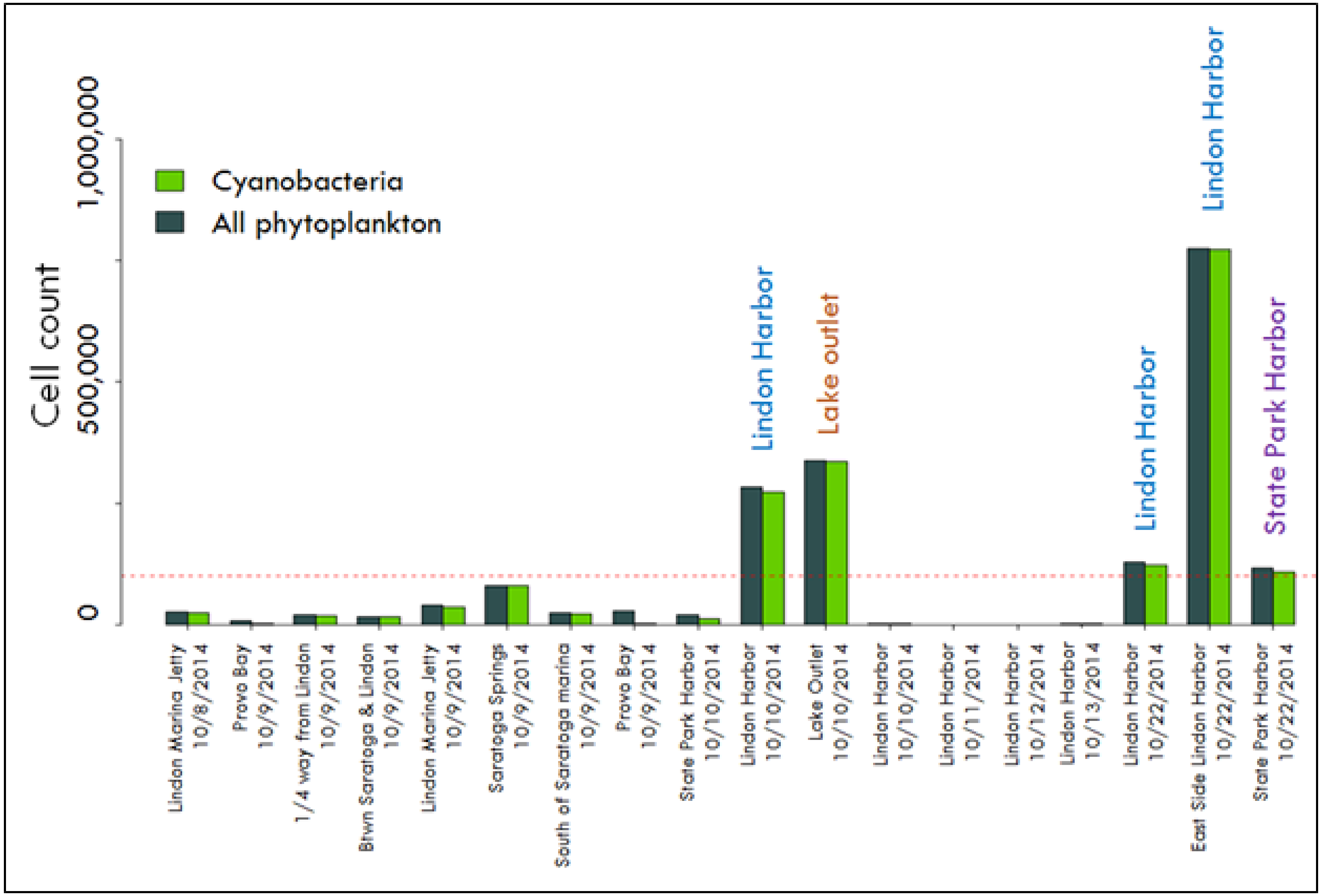
UTAH DEPARTMENT of ENVIRONMENTAL QUALITY
WATER QUALITY

Utah Lake: HABs and potential drivers of algal growth

Jake Vander Laan

2014 Harmful Algae Blooms



Microcystins:

>4 ug/L: 3 samples

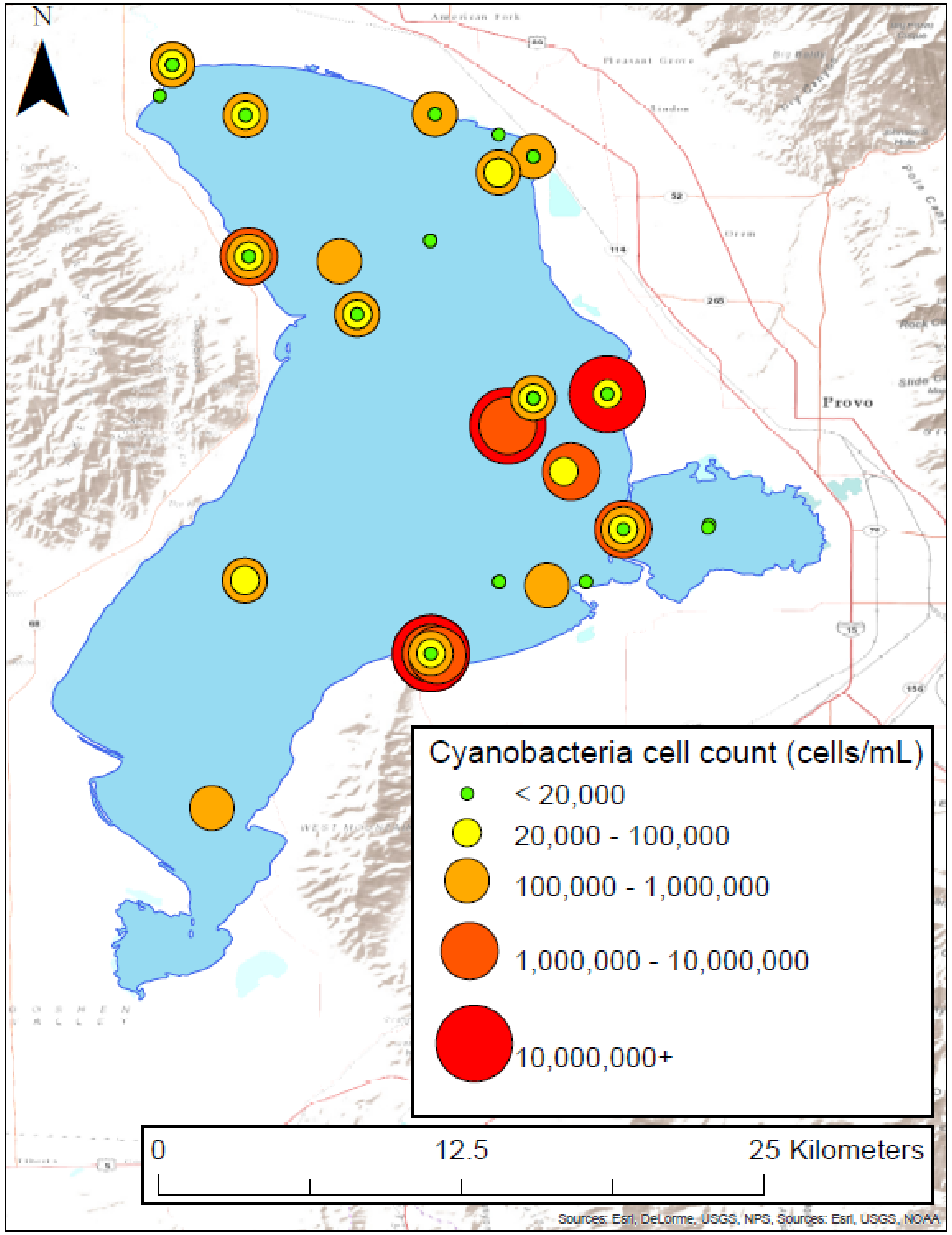
0-4 ug/L: 9 samples

2016 Harmful Algae Blooms

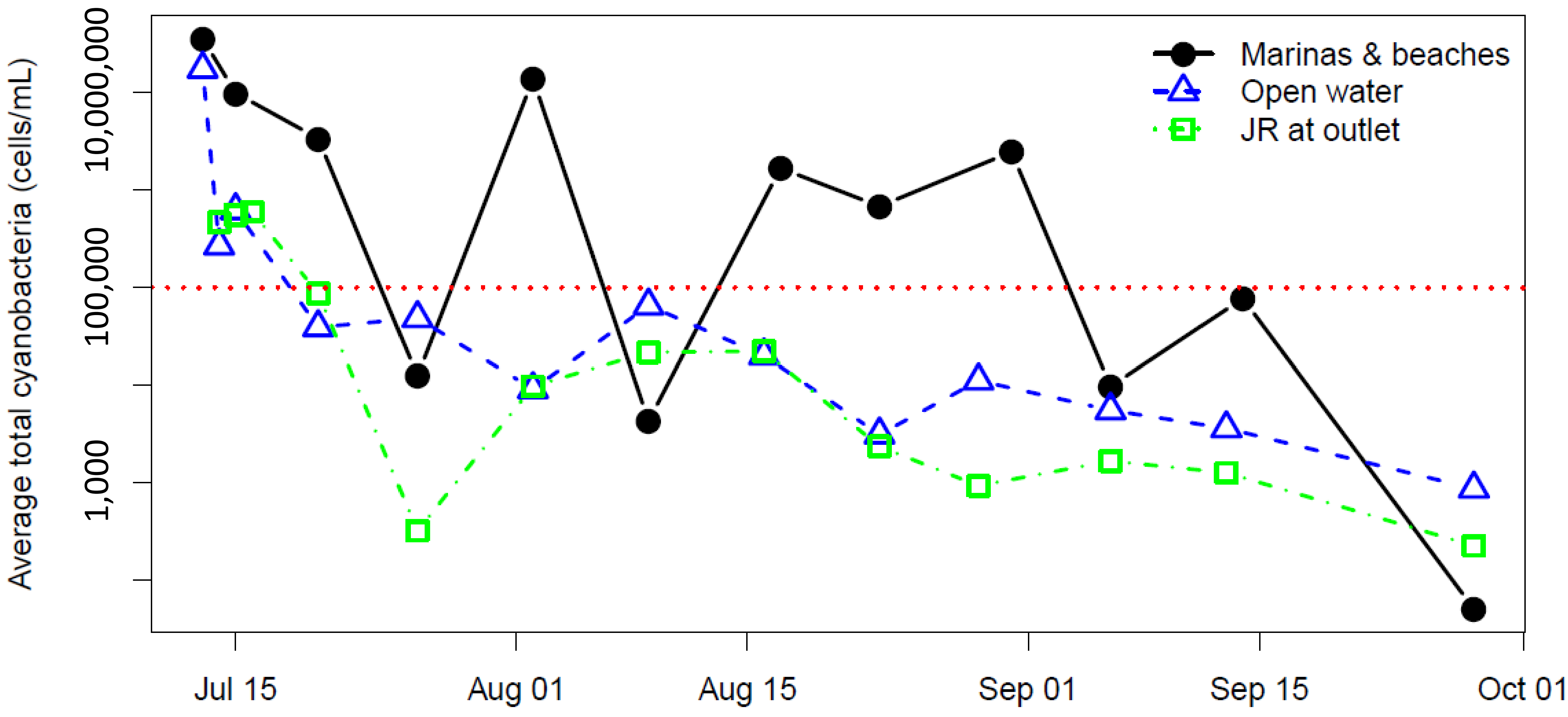
Exceedances of 100K cell/mL benchmark:

- **July 13 – Aug 31**
- **Open water, marinas/beaches, and Jordan River at outlet**
- **Surface scum & integrated samples**
- **34 of 108 samples**

14 samples exceeded 1M cells/mL.

