

# MMIC (Mitigating Microcystis in the Chesapeake)

## Treatment Options For A Cyanotoxin Impacted Lake in Denton Maryland

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US EPA ARCHIVE DOCUMENT



# Algae bloom shuts down lake

By DANIEL DIVILIO Staff Writer | Posted Aug 3, 2011

DENTON An algae bloom has shut down Lake Williston a private lake off state Route 16 near Denton and owned by the Girl Scouts for two summers in a row and officials are trying to find a way to rid the water of the toxic organisms.

The Caroline County Health Department issued earlier this summer water contact advisories for Lake Williston, noting the presence of unhealthy levels of microcystis caused by the blue-green algae bloom. The lake, which covers about 60 acres and has an average depth of 8 feet, also closed late last summer due to the algae.

Health Department officials are warning people not to swim in or drink the lake water and to keep pets and livestock away from it as well. If contact is made with the water at Lake Williston, health department officials recommend cleaning off with fresh water and seeing a health care professional if any skin irritation occurs.

"It's a pretty serious problem," said Bob Foote, property manager for the Girl Scouts camp located on Lake Williston, on July 25.



**WARNING**

**TOXIC ALGAE PRESENT**  
Lake unsafe for people and pets

Until further notice:

- **Do not swim or water ski.**  
No nada ni flequea al esquí en el lago
- **Do not drink lake water.**  
No beba el agua del lago
- **Keep pets and livestock away.**  
Animales domésticos y ganado de la substancia lejos
- **Clean fish well and discard guts.**  
Limpie los pescados bien y desecha la tripa
- **Avoid areas of scum when boating.**  
Evite las áreas de la espuma cuando canotea

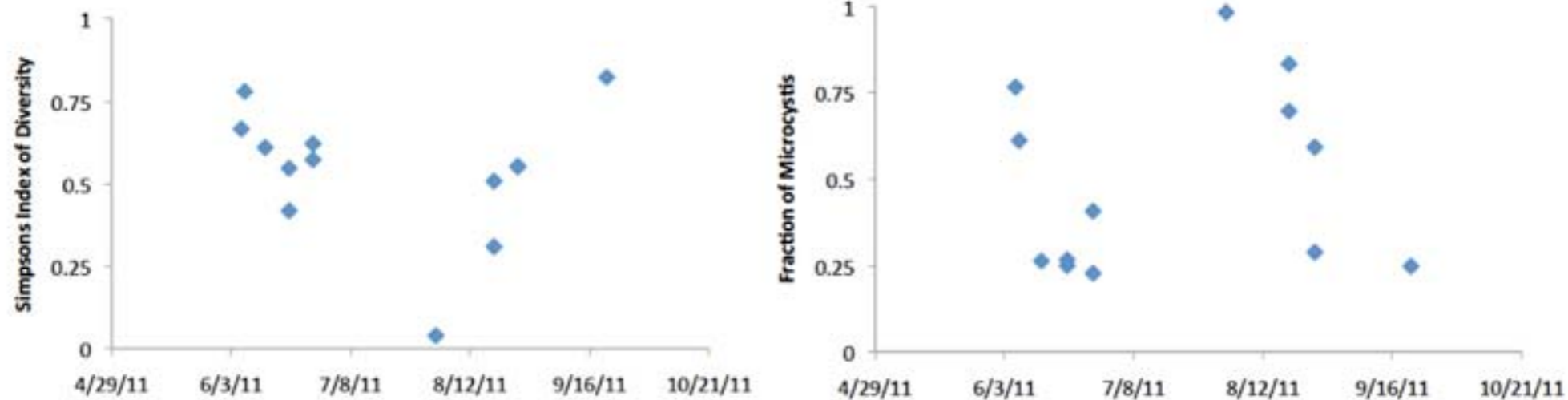
Call your doctor or veterinarian if you or your animals have sudden or unexplained sickness or signs of poisoning.

Call your local health department: **360-407-6000**

Report any algae blooms to Department of Ecology: **360-407-6000**

For more information: [www.doh.wa.gov/ehp/vigilance/health](http://www.doh.wa.gov/ehp/vigilance/health)  
[www.ecy.wa.gov/programs/water/algae/index.html](http://www.ecy.wa.gov/programs/water/algae/index.html)

# Species Composition



Simpson's Index of Diversity indicates infinite diversity of a value of 1.

Williston Lake is dominated by *Anabaena* species throughout June, while *Microcystis* species dominated August.

6/6/11



- Anabaena planctonica
- Aphanizomenon flos-aquae
- Cuspidothrix issatschenkoii
- Microcystis aeruginosa

6/7/11



- Anabaena planctonica
- Aphanizomenon flos-aquae
- Cuspidothrix issatschenkoii
- Microcystis aeruginosa
- Microcystis flos-aquae

6/13/11



- Anabaena planctonica
- Aphanocapsa
- Microcystis wesenbergii

6/20/11



- Anabaena planctonica
- Microcystis aeruginosa
- Microcystis wesenbergii

6/27/11



- Anabaena
- Anabaena planctonica
- Microcystis aeruginosa

8/2/11



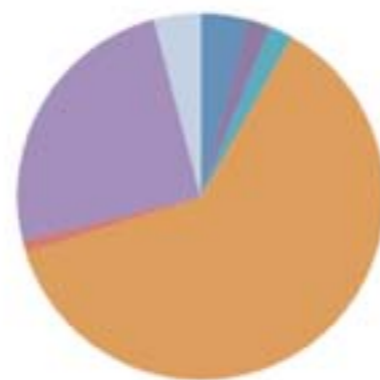
- Anabaena flos-aquae
- Aphanizomenon flos-aquae
- Chroococcus
- Microcystis aeruginosa

8/19/11



- Anabaena planctonica
- Aphanizomenon flos-aquae
- Cuspidothrix issatschenkoii
- Aphanocapsa
- Cylindrospermopsis

8/26/11



- Anabaena
- Aphanizomenon flos-aquae
- Cuspidothrix issatschenkoii
- Aphanocapsa

