

Christian Möllmann

Climate and fisheries effects on the pelagic food web of the Baltic Sea

The Baltic Sea



Characteristics

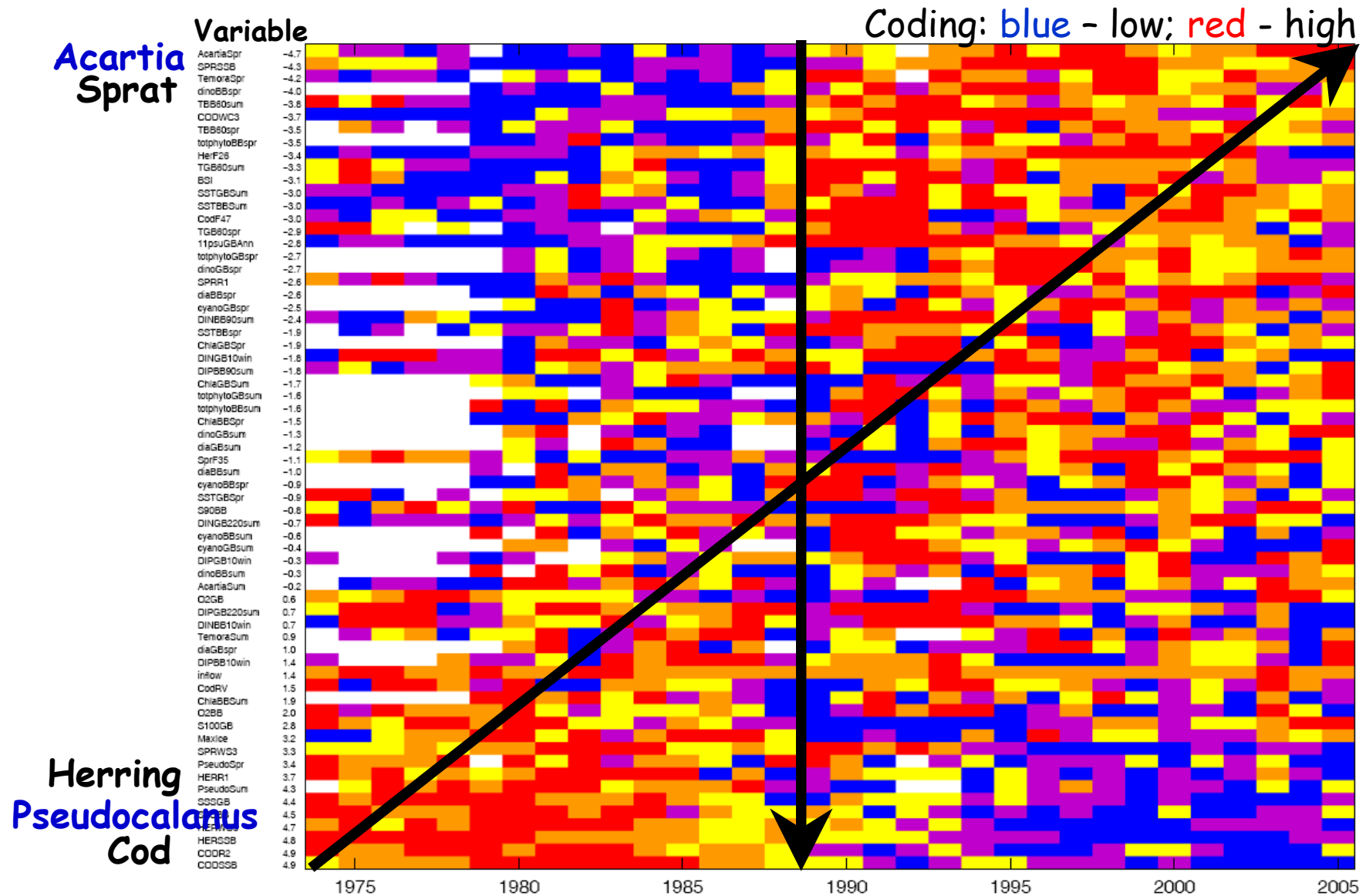
- large semi-enclosed brackish water body
- stratified water-column with a permanent halocline
- low diversity
- high productivity
- eutrophication
- pronounced climate influence through variability in temperature & salinity
- high fishing pressure

Central Baltic Sea

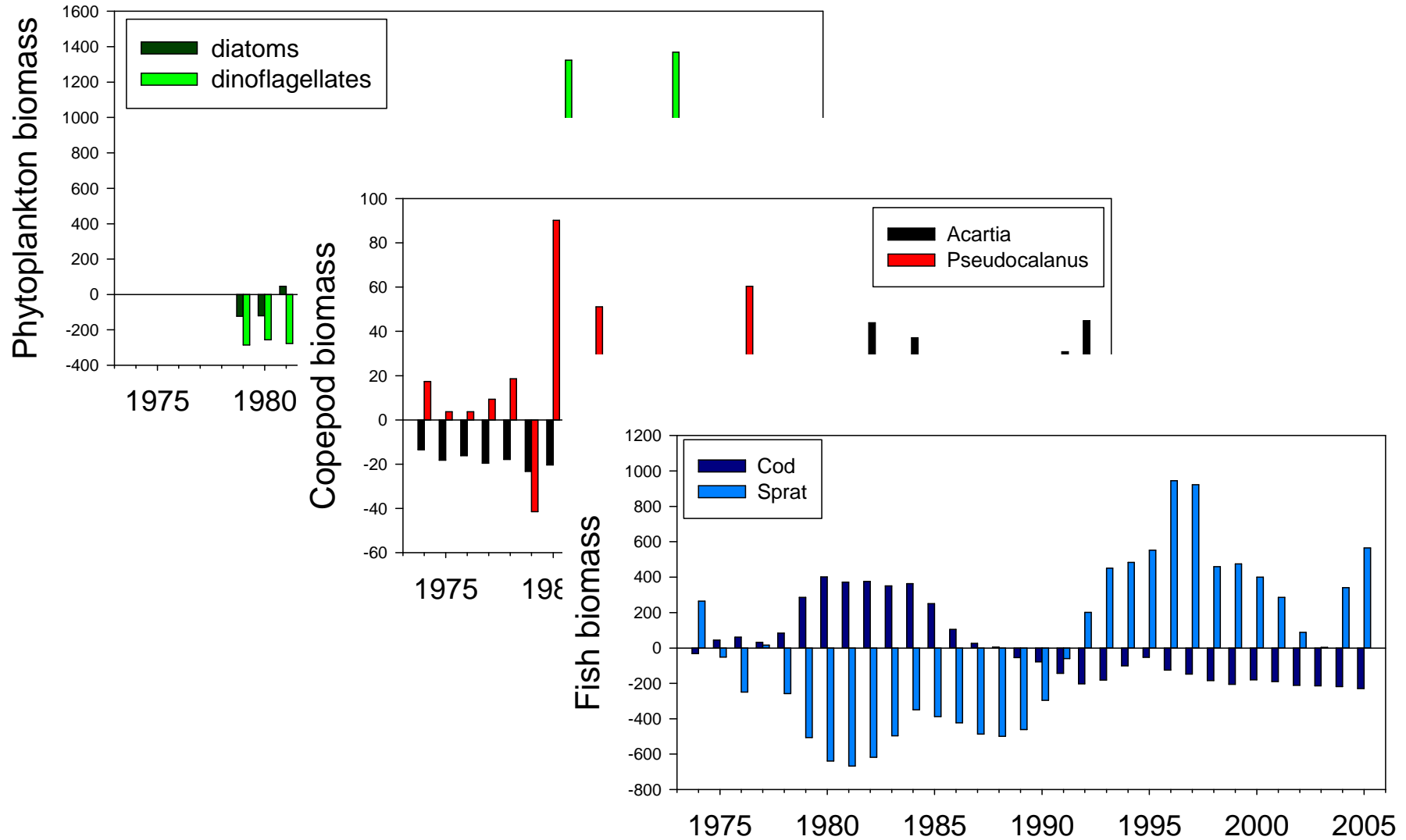
"Ecosystem Assessment"– Data & Methods"

