The effects of repeat bleaching on stable C and N isotopes in the Caribbean coral *Porites astreoides*

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Background

Climate change due to an increase of atmospheric CO_2 concentration has caused sea temperatures in many tropical regions to rise 2-4°C per century (Hoegh-Guldberg et al. 2007). Paired with ocean acidification, decreases in water quality, and overexploitation of key species, coral reefs may soon near the point of collapse (Hoegh-Guldberg et al. 2007). Elevated sea surface temperatures cause coral bleaching, a process where corals lose a significant portion of their vital endosymbionts and/or photosynthetic pigments (Hoegh-Guldberg 1999). As corals get most of their energy from their algal symbionts, bleaching significantly weakens them and can lead to their death. Although bleaching events are predicted to become both more frequent and more intensive over the coming decades with biannual bleaching events being likely by 2030 in the Caribbean (Donner et al. 2007), the effects of repeat bleaching on coral are largely unknown.

Stable isotopes record the physiological changes that occur during coral bleaching and recovery (e.g., Rodrigues and Grottoli 2006). Carbon (C) isotopes in coral's tissue track changes in photosynthesis and feeding, the two main sources of energy in corals, whereas uptake dynamics of the nutrient nitrogen (N) are measured by N isotopes. They are therefore useful indicators of coral health and can be used to assess the impact of repeat bleaching on coral biogeochemistry and resilience.

Objectives

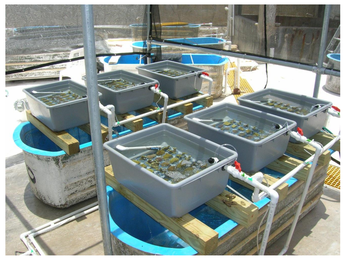
1. Assess the effectiveness of stable C and N isotopes as recorders of physiological changes in *Porites astreoides* (Fig 1).

2. Evaluate the immediate impact as well as short and long term recovery from a repeat bleaching event to understand resilience to future ocean warming.

Figure 1: *P. astreoides* colony

Methods

•Fragments of *Porites astreoides* corals were experimentally bleached (treatment corals) in outdoor flow-through seawater tanks (Fig 2) at temperatures of 31.3°C for 2.5 weeks. Fragments that received ambient seawater (30.3 °C) served as the control. After the experiment, all fragments were placed back on the reef to recover for a year. These fragments were bleached (or used as controls) again the following year using the same experimental protocol.
•Immediately following the repeat bleaching treatment (= 0 month recovery), one third of all fragments were collected, and feeding rates were measured. They were then frozen for chlorophyll a and stable isotope analyses. Another third of the fragments were collected and frozen after 1.5 and 11 months, respectively, to track short and long term recovery. Chlorophyll a and stable isotopes were measured at each recovery interval.
•Coral tissue (incl. symbionts) was removed from the skeleton using an airbrush and separated by homogenization and centrifugation, separately isolated onto glass fiber filters, and combusted in an Elemental Analyzer. Carbon (C) and nitrogen (N) isotopes of the resulting CO_2 and N_2 gas were then measured in a Delta IV stable isotope ratio mass spectrometer according to established methods (Rodrigues and Grottoli 2006).



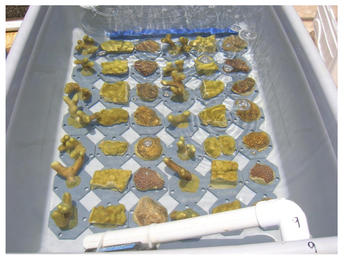


Figure 2: Treatment and control corals in outdoor flow-through seawater tanks

Results

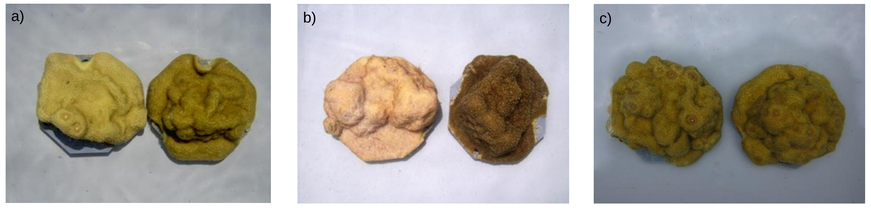


Figure 3: Treatment (left) and control corals (right) of *P. astreoides* (a) immediately after the repeat bleaching, (b) after 1.5 months, and (c) after 11 months of recovery

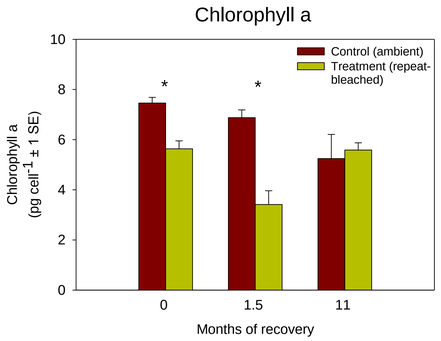


Figure 4: Changes in chlorophyll a concentrations over 11 months of recovery

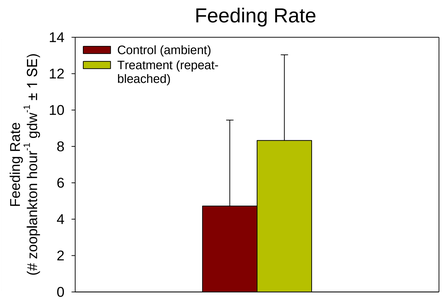


Figure 5: Feeding rate immediately after the repeat bleaching (= 0 month of recovery)

