Assessing the synchronicity of anatoxin-producing benthic cyanobacteria and river ecosystem productivity

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[1]University of Nevada, Reno, [2]George Mason University, [3]U.S. Geological Survey, [4]University of Montana, [5]California Water Board, [6]SUNY College of Environmental Science and Forestry, [7]University of Utah

Society for Freshwater Science 2024

Acknowledgements

Project Collaborators & Supporters

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- Greg Boyer (SUNY-ESF)
- Rich Fadness, Mike Thomas (California Water Board)
- Robert Shriver (UNR)
- Peter Steel (UC-B Angelo Reserve)

Karuk Tribe Mentoring Committee Members

- Grant Johnson (Karuk Tribe Water Quality Program Manager)
- Heather Rickard (Karuk K-12 Environmental Education Division Coordinator)
- Laurel Genzoli (UM-FBLS)

Members of the Blaszczak Lab

- Taryn Elliot
- Meaghan Hickey
- Helen Lei
- Andrea Garcia-Jimenez
- Leon Katona

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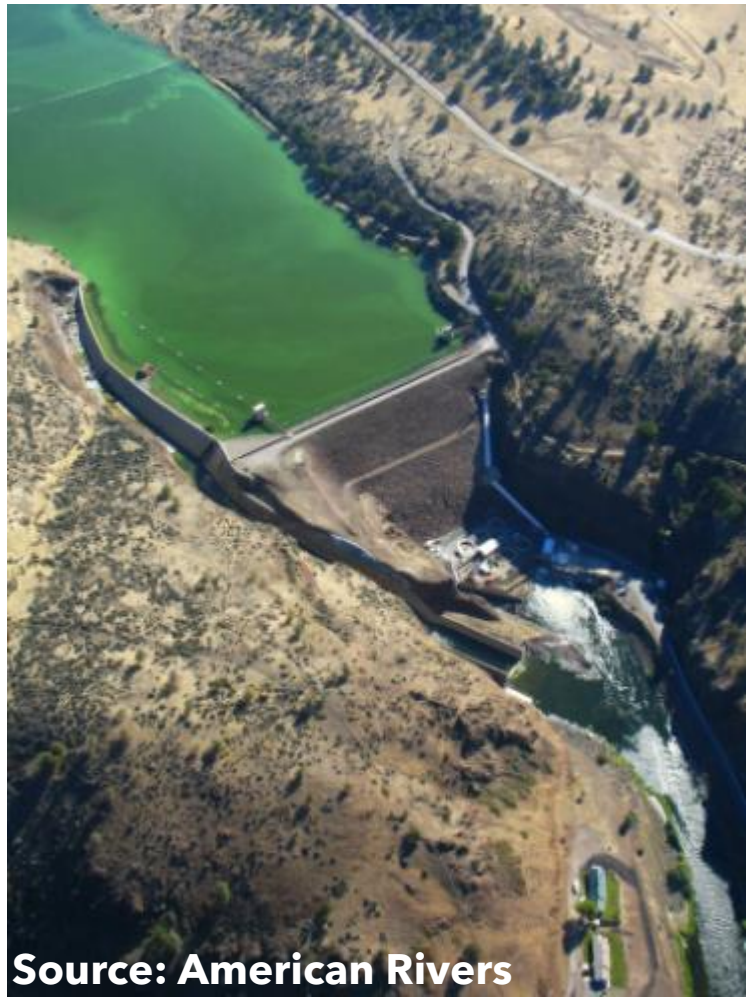
University of Nevada, Reno



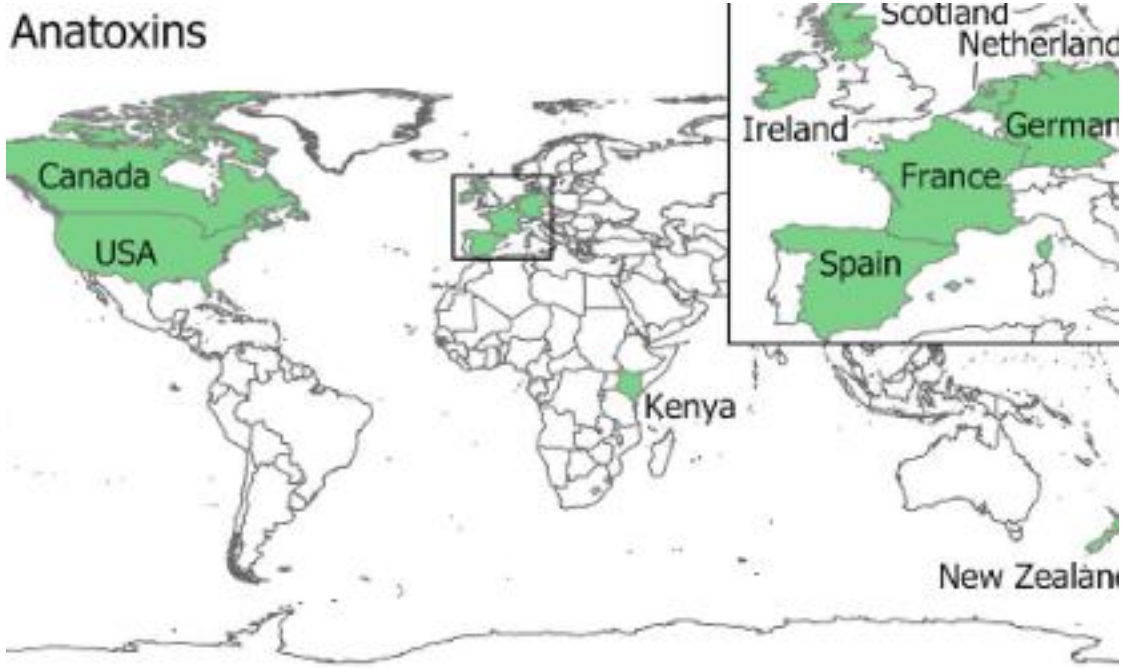
Planktonic or “free-floating”

Benthic or “attached”

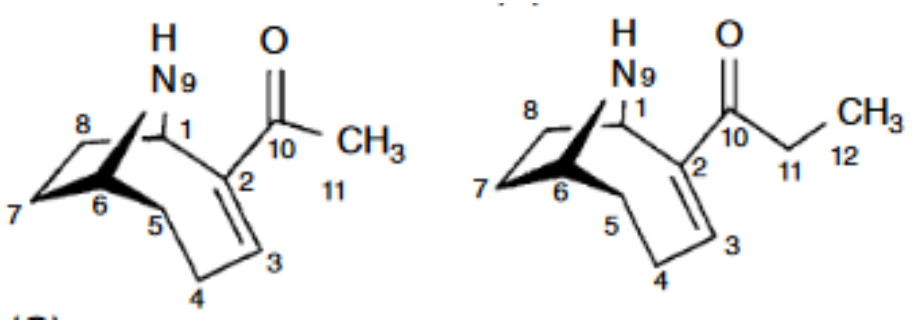
Anabaena

Microcoleus
(formerly known as *Phormidium*)

Benthic or "attached"

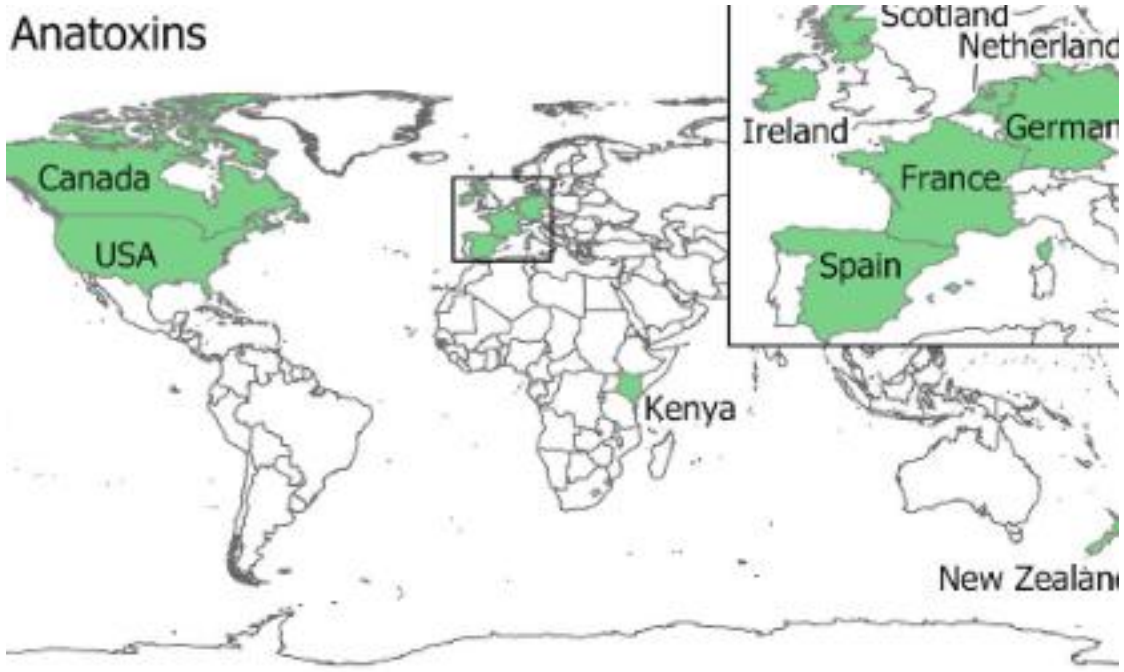


Wood et al. (2020)



Anatoxin-a *Homoanatoxin-a*

Bruno et al. (2017)



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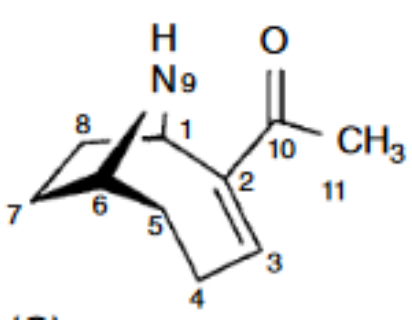

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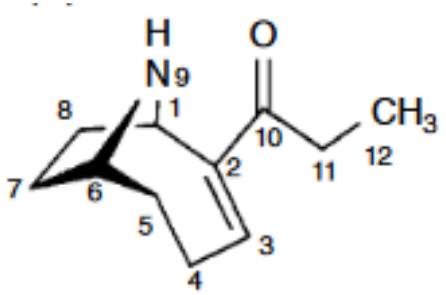

Homoanatoxin-a

Bruno et al. (2017)

The Ukiah Daily Journal

Toxic algae found in Eel River in Mendocino County

Parents of young children and dog owners are advised to avoid the Eel River as Toxic Blue Green Algae has recently been discovered, Mendocino County officials reported.

According to the Mendocino County Executive Office, a dog recently died after swimming in a section of the Eel River located in the eastern part of Mendocino County.

HUMBOLDT COUNTY, CALIFORNIA

July 23, 2021 - Warning issued after person becomes sick from potential harmful algae, dog dies

The Press Democrat

Dog dies on Russian River, tests positive for toxic algae

The test results are preliminary. Sonoma County public health officials are deciding what to do next, including whether to urge people and their pets to avoid the Russian River.

St George News

Virgin River health watch issued after 1 dog dies, 3 fall ill fro
exposure to toxic algae samples indicate a high level of a dangerous toxin
anatoxin-a — is present. Specific areas of the river

Benthic cyanobacteria accrual and **anatoxin production** are affected by multiple abiotic factors…

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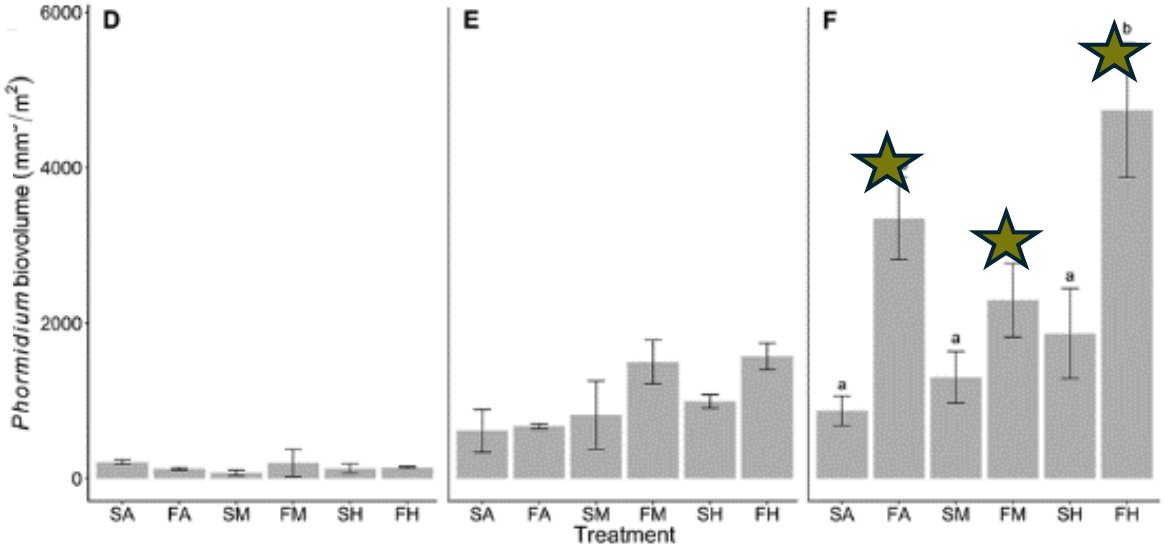
High velocity (McAllister et al. 2018)