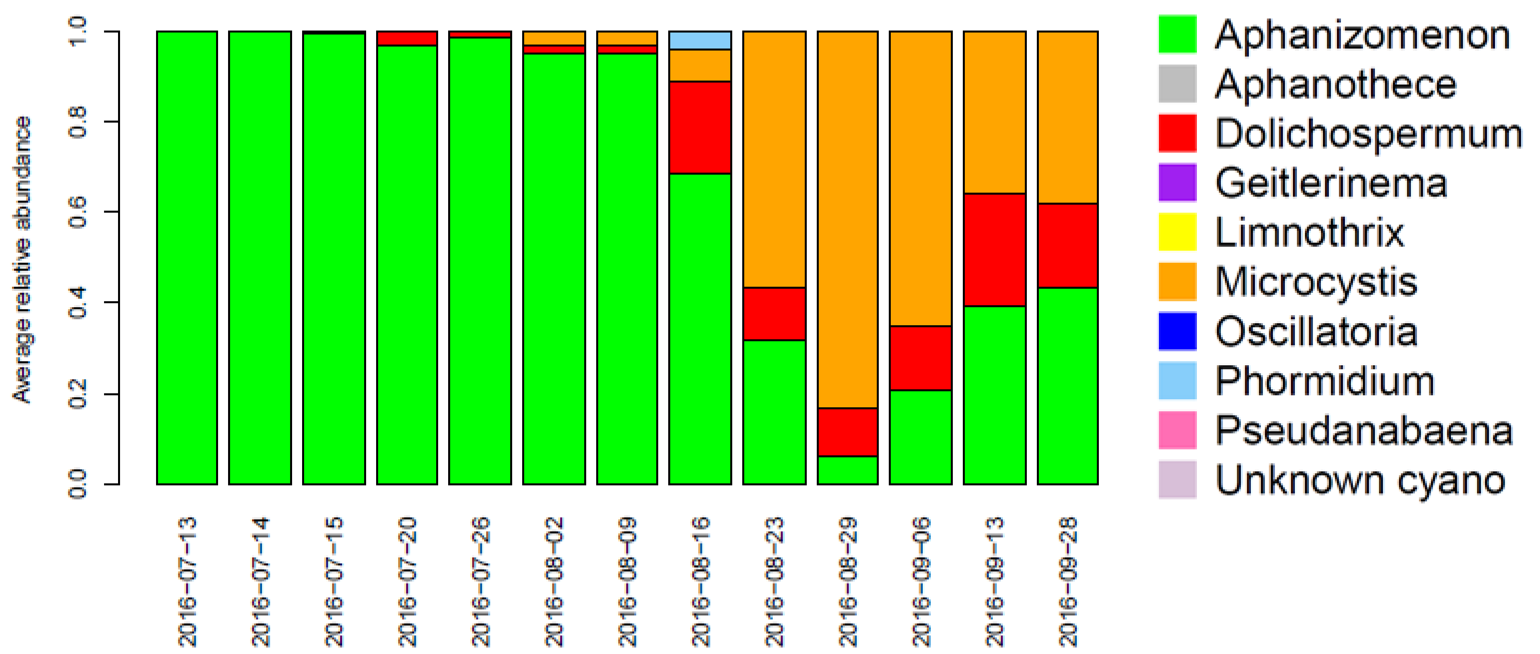


2016 Harmful Algae Blooms

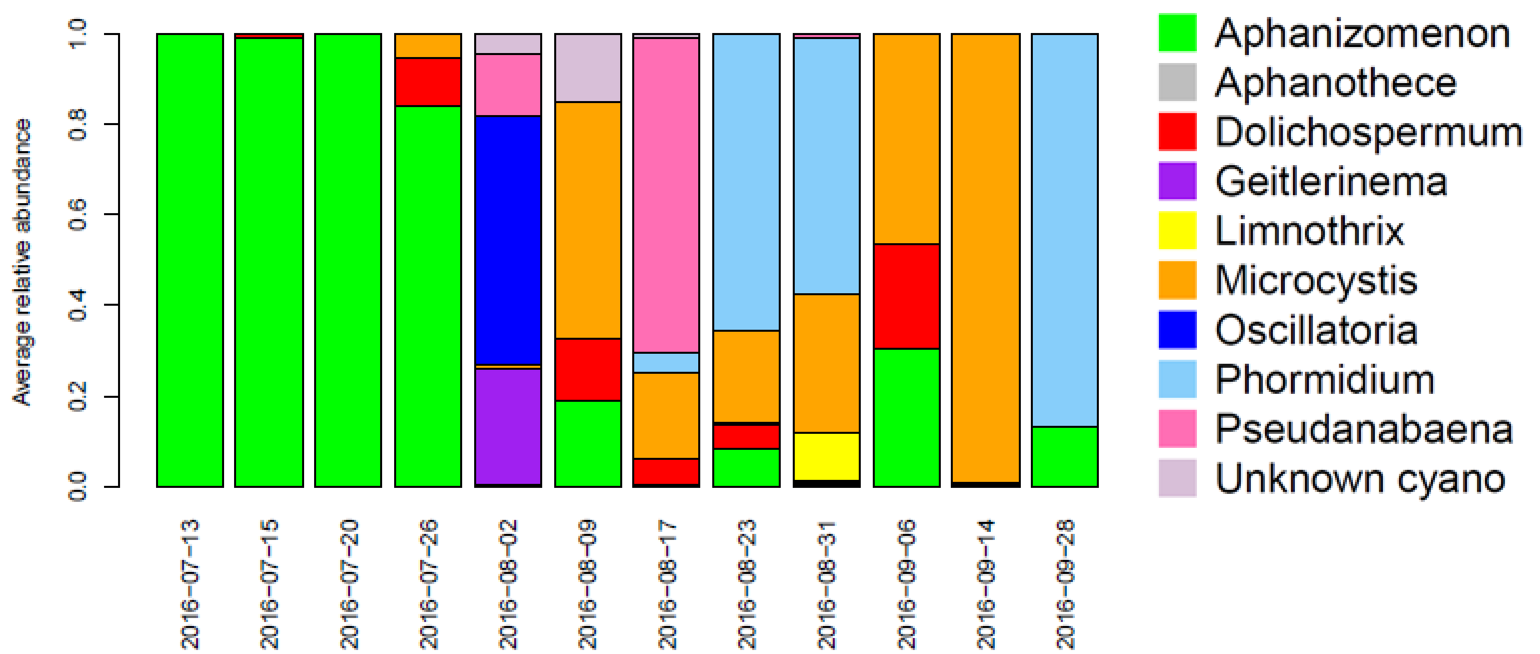


2016 Harmful Algae Blooms

Open water



Marinas and beaches



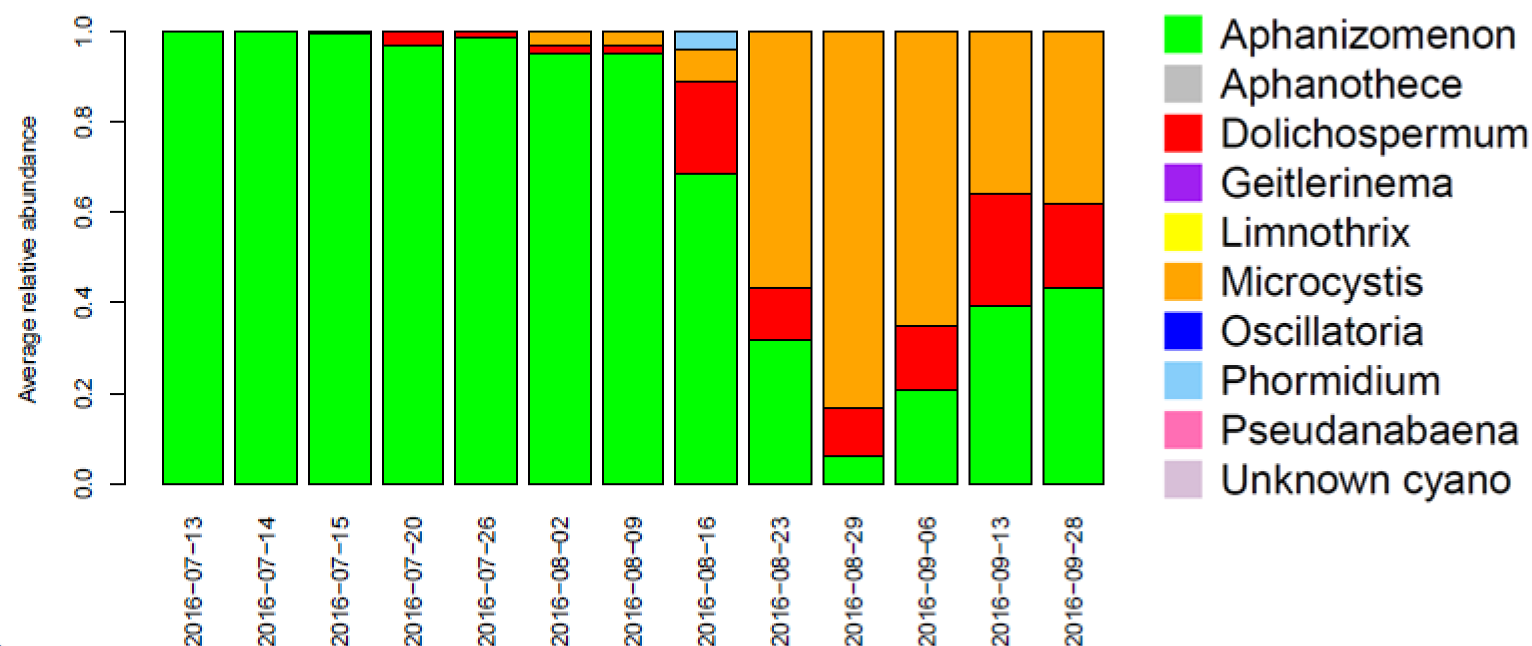
2016 Harmful Algae Blooms

Lincoln Harbor/Beach

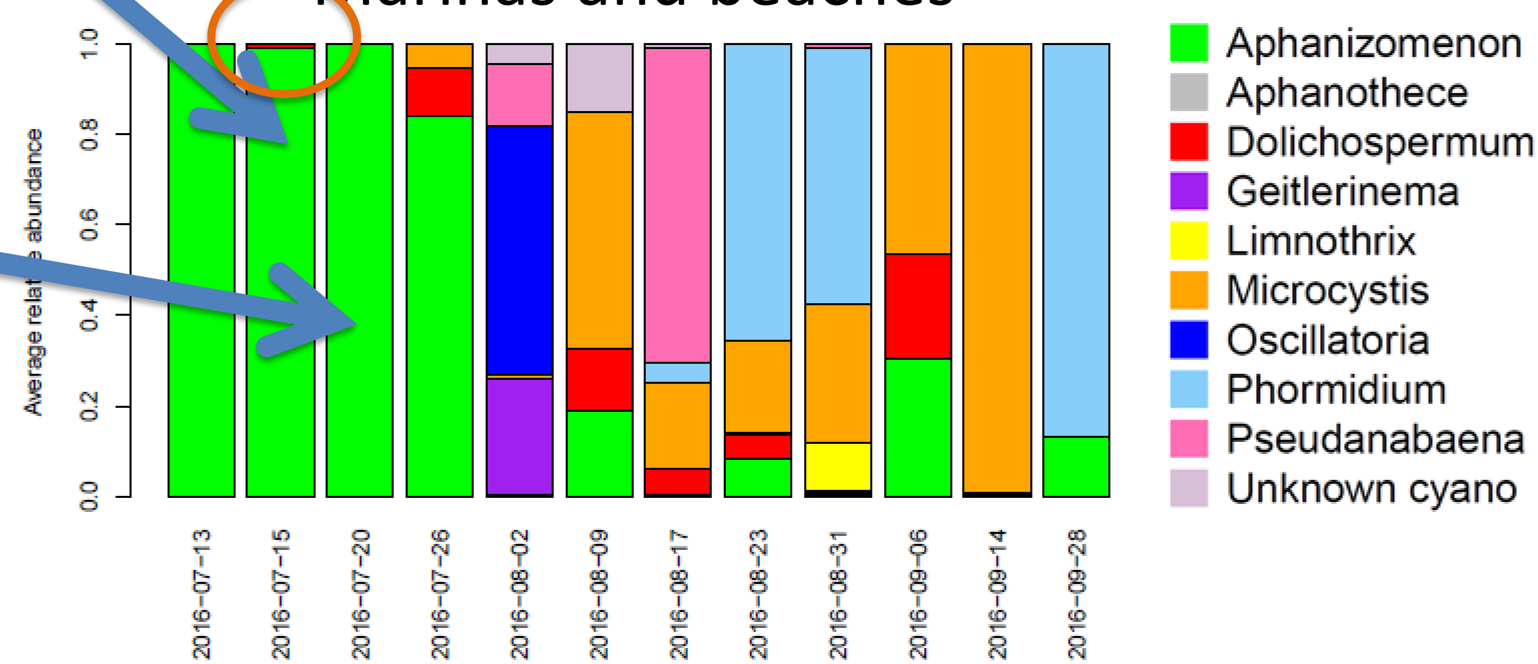
Microcystins: 3.6 - 600+ ug/L
Aphanizomenon: 2 M - 43.5 M
Dolichospermum: 2 K – 225 K

Microcystins: 63 ug/L
Aphanizomenon: 20 M
Dolichospermum: 0

Open water



Marinas and beaches



Potential drivers of algal growth

1. Lake elevation
2. Water temperature
3. Nutrients
4. Mineral turbidity & light

DWQ's Utah Lake dataset

25+ years of data

1. Water temperature
2. Chlorophyll *a*
3. Water clarity
4. Nutrients

Lake elevation data from CUWCD

Chlorophyll *a* as a proxy for HAB likelihood

