

# Early Detection of Cyanobacteria and Cyanotoxins in Drinking Water Supplies



**CAWTHRON**  
The power of science®

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# The Cawthron Institute



- **Thomas Cawthron: Investor, businessman, philanthropist, visionary.**
- **Recognised science as key for NZ's economic prosperity.**
- **Left £233K in his will.**
  - **Equivalent of ca. \$127M**
- **Cawthron Institute established by an Act of Parliament in 1919.**
- **Officially opened in 1921.**



Then....



Now....







**197**

Scientists and specialist staff

73 coastal and freshwater  
33 aquaculture  
71 analytical and lab services  
20 corporate

Sectors we work in

Aquaculture, biosecurity, dairy, energy, fisheries, food export, oil and gas, seafood

Who we work with

Industries, Crown research institutes (CRIs), research organisations and universities, Māori, central and local governments

Our talented teams of scientists and specialist staff help New Zealand's leading export sectors stand out from the crowd and take on the world. **Cutting-edge science, it's in our DNA!**





**Coastal & Freshwater**



**Aquaculture**



**Analytical Services**



# An All-In-One Synergy

- **Research & Consulting services:**
  - Aquatic monitoring tools & technologies
  - Freshwater quality, health and allocation
  - Biosecurity, ecotoxicology and taxonomy
  - Collaborative decision-making
  - Analytical method development
- **Analytical services:**
  - IANZ accredited laboratories
  - 5 day turnaround time (urgent testing available on request)
  - Technical expertise supported by Research team





# Cyanobacteria (blue-green algae)



- Ancient photosynthetic prokaryotic organisms
- Diverse habitats
- 2,000 species worldwide
- Freshwater aquatic species
- Planktonic & benthic
- Create multiple water quality problems

