Do we have the tools and the smarts to quantify nearshore conditions in Lake Michigan?

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Mid-Continent Ecological Division,
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OUTLINE

Why do we care about the nearshore?

What exactly is the nearshore?

What have been done to quantify the nearshore?

Summary and analysis of earlier work

Our preliminary analysis

What have we learned so far and what is next

Why do we care about the nearshore?

Off-shore water of the Great Lakes seems to be fine, but it is not the case for the nearshore

Numerous nearshore issues such as excess eutrophication, *Cladophora*, invasive mussels, HABs

Lake Erie get all the attention for a reason

Lake Michigan not as bad, but…

Great Lakes Water Quality Agreement (2012)

RECOGNIZING that nearshore areas must be restored and protected because they are the major source of drinking water for communities within the basin, are where most human commerce and recreation occurs, and are the critical ecological link between watersheds and the open waters of the Great Lakes

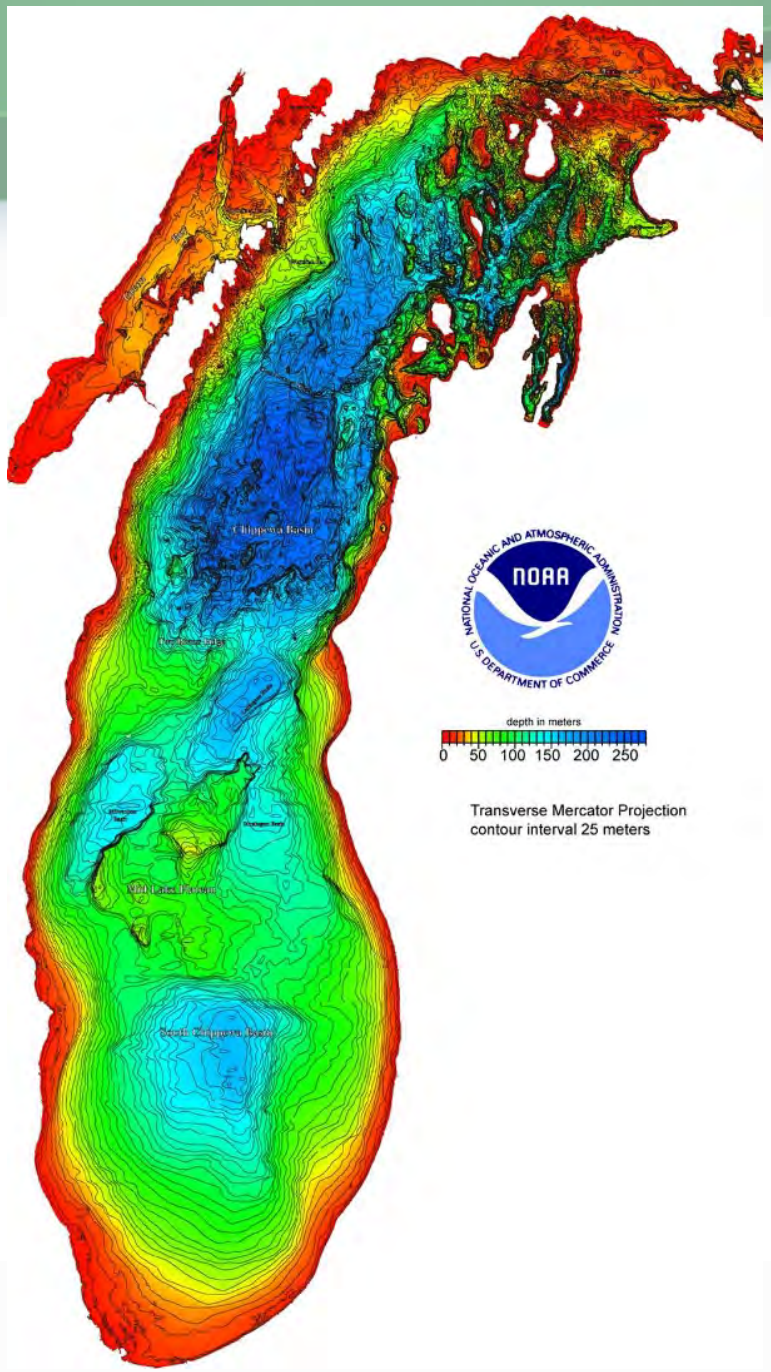
Impact of changes in the watershed and climate on the nearshore of the Great Lakes

What exactly is the nearshore?

