The implications of residence time management for lake restoration in Elterwater

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UK Centre for Ecology & Hydrology

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NATURAL ENGLAND

Environment Agency

PhD project

Water Residence Time (**WRT**) effects on lake ecosystems

1. Process-based lake modelling
2. Field data collection (high frequency data)
3. Historic data (long-term data)

➢ Understanding processes

➢ Informing management

Lake volume

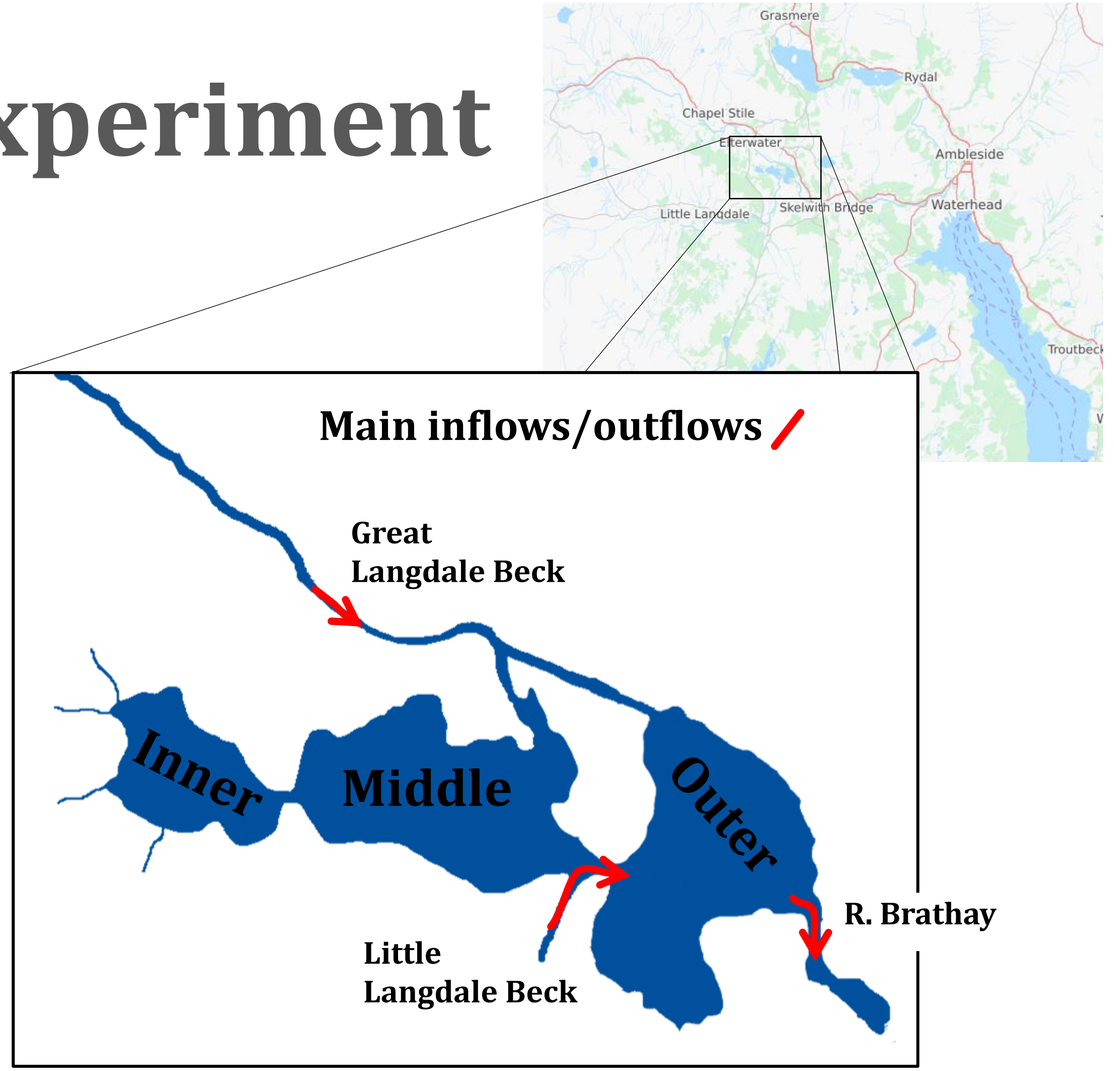
$$WRT = \frac{V}{Q}$$

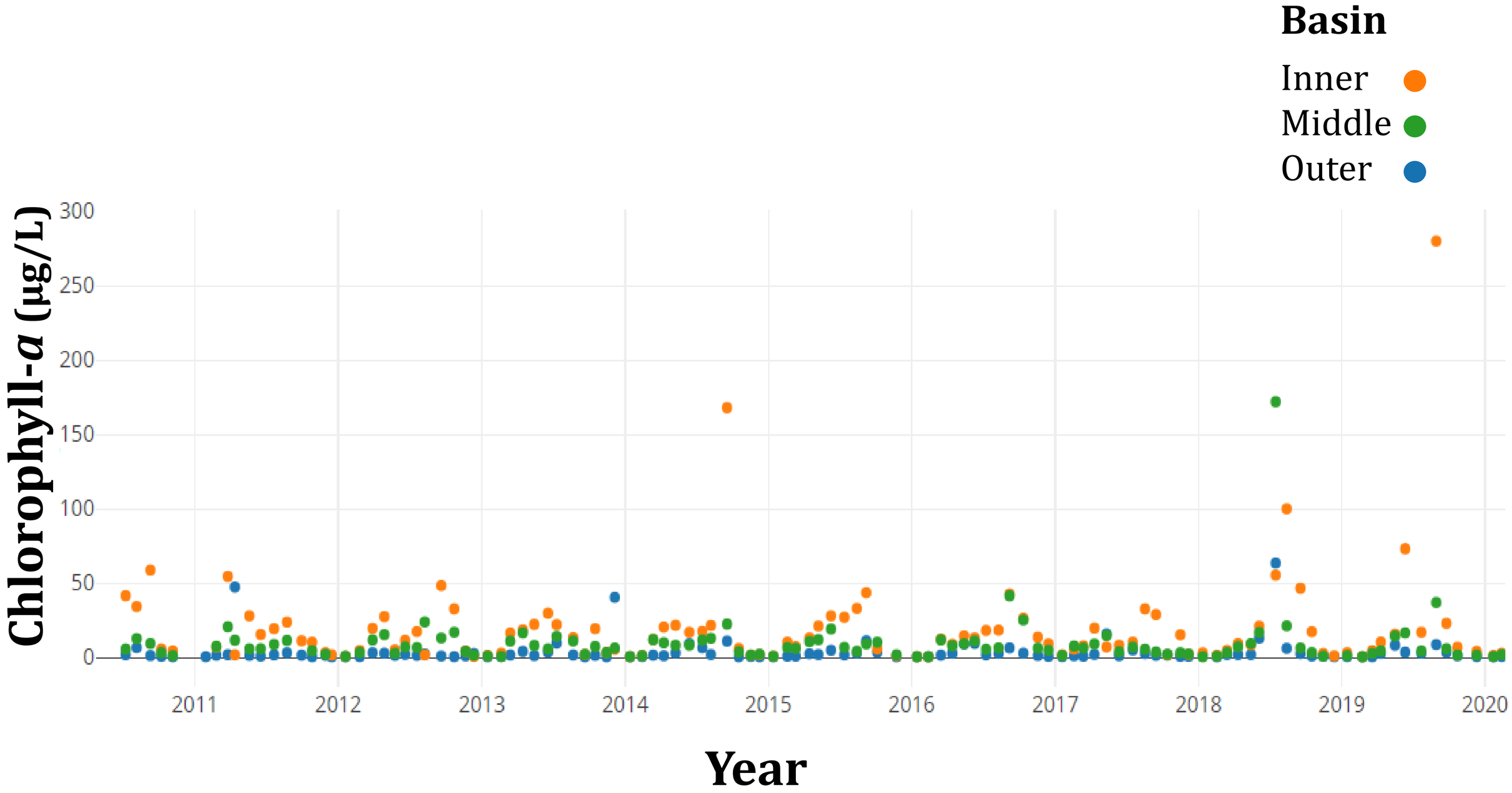
Average time water remains within the lake

Average outflow discharge

Elterwater – a natural experiment

- Small, shallow (< 0.2 km^2, mean depth = 3 m, max depth = 7.5 m)
- Monomictic
- 3 distinct basins
- Meso- to eutrophic lake





