Apr 6th, 1:45 PM - 2:00 PM

Hood canal bridge effect on hydrodynamics and nearfield zone of influence

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Pacific Northwest National Laboratory and Washington State Department of Ecology

2018 Salish Sea Ecosystem Conference

Hood Canal

Recurring Hypoxia and Fish Kills

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Source:
1. WSDOT 1997– William A. Bugge Bridge, (Hood Canal Bridge - 104/5.2), Replacement Plan, for the, East-Half, Floating Portion October, 1997
2. WSDOT 2009 - Hood Canal Bridge Project Progress Report –July 2009

Hood Canal Bridge Impact Assessment

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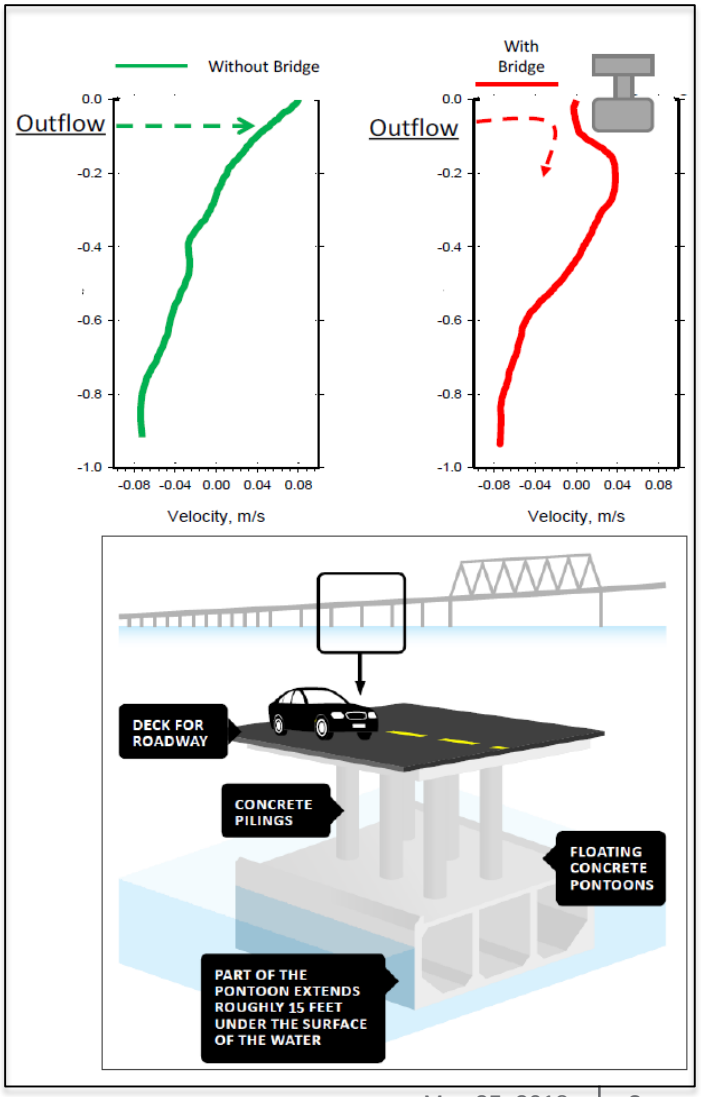
- Hypothesis: Hood Canal Bridge alters nearfield hydrodynamics and could have far-field and basin-wide impacts on circulation and water quality
  - Preliminary assessments
    - HCB restricts the flushing of Hood Canal (Khangaonkar and Wang, 2013)
    - Higher mortality of pelagic fishes near the Bridge (Moore et al. 2010, 2013).
    - Higher near-surface fish density within the vicinity of the Hood Canal Bridge (H. Daubenberger, Port Gamble S'Klallam Tribe)
- HCB – EIAP (LLTK 2016) – 13 Components
  - C8 - Oceanographic data collection
  - C9 - **Nearfield Zone of Influence (ZOI) (Salish Sea Model)**



Oceanographic Measurements (2017)

- ADCPs (Current Profiles)
  - North, Bridge, and South
    - 4/25-6/2 2017
- Point Measurement
  - Nortek Aquadopp
    - 4/27-6/6 2017
- CTD:
  - North: 4 profiles
  - South: 3 profiles

Reference:

RSP Group. 2017. Current Measurements in Hood Canal 2017: Data Report. Prepared for Long Live The Kings. Report draft. Project No. S6584

