CORAL | THE REEF & MARINE AQUARIUM MAGAZINE

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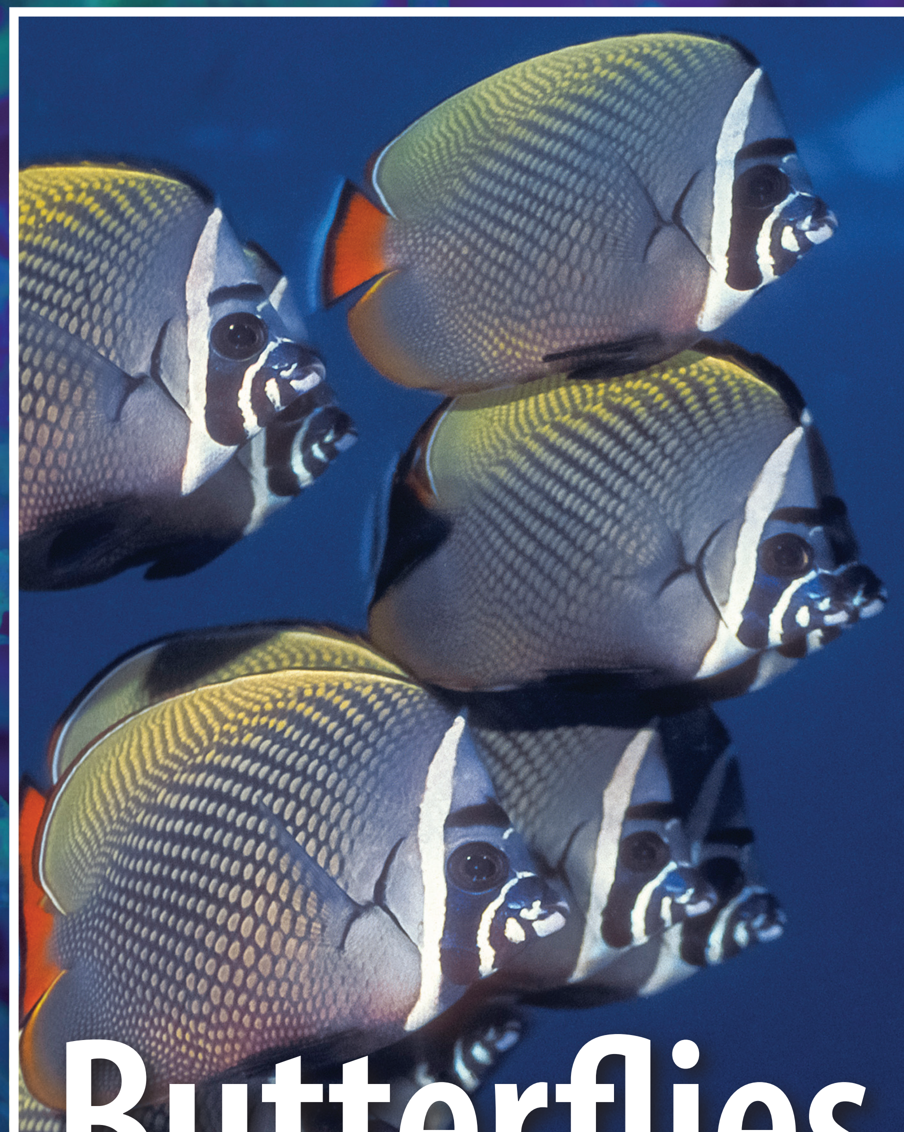

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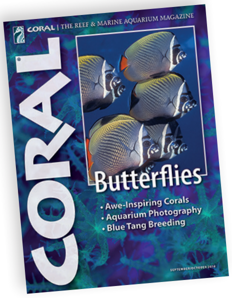
COVER CREDITS: Shoal of Indian Ocean Collare Butterflyfishes, *Chaetodon collare*, Mark Strickland/ Seapics.com.Background: *Clavularia* sp. coral under blue light. Daniel Knop



