Mitigating Freshwater Cyanobacteria Blooms

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Microcystis Blooms on MD's Eastern Shore, USA

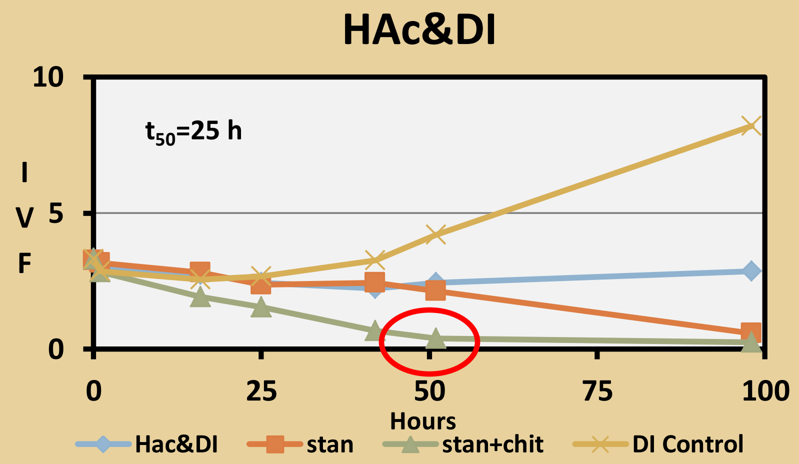
- Dog mortalities in 24-48 h in 2009 at Higgins Mill Pond; [microcystin] = 2 x 10^4 µg/L. Continued blooms today
- Summer blooms in Lake Williston in 2009-2011, exceeding WHO levels for recreational use
- Goal: To adapt Chinese freshwater sediment-cyanobacteria flocculation technology for MD waters as a potential routine mitigation technique by non-science personnel
  - <u>Any</u> local sediment + chitosan
  - 100 mg sed/L + 10 mg chitosan
- Foundation: GEMSTONE Team lab results (Crete, 2010)
- Preliminary flocculation expt. in 2011 at Williston brought cyanobacteria to the bottom

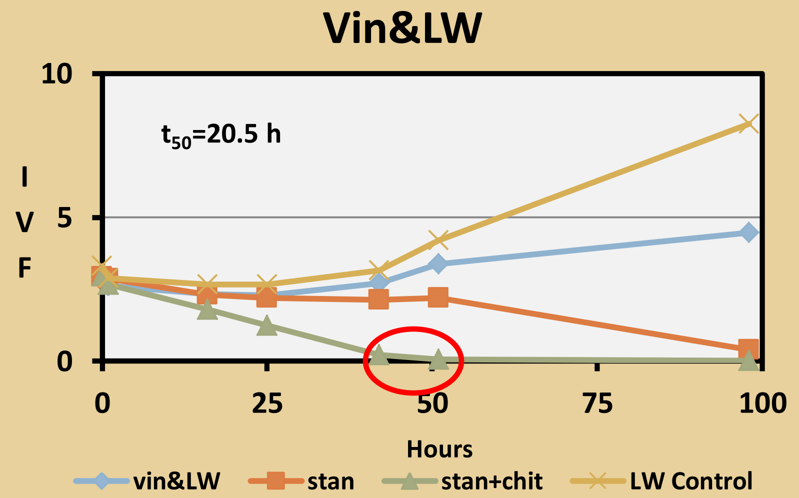
Established Methods: Preliminary Lab Results

To minimize costs + facilitate easy mixing in the field

- Pan et al. (2006) chitosan sol^n lowers pH<4; same sol^n in diluted table vinegar (0.5% HAc) & filtered lake water results in pH>6.7

- Flocculation as effective (97%-98% in 51 h)

