Seasonal Variations in Flushing Time for Quartermaster Harbor, an Enclosed Puget Sound Estuary

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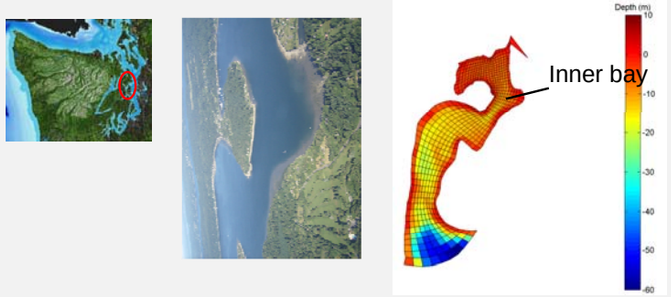
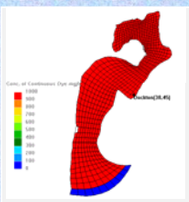


Fig. 1 – Location, grid cell structure, and depths of QMH model.

Abstract

A (computer) model of Quartermaster Harbor (Vashon, WA) a marginal bay in Puget Sound has been developed as part of the Quartermaster Harbor Nitrogen Management Study, funded in part by a West Coast Estuaries Initiative grant from Region 10 of US EPA. The model consists of a structured grid with nearly 10,000 curvilinear cells (~100-meter horizontal dimensions), composed of 37 vertical depth layers with vertical bin sizes ranging from 1 meter throughout the euphotic zone, to 5 meter thicknesses at its deepest extent (60m). It is based on the Generalized Environmental Modeling System for Surface waters (GEMSS) three-dimensional hydrodynamic model, and is driven with data from monthly CTD cruises collected by UW-Tacoma and King County Dept. of Natural Resources (KCDNR), as well as results from a surface/bottom mooring positioned near the mouth of the bay and operated by KCDNR. The calibrated model is used to show seasonal and spatial variations in flushing time. Unlike most estuaries in Puget Sound, that have longest flushing times in late summer and quickest flushing times in November, the late-spring (snowmelt-driven) freshet from the Puyallup River can dramatically increase flushing times inside Quartermaster Harbor, when and if the Puyallup River plume is present at its mouth.



Equation 1:

$$D(I,J,t)=D_o\, e^{-t/\tau(I,J)}$$

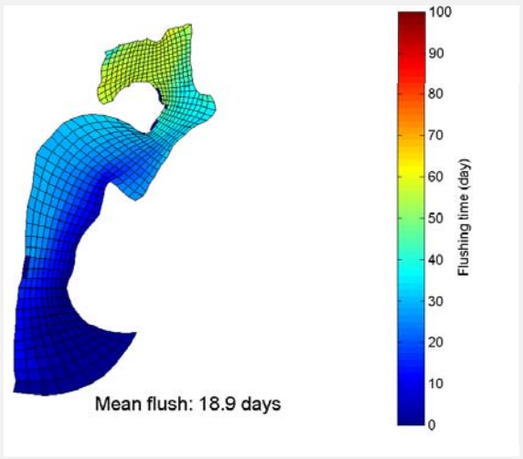


Fig. 2. a) Initial dye concentration (in red) showing open seaward boundary (in blue) and b) a conversion to flushing time.

We made 14-day runs of the Quartermaster (QMH) model (Fig. 1) for each week of 2009 (a full neap/spring cycle) after spinning-up the model and initializing the entire grid with dye tracer (Fig. 2). The final dye pattern was converted to flushing time by inverting equation 1. Figure 3 shows the results for October where we see the longest flushing times (red color, higher numbers) in the inner bay and the quicker flushing times toward the mouth of the bay. The mean flushing time for the bay as a whole is 23.6 days. Figure 4a shows model-produced flushing times for the entire year under two different estimations of stratification, to which it is quite sensitive.

- Fill bay up with dye, using model
- See how it flushes out
- Convert final dye levels to flush time for each grid cell

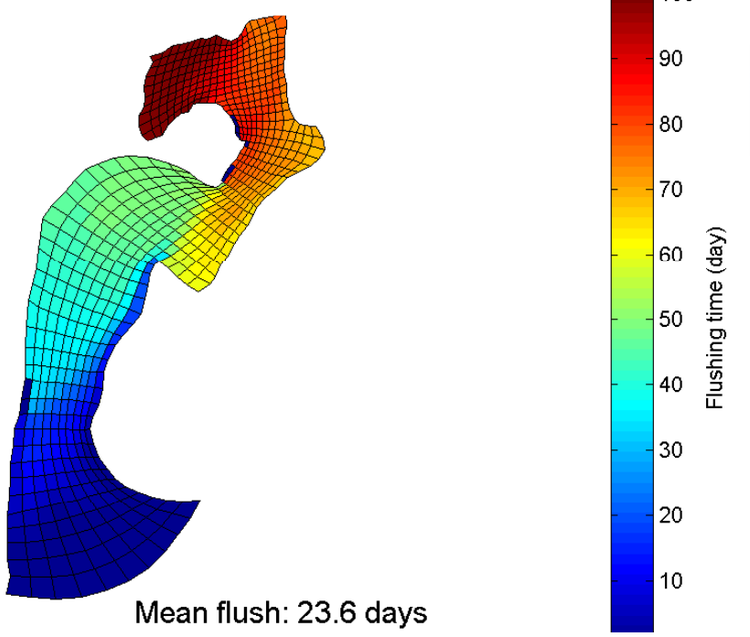


Fig. 3. Flushing time to a 90% reduction level (10% remaining) of initial dye levels for October 2009.

