Response of the Algal Community in Boulder Basin, Lake Mead to the Introduction of Quagga Mussels and Reduced Water Levels, 2002-2013

Ann L. St. Amand[1], Todd Tietjen[2], Peggy Roefer[2], James F. LaBounty[2], and Joel Gerweck[1]

1. PhycoTech, St. Joseph, MI
2. Southern Nevada Water Authority, Las Vegas, NV

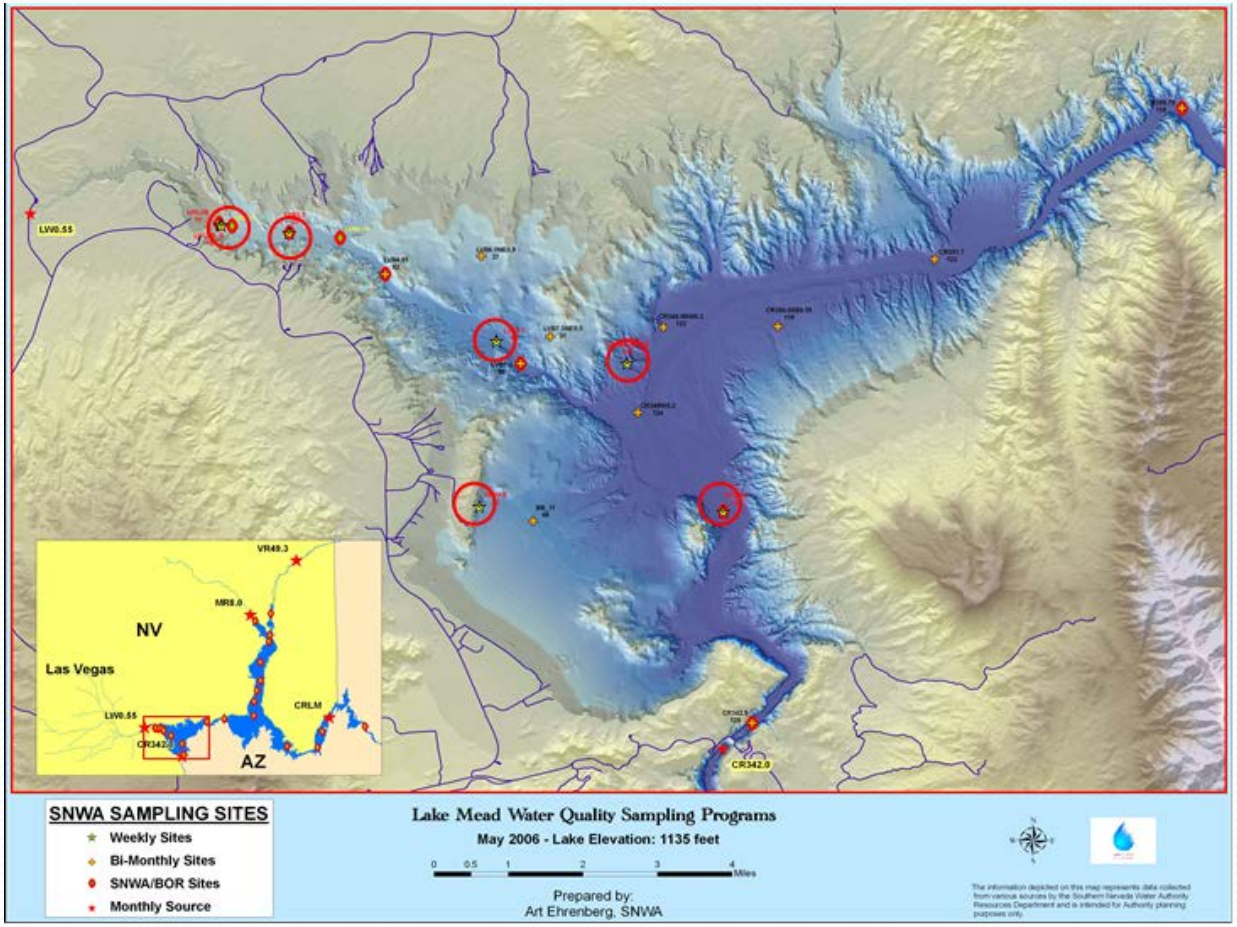
Purpose

- Analyze algal data to see if we can distinguish the relative importance of different stressors from 2002-2013.
  - **Lower Water Levels**
  - **Introduction of Quagga Mussels**
  - **Water Quality Changes**

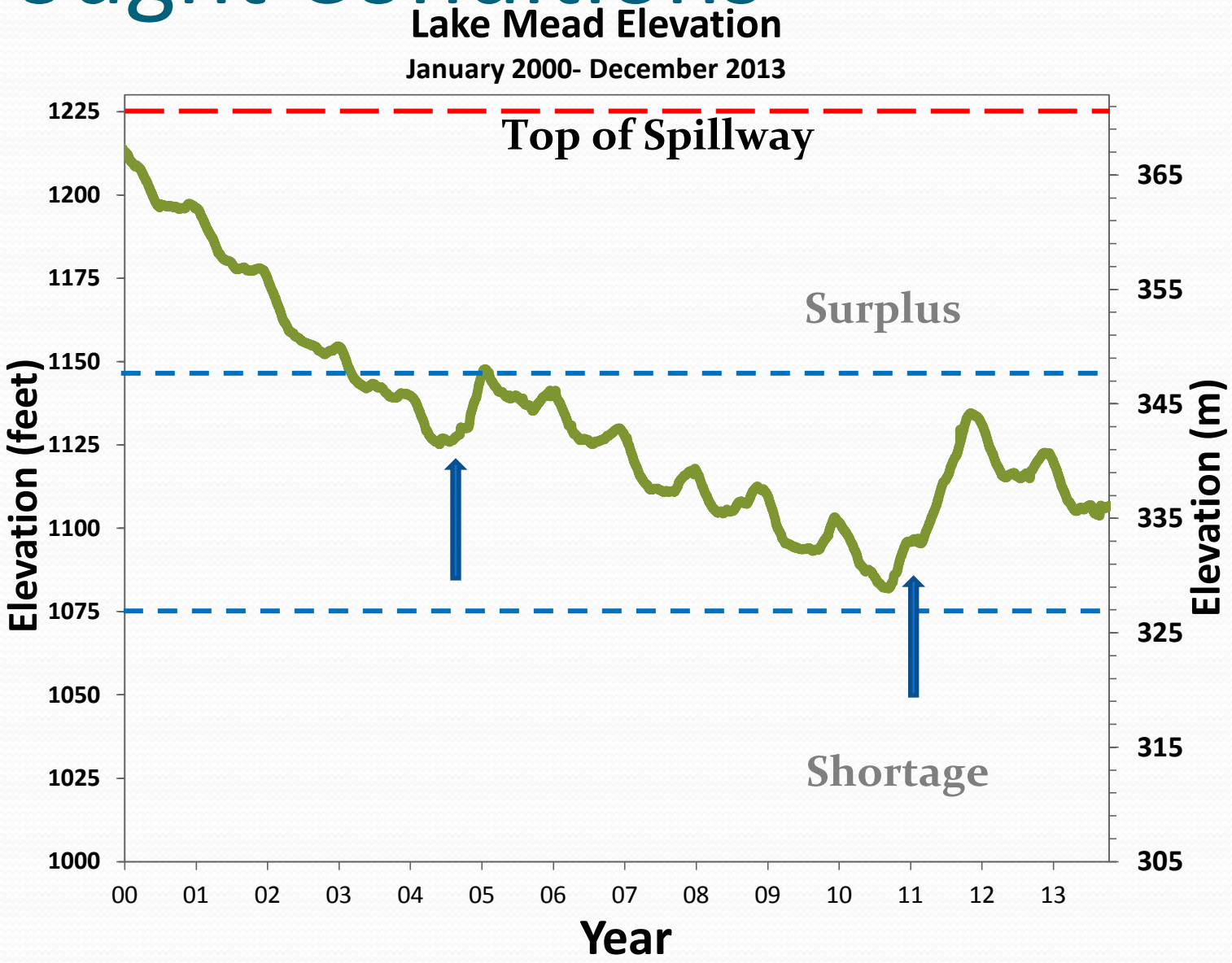
Background

- Large complex reservoir system with multiple basins formed by the Colorado River, its tributaries (Muddy, Virgin Rivers) and runoff via the Las Vegas Wash.
- 4 major basins
  - Gregg
  - Temple
  - Virgin
  - **Boulder**
- Several major environmental impacts since early 2000's

Boulder Basin



Drought Conditions



Phosphorus Reductions

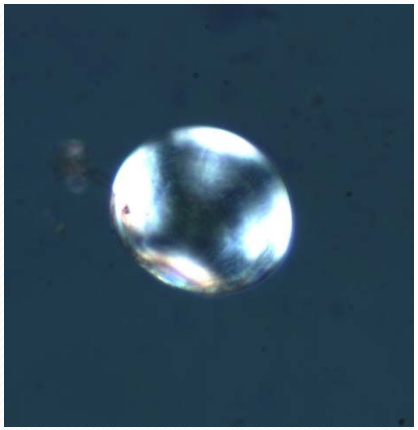
Lake Year	LV Wash No. Shore Road	LV Bay at Wash Inflow	INTAKE
2000-01	242	6.5	4.2
2001-02	168	5.4	4.6
2002-03	117	4.2	3.1
2003-04	120	5.2	3.4
2004-05	111	4.1	2.8
2005	41	2.9	1.4

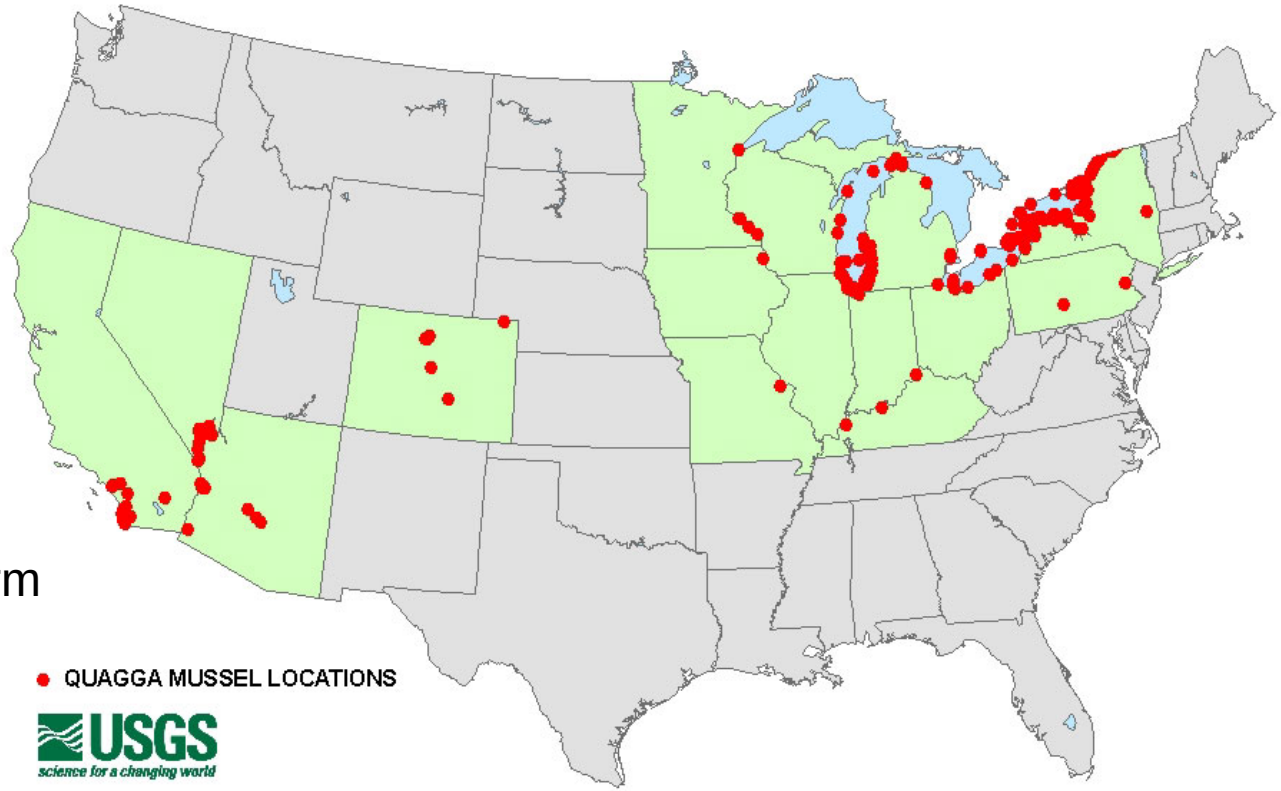
Source of data: Jim LaBounty, Todd Tietjen Unit: ug/L

- Reductions in SRP expanded and completed through 2005, generally loading has remained low.
- Slightly higher/lower loading after 2005 due to continued refinement and changes in wastewater treatment.