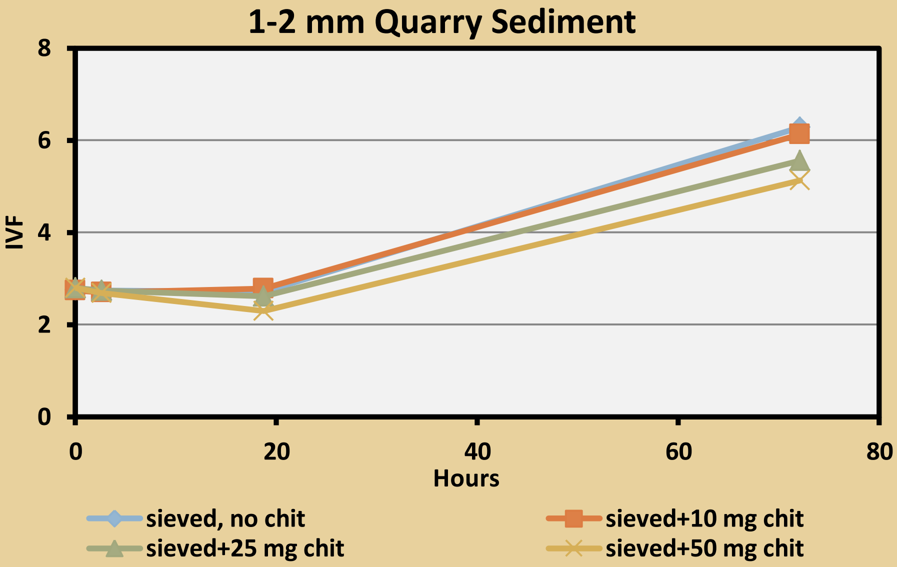


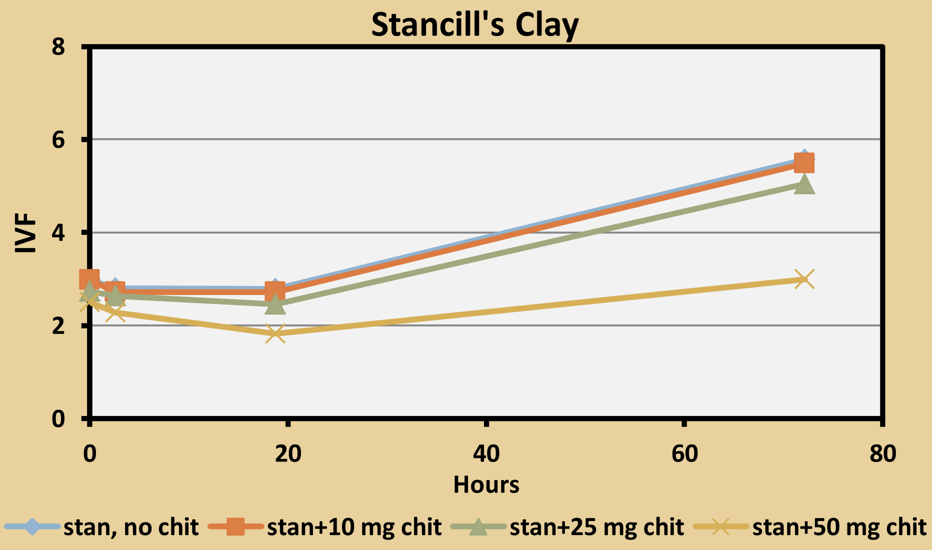


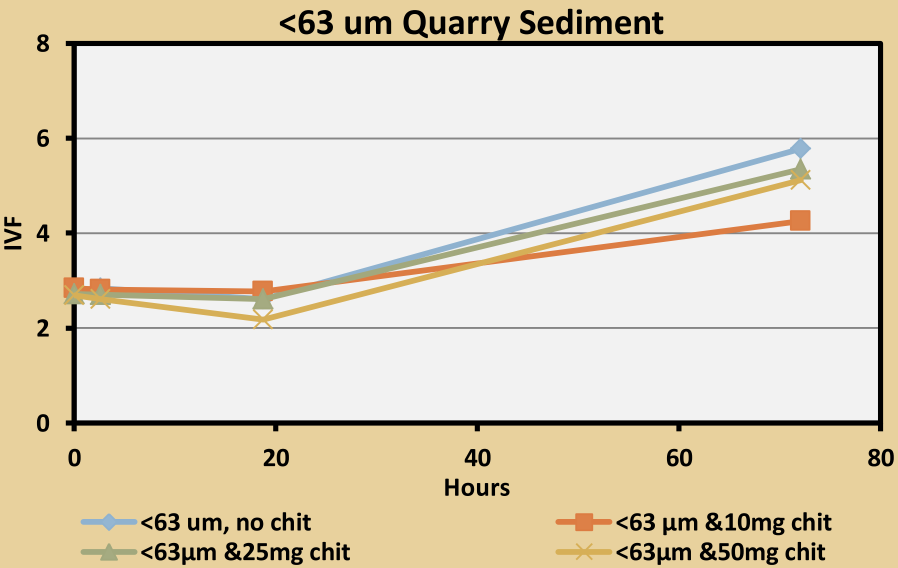
[200 mg sed+50 mg chit]/L

Preliminary Lab Results

Contrary to Pan et al. (2006), little flocculation at [100 mg sed+10 mg chit]/L regardless of sediment size or mineralogy

