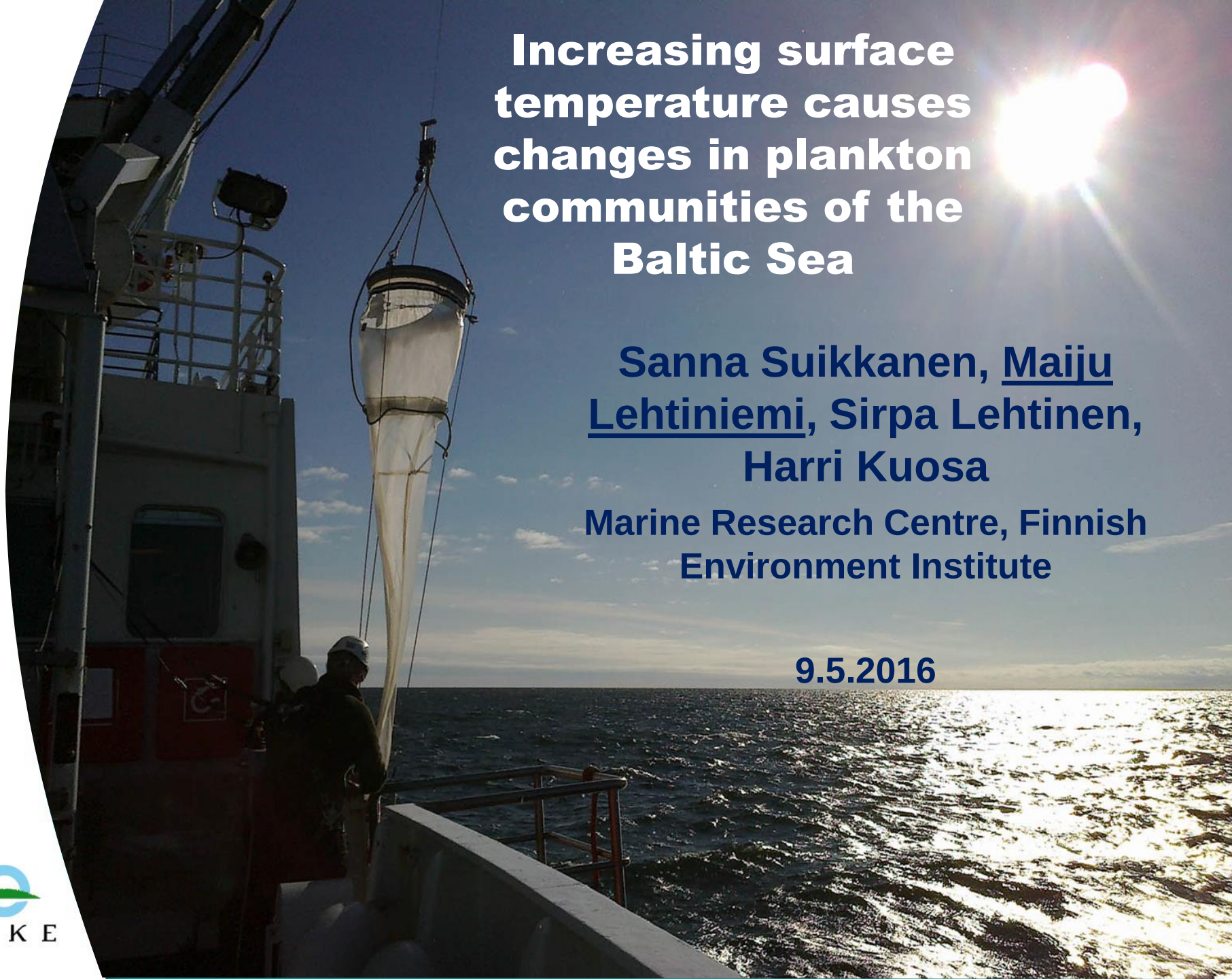

Increasing surface temperature causes changes in plankton communities of the Baltic Sea

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Marine Research Centre, Finnish Environment Institute

9.5.2016

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SYKE

Motivation

- ~40 years of environmental monitoring in the Baltic Sea enables analysis of long-term trends
- Recent analyses mostly focused on single ecosystem components, or on the more southern basins
- Whole-ecosystem analysis can reveal resource-based bottom-up effects, climate change effects and cascading food web effects, which act simultaneously

