Lake Guard Oxy Treatments for Cyanobacterial Blooms at a Lake Okeechobee Outflow Structure

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A HAB (harmful algal bloom) found at S-235 in 2024

Study site: S77 on the Caloosahatchee River at Moore Haven, Florida

TEST 1 (06/24/2024)

- ✓ S-77 flows ~500 cfs
- ✓ S-77 flows continuous

TEST 2 (07/01/2024)

- ✓ No flows from S-77 before and during product application
- ✓ S-77 flows @ ~500 cfs ~1.5 hr after treatment

TEST 3 (07/15/2024)

- ✓ S-77 flows ~1000 cfs
- ✓ S-77 flows continuous

The change of **hydrogen peroxide** concentrations

Hydrogen peroxide (mg/L)

Test 1(HP)	Pre	Post	Day 2	Day 3
S1	0.18	0.12	0.25	0.18
S2	0.16	0.20	0.26	0.18
S3	0.14	0.20	0.29	0.23
S4	0.14	0.27	0.32	0.26
S5	0.11	0.31	0.31	0.25
S6	0.17	0.25	0.36	0.24

Test 2(HP)	Pre	Post	Day 2	Day 3
S1	0.10	0.00	0.21	0.20
S2	0.03	0.17	0.20	0.24
S3	0.11	0.14	0.45	0.20
S4	0.00	0.22	0.24	0.17
S5	0.01	0.17	0.26	0.22
S6	0.08	0.05	0.19	0.23

Test 3(HP)	Pre	Post	Day 2	Day 3
S1	0.16	0.53	0.07	0.20
S2	0.25	0.63	0.12	0.22
S3	0.22	0.44	0.20	0.19
S4	0.32	0.38	0.11	0.28
S5	0.23	0.57	0.12	0.30
S6	0.25	0.52	0.29	0.20

Dissolved oxygen (mg/L)

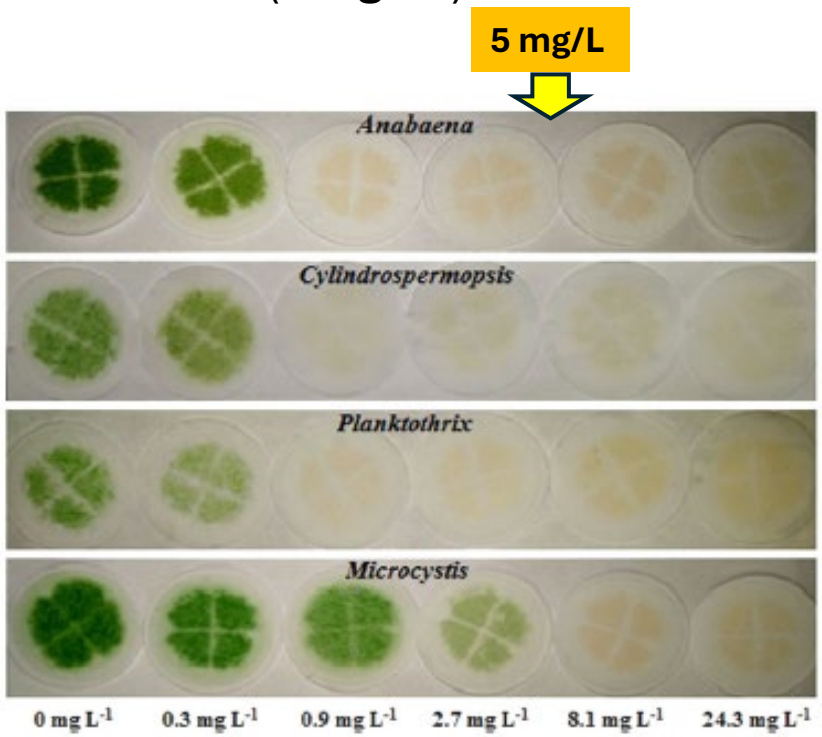
Test 1(DO)	Pre	Post	Day 2	Day 3
S1	6.1	6.5	6.3	6.3
S2	4.7	6.9	5.8	5.8
S3	4.9	5.2	5.0	5.0
S4	3.9	7.3	5.6	5.6
S5	4.4	4.2	4.3	4.3
S6	5.0	4.9	5.0	5.0

Test 2(DO)	Pre	Post	Day 2	Day 3
S1	2.9	3.8	2.6	2.5
S2	2.8	3.7	2.1	2.5
S3	2.3	4.3	2.2	2.9
S4	2.1	3.9	1.9	1.6
S5	2.9	3.1	1.9	1.9
S6	3.3	6.3	2.1	2.1

Test 3(DO)	Pre	Post	Day 2	Day 3
S1	2.5	2.9	2.6	4.0
S2	2.3	2.4	1.9	1.9
S3	1.7	2.0	1.7	2.0
S4	3.5	2.4	2.4	3.0
S5	1.5	1.5	1.8	2.6
S6	1.2	1.5	1.8	2.5

- T1: H2O2 (25%) & O2 (47%) increased.
- T2: H2O2 (567%) & O2 (32%) increased.
- T3: H2O2 (252%) & O2 (4%) increased.

