5.2.5 The Marine Ecosystem

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Markku Viitasalo SYKE Marine Research Centre
- ✓ Pelagic ecology, cyanobacteria, zooplankton, fish

Thorsten Blenckner Baltic Nest Institute
- ✓ Regime shifts, social-ecological systems

Anna Gårdmark Swedish Univ. Agricultural Sci.
- ✓ Food web modelling, fish ecology

Lena Kautsky Stockholm University
- ✓ Biodiversity of shallow water ecosystems, macroalgae

Harri Kuosa SYKE Marine Research Centre
- ✓ Pelagic ecology, microbial loop, winter ecology

Martin Lindegren Technical University of Denmark
- ✓ Modelling, effects of climate change on fish and fisheries

Alf Norkko University of Helsinki
- ✓ Biodiversity and biogeochemistry of benthic ecosystems

Kalle Olli University of Tarto
- ✓ Biodiversity, pelagic ecology, phytoplankton

Johan Wikner Umeå University
- ✓ Bacterioplankton, climate related O_2 consumption of Baltic Sea basins

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Outline of the Chapter - Present

Main questions / objectives for the Chapter Marine Ecosystem

(1) Focus on SYSTEM-LEVEL responses to CC

(2) What are the true advances in each field since BACC I?

(3) What can be said for sure and what is speculation?

Should COMPLEMENT the BACC I with new insight, not only review the literature 2007-2012

5.2.5.1 Classification of climatic effects

(1) Species ecology
(2) Species interactions
(3) Species evolution

(i) **Direct** effects through physiology of individuals
(ii) **indirect** effects on the productivity of populations via, e.g. changes in biogeochemistry
(iii) **indirect** effects on the structure of communities through interspecific interactions

Red = examples of interesting new papers since BACC I

Phytoplankton

Cyanobacteria increase
-benefit from T increase, stratification, P load
(Suikkanen et al. 2007)

The ratio dinoflagellates/diatoms has increased
(Wasmund et al. 2010; Klais et al. 2011)

Decadal-Scale Changes of Dinoflagellates and Diatoms in the Anomalous Baltic Sea Spring Bloom

Riina Klais, T. Tamminen, A. Kremp, K. Spilling, K. Olli (2011). **PLoS ONE** 6

THE CC AFFECTS PELAGIC PRIMARY PRODUCERS VIA LIFE CYCLE STRATEGIES

Zooplankton

Responses to T and S by copepods, cladocerans, rotifers
-mechanisms? Osmotic stress; food conditions

Not much new on zooplankton ecology.

New since BACC I: the acceptance of the **regime shift** concept for the Central Baltic
(Casini et al. 2008, Möllmann et al. 2009)