(Downing et al. 2001, Rogalus and Watzin 2007, Lindon and Heiskary 2009, Yuan et al. 2014)

Buoy network for specific HAB event predictions

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Trophic State Indices

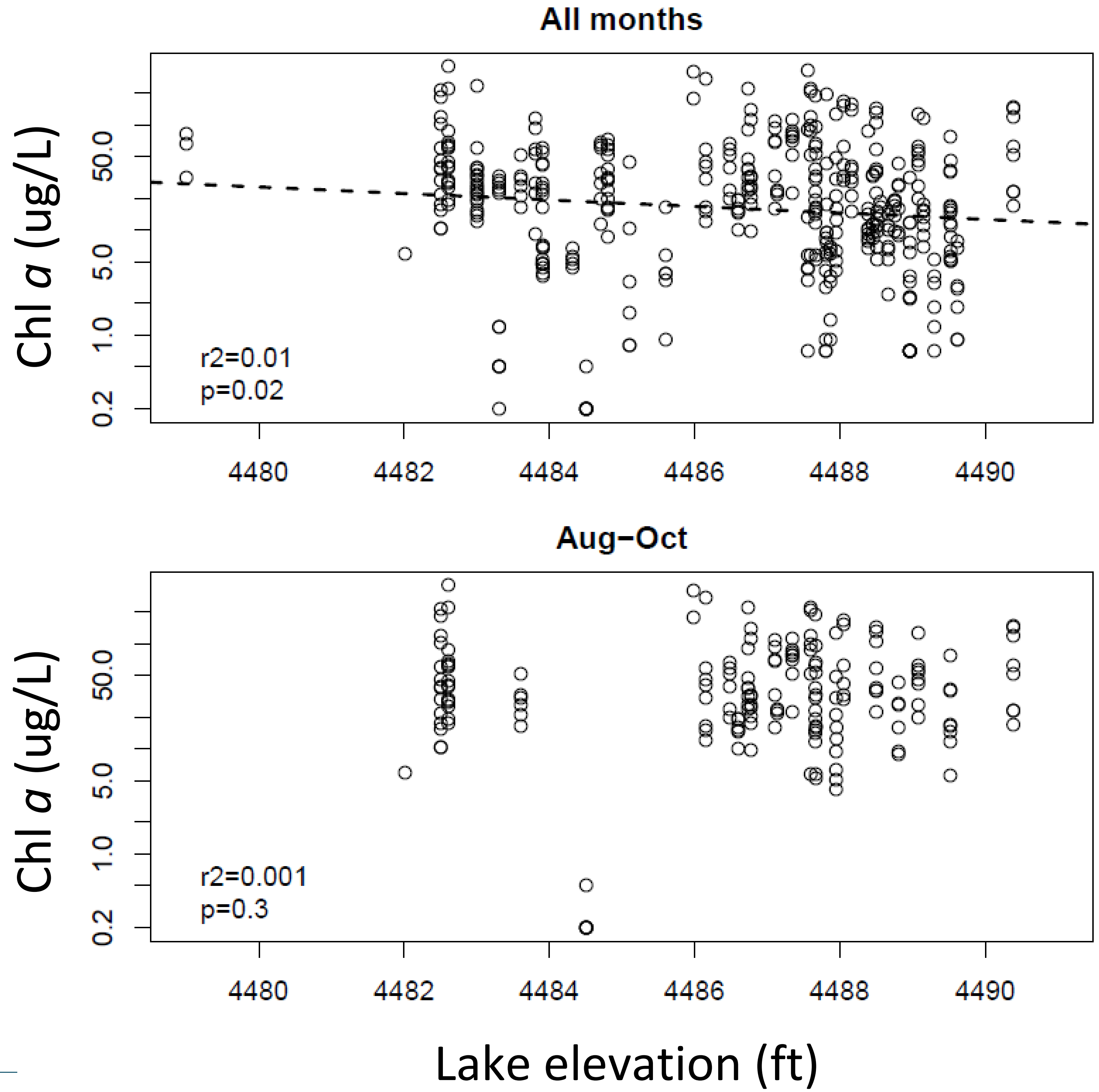
Lake elevation data from CUWCD

Chlorophyll *a* as a proxy for HAB likelihood

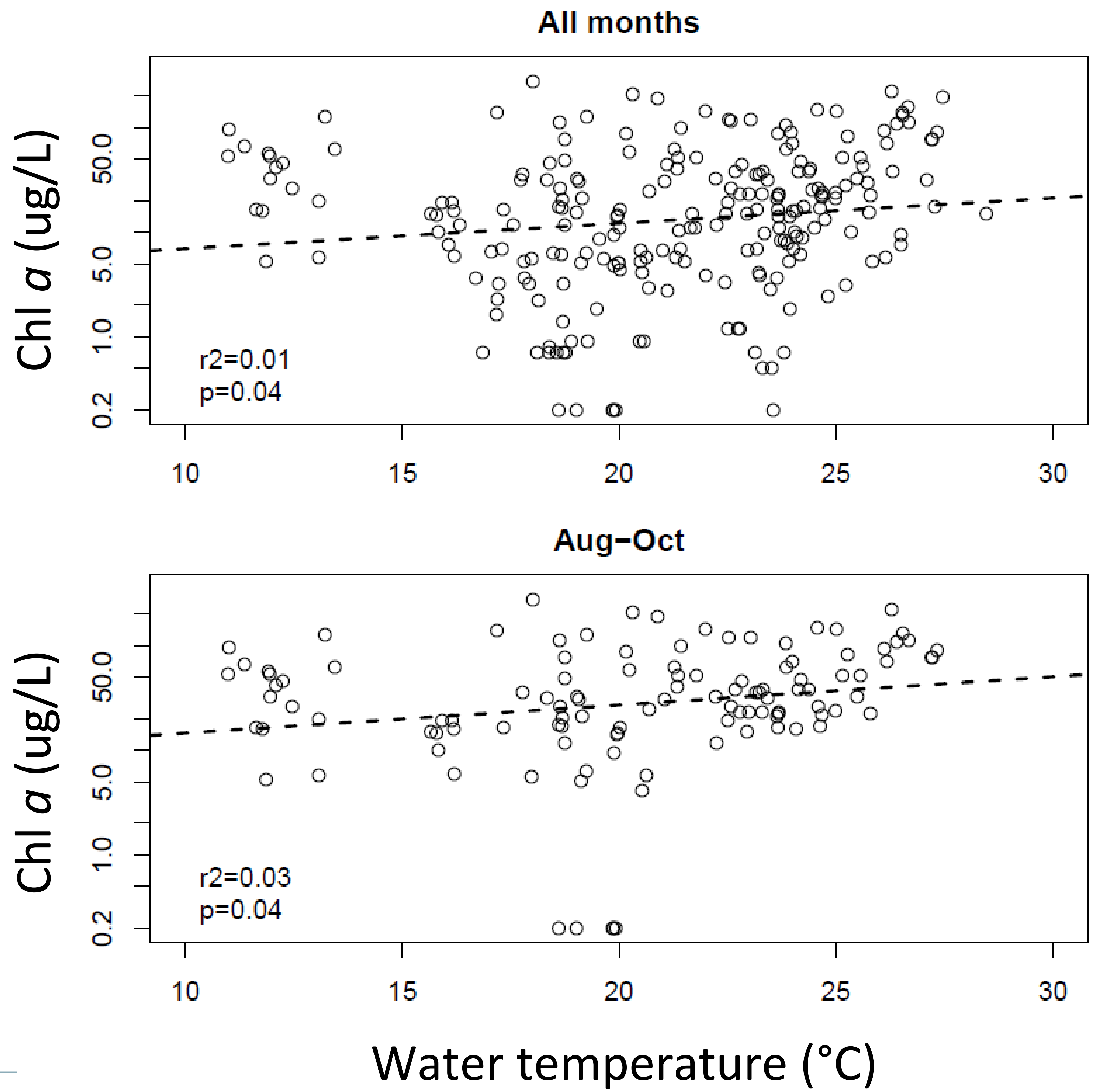
(Downing et al. 2001, Rogalus and Watzin 2007, Lindon and Heiskary 2009, Yuan et al. 2014)

Buoy network for specific HAB event predictions

Chlorophyll *a* and lake elevation



Chlorophyll *a* and temperature



Trophic State Indices

Tool for estimating primary productivity in lakes

1. Chlorophyll *a*
2. Nutrients (total phosphorus)
3. Water clarity (Secchi disk depth)

Effectively re-scales trophic indicators into consistent units.

