A coupled physical-biogeochemical FVCOM model for the Discovery Islands

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[2] also Simon Fraser University

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Outline

- The Discovery Islands region and motivation
- Description of the model:
  - Physics
  - Biogeochemistry
  - How do we represent ungauged rivers?
- Preliminary model validation
- Future work

Discovery Islands Region

- Productive area for aquaculture in British Columbia, Canada

2016 Marine Finfish Aquaculture in BC

2016 Shellfish Aquaculture in BC

Maps source: http://www.dfo-mpo.gc.ca/aquaculture/bc-cb/maps-cartes-eng.html

Discovery Islands Region

- Productive area for aquaculture in British Columbia, Canada
- **Hydrodynamic ocean models** have been applied to address aquaculture issues in the region

PLOS ONE

RESEARCH ARTICLE

Modelling Infectious Hematopoietic Necrosis Virus Dispersion from Marine Salmon Farms in the Discovery Islands, British Columbia, Canada

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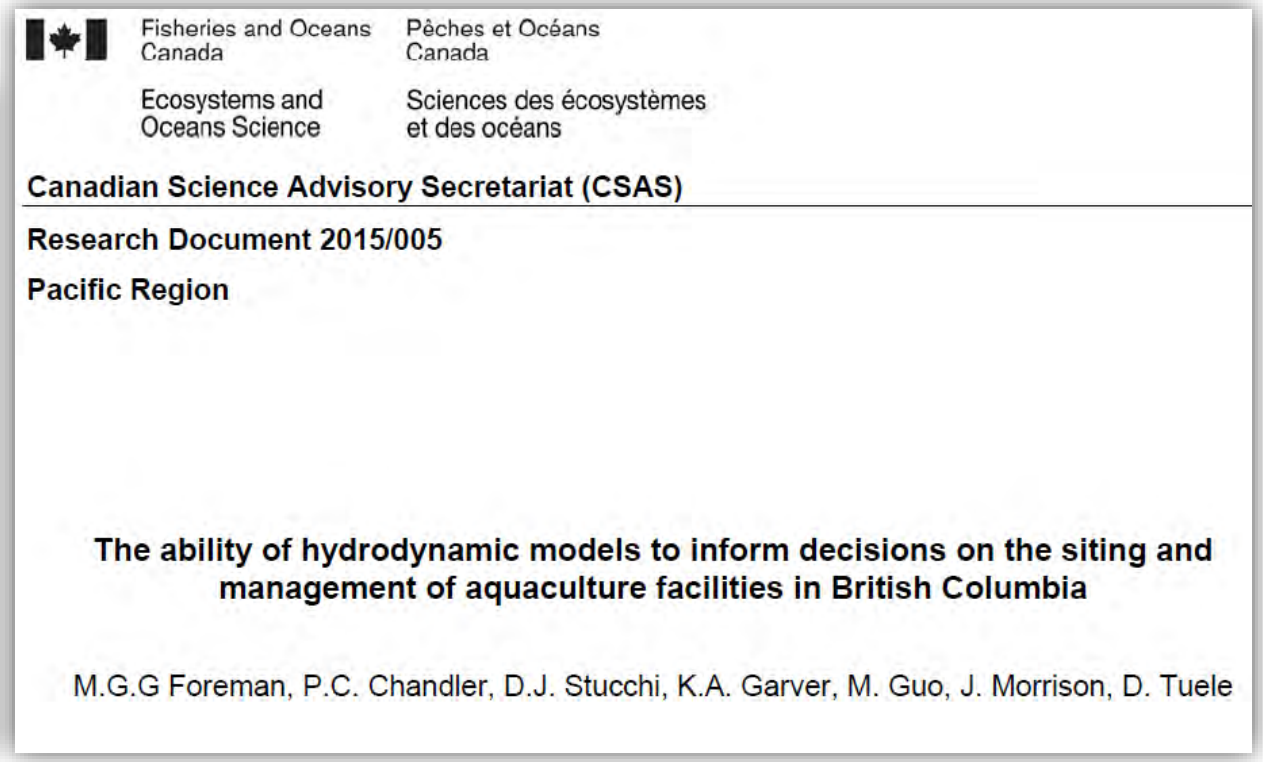
2015



Fisheries and Oceans Canada / Pêches et Océans Canada

Ecosystems and Oceans Science / Sciences des écosystèmes et des océans

Canadian Science Advisory Secretariat (CSAS)

Research Document 2015/005

Pacific Region

The ability of hydrodynamic models to inform decisions on the siting and management of aquaculture facilities in British Columbia

M.G.G Foreman, P.C. Chandler, D.J. Stucchi, K.A. Garver, M. Guo, J. Morrison, D. Tuele

Discovery Islands Region

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- **Hydrodynamic ocean models** have been applied to address aquaculture issues in the region
- **Biogeochemical ocean modules** are also of interest

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Mortality Events in Finfish Farms (2017)

Table 1. Event-based Report – Mortality Events, 2017

Number of Events	Type and Number of Reported Mortality Events
40	Harmful algae (7) Low dissolved oxygen (20) Environmental (3) Handling (4) Predation (2) Health Management Treatment (4)

From "Regulating and Monitoring BC's Marine Finfish Aquaculture Facilities", DFO, 2017

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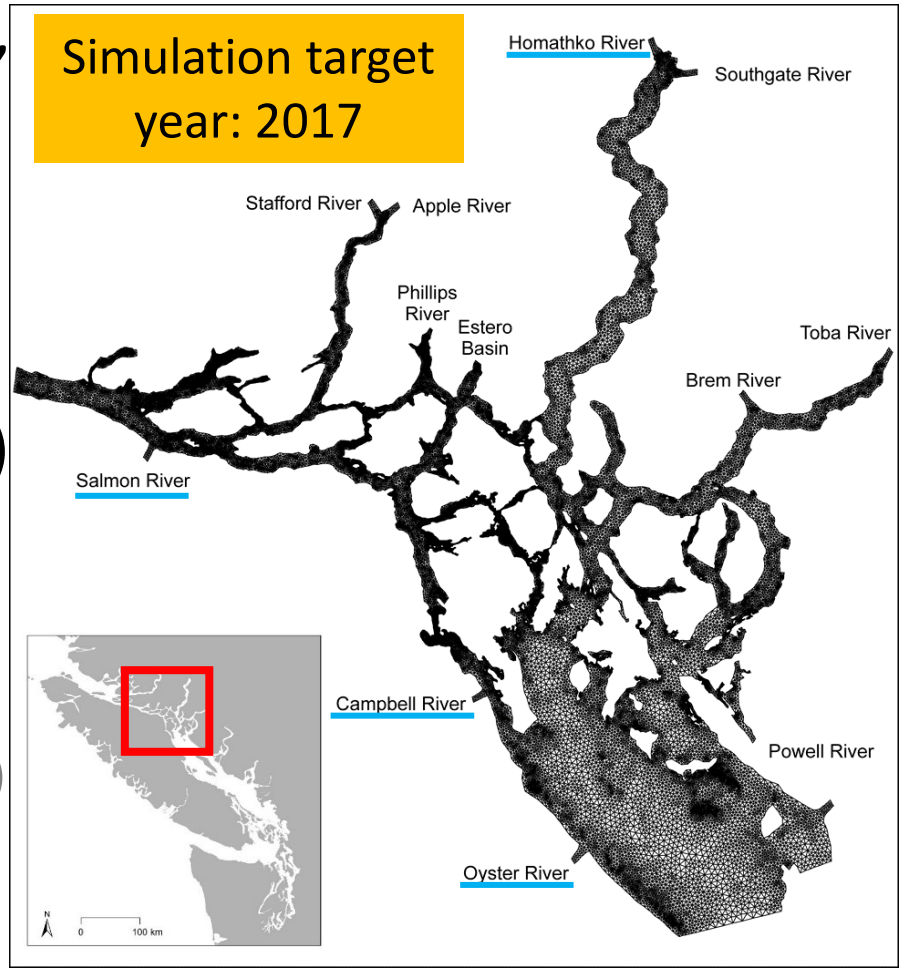
Program for Aquaculture Regulatory Research (PARR) project:

Develop a **coupled physical-biogeochemical model** of the Discovery Islands to

- understand the key drivers of dissolved oxygen
- how these drivers may change along with climate

