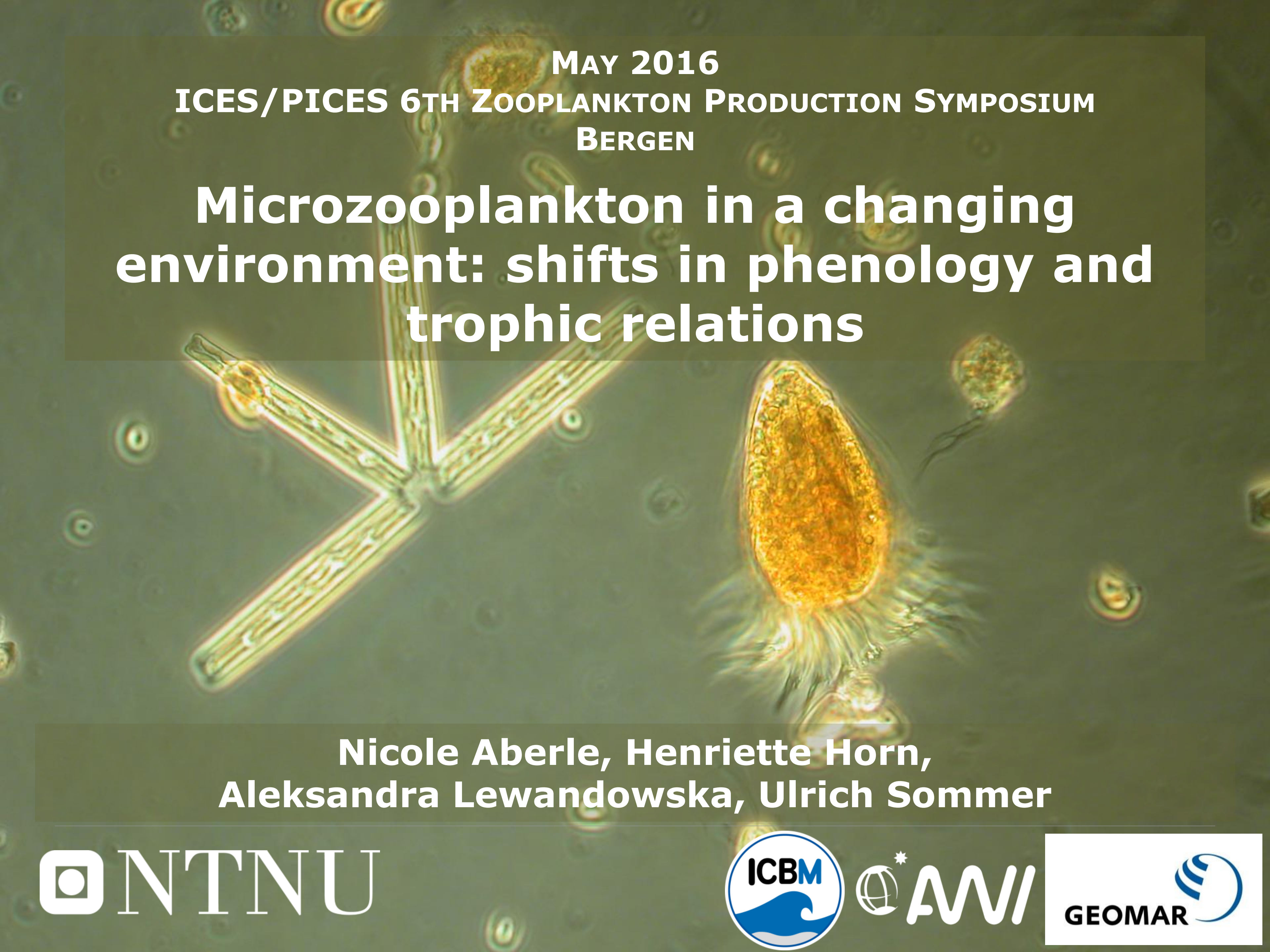


May 2016

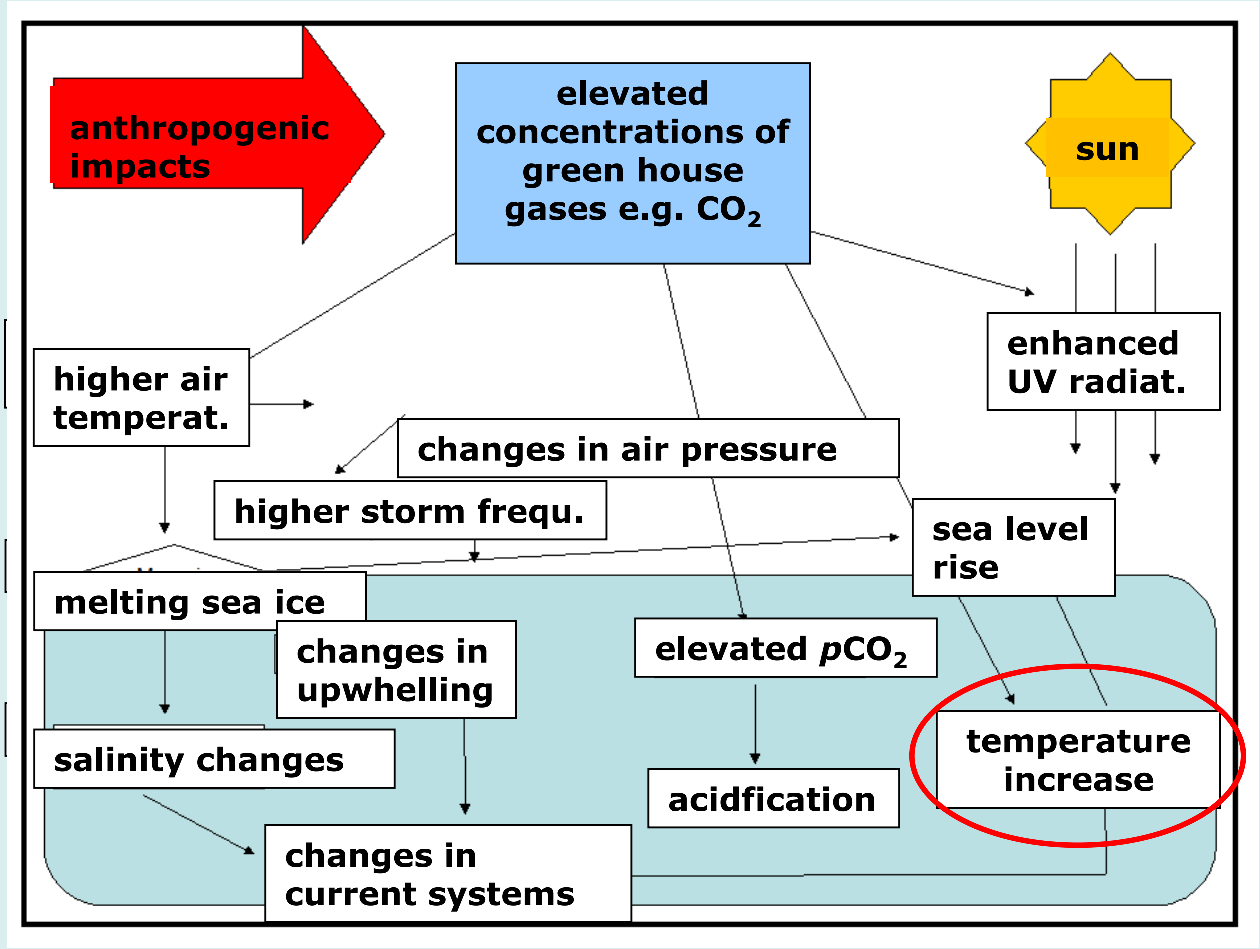
ICES/PICES 6th Zooplankton Production Symposium

Bergen

Microzooplankton in a changing environment: shifts in phenology and trophic relations

