Times Standard

Not My Fault: How scary are Kelvin waves?
Lori Dengler for the Times-Standard
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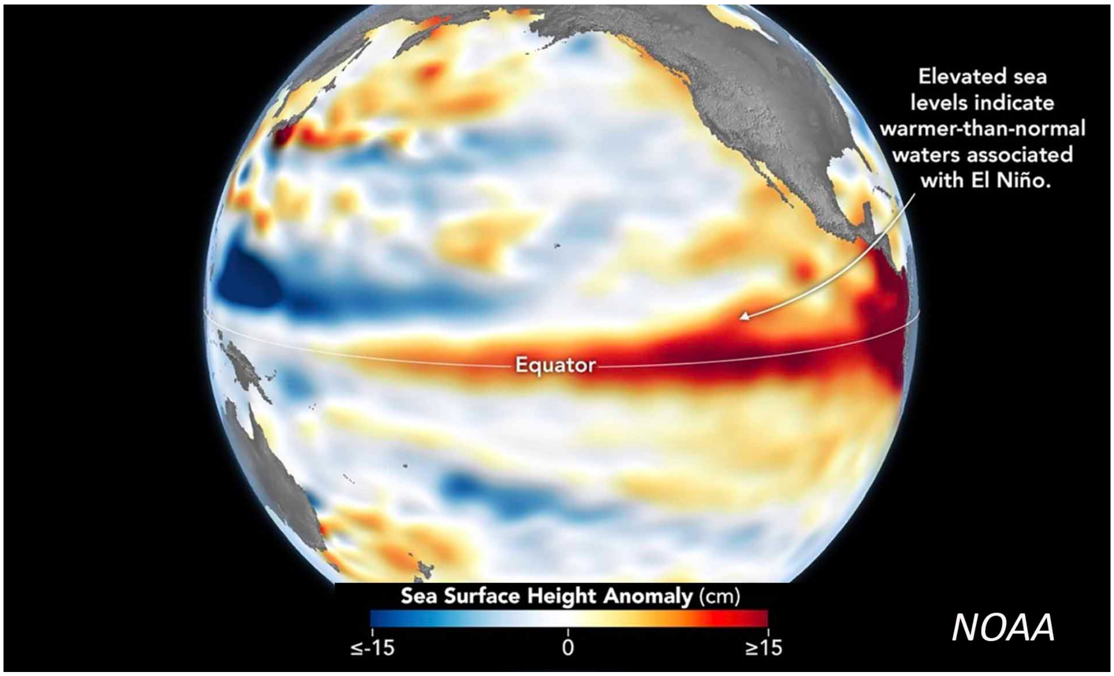

Snapshot of the 2026 El Niño-driven Kelvin wave in June 2026. A Kelvin wave is the movement of warmer-than-average water along the west coast of North and South America. This year's Kelvin wave is projected to elevate sea levels along the California coast by as much as a foot above the long-term average.

There are many different types of waves in the ocean. Tsunamis, rogue waves, and sneaker waves are all worthy of respect and caution. This week a new wave appears to have entered the lexicon. Like most of you, I had never heard of Kelvin waves until recently (Times-Standard 9/14). It turns out they aren't new, just a more scientific description of what happens in a strong El Niño.

A wave is any phenomena that transfers energy from one point to another without permanently displacing that material in the process. When a wave travels through water, the water particles may rotate and bump into one another as they pass along the kinetic, gravitational, or heat energy, but eventually return to their original position. Watch a buoy bob as a wave passes under it. The buoy will describe a small backward circle as the wave travels, moving up, back, down and forward. Note that the motion of the buoy (the particle motion) is much slower than the speed of the wave as it travels by.

The waves that moved the buoy are the most common you see in water. They are called wind or surface waves and are caused by wind forces acting on the surface with periods on the order of 7 to 15 seconds and heights ranging from a few feet in quiet times to over 20 feet during winter storms. The size of the waves depends on how hard the wind blows, how long the winds last, and the area over which the wind forces are exerted. In the deep ocean, wind waves only disturb surface waters and at depth, the water remains perfectly still. Scuba divers can tell you of days when the ocean chop was strong enough to cause seasickness but 50 feet below the surface, everything was still.

Oceanographers call waves that die out with depth deep water waves because the ocean bottom plays no role in their speed and characteristics. Mathematically, the bottom is infinitely far away and creates no boundary effects. Wind waves can be huge. In 2000 a British oceanography research vessel in the northern Atlantic recorded 23 waves exceeding 65 feet with the highest at 95, the highest ever recorded by shipborne instruments. Sometimes called rogue waves these largest waves are caused by interactions of waves from storm systems with different wave characteristics. The constructive interference of can cause monster waves to suddenly appear.

