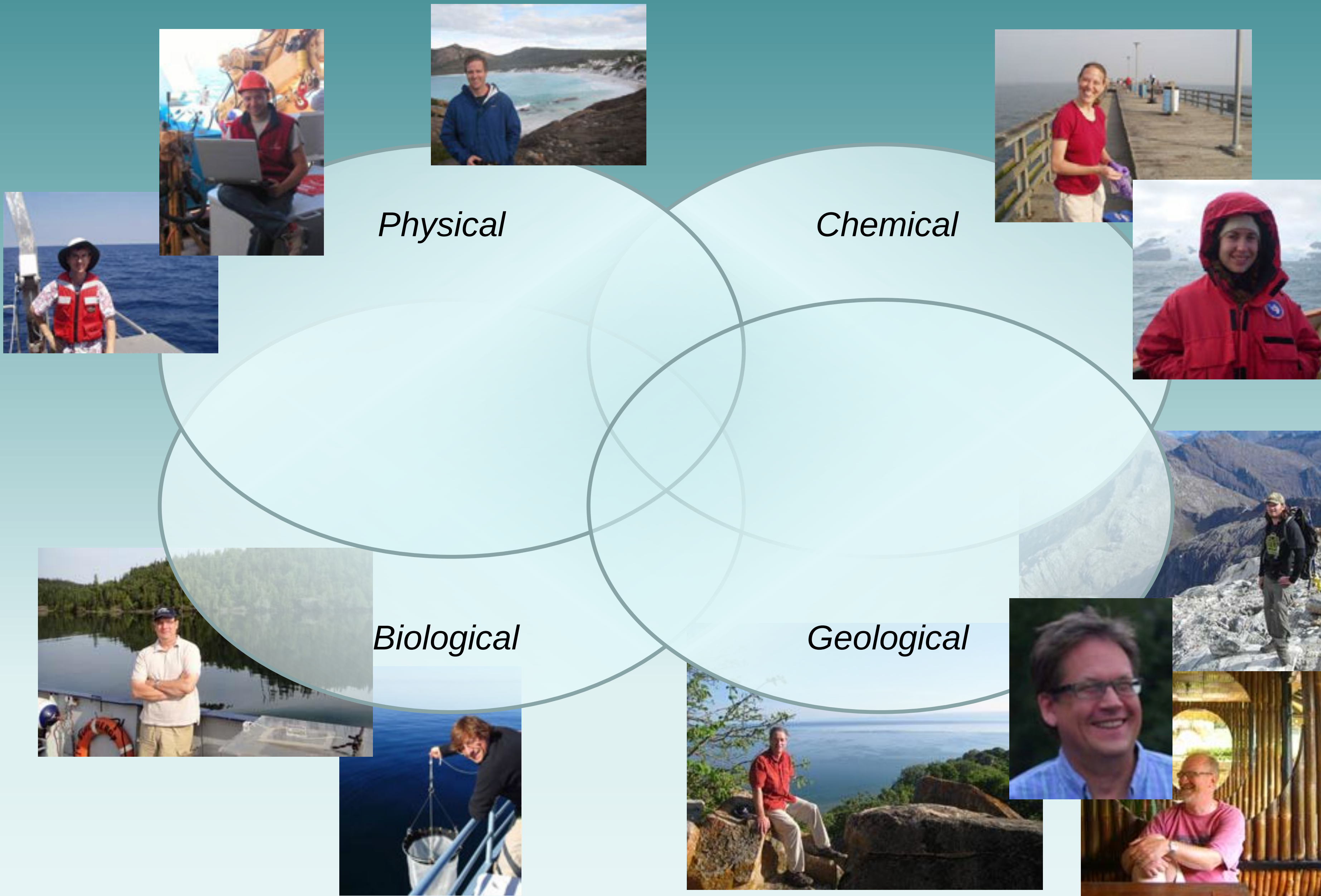
Lake Superior Collaborative
MTU March 19, 2015

Robert Sterner/LLO

University of Minnesota Duluth

Large Lakes Observatory



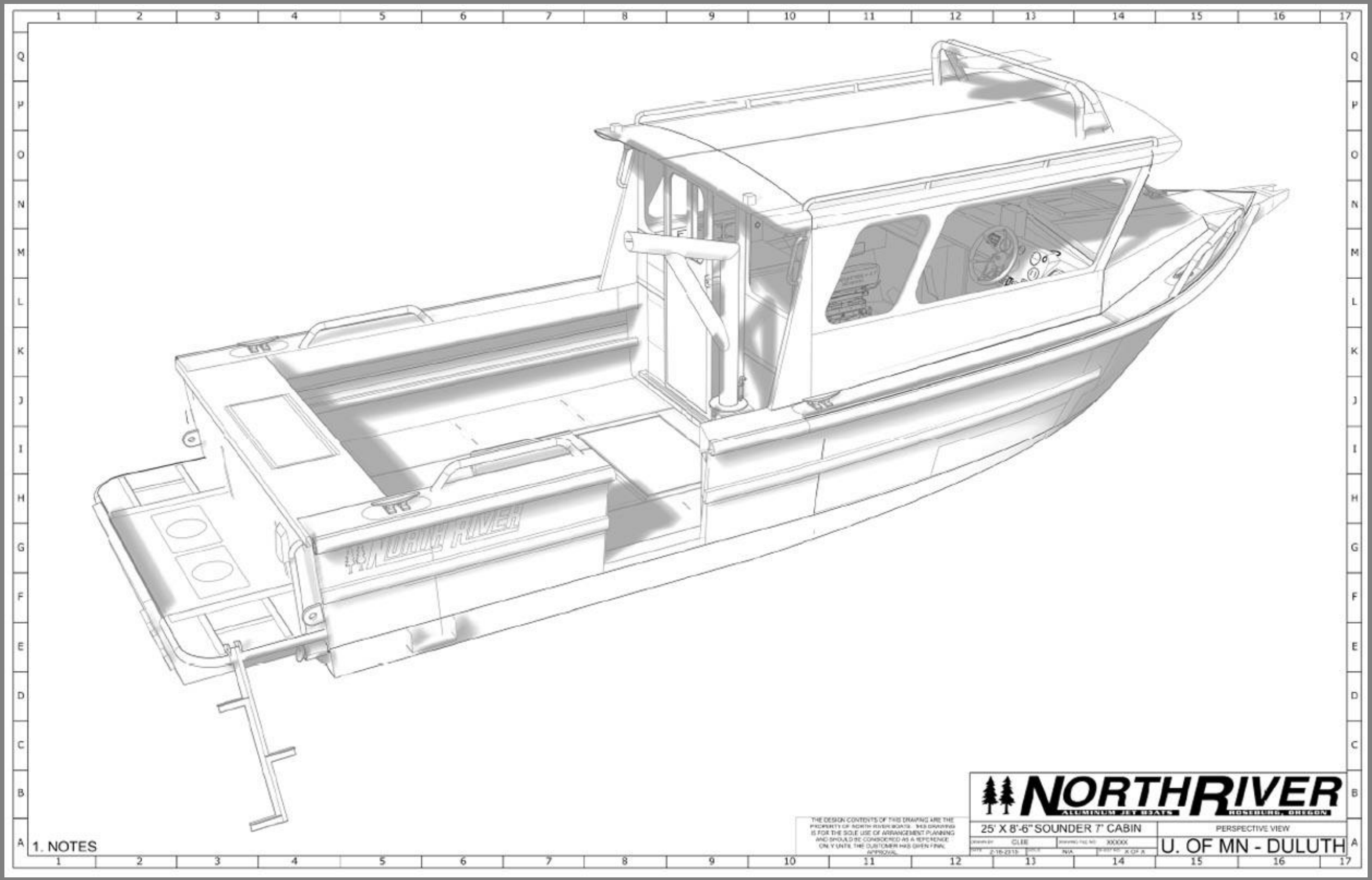
(Geomicrobiologist)