- Time series from 1974-2005
- 65 variables (12 fish-related, 6 zooplankton, 20 phytoplankton-related, 8 nutrient, 19 physical datasets)
- **P**roincipal **C**omponent **A**nalysis
- Traffic-light plot

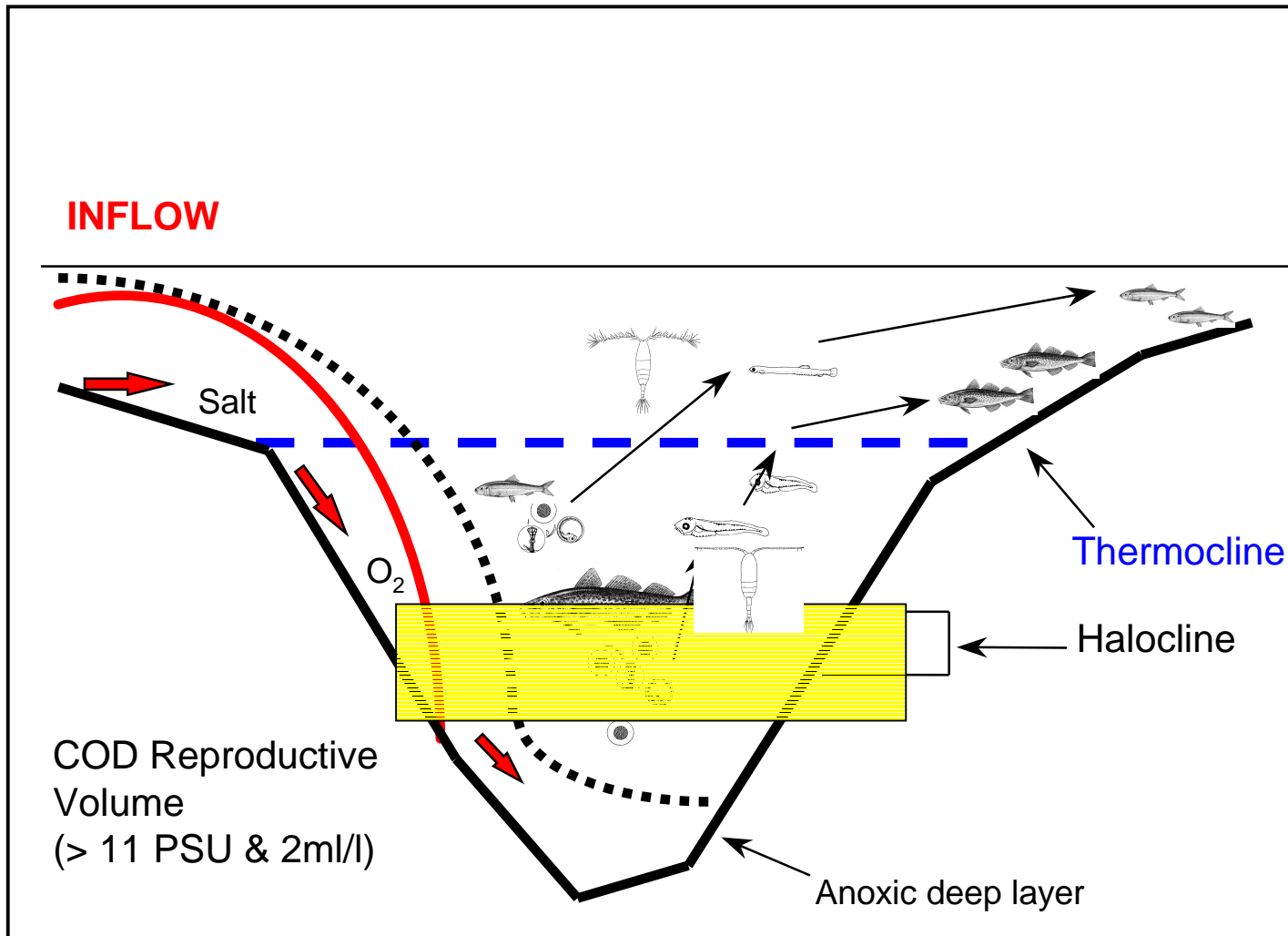
Ecosystem Regime Shift – “Traffic lights”



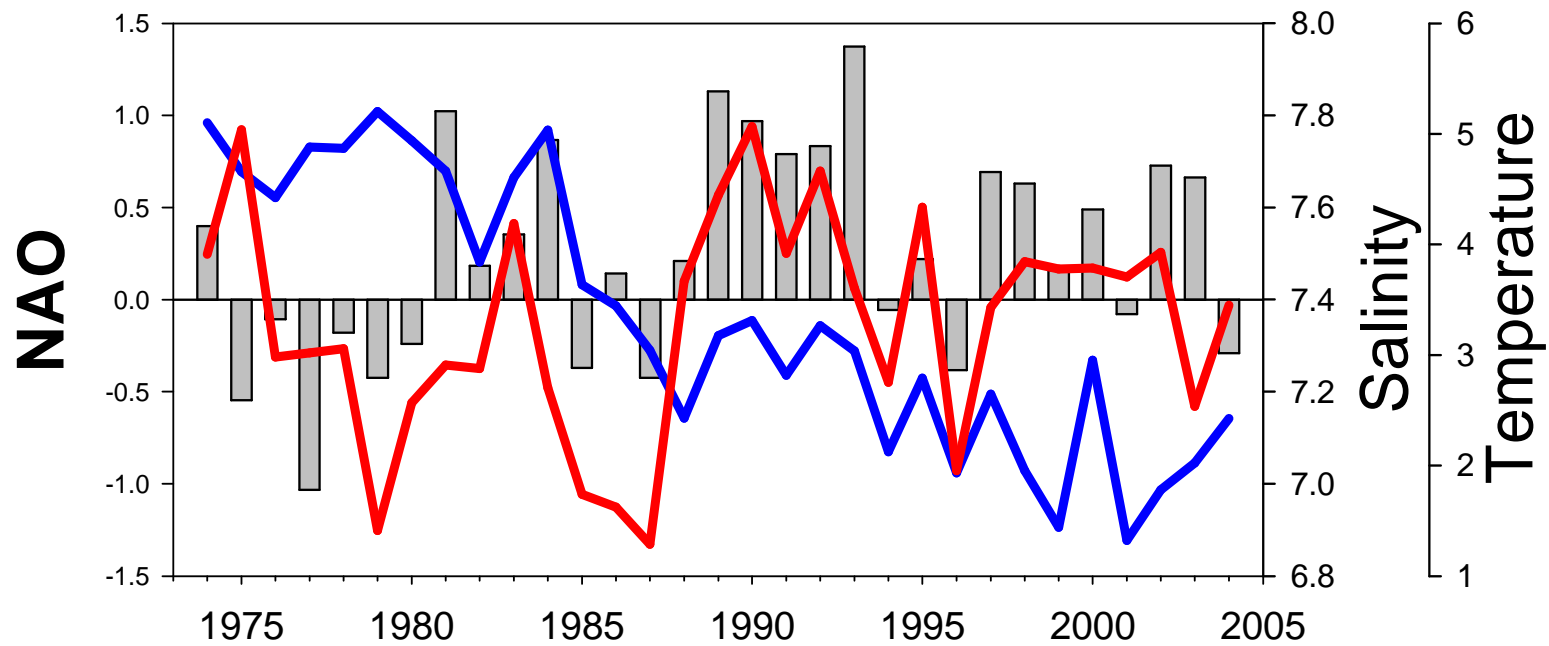
Some trends ...



