Seasonal dynamics in pelagic fish abundance around Set-net in Kochi prefecture

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Introduction: Fishery resources in Japan

Kuroshio Current
Bring fish from southern sea areas to waters around Japan

Oyashio Current
Rich in nutrient salt

Wide variety of fish exist around Japan
Introduction: Characteristic of Kuroshio current

One of the largest world's scale ocean currents

Features of the Kuroshio current flow?

Biological influence on fish population are quite strong

High temperature and salinity

Maximum flow: 2m/s (Stommel, 1948)
Introduction: Characteristic of Kuroshio current

Even if in the same pattern

Change of Kuroshio has an important effect on fish ecology

Kuroshio current exhibits distinct seasonal fluctuations (Narukiyo, 2007)
Introduction: Previous research about Kuroshio

Many researches focus on single species and one season

*Scombrops boops* catch is controlled by change of Kuroshio in summer season

Japanese common squid are migratory riding the Kuroshio (Kawabata, 2006)

Common Mackerel catch was influenced by Kuroshio flow path (Takeuchi, 2018)

↓ BUT

- Kuroshio large meander
- Seasonal dynamics

Scarce
Purpose

Change of Kuroshio current

- Two patterns (Regular course & Large meander)
- Seasonal dynamics

To clarify the variation in fish composition, abundance, and distribution bases on the change of Kuroshio current

Requirement for efficient fishery
Main industry in Suzu
Set-net fishery

Characteristic of Set-net
・ Set in the sea all year around (Passive fishing method)
・ Only capture fish which passes around Set-net

Set-net fishery is more depended on fish distribution and composition

A case study in the south of Japan (Kochi prefecture)
Kuroshio Current curves from 2017/8 for the first time in 12 years

Survey period

• **Kuroshio regular course**
  Autumn (2016/11)
  Winter (2017/2)
  Spring (2017/5)

• **Kuroshio large meander**
  Autumn (2017/11)
  Winter (2018/2)
  Spring (2018/5)
Materials and methods: Survey of fish distribution

Acoustic surveys are commonly used to estimate indices of fish distribution worldwide (Baussant et al., 1993; Simmonds et al., 2005)

- **Research equipment**: Quantitative echo sounder (KSE300 SONIC, 38kHz)
- **Research area**: Survey area 50km²

**Indicator of fish density**

\[ S_a (\text{dB}) \]: Area backscattering strength
\[ S_v (\text{dB}) \]: Volume backscattering strength

![Map and graph showing survey area and fish school with labels for Sa and Sv](image)
**Fish distribution**

- Extract fish school data *(Echoview 7.1)*
  - \( Sa; Sv \)
- Calculate fish position *(ArcGIS 10.2.1)*
  - Distance from shore
  - Depth

**Generalized Additive Model**

<table>
<thead>
<tr>
<th></th>
<th>Response variable</th>
<th>Explanatory variable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Horizontal structure</td>
<td>( Sa )</td>
<td>Distance from shore</td>
</tr>
<tr>
<td>Vertical structure</td>
<td>( Sv )</td>
<td>Depth</td>
</tr>
</tbody>
</table>

**Fish composition**: Catch data of Set-net

*(every month: 2016/11~2018/5)*
### Results: Horizontal structure ($S_a$ & Distance from shore)

<table>
<thead>
<tr>
<th>Season</th>
<th>&lt;2000m</th>
<th>&gt;2000m</th>
</tr>
</thead>
<tbody>
<tr>
<td>Autumn</td>
<td>N=2 N=34</td>
<td>N=11 N=161</td>
</tr>
<tr>
<td>Winter</td>
<td>N=185 N=24</td>
<td>N=138 N=286</td>
</tr>
<tr>
<td>Spring</td>
<td>N=41 N=97</td>
<td>N=128</td>
</tr>
</tbody>
</table>

- **Regular course**
- **Large meander**

N: Number of fish school

- Increase of density on offshore side with Kuroshio large meander in Autumn and Winter.
Results: Vertical structure ($S_v$ & Depth)

Autumn | Winter | Spring

- Increase of density in under layer with Kuroshio large meander in Autumn and Winter
## Results: Fish catch and composition (totality)

<table>
<thead>
<tr>
<th></th>
<th>Regular course</th>
<th>Large meander</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual Total Catch (kg)</td>
<td>179,578</td>
<td>372,769</td>
</tr>
</tbody>
</table>

### Fish Catch by Species

- **Common Mackerel**
  - Regular course: 37,853 kg (21%)
  - Large meander: 36,289 kg (20%)

- **Yellowtail**
  - Regular course: 44,562 kg (25%)
  - Large meander: 197,846 kg (53%)

- **Horse Mackerel**
  - Regular course: 26,553 kg (7%)
  - Large meander: 75,285 kg (20%)

- **Others**
  - Regular course: 60,873 kg (34%)
  - Large meander: 73,086 kg (20%)

### Significantly change of Yellowtail and Japanese Horse Mackerel with Kuroshio large meander

### Seasonal variation (two species)

- **Twofold Increase!**
- **Regular course**: Total Catch 179,578 kg
- **Large meander**: Total Catch 372,769 kg
Results: Seasonal variation of fish catch (two species)

**Yellowtail**
- Winter: 100-120 cm

**Japanese Horse Mackerel**
- Spring: 10 cm
- Autumn & Winter: 34 cm

Fish catch (kg)

<table>
<thead>
<tr>
<th>Month</th>
<th>Yellowtail</th>
<th>Japanese Horse Mackerel</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>× 5</td>
<td>× 3</td>
</tr>
</tbody>
</table>

Total length (average)

**Yellowtail**: Winter (100-120 cm)

**Japanese Horse Mackerel**: Spring (10 cm), Autumn & Winter (34 cm)

Results in our study

With the Kuroshio large meander

① Fish abundance increased greatly
   - Mainly two species

Yellowtail
Japanese Horse Mackerel

② Fish distribution changed significantly (Autumn & Winter)
   - Increase of density on offshore side
   - Increase of density in under layer

Why did that turn out like this?
Discussion: Fish abundance and Temperature

Changes in water temperature due to Kuroshio meander effect fish abundance

Survey area

Regular course (Winter)

Large meander (Winter)

Δ $-3\,^\circ C$

Survey area

Water temperature will drop along with the Kuroshio large meander (Winter)

Regular course

Large meander

Deviation

The catch of Yellowtail and Japanese Horse Mackerel were tended to increase when water temperature is lower than normal (Aono, 2006; Kuno, 2004)

What kind of effect???

Fish abundance

Fish distribution

What kind of effect???
Discussion: Ecology of two species

Japanese Horse Mackerel

Change of distribution depth based on fish length

Surface

Juvenile fish (Spring)

Bottom

Adult fish (Autumn & Winter)

Juvenile fish (spring): Inhabit the surface layer
Adult (autumn & winter): Move to the under layer
Discussion: Fish ecology and distribution

Fish ecology

Yellowtail
To southward from offshore in early winter
Japanese Horse Mackerel
Move to the under layer in Autumn & Winter

Fish distribution
Increase of density on offshore side and under layer in Autumn & Winter

Changes of fish distribution with Kuroshio large meander due to ecology of Yellowtail and Japanese Horse Mackerel
To Grasp the change of fish distribution due to the change of Kuroshio over the years

Future work

For sustainable and efficient fishery in Suzu

Appropriate fishery form that matches fish distribution is important

To Grasp the change of fish distribution due to the change of Kuroshio over the years
THANK YOU for your ATTENTION!