Did Regime Shift Occur in the East China Sea too?

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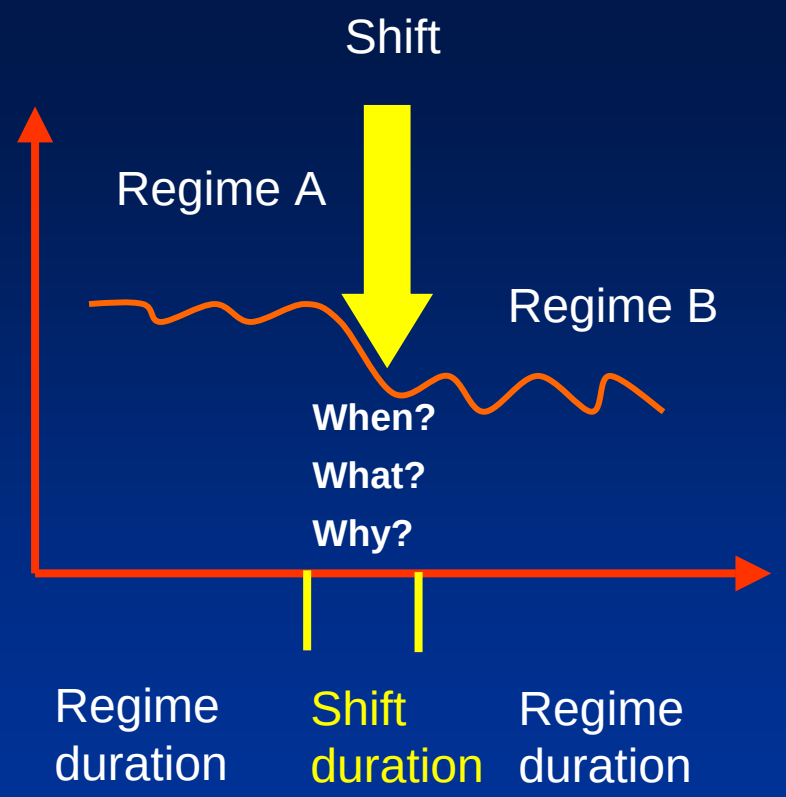
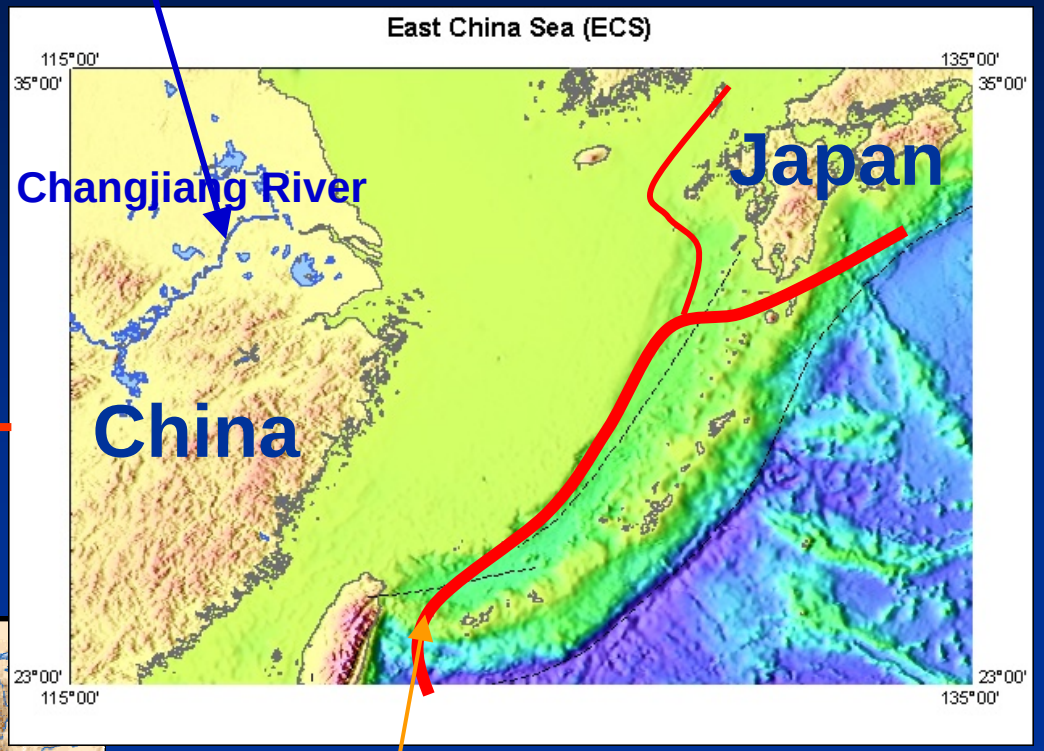
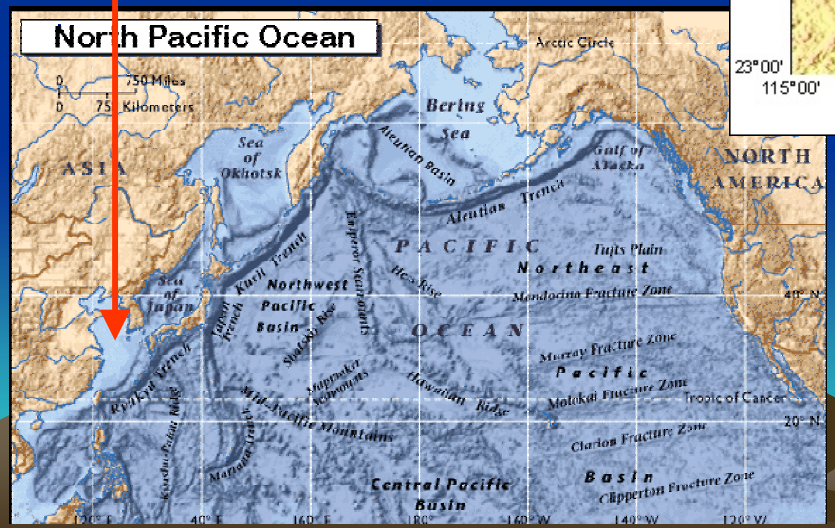
- Ecological Regime Shift:
  - the shift of ecosystem state including the shift of biological & environmental factors
  - at decadal scale, (even century scale)
  - at large spatial scale. e.g. Large marine ecosystem
  - Regime duration is significantly longer than the shift duration



East China Sea (ECS)

3rd longest in the world





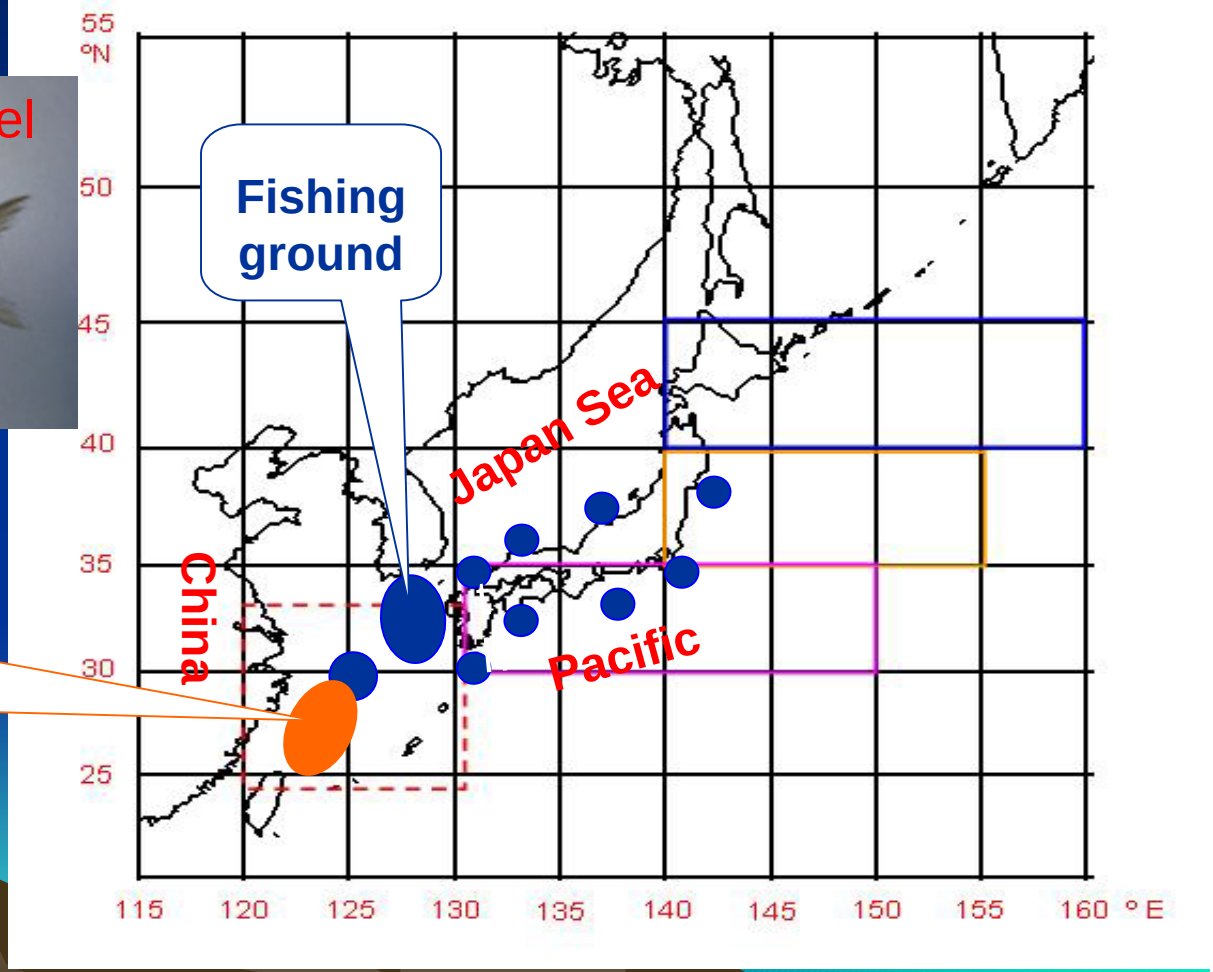
Kuroshio Current

- Target fishes:

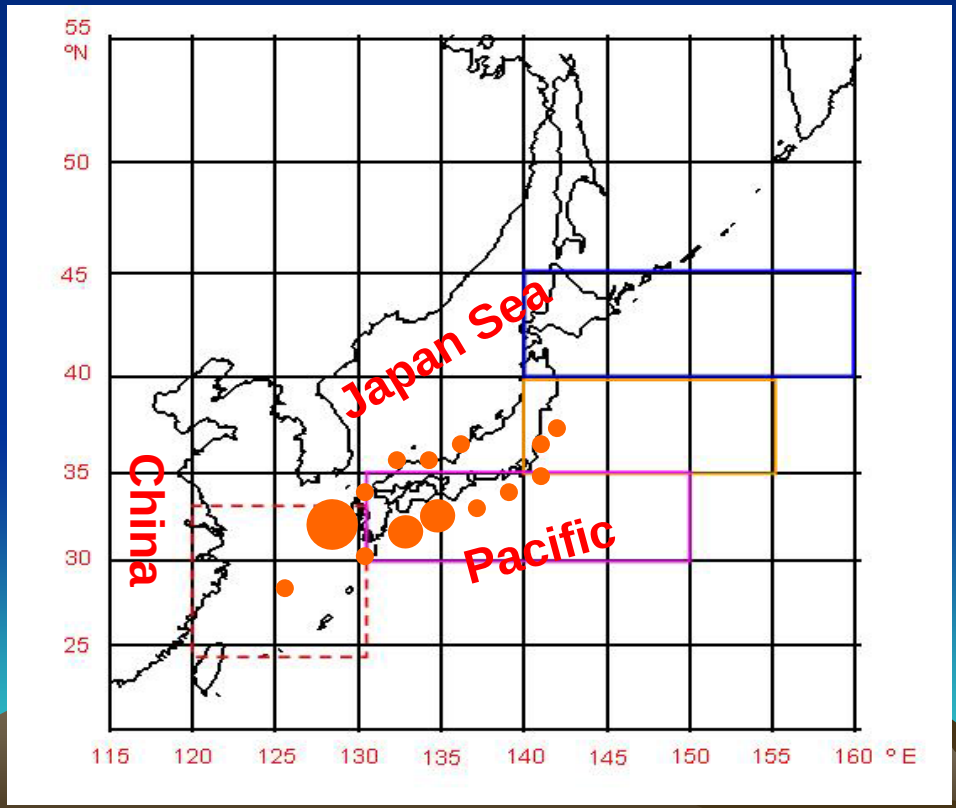
  Japanese Jack Mackerel (*Trachurus Japonicus*)

