Coral–Current Connections

REMOTE ISLAND LIES IN A STRATEGIC SPOT FOR RESEARCH

by Alice Alpert

I remember the moray eel's toothy grin as it peeked out from a crevice beneath a lumpy yellow coral colony. Jewellike turquoise parrotfish flitted before my eyes. Tiny iridescent fish formed curtains of flashing colors. Sharks peered up from the abyss.

I was scuba diving amid massive coral colonies off Jarvis Island in the central equatorial Pacific Ocean, one member of a small team of researchers. The most exciting feeling was that we knew that we were the only humans for hundreds of miles.

We had sailed to this remote uninhabited 1¾-square-mile sandy island that barely rises 20 feet out of the ocean. Scuba diving, we used underwater pneumatic drills to extract 1½-inch-wide by up to three-foot-long cores of coral skeletons. Once we brought the coral cores aboard they got stinky, really stinky. The smell was akin to rotting fish and took away my appetite as it wafted below decks. But the funny thing is that by the time these cores were back in the lab and thoroughly dried out, I came to love the smell of the coral. It's chalky, with a whiff of something earthy and alive.

Coral reefs are wonderlands of beauty and extraordinary biodiversity. But they also have stories to tell. Growing slowly over centuries, they silently record information about their surrounding environment. The coral skeletons we collected at Jarvis Island could help us to learn how ocean currents in the Pacific may be shifting because of climate change, and what these current shifts may mean for the health of coral ecosystems.

Skeletons and currents

You could say that the stories corals can tell are written in their bones. Corals make their hard skeletons using calcium and carbonate from the seawater they live in. They build new layers of skeleton on top of the old, and the layers accumulate like tree rings, marking time.

The skeletons contain not only calcium, but also measurable quantities of other elements, including strontium, magnesium, barium, and uranium. It turns out that how these elements are incorporated into coral skeletons is sensitive to temperature differences: Some elemental levels increase when the water is warmer, while others decrease. Well before anyone was measuring water temperature with thermometers, corals were recording temperature by writing it into the chemistry of their skeletons.

The corals at Jarvis Island are perfectly positioned to tell us about a key current in the Pacific called the Equatorial Undercurrent, or EUC. It is a cold current that flows directly underneath the equator from the western to eastern Pacific, at a depth of 325 to 650 feet. But when it hits the island, some of its water is deflected upward and creates a cool patch at the surface, where corals grow.

When the current is stronger, it carries more cool water to the surface, and when it's weaker, water on the surface is warmer. As the corals sit on the reef, building their skeletons, they record changes in water temperature caused by shifts in the current. By measuring variations in the amount of elements in the skeletal layers, I hope to discern how ocean temperatures in the waters surrounding the corals have risen and lowered over time. And that archive could tell me when and how the EUC has been weaker or stronger in the past.

A hill of water

The EUC is just one of many interconnected currents in the oceans. Currents are like rivers in the ocean, moving water around and distributing heat and nutrients throughout the

globe. Whereas rivers on land are pulled downslope by gravity, these rivers in the ocean are pulled and pushed by forces in the oceans and can move upward, downward, around oceans, and across them. And unlike rivers on land, currents in the ocean are all connected, both to one another and to the winds, which in turn are like currents in the air.

The story of the EUC involves both wind and water. Powerful winds known as trade winds blow across the surface of the tropical Pacific from east to west, pushing the water in front of them and creating a westward surface current. Enough water flows in this surface current that it literally piles up into a "hill" in the western Pacific. It's hard to imagine a hill of water, and in this case, it is very, very gradual: On average, the surface of the far western Pacific is 16 to 24 inches above the surface of the eastern Pacific. As the water piles up in the hill, it creates greater pressure that drives waters to flow down and away.

The water flowing away is the EUC. It can't flow at the surface, since the surface current is already flowing the opposite way. Instead the water sneaks underneath the surface current and makes a beeline back toward the east. Where the EUC encounters small islands like Jarvis along its path, it creates small patches of cool, nutrient-rich water at the surface, which sustain healthy reef ecosystems. Eventually, the EUC rises to the surface off the coast of Peru, bringing cool, nutrient-rich water from the depths up to the surface to nourish the rich fisheries there.

