Photo: 2013, Hiroshi Seno

Spatio-temporal distribution of Albacore *Thunnus alalunga* and its relationship with environmental changes in the Pacific Ocean

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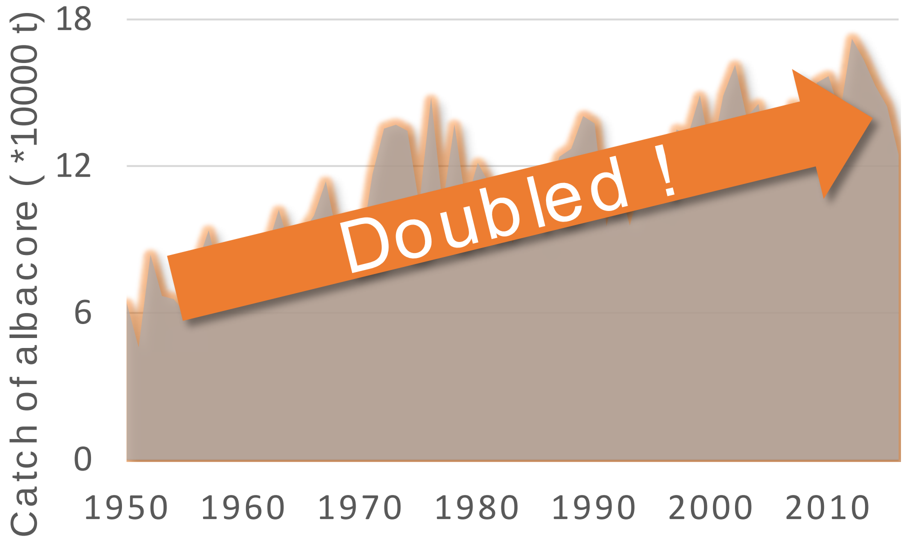
Introduction

Albacore tuna (*Thunnus alalunga*)

120 cm



Time series of albacore catch in the Pacific

From FAO Statistics

Albacore tuna

- Catch in the Pacific Ocean has almost doubled in the past 60 years
- Compared with most other tuna species, albacore is relatively slow growing, late maturing and has an extended life span, which makes it vulnerable to overexploitation

Appropriate management plans are essential for sustainable use of this food resource

Introduction

Photo: 2013, Hiroshi Seno

Albacore tuna (*Thunnus alalunga*)

← 120 cm →

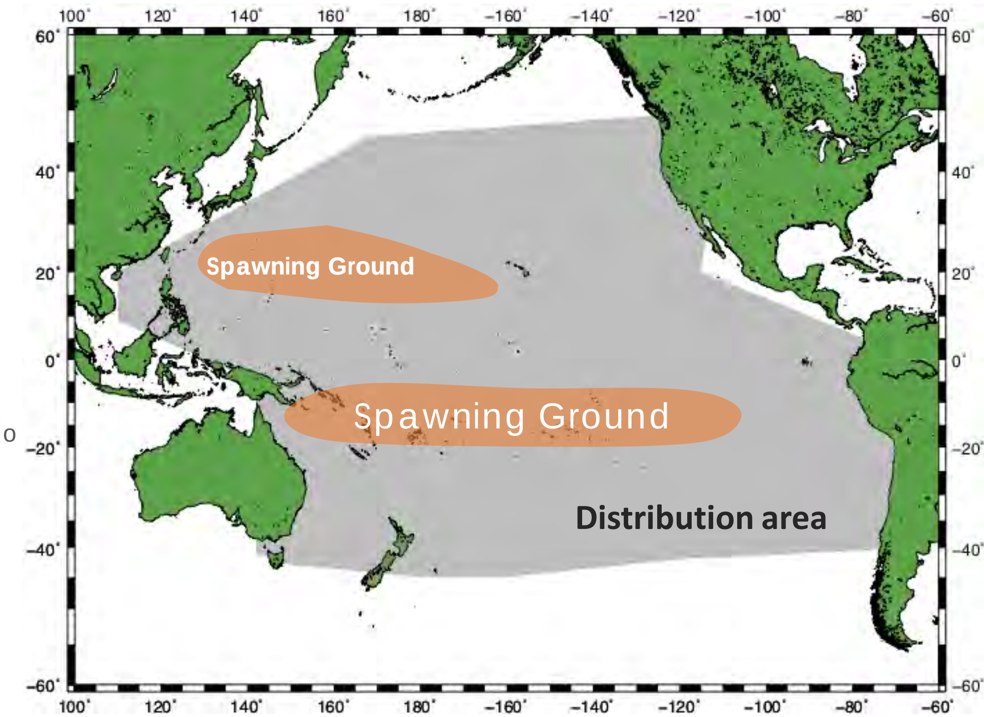
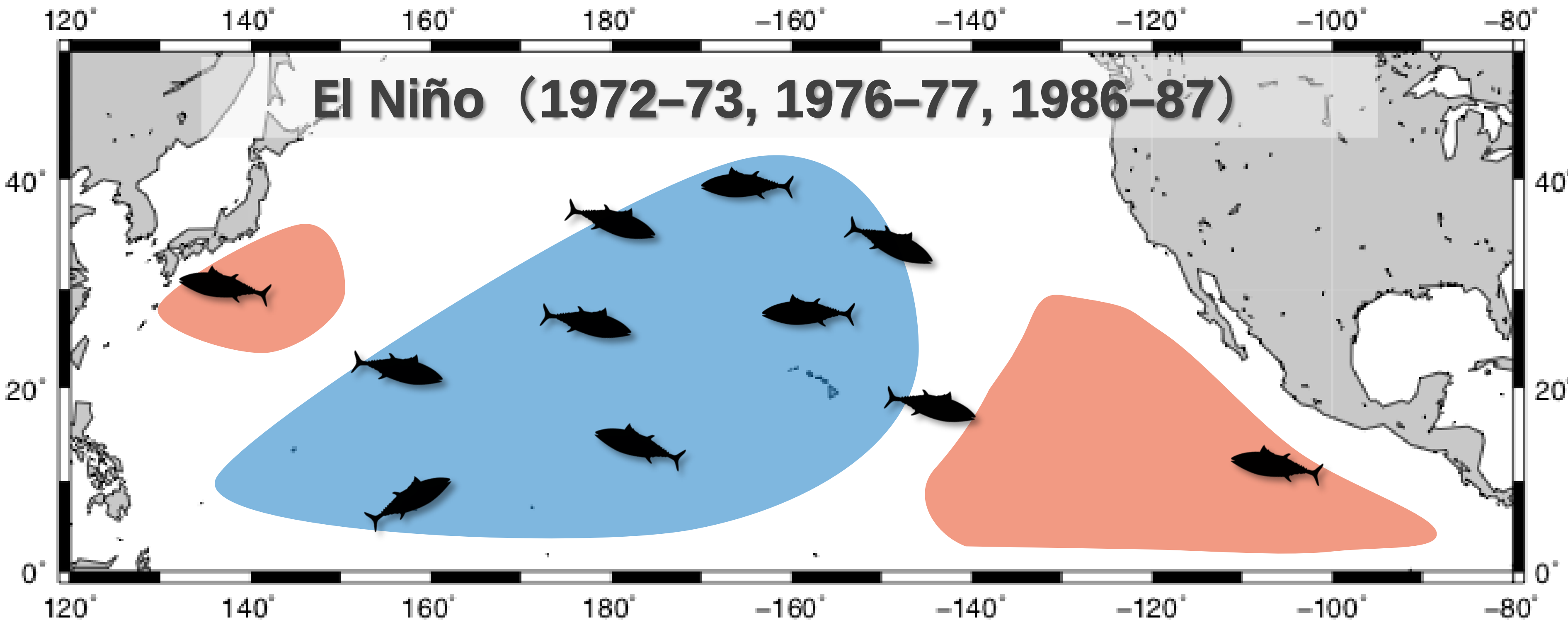


Fig. Distribution and spawning area of Albacore in the Pacific Ocean
Based on FRA 「国際水産資源の現況」

Albacore tuna in the Pacific

- A wide distribution range from 45°S to 50°N
- There exists two stocks — the North Pacific stock and the South Pacific stock
- They feed on Sardine primarily

Introduction



Kimura *et al.* (1997)

Previous study

ENSO events affected the distribution of Albacore tuna in the North Pacific

Introduction

Clarifying the variation of Albacore distribution and its relation to environmental changes are essential for establishing appropriate fishery management plans

However, there has been little research on relationships between distribution of Albacore and global environmental changes in the Pacific

This study aims to

investigate long-term spatio-temporal distribution of Albacore and its relation to environmental changes

Materials and Methods

Fishery data set

source: Japan Fisheries Research and Education Agency (FRA)