Nicole Aberle, Henriette Horn,
Aleksandra Lewandowska, Ulrich Sommer

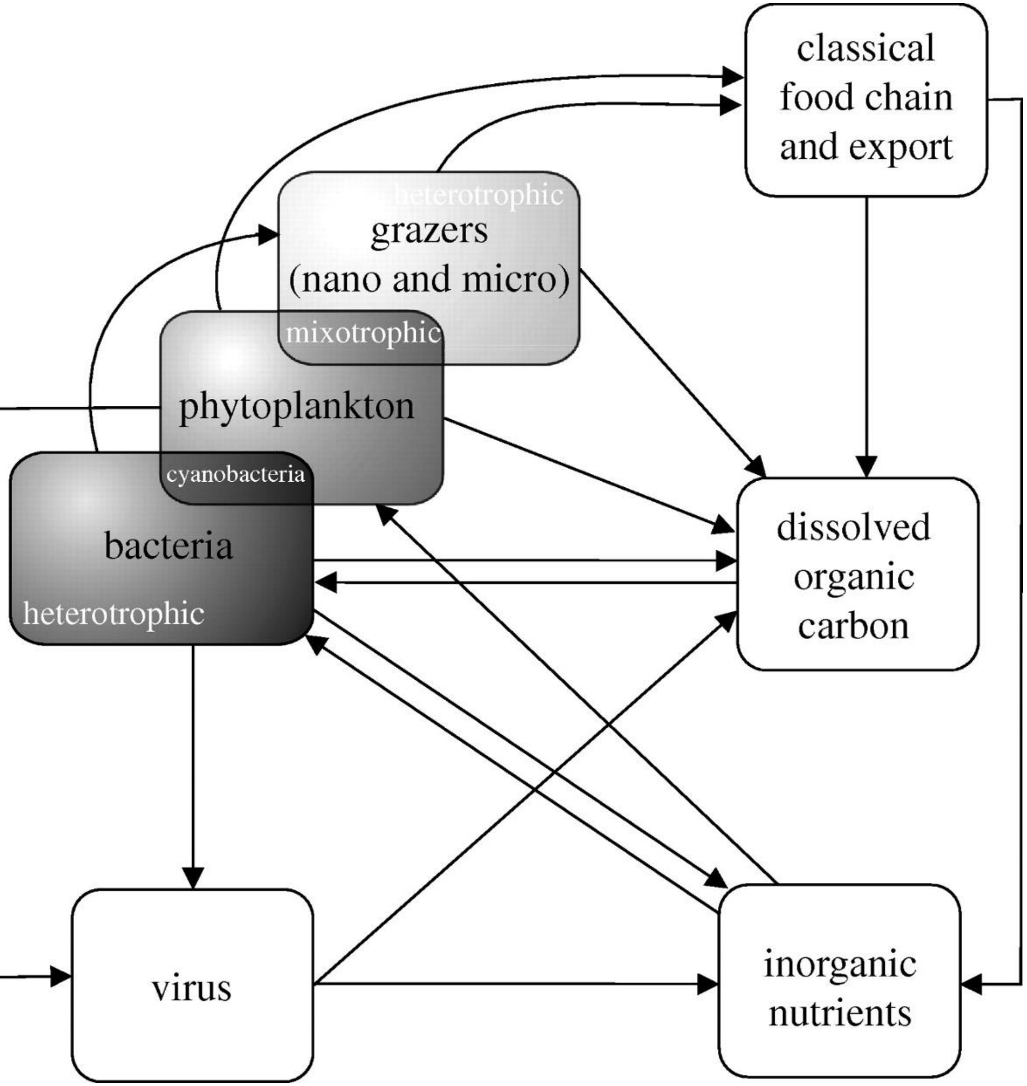
Climate changes effects on oceans



Kraberg et al. 2008

Microbial food webs in a warming ocean

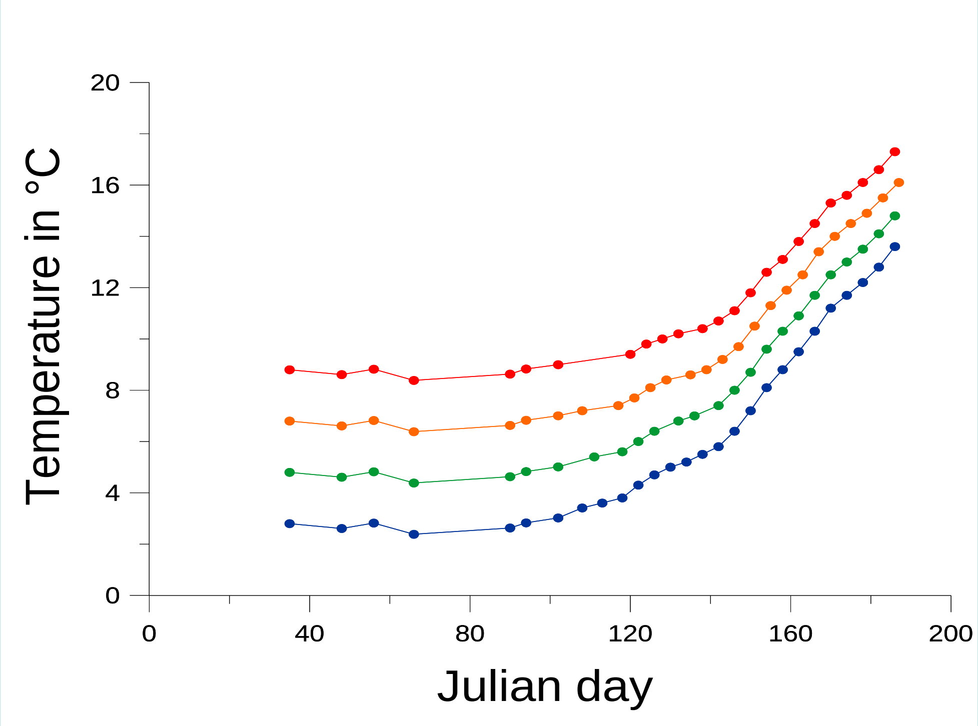
Sarmento et al.
Phil. Trans. R. Soc. B
2010;365:2137-2149



Warming: Aquatic food webs become more microbial

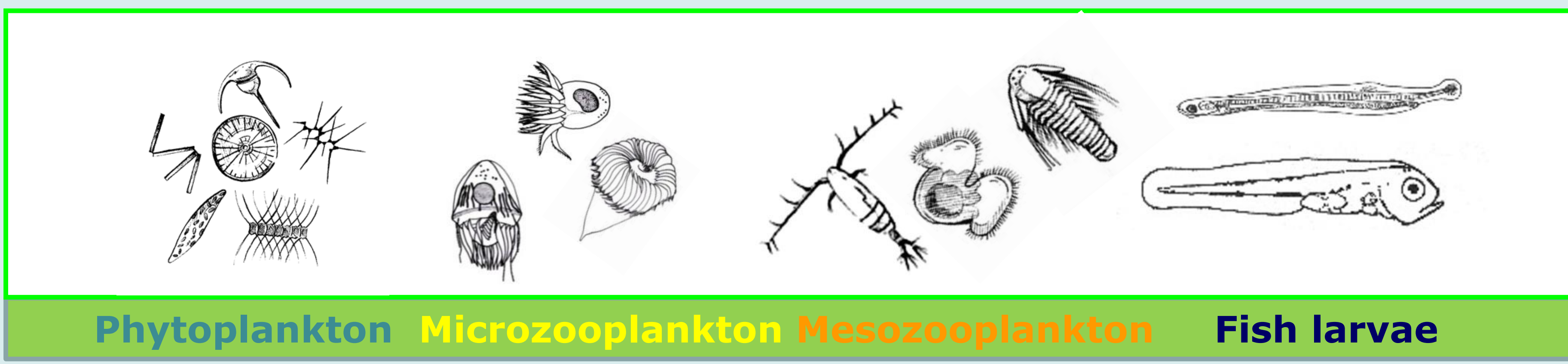
DFG Priority Programme AQUASHIFT:
Kiel Plankton Mesocosm Cluster

Bacteria, Phyto- and Zooplankton, Biogeochemistry, Modelling



Δ0°C: decadal mean (1993-2002)

Spring scenario (temperate regions)



Seasonal succession patterns of spring plankton

Phenology shifts with warming

Heterotrophic processes are more vulnerable to temperature changes than autotrophic ones

'Metabolic Theory of Ecology' (Brown et al. 2014)

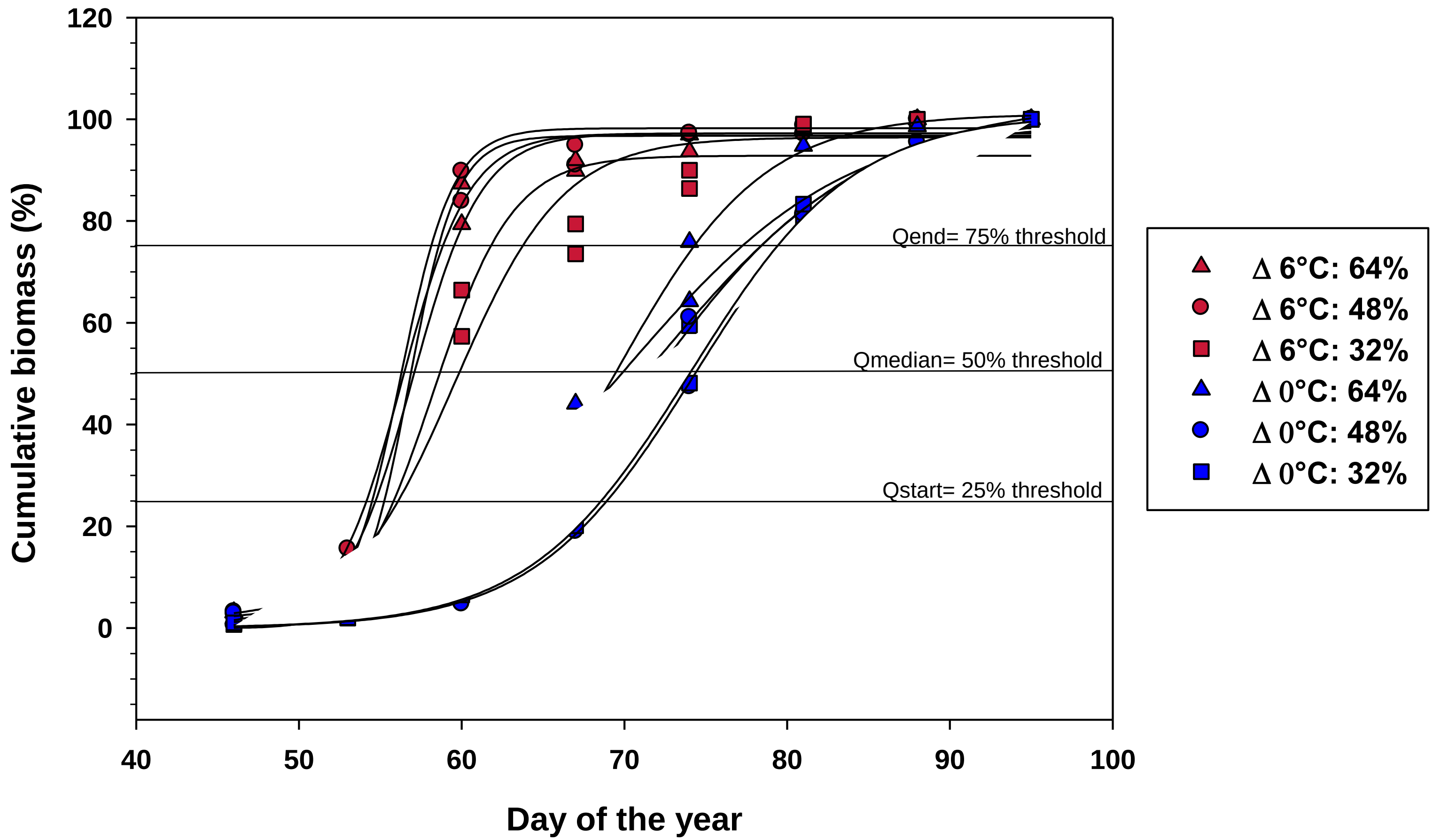
- Reduced time-lags between autotrophs and heterotrophs with warming
- Shifts in timing (and magnitude) of MZP biomass
- Stronger top-down control of phytoplankton by MZP
- Alterations in energy transfer (enhanced dietary competition between MZP and mesozooplankton)

WARMING

'Trophic link' ⟷ **'Trophic sink'**

?