Physical Model: FVCOM

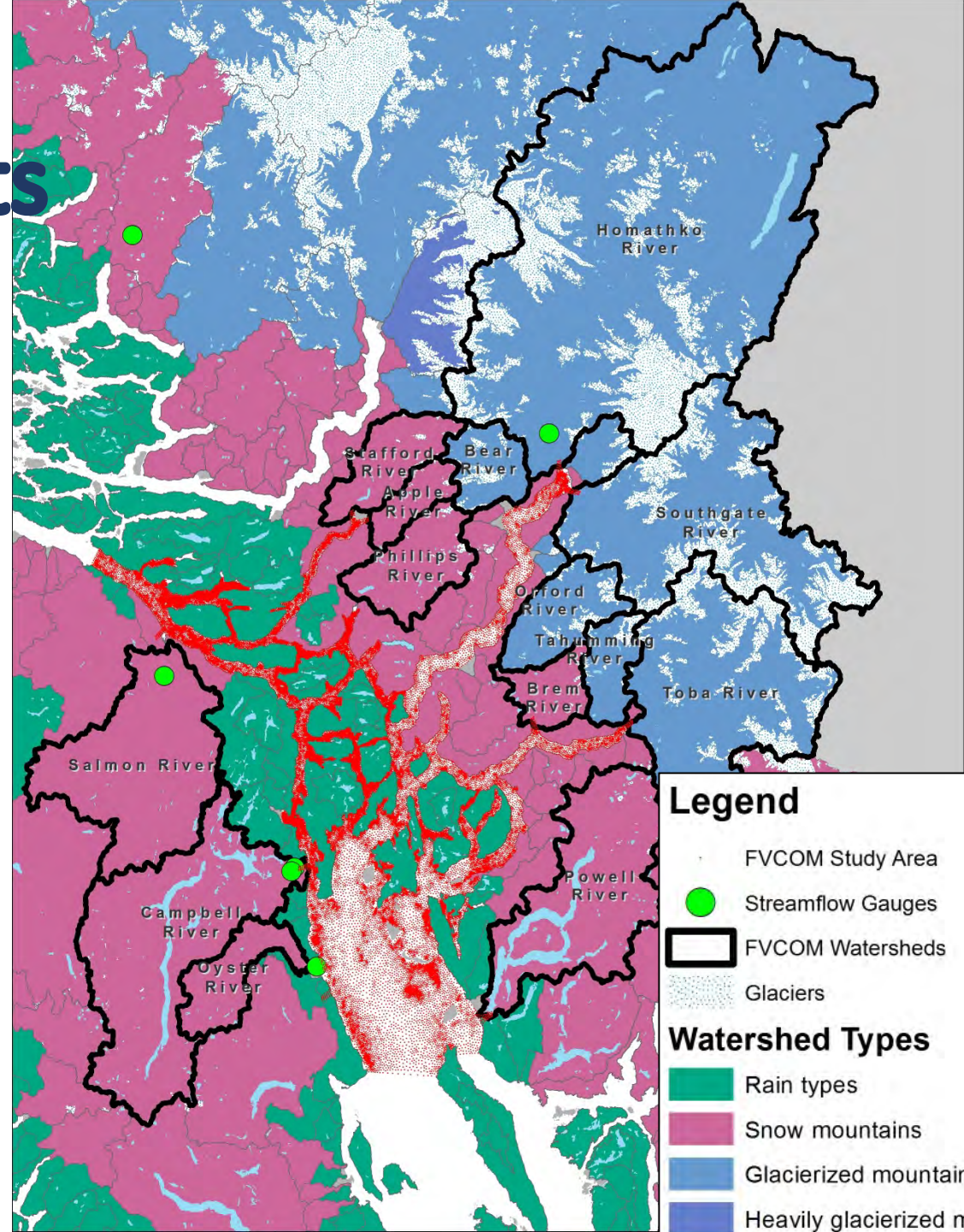
- **F**inite **V**olume **C**ommunity **O**cean **M**odel, v4.1 *(Chen et al. 2006)*
- Unstructured triangular grid (from 90 m to 1.7 km, ~35K nodes)
- 20 terrain-following sigma levels
- Winds and surface fluxes: **H**igh **R**esolution **D**eterministic **P**rediction **S**ystem (2.5 km, *1 km soon?*)
- Tides: 5 constituents (M2, S2, N2, K1 and O1)
- Initial, open boundary conditions: SalishSeaCast *(Soontiens et al. 2016)*
- Rivers: 12 (only 4 are gauged).



Physical Model: River Inputs

Approach to represent flow from ungauged rivers:

- Characterize watersheds types



(Giesbrecht et al. in prep)

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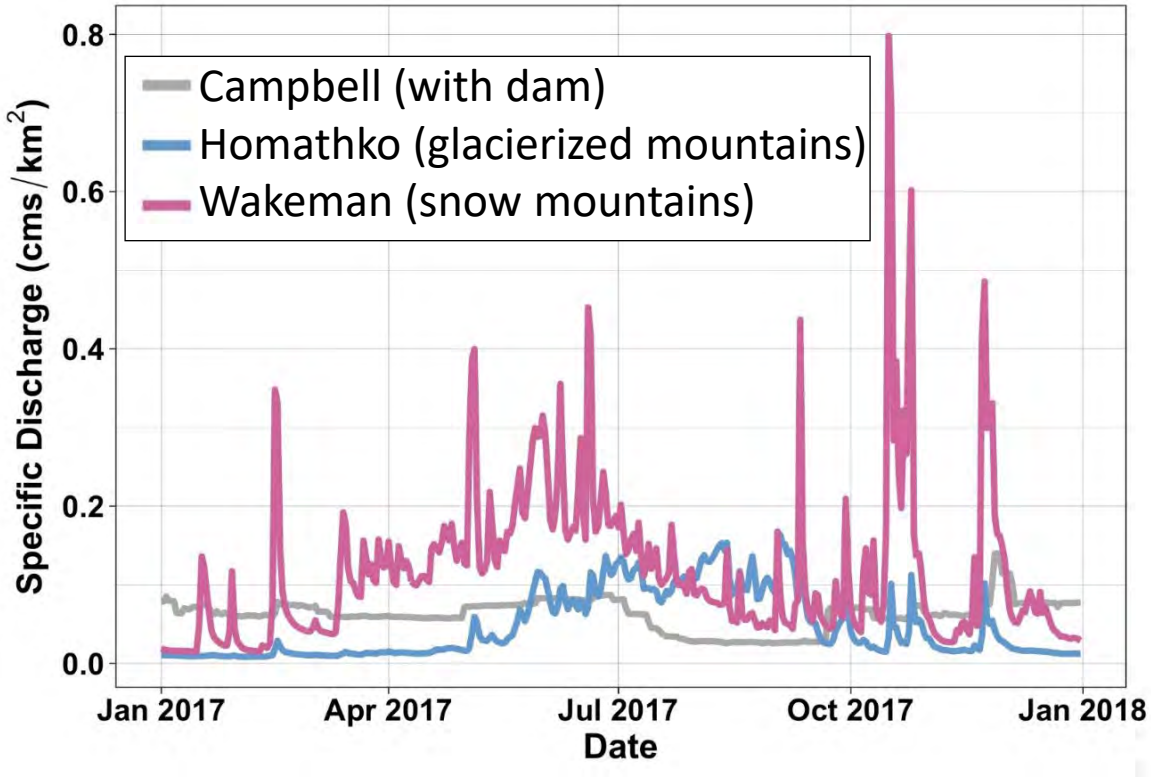

