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Response of Salish Sea circulation and water quality to climate change and sea level rise

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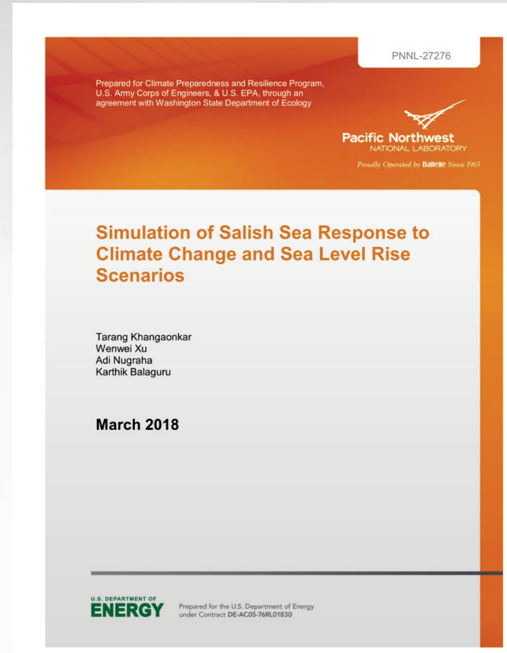
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Simulation of Salish Sea Response to Climate Change and Sea Level Rise Scenarios

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U.S. DEPARTMENT OF ENERGY

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Response of Salish Sea Circulation and Water Quality to Climate Change and Sea Level Rise Perturbation

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*Pacifc Northwest National Laboratory in collaboration with U.S. EPA & U.S. ACE

SSEC 2018

U.S. DEPARTMENT OF ENERGY

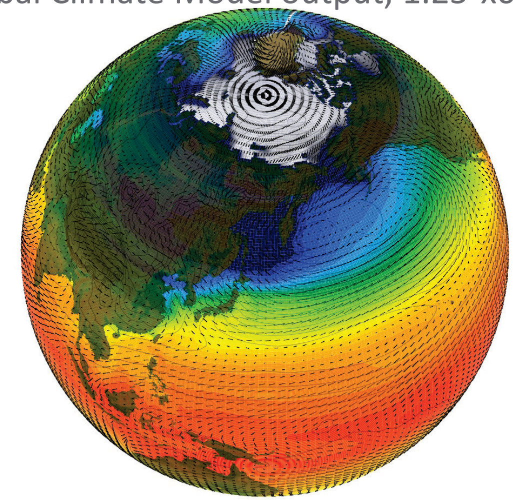
EPA United States Environmental Protection Agency

DEPARTMENT OF ECOLOGY State of Washington

Study Area & Motivation

- How will nearshore estuarine environment be affected by climate change
  - Global predictions vs estuarine resolution
- <u>Objective</u>: Proof of concept level feasibility assessment for Salish Sea
  - Nearshore estuarine response simulation using downscaled global climate change predictions
    - Hydrology
    - Meteorology
    - Ocean boundary
    - Sea Level Rise

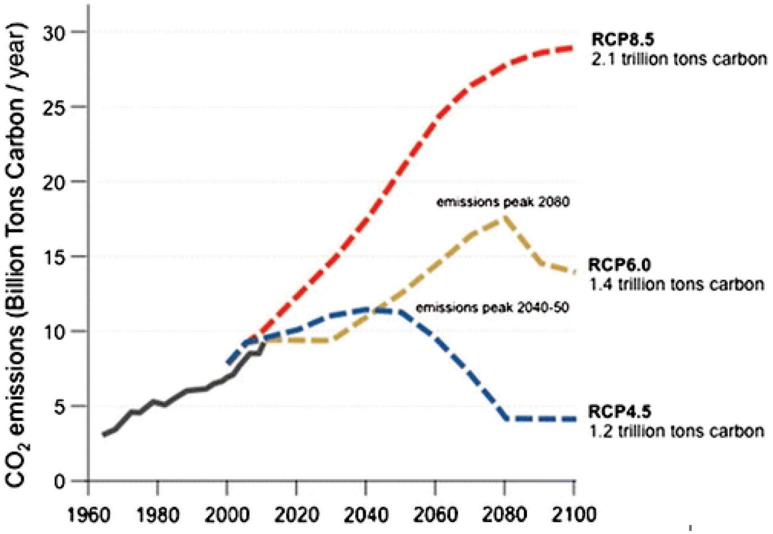
Example Global Climate Model output, 1.25˚x0.9˚ (credit: NCAR)



Salish Sea Model Domain

Climate Scenarios: Definitions and Data Sources

- Community Earth System Model (CESM, Hurrell, et al. 2013) (http://www.cesm.ucar.edu/models/)
  - A fully-coupled, community, global climate model (NCAR)
    - Consists of five geophysical models: **atmosphere,** sea-ice, land, **ocean,** and land-ice, plus a coupler
- Future Climate Simulations (based on future emissions scenarios)
  - IPCC 5th Assessment Report (2014)
    - Representative Concentration Pathways (RCP)
      - RCP 8.5 : High emissions scenario
  - CESM Climate Scenarios
    - Historical: 1995-2004 ≈ Y2000
    - Future: RCP 8.5 2091-2100 ≈ Y2095



