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Major Caribbean Earthquakes and Tsunamis a Real Risk

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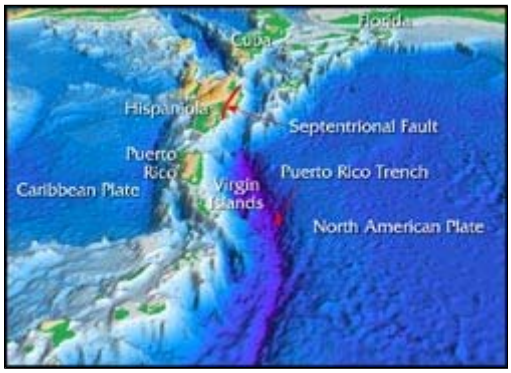
Published on Jan 31, 2005, 06:39

A dozen major earthquakes of magnitude 7.0 or greater have occurred in the Caribbean near Puerto Rico, the U.S. Virgin Islands and the island of Hispaniola, shared by Haiti and the Dominican Republic, in the past 500 years, and several have generated tsunamis. The most recent major earthquake, a magnitude 8.1 in 1946, resulted in a tsunami that killed a reported 1,600 people.

With nearly twenty million people now living in this tourist region and a major earthquake occurring on average every 50 years, scientists say it is not a question of if it will happen but when. They are calling for the establishment of tsunami early warning systems in the Caribbean Sea, Gulf of Mexico and Atlantic Ocean, and better public education about the real tsunami threats in these regions.

In a new study published December 24, 2004 in the Journal of Geophysical Research from the American Geophysical Union, geologists Uri ten Brink of the U.S. Geological Survey in Woods Hole and Jian Lin of the Woods Hole Oceanographic Institution (WHOI) report a heightened earthquake risk of the Septentrional fault zone, which cuts through the highly populated region of the Cibao valley in the Dominican Republic. In addition, they caution, the geologically active offshore Puerto Rico and Hispaniola trenches are capable of producing earthquakes of magnitude 7.5 and higher. The Indonesian earthquake on December 26, which generated a tsunami that killed (to date) an estimated 150,000 people, came from a fault of similar structure, but was a magnitude 9.0, much larger than the recorded quakes near the Puerto Rico Trench.



3-D view of the Puerto Rico Trench. (Courtesy Christopher Polloni, USGS and Jack Cook, Woods Hole Oceanographic Institution)

The Puerto Rico Trench, roughly parallel to and about 75 miles off the northern coast of Puerto Rico, is about 900 kilometers (560 miles) long and 100 kilometers (60 miles) wide. The deepest point in the Atlantic Ocean, the trench is 8,340 meters (27,362 feet) below the sea surface. The Hispaniola Trench parallels the north coast of the Dominican Republic and Haiti, and is 550 kilometers (344 miles) long and only 4,500 meters (14,764 feet) deep.

Earthquakes typically occur near faults or fractures in the Earth's crust where rock formations, driven by the movements of the crustal or tectonic plates that make up the Earth's surface, grind slowly past each other or collide, building up stress. At some point, stress overcomes friction and the rocks slip suddenly, releasing seismic energy in the form of an earthquake, which drops the stress in one area but raises the stress elsewhere along the fault line. Eighty percent of earthquakes on Earth occur on the sea floor and most of them along the plate boundaries.

Hispaniola, Puerto Rico and the U.S. Virgin Islands sit on top of small crustal blocks that are sandwiched between the North American and Caribbean plates. The island of Hispaniola faces a double risk: an earthquake from the Septentrional fault on the island itself as the plates move past each other, and an earthquake deep in the earth in the subduction zone on which the island sits. Both could cause severe damage and loss of life, although the researchers say an earthquake in the subduction zone could be more devastating and has the potential to cause a tsunami.

The two scientists studied the geology of the northern Caribbean plate boundary, looked at historical earthquake data in the region, and used three-dimensional models to calculate the stress changes in and near the trenches after each earthquakes. Ten Brink, who is also an adjunct scientist at WHOI, and Lin say stress has increased for the Hispaniola area, and that the potential threat of earthquakes and resulting possible tsunamis from the Puerto Rico and Hispaniola trenches is real and should be taken seriously. In addition to establishing warning systems and informing the public about the risk, they call for improved documentation of prior earthquake and tsunami events and better estimates of future threats from the Puerto Rico and Hispaniola trenches through underwater studies.

