

Blue-green Algal Toxins in Minnesota Lakes

Harmful Algal Bloom Workshops 2008

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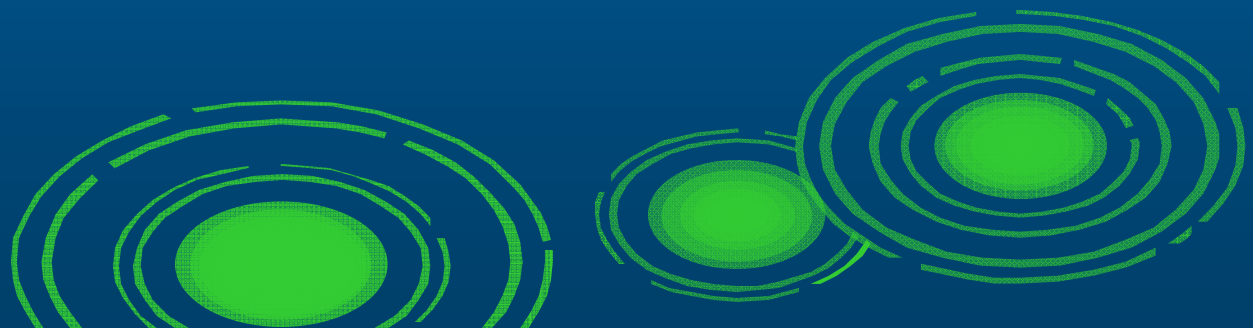


Minnesota Pollution Control Agency



Outline

- **Brief history on MN algal toxin issues;**
- **Overview 3 studies that examine blue-green algal toxins in MN – focus on microcystin (MC);**
- **Overview of findings**
- **Recommendations based on studies to date;**

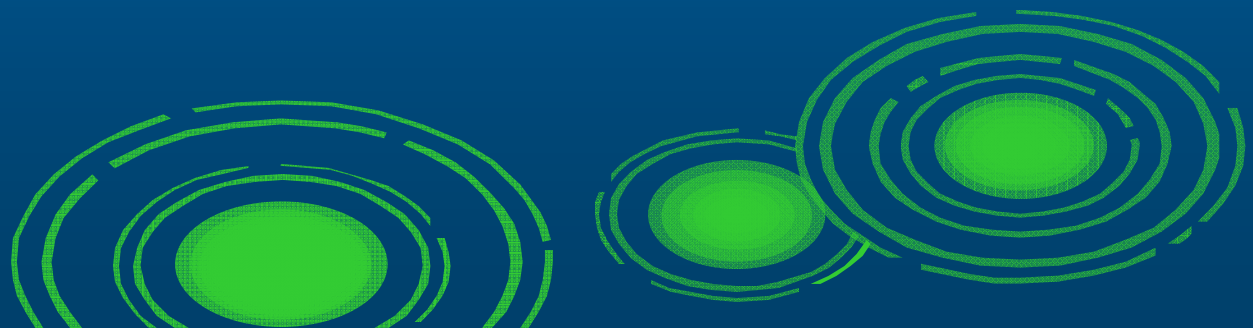


Minnesota History With Algal Toxins

- Accounts of algal toxicity in MN go back to 1800's on live stock
- Increasing concern and reports world wide
- Three dog deaths in 2004 (Fish and Benton) prompted further work on this issue.
- 2005 MPCA joined MDNR, MDH and the Minnesota Veterinary Medicine Association (MVMA) to form the Minnesota Blue-green Algal Toxicity Workgroup
- 2006 study conducted to examine MC in several eutrophic lakes in two south central MN counties
- 2007
 - Five confirmed dog deaths
 - Very high MC results (>80,000 µg/l)
 - National Lake Assessment assessed MC in 50 randomly-selected lakes;
 - MC monitored in 35 southern MN lakes;

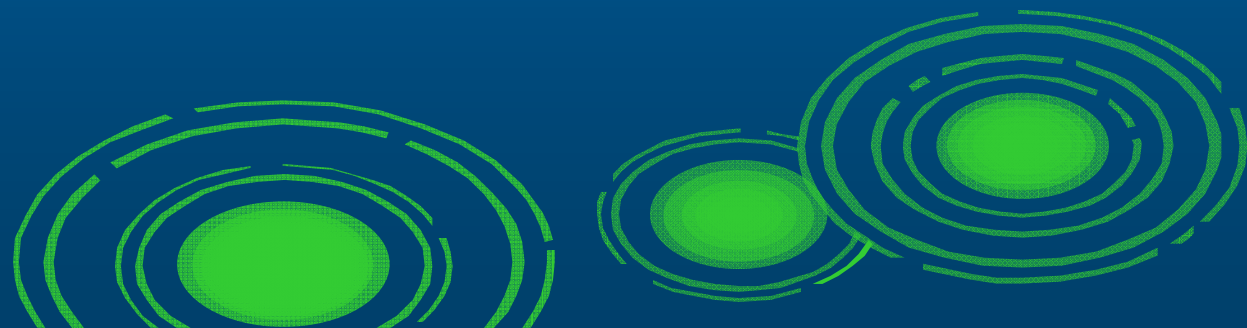
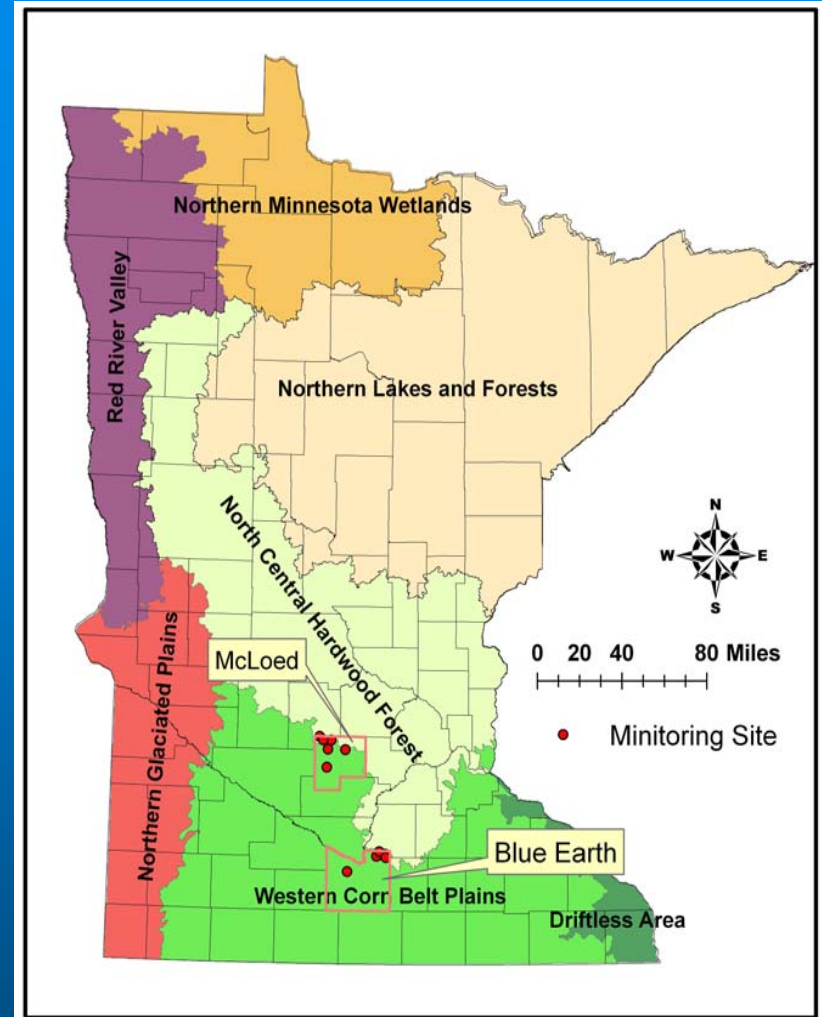
Questions addressed in the 2006 study

- What is the range in MC in eutrophic / hypereutrophic MN Lakes
- Is there a significant difference in near-shore MC as compared to mid-lake?
- Is there seasonality to MC concentrations?
- What limnological and physical factors appear to be associated with high MC?
- How can these findings be used to communicate risk to lake users?



