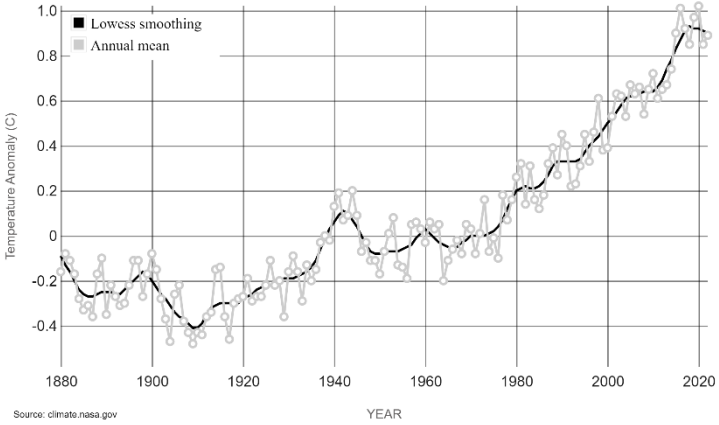
Metagenomic insights into Cyanobacterial blooms triggered by climate warming in NZ's freshwater lakes

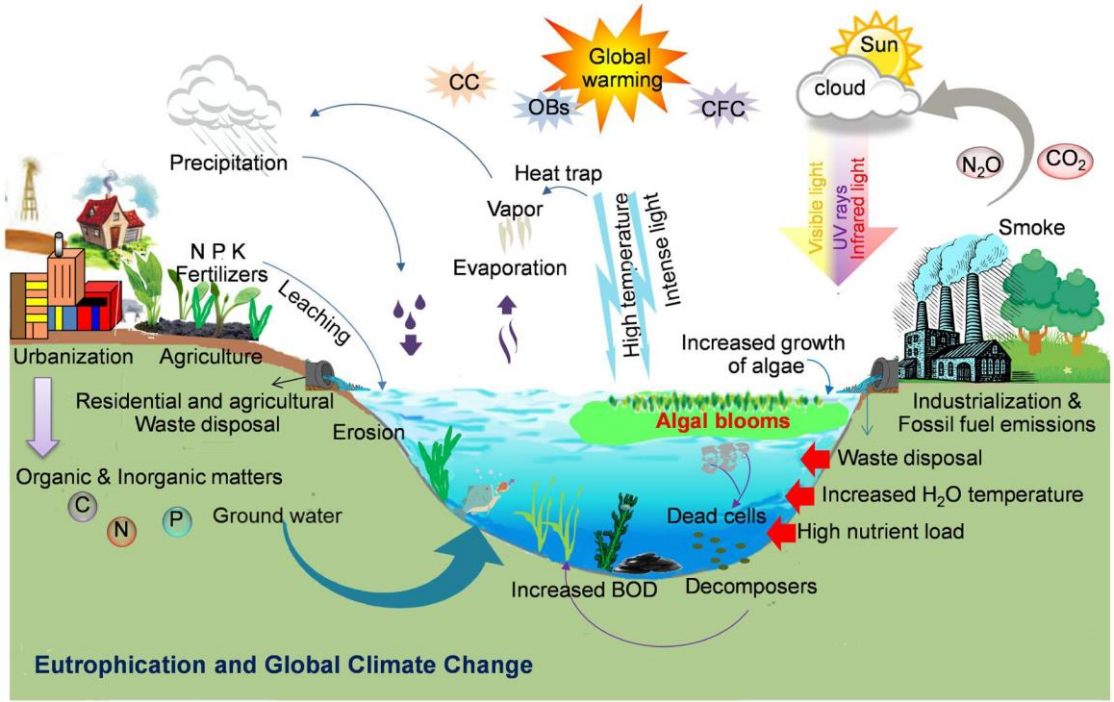
Bharat Manna, Emma Jay, and Naresh Singhal

Department of Civil and Environmental Engineering
The University of Auckland, New Zealand

Response of freshwater systems to climate change

Trend in Global Temperature Rise





Global temperature rise data source: NASA's Goddard Institute for Space Studies (GISS). Credit: NASA/GISS

Rastogi RP, Madamwar D, Incharoensakdi A. *Frontiers in microbiology*. 2015 Nov 17;6:1254.

