The effects of climate on the food web in the Baltic Sea

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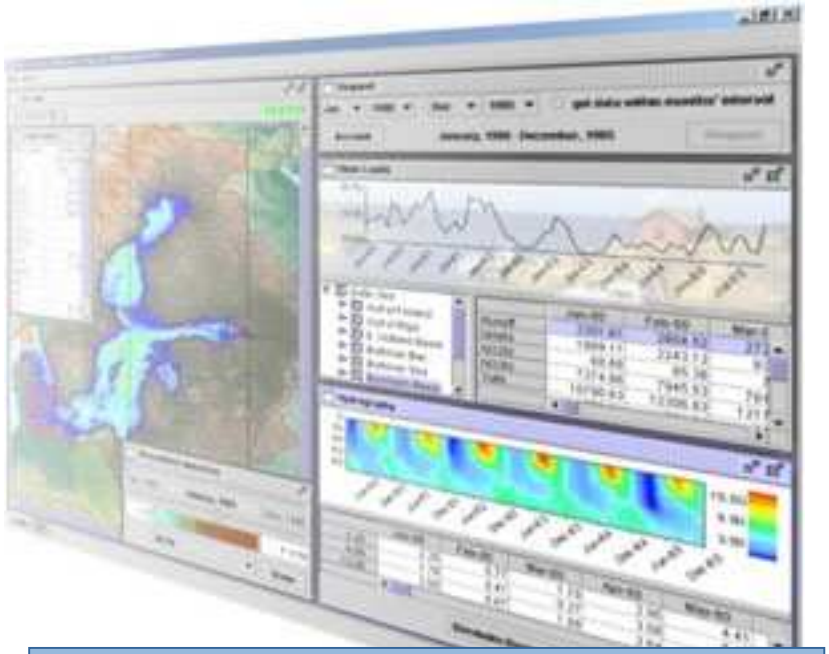
Linking Science and Management

- Baltic NEST is a science-based decision support system (DSS) to :
- Explore and synthesize information
- Calculate cost of different management options
- Evaluate the effect of eutrophication and fishery



DSS is based on models for:
-Atmospheric deposition
-Drainage basins
-Marine biogeochemistry
-Fishery management
-Cost optimization for Nutrient reduction

Outlook of the talk

- Introduction
- Regime shifts
- ICES Working Group
- Methods
- Results
- Summary

Consequences of Climate Change

- Higher temperature
  - prevents winter convection
  - Shift in species composition
  - Enhanced cyanobacteria blooms
- Increase in precipitation
  - Higher river runoff
  - Decrease in salinity
  - Higher nutrient input
- Increasing wind speed
  - deepens the thermocline

Food web

cod

↓

sprat

↓

zooplankton

↓

phytoplankton

↓

nutrients

Harbor porpoise?

Birds?

Ringed seal

Grey seal

Cod

Age 2, etc

Age 1

Age 0

Eggs/larvae

Fishery

Forcing factors

Salmon?

RV

Salinity

Herring

Age 2 etc..

Age 1

Age 0

Eggs/larvae

Sprat

Age 2, etc...

Age 1

Age 0

Eggs/larvae

Jellyfish?

Flounder?

Saduria

Other...

Pseudocalanus

Acartia

Temora

Cladocerans

Other...

Bottom anoxia

Mysids

Meiobenthos

Microzoopl.

Eutrophication

Bacteria

Temp/Climate

Detritus

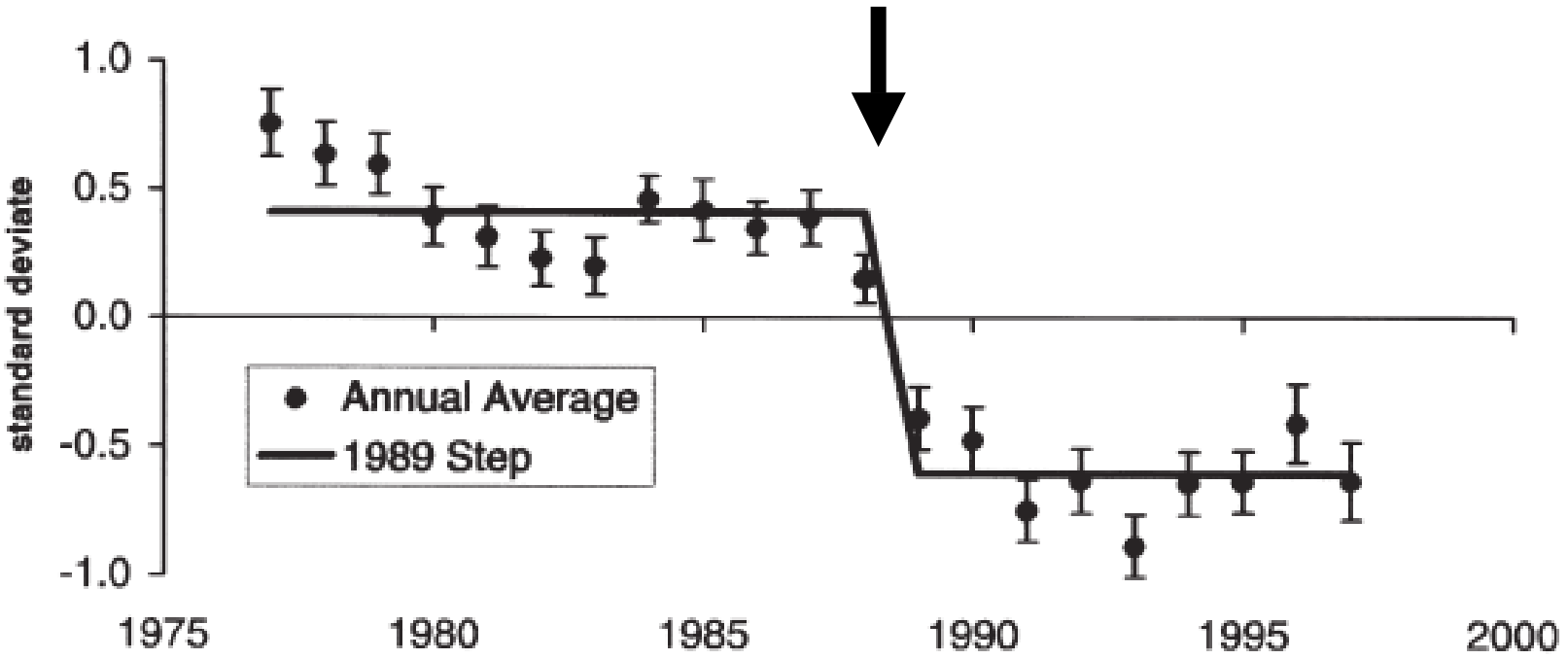
Diatoms

Dinoflagellates

Cyanob.

Other...

Regime shifts



Research needs

Analysis of the long-term time-series

- Understanding of thresholds and abrupt ecosystem changes by analysing:
  - Trophic levels
  - Temporal and spatial differences
  - Benthic-pelagic coupling
- Multiple stressors (overfishing, climate..)
- System approach

ICES/HELCOM Working group on Integrated Assessments of the Baltic Sea (WGIAB)

Chairs: Christian Möllmann, Juha Flinkmann, Anna Gårdmark

Data sources and analysis

Local time series from 1979 – 2007 of:

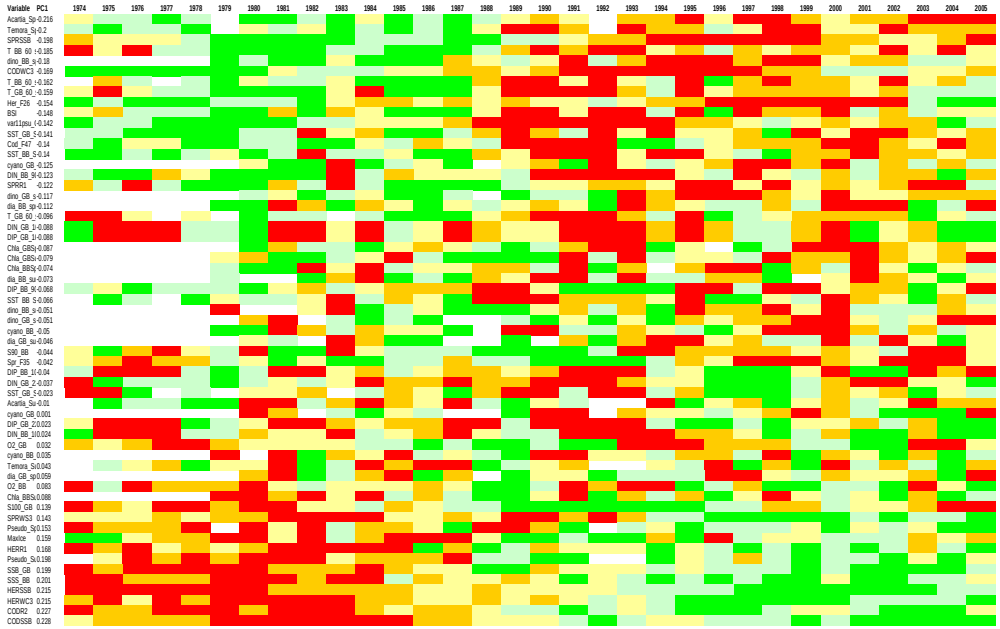
- Environmental data (e.g. T, S, O2, BSI, Nutrients)
- Biotic variables (e.g. abundance/ biomass of phyto-, zooplankton and/or benthic species, Chla)
- Fish and Fisheries data (e.g. species specific SSBs, recruitment indices, CPUE, F, landings)

