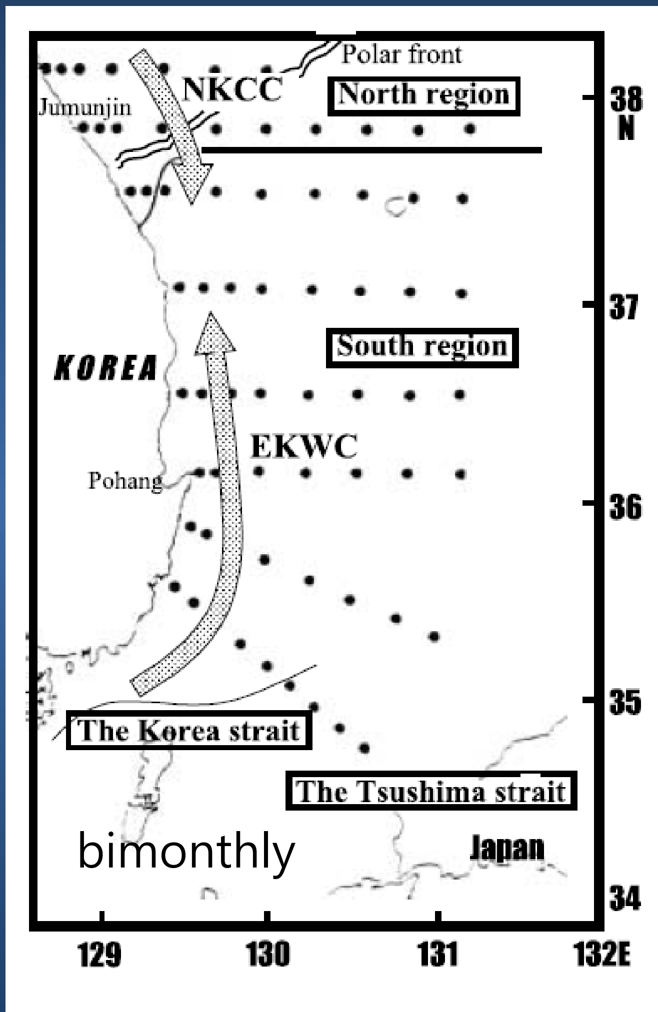
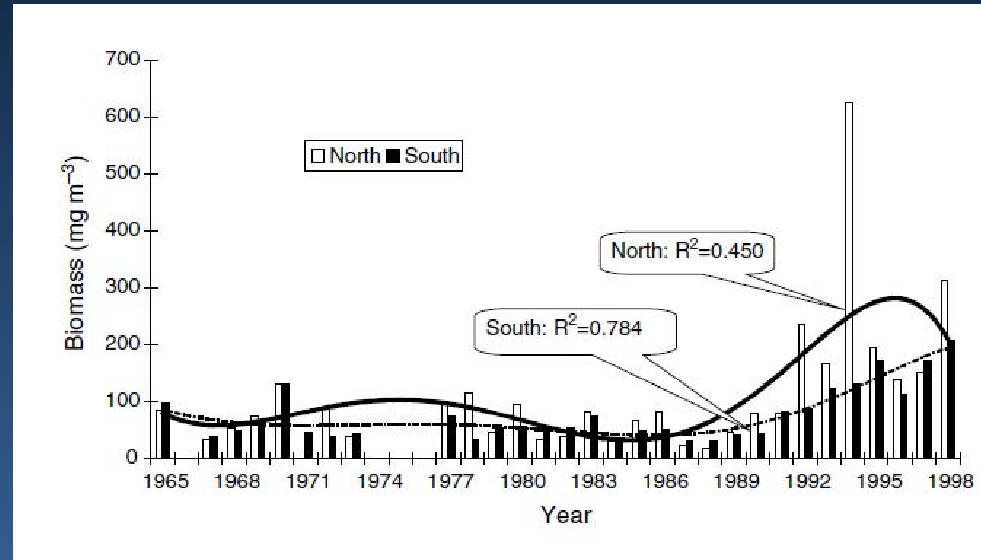
How much do we know about the 88-91 regime shift in the southwestern East Sea ecosystem?

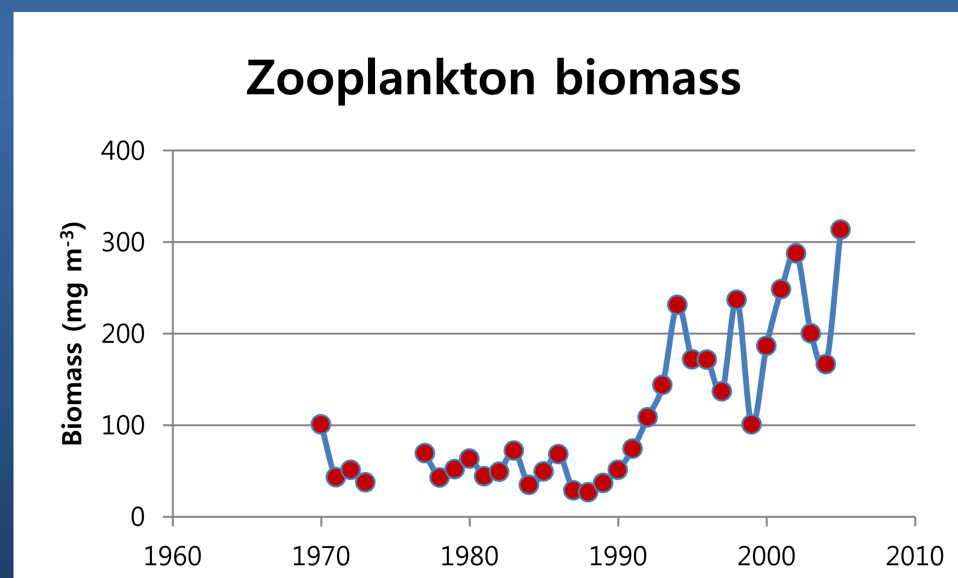
Sinjae Yoo, Chan Joo Jang, Joo-Eun Yoon, and Soonmi Lee