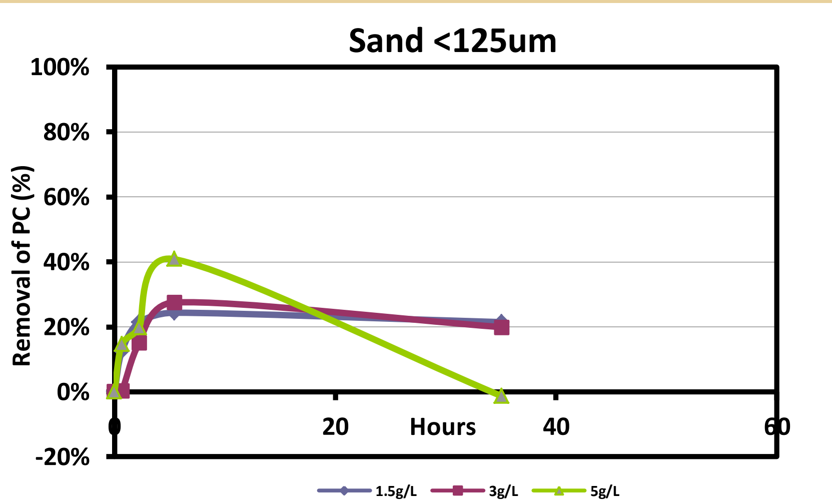


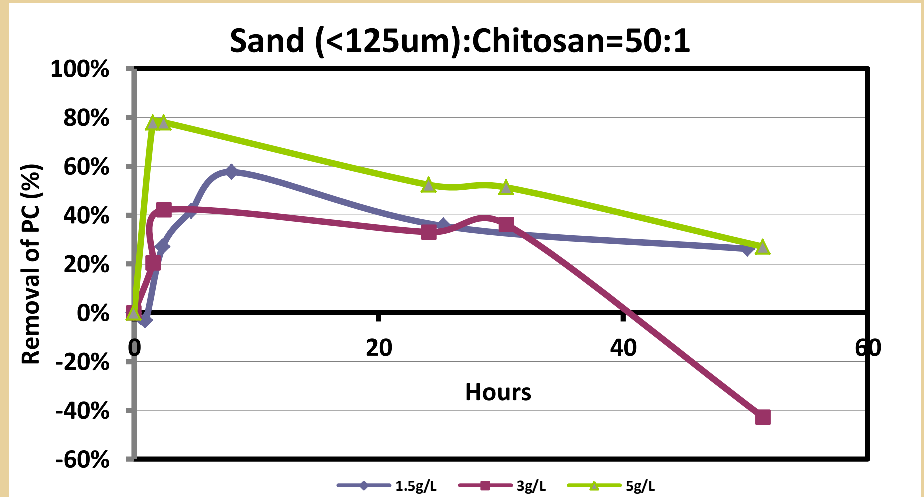


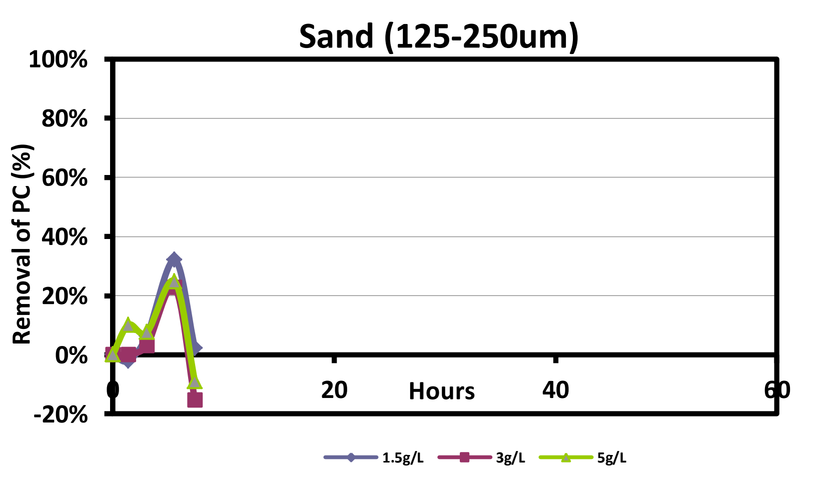


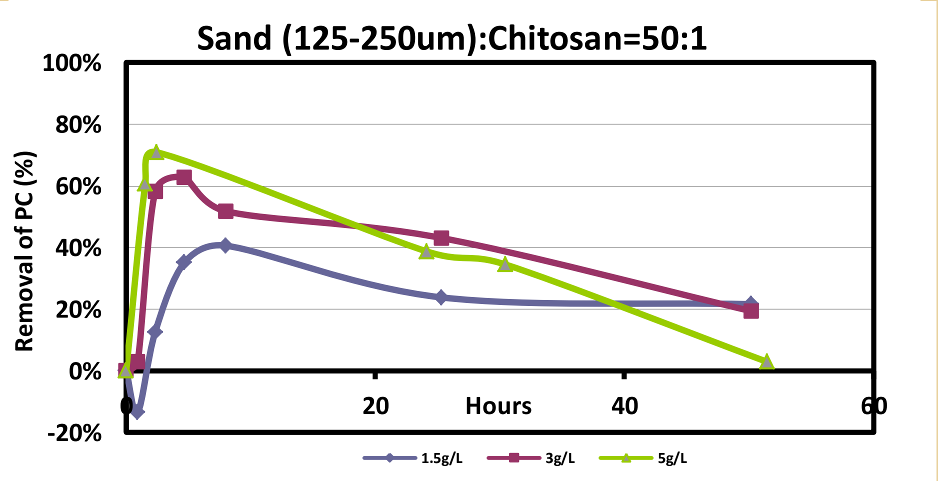
Sand Flocculation of HMP Blooms

- Greater flocculation of cyanobacteria with smaller sand grain size & chitosan addition (similar result for all Chl *a*)
- Much more sediment & chitosan required vs. Pan et al. (2006)