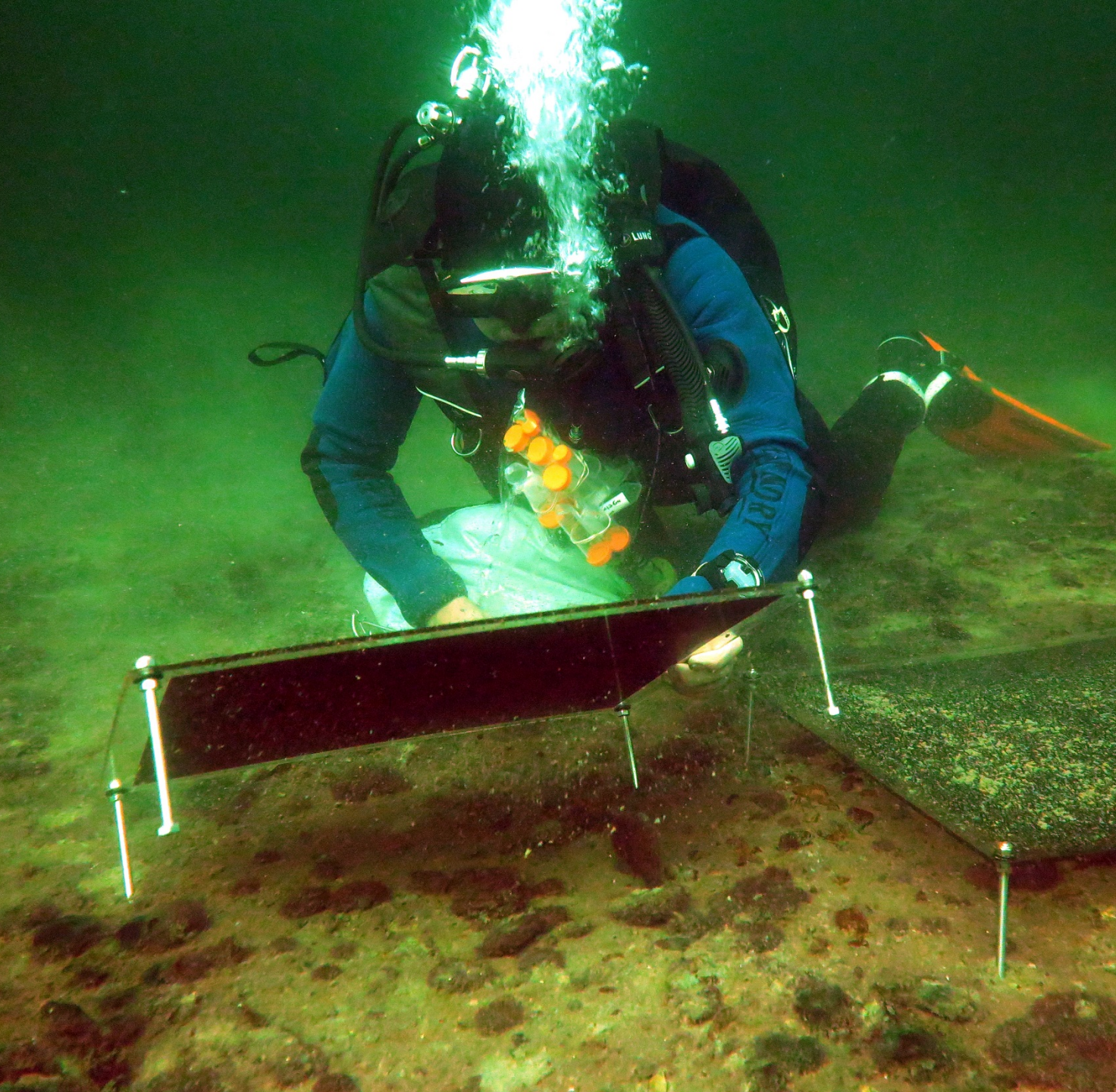




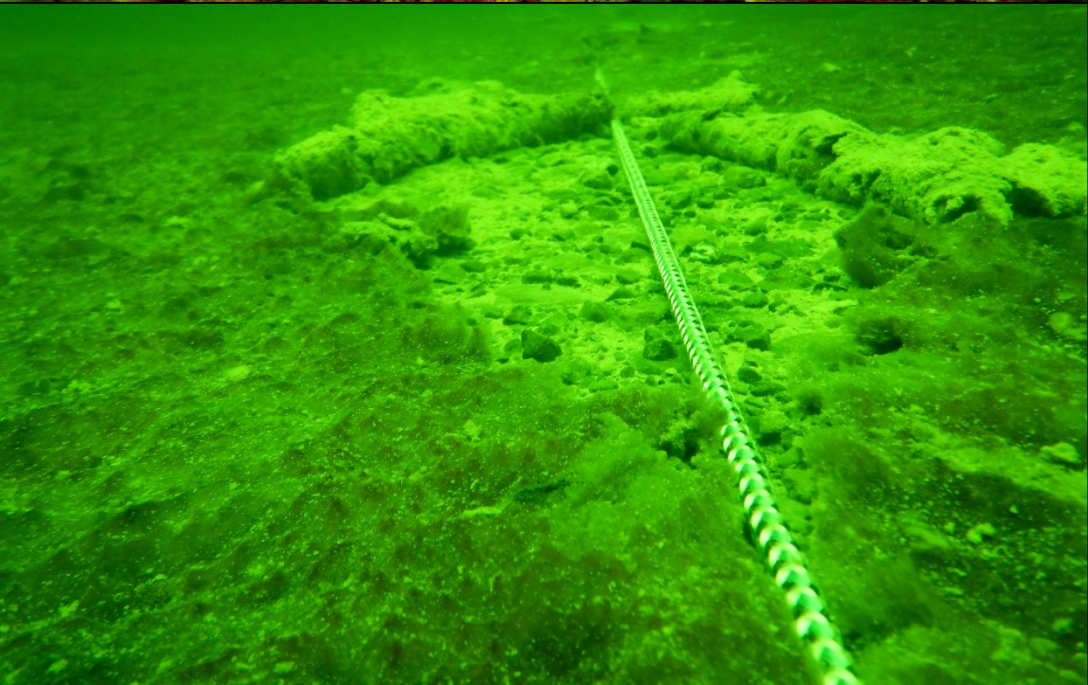










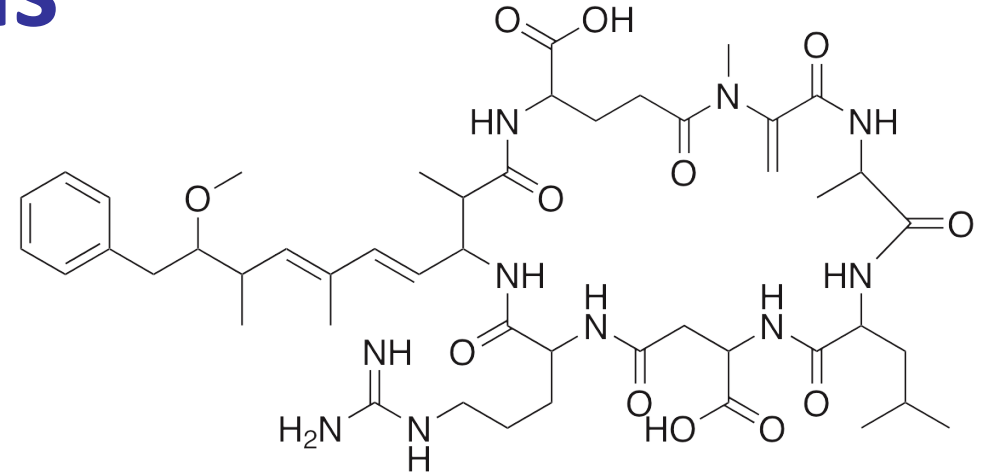




# Cyanotoxins

## Hepatotoxins

- Microcystin (e.g., *Microcystis*, *Anabaena*)
- Nodularin (e.g., *Nodularia*)
- Cylindrospermopsin (e.g., *Cylindrospermopsis*)



## Neurotoxins

- Anatoxin-a (e.g., *Aphanizomenon*, *Anabaena*)
- Saxitoxins (e.g., *Lyngba*, *Anabaena*)

## Dermatotoxins

- Lyngbyatoxin-a (e.g., *Lyngba*, *Anabaena*)
- Aplysiatoxins
- Lipopolysaccharides





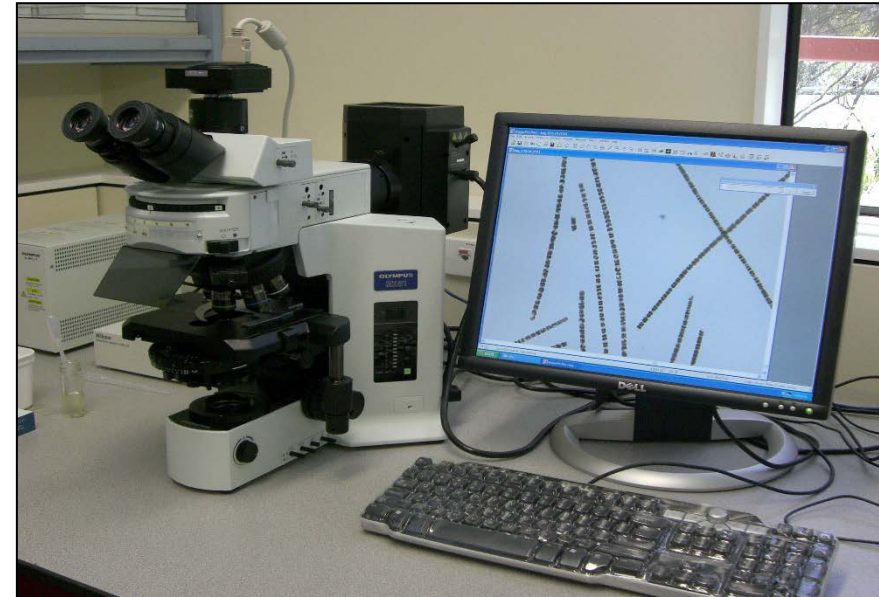
# Analytical Testing Services

- **Microalgae:**

- Identification, enumeration, relative abundance, biovolumes
- Phytoplankton and periphyton

- **Cyanotoxins:**

- LC-MS quantification
- Algal mats, bloom (lake) water and drinking water



# Drinking Water Standards for Cyanotoxins

Toxin	PMAVs ( $\mu\text{g/L}$ )
Anatoxin-a ✓	6
Homoanatoxin-a ✓	2
Cylindrospermopsin ✓	1
Anatoxin-a(S)	1
Microcystin (MC-LR toxicity equivalents) ✓	1
Nodularin ✓	1
Saxitoxins (as STX equivalent) ✓	3



