Monitoring and Managing Cyanobacterial Risks in Freshwater Lakes

University of Glasgow
Department of Statistics

Claire Ferguson[1], Marian Scott[1], Laurence Carvalho[2], Geoffrey. A. Codd[3] and Andrew Tyler[4]

[1]University of Glasgow, Glasgow, [2]Centre for Ecology & Hydrology, Edinburgh, [3]University of Dundee, Dundee, [4]University of Stirling, Stirling, UK

Correspondence email: c.ferguson@stats.gla.ac.uk

Introduction

Mass populations of cyanobacteria (blue-green algae) are an increasingly common occurrence in inland waters (Figure 1). Effective strategies for monitoring and managing the health risks of cyanobacteria toxins are required to safeguard animal and human health.

FIGURE 1: A potentially-toxic bloom of cyanobacteria on Loch Leven, Scotland.

Approach

A multi-disciplinary study was undertaken to explore approaches for the identification, monitoring and management of potentially-toxic cyanobacterial populations and their associated risks. This included:

- **using statistical** and process-based **models to investigate cyanobacterial bloom occurrence**;
- monitoring lake status using remote sensing (Figure 2);
- investigating cyanobacterial toxin transfer to spray-irrigated crops;
- assessing public attitudes and perceptions towards associated risks.

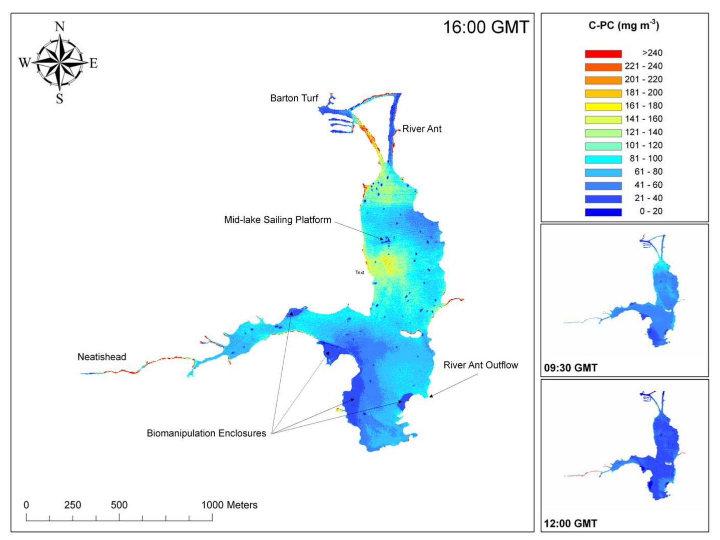

FIGURE 2: Spatio-temporal change in potential cyanobacterial abundance in Barton Broad, UK (from remote sensing).

Methodology

Phytoplankton data from 134 UK lakes were used to develop a series of Generalized Additive Models (Wood, 2006) for the **responses:**

$$\left.\begin{array}{c}\text{presence/absence (p/a)}\\ \text{relative proportion (\%)}\\ \text{actual biovolume}\end{array}\right\}\text{ of cyanobacteria}$$

with **potential covariates:** alkalinity, colour, altitude, total phosphorus (TP) and retention time.

The responses p/a and % do not represent potential toxin concentrations and cannot be related to World Health Organisation (WHO) guideline levels. These responses are not considered suitable measures for hazard assessment.

Results

The predictive power of all models was low. However, the best model was developed for the response of **log total cyanobacterial biovolume**, model (1).

$$\begin{aligned}\log \text{cyano} &= \beta_0 + \beta_1 \log(\text{ret. time}) + s_1(\log \text{alkalinity}) \\ &+ s_2(\log \text{colour}) + \beta_2 \log(\text{TP}) + \epsilon \end{aligned} \quad (1)$$

where $s()$ are smooth functions and $\epsilon \sim N(0, \sigma^2)$.

- Alkalinity and water colour were significant nonparametric predictors (Figure 3).
- Retention time and total phosphorus were borderline significant linear predictors with positive coefficients.