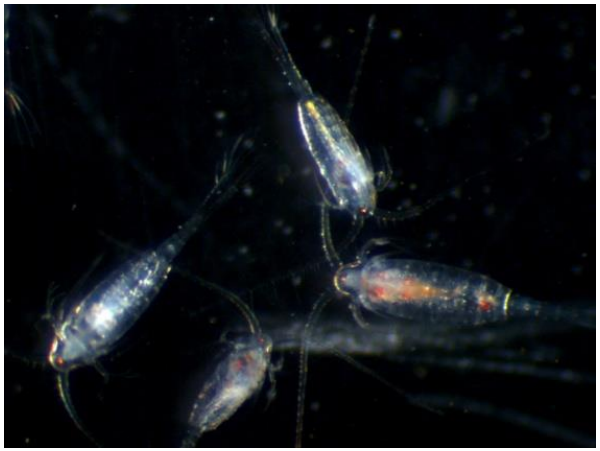
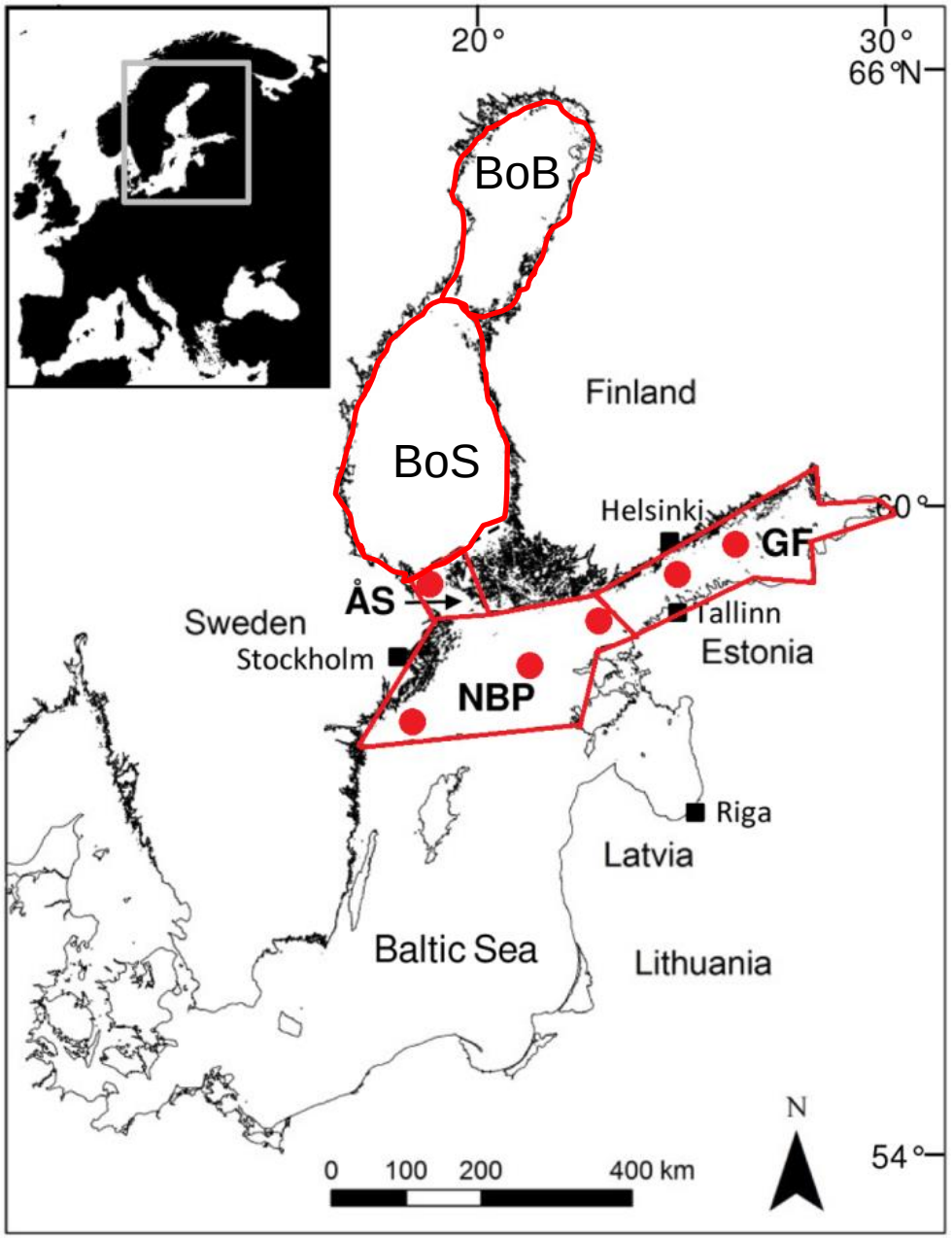


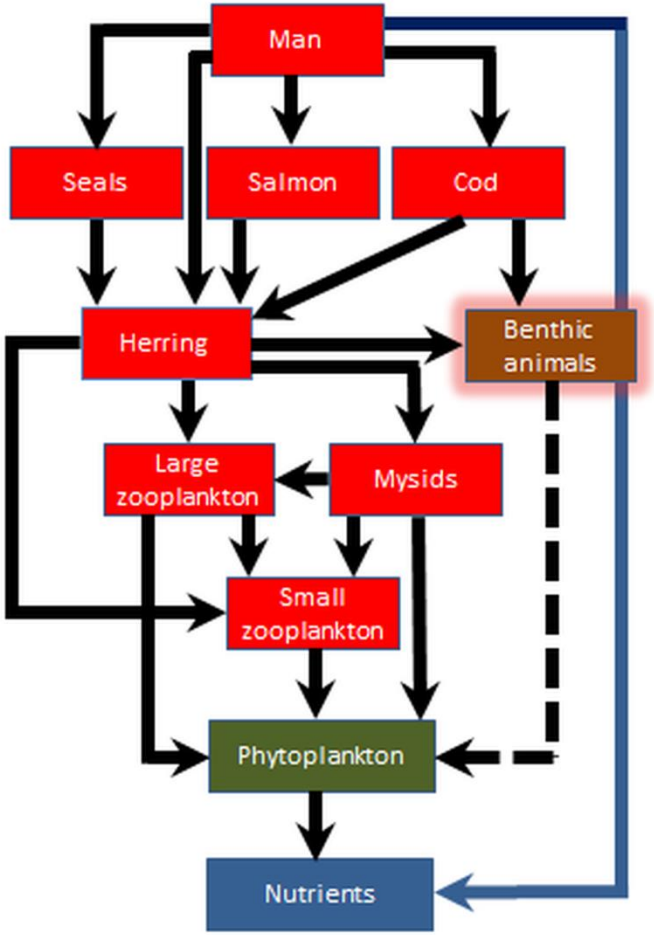
Photo: Seija Hällfors

Study area

- Five northern Baltic Sea sub-basins
- NBP and GF connected without a sill, ÅS and GoB separated by a sill
- O_2 deficiency, internal nutrient loading in the GF and NBP



Aims



- The goals of our analysis were to reveal:

1. How the physical environment and nutrient status has changed during the last 35 years
2. How these changes are reflected in the food web structure
3. How strong is top-down control vs. bottom-up limitation

Long term monitoring data used

Surface water temperature, salinity
Deep water temperature, salinity
Stratification index, E
Deep water oxygen
Dissolved inorganic nutrients (DIN, PO_4, SiO_4)
Total nutrients (TotN, TotP)
Secchi depth
Chlorophyll *a*
Phytoplankton biomass
Zooplankton abundance
Mysid abundance
Benthic fauna (abundance)
Fish

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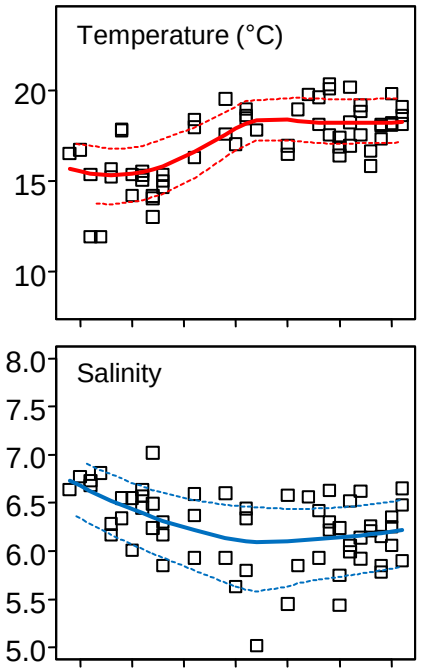
Statistics