KIOST
Ansan, Korea

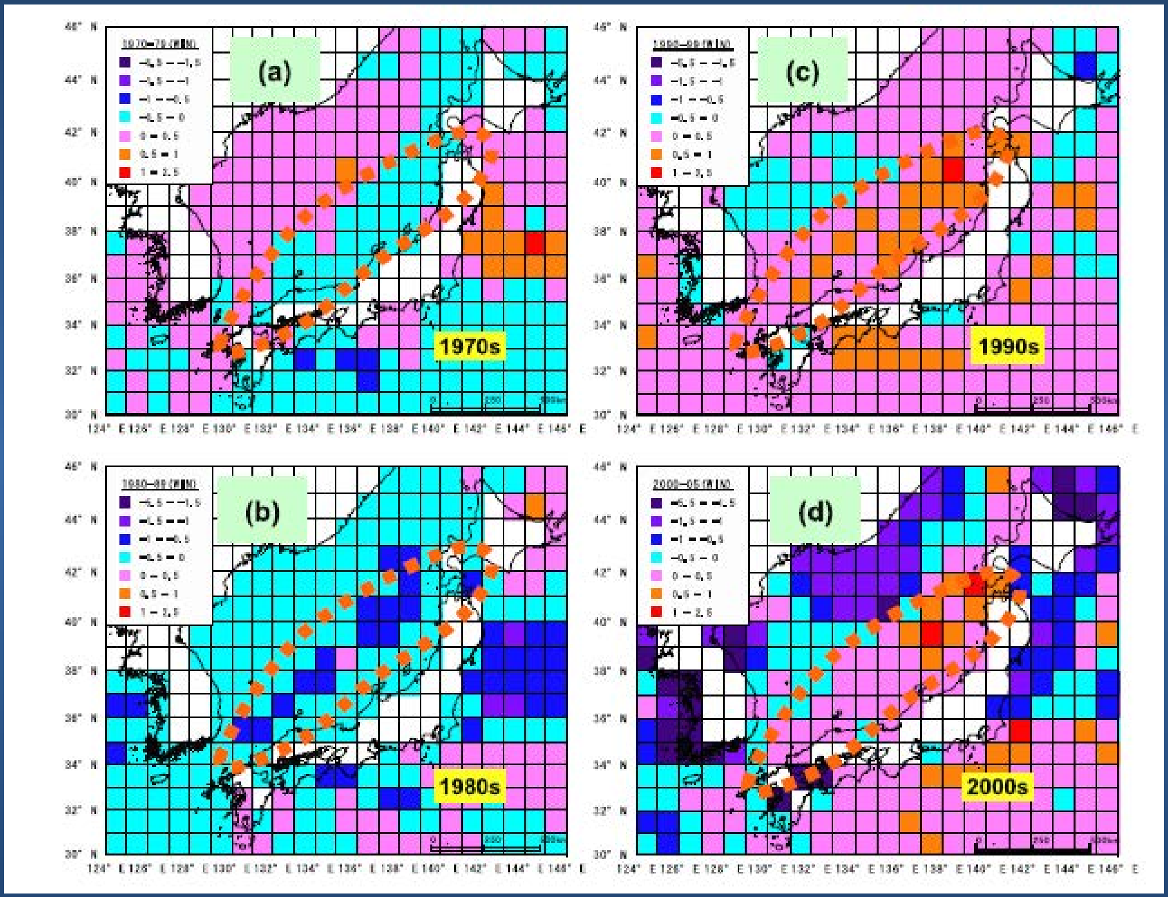


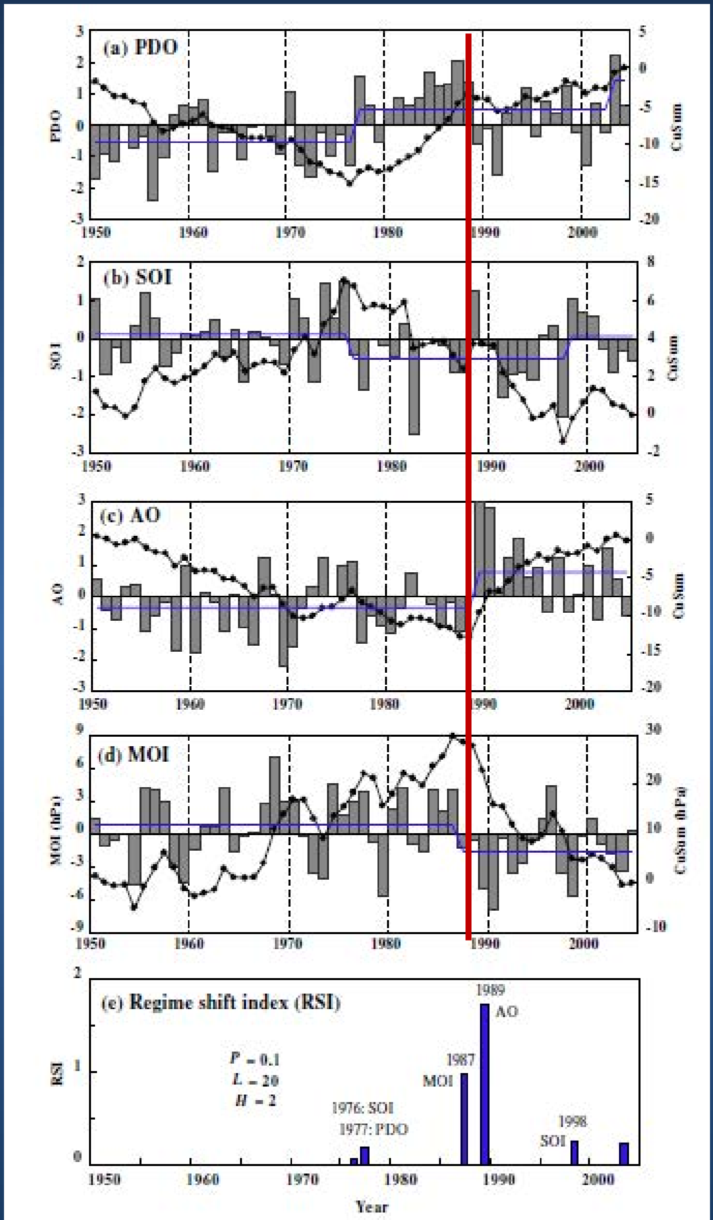


Kang et al. (2002, 2012)

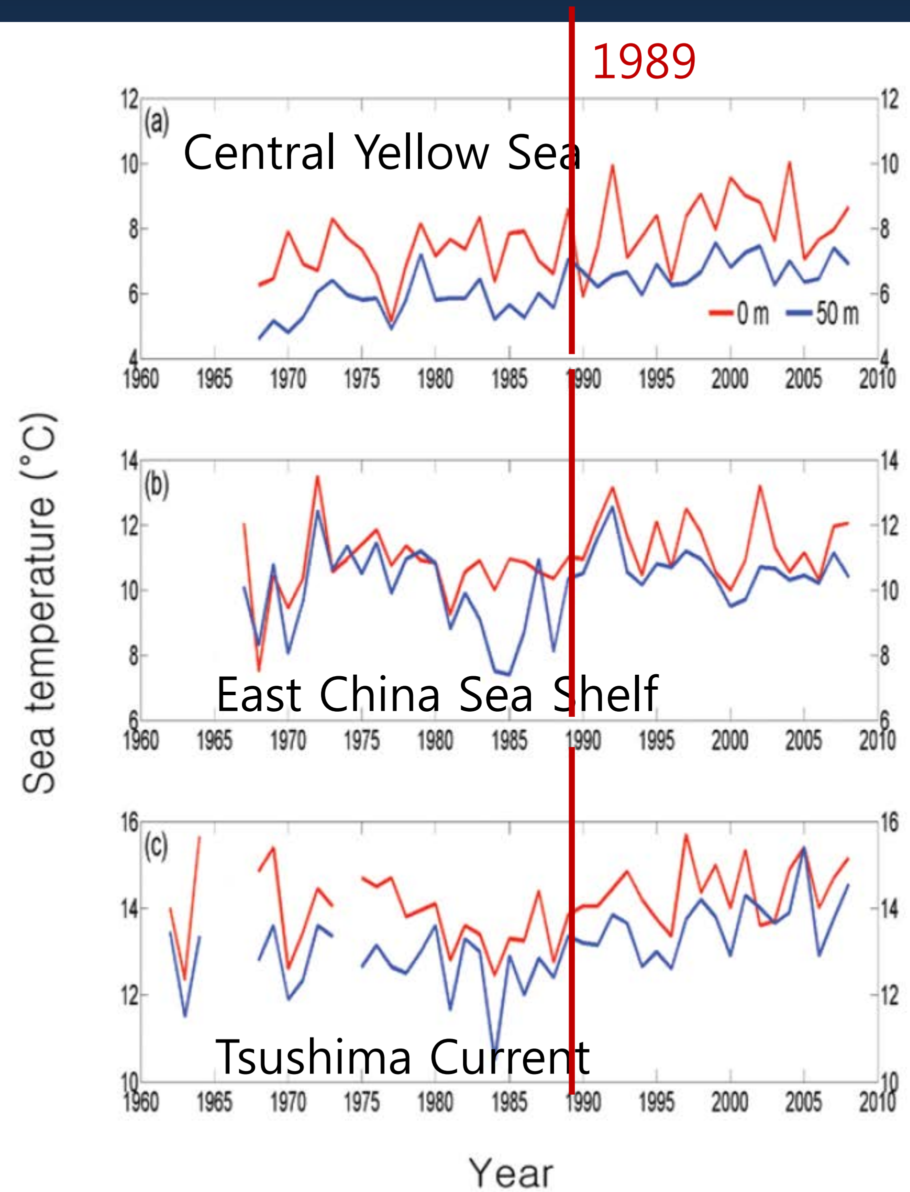


Winter SST anomalies in the East Sea





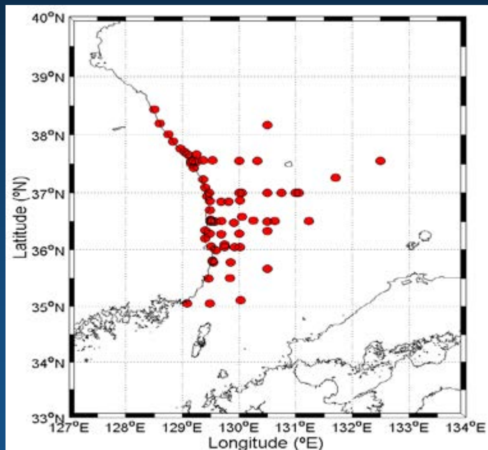
Tian et al., 2008



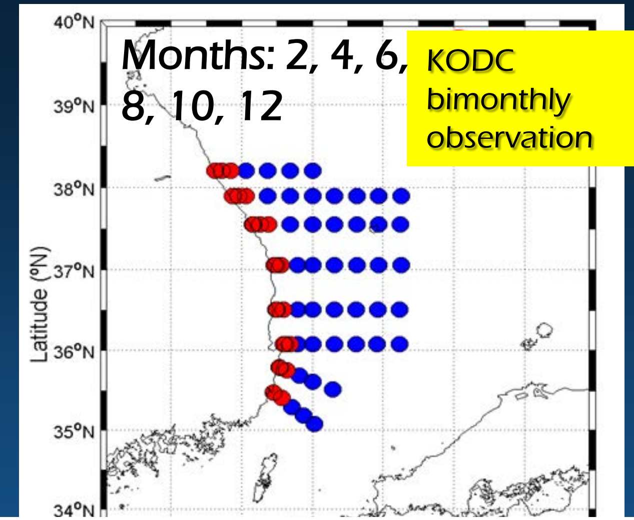
[Figure YS-9] The long-term trend of the temperature in April at the surface and 50 m in: (a) central Yellow Sea, (b) shelf of northern East China Sea, and (c) Tsushima Current area. The data were taken bimonthly at the stations of Korea Oceanographic Data Center (http://kodc.nfrdi.re.kr/page?id=eng_index).