Biomass



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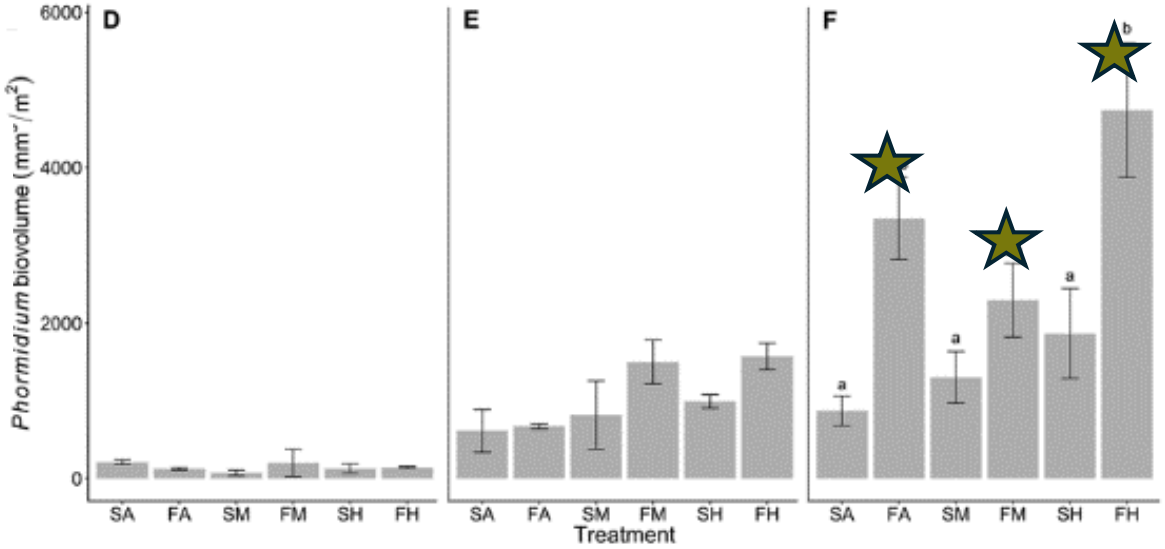

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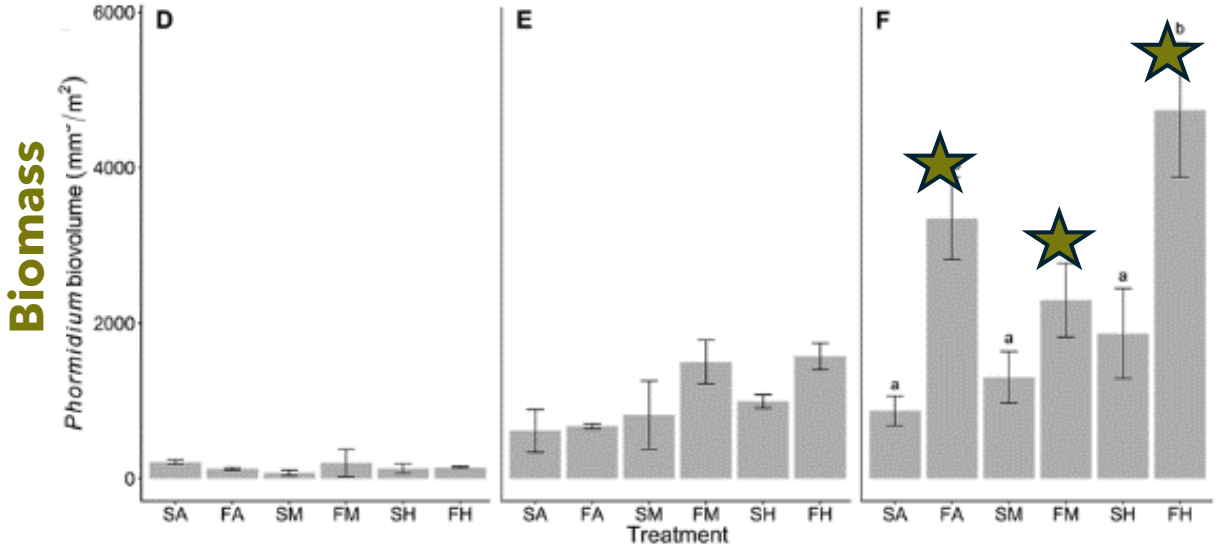
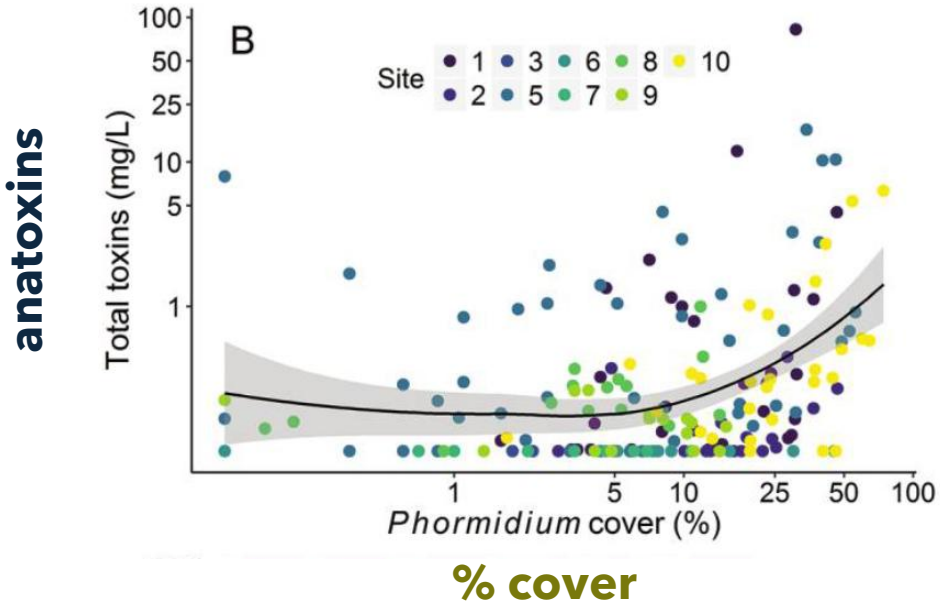


Higher ATX w/ higher % cover (Wood et al. 2017)



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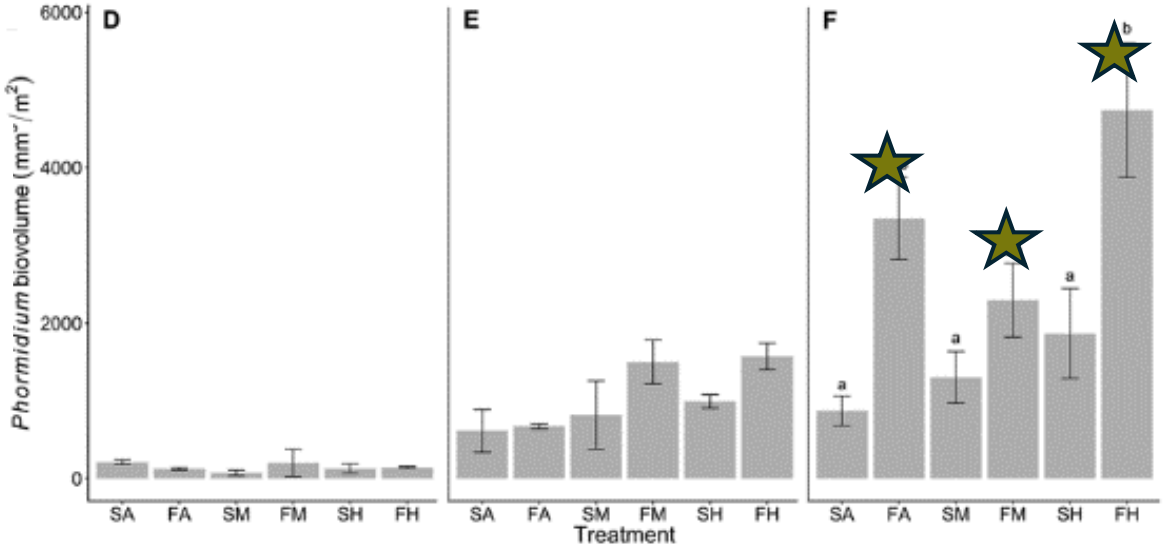
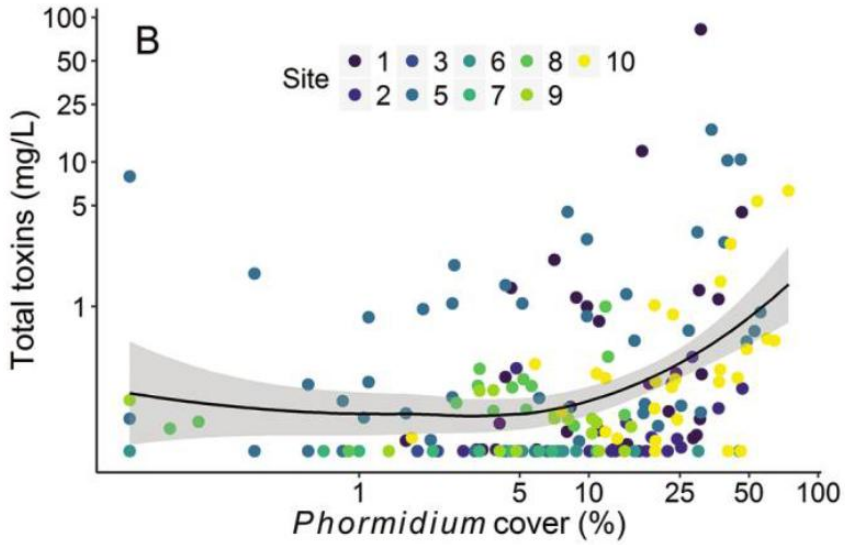


Higher ATX w/ higher % cover (Wood et al. 2017)

anatoxins



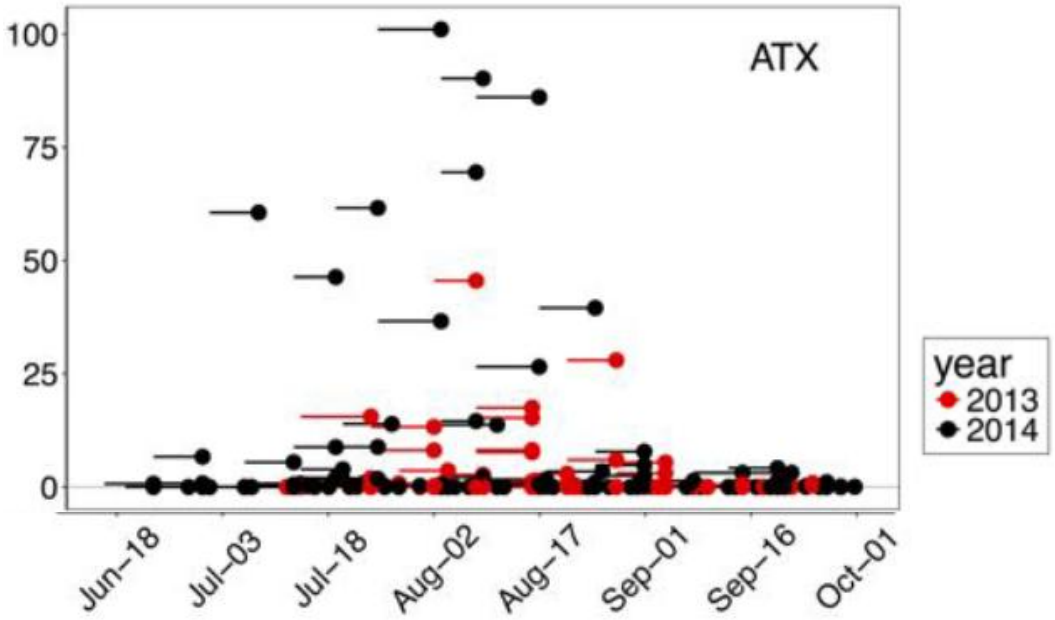
% cover

- Higher temperatures
  (Wood et al. 2017, Robichon et al. 2023)
- Nutrients (N & P)
  (Wood et al. 2017, McAllister et al. 2018, Robichon et al. 2023)

- But some studies find no relationship between ATX & % cover
  (McAllister et al. 2018, Echenique-Subiare et al. 2018)
- Mixed relationships with N & P
  (Heath et al. 2016, Wood et al. 2017, Echenique-Subiabre et al. 2018)

Benthic cyanobacteria accrual and **anatoxin production** are affected by multiple abiotic factors…

We know that anatoxin concentrations peak at some point in the late summer or fall…



Bouma-Gregson et al. (2018) *PLoS One*

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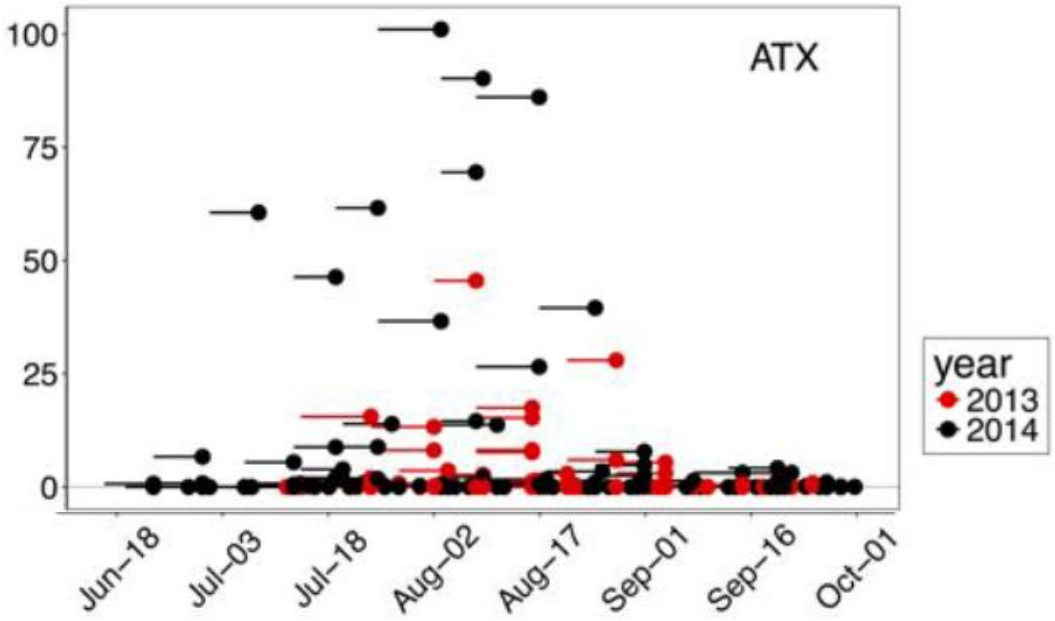
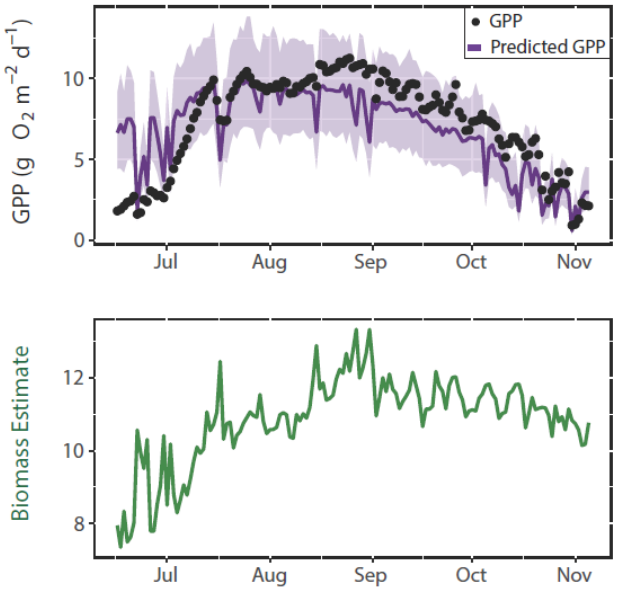