Reports on Cyanobacteria and Cyanotoxins in NZ Lakes

Table 1: Cyanobacterial genera known to occur in New Zealand fresh waters and the toxins they are known to produce worldwide.[5,9]

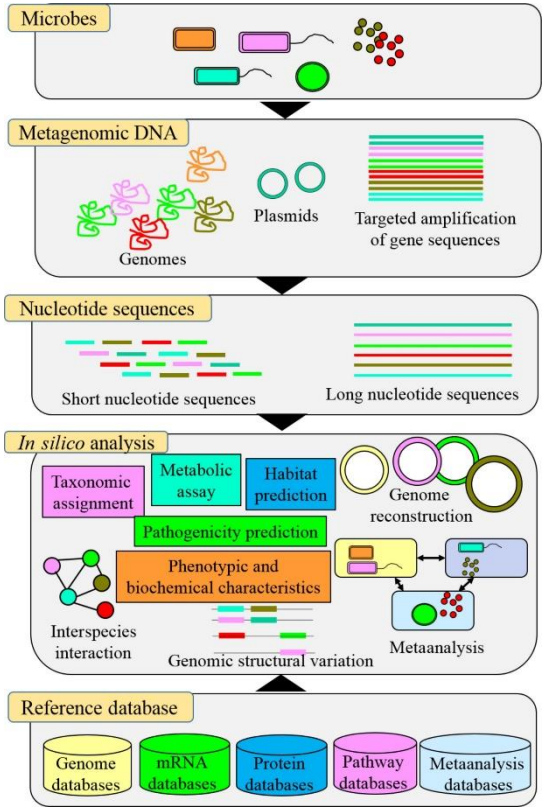
Genera	Cyanotoxins known to be produced
Anabaena	anatoxin-a,[a] anatoxin-a(S), microcystins,[a] saxitoxins,[a] cylindrospermopsin
Anabaenopsis	microcystins
Aphanocapsa	microcystins
Aphanizomenon	**anatoxin-a**, cylindrospermopsin, saxitoxins, microcystins
Arthrospira	microcystins, anatoxin-a
Cylindrospermum[b]	**cylindrospermopsin**
Cylindrospermopsis	**cylindrospermopsin**, saxitoxins
Lyngbya	aplysiatoxins, **lyngbyatoxin-a**, saxitoxins
Microcystis	anatoxin-a, cylindrospermopsin, **microcystins**, saxitoxins
Nodularia	**nodularin**
Nostoc	microcystins[a]
Oscillatoria	**anatoxin-a**, aplysiatoxins, microcystins,[a] anatoxin-a(S), **homoanatoxin-a**
Phormidium	microcystin,[a] **anatoxin-a, homoanatoxin-a**
Planktothrix	microcystins,[a] homoanatoxin-a, anatoxin-a, aplysiatoxins, saxitoxins
Pseudanabaena	microcystins
Raphidiopsis	cylindrospermopsin, anatoxin-a, homoanatoxin-a, microcystins
Snowella	microcystins
Synechocystis	microcystins
Woronichinia	microcystins

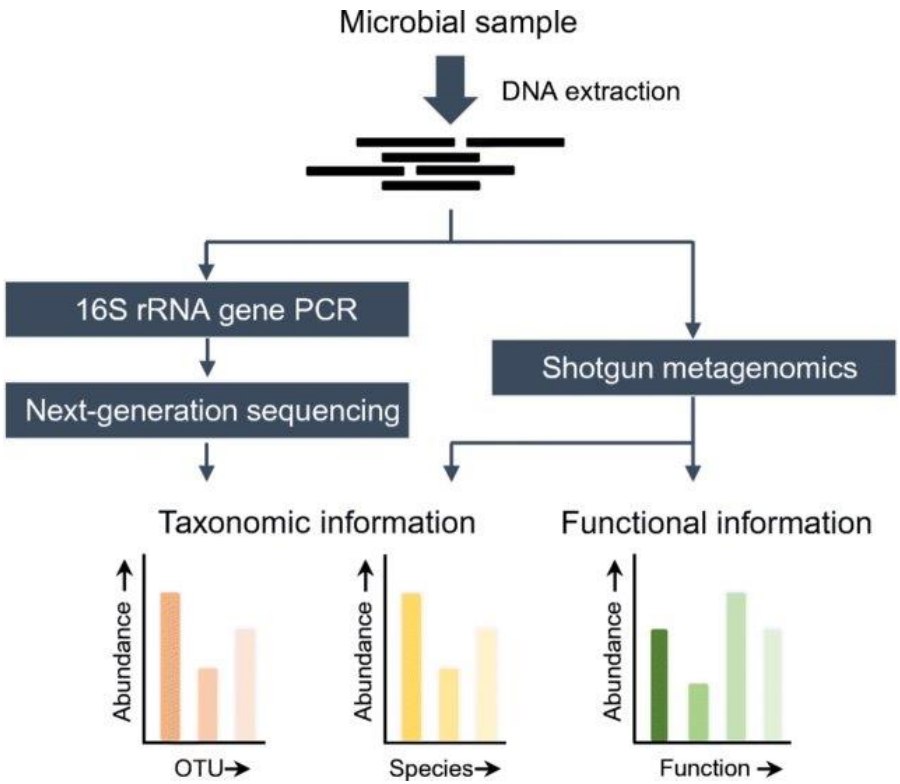
Current Cyanotoxin detection approach:

- Key cyanobacterial gene (*e.g.*, *mcyE*, *anaC*, *cyrJ*, *sxtA* etc.) detection through qPCR techniques.
- Detection of cyanotoxins (*e.g.*, Anatoxins, dihydro-anatoxins, Cylindrospermopsin, Microcystins/Nodularin, and Saxitoxins etc.) using LC-MS.

Kouzminov A, Ruck J, Wood SA. Australian and New Zealand Journal of Public Health. 2007 Jun 1;31(3):275-81.

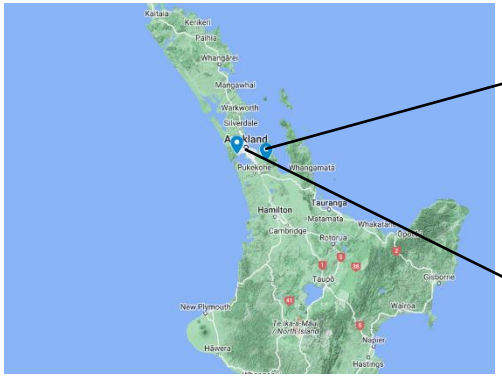
Metagenomics: Who are they? What are they doing?



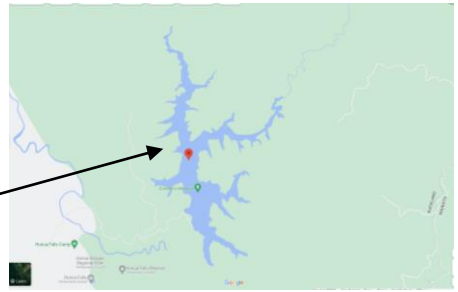


Dash HR, Das S. InMethods in Microbiology 2018 Jan 1 (Vol. 45, pp. 89-122). Academic Press.
Boers SA, Jansen R, Hays JP. European Journal of Clinical Microbiology & Infectious Diseases. 2019 Jun 1;38:1059-70.

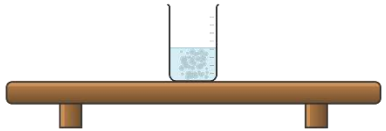
Simulating Climate warming induced microbial shifts



Cossey



Lower Nihotupu



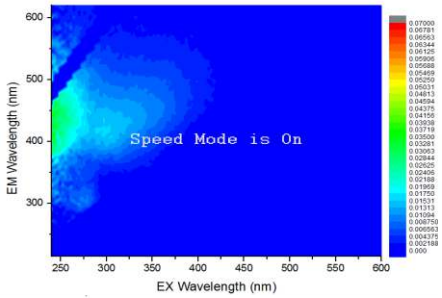
Base (22°C)

