Changes in spatial distribution of chub mackerel under climate change: the case study using Japanese purse seine fisheries data in the East China Sea
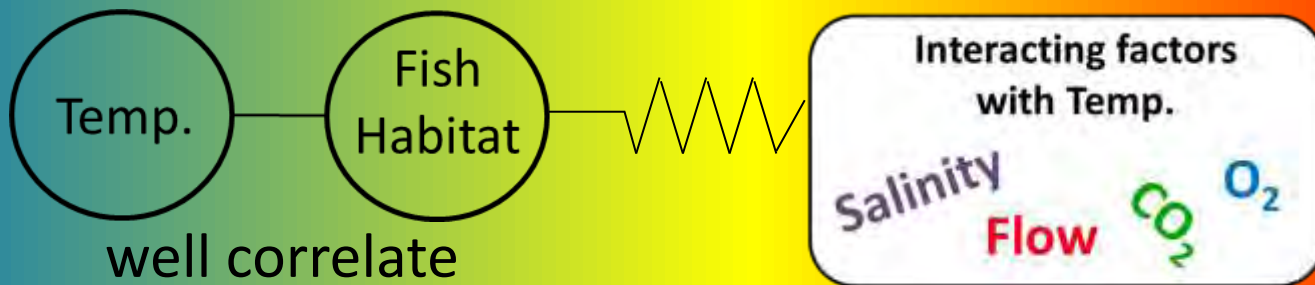
Tohya Yasuda, Ryuji Yukami, Seiji Ohshimo

Seikai National Fisheries Research Institute, FRA

Temperature impacts on habitat selection in fish

Migratory fish
(Adult)

- High locomotion ability
- can respond against environment changes

Temp. — Fish Habitat

well correlate

Interacting factors with Temp.

Salinity

Flow

CO_2

O_2

Temperature impacts may be complicated by interacting factors.

Studies on fish migration

Model Laboratory

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

Japanese purse seine in the ECS

- Many target species

- **Wide operation range**

- **High quality logbooks**
  - Species
  - Body size class

Fishing effort distribution in 1981

- Chub mackerel *Scomber japonicus*

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

High ⟵ Swimming performance ⟶ Low

L   M   S   SS

2+ Age, > 85% matured
(Yukami et al. 2012)
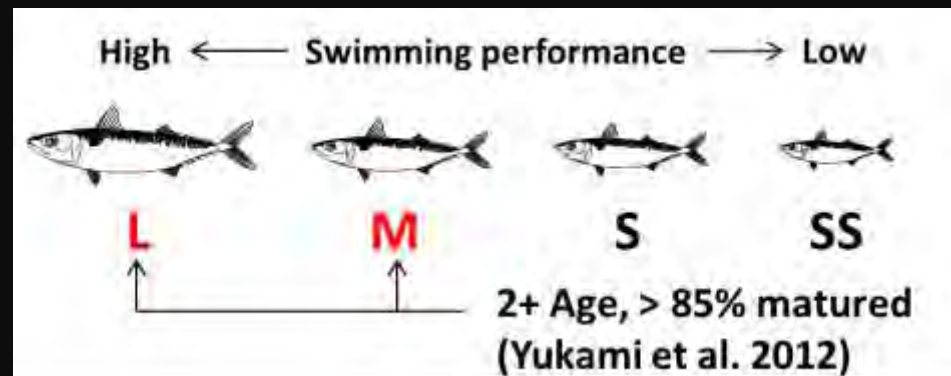
Questions and approaches

- 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?
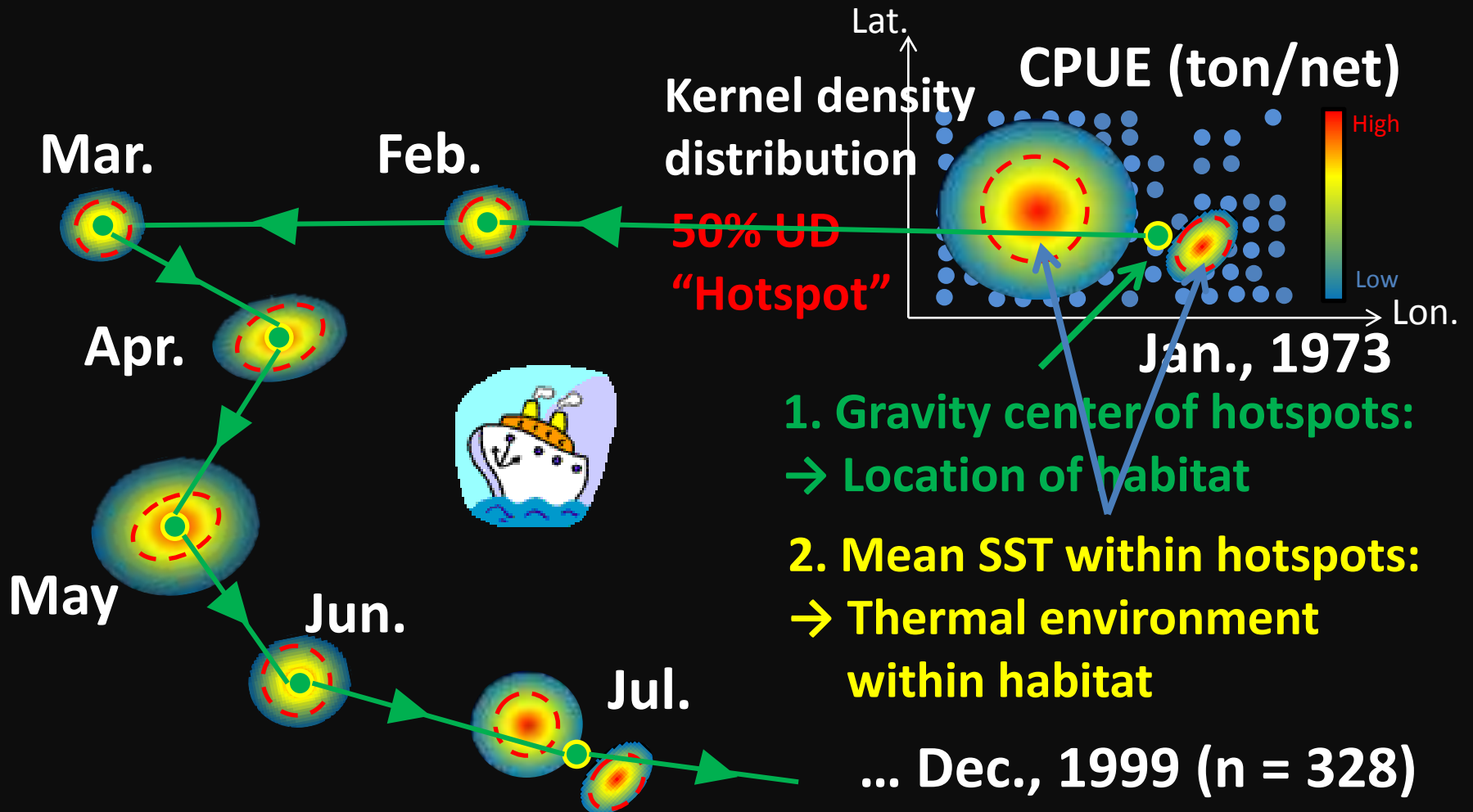
- A simple simulation analysis

