Monitoring and Control of Nuisance Algae

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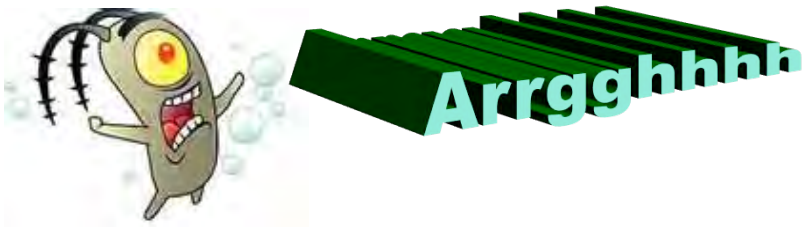


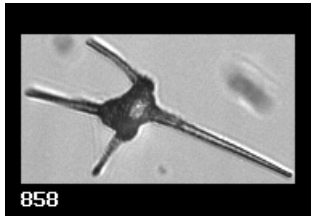
AGENDA

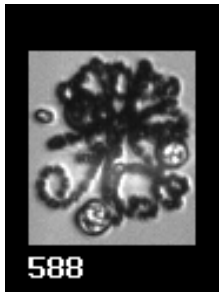
- Basics of our program
- Monitoring and Program Improvements
- Effects of ozone
- Harmful algal blooms

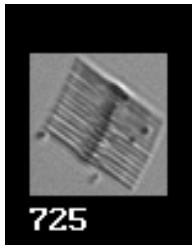
Why Worry About Algae?

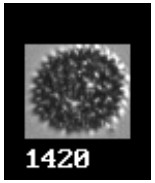
- Algae/Plankton are naturally occurring - Not all algae are bad
- Depending upon conditions, especially nutrients, certain algae may predominate
- Some algae may be a nuisance or a health issue
  - Taste and Odor Complaints - MIB and geosmin
  - Recreational Water Use - Toxic compounds, microcystin
- Drinking Water Systems and Do Not Use Orders