## Species Distribution in Williston Lake Beach



Indicates high anatoxin-a levels

# Sampling Sites



# The Problem Nutrients

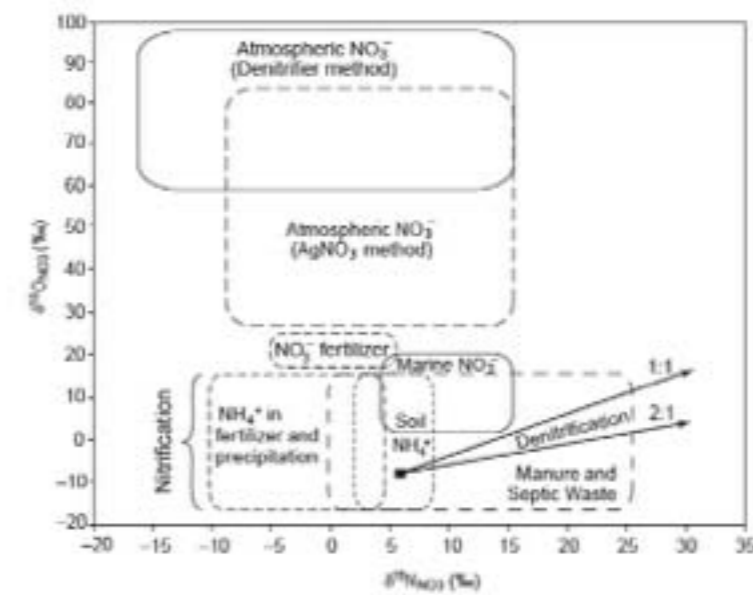
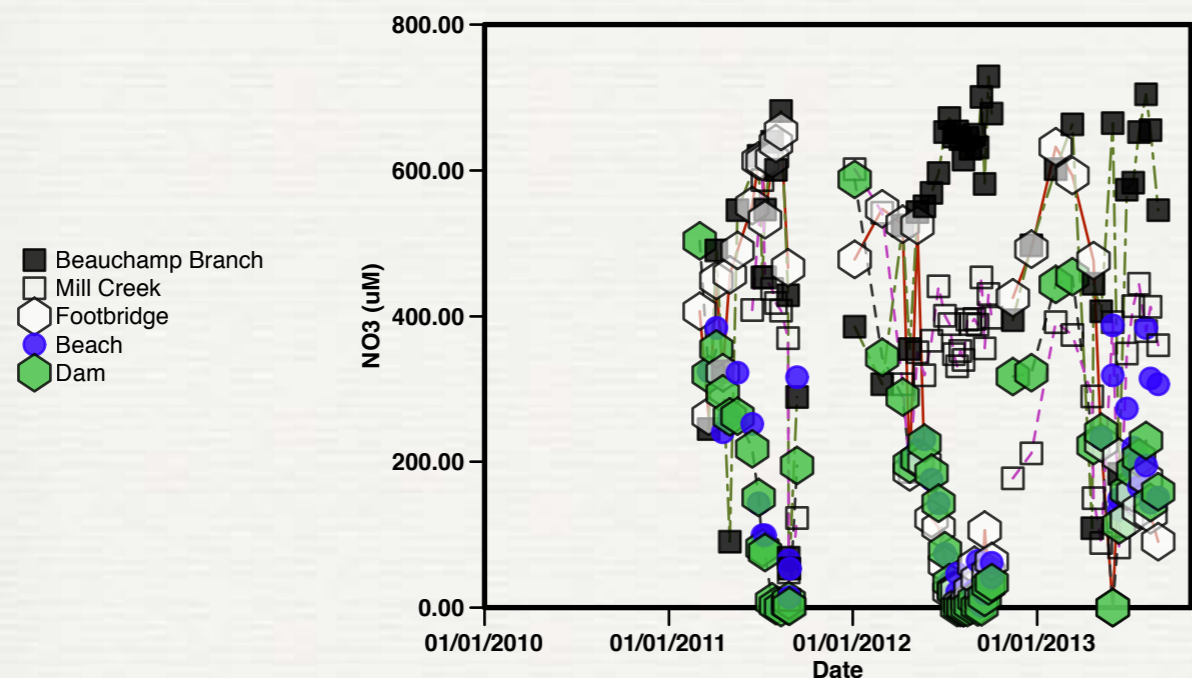
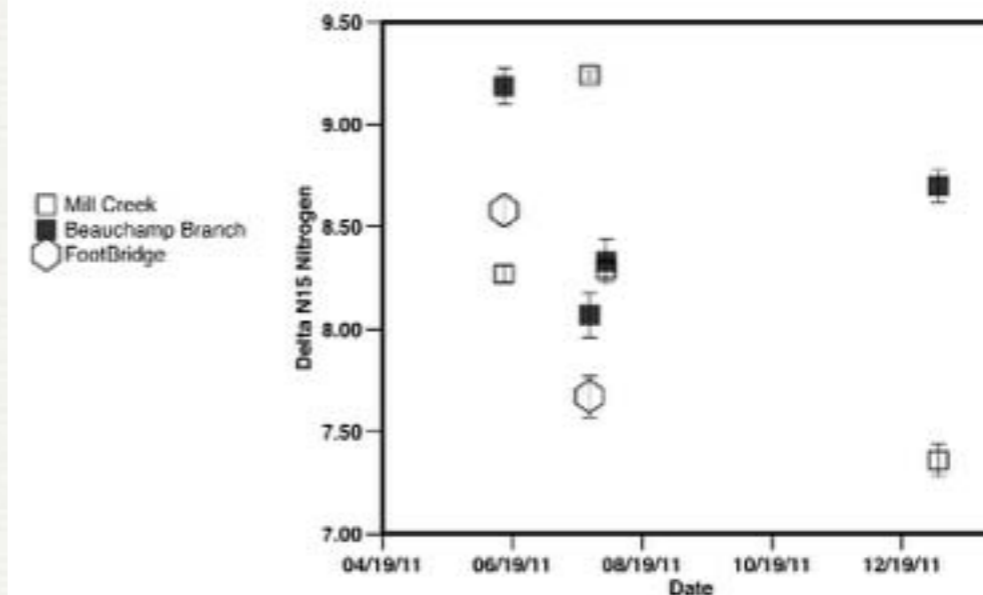
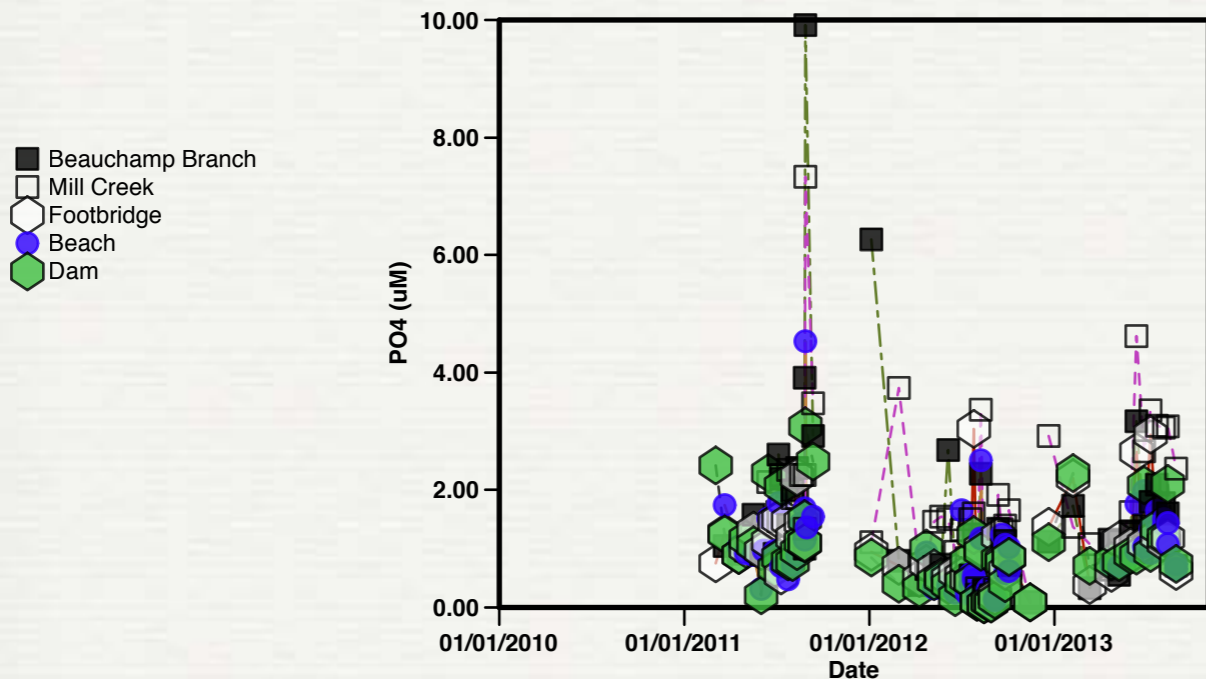


Figure 12.1 Typical values of  $\delta^{15}N$  and  $\delta^{18}O$  of nitrate derived or nitrified from various N sources. Atmospheric  $\delta^{18}O_{NO_3}$  data are divided into the ranges observed for samples analyzed using the denitrifier and  $AgNO_3$  (non-denitrifier) methods. The two arrows indicate typical expected slopes for data resulting from denitrification of nitrate with initial  $\delta^{15}N = +6$ ‰ and  $\delta^{18}O = -9$ ‰. The typical ranges of  $\delta^{18}O_{NO_3}$  values produced by nitrification of ammonium and organic matter are denoted by "nitrification".

