Yeosu Symposium 2012.05.16

Latitudinal shifts in catch distribution of fisheries species in Korean waters during the past 30 years in relation to climate change

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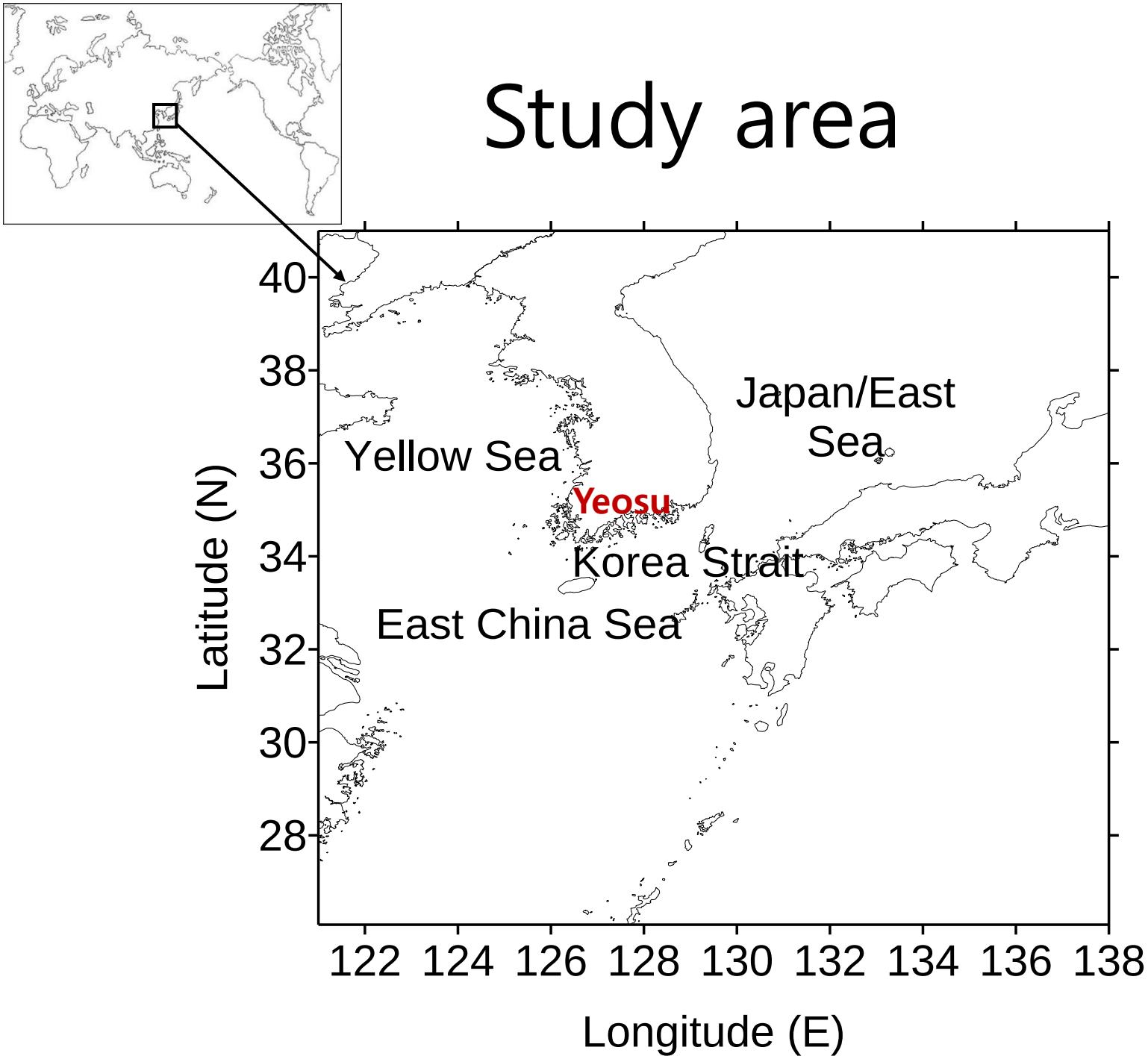
Study area


Yellow Sea
Japan/East Sea
Yeosu
Korea Strait
East China Sea
Latitude (N)
40
38
36
34
32
30
28
122
124
126
128
130
132
134
136
138
Longitude (E)

Problem and Objective

- Lack of studies on latitudinal shifts of fish species in the Pacific (IPCC AR5)
  - Mostly confined to the North Atlantic
- Document range shifts of fish species in Korean waters based on fisheries statistics despite uncertainty
- Implications for fisheries management in adapting to climate change in Korea

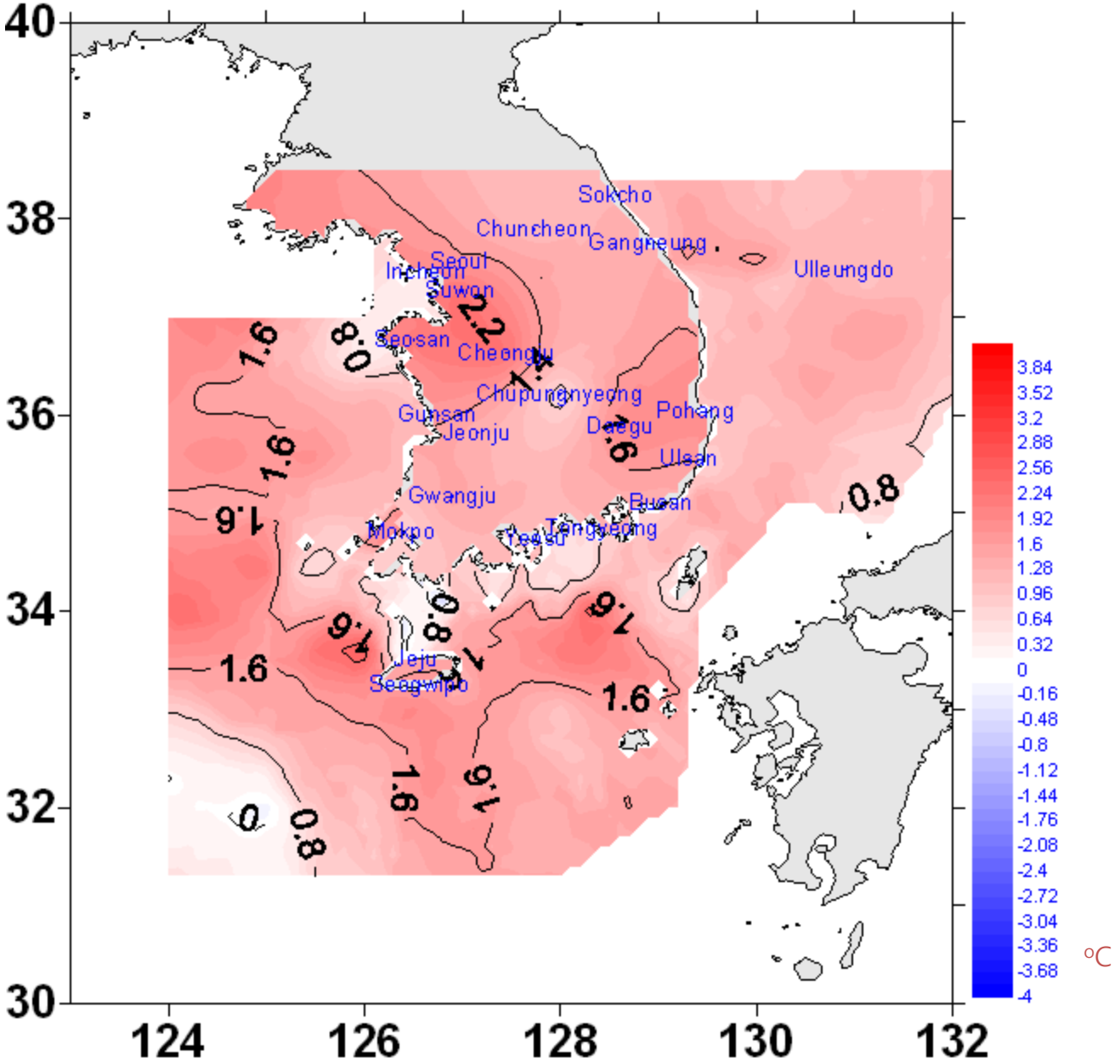
Outline

- Long-term oceanographic changes in Korean waters
- Range shifts of major commercial fish species
  - Small pelagic species
  - Large pelagic species
  - Demersal/Bentho-pelagic species
- Implications to fisheries management in adapting to climate change

Long-term Data in Korea

- NFRDI, Korea
  - Depth-specific water temperature, salinity and dissolved oxygen (1968-2010)
  - Bimonthly
- MIFAFF, Korea
  - Spatially-explicit daily catch data of marine capture fisheries in South Korea (1983-2010)
- Korea Meteorological Administration
  - Air temperature and precipitation at 22 cities (1968-2010)

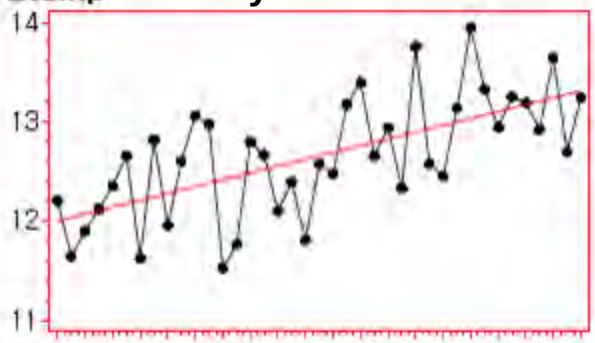
Linear trend of temperature change (°C) in the land and sea surface (1968-2010)



Linear trend of air & water temperature changes 1968-2006

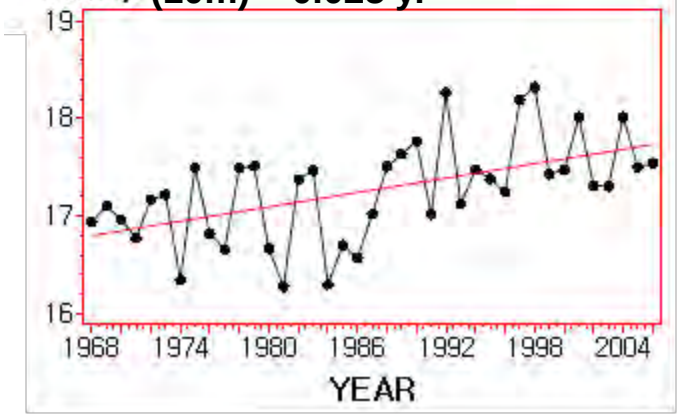
Annual mean values averaged for the entire area

