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

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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
Broughton Biophysical Models

1. Physical model:
   • FVCOM

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

- Triangular grid
- 43K nodes, 75K $\Delta s$
- resolution: ~ 3km to 50m
- 20 sigma layers in vertical
- Depths up to 500m
**Biological Importance of Salinity**

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

- Nauplii mortality increases with lower salinity

<table>
<thead>
<tr>
<th>Salinity</th>
<th>% viable</th>
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<tbody>
<tr>
<td>&lt;15</td>
<td>0</td>
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<tr>
<td>20</td>
<td>20</td>
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<tr>
<td>25</td>
<td>51</td>
</tr>
<tr>
<td>30</td>
<td>55</td>
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</tbody>
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\[
\frac{\partial N_{nau}}{\partial t} = \mu_{nau} N_{nau}(t)
\]

\[
\mu_{nau} = -0.32 / \text{day}, S \geq 30 \text{ psu}
\]

\[
\mu_{nau} = 0.15S - 5.11 / \text{day}, S \leq 30 \text{ psu}
\]
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 m³, -2 implies 1 per 100 m³, …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

near surface along channel
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

0.30 correlation between model and observations at 2m
Modified $k-\epsilon$ 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

• $k-\omega$ (Umlauf & Burchard, 2003)

• MY2.5 with UMOL $\sim N^{-a}$ where
  • $N =$ Brunt-Väisälä frequency
  • $a = 1.0 \rightarrow 2.0$
  • 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