# The Problem

## Not New

152

Coastal Lagoons: Critical Habitats of Environmental Change

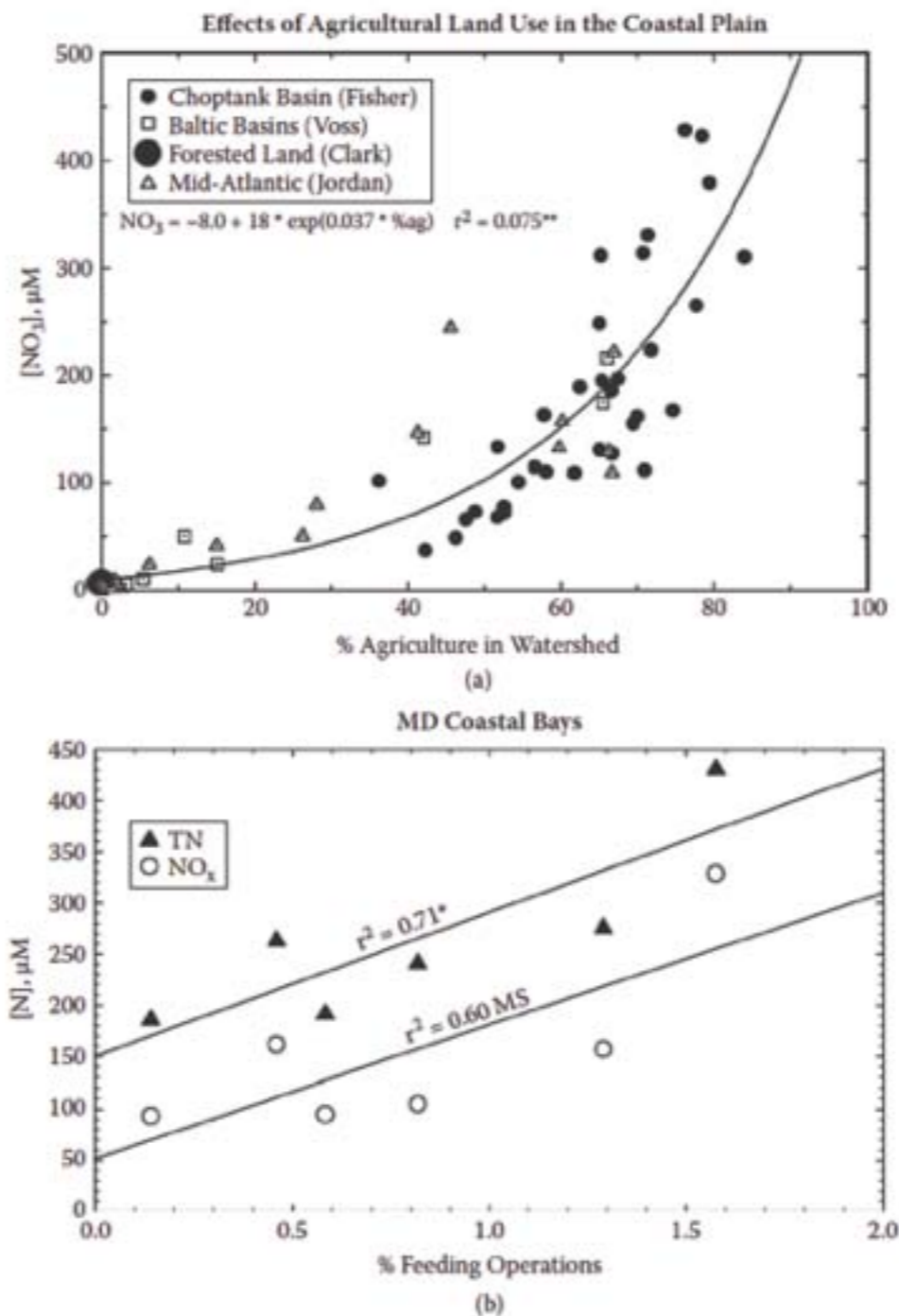


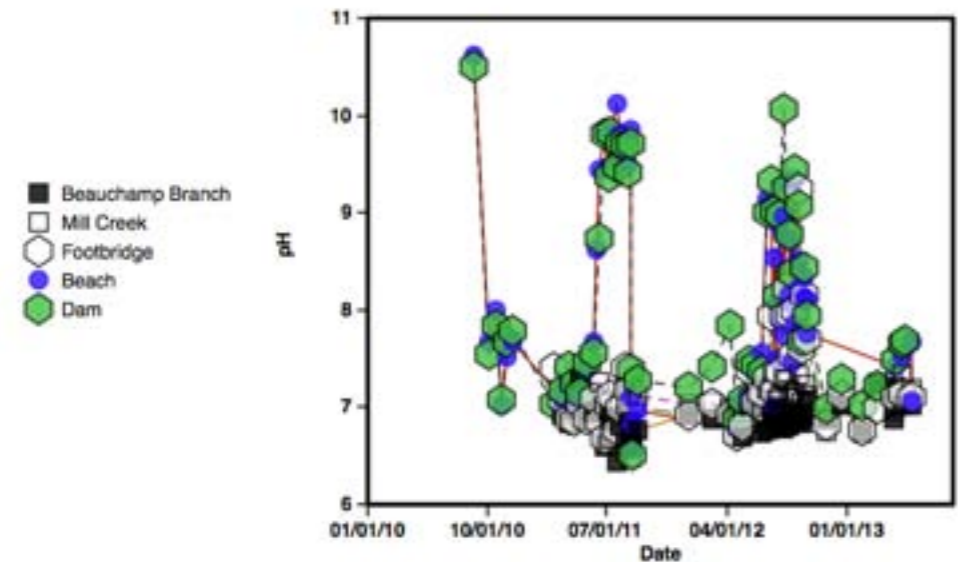
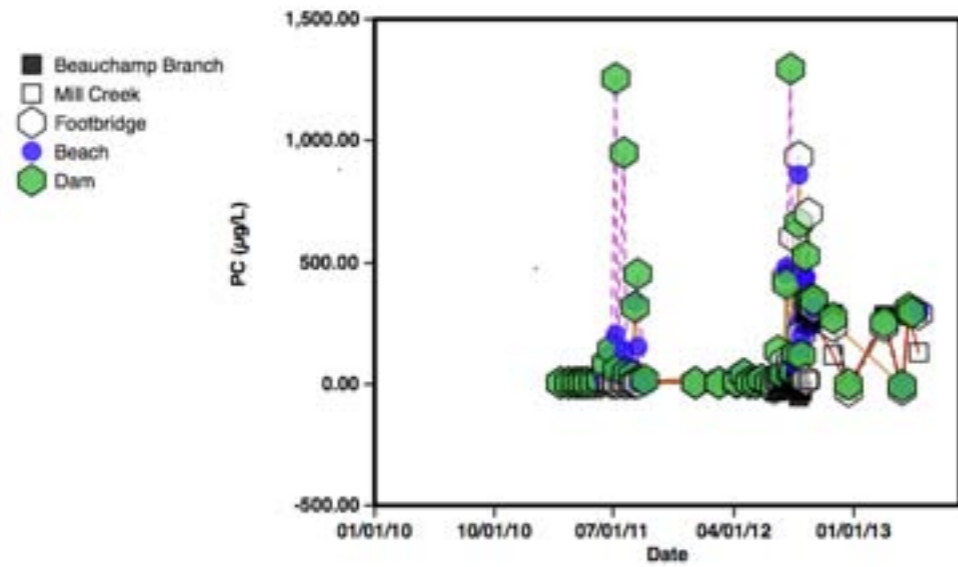
FIGURE 7.8 (a) Effects of percent agriculture (cropland) on nitrate concentrations  $[NO_3^-]$  in coastal plain watersheds. The exponential curve was forced through the extensive summary by Clark et al. (2000) on forested lands (= 0% agriculture). (b) Effects of animal feeding operations on average stream N in the St. Martin Basin in the Maryland coastal bays (Beckert 2008). The correlation with TN is significant, whereas the nitrate correlation is marginally significant ( $p = 0.07$  and not significant for ammonium ( $p > 0.10$ )).

# The Problem

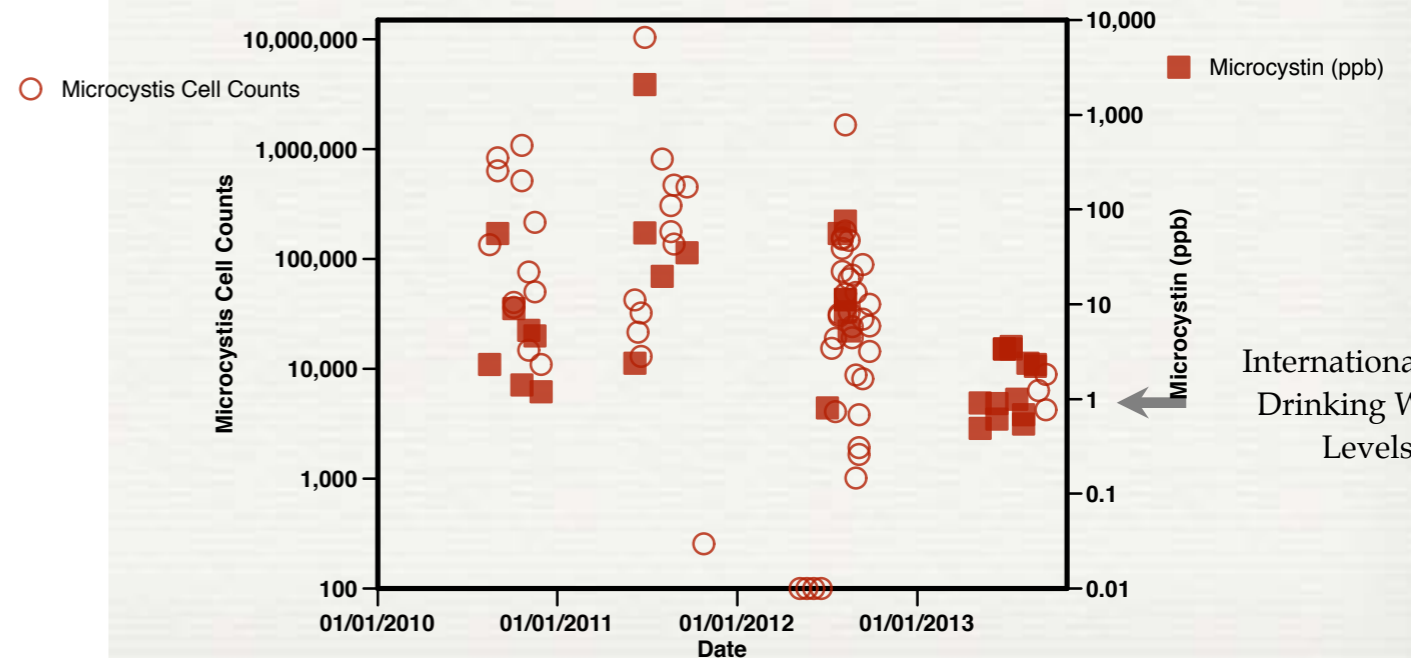
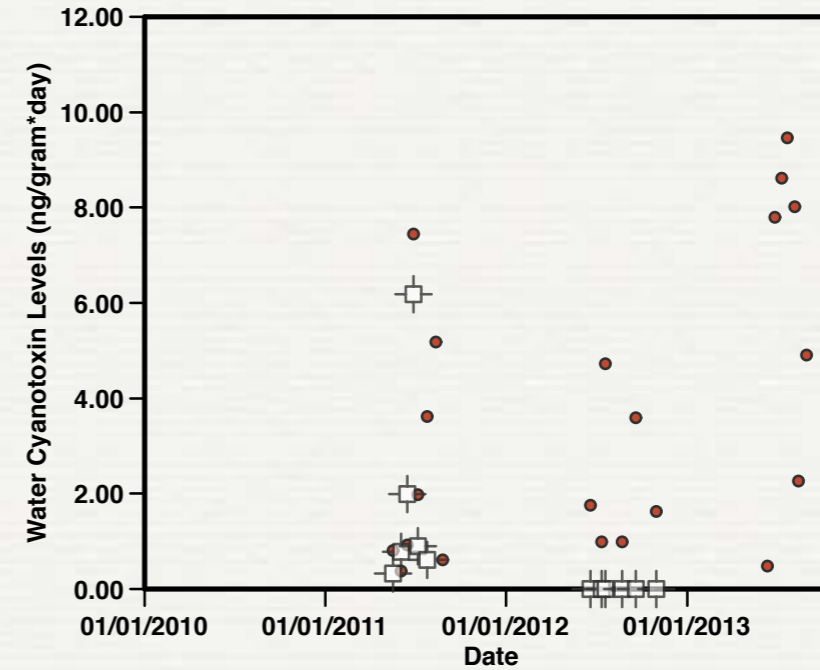
## Algae and Cyanotoxins



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● SPATT Microcystin (ng/gram resin day)  
 □ SPATT Anatoxin-a (ng/gram resin day)