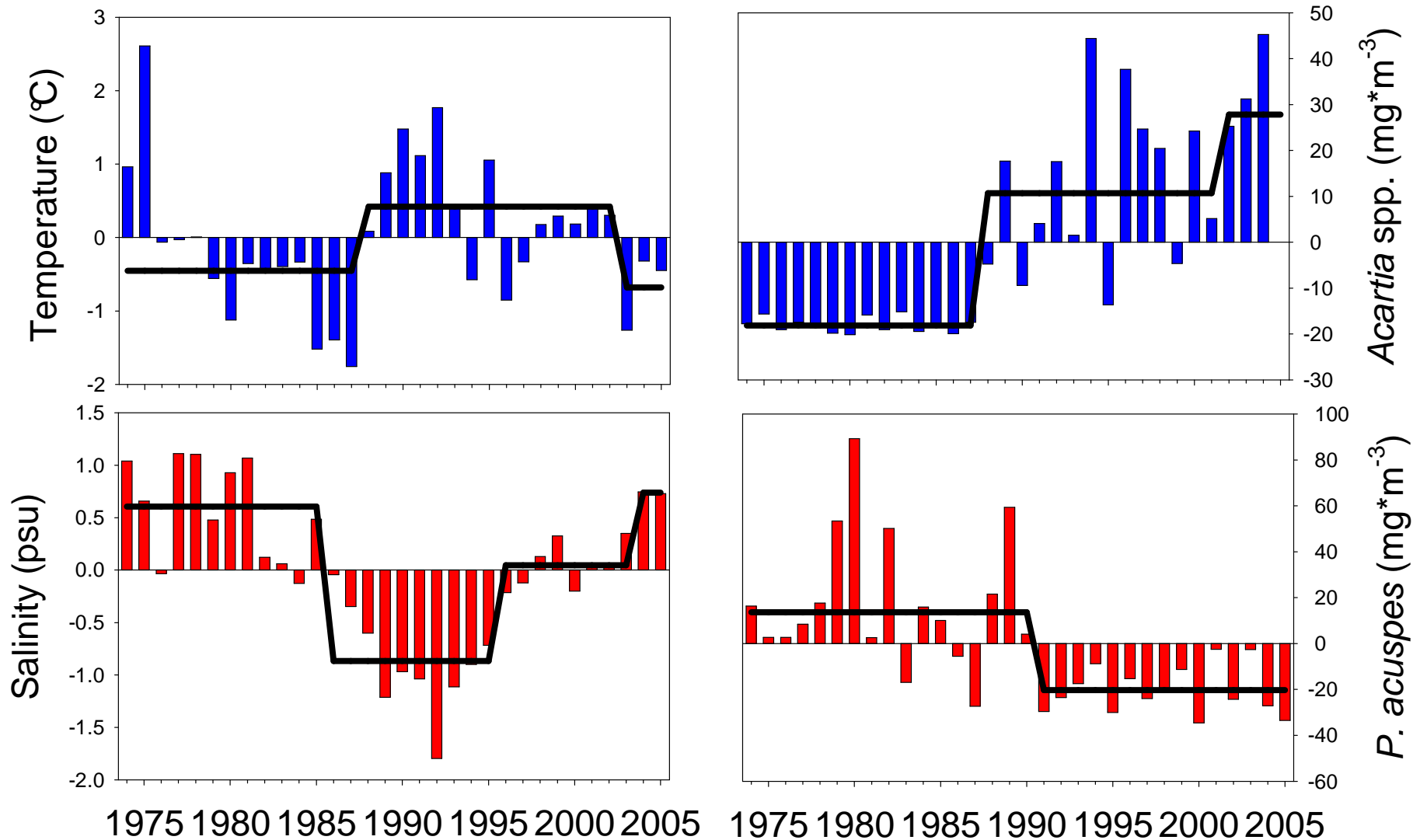
Basin dynamics



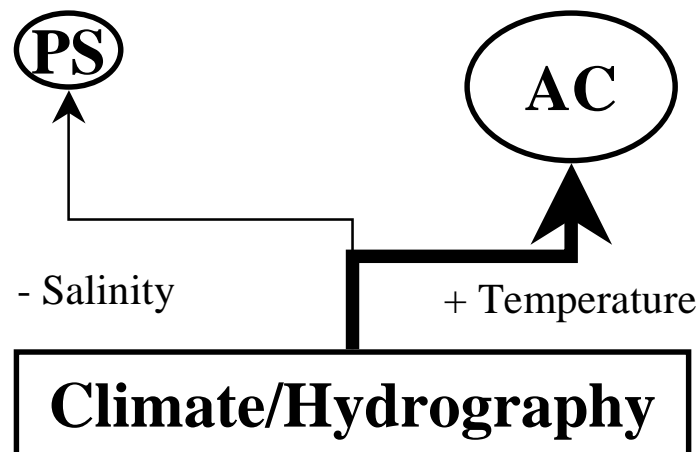
What has caused the regime shift? **CLIMATE?**



