Predicting present and future distributions of yellowtail in the Japan Sea

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Introduction

* Fishes in marine are not distributed randomly (Planque, B. & Loots, 2011*)

* To recognize the link between fish and other components of the ecosystem is an essential step to adopt ecosystem-based fisheries management (Johnson et al., 2013**)
Introduction

Target species

*Seriola quinqueradiata* (Temminck & Schlegel, 1845)

Image from Tian, et al. 2012

* a pelagic, highly migratory and predatory fish

Spawning grounds and migration pattern (Tian, et al. 2012*)

Annual landing trend of yellowtail (unit: ton)

Data source: Fisheries Agency and Fisheries Research Agency of Japan

*J. Mar. Syst. 91, 1–10 (2012)*
Introduction

Migration patterns in the Japan sea

Migration patterns of yellowtail in Tsushima Warm Current Area
(Watanabe et al. 2010*)
A 0 year old  B 1 year old  C 2 year old  D 3 year old  E 3+ year old

Relationship between the migration and environment is still unclear

Introduction  Global warming in the Sea of Japan

The increase in SST is sure to alter physicochemical features of the sea thus affect ambient organisms
Introduction  

Impacts of climate change on fishes

Warming Oceans Are Reshaping Fisheries

Marine species are gradually moving away from the equator into cooler waters, and, as a result, species from warmer waters are replacing those traditionally caught in many fisheries worldwide. Scientific studies show that this change is related to increasing ocean temperatures.

Subtropic and temperate ocean

From 1970 to 2006, as open temperatures were rising, catch composition in the subtropic and temperate areas slowly changed to include more warm-water species and fewer cool-water species.

Tropics

In the tropics, the catch composition changed from 1970 to 1980 and then stabilized, likely because there are no species with high enough temperature preferences to replace those that declined.

These shifts could have negative effects including loss of traditional fisheries, decreases in profits and jobs, conflicts over new fisheries that emerge because of distribution shifts, food security concerns, and a large decrease in catch in the tropics.

Distribution, catch composition would be changed
Introduction  A phenomenon in Hokkaido

More fish move northwards, but mechanism is still unclear.

The need to develop adaptation plans to minimize negative impacts
Objectives

* To construct habitat model to identify optimal habitat in the Sea of Japan
* To predict possible distribution of yellowtail in future under alternative scenarios of climate change
Data and methods

✶ Data
✓ Archival tagging data (0 and 1 year old fish)
✓ Environmental data (remotely sensed data)

✶ Methods
✓ Species distribution models
  (GLM, GAM, MaxEnt models)
Tagging data

542 presence positions
26 individuals
May 2006-Feb 2009
Environmental data

<table>
<thead>
<tr>
<th>Data</th>
<th>Source</th>
<th>Spatial resolution</th>
<th>Temporal resolution</th>
</tr>
</thead>
<tbody>
<tr>
<td>SST</td>
<td>Ocean color site</td>
<td>1km</td>
<td>Ten days (2006.1-2009.12)</td>
</tr>
<tr>
<td>Chla</td>
<td>Ocean color site</td>
<td>1km</td>
<td>Ten days (2006.1-2009.12)</td>
</tr>
<tr>
<td>Kd490</td>
<td>Ocean color site</td>
<td>1km</td>
<td>Ten days (2006.1-2009.12)</td>
</tr>
<tr>
<td>u</td>
<td>AVISO site</td>
<td>0.25 degree</td>
<td>Ten days (2006.1-2009.12)</td>
</tr>
<tr>
<td>v</td>
<td>AVISO site</td>
<td>0.25 degree</td>
<td>Ten days (2006.1-2009.12)</td>
</tr>
<tr>
<td>EKE</td>
<td>Derived from u, v</td>
<td>0.25 degree</td>
<td>Ten days (2006.1-2009.12)</td>
</tr>
<tr>
<td>SSH</td>
<td>AVISO site</td>
<td>0.25 degree</td>
<td>Ten days (2006.1-2009.12)</td>
</tr>
<tr>
<td>SSHA</td>
<td>AVISO site</td>
<td>0.25 degree</td>
<td>Ten days (2006.1-2009.12)</td>
</tr>
<tr>
<td>Bathymetry</td>
<td>NOAA</td>
<td>0.0167 degree</td>
<td>None</td>
</tr>
</tbody>
</table>


During processing, I resampled the data into 0.01 degree though it did not increase the spatial resolution.
Results

GLM:
Presence ~ EKE + depth + SSH + u + v + SST + Chla + SSHA +ε (without Kd490)

GAM:
Presence~s(EKE)+s(depth)+s(SSHA)+s(SSH)+s(u)+s(v)+s(SST)+s(Chla)+s(Kd490) + ε

MaxEnt:
Presence~f(EKE, depth, SSHA,SSH, u, v, SST, Chla, Kd490)
Mar. 2007

Present probability map by GLM

Jun. 2007

Sep. 2007

Dec. 2007

Hokkaido

Oga Peninsula

Noto Peninsula

Tsugaru strait
Present probability map by GAM
Present probability map by MaxEnt
How about future distribution?
Future probability map by GLM

- March SST + 0.5 °C
- March SST + 1 °C
- March SST + 1.5 °C
- March SST + 2 °C
Future probability map by GAM

- March SST + 0.5 °C
- March SST + 1 °C
- March SST + 1.5 °C
- March SST + 2 °C
Future probability map by MaxEnt

- March SST + 0.5 °C
- March SST + 1 °C
- March SST + 1.5 °C
- March SST + 2 °C
Discussion

* From archival tagging data we can get useful information about spatial and temporal distribution of the fish, remote sensing data help us better understand marine environment. Archival tag plus remote sensing will lend us an edge in studying fishes’ migration patterns and the environmental factors that control these patterns.

Archival tagging data + Remote sensing data
Monthly habitat change in 2007
The geographical distribution of yellowtail in winter (overwintering area) is projected to change with thermal regimes and will extend northward with warming to the coast of Hokkaido by 2050 (Tian, et al., 2012).
Conclusion

- Archival tagging combined with satellite remote sensing have potentially far-reaching application in the understanding fishes and their relationship with physical environment.

- As temperature increased, the distribution range of yellowtail in winter would move northward in future compared with recent status.
Future work

* Incorporating more environmental variables into future prediction
Acknowledge

* Prof. Saitoh, Associate Prof. Hirawake from Hokkaido University
* Dr. Yongjun Tian from Japan Sea National Fisheries Research Institute
* My colleagues: Dr. Xun Zhang, Dr. Irene Alabia, Dr. Yang Liu, Dr. A. Fachrudin, Dr. Christopher M. Aura, Dr. Zhe Li
* China Scholarship Council (CSC)
Thank you for your attention!

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