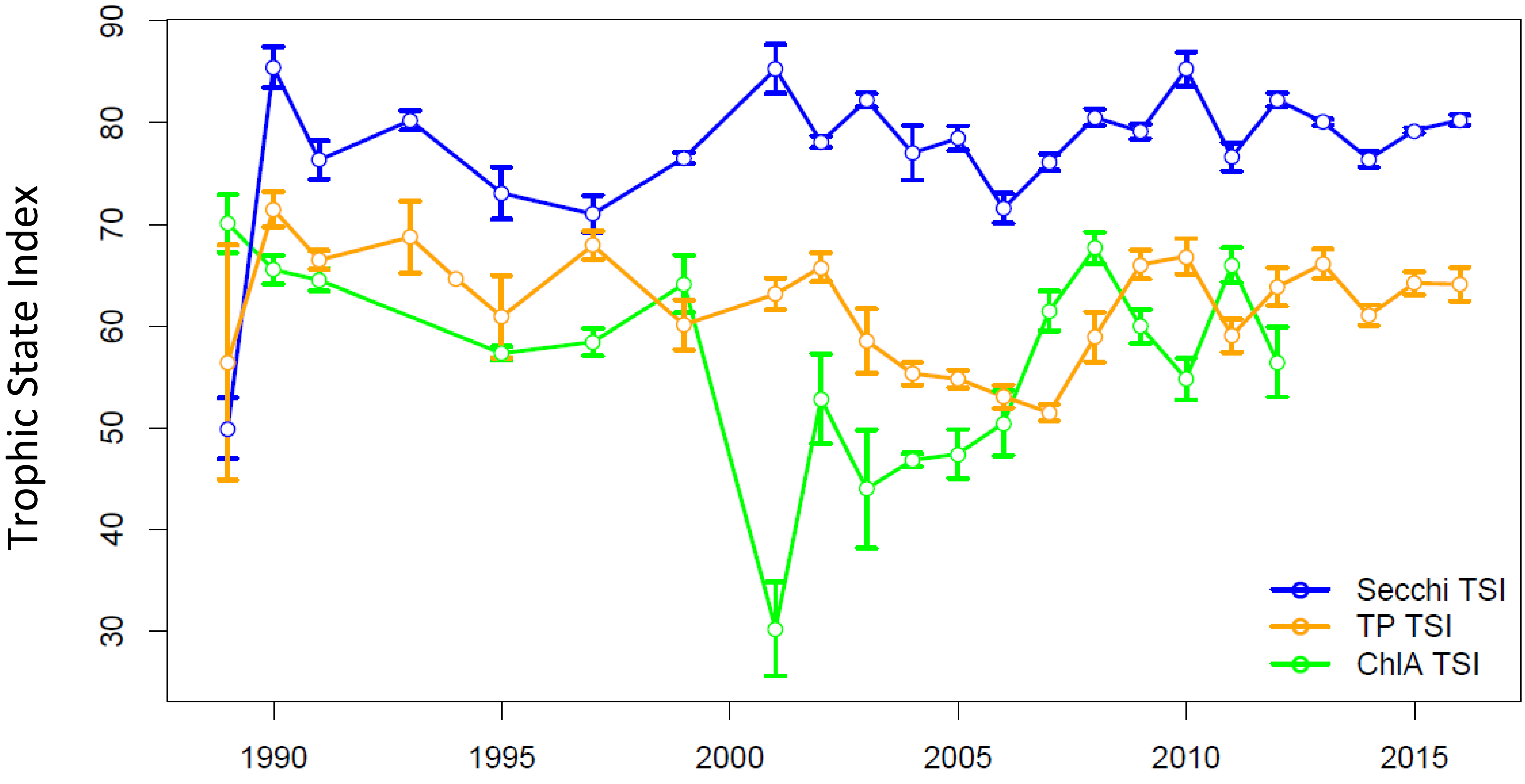
Differences or similarities in TSI values among types can be used to make inferences regarding limiting factors or lake processes.

(Carlson and Simpson 1996, Carlson and Havens 2005)

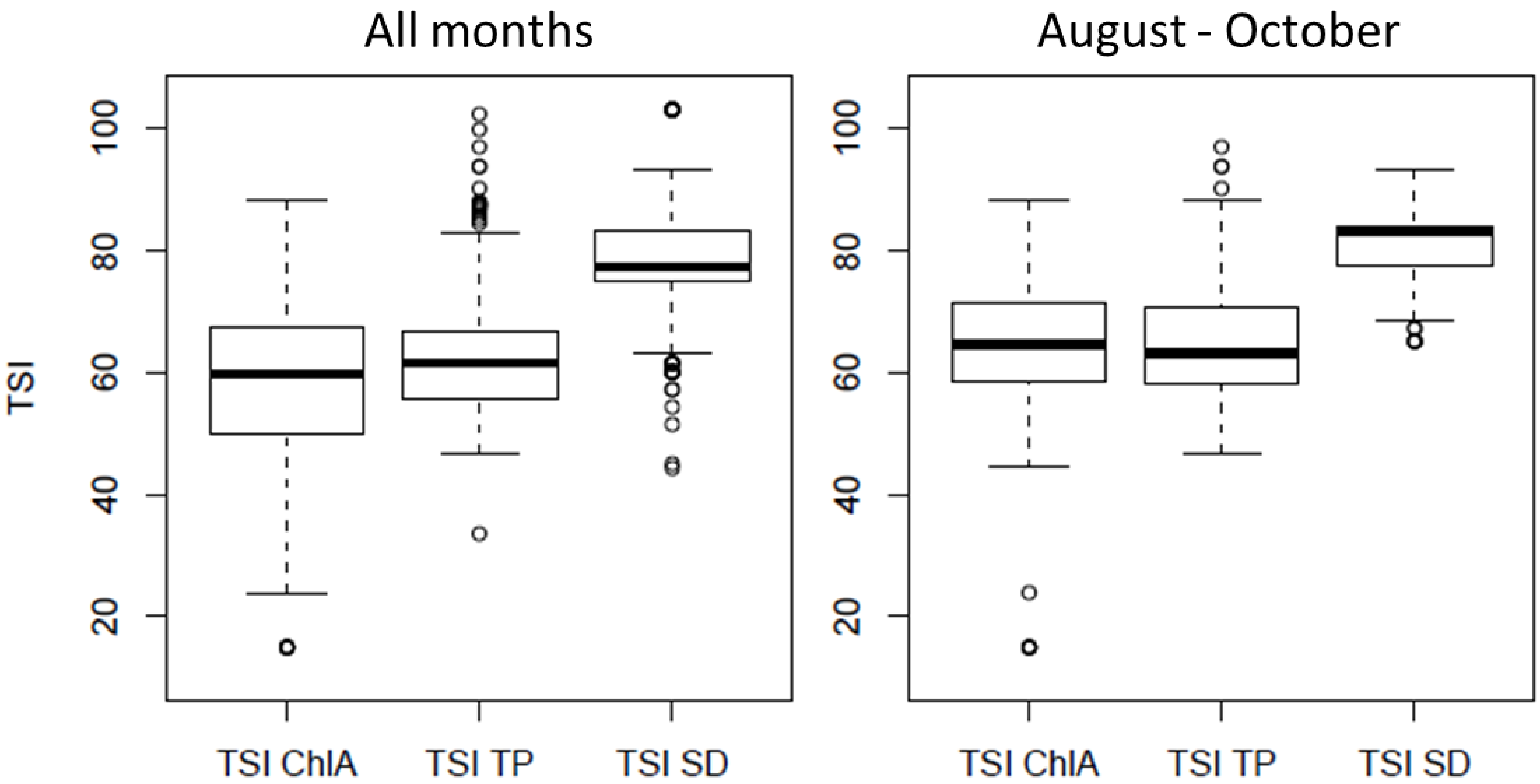
Table 1. Suggested interpretations of TSI relationships (adapted from Carlson and Havens 2005).

TSI Relationship	Suggested interpretation
TSI (Chl-a) = TSI (SD)	**Algae dominate light attenuation.**
TSI (SD) = TSI (Chl-a) ≥ TSI (TP)	Phosphorus limits algal biomass, and algae dominate light attenuation.
TSI (TP) > TSI (Chl-a) = TSI (SD)	Some factor other than phosphorus (zooplankton grazing, nitrogen, etc.) limits algal biomass.
TSI (Chl-a) < TSI (SD)	**Small particles, not necessarily related to algae, dominate light attenuation**
TSI (TP) = TSI (SD) > TSI (Chl-*a*)	Non algal particulate matter dominates light attenuation. Particles contain phosphorus, but do not contain chlorophyll.
TSI (SD) > TSI (Chl-*a*) = TSI (TP)	Dissolved color affects transparency but not chlorophyll or total phosphorus concentrations.
TSI (TP) > TSI (SD) > TSI (Chl-a)	Zooplankton grazing Has reduced the number of samller particles, leaving larger particles. Biomass has been reduced below levels predicted from total phosphorus.
TSI (Chl-a) > TSI (SD)	**Large phosphorus-containing particulates dominate.**
TSI (Chl-a) = TSI (TP) >> TSI (SD)	Large chlorophyll-containing particulates, such as Aphanizomenon flakes, dominate.

TSI: Long term trends



TSI differences in Utah Lake



TSI Interpretations (Carlson and Havens 2005)