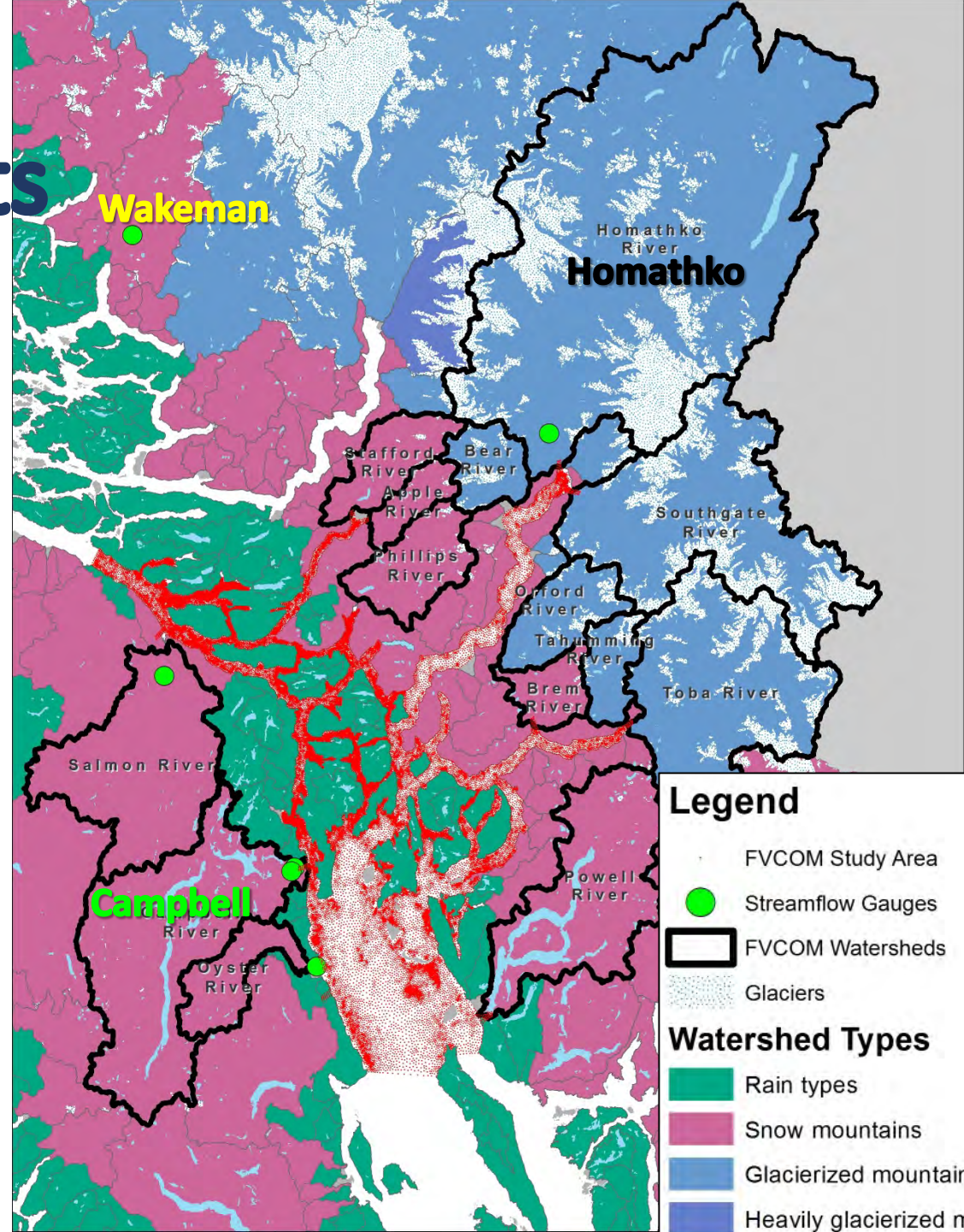

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Approach to represent flow from ungauged rivers:

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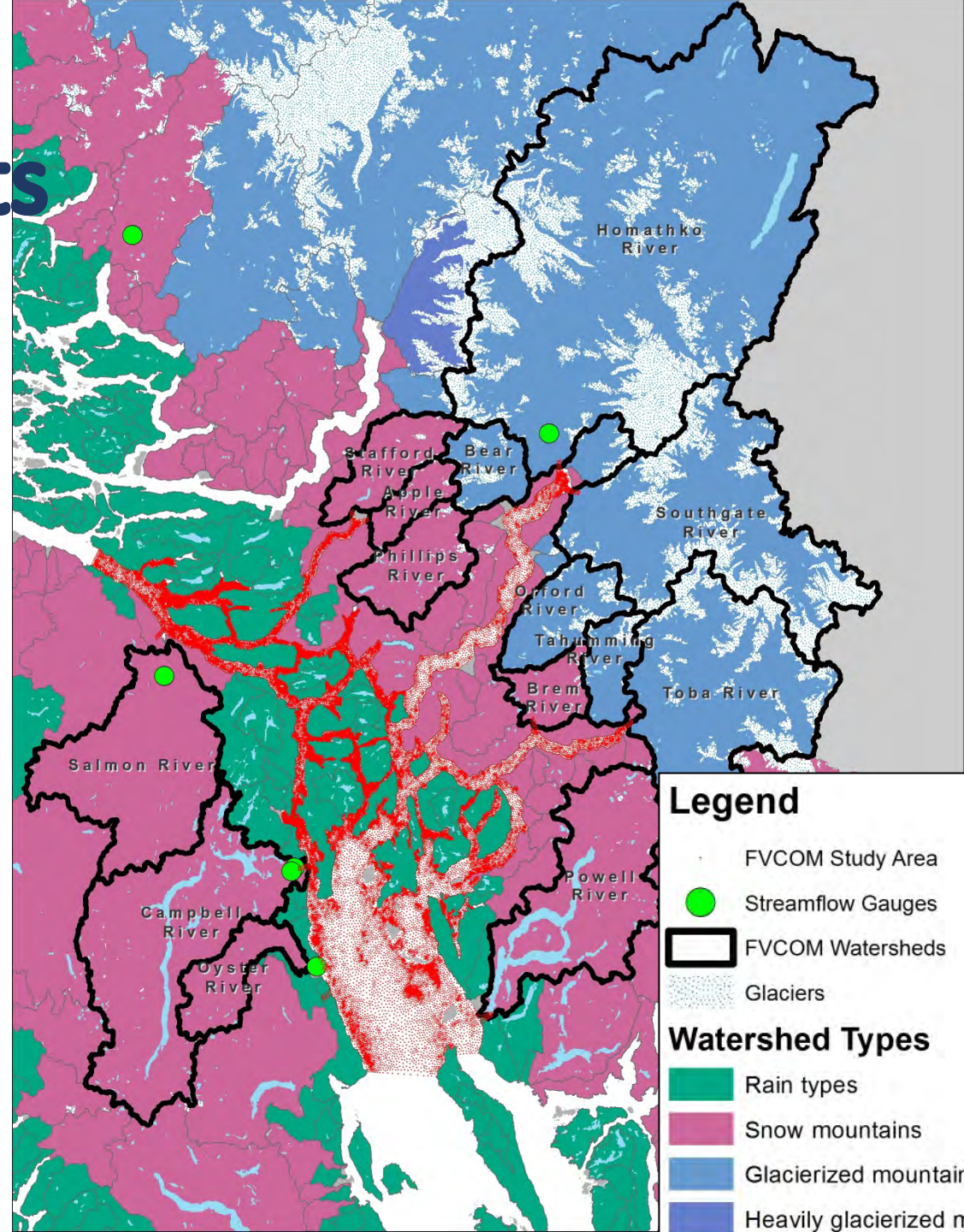

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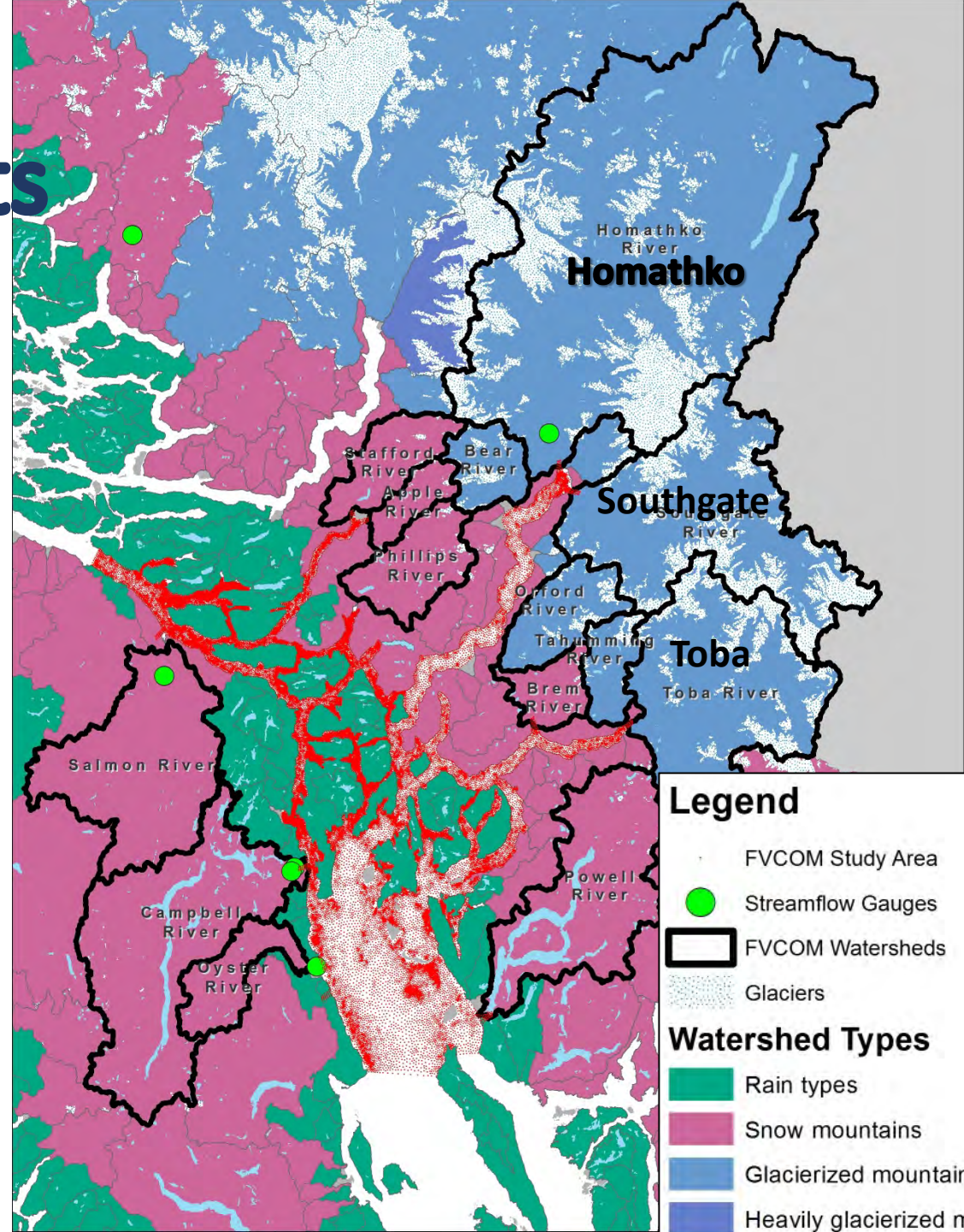