The model relies on a mooring placed at the mouth of the bay by King County Dept. of Natural Resources (Fig. 5b upper margin) recording surface conditions at 15-minute intervals to duplicate the timing of the river's presence. These data were merged with monthly profile data from cruises made by UW-Tacoma to obtain estimates of density-structure below the pycnocline (Fig. 4b).

- Typical PNW estuary has slowest flush time in Sep/Oct and quickest in Nov/Dec
- Flushing time of QMH also slow in late spring, which is atypical
- Slow flush of QMH coincident with Puyallup plume
- Slow flush can exacerbate water quality problems (e.g., low oxygen)

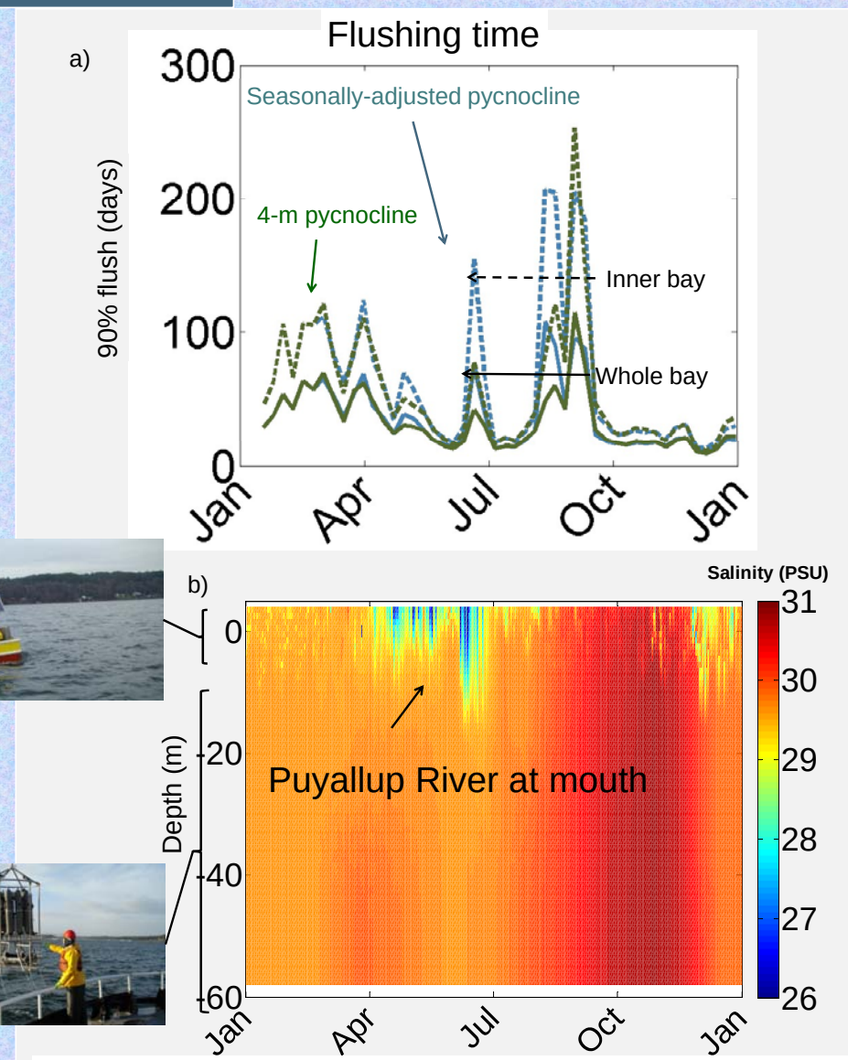


Fig. 4. a) model-derived flushing times for a **4-m pycnocline (green)** and **seasonally-adjusted pycnocline (blue)** for the whole bay (solid) and inner bay (dashed) regions, and b) Puyallup River affecting salinity.

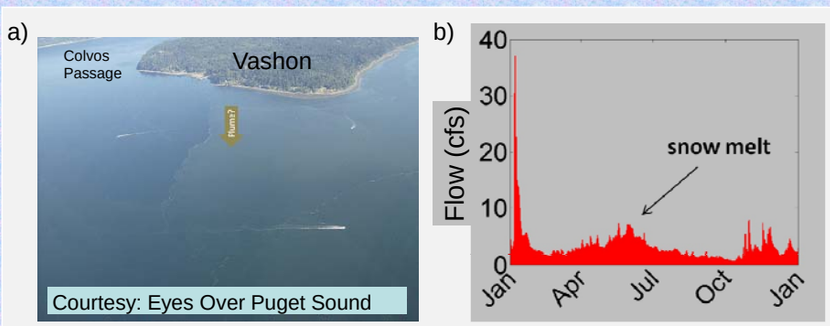


Fig. 5. Puyallup River a) plume, and b) USGS flow (station 12101500).

See other QMH ***Salish Sea 2011 presentations*** by -- DeGasperi, Greengrove, Huber, and Masura
http://www.kingcounty.gov/environment/watersheds/central-puget-sound/vashon-maury-island/quartermaster-nitrogen-study/QMH-documents.aspx

This presentation is also available from Ecology as Publication 11-03-062 -- www.ecy.wa.gov/biblio/1103062.html (November 2011).