TSI Chl-*a* < TSI SD

Small particles, not necessarily related to algae, dominate light attenuation

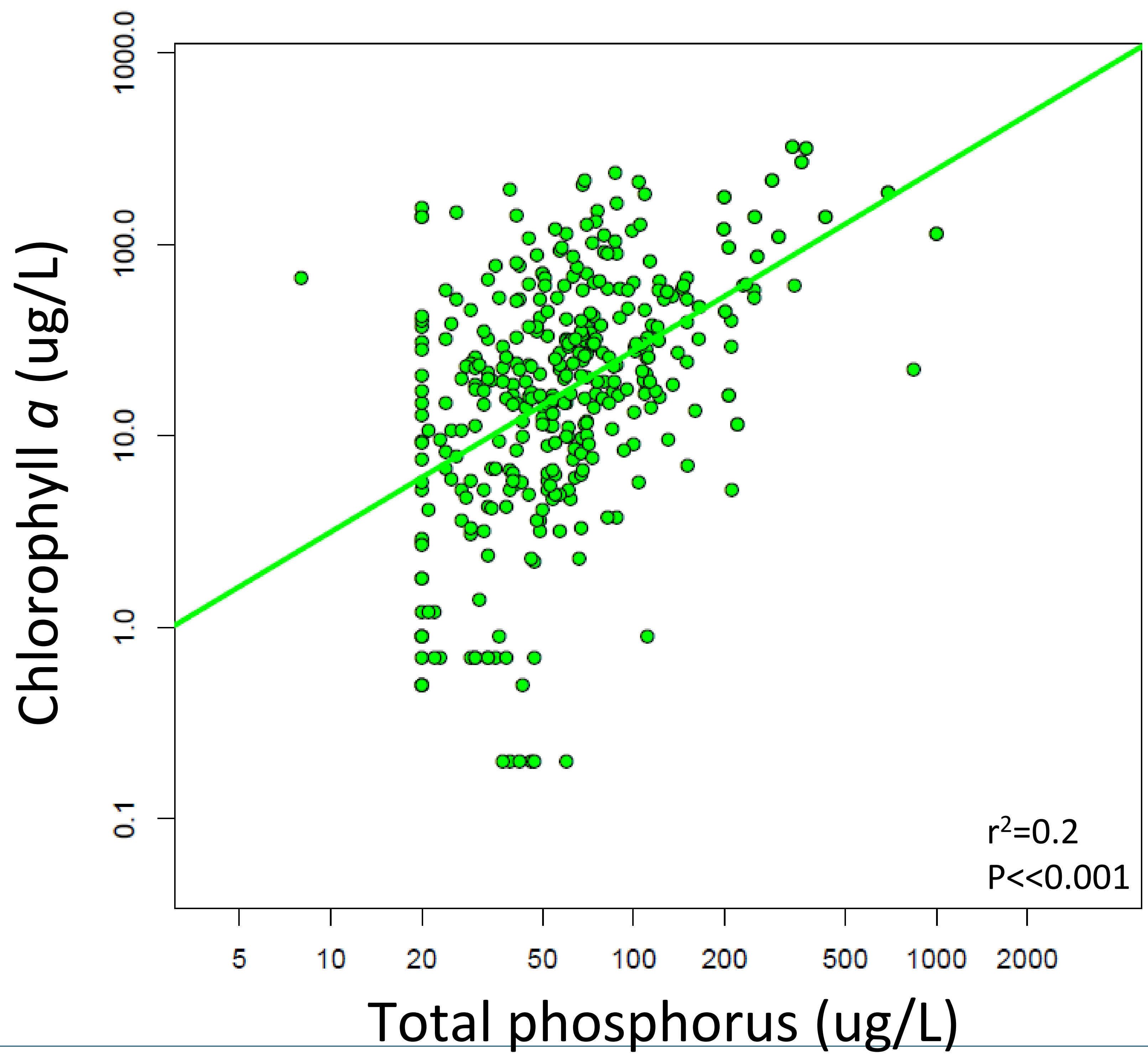
TSI Chl-*a* ≥ TSI TP

Phosphorus limits algal biomass.

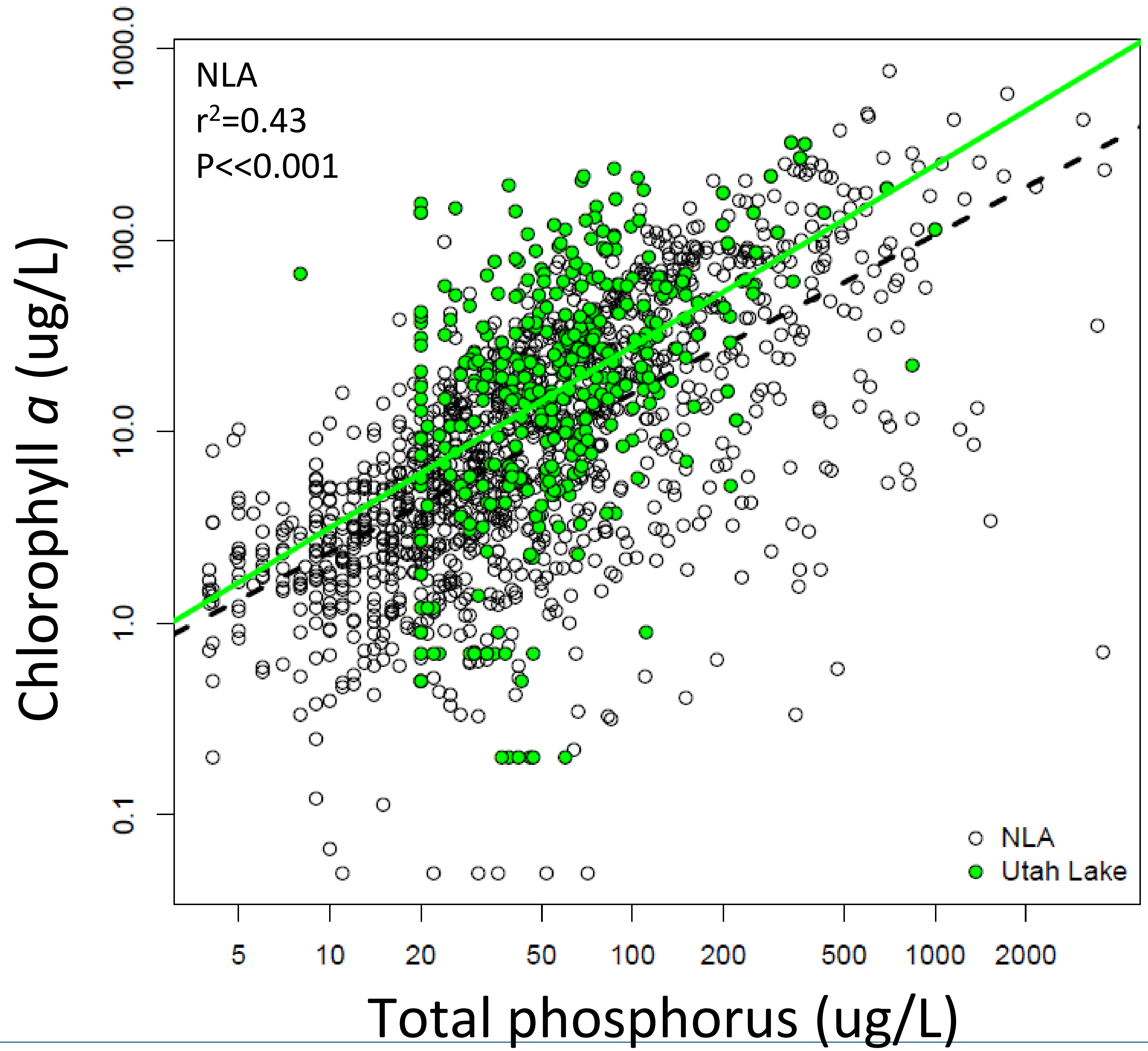
TSI SD > TSI Chl-*a* = TSI TP

Dissolved color affects transparency but not chlorophyll or total phosphorus concentrations.

