PICES 2009.10.26 S2

Climate-driven ecosystem shifts indicated in fishery catch statistics (1968-2008) from Korean coastal waters

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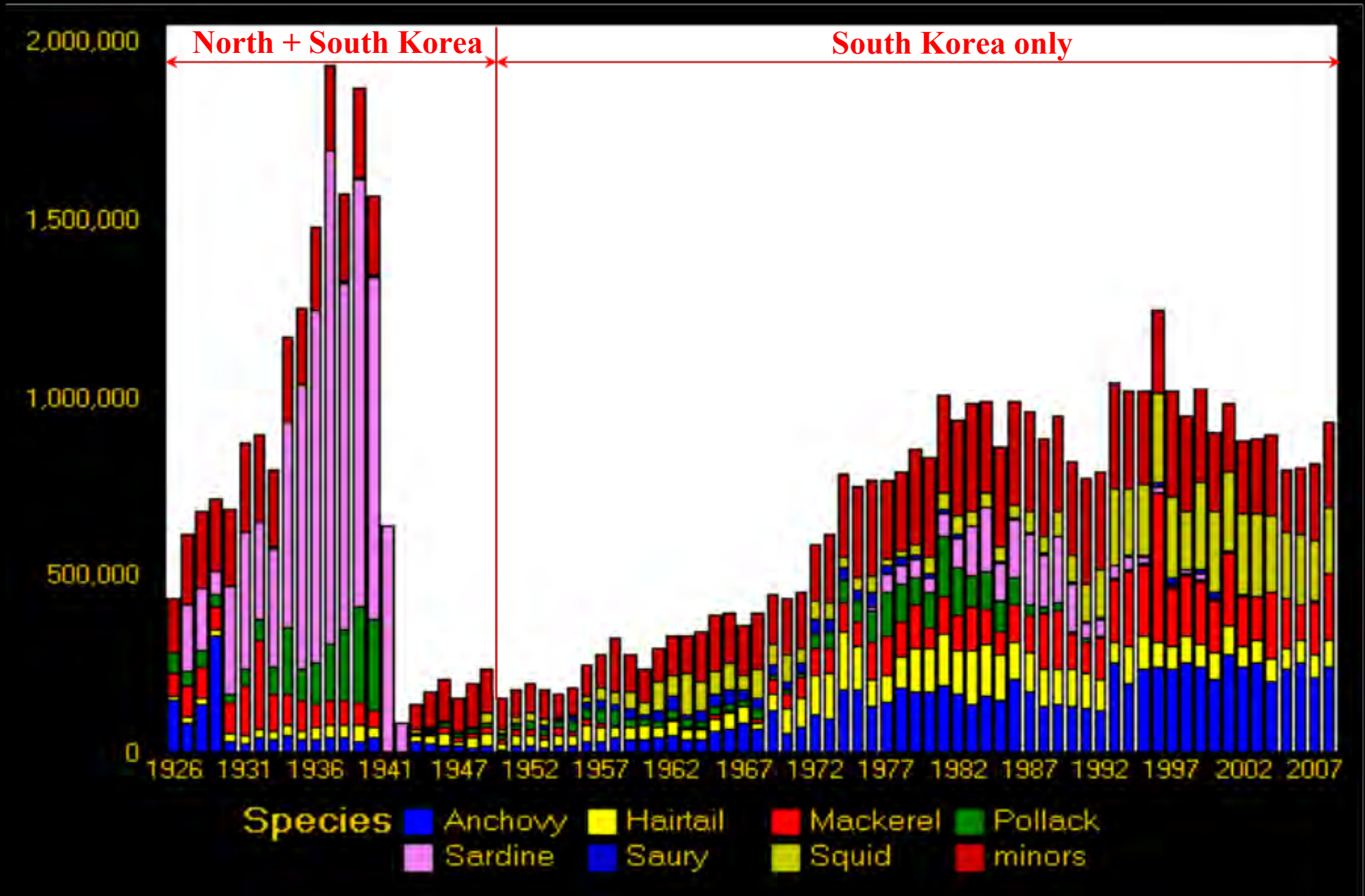
Young-Sang Suh, Sukyung Kang and Yeong Gong

Annual Catch from Korean Sea Waters (marine capture fisheries, metric tons)



Issue

- Fishing vs. Climate hypotheses
  - Traditional stock assessment
    - Overfishing has been the major factor in fluctuating fish catch
    - The major culprit is fishermen
  - Climate change and global warming
    - Natural and anthropogenic forcing and subsequent environmental changes have been the major factor
    - No culprit or all of us are responsible

Question

- What has been the major factor of fluctuating catches and changing dominant fishery species in Korean waters?
  - Fishing vs. Climate

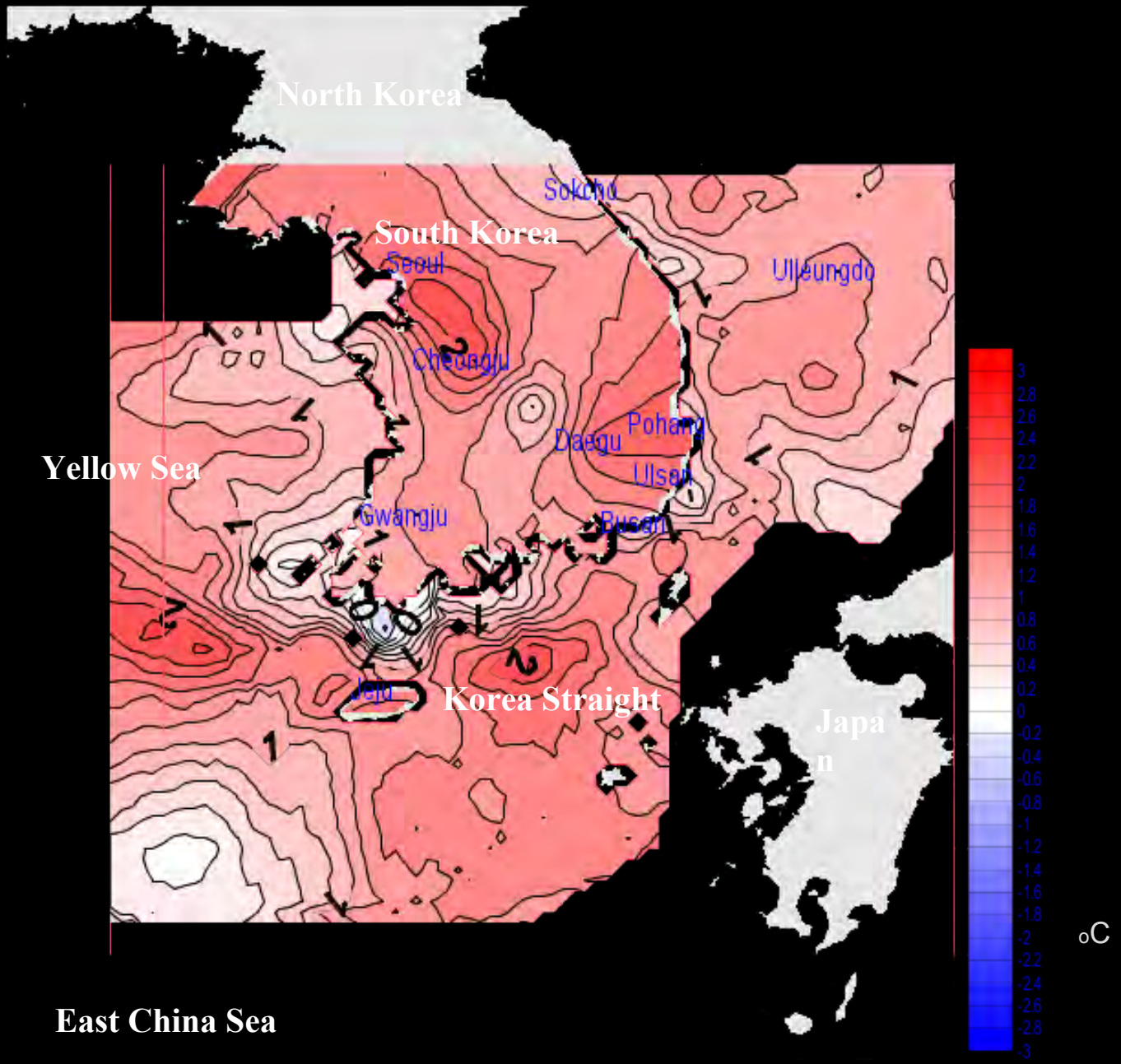
1. Global warming and oceanic changes in Korean waters

