Prediction of Japanese common squid (*Todarodes pacificus*) fishing grounds using Generalized additive models in the Japan Sea

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Japanese common squid
*(Todarodes pacificus)*

Investigating squid fishing grounds from 1960’s
(Uda, 1960; Tameishi, 2003; Kiyofuji and Saitoh, 2004)
Suggesting qualitatively the environmental factor in
distribution of fishing grounds.

**Multivariate model-Building** such as *GAM*
and **GLM** are now used within the
fisheries context  (Swartzan et al.,1992;
Dickey & Nash,2000; Agenbag et al.,2003;
Howell and Kobayashi, 2006)

*GAM: Generalized Additive Model
**GLM: Generalized Linear Model

It is very important to clarify the mechanism
of distribution of squid fishing grounds
Objectives

• To clarify the relationship between squid fishing grounds and their oceanographic conditions in the Japan Sea

• To predict potential fishing grounds using satellite remote sensing
Data and Methods

**Satellite data**

- **DMSP/OLS** Night time imagery
  - Vessel positions of squid fishing (Kiyofuji and Saitoh, 2004)
- **Orbview-2/SeaWiFS** (MLAC data, about 1 km resolution)
- **NOAA/AVHRR** (1 km resolution MCSST, 4 km resolution pathfinder)
- **SSHA**
- **GC**
  - Sea Surface Height Anomalies
  - Geostrophic Current from **AVISO**

**Biomass data**

- **CPUE**
  - CPUE data of squid jigging fishery collected by the National Research Institute of Fisheries Sciences (1997 ~ 2000)
  - \[CPUE = \frac{\text{Number of Catch}}{\text{(Number of jigging machine x time)}}\]
Data and Methods

Japan Sea, 1997 - 2000

DMSP/OLS → Vessel positions of squid fishing

CPUE → Horizontal distribution

GAM analysis

SST

CHL

SSHA

GC

Seasonal change of squid fishing grounds

Relationship between CPUE and environmental variability

Prediction of squid fishing ground
Seasonal change of squid fishing grounds (1997-2000, April - November)

- Mean of CPUE
- Frequency of the fishing grounds by 30’x30’
Prediction of fishing grounds using the GAM with CPUE and remote sensing data

\[ \ln(\text{CPUE}+1) = s(\text{SST}) + s(\text{CHL}) + s(\text{SSHA}) + s(\text{Geostrophic Current}) \]

- SST: Sea Surface Temperature
- CHL: Chlorophyll a concentration
- SSHA: Sea Surface Height Anomaly
- GC: Geostrophic Current
- \( s \): Smoothing Spline

![Graphs showing CPUE and ln(CPUE) over months with data distribution](image)
Prediction of fishing grounds using the GAM with CPUE and remote sensing data  Apr. – Jul.

*** : p<0.001  ** : p<0.01  * : p<0.05  . : p<0.1
Prediction of fishing grounds using the GAM with CPUE and remote sensing data Aug. - Nov.

*** : p<0.001  ** : p<0.01  * : p<0.05  . : p<0.1

Four graphs showing the relationship between various environmental variables and fishing grounds:
- SST (°C) vs. s(SST)
- SSHA (cm) vs. s(SSHA)
- CHL (mg m⁻³) vs. s(CHL)
- GC (cm/s) vs. s(GC)
Prediction of fishing grounds using the GAM with CPUE and remote sensing data

<table>
<thead>
<tr>
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<tbody>
<tr>
<td>Deviance</td>
<td>17.2%</td>
</tr>
<tr>
<td>Explained</td>
<td></td>
</tr>
<tr>
<td>AIC</td>
<td>687.55</td>
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<tr>
<td>Number of Data</td>
<td></td>
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<td></td>
<td>239</td>
</tr>
</tbody>
</table>

Total ...

$r = 0.51$

Error = 0.2±0.9

$|\text{Error}| = 0.74±0.5$
Prediction of fishing grounds using the GAM with CPUE and remote sensing data

\[ R^2 = 0.74 \]

1998 Predicted > Observed

1999 Predicted < Observed

2000 Predicted ÷ Observed
Prediction of fishing grounds using the GAM with remote sensing data (Oct. 14th 2002)

SST

CHL

GC & SSHA

Correspond
Offshore of Hokkaido
Center of the JS

Not correspond
East Coast of Korea

Fishing position
Conclusion

Relationship between squid fishing grounds and environmental variables

SST >> SSHA > GC >> CHL

Strong effect depend on ecological significance (Physiology, migration, …)

Prediction of fishing grounds using the GAM analysis

• Enable to detect fishing grounds using GAM with four environmental parameter from satellite remote sensing data.

• The prediction of fishing ground will enable to be applied to navigation, improving the model more accurately. – Future work
Thank you!
Introduction

Japanese common squid (*Todarodes pacificus*)

- Most popular of squids
- Annual catches have fluctuated widely
- Target species in TAC (Total allowable catch) system in 1998

Efficient and sustainable fishing activity are required

It is very important issue to manage its resource such as predicting the fishing grounds
Seasonal change of squid fishing positions (1997-2000, April - November)
Prediction of fishing grounds using the GAM with CPUE and remote sensing data

<table>
<thead>
<tr>
<th></th>
<th>F</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>s(SST)</td>
<td>4.01</td>
<td><strong>0.000134</strong> ***</td>
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<tr>
<td>s(SSHA)</td>
<td>1.98</td>
<td>0.096459 .</td>
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<tr>
<td>s(CHL)</td>
<td>3.50</td>
<td>0.061907 .</td>
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<tr>
<td>s(GC)</td>
<td>5.08</td>
<td><strong>0.000157</strong> ***</td>
</tr>
</tbody>
</table>

*** : p<0.001   ** : p<0.01   * : p<0.05   . : p<0.1

AIC=1196.42   n=427   Deviance explained = 17%