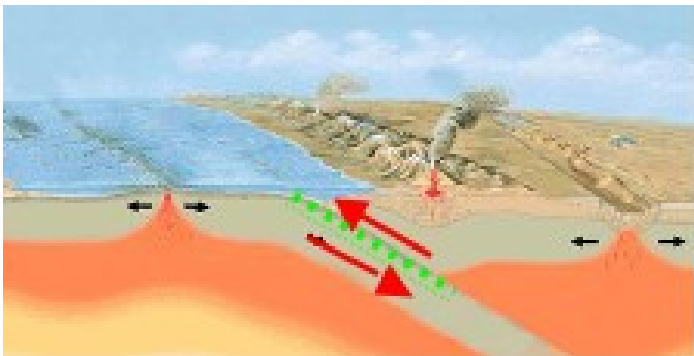


Is California at risk from tsunamis?

"... though the yesty waves confound and swallow navigation up; though bladed corn be lodged and trees blown down; though castles topple on their warders' heads; though palaces and pyramids do slope their heads to their foundations; though the treasure of nature's germens tumble all together, even till destruction sicken; answer me to what I ask you." Macbeth, iv., 1., Wm. Shakespeare, 1564–1616).

What is a tsunami and how is it formed?

Earthquakes happen when one block of the Earth's crust slides past another, releasing shaking waves. Earthquakes happen over the whole fault surface, and not just at an epicenter. The magnitude of the earthquake is proportional to the area of the fault over which the ground moves and the distance the ground moves during the earthquake.

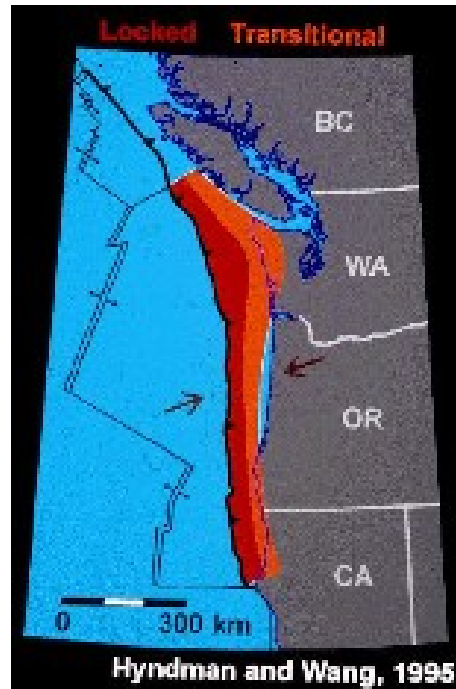


In some faults, called thrust faults, one side moves up and over the other, like the green line in this picture. The ground above the fault then moves up. If the fault is under water, that movement displaces water that has to then move somewhere else. If the earthquake was large (from a long fault with a lot of motion), the amount of displaced water becomes very large. It travels out from the fault as a tsunami.

Tsunami can also result from other changes in the shape of the sea floor. Some earthquakes trigger underwater landslides that create local tsunamis. Underwater volcanic eruptions are another source of tsunamis.

Could a tsunami hit California?

Yes! Locally generated tsunamis are possible along the whole Pacific Coast of North America. Some of the offshore faults are thrust faults and any earthquake shaking can cause underwater landslides, which create tsunamis. Historic tsunamis generated in California waters include a localized event that caused damage in Santa Barbara in 1812 and a half meter tsunami in 1992



Cascadia Subduction Zone

at Eureka. The worst threat is posed by a fault very similar to the Indian Ocean subduction zone fault that moved Christmas day in 2004 – the Cascadia subduction zone. This fault extends from Cape Mendocino in northern California to Victoria Island in British Columbia. and produced a M9.0 earthquake in 1700, and generating a tsunami that was

recorded in Japan. In geologic terms, it is inevitable that another earthquake like the 1700 earthquake, and a large tsunami, will occur again along the Cascadia subduction zone. They occur on average about once every 500 years. That tsunami will affect the whole west coast of the United States, as well as Hawaii and Japan.

Tsunamis from Alaskan earthquakes also affect California. The 1964 tsunami killed people in Crescent City and caused damage as far south as Long Beach.

Will California get a warning?

Yes. The National Oceanic and Atmospheric Administration (NOAA) operates a Pacific Ocean Tsunami Warning System to detect and provide warnings of tsunamis in the Pacific Ocean, so a warning will be issued. The system relies on seismic data from the California Integrated Seismic Network, supported by the California Office of Emergency Services (OES)

and the Advanced National Seismic System (ANSS) of the U.S. Geological Survey. Once a M7.0 or larger earthquake has been detected, the system uses tide gauges and 6 deep water buoys to detect the water waves. However, the system has limitations and could be improved.

- The possibility of hardware or software failures during a crisis is very real. The tide gauges are old, the seismic system is funded at 10% of its authorized level and the deep water buoys are deployed in a very hostile environment. Two of the six buoys were not working during the Indian Ocean tsunami of December 2004.
- NOAA tsunami warnings are issued to the California OES 24/7 operations center as well as through the Emergency Managers Weather Information Network (EMWIN) and NOAA Weather Radio. Modern technology could be applied to the tsunami warning system to improve delivery to first responders. Improvements in the warning system are being developed to increase the information from just arrival time to include amplitude and duration of the tsunami risk.
- First responders and the general population have not uniformly been trained in how to respond to a warning. The warning could be issued and still not lead to improved safety. In particular, a tsunami produced on the Cascadia subduction zone will hit the US West Coast within minutes to tens of minutes of the earthquake. Any response will need to happen quickly.

What can we do to reduce our risk?

The existing tsunami warning system operated by NOAA is incorporated within the State's new *Multi-Hazard Mitigation Plan* and the *California Earthquake Loss Reduction Plan*. We could increase the effectiveness of the warning system with the following steps.

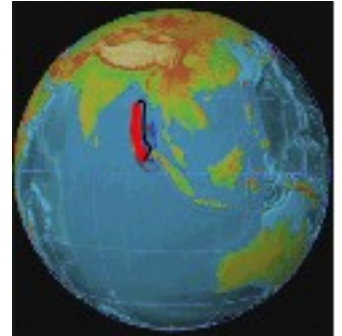
- Assess the State's vulnerability to nearsource tsunamis. Encourage the coastal counties to complete their tsunami evacuation planning.
- Upgrade the technology and robustness of seismic and oceanic monitoring and warning systems.
- Modernize the information distribution systems. Develop/improve training programs to prepare

first responders to better use the tsunami warning system.

- Expand public education programs to inform residents how to respond to a tsunami warning. The State of Oregon has a tsunami education requirement for grades K-8 for students living in coastal areas. A similar program should be adopted for California.

What happened in the Indian Ocean?

The December 26, 2004 earthquake occurred on a fault almost 1,600 km (1000 mi) long that pushes the Indian Ocean under Indonesia. Indonesia moved almost 20 m (60 ft) towards India.



That motion of the floor of the Indian Ocean displaced more than one trillion cubic meters of water (equal to 30 times the volume of the Great Salt Lake in Utah) that traveled out as a tsunami. Its speed was about 500 mi/hr and arrived at Sri Lanka and India about 3 hours after the earthquake began. It arrived in Indonesia just minutes to tens of minutes after the earthquake.

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