Long-term Data in Korea

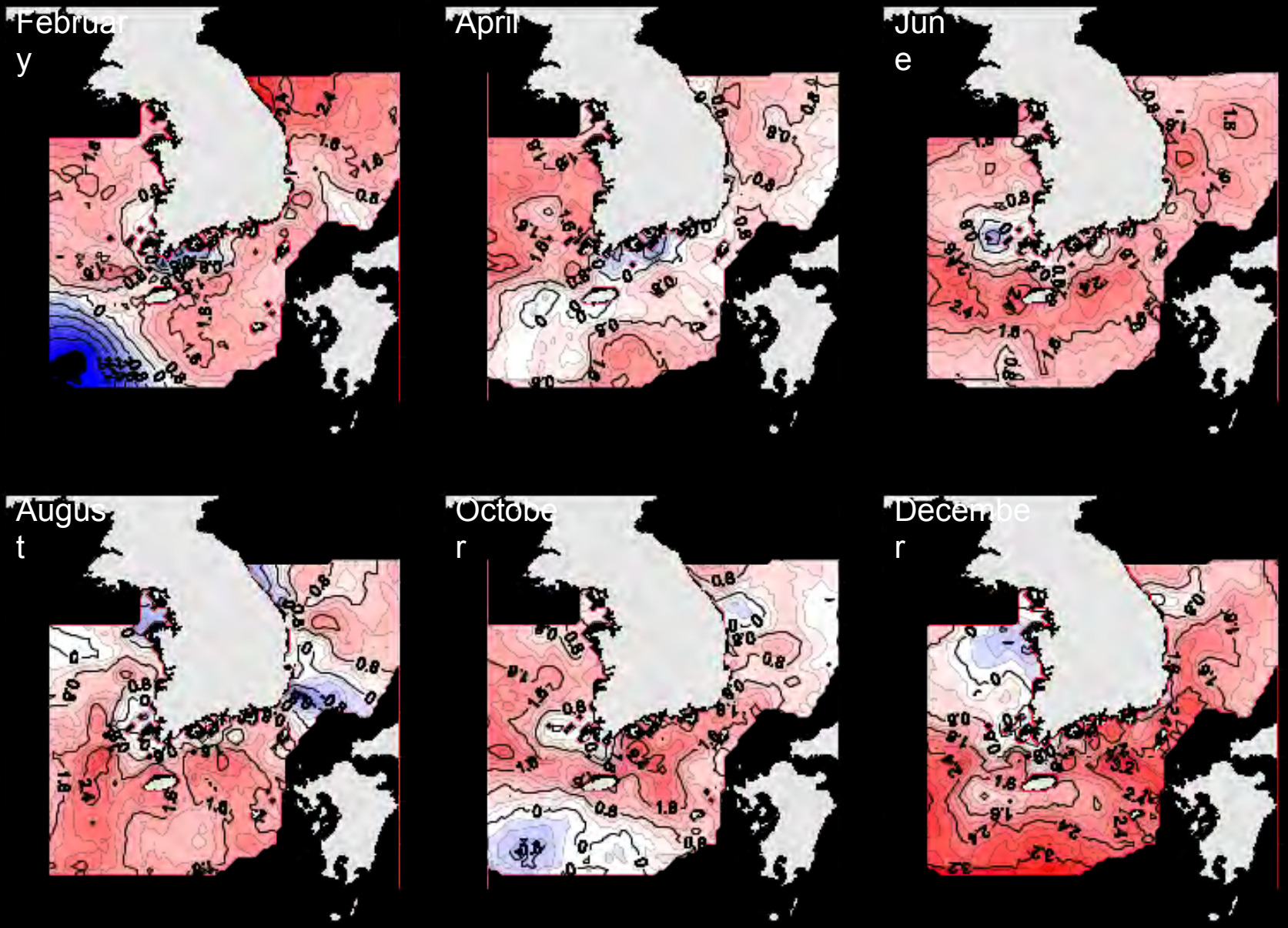
- NFRDI, Korea
  - Depth-specific water temperature, salinity and dissolved oxygen (1968-2006)
  - Zooplankton: vertical tows by a NORPAC net with 0.33-mm mesh size (1965-2006)
  - Bimonthly
- MIFAFF, Korea
  - Statistics of Marine Capture Fisheries (1968-2008)
- Korea Meteorological Administration
  - Air temperature and precipitation at 22 cities (1968-2006)

Stations for Serial Oceanographic Data
NFRDI (Korea Oceanographic Data Center)
1921-2008, ca. 190 stations

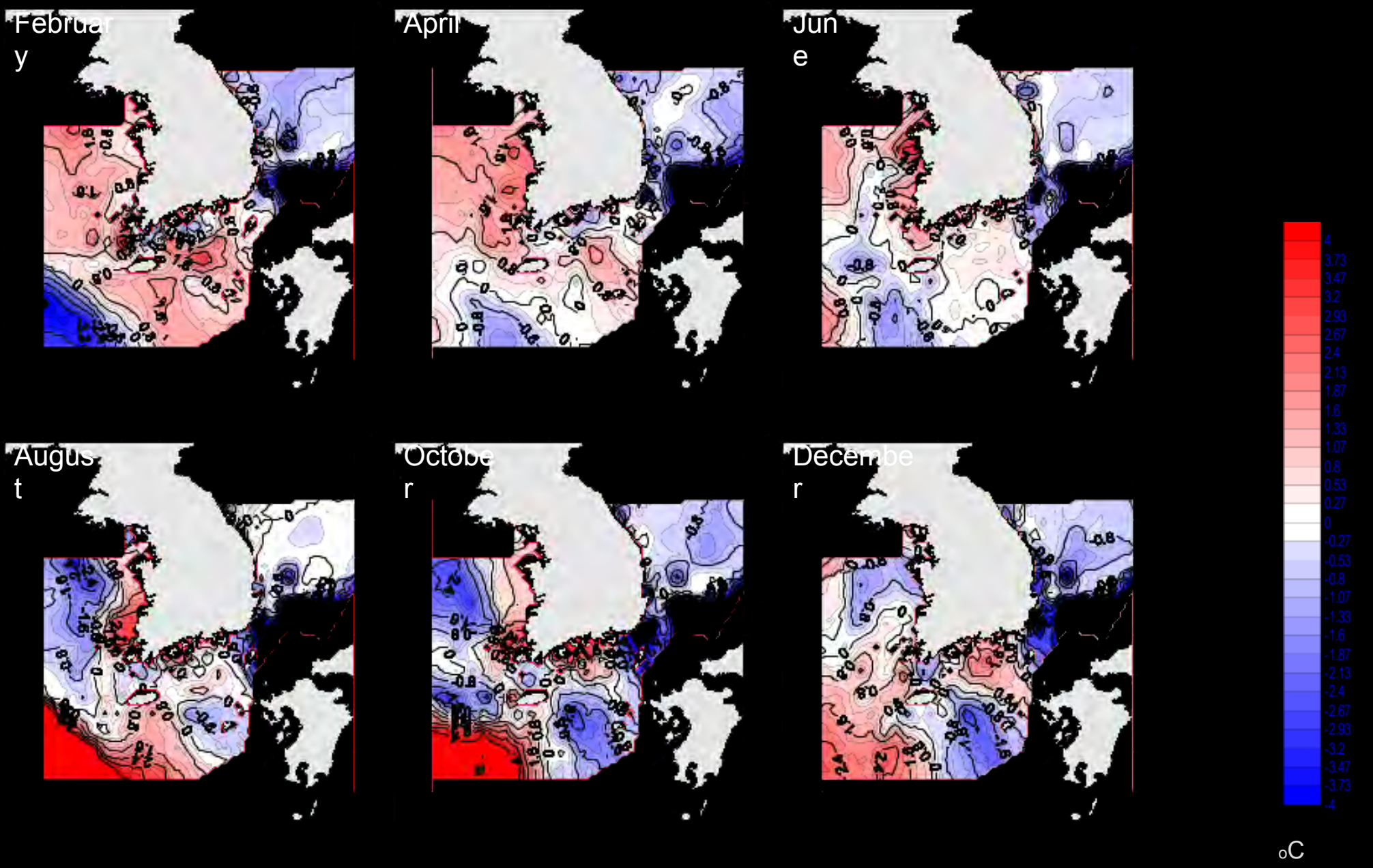
Linear trend of temperature change (oC) in the land and sea surface (1968-2007)



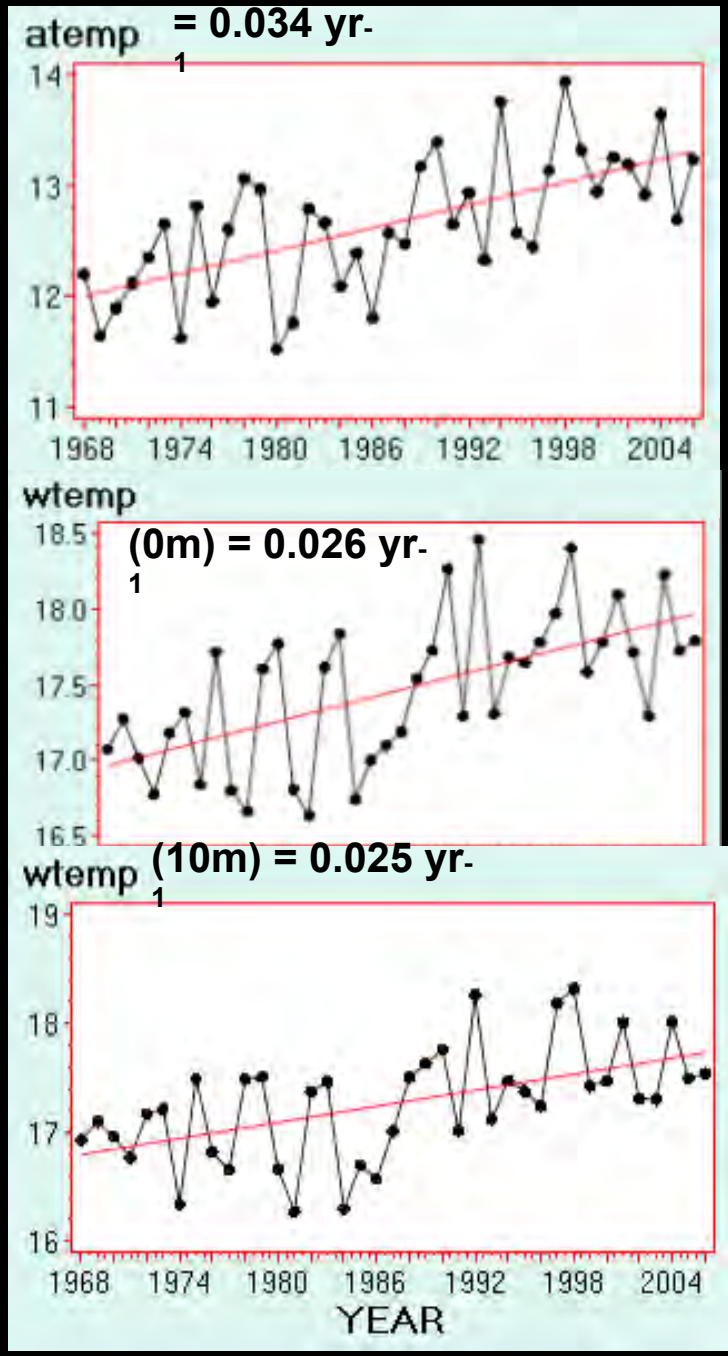
Linear Trend of Change in Water Temperature at 0 m (1968-2007)

