

Cool Coral Refuges in a Warmer World

Global-scale climate models predict that ocean temperatures will rise nearly 3°C (5.4°F) in the central tropical Pacific Ocean by the end of the century, wreaking havoc on coral reef ecosystems. Warmer waters often cause corals to “bleach” (right). They turn white because they lose the tiny colorful symbiotic algae that live in them and provide them with nutrition.

But climate change could shift ocean currents in a surprising way that lessens the warming near the tiny Gilbert Islands right on the equator, say scientists at Woods Hole Oceanographic Institution (WHOI). As a result, these islands may become isolated refuges for corals and fish, according to research published in April 2012 in the journal *Nature Climate Change*.



Jessie Kneeland, WHOI

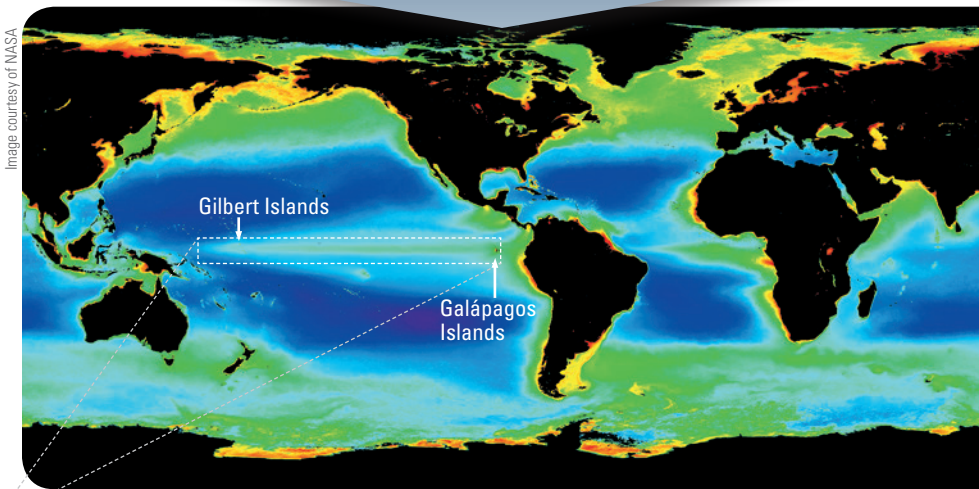


Image courtesy of NASA

Kristopher Karnauskas, a climate scientist, worked with coral scientist Anne Cohen to explore how climate change would affect central equatorial Pacific islands, where marine life such as algae, coral reefs, and fish grow.

Karnauskas examined satellite maps showing measurements of chlorophyll levels in the global ocean (left). Bright red, yellow, and green spots indicate productive patches of ocean where phytoplankton flourish. Prominent patches occur around islands such as the Galápagos in the eastern Pacific.

HERE'S WHY

At the equator, trade winds push a surface current from east to west. About 100 to 200 meters below, a swift countercurrent flows in the opposite direction. This Equatorial Undercurrent (EUC) is cooler and rich in nutrients. When it hits an island, like a current hitting a rock in a river, water is deflected upward on the island's western flank and around the islands. This well-known upwelling process brings cooler water and nutrients to the sunlit surface, creating localized areas where tiny chlorophyll-rich marine plants and corals thrive.