Salish Sea Model – PNNL / Ecology / EPA
Hydrodynamics and Water Quality

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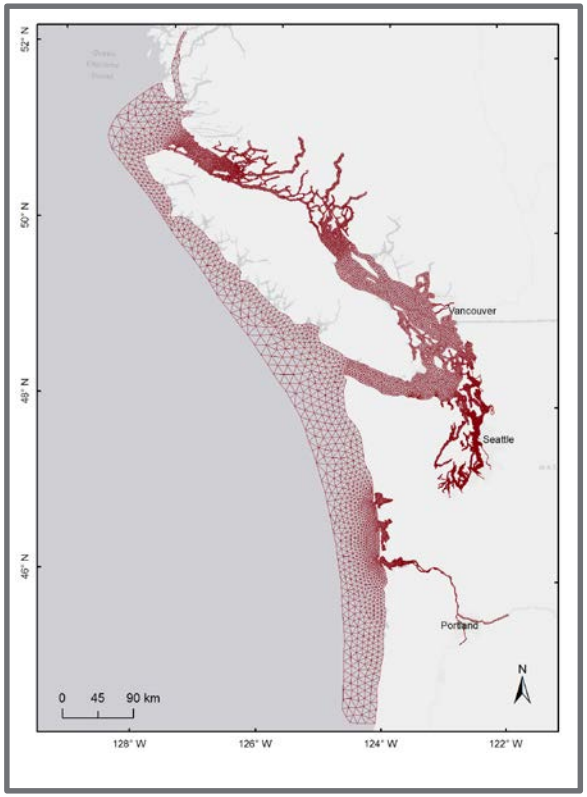
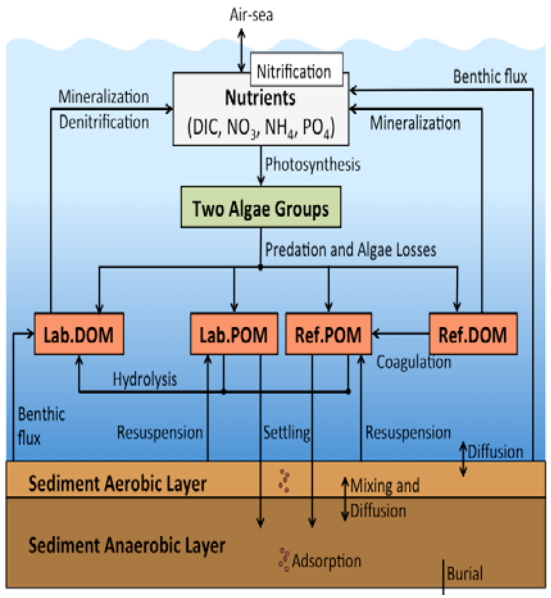
Salish Sea Model (SSM) - Grid



Biogeochemical Component



- **Sediment Diagenesis**
- **Carbonate Chemistry & pH**

Model Specifications

Hydrodynamic Model
- FVCOM (Chen et al 2003)
- 3-D Baroclinic
- 10-layers, sigma coordinates
- Boundaries
  - Strait of Juan de Fuca
  - Strait of Georgia
  - S, T, and Elevation
- Meteorology
  - UW – WRF Model
- Hydrology
  - River flows
  - Watershed models

Water Quality Model
- CE-QUAL-ICM / USACE
- FVCOM-ICM (Kim and Khangaonkar 2011)
- Nutrients, phytoplankton/algae, carbon, DO, …. 19 variables
- Benthic fluxes, pH
- Boundary loads based on DFO monitoring data
- Point source loads (99)…

Salish Sea Model – http://salish-sea.pnnl.gov/
- Khangaonkar et al. (2011 a,b, 2012, 2013, 2016, 2017)
- Pelletier at al. 2017 a,b, Bianucci et al 2018,
- Khangaonkar et al 2018 (under review)]