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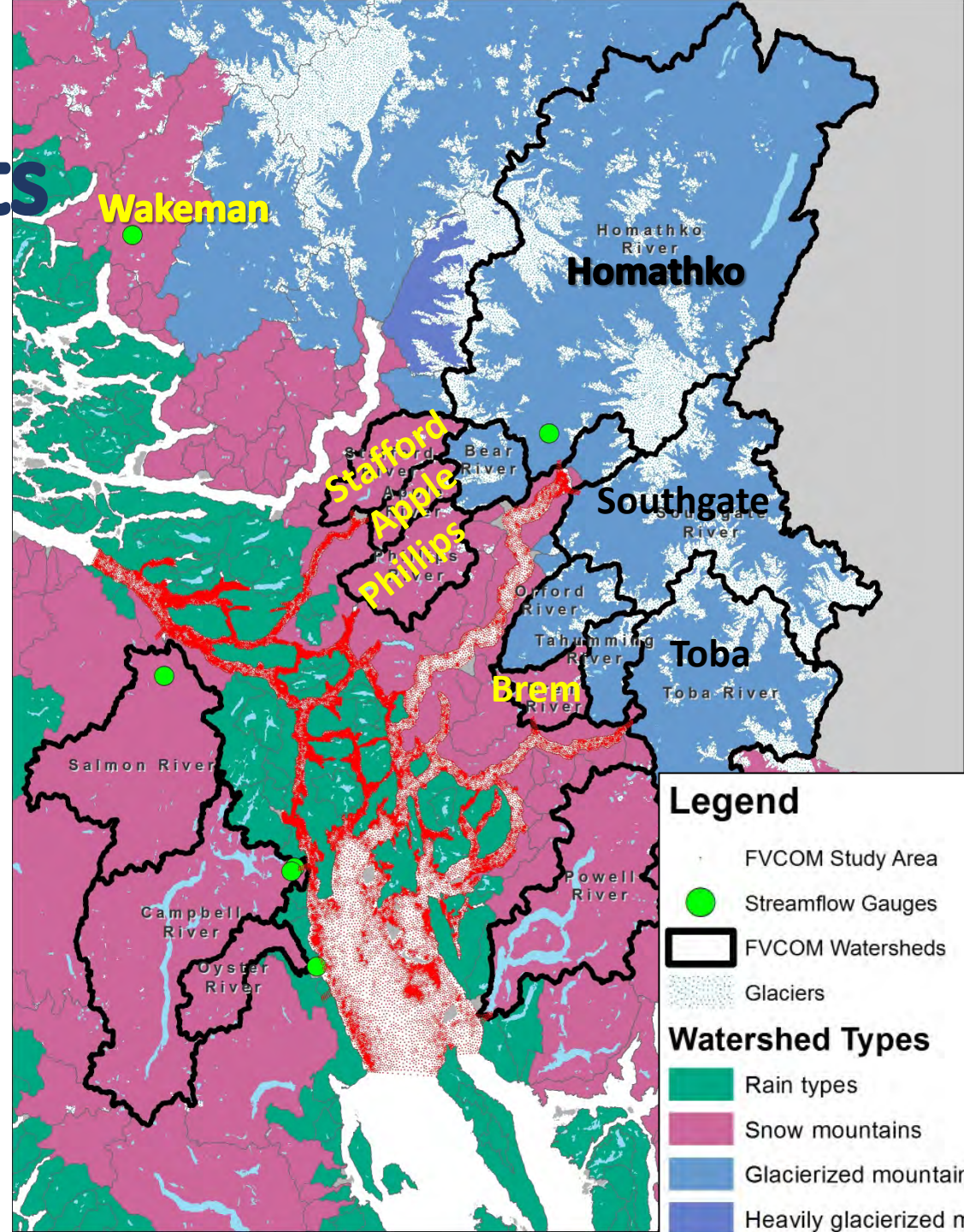

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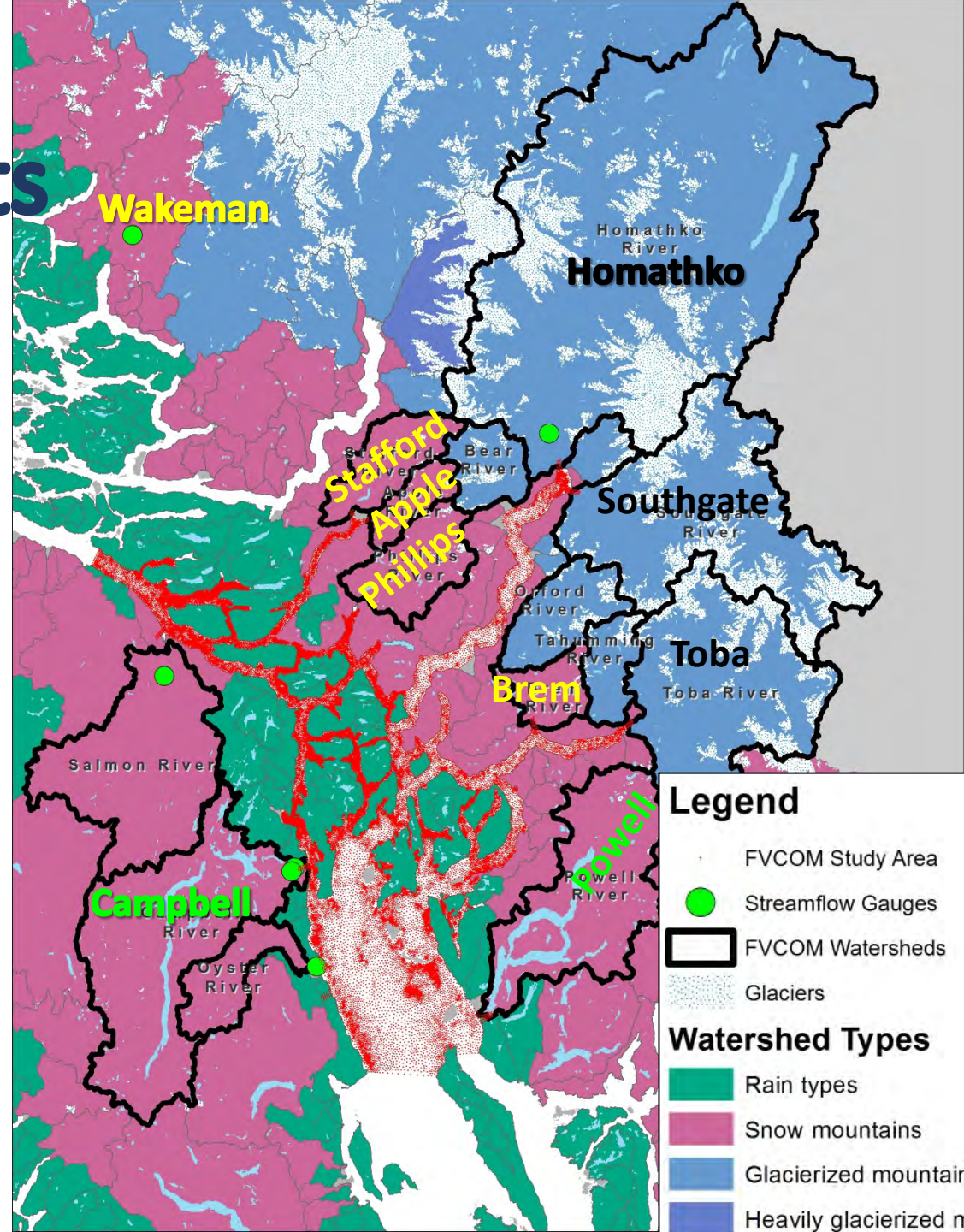