Sea Level Rise

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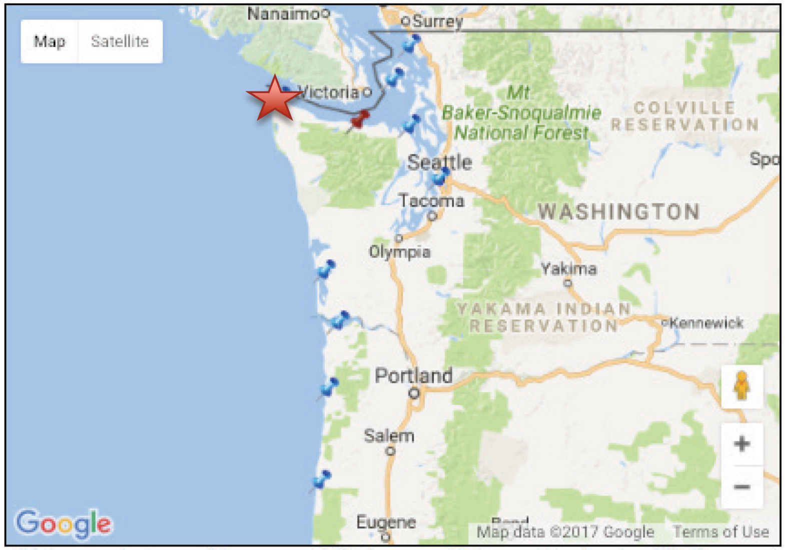
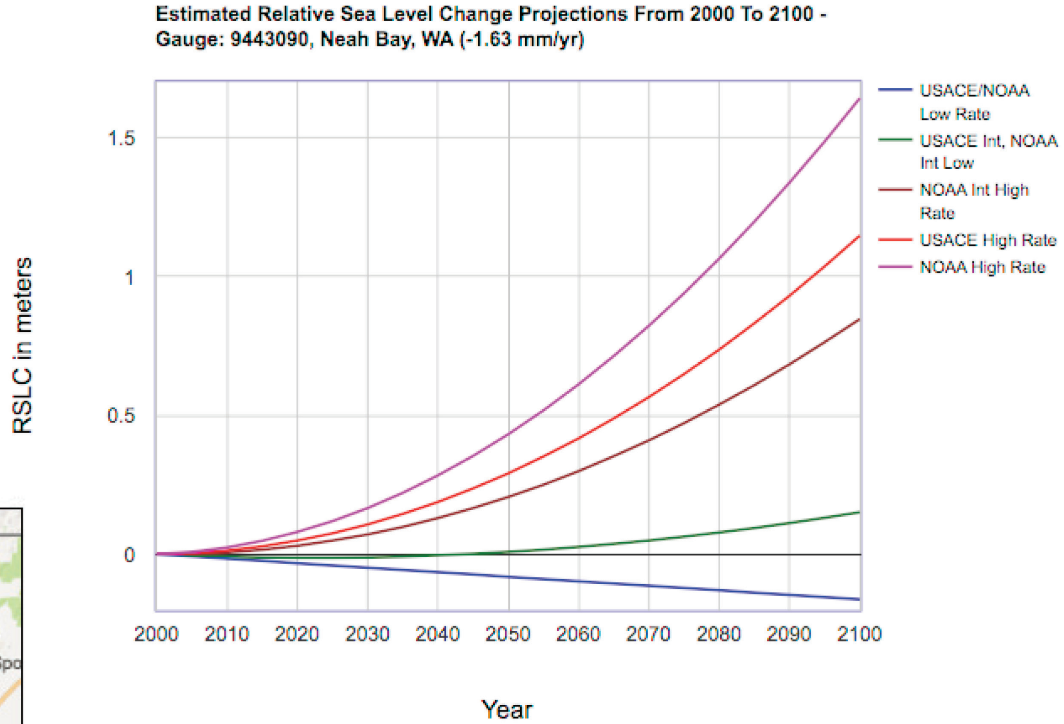
- USACE - Sea-Level Change Curve Calculator (2015.46)

  [Huber and White (2015)]

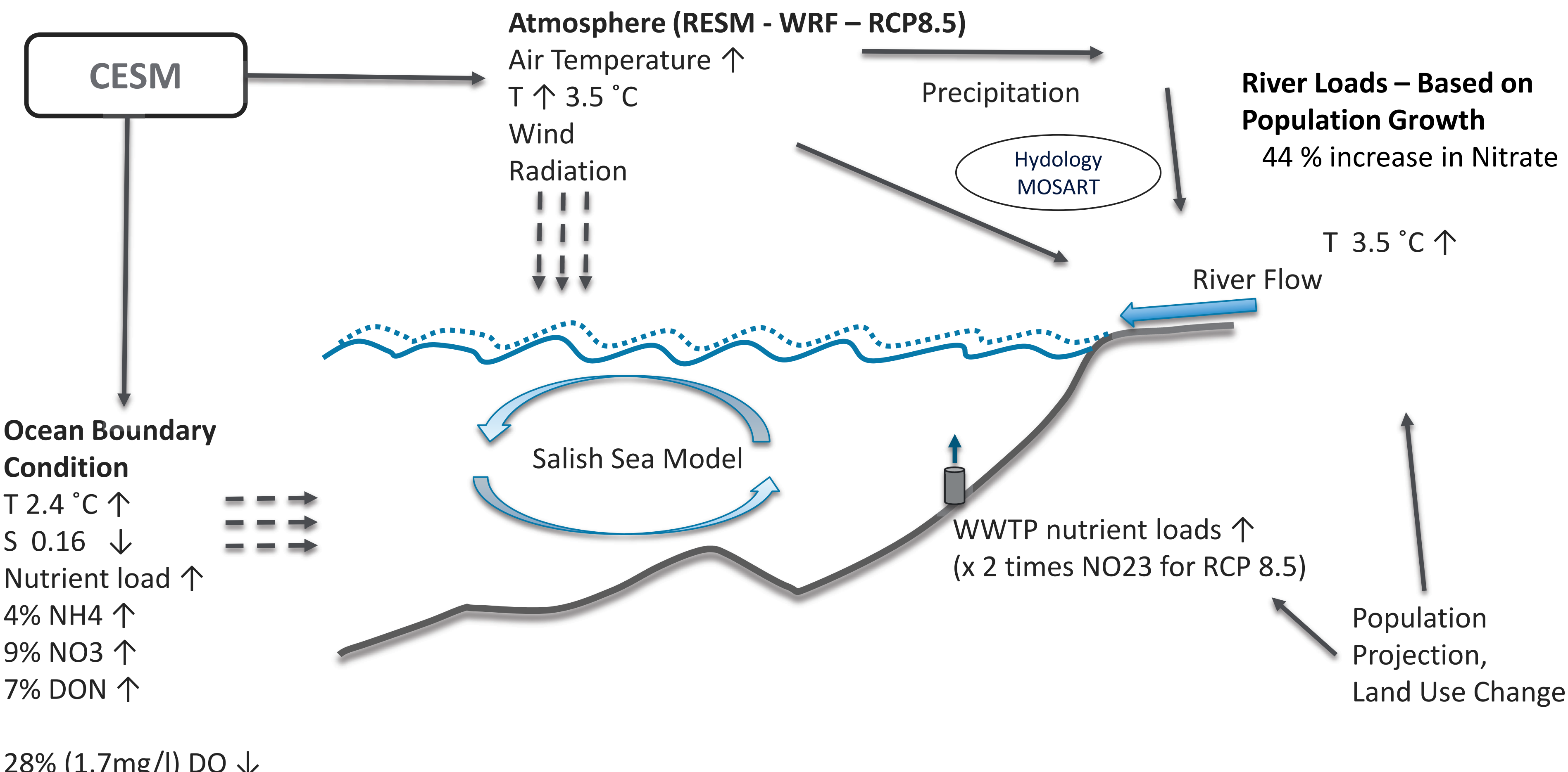
- Year 2095 SLR Prediction
  - 1.5 m (Neah Bay)