Includes bays, harbors, coastal wetland, river mouths, "shallow areas" of the lake

Is Green Bay, Saginaw Bay etc. the nearshore?

What about western Lake Erie?


NOAA
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
U.S DEPARTMENT OF COMMERCE
depth in meters
0 50 100 150 200 250
Transverse Mercator Projection
contour interval 25 meters

What have been done to quantify the nearshore?

Little or lots depending how you define the nearshore!

A few good papers have been published

Summary and analysis of earlier work

Not going to discuss Great Lakes bays or western Lake Erie

Lake Ontario study (Makarewicz et al. 2012)

..transition zone between the shoreline and open waters… refers to as the nearshore zone

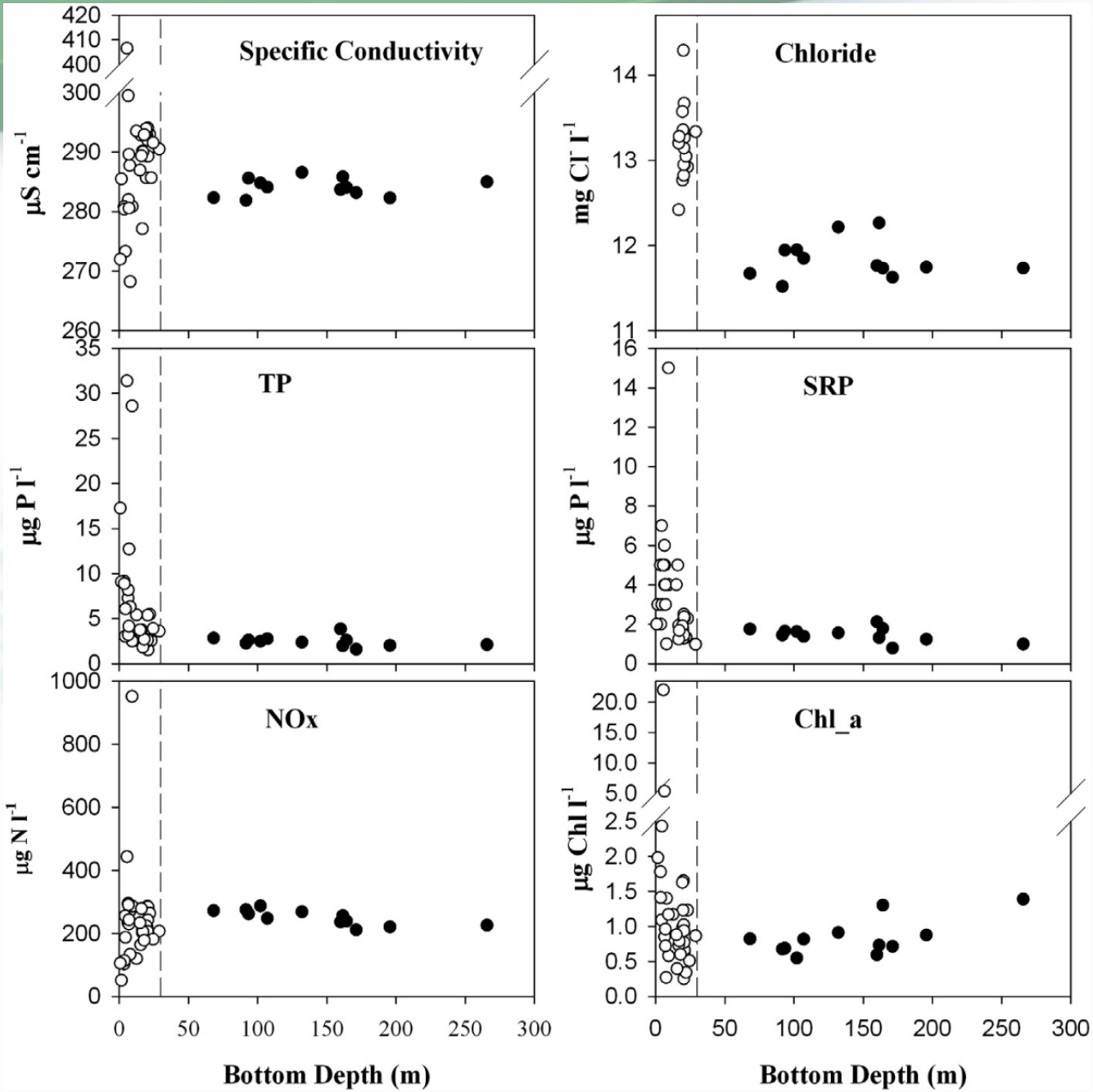
Shoreline of the lakes: small bays, harbors, river confluences, coastal wetlands, rivers, shoreside waters, “0-30m” and off-shore waters

