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Ripple Marks

The Story Behind the Story

BY CHERYL LYN DYBAS

LIFE IN A TANGLED MANGAL

Turning the Tide for Mangroves

Kampung Pangkalan Ladang. This exotic-sounding coastal town in peninsular Malaysia is acclaimed for its beautiful, if eerie, brand of ecotourism: synchronized "light shows" by fireflies (*Pteroptyx tener*) that live in mangrove trees. The Selangor River flows past Kampung Pangkalan Ladang; mangroves grow along its riverbanks. The fireflies use the trees as communal display and mating grounds.

The insects are partial to one mangrove species, *Sonneratia caseolaris*, known to locals as the *berembang*, otherwise as the mangrove apple or crabapple mangrove. It's also called the cork tree. Fishers turn its pneumatophores, or aerial roots, into floats for fishing nets.

The tree has a sweeping range, thriving in tropical tidal mudflats from Africa to Indonesia, southward to Australia, and northward to China and the Philippines. Only in Southeast Asia, however, is *Sonneratia caseolaris* home to congregating fireflies. Their nightly "shows" are so bright they've been compared to the blinking lights on a seemingly endless row of Christmas trees. The fireflies perform in sync, each one timing its flash to coincide with that of all others.

Adult fireflies may live only a few weeks. This population breeds year-round, however, sustaining an ecotourism industry that never goes "dark." Boat trips to see the brightly lit mangroves are offered out of Kampung Kuantan and Bukit Belimbing, providing villagers a source of income.

Of the many ecosystem services mangroves offer—from wave protection to sediment stabilization to cork for floats—firefly ecotourism may be among the most unusual.

