Modeling water exchange and transport timescales in a multi-inlet bay system of Puget Sound, Washington

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Background & Motivation

- **PNNL’s Puget Sound circulation model**
  - Based on open source, unstructured grid, finite-volume coastal ocean model (FVCOM, Chen et al. 2003)
  - Flexible grid configuration especially suitable for complex geometry
  - Mass conservative and robust wetting & drying schemes

- **Study site - the West Sound**
  - Unique multi-inlet bay system – potentially with restricted flushing
  - Water quality issues (low DO, bacteria etc.)
  - Potential tidal energy site
  - EPA and ECY’s previous ENVVEST modeling study using HSPF and CH-3D for Sinclair and Dyes Inlets

- **Objective**
  - Develop an integrated watershed-estuary modeling framework utilizing PNNL’s PS model
  - Quantify the transport timescales of the system
Methodology

  - Open boundaries: X Tide predictions, monthly ECY salinity data
  - River input: HSPF model prediction for watershed surrounding the study area, and daily flows from 19 major rivers of Puget Sound.
  - Wind forcing: hourly, interpolated from NARR 3-hr data.

- Residence time (RT) calculation
  - Tracer method – remnant function (Takeoka, 1984)
  - Lagrangian particle tracking method

Tracer/particles released at both ebbing and flooding tide
Tidal Simulation

Poulso

Brownsville

Tracyton

Port Madison

Brownsville

Tracyton

Clam Bay

Bremerton

Proudly Operated by Battelle Since 1945
Tidal amplitude and phase

Changes of tidal amplitude and phase
- M2: ~20 cm for amplitude, and 1-2 hours for phase lag
- K1: ~5 cm for amplitude, and 1-2 hours for phase lag
Ebb Release

Flood Release
Residence Time (tracer method)

- Depth-averaged RT varies from near 0 to ~32 days.
- System-wide averaged RT is about 18 days, which could be shorter if freshwater discharge from the watershed is included.
Residence Time (particle tracking method)

- Surface RT varies from near 0 to >24 days, and expect to increase with time.
- Will need a number of ensemble runs to reach the final results.
Summary & Future Work

- A 3-D hydrodynamic model was developed for the West Sound.
- Tides vary substantially in the system due to complex geometry.
- Preliminary results suggest the residence time in the system varies from 0 to ~32 days.

Future work

- To include watershed model (HSPF) predicted river discharge into the hydrodynamic model and improve model results
- To connect physical transport with water quality issues in the system
Thank you!

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