

Modeling the Effect of Tidal Flats on Estuarine Circulation & Stratification

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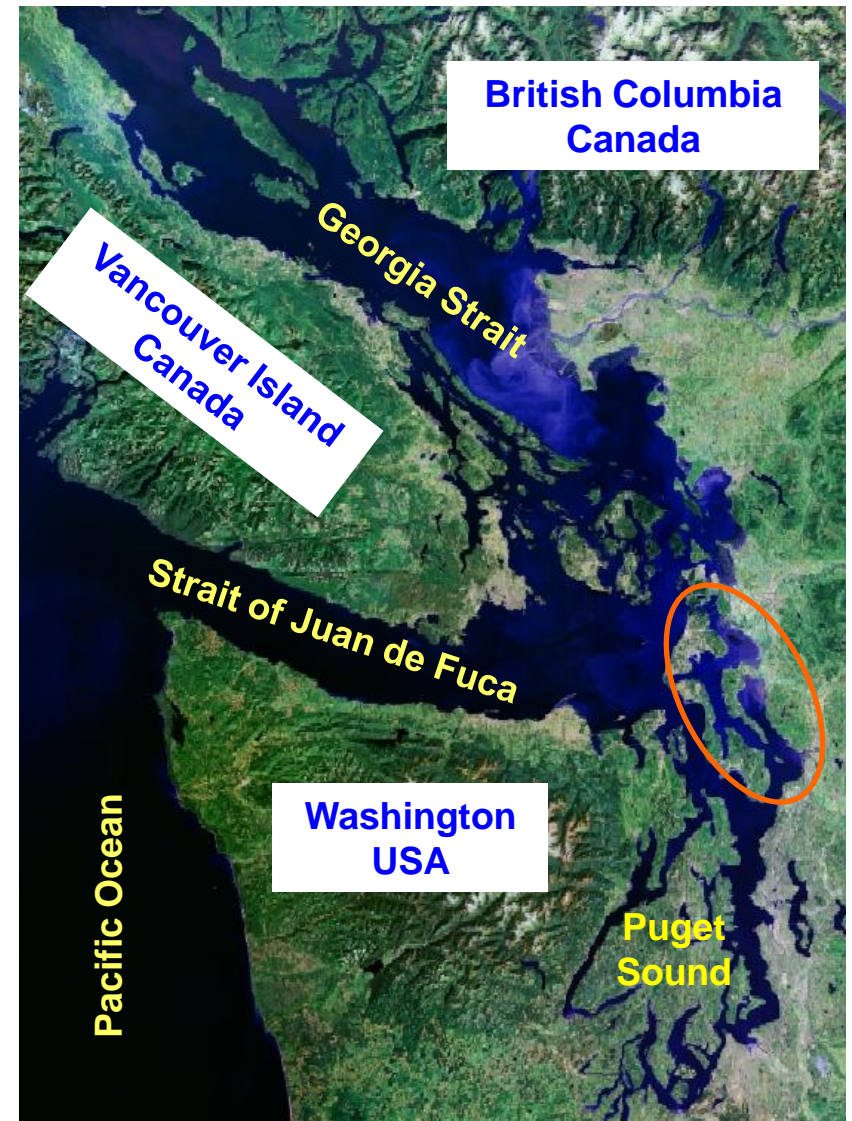


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Whidbey Basin of Puget Sound, USA

- ▶ Puget Sound - Washington State, USA
- ▶ One of the most prestigious ecosystems in Pacific NW
- ▶ 70% runoff into Puget Sound
 - Skagit River
 - Snohomish River
 - Stillaguamish River
- ▶ High sediment load
- ▶ Large tidal flats
- ▶ Multiple distributary channels



Motivation



- ▶ Nearshore habitat restoration
 - Dike breach and removal
 - Tidal wetland habitat
 - Downstream salmon migration
- ▶ A predictive modeling tool
 - Understand physical processes
 - Assist nearshore restoration



Hydrodynamic Model

- ▶ 3D Finite Volume Coast Ocean Model (FVCOM)
- ▶ Unstructured grid – best suited for complex geometry
- ▶ Wetting and drying simulation
- ▶ Baroclinic simulation
- ▶ Water quality
- ▶ Sediment transport
- ▶ Public domain
- ▶ Parallel computation



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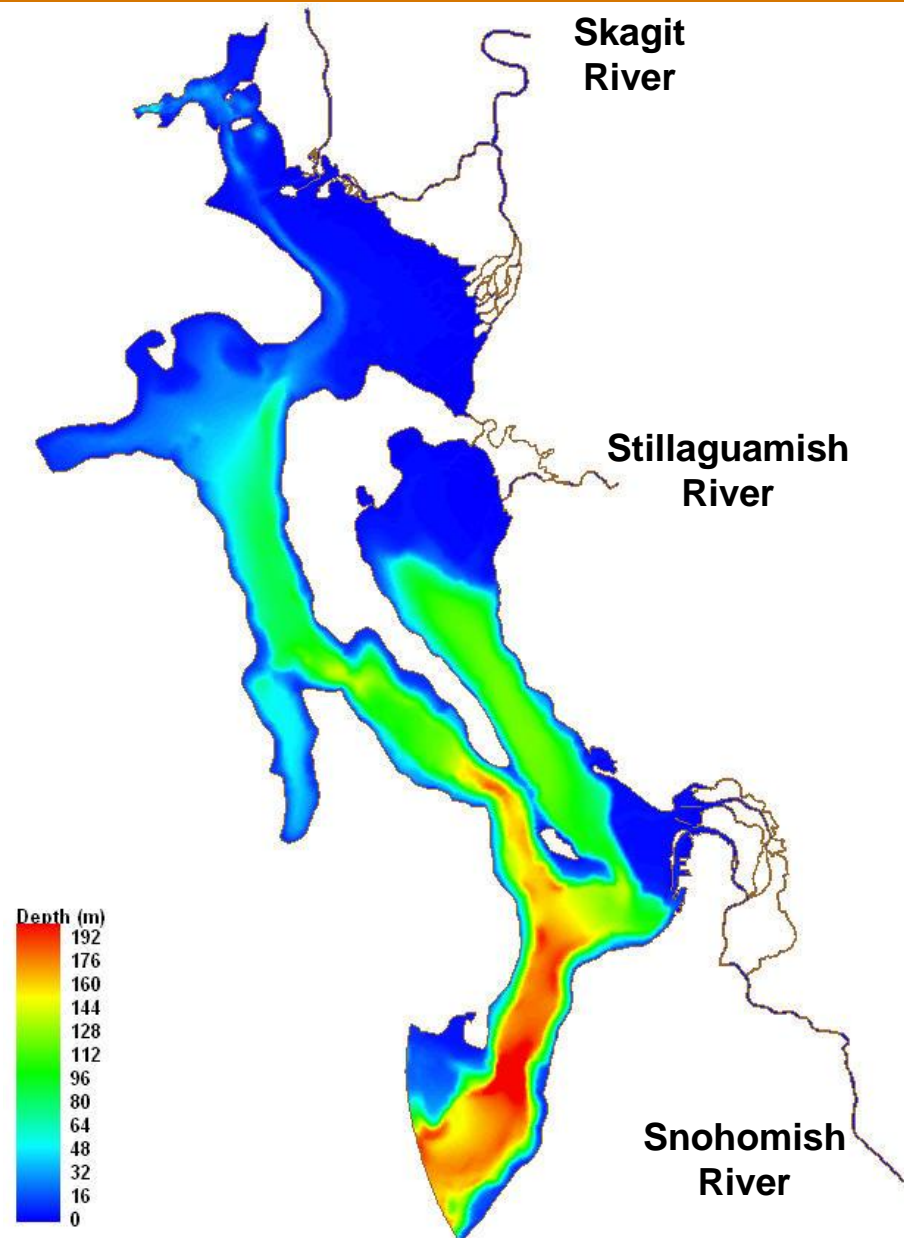
Model Grid and Bathymetry

▶ Model Grid

- Node=25,478
- Element=45,215
- Layer=25
- Cell size: 10m – 250m

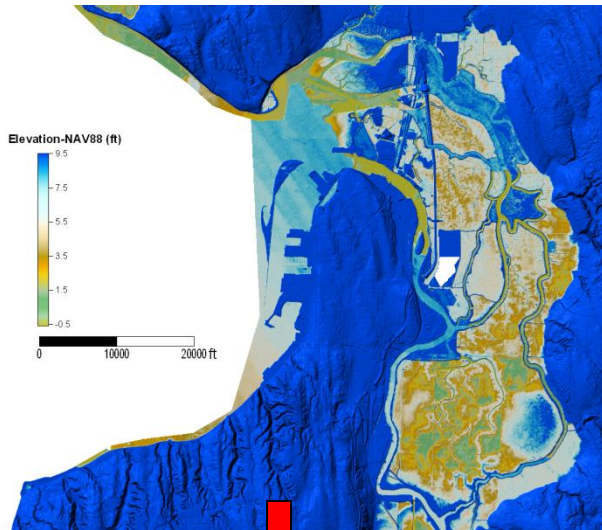
▶ Model Configuration

- Tide and salinity open boundary conditions
- Wind and river inflows
- Wetting-drying simulation
- Baroclinic mode