http://www.corpsclimate.us/ccaceslcurves.cfm

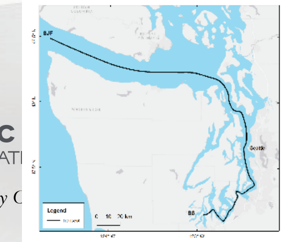
Model Inputs – Historical Y2000 and Future RCP8.5 (Y2095) conditions

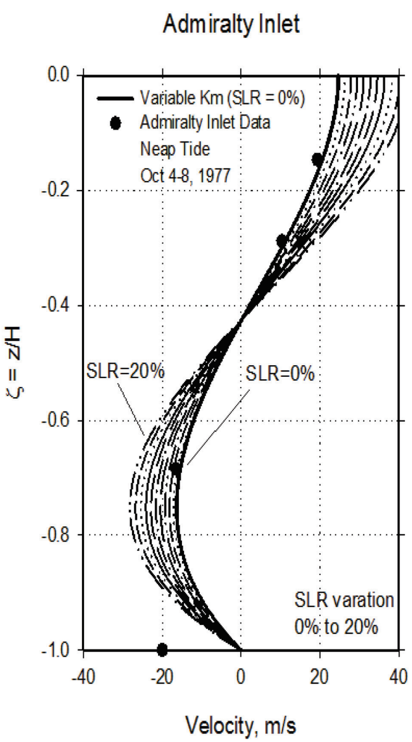


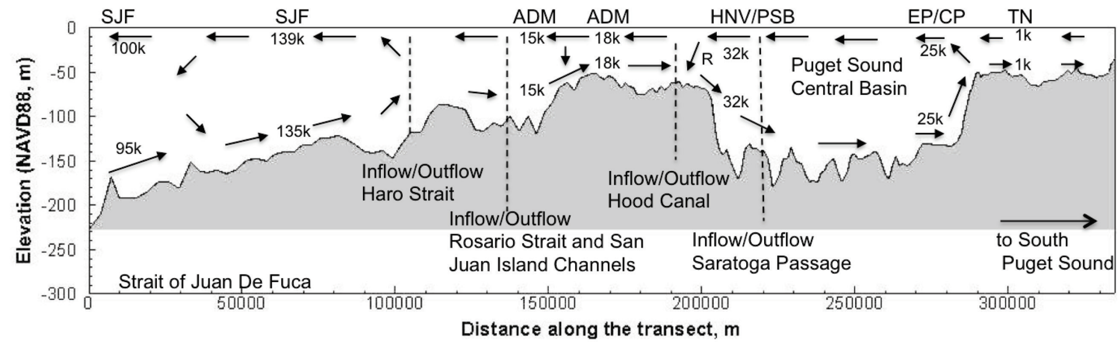
* All labeled numbers are annual averaged values.

MOSART Model - Li et al (2013) Journal of Hydrometeorology
RESM-WRF Model – Gao et al (2014) Geophysical Research Letters