# Lake Williston

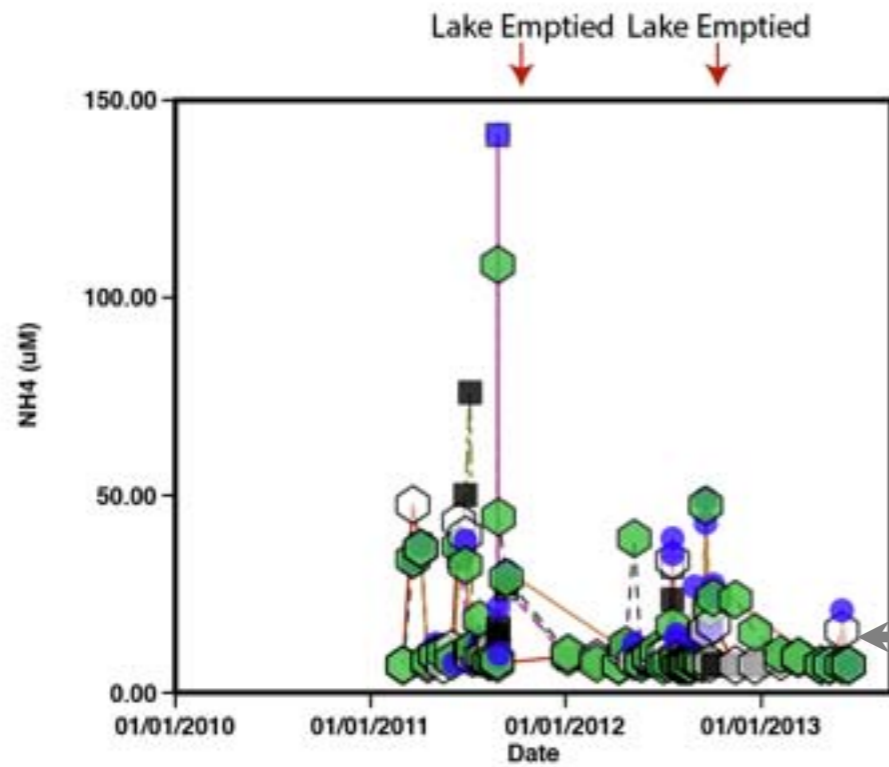
Girl Scout Camp  
Operated Since 1935



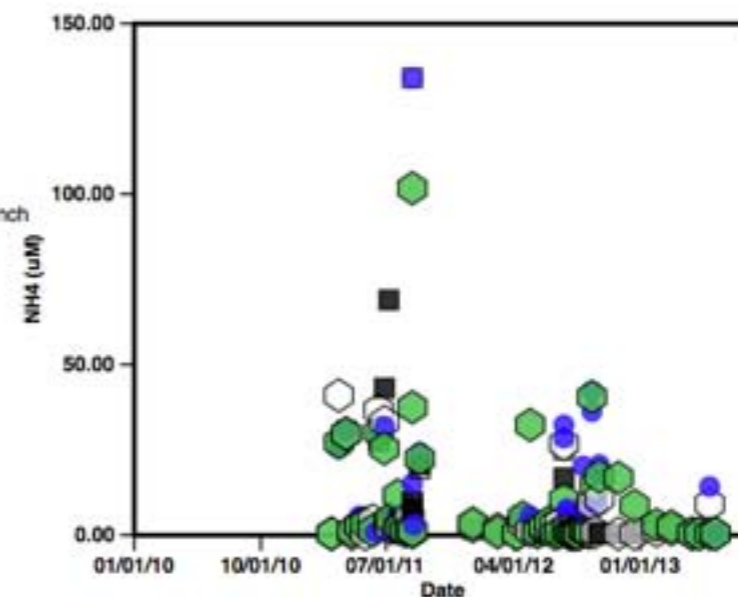
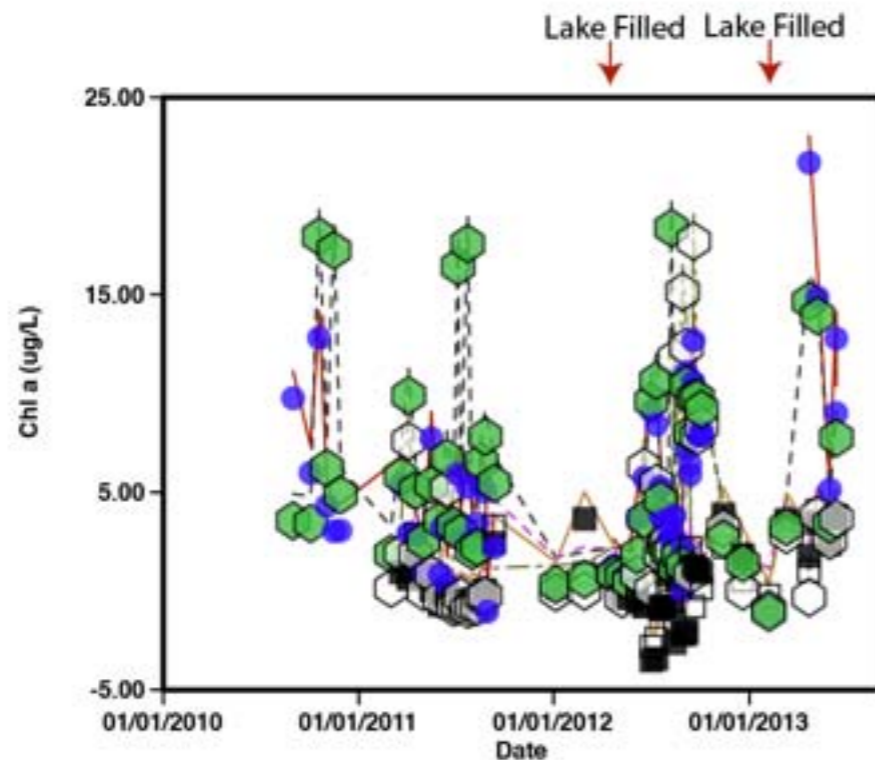
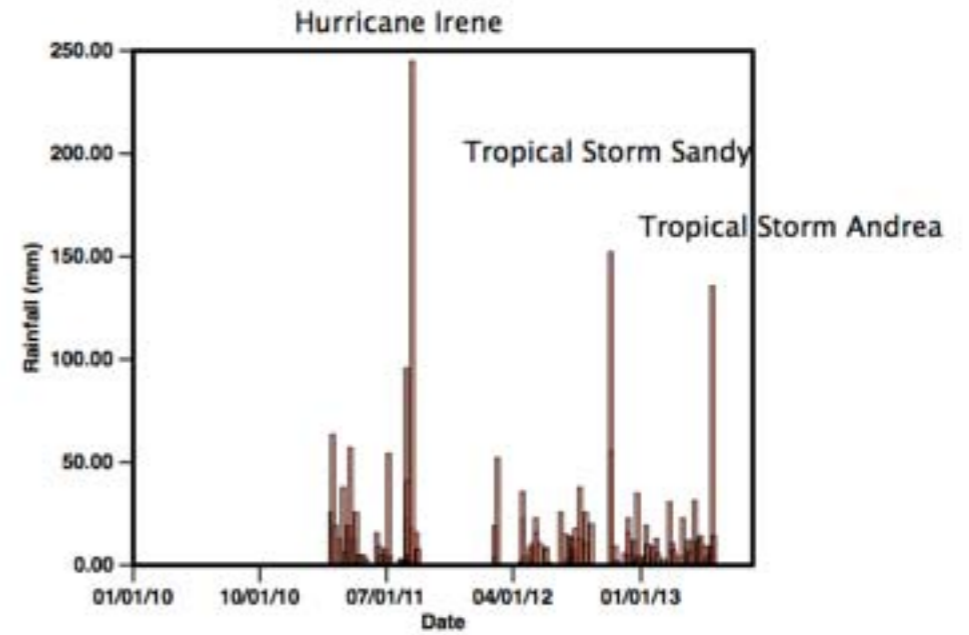
Lake Williston  
May 30, 2012

# The Solution Part 1

## Hydraulic Flushing



Current Baltimore Harbor Values



# Drain the Lake

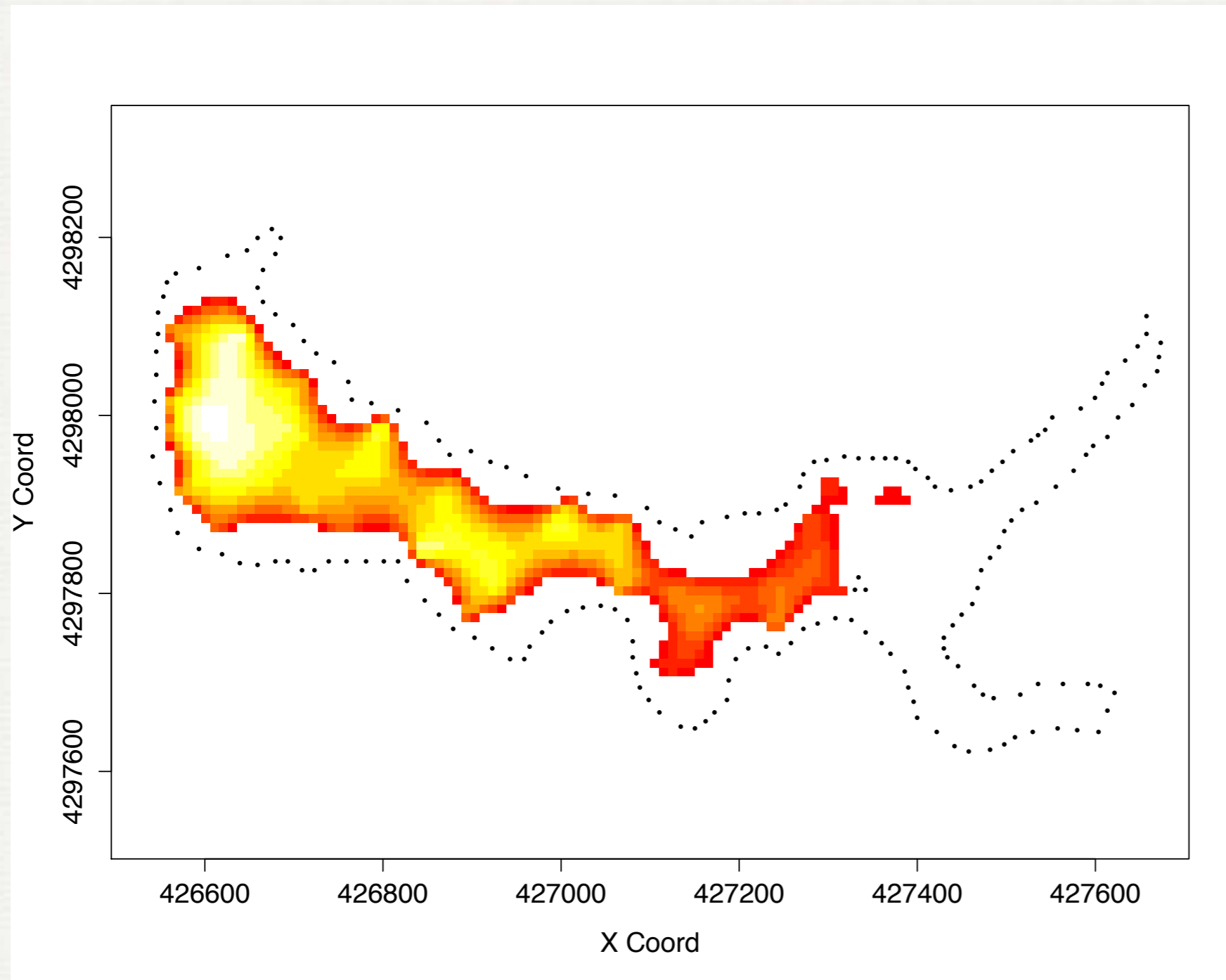


September 12, 2011



February 28, 2012

# Drain the Lake



Initial Volume  
464,297 m<sup>3</sup>

Drained Volume  
98,234 m<sup>3</sup>

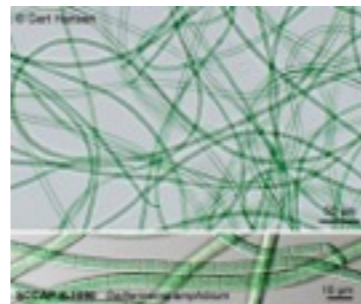
79.8 % Volume Reduction

# Cyanobacteria from Cores

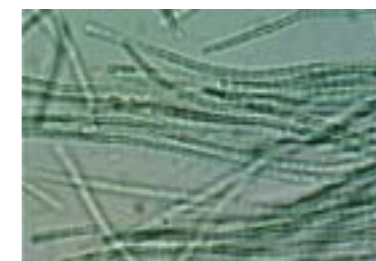
- Cores from littoral zone of refilled lake, May 2012
- Water over core transferred to tubes and incubated L and D in windowsill
- Added 100 mL filtered lake water into each core and placed in windowsill
- Read IVF of overlying water and tubes after 19 d (20°C)
- Transferred to 25°C and read IVF after 8 d
- Increased to 28.5°C and after 7 d read IVF and removed samples for PP counts/IDs for samples with Chl/PC <10



*Geitlerinema acutissimum*



*Pseudanabaena* sp.



