



Fluidity of the freshwater seasons

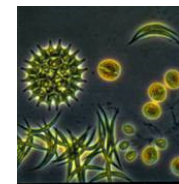
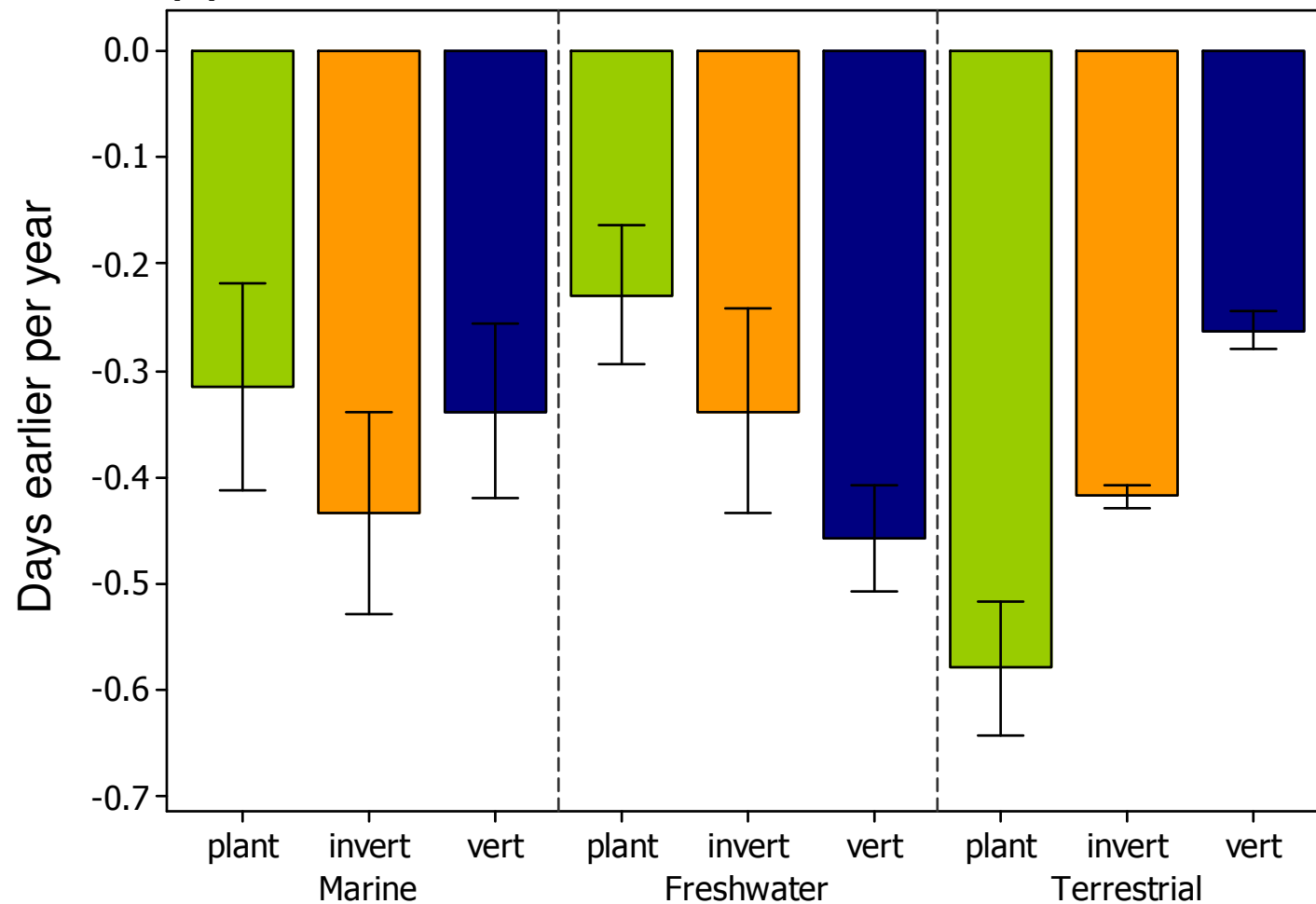
Steve Thackeray

