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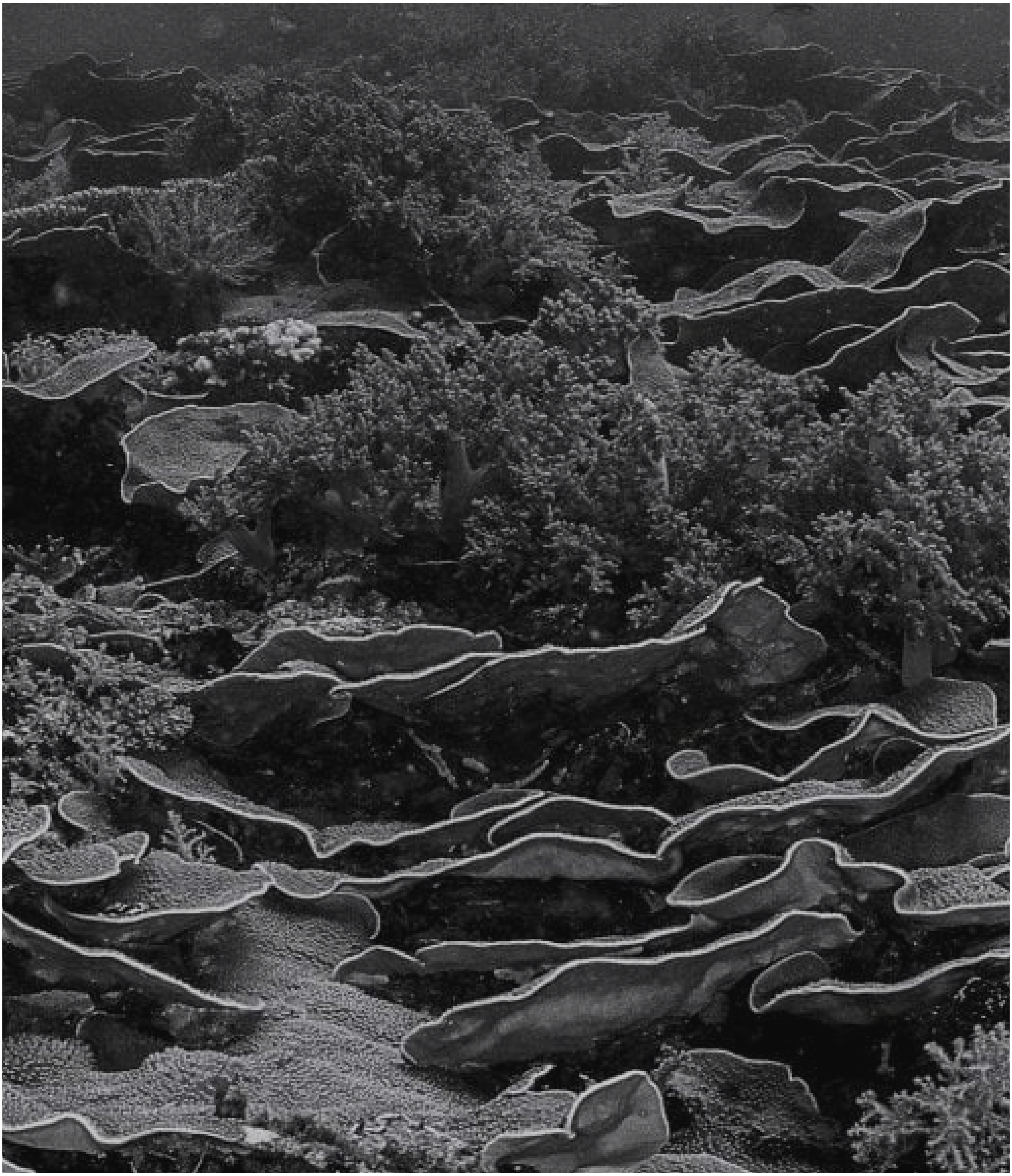

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WORDS BY
EMILY DARLING

IT WAS 2PM AND I WAS STUCK 500 METRES OFF THE KENYAN COAST.