*Synechococcus*



**RESULT: No Microcystis from cores or overlying water**

# Refill the Lake



April 24, 2012



May 8 2012

# Allow Grasses to Regrow



April 9, 2012



April 9, 2012

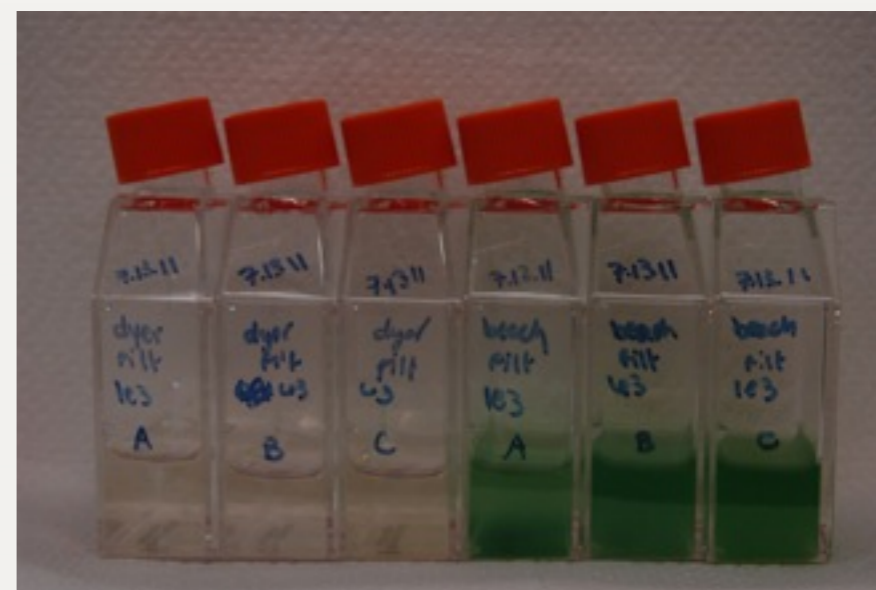
# Repeat The Process

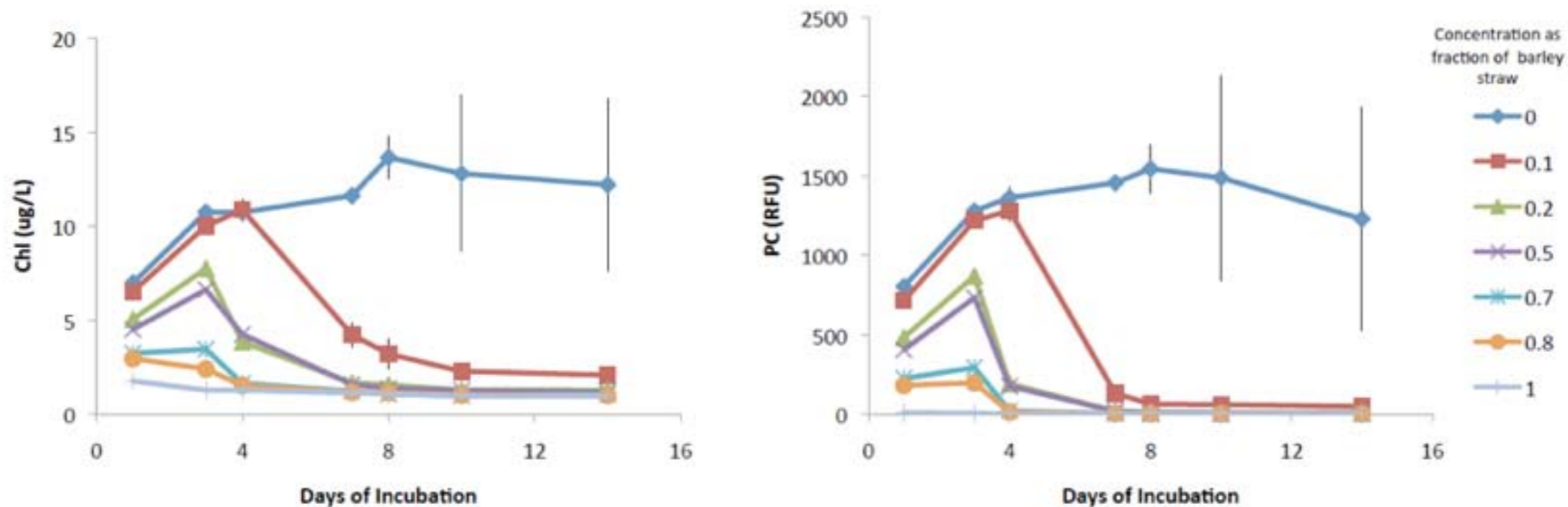




# The Solution Part 2

## Barley Straw





Varying concentrations of barley straw dosage were set up in the lab to replicate last experiment using filtered pond water and unfiltered lake water as inoculum.

	<u>pH</u>	<u>NH<sub>4</sub><sup>+</sup> (µM)</u>	<u>NO<sub>2</sub><sup>-</sup> (µM)</u>	<u>PO<sub>4</sub> (µM)</u>	<u>NO<sub>3</sub> (µM)</u>
0	7.02	0.449	0.587	1.864	417.870
0.1	7.04	0.959	0.824	1.763	380.131
0.2	7.07	1.468	1.061	1.661	342.392
0.5	7.14	2.996	1.772	1.358	229.175
0.7	7.19	4.015	2.245	1.156	153.697
0.8	7.21	4.525	2.482	1.055	115.958
1	7.26	5.544	2.956	0.853	40.481

## Algal growth control by a barley straw extract

Andrew S. Ball \*, Matthew Williams, David Vincent, James Robinson

*Department of Biological Sciences, John Tabor Laboratories, University of Essex, Wivenhoe Park, Colchester, Essex CO4 3SQ, UK*

Received 2 August 2000; received in revised form 4 September 2000; accepted 14 September 2000

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Journal of Fisheries and Aquatic Science 5 (5): 394–401, 2010

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### **The Use of Barley Straw for Controlling of Cyanobacteria Under Field Application**

<sup>1</sup>H. Rajabi, <sup>2</sup>Y. Filizadeh, <sup>3</sup>M. Soltani and <sup>2</sup>M.H. Fotokian

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University of Tehran, Tehran, Iran

J Appl Phycol (2009) 21:333–340

DOI 10.1007/s10811-008-9373-x

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### **Chemical characterization of the aqueous algistatic fraction of barley straw (*Hordeum vulgare*) inhibiting *Microcystis aeruginosa***