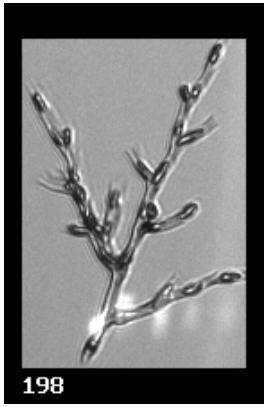
FlowCAM - Algae Images

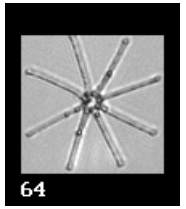


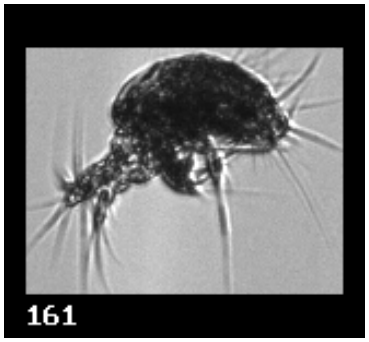


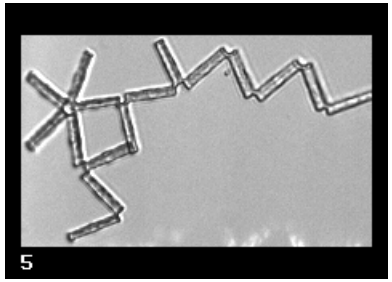




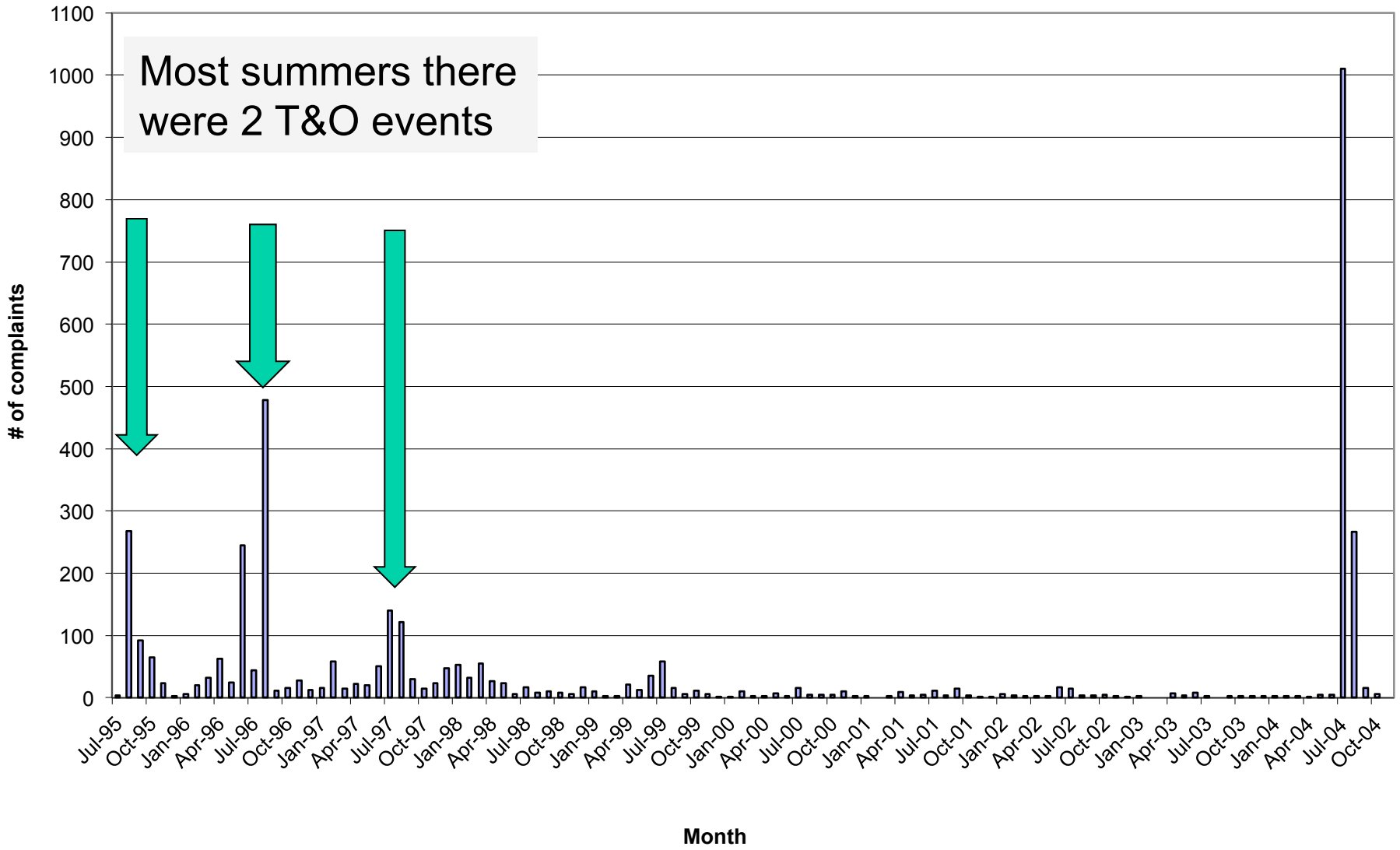








Monthly Taste and Odor Complaints



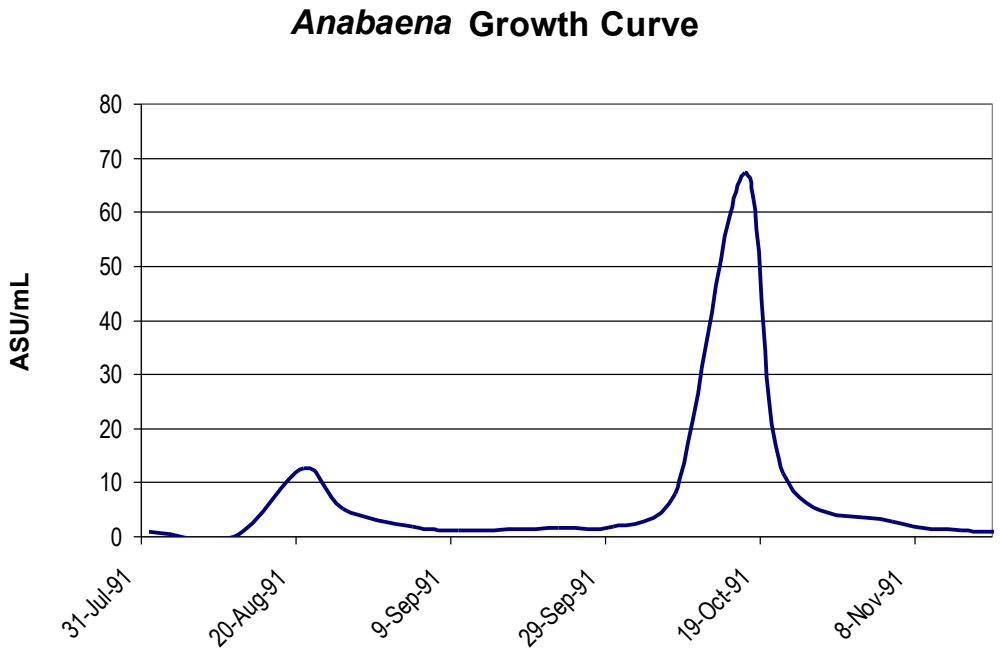
Algae - Taste and Odor

- Nuisance algae release taste and odor substances including geosmin and MIB *(2-methylisoborneal)*
- Other compounds, besides MIB and geosmin, generate taste and odor complaints
- T&O compounds may be released from the cells during log growth phase, or may be released when the cells are lysed

Algae Growth

- Goal is to control algae just as they are entering log growth

- Some algae may immediately “crash” after a bloom – but you are still stuck with the T&O problem!



When do algae need to be controlled?

