Patterns and drivers of community-level phenological change in the English Lake District

Ellie Mackay, Stephen Thackeray & Peter Henrys
Lake Ecosystems Group,
CEH Lancaster, UK
ellcka@ceh.ac.uk

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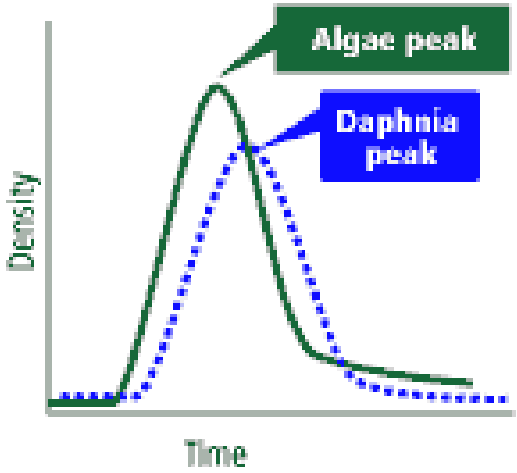
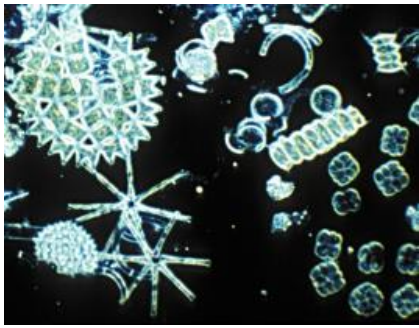
Structure

- What is phenology?
- Project Aims
- Study area and data
- Classifying plankton phenology
- Results
- Next steps

What is phenology?

- The timing of seasonal events:
  - Bud burst
  - Egg laying and hatching
  - Plankton blooms
  - Fish spawning
  - Insect emergence





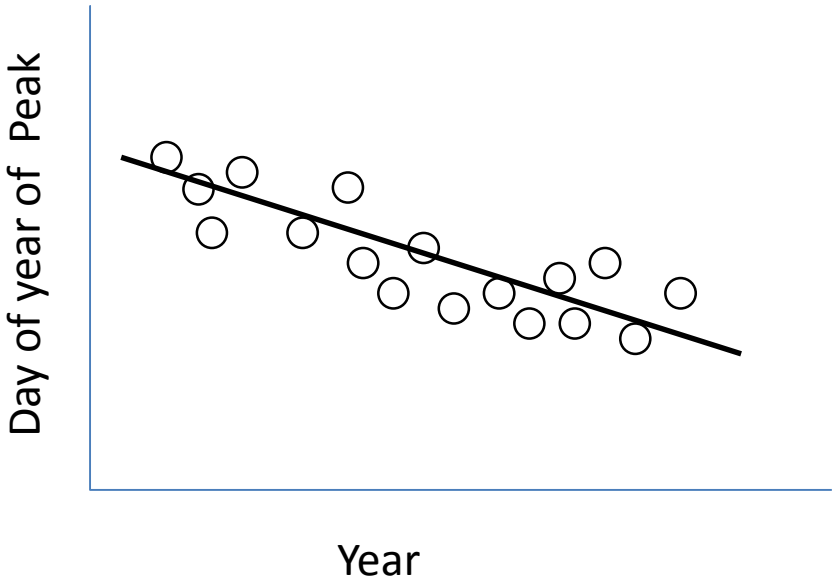
Plankton community phenology

- Aims:

  1. Estimate an index of seasonal timing to quantify average phenological trends

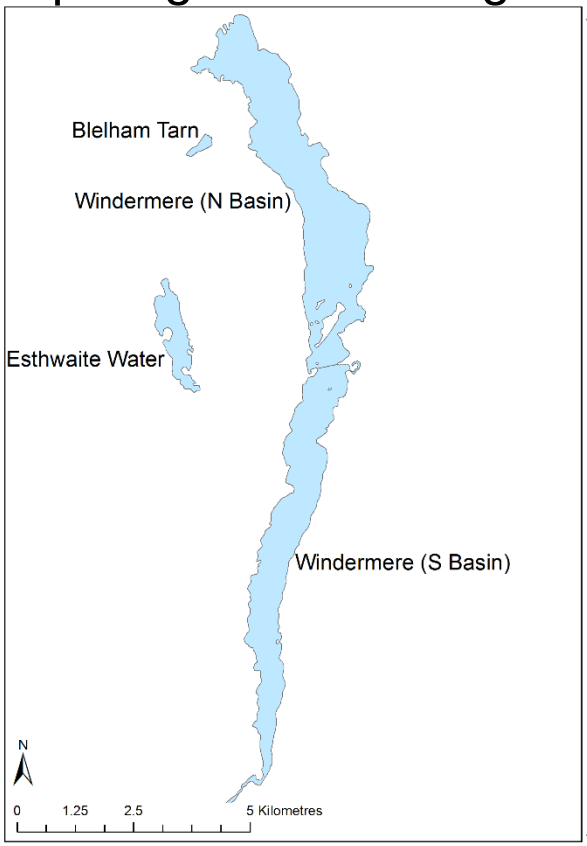
  2. Investigate whether trends vary with different plankton functional traits