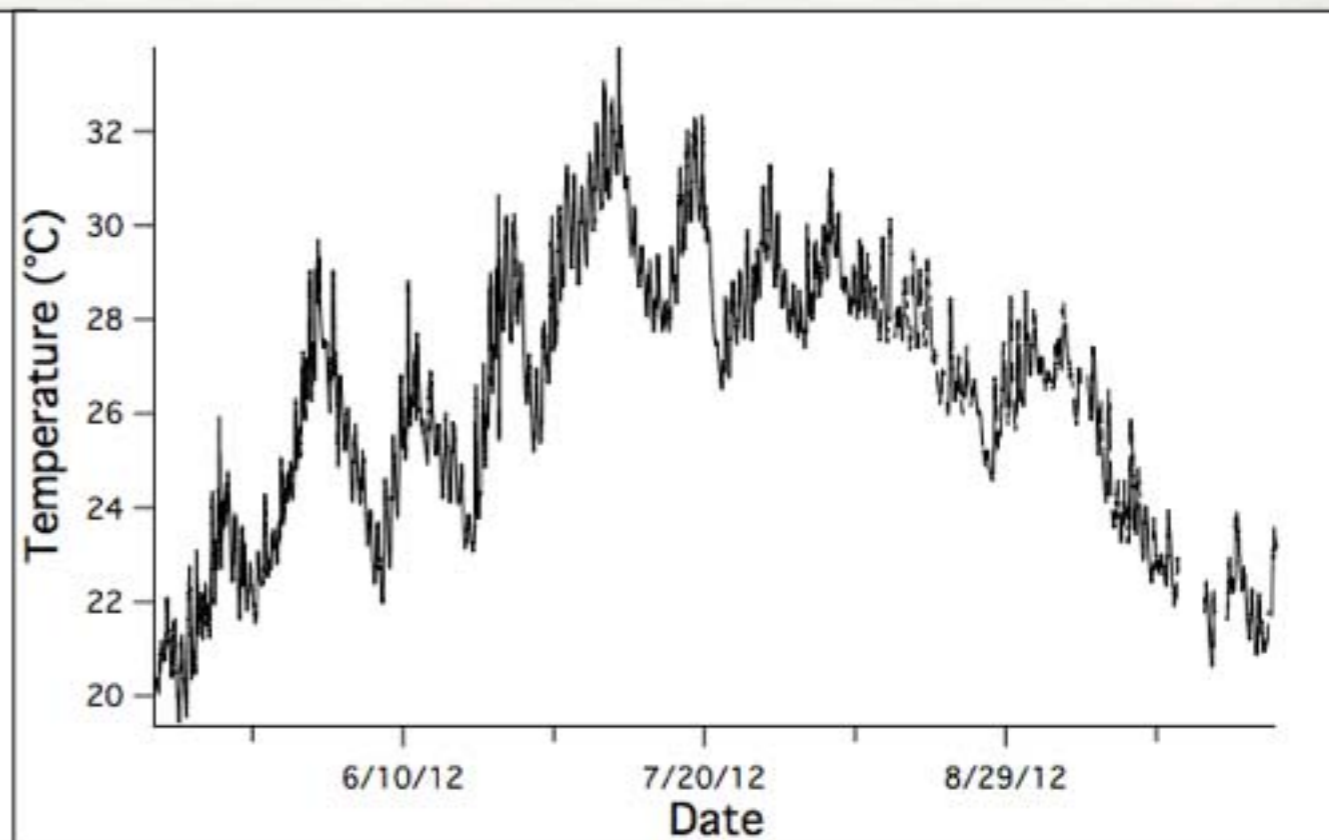
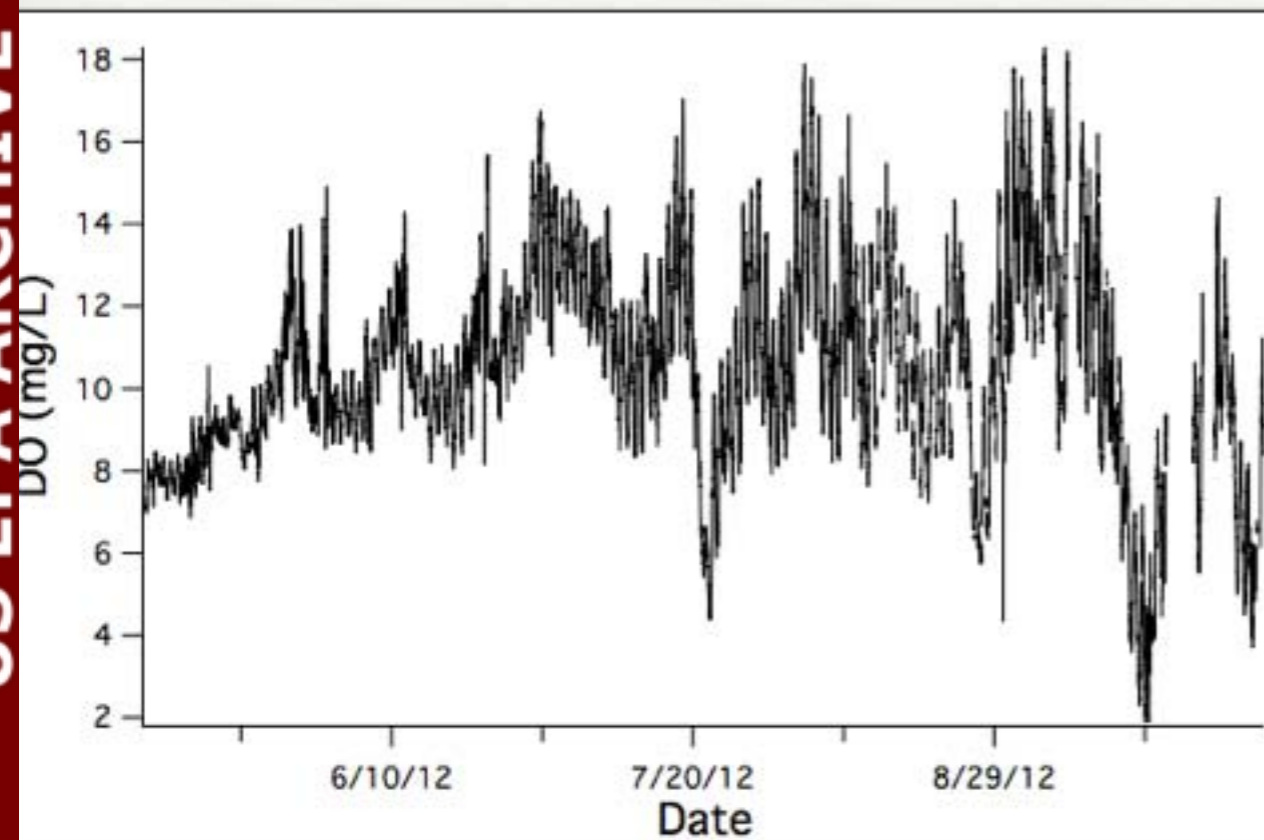
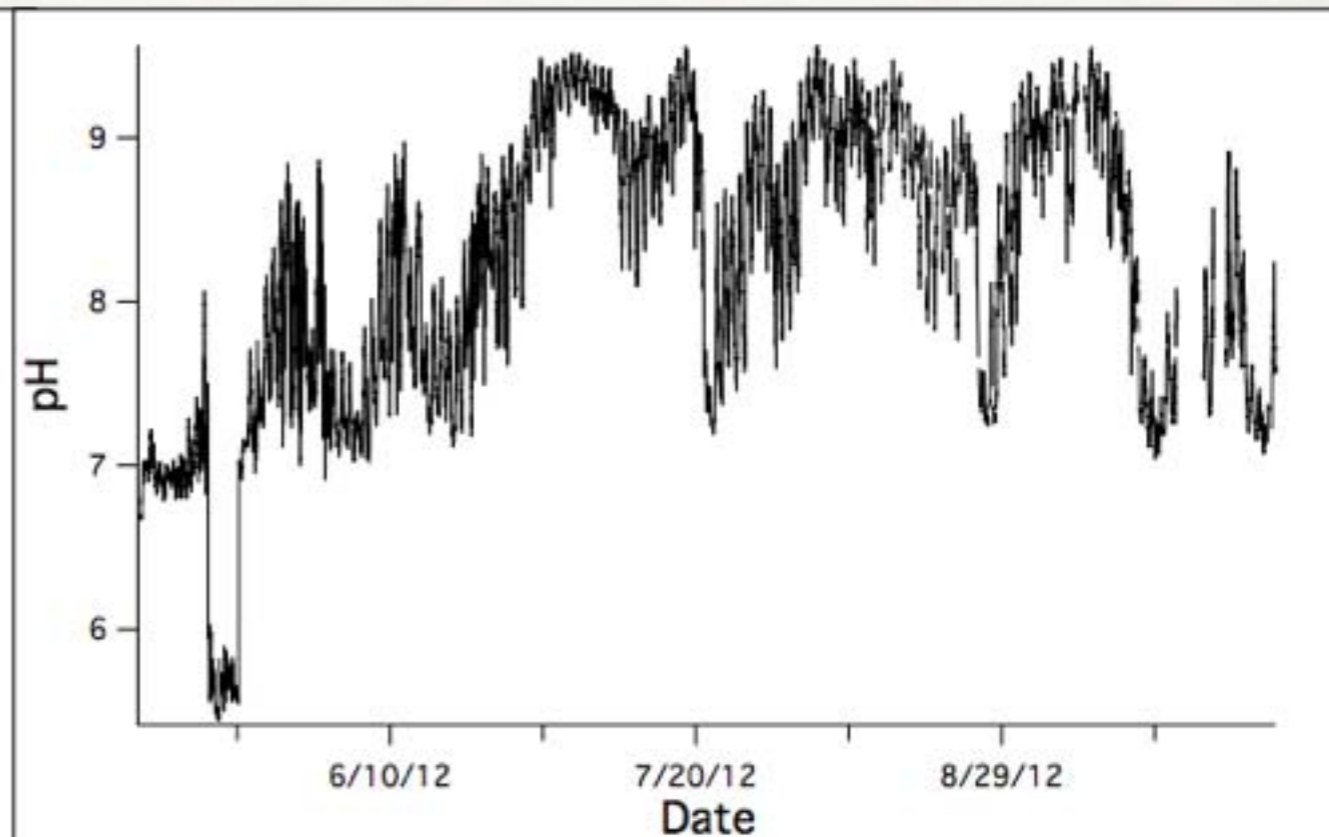
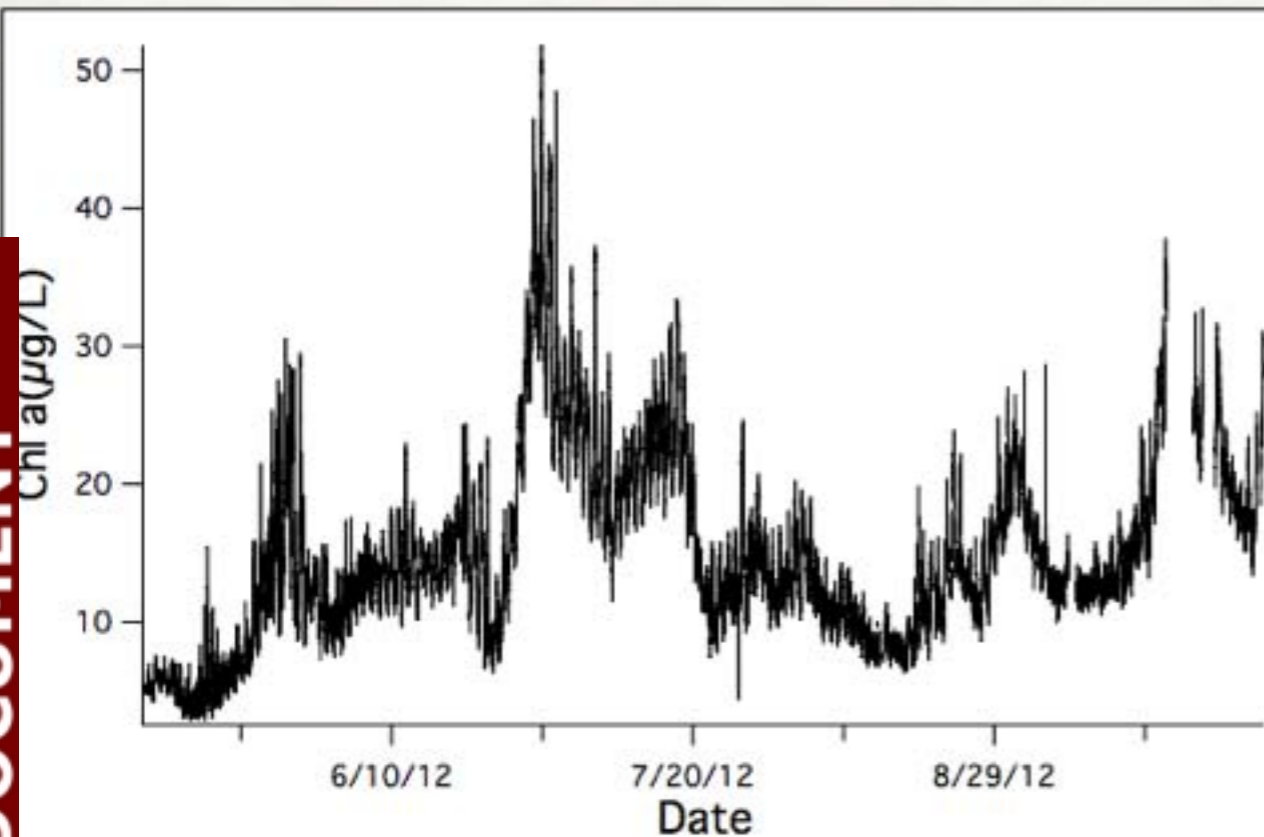
Timothy J. Waybright • Daniel E. Terlizzi •  
M. Drew Ferrier