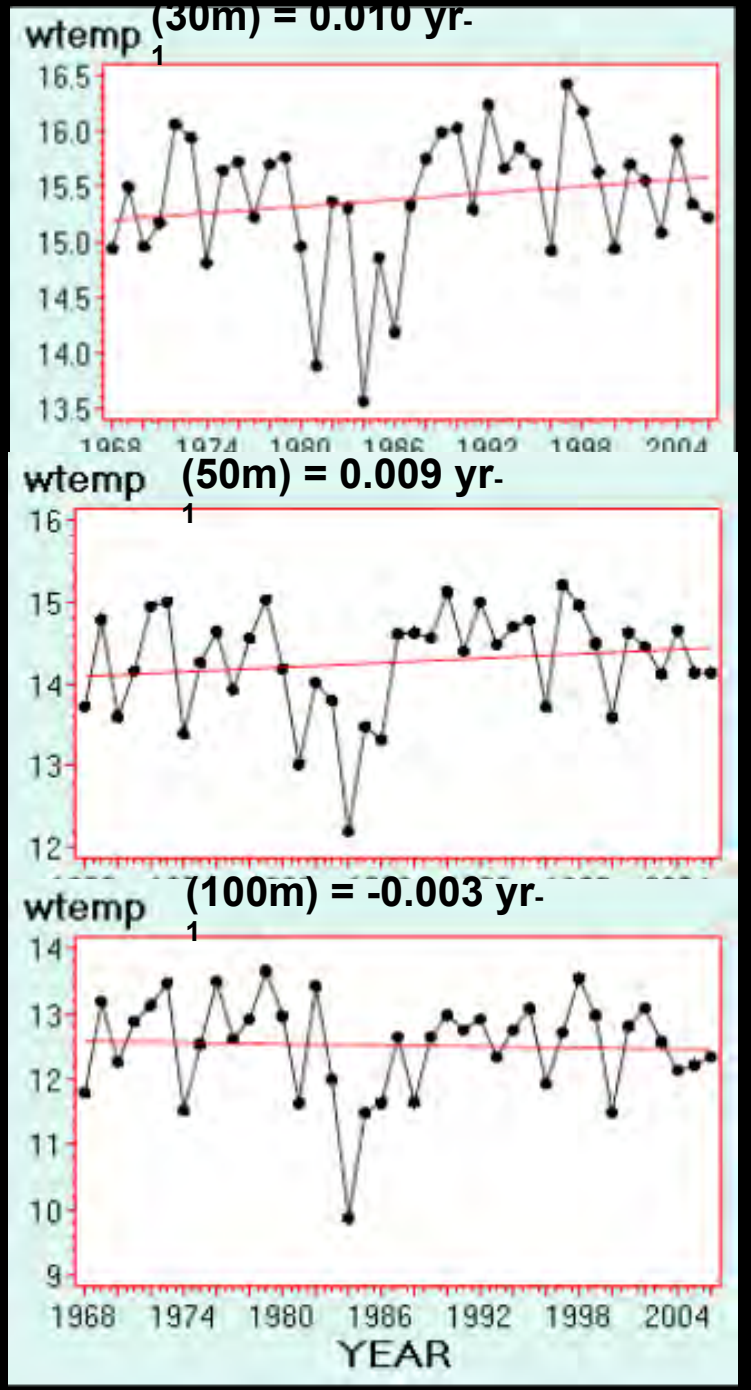


Linear Trend of Change in Water Temperature at Bottom (1968-2007)