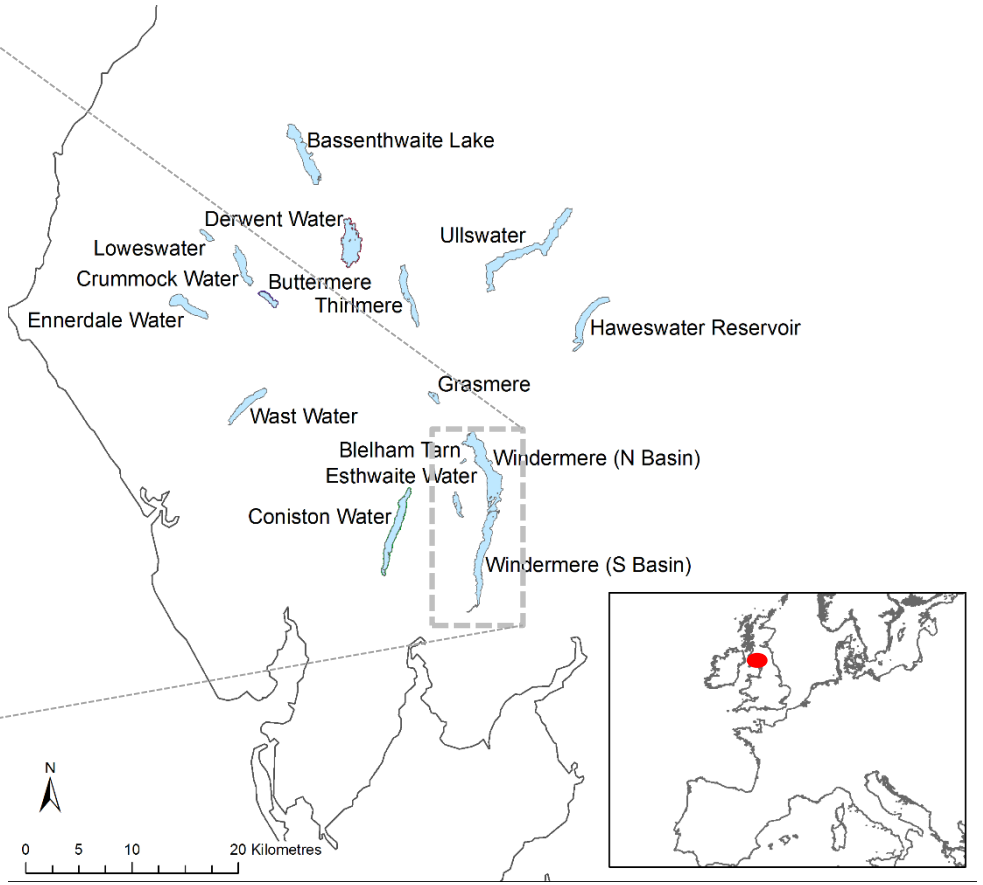
  3. Investigate importance of different drivers of change



Study area

- North west United Kingdom
- 4 lakes – Blelham Tarn 0.1 km^2, Esthwaite Water 1 km^2, Windermere South Basin 6.7 km^2, Windermere North Basin 8.1 km^2
- Trophic gradient – Oligo-mesotrophic to eutrophic





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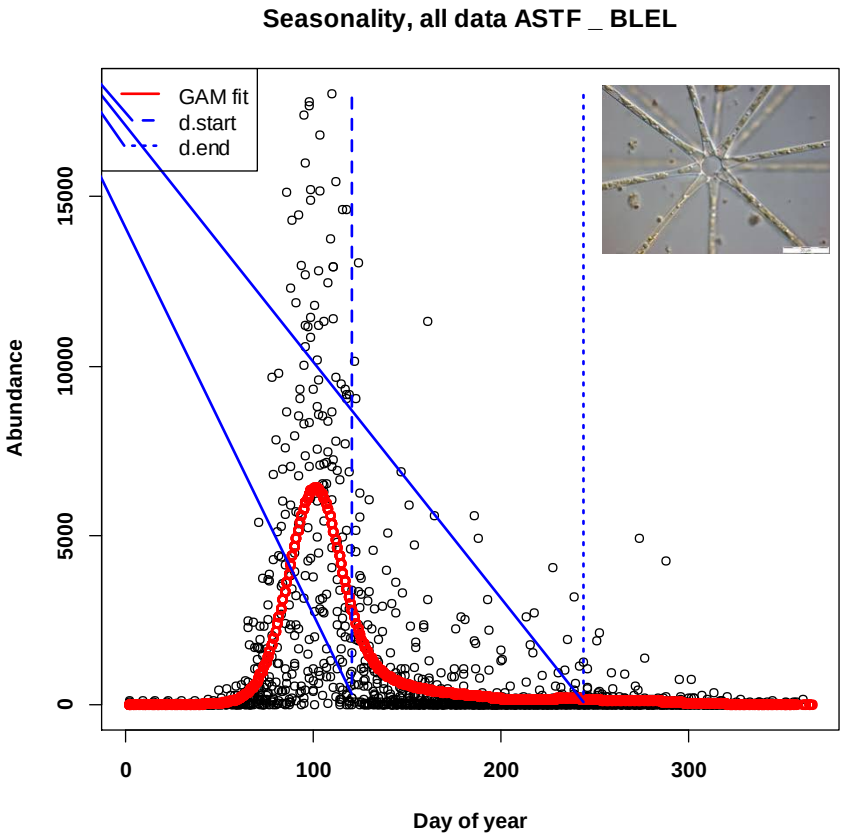
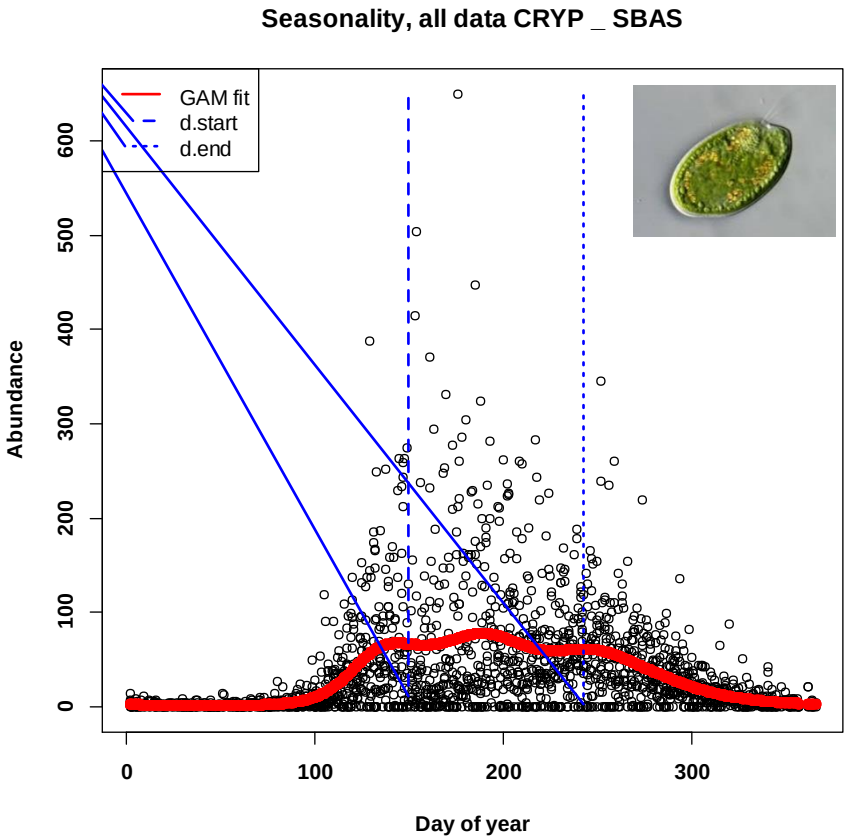
How plankton phenology is classified