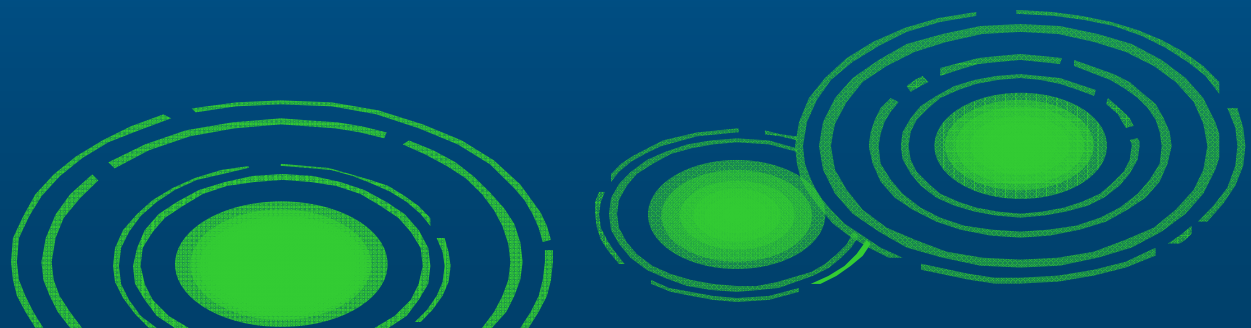
2006 South-Central MN Study

- 12 eutrophic –hyperutrophic lakes
- Sampled six times May- Sept.;
- Mid-lake “pelagic” site – full water chemistry
- Near-shore (bloom hunting) site, typically downwind or distinctly higher algal concentration;



Methods

- Surface grab samples were taken monthly
- MC samples underwent triple freezing, cell lysis procedure.
- MC analysis was done at MDH
 - ELISA (Enzyme-Linked ImmunoSorbent assay)
 - Method detection limit (MDL) 0.15 µg/L.
 - The analysis tests for total MC

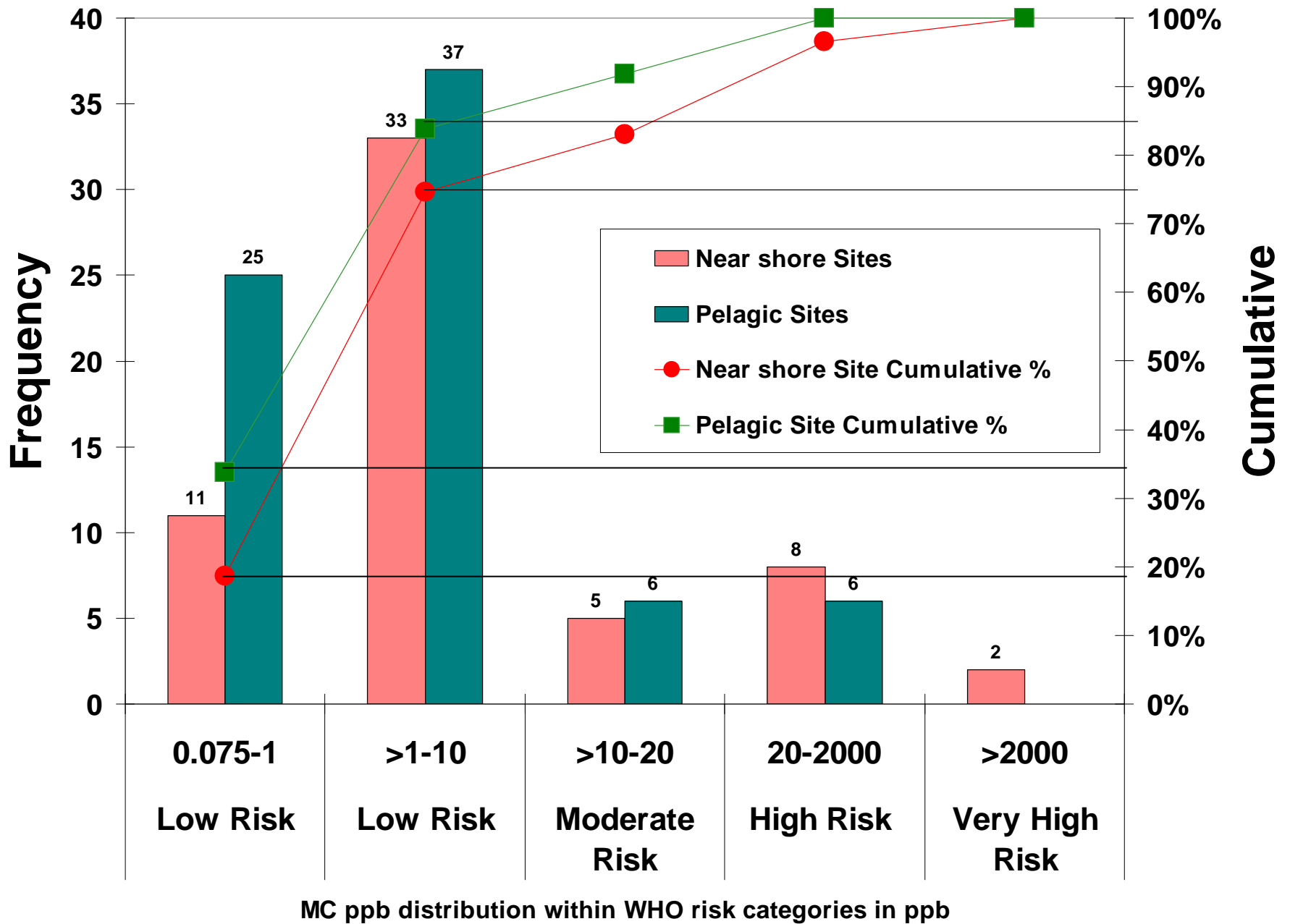


Standards or guidelines

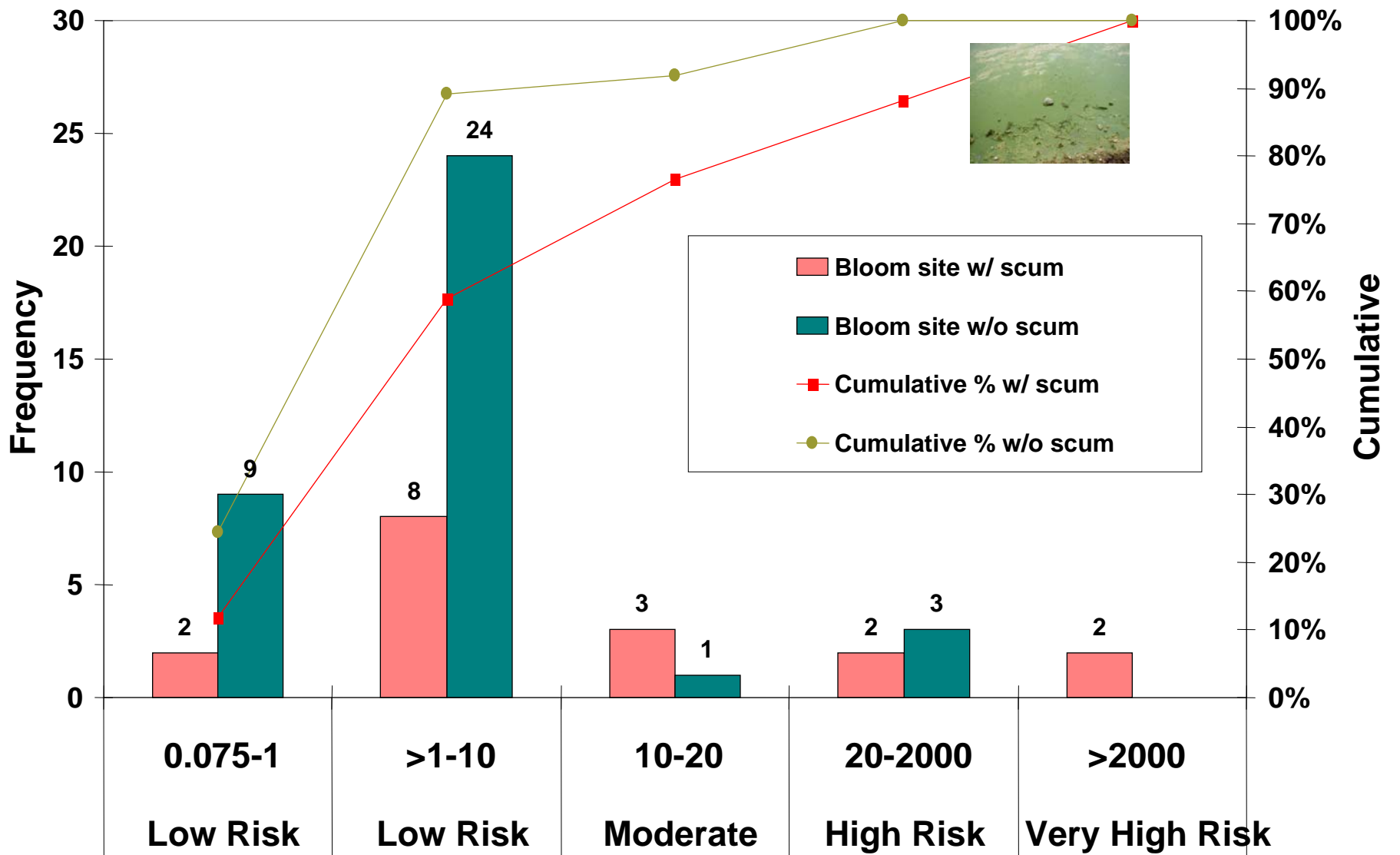
- ***No MN standards***
- **World Health Organization (WHO) Risk Categories**
(used as reference in our study)
 - **<1 µg/L (ppb) very low (below drinking water guideline),**
 - **1-10 µg/L Low,**
 - **10-20 µg/L Moderate,**
 - **20-2000 µg/L High**
 - **>2000 µg/L Very high**

Guidelines for safe recreational water environments (WHO, 2003).