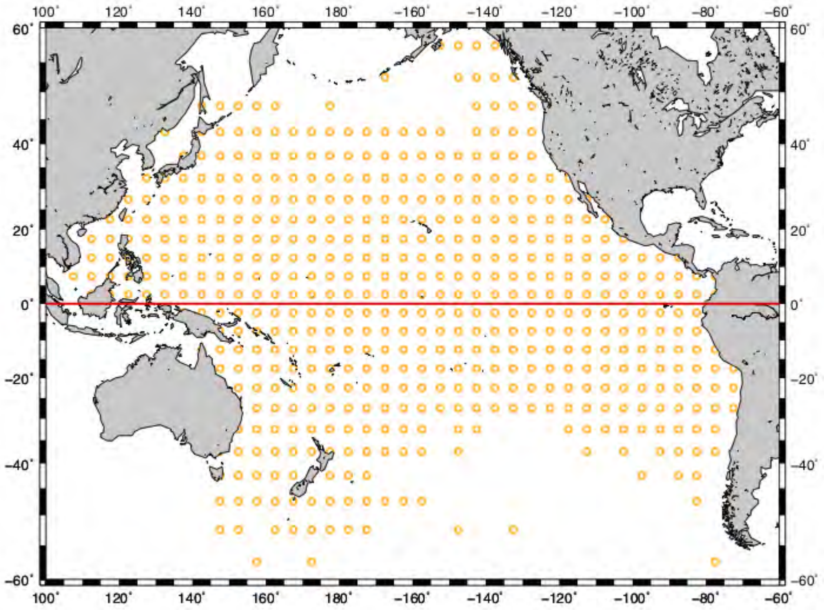


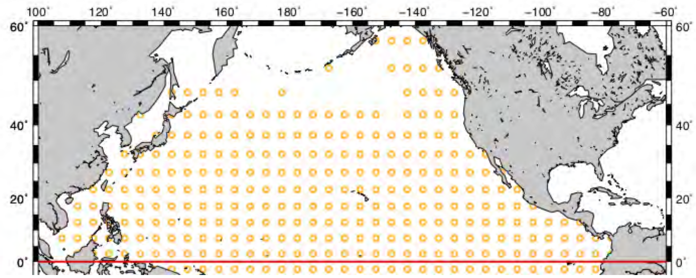
Fig. Grid cells in our data set

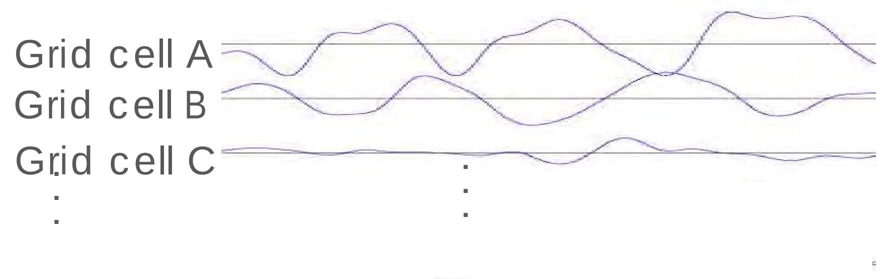
- ✓ Longline fishing data included albacore catch number per unit effort (CPUE; per 1000 hooks)
- ✓ Grid : 5° * 5° resolution (527 grid cells)
- ✓ Terms : 1971–2013 (43 years)
- ✓ We focused on mature albacore of the North Pacific Stock

Materials and Methods

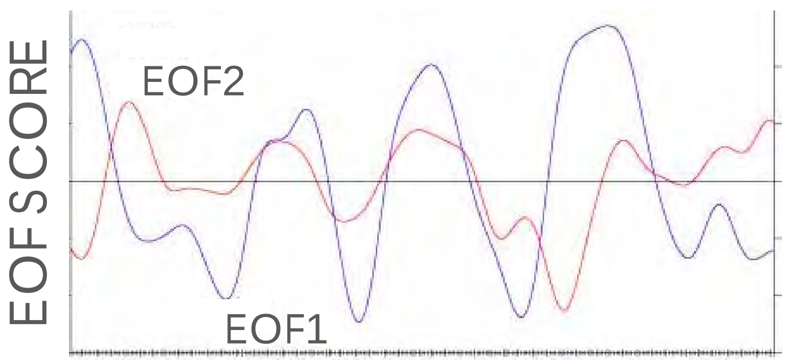
Each time series data of multiple grid cells precludes our understanding of characteristics of the data set

So complicated !!





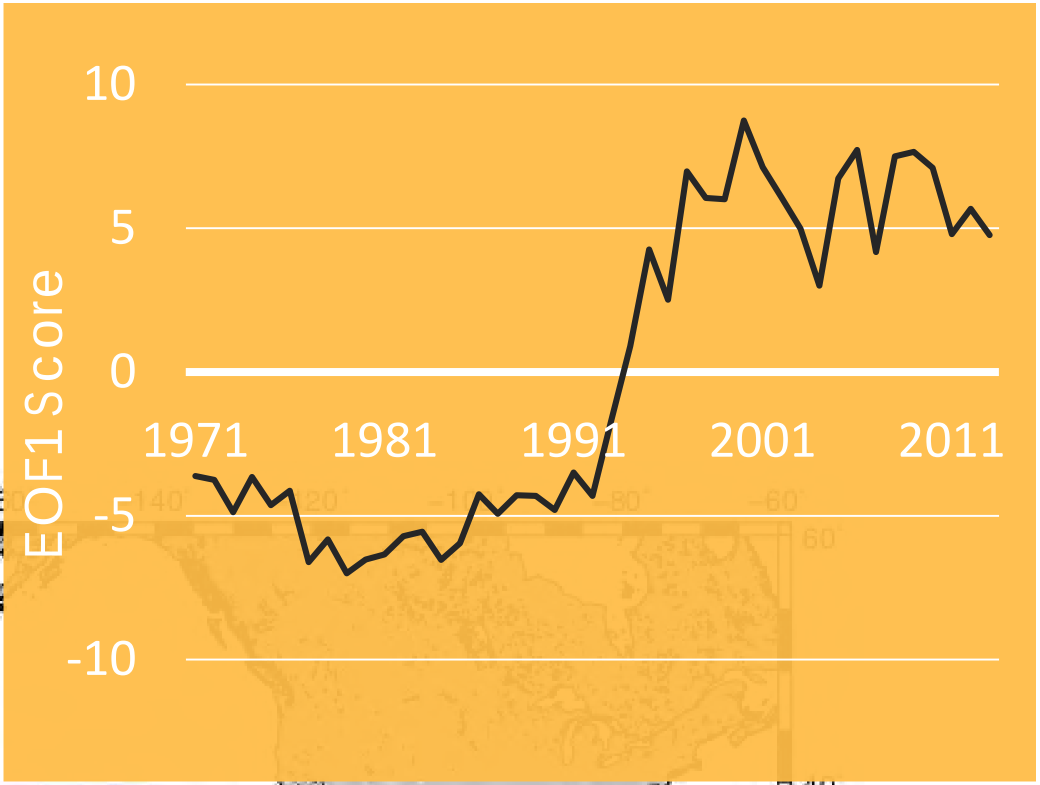
EOF Analysis (PCA)

