Modelling lower trophic level ecosystem dynamics in the Strait of Georgia

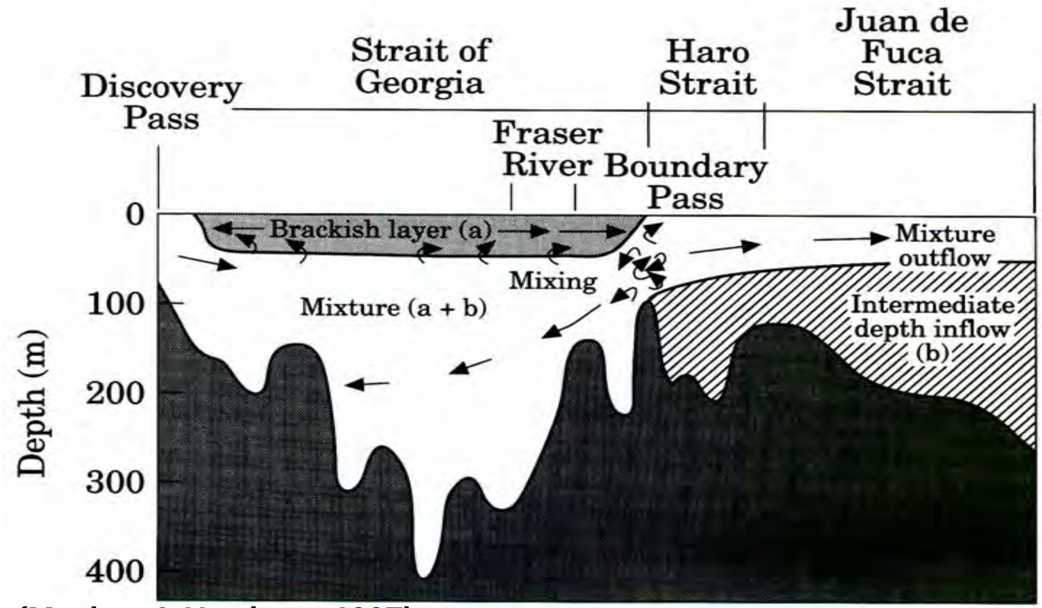
Angelica Peña & Diane Masson

Institute of Ocean Sciences, Fisheries & Oceans Canada, Sidney, BC, Canada

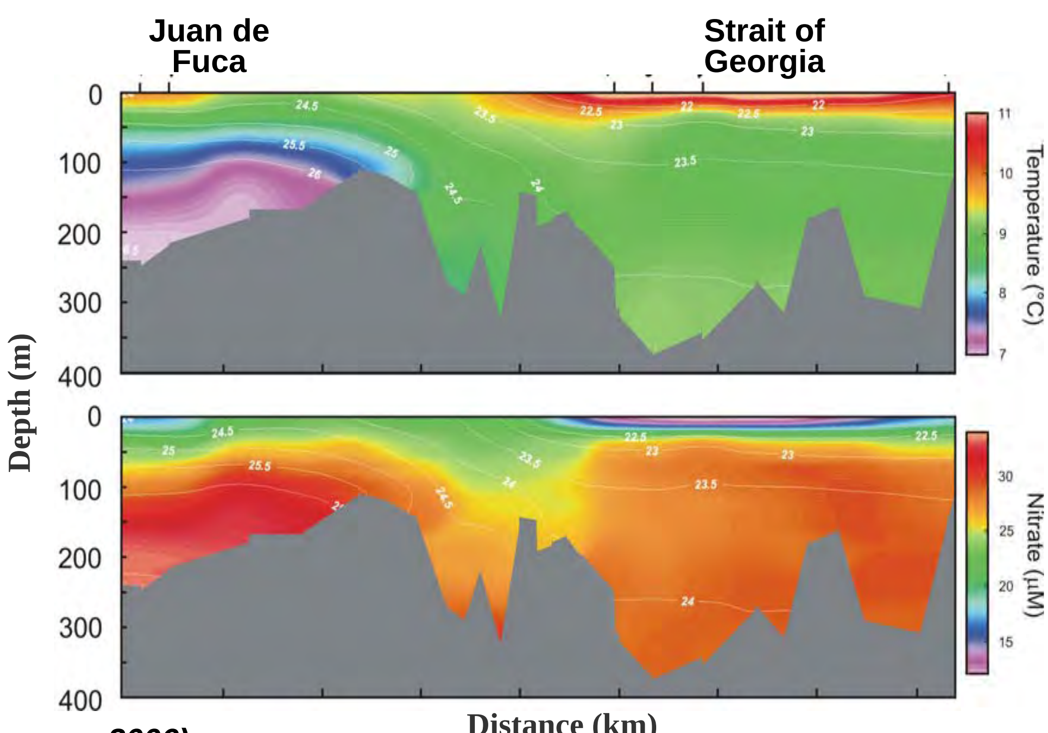
Fisheries and Oceans Canada
Pêches et Océans Canada

Main characteristics:

- The Strait of Georgia is a semi-enclosed productive estuary (~220 km in length and up to 420 m depth).
- The main connection for the SoG to the Pacific Ocean is the Juan de Fuca Strait.
- Estuarine flow primarily from Fraser River
- The flux of freshwater and coastal wind stress are subject to strong seasonal modulations
- It is an important nursery and rearing ground for many species such as Pacific salmon and Herring.



(Mackas & Harrison, 1997)

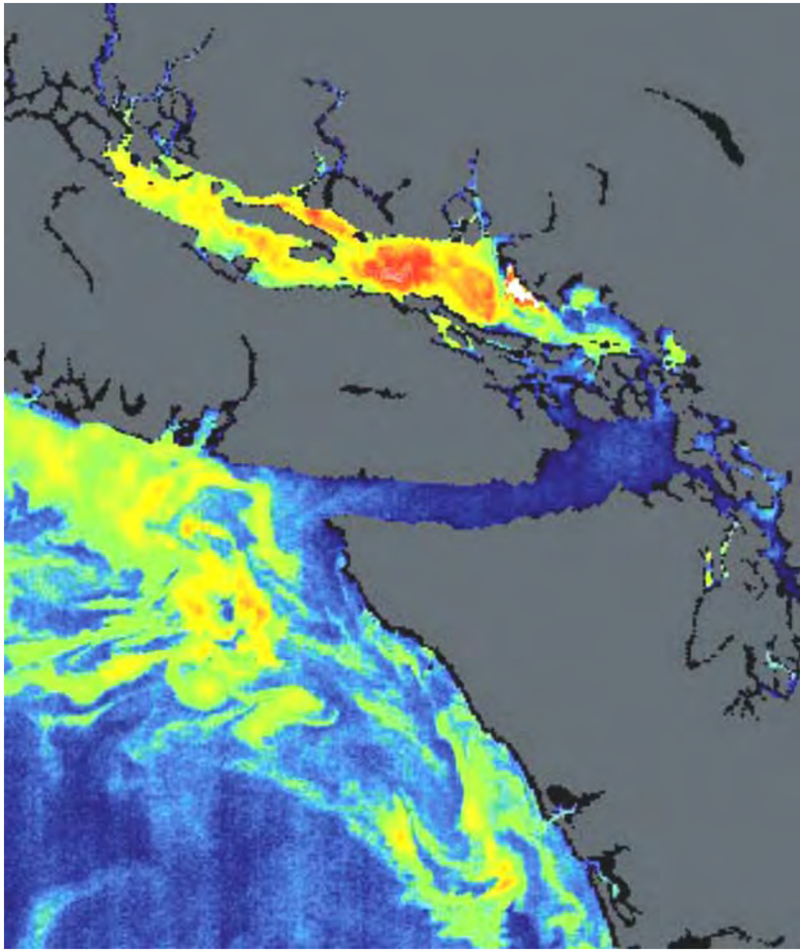


(Masson, 2006)