Q1

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

Quantifying chub mackerel distribution

Mar. **Feb.** Lat. **CPUE (ton/net)**

Kernel density distribution

50% UD "Hotspot" High

Apr. Low

Lon.

May **Jun.** **Jul.** **Jan., 1973**

1. Gravity center of hotspots: → Location of habitat

2. Mean SST within hotspots: → Thermal environment within habitat

… Dec., 1999 (n = 328)

Time-series data of location and thermal environment

Thermal environment in the ECS

- Satellite-derived SST maps
    - Meridian Positional Deviance of 15 °C isotherms (*MPD15*)
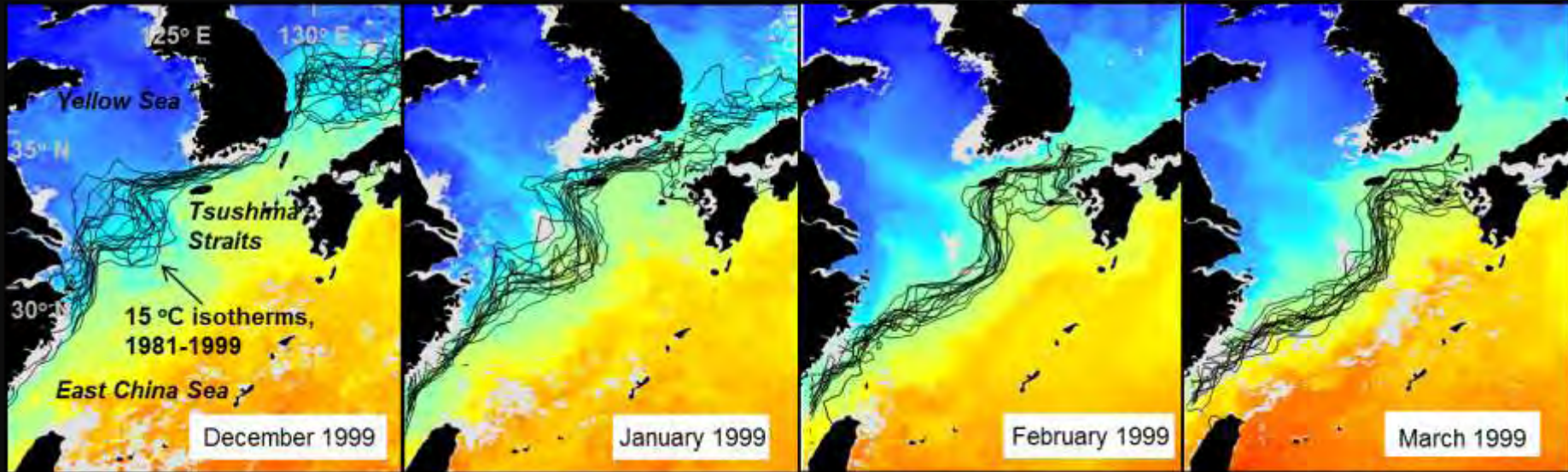   - Indices of space-time variability in the ocean's SST conditions