  Japanese Anchovy (*Engraulis japonicus)*

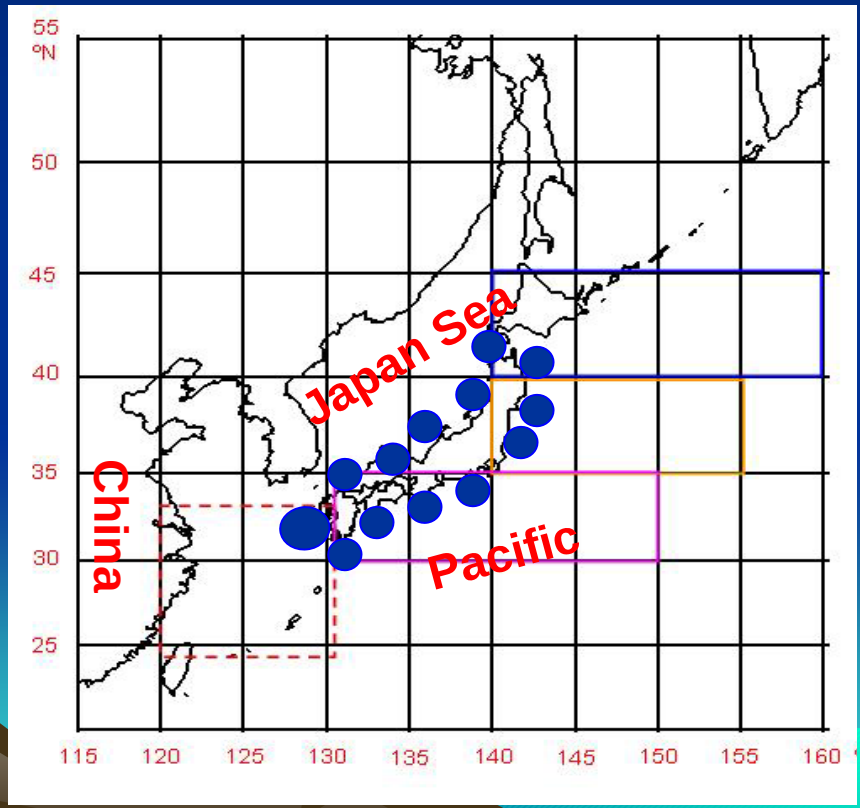
  Japanese Sardine (*Sardinops melanostictus*)



Spawning ground

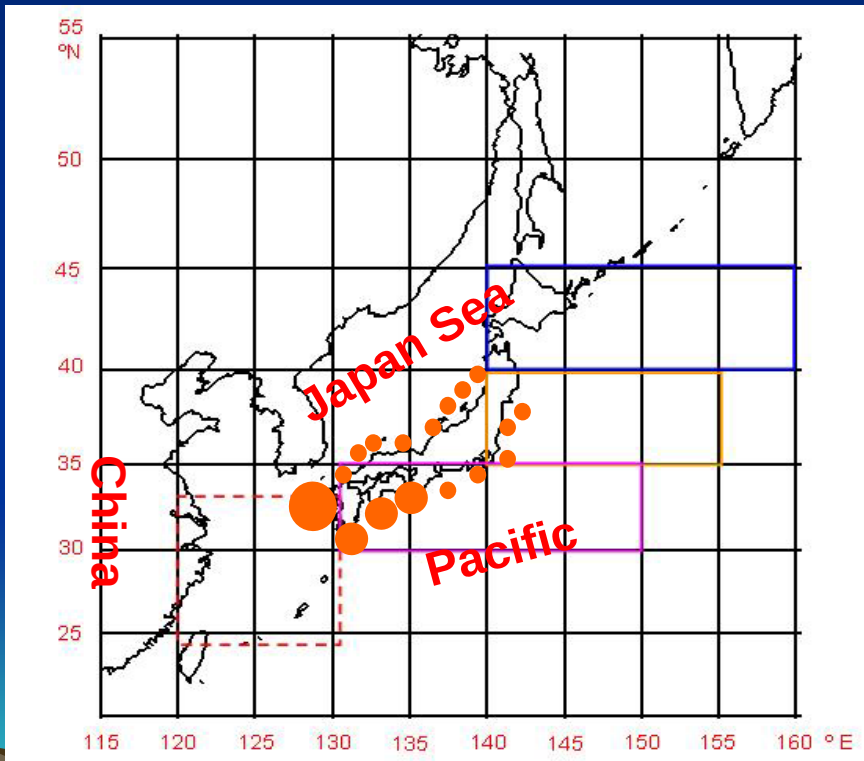


Fishing ground

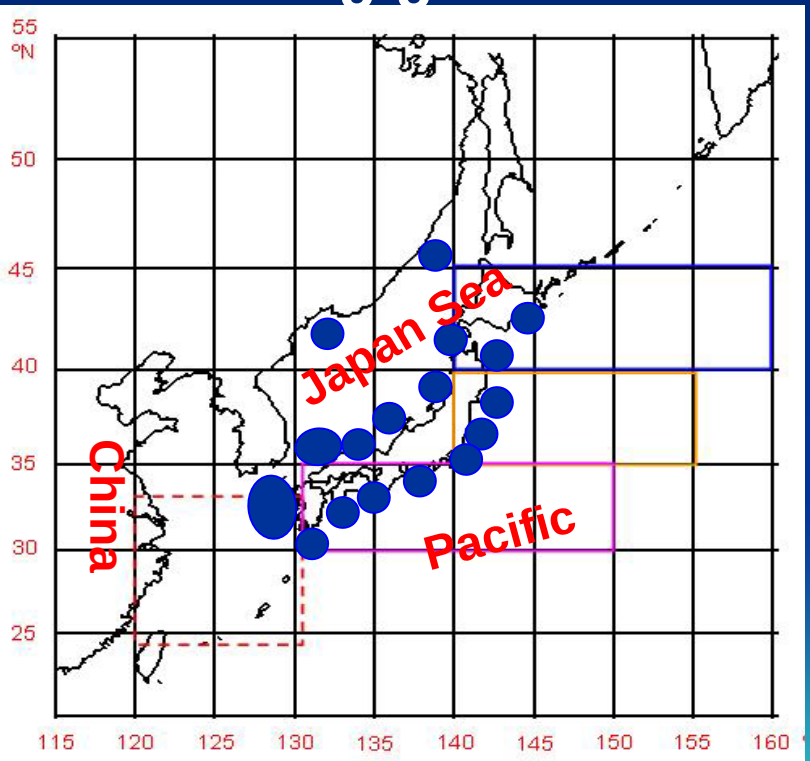


Japanese Sardine

Spawning ground



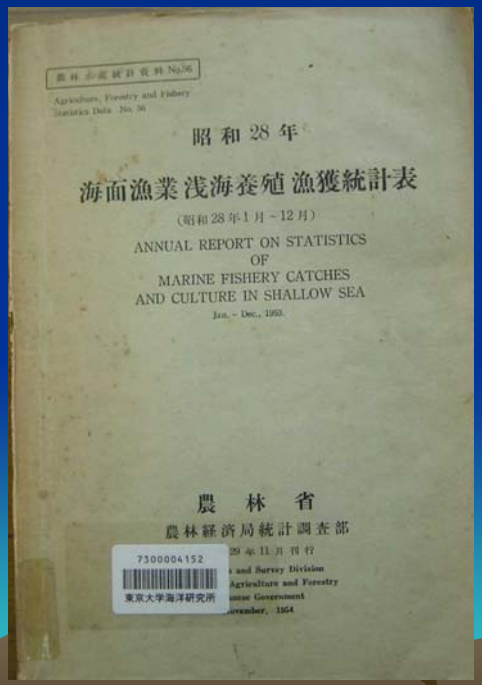
Fishing ground

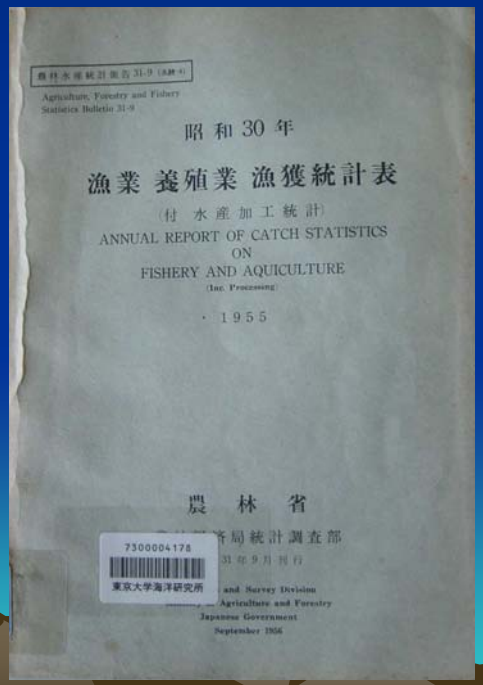


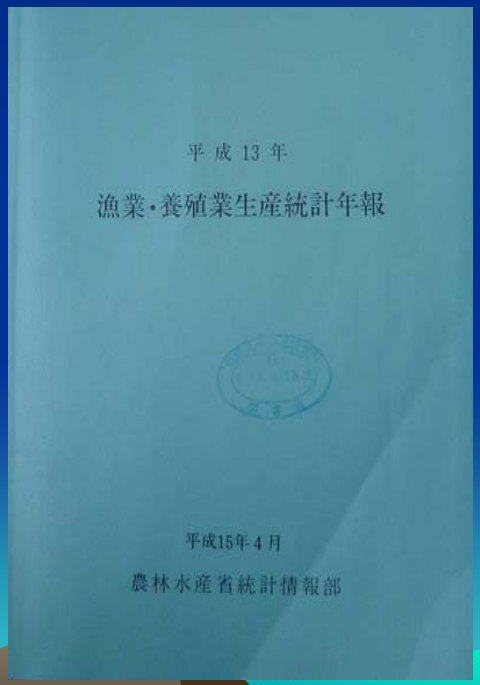
Main Spawning (red dot) and Fishing (blue dot) grounds

Data sources

Catch data: Japanese Fisheries Statistical Report
(1951-2001)





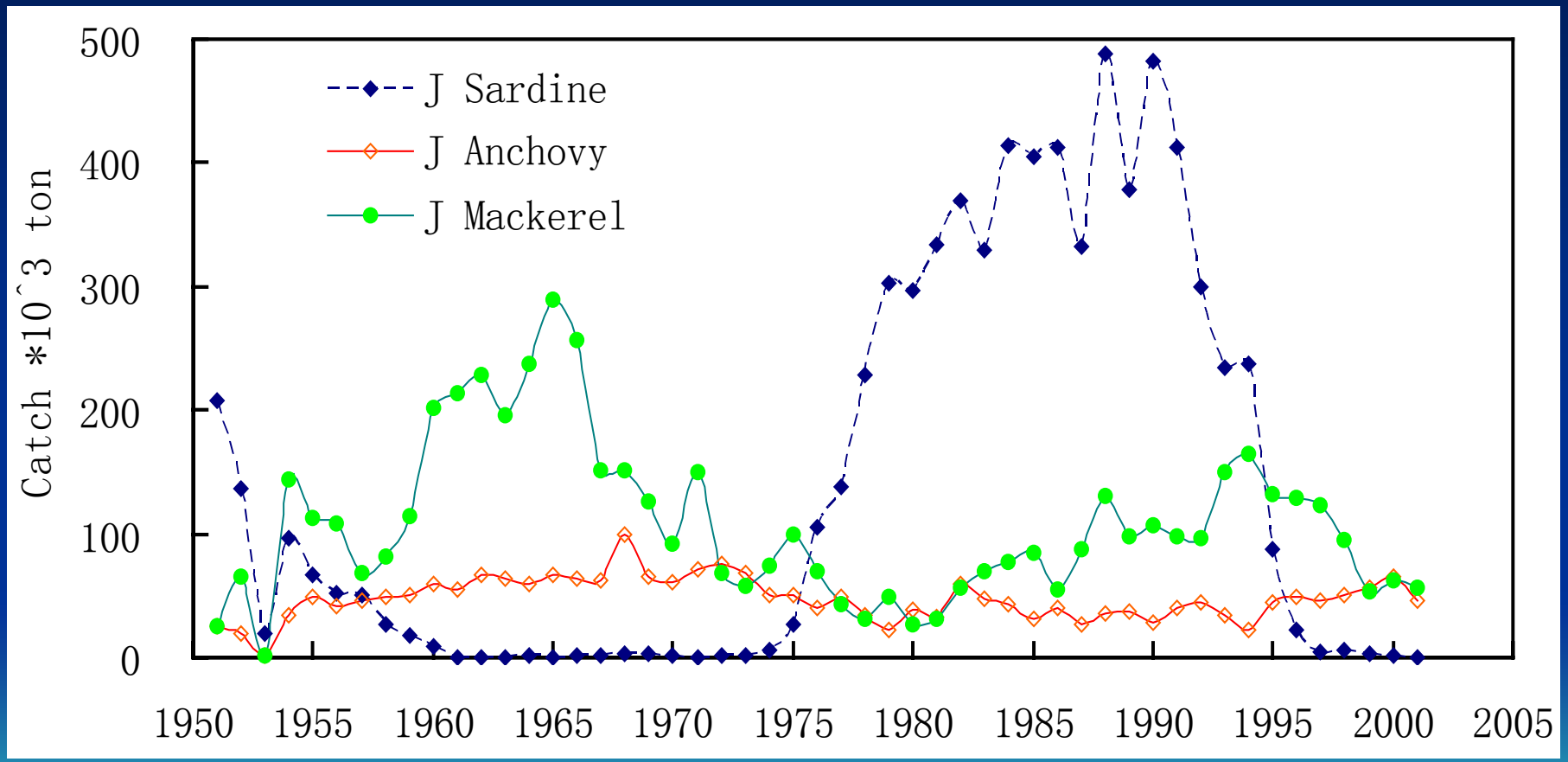


Environmental factors

1. SST: UK-MET
2. Runoff of Changjiang River: China
3. EAMOIw: East Asian Monsoon index, from Watanabe. Differences in SLP between Nemuro (43.02° N, 145.45° E), Japan and Irkutsk (52.16° N, 104.21° E), Russia.
4. PDO: Pacific Decadal Oscillation, Leading Principle Component of monthly SST anomalies in N. Pacific to the north of 20N latitude
5. ALPI: Aleutian Low Pressure Index, measures the relative intensity of the winter (Dec-Mar) Aleutian Low pressure system. It is calculated as the mean area in square kilometers with sea level pressure <= 1005 hPa and expressed as an anomaly from the 1950-1997 mean. A positive index value reflects a relatively strong Aleutian Low.
6. NPI: North Pacific Index (NPI-NCAR), is the area-weighted sea level pressure over the region 30oN-65oN, 160oE-140oW. Here we use mean November through March anomalies from the 1900-2000 base period normalized by the standard deviation.
7. AOI: Arctic oscillation index.