Salish Sea Model Grid Refinement

Hood Canal Bridge

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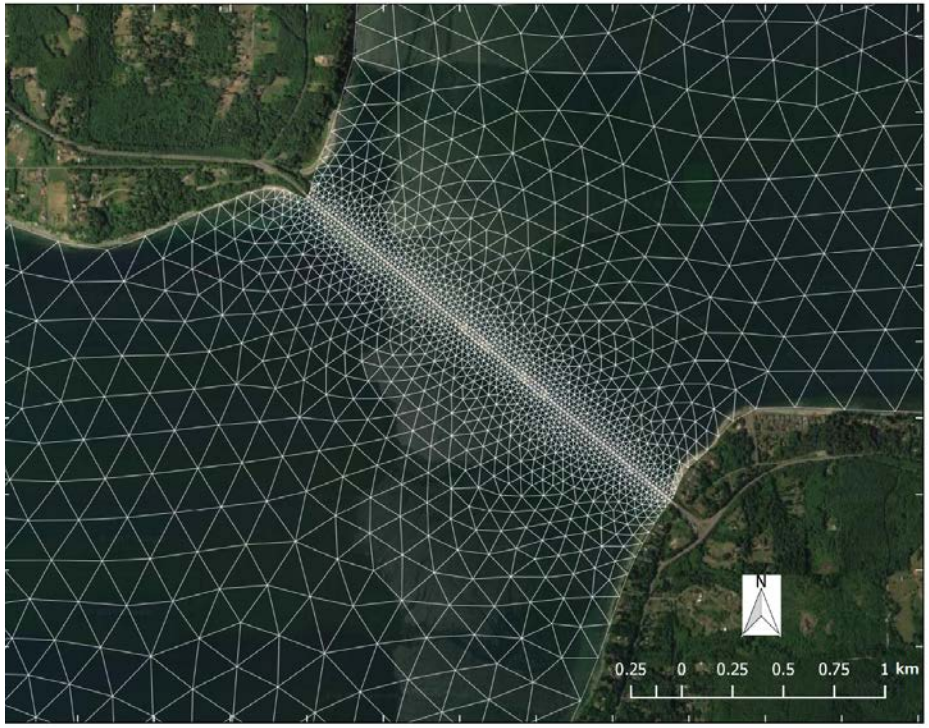
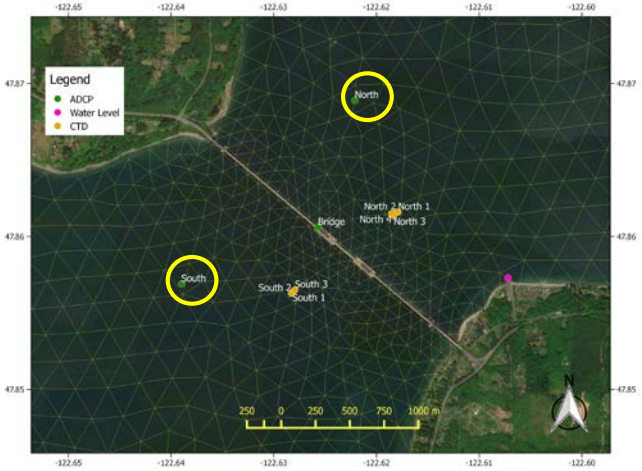
Original

Refined

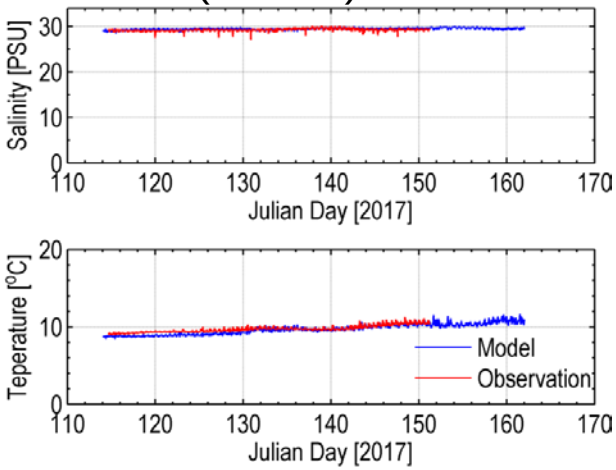


Model Validation – Year 2017
Temperature and Salinity

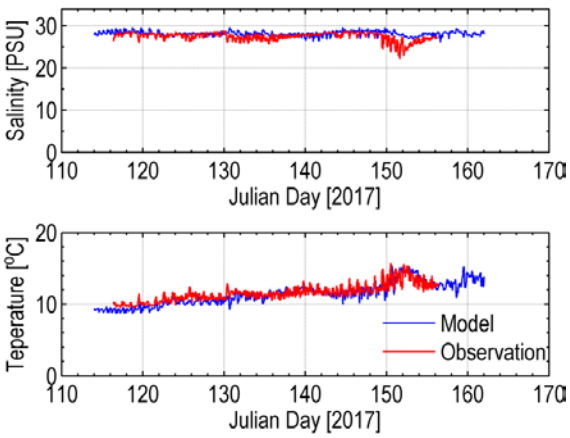


Deployment - 4/25/2017- 6/11/2017

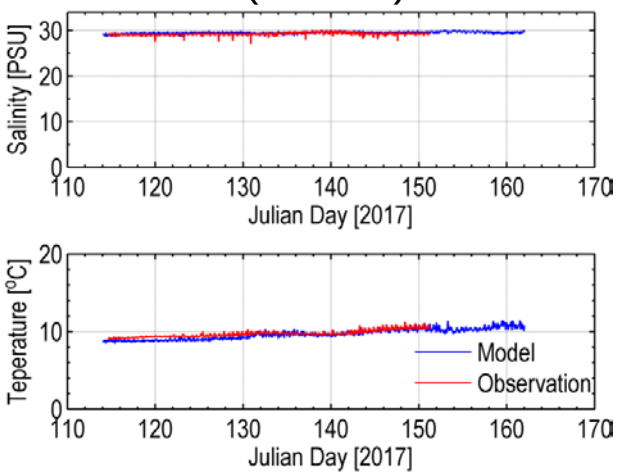
Hood Canal North in situ CTD (Bottom)