# Deploy Barley Straw Bales



# DNR YSI Continuous

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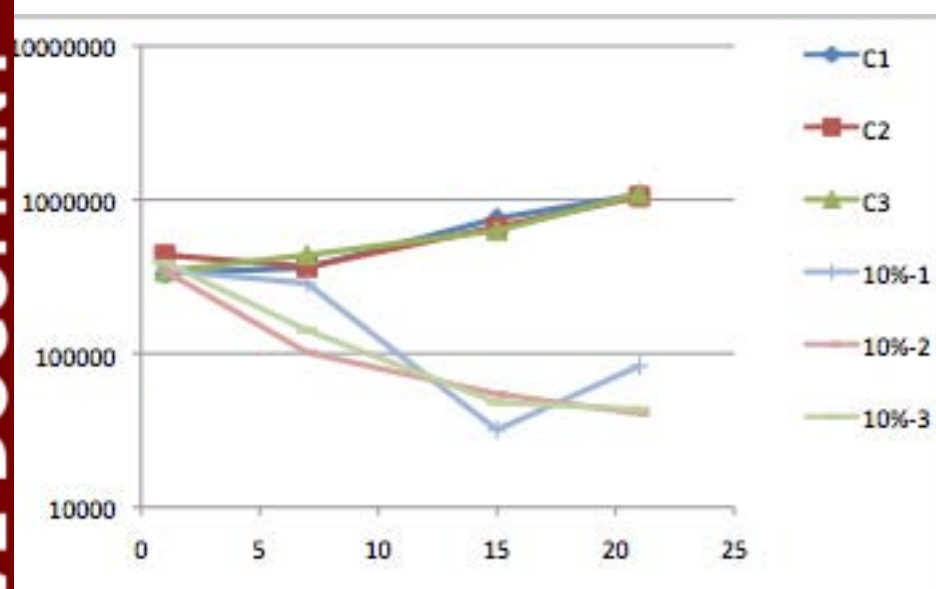
# Sampling Locations

- Within 20 centimeters of the barley bales deployed in the South stream of the Williston Lake footbridge



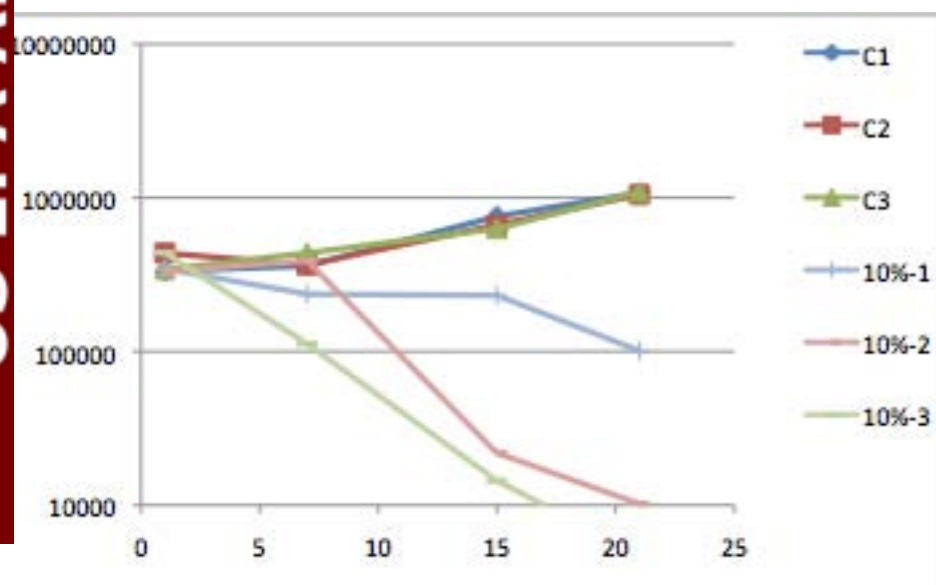
# Williston footbridge late season

8/15/12

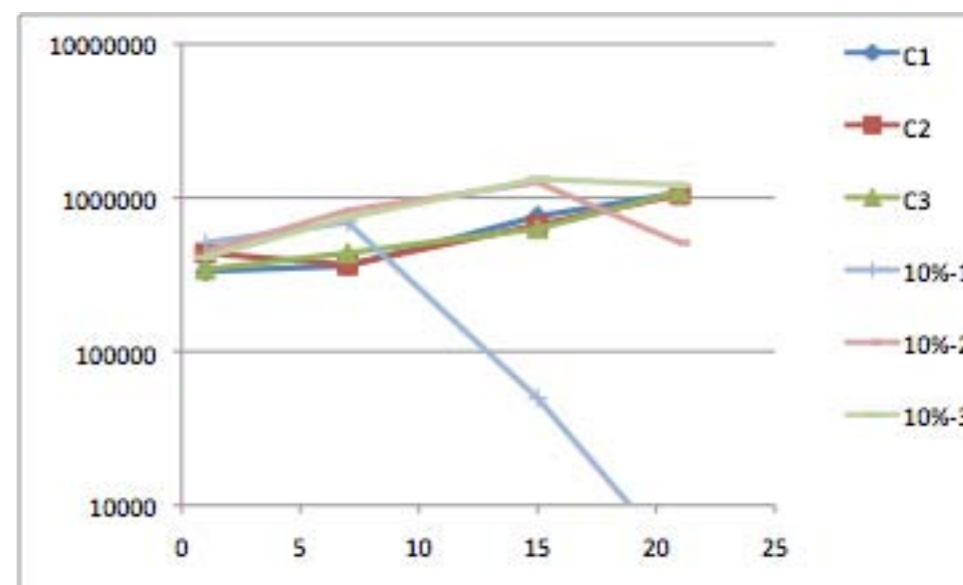


Activity of the footbridge barley water was evident through August and decreased in September.

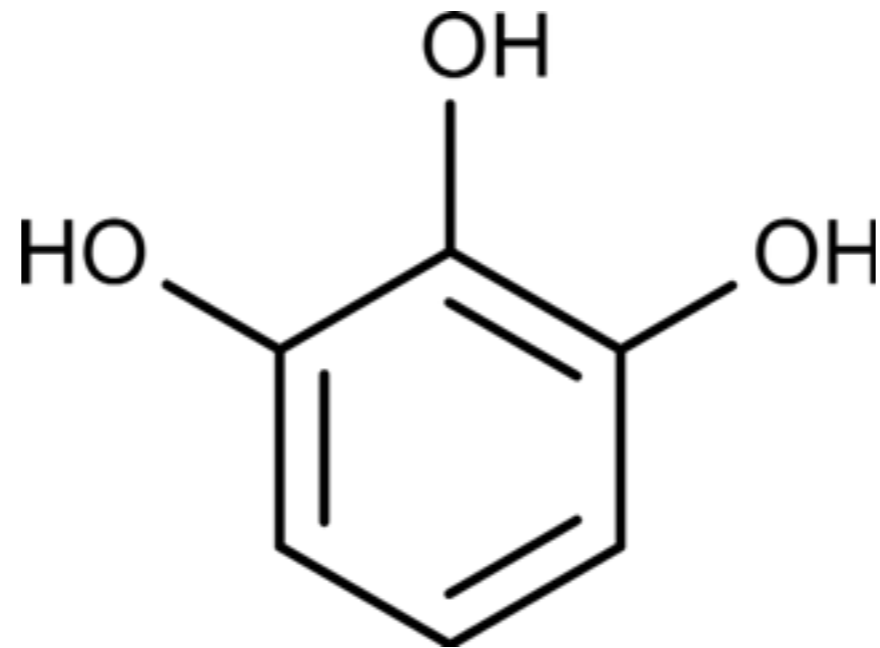
8/29/12



9/6/12



# Pyrogallol- a potential barley straw breakdown product for direct treatment



- Has been shown to up-regulate expression of several antioxidant and stress genes.
- The most linear correlation was observed with the peroxiredoxin gene.

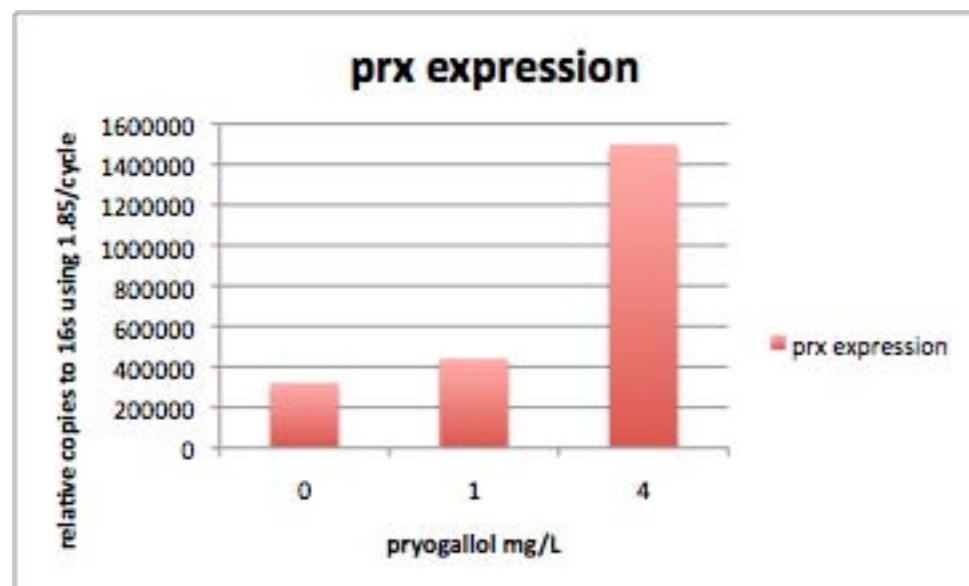


# Treatment of *M. aeruginosa* with pyrogallol

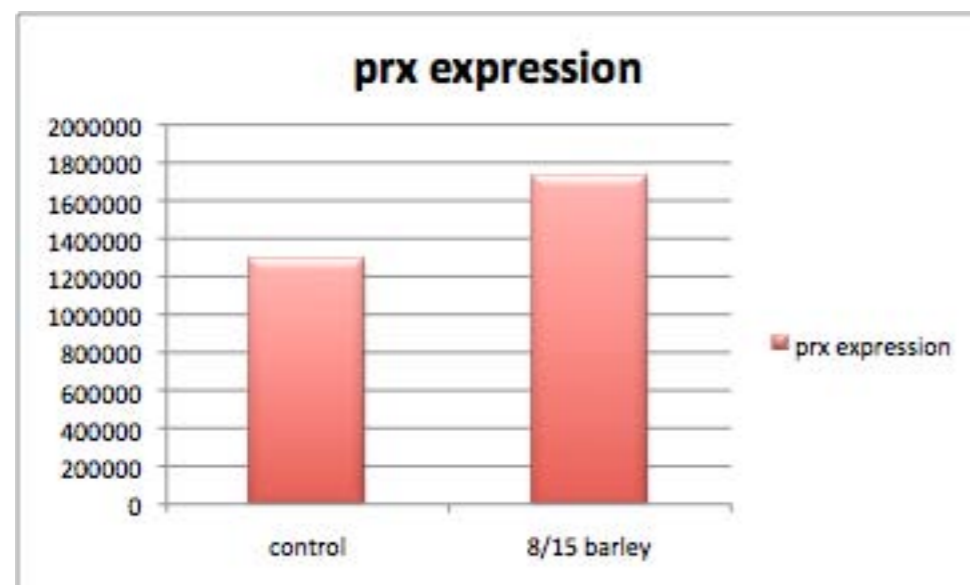
- Cultures of *M. aeruginosa* Le3 were treated with 0, 1, and 4 mg/L pyrogallol overnight.
- RNA was extracted and reverse transcribed
- qPCR was used to determine relative expression of the peroxiredoxin gene normalized to 16s

# They were telling the truth

The results of Shao *et al.* 2009 were confirmed. However, the treated cultures were maintained for 8 days and no decrease in cell count was observed at these concentrations. Thus, the results of Nakai *et al.* 2000 were not confirmed.