Effect of SLR (1.5 m) and Future Hydrology on Estuarine Exchange flow

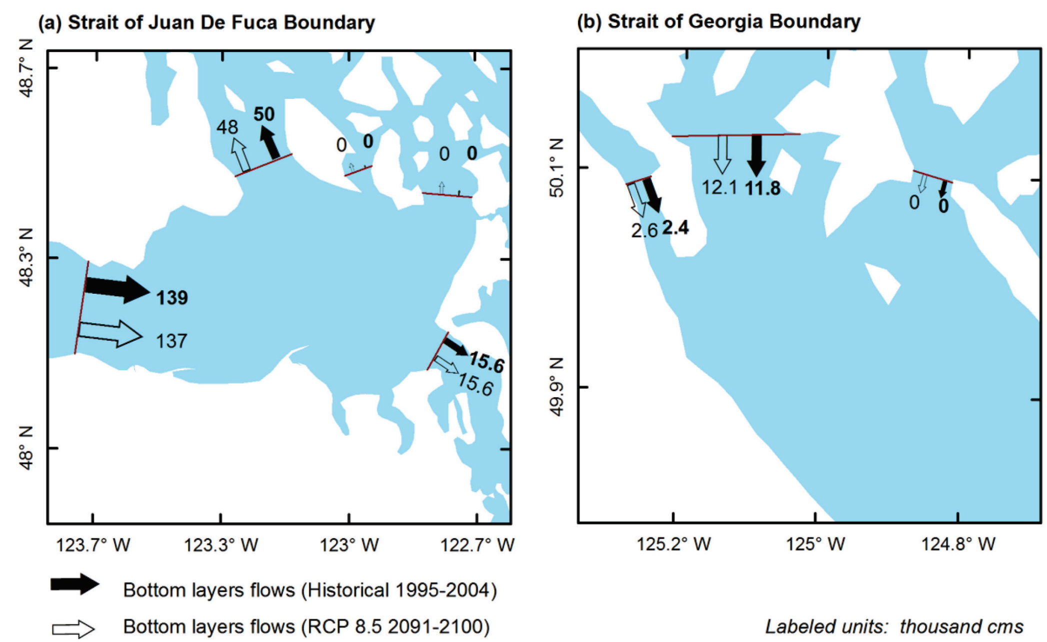






SJF = Strait of Juan De Fuca
ADM = Admiralty Inlet
HARO = Haro Strait
R = Reflux Flow at Admiralty Sill (estimated at 19 k, ≈ 60% of surface outflow)

HNV/PSB = Hansville, Puget Sound
EP/CP = East Passage / Colvos Passage
TN = Tacoma Narrows



- $\Delta H \approx +1.3\%$
- $\Delta Q \approx -4.5\%$
- ΔS_{obc}= -0.16 psu (ave)
  =- 0.5 psu (surf)

Annual mean sea surface T & S Difference

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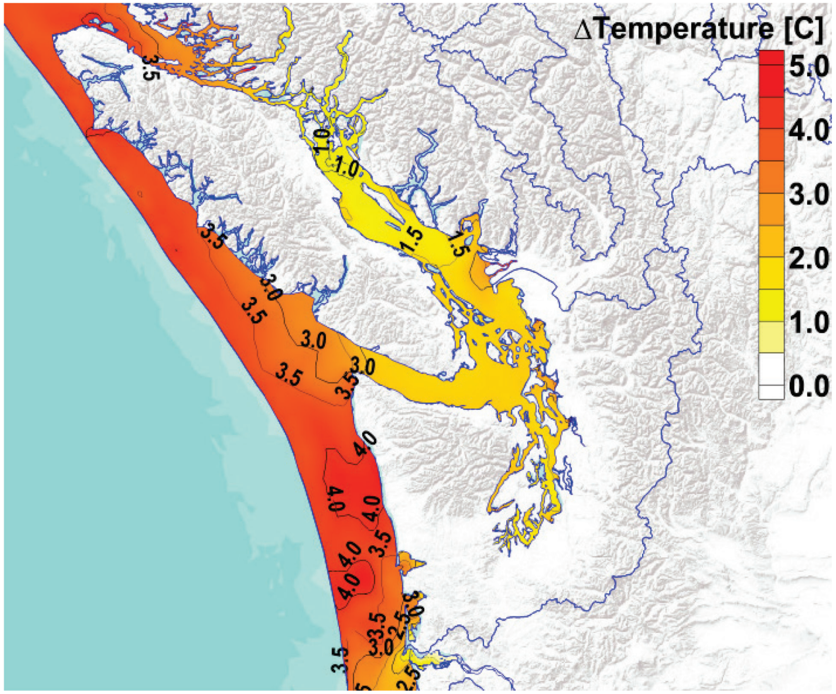
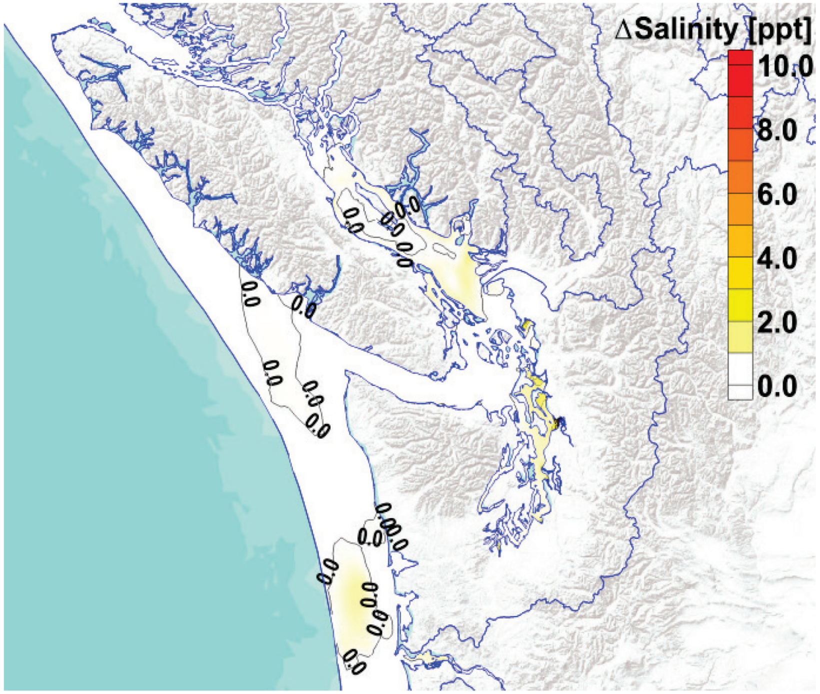
RCP 8.5 (2095) - Historical (2000)



