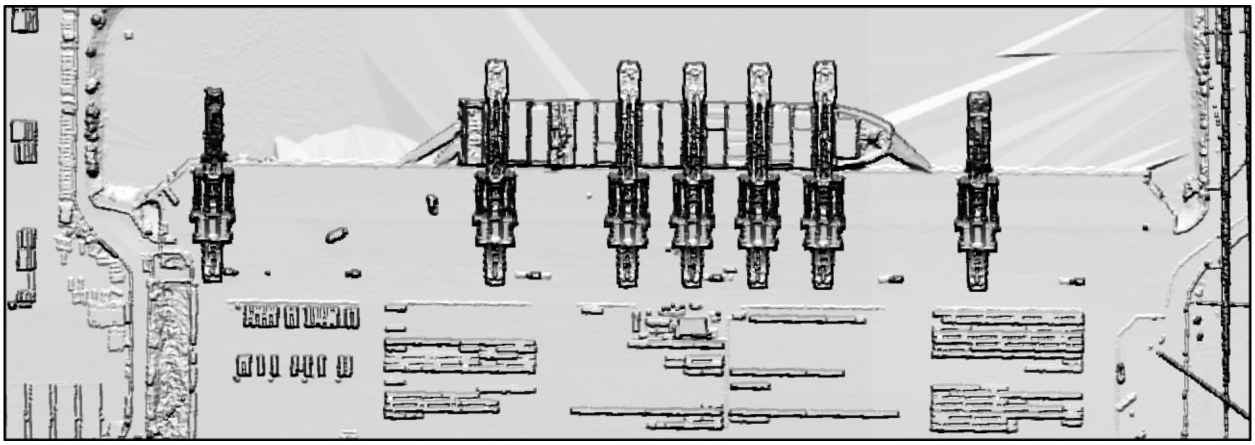
Impacts to the Port of Tacoma from Potential Sea Level Rise

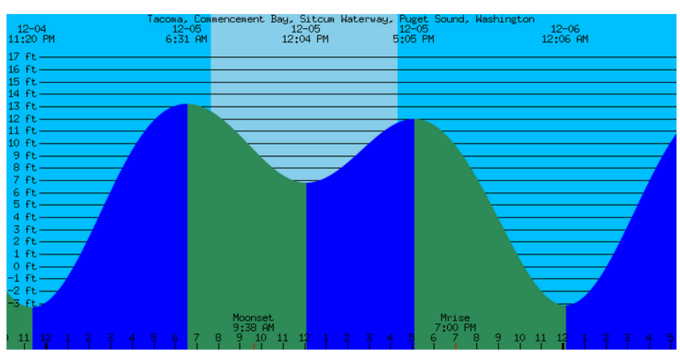
Steve Schultz, Heather Warren and Jake Root; May 18, 2021

Goal: Following a 2019 study by Gracia, et al., we wanted to see what a projected sea level rise may do to the Port of Tacoma. The Port is a major industry for the area, responsible for 42,100 jobs and nearly $3 billion in economic activity (Port of Tacoma). Using digital elevation models derived from LiDAR data, we assessed how sea level rise may impact port operations in the future.



Pierce County Terminal seen with a DSM hillshade

Data: Our LiDAR data came from the Washington LiDAR Portal. The portal provided a 2017-18 data collection of the Tacoma Water Service Area based on the Green River Watershed and Corridor (Washington LiDAR Portal). This LiDAR capture included a detailed digital surface model (DSM) and digital terrain model (DTM) of the Port. We limited our extent to the Port by creating a mosaic raster for four raster files. This allowed us to align the four raster files vertically and limit the extent to our area of study. According to the LiDAR metadata, the non-vegetated vertical accuracy was collected with a 95 percent confidence interval (Gleason, 2019). This was ideal for calculating the effects of sea level rise.