- **Mann-Kendall test** (non-parametric): Monotonic trends
- **Redundancy analysis (RDA)**: Relationships between plankton community composition and environmental variables
- **Generalised additive models (GAM)**: Long-term trends in the environmental and biological variables

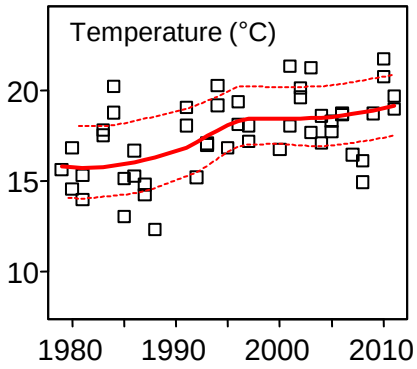
SYKE

Significant trends in hydrography

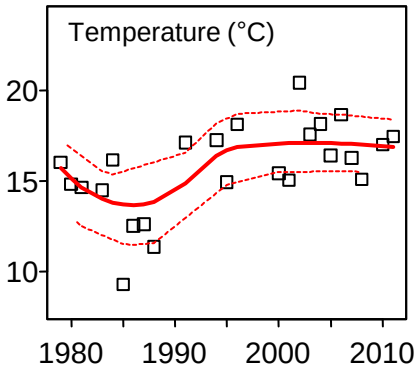
Northern Baltic Proper



Gulf of Finland

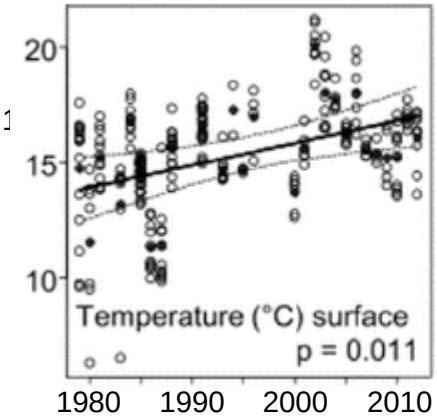


