Understanding the causes of algal blooms in rivers

Dr Mike Bowes

UKCEH

Wallingford

Oxfordshire

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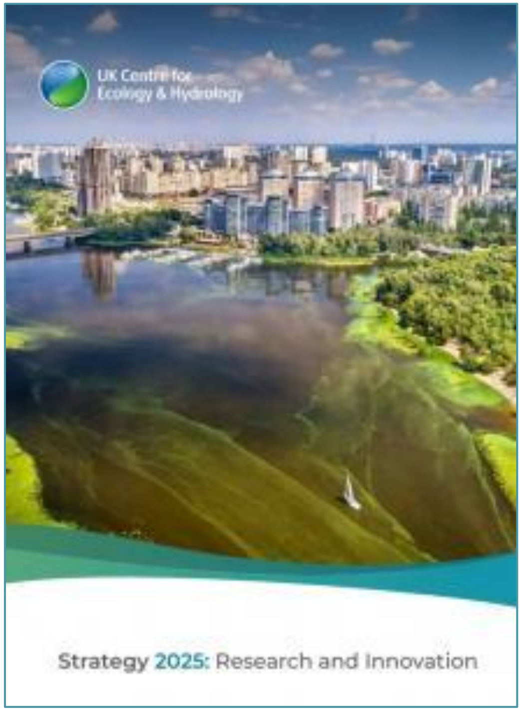
UK Centre for Ecology & Hydrology

River eutrophication

Major environmental problem nationally and internationally

55% of UK rivers failing to reach EU phosphorus targets

85% of UK rivers not in good ecological status

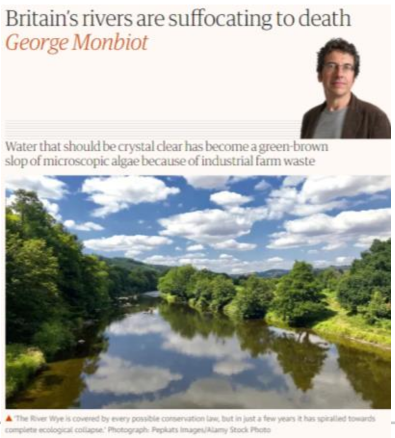



Sewage discharged into rivers 400,000 times in 2020

BBC NEWS

By David Brown
BBC News

Campaigners are concerned about the impact of sewage discharges on many rivers


Britain's rivers are suffocating to death
George Monbiot

Water that should be crystal clear has become a green-brown slop of microscopic algae because of industrial farm waste

'The River Wye is covered by every possible conservation law, but in just a few years it has spiralled towards complete ecological collapse.' Photograph: Pepkats Images/Alamy Stock Photo


Why blue-green algae can be toxic to pets and humans

16 August 2018

BBC NEWS

NRW

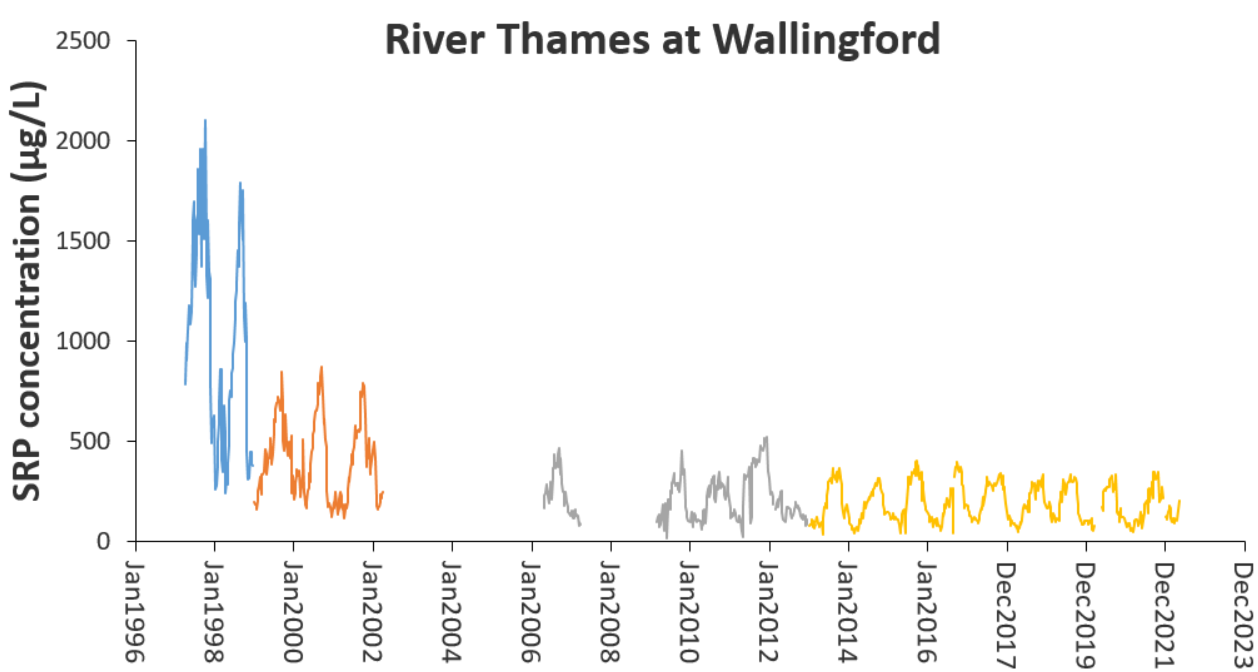

The Ganges: holy, deadly river

Pollution has turned the sacred waters into a lethal cocktail of industrial and human waste. Can the river be saved?

