POC 19266

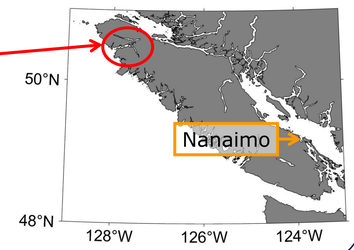
Development of a coupled physical-biogeochemical model of a mid-latitude fjord on Vancouver Island



Kyoko Ohashi and Laura Bianucci
Fisheries and Oceans Canada, Institute of Ocean Sciences, Sidney, BC, Canada

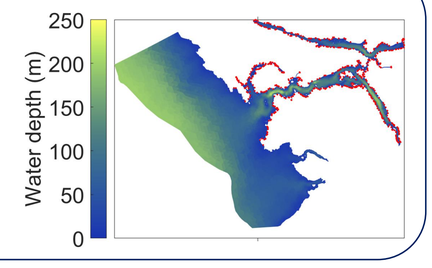
1. Study area: Quatsino Sound

- Fjord system on Pacific coast of northern Vancouver Island
- Home to Quatsino First Nation
- Site of salmon farms run by Mowi Canada West



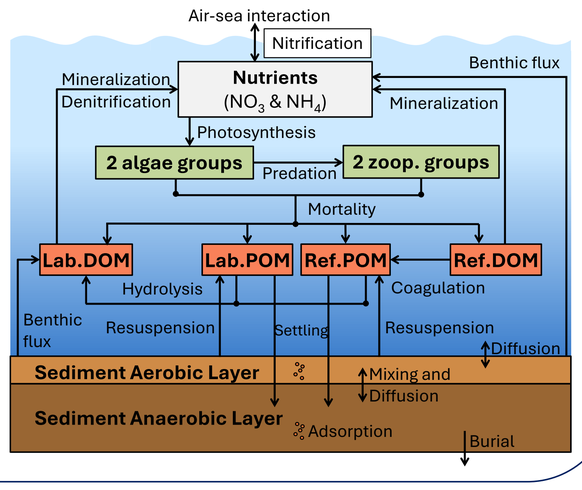
2. Hydrodynamic Model

- **FVCOM** (*Finite Volume Community Ocean Model*; Chen *et al.*, 2003) ver. 5
- 181,696 triangular elements (~10–800 m resolution)
- 20 terrain-following layers
- River discharge specified at ~580 nodes (red dots)
- Model setup & inputs follow Rutherford *et al.* (2024)

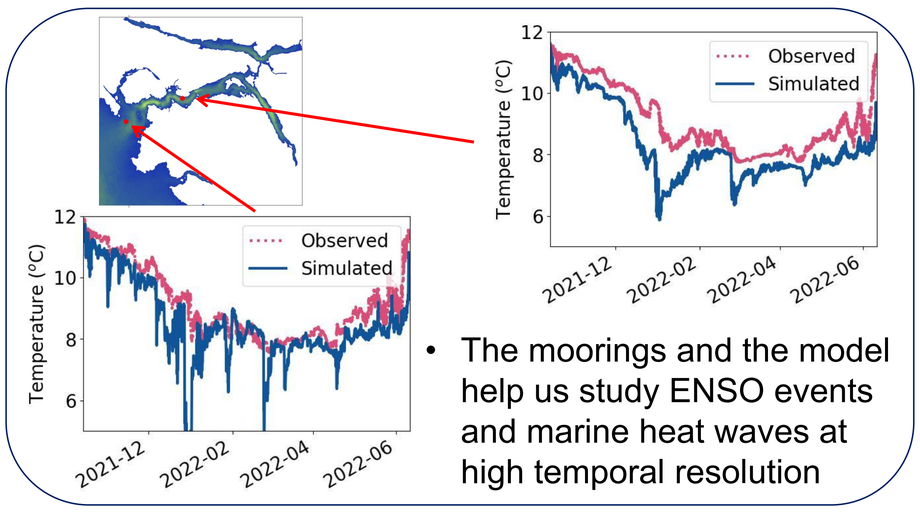


3. Biogeochemical Model

- **FVCOM-ICM** (*Integrated Compartment Water Quality Model*; Kim & Khangaonkar, 2012; Bianucci *et al.*, 2018)
- **Initial & lateral boundary conditions:**
  - DO & NO_3: NEP36-CanOE output (1/36° grid; Holdsworth *et al*., 2021)
  - Other variables: observation-based values or trace level
- **Riverine input:**
  - DO: Saturation value (*i.e.*, based on river temperature)
  - Other variables: observation-based values or zero/trace
- Offline coupling with hydrodynamic model