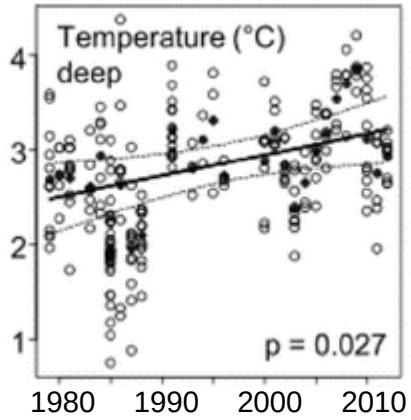
Åland Sea

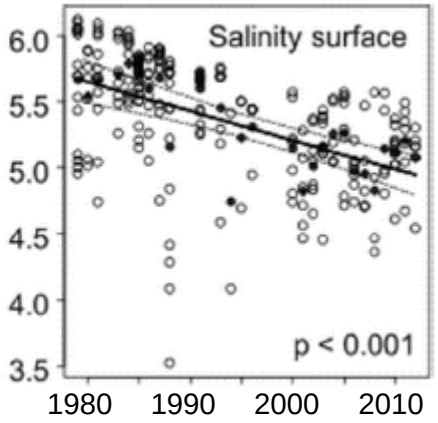


Significant trends in hydrography

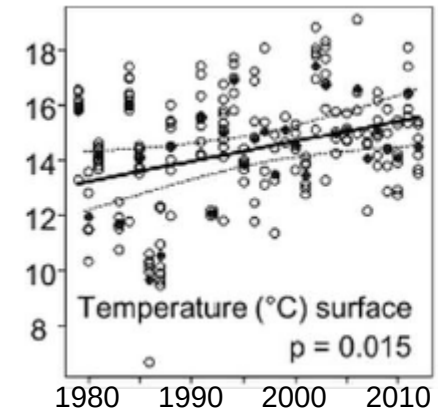
Bothnian Sea

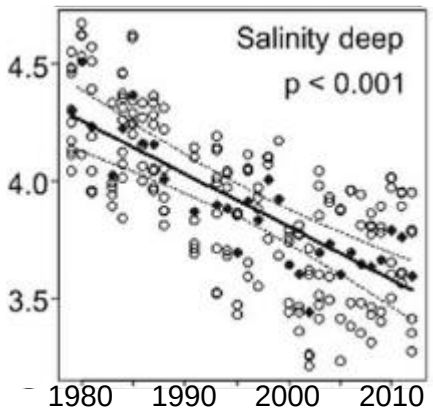


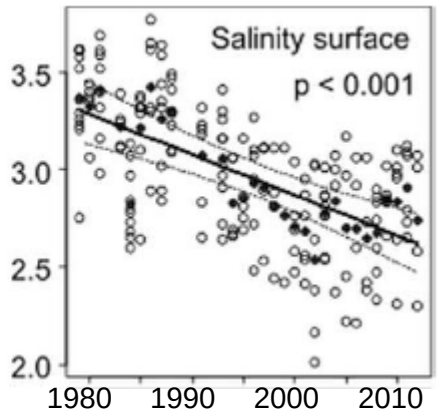




Bothnian Bay

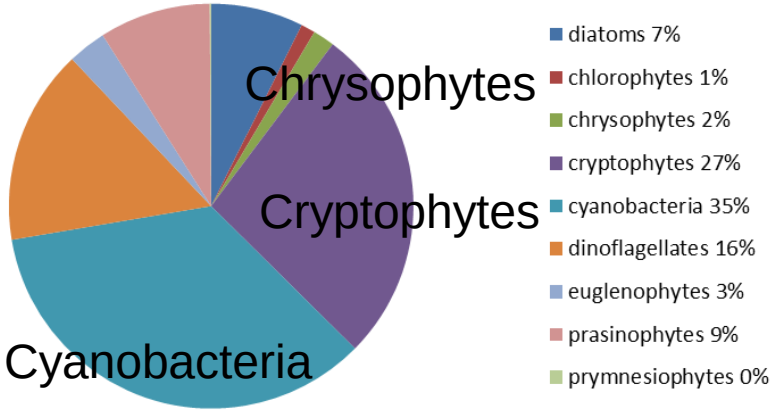




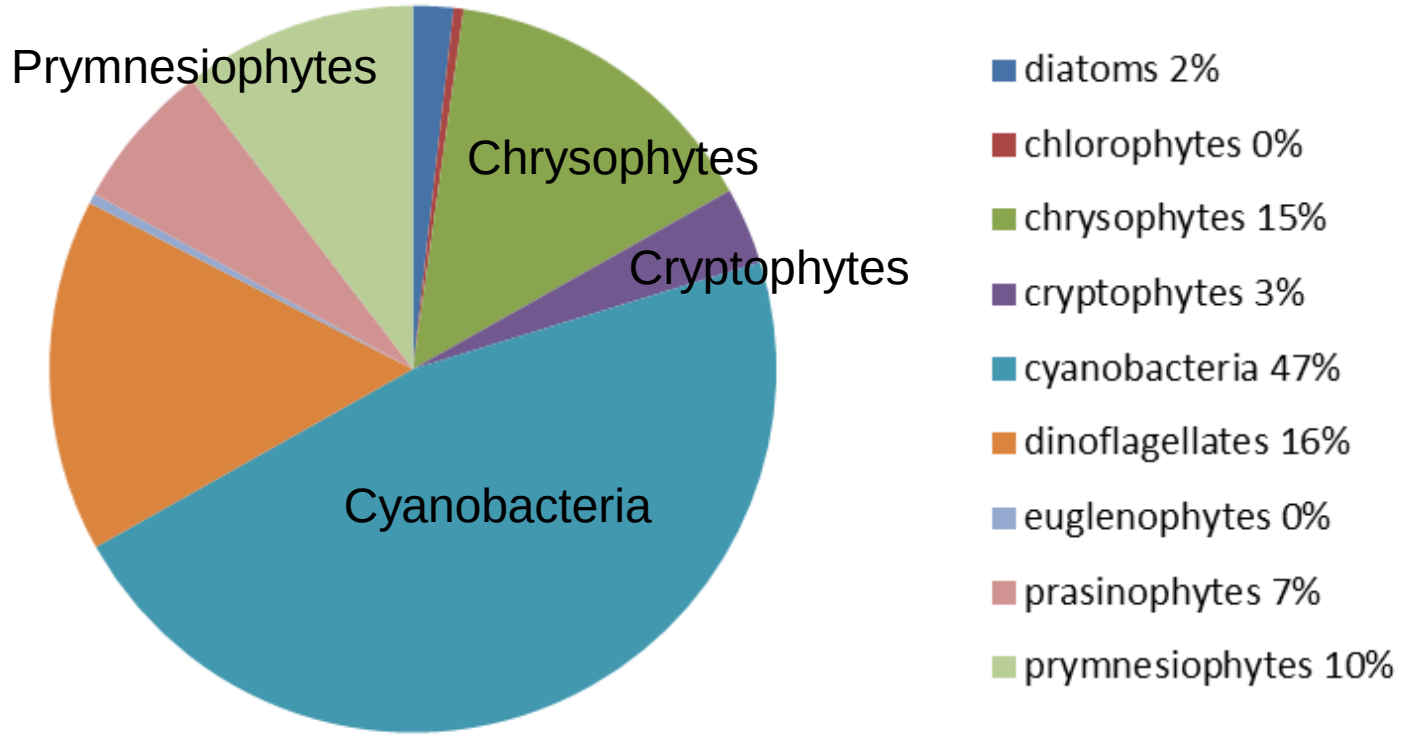


Phytoplankton community change in the Northern Baltic Sea

1979-1983 (TotBM 261 µg L^{-1})



2004-2008 (TotBM 466 µg L^{-1})