Two boys make their way back to shore after bathing in the heavily polluted Ram Ganga tributary of the Ganges in Moradabad, Uttar Pradesh

Phosphorus concentrations in the Thames

- Major reductions in phosphate concentrations in most major UK rivers
- Usually step decreases (sewage treatment improvements)
- Often no response from the aquatic ecology / algal bloom risk



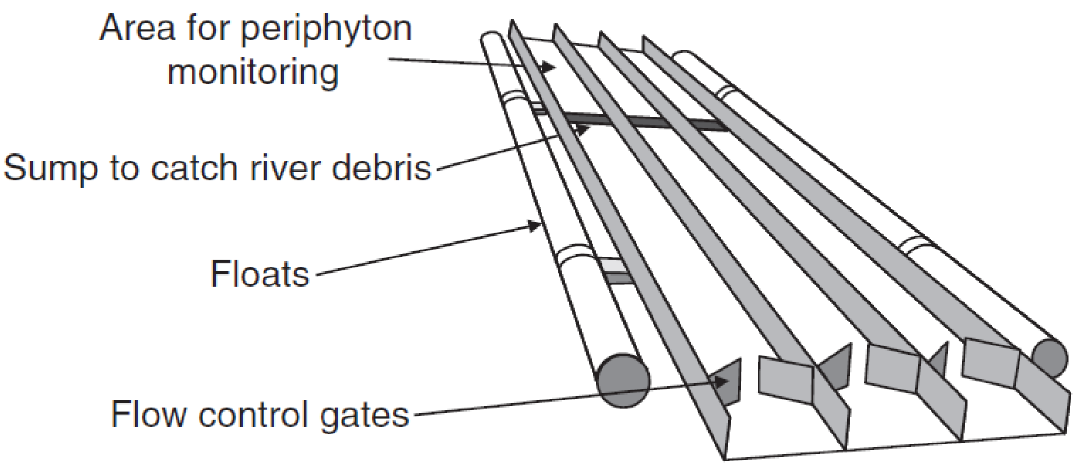
Bowes et al. 2018. Weekly water quality monitoring data for the River Thames (UK) and its major tributaries. ESDD.

Key questions

- What phosphorus concentrations need to be attained before aquatic ecology improves?
- What other factors can impact algal bloom risk?

Identifying P concentration targets

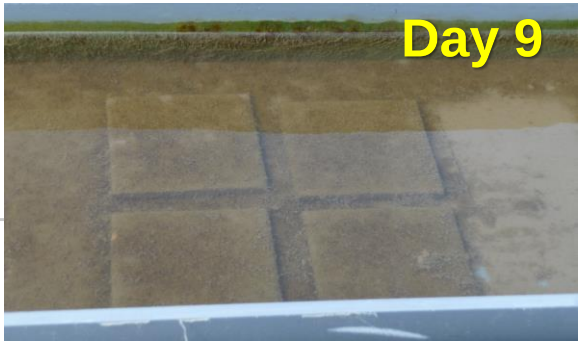
Flume mesocosms used to determine impact of nutrient concentrations on biofilm biomass and community composition.



Phosphorus treatments -

- P addition
- No addition (control)
- Iron sulphate addition to reduce P concentration

Quantity of algae determined by chlorophyll-*a*, dry mass and flow cytometry.



Identifying P concentration targets

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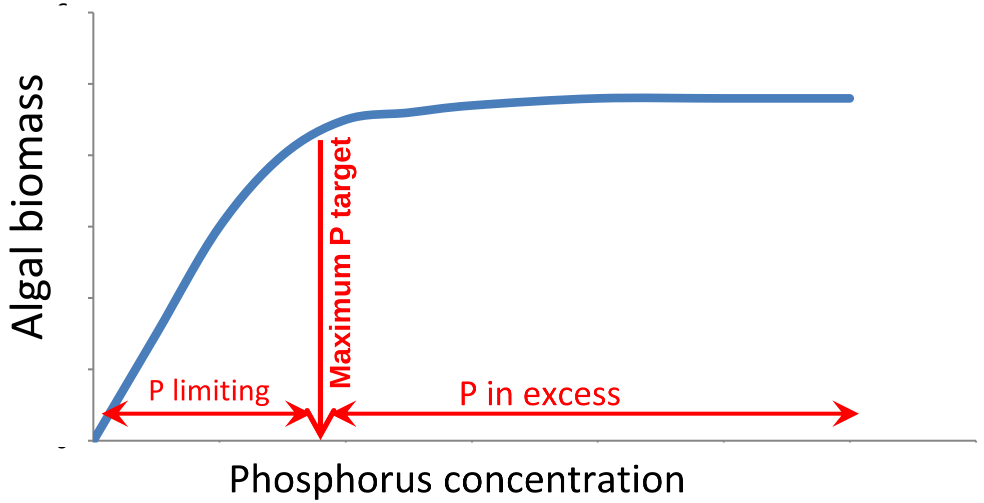