Based on national monitoring data

Data visualisation

Data exploration:

- Plotting of single time-series (simple scatterplots)
- Calculating quartiles, quintiles, anomalies from the mean etc. for each metric
- Produce „ traffic-light-plot“ by colour coding



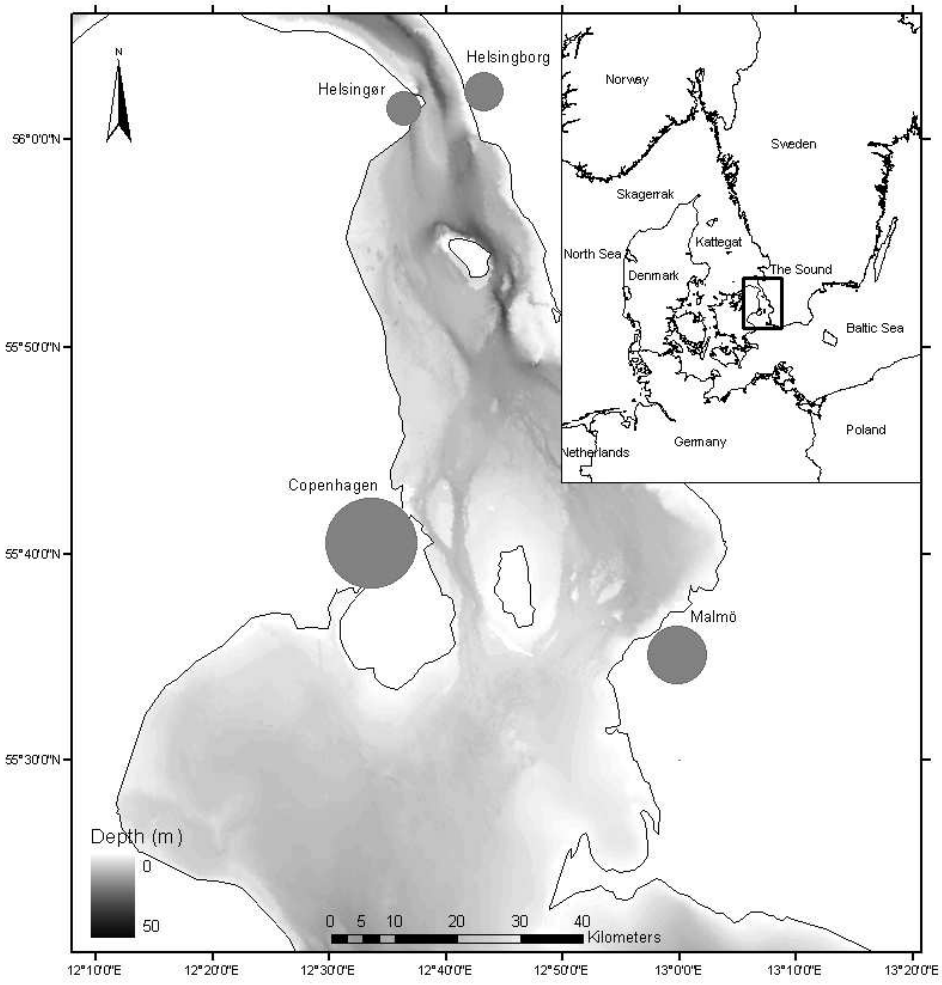
Standard methods for WGIAB

- Plotting of selected time-series
- PCA of full dataset (abiotic and biotic variables)
- PC time-trajectories
- Traffic-light plot
- Regime shift detection:
  - Chronological Clustering
  - STARS
- PCA of data subsets (explanatory and response variables)

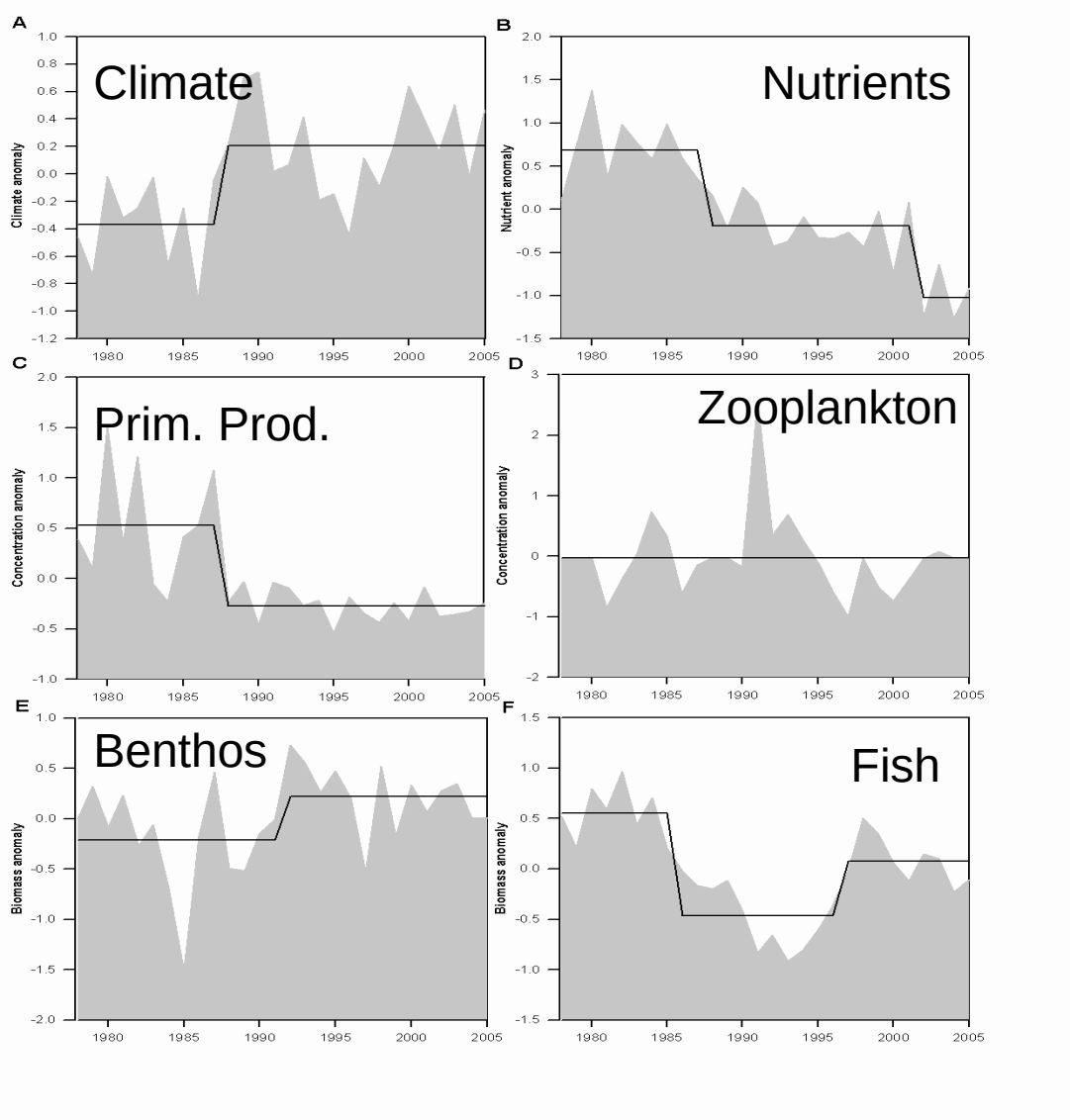
7 Integrated Assesments of the Baltic Sea

The Sound

- 118 km long and 4-28km wide strait
- Strong halocline at 10-12m
- High diversity



