Stormy days ahead for coral reefs

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The increasing violence of storms under global climate change will have major effects on coral reefs – and has important implications for their future management.

A scientific team from the ARC Centre of Excellence for Coral Reef Studies (CoECRS) at James Cook University has produced the world's first engineering model to predict how much damage a reef is likely to suffer when confronted with might of an angry sea.

In a paper in the international scientific journal Nature, Dr Joshua Madin and Dr Sean Connolly use mathematical models to calculate the forces that coral is subjected to by wave, storm surge or tsunami, and the probability of the colonies being ripped from the sea-bed.

How coral assemblages respond to the power of the sea is essential for understanding the natural distribution of coral types on present-day reefs as well as for projecting how they will change in response to more violent or frequent storms, the researchers say.

"Coral reef experts have long had a general sense of which coral shapes are more vulnerable during storms than others," says the study's lead author, Dr. Madin, who now works at the National Centre for Ecological Analysis and Synthesis (NCEAS) in California, USA. "However, to really predict how these events impact the dynamics of coral reefs we needed a way to quantify these vulnerabilities."

"Our study offers a solution to this longstanding problem by factoring in the shape of different coral colonies, the strength of the sea-bed to which they attach and the change in force of the waves as they move across the reef.

"This enables us to predict the likely changes in composition of the coral in response to present and future storms or tsunamis."

This understanding, in turn, can be used by managers to better understand how the world’s coral reefs might change under a more unpredictable climate, the researchers say. "The predictive tool we have developed allows managers to assess the vulnerability of their reefs to extreme wave events," says Dr. Madin. "The ability to estimate the potential damage on a reef for different disaster scenarios could help managers plan for economic losses as well as promote strategies that help the reef recover."

The researchers' model uses mathematical models borrowed from engineering theory to translate the movement of storm waves into mechanical stresses on the coral in different parts of the reef, incorporates the various shapes of coral colonies and calculates whether they will be dislodged during extreme weather.

The research introduces a new concept – colony shape factor (CSF) – to translate the myriad shapes and sizes of coral colonies onto a simple scale that measures their vulnerability to dislodgment. Any severe event, like a cyclone, imposes a threshold that can be scored on the same scale, allowing scientists to determine which corals will live and which will die.

The most vulnerable corals are the table corals which have a broad flat top supported by a narrow stalk, making them more susceptible to strong wave forces than bushy or mounded corals. Vulnerability also depends on whether the coral grows on the front, crest, flat or the back of the reef, where the force of the waves progressively dies away.

The team ran a field test at Lizard Island, in the northern part of the Great Barrier Reef, taking digital photographs of corals, and calculating their vulnerability.

They found that the threshold imposed by the previous year's biggest storm predicted the pattern of coral sizes and shapes almost perfectly. "There were a lot of table corals present that went right up to the threshold from the last big storm, and then suddenly nothing above it," says Dr Connolly, a CoECRS researcher and Senior Lecturer at James Cook University. "They even followed the predicted trends from the reef crest to the reef back."

The researchers say that more severe storms, by themselves, would probably not pose a large threat to reefs. "Corals are adapted to life in stormy seas. Even the vulnerable species are quite stable when they're young," says Dr Connolly. "They also tend to grow and mature quickly, so the species can recover before the next big storm arrives."

However, one effect of the increased production of greenhouse gases is an increase in the acidity of the ocean. This is likely to reduce the stability of coral reefs, and amplify the damage done by tropical storms in coming decades.

Moreover, other effects of global warming and human activity could impair reefs' capacity to bounce back from periods of high wave forces, say the researchers. These include episodes of unusually hot temperatures, which can cause corals' cells to become toxic ("coral bleaching"); and overfishing, which can deplete the fish that eat seaweeds and dead coral and keep the reef clear for the next generation of corals.

"Regardless of whether we think of more severe storms as a looming threat or just the ramping up of a natural cycle, one thing is certain," says Dr Connolly. "To predict how coral reefs will look under different future scenarios, and to plan accordingly, we needed to know exactly how wave forces impact who lives and who dies on the reef. These new models provide us with that essential tool."

Source: James Cook University