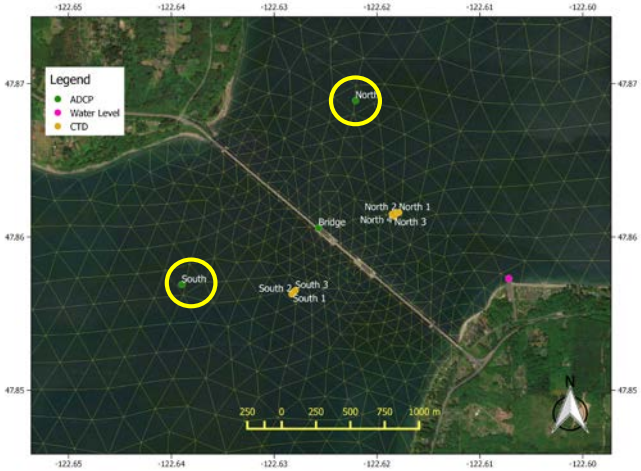
Bridge situ CTD (Surface)

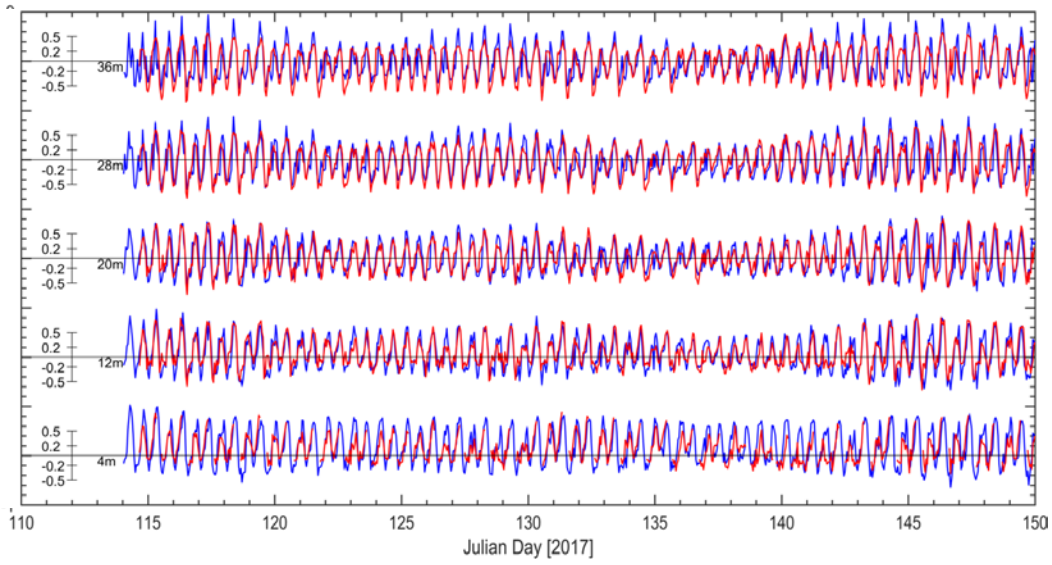


Hood Canal South in situ CTD (Bottom)

