Relating Ecosystem Shifts to Climate Variability

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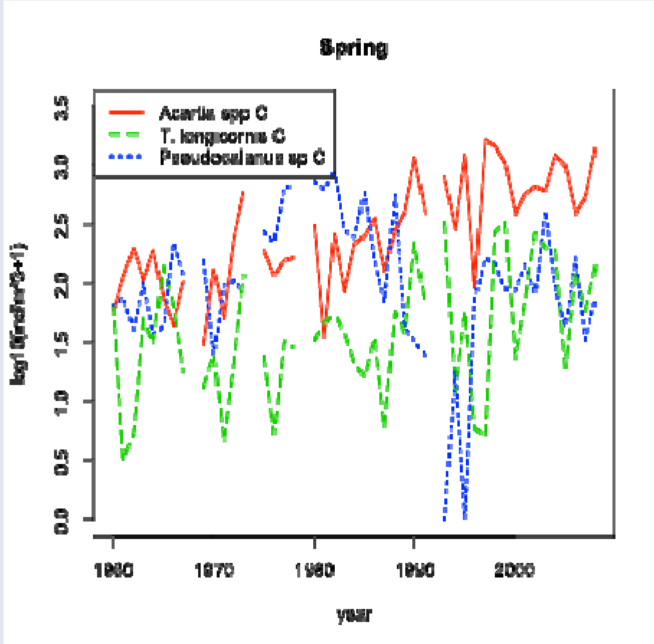
Climate influence on ecosystem variability and shifts

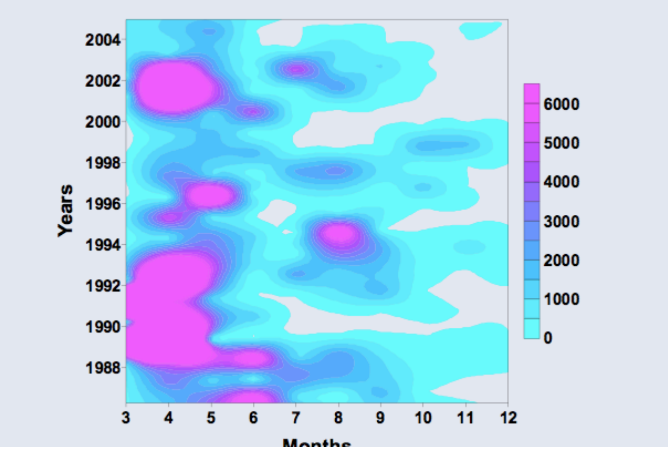
- Variability of the Baltic Sea ecosystem
- Climate variability
- Climate indices
- Baltic Sea Environmental Index (BSE)
- Results of Downscaling experiments
- Conclusion

Changes in the Baltic Sea Ecosystem

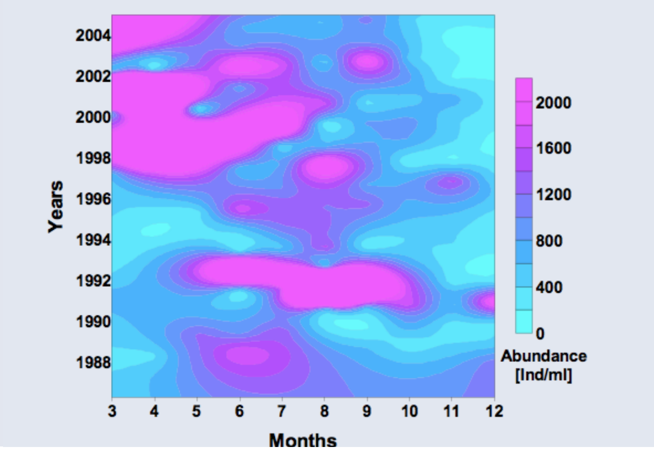
- Cod stock collapsed, sprat took over, herring weight decreased
- Zooplankton community changed: *Pseudocalanus* sp. decreased, *Acartia* spp and *Temora longicornis* increased
- Phytoplankton communitiy changed: Diatom biomass decreased, biomass of Dinoflagelates increased
- Timing of spring blooms earlier