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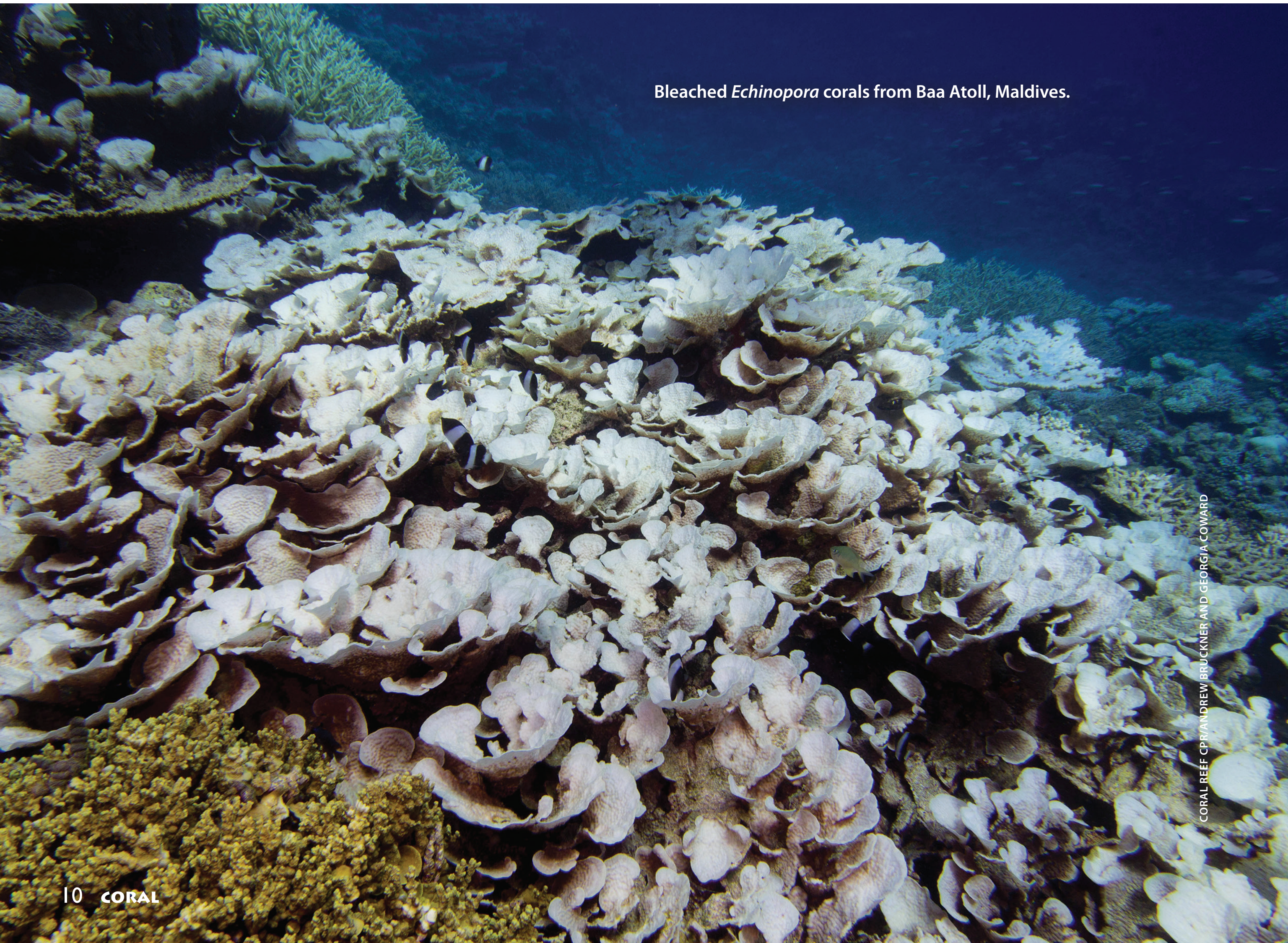
Maldives bleaching 2016: Coral reefs continue to get themselves into hot water. Is there hope?