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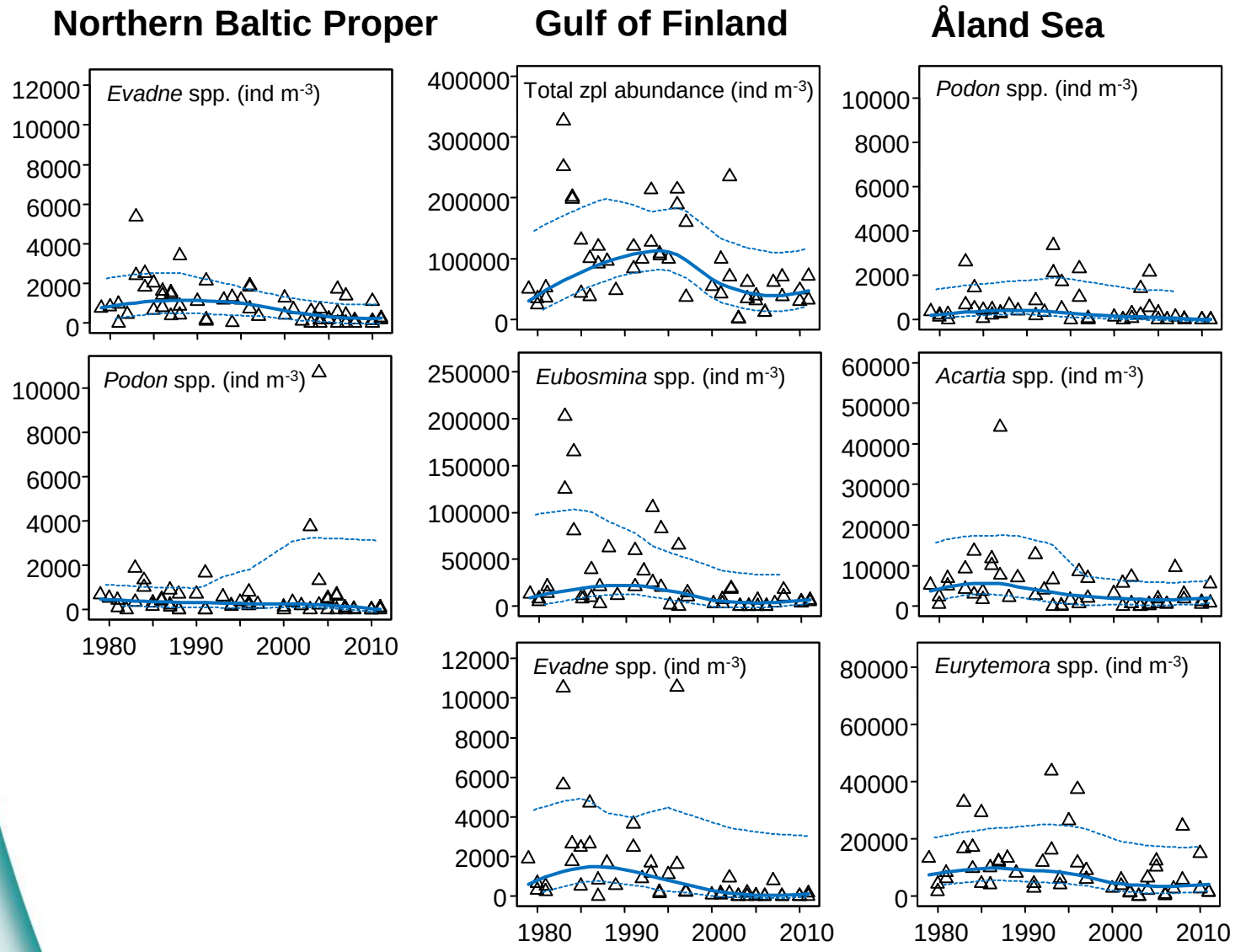