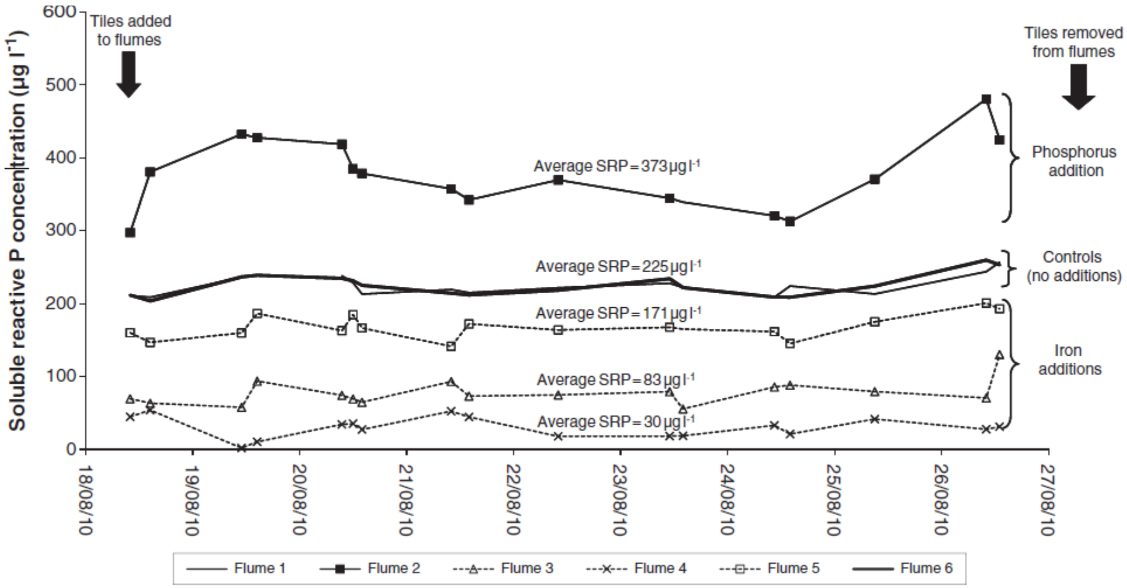

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R Nadder, Hampshire


R. Kennet, Wiltshire


R. Thames, Oxfordshire


R. Rede, Northumberland


R. Conwy, Wales

Sites of flume experiments

Pristine sites

River Rede, Northumberland
(SRP = 10 µg/L)
River Conwy
(SRP = 10 µg/L)

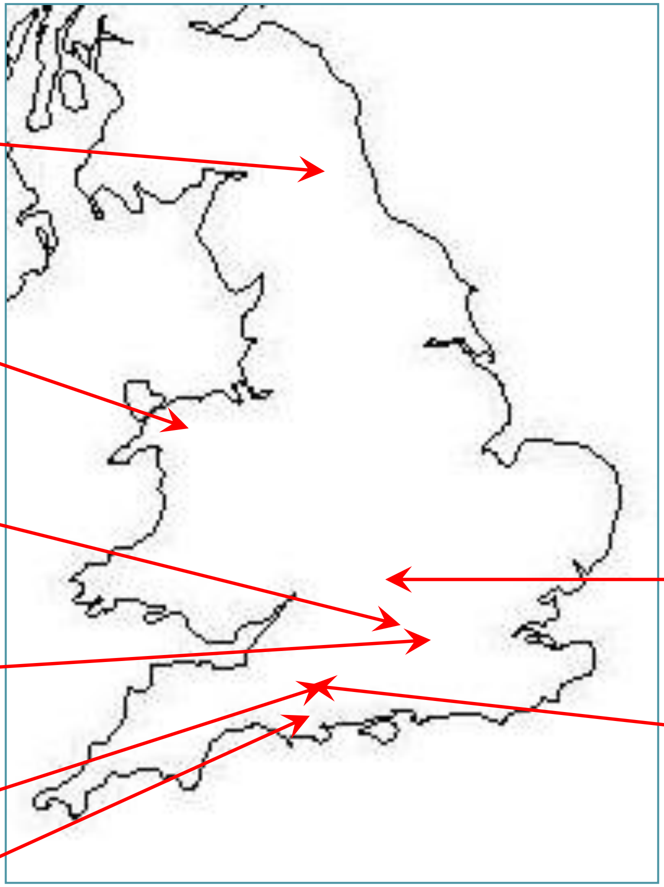
Moderately enriched sites

River Kennet at Marlborough
(SRP = 60 µg/L)

River Lambourn at Boxford
(SRP = 45 µg/L)

River Nadder, Hampshire
(SRP = 106 µg/L)

River Frome, Dorset
(SRP 100 µg/L)