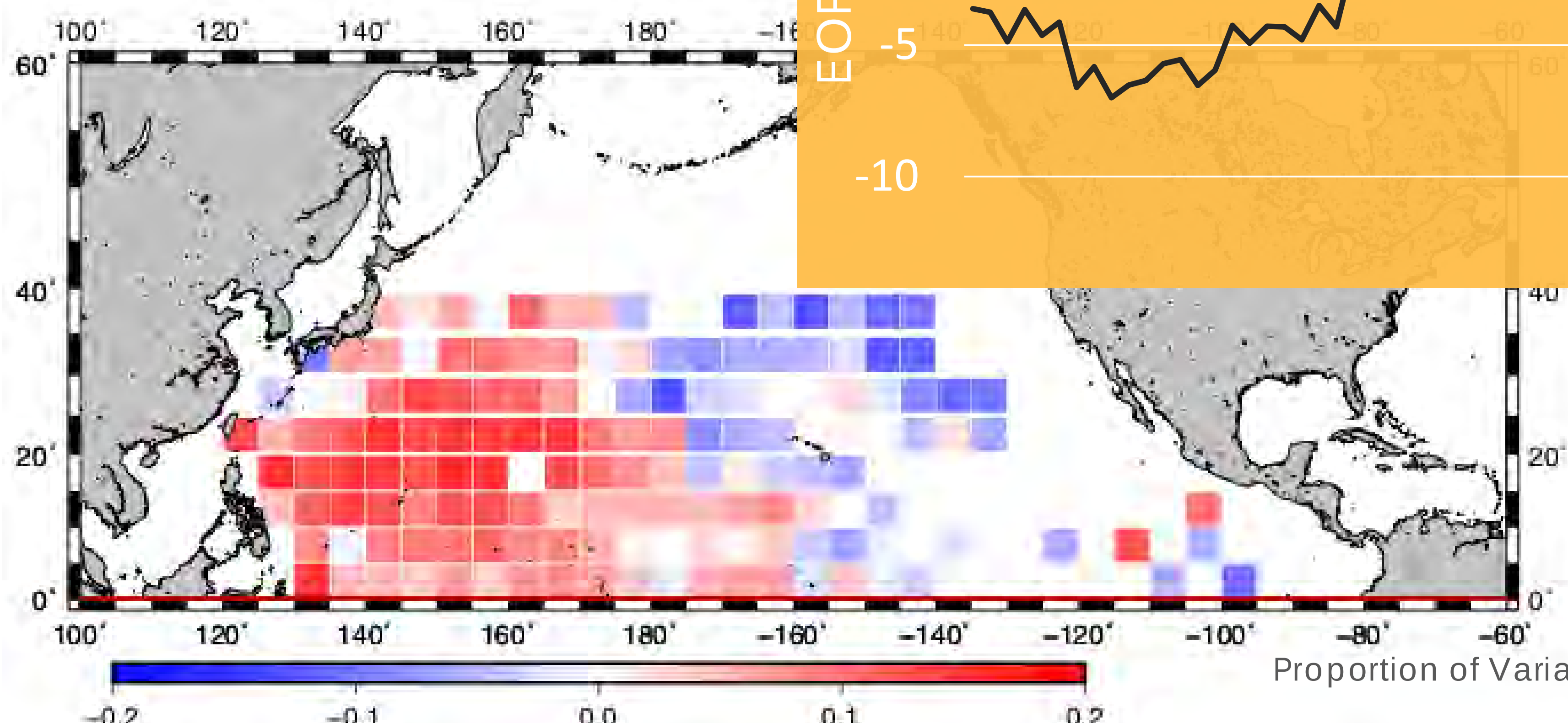


- ✓ A technique used to bring out strong patterns (EOF1, EOF2, ・・・) in a data set and to visualize the given data
- ✓ We acquired a time function termed as EOF SCORE

Result and Discussion – EOF1

EOF1





Proportion of Variance: 20.6%

Result and Discussion – EOF1

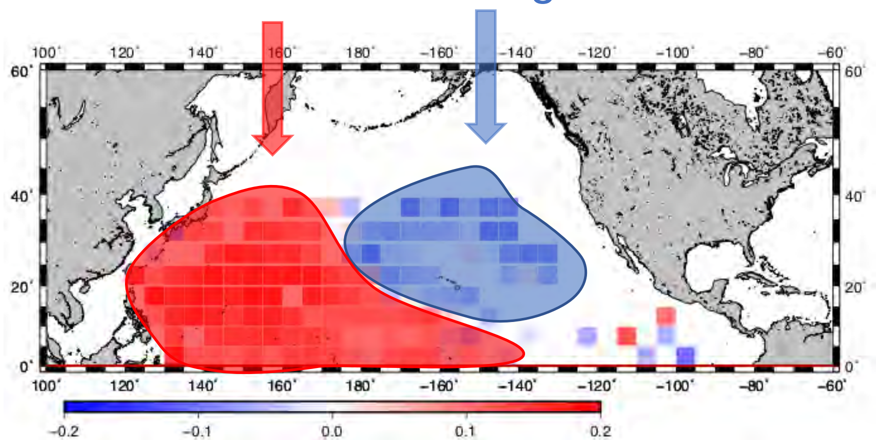
EOF analysis

How to calculate EOF Score

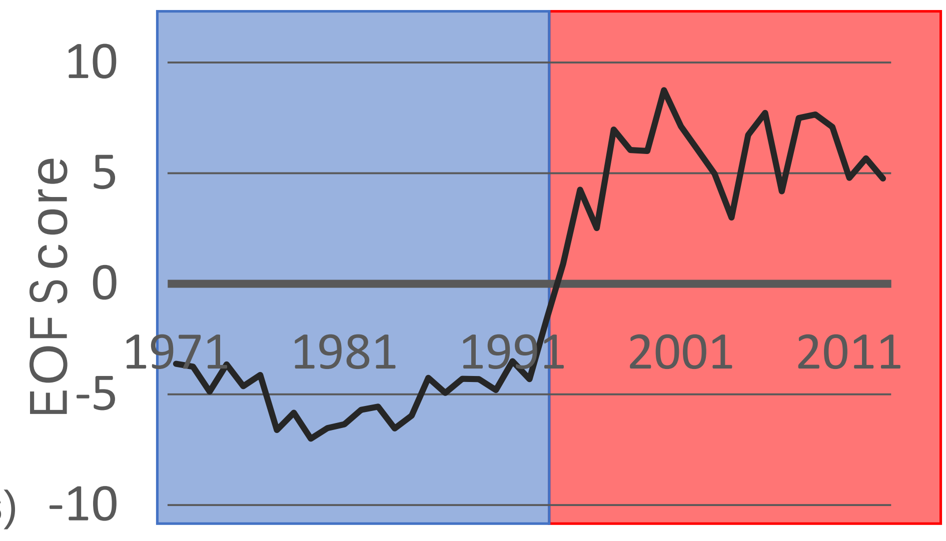
$$\text{EOF Score}_{1971} = \text{CPUE}_{1971\cdot1}{*}\text{EV}_1 + \text{CPUE}_{1971\cdot2}{*}\text{EV}_2 + \cdot\cdot\cdot + \text{CPUE}_{1971\cdot572}{*}\text{EV}_{527}$$