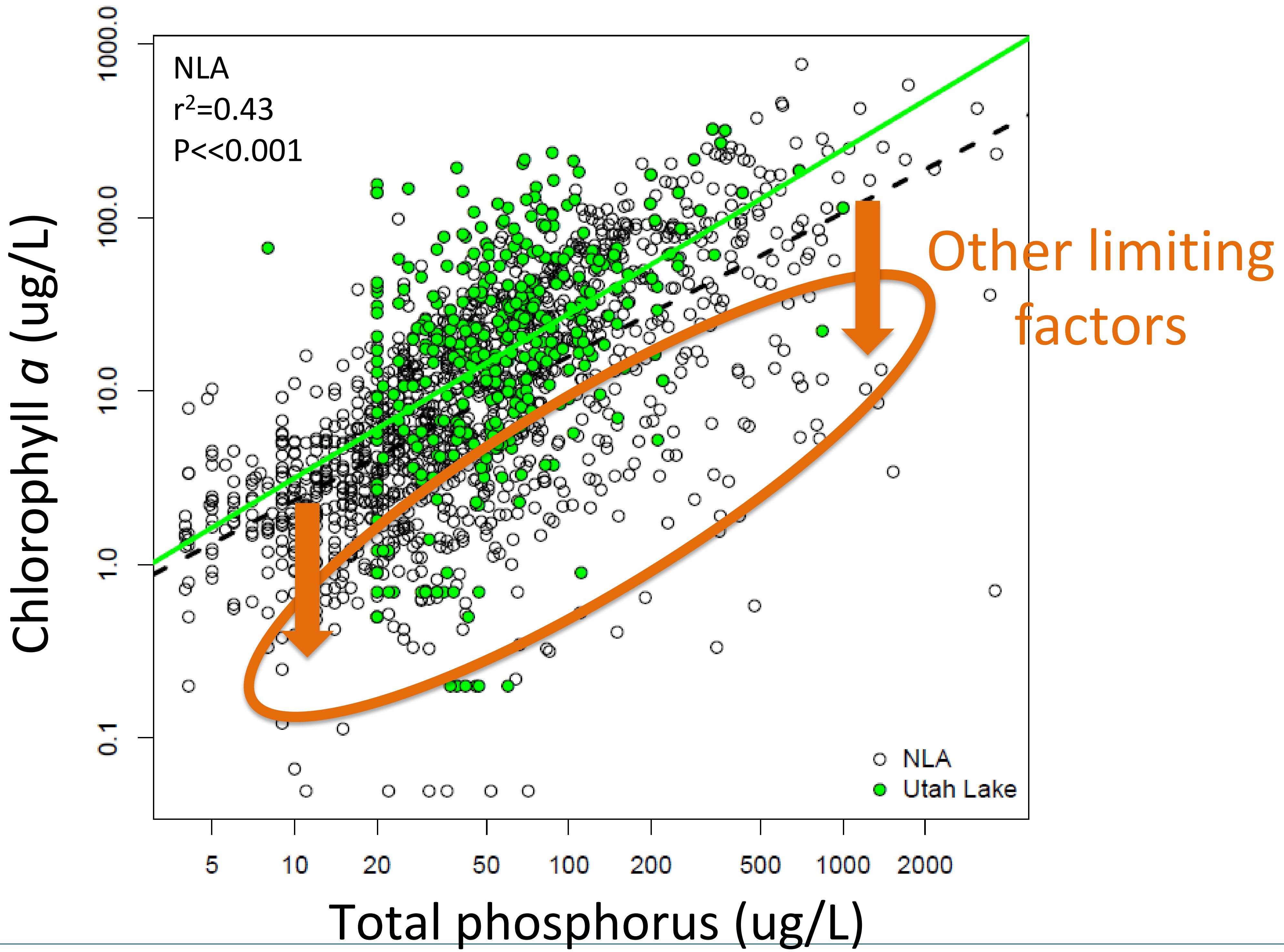
National context for Utah Lake



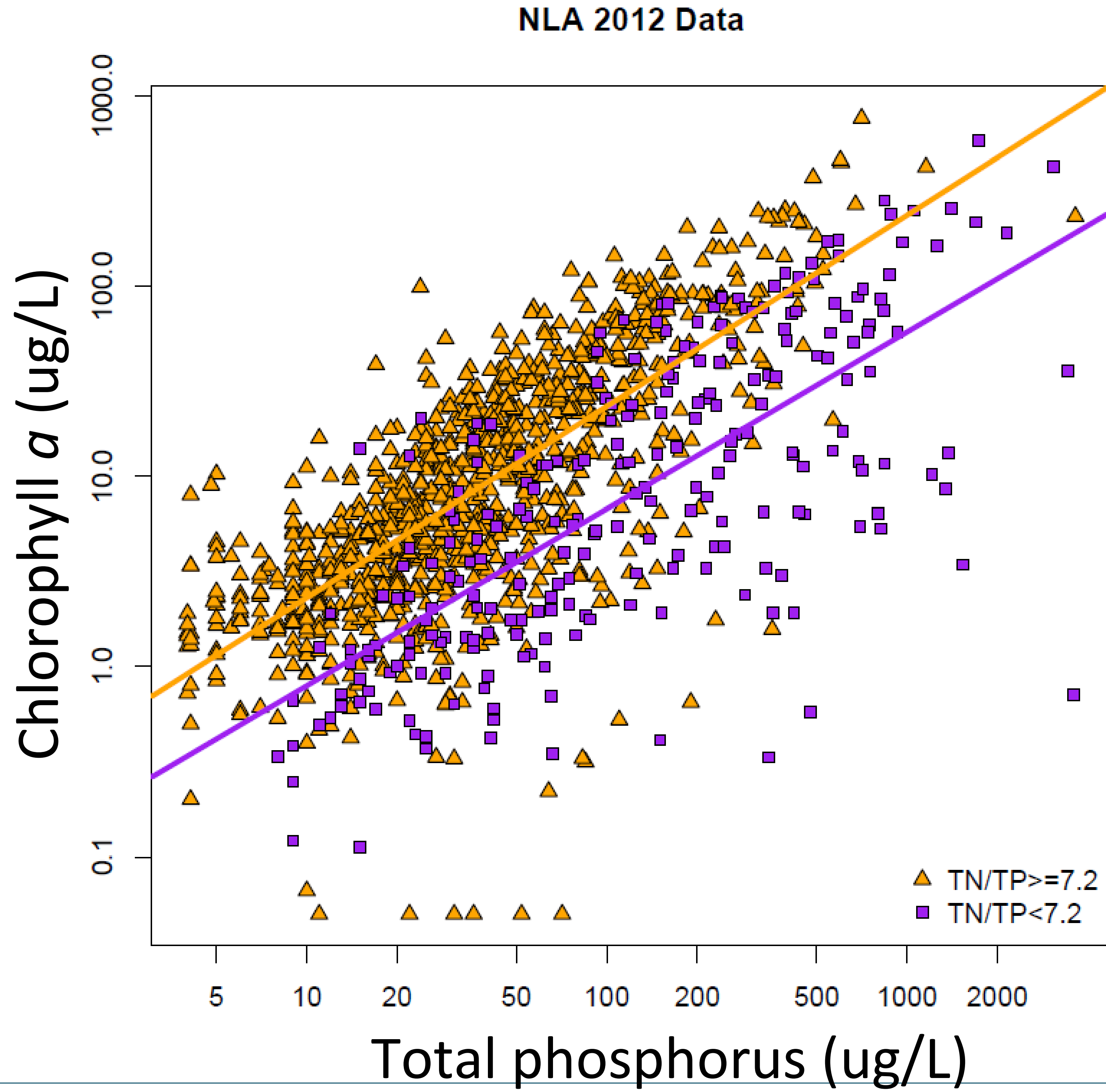
National context for Utah Lake



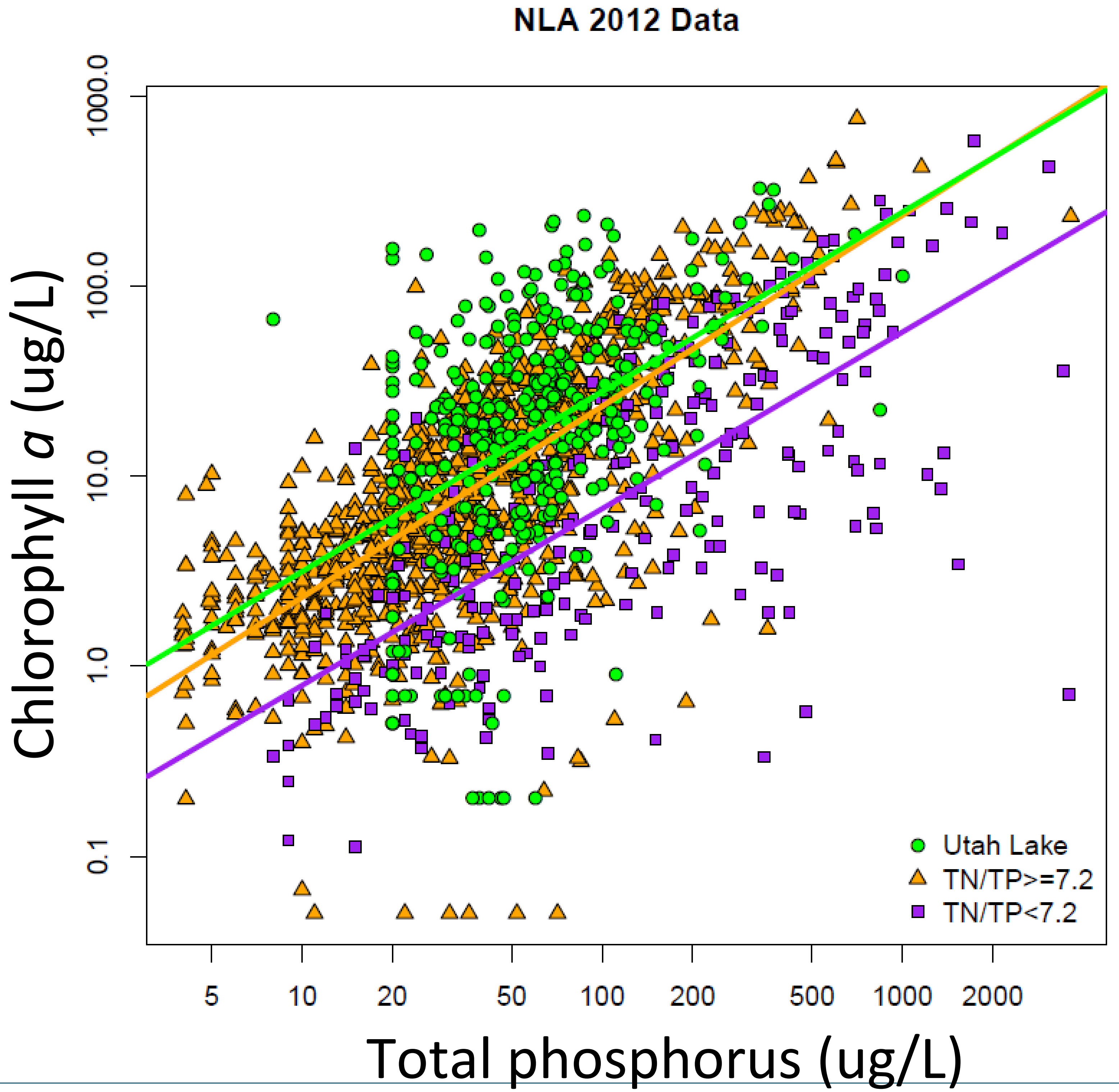
National context for Utah Lake



National context for Utah Lake



National context for Utah Lake



Questions

Citations

Carlson, R.E. and J. Simpson. 1996. A Coordinator's Guide to Volunteer Lake Monitoring Methods. North American Lake Management Society. 96 pp.

Carlson, R.E. and K.E. Havens. 2005. Simple graphical methods for the interpretation of relationships between trophic state variables. Lake and Reservoir Management 21:107-118.

Downing, J.A., S.B. Watson, and E. McCauley. 2001. Predicting cyanobacterial dominance in lakes. Canadian Journal of Fisheries and Aquatic Sciences 58:1905-1908.

Rogalus, M.K., and M.C. Watzin. 2008. Evaluation of sampling and screening techniques for tiered monitoring of toxic cyanobacteria in lakes. Harmful Algae 7: 504-514.

Lindon, M. and S. Heiskary. 2009. Blue-greeen algal toxin (microcystin) levels in Minnesota lakes. Lake and Reservoir Management 25:240-252.

Yuan, L.L., A.I. Pollard, S. Pather, J.L. Oliver, and L. D'Anglada. 2014. Managing microcystin: identifying national-scale thresholds for total nitrogen and chlorophyll a. Freshwater Biology 59:1970-1981.

IR 2016 Methods

Beneficial Use Supported

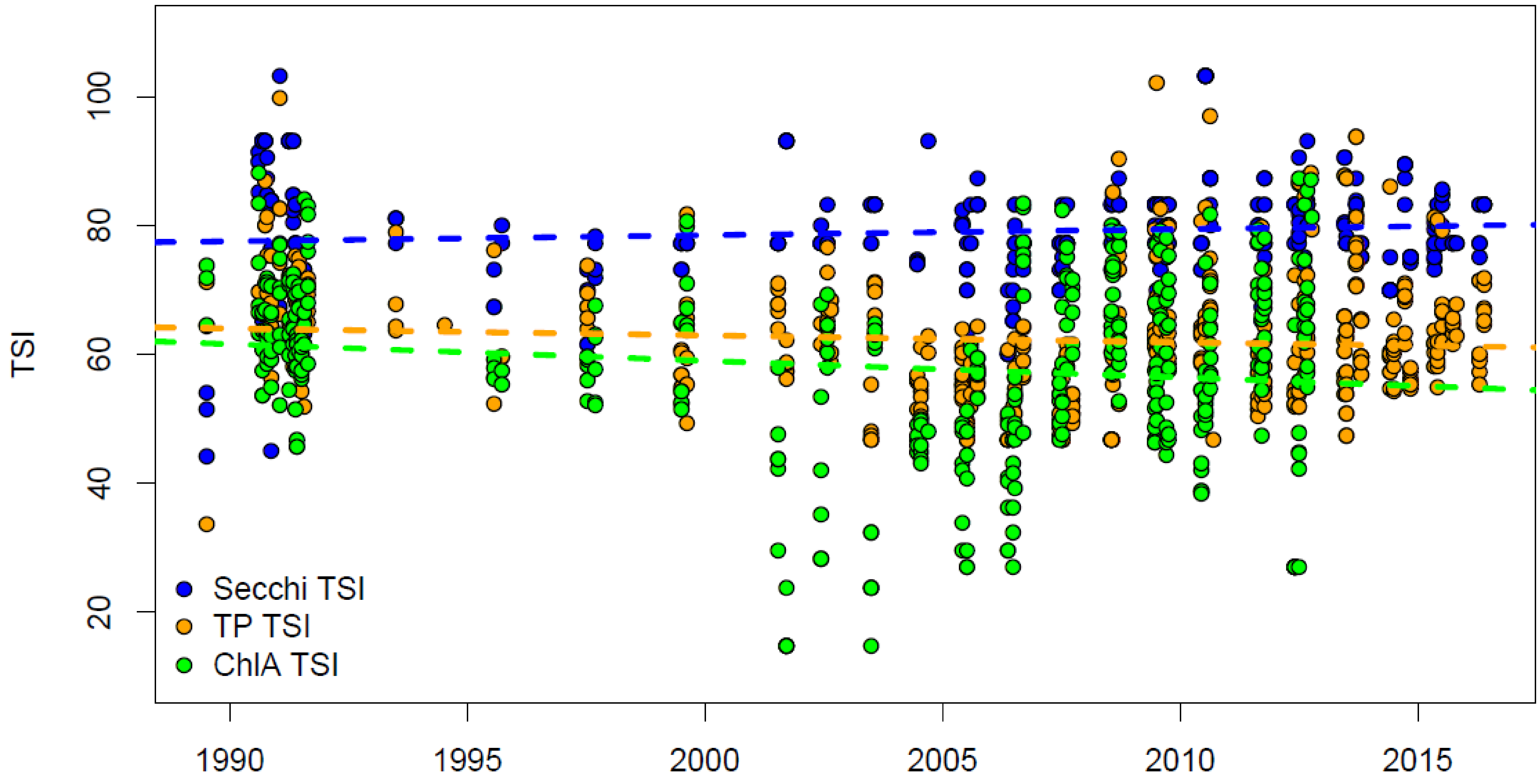
The beneficial use is supported if cyanobacteria cell counts are < 20,000 cells/ml.