I realised I had misjudged the four-metre tides for my afternoon coral reef surveys and I was holding on for dear life to a truck-sized Porites coral colony as the outgoing tide tried to sweep me out of the lagoon and into East Africa's busiest shipping channel.

Other than my unfortunate situation, I was enjoying a beautiful afternoon. Back on the beach, which was a tantalisingly short distance away, the palm trees swayed gently in the breeze on a white sand beach. Feeling more embarrassed than actually worried, I tried to calm my breathing through my snorkel as the water powered past me, counting each breath in an attempt to patiently wait for the tides to weaken enough so I could swim back into shore. However, until that happened, I had some time to kill, so I took a good look at the reef around me.

Coral colonies had been living and dying on this reef for thousands of years. Luckily, some corals were so large I could stretch my arms out and hold onto in the outgoing tide. It was 2009, I was a PhD student and scientist-in-training with the Coral Reef Conservation Program of the Wildlife Conservation Society (WCS). Ever since I arrived as an intern back in 2006, I had been fascinated by corals, the tiny upside-down jellyfish who live together to build vast colonies of calcium carbonate to form the backbone of every coral reef in the world. How could you not be impressed by these humble reef builders, each one beginning life as small as a poppy seed that could eventually come to build the planet's largest living structure – Australia's Great Barrier Reef – which is large enough even to be seen from space.

Most of the corals in the Mombasa National Marine Park were vast and brown Porites corals. It's a tough life for coral these days. In 1998, ocean temperatures skyrocketed during an El Niño heatwave that bleached and killed nearly half of the living coral cover throughout the Western Indian Ocean. To study long-term reef recovery, I was working with WCS scientists in order to survey dozens of coral reef sites from Malindi to Shimoni, covering approximately 200km of Kenyan coastline. We saw delicate branching colonies of Porites and Pocillopora, the lettuce-like Pavona or brain-shaped Faviids, but generally the reefscape was dominated by those boulder-like Porites.

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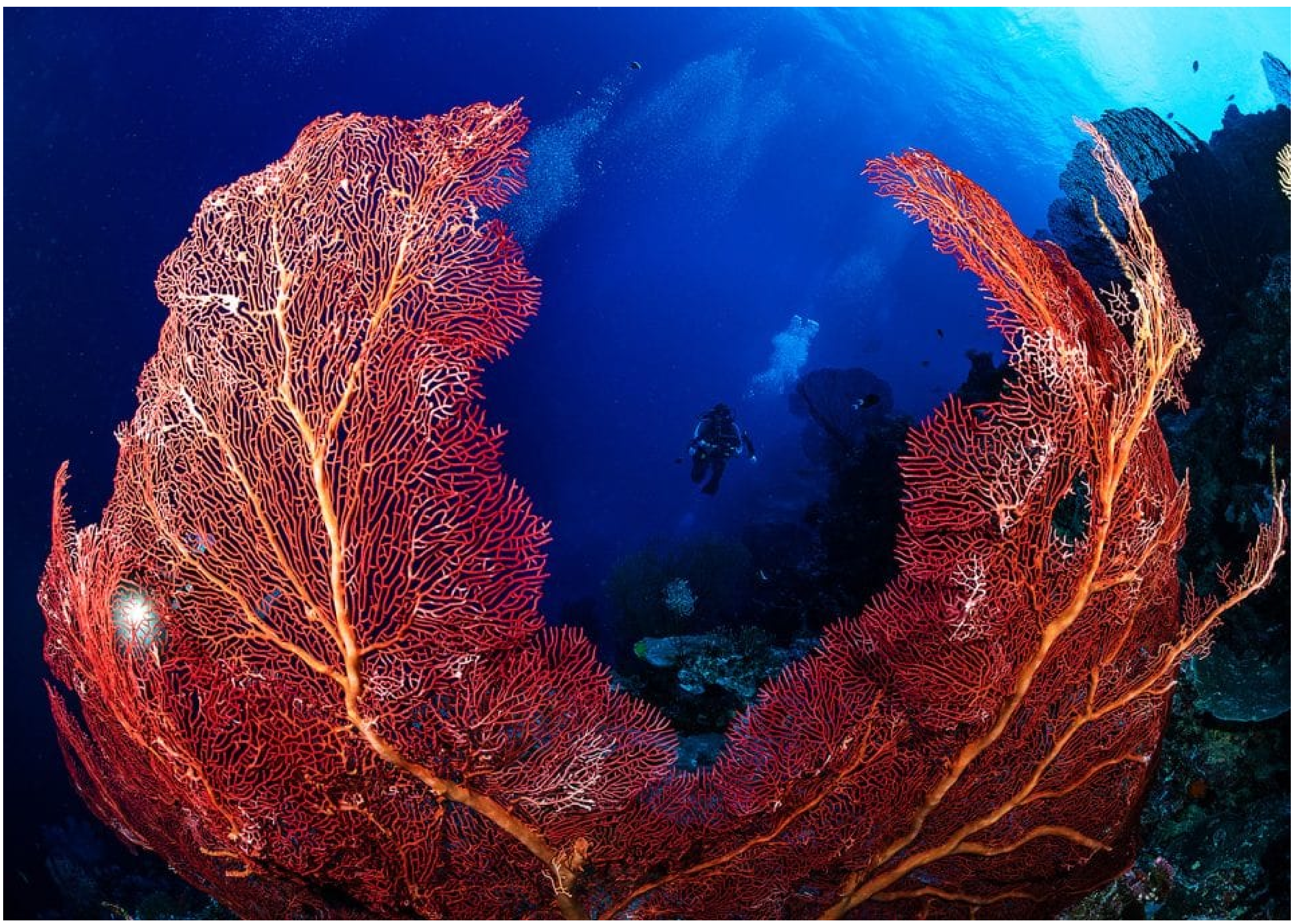

