

# Tsunamis

## The next big wave

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### **New ways of tracking these killer waves may help save lives**

FOR many inhabitants of the Pacific coast, powerful waves caused by earthquakes or underwater landslides—generally known by their Japanese name, tsunamis—are an ominous threat. When a wave 15 metres (50 feet) high pounded the northern shores of Papua New Guinea in July 1998, the inhabitants were taken by surprise. This tsunami killed more than 2,200 villagers, making it one of the most destructive in recent years. But it was just one of a string of killer waves that have struck the western Pacific over the past few years. Since 1990, ten big tsunamis have claimed more than 4,000 lives. So it would be nice to be able to detect such tsunamis far enough in advance for people to be evacuated. But that is not easy.

Seismometers and coastal tidal gauges—instruments already deployed for other purposes—can provide some warning. Seismometers measure earthquakes that might cause tsunamis, but they cannot detect the waves themselves. Nor can they normally detect landslides triggered by earthquakes, since the energy released in a landslide is small compared with that released by an earthquake. Yet landslides are often the cause of the most destructive tsunamis. (The New Guinea tsunami mentioned above is believed to have been amplified in this way.) The result is error on the side of caution: since the 1950s,

75% of tsunami warnings that led to evacuations have turned out to be false alarms. Such evacuations are not cost-free. A false alarm that triggered the evacuation of Honolulu, in May 1986, resulted in losses of more than \$30m.

Tidal gauges, by contrast, can spot tsunamis reliably from their effect on the sea level, at least when they are close to shore. But since a tsunami may travel at more than 700kph (450mph), that does not give much warning. Tidal gauges cannot measure tsunamis in the deep ocean.

## Waving, not drowning

What is needed are specific detectors that take advantage of the fact that tsunamis are felt throughout the ocean's depths, unlike wind-generated waves, which affect only its surface. One approach is to put pressure detectors on the seabed. When a tsunami passes by, the detector records the increased pressure caused by its passage.

Japan was the first country to deploy such detectors. It now has 14 of them. But they are connected to the mainland by submarine cables. That means, in practice, that they can be deployed only some 50km from land, which is better than tidal gauges, but not ideal. The network can give local warnings. But the only way to be sure whether a dangerous wave is headed towards a distant coastline is to track it across the open ocean.

America's National Oceanic and Atmospheric Administration (NOAA) hopes to do just that. Its "tsunameters", as they are dubbed by Eddie Bernard, the director of the agency's Pacific Marine Environmental Laboratory, have cut the umbilical cord with the land. Instead, they transmit warnings to buoys on the surface, and these, in turn, relay the information to NOAA via satellite. Besides allowing the detectors to be deployed almost anywhere, this system is cheaper than using cables. Each detector costs about \$200,000 to set up. The Japanese versions cost more than \$5m each.

According to Frank Gonzalez, who heads NOAA's tsunami research programme, five tsunameters have been deployed in the North Pacific and one in the South Pacific, with the actual detectors located at depths of up to 4km. A seventh will be set up near Chile in November this year, to intercept tsunamis generated off South America. Although the system has yet to detect a big tsunami (none has occurred since it began operations), it has successfully identified small ones.

The Japanese, meanwhile, are trying an alternative approach to the job of cutting the cable. A group of researchers at Tokyo University's Earthquake Research Institute are developing a warning system that relies on global positioning system (GPS) navigation satellites to monitor the motion of buoys moored in the open ocean. By placing GPS antennae on shore and on the buoys, the researchers are able to compare a buoy's "altitude" with that of a stable location on land. According to Teruyuki Kato, the project's leader, this arrangement can measure a buoy's vertical motion with an accuracy of a few centimetres, which will pick up dangerous tsunamis in the open ocean where they are

mere ripples on the surface (they rear up into killer waves only when they reach the shallows). Dr Kato's team has already tested the system successfully in the sea off Ofunato, in the east of the country, and a new system will be placed off Muroto promontory, in the west, early next year.

Another line of research that holds promise is the analysis of a type of sound wave known as a T-phase wave. Rocks rumbling downhill produce T-phase waves that are carried by the ocean to both nearby and distant coastlines. Emile Okal of Northwestern University in Evanston, Illinois has observed that T-phase waves produced by landslides can be heard by hydrophones (underwater microphones) of the sort used to detect submarines. Dr Okal has used this technology to identify tsunamis caused by landslides (ie, the sort most likely to be dangerous, and thus require evacuations to be organised). He has also been able to process seismograms and identify differences between the seismic signals from earthquakes that produce tsunamis directly and those that trigger tsunami-producing landslides.

Merely detecting tsunamis, though, is not enough. Tsunamis must be classified to predict the level of danger. One way of doing that is by computer modelling. Models developed by Vasily Titov, at NOAA, and Costas Synolakis, at the University of Southern California, can predict the size and shape of the waves that will be generated by a particular tsunami, as well as the resulting coastal inundation. Knowing how far inland a tsunami will penetrate should help the authorities to evacuate the right areas.

Technology, though, can do only so much. The best protection, according to Dr Synolakis, is common sense. Coastal dwellers must be able to recognise the signs of a possible tsunami—such as strong, prolonged ground shaking—and seek higher ground at once. As with any hazard, the more informed the public are, the better their chances of survival. For instance, after the Papua New Guinea tsunami, an international team was dispatched to Vanuatu, a group of islands in the Pacific, where they showed videos of tsunamis to the villagers. When a tsunami struck Vanuatu in 1999, only five people died in it. The message is clear enough. There is no way to stop a tsunami once set in motion, but there is certainly a way to avoid getting killed by one. Run like hell.