- At both ends of the SoG, strong tidal currents mix the water column and reduce local stratification
- Strong mixing in these shallow areas controls water exchange within the estuary
- Inflow of dense, cold, nutrient-rich waters at depth into JdF Strait
- During summer, upwelling on the shelf provides colder and saltier water.
- In winter, due to mostly downwelling winds, warmer and less saline waters enter the strait

Objectives - Biophysical Modeling

- Develop coupled plankton ecosystem / circulation model to:
  - Study the dynamics of the planktonic ecosystem
  - Identify key factors responsible for temporal and geographical changes in lower trophic levels.
  - Explore potential responses to climate change.
- Study is part of the Strait of Georgia Ecosystem Research Initiative, a multi-disciplinary project of F&O Canada
- This talk: preliminary results from model validation



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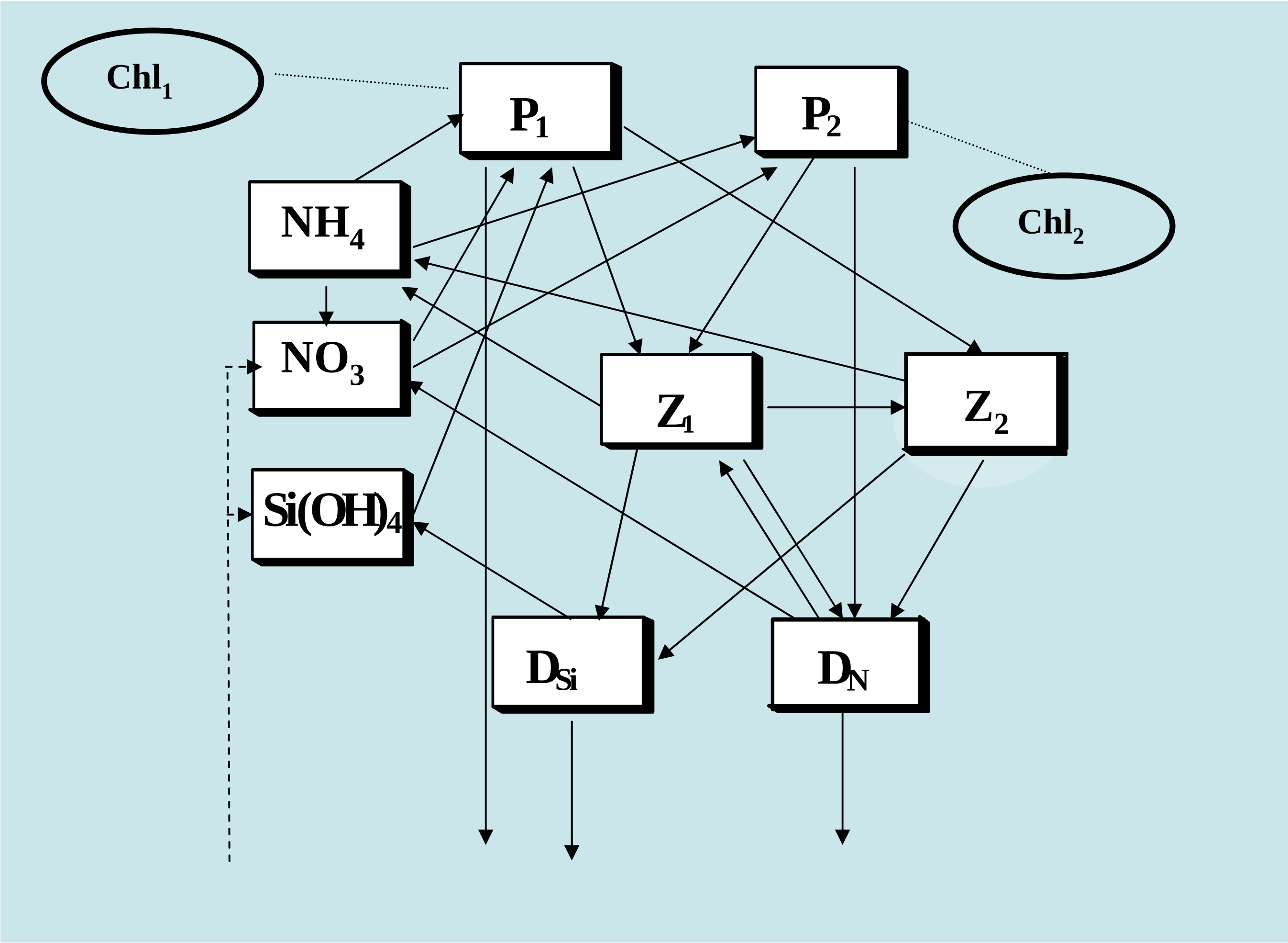
Plankton ecosystem model:

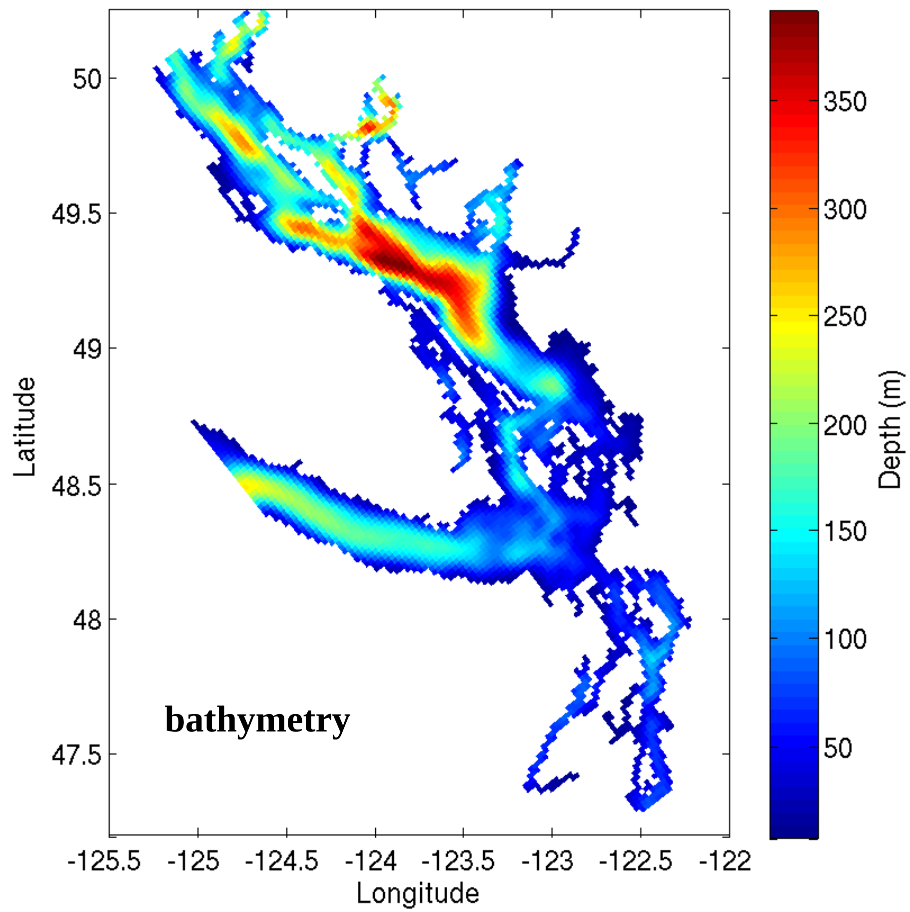


- Multiple nutrient limitation (NO_3, NH_4 and Silicate)
- Two-types of phytoplankton and of zooplankton
- Dynamic chlorophyll compartments
- Temperature dependence of physiological rates