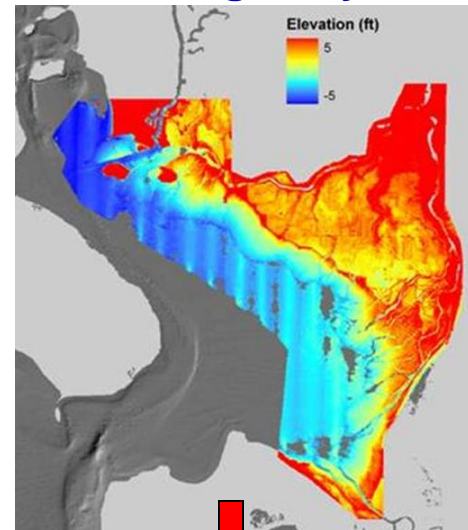


LiDAR Data in Nearshore Tide Flat Regions

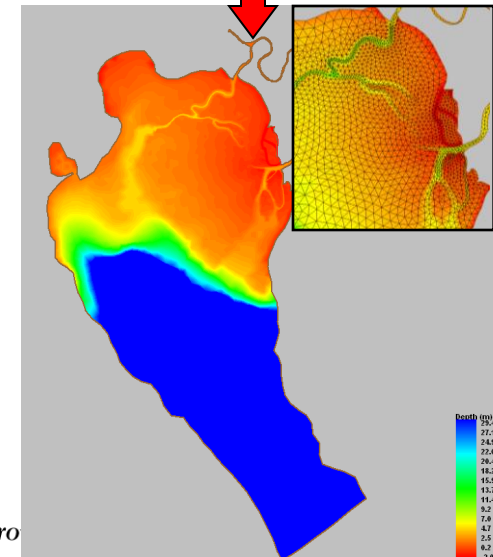
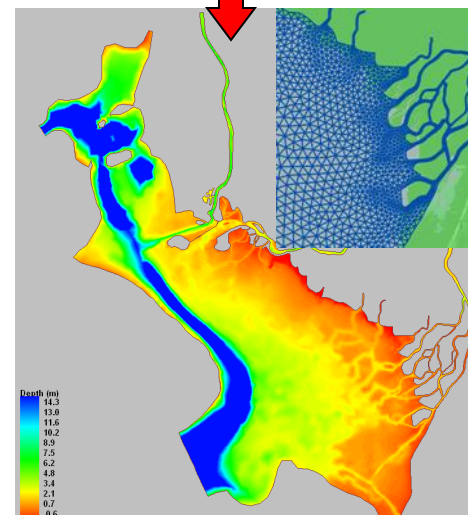
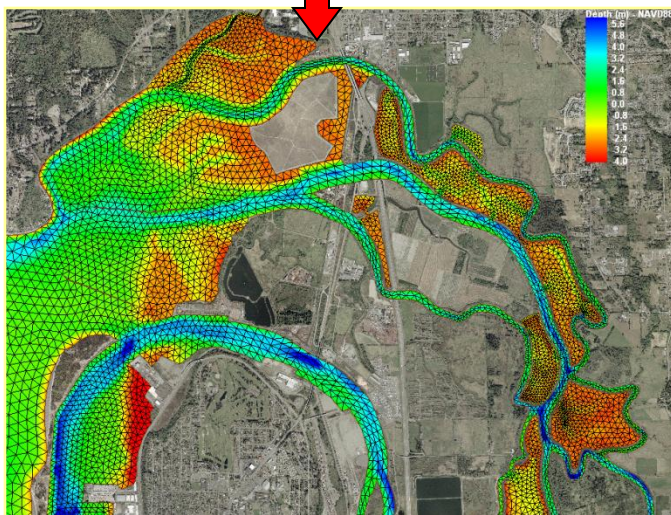
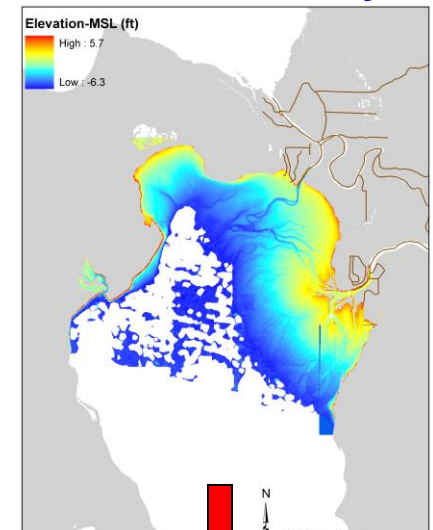
Snohomish River