The sound

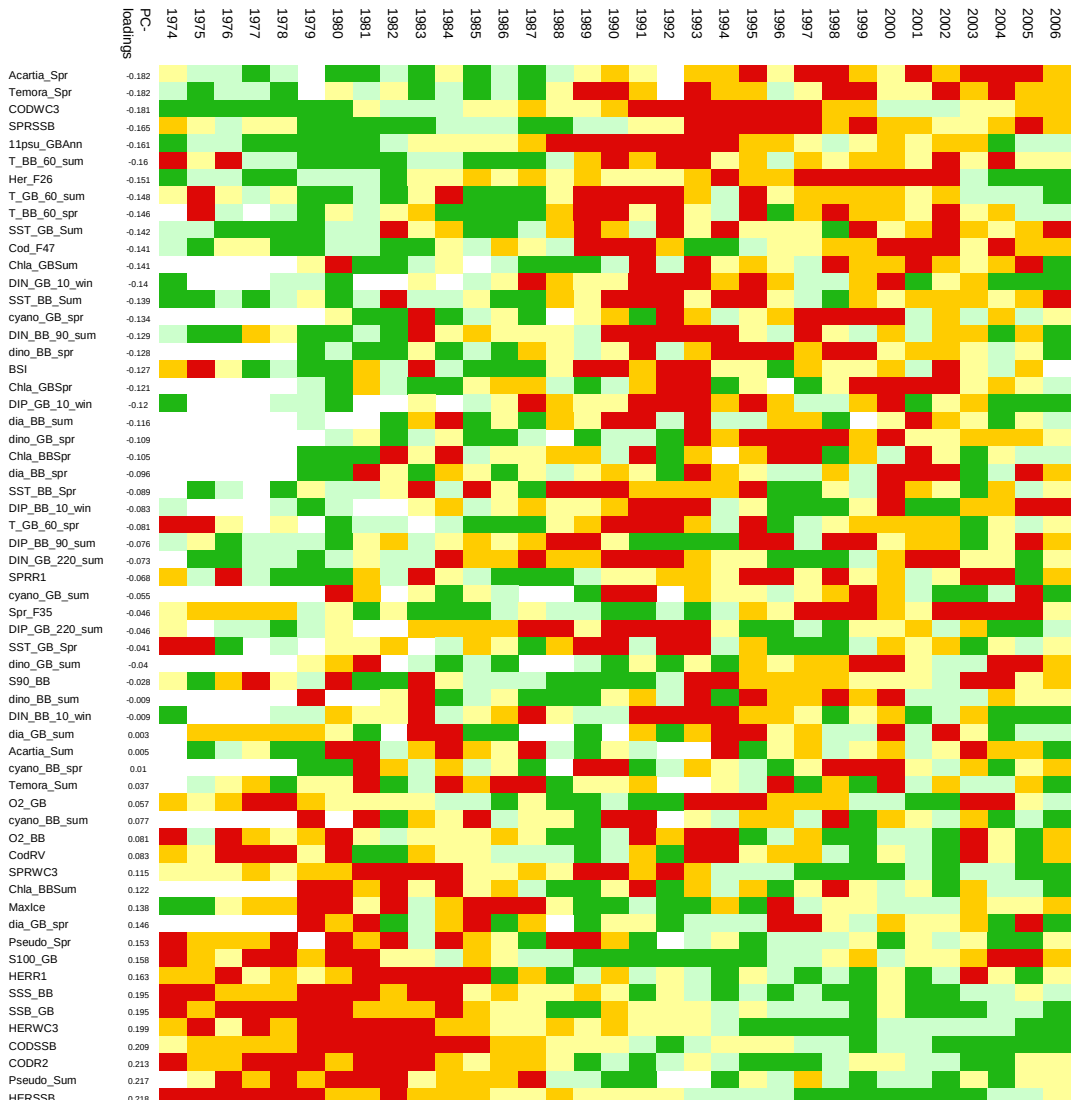

A
Climate
Climate anomaly
B
Nutrients
Nutrient anomaly
C
Prim. Prod.
Concentration anomaly
D
Zooplankton
Concentration anomaly
E
Benthos
Biomass anomaly
F
Fish
Biomass anomaly
1980
1985
1990
1995
2000
2005

The sound summary

- First regime:
  - High nutrient loadings
  - High primary productivity
- Second regime:
  - Higher temperature and BSI
  - Diatoms and dinoflagellates
  - Landings of flatfish and cod

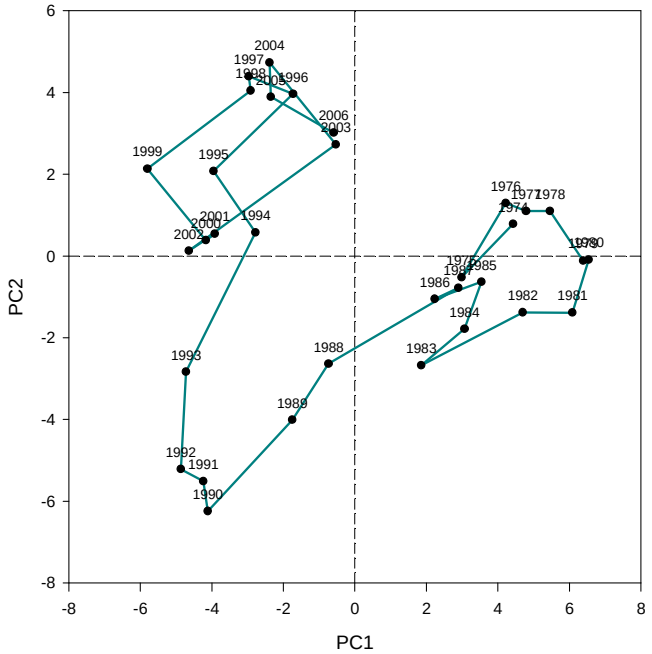
Central Baltic Sea

(ICES subdivisions 25, 26, 27 and 28)

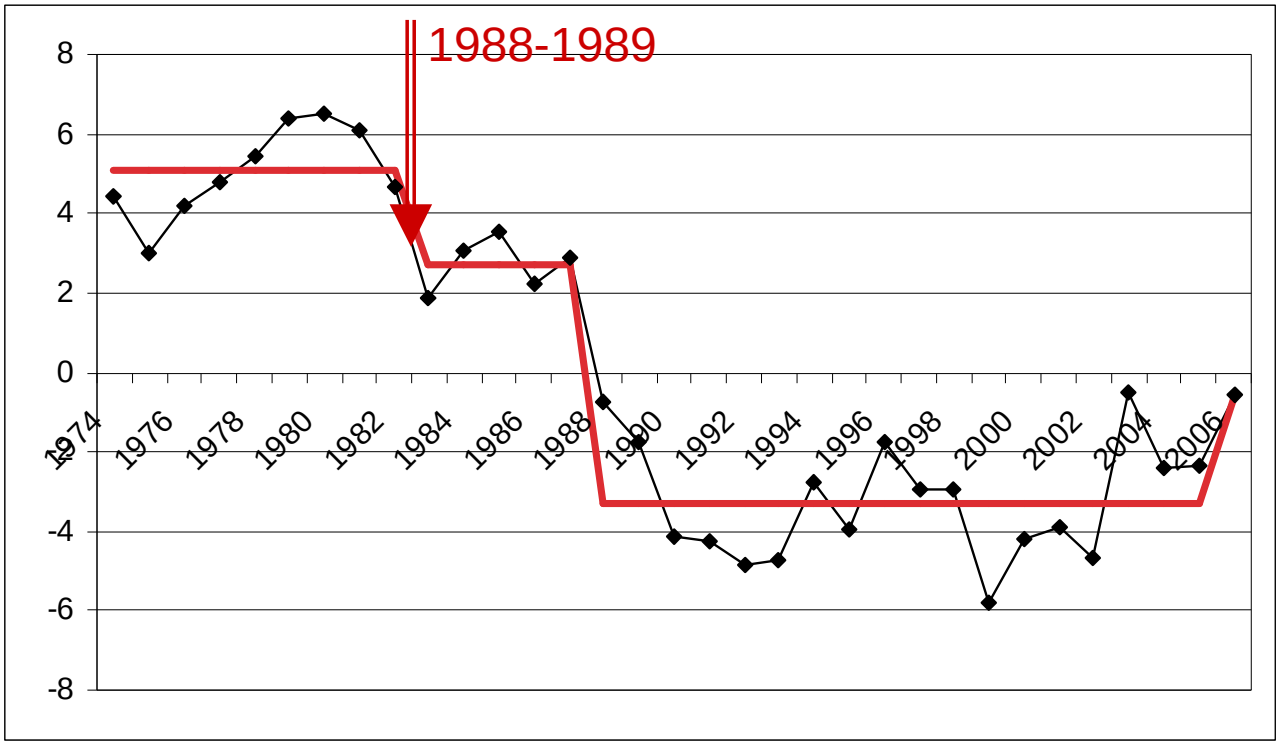


CBS summary

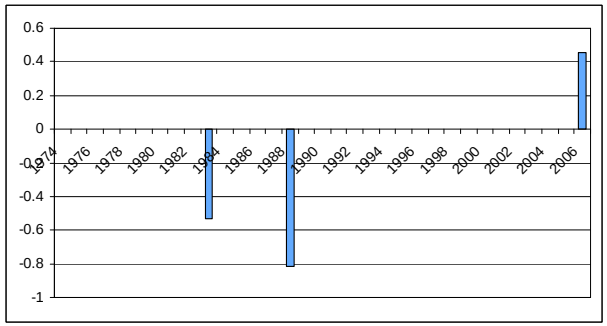
- First period:
  - Cod, herring, Pseudocalanus and ice extent
- Second period:
  - Sprat, Acartia, Temora, dinoflagellates and temperature



