Future projected impacts of ocean warming to potential squid habitat in the North Pacific

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Introduction: Climate-driven changes in marine biodiversity

Increase in species richness at higher latitudes

Warming climate drives the changes in species abundance and distribution.

Cheung et al. 2014
Introduction: Squid as biological proxy of climate changes


Responds quickly to the changes in the environment

Squid fishery occurs off a highly dynamic region (e.g. major currents & frontal systems) – Roden 1991; Talley et al. 1995; Yasuda et al. 2003; Polovina et al. 2006
Objective

Examine the squid potential habitat distribution patterns in response to future ocean warming and quantify its regional impact in the North Pacific

Significance of the study

- Baseline understanding of squid habitat responses to ocean warming
- Relevant insights to inform decisions amongst resource stakeholders
### Data & Methods

<table>
<thead>
<tr>
<th>Environmental variables</th>
<th>Source</th>
<th>Temporal Resolution</th>
<th>Source Resolution</th>
<th>Model AUC Contribution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sea surface temperature</td>
<td>AVHRR-OI</td>
<td>monthly</td>
<td>25 km</td>
<td>0.8697</td>
</tr>
<tr>
<td>Sea surface salinity</td>
<td>MOVE-MRI</td>
<td>monthly</td>
<td>10 km</td>
<td>0.8203</td>
</tr>
<tr>
<td>Sea surface height</td>
<td>AVISO</td>
<td>monthly</td>
<td>25 km</td>
<td>0.8286</td>
</tr>
<tr>
<td>Net Primary Production</td>
<td>OSU</td>
<td>monthly</td>
<td>9 km</td>
<td>0.7501</td>
</tr>
<tr>
<td>Squid fishing locations</td>
<td>APITRC</td>
<td>monthly</td>
<td>May-July 2000-2010</td>
<td></td>
</tr>
</tbody>
</table>

#### IPCC-5 Models

<table>
<thead>
<tr>
<th>Model</th>
<th>Country</th>
<th>Temporal Resolution</th>
<th>Spatial Resolution</th>
<th>Scenarios</th>
</tr>
</thead>
<tbody>
<tr>
<td>MIROC-ESM</td>
<td>Japan</td>
<td>monthly</td>
<td>0.2°x0.3°</td>
<td>RCP4.5, RCP6.0, RCP8.5</td>
</tr>
<tr>
<td>CSIRO MK3.6</td>
<td>Australia</td>
<td>monthly</td>
<td>0.8°x1.9°</td>
<td>RCP4.5, RCP6.0, RCP8.5</td>
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<tr>
<td>GFDL CM3.0</td>
<td>USA</td>
<td>monthly</td>
<td>0.3-1.0°x1.0°</td>
<td>RCP4.5, RCP6.0, RCP8.5</td>
</tr>
<tr>
<td>HadGEM2ES</td>
<td>UK</td>
<td>monthly</td>
<td>0.3-1.0°x1.0°</td>
<td>RCP4.5, RCP6.0, RCP8.5</td>
</tr>
</tbody>
</table>

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1Watanabe et al. 2011; 2Rotstayn et al. 2012; 3Donner et al. 2011; 4Jones et al. 2011; 5van Vuuren et al. 2011
Data & Methods: Attributes of IPCC CMIP5 model scenarios

RCP 8.5: Rising emissions throughout the 21st century

RCP 6.0: Peak emissions around 2080, then decline

RCP 4.5: Peak emissions around 2040, then decline

Meinshausen et al. 2011

Knutti & Sedlacek 2013
Data & Methods: habitat model framework

Maximum Entropy HSI Model\(^1\)
Results & Discussion: Squid habitat in the late century (2100)

- Early formation and shorter duration of squid potential habitat in summer.

[Images showing habitat suitability index across different months (MAY, JUN, JUL) and RCP scenarios (PRESENT, RCP4.5, RCP6.0, RCP8.5).]
Results & Discussion: Latitudinal shift in potential habitat

Northward retreat and decrease in HSI magnitude (favorable habitat)
Results & Discussion: Warming impact on spatial habitat pattern

Squid habitat changes were proportional to the degree of warming.
Results & Discussion: Spatial distribution of favorable SST

Optimal SST showed highest areal reduction under the highest warming scenario
Summary & Conclusion

Ocean warming scenario

Projected impacts
- Northward retreat and decrease in extent of potential squid habitat

Ecological implications
- Changes in pelagic food web structure (squids’ mid-trophic position)

Economic relevance
- Changes in fishing grounds, with higher fuel requirements; higher fishing cost

Proposed potential physical and biological mechanism
- Stratified conditions
- Shoaling of the seasonal MLD
- Drop in primary production
- Limited nutrient supply
- Unfavorable foraging conditions

Projected impacts:
- Shoaling of the seasonal MLD

Ecological implications:
- Changes in pelagic food web structure (squids’ mid-trophic position)

Economic relevance:
- Changes in fishing grounds, with higher fuel requirements; higher fishing cost
Thank you for your kind attention