EA data – UK Lakes Portal

Elterwater – a natural experiment

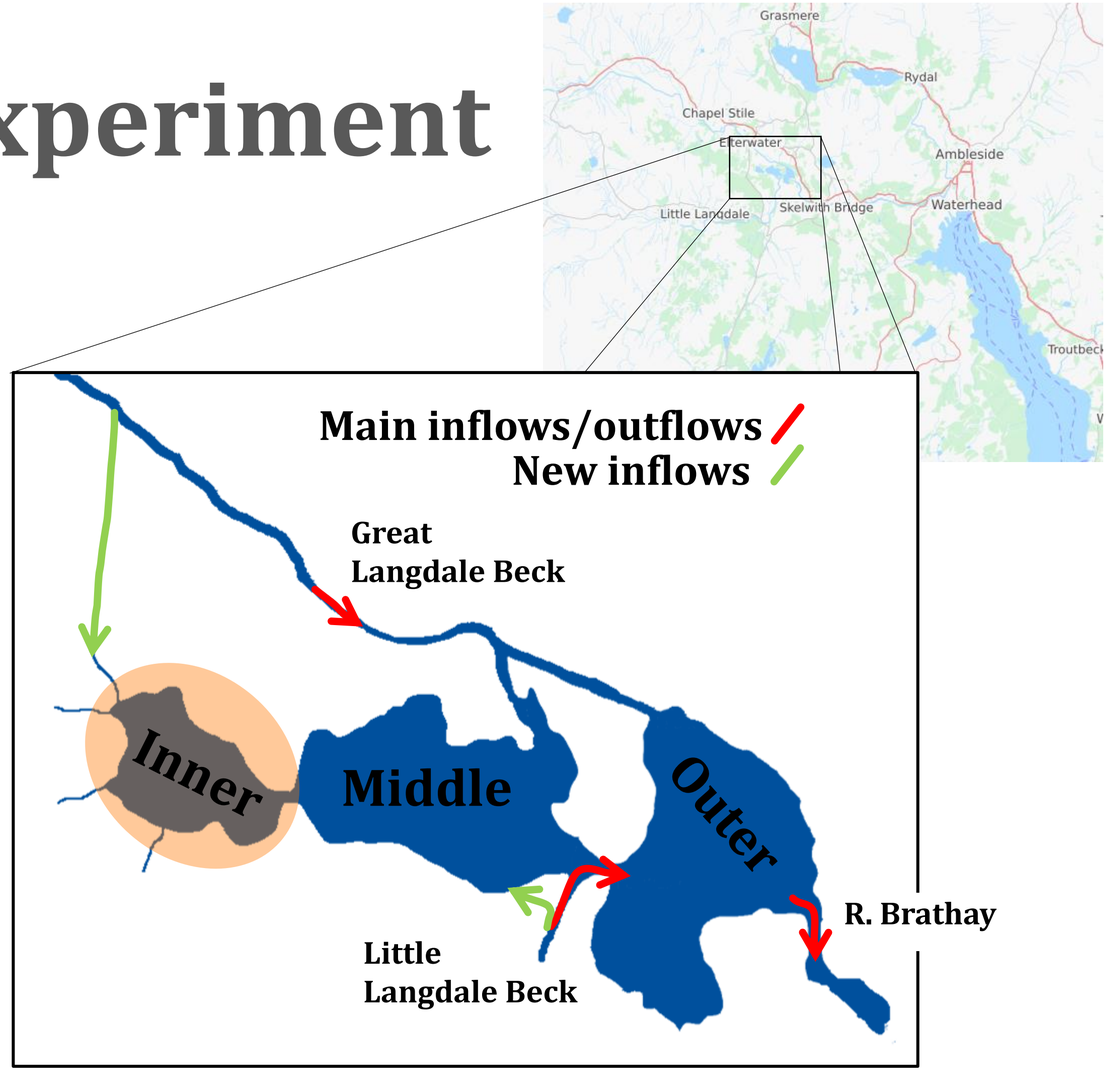
Small, shallow (< 0.2 km^2, mean depth = 3 m, max depth = 7.5 m)