Biophysical model:

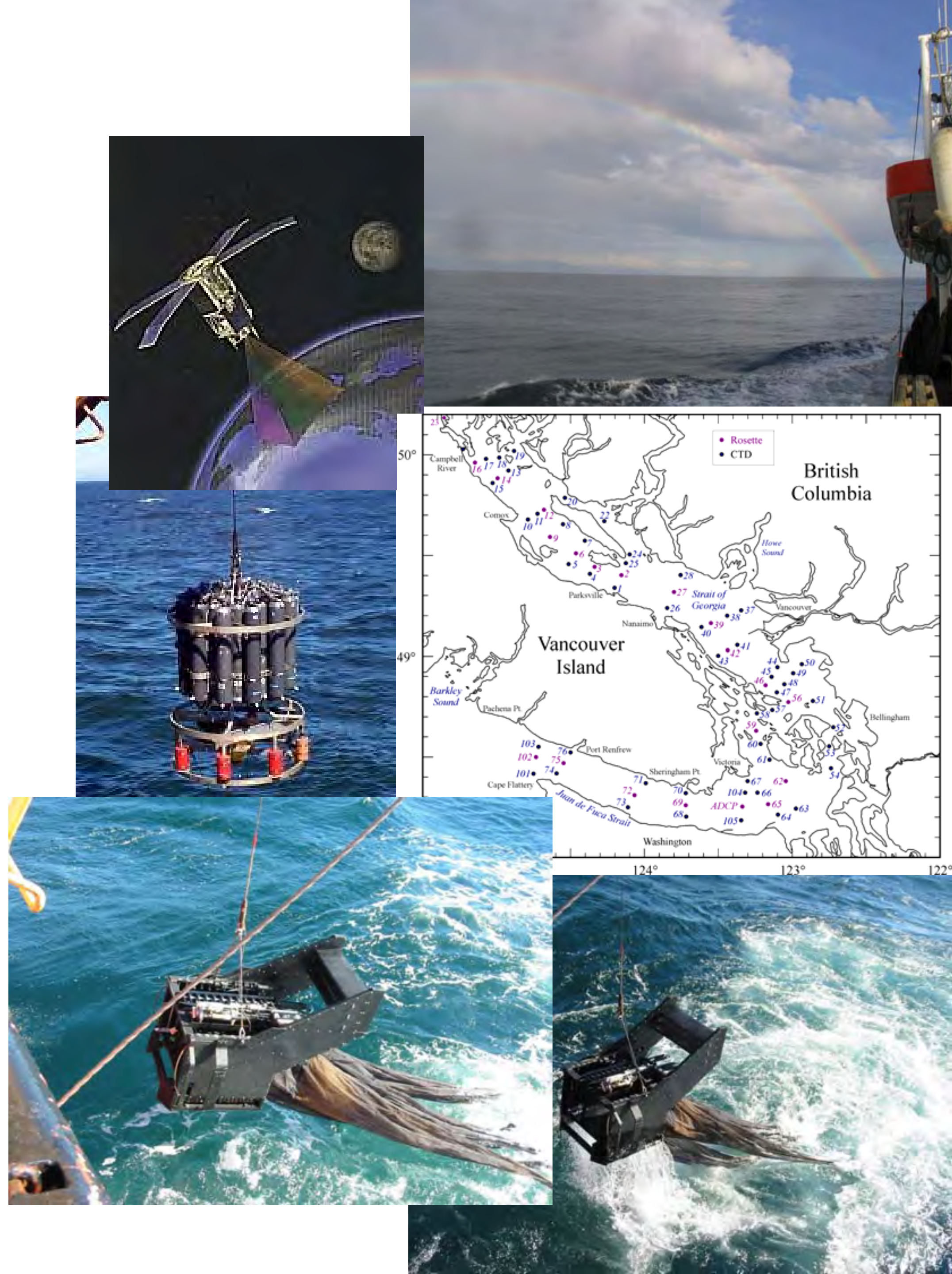
- ROMS = Regional Ocean Modeling System
- Grid resolution of 2 km (184 x 92)
- Sigma coordinate model: 31 vertical layers.
- Forced by wind, tides, fresh-water input and daily solar radiation
- Initial conditions of temperature, salinity and nutrients (nitrate and silicate) from seasonal climatologies
- Results from model simulation forced by winds, fresh-water flow and solar radiation in 2007