Skagit Bay

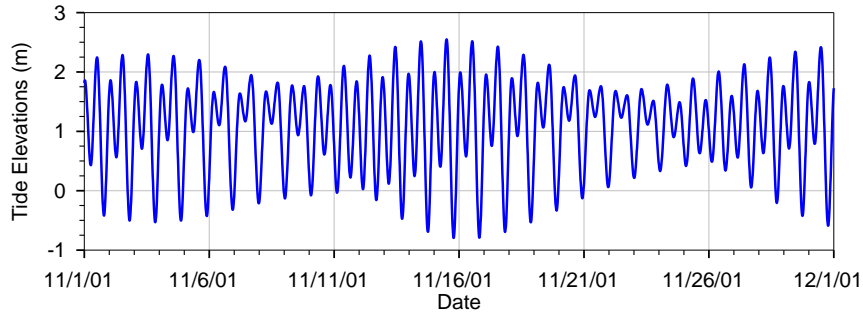


Port Susan Bay

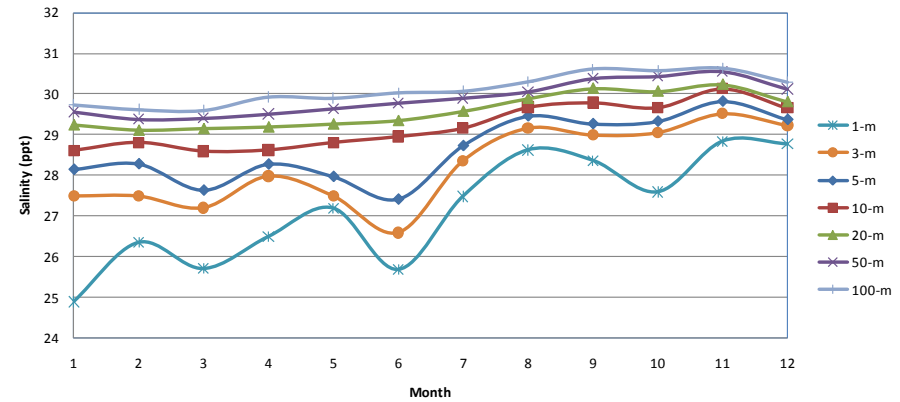


Model Forcing

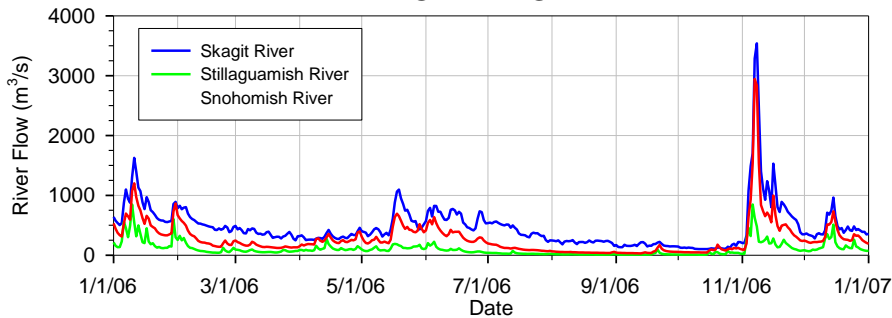
Tide



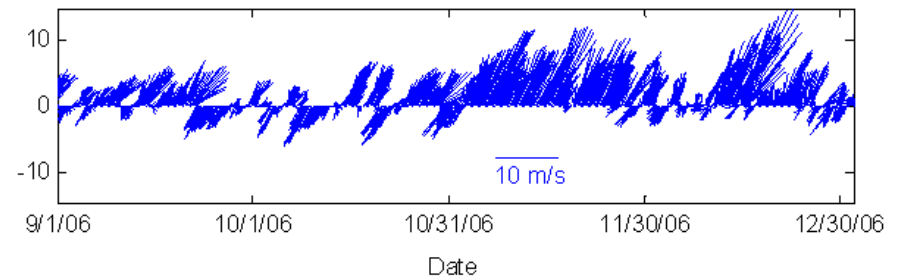
Salinity Profile



River Inflow



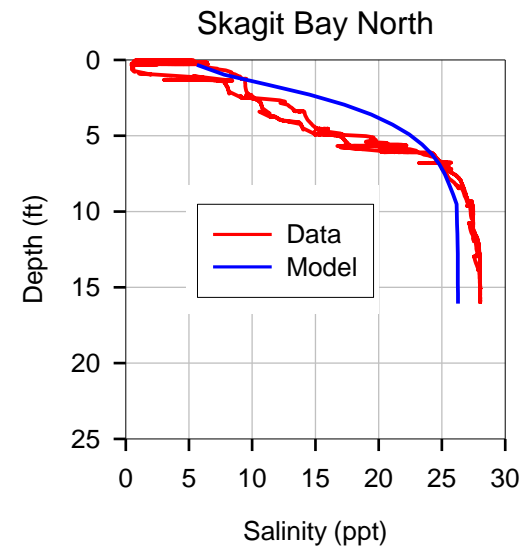
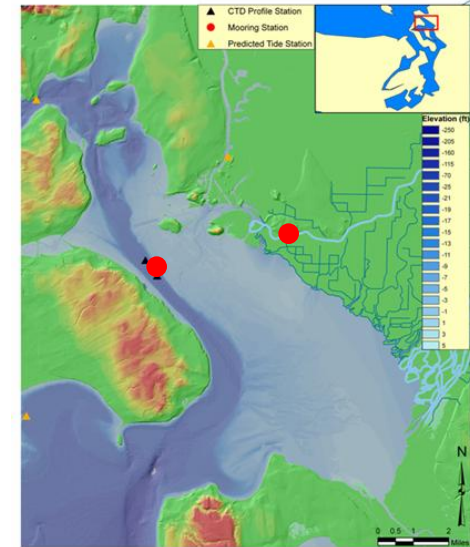
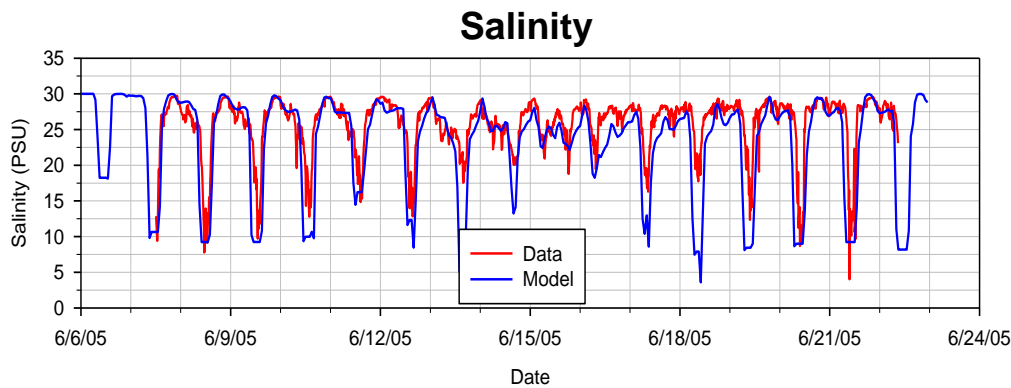
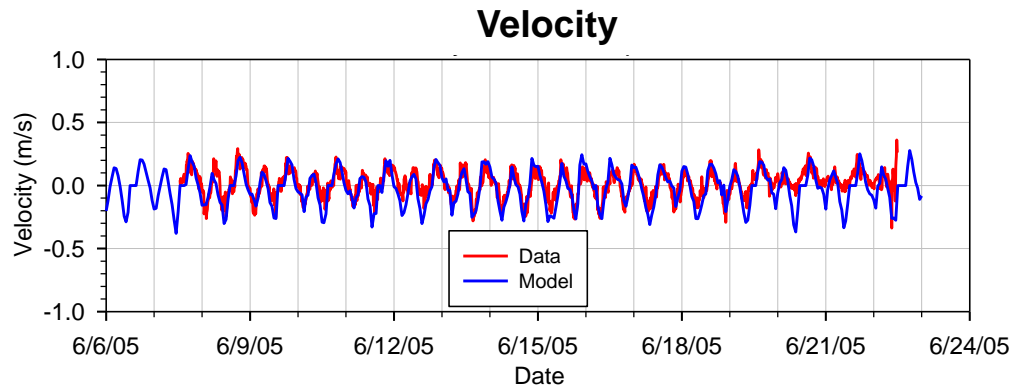
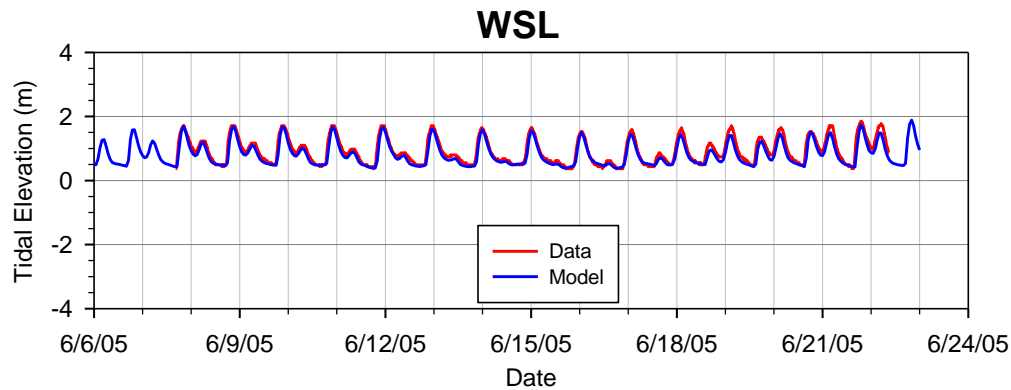
Wind



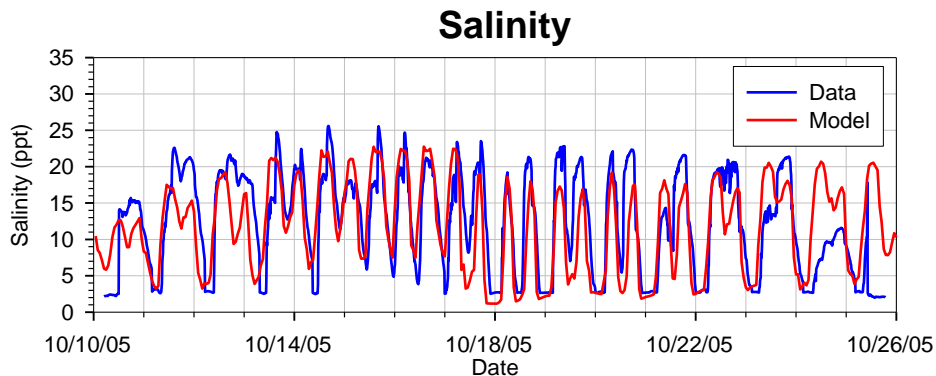
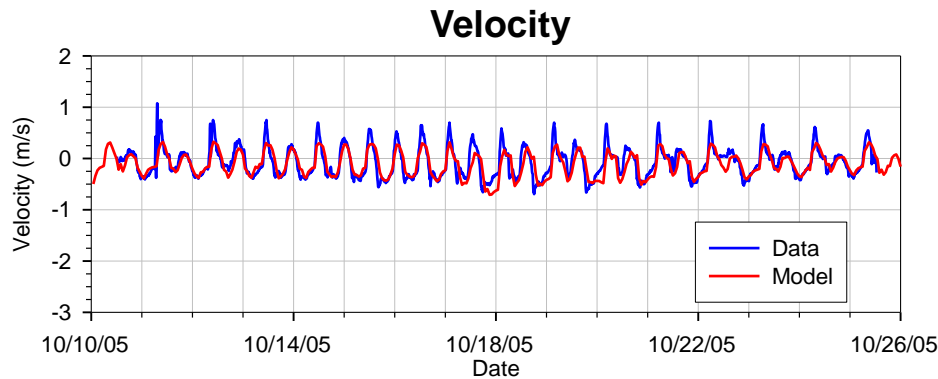
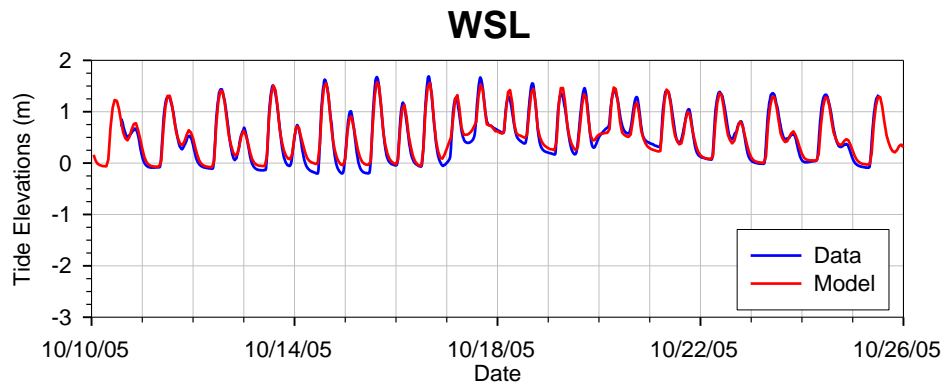
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Model – Data Comparison: Skagit Bay