0.22

NOAA CoastWatch

Example of *MPD15*

15°C isotherm

NOAA CoastWatch

−0.39

NOAA CoastWatch
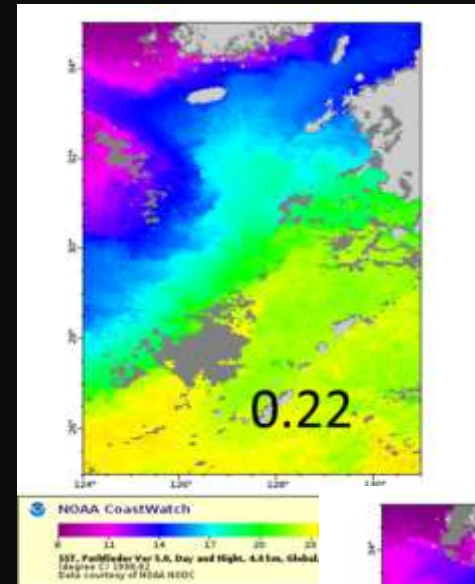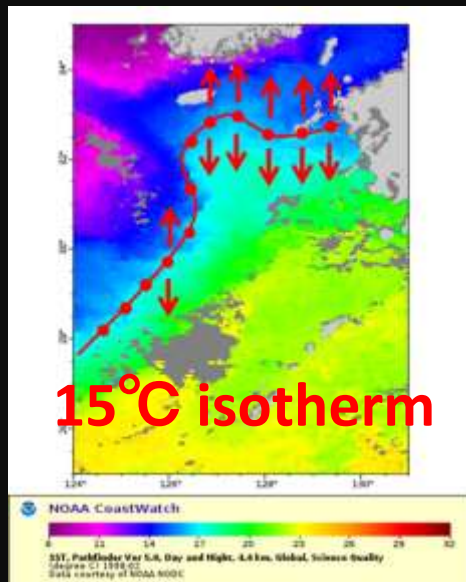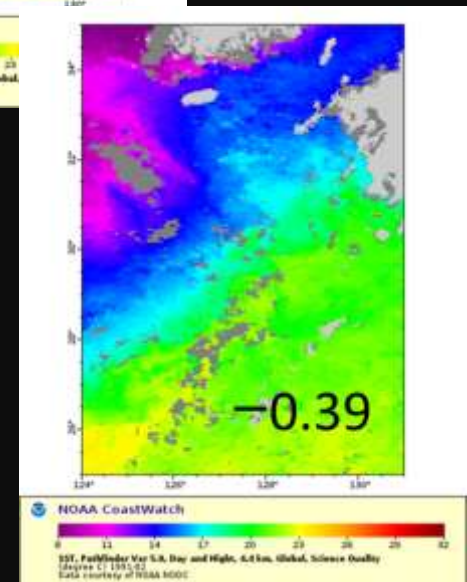
Space-time variability in SSTs Winter 1981-1999

MPD15s in the ECS

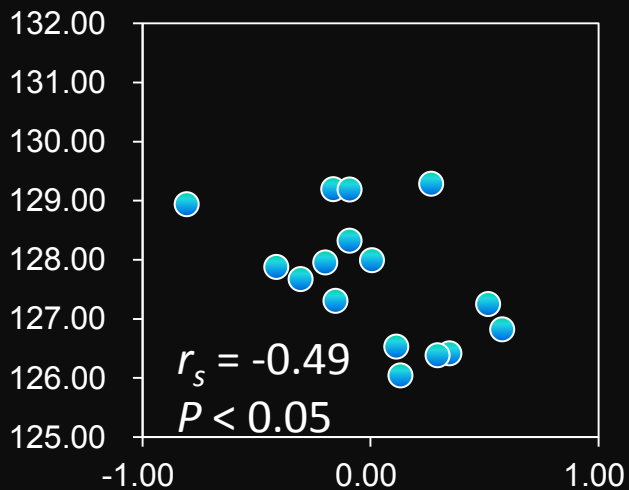Month: $F = 0.0721$, df = 3, *N.S.*

Year: $F = 2.6957$, df = 18, $p < 0.05$

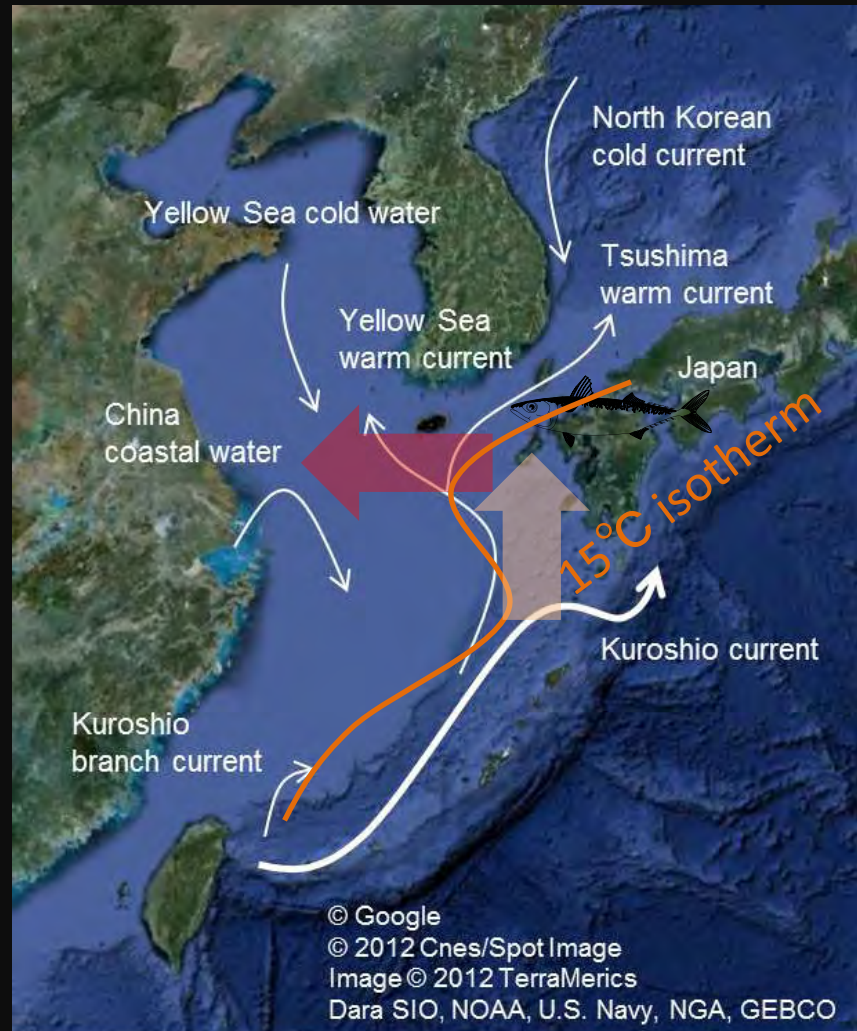This ocean changed in terms of MPD15

Hotspot locations and *MPD15*s

Location of the hotspot (degree, N)