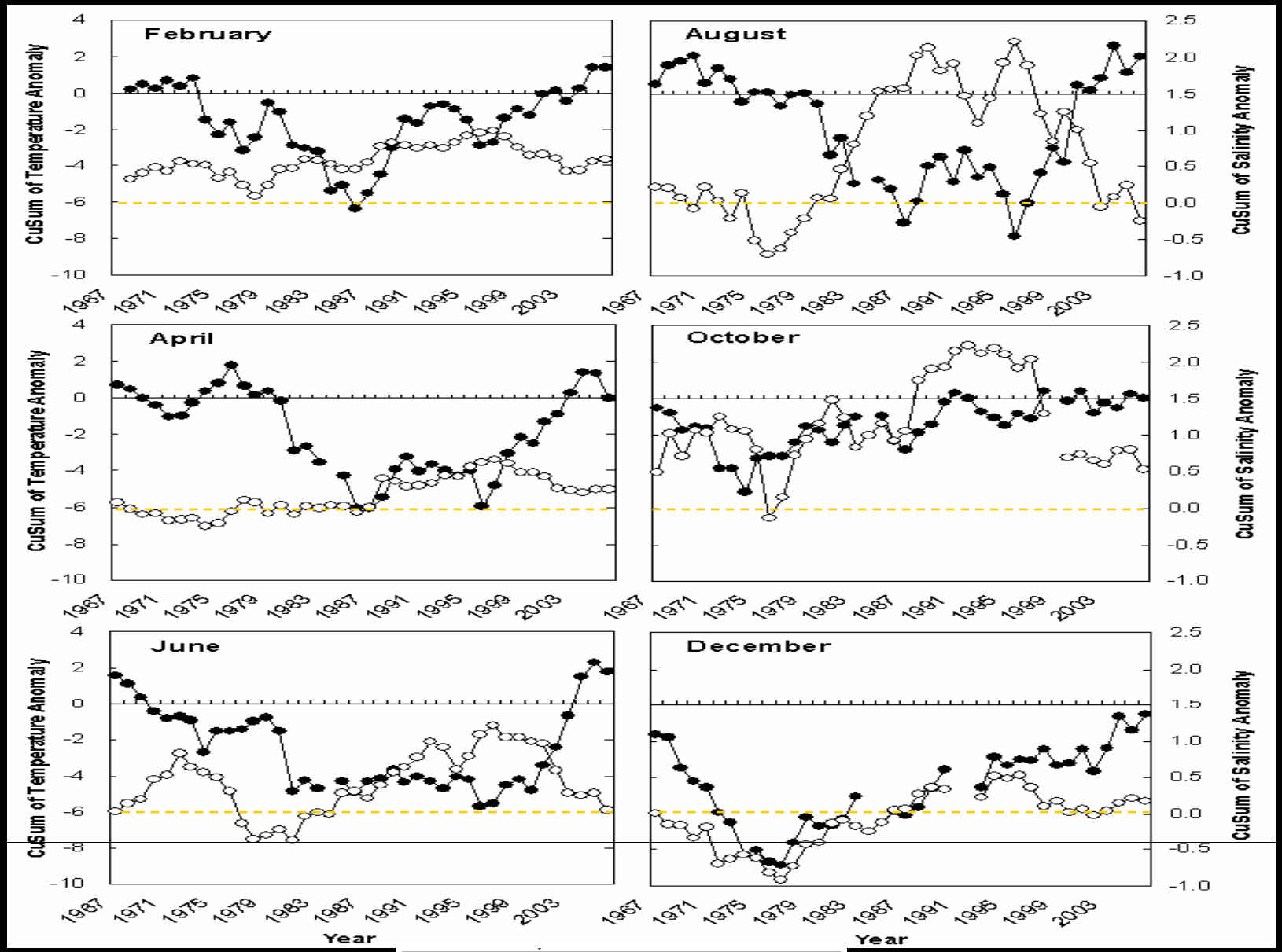


Linear trend of air & water temperature changes 1968-2006

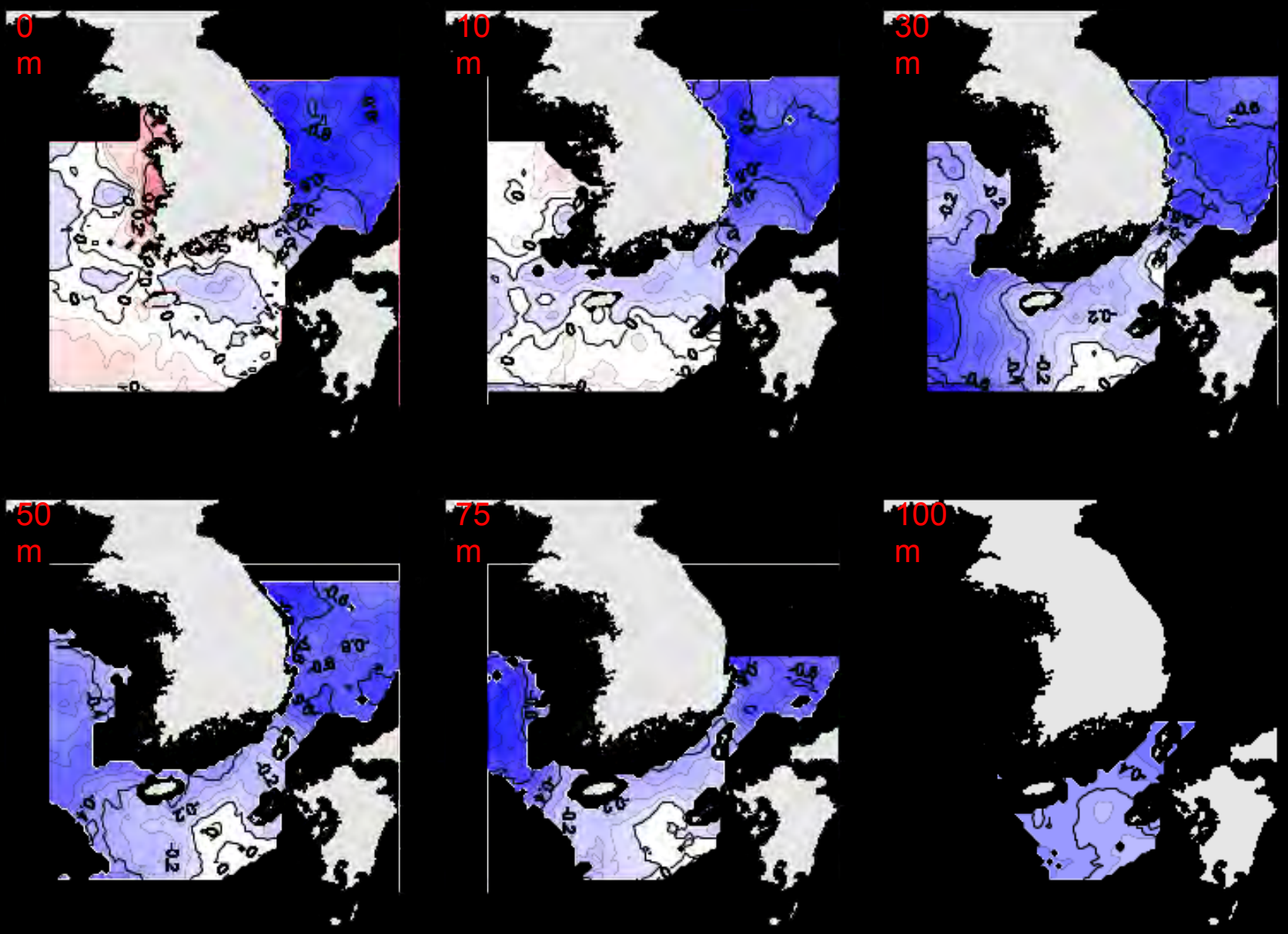




CuSum of annual mean anomalies of temperature and salinity at 10-m depth 1967-2006 , southwestern Janpan/East Sea (Kang et al, submitted)



DO Decadal Change (1968-2005)



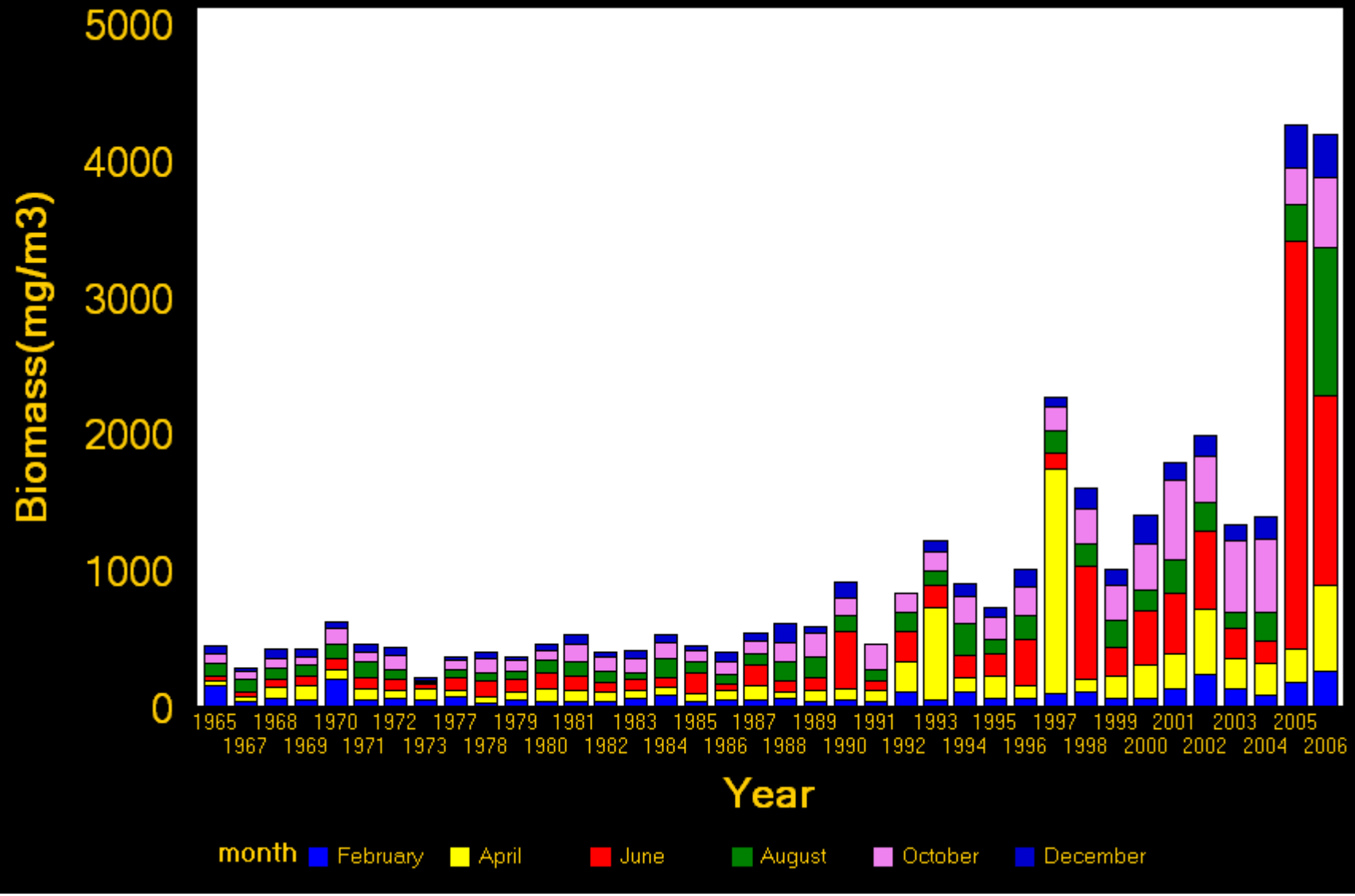
Summary

- From 1968 to 2007, air temperatures increased on average by 1.4^{o}C, and sea surface temperatures by 1.2^{o}C.
- The increase by 1.2^{o}C in both of the land and sea seems to be related with global factors, but 2 x higher than the global mean reported by IPCC .
- The increasing trend diminished with water depth
- Decreasing dissolved oxygen has been probably related with strengthened pycnocline and deteriorated water quality.

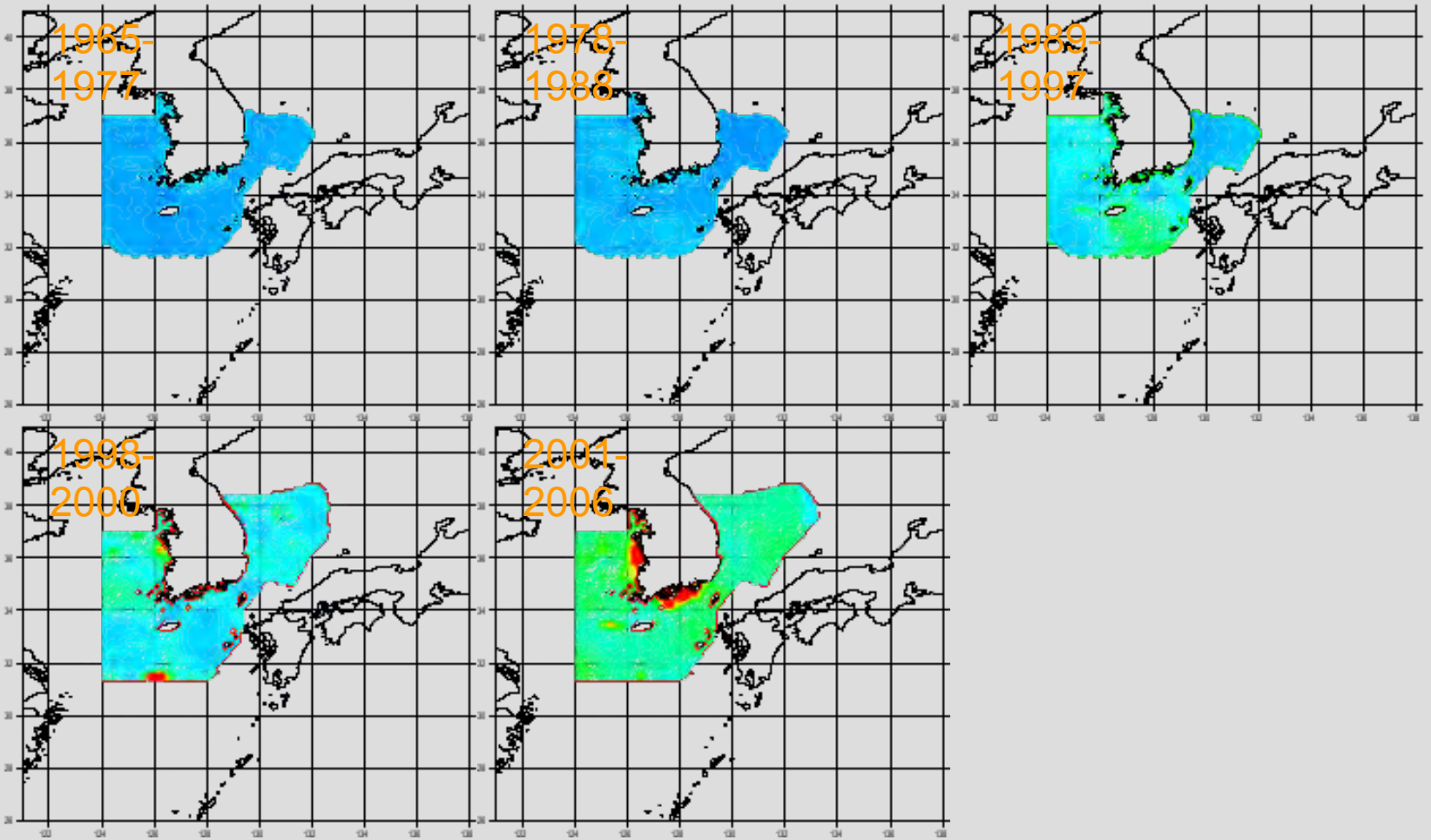
2. Responses of marine ecosystems to the global warming