atemp = 0.034 yr^{-1}

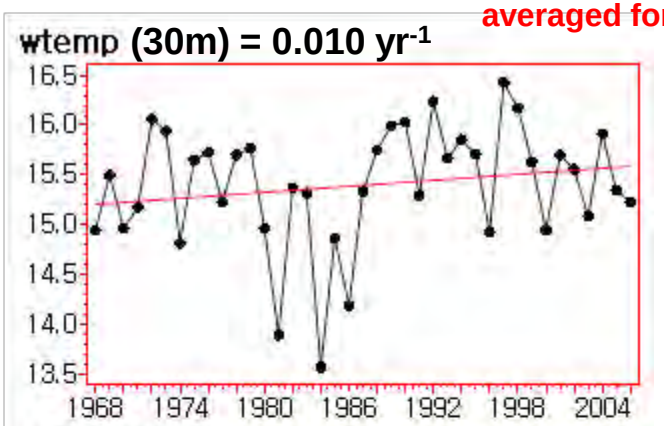


wtemp (0m) = 0.026 yr^{-1}

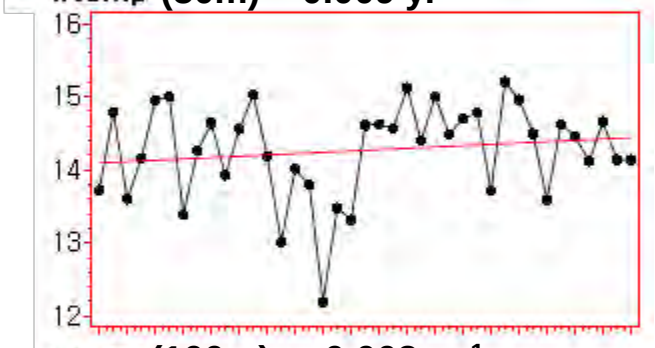
wtemp (10m) = 0.025 yr^{-1}



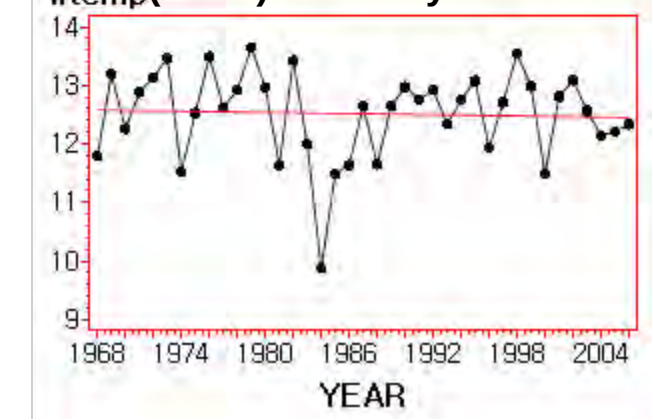
wtemp (30m) = 0.010 yr^{-1}



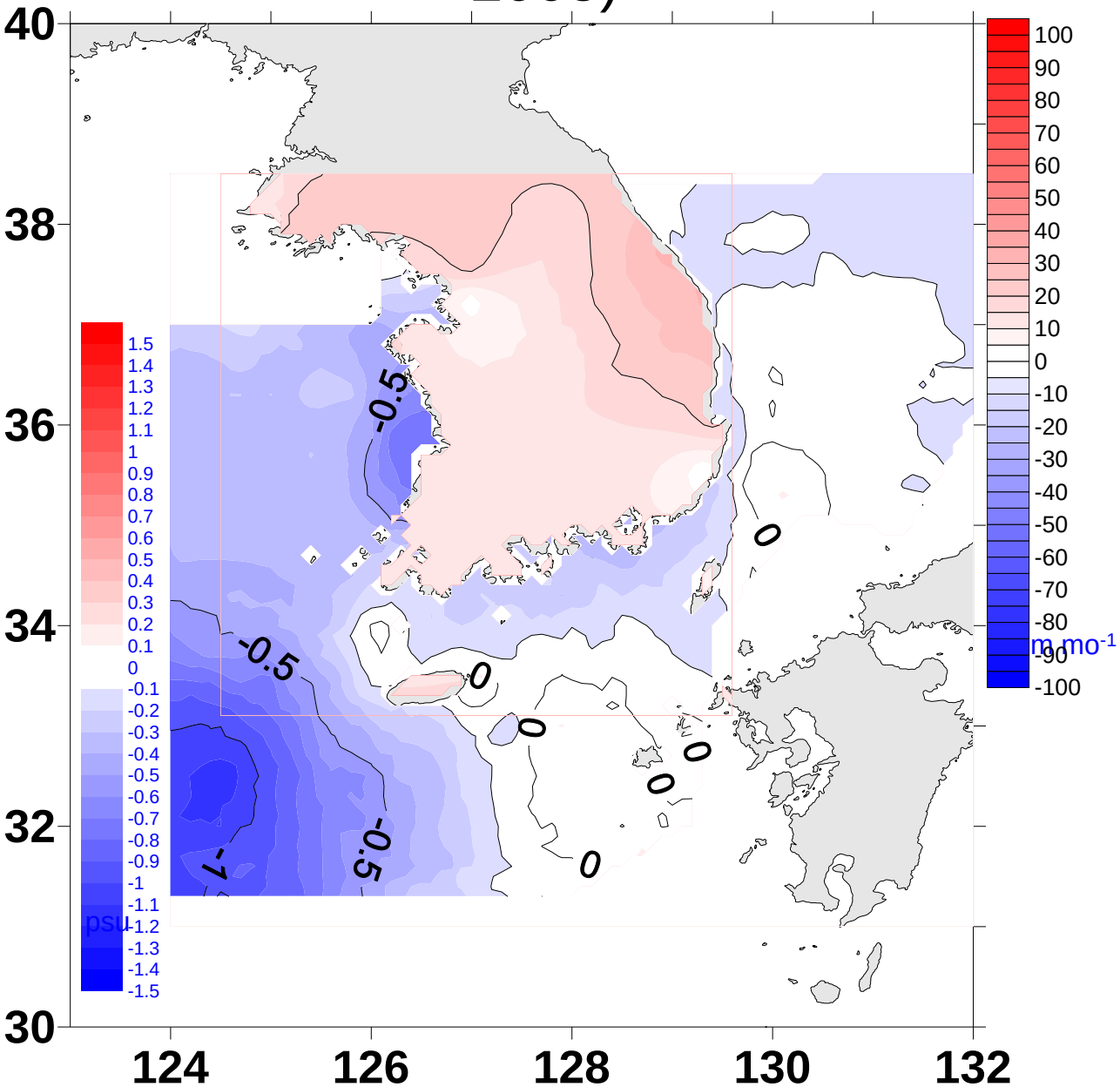
wtemp (50m) = 0.009 yr^{-1}



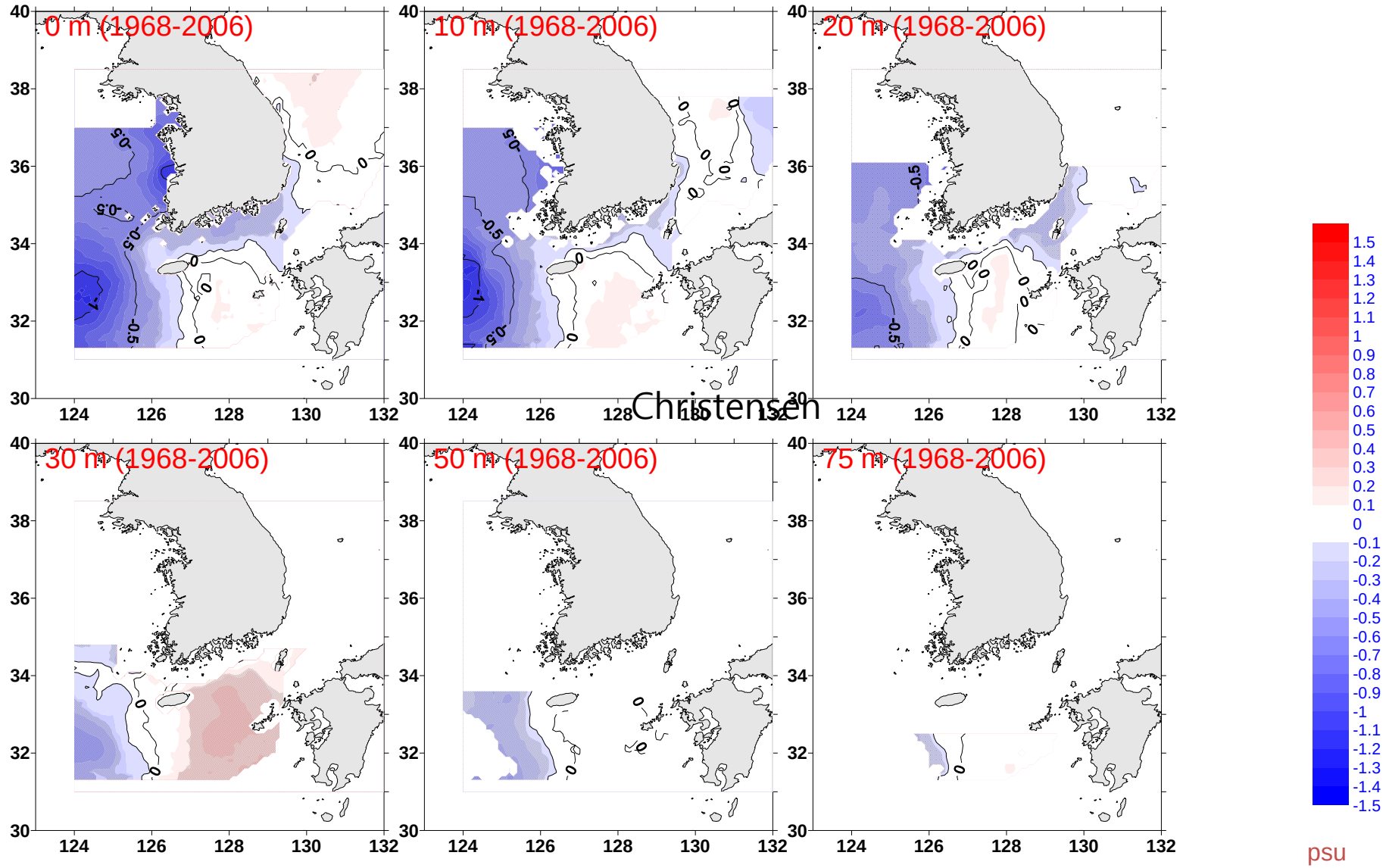
wtemp(100m) = -0.003 yr^{-1}



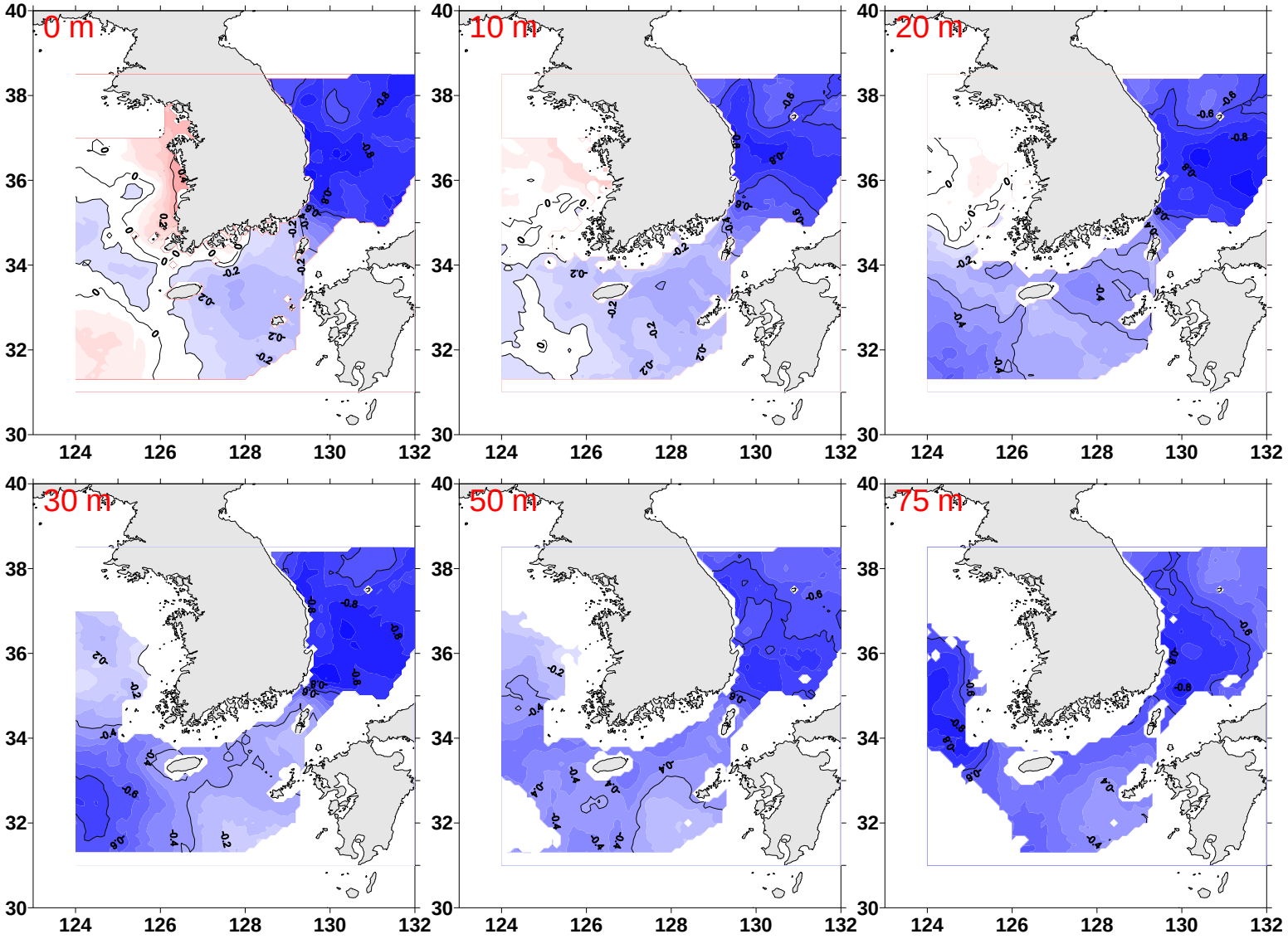
Linear Trend of Mean rainfall and salinity changes (1968-2005)



Long-term change in Salinity (1968-2006)



Linear trend of Dissolved Oxygen Change (1968-2005)



Statistical Methods

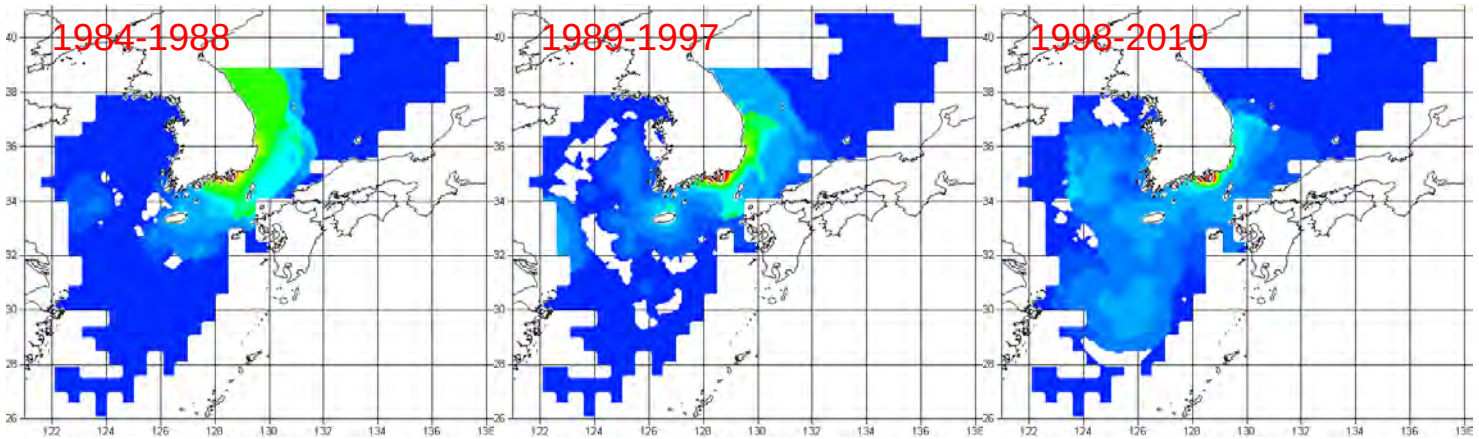
Range shifts of major commercial fish species

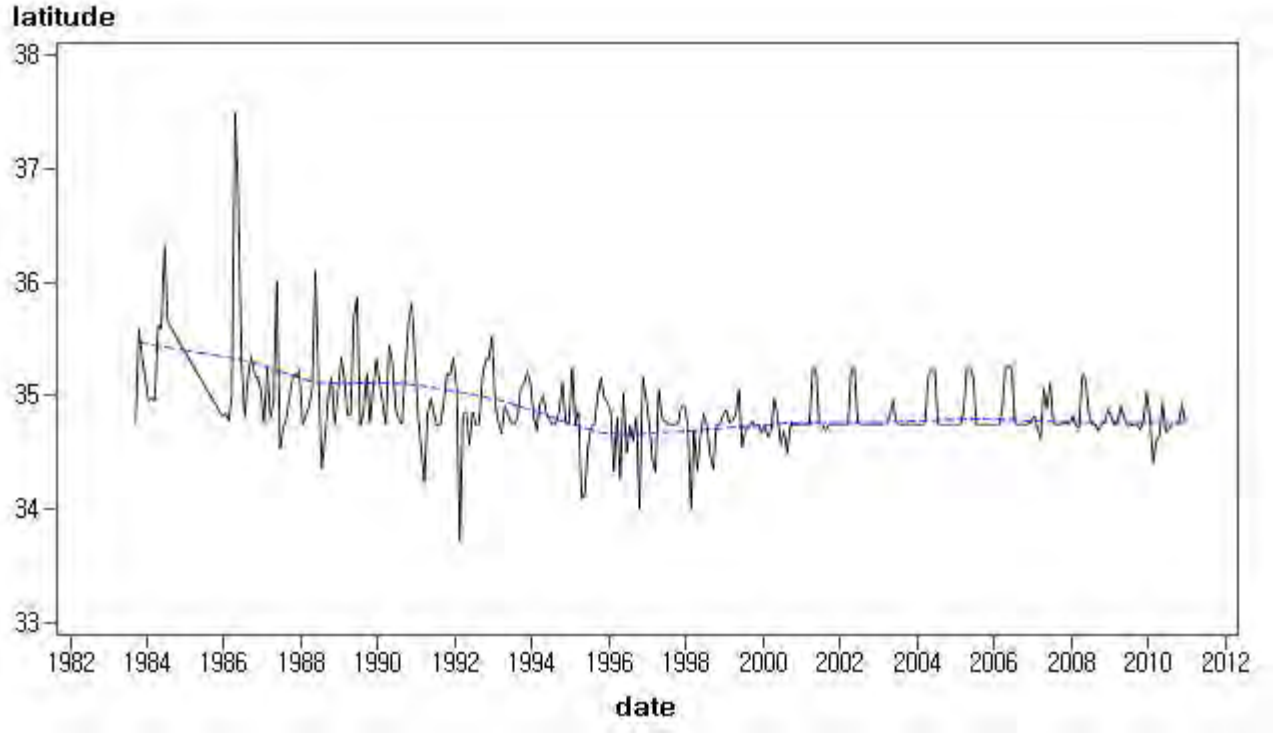
- Monthly catch-weighted mean latitude
- Monthly-averaged region- and depth-specific environmental variables (temperature, salinity and dissolved oxygen)
- Linear regression between monthly mean latitude and mean value of environmental variable
- Removing seasonality
  - Monthly anomaly of mean latitude vs. Monthly anomaly of environmental factors

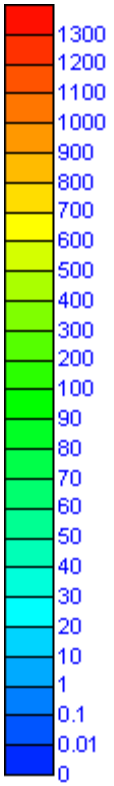
Small pelagic species

- Pacific Anchovy
- Chub mackerel
- Horse mackerel
- Gizzard shad
- Pacific herring
- Pacific sardine
- Common squid