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scientists. The other corals were only exotic names to me in Excel files: Acropora, Montipora, Echinopora, Diploastrea

National Geographic magazine as a child. But why weren't they on the reefs?

Off the coast of Mombasa, like most of the fringing reefs of East Africa, these corals had died first during the 1998 heatwave. Even no-take national Marine Protected Areas (MPAs) guarded by national rangers with camouflage uniforms and rifles couldn't stop climate change. Some of my first scientific discoveries were that Kenya's MPAs lost more corals than nearby unprotected reefs, largely because they had more to lose: their coral communities dominated by species more sensitive to coral bleaching. After the heatwave, the sensitive species disappeared from the reefs and slipped into the history of Excel records.

Eventually, as the tides weakened, I gently released my Porites coral saviour, swimming back to shore past a quiet battalion of corals, the survivors of a first battle with climate change.

But not all the reefs in the Kenya's larger coral reef region of the Western Indian Ocean had been changed by 1998. In 2011, I joined WCS scientists to survey reefs in the Quirimbas archipelago of northern Mozambique. My first dive splashing into clear turquoise waters of the reef left me stunned. Here finally, were the vibrant corals I'd only ever seen in Excel files. Not only did they exist, but they made up the entire reefscape. These reefs and corals were completely different to what I was used to seeing in Kenya. Why did they survive? I would learn that these reefs escaped the 1998 marine heatwave as a consequence of ocean geography. The Quirimbas archipelago is a string of pearl islands close to the Mozambique channel that plummets into nearly 4,000 metres of cold and plankton-rich ocean before it rises back up to meet the coast of Madagascar. The Quirimbas corals were more likely to be exposed to cooler waters from these deep channels and strong ocean currents, preventing severe coral bleaching. If the Quirimbas corals had natural air conditioning, then Mombasa's lagoon corals were living in a hot tub. With little flow and cooler, deeper waters too far out of reach, Mombasa's corals cooked and died in 1998. These experiences left me with a strong appreciation of how much different species and ocean geography matters. If vulnerable corals could survive and thrive in certain environments, were these reefs of hope? What else could be done to save them? Did these same patterns affect other coral reefs around the world? Were there other climate 'cool spots'?