- Treatment to control a bloom must happen during a narrow window of opportunity*
- If taste and odor complaints have started, it is already too late!
- Taste and odor compounds may be released in the process of controlling the bloom
- Treatment once a bloom is established is less effective

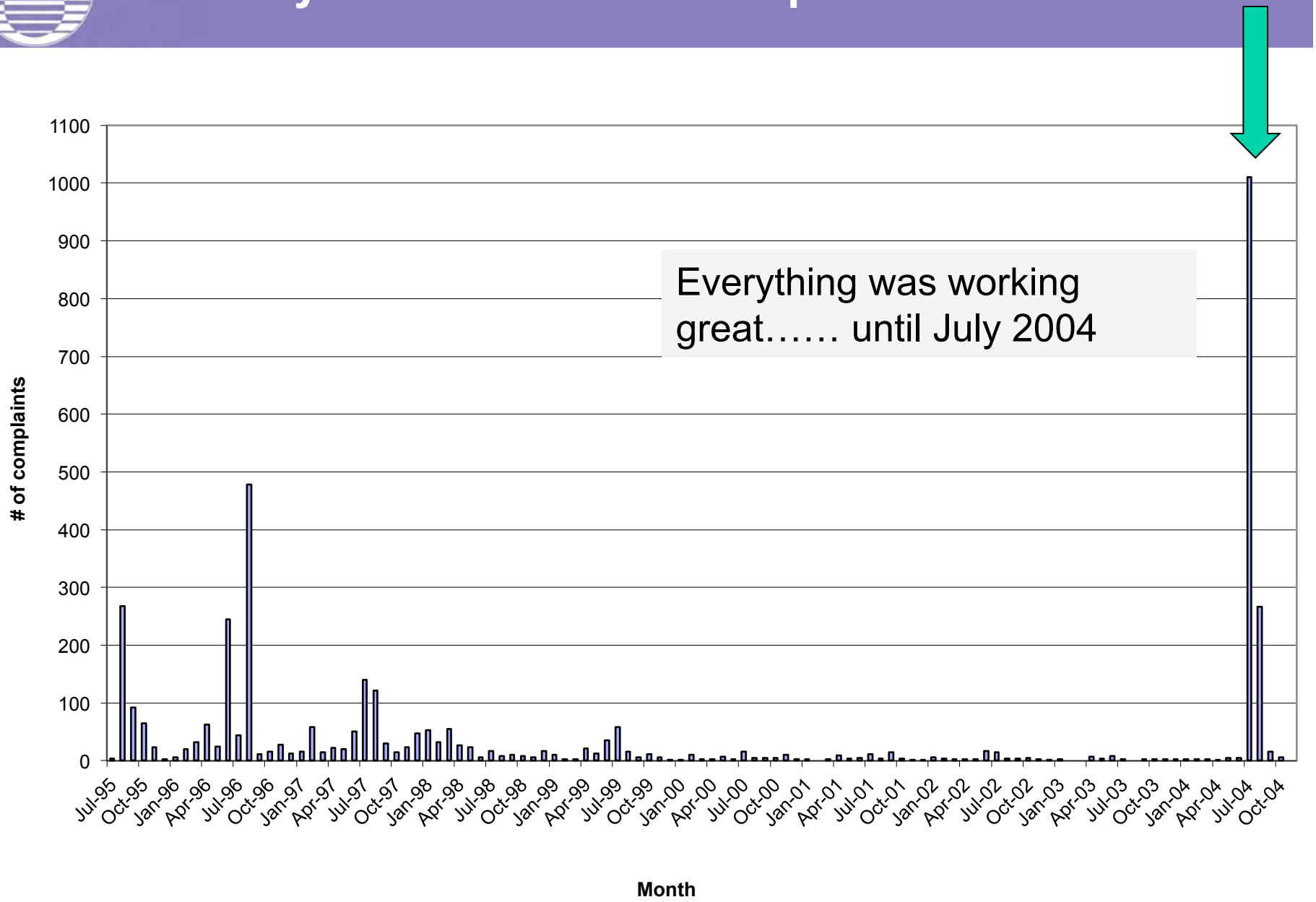
**AwwaRF Report "Early Warning and Management of Surface Water Taste-and-Odor Events"*

MMT Plan: A Strategy to Prevent, Mitigate, and Treat Harmful Algae Blooms

United Water addressed concerns raised by cyanotoxins from blue-green algae blooms by implementing a **Monitoring, Management and Treatment (MMT) Plan** to reduce the likelihood and magnitude of these blooms, and to effectively treat the water, should a bloom occur.

Treatment: The improved treatment strategy was a key contributor to improved reservoir water quality. This strategy included the use of the water quality data from United Water's monitoring efforts to determine exactly when to treat for algae, rather than sticking to scheduled treatments.

