

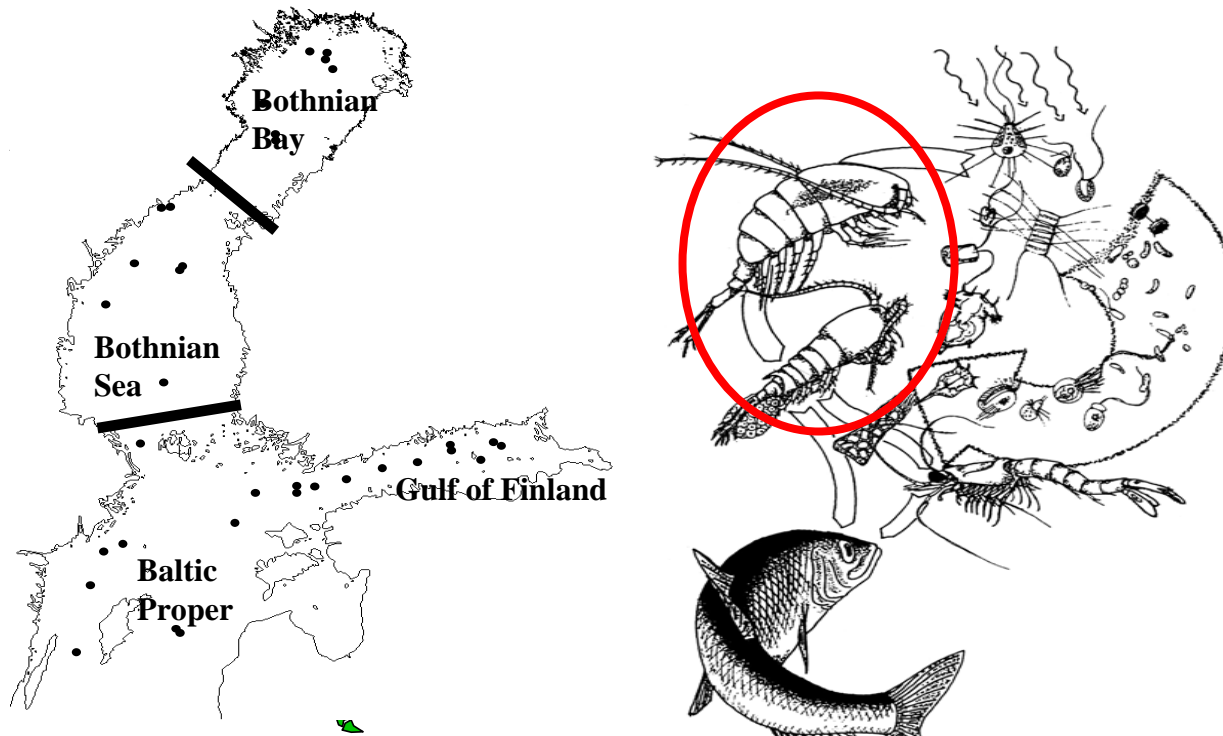
# Northern Baltic zooplankton, climatic forcing, eutrophication and clupeid stocks in 1979-2006: bottom-up regulation revisited



Flinkman J, Pääkkönen J-P, Saesmaa S & Bruun J.

Finnish Institute of Marine Research

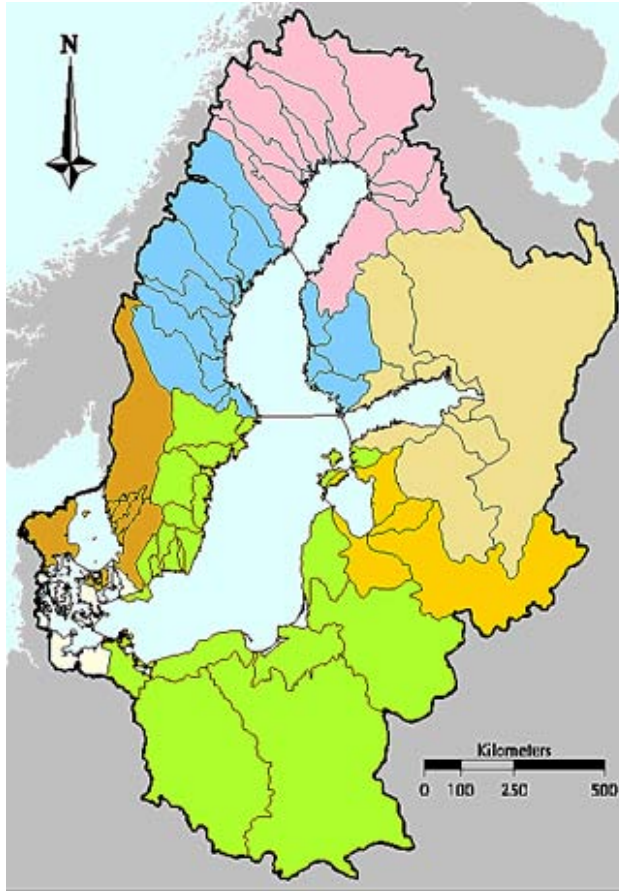
# Northern Baltic zooplankton, climatic forcing, eutrophication and clupeid stocks in 1979-2006: bottom-up regulation revisited



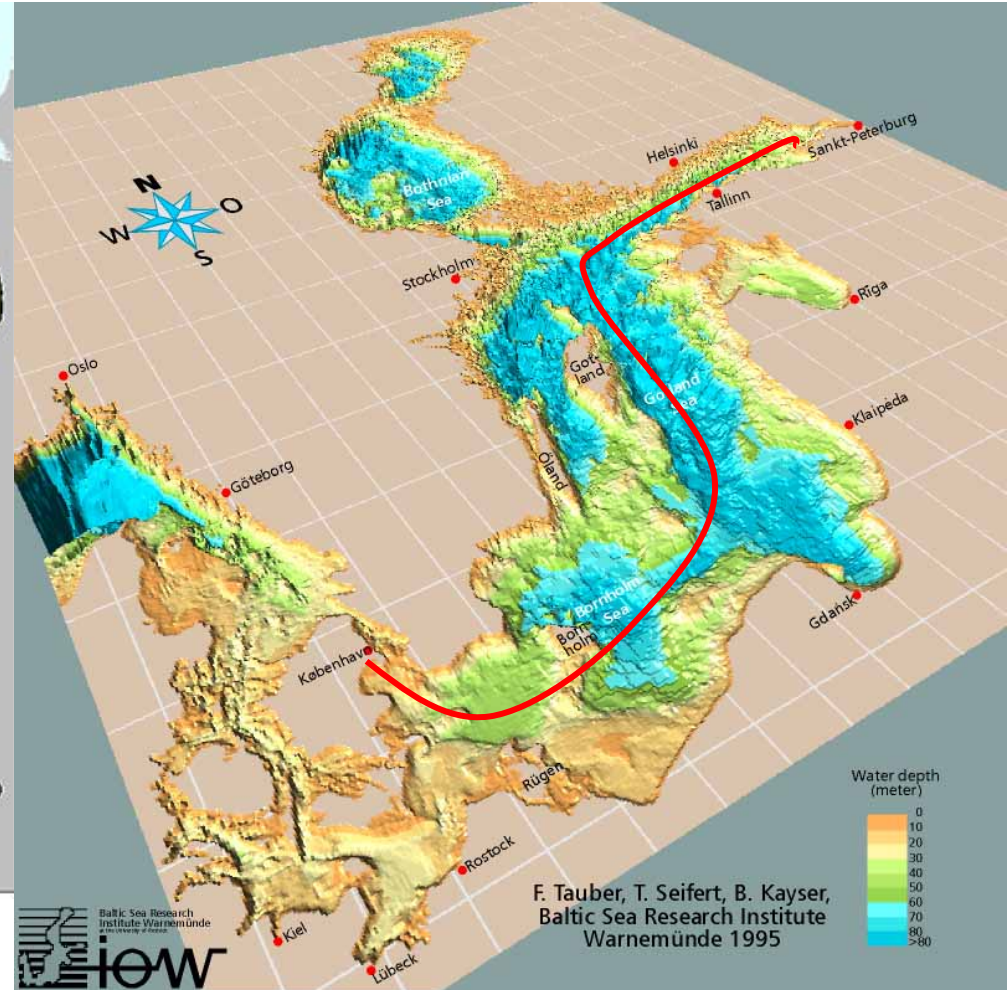
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# Peculiarities of the Baltic Sea hydrography

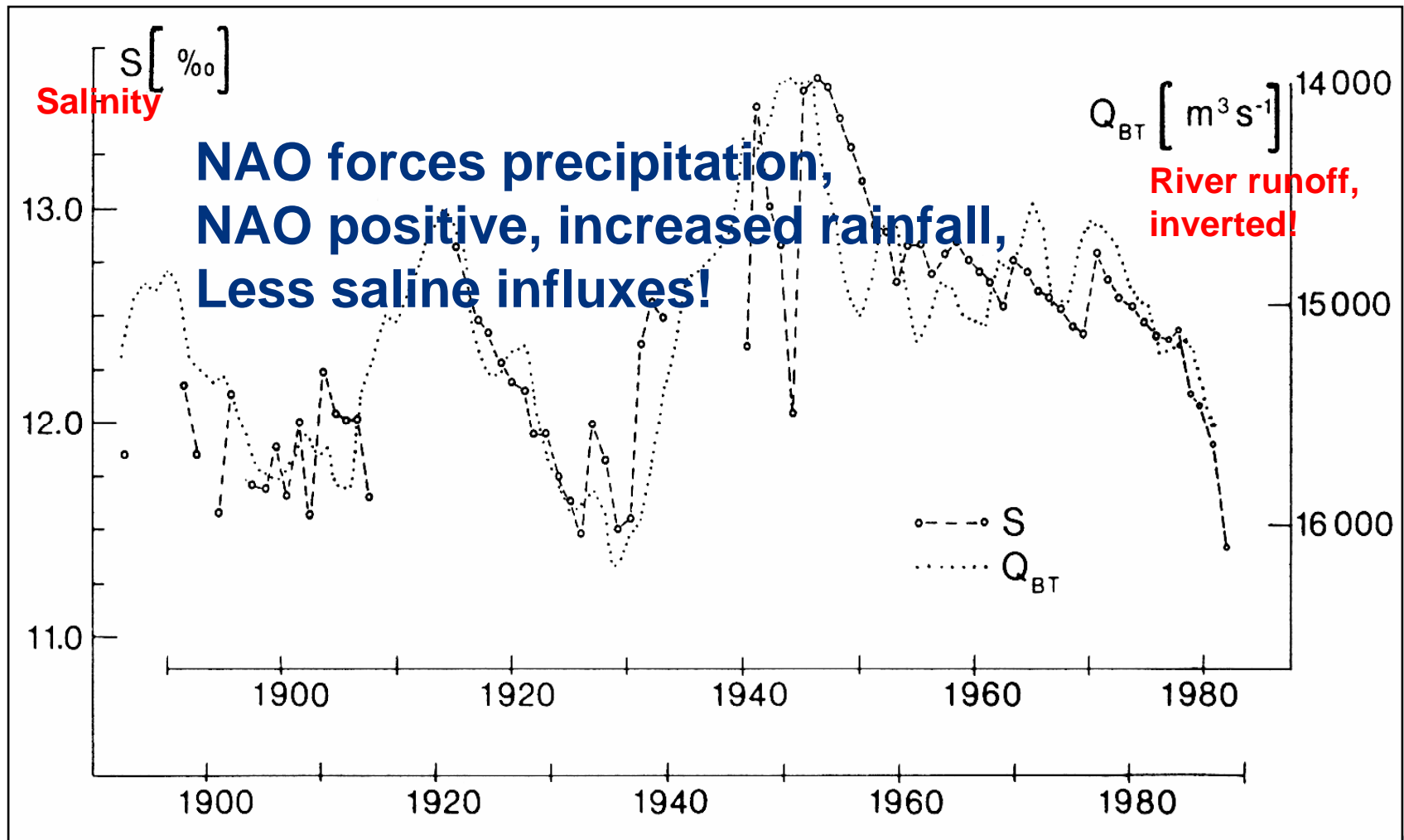


Very large drainage area,



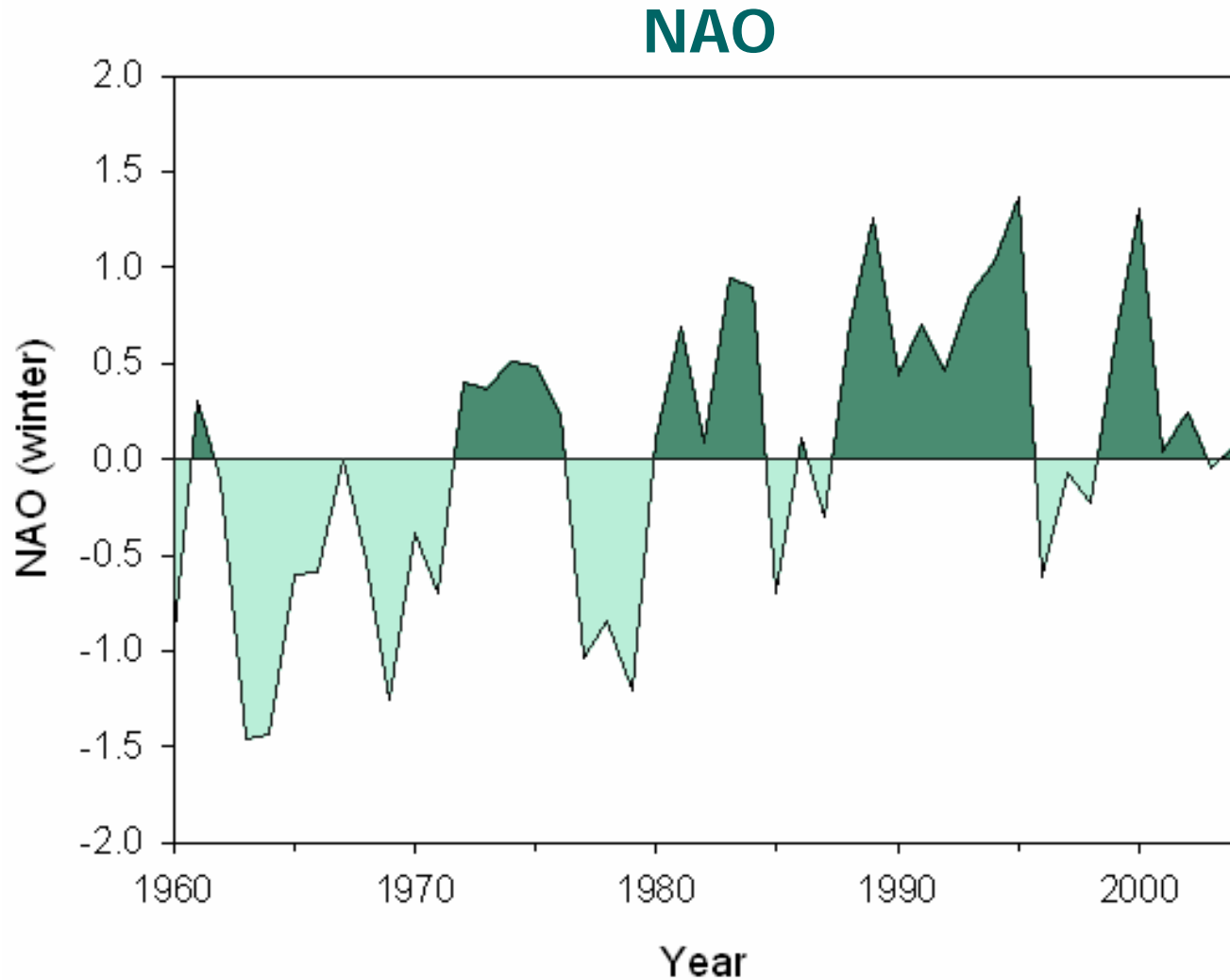
and connection to North Sea very restricted

# Peculiarities of the Baltic Sea hydrography



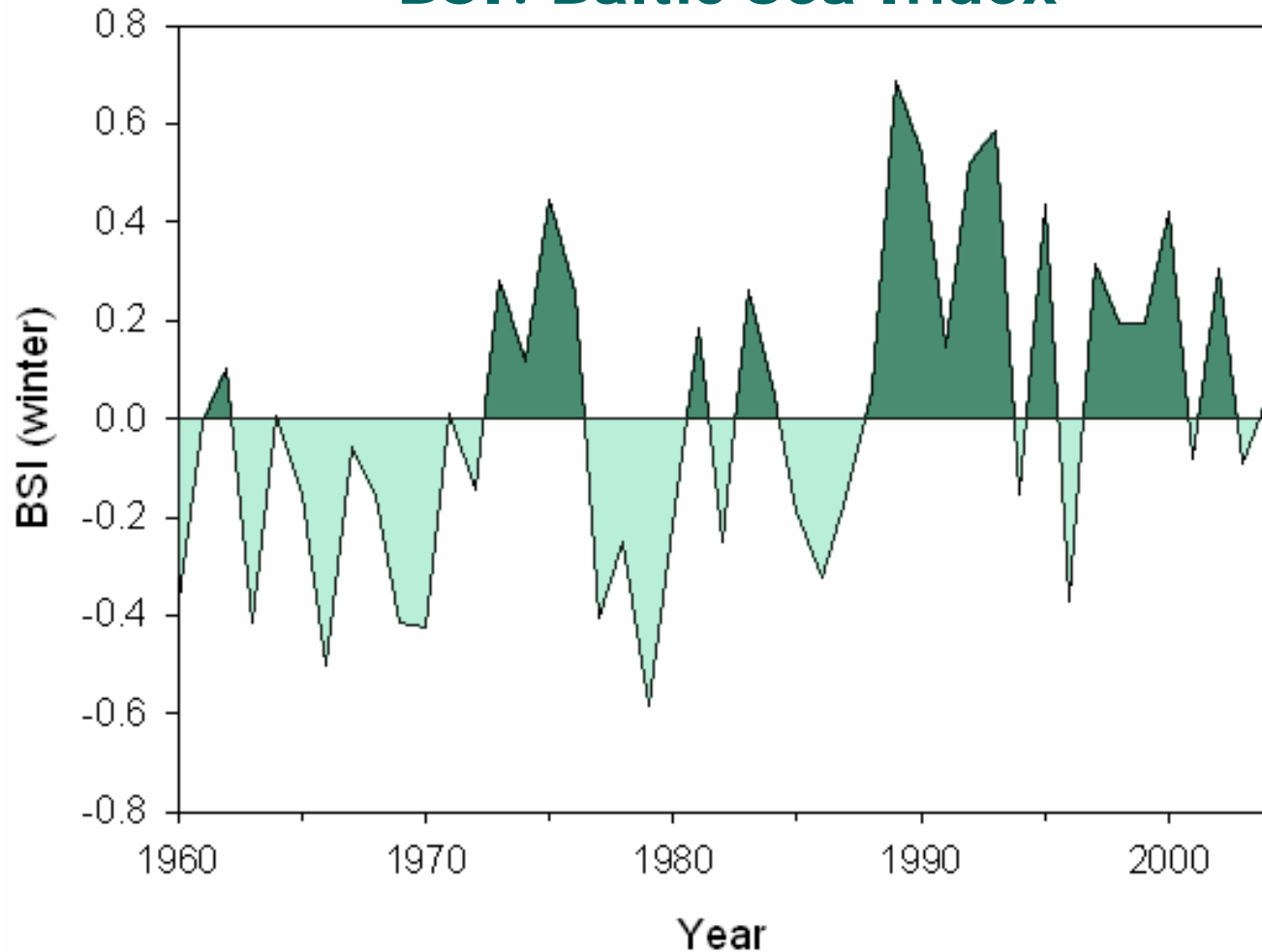
and connection to North Sea very restricted