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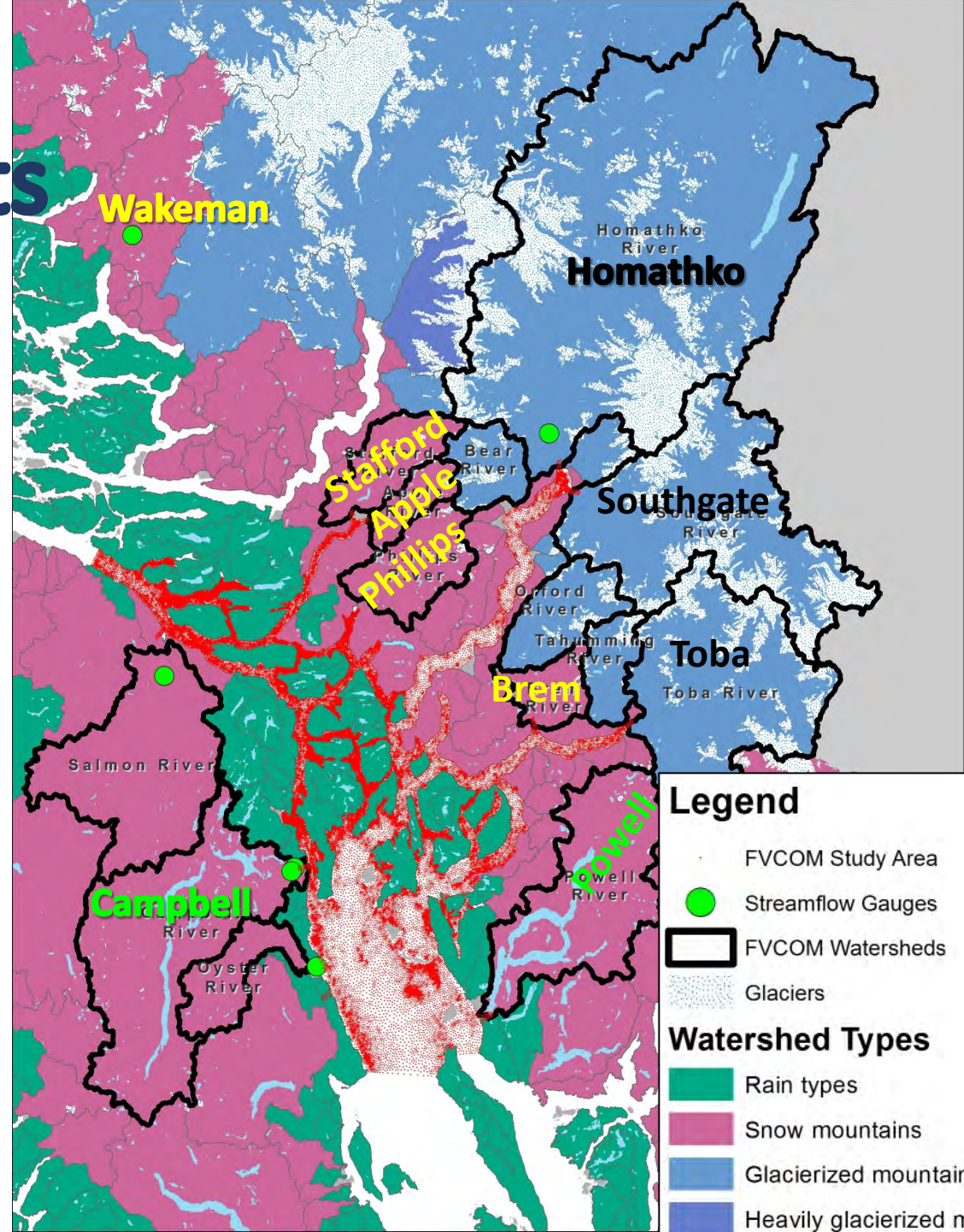
(Giesbrecht et al. in prep)



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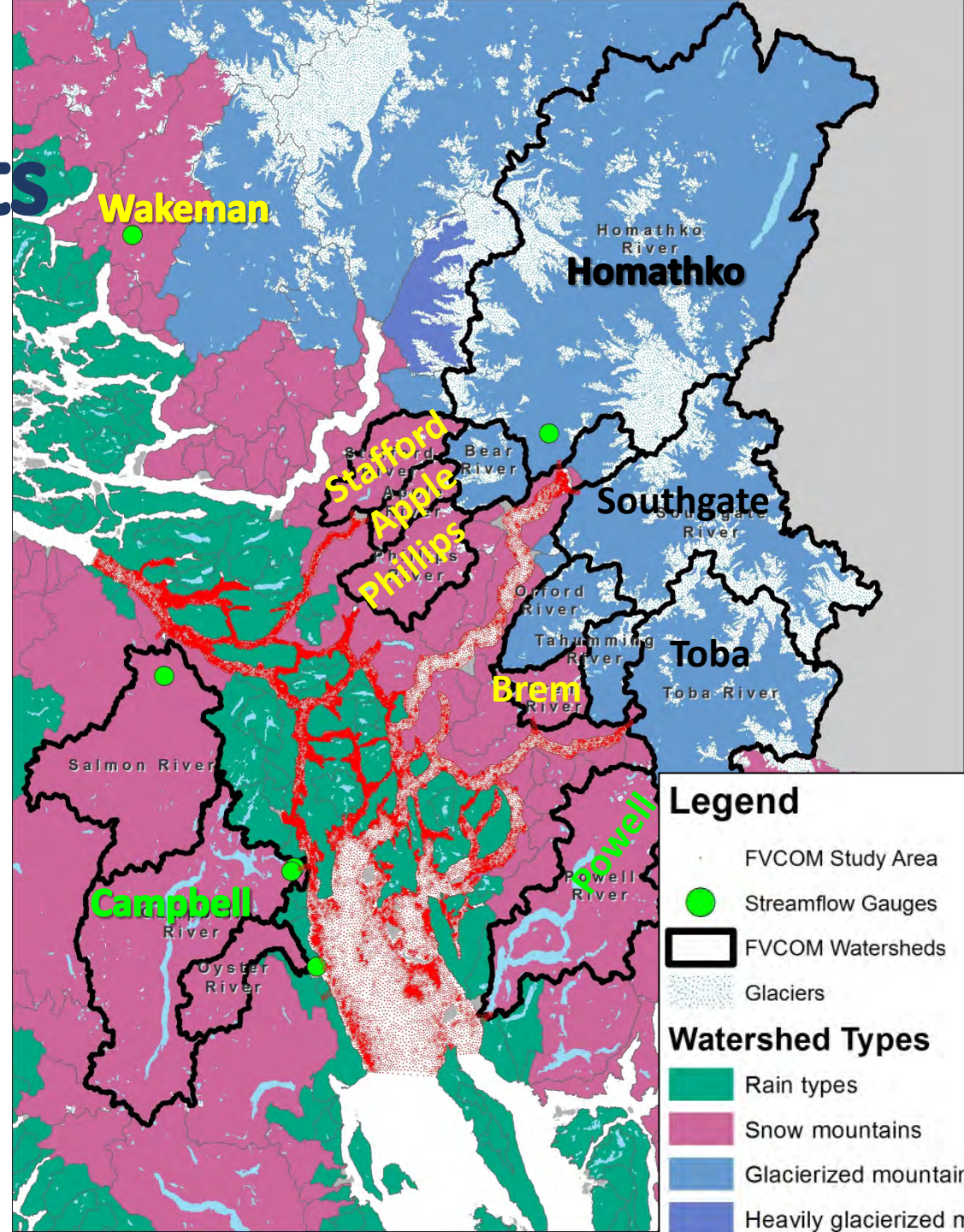
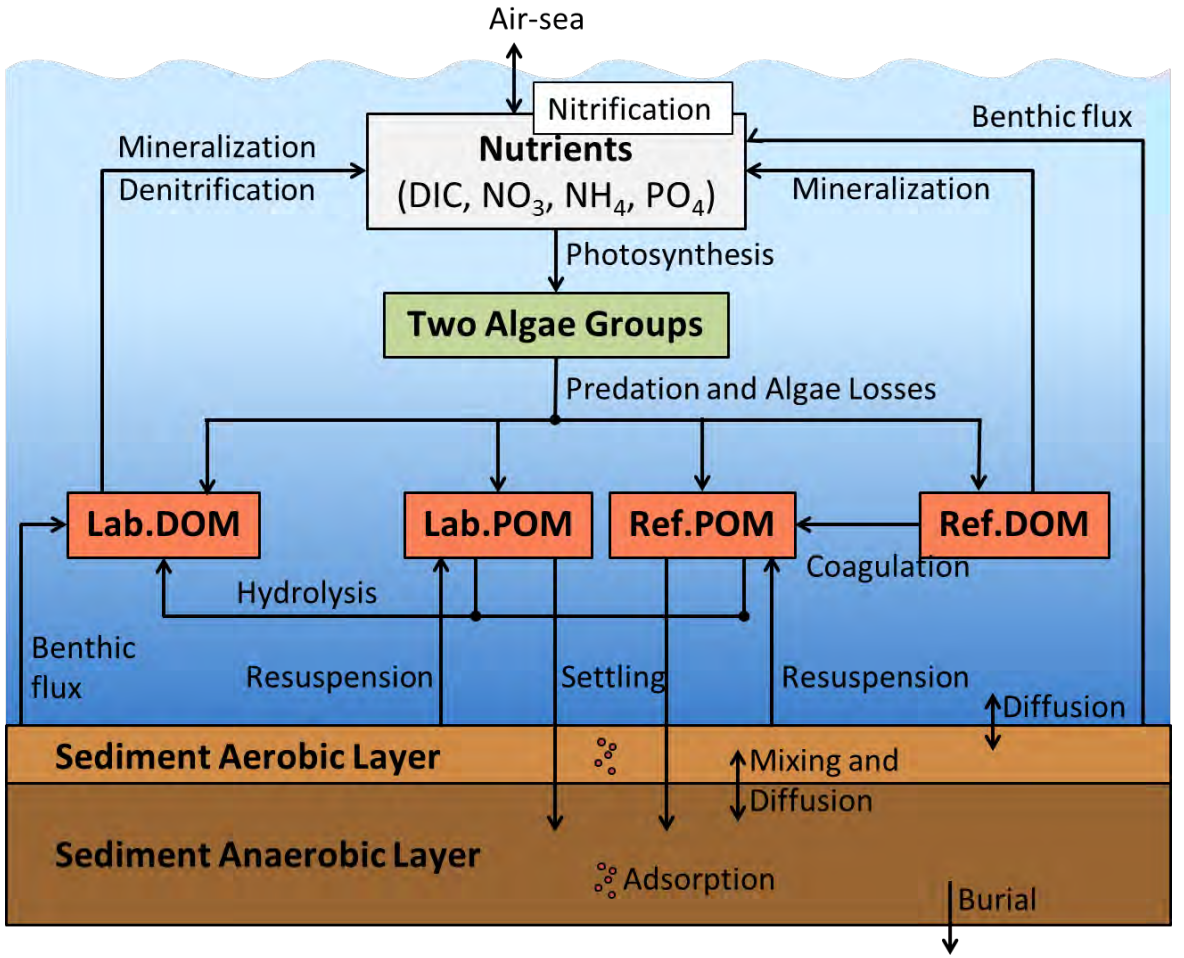