(and many more...)

sjtr@ceh.ac.uk

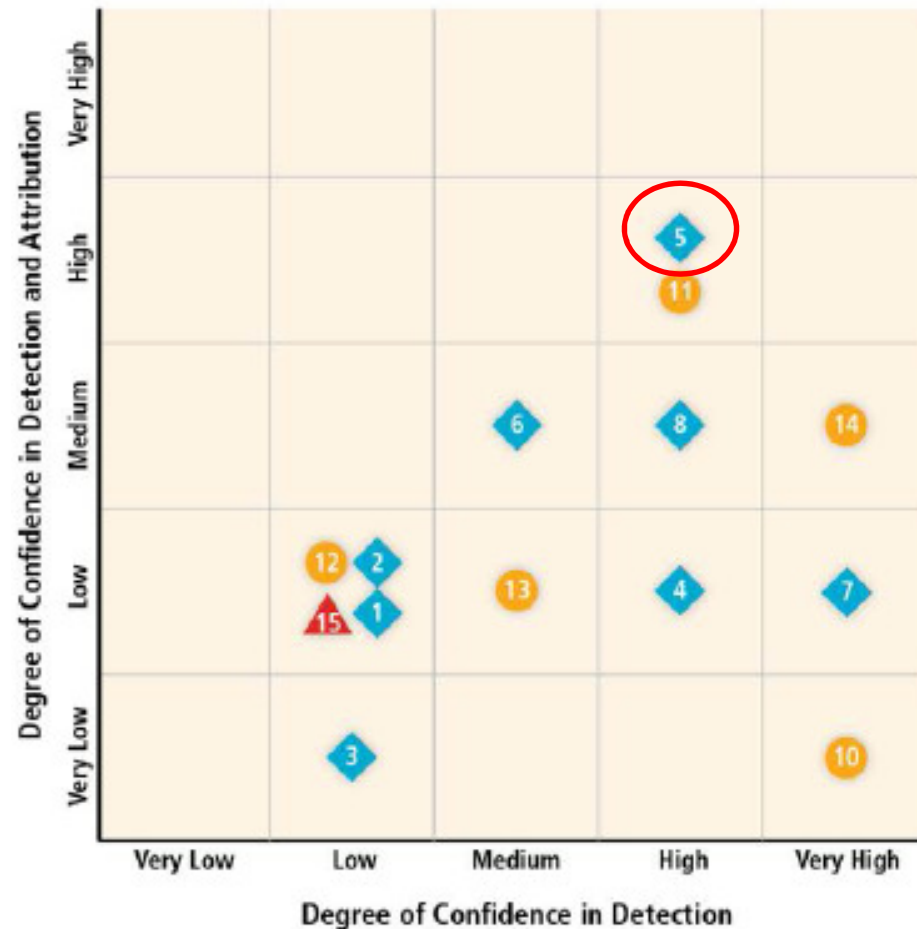
@SteveThackeray, #CumbLakeRF

Shifts in the UK seasons



Thackeray et al (2010), *Global Change Biology*, **16**, 3304-3313.

