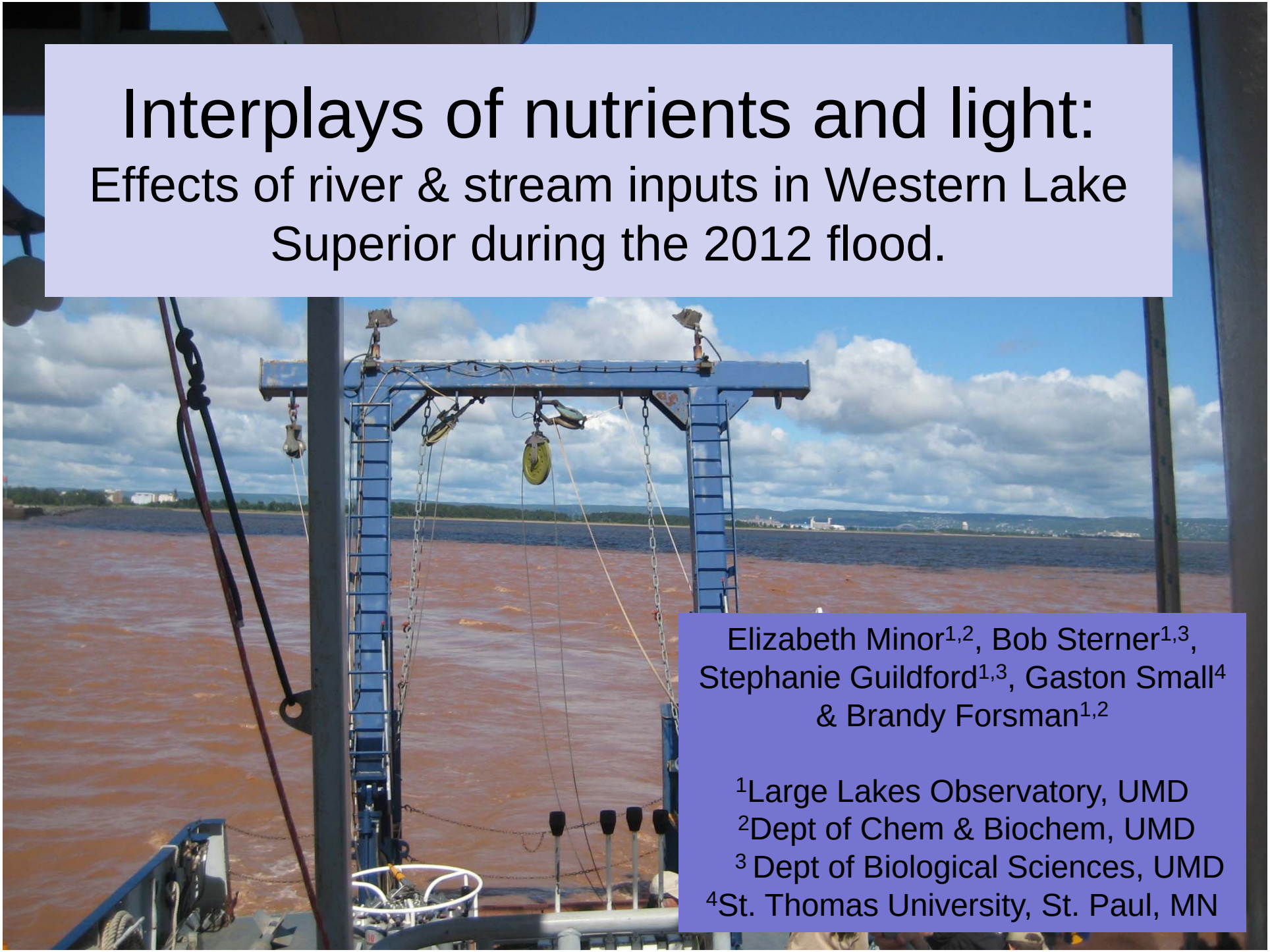
Interplays of nutrients and light:

Effects of river & stream inputs in Western Lake Superior during the 2012 flood.