Distinct hydrology

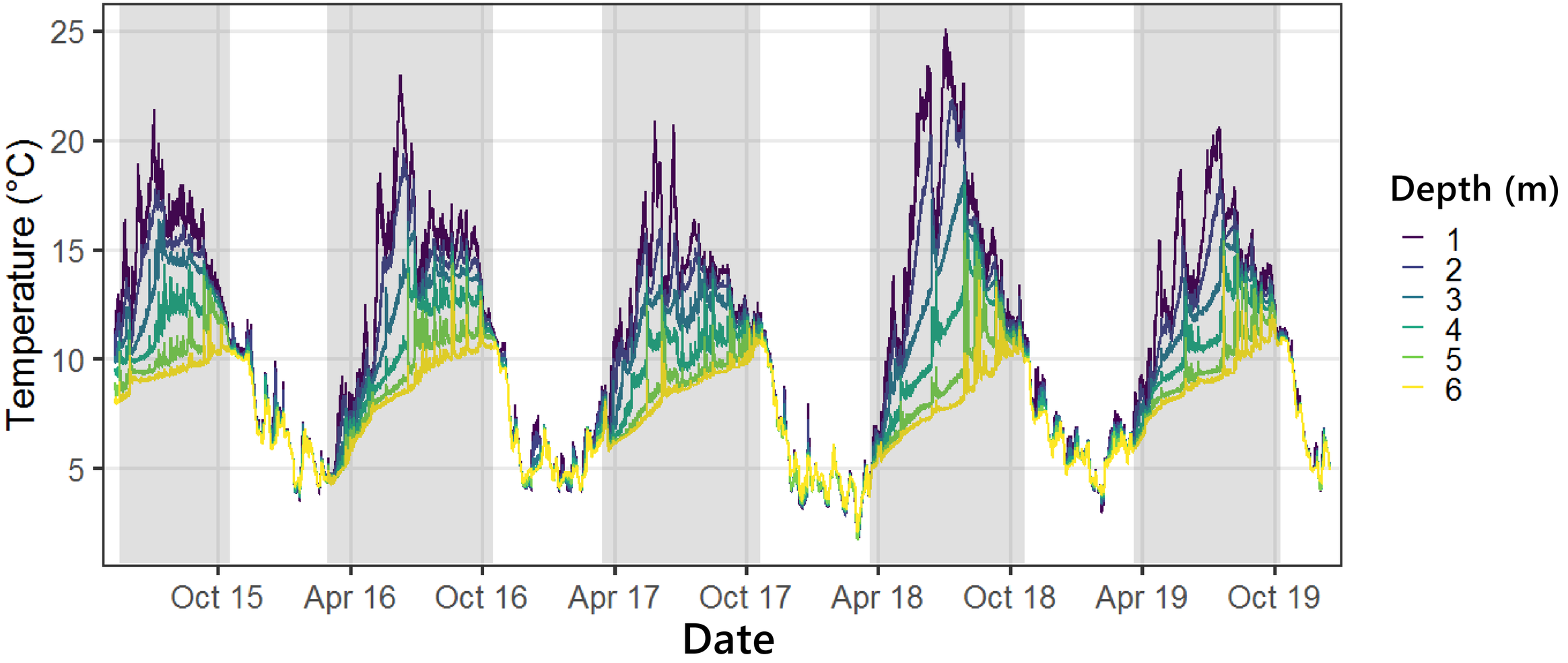
Meso- to eutrophic lake

Restoring inner basin

Understand the processes

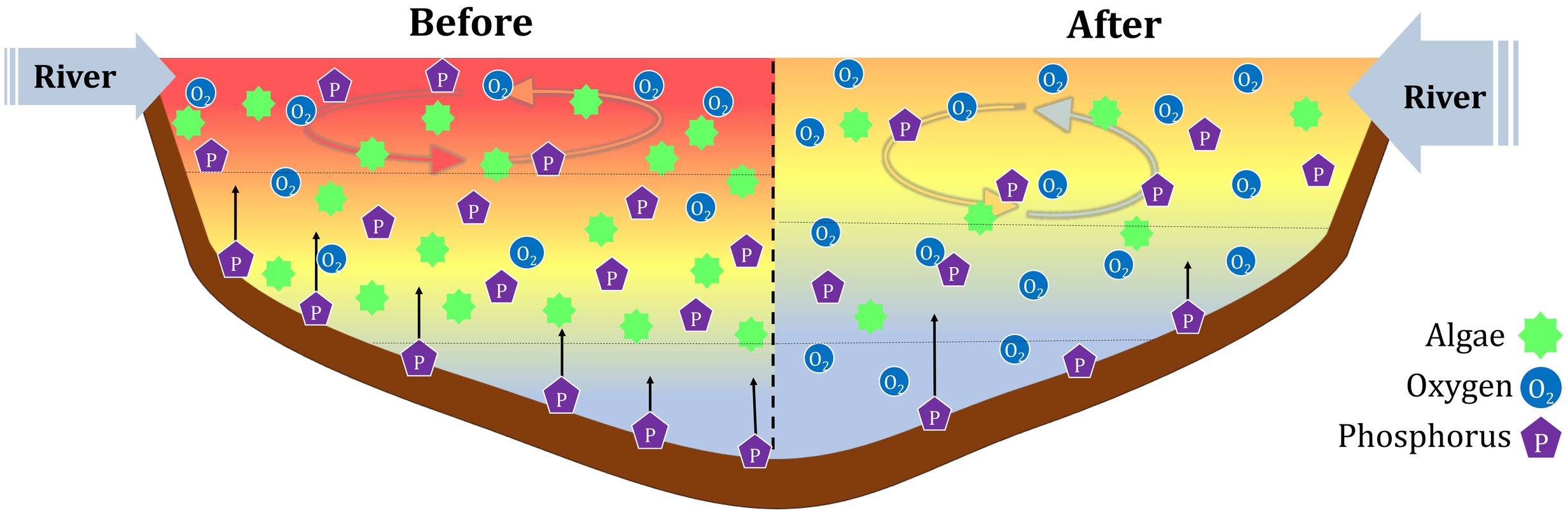


Water temperatures 2015-2019