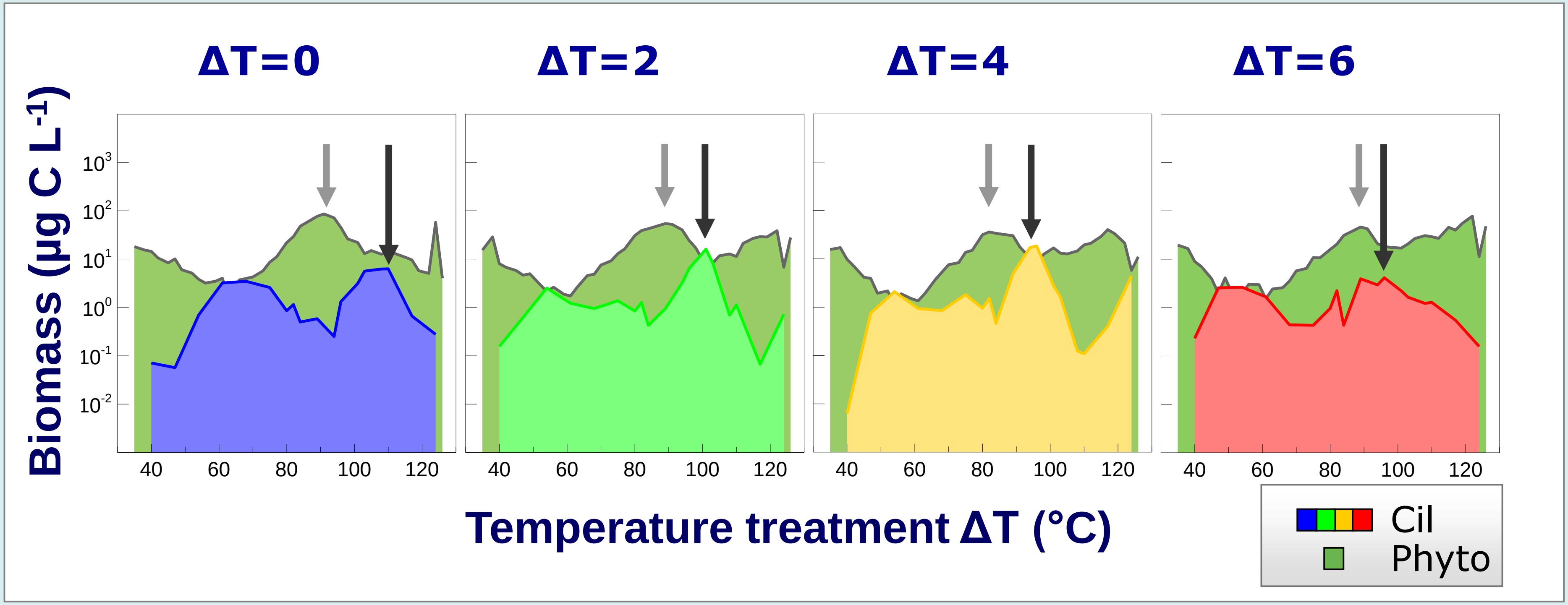
MZP biomass (2008)



→ **Earlier timing of MZP in the mesocosms**

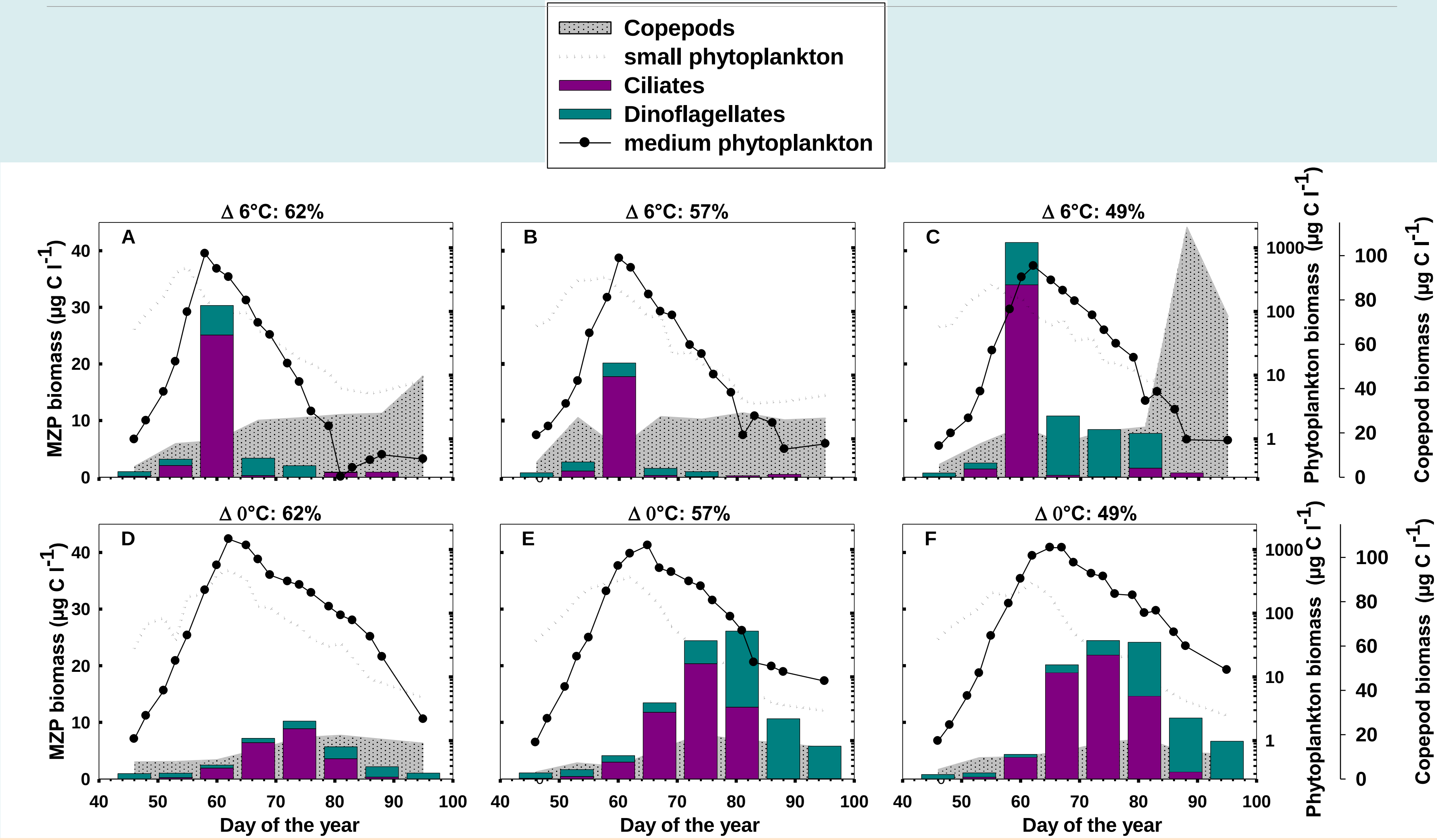
Phenology shifts

Time-lags between ciliates and phytoplankton



→ **Reduced time-lags between phytoplankton and MZP with warming**

Phenology shifts (2008)



→ Reduced temporal occurrence of MZP

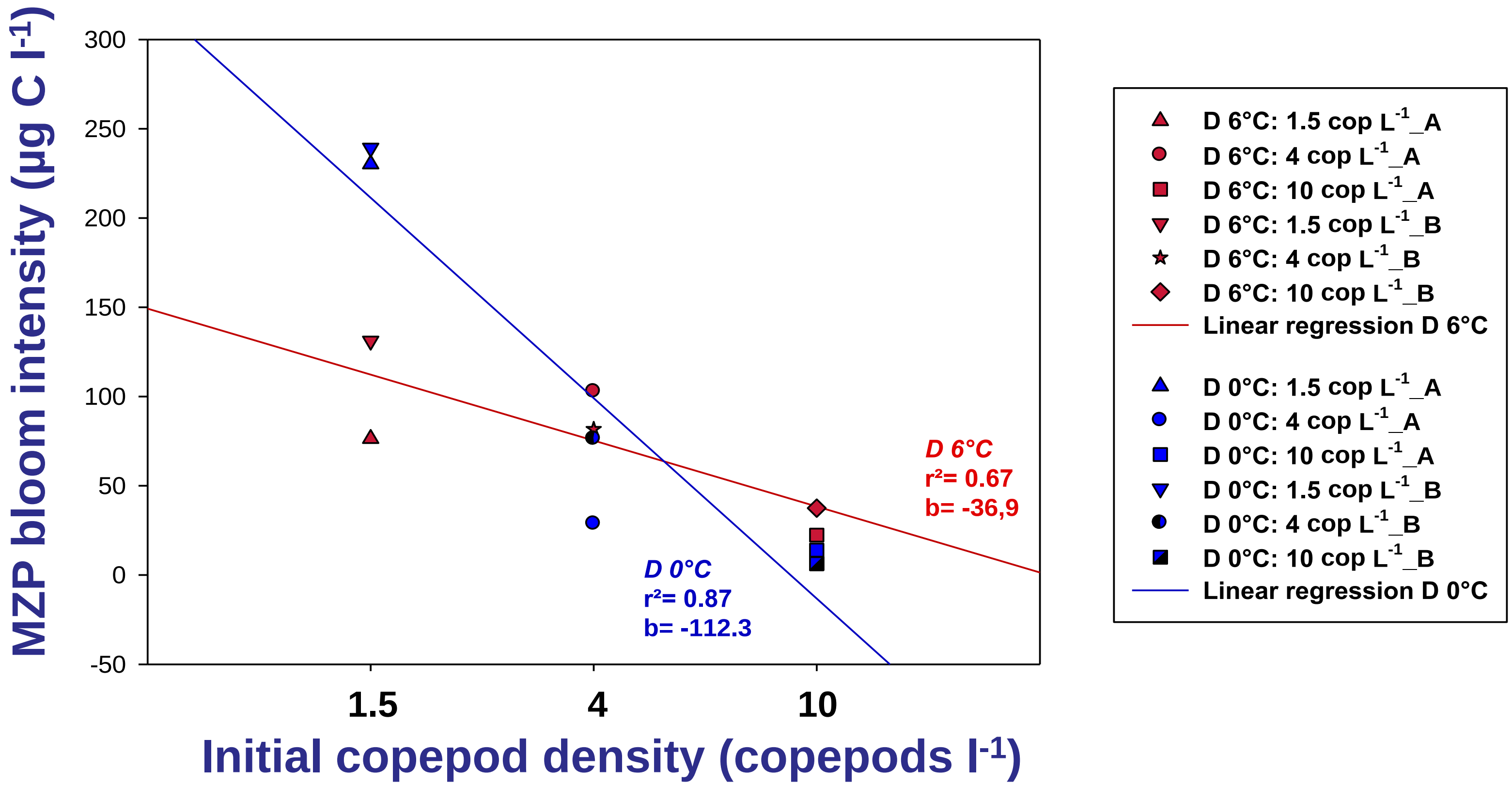
Warming & overwintering copepod densities