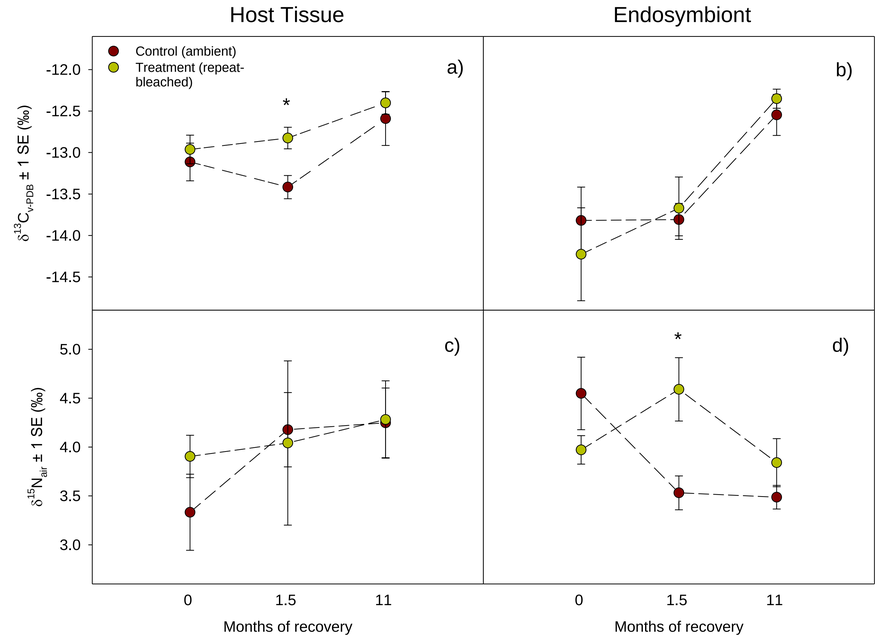


Figure 6: Stable (a, b) carbon and (c, d) nitrogen isotopes of the host tissue and endosymbiont

* Asterisks indicate significant differences between treatment and control corals at a specific recovery interval.

Discussion

- Treatment *P. astreoides* corals appeared visibly pale for 1.5 months after repeat bleaching (Fig 3A, B), reflecting significantly decreased chlorophyll a concentrations (Fig 4) and, thus, reduced photosynthesis rates. However, pigmentation was fully recovered by 11 months recovery (Fig 3C, Fig 4).

- Feeding rates of repeat bleached *P. astreoides* did not significantly differ from the ambient controls (Fig 5), as is also shown by $\delta^{13}C$ of the host at 0 month of recovery (Fig 6A). This suggests that *P. astreoides* is not able to increase feeding rates in response to repeat bleaching.

- Host $\delta^{13}C$ ($\delta^{13}C_h$) was significantly enriched relative to controls at 1.5 months recovery (Fig 6A). This is surprising and can not be attributed to increases in photosynthesis (Fig 4). Reduced feeding rates may have caused this enrichment in the treatment corals (Rodrigues and Grottoli 2006). Additional research is needed to determine a cause.

- Endosymbiont $\delta^{13}C$ ($\delta^{13}C_z$) did not track decreases in chlorophyll a (photosynthesis), which is atypical (Rodrigues and Grottoli 2006).

- Enriched host and endosymbiont $\delta^{13}C$ at 11 months recovery compared to 0 and 1.5 months (Fig 6A, B) is probably due to a seasonal component (Fitt et al. 1993) that reflects peak endosymbiont densities and chlorophyll a during winter/spring months.

- Repeat bleaching and recovery did not affect host $\delta^{15}N$ ($\delta^{15}N_h$) (Fig 6C). In contrast, endosymbiont $\delta^{15}N$ ($\delta^{15}N_z$) was significantly enriched at 1.5 months recovery relative to controls (Fig 6D), which reflects increased dissolved inorganic nitrogen (DIN) uptake required for chlorophyll a and symbiont recovery (Rodrigues and Grottoli 2006).

- Although repeat bleaching significantly impacts the biogeochemistry of *P. astreoides*, the coral health proxies measured here indicate full recovery after 11 months, suggesting that this species may be resilient to a future of frequent bleaching events.

Future Work

Measure skeletal C and O isotopes, calcification, and energy reserves. Rerun samples that have large error bars or those that are statistical outliers to get a more accurate representation of the data.

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References

Donner S.D., Knutson T.R., Oppenheimer M. 2007. Model-based assessment of the role of human-induced climate change in the 2005 Caribbean coral bleaching event. Proceedings of the National Academy of Sciences USA. 104: 5483-5488.

Fitt et al. 1993. Recovery of the coral *Montastrea annularis* in the Florida Keys following the 1987 "Bleaching Event". Coral Reefs. 12: 57-34.

Hoegh-Guldberg O. 1999. Climate change, coral bleaching and the future of the world's coral reefs. Marine & Freshwater Research. 50: 839-836

Hoegh-Guldberg O., et al. 2007. Coral reefs under rapid climate change and ocean acidification. Science. 318: 1737.

Rodrigues L.J. and A.G. Grottoli. 2006. Calcification rate and the stable carbon, oxygen, and nitrogen isotopes in the skeleton, host tissue, and zooxanthellae of bleached and recovering Hawaiian corals. Geochimica et Cosmochimica Acta. 70: 2781–2789.