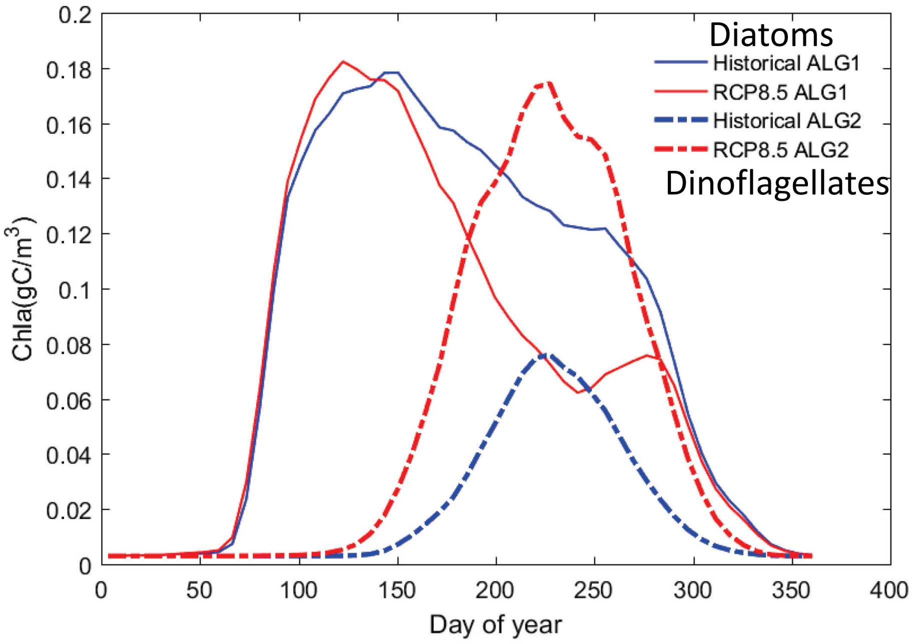
RCP 8.5 (2095) - Historical (2000)

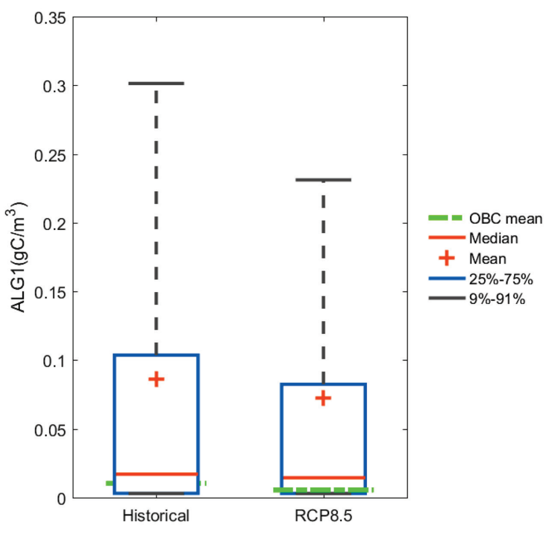


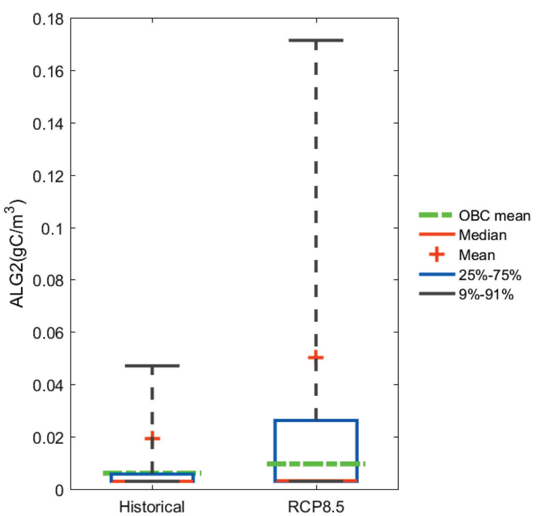
Salish Sea-wide impact: Algae species change

Salish Sea-wide Chlorophyll *a* concentration time series.

- Algae species change - Historical (2000) vs and RCP8.5 Future (2095)







Salish Sea-wide Impact: pH

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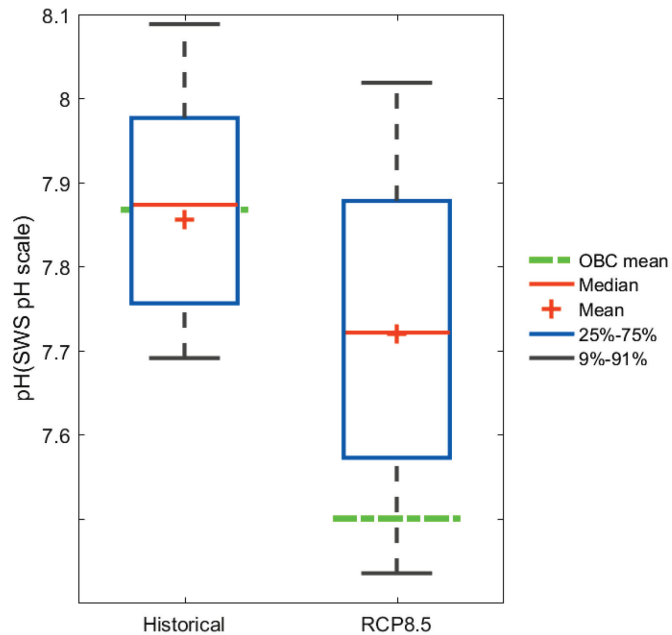
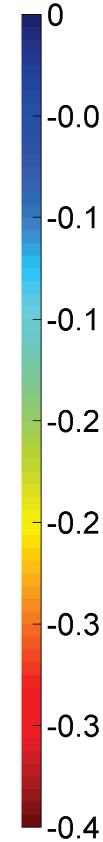
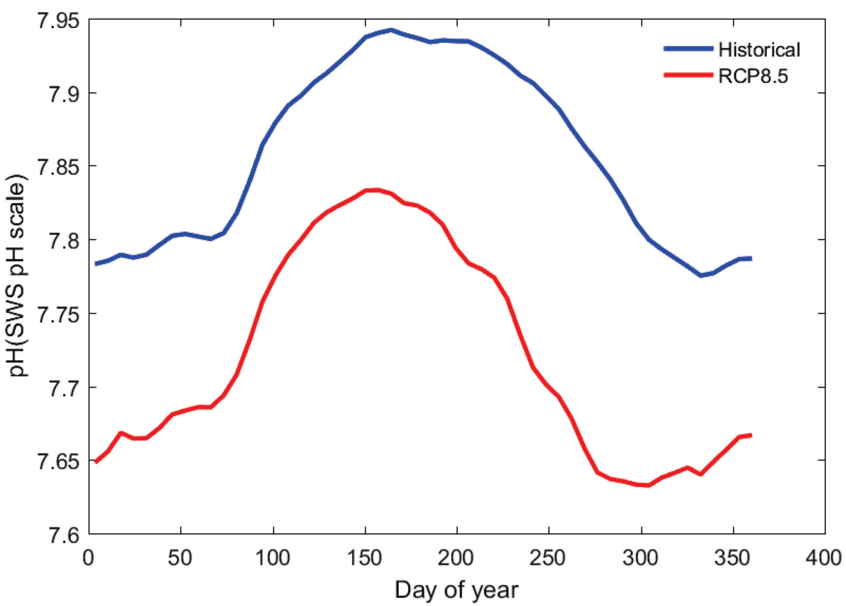
Historical (2000) - RCP8.5 Future (2095)