Hydrography & Copepods



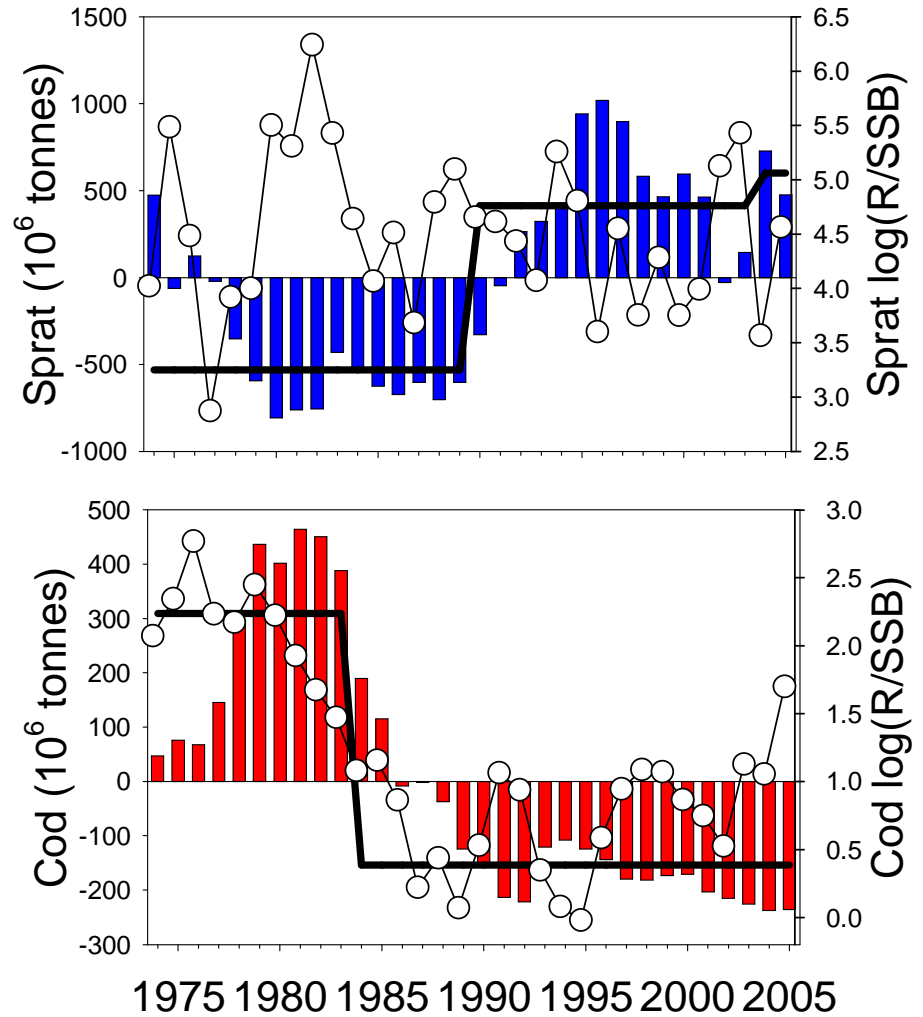
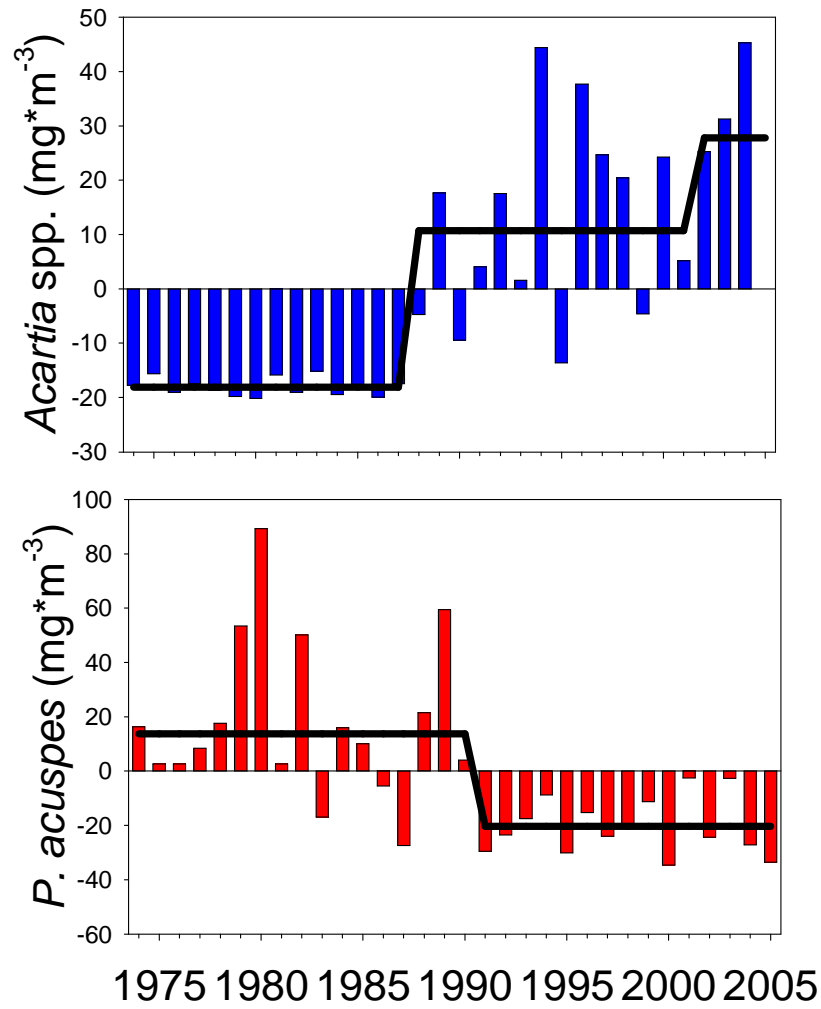
Copepods & hydrography



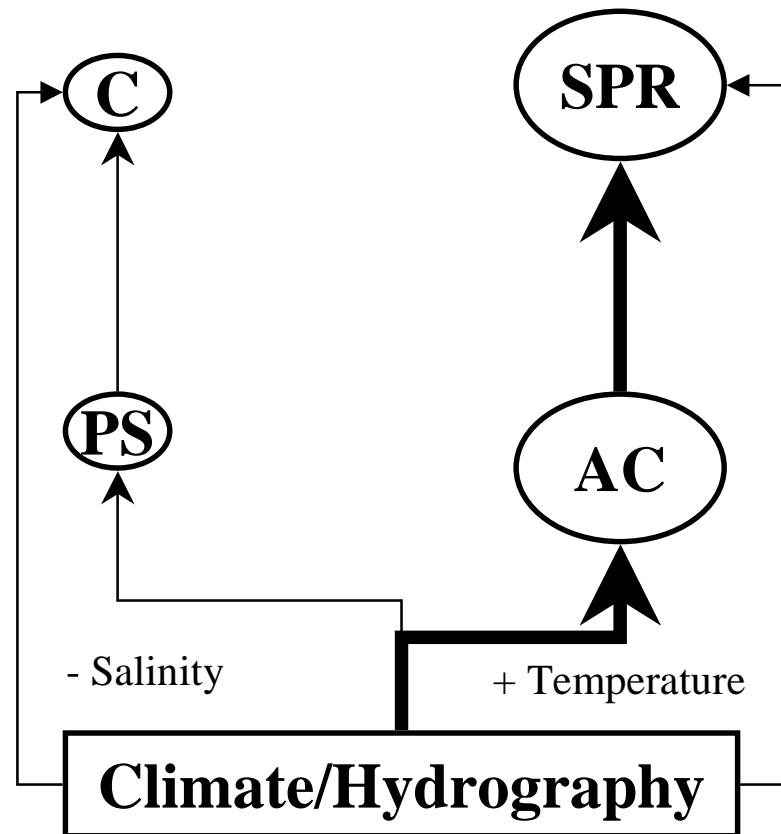
	PS	AC
<i>Type</i>	GAM	LM
<i>GCV</i>	0.02	
<i>AIC</i>		71.17
<i>R</i> ² (%)	81.6	92.0
<i>P</i>	< 0.0001	< 0.0001
<i>Predictors</i>	S, NAO, Spr	T, dinos

PS - *Pseudocalanus acuspes*, AC - *Acartia* spp., S - Salinity, T - Temperature, Spr - sprat biomass, dinos - dinoflagellates biomass

Copepods & fish stock recruitment



Cod & sprat recruitment success



	C	Spr
<i>Type</i>	<i>GAM</i>	<i>GAM</i>
<i>GCV</i>	0.187	0.214
<i>R² (%)</i>	85.5	96.6
<i>P</i>	< 0.0001	< 0.0001
<i>Predictors</i>	SSB, RV, PS	SSB, T, AC, NAO

C - Cod (log R/SSB), *SPR* - Sprat (log R/SSB), *PS* - *Pseudocalanus acuspes*, *AC* - *Acartia* spp., *RV* - reproductive volume, *T* - Temperature

Trophic cascades in the Baltic sea ?

