Simulating Spring-Neap (?) Salinity Variations in Knight Inlet, Canada

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IOS

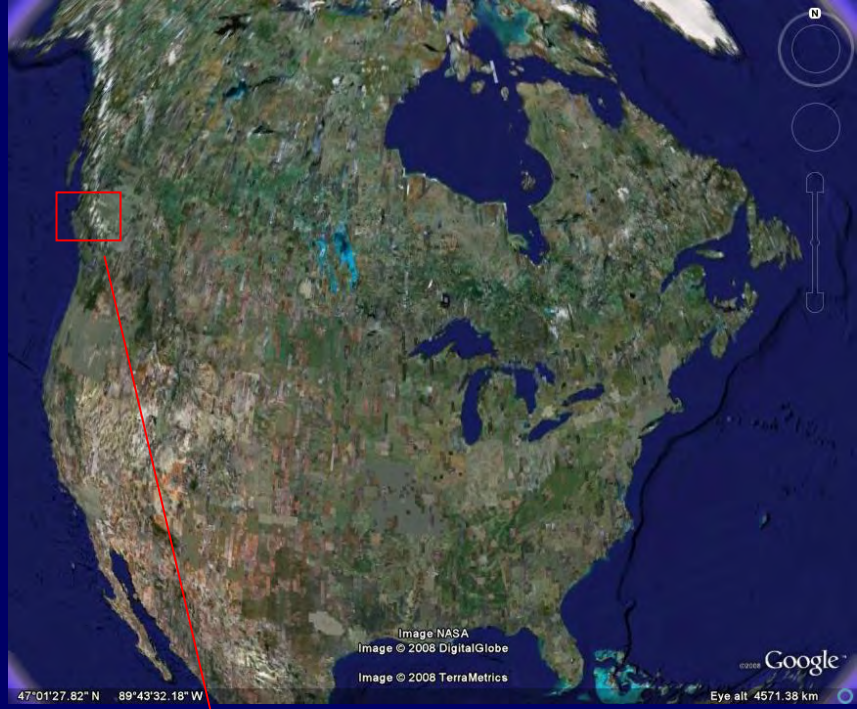
Outline

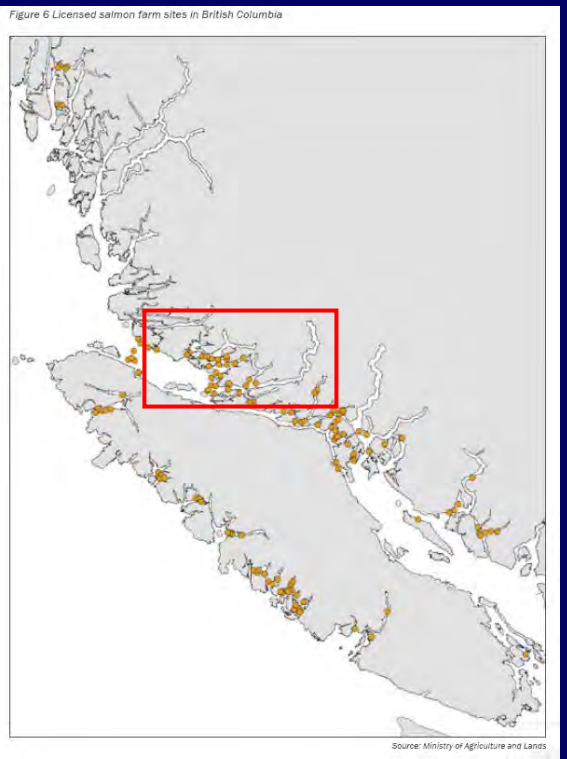
- Project background & motivation
- Observed salinity variations in Knight Inlet
- FVCOM simulations
- Summary & future work

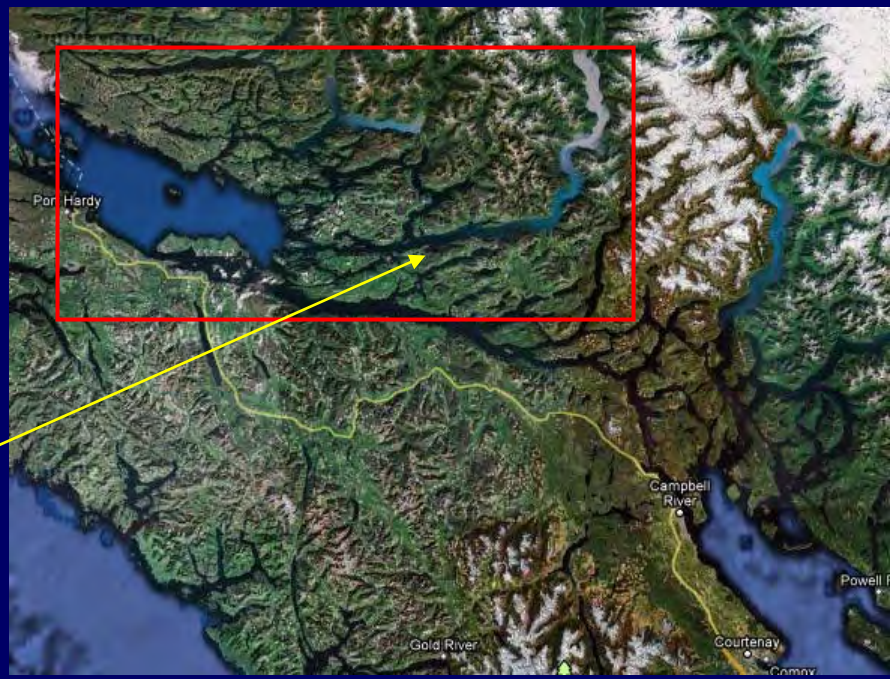
Background

Project Objective

- Simulate circulation and sea lice dispersion near salmon farms in the Broughton Archipelago, Canada
- Stucchi talk, Oct 24 in W7