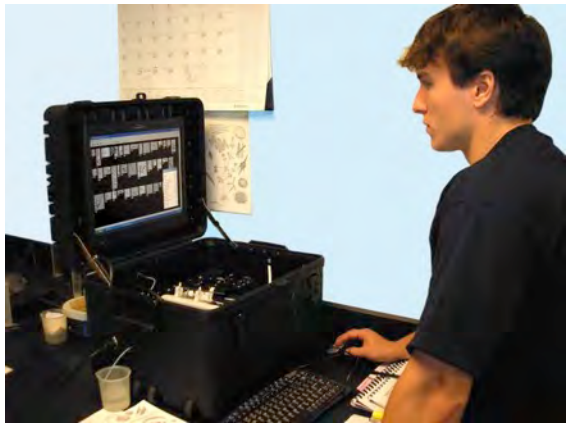
Monthly Taste and Odor Complaints

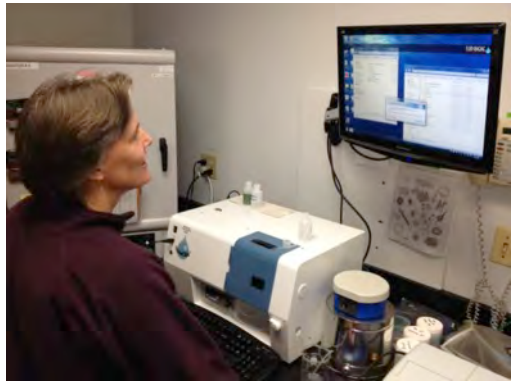


Improvements to Monitoring

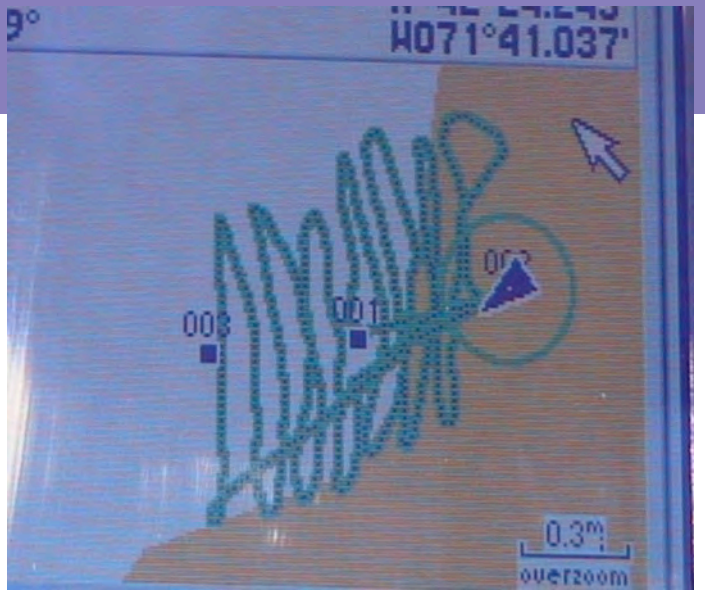
- Sample Analysis – *manual* - Concentration of sample, followed by microscopic exam (DCR)

- Sample Analysis – *semi automated* – FlowCAM (EnQual/ QA)

