The researcher, the reef, and a storm

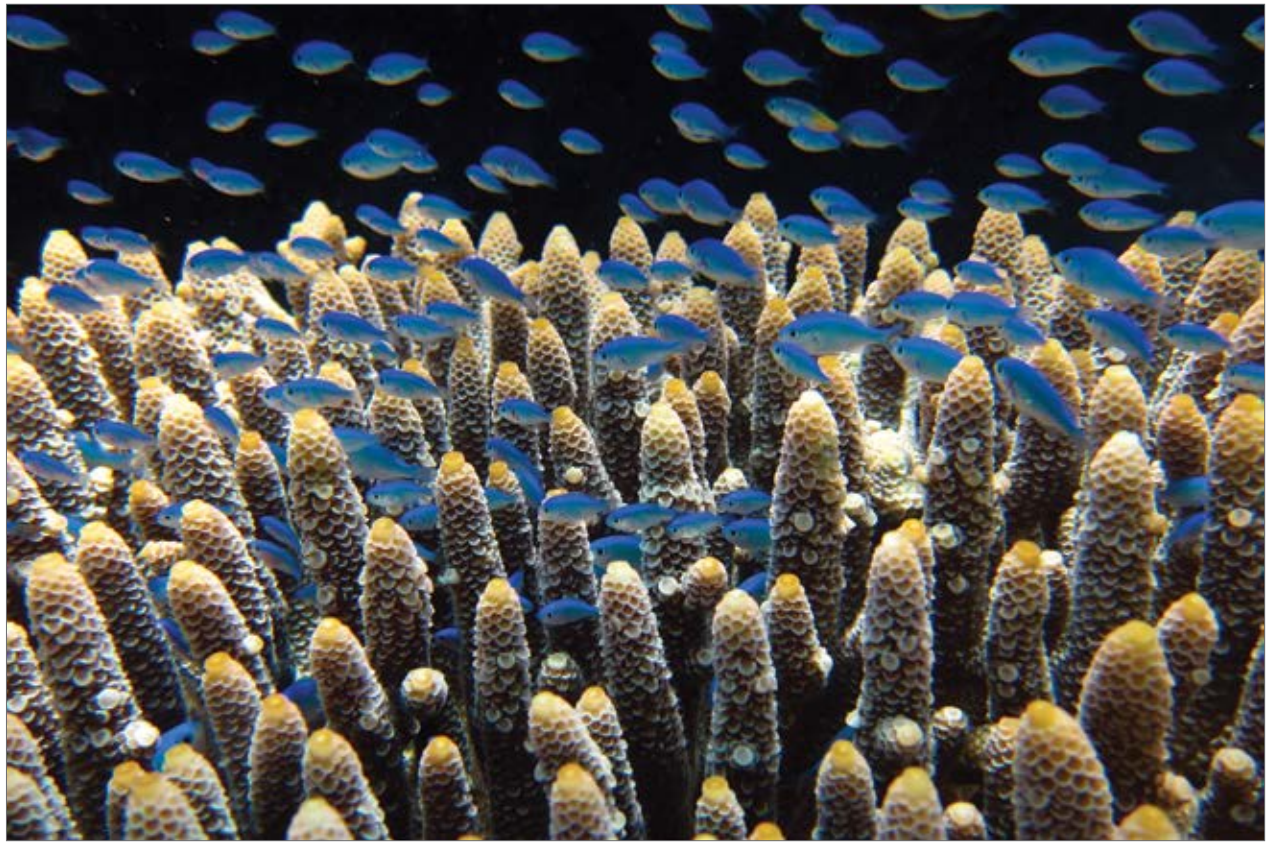
"Just like us, corals are animals that can become injured or wounded."

Joleah Lamb
Cornell University

by Natasha Vizcarra

It was just her luck. Marine ecologist Joleah Lamb was organizing a coral reef survey in Australia's Great Barrier Reef when a cyclone plowed through her study sites. Cyclone Yasi had crept in from the east, near the Fiji Islands, as a tropical depression. By the time it crossed the Coral Sea and landed over touristy Mission Beach it was a Category 5 behemoth.

But the tenacious PhD student carried on. Two weeks after the storm, she picked her way over roads littered with branches and sand, passing houses with roofs ripped off and boats washed ashore. She and her colleagues pulled on their



Juvenile blue chromis linger near the branches of an *Acropora millepora* colony off Lizard Island on the Northern Great Barrier Reef. Corals are an important habitat for fish, especially young fish that hide in the reefs to avoid predators. (Courtesy F. J. Pollock, Pennsylvania State University)

wetsuits, got on boats, and headed to the reefs. "This happens a lot in ecological studies and we just roll with it," she said. "Data is data!"

