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Residual Circulation in Fjordal Sub-basins of Puget Sound – Simulation and Validation Using Historical Records

Tarang Khangaonkar[1] and Zhaoqing Yang

Integrated Coastal Ocean Modeling
Marine Sciences Division
Pacific Northwest National Laboratory, 1100 Dexter Avenue North, Suite 400, Seattle, WA 98109, USA

Puget Sound is generally recognized as a glacially carved estuary, with diverse hydrodynamic response to tides and freshwater inflow in its various sub-basins. The circulation pattern ranges from the commonly observed characteristics of partially mixed estuary to that unique to classic fjords supporting a shallow brackish outflow and compensating inflow immediately below. Complex interactions between multiple connected basins, presence of numerous islands, partitions induced by bathymetric and geometric features, and site specific strong advective vertical mixing created by shallow sills are generally understood as the causes for these variations. A circulation and transport model of Puget Sound (PS-CTM) has been developed using an unstructured grid sigma-stretched coordinate system to account for the above complexities, to assist regulatory agencies develop long term water quality management and restoration action plans. While the numerical model has been calibrated using available recent short term oceanographic time series data sets from different parts of the Puget Sound basin, this paper presents an attempt to test its capability of reproducing long term tidally averaged circulation patterns and to reconfirm our qualitative understanding of the characteristic oceanographic behavior of Puget Sound. Results are validated against (i) an analytical solution of narrow deep estuaries developed for the Puget Sound basin, and (ii) a well established set of previously analyzed historical records, mostly from the 1970s. Supported by the analytical formulation and measured data, the model results demonstrate that vertical current structure and therefore flushing in Puget Sound is primarily controlled by bathymetric features and shoreline geometry and influenced by longitudinal salinity gradients maintained by the inflows. The resulting vertical current profile also determines the level stratification, mixing, and the depth of the surface layer responsible for most of the out flow from Puget Sound.

Keywords: modeling, fjords, partially mixed estuaries, analytical solution, 3-D hydrodynamic model, unstructured grid, Puget Sound

* Corresponding author: Tel: + 1-206-528-3053; Fax: + 1-206-528-3556; E-mail: tarang,khangaonkar@pnl.gov