Bacillariophyceae (Abundance) OB4



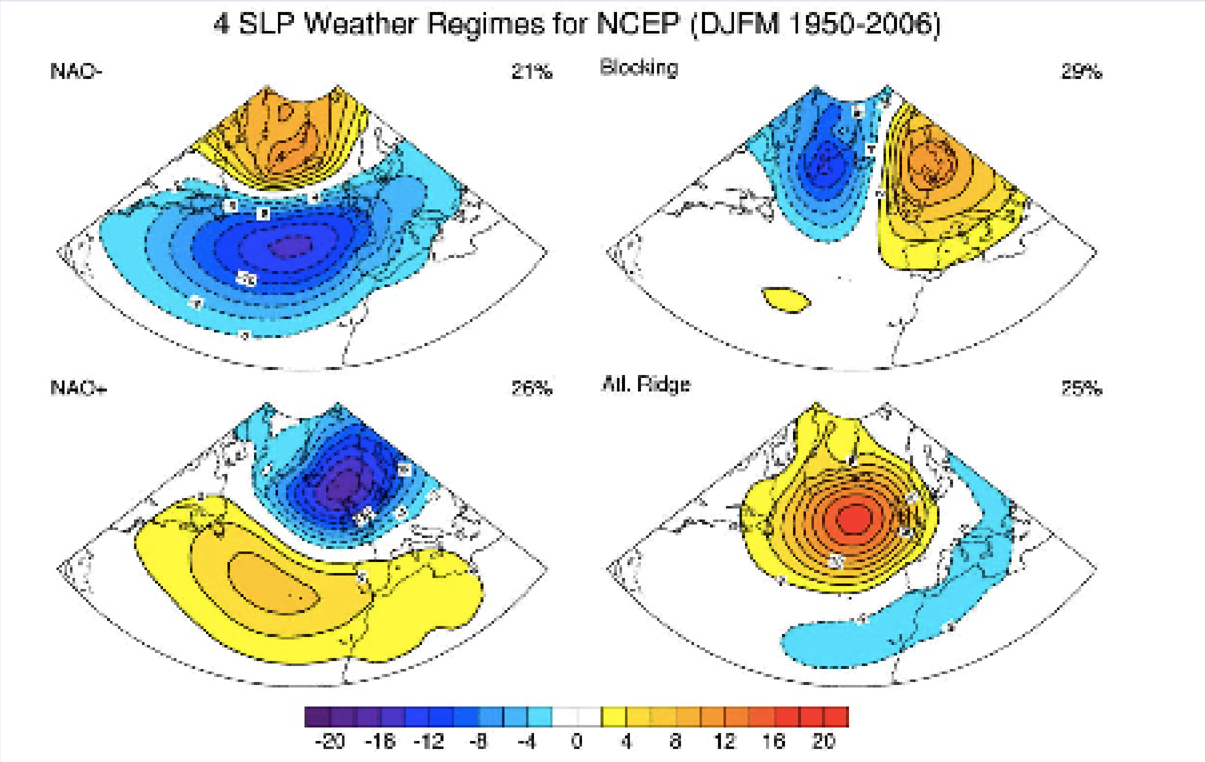
Cryptophyta (Abundance) OB4



- ➔Driving Forces?
- ➔Predictability?

Climate Variability
-Major Modes-

4 major modes describe climate variability for North Atlantic: positive and negative North Atlantic Oscillation (NAO+, NAO-), Blocking, Atlantic Ridge.



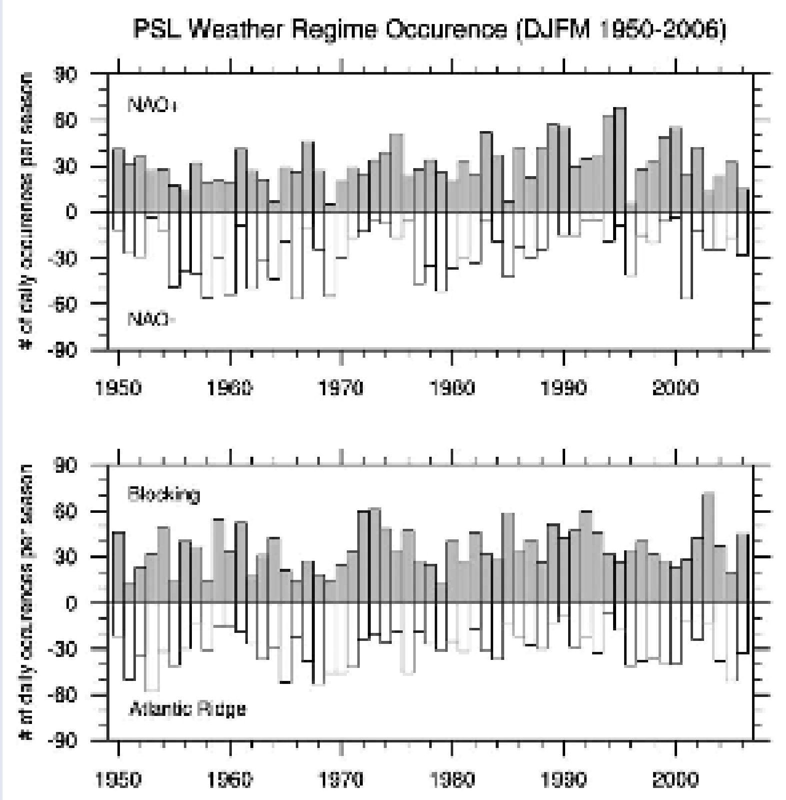
Hurrel and Deser, 2010

History of Mode Occurences

•NAO+ occurs more often than NAO- in the 1990
•in the 1960's mostly NAO- occured

•comparison of time series of occurence of the modes show that Blocking and and Atlantic Ridge become more prominent in winter after 2000

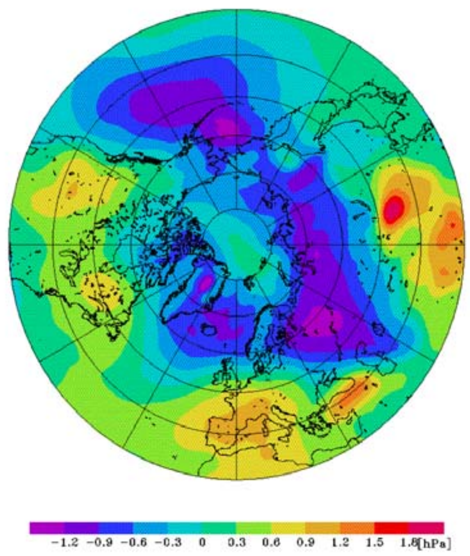
-> the NAO explains only part of the total variance in winter
-> winter atmospheric circulation is unsufficiently characterized by the canonical NAO pattern



