

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

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Sea-Level Rise- What can we expect?

Global sea level has been rising ever since the last Ice Age ended about 20,000 years ago and the planet began to thaw out. As the Earth warmed, sea level rose for two main reasons: (1) ocean water expands as it warms; and (2) water from melting glaciers and ice sheets flows into the ocean.

During the past 20,000 years of gradual warming, about 10,000,000 cubic miles of water has been added to the ocean. That's a lot of water and it has raised the level of the ocean about 350 feet around the world, gradually bringing the ocean right up to today's shoreline, and to the doorsteps of many homes. Humans had virtually no influence on climate or sea level for the first 19,900 years of this period, however. It was all natural.

Tide gages show that sea level rose globally about 7 inches over the 20th century, not a lot unless you happened to live within a foot or so of sea level in Bangladesh, on some very low-lying Pacific Islands, or perhaps below sea level in a place like The Netherlands, New Orleans or the Sacramento delta.

That's the past, however. California and most other coastal states and nations are concerned with what is likely to happen in the future. How high is sea level likely to rise and how fast? And that's what the National Research Council Committee worried about for the last 18 months.

Satellite observations over the past 20 years tell us that the rate of global sea-level rise has nearly doubled over what it was during the previous century. In large part this is due to land ice melting at a more rapid rate, particularly in and around Antarctica and Greenland. There are still a lot of unknowns, however.

It has been said that prediction is really difficult, especially about the future. And sea-level rise predictions are no different.

There are a couple of different ways that we can develop projections for future sea level: 1) extrapolating historic trends; 2) using climate models that incorporate a range of greenhouse gas emissions (carbon dioxide, nitrous oxide and methane); or 3) by developing historical relationships between global temperature and past sea level, and then using estimates of future temperatures to predict future sea levels. The Committee used a combination of approaches.

Global sea level is expected to rise between 3 and 9 inches by 2030, compared to 2000 levels, 7-19 inches by 2050, and 20 to 55 inches by 2100. Uncertainties grow as we get farther out into the future simply because of the uncertainties in things like global production of greenhouse gases. How much more coal, oil and gas will the US, China and India use in the decades ahead? No one knows.

While these global values are useful to keep in mind, sea-level rise isn't the same everywhere, primarily because the land or coastline may well be moving around. Large-scale tectonic forces, such as those that raised the flat terraces along the Santa Cruz coast, can drive vertical land motion. Or due to oil, gas or water withdrawals from subsurface reservoirs, or the compaction of sediments, some sections of coastline may actually be sinking. Huntington Beach is sinking and so are Venice and Mexico City.

So while the total volume of water in the ocean will determine the average global sea level, the rate of rise along any particular coastline is also affected by what that particular land area might be doing, whether rising, sinking or stable.

From San Diego to Cape Mendocino in northern California, the tectonics of the coastline is controlled primarily by movement along the San Andreas Fault. There is little vertical land motion so that projections for future sea level are similar to global values: 2-12 inches by 2030, 5-24 inches by 2050 and 17-66 inches by 2100.

Confidence in these projections is high for 2030, and perhaps 2050. But by 2100, due to the uncertainties mentioned previously and discussed in the report, we are only confident that the actual value will fall within the range given: 17 to 66 inches, or 1.5 to 5.5 feet. While that's a big range, even the midpoint of the range, 3.5 feet, spells trouble for many coastal areas. But the good news is that we have some time to adapt if we start right now.