R/V Blue Heron

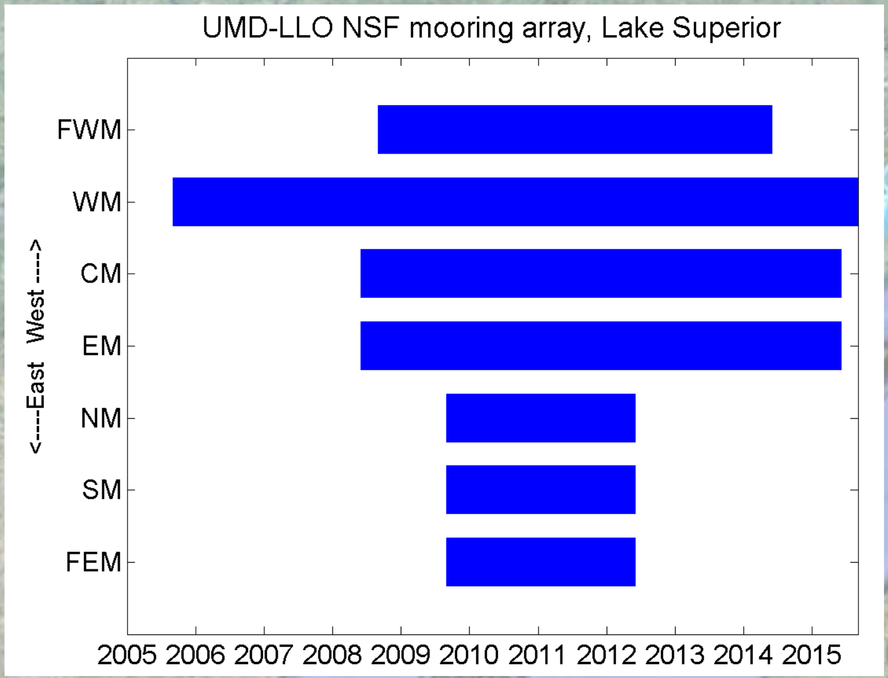
Contact Dr. Doug Ricketts (ricketts@d.umn.edu) for more information

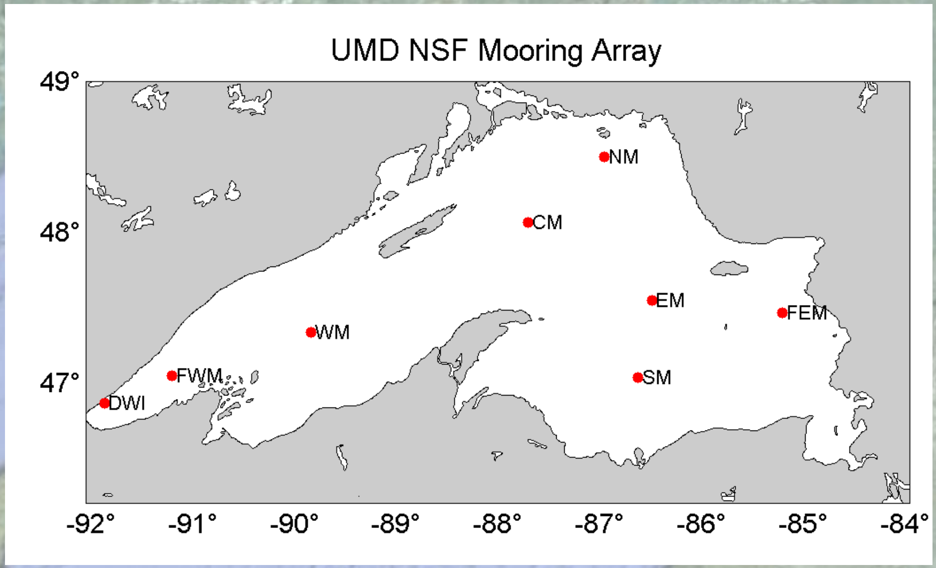
New research vessel under construction – available in June 2015

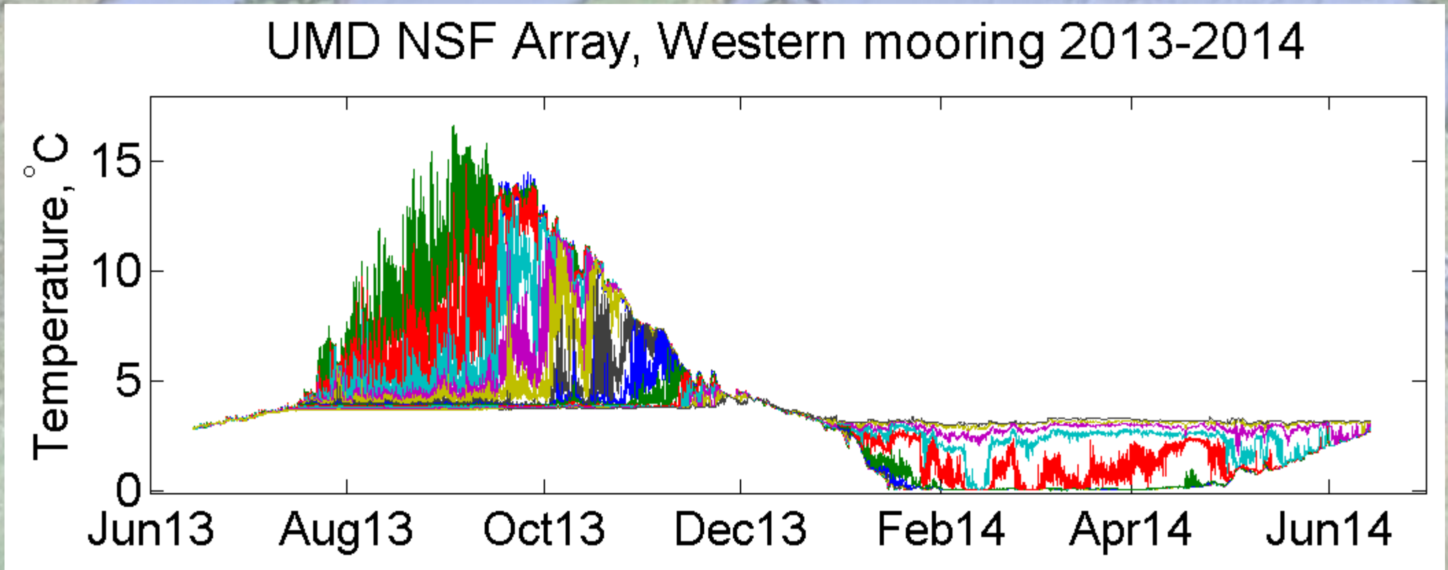
Available for nearshore, estuarine, river and lake work