When they reached Cairns, the damage was breathtaking. "We observed many reefs with immense levels of damage, such as broken and exposed coral skeletons and overturned coral colonies the size of cars," Lamb said.

She noticed something else. "There was a lot of disease where the cyclone hit," Lamb said. She tweaked her research plan and collected storm damage data as well. In a follow up survey six months later, she saw the same. Were the diseases somehow intensified by storm damage?

Underwater epidemics

Lamb was in Australia to investigate whether marine reserves like the Great Barrier Reef Marine Park protect coral reefs from marine diseases. Beginning in the 1950s, various countries established marine reserves to protect reefs from increasing overfishing and other human activities. It is unclear to scientists whether reserves can also shield reefs from diseases.

Lesions, bleaching, black bands, and white spots: Lamb studies these ghoulish markings and other signs of disease on corals worldwide. "Just like us, corals are animals that can become injured or wounded," Lamb said. And just like humans, injured corals are less able to fight off diseases.

While they look like underwater plants, corals are animals and are closely related to jellyfish. Each coral is made up of thousands of tiny animals, called polyps. The polyps feed on plankton, but also rely on algae that live in their tissues to provide energy.

Millions of marine species begin their lives on coral reefs. On a night dive, life and death dramas unfold under the divers' bright lights. Billions of coral polyps emerge, snatching plankton with their stinging tentacles. Tiny wrasses nibble parasites off larger fish that would otherwise eat them. Among rocky coral, feisty damselfish farm algae. Under the reefs, shrimp hide with baby fish, eaten by bigger fish, and then larger fish.

Everything changes when the corals get sick. "Once a pathogen infects a coral, the tissue loss typically continues to spread across the coral and is unstoppable," Lamb said. That could mean death for the whole colony and the marine creatures that depend on it for food and shelter.

Zoom in, zoom out

Lamb planned to compare the rates of disease inside and outside the reserves. After recording signs of disease affecting colonies off the Whitsunday Islands and the coastal towns of Port Douglas and Cairns, she surveyed for two more summers around the Palm Island group that was hit the hardest by Cyclone Yasi, and further south around the Keppel Island group where yearly floods dump silt on the reefs. She also noted evidence of recent injuries, like broken corals and open wounds from entangled fishing line.

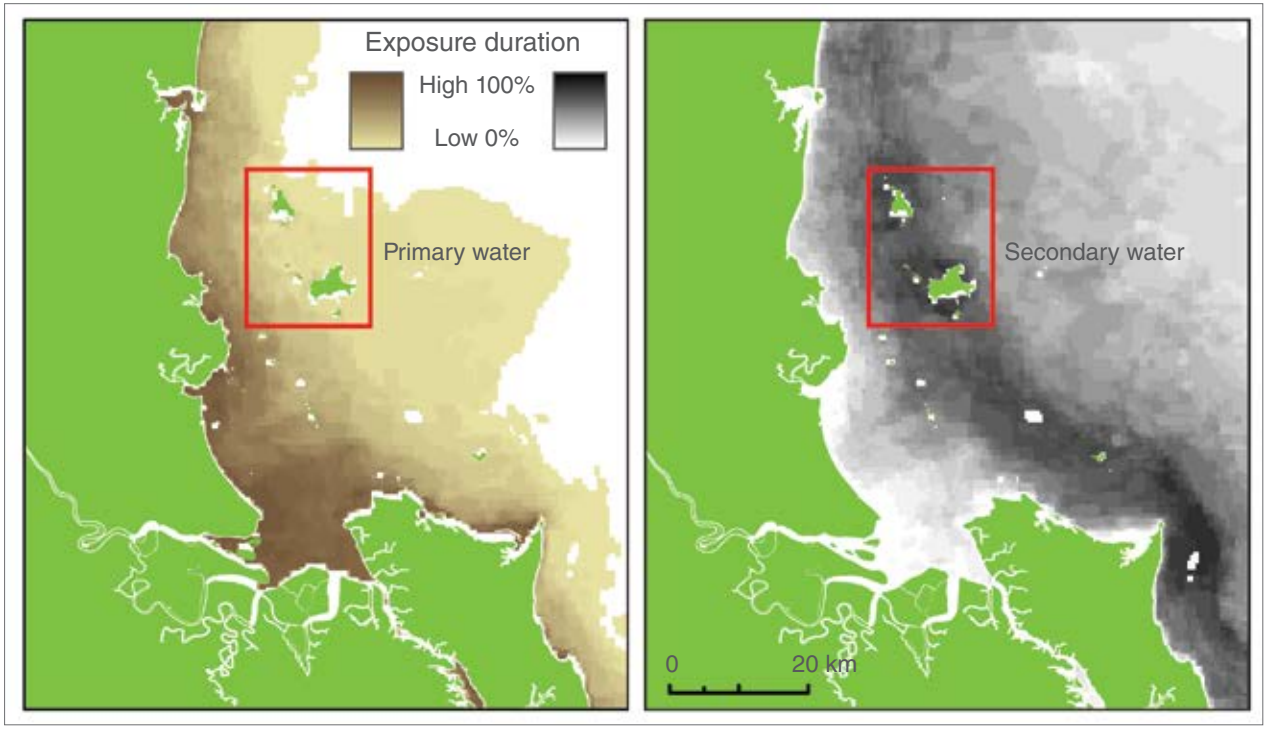
Months later, when Lamb compared the average number of diseases inside and outside the reserves, she found that marine reserves can, to a degree, protect coral reefs from disease, despite damage from storms. Coral disease levels in the Palm Islands were seven times lower inside marine reserves compared to outside reserves a year after Cyclone Yasi. Reefs outside reserves did not fare well: Coral diseases were more prevalent,