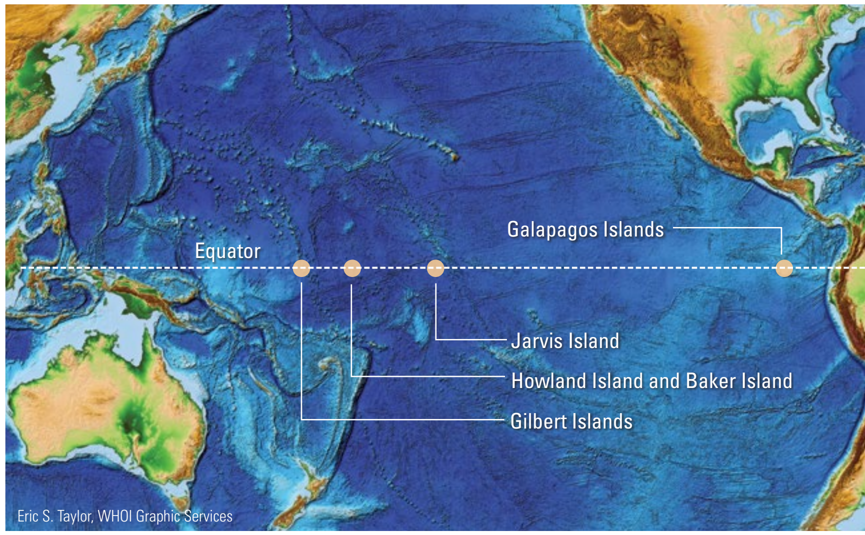
A shifting climate system

On a larger scale, the EUC is an important cog in the system that helps maintain the trade winds and surface currents. This system not only maintains the Pacific region's climate, it has far-flung impacts throughout the world.

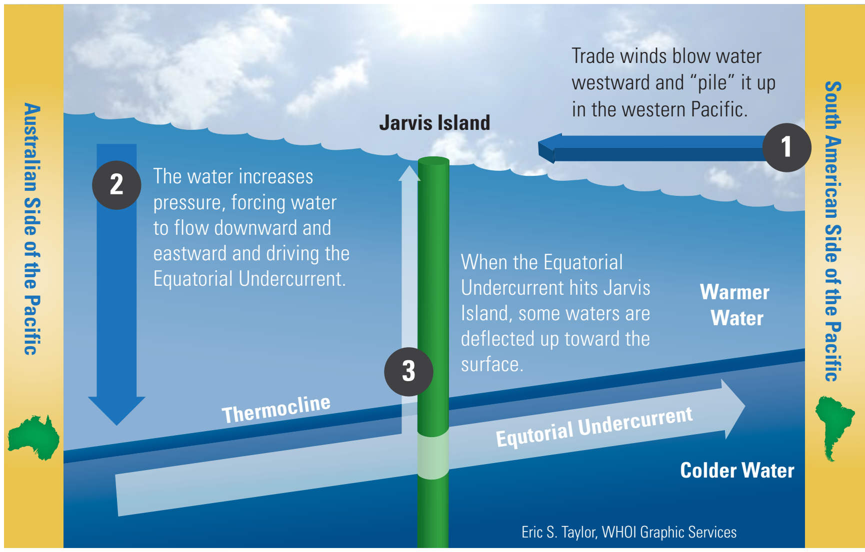
The "hill" of warm surface water that the surface current creates in the western Pacific drives evaporation of water vapor from the ocean into the atmosphere. That produces the highest rainfall of any region on Earth. The rising water vapor also sucks in more air from the east to replace it, strengthening the easterly trade winds.

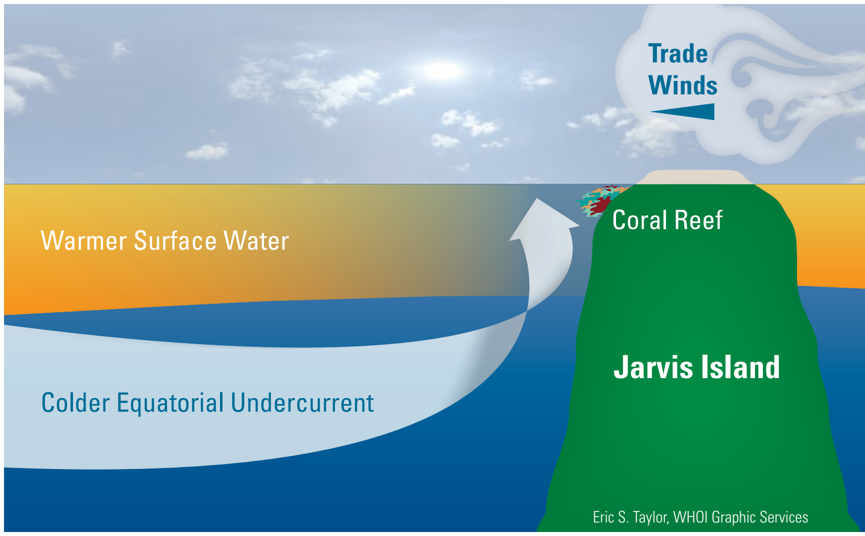
At times, however, the Pacific trade winds and surface current weaken, generating the well-known El Niño phenomenon. This shifts the patterns of heat and rainfall both in the Pacific and around the globe.

