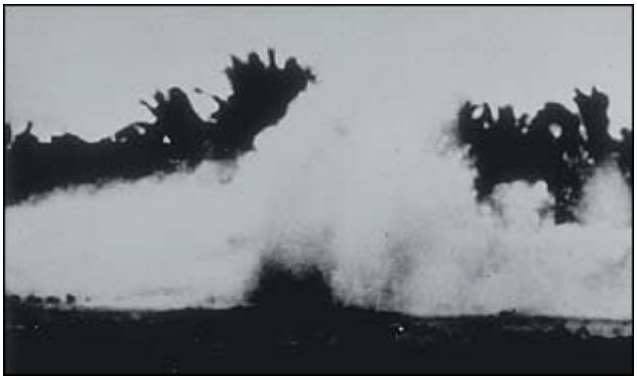
A Deadly Force
by Daniel Pendick

Though it's true that tsunamis are ocean waves, calling them by the same name as the ordinary wind-driven variety is a bit like referring to firecrackers and atomic warheads both as "explosives." Triggered by volcanic eruptions, landslides, earthquakes, and even impacts by asteroids or comets, a tsunami represents a vast volume of seawater in motion -- the source of its destructive power.

The Japanese characters for tsunami mean "harbor wave," and many people commonly refer to them as tidal waves, but in reality tsunamis have little to do with tides. They are creatures of the open ocean, trains of giant waves that can travel for thousands of miles across the sea and still pack enough energy to smash towns and drown the unwary.



A tsunami generated in the Aleutian Islands struck Hawaii in 1946.

Toss a stone in a pond and you create a series of concentric ripples. A tsunami is just like those ripples, except the disturbance that sets them in motion is of a much greater magnitude. Undersea landslides and the collapse of oceanic islands into the sea make tsunamis. Volcanic eruptions can also do it. In fact, the most deadly tsunami in recorded history followed the eruption and virtual obliteration of Indonesia's Krakatoa Volcano in 1883. An estimated 36,000 people died as a result of the eruption, the majority of them from the tsunamis.

Impacts by comets or asteroids can also generate giant tsunamis. No one has actually witnessed such an event, except perhaps in films like DEEP IMPACT. But computer simulations show that the giant tsunamis unleashed by Hollywood special effects wizards -- large enough to swamp the Manhattan skyline -- are possible and have almost certainly happened in the distant past. Scientists at the Los Alamos National Laboratory in New Mexico calculated that if an asteroid three miles across hit the middle of the Atlantic Ocean, the tsunami would swamp the upper East Coast as far inland as the Appalachian Mountains and drown the coasts of France and Portugal.

But by far the most frequent tsunami-maker is the buckling of the seafloor caused by an undersea earthquake. Tsunami earthquakes happen at subduction zones, places where drifting plates that make up Earth's outer shell, or lithosphere, converge, and the heavier oceanic plate dips below the lighter continents. There are subduction zones off Chile, Nicaragua, Mexico, and Indonesia that have generated killer tsunamis

in the past decade. In the Pacific, there were 17 tsunamis from 1992 to 1996, and they took nearly 1,700 lives.

As a plate plunges down into Earth's interior, it moves in fits and starts -- sticking for awhile, then slipping. When it's stuck against the edge of a continental plate, stresses build up. When the locked zone gives way, parts of the seafloor may snap upward like a diver's springboard as the tension is released; other areas may sink downward. In the instant after the quake, the shape of the sea surface mirrors the contours of the seafloor below. But, just as quickly, gravity acts to return the sea surface to its original shape. As the rumpled sea flattens out, ripples race outward. A tsunami is born. (See Tsunami Attack animation, 17K. You will need the free Flash plug-in to view this animation.)

On the open ocean, tsunami waves approach speeds of 500 mph, almost fast enough to keep pace with a jetliner. But gazing out the window of a 747, you wouldn't be able to pick it out from the wind-driven swells. In deep water, the waves spread out and hunch down, with hundreds of miles between crests that may be just a few feet high. A passenger on a passing ship would scarcely detect their passing. But in fact the tsunami crest is just the very tip of a vast mass of water in motion. Though wind-driven waves and swells are confined to a shallow layer near the ocean surface, a tsunami extends thousands of feet deep into the ocean.

Because the momentum of the waves is so great, a tsunami can travel great distances with little loss of energy. The 1960 earthquake off the coast of Chile generated a tsunami that had enough force to kill 150 people in Japan after a journey of 22 hours and 10,000 miles. The waves from a trans-Pacific tsunami can reverberate back and forth across the ocean for days, making it jiggle like a planetary-scale pan of Jell-O.

As the waves in the tsunami reach shore, they slow down due to the shallowing sea floor, and the loss in speed is often accompanied by a dramatic increase in wave height. The waves scrunch together like the ribs of an accordion and heave upward. Depending on the geometry of the seafloor warping that first generated the waves, tsunami attacks can take different forms. In certain cases, the sea can seem at first to draw a breath and empty harbors, leaving fish flopping on the mud. This sometimes draws the curious to the shoreline and to their deaths, since the withdrawing of the sea is inevitably followed by the arrival of the crest of a tsunami wave. Tsunamis also flood in suddenly without warning. Tsunami waves usually don't curve over and break, like Hawaiian surf waves. Survivors of tsunami attacks describe them as dark "walls" of water. Impelled by the mass of water behind them, the waves bulldoze onto the shore and inundate the coast, snapping trees like twigs, toppling stone walls and lighthouses, and smashing houses and buildings into kindling.

The contours of the seafloor and coastline have a profound influence on the height of the waves -- sometimes with surprising and dangerous results. During the 1993 tsunami attack on Okushiri, Japan, the wave "runup" on the coast averaged about 15 to 20 meters (50 - 65 feet). But in one particular spot, the waves pushed into a V-shaped valley open to the sea, concentrating the water in a tighter and tighter space. In the end, the water ran up to 32 meters (90 feet) above sea level, about the height of an 8-story office building.

Editor's Note: This article was originally entitled "Surf's Up!" While no levity was ever intended, we have changed the title in light of the devastating tsunamis of December 26, 2004. The content of the article remains unaltered.

Tsunami photo: Mrs. Harry A. Simms, Sr., courtesy of the U.S. Geological Survey.

http://www.pbs.org/wnet/savageearth/tsunami/