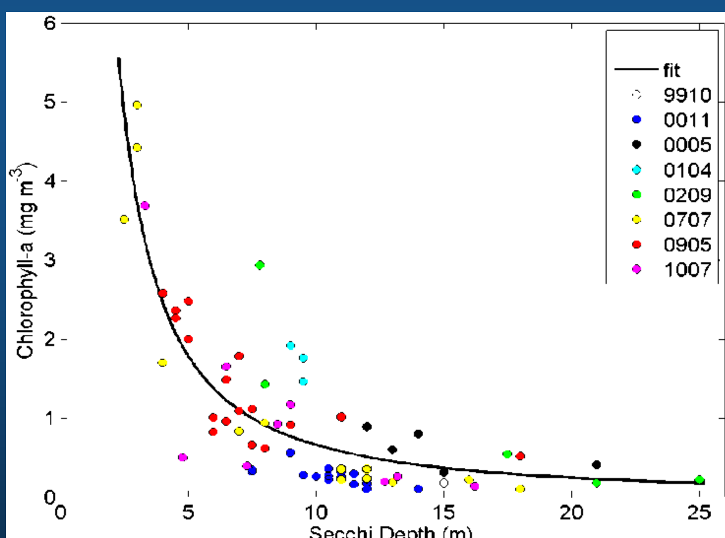
But there is no available chlorophyll-a or nutrient time series for the period!

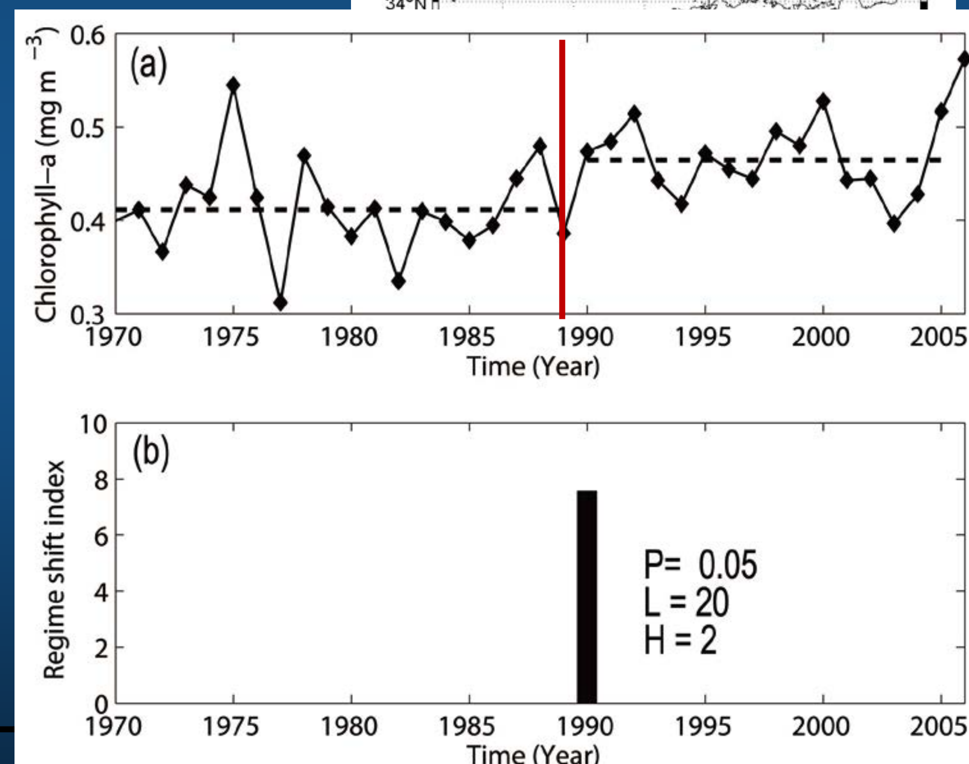
Retrieval of chlorophyll-a time series from Secchi depth



Stations where SD-Chla data were collected 1999-2010



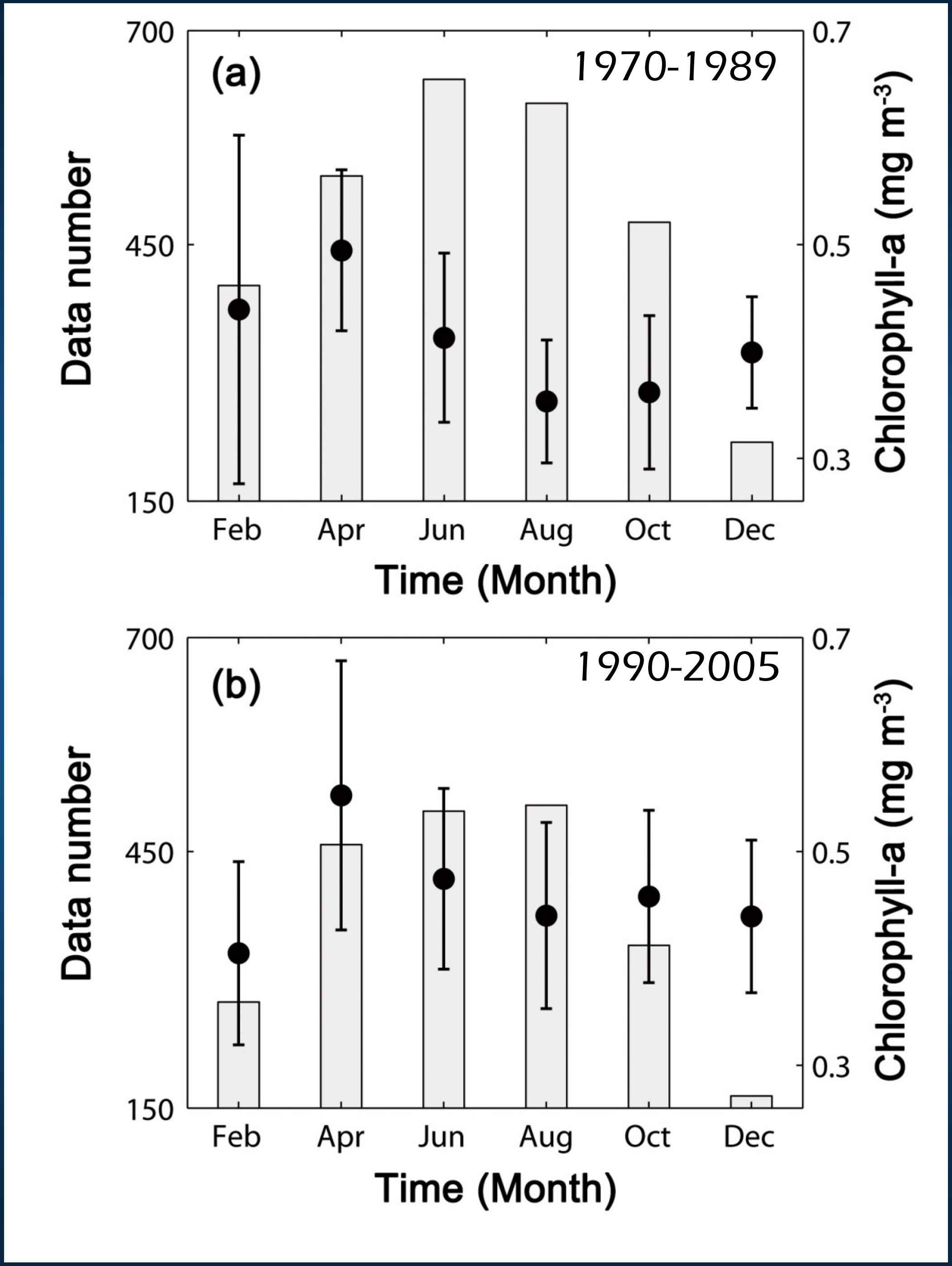




$$Chlorophyll-a = 18.15 \times SD^{-1.441}$$

(r^2= 0.7386, $p < 0.05$, n = 73)

(Yoo and Yoon, in preparation)



The data number (bars) and mean of chlorophyll-a concentrations (dots). The error bars represent standard deviation of chlorophyll-a concentrations.