Pacific Anchovy

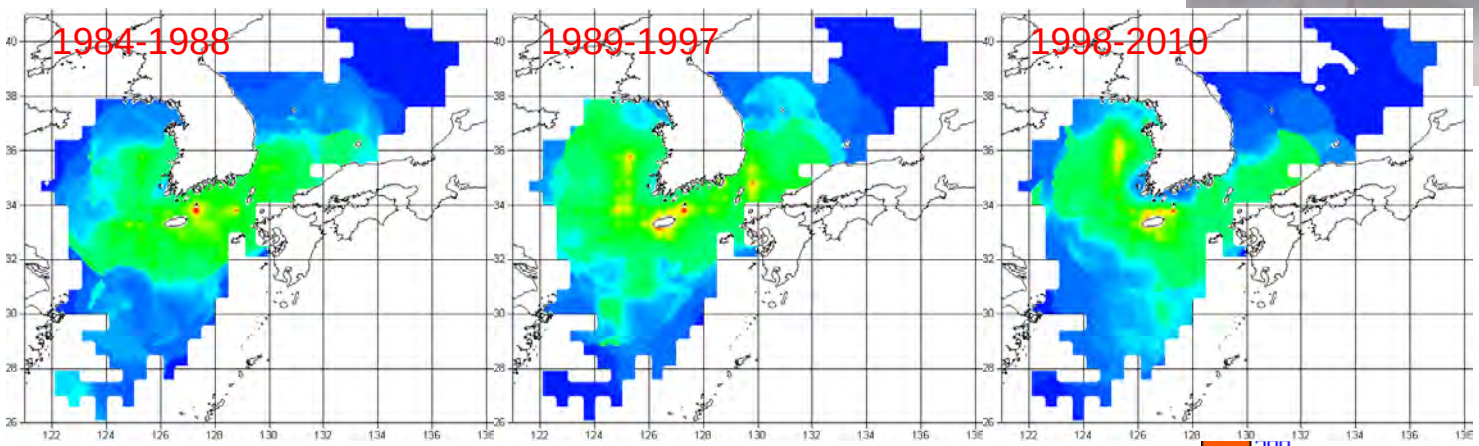


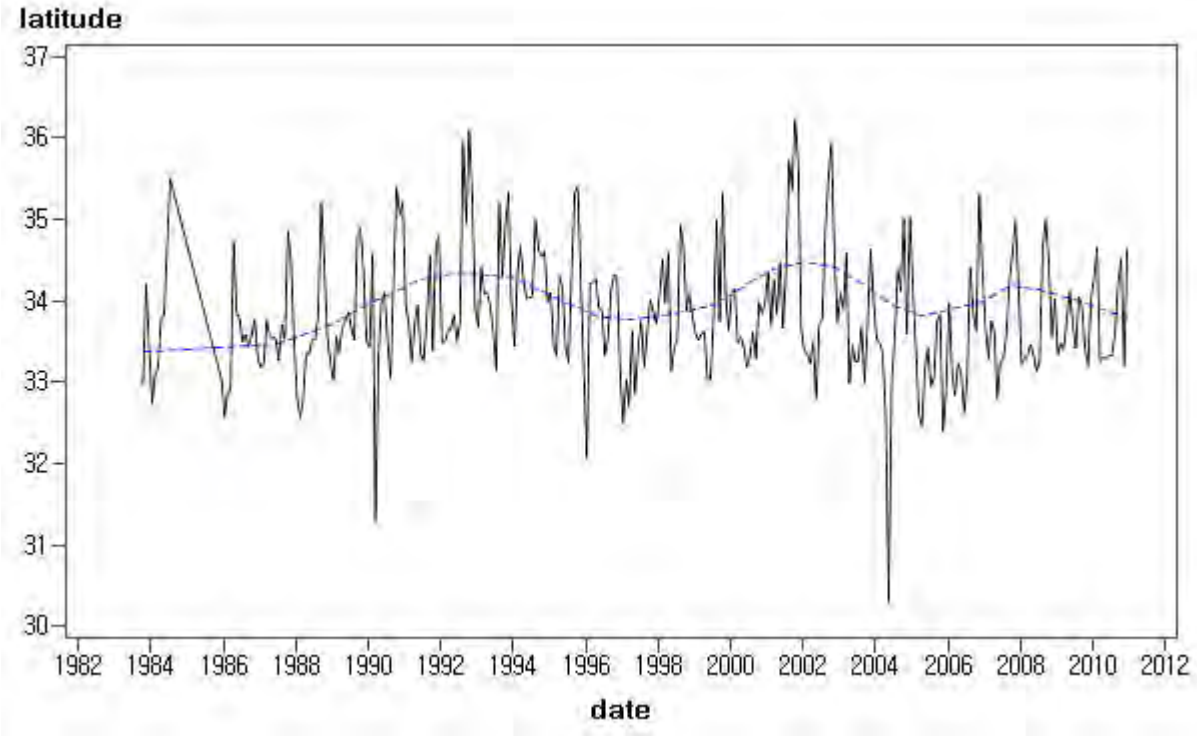


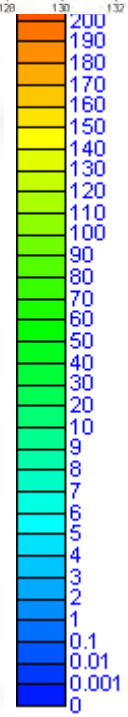


kg km^{-2}

Chub mackerel

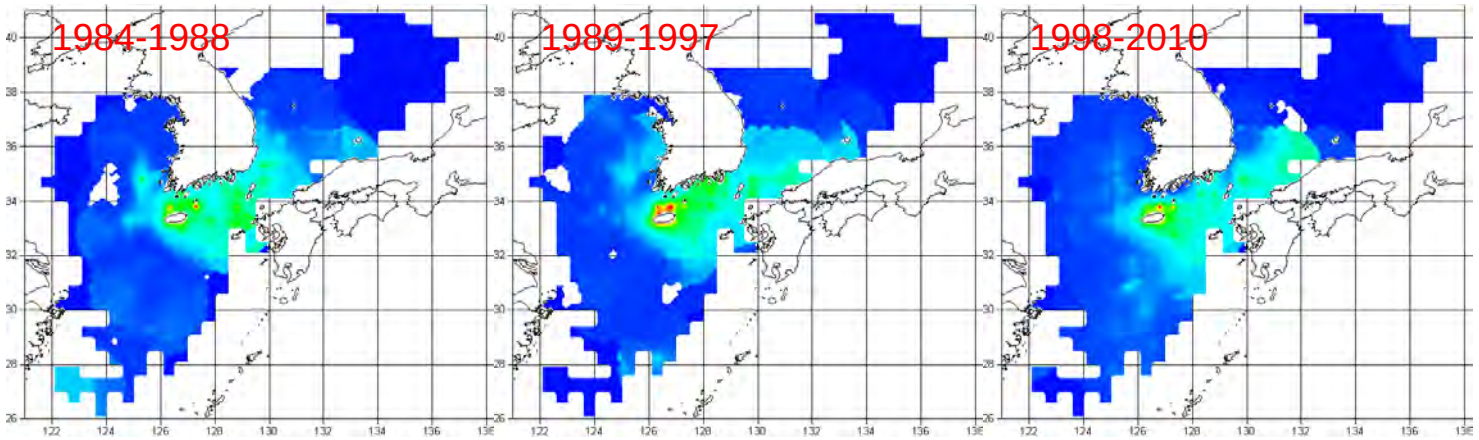


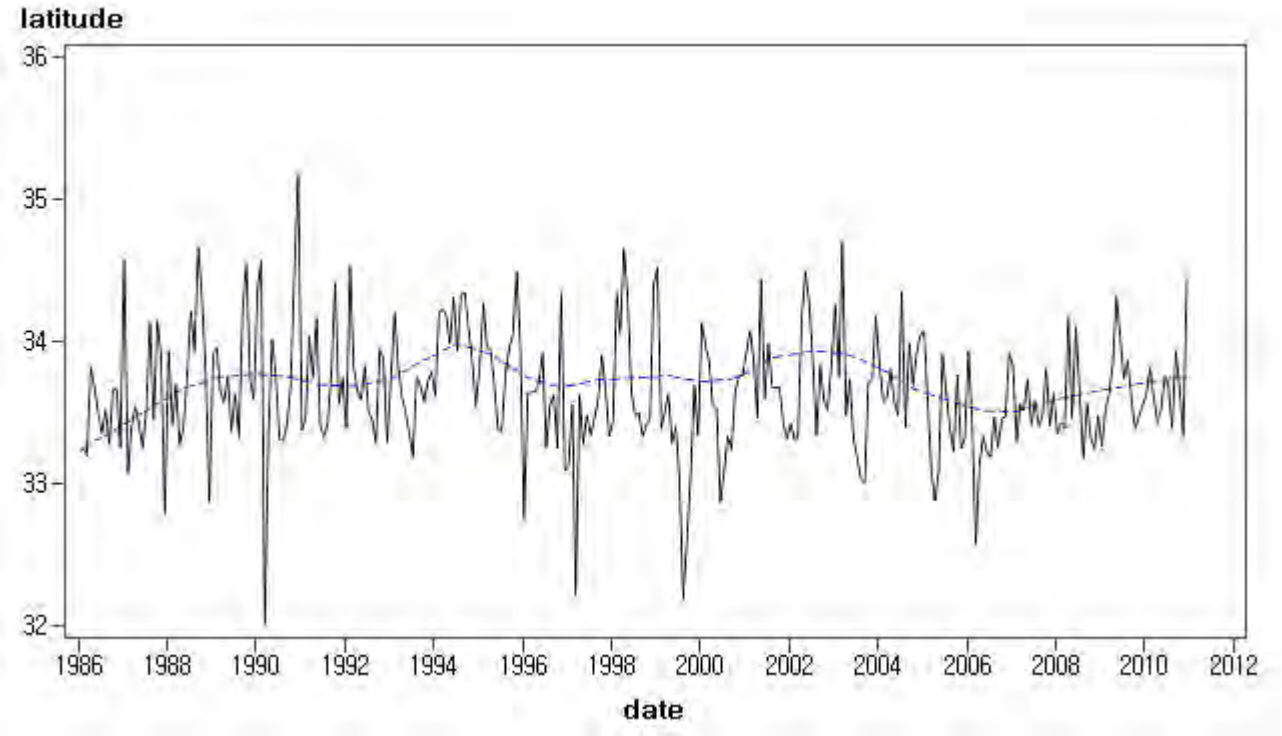


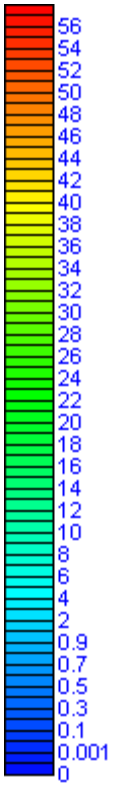


g km^{-2}

Horse mackerel

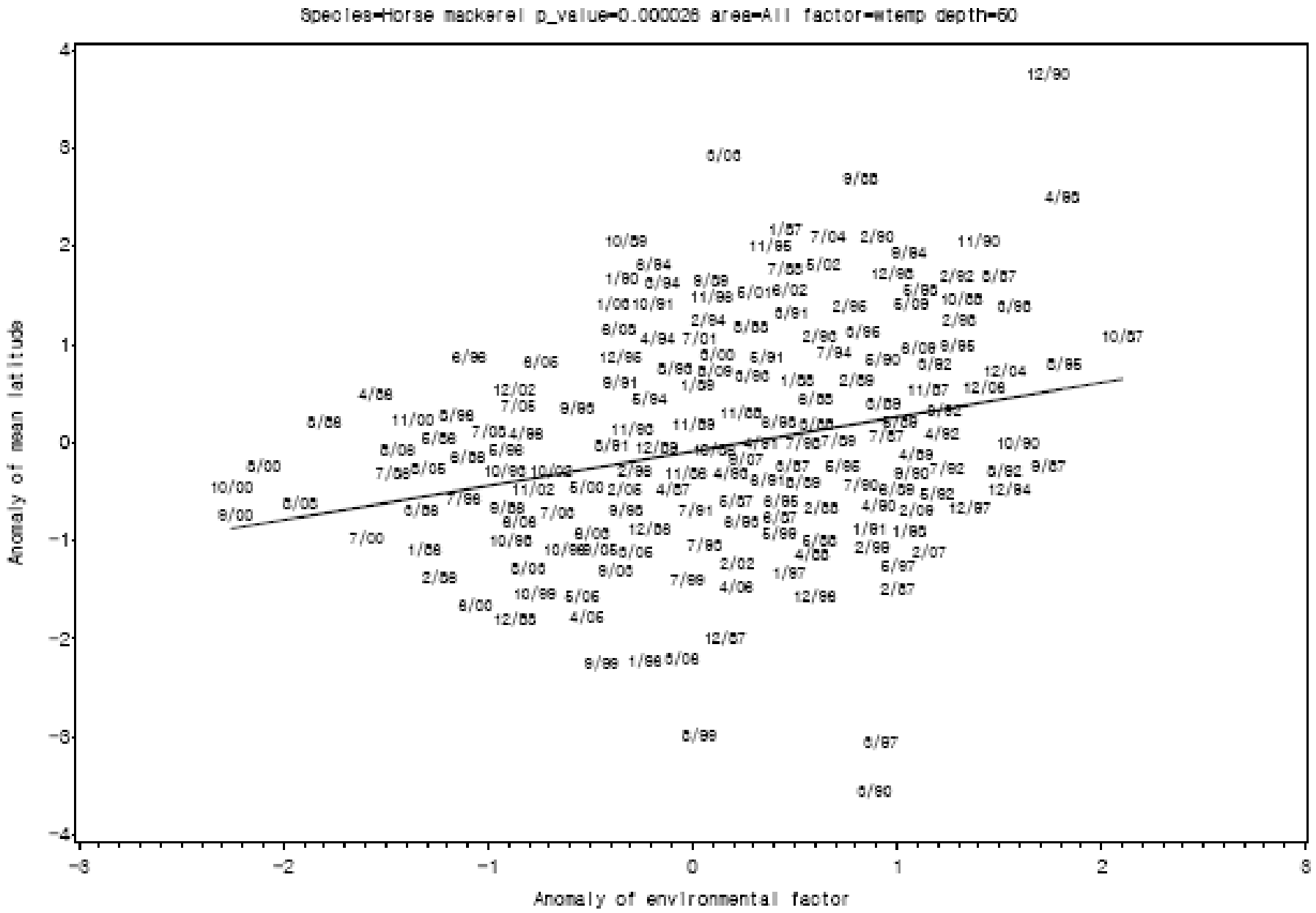




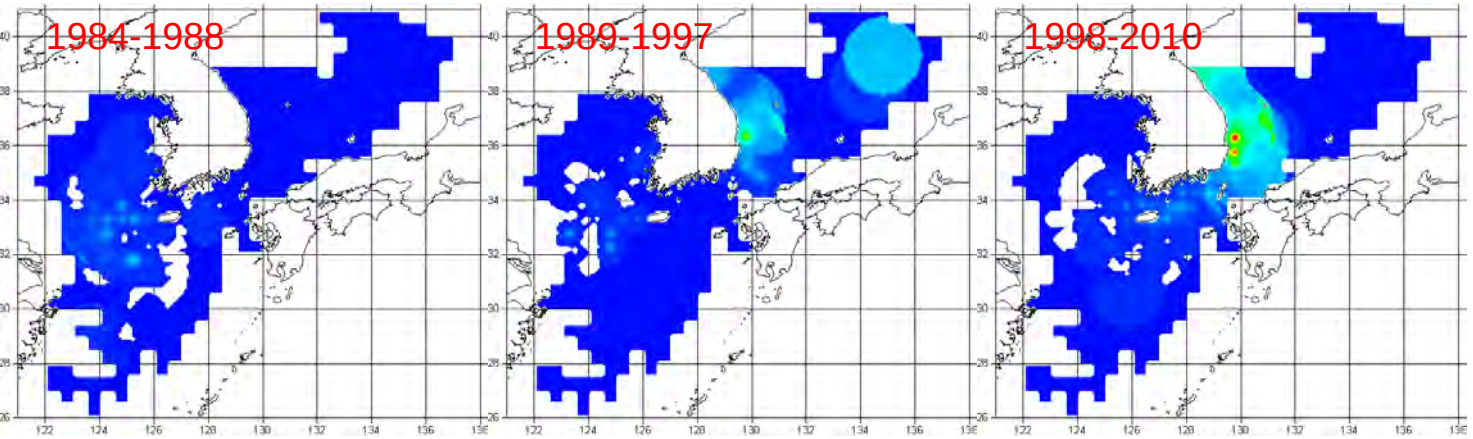


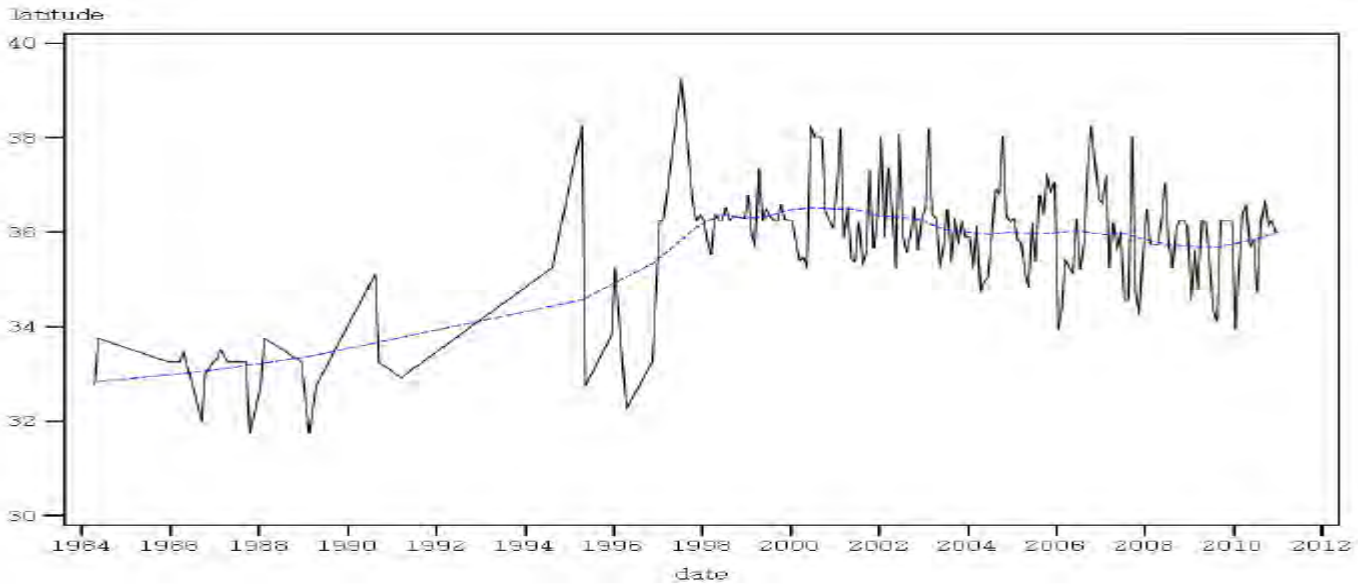
kg km^{-2}

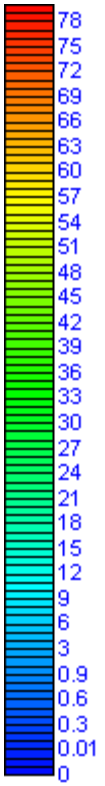
Anomaly correlation with Temperature at 50 m