# High-Throughput DNA Sequencing



**Identifies cyanobacteria  
by assessing morphology**

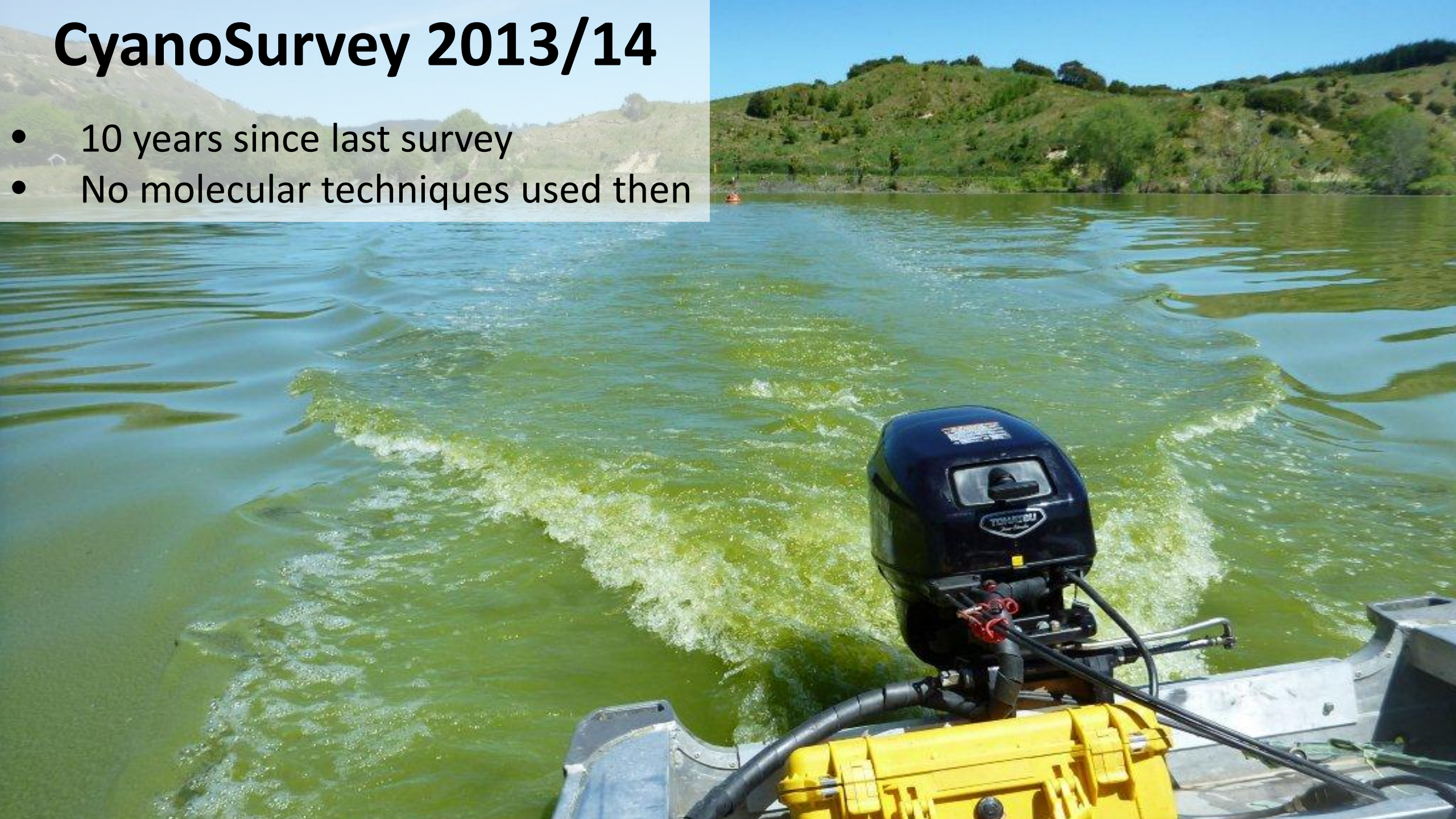


**Identifies cyanobacteria  
using DNA sequence**