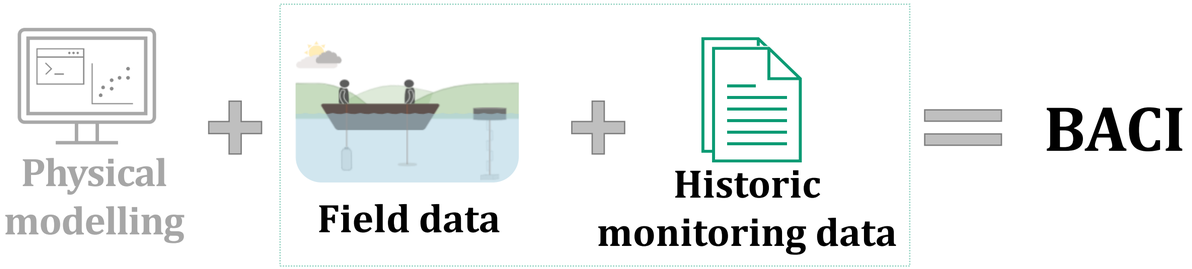


Water temperatures – Elterwater inner basin
UKCEH thermistors

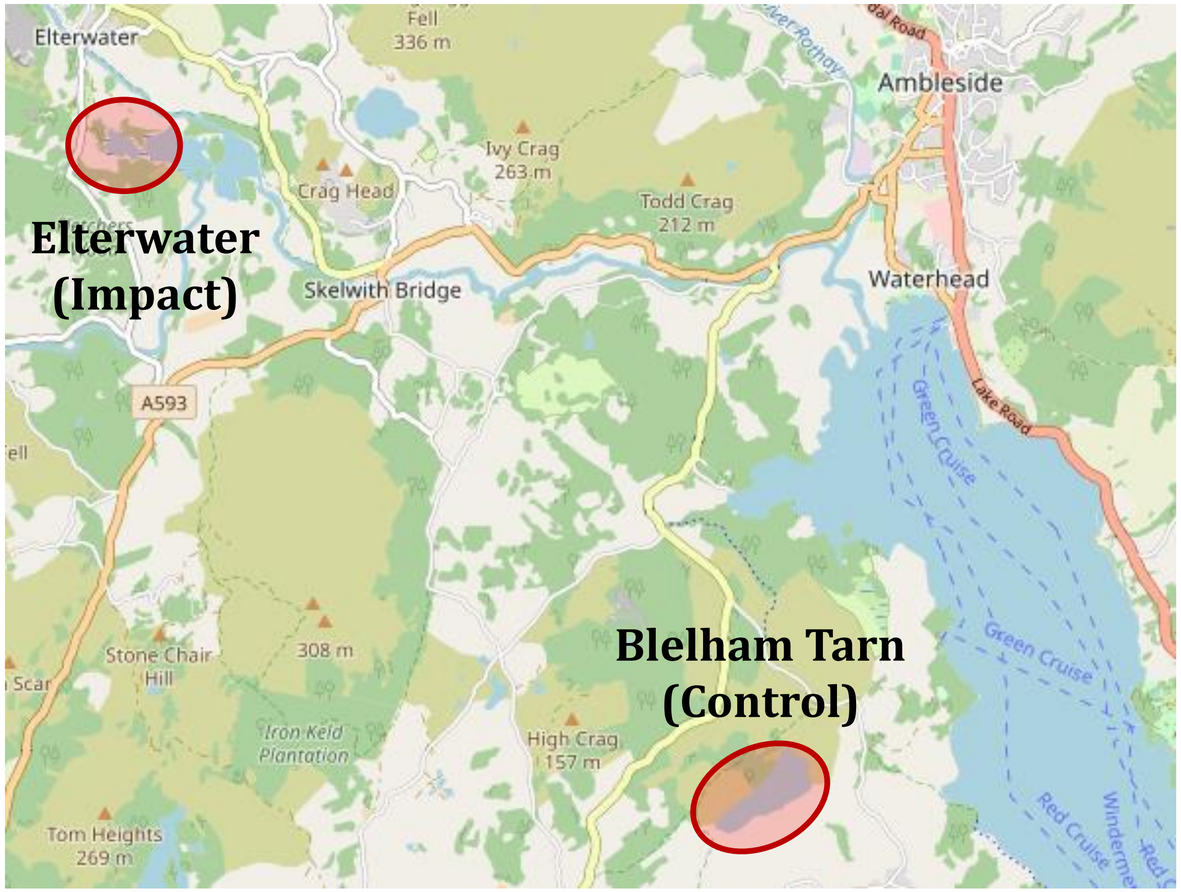
Disrupt stratification → reduce anoxia → decrease internal loading



