Direct and indirect effects of climate on the zooplankton community of the Central Baltic Sea

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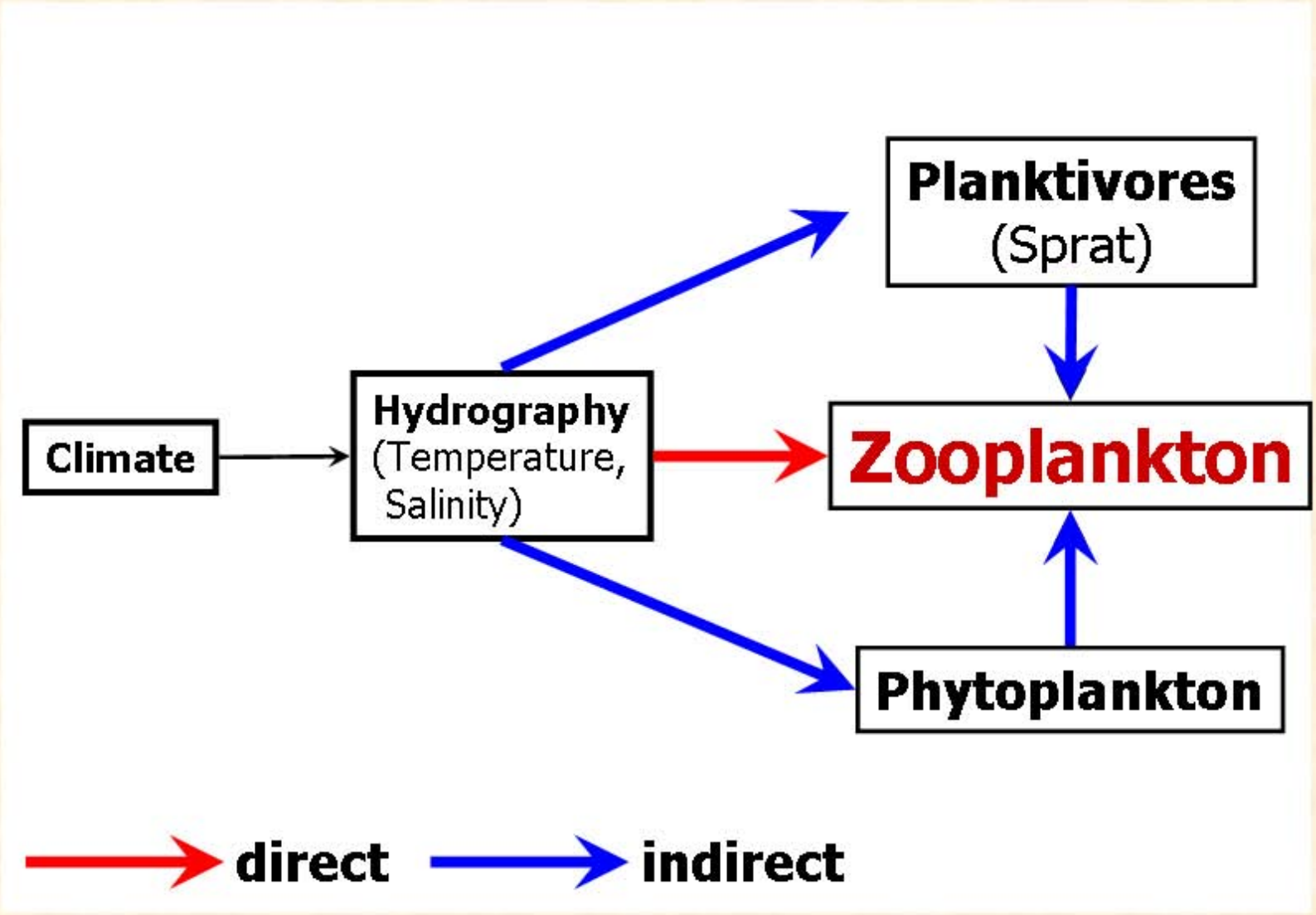
University of Hamburg*

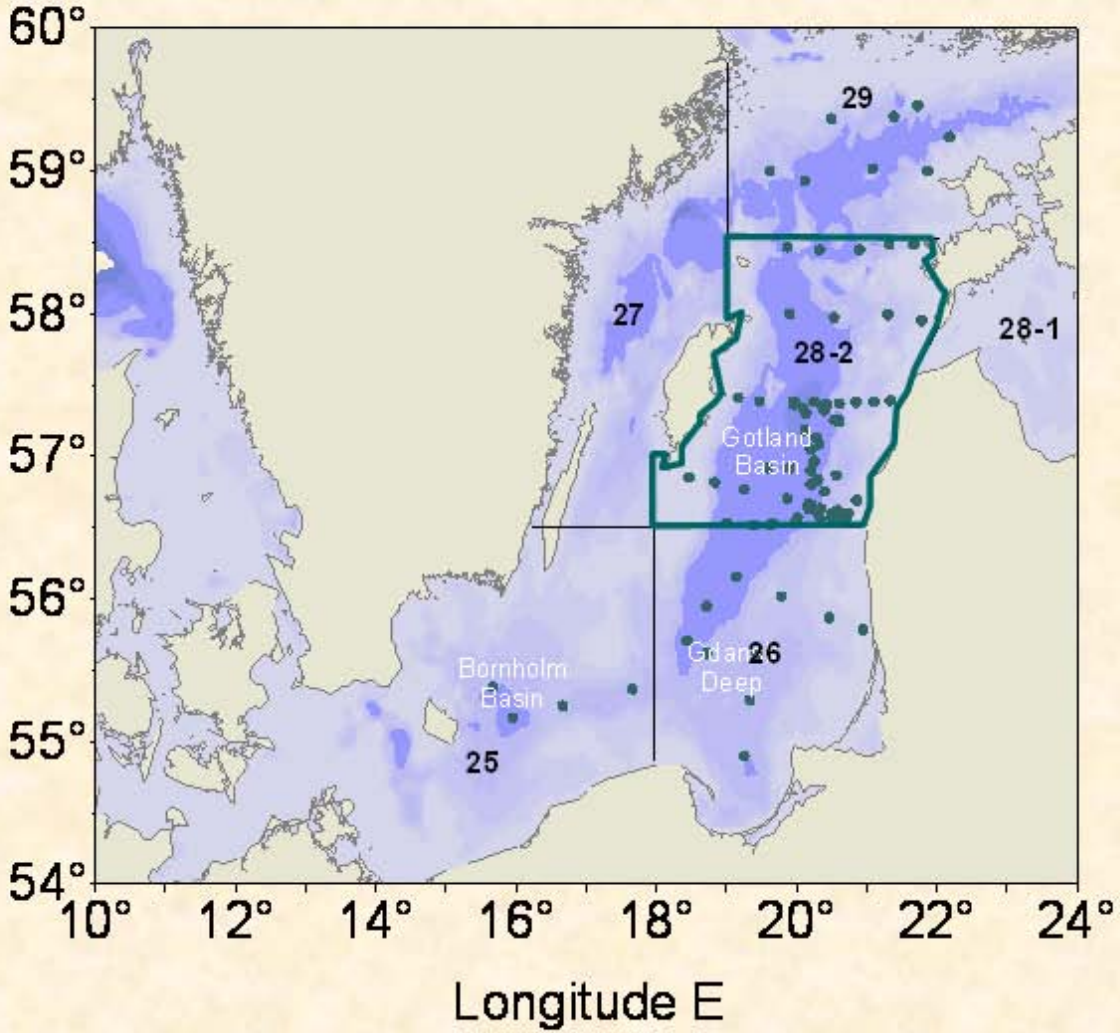
Latvian Fish Resources Agency **

Direct and indirect effects of climate



Zooplankton dataset

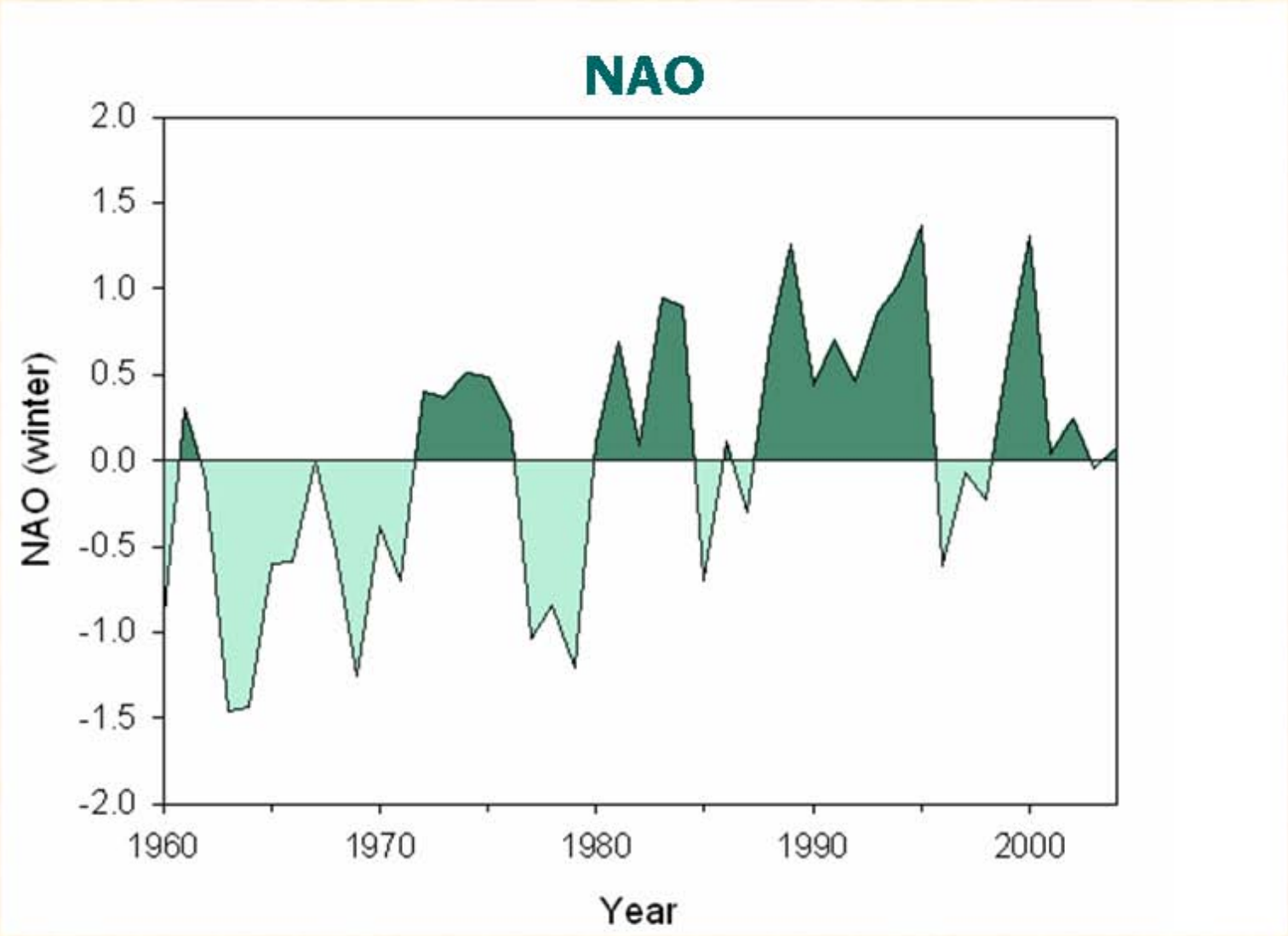
- Sampling performed by the Latvian Fish Resources Agency (LATFRA)
- Seasonal surveys since 1960 (we use spring data until 2004)
- Jeddy Net (160µm mesh size, 0.36m opening diameter)
- Identification to species level and developmental stage