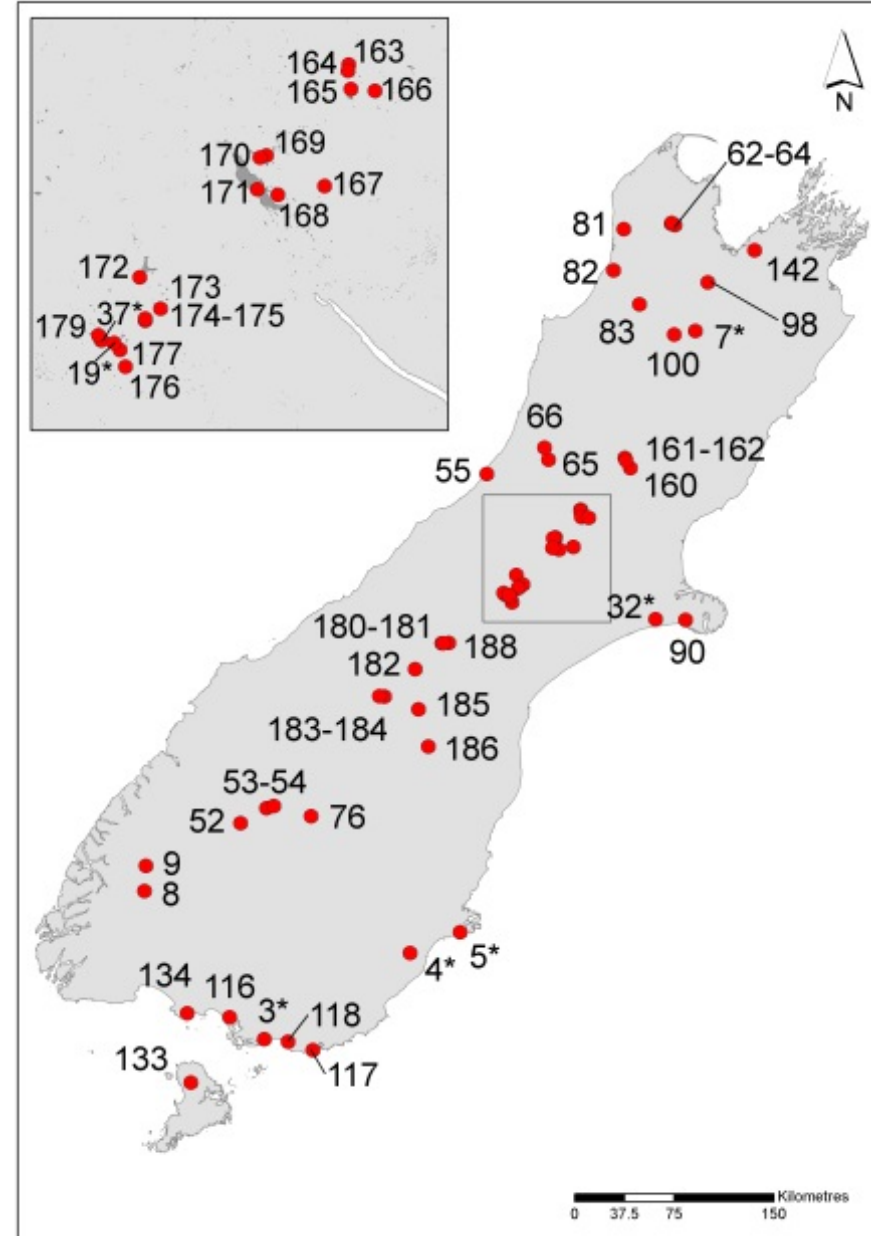
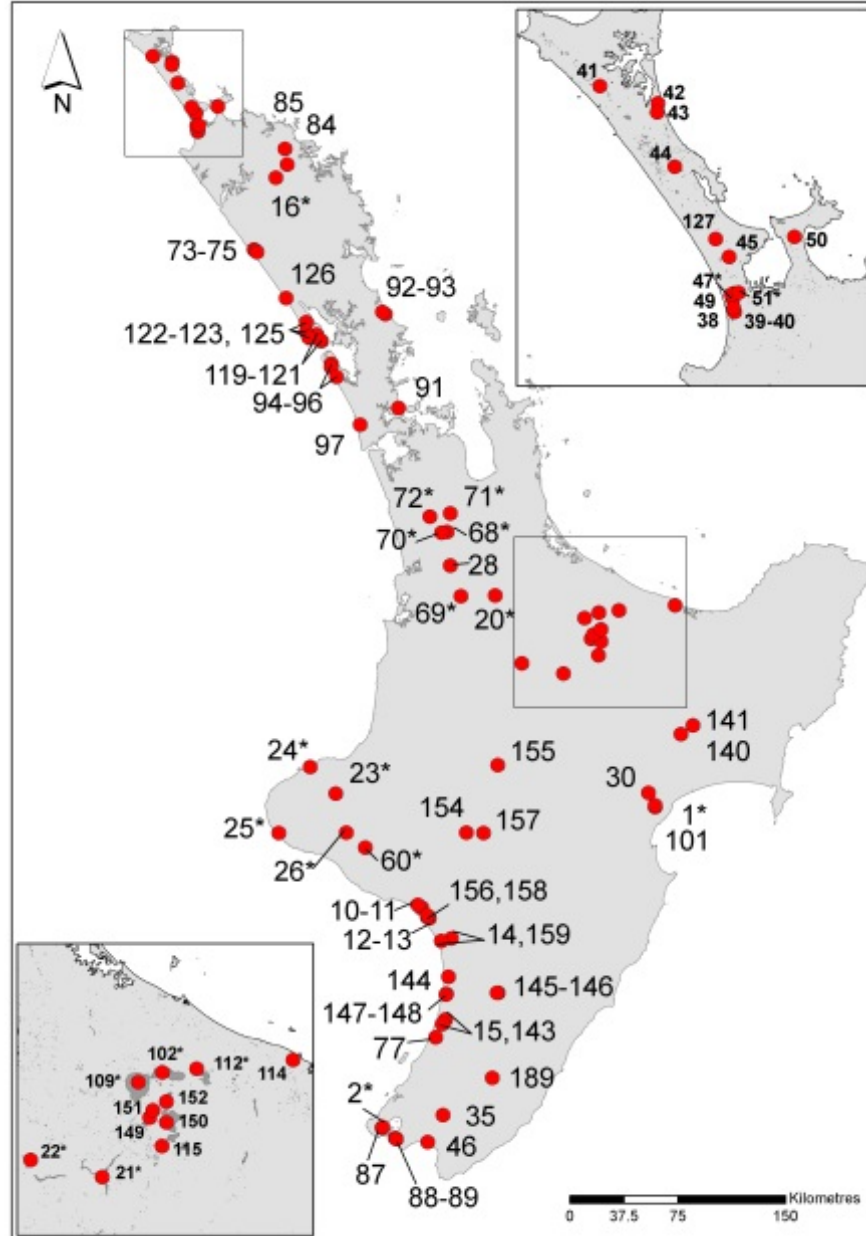
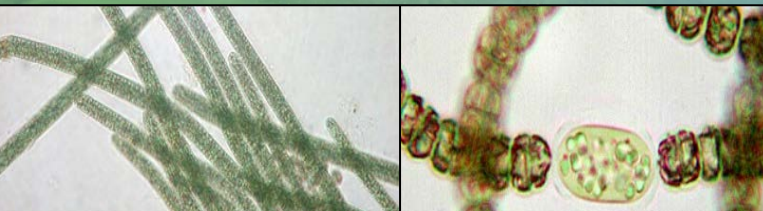
# CyanoSurvey 2013/14