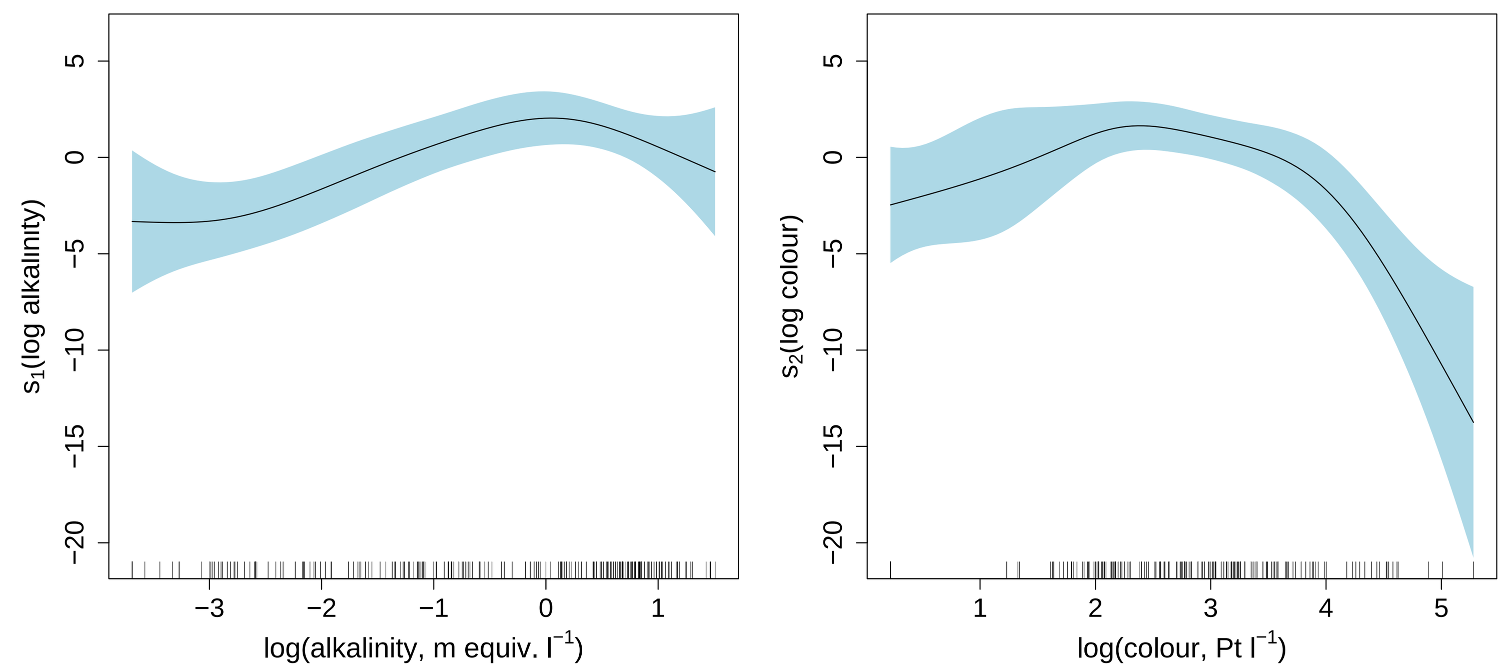

FIGURE 3: Response of log cyanobacterial biovolume to log alkalinity and log colour respectively with shading to indicate ± 2 standard errors.

Conclusion and Discussion

- In the highest risk lakes (alkaline, low colour lakes), risks can be lessened through reducing nutrient loads and increasing flushing during summer.
- The models for cyanobacterial biovolume can contribute to the assessment of risks to public health.

FIGURE 4: A thick cyanobacterial scum on Esthwaite Water in April 2007.

- Lake monitoring and management can be targeted, using these models, at those lakes (e.g. Figure 4) at highest risk of breaching WHO guideline levels or national legislation.

Reference

Wood, S.N., (2006). *Generalized Additive Models, An Introduction with R*, Chapman & Hall, Boca Raton.

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