- Using a General Additive Model to quantify timing of blooms





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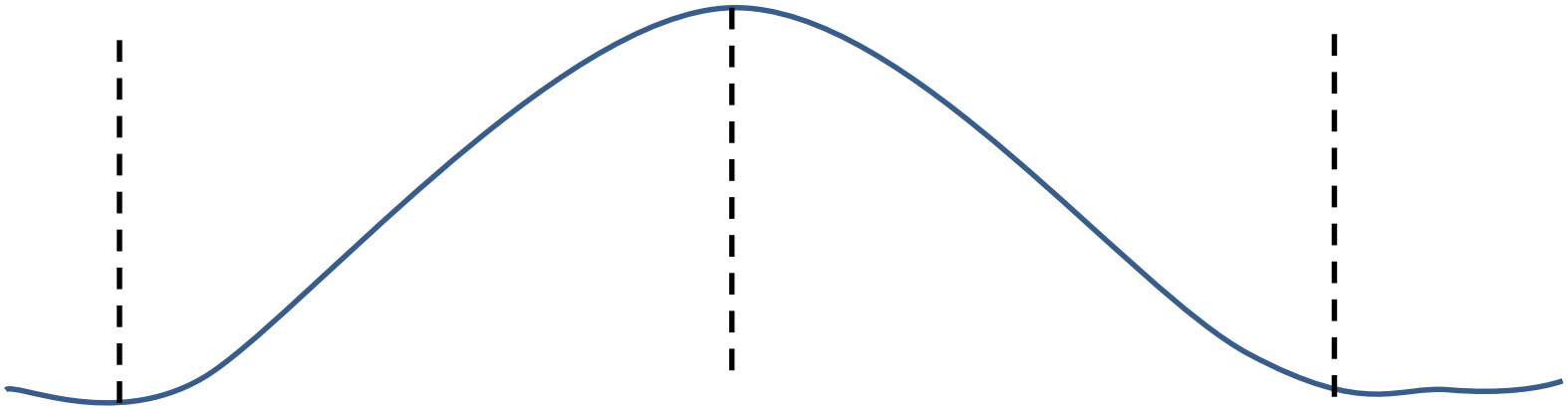
Characterising the seasonal pattern

- Selecting characteristics of the seasonal pattern – day of maximum, 25th and 75th percentiles of annual abundance and duration (day75th-day25th)

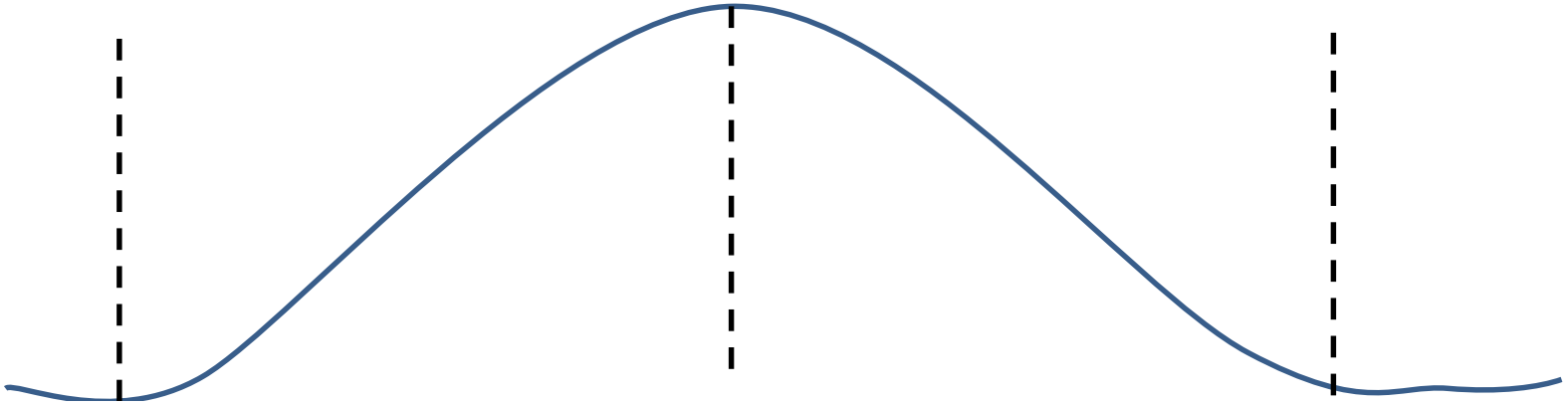


Results

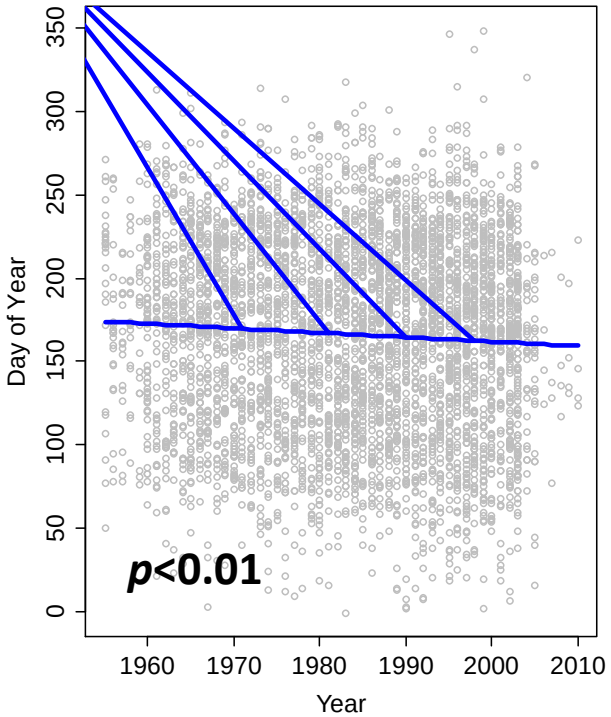
1. Estimate an index of seasonal timing to quantify average phenological trends