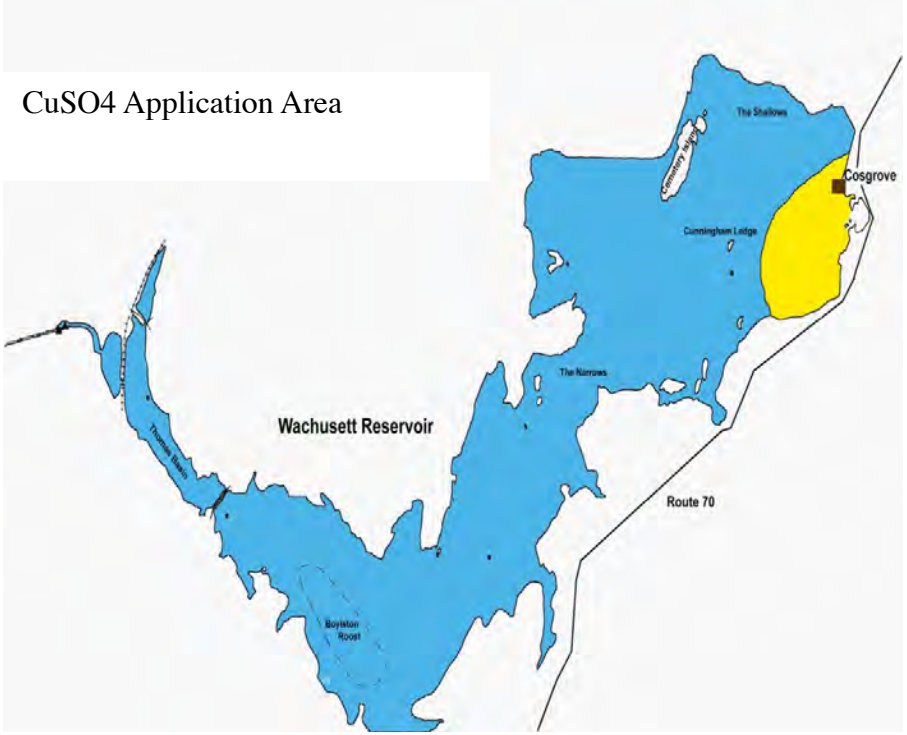




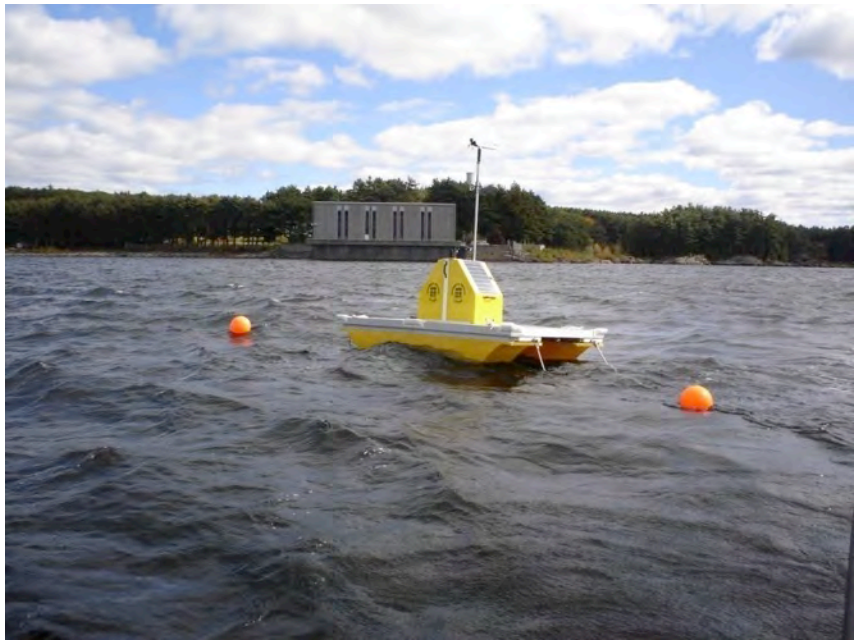
Boat and Tracking Improvements



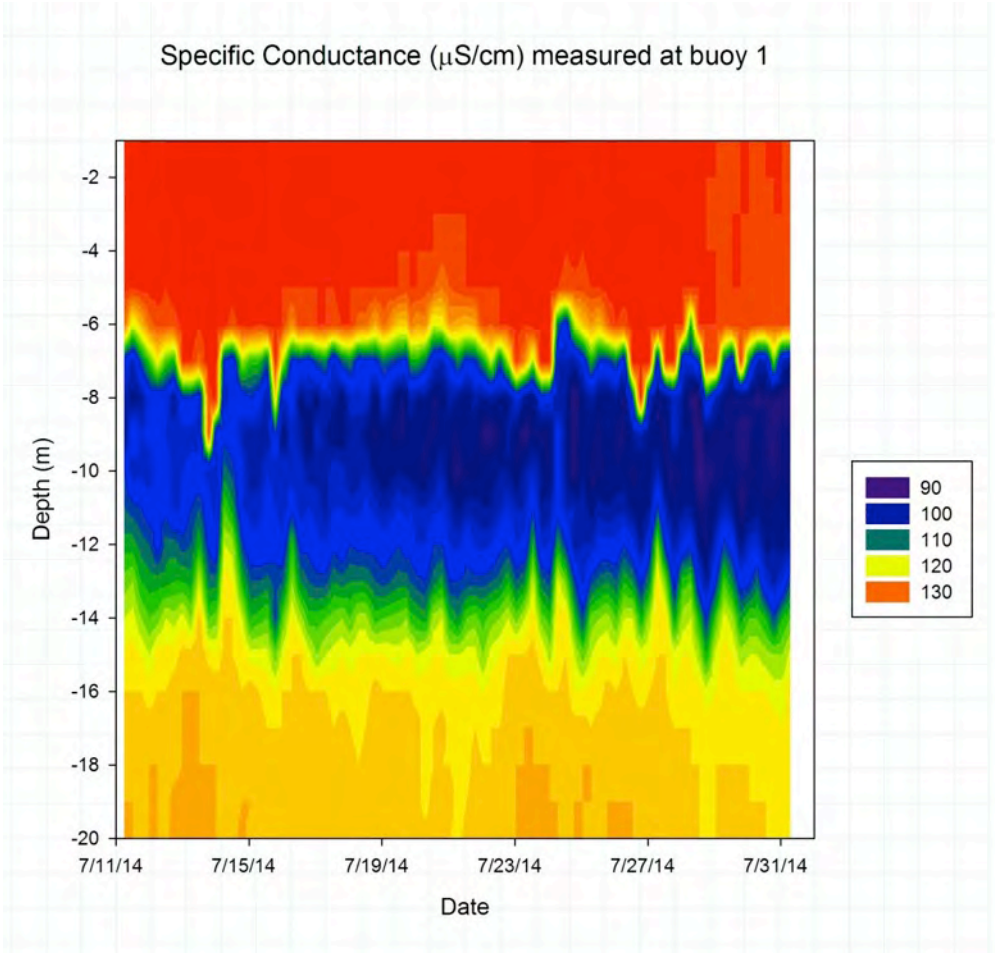
- Use Navigation System to identify treatment area - Repeatable