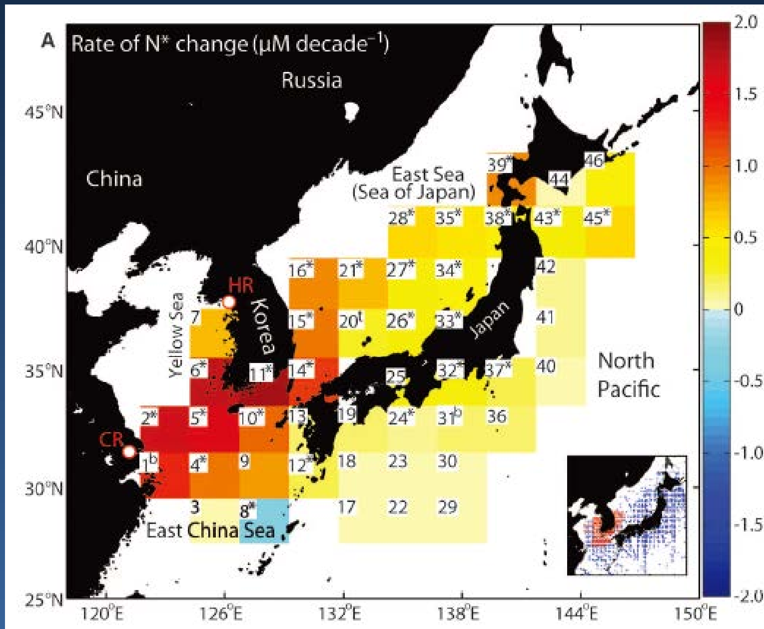


Fig. 1. (A) Rate of change (μM decade^{-1}) of N* in surface waters (≤50 m) of and Han ri

Rate of change (μM decade^{-1}) of N* (excess N over P) in surface waters (≤50 m) of the study area.

The relative abundance of nitrate (N) over phosphorus (P) has increased over the period since 1980 in the marginal seas bordering the northwestern Pacific Ocean, located downstream of the populated and industrialized Asian continent. Most likely due to deposition of pollutant nitrogen from atmospheric sources.

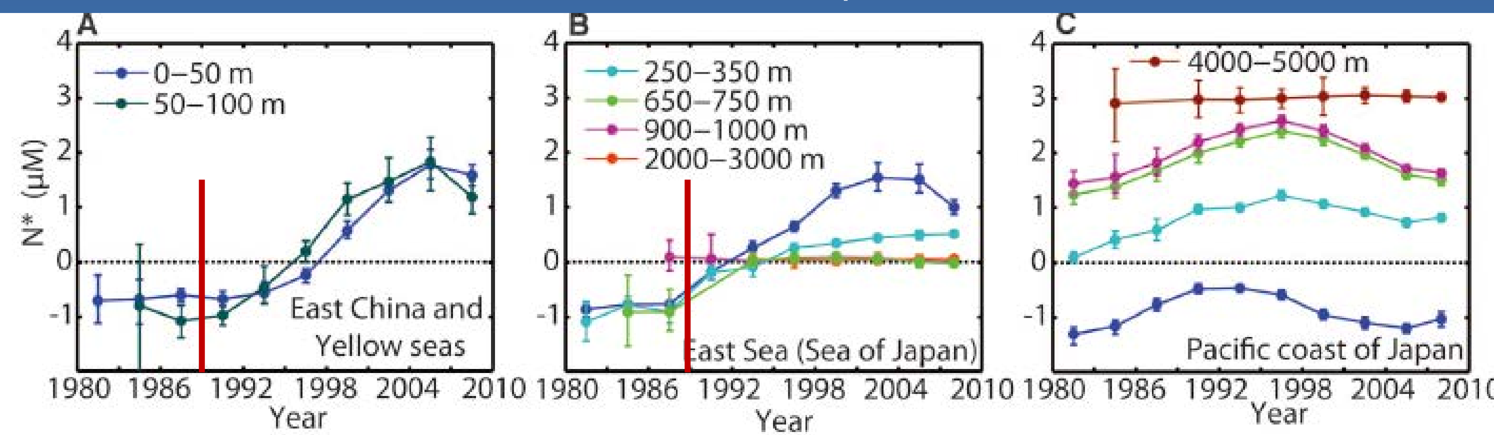
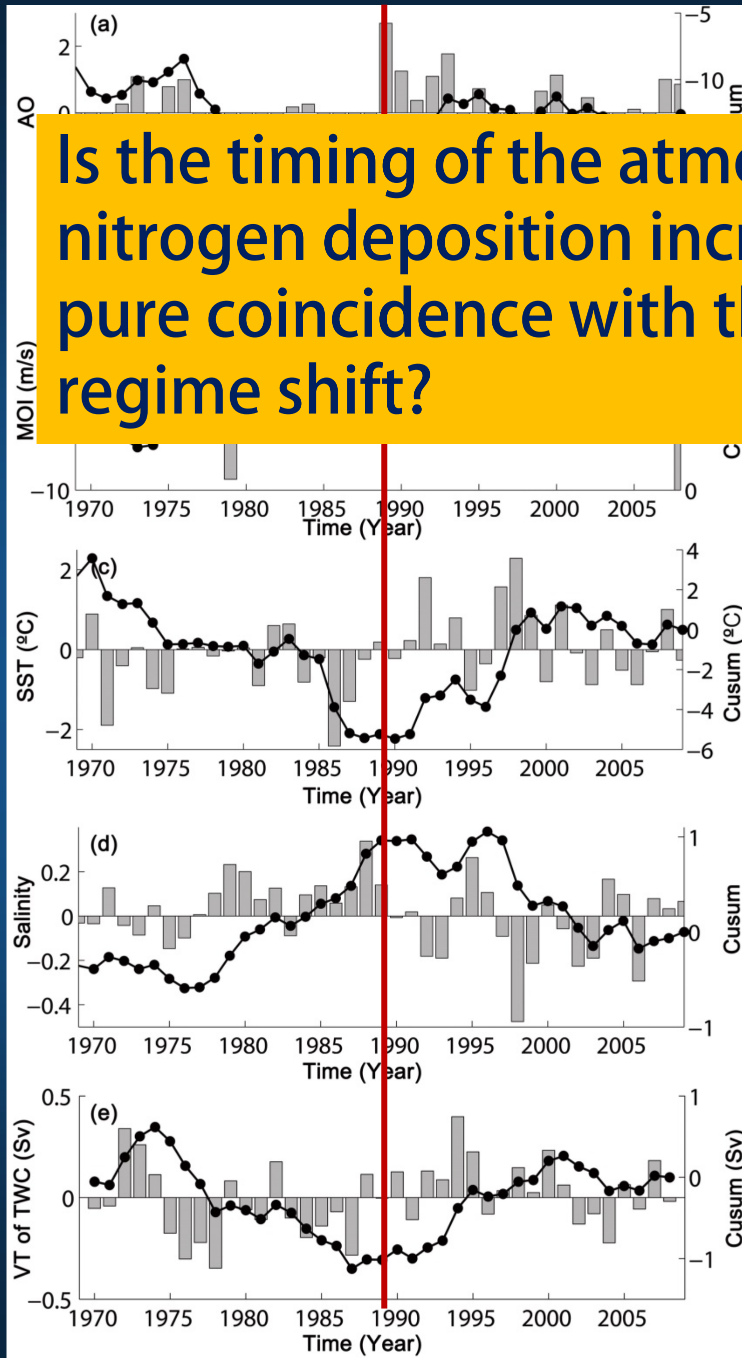
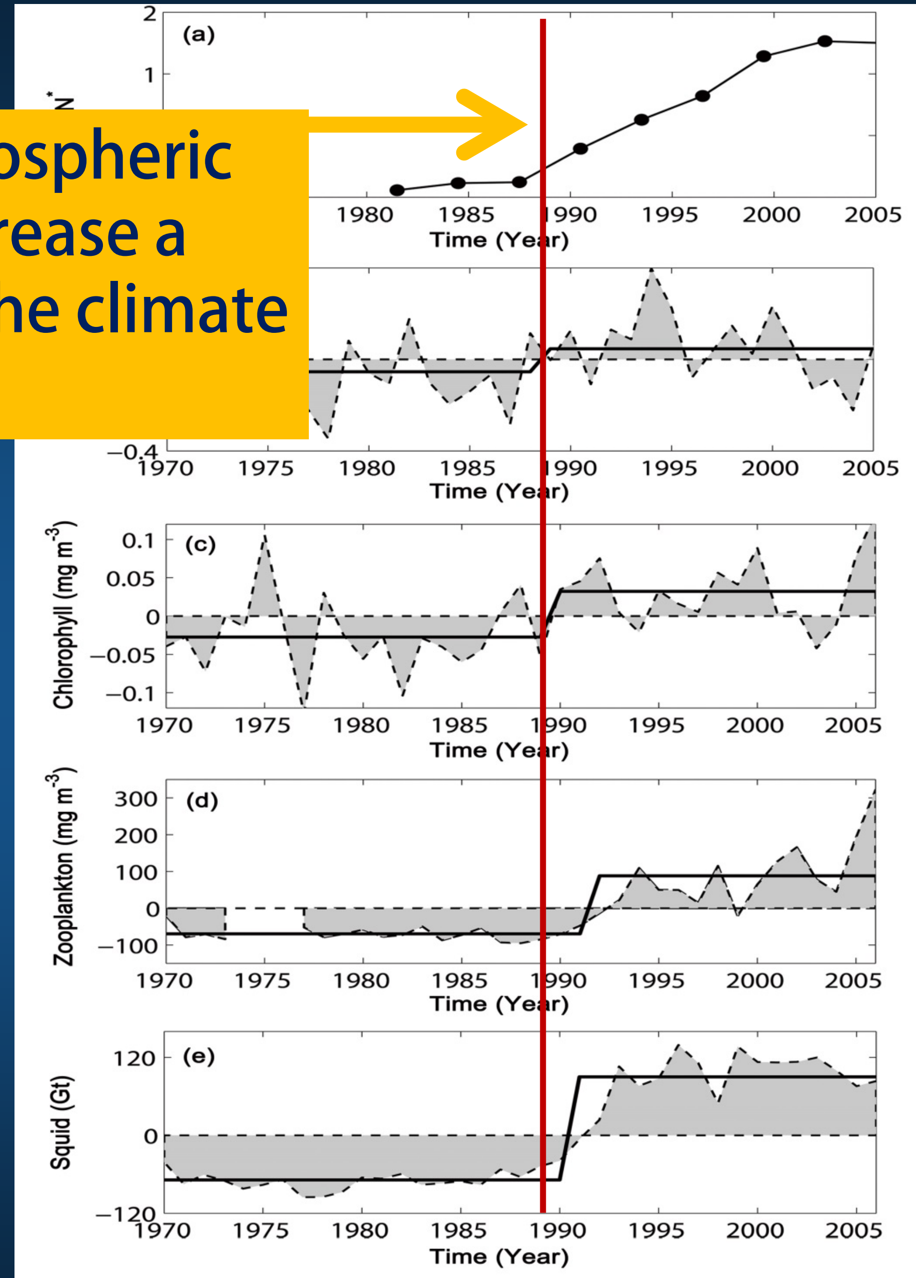