Strait of Georgia, 2 km x 2 km grid

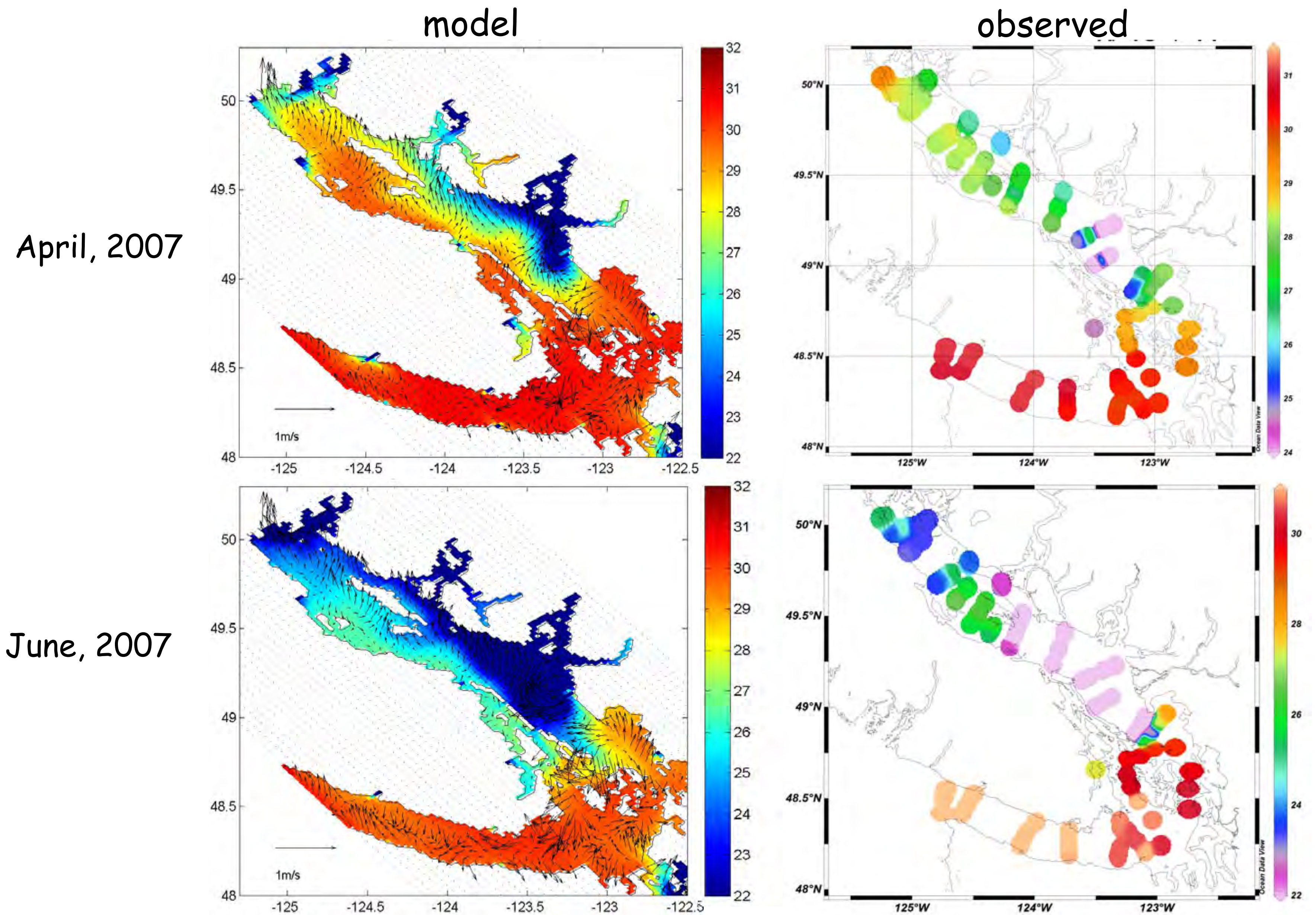


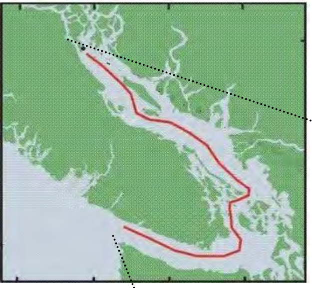
Observations

- Field work: 1 week cruises 4 times a year (April, June, Sept. and Dec.)
  - CTD profiles
  - Nutrients & chlorophyll concentrations (2001 – present)
- Satellite chlorophyll data
- Historical data of zooplankton