Methods



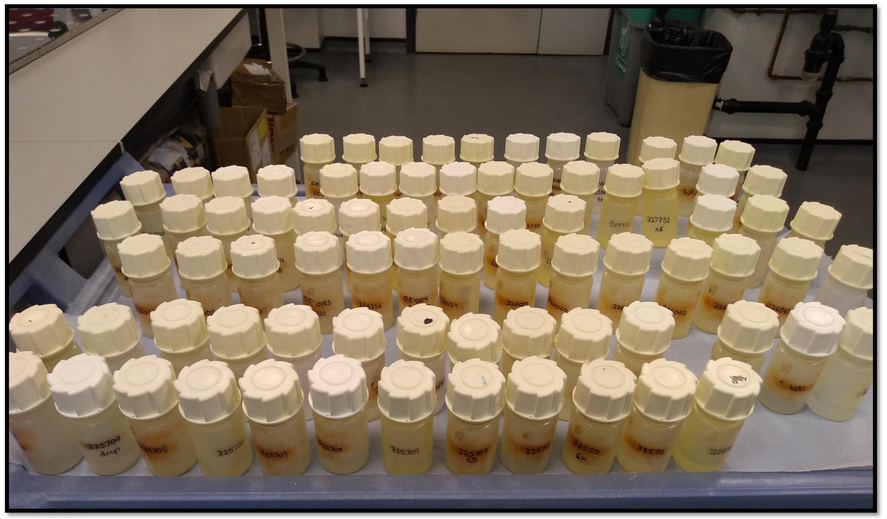
- Before – After – Control – Impact
- Change in the difference between lakes following intervention
- Historic (EA data) and on-going monitoring data