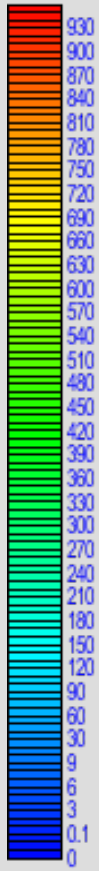
Meso-zooplankton biomass

KODC



Meso-zooplankton Averaged biomass (1965-2006)

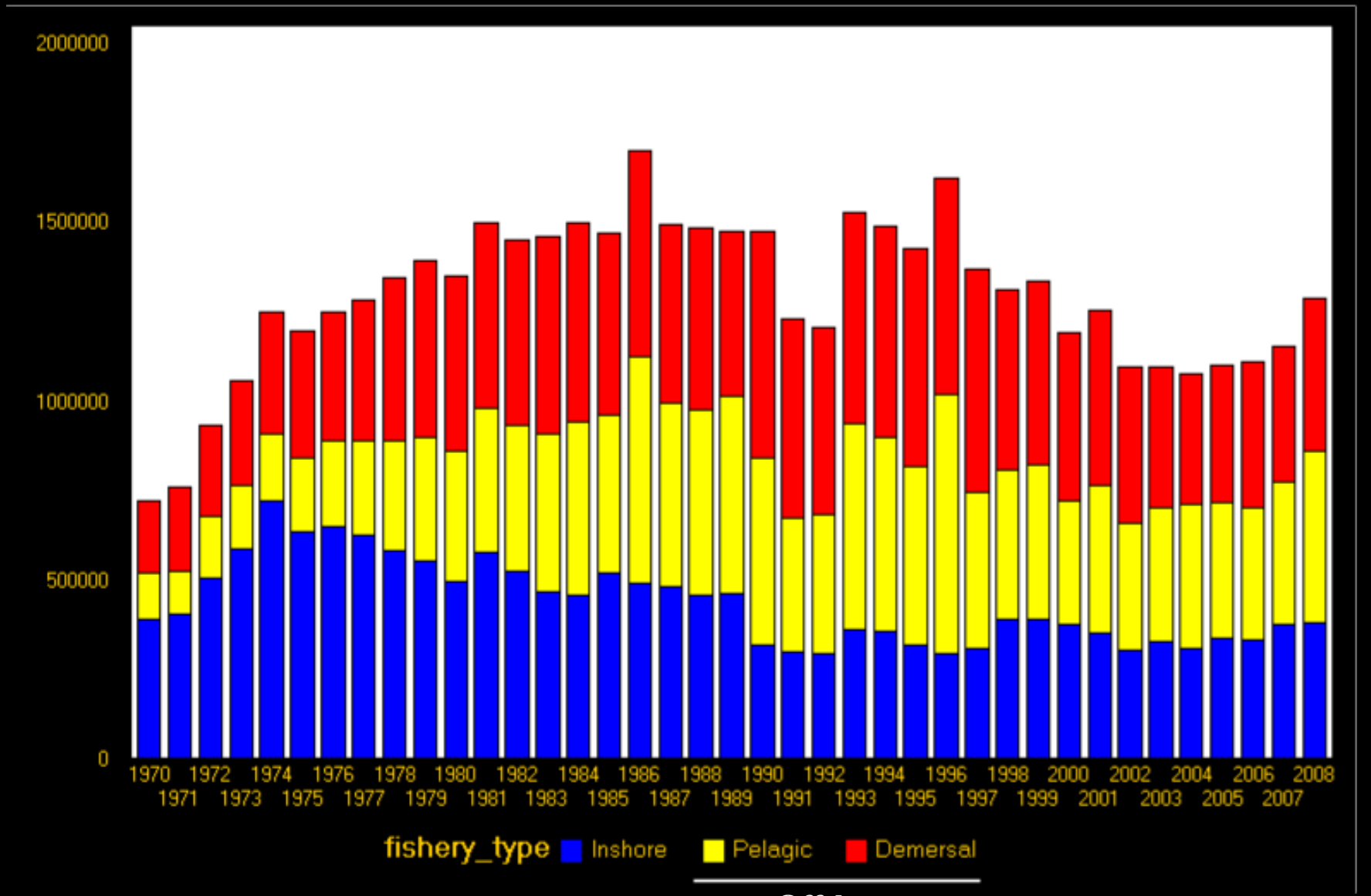


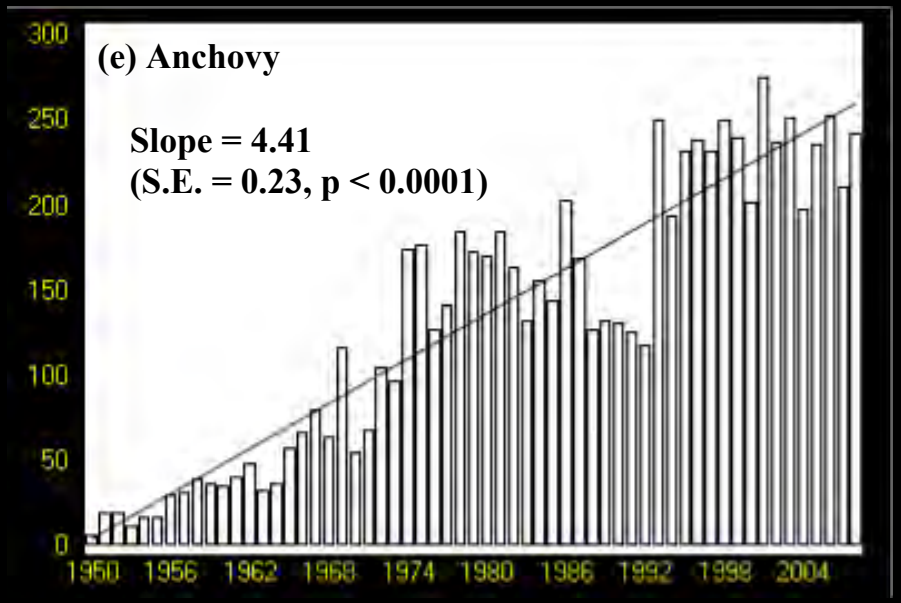


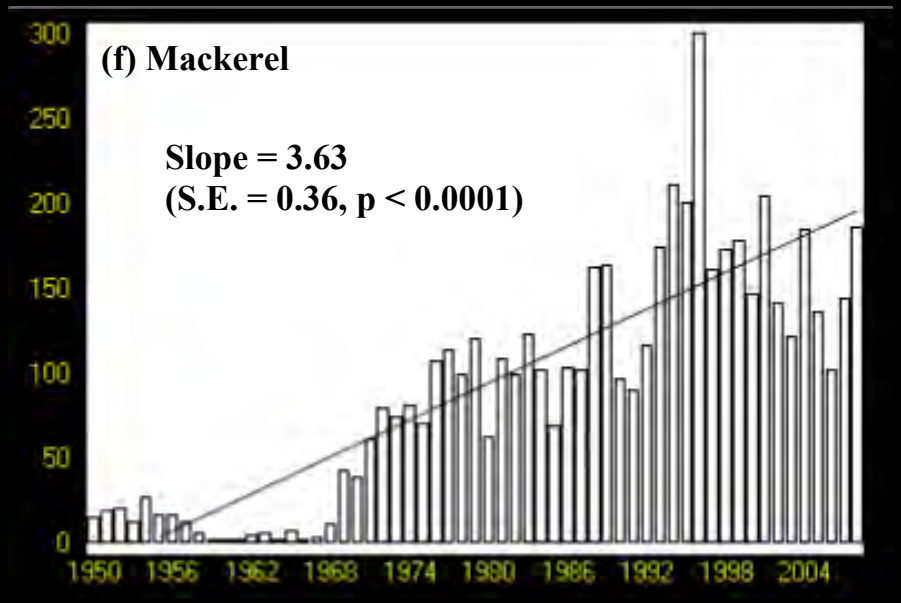
mg m^{-3}

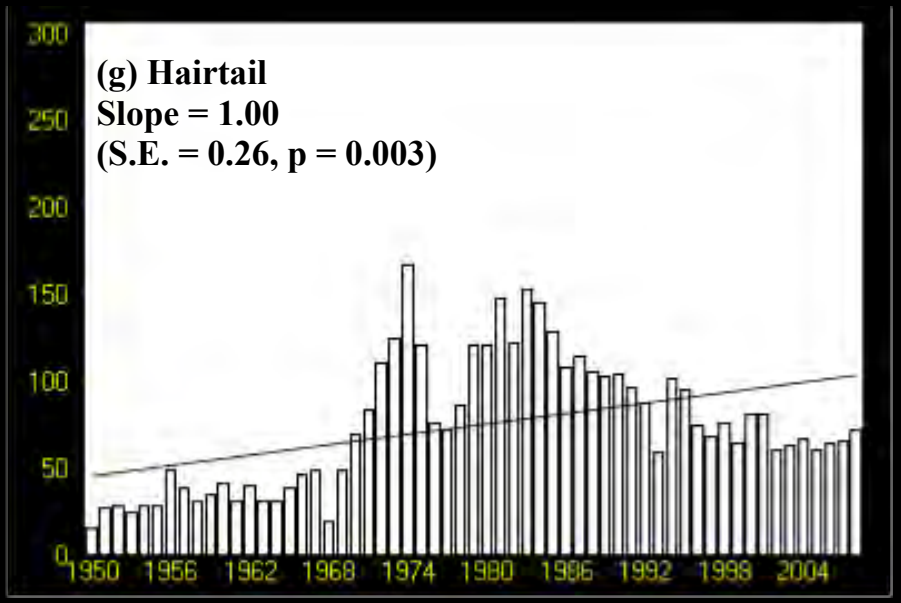
- Mesh size = 330 micron

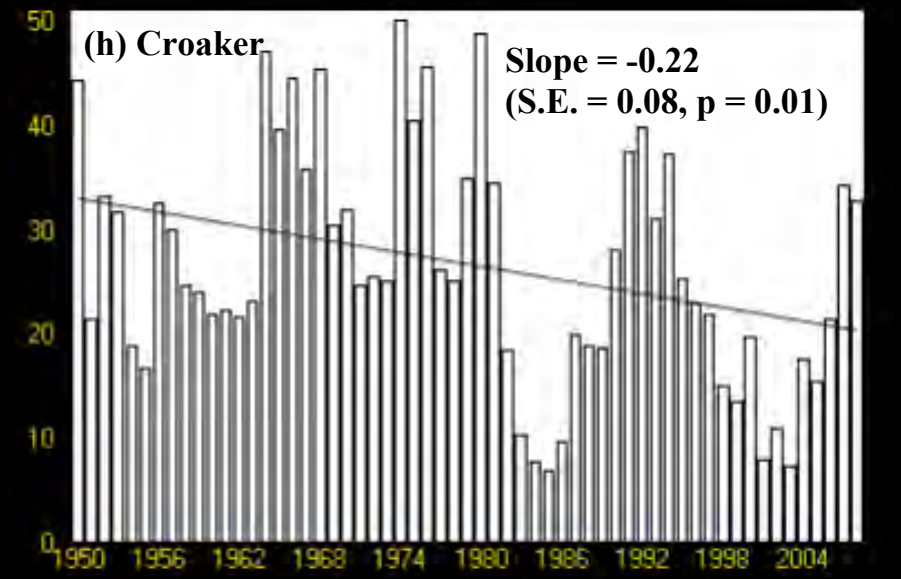
Annual Change in Catch by Korean Marine Capture Fisheries




(e) Anchovy
Slope = 4.41
(S.E. = 0.23, p < 0.0001)
300
250
200
150
100
50
0
1950 1956 1962 1968 1974 1980 1986 1992 1998 2004


(f) Mackerel
Slope = 3.63
(S.E. = 0.36, p < 0.0001)
300
250
200
150
100
50
0
1950 1956 1962 1968 1974 1980 1986 1992 1998 2004