UMD-LLO NSF mooring array, 2005-present

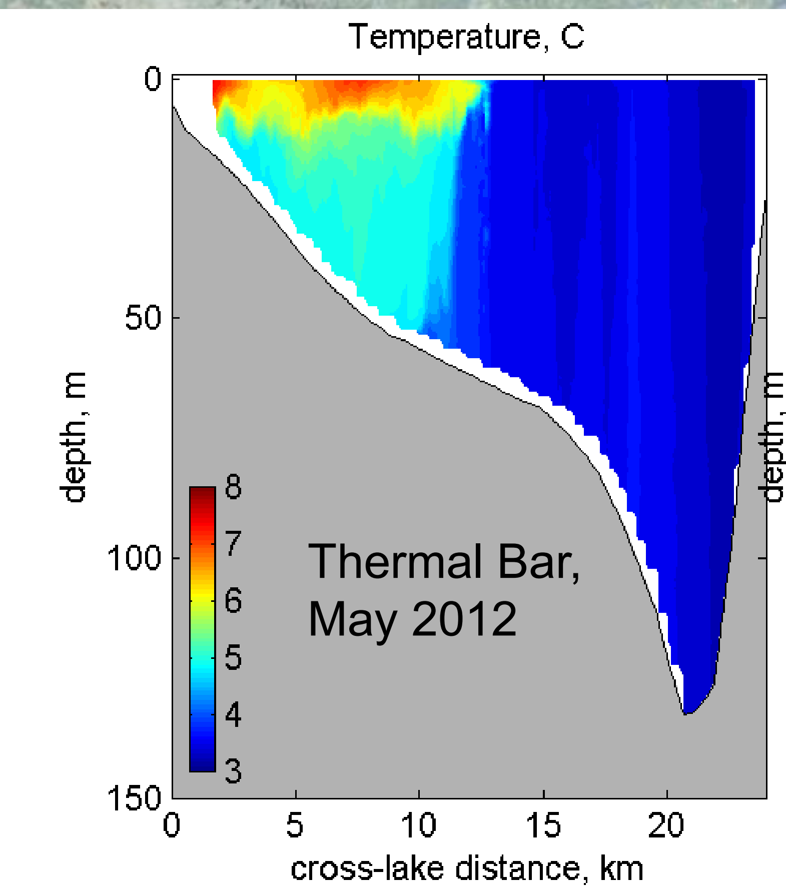


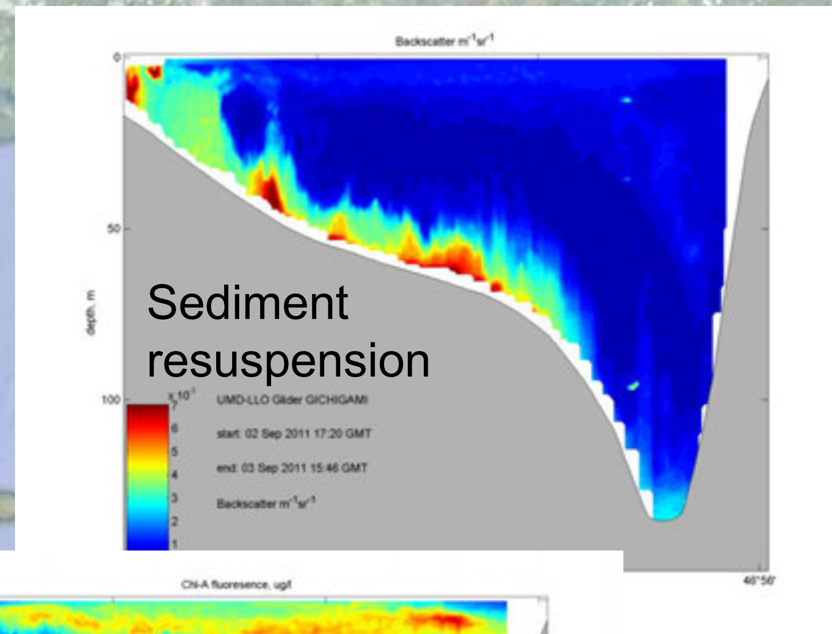


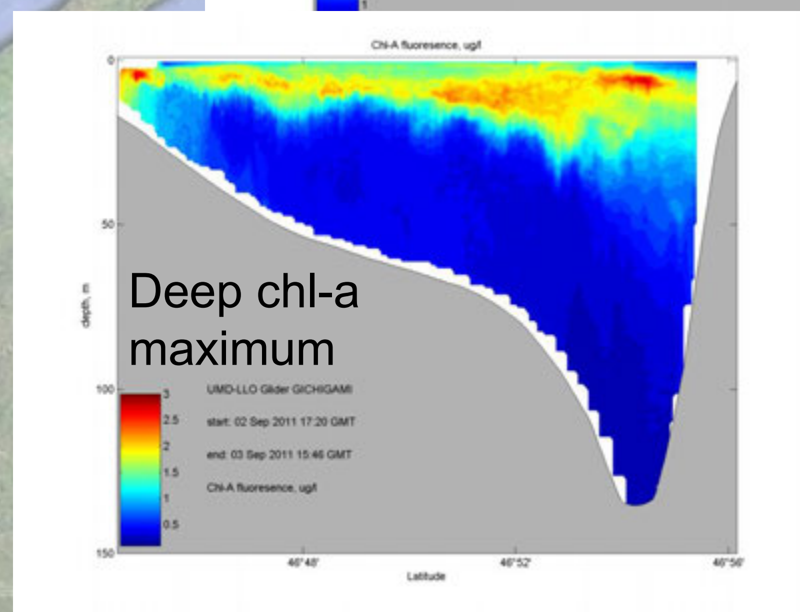


UMD-LLO glider program

- 2011-present
- T, C, CDOM, chl-A, DO, B







To contact Jay Austin:

JAUSTIN@D.UMN.ED

Sterner & Collaborators, Lake Superior Projects

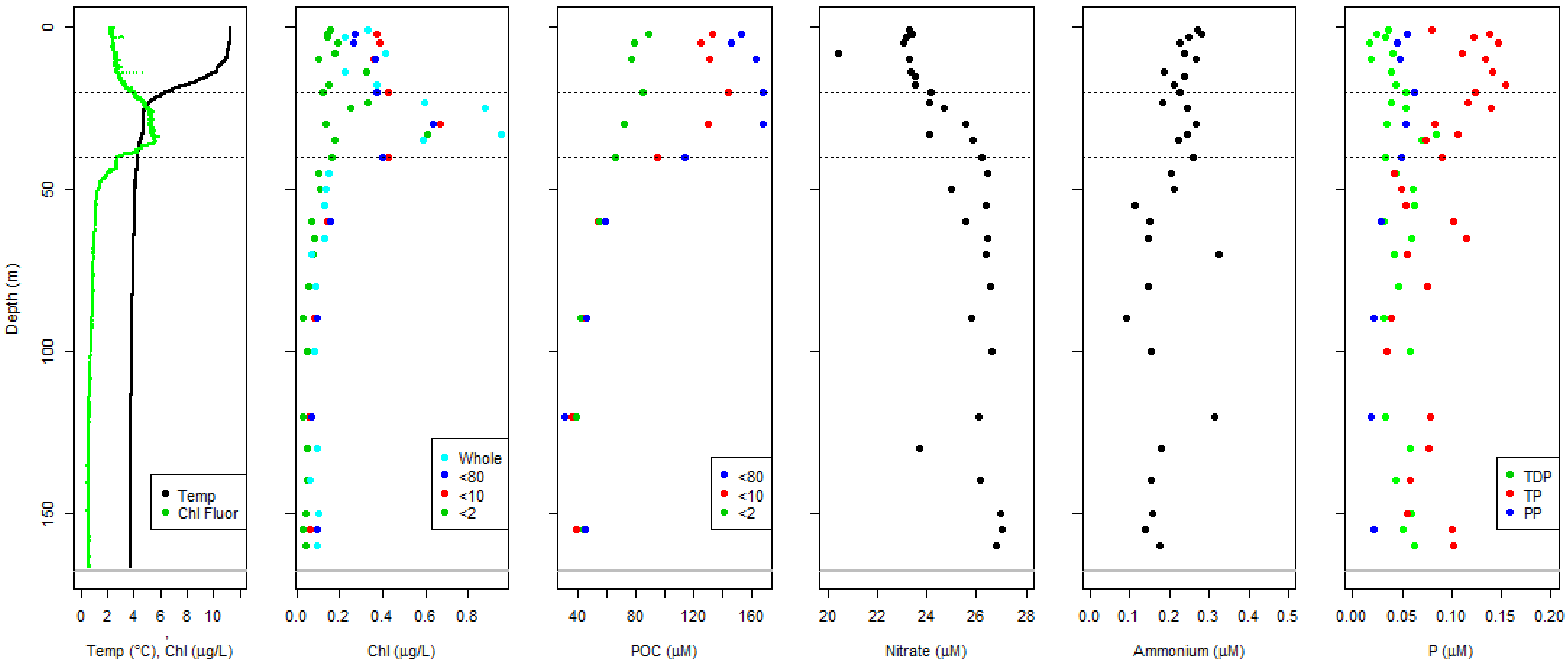
	Project	Funding	Notes
1996-97	Light:nutrient	Sea Grant	Began sampling of stoichiometry
1998-99	IRONMAN	US-NSF	Trace metals
2000-2004	NILS	US-NSF	Showed NO_3 produced in lake
2005-6	none	U of M	
2007-08	CARGO	Sea Grant	Primary production and grazing
2009-12	SINC	US-NSF	N cycle measurements Superior to Erie
2013-2014	LCCMR	State of MN	Interdisciplinary observations

Core variables

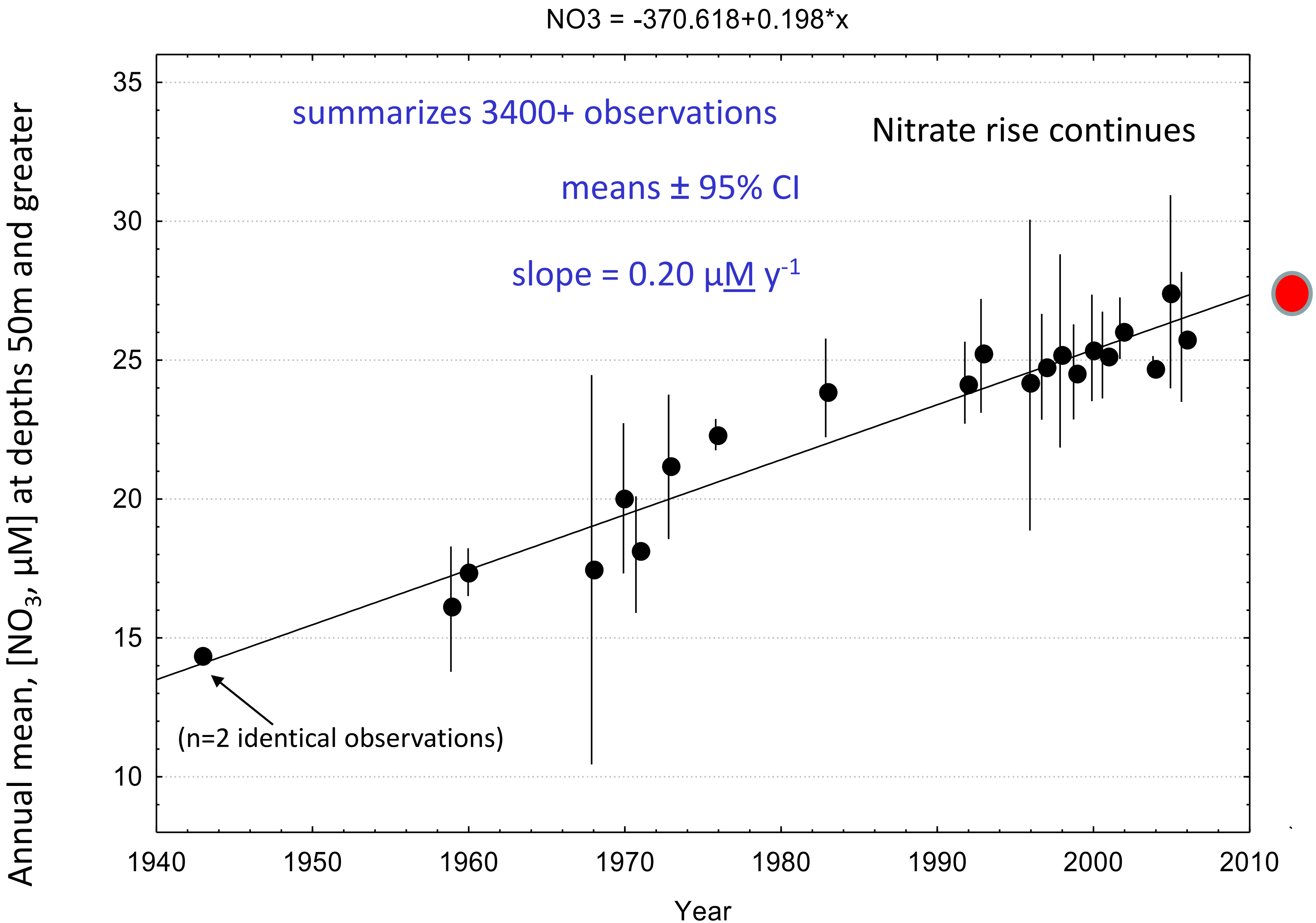
- Carbon
  - Particulate organic carbon (1 to several size fractions) plus particulate N.
  - DOC, DIC
- Chlorophyll (1 to several size fractions)
- Nutrients
  - NO3, NH4, TDP (enhanced freeze dried), TP (f.d.), Particulate P
- Primary productivity