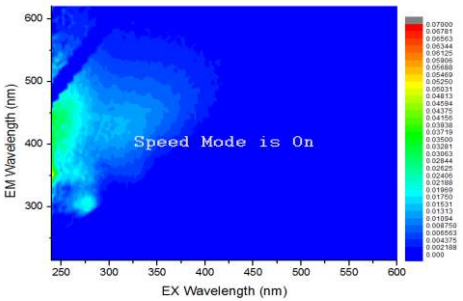
Normal 24°C

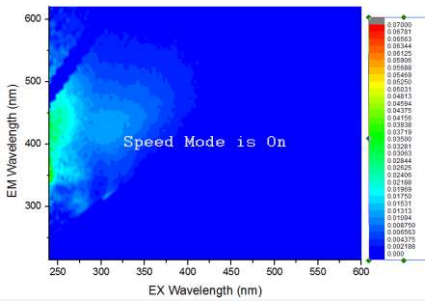
Future 27°C

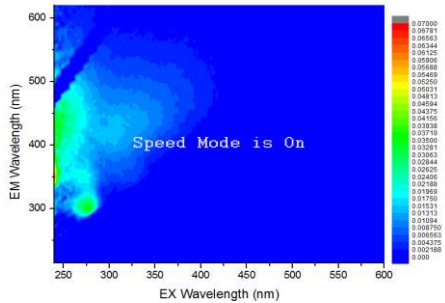
Variation in dissolved organic matter

Cossey

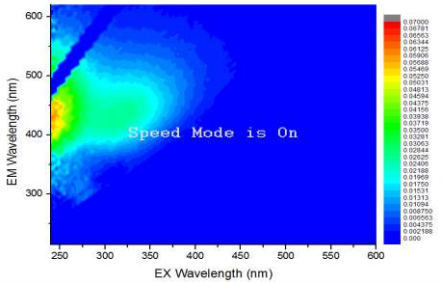


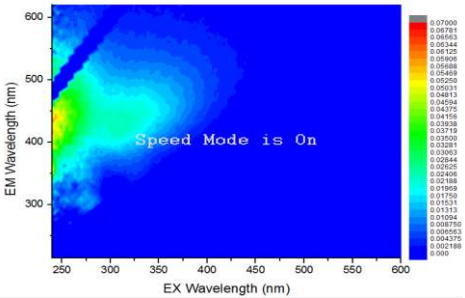