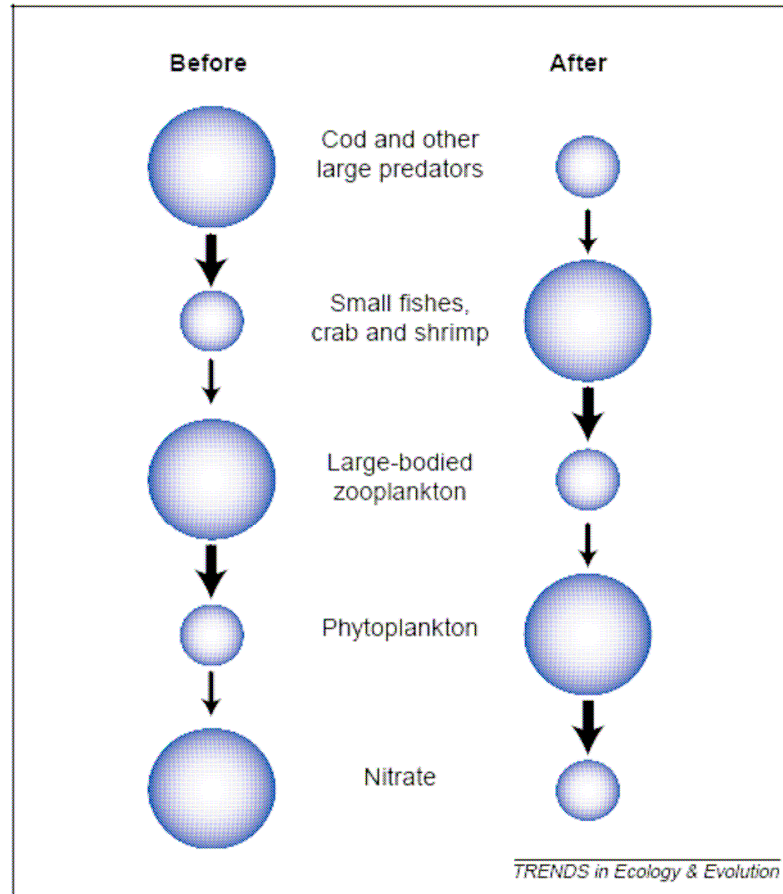
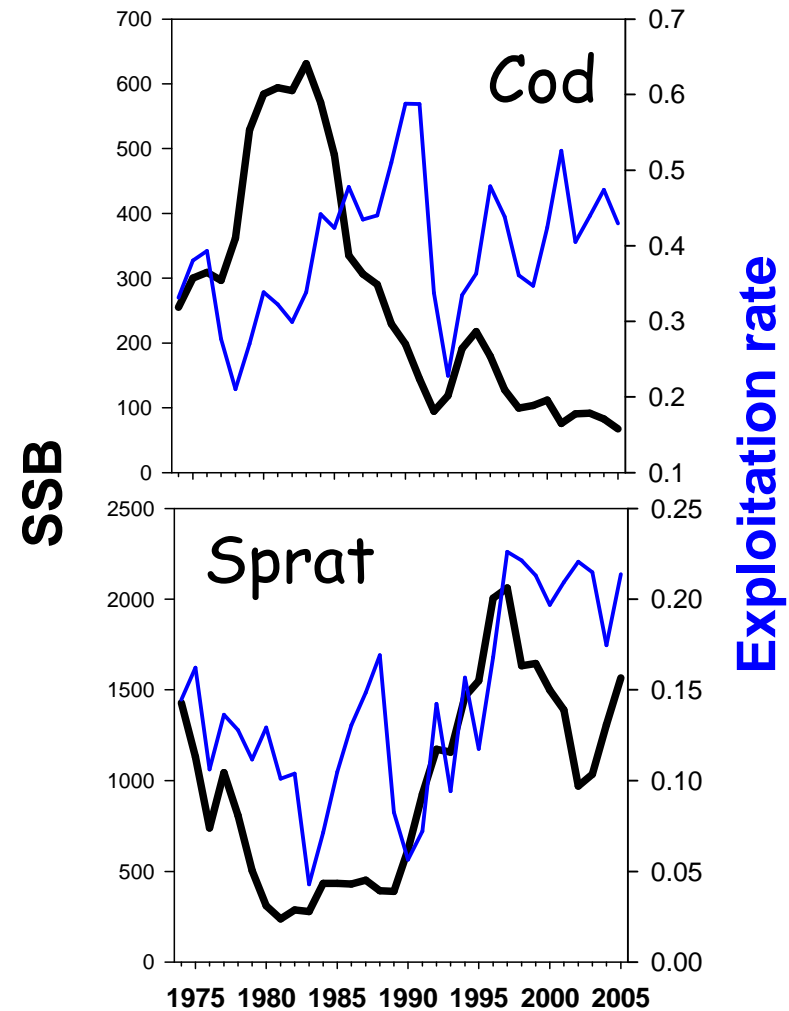
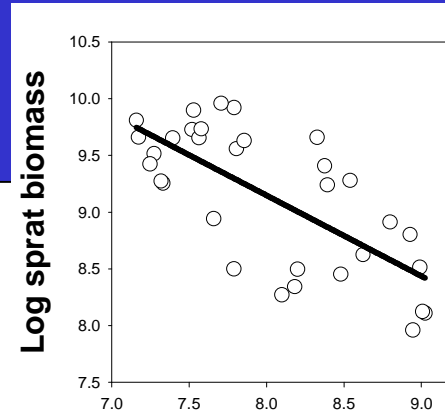
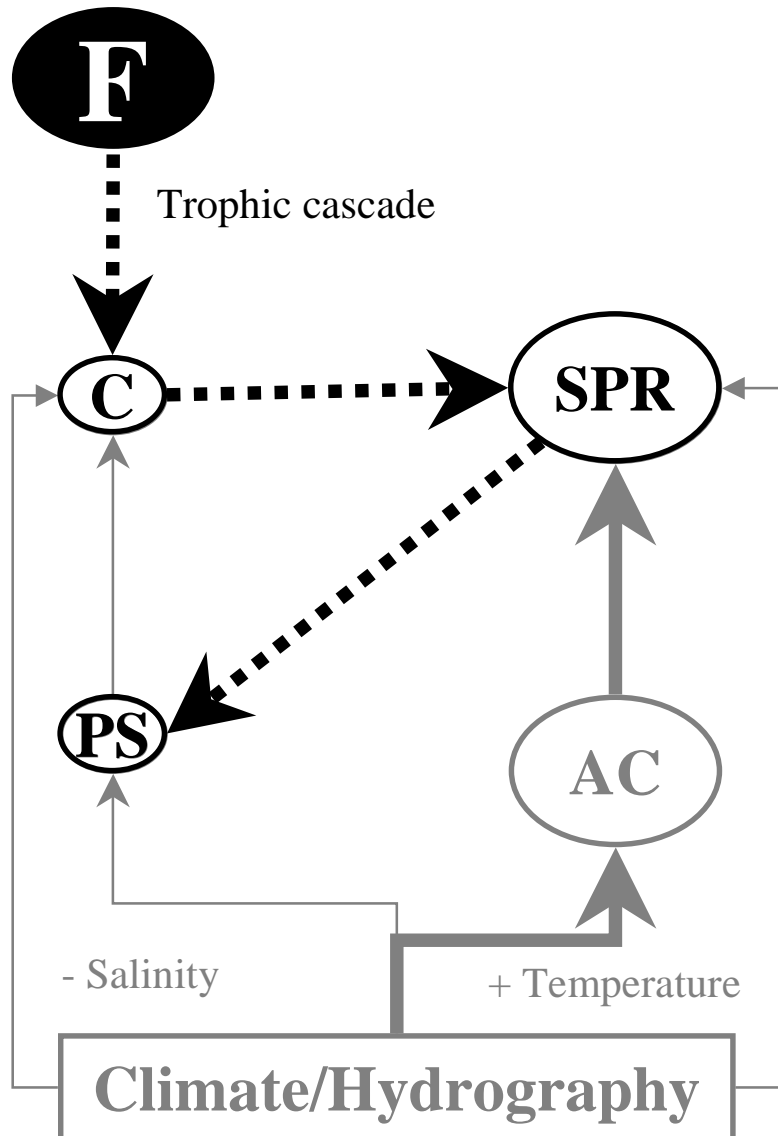


Figure 1. The cascading effect of the collapse of cod and other large predatory fishes on the Scotian Shelf ecosystem during the late 1980s and early 1990s. The size of the spheres represents the relative abundance of the corresponding trophic level. The arrows depict the inferred top-down effects.