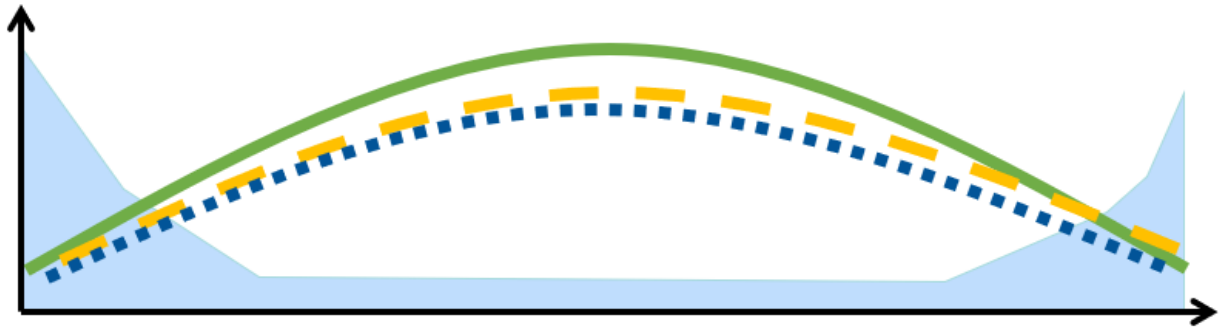
Bouma-Gregson et al. (2018) *PLoS One*

How well could incorporating a biotic factor such as GPP improve our predictions?



To what degree do processes that shape the overall productivity dynamics in rivers predict the occurrence and dynamics of toxin-producing benthic cyanobacteria?

a. Synchronous peak timing across all



Gross Primary Productivity (GPP)

Cyanobacterial Occurrence

Anatoxin Concentration

Seasonal Discharge Pattern

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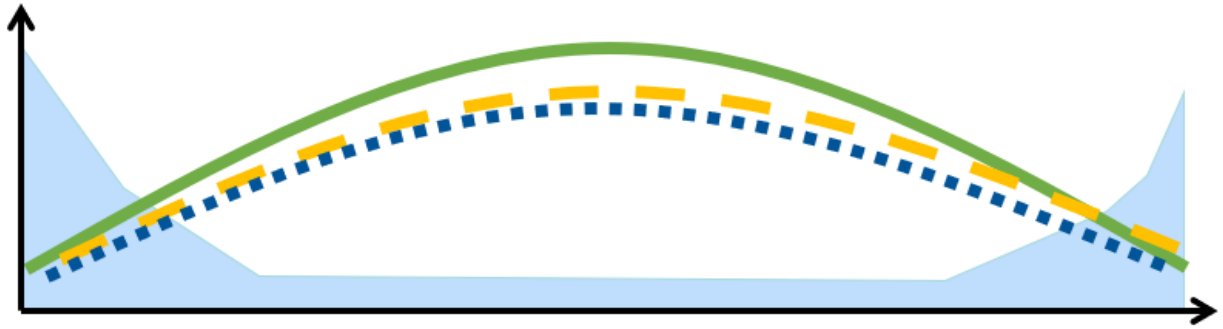
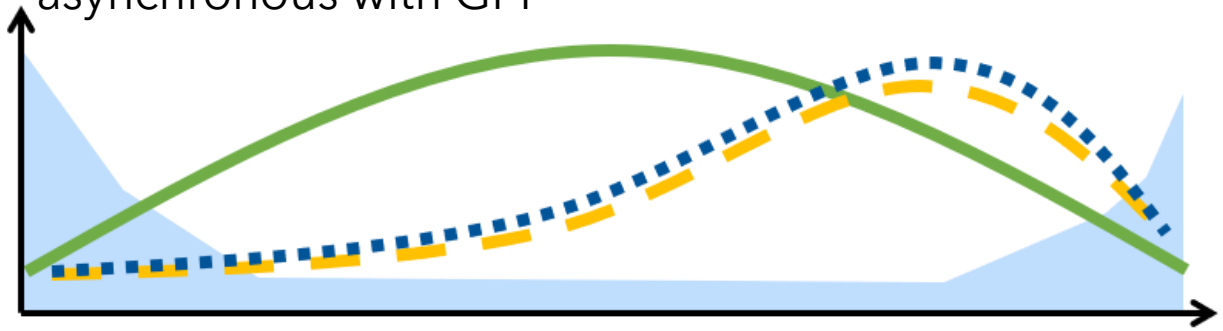


b. Cyanobacterial occurrence & anatoxins asynchronous with GPP



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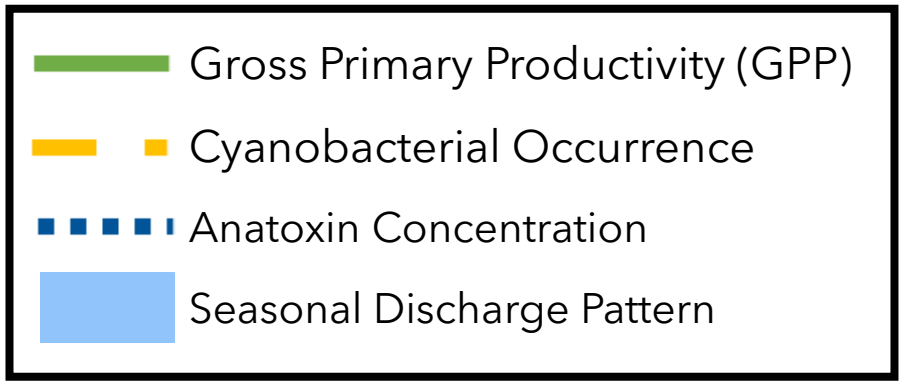

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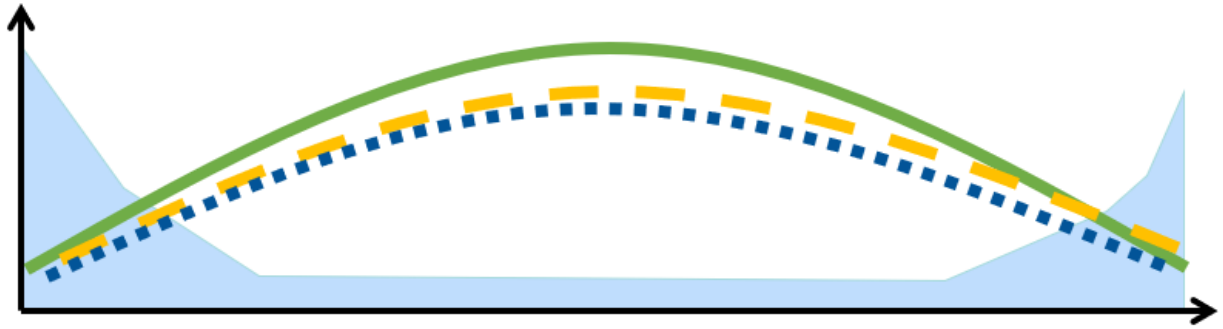

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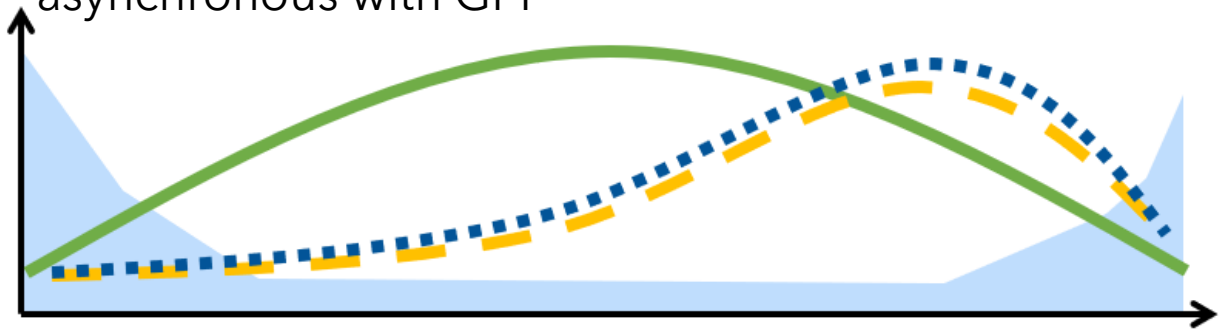
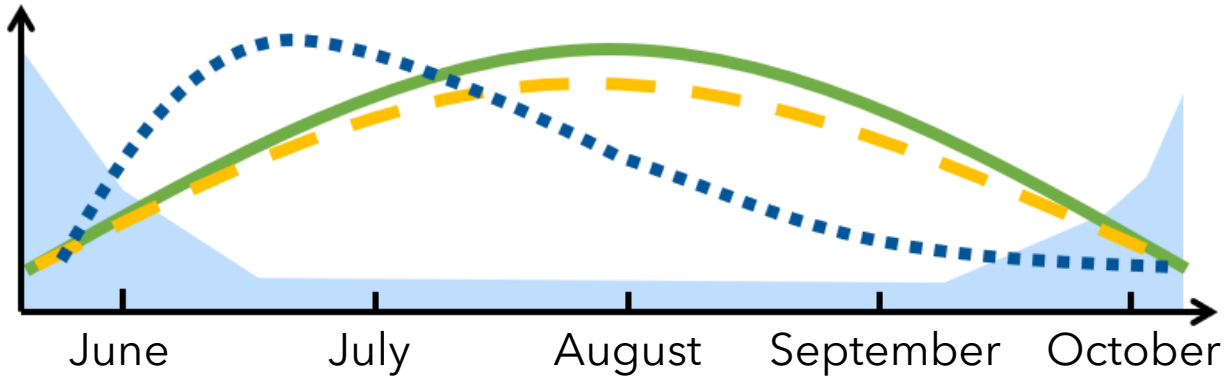
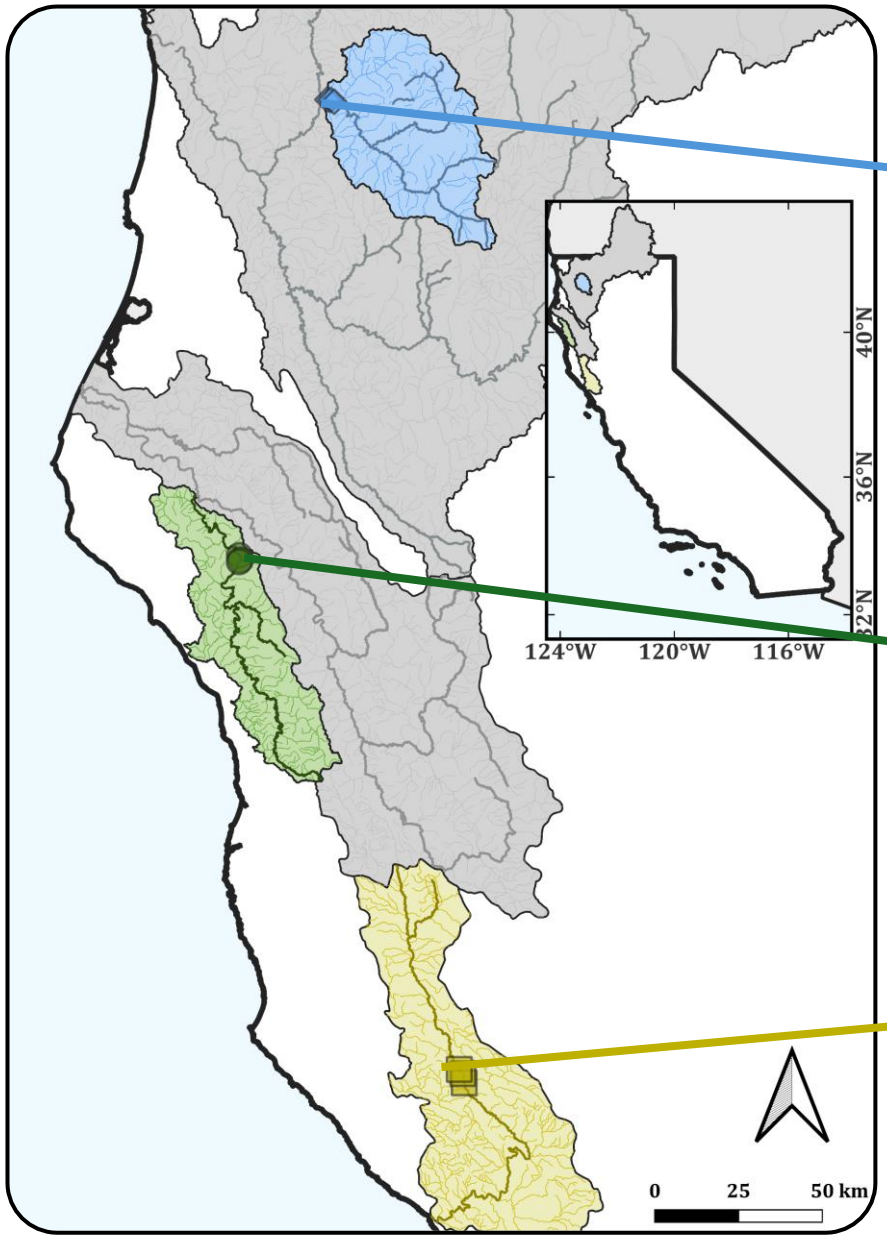