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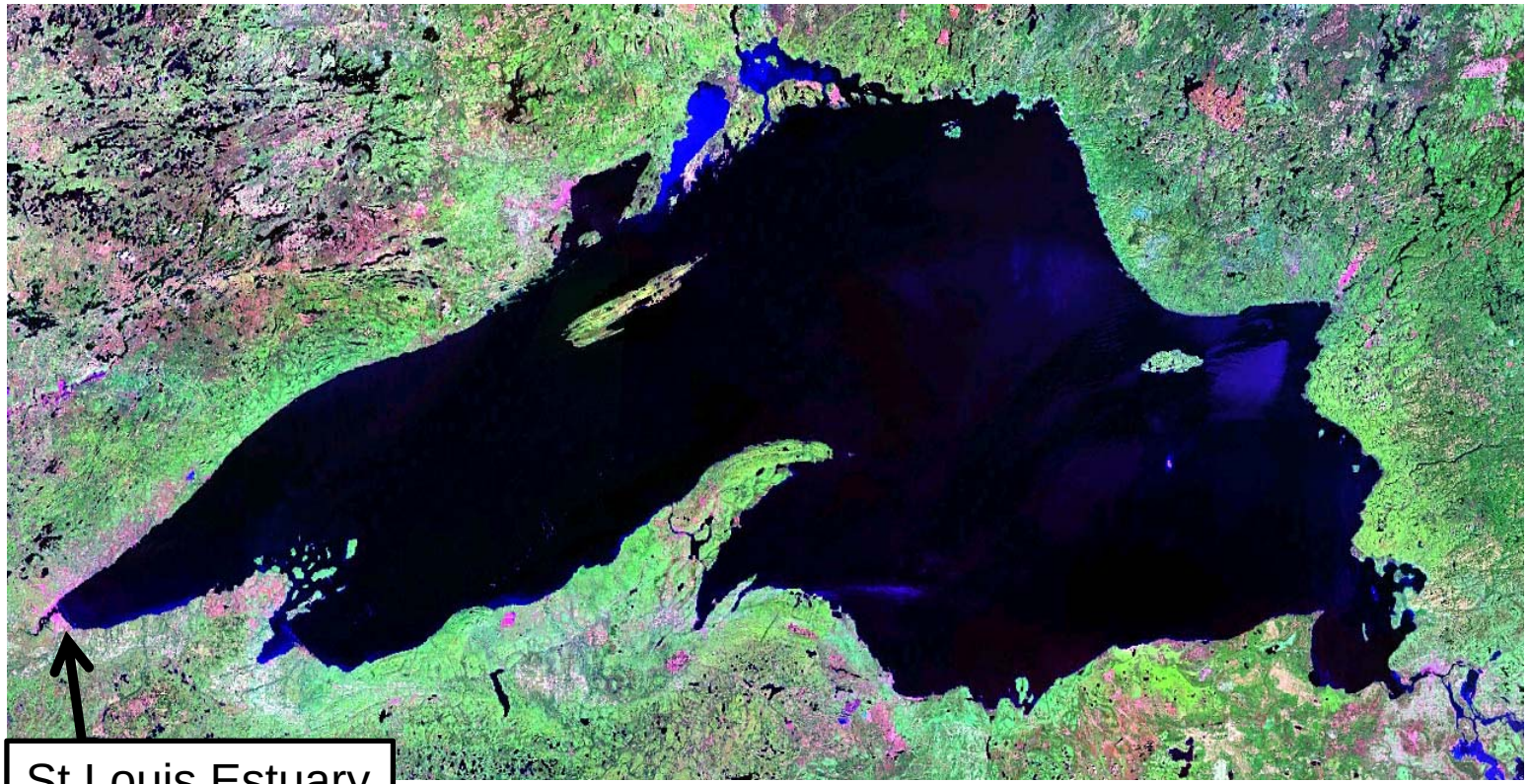
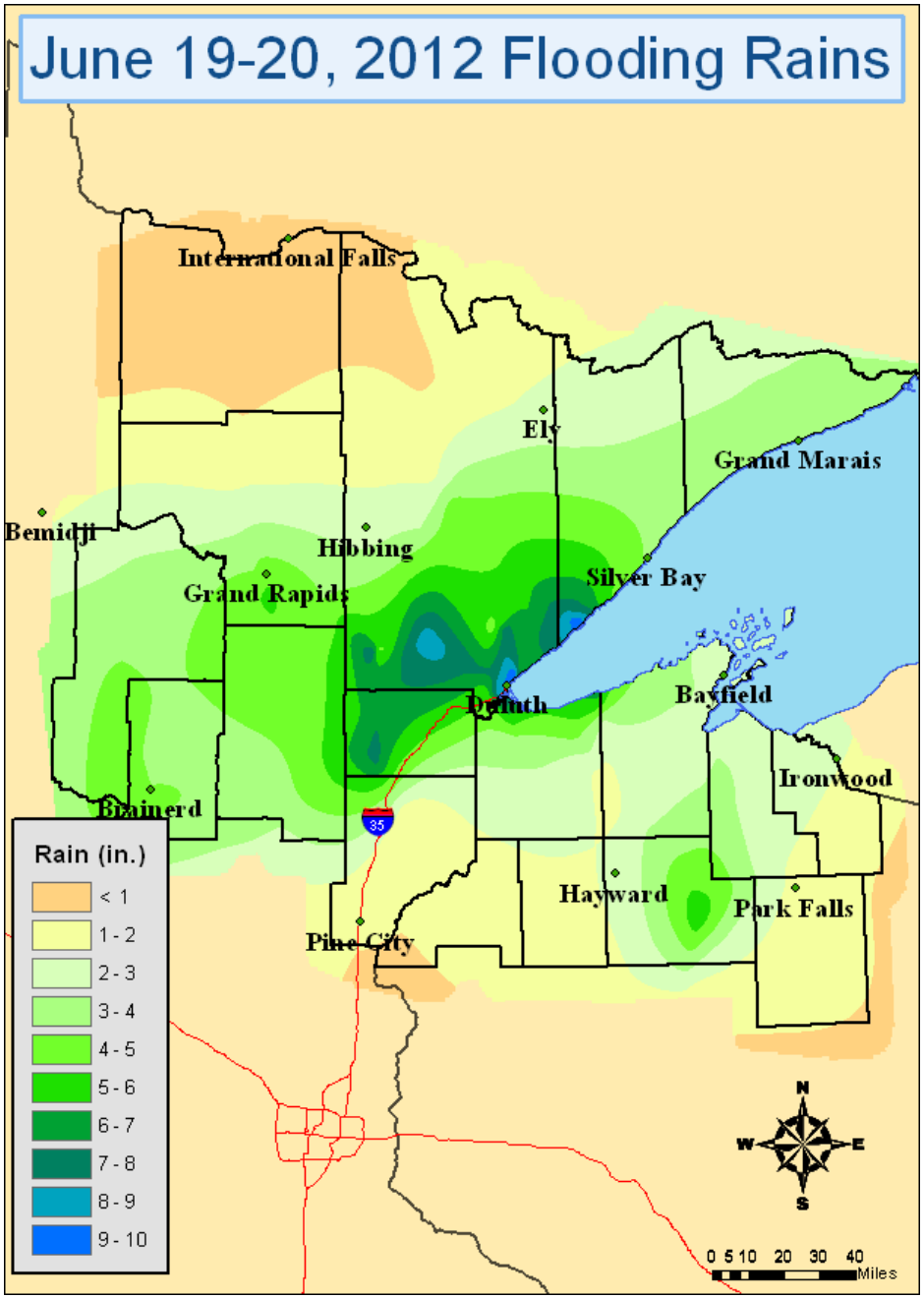
[3] Dept of Biological Sciences, UMD
[4]St. Thomas University, St. Paul, MN

Lake Superior:

- Largest freshwater lake in world (by area, 82,100 km^2).
- Fairly pristine: 610,000 people live in its watershed (MN SeaGrant).
- P (and maybe Fe) limited (Sterner et al., 2004, Limnology and Oceanography, 49(2). 495-507) with very high N:P ratios



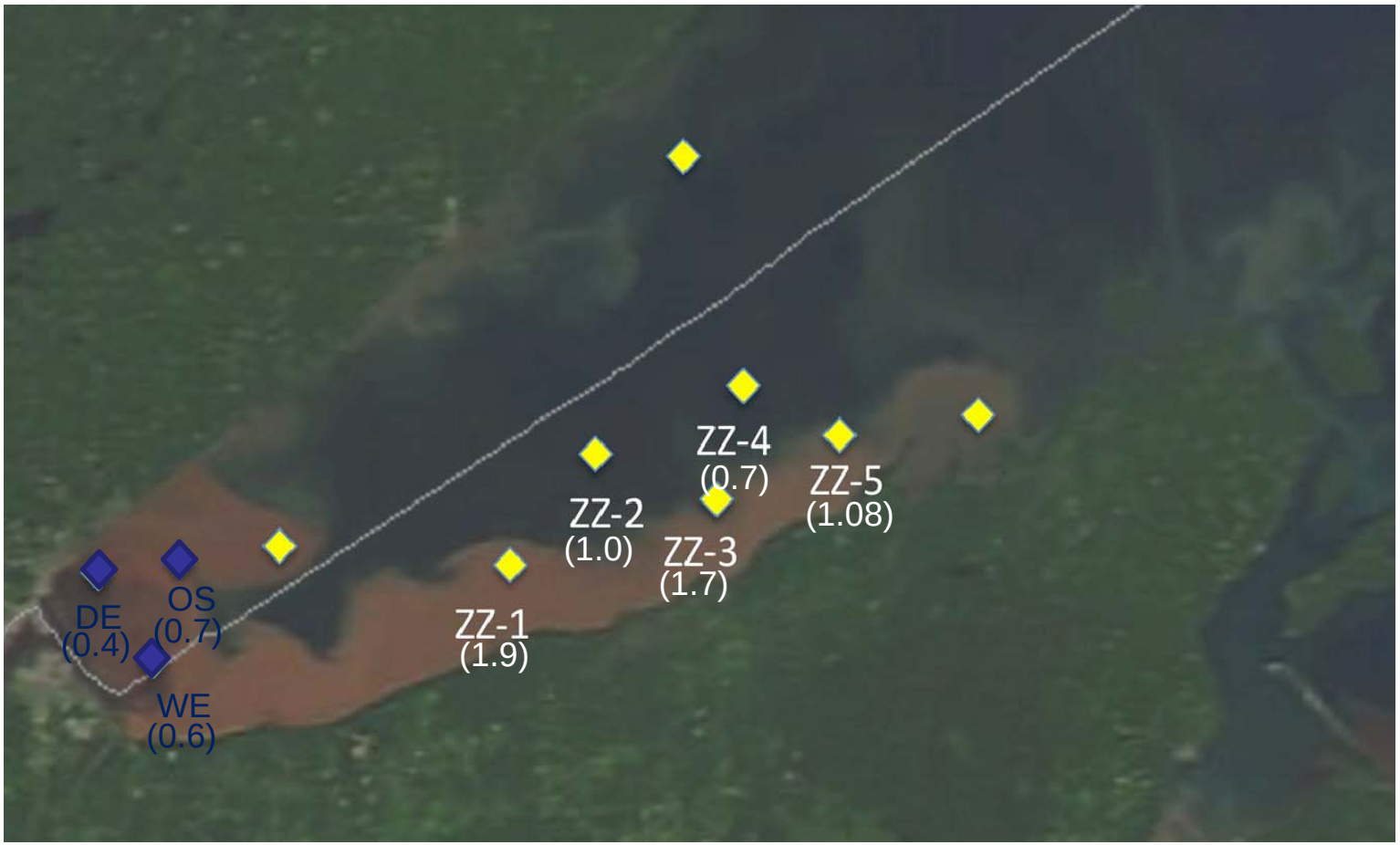


One of 11 identified mega-rain events in Minnesota since 1866:

mega-rain event = 6 inches of rain or more delivered over an area of 1000 square miles

Of 11 events, 4 have occurred in the last decade

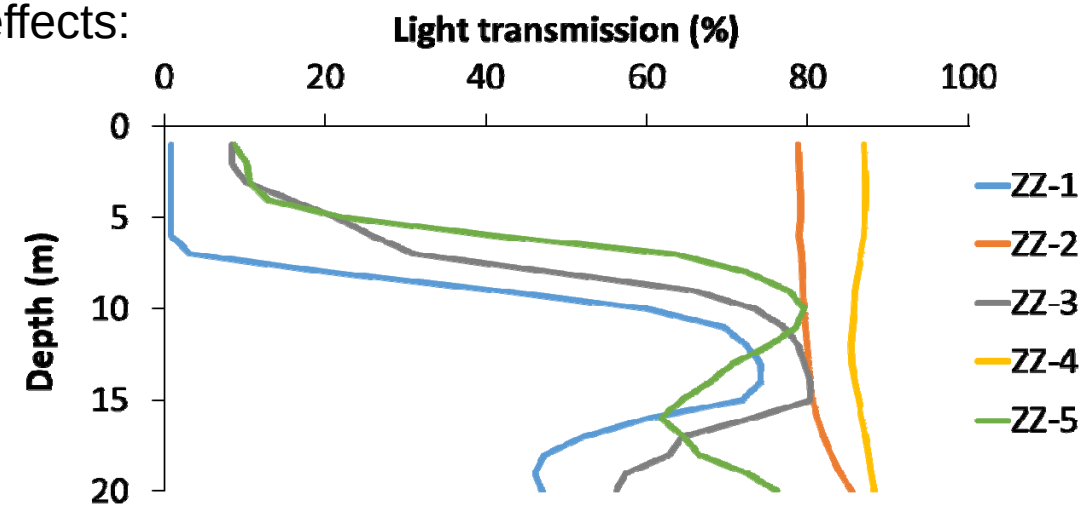
(climate.umn.edu/doc/journal/mega_rain_events.html, accessed July 9, 2012).