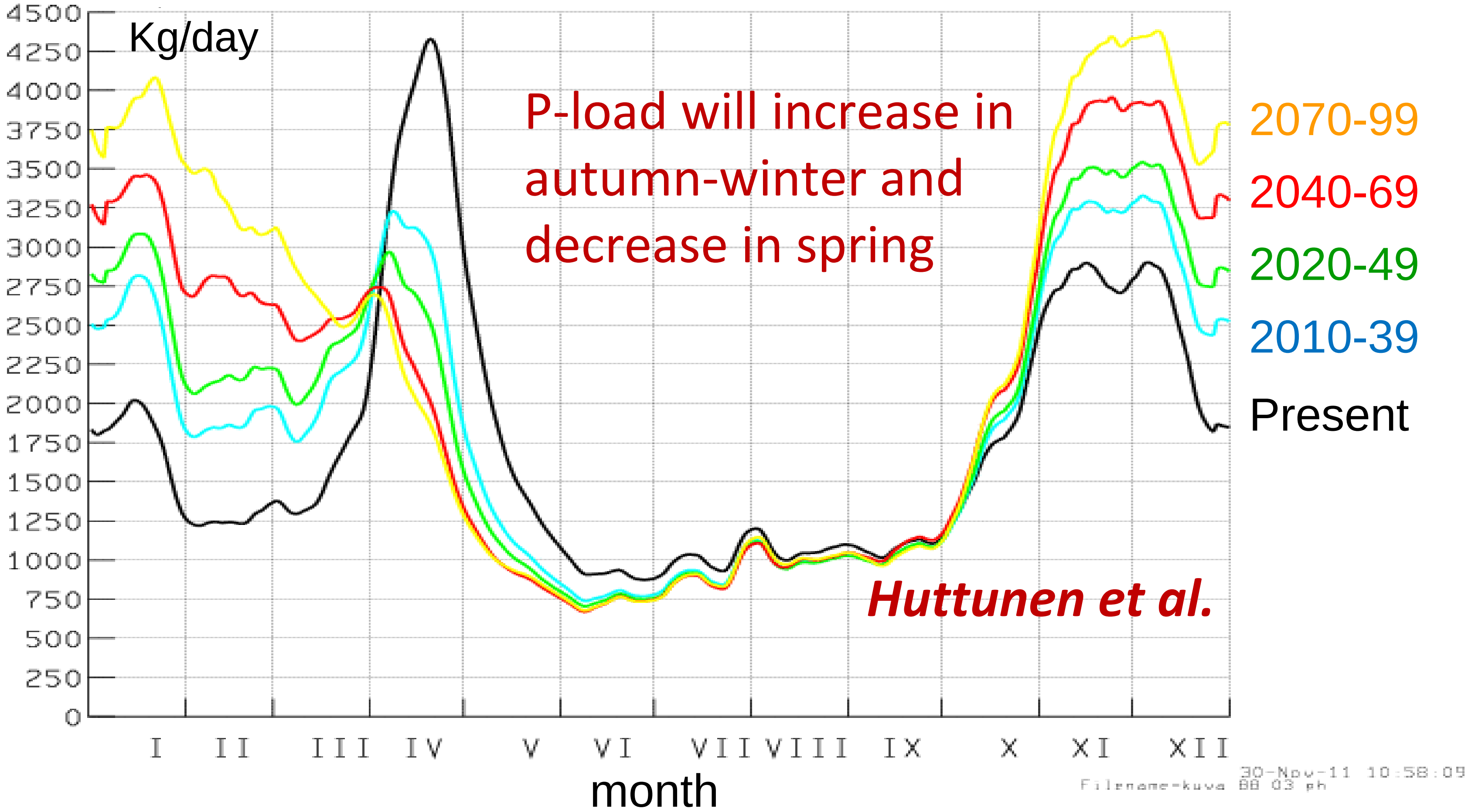
Some advances in the field of Non-indigenous species
-combine hydrodynamical modelling with spreading possibilities
(Lehtiniemi et al. 2011)

An indoor mesocosm system to study the effect of climate change on the late winter and spring succession of Baltic Sea phyto- and zooplankton

Ulrich Sommer, N. Aberle, A. Engel, T. Hansen, K. Lengfellner, M. Sandow, J. Wohlers, E. Zöllner, U. Riebesell. **Oecologia** 150

