FORCE Management Brief #1 for Caribbean Reef Management

Managing for climate change: incorporating bleaching vulnerability in MPA planning

The issue

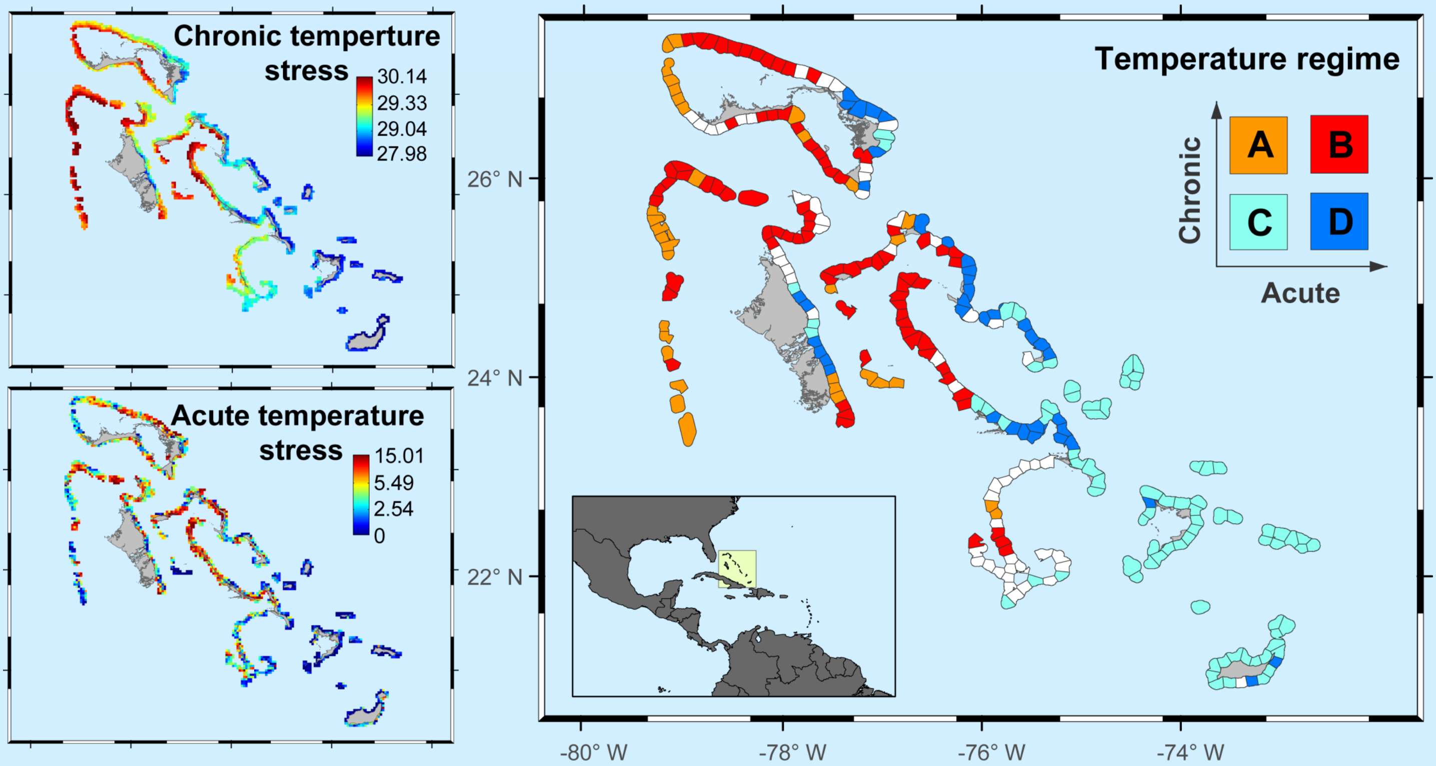
Coral bleaching, a stress condition in corals, happens when the algae that live in the coral's tissue, providing food and its normal healthy colour, are expelled. When bleached, corals starve, weaken and become more vulnerable to diseases and death. In many parts of the Caribbean, 80% of corals bleached and 40% died after the 2005 mass bleaching event. Since mass coral bleaching occurs when water temperatures increase, bleaching events will become more common and intense as the world's oceans become warmer.

In the long term it is clear that decreasing greenhouse gas emissions is the appropriate course of action to reduce the impacts of warming temperatures in corals. But what can we do at local levels?

When looking across reefs within a single country, there is large variability in where bleaching occurs. Reefs differ in their preparedness (acclimation) to bleaching and how intensively they are impacted by warming events. This variability can be harnessed by local managers by protecting reefs that are more prepared and have been less impacted by sea warming.

