

SHIFTING SEASONS IN THE PELAGIC: EXPANDING OUR ECOLOGICAL PERSPECTIVE

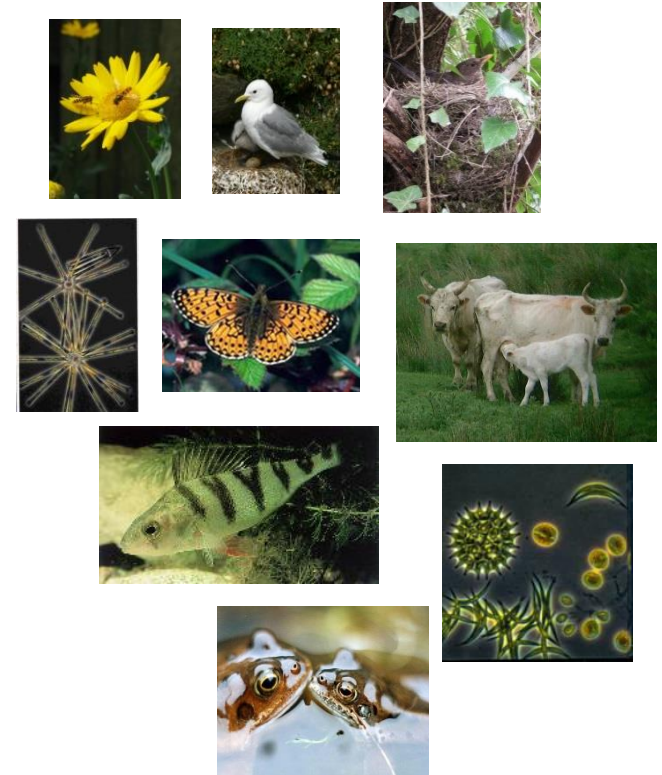
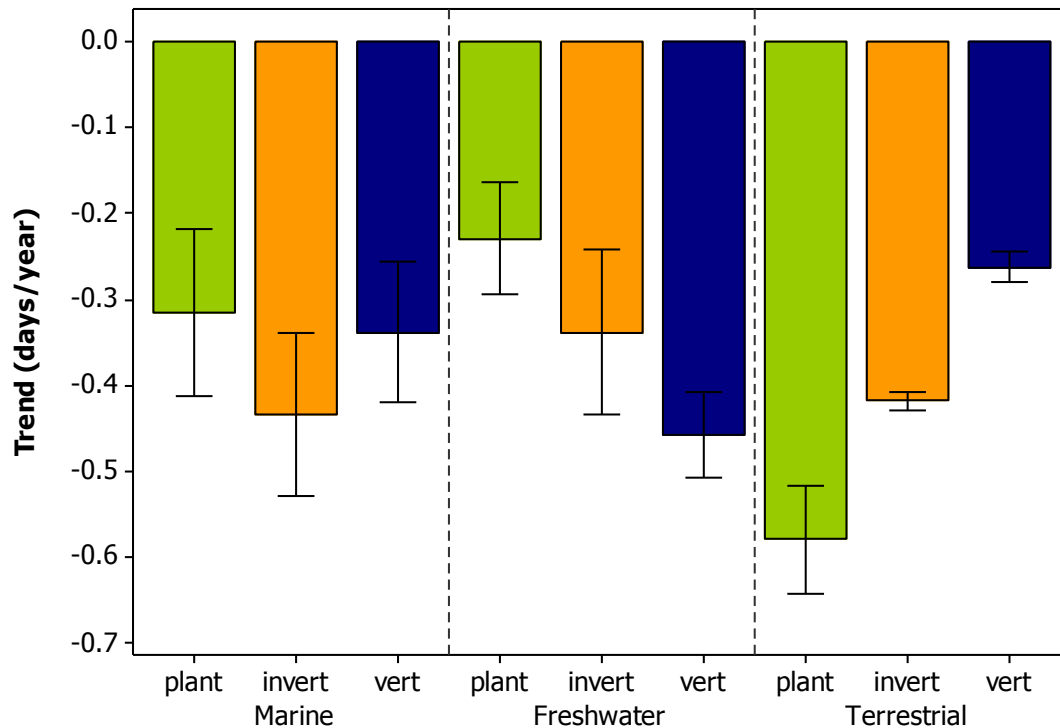
Stephen Thackeray (and many others....)