Results – Phenological trends over time

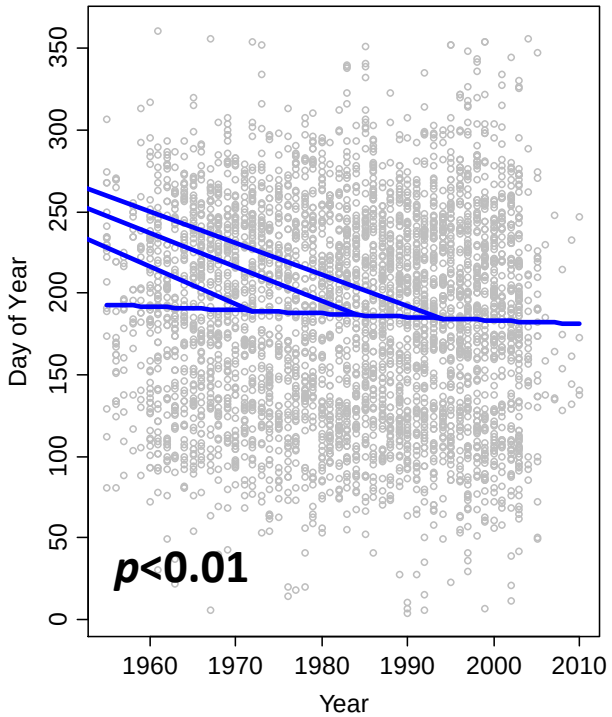
Combined analysis– significant trend towards earlier blooms



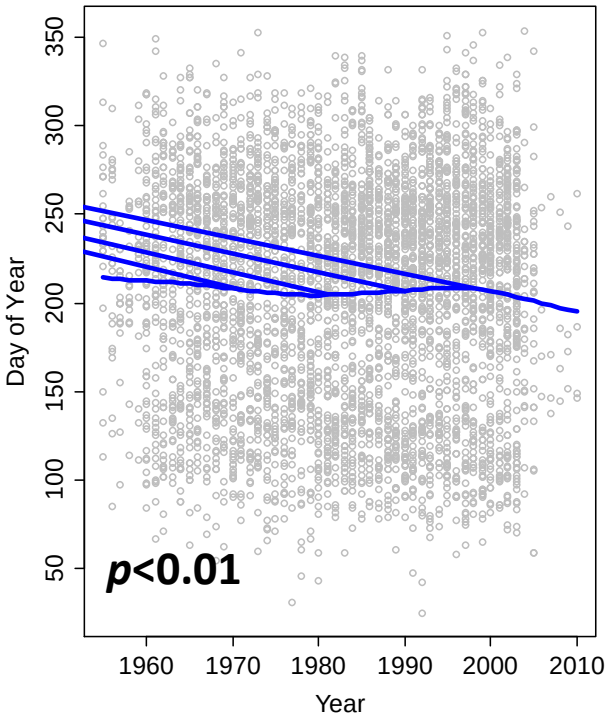
Timing of bloom onset



Timing of bloom peak

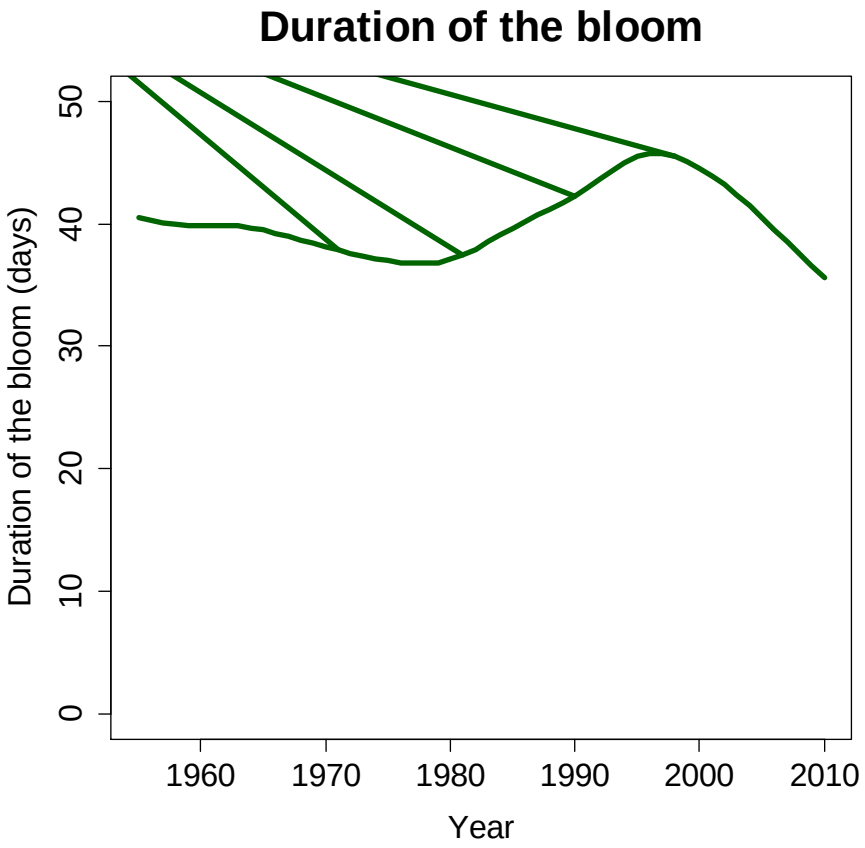


Timing of bloom end



Results - Community index of change

- Overall rate of change for plankton blooms is -0.19 days per year
- For bloom onsets: -0.27 days per year
- For bloom peaks: -0.21 days per year
- For bloom ends -0.11 days per year
- The duration of the bloom has changed over time but now appears to be around 5 days shorter, on average