Beneficial Use Not Supported

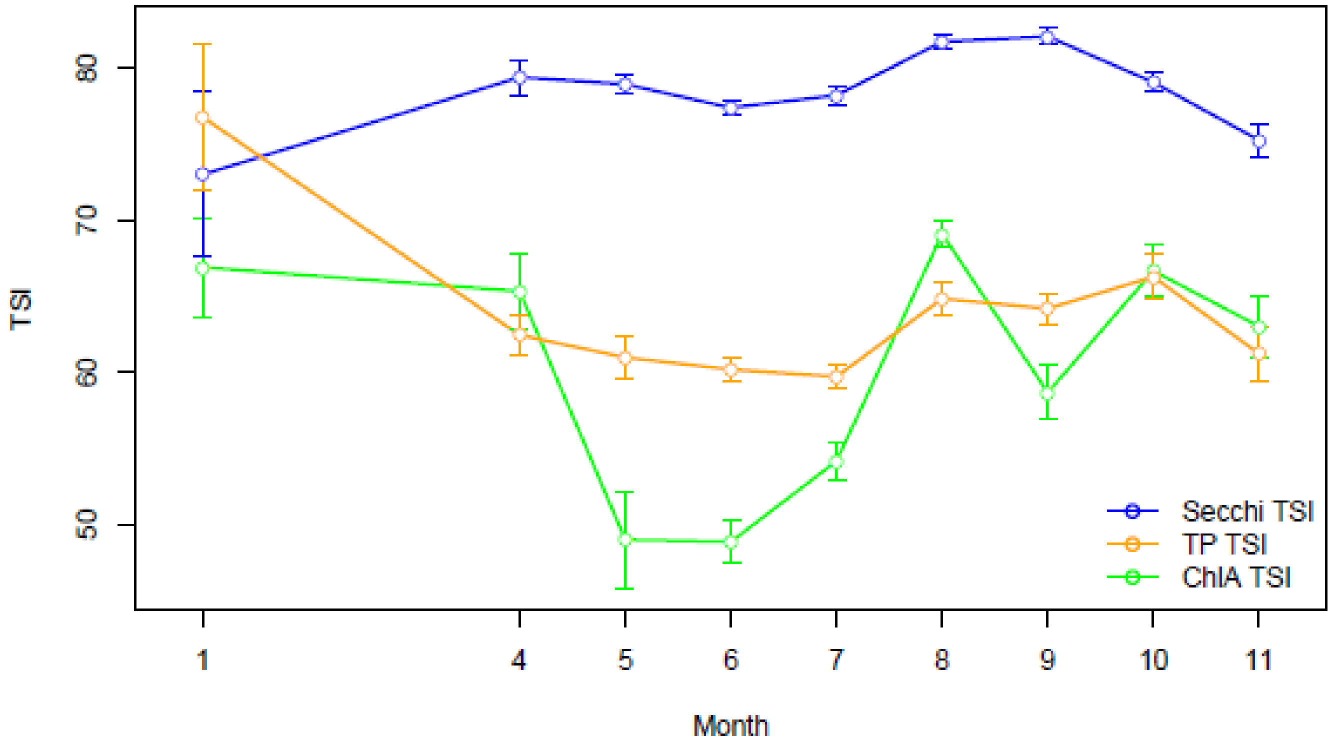
The beneficial use is not supported if the **cyanobacteria cell count exceeds 100,000 cells/ml for more than one sampling event** or other narrative indicators (e.g., phycocyanin, chlorophyll a, harmful algal bloom–related beach closures) suggest recreational uses are not being attained.

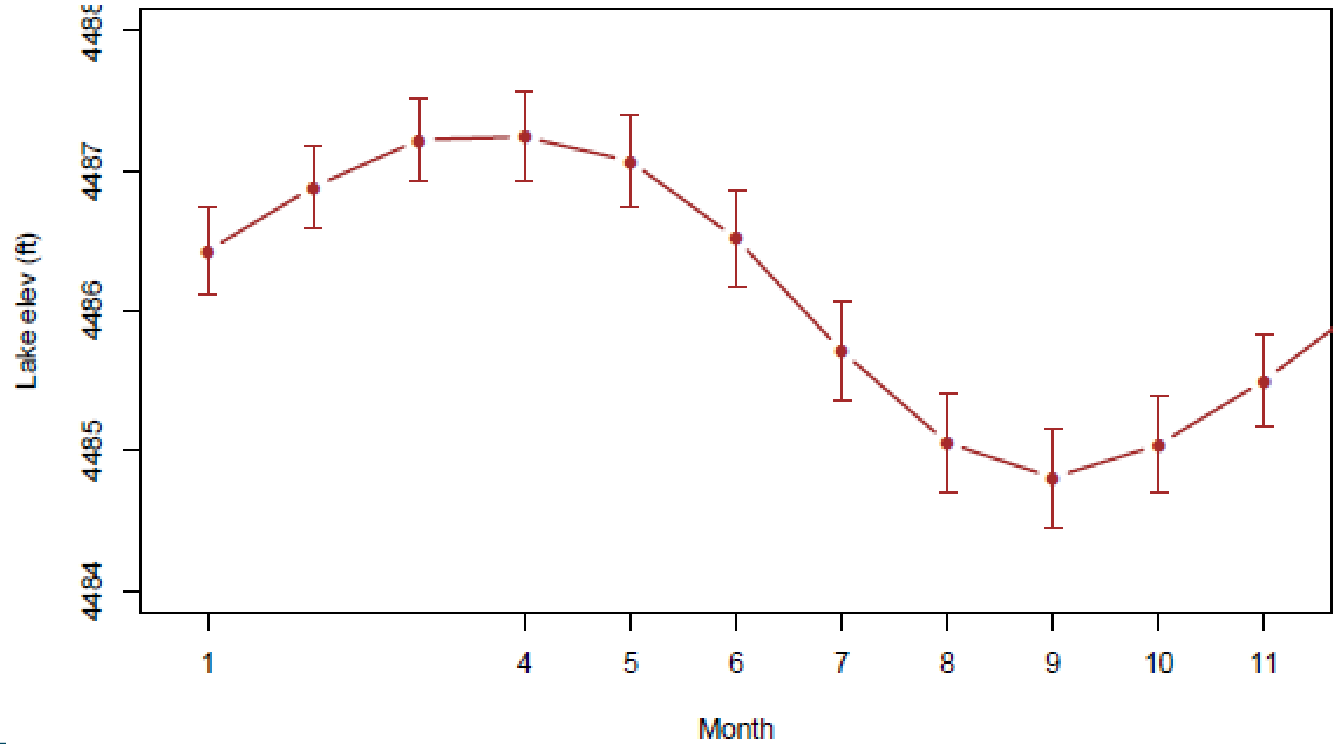
Insufficient Data and Information

The waterbody will be categorized 3A if there is one exceedance of 20,000 cells/mL. These waterbodies will be prioritized for further evaluation with respective public health managing partners such as the Utah Department of Health and state parks departments.