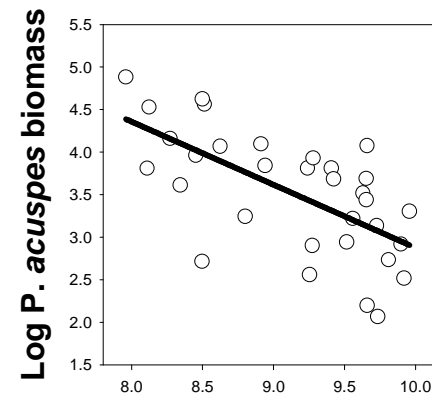
Scheffer et al. 2005



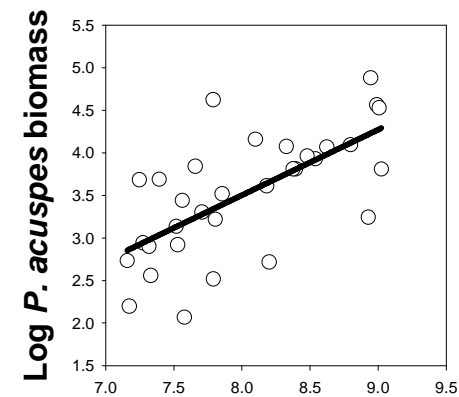
The Baltic Cascade



Log cod biomass

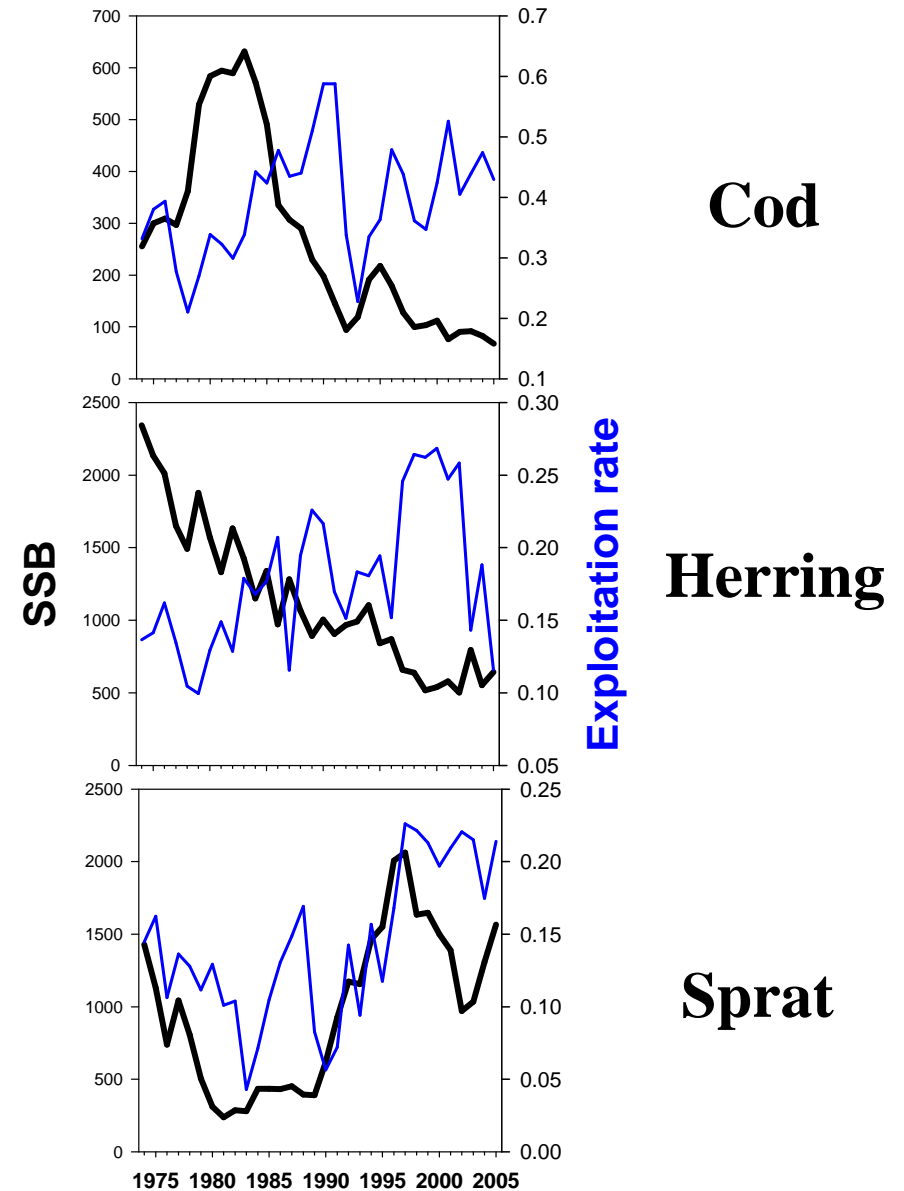
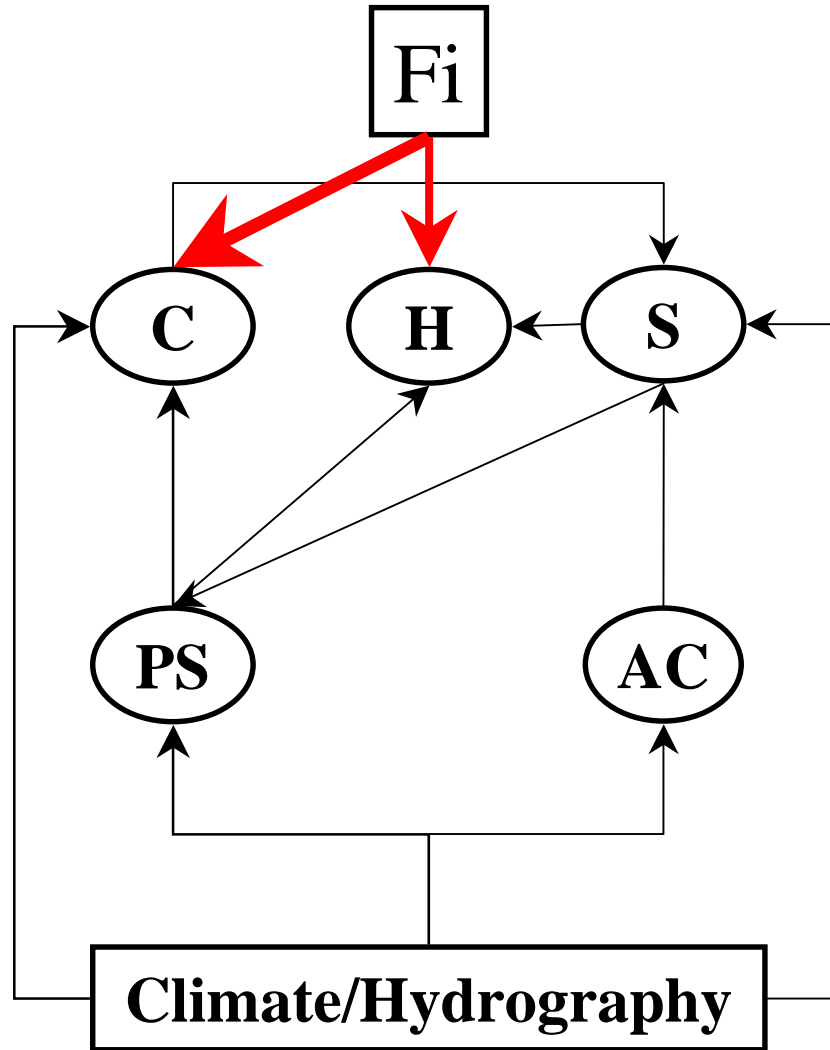