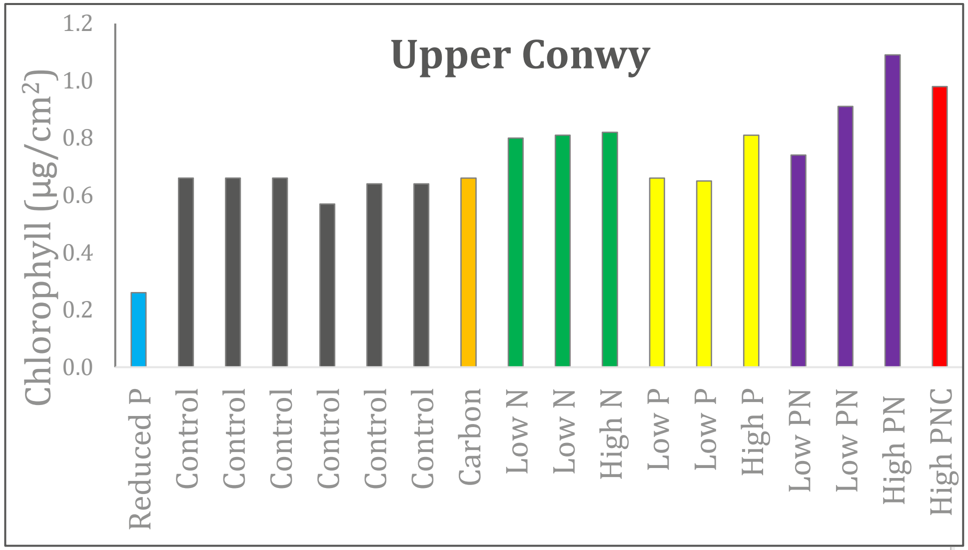
Heavily enriched sites

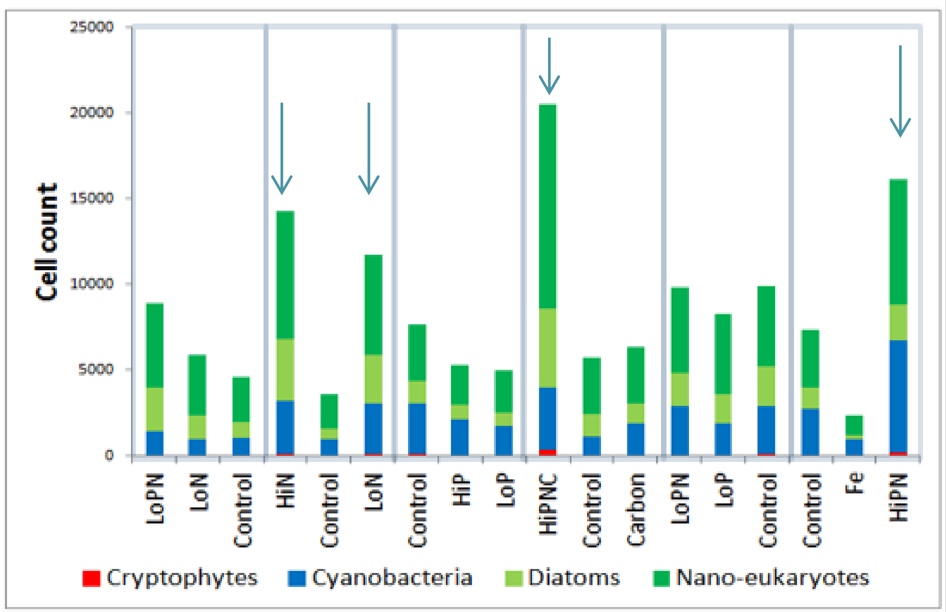
River Thames at Oxford
(SRP = 230 µg/L)

River Sem near Shaftsbury
(SRP = 250 µg/L)

Findings

N or P/N co-limitation in "pristine" rivers (SRP = ~10 µg/l)





McCall, S. J., M. J. Bowes, et al, 2014. Phosphorus enrichment of the oligotrophic River Rede (Northumberland, UK) has no effect on periphyton growth rate. Inland Waters 4(2):121-132

McCall, S. J., M. S. Hale, J. T. Smith, D. S. Read & M. J. Bowes, 2017. Impacts of phosphorus concentration and light intensity on river periphyton biomass and community structure. Hydrobiologia 792(1):315-330

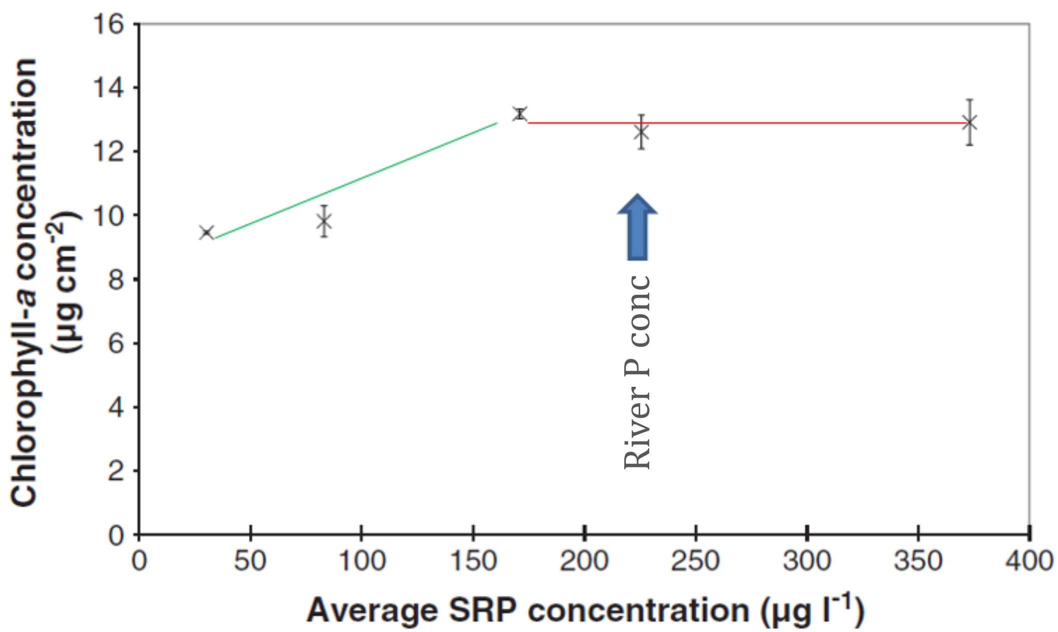
Findings

N or P/N co-limitation in “pristine” rivers (SRP = ~10 µg/l)

P concentration is not limiting periphyton growth in most UK rivers

SRP concentrations need to < 100 µg/l before biofilm growth may be reduced.