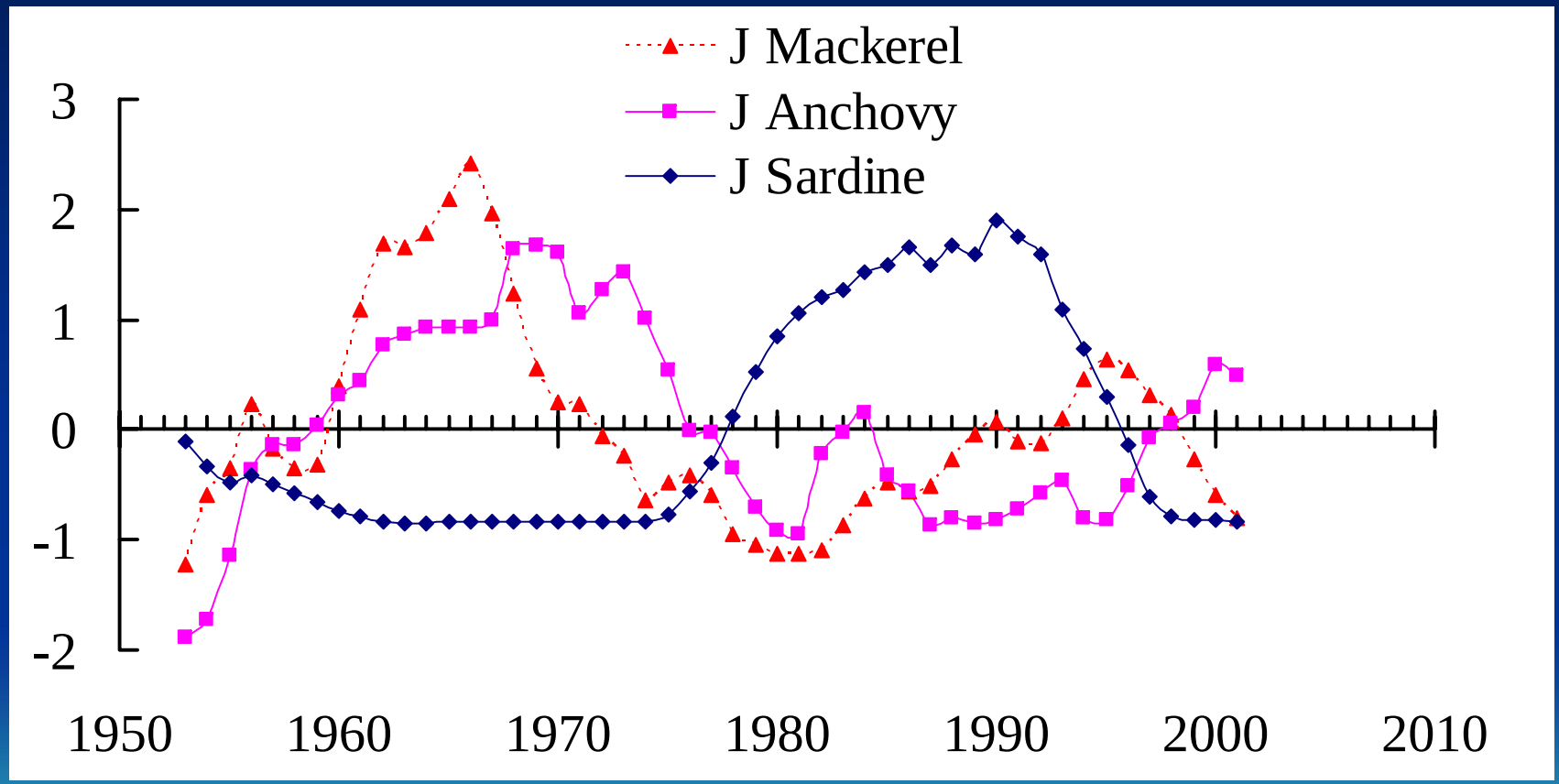
8. **MEnso:** Multivariate ENSO index, is based on six observed variables over the tropical Pacific: sea-level pressure, zonal and meridional components of the surface wind, SST, surface air temperature, and total cloudiness fraction of the sky. The MEI is calculated as the first unrotated Principal Component of all six observed fields combined.
9. SAI: Siberian-Alaskan Index represents a difference between the mean winter (DJFM) normalized 700 hPa anomalies in two regions, Siberia (55oN-70oN, 90oE-150oE) and Alaska/Yukon (60oN-70oN, 130oW-160oW).
10. WPI: West Pacific Index. From http://www.pfeg.noaa.gov/products/PFEL/modeled/indices/
11. SOI: Southern Oscillation Index. From http://www.pfeg.noaa.gov/products/PFEL/modeled/indices/NOIx/noix.html
12. SOIx: Extratropical-based Southern Oscillation index, From http://www.pfeg.noaa.gov/products/PFEL/modeled/indices/NOIx/noix.html
13. NOI: Extratropical-based Northern Oscillation Index.

Catch of 3 pelagic fishes from ECS



Sardine: 200-488,000 tonnes. 2,400-times range
Mackerel: 700-289,000 tonnes. 400-times range
Anchovy: 1,200-100,000 tonnes. 100-times range

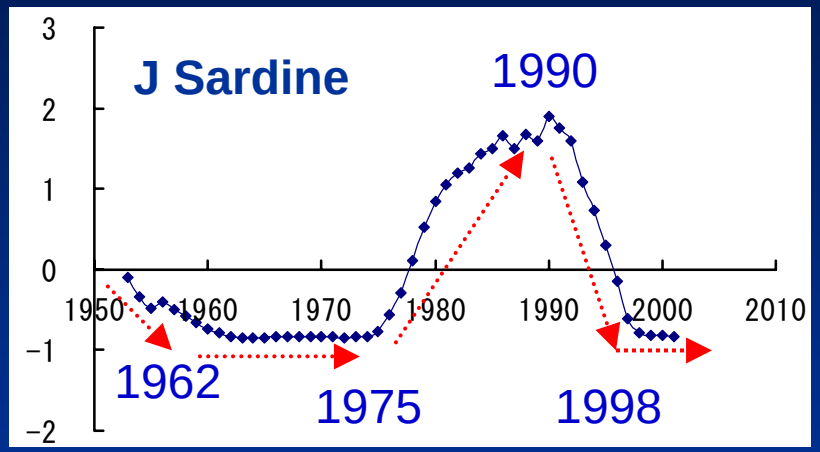
Standardized Catch
=(Catch-ave)/stdev

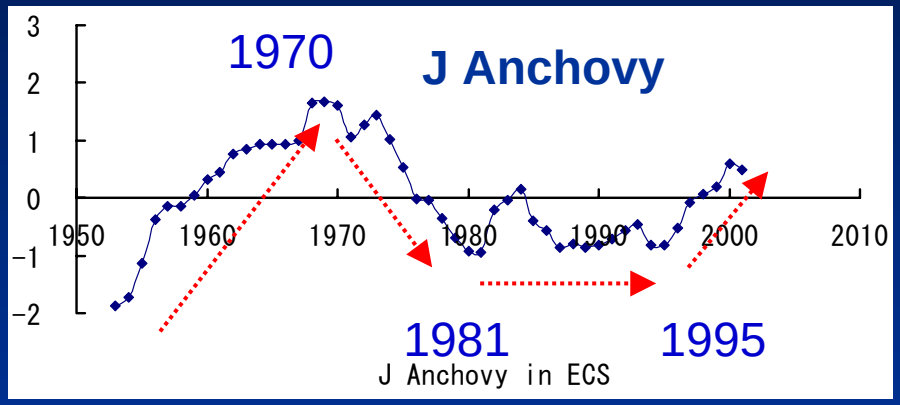


Correlation coefficient:

R_sadi_anch=-0.63, R_sadi_Jack=-0.42 , R_Anch_Jack=0.53

Trend analysis of Catch (1951-2001)



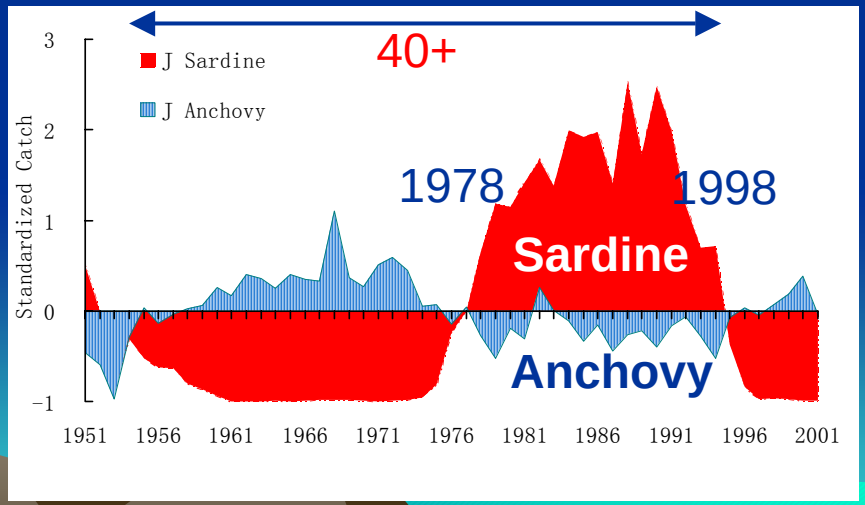


Trend of Sardine: 4 turns.

Trend of Anchovy: 3 turns.