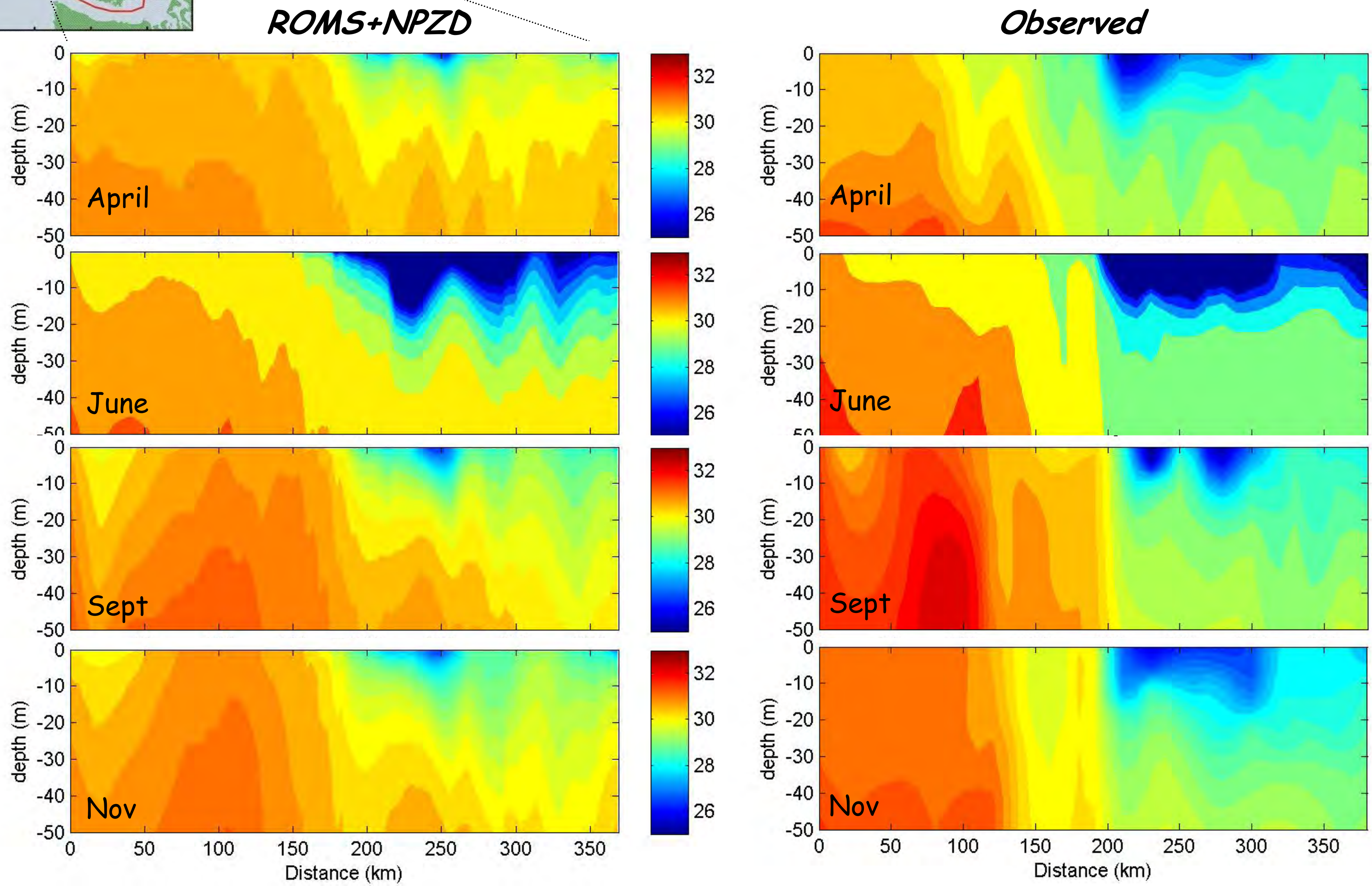


Surface salinity

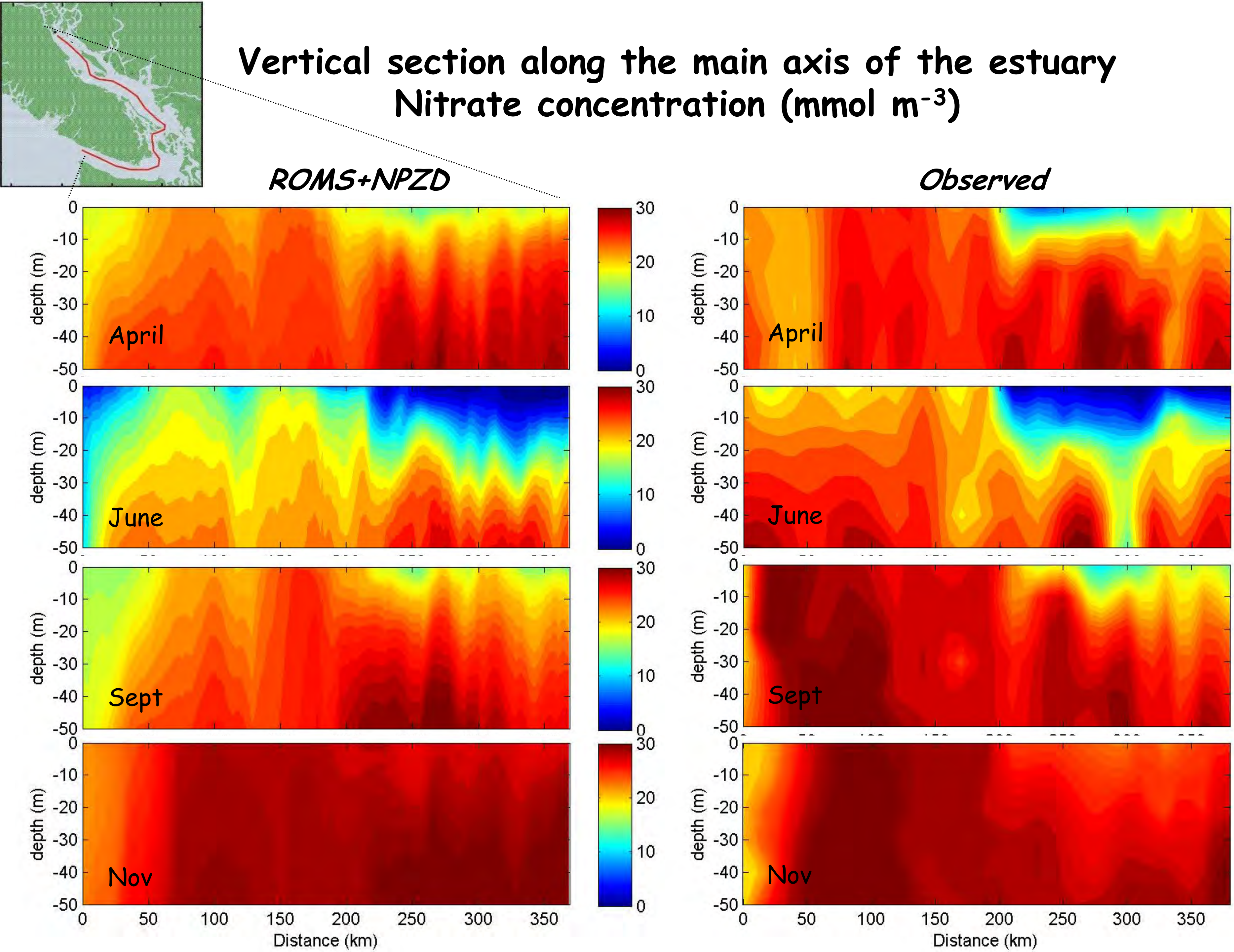


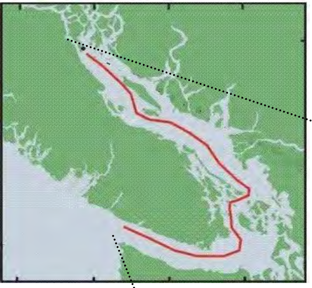


Vertical section along the main axis of the estuary
Salinity

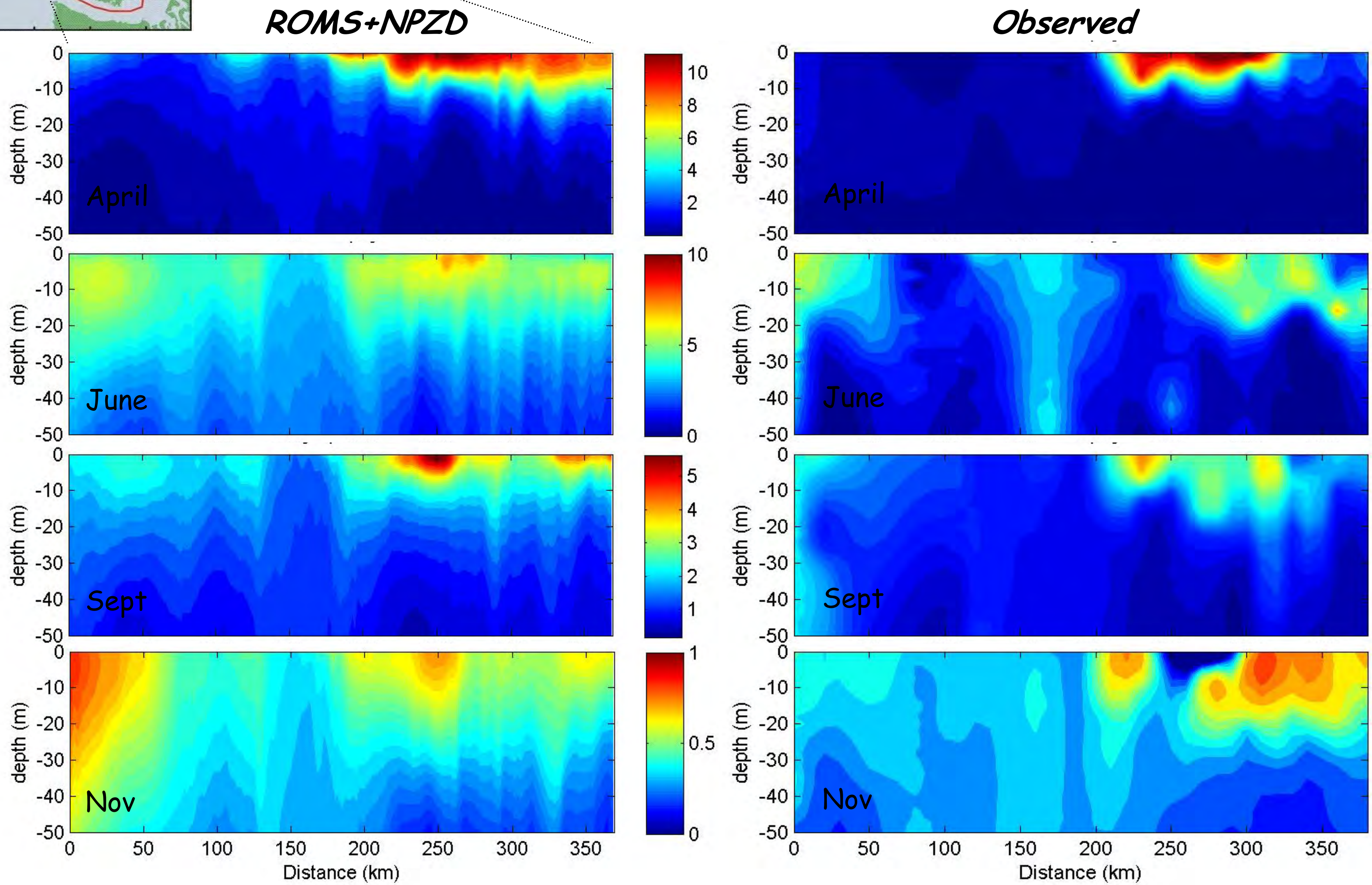


Vertical section along the main axis of the estuary
Nitrate concentration (mmol m^{-3})