Marine ecologist Joleah Lamb hovers near table coral as she examines the reef for signs of disease and damage. (Courtesy J. Rumney)

particularly where reefs had high levels of injured corals and discarded fishing line.

"Corals have an immune system to fight pathogens, but if they are stressed in any other way, they are less likely to be able to fight off the infection," Lamb said. "Fishing line not only causes coral tissue injury and skeleton damage; it also provides additional surfaces for potential pathogens to colonize, increasing their capacity to infect wounds caused by entangled fishing line."

However, she found no clear pattern for this in regions affected by flooding. "Maybe there are



These images compare how frequently coral reefs around the Keppel Islands (red box) were exposed to primary water, or runoff from floods containing large sediment (left); and secondary water, or runoff containing fine sediment (right). Shading intensity indicates the duration of exposure. Data are derived from the Moderate Resolution Imaging Spectroradiometer (MODIS) on the NASA Aqua satellite. (Courtesy J. B. Lamb, et al., 2016, *Philosophical Transactions of the Royal Society B*)

other drivers for why this is happening," she said. "I thought, we need to look at the long-term history of these sites."

So Lamb worked with Amelia Wenger, then a researcher at the ARC Centre of Excellence for Coral Reef Studies at James Cook University, to find water quality data for her study sites. "We were fortunate to have a long-term data set that combined in situ water quality and remote sensing data," Wenger said.

The data set uses true color satellite imagery from the NASA Moderate Resolution Imaging Spectroradiometer (MODIS). Wenger used this to map water quality and flood plumes at their study sites. When they combined this with their field data and ran these through statistical models, clear patterns emerged.

A caveat

Here was the catch: Marine reserves can protect coral reefs from disease only if the water quality is good. In the Keppel Islands, coral reefs were repeatedly exposed to higher than average levels of fine sediments and nutrients. In these sites, disease levels inside the marine reserves were the same as outside the reserves.

"It was a huge surprise," Lamb said. She had assumed that large sediment from the yearly floods draining into the sites would smother coral and cause diseases. Instead the diseases were related to finer sediment and chlorophyll-rich waters.

"When a flood takes everything off land, you have sediment, you have nutrient from fertilizers, you have pesticides from farms," Wenger said. "It's obvious in the satellite image, because you see this murky brown plume sitting in otherwise bluish sea water."

Large sediments float in the plume for a few days. When they sink, smaller sediments remain. Sunlight breaks into the plume, allowing nutrient-fed algae to bloom, which causes oxygen levels in the water to drop. "Chronic hypoxia or exposure to algal blooms could be equally detrimental in the development of disease," Lamb said.

Lamb and her colleagues urge marine reserve managers to improve water quality and limit human activities that injure corals. "I hope this sends a clear message to other regions in the world about the benefits that reserves can have on reef health and the importance of incorporating land management into the reserve planning process," she said.