Model – Data Comparison: Port Susan

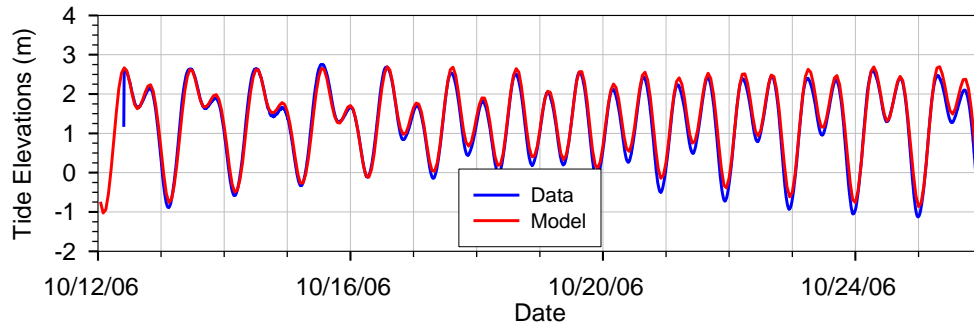


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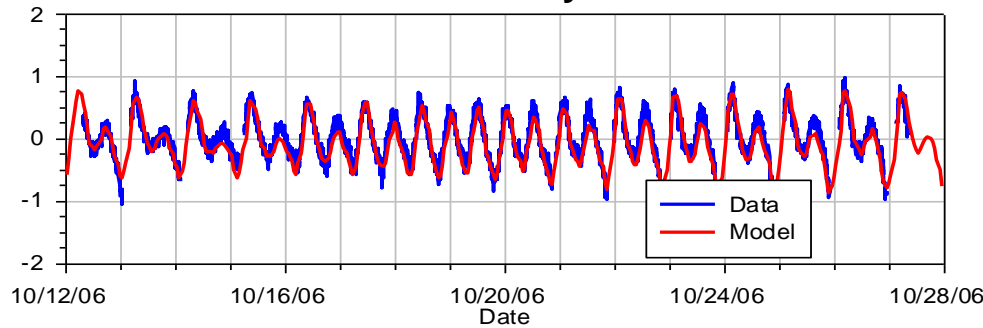
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Model – Data Comparison: Snohomish

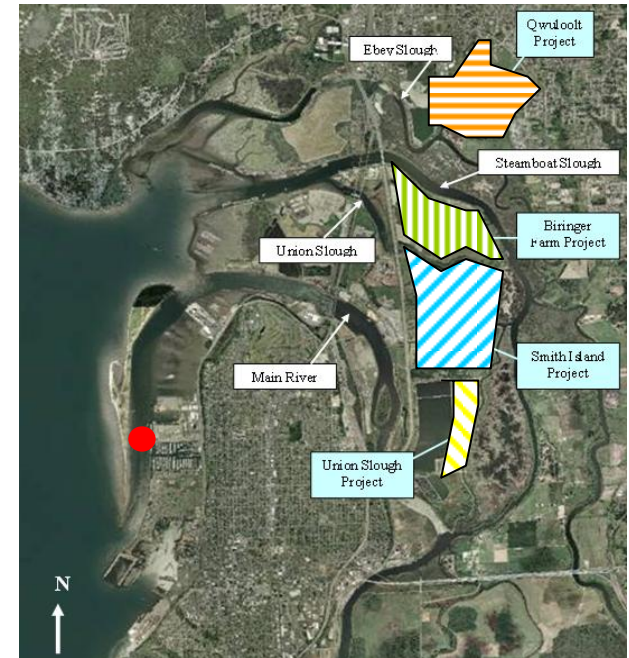
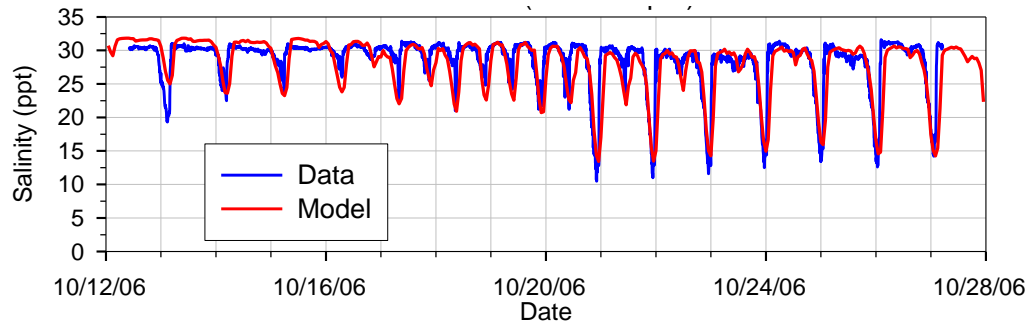
WSL



Velocity

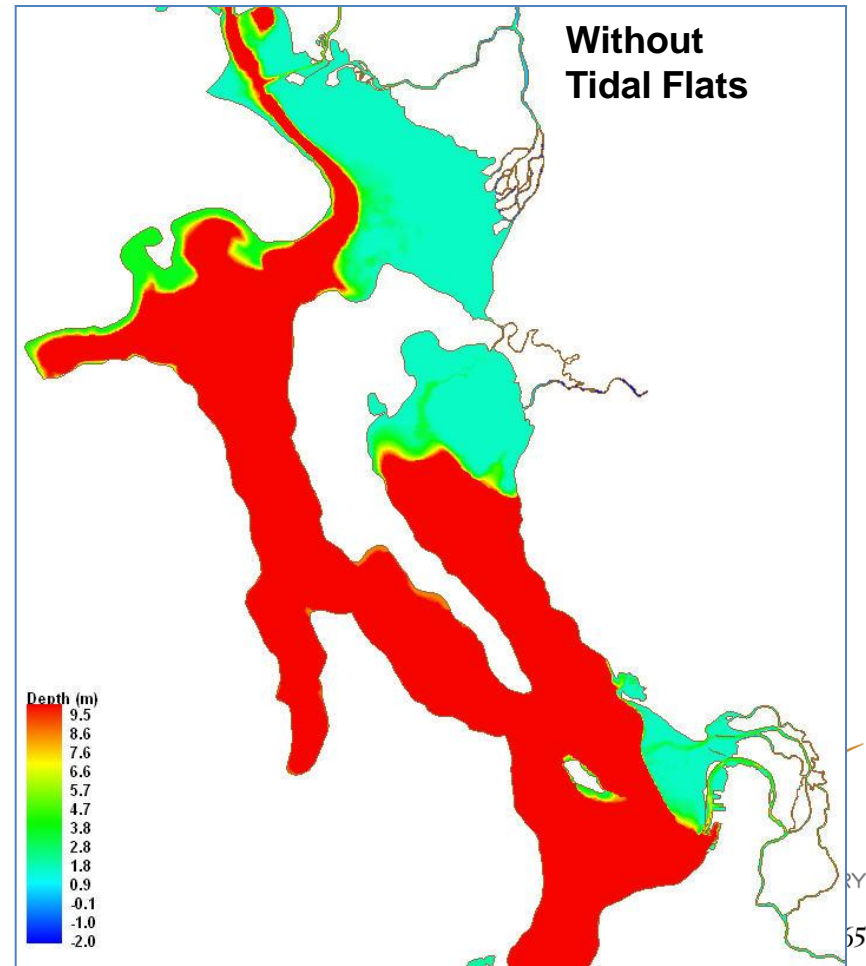
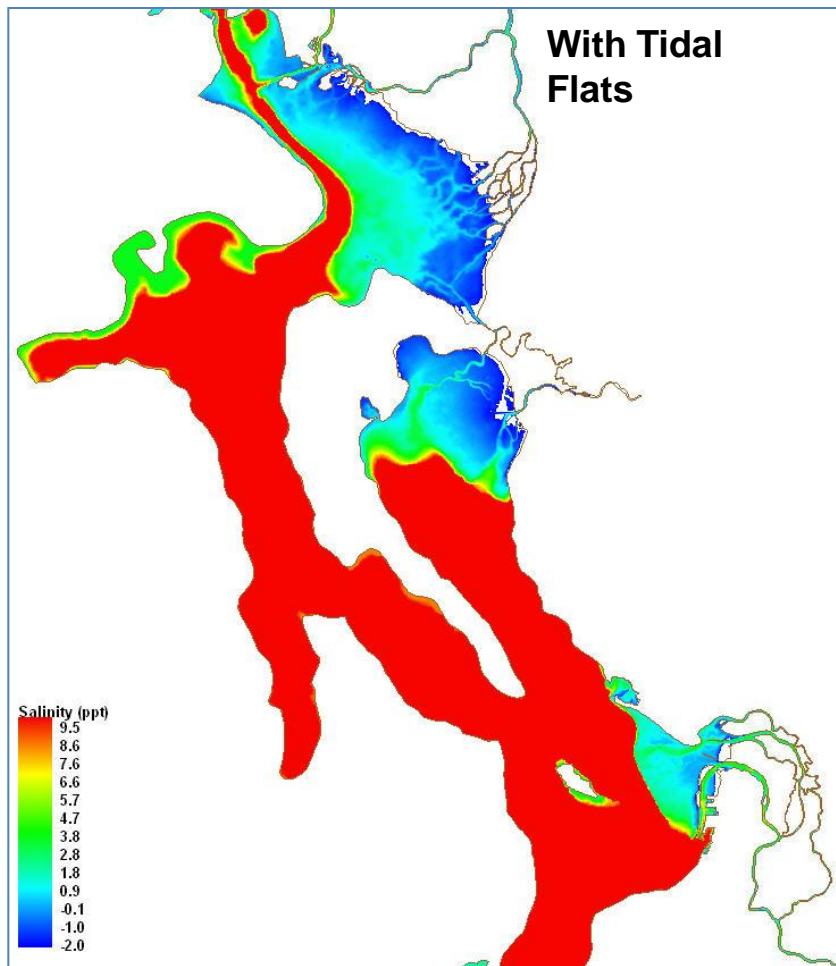