Introduction of Quagga Mussels

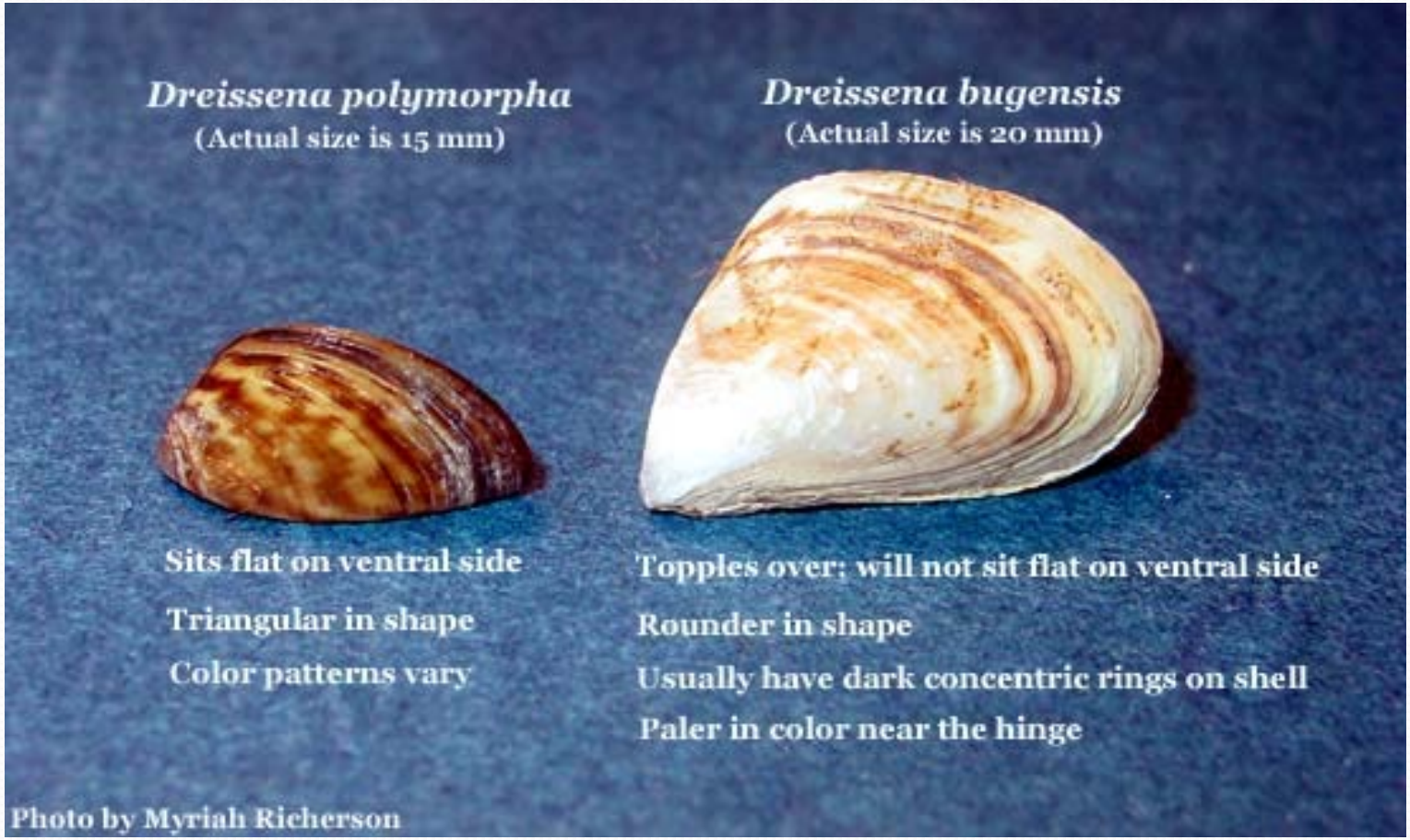
Origins: *Dreissena rostriformis bugensis*, Dneiper River drainage of Ukraine





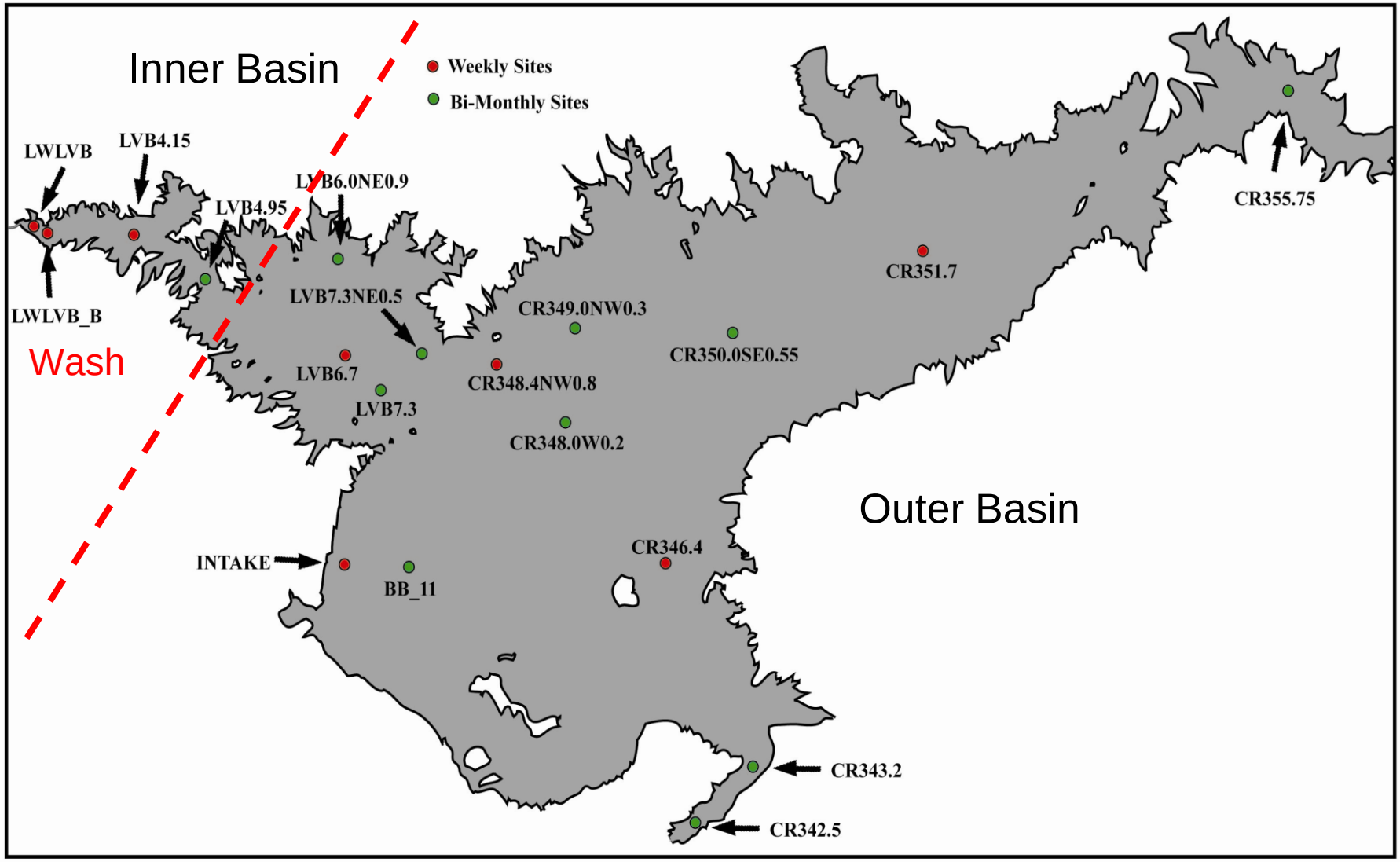
- Larger than zebras
- Can colonize both warm shallow water and deeper, colder water
- Extended fecundity at lower temperatures

Zebra Mussels vs Quagga Mussels



http://nas.er.usgs.gov/

Sampling Stations – Boulder Basin



Sampling Stations

- Inner Basin (Wash up to 4.95)
  - Wash (LWLVB_B, LWLVB)
  - The Wash often drove the Inner basin dynamics
- Outer Basin (>4.95 including CR stations)
- Used MDS to determine Basins

Data Analysis & Counting Methods

- Weekly/Bi-weekly Sampling – High Resolution
  - Counted at least 400 Natural Units at 500x, scanned at 300x and 1250x
  - 3 slides per sample
  - Measured up to 28 dimensions for each taxon
  - Used ASA System, Primer-e, v6 (multi-dimensional scaling, MDS), Sigmastat 13
    - Did not eliminate rare taxa.
- Used growing season data: April-October each year.

Samples

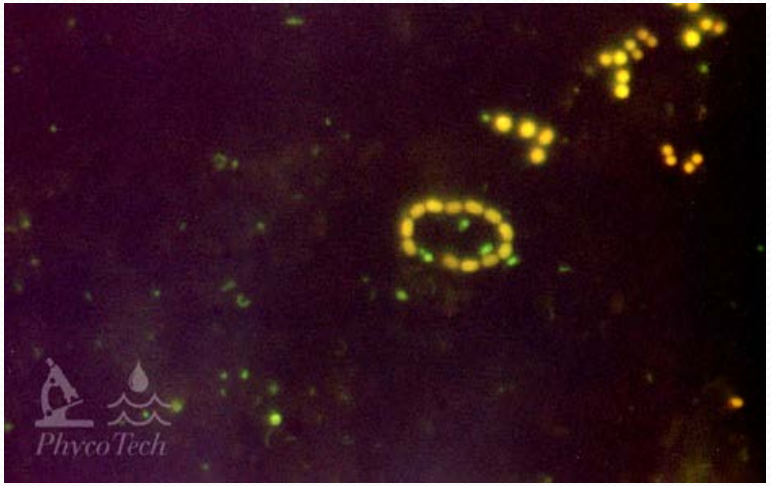
Genus level data for 1865 samples

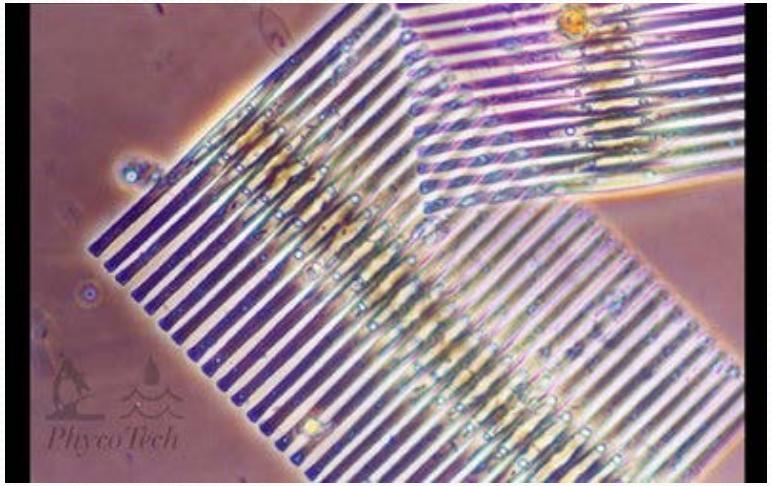
Response Variables for Algae

- **Natural Unit Concentration**
- **Cell Concentration**
- ***Biovolume***
- **Volume**
- **Area**

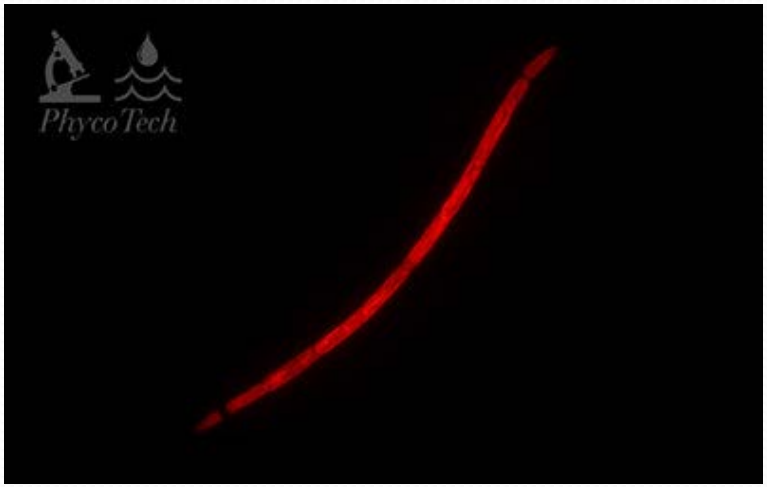
Groups and Taxa of Interest

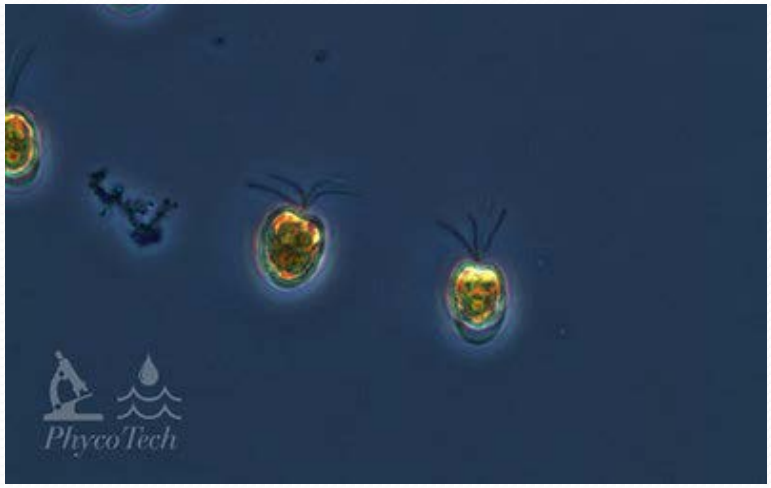
- ***Totals***, Divisions, Families
- Blue-greens
  - *Aphanizomenon flos-aquae*
  - *Cylindrospermopsis raciborskii* (curled and straight)
  - ***Microcystis aeruginosa/wesenbergii***
  - Picoplankton (*Cyanogranis ferruginea*)
- Diatoms
  - Total Diatoms
  - *Fragilaria crotonensis*
  - *Cyclotella ocellata*
- *Greens*
  - *Pyramichlamys dissecta (Tetraselmis cordiformis)*