Today, there is evidence that elements of this Pacific climate system are changing their long-established behavior. For one, the trade winds have weakened over the past century. Without the wind to push it along, the surface current has slowed down, too. With less water being pushed up to make the hill in the western Pacific, the EUC could slow down. That could further slow the entire cycle and deliver fewer nutrients to the eastern Pacific. If the Pacific climate system is changing, scientists want to be able to anticipate how the EUC may change and how those changes might affect the ocean ecosystems it sustains.



Jarvis Island is a tiny, uninhabited island that rises barely 20 feet out of the ocean. It is located in a strategic spot that allows scientists to study the Equatorial Undercurrent, which flows along the equator from west to east.





Where the Equatorial Undercurrent (EUC) encounters Jarvis Island, it creates small patches of cool, nutrient-rich water at the surface, which sustain healthy coral reef ecosystems. Coral skeletons record changes in their surrounding water, and therefore could contain records of changes in the EUC.

Emily Penn, Pangaea Explorations

Pat Lohmann, WHOI

To investigate corals and currents, WHOI scientists journeyed on ship called *Sea Dragon*, operated by Pangaea Explorations, to Jarvis Island, a remote atoll in the central equatorial Pacific Ocean. Right, a shark wanders over a coral reef during diving and coring operations off Jarvis Island.

What's in store for the future?

The EUC, however, still has a few tricks up its sleeve. Recent measurements show that it has actually been speeding up. This sounds counterintuitive and demonstrates the complexity of the climate system. When the EUC flows eastward down the water "hill," friction with the surface current applies a brake to slow it down. The weakened surface current lowers the hill of water in the western Pacific, but it also decreases the friction slowing down the EUC.

Between the opposing forces of a smaller hill versus weaker brakes, the lack of brakes is winning out for now, and the EUC is speeding up. So it is unclear how changes in one component of the system will affect others. Many researchers, including me, are piecing this picture together to understand how sensitive the Pacific climate system will be to changes already underway and how different components in the system will respond.

Scientists have been measuring the EUC's speed since only 1983. In the ocean, 30 years is a short time, and it is difficult to know if the EUC's recent speedup is part of a longer-term trend related to climate change, or if it is random natural variation.

Variability can be natural or human-caused, and climate scientists' task is to separate the two. Here corals are the key, because I think they may be able to tell the story of the EUC's more distant past and help us understand the relationship of natural versus human-caused changes.

Recognizing how the EUC responds to shifts in the trade winds can help scientists predict whether those winds will continue to slow down and how that could affect climate in the Pacific. It will also help environmental managers choose where to focus coral conservation efforts. If reefs on islands like Jarvis continue to receive cool, nutrient-rich water from the EUC, they might have a better chance of continuing to thrive, even as ocean temperatures around them rise.

It is amazing that a few corals on a remote island can shed even the smallest amount of light on these big questions. As an earth scientist, there are so many things to study and ways to learn, and one of the things I love about my research is that I still have pieces of Jarvis with me in the lab. The coral in my hands is so much more than a mineral skeleton. It is a message from the past, and for the future. ▲

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Alice Alpert
Geology & Geophysics

Edgar Woznica

Alice Alpert grew up hiking in the mountains of California, but it wasn't until her undergraduate studies at Brown University that she realized she could actually get paid to study the Earth. Paleoceanography hooked her right away with its seemingly magical translation of chemical quantities in sediments into information about the environment in the past. After graduation, she worked as a research technician at Palmer Station, Antarctica, where she observed some of the most rapid climate change on Earth. With her Ph.D. advisors, WHOI scientists Anne Cohen and Delia Oppo, Alpert has combined her fascination with paleoceanography with her desire to investigate recent and current climate change. She loves the dynamic combination of chemistry, biology, geology, and physical oceanography in her work. When not scuba diving for corals or pulverizing them with a dental drill, she loves cooking for large dinner parties, biking the back roads of Cape Cod, tromping in the woods, and wrapping it all up with a beach bonfire. Her mentor for this article was Samir Patel, senior editor and writer at *Archaeology* magazine.