Changes in spatial distribution of chub mackerel under climate change: the case study using Japanese purse seine fisheries data in the East China Sea

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Temperature impacts on habitat selection in fish

Temperature impacts may be complicated by interacting factors.

Migratory fish (Adult)

• High locomotion ability
• Can respond against environment changes

Temp.  Fish Habitat

well correlate

Interacting factors with Temp.

Salinity Flow CO₂ O₂
Studies on fish migration

Field

Data Limitation
Data Noise

Fisheries data

Appropriate data selection
Intensive analysis

Insight into fish migration
in a large spatial and temporal scales

Real environment

Model Laboratory
Japanese purse seine in the ECS

- Many target species
- **Wide operation range**
- **High quality logbooks**
  - Species
  - Body size class

- **Chub mackerel** *Scomber japonicus*

Long-term changes in spatial distribution pattern with a focus on **adult chub mackerel**

Fishing effort distribution in 1981

(Yukami et al. 2012)
Questions and approaches

• Do adult chub mackerel change their habitat in response to space-time variability in thermal environment?

• Quantifying space-time variability of fish distribution and ocean thermal environments

• Does thermal environment actually determines the habitat distribution of fish?

• A simple simulation analysis
Q1
Do chub mackerel change their habitat in response to space-time variability in thermal environment?
Quantifying chub mackerel distribution

1. Gravity center of hotspots: → Location of habitat
2. Mean SST within hotspots: → Thermal environment within habitat

Jan., 1973

50% UD “Hotspot”

Time-series data of location and thermal environment...

Feb.

Mar.

Apr.

May

Jun.

Jul.

High

Low

CPUE (ton/net)
Thermal environment in the ECS

- Satellite-derived SST maps
  - Meridian Positional Deviance of 15 ºC isotherms (MPD15)
  - Indices of space-time variability in the ocean’s SST conditions

Example of MPD15

15°C isotherm

-0.39

0.22
Space-time variability in SSTs
Winter 1981-1999

MPD15s in the ECS
Month: $F = 0.0721$, df = 3, N.S.
Year: $F = 2.6957$, df = 18, $p < 0.05$

This ocean changed in terms of MPD15
Hotspot locations and MPD15s

Location of the hotspot (degree, N)

Location of hotspot (degree, E)

Mean MPD15 (relative value)

$r_s = -0.33$
$P > 0.05$

$r_s = -0.49$
$P < 0.05$
Long-term change in hotspot location

Monthly hotspot locations from 1970s to 1990s

MPD15 (winter) from 1981 to 1999

MPD15 (relative value)

North

South

December January February March Mean
Periodicity of hotspot locations

Scomber japonicus

Location of the chub mackerel hotspot (degree, N)

12-months moving average

Liner regression line

Purse seine fishing activity

Location of the fishing activity hotspot (degree, N)

Location of the chub mackerel hotspot (degree, E)

Jan-73 Jan-83 Jan-93

Jan-73 Jan-83 Jan-93

Jan-73 Jan-83 Jan-93

Jan-73 Jan-83 Jan-93

North

South

East

West

North

South

East

West
An answer of Q1

• Do adult chub mackerel change their habitat in response to space-time variability in thermal environment?

• Yes they do. The adult chub mackerel changed their main habitat with multi-year periodicity. This fluctuation was more or less correlated with space-time variability in SSTs in the ECS.
Q2

Does thermal environment actually regulate the habitat distribution of adult?
Thermal environment

Schematic diagram showing inter-annual difference in seasonal distribution

How similar are thermal environment?

-> Inter-annual standard deviation

SST Effects

How different?
Simulation analysis

Real Distribution & Real SST → Mean SSTs within habitat

Jan., 1982 → Jan., 1990

Jan., 1982 → Dec., 1999

Simulated Distribution & Real SST → Sim. mean SSTs


Jan., 1982 → Dec., 1982

Jan., 1990 → Dec., 1974
Habitat change provides different SST environments

Other factors affect habitat destinations of fish
An answer of Q2

• Does thermal environments determine the habitat distribution?

• Yes it does. Habitat change provides different SST environments for fish. But, large inter-annual standard deviations suggest their habitat destinations are not determined by only SSTs.
Possible effect of flow environments
(Next steps in future studies)

Tsushima current transport volume (1985-1999)

Kuroshio transport volume (1973-1999)

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Conclusion

• Temperature impacts on fish migration may be complicated by interacting factors. Intensive analysis of them will provide useful information for model building of fish migrations.

• In adult chub mackerel in the ECS, we suggest they change habitat in response to space-time variability in SSTs. However, simulation analysis revealed their habitat destinations were not determined by absolute values of SSTs.