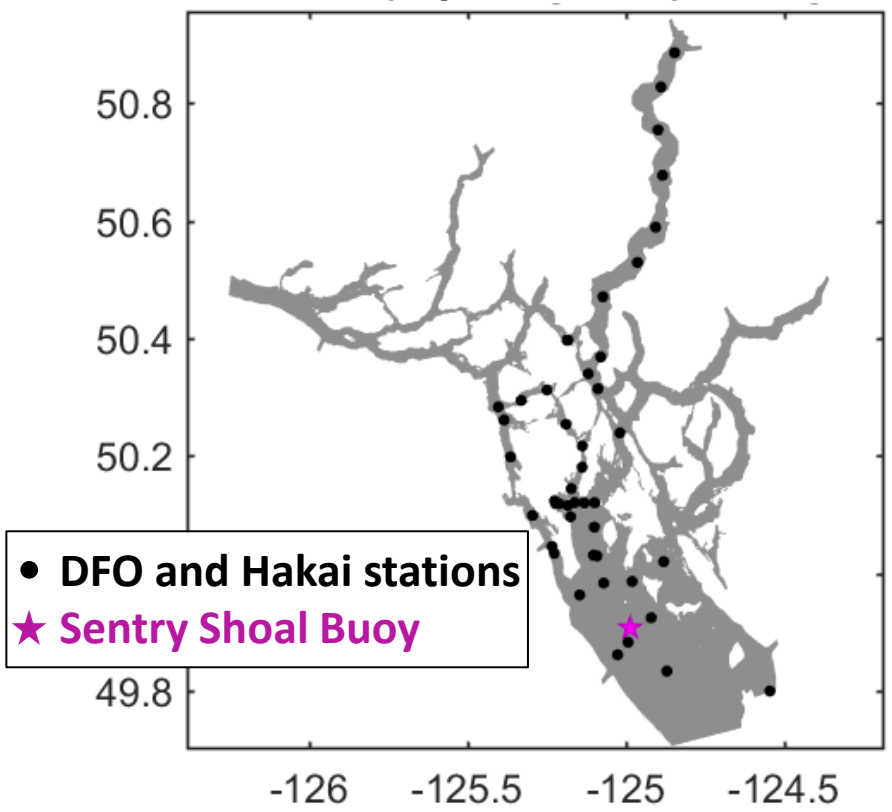
Biogeochemical Model: FVCOM-ICM

- FVCOM-**I**ntegrated **C**ompartment **M**odel *(Kim & Khangaonkar 2012; Bianucci et al. 2018)*
- Coupled to a 2-layer sediment diagenetic model *(Di Toro 2001)*
- Initial, open boundary conditions: SalishSeaCast *(Soontiens et al. 2016)*
- Rivers:
  - Some BGC data available for 2 rivers: Homathko and Campbell
  - Other rivers use a Campbell climatology