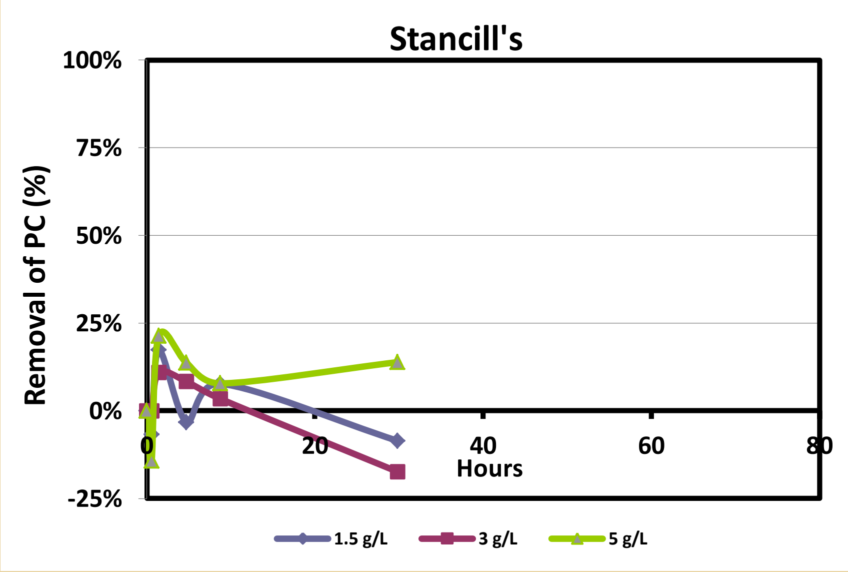


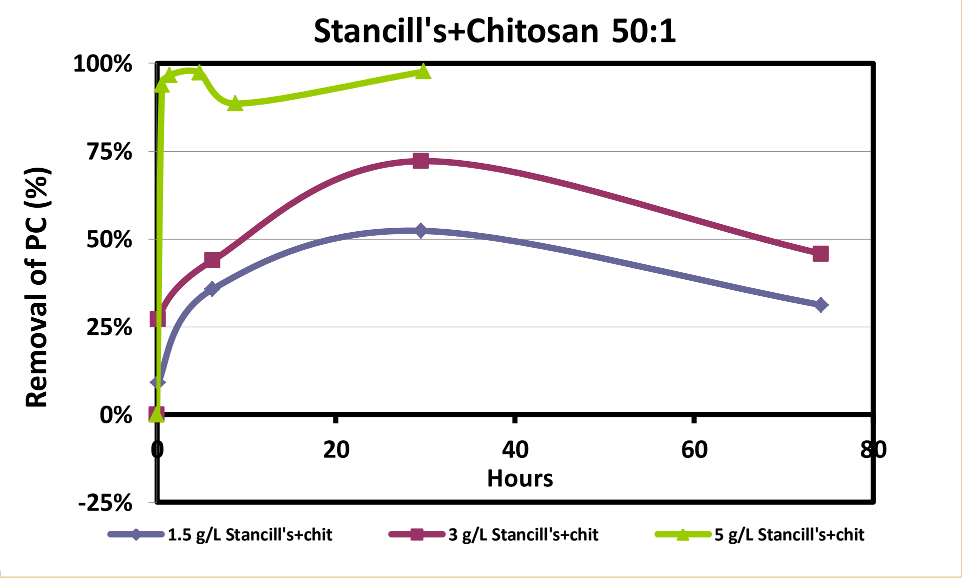




Stancill's Clay Flocculation of HMP Blooms

- To rapidly remove HMP cyanobacteria blooms, must add very high sediment & chitosan levels





Note: Near 100% & faster removal at [5 g Stancill's+0.15 g Chit/L] vs. SANDS+Chit

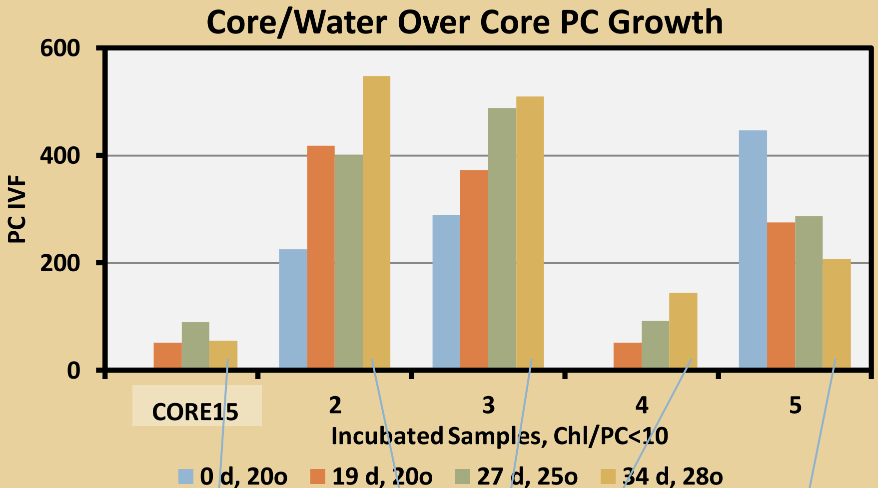
Summary Table of Flocculation Abilities for Field Blooms

SEDIMENT + CHITOSAN/L	t_{50} (h)
1.5 g <125 µm SAND + 0.03 g	6.9
3 g 125-250 µm SAND + 0.06 g	2
5 g <125 µm SAND + 0.15 g	0.98
5 g 125-250 µm SAND + 0.15 g	1.15
1.5 g STANCILL'S + 0.03 g	28.19
3 g STANCILL'S + 0.06 g	20.44
5 g STANCILL'S + 0.15 g	0.3
102 g STANCILL'S + 1.235 g to 4650 L*	0.16
All other lower concentrations of sediments with or without chitosan never removed 50% of bloom cyanobacteria t_{50} = time (h) to remove 50% of the field cyanobacteria bloom	

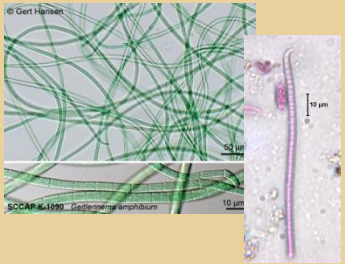
*October, low cyanobacteria abundance

Lake Draining+Barley Straw: Cyanobacteria from Cores

- Cyanobacteria bloom in 2011 with microcystin >10 ug/L
- Drained lake in fall, flushing bloom and sedimented vegetative populations out
- Exposed 2/3 of lake bottom for >5 months
- Deployed barley straw along lake shore in early spring
- Collected and incubated cores in May 2012, gradual inc to 28.5^{o}C
- For samples with chl/PC<10, collected samples for PP composition