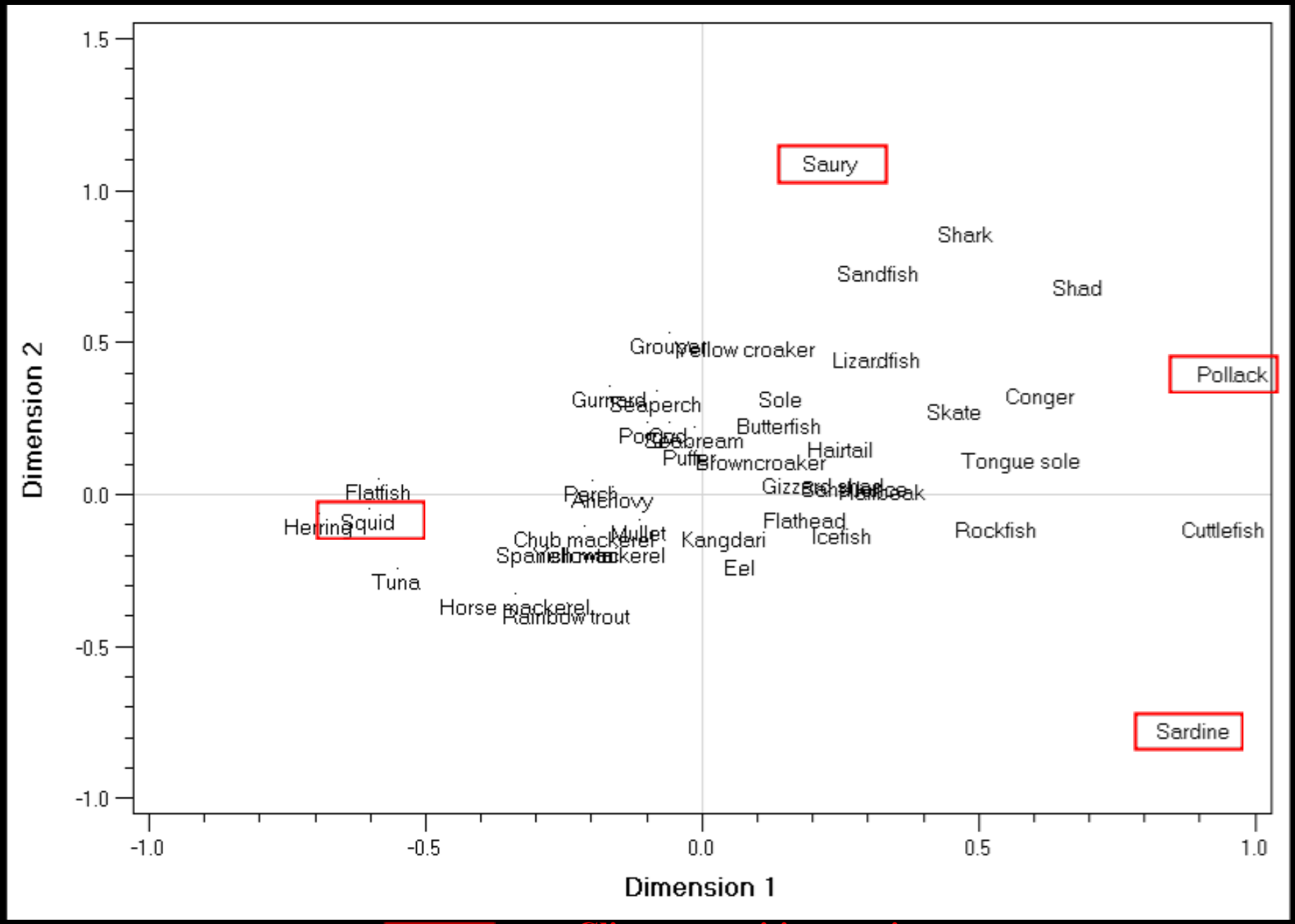

(g) Hairtail
Slope = 1.00
(S.E. = 0.26, p = 0.003)
300
250
200
150
100
50
0
1950 1956 1962 1968 1974 1980 1986 1992 1998 2004


(h) Croaker
Slope = -0.22
(S.E. = 0.08, p = 0.01)
50
40
30
20
10
0
1950 1956 1962 1968 1974 1980 1986 1992 1998 2004

Problems of Korean fisheries catch statistics in evaluating effects of climate changes

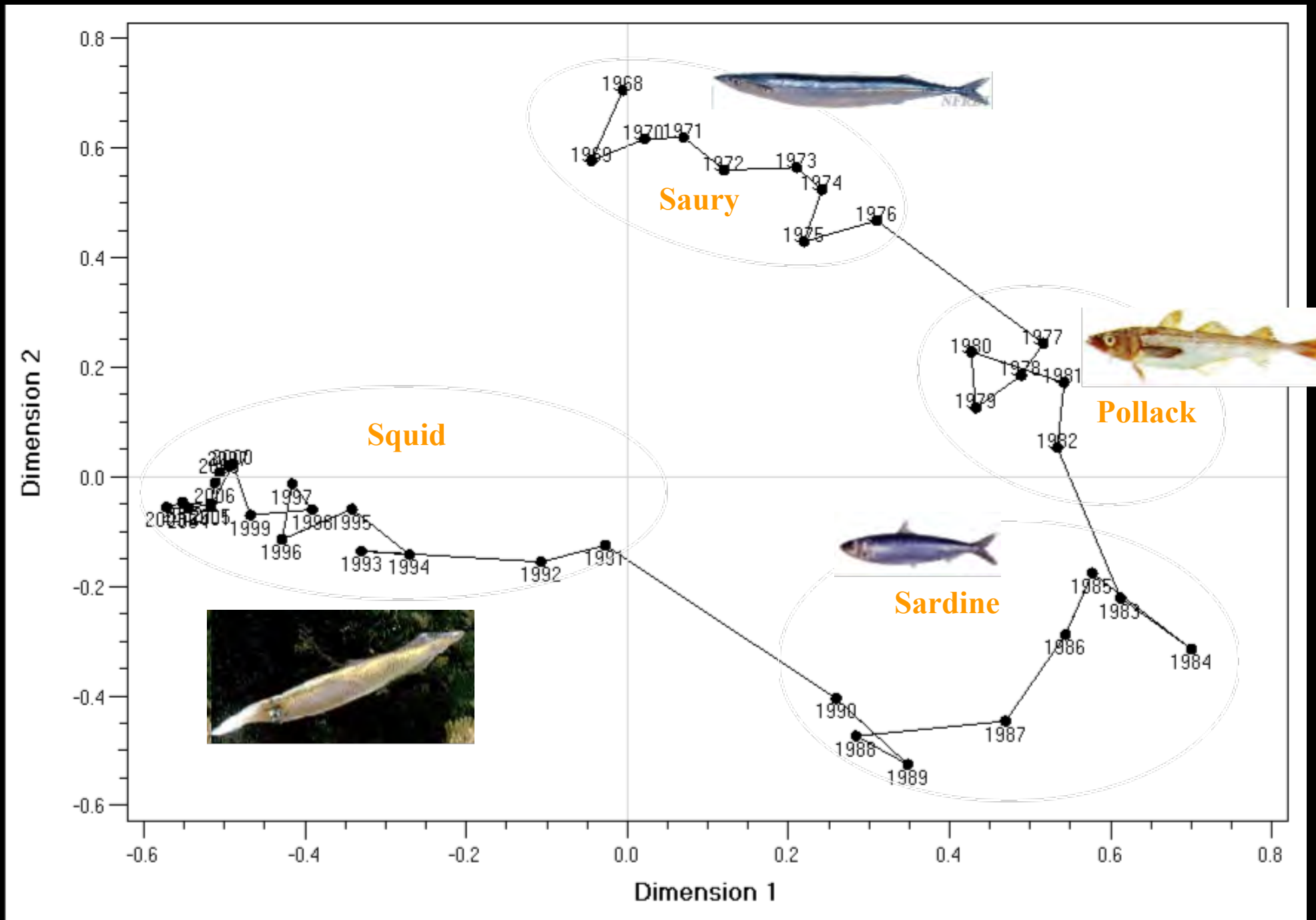
- Spatially-explicit catch data are available just since 1983.
- Greater uncertainty in fishing effort
- Derived CPUEs are unreliable to represent standing stock biomass.
- However, species composition may be less biased than catch or CPUE data → Correspondence analysis