Log sprat biomass

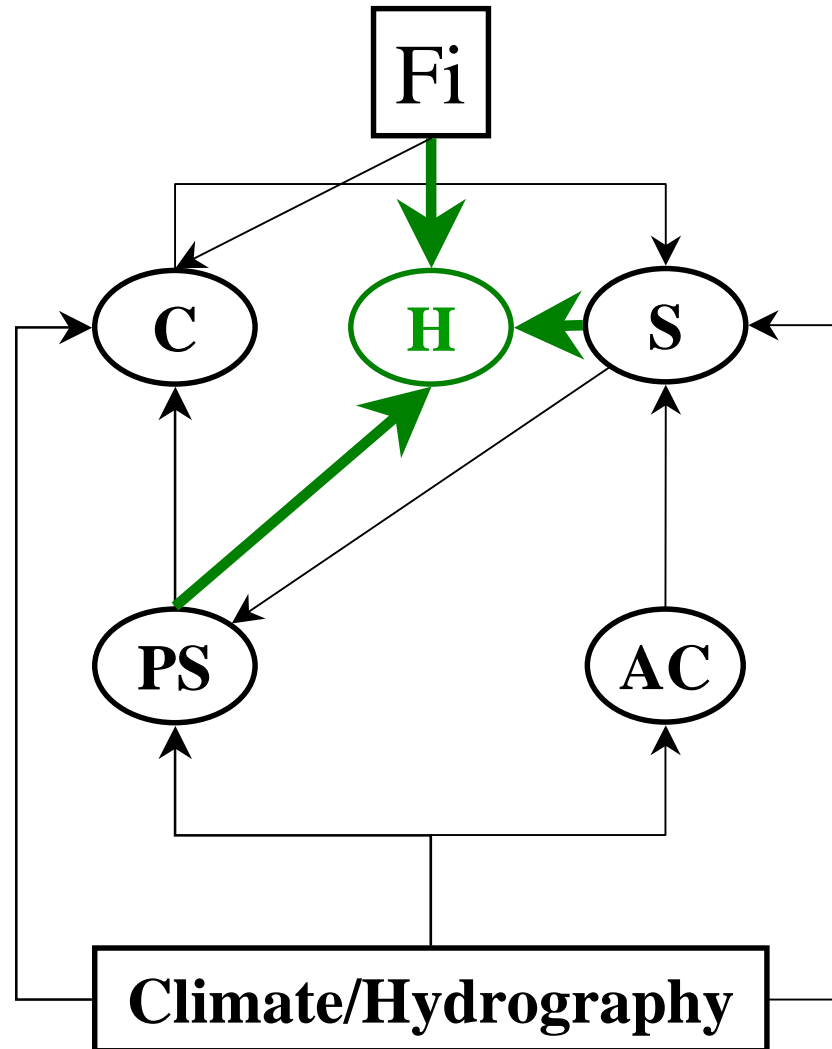


Log cod biomass

What about the poor herring ?

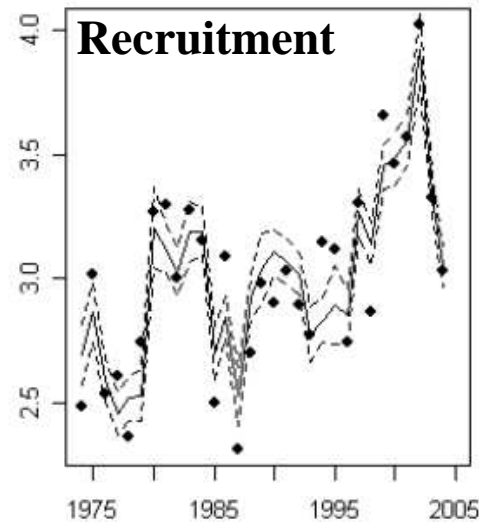


What about the poor herring ?



Growth changes (decline)

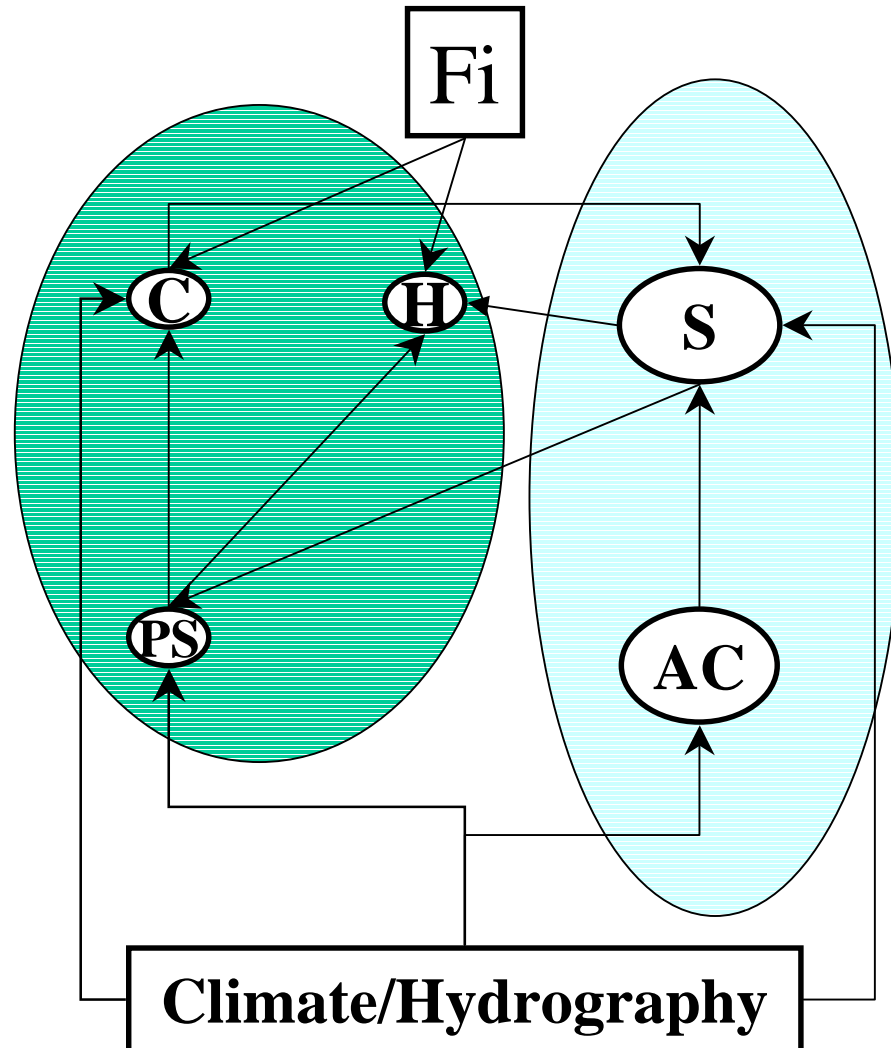
- decrease in *Pseudocalanus acuspes* [Möllmann et al. 2003; Rönkkönen et al. 2004]
- competition with the large sprat stock [Möllmann et al. 2005, Casini et al. 2006]