Evx ; EigenVectors of grid X, $\text{CPUE}_{y\cdot x}$; CPUE of grid X in year y

Positive Coefficients Negative Coefficients

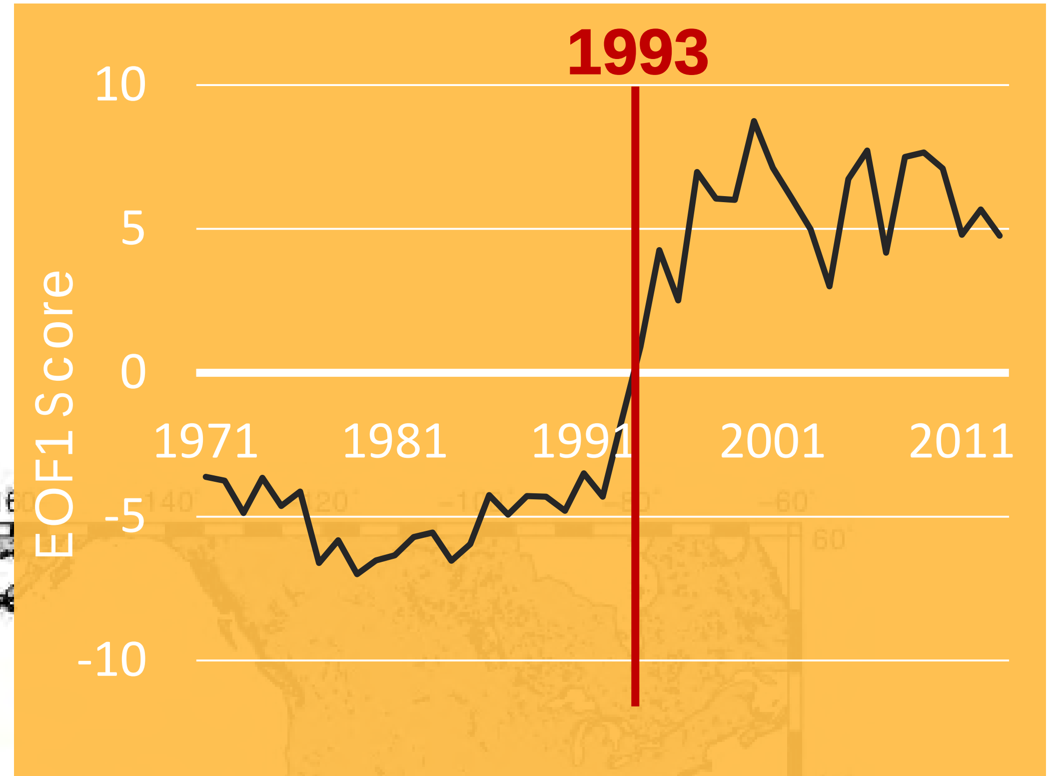


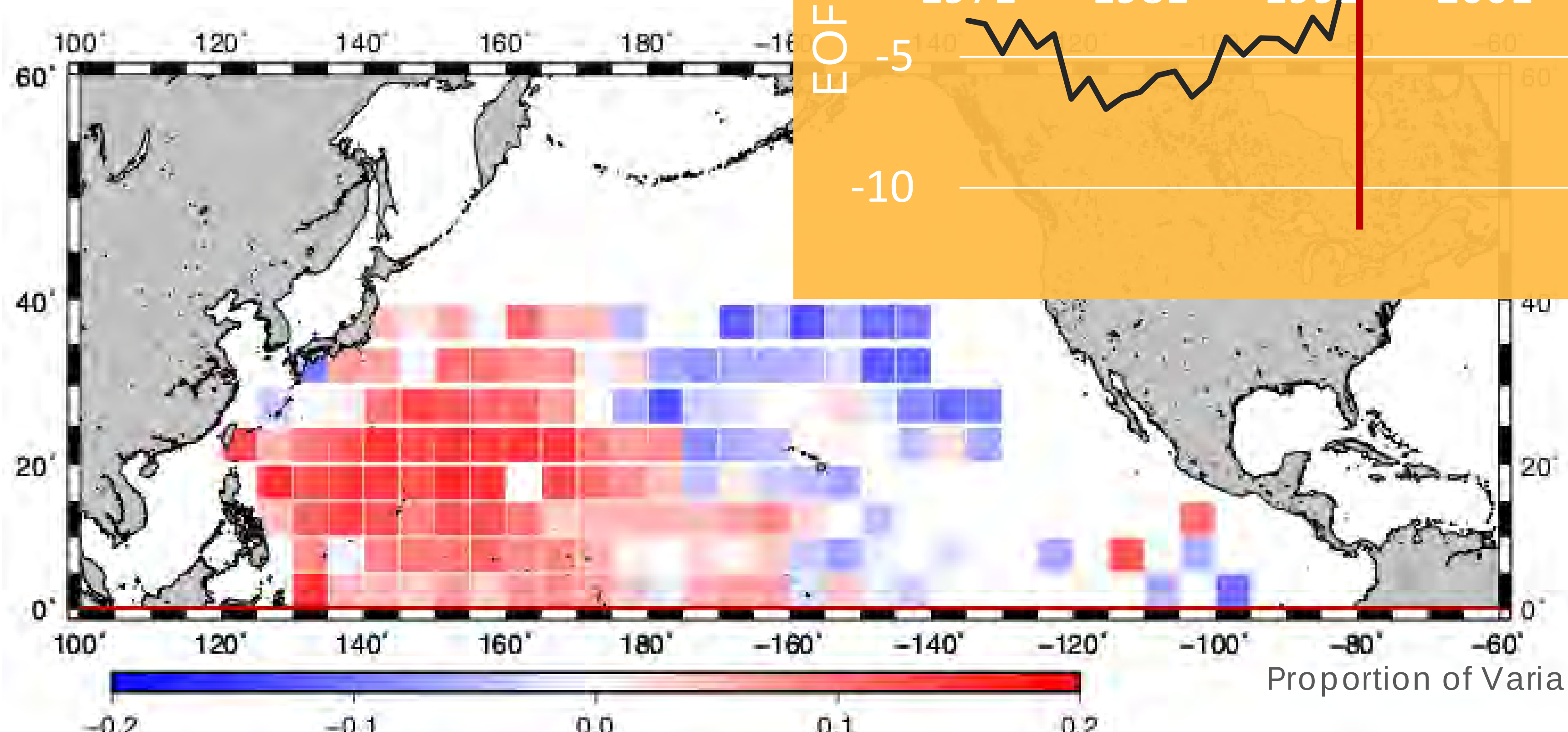
Distribution of eigenvectors (coefficients)