Baltic Sea - Regime shift

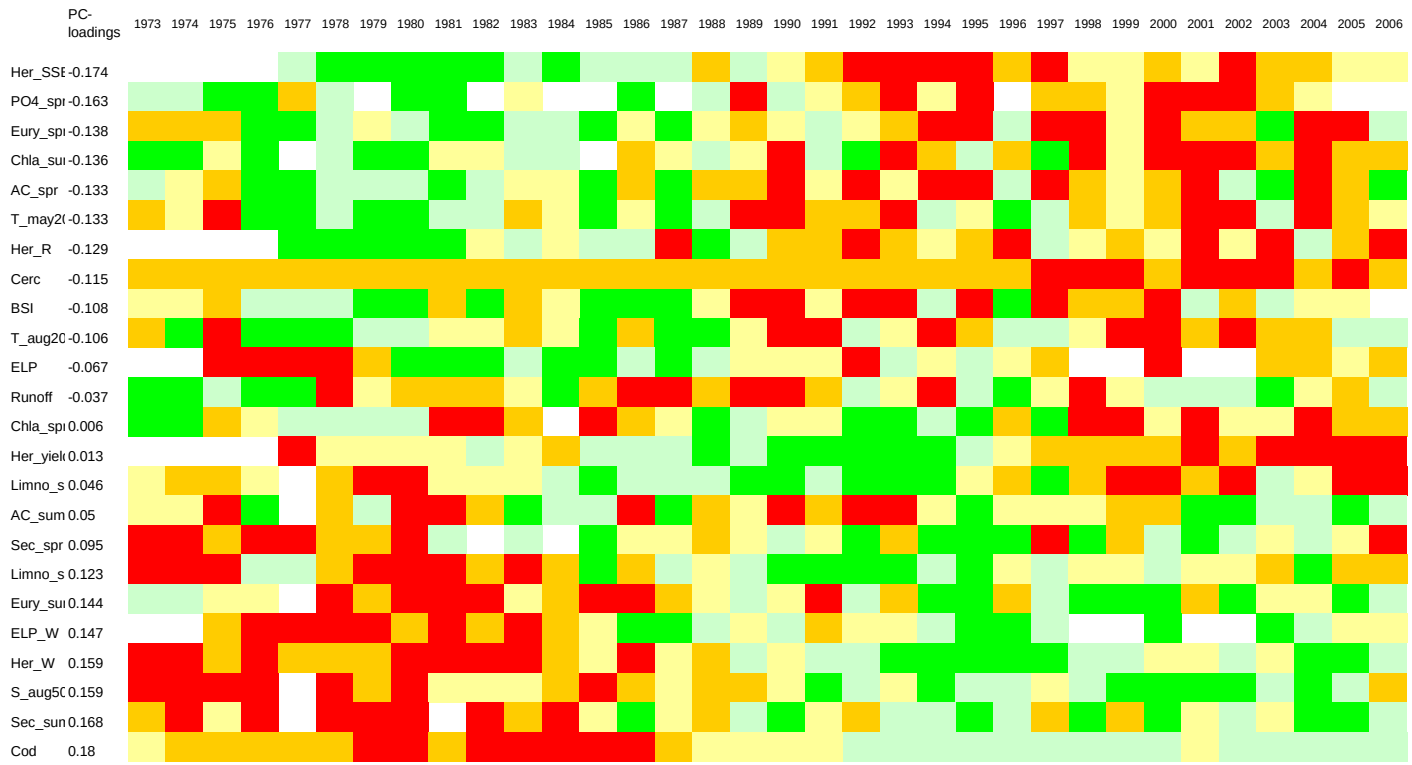


Regime Shift Index:

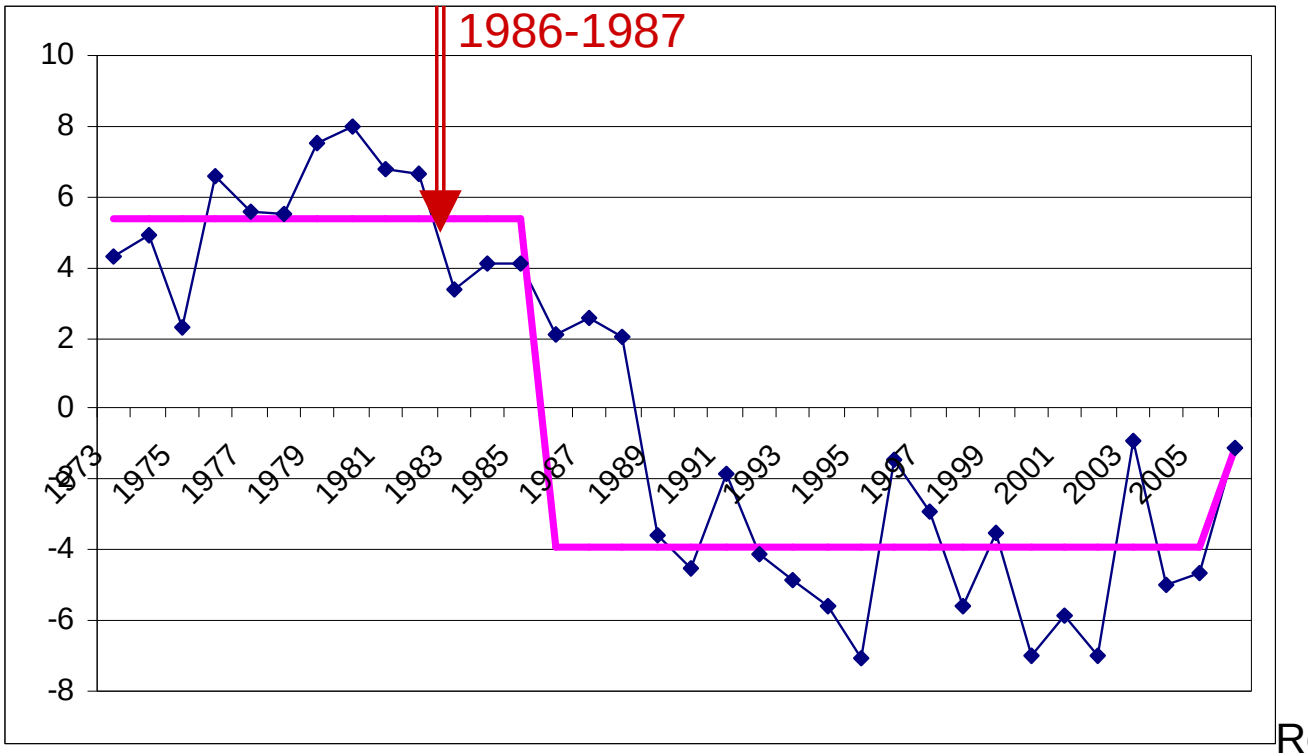


The Gulf of Riga

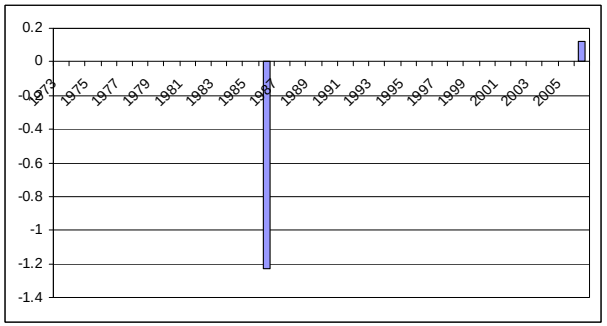
- Shallow basin
- Highly influenced by riverine runoff
- Lacks a permanent halocline



