High-frequency variability of dissolved oxygen in the subpolar North Pacific

PICES Annual Meeting 2012 (POC-P-8562)

Yohei Takano (Georgia Tech)
Taka Ito (Georgia Tech) and Curtis Deutsch (UCLA)

Acknowledgements: Ken Johnson (MBARI), Mike Alexander (NOAA), Matt Newman (NOAA), Yisen Zhong (GT) and Kevin Grise (LDEO)
Background

- Dissolved Oxygen (DO) is a widely observed tracer
- It responds to both physical and biological change
- Existing DO observational studies are mainly focusing on seasonal and longer timescales
New opportunity for monitoring high-frequency variability

- DO and NO$_3$ sensors on profiling floats (Apex/ISUS)
- Increased measurement frequency (~70 times/year)
- Short-timescale analysis

http://www.mbari.org/chemsensor/APEXISUS.htm
Main causes of DO variability

Thermocline

ML

Mixed layer

Heaving

OUR' (sinking particles)

Lateral advection

\(-w' \frac{\partial O_2}{\partial z}\)

\(-U'_H \cdot \nabla \bar{O}_2\)
Objective

• Determine and understand high-frequency variability of the DO and NO$_3$ in Gulf of Alaska
Apex/ISUS Float Data

- Location (OSP, 50°N, 145°W)
- Time period 9/2008 - 8/2011 every 5 days
- Vertical coverage surface - 1000m
- T,S,DO,NO$_3$

Data provided by Ken Johnson, Johnson et al., 2012, submitted
Apex/ISUS Float Data

- Location (OSP, 50°N, 145°W)
- Time period 9/2008 - 8/2011 every 5 days
- Vertical coverage surface - 1000m
- T,S,DO,NO$_3$

Data provided by Ken Johnson, Johnson et al., 2012, submitted
Background Sea Level Anomaly (SLA)

No wave propagation signal in SLA at 145°W

ETOPO1 from http://www.ngdc.noaa.gov/mgg/global/global.html
Observed Tracers

- **a)** S.D Profiles
- **b)** Nitrate
- **c)** Potential Density
- **d)** AOU
- **e)** Dissolved Oxygen
- **f)** Nitrate
- **g)** Potential Density
- **h)** AOU

*Black line: raw data S.D  
Blue dotted line: high-freq S.D*
High-frequency Variability in the Main Thermocline
Power Spectrum of the Thermocline DO and NO$_3$
Indications from the Power Spectrum

- Mesoscale and sub-mesoscale eddies, inertial motion or tides
- Aliased tides or inertia oscillation
Aliased Spectral Peak
Aliased Power Spectrum

Power Spectrum Analysis Thermocline DO, NO$_3$

- High-freq DO
- High-freq NO3
- Inertial Motions

- $\phi = 50.8^\circ$N
- $\phi = 49.5^\circ$N
- 19.9-day
- 12.8-day
Aliased Internal Processes

• Inertial motion (simply sine wave) based on latitude in Gulf of Alaska can generate similar spectral peak (shown in the previous slide) as an aliased signal.

• Internal wave (e.g. $M_2$ tide generated) has similar frequency which could also result in aliased signals.
Correlation between Thermocline DO and Surface Properties

Table 1: OUR Relationship (Lag-linear Correlation Coefficient)

<table>
<thead>
<tr>
<th>Variables</th>
<th>5-day</th>
<th>10-day</th>
<th>15-day</th>
<th>20-day</th>
<th>25-day</th>
</tr>
</thead>
<tbody>
<tr>
<td>MLD</td>
<td>-0.07</td>
<td>-0.08</td>
<td>0.12</td>
<td>0.06</td>
<td>-0.18</td>
</tr>
<tr>
<td>SST</td>
<td>-0.08</td>
<td>0.02</td>
<td>0.00</td>
<td>-0.04</td>
<td>0.07</td>
</tr>
<tr>
<td>Surface $O_2$</td>
<td>-0.16</td>
<td>0.12</td>
<td>0.03</td>
<td>0.05</td>
<td>-0.13</td>
</tr>
<tr>
<td>Surface $NO_3$</td>
<td>0.00</td>
<td>0.01</td>
<td>0.04</td>
<td>-0.03</td>
<td>-0.10</td>
</tr>
<tr>
<td>SLA</td>
<td>-0.08</td>
<td>0.06</td>
<td>0.05</td>
<td>-0.08</td>
<td>0.04</td>
</tr>
<tr>
<td>NPP(8-day)</td>
<td>-0.04</td>
<td>-0.08</td>
<td>0.08</td>
<td>0.04</td>
<td>-0.01</td>
</tr>
</tbody>
</table>

◆ No evidence of biologically or eddy driven DO variability

* SLA and NPP are downloaded from AVISO and OSU, respectively.  
  http://www.science.oregonstate.edu/ocean.productivity/index.php
Conclusions

• High-frequency variability is observed in DO with a 17-day spectral peak
• No correlation with surface physical and biological processes
• Spectral peak may come from aliased internal processes