Result and Discussion – EOF1

EOF1

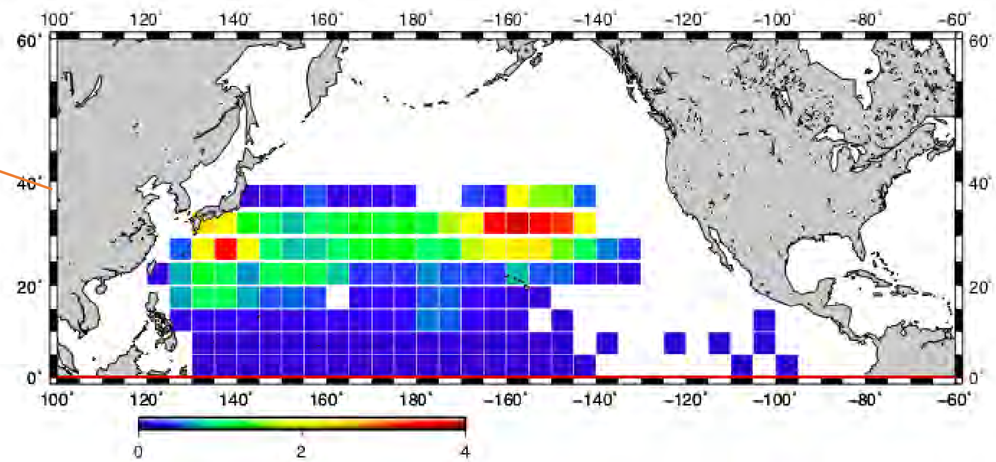




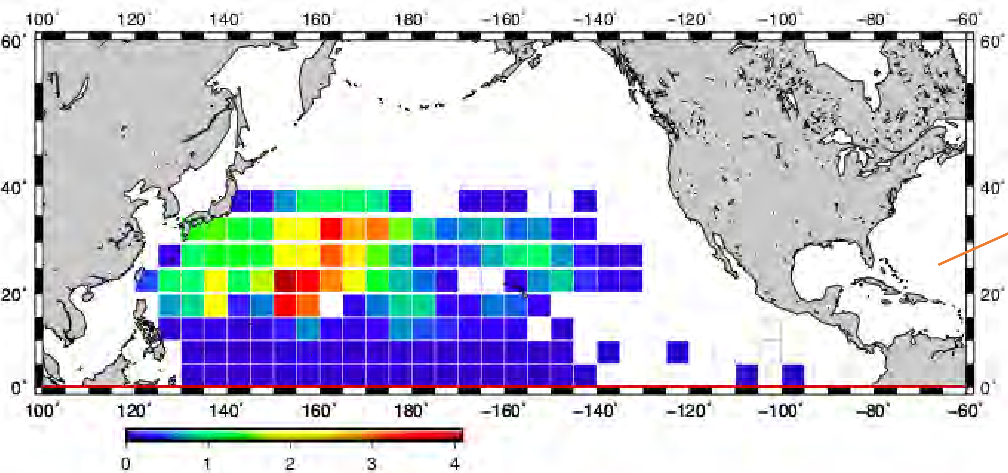
Proportion of Variance: 20.6%

Result and Discussion – EOF1

1st Term
1971–1993
Mean CPUE %



They distributed around **150°W** mainly



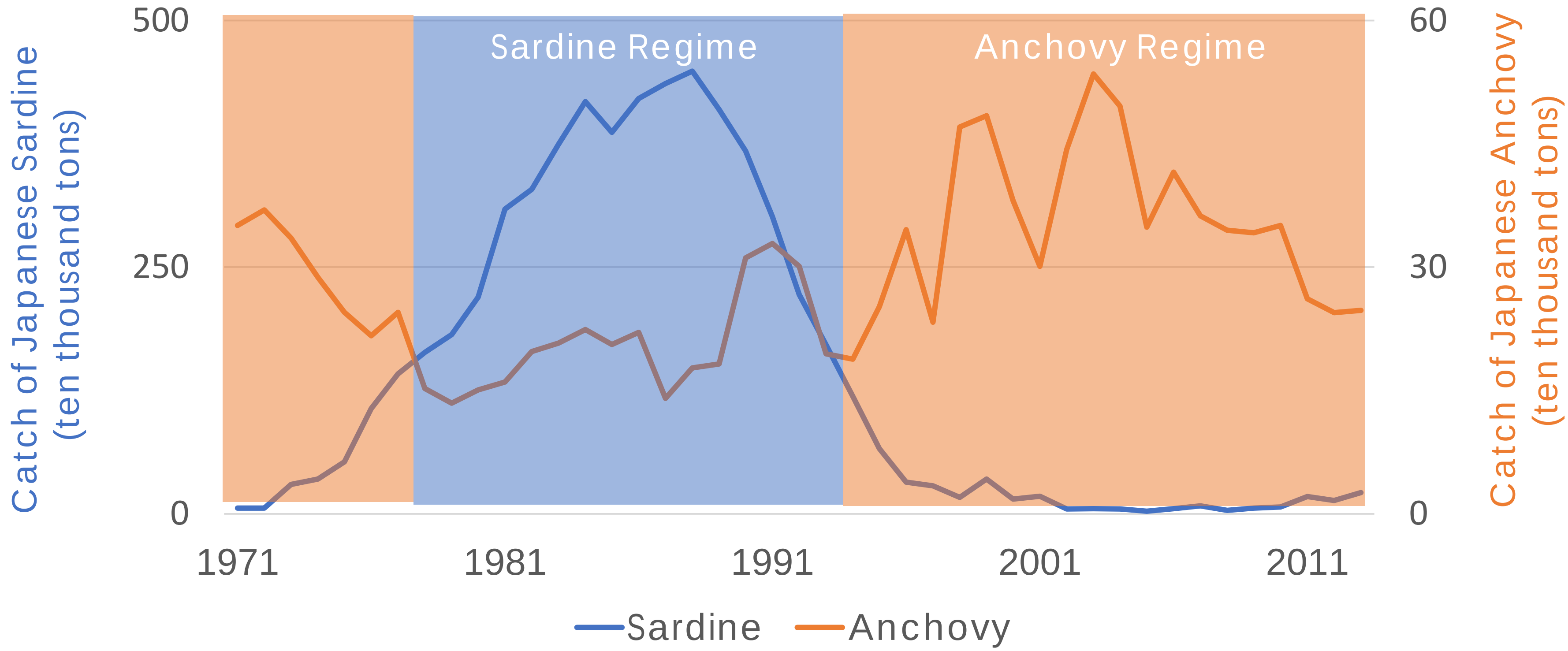
2nd Term
1994–2013
Mean CPUE %

They distributed around **150°E** mainly

Albacore distribution have shifted to west in the 1990s

Result and Discussion – EOF1

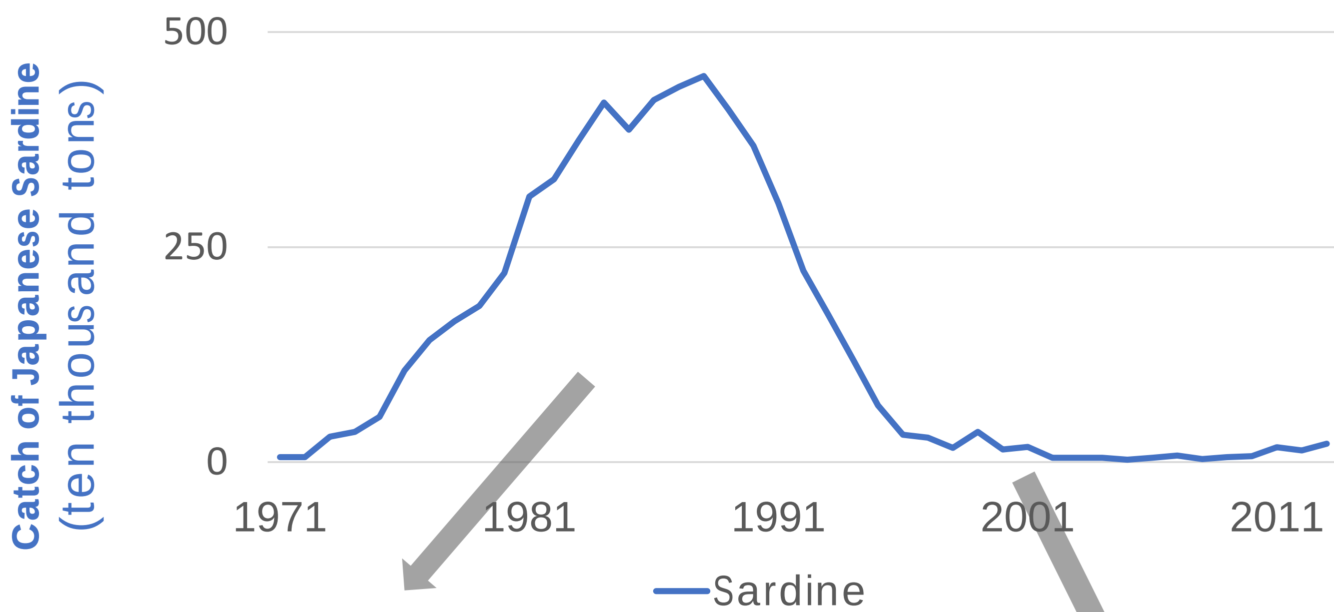
Regime Shift



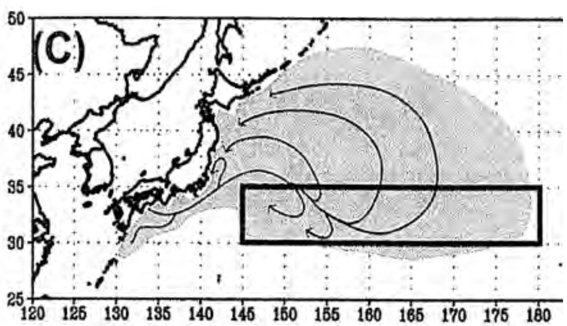
Catch of Japanese Sardine and Anchovy