THE MISMATCH BETWEEN PHYTOPLANKTON AND ZOOPLANKTON MAY GET WORSE

Phosphorus load into the GoF



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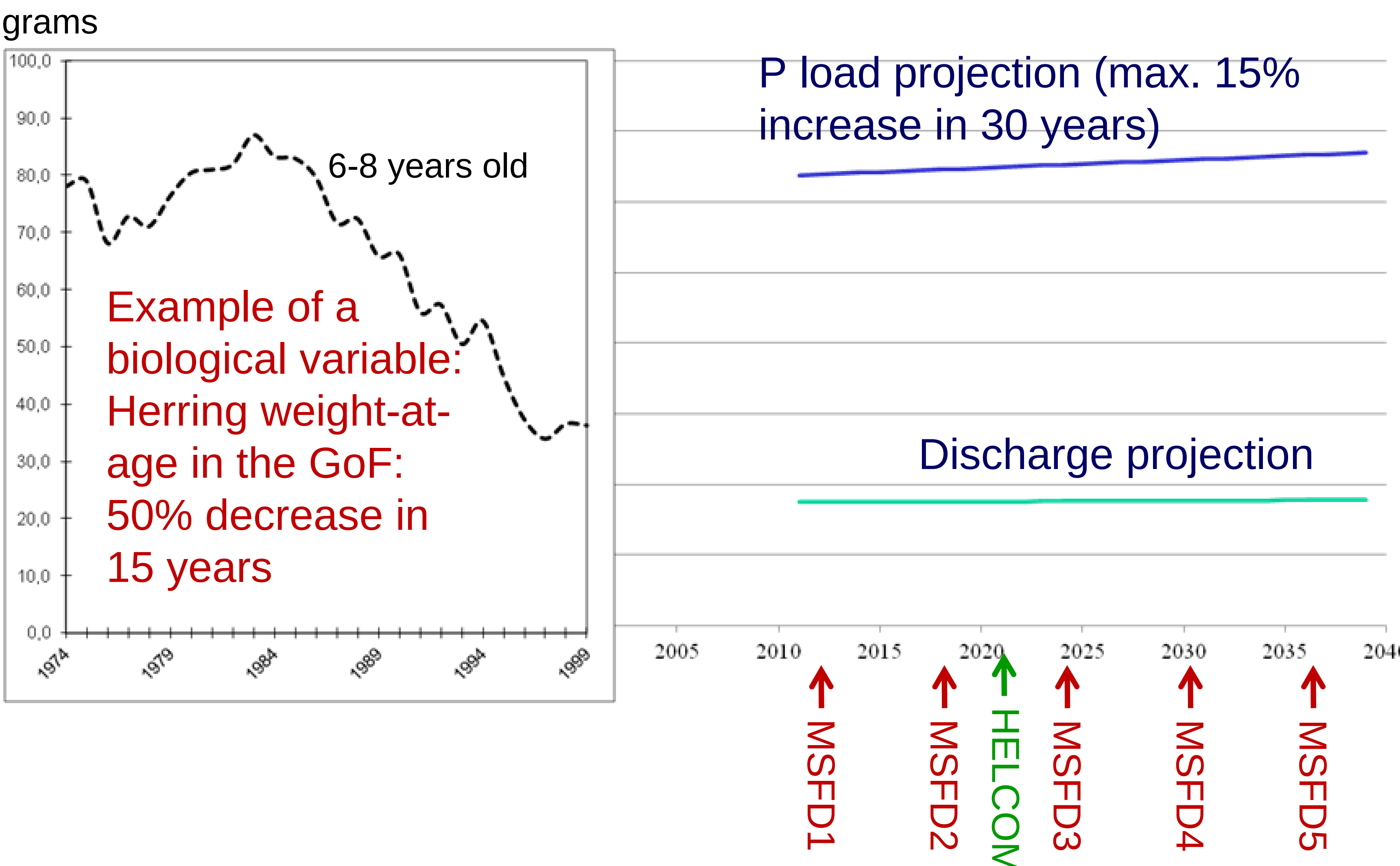
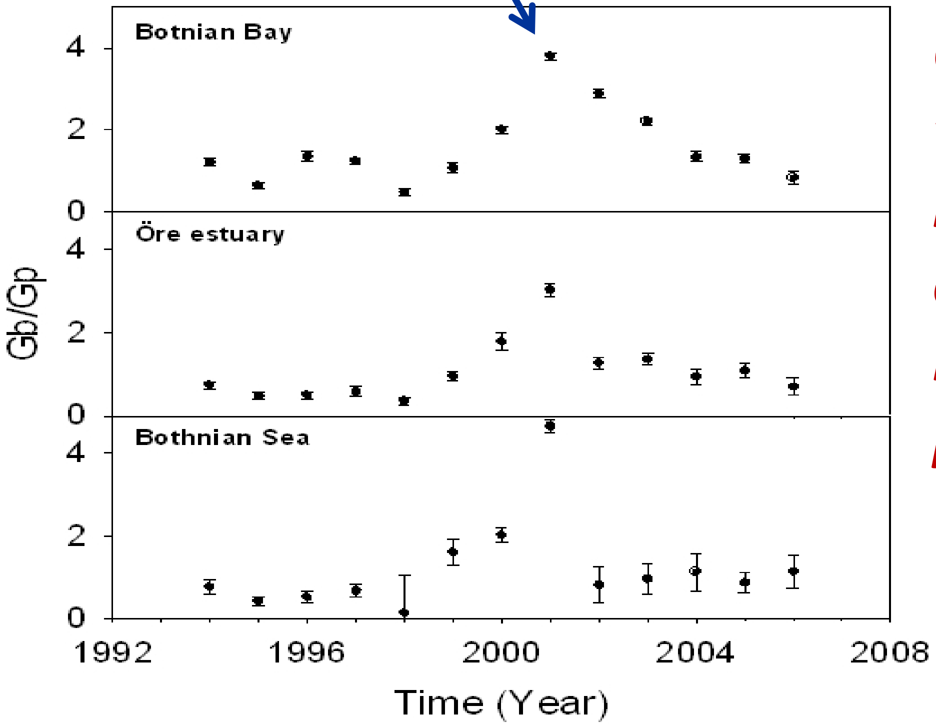
Hydrological changes vs. Biological changes

and Time scales of HELCOM BSAP and MSFD 6-yr cycle

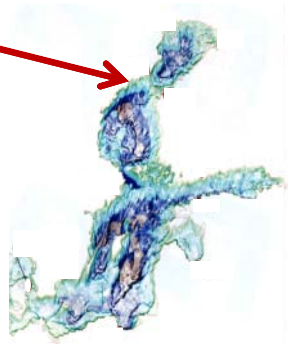


CC worsens eutrophication… Or does it?