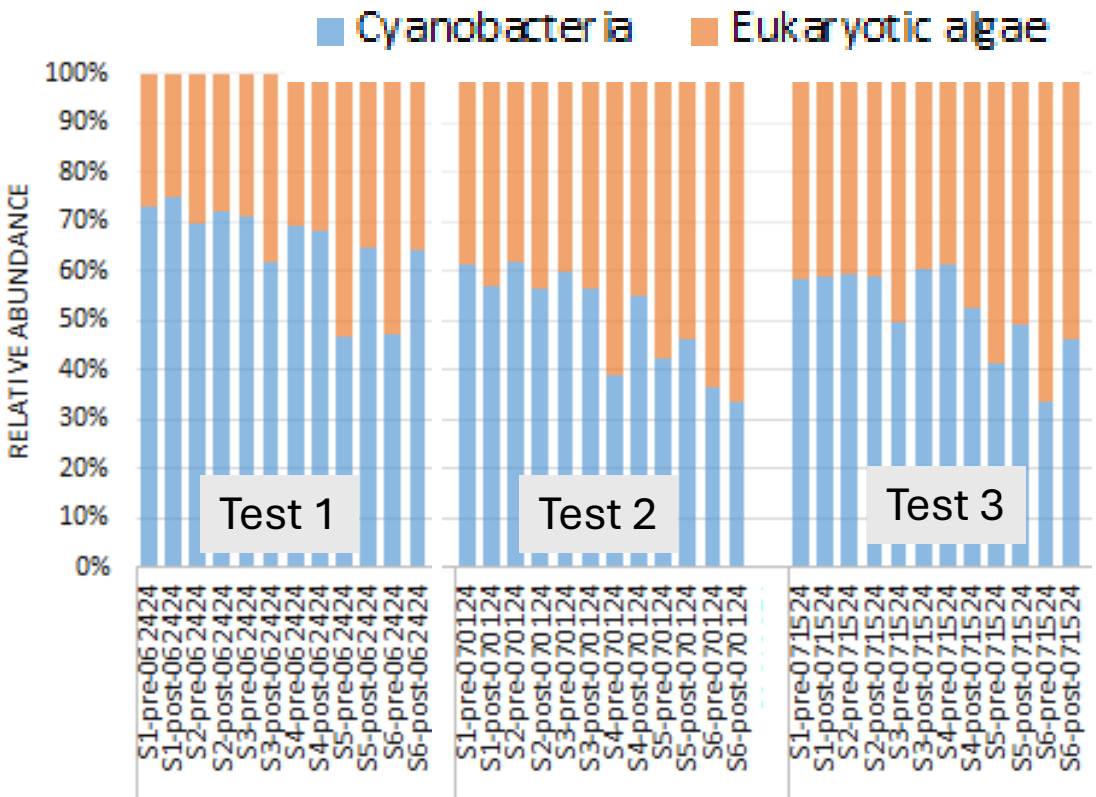
- We were able to detect the added LGOxy.
- The impact of the treatment was also observed in **downstream** sites.
- However, the detected concentration **(<0.63 mg/L)** was lower than the target concentration (**5 mg/L<**).

