# Corals die as global warming collides with local weather in the South China Sea

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Bleached *Acropora* colony was photographed in July 2015. A new study finds that a 2°C rise in the sea surface temperature of the South China Sea in June 2015 was amplified to produce a 6°C rise on the Dongsha Atoll, killing approximately 40 percent of the resident coral community. Credit: Photo by Thomas DeCarlo, Woods Hole Oceanographic Institution

In the South China Sea, a 2°C rise in the sea surface temperature in June 2015 was amplified to produce a 6°C rise on Dongsha Atoll, a shallow coral reef ecosystem, killing approximately 40 percent of the resident coral community within weeks, according to a study published in *Scientific Reports* this week.

Wind and waves churn the sea, flushing shallow-water coral reefs with seawater from the open ocean to help them stay cool. But according to new research from the Woods Hole Oceanographic Institution (WHOI), when the weather turns still and these natural cooling mechanisms subside, just a few degrees of ocean warming can prove lethal to the corals that live there.

Scientists at WHOI studied this phenomenon in June 2015 while conducting research on Dongsha Atoll, an almost perfectly circular coral reef in the remote South China Sea. The findings, published in the March 24, 2017 issue of the journal *Scientific Reports*, highlight the devastation caused when global-scale ocean warming interacts with short-lived weather anomalies, and adds urgency to the question of how reefs will fare through the end of this century.

"Dongsha Atoll is typically hit with tropical storms and strong winds in June, which keep the corals as cool as the open ocean," said Tom DeCarlo, lead author of the study and a then-graduate student in the MIT-WHOI Joint Program in Oceanography. "But in 2015, the weather in June was exceptionally calm—at one point, there was basically no wind and no waves. This had an amplifying effect on the water temperatures, which were already feeling the heat from global warming and El Niño. The whole reef became a giant swimming pool that just sat there and baked in the sun."

According the DeCarlo, who is now a scientist with the University of Western Australia, it only took a few days of calm winds and waves

before the reef lost its supply of cooler water from the open ocean. "We saw water temperatures surge to 36 °C (97 °F) - a full 6° C above normal summertime temperatures. This caused 100% of the corals to bleach, and 40% of them died," he said.

## Gone and back again

DeCarlo, WHOI scientist Anne Cohen, and dive master Pat Lohmann, witnessed the start of the mass die-off on the last day of their month-long field visit to Dongsha. They had just finished up an ecological survey of coral cover on the reef, and before heading home, jumped in the water to retrieve instruments they use to monitor water temperature, pH and currents. "That's when we saw that all the corals had turned white," said DeCarlo. "We had to catch our flights the next day, but the situation looked dire so Anne sent us back out to the site within a few weeks.

According to Cohen, the lead principal investigator on the project, the timing was remarkable given they were still on site when the bleaching started. "It's quite uncommon to be out there in such a remote place as a massive bleaching event is actually happening," said Cohen. "From Tom's surveys, we knew what the healthy reef looked like just before the bleaching, so we could make a direct comparison with the post-bleaching data to assess the effects of the warming."

Upon their return, the scientists boated back out to the reef and saw a green tint shimmering through the water - a possible sign that the corals made it through the bleaching event and were returning to a normal state. But when they dove in, they realized what they had seen was actually green turf algae covering dead corals. "This was the fastest-calcifying reef we've ever studied," said DeCarlo. "So we thought it would have shown resiliency. But everything had come crashing down in the space of a few weeks."

## Cooling system shutdown

The team suspected the amplified warming was due to the weather lull, but they couldn't automatically rule out the possibility that fewer clouds and more sunlight in 2015 versus previous years had caused the event. To test this hypothesis, DeCarlo and co-author Kristen Davis, using data recorded by instruments deployed on the reef, conducted a number of "heat budget" calculations to hone in on the specific factors that drove the extreme heating.

"We saw that air-to-sea heating mechanisms like sunlight and air temperature had remained nearly constant throughout June, but the wind- and wave-driven currents pushing in cooler offshore water were essentially turned off for a few days. This was the big change that caused the water temperatures to spike on the reef, so our hypothesis was correct - the unusually calm weather pattern was the primary culprit," said DeCarlo.

## Scanning history

Water temperatures stabilized in early July as the winds and waves finally kicked up. But the widespread damage had already been done. Given the magnitude of the event, the scientists wanted to know if this reef had experienced similar temperature extremes in the past, and if so, whether the corals recovered. According to Cohen, however, few historical bleaching data existed for the region.

"This is a super-remote place that takes two hours to get to by plane from mainland Taiwan," she said. There were unpublished accounts of bleaching in 1997, but the severity and extent of that event were not quantified.

Without precise historical records, the team drilled core samples from corals living on the reef and used Computed Tomography (CT) scans to look for signals of thermal stress in the past. The scans, which look like an x-rayed mop handle, reveal annual rings or "bands" of varying densities in the coral's skeleton.

"These bands are like a history book for coral reefs, allowing you to count back in time to specific years and events," said Cohen, who attributes her lab's unique "paleo perspective" to her background in paleo-oceanography. "The brighter, high-density bands, which we call 'stress bands,' are signatures of long and intense bleaching events. Based on cores we scanned, it appears there had been only three previous bleaching events between 1983 and 2015, each of which happened in El Niño years. But we detected very few stress bands in the cores, so while there had been bleaching, these events were not nearly as severe as 2015."

Interpreting the CT scan data, DeCarlo says many corals that had bleached in the past appear to have recovered. "The skeletal records show that less than 50 percent of the colonies had bleached during these historical events, which is a stark contrast to the 100 percent bleaching we saw in 2015. This suggests that the area had not seen thermal stress this extreme in the last forty years at least - maybe even in the last 100 years."

## 21st century reef

The study highlights the consequences for shallow-water coral reefs when global warming intersects with short-lived weather anomalies. But the scientists say their observations also suggest the possibility that climate model projections may underestimate what some coral reefs will experience as the ocean continues to warm over this century.

"The current global climate models and prognosis for reefs are based on a 2 °C warming scenario for the open ocean," said DeCarlo. "But these projections usually don't account for the kind of regional and local weather anomalies we saw at Dongsha. When you have weather amplification events superimposed on top of carbon dioxide-driven ocean warming, that's when things can get really bad for corals. Models based on open-ocean warming already paint a dire picture for coral reefs, but the scary reality is that they may be too optimistic for many shallow reefs."

"Projections based on open-ocean temperatures may not be 100% relevant to these shallow-water environments, where many coral communities live," Cohen added. "It's possible that coral reefs are in much more immediate danger than we have anticipated. When global and regional anomalies align, a seemingly-mild two-degree warming could be more like six degrees."

Provided by Woods Hole Oceanographic Institution