Lagrangian analysis of seasonal and interannual trends in estuarine flow composition and path between Juan de Fuca Strait and Strait of Georgia and Puget Sound

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Lagrangian analysis of seasonal and interannual trends in estuarine flow composition and path between Juan de Fuca Strait and Strait of Georgia and Puget Sound

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Acknowledgements
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WHY?
Little is known about the contribution of the Pacific currents to the water entering the Salish Sea through Juan De Fuca Strait (JdF) both annually and interannually, particularly in the winter. This has a significant impact on the accuracy of biogeochemical models of the region.

HOW?
Apply Lagrangian particle tracking to find the trajectories of water entering the Sea and their physical/chemical characteristics to discern their source.

Results
The amount of water entering the Salish Sea through the JdF differs significantly seasonally (figure 4) due to the variability in the strength of the estuarine regime (due to variable shelf salinity and river discharge), but the ordering of ‘importance’ of the different paths does not change.

Methods
The Model – SalishSeaCast
3D circulation model with coupled biological and carbonate chemistry models, created and maintained by the UBC Mesoscale Ocean and Atmospheric Dynamics (MOAD) Laboratory [6]. The horizontal resolution is 500 m and the vertical resolution is split into 40 cells between 1 m (closer to the surface) and 27 m (at depth).

The Analysis – Lagrangian Tracking
Lagrangian ocean analysis tracks the movement of free moving entities to estimate pathways. Virtually, this method tracks simulated particles (or in this analysis, virtual water parcels) to see their path and how their physical characteristics change along this path based on the velocity and tracer fields of an ocean model [7]. This is more involved than other common oceanographic analysis techniques (ex. Eulerian) but can result in a much more realistic prediction [7].

Ariane
Based on the volume conservation equation, the model calculates 3D-streamlines to predict water parcel trajectories forward and backwards in time [8].

• Well established (25 years of use)
• Quantitative mode: distribution function and volume transport past cross-sections
• Qualitative mode: detailed particle trajectories

Conclusions
Significant seasonal variability in flow rates, path, and composition
Summer conditions are similar interannually while winter conditions vary noticeably year-to-year
Water reaching the SoG and Puget sound from JdF varies between tracer rich in the summer to tracer poor in the winter

Next Steps
Similar analysis with another 3D circulation model (CIOPS BC12) that covers the Salish Sea (at a lower resolution) but goes off shore. These results alongside the SalishSeaCast results will allow us to produce an estimate of the contribution of different Pacific water masses by following this process:
1. CIOPS BC12 qualitative run for open ocean boundary selection
2. CIOPS BC12 within Salish Sea and comparison to SalishSeaCast
3. CIOPS BC12 yearlong (2017) shelf quantitative runs
4. Origin of flow into JdF based on the location of the centers of flow, and the salinity and temperature from step (3)

References
5. Figure 1: General circulation pattern of the Salish Sea [1] (adapted from R. Pawlowicz). High-salinity water from the Pacific flows into the JdF and a mixture of this water and fresh water flows out at the surface.
6. Figure 2: SalishSeaCast model domain, with bathymetry [6].
7. Figure 3: Water (SalishSeaCast) versus observations of salinity (top) and temperature (bottom) at a 125 m deep mooring at the mouth of the JdF. The model is largely fresher and slightly colder.
8. Figure 4: JdF cross-section of the flux of parcels that reach the SoG or Puget Sound in a typical winter month (left) and a typical summer month (right).
9. Figure 5: General circulation pattern of the Salish Sea [2] (adapted from R. Pawlowicz). High-salinity water from the Pacific flows into the JdF and a mixture of this water and fresh water flows out at the surface.
10. Figure 6: Plumes from Figure 5 illustrate the difference between the flux of higher salinity, colder, inorganic carbon, nitrate, dissolved silica (blue) and the ambient tracer concentration in the region (red meaning the influx is a higher concentration than the transect, and blue meaning a lower concentration).
11. Figure 7: Composition hydrographs of parcels that make it to the SoG or Puget Sound from JdF in the winter (left) and summer (far right).