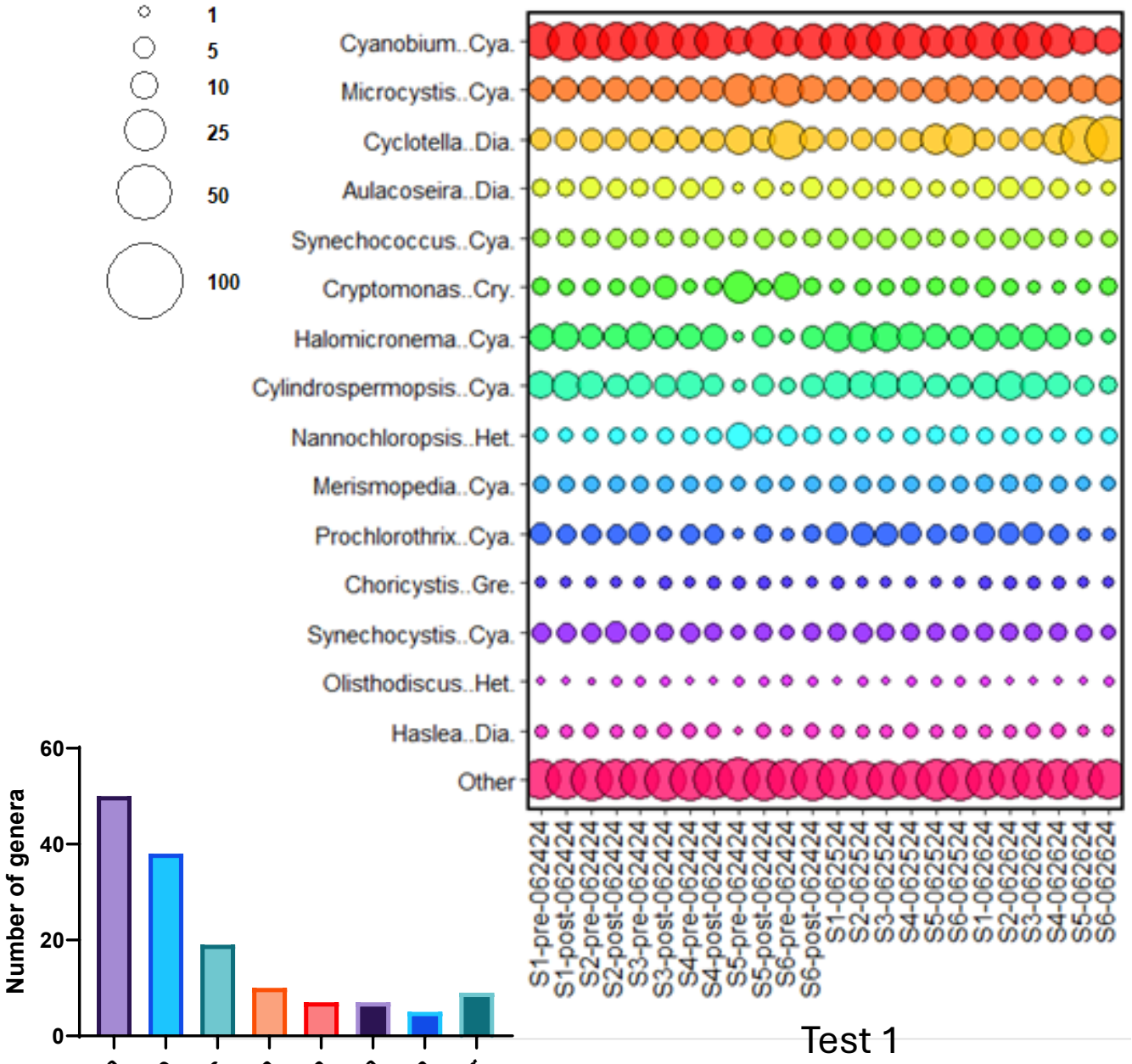


Yang et al. 2018

Phytoplankton community analysis

- Cyanobacteria/Green algae/Diatoms were three dominant phytoplankton groups.
- Cyanobacteria communities were mainly dominated by picocyanobacteria (*Cyanobium*, *Synechococcus*, *Merismopedia*) and *Microcystis*.
- Previously reported community shift from cyano to EUK was not found.





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Synechococcus dominance induced after hydrogen peroxide treatment of *Microcystis* bloom in the Caloosahatchee River, Florida☆