MC Distribution by Site and Risk Category

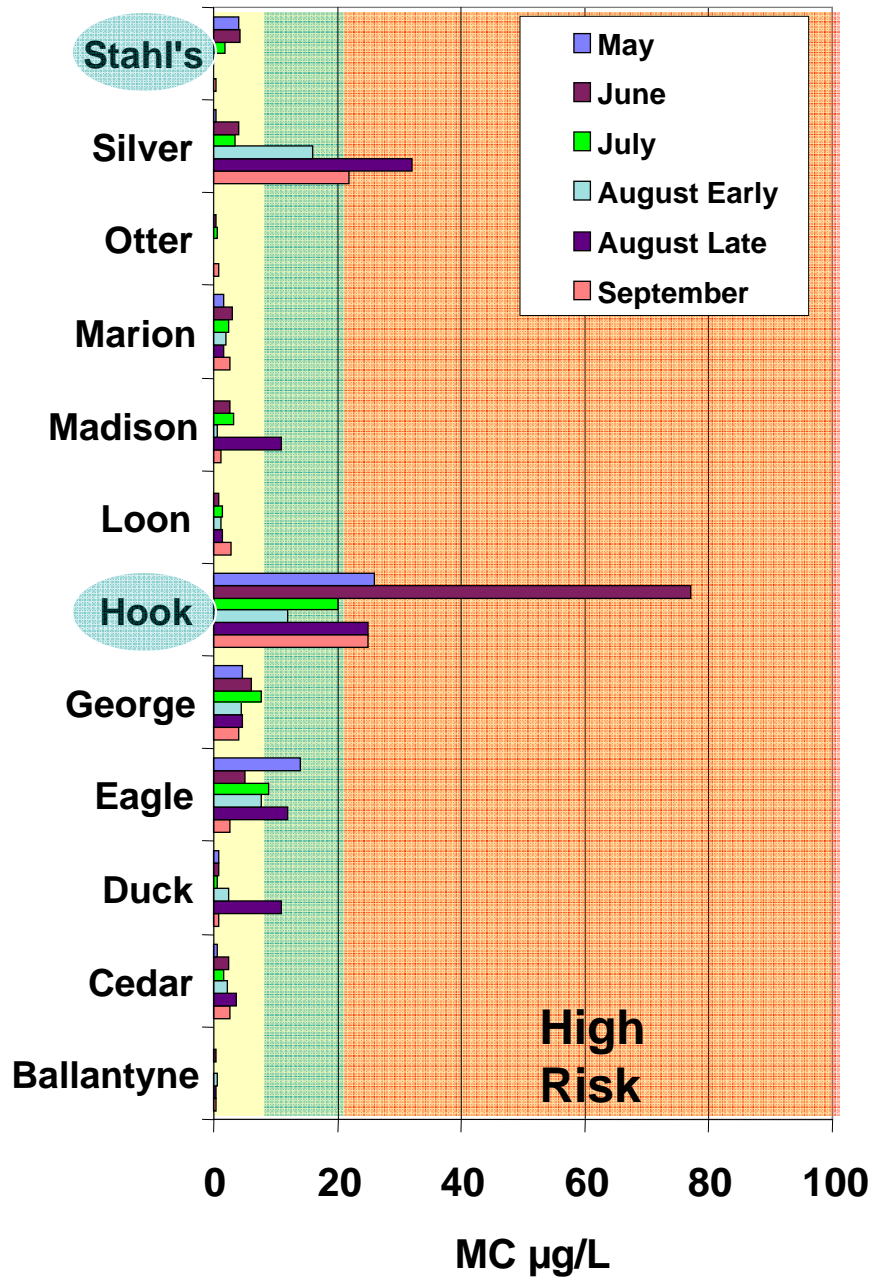


Near-shore: Scum vs. no Scum

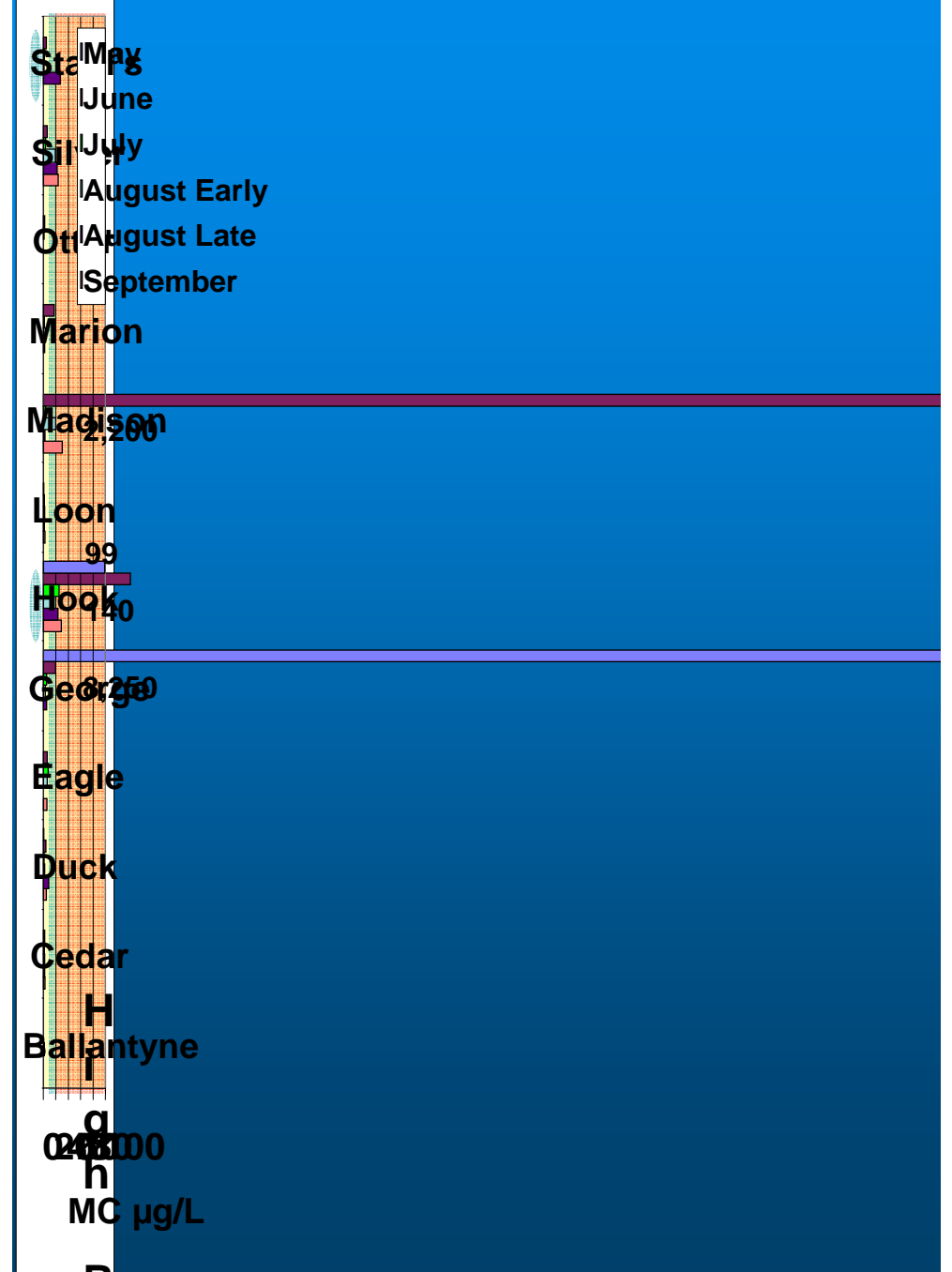


MC $\mu\text{g/L}$ Range and WHO risk categories

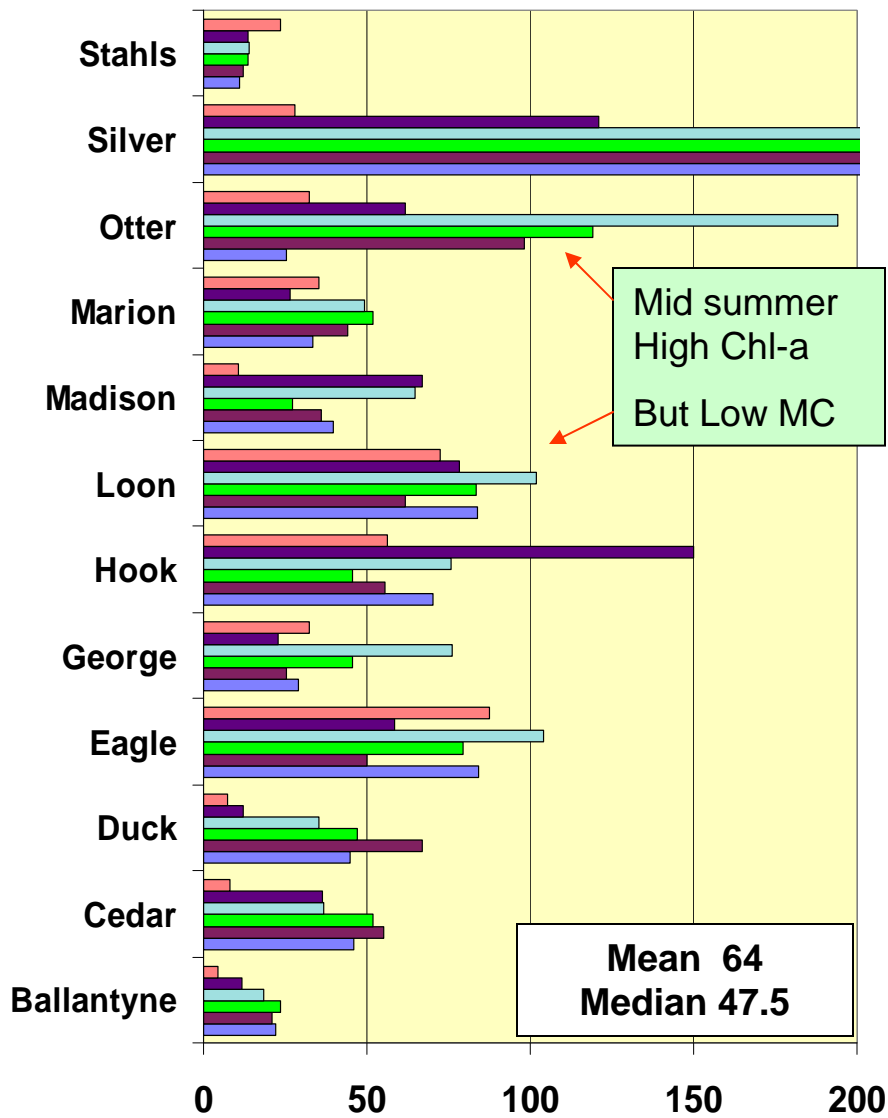
Pelagic sites



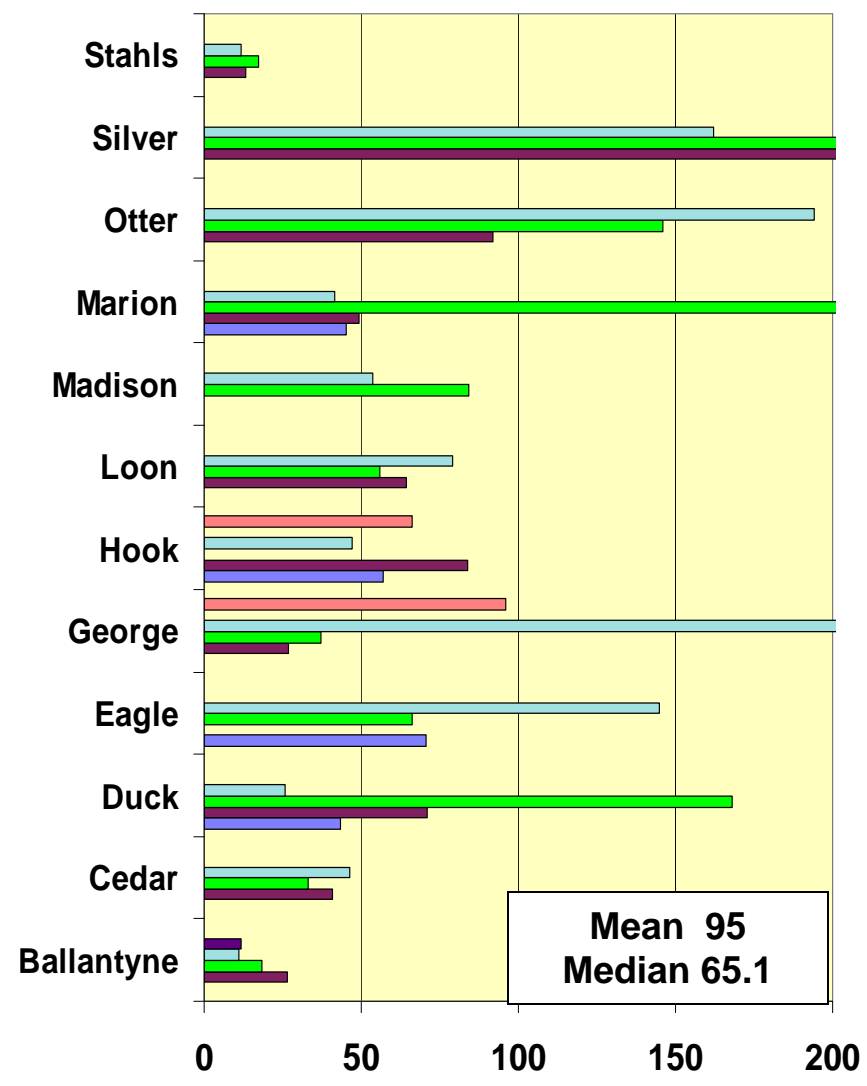
Near Shore sites



Pelagic Sites

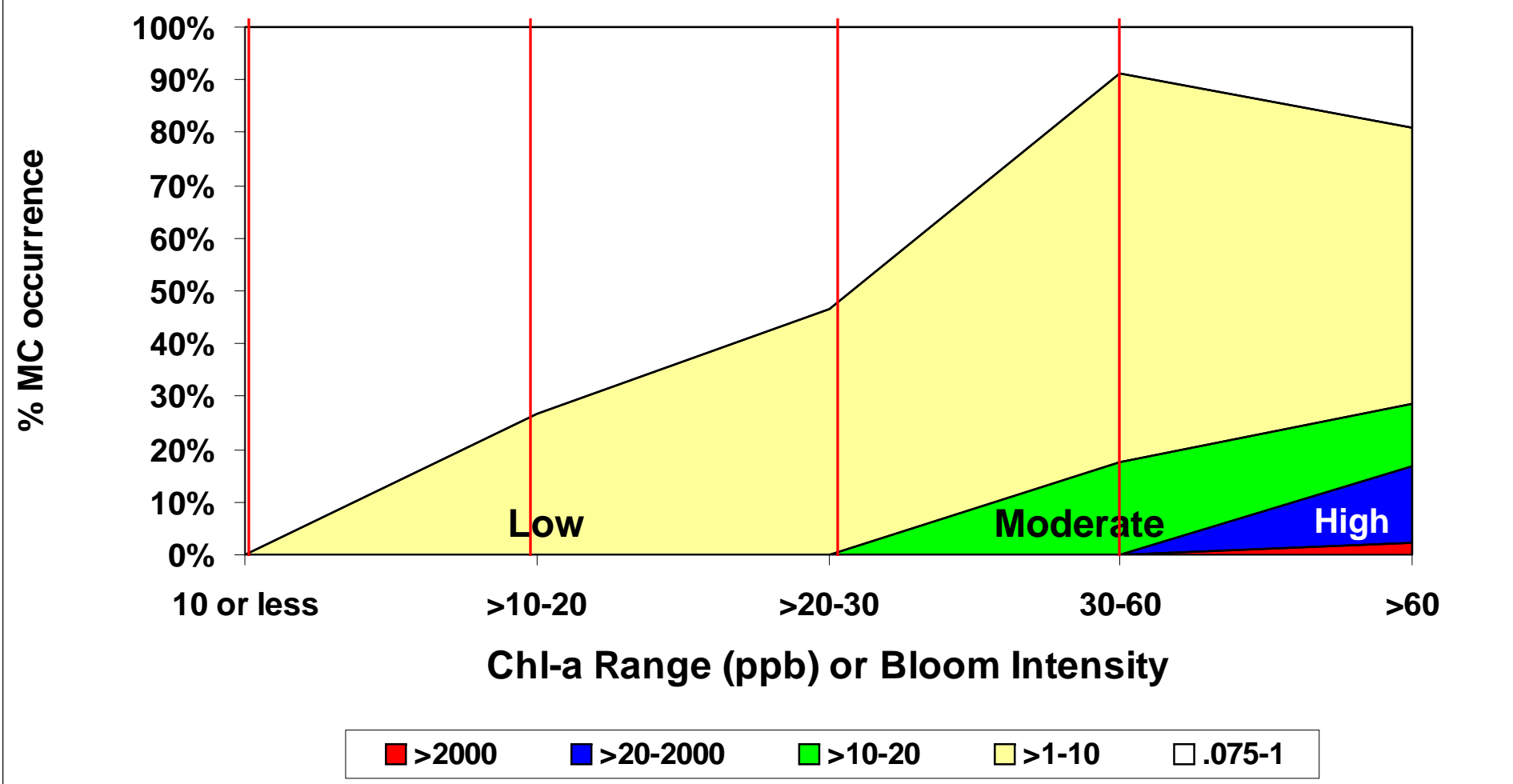


Near Shore Sites



Percent occurrence of MC risk levels relative to algal bloom intensity

