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Technical methods for spatial delineation of Highest Astronomical Tide (HAT) in Willapa Bay, Washington

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Highest Astronomical Tide (HAT) was delineated using a simple "bathtub" approach in ArcGIS software and using the following data inputs:

- 1-meter horizontal resolution digital elevation model (DEM) produced from a LiDAR remote sensor with NAVD88 vertical datum (citation needed);
- Polygon shapefile describing three geographic regions in Willapa Bay to apply information from three respective NOAA tidal gages (The Nature Conservancy 2015);
- HAT and local datum-to-NAVD88 datum conversion values obtained from NOAA's online Tidal Gage information for Toke Point (NOAA 2016);
- HAT and local datum-to-NAVD88 datum conversion values obtained from NOAA's online Tidal Gage information for South Bend (NOAA 2016) ;
- Datum conversion values obtained from NOAA's online Tidal Gage information for Nahcotta (NOAA 2016);
- Difference in feet between Mean Low Low Water (MLLW) and NAVD88 at Nahcotta (Wecker et al., date unspecified).

The "bathtub" approach simply applies a binary reclassification of the DEM such that everything above the HAT value is classified as 1 and everything below it is classified as 0(zero). A second step fills the "sinks" which are defined as 0 value cells that are completely surrounded by 1 values. In other words, these are locations where the elevation is lower than the HAT but are disconnected from the bay water by high ground and thus should not be considered part of the HAT line. A third step converts the filled binary data to vectors (polygons) using geometry simplification to decrease file size and smooth the output lines. A final step is to select and export only polygons categorized as below the HAT which also are greater than 5,000 square meters. This 5,000 sq meters is a somewhat arbitrary division based on the author's interpretation of a histogram of polygon areas and visual spot-checking of the polygons themselves compared to satellite imagery. The output polygons may be converted to a line vector file as needed for display, length calculation, etc.

The advantages of this "bathtub" approach are that the concepts are relatively easy to communicate, the processing relatively quick and doesn't require extraordinary hardware or software, and it has been widely applied to various purposes including shoreline and tidal processes.

The downsides of the "bathtub" approach are that it does not take into account hydrological or geomorphological dynamics and it applies a single value based on a single tidal gage to a broad region. The regions likely contain physical variability within them, but this approach does not address that variability or assess accuracy away from that single tidal gage location.

The particular difficulty in producing a spatially explicit HAT line in Willapa Bay is the lack of data points describing HAT and datum conversions. Currently, only two tidal gages (Toke Point and South Bend)

provide a HAT value and a conversion between local datum and NAVD88 (used by the DEM). For those two locations, simple conversion was made to provide the HAT in NAVD88, where (STND HAT) – (NAVD88 above STND) = (HAT in NAVD88).

- Toke Pt: 15.96 ft is the STND HAT; 5.34 ft is the NAVD88 above STND; therefore NAVD88 HAT is 10.62 ft.
- South Bend: 16.80 ft is the STND HAT; 5.97 ft is the NAVD88 above STND; therefore NAVD88 HAT is 10.83 ft.

The third gage with a HAT value, Nahcotta, does not provide a NAVD88 above STND. However, a white paper by Wecker et al. (date not specified), provides a conversion between MLLW and NAVD88 for Nahcotta. The NOAA tidal gage at Nahcotta does provide a conversion where MLLW is 0.73 ft above STND. With this information, the conversion here was (STND HAT) – (MLLW) – (NAVD88 above MLLW).

- Nahcotta: 13.49 ft is the STND HAT; 0.73 is the MLLW above STND HAT; 1.44 ft is the NAVD88 above MLLW; therefore NAVD88 HAT is 11.32 ft.

Disclaimer: *To date, The Nature Conservancy has not made further attempts to confirm or search for further information about the converted datum values or final HAT values. One concern is that the STND HAT in Nahcotta is much lower than the STND HAT for both Toke Point and South Bend, yet the converted values to NAVD88 at Nahcotta are higher than both the converted values at the other two locations. This does not mean it is not accurate; however, it does warrant further investigation by Pacific County or its partners. The Nature Conservancy does not claim that any values are absolutely correct and does not take responsibility for any use of these data by Pacific County or anyone else.*

Sources

NOAA. 2016. Datums – Station Selection. Viewed online on 2/24/2016 at http://tidesandcurrents.noaa.gov/stations.html?type=Datums.

The Nature Conservancy. 2015. HAT Regions in Willapa Bay. Digital spatial data, unpublished.

Wecker, M., K. Bennett, and T. Alcock. Date not specified. *Mapping Predicted Tidal Exposure Durations Using a LiDAR-Based MLLW Referenced Terrain Model for Treatment and Control of Invasive Spartina alterniflora in Willapa Bay, Washington.* University of Washington Olympic Natural Resources Center. Viewed on 2/24/2016 at http://www.onrc.washington.edu/mdai/Data/docs/MappingPredictedTidalExposureDurationDraft1.pdf.