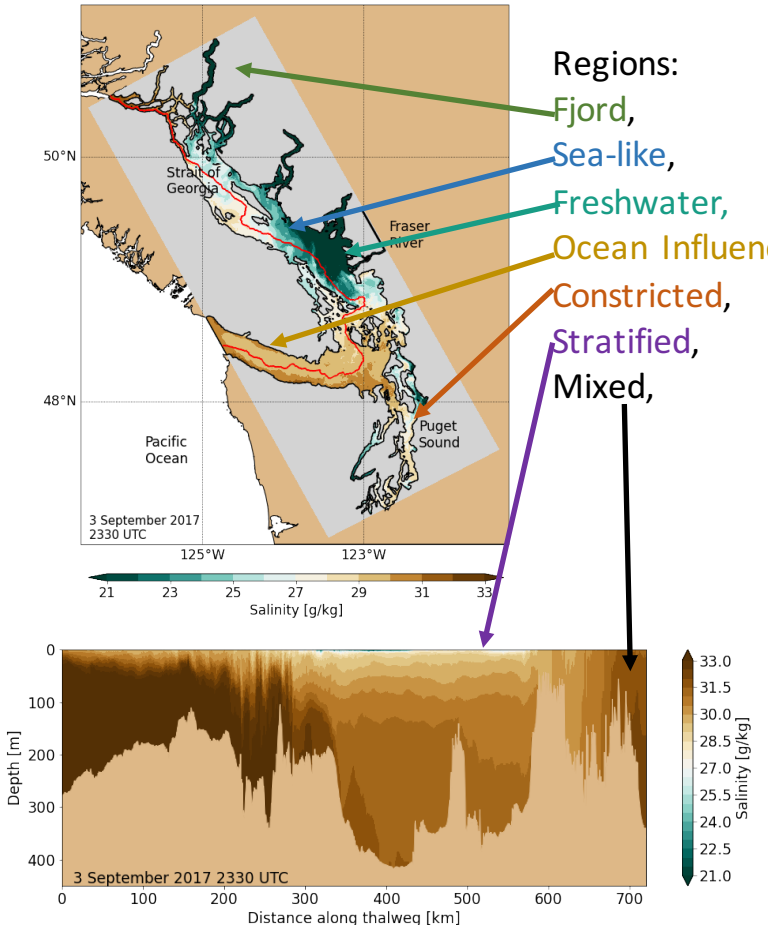
Clustering coupled biochemical-physical model results formalizes regional provinces in a coastal region

Susan Allen (presenting), Tereza Jarníková (lead author), Elise Olson, Debby Ianson

This presentation is based on clustering by Tereza Jarníková and Elise Olson's ideas on model evaluation.

All: Department of Earth, Ocean and Atmospheric Sciences, University of British Columbia
D. Ianson primary affiliation: Institute of Ocean Sciences, Fisheries and Oceans Canada

PACIFIC SALMON FOUNDATION psf.ca
MEOPAR
NSERC CRSNG
OCEAN NETWORKS CANADA
UBC
compute canada | calcul canada
Fisheries and Oceans Canada



Like many coastal regions, the Salish Sea contains a variety of regional provinces with substantially different physical and biological dynamics. Different authors divide these provinces in different ways using various names.

How do we make a formalized, less arbitrary, separation into dynamical provinces?

Figure shows the output from the SalishSeaCast model (see references) at a given hour in September 2017. Upper panels shows surface salinity and lower panel shows a vertical cross-section along the thalweg. Thalweg is marked as a red line in the upper panel. Some dynamical variations are illustrated.

We use unsupervised clustering of numerical model output. The numerical model is SalishSeaCast, based on NEMO. We find that the ecosystem variables (here depth integrated phytoplankton biomass) spatially coincide with the physical variables (showing halocline depth). These clusters have many similarities to the boundaries used by previous authors but also differences.