Source of graph; Japanese Fisheries Agenc

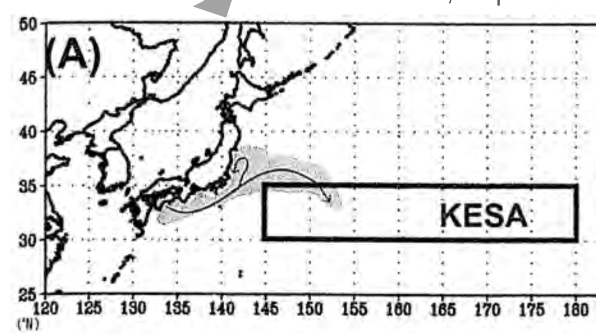
Result and Discussion – EOF1



Source; Japanese Fisheries Agenc



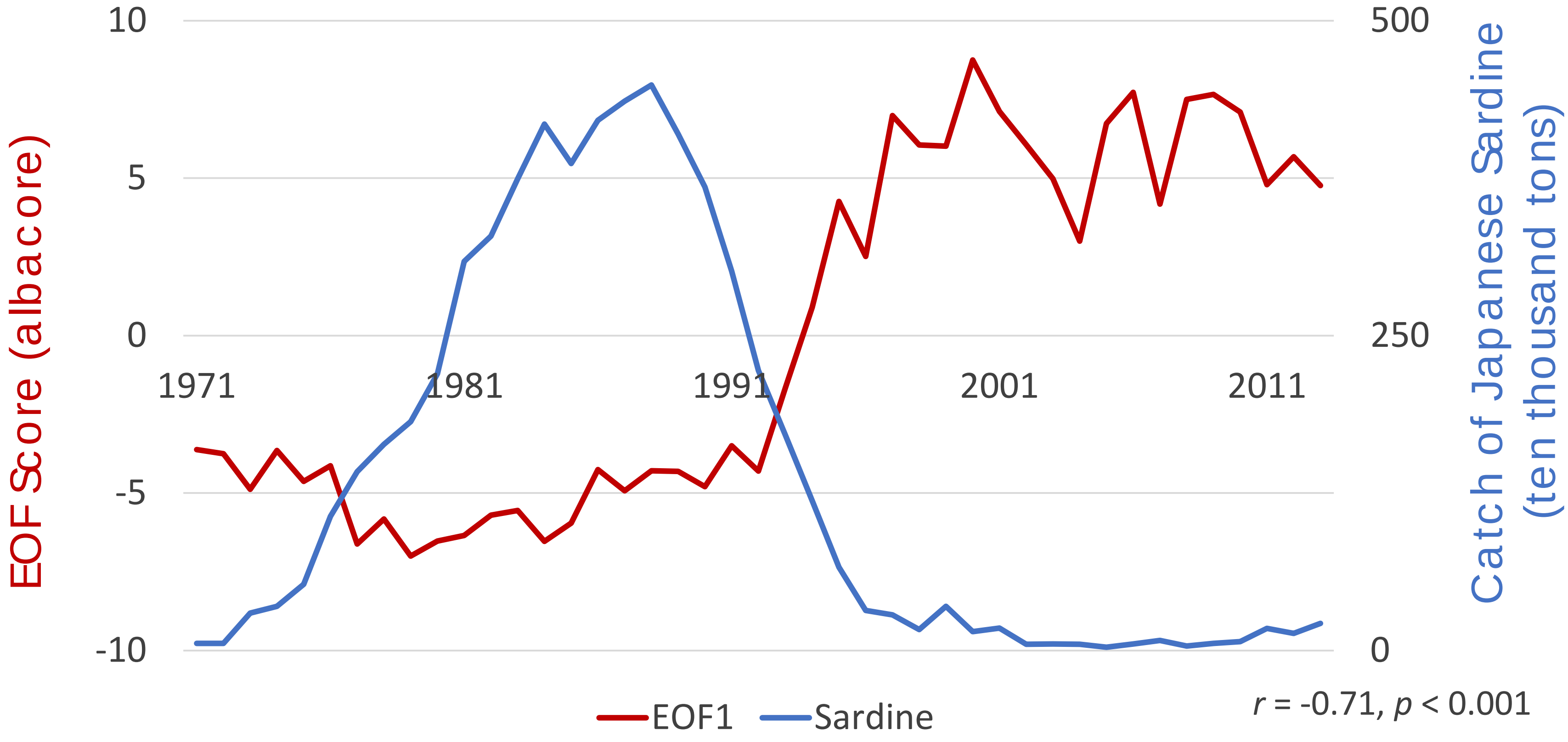
High biomass



Low biomass

Distribution area of Japanese Sardine has also changed in the 1990s

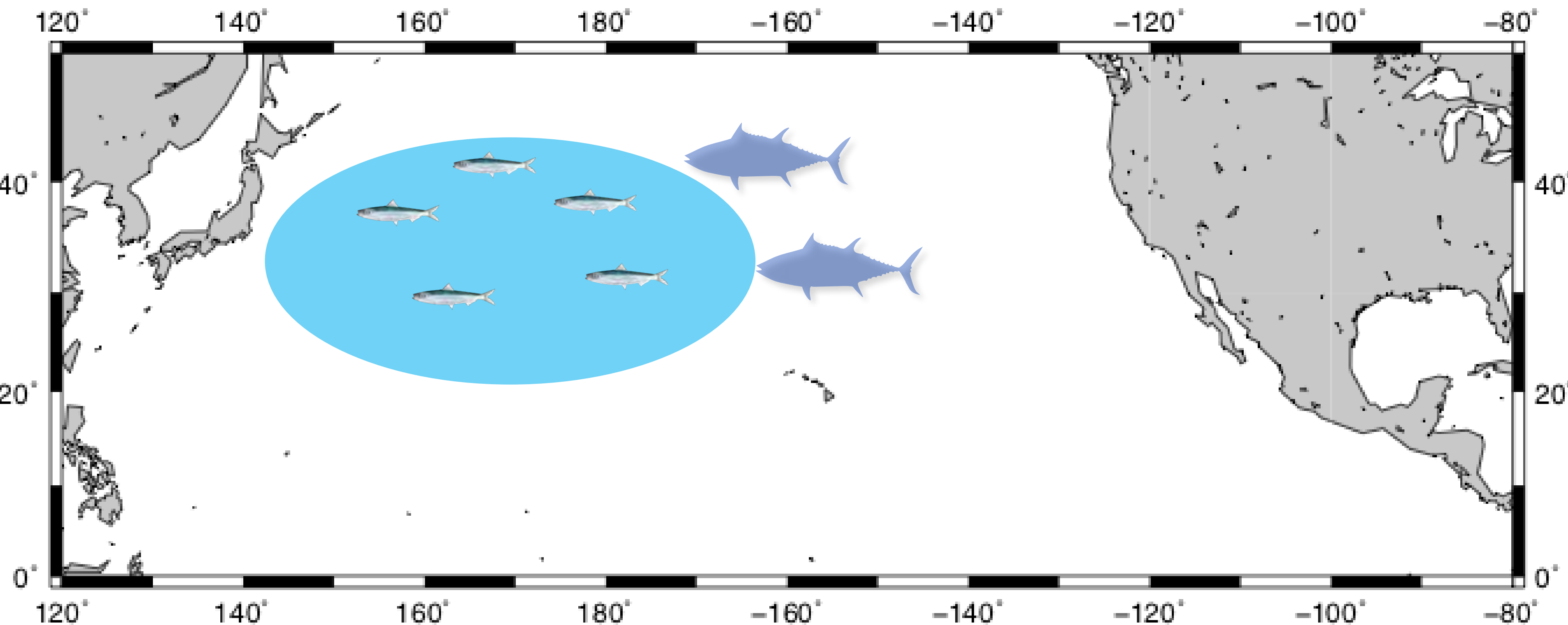
Result and Discussion – EOF1



✓ EOF1 Score which shows distribution shift of the **Albacore** had significant negative correlation with commercial catch of **Japanese Sardine**

Distribution shift of Albacore and distribution change of Japanese Sardine occurred in the same period