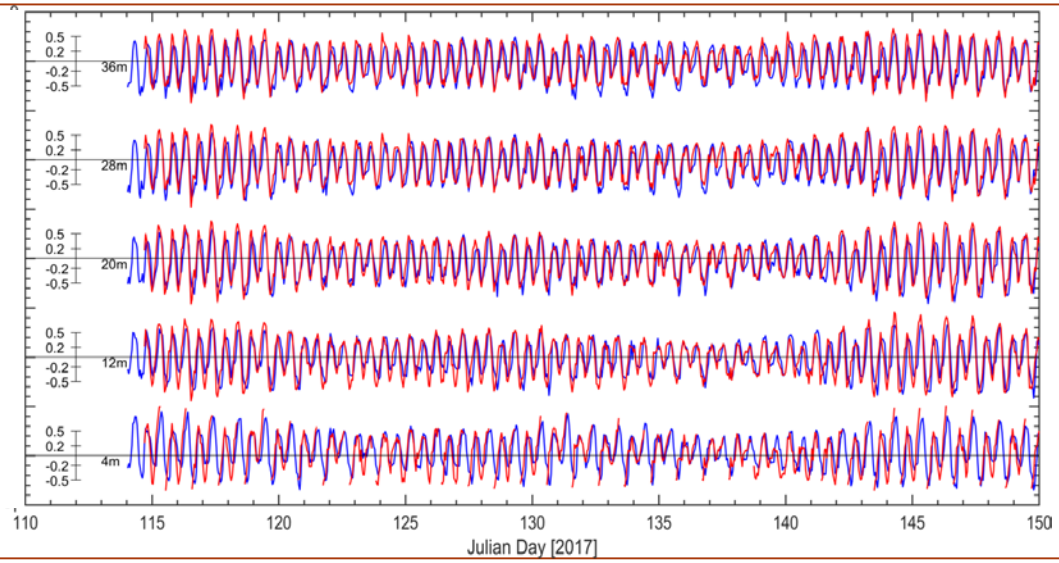


ADCP Data – Model Comparison





South



North

Model
Observation

Maximum Ebb and Flood Velocities

Effect of the Bridge on Surface Currents

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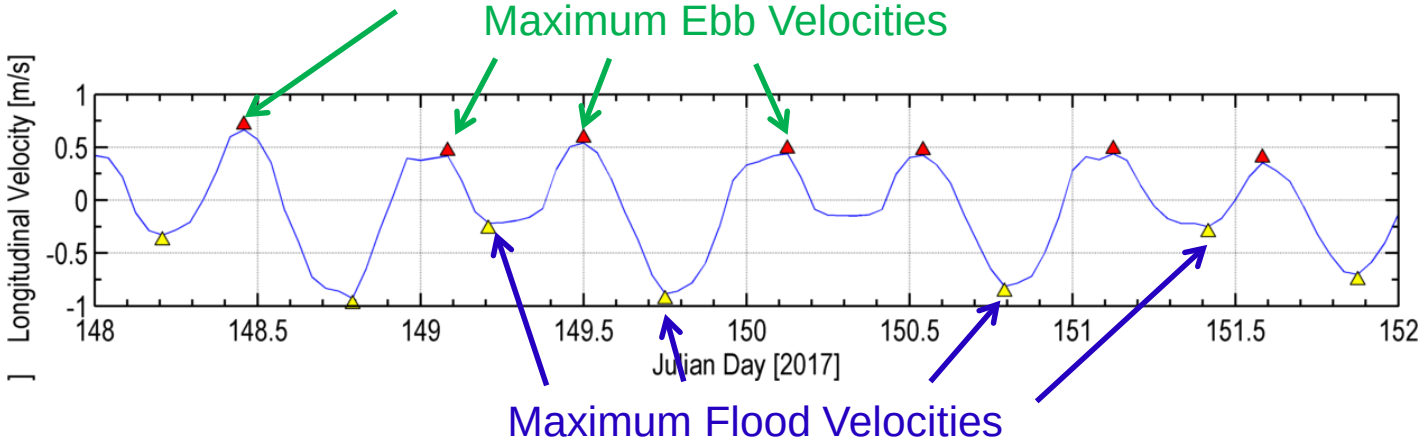
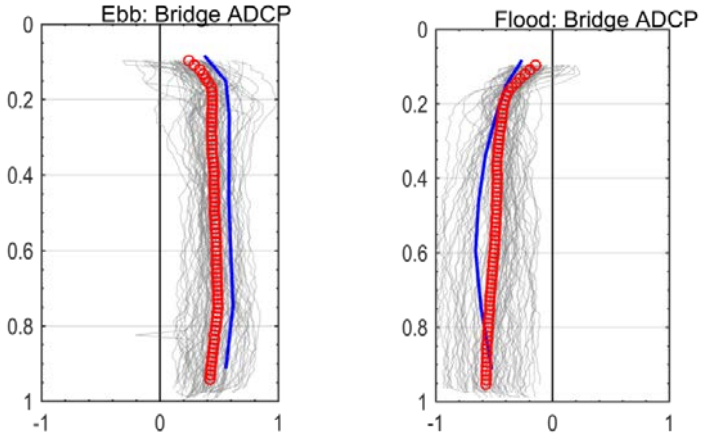
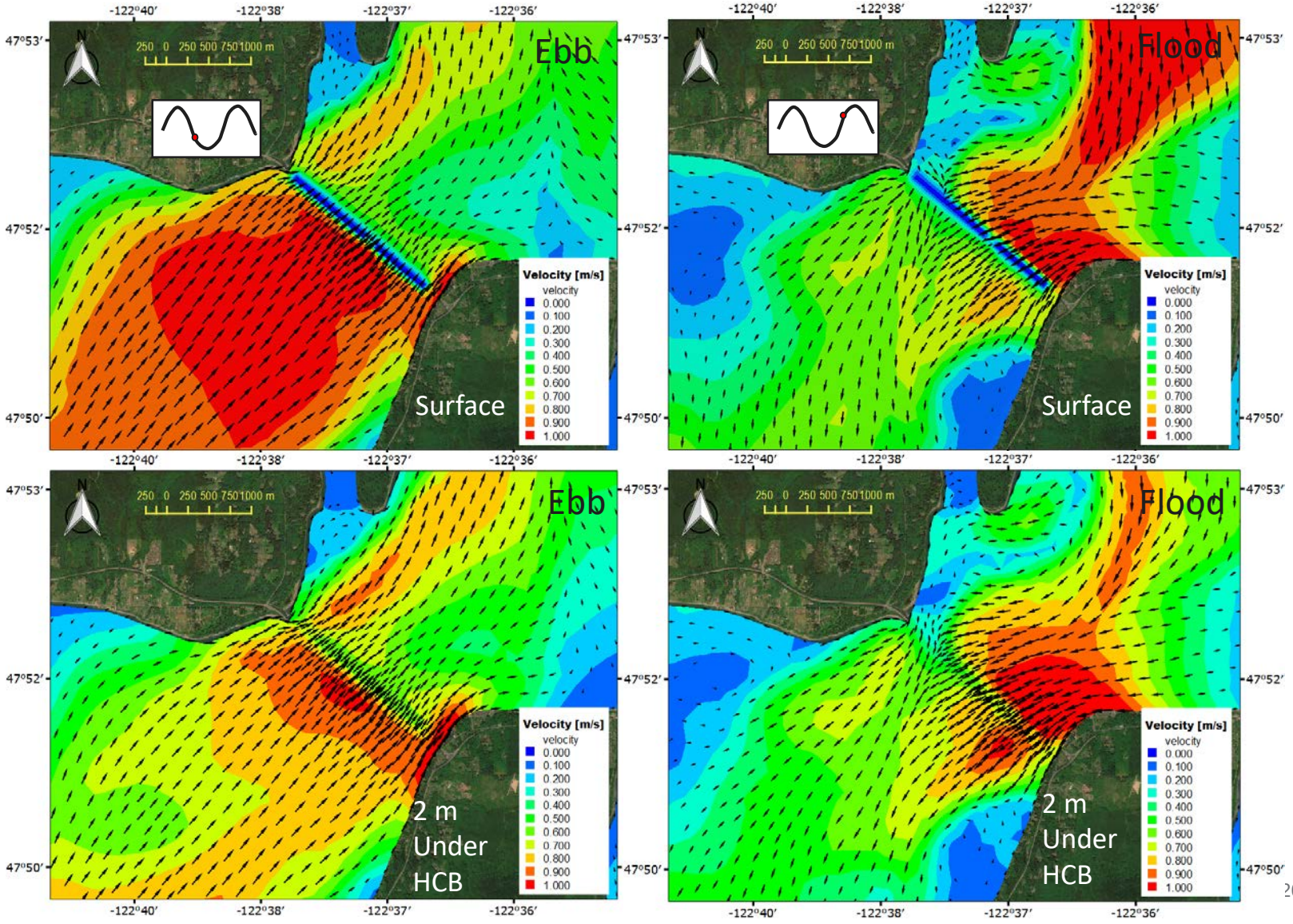