Salinity

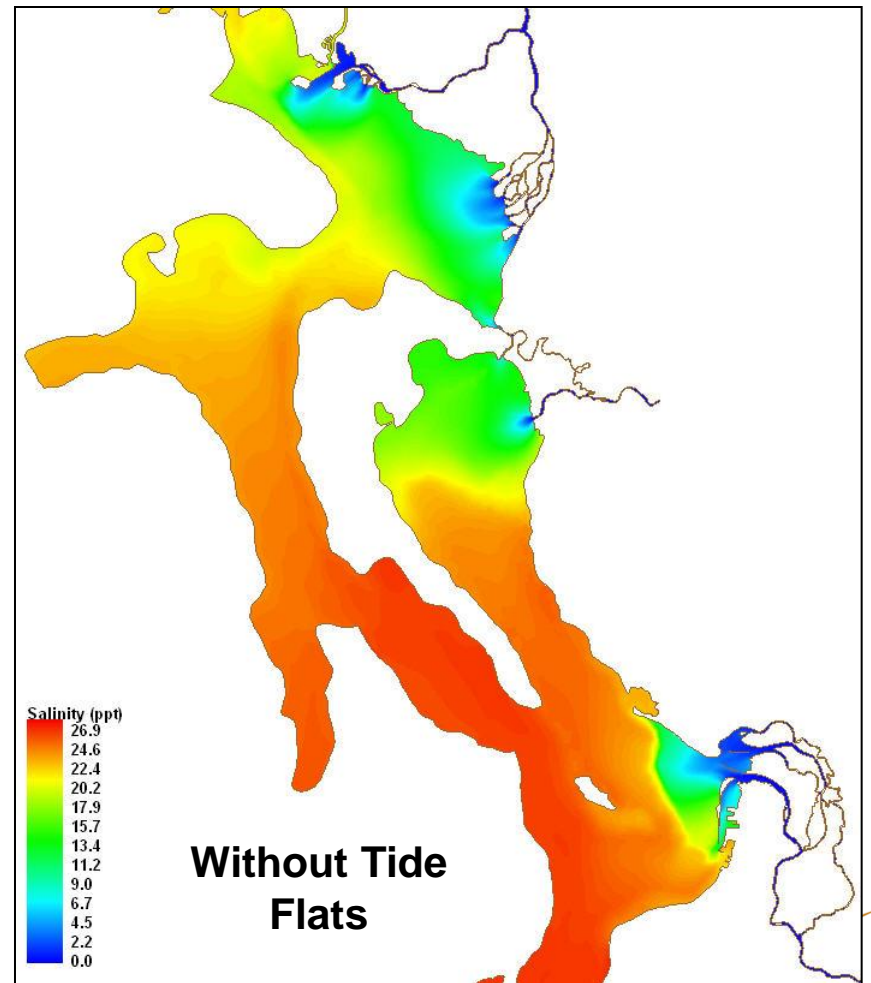
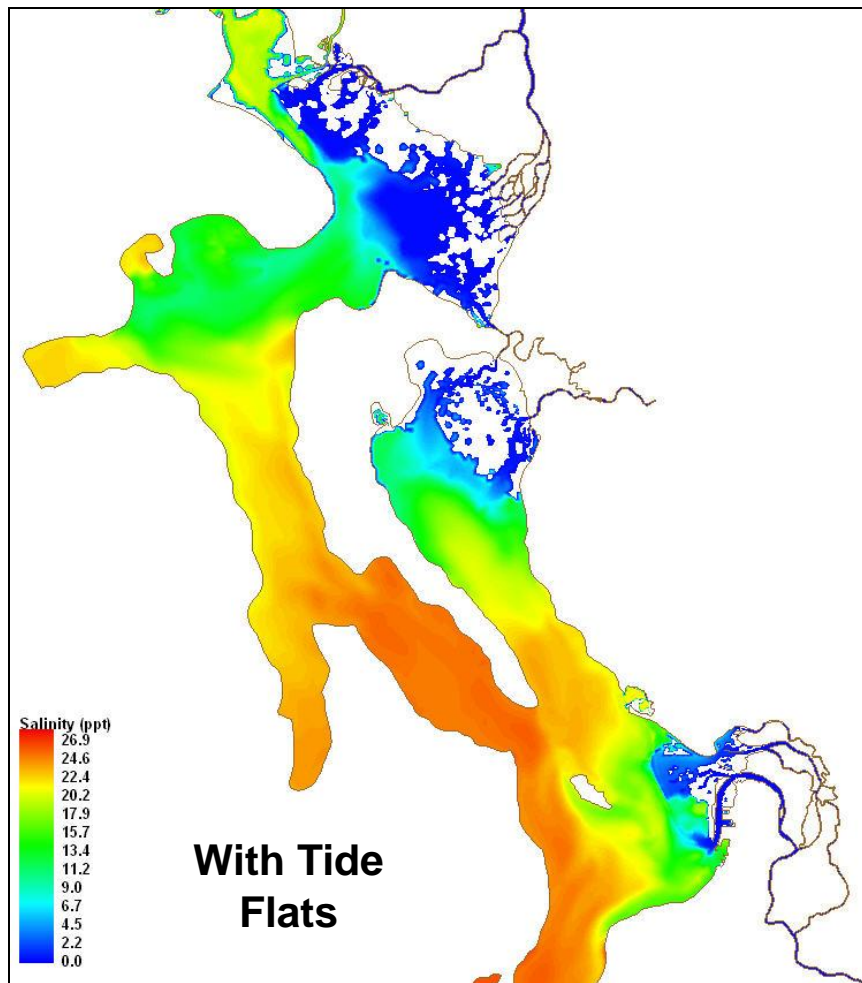