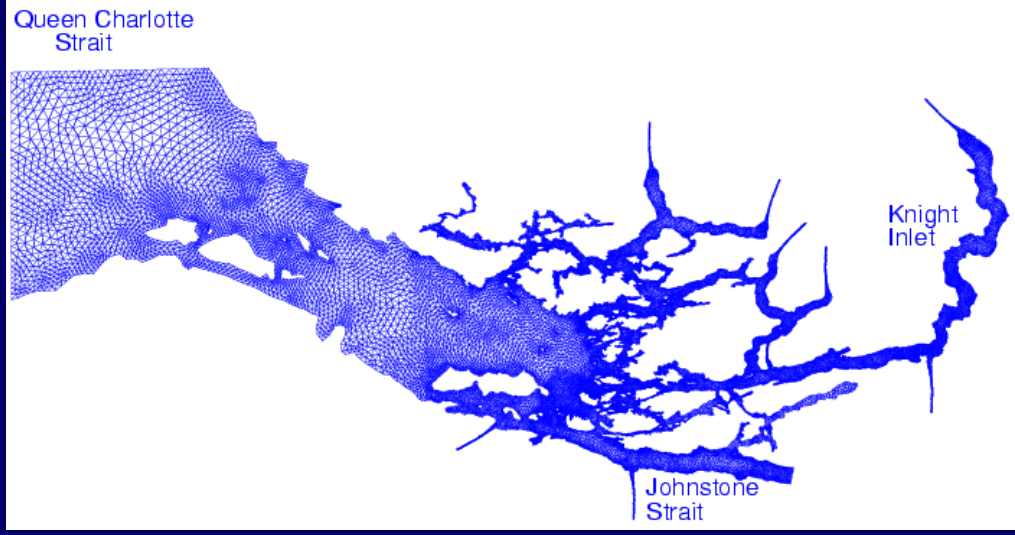






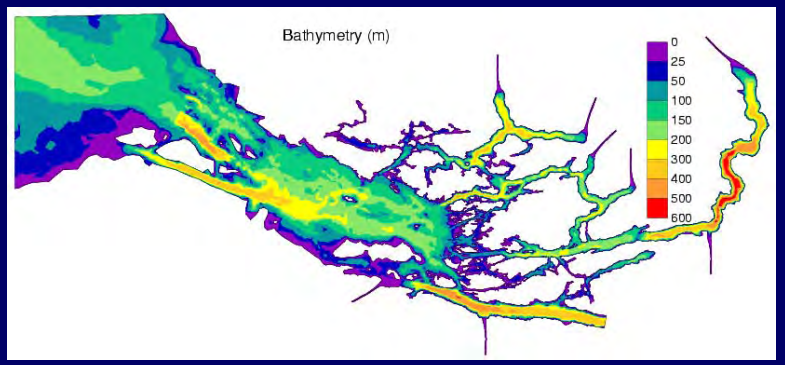
Knight Inlet

Broughton Biophysical Models



1. Physical model:

- FVCOM

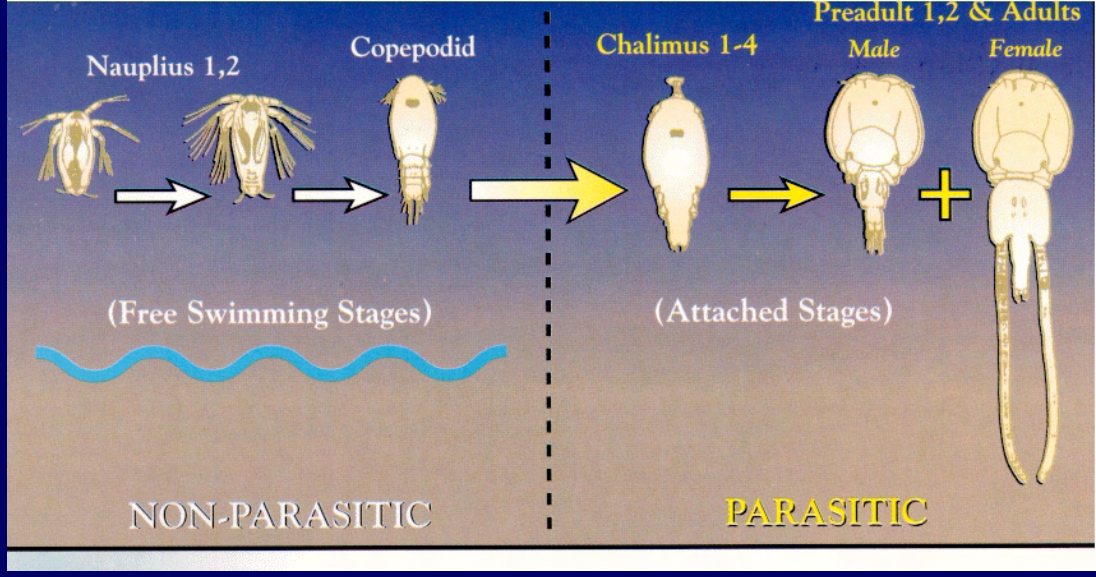


- Triangular grid
  - 43K nodes, 75K Δs
  - resolution: ~ 3km to 50m
- 20 sigma layers in vertical
  - Depths up to 500m

2. Biological model:

- uses 4D velocity, salinity, temperature & mixing fields from FVCOM
- transports and develops lice originating on farms from egg to (infective) copepodid life stages

Biological Importance of Salinity



- Egg viability varies inversely with salinity (Johnson & Albright, 1991)

Salinity	% viable
<15	0
20	20
25	51
30	55

- Nauplii mortality increases with lower salinity

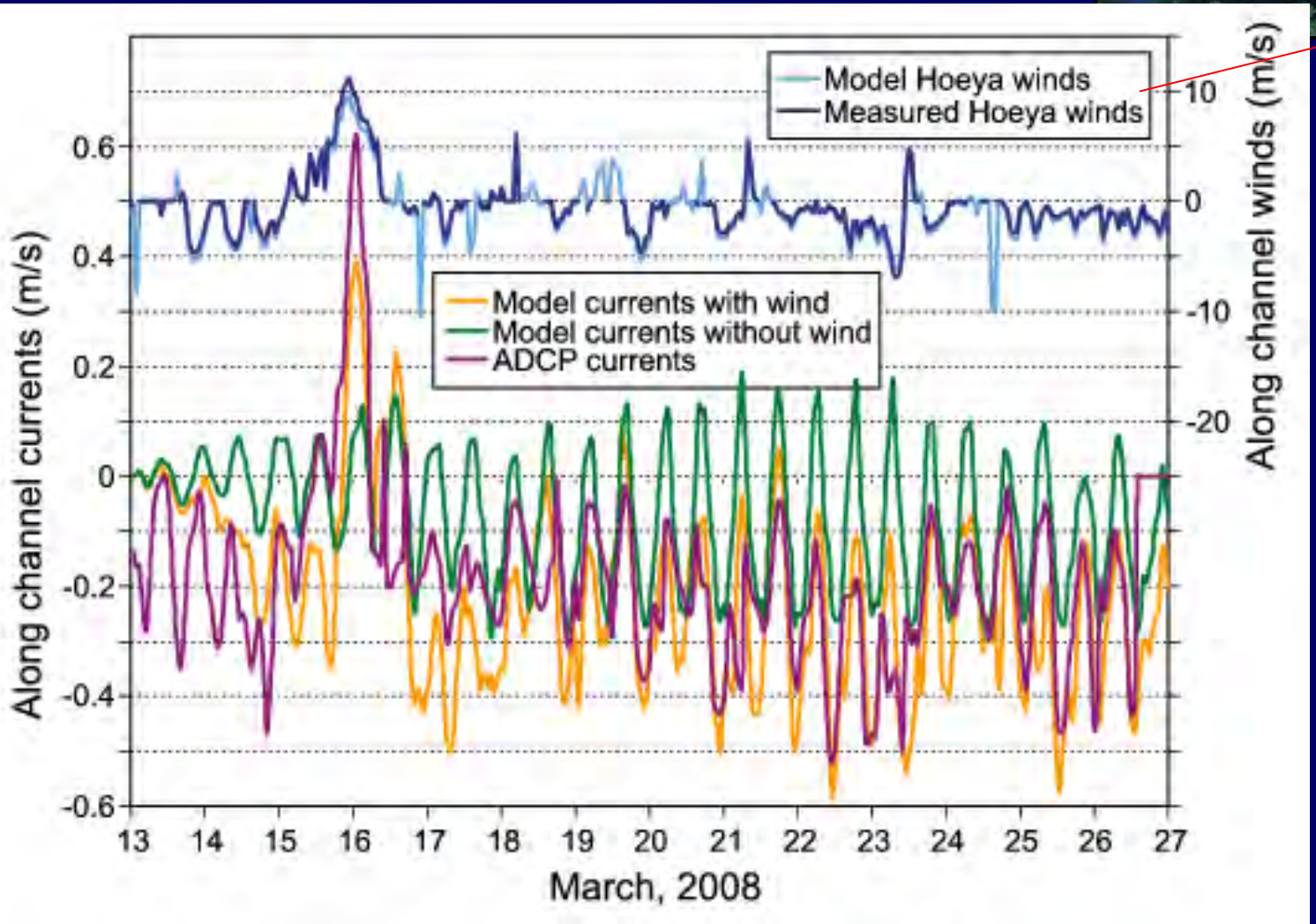
$$\frac{\partial N_{nau}}{\partial t} = \mu_{nau} N_{nau}(t)$$