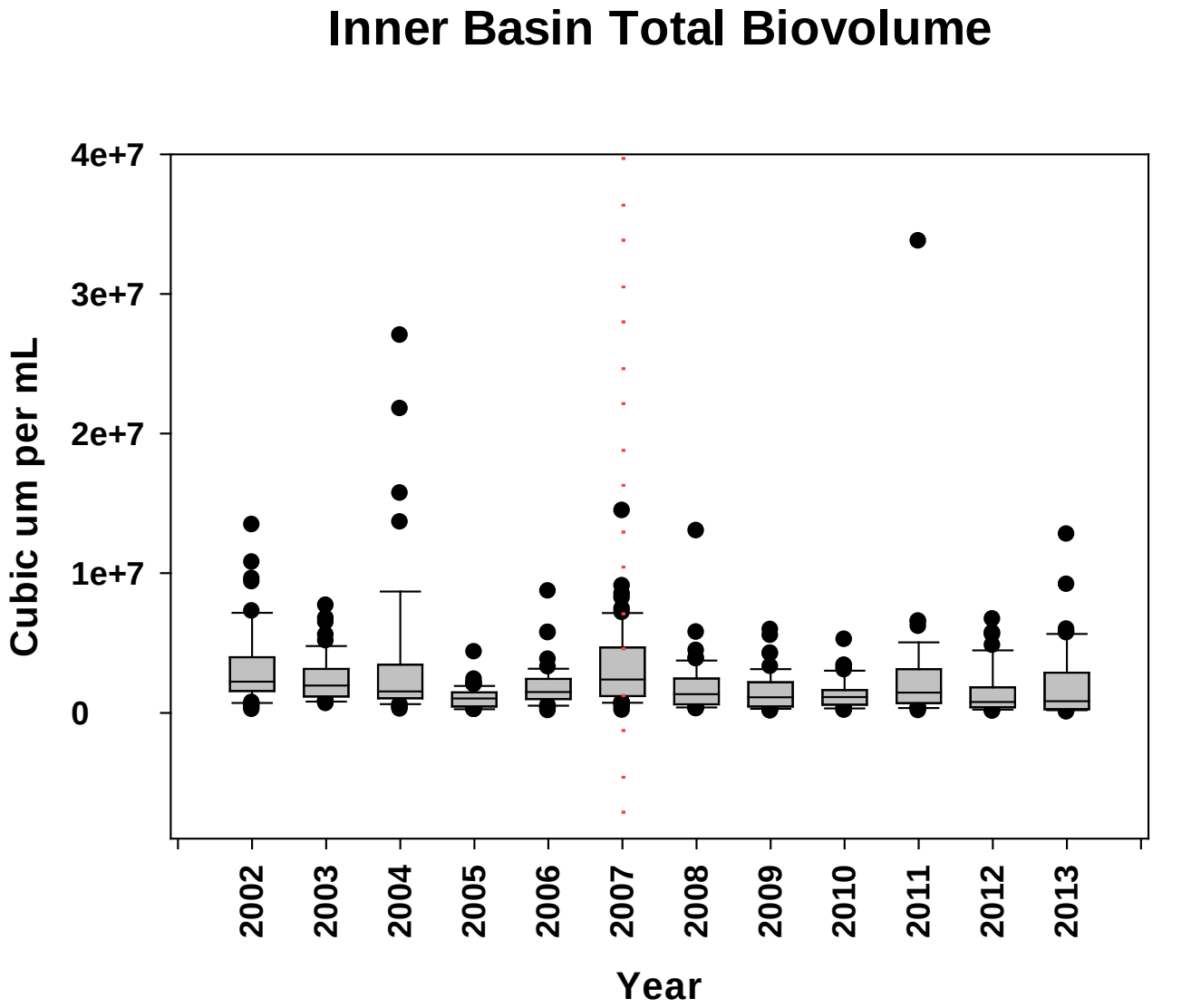


Totals

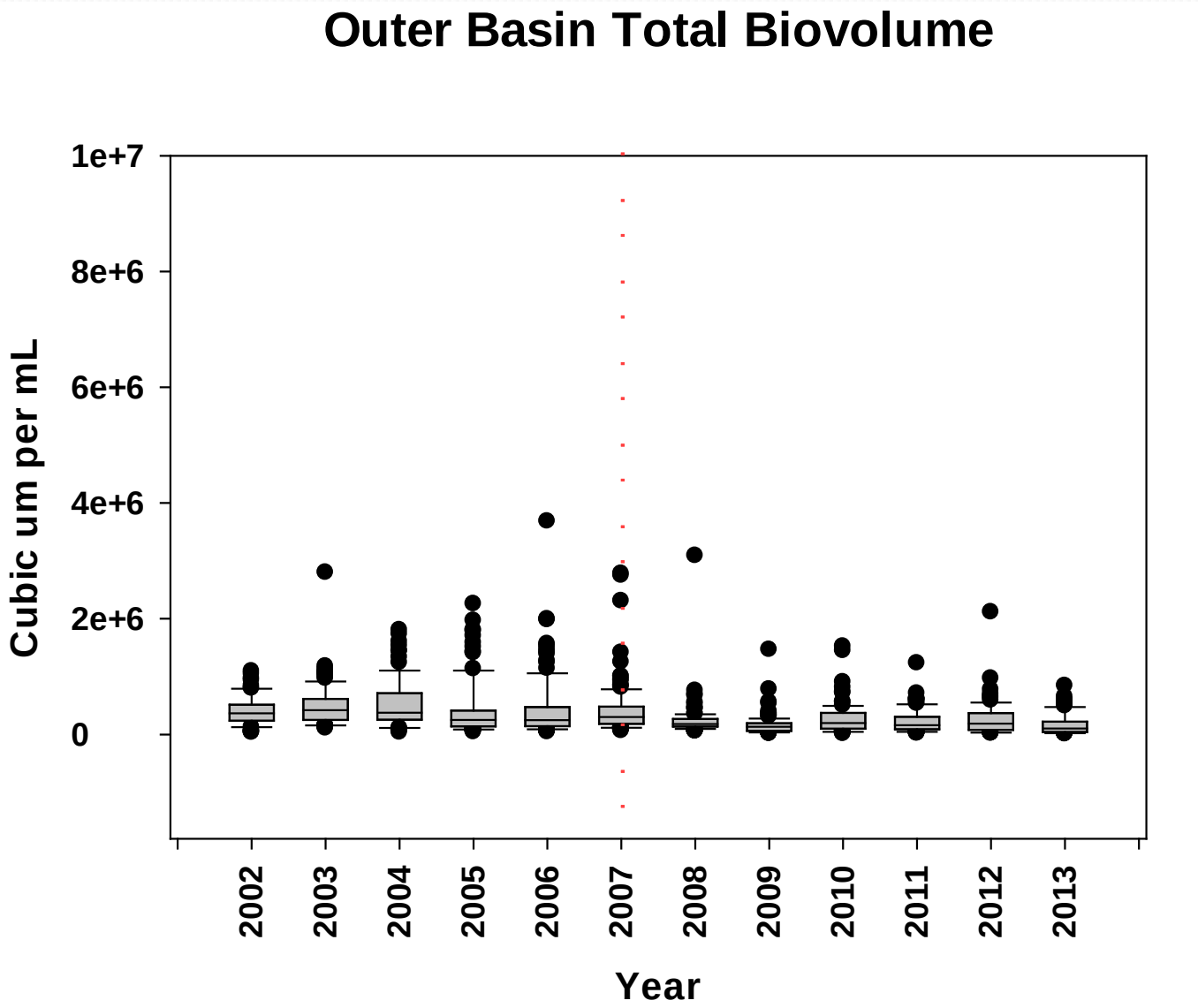




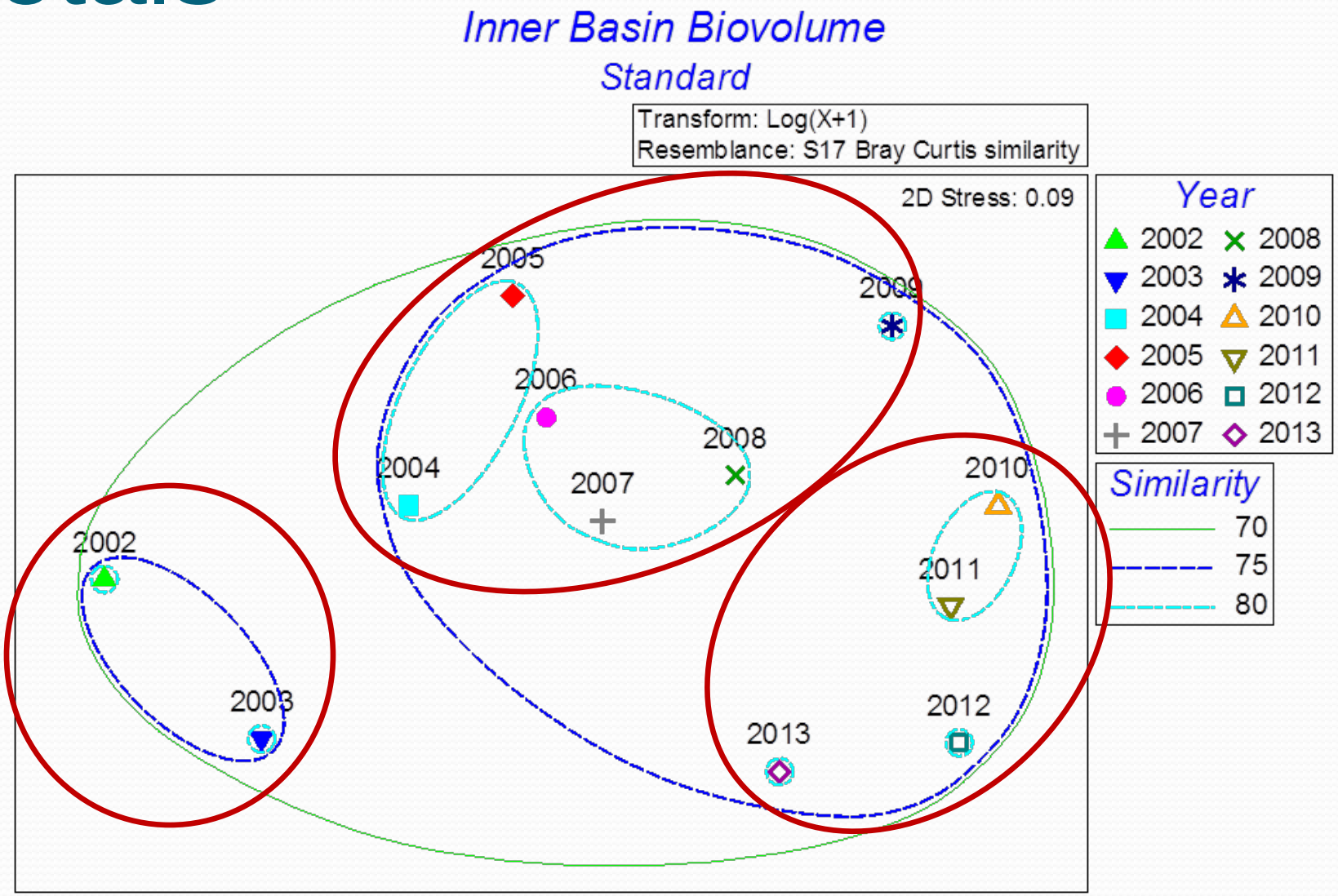
Totals


Inner Basin Total Biovolume
4e+7
3e+7
2e+7
1e+7
0
Cubic um per mL
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Year

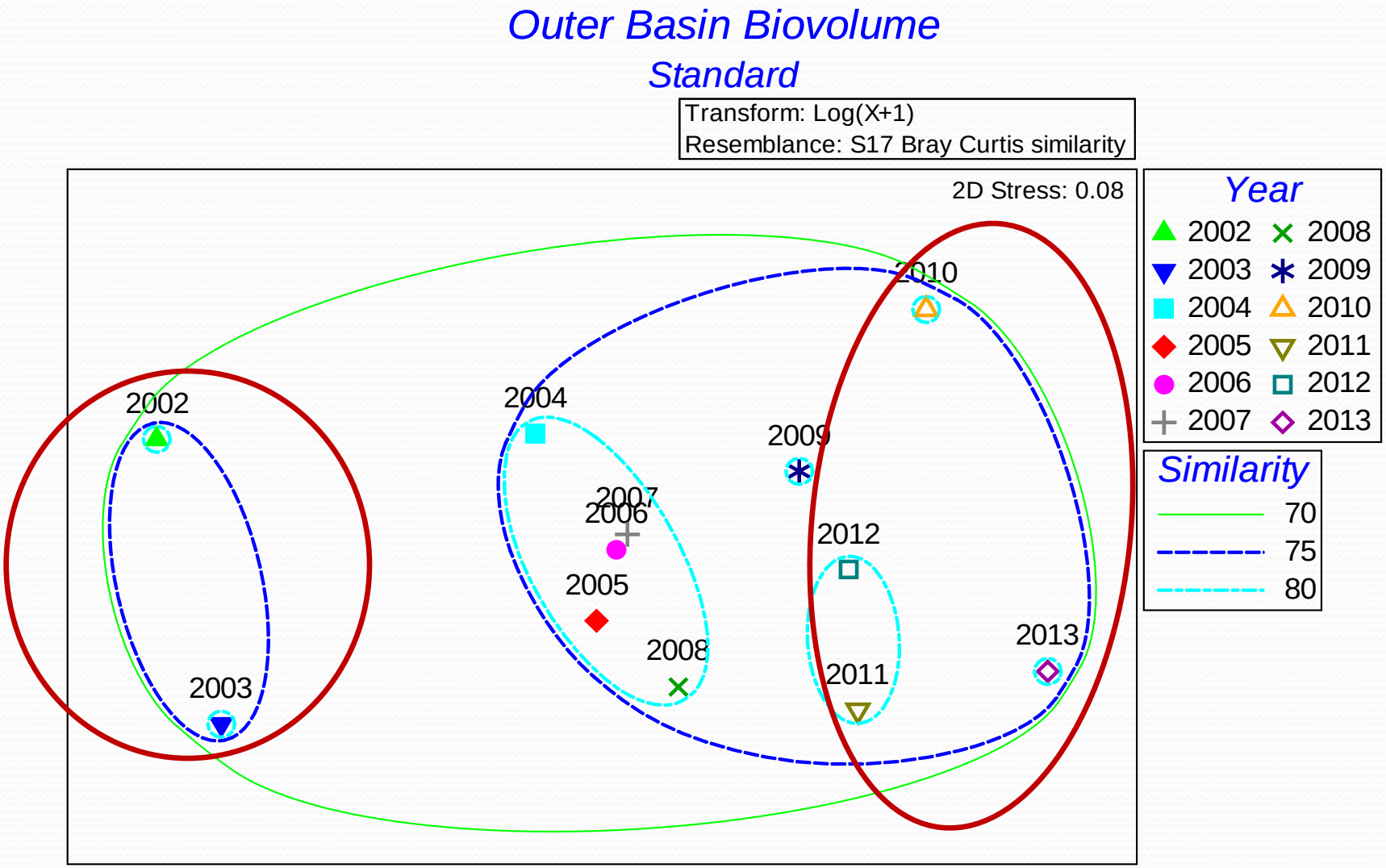
Totals


Outer Basin Total Biovolume
1e+7
8e+6
6e+6
4e+6
2e+6
0
Cubic um per mL
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Year

Totals


Inner Basin Biovolume
Standard
Transform: Log(X+1)
Resemblance: S17 Bray Curtis similarity
2D Stress: 0.09
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Year
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Similarity
70
75
80

Totals


Outer Basin Biovolume
Standard
Transform: Log(X+1)
Resemblance: S17 Bray Curtis similarity
2D Stress: 0.08
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Year
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Similarity
70
75
80

Totals

- When you run the MDS on totals without taxa detail, and look at biovolume averaged on a yearly basis, there are no patterns or statistically significant groupings.