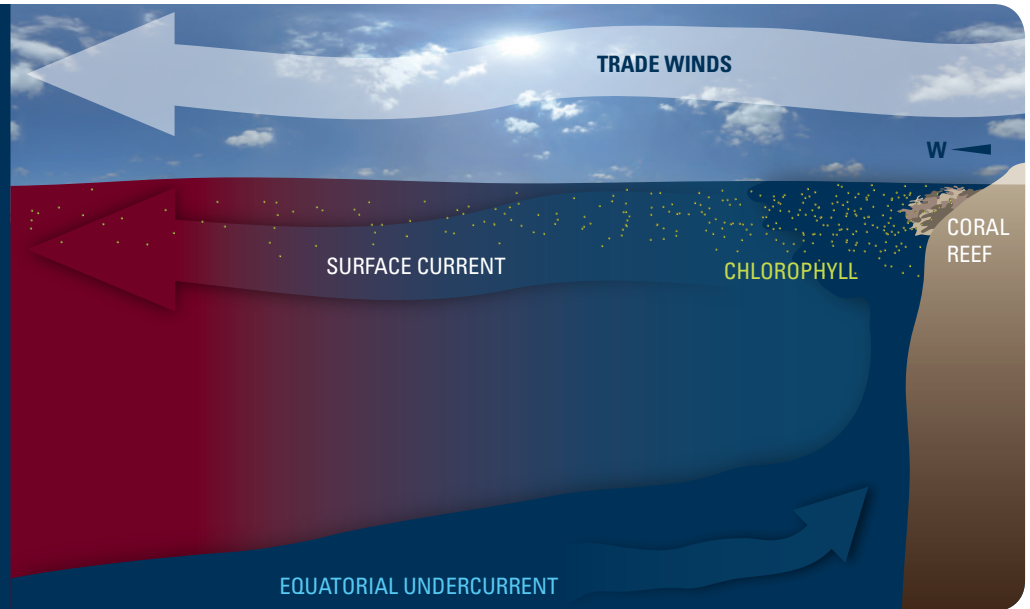


Illustration by Amy Caracappa-Qubeck, WHOI

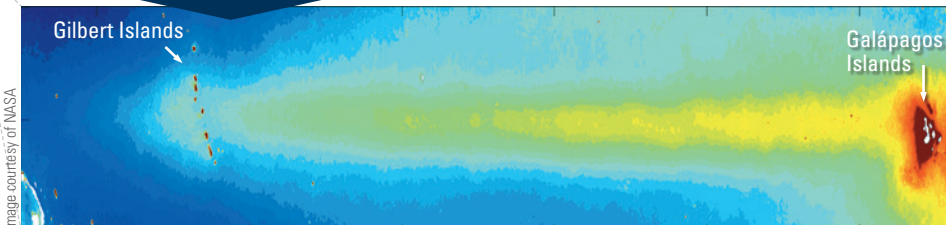
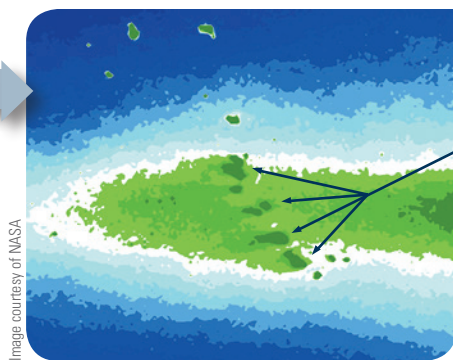


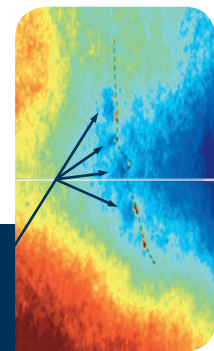
Image courtesy of NASA

Chlorophyll levels fade out farther westward like a comet's tail. So scientists had little reason to look closely at coral atolls farther west in the Pacific.



But Karnauskas zoomed in on the Gilbert Islands, part of the nation of Kiribati. To his surprise, he saw that chlorophyll levels increased again around the islands.

Satellite maps of sea surface temperatures also showed cooler (blue) waters on the west sides of these islands.



"I've been studying the tropical Pacific Ocean for most of my career, and I had never noticed that," Karnauskas said. "It jumped out at me immediately, and I thought, 'There's probably a story there.'" He and Cohen began to investigate how global climate change might affect coral reefs around small islands scattered along the equator.