$$\mu_{nau} = -0.32/day, S \geq 30\,psu$$

$$\mu_{nau} = 0.15S - 5.11/day, S \leq 30\,psu$$

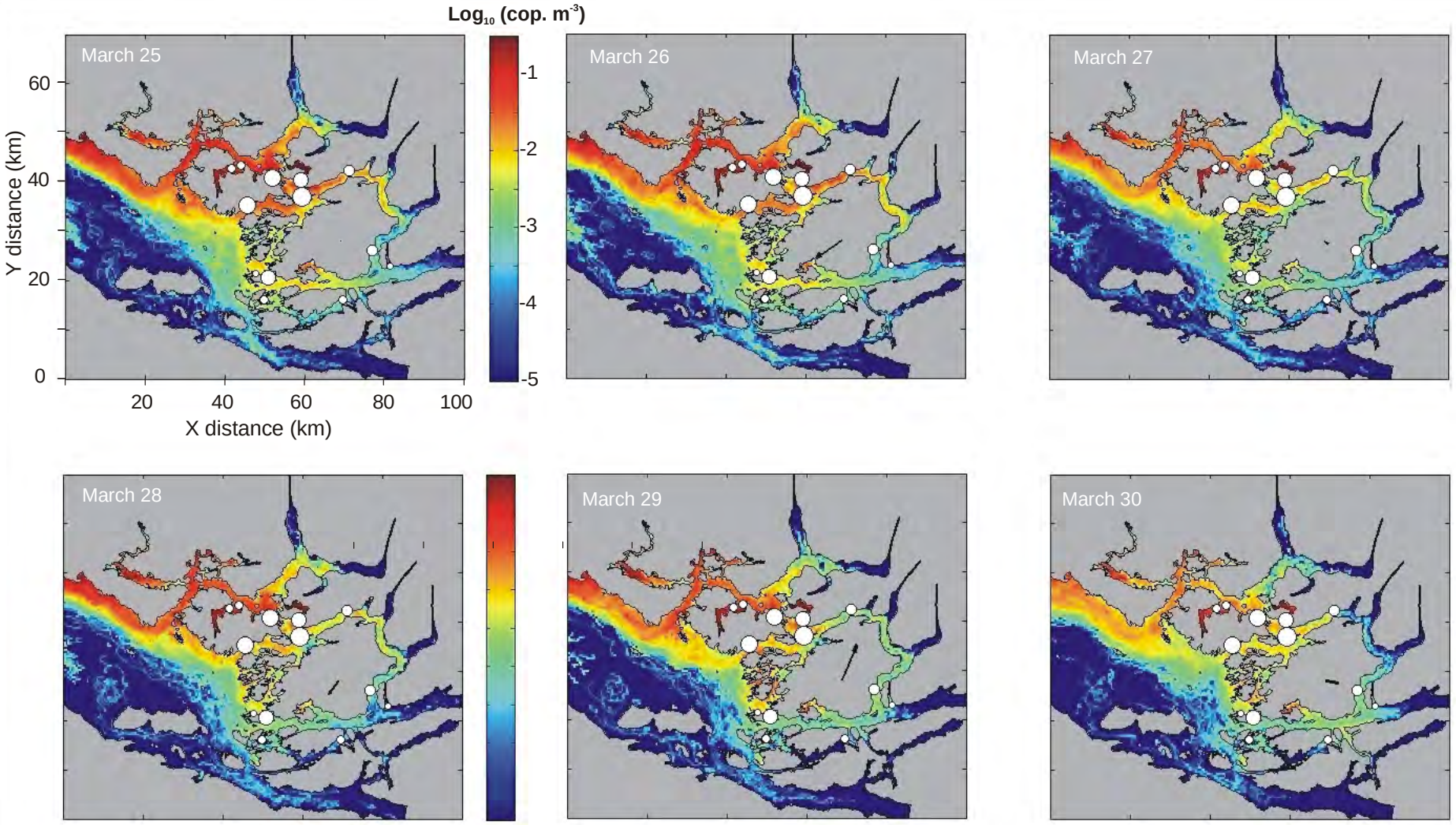
Model Currents Evaluation at KIW05

March 13-26, 2008



- *Currents at 4.5m depth*
- *Model spin-up = 2.5 days*
- *Wind forcing is important*
- *0.74 correlation between purple & orange*

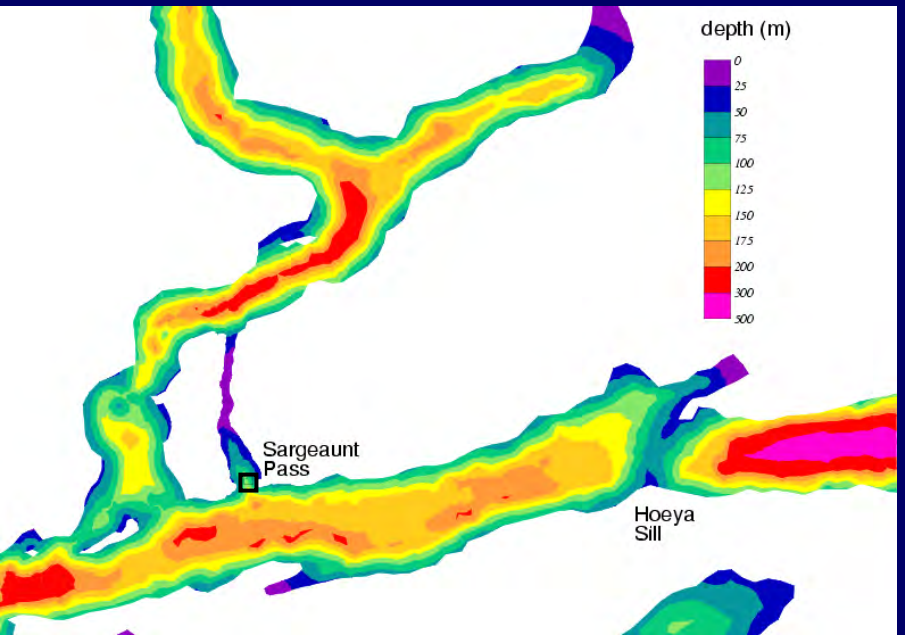
Copepodid concentration in surface layer

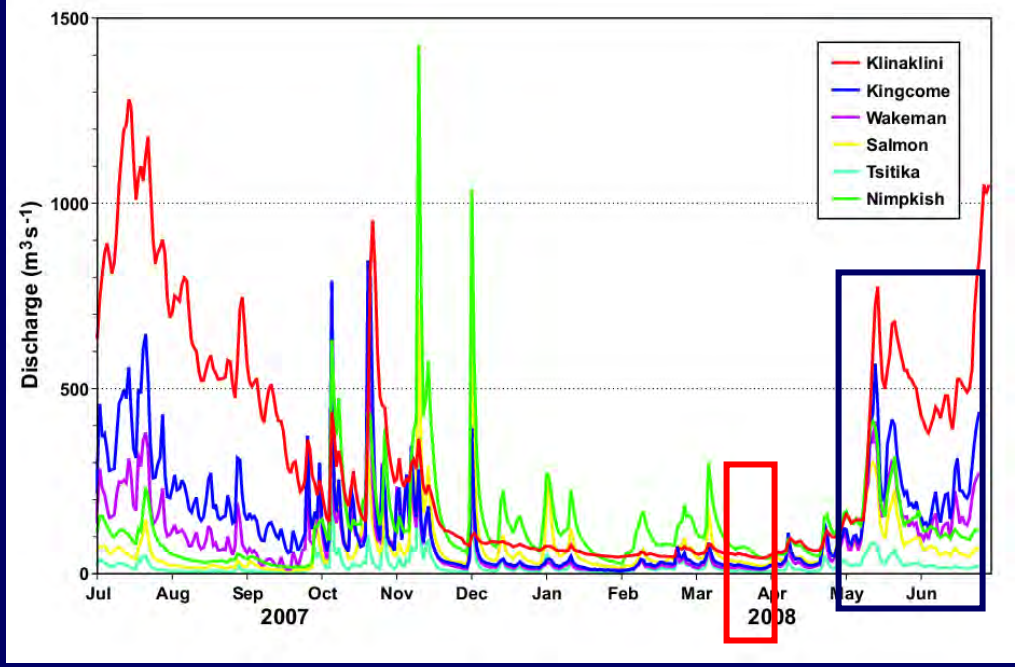


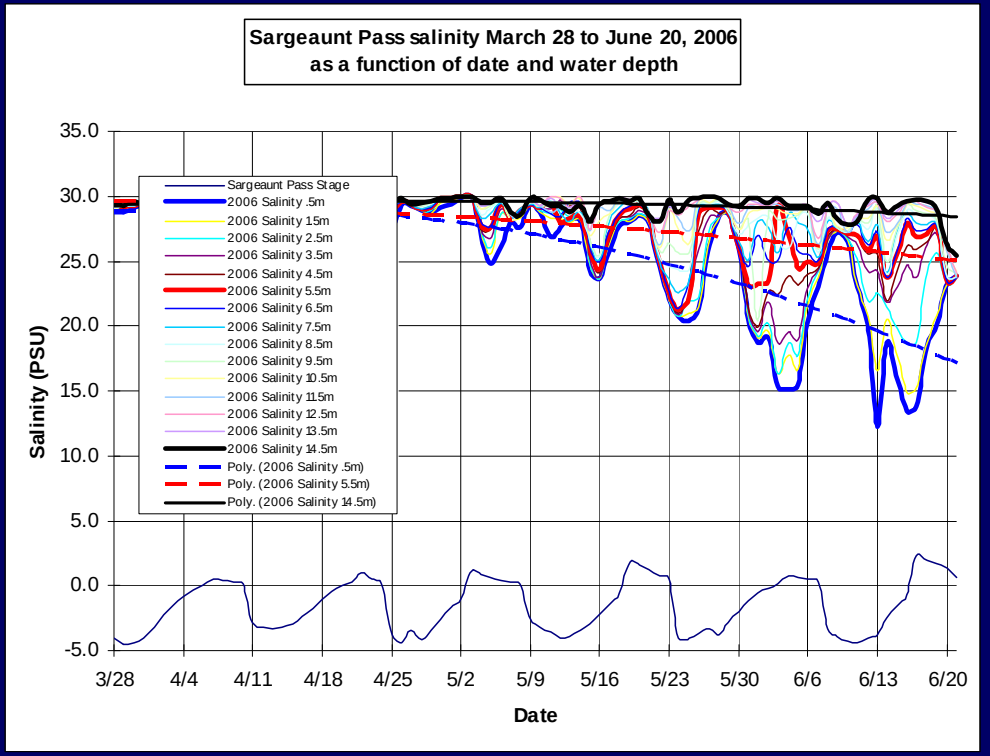
"-1" implies 1 copepodid per 10 m^3, -2 implies 1 per 100 m^3, …etc