Test for the combined effects of ***warming*** and ***densities of overwintering copepods*** on MZP biomass and phenology

Hypotheses:

1. High overwintering copepod densities will affect MZP biomass (size classes/community composition)
2. Warming <u>at high copepod densities</u> will lead to a strong top-down control on MZP
   → MZP functions as a 'trophic link'
3. Warming <u>at low copepod densities</u> will lead to an earlier timing of MZP and a shortened temporal occurrence
   → MZP functions as a 'trophic sink'

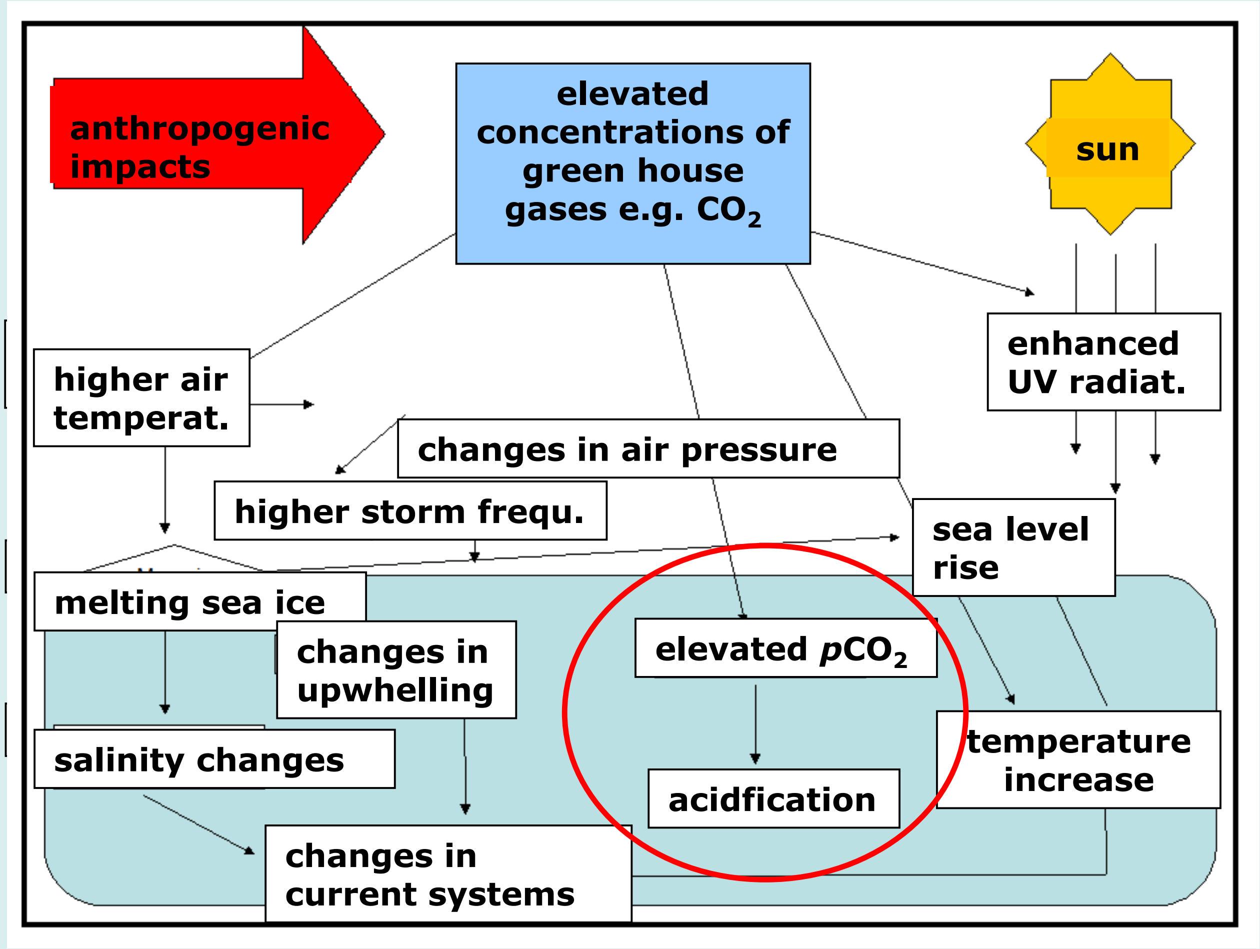
Top-down control by copepods



→ MZP bloom intensity was highly affected by copepod density

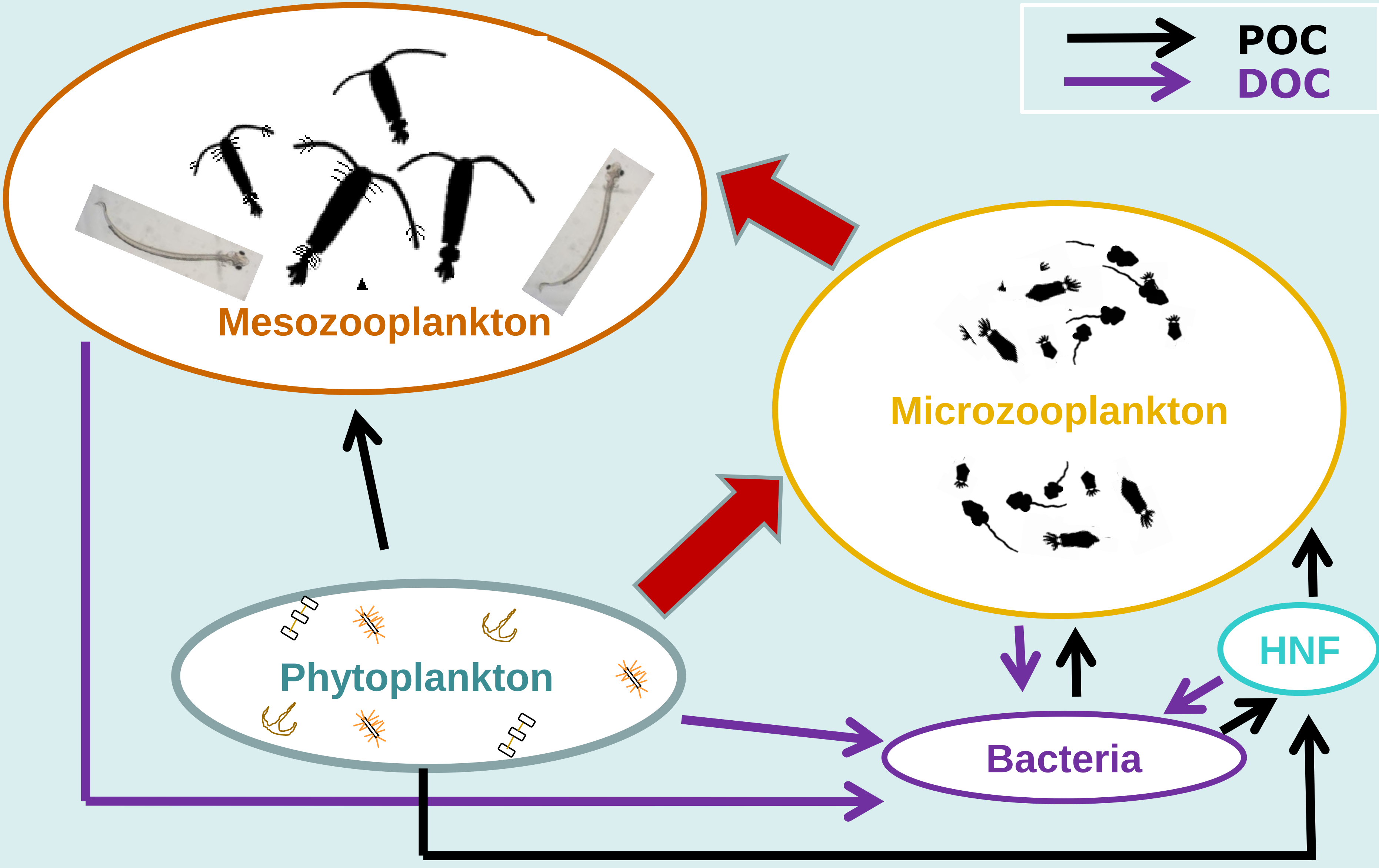
→ Strong suppression of MZP (especially ciliates <30 µm) at elevated temperatures

Effects of warming & ocean acidification (OA)

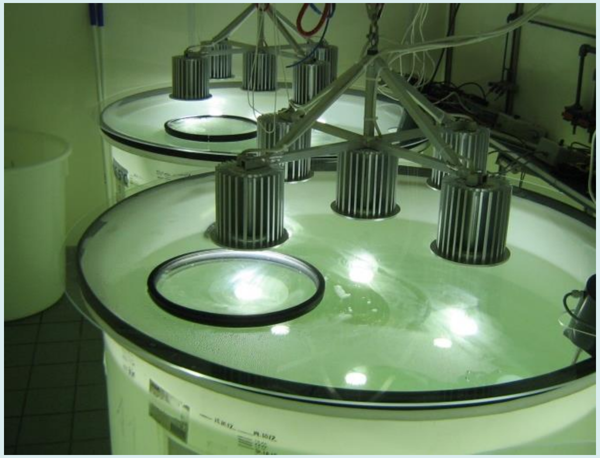


Kraberg et al. 2008

Will OA affect lower food web dynamics?