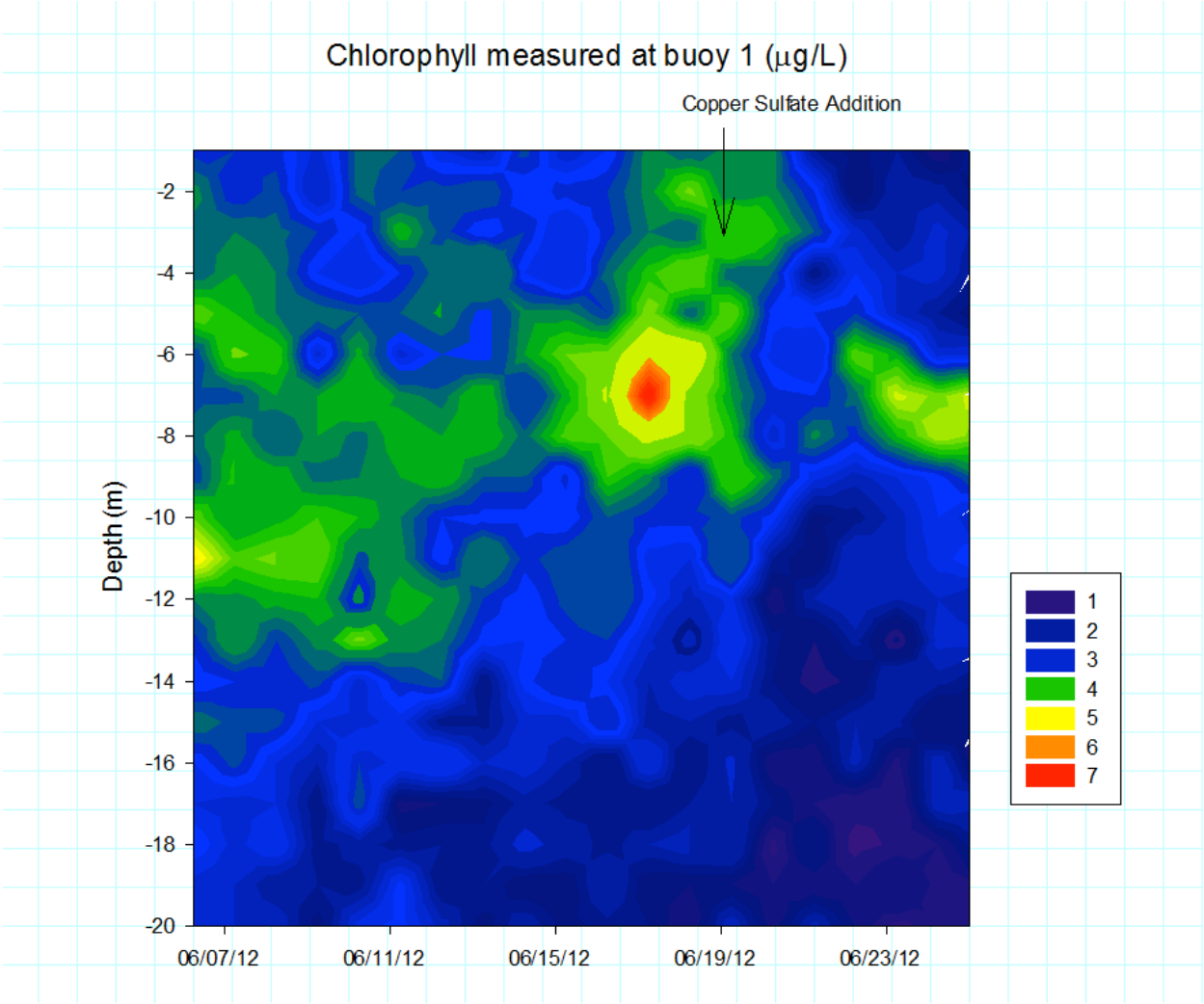
YSI buoys: the pontoon style is shown at left and the right shows the smaller buoy being deployed



Quabbin interflow in July 2013



Chlorophyll measurement to supplement Copper sulfate treatment in June 2012 for *chrysosphaerella* at 7m depth



What's Next: Towable Sondes

- **Turner Design C-FINS™ Fluorometric Integrated Nautical Mapping System**
  - **Provides data for both Petroleum Products and Algae**
  - **Similar product that is utilized on the buoys**
  - **GPS mapping feature**
  - **Continuous Measurements**

EFFECTS OF OZONE

CWTP Treatment - OZONE

- The most consistently efficient process for destruction of both ultra- and extracellular microcystins appears to be ozonation, which can rapidly achieve essentially complete destruction of microcystins,nodularin and anatoxin-a at low doses and contact times (Keijola et al., 1988)(Himberg et al., 1989)(Rositano and Nicholson, 1994)(Croll and Hart, 1996)(Rositano et al., 1996) (Hart et al., 1997).

- At low pH, an ozone dose of as little as 0.4 mg/L removed 97% of microcystin-LR (WaterRF, 2010).