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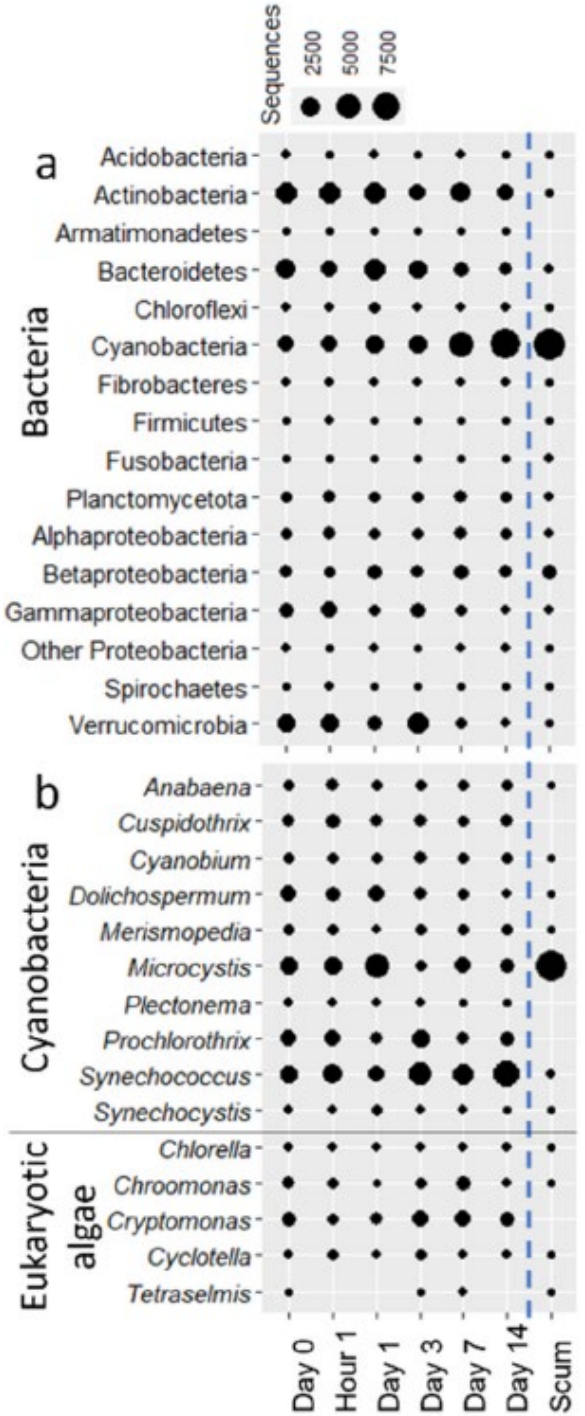
ABSTRACT

Few field trials examining hydrogen peroxide as a cyanobacterial harmful algal bloom (cHAB) treatment have been conducted in subtropical and tropical regions. None have been tested in Florida, home to Lake Okeechobee and downstream waterways which periodically experience *Microcystis* bloom events. To investigate treatment effects in Florida, we applied a 490 μM (16.7 mg/L; 0.0015%) hydrogen peroxide spray to a minor bloom of *Microcystis aeruginosa* on the downstream side of Franklin Lock and Dam in the Caloosahatchee River. Although hydrogen peroxide decreased to background level one day post-treatment, succession was observed in phytoplankton community amplicon sequencing. The relative abundance of *Microcystis* decreased on day 3 by 86%, whereas the picocyanobacteria *Synechococcus* became dominant, increasing by 77% on day 3 and by 173% on day 14 to 57% of the phytoplankton community. Metatranscriptomics revealed *Synechococcus* likely benefitted from the antioxidant defense of upregulated peroxiredoxin, peroxidase/catalase, and rubrerythrin expressions immediately after treatment, and upregulated nitrate transport and urease to take advantage of available nitrogen. Our results indicated hydrogen peroxide induces succession of the phytoplankton community from *Microcystis* to non-toxic picocyanobacteria and could be used for selective suppression of harmful cyanobacteria.



The change of **total chlorophyll** and **phycocyanin** (YSI)

Test 1(CHL)	Pre	Post	Day 2	Day 3
S1	16.1	17.7	31.4	32.6
S2	16.7	14.9	31.8	31.0
S3	27.6	28.4	26.1	32.8
S4	27.6	25.2	28.0	33.7
S5	42.8	34.3	48.5	50.5
S6	42.7	38.2	39.6	54.8

Test 1(PC)	Pre	Post	Day 2	Day 3
S1	3.9	3.9	3.0	3.0
S2	4.1	1.5	3.3	3.0
S3	2.8	3.0	3.0	3.4
S4	2.5	2.5	2.9	3.4
S5	1.8	2.8	3.2	2.9
S6	2.1	2.8	3.3	3.1

Test 2(CHL)	Pre	Post	Day 2	Day 3
S1	15.1	16.3	32.0	31.4
S2	13.8	15.0	32.1	34.0
S3	20.5	27.3	24.0	27.4
S4	31.7	24.6	20.3	24.7
S5	38.3	32.1	29.2	31.7
S6	39.0	51.3	31.5	34.7

Test 2(PC)	Pre	Post	Day 2	Day 3
S1	1.0	1.0	1.5	1.9
S2	1.1	1.0	1.8	1.8
S3	1.1	1.5	1.4	1.8
S4	0.9	1.3	1.3	1.5
S5	1.2	1.2	1.3	1.4
S6	1.3	1.8	1.1	1.5

Test 3(CHL)	Pre	Post	Day 2	Day 3
S1	8.0	7.9	24.8	15.4
S2	8.2	6.8	26.2	25.9
S3	18.9	14.2	30.4	30.4
S4	60.7	17.8	29.1	26.5
S5	24.9	23.5	22.3	21.5
S6	25.8	24.9	22.0	22.5