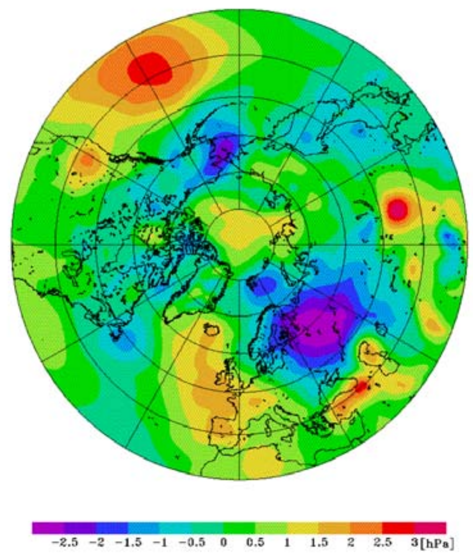
Hurrell and Deser, 2010

SLP Composite (DJFM average)

1978-1999



2000-2009



Climate Indexes

- **North Atlantic Oscillation (NAO)**: e.g. anomaly of normalized pressure difference between Lisbon and Stykkisholmur
- **Arctic Oscillation (AO)**: dominant pattern (the first EOF) of monthly mean height anomalies at 1000 hPa poleward of 20° N
- **Baltic Sea Index(BSI)**: difference of normalised sea level pressures between Oslo in Norway and Szczecin in Poland.
- **Atlantic Multidecadal Oscillation (AMO)**: monthly SST anomalies in the North Atlantic area weighted from 0° –70° N
- **Chen "Index"**: 1st EOF of components of geostrophic wind and the relative vorticity for the baltic sea area

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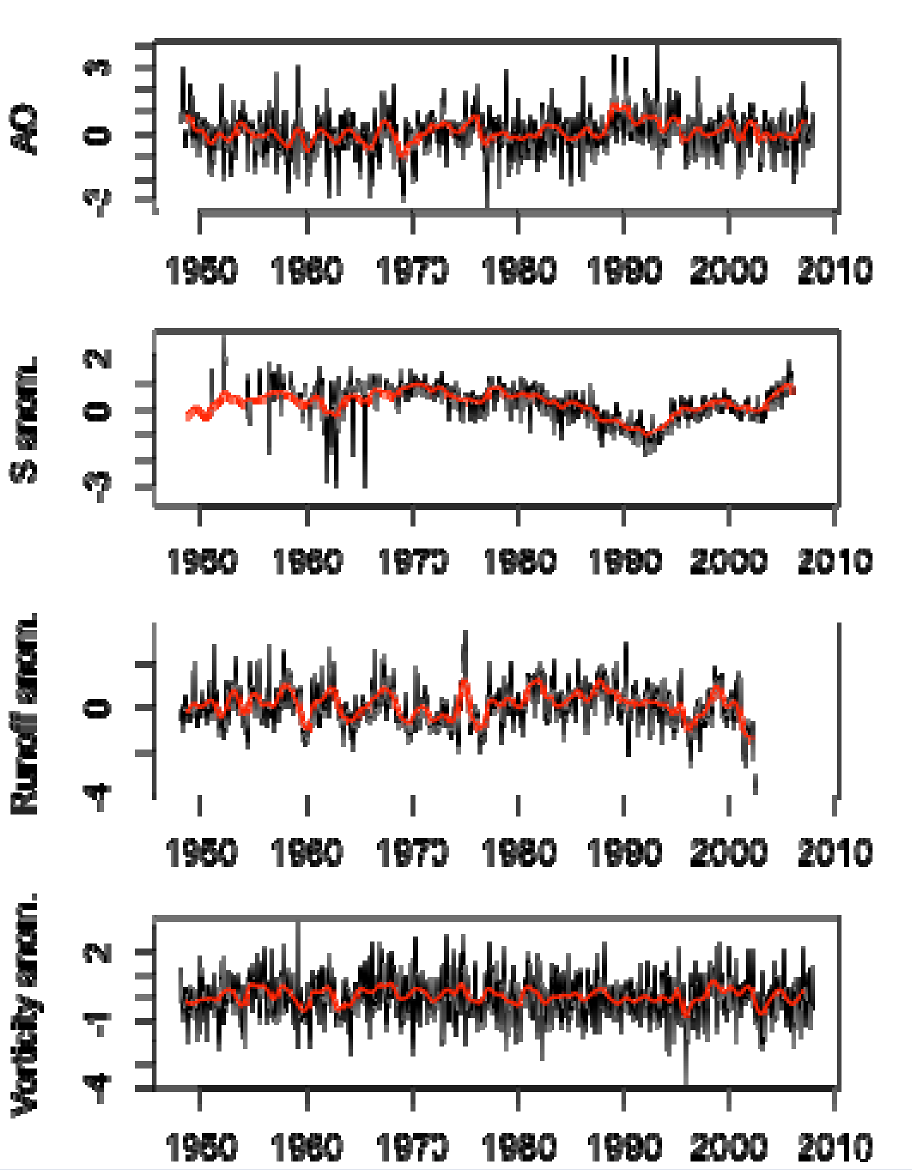
Baltic Sea Environmental Index