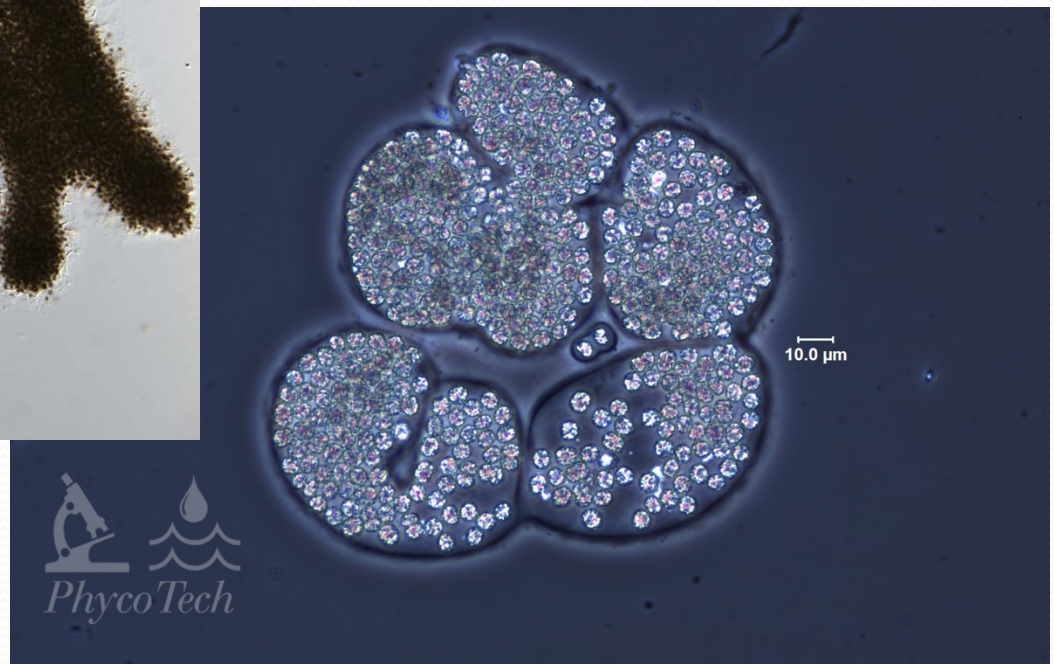
- When you run the MDS based on taxa composition, there are 2-3 statistically significant groups in both the Inner and Outer Basins.

Pre- and Post-Quagga Introduction

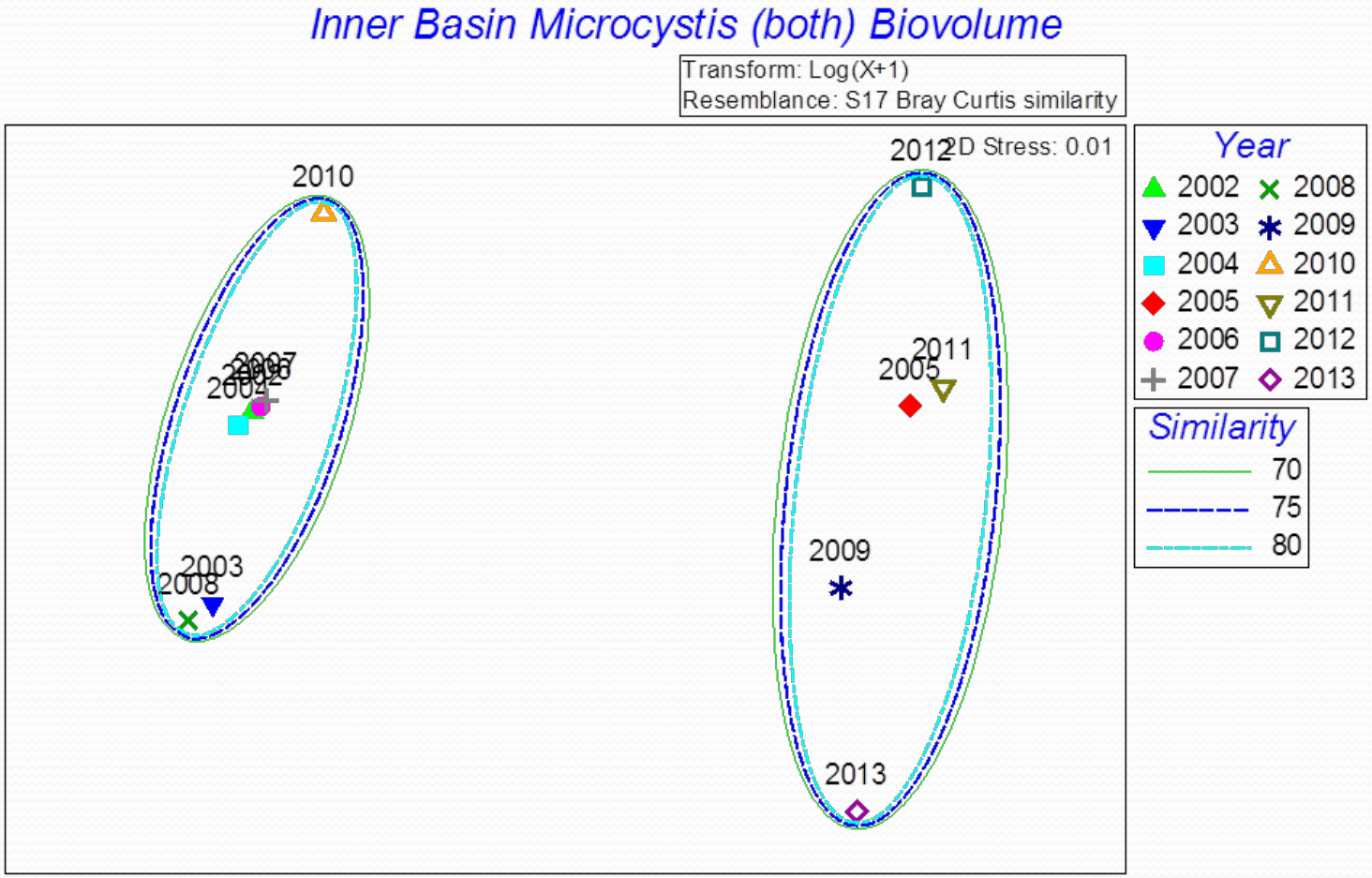
- One of the effects of Zebra/Quagga mussel introduction in other large lake systems (e.g Great Lakes) is an increase in toxic *Microcystis* blooms.

Microcystis spp

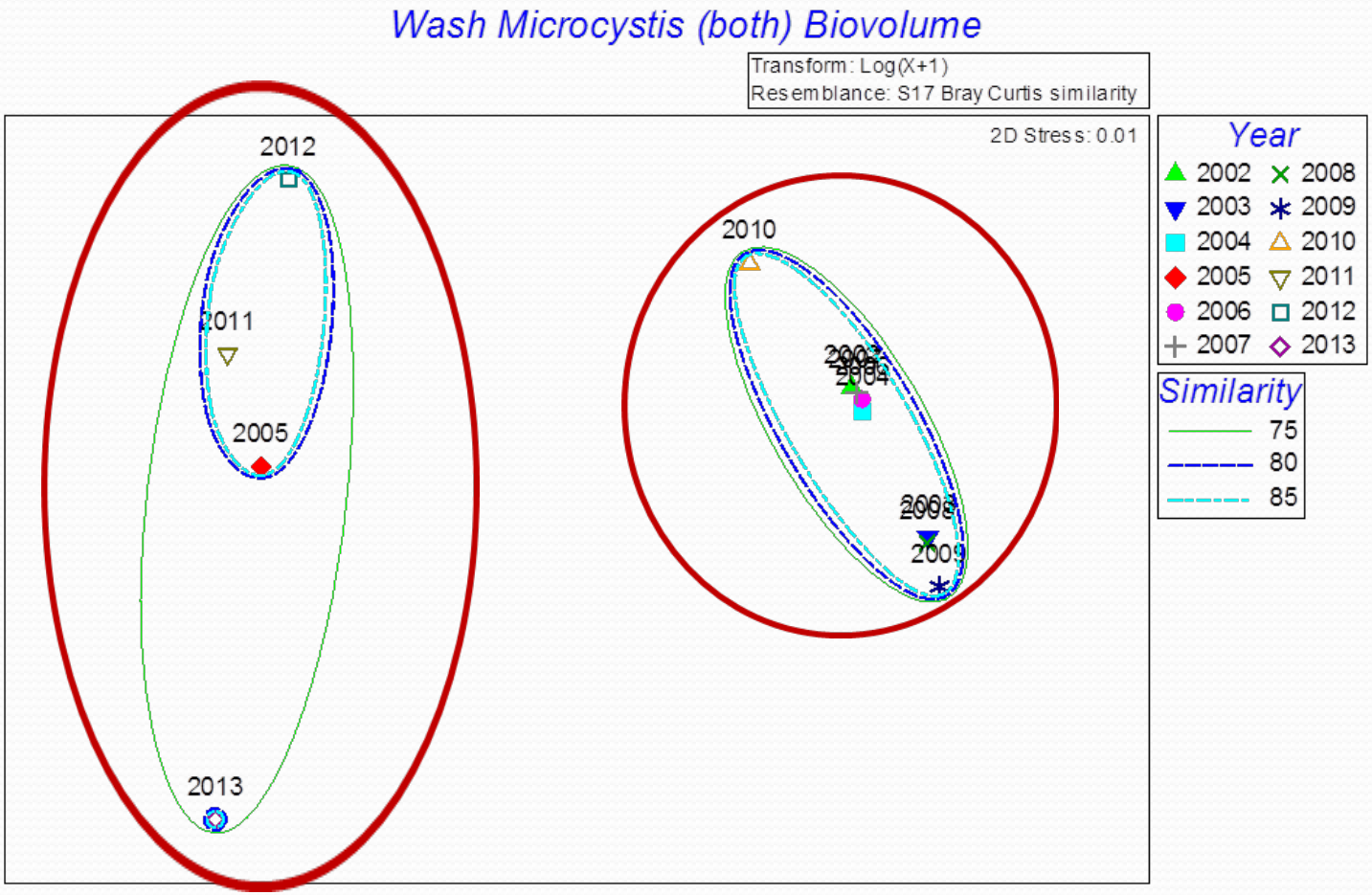
(M. aeruginosa and M. wesenbergii)