Pacific herring

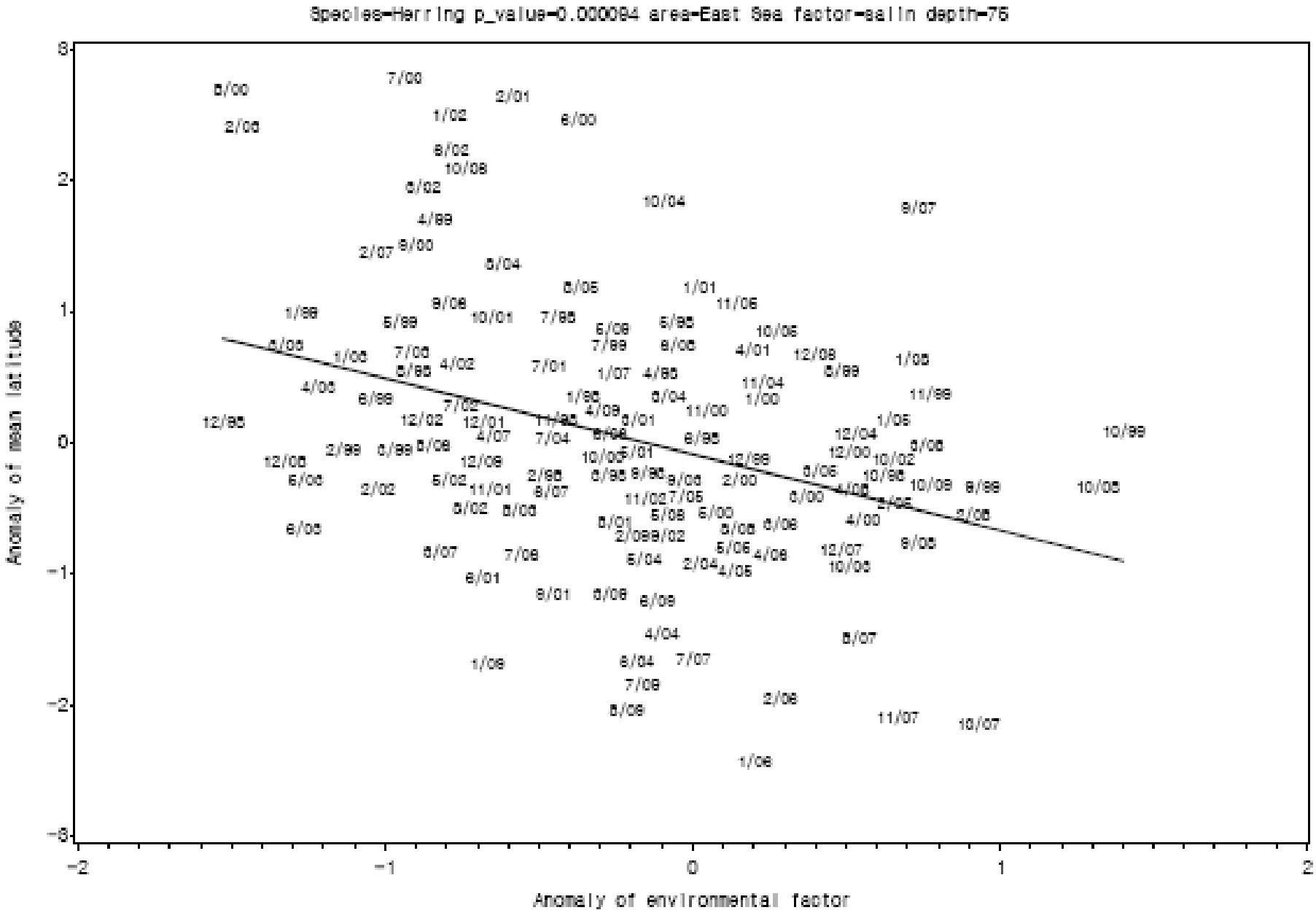




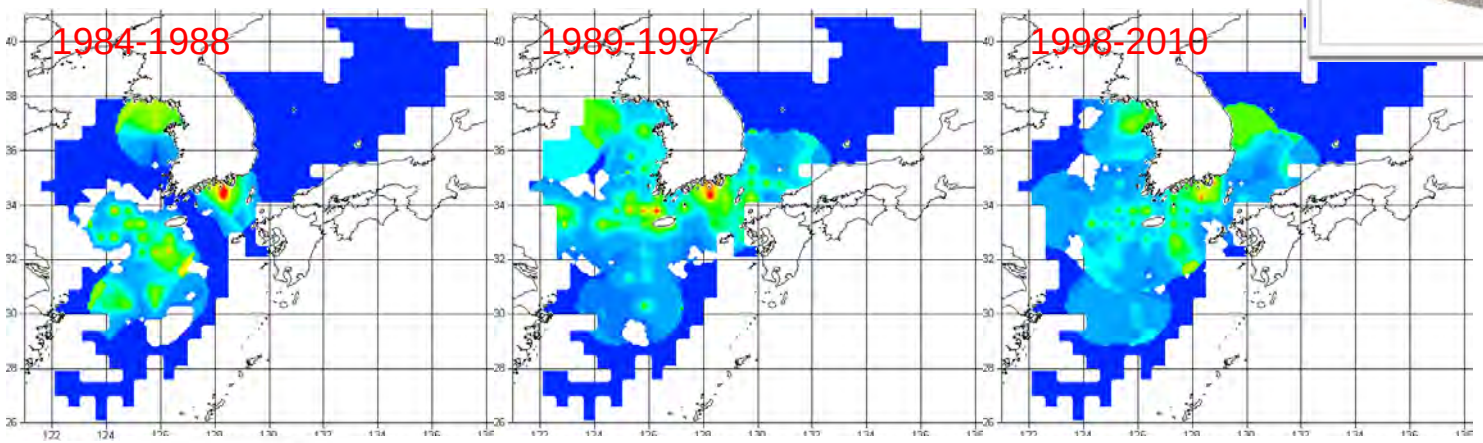


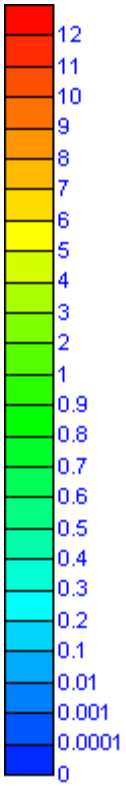
kg km^{-2}

Anomaly correlation with 75-m salinity of the Japan/East Sea

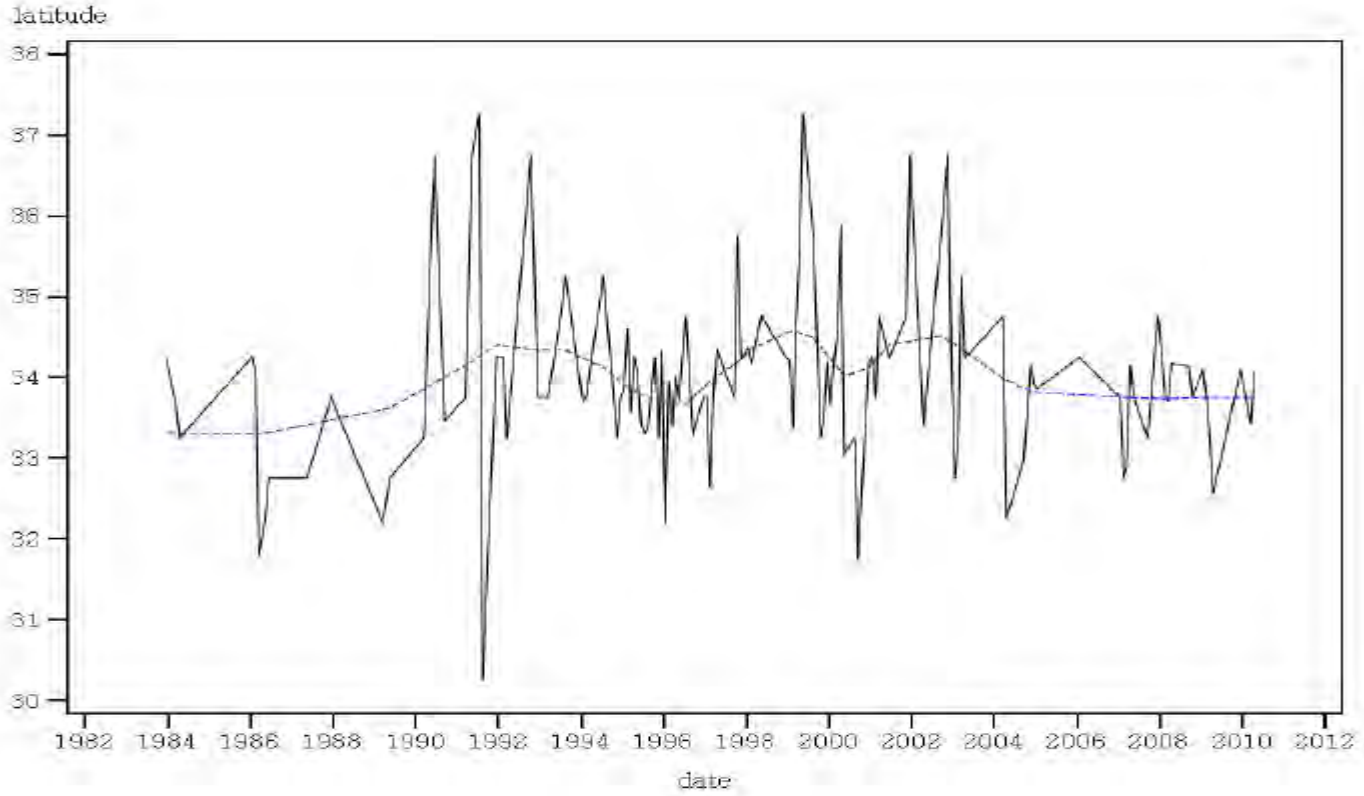


Gizzard shad

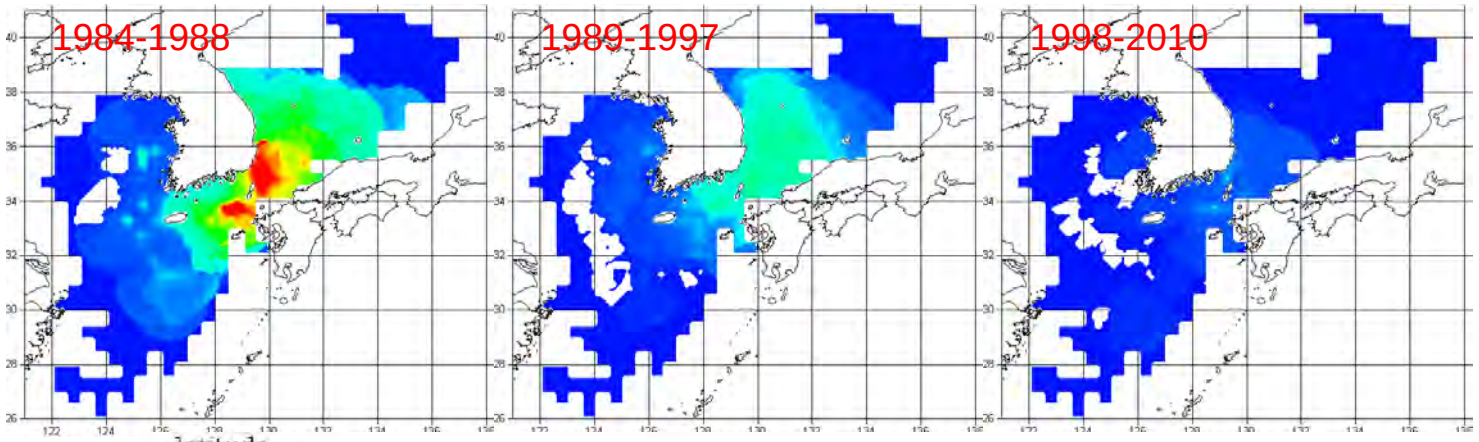


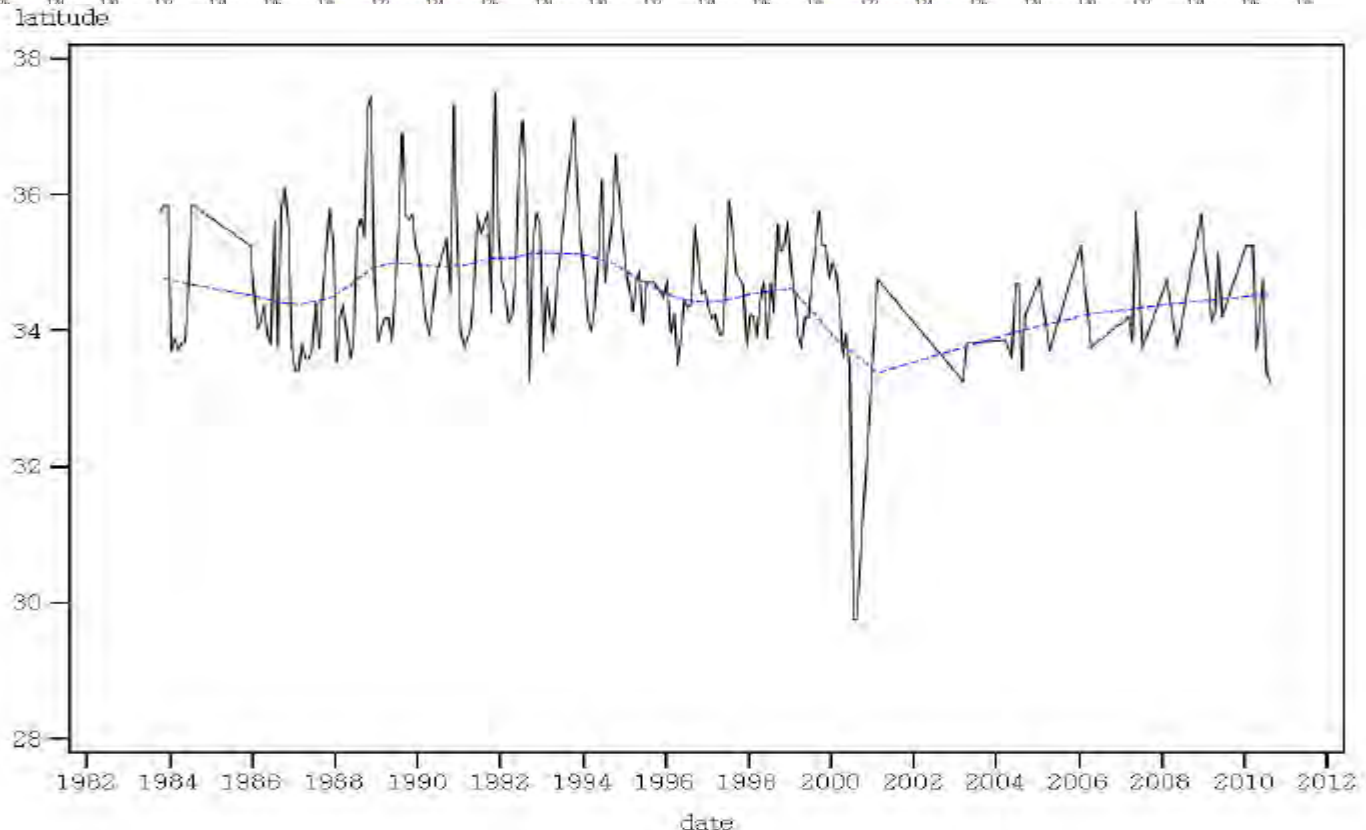


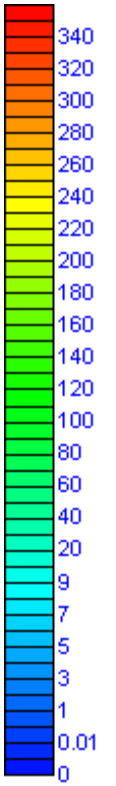
kg km^{-2}



Pacific sardine

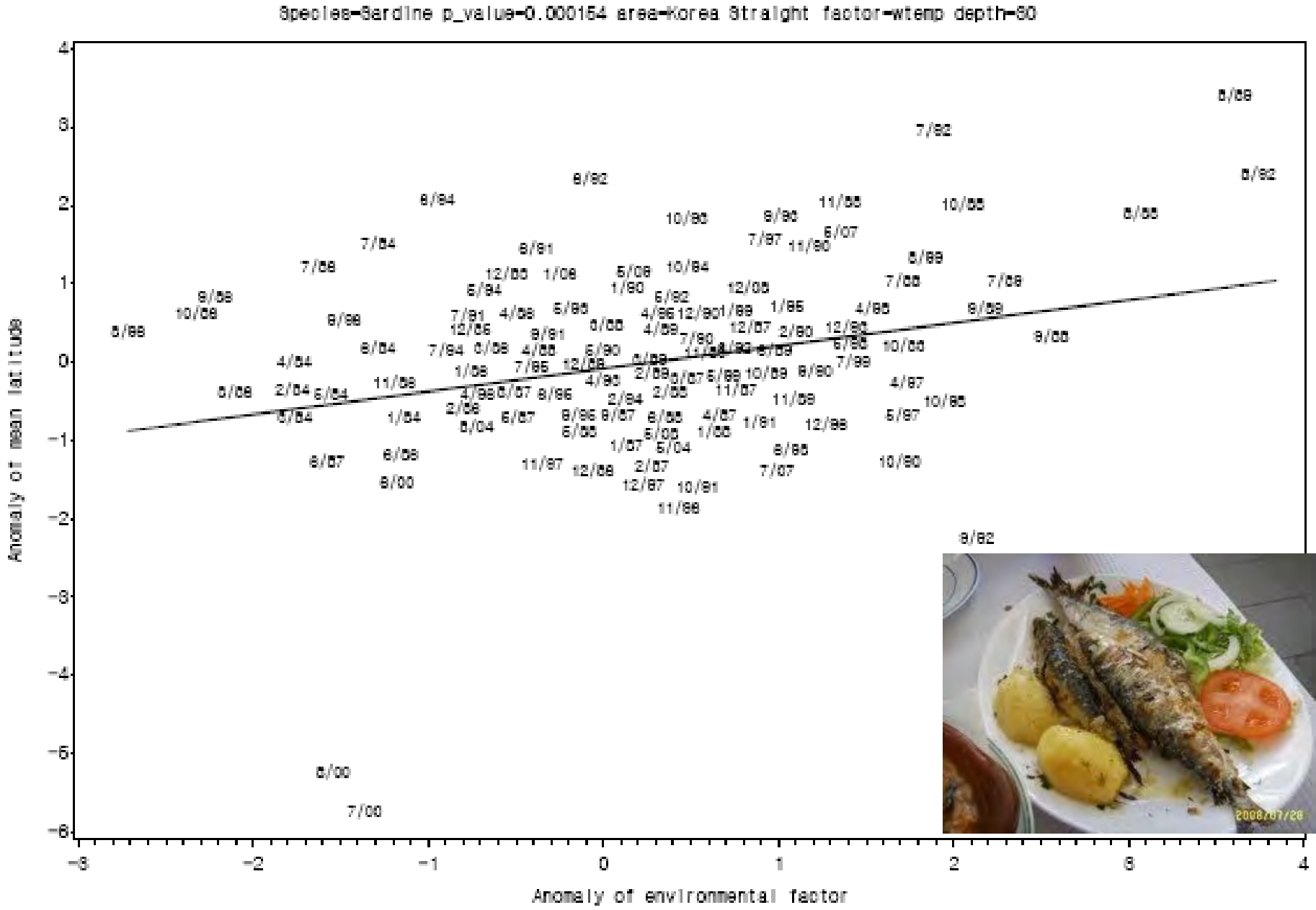




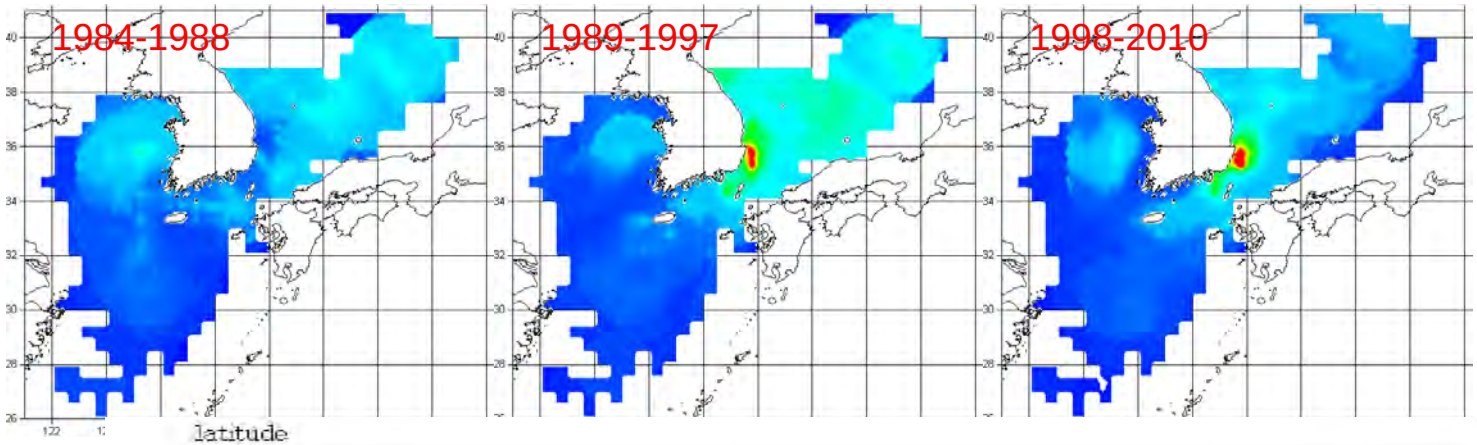


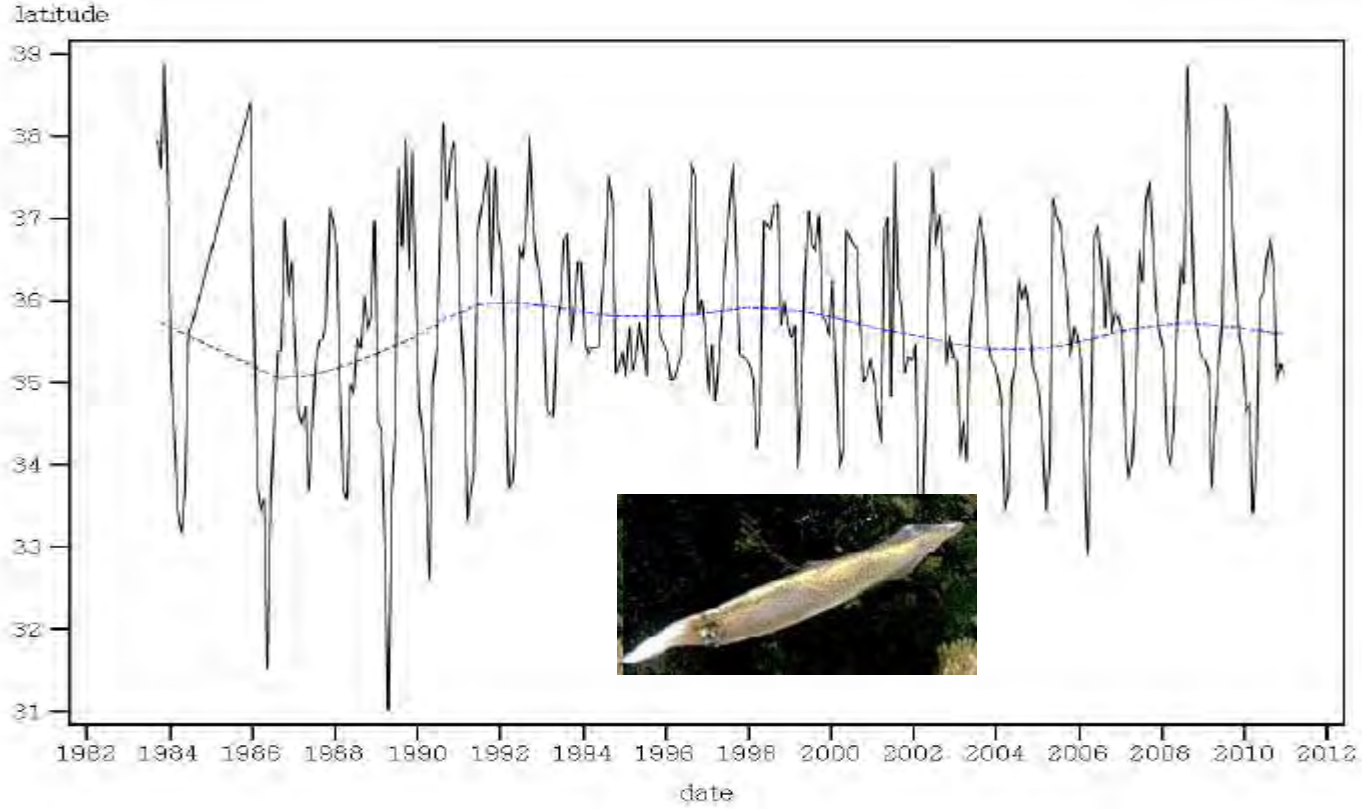
kg km^{-2}

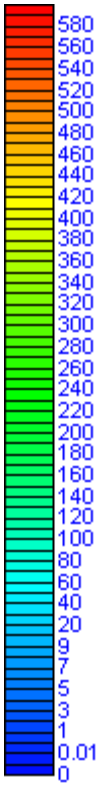
Anomaly correlation with 50-m temperature of the Korea Strait



Common squid

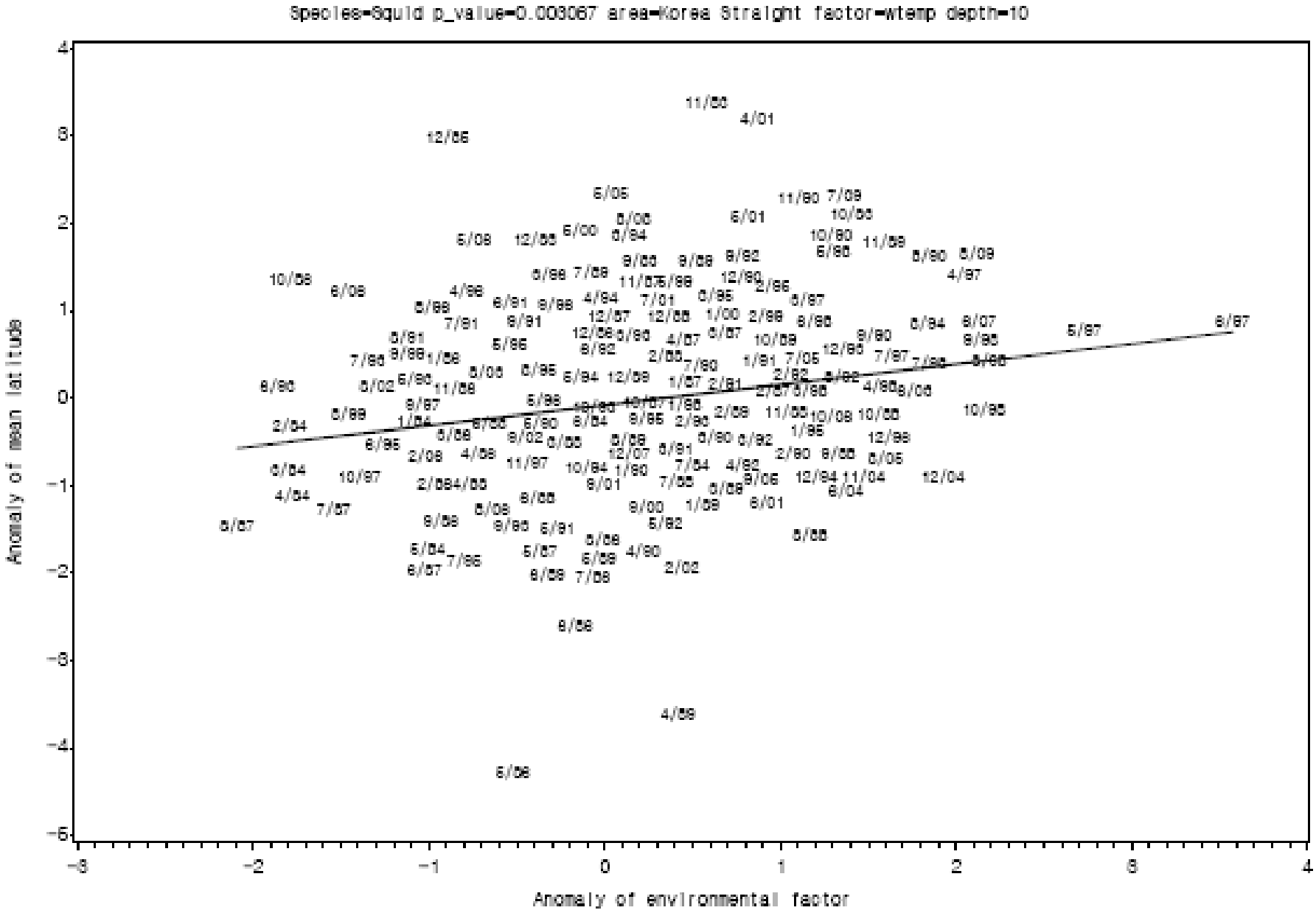






kg km^{-2}

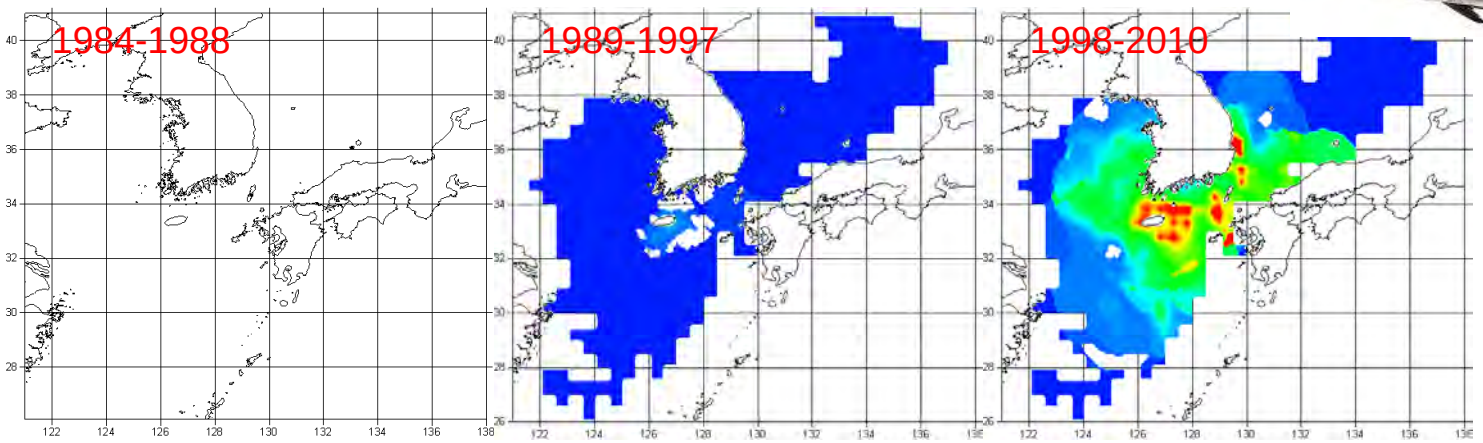
Anomaly correlation with 10-m temperature of the Korea Strait