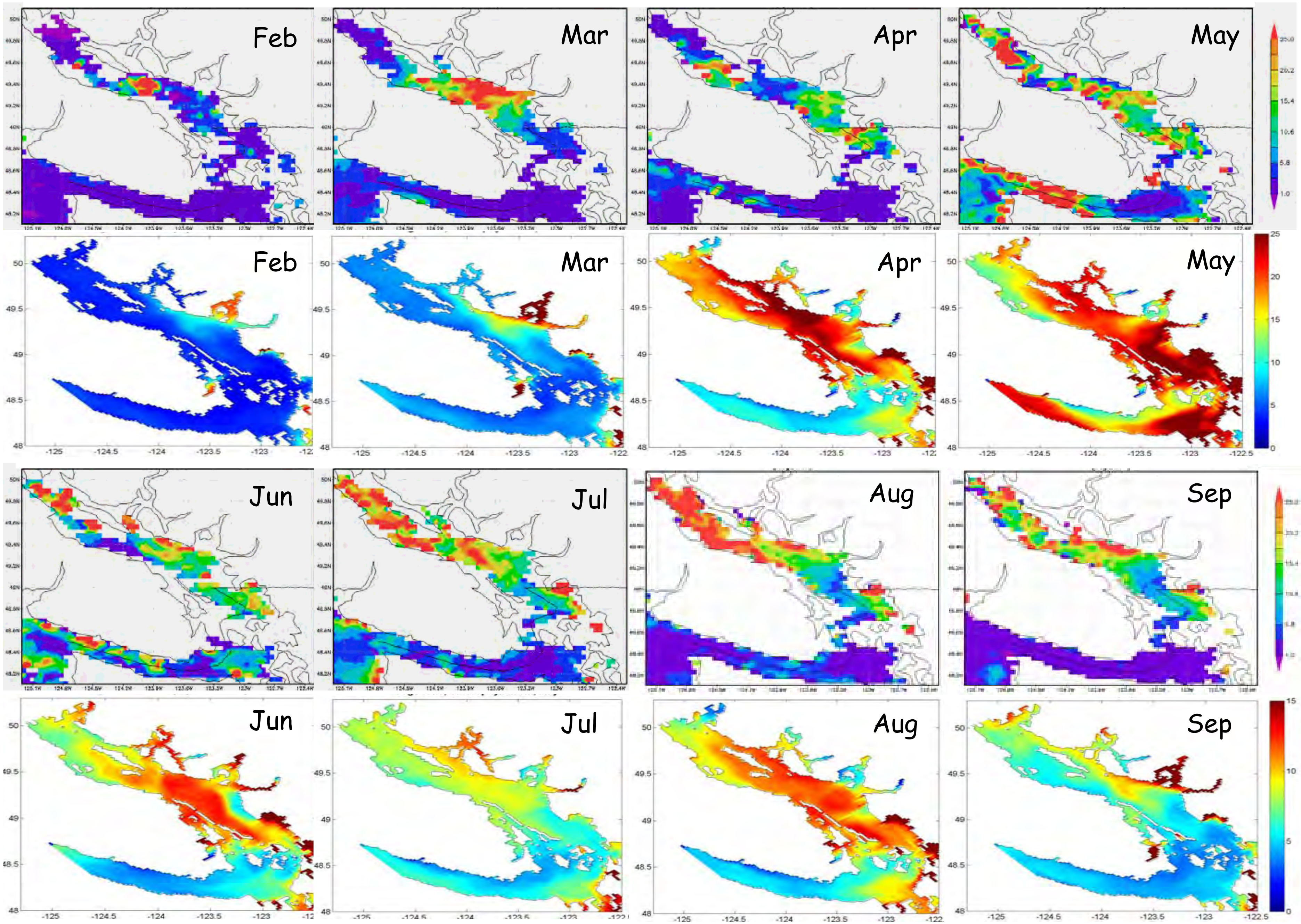




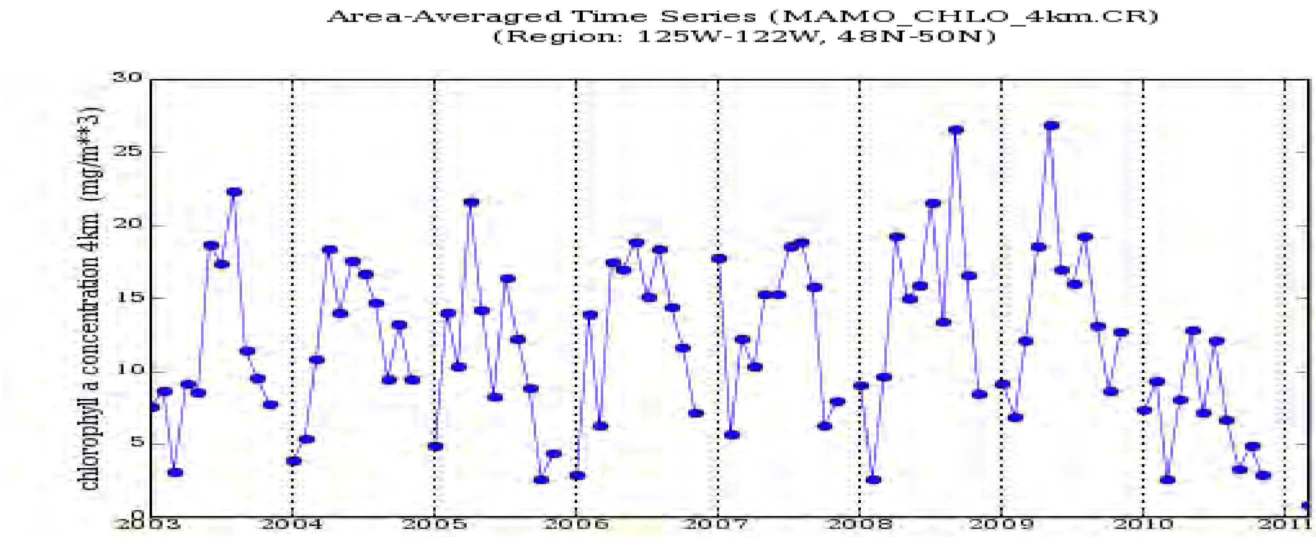
Vertical section along the main axis of the estuary
Chlorophyll concentration (mg m^{-3})

