Discoveries

The corals that come back from the dead

In an astonishing and unexpected revival, dubbed the 'Phoenix Effect', reefs around the world are returning to life

Presented by
Jane Palmer

Last year, marine biologist Peter Mumby took a dive into the Rangiroa lagoon, in French Polynesia. What he saw shocked him so much he thought he might be lost.

He'd expected to be surrounded by death, by a reef of dying coral whose skeletons were slowly crumbling into the sea. Instead, majestic, olive-green *Porites* corals, the size of large hippos, carpeted the sea floor, providing a playground for parrotfishes and the occasional shark that weaved between the cauliflower-shaped giants.

"I was absolutely astonished and delighted," says Mumby, a professor at the Marine Spatial Ecology Lab of the University of Queensland, Australia.

Bleached Acropora species of coral (credit: Georgette Douwma / NPL)

He had good reason to be. In 1998, a heatwave, which raised ocean temperatures, had caused corals worldwide to go a deathly white - a process called bleaching - and die.

When Mumby had visited Tivaru on the Rangiroa lagoon six months later, he'd found a vast majority of the region's prolific Porites coral, normally the hardiest of coral species, had followed suit. Based on the known growing rates for the species, Mumby predicted it would take the *Porites* nearly 100 years to recover, not 15.

"Our projections were completely wrong," he says. "Sometimes it is really nice to be proven wrong as a scientist, and this was a perfect example of that."

> *We now need to understand exactly how they do it*

Mumby's discovery marks a high point spot in the scientific community's research into, and gloomy prognosis for, coral reefs around the world. The single bleaching event of 1998 killed nearly 16% of the world's corals.

The damage is caused when the heat forces the corals to expel symbiotic algae living in their tissues, turning the corals white. Corals usually rely on the algae to convert sunlight to energy.

With ocean temperatures expected to increase an additional 1 to 2 degrees Celsius over the next century, scientists estimate such disasters to become more frequent. Eventually, they predict the majority of the world's corals will bleach and die.

Bleached brain coral with algae expelled (credit: Alex Mustard / NPL)

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But some corals aren't complying with their death sentence.

The 1998 heatwave also bleached and killed corals on the outer exposed reefs of Palau in the western Pacific Ocean. But by 2005 they'd made a full recovery.

We are learning rapidly about coral reefs that there is a lot that we didn't know

James Gilmour, a coral ecologist at the Australian Institute of Marine Science, in Crawley, Western Australia, also watched his research site, Scott Reef, in the Kimberly region of northwestern Australia, make a robust recovery from the 1998 heatwave. The site has since survived a category-five cyclone and further bleaching events in 2010 and 2011 (see video below of a bleached Scott Reef credit: J. Gilmour).

"We are learning rapidly about coral reefs that there is a lot that we didn't know," Gilmour says.

Mumby concurs. "It makes us realise that some corals have a number of strategies to cope with stress that we don't understand very well," he says. "That is good news and we now need to understand exactly how they do it."

Rising from the ashes

"The Phoenix Effect" is a term coined in 1992 by David Krupp, a coral researcher based in Hawaii. He used it to describe how some corals can spring back to life from an almost imperceptible fragment of themselves.

But typically scientists have only seen the Phoenix Effect in certain species known as disc corals, including those in the *Fungia*, *Cycloseris* and *Ctenactis* genera. It wasn't thought possible in the *Porites* corals that Mumby studies.

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So how did these corals recover?

When Mumby first surveyed the corals in the Rangiroa lagoon he noted something unusual. Some *Porites* corals, while appearing dead, had a few small slivers of live tissue on them "about the width of a finger and maybe as long as a finger."

> *It is not impossible that deeper into that skeleton there is still living coral*

These surviving strips of coral lay deep in shadowy recesses, so they suffered less from the combined effects of heat and sunlight. It could be that these tiny shards of life were able to regrow and rebuild the immense *Porites* once conditions became more normal, Mumby says.

But so fast?

Starting from scratch a *Porites* coral starts off the size of a marble and grows like an onion, depositing a mere centimetre or so of new skeleton each year on its surface. That means it usually takes nearly

600 years to reach a height of five metres and a width of seven metres.

But the regrowing corals have a head start, provided by the skeleton left behind by the corals that have died. “The actual body of the coral, which is a soft gelatinous bit of stuff, a bit like a sea anemone, doesn't have to build any skeleton,” Mumby says. “It just has to shoot across the existing skeleton.”

Rangiroa's turquoise lagoon in French Polynesia (credit: Roberto Rinaldi / NPL)

Rangiroa's turquoise lagoon in French Polynesia (credit: Roberto Rinaldi / NPL)

He also has another theory to explain the *Porites* corals’ stunning recovery; they may not have been as dead as first thought.

These species have a thick body that extends more than a centimetre into the skeleton. “It is not impossible that deeper into that skeleton there is still living coral even though it wasn't extending back up to the surface.” This “inner coral” may have taken more than a year to recover. But once it did, it could quickly grow back to the surface and across the skeleton.