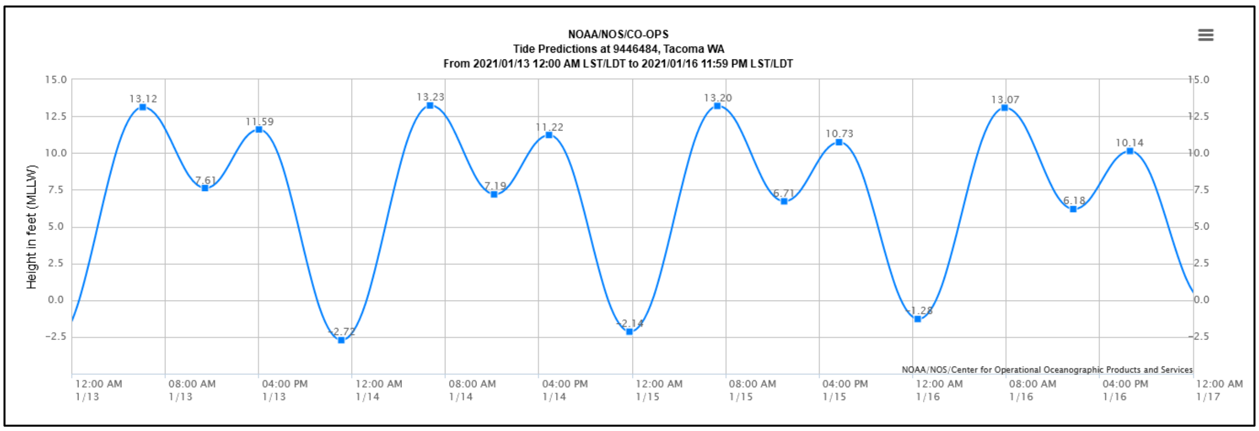


Analysis: After creating a DTM of the Port we set about understanding the data. By adjusting the raster file's symbology to show only 0-25 feet, we were able to make out significant detail of the port – even without the use of hillshade filtering. We realized the LiDAR showed different water levels in the port which we took to indicate the data capture may have taken place over different times. By filtering out the raster data from 0-7 feet, we were able to see the port with no water returns in the estuaries. This corresponded to a tide table from the first date of the capture. At noon, the low tide was at nearly +7 feet (Old Farmer's Almanac). By finely adjusting the raster data symbology we were confident that the symbology for 0 feet matched sea level (or mean lower, low tide).

Sea level rise may impact port operations well before inundating the port. According to the study conducted by Gracia, et al. (2019, page 6), commercial piers need five feet of freeboard to conduct regular loading and unloading. During times when the sea level rises to within five feet of the top of the pier, the cranes may not be able to safely offload cargo.

Our research indicated that a very likely prediction of sea level rise is an overall increase of 3.4 feet by the year 2150. While much more dramatic sea level increase scenarios exist, the 3.4-foot increase is a central estimate if greenhouse gas production continues at the current rate (Miller, et al., 2018). Fortunately, this provides ample time to prepare the Port as operations evolve over the next century.

Early in our analysis we realized the Port can handle a wide tidal range. An increase of three feet over the next 129 years seemed like an insignificant development. However, when following up on the effects of king tides, or the highest predicted annual tides, we realized a cumulative effect with sea level increase may seriously impact port operations. The king tide in January 2021 saw four days just over 13 feet (Tide Predictions). By comparing a 13-foot tide to our LiDAR data we realized that port operations were likely affected.



Tide prediction for king tide, 2021

We used the raster calculator tool in ArcGIS Pro create a new raster dataset of the Port's DTM that was divided into two categories: up to 13 feet and above 13 feet. The reclassify tool allowed us to effectively remove the over-13-feet information and see that significant areas of the port were lower than the sea level during those peak high tides. Using the raster to polygon tool we changed our data to a vector dataset. This allowed us to remove the low-lying areas that were not in contact with the tidal waters since they are less likely to flood. Some areas of the Husky Terminal on the Blair Waterway probably saw flooding during those three days. Other portions of the Husky Terminal were likely to have port operations impacted when the freeboard was less than five feet. Many other areas in the Middle Waterway and Hylebos Waterway saw flooding that would have impacted companies operating there. To rule out the possibility of the DTM missing a sea wall or other barrier to flooding, we repeated these steps substituting the DSM for the DTM. Flooding patterns were similar. For a better understanding of the imagery, we included the DSM in this report. See Figure 1, Port of Tacoma 13 Foot Tide. Flooding areas are denoted in red.