Geitlerinema* *acutissimum



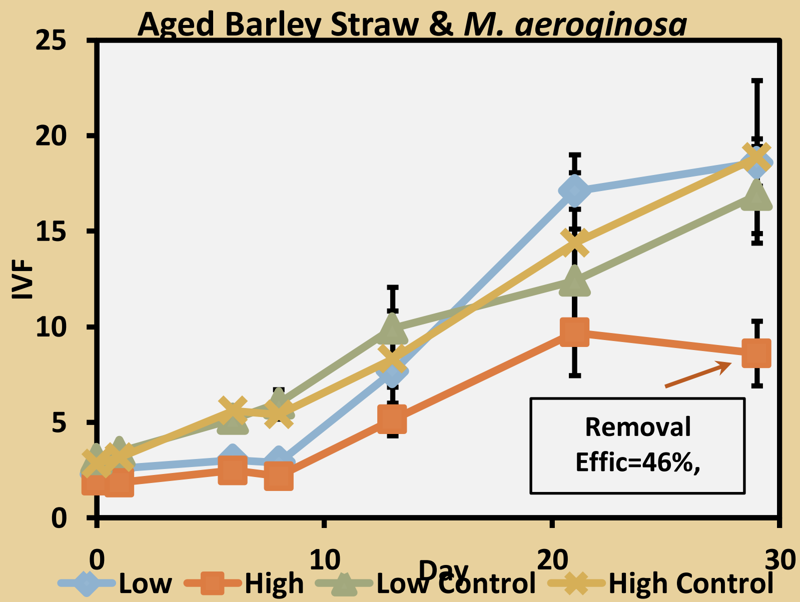
Pseudanabaena sp.