Millions of tiny survivors

At Palau in the western Pacific, a survey completed just three years after the 1998 bleaching event showed more coral had recovered on reefs within protected bays and on deep slopes.

Scientists suggest this is because heat and light serve as a double-whammy to coral health and corals that hang out in shady zones will escape the scorching combination, upping the chances that remnants will survive.

At night, polyps of Acropora coral open (credit: Jeff Rotman / NPL)

Seven years after the bleaching event, some reefs had regained nearly 40 per cent of their corals, with two species of plate-like acroporid coral, *A. digitifera* and *A. hyacinthus*, particularly prevalent. “We sampled plating coral colonies there a few years ago and found them to be pool-table size,” says Stephen Palumbi, Director of Stanford University's Hopkins Marine Station, in Pacific Grove, California, US.

On Scott Reef, the speed and extent of the recovery were influenced by environmental factors such as water quality and the number of herbivores present, according to James Gilmour’s research.

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All of a sudden, you might see coral following a disturbance, when you thought it was 100 per cent dead

Polluted water and high nutrients encourage harmful algae, while herbivores, such as urchins or fish, keep such algae in check. When corals’ surfaces are clear from algal growth, new baby corals can then settle on them and grow. “So you see quite high survival and quite high growth under natural conditions,” Gilmour says.

Early research on coral degradation in the Caribbean, where herbivore numbers have fallen, determined that new coral roots had very low survival rates. “They struggled to settle and they got outcompeted by the algae,” Gilmour says, “and consequently there was this belief that the tiniest corals had very low survival rates.”

A giant Porites coral and diver (credit: Jurgen Freund / NPL)

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But Gilmour’s findings contradicted this assumption. Because the local conditions at Scott Reef were so good, the algae didn’t edge out the tiny corals and they survived as well as the adults. Corals produce millions of eggs but typically very few make it to adulthood.

“But the real surprise was after the bleaching we’d find millions and millions of surviving little corals,” Gilmour says, “and then they reproduced and then the recovery happened quite quickly.”

Better understanding the lifecycles of corals might provide insights into the resilience of coral reefs. “What you see on the reef is a consequence of how many new corals were born, how they competed, how they survived,” he says. The same could be said of a reef that bounces back.

We concluded that this was the most severe impact on these corals that anyone had ever observed

“What we didn't know is that there are these tiny, tiny bits of tissue remaining and that tissue can grow quite quickly,” Gilmour says. “All of a sudden, you might see coral following a disturbance, when you thought it was 100 per cent dead.”

Environmental conditions influence whether a bleached or damaged reef will survive or crumble. But “if conditions are good after, then these little remaining bits can really recover quite quickly,” Gilmour says.

Quest to save the corals

The rebirth of the *Porites* corals in French Polynesia had shocked Peter Mumby. But the extent of their death in 1998 surprised him too. These hardy corals typically prove resistant to heat stress: when a bleaching event hits Porites, they may go white but then they’ll typically return to normal within a few weeks. The 1998 heatwave served such a bitter blow, however, that even *Porites* corals suffered.

“When we found that a quarter of the [*Porites*] corals had died entirely, we concluded that this was the most severe impact on these corals that anyone had ever observed,” Mumby says.

Shallow bleaching corals at sunset, Papua New Guinea (credit: Jurgen Freund / NPL)

So in a quest to save coral species around the world, scientists are not just looking at how corals recover, but what makes some of them able to withstand high ocean temperatures to begin with.

Using Ofu Island in American Samoa as his laboratory, Palumbi is investigating which populations within a species, even which individual corals within a population, are heat resistant, and why.

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“If corals can adapt their own physiology to adjust to heat, does that mean they have a little way of responding individually to gradually increasing ocean temperatures?” Palumbi says. “And if they do, then that changes how we look at the future. Maybe that gives them a bit of extra time before things get dramatically awful.”

Scientists might exploit this and protect specific regions of reefs that are home to the most heat resistant corals, similar to the corals on Ofu Island. They can also try to limit the impacts of pollution and overfishing, in a bid to create healthy protected reefs that will survive 50 years hence.

They could even transplant heat-resistant corals to other reefs. Palumbi is trying this experiment, testing to see if corals retain their resistance when moved. Early results suggest that about half do.

A new coral grows at Scott Reef, Australia (credit Nick Thake / AIMS)

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“Part of our job as conservation biologists is to take a triage approach, letting us buy some time to save as much as possible now,” Palumbi says. “So when we come to grips with climate change, which we will have to do, then there is something to grow reefs back from.”

Although ambitious bioengineers may one day find ways of propagating corals that could resist bleaching altogether, Palumbi isn’t taking that approach. “We prefer to let the corals do the seeding themselves because they have a quarter of a billion years doing that and they are good at it,” he says.