Test 3(PC)	Pre	Post	Day 2	Day 3
S1	1.0	1.0	0.8	0.8
S2	1.0	1.0	0.6	1.1
S3	0.5	0.5	0.4	0.5
S4	6.4	0.5	0.4	0.6
S5	0.4	0.4	0.5	0.6
S6	0.4	0.4	0.5	0.6

Test 3(DO)	Pre	Post	Day 2	Day 3
S1	2.5	2.9	2.6	4.0
S2	2.3	2.4	1.9	1.9
S3	1.7	2.0	1.7	2.0
S4	3.5	2.4	2.4	3.0
S5	1.5	1.5	1.8	2.6
S6	1.2	1.5	1.8	2.5

- T1: Reduction of Chl (11%) & PC (63%).
- T2: Reduction of Chl (0%) & PC (9%).
- T3: Reduction of Chl (17%) & PC (0%) at S2.
- T3: Reduction of Chl (70.7%) & PC (92.2%) at S4.

- The lowest Chl & PC was found at the treated area S2.
- In Test 3, a small bloom was found at S4. DO was also high at this site.

Photosynthetic efficiency (quantum yield, QY) of phytoplankton

Test 1(QY)	Pre	Post	Day 2	Day 3
S1	0.48	0.48	0.57	0.56
S2	0.52	0.43	0.55	0.56
S3	0.52	0.47	0.52	0.56
S4	0.51	0.49	0.54	0.58
S5	0.50		0.53	0.58
S6	0.53		0.56	0.57

Test 2(QY)	Pre	Post	Day 2	Day 3
S1	0.52	0.51	0.45	0.47
S2	0.46	0.50	0.48	0.43
S3	0.48	0.51	0.46	0.41
S4	0.43	0.47	0.48	0.43
S5	0.50	0.49	0.44	0.42
S6	0.49	0.55	0.43	0.43

Test 3(QY)	Pre	Post	Day 2	Day 3
S1	0.41	0.41	0.36	0.35
S2	0.44	0.33	0.23	0.22
S3	0.37	0.34	0.18	0.23
S4	0.34	0.31	0.19	0.24
S5	0.30	0.33	0.23	0.25
S6	0.38	0.31	0.22	0.32

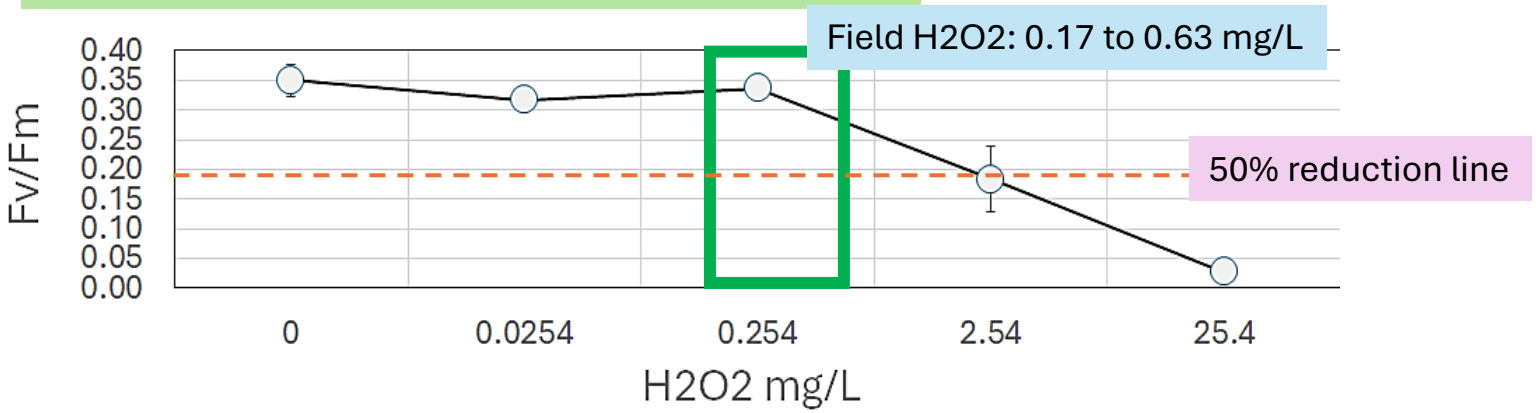
Our H2O2 treatment concentration was not strong to treat *Microcystis*.

- T1: Reduction of photosynthesis efficiency (17%).
- T2: Reduction of photosynthesis efficiency (0%).
- T3: Reduction of photosynthesis efficiency (25%).

- Overall, the data showed marginal effect of H2O2 treatments in Test 1 & 3.
- No effect in Test 2.