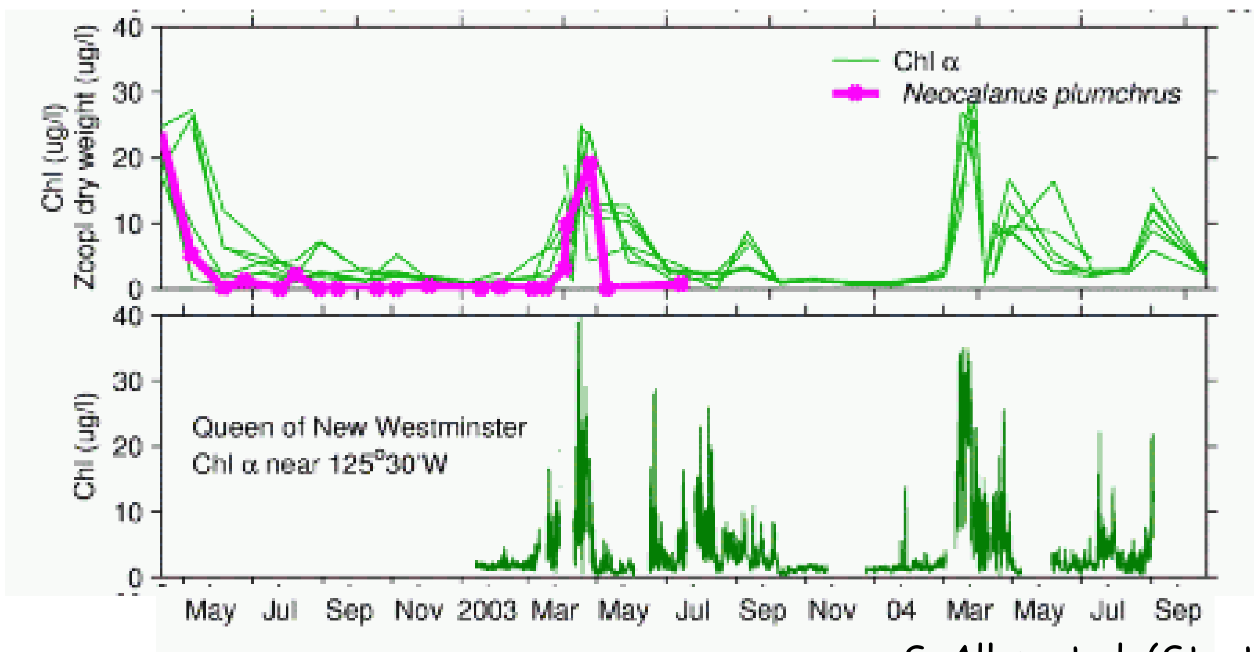


Chlorophyll concentrations from SeaWiFS vs. simulated surface concentrations



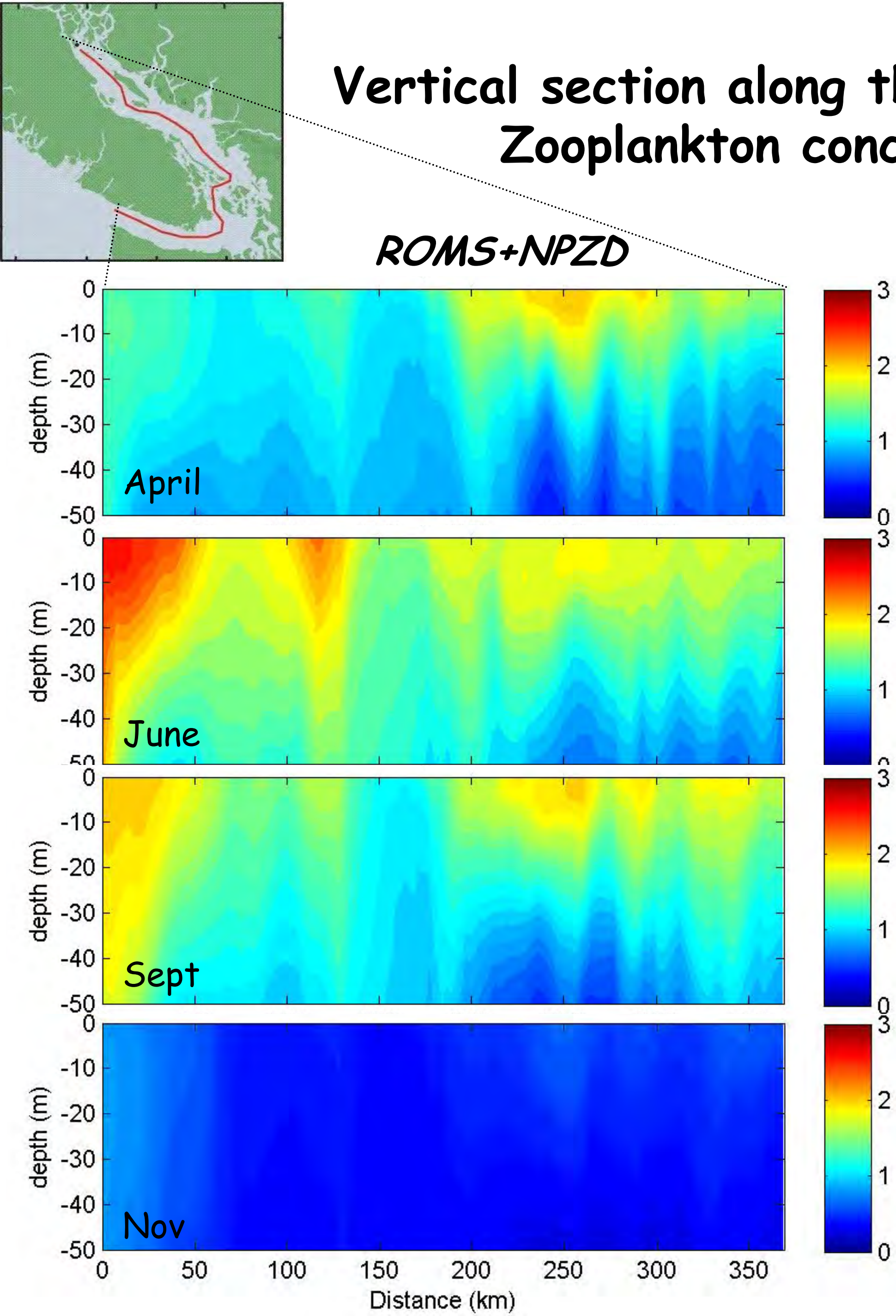
Seasonal cycle of chlorophyll concentration



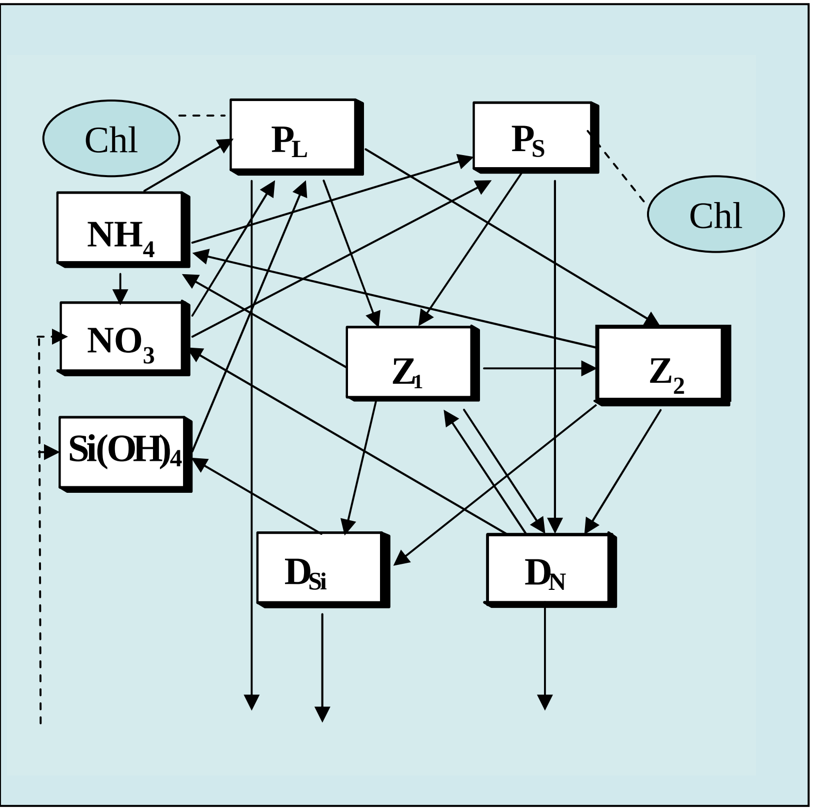


S. Allen et al. (Stratogem program)

Vertical section along the main axis of the estuary
Zooplankton concentration (mmol m^{-3})