# NAO dictates saline influxes through rainfall!



# NAO dictates saline influxes through rainfall!

## BSI: Baltic Sea Index

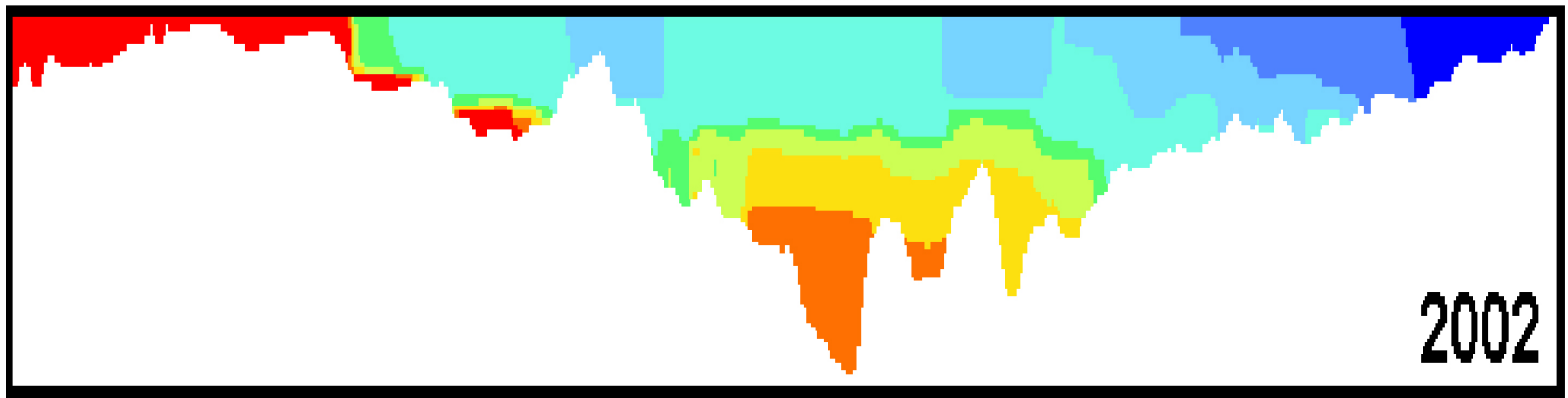


# Baltic Sea water is strongly stratified – sub-halocline water is only oxygenated through saline influxes!

Danish Straits

Gotland Deep

Gulf of Finland

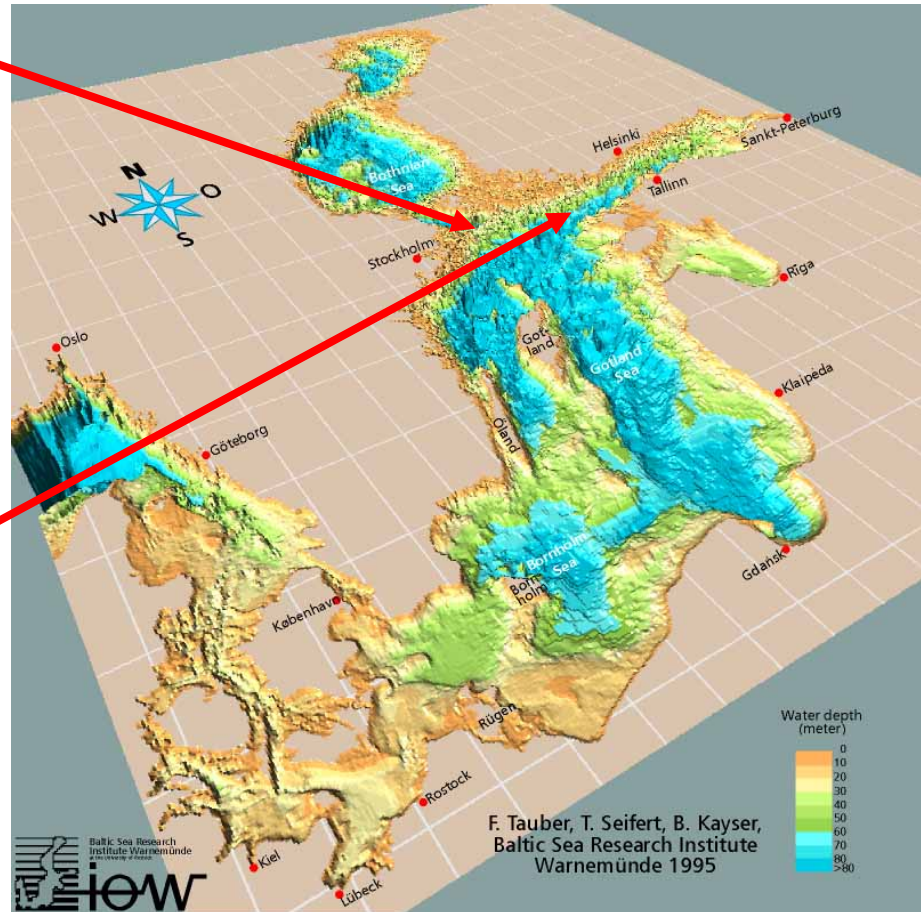


Salinity ‰



# Major differences in hydrography between sub-areas

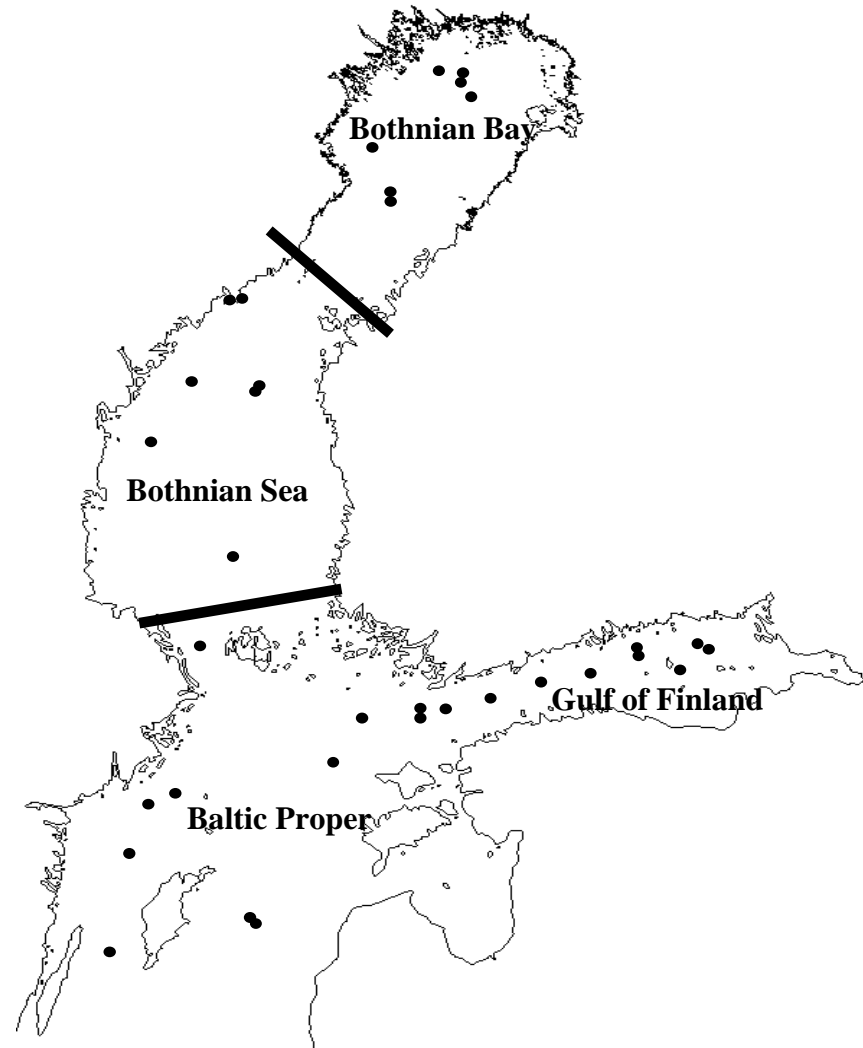
- Åland sill separates Gulf of Bothnia from Baltic Proper, restricting deep saline water inflow
- GoB system does not suffer from anoxic deep water!
- Gulf of Finland has no sill to BP, anoxic deep water enters!



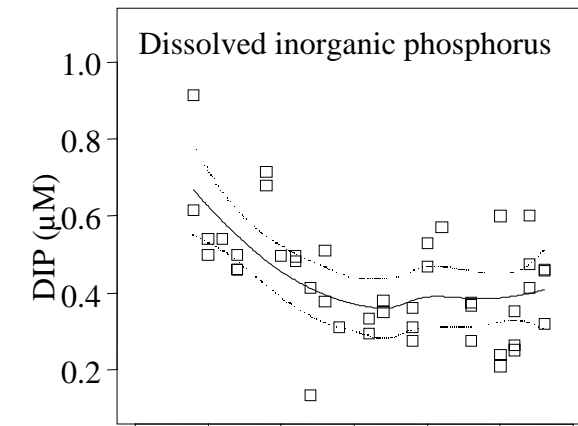
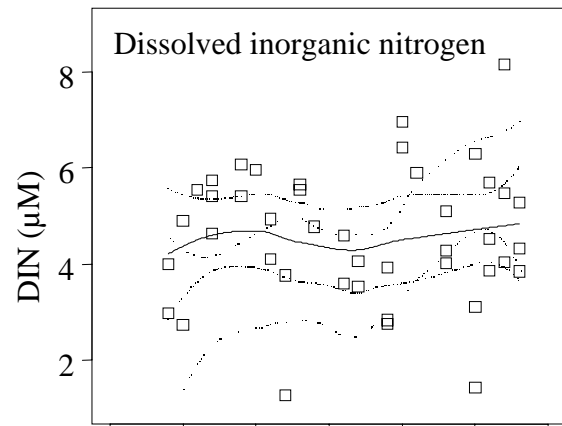
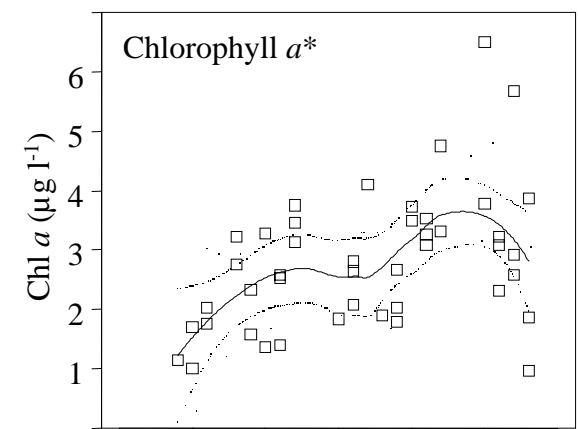
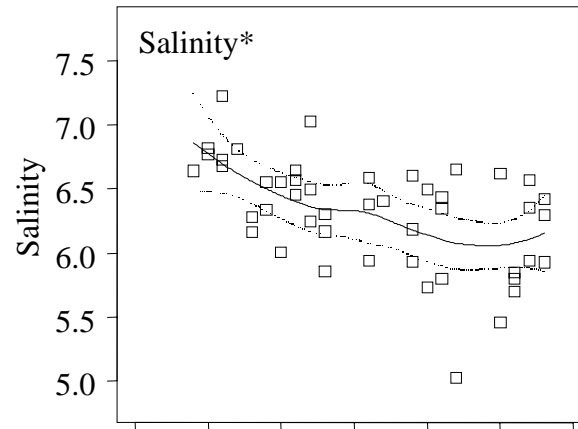
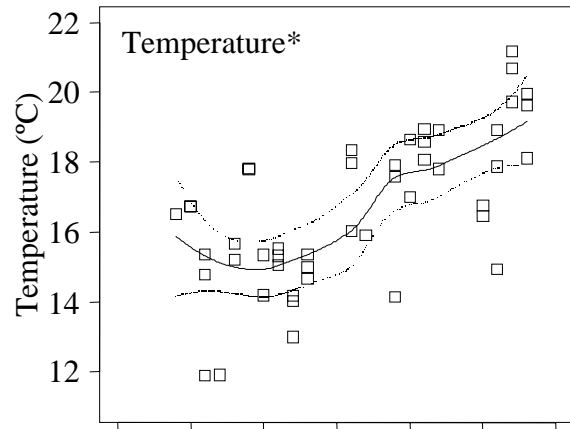


# Zooplankton time series and hypotheses

- HELCOM COMBINE monitoring program 1979-present
- stations sampled once per annum, usually August
- long-term salinity decrease and eutrophication
- zooplankton sensitive for salinity changes
- neritic species decrease, limnic species increase?
- secondary effects of eutrophication?