Correspondence analysis on species composition of fishery catch in Korea



Climate-sensitive species

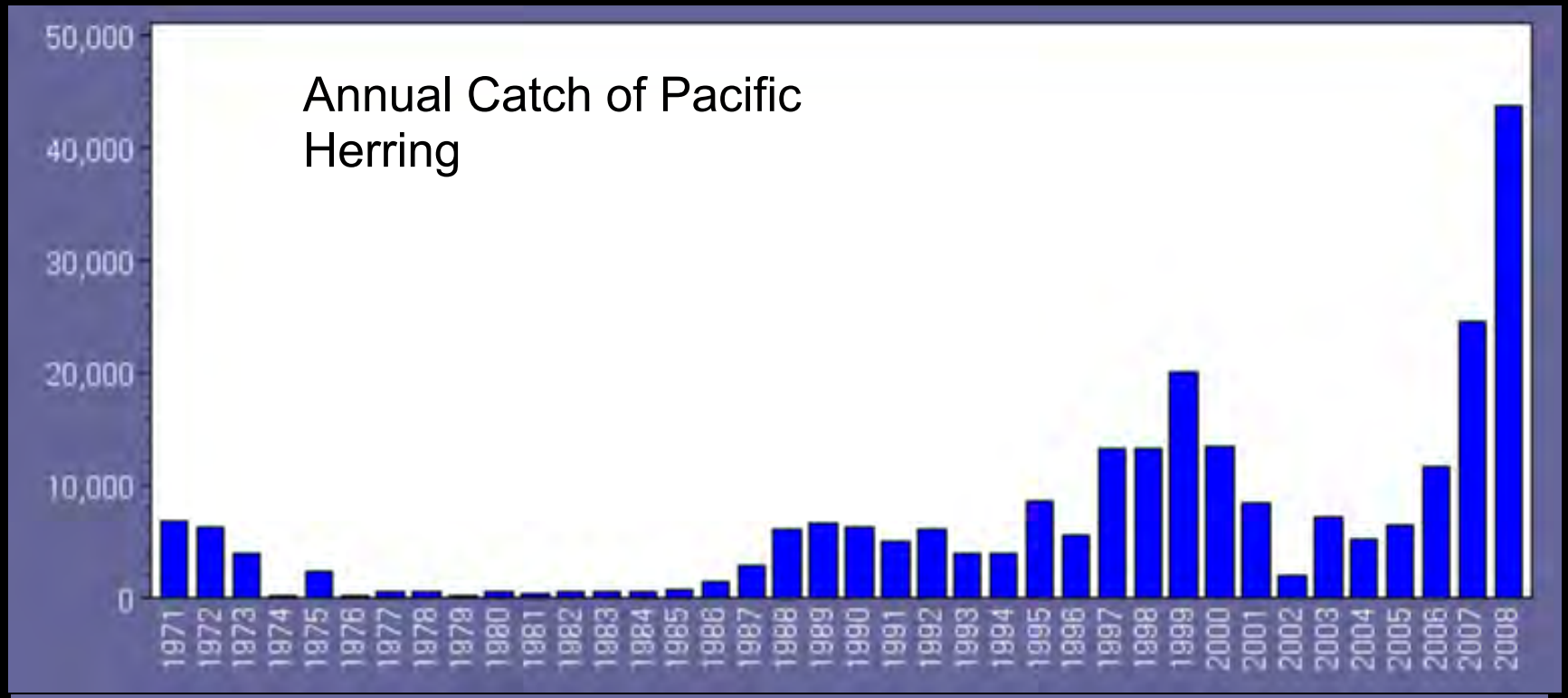
Correspondence analysis on species composition of fishery catch in Korea

