

Our Ocean Backyard — *Santa Cruz Sentinel* columns by Gary Griggs, Director, Institute of Marine Sciences, UC Santa Cruz.

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How fast will sea level rise?



High tides, storm waves and sea level elevated by a large El Nino event in early 1983 overtopped East Cliff Drive at Corcoran Lagoon.

The West Coast Sea Level Rise Committee of the National Research Council held four meetings over the past six months in exotic places like Santa Cruz, Portland, Seattle and Irvine. The final report is now well along and release is planned before the end of the year.

There are some who might ask- why bother or worry about future sea level rise? What difference will it make? I guess in some ways it's like asking any question about the future. How much should we save for our children's college expenses, or how much money will I need when I retire?

Because we have built so much of our civilization so close to the shoreline and so close to sea level, there are going to be some significant impacts to deal with in the

future. The San Francisco International Airport is just one example, but it's a big one. It's not a question of whether sea level rise will happen; that's been going on for thousands of years. But how fast it will happen, how high it will get, and how will this affect the coastline. This is what the Committee is trying to figure out. Being on the Committee, I'm thinking a lot about these issues right now, as are all the members.

There are several ways to approach these questions, with some similarity to the question of how much to save for retirement. You could take the simple approach and look at your overall monthly cost of living now, how it probably has increased over time, and extrapolate that into the future and hope you are not surprised. Or you could dissect your monthly expenses - how much you spend for housing, food, medical expenses, and all the other things that consume your paycheck - and then try to carefully evaluate each of these and how they might change in the future, 10, 20 or 30 years from now, and add them all up.

There are some uncertainties with each. How far out into the future do you feel comfortable simply extrapolating or extending your total monthly expenses based on the past 15 or 20 years? Or if you choose the item by item approach, how certain are you about future medical expenses, food, or any of the other costs of living? What if the economy tanks and your savings or IRA disappear, or your house value drops, or social security is reduced? There are a lot of unknowns.

We face some of the same challenges in projecting sea level very far into the future. The committee is taking several different approaches, and using the best science in an effort to develop the most reasonable and scientifically sound conclusions.

One approach is to take the rate at which sea level has risen over the past 100 years or so, and then use our best judgment to extrapolate this curve into the future. Like your retirement savings estimate, the next 10 years isn't too much of a stretch, but at 2030, 2050 or 2100, the uncertainties get progressively larger, simply because there are so many factors affecting future sea level rise that we can't accurately predict. Things like, how much more fossil fuel will the world's largest carbon dioxide emitters (China, USA, the European Union and India) burn before they transition to renewable energy sources. The more carbon dioxide that enters the atmosphere, the more the Earth and the oceans heat up and expand, the more ice that will melt, and the higher sea level will rise.

Another approach is to look carefully at all the factors that contribute to sea level rise and then try to determine how much each source has contributed historically and how these might change in the future. How fast will the ice sheets and glaciers of Antarctica and Greenland, the ice cover of the Arctic Ocean, and the other smaller mountain glaciers around the world retreat or melt by some future date, and how much will each of these contribute to future sea level rise? How much warmer might the oceans get, and therefore, how much will they expand? Again, these are difficult questions to answer because there are so many uncertainties about the future of human behavior globally, as well as uncertainties about how each of these natural systems actually responds to a warming Earth.

All evidence indicates that sea level will continue to rise for at least the next several hundred years. Global tide gauge records over the past century indicate that sea level rose at an average rate of about 1.7 mm/yr, or nearly 7 inches over the last 100 years, not too much really. Satellites have provided a more precise set of observations over the past 18 years and indicate that the global rate of rise has increased to about 3.2 mm/yr, equivalent to a little over 12 inches/century. While this rate is still quite low, it represents a significant increase over what we experienced during the last century.

What does seem clear is that over at least the next 25 or 30 years that it will be the short-term increases in sea level, during large El Niño events, for example, combined with large storm waves and high tides, that will inflict the most damage on the coastline. The El Niño winters of 1978, 1982-83 and 1997-98 caused hundreds of millions of dollars in damage along the California coast as a result of large waves, arriving at times of high tides, when sea level was already elevated due to an El Niño driven bulge of warm water along our coastline.

Over time, the continued rise in sea level will begin to threaten and inundate low-lying coastal areas, such as the San Francisco and Oakland International Airports, and will also allow waves to gradually break closer to the shoreline, increasing coastal erosion rates.

Eventually sea level rise will also begin to threaten many of the state's heavily used beaches. For natural or undeveloped beaches, such as Natural Bridges, or those along the interior of Monterey Bay, a rise in sea level will gradually move the beach and shoreline east or inland, as it has done for the past 20,000 years of sea level rise. We will still have a beach, it will just move a ways inland.

Where the inner edge of the beach is fixed by a seawall, road, or buildings, however, which is the case for the Santa Cruz Main Beach, the shoreline cannot migrate inland so a rise in sea level of 2 or 3 feet will permanently inundate the beach, as it does during large winter storms now. While this won't happen immediately, all evidence suggests that this will begin to be an increasing concern within the next 25 or 30 years. I hope I'm wrong