Sensitivity Analysis - Effect of Tidal Flats

- ▶ Eliminate Tidal Flats: Minimum water depth = 1 m below MLLW



Surface Salinity Distributions at Ebb Tide

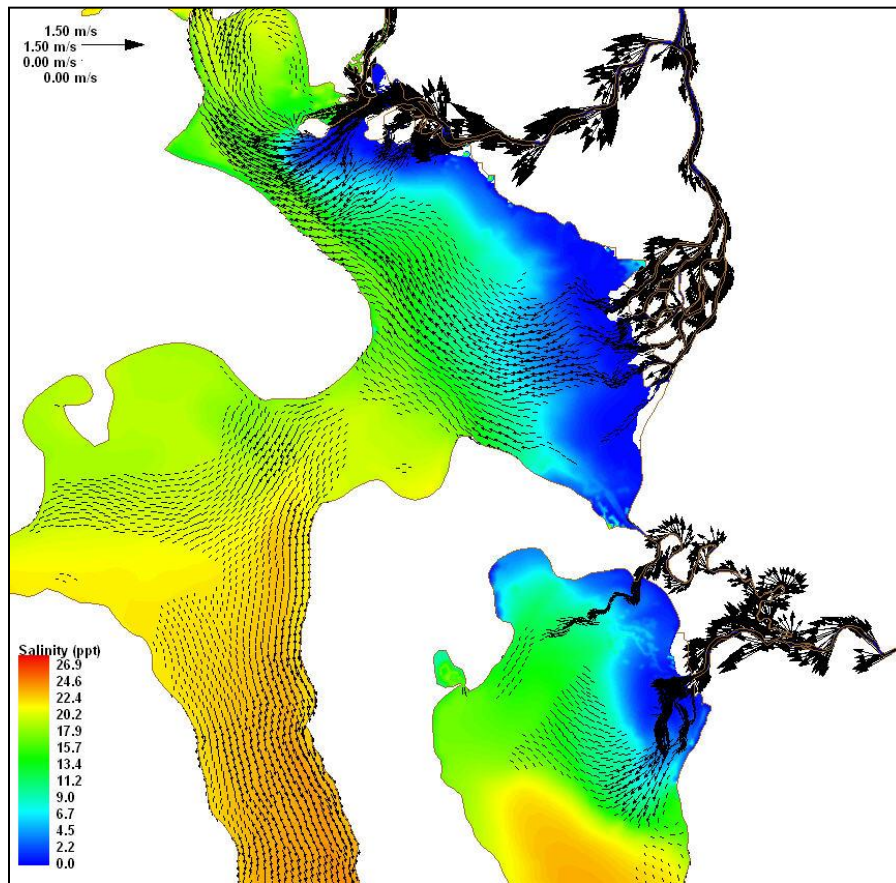


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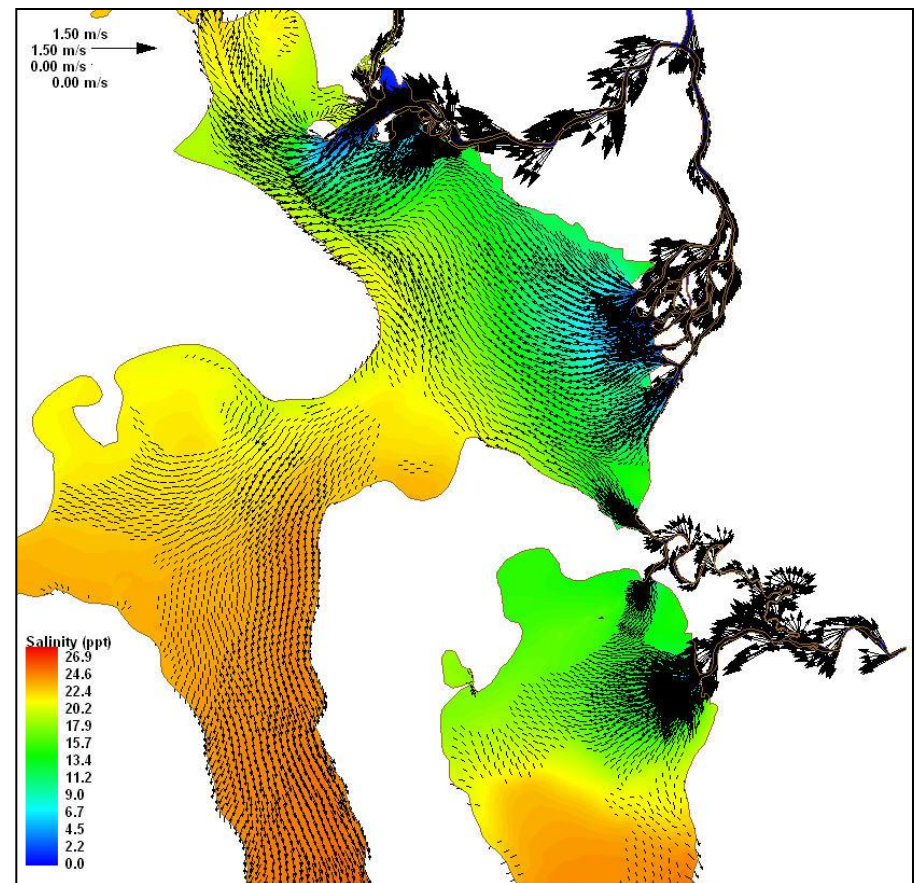
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14-Day Mean Surface Salinity and Velocity

With Tidal Flats

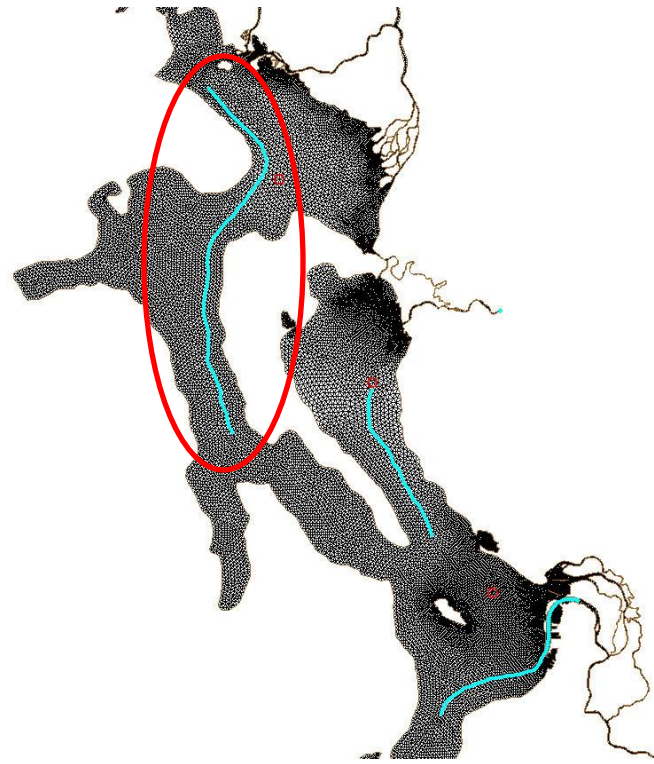


Without Tidal Flats



Effect on Mean Salinity and Velocity (14-Day Average)

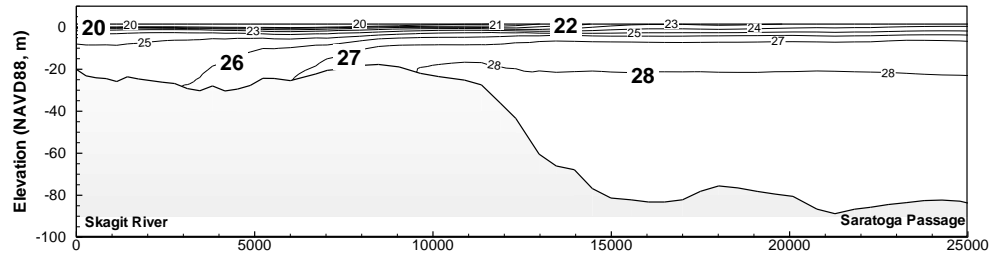
Skagit Bay



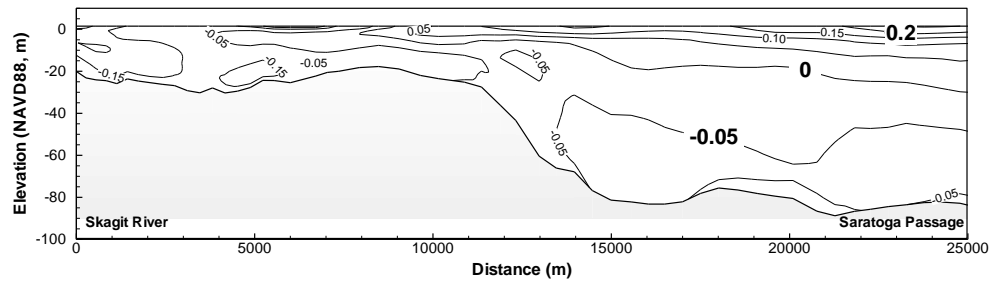
With Tidal Flats

Without Tidal Flats

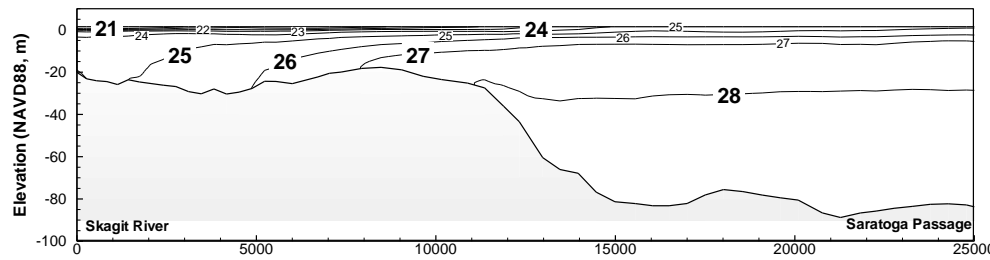
Mean Salinity (ppt)



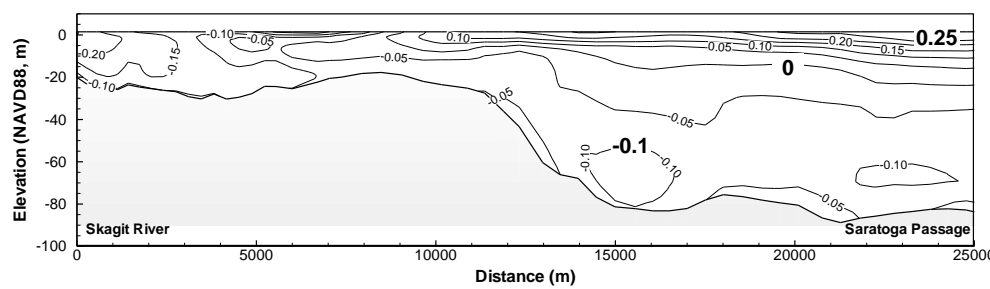
Mean Velocity (m/s)



Mean Salinity (ppt)