Summer Simulations: More Freshwater

- Brooks hypothesis:
  - 2006 spring-neap salinity modulation due to tidal mixing over Hoeya Sill?
- Salinities impact lice mortality → important

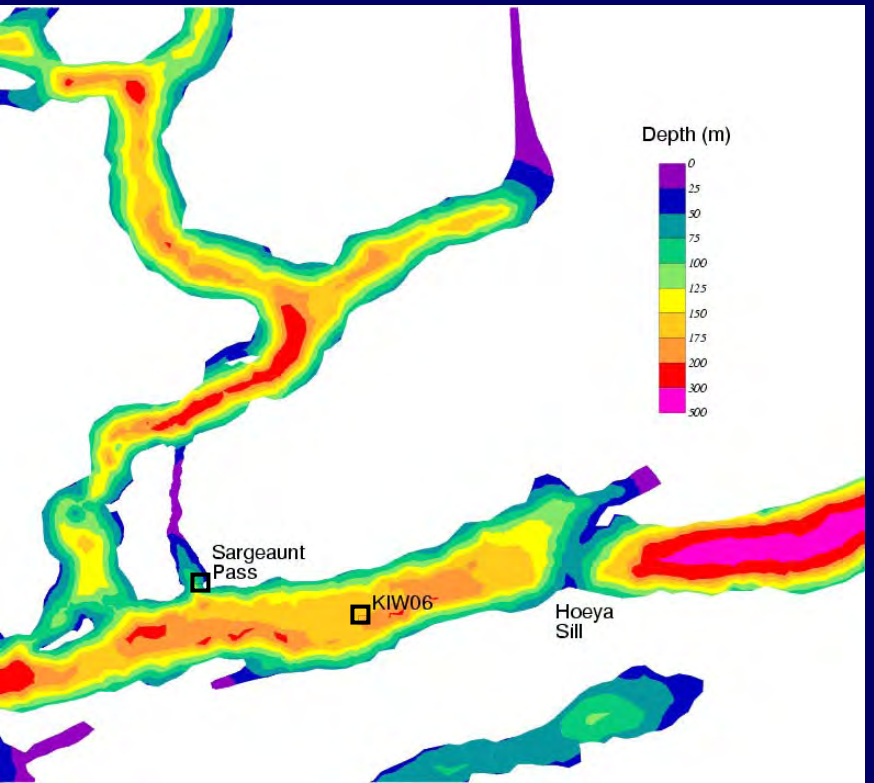


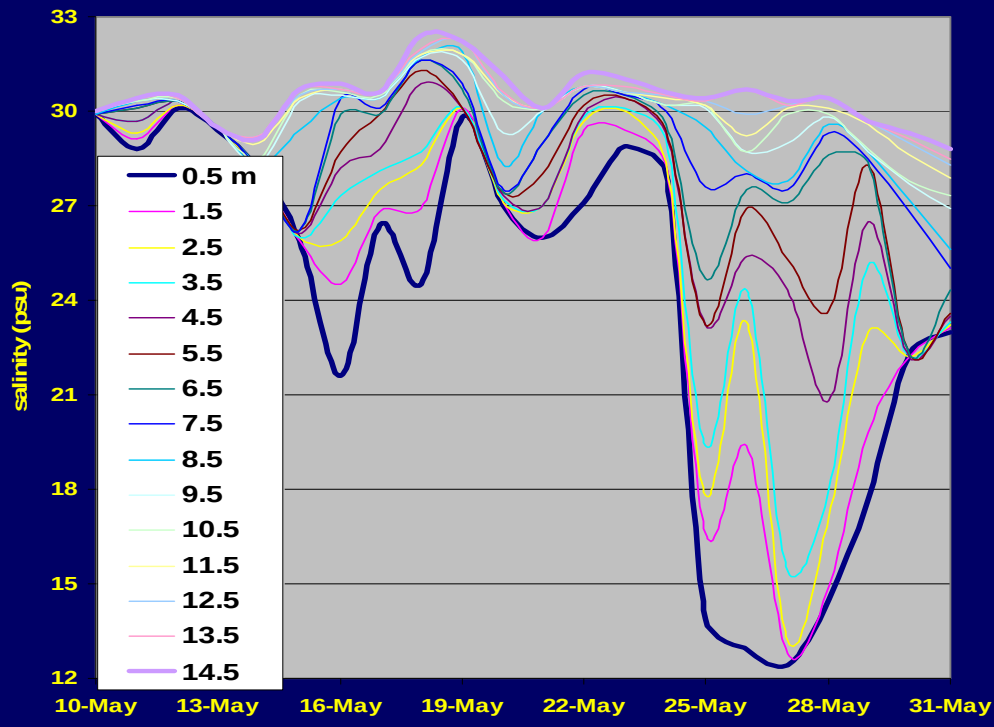


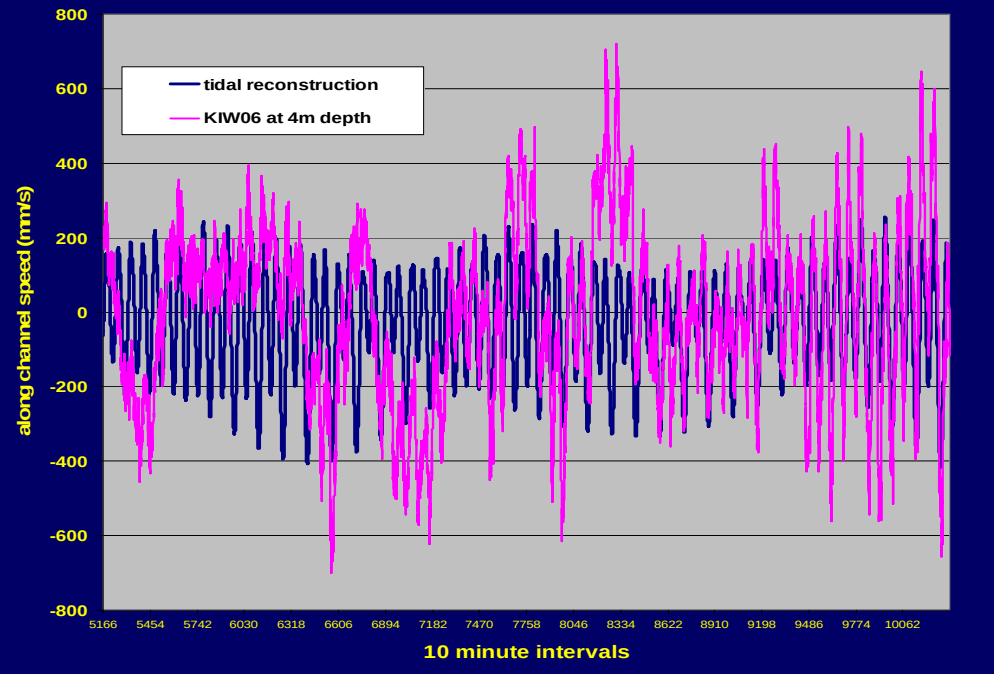


2008 Salinities at Sargeaunt Pass

- Low values on May 25-27 roughly align with neap tides
- But 4m currents at KIW06 suggest more going on
  - Wind mixing??





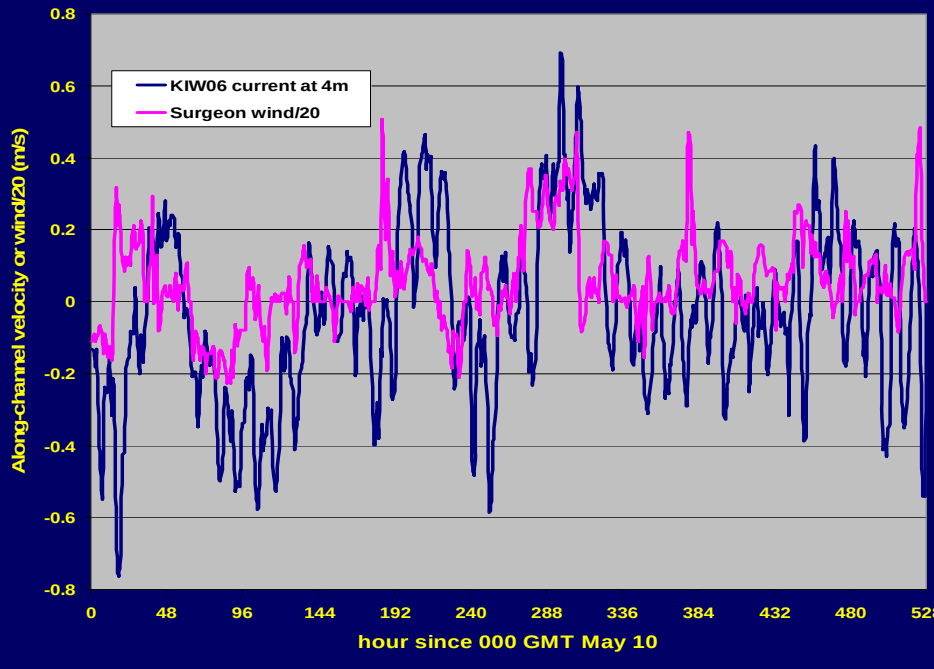


Model Simulations

- FVCOM:
  - May 10-31, 2008
  - M_2, S_2, K_1, O_1, tides
  - River discharges
  - Winds from weather stations
  - GOTM (Burchard, 2002)
    - Several mixing choices