Gulf of Riga, Regime Shift

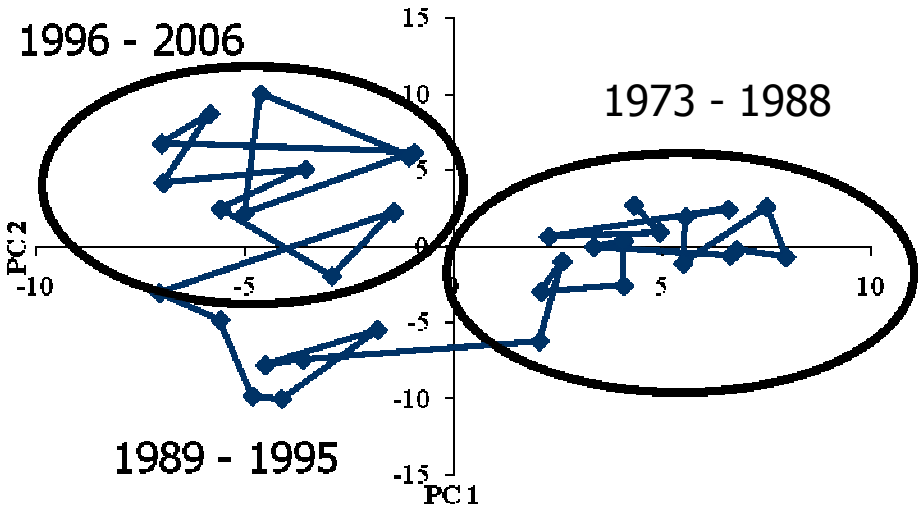


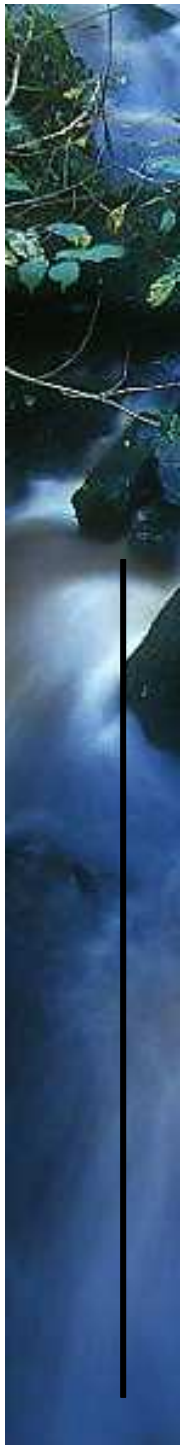
Regime Shift Index:



GoR summary

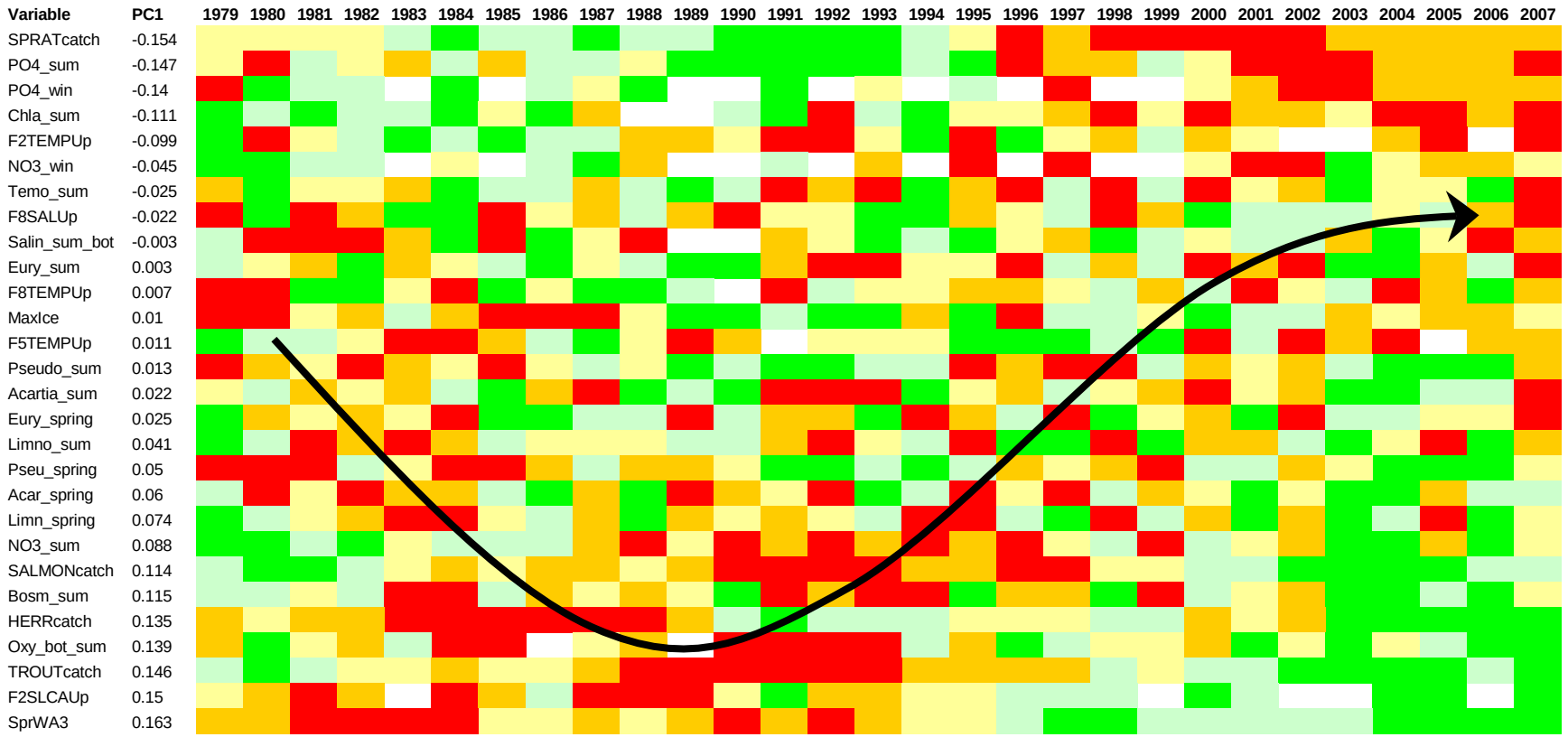
- First period:
  - Higher salinity, low spring zooplankton and low herring but high cod stock,
- Second period:
  - Higher Temp., higher winter DIP and high summer Chl a



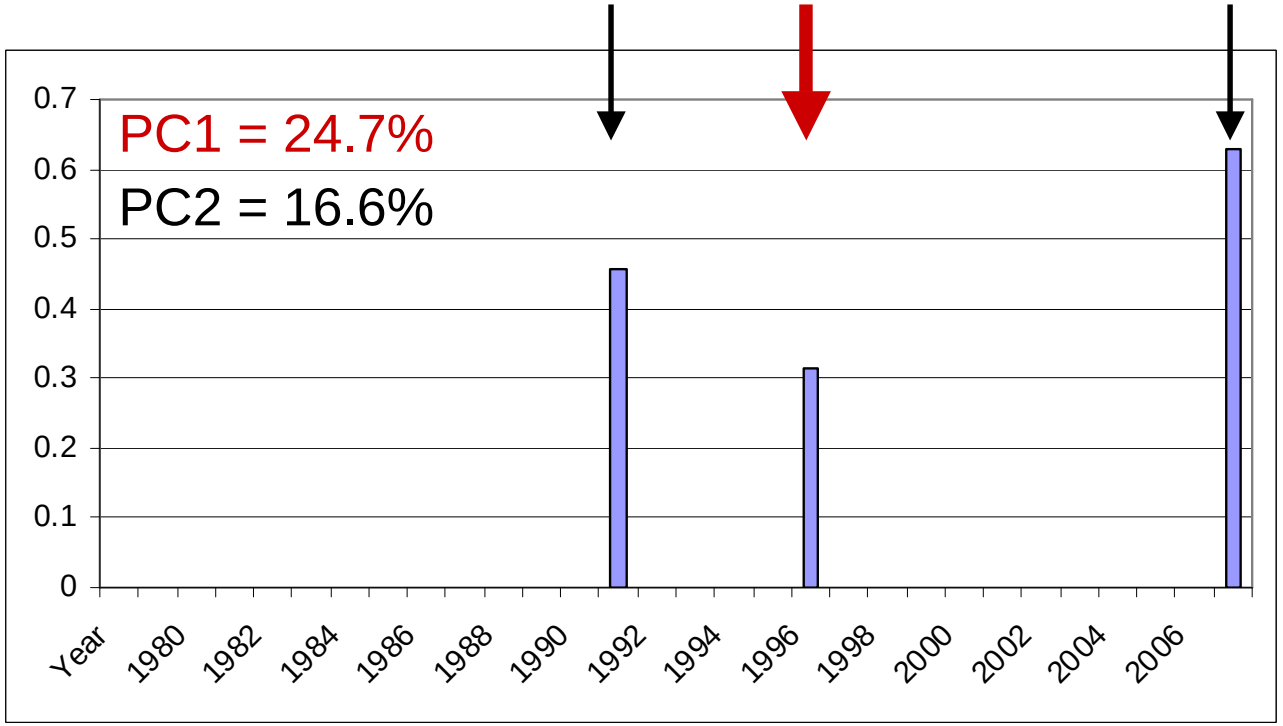


Gulf of Finland

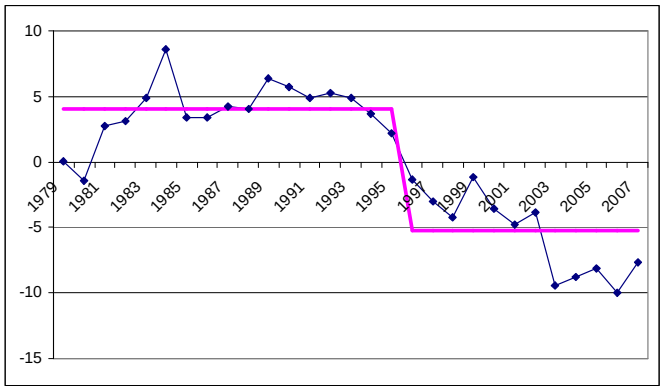
- Hydrography similar to Baltic Proper
- Ice cover determines complete mixing