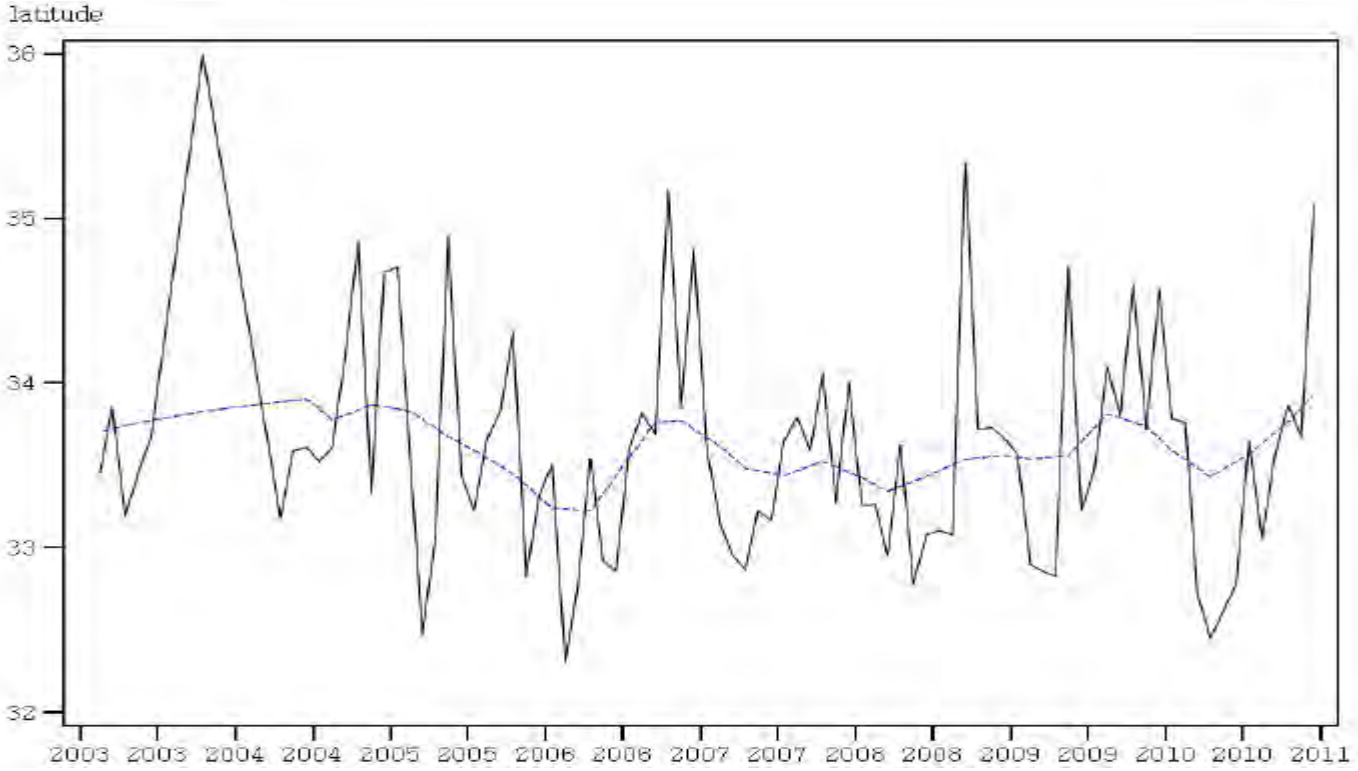


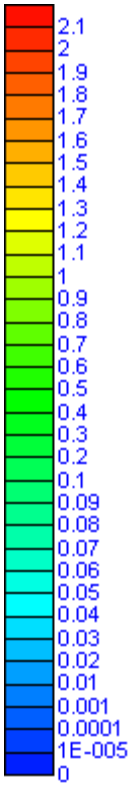
Large pelagic species

- Bluefin tuna
- King mackerel
- Yellow tail

Bluefin tuna

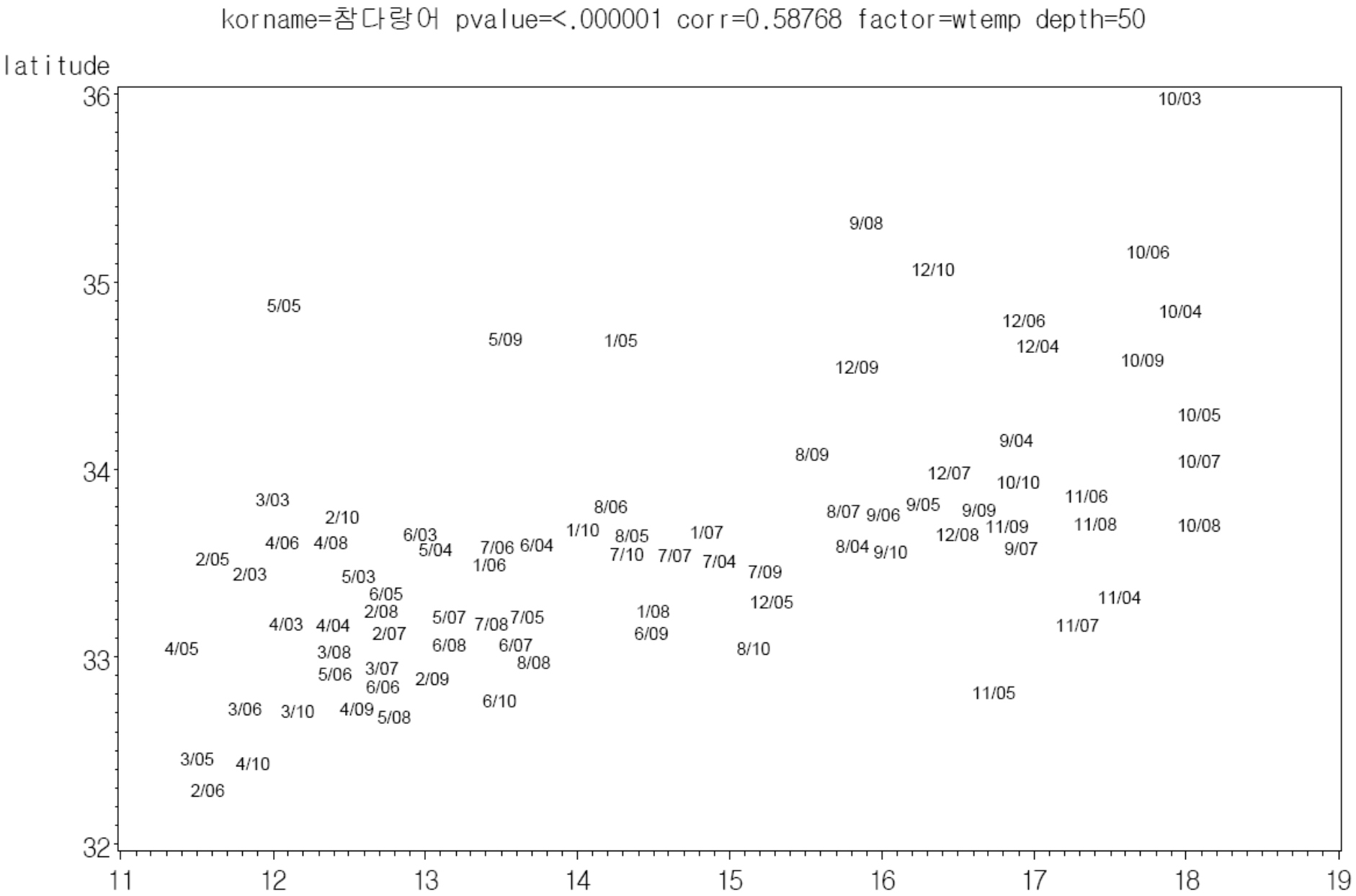




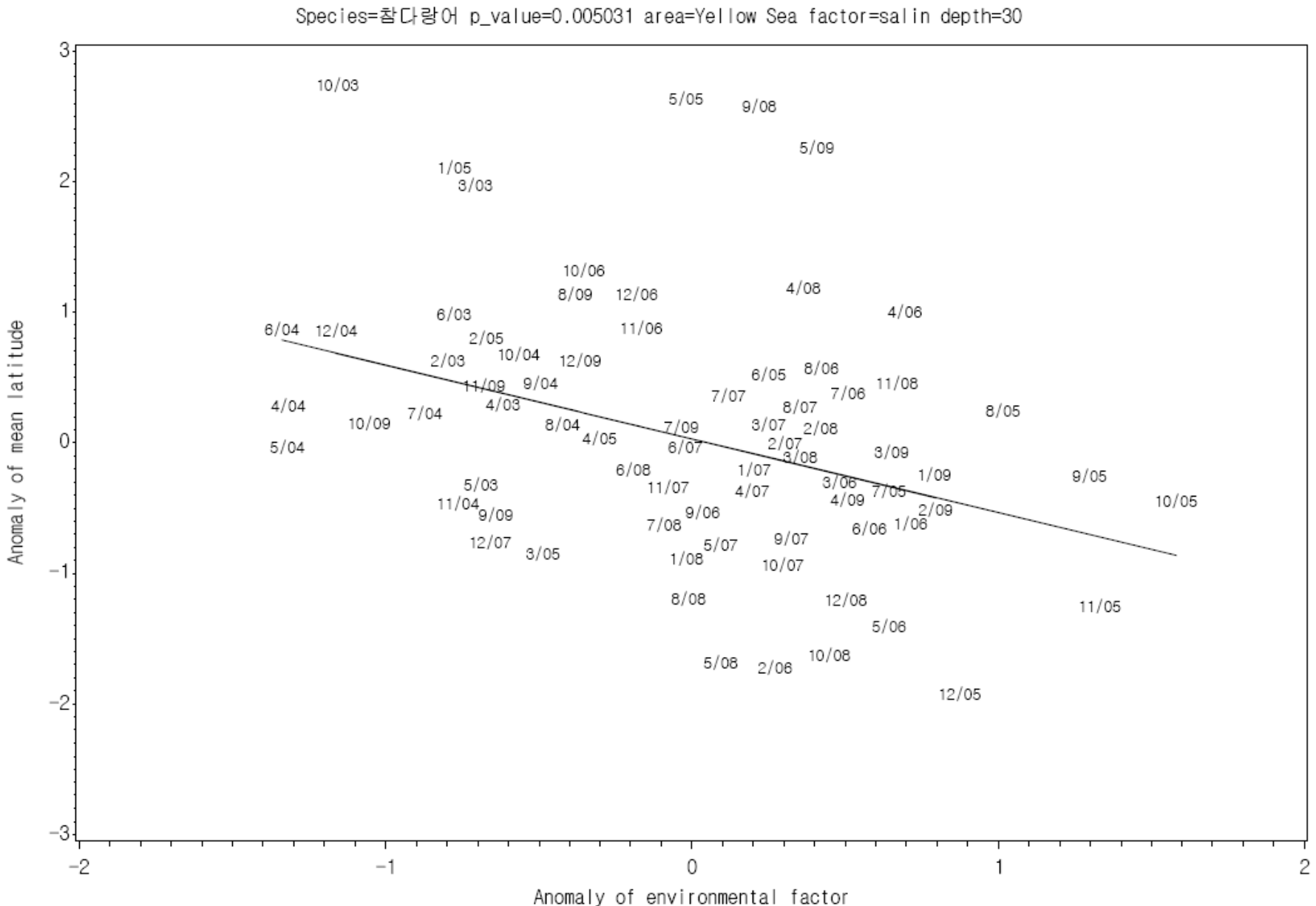


km^{-2}

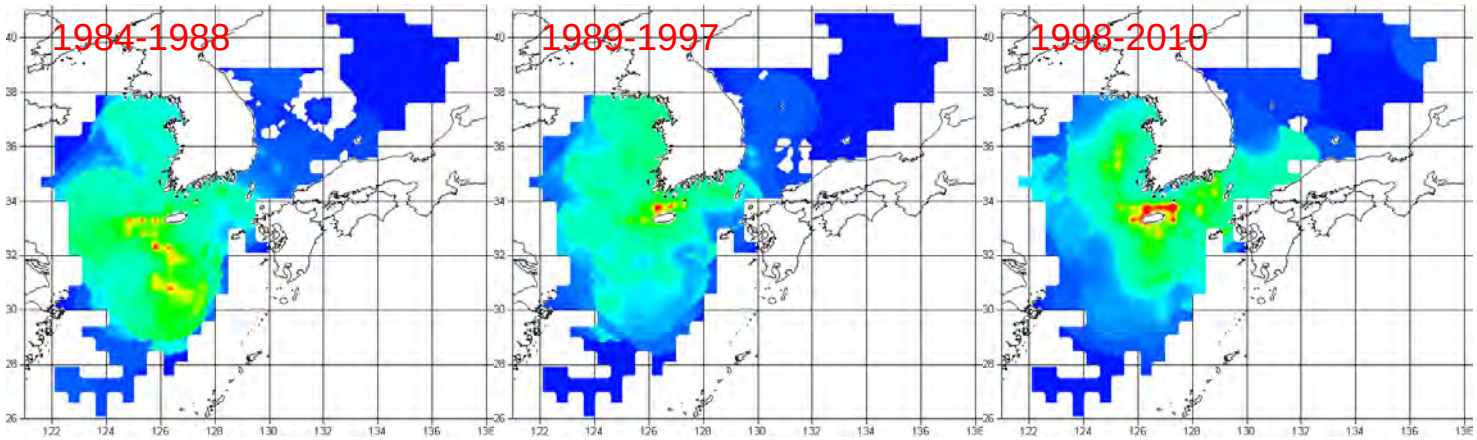
Correlation with 50-m temperature (2003-2010)

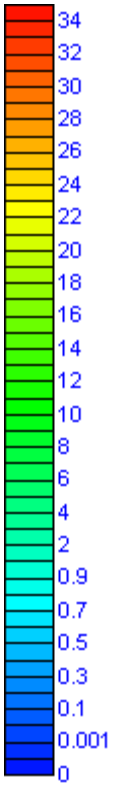


Anomaly correlation with 30-m salinity of the Yellow Sea (2003-2009)