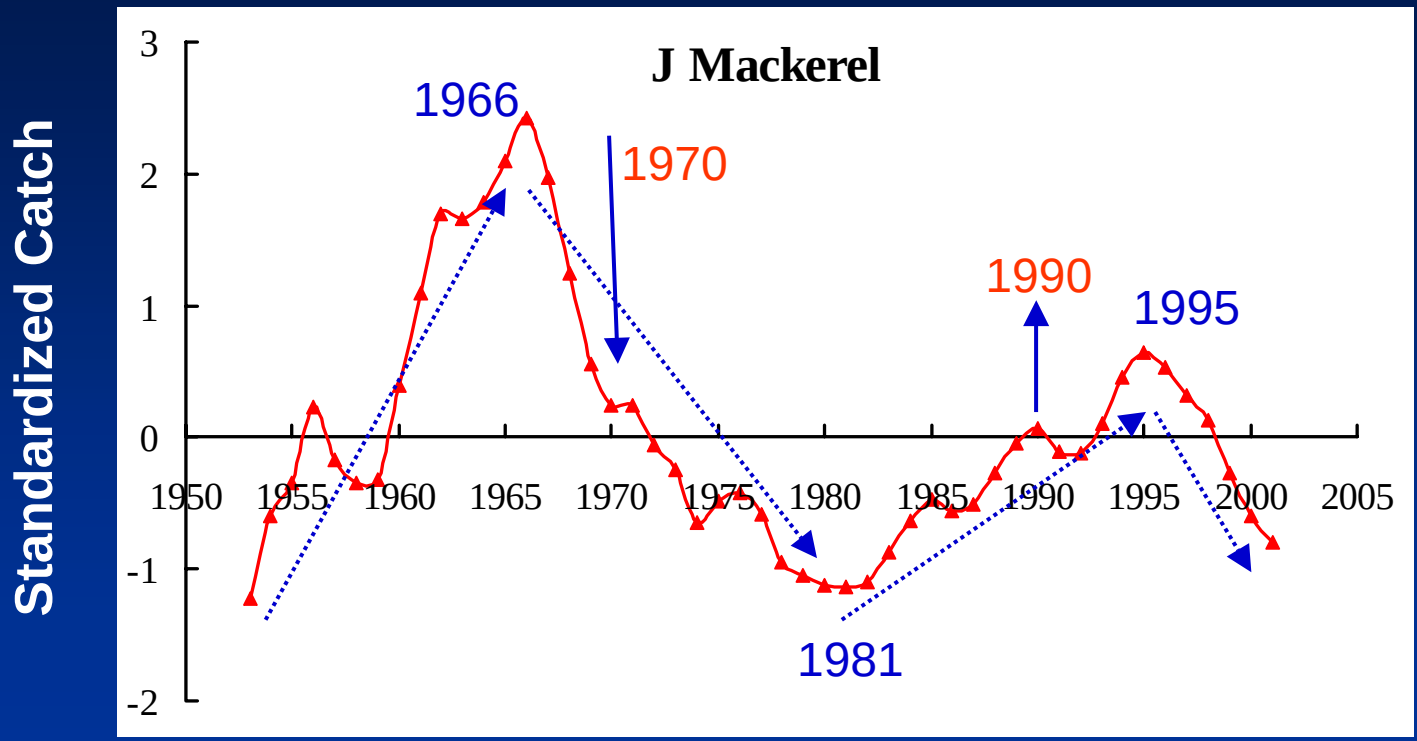
Phase shift of Sardine: ↑1978 ↓1989

Phase shift of Anchovy: ↓1978 ↑1989



Phase shift year identifies by Mann-Kendal

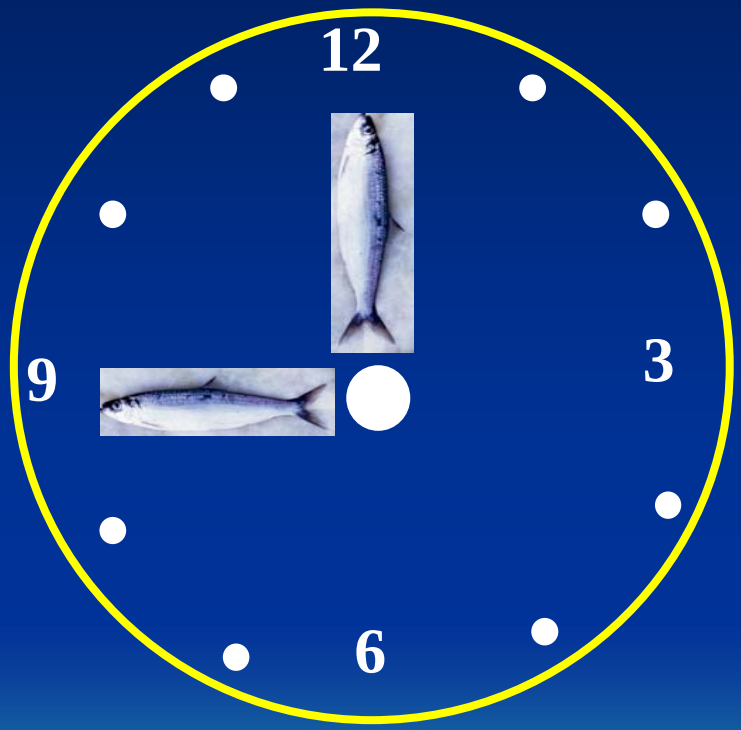
Trend analysis of Catch (1951-2001)



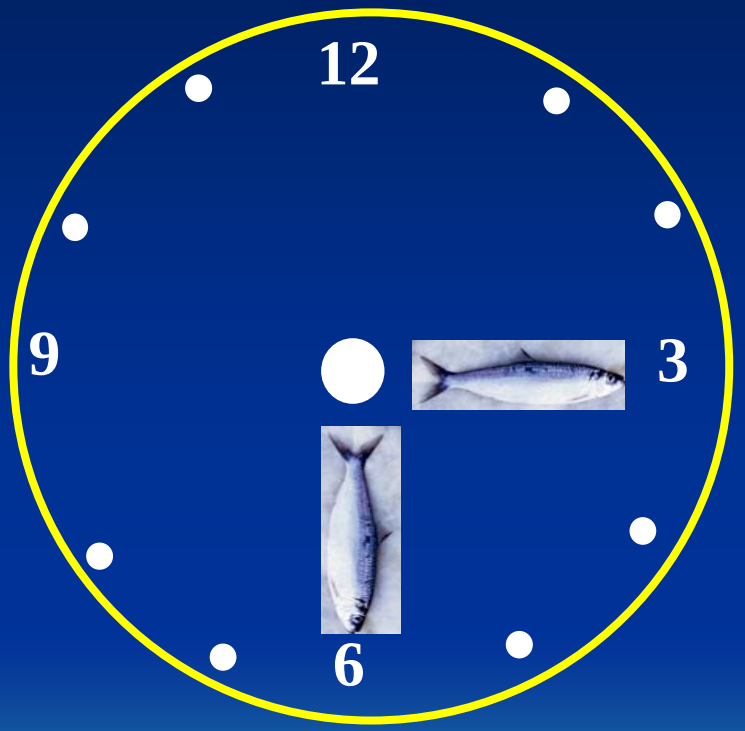
Trend of Jack Catch has turned 3 times

Phase shift of Jack: 1970 1990

Why did Anchovy and Sardine appear opposite shift at same year?



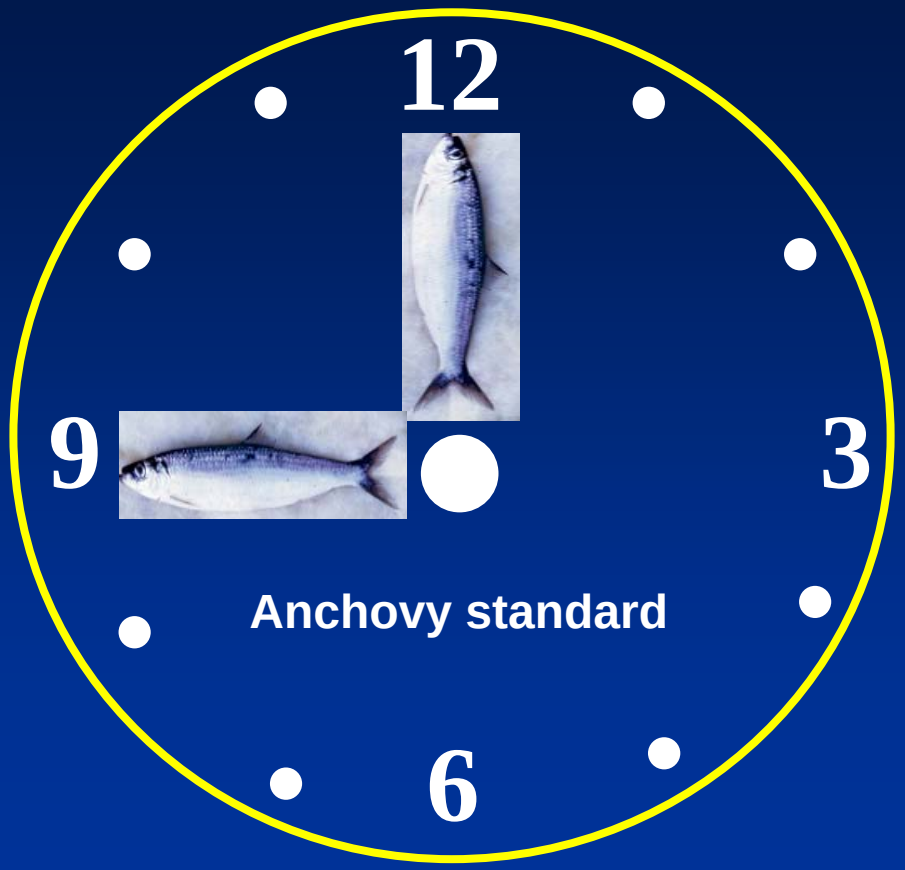
Anchovy standard

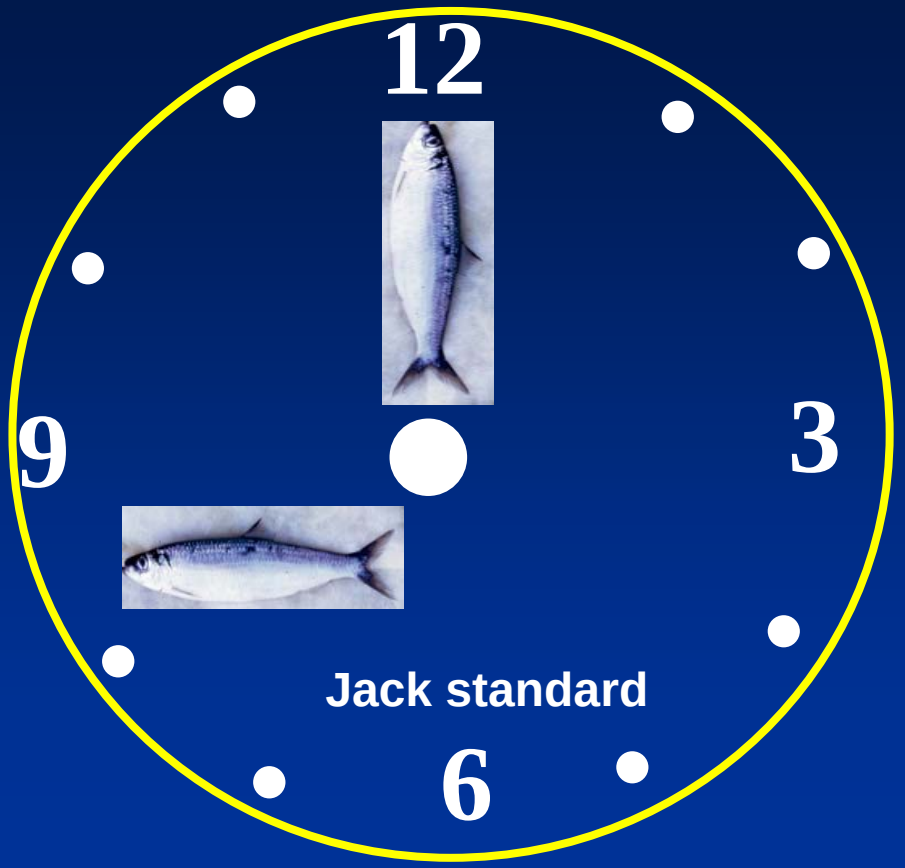


Sardine standard

Modified from Doug Hay 2003

Modified from Doug Hay 2003

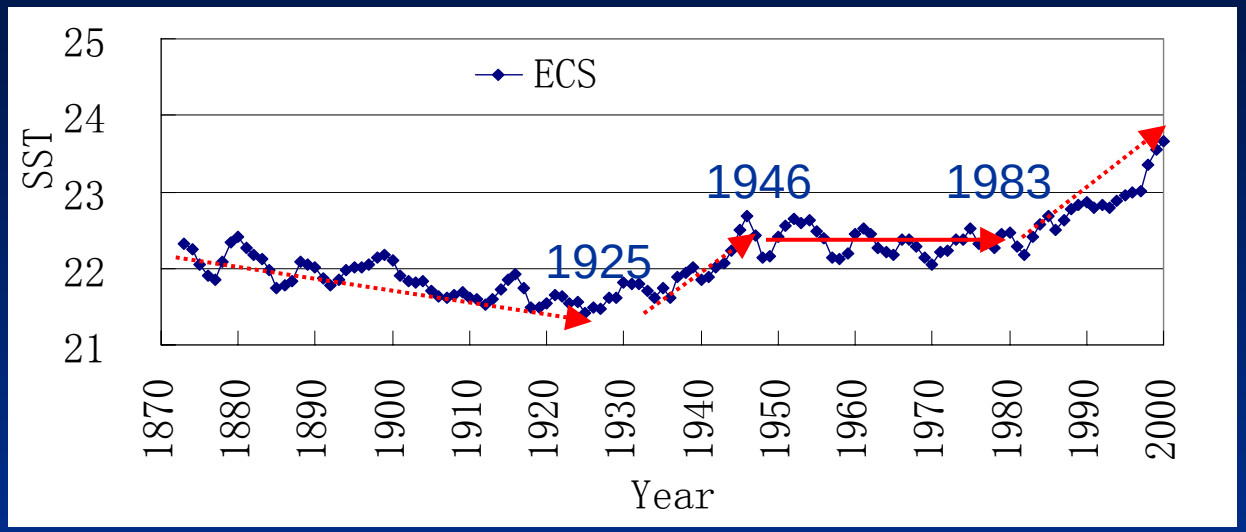




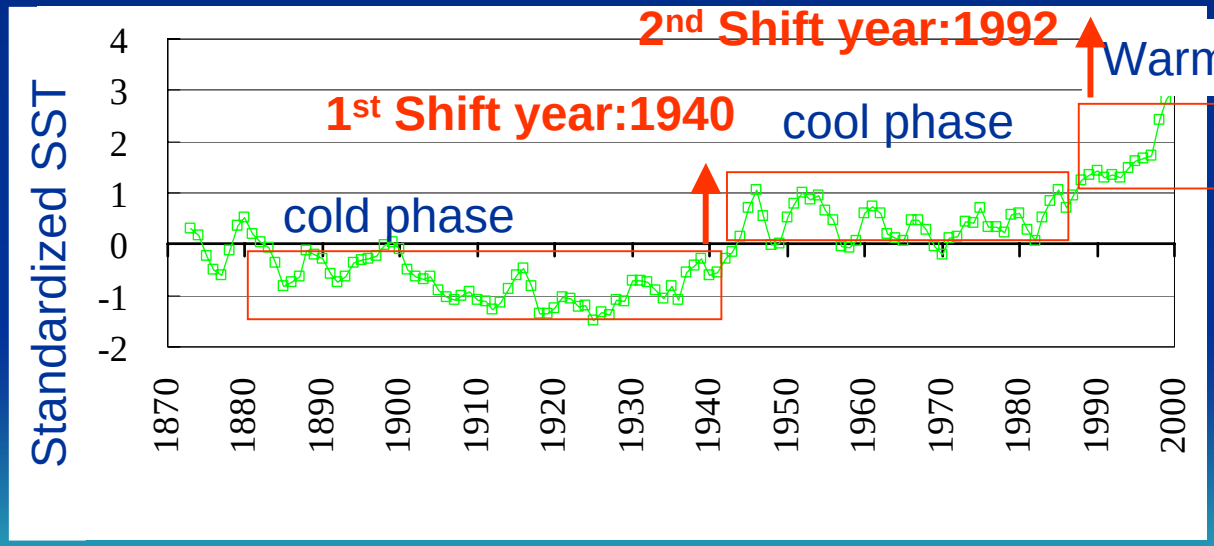
Why did Jack and J Anchovy show the similar pattern ?