MODIS satellite image from June 25, 2012, showing sediment plumes in western Lake Superior, with sampling stations overlayed.
All sites: plume view sampled on June 25 (yellow at 2m; blue at 5m). Blue sites: over-time view with ~ biweekly sampling from June 22 to October 18, 2015

PLUME VIEW

Light effects:

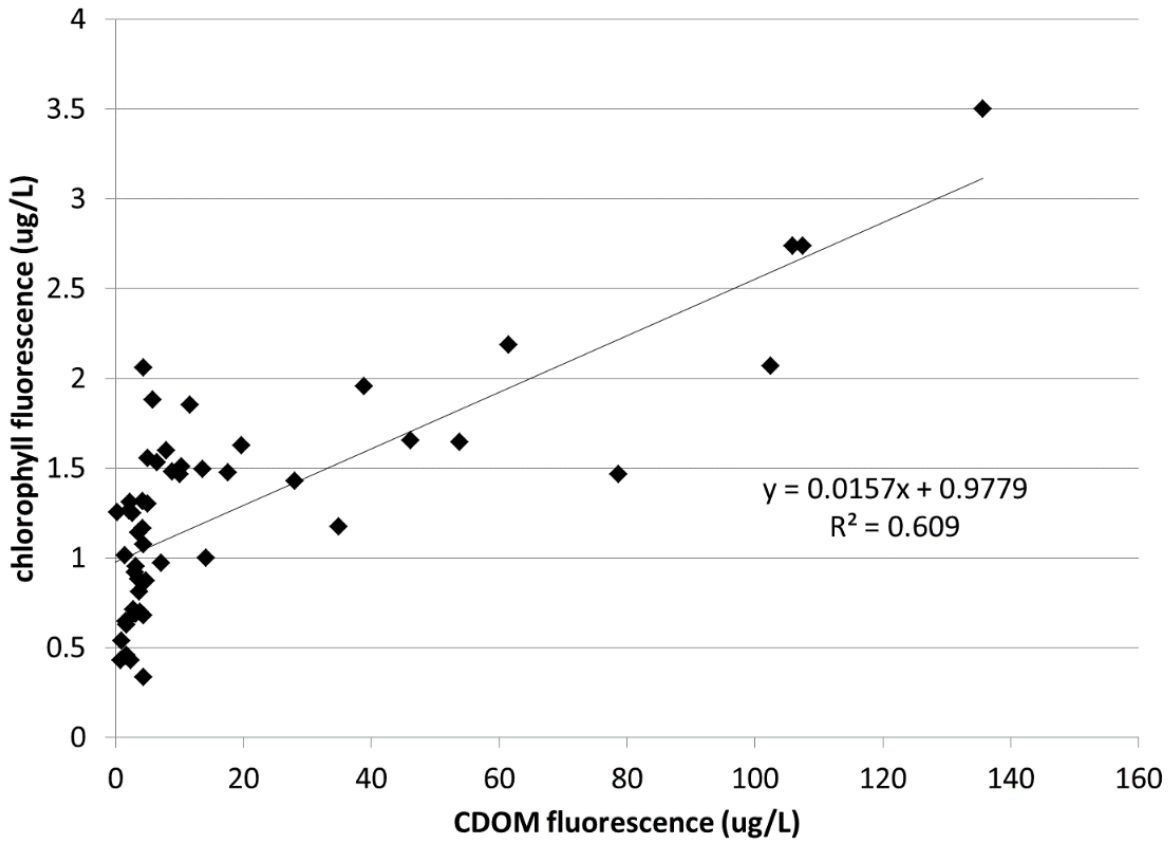


Nutrient effects:

Area of plume: 678 km^2
Depth of plume: 10 m
Particulate P: 26.7 ug L^{-1}
Total dissolved P: 61.5 ug L^{-1}
Total P: 88.2 ug/L = 882 kg P/km^2
Total P in plume: 598,000 kg P
Estimated annual P loading to lake: 1,470,000 kg
(derived from Robertson and Saad 2001)
The mega storm supplied 44% of typical annual P load

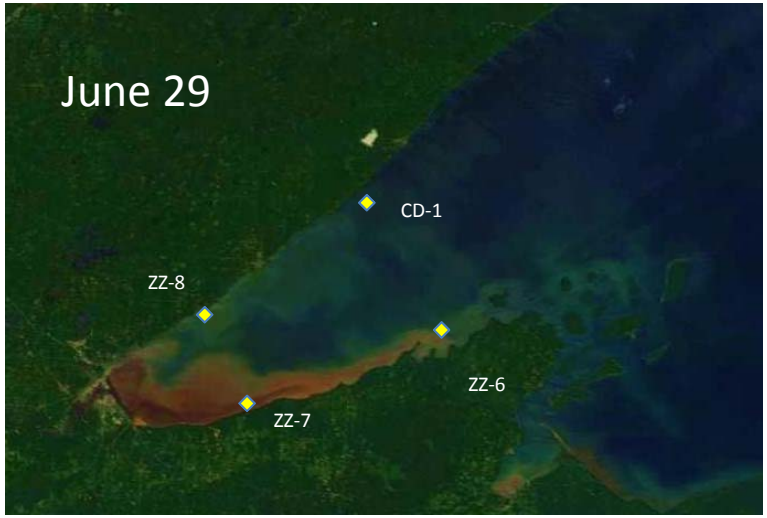
So what happens to the phytoplankton, base of food web?