The “fingerprint” of climate change

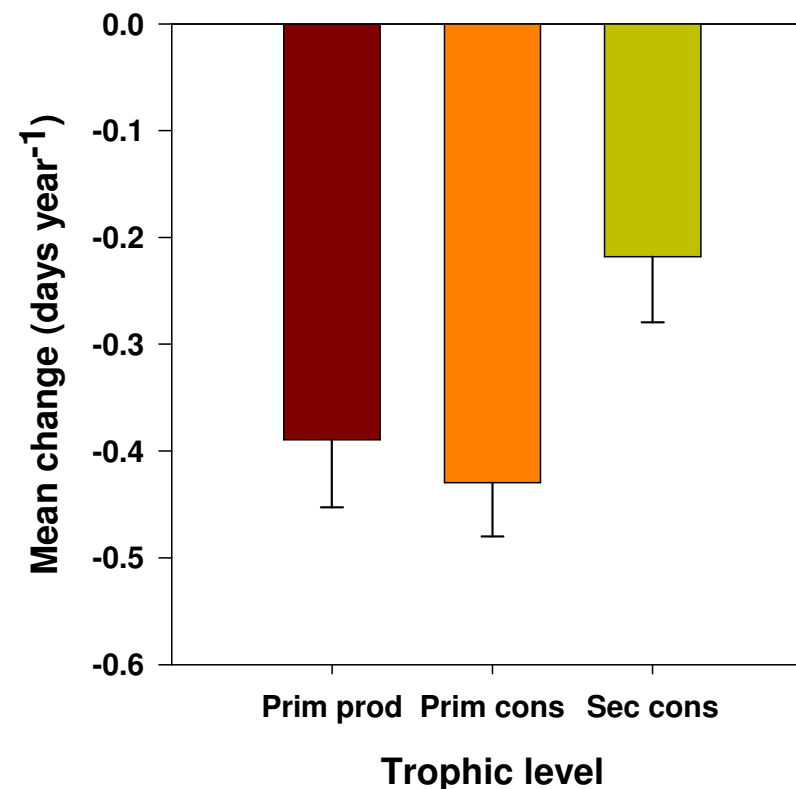
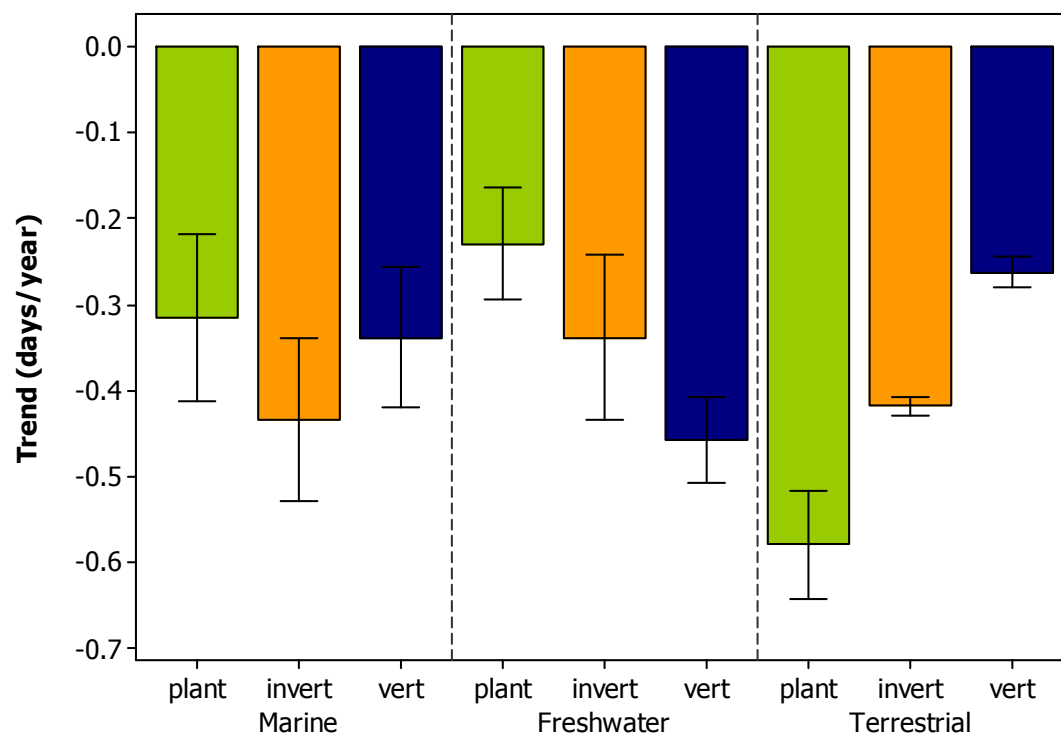