Lake Ontario study (Makarewicz et al, 2012)

	TP (ug/L)	Chl a (ug/L)
Shoreside (< 1m)	61.9	17.9
Rivers	84.3	6.7
Embayments	129.7	20.9
Ontario (30m)	10.4	2.1
Ontario (100m)	9.5	2.7

Yurista et al. 2014
J. Great Lakes Res.

Constituent vs. depth in Lake Michigan

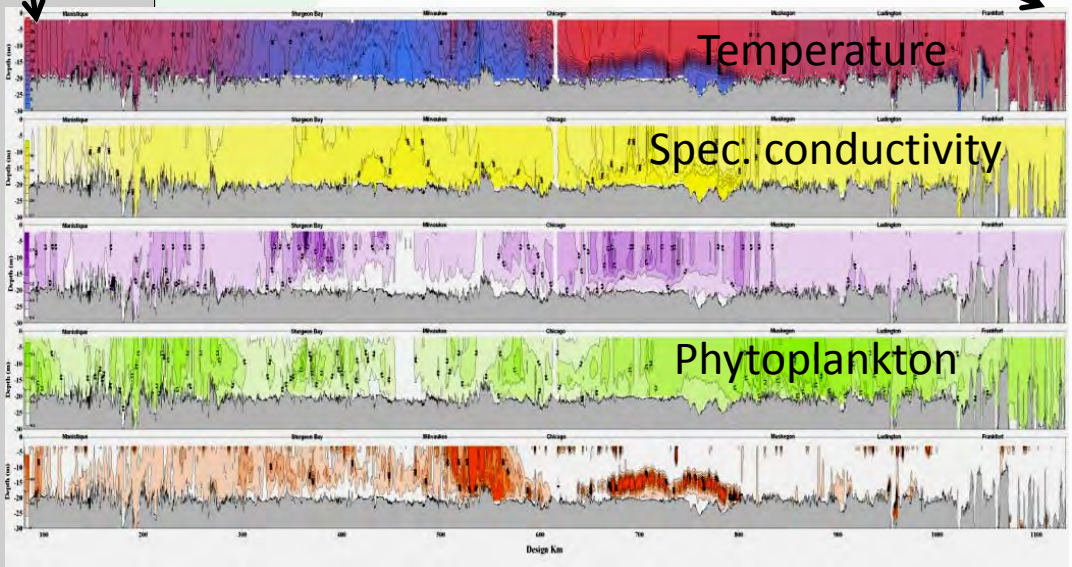


Surface mixed layer chlorophyll by location/season (Pothoven & Fahnenstiel. 2014)