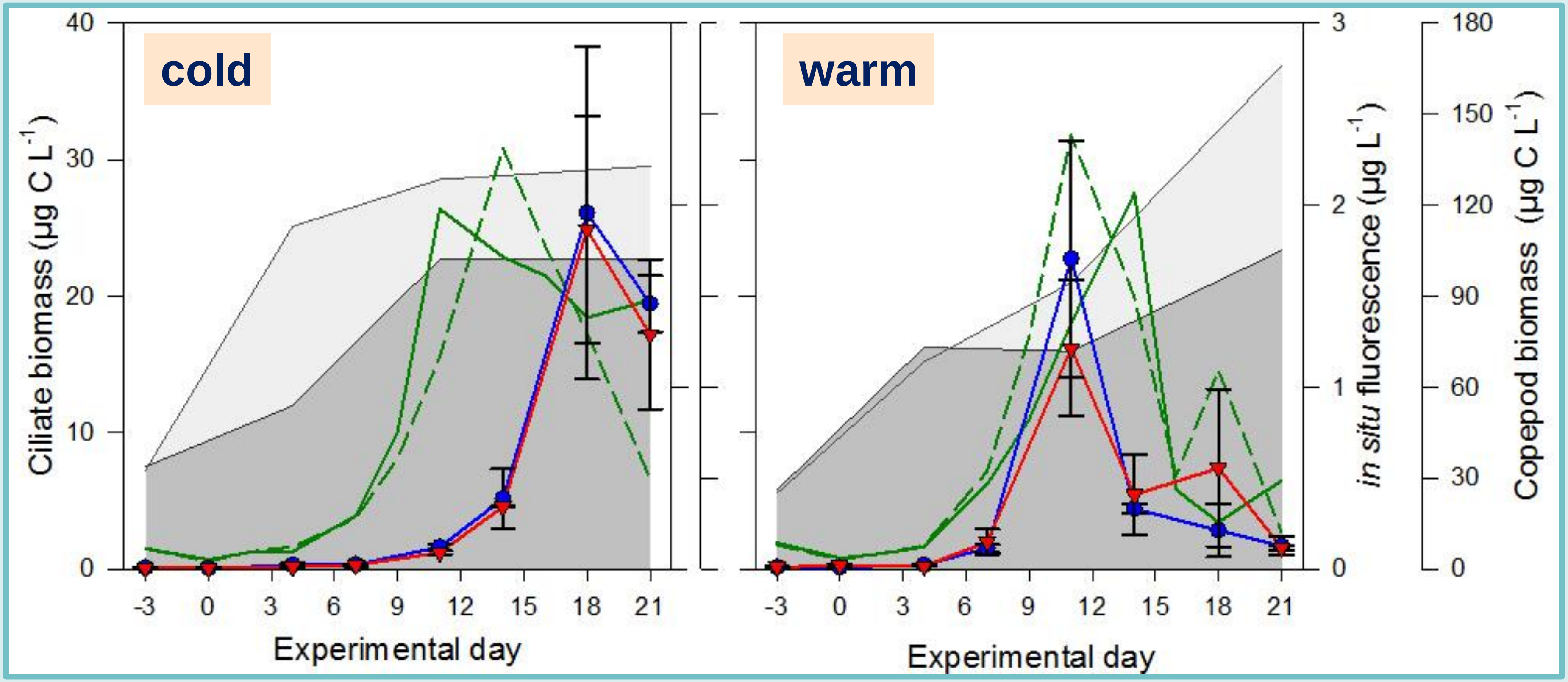
Warming vs. OA: an indoor mesocosm study (BIOACID II 2012-2015)



- 12 mescocosms filled with Baltic Sea plankton communities
- Two different temperatures levels: cold and warm (Δ 6°C)
- CO_2 gradients: 500 ppm (low) to max. 3000 ppm (high)

Will the combined effects of warming and OA induce direct or indirect effects on the phenology, community composition and carrying capacity of MZP?

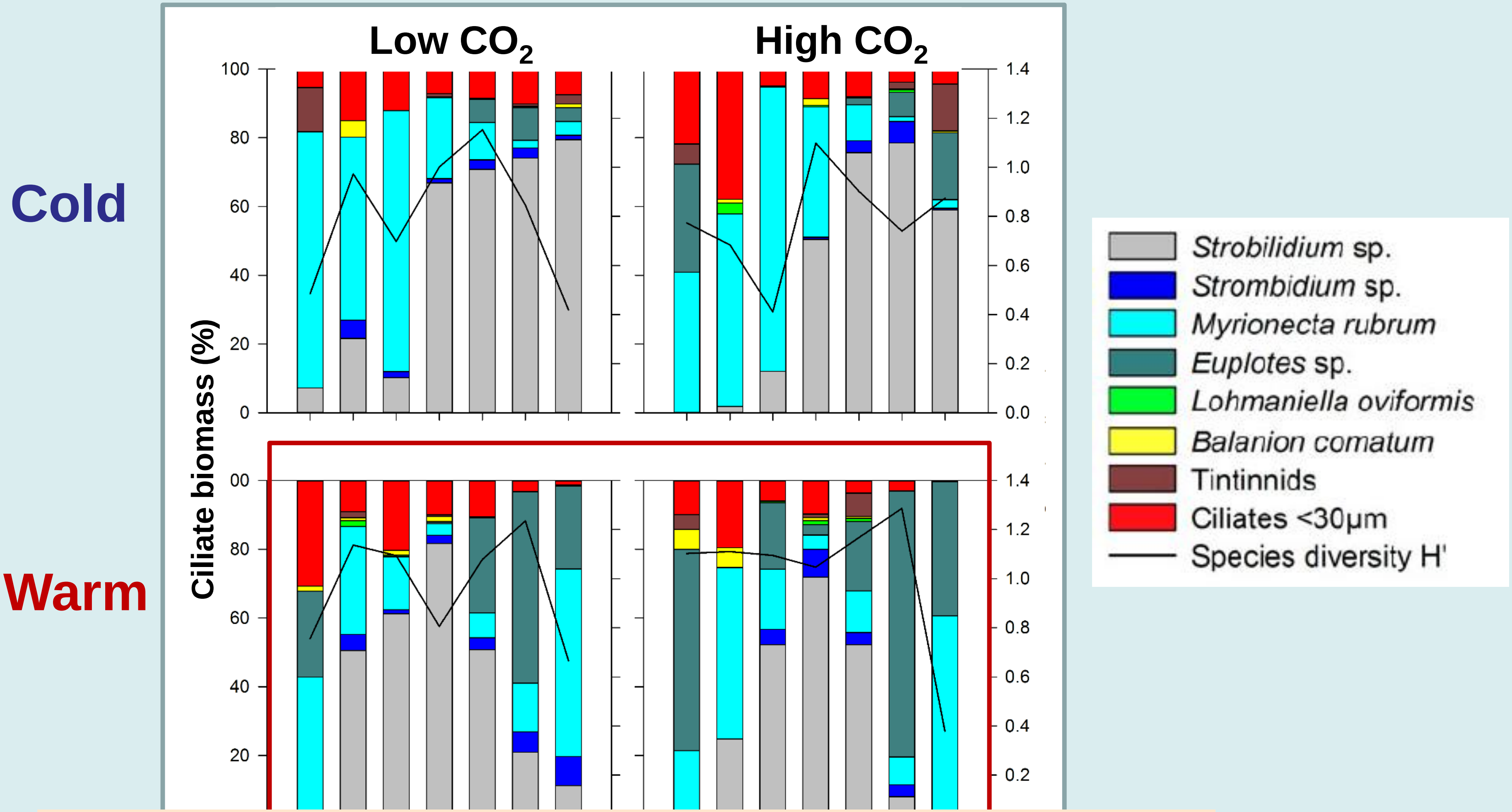
Ciliate biomass (BIOACID II 2012)



→ Warming: earlier timing and higher growth rates

→ No effects of pCO_2 on total ciliate biomass

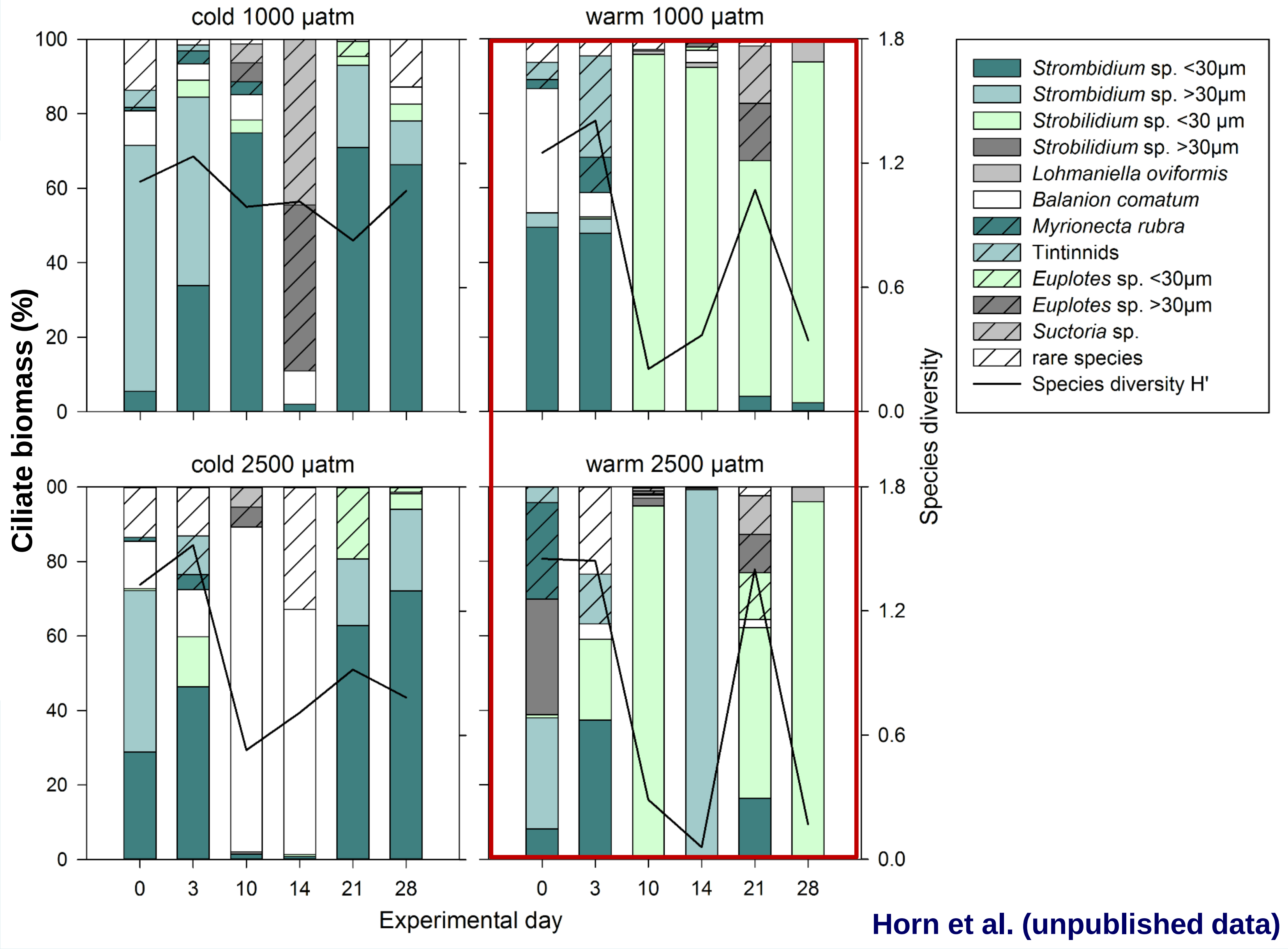
Species composition (BIOACID II 2012)