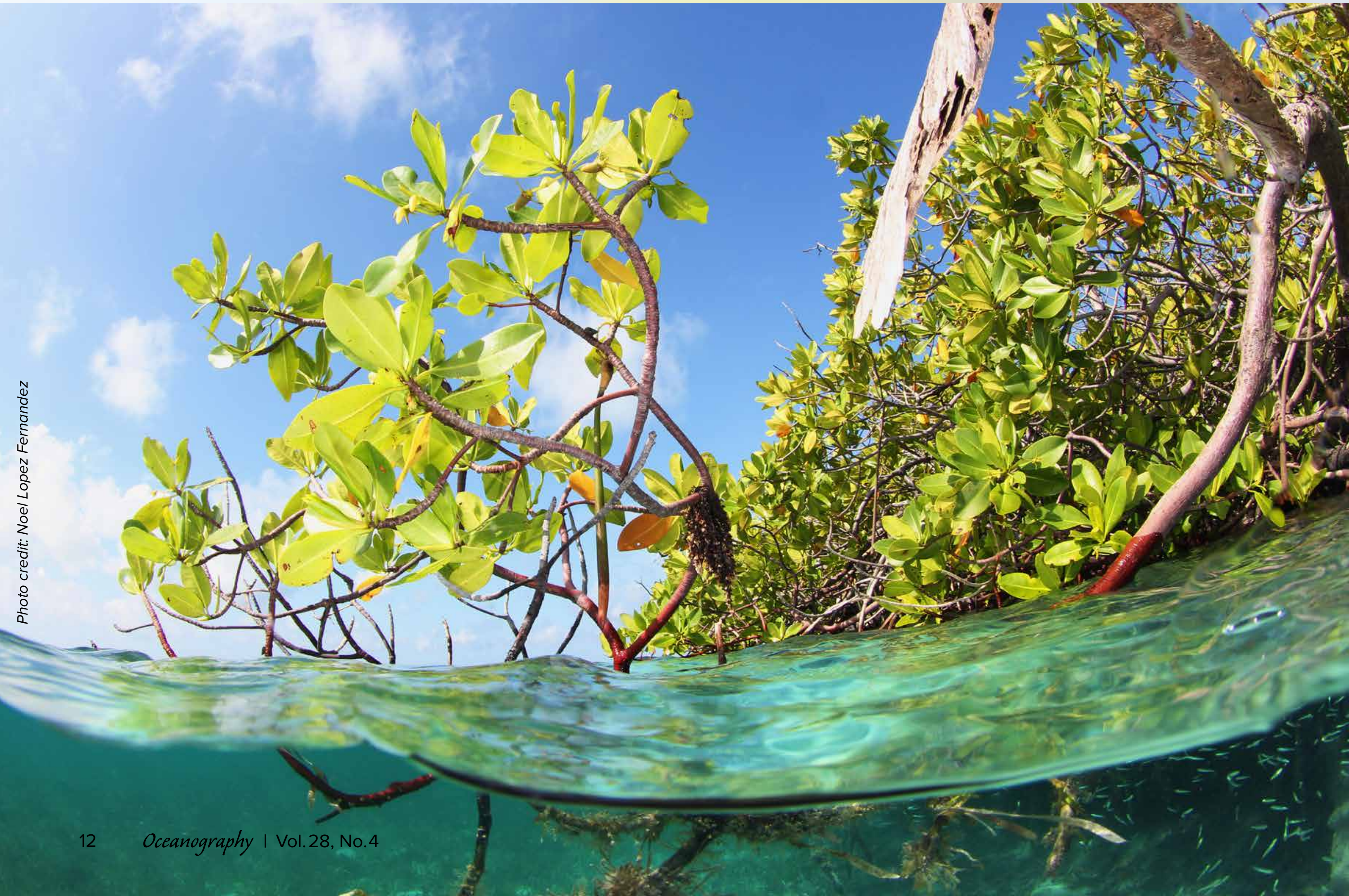


Photo credit: Noel Lopez Fernandez

FORESTS BETWEEN THE TIDES

Perhaps no more unusual, however, than the mangrove biome itself. There, trees with twisted limbs live in two worlds—one foot on land, the other in the sea.

Mangroves, also called mangals, thrive in saline coastal sediment habitats in the tropics and subtropics. Red, black, and white mangrove trees, along with buttonwoods, may all grow along the same shoreline. When these species are found together, each stakes out a spot in the tidal zone.

Neither solely of land nor of sea, these forests-of-the-tide collectively cover a worldwide area of 53,190 km^2 in 118 nations—less than 1% of all tropical forests. And that number is dropping. Now researchers are finding new ways of tracking the health of the planet's dwindling mangroves.

The challenge for mangroves, maintains ecologist Stuart Pimm of Duke University and the conservation organization Saving Species, is that when we are not apathetic toward them, we are often downright hostile.

"Some of my neighbors in the Florida Keys build their homes at the sea's edge, then cut down mangroves to a short hedge," Pimm says. "These people have no sense of how angry the ocean can become in a storm—nor how well a mangrove forest could protect them."

Keys residents were lucky October's Hurricane Joaquin missed the region, says Pimm. "Our mangroves would have stood guard along the shore, but they weren't tested. This time."

TURNING THE TIDE

How do we begin to turn the tide for mangroves? Perhaps by knowing how much mangrove habitat there is left, not an easy figure to derive.

Using a new technique, Chandra Giri of the US Geological Survey (USGS) and Duke University may have the most accurate answer. He and colleagues developed the first high-resolution, satellite-based global map of mangroves. The results were published in 2010 in the *Journal of Global Ecology and Biogeography*.

The map suggests that mangroves cover some 12% fewer coastlines than reported in previous studies. That's concerning, says Giri, when 35% of Earth's mangrove ecosystems disappeared between 1980 and 2000.

The decline is mainly a result of agriculture, urban development, shrimp farming, climate change, and oil spills like that of December 2014 in the Sundarbans. The Sundarbans region covers some 10,000 km^2; 60% is in Bangladesh, with the rest in India. The mangrove forest there, which lies along the delta of the Ganges, Brahmaputra, and Meghna Rivers at the Bay of Bengal, is one of the largest such forests in the world—some 140,000 hectares. Last year, however, untold numbers of its mangroves were smothered by oil that spread over a 350 km^2 area. Such rare species as the Irrawaddy dolphin and Bengal tiger live in this "oil zone."

Giri's map shows that 75% of Earth's mangrove forests are concentrated in just 15 countries. Asia and Africa have the most mangroves, with 42% and 21%, respectively; 15% are in North and Central America; 12% in the Pacific islands; and 11% in South America.

Before Giri's effort, mangroves hadn't been mapped by global land cover projects. The resolution wasn't fine enough across small geographic areas, and Landsat satellite mapping was expensive and time-consuming.

Then the USGS began to offer Landsat data free of charge. "And computers reached the point where we can now process large volumes of data," says Giri. "That opens the way to looking at mangroves from another perspective: space."

Satellites offer images of Earth with several degrees of resolution, says Giri, similar to pixel sizes on a computer screen. Previously, scientists had visualized global land cover in pixels equal to about 1 km^2, not enough detail to identify mangroves. Giri's technique used a finer resolution: 30 m^2. "That made it much easier to find mangroves in small patches," he says.

Once scientists know where mangroves are, they can better estimate their value as bulwarks against sea level rise, severe storms such as hurricanes, and tsunamis.

As a next step in the research, Giri and colleagues are looking at mangroves through the eyes of remote-sensing techniques such as lidar. Lidar illuminates a target with a laser and analyzes the reflected light to make measurements. It may offer even more precise estimates, Giri says, of the extent of mangrove forests.