CD-1
WM

Site WM, August 2010



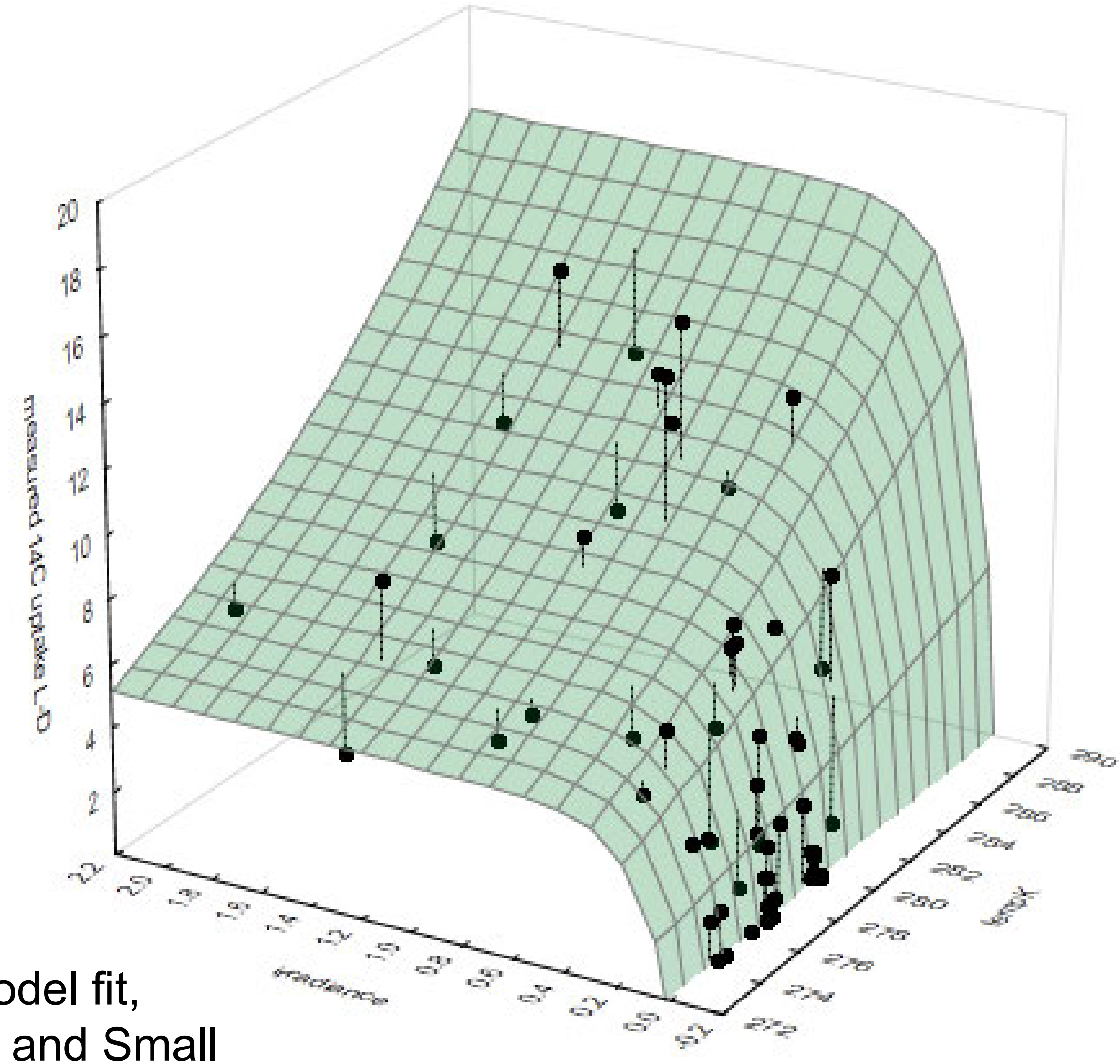
To understand the water column, we need lots of depths.



NO3 = -370.618+0.198*x
summarizes 3400+ observations
Nitrate rise continues
means ± 95% CI
slope = 0.20 µM y-1
(n=2 identical observations)
Annual mean, [NO3, µM] at depths 50m and greater
Year
35
30
25
20
15
10
1940
1950
1960
1970
1980
1990
2000
2010