→ No effect of pCO_2 conditions

→ Changes in MZP composition and succession patterns with warming

Species composition (BIOACID II 2013)

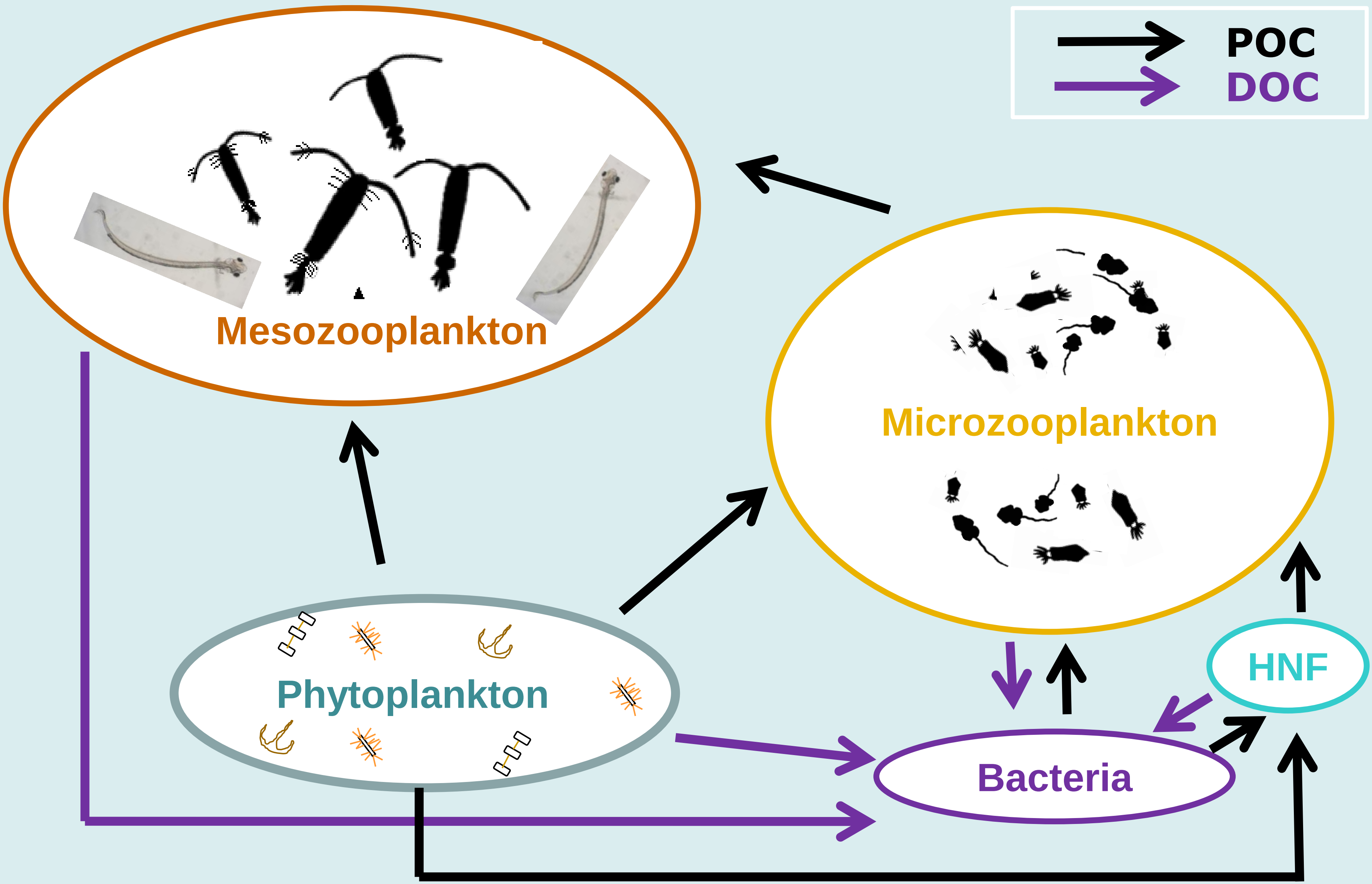


Horn et al. (unpublished data)

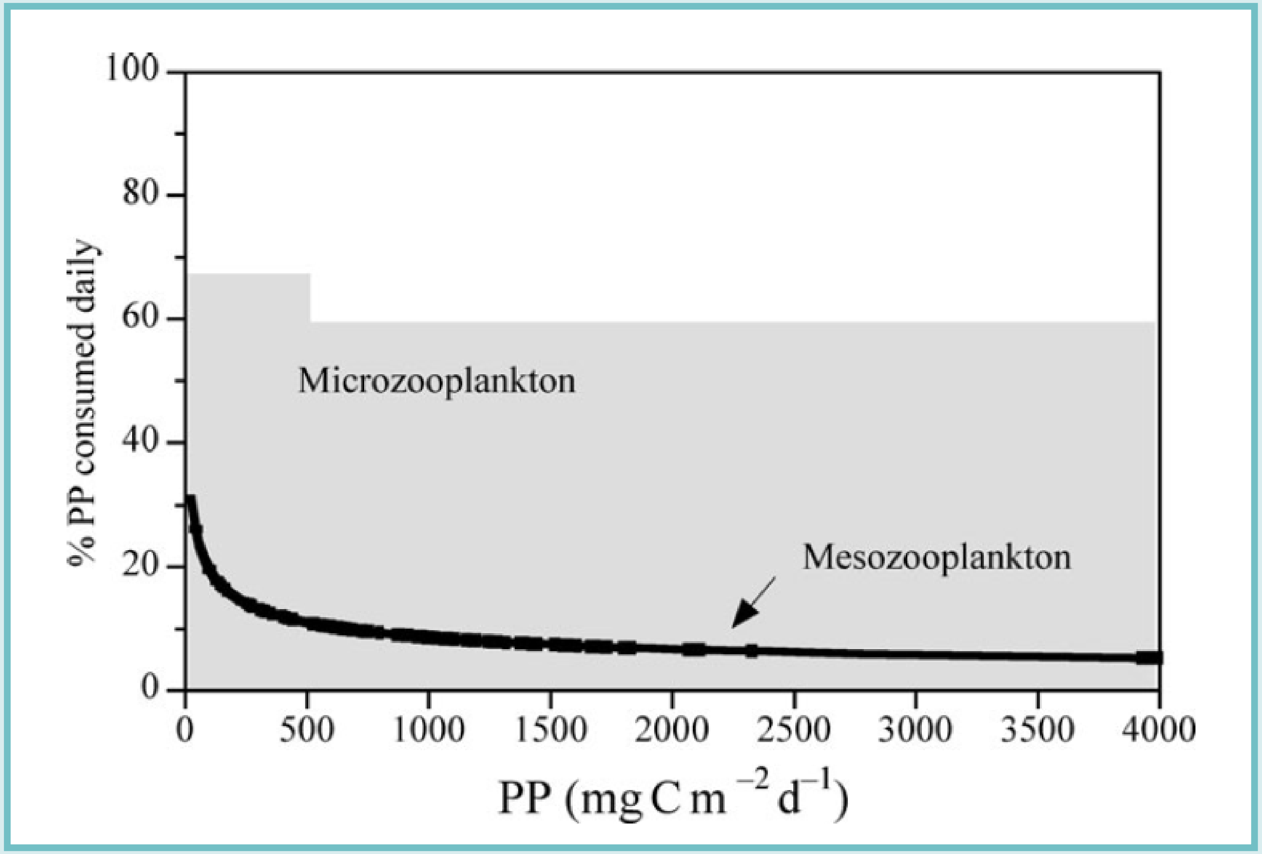
Conclusions: OA & warming

- Warming affects MZP timing, growth, community composition and succession
- Warming leads to reduced time-lags between phytoplankton and MZP
- Reduced temporal occurrence of MZP with warming
- Stronger top-down control by copepods on MZP at high temperature conditions
- High tolerance of MZP to changes in pCO_2 (peak timing, biomass and community composition remained unaffected)

Key role of microzooplankton (MZP)