Fig. 4. Time series of the 3-year mean N* (μM) for various depth ranges in (**A**) the East China and Yellow seas, (**B**) the East Sea (Sea of Japan), and (**C**) the Pacific coast of Japan. The colors indicate the N* values derived from the data collected at the indicated depth ranges. The dotted lines correspond to N* = 0 μM. The error bars are the confidence intervals of the resulting N*, for $P = 0.05$. The colored lines in (C) not indicated in the legend correspond to the depths indicated in (A) and (B).

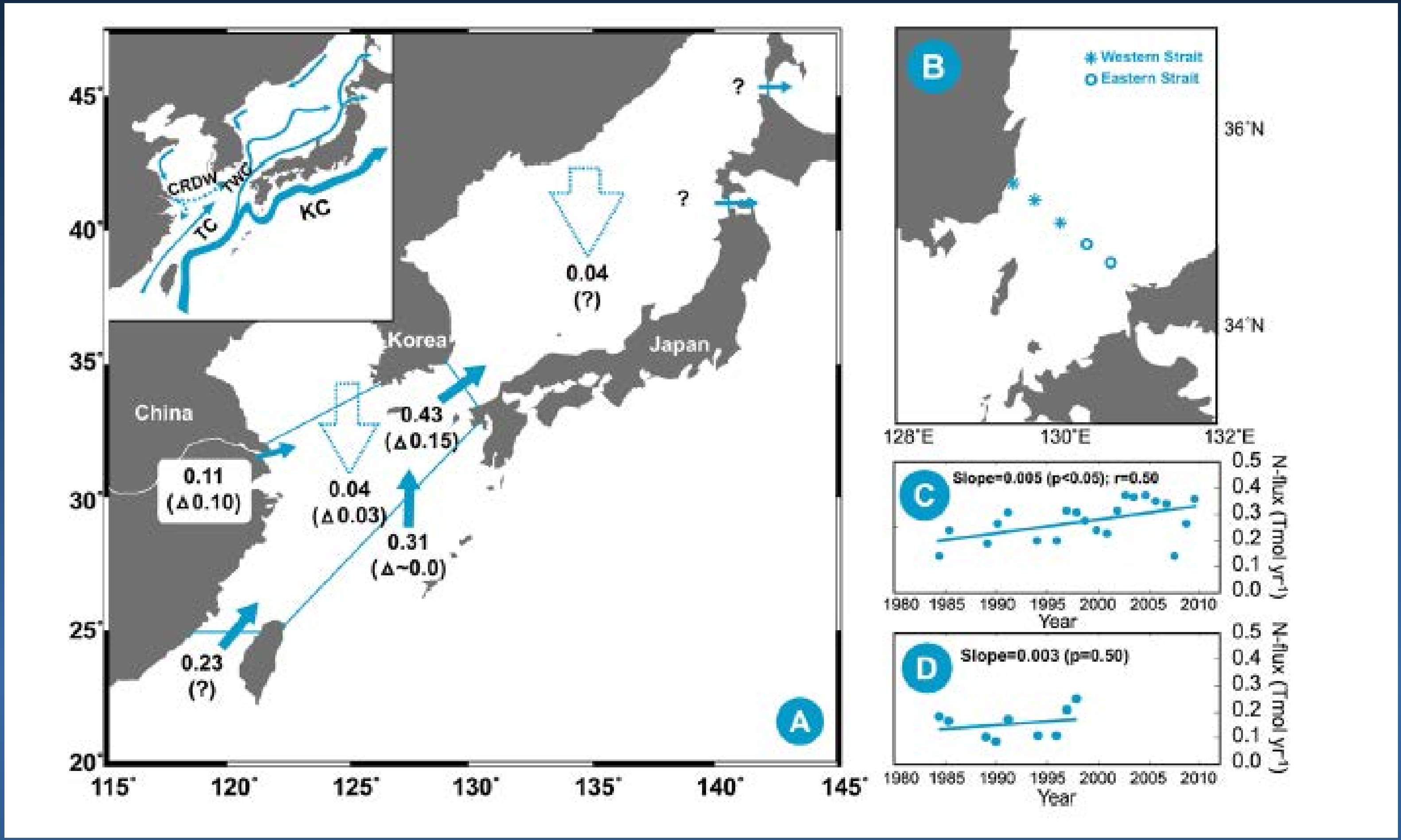
Kim et al., 2011





Is the timing of the atmospheric nitrogen deposition increase a pure coincidence with the climate regime shift?

a) Redrawn from Kim et al. 2011



Average N fluxes during the late 1990s to the mid-2000s by riverine discharge (thin arrow), current-driven transport (solid arrows), and atmospheric deposition (open arrows) . Numbers in parentheses represent the increments in the annual N-fluxes during the last 30 years. Units are Tmol yr^{-1}.

Kim et al., 2013

Changjiang Discharge Anomaly

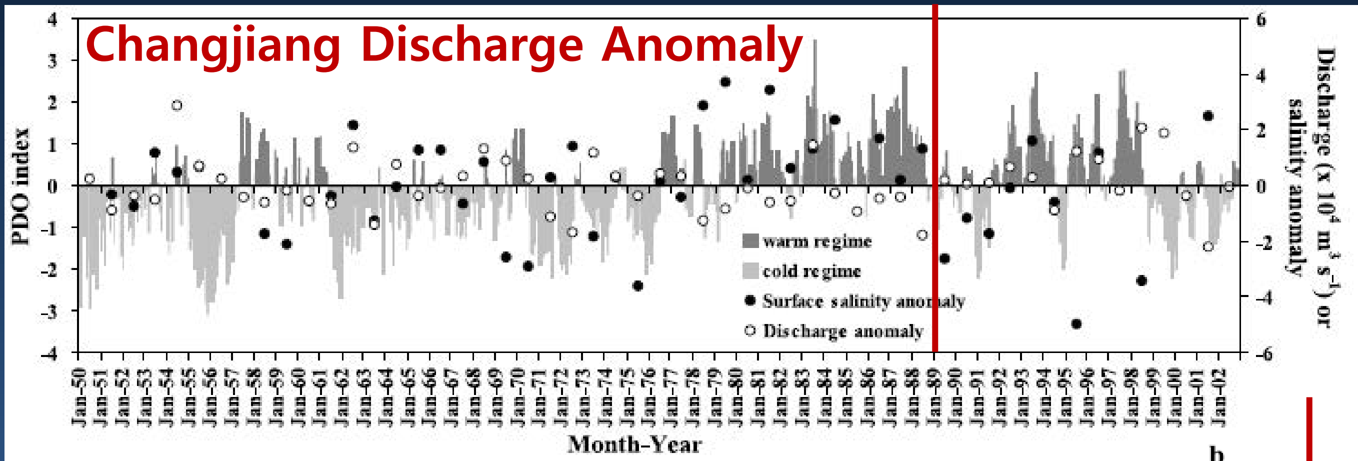
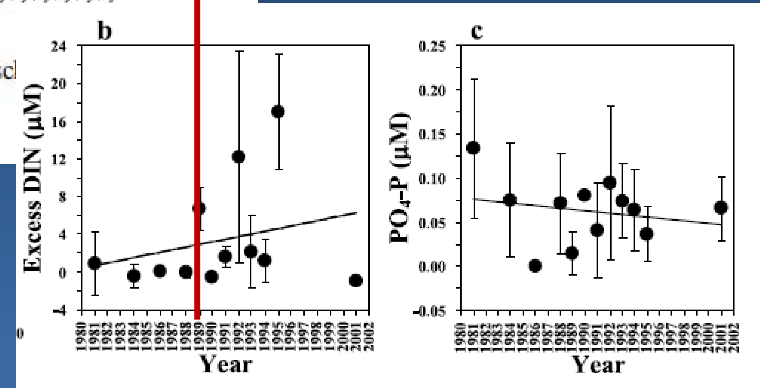
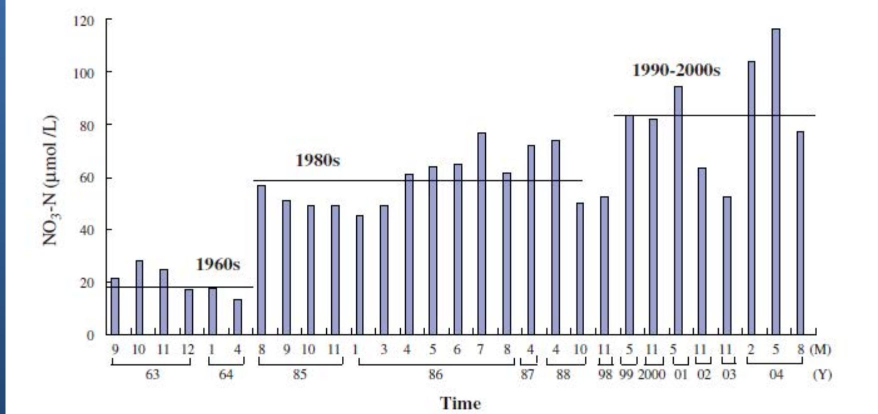