- 10 years since last survey
- No molecular techniques used then

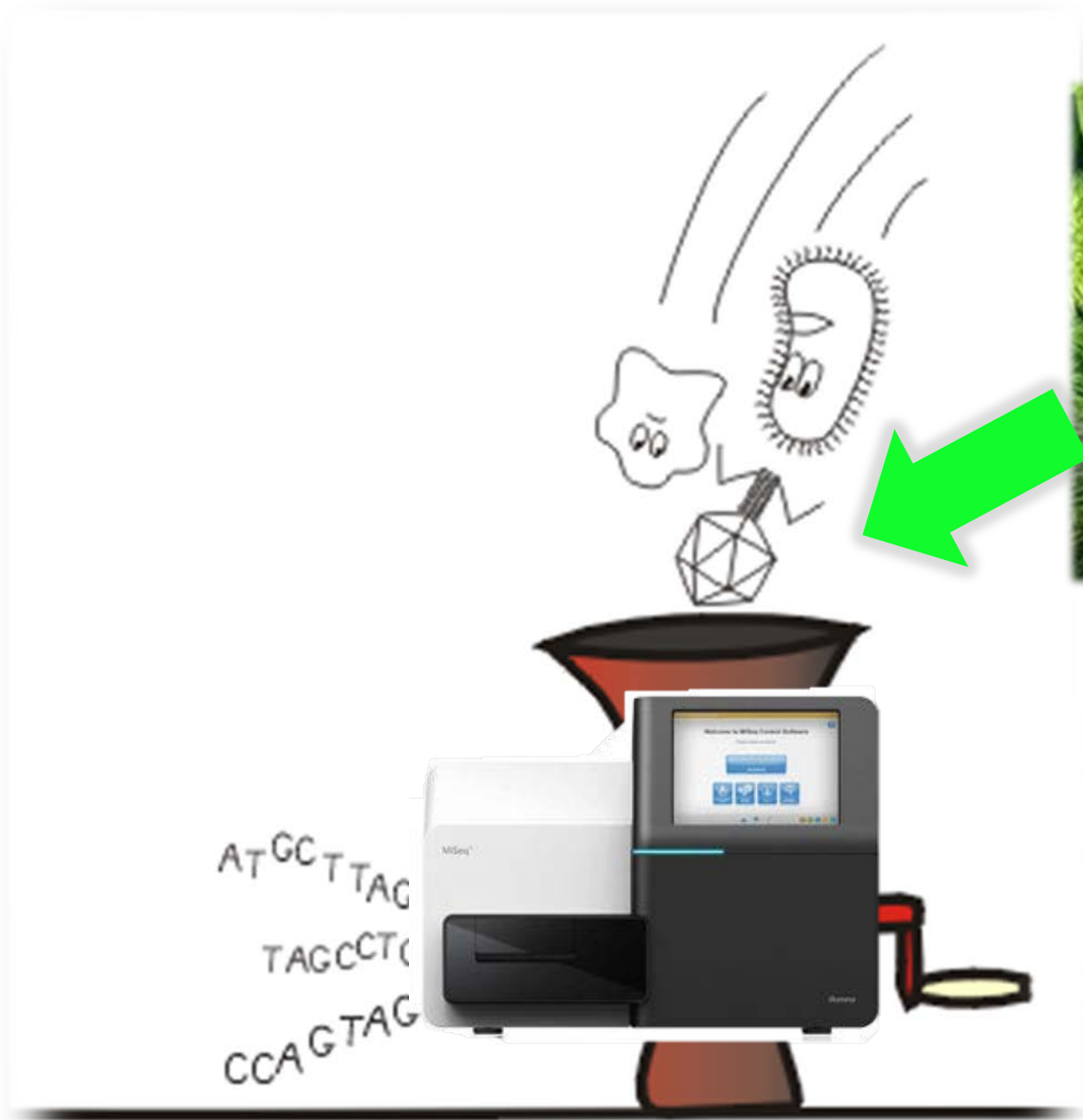




# CyanoSurvey – 2013







by Viktor S. Poór

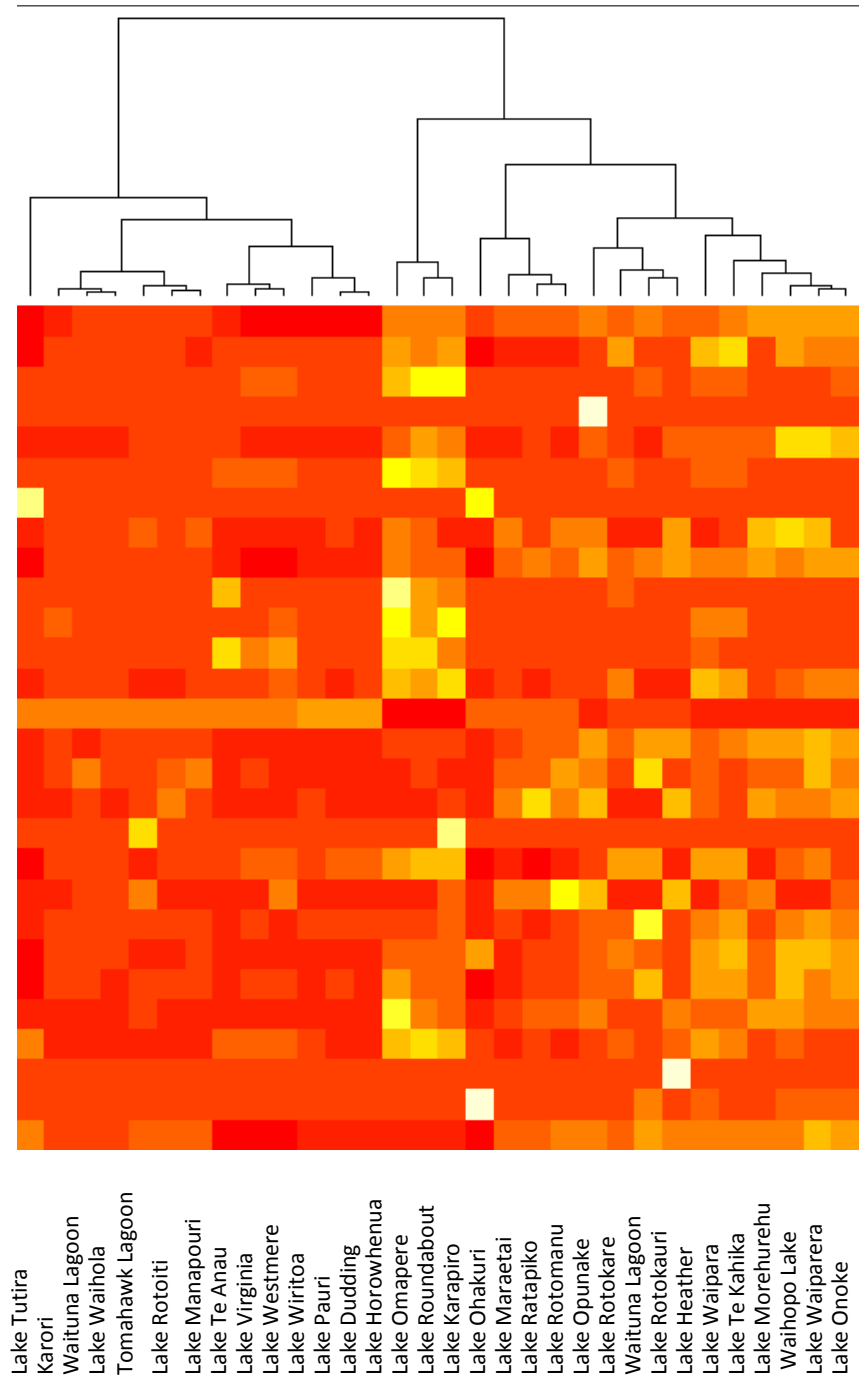
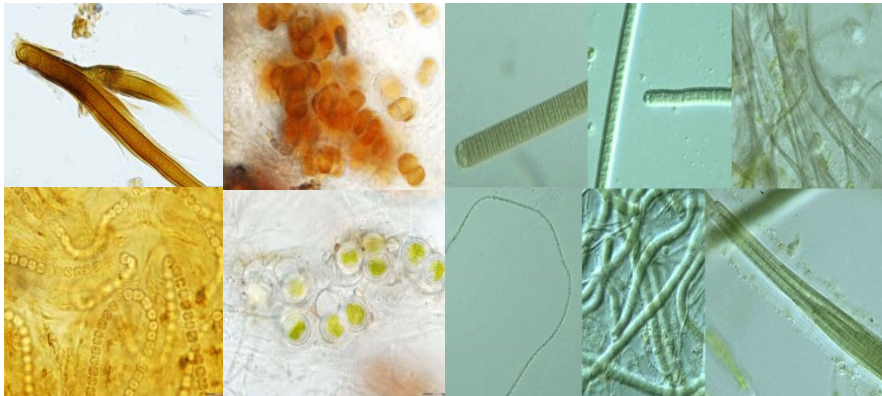


# 'Snap-shot' of Diversity

- 30-60% per sample not cyanos
- 4.8 million cyanobacterial seq.