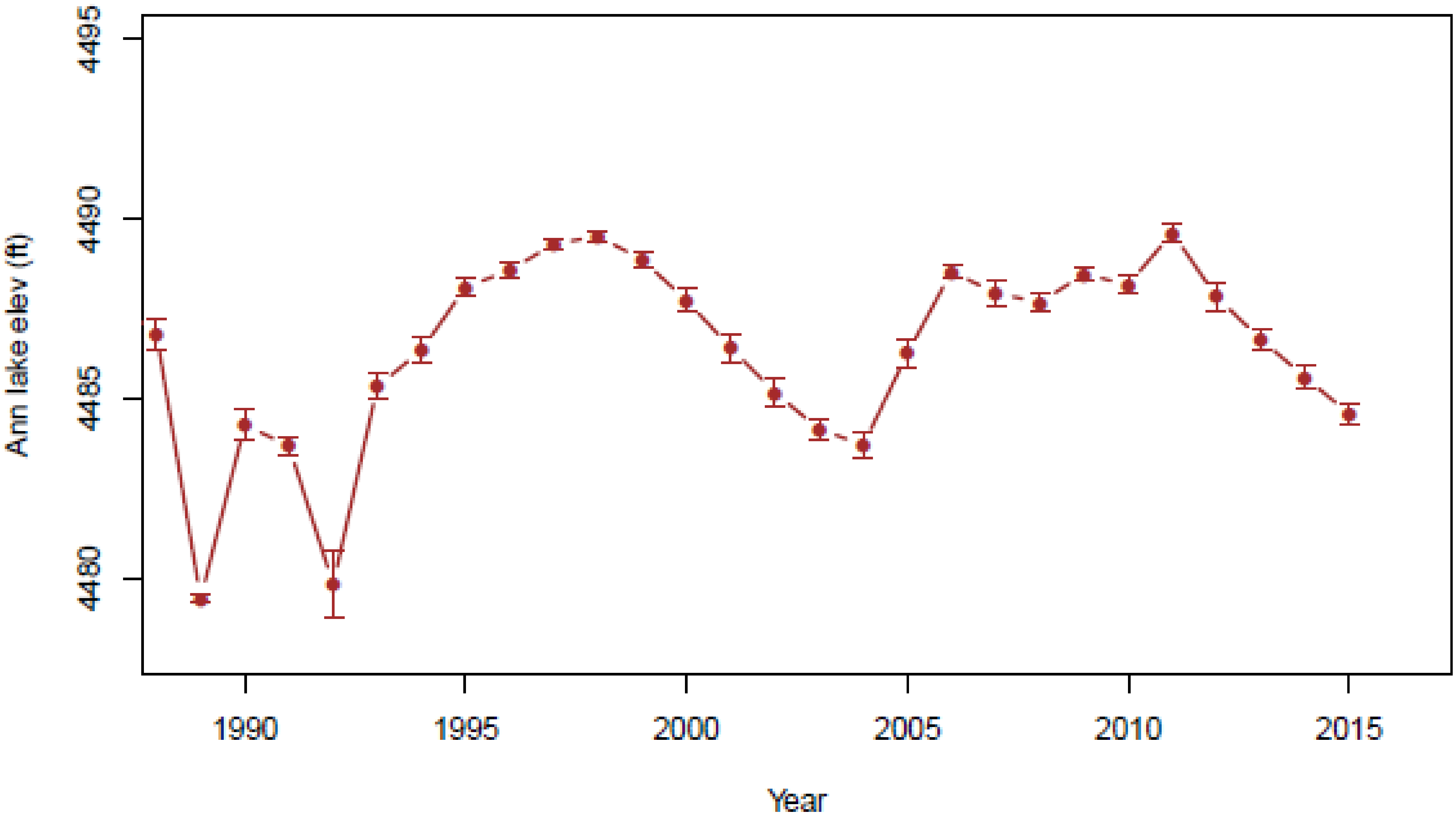

TSI
20
40
60
80
100
1990
1995
2000
2005
2010
2015
Secchi TSI
TP TSI
ChlA TSI

Seasonal patterns

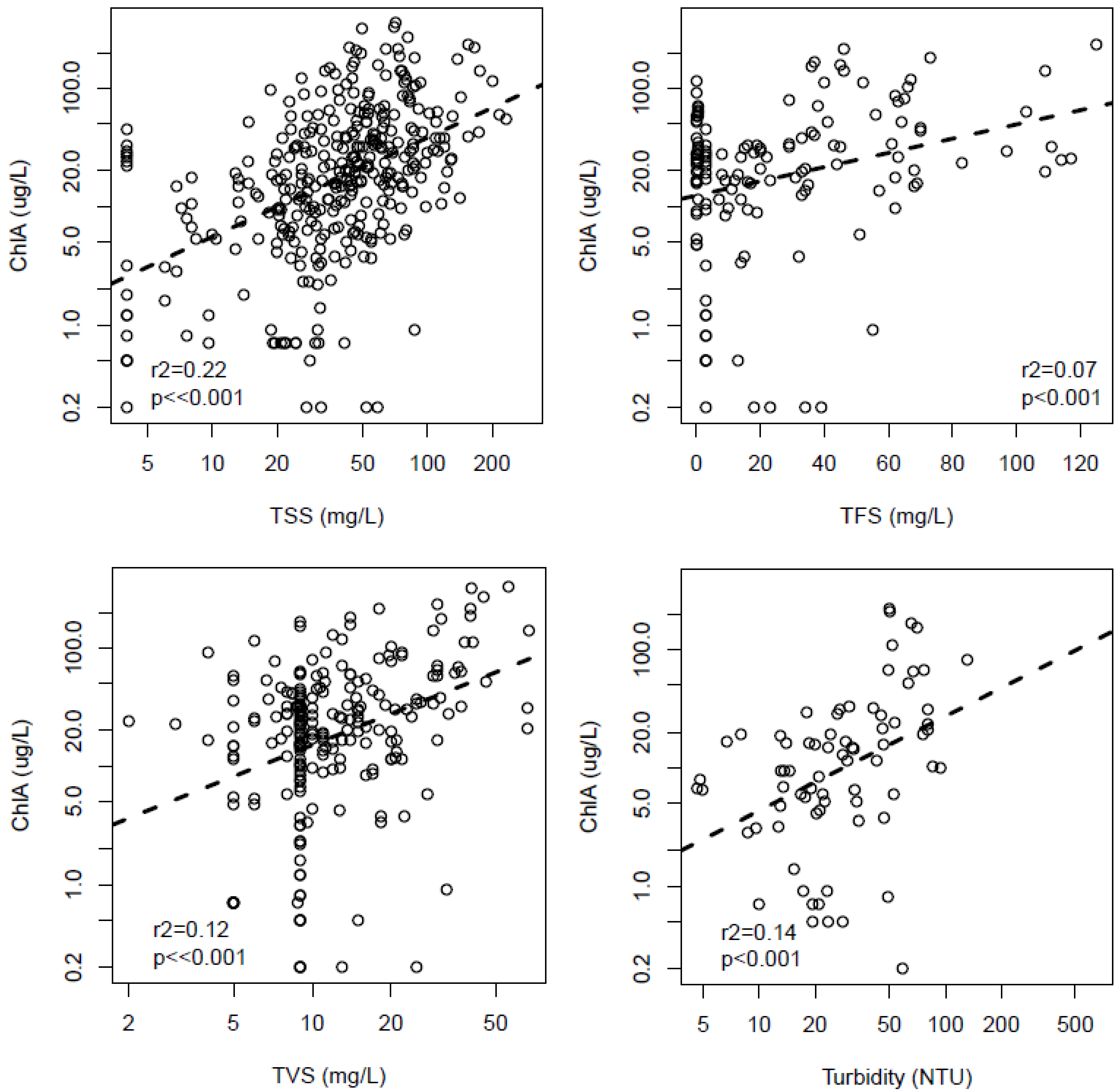




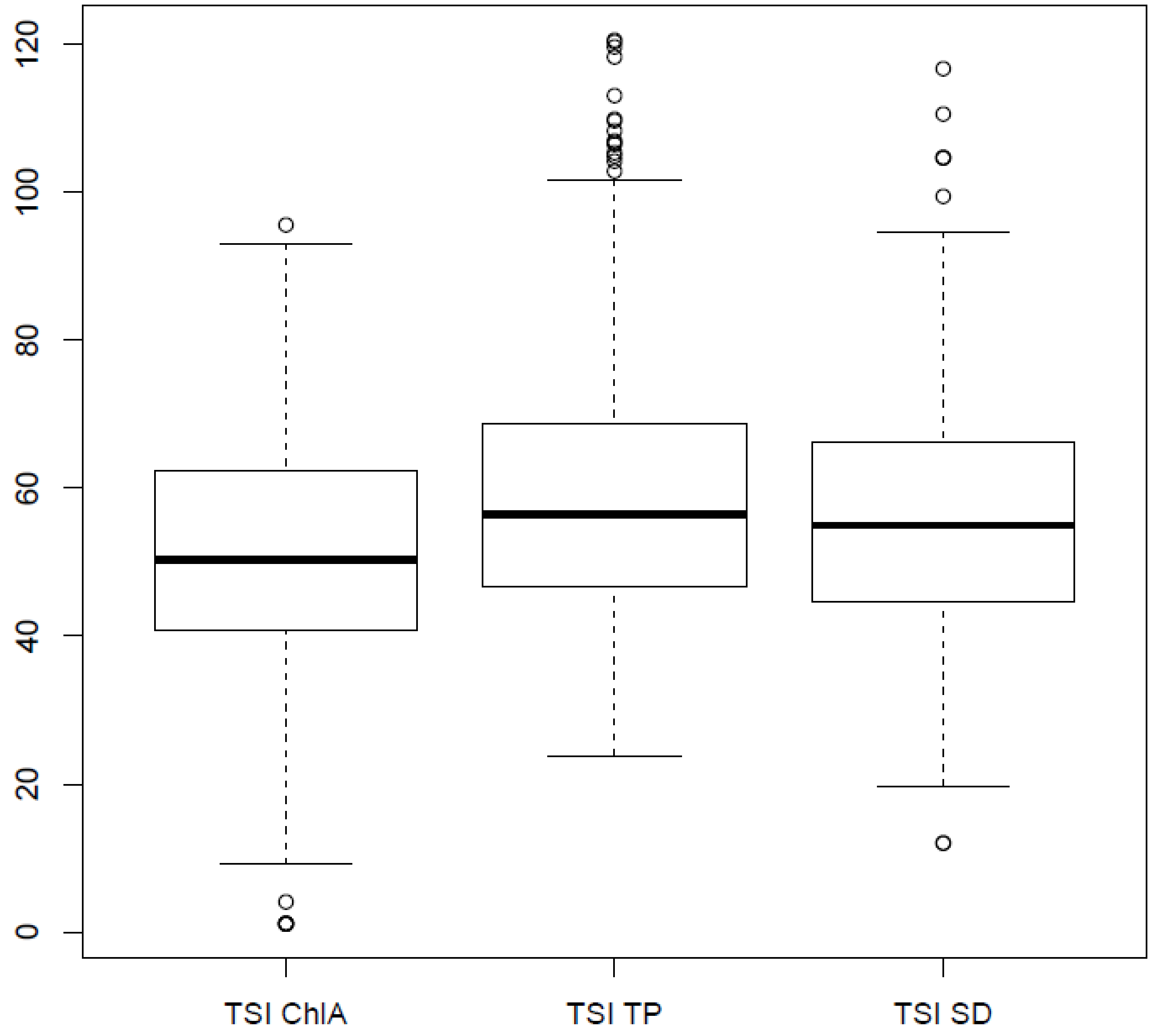
Annual lake elevation



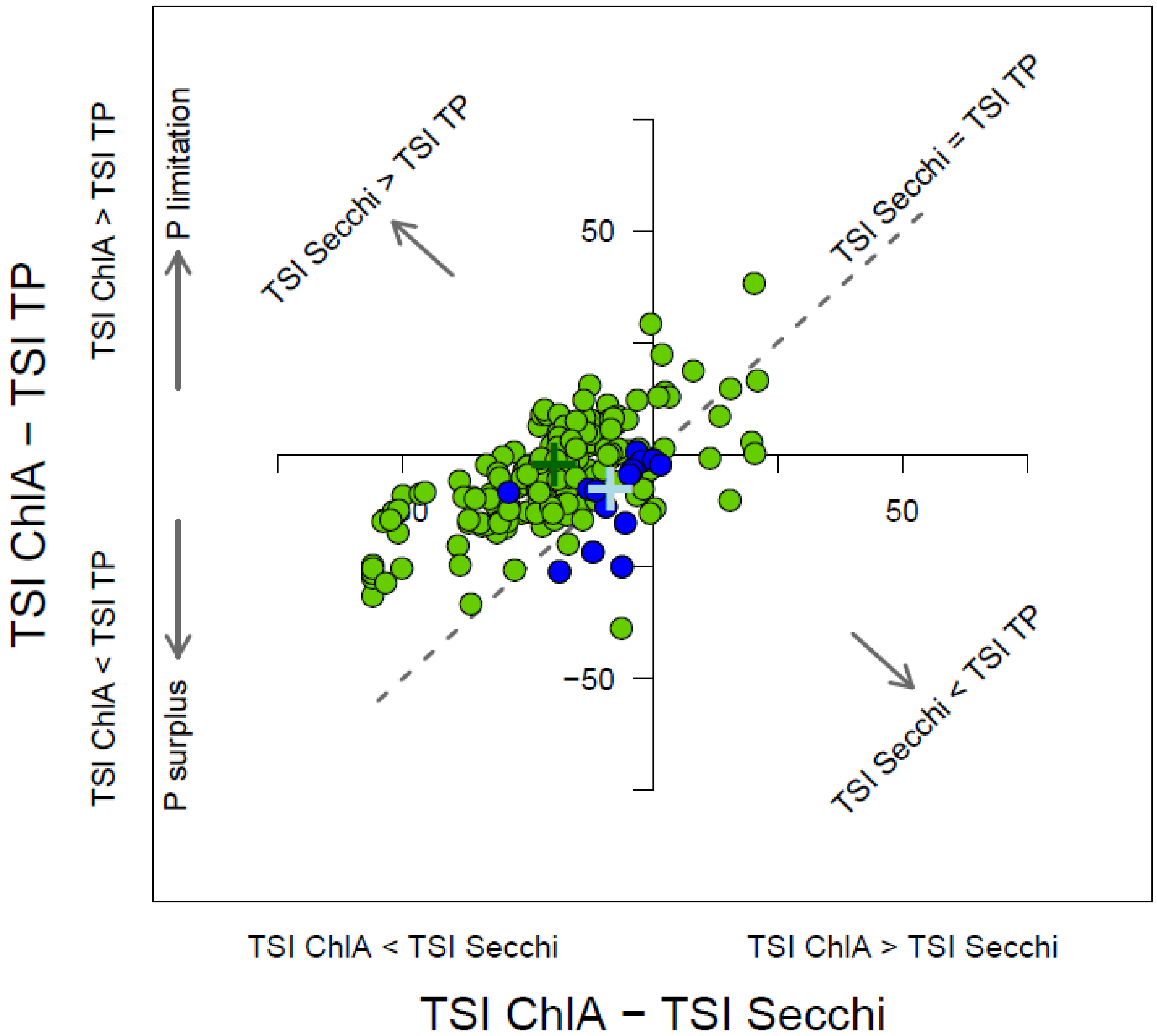
ChlA and Turbidity Measures



NLA TSIs



Utah Lake TSI difference plot



Blue = Provo Bay

Utah Lake and NLA Trophic Relationships