- ◆ **Evidence of Change in Species and Ecosystems**
 1. Changes in Evapotranspiration
 2. Increased tree mortality
 3. Increased extinctions
 4. Increased primary productivity & carbon stocks
 5. Changes in phenology
 6. Species range shifts
 7. Invasive species
 8. Flow related impacts on freshwater ecosystems
- **Impacts on Major Systems including early signs of regime shifts**
 10. Cultural Landscapes – species composition changes
 11. Tundra – increase in shrubs, melting of permafrost
 12. Boreal – tree mortality
 13. Amazon – tree mortality
 14. Savannas – woody encroachment
- ▲ **Adaptation**
 15. Evolutionary & genetic adaptation

IPCC WGII AR4, Chapter 4.

UK-scale changes, by trophic level

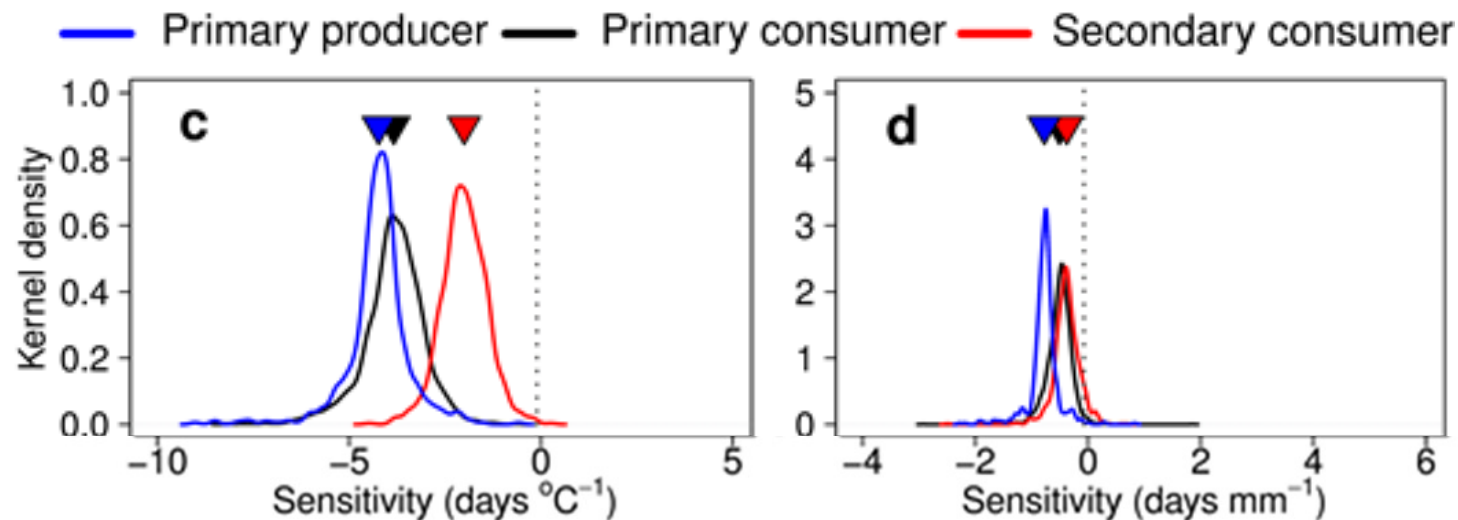
Based upon >25,000 phenological trends for >700 marine, freshwater and terrestrial species...



Thackeray et al (2010), *Global Change Biology*, **16**, 3304-3313.