Work on the carbon budget

In situ, daily integrated primary production



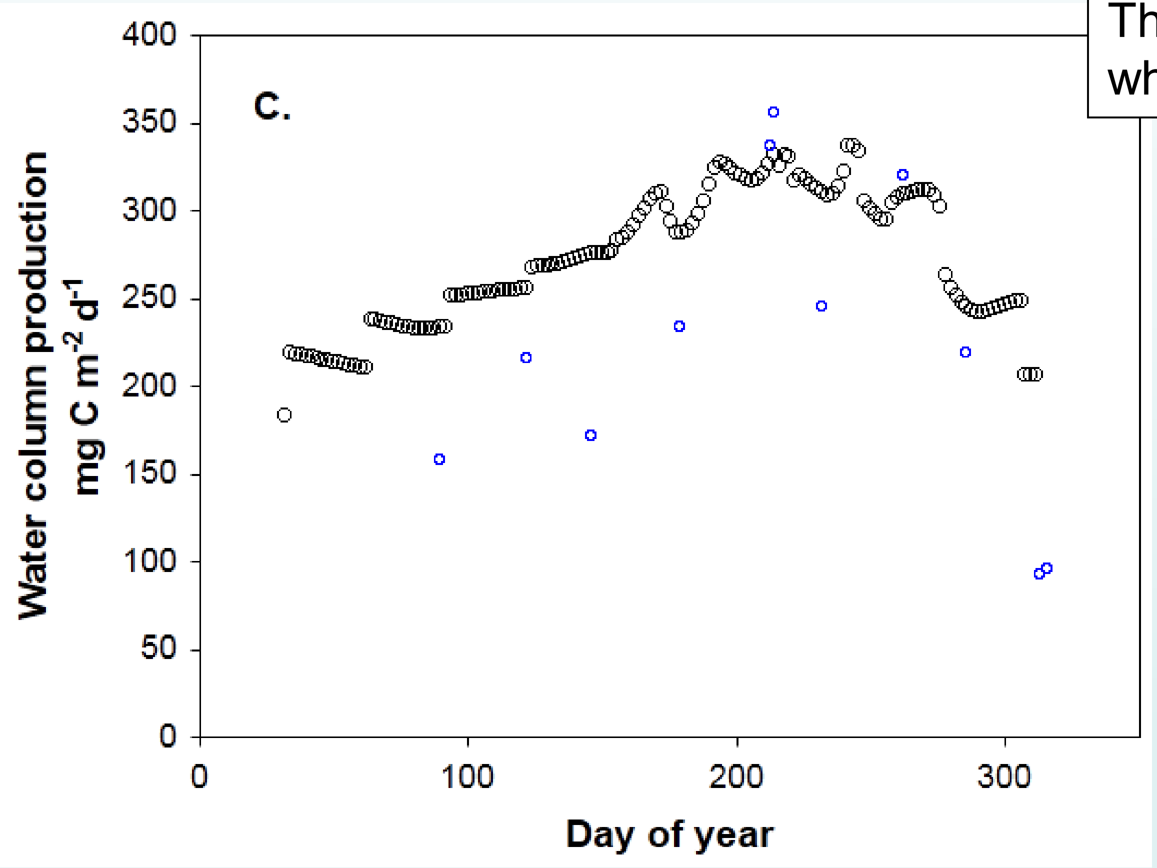
$R^2 = 0.87$

New model fit,
Sterner and Small
unpublished

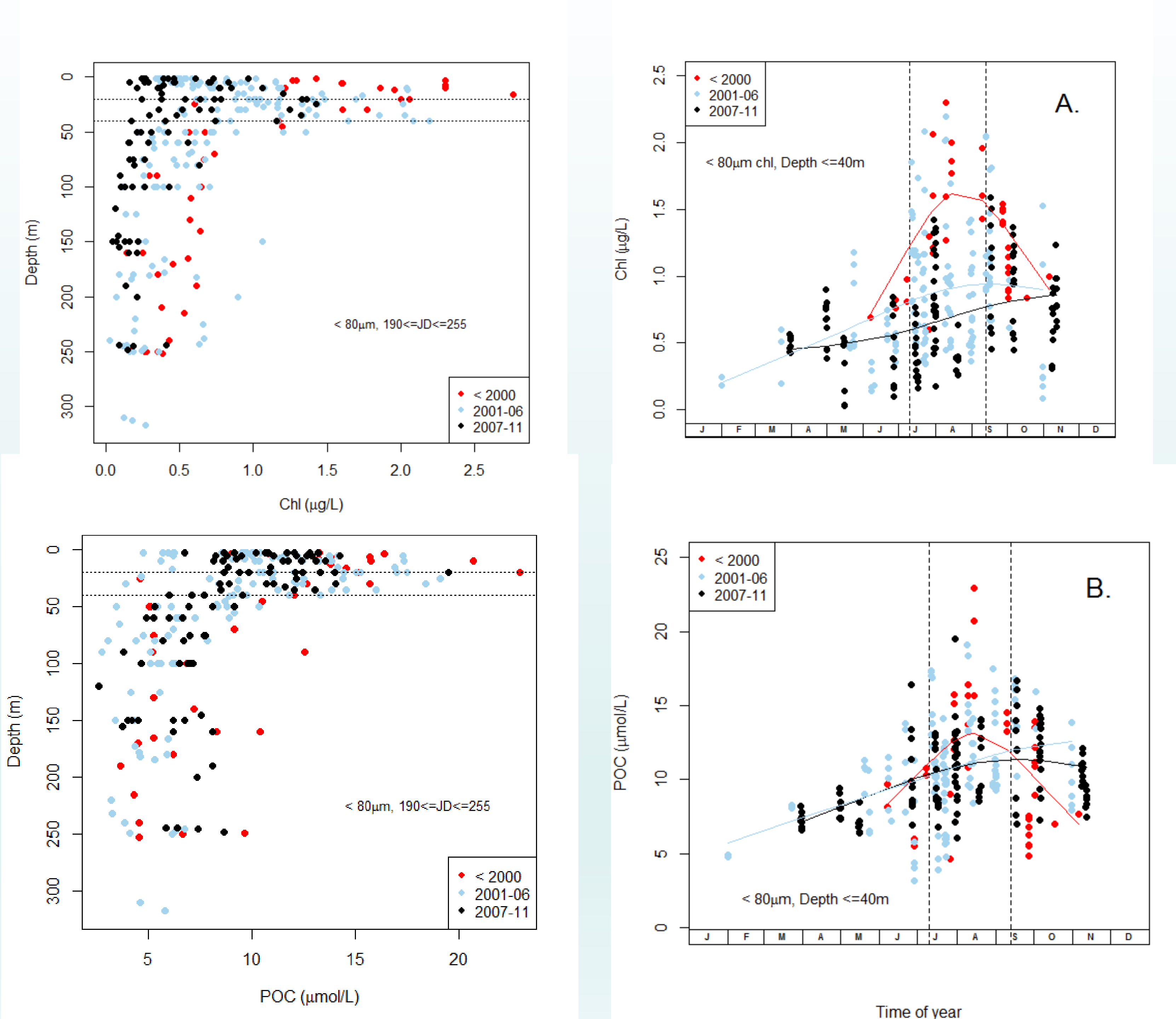
Modeled and measured production

250 mg C m^{-2} d^{-1} over a water column with average depth of 149 m, means 1.7 mg C made available m^{-3} d^{-1}. This must run the whole ecosystem.

mg C m^{-2} d^{-1}



Assumes zero ice cover



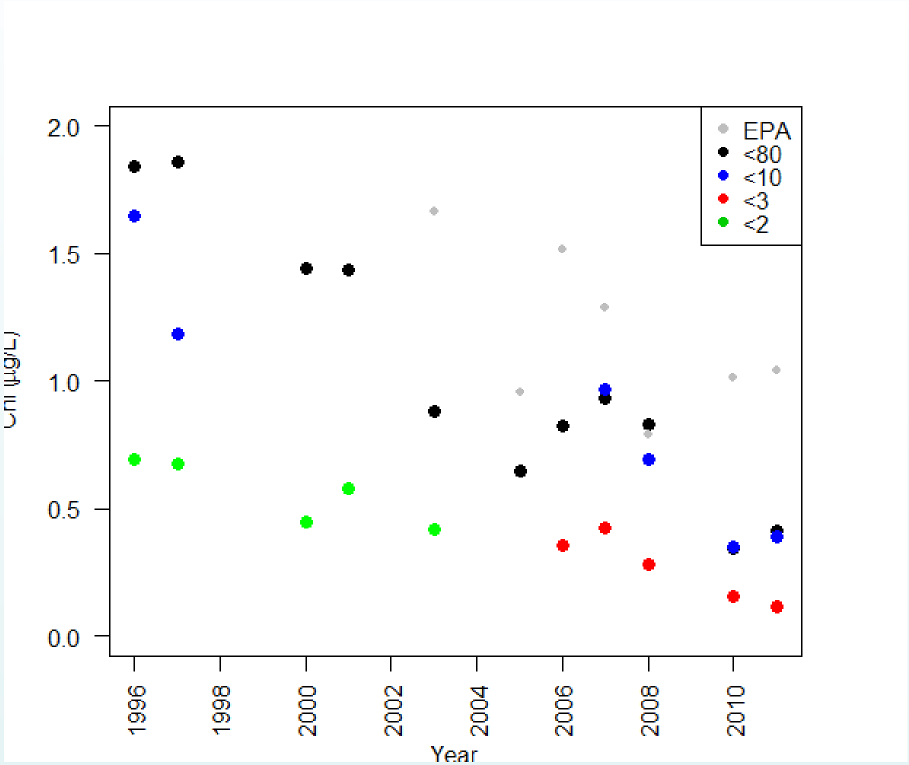
< 80µm, 190<=JD<=255
< 2000
2001-06
2007-11
Depth (m)
Chl (µg/L)
A.
< 80µm chl, Depth <=40m
B.
< 80µm, Depth <=40m
POC (µmol/L)
Time of year
J F M A M J J A S O N D

Declining chlorophyll and to a lesser extent POC.

Large size classes.
Above thermocline.
Summer.

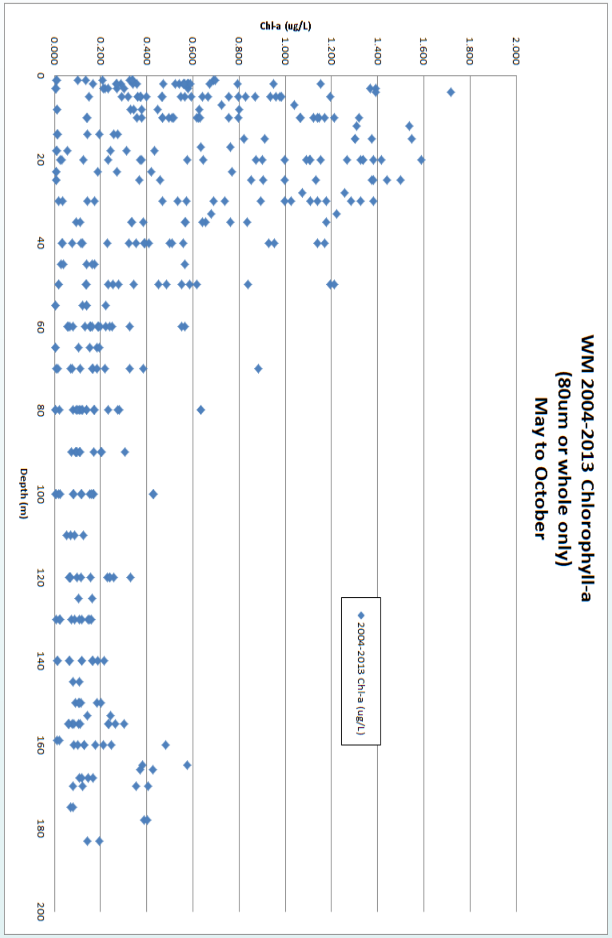
(time/place of highest production)