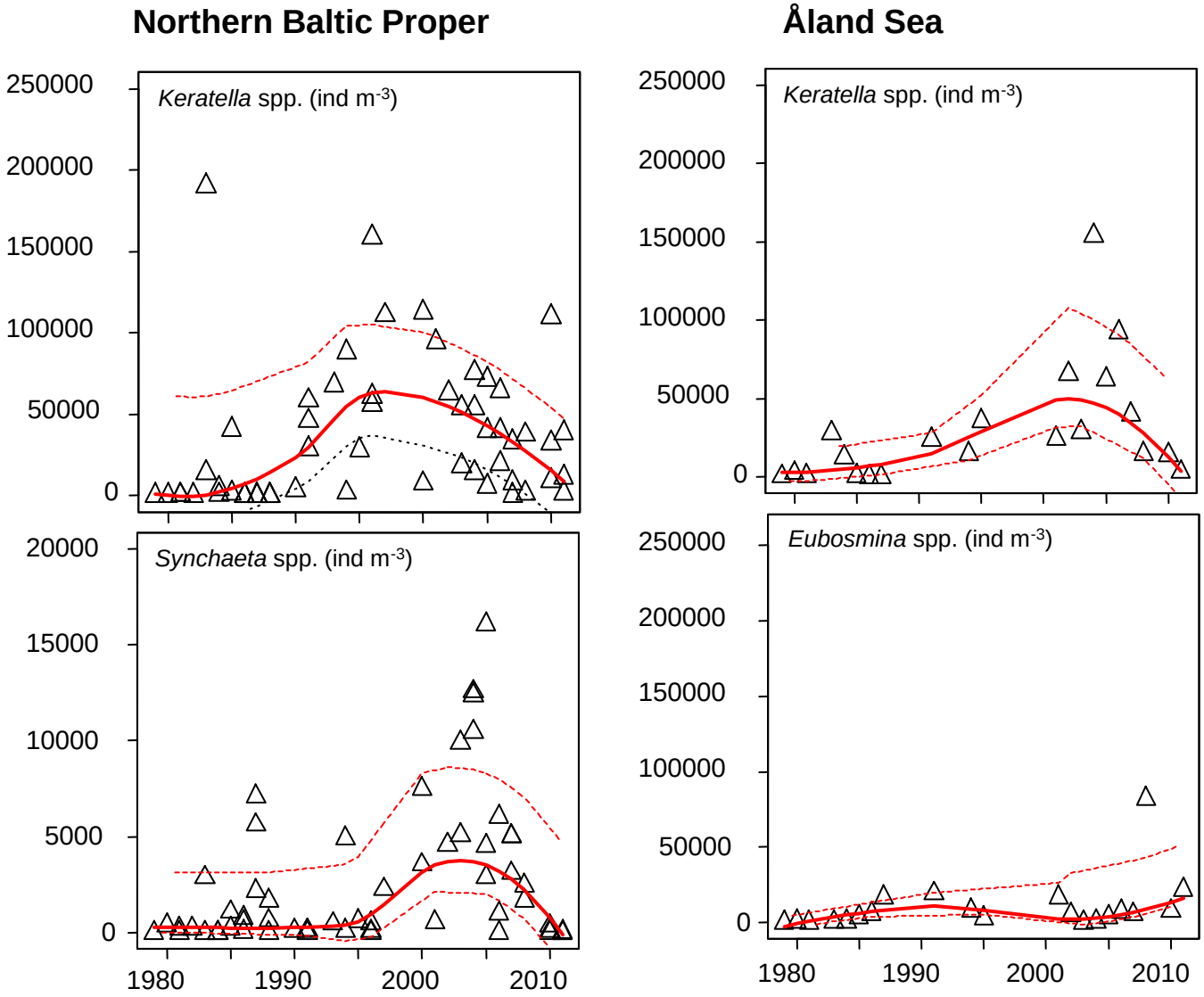
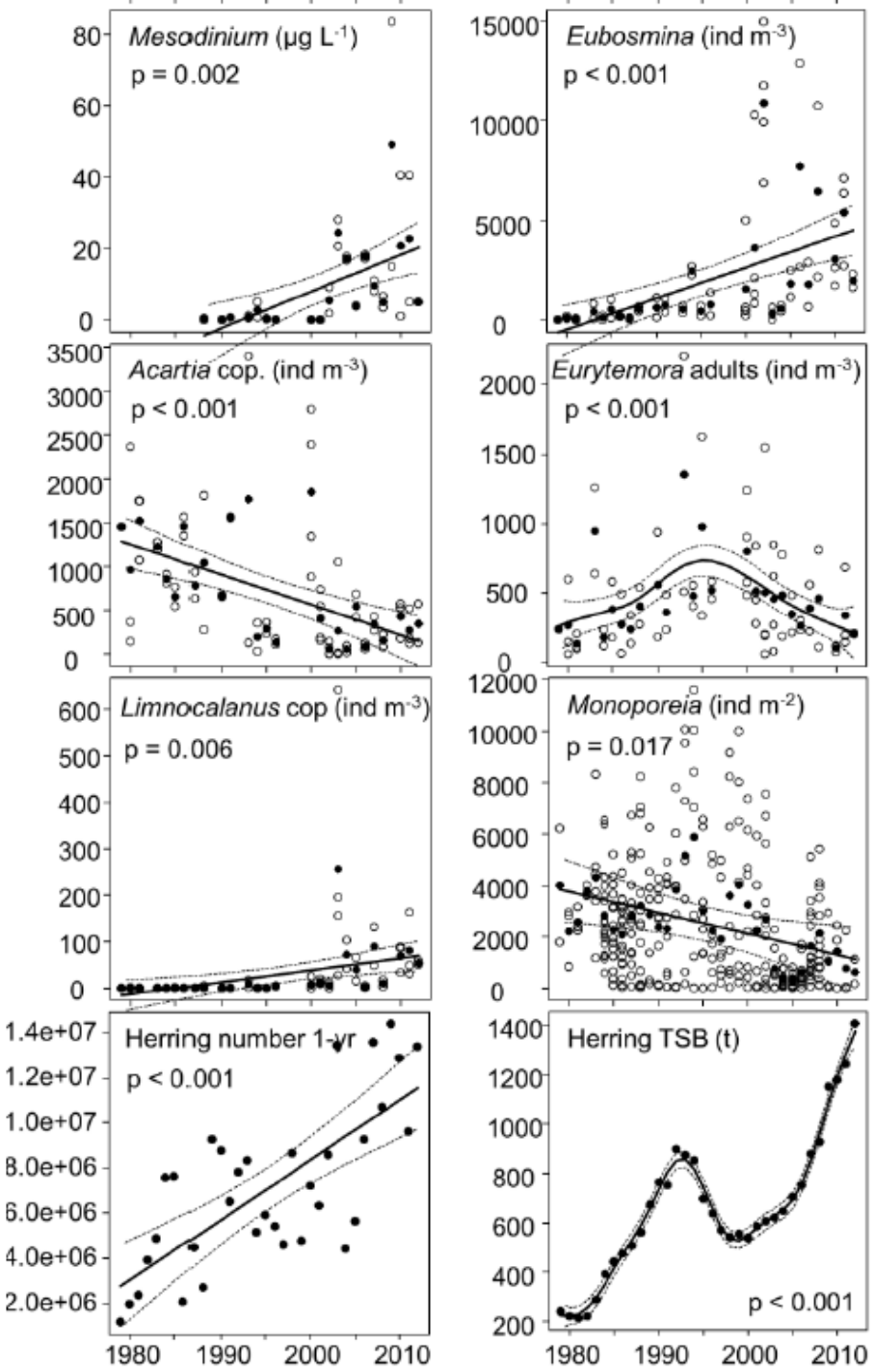
Negative zooplankton trends