A few years later, I finished my PhD and had two years of unique postdoctoral research funding where we were tasked with taking biggest risk we could think of. "If you fail, you'll learn something," said Smith Fellows Executive Director Dr Mike Dombeck. Not wanting to disappoint, I tried to dream up the biggest scientific risk I could take. What if coral reef field scientists across the Indian and Pacific Oceans – the heartland of coral reef diversity – shared their survey data so that we could compare coral communities and find other climate 'cool spots'?

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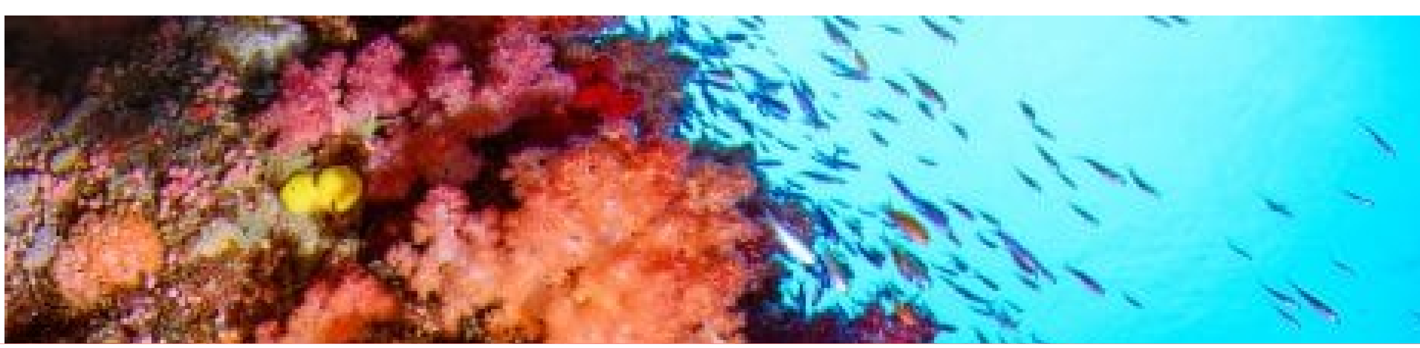