Zooplankton data analysis

- Data aggregated to annual abundance values per species
- Biomass estimated applying standard weights (from HELCOM) for each species to abundance values
- Statistical analyses:
  - **Principal Component Analysis** (PCA)
  - **Chronological Clustering** (for Regime Shift detection)
  - **Redundancy Analysis** (RDA)
  - **Correlation analysis**

Climate indices



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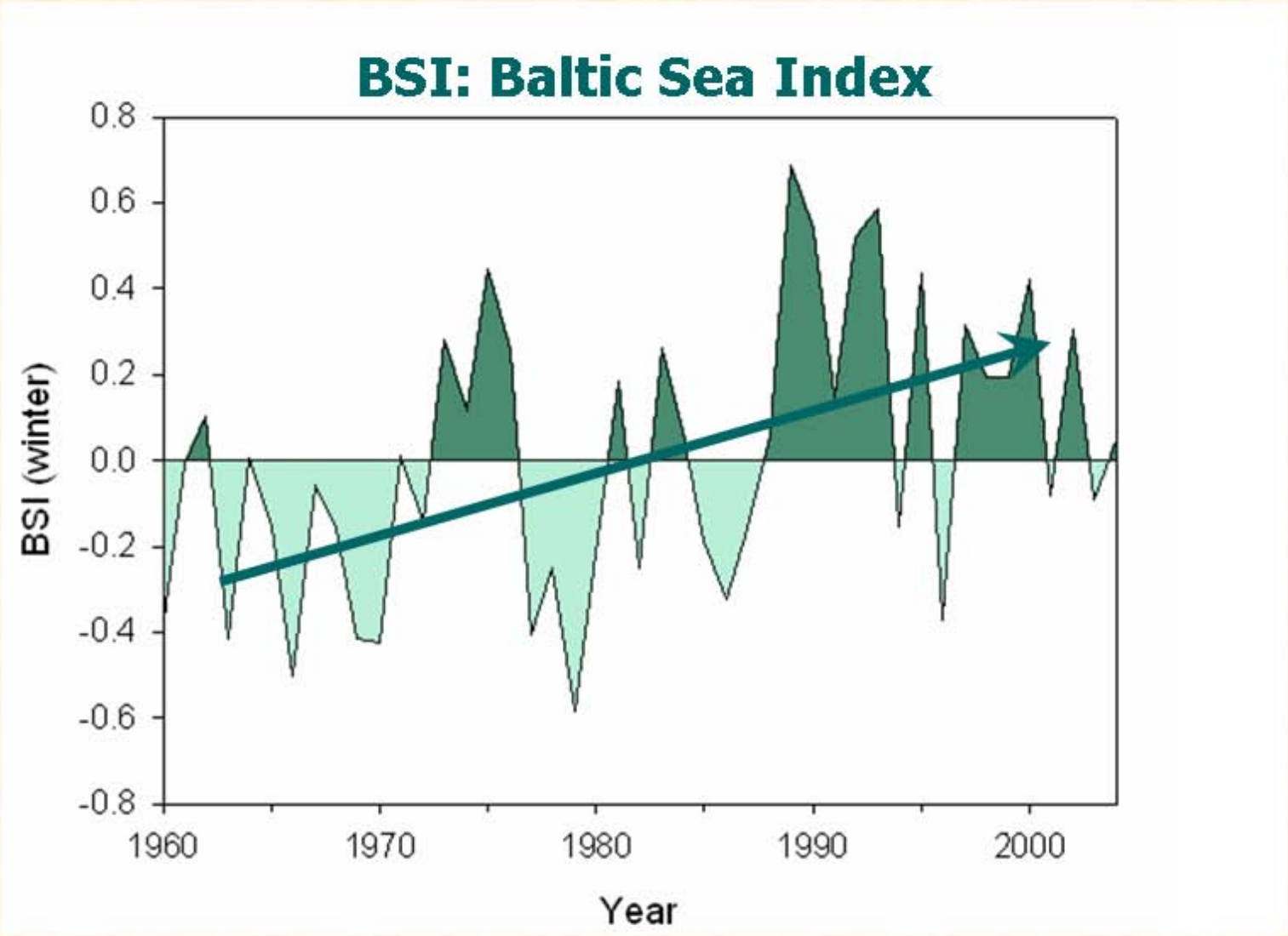
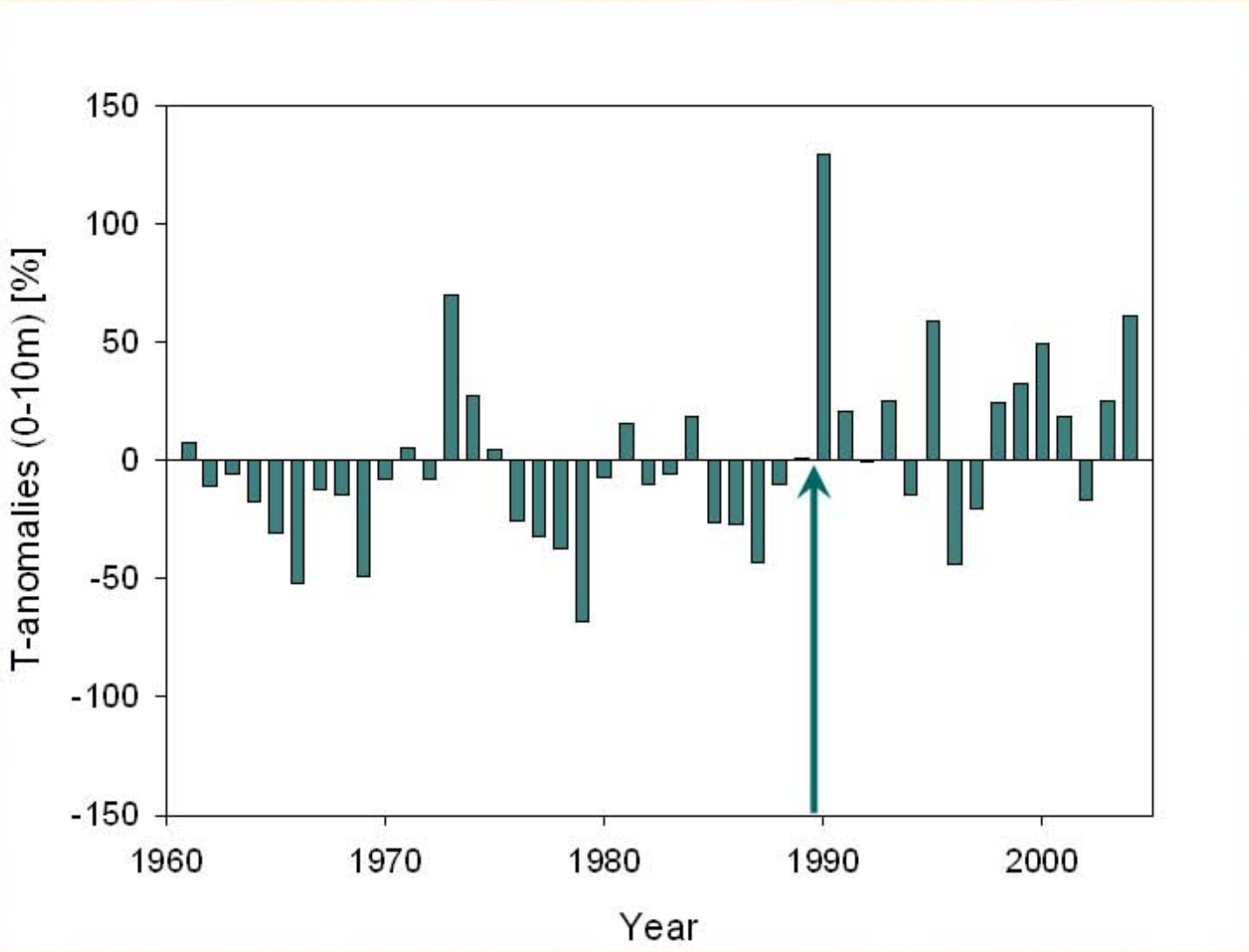
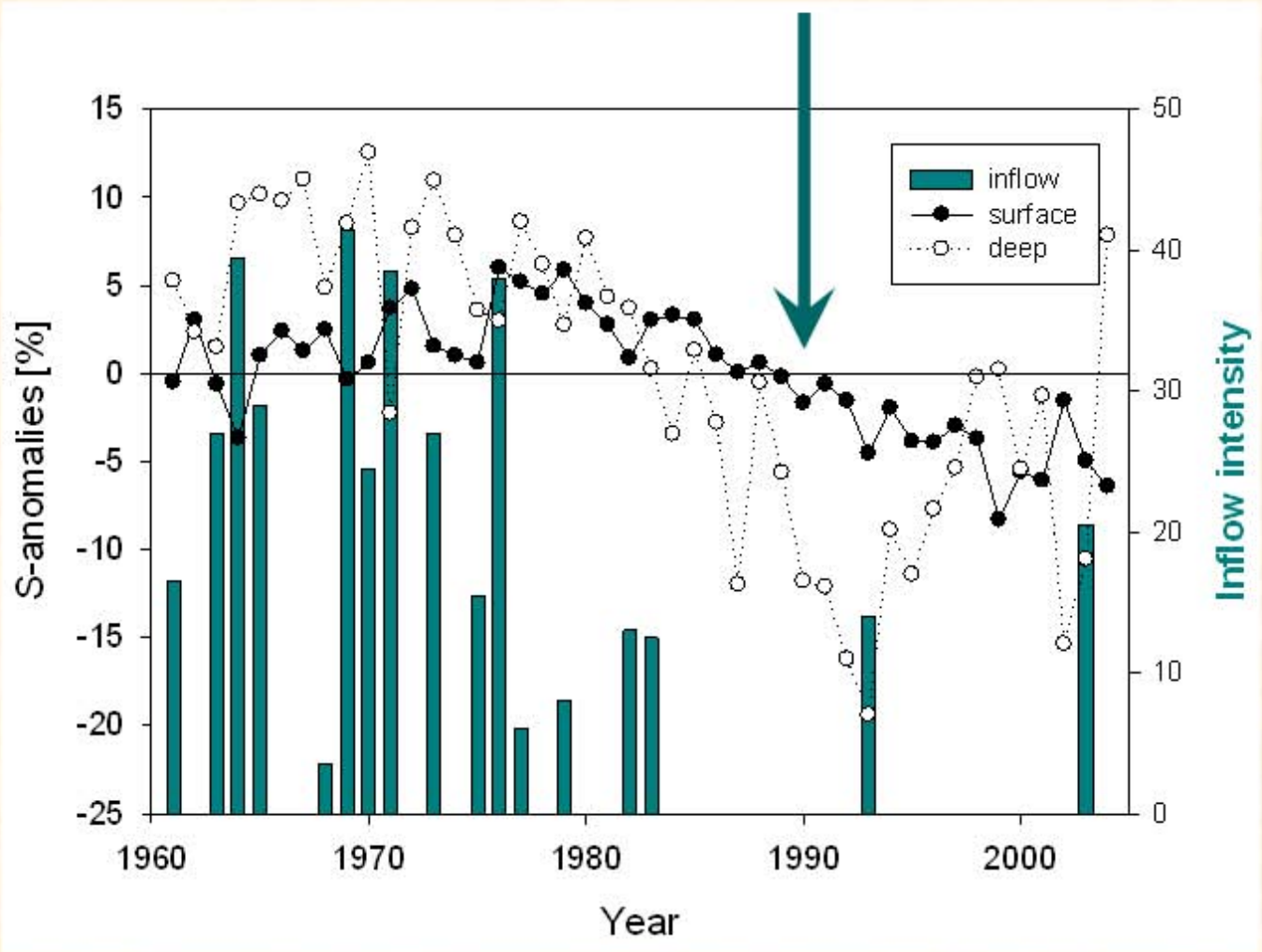