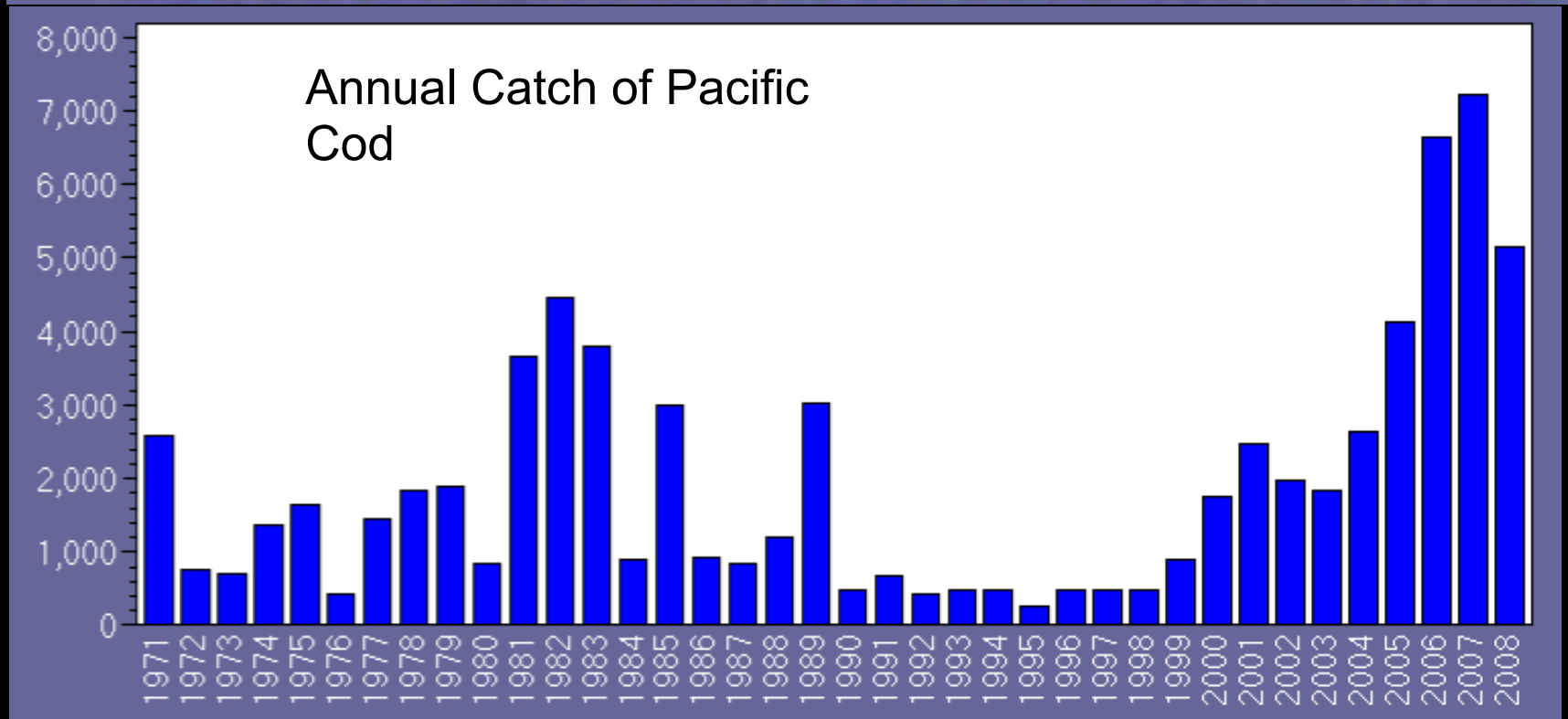


Comparison with regime shifts in the North Pacific

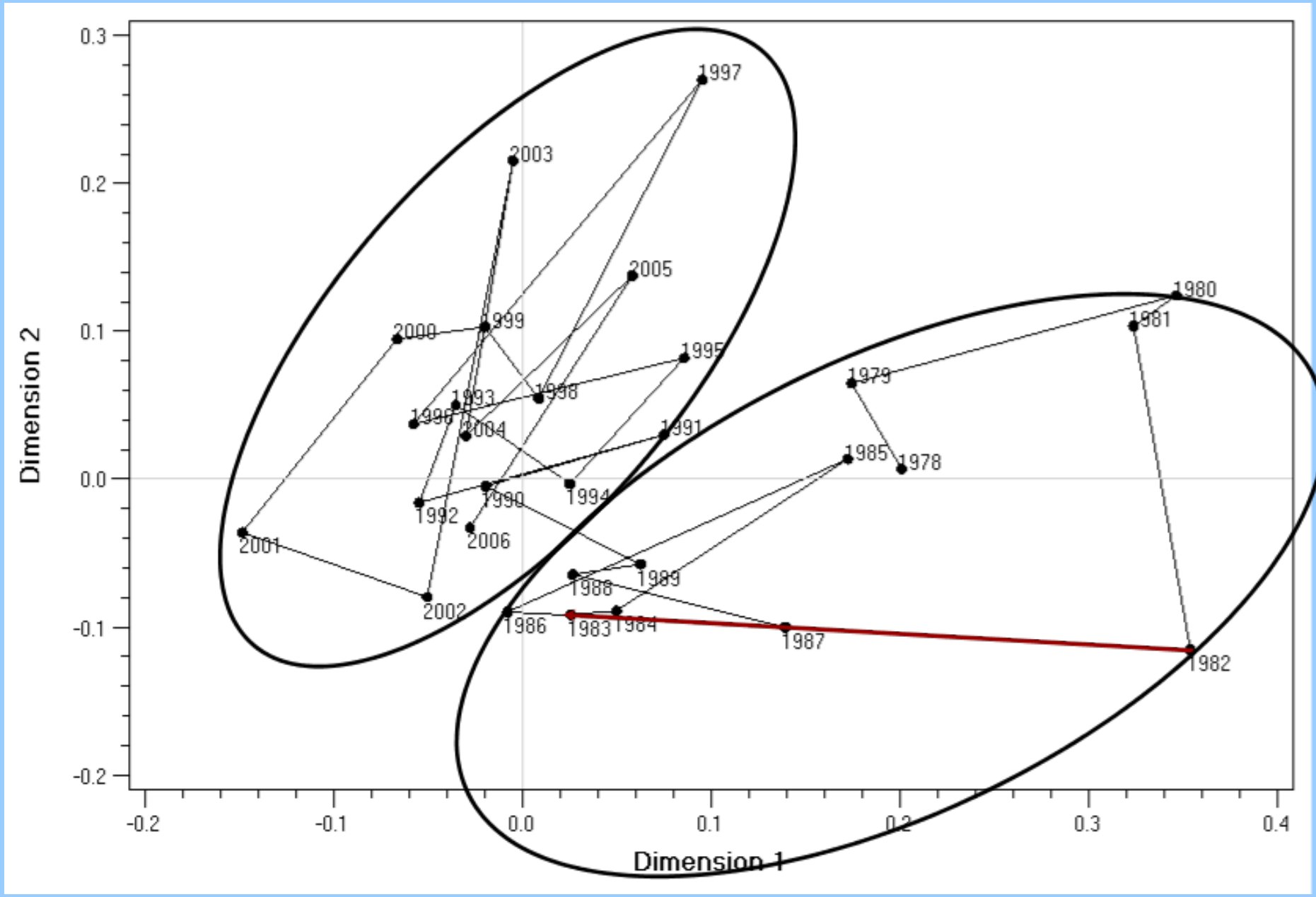
Past studies*	This study
1976-1977	1976-1977
? (ENSO)	1982-1983
1988-1989	1990-1991 1-yr delay
1998-1999	Not evident

*** Refs: Zhang et al. (2000), Yasunaka & Hanawa (2002), Chavez et al (2003)**


Annual Catch of Pacific Herring
50,000
40,000
30,000
20,000
10,000
0
1971 1972 1973 1974 1975 1976 1977 1978 1979 1980 1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008

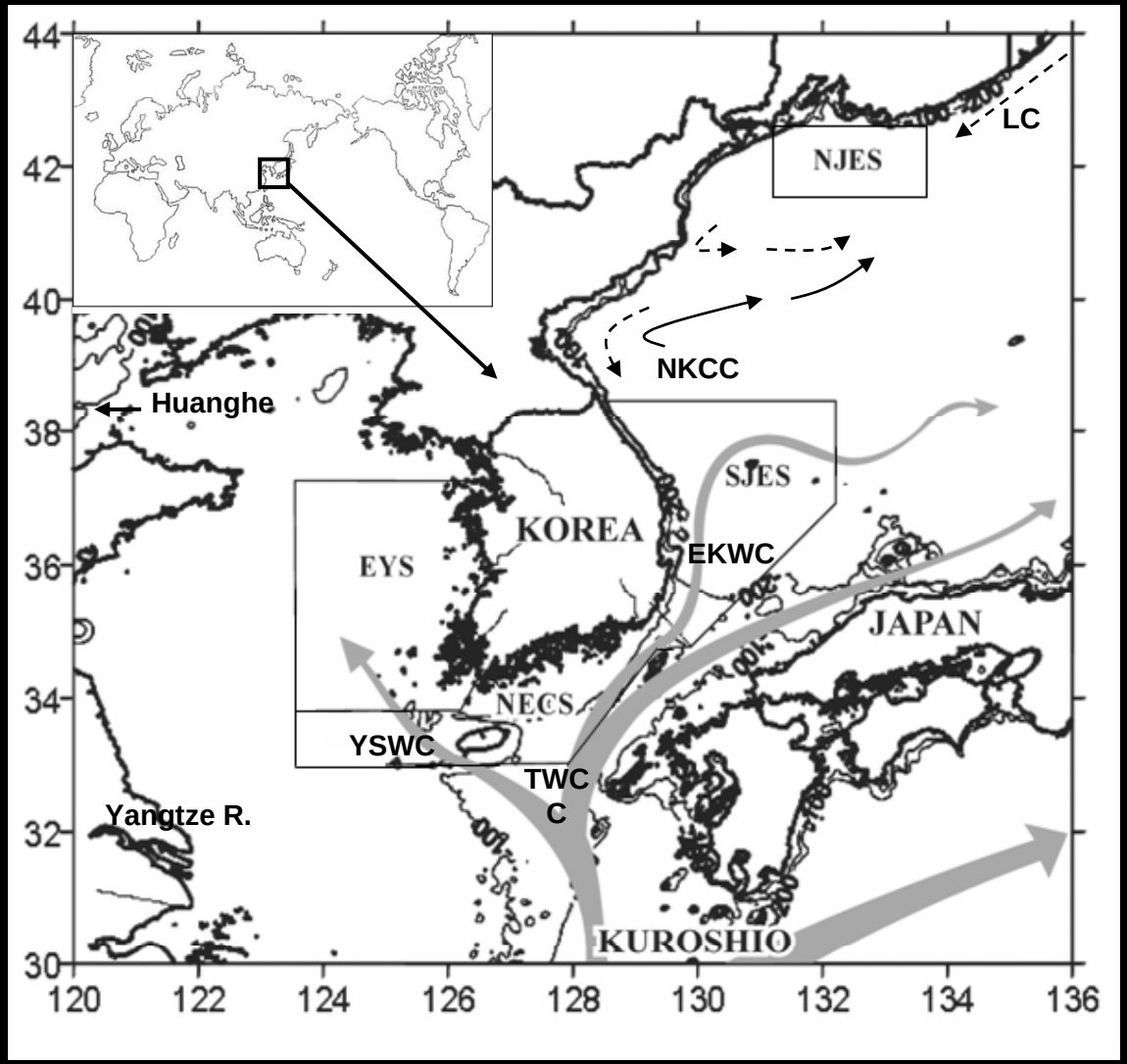

Annual Catch of Pacific Cod
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
1971 1972 1973 1974 1975 1976 1977 1978 1979 1980 1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008

Correspondence analysis of composition in abundance of the 4 meso- and micro- zooplankton groups



Zooplankton Study Area (1976-2006) Japan/East Sea (NJES)

1. **Eastern Yellow Sea (EYS)**
2. **Northern East China Sea (NECS)**
3. **Southern Japan/East Sea (SJES)**
4. **Northwestern Japan/East Sea (NJES)**



Summary of responses to the past regime shifts and El Niño event

(Kang et al. Submitted to Progress in Oceanography)

	Region	1977 regime shift	1982 El Niño	1989 regime shift	1998 El Niño
Temperature	EYS	X	X	O	O
	NECS	X	X	O	O
	SJES	X	X	O	O
	NJES	X	X	O	X
Salinity	EYS	O	X	X	O
	NECS	X	X	X	O
	SJES	O	X	X	O
	NJES	–	–	–	–
Zooplankton biomass	EYS	X	X	O	O
	NECS	X	X	O	X
	SJES	X	X	O	X
	NJES	–	–	X	O
Zooplankton community structure	EYS	–	O	O	O
	NECS	–	X	O	O
	SJES	–	X	O	O
	NJES	–	–	X	O
Fish	Korean waters	O	O	O	X

Symbols: X = Not detected, O = Detected, – = Data unavailable

Summary of Fish Species Changes in Korea,1968-2008

- Dominant species along the Tsushima current have fluctuated greatly.
- Short-lived (anchovy and squid), pelagic species (chub mackerel) have become dominant.

3. Future works

- Regime shifts could be detected and forecast through monitoring (e.g., KODC)
- Risk assessment and flexible TAC to minimize economic impact of regime shift
- Incorporate climatic changes in fisheries management plans
- Develop Individual-based models and meta-population models (e.g., anchovy & cod) to project influences of climate change

Acknowledgement

- MIFAFF-NFRDI
  - A program titled “consequences and countermeasures for the effects of climate change on marine ecosystems and fisheries resources”.