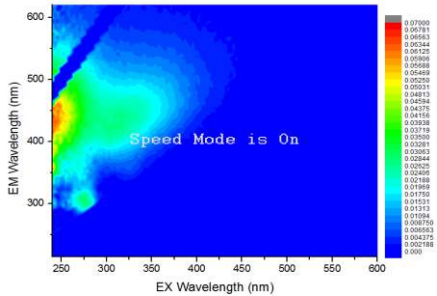


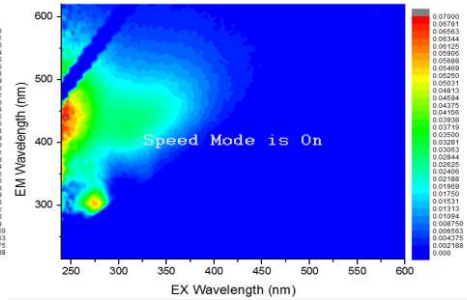


Lower Nihotupu

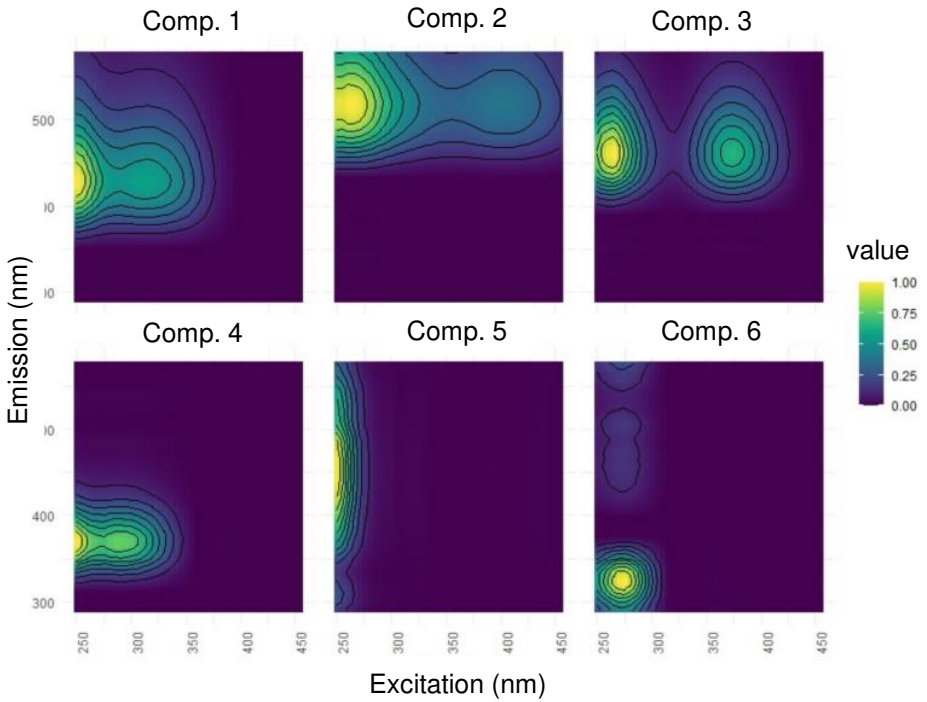


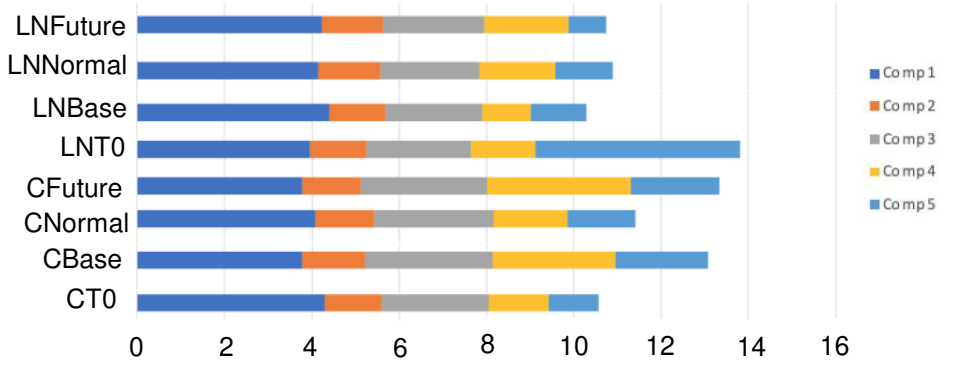






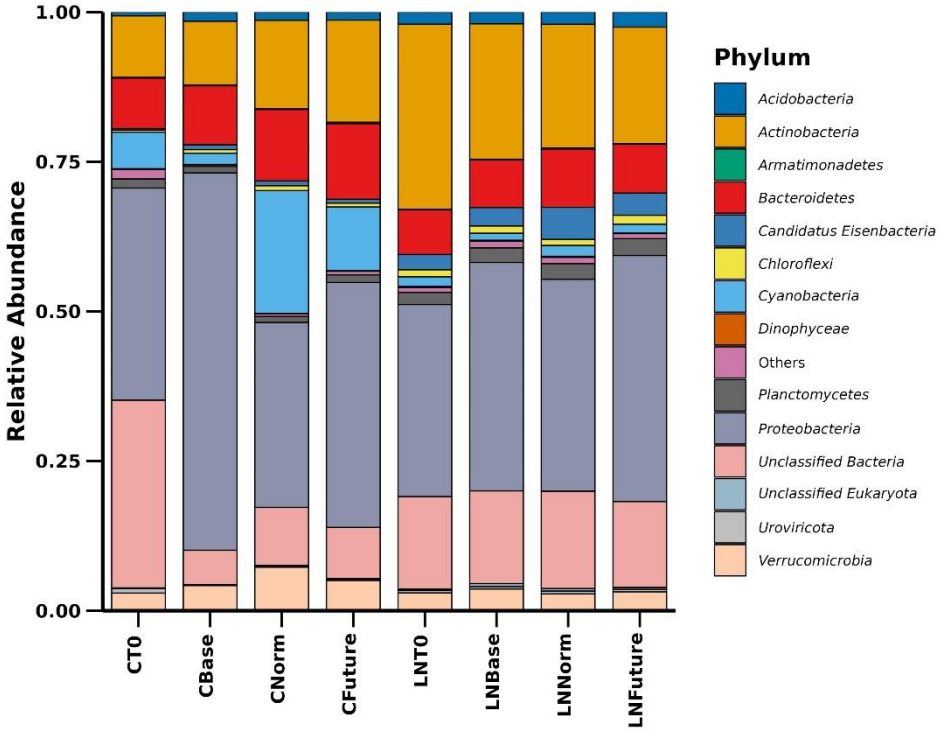
Variation in dissolved organic matter components