c. Anatoxins peak asynchronous with GPP



1. Site selection- Northern California



Salmon River

South Fork Eel River

Russian River

2022 **biweekly** sampling
June - September

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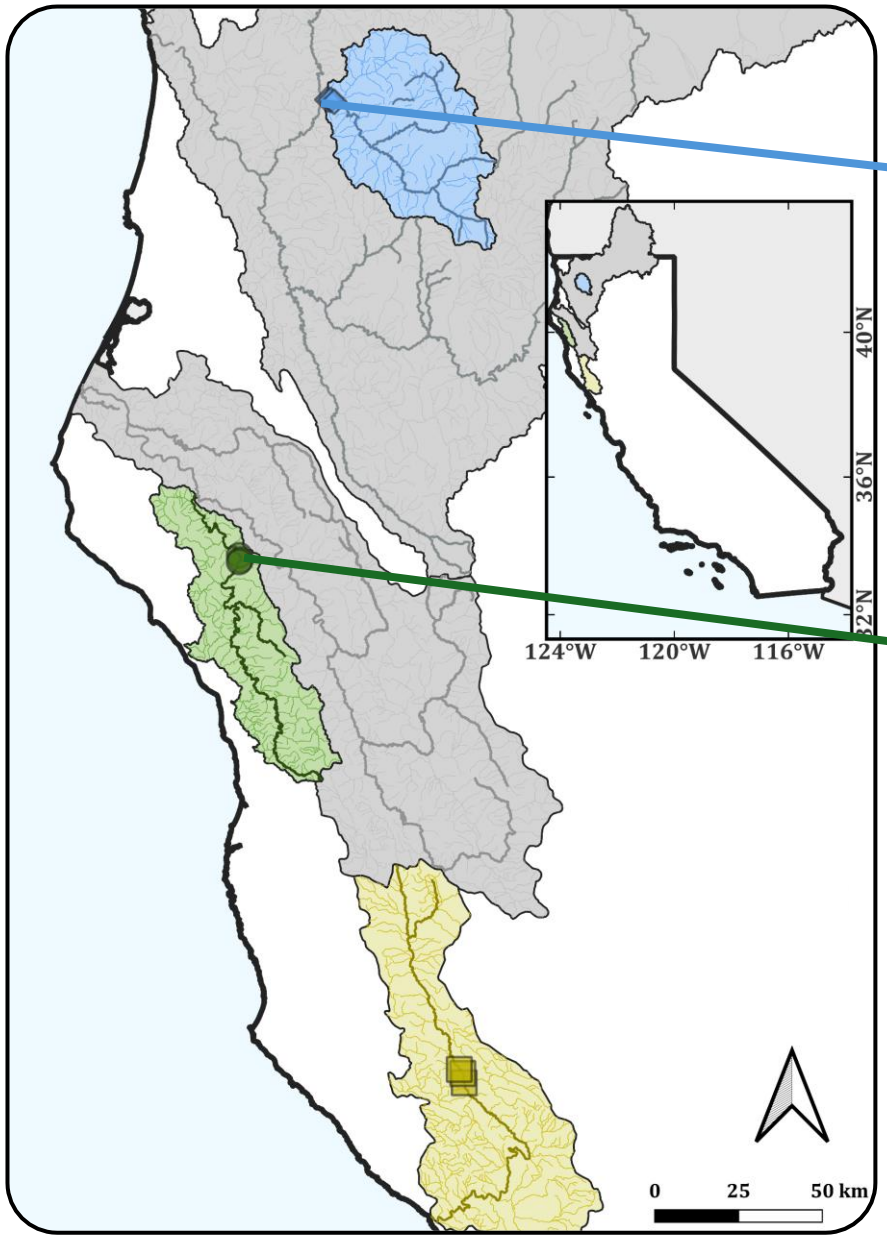

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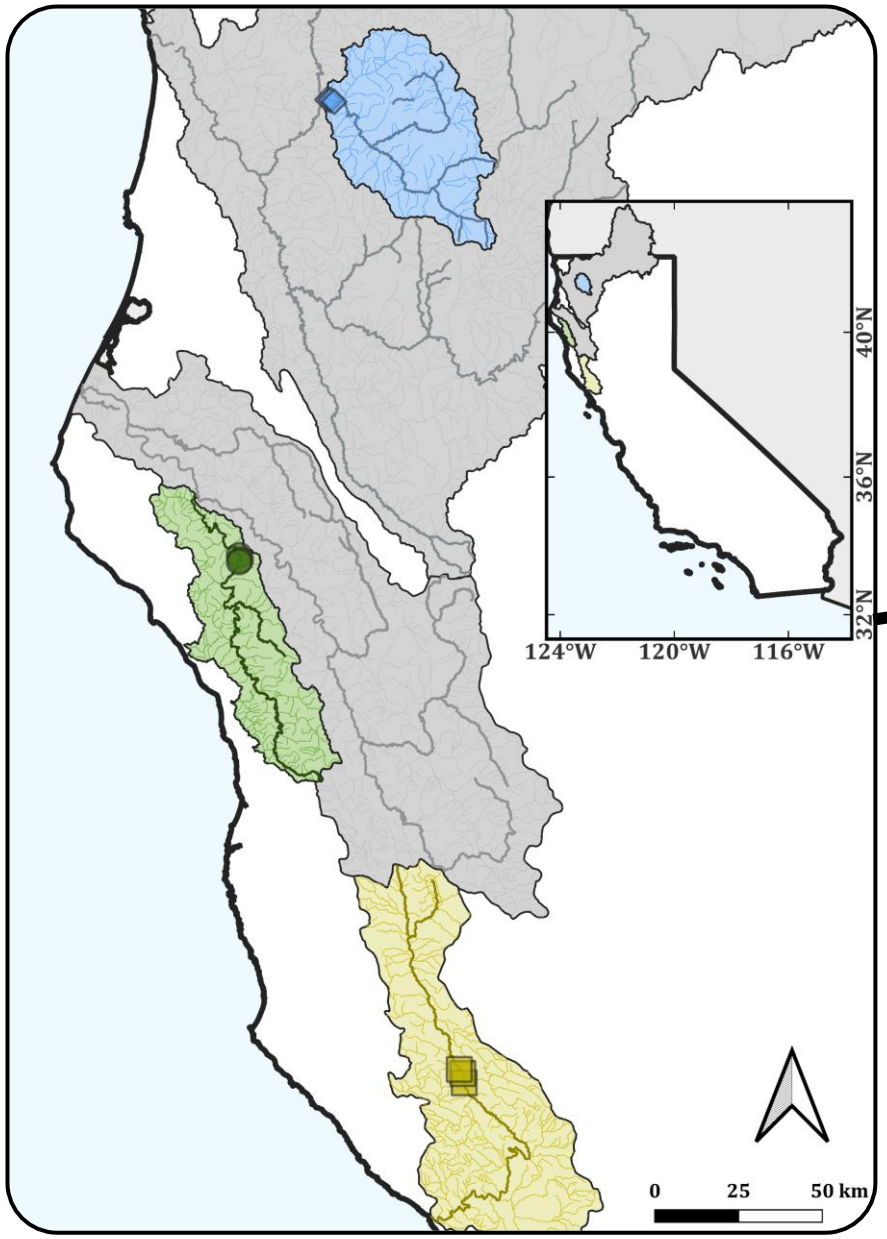
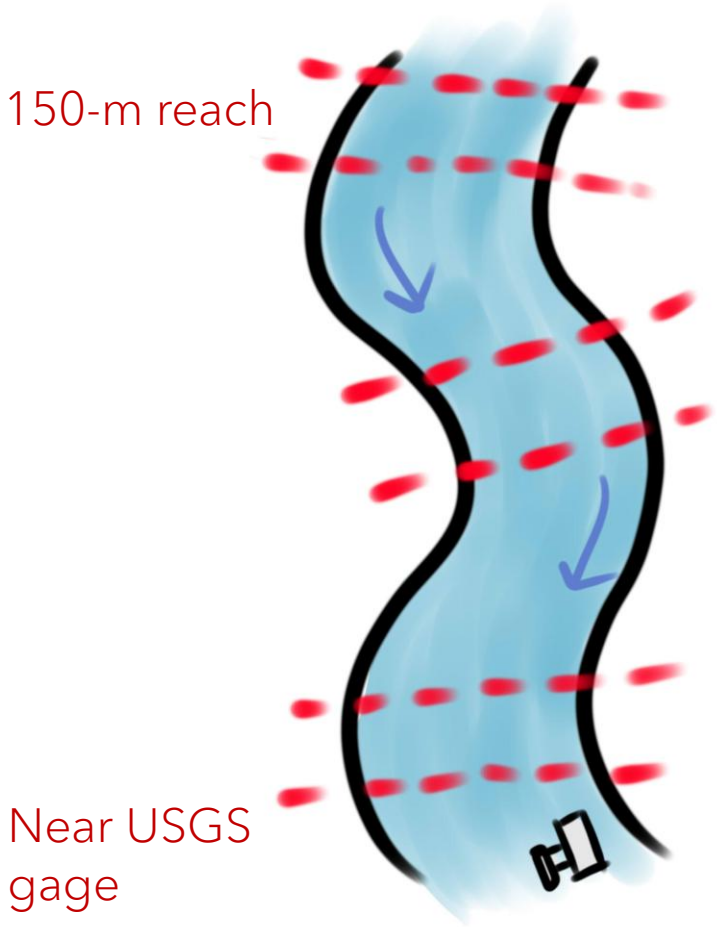


2b. Benthic surveys upstream



2a. Sensor maintenance

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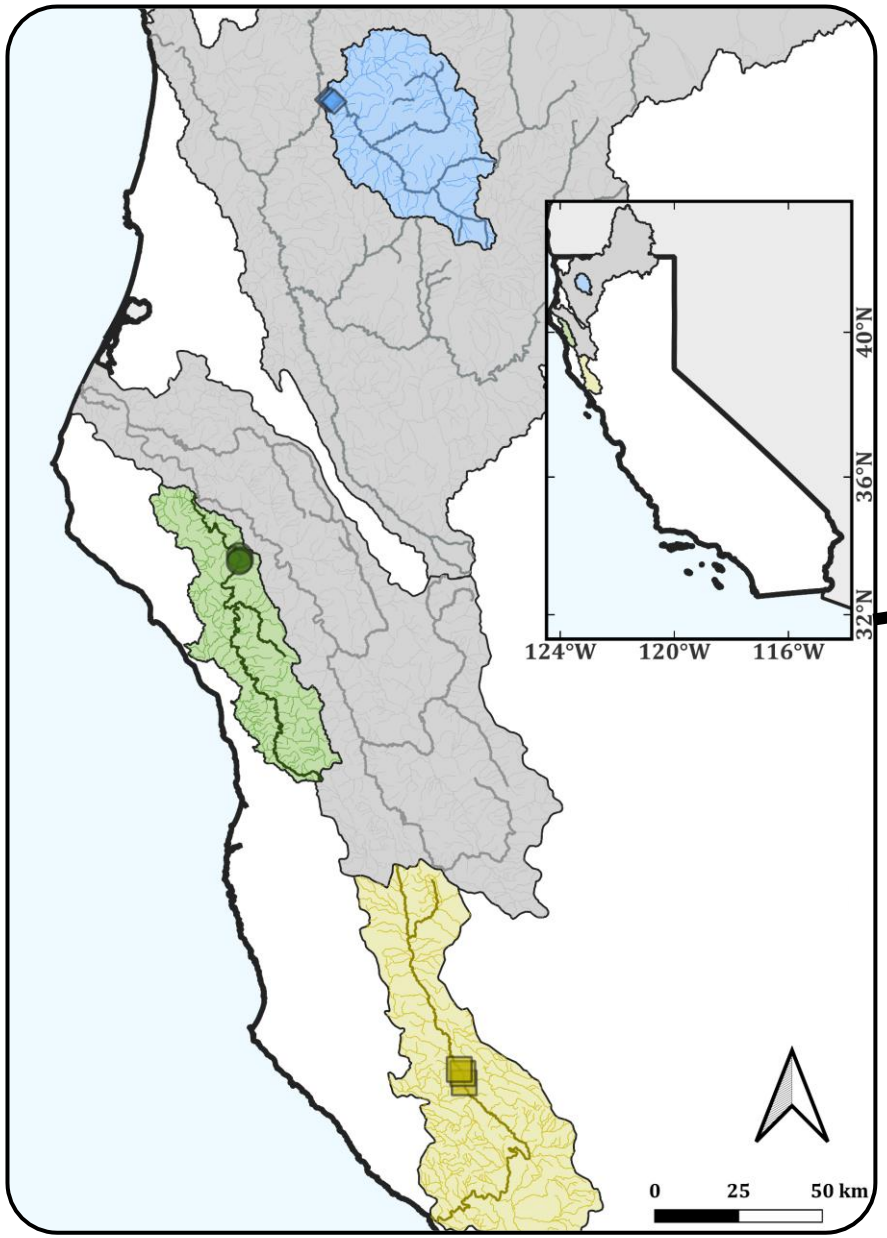

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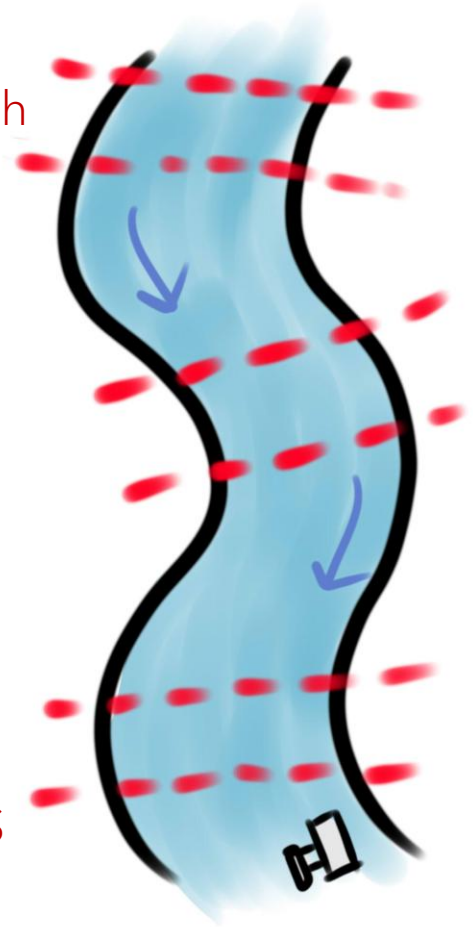
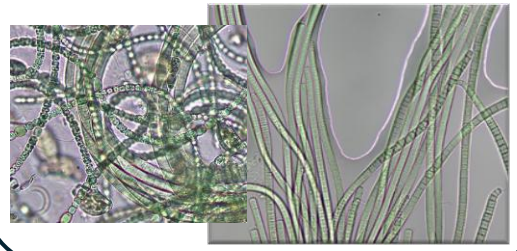
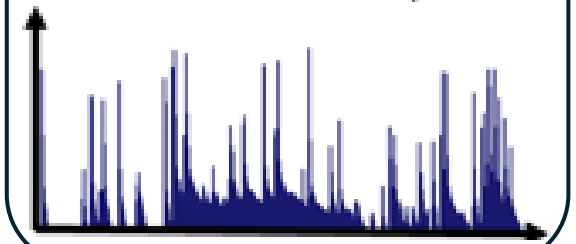