Environmental Indices

Mean SST of ECS: 24-34N, 120-131E

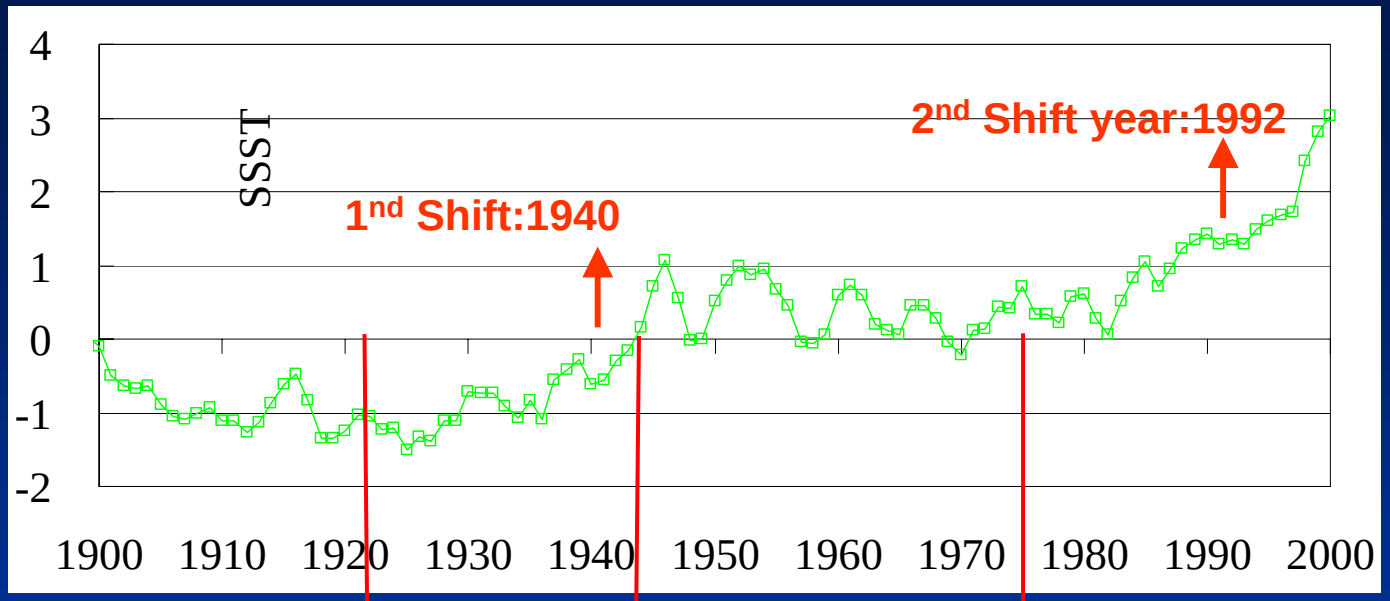


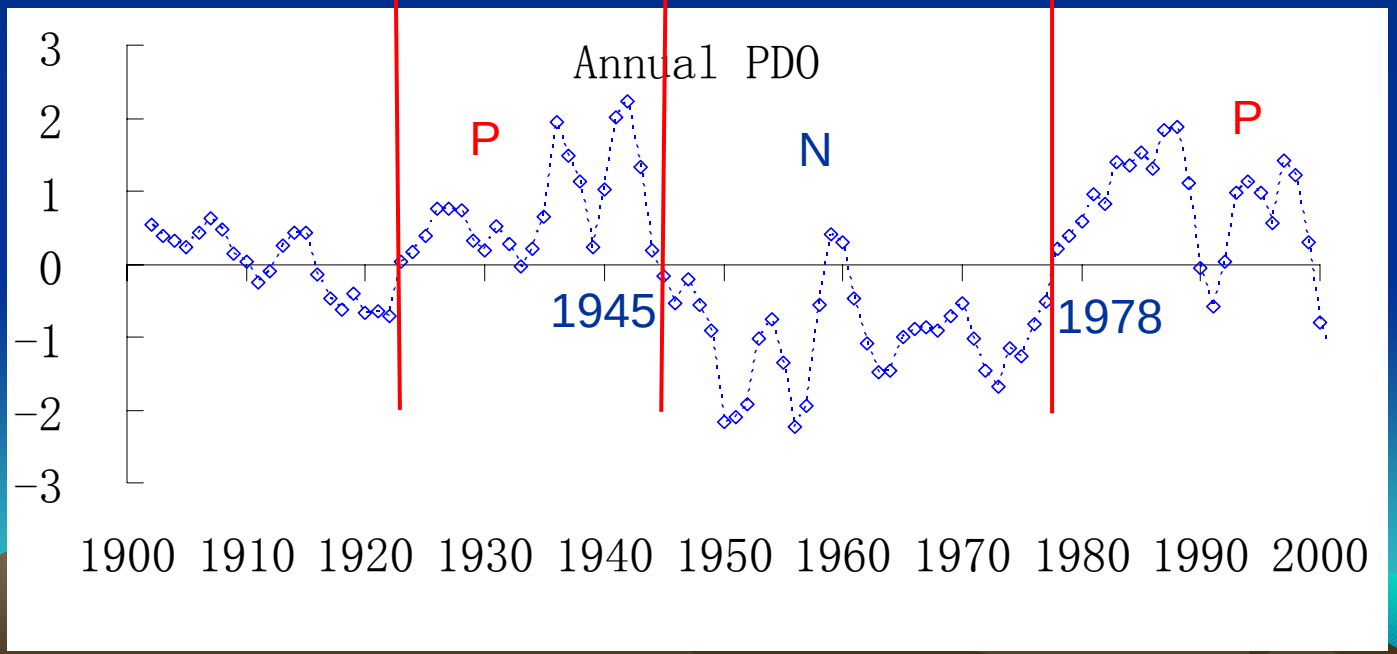
- 3 turns since 1871
- Increasing trend since 1925



Question:
when did SST shift?

Phase shift of SST in ECS is different with PDO's

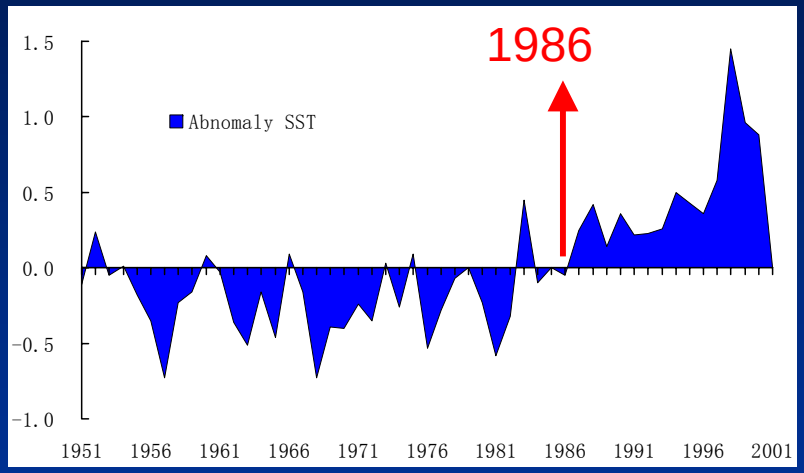




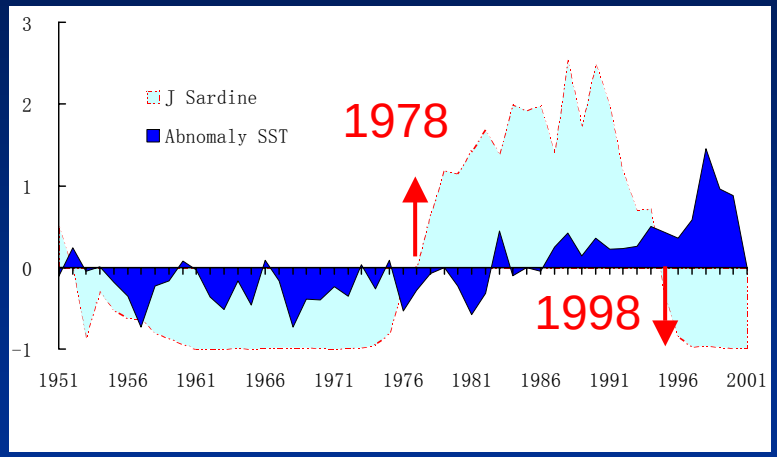
- Maybe due to the local effects from Runoff of Changjiang River ?

SST anomaly & Standardized Catch in ECS (1951-2001)