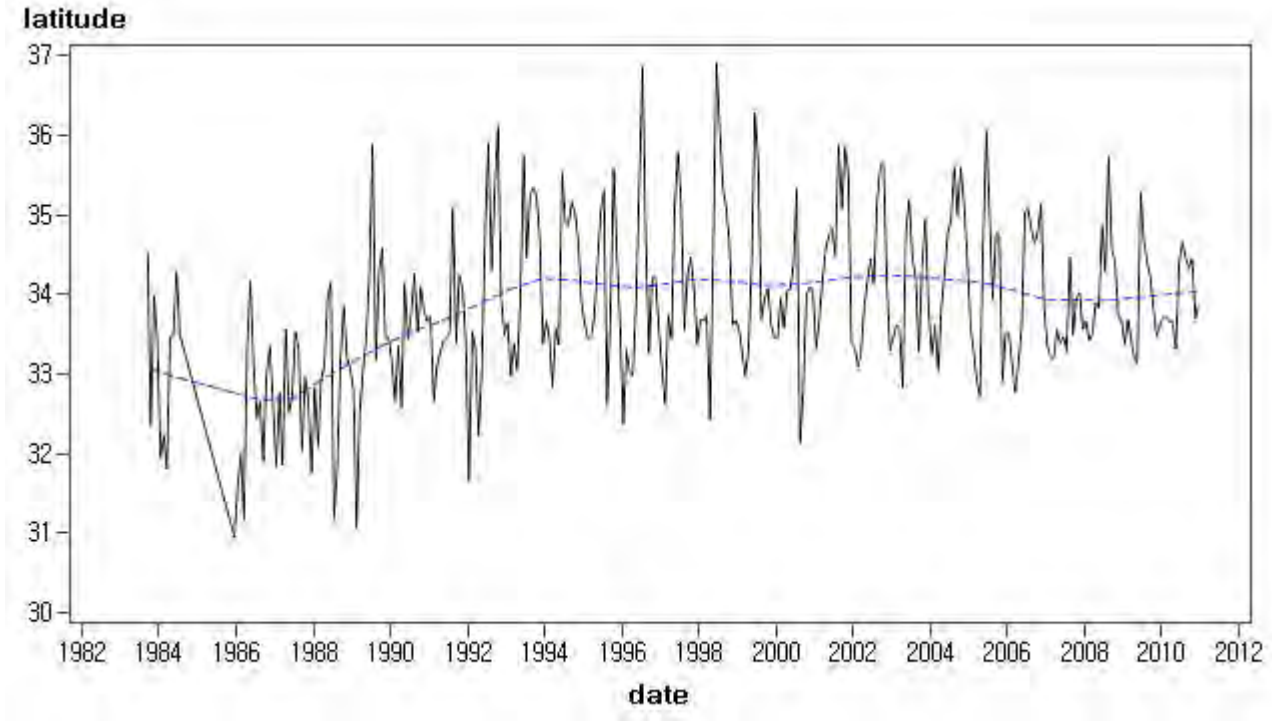


Spanish mackerel

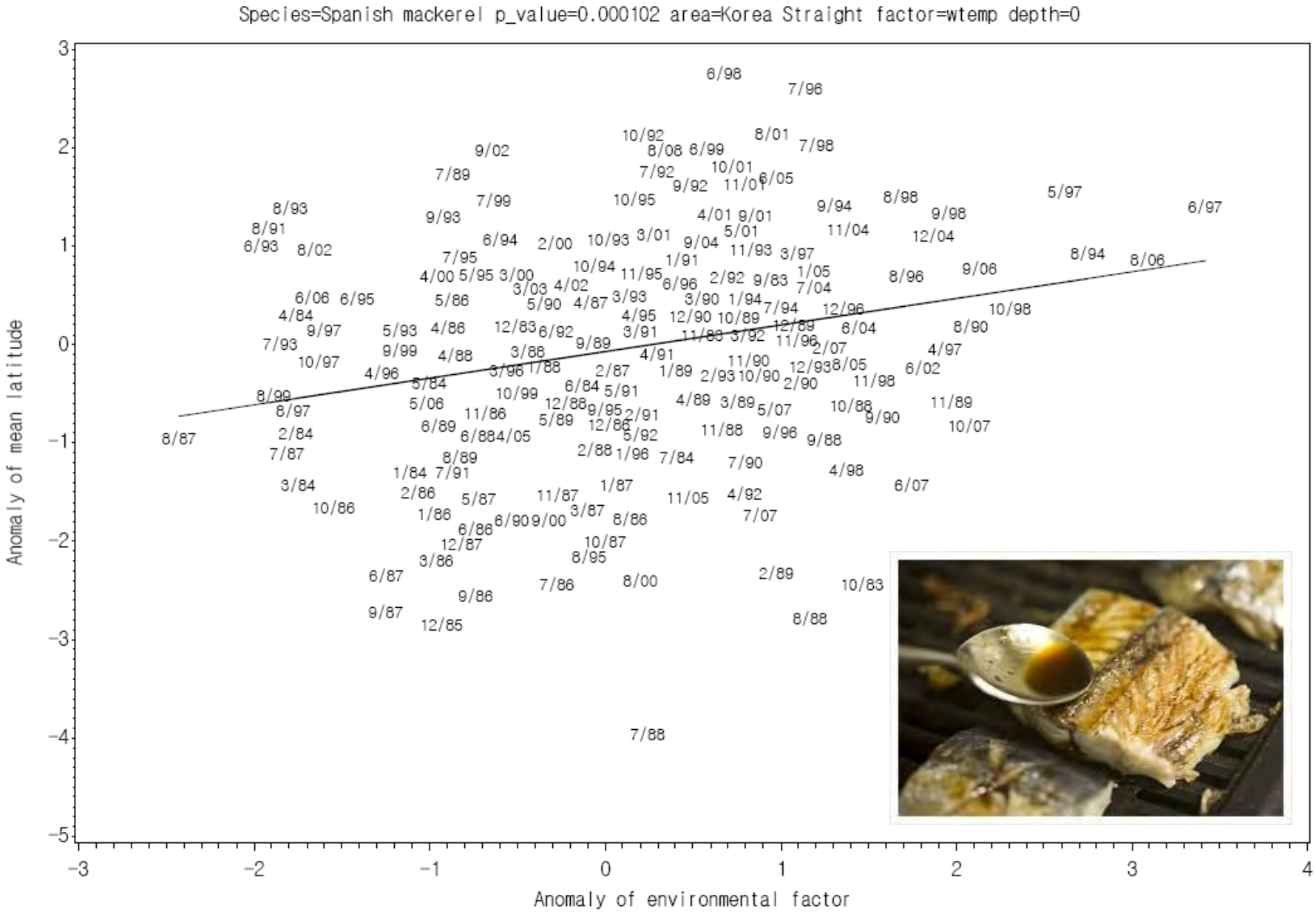




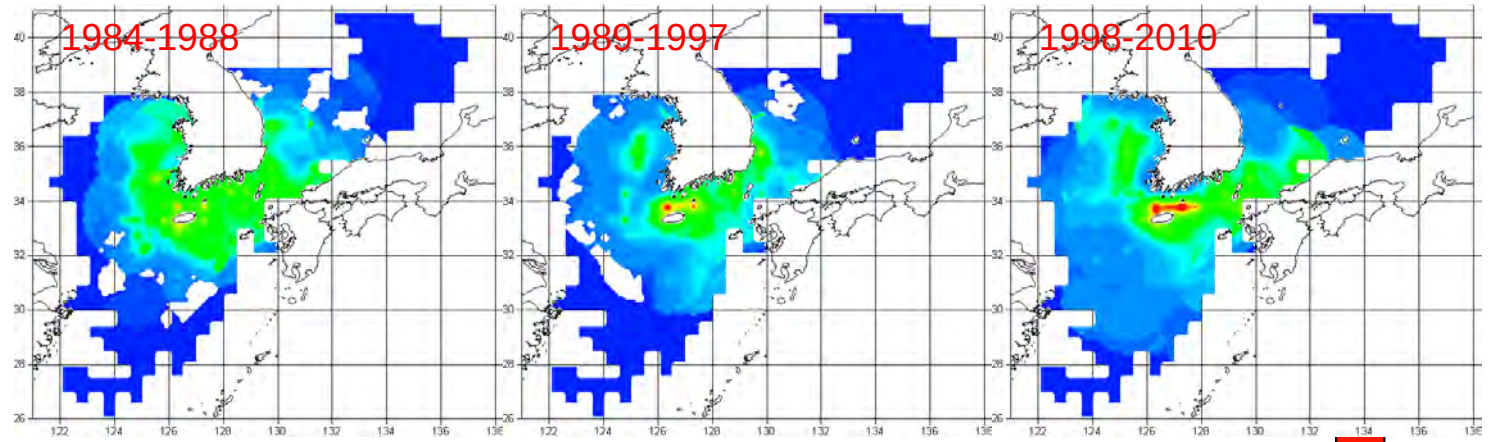
kg km^{-2}

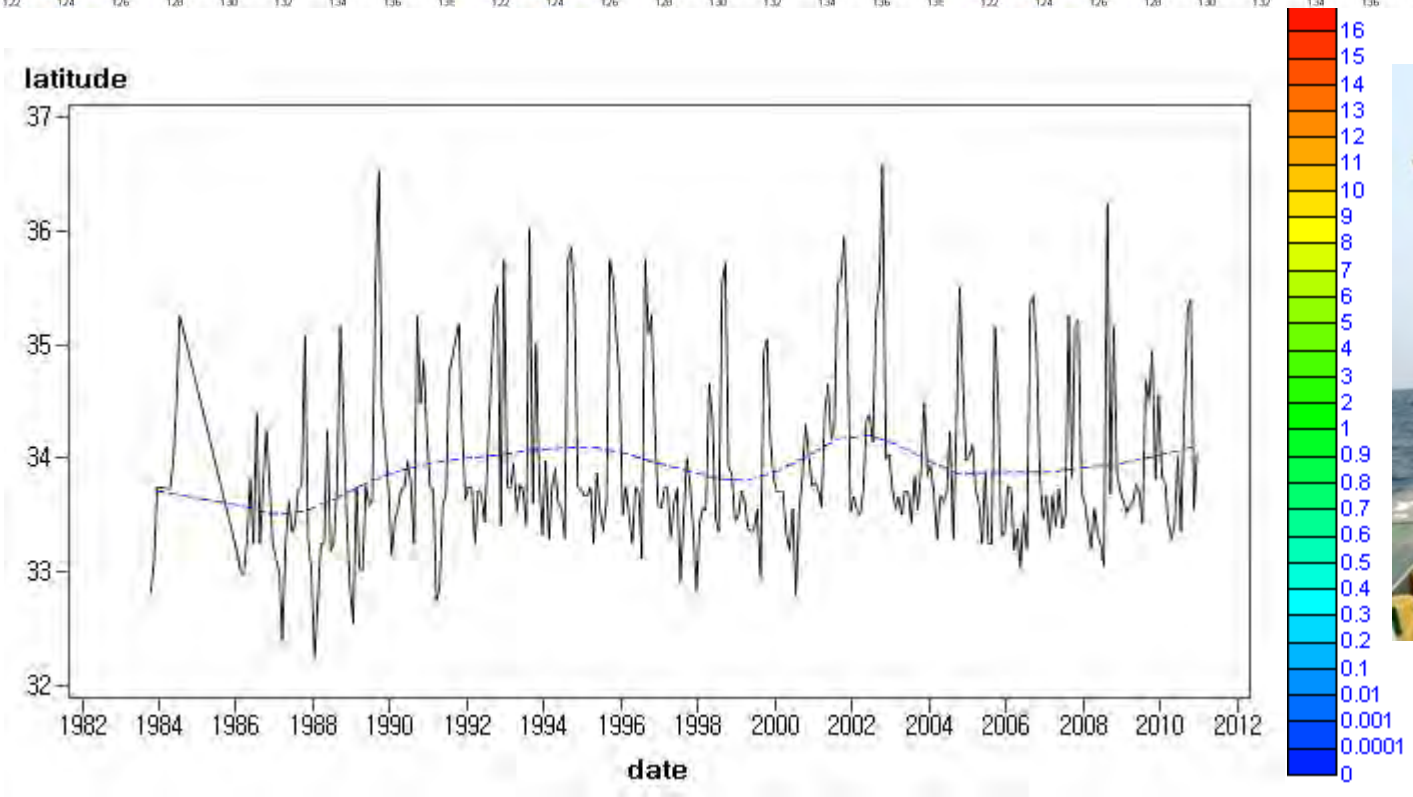


Anomaly correlation with SST of the Korea Strait



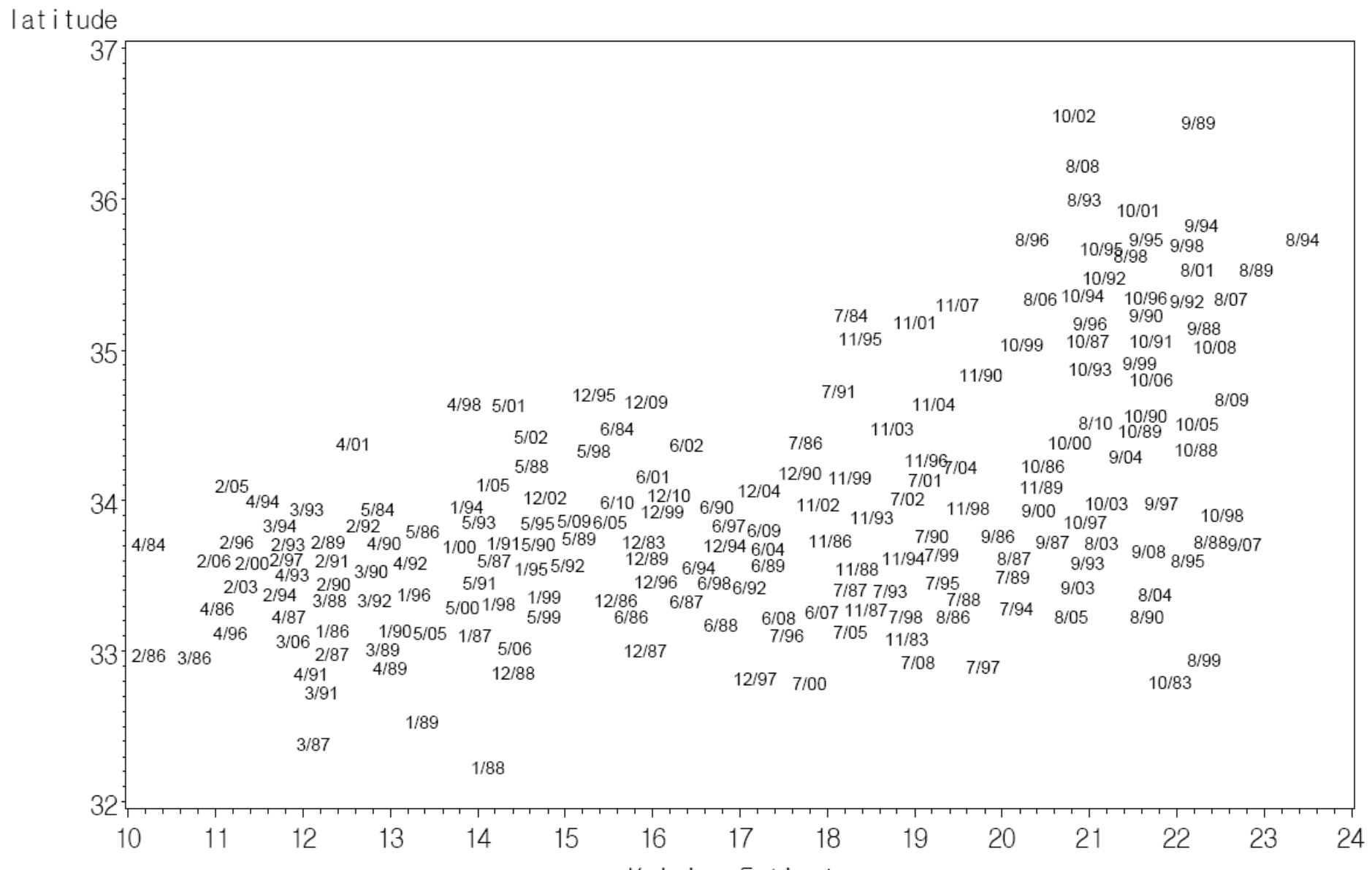
Yellow tail





kg km^{-2}

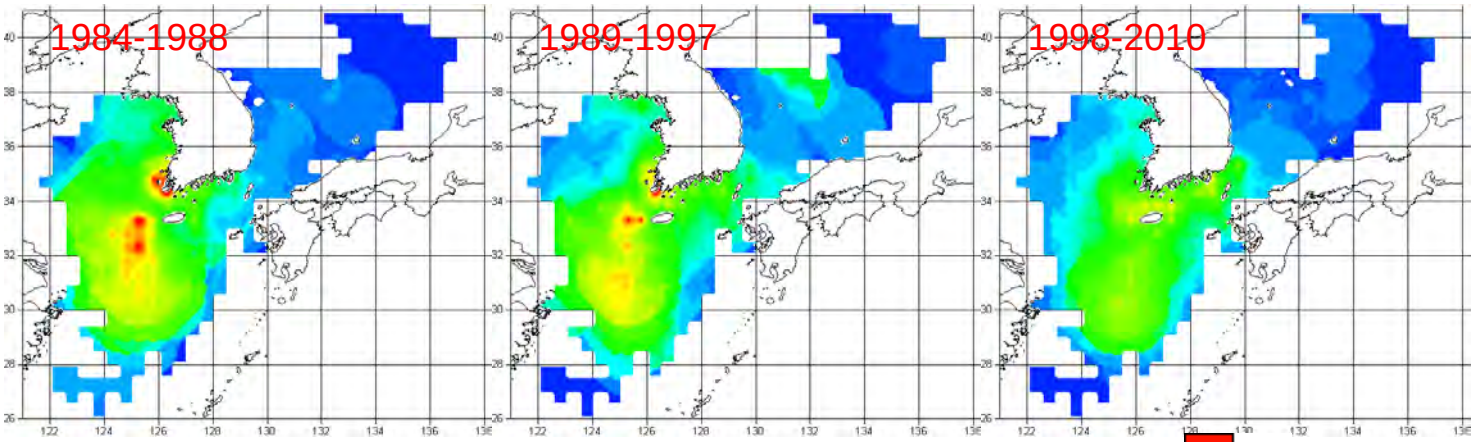
Correlation with water temperature

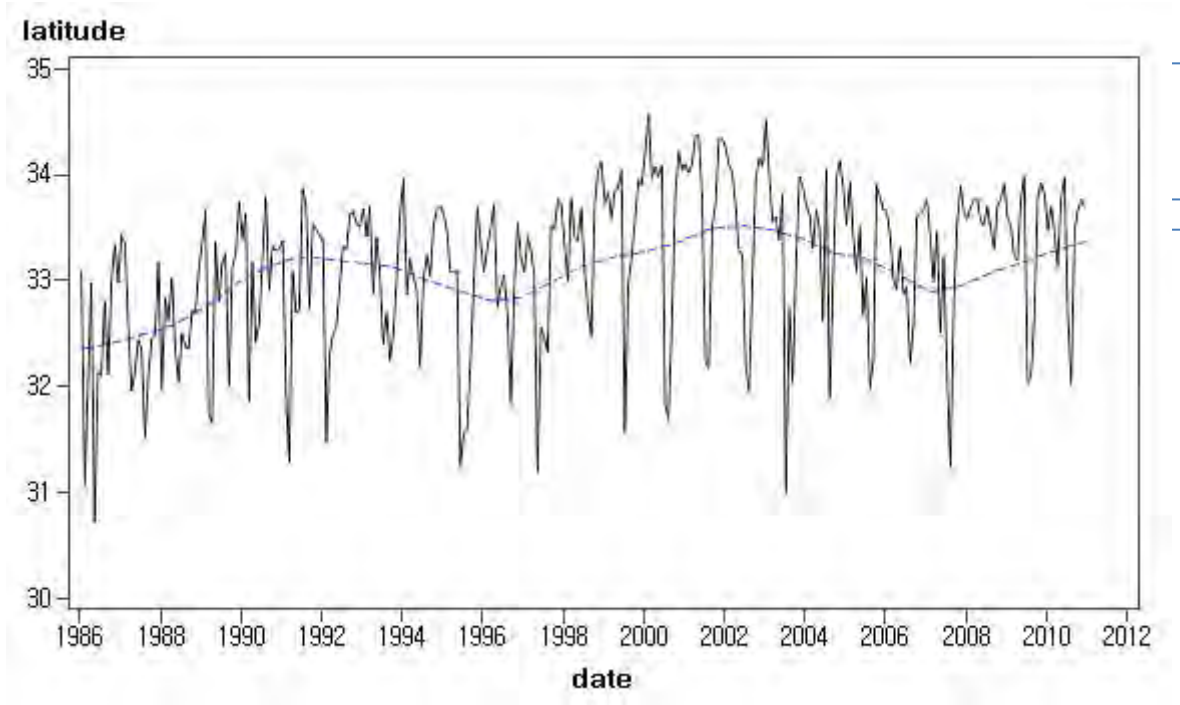


Bentho-pelagic species

- Hairtail
- Small yellow croaker
- Filefish

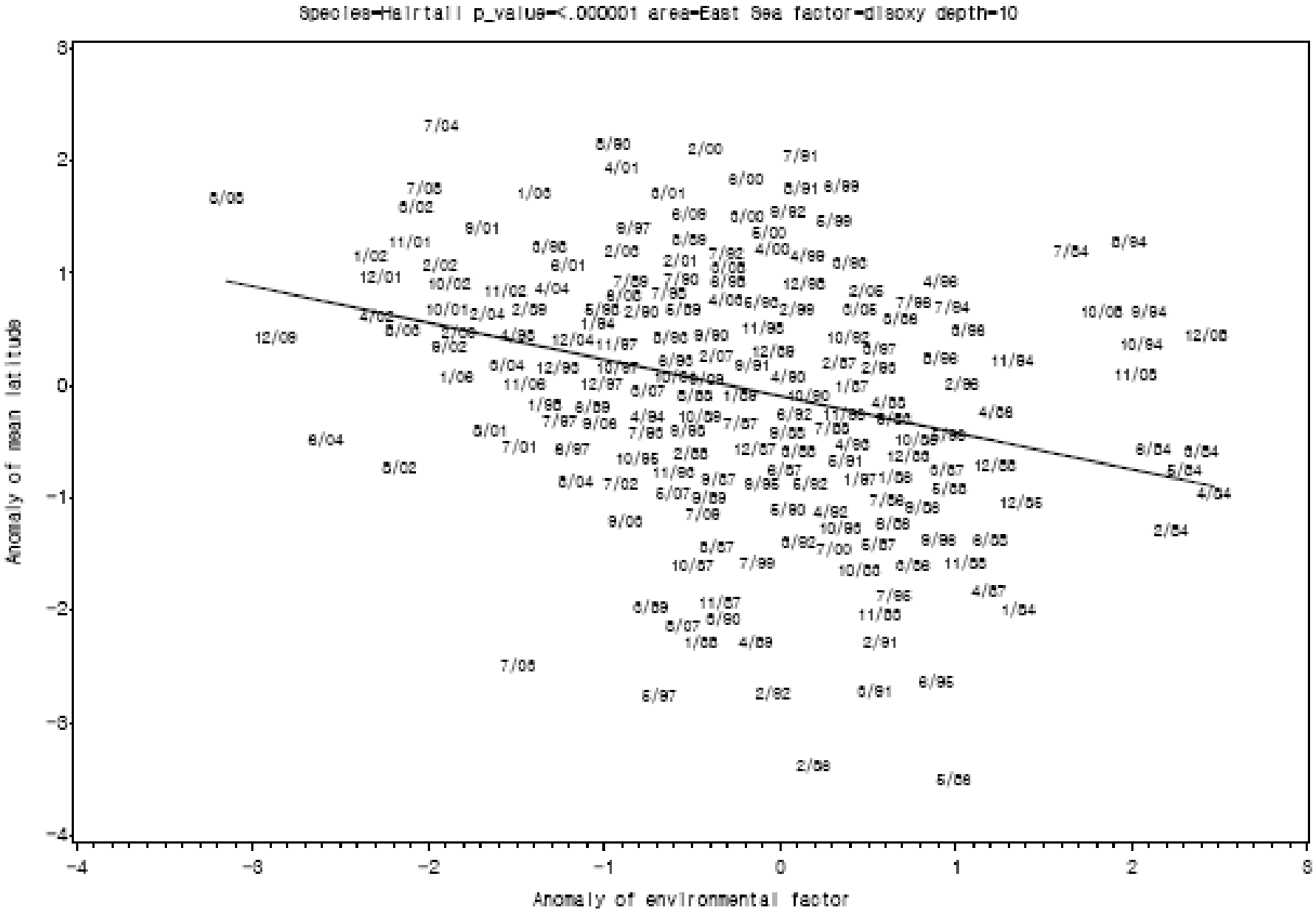
Hairtail



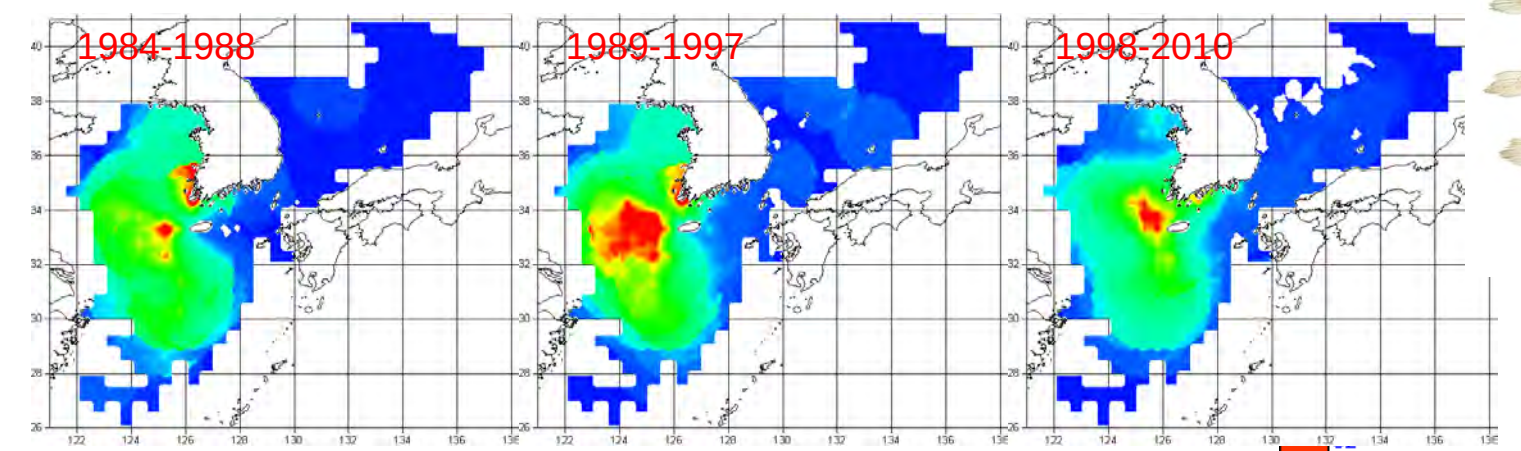


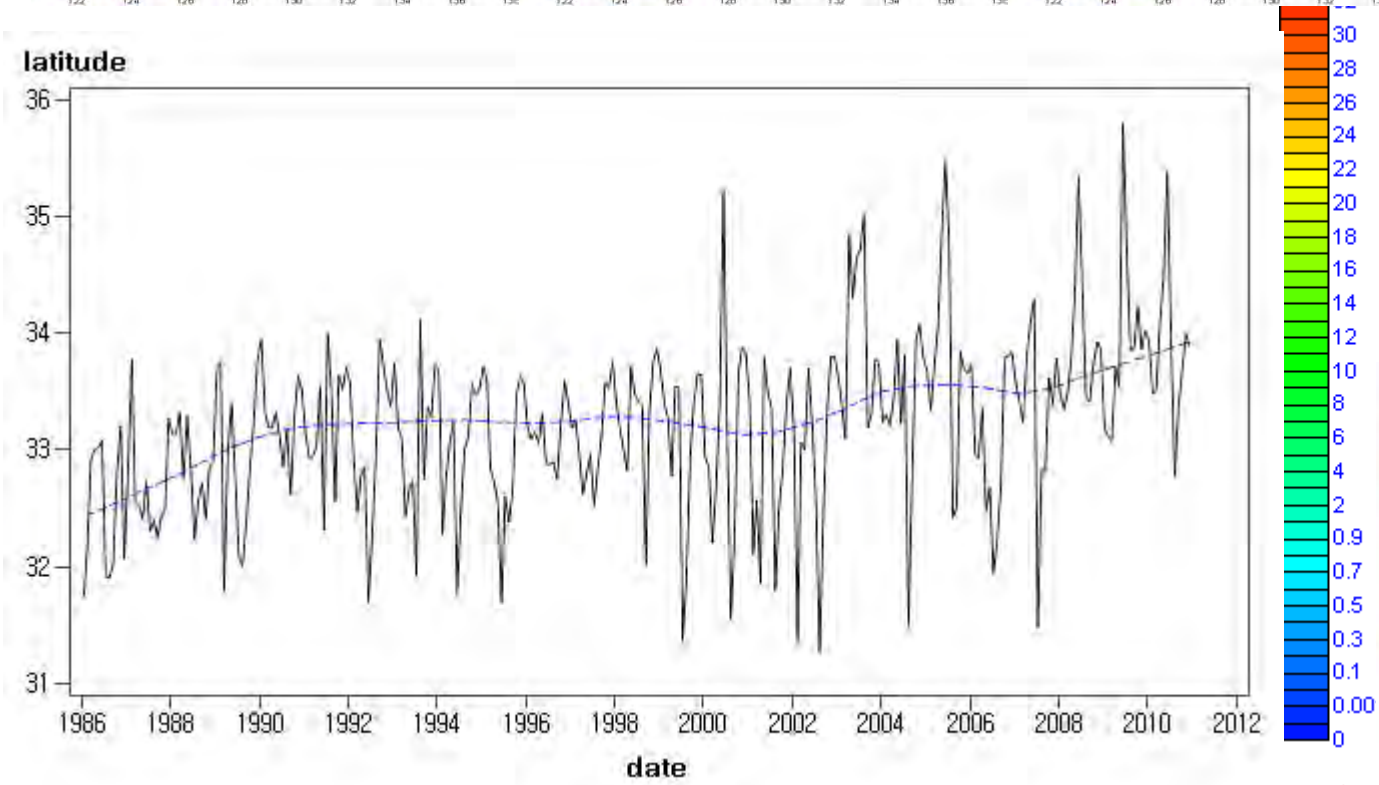
kg km^{-2}

Anomaly correlation with 10-m DO of the Japan/East Sea

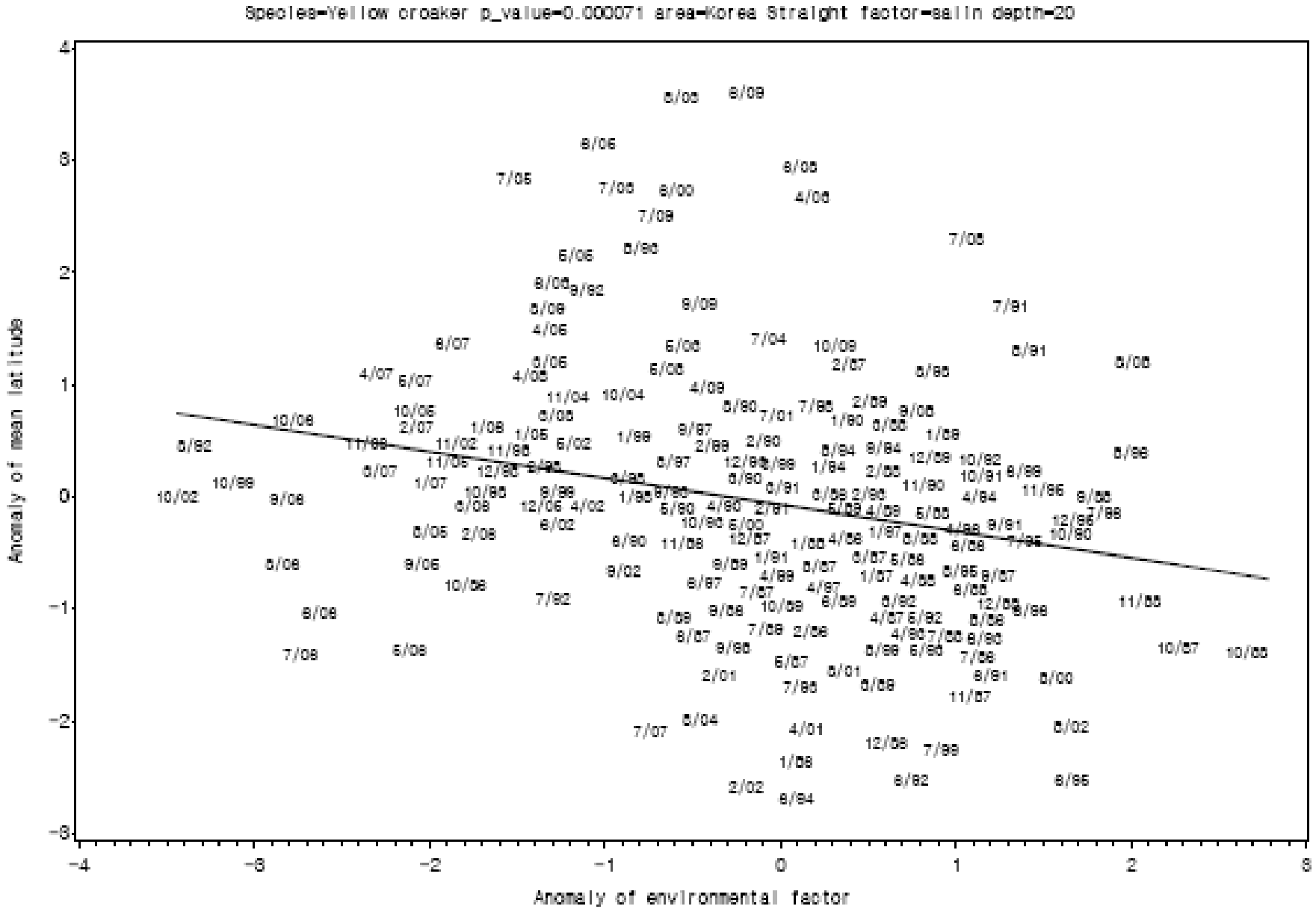


