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Not My Fault: tsunamis are not just an ocean hazard

Lori Dengler for the Times-Standard

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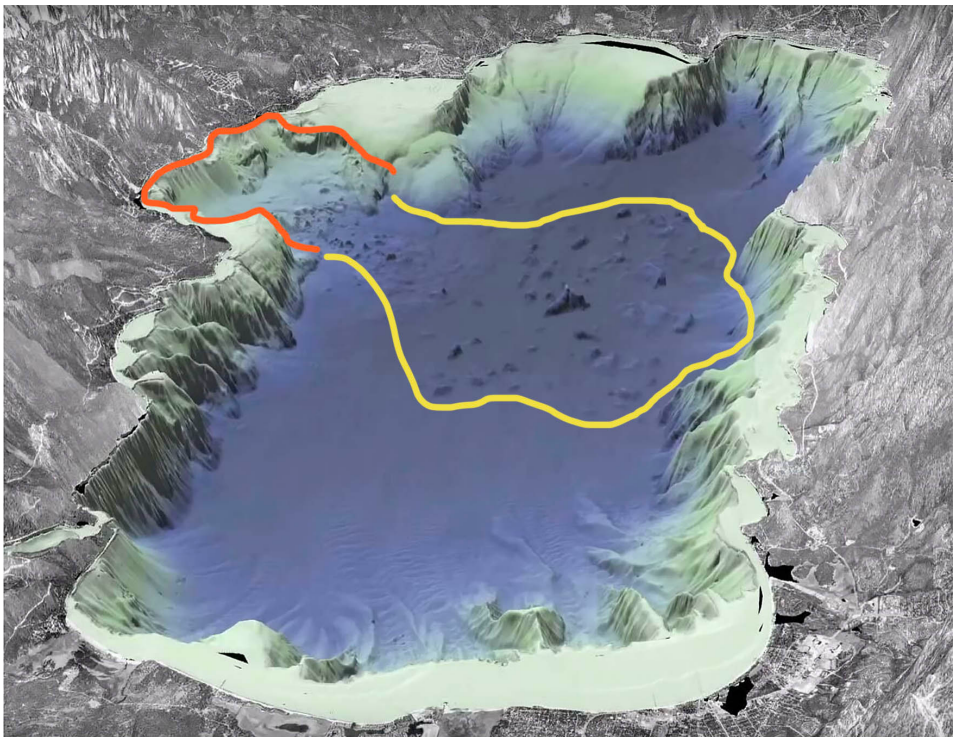

Lake Tahoe sea floor shape (bathymetry), deepest areas in blue. Approximate scarp of the McKinney Bay landslide shown in red, debris field outlined in yellow. From the USGS and California Water Science Center.

Are oceans the only places where tsunamis are a threat? What about lakes or other nearly closed bodies of water?

Unpredictable waves in a lake can come from several sources. The most common, like the ocean, is strong winds. Wind waves have reached heights of nearly 30 feet in the Great Lakes. But these monsters are not tsunamis, and only involve near surface water.

Winds can set up a second type of wave in lakes and inlets. Pressure differences and strong winds cause water to pile up and initiate a rhythmic oscillation. Called seiche (saysh), they are standing waves where the entire water column moves up and down. Their period depends on the shape and volume of the water body and are on the order of tens of minutes to hours.

First described in the late 19th century in Lake Geneva, seiches are observed in lakes around the world. With sensitive instruments, seiche oscillations can be most of the time. Usually unnoticed to the casual observer, they can become large and hazardous within minutes when forced by weather or other triggers.

Lake Erie boasts some of the largest seiches. In October 1844, a 14-foot sea wall was breached flooding Buffalo's harbor area. Estimated to have peaked at 22 feet, the combination of water and wind wreaked havoc on the lake and in port areas and drowned 78. Another seiche four years later caused ice to dam the Niagara River and stopped the Falls from flowing for nearly 30 hours.