SRP concentrations < 30 µg/l before diatom community responds (TDI)



Bowes, M. J., N. L. Ings, et al., 2012. Nutrient and light limitation of periphyton in the River Thames: Implications for catchment management. Science of the Total Environment 434:201-212

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Thames high-frequency biogeochemical monitoring

Biogeochemical monitoring

- Temperature, turbidity, dissolved oxygen (Hourly)
- Total and dissolved phosphorus / nitrate (hourly)
- Chlorophyll (Hourly)
- Phytoplankton identification (Weekly)
- Flow cytometry (phyto- and bacterioplankton) (Daily / weekly)

Collaboration with Environment Agency' National Water Quality Instrumentation Service

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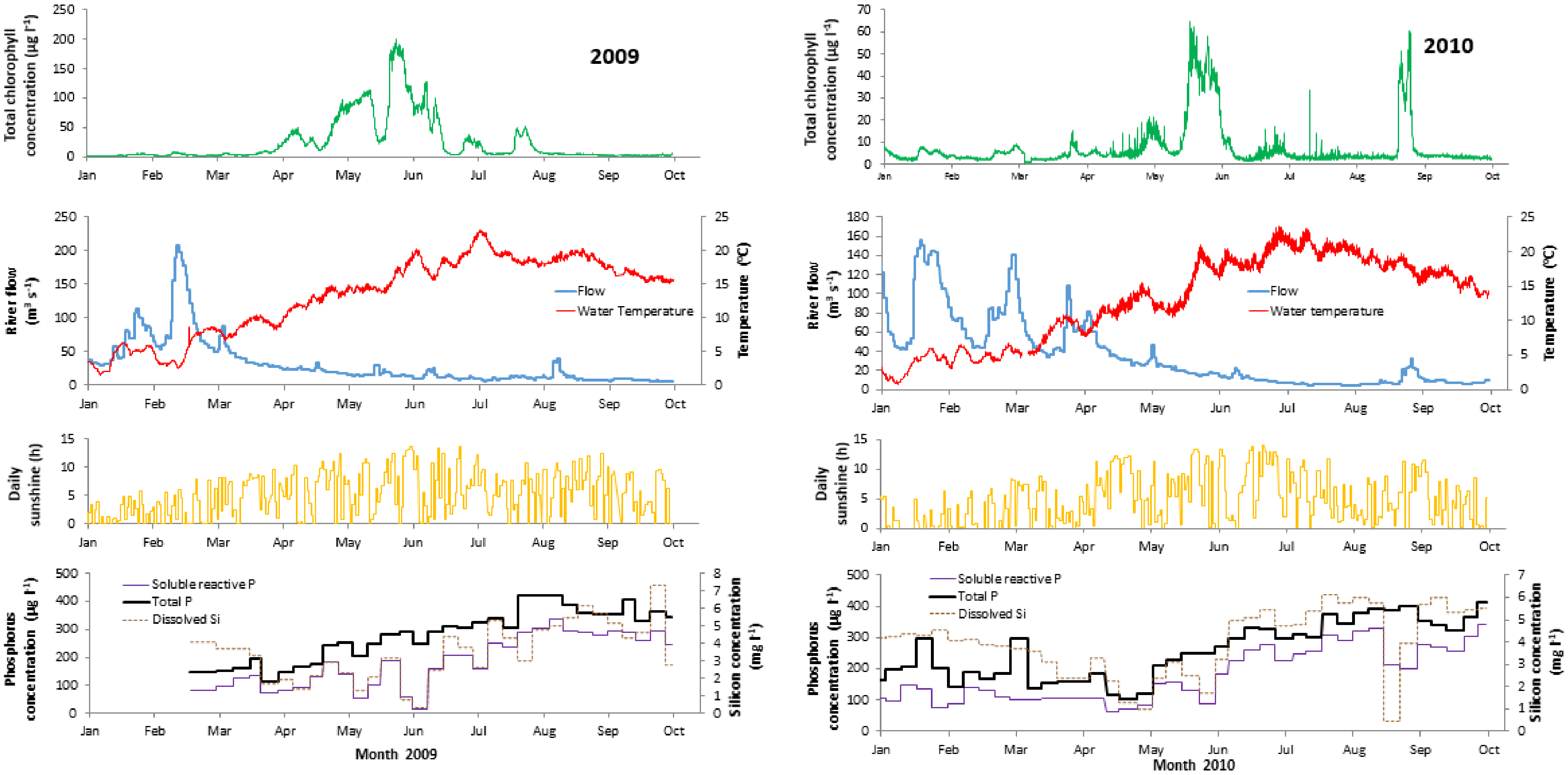
Understanding controls on chlorophyll concentrations

Hourly EA data sets for Thames at Reading integrated with CEH weekly nutrient and daily light data (2009 – 2013)



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Bowes, MJ et al, 2016. Identifying multiple stressor controls on phytoplankton dynamics in the River Thames (UK). Sci Total Environ 569–570:1489-1499