$r_s = -0.33$
$P > 0.05$
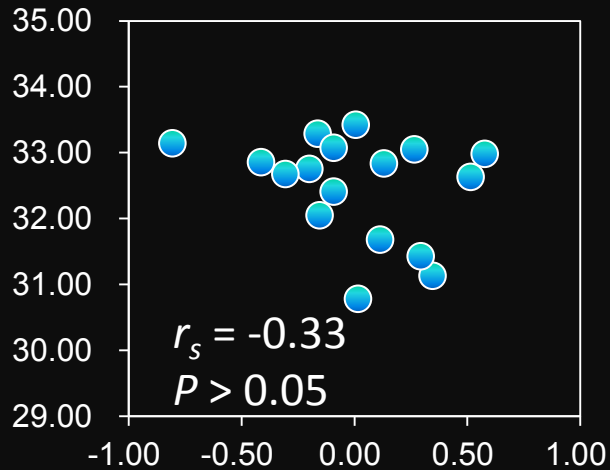
Location of hotspot (degree, E)

$r_s = -0.49$
$P < 0.05$

Mean MPD15 (relative value)

North Korean cold current

Yellow Sea cold water

Tsushima warm current

Yellow Sea warm current

Japan

China coastal water

15°C isotherm

Kuroshio current

Kuroshio branch current

© Google
© 2012 Cnes/Spot Image
Image © 2012 TerraMerics
Dara SIO, NOAA, U.S. Navy, NGA, GEBCO