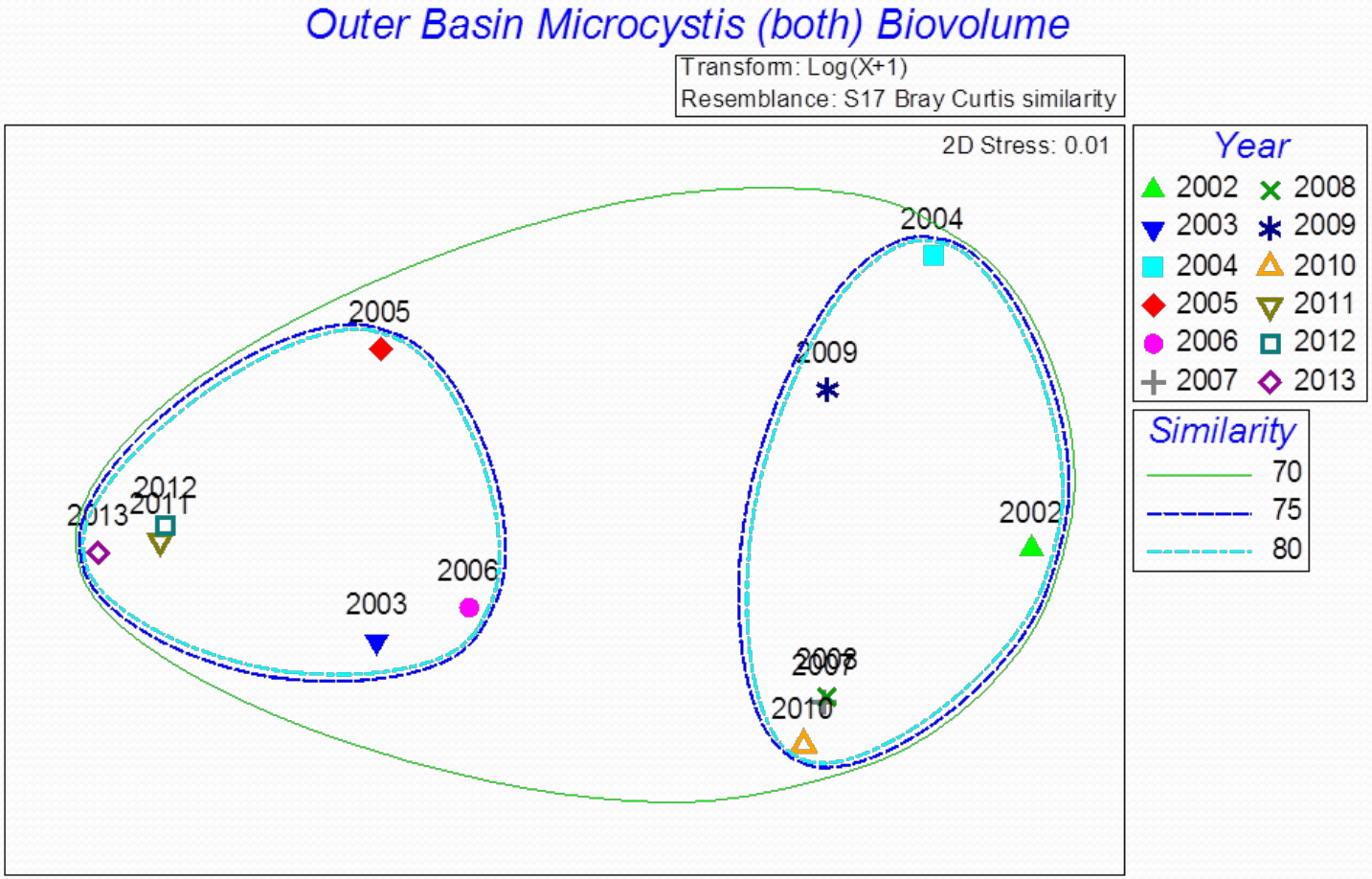
Microcystis spp



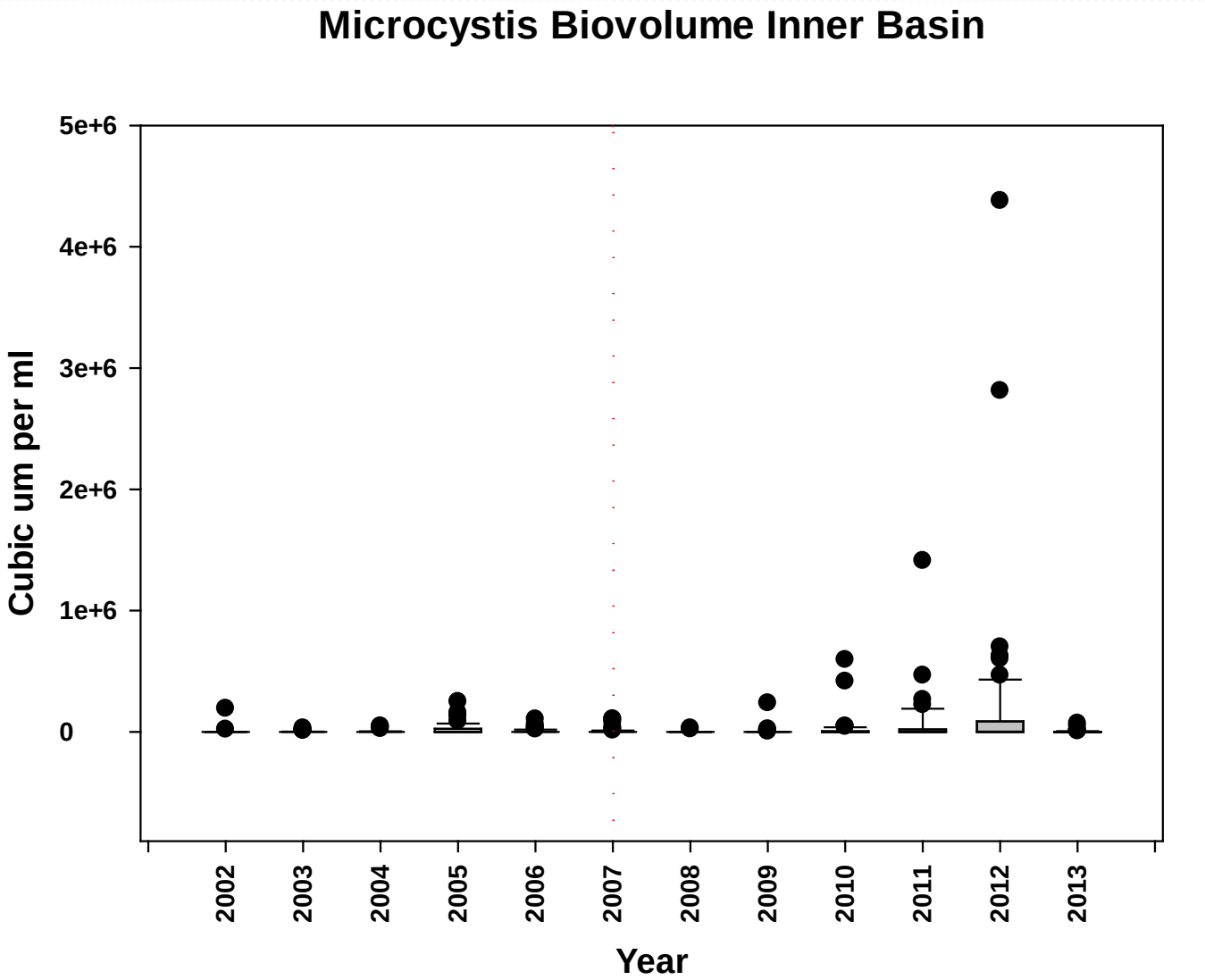
Microcystis spp.



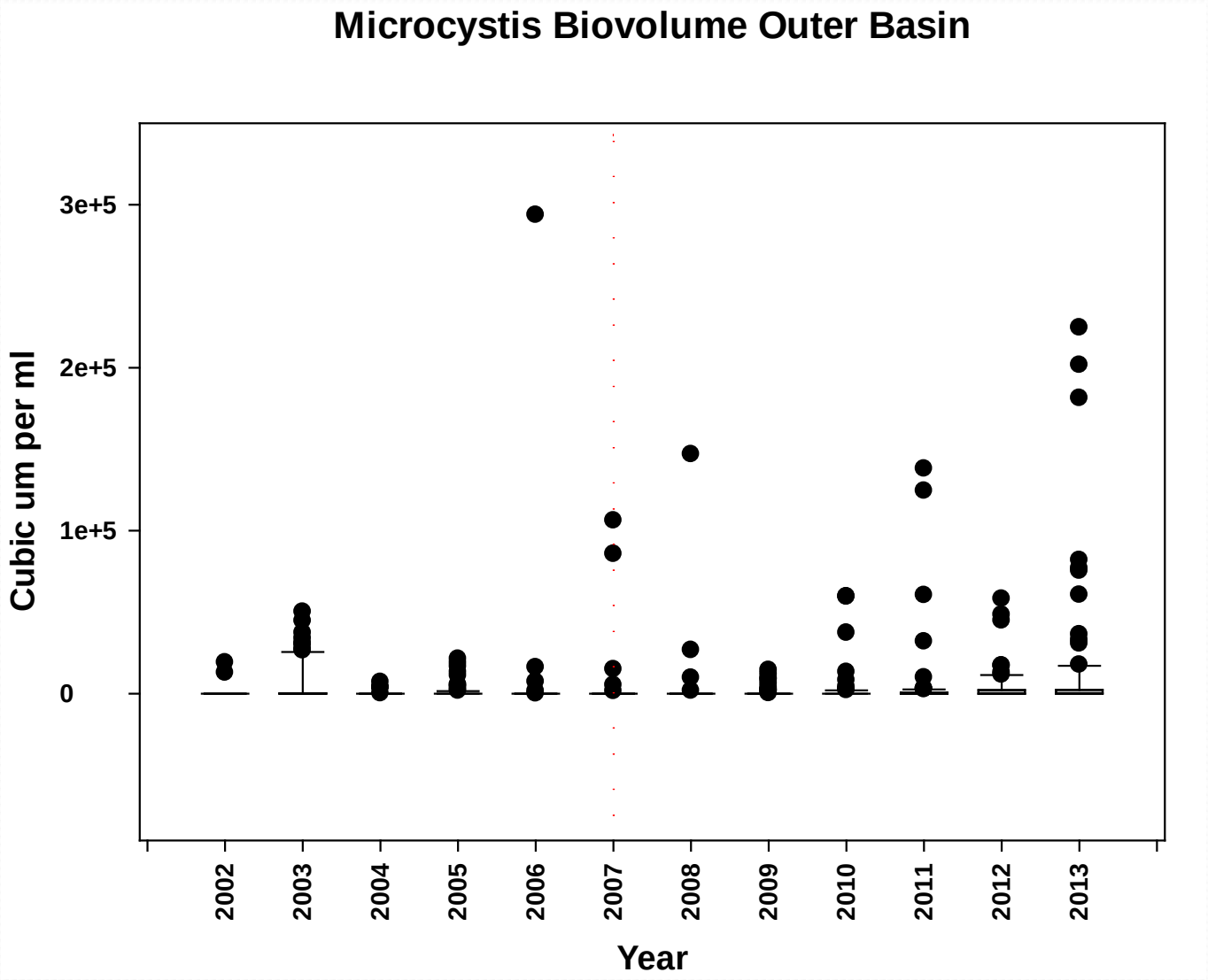
Microcystis spp



Microcystis spp.



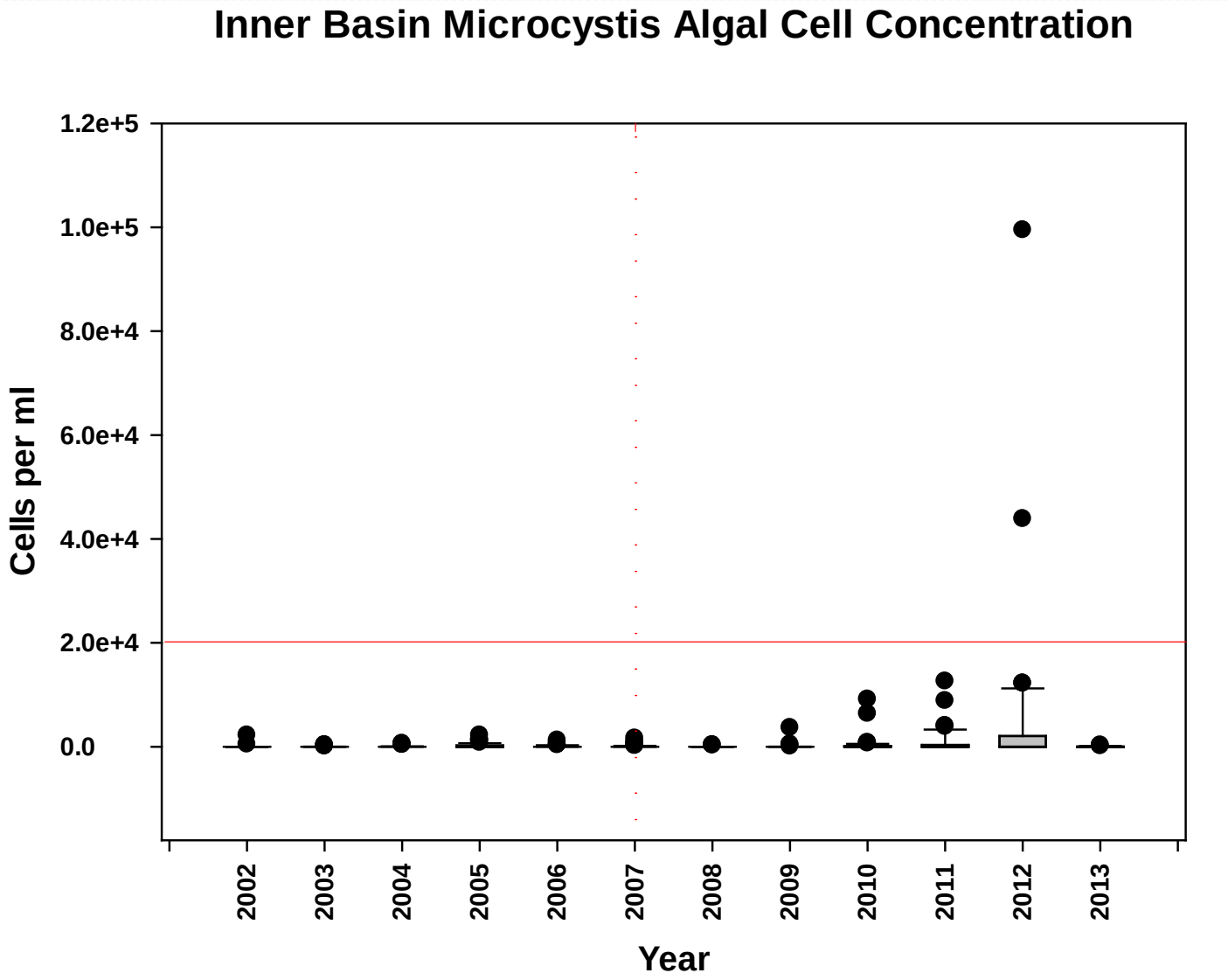
Microcystis spp.