constructed of 4 time series:
AO

Salinity between 120-200 m in the Gotland Sea

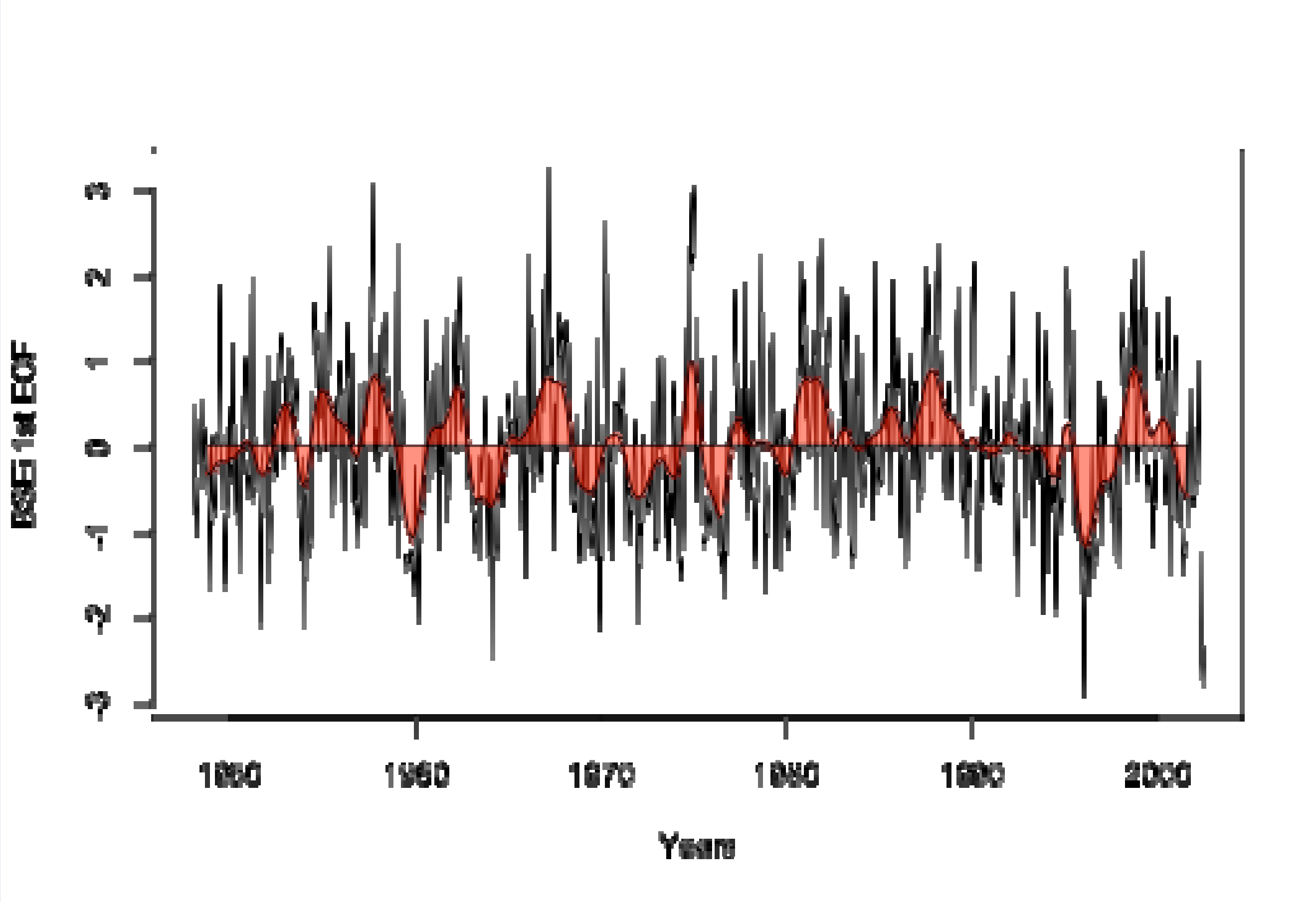
Integrated runoff of all rivers draining into the BS

Relative vorticity of geostrophic wind over the BS area (Chen, 2000)



BSE Index (cont.)

1st EOF



Downscaling Experiments 1st Set: Physical

Predictors:

AMO, AO, NAO, BSI, Chen, BSE index

Response Variables:

•SST of the Gotland Sea (GS)

•Landsort gauge (LG)

•ice extent (IE)

	SST-GS (2/-1)	LG (1/0)	IE (1/0)
AMO	ns	ns	ns
AO	0.64 (0.39)	0.62 (0.37)	0.61 (0.34)
NAO	0.62 (0.35)	0.65 (0.41)	0.54 (ns)
BSI	0.71 (0.49)	0.66 (0.42)	0.67 (0.43)
Chen	0.75 (0.45)	0.84 (0.64)	0.72 (0.42)
BSE	0.73 (0.48)	0.87 (0.68)	0.70 (0.45)

Numbers: Correlation, in Brackets: Brier based skill score

Downscaling Experiments 2nd Set: Zooplankton

Predictors:

AMO, AO, NAO, BSI, Chen, BSE index

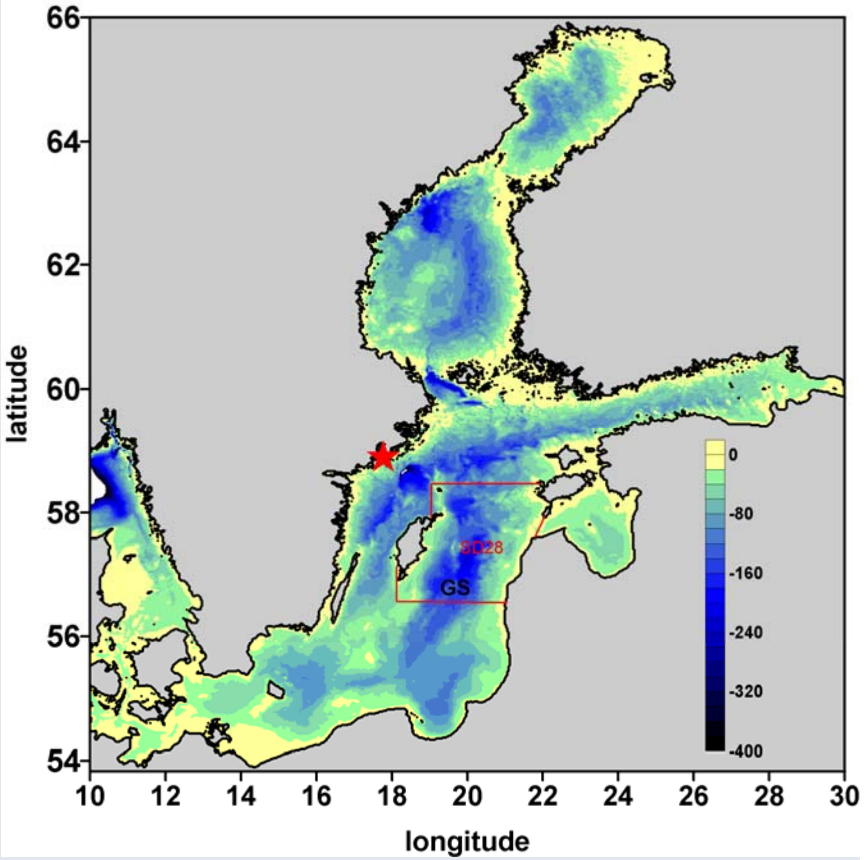
Response Variables:

Biomass and abundance for the period 19
2008 of:

- *Acartia* spp.
- *Pseudocalanus* sp.
- *Temora longicornis*

additionally Biomass for 1960-1997 of:

- *Bosmina longispina*
- *Evadne nordmanni*
- *Synchaeta* spp.

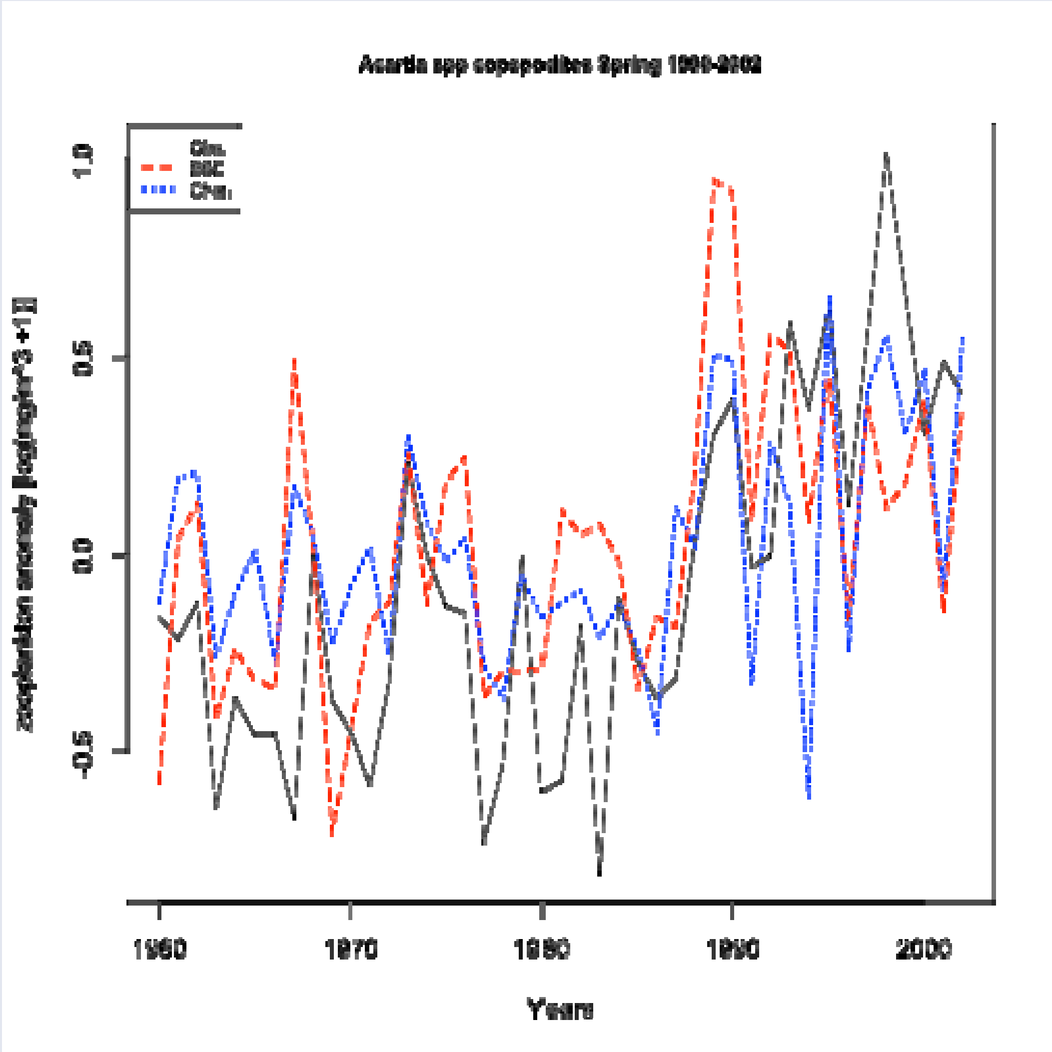


Data from the Latvian Institute for Food Safety, Animal Health and Environment for the Central Baltic Sea (ICES Subdivision 28)
The newer data set has been compiled from original data by Saskia Otto, Univ. of Hamburg.

