Connecting science, modelling capability and management of harmful cyanobacteria blooms
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Complexity of models

Factors affecting development of CyanoHABs

- Meteorology
- Catchment management & BMPs
- Sample capture
- Cell physiology
- Water chemistry
- Hydrodynamics

Risk assessment
Human Health
Water policy
“We have not yet come face-to-face with our failure to do effective ecological science. If we had effective, interesting ecological theories we could be testing them, and they would dictate the accuracy of our measurements. In the absence of theories, we can be as careless as we like”

Outline

Hydrodynamics and modelling

• Are we making the connections (to specialists in this area)?

Emerging technology

• Remote sensing (in situ, aerial)
• Fine-scale sampling

What are we missing

• Prioritising key processes
“Without doubt, it would help if sessions at conferences were mixed rather than putting the modellers into their own room”

A common feature of blooms...
Lake Rotoehu phycocyanin monitoring

- Shallow (max. depth 14 m)
- Polymictic
- Eutrophic
- Cyanobacterial blooms
Lake Rotoehu: temperature, chlorophyll and phycocyanin fluorescence

Water temperature [°C]

- Buoy; 0.5 m
- Model; 0.5 m

Fluorescence [RFUB]

- Chlorophyll
- Phycocyanin

Temperature 0.5 m, 12 m
Lake Rotoehu: High-frequency monitoring and modelling results - temperature

Water temperature (°C)

Buoy 0.5 m
Model 0.5 m

Buoy 10.5 m
Model 10.5 m

Time (14 May to 19 July)
Lake Rotoehu cyanobacteria: High-frequency surface measurements and modelling

Hamilton et al. 2014. A Global Lake Ecological Observatory Network (GLEON) for synthesising high-frequency. Inland Waters
Simulation of temperature and cyanobacteria

Buoy diatoms
Model chlorophyll

Depth (m)

Temperature (°C)

Cyanobacteria chl (mg m⁻³)
Interactions of buoyancy and turbulence

Wallace and Hamilton (1999) L&O
Interactions of buoyancy and turbulence

Rabouille et al. (2003) C.R. Biologies
Shallow lakes can stratify strongly (e.g. diurnally) – Lake Rotorua (z ~ 3 m)
3-D modelling of cyanobacteria in a large, shallow Lake Rotorua (North Island)
Simple models or complex ones?

“...in defence of big ugly models, Logan (1994) pointed out that complex systems need complex solutions”

Cells will aggregate at a critical ratio of diffusion to floating

\[ T_{mix} = \frac{z_m^2}{K} \]
Time scale of mixing in surface layer
(mixed layer depth\(^2\)/eddy diffusivity)

\[ T_v = \frac{z_m}{v_s} \]
Time scale of cells floating
(mixed layer depth/floating velocity)

\[ Pe = \frac{T_{mix}}{T_v} \]
Péclet number
(mixed time scale/floating time scale)
Interactions of turbulence, colony size and buoyancy

\[ d_{p10} = 159 - 1.44f^3 \]

\[ R^2 = 0.85 \ (p < 0.01) \]

O’Brien et al. (2003) Hydrobiologia
Cryo-sampling of cyanobacteria

Puddick et al. (2016) L&O Methods
On-Land Mesocosms
Use of remote sensing for bloom monitoring: a surface-temporal component

High spatial variability in a *Microcystis* bloom

Distributions of fluorescence: cyanobacterial bloom vs DCM

Linking surface and depth observations across Rotorua lakes
How good are our measurements for validating our model?

Spatial scale in modelling cyanobacteria

• Highly heterogeneous horizontally and vertically (→ 3D model application)

• Heterogeneous vertically, homogeneous horizontally (→ 1D model application)

Where do we need more work to enhance models?

**Spatial variability and toxicity**

- 28 surface samples
- 3 h routine
- Cell enumeration
- Nutrients
- Total microcystin
- Extracellular microcystin
- DNA
Where do we need more work to enhance models?

**Benthic Microcystis**

Large quantities of *Microcystis* on sediment surface
Where do we need more work to enhance models?

Competition – competitive exclusion, N-fixation?

Borges et al. (2016)
Where do we need more work to enhance models?

Toxicity – variability in time, species, strain

Where do we need more work to enhance models?

Lake Rotorua modelling as a decision support tool

ROTAN catchment model

Climate model

High frequency monitoring

Lake model

Inform

Lakes Rotorua and Rotoiti Action Plan
Major cyanobacteria management decisions are based around models

Lake Rotoiti diversion wall

Conclusions

Hydrodynamics and modelling
• We require further progress in the application of coupled hydrodynamic-bloom models. Many blooms are driven in the short-term by favourable physical environments that allow cyanobacteria to dis-entrain from bulk water movement.

Emerging technology
• Many of the tools to support detailed understanding of in situ cyanobacteria distributions exist currently, at various scales (e.g., remote sensing (in situ, aerial) and cryo-sampling). Integration and cross-referencing of these tools is required.

What are we missing
• Major gaps in cyanobacteria modelling include: life cycle models (particularly given the importance of benthic recruitment), colony formation and scale analysis to distinguish critical turbulence levels.