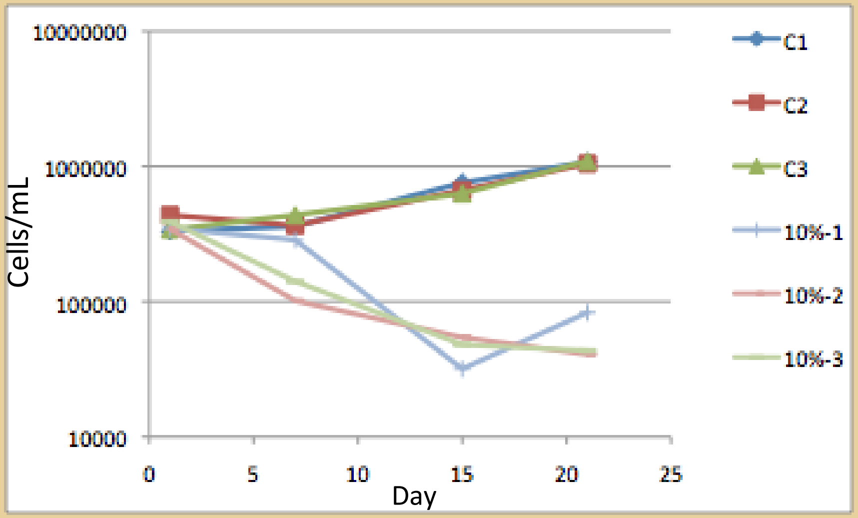
Synechococcus

RESULT: No *Microcystis* from cores or overlying water

Barley Straw & *M. aeruginosa*

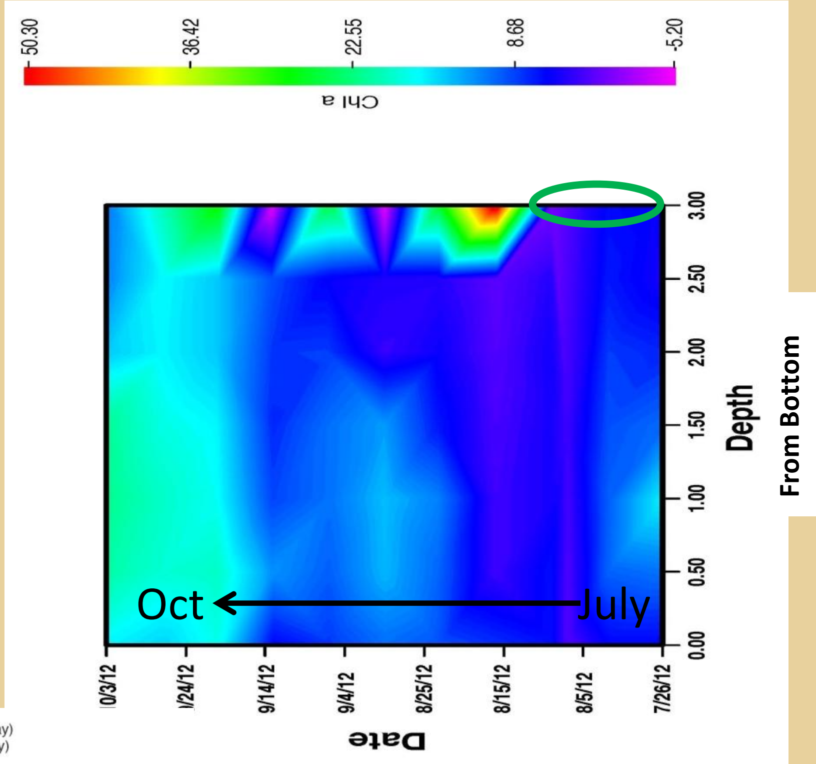
- Previous lab & field results have indicated barley straw effects on freshwater cyanobacteria
- *M. aeruginosa* LE3 + 4.5 & 9.1 g barley straw/L
- 46% reduction in *M. aeruginosa* over 29 d, with removal beginning at day 13
- Extract from water logged barley straw inhibited cultured *M. aeruginosa* growth on occasion
- Short half-life of extract

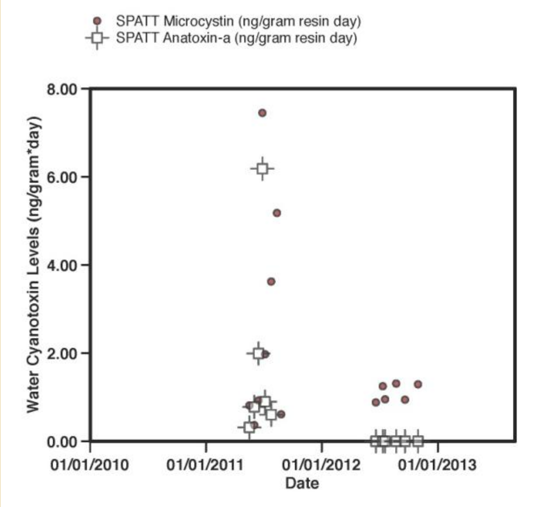




2012 Lake Draining + Barley Straw

- Absence of vegetative *Microcystis* in sediments
- Very late appearance of *M. aeruginosa*
- Low toxin levels





2013 Barley Straw

- Just begun barley straw bale deployments in
  - Lake Williston (yr 2)
  - 240 acre saline (S=11) pond on dredge material island in Chesapeake Bay
- Monitoring sediment & water column cyanobacteria & toxins

Future Research

- Large 4 m^3 lake limnocorral expts (before, during, late bloom)
- Chitosan additions, then sediment?
- Kill surface bloom, then flocculate+ballast
- Conduct ‘impacts’ assessments (fish, in- and epi-fauna)
- Assess lake draining/flushing effects
- Barely straw exposures in lake & saline pond: cyano growth & toxin production