Long-term change in hotspot location

Monthly hotspot locations from 1970s to 1990s

1970s

1980s

1990s
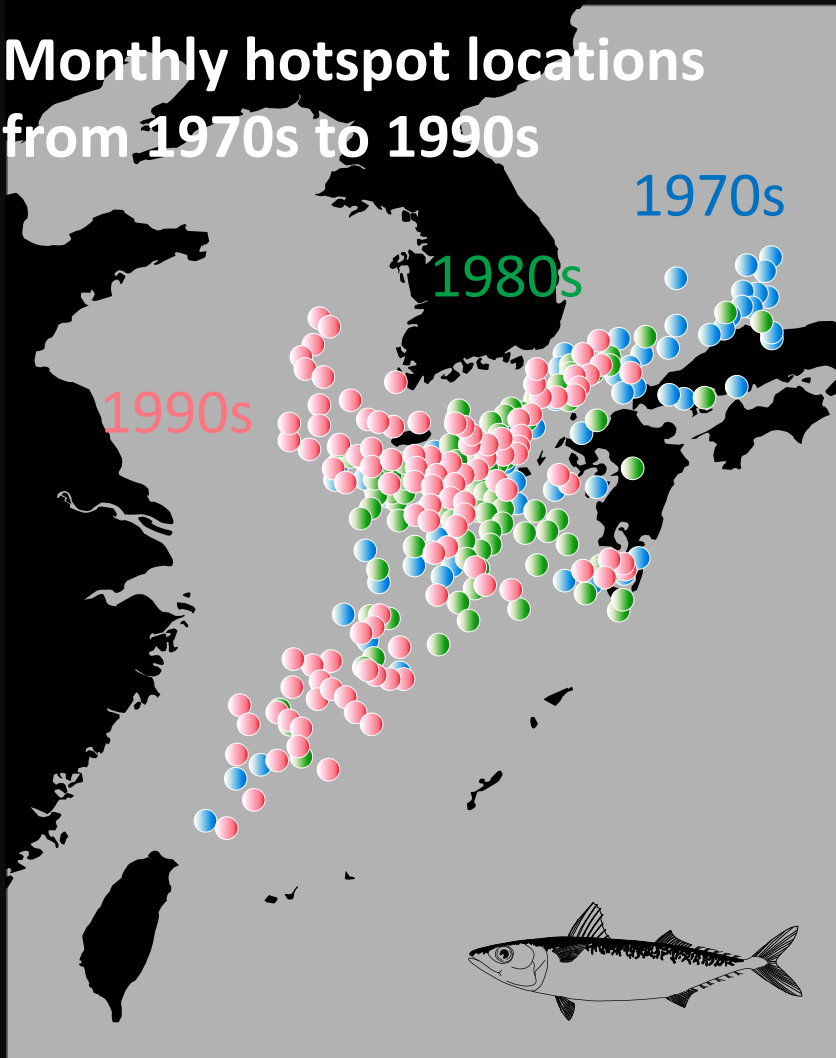
MPD15 (winter) from 1981 to 1999

North

South

December · January · February · March · Mean
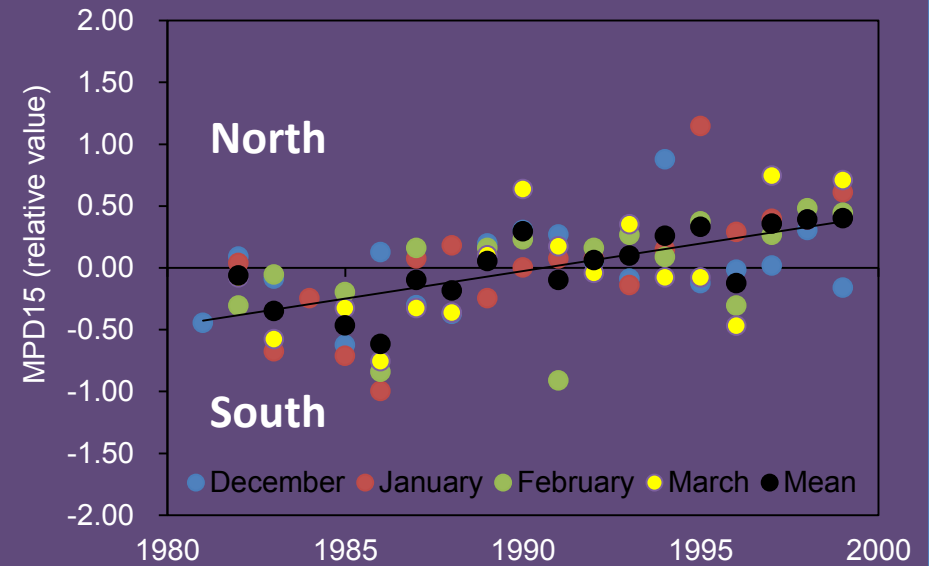
Periodicity of hotspot locations
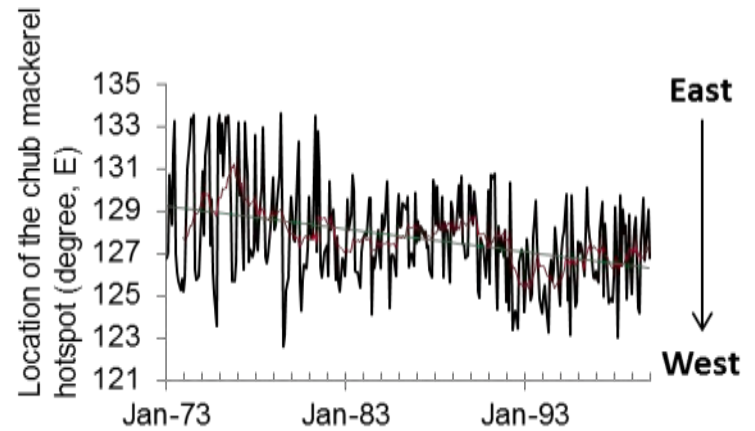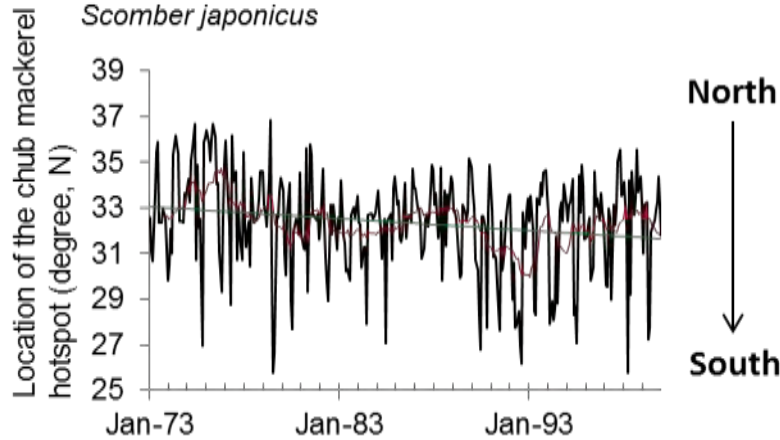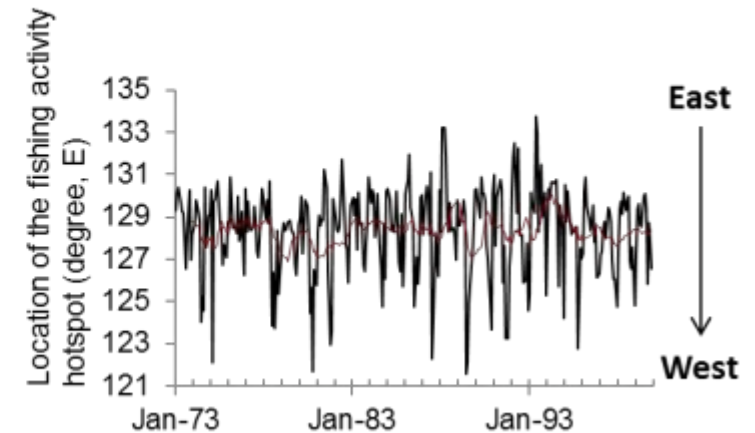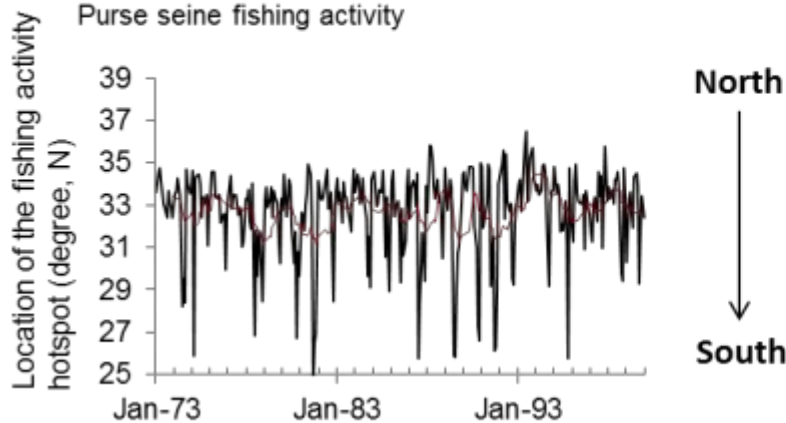
- Do adult chub mackerel change their habitat in response to space-time variability in thermal environment?

