



### INDIAN OCEAN TSUNAMI

## In Wake of Disaster, Scientists Seek Out Clues to Prevention

Having claimed more than 150,000 lives and destroyed billions of dollars' worth of property, nature last week reminded the world of the terrible cost of ignorance. Now the nations devastated by the massive earthquake and tsunami that ravaged the Bay of Bengal the morning after Christmas Day are hoping to marshal the political and scientific will to reduce the toll from the next natural disaster.

A week after the tragedy, the question of how many lives might have been saved had authorities in those countries recognized the danger in time to evacuate their coasts remains unanswered. But it's a hypothetical question, because the information needed to take such steps doesn't exist. That's why researchers are gearing up for an international data-collection effort in the affected countries, aimed at improving models of how tsunamis form and setting up a warning system in the Indian Ocean. "This was a momentous event both in human and scientific terms," says Costas Synolakis, a civil engineer and tsunami researcher at the University of Southern California in Los Angeles. "It was a failure of the entire hazards-mitigation community."

As relief efforts continue, scientists are traveling to the ravaged coasts to survey how far inland the water ran up at different points along the shorelines, how tall the waves were, and how fast they hit. In addition to providing a detailed picture of the event, says Philip Liu, a tsunami expert at Cornell University who is flying to Sri Lanka this week, information from these field surveys will enable researchers to test computer models that simulate the propa-

gation of tsunami waves and the pattern of flooding when they break upon the shore. The geographical span of the disaster presents an opportunity to "run simulations on a scale that has not been possible with data from smaller tsunamis in the Pacific," says Synolakis, who is joining Liu in Sri Lanka.



**Surprise attack.** While tsunami waves ravaged towns such as Lhoknga, Indonesia (as shown in before-and-after satellite photos), scientists across the Bay of Bengal saw no danger coming.

Among other surveys being conducted in the region is one led by Hideo Matsutomi, a coastal engineer at Japan's Akita University, who is studying the disaster's effects on Thailand's shoreline.

Testing and refining tsunami models would increase their power to predict future

events—not just in the Indian Ocean but elsewhere, too, says Vasily Titov, an applied mathematician and tsunami modeler at the Pacific Marine Environmental Laboratory in Seattle, Washington. Synolakis says the goal is to be able to predict, for any given coast with a given topography, which areas are most vulnerable and thus in greatest need of evacuation.

Such predictions would be easier to make if ocean basins resembled swimming pools and continents were rectangular-shaped slabs with perfect edges. But the uneven contours of sea floors and the jagged geometry of coastlines make tsunami modeling a complex engineering problem in the real world, Titov says. Exactly how a tsunami will travel through the ocean depends on factors including the intensity of the earthquake and the shape of the basin; how the waves will hit depends, among other factors, on the lay of the land at the shore.

What makes tsunami warnings even more complicated, Synolakis says, is that undersea quakes of magnitudes as great as 7.5 can often fail to generate tsunami waves taller than 5 centimeters. "What do you do without knowing precisely where and when the waves will strike and if they will be tall enough to be a threat?" he says. "Do you just scare tourists off the beach, and if nothing comes in, say, 'Oh, sorry?'"

It wasn't concerns about issuing a false alarm, however, that prevented scientists in India, Sri Lanka, and the Maldives from alerting authorities to the tsunami threat. Instead, researchers say, the reason was near-total ignorance. At the National Geophysical Research Institute (NGRI) in the south Indian city of Hyderabad, for example, seismologists knew of the earthquake within minutes after it struck but didn't consider the possibility of a tsunami until it was too late. In fact, at about 8 a.m., an hour after the tsunami had already begun its assault on Indian territory by pummeling the islands of Andaman and Nicobar some 200 km northwest of the epicenter, institute officials were reassuring the media that the Sumatran event posed no threat to the Indian subcontinent.

About the same time, in neighboring Sri Lanka, scientists at the country's only seismic monitoring station, in Kandy, reached a similar conclusion. "We knew that a quake had occurred—but on the other side of the ocean," says Sarath Weerawarnakula, ▶

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