Swells are another common coastal wave, produced by storms thousands of miles away. Near the storm center, a whole symphony of wave periods is produced from choppy seas to longer periods. The shorter period waves oscillate faster and die out much more quickly as they travel away from the source region and only the longer period waves persist over these distances. Generally, not hazardous far from the coast, they are often the culprit for seasickness because their long period, rolling motion causes conflicts between your inner ear and what your eyes perceive.

In the deep ocean, wind waves and swells are deep water waves. Their speed depends only on the driving forces of the wind. When the sea floor shallows, the physics change and suddenly the boundary plays a role. As soon as the particle motion in a wave feels that boundary, it becomes the most important parameter in how fast the wave travels. In shallower water, the speed slows, allowing the faster water behind to catch up and build in height. At some point, the bottom of the wave has slowed so much that the faster water on top topples over, causing the wave to break.

These are the waves that cause damage to coastal structures. Large winter storms can produce waves of 30 feet or more and some places over 100 feet. There are widespread alerts for these major storm-driven wave events, and most of us know to stay away from the coast. Ironically, it's the peaceful sunny day that can be more hazardous to the casual beach visitor.

Sneaker waves can occur on the mildest of days when many people are enjoying the beach. Like rogue waves, constructive wave interference is the cause, but the sources are so far away you are likely unaware of any impending danger. Swells from distant storm systems vary in period and interfere with each other, sometimes diminished in amplitude and sometimes much larger. For people on the beach not paying close attention, that larger surge may suddenly pull you into the water. Each year sneaker waves claim lives in California, all preventable by keeping an eye on the ocean. If your dog gets pulled into the water, don't try to help; your dog will most likely make it out on their own, but you won't.

Deep water waves and shallow water waves are driven by gravity acting on ocean displacements caused by wind and tectonics. Kelvin waves are caused by thermal differences and involve transfer of heat from warmer areas to cooler ones. While the name may be new to you, the phenomena probably is not. Kelvin waves are the mechanism by which the El Niño – driven warm waters propagate first towards South America from the western Pacific as the trade winds die and then outward to the north and south.

Named after Lord Kelvin, the Scottish Irish physicist and engineer, I became familiar with some of his work in thermodynamics classes as an undergraduate at Berkeley. In 1879, he published a paper on the mathematics of warm fluids pushed by rotation against a solid barrier. Kelvin waves in the ocean weren't directly observed until the 1960s, but Lord Kelvin's mathematics described them almost perfectly, so the name stuck.

The first 2026 Kelvin wave was detected in March and took nearly three months to traverse the equatorial Pacific and reach Peru. Warm water expands and the Kelvin wave heat bulge has already caused the waters off Peru to rise roughly 6 inches above average. The wave then split with some of the warm water pulse traveling north and some south trapped along the coast by rotational forces. The warmer waters and elevated sea level height can be tracked by satellite, and the northern branch has now been detected in the Gulf of California. It is projected to reach San Diego in early October, raising the sea level by 6 to 12 inches above the current average height. Kelvin waves travel at the speed of a jog, and the warm water bulge will reach San Francisco in mid-October, and the North Coast should feel the first effects by the end of next month. It won't stop here but will continue its slow slog northward arriving in the Gulf of Alaska by the end of November.

Strong El Niño events produce multiple Kelvin waves and so after the heat bulge passes, the water won't cool substantially. Humboldt County will likely see sea levels as much as a foot higher than usual into the spring of 2027. These Kelvin waves don't oscillate and won't cause battering of the coast or strong surges in harbors, but they will make all of the ordinary coastal perils more hazardous. Storm waves can penetrate further inland and king tides will cause much more coastal flooding. Were your neighbors affected by flooding last year? This year be prepared for those coastal flooding events to affect you too. Now is the time to improve your drainage, acquire sandbags and know how to use them.

A more ominous impact of Kelvin waves may be in the marine ecosystem. Warm water affects both the chemical and biological ocean environment potentially disrupting the entire food chain. Upwelling that brings nutrients near the surface may fail because the warm water bulge depresses the boundary between cold waters and surface water. All of our fisheries could be impacted. In the equatorial regions, the effects could be far worse with coral bleaching and long-term damage to kelp forests.

The Kelvin wave is one more factor in elevating ocean temperatures and raising sea level above the long- term averages of the last century. It won't cause violent oscillations in harbors or batter coastal cliffs with high velocity waves. But it will give a boost up to all of the other waves that will.

Lori Dengler is an emeritus professor of geology at Cal Poly Humboldt, and an expert in tsunami and earthquake hazards. The opinions expressed are hers and not the Times--Standard's. Not My Fault columns are archived online at https://rctwg.humboldt.edu/news-archive and may be reused for educational purposes. Leave a message at (707) 826-6019 or email Kamome@humboldt.edu for questions and comments about this column or to request copies of the preparedness magazine "Living on Shaky Ground."