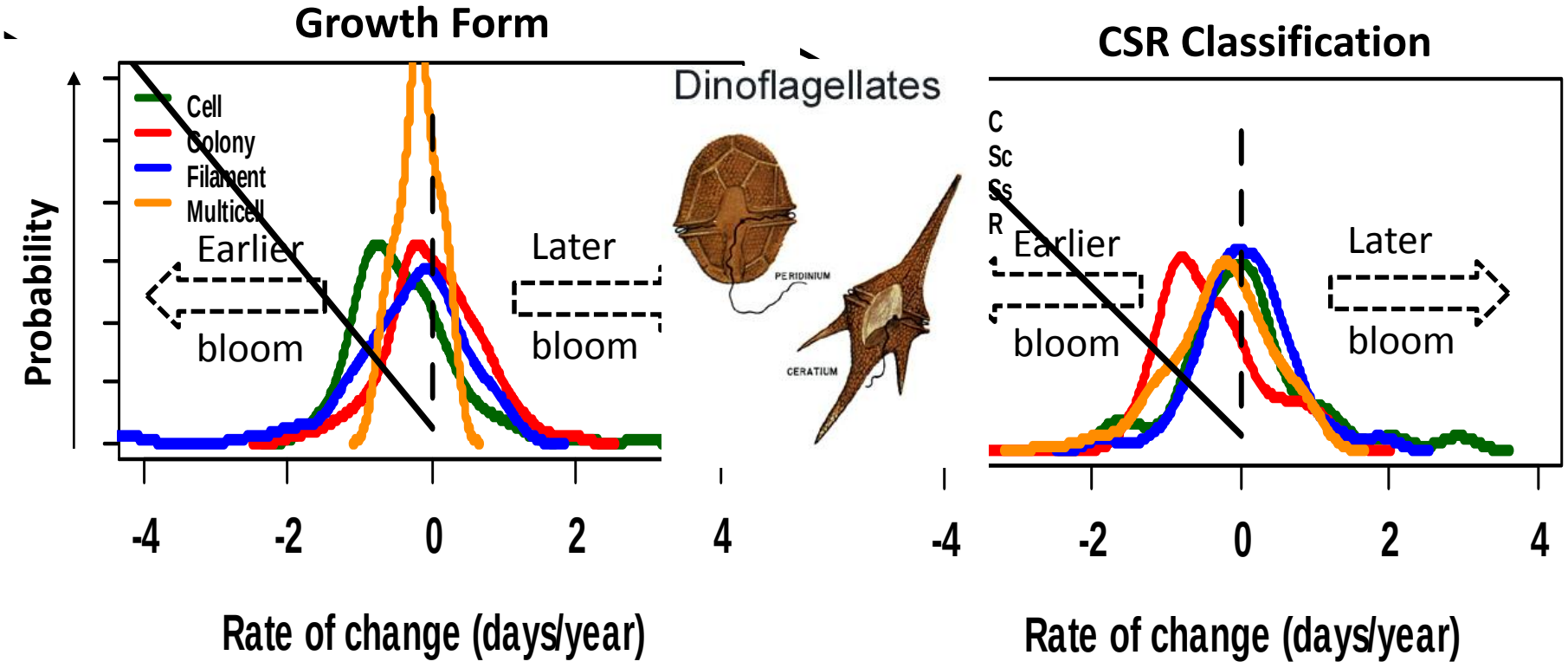


Results

2. Investigate whether trends vary with different plankton functional traits

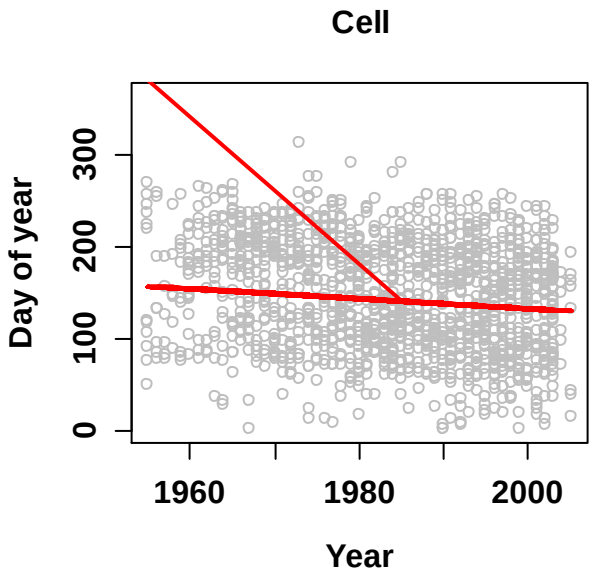
Results – Trends by trait groups

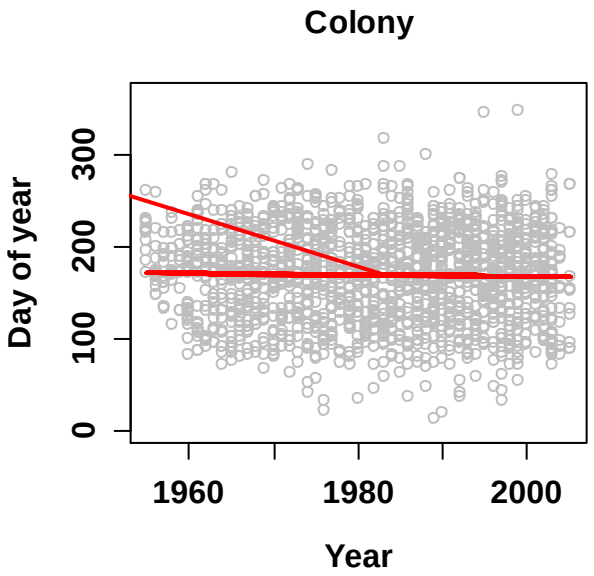
- Traits used:
  - Growth form
  - CSR classification
  - Motility or Buoyancy
  - Trophy – auto-, mixo-, heterotrophic