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@SteveThackeray

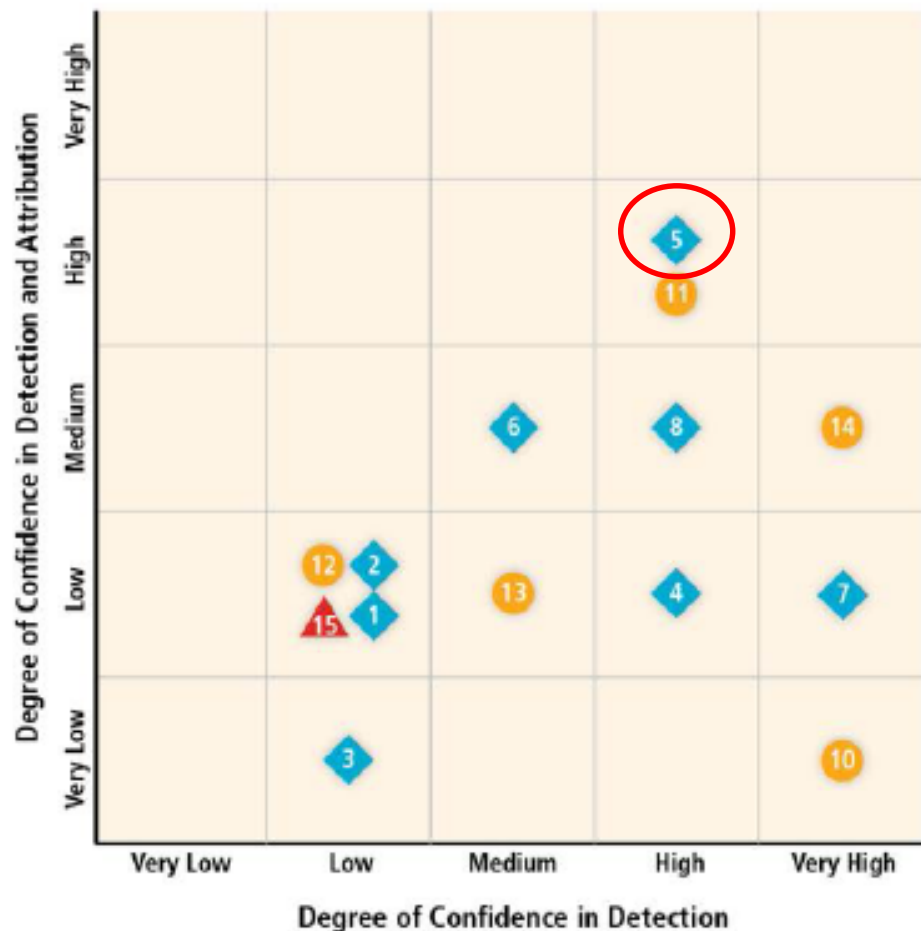
Shifting seasons

- The study of the timing of natural events (egg laying, flowering, migration).
- Many spring events have been getting earlier – linked to climate change.



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

Phenology and climate change

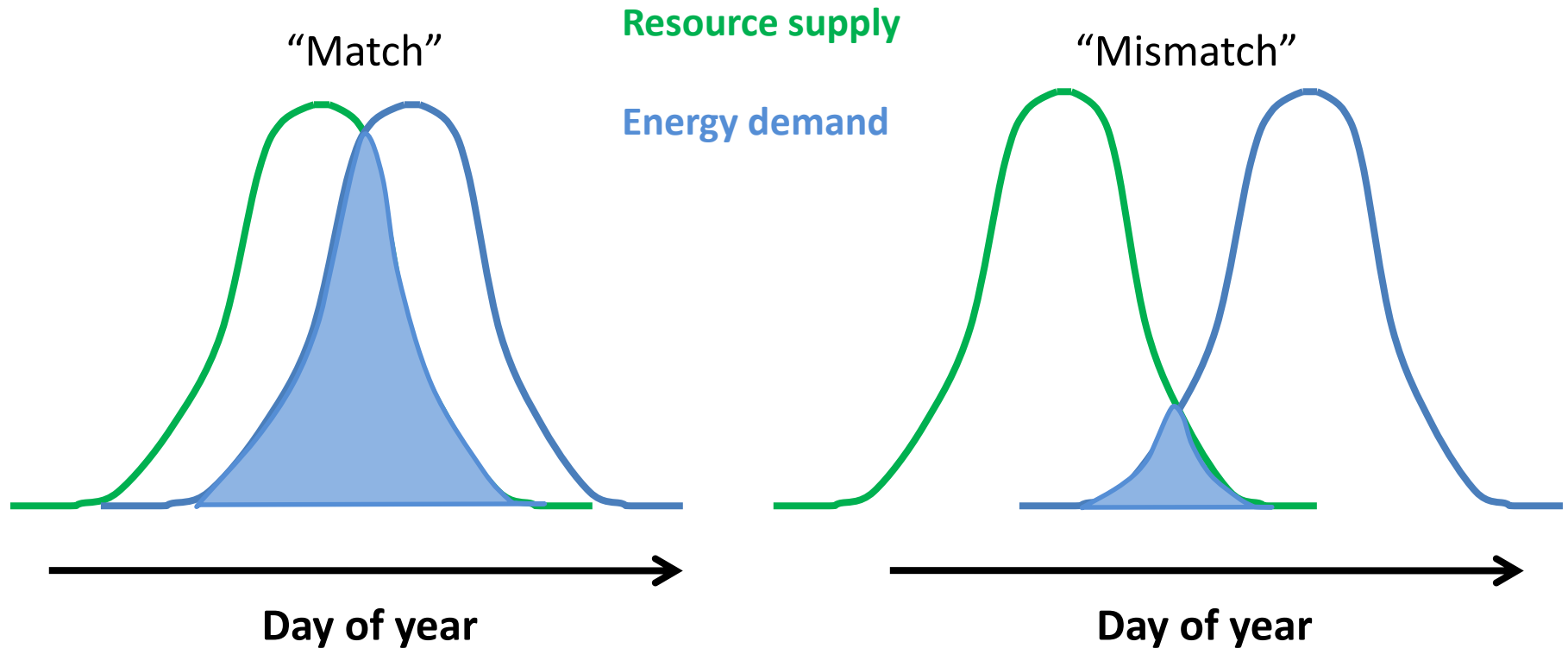


- ◆ **Evidence of Change in Species and Ecosystems**
 - 1. Changes in Evapotranspiration
 - 2. Increased tree mortality
 - 3. Increased extinctions
 - 4. Increased primary productivity & carbon stocks
 - 5. Changes in phenology
 - 6. Species range shifts
 - 7. Invasive species
 - 8. Flow related impacts 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.

Why is phenology important?