- 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.
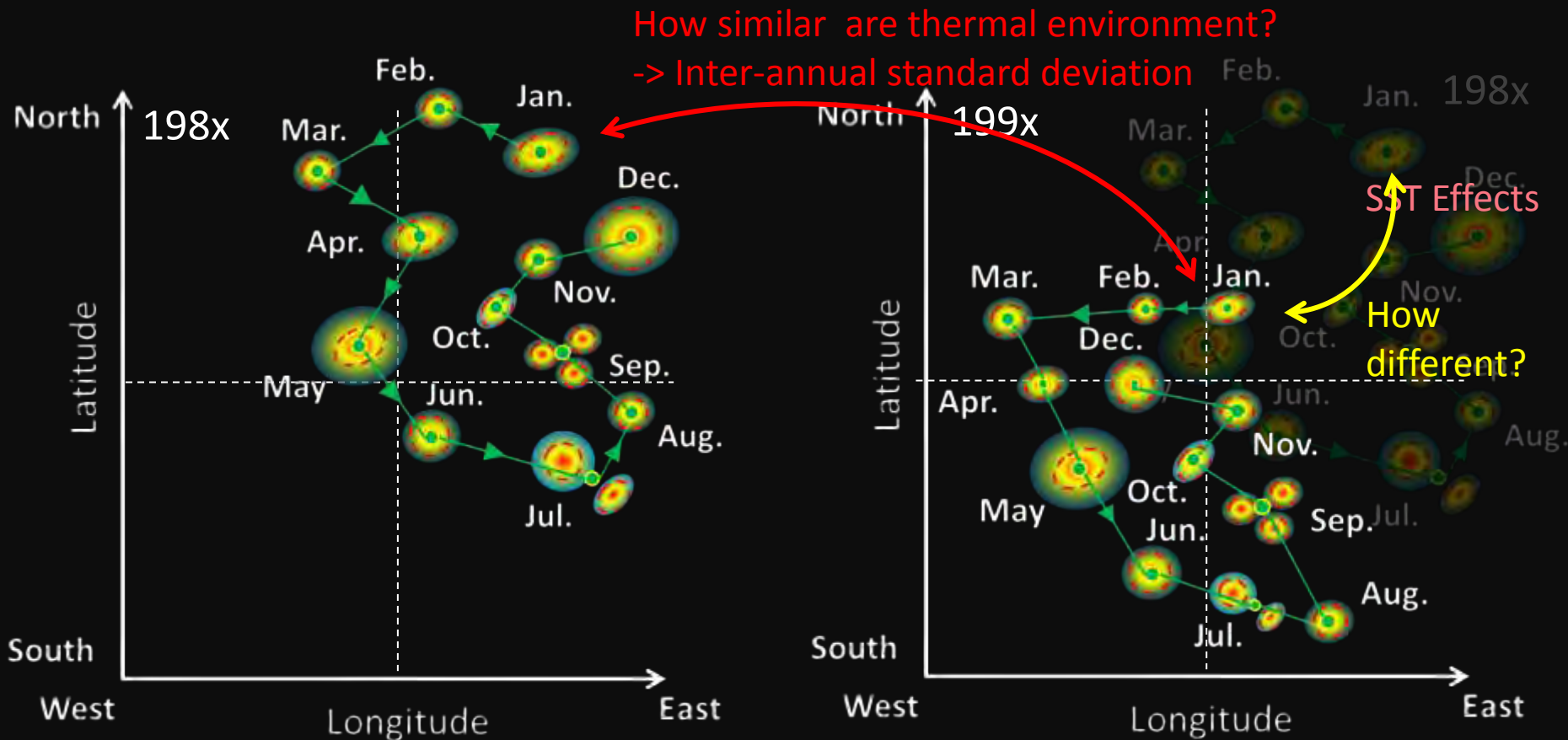
Q2

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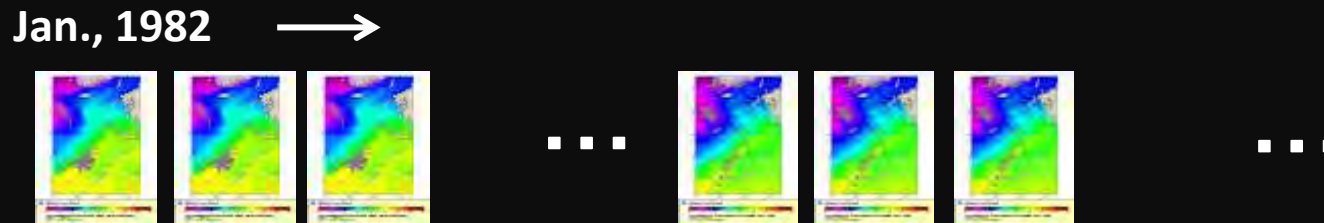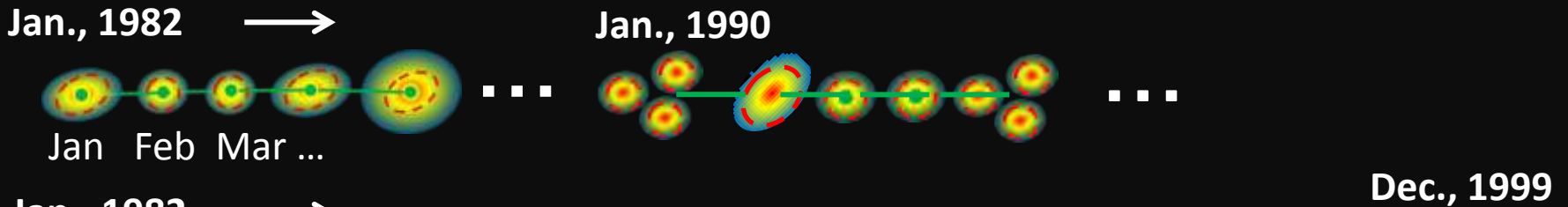
Thermal environment