Longitudinal Velocity, m/s

Horizontal Velocity: With Bridge



Horizontal Surface Velocity Difference

Present condition with HCB - indicated scenario

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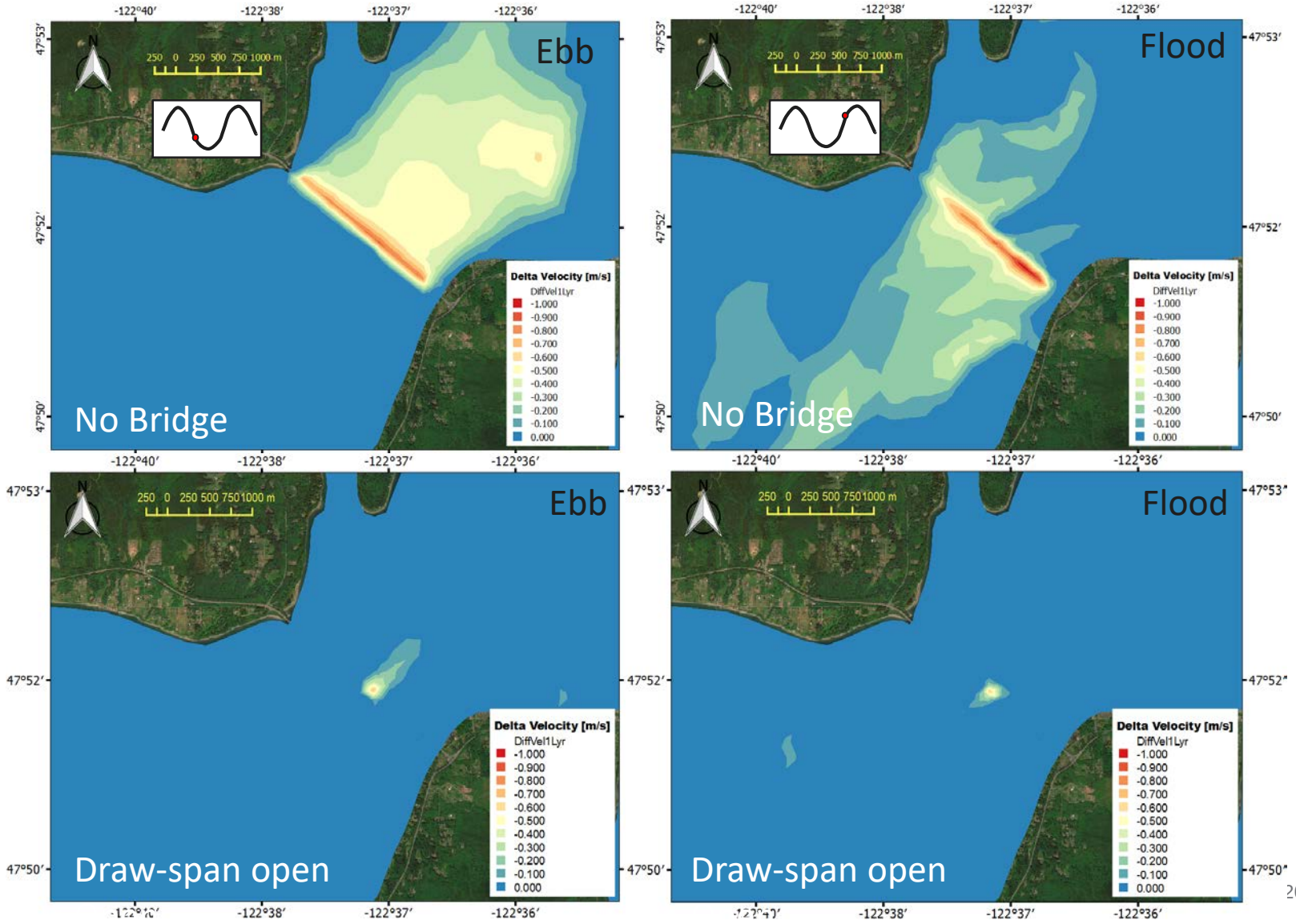