AquaPen fluorometer

QY lab experiment:
M. aeruginosa NIES-102 (pure culture)
QY results after 24 h of reaction



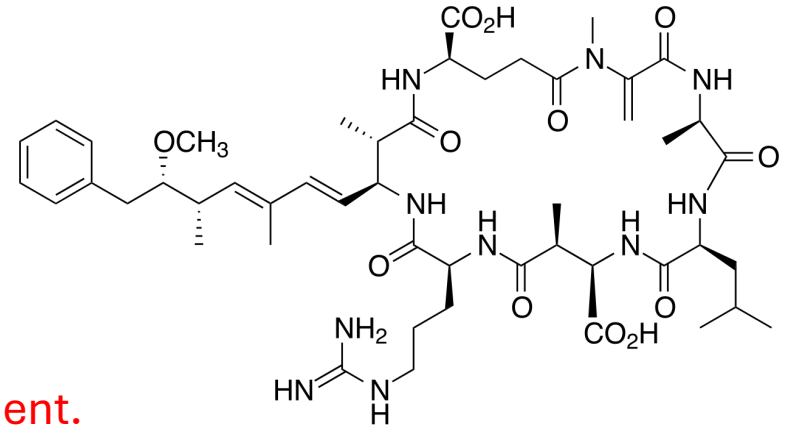
The change of **microcystin** concentrations

Test 1(MCt)	Pre	Post	Day 2	Day 3
S1	0.60	0.01	0.30	0.61
S2	0.00	0.00	0.21	0.47
S3	0.25	0.10	0.18	0.41
S4	0.78	0.00	0.09	0.27
S5	0.03	0.04	0.13	0.27
S6	0.26	0.00	0.20	0.44

Test 2(MCt)	Pre	Post	Day 2	Day 3
S1	0.03	0.06	0.03	0.00
S2	0.05	0.00	0.01	0.00
S3	0.07	0.07	0.02	0.00
S4	0.01	0.03	0.01	2.54
S5	0.08	0.00	0.01	0.01
S6	0.03	0.27	0.01	0.00

Test 3(MCt)	Pre	Post	Day 2	Day 3
S1	0.03	0.04	0.11	0.07
S2	0.01	0.02	0.04	0.07
S3	0.02	0.02	0.03	0.30
S4	0.05	0.02	0.08	0.07
S5	0.02	1.51	0.03	0.05
S6	0.02	0.02	0.02	0.05

Microcystin-LR



- T1: 0% increase after the treatment.
- T2: 0% increase after the treatment.
- T3: 200% increase after the treatment.

- Extremely low level of microcystin was detected (T1 mean 0.32 mg/L, T2 0.045 mg/L, T3 0.055 mg/L).
- The detection limit of microcystin measurement is 0.3 µg/L.
- Thus, the measurements were not accurate enough.
- No evidence of cell lysis or microcystin degradation by H2O2.

Zooplankton counting

Total counts

Test 1(ZOO)	Pre	Post	Day 2	Day 3
S1	360	290	206	382
S2	249	260	81	240
S3	112	108	516	313
S4	136	221	261	263
S5	49	212	209	446
S6	139	141	218	578

Test 2(ZOO)	Pre	Post	Day 2	Day 3
S1	343	685	233	222
S2	253	635	622	309
S3	213	194	35	54
S4	366	142	139	142
S5	366	465	439	304
S6	543	602	315	518

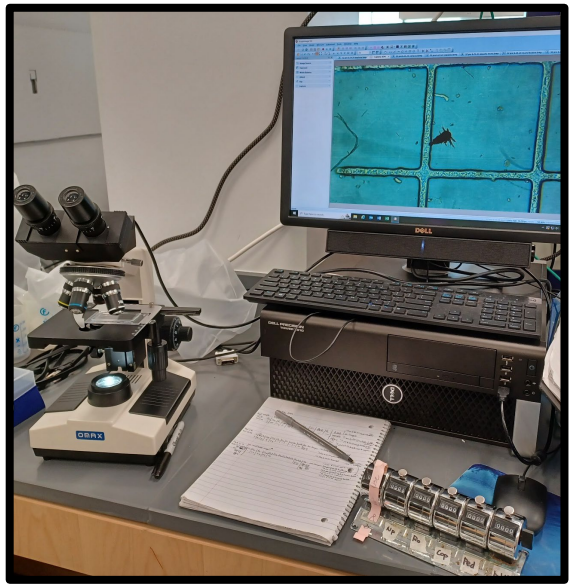
Test 3(ZOO)	Pre	Post	Day 2	Day 3
S1	409	500	704	384
S2	387	329	955	186
S3	384	301	184	162
S4	336	323	221	213
S5	183	279	403	242
S6	197	447	504	433