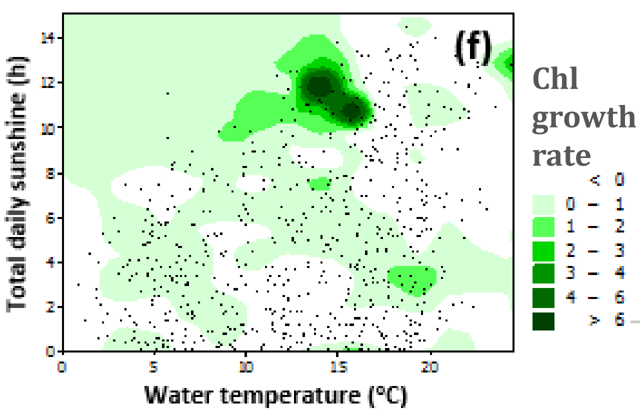
Q3.Understanding causes of algal blooms

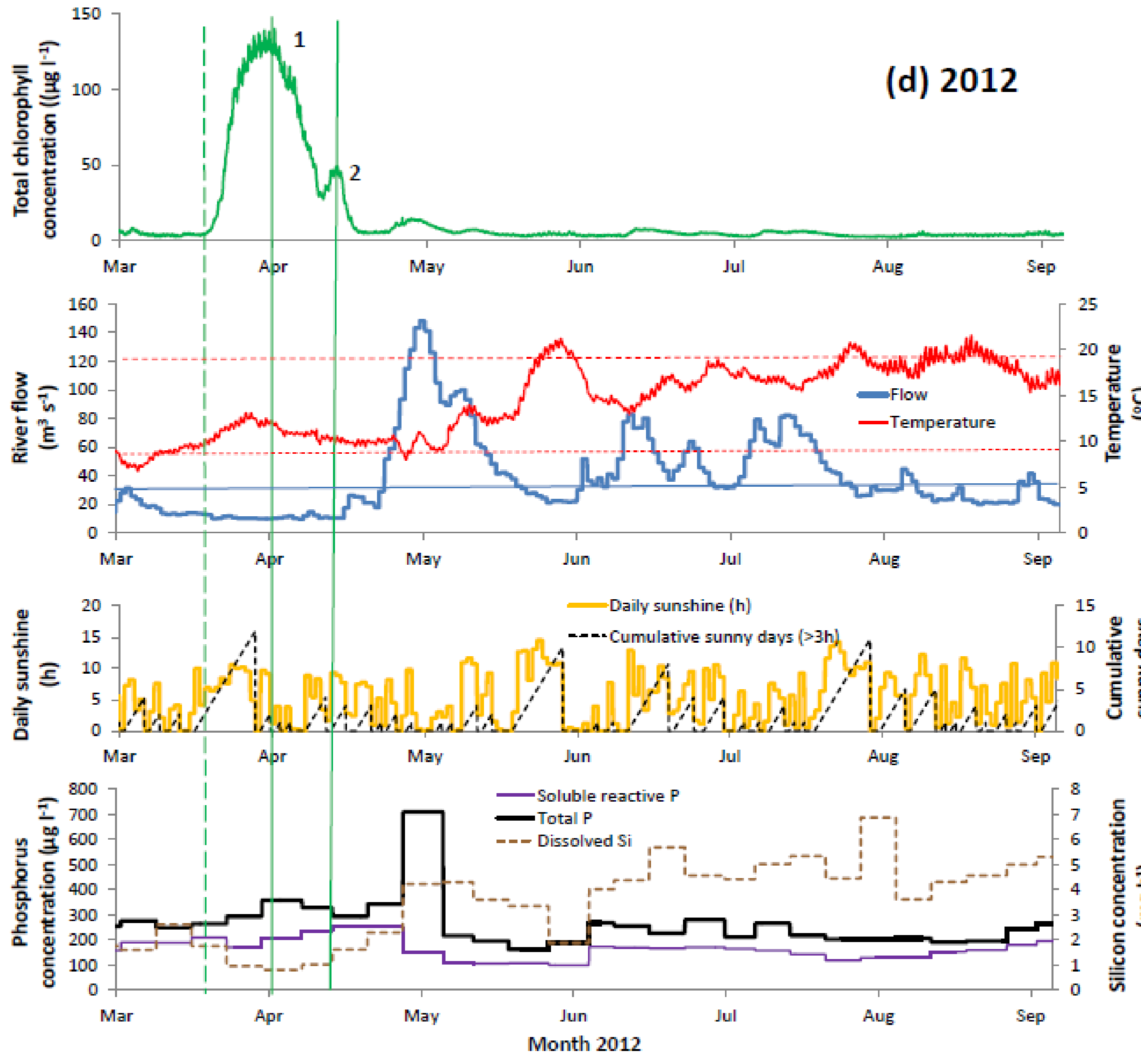
6 years of high-frequency data on Thames used to identify thresholds in -

- Flow
- Water temperature
- Sunlight duration
- Nutrient concentrations

Thresholds applied to time-series to explain algal bloom timing, size and duration.

Could provide an early warning system for regulators and the Water Industry.