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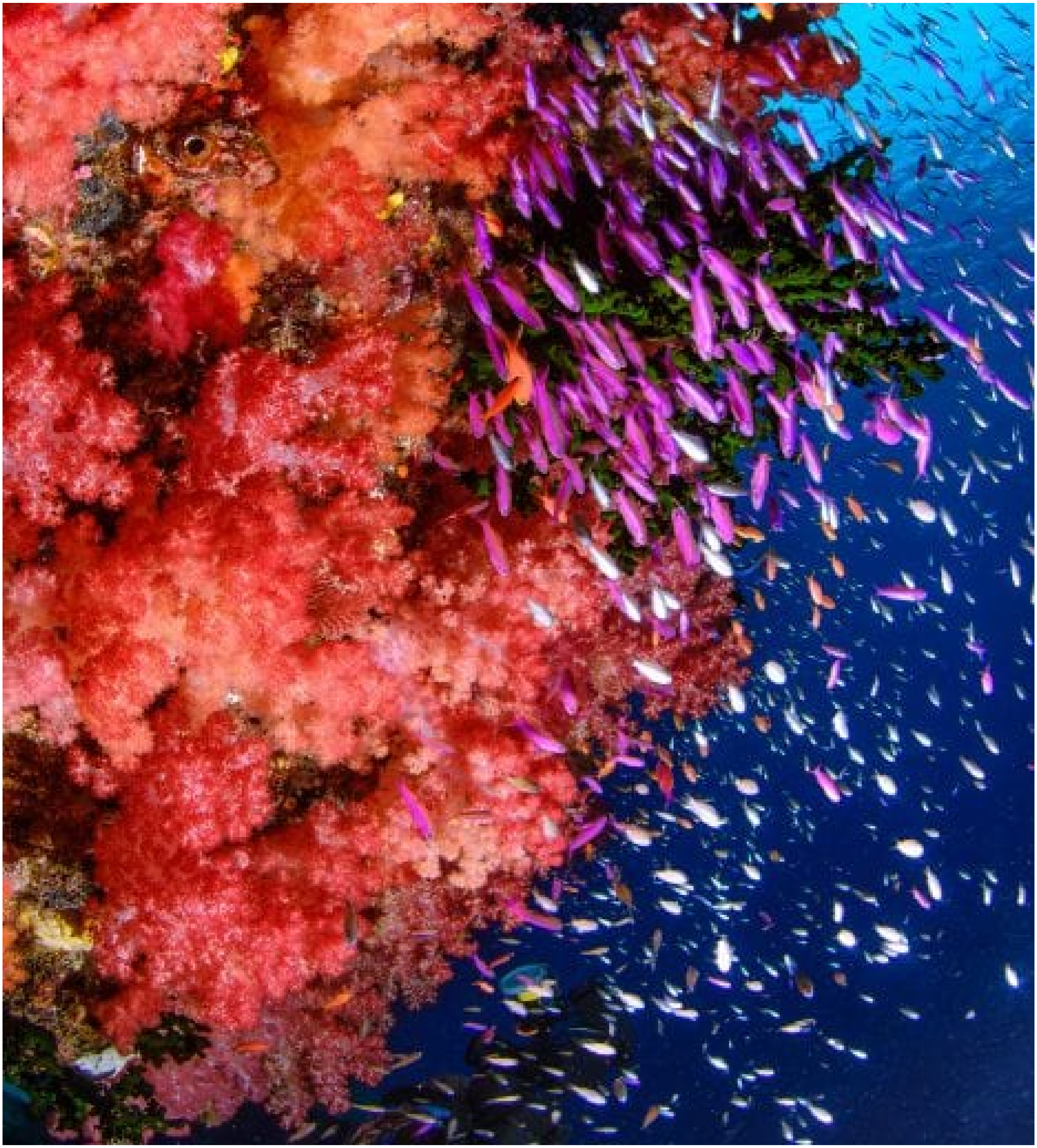

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Incredibly, over the following years, more than 100 scientists generously shared their data with me. This brought together the largest dataset of coral communities in the Indian and Pacific: 2,584 reefs in 44 countries from East Africa to India and Myanmar, across southeast Asia and the Coral Triangle and stretching thousands of kilometres across the Pacific Ocean to reach remote islands of the Eastern Tropical Pacific. Scientists from the National Oceanic and Atmospheric Administration (NOAA) shared new developments in global satellite estimates of climate change on coral reefs. Ecologists defined environmental drivers – including global layers of cyclones, wave exposure, depth, habitat and coastal productivity – that could influence climate impacts and recovery. Social scientists joined the project to interpret global datasets of human populations, fishing markets, agriculture and local management. Eventually, hundreds of Excel files were coded into the same format, dozens of social-environmental data layers were extracted and analysed, thousands of models were run using a Bayesian framework, and 80 co-authors had joined the project. We worked remotely and met in person at workshops, international conferences, or sometimes even underwater on monitoring expeditions. Slowly, we were getting results.

In 2014, partway through our analysis of climate 'cool spots' on coral reefs, NOAA's Coral Reef Watch – a global satellite warning system for coral bleaching – flagged an emerging thermal anomaly. During the next three years, a massive heatwave would sweep across the world's oceans and coral reefs, and would be described as the longest, most extensive, most intense and possibly most damaging coral bleaching event on record. Half of the corals on the Great Barrier Reef died from successive heatwaves in 2016 and 2017. Coral reproduction and recruitment of new baby corals failed following the collapse of adult populations. A global analysis found recovery windows between modern bleaching events were too short for even the fastest growing corals. The media headlines were grim.

