Earth & Space

Corals display bright colours to fight bleaching

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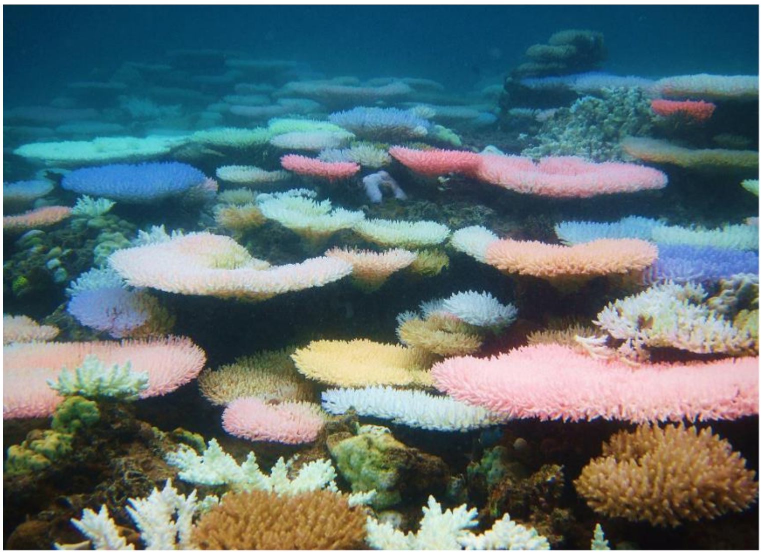
Stressful conditions do not always render reef corals white. We found that mild or brief exposure of corals to heat stress or to unfavourable nutrient conditions does not only cause the loss of the vital symbiont alga but also switches on an optical feedback loop that results in a dazzling display of coral colours. The enhanced pigmentation is thought to help the corals to recover.



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A seemingly endless sea of ghostly white corals more and more often replaces a once-thriving reef. The image of mass coral bleaching is a striking portrait of how climate change is threatening marine ecosystems' survival and the millions of people they support. Coral bleaching occurs when corals lose the brown symbiotic algae that live inside their tissue and provide vital nutrition. Once the symbionts are gone, the white skeletons shine through transparent coral tissue, giving the corals their bleached appearance that lends the name to the process. Unfavourable conditions such as warming waters or a disturbed nutrient environment cause these algae to become toxic to their hosts, so corals expel them exposing themselves to the risks of starvation, disease and, frequently, death.

However, bleached corals do not always turn white. For instance, during a bleaching event in New Caledonia in 2016, popularised through the Netflix documentary "Chasing Coral", at least half the bleached corals were glowing with brilliant shades of blue, yellow and pink. Despite the striking nature of colourful bleaching events, we knew surprisingly little about what causes them.

When we compiled scientific papers and eyewitness reports, we found that colourful bleaching is a recurring phenomenon worldwide. The bright colours derive from a family of protein pigments produced by the coral host. Some of them are fluorescent and lend a neon glow to the corals when accumulated in high amounts. We had learned from our previous research that in healthy shallow water corals these pigments protect the symbiotic algae from excess sunlight by shading the tissue in which the algae are found. When these corals sense an increase in sunlight, specifically the spectrum's blue range, they start to produce more of the sunscreen pigments. This knowledge proofed to be critical to the understanding of why the bright colours sometimes appear during bleaching events.

We recreated coral bleaching in our experimental aquarium using different conditions that cause stress to corals. After the corals bleached, the colourful pigments increased slowly in a pattern that closely resembled what happens in healthy corals under high light. Also, similarly to the increased light response, bleached corals only developed bright colours when the light spectrum contained blue wavelengths. We concluded that our corals were responding to an increase in light levels occurring inside their own tissue due to bleaching. In healthy coral tissue, incoming light gets quickly absorbed by the algae and is used to power photosynthesis. After the algae are lost, excess light travels freely in the tissue and is reflected by the white skeleton, creating a very bright environment and causing light stress to any residual symbiont cells. Simultaneously, these increased internal light levels stimulate the production of protective pigments, causing a colourful response.

We then allowed white and colourful bleached corals to recover under their original non-stressful conditions. Colourful corals were able to repopulate their tissue with symbiotic algae more rapidly than white ones, and their algae population had healthier photosynthetic machinery. We believe that the colourful pigment layer gives bleached corals a better chance at recovering. It reduces light levels inside the tissue and creates a favourable environment for the algae to settle back in. Once the symbiont population recovers, the algae start taking up more and more light for photosynthesis and doing so it reduces the internal light levels to a point where the enhanced protection by the colourful coral pigments is no longer needed. This also triggers the reduction of the levels of colourful pigments themselves. Thereby, a complete optical feedback loop senses and regulates coral pigmentation to adjust light levels inside the tissue to benefit both partners of the symbiotic association.

Finally, we matched reports of colourful bleaching with local water temperature profiles at the time of the event that we reconstructed from satellite data. In all cases analysed, we found that colourful bleaching manifested during mild heat stress episodes when the water had warmed to just above the local critical temperature that makes corals bleach. This is in line with previous findings that the genes responsible for the pigment production are down regulated during intense heat stress. Indeed, when we bleached our experimental corals with warm water, the colourful response was only evident after the temperature returned to non-stressful levels.

Colourful bleaching shows us that evolution has given corals some remarkable tools to survive bleaching events. If we step up our efforts to reduce greenhouse gas emissions and protect the water quality in coral reefs, these incredible ecosystems might still be around in the years to come.