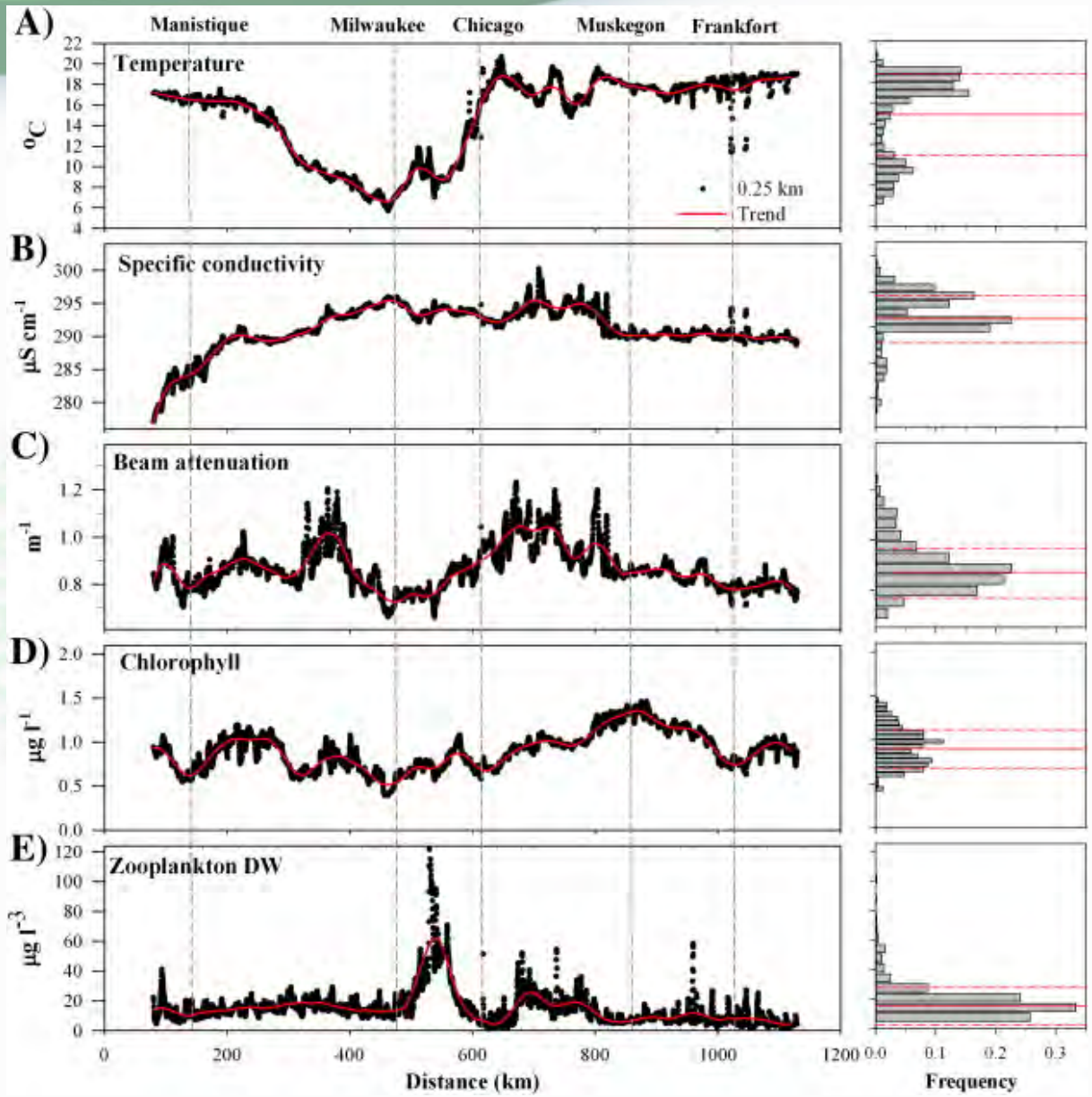
Nearshore	Spring	2.5 ug/L
(depth = 15m)	Early summer	2.7 ug/L
	Late summer	1.8 ug/L
	Fall	2.0 ug/L
Mid-depth		
(depth = 45m)	Spring	0.7 ug/L
	Early summer	1.6 ug/L
	Late summer	1.2 ug/L
	Fall	1.5 ug/L
Offshore		
(depth = 110m)	Spring	0.9 ug/L
	Early summer	0.9 ug/L
	Late summer	1.0 ug/L
	Fall	1.8 ug/L

Lake Michigan Tracks
August-Sept 2010

Towing in situ sensors
to produce an environmental
"CAT" scan along the shore



Yurista et al. 2014
J. Great Lakes Res.