- Salish Sea-wide future pH reduction = **0.13** units





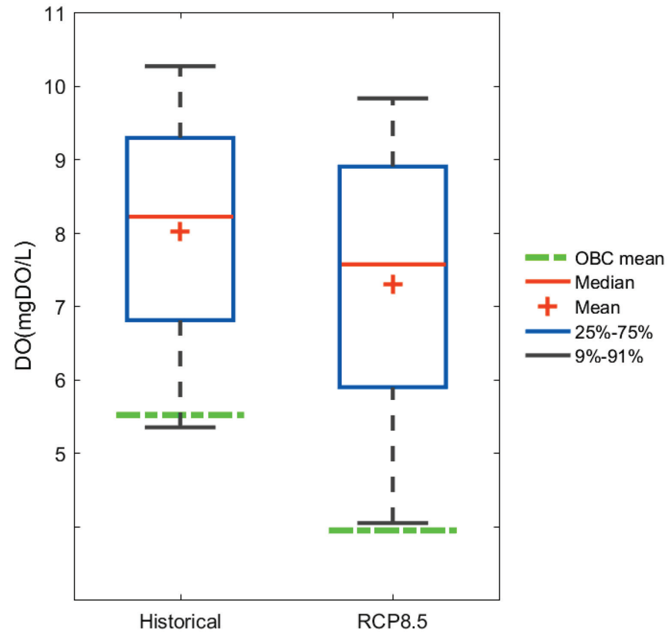
Salish Sea-wide mean pH

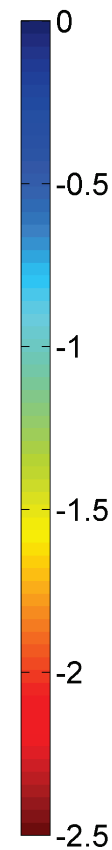


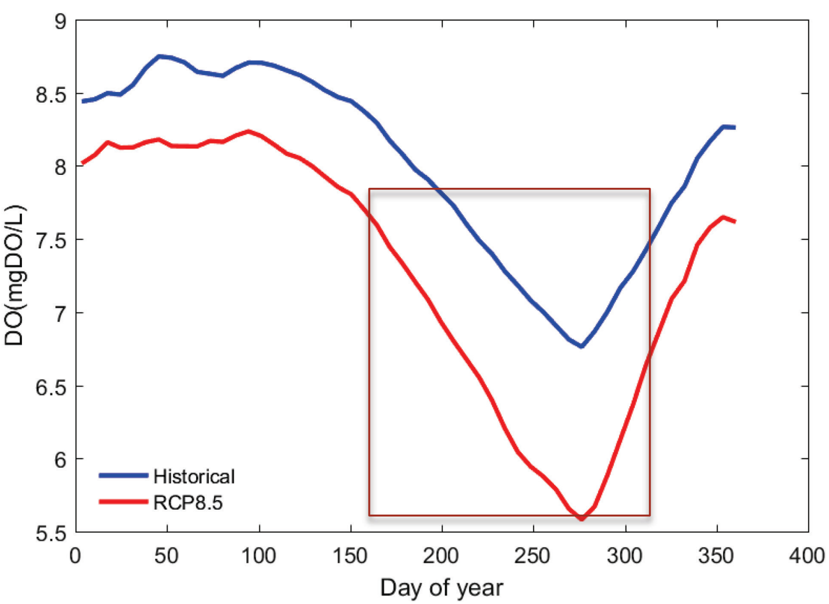
Salish Sea-wide impact: DO

Historical (2000) - RCP8.5 Future (2095)

- Boundary DO reduction = 1.7 mg/L
- Salish Sea-wide DO reduction = **0.7** mg/L







Average DO depletion ≈1.5 mg/l in late summer

Salish Sea Hypoxia Zones (Bottom DO < 2 mg/l)