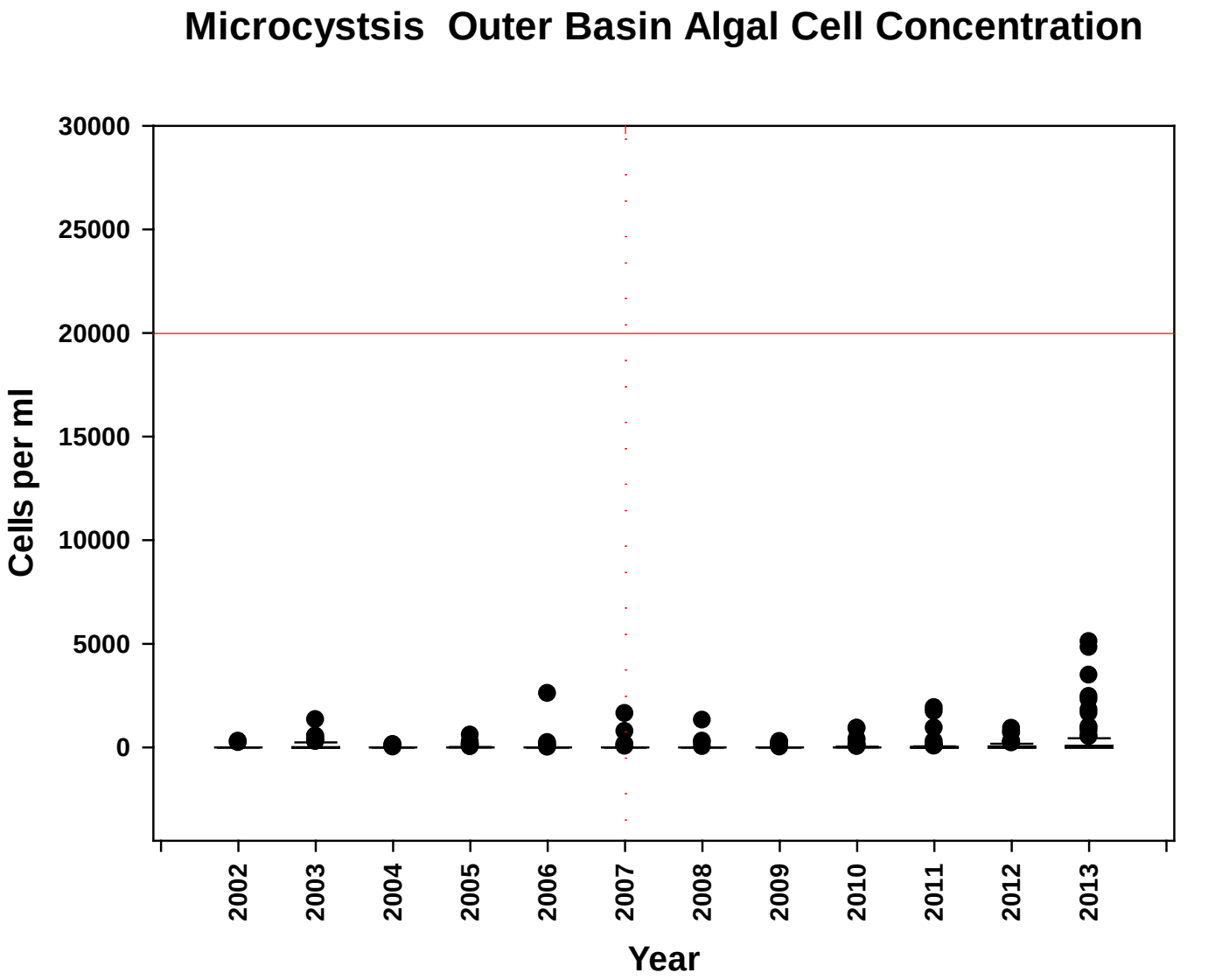
Microcystis spp.

- SNWA is not detecting microcystin, despite increasing *Microcystis* populations.
  - Primary species seems to be *M. wesenbergii*
  - Cell numbers rarely reach high enough concentrations to produce detectable toxin
  - Conductivity can influence microcystin production

Microcystis spp.

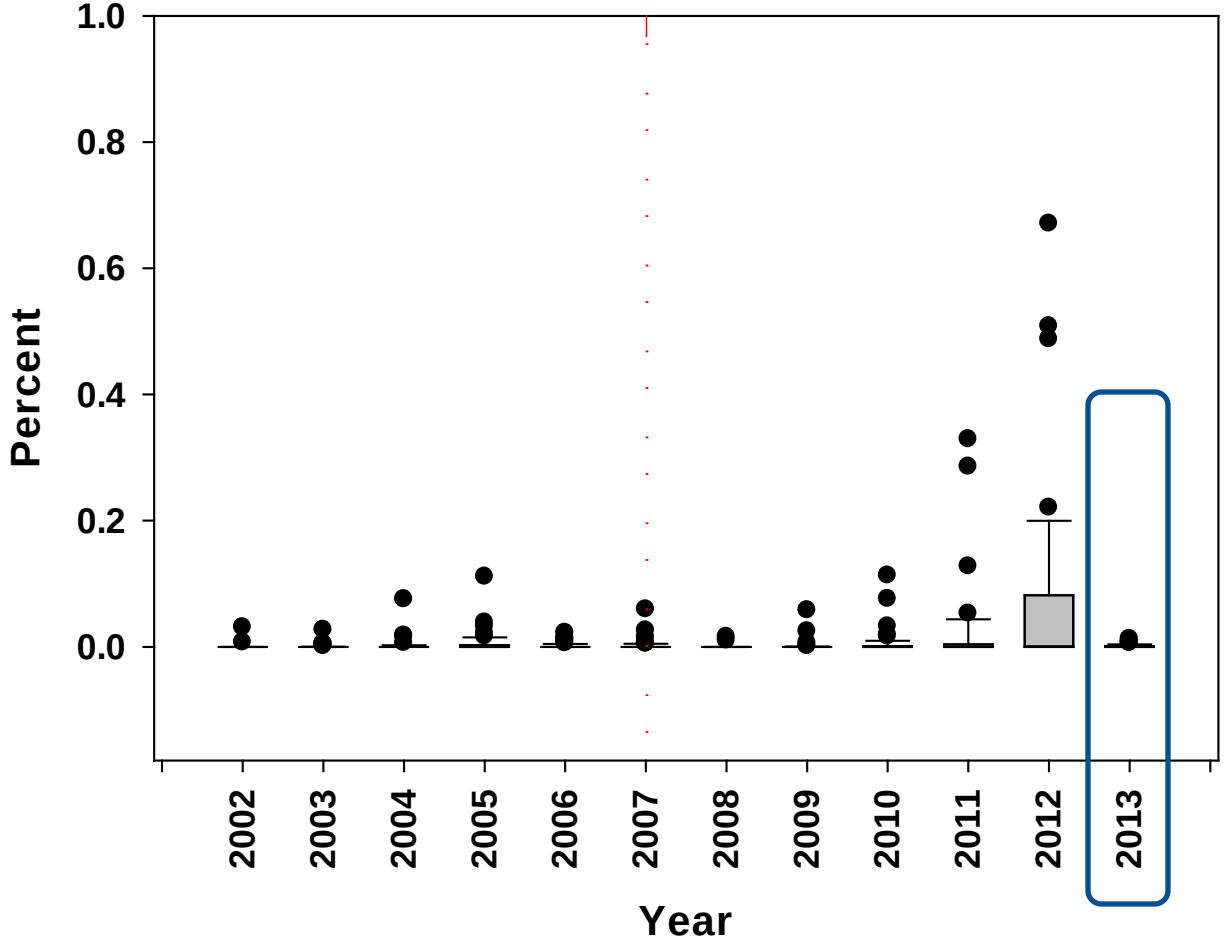


Microcystis spp.



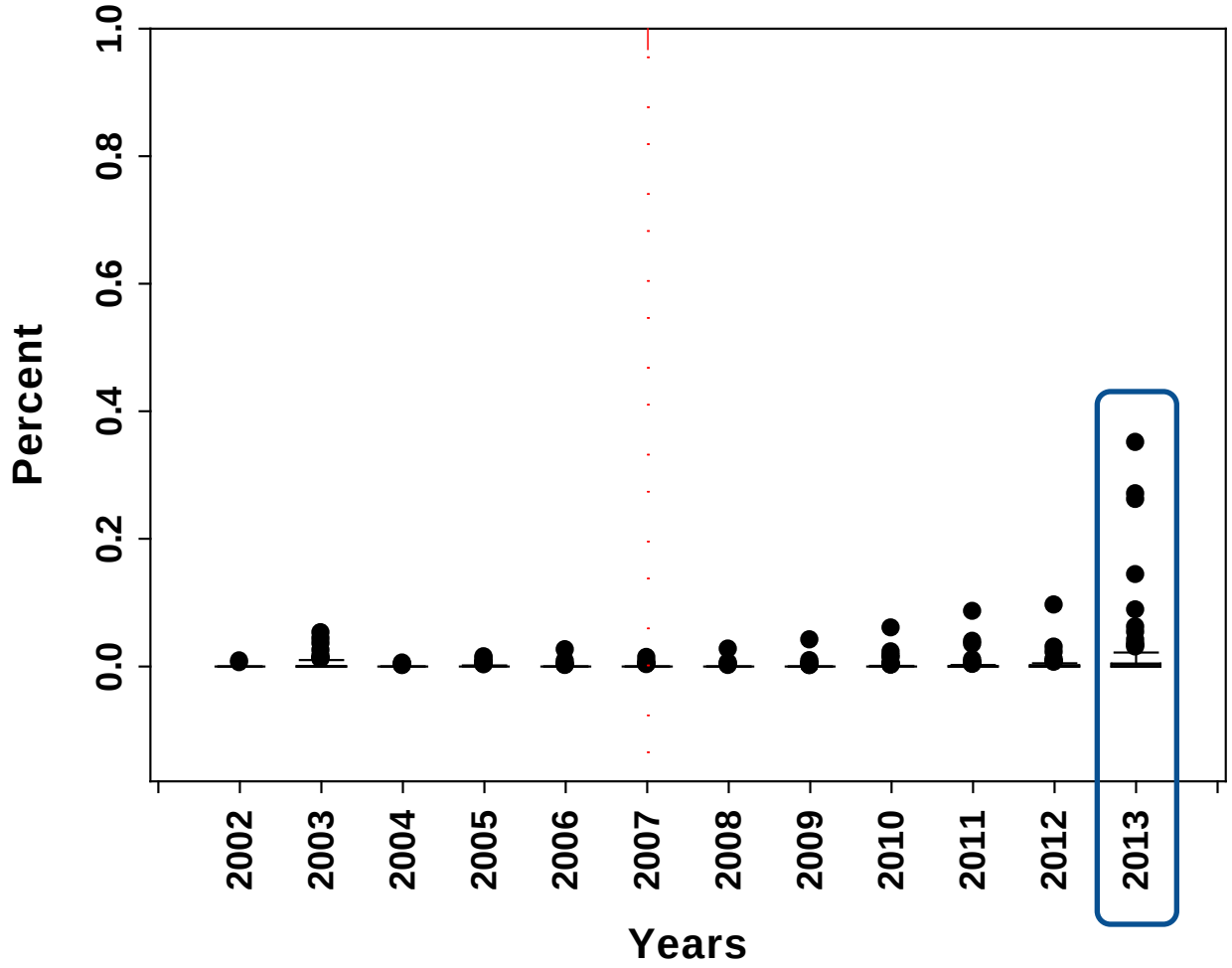
Microcystis spp.

Inner Basin Relative Microcystis Algal Cell Concentration

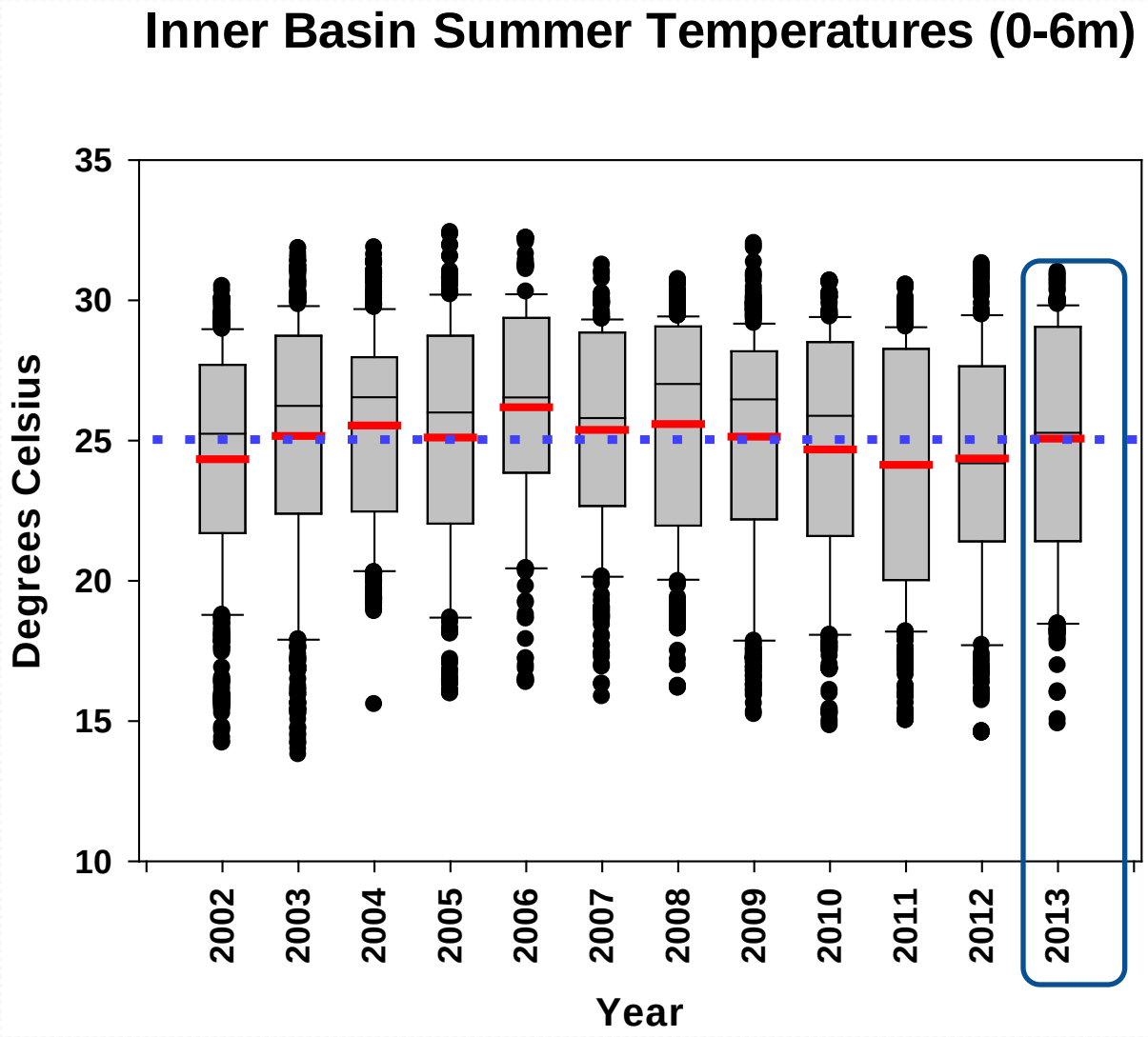


Microcystis spp.