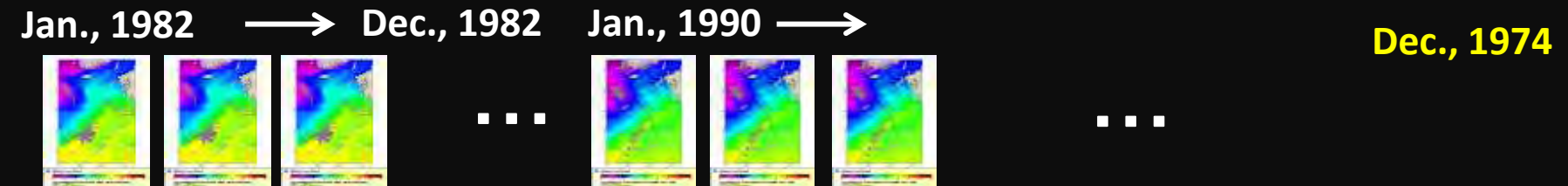Schematic diagram showing inter-annual difference in seasonal distribution

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 Feb Mar …

Dec., 1999

Jan., 1982 ⟶

Simulated Distribution & Real SST → Sim. mean SSTs

Jan., 1974 ⟶ **Dec., 1974**   **Jan., 1974** ⟶ **Dec., 1974**

Jan., 1982 ⟶ **Dec., 1982**   **Jan., 1990** ⟶

Dec., 1974
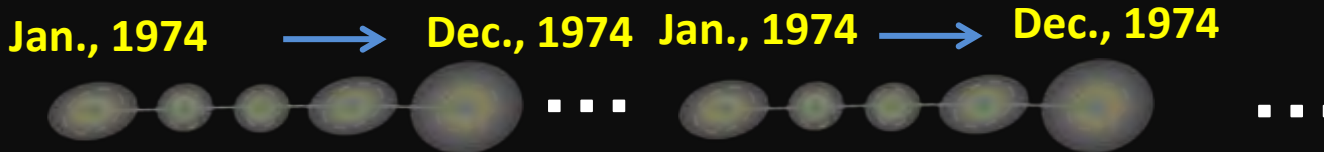
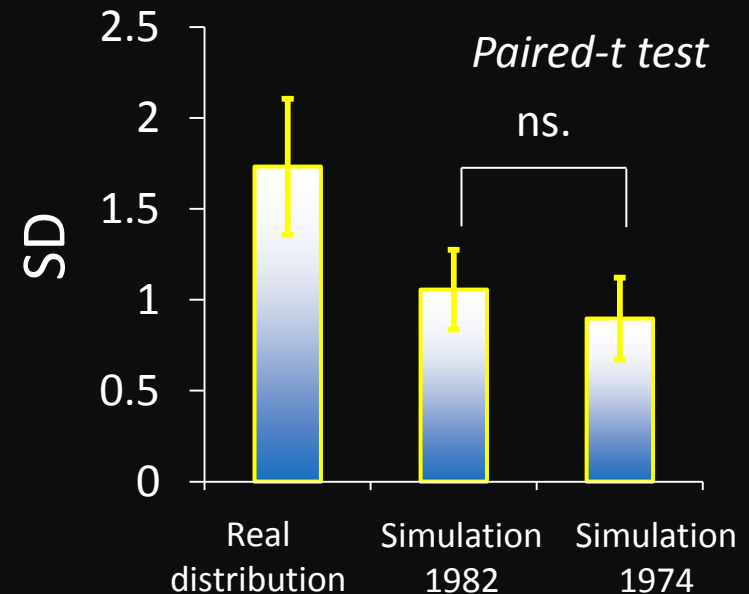# SSTs within mackerel hotspot Simulation results
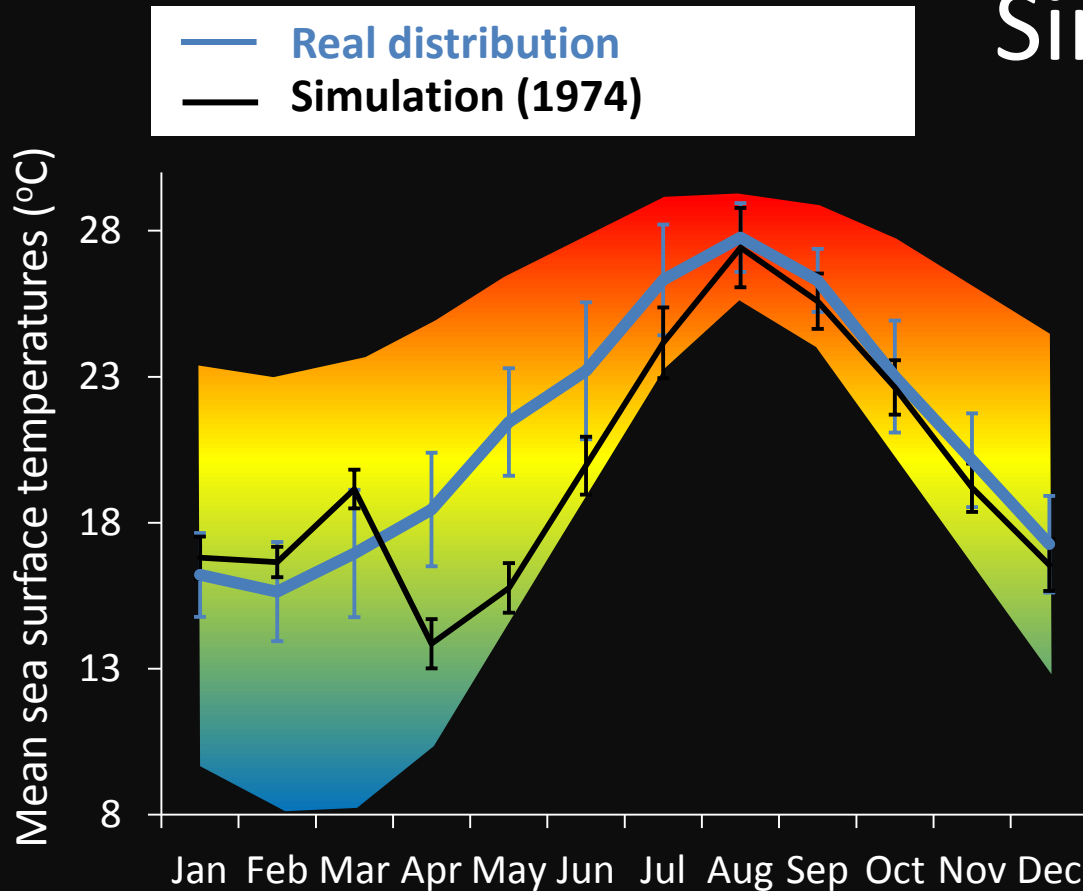
- Habitat change provides different SST environments

