Salish Sea model: ocean acidification module and the response to regional anthropogenic nutrient sources

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Speaker

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Salish Sea Model
Ocean acidification and the response to regional anthropogenic nutrient sources

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SSEC2018, 05 Apr 2018

Apr-Sep 2008 cumulative days with $\Omega_A < 1$ for > 7 days, 0-20m
(a) Location of observations in 2008, and (b) the Salish Sea Model domain.
Model scenarios

1. Realistic historical conditions during 2008

2. Reference conditions that are the same as historical 2008 conditions, except with regional anthropogenic nutrient sources excluded

3. Reference conditions that are the same as historical 2008 conditions, except with atmospheric pCO$_2$ = 280 ppm, and ocean pCO$_2$ reduced by 110 ppm

4. Reference conditions without regional anthropogenic nutrients and without global anthropogenic atmospheric CO$_2$
Annual average change in $\Omega_A$ due to regional anthropogenic nutrients
Annual average change in $\Omega_A$ due to global anthropogenic CO$_2$
Thresholds for adverse impact on pteropods (Bednaršek et al., in prep)

- Egg development
- Survival
- Respiration
- Growth/calcification
- Severe dissolution
- Mild dissolution
Apr–Sep cumulative days with $\Omega_A < 1$ for $> 7$ days, 0-20m

Point Roberts
- High duration
- Low frequency

Lynch Cove
- High duration
- High frequency

Main basin
- Low duration
- Low frequency

Case Inlet
- Medium duration
- Low frequency
Aug-Sep cumulative days with $\Omega_A < 0.9$ for $> 2$ days, 0-20m
Conclusions

• Significant changes in carbonate system variables are due to regional anthropogenic nutrient sources and global atmospheric CO$_2$

• Added nutrients significantly decrease $\Omega_A$ and pH, and increase DIC, especially in deeper water

• Added nutrients significantly increase the duration of exposure of pteropods to corrosive conditions below vulnerability thresholds.
The End

Following are extra slides in case they are needed for Q + A
Skill metrics for the Salish Sea Model

<table>
<thead>
<tr>
<th></th>
<th>$R^2$</th>
<th>RMSE</th>
<th>Bias</th>
<th>RMSE$_{diff}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>T ($^\circ$C)</td>
<td>0.81</td>
<td>1.48</td>
<td>1.28</td>
<td></td>
</tr>
<tr>
<td>S (psu)</td>
<td>0.37</td>
<td>1.33</td>
<td>-0.68</td>
<td></td>
</tr>
<tr>
<td>Chl ($\mu$g/L)</td>
<td>0.25</td>
<td>2.78</td>
<td>-0.30</td>
<td></td>
</tr>
<tr>
<td>DO (mg/L)</td>
<td>0.64</td>
<td>1.80</td>
<td>-1.56</td>
<td>0.10</td>
</tr>
<tr>
<td>NO$_3$ (mg/L)</td>
<td>0.64</td>
<td>0.08</td>
<td>-0.001</td>
<td></td>
</tr>
<tr>
<td>DIC ($\mu$mol/kg)</td>
<td>0.59</td>
<td>70.33</td>
<td>-20.13</td>
<td>0.76</td>
</tr>
<tr>
<td>TA ($\mu$mol/kg)</td>
<td>0.66</td>
<td>60.89</td>
<td>-38.75</td>
<td>0.23</td>
</tr>
<tr>
<td>pH (total scale)</td>
<td>0.41</td>
<td>0.14</td>
<td>-0.07</td>
<td>0.0061</td>
</tr>
<tr>
<td>pCO$_2$ (uatm)</td>
<td>0.42</td>
<td>330.33</td>
<td>183.4</td>
<td>26.2</td>
</tr>
<tr>
<td>$\Omega_{arag}$</td>
<td>0.47</td>
<td>0.32</td>
<td>-0.12</td>
<td>0.027</td>
</tr>
</tbody>
</table>
Time-series of predicted and observed variables at four locations

**Surface layer**

- Chl a
- NO3
- DO
- DIC
- TA
- pH
- $\Omega_{ar}$

**Bottom layer**

- Chl a
- NO3
- DO
- DIC
- TA
- pH
- $\Omega_{ar}$

Locations:
- Gordon Pt
- West Pt
- Hood Canal
- Saratoga
Changes in pH and $\Omega_{\text{arag}}$ due to anthropogenic sources

<table>
<thead>
<tr>
<th></th>
<th>Regional anthropogenic nutrient sources (this study)</th>
<th>Global anthropogenic sources (Feely et al. 2010)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Range of monthly average differences</strong></td>
<td>Range of monthly average differences between historical (2008) and estimated pre-industrial</td>
<td>Difference between cruise observations (February and August, 2008) and estimated pre-industrial</td>
</tr>
<tr>
<td><strong>pH (surface 20 m)</strong></td>
<td>-0.07 to 0.06</td>
<td>-0.11 to 0.03</td>
</tr>
<tr>
<td><strong>pH (bottom)</strong></td>
<td>-0.10 to 0.05</td>
<td>-0.06 to 0.00</td>
</tr>
<tr>
<td><strong>$\Omega_{\text{arag}}$ (surface 20 m)</strong></td>
<td>-0.06 to 0.19</td>
<td>-0.33 to -0.09</td>
</tr>
<tr>
<td><strong>$\Omega_{\text{arag}}$ (bottom)</strong></td>
<td>-0.12 to 0.17</td>
<td>-0.16 to -0.02</td>
</tr>
</tbody>
</table>
Annual average change in $\Omega_A$ due to combined regional anthropogenic nutrients and global CO$_2$.
Annual average change in $\Omega_A$ due to global anthropogenic CO$_2$ as a percentage of the total change from nutrients and CO$_2$
Maximum monthly average decrease in $\Omega_A$ due to regional anthropogenic nutrients.
Maximum monthly average decrease in $\Omega_A$ due to global anthropogenic CO$_2$
Maximum monthly decrease in $\Omega_A$ due to regional anthropogenic nutrients as a percentage of the max total depletion.