- Hand-off effective, inexpensive strategies to state for routine use?

So Practical, Inexpensive Options for Freshwaters/Tidal-freshwaters?

- Little confidence in previously published clay flocculation results for freshwaters, i.e., any sediment + low chitosan can remove *Microcystis*
- Sediment additions effective in removing *Microcystis* in freshwaters are far above TSS levels permitted in loads allowed
- Increasing chitosan concentrations might work but then $$$ become an issue
- Lake draining & pre-bloom barley straw looks promising and are CHEAP!

Management in Future


LIFE

Lessons of Williston Lake

Girl Scouts swim again in clean lake water

Ultimately mitigation is a BAND-AID for much larger problem of nutrient load reductions

Need political will to manage land use to insure nutrient inputs decline

Acknowledgements

- *G. acutissimum*: http://nordicmicroalgae.org/taxon/Geitlerinema%20amphibiium; F. Acker, ANSP
- *Pseudanabaena*: http://enpub.fulton.asu.edu/pwest/myweb/Taste%20and%20Odor%20Stuff/Taxonomic%20guide/Guide_Images/Pseudanabaena_2_photos.html
- *Synechococcus*: http://protist.i.hosei.ac.jp/pdb/images/Prokaryotes/Chroococcaceae/Synechococcus/index.html
- Stancill's = kaolinite, illite, and some quartz (D. Vanko, pers. comm.)