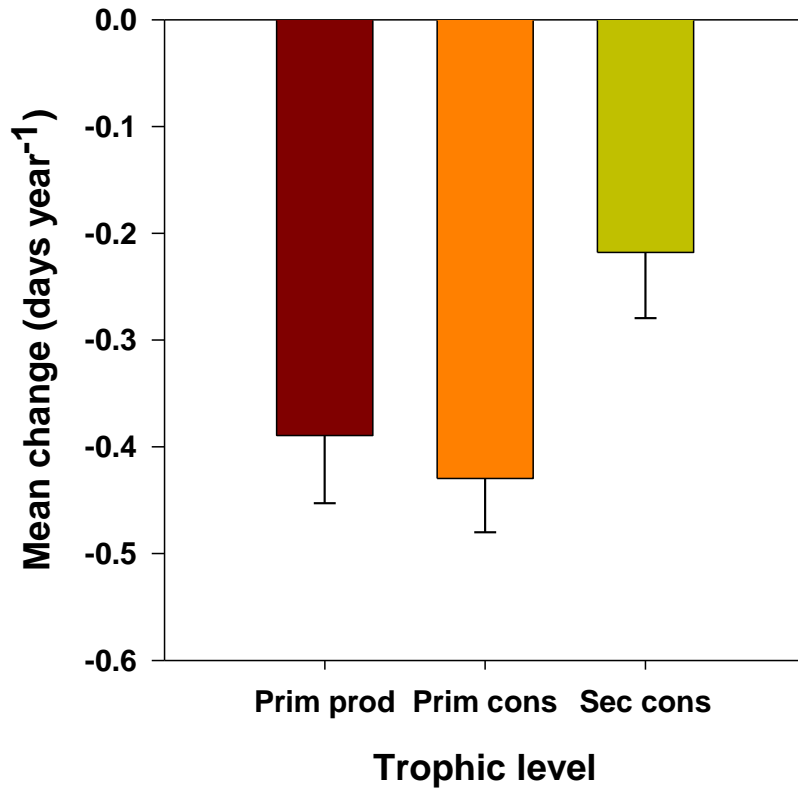
Synchronisation of species interactions: the Match-Mismatch Hypothesis



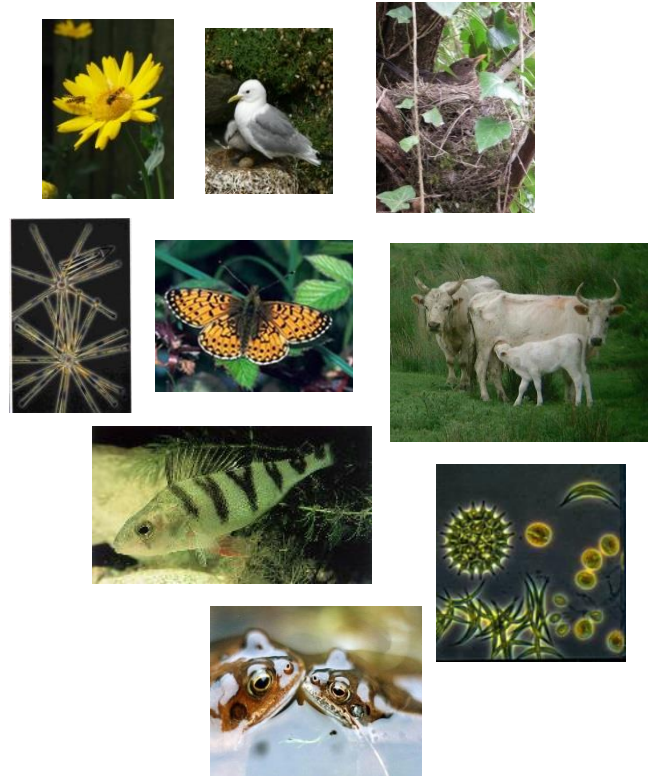
Cushing (1969) *J. Cons. Int. Explor. Mer.* **33**: 81-92

Is de-synchronisation occurring?

- Differences in rates of change among trophic levels at broad scales

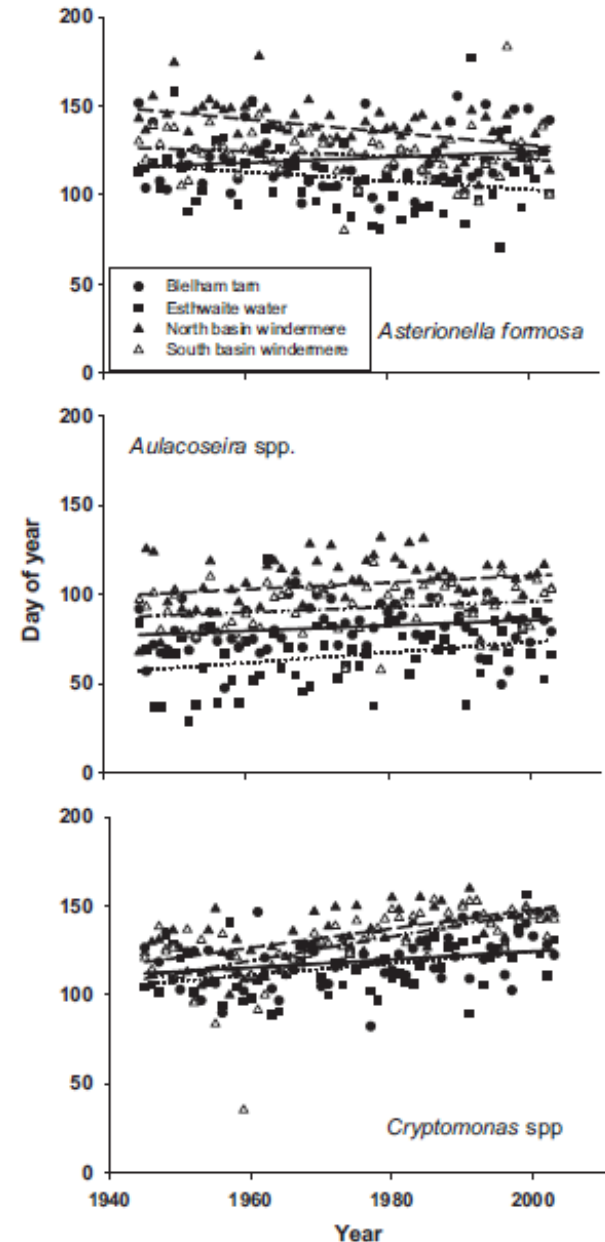
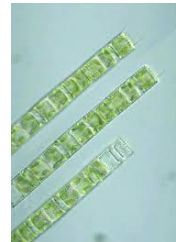
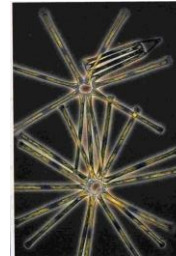


Thackeray et al (2010), *Global Change Biology*, **16**, 3304-3313.