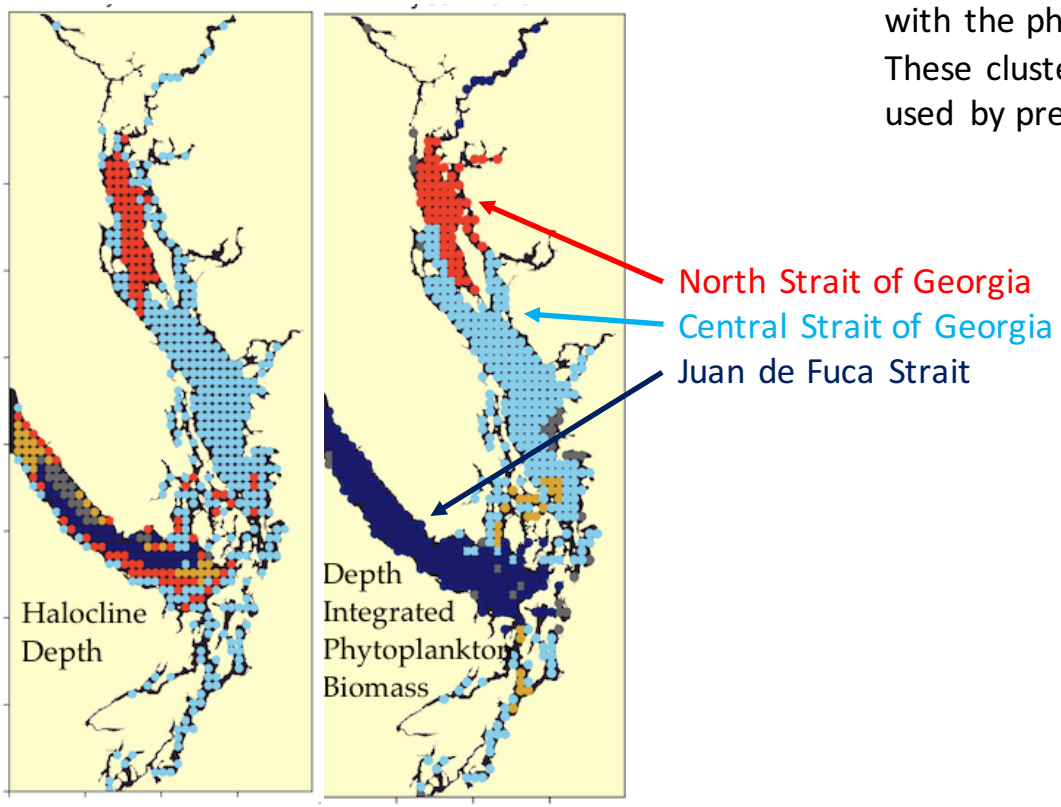
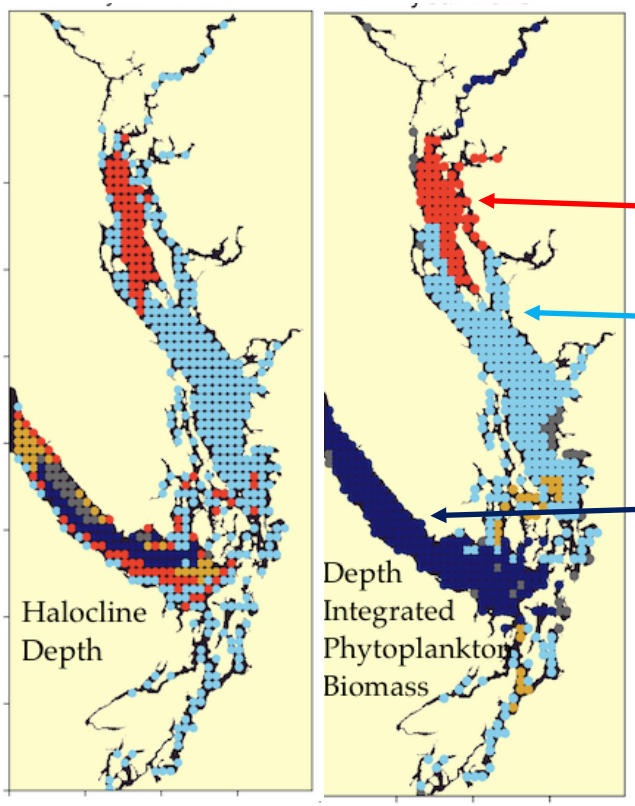


Figure shows the clusters for year 2015 based on left) the halocline depth (depth of steepest gradient in the salinity profile) and measure of stratification right) the depth integrated biomass of the three phytoplankton classes.