By this time, my postdoctorate funding had ended and I had taken a full-time job with the WCS as a conservation scientist leading the organisation's global coral reef monitoring efforts. I joined our WCS monitoring teams in Fiji, Madagascar, Indonesia and the Solomon Islands. Even during the 2014-2017 heatwave, we were often diving on healthy coral reefs that supported local communities, who had successful fishing and tourism industries, food security and long-standing cultural practices in coral reef management. Even amidst global bleaching, there remained coral communities dominated by important branching and plating corals. Many of these reefs has escaped the devastation that struck Australia's Great Barrier Reef. Surely, there was still some hope, even in spite of the media headlines proclaiming the widespread death of coral reefs?

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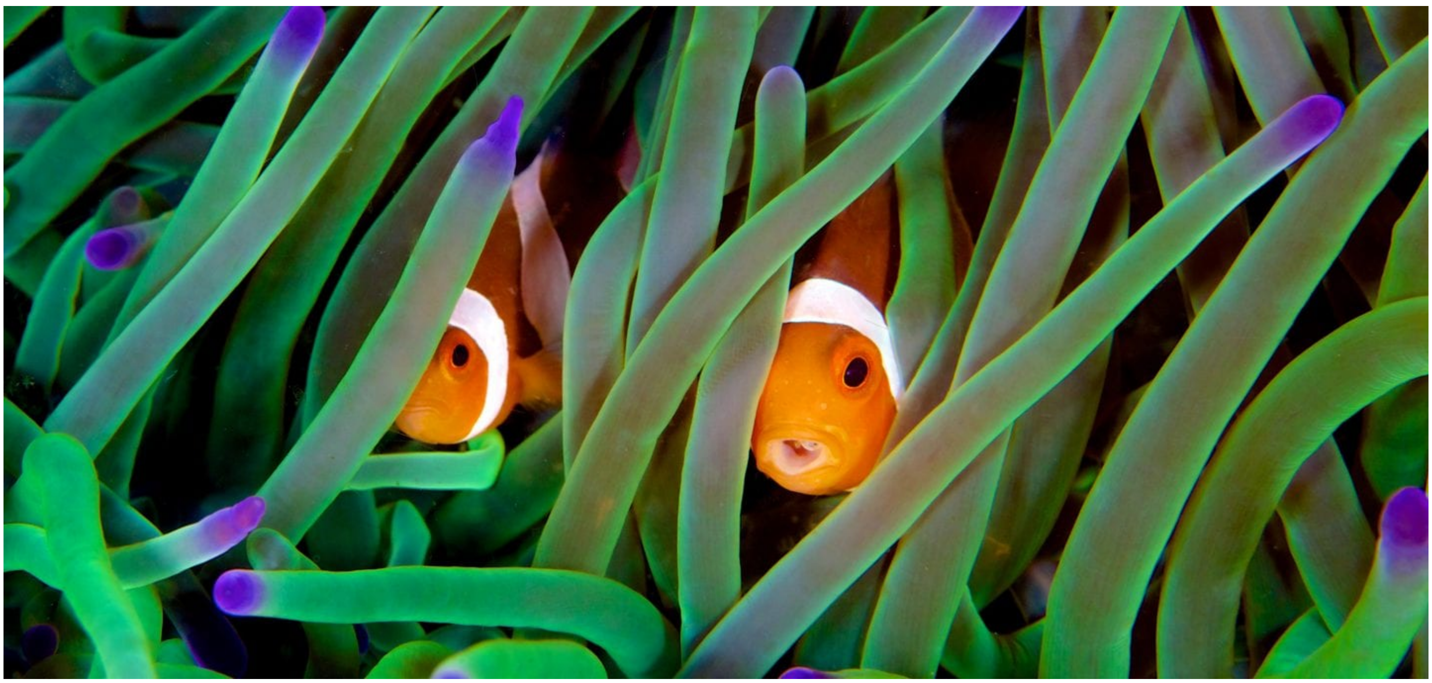
three-quarters of the reefs in our study maintained coral cover above potentially functioning thresholds. 'Functioning' is never

attain large branching, plating or massive colonies.