Phenology and lakes: what do we know?

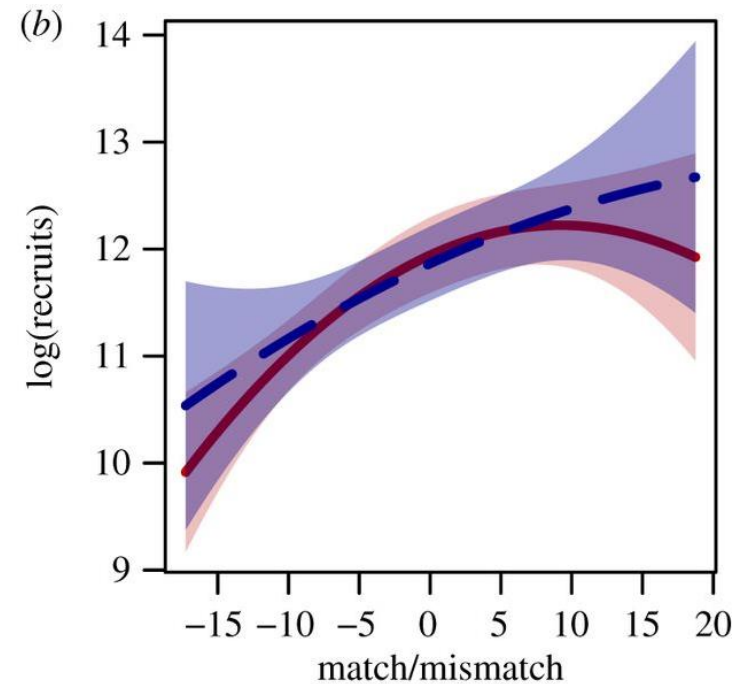
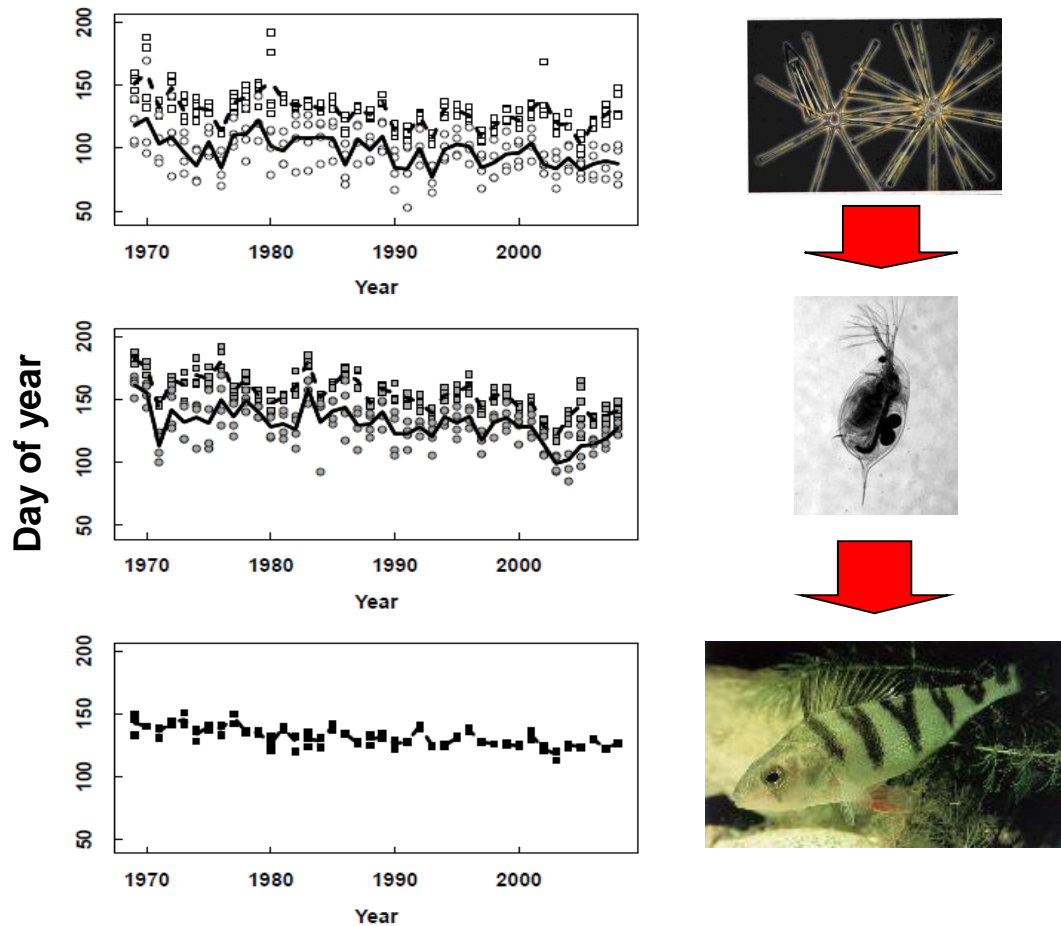
- Plankton seasonality is changing.
- Drivers are climatic and non-climatic.
- Species' responses differ.



Feuchtmayr et al (2012),
Freshwater Biology,
57, 331-344.

Is de-synchronisation occurring?

