

## Explaining Norfolk's Creeping Tides

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Data accumulated by ocean scientists indicate that sea-level rise has been accelerating.

Some readers responded skeptically to my Friday article about how Norfolk, Va., is handling encroaching seas. Many argued that auxiliary factors that I highlighted in my article like the compacting of landfill and natural land sinkage explained Norfolk's problems in full and dismissed the notion that global sea rise played a role.

In fact, as my article explained, both land sinkage and the rising sea levels that scientists link to global warming are involved. But let me break it out a bit more. Sea level rise is complicated to measure, of course, but there are two basic categories of statistics: local or isostatic, and global or eustatic. There is a fairly large scientific consensus that the eustatic sea rise has been 1.2 inches over the last decade and is accelerating.

In my article I note that Sewells Point Naval Station estimates the local sea-level rise since 1930 as 14.5 inches. Global sea-level rise could conceivably account for about one-half of it.

An assortment of factors is thought to play a role in how localities experience sea rise, from sea currents to proximity to glaciers (which are thought to act as water magnets) to geology. Norfolk certainly experiences tidal changes more acutely because of local geological factors, most notably its location on the edge of an ancient crater hole; the Chesapeake Bay area is sinking. But scientists agree that land sinkage alone does not begin to answer why the tide is encroaching on Norfolk.

*An earlier version of this post estimated global sea-level rise from 1930 to 2010 at 9.6 inches, accounting for about two-thirds of the sea rise at Norfolk; mainstream scientific estimates suggest that the total was closer to 7.4 inches, accounting for roughly half of the sea rise at Norfolk in that period.*

*A clarification from Ms. Kaufman:*

*In Friday's Times, I wrote about how the city of Norfolk was handling the worrisome phenomenon of sea rise. The article made clear that the problem arose both from land sinkage and a general rise in sea levels. Skeptical readers wanted me to deconstruct a relative sea level rise of 14.5 inches that has been measured at nearby Sewells Point Naval Station since 1930; did sea-level rise play that critical a part in this?*

*In this follow-up post, I wrote that an assortment of complicated factors come into play when measuring sea-level rise at specific coastal points. I wrote that eustatic sea rise (global sea rise) from 1930 to 2010 was roughly 1.2 inches a decade, and that we might*

*therefore estimate global sea rise over that 80-year period at 9.6 inches. This was an error, and many readers wrote in to challenge the number.*

*They pointed out that the Environmental Protection Agency and the Pew Center on Climate Change, among others, calculate the annual sea-level rise at an average of 1.8 millimeters in the 20th century, for example; if that average were applied to 1930 to 2010, you would come up with 144 millimeters, or about 5.33 inches. (Applying a century-long rise to an 80-year period is problematic, however.)*

*I checked with Rob Young, director of the Program for the Study of Developed Shorelines, a joint venture of Duke University and Western Carolina University, and the co-author of "The Rising Sea." First of all, he explained that the commonly cited estimate of an average 1.8-millimeter annual rise in sea level is based largely on the interpretation of a century's worth of sea gauge data by scholars like John A. Church and Neil J. White, two professors of marine and atmospheric research.*

*If you look at their year-by-year chart of estimated sea level rise up to 2006 (now reproduced at the top of this post), you can see that they put the eustatic sea-level rise at about 6.9 inches from 1930 to 2006 — lower than the 9.6 inches that I came up with by extrapolating backward from a recent period in which sea rise accelerated.*

*Add 3.4 millimeters a year for 2007 through 2010, and you get about another half-inch. In sum, eustatic sea level rise might more accurately be said to account for about half of Norfolk's sea rise since 1930, — not two-thirds, as I estimated on Friday.*

*I need to re-emphasize that global sea level rise is not a perfect prediction of local sea-level rise, which could actually be higher or lower depending on a wide variety of factors.*

*The chart also reflects how strikingly sea rise is accelerating.*