Maybe, just maybe, it is not going to be as bad as we think

Over that very long time, corals have evolved, partially dying off and rising again like a phoenix, producing a group of organisms that seem able to cling to life in ways that science still does not understand. And comprehending why corals bounce back, or resist bleaching in the first place, could help preserve whole corals species and create a legacy for the future.

If a similar bleaching event were to happen now in Tivaru, Mumby says he’d immediately visit where *Porites* bleached and core out sections of the coral to see if any living tissue still exists inside. “This is one of the great things about ecosystems - they have a natural ability to surprise us.”

Shallow bleaching corals in Papua New Guinea (credit: Jurgen Freund / NPL)

Shallow bleaching corals in Papua New Guinea (credit: Jurgen Freund / NPL)

Mumby has no illusions that corals face anything but a challenging future. Although the *Porites* at Tivaru look to have recovered, telltale signs of stress remain on the reef, he says.

But when he investigated the site last year, the underwater scene ignited a slim spark of hope. “It just made me feel that maybe, just maybe, it is not going to be as bad as we think,” Mumby says.

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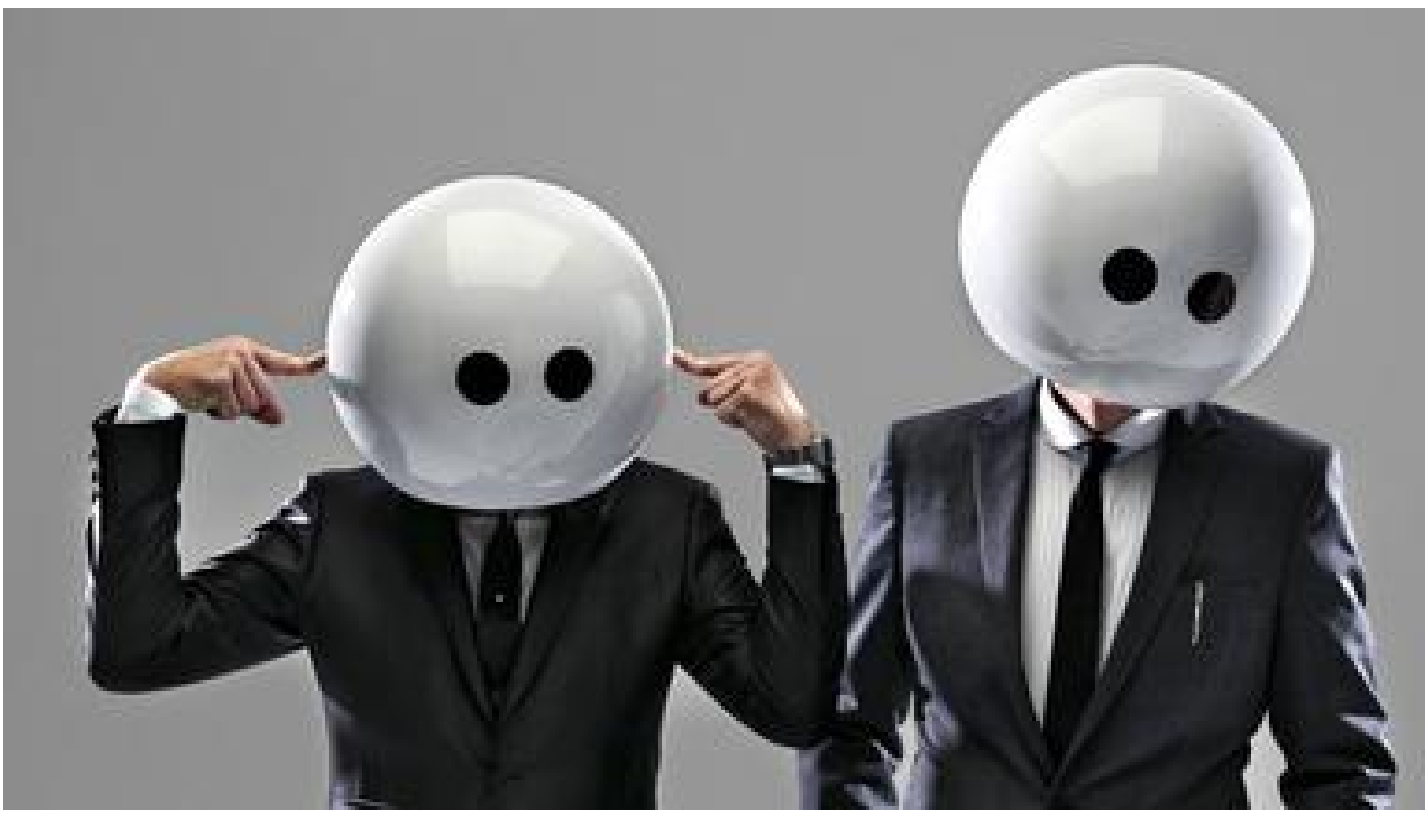

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