2a. Sensor maintenance

3a. Cyanobacteria ID



3b. LC-MS/MS anatoxins analyses



3c. Model metabolism from sensor data

$$\frac{dO}{dt} = \frac{GPP}{z} + \frac{ER}{z} + K_O(O_{sat} - O)$$

StreamMetabolizer
(Appling et al. 2018)

**Preliminary Results

South Fork Eel River

2022

2023

Salmon River

2022

2023

Russian River

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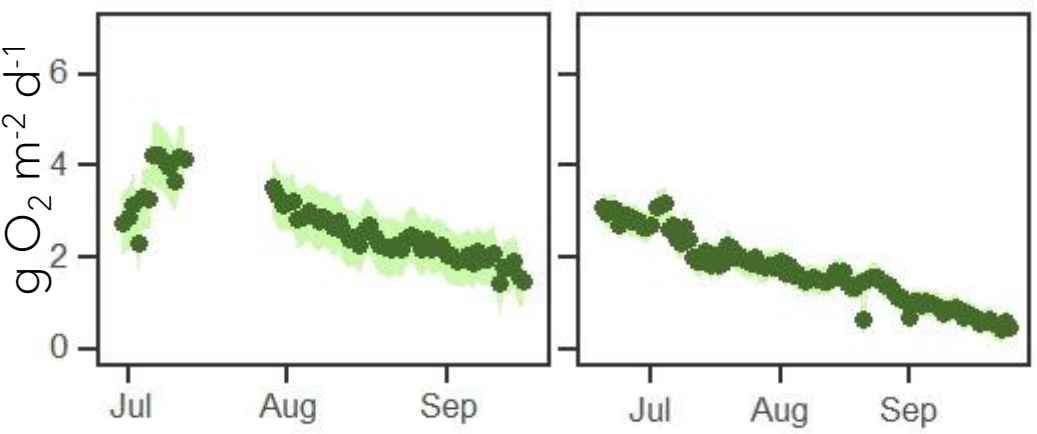

<u>Preliminary observations</u>:

- GPP dynamics are unique to each river and year

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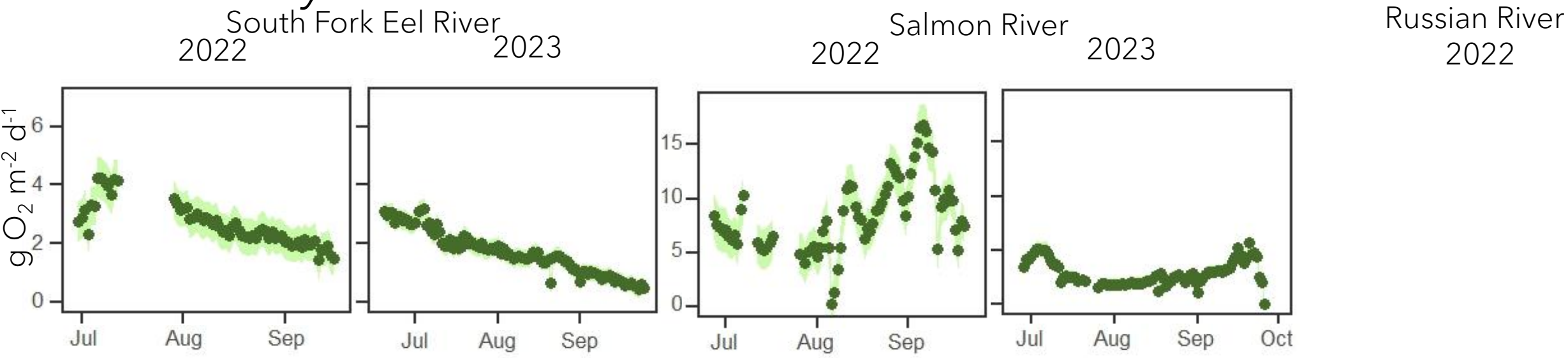

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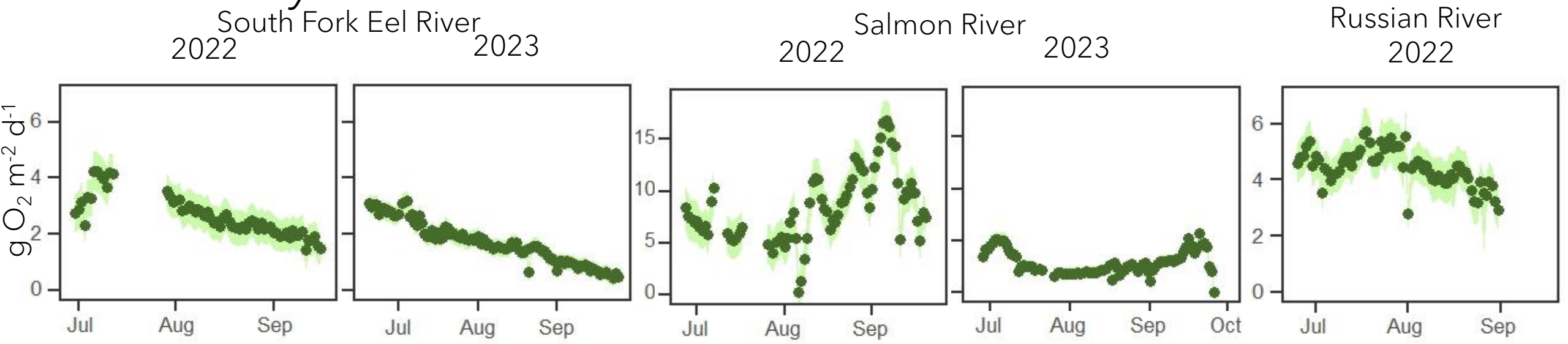

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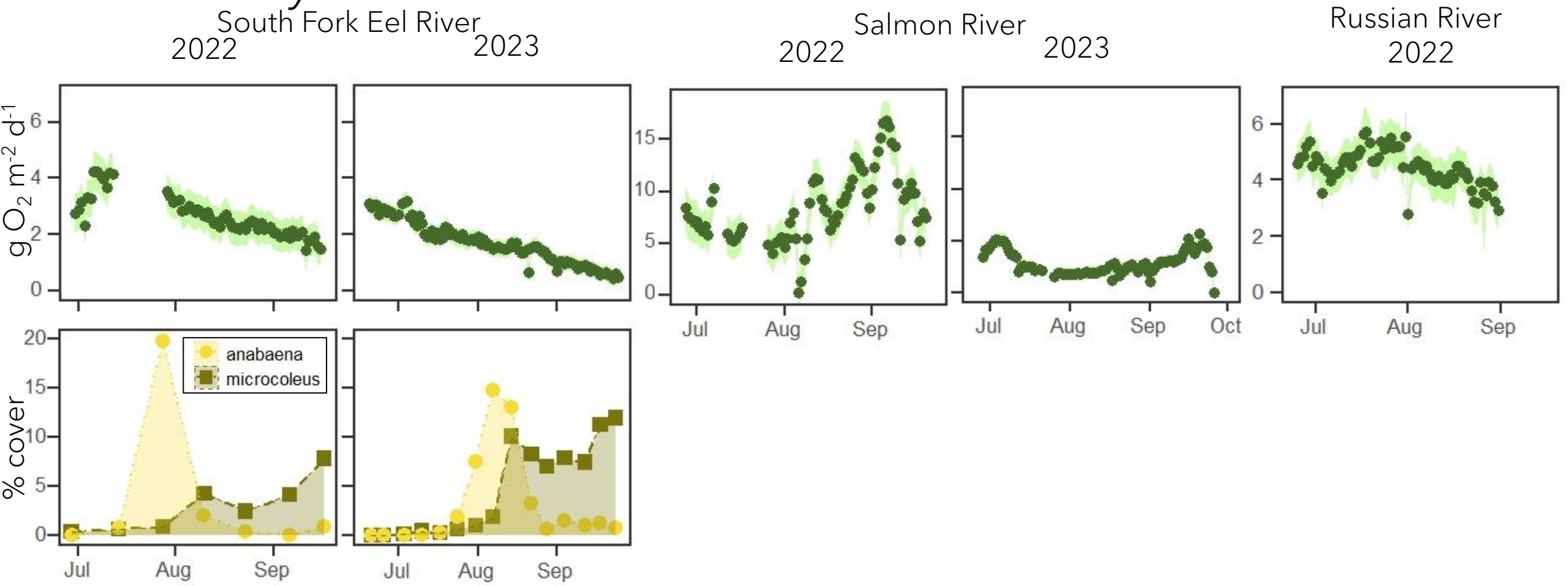

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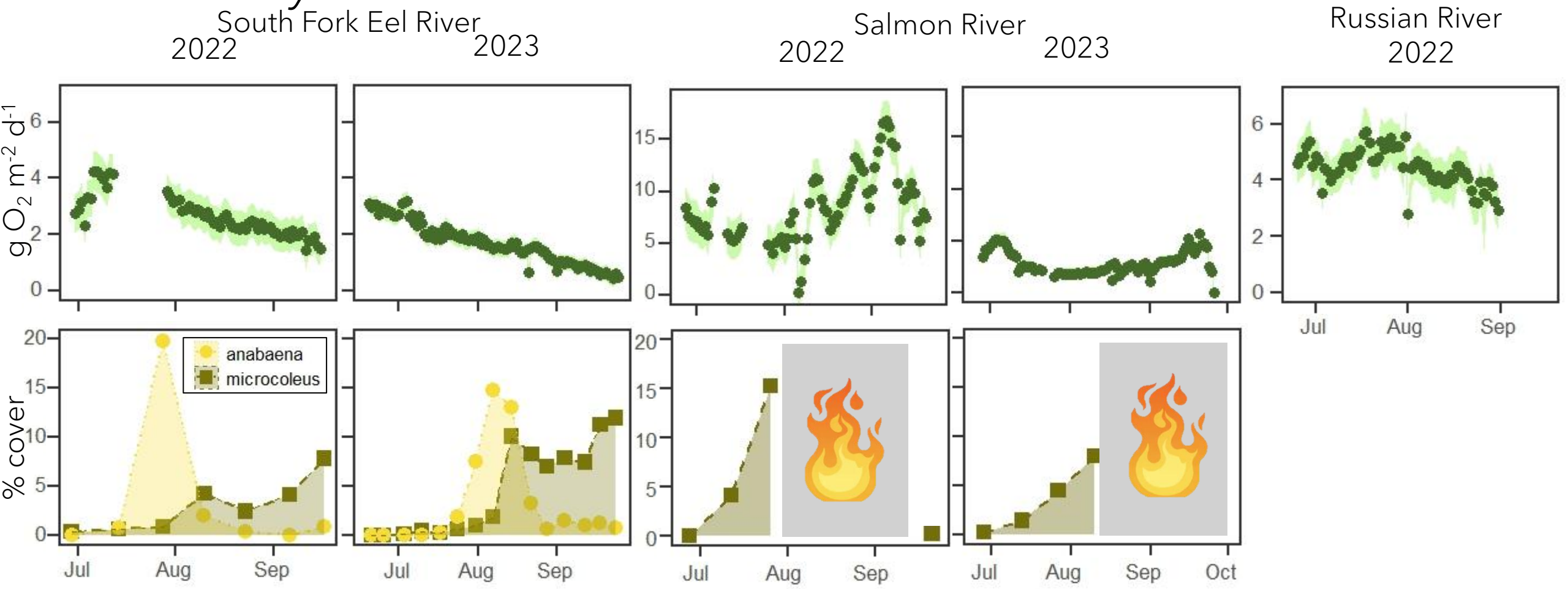

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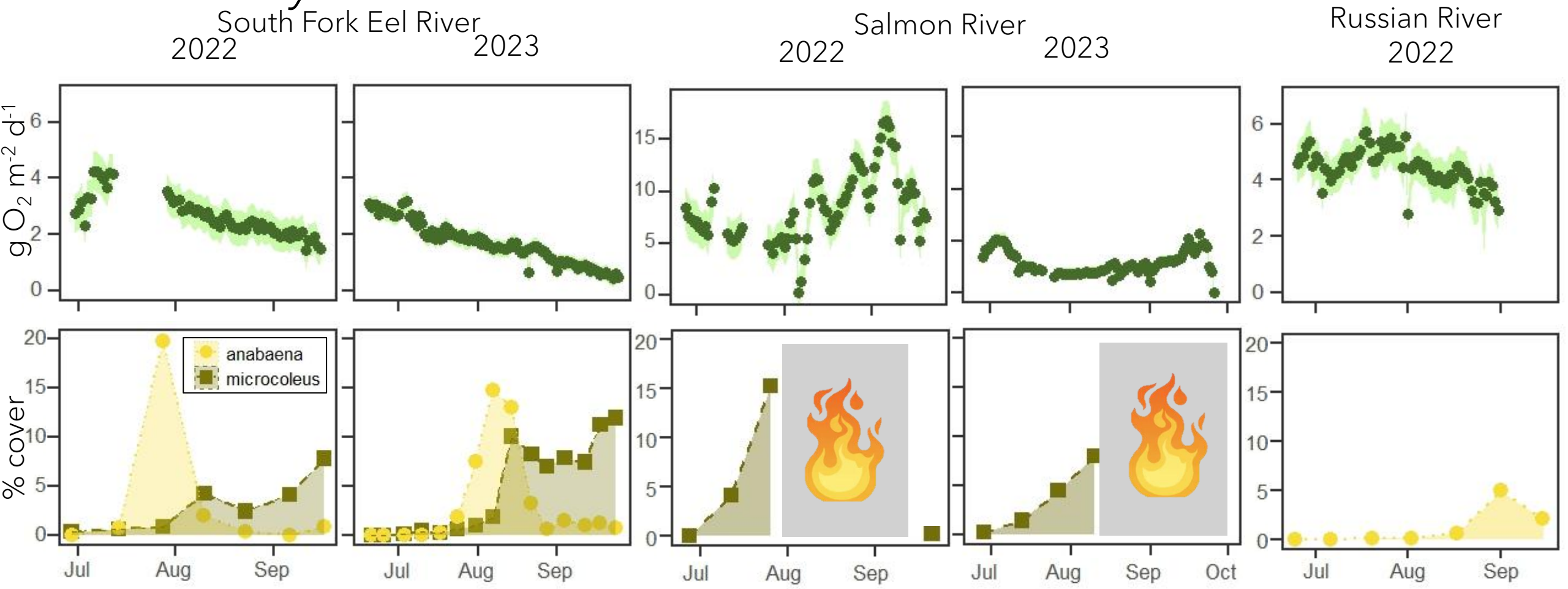