# Long-term changes, Baltic Proper: salinity, nutrients, chlorophyll-a



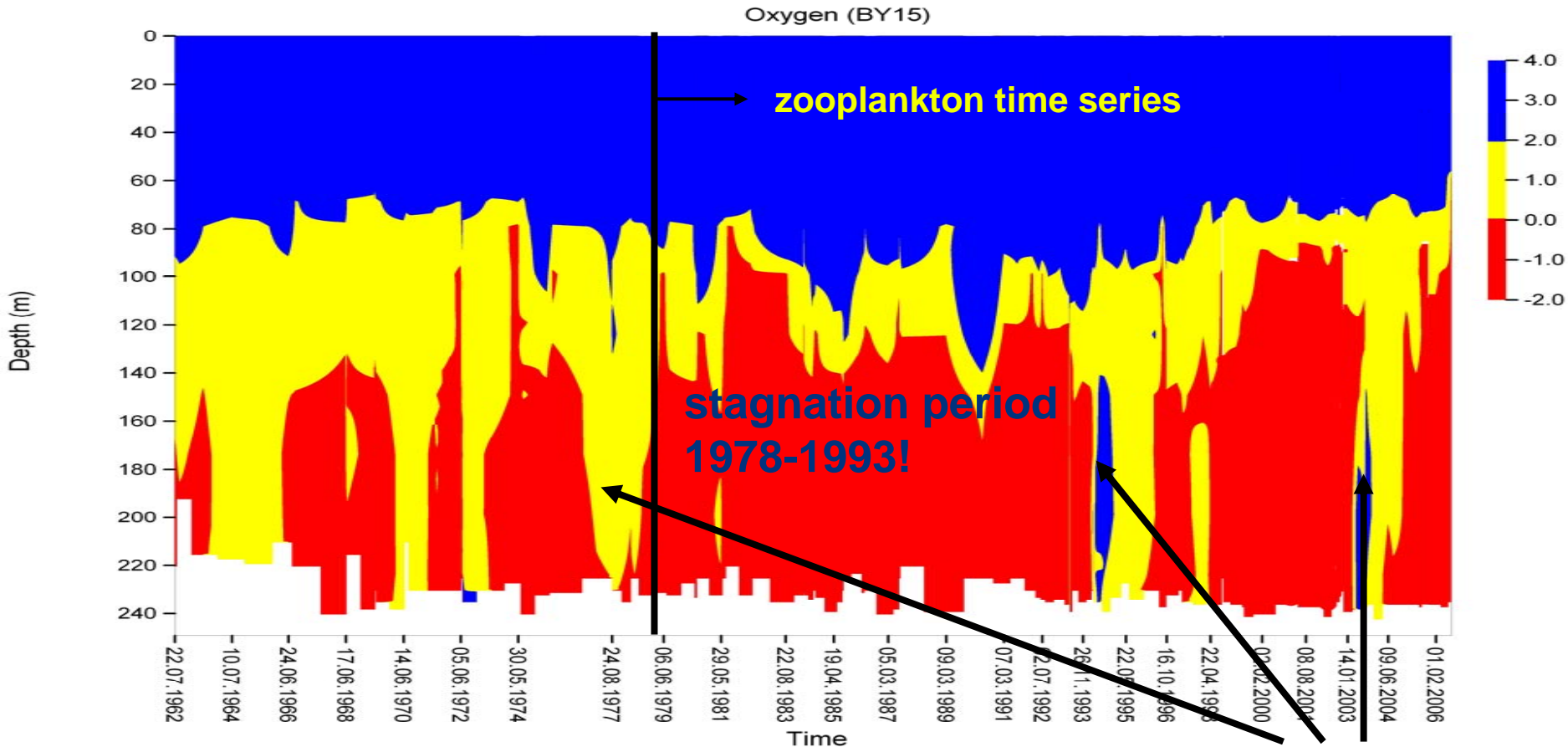
1975 1985 1995 2005

1975 1985 1995 2005

Suikkanen et al. 2007

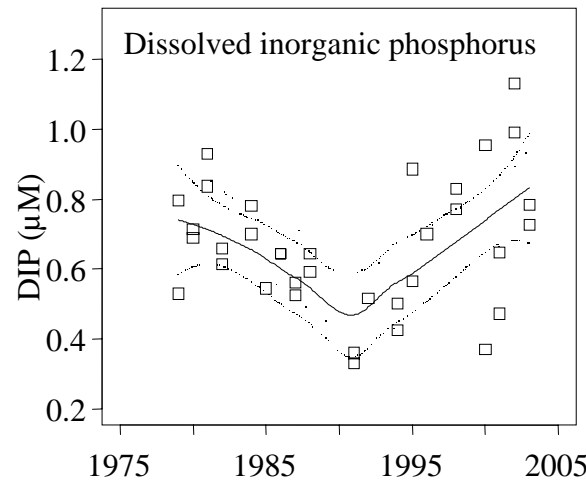
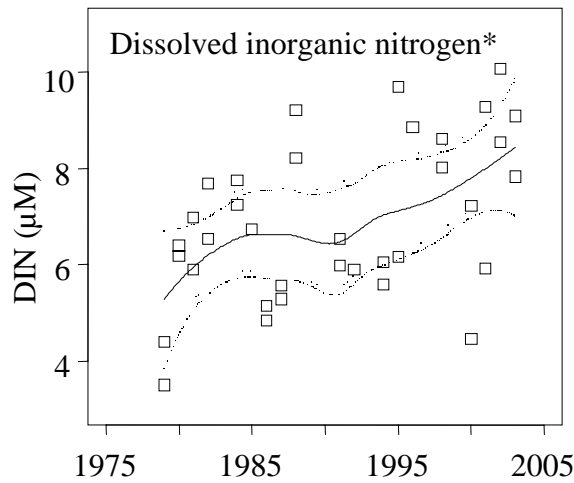
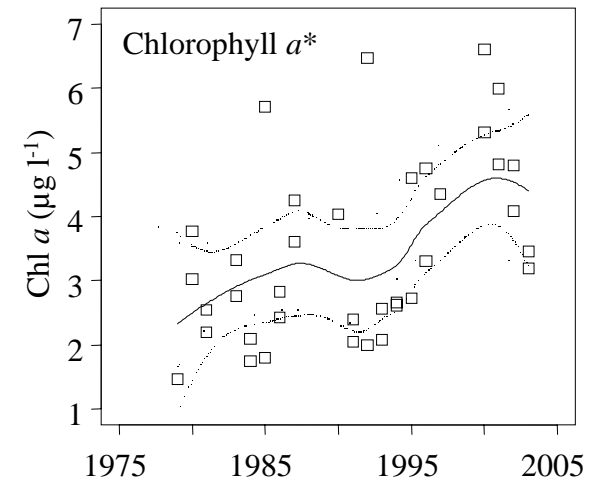
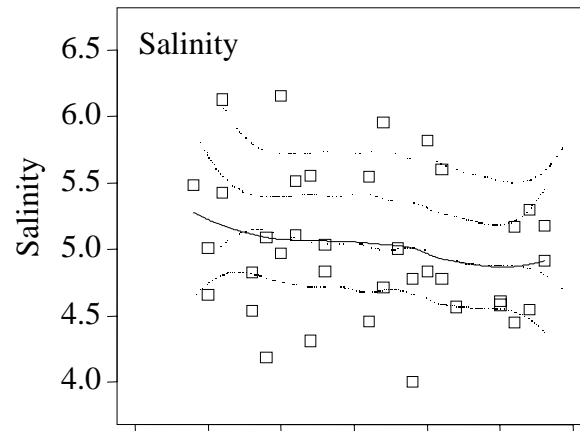
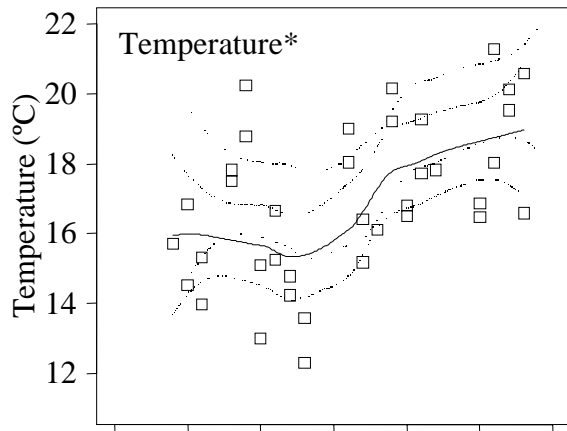


# Baltic Proper, oxygen content at Gotland Deep, station BY15



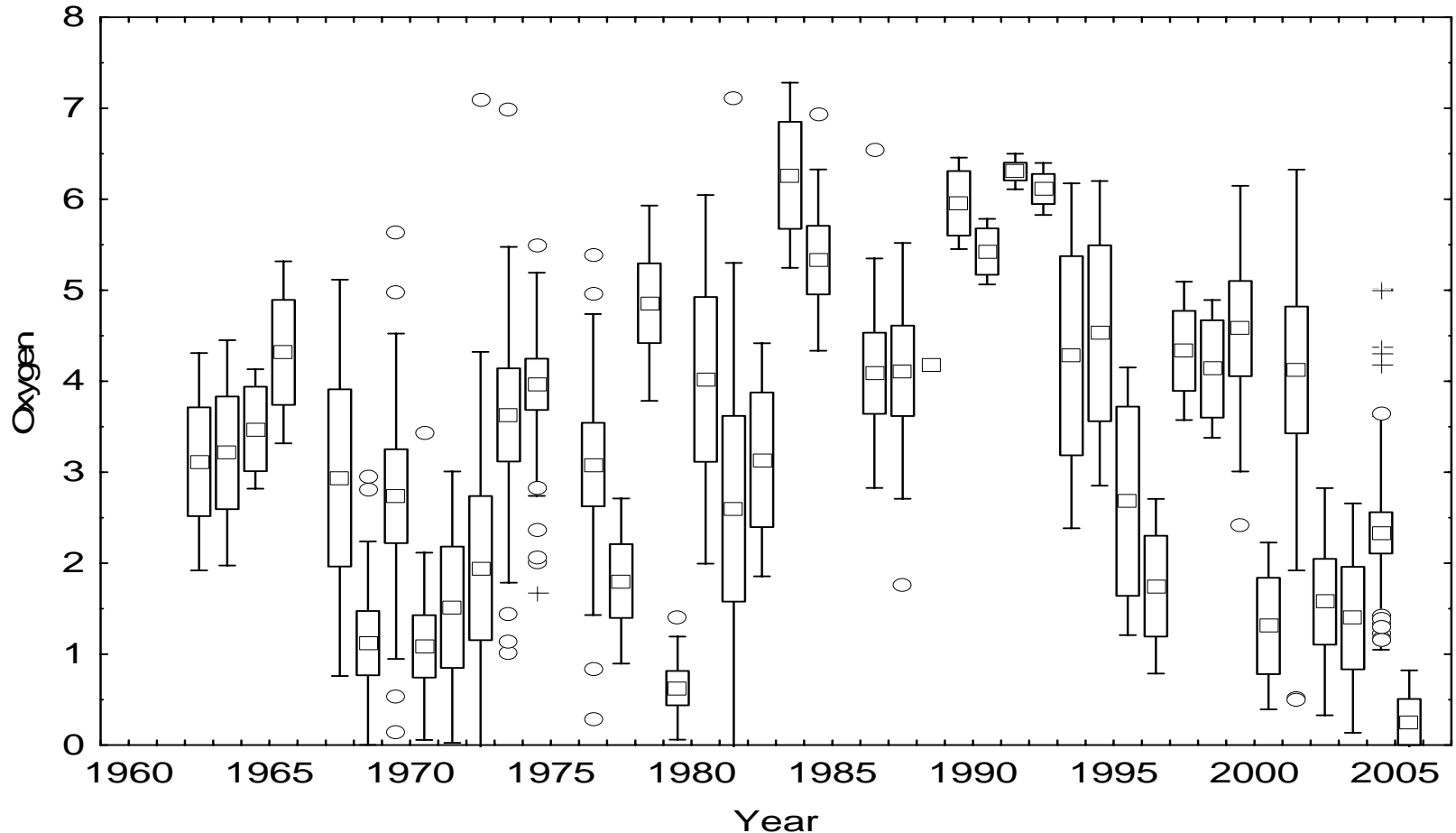
saline water influxes:  
1977-78, 1993, 2003

# Long-term changes, Gulf of Finland: salinity, nutrients, chlorophyll-a



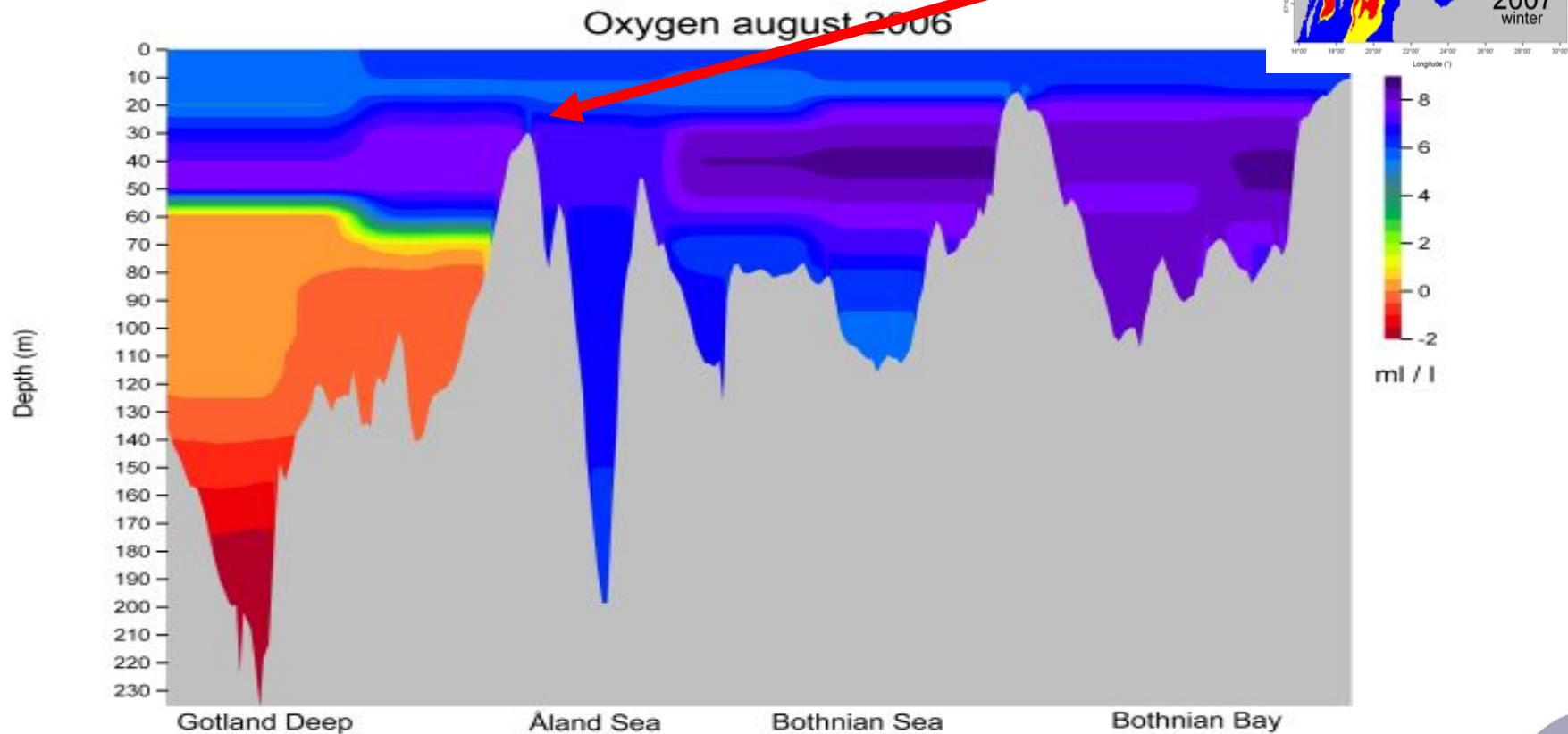
Suikkanen et al. 2007

# Gulf of Finland, oxygen depletion



**Inflow of oxygen depleted saline deep water from the Baltic Proper has caused decrease in bottom oxygen in the Gulf of Finland.**