Figure 10. Long-term anomalies of summer surface salinity and summer Changjiang disc
removing their long-term trends) superimposed on the PDO index.

Siswanto et al., 2008



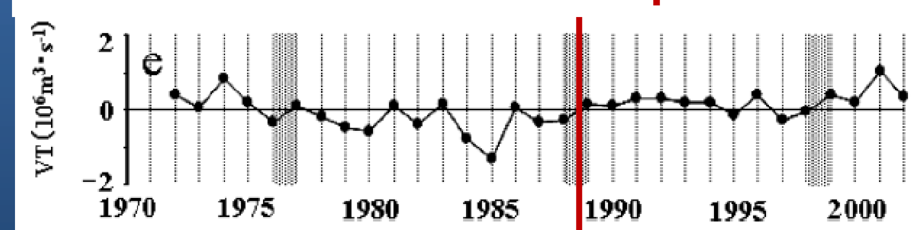
NO3 loading in Changjiang Discharge



on of nitrate concentration at the mouth of the Changjiang River. (Y) and (M) are the year and the month of sample collec
dicates the averaged value of nitrate concentration during the sampling period marked above the line (data collected duri

Zhu et al., 2008

The eastward volume transport of TWC



The eastward volume transport (VT) of TWC water was calculated from the geostrophic current assuming 500 dbar (104 Pa) (Nagai *et al*., 2008)

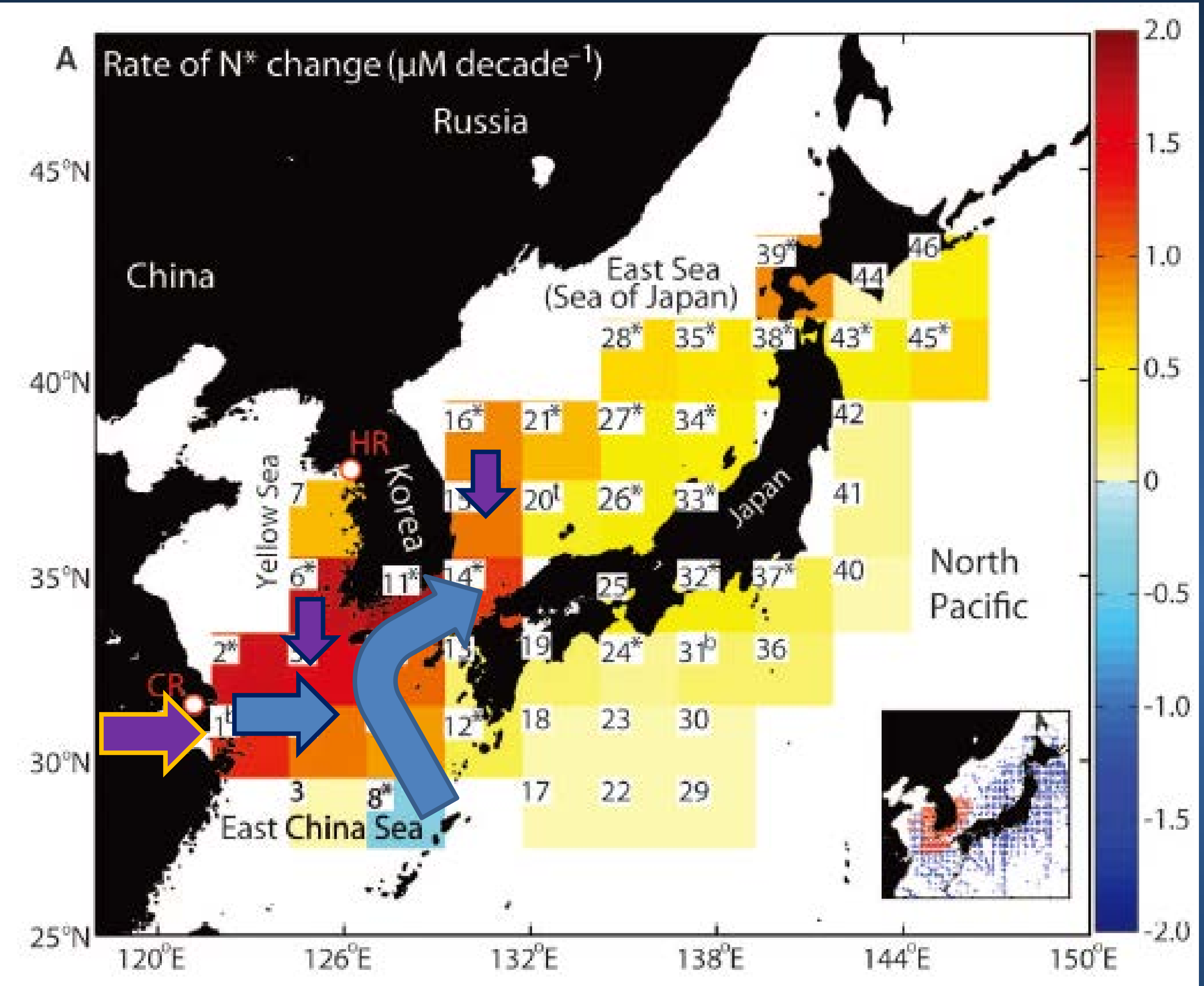
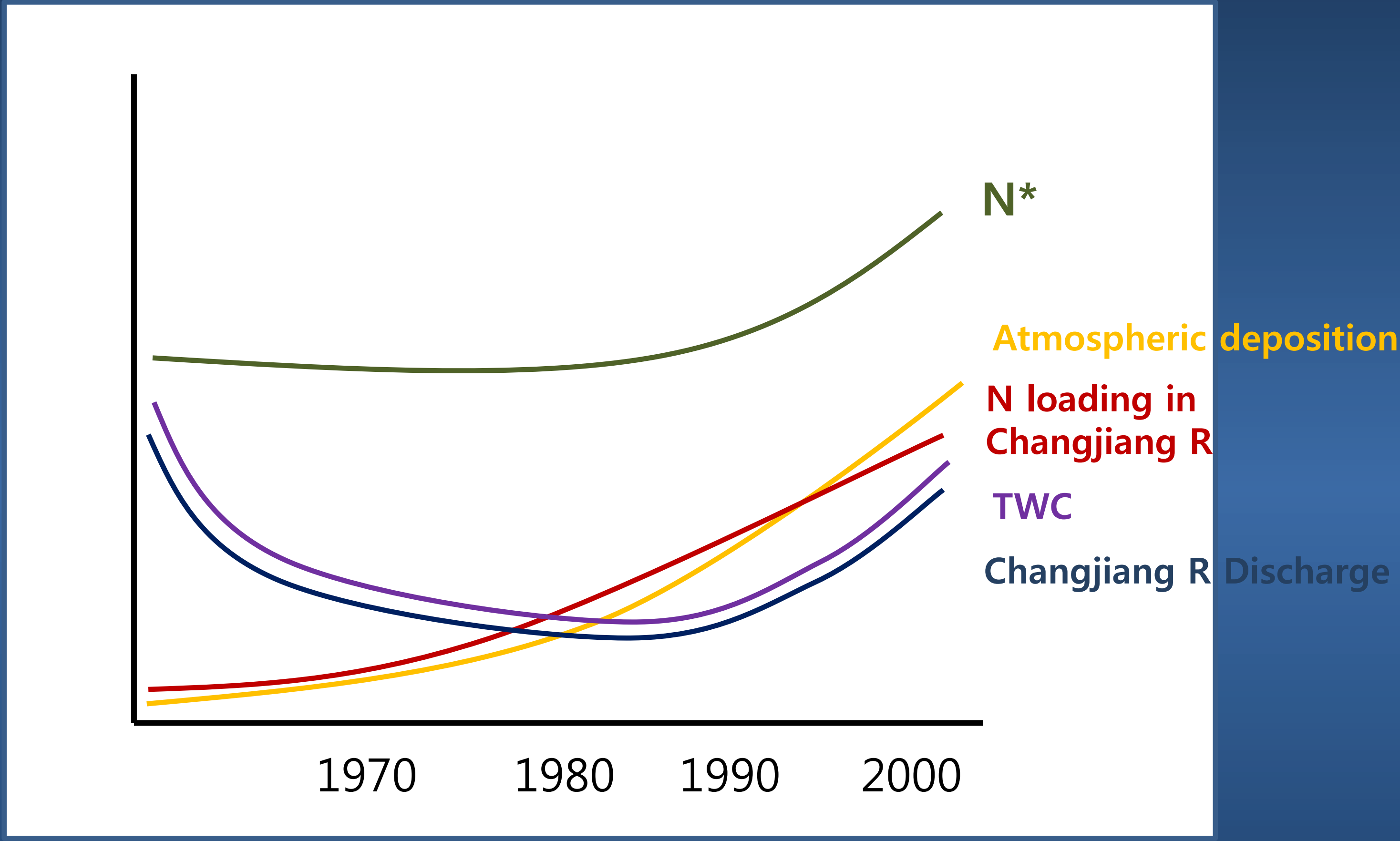