Peak = high bacterial production, low primary production!



Gulf of Bothnia: "During years with high freshwater discharge, the ratio of bacterial vs. primary production <u>increases</u>."



Johan Wikner & Agneta Andersson
Umeå University, Sweden

Why? Because organic carbon is "good food" for bacteria!
And it shades the phytoplankton

Open sea benthos

Responses to salinity and oxygen dominate
-very few papers address CC

-Marine species will decline; changes in functional diversity expected
(Villnäs & Norkko 2011)

-Acidification will hamper calcification: NOT STUDIED.

-Sea ice effects: NOT KNOWN

Sublittoral ecosystem

- Littoral organisms well adapted to large daily and seasonal variations in T, pH
- Few studies have addressed CC
- Eelgrass (*Zostera marina*) declines when subjected to simulated heat waves (Ehlers et al. 2008)
- Macrophyte communities in the E Baltic proper vary with CC induced changes in salinity and ice (Kovtun et al. 2009)
- Ice scraping will decline, T increase: cascading effects to grazers?

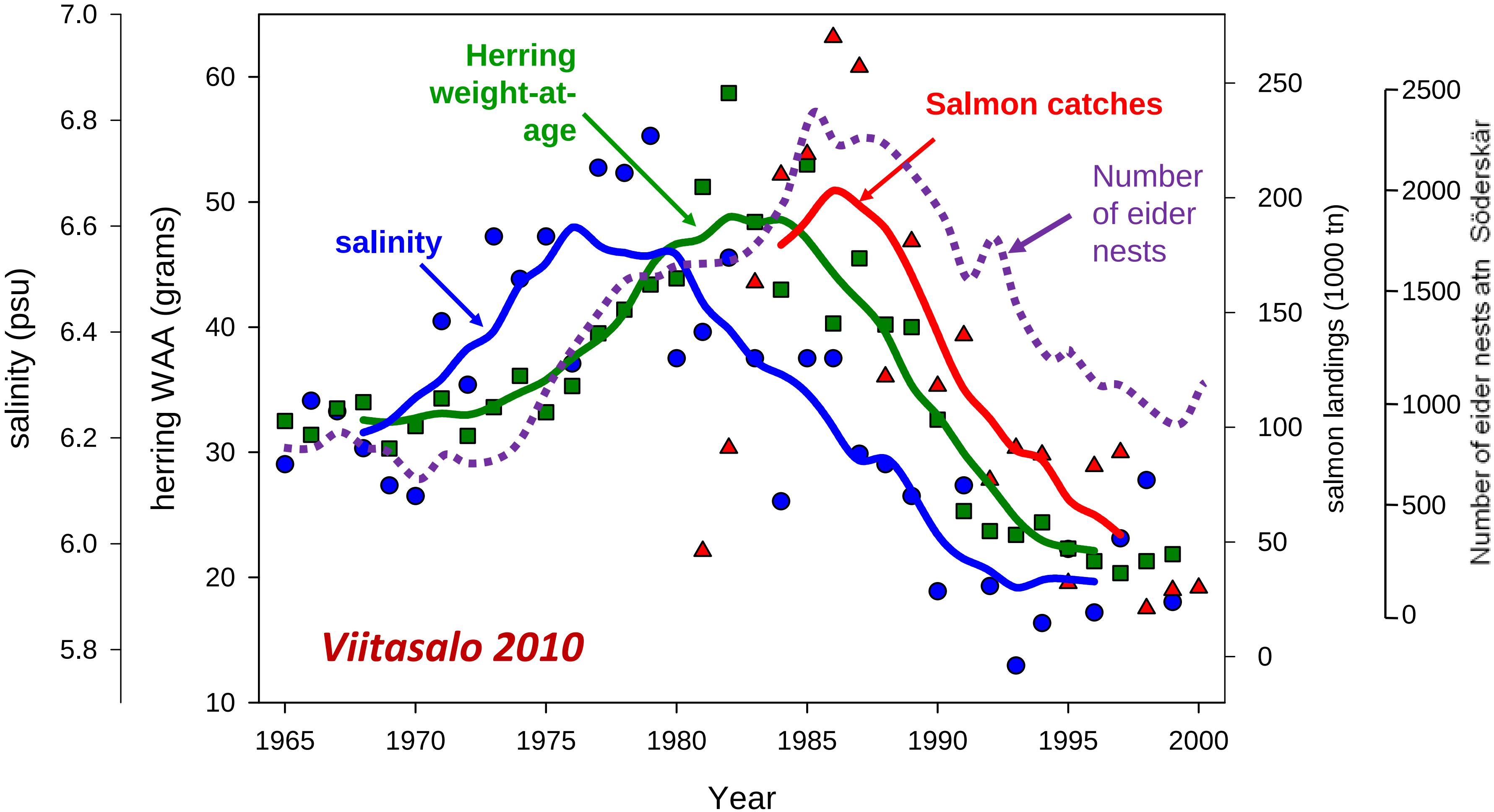
Regime shifts: the case of cod, sprat and herring