Soberingly, 75% of these 'functioning' reefs were exposed to potentially lethal levels of extreme heating during the 2014-2017 bleaching event. That left only 449 coral reefs with more than 10% cover of framework corals and exposed to minimal heat stress between 2014-2017. These reefs seemed to be clearly in need of protection from other local stressors – on these last functioning reefs, if the effects of destructive fishing, pollution or development could be managed, then 22 countries could be connected into a network of functioning coral reefs. Facing 90% losses of coral reefs by 2050, this seemed to be better news than usual.



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OUR RESEARCH SHOWS THAT CORALS NEED LONG RECOVERY

Of the remaining reefs, 1,407 reefs (out of 2,584) were above functioning levels but experienced potentially ecologically-significant bleaching and mortality. Some 728 reefs were below 10% cover of framework corals even before the 2014-2016 bleaching event.

These different outcomes defined by ecological functioning and the impacts of climate change led us to define three strategies for coral reef management: protect, recover, or transform. On functioning reefs that escaped the worst effects of the 2014-2017 bleaching event, protecting these spots from further impacts was the priority. For functioning reefs exposed to damaging levels of thermal stress, recovering their coral communities and function would be crucial. And for degraded reefs below functioning levels even before the 2014-2017 bleaching event, a transformation was urgently needed, either in management or ultimately towards new livelihoods for coastal communities that relied on these reefs.

After studying more than 2,500 coral reefs, functioning coral reefs that occurred in a climate 'cool spot' were found in 22 countries from East Africa to South East Asia, the Coral Triangle, and the Pacific. These are the other reefs that are potentially like the Quirimbas reefs. Many more may exist, and we can identify them by combining underwater surveys with satellite information. We found hope that an international network of coral reef conservation could save the world's last functioning coral reefs by protecting refuges for corals trapped in a warming ocean.

We also have to speed up how we turn data to decisions. Coral reef scientists can't spend five to six years cleaning data for large-scale synthesis projects. To speed up global syntheses, scientists and developers from WCS, the World Wildlife Fund (WWF) and Sparkgeo have developed MERMAID, the first online-offline data platform for coral reef monitoring surveys. Going forward, scientists can collect, analyse and share their monitoring surveys faster than ever before.

We also learned the critical value of underwater surveys for checking the pulse of coral reef health. Scuba tanks and snorkels allow scientists to track the health of coral colonies and understand how all the different types of coral communities are changing. Despite a growing appetite for drones and satellites, this technology simply can't compare with what scientists can record underwater. Funding a global network of coral reef scientists should be at the forefront of climate and ocean research.

With our planet changing faster than ever, we have to think big and act fast. It's been more than ten years since I was holding onto that boulder coral in Mombasa. But how long much longer can even those corals hold out? Our new research on coral bleaching is finding that even the large and strong corals that survived past bleaching events are now weakening and bleaching during repeating heatwaves. We face a cascading loss of our coral reef's life support systems: the corals themselves. Climate 'cool spots' can help corals survive and will be important refuges of coral reef biodiversity. Strong local management is key for the survival of biodiversity – and coastal societies – in these areas. But urgent action on climate change is needed to cool down our planet and our oceans. Our research shows that corals need long recovery windows from climate disasters. Limiting global warming to 1.5°C is critical for their survival and for our own. I have hope for coral reefs, and that humans will make the right decisions to save future generations in the decades to come. But I hope we make these decisions fast enough to save coral reefs as I've known them.

To discover more about Emily's work, read the full study: *Social–environmental drivers inform strategic management of coral reefs in the Anthropocene.*

Emily will be speaking at the 2019 Jackson Wild Summit, running September 21st-27th, which will have a conservation focus of 'Living Oceans'. She will be a part of the 'Species at Risk' series, talking all things coral protection and warming oceans. Click here to register to attend the summit.

Photographs by Tracey Jennings, Gregory Piper, Gaby Barathieu and Yen-Yi Lee, via The Ocean Agency's Coral Reef Image Bank.