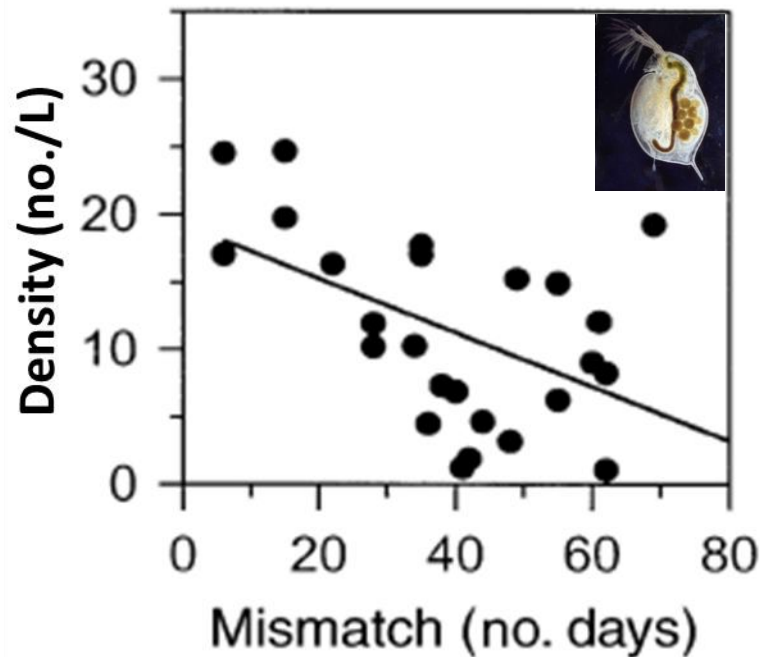
- Mismatching of fish reproduction and plankton food peaks



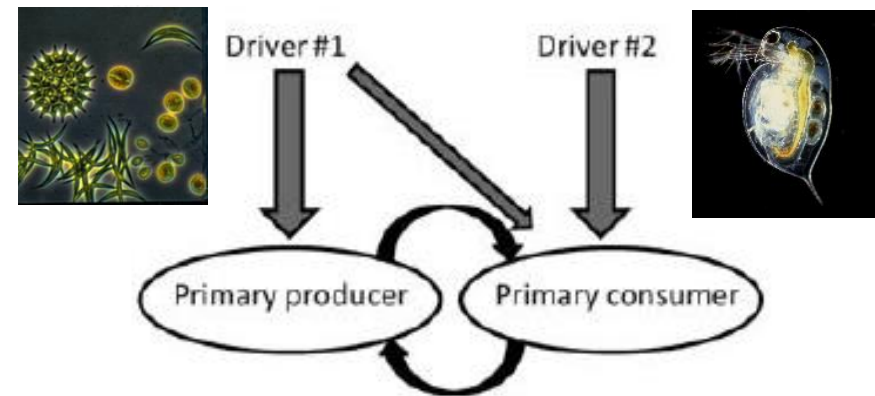
- Thackeray et al. (2013) *Global Change Biology*, **19**: 3568-3580
- Ohlberger et al (2014), *Proc. R. Soc. B*, **281**, 20140938.

Is de-synchronisation occurring?

- Less evidence at plankton grazer-producer interface



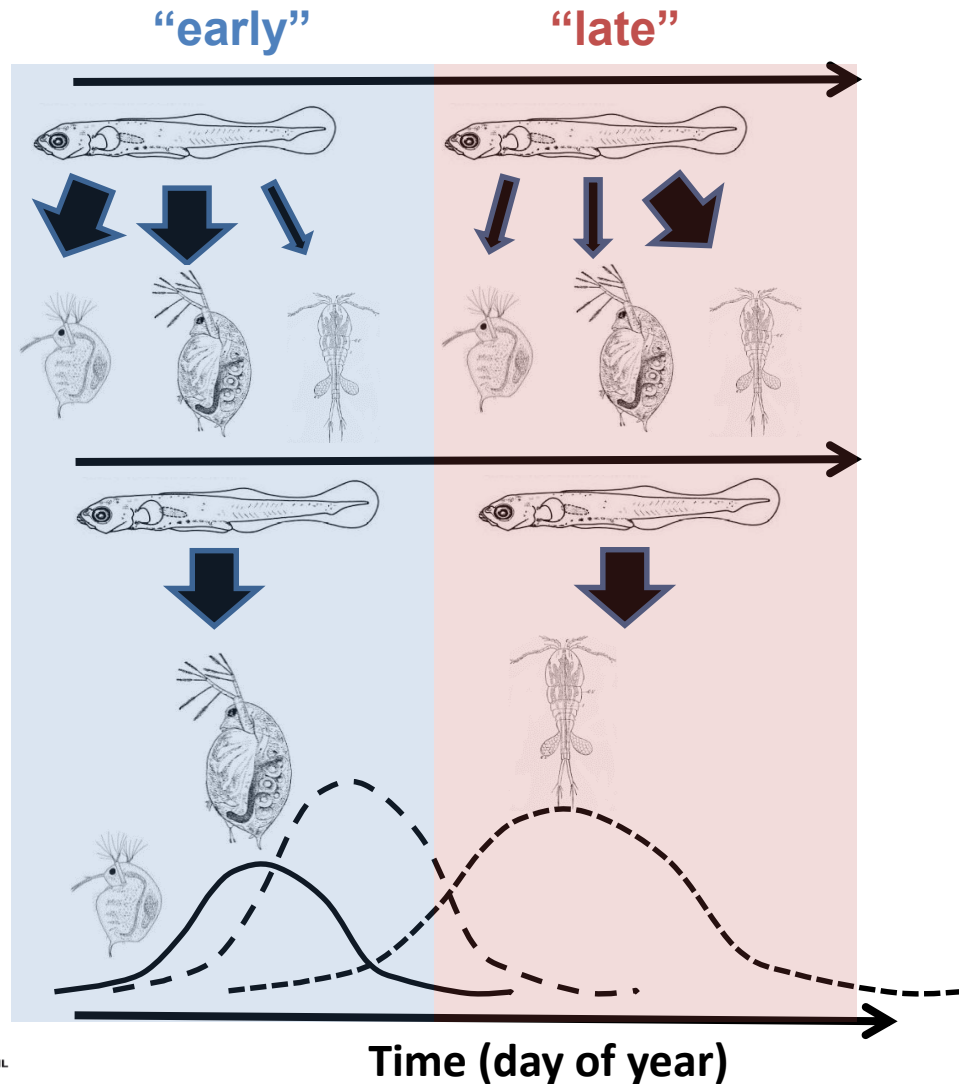
Winder & Schindler (2004)
Ecology **85**: 2100-2106