## Genera detected

- Nostocales - 8
- Stigonematales - 1
- Oscillatoriales - 9
- Chroococcales - 9





# Toxin Results

<b>Cyanotoxin</b>	<b>Toxin Detected? (LC-MS)</b>	<b>Toxin Concentration [µg/L]</b>
<b>Microcystin / Nodularin</b>	11% 0.01%	0.01 – 55.40 0.04
<b>Anatoxin</b>	0.01%	0.25
<b>Saxitoxin</b>	0	n/a

- **No new toxin producers identified**



# Pros and cons

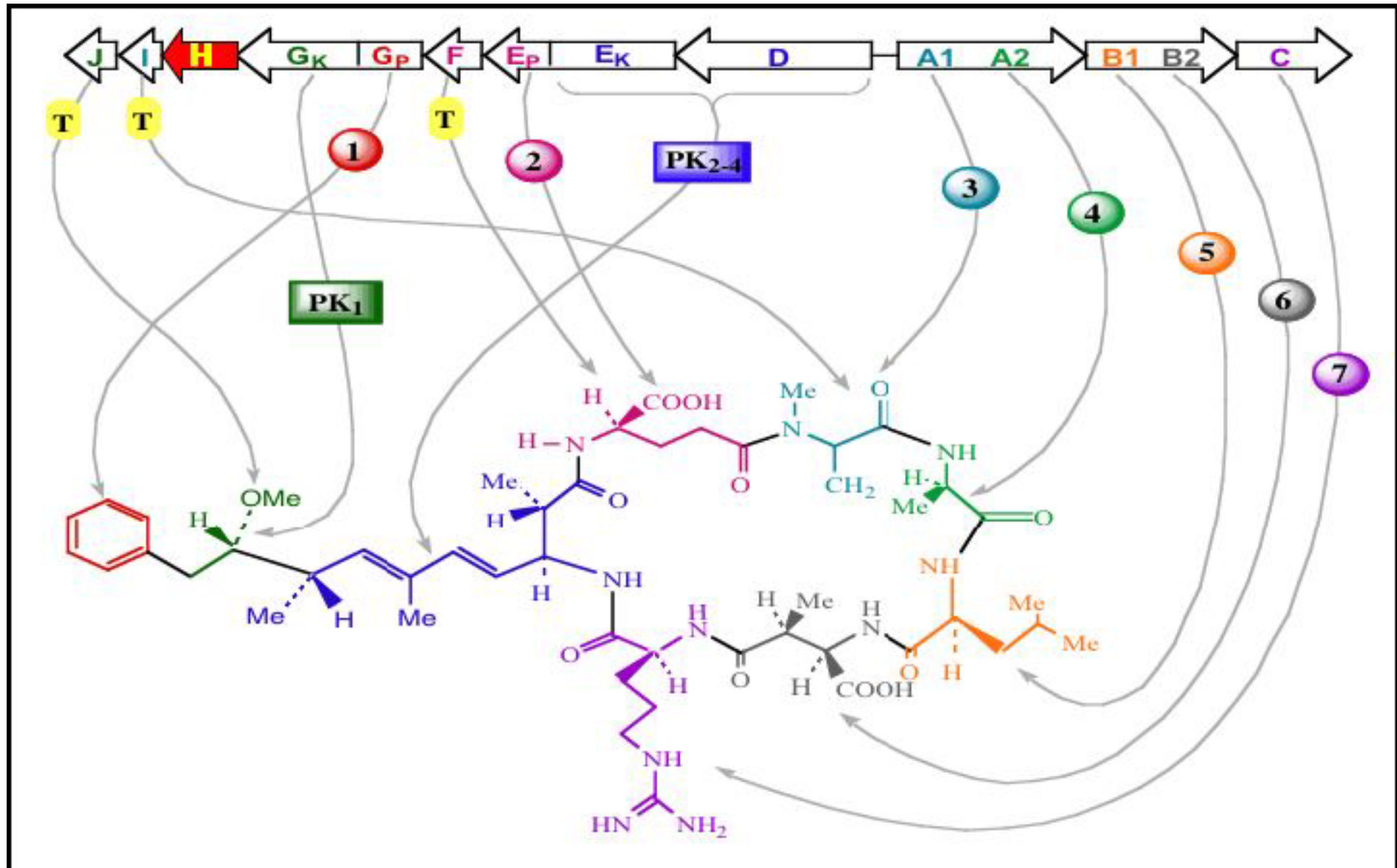
	Molecular	Microscope
Cost	\$150-\$200/sample	\$150-\$200/sample
Detect multiple species	Yes	Yes
Runtime	ca. 1 hr for 100	30-60 mins (or more) per sample
Throughput	100's of samples	Slow
Expertise required	Good lab skills	Taxonomic expertise
Quantify	Yes (but only a few species)	Yes

Excellent research tool....

Excellent for screening samples....