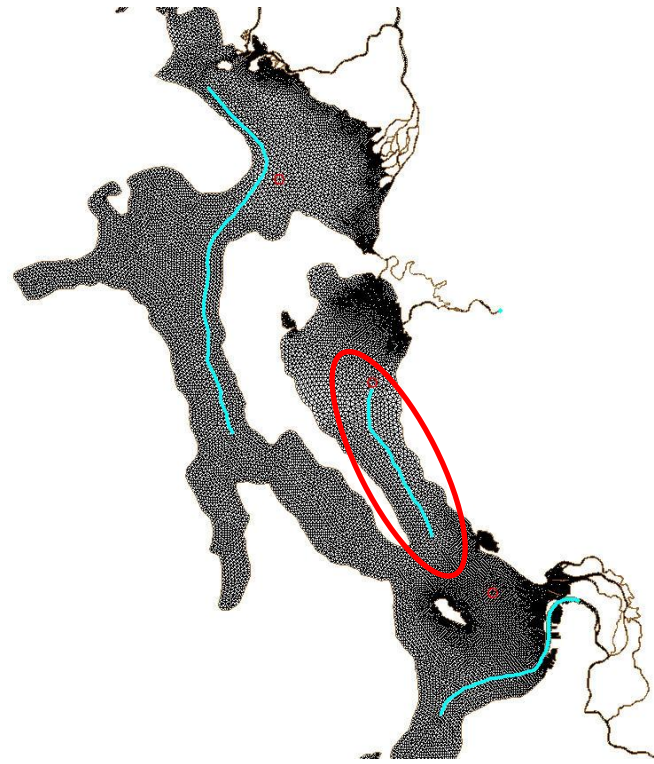


Mean Velocity (m/s)

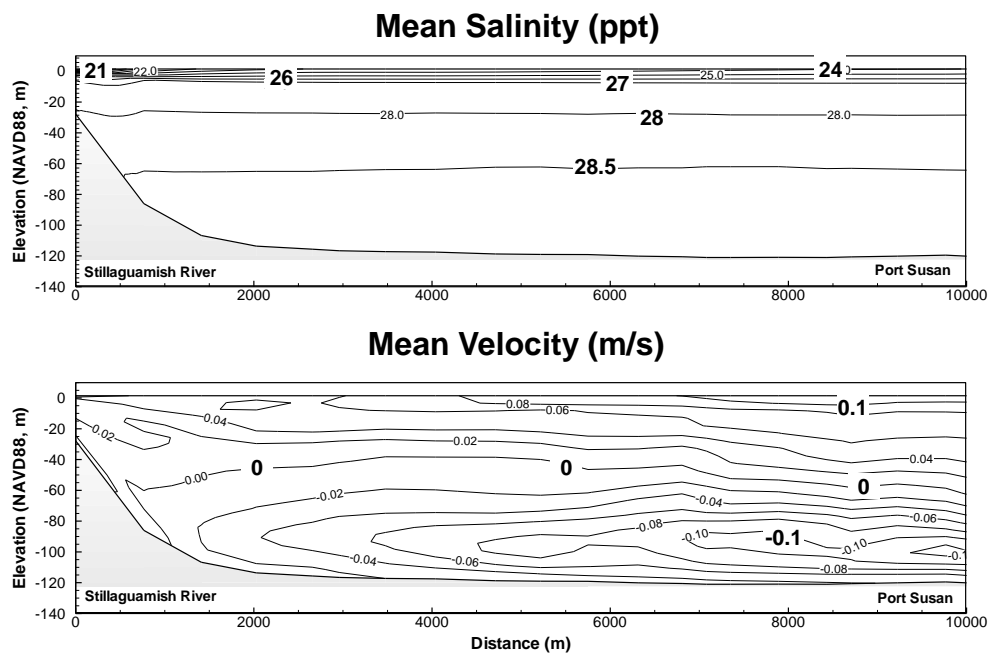


Effect on Mean Salinity and Velocity (14-Day Average)

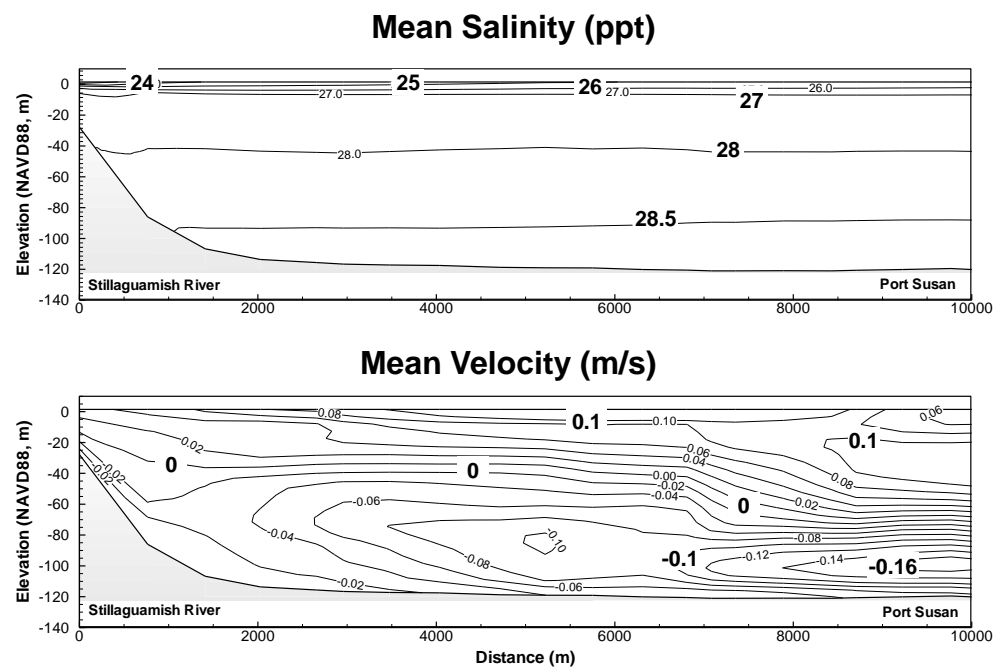
Port Susan Bay



With Tidal Flats

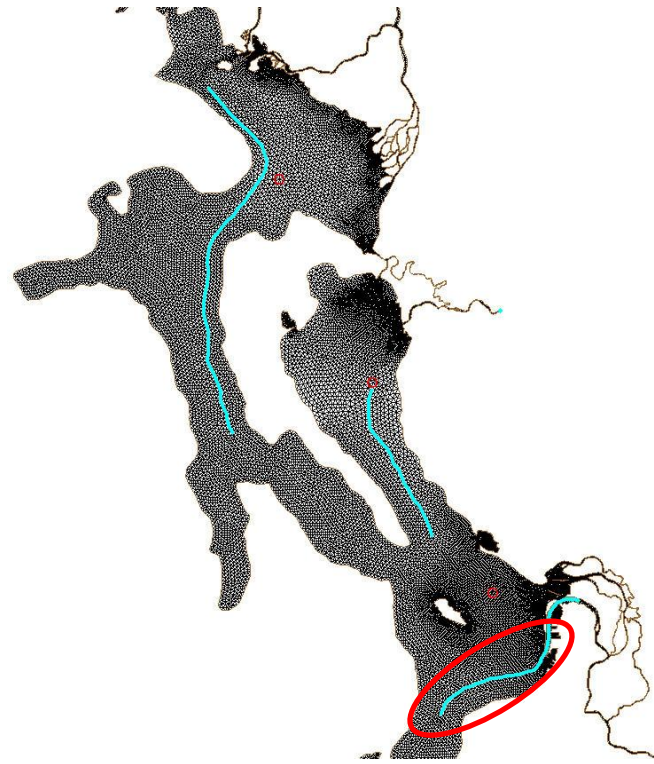


Without Tidal Flats

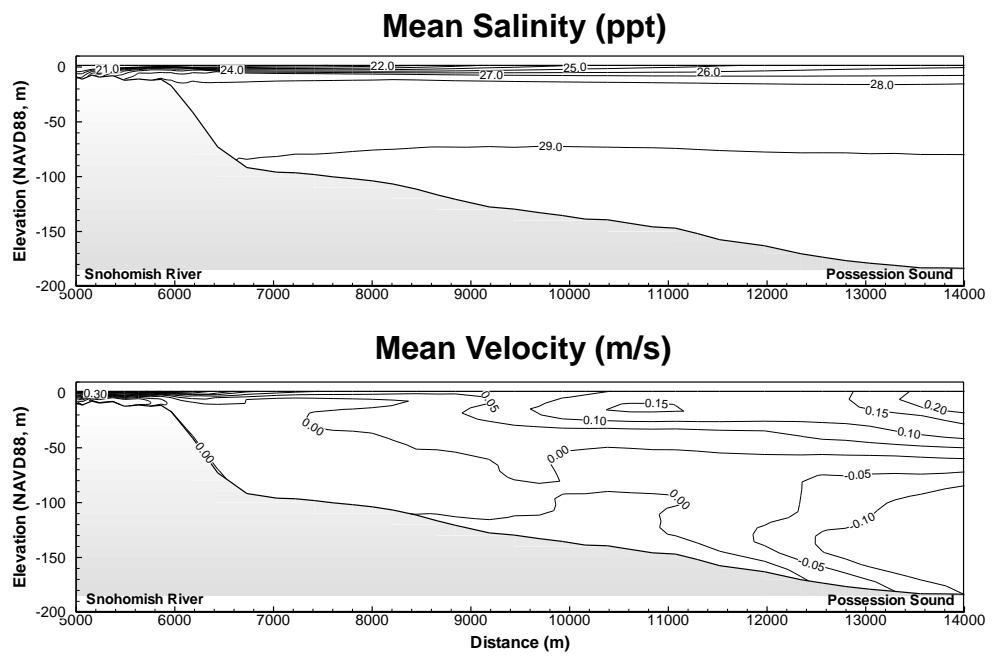


Effect on Mean Salinity and Velocity (14-Day Average)