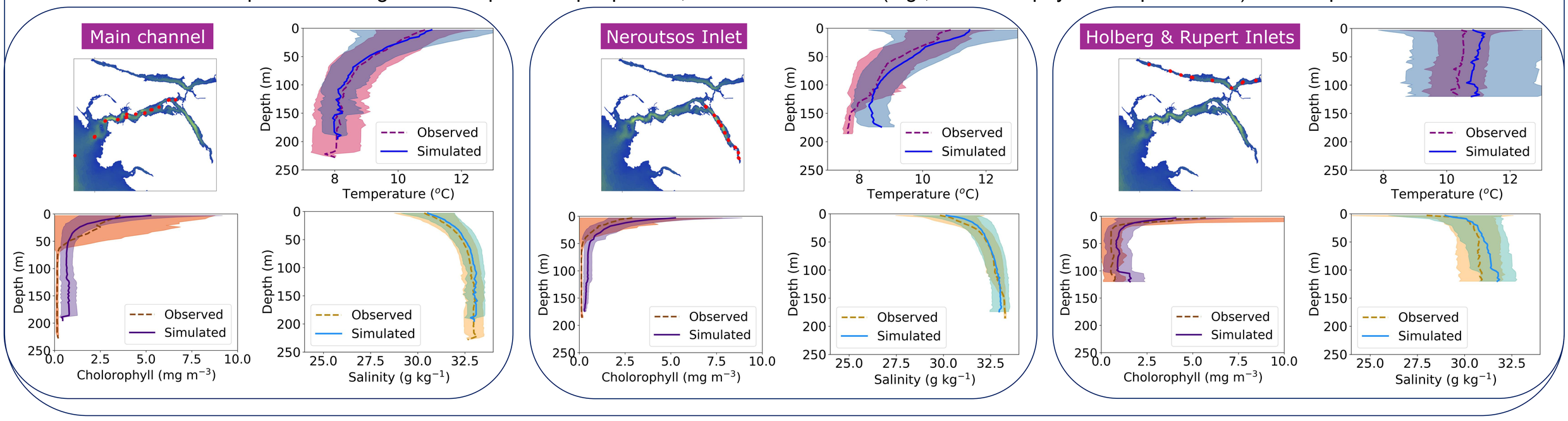
4. Model validation (1): Comparisons to observations at moored CTDs (40-m depth)



- The moorings and the model help us study ENSO events and marine heat waves at high temporal resolution

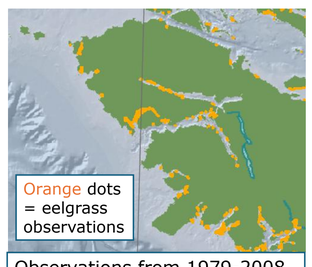
5. Model validation (2): Comparisons to observations along transects

- Model results are compared to CTD observations (made at 1-2 month intervals) using depth profiles of averages (lines) and standard deviations (shaded areas) for 2021/11/01 – 2022/10/31
- The model reproduces the general shapes of depth profiles, but certain features (*e.g.*, low chlorophyll in deeper waters) need improvement