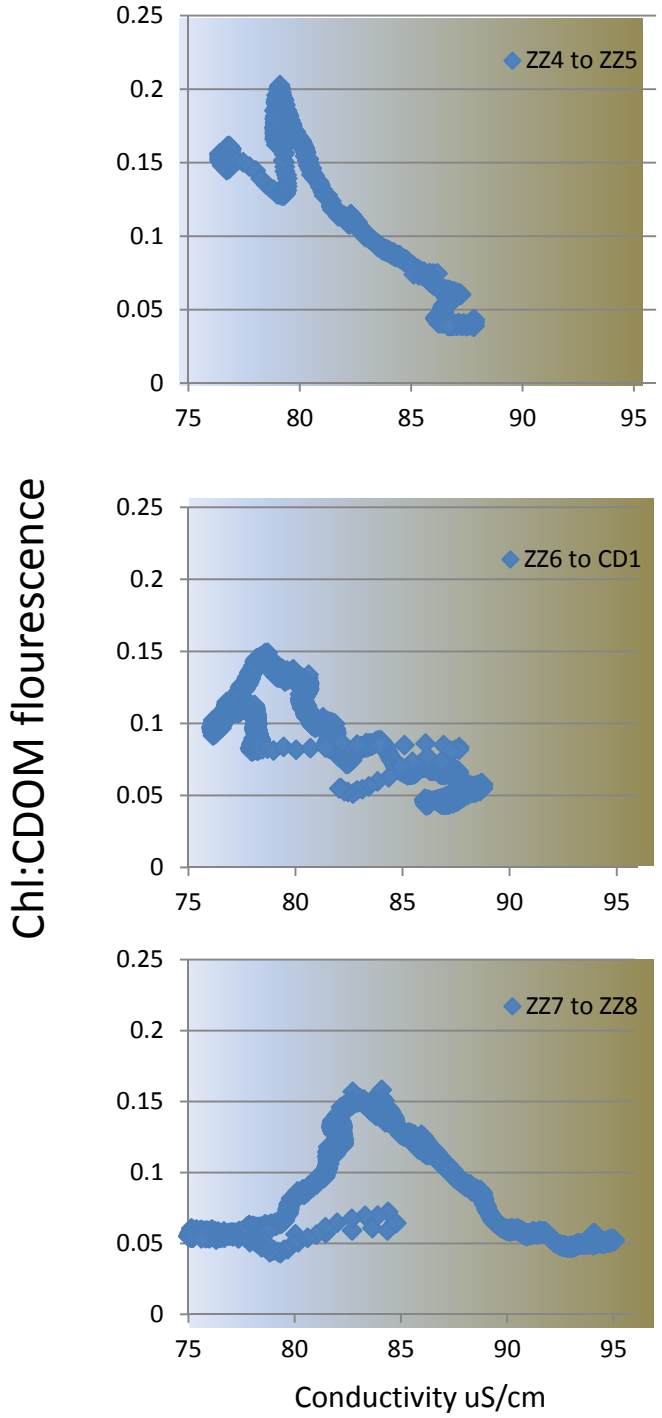
A complication….