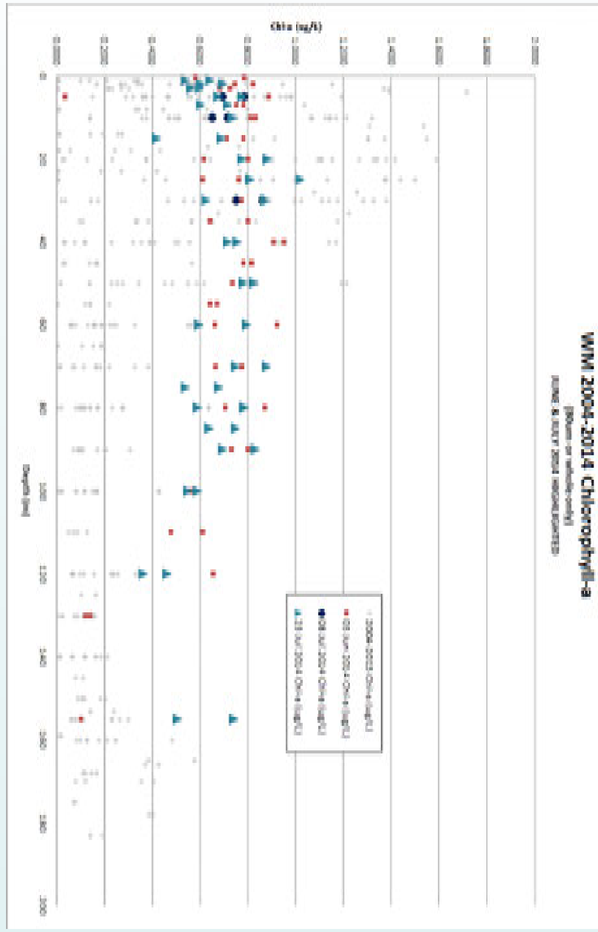
Whole lake production?

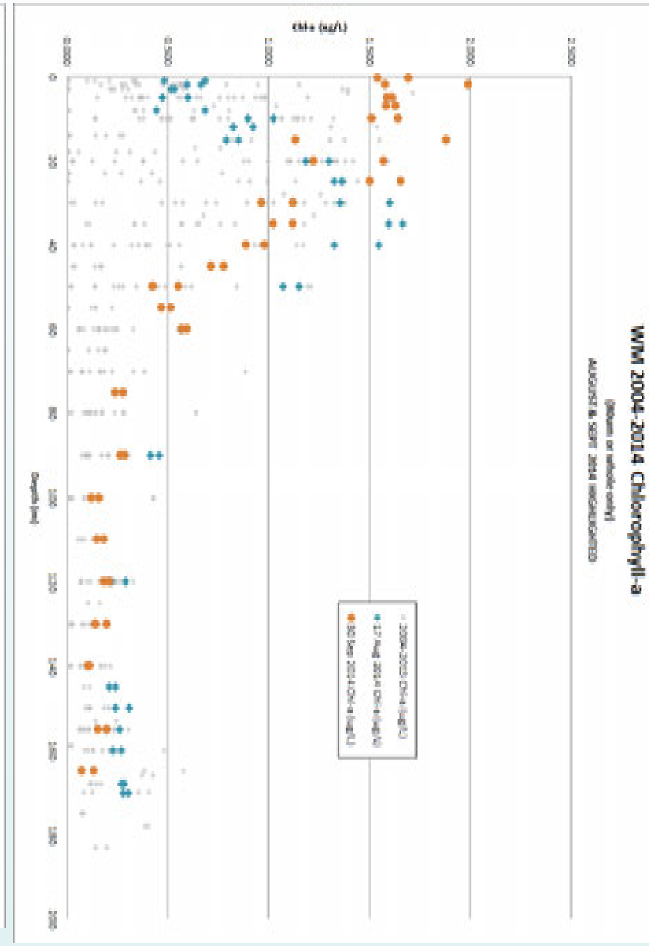


Mechanisms hard to sort out. Sinking of large algae?


ORIGINAL MOTION PICTURE SOUNDTRACK
THE
BIG CHILL
COMPACT
disc
DIGITAL AUDIO
Plus Additional Classics From The Era

