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Comments on the 2017 Rising Seas in California: An Update on Sea-Level Rise Science and the upcoming update to California's Sea-Level Rise Guidance document

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To: Ocean Protection Council, State of California

Re: Comments on the 2017 *Rising Seas in California: An Update on Sea-Level Rise Science* and the upcoming update to *California's Sea-Level Rise Guidance* document

The Ocean Protection Council (OPC) Science Advisory Team (SAT) has just released its *Rising Seas in California: An Update on Sea-Level Rise Science* report (Griggs et al., 2017). The OPC and California Natural Resources Agency (CNRA) are now seeking comments to update *California's Sea-Level Rise Guidance* document (2010 and 2013).

The *Rising Seas in California: An Update on Sea-Level Rise Science* report (update report) provides a much needed and timely update regarding the state of the science on sea-level rise projections along the California coast, particularly with our current scientific understanding of potential Greenland and Antarctic ice sheet loss. Unfortunately, the update report falls short in providing the best and most up to date sea-level rise science to the largest California coastal population north of the San Francisco Bay Area.

The Humboldt Bay-Eel River Delta region of Humboldt County has the highest concentration of people, development, and coastal agriculture on the North Coast of California. Humboldt Bay is the second largest estuary and bay in California. The Bay is surrounded by 102 miles of shoreline and several critical regional assets (port/harbor and coastal dependent infrastructure, U.S. Highway 101, Humboldt Bay Power Plant and nuclear storage facility, and two municipal wastewater treatment plants) that are exposed to sea-level rise.

There are two tide gauges operated by NOAA located north of Cape Mendocino: one at North Spit on Humboldt Bay and another near Crescent City in Del Norte County. The update report utilized data from the Crescent City tide gauge, which has recorded the least sea-level change in California rather than the North Spit tide gauge on Humboldt Bay, which has recorded the highest sea-level rise rate in California (Russell and Griggs, 2012; NHE, 2015; Patton et al., 2017).

The update report attempts to provide a synthesis of the state of the science of sea-level rise. Yet, references for two critical scientific sea-level rise studies of the North Coast are notably missing: Cascadia Geoscience's *Tectonic Land Level Changes and their contribution to sea-level rise, Humboldt Bay region, Northern California* (Patton et al., 2017), and Northern Hydrology and Engineering's *Humboldt Bay: Sea Level Rise, Hydrodynamic Modeling, and Inundation Vulnerability Mapping* (NHE, 2015). The Patton et al. vertical land motion and sea-level rise work produced working updates in 2013, 2014, 2015, and 2016.

Land subsidence (or downward vertical land motion) in the Humboldt Bay region contributes to relative sea-level rise at rates that are two to three times greater than anywhere else in California. In fact, sea-level change at the Humboldt Bay North Spit tide gauge is much greater than any other tide gauge in the Pacific Northwest (Patton et al., 2017). The Crescent City tide gauge does not accurately represent the level of exposure to most of the people and developments north of Cape Mendocino. However, data from the North Spit tide gauge, and more importantly the local scientific and engineering work of Patton et al. (2017) and NHE (2015) does. Methods used by Patton et al. (2017) and NHE (2015) are based upon methods published in peer review journals (e.g. Mitchell et al., 1994; Burgette et al., 2009).

To demonstrate this, the median (50% probability) projected sea-level rise rates for Crescent City, San Francisco and San Diego from Table 1 of the Griggs et al. (2017) update report are compared to estimated sea-level rates for Trinidad, Mad River Slough, North Spit, and Hookton Slough in the table below. Trinidad is located just north of Humboldt Bay, and Mad River Slough, North Spit and Hookton Slough are located on Humboldt Bay. The estimated sea-level rise rates for these four Humboldt Bay region locations were determined using the Crescent City rates from Table 1 of the update report and the vertical land motion estimates from Patton et al. (2017), using the same approach for adjusting sea-level rise projections outlined in NHE (2015). Results clearly demonstrate that the estimated relative sea-level rise projections for the Humboldt Bay region will exceed the California projections provided in the update report for the same time periods. Especially compared to the projections for Crescent City, which is the nearest location to the Humboldt Bay region, and as discussed earlier the only tide gauge north of Cape Mendocino included in the Griggs et al. (2017) update report.