GoF - Regime Shift



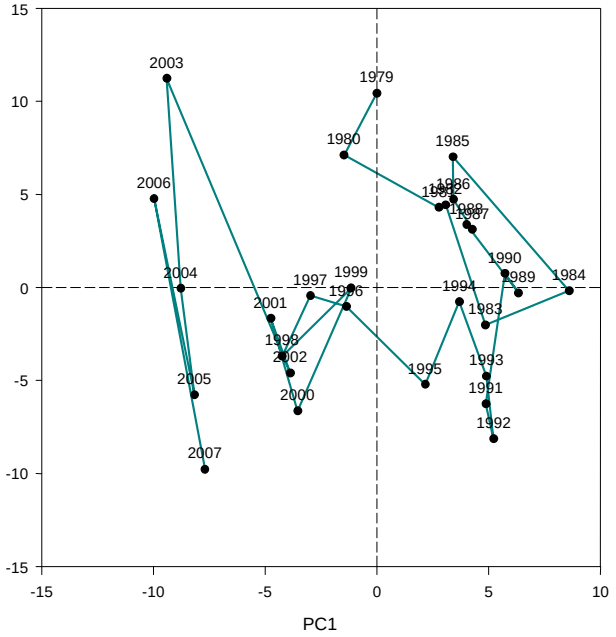
PC1-shift



GoF summary

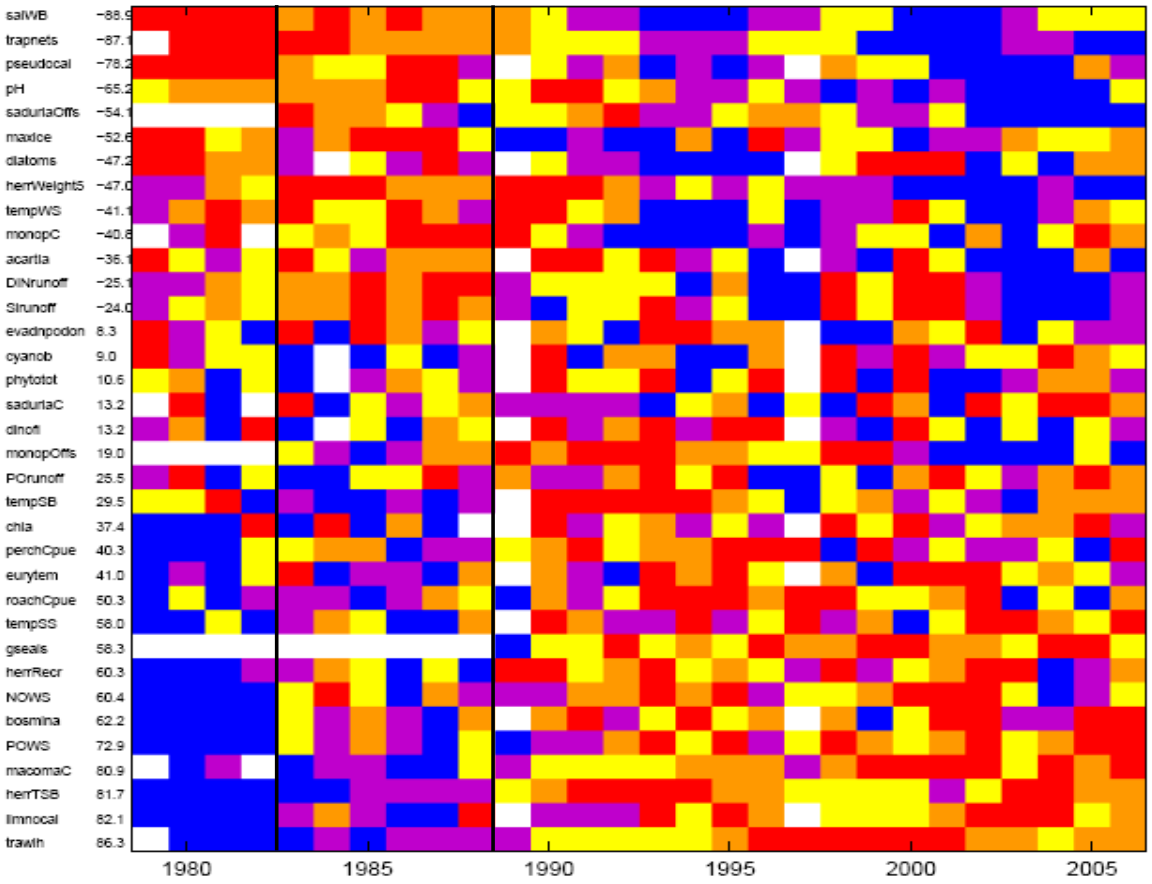
- similar to Baltic Proper -

- First period:
  - Higher salinity, Pseuocalcanus,
- Second period:
  - Higher Temp., low salinity, higher anoxia and high summer Chl a



Bothnian Sea

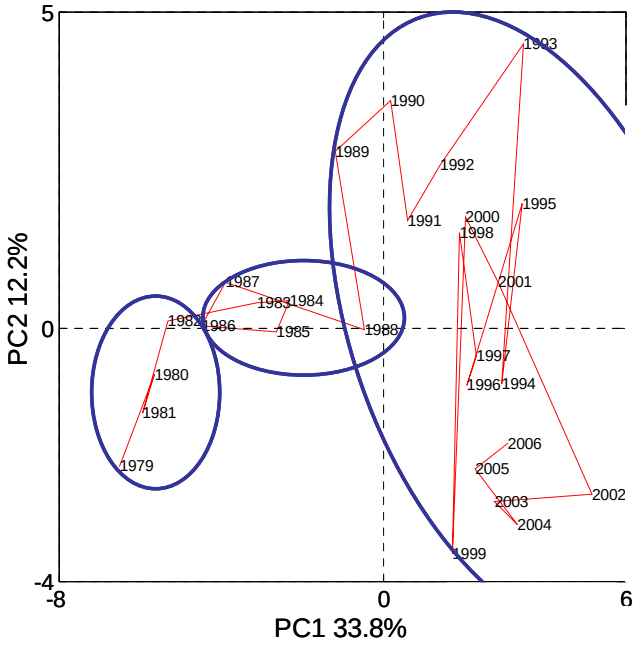
- Low salinity
- Never anoxic in the deep water