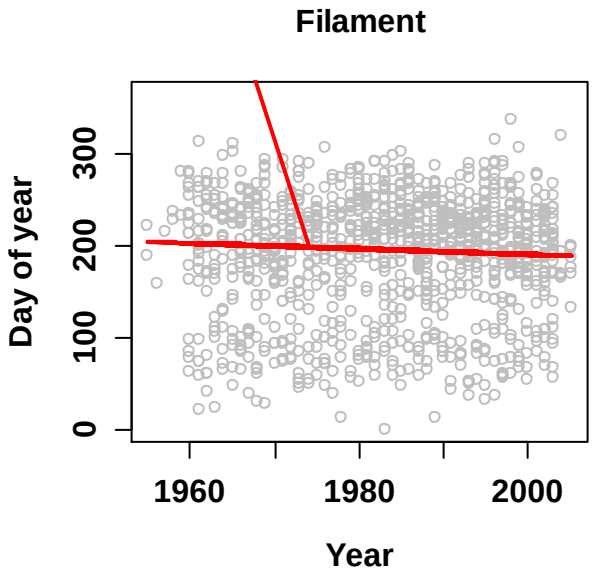


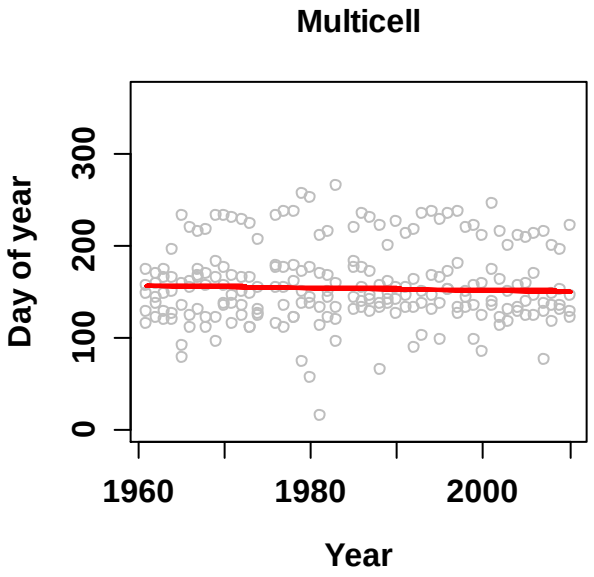
Results - Example of growth form

- Only using onset data
- All forms have advanced their timing
- Only significant for ‘Cell’ and ‘Filament’ forms
- Timing of ‘Cell’ growth onset has changed the most (steepest slope)









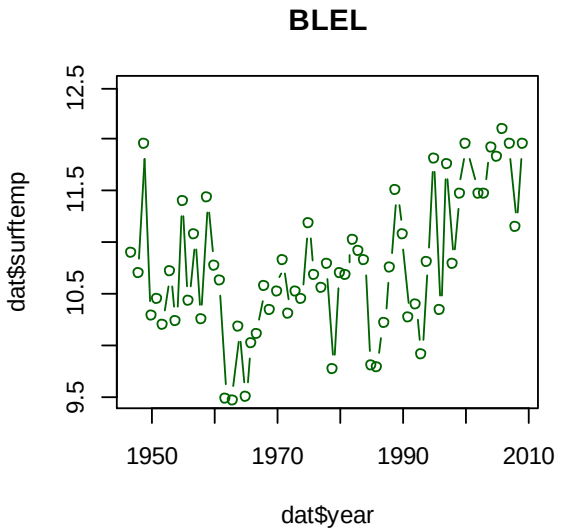
Results

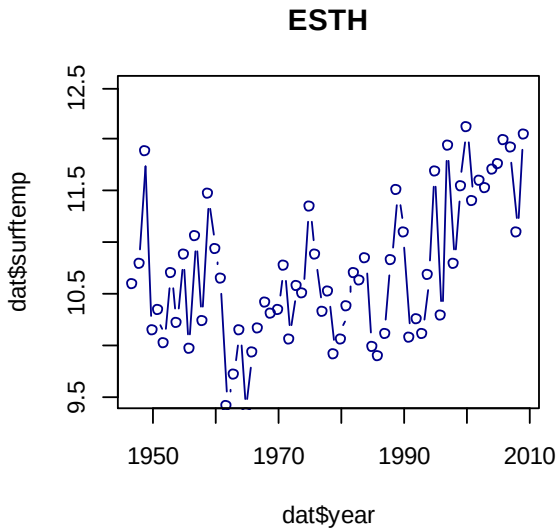
3. Investigate importance of different drivers of change – preliminary results

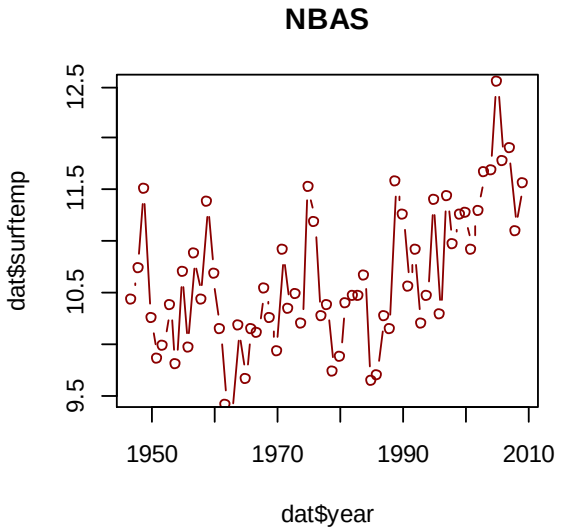
Results – Drivers of change

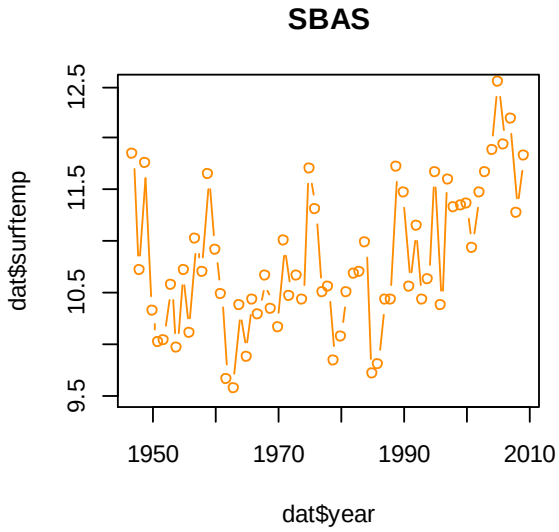
- Drivers
  - Temperature
  - Winter nutrients
  - Stratification strength
  - Discharge