In early April 2016, three months after setting up our permanent sites in the Maldives, we (Coral Reef CPR) returned to assess changes. Temperatures in the previous month had climbed above 86°F (30°C) and the reefs were already beginning to bleach. Not all sites and corals were responding in the same way or at the same speed, however. Some sites were already fully bleached, while the corals at other sites were pale or not bleached at all. Adjacent colonies of the same species of coral, at the same depth and on the same reef, displayed very different characteristics. Some were stark white, others were pale, and some were brightly fluorescent—lemon yellow, lime green, purple, blue, and pink. There were also a handful of colonies that didn't appear to be affected at all. What did this mean?

In 2015, the earth experienced its hottest year since recordkeeping began. It was also the beginning of a "super" El Niño, the worst in over 15 years. Active since March 2015 and steadily strengthening into 2016, this El Niño had already caused torrential downpours, thunderstorms, devastating floods, and landslides in some parts of the world, severe droughts and drier-than-normal monsoons in others. Two previous super El Niños occurred in 1982/1983 and 1997/1998, but the damage from the current El Niño may far surpass both, especially in coral reef ecosystems.

El Niño Southern Oscillation (ENSO) is a periodic shift in the ocean-atmosphere weather system, generally occurring every two to nine years. It typically begins



Bleached *Echinopora* corals from Baa Atoll, Maldives.

CORAL REEF CPR/ANDREW BRUCKNER AND GEORGIA COWARD

A school of herbivorous Powder Blue Surgeonfish (*Acanthurus leucosternon*) moves through a shallow reef in the Maldives.

Far left: A bleached digitate *Acropora* displaying a fluorescent blue color. Near left: This *Galaxea* coral turned yellow as water temperatures became intolerable.

between December and February and lasts only about six months, but it is always associated with abnormally warm ocean temperatures and unusually stressful conditions for the ocean's animals and plants. During normal, non-ENSO conditions, Pacific trade winds blow from South and Central America toward the west, causing warm water to pile up around Indonesia and an upwelling of cool, nutrient-rich waters off the coasts of Mexico and South America. During an ENSO event, trade winds in the Pacific weaken and the westward-moving currents break down, triggering the flow of warm water from the western Pacific back to the eastern Pacific and into the Indian Ocean. The effects of El Niño can be erratic and are not always predictable, but they can have far-reaching global impacts on both the environment and the economy.

ENSO events are natural processes that have occurred for thousands of years. Nevertheless, many scientists believe global climate change is altering the way the El Niño cycles behave, possibly increasing their frequency and duration as a result of warmer global sea surface temperatures and likely worsening the impacts. This appears to be the case today, as the 2015/2016 El Niño, exacerbated by seawater temperatures that have been rising around the world, is pushing coral reefs ever closer to the brink of extinction. Corals are unable to cope with the rapidly rising ocean temperatures; they simply haven't had adequate time to adapt to them.

As a result of these unsustainably high ocean temperatures, coral reefs are experiencing the longest global coral bleaching event ever observed. Since mid-2014, severe bleaching has affected the western Pacific, including reefs around Guam, the Commonwealth of the Northern Mariana Islands, Hawaii, and the Marshall Islands. By 2015, bleaching had spread to many South Pacific islands and into the central to eastern equatorial Pacific, hitting the Indian Ocean in April and possibly the Caribbean later in the year. In Australia, beginning in March 2016, the northern Great Barrier Reef experienced the most severe bleaching event ever documented, and as many as 35 percent of the corals are now dead. Just as reefs in the Indian Ocean that bleached in 2015 had started to recover, they began to bleach once again in March and April 2016, this time much more severely. NOAA coral scientists predict a similar fate for Caribbean reefs, with bleaching beginning as early as September.