Temperature



Salinity & Inflows

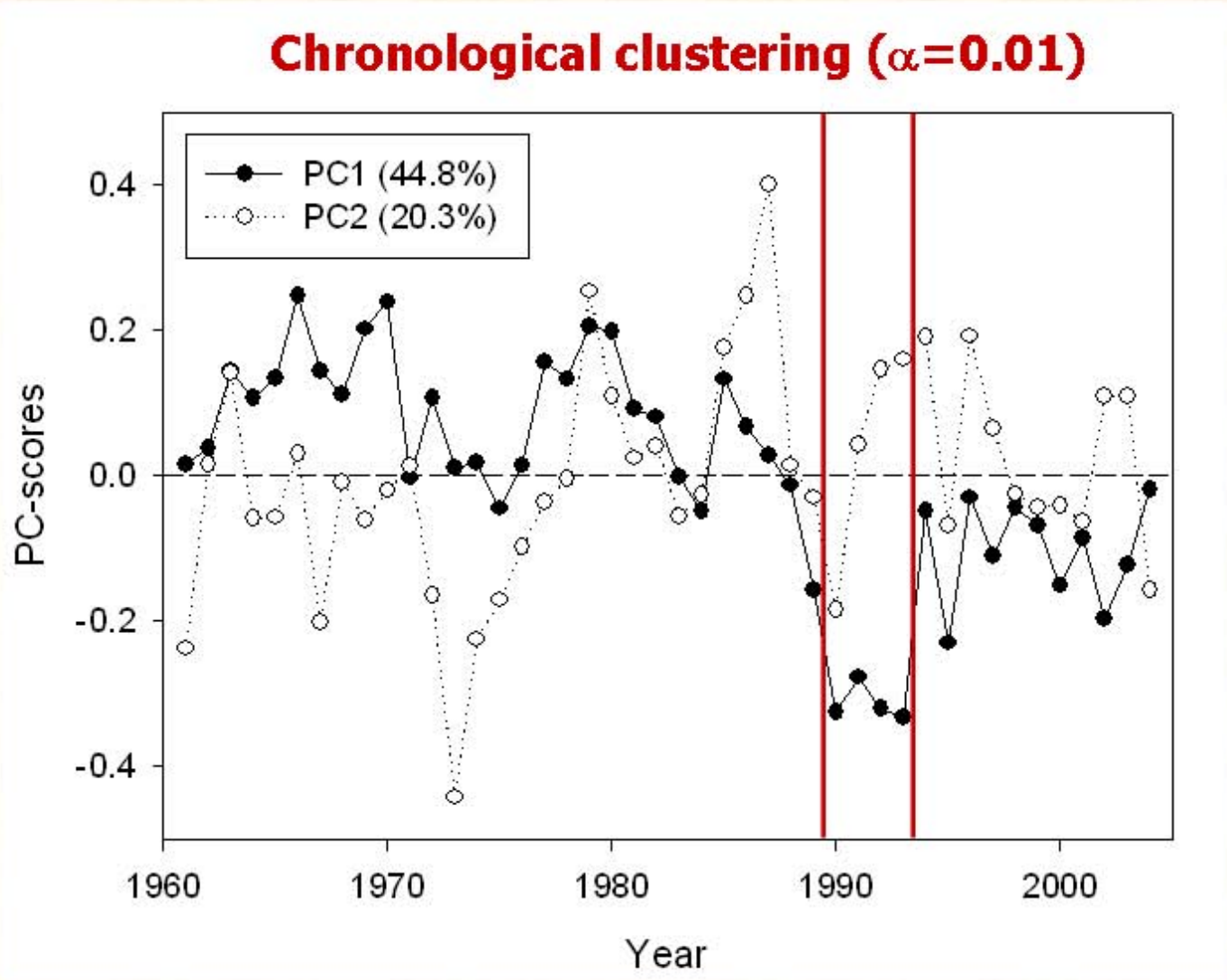


PCA - Hydrography

8 variables:

Spring:
- T (0-10m)
- T (40-60m)
- S (0-10m)
- S (80-100m)
- O_2 (60-80m)

Annual:
- Depth of 11psu isoline
- Runoff
- Icecover



PCA - Zooplankton biomass

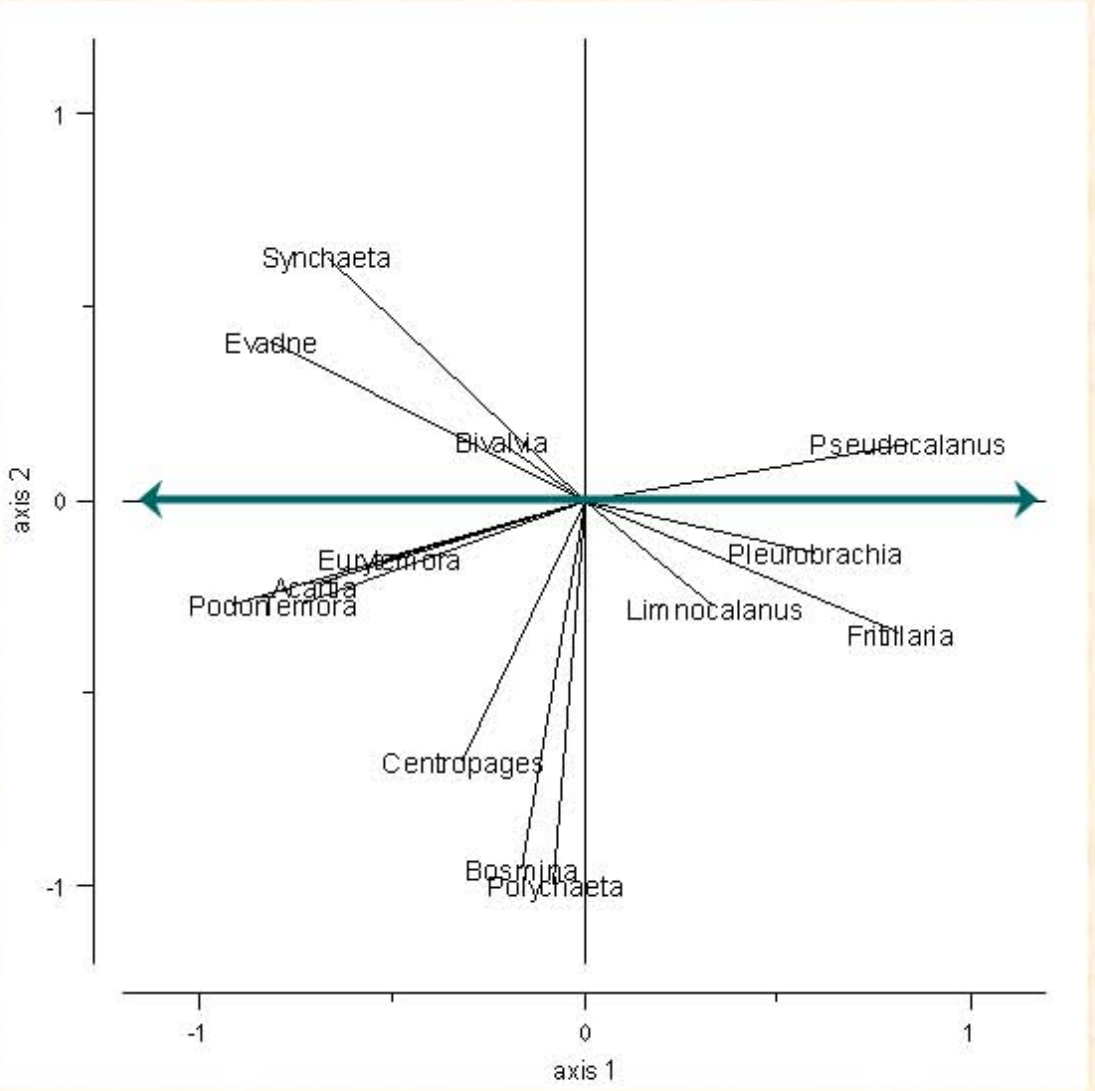
Response variables:

- 14 zooplankton groups/species
- Annual biomass values were **chord** transformed

Explained variance:

PC1 = 25.3%

PC2 = 16.5%



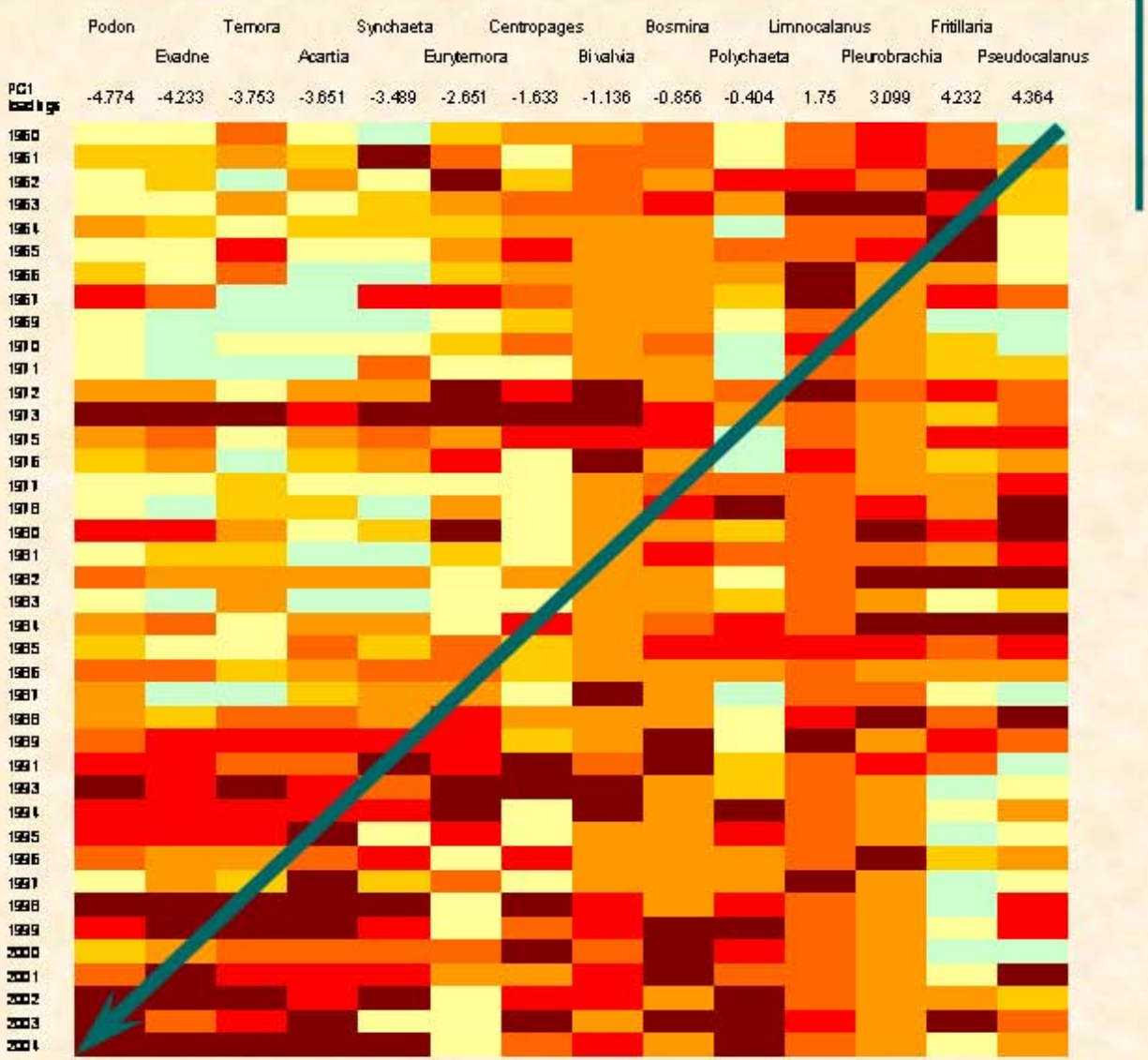
Temporal mesozooplankton variability

Annual biomass of 14 mesozooplankton groups sorted according to PC1 loadings

Colours according to 7 biomass quantiles:

1st 2nd 3rd 4th

5th 6th 7th



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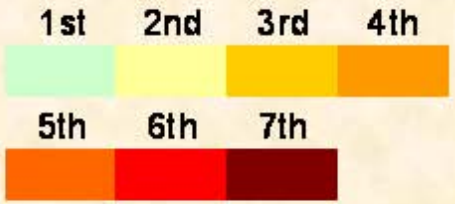

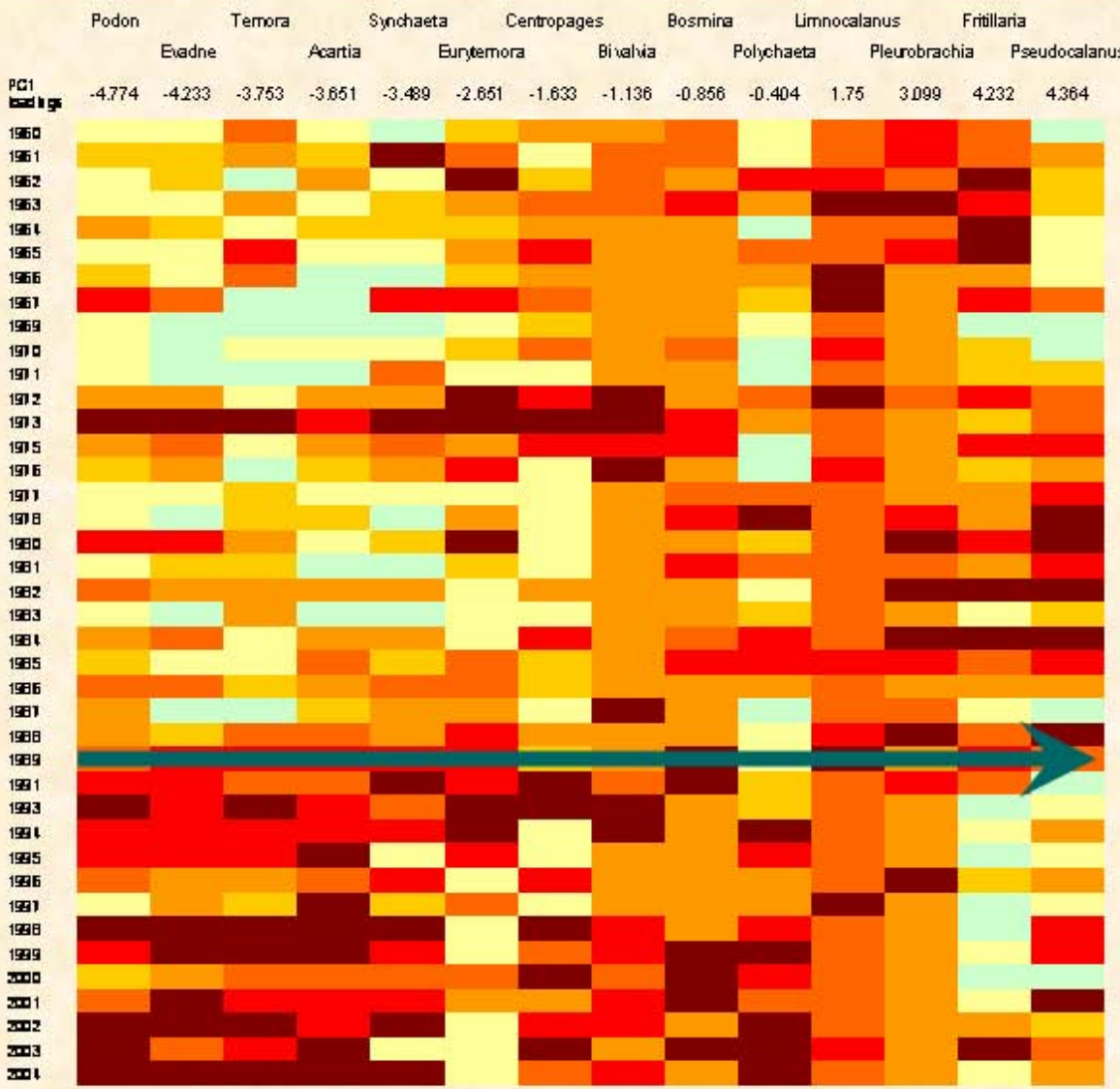

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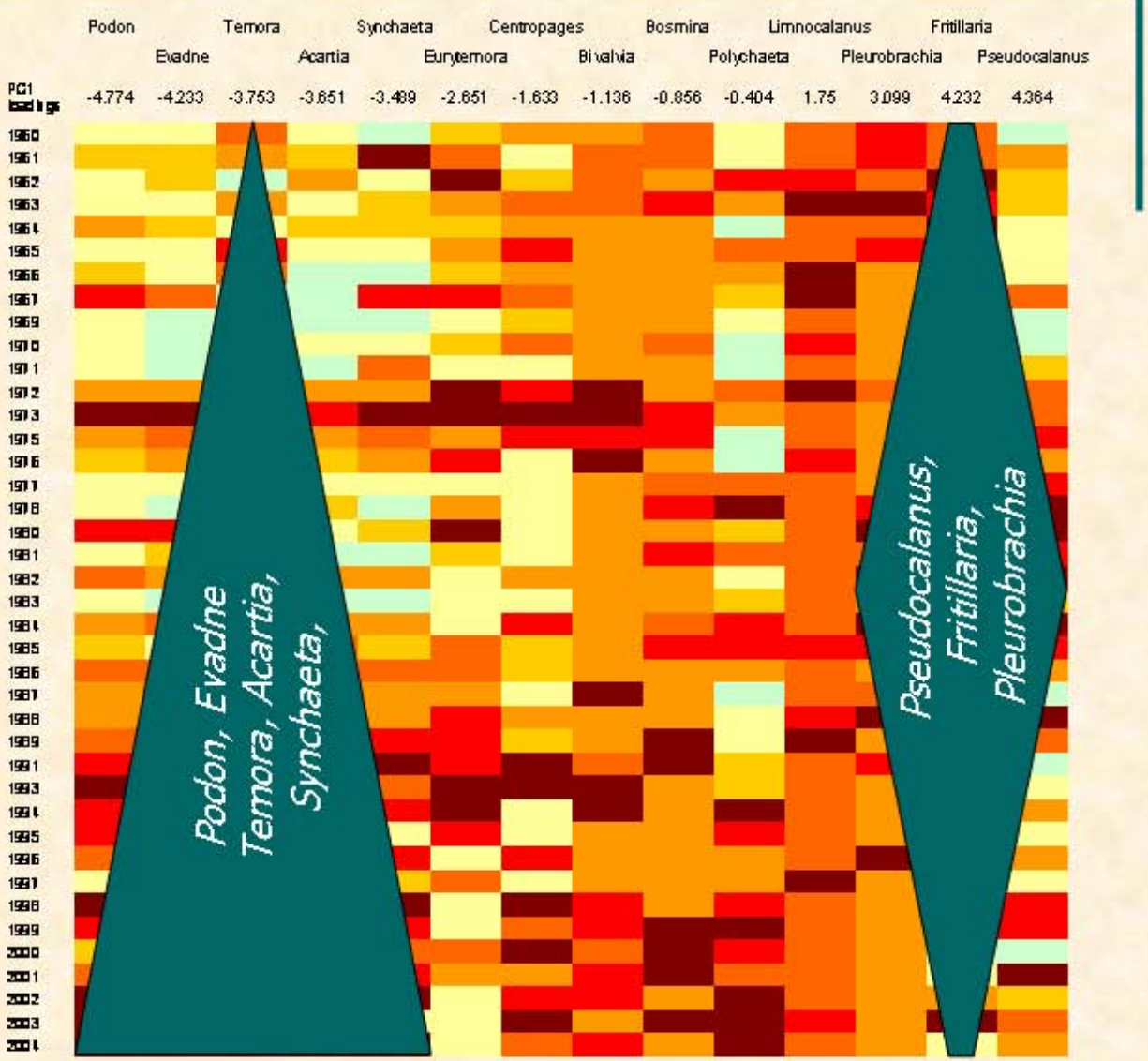
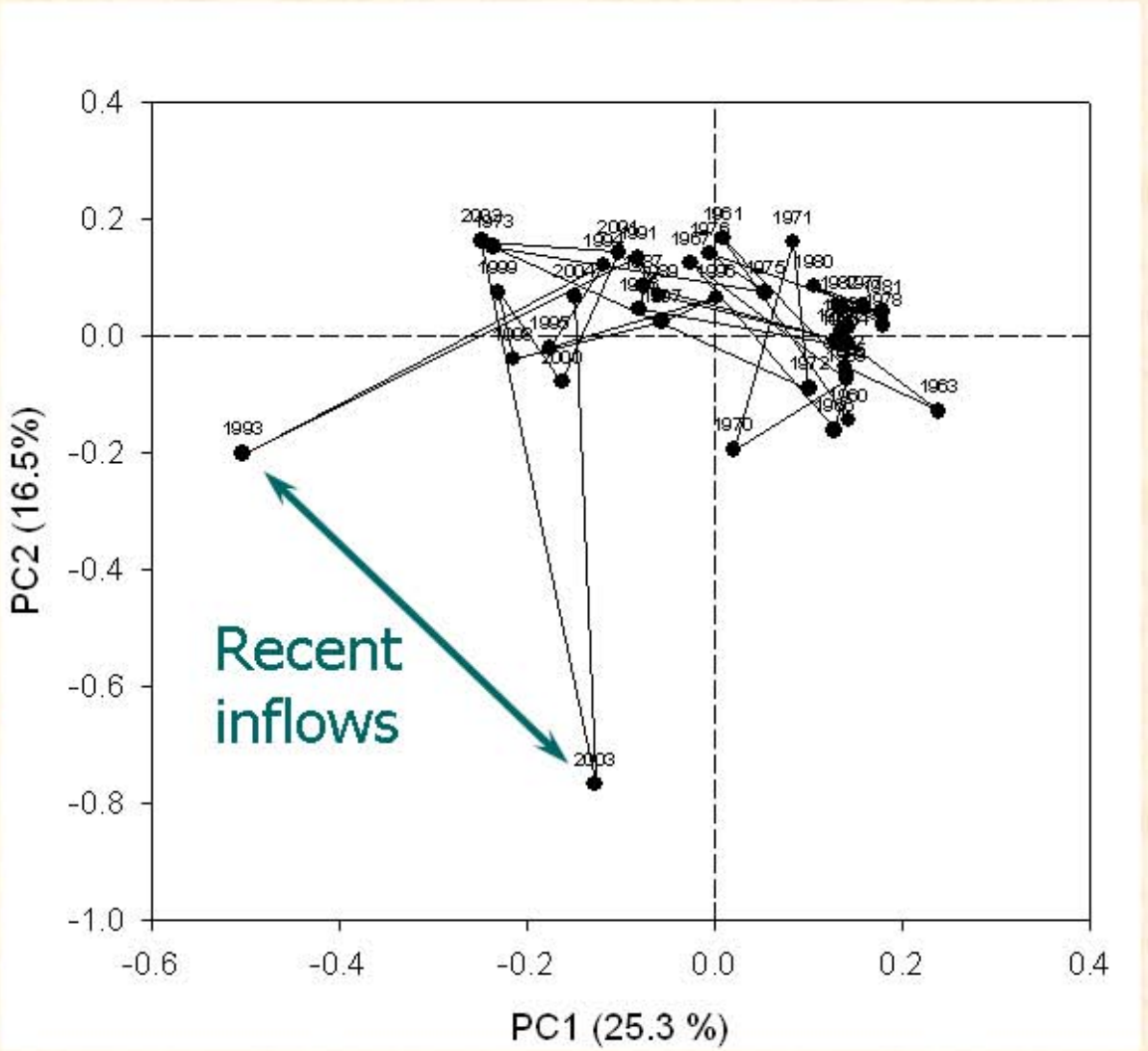


