Bioclimatic velocity for walleye pollock in the Bering Sea

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Introduction

Walleye pollock (*Gadus chalcogrammus*) is the second most extensively fished species in the world.

Bulatov, 2014
Introduction

Bulatov, 2014
Introduction

Environmental and climate conditions influence abundance & distribution of walleye pollock in the Bering Sea inferred from statistical model (GAM)

Swartzman et al. 1995, Smart et al, 2012
Introduction

- **Bioclimatic velocity**: rate at a species must migrate to maintain constant habitat conditions.
- Distribution-based analysis of climate-induced shift on species suitable habitat
Introduction

Objectives

- Map the preferential habitat of walleye pollock in Bering Sea using species distribution models
- Examine the sensitivity of walleye pollock to climate changes within a sub-decadal (7-8 years) temporal scale
- Compare the spatio-temporal trends of climatic and bioclimatic velocities in Bering Sea

Rationale

Climate & environmental impacts vary across species and climate shifts from multiple bioclimatic variables show more complex and informative patterns than those of temperature change alone
Data and Methods
## Data and Methods

<table>
<thead>
<tr>
<th>Environmental variables</th>
<th>Abbreviation</th>
<th>Unit</th>
<th>Raw spatial resolution</th>
<th>Raw temporal resolution</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean Sea surface temperature (SST)</td>
<td>sstmean</td>
<td>°C</td>
<td>0.25°</td>
<td>Daily</td>
<td>AVHRR-OI</td>
</tr>
<tr>
<td>SST standard deviation</td>
<td>sstsd</td>
<td>°C</td>
<td>0.25°</td>
<td>Daily</td>
<td>AVHRR-OI</td>
</tr>
<tr>
<td>SST maximum</td>
<td>sstmax</td>
<td>°C</td>
<td>0.25°</td>
<td>Daily</td>
<td>AVHRR-OI</td>
</tr>
<tr>
<td>SST minimum</td>
<td>sstmin</td>
<td>°C</td>
<td>0.25°</td>
<td>Daily</td>
<td>AVHRR-OI</td>
</tr>
<tr>
<td>SSHA</td>
<td>ssha</td>
<td>cm</td>
<td>0.33°</td>
<td>Daily</td>
<td>AVISO</td>
</tr>
<tr>
<td>Geostrophic u</td>
<td>u</td>
<td>cm/s</td>
<td>0.33°</td>
<td>Daily</td>
<td>AVISO</td>
</tr>
<tr>
<td>Geostrophic v</td>
<td>v</td>
<td>cm/s</td>
<td>0.33°</td>
<td>Daily</td>
<td>AVISO</td>
</tr>
<tr>
<td>Depth</td>
<td>dep</td>
<td>m</td>
<td>0.02°</td>
<td>–</td>
<td>ETOPO1</td>
</tr>
</tbody>
</table>

### Fishery-independent data

<table>
<thead>
<tr>
<th>Catch-per-unit-effort &amp; geographic survey position</th>
<th>CPUE</th>
<th>kg/ha</th>
<th>37 km x 37 km</th>
<th>Daily</th>
<th>NOAA-RACE</th>
</tr>
</thead>
</table>

**Temporal coverage:** June–July, 1993–2015 (Based on the earliest availability of environmental data for SSHA and geostrophic velocity)
Data and Methods

**Bioclimatic velocity**

<table>
<thead>
<tr>
<th>Period 1 (p1)</th>
<th>Period 2 (p2)</th>
<th>Period 3 (p3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Climate data (p1)</td>
<td>Climate data (p2)</td>
<td>Climate data (p3)</td>
</tr>
<tr>
<td>Fishery data (p1)</td>
<td>Fishery data (p2)</td>
<td>Fishery data (p3)</td>
</tr>
<tr>
<td>MaxEnt model (p1)</td>
<td>MaxEnt model (p2)</td>
<td>MaxEnt model (p3)</td>
</tr>
<tr>
<td>Observed range (p1)</td>
<td>Projected range (p2)</td>
<td>Observed range (p2)</td>
</tr>
<tr>
<td>Expected range shift (T1)</td>
<td>Projected range (p3)</td>
<td>Expected range shift (T2)</td>
</tr>
</tbody>
</table>

*Expected range shift (T1) (bioclimatic velocities)*

*Expected range shift (T2) (bioclimatic velocities)*

Redrawn from Comte & Grenouillet, 2015
Data and Methods

**Multivariate climatic velocity**

<table>
<thead>
<tr>
<th>Period 1 (p1)</th>
<th>Period 2 (p2)</th>
<th>Period 3 (p3)</th>
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<tr>
<td>Climate data (p1)</td>
<td>Climate data (p2)</td>
<td>Climate data (p3)</td>
</tr>
<tr>
<td>Multivariate PCA</td>
<td>Multivariate PCA</td>
<td>Multivariate PCA</td>
</tr>
<tr>
<td>Retained PCA components (p1)</td>
<td>Retained PCA components (p2)</td>
<td>Retained PCA components (p3)</td>
</tr>
</tbody>
</table>

Transition 1 (T1) – cold to warm

Transition 2 (T2) – warm to cold

Results & Discussion

Magnitude of bioclimatic velocity between transitions

- Cold to warm
- Warm to cold
Results & Discussion

Regional patterns of bioclimatic velocity

Habitat decrease
Results & Discussion

Climatic velocity patterns between transitions

Transition 1

Transition 2
Results & Discussion

Bioclimatic & climatic divergence for all transitions
Summary & Conclusion

- Cooling/warming patterns were spatially homogeneous in Eastern Bering Sea & SCS
- Promotes habitat loss for walleye pollock in SBS, with no apparent habitat change in NBS & SCS
- Potential ill effects of warming on food availability in SBS (Stabeno et al. 2012)

- Regional cooling in SBS and warming off NBS & SCS
- Promotes habitat gain for walleye pollock in SBS
- Net northward expansion of favorable habitat for walleye pollock
- Implication on ecosystem shift in Bering-Chukchi Seas (Grebmeier et al. 2006)
Thank you for your attention.