Climate sensitivity, by trophic level

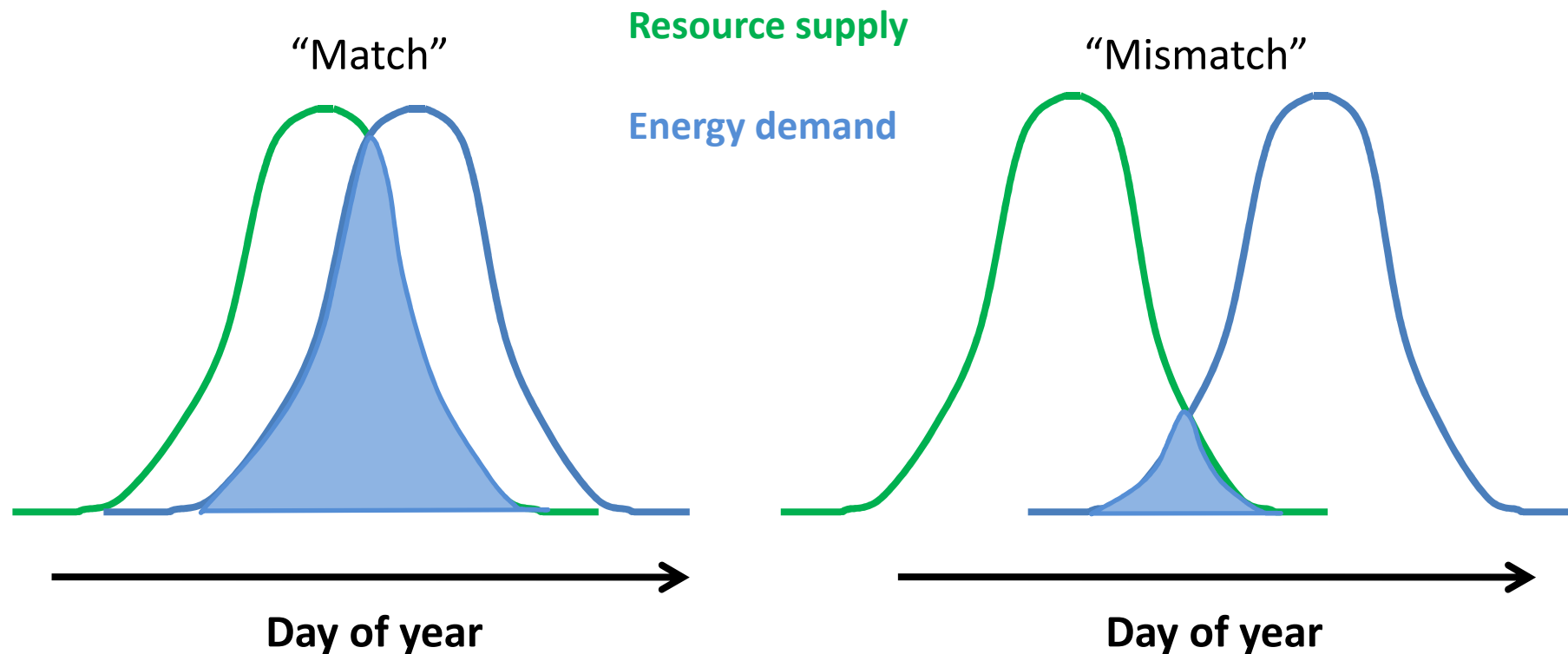
Climate sensitivity lowest for secondary consumers (top predators).