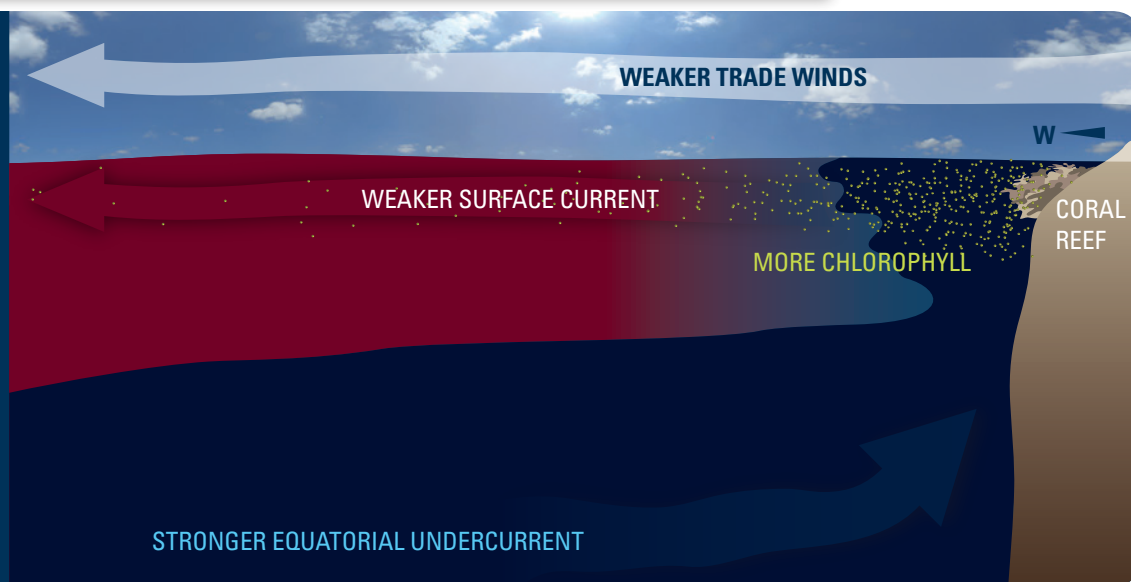


Photos by Tom Kleindinst, WHOI

Global models, with their planet-scale views, can't provide high-resolution details in small areas. So Karnauskas and Cohen combined the global models with a fine-scale regional model that provided sharper details of what might happen in the future around the Gilbert Islands. To accommodate the

trillions of calculations required to bring such small areas into clearer focus, they needed computing firepower. They used a new cluster of high-performance computers at WHOI called "Scylla" (named after the many-headed, multi-tentacled mythological beast).

The scientists' model revealed a potential change in how the EUC would operate in a warmer world: As temperatures rise and equatorial trade winds weaken, the Pacific surface current would weaken by 15 percent by 2100. The weaker surface current would impose less friction and drag on the EUC, so this deeper current would strengthen by 14 percent.



The cool EUC hits islands only 2 degrees (or 138 miles) north and south of the equator, and only their west sides. As a result, waters on the western sides of the islands in the EUC's path will warm more slowly than on other islands, Cohen said.

"Our model suggests that the amount of upwelling will actually increase by about 50 percent and reduce the rate of warming waters on the west sides of the islands by about 0.7°C (1.25°F) per century," Karnauskas said.

A handful of coral atolls on the equator, some as small as 1.5 square miles in area, may not seem like much, but it gives the Gilbert Islands a significant advantage over neighboring reef systems.

"While the mitigating effect of a stronger Equatorial Under-

current will not spare the corals the perhaps-inevitable warming expected for this region, the warming *rate* will be slower around these equatorial islands, which may allow corals and their symbiotic algae a better chance to adapt and survive," Karnauskas said.

Thus, corals at these small geographically and oceanographically well-placed islands may hold on, and they could provide a source of new corals and other reef species that could re-colonize damaged reefs, Cohen said. To preserve them as potential seed banks for the future, these islands' coral reefs may need to be protected now from other threats such as pollution and overfishing.

—Kate Madin

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