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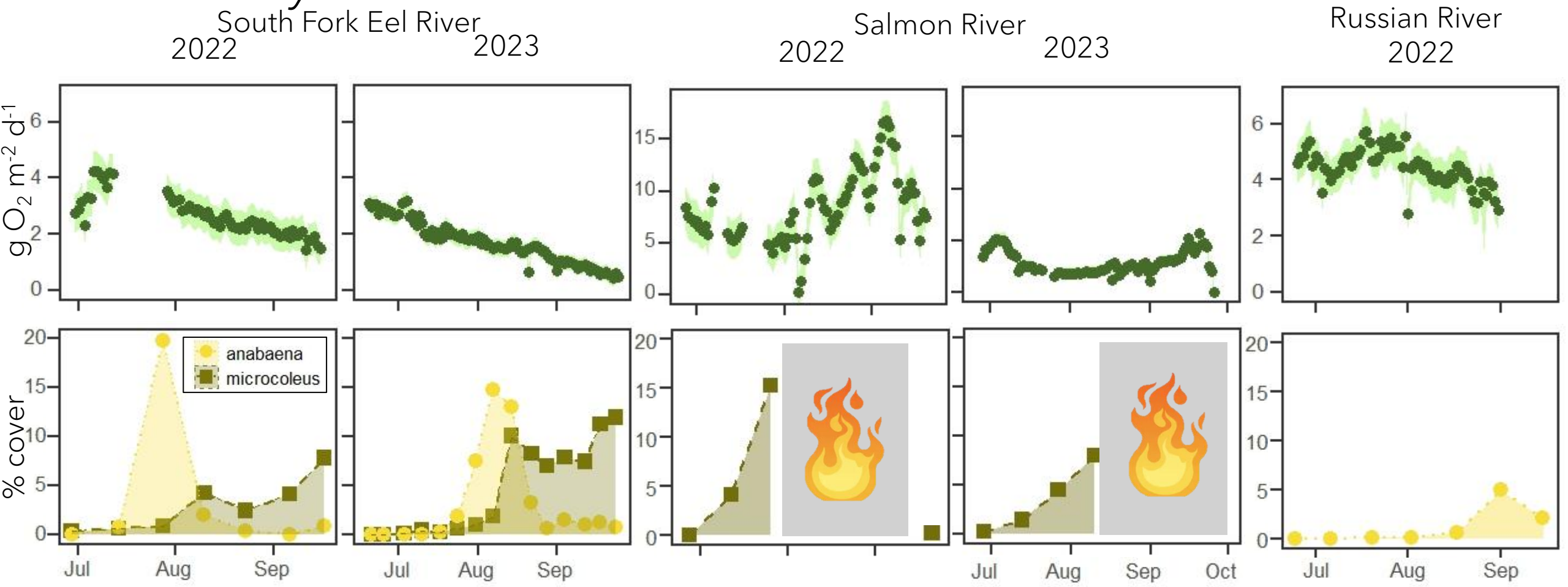

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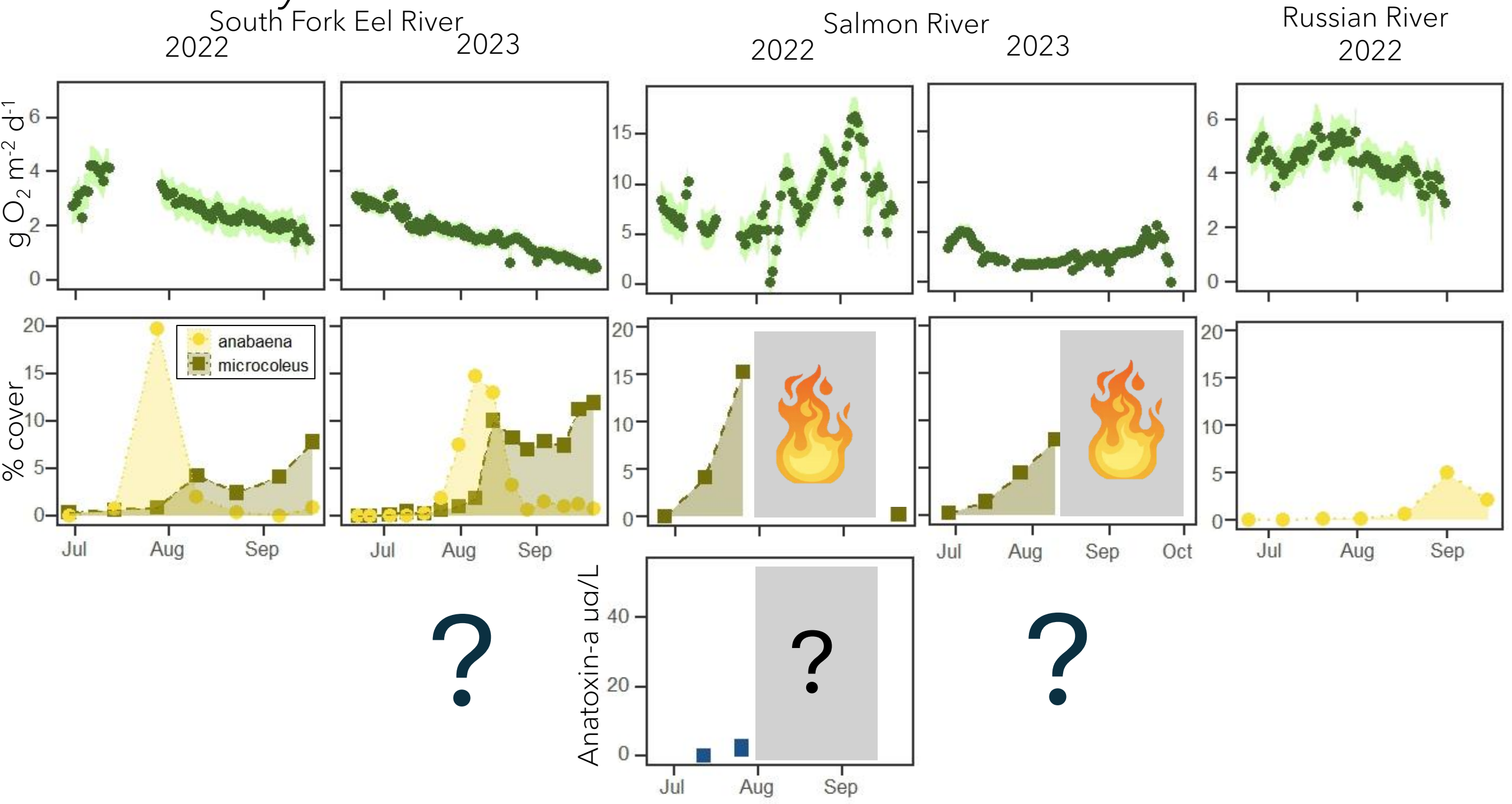

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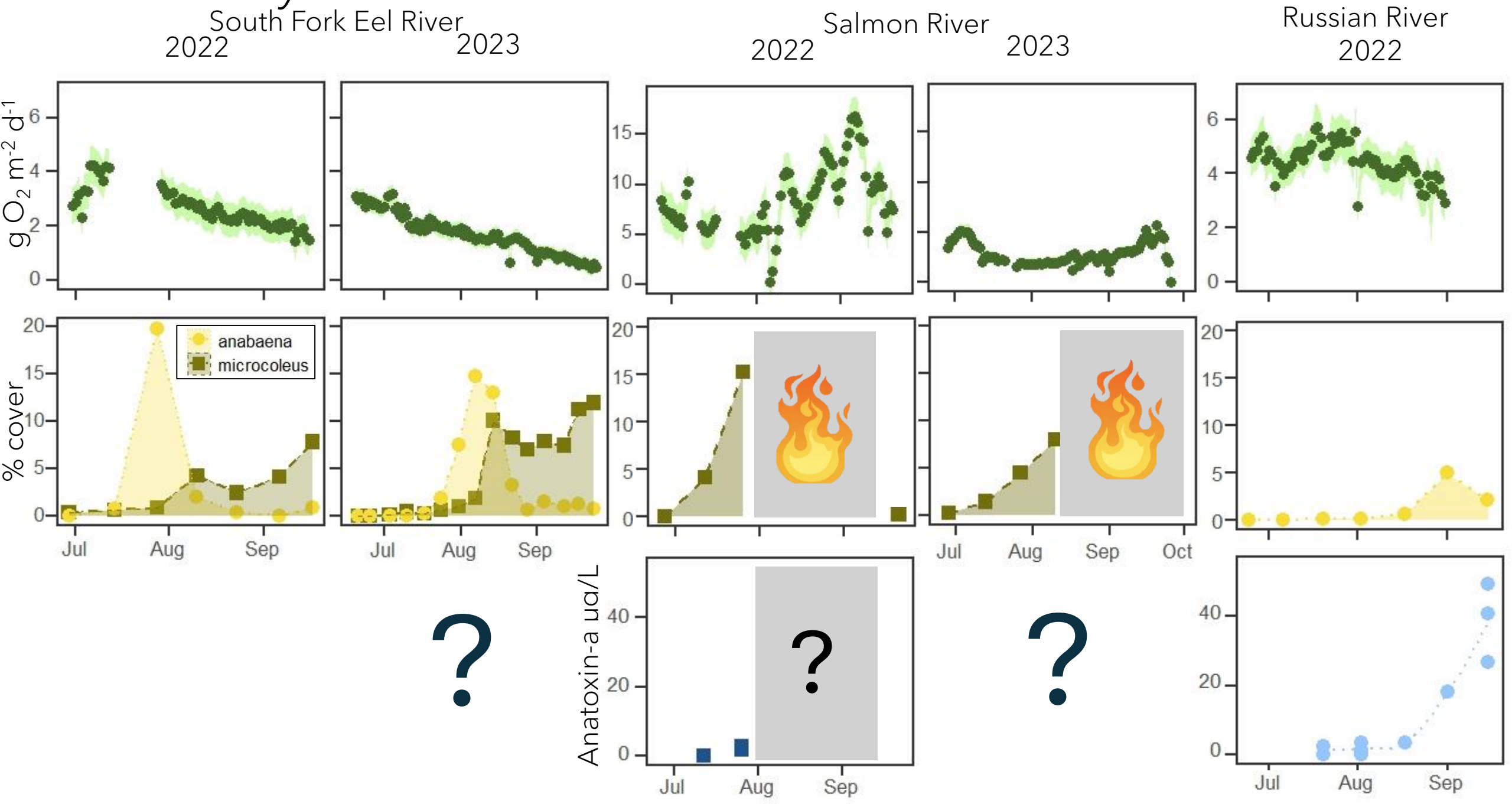

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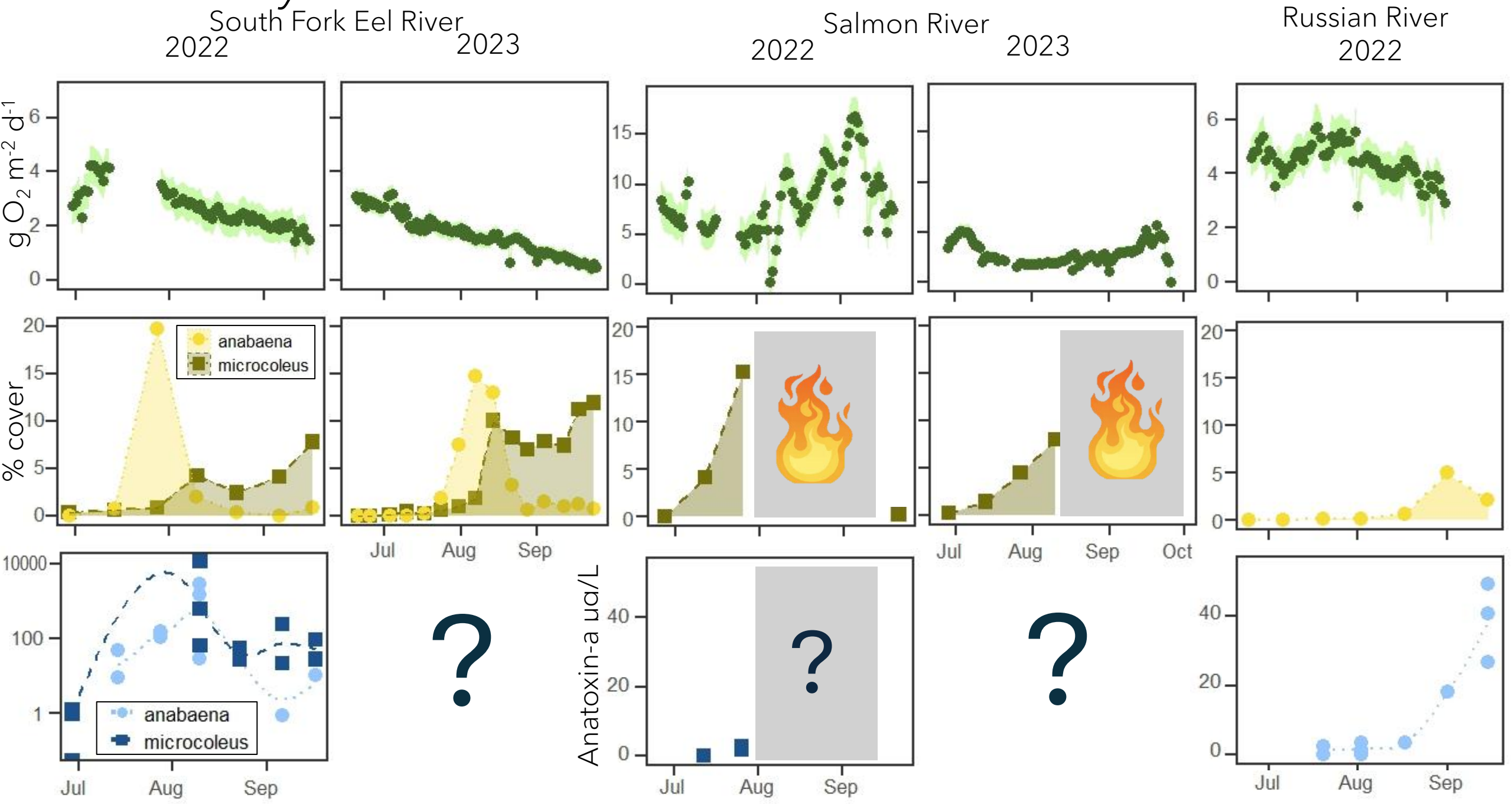