PCA - Zooplankton - year scores

Chronological Clustering (α=0.01):

→ **Shift in 1989 – 1991**



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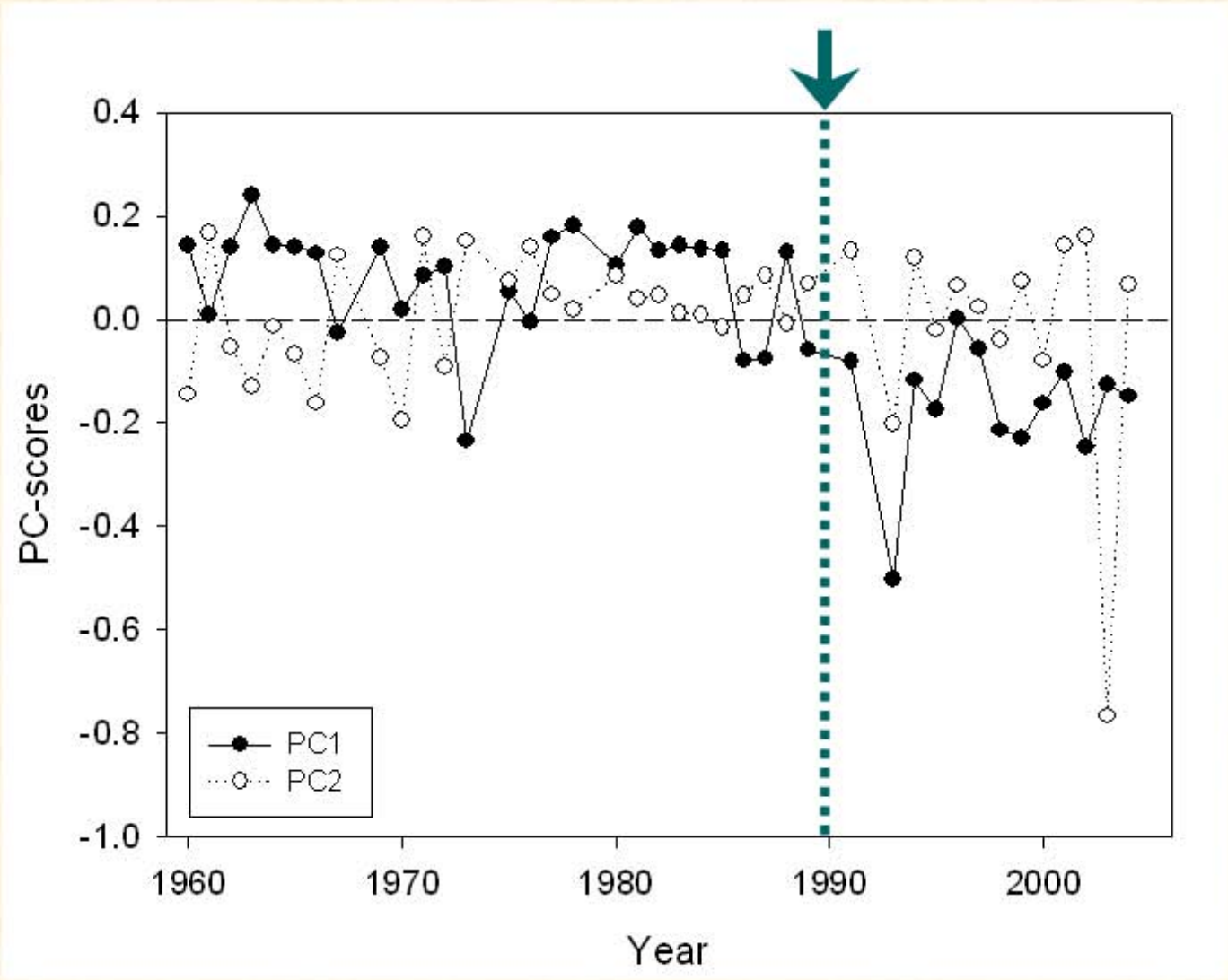
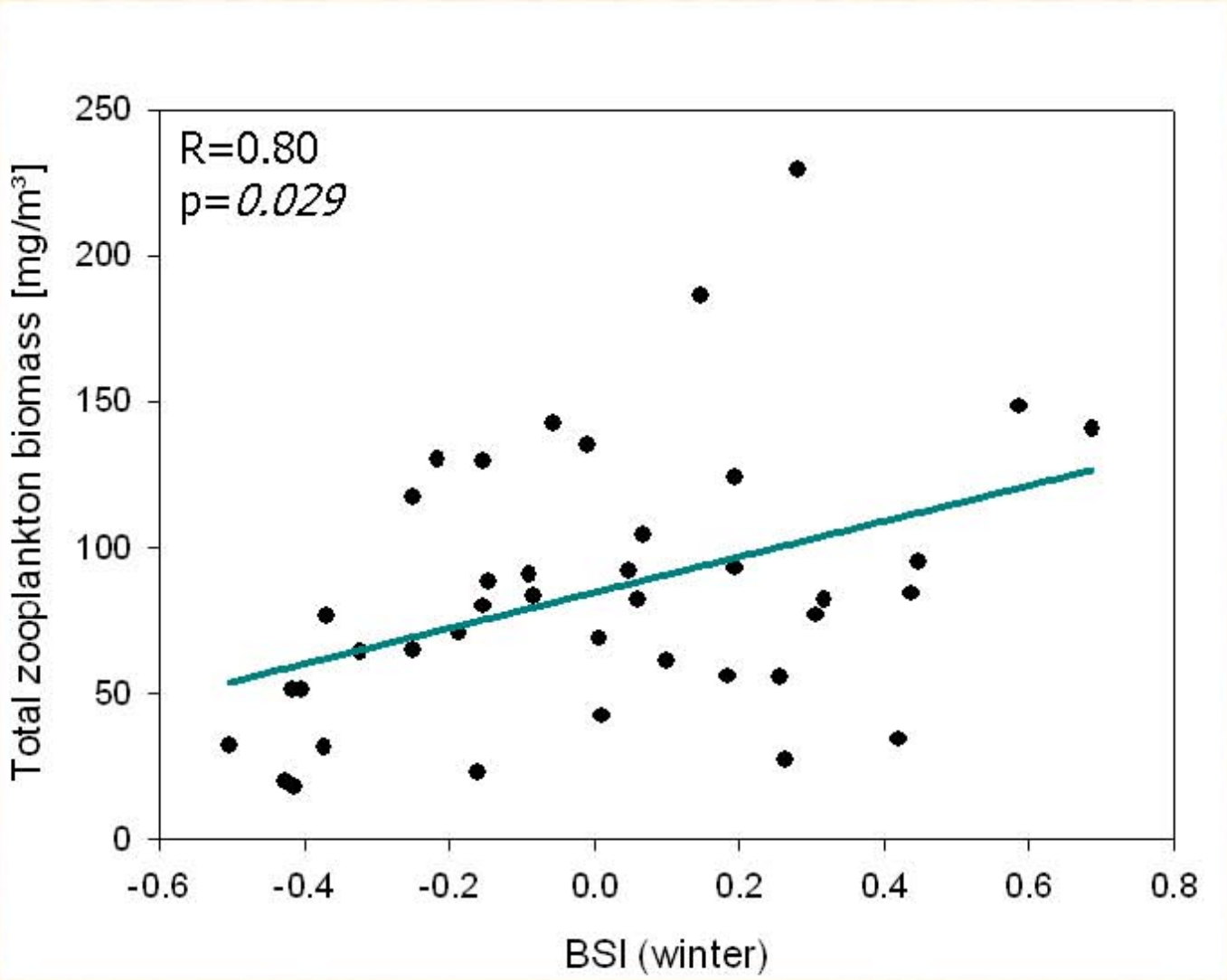
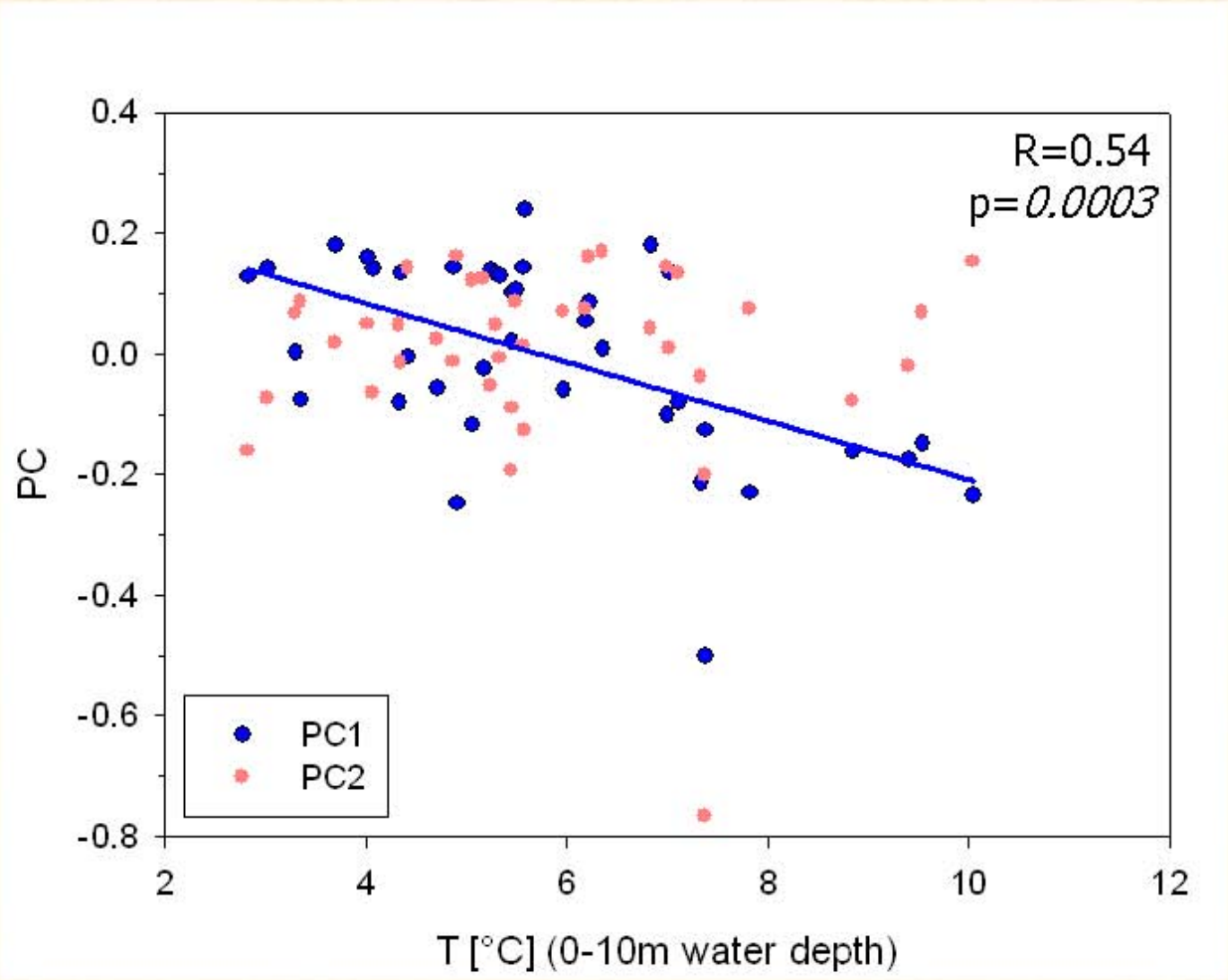


