Climate Change's Impact on Coral Eating Sea Star Outbreaks

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Uthicke, S., Logan, M., Liddy, M., Francis, D., Hardy, N., and Lamare, M. (2015). Climate change as an unexpected co-factor promoting coral eating seastar (*Acanthaster planci*) outbreaks. *Scientific Reports* **5**, 1-8.

Climate change is a controversial topic with a pervasive impact on ecosystem functioning. In particular, the Great Barrier Reef (GBR) has been subject to numerous adverse effects. Recent nutrient discharges from land-runoff have triggered the growth of large phytoplankton. Beyond the detrimental impact of the runoff's acidification, there is yet another variable in play. *Acanthaster planci*, more commonly known as the "crown-of-thorns sea star," (COTS) is an invertebrate that has had an especial impact on coral vitality. Approximately 50% of the GBR's coral loss is attributed to COTS outbreaks. Increases in phytoplankton have been observed to lead to nearly 10-fold increases in COTS larval development and bolstered their outbreaks (Brodie et al. 2005). In a recent paper, Uthicke et al. (2015) further explore the effects of climate change on *A. planci*, and the resultant consequences upon corals. While prior papers have studied the effects of rises in primary productivity on development, none have simultaneously looked at temperature's potential role as a co-factor. Consequently, the authors sought to determine how increases in food availability and temperature would interact to impact the growth of COTS larvae and their subsequent consumption of coral. Their hypothesis was that these increases would interact and result in a shortening of the larval development cycle.

For the experiment, adult A. *planci* were collected and transported from the Great Barrier Reef to the Australian Institute of Marine Science. After combining sperm into a solution of eggs, excess sperm was washed off, and eggs were diluted in tanks at the three experimental temperatures. After 24 hours, larvae were washed and kept under the same conditions for 72 hours at which point they started feeding. Scoring of density and larval stage was conducted on days 10, 17, and 24. The nutritional source was a mix of 3 algae types found in the GBR and maintained in a light dark cycle at 24C. To control for chlorophyll content, the algae were fed in equal proportions. The medium was prepared in filtered and autoclaved seawater to ensure no foreign elements entered into the system. The concentration of algal cells was monitored 5 times a week using a haemocytometer. There were 5 food concentrations (1100, 2800, 4200, 7000, and 9800 cells/mL) at 28C, while the other 2 temperatures had concentrations of 1100, 4200, and 7000 cells/mL. The three temperatures (28, 29, 30C) were selected because the known thermal window for A. planci development is between 24 and 32. Temperatures were tightly controlled throughout the experiment by using flow-through water jackets, and recording the temperatures every minute. The authors were careful to be representative of average sea temperatures in the GBR during larval development as well as the potential increases due to warming.

The experiment's results revealed the greatest additive and synergistic effects of increased food and temperature at Day 10 and Day 17 (Focus Fig. 1). Their statistical analysis used algal concentrations as a continuous variable (designated as Algae Cells on the x-axis), while the 3 temperatures were a categorical variable. The Mid-Late Brachiolaria percentage (y-axis) represents the final stage of *A. planci* prior to settlement, which is an indicator of advanced development. At Day 10, there were was a noticeable increase in advanced larvae with increases in temperature and algae concentration. Specifically, a 2C increase elicited a 4.2 to 4.9-fold increase in advanced larvae (Focus Fig. 1A). By Day 17, there was an interaction between food supply and temperature. As food concentrations rose, the level of larval response increased most at the higher temperatures (Focus Fig. 1B). At Day 24, food was still a significant factor as the lowest concentrations continued to be limiting, but temperature no longer enhanced the effect (Focus Fig. 1C). Ultimately, the sea star's survival probability is increased by higher food availability, and further reinforced by a temperature increase. It is therefore a growing possibility that as surface temperatures continue to warm, coral reefs will become increasingly at risk.

The extensive impacts of climate change accumulate with each passing day. This study takes a look at one aspect of our world that is threatened by its corollaries. On one hand, as carbon dioxide emissions rise, surface temperatures of the sea are warming. On the other, as land-runoff finds its way into the sea, eutrophication is triggered and algal concentrations increase. As a result, the Great Barrier Reef's coral cover has been declining due to an overabundance of COTS. While contributing factors have been studied in isolation, this study was able to study multiple factors with impressive breadth and depth. The authors were able to determine that the interaction between the effects of land-runoff and ocean warming increases the likelihood and intensity of COTS outbreaks. Furthermore, at higher temperatures, the rapidity of larval development is bolstered at a faster rate. Given the projected increase in seawater surface temperature in the forthcoming years, there is substantial reason to anticipate these observed effects becoming a grim reality. The findings of this paper clearly depict the implications of global warming on corals and COTS, but we are still left with several questions to ponder. Chiefly, what can be done? What are the potential management strategies to reduce the negative consequences of anthropogenic impact? Are there ways to reduce the population growth of COTS without adversely affecting the surrounding ecosystem?

Other Literature Cited

Brodie, J., Fabricius, K., De'ath, G., and Okaji, K. (2005). Are increased nutrient inputs responsible for more outbreaks of crown-of-thorns starfish? An appraisal of the evidence. *Marine Pollution Bulletin* **51**, 266-278.

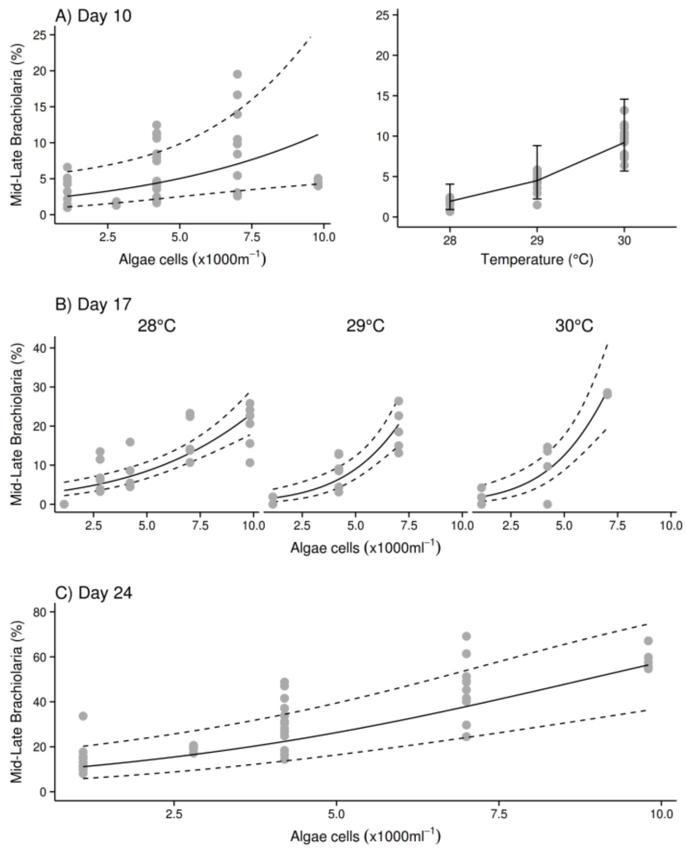

Fig. 1. Effects of increased food and temperature on the percentage of *A. planci* larvae developing late A) 10 days of development, B) 17 days of development, and C) 24 days of development. Dotted lines represent the 95% confidence interval and fit. (Adapted from Uthicke et al. 2015)