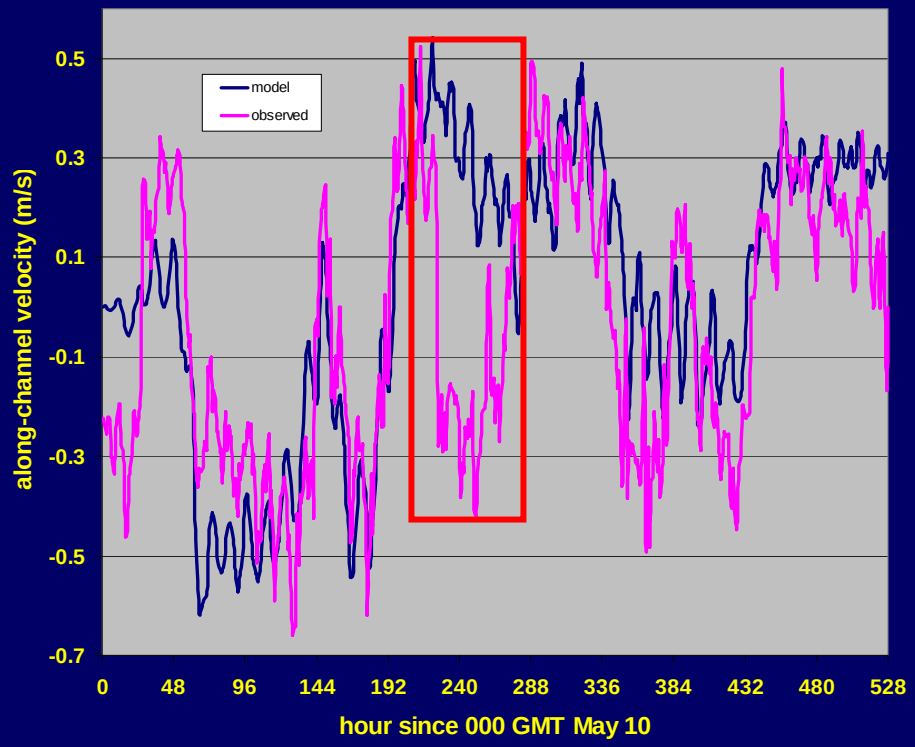
With & without winds

- southern winds lost May 20 – June 23
- 0.61 correlation between KIW06 currents at 4m & Surgeon winds when lagged by 16hr
- Re-constructed Knight winds from Surgeon & KIW06

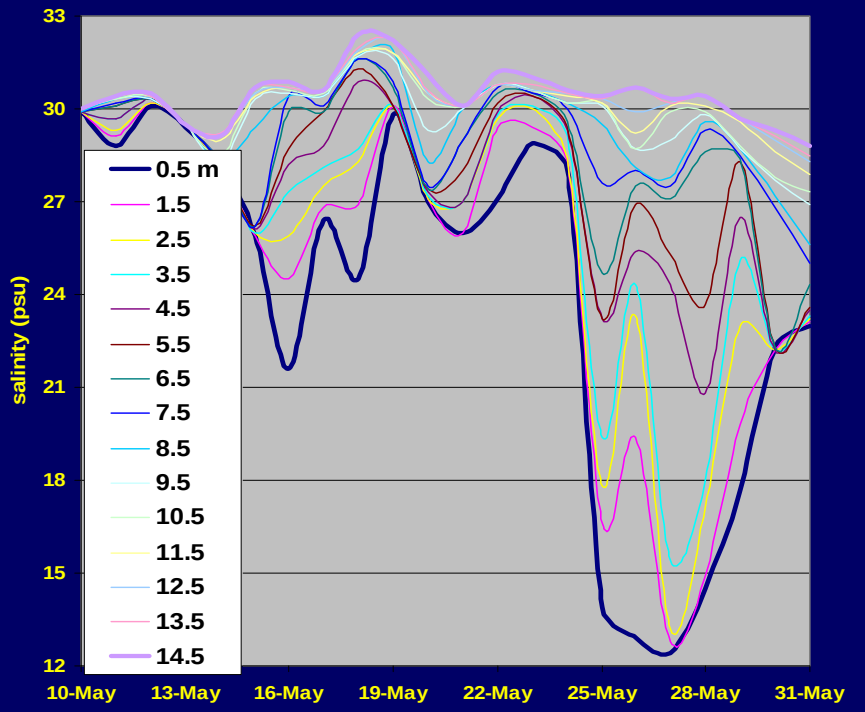


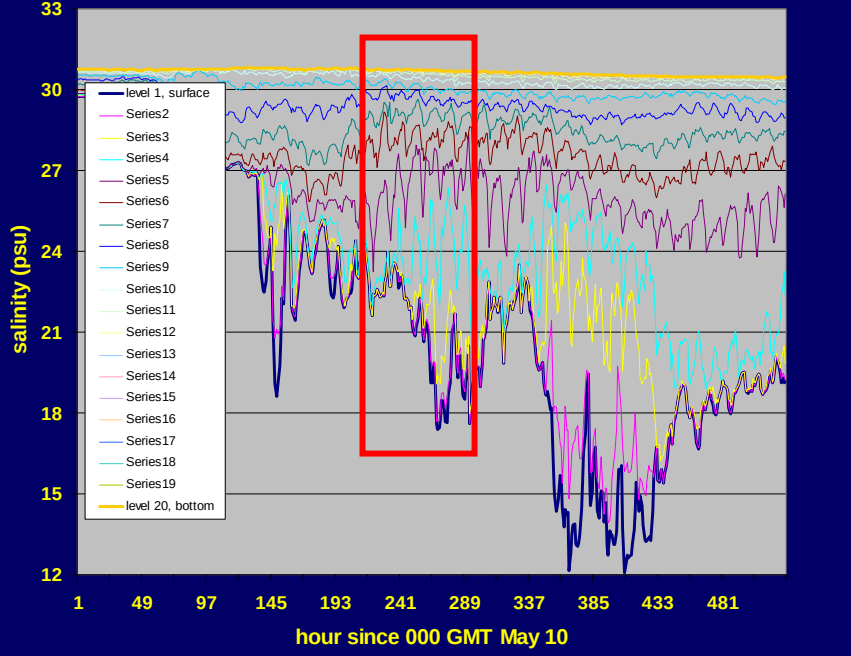
Mellor-Yamada Turbulence

- With Galperin et al. (1988) stability method



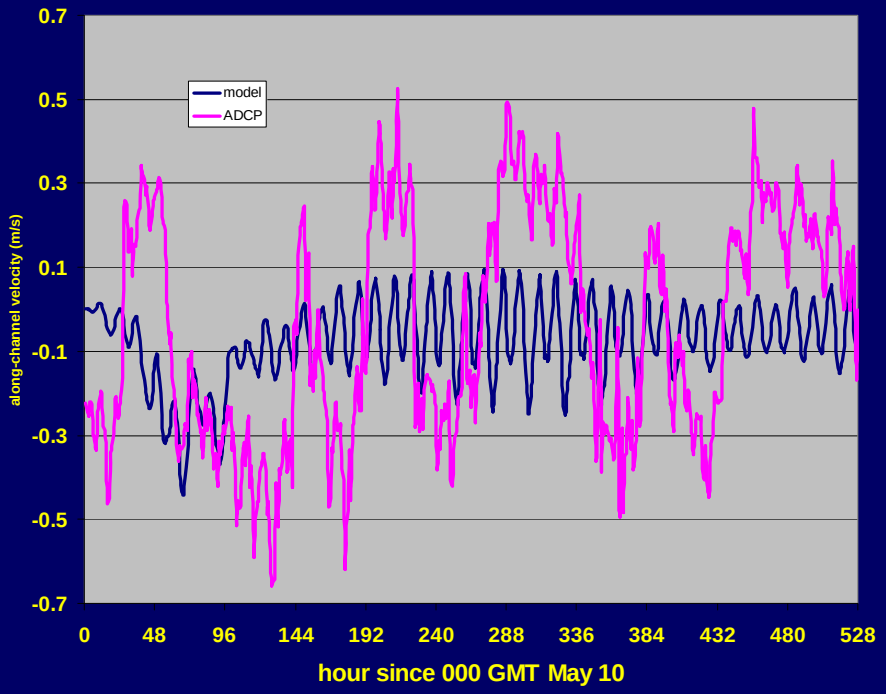
- 0.70 correlation: model and observations at 2m