Ozone

- With 10 years of Carroll Water treatment Plant operation, we have collected data on elevated algae levels and documented no taste and odor after treatment.
- Staff reevaluating the algae response program
- Focus continues to be on preventing T&O problems, and controlling toxin levels
- Minimizing copper applications is also beneficial
- Pesticide General Permit now required under EPA's NPDES program – treatments >14 days

Algal Taste and Odor Study with UMass

- Identify some of the algal taste and odor compounds in Wachusett Reservoir
- Quantify impact of CWTP treatment on T&O compounds
- This will be used along with algae monitoring to develop better algae management policies

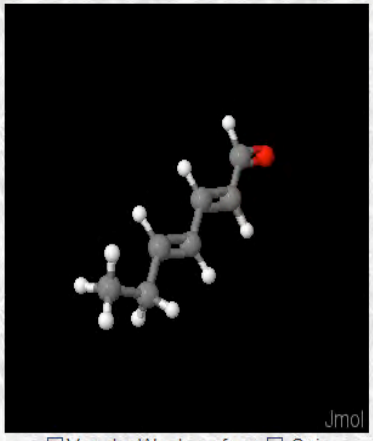
Approach

- Weekly samples collected from raw water inlet as well as FINB tap, supplemented by occasional in-reservoir samples (10 weeks currently scheduled started in July, 2014)
- Analysis using FTT sensory test and the SPME/GC/MS chemical analysis for dienals
- In October Umass will receive a Quadrupole-time-of-flight mass spec that will allows them to identify unknowns

Findings so far

2,4- heptadienal

Right Click Jmol Molecule For More Options. (Safari 1.2 (v125) Compatible). Jmol is a free download found Here. Close Window



☐Van der Waals surface ☐ Spin

IUPAC Name : hepta-2,4-dienal

InChI : InChI=1/C7H10O/c1-2-3-4-5-6-7-8/h3-7H,2H2,1H3

Search Google for structures with same skeleton

InChIKey : SATICYYAWWYRAM-UHFFFAOYAP

Search Google for exact structure

SMILES : CCC=CC=CC=O

Molar Refractivity : 34.78 ± 0.3 cm3 (est)

Parachor : 293.9 ± 4.0 cm3 (est)

Index of Refraction : 1.453 ± 0.02 (est)

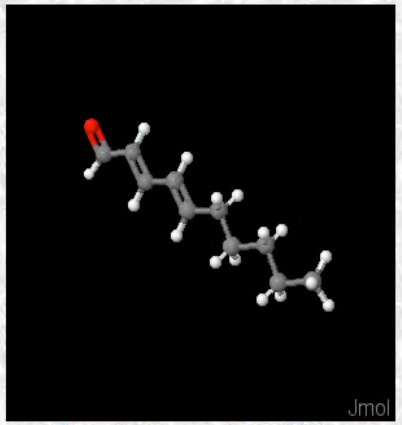
Surface Tension : 27.2 ± 3.0 dyne/cm (est)

Density : 0.856 ± 0.06 g/cm3 (est)

Polarizability : 13.78 ± 0.5 10-24cm3 (est)

(E,E)-2,4- decadienal

Right Click Jmol Molecule For More Options. (Safari 1.2 (v125) Compatible). Jmol is a free download found Here. Close Window



☐Van der Waals surface ☐ Spin

IUPAC Name : (2E,4E)-deca-2,4-dienal

InChI : InChI=1/C10H16O/c1-2-3-4-5-6-7-8-9-10-11/h6-10H,2-5H2,1H3/b7-6+,9-8+

Search Google for structures with same skeleton

InChIKey : JZQKTMZYLHNFPL-BLHCBFLLBF

Search Google for exact structure

SMILES : CCCCC\C=C\C=C\C=O

MDL: MFCD00007007

Molar Refractivity : 48.67 ± 0.3 cm3 (est)

Parachor : 413.3 ± 4.0 cm3 (est)

Index of Refraction : 1.458 ± 0.02 (est)

Surface Tension : 28.9 ± 3.0 dyne/cm (est)

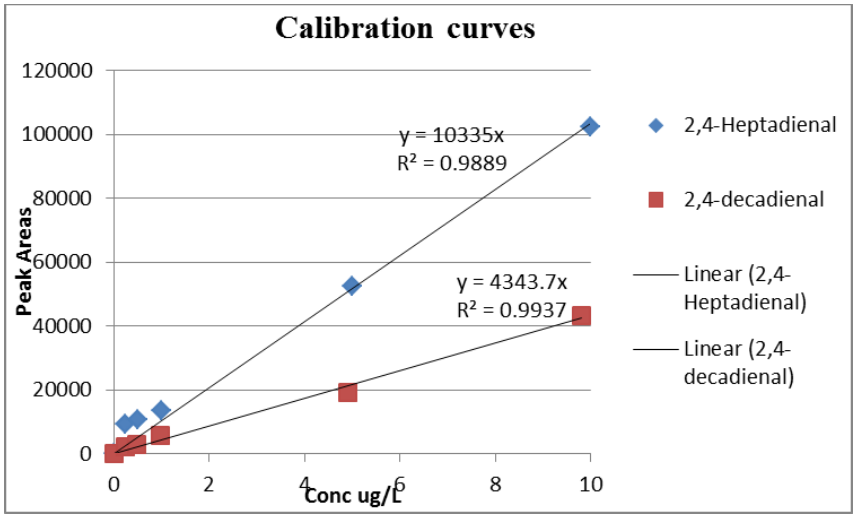
Density : 0.854 ± 0.06 g/cm3 (est)