BoS –Regime shifts

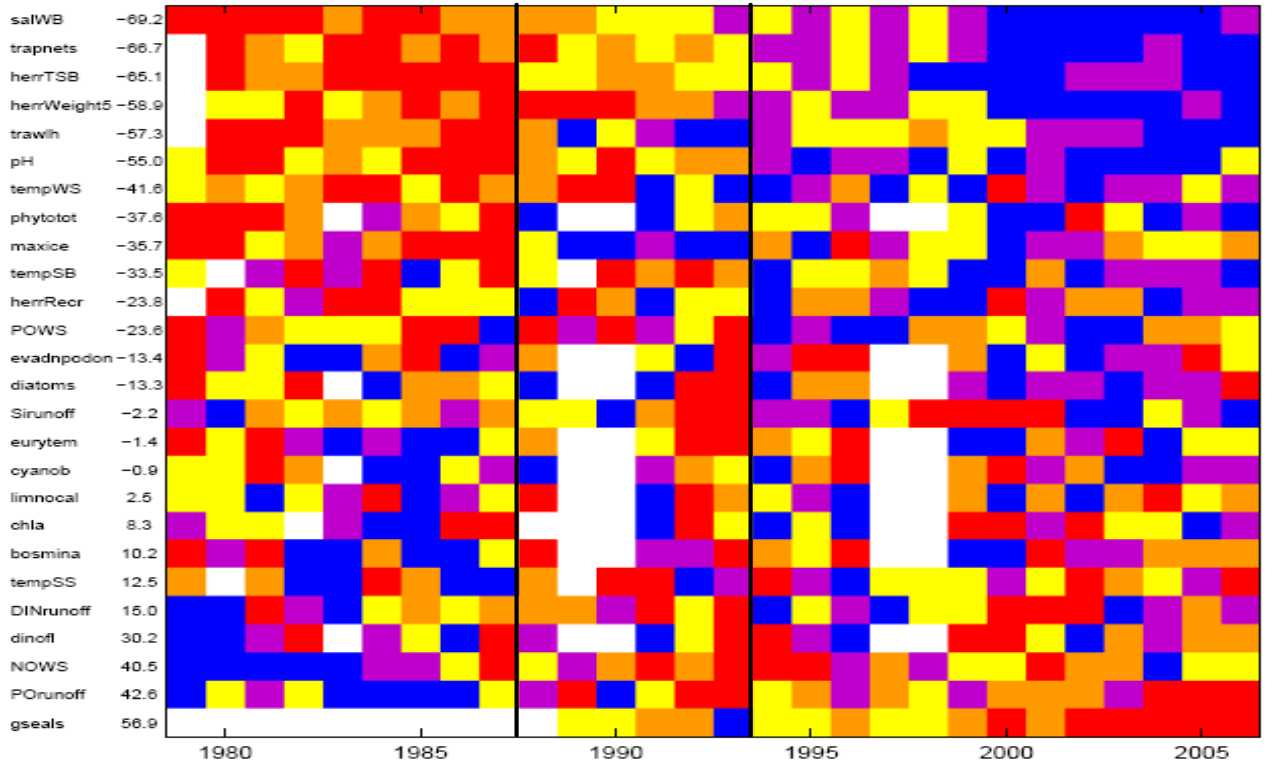
BoS summary

- First period:
  - Cold, saline, Pseudocalanus
- Second period:
  - Warm, less saline, higher nutrient conc.