Raw water samples

Chlorophyll analysis

TP analysis



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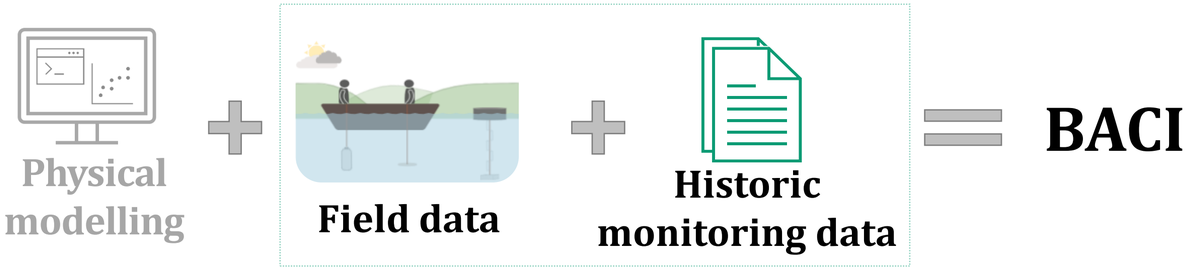
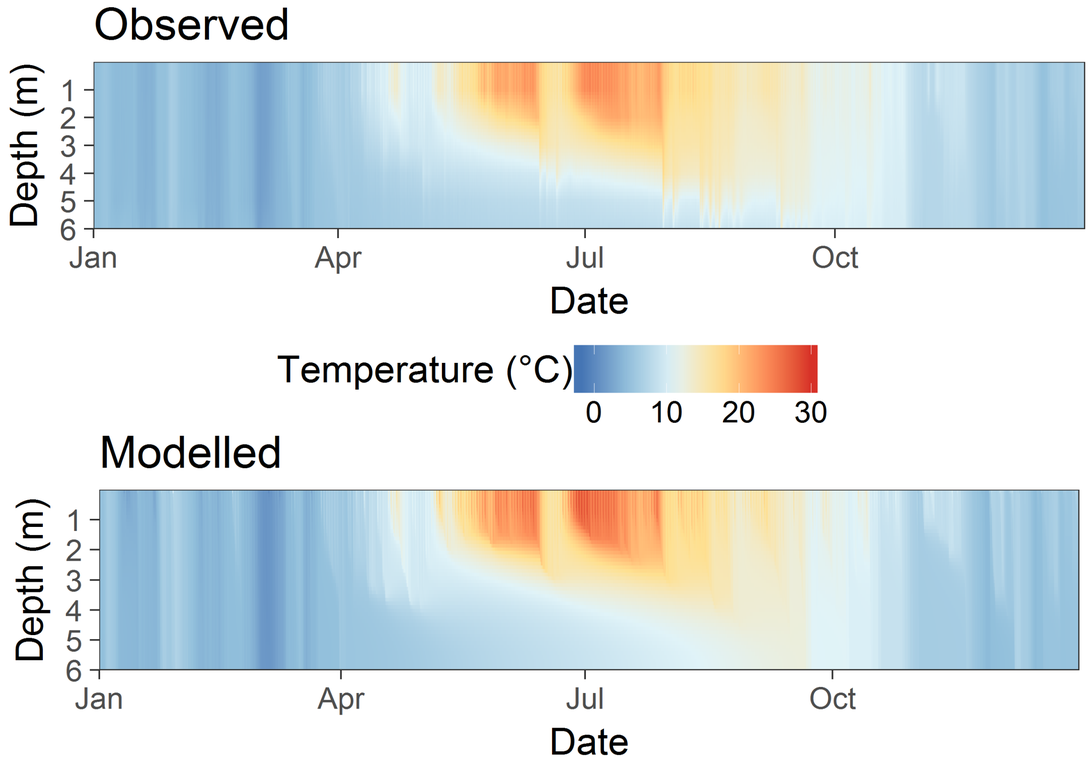


Physical lake model – validated against observations

Blelham observations

With intervention vs without

Before – After – Control – Impact



Modelled vs observed water temperatures Elterwater Inner Basin 2018

Conclusions

- Seasonal average **WRTs have decreased** following intervention but are within inter-annual variability
- Minor **changes in stratification** and stability
- The magnitude of **change in stratification have not induced significant water quality improvements** (chl-*a*, nutrients)

Recommendations for future projects

Recommendations for future projects:

- **Pre-intervention investigation** using a physical lake model – what change is required to affect the stratification?
- Field **data collection for >> 1 year** (understand inter-annual variability) at **Control and Impact sites**




Thank you, any questions?

- ✓ Little change in the trophic condition – based on the samples and time scale investigated
- ✓ Importance of monitoring design (> 1 year, control site)
- ✓ Modelling presents a useful tool

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