Positive zooplankton trends



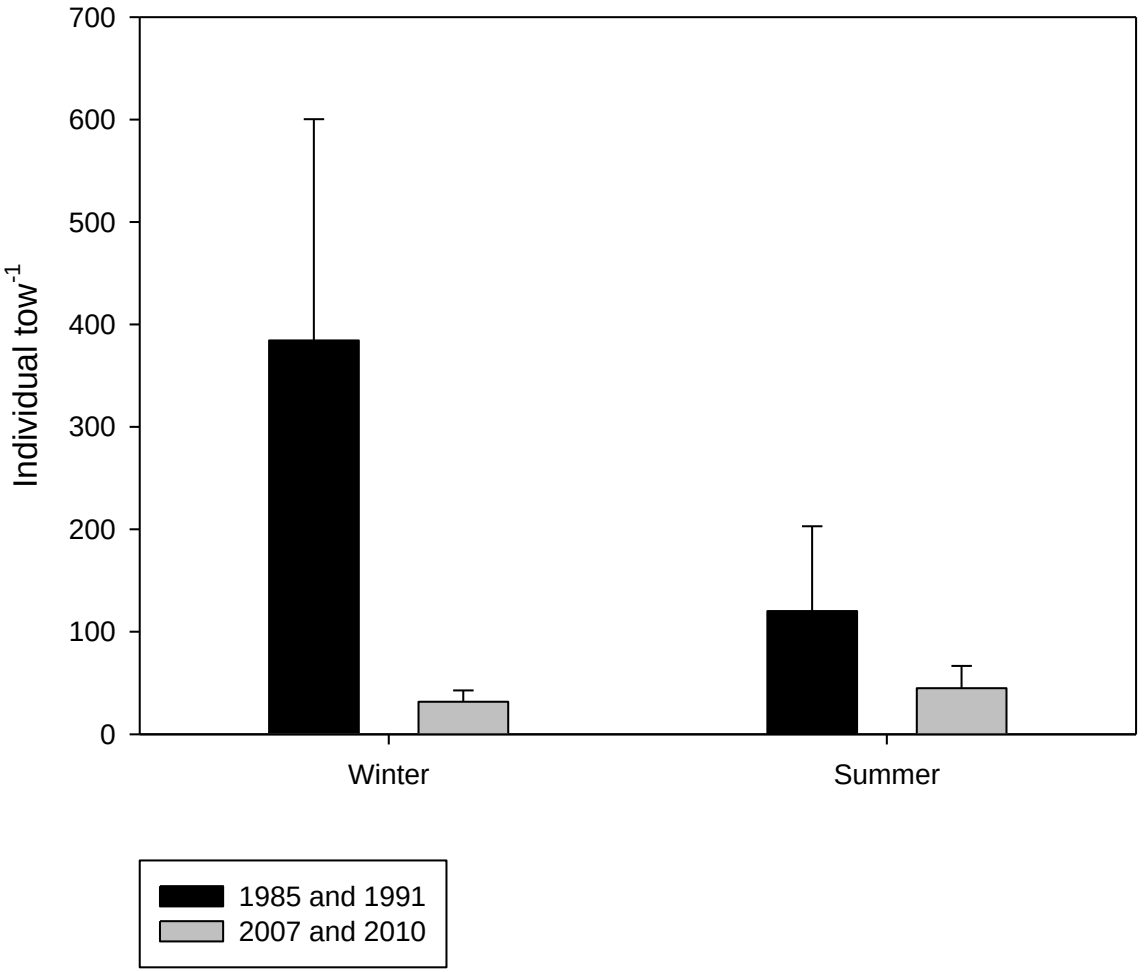


Bothnian Sea

Significant trends in

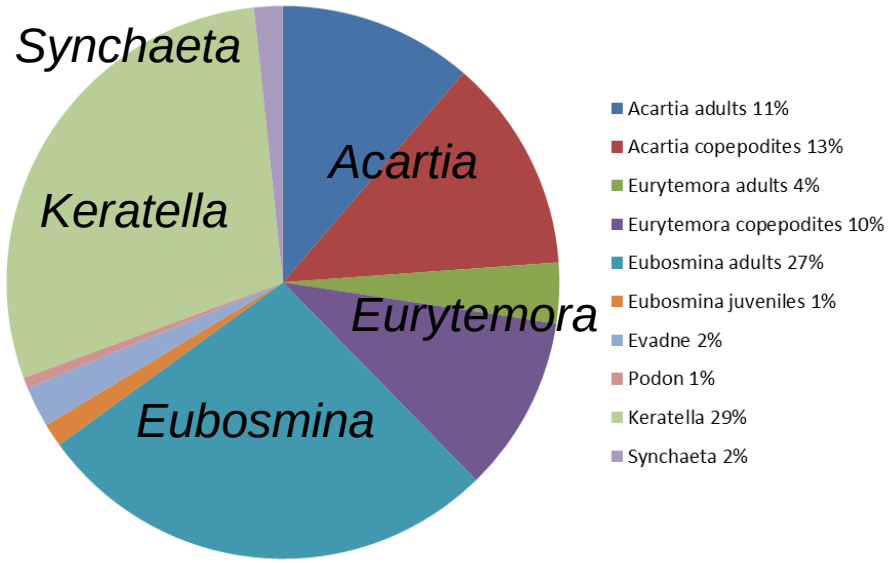
- Zooplankton
- Benthos
- Herring

Bothnian Sea, abundance of nektobenthic mysid shrimps

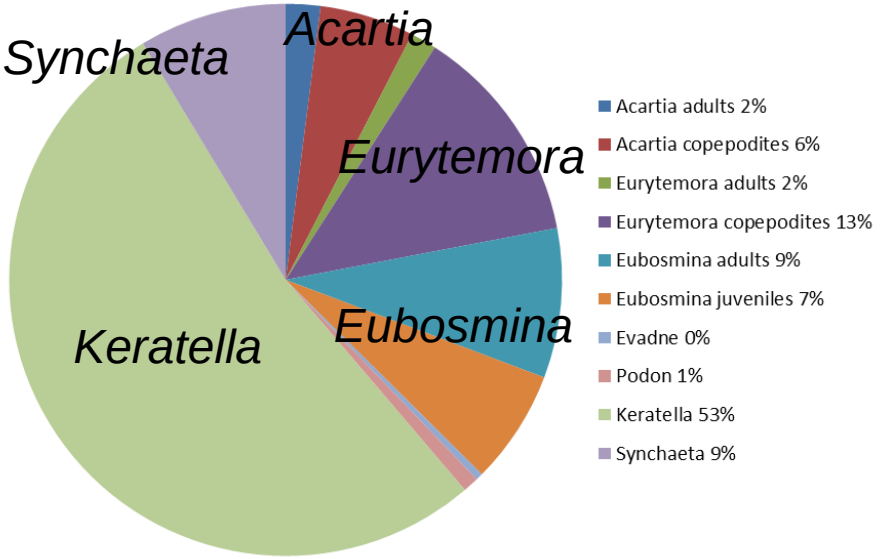


Zooplankton community change in the Northern Baltic Sea

1979-1983 (Tot abundance 62 763 ind m^{-3})



2004-2008 (Tot abundance 63 186 ind m^{-3})



Tendency towards smaller organisms (smaller species or younger individuals) in the community

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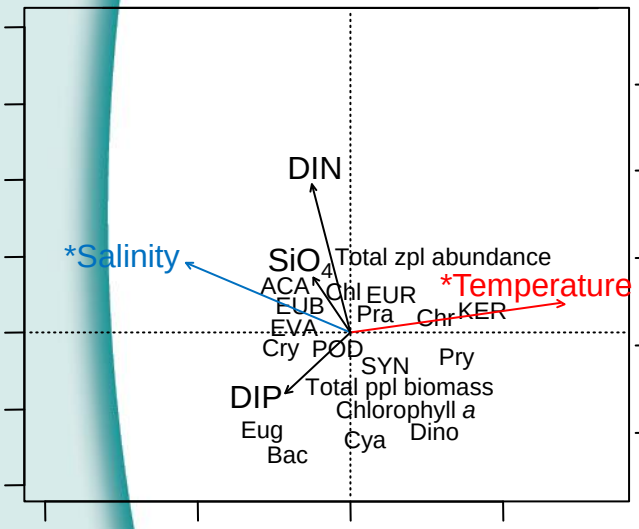
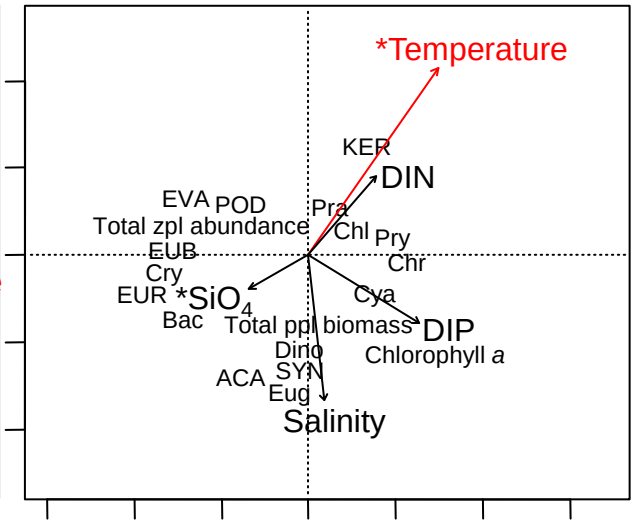
Relationships between plankton and environment - RDA