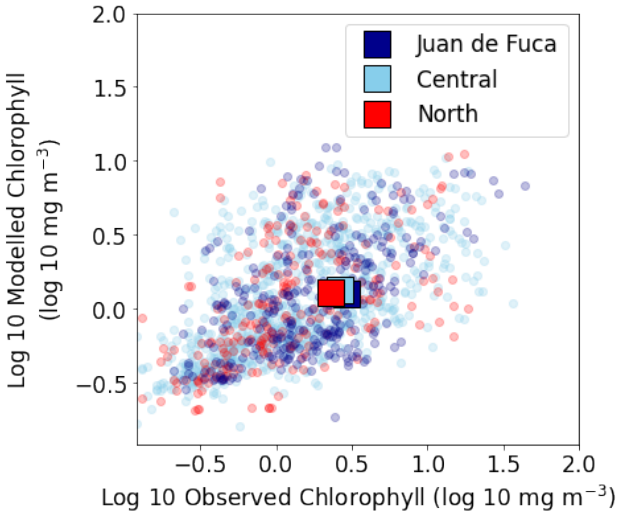


Having formalized provinces allows us to ask better formulated science questions of both model and observations such as:

Does the North have less biomass than the Central region? The Central region is more stratified due to proximity to the Fraser River.

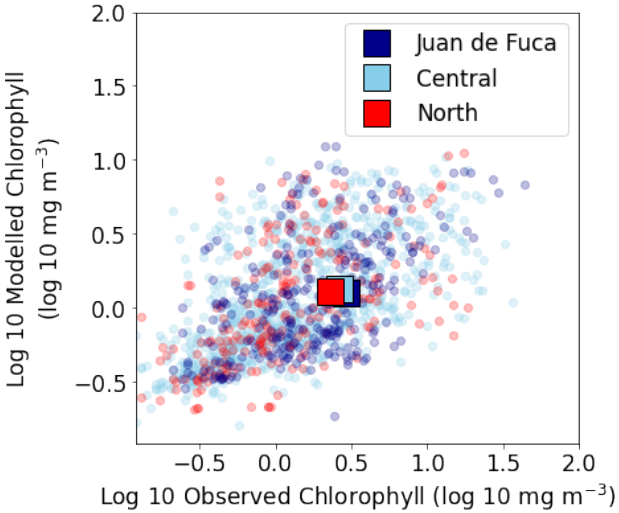
Does the model have too much biomass in Juan de Fuca Strait? The Juan de Fuca region is more ocean-like with a much deeper more mixed surface layer.

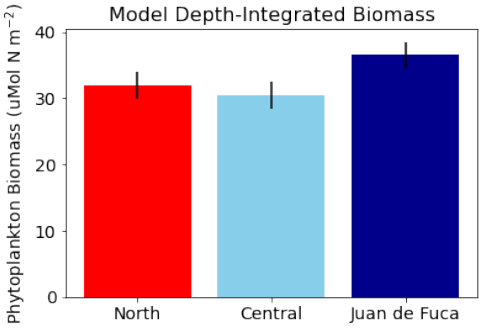
These are long standing questions in the region. Although we see no significant biomass differences in the North versus the Central region, we do see different phytoplankton communities due to the different physical environment.



Defined regions allows us to evaluate the model across these different dynamics. We see that the model reproduces Chl equally well in the different regions. In particular, we see that the model does not over-predict Juan de Fuca Strait and thus that Juan de Fuca really is one of the most productive provinces. Other models have also seen this high biomass but timing of observations led to its characterization as a low Chl region.

Figure shows log transformed Chl from observations (horizontal axis), versus modelled (vertical axis) coloured by cluster.