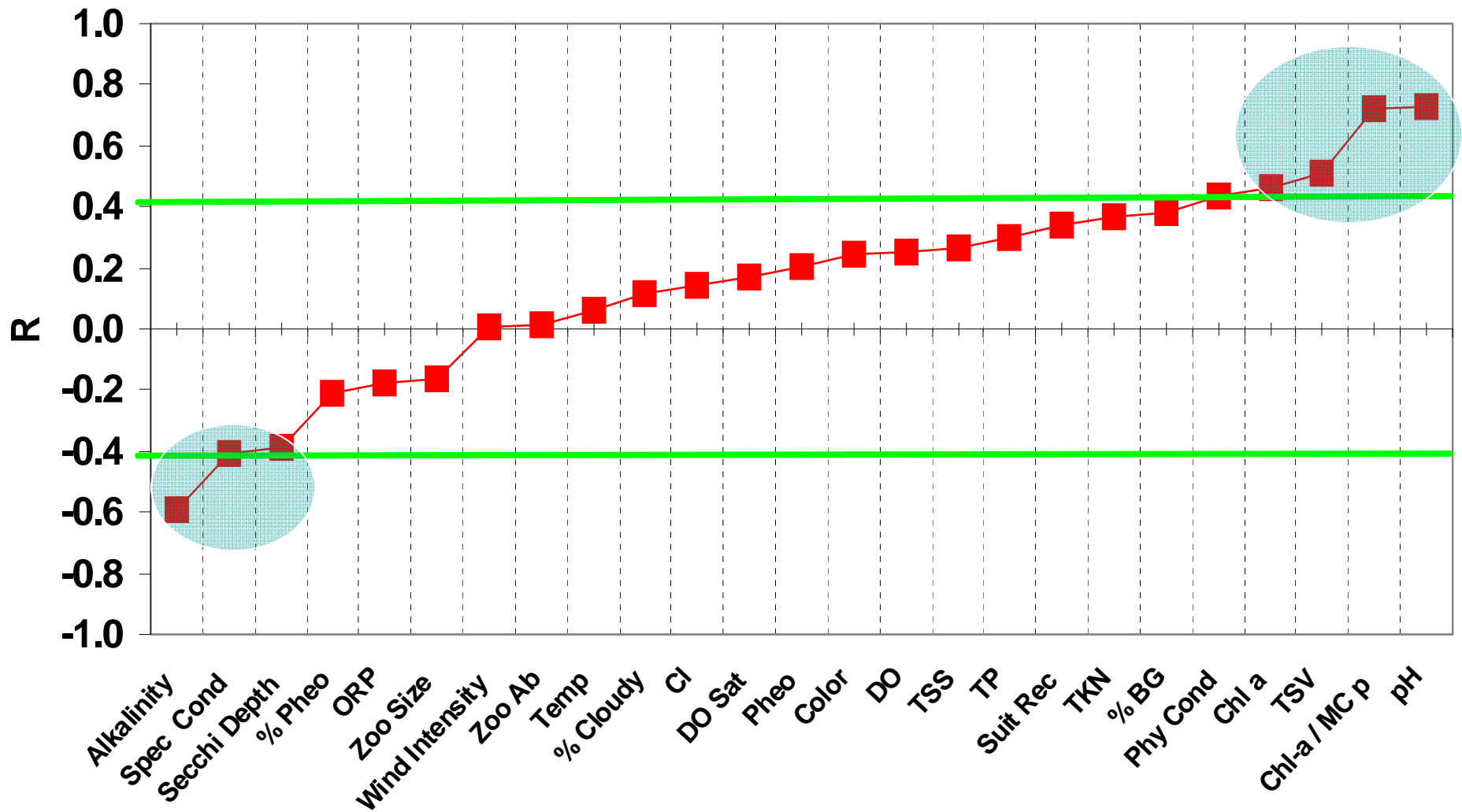
MC versus bloom intensity. Based on 109 pairs of MC & chl-a data



Spearman Rank Correlations for MC and Select Variables:

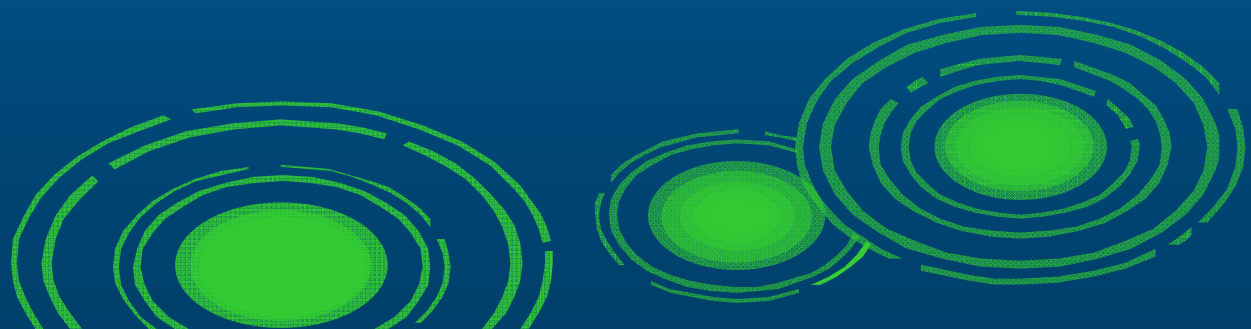
Sig. pos (+): pH, chl-a attributed to MC producers & chl-a/TSV

Sig. neg (-): alkalinity, conductivity, Secchi



Conclusions from the 2006 Study

- Likelihood of encountering measurable MC at pelagic site?
 - **94% MC results were above mdl at all sites (n=79)**
- How do they compare to WHO guideline levels?
 - **25% of the results were above the WHO low risk category**
- Do MC conc. differ between near-shore and pelagic sites?
 - **Significantly different distributions**
 - **40 % of mid-lake were less than 1 µg/L vs. 23% of near-shore**
 - **Greater occurrence of high risk levels at near-shore**
 - **The likelihood of a moderate to high risk MC at a near-shore with a scum is 25%**