Thackeray (2012), *J Plankt Res.*,
34, 1001-1010

Adopting a food-web perspective

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



Spatial variation in seasonality (globally)



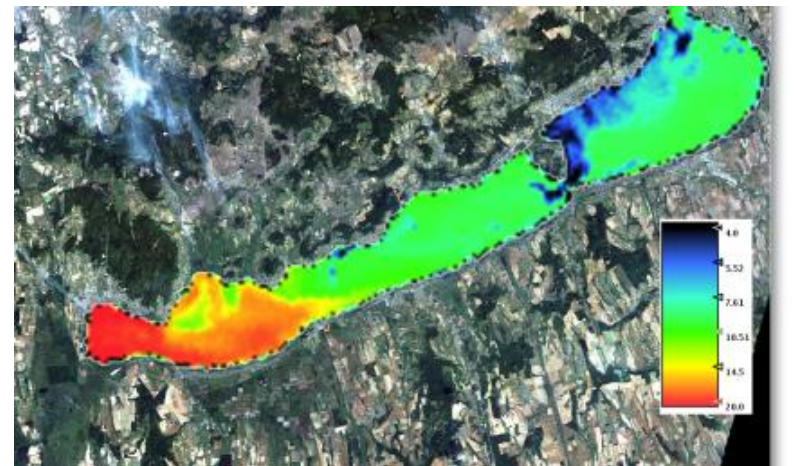
GloboLakes

Global Observatory of Lake Responses to Environmental Change



<http://www.globolakes.ac.uk>
@globolakes

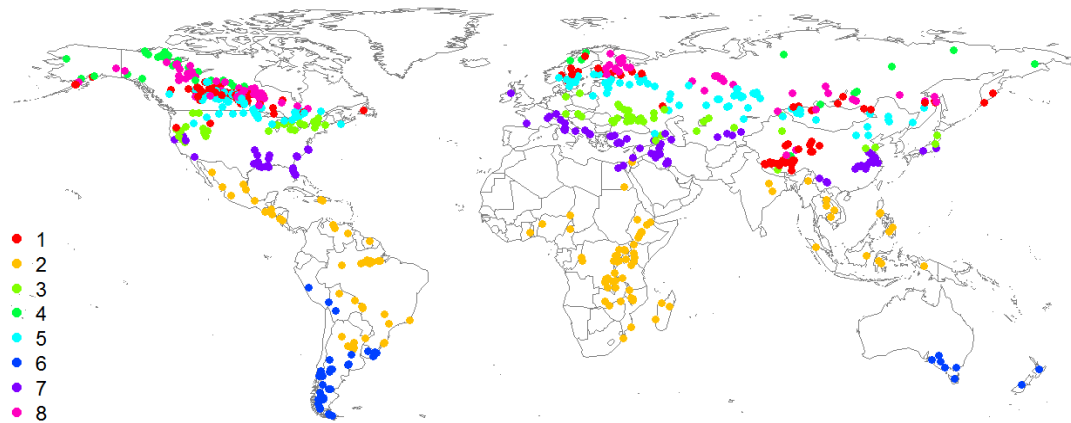
"The 1000 Lakes"



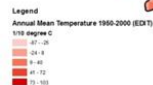
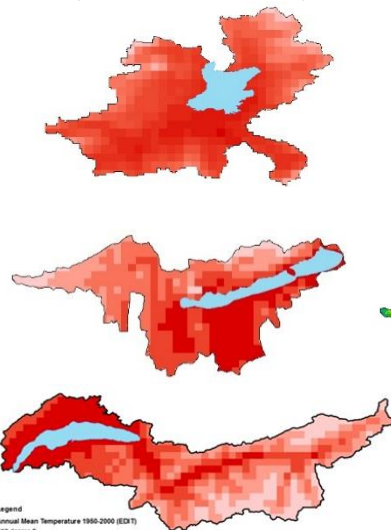
**Centre for
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NATURAL ENVIRONMENT RESEARCH COUNCIL

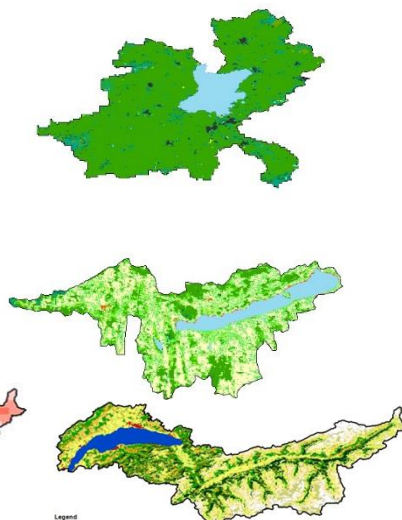
A spatially-resolved approach



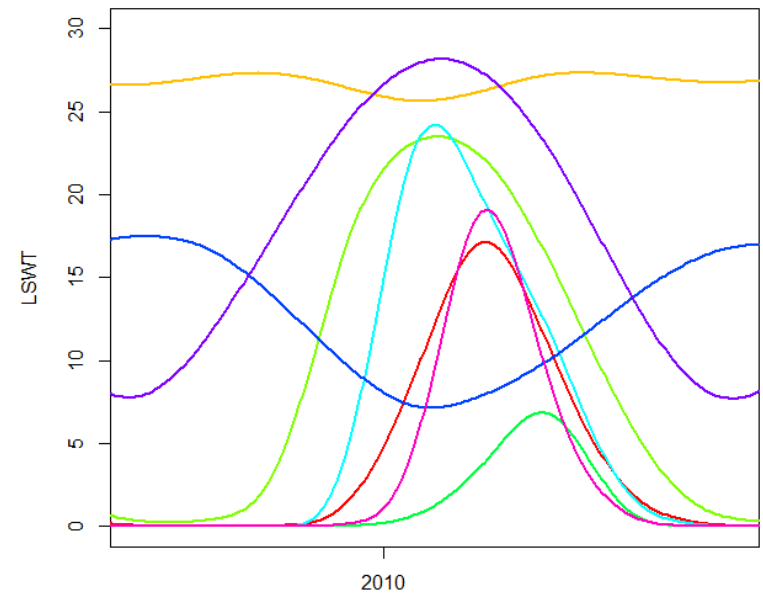
Air temperature
(WorldClim, 1950-2000)