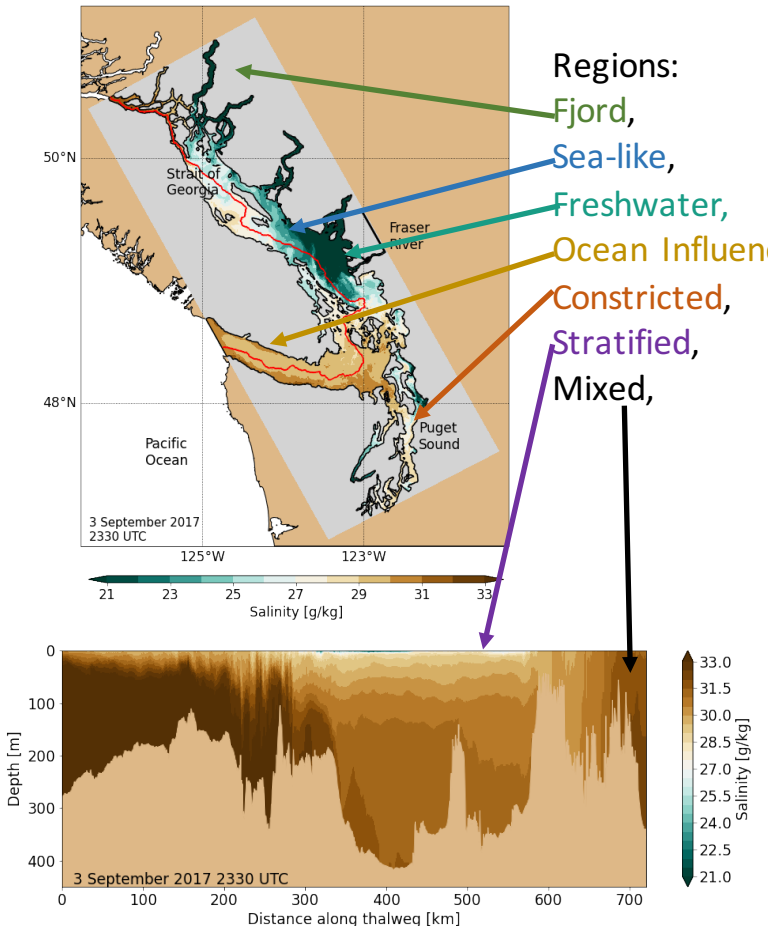


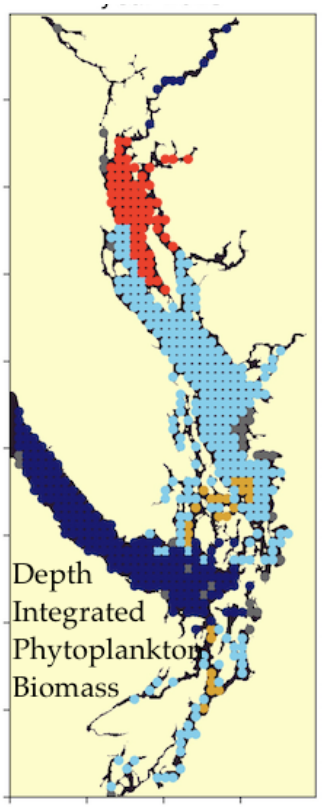


As for the difference between the North and Central Strait, it is very small in biomass and not well characterized by the available data. The difference in stratification between the regions rather drives differences in the phytoplankton groups.

Lower figure shows depth integrated average biomass for 2015 from the model with full temporal and spatial coverage. North and Central have very similar biomass with North, if anything, higher.

Clustering of coupled biochemical-physical model results can formalize regional provinces in a coastal region making divisions less arbitrary





References

- Jarníková, T, Allen, S, Ianson, D, Olson, E., 2021. A Clustering approach to identifying physical drivers of primary productivity dynamics in the Salish Sea. In preparation for *Ocean Sciences.*
- Olson E, Allen S, Do V, Dunphy M, Ianson D., 2020. Assessment of nutrient supply by a tidal jet in the northern Strait of Georgia based on a biogeochemical model. *Journal of Geophysical Research, Oceans*. 125 https://dx.doi.org/10.1029/2019JC015766
- Soontiens, N. and Allen, S. Modelling sensitivities to mixing and advection in a sill-basin estuarine system. *Ocean Modelling*, **112**, 17-32. https://dx.doi.org/10.1016/j.ocemod.2017.02.008
- Soontiens, N., Allen, S., Latornell, D., Le Souef, K., Machuca, I., Paquin, J.-P., Lu, Y., Thompson, K., Korabel, V., 2016. Storm surges in the Strait of Georgia simulated with a regional model. *Atmosphere-Ocean* **54** 1-21. https://dx.doi.org/10.1080/07055900.2015.1108899