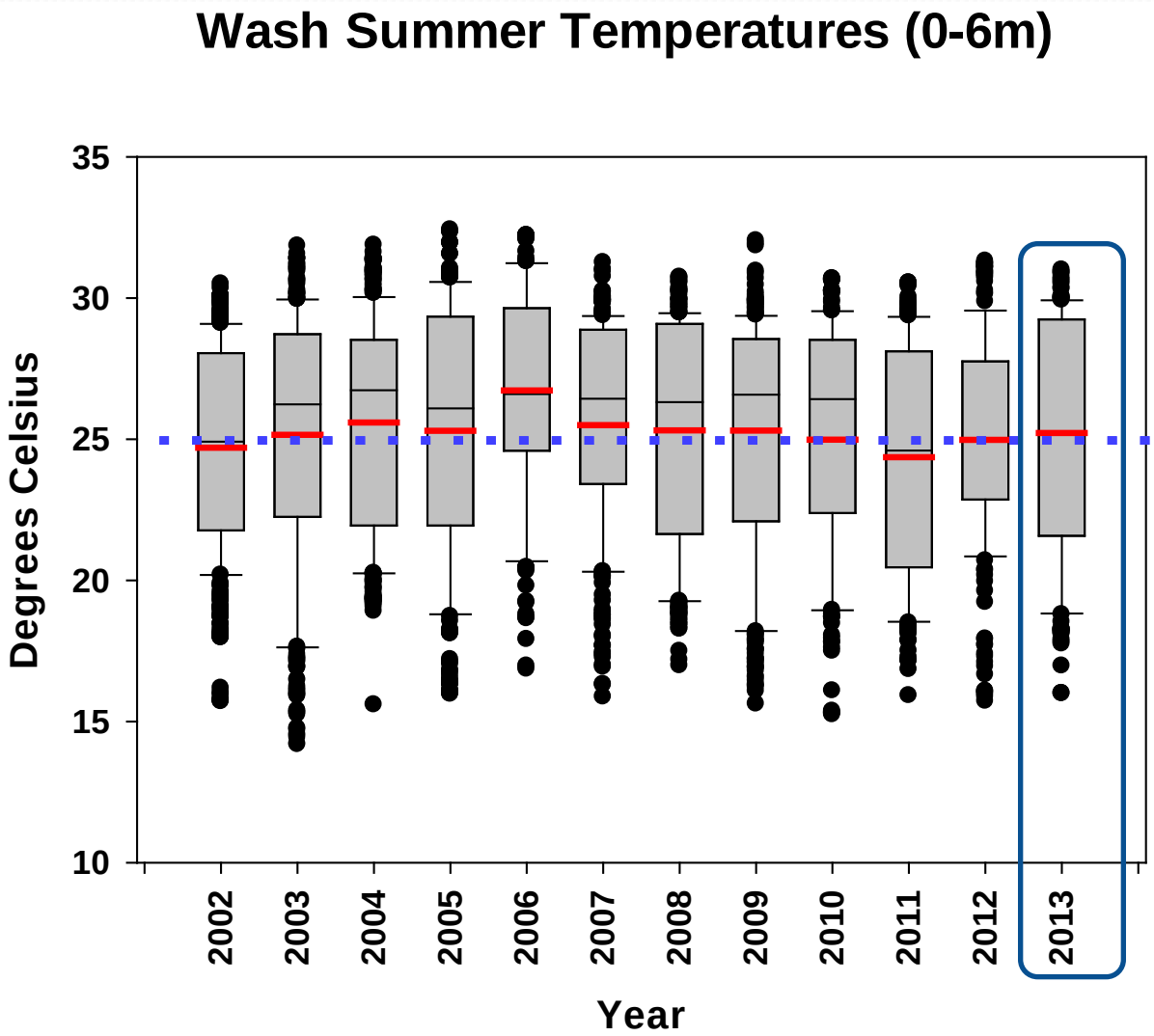
Outer Basin Microcystis Relative Algal Cell Concentration