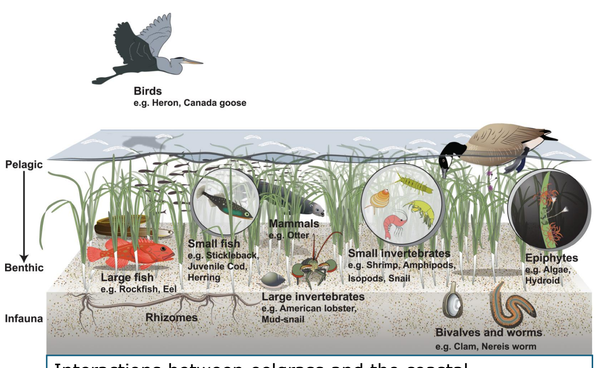


5. What can we do with this model?

- The BGC model has a Submerged Aquatic Vegetation (SAV) module (Khangonkar *et al.*, 2021)
- The SAV module can be used to simulate eelgrass (*Zostera marina*) beds
- Eelgrass is:
  - A traditional source of food and materials for Indigenous Peoples on Vancouver Island
  - A source of habitat for many aquatic species, including juvenile Pacific salmon (Eriksson & Clowater-Eriksson, 2026)
- Eelgrass covered an area of about 460 ha within Quatsino Sound in the early 2000's (BC Ministry of Sustainable Resource Management & Fisheries and Oceans Canada, 2004)
- Eelgrass coverage along the British Columbia coast is declining (e.g., by ~45% between 1932 and 2016 in an area of southern Vancouver Island (Nahirnick *et al.*, 2020)).



Observations from 1979-2008 (BC Marine Conservation Analysis, 2010 & 2013)



Interactions between eelgrass and the coastal environment (© Sylvia Heredia via Murphy *et al.* (2021))

Acknowledgements

This study was funded by Fisheries and Oceans Canada's Competitive Science Research Fund. We are grateful for the help received from our collaborators at the Quatsino First Nation, Mowi Canada West, and Fisheries and Oceans Canada.

References

Bianucci, L., Long, W., Khangaonkar, T., Pelletier, G., Ahmed, A., Mohamedali, T., Roberts, M., & Figueroa-Kaminsky, C. (2018). Sensitivity of the regional ocean acidification and carbonate system in Puget Sound to ocean and freshwater inputs. *Elem. Sci. Anth.*, 6, 22.

British Columbia Marine Conservation Analysis (2010 & 2013). *Marine Atlas of Pacific Canada*.

British Columbia Ministry of Sustainable Resource Management & Fisheries and Oceans Canada (2004). *Quatsino Sound Coastal Plan*.

Chen, C., Liu, H., Beardsley, R. C. (2003). An unstructured grid, finite-volume, three-dimensional, primitive equations ocean model: Application to coastal ocean and estuaries. *J. Atmos. Ocean. Technol.*, 20(1), 159–186.

Eriksson, A. & Clowter-Eriksson, C. (2026). *Eelgrass state of knowledge for the Salish Sea and west coast Vancouver Island region*. Vancouver, BC: Pacific Salmon Foundation.

Holdsworth, A. M., Zhai, L., Lu, Y., & Christian, J. R. (2021). Future changes in oceanography and biogeochemistry along the Canadian Pacific continental margin. *Front. Mar. Sci.*, 8, 602991.

Khangaonkar, T., Nugraha, A., Premathilake, L, Keister, J., & Borde, A. (2021). Projections of algae, eelgrass, and zooplankton ecological interactions in the inner Salish Sea – for future climate, and altered oceanic states. *Ecol. Model.*, 441, 109420.

Kim, T. & Khangaonkar, T. (2012). An offline unstructured biogeochemical model (UBM) for complex estuarine and coastal environments. *Environmental Software*, 31, 47–63.

Murphy, G. E. P., Dunic, J. C., Adamczyk, E. M., Bittick, S. J., Cote, I. M., Cristiani, J., Geissinger, E. A., Gregory, R. S., Lotze, H. K., O'Connor, M. I., Araujo, C. A. S., Rubidge, E. M., Templeman, N. D., & Wong, M. D. (2021). From coast to coast to coast: ecology and management of seagrass ecosystems across Canada. *FACETS* 6: 139–179.

Nahirnick, N. K., Costa, M., Schroeder, S., & Sharma, T. (2020). Long-term eelgrass habitat change and associate human impacts on the west coast of Canada. *J. Coast. Res.*, 36(1), 30–40.

Rutherford, K., Bianucci, L., & Floyd, W. (2024). A simple approach to represent precipitation-derived freshwater fluxes into nearshore ocean models: an FVCOM4.1 study of Quatsino Sound, British Columbia. *Geosci. Model Dev.*, 17, 6083-6104.