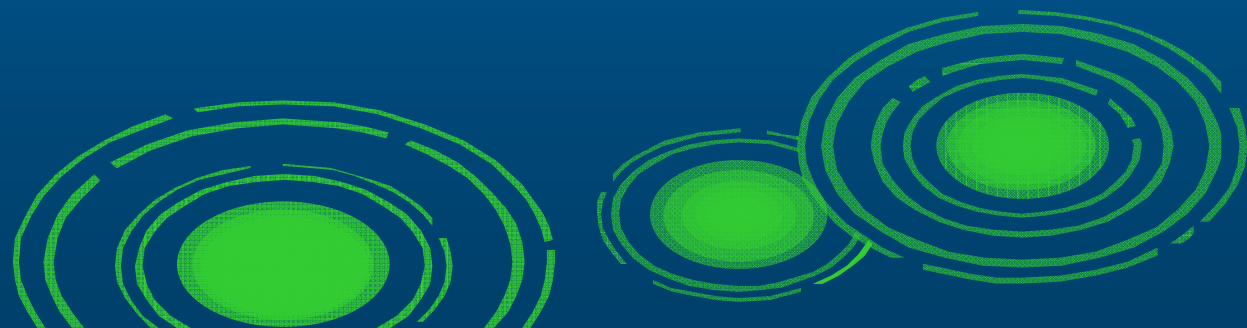


Continued

- Is there seasonality to MC levels in these lakes?
 - **No distinct seasonal trend evident;**
- As bloom intensity increases is there a greater likelihood of encountering high MC values?
 - **Yes, as chl-a exceeded 30 µg/L (severe nuisance bloom levels) risk of high MC increased to ~ 15%; in contrast at lower bloom levels all MC was in the low risk category.**
- What limnological factors appear to be associated with high MC?
 - + **association with: pH, TSV and chl-a of MC producers**
 - **association with: alkalinity, Cond. and Secchi**
- How can these findings be used to communicate risk to lake users?
 - **Highest risk MC is most often associated with severe nuisance blooms that result in low transparency (0.5 m or less), high pH (9.0 or more), and that occur most frequently in downwind near shore areas;**

Algal Toxin studies: 2007

- NLAP study with mid-lake & near-shore MC measures for 50 lakes;
- 35 lakes in SW MN included Saxitoxin as well as MC;
- Responding to reports of severe blue-green blooms, dog deaths and related concerns – as early as June;



NLAP Methods

Collection



index site for EPA & MPCA



random near-shore site

Analysis



Cells were lysed



Analyzed with ELISA for total MC



MDH Lab for PCA



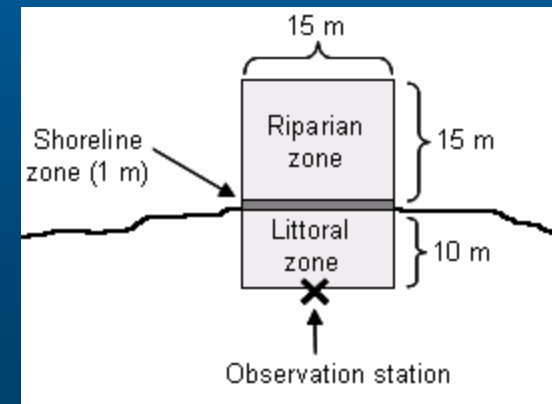
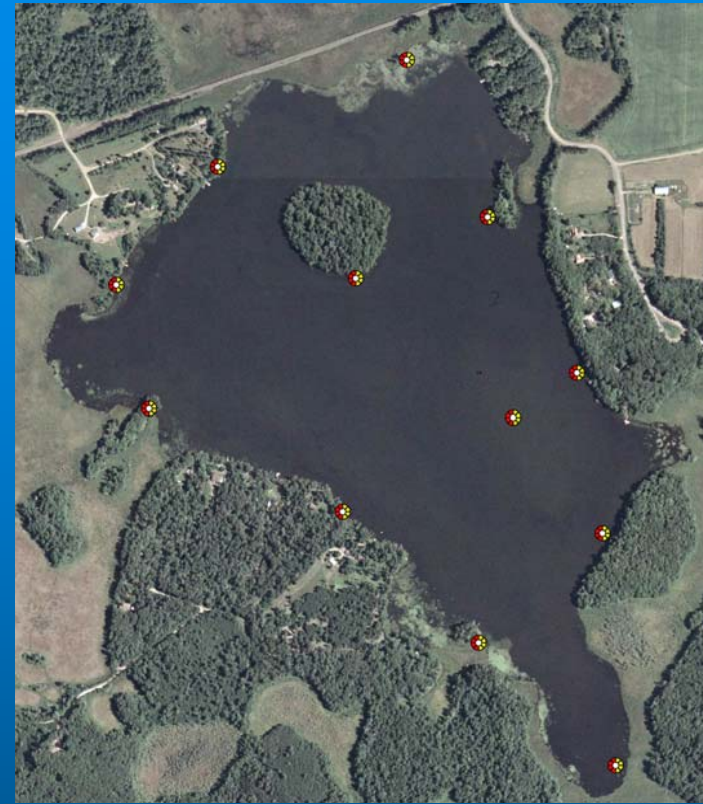
USGS Lawrence KS for EPA samples



10 of EPA samples will be scanned

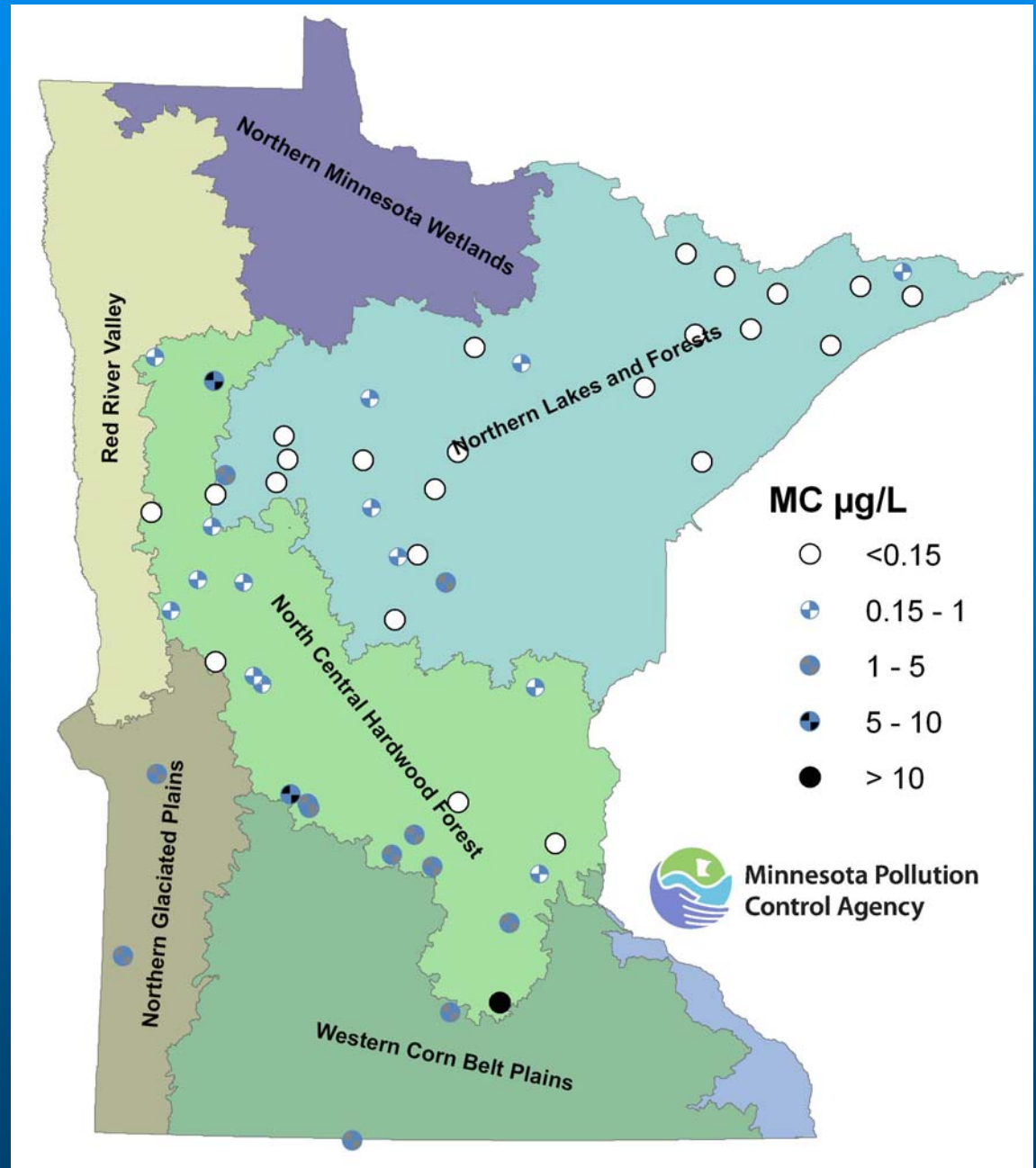


MDL 0.15 $\mu\text{g/L}$.