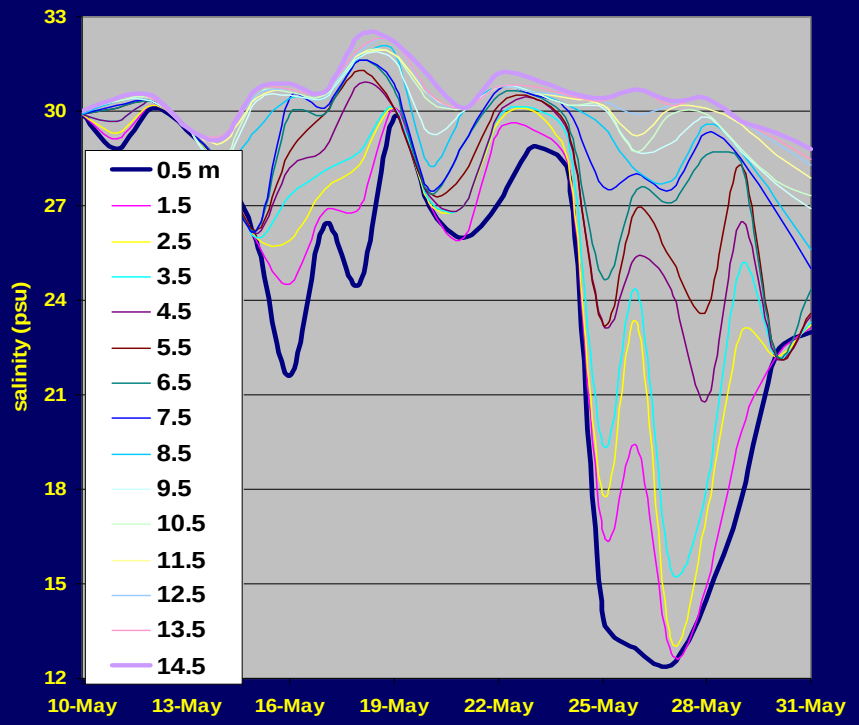




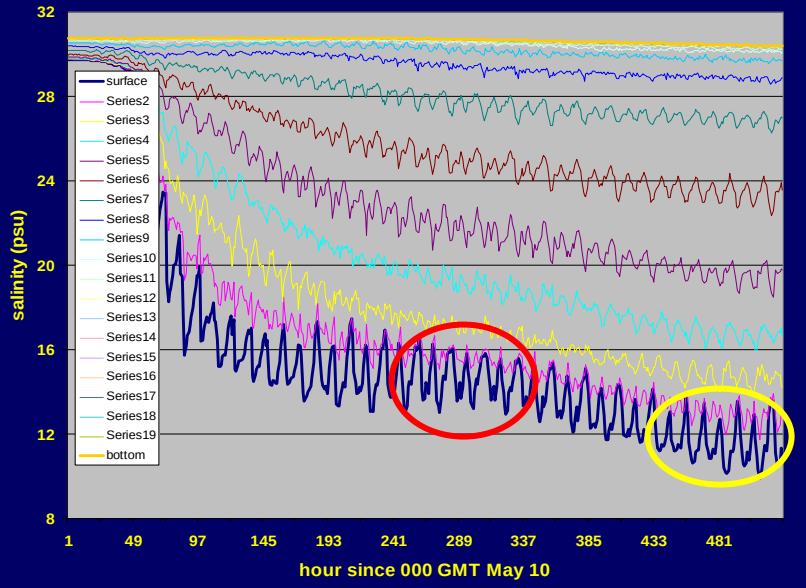
Mellor-Yamada Turbulence

- Repeat of previous but no wind





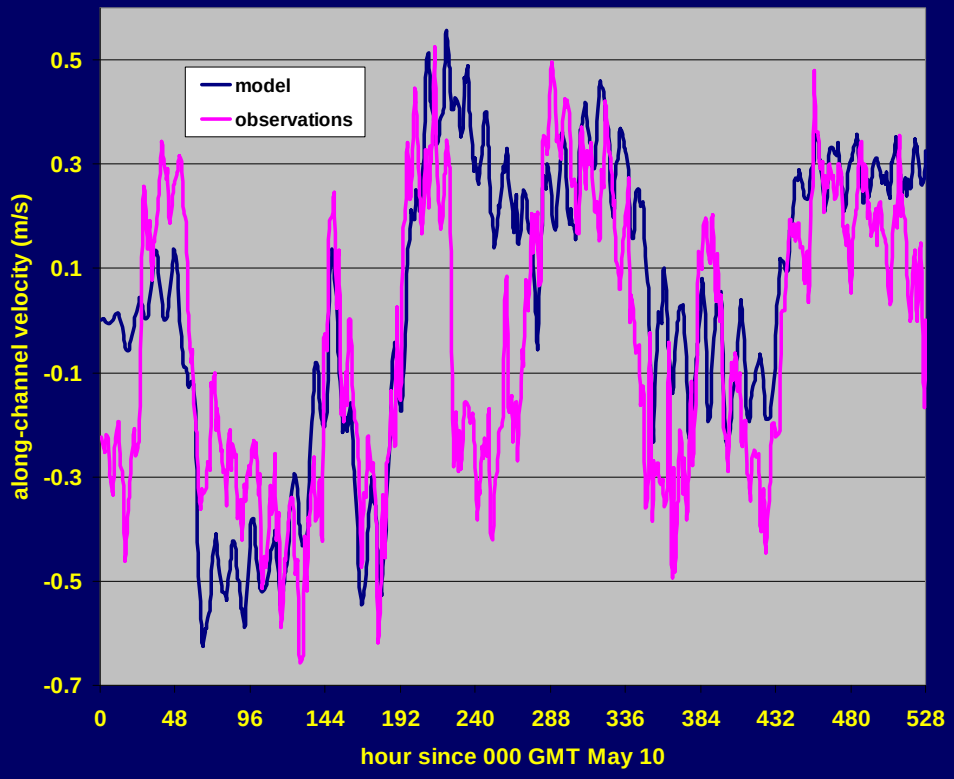
no wind



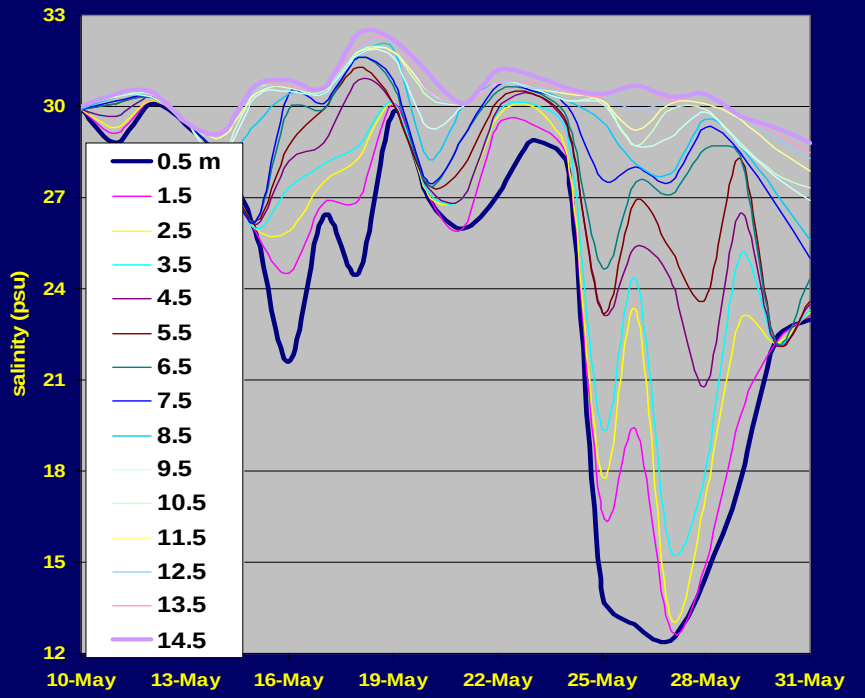
0.30 correlation between model and observations at 2m