Land cover
(ESA GlobCover 2009)

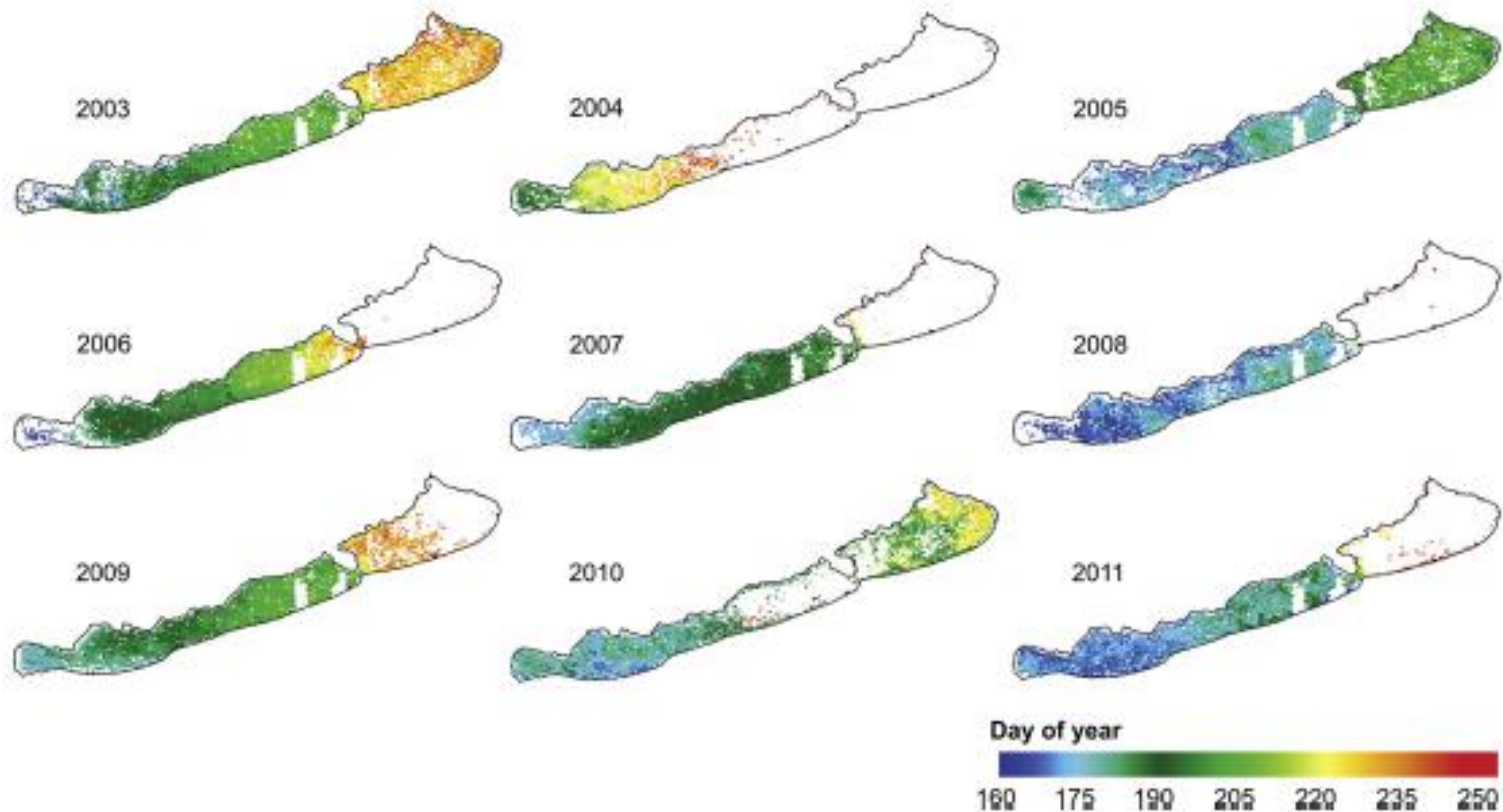


Insights into underlying
drivers of seasonality



Spatial variation in seasonality (in lakes)