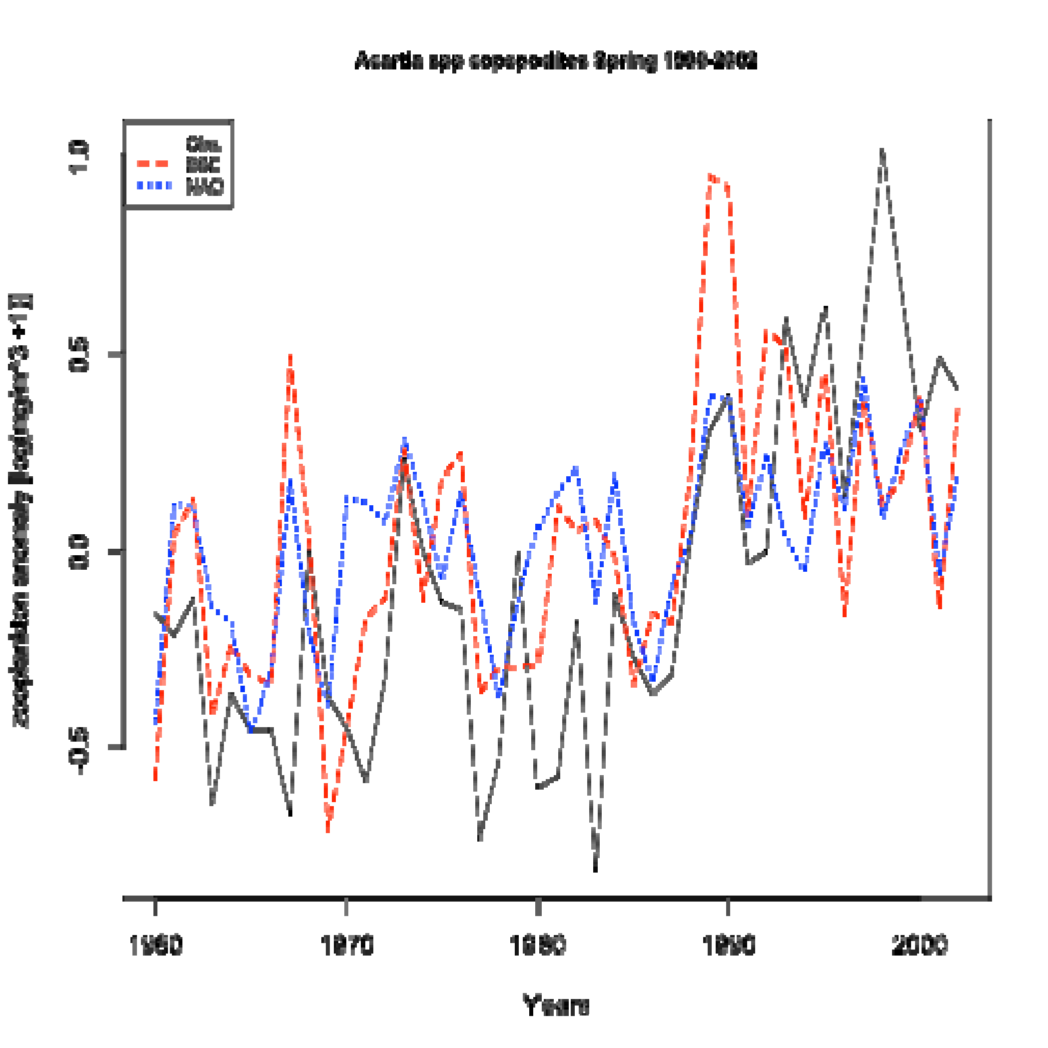
Downscaling Period 1960-2002

	BSE	AMO	AO	BSI	Chen	NAO
AcarA b S1/M2	**0.66(0.32)**	**ns**	**0.57(0.28)**	**0.57(0.29)**	**0.64(0.32)**	**0.56(0.29)**
AcarA a S1/M2	**0.65(0.32)**	**ns**	**0.57(0.28)**	**0.55(0.27)**	**0.61(0.29)**	**0.56(0.29)**
AcarC b S1/M1	**0.58(0.16)**	**ns**	0.37(0.11)	0.37(0.09)	0.41(0.03)	0.33(0.07)
AcarC b S1/M2	**0.69(0.26)**	0.22(ns)	**0.57(0.3)**	**0.59(0.32)**	**0.67(0.37)**	**0.51(0.25)**
AcarC b S2/M4	**0.53(ns)**	**0.53(0.24)**	ns	ns	ns	ns
AcarC a S2/M4	**0.51(ns)**	**0.55(0.26)**	ns	ns	ns	ns
AcarC b S3/M10	**0.57(0.13)**	0.48(0.19)	0.37(0.1)	0.33(0.03)	0.35(ns)	0.12(ns)
TemoC b S1/M2	**0.72(0.36)**	0.23(ns)	**0.59(0.33)**	**0.61(0.34)**	**0.68(0.38)**	**0.54(0.27)**
TemoC a S1/M2	**0.76(0.45)**	0.17(ns)	**0.73(0.51)**	**0.66(0.4)**	**0.7(0.41)**	**0.66(0.41)**