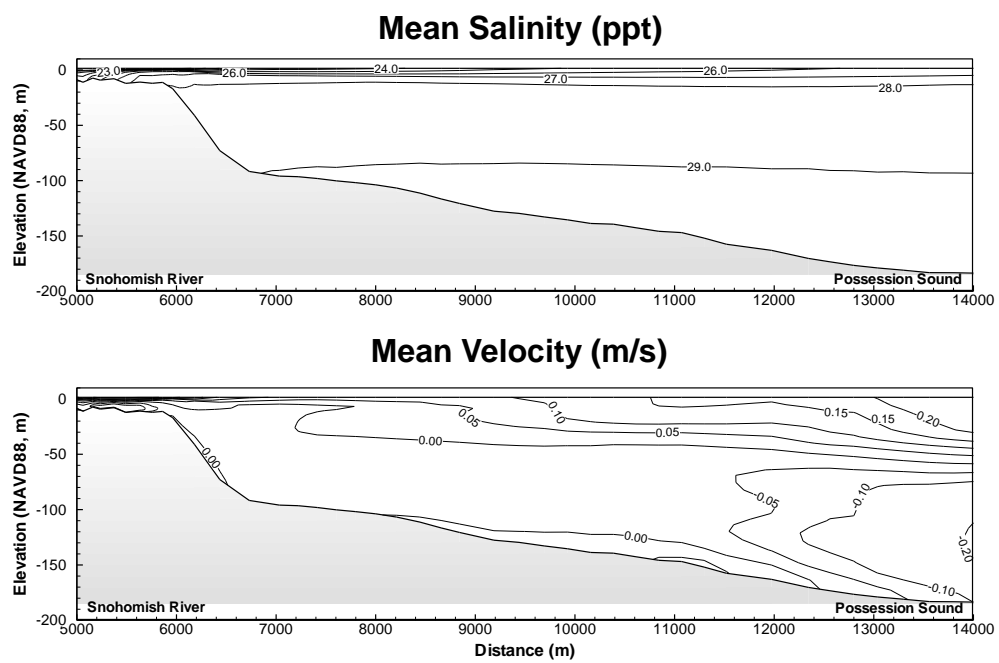
Snohomish Basin



With Tidal Flats

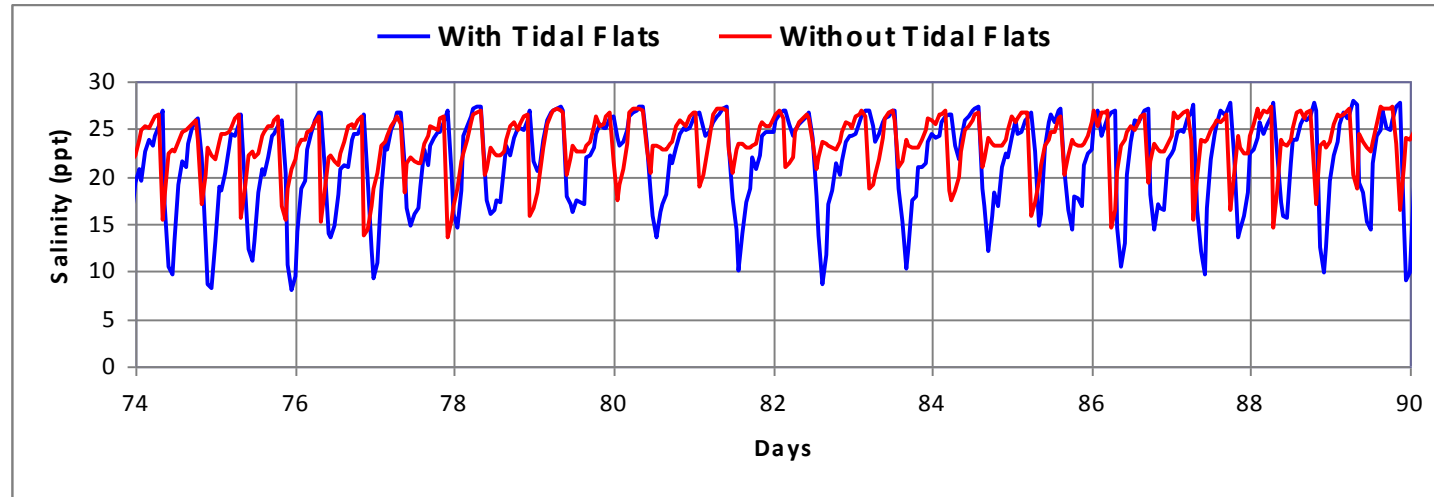


Without Tidal Flats

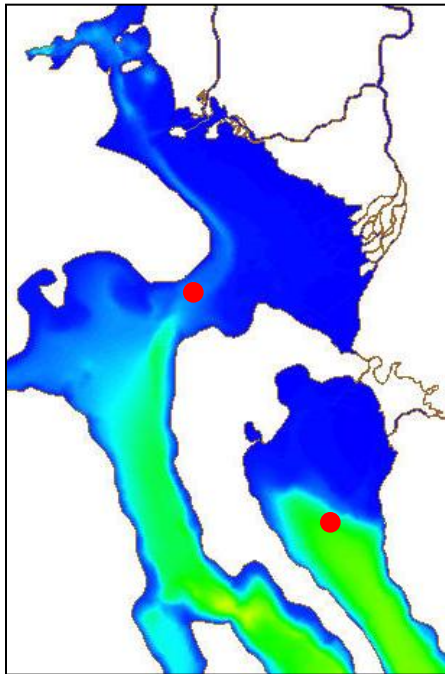
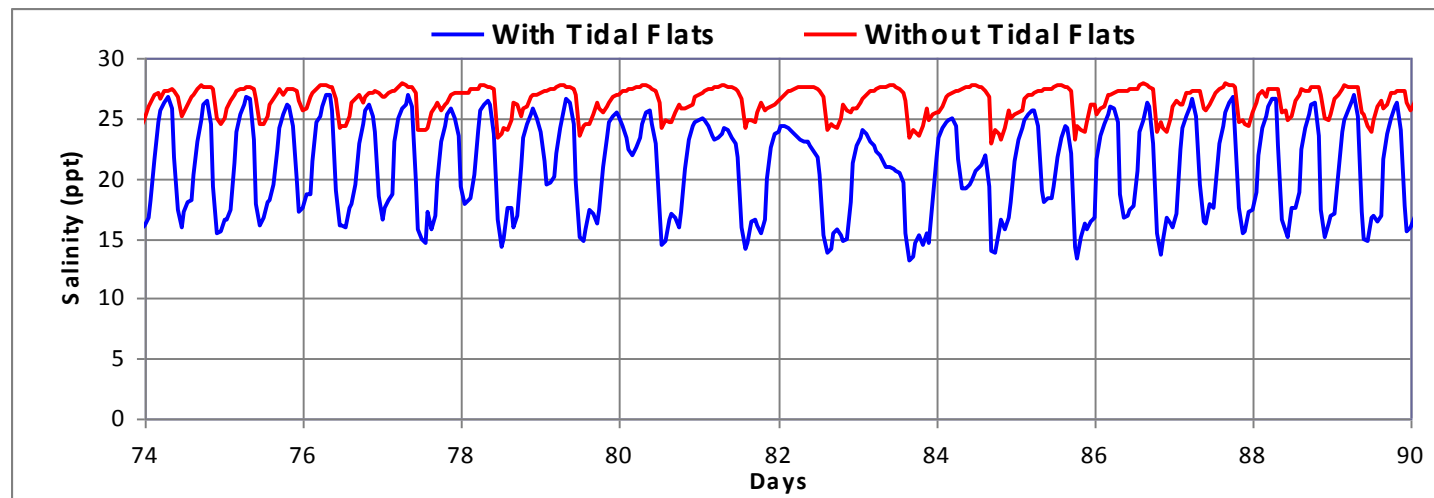


Comparisons of Salinity Time Series

Skagit Bay



Port Susan Bay



Summary

- ▶ Importance of bathymetry data in tide flats
 - High resolution LiDAR data with ground-truth survey
- ▶ Neglecting tide flats may result in
 - Inaccurate flow balance in river distributary channels
 - Inaccurate horizontal salinity distributions
 - Under-prediction of salinity stratification
 - Over-prediction of mean two-layer estuarine circulation
- ▶ Future work/analysis
 - Temperature simulation in tide flats - sediment bed? data?
 - Residence time/age calculation – challenge in tide flats
 - Transverse circulation and mixing



Thank You!

**Surface Salinity and
Tide Flat Animation**