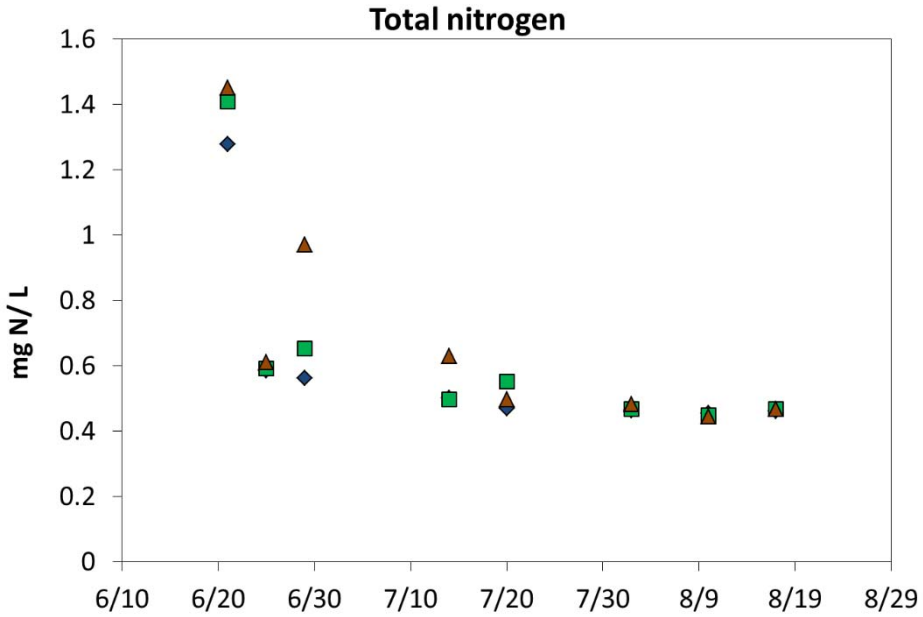
Minor et al 2014. JGLR 40: 455-462

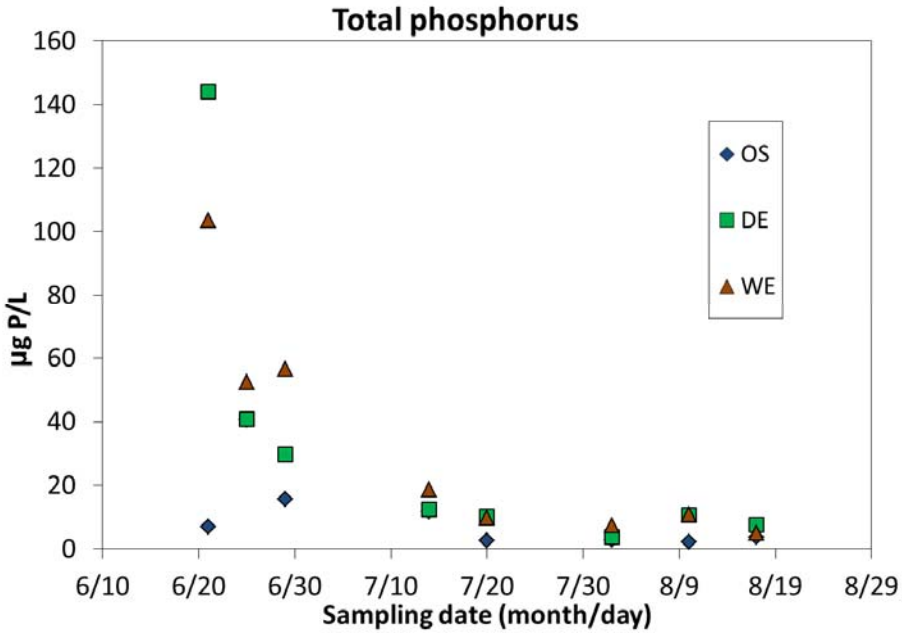

June 25
ZZ-4
ZZ-5

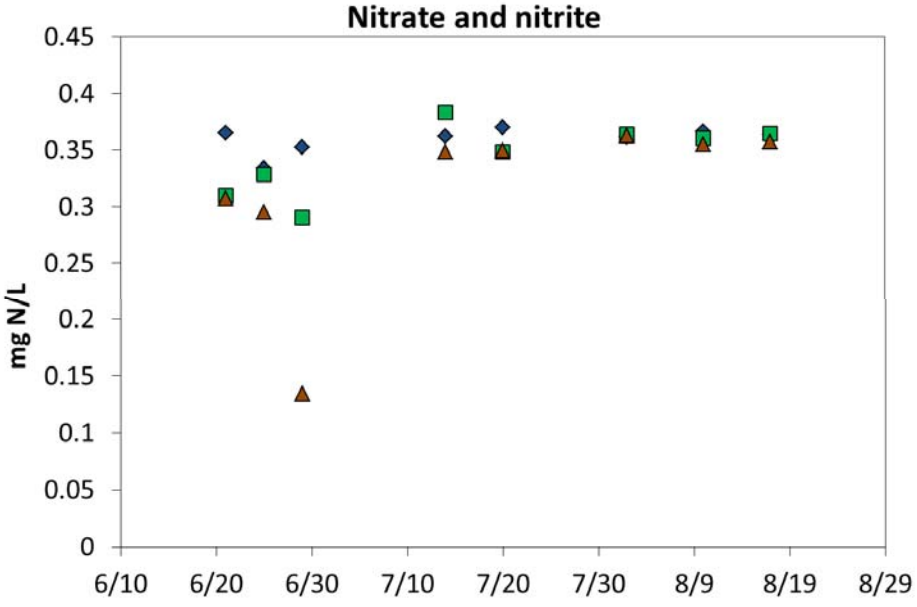

June 29
CD-1
ZZ-8
ZZ-6
ZZ-7

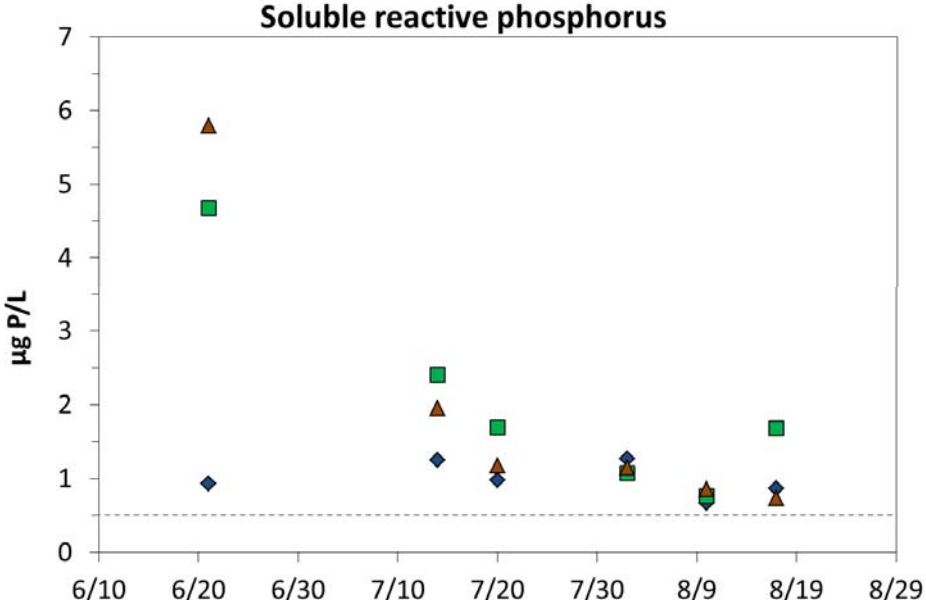

Chl:CDOM flourescence
ZZ4 to ZZ5
ZZ6 to CD1
ZZ7 to ZZ8
0.25
0.2
0.15
0.1
0.05
0
75
80
85
90
95
Conductivity uS/cm

