Bidecadal variability in the intermediate waters of the northwestern subarctic Pacific and the Okhotsk Sea in relation to the 18.6-year nodal tidal cycle

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Introduction

- Bidecadal oscillation of AOU (apparent oxygen utilization) in the intermediate layer in Oyashio area (Ono et al., 2001)
- Correlated with NPI
  - Atmospheric forcing?
  - not outcrop
The 18.6-year period nodal tide

• The 18.6-year period nodal tidal cycle
  ... diurnal tide amplitude is modulated 20% (Ono et al., 2001)

Investigate the relation between the intermediate water variation and the nodal tide
The intermediate water formation and tidal mixing

- East Kamchatska Current
- Dense Shelf Water
- Okhotsk Sea Mode Water

Vertical mixing induced by the diurnal tide around the Kuril Islands is important --- direct effect & upward salt flux (Nakamura et al., 2004)

The nodal tide may influence the intermediate waters around this area
Data and Method

- World Ocean Database 2001
- Standard level data
- Linearly interpolated to the density surfaces
- Average in 5 years (between 2 years before and after)
When the diurnal tide is strong, in the intermediate layer …

- AOU is low (water is young)
- Potential temperature is low
- Thickness is large
When the diurnal tide is strong, in the intermediate layer …

- AOU is low (water is young)
- Potential temperature is high
- Thickness is large
Midterm Summary

When the diurnal tide is strong, in the intermediate waters...

<table>
<thead>
<tr>
<th></th>
<th>Oyashio</th>
<th>Upstream Oyashio</th>
<th>OSMW</th>
</tr>
</thead>
<tbody>
<tr>
<td>AOU</td>
<td>low</td>
<td>(not clear)</td>
<td>low</td>
</tr>
<tr>
<td>T</td>
<td>cool</td>
<td>cool</td>
<td>warm</td>
</tr>
<tr>
<td>Thickness</td>
<td>thick</td>
<td>thick</td>
<td>thick</td>
</tr>
</tbody>
</table>

- AOU and thickness variations indicate that the intermediate water formation rate is increased.
- Why temperature variations are opposite between Pacific side and the Okhotsk Sea?
When the diurnal tide is strong, SSS is high. This possibly change the DSW formation.

- High \( S = \) High \( T \), on an isopycnal surface
- Need less cooling to sink > volume ↑
Mixing Ratio of OSMW in the Upstream Oyashio water

Assumption:
U-OY water is produced by the isopycnal mixing between EKC and OSMW

$$R = \frac{\theta_{EKC} - \theta_{U-OY}}{\theta_{EKC} - \theta_{OSMW}}$$

When the diurnal tide is strong, the Mixing Ratio is high.
Large outflow of OSMW cool the Pacific water.

$$\leqslant$$ OSMW is colder than the Pacific water even in strong tide / warm OSMW period
Summary & Possible Mechanism

- We found bidecadal water variations in the northwestern subarctic Pacific and the Okhotsk Sea.
- These temporal variations are synchronized with the 18.6-year period nodal tidal cycle.
- This could be explained by the nodal modification of the vertical mixing around the Kuril Straits.

Diagram:
- **DSW** formation
- High T-S volume up
- High SSS
- Strong Mixing
- Large Outflow
- Low AOU
- Thick intermediate layer

Legend:
- **High SSS**
- **High T**
- **Low T**
- **All Areas:** Low AOU

Map:
- Sakhalin
- Hokkaido
- Kamchatska
- Kuril Islands
END