Satellite imagery could be useful and informative to quantify the nearshore but so far I have not been successful…

Important conclusions from these studies

All/most of the studies are snapshots of the nearshore area at a specific location and time

0 to 20m is a heterogeneous transition zone and is likely also affected by the season

The “0 to 5 meter” area can be strongly affected by river inputs, and is very different from the open lake, but is this regarded as the nearshore?

Important conclusions from these studies

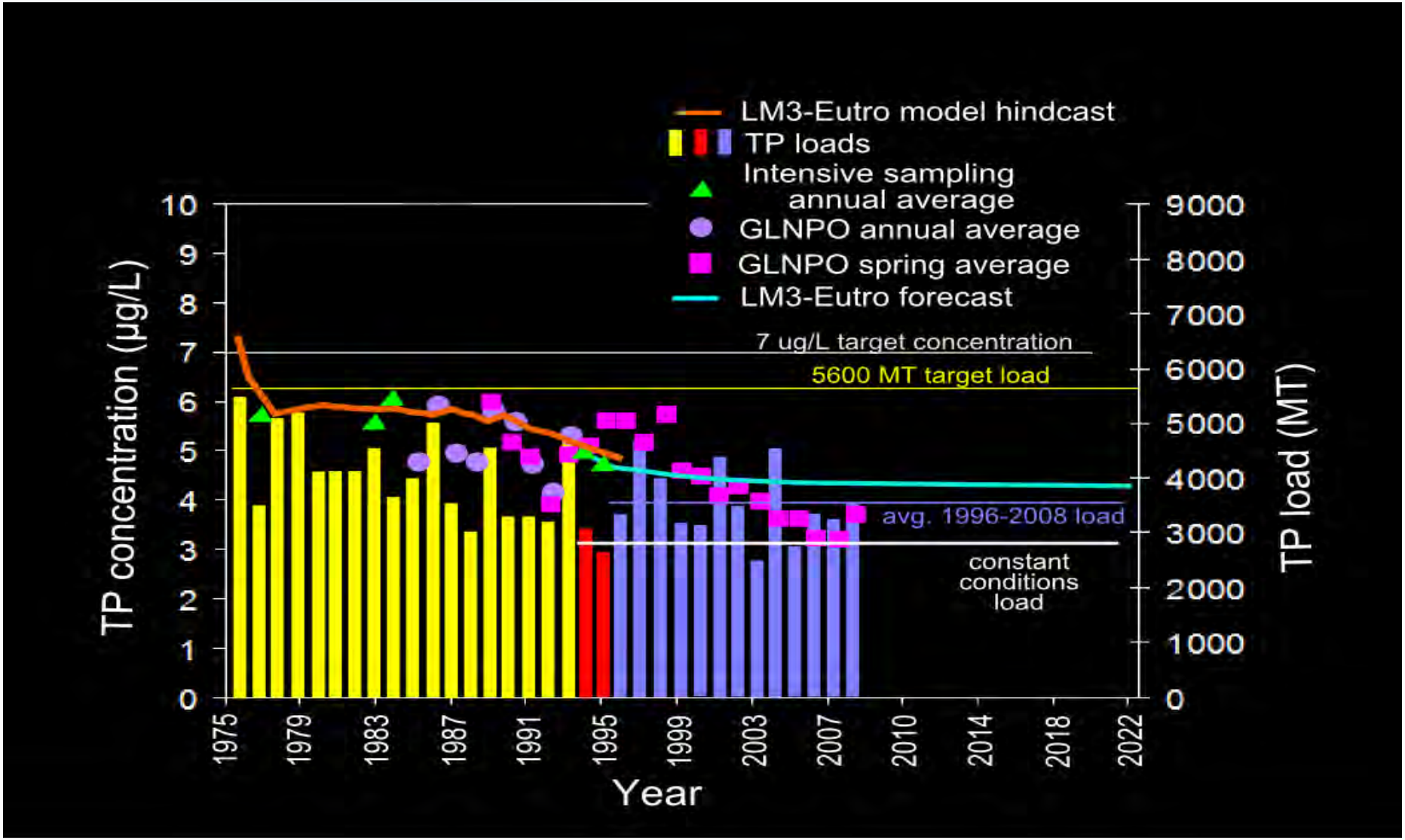
"Although identifying local input points and plume dynamics is an important part of research into coastal processes, this may be of less importance for assessing a general nearshore condition. Missing a small tributary plume on a contour tow will not greatly change the representation of the great spatial nearshore region, even though it may not capture the anomalies within the specific plume" (Yurista et al. 2012)

