Food web trophic control modulates tropical Atlantic reef ecosystems response to marine heat wave intensity and duration

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Marine Heat Waves (MHWs) are episodes of anomalous warming in the ocean that can last from a few days to months. MHWs have different characteristics in terms of intensity, duration, and frequency and generate thermal stress on marine ecosystems. In reef ecosystems, they are one of the main causes of decreased presence and abundance of corals, invertebrates, and fish. The deleterious capacity of thermal stress often depends upon biotic factors such as resource availability (bottom-up control on predators) and predation (top-down control on prey). Despite the evidence of thermal stress and biotic factors affecting individual species, the combined effects of both stressors on the entire reef ecosystems are far less studied. Here, using a food-web modeling approach, we estimated the rate of change in species' biomass due to different MHW scenarios based on their physical characteristics. Specifically, we modeled the mechanistic link between species' consumption rate and seawater temperature (thermal stressor), simulating species' biomass dynamics for different MHW scenarios under different trophic control assumptions (biotic factor). We find that total reef ecosystem biomass declined by 10% $\pm$ 5% under MHWs with severe intensity and top-down control assumption. The bottom-up control assumption moderates the total ecosystem biomass reduction by 5% $\pm$ 5%. Irrespective of the MHW scenario and the trophic control assumption, the most substantial biomass changes occur among top, meso-predators, and corals (5% to 20% $\pm$ 10%). Since habitat degradation may lead to reef ecosystems governed by top-down control on prey, our findings point to the critical importance of protecting reef ecosystems as a pivotal strategy to alleviate the impacts of thermal stress induced by MHWs. Overall, our results provide a unified understanding of the interplay between abiotic stressors and biotic factors in reef ecosystems under extreme thermal events, offering insights into present baselines and future ecological states for reef ecosystems.