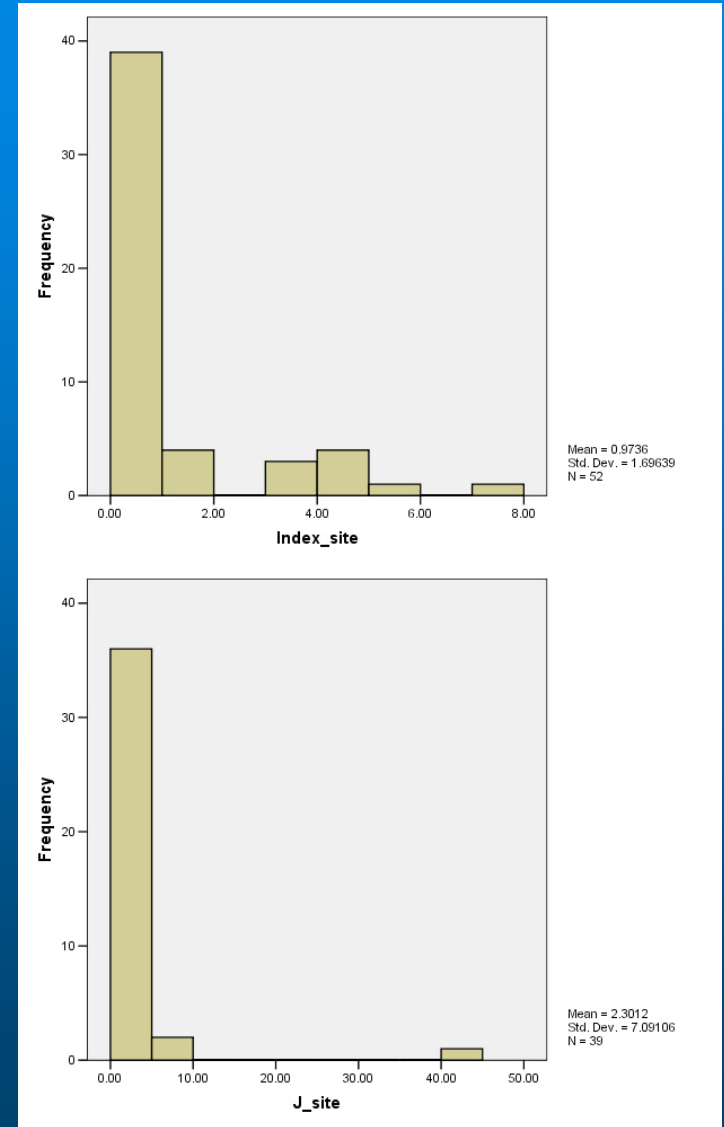
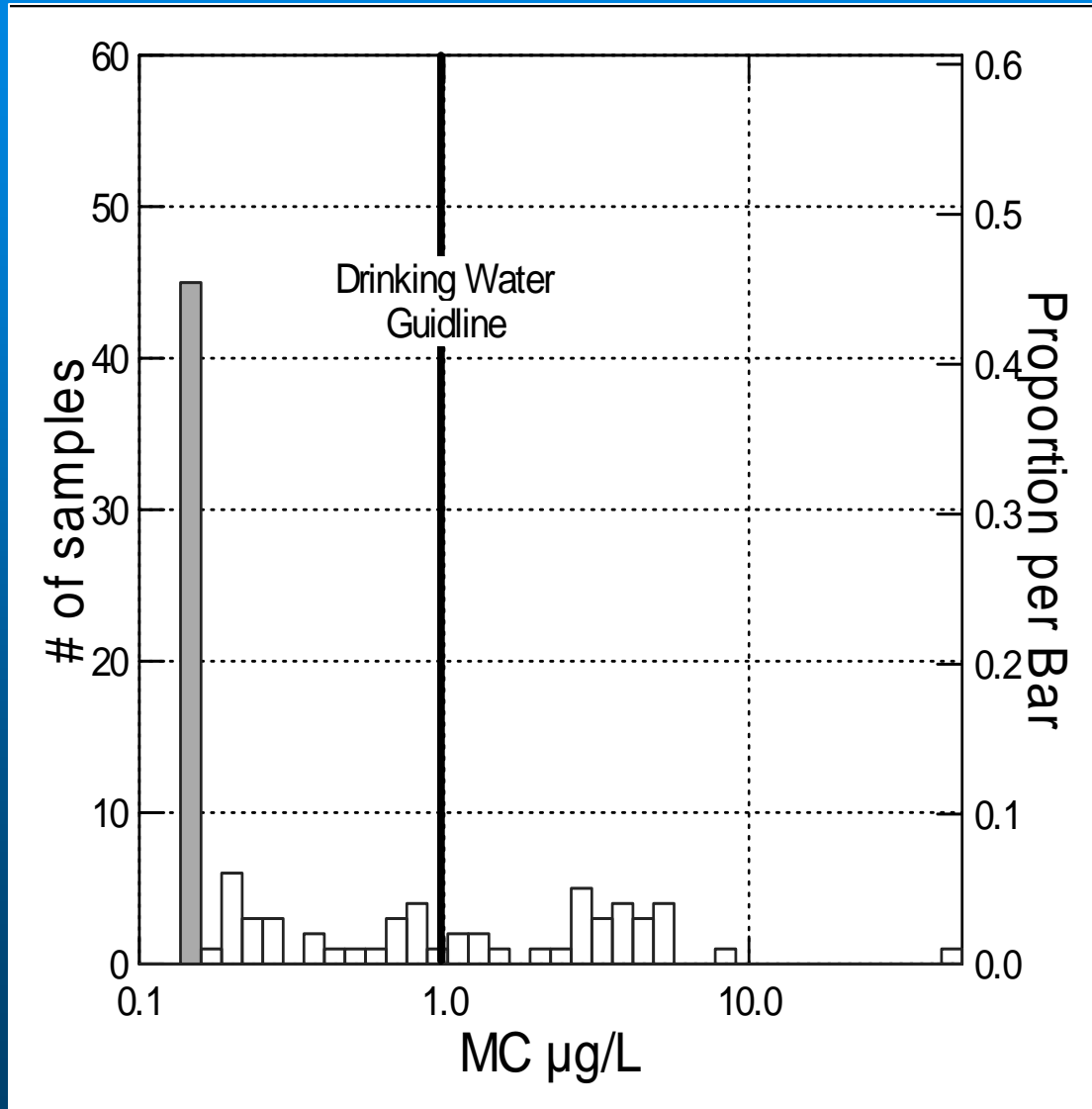