Vertical Transect Salinity Difference

Present condition with HCB - indicated scenario

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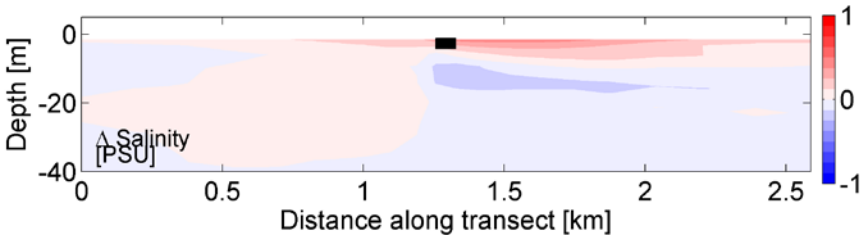
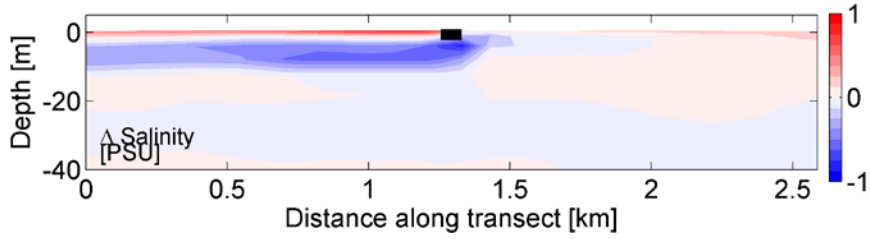
Bridge Present – No Bridge

Ebb (147.42 JD)

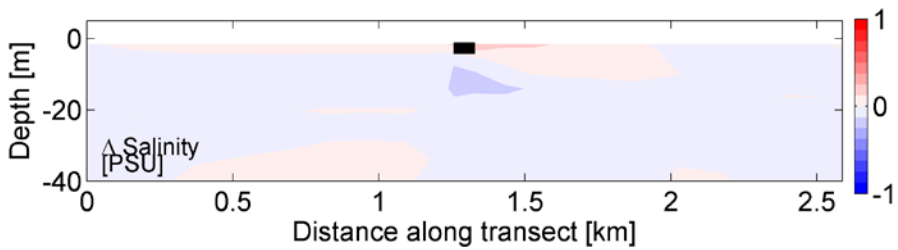


Flood (147.75 JD)

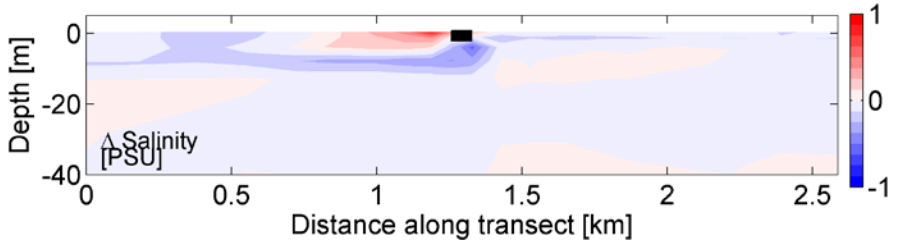


Bridge Draw-span Closed – Bridge Draw-span Open

Ebb (147.42 JD)



Flood (147.75 JD)