Zooplankton grazing on phytoplankton



Calbet et al. 2008

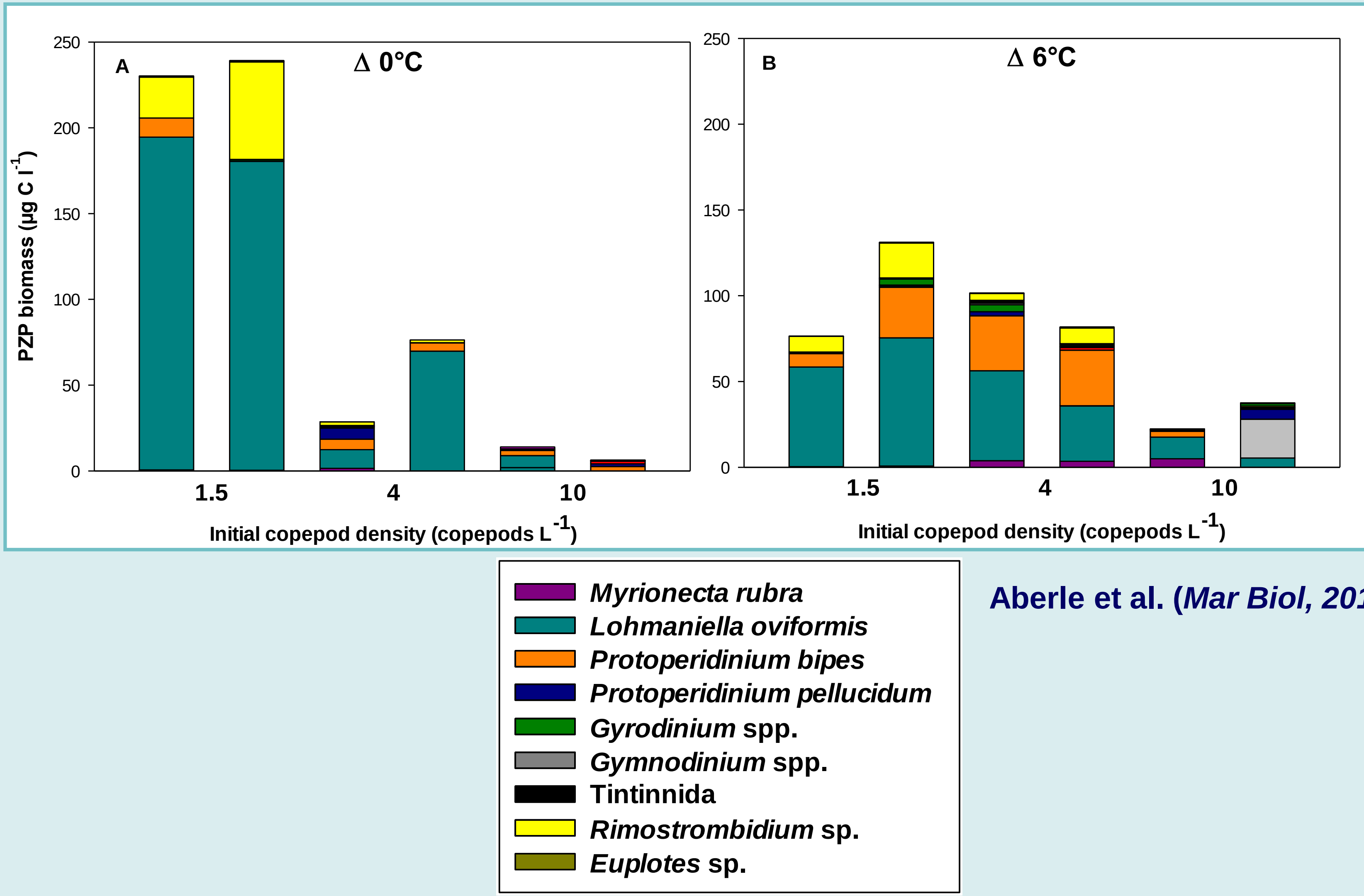
60% of the primary production consumed daily by MZP and only 10% by mesozooplankton

WINTER WARMING SZENARIO

Warming will lead to:

1. Reduced time-lags between autotrophic and heterotrophic processes with warming
2. Shifts in timing and magnitude of MZP biomass
3. Stronger top-down bloom control by MZP
4. Enhanced trophic overlap and dietary competition between MZP and mesozooplankton

PZP community composition

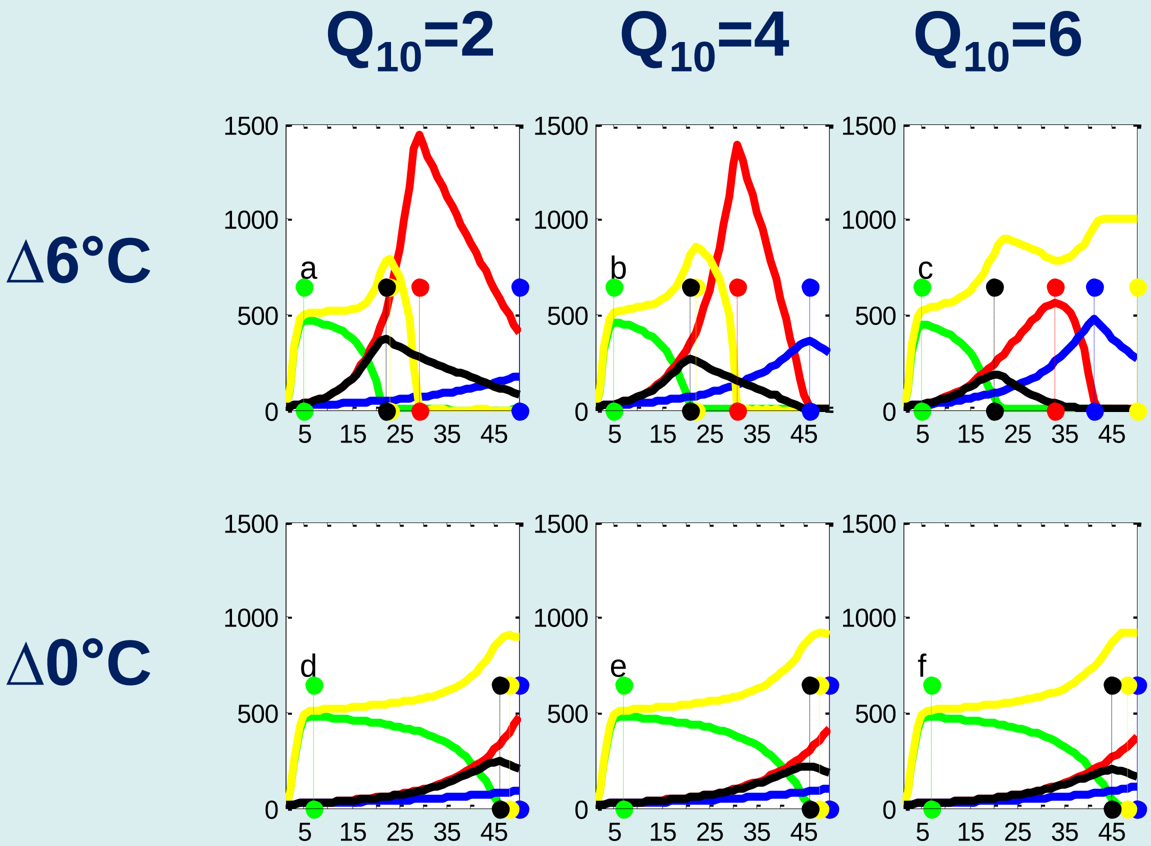


Aberle et al. (*Mar Biol, 2012*)

→ Strong suppression of the ciliate *Lohmaniella oviformis*

Predator prey model (2008)

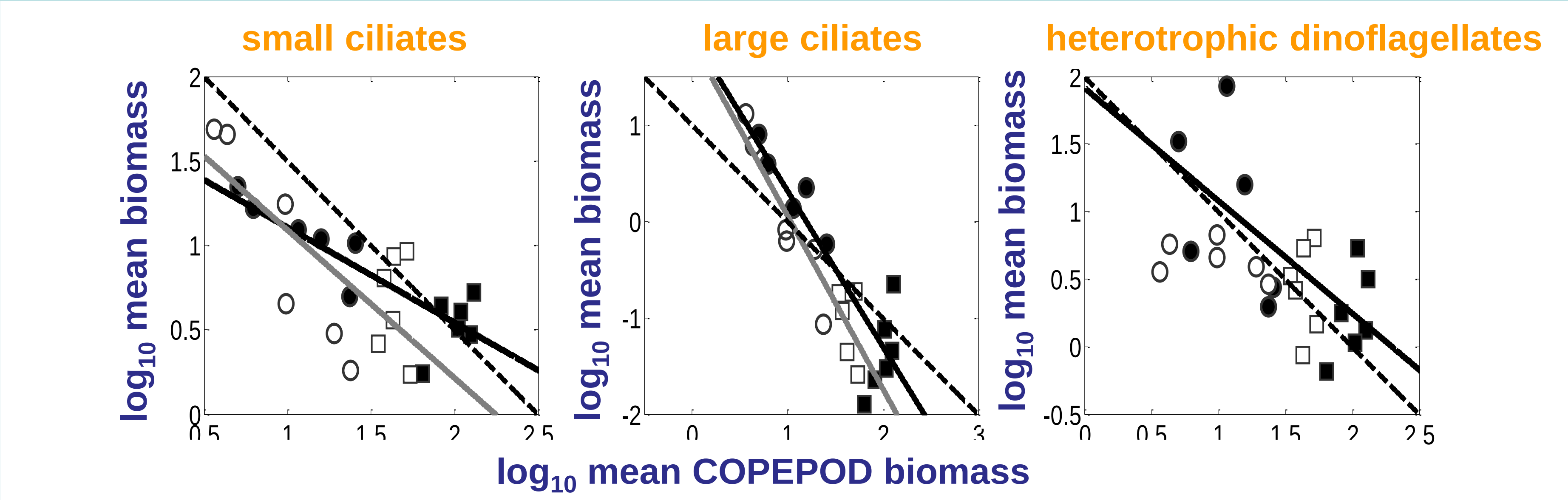
Time course of small algae (yellow), diatoms (green), ciliates (red), dinoflagellates (black) and copepods (blue)



Aberle et al.
***Mar Biol* 2012**

→ With increasing Q_{10} of copepods a tighter coupling between PZP and copepods occurs (strong top-down control of PZP)