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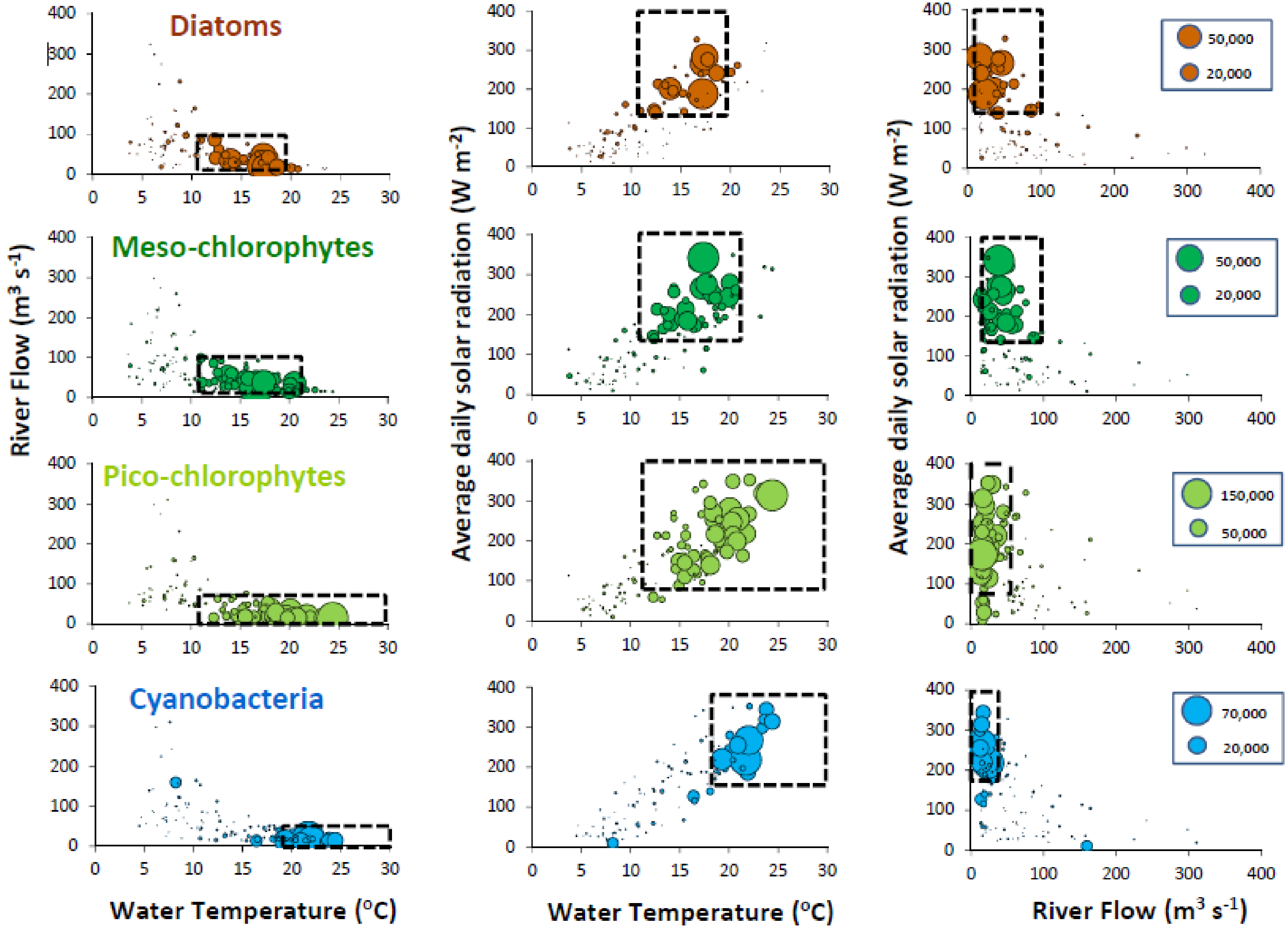
Phytoplankton bloom thresholds



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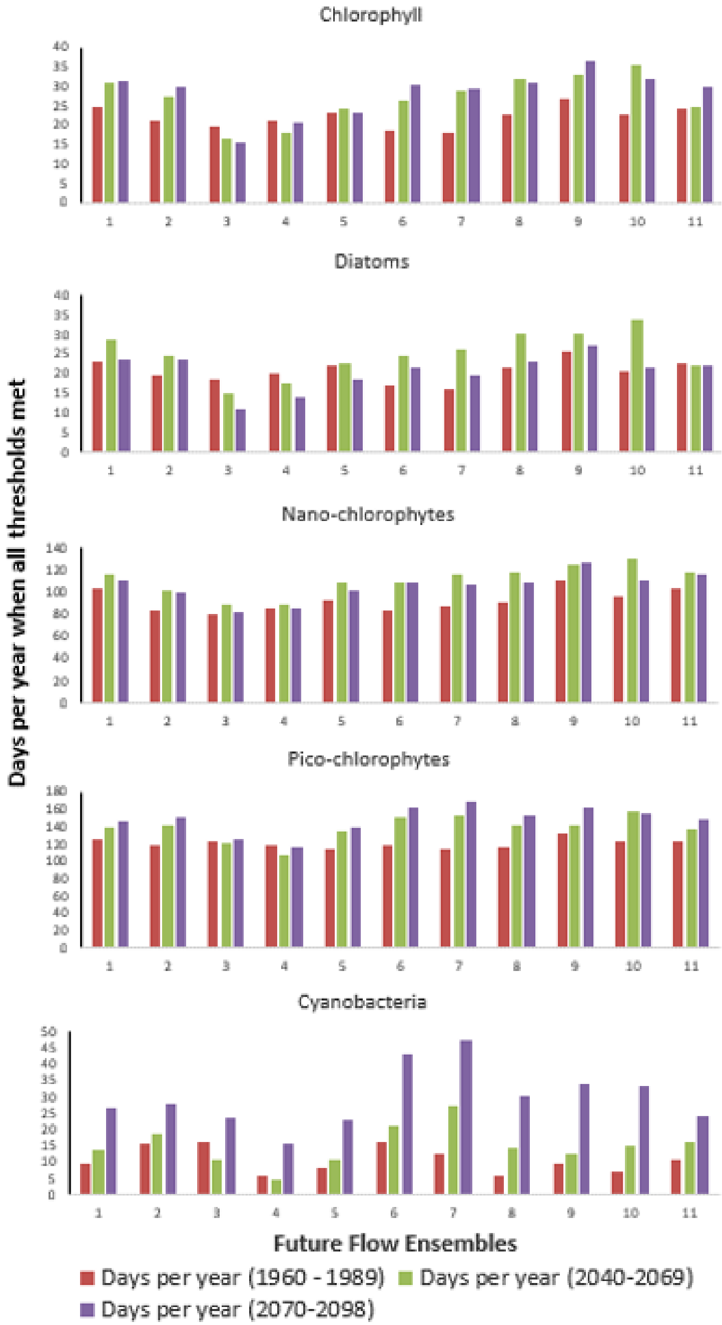
Thames bloom predictions