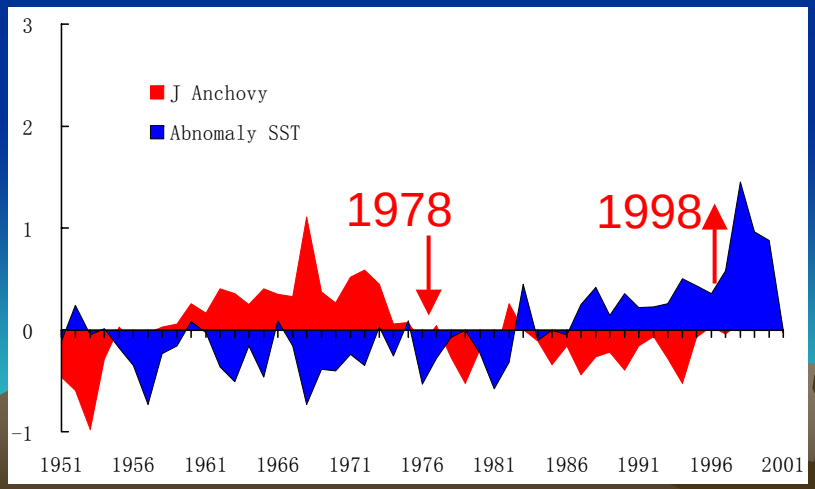
SST anomaly



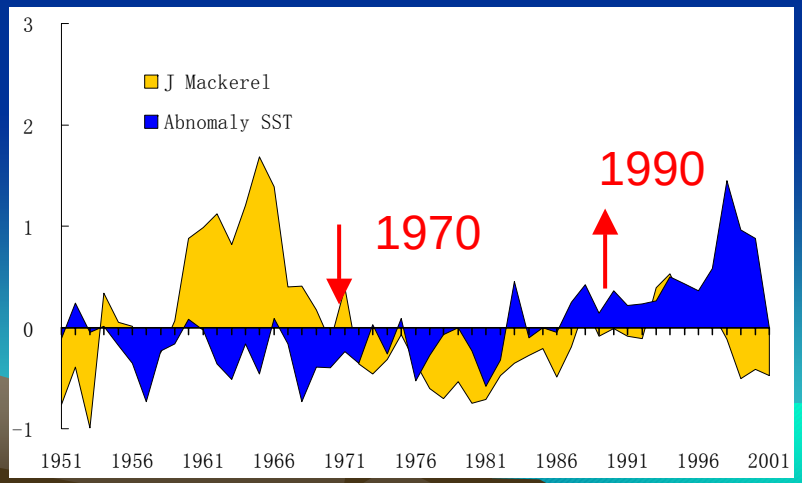
Sardine



Anchovy

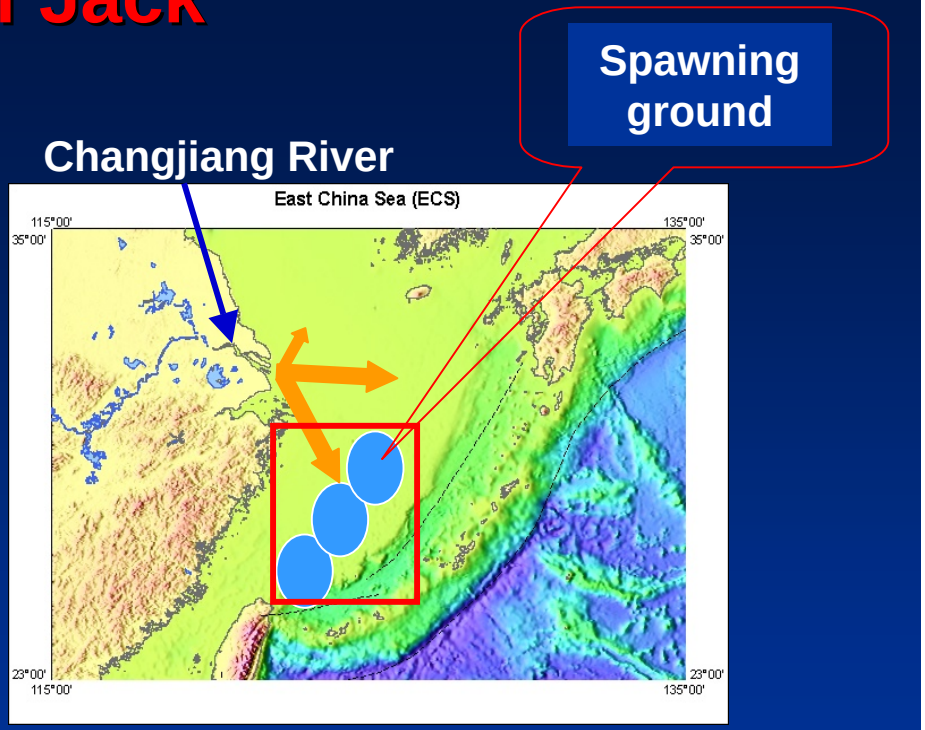


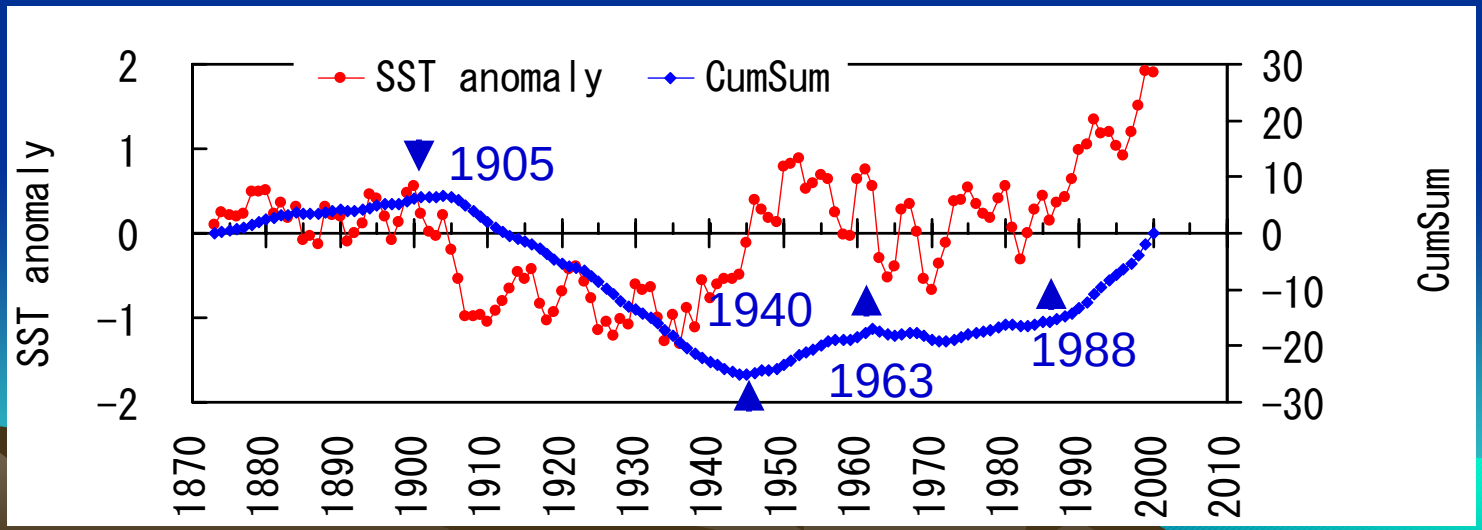
Jack Mackerel



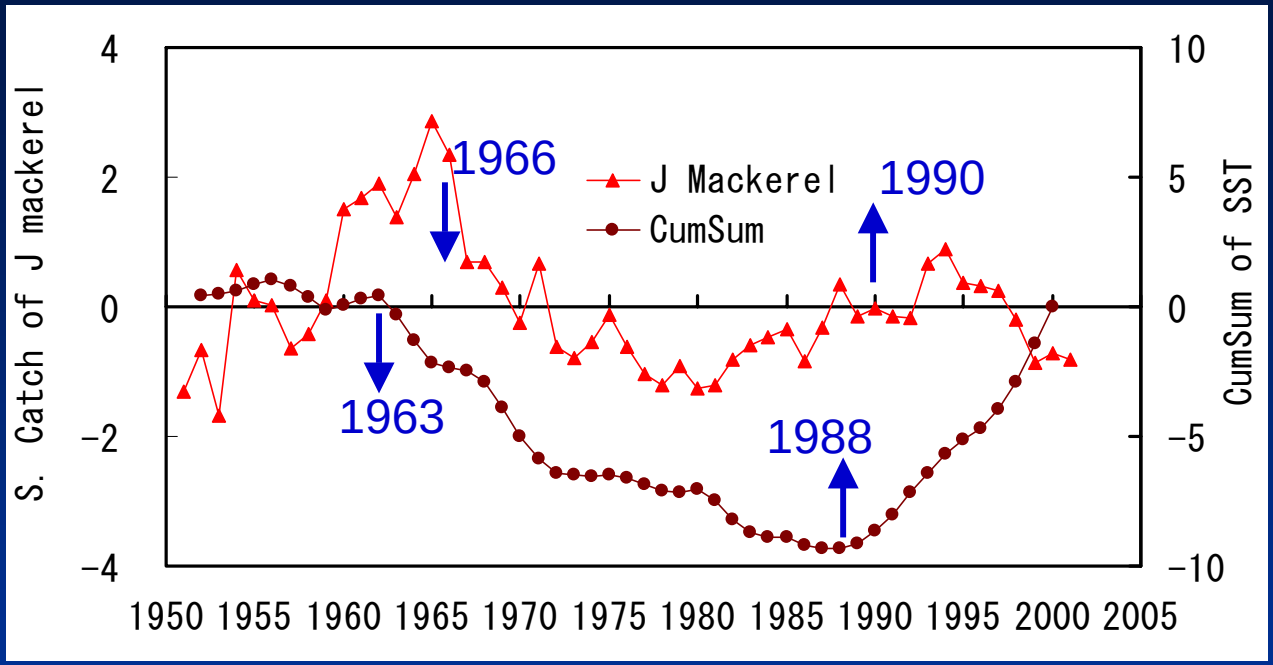
SST in spawning ground of Jack during spawning season

- Spawning is affected by runoff
- Spawning season: Feb-April
- Longevity: 4 yrs
- SST in past 4 yrs affects current population.
- Trend of SST: 4 turns





Catch of Jack

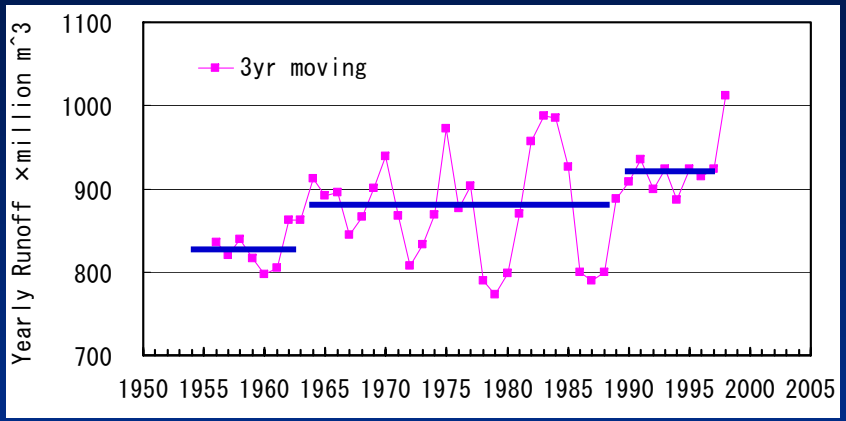


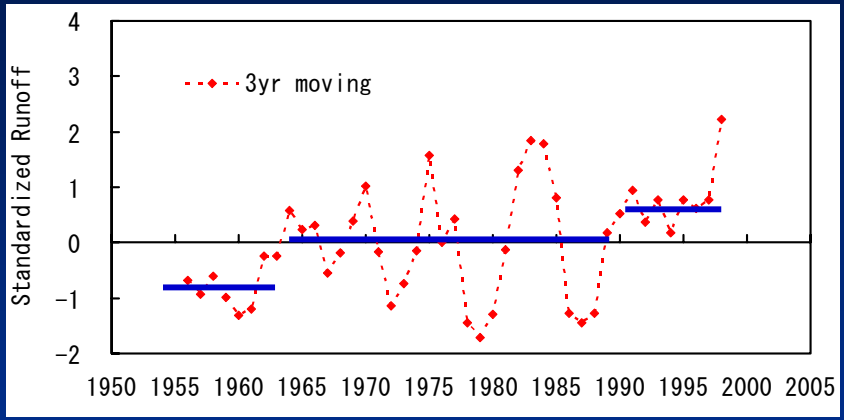
CumSum of SST anomaly

- 1963 turn of SST in ECS in spawning ground occurred 3 years earlier than before 1966 turn of Jack
- 1988 turn of SST was just 2 years before 1990 phase shift of Jack.

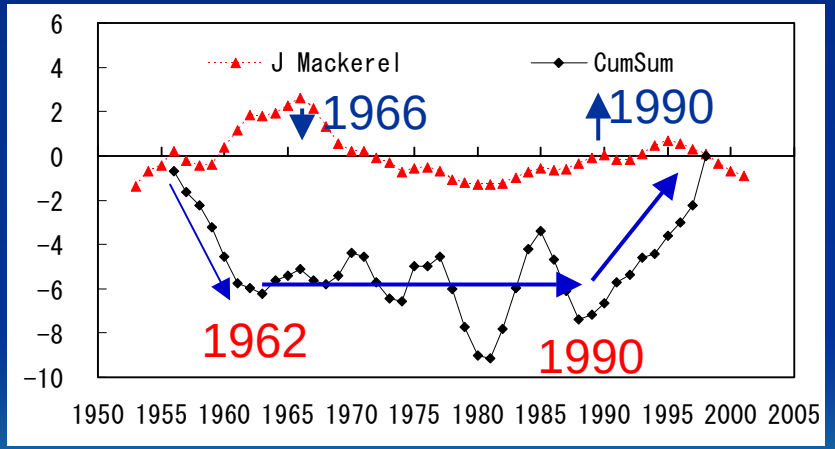
•~3 year lag between J Mackerel & SST implies the phase shift of Jack Mackerel is dependent on SST shift in its spawning ground during spawning season.

Annual Runoff of Changjiang River





- Annual runoff: 883.5 million m^3
- Increasing trend from 1956 to 1998,
- Experienced 3 phase:
  - 1956-61: Low level and stable
  - 1962-1989: middle and big oscillating
  - 1990-1998: high and stable

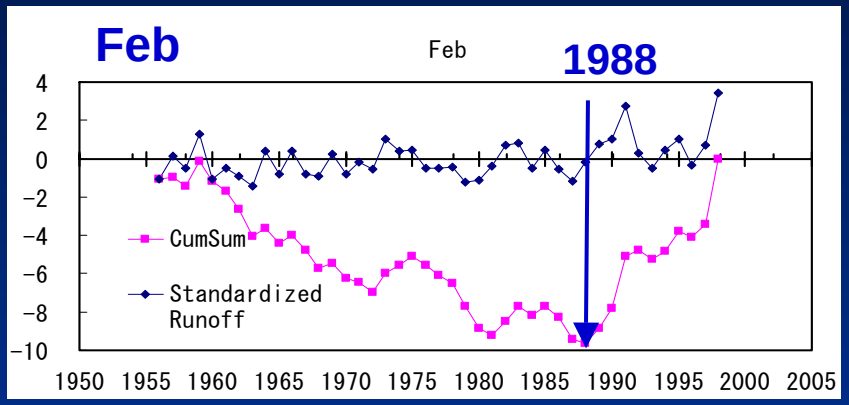


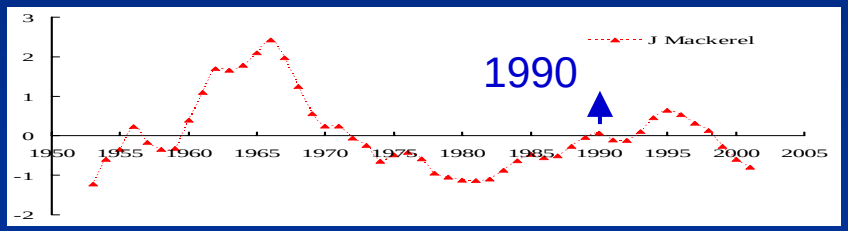
Runoff shift in 1962 was 4 years earlier than 1966 turn of Jack catch

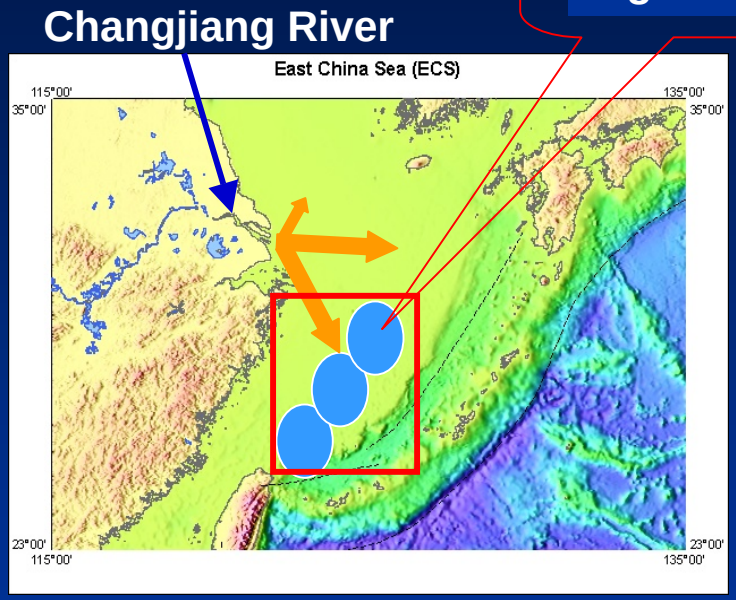
Runoff shift in 1990 was on the same year with phase shift of Jack catch

Trend turn of Jack is relative to the runoff shift of Changjiang River

Runoff in Feb and Jack Catch







Runoff in Feb:

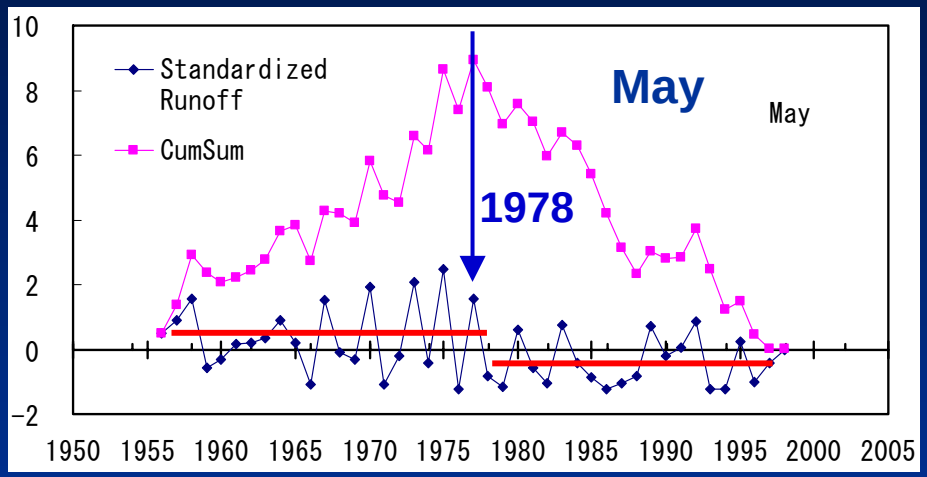
- Trend shift in 1988
- negative before 1988,
- positive after 1988.