Small yellow croaker





Anomaly correlation with 20-m salinity of the Korea Strait



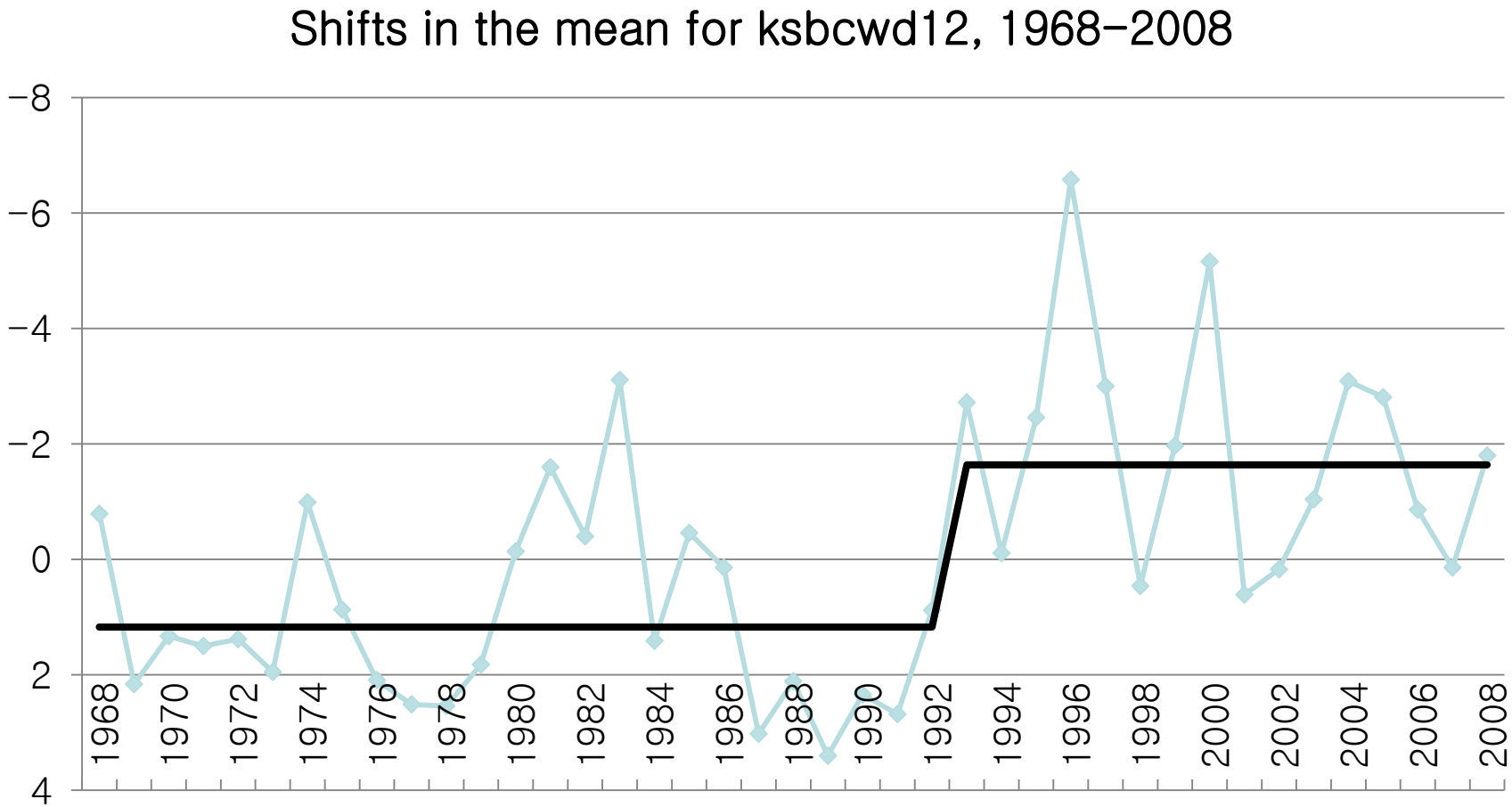
Demersal Fish

- Pacific cod
- Red horsehead

Korea Strait Bottom Cold Water in December

Estimated relative volume transport of bottom cold water from the Japan/East Sea

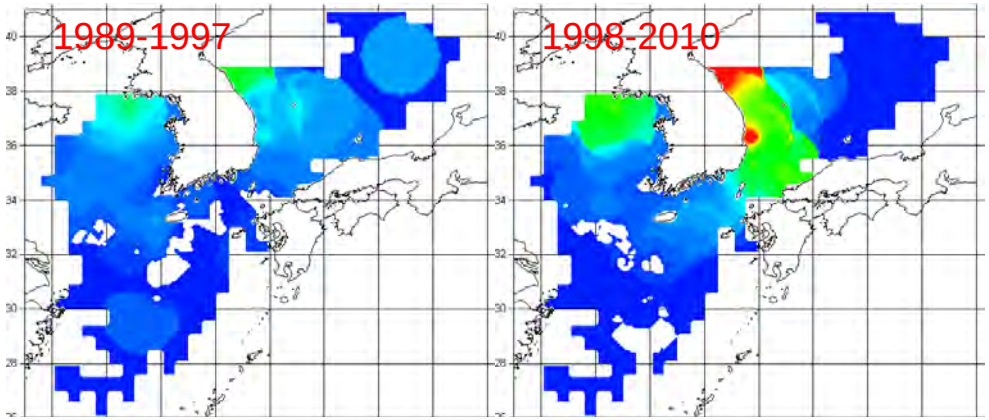
Courtesy of Hanna Na, Seoul National University

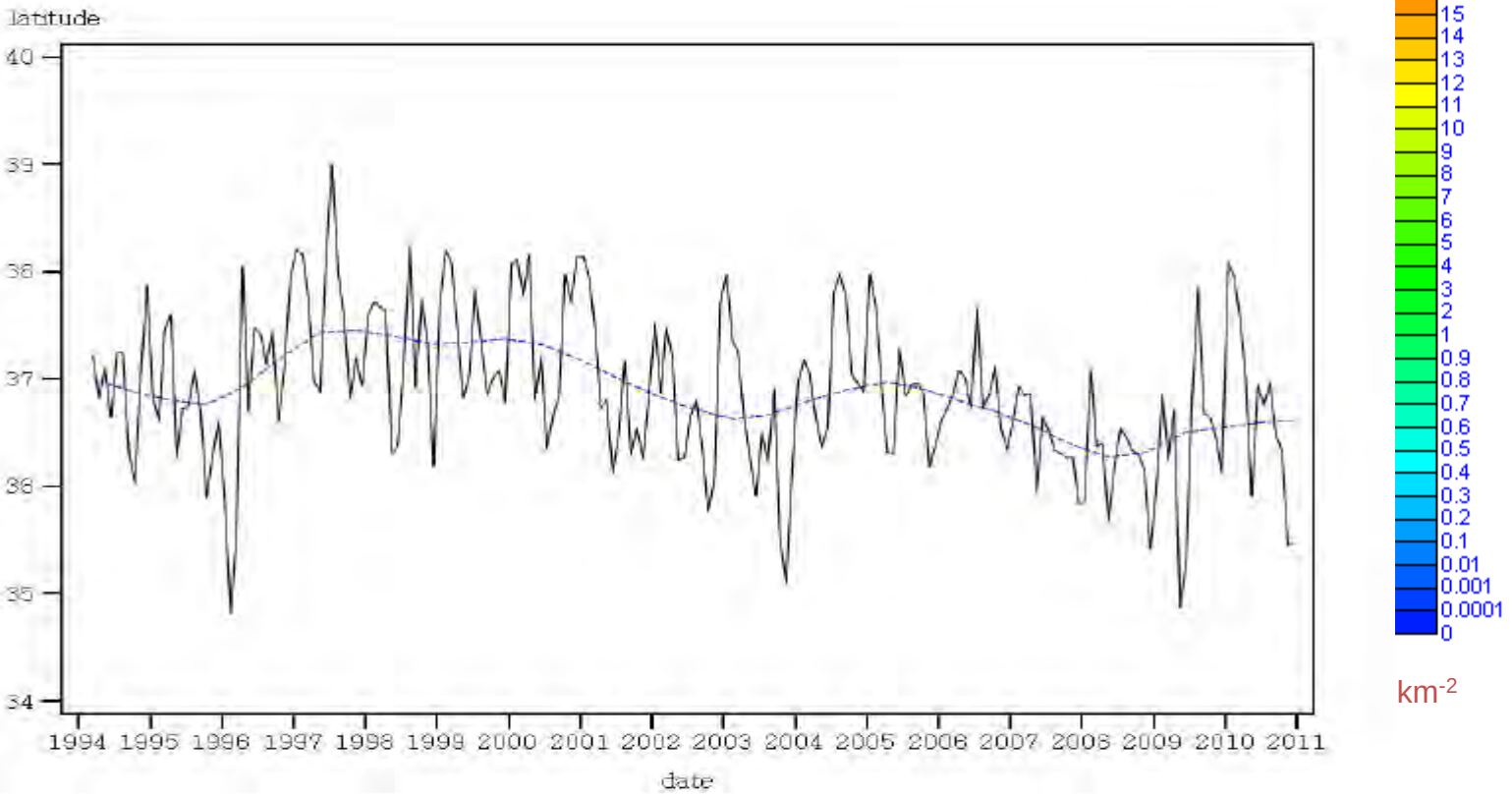


1993

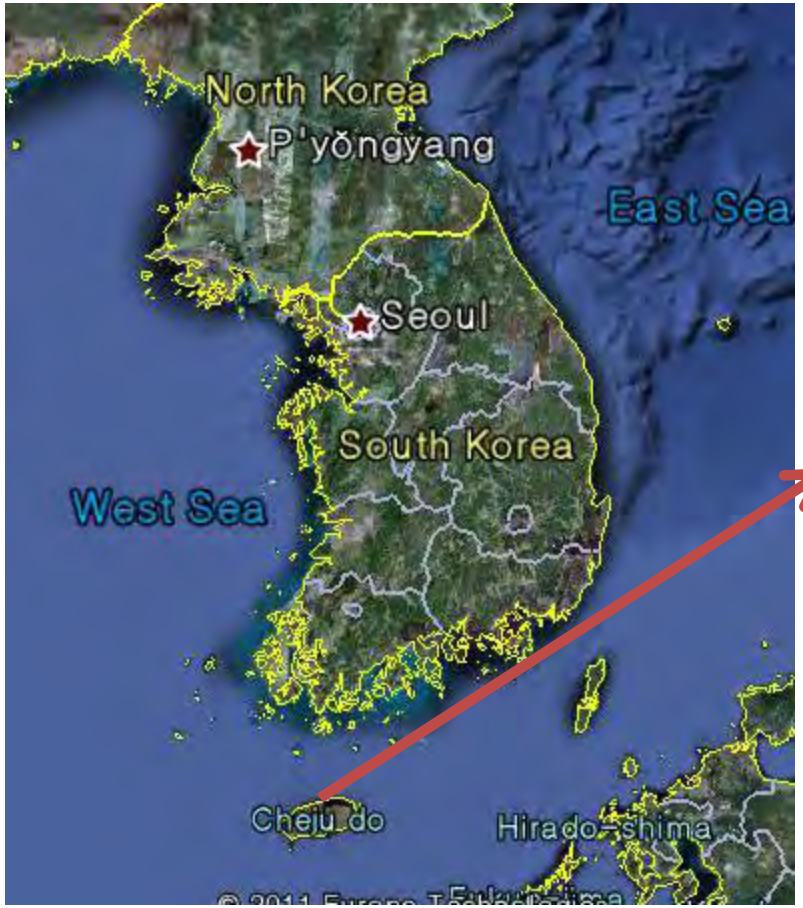
Pacific cod

Catch by set net is not included here, but cod catch has increased in the southern coastal area of Korea



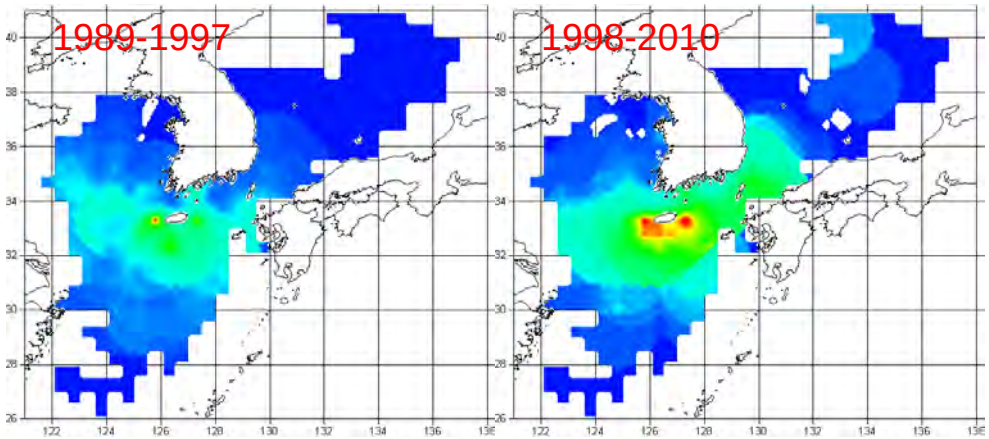


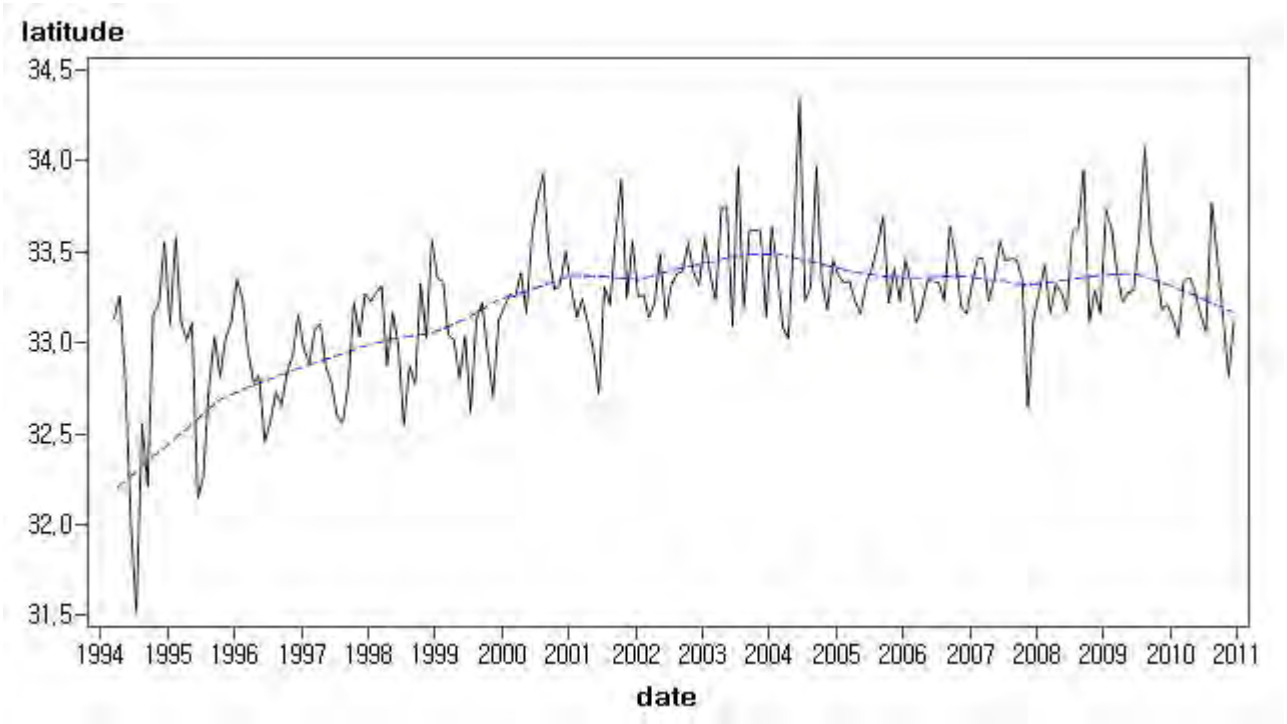
Southward Expansion of Pacific cod to Jeju Island