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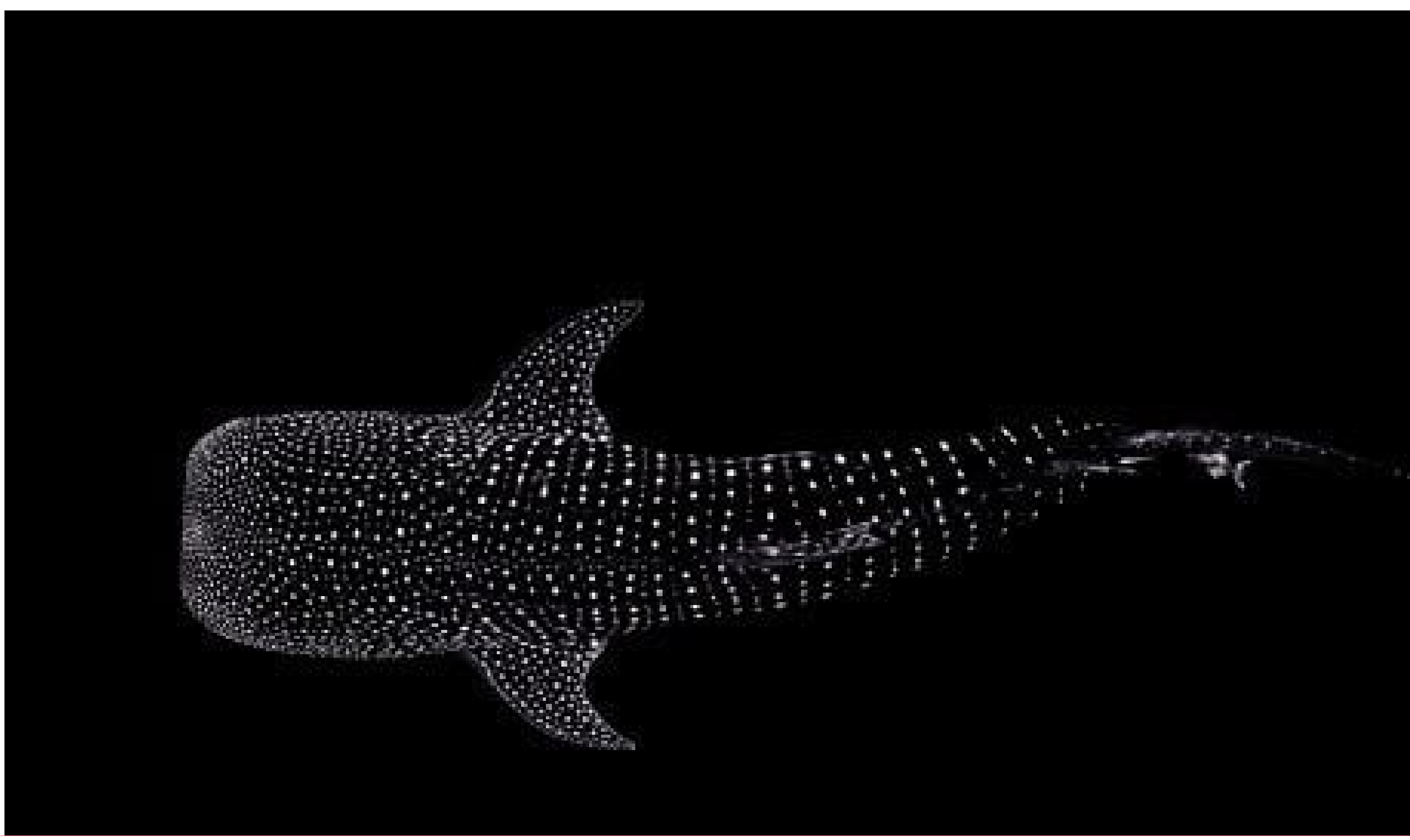

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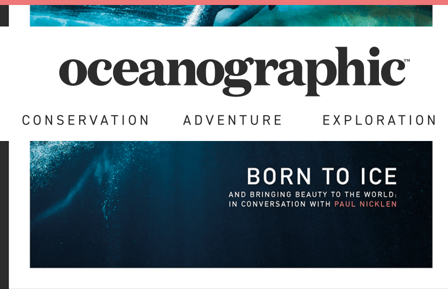

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