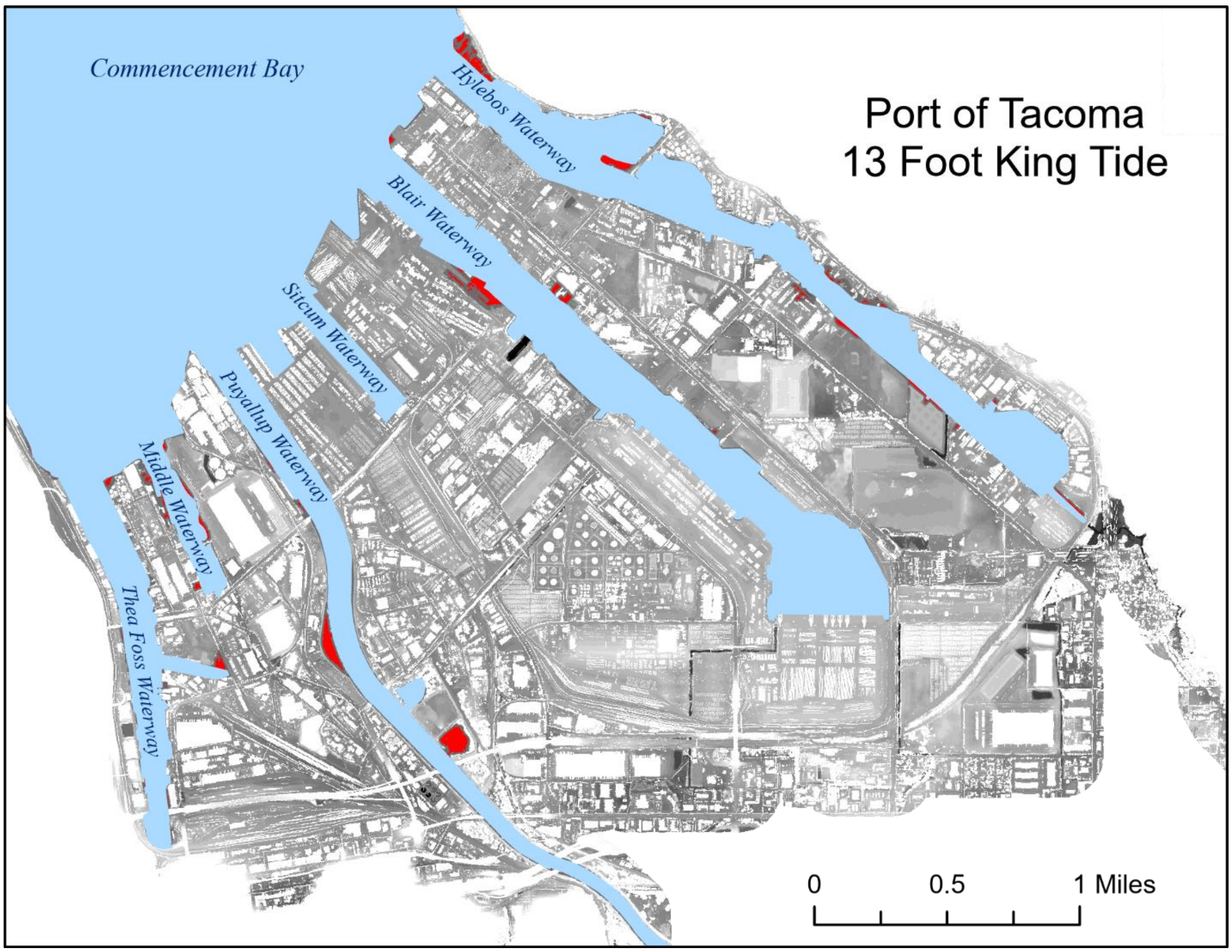


Figure 1, Port of Tacoma 13 Foot Tide

We repeated the previous workflow to see the effects of a 16-foot king tide. This height would denote a 13-foot king tide coupled with three feet of overall sea level rise. Significant portions of all waterways were flooded including most of the major shipping terminals. TOTE, Husky, Olympic Container, and APM Terminals (located in the Blair and Sitcum Waterways) saw severe flooding. Only two major terminals, Washington United and Pierce County (further up the Blair Waterway), avoided flooding. However, these terminals may have suffered work stoppages if their freeboard were too low. See figure 2, Port of Tacoma 16 Foot Tide. Flooding areas are denoted in red.