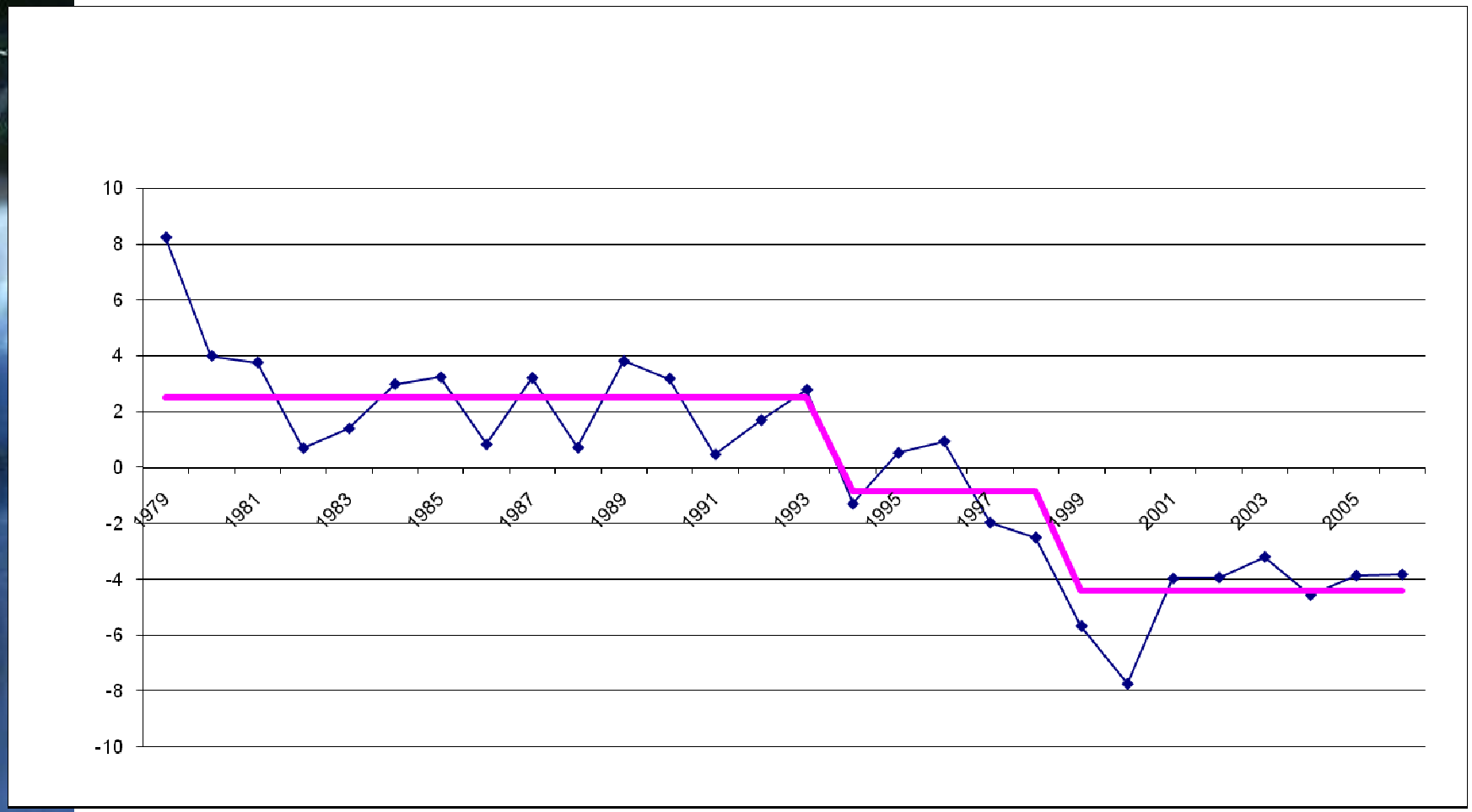


Bothnian Bay

- Low salinity and high humic substances
- Higher importance of bacteria

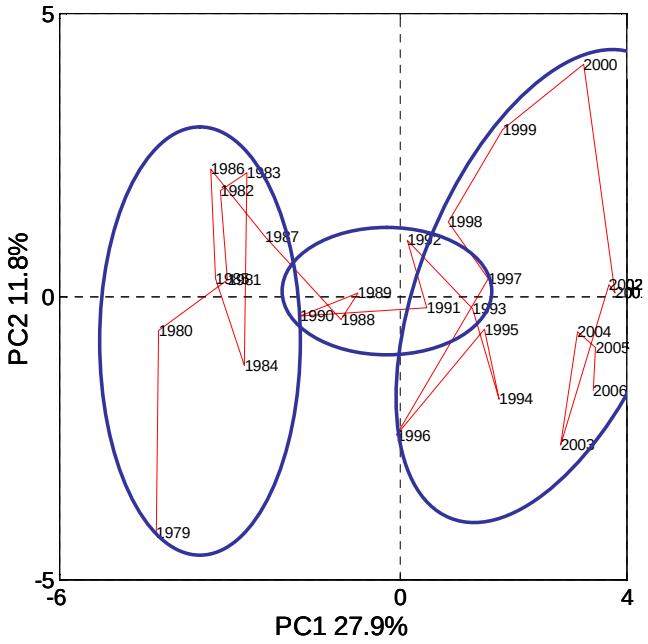


BoB Regime shift



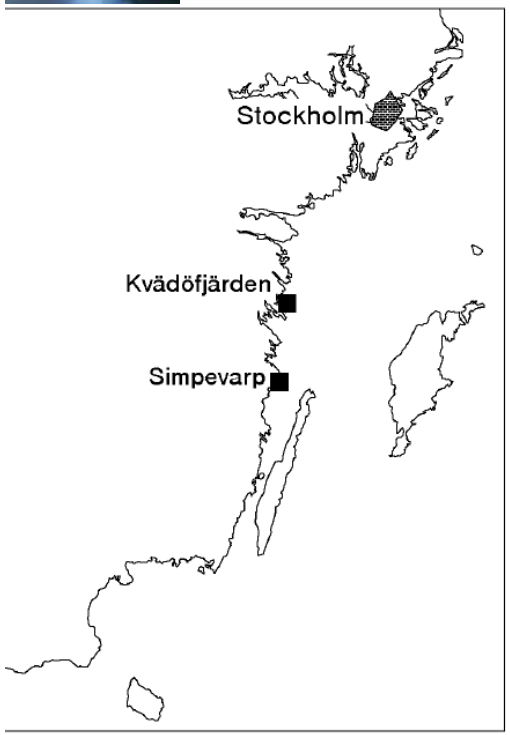
BoB summary

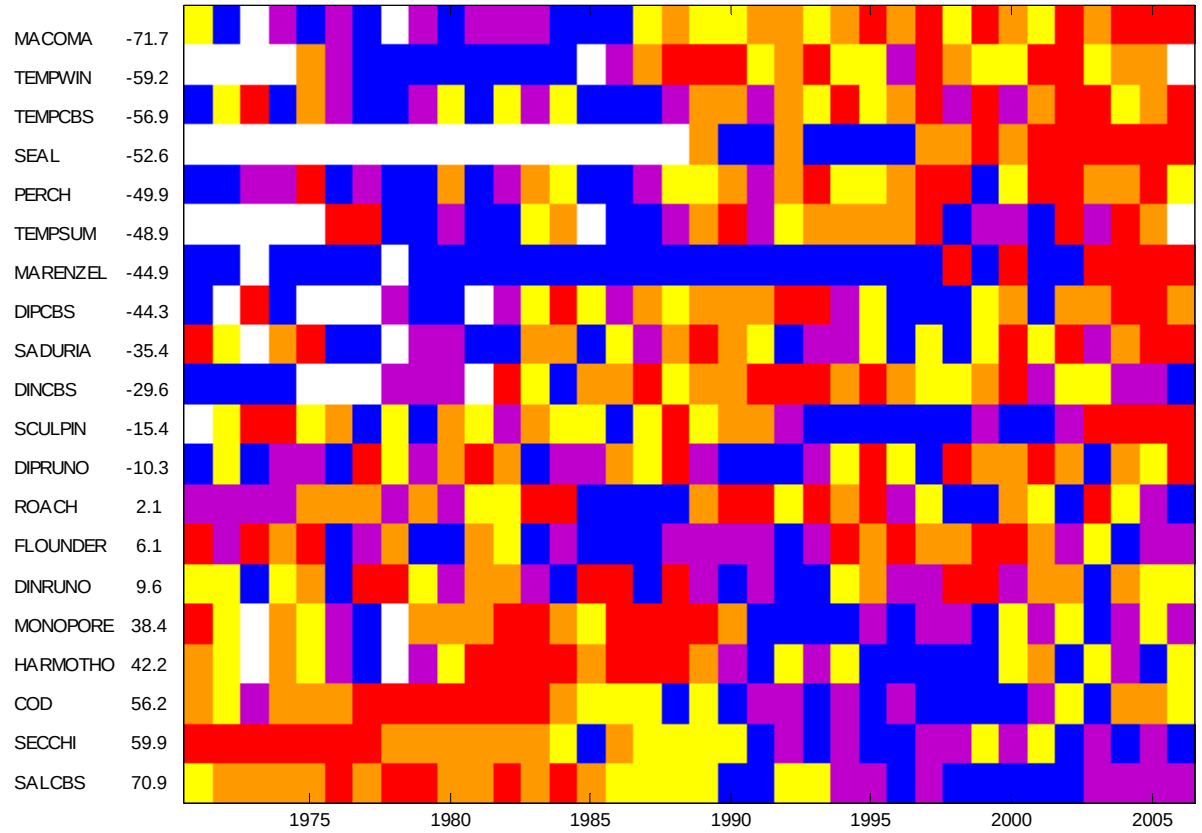
- First period:
  - Cold, saline, high phytoplankton biomass
- Second period:
  - Warm, less saline, higher P load, more seals



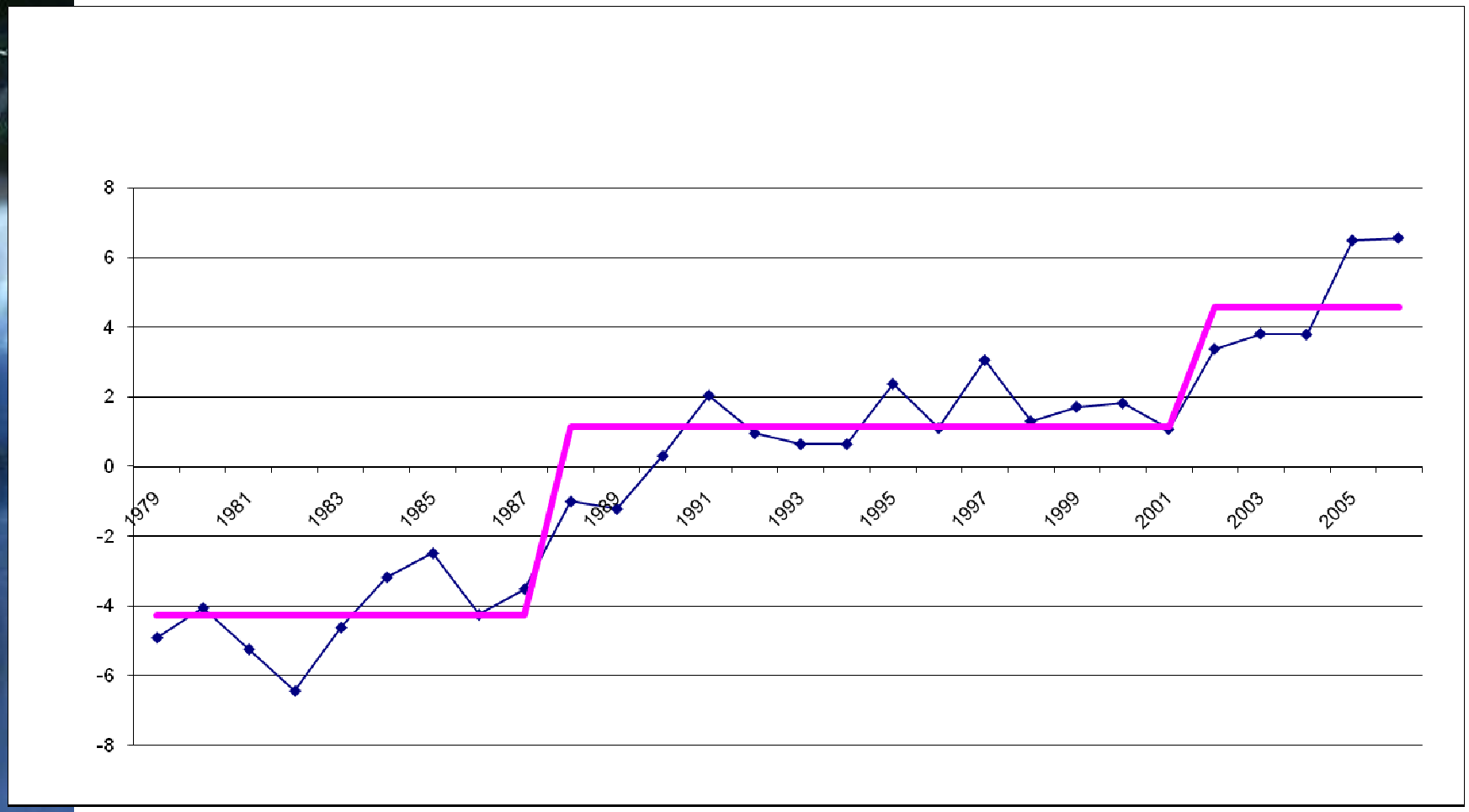
Coast

HELCOM Baltic reference area



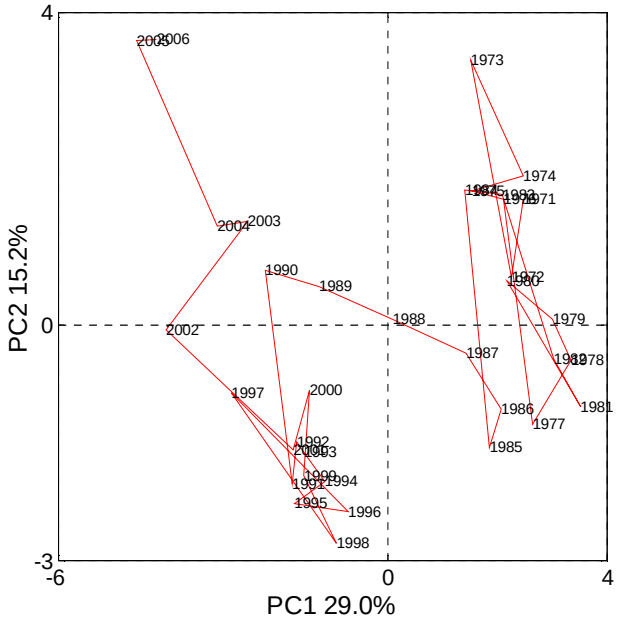


Coast Regime shift



Coast summary

- First period:
  - Cold, saline, Cod, Monoporeia
- Second period:
  - Warm, less saline, lower Secchi depth, Macoma



Summary

System	Period covered	RS 1	RS 2	RS 3	RS 4
ÖS	1979-2005		1987/88	1995/96	
CBS	1974-2006.		1987/88	1994/95	
GOR	1974-2006		1988/89	1997/98	
GOF	1979-2007		1988/89	1995/96	2002/03
BOS	1979-2006	1982/83	1988/89		
BOB	1979-2006		1987/88	1993/94	
COAST	1971-2006	1976/77	1987/88		2004/05[1)]

Climate-related changes

Conclusion

- Regime shifts in all basins
- Climate –induced change in 1988/89
- Often a transition period, time-lag response of the food web

- Only one coastal zone
- Interaction between coastal and open sea unclear
- More data, i.e. abiotic, benthic, phyto-/zooplankton


The End