Relationship MZP-copepods

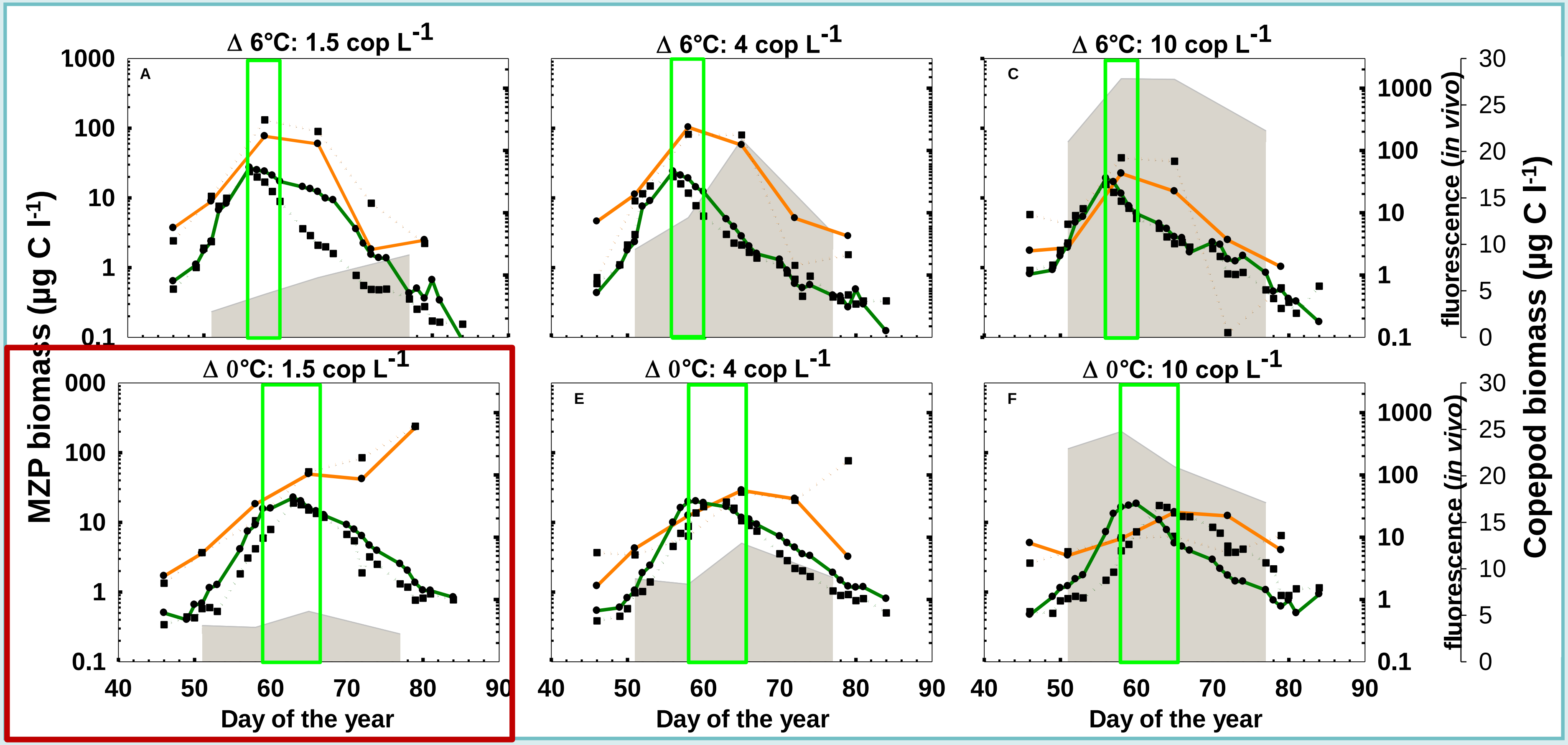


- **Mean biomass of small (CS) and large ciliates (CL) and heterotrophic dinoflagellates (DINO)**
- **Black (ΔT=4°C, ΔT=6°C) and grey (ΔT=0°C, ΔT=2°C) linear regressions ($P<0.05$)**

→ Strong suppression by coperpods

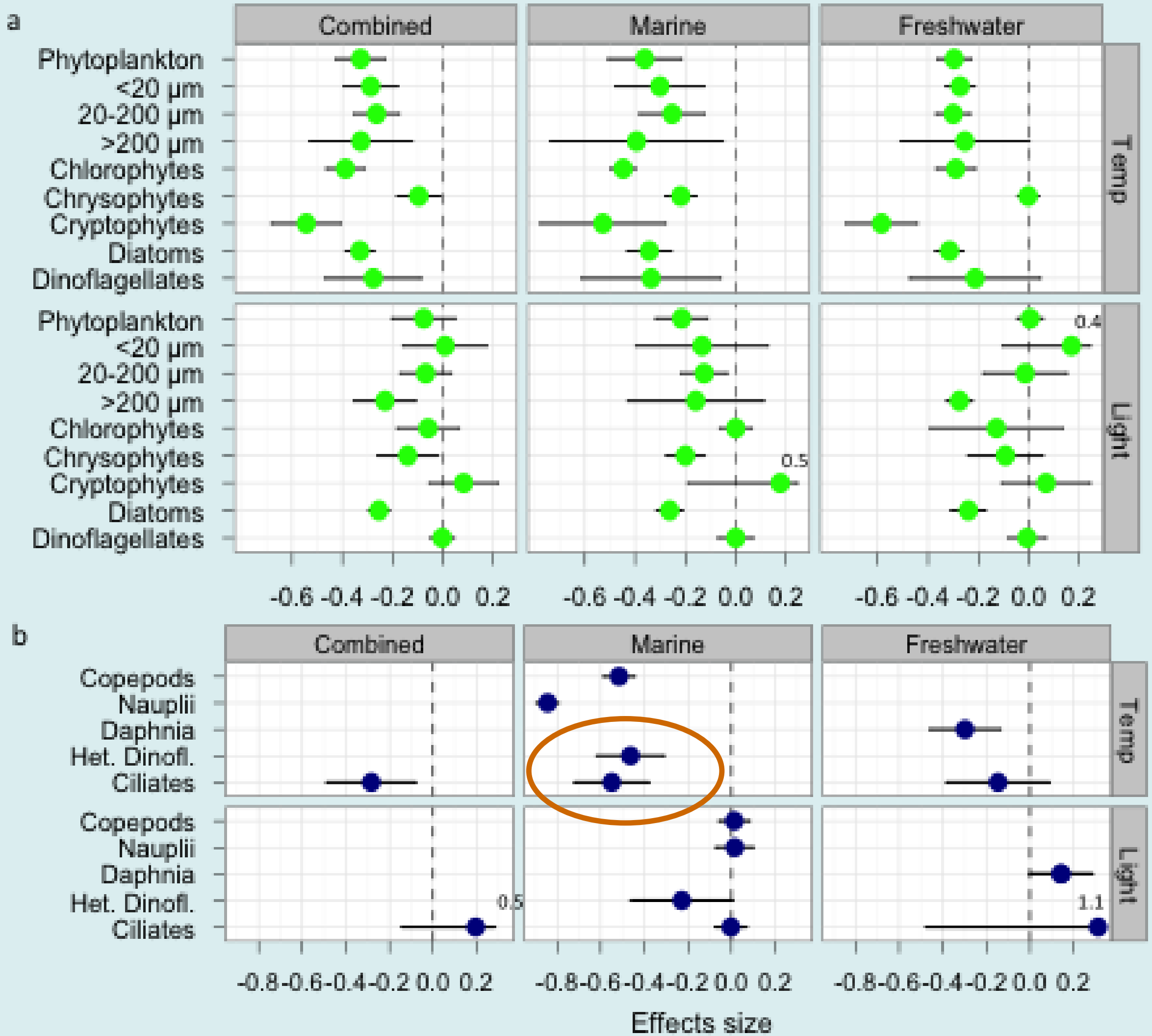
Klauschies et al. (*Mar Biol 2012*)

Plankton succession (2009)



→ **No top-down control of MZP at low temperatures + copepod density**

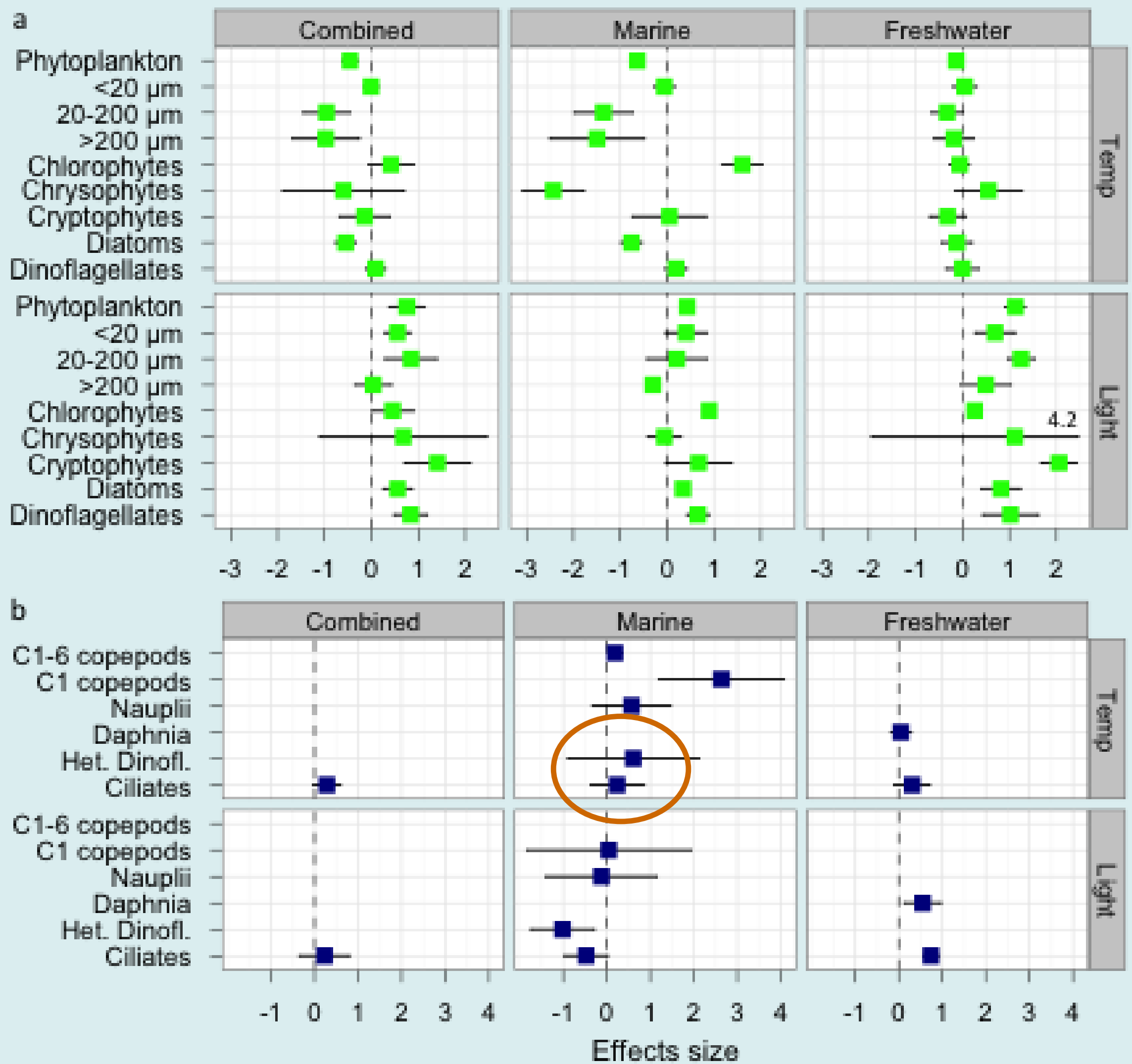
Peak timing (2005-2009)



Winder et al.
***Mar Biol* 2012**

→ Advanced peak timing of PZP

Peak magnitude (2005-2009)



Winder et al.
***Mar Biol* 2012**

→ No impact on peak magnitudes of PZP