Corals bleach when exposed to stressful conditions,

CORAL REEF CPR/ANDREW BRUCKNER AND GEORGIA COWARD

such as high water temperatures and elevated light levels. When exposed to elevated temperatures for prolonged periods, the corals expel the symbiotic algae (zooxanthellae) that live within their tissues and turn translucent and clear, exposing the stark white skeleton beneath the tissue. These algae are critical to the survival of corals and the reefs. They photosynthesize to produce nutrients for themselves, and they share these with coral hosts, providing the corals with up to 90 percent of their nutrition. Without the colorful algae, corals lose a major source of food and slowly starve to death.

The first widespread mass bleaching occurred during the 1982/1983 El Niño, affecting mostly the eastern Pacific and Caribbean. Between 1997 and 1998, a particularly strong El Niño caused the oceans to heat up more than ever before: some reefs experienced temperatures that were 4–6° C higher than their normal maximum. Reef-building corals worldwide began to bleach and die. This event had a devastating impact, killing as much as 18 percent of the world's coral reefs. The Indian Ocean was affected most severely, losing up to 95 percent of its corals in shallow water.

Recovery from the 1997/1998 El Niño was relatively slow, as few locations remained healthy and sources of coral larvae were limited. The fastest-growing branching corals slowly recolonized the reefs and began to grow back over the next 12 years. The slower-growing, massive corals that form the framework of these reefs were less fortunate—they showed much less recovery. A second global bleaching event occurred in 2010, once again killing many of the sensitive branching corals as well as some of the surviving massive corals. Fortunately, the 2010 El Niño was less severe and damage was limited.

In the Maldives and other parts of the Indian Ocean, virtually all corals in shallow water (to about 33 feet/10 m of depth) bleached and died during the 1997/1998 El Niño. For recovery, these reefs relied on healthy reefs upstream—off Africa or Indonesia—that were able to provide larvae. In locations where only part of the reef was killed, the fast-growing branching and foliose corals rebounded within 5–10 years, while communities composed of slower-growing massive and encrusting corals would require 20 to 25 years or longer.

In addition to a good source of larvae, the reef community needs to be intact. Other stresses, such as high fishing pressure, pollution, or sedimentation, must be minimal, and sufficient populations of grazing fishes and sea urchins must be present to maintain clean substrates. For reefs that are effectively dead, especially those located off heavily populated coastlines, recovery to their former condition is unlikely. The reef may become dominated by fleshy algae (seaweeds) or pest species such as cyanobacteria, certain soft corals, and encrusting sponges, with a progressive loss of the species that depend on live corals, such as butterflyfishes. Over time, bioerosion by molluscs, worms, and sponges may increase; this weakens the reef structure, and eventually the coral framework will collapse into a pile of rubble.

Fortunately, many of the corals in deeper water survived the 1998 bleaching event in the Maldives, and most locations (excepting reefs near Malé City) have very minimal human impacts. Recovery, albeit slow, occurred throughout the Maldives, and by 2015 most Maldivian reefs once again had thriving coral communities.

Nevertheless, the recent losses sustained due to Crown of Thorns Starfish outbreaks and the predicted stresses of a mass bleaching event were a premonition of a bleak future. Returning to assess the severity of bleaching and subsequent damage at our monitoring sites in the Maldives would provide us with the opportunity to witness the rapid impact of abnormally high ocean temperatures on coral reefs and to identify signs of optimism. Historically these reefs have exhibited high resilience and the ability to rebound following catastrophic losses. They bleached in 2015 and recovered quickly. Are they starting to adapt to higher water temperatures? Find out more in the next article.

—Andrew Bruckner and Georgia Coward
Coral Reef CPR

Corals and sponges communicate via their metabolisms

An international research team recently made this surprising discovery: Corals and sponges communicate via their metabolites. This applies to tropical coral reefs in warm, shallow water as well as to cold-water coral reefs in the depths of the North Atlantic.

The researchers found that the slime corals discharge continuously, often in large amounts, is welcomed as food by sponges. The majority of the slime is microscopic and dissolves instantly in the water. This energy- and nutrient-rich matter is therefore not suitable for most organisms on warm- or cold-water coral reefs. However, sponges have an ability that is unique in the animal kingdom: In a process known as "sponge loop" they can convert invisible dissolved organic material into visible particles of particulate organic matter, thanks to an extremely rapid cell metabolism. This means that shortly after taking up dissolved organic material the sponges release cellular lumps. These can then be used as food by many invertebrate reef organisms, including worms, snails, crabs, and starfishes.