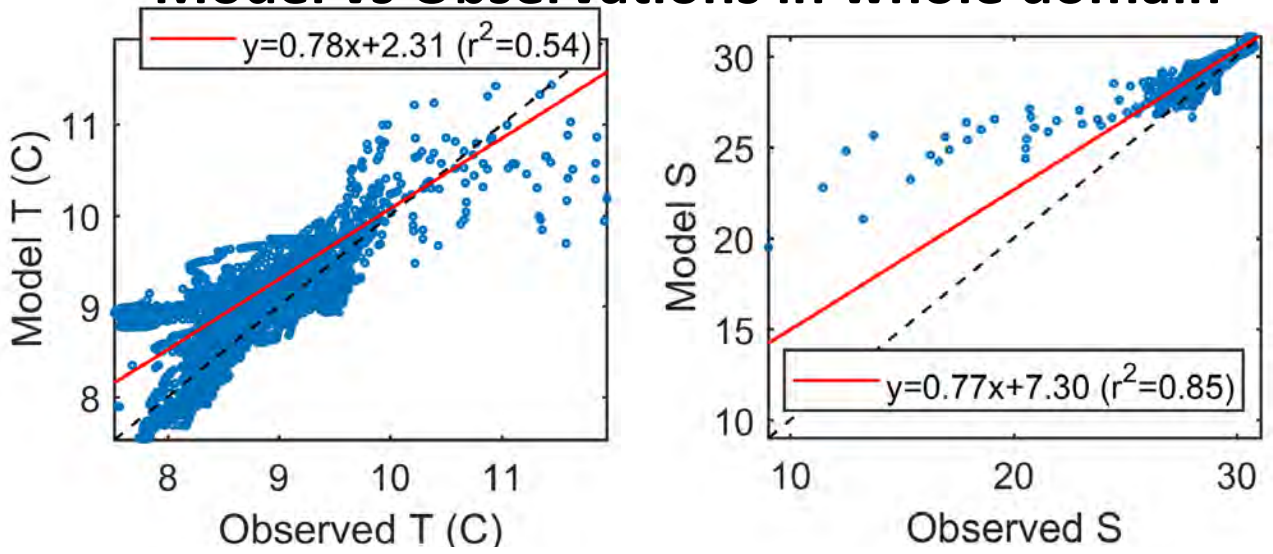


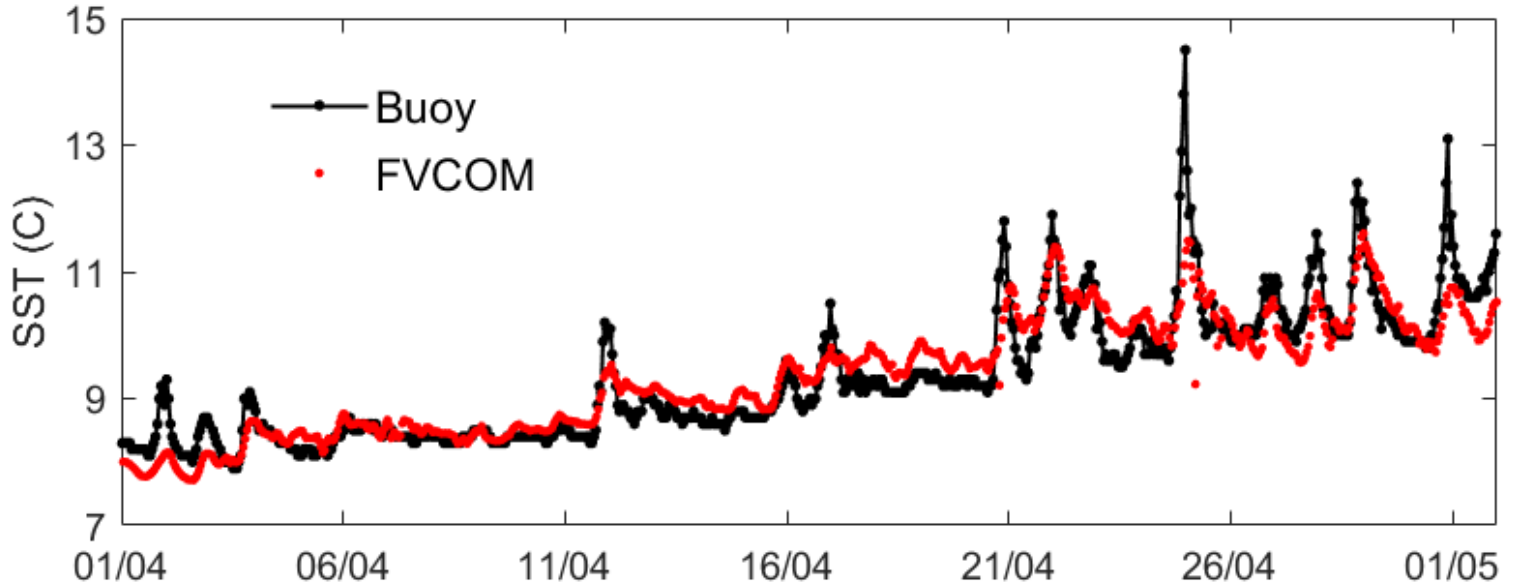
Model Validation: Physics

Location observations (April 2017)



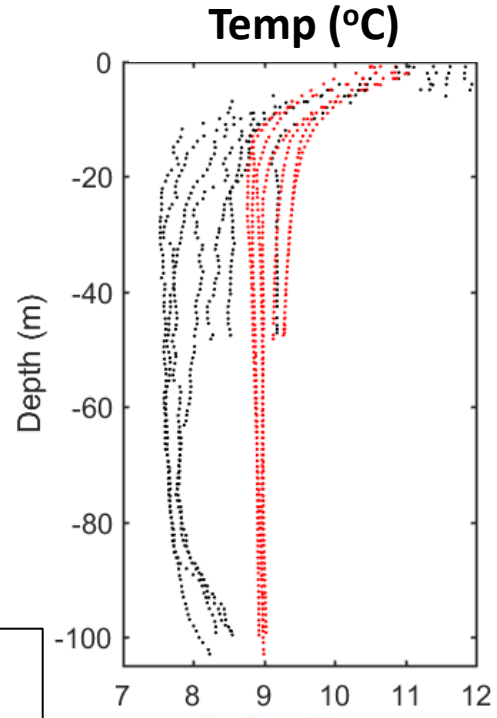
Model vs Observations in whole domain

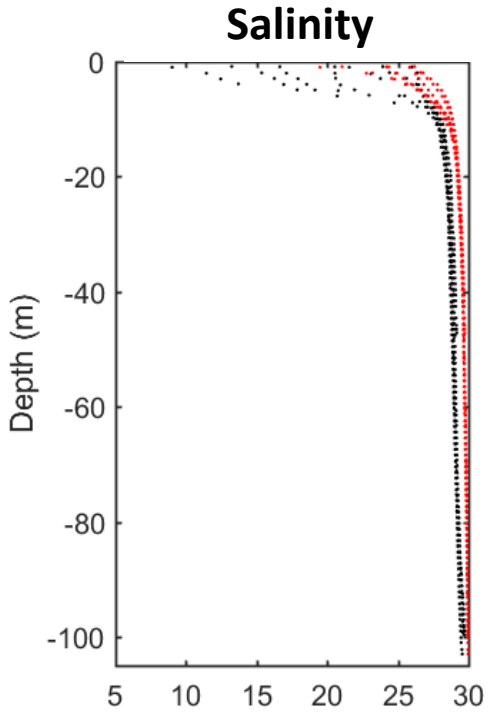


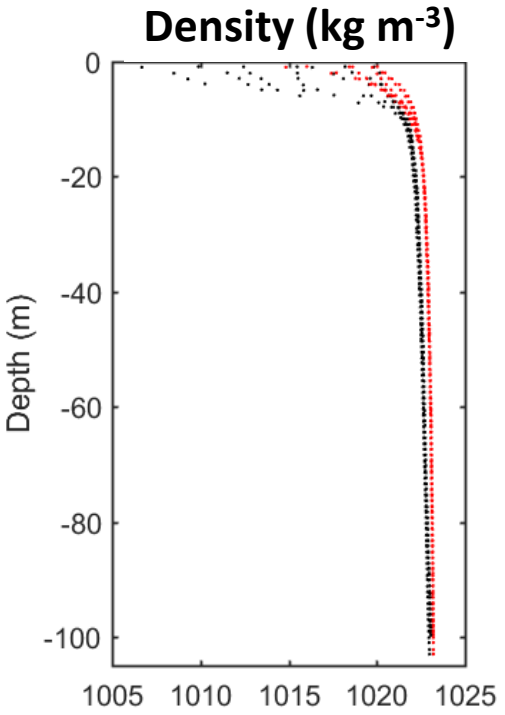


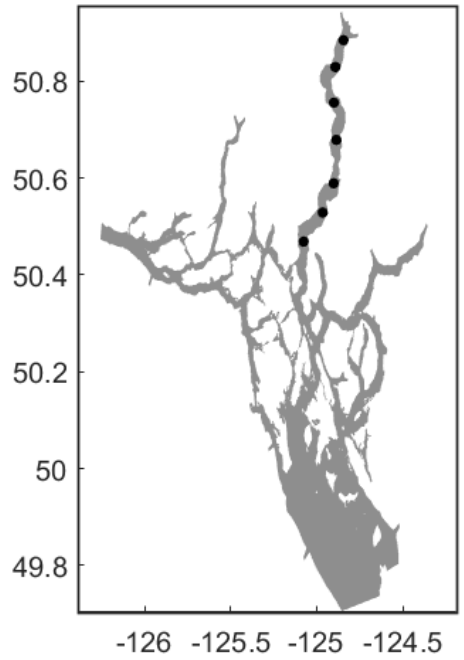
Model

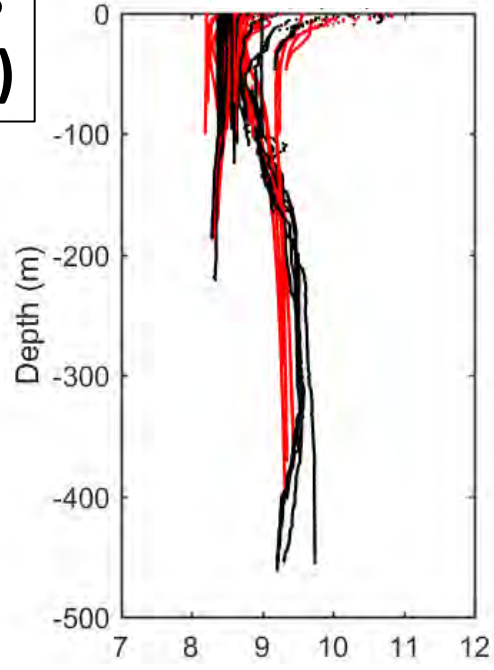
Observations (CTD)