Fig. 1. (**A**) Rate of change (μM $decade^{-1}$) of N* in surface waters (≤50 m) of and Han ri

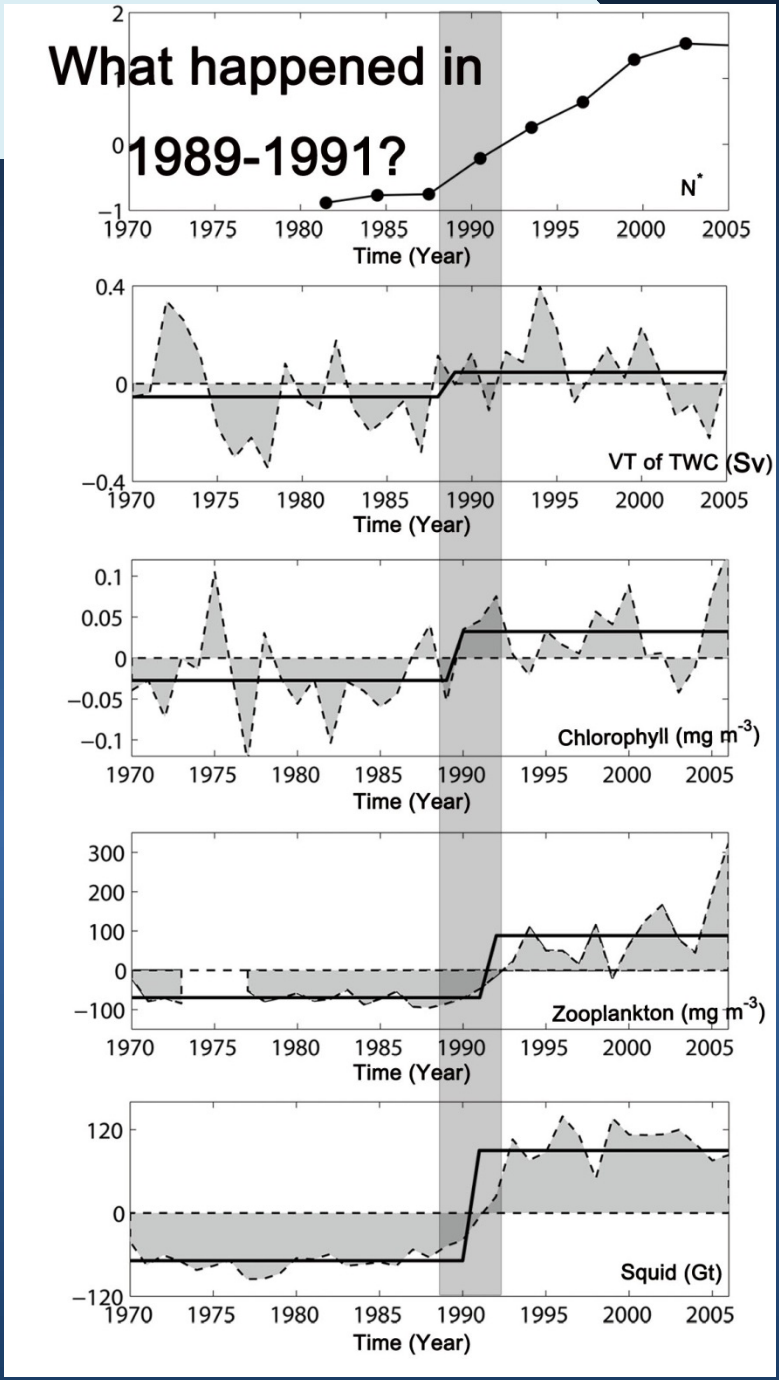
The hypothesis



Why N* increased after 1990?

Summary

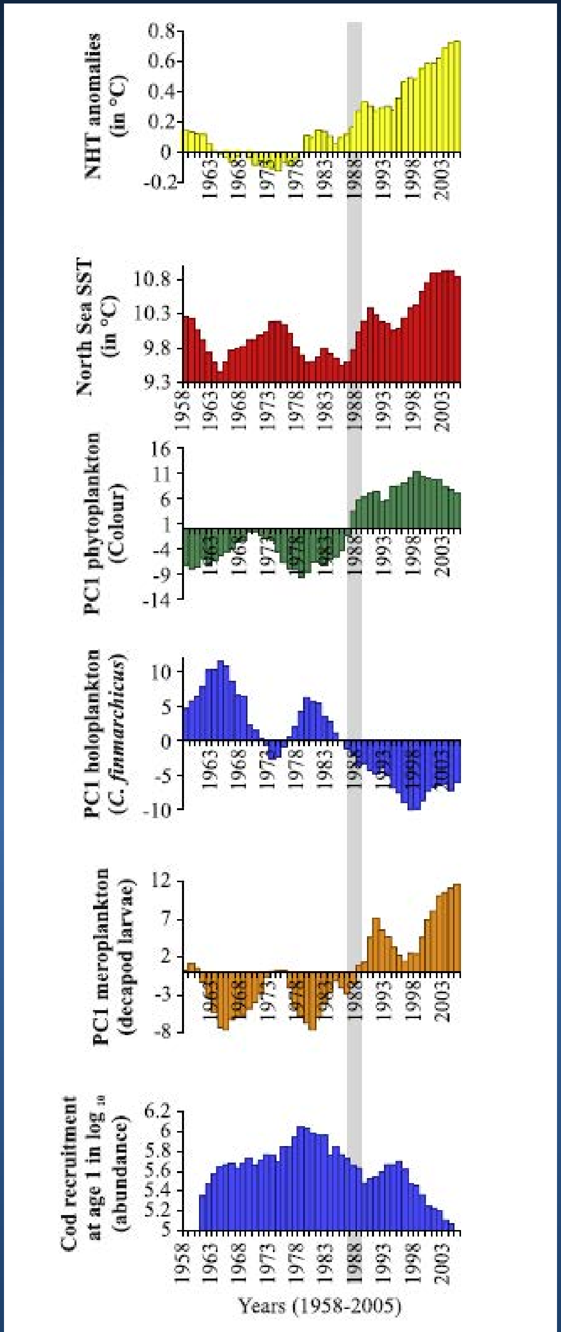
- We constructed a long term time series of chlorophyll-a in the East Sea which shows a step change at 88/89 consistent with other variables.
- We put forward a hypothesis that several factors, anthropogenic and climate change-related, worked together to induce the jump in the system.
- If such is the case, the 89-91 regime shift in the East Sea ecosystem presents an interesting case where climate change and anthropogenic forcing interacted and produced synergistic effects leading to a step change.



Question 1.

Did the circulation change (VT increase) on the shelf around 1989?
And how was it linked to large scale variability?