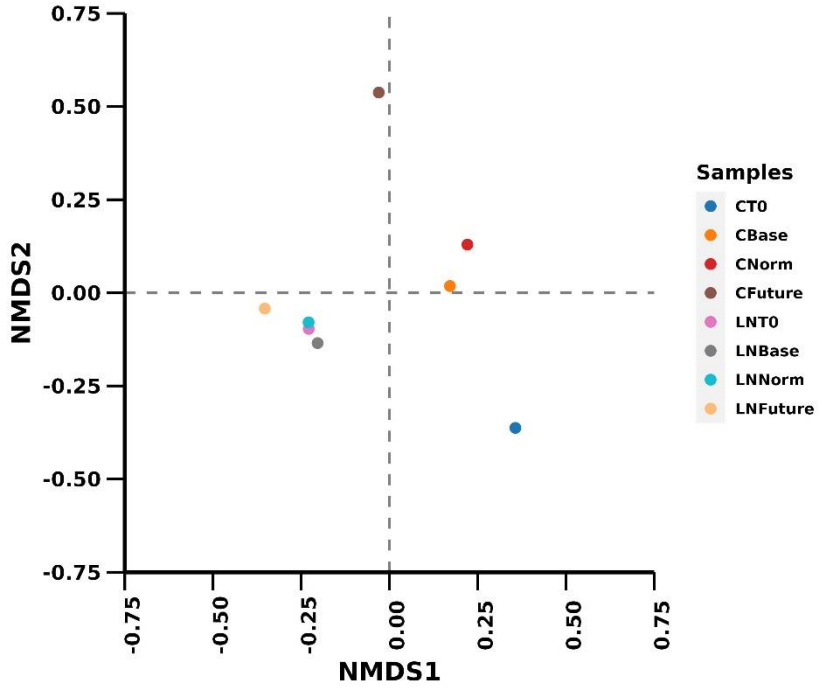




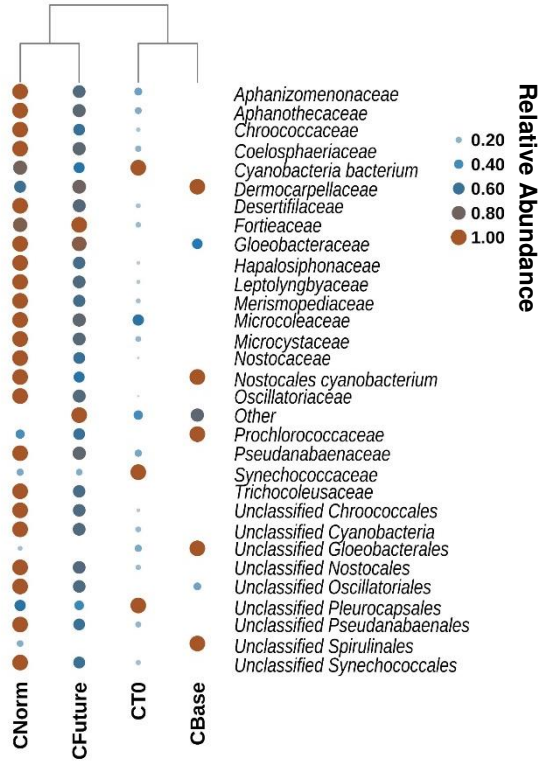
Component	Assignment
Comp. 1	Humic like Terrestrial
Comp. 2	Humic like Microbial derived
Comp. 3	Humic like
Comp. 4	Protein like Or Tryptophan-like

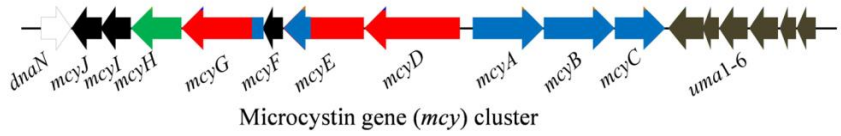
Climate warming induced shift in microbial communities