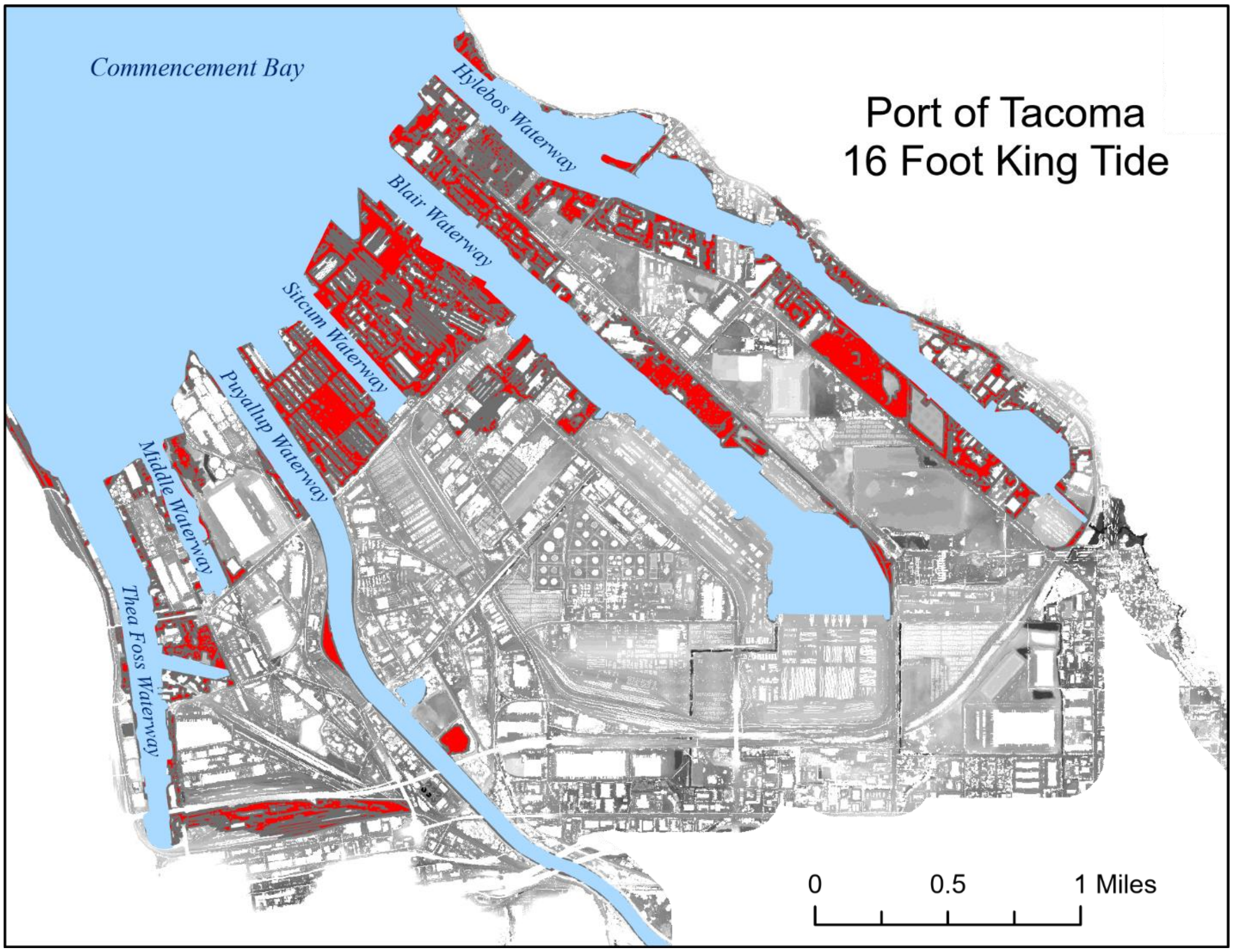


Figure 2, Port of Tacoma 16 Foot Tide

Findings. One item to stress is that the red fields in the visualizations do not indicate imminent calamity. In a worst-case scenario, these areas may flood over several days during a king tide in the year 2150, almost 130 years from now. It's quite possible that the course of normal port operations will build up the infrastructure to accommodate a 3.4-foot sea level rise by then. By knowing this potential now, the Port of Tacoma can take incremental steps to reduce its risk with normally anticipated foundation upgrades.

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