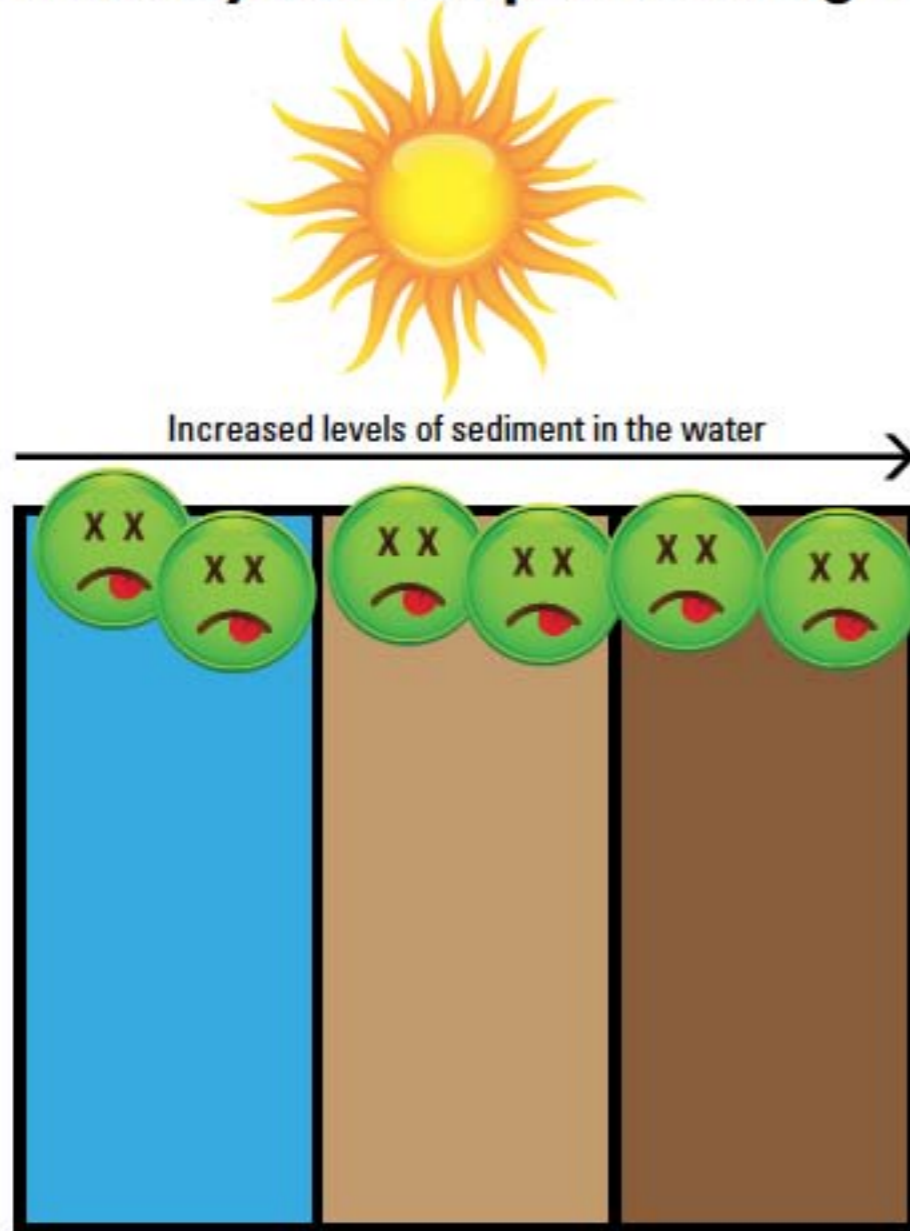


# Expression of peroxiredoxin following treatment with barley straw water

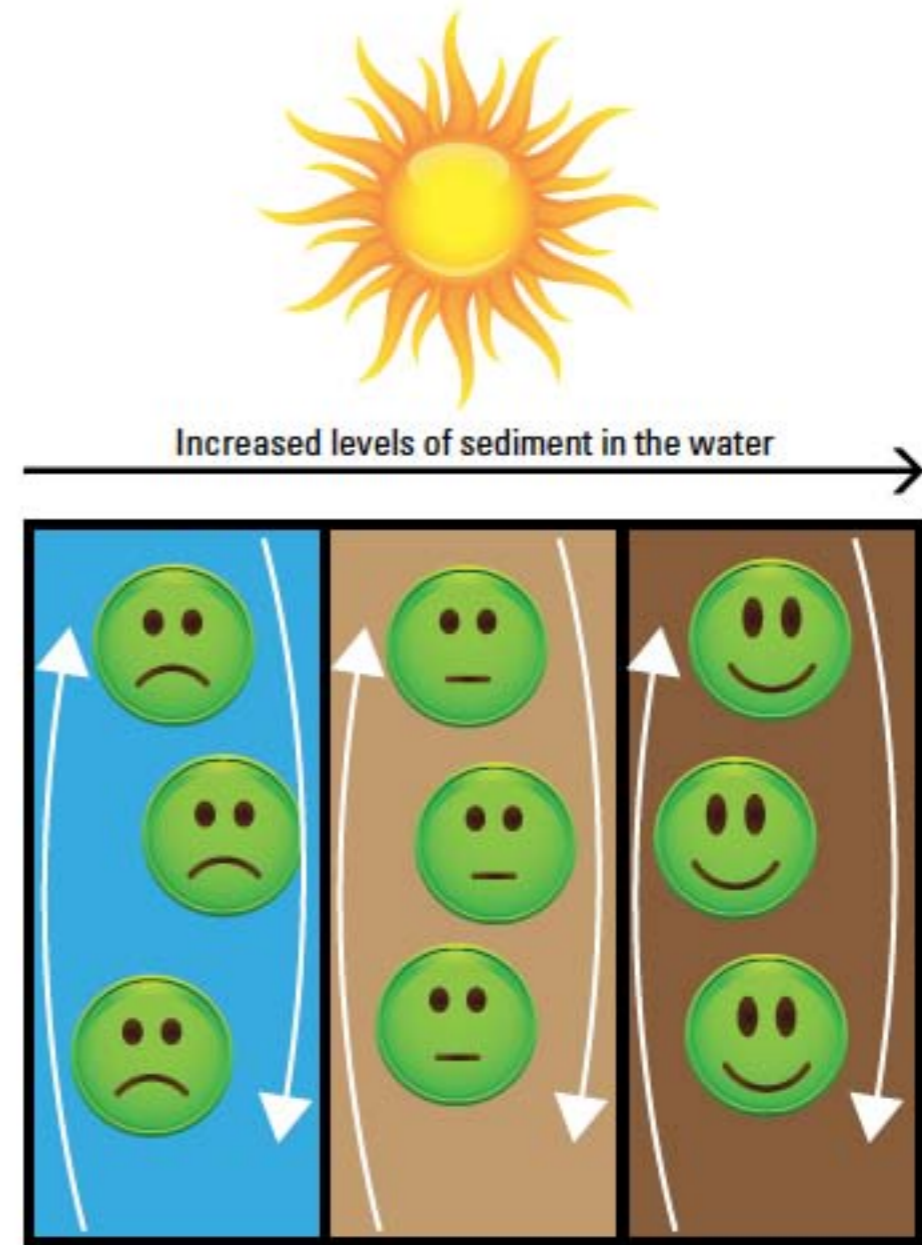


Treatment using barley straw water collected on 8/15 from the Williston Lake footbridge showed a slight increase in prx expression. Similar to the 1mg/L exposure of pyrogallol

## *Microcystis*' Response to Light



**Figure A** – *Microcystis* is damaged on calm, sunny days when they float on the surface of the water



**Figure B** – Sediment protects *Microcystis* when the lake is mixing

Bright, direct sunlight in calm water can actually damage *Microcystis*, even if the water is muddy, because of its tendency to float on the water's surface (Figure A). However, when the water is filled with sediment and breezes mix the water column, muddiness acts as a protective shield, helping the *Microcystis* to thrive (Figure B).

# Can we enhance the Activity?

- Performed controlled extracts of Barley straw at defined temperatures and light incidents.
- Compared nutrient content to the inhibitory effects of barley straw in stagnant conditions long term.
- Test the white rot fungus on it's ability to enhance the release of inhibitory compounds from barley straw.
- Test combinations of barley breakdown products to maximize inhibition.

# White Rot Fungus

*Trametes versicolor* and *C. subvermispora*

Optimum Temperature 20-28°C



# Inoculation of Barley Bales



# Results from White Rot Inoculation

- 10 fold higher production of inhibitory activity with inoculation
- Bales need to be in open sunny areas to keep the bale temperature above 25°C
- Will the same effect be evident upon purification of the polyolignols?



## Lessons of Williston Lake



Lucy Morris, left, and Madison Jones swim in Williston Lake on a summer day at Camp Todd.

### Girl Scouts swim again in clean lake water

Future winter lake drains possible to prevent blue-green algae's return

Photo and Story  
by DUSTIN HOLT  
Caroline Editor