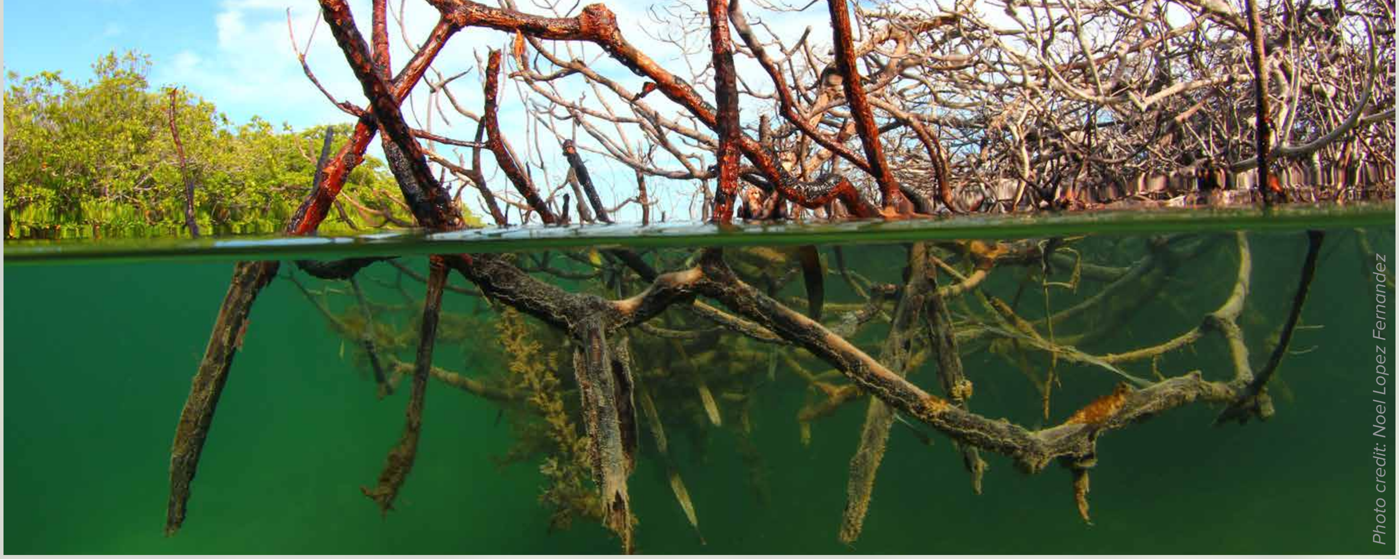
Photo credit: Stuart Pimm

WARMLY WELCOMED IN CUBA: MANGROVES

Just 150 km from where Stuart Pimm's Florida Keys neighbors are chopping away at mangroves lies a place that's hospitable to these trees between the tides.

Cuba, the largest island in the Caribbean, is second only to Mexico in the North and Central America region in numbers of mangroves. The country is host to some 4% of the world's total mangroves; the trees encircle much of the island. Mangals cover about 5.1% of the country's land, or 565,000 hectares. In good news for mangroves, that number is on the rise, up from 4.8% in 1983.

"More than half the country's shoreline is protected by mangroves," says Doug Rader, chief ocean scientist at the Environmental Defense Fund (EDF). EDF is spearheading several marine ecosystem protection projects in Cuba. "That's a big deal in hurricane alley, and in the face of rising seas and intensifying storms," says Rader. Throughout the Caribbean, mangrove-lined "hurricane holes" have functioned for centuries as safe havens for fishers and others needing to ride out storms.



"Cuba has far and away the greatest mangrove presence of any Caribbean island, with about 69% of the mangroves in the entire Caribbean," Rader says. "Many mangroves in Cuba are inside protected areas, including the spectacular Jardines de la Reina, or Gardens of the Queen." The "gardens" are one of the Caribbean's healthiest coral reefs, thanks to the mangroves that line the nearby shoreline.

"Mangroves provide critical habitat for the early life stages of many reef species," says Rader. "They're also important for us. No mangroves, no coral reef seafood."

Commercial and subsistence fishing are important in Cuba, he says, with many species using mangroves for part of their life cycle, including lobsters and shrimp.

Then there's mangrove honey, "big business in Cuba," Rader reports. "Each year, people move their beehives into the mangroves for the four months or so the trees flower. The yield is an astounding 1,700 to 2,700 metric tons of honey."

Even in a seeming mangrove paradise, however, trees have been lost to pollution, land reclamation, illegal deforestation, and road-building and other infrastructure projects. The digging of a long dike along the south coast of Havana Province—an effort to address saltwater intrusion into an adjacent aquifer—is one example. According to the *World Atlas of Mangroves*, it's not clear whether the dike controlled the saltwater, but it unfortunately reduced water flow into nearby mangroves. In turn, that's led to increased erosion and coastal flooding.

Despite intermittent threats to Cuba's mangroves, efforts to conserve the country's half-wet, half-dry trees have been considerable, says Rader. "That's why a map of the island shows it ringed with green [mangroves]."