Rotifer counts

Test 1(ROT)	Pre	Post	Day 2	Day 3
S1	114	91	78	122
S2	55	141	27	105
S3	40	56	206	132
S4	57	84	134	105
S5	41	125	117	343
S6	120	80	144	521

Test 2(ROT)	Pre	Post	Day 2	Day 3
S1	60	106	74	63
S2	45	200	99	86
S3	32	36	7	22
S4	318	35	42	40
S5	304	369	273	213
S6	472	556	211	393

Test 3(ROT)	Pre	Post	Day 2	Day 3
S1	12	25	15	34
S2	16	26	100	26
S3	18	19	7	23
S4	20	26	14	41
S5	40	22	42	31
S6	12	25	58	71



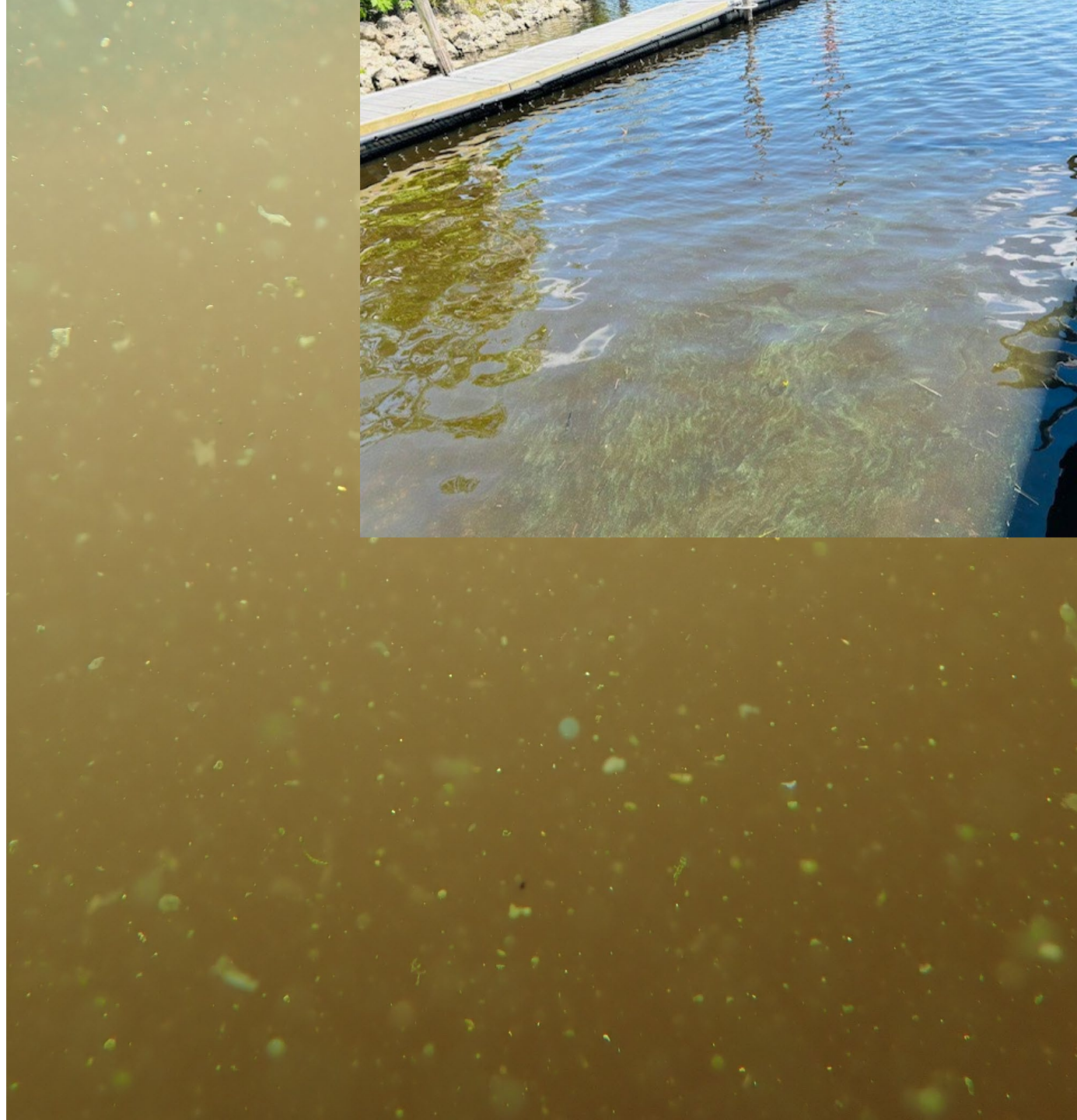
Our total zooplankton counts were similar to the zooplankton counts previously documented (e.g., Schmitz & Osborne, 1984).