Annual surface temperatures for each lake site









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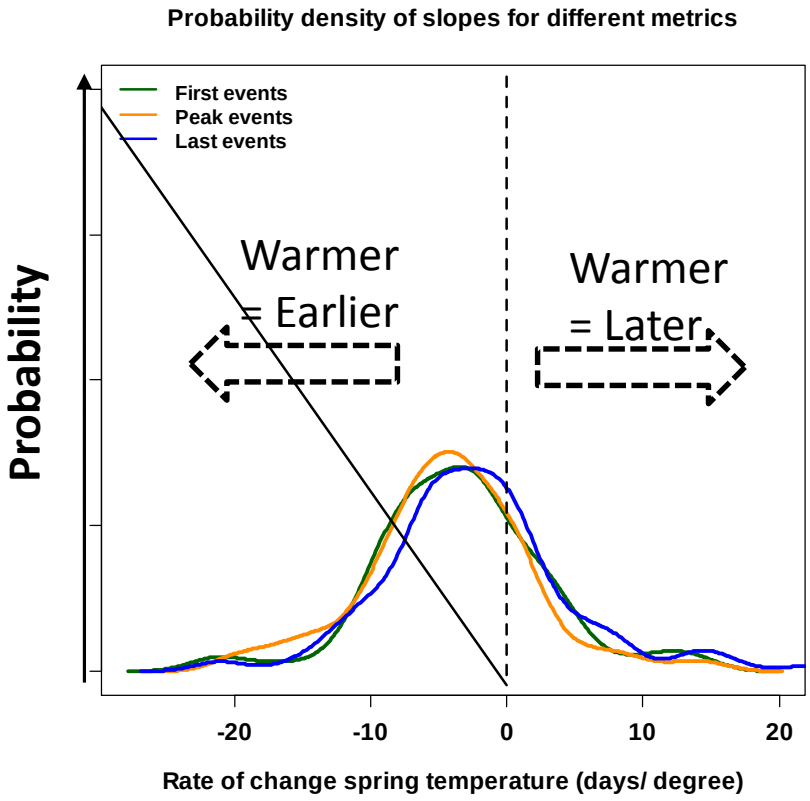
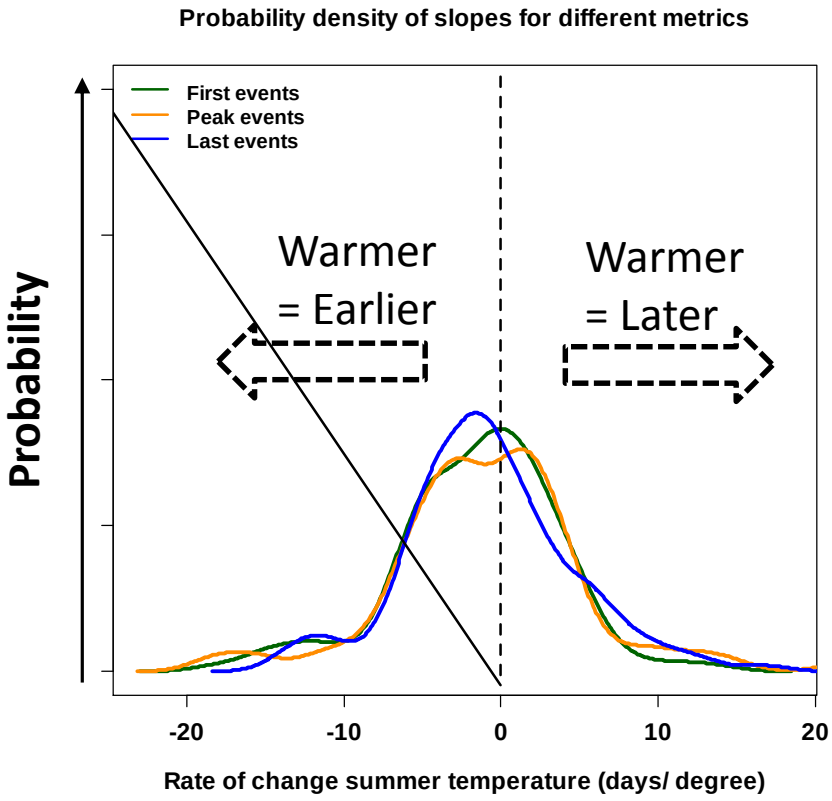
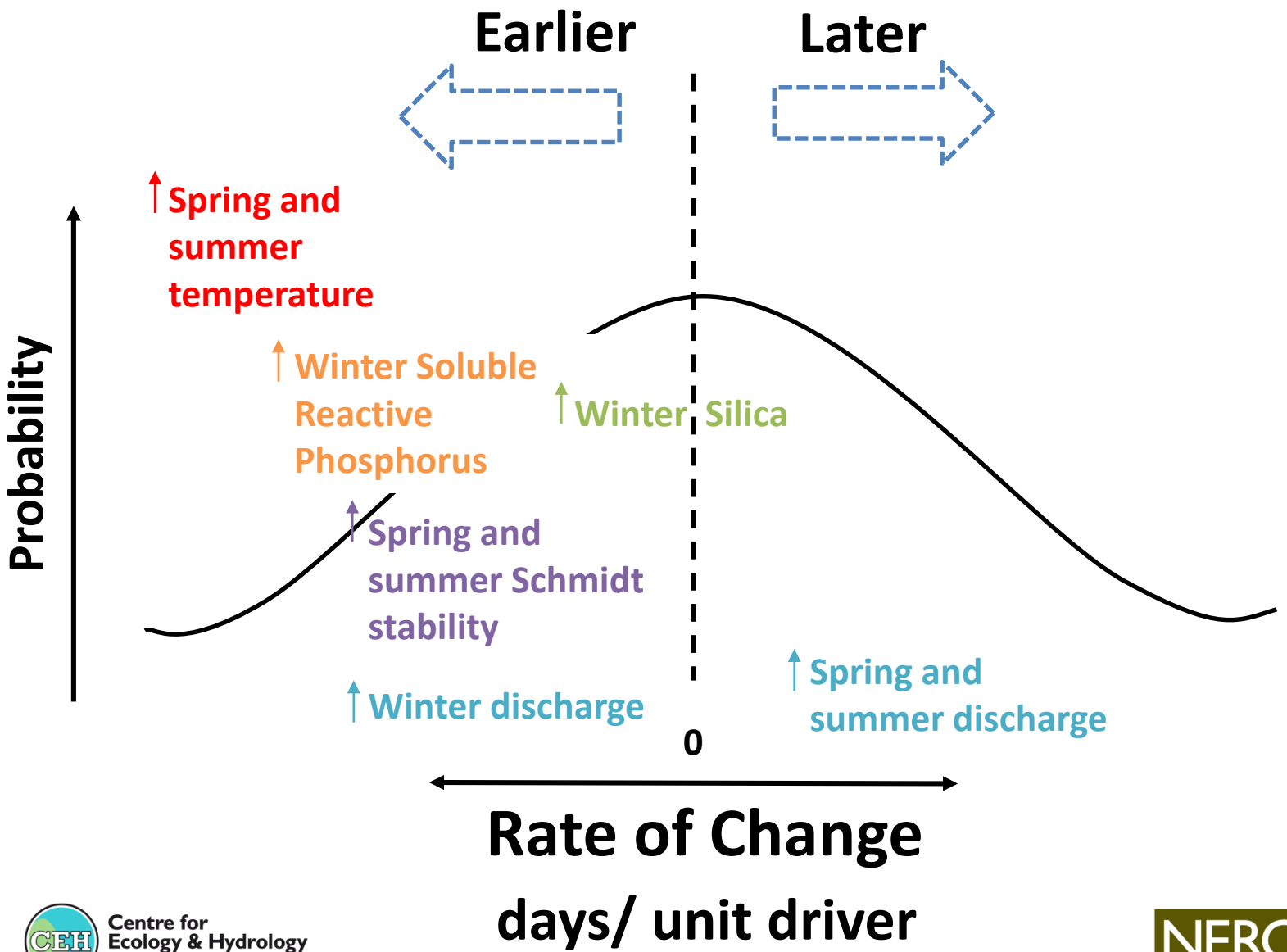
Results - Example of Seasonal temperature