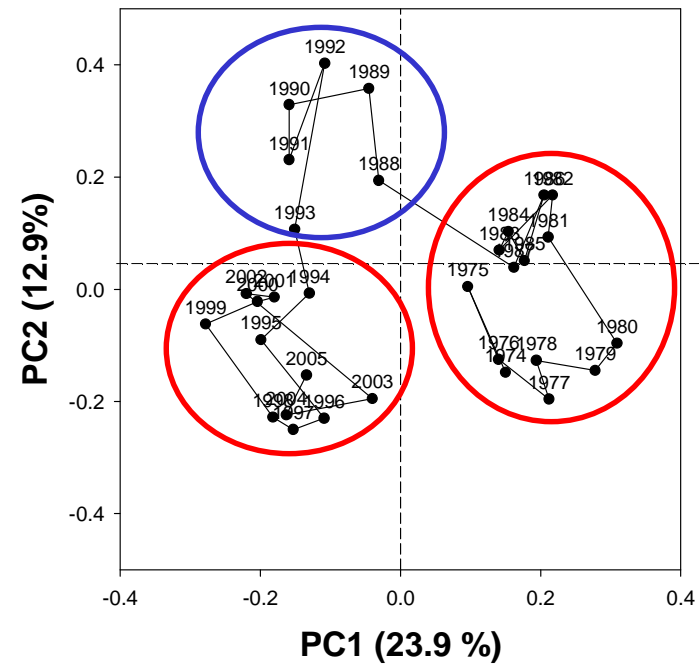
- GAM
- Predictors:
 - SSB
 - WAA
 - *P. acuspes*
 - Temperature
 - BSI
- R^2 (%) = 83.6

Source: ICES/BSRP Workshop on Herring Recruitment Processes in the Baltic Sea (WKHRPB)

The result: Regimes and Regime shifts !



- Temperature path dominates
- Salinity/oxygen/overfished path depressed
- Regime shift ... Community-wide !



Source: ICES/HELCOM Working Group on Integrated Assessments of the Baltic Sea (WGIAB)

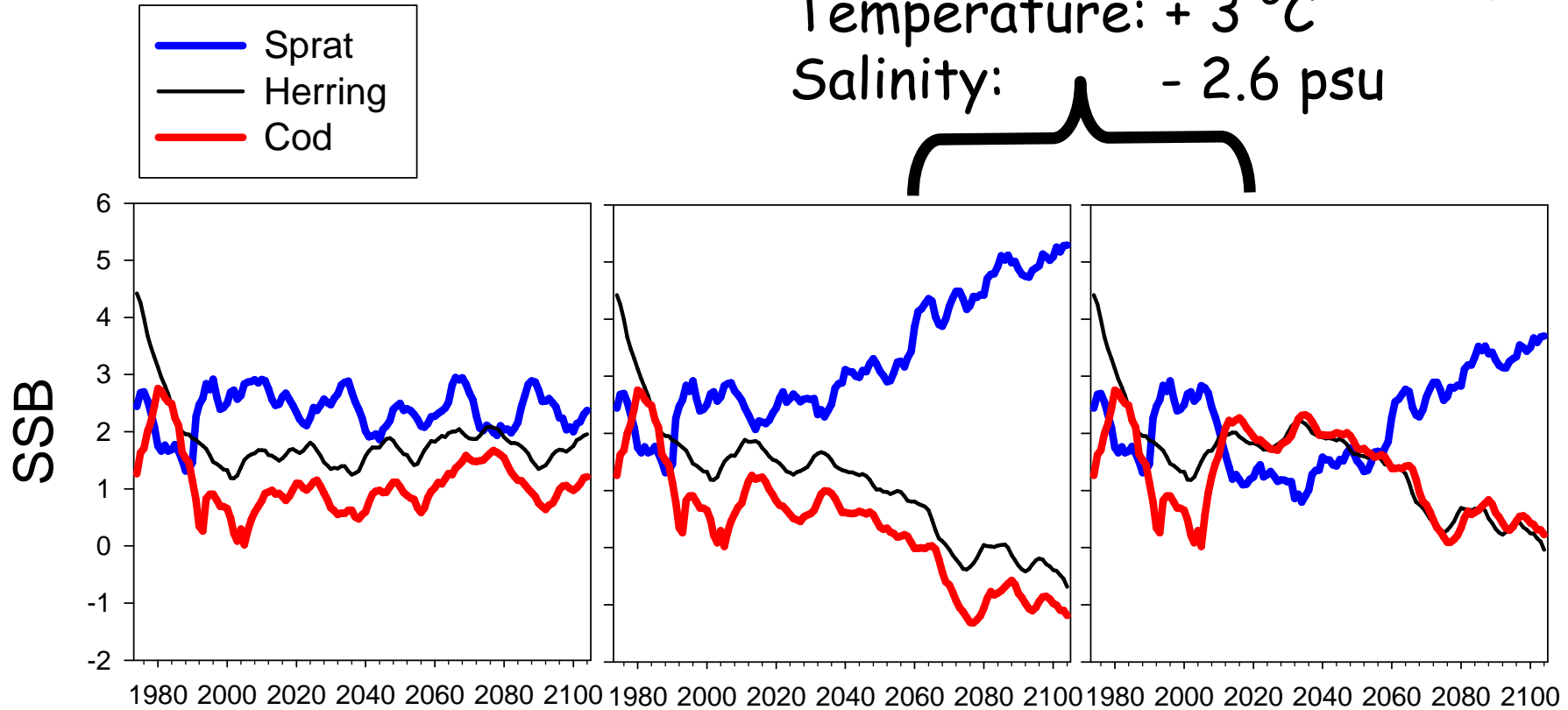
What might be the future ?

- Generalized Lotka-Volterra (GLV) competition model for cod, herring and sprat
- externally forced by hydrographic variables (salinity – cod, herring, temperature for sprat) and fishing pressure
- used to predict the development of the stocks under future hydrographic conditions

The future under climate change ?

BACC, 2008

Temperature: + 3 °C
Salinity: - 2.6 psu



Status quo climate
& fishery

Status quo
fishery

Reduced cod
fishery

Summary of changes

- Both climate-induced **changes in salinity and temperature** and **cod overfishing** have caused a *Regime-shift* in the pelagic Baltic ecosystem
- *Regime-shift* from **salinity-controlled** (*P. acuspes*/cod) to **temperature-controlled** (*Acartia* spp./sprat) species
- **Overfishing of cod cascades down** the foodweb
- Increase in sprat and decrease in *P. acuspes* caused bad herring condition

Interactions between open-sea food-web changes and the coast ?

- Cod decline and herring growth changes affect(ed) Baltic fishing communities
- Sprat increase is suspected to cause decline of coastal fish populations
- Coastal destruction of habitats , pollution and eutrophication negatively affects spawning areas for herring and nursery and feeding areas for cod and sprat
- Climate and coastal activities may change coastal food-webs feeding back to open-sea food-webs and fisheries