Factors of uncertainty in simulating the response of estuarine habitat for juvenile Chinook salmon to a large-magnitude subduction earthquake

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The Columbia River estuary has historically provided important nursery habitats, food resources, and transition zones for salmonids. However, the structural and functional attributes of the estuary have been substantially altered by human activity and environmental variability, to the point that multiple salmon stocks are now listed as either endangered or threatened under the Endangered Species Act. As expensive recovery efforts are being conducted, the possible implications on those efforts of a large Cascadia Subduction Zone (CSZ) earthquake are pertinent but poorly understood.

While infrequent (the last major event occurred circa 1700), CSZ earthquakes can reach magnitudes of 8.8 to 9.2, likely leading to extensive subduction across the lower estuary. To characterize the associated salmon habitat changes, we conduct simulations of river-to-ocean circulation and sediment dynamics, using an unstructured-grid model (SELFE). Year-round estuarine salmon habitat is compared between contemporary bathymetry conditions and conditions resulting from multiple scenarios of CSZ deformation, as developed by the Oregon Department of Geology and Mineral Industries and collaborators.

For each bathymetric scenario, variables of interest for assessing salmon habitat—water depth, 3D fields of velocity, salinity, and temperature—are extracted from the simulation. These variables are then filtered through criteria informed by fisheries research, which are sensitive to life stage and distinguish between nursery and migratory habitat for juvenile salmon.

Early simulations suggest the potential for major disruption in estuarine circulation in case of a large CSZ earthquake, with significant associated implications for salmon habitat. However, the simulations have multiple factors of uncertainty, ranging from the definition of forcing and habitat criteria, to intrinsic model error and to the nature of sedimentary adjustments post-event. Here, we seek to identify main factors of uncertainty, and to characterize their implications on the robustness of the predictions of change for salmon habitat.