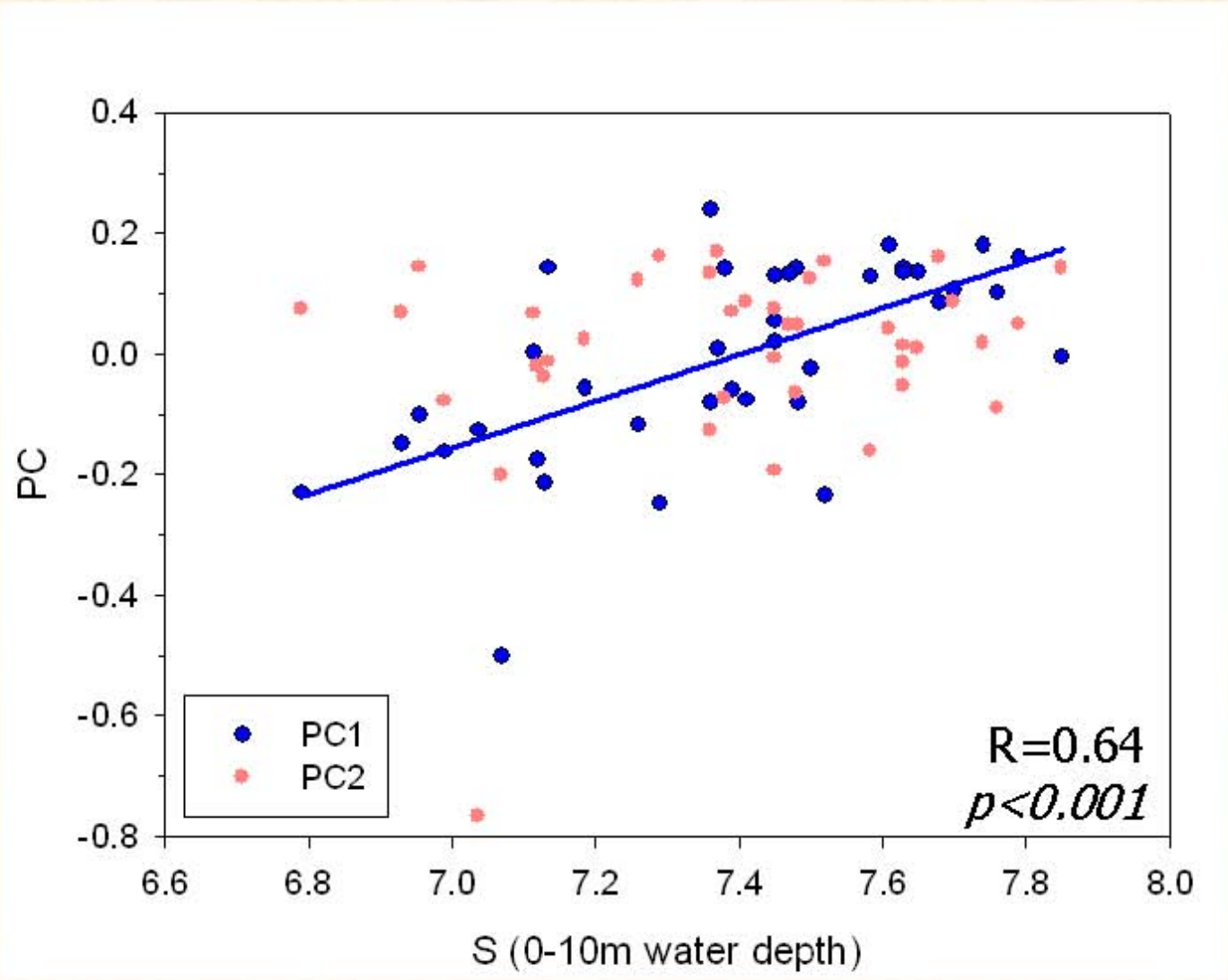
Direct effect - climate



Direct effect - temperature



Direct effect - salinity



RDA – Zooplankton, hydrography & phytoplankton

PC1: 18.7% (48.9%)

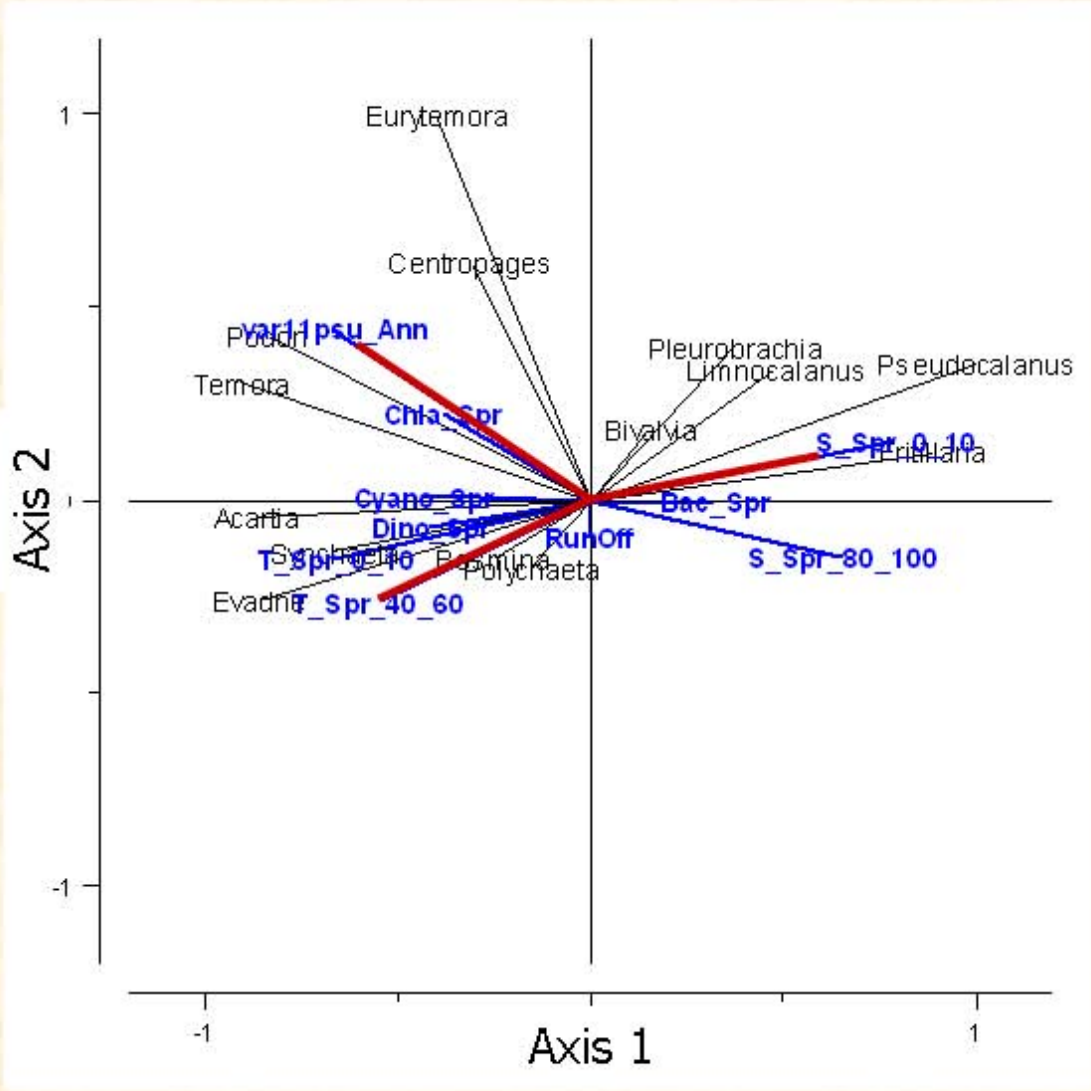
PC2: 6.9% (18.1%)

Variables with highest marginal effects:

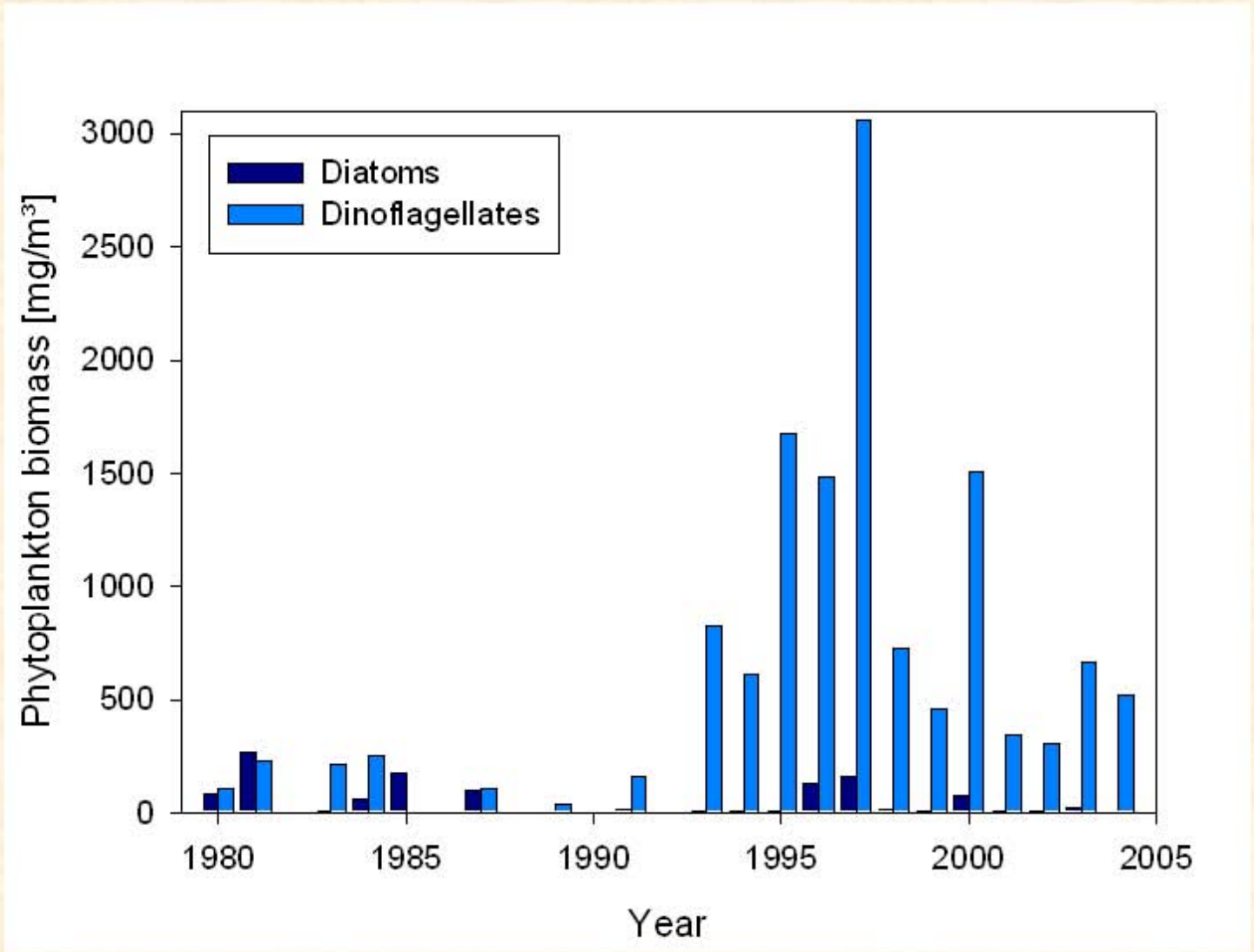
- S(0-10m)=33.7%
- S(80-100m)=25.9
- var11psu= 27.1%
- T(0-10m)=22.5%

Significant variables (forward selection):

- S(0-10m)
- var11psu
- T(40-60m)



Indirect effect – phytoplankton (bottom-up control)



Data from ICES/HELCOM WGIAB (2007)

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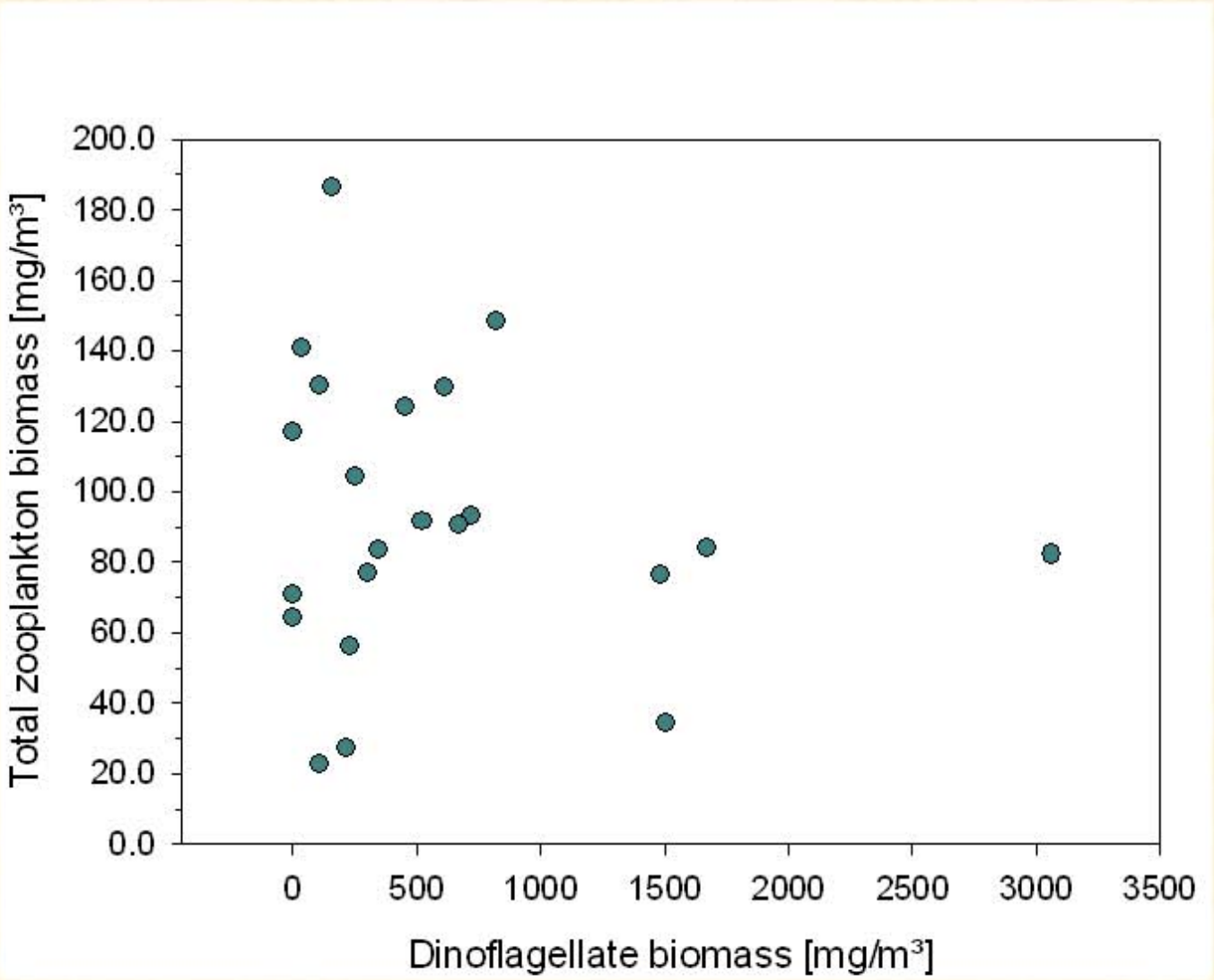

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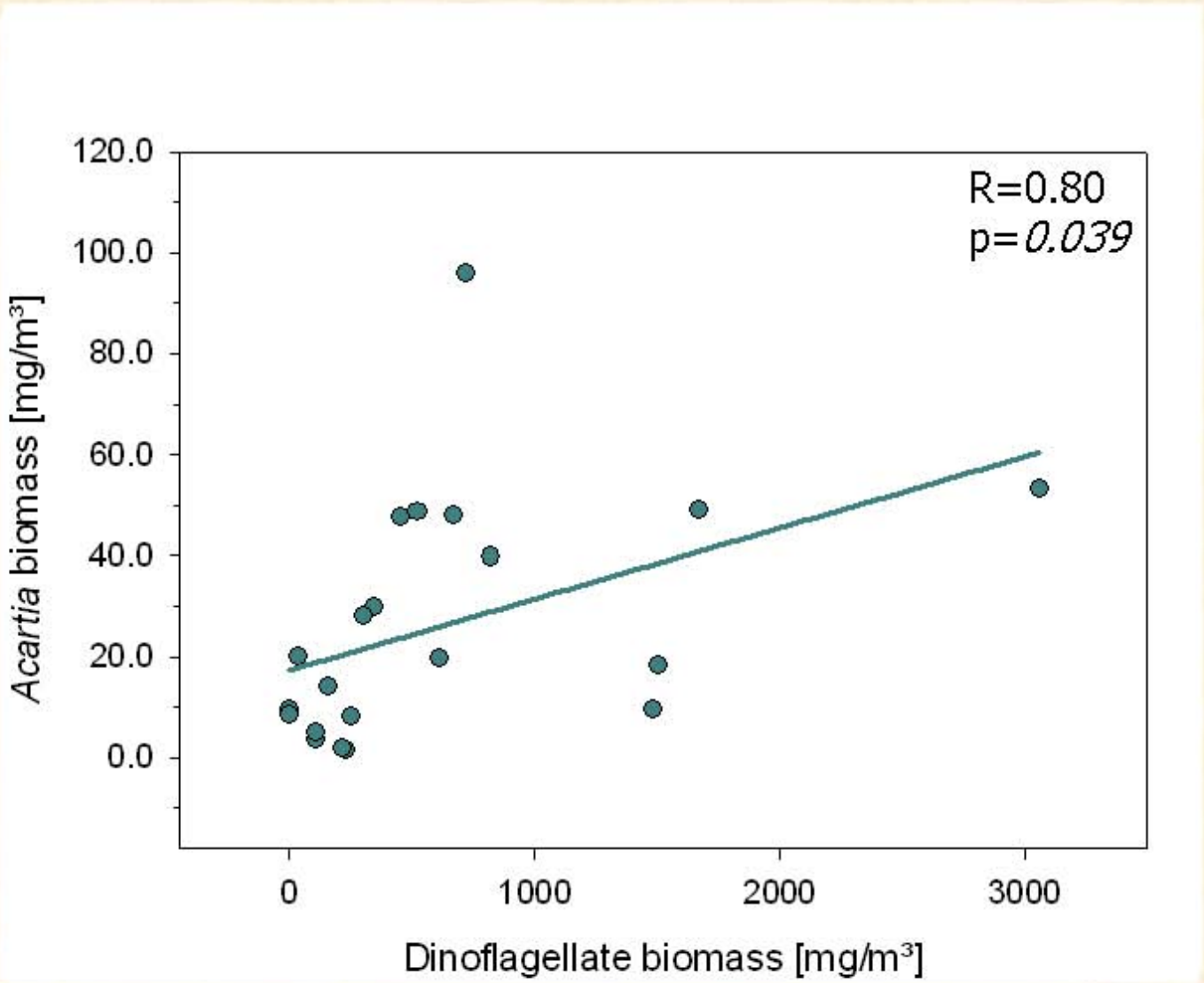