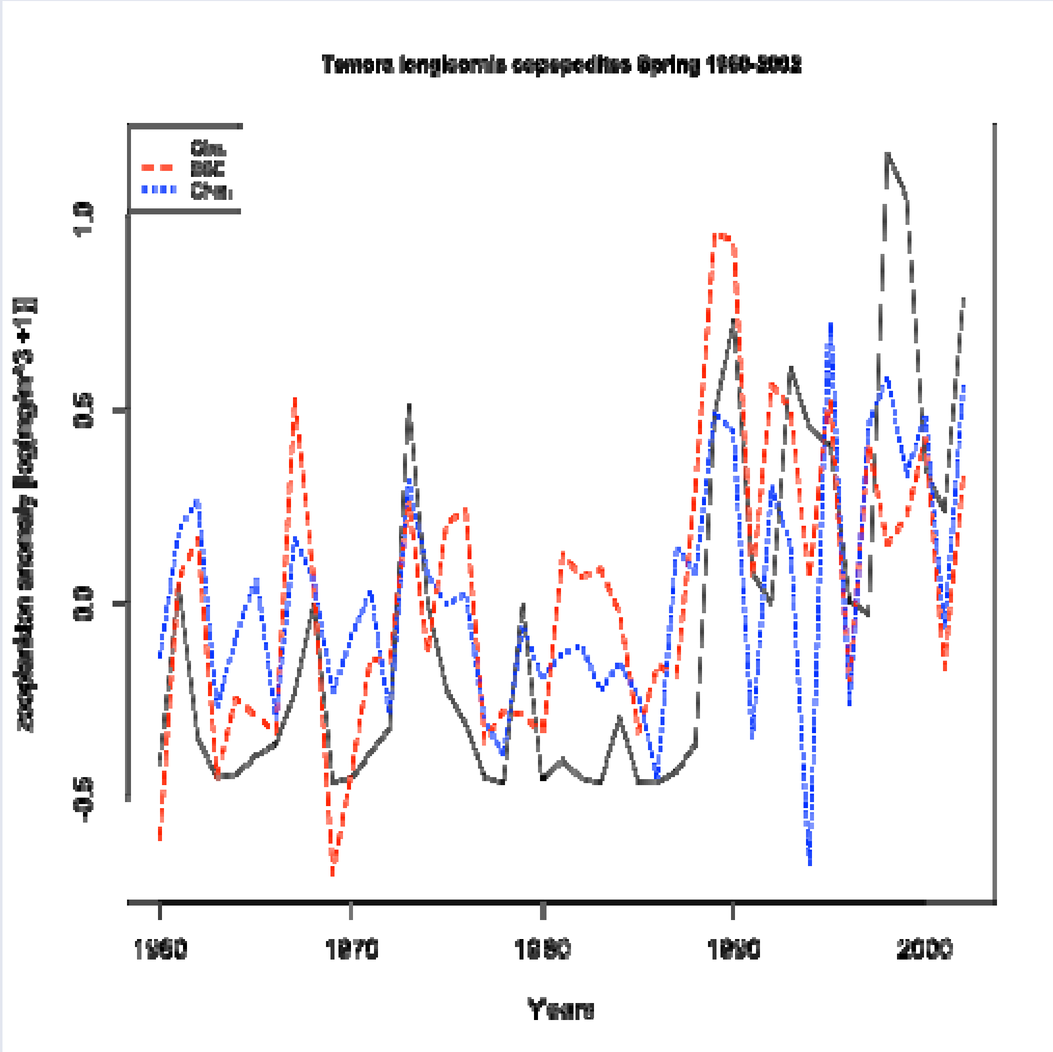
Downscaling *Acartia* spp cop.1960-2002



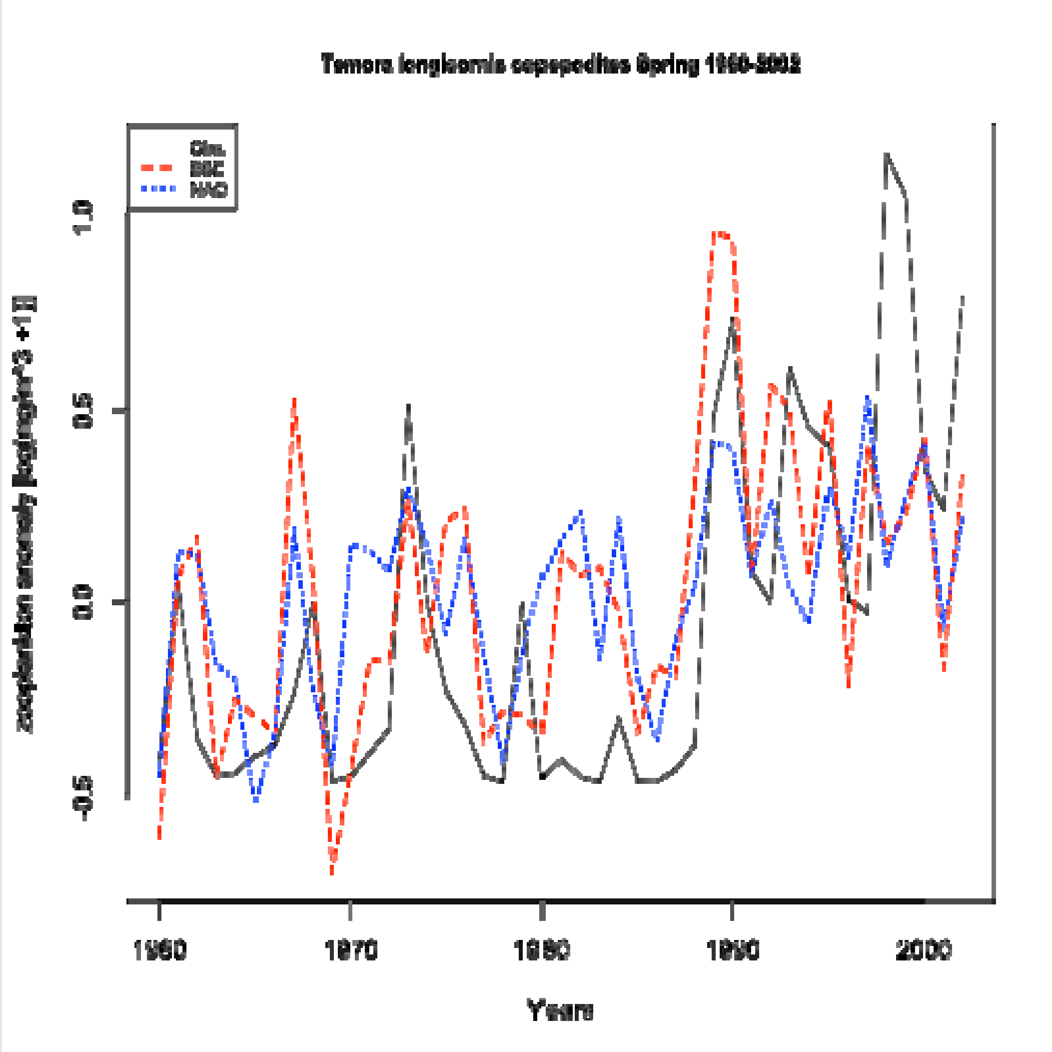
Downscaling *Acartia* spp cop.1960-2002



Downscaling Temora Longicornis cop.1960-2002



Downscaling Temora Longicornis cop.1960-2002



Results

- Strong linear relationship between Gotland Sea SST, Landsort gauge and Ice extent variability and climate
- Interannual variability and trend of *Acartia* spp and *T. longicornis* is controlled by climate
- Pseudocalanus biomass or abundance cannot be reproduced using climate predictors using linear methods
- BSE index and Chen are yielding the best correlations
- BSE index is most versatile – Acartia spp., T. longicornis, Evadne normanni and Synchaeta spp could be reproduced
- The shift in the end of the 1980's can be reproduced for some species
- The correlation fails after 2000 for all species

Conclusions

- The predictability of zooplankton species using linear statistical downscaling and climate predictors indicates that the 1988/1989 ecological regime shift (Alheit et al., 2005; Möllmann et al., 2008) is a smooth shift (Collie et al., 2004; Scheffer et al., 2001)
- The failure of the linear correlation after 2000 indicates an abrupt or discontinuous shift which might be triggered by a global climate regime shift in 2000/2001 (Swanson and Tsonis, 2009)