Weather is not the only cause of seiche. Surface waves from large earthquakes can also trigger standing waves. The 2002 Denali earthquake triggered a seiche in Seattle's Lake Union that damaged 20 houseboats. The 1964 M9.2 Alaska earthquake elicited seiche observations in many inland areas of North America and the Gulf of Mexico. In 1992, a man in Davis called me after the Cape Mendocino earthquake to report the sudden appearance of waves in his swimming pool.

Tsunamis can occur in lakes as well. Tsunamis and seiches are similar in that both involve the entire column of water from surface to the bottom. But a tsunami is a progressive wave, starting in one area and traveling outwards.

To make it more complicated, a tsunami can trigger a seiche and the resulting combination of standing and progressive waves can exacerbate the tsunami impacts. The 2011 tsunami in Crescent City is a good example. When the tsunami entered Crescent Harbor, it displaced the water setting up standing waves. Three different seiches were triggered: oscillations of the water in the Citizen's Dock boat basin, oscillations in the larger harbor area, and oscillations on the somewhat bowl-shaped continental shelf just offshore. These standing waves were responsible for the long duration of the tsunami. One can clearly see the tsunami-seiche signal for more than six days on the Crescent City tide gauge.

Tsunamis (progressive waves) do occur in lakes and will set up seiches (standing waves) that can amplify duration and impacts. I'm not going to split hairs to differentiate the two but will lump them together under tsunami. Landslides into lakes, earthquakes that deform the lake floor, and volcanic processes have all caused lake tsunamis.

One of the most dramatic and deadly of lake tsunamis was caused by a 1986 "lake overturning" event in Cameroon's Lake Nyos. A buildup of methane and other gasses near the lake bottom suddenly became unstable and moved rapidly upward, displacing the water. The combination of toxic gas and tsunami killed over 1700 people.

The Nyos scenario could occur in other areas where volcanic activity and large lakes coincide but is unlikely in California. But there is one spot in the State where geologic

evidence points to a significant lake tsunami in the past. The same conditions exist today and suggest a similar event in the not-so-distant future.

Lake Tahoe perched on the California – Nevada border is unusual in several respects. The second deepest (after Crater Lake) and one of the oldest lakes in North America, it owes its existence to several fault systems. The steep slopes and relatively frequent seismic hazard make it susceptible to landslides.

Forty years ago, the first sonar survey of the Tahoe lake floor revealed a surprising debris field. A number of papers since then describe a massive landslide that occurred roughly 20,000 years ago. Called the McKinney Bay landslide, it can be easily seen in the lake bottom bathymetry. High resolution mapping reveals not only the landslide scar, but a debris field that extends across much of the central and northern part of the lake. From the volume and distribution of the landslide debris, it is estimated that the tsunami resulting from the slide may have approached 300 feet in height.

It doesn't take much imagination to envision other potential landslide sites around the perimeter of Lake Tahoe. In California, tsunami hazard mapping is the responsibility of the California Geological Survey. Lake Tahoe is on their list for future study, but the priority has been to map coastal areas where the tsunami threat is much greater.

Researchers are beginning to pay more attention to lake tsunamis. Glacial retreat and climate change exacerbate landslide size and frequency, putting the lakes below them at greater threat. There is still much to be learned dynamics of such slides and the resulting tsunami-seiche combo.

The bottom line? Tsunamis are tricky and not just confined to ocean coasts. Wherever there is water, pay attention to it. If you hear a roar or see a sudden change in water behavior, get away from the water's edge.

Note: view an animation of seiche at https://en.wikipedia.org/wiki/Seiche#/media/File:Standing_wave_2.gif and https://www.buffalohistorygazette.net/2010/09/the-lake-erie-seiche-disaster-of-1844.html for an account of the 1844 Lake Erie seiche. More on the Lake Tahoe tsunami at https://pubs.geoscienceworld.org/gsa/geosphere/article/10/4/757/132174/Tsunami-generated-sediment-wave-channels-at-Lake

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