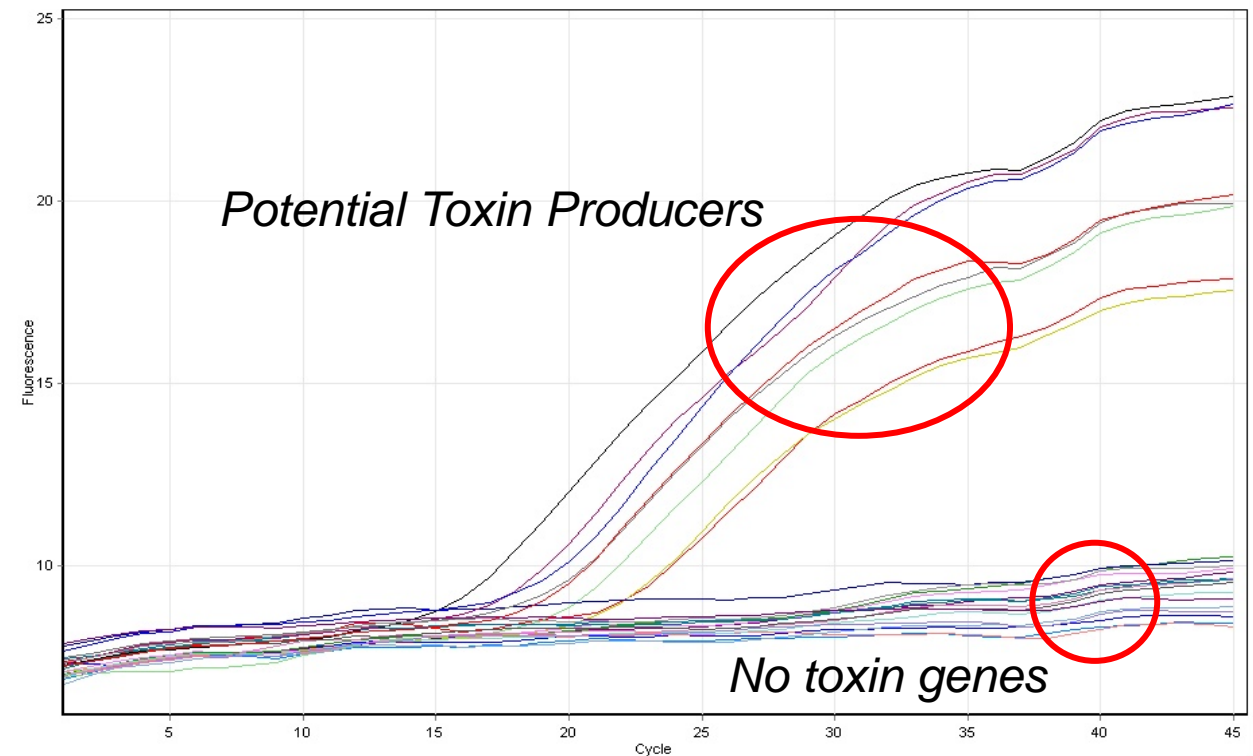
# Molecular Detection of Toxin Genes





# Quantitative PCR (qPCR)

- Amplification of DNA is monitored in real-time.
- Target toxin production genes:
  - Microcystin/Nodularin (*mcyE*)
  - Anatoxin (*anaC*)
  - Cylindrospermopsin (*cyrJ*)
  - Saxitoxin (*sxtA*)
- Also other genes: e.g., geosmin production



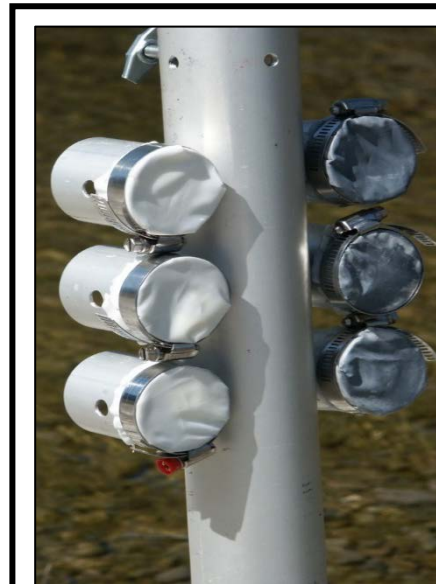
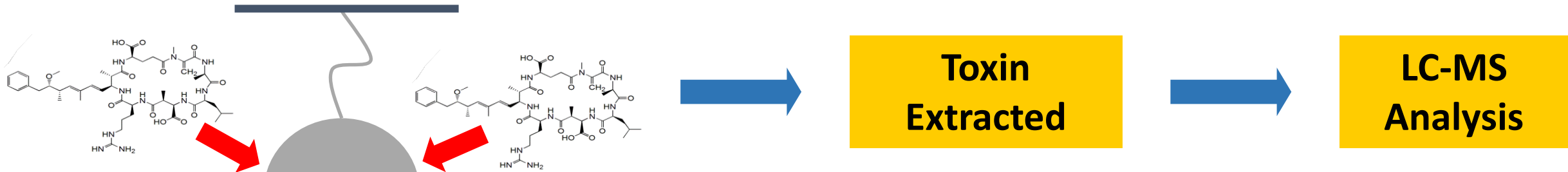






# Early Warning of Cyanotoxins

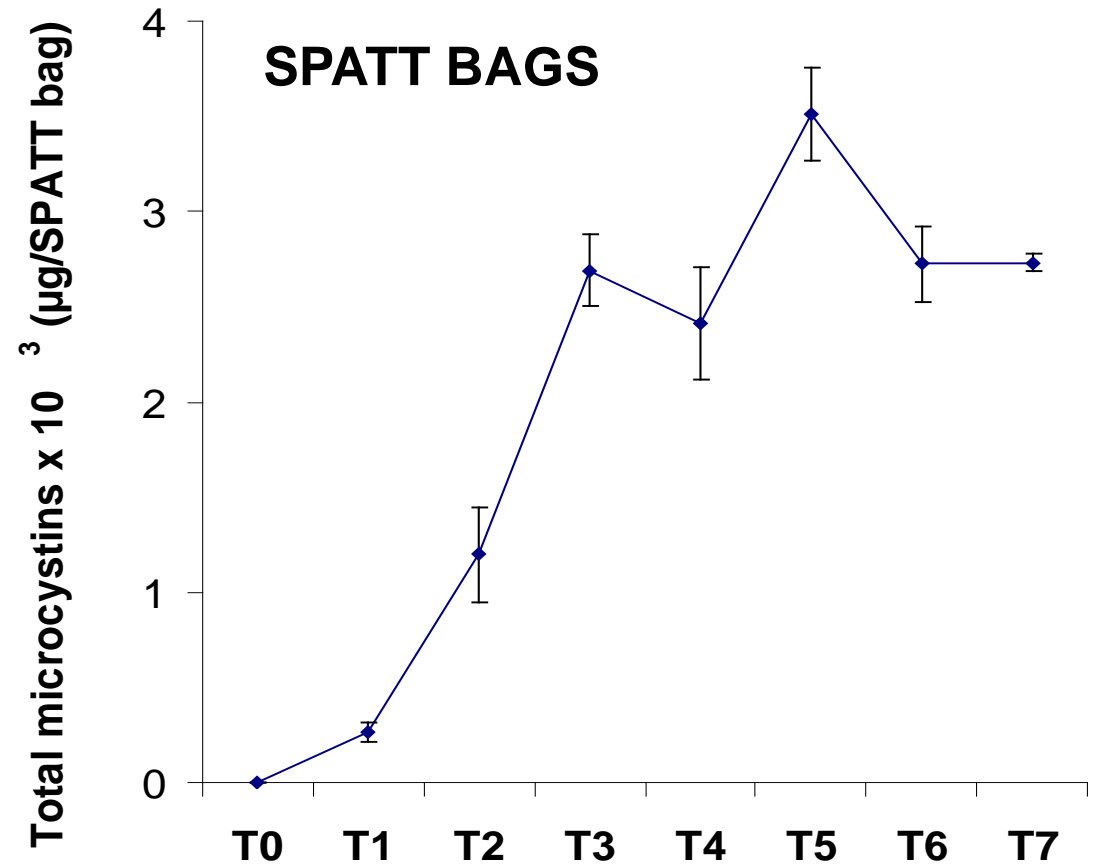
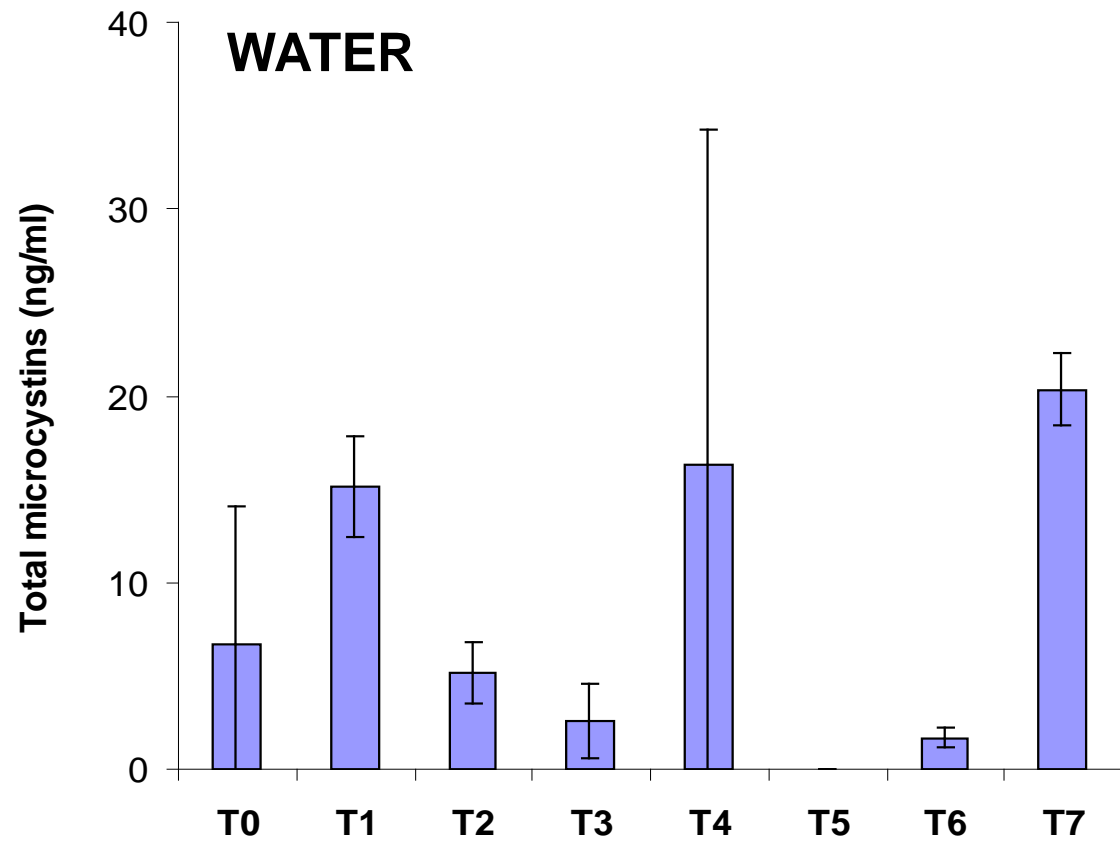
- **SPATT – Solid Phase Absorption Tracking Technology.**
- **Overcomes some challenges of sampling/monitoring.**