- Other factors affect habitat destinations of fish

- 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.
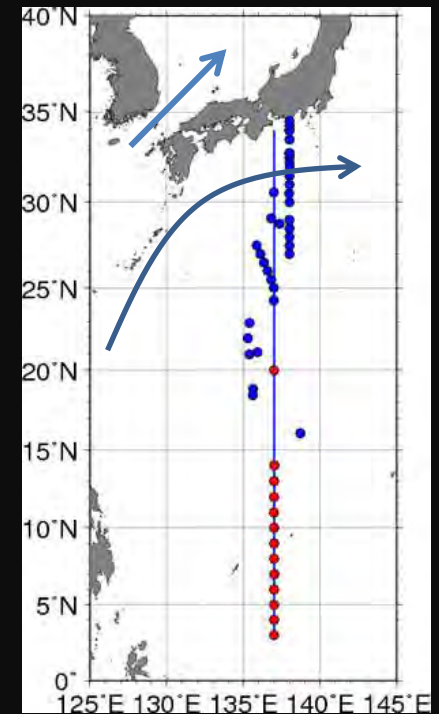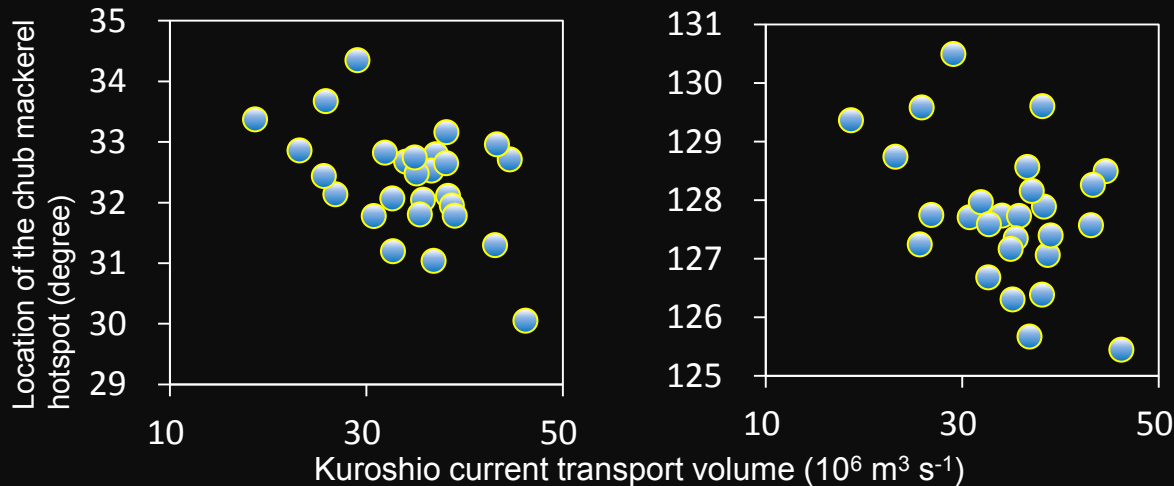
Possible effect of flow environments
(Next steps in future studies)

Tsushima current transport volume (1985-1999)
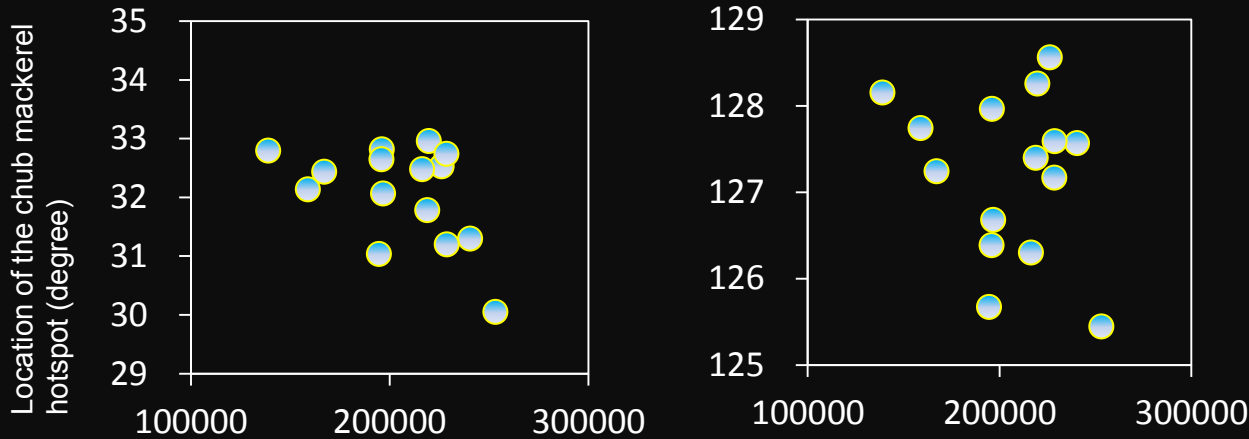
Kuroshio transport volume (1973-1999)

©Maizuru Marine Observatory
©Japan Metrological Agency

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