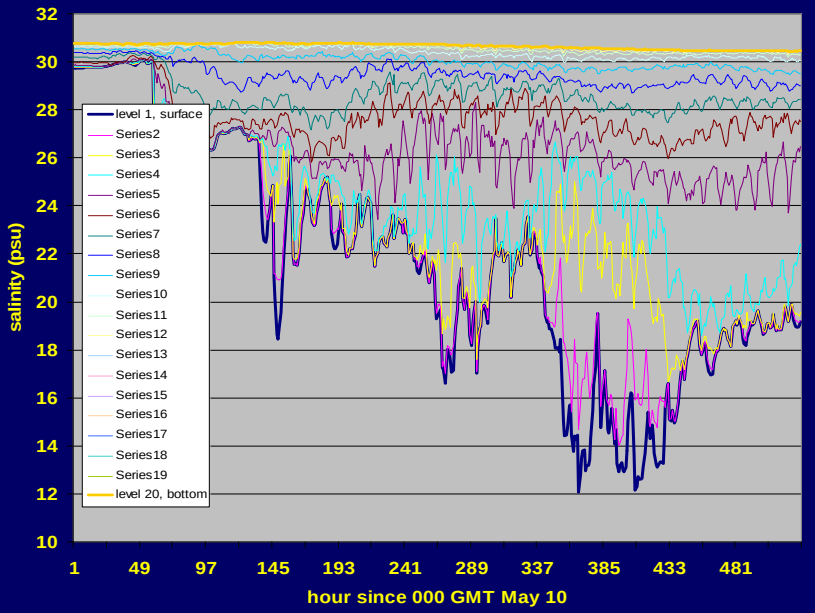
Modified k-ε Turbulence

- Burchard et al. (1998):
  - c_3^-, c_3^+ = -0.4, 1.0
  - ⇨ damping effect of stratification on turbulence



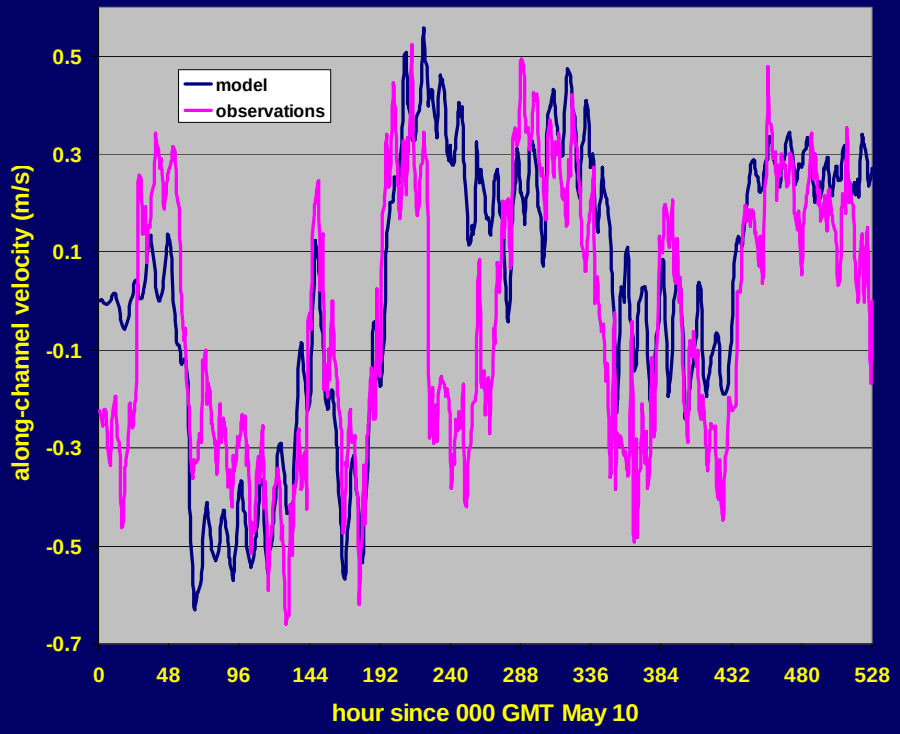
- 0.71 correlation between model & observed at 2m

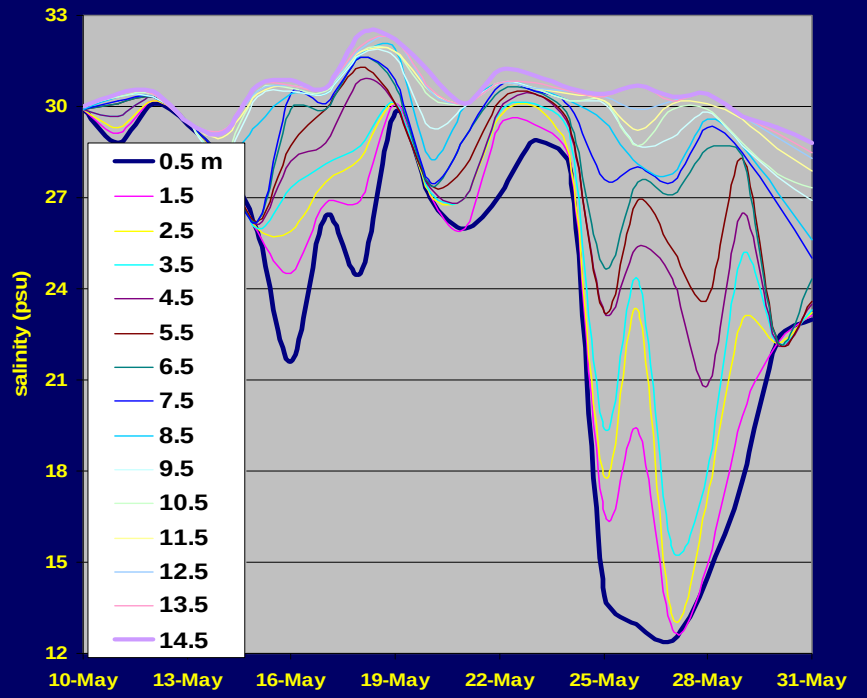


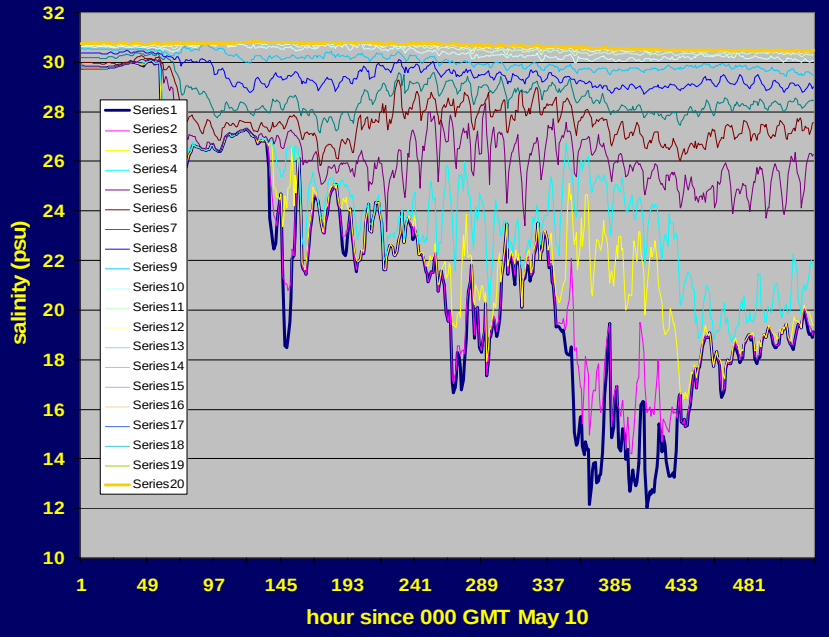


GLS Turbulence

- Canuto et al. (1998) stability function A

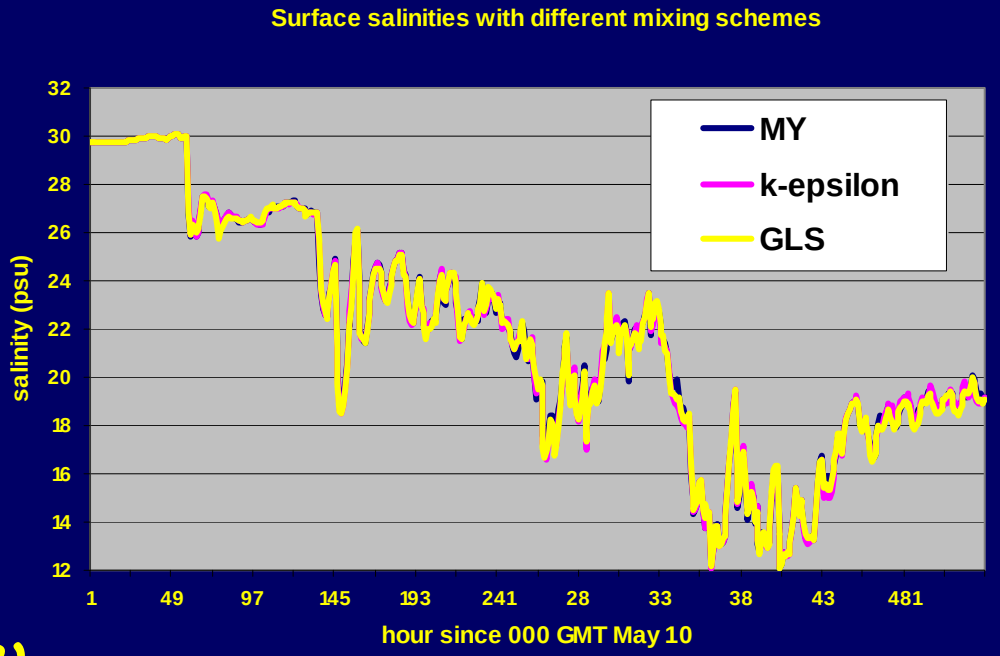






- 0.70 correlation between model & observed at 2m

Next ?