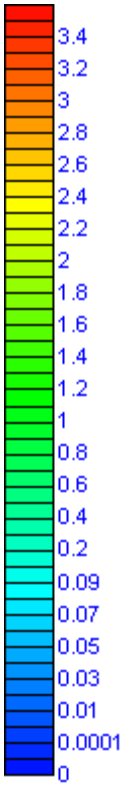


Caught on September 9, 2011
Length = 32~35 cm (2 yrs old)

Red horsehead

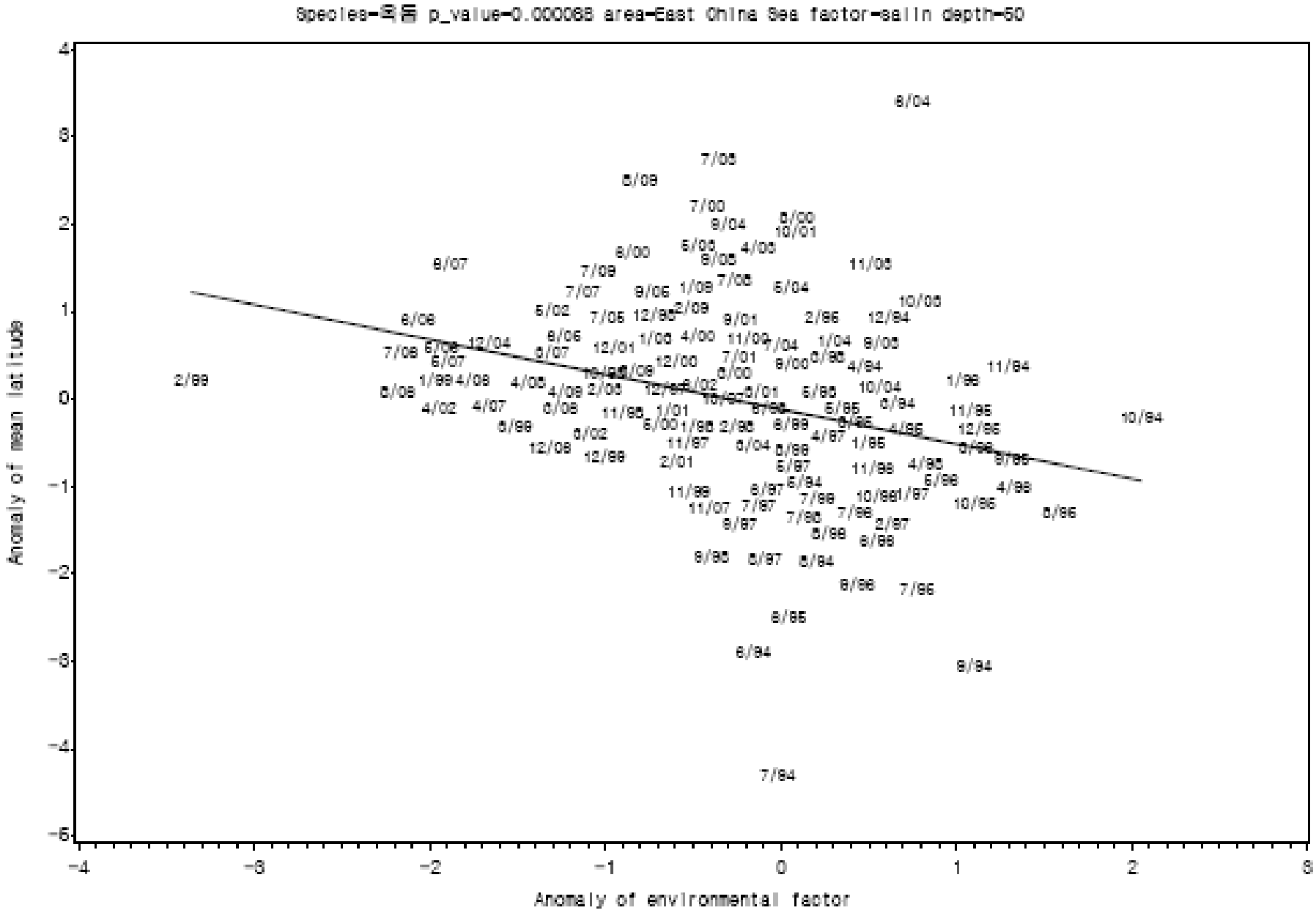




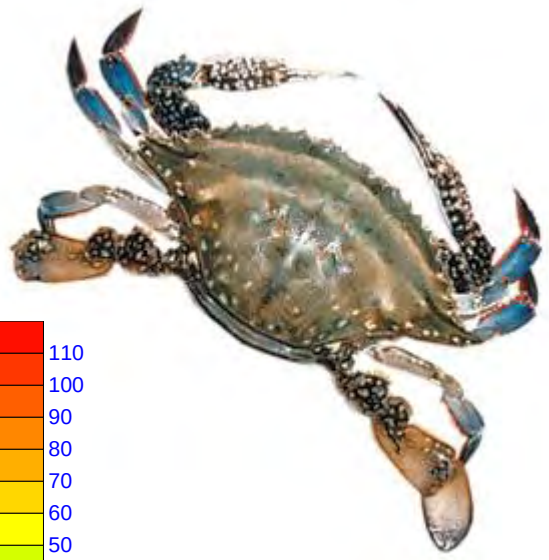


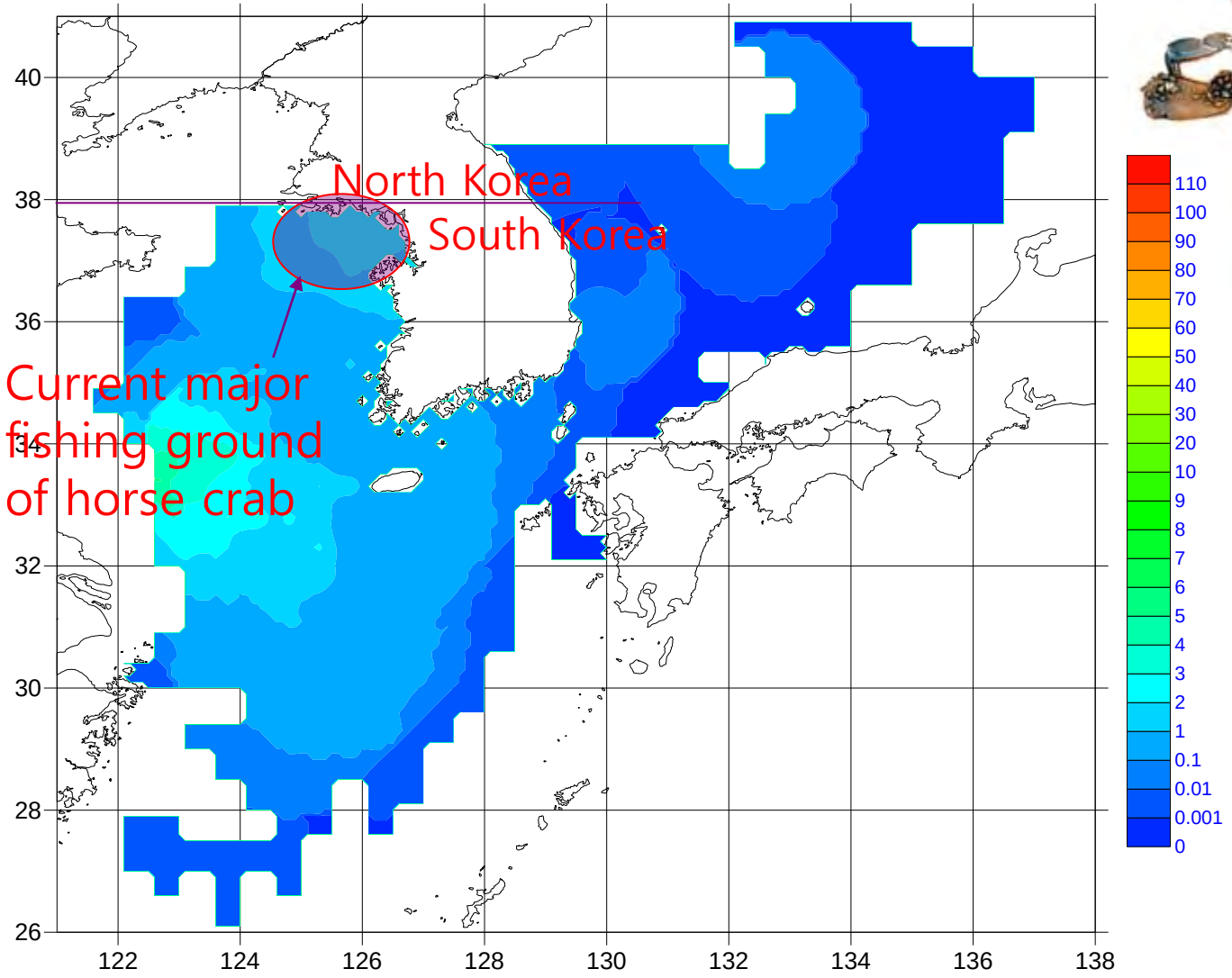
kg km^{-2}

Anomaly correlation with 50-m salinity of the East China Sea

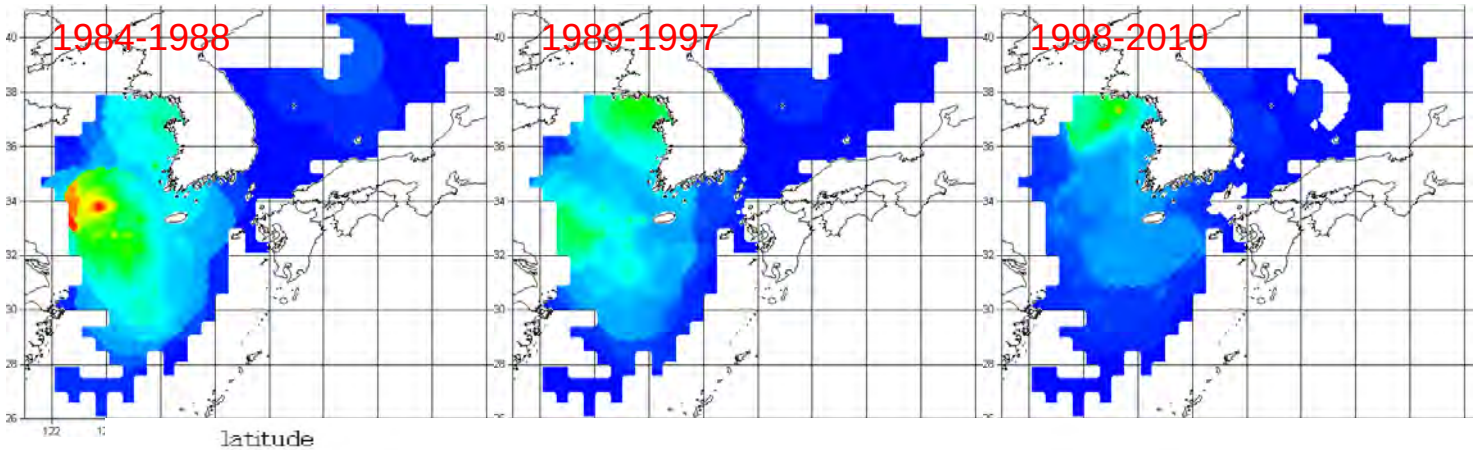


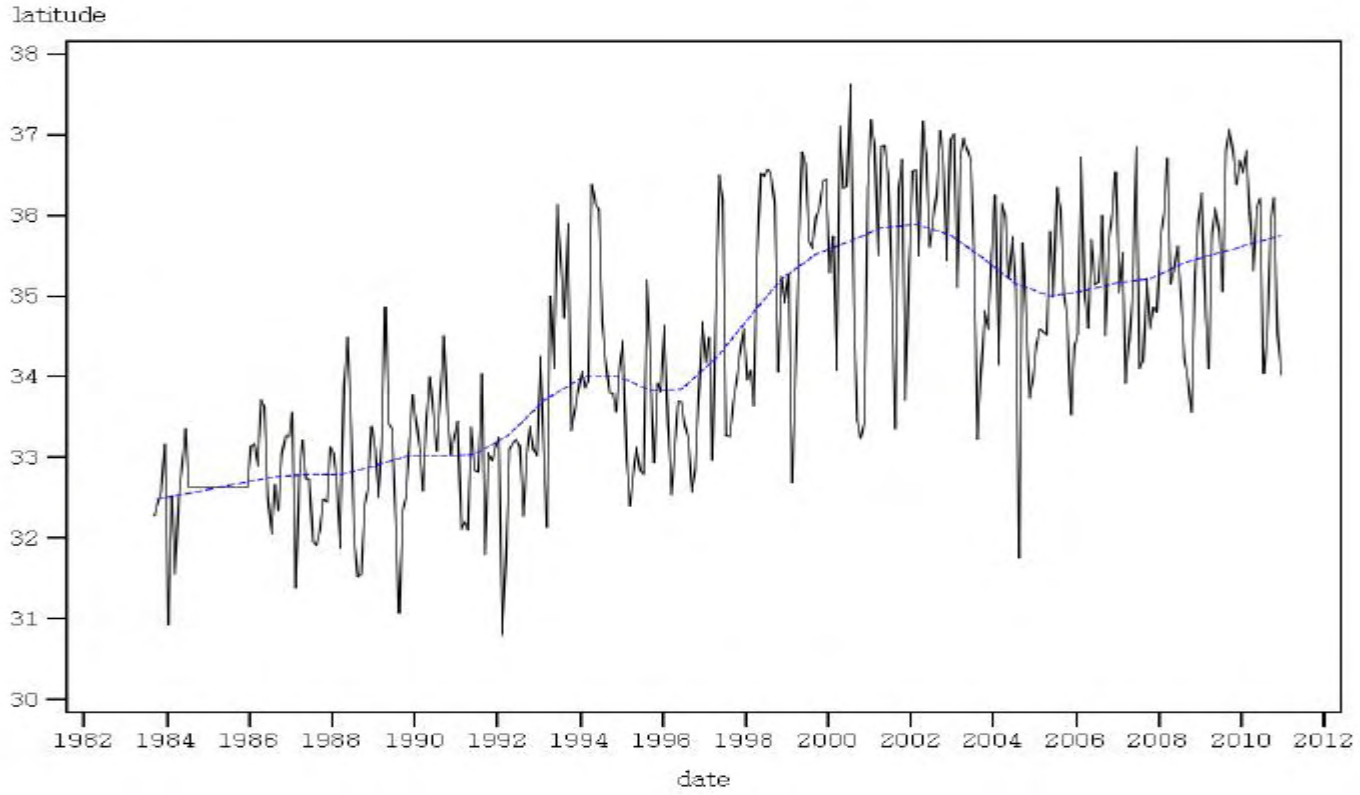
Catch of horse crab (*Portunus trituberculatus*) in South Korea, averaged for 1983-2007

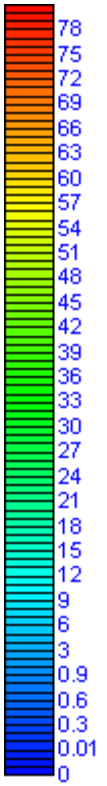




Horse crab

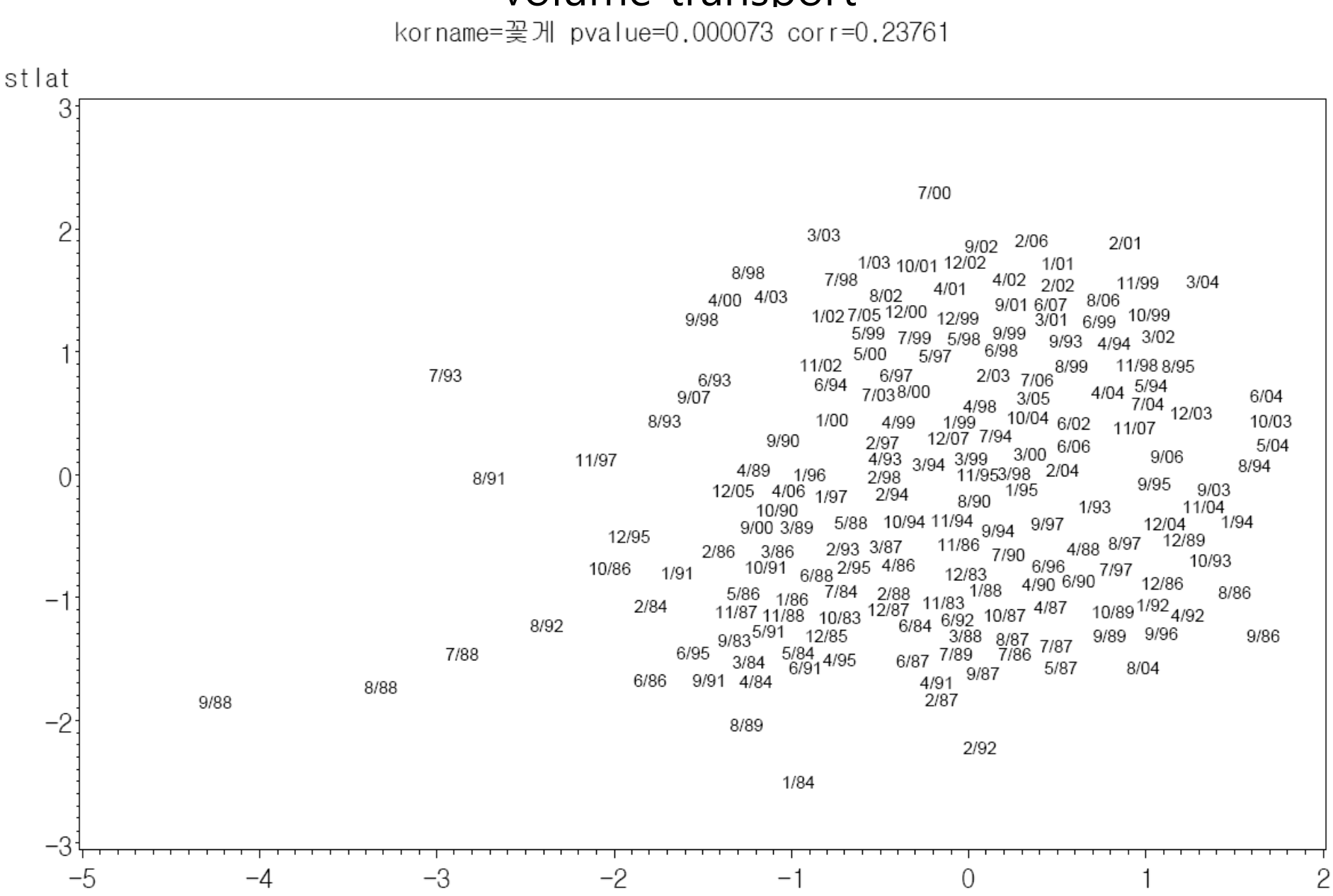






kg km^{-2}

Correlation with standardized Tsushima Warm Current volume transport



Summary of latitudinal shifts of fishes (1983-2010)

- Small pelagic species
  - Common squid, Anchovy, Horse mackerel, Chub mackerel, Herring and Sardine
  - Stationary
- Large pelagic species
  - Tuna, King mackerel, Yellowtail
  - Northward shift
- Demersal and bentho-pelagic species: inconsistent
  - Stationary: Hairtail, File fish
  - Northward: Small yellow croaker, Red horsehead
  - Southward: Pacific cod
- Blue crab: northward

Implications to fisheries management adapting to climate change (tentative)

- **Small pelagic species**
  - Despite greater decadal variability in recruitment, they seem to be resilient to climate change.
  - Significant changes in habitat range are unlikely.
  - Minimize fisheries regulations (e.g., sardine)
- **Large pelagic species**
  - Ranges are sensitive to climate change
  - Long-term plans need to be developed to adapt related fisheries to climate change and global warming (e.g., vessels equipped with freezers)

Implications 2

Artisanal vs. Industrial fisheries

- **Demersal/bentho-pelagic species**
  - Trends of shift are inconsistent among species.
  - Both artisanal and industrialized fisheries exploit these species.
    - Artisanal fisheries are the major provider of hairtail (ca. 300 million USD in 2010)
    - Industrialized fisheries are the major provider of yellow croaker (ca. 250 million USD in 2011)
  - Artisanal fisheries will be less competitive in adapting to range shifts of their target species

Future work

- Inclusion of socio-economic factors
  - Gear type
  - Fishing effort
  - Competition with Chinese fishermen
  - Fishing regulation
- Reliable estimates of volume transports by the Tsushima Warm Current and the Korea Strait Cold Bottom Water
- Bio-physical coupling individual-based model (S7, Sunday)

Acknowledgement

MIFAFF-NFRDI

- Program titled “consequences and countermeasures for the effects of climate change on marine ecosystems and fisheries resources”.

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Ministry for Food, Agriculture, Forestry and Fisheries

NFRDI
National Fisheries Research & Development Institute

APN
Asia-Pacific Network for Global Change Research

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