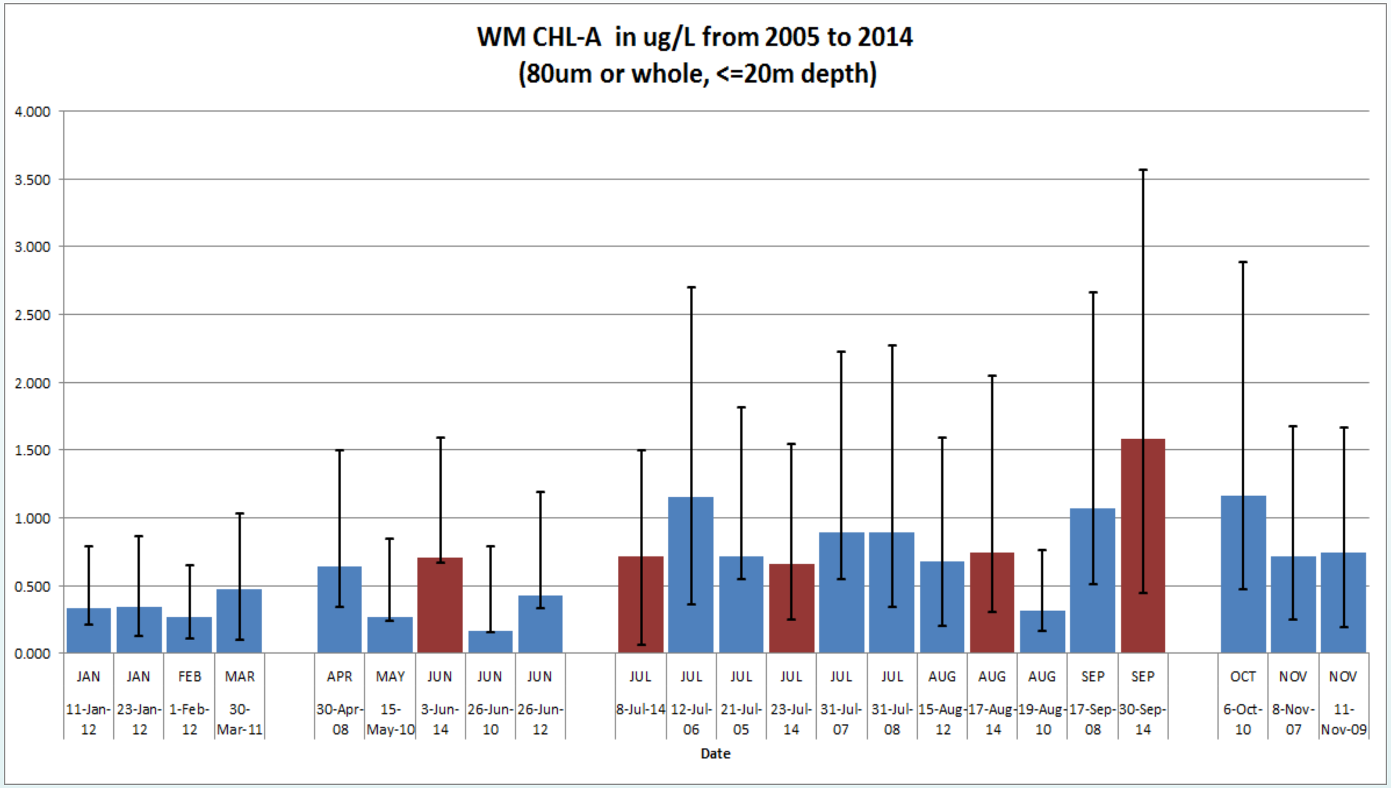




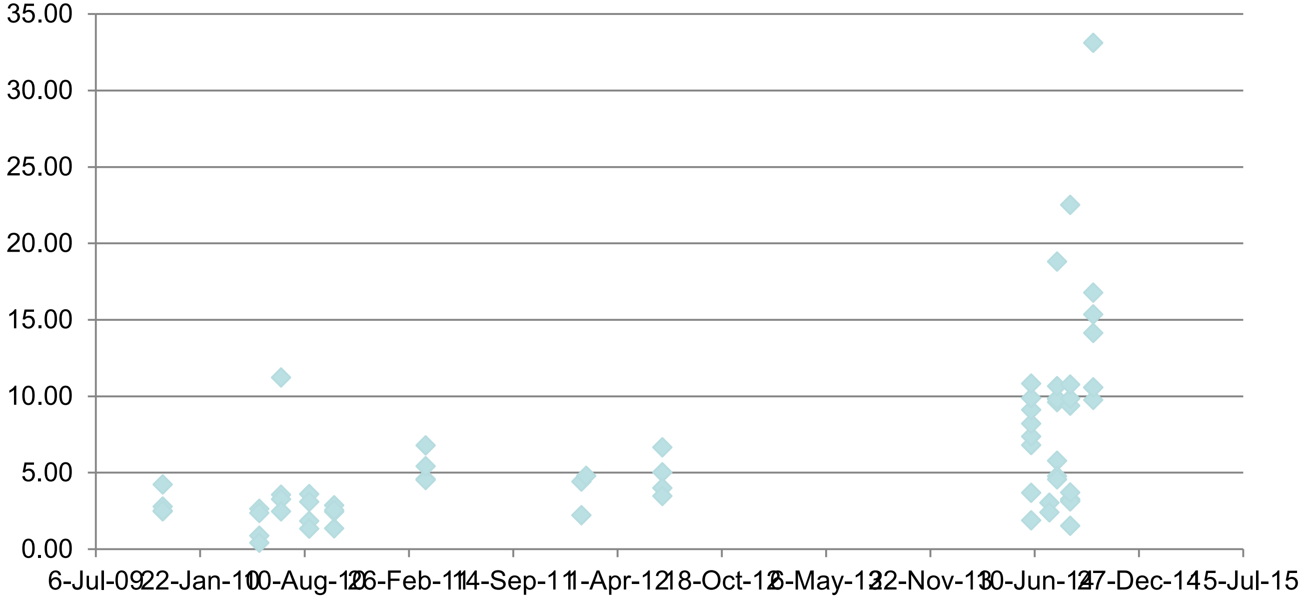


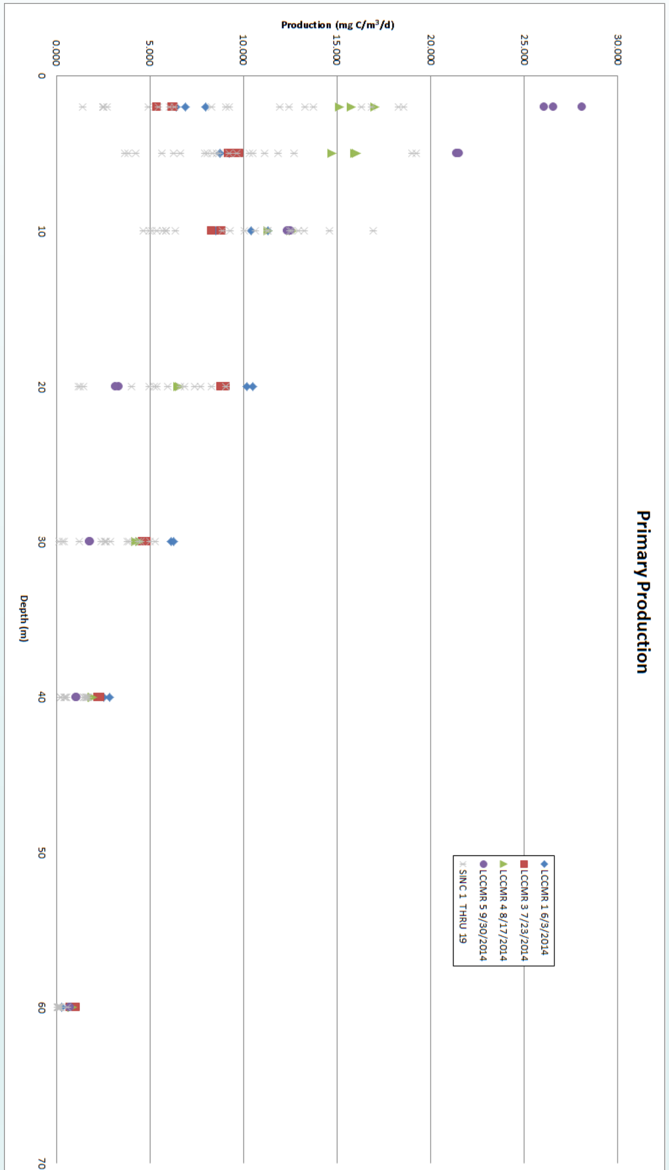
In June and July, chl was elevated in the 50-120m stratum compared to previous years.

In Aug and Sept, chl had very high peak concentrations, as high or higher than in previous years. Absence of DCM in September very unusual.


WM CHL-A in ug/L from 2005 to 2014
(80um or whole, <=20m depth)
4.000
3.500
3.000
2.500
2.000
1.500
1.000
0.500
0.000
JAN
11-Jan-12
JAN
23-Jan-12
FEB
1-Feb-12
MAR
30-Mar-11
APR
30-Apr-08
MAY
15-May-10
JUN
3-Jun-14
JUN
26-Jun-10
JUN
26-Jun-12
JUL
8-Jul-14
JUL
12-Jul-06
JUL
21-Jul-05
JUL
23-Jul-14
JUL
31-Jul-07
JUL
31-Jul-08
AUG
15-Aug-12
AUG
17-Aug-14
AUG
19-Aug-10
SEP
17-Sep-08
SEP
30-Sep-14
OCT
6-Oct-10
NOV
8-Nov-07
NOV
11-Nov-09
Date

whole or 80um:2um ratio





^{14}C in situ productivity

Primary productivity in 2014 mostly not remarkably different from previous years with the clear exception of September when productivity in the < 5m stratum was unusually high.

So, if anything the Big Chill caused higher PP, but only in particular depths at the very end of the season.

Summary

- Core carbon and nutrient variables have been measured lakewide, but with heavy emphasis on western portion, using consistent methods since 1996 with few gaps.
- Temporal trends exist, but these are most obvious in portions of the year, at certain depths, and for certain size classes of phytoplankton.
- The Big Chill year seems to have shifted depths of production and possibly increased late season production.

CHALLENGES

- Integration in space (horizontal and vertical) and time (within and across years).
- Combining data from different sources.
- “Selling” monitoring in a research context.

NEEDS

- True time series station offshore. High resolution depth sampling. Combination of moorings/gliders/etc. with ship-based process studies.
- Improved knowledge of land-lake couplings, loadings.

Thanks!

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