- Pros:
  - SODA v2.2.4
  - Nagai et al. (2008)
- Cons:
  - Zhang et al. (2004)
  - Takikawa and Yoon (2005)



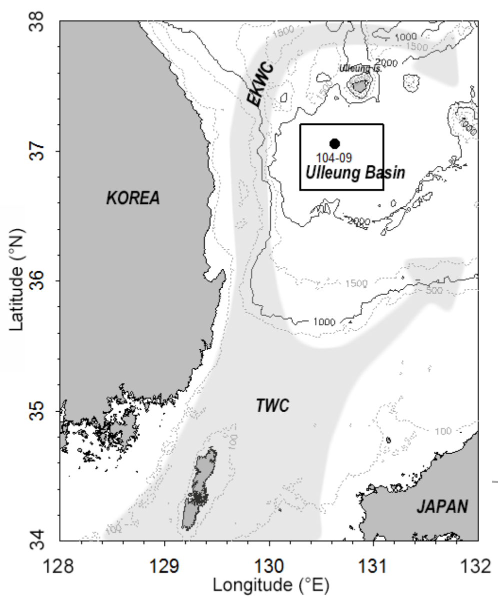
North Sea (Beaugrand, 2009)

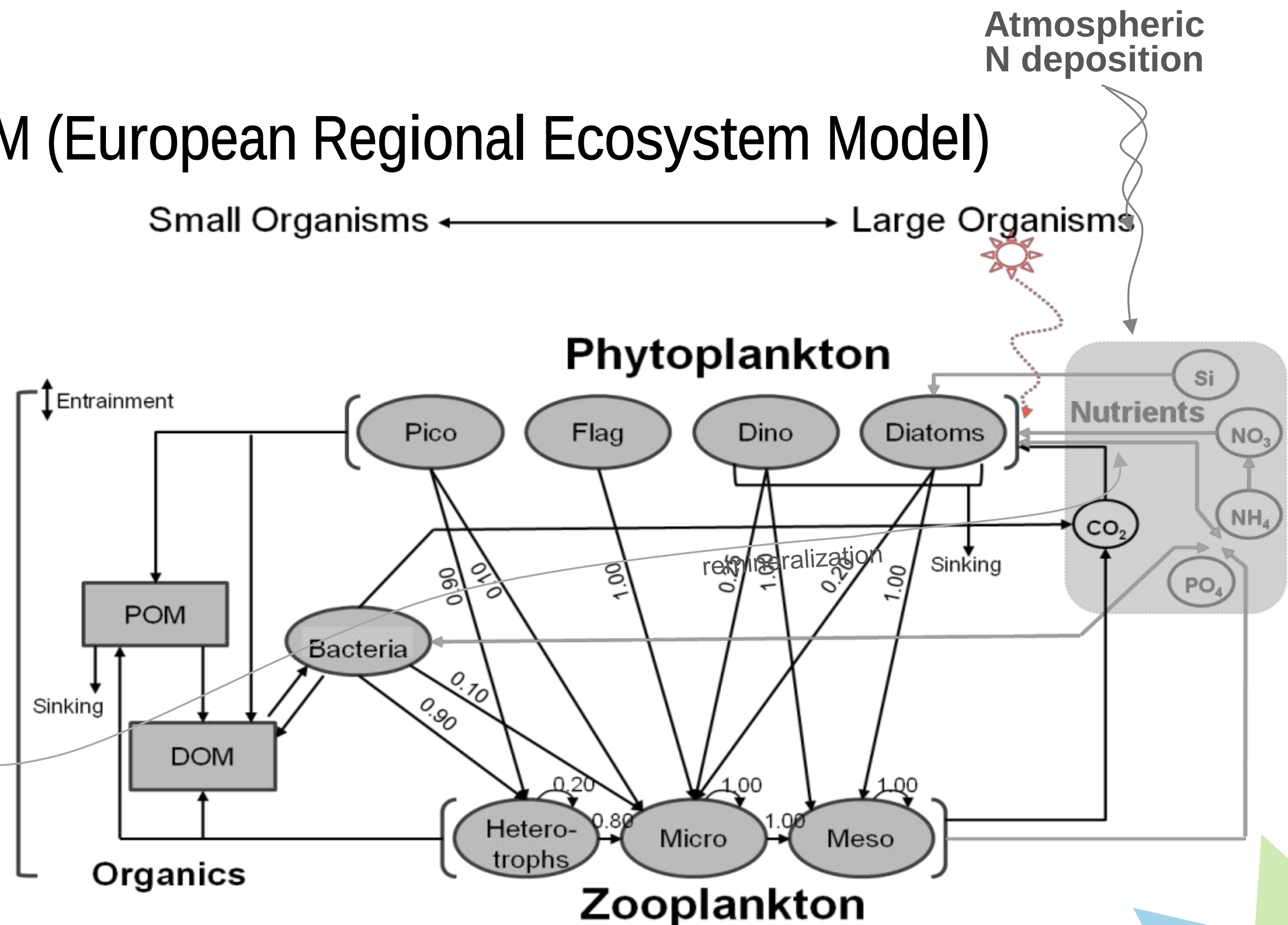
Question 2.

What are the ecosystem consequences of N enrichment?

N-limited (~1990) → N-Excess (1990~)

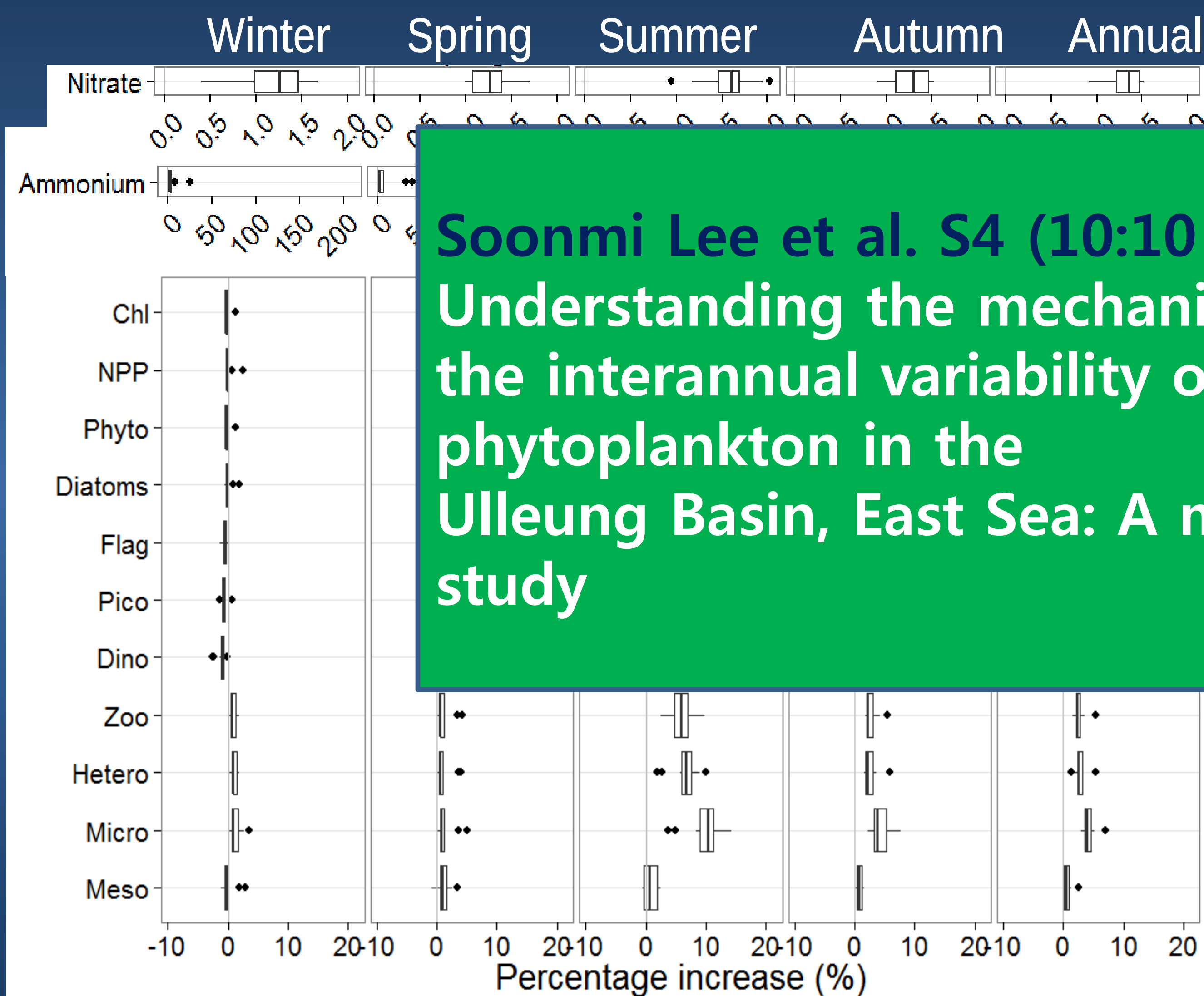
ERSEM (European Regional Ecosystem Model)





The effect of atmospheric deposition

- The percentage increase (%) of variables



Soonmi Lee et al. S4 (10:10 Fri): Understanding the mechanisms of the interannual variability of phytoplankton in the Ulleung Basin, East Sea: A modeling study

THANK YOU!