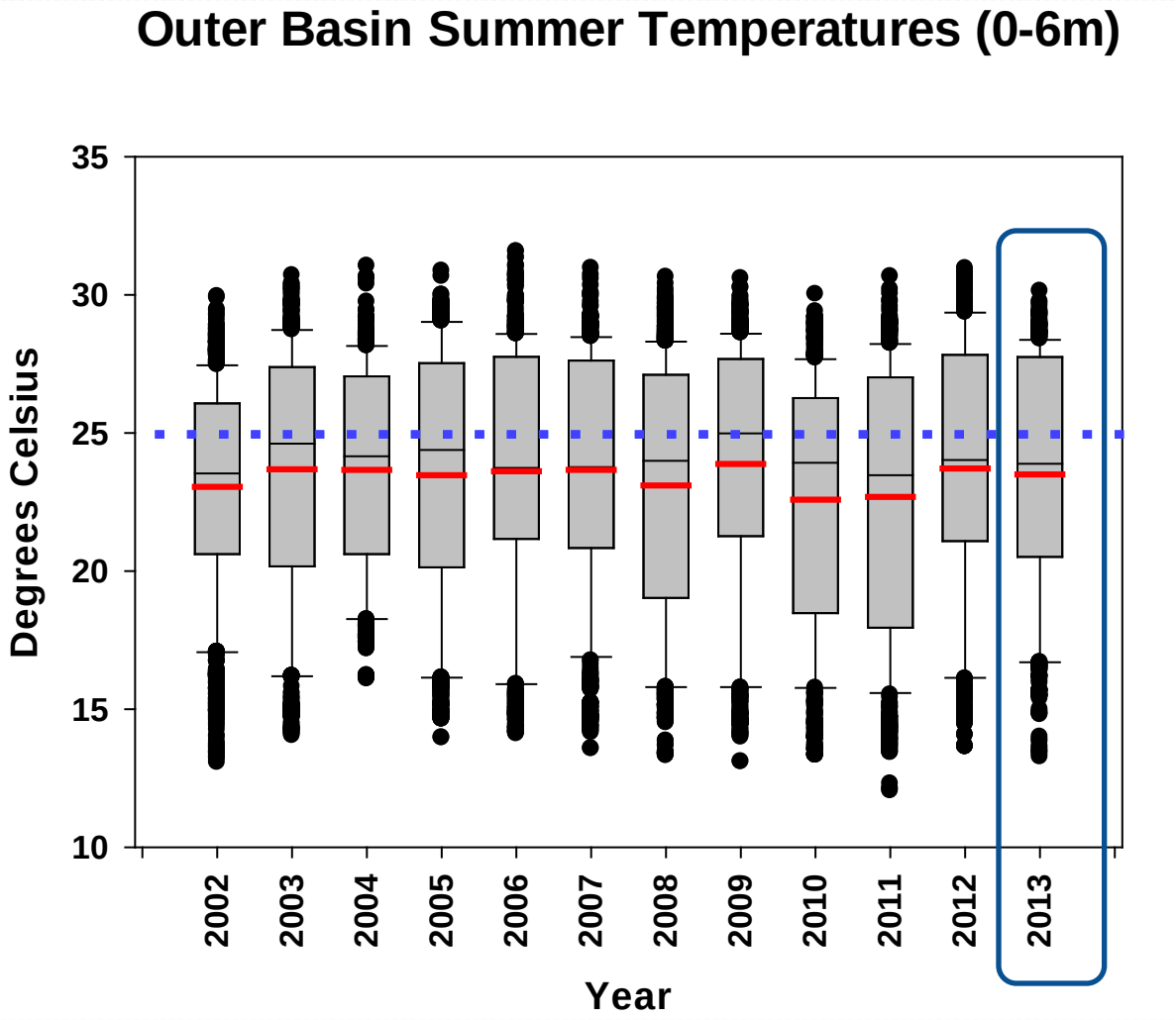
Temperature: 0-6 m



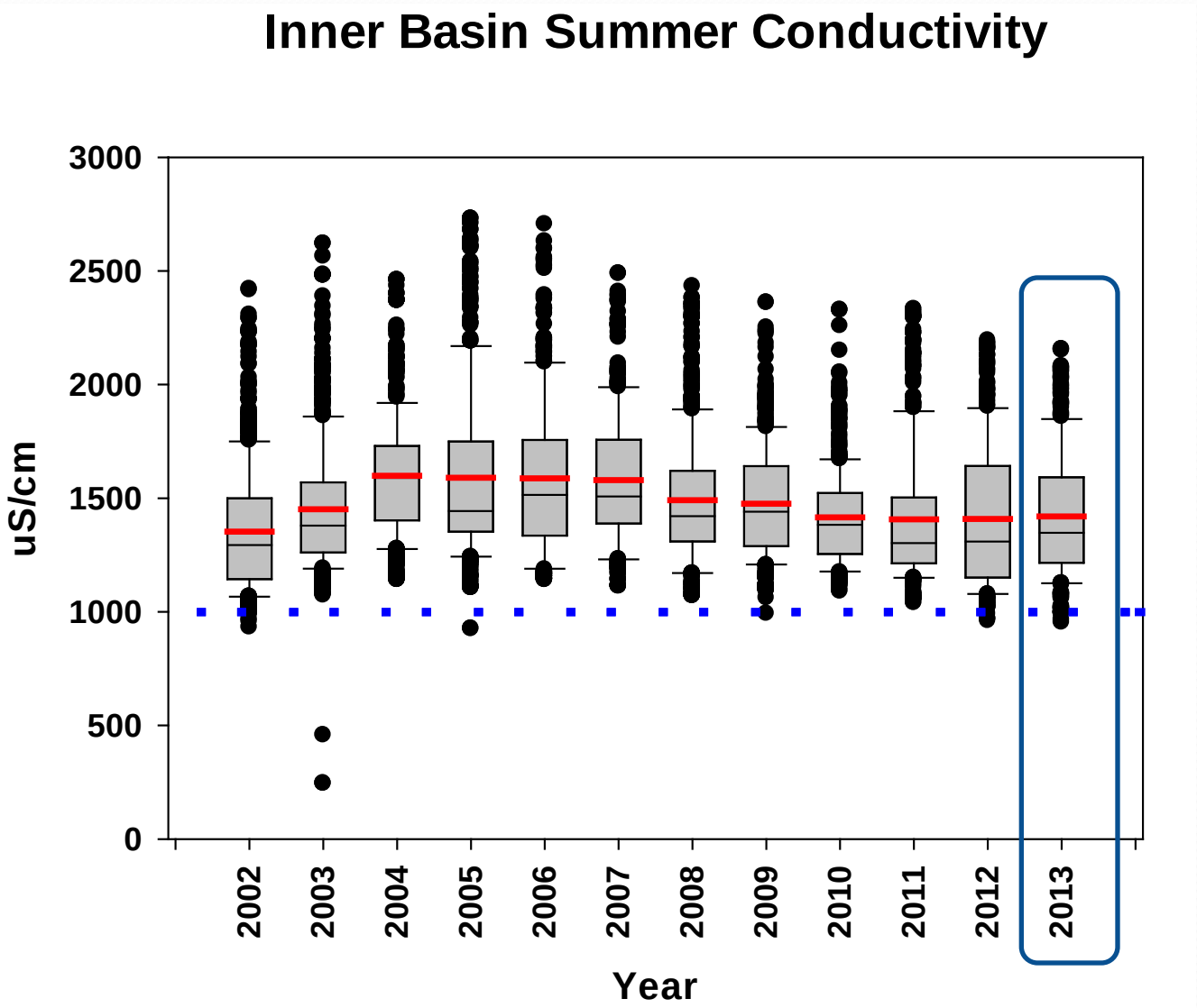
Temperature: 0-6 m



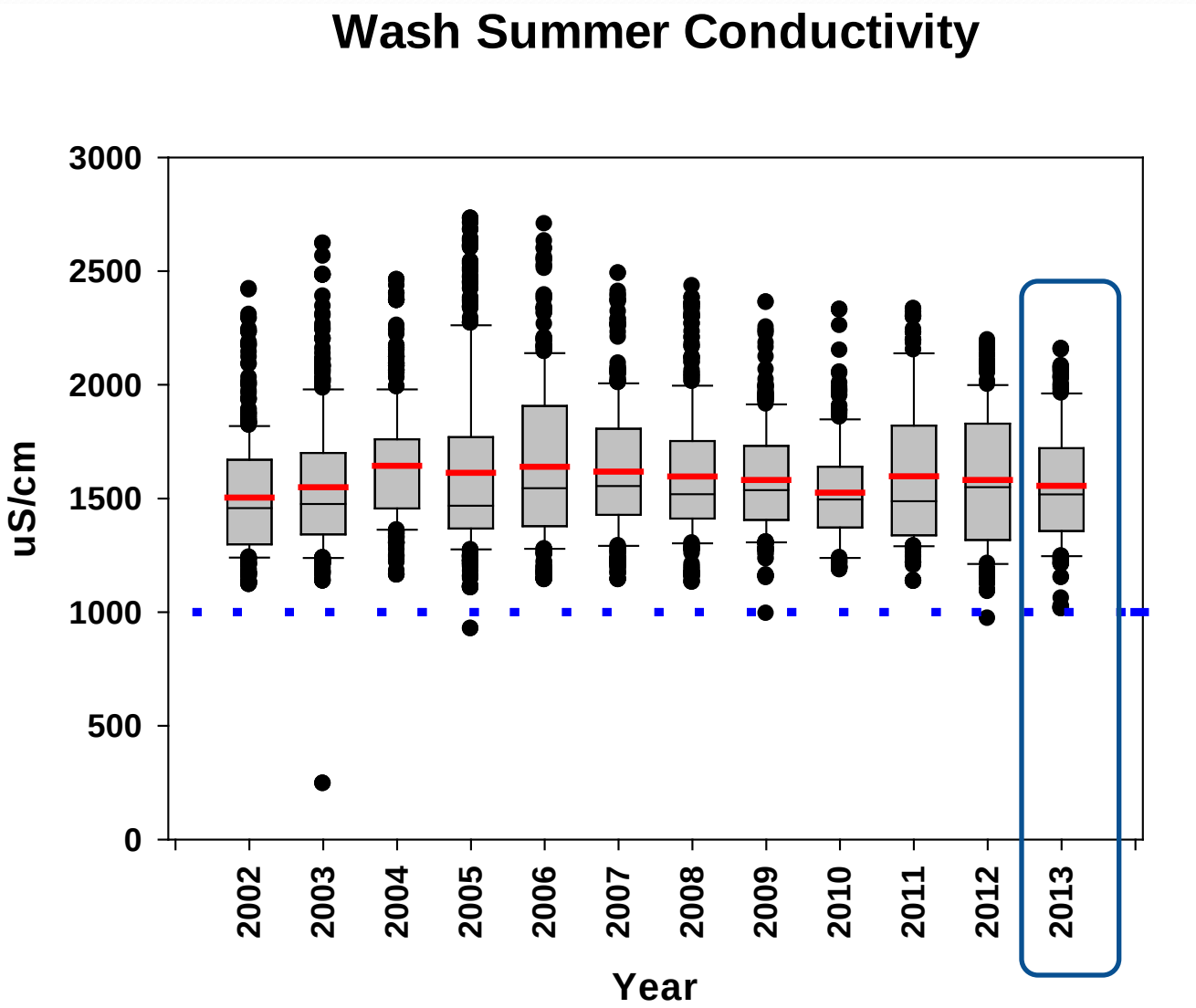
Temperature: 0-6 m



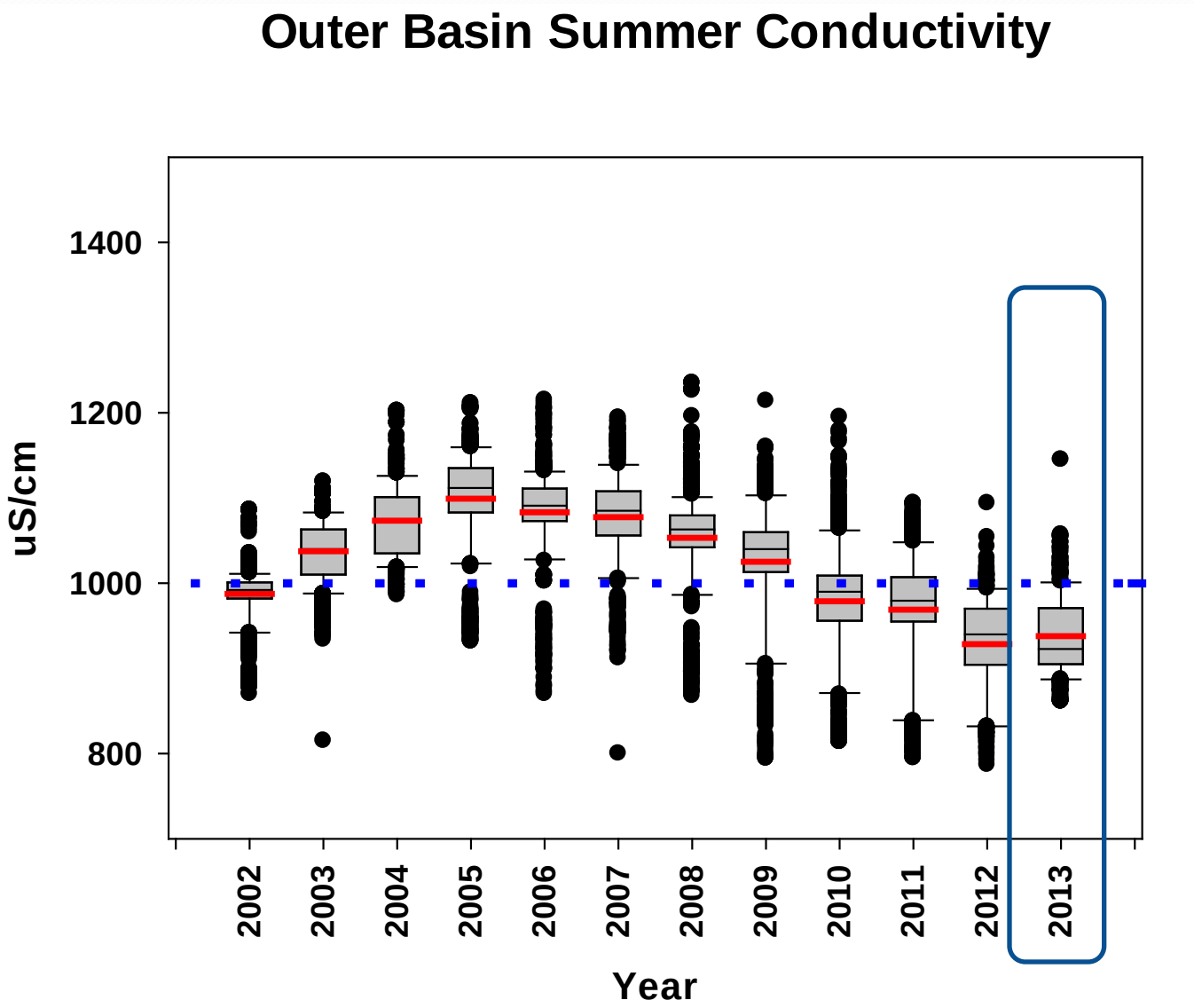
Conductivity: 0-6 m



Conductivity: 0-6 m



Conductivity: 0-6 m



Summary

- 2002-2003 is a distinct period.
  - Major Nutrient Reduction, rapid decline in elevation
- 2004-2009 is a transition period.
  - Nutrient reduction, Slight bump in elevation in 2005, Introduction of Quagga Mussels
- 2010-2013 often groups together, even if the groupings are not always statistically significant.
  - High veliger counts, but relatively few adults
  - Increase in elevation
  - Increasing importance of *Microcystis*

Conclusions

- Nutrient reductions seem to have affected the taxa community composition, slightly affected summer means, but not necessarily affected the amplitude of community abundance throughout the season.
- Conductivity has clearly changed as the lake elevation has decreased.
  - Inner Basin conductivity has **increased**, with less dilution of the wash water.
  - Outer Basin conductivity has **decreased**, with lower conductivity water coming downstream from Lake Powell.
- Taxa changes have implications for perceived water quality and fisheries.

Conclusions

- *Microcystis* has increased in relative proportion of the assemblage of both basins since Quagga mussel introduction, especially between 2010-2012/13.

- If the conductivity is relatively low, *Microcystis* abundance appears to increase.

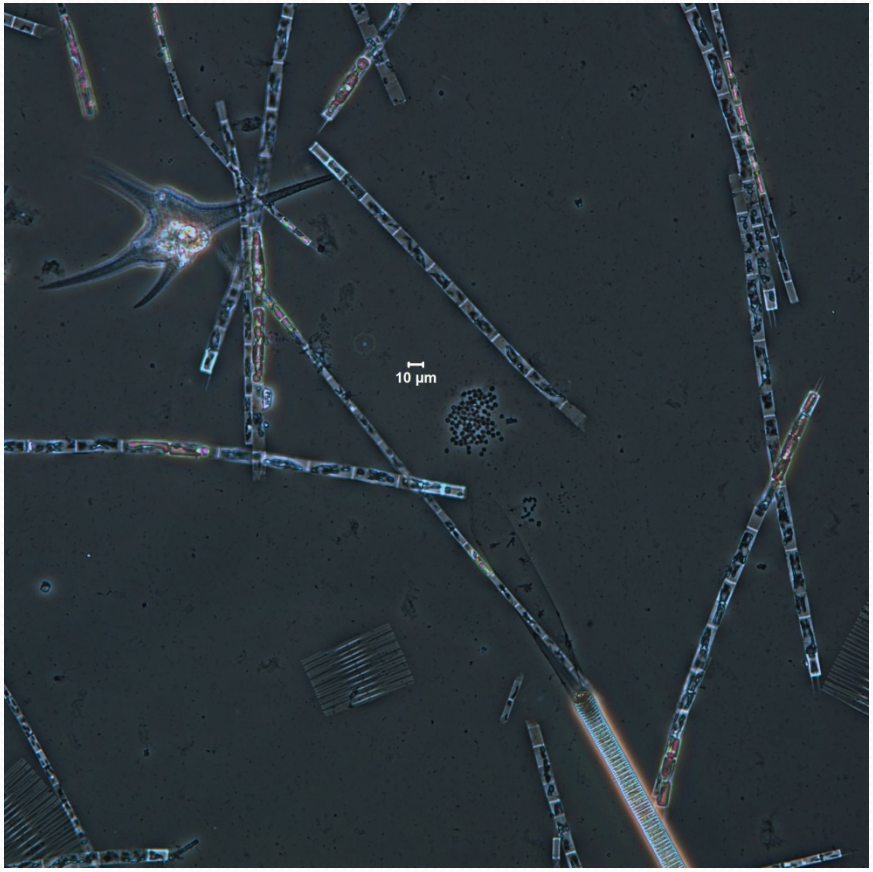
- If the conductivity is relatively high, *Microcystis* abundance appears to decrease.
  - High conductivity also seems to reduce microcystin production in other systems, which may help explain ND on microcystin.
  - *M. wesenbergii* does not consistently produce toxin.

Next Steps

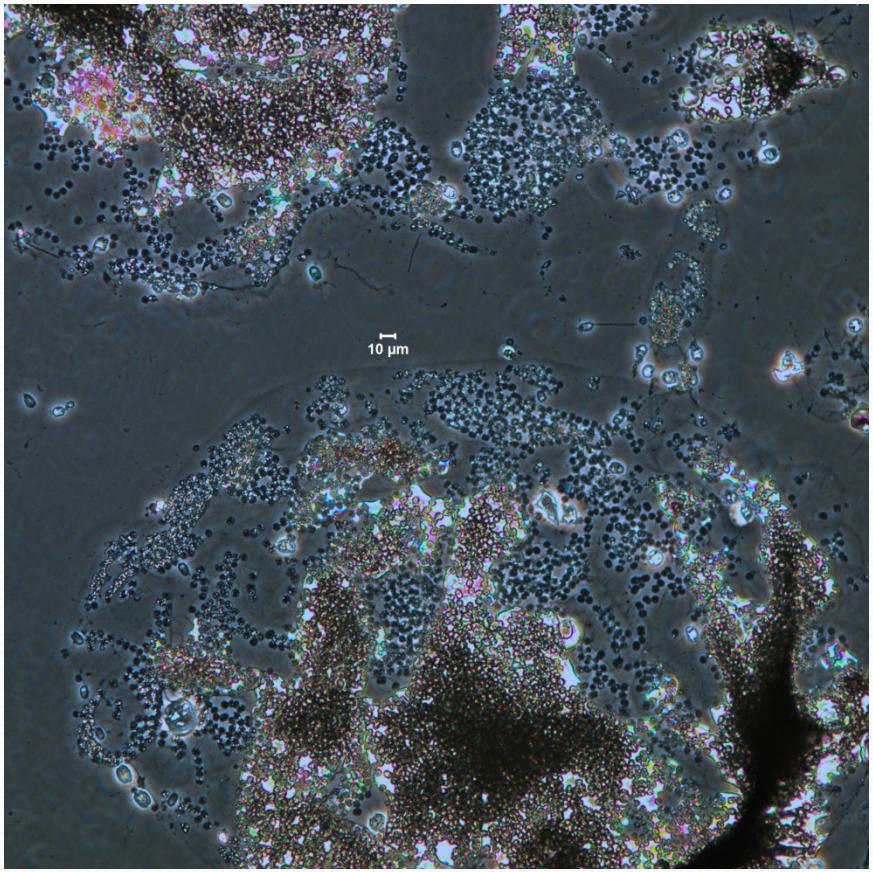
- Fully analyze the other response variables.
- Analyze the rest of the taxa of interest
  - Pyramichlamys (Tetraselmis)
  - Aphanizomenon
  - Cylindrospermopsis
  - Cyclotella
  - Fragilaria
  - Picoplankton
- Look at fine tuning basin definition
- Incorporate environmental variables into MDS analysis.

Then and Now…

Wash – 10/14/1992



Wash – 10/18/2012



PhycoTech

Questions?