The approach

Maps showing vulnerability to bleaching can help manage reefs for climate change. The response of corals to temperature stress depends on the temperatures they are used to (preparedness or chronic stress) and the elevated temperatures they experience during extreme heating events (acute stress). Using this information, reefs can be classified into four categories based on their exposure to high temperature and the corals' preparedness: **(A)** those reefs accustomed to higher temperatures that have experienced relatively weak acute stress during bleaching, are expected to cope best with rising temperatures; **(C)** reefs with low preparedness but subjected to relatively weak bleaching stress should do reasonably but not as well as (A); **(B)** reefs that are prepared but suffer intense acute bleaching stress will likely fare worse than C; and **(D)** reefs with low preparedness that experience intense bleaching impacts will likely fare worst by climate change.



Maps for the Bahamas showing chronic temperature stress; acute temperature stress for 1998 and temperature regimes

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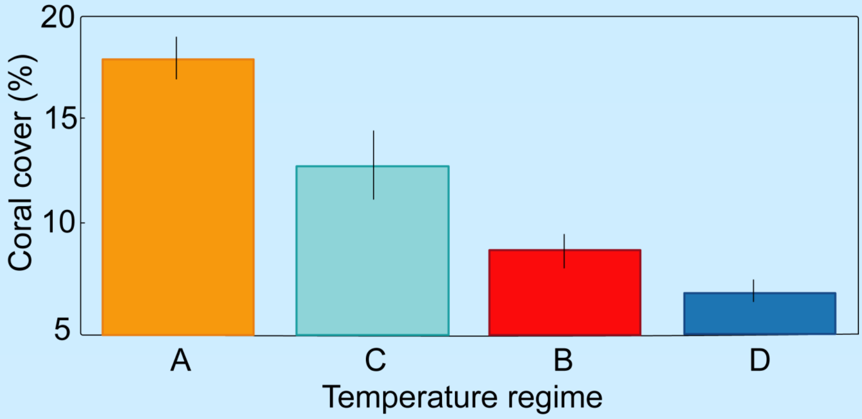
The evidence:

There is large spatial variability in chronic and acute temperature stress and bleaching incidence within the Caribbean which indicates that differences in bleaching vulnerability do exist. While the bleaching response has been related to the intensity of a warming event (acute stress), experimental studies have also shown that differences in preparedness or chronic stress also influence the response of corals to elevated temperature. For example, the pattern of coral cover in Belize after the 1998 bleaching event followed the combined effect of these factors, indicating that reefs under temperature regimes A and C are better suited to a climate change scenario.



Mean cover of living coral after the 1998 beaching event in Belize, stratified by temperature stress regime

Management use

To maximize chances of success, we recommend managers focus protection on areas that are predicted to cope better with climate change (regimes A and C). If feasible, including also areas that offer the greatest potential for acclimation (regime B) could serve to hedge your bets. This information can be factored in with other relevant layers (e.g. habitat maps, maps of current uses) to prioritize conservation actions.

How is it done?

Maps on thermal regime for selected locations across the globe can be found at http://msel.abcgis.co.uk/tre/index.html. If your area is not included there, thermal regimes can be identified using data freely available on sea surface temperature (http://www.nodc.noaa.gov/SatelliteData/pathfinder4km/) and the methods outlined below. A full description of the methods is available in the manuscript referenced in the *further information* section.

The method's only input is sea surface temperature data. A measure of chronic stress is the average monthly summer temperature experienced over the entire data record available from satellites. The annual frequency of Degree Heating Weeks, a measure of accumulated temperature stress, is used as a measure of acute stress. When chronic and acute temperature stress have been quantified for each location within the area of interest, the measures are divided independently into three groups and locations at the extremes of each stress measure (i.e. upper and lower thirds) are used to generate the four contrasting temperature stress regimes. This method is based on historical data, therefore assumes that future incidence of bleaching events will be similar than past incidence. We currently are not able to predict future bleaching events at a fine, local scale relevant for management, but this approach provides a viable option to manage reefs for climate change.

Further information

www.force-project.eu

Bilko lesson on how to calculate thermal stress from satellite data: http://www.noc.soton.ac.uk/bilko/noaa_crw.php

Mumby PJ, Elliott IA, Eakin CM, Skirving W, Paris CB, Edwards HJ, Enríquez S, Iglesias-Prieto R, Cherubin LM, Stevens JR. 2011. Reserve design for uncertain responses of coral reefs to climate change. Ecology Letters 14: 132-140. Available at http://dx.doi.org/10.1111/j.1461-0248.2010.01562.x

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