

CLIMATE

Large Sections of Australia's Great Reef Are Now Dead, Scientists Find

By DAMIEN CAVE and JUSTIN GILLIS MARCH 15, 2017

SYDNEY, Australia — The Great Barrier Reef in Australia has long been one of the world's most magnificent natural wonders, so enormous it can be seen from space, so beautiful it can move visitors to tears.

But the reef, and the profusion of sea creatures living near it, are in profound trouble.

Huge sections of the Great Barrier Reef, stretching across hundreds of miles of its most pristine northern sector, were recently found to be dead, killed last year by overheated seawater. More southerly sections around the middle of the reef that barely escaped then are bleaching now, a potential precursor to another die-off that could rob some of the reef's most visited areas of color and life.

“We didn't expect to see this level of destruction to the Great Barrier Reef for another 30 years,” said Terry P. Hughes, director of a government-funded center for coral reef studies at James Cook University in Australia and the lead author of a paper on the reef that is being published Thursday as the cover article of the journal *Nature*. “In the north, I saw hundreds of reefs — literally two-thirds of the reefs were dying and are now dead.”

The damage to the Great Barrier Reef, one of the world's largest living structures, is part of a global calamity that has been unfolding intermittently for

nearly two decades and seems to be intensifying. In the paper, dozens of scientists described the recent disaster as the third worldwide mass bleaching of coral reefs since 1998, but by far the most widespread and damaging.

The state of coral reefs is a telling sign of the health of the seas. Their distress and death are yet another marker of the ravages of global climate change.

If most of the world's coral reefs die, as scientists fear is increasingly likely, some of the richest and most colorful life in the ocean could be lost, along with huge sums from reef tourism. In poorer countries, lives are at stake: Hundreds of millions of people get their protein primarily from reef fish, and the loss of that food supply could become a humanitarian crisis.

With this latest global bleaching in its third year, reef scientists say they have no doubt as to the responsible party.

They warned decades ago that the coral reefs would be at risk if human society kept burning fossil fuels at a runaway pace, releasing greenhouse gases that warm the ocean. Emissions continued to rise, and now the background ocean temperature is high enough that any temporary spike poses a critical risk to reefs.

“Climate change is not a future threat,” Professor Hughes said. “On the Great Barrier Reef, it's been happening for 18 years.”

Corals require warm water to thrive, but they are exquisitely sensitive to extra heat. Just two or three degrees Fahrenheit of excess warming can sometimes kill the tiny creatures.

Globally, the ocean has warmed by about 1.5 degrees Fahrenheit since the late 19th century, by a conservative calculation, and a bit more in the tropics, home to many reefs. An additional kick was supplied by an El Niño weather pattern that peaked in 2016 and temporarily warmed much of the surface of the planet, causing the hottest year in a historical record dating to 1880.

It was obvious last year that the corals on many reefs were likely to die, but now formal scientific assessments are coming in. The paper in Nature documents vast

coral bleaching in 2016 along a 500-mile section of the reef north of Cairns, a city on Australia's eastern coast.

Bleaching indicates that corals are under heat stress, but they do not always die and cooler water can help them recover. Subsequent surveys of the Great Barrier Reef, conducted late last year after the deadline for inclusion in the Nature paper, documented that extensive patches of reef had in fact died, and would not be likely to recover soon, if at all.

Professor Hughes led those surveys. He said that he and his students cried when he showed them maps of the damage, which he had calculated in part by flying low in small planes and helicopters.

His aerial surveys, combined with underwater measurements, found that 67 percent of the corals had died in a long stretch north of Port Douglas, and in patches, the mortality reached 83 percent.

By luck, a storm stirred the waters in the central and southern parts of the reef at a critical moment, cooling them, and mortality there was much lower — about 6 percent in a stretch off Townsville, and even lower in the southernmost part of the reef.

But an Australian government study released last week found that over all, last year brought “the highest sea surface temperatures across the Great Barrier Reef on record.”

Only 9 percent of the reef has avoided bleaching since 1998, Professor Hughes said, and now, the less remote, more heavily visited stretch from Cairns south is in trouble again. Water temperatures there remain so high that another round of mass bleaching is underway, the Great Barrier Reef Marine Park Authority confirmed last week.