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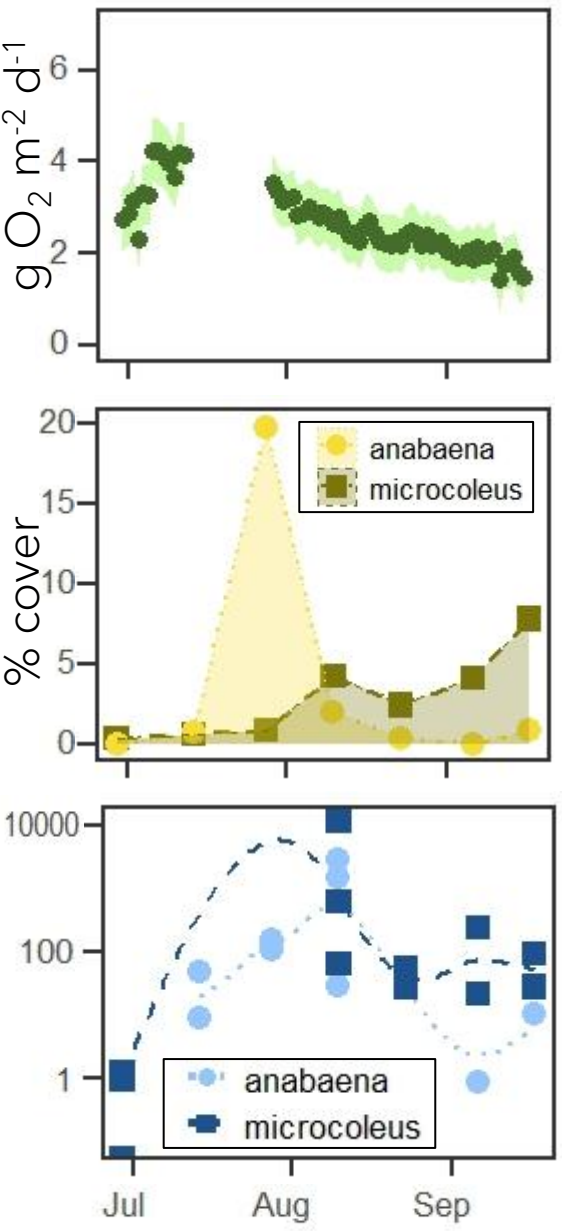
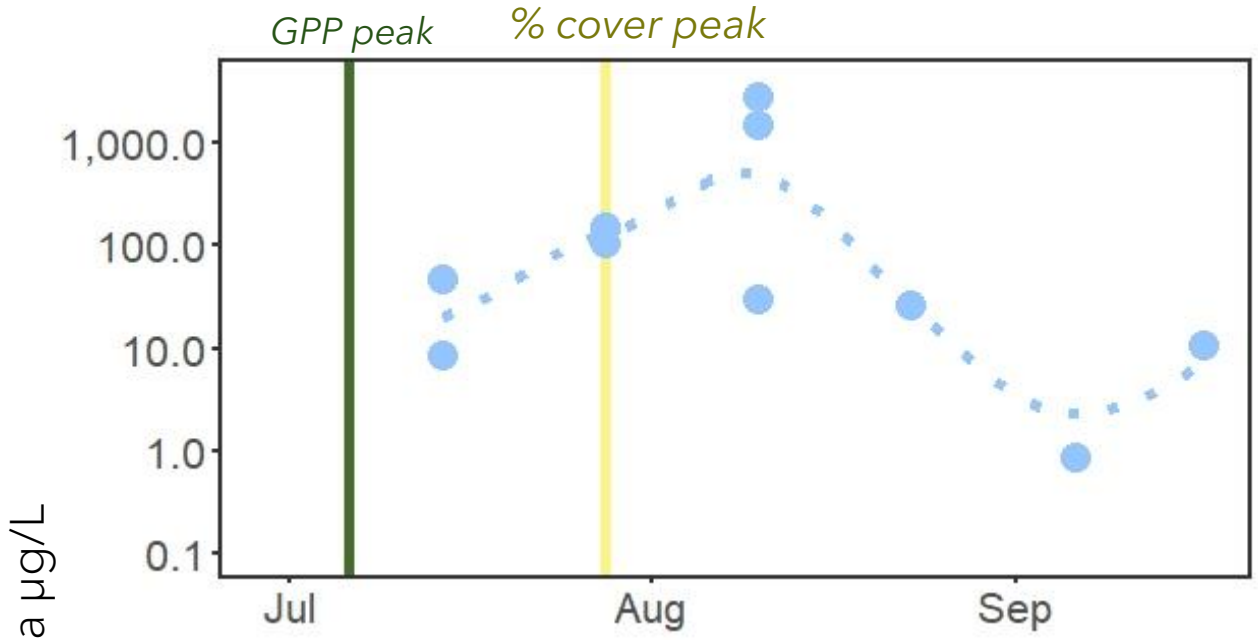
South Fork Eel River

2022



Anabaena



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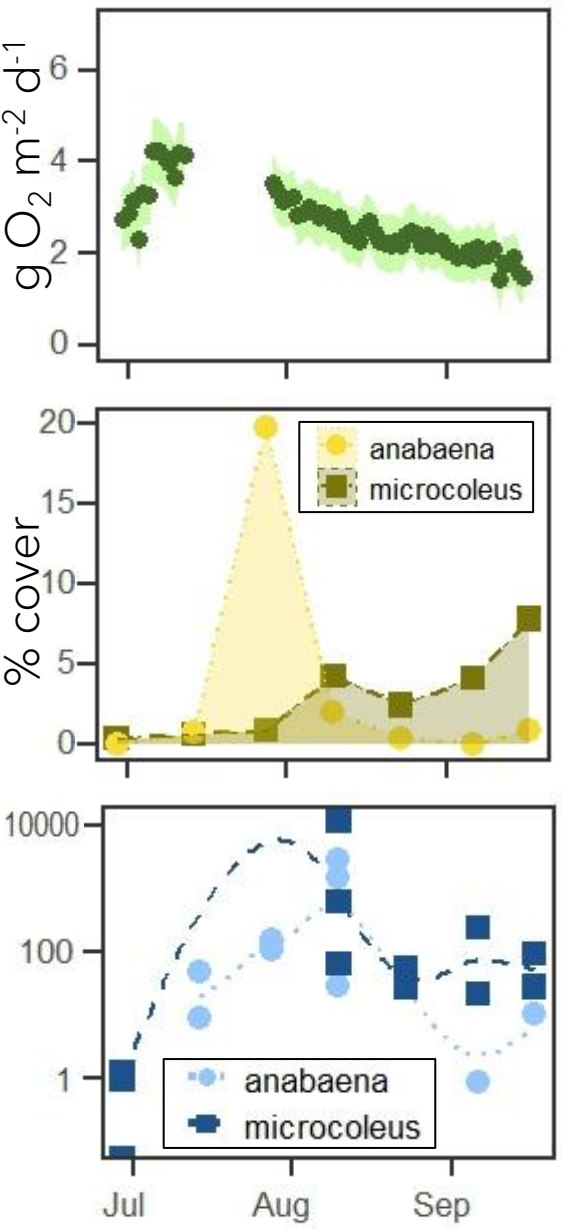
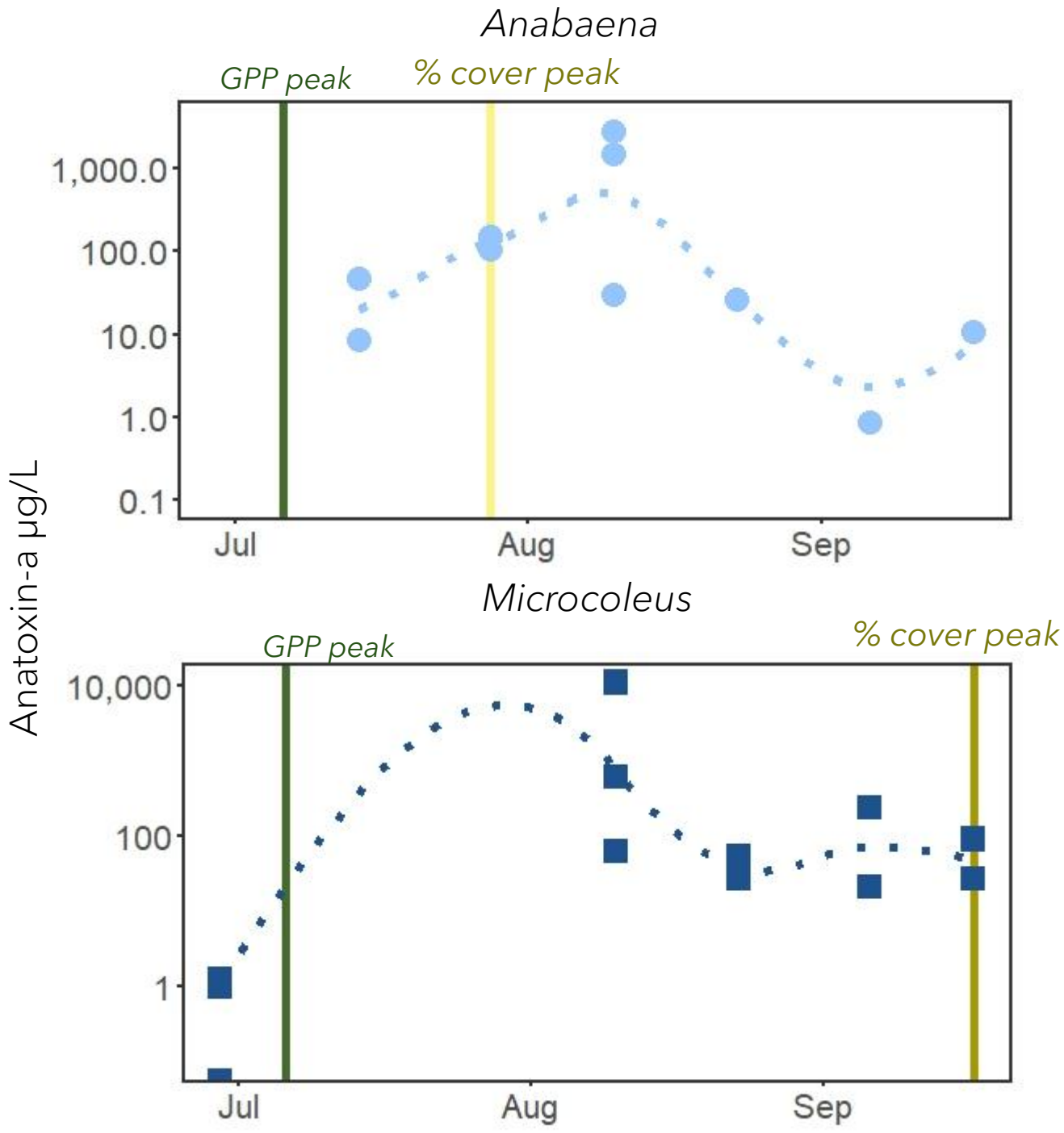
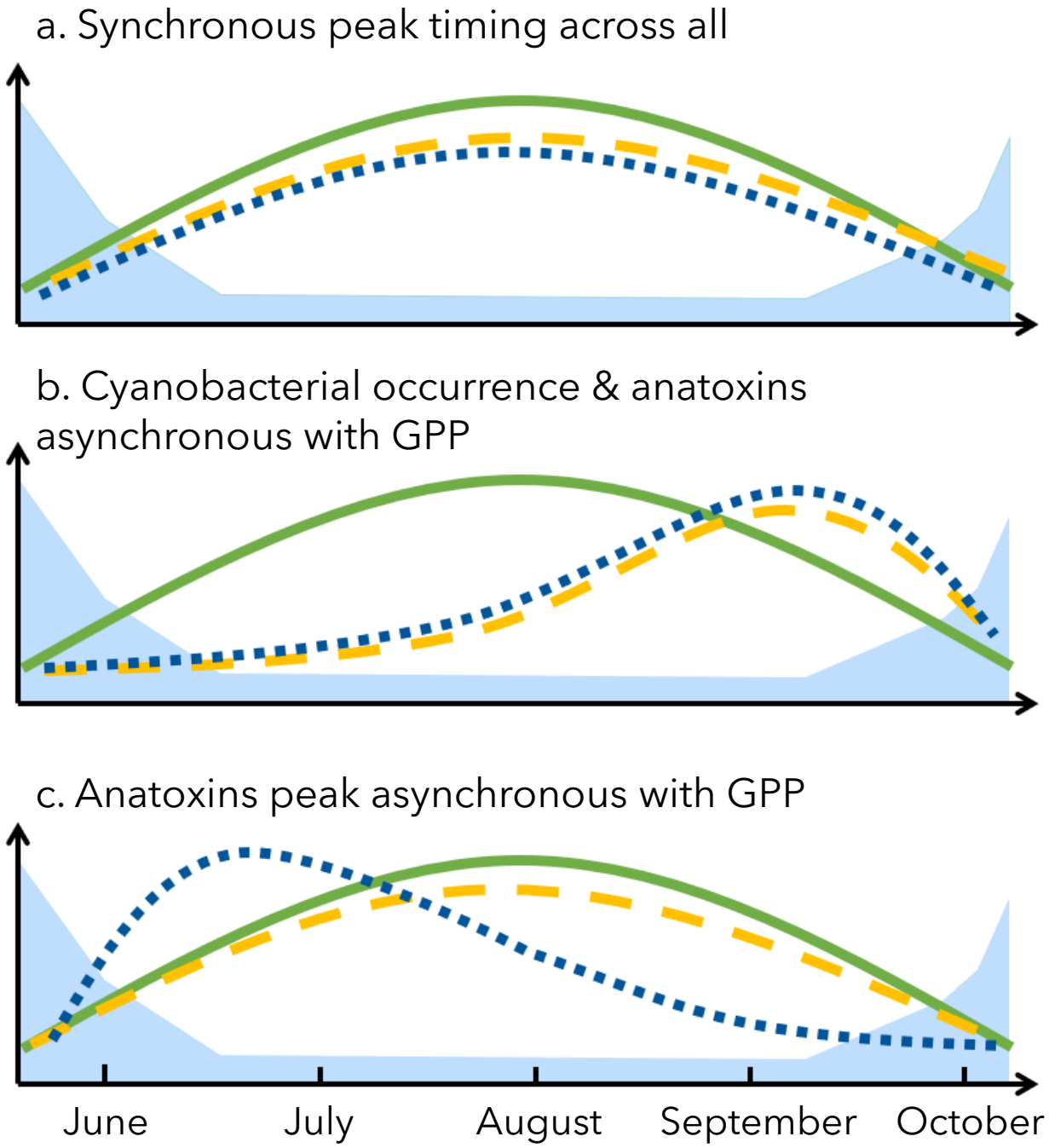