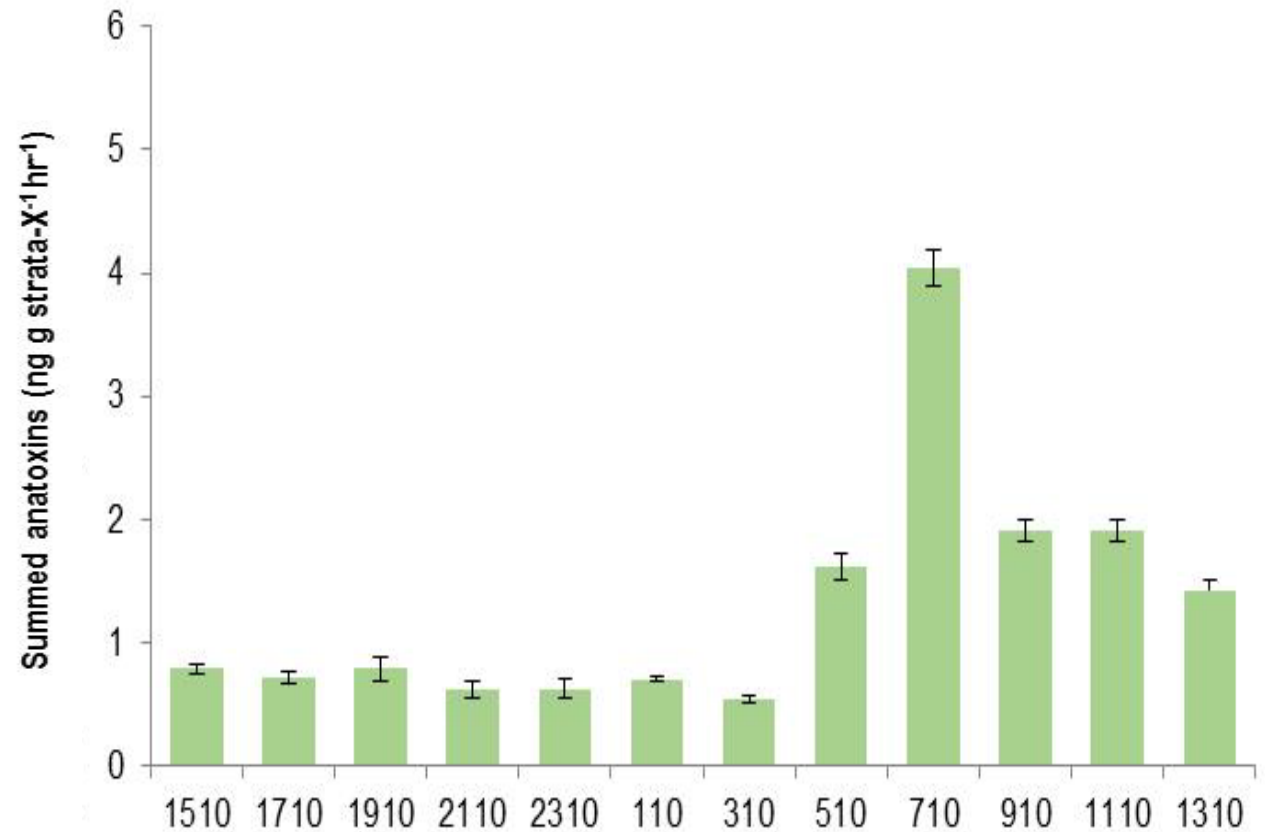
# SPATT - Microcystins

- Evens out pulses of cyanotoxin release



# SPATT - Anatoxins

- Increases detection sensitivity when low levels of toxins are present.



- No dissolved toxins detected in the water samples (<0.03 µg/L).



# Concluding Remarks

- Accredited LC-MS cyanotoxin testing with a quick turnaround
- Molecular testing for toxin genes:
  - Rapid, sensitive & specific
  - Early warning of toxin potential in water reservoirs
- SPATT Sampling:
  - Early detection of toxin production
  - Useful for post-treatment in DW supplies
- Incorporation of alternative sampling and testing into monitoring programmes can provide early warning mechanisms



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