Professor Hughes said he hoped the die-off this time would not be as serious as last year's, but “back-to-back bleaching is unheard-of in Australia.” The central and southern part of the reef had already been badly damaged by human activities like dredging and pollution.

The Australian government has tried to combat these local threats with its Reef 2050 plan, restricting port development, dredging and agricultural runoff, among other risks. But Professor Hughes's research found that, given the high temperatures, these national efforts to improve water quality were not enough.

"The reefs in muddy water were just as fried as those in pristine water," Professor Hughes said. "That's not good news in terms of what you can do locally to prevent bleaching — the answer to that is not very much at all. You have to address climate change directly."

With the election of Donald J. Trump as the American president, a recent global deal to tackle the problem, known as the Paris Agreement, seems to be in peril. Australia's conservative government also continues to support fossil fuel development, including what many scientists and conservationists see as the reef's most immediate threat — a proposed coal mine, expected to be among the world's largest, to be built inland from the reef by the Adani Group, a conglomerate based in India.

"The fact is, Australia is the largest coal exporter in the world, and the last thing we should be doing to our greatest national asset is making the situation worse," said Imogen Zethoven, campaign director for the Australian Marine Conservation Society.

Australia relies on the Great Barrier Reef for about 70,000 jobs and billions of dollars annually in tourism revenue, and it is not yet clear how that economy will be affected by the reef's deterioration. Even in hard-hit areas, large patches of the Great Barrier Reef survived, and guides will most likely take tourists there, avoiding the dead zones.

The global reef crisis does not necessarily mean extinction for coral species. The corals may save themselves, as many other creatures are attempting to do, by moving toward the poles as the Earth warms, establishing new reefs in cooler water.

But the changes humans are causing are so rapid, by geological standards, that it is not entirely clear that coral species will be able to keep up. And even if the corals

do survive, that does not mean individual reefs will continue to thrive where they do now.

Coral reefs are sensitive systems, built by unusual animals. The corals themselves are tiny polyps that act like farmers, capturing colorful single-celled plants called algae that convert sunlight into food. The coral polyps form colonies and build a limestone scaffolding on which to live — a reef.

But when the water near a reef gets too hot, the algae begin producing toxins, and the corals expel them in self-defense, turning ghostly white. If water temperatures drop soon enough, the corals can grow new algae and survive, but if not, they may succumb to starvation or disease.

Even when the corals die, some reefs eventually recover. If water temperatures stay moderate, the damaged sections of the Great Barrier Reef may be covered with corals again in as few as 10 or 15 years.

But the temperature of the ocean is now high enough that global mass bleaching events seem to be growing more frequent. If they become routine, many of the world's hard-hit coral reefs may never be able to re-establish themselves.

Within a decade, certain kinds of branching and plate coral could be extinct, reef scientists say, along with a variety of small fish that rely on them for protection from predators.

“I don't think the Great Barrier Reef will ever again be as great as it used to be — at least not in our lifetimes,” said C. Mark Eakin, a reef expert with the National Oceanic and Atmospheric Administration, in Silver Spring, Md.

Dr. Eakin was an author of the new paper and heads a program called **Coral Reef Watch**, producing predictive maps to warn when coral bleaching is imminent. Even though last year's El Niño has ended, water temperatures are high enough that his maps are showing continued hot water across millions of square miles of the ocean.

Kim M. Cobb, a climate scientist at the Georgia Institute of Technology who was not involved in the writing of the new paper, described it and the more recent

findings as accurate, and depressing. She said she saw extensive coral devastation last year off Kiritimati Island, part of the Republic of Kiribati several thousand miles from Australia and a place she visits regularly in her research.

With the international effort to fight climate change at risk of losing momentum, “ocean temperatures continue to march upward,” Dr. Cobb said. “The idea that we’re going to have 20 or 30 years before we reach the next bleaching and mortality event for the corals is basically a fantasy.”

Damien Cave reported from Sydney, and Justin Gillis reported from New York.

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