Conclusion

H2O2 levels were too low to expect strong bloom control

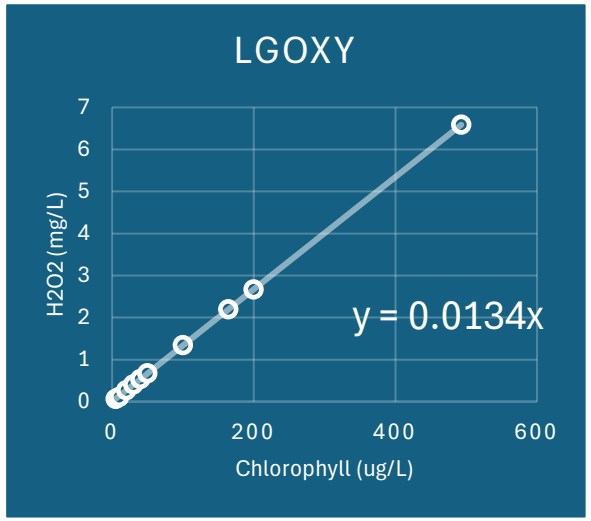
The 2024 blooms were non-toxic blooms. No evidence of cell lysis or microcystin degradation by H2O2.

Zooplankton were unaffected in our field studies.



A facing challenge: Low H2O2 concentrations

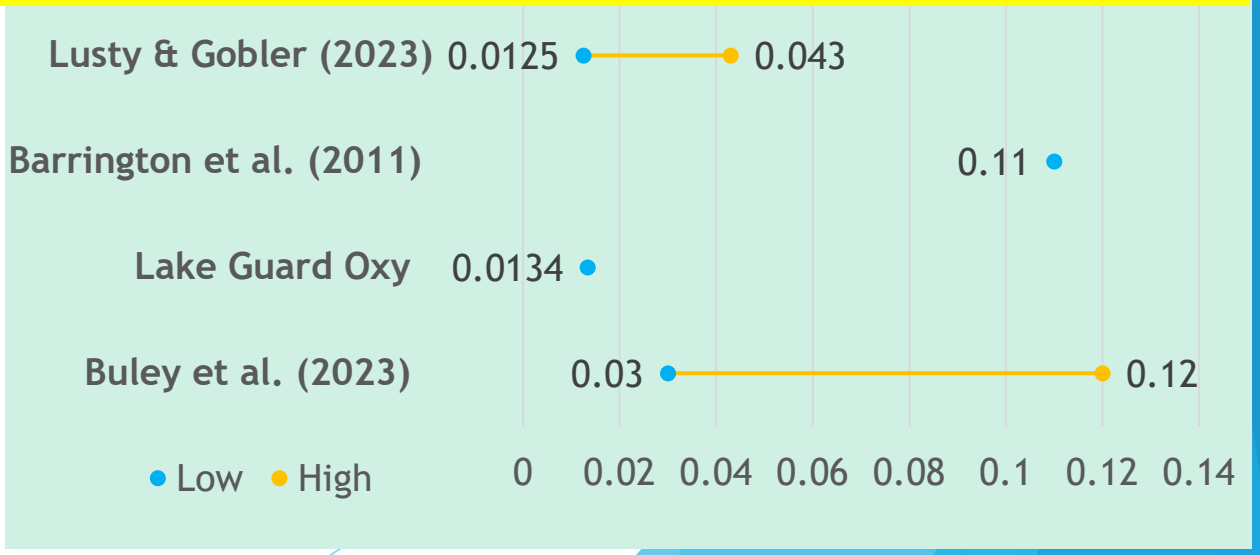
- In the field application, the concentration of H2O2 is determined based on the Chl-a concentration.
- More Chl means more H2O2. Their relationship is linear.
- Lusty and Gobler (2023) suggest to use the range of slope between **0.0125 to 0.043**.
- 2025? We will relocate the test field to high chlorophyll locations (S-77 to S-308, up to 294 lbs./acre).



Lake Guard oxy label instruction

Treatment timing	Cell density (cells/mL)	Chl a (ug/L)	Dose (lbs/acre)	Minimum retreatment interval (hrs)	Remarks
Early treatment	5,000-20,000	< 10	0.5-5	12	
Late treatment	20,000-100,000	10-50	5-30	12	
Delayed treatment	100,000 <	50 <	30-98	24	Visible to the naked eye
Maximum single treatment	100,000 <<	50 <<	294	48	Less than ½ of the area

An effective range of slope of regression line of Chl-H2O2 relationship



Acknowledgments

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Boat Captains:
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US ACE:
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Credit: Joe Lopez