Parallel experiments yield similar results

The research team made this discovery through a series of parallel experiments at field stations in Jordan on the Red Sea and on Skagerrak in southern Sweden—two extremely different locations more than 1,864 miles (3,000 km) apart. In Jordan, the corals and sponges for the experiments were collected by divers at depths of 18–33 feet (5–10 m), and in Sweden a submersible robot was used to collect at depths of more than 328 feet (100 m). Although these locations were very different, the results of the experiments were similar: sponges always rapidly converted the coral mucus into particles at a rate of 20–40 percent.

The exciting thing about these findings is that there is obviously a link between

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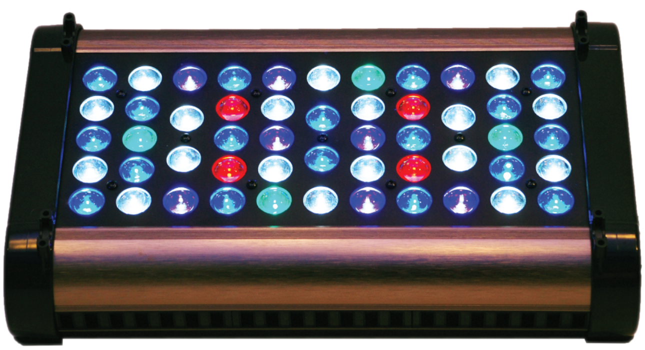

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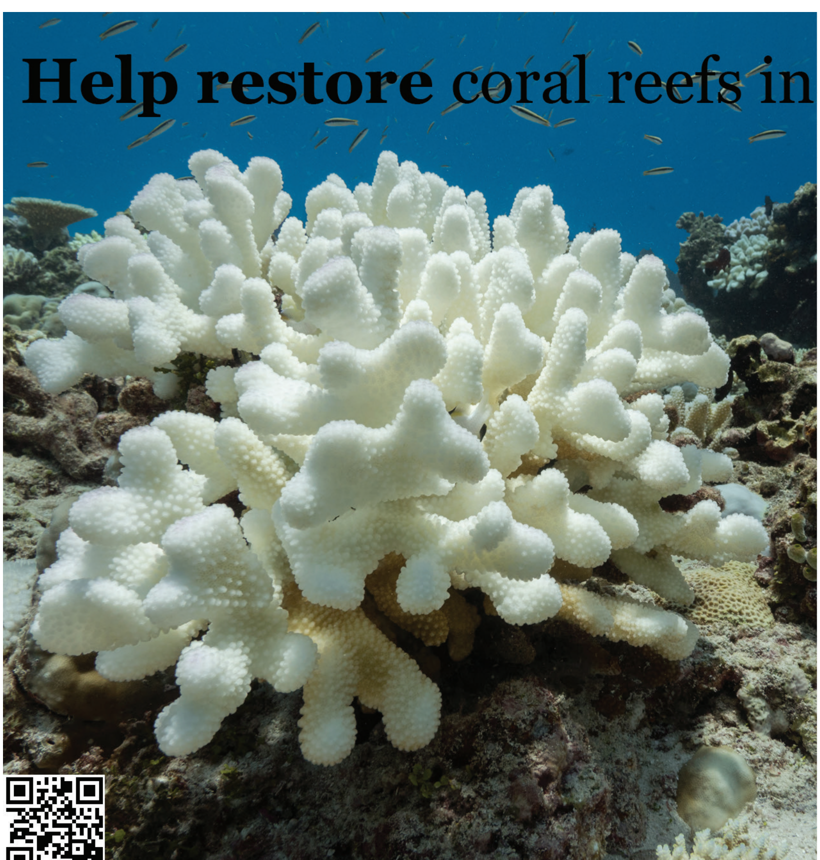

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