The model simulate the annual cycle reasonable well

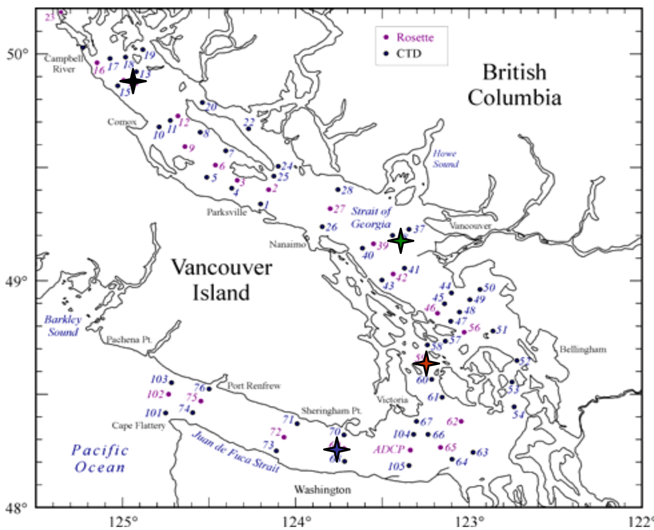


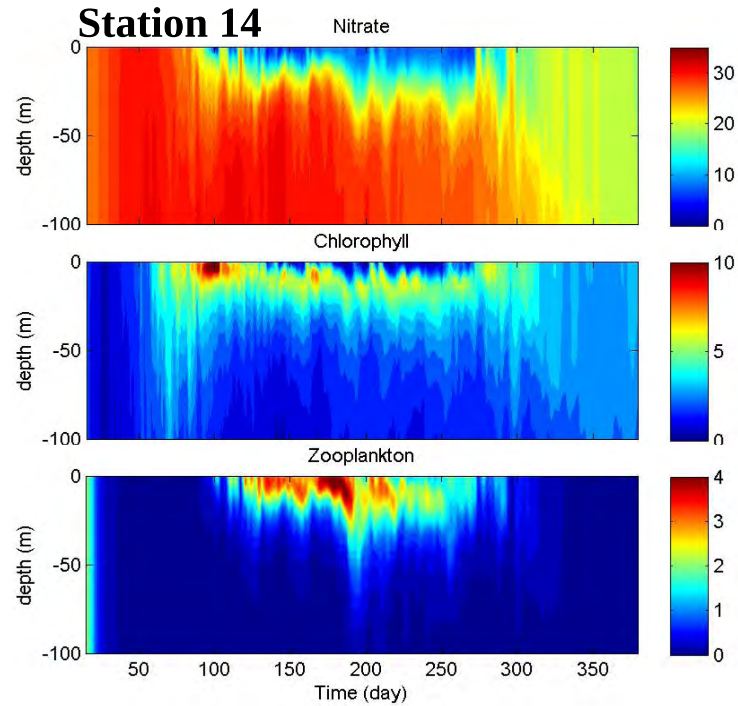
However …

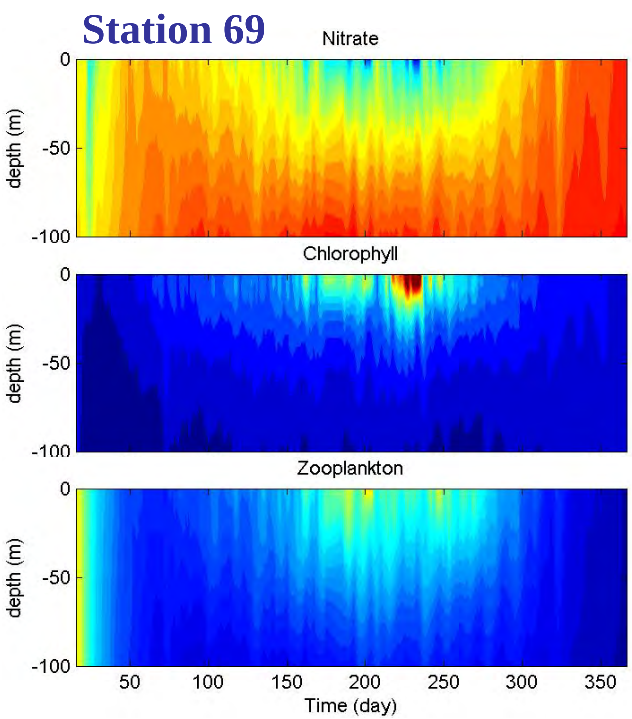
- Model output are sensitive to parameter values
- There are 34 model parameters that are not well constrained
- Parameter values were set from:
  - observations
  - previous model studies
  - tuned to reproduce observations (i.e. chlorophyll concentration)

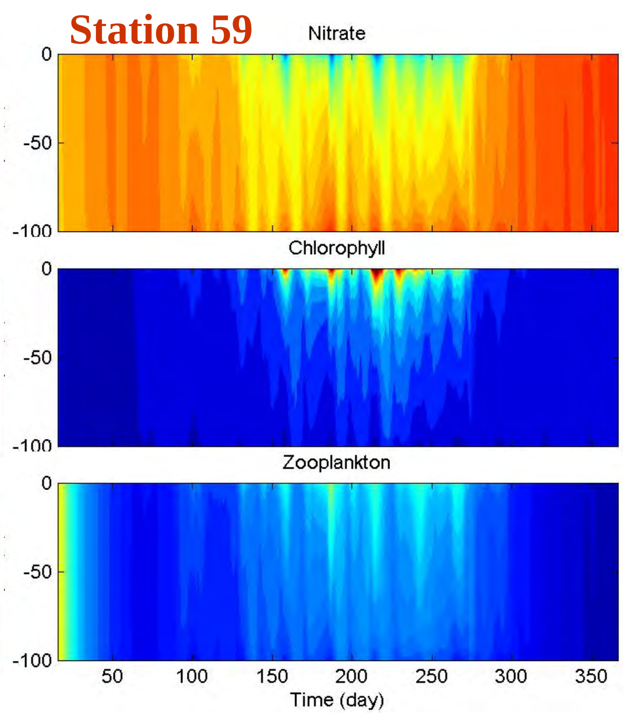
➢ How sensitive (or conversely, robust) is the model to changes in the values of its parameters?

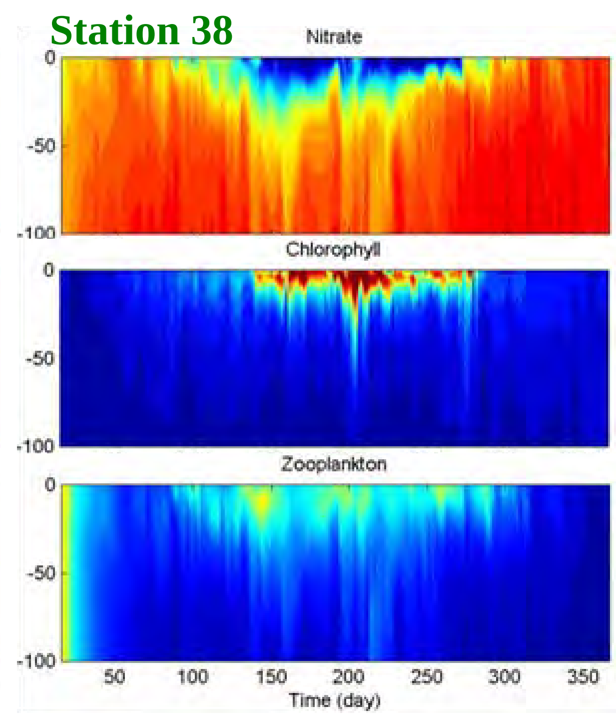
High spatial and temporal variability











Summary

- A biophysical model of the SoG/JdF straits is being developed.
- The model is able to simulate the major biological features off the Entrance of Juan de Fuca Strait and Salish Sea. Also, it reproduces the annual cycle reasonable well.
- Available remotely sensed (SeaWiFS) chlorophyll concentrations are not adequate for model validation in this region.
- Model outputs are sensitive to forcing by winds and fresh water input and by parameter values of biological model
- Model results suggest that complex physical processes results in high spatial and temporal variability of phytoplankton biomass and primary production.
- Available observations are not adequate to validate complex model dynamics (need for higher temporal resolution)
- Most observations are standing stock. Important to improve observations of fluxes (e.g. primary production, grazing rates).

Next…

- Run the model for contrasting year to study year to year variability

Acknowledgements

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