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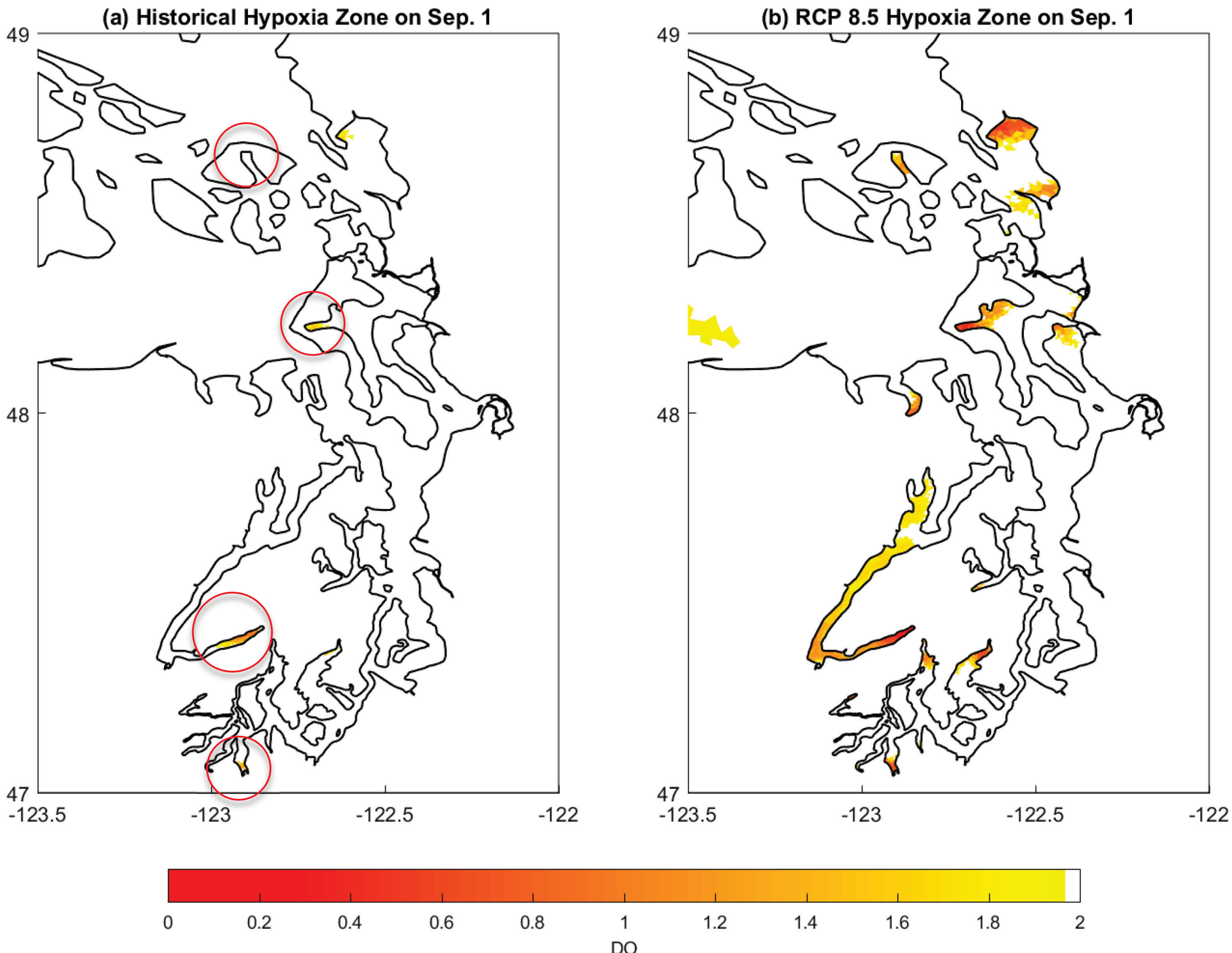
Hypoxic Zone: increase from 0.6% (Historical) to 16.9% (RCP8.5) of Salish Sea Area



Intertidal response in Snohomish Estuary

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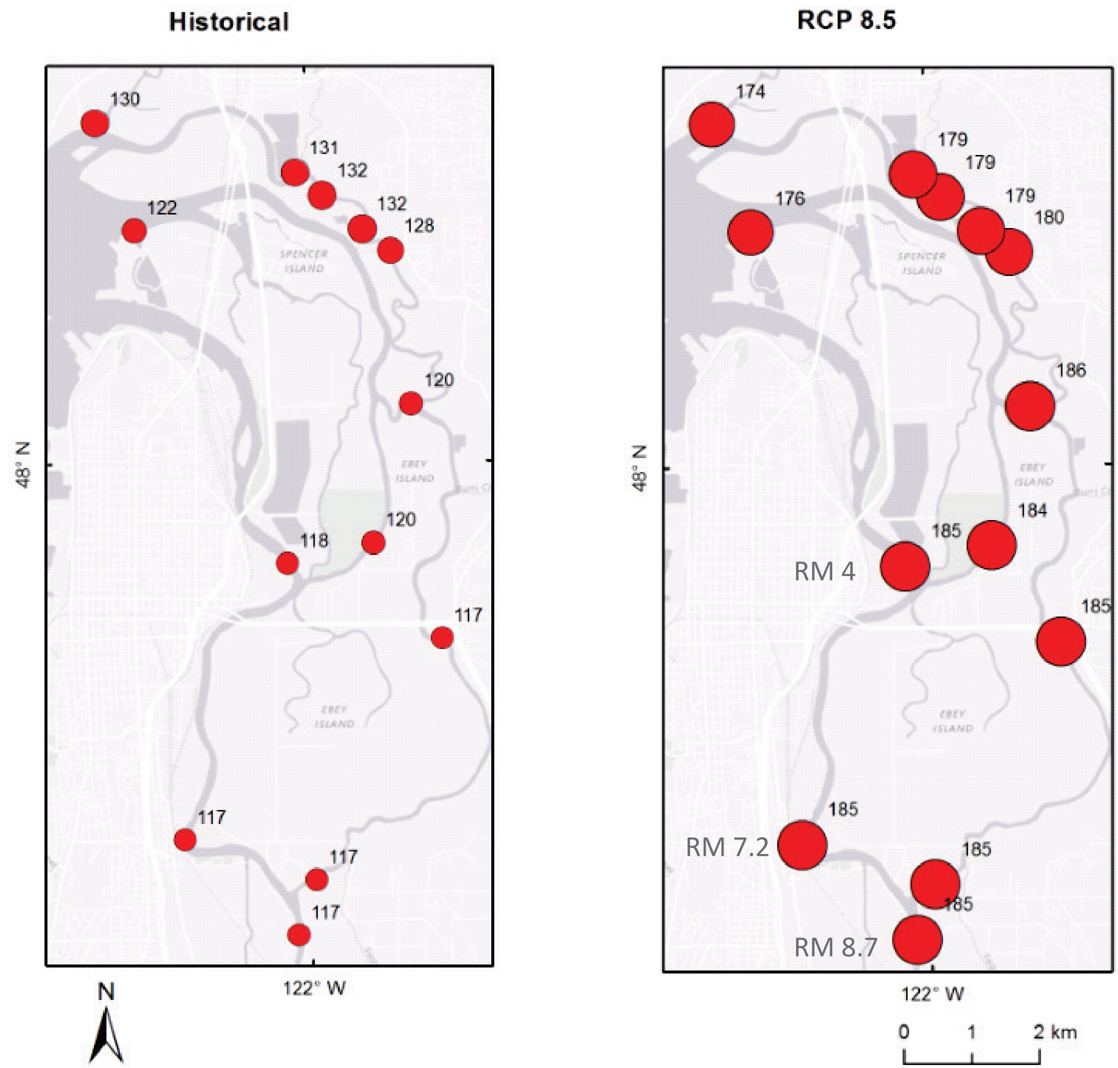
Number of days with mean temperature above 13 ˚C



