CALIFORNIA GEOLOGICAL SURVEY

TSUNAMIS NOTE 55

What is a tsunami?

A tsunami is a wave, or series of waves, generated by an earthquake, landslide, volcanic eruption, or even large meteor hitting the ocean (The Japanese word *tsu* means "harbor"; *nami* means "wave"). What typically happens is a large, submarine earthquake (magnitude 8 or higher) creates a significant upward movement of the sea floor resulting in a rise or mounding of water at the ocean surface. This mound of water moves away from this center in all directions as a tsunami. A tsunami can travel across the open ocean at about 500-miles per hour, the speed of a jet airliner. As the wave approaches land and as the ocean shallows, the wave slows down to about 30 miles-per-hour and grows significantly in height (amplitude).

Although most people think a tsunami looks like a tall breaking wave, like the wave shown in the image of Japanese artwork (*below left*), it actually resembles a flood or surge, like that shown in the picture below right from the 2004 Indian Ocean Tsunami (*images courtesy of NOAA*).

Tsunamis can cause great loss of life and damage to property, as we learned in the 2004 Indian Ocean Tsunami which killed over 230,000 people in eleven different countries. The key to surviving a tsunami is to know what the warning signs are, and know what to do and where to go if you think a tsunami is about to strike.

Pictures of evacuation drill in Samoa, California, courtesy Lori Dengler (Humboldt State University) and Jim Goltz (California Emergency Management Agency).

Tsunami Warning Signs

Earthquake! If you feel an earthquake or become aware that one has occurred, do not stay in an area that is susceptible to a tsunami….move to high ground! Even a large earthquake thousands of miles away can trigger a tsunami that can cross an ocean hours later.

Watch the tides! An approaching tsunami is sometimes proceeded by a rise or fall of water levels or strange bubbling in the tidal areas. If this occurs, it could be a sign that a tsunami is on its way. Head for higher ground!

Stay tuned in! Television, radio, and internet resources are good places to find out whether a tsunami is heading your way. Emergency evacuation procedures will be relayed and should be followed as soon as possible.

Tsunami Hero

The Story of 10-Year-Old Tilly Smith

When you learn about the warning signs of a tsunami, it might not only save your life…it might help save the lives of your family and others.

On December 26th, 2004, while vacationing with her family on a beach in Thailand, Tilly Smith, a 10-year old girl from Great Britain, noticed that the tide was rushing out and the ocean was strangely bubbling (*similar to the picture shown below; courtesy NOAA*). Tilly, who had studied tsunamis in a geography class two weeks earlier, quickly realized they were in danger. She warned her mother that it could be a tsunami and that they had to get off the beach immediately. Her parents alerted the others at the beach, which was quickly evacuated. The tsunami hit a few minutes later, but no one on the beach was killed or seriously injured.

Although the 2004 Indian Ocean Tsunami claimed the lives of over 200,000 people, Tilly Smith likely saved the lives of her family and over 100 other people on that beach. If you remember the warning signs, you too can become a "tsunami hero."

Tsunami Hazards in California

Have tsunamis occurred in California?

More than eighty tsunamis have been observed or recorded in California in historic times. Fortunately, almost all of these were small and did little or no damage. Though damaging tsunamis have occurred infrequently in California, they are a possibility that must be considered in coastal communities. There are two sources for California tsunamis, based on distance and warning time:

Local sources Local tsunami sources, like large offshore faults and massive submarine landslides, can put adjacent coastal communities at the greatest risk of a tsunami because the public must respond quickly with little or no official guidance. The Cascadia Subduction Zone is an example of a local tsunami source that could threaten northern California. Stretching from Cape Mendocino, California, to Vancouver Island, British Columbia, this 700-mile long submarine fault system forms the crustal plate boundary where the offshore Gorda and Juan de Fuca plates dive, or subduct, beneath the North American plate. Examples of local tsunamis that have impacted California include:

January 26, 1700 - An earthquake estimated at a magnitude 9 ruptured the entire length of the Cascadia Subduction Zone, likely causing a 50-foot tsunami in parts of northern California. Though there were no local written accounts, scientists have reconstructed the event based on geologic evidence and oral histories from the Native American people in the area, and determined the exact date and time from Japanese documents that describe the effects of a large tsunami that hit the coast of Japan later that same day.

December 21, 1812 – A tsunami struck the Santa Barbara and Ventura coastline shortly after a large earthquake was felt in the area. Though reports of the size of this tsunami have been debated, the event was large enough to inundate lowland areas and cause damage to nearby ships. One theory is that the tsunami was caused by a nearby submarine landslide triggered by the earthquake.

Distant sources A tsunami caused by a very large earthquake elsewhere on the Pacific Rim could reach the California coast many (4 to 15) hours after the earthquake. The Alaska-Aleutians Subduction Zone is an example of a distant source that has caused destructive tsunamis in California. Notable distant tsunamis that have impacted California include:

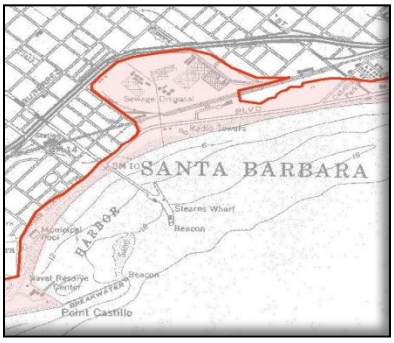
April 1, 1946 – A magnitude 8.8 earthquake in the Aleutian Islands generated a tsunami that caused damage along the coast of California, including flooding over 1000-feet inland in Half Moon Bay.

March 28, 1964 – Twelve people were killed in California when a tsunami was generated by a magnitude 9.2 earthquake off the coast of Alaska. A surge approximately 20-feet high flooded 29 city blocks of Crescent City.

March 11, 2011 – A magnitude 9.0 earthquake in the Tohoku region of Japan produced a moderate amplitude tsunami in California. Although it did not generate significant flooding in California, strong tsunami currents caused one death and over $50-million in damages to 27 harbors statewide, with the most significant damage occurring in Crescent City and Santa Cruz (*pictured below; courtesy Santa Cruz Port District*).

What is your risk?

The **California Geological Survey (CGS)** provides geologic and seismic expertise to the public, other State government offices, such as the California Emergency Management Agency (CalEMA), and local government agencies (cities and counties). With funding from the National Tsunami Hazard Mitigation Program, CGS worked closely with CalEMA and the Tsunami Research Center at the University of Southern California to produce statewide tsunami inundation maps for California (*an example from the Santa Barbara area is shown to the right*). These maps are used by coastal communities to produce emergency evacuation plans. You can check to see if you live, work, or vacation in one of these potential tsunami inundation areas. Visit the CGS tsunami website below to view these maps, and to learn more about what YOU can do to prepare you and your family for a tsunami.



Related Websites

California Geological Survey tsunami page - www.tsunami.ca.gov
California Emergency Management Agency – www.calema.ca.gov and myhazards.calema.ca.gov
Tsunami Research Center at University of Southern California - www.tsunamiresearchcenter.com/
National Tsunami Hazard Mitigation Program - nthmp.tsunami.gov/
Redwood Coast Tsunami Working Group - www.humboldt.edu/rctwg/
National Ocean and Atmospheric Administration Tsunami page - www.tsunami.noaa.gov

www.conservation.ca.gov/cgs

THE RESOURCES AGENCY
JOHN LAIRD
SECRETARY FOR NATURAL RESOURCES

STATE OF CALIFORNIA
EDMUND G. BROWN, JR.
GOVERNOR

DEPARTMENT OF CONSERVATION
MARK NECHODOM
DIRECTOR