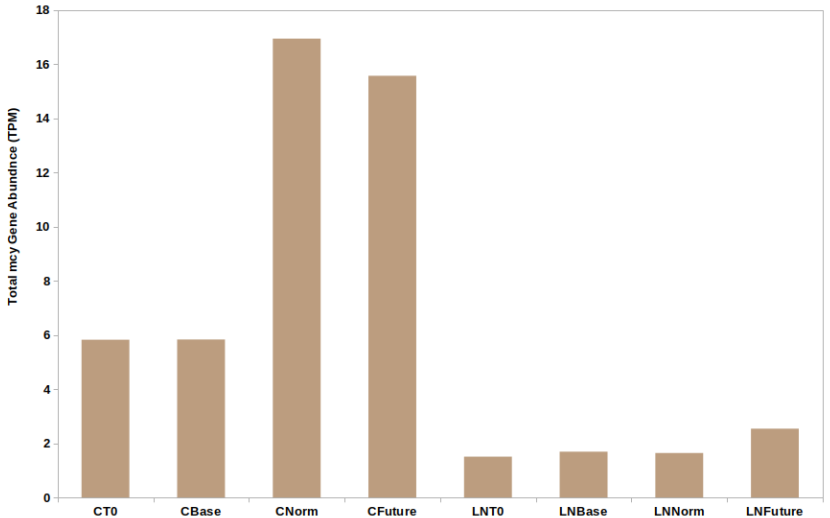


Cyanotoxin producers and total *mcy* gene Abundance

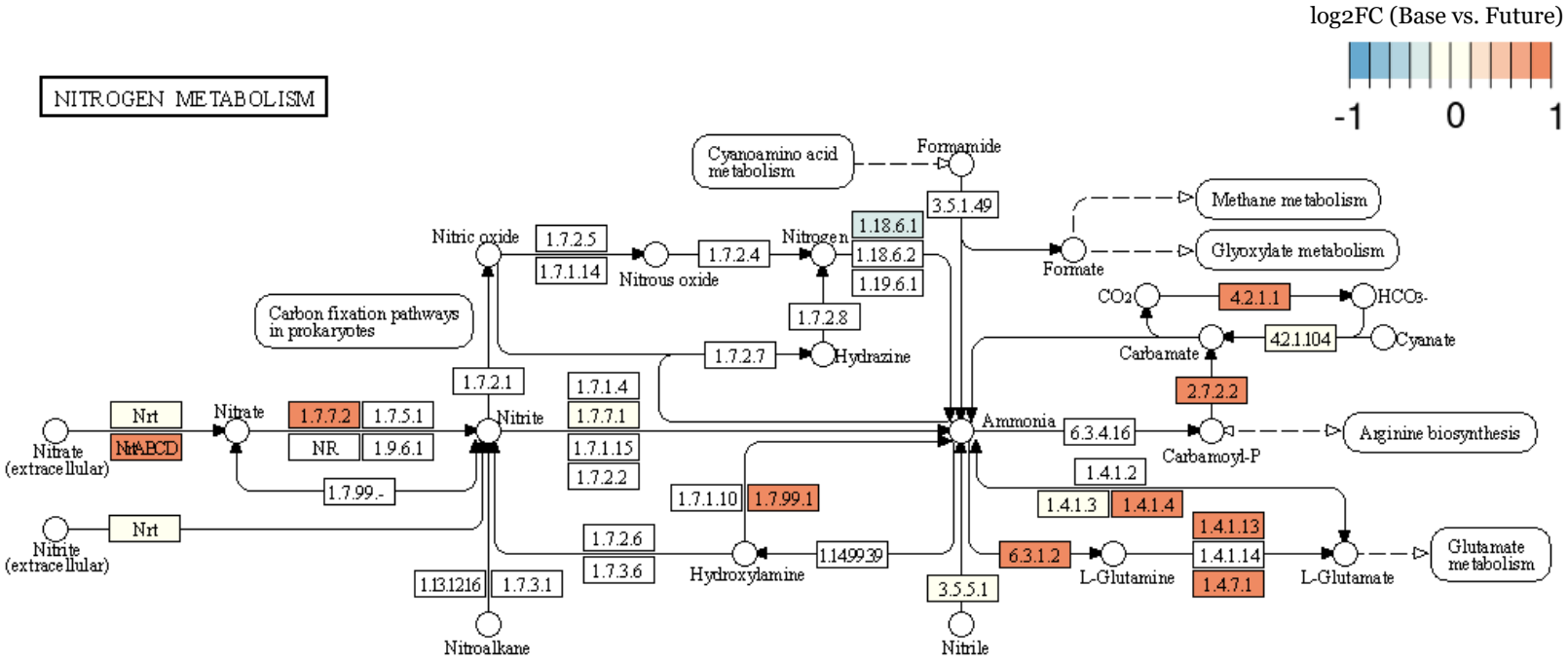




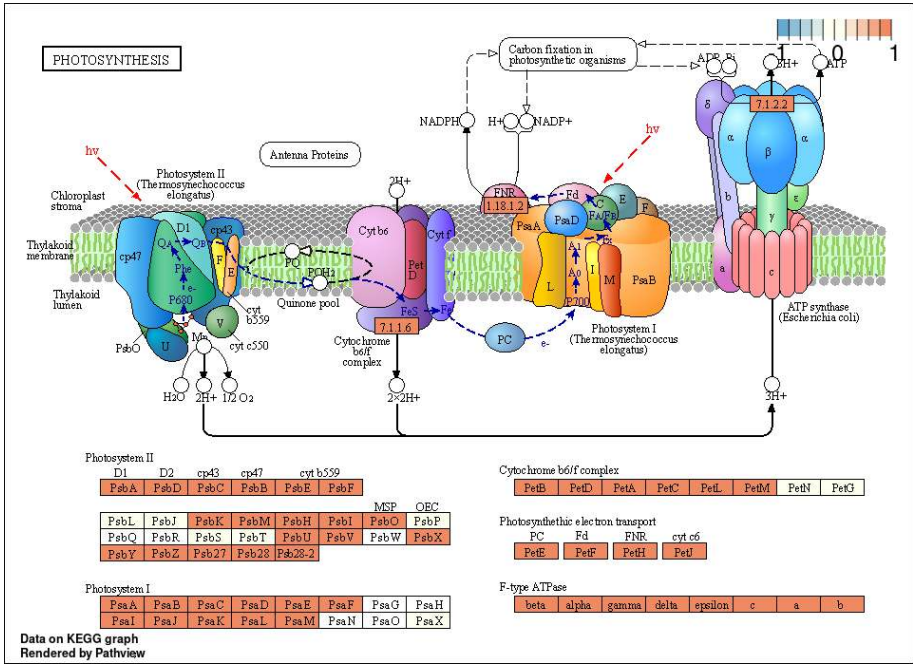
Microcystin gene (*mcy*) cluster

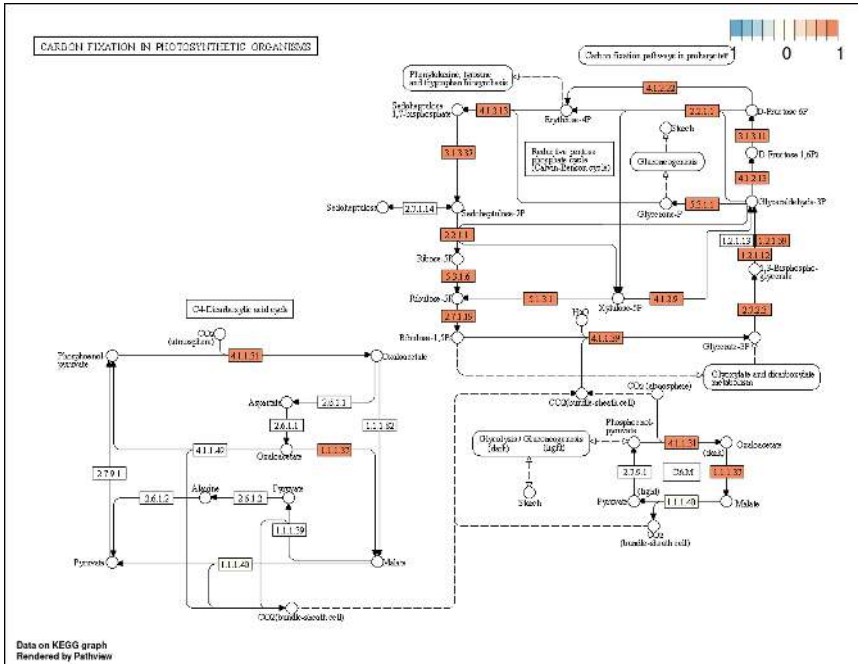


Increase in Cyanobacterial Nitrogen Metabolism



Enhanced Photosynthesis and Carbon fixation Capacity





Summary

- Climate change poses significant risks to drinking water sources by promoting algal growth, pathogen proliferation, and toxin formation.
- Metagenomics analysis detects notable variations in microbial communities. Rising temperatures impact the population of cyanobacteria in Cosseys Reservoir.
- Warmer conditions lead to an increase in Cyanobacteria like *Microcystis*, *Nosotc*, *Anabaena*. The mcy gene clusters, linked to microcystin production, show an upward trend with higher temperatures.
- Elevated temperatures stimulate cyanobacterial pathways involving nitrogen, photosynthesis, and carbon fixation. This promotes toxin-producing organisms and amplifies toxin production.
- Findings shed light on climate change's potential influence on freshwater lakes with greater susceptibility to cyanobacterial blooms.
- Metagenomics based approach can enable early detection of harmful blooms in freshwater systems.

Acknowledgements

Emma Jay

NS Group

Funding Body

Industrial Collaboration

High-performance Computing and Storage Facility

International Relations


Any
Question