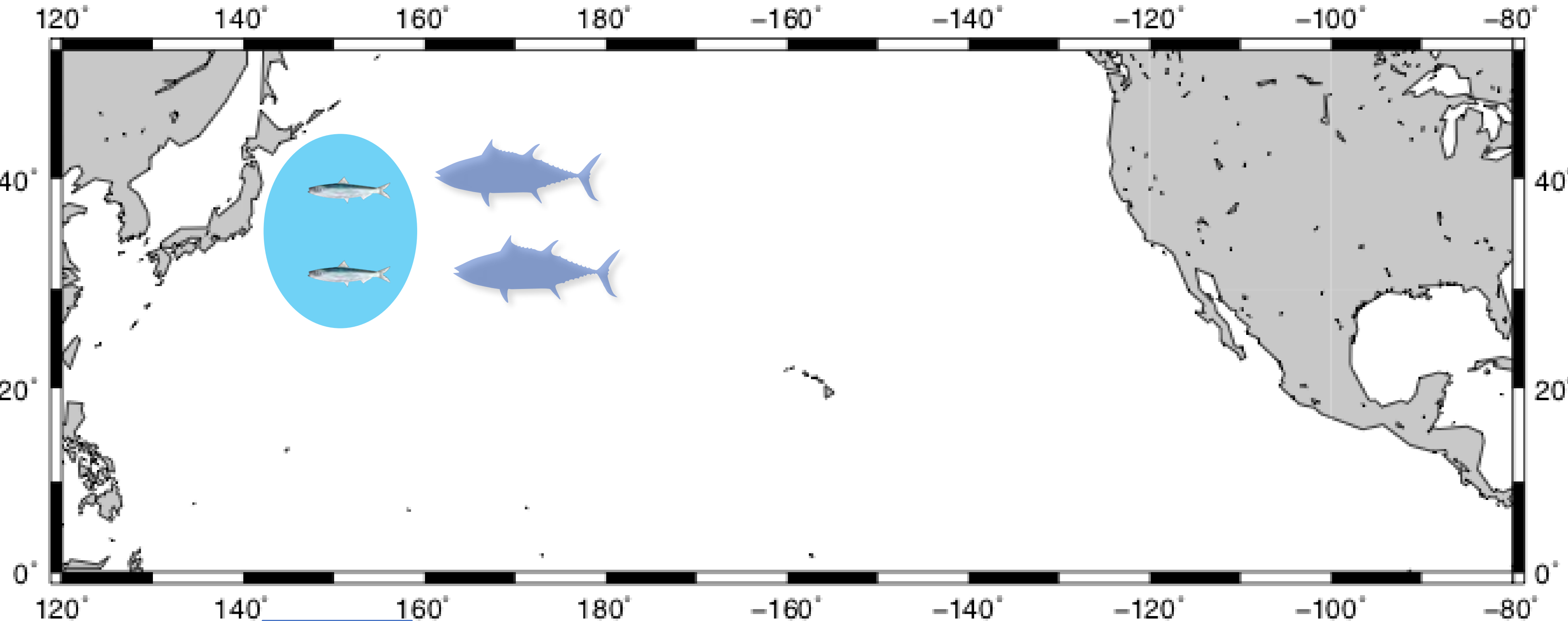
Result and Discussion – EOF1



1970s – 1980s

Albacore have centered in the north Pacific feeding on Japanese Sardine mainly

Result and Discussion – EOF1

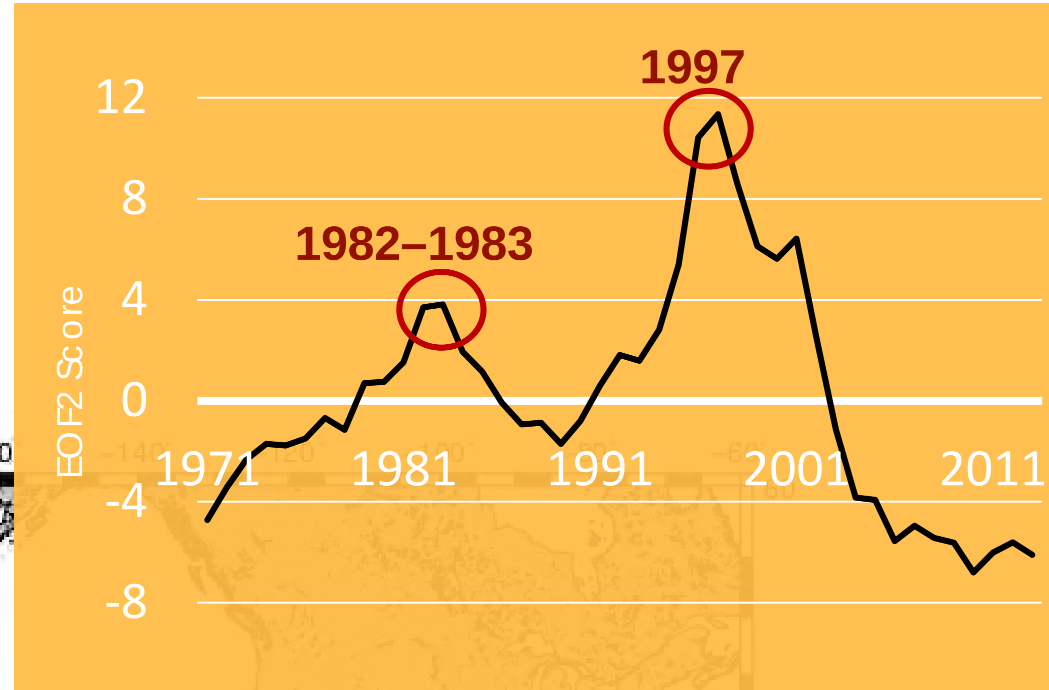


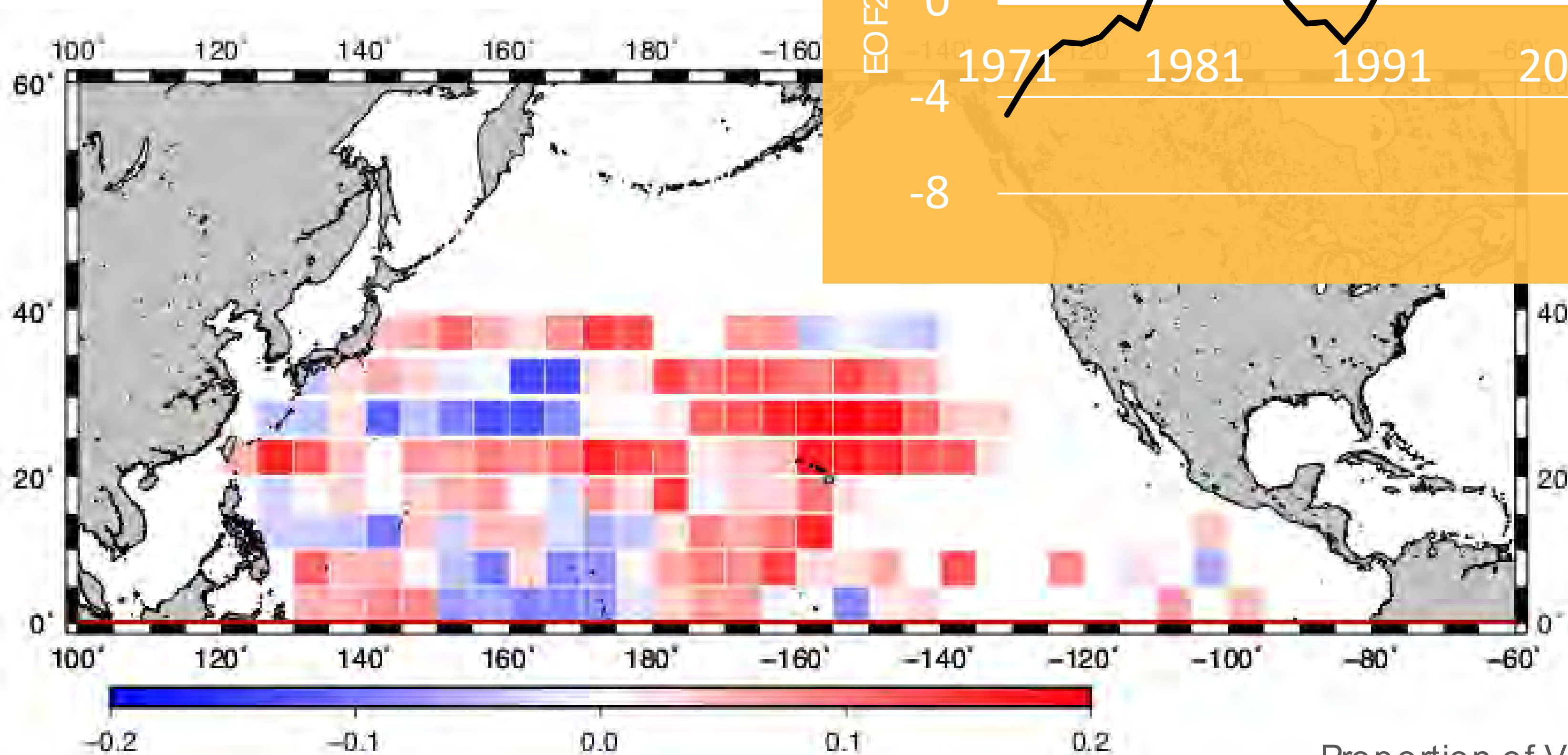
1990s -

Japanese Sardine has decreased dramatically limiting their distribution area towards the coast of Japan.
This might be one of the factors of Albacore distribution shift.

Result and Discussion – EOF2

EOF2





Proportion of Variance: 13.7%

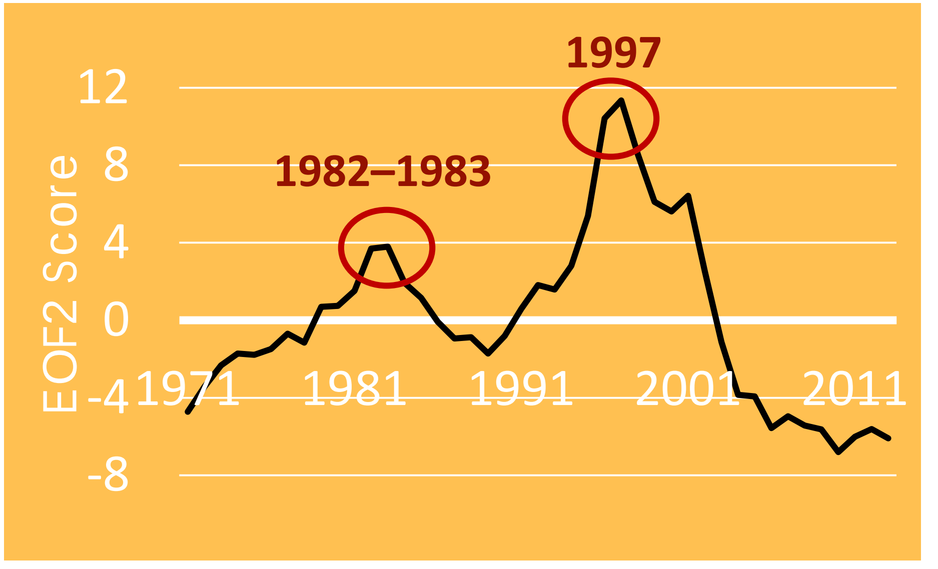
Result and Discussion – EOF2

El Niño and La Niña Years and Intensities Based on Oceanic Niño Index (ONI)

El Niño				La Niña		
Weak - 10	Moderate - 7	Strong - 5	Very Strong - 3	Weak - 10	Moderate - 4	Strong - 7
1952-53	1951-52	1957-58	1982-83	1954-55	1955-56	1973-74
1953-54	1963-64	1965-66	1997-98	1964-65	1970-71	1975-76
1958-59	1968-69	1972-73	2015-16	1971-72	1995-96	1988-89
1969-70	1986-87	1987-88		1974-75	2011-12	1998-99
1976-77	1994-95	1991-92		1983-84		1999-00
1977-78	2002-03			1984-85		2007-08
1979-80	2009-10			2000-01		2010-11
2004-05				2005-06		
2006-07				2008-09		
2014-15				2016-17		
				2017-18		