Table summarizing sea-level rise projections for California and the Humboldt Bay region. Projections for Crescent City, San Francisco and San Diego (highlighted in green) are from Table 1 in Griggs et al. (2017). Estimated projections for Trinidad, Mad River Slough, North Spit and Hookton Slough (highlighted in blue) based on vertical land motion estimates from Patton et al. (2017), and the approach outlined in NHE (2015).

Year / Percentile	Median (50% probability) sea-level rise projections (feet above 1991-2009 mean)						
	Crescent City	San Francisco	San Diego	Trinidad	Mad River Slough	North Spit	Hookton Slough
2030	0.1	0.4	0.5	0.5	0.5	0.6	0.8
2050	0.4	0.9	0.9	1.1	1.1	1.3	1.5
2100 (RCP 2.6)	0.7	1.6	1.7	2.1	2.1	2.5	2.9
2100 (RCP 4.5)	1.0	1.9	2.0	2.4	2.4	2.8	3.2
2100 (RCP 8.5)	1.5	2.5	2.6	2.9	2.9	3.3	3.7
2100 (RCP H++)	9.3	10	10	11	11	11	12
2150 (RCP 2.6)	1.0	2.4	2.5	3.0	3.1	3.7	4.4
2150 (RCP 4.5)	1.6	3.0	3.1	3.6	3.7	4.3	5.0
2150 (RCP 8.5)	2.6	4.1	4.3	4.6	4.7	5.3	6.0
2150 (RCP H++)	21	22	22	23	23	24	24

It should be noted that the issues associated with the high rate of land subsidence and the resulting high rates of relative sea-level rise at the North Spit tide gauge is not unique to the NHE (2015) or Patton et al. (2017) work. These elevated rates have been documented in other sea-level rise work, such as NOAA (2013). Furthermore, the OPC-SAT should have been aware of this situation based on Griggs' earlier work which stated (pg. 8, Russell and Griggs, 2012):

“The State’s two northernmost stations record the complex land motion along the northern California coast, just offshore of Cape Mendocino, where three large tectonic plates come together. At Humboldt Bay’s North Spit, sea level is rising by 18.6 inches per century (4.73

millimeters per year), the highest rate in California. Just 80 miles north at Crescent City, sea level is dropping relative to the coastline by 2.5 inches per century (0.65 millimeters per year). The shoreline at Humboldt Bay is subsiding, whereas Crescent City's coastline is rising"

Likewise, both the high rates of land subsidence and relative sea-level rise unique to the Humboldt Bay region of California were noted in the recent 2015 California Coastal Commission Sea Level Rise Policy Guidance document (pg. 17):

"Humboldt Bay has not experienced the regional uplift that characterizes most of the coast north of Cape Mendocino, and instead has shown the highest subsidence recorded for the California coast. As a result, the projections for north of Cape Mendocino may not be appropriate for use in or near Humboldt Bay and the Eel River Estuary. Please see Humboldt Bay: Sea Level Rise Hydrodynamic Modeling, and Inundation Vulnerability Mapping (Northern Hydrology and Engineering 2015) for additional information on sea level rise projections for the Humboldt Bay region"

There has been much effort over the past few years by the local scientific, planning and engineering community to educate the public regarding the unique tectonic and relative sea-level rise issues specific to the Humboldt Bay region. These efforts have been supported through federal, state and local funds, along with a large proportion of professional pro-bono work. Given the current politics regarding climate change and sea-level rise science, it seems that any state funded sea-level rise science document should use the best available science for all regions of California. Particularly any locally generated science that describes and/or explains unique regional issues that affect relative sea-level rise rates, such as the tectonic land level changes of the Humboldt Bay region.

To put this into perspective, we feel that the high rates of tectonic land level change unique to the Humboldt Bay region is as critical to understanding relative sea-level rise rates in this area, especially up to the year 2100, as the polar ice sheet losses are to long-term global sea-level rise.

The update of *California's Sea-Level Rise Guidance* document must use the best available science to inform local and state decision makers of their exposure to sea-level rise, particularly north of Cape Mendocino in the Humboldt Bay region.

Please contact us if there are any questions or if we can help provide further guidance about incorporating these significant findings into the *OPC California's Sea-Level Rise Guidance* document. In the references, we provide urls for the two gray literature reports documenting the analyses we have conducted for the Humboldt Bay region.

Sincerely,

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References:

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