# Bothnian Sea and Bothnian Bay do not suffer of anoxic conditions due to Åland sill!

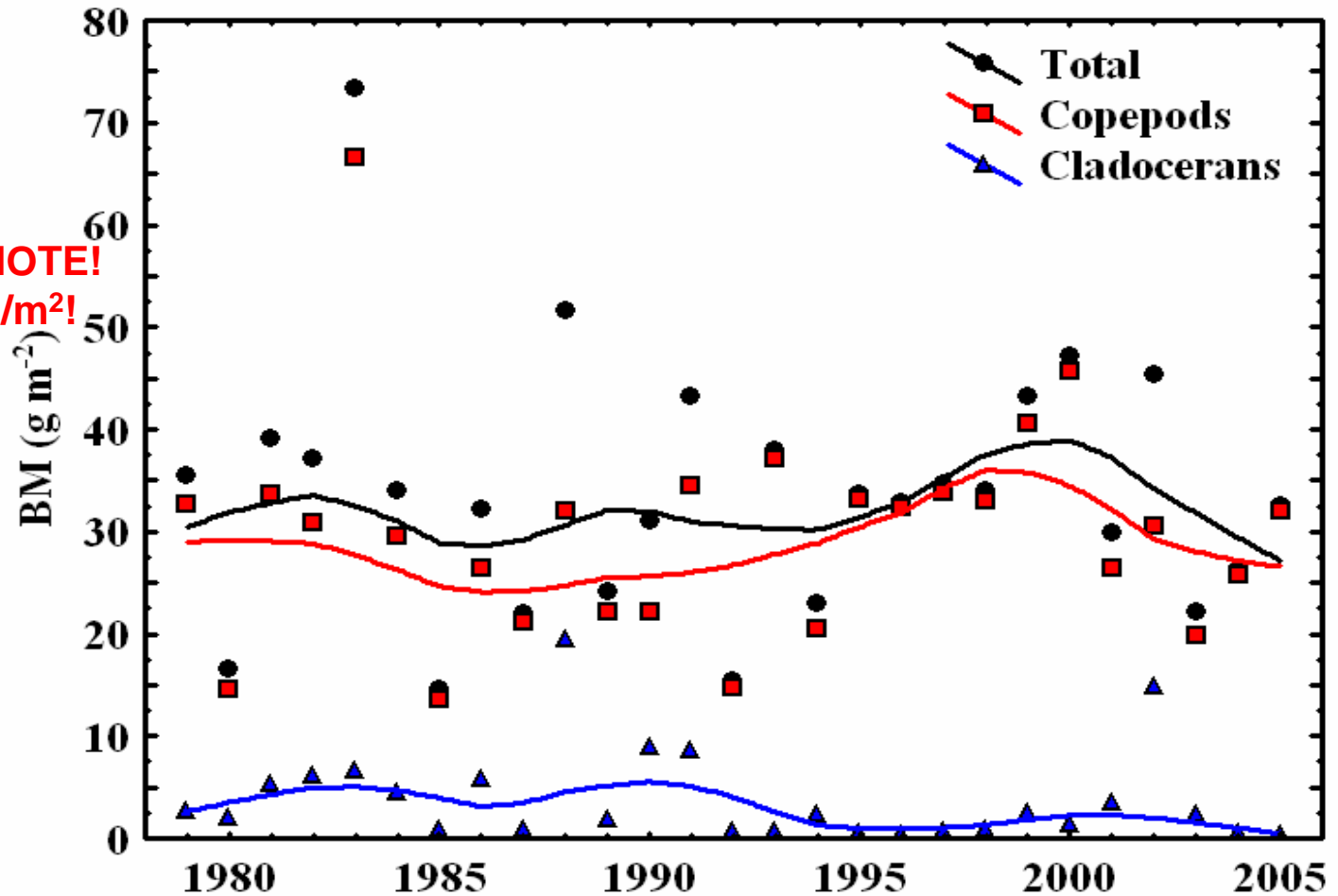




# Zooplankton species biomass (mg/m<sup>2</sup>), Baltic proper:

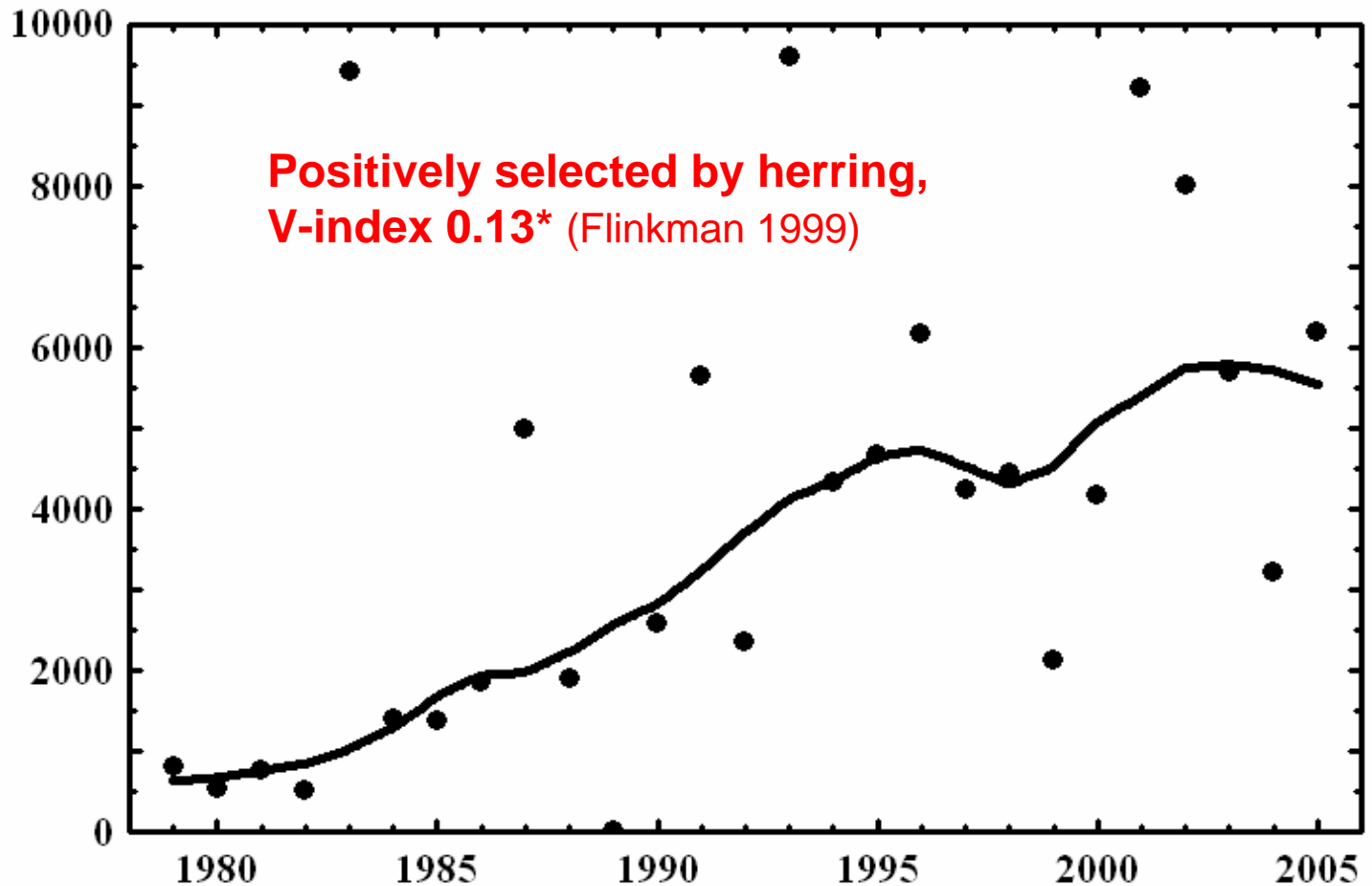


**NOTE!**  
g/m<sup>2</sup>!



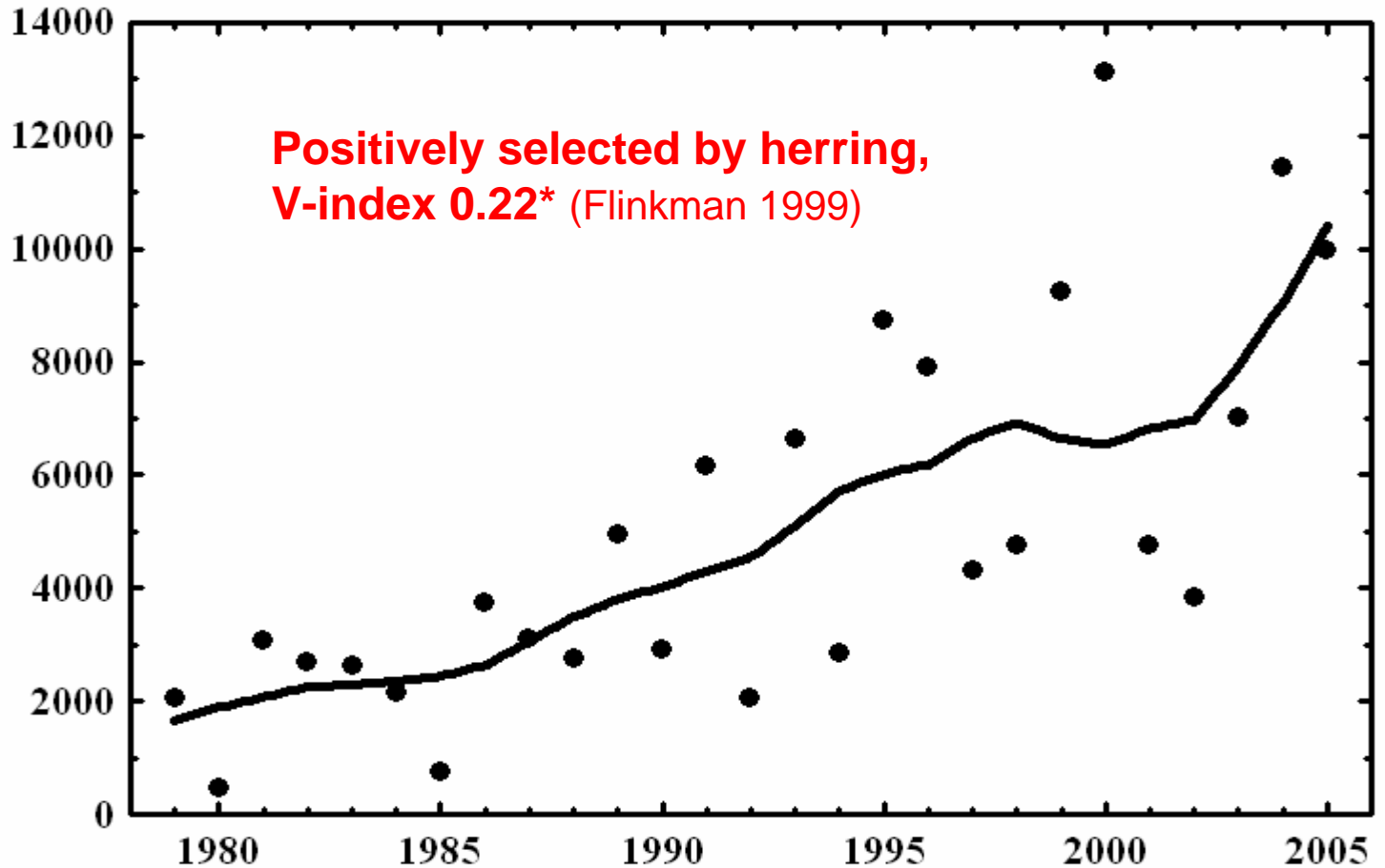
# Zooplankton species biomass (mg/m<sup>2</sup>), Baltic proper:

## *Eurytemora affinis*



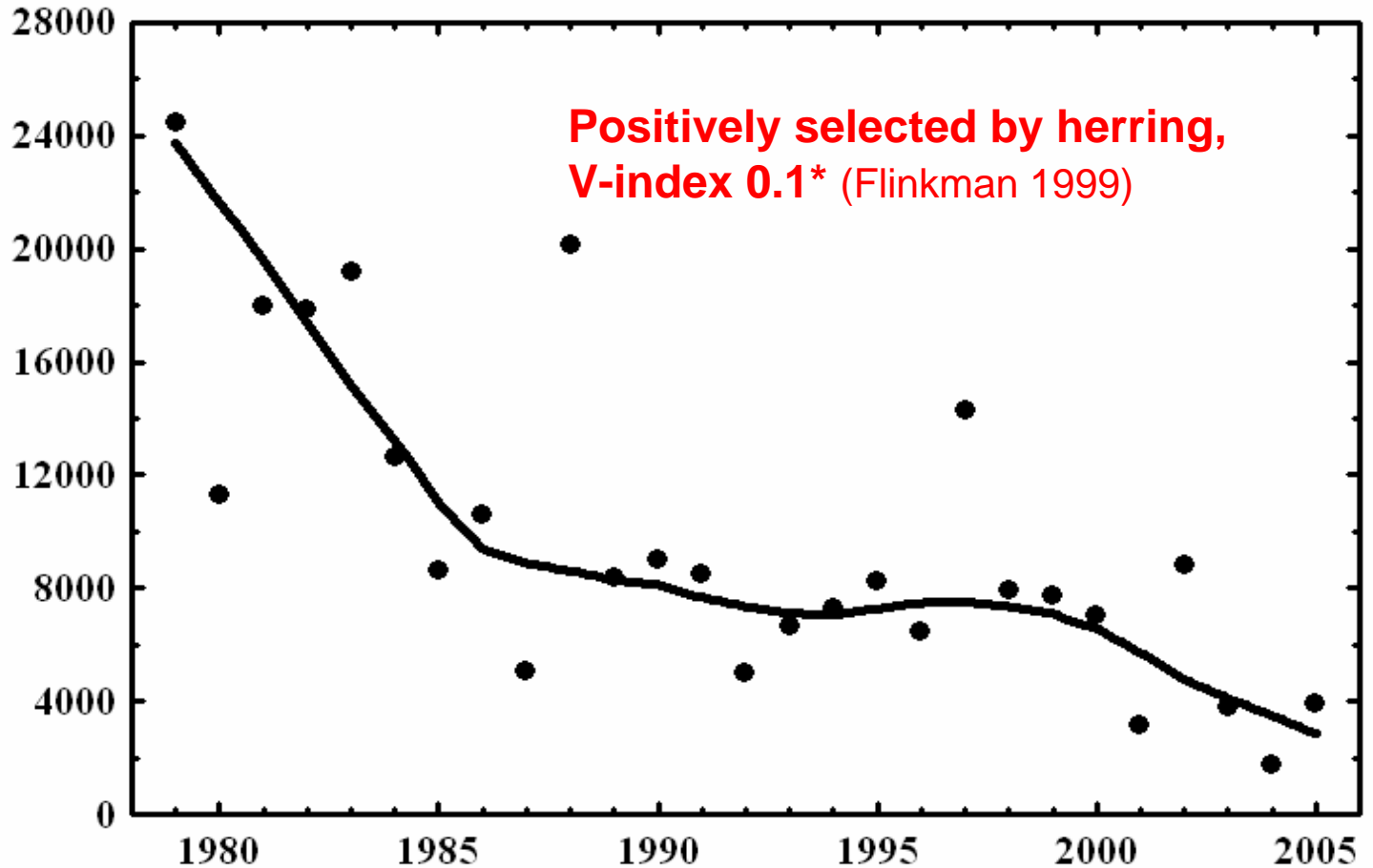
# Zooplankton species biomass (mg/m<sup>2</sup>), Baltic proper:

## *Temora longicornis*



# Zooplankton species biomass (mg/m<sup>2</sup>), Baltic proper:

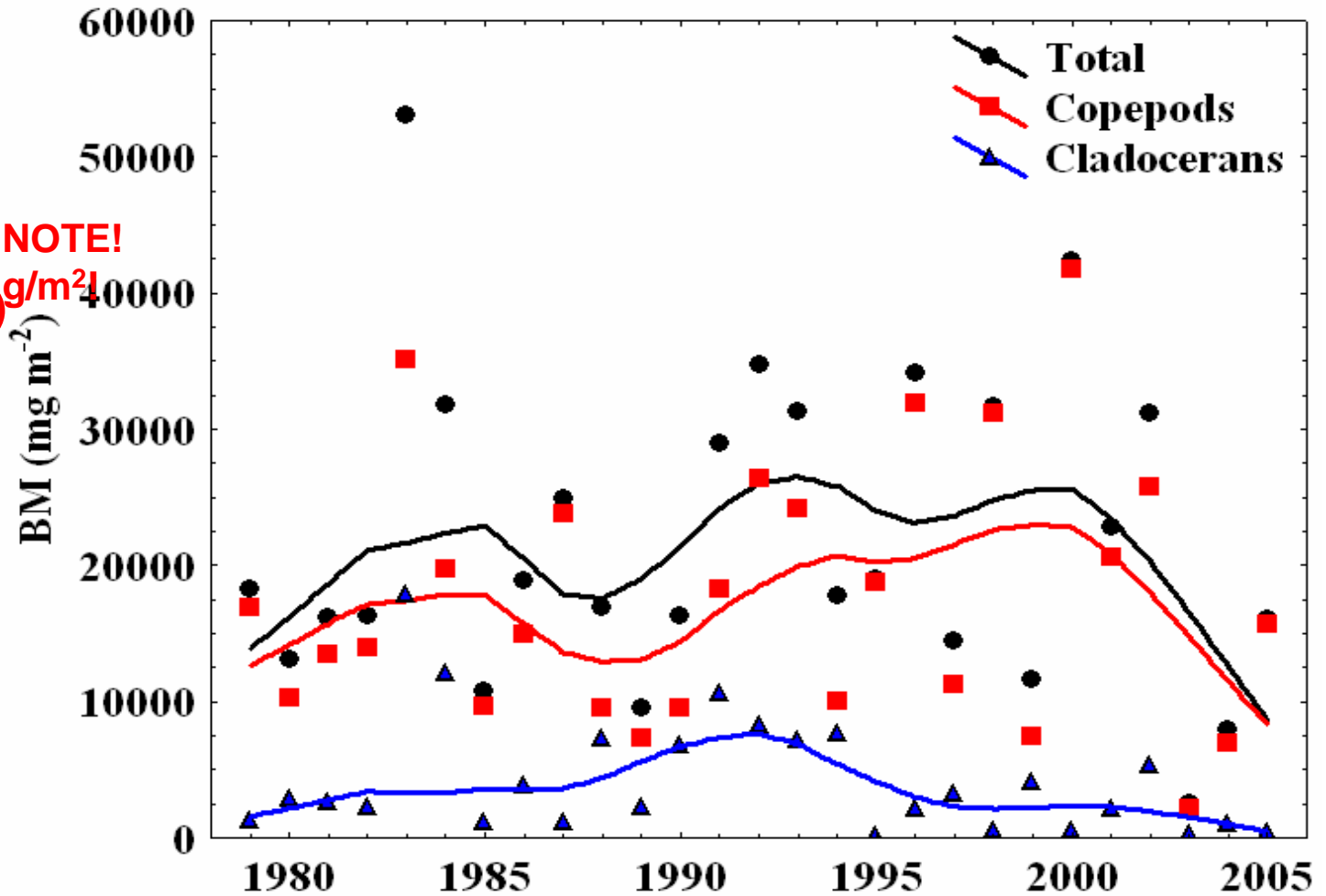
## *Pseudocalanus acuspes*



# Zooplankton species biomass (mg/m<sup>2</sup>), Gulf of Finland

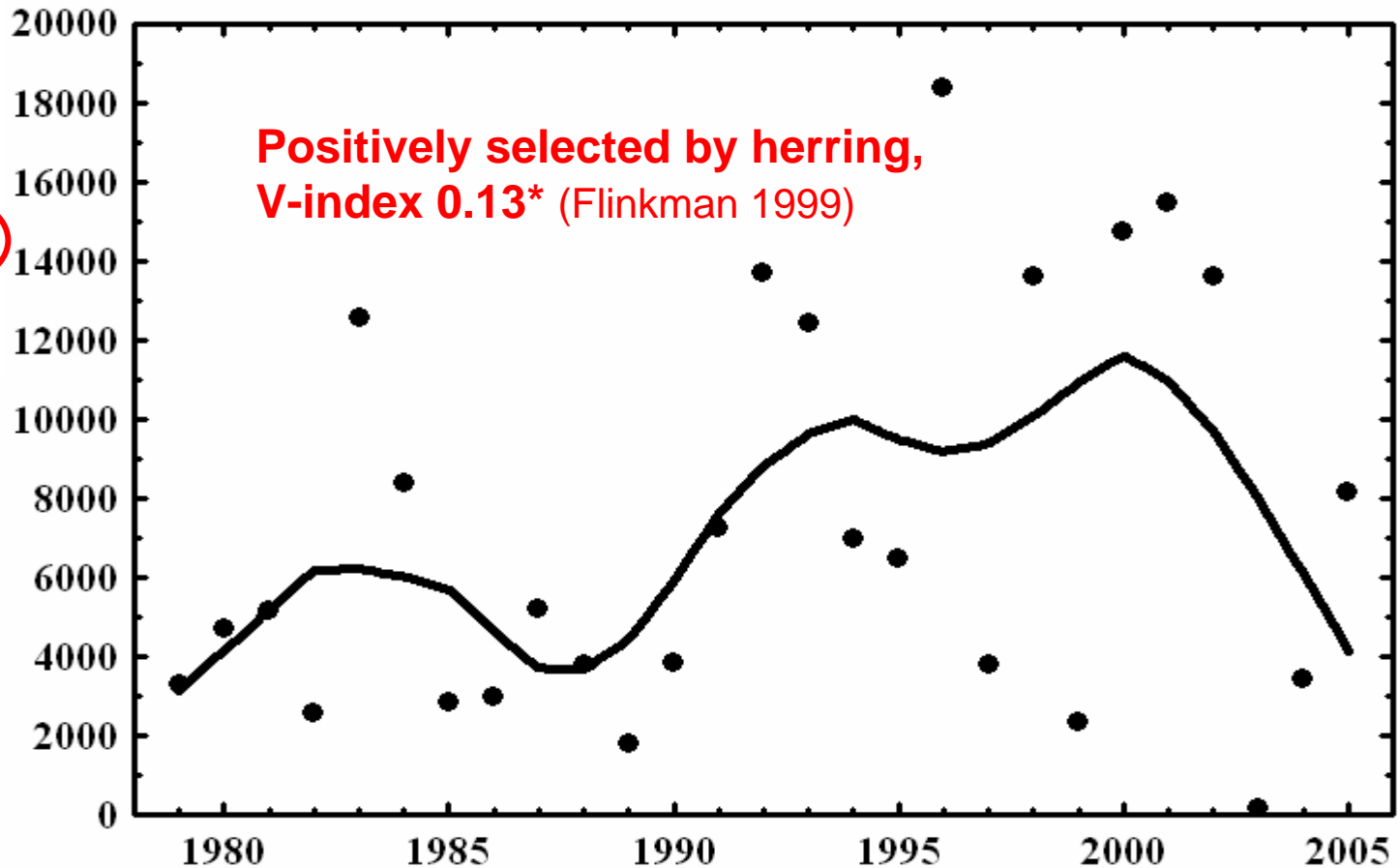


**NOTE!**  
g/m<sup>2</sup>



# Zooplankton species biomass (mg/m<sup>2</sup>), Gulf of Finland

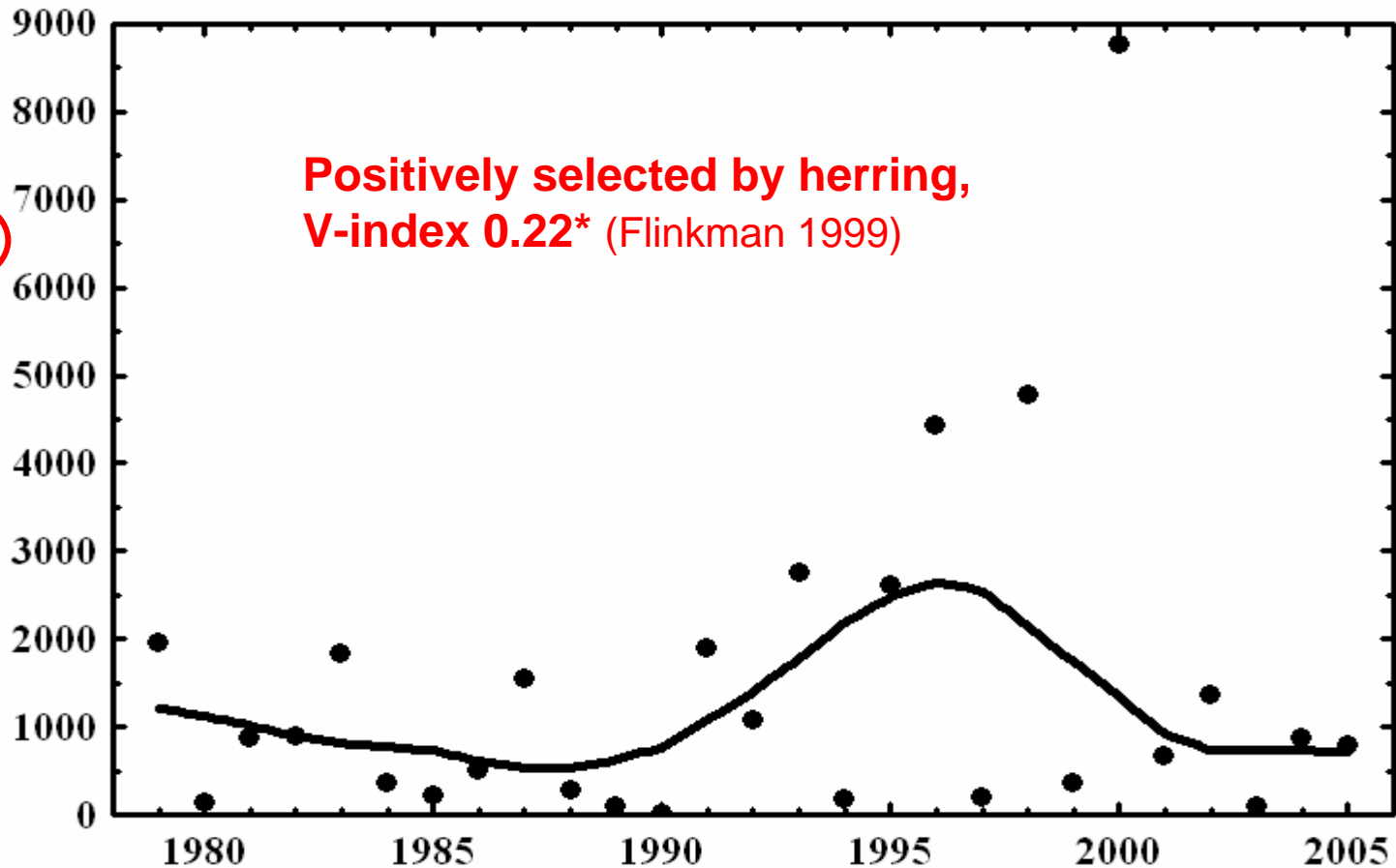
## *Eurytemora affinis*





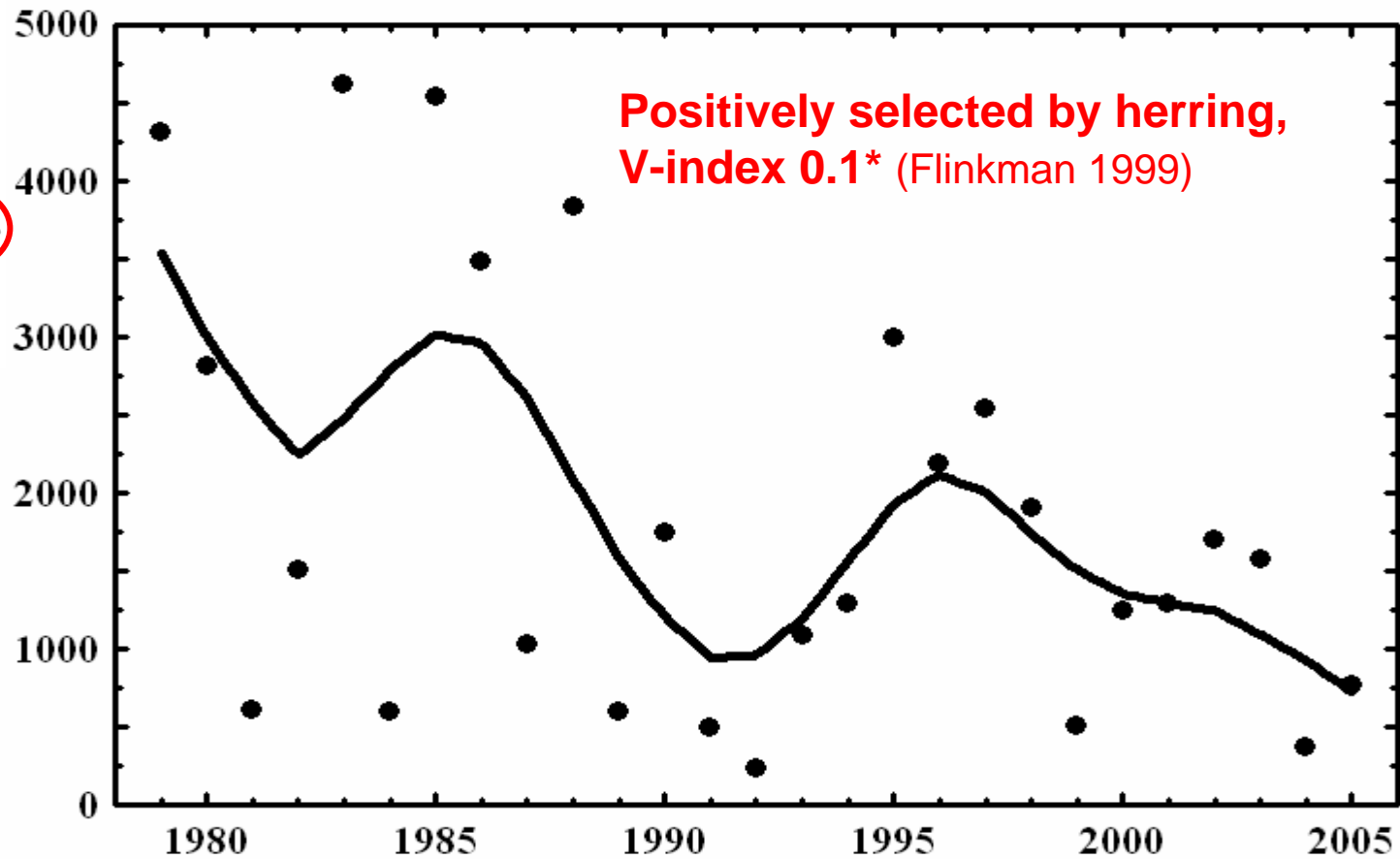
# Zooplankton species biomass (mg/m<sup>2</sup>), Gulf of Finland

## *Temora longicornis*

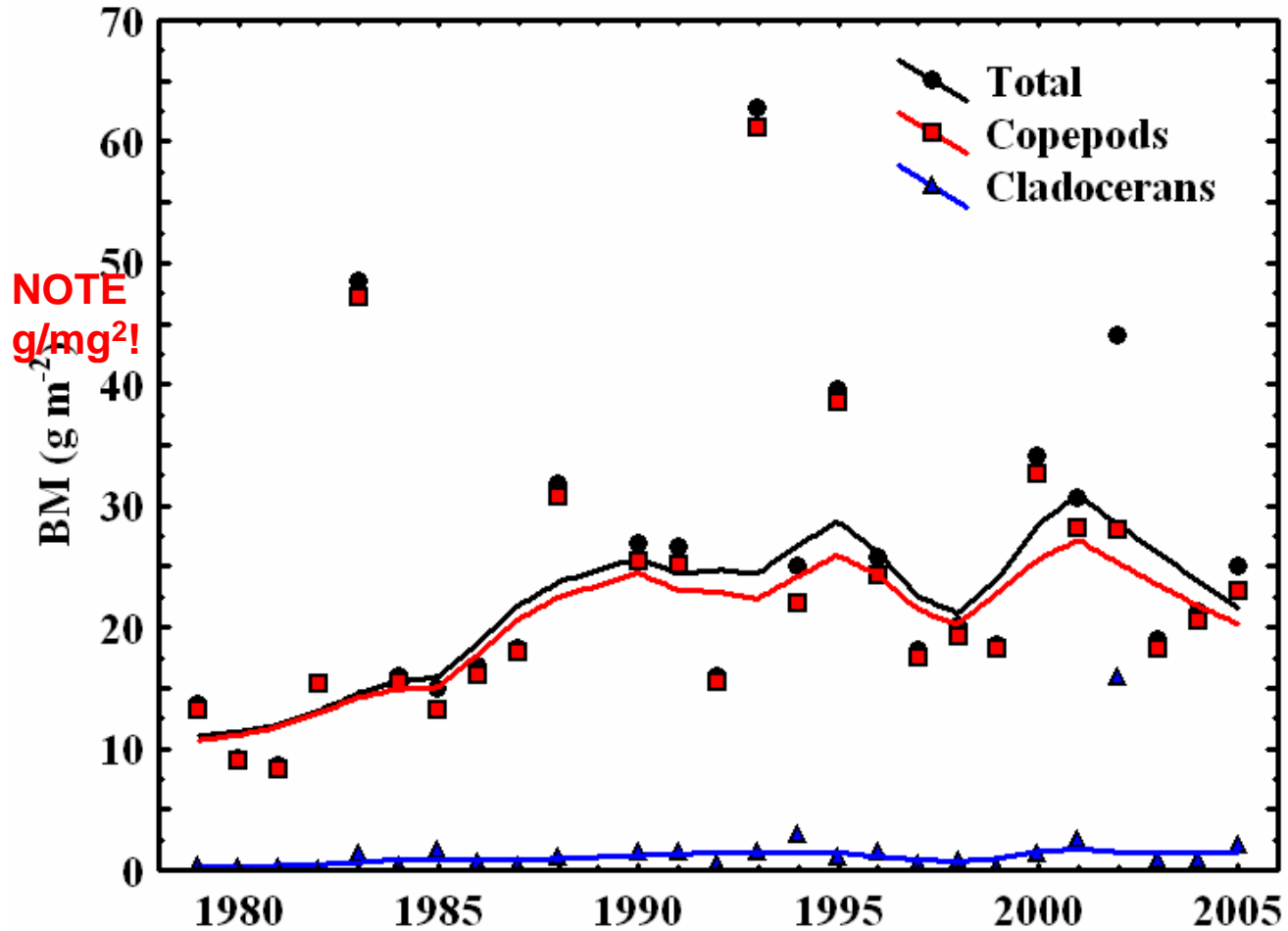
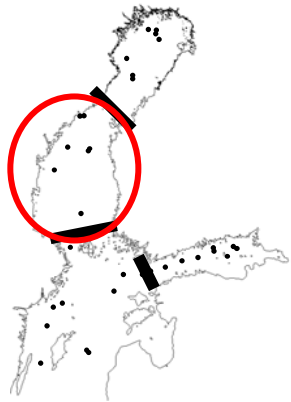


# Zooplankton species biomass (mg/m<sup>2</sup>), Gulf of Finland

## *Pseudocalanus acuspes*

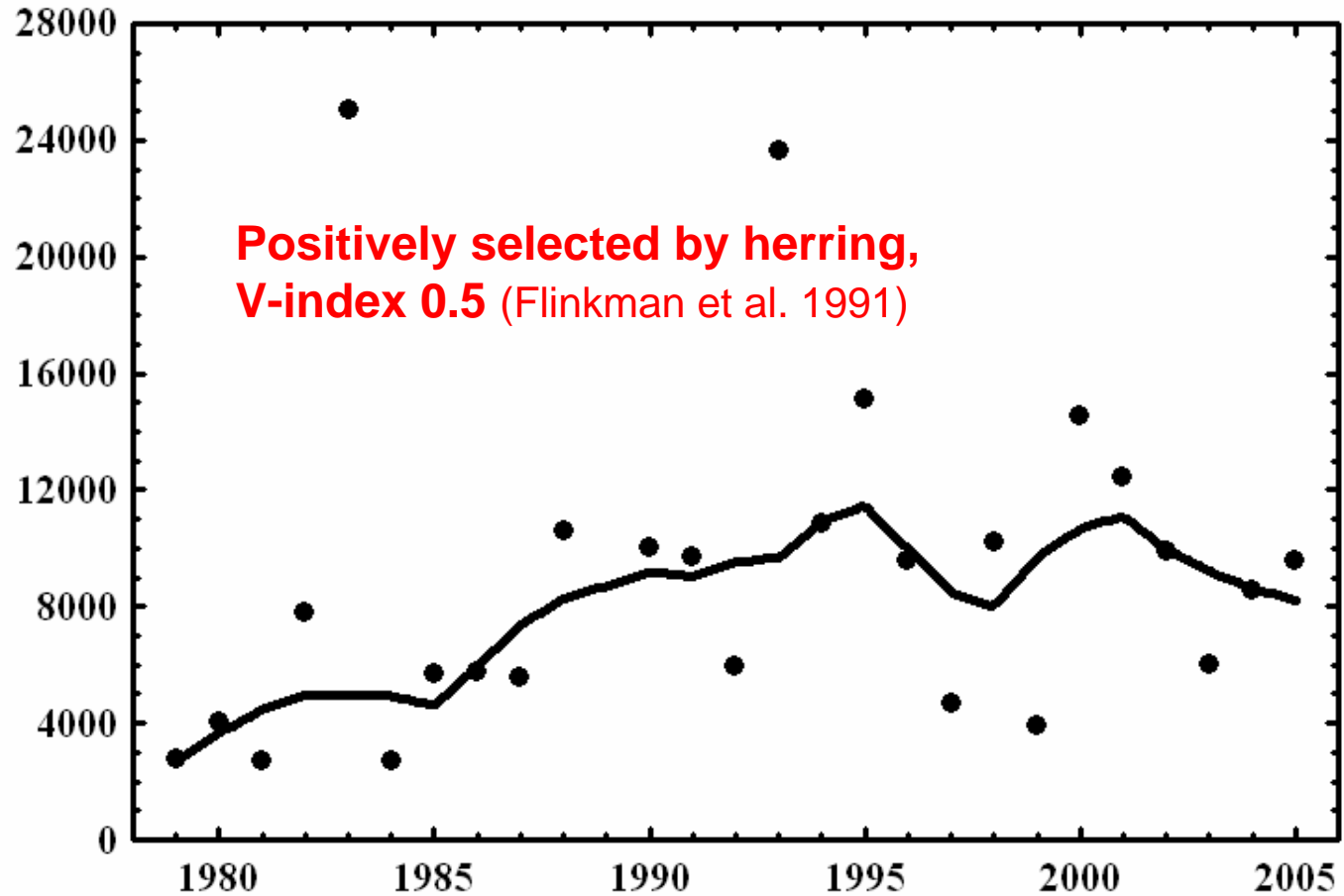


# Zooplankton species biomass (mg/m<sup>2</sup>), Bothnian Sea:



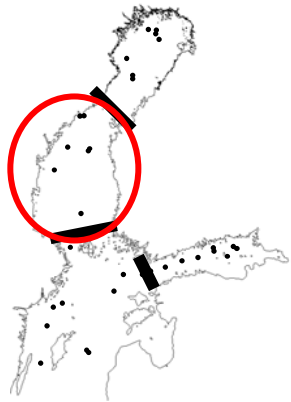
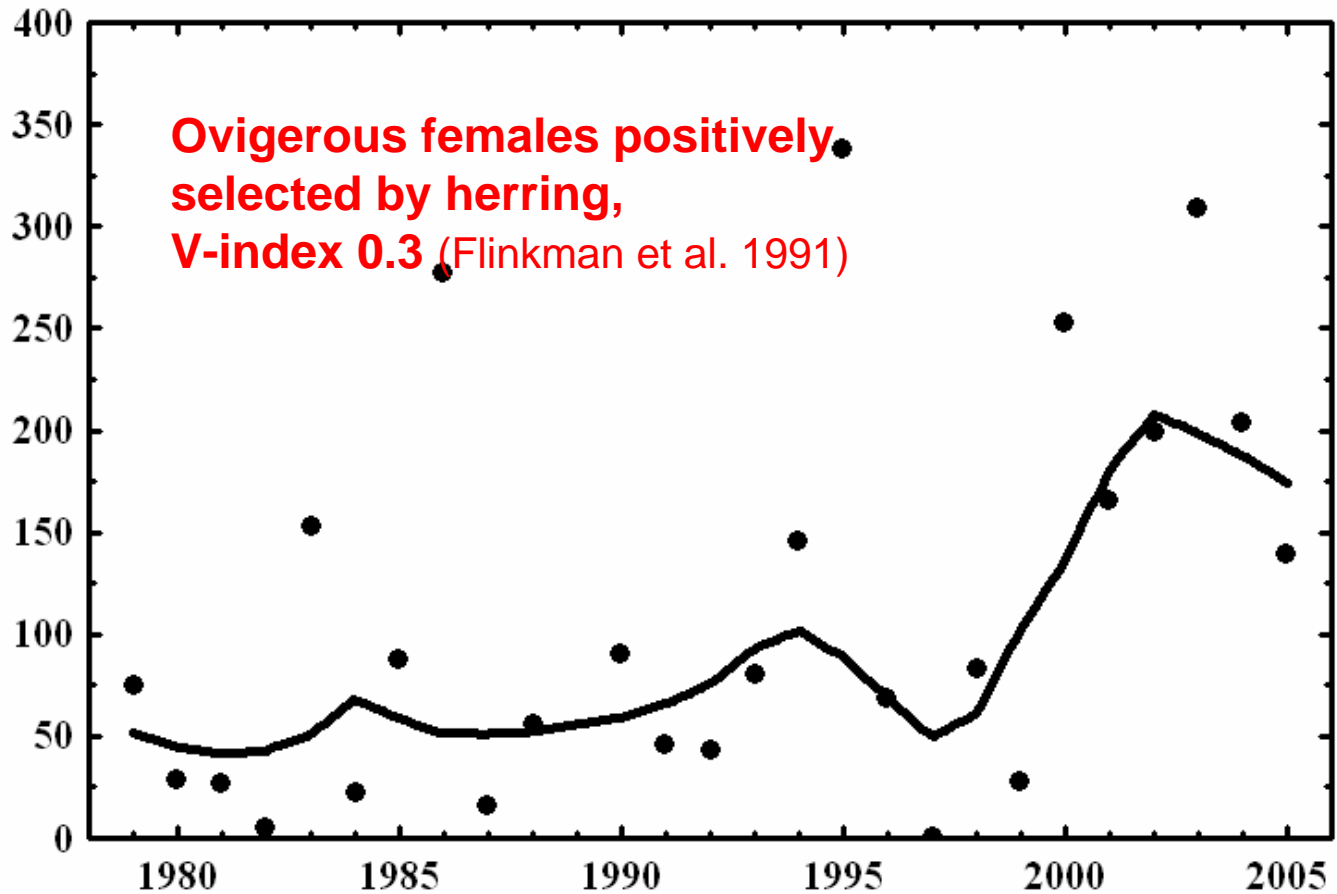
# Zooplankton species biomass (mg/m<sup>2</sup>), Bothnian Sea:

## *Eurytemora affinis*



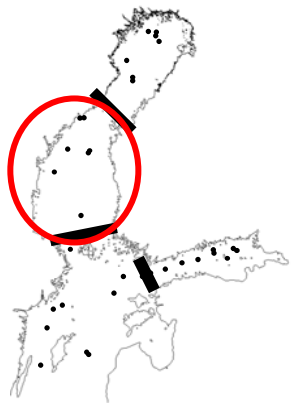
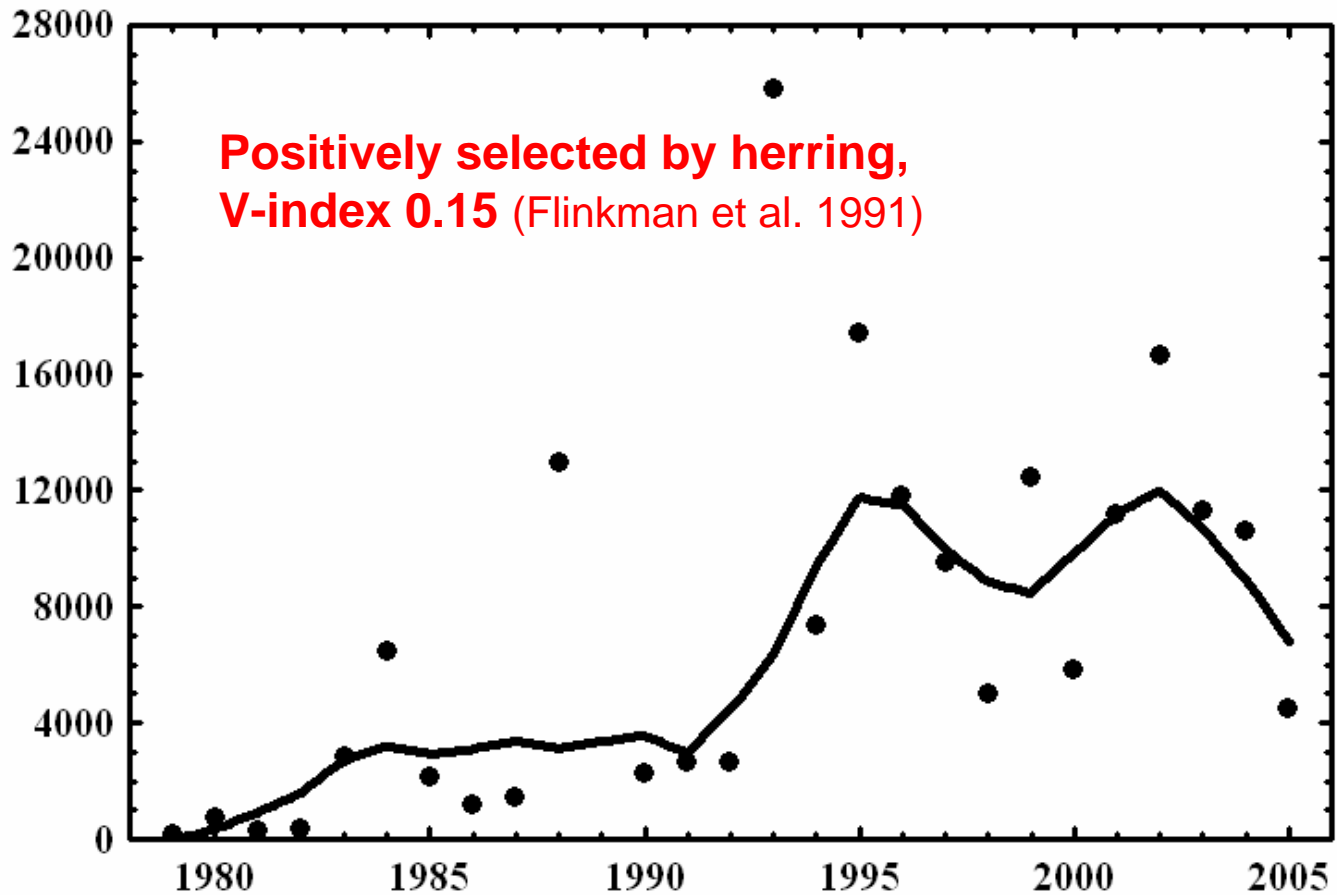
# Zooplankton species biomass (mg/m<sup>2</sup>), Bothnian Sea:

## Podon sp.



# Zooplankton species biomass (mg/m<sup>2</sup>), Bothnian Sea:

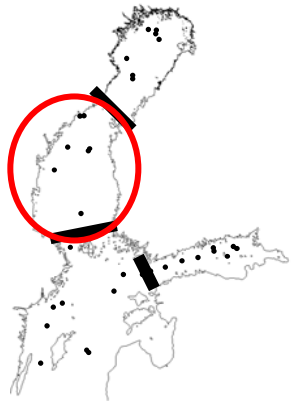
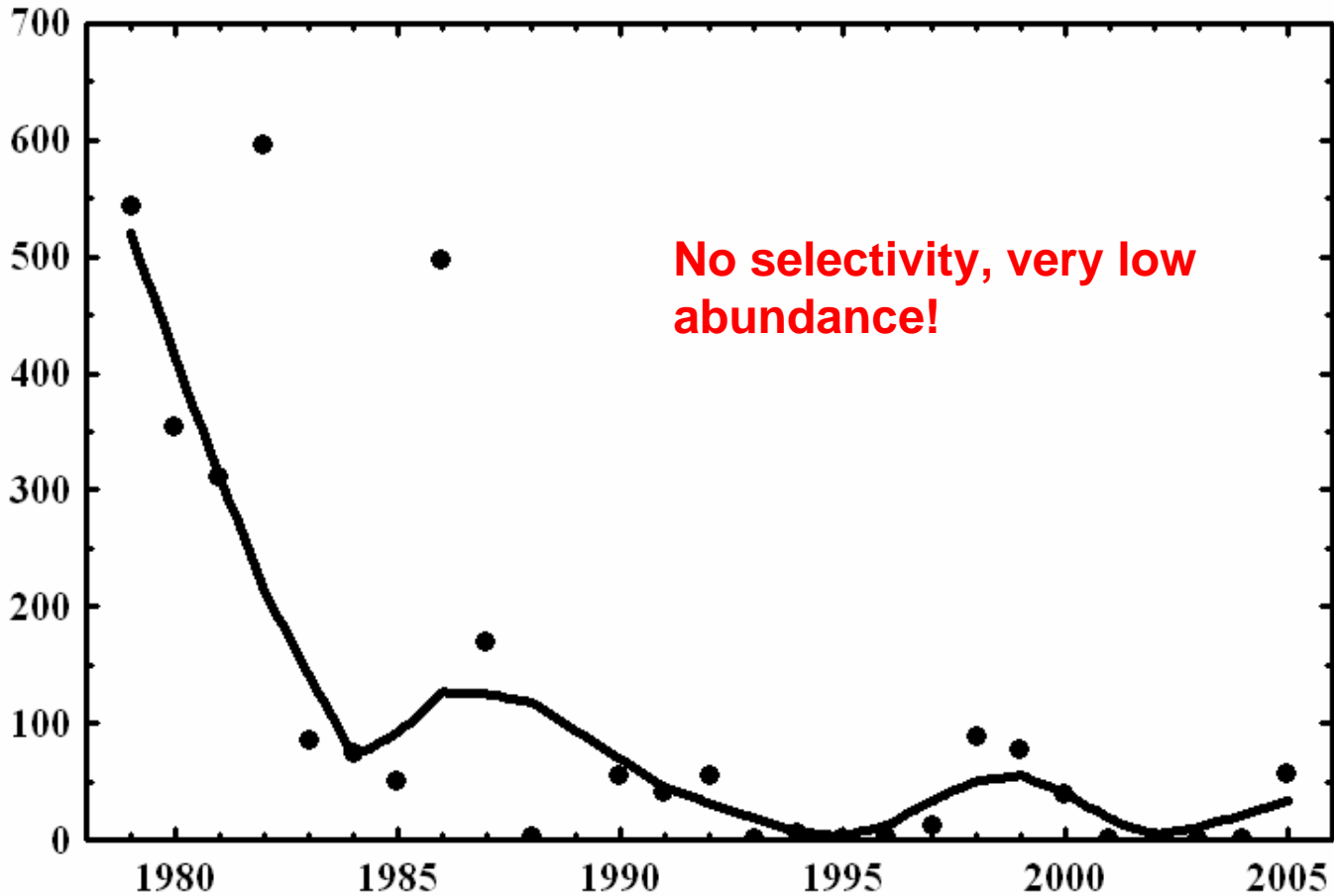
## *Limnocalanus macrurus*



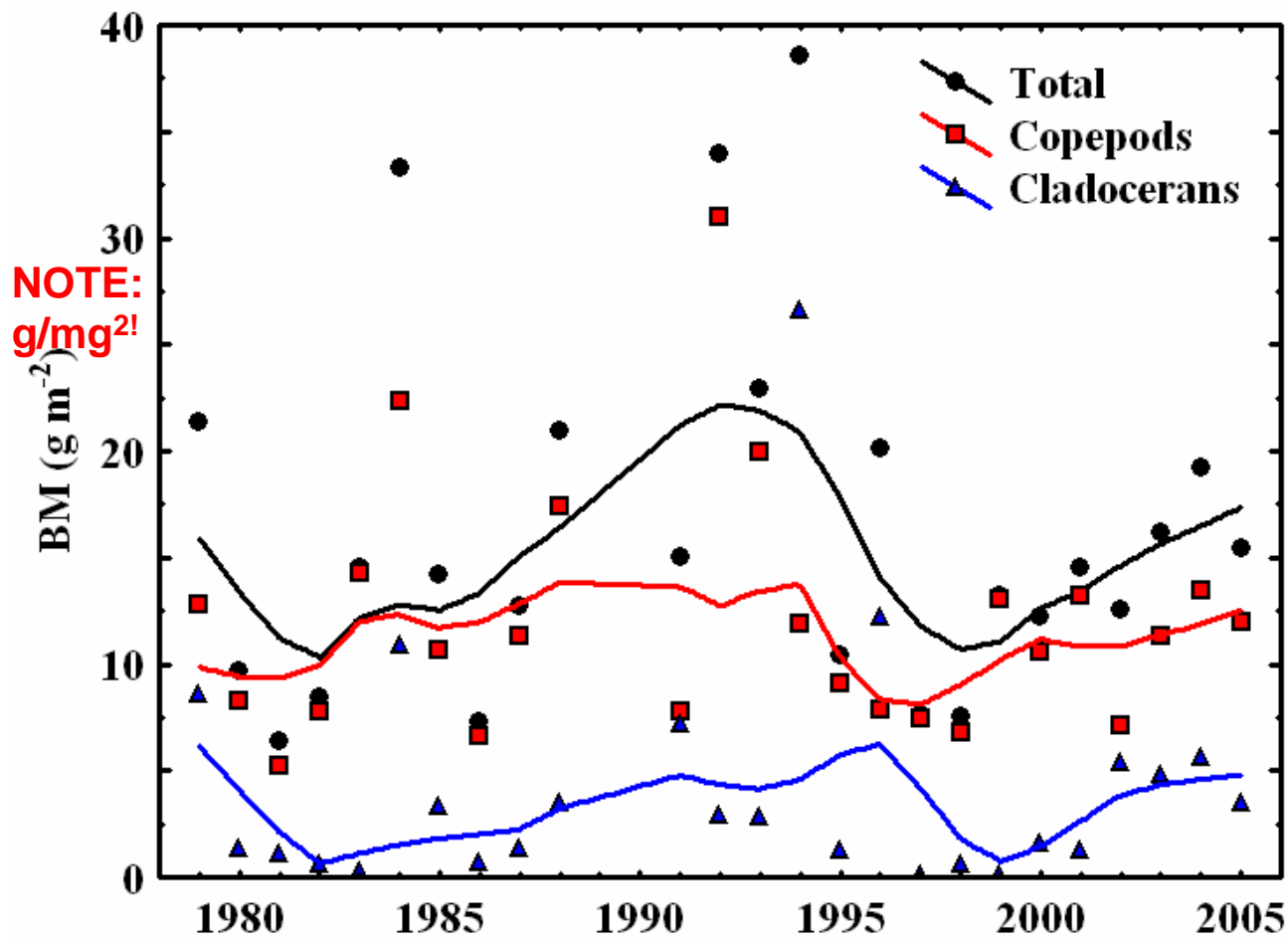


# Zooplankton species biomass (mg/m<sup>2</sup>), Bothnian Sea:

## *Pseudocalanus acuspes*



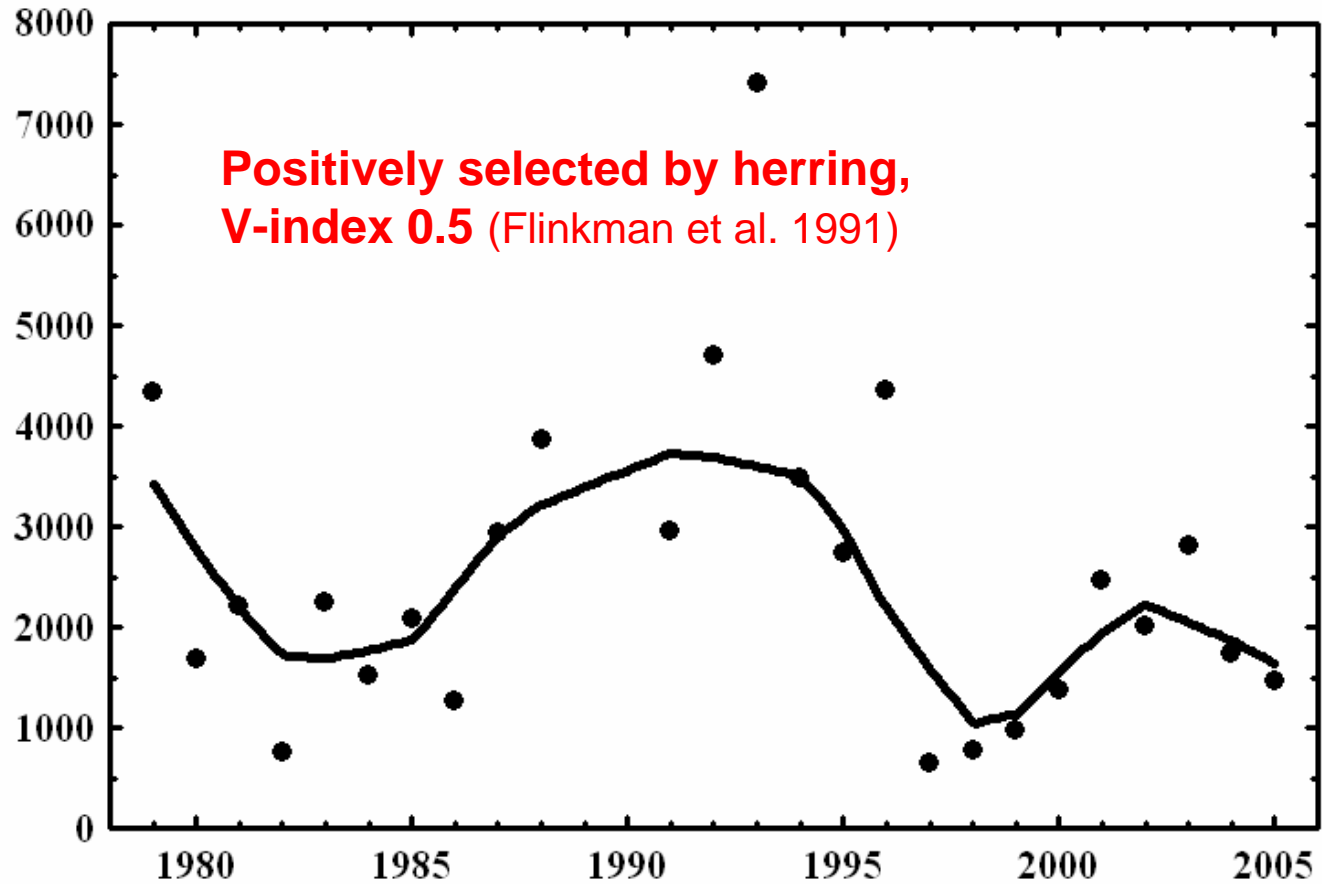
# Zooplankton species biomass (mg/m<sup>2</sup>), Bothnian Bay:



# Zooplankton species biomass (mg/m<sup>2</sup>), Bothnian Bay:

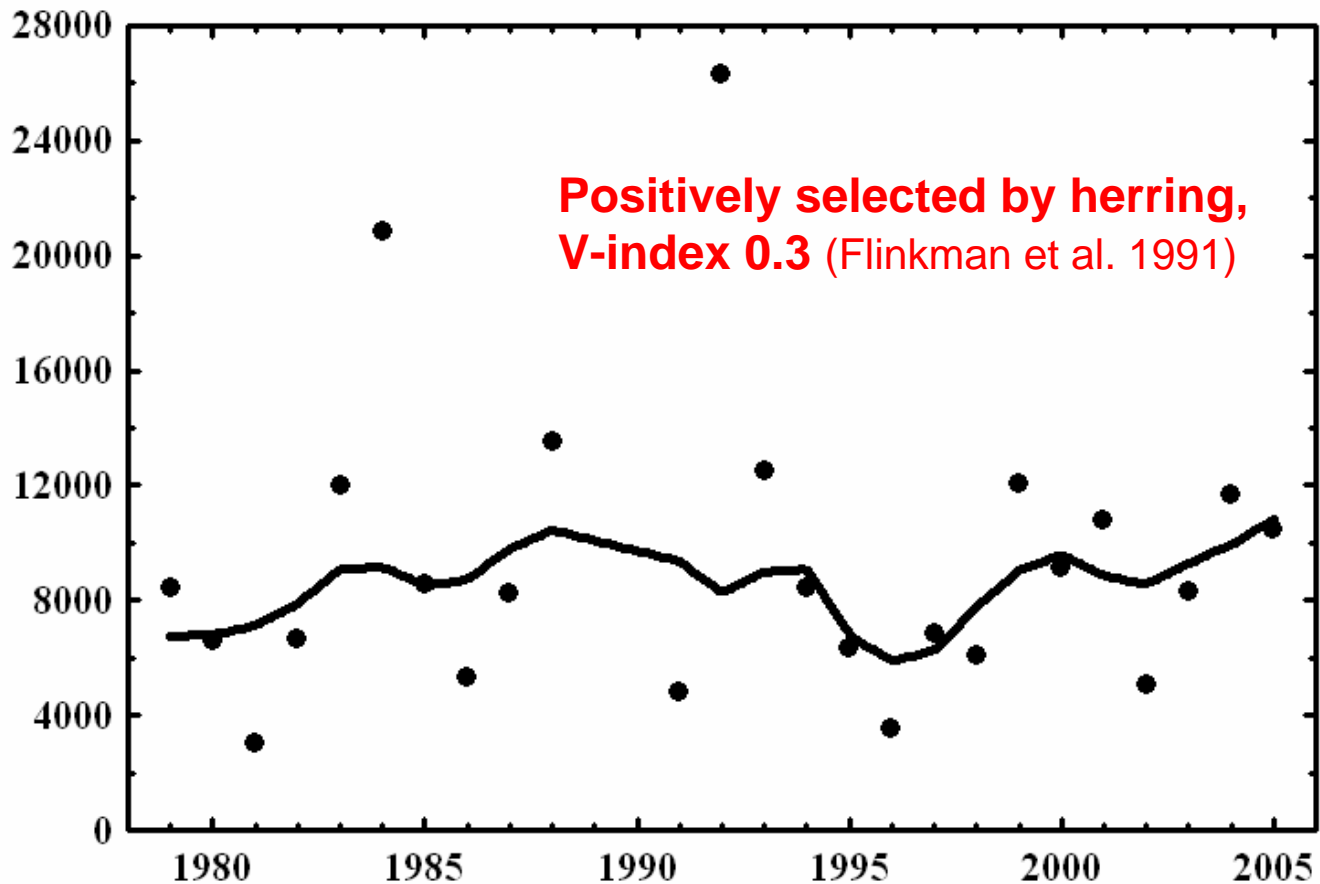


## *Eurytemora affinis*



# Zooplankton species biomass (mg/m<sup>2</sup>), Bothnian Bay:

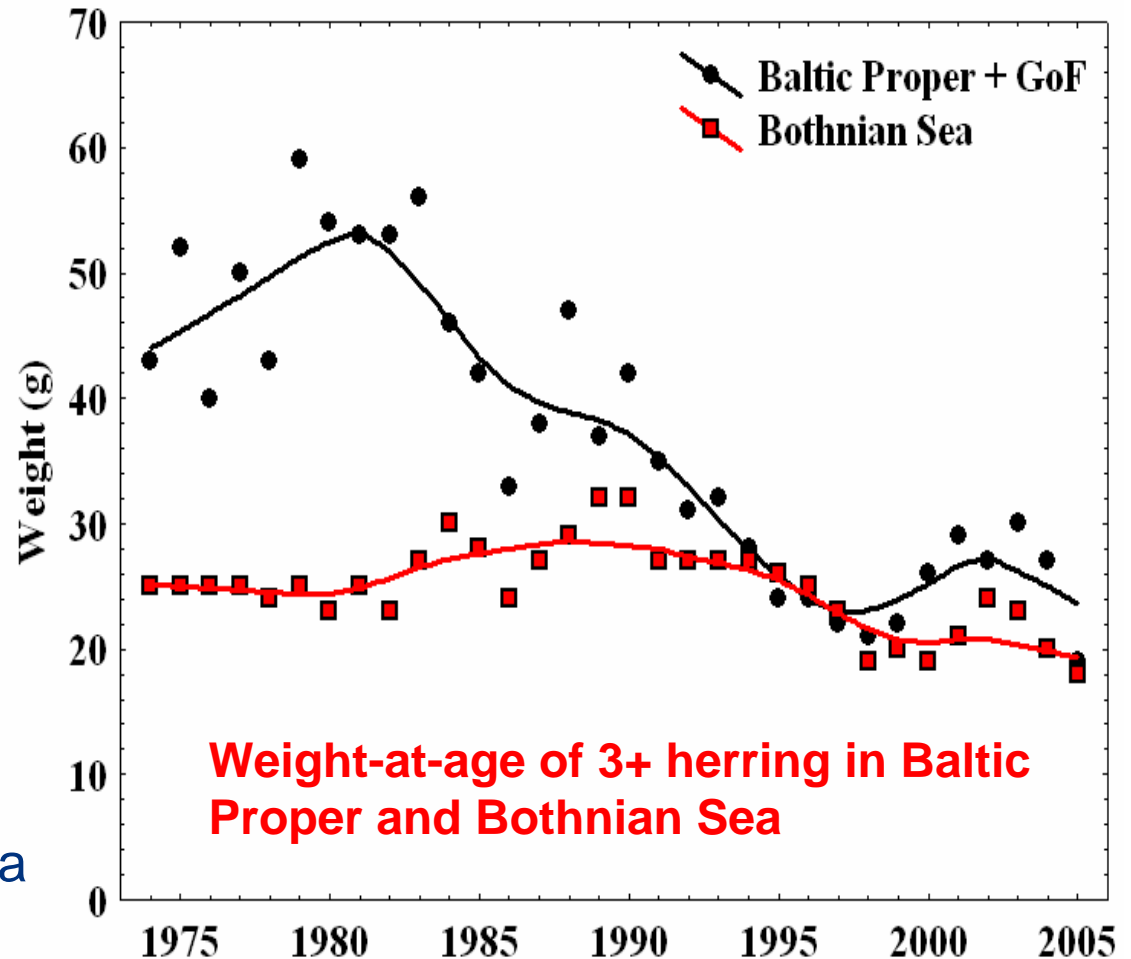
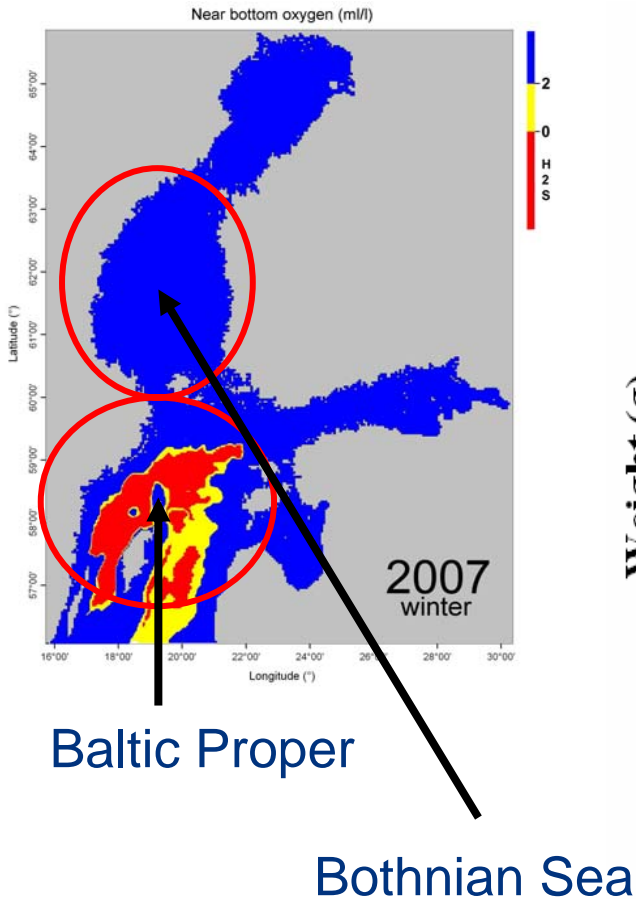
## *Limnocalanus macrurus*



# Trends in zooplankton by areas

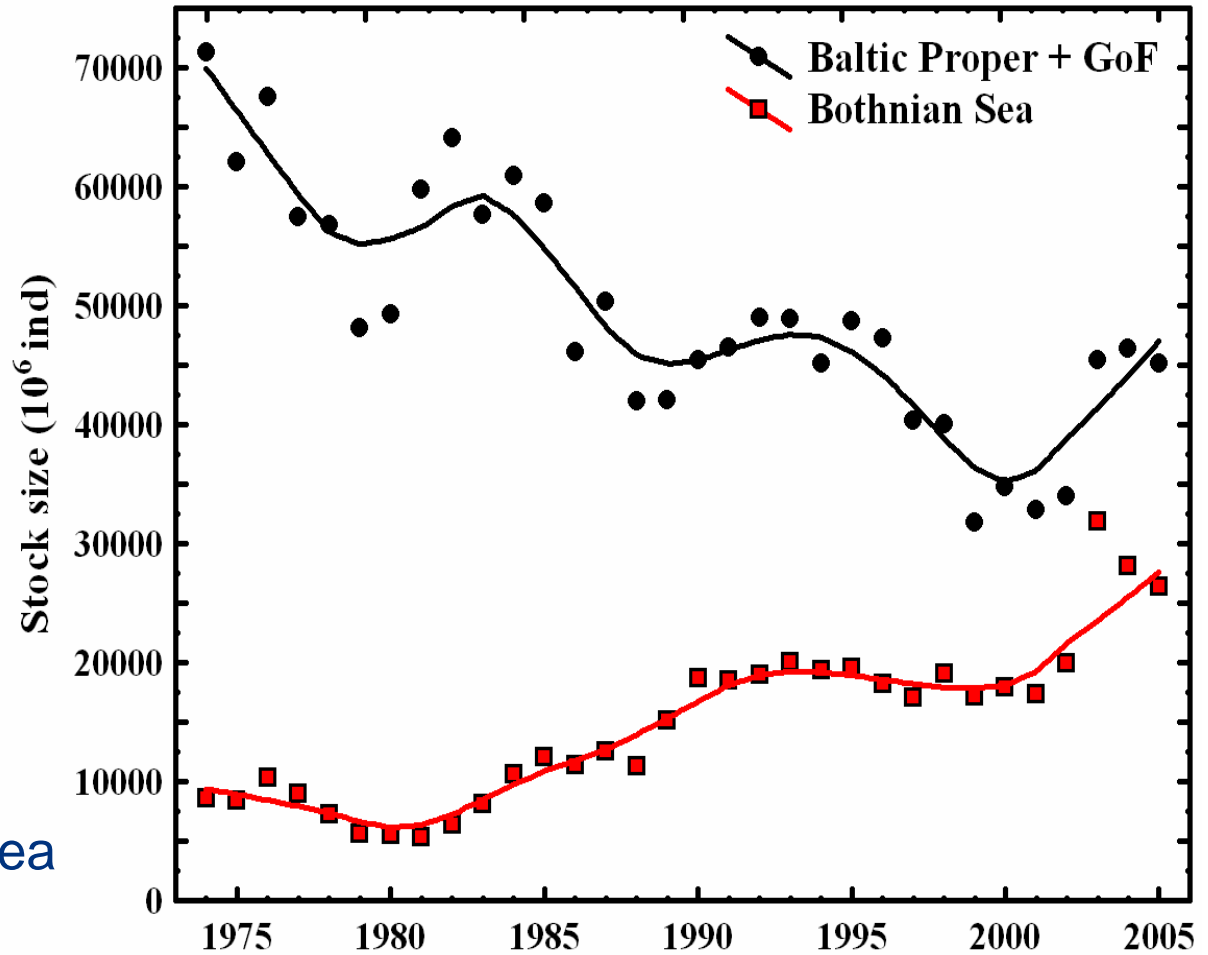
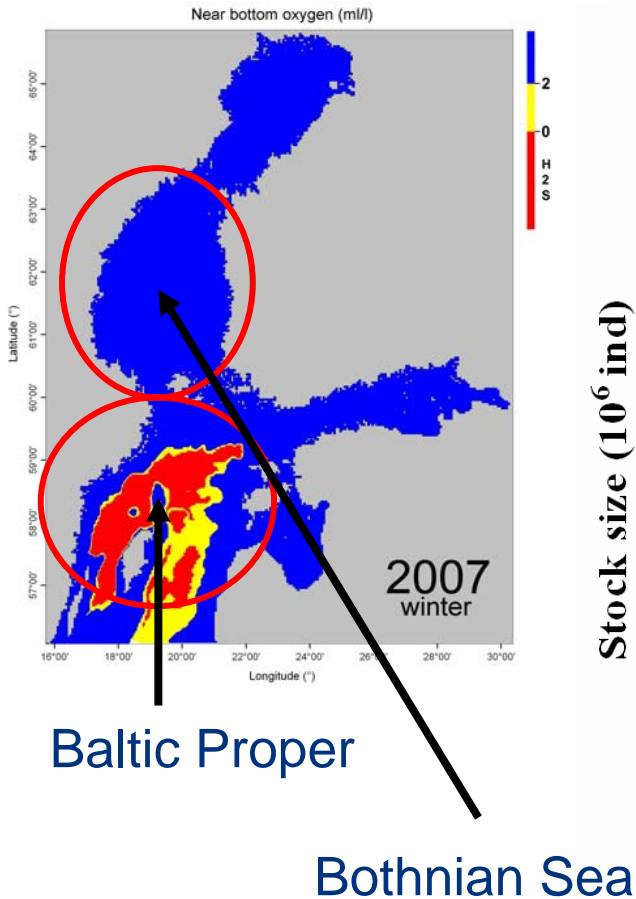
Species	Baltic Proper	Gulf of Finland	Bothnian Sea	Bothnian Bay
Acartia sp.	→	→	↘	→
Eurytemora affinis	↗	→	↗	→
Temora longicornis	↗	→	↘	No occurrence
Pseudocalanus acuspes	↘	↘	↘	→
Centropages hamatus	↗	↗	→	↗
Limnocalanus macrurus	↗	→	↗	→
Bosmina coregoni m.	↘	↘	↗	→
Podon sp.	→	→	↗	↗
Evadne nordmanni	↘	↘	→	→
Daphnia sp.	→	→	→	→
<b>Copepods</b>	→	→	↗	→
<b>Cladocerans</b>	↘	↘	↗	→
<b>Total</b>	→	→	↗	→