- The combination of a large scale index with local scale climate indicators is superiour regarding performance and versatility to using a single large scale index – contrast to Hallett, 2004
- The BSE index is a suitable index for studying the predictability of the Baltic Sea Ecosystem

Thank You!

Regime Shifts
Definitions

Regime
characteristic behavior of a natural phenomenon (sea level pressure, recruitment, etc.) over time (Hare and Mantua, 2000)

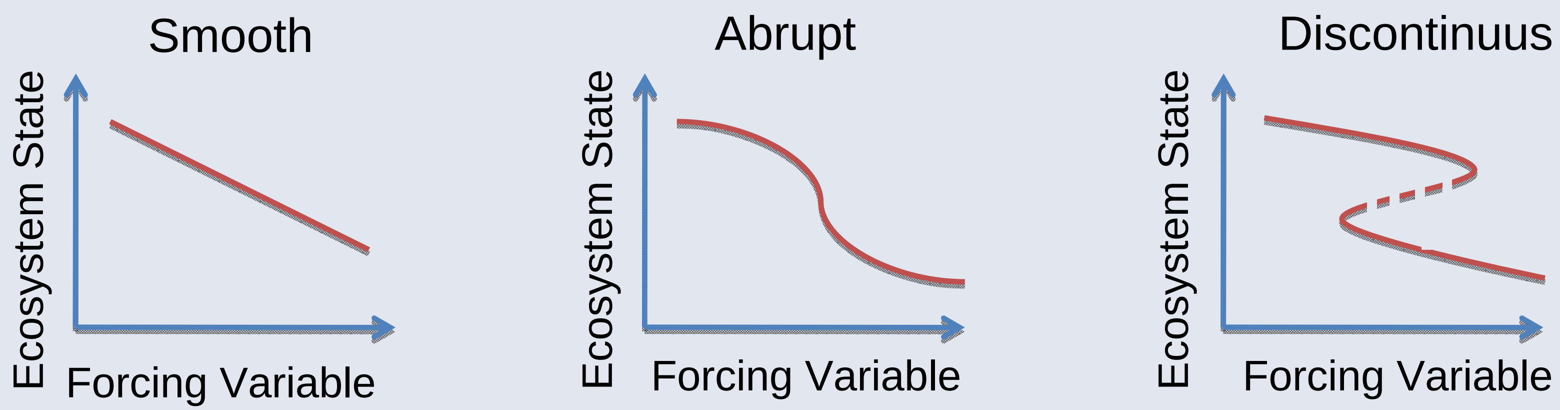
Regime Shift (RS)
Transition from one dynamic regime to another. The change is fast relative to the duration of the regime. (Hare and Mantua, 2000)

Climate Regime Shifts (CRS)
Change trend of in physical properties such as temperature (Swanson and Tsonis, 2009)

Biological Regime Shifts (BRS)
Changes in abundance and composition of plankton and fish and propagate through several trophic levels (Reid et al., 2001)

Types of Biological Regime Shifts

Biological Regime shifts can be caterorized into 3 types according to the type of the response (Scheffer, 2003):



Smooth	Abrupt	Discontinuus
Quasi-linear relationship	Nonlinear relationship	Nonlinear Relationship Several stable states under the same conditions Hysteresis