Intertidal response in Snohomish Estuary

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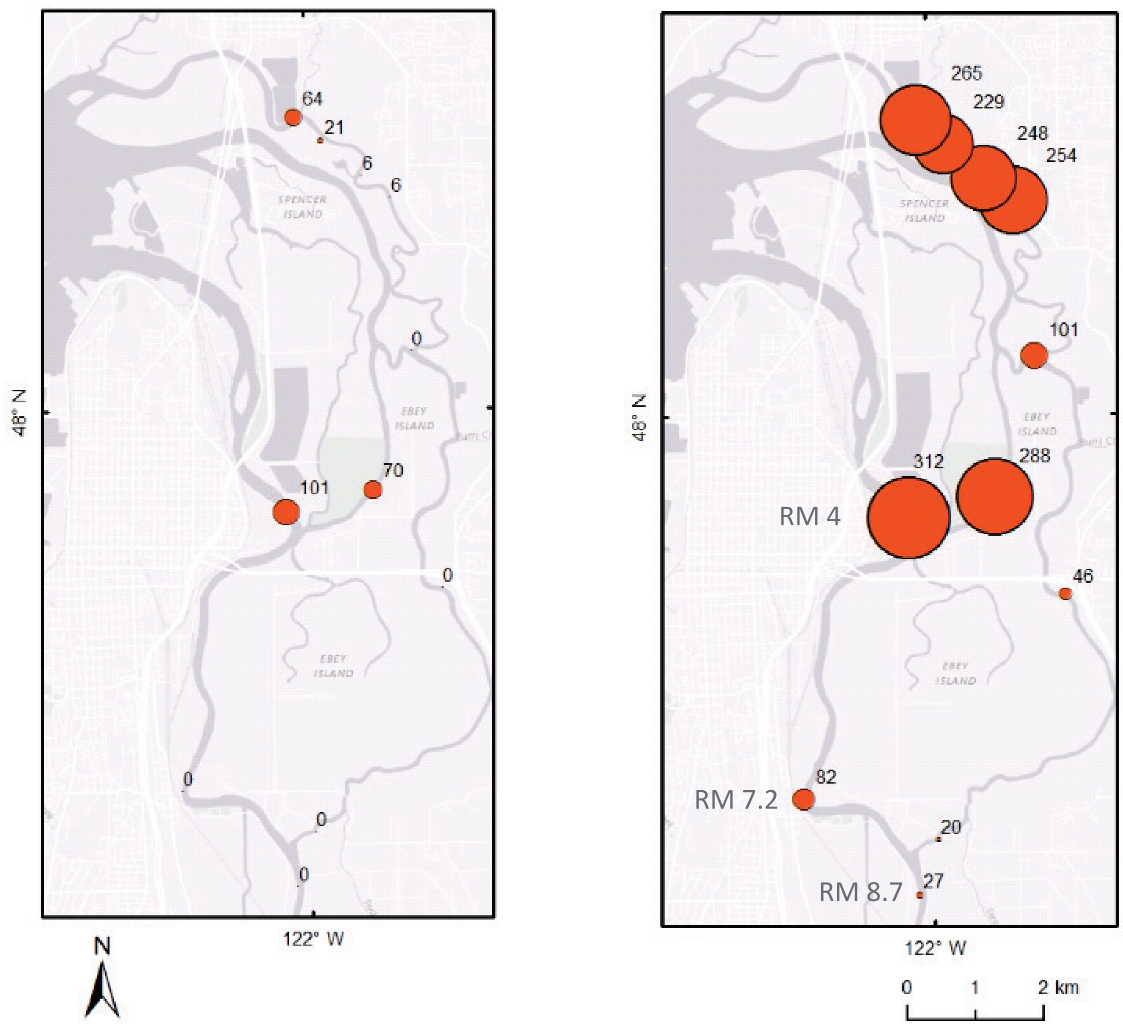
Number of days with maximum salinity above 5 psu

Historical | **RCP 8.5**



Summary

- Strong vertical circulation mitigates climate change impacts in *Salish Sea*
- Overall circulation is relatively unaffected
  - Effect of SLR counteracted by reduction in salinity gradient
- Overall warming of *Salish Sea* expected
  - ΔT = 1.8 ˚C, dominated by global ocean warming
- Higher temperatures will cause algal species shift
  - dinoflagellates increase of 108% ↑; diatom 16% ↓ .
- DO depletion in the future (RCP8.5 - Y2095):
  - Mean DO is expected to decrease by 0.7 mg/l
  - Maximum area of hypoxia (DO<2mg/l) can reach 17% of Salish Sea
- pH level decrease (acidification) in the future
  - Mean pH reduction of 0.13 units
- Intertidal habitat shifts
  - Mean surface temperature increases up to 3 ˚C
  - Salinity intrusion extend to RM 11 (versus RM 4 in Historical – Y2000)