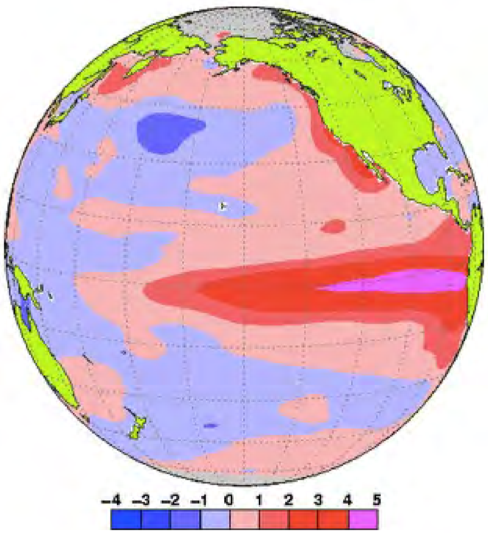
Source; NOAA

EOF2 Score



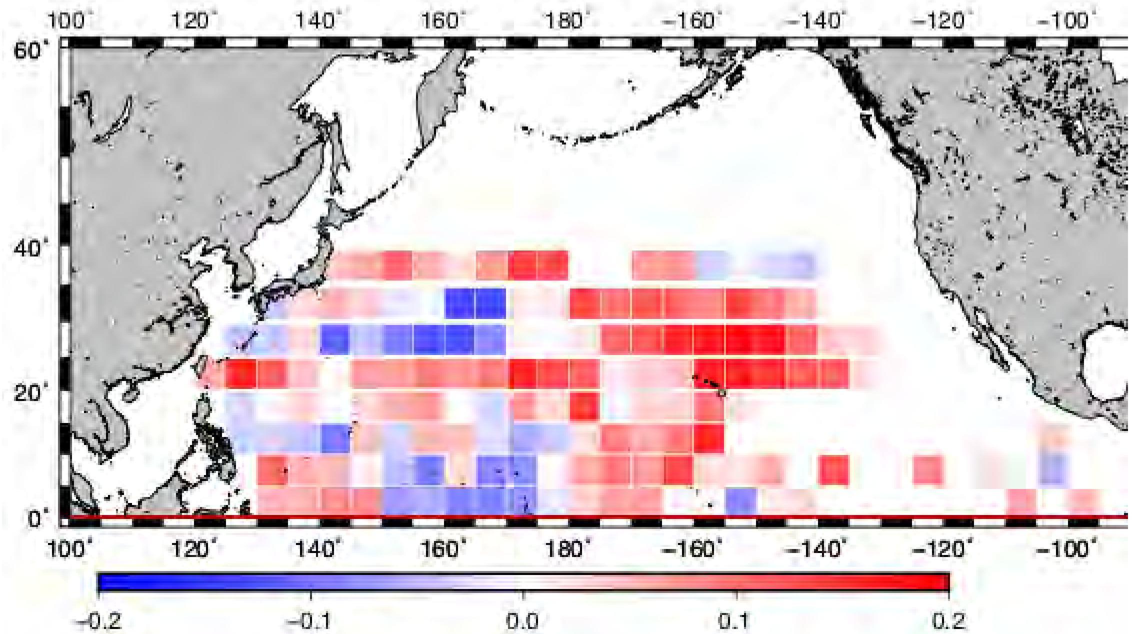
Two peaks of EOF2 scores coincided with the strongest El Niño events

Result and Discussion – EOF2



SST Anomaly in El Niño
Nov. 1997

Source: Japan Meteorological Agency



Spatial distribution of EOF2 eigenvectors

The distribution of eigenvectors is similar to that of the SST Anomaly in El Niño year

Albacore might concentrate in area where SST increased associated with El Niñ

Albacore Distribution has been also influenced by the El Niño phenomena

Conclusion

▷ EOF1

Shift of Albacore distribution to western part of the Pacific occurred in the1990s

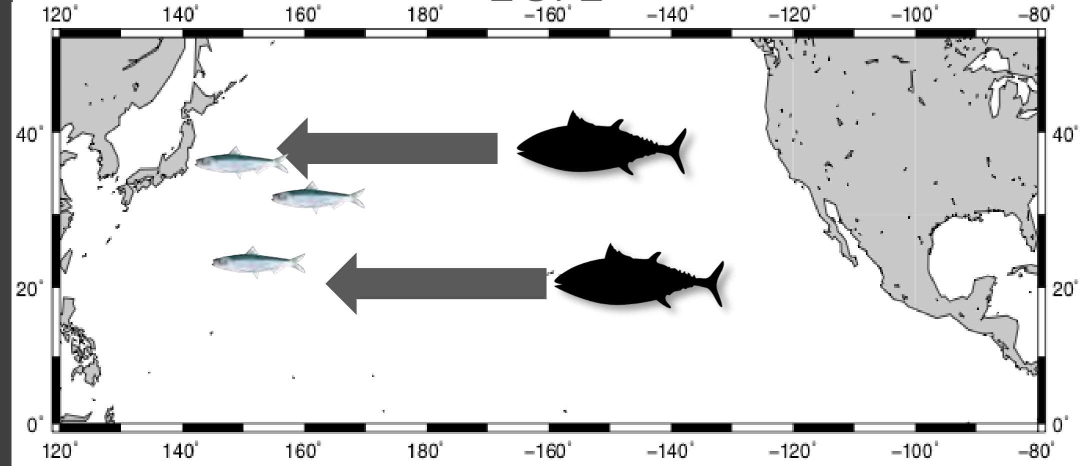
It might be caused by Sardine distribution change associated with Regime Shift

▷ EOF2

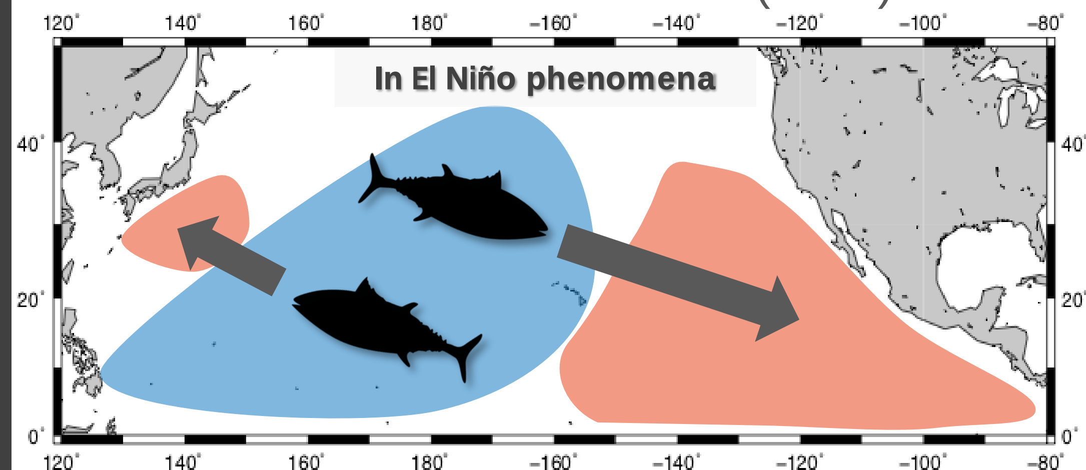
Distribution changes related to El Niño phenomena

This is as same result as the previous study suggested

EOF1



EOF2 and Kimura et al (1997)



Conclusion

▷Kimura et al. (1997)

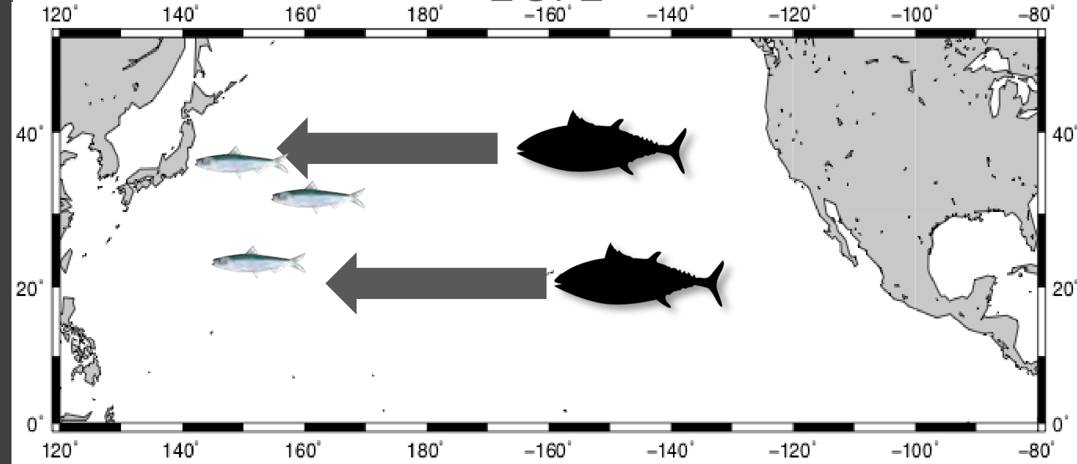
Study period; 1970~1988

▷This study

Study period; 1971 ~ 2013

These difference of study periods might be a factor of results

EOF1



EOF2 and Kimura et al (1997)