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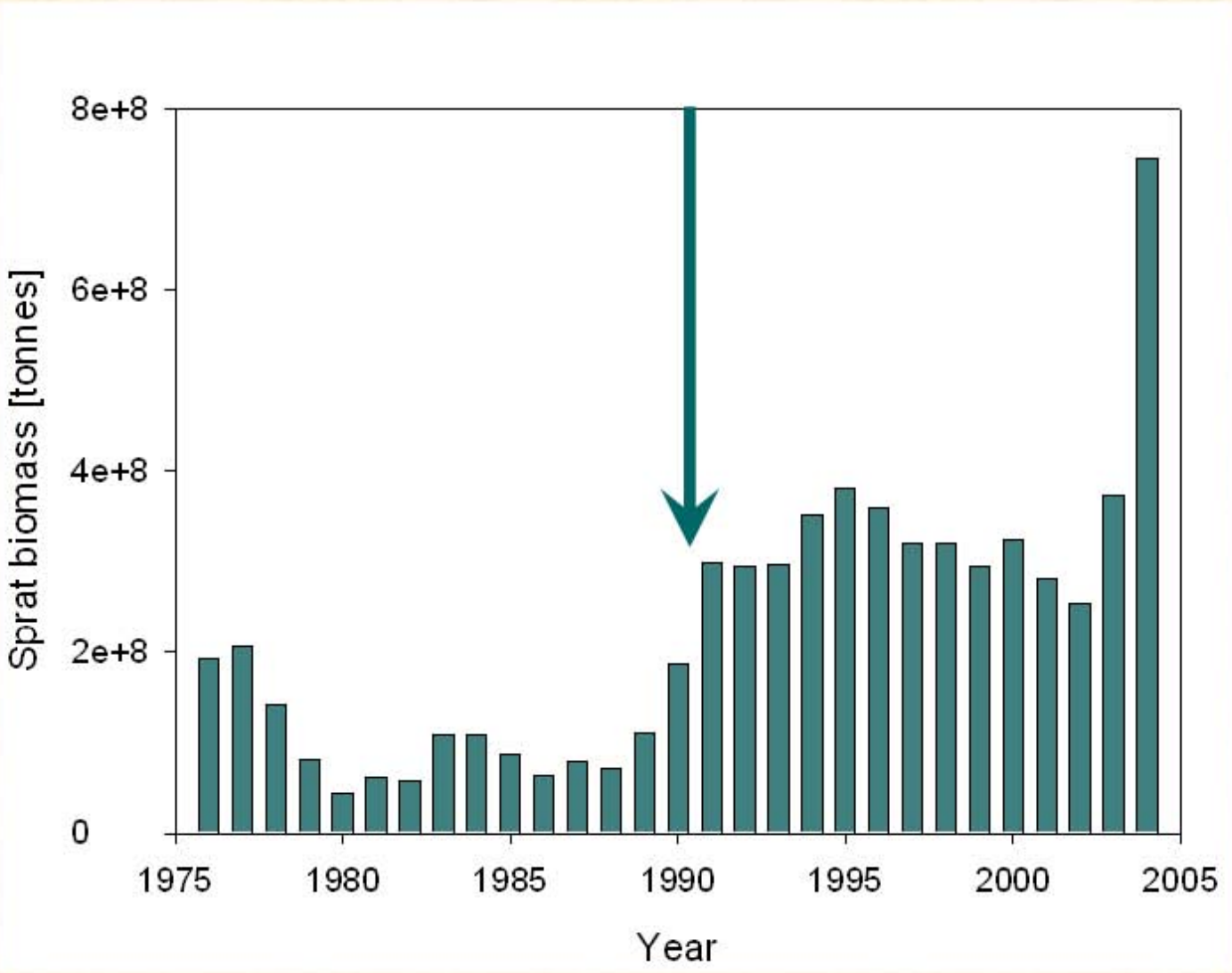
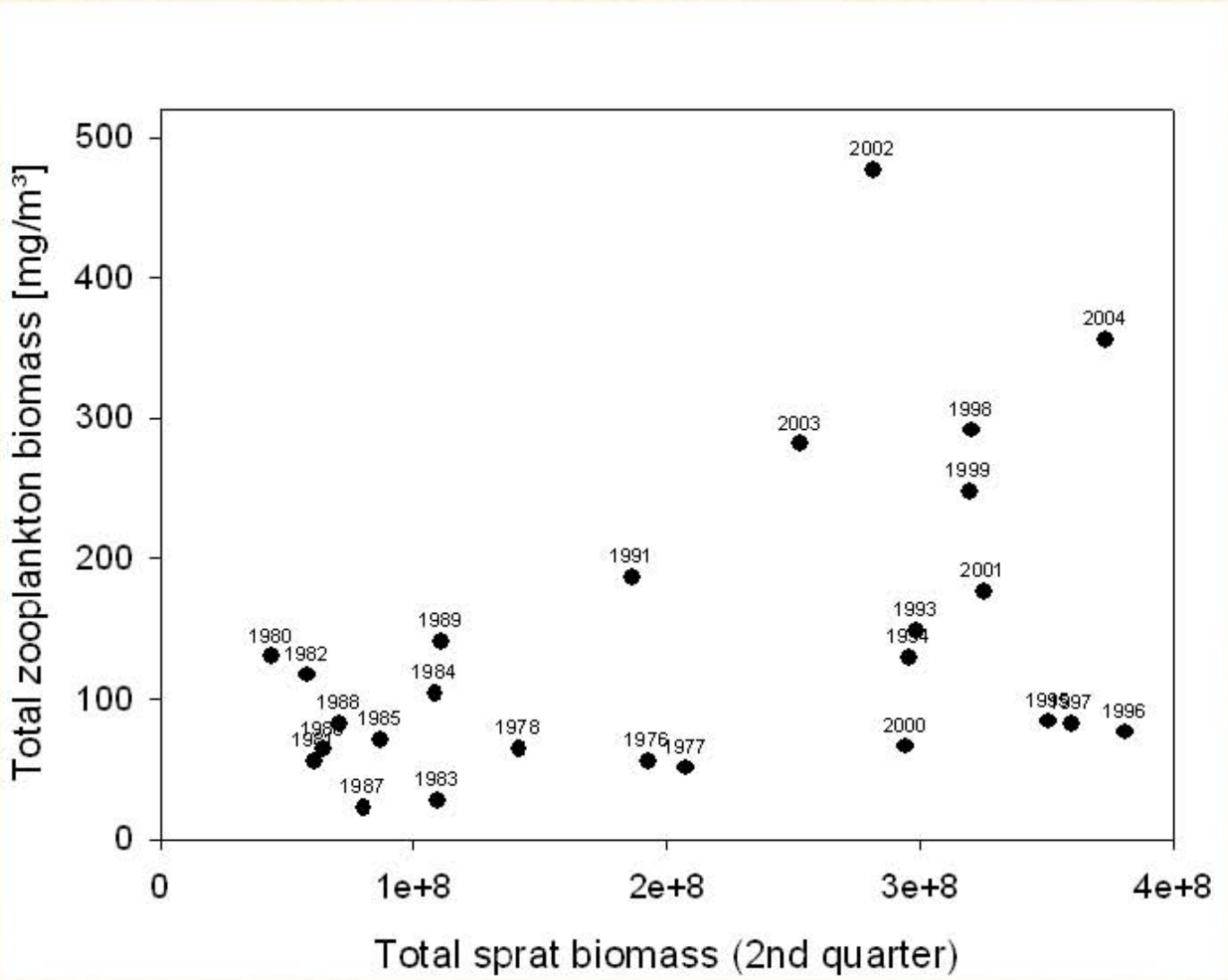
Indirect effect – sprat (top-down control)



Sprat biomass from MSVPA (ICES 2007)

Indirect effect – sprat (top-down control)



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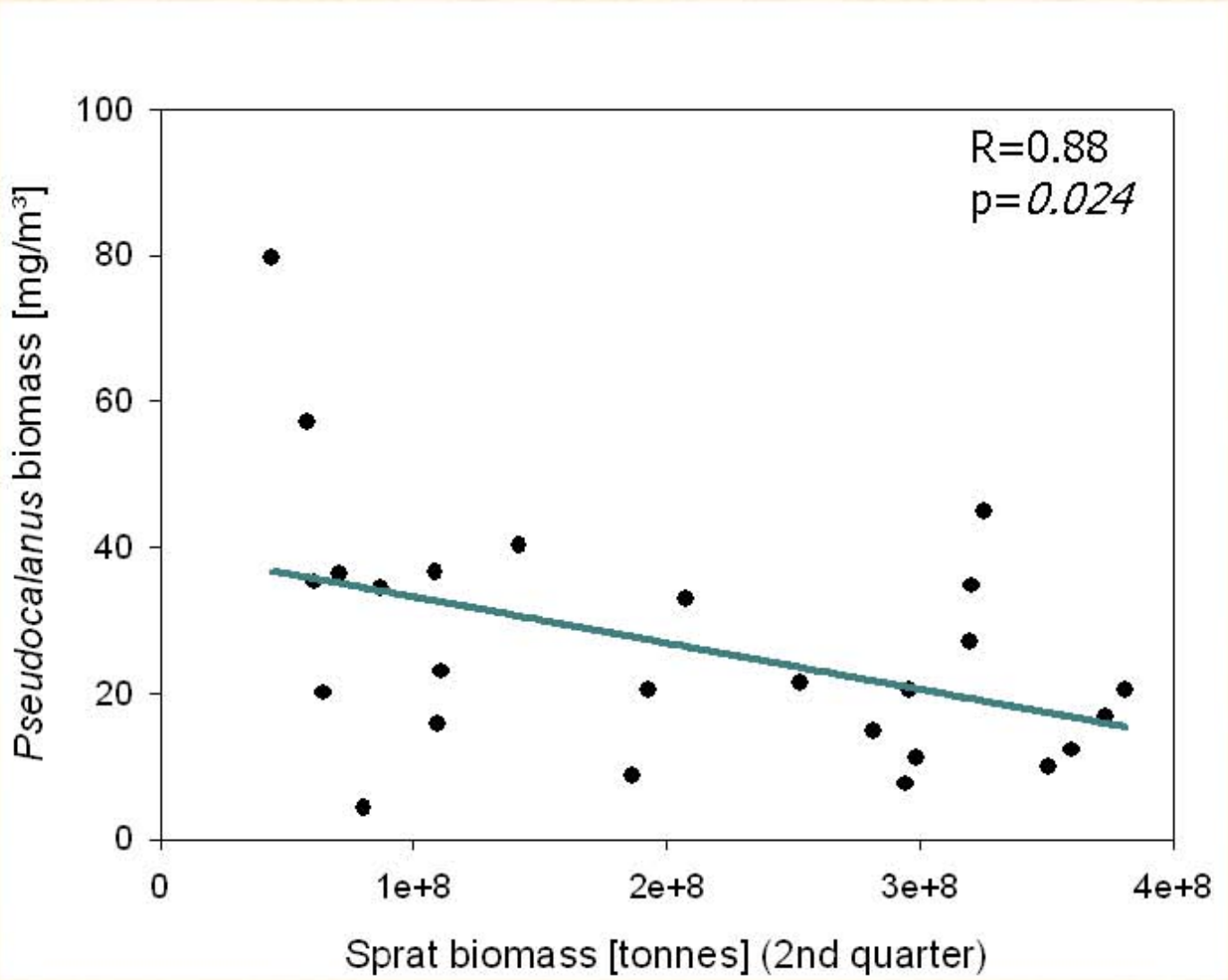

Sprat biomass from MSVPA (ICES 2007)

Conclusions

- **Regime-shift** in the physical environment ca. in 1989
- Pronounced **changes in temperature and salinity** due to atmospheric forcing since the late 1980s
- Total zooplankton biomass positively correlated to the Baltic Sea Index, which increased in the past 15 years
- **Regime-shift** also in the zooplankton community, e.g. *Pseudocalanus* decreased, while *Temora* and *Acartia* increased
- **Salinity** and **temperature** are the major factors driving zooplankton composition and biomass (direct effects)
- **Bottom-up** and **Top-down control** (indirect effects) do not act on the community, but rather on the species level