- High variability in the response of species
- On average, the timing of bloom metrics are more sensitive to spring than summer temperatures
- Warmer spring and summer temperatures tend to result in earlier onsets, peaks and ends of blooms





Results – Summary of the effects of individual drivers



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Next steps - Developing models with multiple drivers

- Investigate correlations between drivers – e.g. is the winter discharge effect on bloom metrics related to nutrient input?
- Investigate variability between species and sites
- Carry out a model selection process to identify which combination of drivers are important for each metric

Summary

- Using long term plankton data we have examined whether the timing of plankton blooms has changed and what drivers may be important to understand this change
- Key results:
  - There is a lot of variability between species and sites
  - Overall blooms getting earlier
  - Onset of blooms advanced more rapidly than peak or end
  - Plankton with different functional traits have changed at different rates
  - Sensitivity of the metrics to different drivers varies between drivers and differs depending on the time of year – more work is needed

Acknowledgements

- Funders: Shifting Seasons project: http://www.ceh.ac.uk/sci_programmes/shifting-seasons-uk.html (NERC standard grant NE/J02080X/1)
- Staff at CEH (formerly FBA) who carry out long term lake monitoring
- Ian Jones for discharge data from Blelham Tarn
- Thank you for listening!

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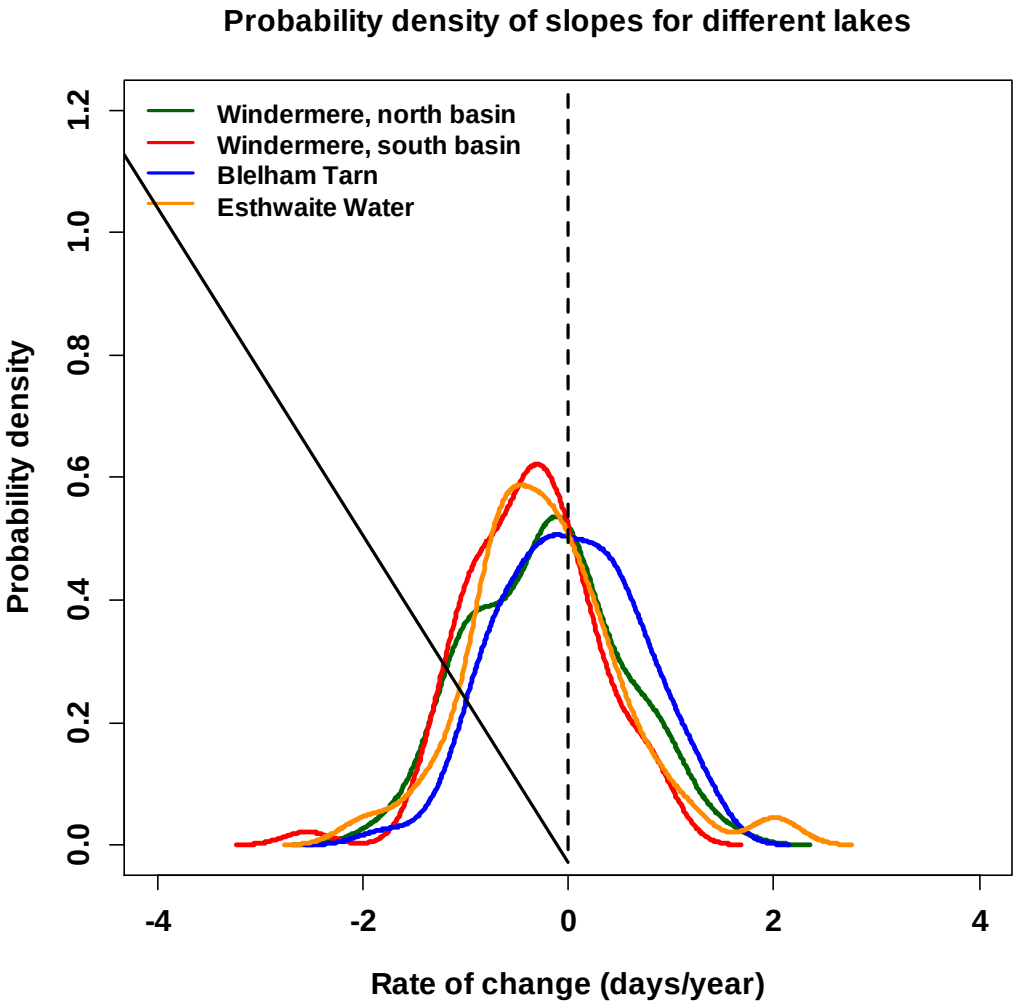
Is the overall rate of change different in different lakes?

- Subset of data with the same 30 taxa in each lake
- Each lake shows a significant change in overall timing of first events but these are different in each lake
- Rate of change is faster in Esthwaite Water and Windermere south basin (~-0.3 days per year) than in Windermere north basin or Blelham Tarn (~-0.2 and -0.01 days per year)



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