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Maggie Villiger.

As the Earth enters its third mass bleaching event, will corals survive?

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Early signs of bleaching coral in Kaheohe Bay Hawaii, August 2015. XL Catlin Seaview Survey / Underwater Earth, CC BY-NC

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The world is experiencing its third mass coral bleaching event. Due to elevated temperatures at tropical locations over the whole planet, large populations of corals are starting to turn white. This is bad, as bleaching can lead to large-scale decreases in coral health and ultimately their death. Coral reefs provide shorelines with protection from storms, are foundational to tropical tourism and provide critical habitat to thousands of species. Large-scale coral death following mass bleaching leads to reef erosion, loss of shoreline protection, loss of tourism income and the livelihoods that depend on them, and loss of critical habitat.

Following the last mass bleaching event in 1997-98, 16% of the world's corals died. This current mass bleaching is projected to be just as disastrous as the last. On top of that, this year's event follows on the heels of bleaching that occurred in some parts of the world last year. In Hawaii, for example, researchers documented coral bleaching in both 2014 and 2015, potentially setting up these reefs for severe declines now.

While many corals die following bleaching events, there are always survivors. Over the past decade, I've focused on trying to figure out why some corals make it. By identifying why some corals survive, we gain a deeper understanding of their biology and can better predict coral diversity and persistence. Ultimately we can make better coral reef management decisions.

Why corals bleach

Corals are symbiotic organisms. They're animals made up of polyps that harbor millions of microscopic plant cells (called algae) within their tissues, which gives corals their color.

Close-up view of coral polyps. Andrea Grottoli,

The algae create sugars through photosynthesis and share the vast majority of that sugar with the coral host, thus providing corals with most of their food. Corals also eat zooplankton that they capture with their tentacles. Zooplankton are microscopic animals that live in the water column and provide corals with essential vitamins and nutrients needed for growth and health. While corals often look like colored rocks, they are actually living animals that deposit skeleton beneath them and can grow for hundreds of years.

Corals bleach when seawater temperatures increase by 1-2 degrees Celsius (1.8-3.6 degrees Fahrenheit) above their normal temperature for as little as 10 days. This heat stress causes the corals to release their algal partners, leaving the still-living animal transparent with its white skeleton visible through its tissue – hence the term "coral bleaching." In the absence of their algae, corals begin to starve. They have a few coping strategies:

decrease growth
increase feeding on zooplankton
shuffle the types of algae they host to favor ones that are heat-tolerant
consume their energy reserves (like fat, protein and carbohydrates within their bodies).

Even with these coping strategies, if the temperature stress persists, corals start to die.

But some corals survive

Research led by my team on Caribbean and Hawaiian corals shows that corals can use one or more of these coping strategies to survive single isolated bleaching events. However, corals appear to need more than one year to fully recover from bleaching stress. So how will coral survive as bleaching events become annual occurrences, as climate change continues to raise ocean temperatures? Can corals rapidly adapt to annual bleaching?

My team has found that the coping strategies of Caribbean corals that recover quickly from bleaching in one year may not be a good predictor of their capacity to recovery from a bleaching event the following year. Basically, even if corals made it through a tough time last year, they might not have what it takes to hang on through another challenging year now. To fully recover from annually recurring bleaching stress, the best coping strategies for corals boil down to just two: corals need to have lots of energy reserves and be able to shuffle their algal types.

Healthy finger coral, close up. Andrea Grottoli,

For instance, we found that the mustard hill coral (*Porites astreoides*) was the least affected by an initial bleaching event but was the most affected by the second bleaching event. It didn't have enough stored energy and wasn't able to shift the types of algae it hosts. On the other hand, the finger coral (*Porites divaricata*) was hard hit by the first bleaching and slow to recover. But it was hardly affected by the second bleaching stress the following year because it had high levels of energy reserves and shuffled its algal types in response to both bleaching stresses. So the finger coral was able to rapidly adapt while the mustard hill coral could not.

How far into the future will we see healthy coral reefs, like this one in the Philippines' Tubbataha Reef Natural Park? XL Catlin Seaview Survey / Underwater Earth, CC BY-NC

What's in the future for coral reefs?

As the climate changes, corals will continue to be confronted with warmer ocean temperatures. In the face of the current global mass bleaching, and the onset of annual bleaching in many locations around the globe, the ability to identify resilient corals has never been more important.

It's clear from our research that some species won't be able to withstand annual bleaching stress and will die out. At the same time, it's encouraging that some species can adapt very quickly and appear to be able to cope with annual bleaching stress. Thus, coral reefs of the future will exist but in a less diverse form – which may or may not have a negative effect on the reef ecosystem function.

This interpretation of recent coral bleaching research offers hope over previous forecasts because, in the past, researchers didn't always consider the possibility of rapid coral adaptation. But there's still reason to be cautious.

As the oceans continue to become more acidic as they absorb more carbon dioxide from the atmosphere, corals are under the dual stress of rising temperatures and acidity. We don't yet know the effect of annual bleaching stress on corals in an increasingly acidic ocean. Ongoing research by my team and many others around the world is currently under way to determine how or if corals will survive bleaching events in an increasingly acidic ocean.

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Coral
Reef
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