Thackeray et al (2016) *Nature* **535**: 241-245

Phenology and synchrony

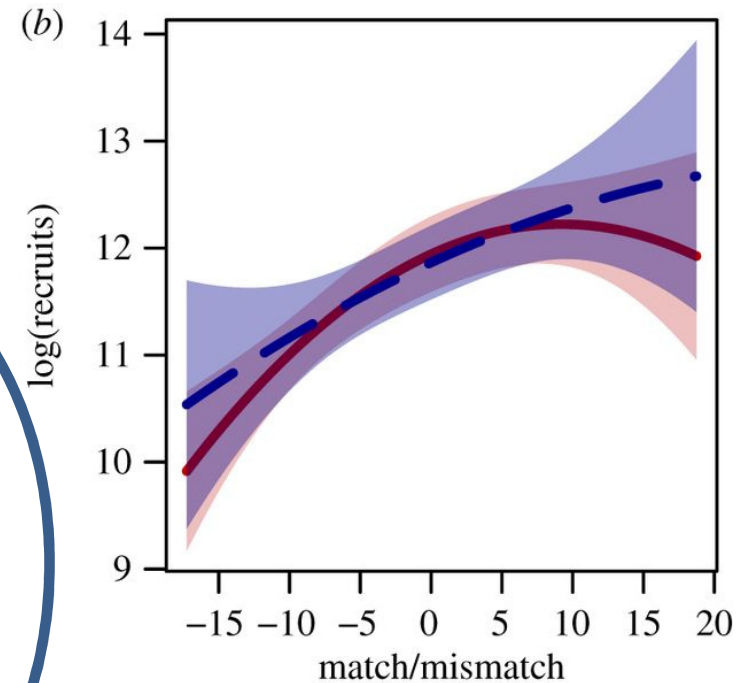
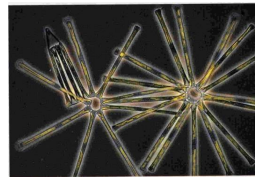
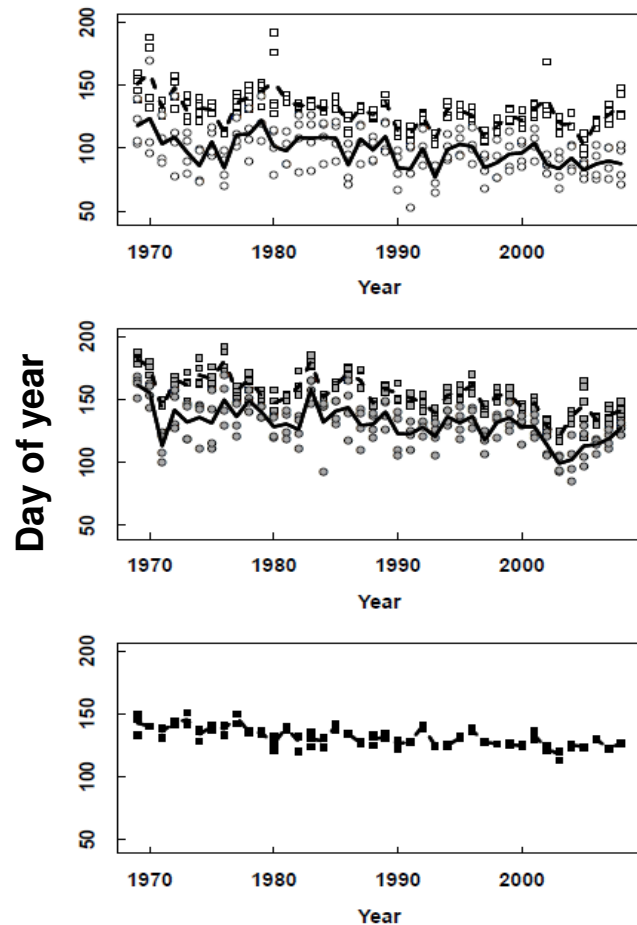
Synchronisation of species interactions: the Match-Mismatch Hypothesis (Cushing 1969).