- **Central Baltic:**
  a Regime Shift that probably involves feedbacks and cascading effects from cod to clupeids. Hysteresis?
- Synergistic forcing: climate, eutrophication, overfishing
  (Casini et al. 2009; Möllmann et al. 2009)

- but do the cascading effects extend to zooplankton and phytoplankton??

- Sound area: A reversible regime shift
  (Lindegren et al. 2010)

Is something odd happening in the GoF?



Biodiversity

- Poleward shift of southern species, and retreat of northern ones:

- More species gained than will be lost?
- Colonization may be restricted, because of the Danish Straits
  (Fish: Hiddink & Coleby 2011)

- Benthos: Salinity decline is predicted to decrease benthic diversity
  (Bleich et al. 2011)

- Phytoplankton: gain of freshwater species exceeds the loss of marine species
  (Ptacknik et al., submitted)

Biodiversity

The reduced genetic diversity makes the Baltic Sea vulnerable to climate changes due to the reduced 'biodiversity insurance‘
(Johannesson & André 2006)

5.2.5.5 Modelling approaches to climate change – what can we learn from simulations of future ecosystems?

- species responses to CC depend on species interactions

- comparative scenario analyses based on multiple ecological models are needed

- coupled physical-biogeochemical models do not account for trophic dynamics above phytoplankton
- food-web models rarely extend below zooplankton

Conclusions 1: Viable hypotheses

1. Temperature increase will speed up metabolism, growth and reproduction of certain groups

2. Salinity decline (if it happens!) will shift species' geographical limits

3. Freshwater increase (if it happens!) will decrease the trophic efficiency in some areas (DOC effect)

4. The change in phytoplankton seasonal succession will have consequences for the pelagic-benthic coupling

Conclusions 2: ”Breaking News”

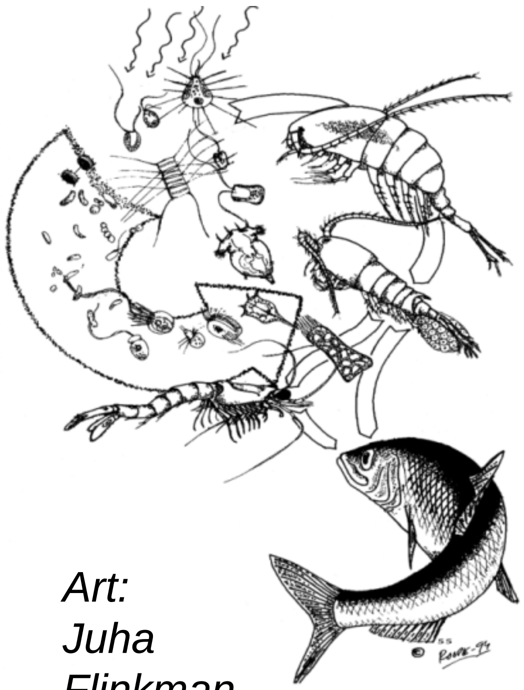
We do not know how the CC affects the eutrophication, because we do not know what will happen to

- Stratification & vertical processes
- internal loading
- trophic dynamics
- species’ distribution limits

Conclusions 3: ”Deeper thoughts”

If the system is not resilient, even a relatively small change in external drivers can trigger a restructuring of the system.

The reason why the regime shift in the Sound was reversible is likely due to an anthropogenic influence (eutrophication, fishing pressure), which affects the resilience of the ecosystem to climate change (Blenckner et al., in prep).



Art: Juha Flinkman