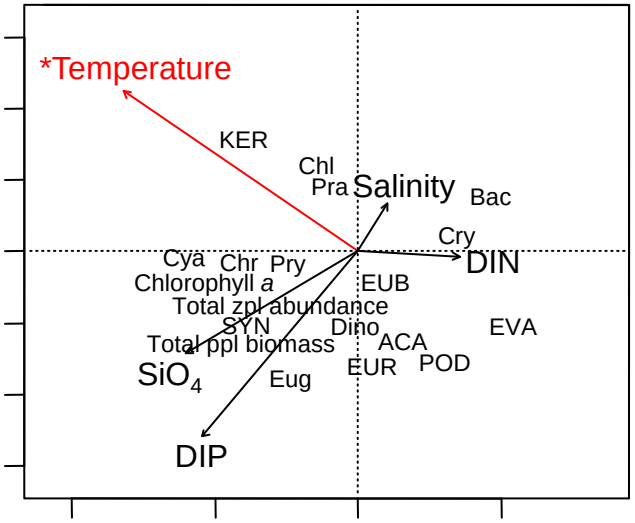
Northern Baltic Proper



Gulf of Finland



Åland Sea

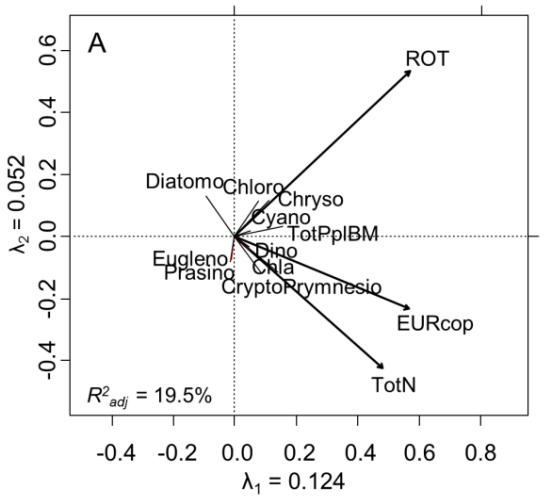


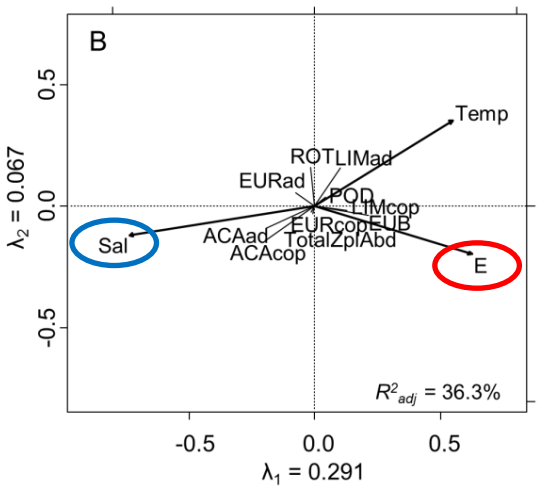
Relationships between environmental and biological factors (RDA)

Response: PPL

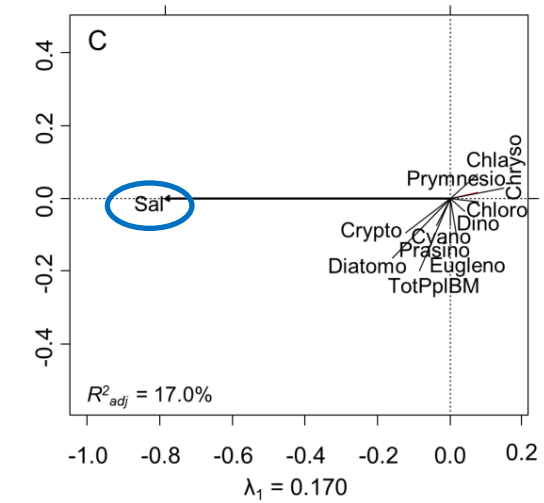
Response: ZPL

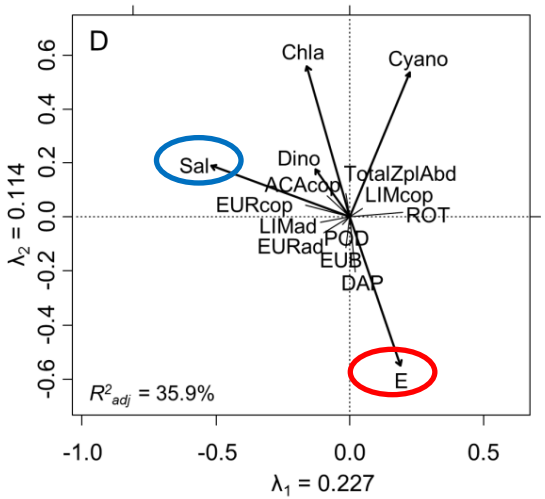
Bothnian Sea





Bothnian Bay





Summary: Changes in the Northern Baltic Sea

Since 1979

- "High-quality" phytoplankton food (Cryptophyceae) ↓
- "Low-quality" phytoplankton food (Cyano+Prymnesiophyceae) ↑
- Small zpl (rotifers) ↑
- Large zpl (copepods, cladocerans) ↓

→ Shift in the food web structure towards more microbial, less energy-efficient food webs consisting of lower-food-quality and smaller sized organisms

→ Less energy available for grazing zooplankton and fish

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Environmental changes in the Gulf of Bothnia, the northernmost basins of the BS

- Increasing water temperature, decreasing salinity, partly due to increasing river inflow → on-going climate change
- Decreased deep-water oxygen, probably caused by inflow of hypoxic deep water, increased amount of settling material, enhanced microbial decomposition and strengthened stratification
- The change in PPL and benthic communities may be a response to an increasingly DOM-based food web
- Surface salinity and stratification play major roles in explaining ZPL community variability
- Baltic herring SSB increased several-fold with a simultaneous decline of weight-at-age: increasing food limitation


Thank you Anders Brutemark, Vivi Fleming-Lehtinen, Jonna Engström-Öst, Silvia Pulina, Mika Raateoja, Jari Raitaniemi, Laura Uusitalo
Thank you for your attention!