# Loss of neritic copepods – effects on herring growth and stock development?

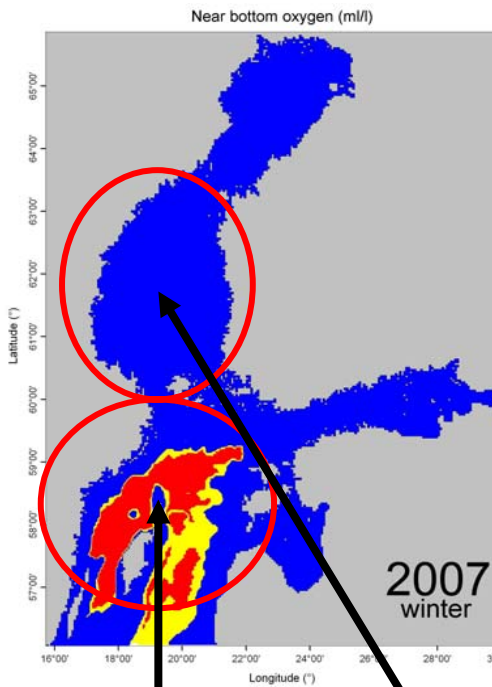




# Loss of neritic copepods – effects on herring growth and stock development?

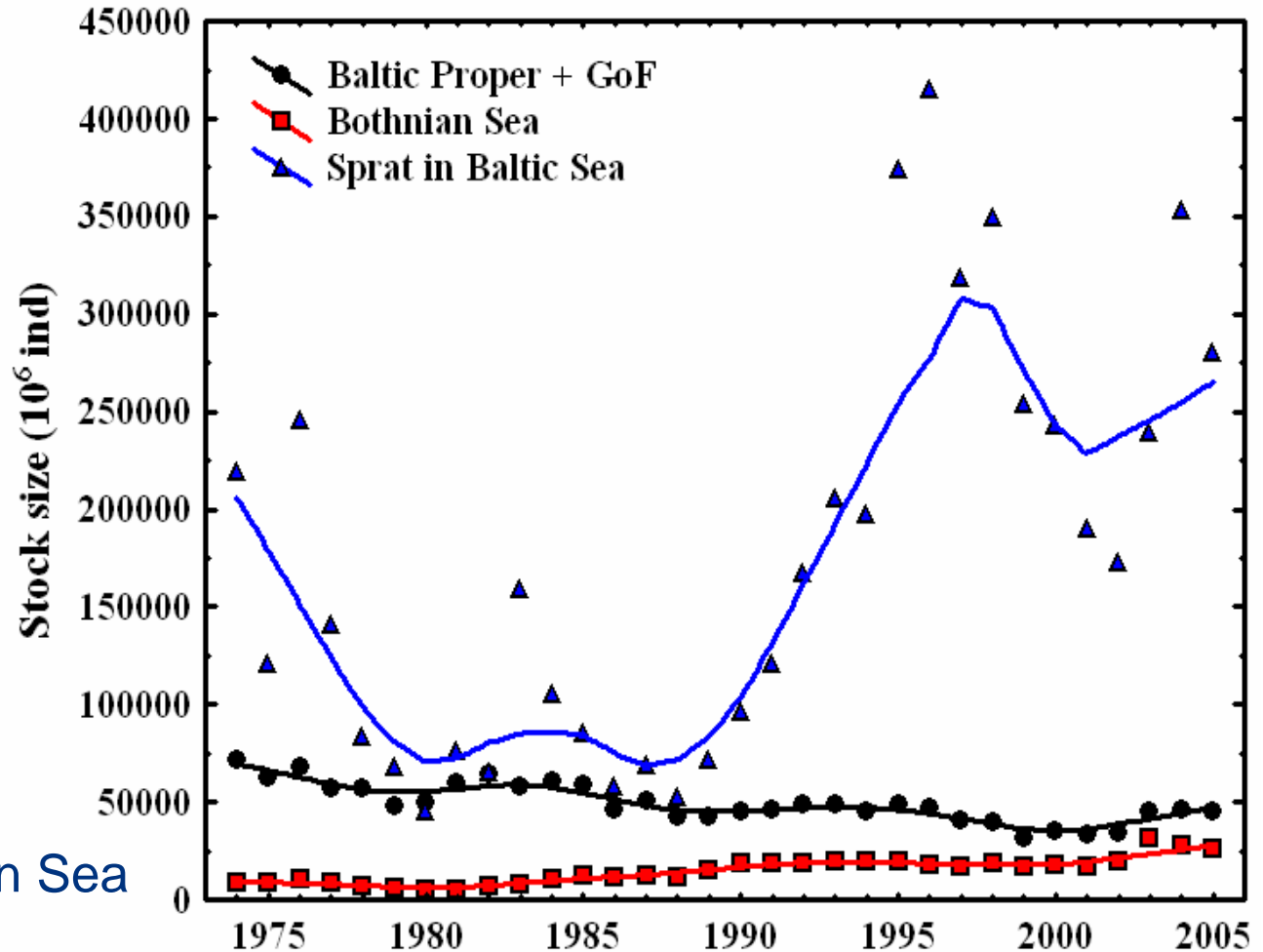


# Loss of neritic copepods – effects on herring growth and stock development?

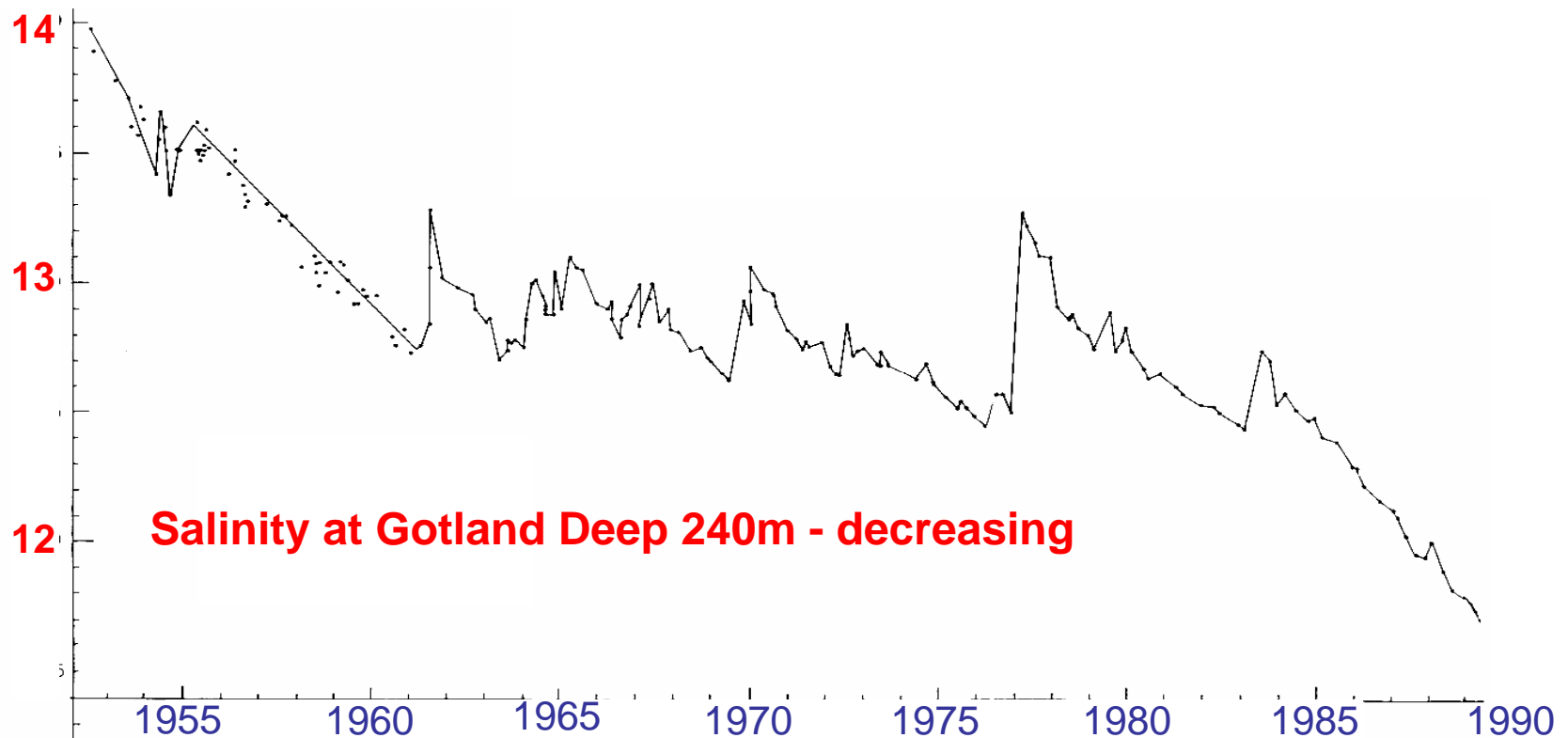


Baltic Proper

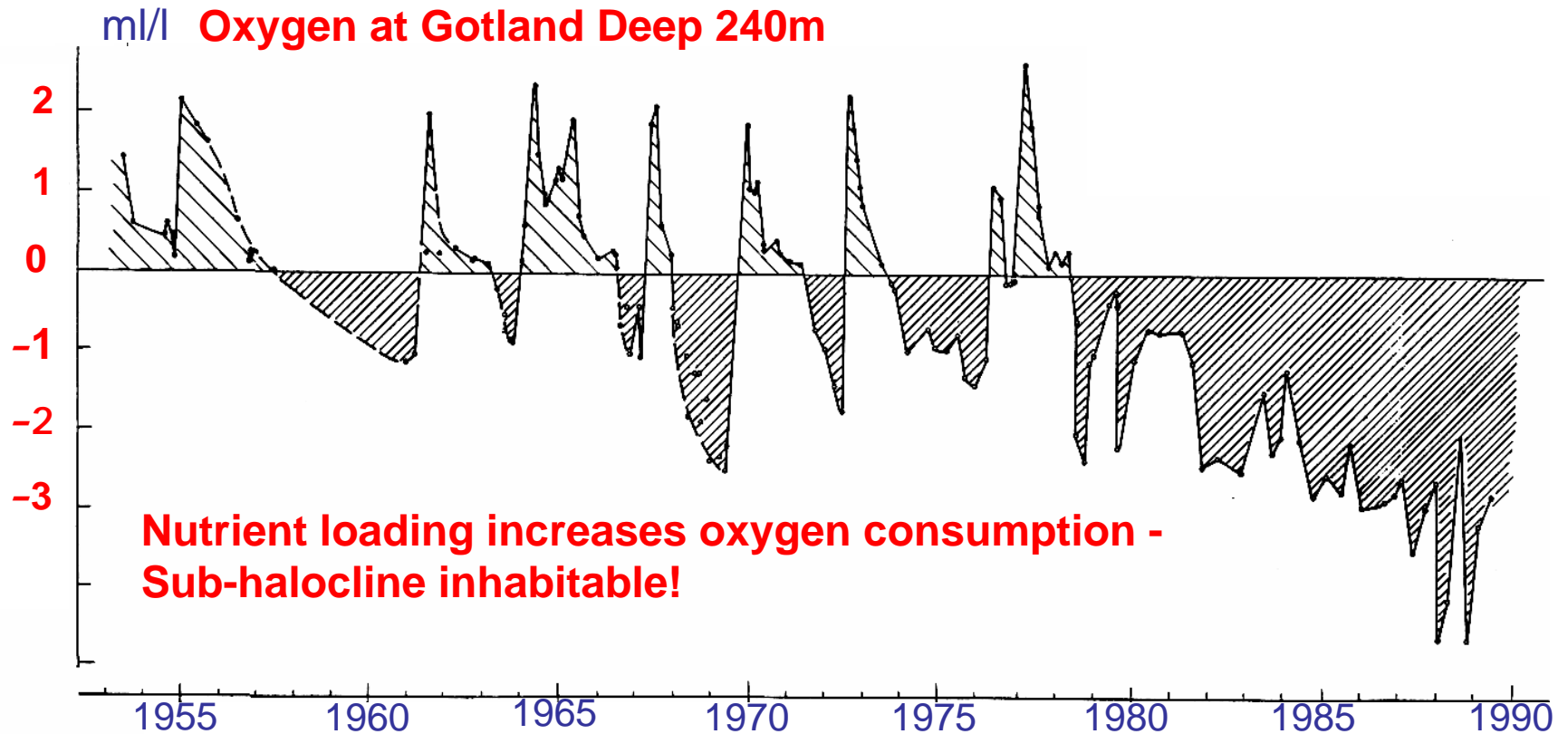
Bothnian Sea



# Conclusions: Baltic pelagic food web suffers:

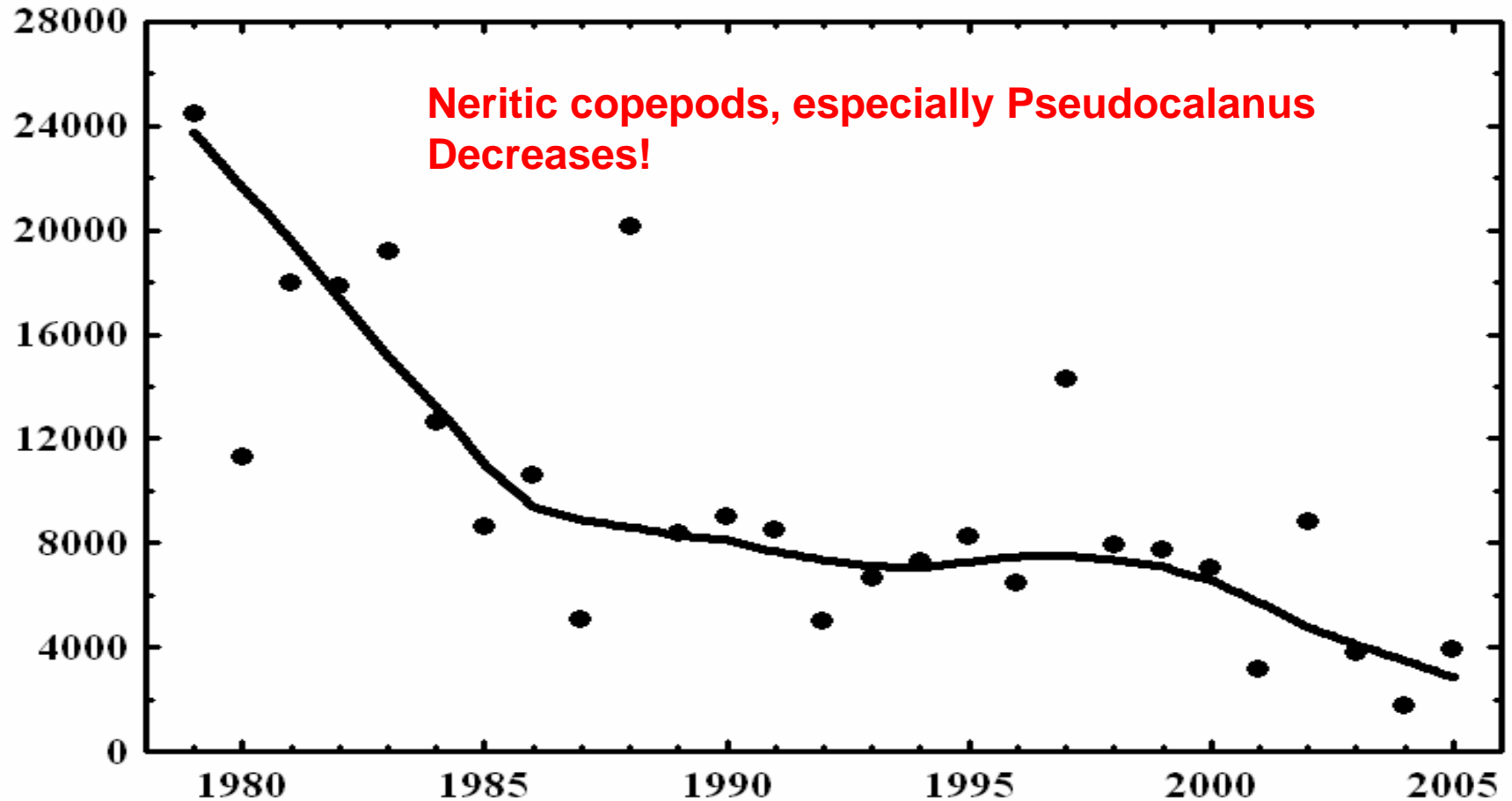


# Conclusions: Baltic pelagic food web suffers:

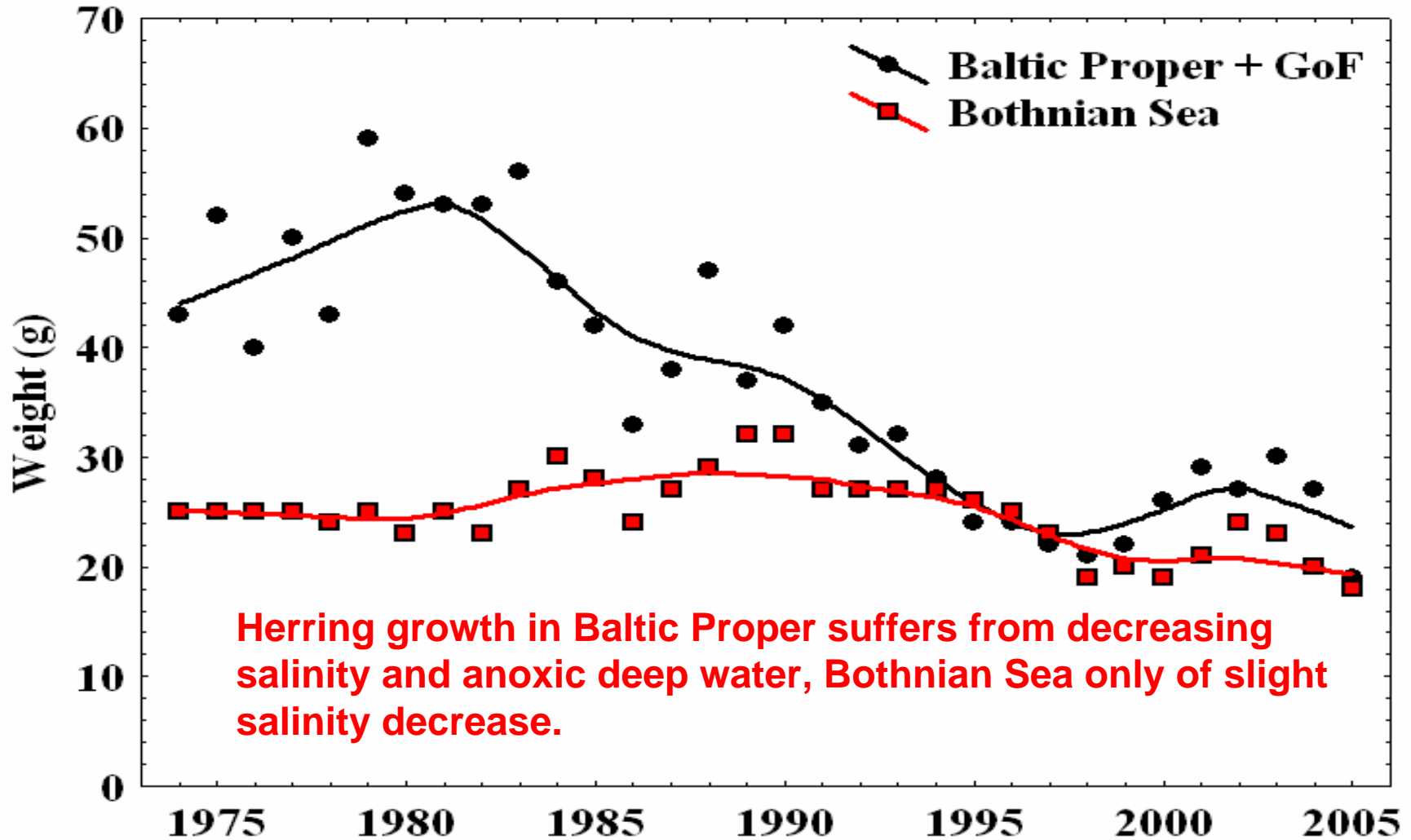


# Conclusions: Baltic pelagic food web suffers:

## *Pseudocalanus acuspes*



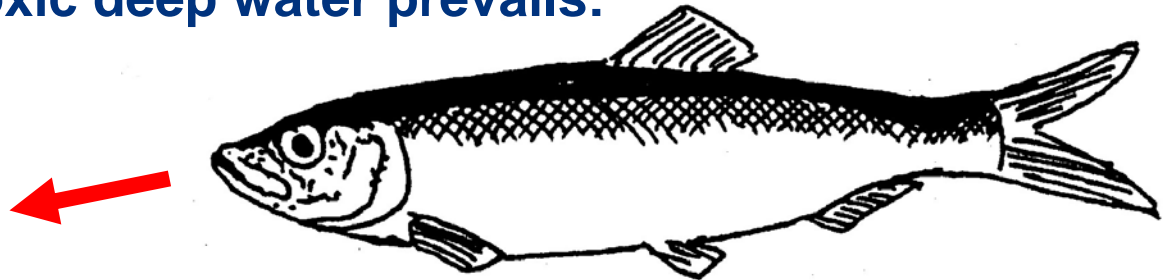
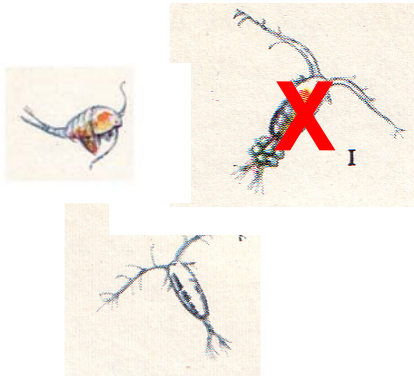
# Conclusions: Baltic pelagic food web suffers:



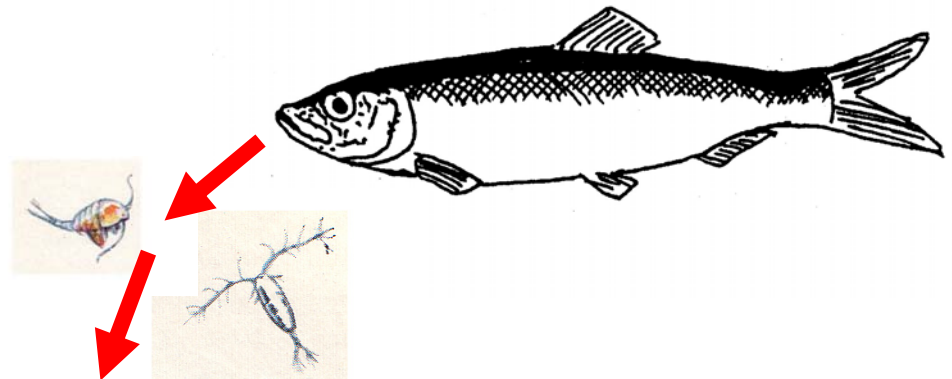
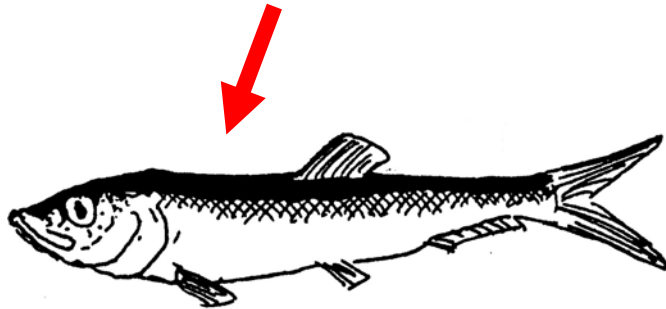
Herring growth in Baltic Proper suffers from decreasing salinity and anoxic deep water, Bothnian Sea only of slight salinity decrease.

..or the same as a cartoon:

**Baltic Proper:**  
salinity decreases, anoxic deep water prevails:



**Bothnian Sea: salinity decrease,**  
no oxygen problems:







**Thank You!**