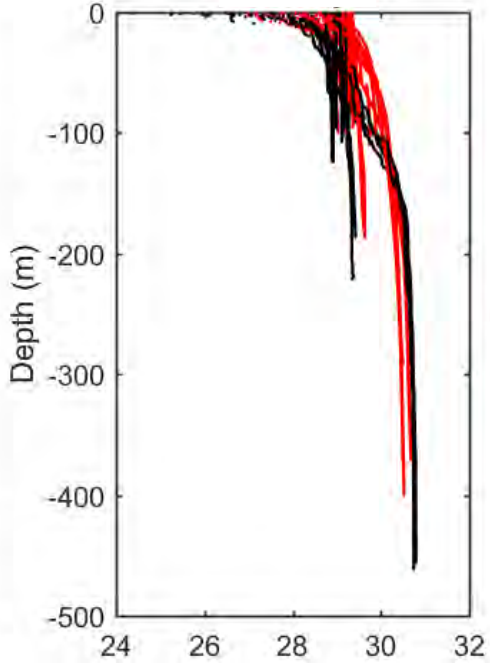


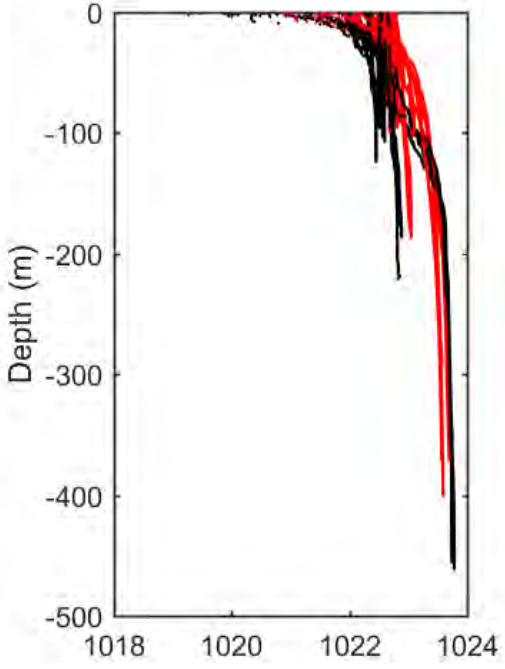


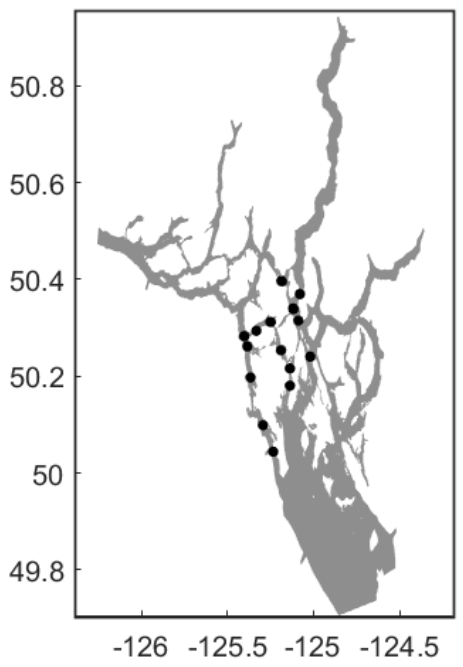






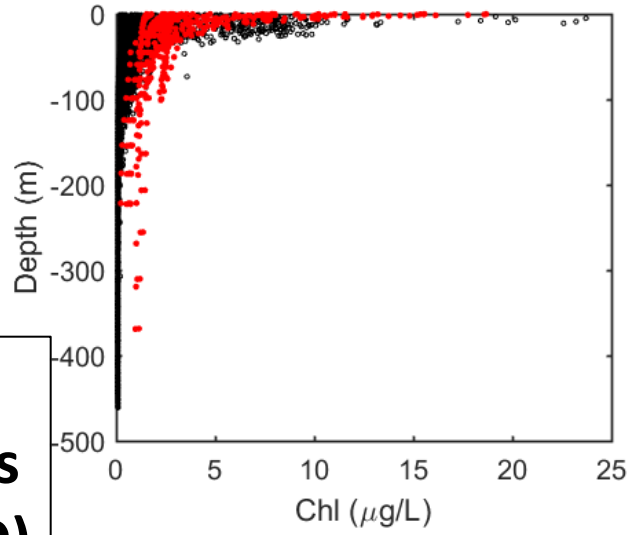


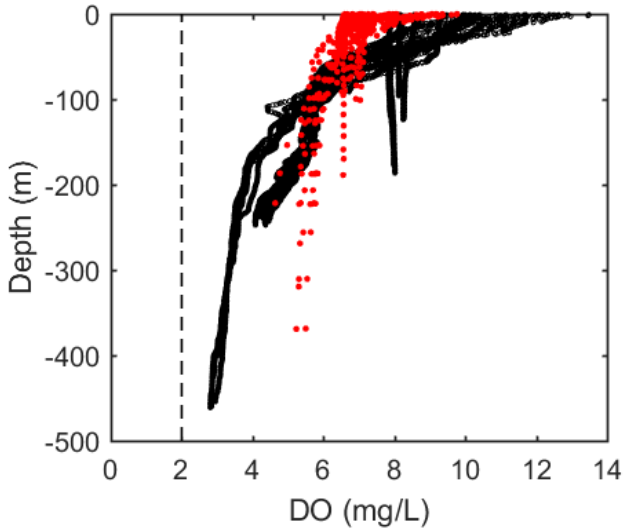




Model Validation: Biogeochemistry

Model
Observations (CTD)





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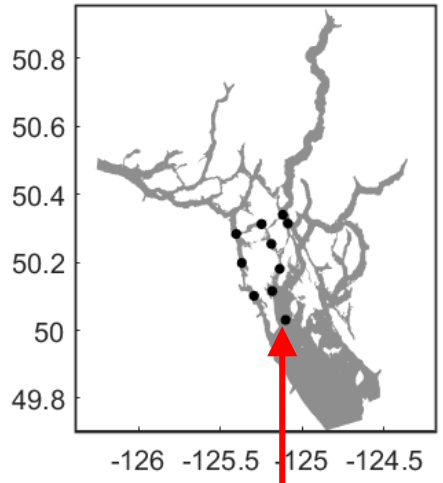

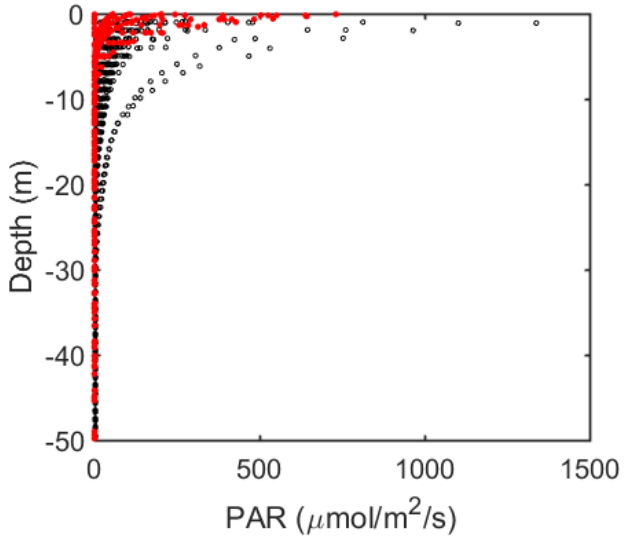

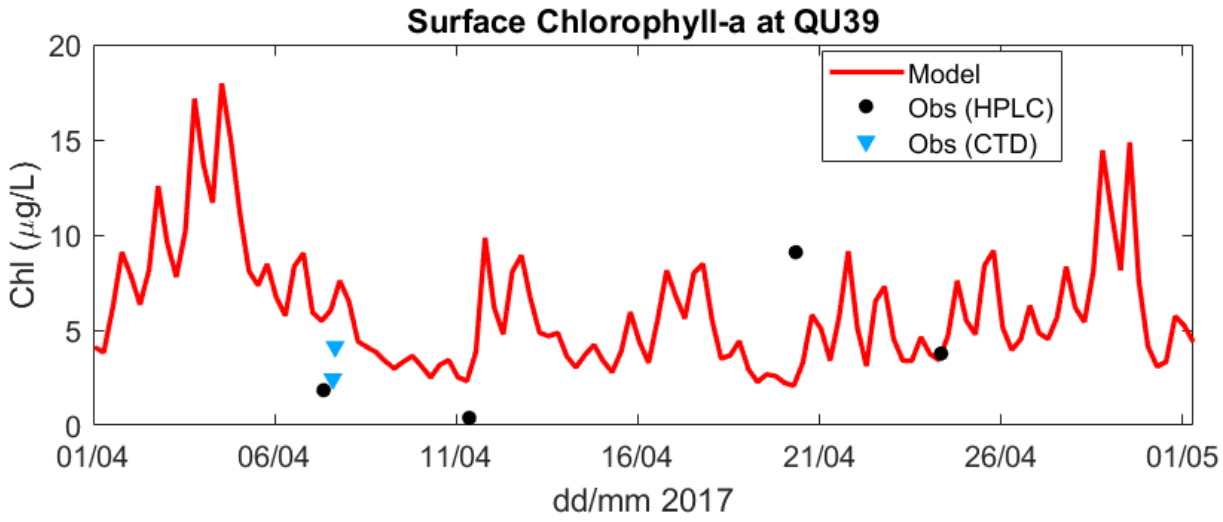

Summary and Future Work

- Still lots of work to do!
  - Physics: Need to keep freshwater at surface
    Too much mixing? Add extra rivers?
  - BGC: Revise and calibrate parameterizations
    Improve surface forcing
- Once the model performance is satisfactory
  - Determine the main drivers of dissolved oxygen concentrations
  - Assess their resilience to changing conditions

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Thank you!

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