Zone of Influence
Summary

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Variable	South HCB		North HCB	
	ZOI (km)	Max. Δ	ZOI (km)	Max. Δ
Velocity Flood (m/s)	**4.22**	-0.19 (m/s)	0.49	-0.15 (m/s)
Velocity Ebb (m/s)	0.53	-0.16 (m/s)	**3.25**	-0.34 (m/s)
Salinity Flood (psu)	**2.429**	+0.47 (psu)	*	*
Salinity Ebb (psu)	*	*	**10.54**	+0.33 (psu)
Temperature Flood (°C)	**0.77**	-0.50 (°C)	NA	0.03 (°C)
Temperature Ebb (°C)	NA	+0.21(°C)	NA	-0.22 (°C)

- ZOI is based on relative reduction of difference to < 10% of the maximum value
- ZOI for temperature based on 0.3°C cut off
- * Needs further analysis / may require basin-wide examination

Particle Tracking Animation
PNNL FVCOM-3DPT Model

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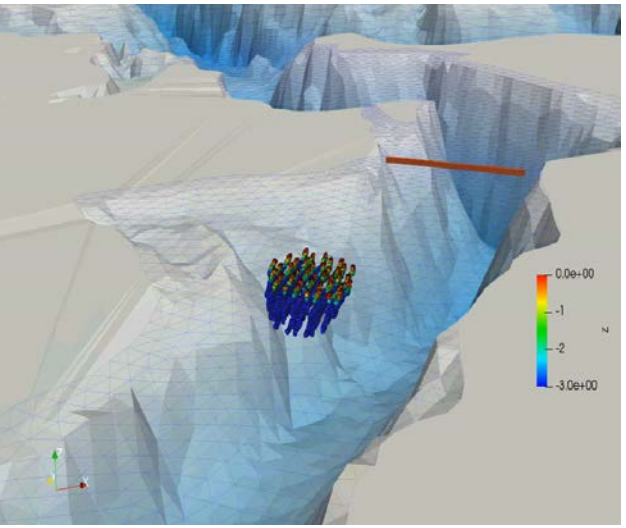
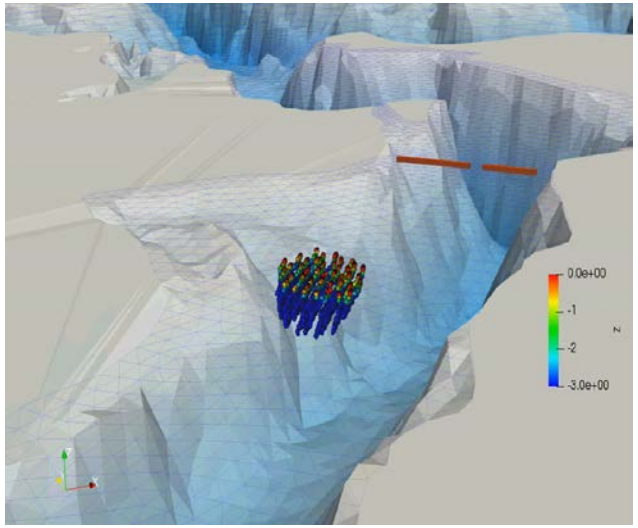
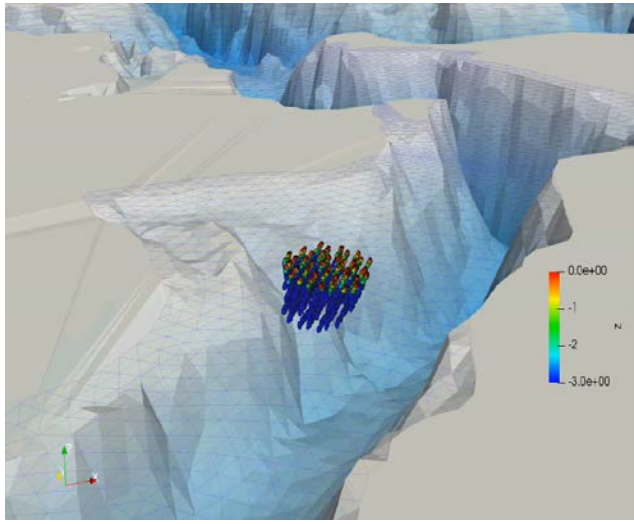
Bridge with Draw-span Closed



Bridge with Draw-span open



No Bridge



3D particle tracking model
Particle Diffusivity: 0.01 m^2/s
Particle release depth: 0-25 m
Number of particles released: 3000

Thank you / Questions?

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- HCB blocks surface layer advection and affects hydrodynamics
  - Induces increased local mixing
  - Causes pooling of water (up-current)
  - Results in shadow/sheltering of water (down-current)
- HCB Zone of Influence (≈ 20 m of the water column)
  - Velocity ≈ 3 – 4 km
  - Salinity ≈ 2 – 11 km
  - Temperature ≈ < 1 km
  - (Note this is work in progress)