- Phytoplankton thresholds applied to flow, water temperature, sunlight and nutrient predictions from Future Flows datasets (2009)
- Increased chlorophyll concentrations and shift to smaller algae
- Large increase in cyanobacteria



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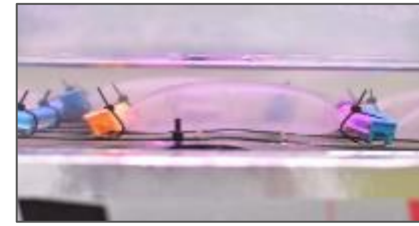
Algal growth experiments

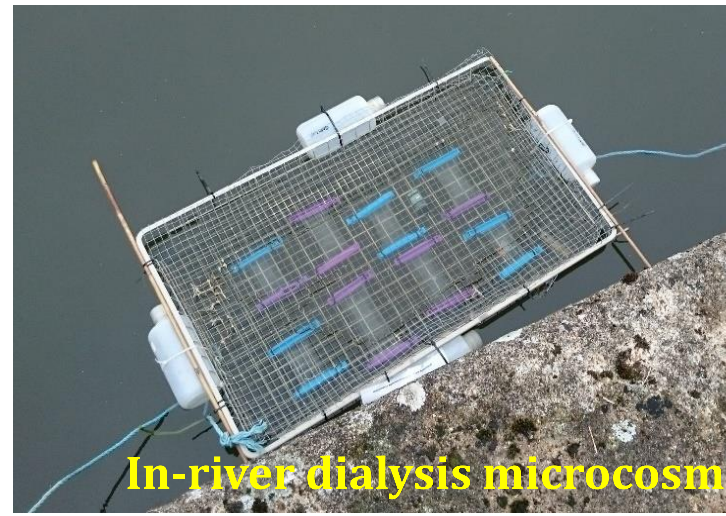


<u>Dialysis microcosm experiments</u>

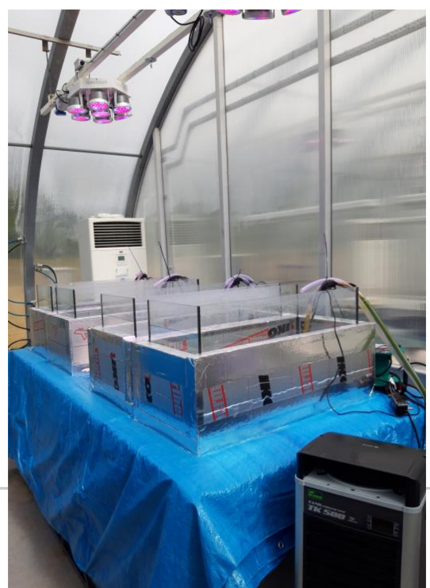
- **In-river experiments**
- **Grodome algal growth facility**

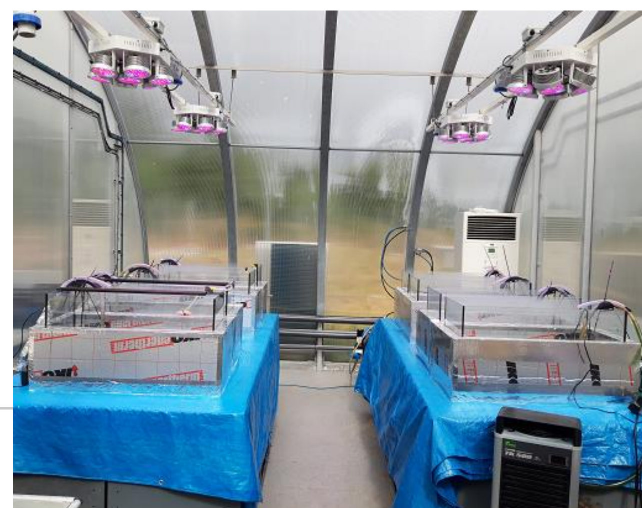
How is algal growth rate affected by

- Nutrient concentrations
- Water temperature
- Light



Allows UKCEH to predict impacts of mitigation and climate change





Conclusions

- P concentrations reducing in most UK rivers. Water Quality improving.
- Algal blooms in larger rivers not caused by nutrient pollution incidents. More likely to be due to weather conditions (low flows, high water temperature and sunlight levels)
- Other mitigation measures (river restoration, use of tree-shading, increased flow velocities by removing impoundments) could be more effective in increasing catchment resilience in the future.