Cushing (1969) J. Cons. Int. Explor. Mer. 33: 81-92

Climate and loss of synchrony

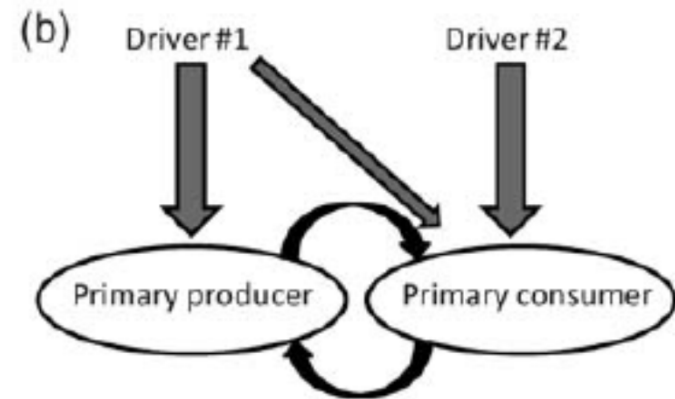
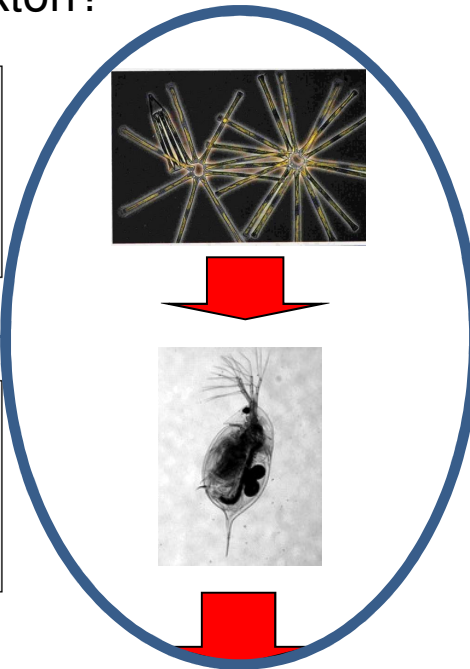
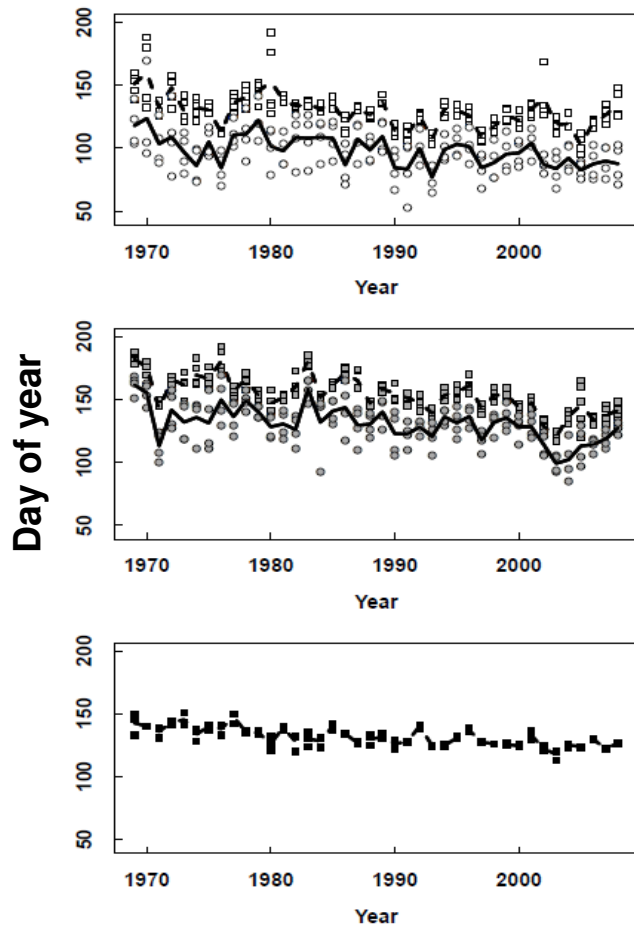
Mismatching of fish reproduction and plankton food peaks



- Thackeray et al. (2013) *Global Change Biology*, **19**: 3568-3580
- Ohlberger et al (2014), *Proc. R. Soc. B*, **281**, 20140938.