"Every earthquake has its own character," says Lin, who has studied mid-ocean ridges, hotspots and undersea volcanoes as well as earthquakes in Southern California, China and the Pacific. "And not all earthquakes generate tsunamis, which form when large areas of the seafloor rise or drop suddenly, causing the ocean above them to move. Many factors come into play in tsunami formation, including the size and type of an earthquake and how much the quake has ruptured the seafloor."

Lin, a senior scientist and a marine geophysicist in the WHOI Geology and Geophysics Department, says that each time an earthquake occurs on the offshore Puerto Rico and Hispaniola trenches, it adds stress to the Septentrional fault zone on Hispaniola. Since the fault is in a highly populated region and is capable of generating magnitude 7.7-7.9 earthquakes, the public should be educated about the risk of this earthquake prone area.

The region has a long history of destructive earthquakes. Historical records show that major earthquakes have struck the Puerto Rico, Virgin Islands region many times during the past 500 years although the locations and sizes of events that occurred more than a few decades ago are poorly known. Major earthquakes, greater than magnitude 7.0, damaged Puerto Rico in 1670, 1787, 1831, 1844, 1846, 1865, 1867, 1875, 1890, 1906, 1918, 1943 and 1946. The 1867,1918 and 1946 earthquakes were accompanied by destructive tsunamis.

"Our results indicate that great subduction zone earthquakes, which often occur in the deep trenches off shore, have the potential to add stress or trigger earthquakes on other types of faults on the nearby islands," Lin says. "We don't want people to overreact, just make them aware of the potential risk of such rare and yet deadly events so they are prepared. It is similar to knowing about hurricanes or tornadoes and being prepared to react when one is coming."

Ten Brink, who studies earthquakes, tsunamis and geology in the Caribbean and Puerto Rico region, and has studied earthquake hazards in the Dead Sea in the Middle East, says there are a number of possible sources for tsunamis in the Caribbean. "The threat of major earthquakes in the Caribbean, and the possibility of a resulting tsunami, are real even though the risks are small in the bigger picture," ten Brink said. "Local earthquakes, such as from the fault on Hispaniola, or effects from distant earthquakes can be severe. Landslides and volcanic eruptions can

also cause major earthquakes and potential tsunamis in this region. It has happened before, and it will happen again." He cautions that the threat of submarine landslides near Puerto Rico is real and residents and tourists, including those on cruise ships, would have very little warning given the close proximity to shore. However, the risk is small and should be put into perspective.

The Puerto Rico Trench, which is capable of producing earthquakes of magnitude 7 to 8 or greater, faces north and east into the Atlantic Ocean. There are few land areas or islands to block a tsunami generated near the Puerto Rico Trench from entering the Atlantic Ocean. The direction of the waves would depend on many factors, including where in the trench the earthquake occurred.

Long-term ocean observatories, new generations of seismic and oceanographic sensors, and information technologies offer great promise to earthquake and tsunami research, Lin says. He and colleague Dezhang Chu of the WHOI Applied Ocean Physics and Engineering Department received WHOI seed funding in 2004 to develop a new technology to measure seafloor change, which could be a step forwards in understanding the processes that trigger underwater earthquakes and tsunamis.

Woods Hole Oceanographic Institution (WHOI) is a private, independent marine research and engineering and higher education organization located in Falmouth, MA. Its primary mission is to understand the oceans and their interaction with the Earth as a whole, and to communicate a basic understanding of the ocean's role in the changing global environment. Established in 1930 on a recommendation from the National Academy of Sciences, the Institution operates the U.S. National Deep Submergence Facility that includes the deep-diving submersible Alvin, a fleet of global ranging ships and smaller coastal vessels, and a variety of other tethered and autonomous underwater vehicles. WHOI is organized into five departments, interdisciplinary institutes and a marine policy center, and conducts a joint graduate education program with the Massachusetts Institute of Technology.

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