Polarizability : 19.29 ± 0.5 10-24cm3 (est)

The dienals

- Fatty type odor, 2,4-Heptadienal is a specific marker of oxidative rancidity[1]. It is also a potential algal metabolite

- **(*E*,*E*)-2,4-Decadienal** is an aromatic substance found in butter, cooked beef, fish, potato chips, roasted peanut,[2] buckwheat[3] and wheat bread crumb.[4] In an isolated state, it smells of deep fat flavor, characteristic of chicken aroma (at 10ppm). At lower concentration, it has the odor of citrus, orange or grapefruit.



Preliminary results

Sample		2,4-heptadienal	2,4-decadienal
		Conc Ug/L	Conc Ug/L
Week 6	Treated	2.18	2.15
	Raw	0.98	1.03
Week 5	Reservoir	0.66	0.74
	Treated	0.38	0.45
	Raw	0.30	0.50

Harmful Algal Blooms (HAB)

- Toledo, Ohio “Do Not Drink” Order July 31 –August 4, 2014

- Algal Toxins:
  - Microcystin-LR (1 ug/L)
  - Anatoxin-a
  - Cylindrospermopsin
  - Saxitoxin

Raw water and finished water levels in Lake Erie area

- Since Ohio EPA began sampling in 2010, microcystin has continued to be present at levels of concern in HAB-affected sources of drinking water.

- In 2013, microcystin concentrations continued to exceed 100 ug/L in Celina's source water and HABs returned to Lake Erie with concentrations at the raw water intakes exceeding **50 ug/L**.

- Ohio's first cyanotoxin-related "Do Not Drink" advisory was issued at Carroll Township in 2013, due to **finished water microcystin detections above 1.0 ug/L.**

- **Toledo Ohio issued a Do Not Drink order July 31, 2014 due to finished water microcystin concentrations of 1.5 to 2.5 parts per billion (ppb), while other detections indicated levels as high as 3 ppb.**

MA DPH and DEP HAB Advisory's

Recreational WQ Requirements:

Advisory warning against water contact issued based on the following criteria:

- Visible scum present
- Cell count >70,000 cells/milliliter
- Microcystin toxin concentration >14 parts per billion (ppb)


PUBLIC HEALTH
ADVISORY
A HARMFUL ALGAL BLOOM OR ALGAL TOXIN HAS BEEN DETECTED AT THIS LOCATION. SWIMMING AND WADING ARE NOT RECOMMENDED. WATER SHOULD NOT BE SWALLOWED AND SURFACE SCUM SHOULD BE AVOIDED.

Toxins, Taste and Odor Compounds, Wachusett

Date	Location	Geosmin, ng/L	MIB, ng/L	Microcystin-LR, ug/L	Max Cyanophytes, ASU/mL	Max Chrysophytes, ASU/mL	Microcystis, ASU/mL	Comments
9/8/2014	CWTP Raw Inlet tap	1.7	<1	<0.5	-	-	-	FlowCam Results: 5 ASU/mL Chryso.
9/8/2014	Cosgrove Intake 12.5m	1.4	<1	<0.5	136	299	136	
8/18/2014	Basin North 9m	2.3	<1	<0.5	250	757	232	
8/18/2014	CWTP Raw Inlet tap	1.5	<1	<0.5	-	-	-	FlowCam Results: 5 ASU/mL Chryso.; 2 ASU/ mL Dinobryon
6/24/2014	Cosgrove Intake 9m	4.6	<1	Not Tested	0	74	-	Data from DCR BN 7/23/14(9m)
10/29/2013	Cosgrove Intake 3m	<1	<1	<0.16	146	0	131	
10/29/2013	Cosgrove Intake 6m	<1	<1	<0.16	293	0	284	
7/13/2011	Cosgrove Intake	1.2	<1	Not Tested	30	210	-	Data from DCR BN 7/14/11 (7m)
7/25/2011	Cosgrove Intake 9m	2.7	<1	Not Tested	0	242	-	Data from DCR CI 7/21/11 (7m)
7/29/2011	Cosgrove Intake 8m	1	<1	Not Tested	50	229	-	Data from DCR BN 7/28/11 (7m)

Actual Comments

"**The water tastes great!** I have noticed a marked taste improvement and a complete lack of odor the water. You are doing splendid work.

MWRA WATER HOLDS ITS OWN AGAINST BOTTLED

Taste test shows price is all that separates them

2014 AWWA ACE14 Conference:

MWRA and BWSC awarded "Best Tasting Water"

Acknowledgements

- Western Operations Staff
- DCR Staff, West Boylston
- EnQual water staff
- Summer Interns!
- Umass Amherst