SCIENCE

Sounding the Alarm on a Tsunami Is Complex and Expensive

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Published: December 29, 2004

If only people had been warned. An hour's notice for those living and vacationing along the coastlines of the Indian Ocean might have saved thousands of lives.

But predictions, and acting on them, are not simple, geoscience experts say.

"It's an inexact science now," said Dr. Laura S. L. Kong, a Commerce Department seismologist and director of the International Tsunami Information Center, an office in Honolulu run under the auspices of the United Nations.

According to a NASA Web site devoted to tsunamis, three of four tsunami warnings issued since 1948 have been false, and the cost of the false alarms can be high.

An evacuation in Hawaii could cost as much as $68 million in lost productivity, according to the National Oceanic and Atmospheric Administration. Since the 1960's, Dr. Kong said, there have been two warnings of tsunamis in Hawaii that ended in evacuations, and both were false alarms.

Dr. Kong said the predictions of tsunamis were, in fact, accurate: the waves do arrive, whether they are 40 feet high or a mere two inches. It is the destructive power of the wave that is hard to predict. That depends on many factors, including the configuration of the ocean floor and the shape of a bay.

Tsunamis, which are common in the Pacific Ocean, are rare in the Indian Ocean. And the earthquake that set the giant waves in motion on Sunday was uncommonly powerful.

But an Indian Ocean tsunami was, to a certain extent, predictable - and scientists from Geoscience Australia, that nation's agency for earth science research, issued a paper last fall describing the tsunami generated by sea-floor disturbances after the explosion of the volcano Krakatoa in 1883, with charts that showed an uncanny resemblance to the wave of destruction that accompanied this week's disaster.

Australia has established a tsunami warning center of its own, which issued an earthquake alert 33 minutes after the quake occurred.

Dr. Kong said her e-mail box had filled in recent days with the signs of a scramble by United Nations organizations and affected governments hoping to create a new warning system for the Indian Ocean. Such a system could be cobbled together, in part, by depending on ocean-measuring sites that are already in place, she said.

The lowest-cost components are water-level gauges, which can be had for as little as $5,000 apiece but which can cost $20,000 or more if they are equipped with better instruments and quick communication abilities. A system could be put into place relatively quickly, she said, for "millions or tens of millions" of dollars.

She said such a system would not include the gold standard for tsunami measurement, a new generation of deep-sea sensors. These devices "wake up" when a tsunami passes over, and transmit data to satellites, which then pass the signal along to warning centers. There are only seven of these "tsunameters" in use so far, and they can cost $250,000 apiece - with annual maintenance costs of $50,000.

Richard A. Posner, a federal judge and author of "Catastrophe: Risk and Response," said tsunamis in the Indian Ocean had a low probability of occurring, but a high risk of damage if they do occur.

A disaster may occur only every 100 years and kill 40,000 people, Judge Posner said, but "one way to think about it is, that's an average of 400 people killed each year."

The problem, he said, is that less developed nations "have such urgent current problems" that worrying about long-term problems is a low priority.

Warning the public of disaster is an age-old problem with modern implications, said Kenneth Allen, the executive director of the Partnership for Public Warning, a nonprofit, public-private partnership devoted to improving crisis communications in the wake of the 9/11 attacks.

Education campaigns are an essential part of any warning system, Mr. Allen said. "You need to tell people how they are going to get information in an emergency, and what to do about it," he said. "If you wait until the emergency occurs, it's too late."

Phil McFadden, the chief scientist of Geoscience Australia, said warnings without such training were useless. "If all you do is phone up the local police station, they don't know what to do," he said. "And in fact, one of the problems is that if you tell untrained people, 'Listen - there's a tsunami coming,' half of them go down to the beach to see what a tsunami looks like."

Andrew C. Revkin contributed reporting from New York for this article, and Thomas Fuller of The International Herald Tribune from Paris.