Climate and loss of synchrony

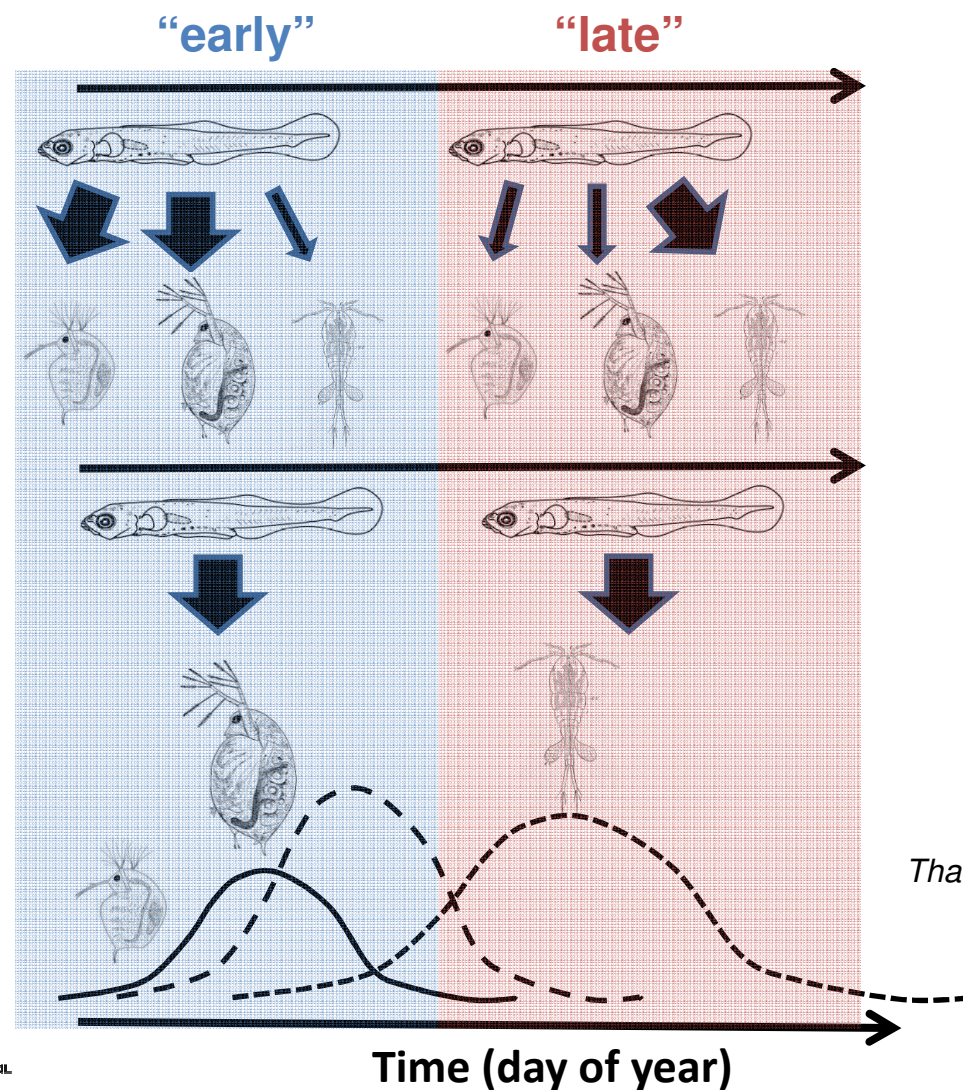
Mismatching within the plankton?



- Thackeray (2012) *J Plankt Res*, **34**: 1001-1010
- Thackeray et al. (2013) *Global Change Biology*, **19**: 3568-3580

Adopting a food-web perspective

How will this impact on energy flow and food web structure?



Thackeray (2016) *Biology Letters* 12:
DOI: 10.1098/rsbl.2016.0181

Lakes are valuable models for phenology

- To investigate and understand climate change effects on seasonality and food webs, we need:
 - Year-round monitoring
 - Information on environmental drivers of change and species responses
 - Information on species throughout the food web
 - Measures of population growth/fitness/reproduction

