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Not My Fault: Sea level measurements and Humboldt tectonics

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Sea level is rising more rapidly in the Humboldt Bay region than in any other place on the US West Coast. Cal Poly Humboldt's Center for Sea Level Rise has been looking at the implications and last Monday, the San Francisco Chronicle gave us feature treatment. *

Sea level rise became news in the 1970s. Studies were published and in 1988 the UN formed the Intergovernmental Panel on Climate Change was formed. Since 1993, satellite altimetry has provided a global picture of the rising oceans. The current estimate of average sea level rise is 3.4 millimeters (.13 inches) a year. There is no gray area here, it is a measured fact.

But the ocean isn't a bathtub, and the rise is not uniform, rising more rapidly in some areas and dropping in others. How water level changes locally is a function of many variables. The three most important are thermal expansion, the supply of water, and deformation of the sea floor.

Water expands as it warms. A warmer ocean raises sea level with no additional water. Expansion rates are complex and depend on salinity, temperature, and pressure. There are seasonal changes and longer ones. Thermal expansion in strong El Nino years can raise the background tide levels by nearly a foot.

Added water comes from three main sources: valley glaciers, the Greenland ice sheet, and the Antarctic ice sheet. I called them the three dominos when I taught about sea level rise. Alas the valley glaciers are nearly gone and much of their contribution is already in the ocean. Melting of the Greenland ice sheet is well under way and all eyes are now on Antarctica. It will be the primary driver of sea level rise over the next century.

Little attention is paid to seafloor depth. It is not a constant. The weight of sediment, ice, or lava flows can depress it; removing weight causes it to rise. Tectonic stresses squeeze or stretch the crust.

Ice sheet melting and the warming climate are my top concerns when it comes to the future of human habitability but the response of sea levels to tectonics is closer to my area of expertise. I am fascinated by how sea levels give a picture of the forces at work beneath our feet.

Sometimes those forces work quickly. The Great Alaska earthquake in 1964 lowered some areas by as much as 8 feet. Other locations like Montague Island rose up 30 feet. But most tectonic changes are very slow, occurring over decades and centuries as strain accumulates in between major earthquakes.

Tide gauges provide a record of those subtle changes. By averaging daily water levels, regional trends going back a half century or longer emerge. NOAA maintains fifteen tide gauges in California. South of Cape Mendocino, they all show a rising sea at rates between 1 and 2.5 mm/year. The North Spit tide gauge south of Fairhaven on the Samoa Peninsula has a rate about twice as high, just under 5 mm/year. And to further complicate the story, Crescent City, 65 miles north of Humboldt Bay, is the only site on the California coast where sea level is falling. The land is rising more rapidly than the water.

Something very unusual is going on along the Northern California coast. Ocean temperatures and water supply are essentially the same yet over a space of 65 miles, we have the most rapidly dropping and the highest uplifting coasts in the State. The culprit has to be tectonics.

USGS scientist George Plafker was the first to note an unusual pattern of land level changes after the 1964 Alaska earthquake. He spent more than a year documenting areas that had uplifted and those that had dropped and proposed what today we know of as the megathrust earthquake cycle. In between great earthquakes, the slow forces of the subducting plate pull down the land near the edge of the plate offshore and squeeze the area further away causing a bulge.

The Cascadia subduction zone is similar to the geologic setting that produced the Alaska earthquake. The edge roughly coincides with the continental shelf. It is almost at the coast at Cape Mendocino and is further and further offshore heading north into Oregon and Washington. The simple megathrust model means we would expect that areas in Humboldt and Del Norte County where the edge is closer to be pulled down during interseismic times.

Tide gauges show a more complex story. The relative sea-level drop in Crescent City and Port Orford in Southern

Oregon point to a rising coast. But what is going on in Humboldt Bay? We are much closer to the subduction zone edge and should be rising even faster.

Ah the complexities of subduction zones. They aren't a single fault and Humboldt County is one of the few places on the planet where we can see the complexity on land. We are perched on the edge of the North American plate and the Gorda plate is being pulled beneath us. The pull may be slow, but it is relentless causing the edge to crumple, fold and, in some cases, break.

The 60-mile zone from the edge to the coast the accretionary fold and thrust belt. The crumpling created Humboldt Bay and the lagoons. Secondary faults such as the Little Salmon and the Mad River fault zone cut across the coastal area. All of these features are also deforming at slow rates.

Could we get a better picture of Humboldt Bay if we had more tide gauges? Yes, and fortunately a group from Cascadia Geosciences led by Jason Patton has done this. There were temporary tide gauges in the past at a number of Bay locations and this team was able to track down four of them and compare their rates to the NOAA gauge. No surprise - their data show differences in rates around the Bay and one area is dropping even more quickly. Their paper is coming out soon and I will revisit the story then.

The implication for Humboldt is enormous. It will require moving waste-water treatment plants and moving/protecting roads and highways. Proposed developments like Arcata's Gateway project will find themselves in the tsunami hazard zone. And of course, these rates won't continue indefinitely. They are signs of accumulating strain on faults that will eventually rupture. When that happens, the Bay will look substantially different.

Note: * NOAA maintains a global database of relative sea level rise as measured by tide gauges at https://tidesandcurrents.noaa.gov/sltrends/,
the Chronicle article is at
https://www.sfchronicle.com/climate/article/california-sea-level-rise-17478689.php?fbclid=IwAR20RKWa3dVVAeXP6on33pdiBK90IAXpzqUB8WUbWC8d34BU74Jq1e3SgCc

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