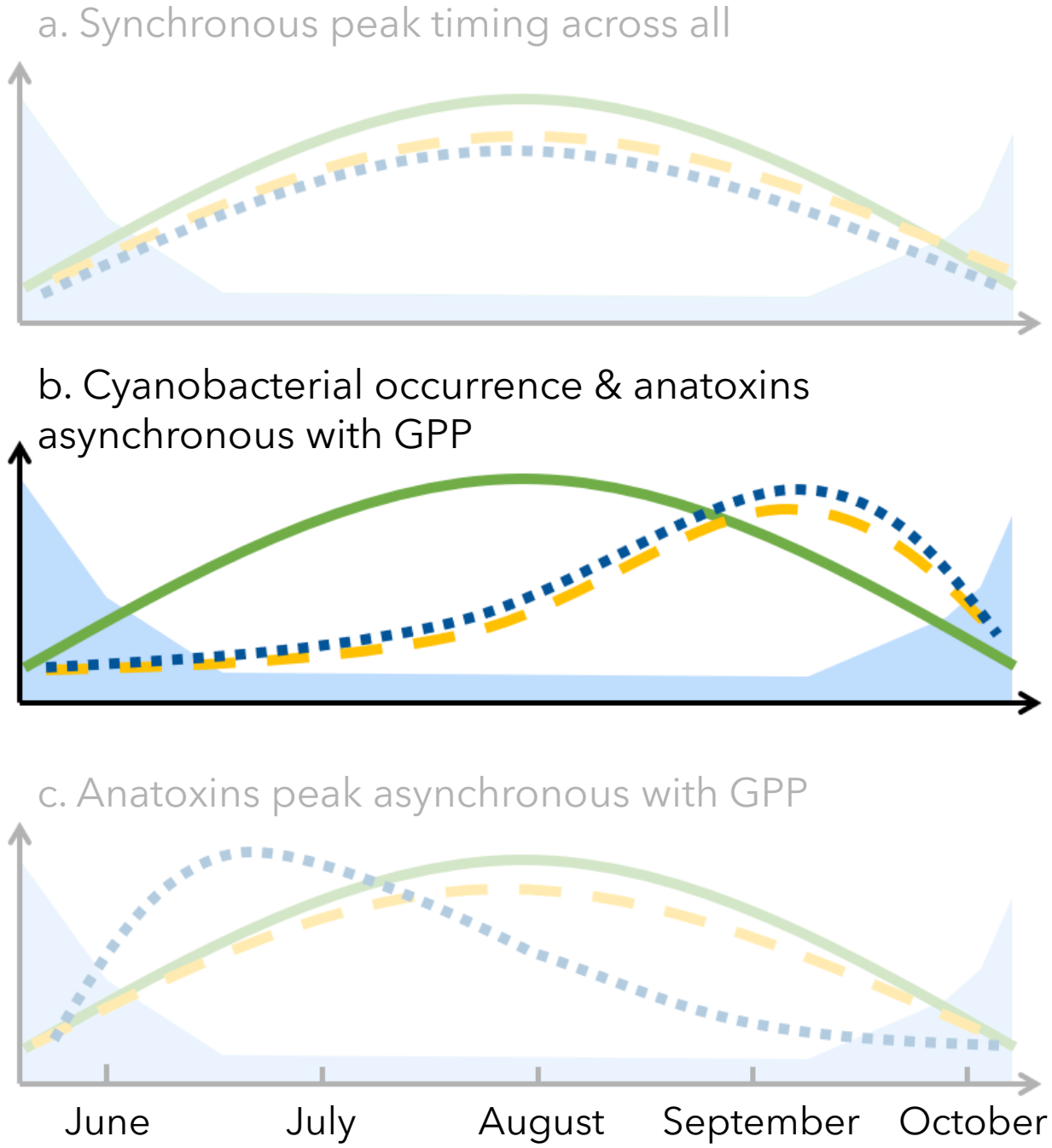
What we are learning….

Synchrony of GPP and benthic cyanobacteria dynamics are dependent on the specific river and cyanobacterial species



What we are learning….

In the South Fork Eel and Russian Rivers peak cyanobacterial occurrence and anatoxin production occur after peak GPP



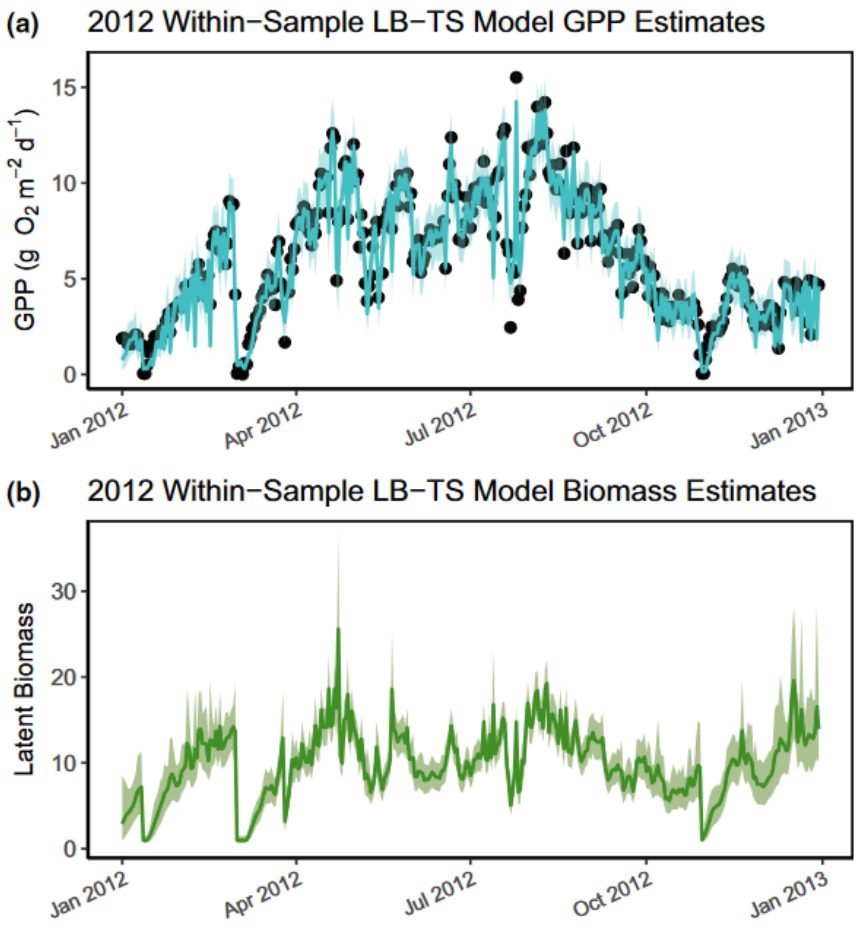
Gross Primary Productivity (GPP)

Cyanobacterial Occurrence

Anatoxin Concentration

Seasonal Discharge Pattern

Next steps: Model Development



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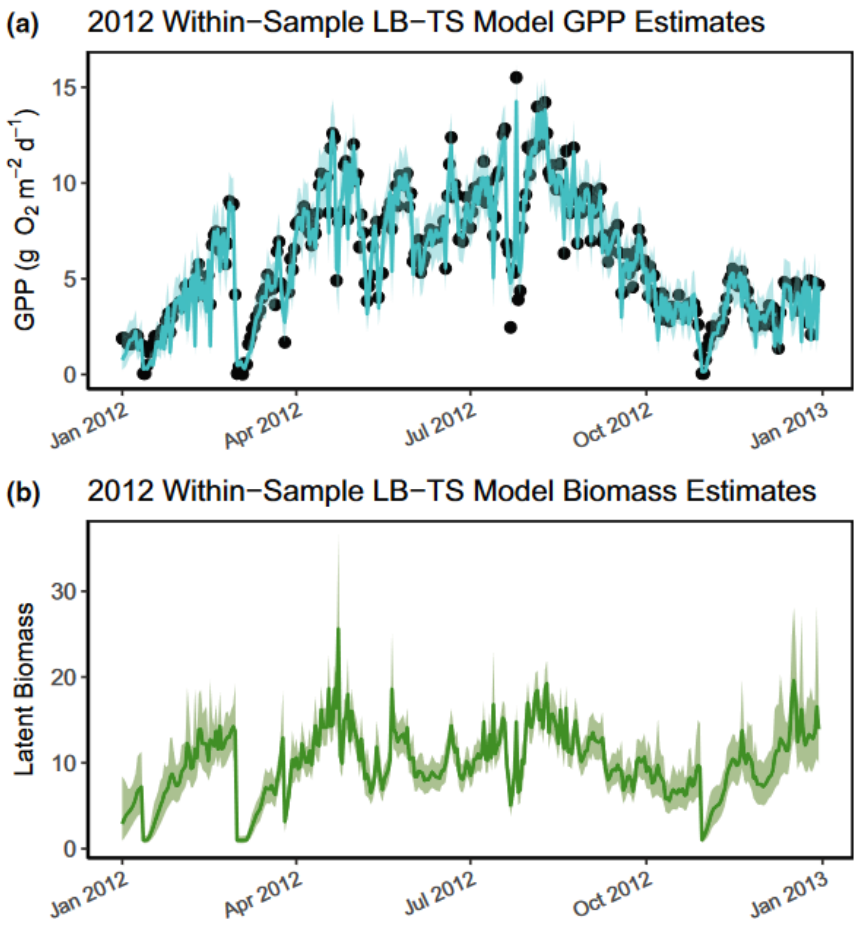
i) Ecosystem biomass (B_t) model

$$B_t = B_{t-1} + r_{max} + \frac{-r_{max}}{K} e^{B_{t-1}} + \varepsilon_{proc,t}$$

$$GPP_t = L_t e^{B_t} + \varepsilon_{obs,t}$$

Next steps: Model Development



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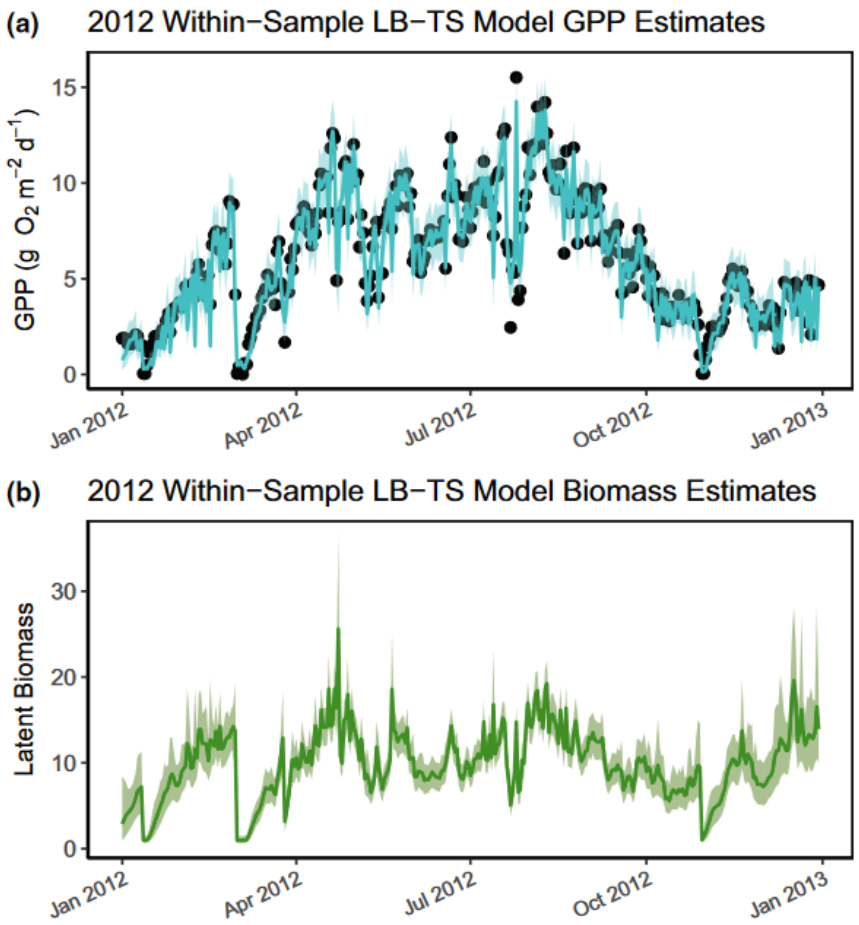
Next steps: Model Development



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$$inv.logit(c_t) = \gamma_1 B_t + \gamma_2 + \varepsilon_c$$

iii) Anatoxin concentration (a_t) model

$$a_t = \alpha_1 c_t + \alpha_2 + \varepsilon_a$$

Thank you!

jzabrecky@unr.edu