"This study looks at things from multiple scales and does a great job of connecting the dots," said Kevin Lafferty, a marine ecologist at the U.S. Geological Survey who was not part of the study. "Oftentimes we look at marine diseases or other environmental problems and get stuck at 'we have a problem.' This study shows us, 'here's what drives the problem and here are specific solutions.'"

Watching the reefs

In hindsight, Lamb should not have been worried about Cyclone Yasi interfering with her research plans. "If the cyclone hadn't hit some of my sites I would not have thought of collecting the data," she said. "It came by accident really, and led me down this whole path of research."

"About 275 million people live within 30 kilometers of coral reefs and rely on them for food, coastal protection, income, and cultural value," Lamb said. "However, disease outbreaks have caused significant declines in coral cover, with losses of up to 95 percent in some reef regions."

Reefs are increasingly threatened by coral bleaching, caused by higher water temperatures or extreme weather events. With Earth's temperature projected to rise, marine ecologists like Lamb will have their hands full and will need to connect more dots double time.

"You do it for the love, that's for sure," Lamb said. It's the same love that keeps divers and snorkelers returning to the reefs.

To access this article online, please visit https://earthdata.nasa.gov/sensing-our-planet/the-researcher-the-reef-and-a-storm.

References

Baith, K., R. Lindsay, G. Fu, and C. R. McClain. 2001. Data analysis system for ocean-color satellite sensors. *EOS Transactions of the American Geophysical Union* 82: 202. doi:10.1029/01EO00109.

Lafferty, K. D., and E. E. Hofmann. 2016. Marine disease impacts, diagnosis, forecasting, management, and policy. *Philosophical Transactions of the Royal Society B* 371: 20150200. doi:10.1098/rstb.2015.0200.

Lamb, J. B., A. S. Wenger, M. J. Devlin, D. M. Ceccarelli, D. H. Williamson, and B. L. Willis. 2016. Reserves as tools for alleviating impacts of marine disease. *Philosophical Transactions of the Royal Society B* 371: 20150210. doi:10.1098/rstb.2015.0210.

NASA Ocean Biology DAAC (OB.DAAC). Level 0 Ocean Color Web. Greenbelt, MD, USA. http://oceancolor.gsfc.nasa.gov/cms.

Wenger, A. S., D. H. Williamson, E. Da Silva, D. M. Ceccarelli, N. Browne, C. C. Petus, and M. Devlin. 2015. Effects of reduced water quality on coral reefs in and out of no-take marine reserves. *Conservation Biology* 30: 142–153. doi:10.1111/cobi.12576.

About the remote sensing data

Satellite	Aqua
Sensor	Moderate Resolution Imaging Spectroradiometer (MODIS)
Data set	Daily MODIS Level 0 Data
DAAC	NASA Ocean Biology Distributed Active Archive Center (OB.DAAC)

The Level 0 data were converted into true color images with a spatial resolution of 500 by 500 meters, using the OB.DAAC NASA SeaWiFS Data Analysis System (SeaDAS).

About the scientists

Kevin Lafferty is a research ecologist at the U.S. Geological Survey at the University of California Santa Barbara. His research focuses on invasive species ecology, the conservation of marine resources, assessing the effects of marine reserves, and investigating strategies for protecting endangered shorebirds, fish, and abalone. Read more at https://goo.gl/TR2SO3. (Photograph courtesy S. Fernandez)

Joleah Lamb is a NatureNet postdoctoral fellow at Cornell University in Ithaca, New York and The Nature Conservancy. Her research focuses on identifying and managing the influence of reef and coastal-based industries on coral health and disease. The Australian Government National Environmental Research Program and The Nature Conservancy supported her research. Read more at https://goo.gl/u0RwxD. (Photograph courtesy S. Beveridge)

Amelia Wenger is a postdoctoral research fellow at University of Queensland, in Australia. Her research focuses on connecting ecological and spatial data to assess responses of coastal and marine systems to threats. The Australian Research Council, the Australian National Environmental Research Program, and James Cook University's Marine Monitoring Program supported her research. Read more at https://goo.gl/tJiVs5. (Photograph courtesy I. McLeod)

For more information

NASA Ocean Biology Distributed Active Archive Center (OB.DAAC)
http://oceancolor.gsfc.nasa.gov

NASA Moderate Resolution Imaging Spectroradiometer (MODIS)
http://modis.gsfc.nasa.gov

NASA SeaWiFS Data Analysis Sytem (SeaDAS)
http://seadas.gsfc.nasa.gov