Variations in the catches of small pelagic fishes from China seas and its responses to climatic regime shifts

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I. SPF in the over-exploited China Seas

II. Catch variation trends and step changes in SPF

III. Climatic regime shifts in China Seas and the responses of SPF

IV. Summary
China seas and currents

Components
- Bohai Sea, Yellow Sea, East China Sea, South China Sea

Current system (except South China Sea)
- Warm: YSWC, TWC, KS
- Cold: YSCC, KCC, ZFCC

China seas as marginal seas, are largely influenced by **West Boundary Current**, and have significant environmental changes which will have important effects on SPF.

(Yellow Sea Coastal Current, Yellow Sea Warm Current, Korea Coastal Current, Tsushima Warm Current, Zhejiang-Fujian Coastal Current, Taiwan Warm Current, Kuroshio)
Chinese catch under over-exploitation

Global:
- Increasing trend since 1950, remain stable after 1990
- 18.2% was from China in 2014

China:
- Increasing rapidly since 1980 to 2000, then remained stable
- CPUE reduced sharply in the 1950s and kept low-level

Under the over-exploitation, how about the SPF?

Data from Global Capture Production 1950-2014, FAO
**SPF catch — From global to China**

**Global marine fishes**
- Cods, hakes, haddocks
- Tunas, bonitos billfishes
- Coastal fishes
- Demersal fishes
- Small pelagic fishes
- Others

**China marine fishes**
- Cods, hakes, haddocks
- Tunas, bonitos billfishes
- Coastal fishes
- Demersal fishes
- Small pelagic fishes
- Others

**SPF catch of global and China**
- SPF 39%
- SPF 26%

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FAO, 2014

Data from Global Capture Production 1950-2014, FAO
Focus

- Clarify the trends of SPF in China seas
- Identify the responses of SPF to climate change

**Fish Species**

- **Chub mackerel**
  *Scomber japonicas*

- **Pacific herring**
  *Clupea pallasi*

- **Japanese anchovy**
  *Engraulis japonicus*

- **Japanese sardine**
  *Sardinops melanostictus*

- **Japanese scad**
  *Decapterus maruadsi*

- **Horse mackerel**
  *Trachurus japonicus*
Data and analyses

**Catch**
Chinese Fishery Statistics 1950-2014
FAO Global Capture Production 1950-2014
Tsushima Stock Assessment Reports 2015

**Sea Surface Temperature**
Grid data with resolution of $1^\circ \times 1^\circ$

**Climatic indices**
Pacific Decadal Oscillation (PDO)
Southern Oscillation (SOI)
Arctic Oscillation Index (AOI)
North Pacific Index (NPI)
Asian Monsoon Index (MOI)

**Regime Shift Detection**

**Cumulative Sum**
Get the variation trends and step changes of data

**Principal Component Analysis**
Calculate the pc1 of SST in summer and winter then get the changing pattern

**Correlation Analysis**
Explore the relationships between catch and environmental indicators
Variation trends in SPF catch

- Chub mackerel
- Pacific herring
- Japanese anchovy
- Japanese scad
- Japanese sardine
- Horse mackerel
Step changes in SPF catch

- **Chub mackerel**: 1976/77, 1995/96, 2007/08
- **Japanese anchovy**: 1996/97, 2006/07
- **Japanese sardine**: 1986/97
- **Japanese scad**: 1983/84
- **Horse mackerel**: 2001/02
- **Pacific herring**: 2000/01
- **Japanese anchovy**: 2001/02
- **Japanese anchovy**: 2007/08
- **Japanese anchovy**: 2001/02
- **Japanese anchovy**: 2007/08
Variation pattern in Climatic indices

Winter PDO Anomalies

Winter AO Anomalies

Winter NPI Anomalies

Winter MOI Anomalies

Annual SOI Anomalies

Regime Shift Index (RSI)

1977: PDO
1987: NPI
1989: AO
1989: PDO
2005: MOI
2015: PDO
2016: NPI
Variation pattern in SST in China Seas

Summer

Bohai Sea

1995/96

Yellow Sea

East China Sea

Winter

Bohai Sea

1986/87

Yellow Sea

East China Sea
Response of SPF to climate change

Catch step changes
- 1976/77
- 1996/97
- 2007/08

Climatic regime shifts
- 1976/77
- 1988/89
- 1995/96 (step change in SST)

### Table 1: Correlation analysis between climatic indices, SST pc1s and SPF catch anomalies in China.

<table>
<thead>
<tr>
<th>Climate indices and SST pc1s</th>
<th>Chub mackerel</th>
<th>Pacific herring</th>
<th>Japanese anchovy</th>
<th>Japanese sardine</th>
<th>Japanese scad</th>
<th>Horse mackerel</th>
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<tbody>
<tr>
<td>PDO</td>
<td>0.45**</td>
<td>-0.3*</td>
<td>0.42*</td>
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<td>SOI</td>
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<td></td>
<td>-0.45*</td>
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<tr>
<td>AO</td>
<td></td>
<td>-0.3*</td>
<td></td>
<td>-0.43*</td>
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</tr>
<tr>
<td>NPI</td>
<td>-0.3*</td>
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<tr>
<td>MOI</td>
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<tr>
<td>Bohai Summer PC1</td>
<td>0.56*</td>
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<tr>
<td>Bohai Winter PC1</td>
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<tr>
<td>Yellow Sea Summer PC1</td>
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<td>0.44*</td>
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<tr>
<td>Yellow Sea Winter PC1</td>
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<td></td>
<td>0.3*</td>
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<tr>
<td>East China Sea Summer PC1</td>
<td>0.57**</td>
<td>0.64**</td>
<td>0.48**</td>
<td>0.5*</td>
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<tr>
<td>East China Sea Winter PC1</td>
<td>0.62**</td>
<td>0.61**</td>
<td>0.47**</td>
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</tr>
</tbody>
</table>

Asterisks denote significance at the following alpha levels: * 0.05>p>0.01, ** 0.01>p

**Variation in SPF catches are driven by climatic regime shifts, particularly the thermal regime shifts.**
Responses of SPF to SST variation pattern

- Rising trend with time lag between winter and summer.
- Catch trends responded well to the SST variation pattern.
Responses of Tsushima catch to the changing SST
Summary


II. SPF catch in China responded well to the climatic regime shifts, particularly the thermal regime shifts, occurred in 1976/77 and 1995/96, but no significant response to the shift in 1988/89.

III. SST variation pattern with regime shift occurred in winter in 1986/87 and in summer in 1995/96 had important effects on SPF catch.
Future works

Based on data collection such as life history traits by species, to verify the effects of the SST variation pattern on SPF.

1986/87

1995/96