OVER-TIME VIEW

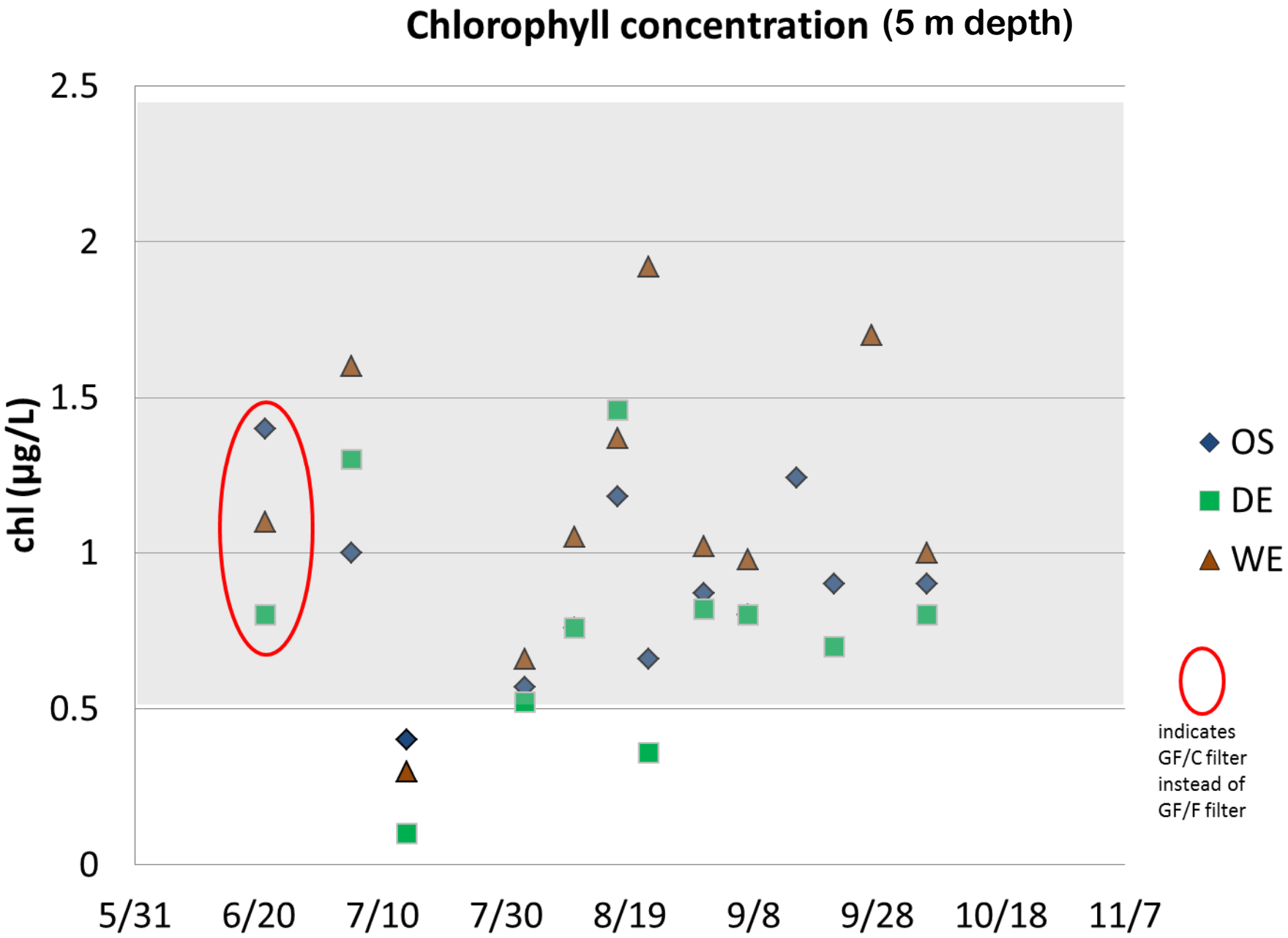




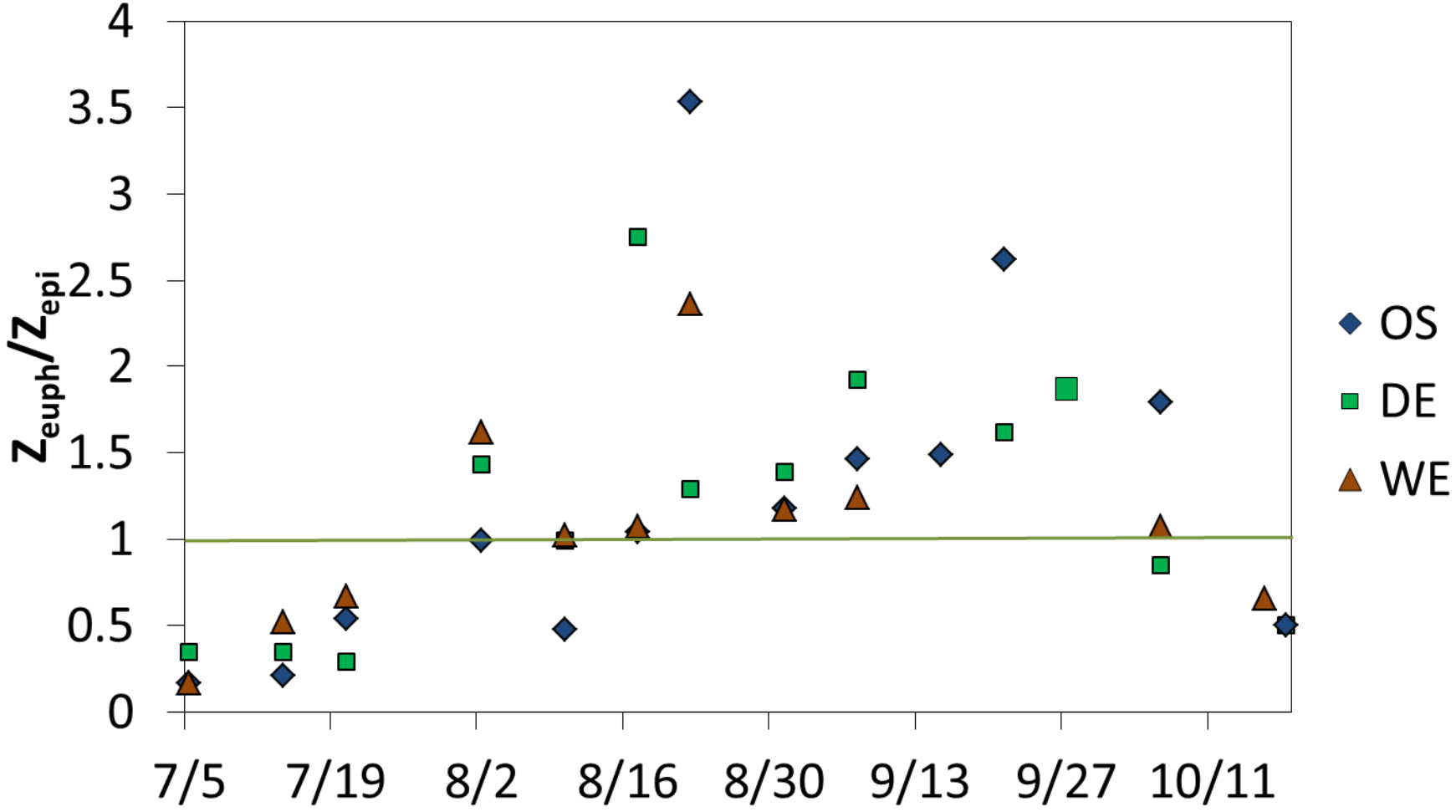




Redrawn from Minor et al 2014. JGLR 40: 455-462

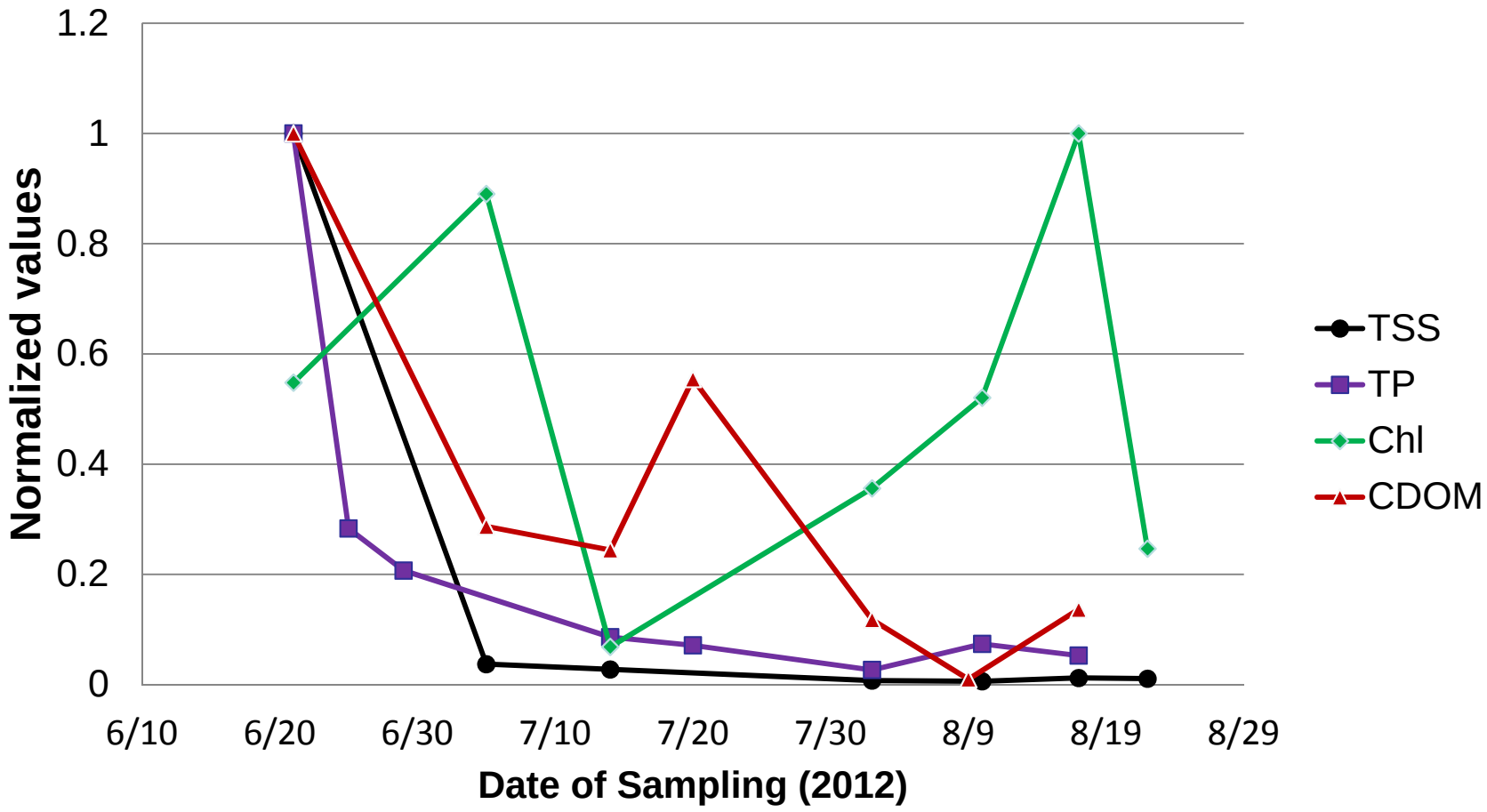

Chlorophyll concentration (5 m depth)
chl (µg/L)
2.5
2
1.5
1
0.5
0
5/31
6/20
7/10
7/30
8/19
9/8
9/28
10/18
11/7
OS
DE
WE
indicates GF/C filter instead of GF/F filter

Euphotic zone depth (from PAR)/surface mixed layer depth



Data from Minor et al 2014. JGLR 40: 455-462. Table 2

Duluth entry (DE) data



Results

- Lake showed a strong immediate flood response (high TSS, DOC, nutrient concentrations).
- Plume View: Indications of increased chlorophyll in plume, especially at edges
- Over-time View: At the far western sites the flood did not appear to cause much effect on phytoplankton growth (either short-term or long term). Are the phytoplankton there adapted to such sediment pulses?

Next steps

- This work is incomplete.
- The spatial information obtained shows that location in the plume matters in terms of ecosystem response.
- The temporal data shows that the timing of nutrient delivery relative to light availability (a function of lake stratification and sediment & CDOM delivery) is important.
- For future events (predicted to occur more frequently) we need to

  1. Increase discrete sampling stations across the plume in conjunction with real-time underway sampling and satellite overviews.

  2. Look at growth rates of phytoplankton, zooplankton and microbial respiration rates, add sonar work on fish distributions (compare inside and outside plume)

  3. Follow plume evolution over time

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