J Mackerel:

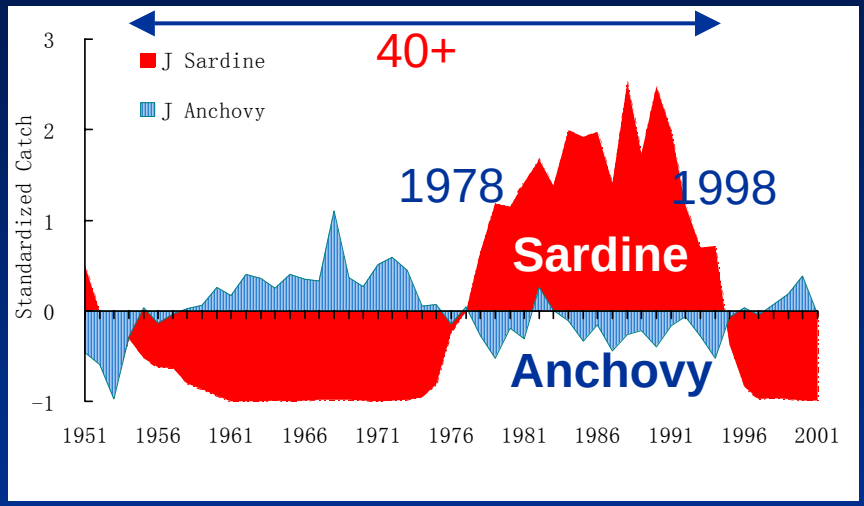
- Phase shift of Jack in 1990 was 2 yrs after runoff shift in 1988.

Implication: 1990's shift of Jack maybe is affected by 1988's shift of runoff of Changjiang River in Feb.

Standardized Runoff of Changjiang River in May



Standardized Catch of Sardine & Anchovy



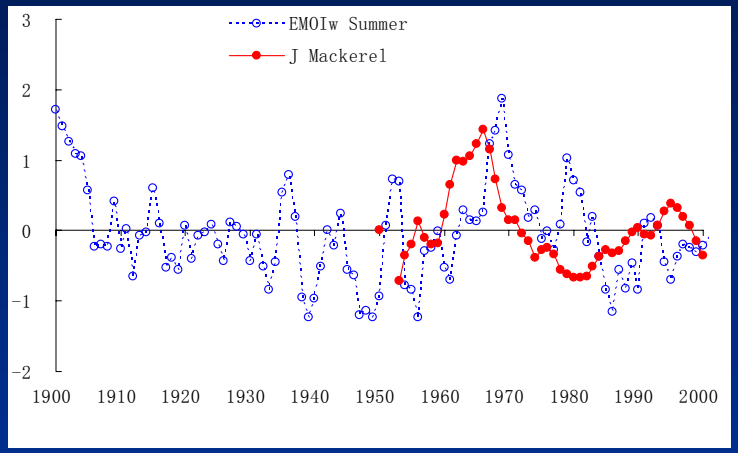
Runoff in May:

- **Trend turn on the same year with Sardine and Anchovy**

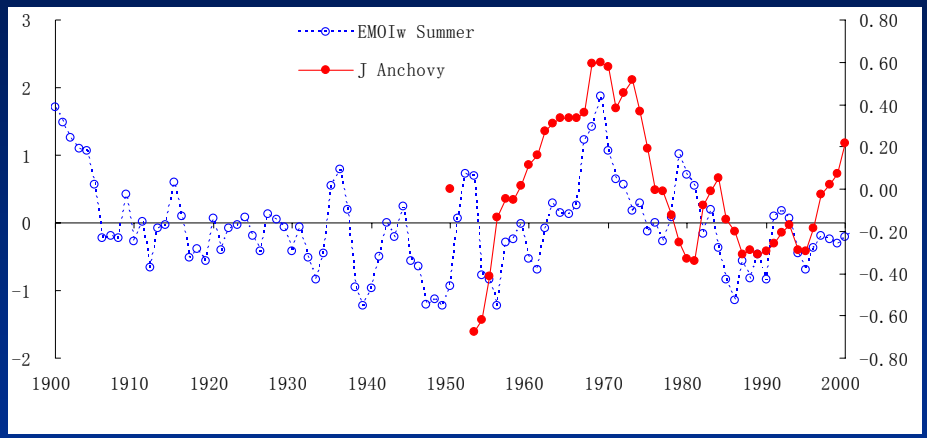
Are there some relationship between runoff in May and Sardine/Anchovy??

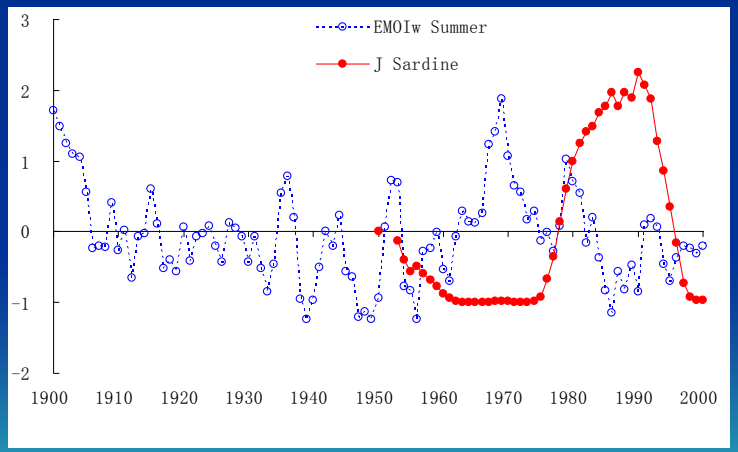
EAMOIw summer and catch in ECS

Jack, R=0.51



Anchovy, R=0.15





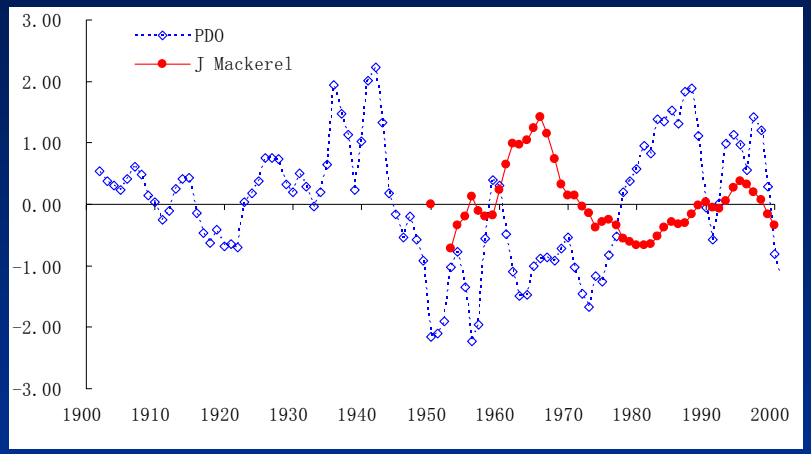
1950-2000:

- Generally, JM and JA shared same pattern with EMOI summer,
- While JS showed completely reverse pattern

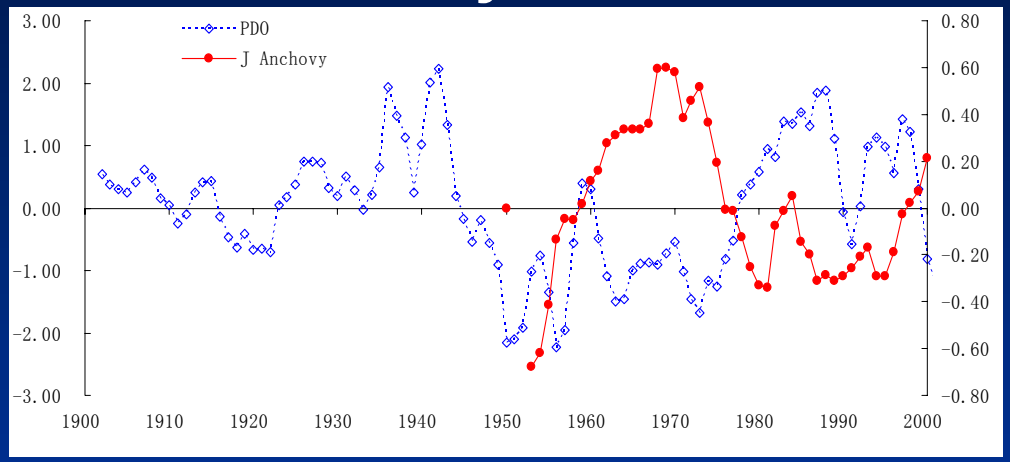
Sardine, R=-0.32

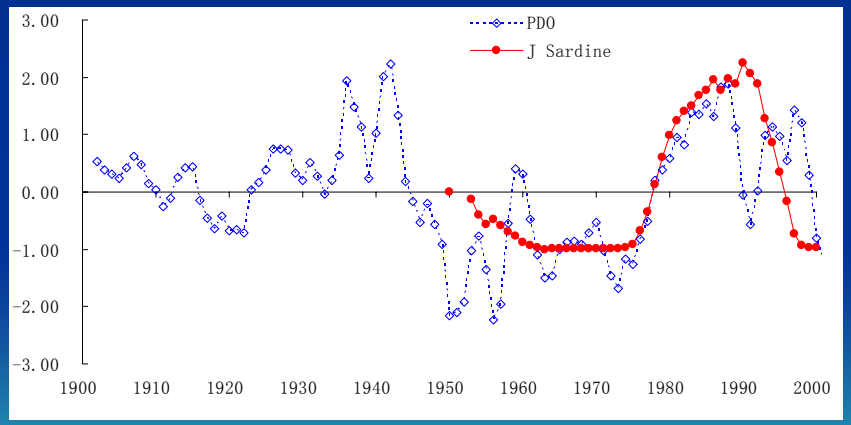
Annual PDO and Catch from ECS

Jack, R=-0.33



Anchovy, R=-0.45





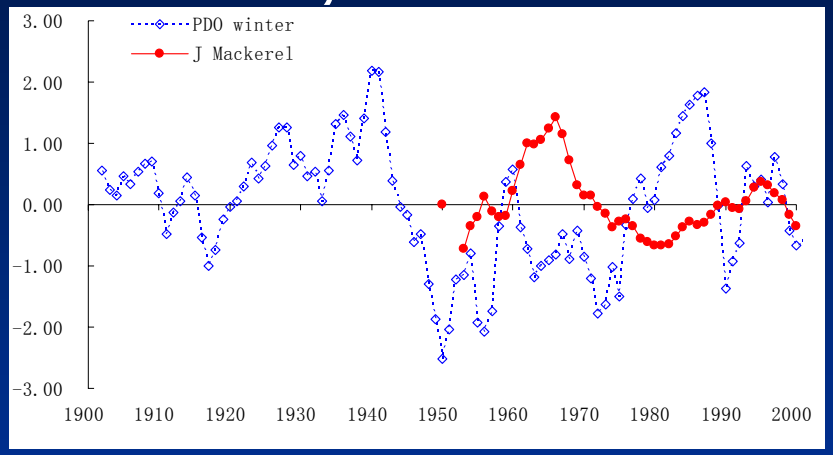
Sardine, R=0.68

1950-2000:

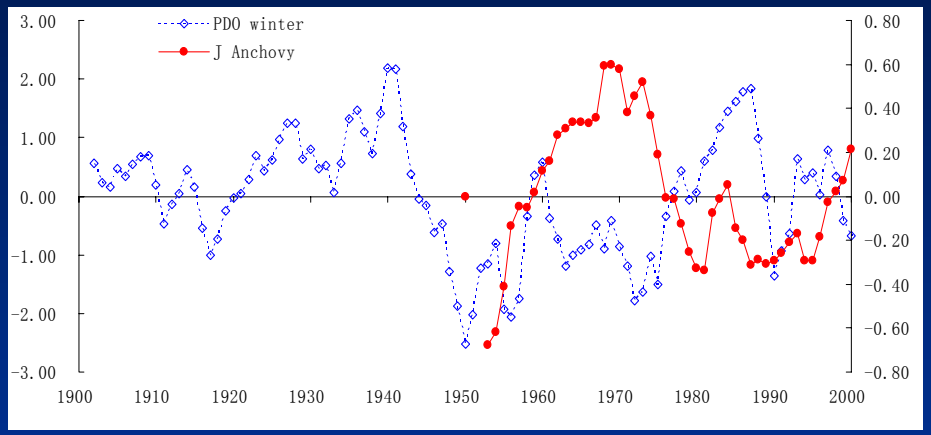
- Low PDO, more JM & JA, less JS
- High PDO, less JM & JA, more JS
- Opposite pattern between PDO & JM & JA
- Same pattern between PDO & JS

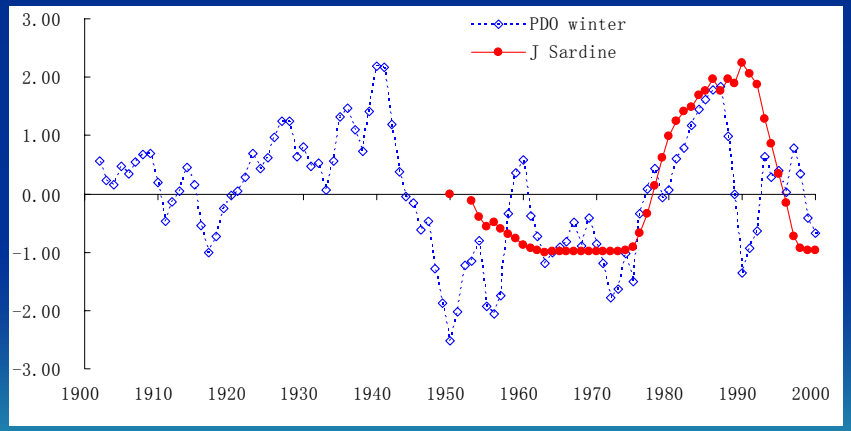
PDO winter and Standardized Catch

Jack, R=-0.29



Anchovy, R=-0.31





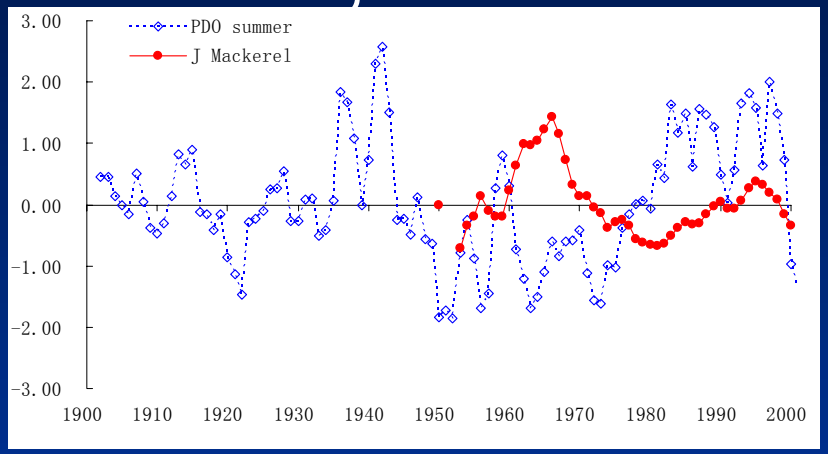
Sardine, R=0.57

1950-2000:

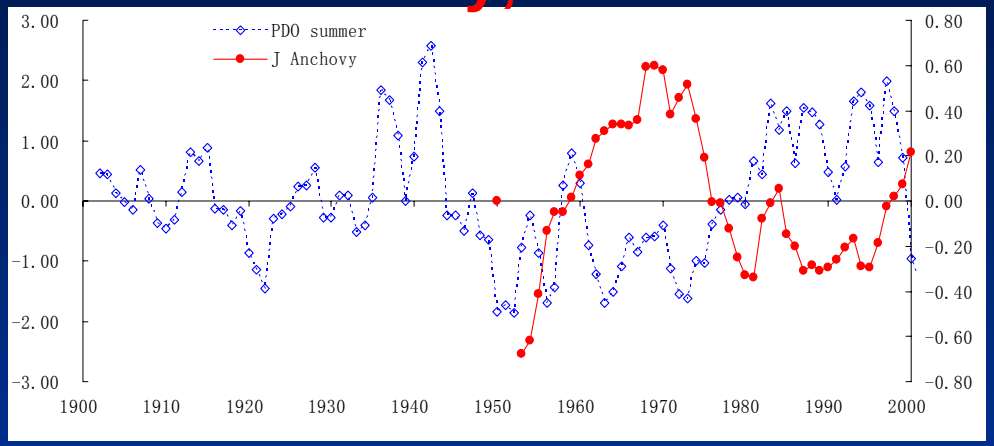
- Low PDO winter, more JM & JA, less JS
- High PDO winter, less JM & JA, more JS
- Opposite pattern between PDO win & JM & JA,
- Same pattern between PDO win & JS

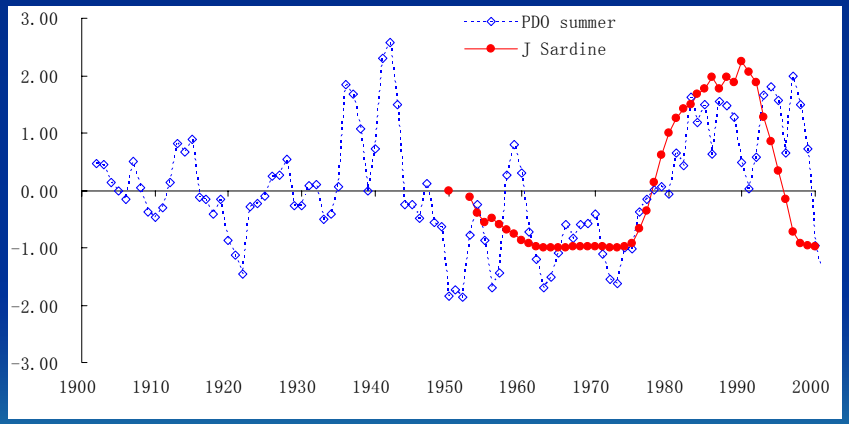
PDO summer and Standardized Catch

Jack, R=-0.31



Anchovy, R=-0.50





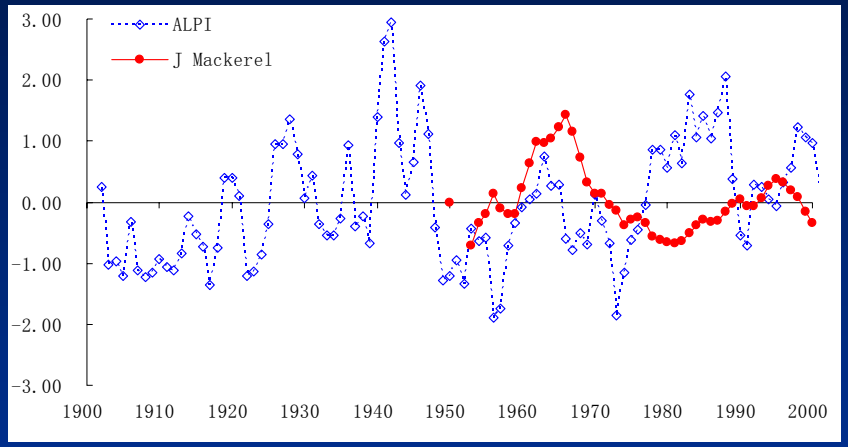
Sardine, R=0.64

1950-2000:

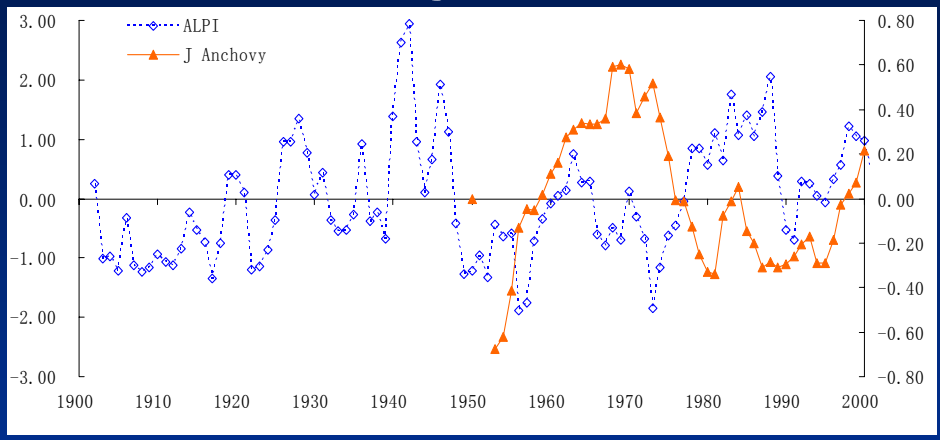
- Low PDO summer, more JM & JA, less JS
- High PDO summer, less JM & JA, more JS
- Opposite pattern between PDO sum & JM&JA,
- Same pattern between PDO sum & JS

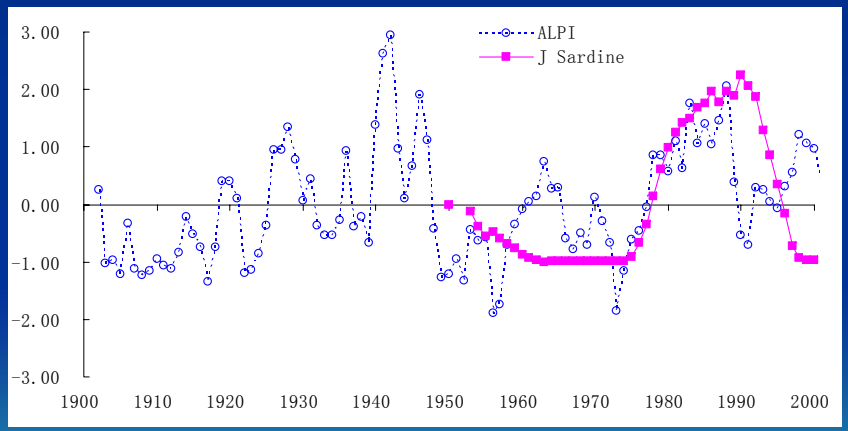
ALPI and Catch in ECS

Jack, R=-0.21



Anchovy, R=-0.25





JM & JA:
1963-2000: Opposite pattern with ALPI,

JS:
Same pattern with ALPI

Sardine, R=0.47

Summary

	J Mackerel
EAMOIw Summer	S
WPI winter	S-
SAI	No
SOIX	No
NOI	No
EAMOI summer	No
EAMOIw Winter	No
EAMOIw Spring	No
NPI_NCAR	O-
AOI	O-
MEnsoi	O-
SOI	O-
ALPI	O-
PDO	O
PDO winter	O
PDO summer	O


J Anchovy
EAMOIw Summer S
SAI S-
WPI winter S-
SAI No
SOIX No
SOI O-
AOI O-
MEnsoi O-
NPI_NCAR O-
EMOIw Winter O-
EMOIw Spring O
PDO O
PDO winter O
PDO summer O
ALPI O
J Sardine
PDO S+
PDO winter S+
PDO summer S+
ALPI S
SAI S-
AOI S-
MEnsoi S-
WPI winter S-
SOI S-
NOI No
EAMOIw Winter No
EAMOIw Spring No
SOIX O-
NPI_NCAR O
EAMOIw Summer O+

Conclusions:

SST: increasing in ECS since 1925,
From cold to cool phase in 1940
From cool to warm phase in 1992

J Sardine and Anchovy appeared the opposite pattern of biomass trend at same years.
J S: ↑ in 1978, ↓ in 1998.
J A: ↓ in 1978, ↑ in 1998.

J Mackerel and Anchovy appeared the similar pattern of biomass trend. But the shift of J Mackerel came earlier than JA.

Trend of Jack in ECS is dependent on SST of ECS and runoff of Changjiang River. However Sardine & Anchovy are different with it.

Dynamics of Jack mackerel is strongly related to East Asian Summer Monsoon.
Dynamics of Japanese Sardine and Anchovy are strongly related to PDO summer.

Did Regime Shift Occur in East China Sea too?

- Yes! Regime shift has occurred in ECS although the phase shift of fishes does not match with SST and runoff.
- More evident and further analysis wanted.
- The regime shift of ECS should be considered in marine management and prediction.


Thanks

Mann-Kendall Method

- Firstly built to check the trend of time series data by Mann in 1945
- Improved by Goossens(1986) to check jump point or abrupt change point of climate change.
- to check the jump point of long-term time series data, e.g. SST, PDO,NOI, AOI,MOI, fish catch etc.
- To answer which year the regime shifted in.

  Although shift duration usually lasts several years, but it is still our interest to know when the regime shifted.