- so far, not much difference in mixing schemes

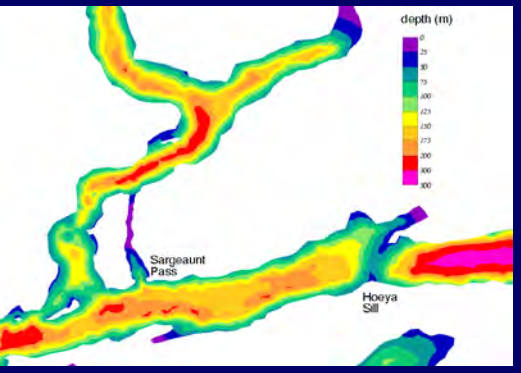
- k-ω (Umlauf & Burchard, 2003)

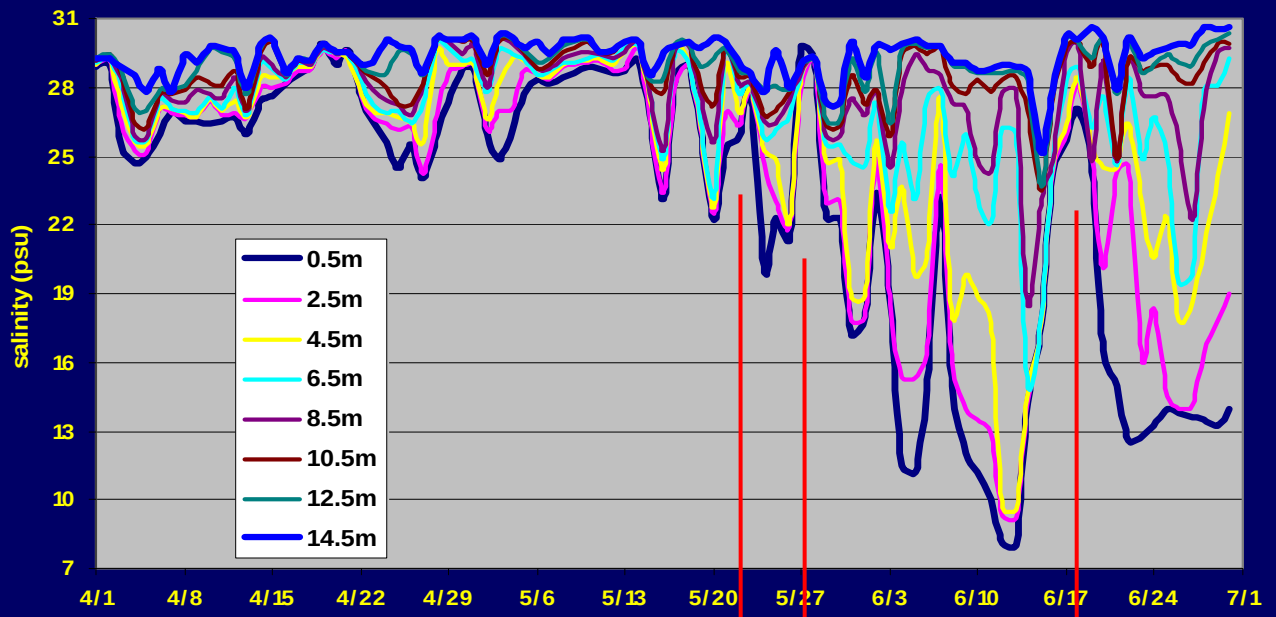
- MY2.5 with UMOL ~ N^{-a} where
  - N = Brunt –Väisälä frequency
  - a=1.0 → 2.0
  - Stigebrandt & Aure (1989), Stacey et al. (1995)
  - Accounts for mixing caused by breaking internal waves in fiords (?)

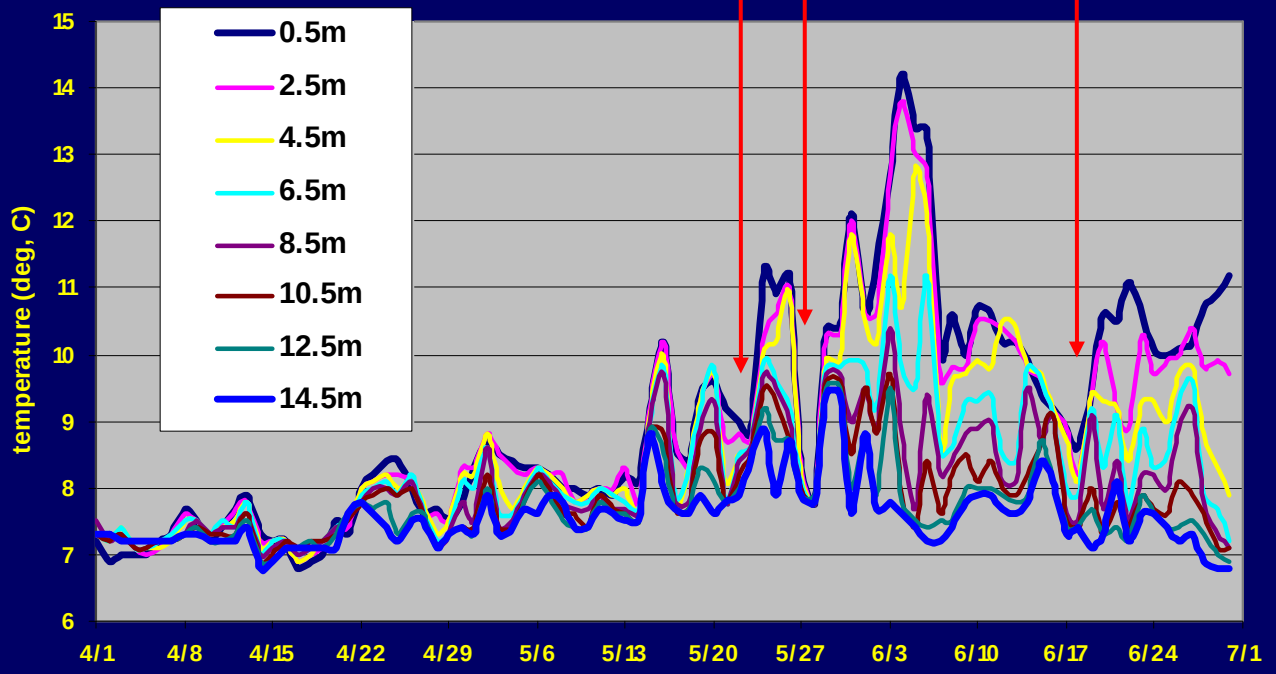
- must also evaluate temperature accuracy
  - Heat flux contributions

2007 at Sargeaunt Pass

- Strong mixing events on May 19, May 28, & June 18

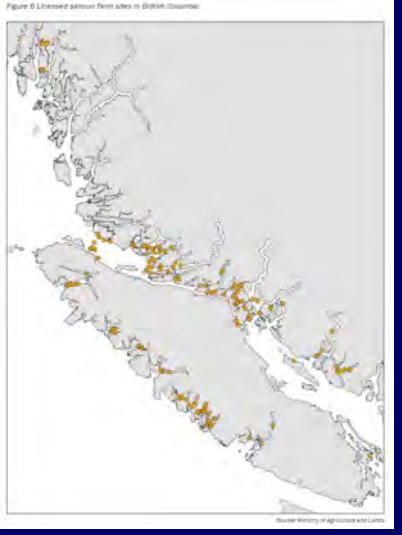






Summary & Future Work

- FVCOM has provided reasonably accurate simulations of March circulation, temperature, salinity in Knight Inlet (& Broughton Archipelago)
  - May/June tougher due to more freshwater
  - Important to get mixing right but not much difference in schemes so far
  - Salinity variations mainly due to winds, not spring-neap tidal mixing



Summary & Future Work

- FVCOM application to aquaculture issues in Discovery Islands will be challenging

  - More next year

Acknowledgements:

- Pacific Salmon Forum
- Marine Harvest Canada
- FVCOM community