NLAP: Geographic Distribution of MC

Highest MC concentration:
Upper Sakatah 44 ug/L

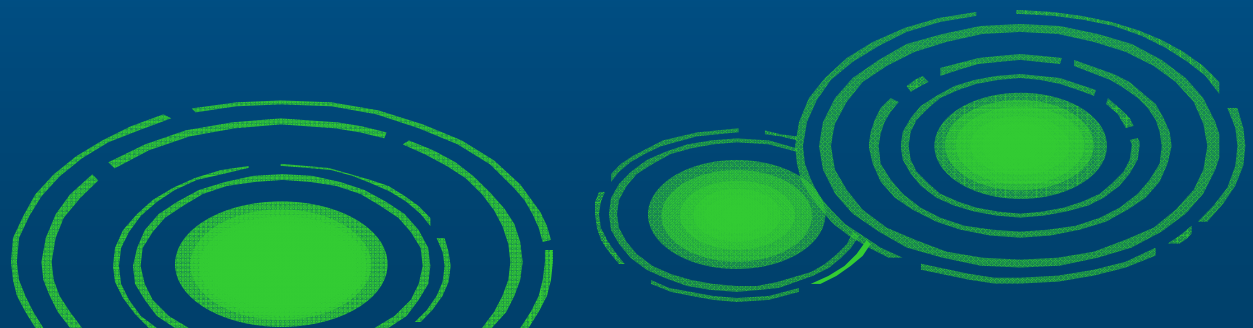


NLAP MC distributions for mid-lake & near-shore

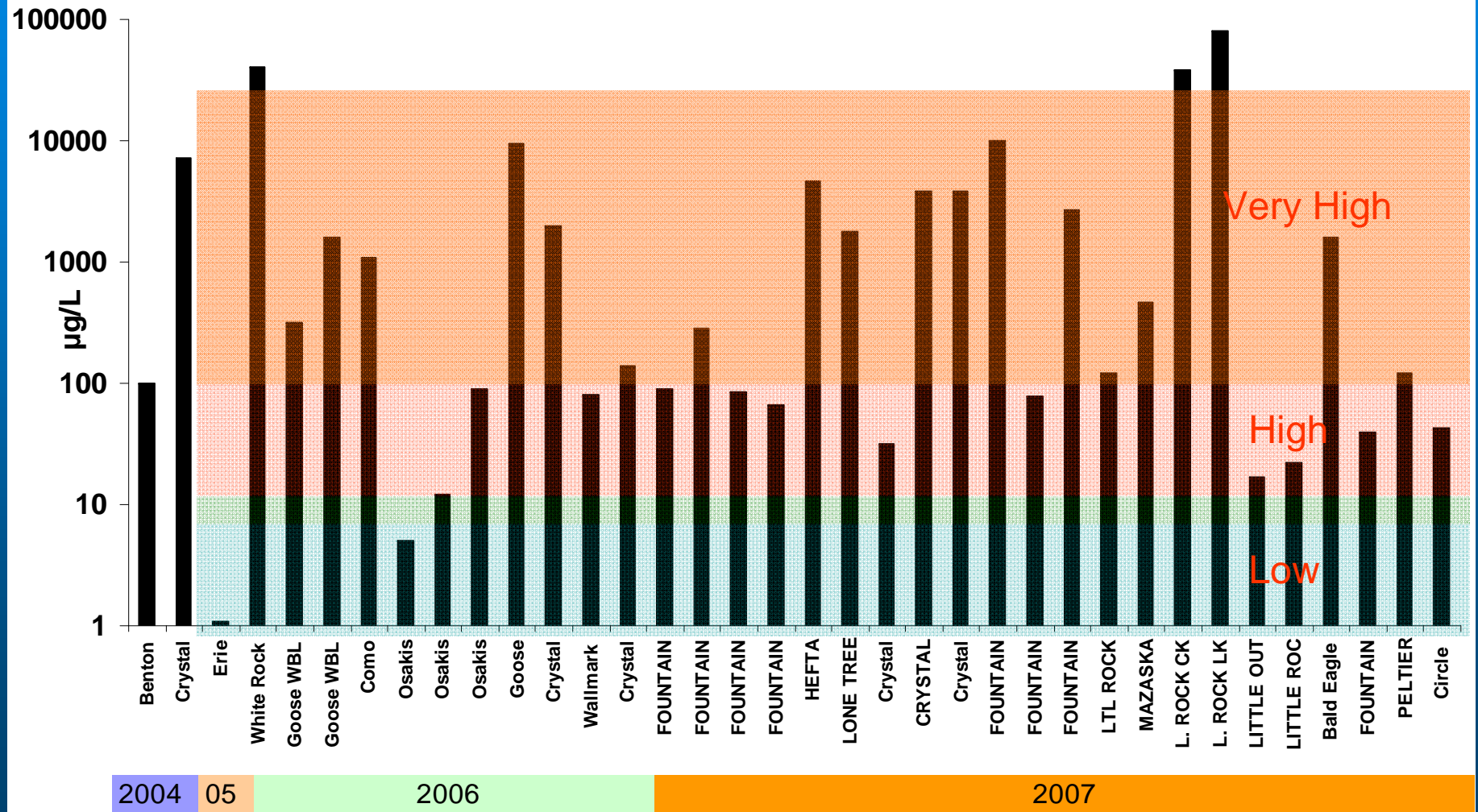


NLAP MC Study Conclusions

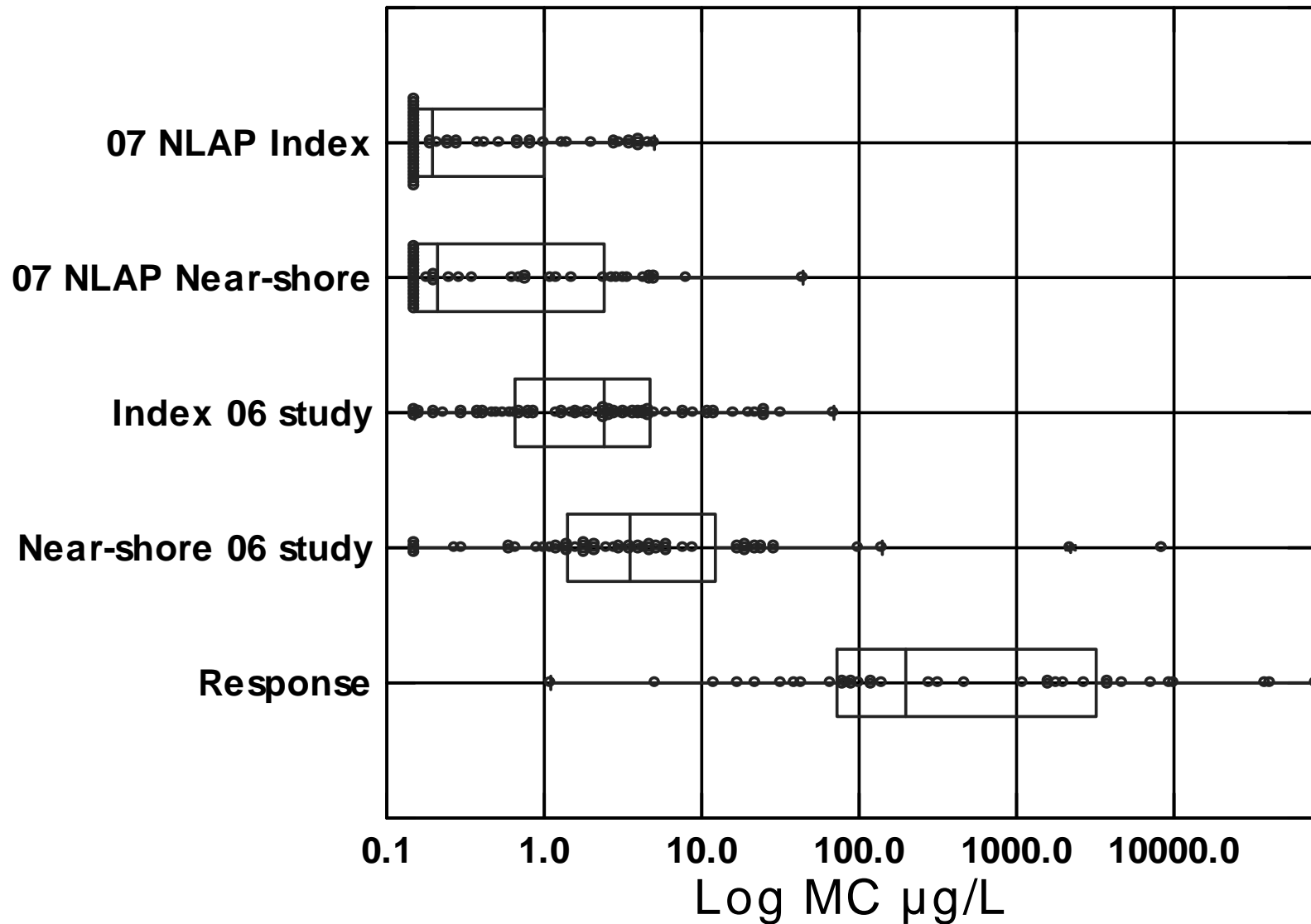
- Stratified random MC results were lower than previous targeted studies (MC max 44 ppb)
- Somewhat of a geographic trend in MC distribution
- Index and Nearshore results were similar (when lakes and sites are selected randomly);



Responding to Public Concerns



Comparison of MC concentrations from: NLAP study, 2006 south-central MN lakes, & response –based monitoring.



Summary

- 2006 study supplied useful information relative to the range, seasonality and association of MC and other factors in eutrophic MN lakes.
<http://www.pca.state.mn.us/water/lake.html>
- 2007 stratified-random study exhibited lower MC (relative to other studies); however it demonstrated that MC is present at measurable concentrations in a wide range of lakes in MN; (posted at:
<http://www.pca.state.mn.us/water/nlap.html>)
- Incident response sampling often results in high MC levels;
- Based on these studies - Current recommendation to avoid contact with blue-green algal blooms is sound; further, blooms that yield very low transparency (< 0.5 m), high pH (>9.0), and distinct surface scums are highly likely to have high MC concentrations.