Cyanobacterial bloom dynamics - some lessons from the Nineties

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CSIRO BGA research 1992-2000 field studies

  - Explained relationship between discharge and Anabaena dominance
- Fitzroy Barrage (1997 - 2000)
  - Algal bloom dynamics in a tropical river barrage
- Chaffey Dam (1995 - 1997)
  - Destratification and water quality
Research Strategy

• Field studies
  • Hydrodynamics
    • Stratification and mixing
  • Chemistry
    • Nutrient dynamics
      • Sediments
      • Water column
  • Biology
    • Algal dynamics
      • Population dynamics
      • Species shifts
    • Photophysiology

• Modelling
  • Establish fundamental relationships between drivers
Blooms in rivers - Maude Weir, Fitzroy Barrage

- Persistent stratification occurred below flow threshold for mixing
  - We can model this accurately
- Blooms occur following onset of persistent stratification
  - $Z_{sml}:Z_{eu} < 3$

Blooms in rivers - Maude Weir, Fitzroy Barrage

- Population grew at light-limited rate
  - same growth rate observed in lab cultures
- Population stopped growing when phosphorus exhausted

Blooms in rivers - Maude Weir, *Fitzroy Barrage*

- Persistent stratification when flow below mixing threshold
  - Settling of TSS
  - Decreased turbidity
  - $Z_{sml}/Z_{eu} < 3$
- Mixed *Cylindrospermopsis* /*Anabaena* bloom

Blooms in rivers - Maude Weir, *Fitzroy Barrage*

- Population grew at light-limited rate
- Population stopped growing when phosphorus exhausted

**Fig. 9.** *Cylindrospermopsis* concentrations (cell ml$^{-1}$) over the top 3 m of the water column at WTP during the exponential growth phase in December 1997. The inferred *in situ* net growth rate of $\mu = 0.31$ day$^{-1}$ is indicated by the dashed line.

Blooms in reservoirs - Chaffey Dam

What makes this become ->
Intrusions

- Nutrient rich inflow 13-15 Feb 1997
- 5000 kg TP, 11800 kg TN
- Intrusion below surface mixed layer
SML deepening entrains FRP and reduces photon dose
Summary - Chaffey Dam intrusion event

• Entrainment and intrusion characteristics are well predicted by text book theory

• Intrusion below SML separates light and nutrients

• Deepening of SML by penetrative convection entrains nutrients

• Phytoplankton response is immediate following nutrient supply to SML

• No evidence that phytoplankton migrate to exploit nutrient-light separation even though distance is small (1-2 m)
Destratification - Chaffey Dam

10 plumes @ 10 L/s air flow per plume

- No effect on surface layer depth
- Low mean wind speed
- Cyanobacterial blooms continue
- 80% reduction of internal FRP load

\[ y = -3.21 + 35.1x \quad r^2 = 0.88 \]

Summary

• BGA populations grow at light-limited rate
  • Require $Z_{sml}:Z_{eu} < 2-3$
  • $\mu \sim 0.35 \text{ d}^{-1}$
    • Population doubles every 2 days (from 100 to 13000 cells mL$^{-1}$ in 2 weeks)

• BGA population biomass is probably limited by P
  • Seldom observed evidence of nutrient limitation in the field despite very low nutrient concentrations
  • $\sim 7 \mu g \text{ L}^{-1}$ P can support 15000 cells mL$^{-1}$ of Anabaena

• No evidence of buoyancy-regulated movement to exploit light-nutrient separation
  • Explicitly observed not to happen
  • Surface layer population redistributed throughout SML every night due to penetrative convection
Summary - destratification/enhanced circulation

- Generally has not produced deeper SMLs
  - Unlikely to induce light-limitation of cyanobacteria
  - Success depends on local climatic conditions and flow rate relative to reservoir volume (it’s an engineering design and cost issue)
    - Smaller storages (< 10000 ML) appear to be the best candidates
- Generally does increase dissolved oxygen
  - Reduced internal nutrient load > lower algal biomass
  - Consider oxygenation as an alternative?

“If all you have is a hammer, everything looks like a nail”

“Millions saw the apple fall, but Newton was the one who asked why”

Bernard Baruch (1870-1965)
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Thank you