcast the likely magnitude and distribution of cyclone winds from the meteorological record. This hindcast energy, along with measures of the spatial patterning of reefs, was linked statistically to field observations of reef damage to predict the distribution of cyclone disturbance of areas not surveyed. This was done for eight types (coral breakage, debris scars, soft coral stripping, trenching, sand movement, removal of intact slabs, dislodgement of massive corals, and exfoliation) and seven severities (presence versus absence of: damage of any type, damage of each type, severe damage of any type, total damage score, maximum severity of damage, total damage score across low-energy damage types, total damage score across high-energy damage types) of damage. Of these models, those that were successful were then used to predict the spatial distribution of cyclone damage of various types across the GBR for each of the 85 cyclones that passed nearby from 1969-2003. The timing of predicted cyclone damage was then examined at each of 24,224 individual reef sites across the region, and trends were summarized by one-degree latitude by one-degree longitude blocks.

Results and conclusions

Four types / severities of cyclone wave damage (coral breakage, dislodgement of massive corals, exfoliation and severe [widespread] damage of any type) were successfully modeled using a mix of cyclone energy (maximum and duration of high winds) and reef vulnerability (geomorphologic type, slope, normal wave exposure) parameters. For these, on average, the most recent predicted cyclone damage event (measured from 2003) occurred less recently that what was typical over the entire time series. This suggests that coral communities have had more time to recover since the last cyclone disturbance than would normally be the case, which could mean that present measures of broad community structure are not indicative of past conditions (i.e. coral coverage may be higher at present than normal). Overall, the timing of predicted damage indicates that cyclone disturbance of the GBR is most likely intermediate in nature – coral communities at most reef sites would have had time to recover between subsequent cyclone disturbances only some of the time over the period 1969-2003. Finally, reefs in the far northern GBR were generally disturbed less frequently than elsewhere.

LIST OF ACRONYMS

AIMS	Australian Institute of Marine Science
BOM	Bureau of Meteorology
BPA	Beach Protection Authority
GBR	Great Barrier Reef
GBRMPA	Great Barrier Reef Marine Park Authority
GIS	Geographic Information Systems
LTM	Long Term Monitoring

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