As a new US-Cuba relationship evolves, will the island still be a refuge for mangroves?

"The tidal wave of American tourists—and skyrocketing demand for new marinas, resorts, golf courses, and cruise ship facilities—will test Cuba's resolve to protect its mangroves," says Dan Whittle, director of Cuba programs at EDF. "It's important for Cuba and for all of us in the region that future development be done sustainably, with the long-term health of mangroves and other natural areas in mind."

A new agreement between the United States and Cuba, announced in October 2015 at the *Our Ocean* conference in Chile, advances efforts to protect the seas the two countries share. "The invisible lines in the ocean that have separated us for nearly six decades are disappearing," says Whittle. "Scientists in the US and Cuba are working together to conserve our shared waters—home to a vast array of biodiversity—from the mounting threats of overfishing, pollution, and climate change."

The agreement, which will allow researchers to map and inventory marine life in the Florida Straits and Gulf of Mexico, opens the door for US scientists to study Cuba's pristine reefs in hopes of learning how to protect dying American reefs, Whittle says. "It allows scientists from both countries to trade best practices for protection of endangered species and for keeping out invasive species."

As *Oceanography* went to press, Whittle was heading to the *MarCuba* 2015 conference, held in Havana in November. Hosted by the National Oceanographic Committee of Cuba and other marine science institutions, the meeting's theme was "Integration of Science for Marine Resources Management." The event brought together marine scientists, educators, economists, sociologists, and policymakers to foster conservation of Cuba's marine resources, including its mangroves.

MANGROVES AND SHARKS

EDF and Cuban government scientists are joining forces to put in place new protections for sharks in Cuban waters, including species that swim through the country's mangroves.

The plan marks an important first step for addressing shark conservation in the region, scientists say. Some 20% of the world's 500 shark species are found in Cuba's waters. As a part of the new agreement, Cuba will develop measures to protect the most vulnerable and threatened shark species, and guard against overfishing of sharks in Cuban waters. Because some sharks travel thousands of kilometers, protecting those in Cuba will likely help shark populations in the United States, Mexico, and beyond.

Scientists from Cuba, EDF, and other

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institutions developed the plan through a process that included training fishers to collect critical data on species. It was modeled after one used by the United Nations Food and Agriculture Organization to address the conservation of vulnerable species.

"This historic commitment by Cuba will have effects beyond its borders, and provide managers with the information they need to rebuild and sustain shark populations throughout the region," says Whittle. "It emphasizes Cuba's focus on the importance of sharks and their habitat, the threat of overfishing, and the need for international collaboration on science."

Conservation of sharks can be a challenge due to their migratory nature. Cuban officials recruited biologists from the United States and Mexico to help train Cuban fishers on how to collect data on species, locations, and frequency of shark catches.

"This plan is a huge step forward for Cuba and the rest of the region," says Elisa Garcia, Director of Cuba's Office of Fishing Regulations and Science. "It lays the foundation for coordinated data collection to understand the threats sharks face and to take action by setting limits on fishing, establishing closures, and protecting juveniles and critical habitat."

Marine biologists at the University of Havana's Center for Marine Research are working with fishers in Cuba's coastal communities to better understand which shark species are most common and which are most vulnerable.

"Getting fishermen involved in collecting data has been critical," says Jorge Angulo, senior scientist with Cuba's Center for Marine Research. "The more we understand about sharks, the better we can manage and conserve them."

And the mangroves and other marine ecosystems of which they're a part.

HUMAN, BIRD, MANGROVE. MANGROVE, BIRD, HUMAN.

Far beyond Cuba, mangroves and humans are linked.

In one of the more unusual connections among mangroves and other species, including *Homo sapiens*, mutations in red mangroves in swamps on the island of Trinidad turned out to be the result of mercury in sediment beneath the trees. The contamination is restricted to a small area. How did it get there?

A clue: it's directly below a large roost of scarlet ibises, wading birds that flock to mangroves. For decades, some 5,000 to 10,000 ibises each year have roosted in Trinidad's mangroves. As the birds molt, their feathers, laden with mercury, drift down, eventually becoming part of the sand and mud in which the mangroves are anchored.

How did the birds acquire the mercury? They picked it up by eating freshwater crustaceans in northeastern South America's wetlands. The birds spend their summer breeding seasons there, then winter in Trinidad. The South American wetlands and their aquatic inhabitants are contaminated with mercury from the region's gold mines. When the ibises migrate back to Trinidad, mercury goes with them.

This conveyor belt could cause problems for plants beyond mangroves, as well as for the wildlife and human populations that eat fish, crustaceans, and mollusks caught near the affected mangals.

From human, to freshwater crustacean, to ibis, to mangrove. And—full circle—from mangrove, back to ibis, crustacean, and human. Life in a tangled mangal.

A version of this article was previously published in BioScience.