A comparison of fish community and trophic structure from three marine ecosystems around Japan: Synchronies, differences and environmental forcing

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Outline

● Background and Objectives: Features of the three marine ecosystems

● Variability in the fish community structure
  A comparison between the three ecosystems from PCA result and community index

● Impacts of climate variability
  GAM (Generalized Additive Model) determined environmental forcing

● Summary
Oceanographic structure and fisheries region

Subarctic Circulation
Decadal Scale

Subtropical Circulation
ENSO-scale

-Pacific

Arctic Oscillation
PDO

Oceanographic structure and fisheries region
The late 1980s regime shift was the most evident change in TWC, seemed different with the mid-1970s regime shift in the North Pacific. Even within an ecosystem such as TWC, response to climate regime shift is species-specific, and the forcing is different.

Our question: What is the difference and the similarity between ecosystems?
Objective

• To identify the variability in the three marine ecosystems (TWC, KC and OC) around Japan using common approach.

To make a comparison between the three ecosystems to determine the synchronies, differences and environmental forcing.
Selection of Indicator Species

25 commercially important species from small pelagic to large predatory fishes with different trophic level and habitat are selected to representing the ecosystem.
Data and Analysis

1. Data sets: 1955-2010
   1) Japanese catch statistics: 25 taxa by fisheries region
   2) SST: JMA data set → area-averaged time series as index of the ecosystem
   3) Four climate indices: AOI, PDO, SOI, and MOI

2. Same analysis done for the three ecosystems
   1) Data transfer: \( \log (\text{catch} + 1) \)
   2) PCA: applied fisheries data to determine the PCs
   3) GAM: applied to PCs ~ environmental variables.
      (AIC was used as model selection.)
   3) Community index: MTL, DI, FiB and PS/ZS ratio
      (Tian et al., 2006, 2008)
SST trends

[Graphs showing SST trends for different regions: Tsushima, Oyashio, ECS, Kuroshio, and Tsushima Anomaly. Key features include highlighting of specific years (Late 1980s, Mid-1970s) and visual representation of SST anomaly and CuSum over the years from 1950 to 2010.]
These 25 species from the three regions accounted for about 83% of total Japanese catch, and the trends are generally same to total.

The 25 species are suitable as indicators of ecosystems.
These results indicate similarity between TWC and KC but differences between OC and other two ecosystems.
These results indicate that the most marked change across the three ecosystems occurred in the late 1980s, but OC responded strongly to the mid-1970s regime shift in comparison with other two ecosystems.
GAM: TWC PC1

Tsushima (model 3): D.E. (Deviance explained) = 51.8%
GAM: KC & OC PC1

Kuroshio (Model 5)
D.E. = 24.4 %

Oyashio (Model 6)
D.E. = 21.6%
Summary of GAM for PC1-3

<table>
<thead>
<tr>
<th>PCs</th>
<th>Tsushima</th>
<th>Kuroshio</th>
<th>Oyashio</th>
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<tr>
<td>PC1</td>
<td>SST_WIN, SST_SPR</td>
<td>SST_WIN, SST_SUM</td>
<td>SST_AUT, SST_SUM</td>
</tr>
<tr>
<td></td>
<td>PDO, AO, SOI</td>
<td>SOI</td>
<td>(D.E =21.6%)</td>
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<td></td>
<td>(D.E =51.8%)</td>
<td>(D.E =24.4.8%)</td>
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</tr>
<tr>
<td>PC2</td>
<td>SST_WIN, AO</td>
<td>SST_WIN</td>
<td>SST_WIN, SST_SPR</td>
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<td></td>
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<td>PDO, AO, SOI, MOI</td>
<td>PDO, AO</td>
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<tr>
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<td>(D.E =17.1%)</td>
<td>(D.E =44.6.8%)</td>
<td>(D.E =57.2%)</td>
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<tr>
<td>PC3</td>
<td>SST_WIN, SST_AUT</td>
<td>SST_WIN, SST_AUT</td>
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<tr>
<td></td>
<td>PDO, AO</td>
<td>PDO</td>
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<tr>
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<td>(D.E =37.8%)</td>
<td>(D.E =54.1%)</td>
<td>(D.E =33.6%)</td>
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- SSTs, particularly winter SST have significant and strong effects on PCs across the three ecosystems.
- Climate effects are also significant for some regions
Summary

• A comparison study was done for three marine ecosystems around Japan.
• Community indices indicate similarity between TWC and KC, but difference with OC.
• Variation patterns from PCA indicate synchronies in the three ecosystems around the late 1980s, but OC also strongly respond to mid-1970s regime shift.
• GAMs indicate the importance of regional oceanographic conditions to the variability of fish communities.