Summer bloom start timing

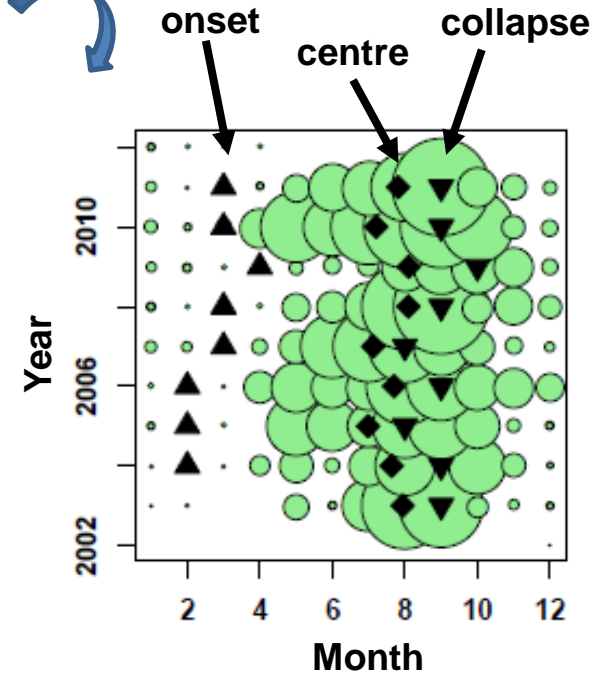
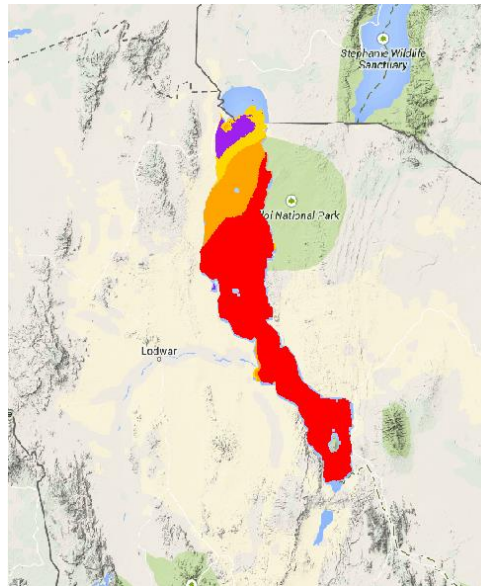


Palmer et al. (2015) *Remote Sensing of Environment* **158**, 441-452

Plankton phenology metrics

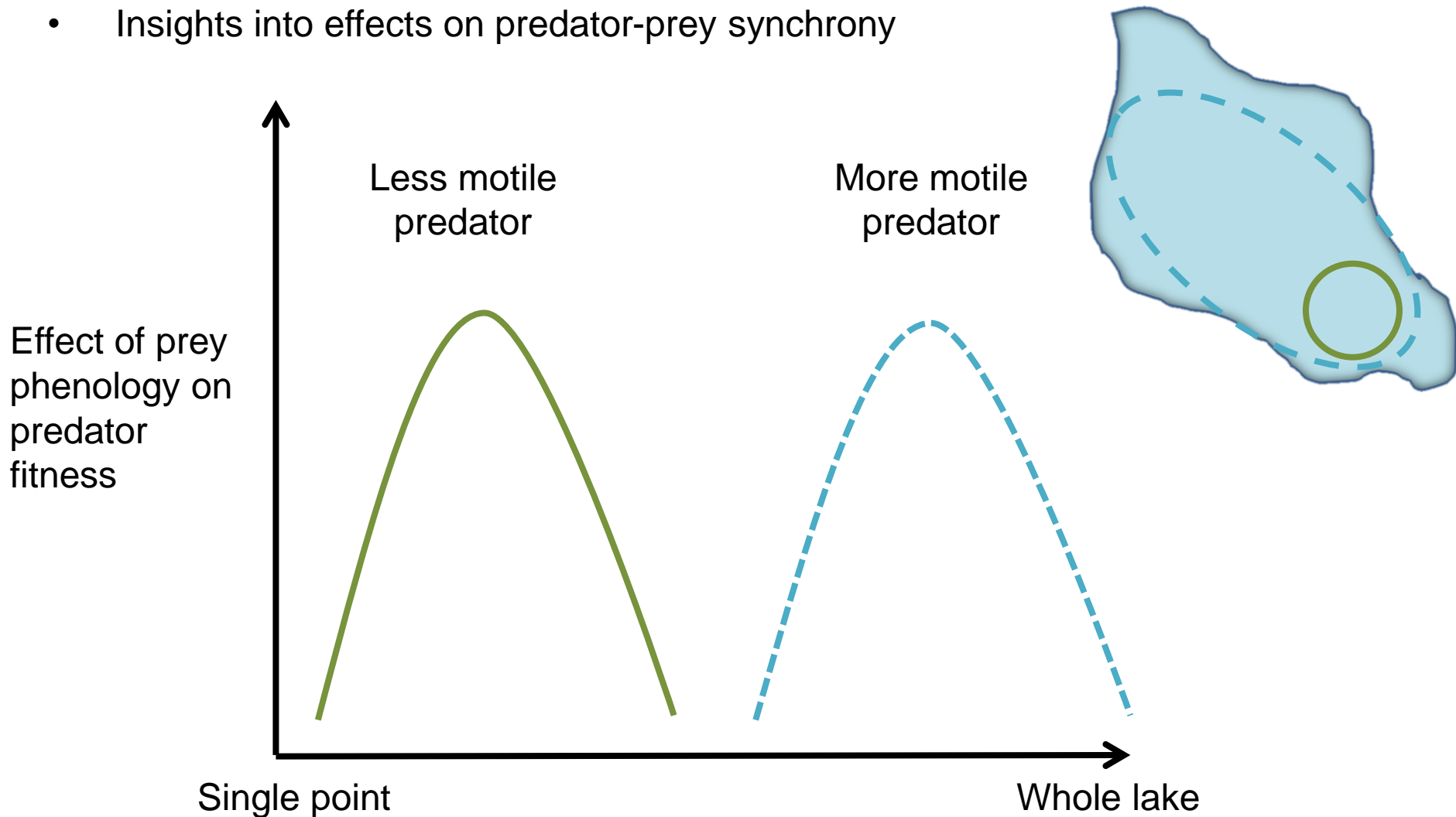


Avery (2013) What Future for Lake Turkana? University of Oxford



A spatially-resolved approach

- Insights into effects on predator-prey synchrony



Summary

- Seasons are shifting beneath the waves, just as much as on land.
- Great among-species variation in the extent of change.
- Need to move beyond detection of change to understand ecosystem consequences.....
 -for predator-prey synchrony, this requires a food web approach.
- Earth observation will allow us to examine the spatial dimension of phenological change, within and among lakes
 -new insights into drivers of seasonality and impacts of synchrony