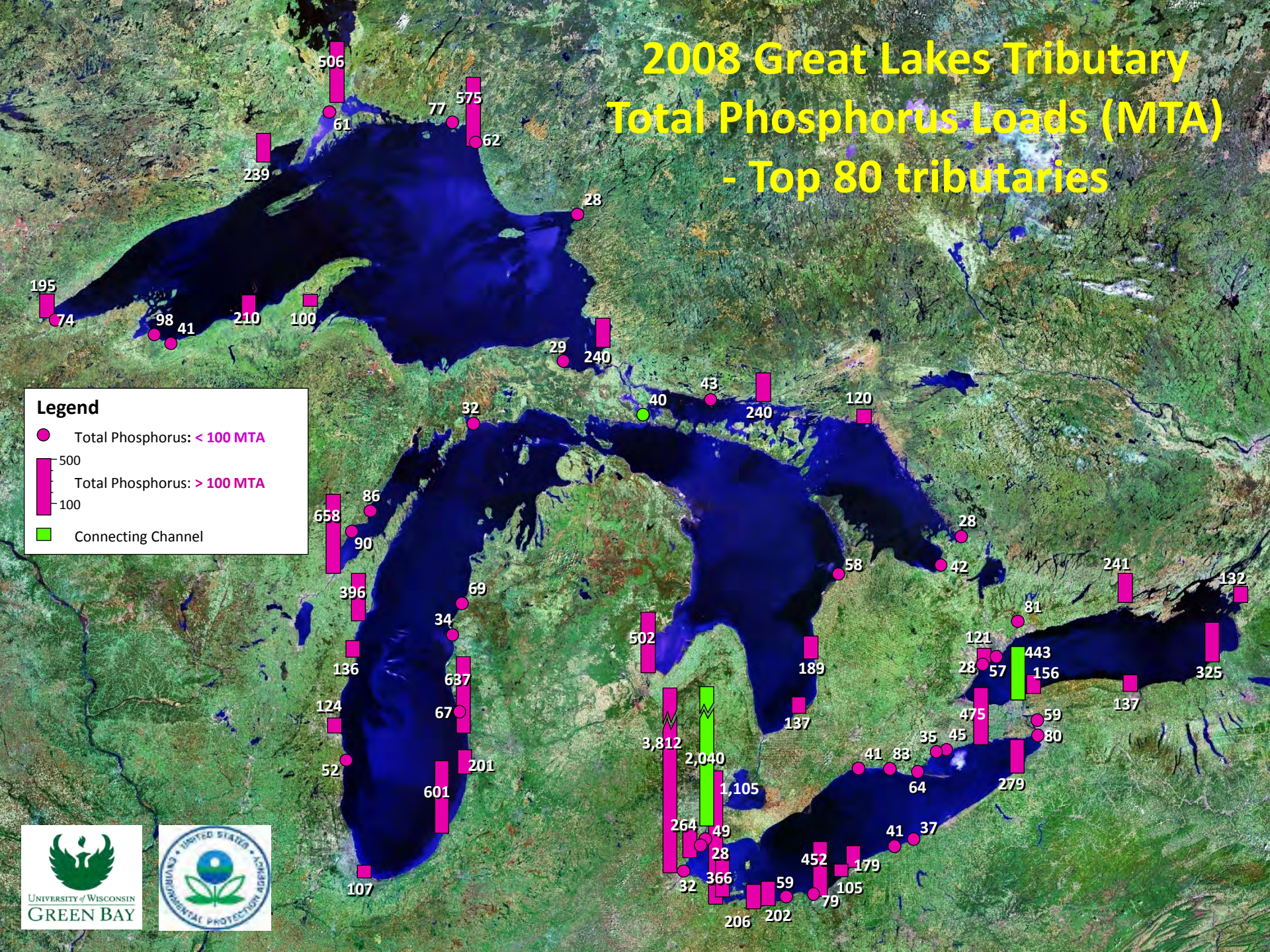
Our preliminary analysis

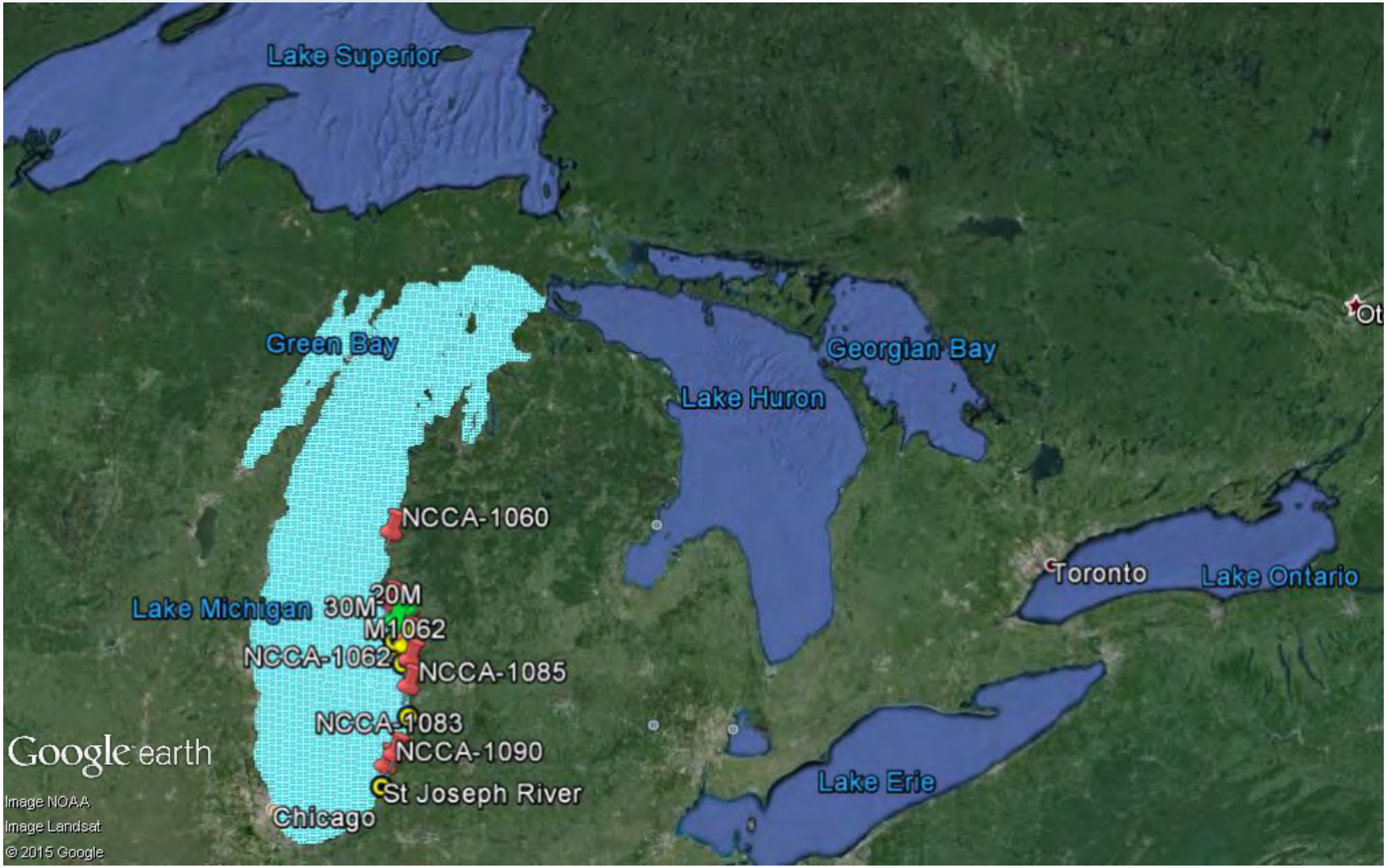
Limited measurements (2003) – transects off the Muskegon and Grand river

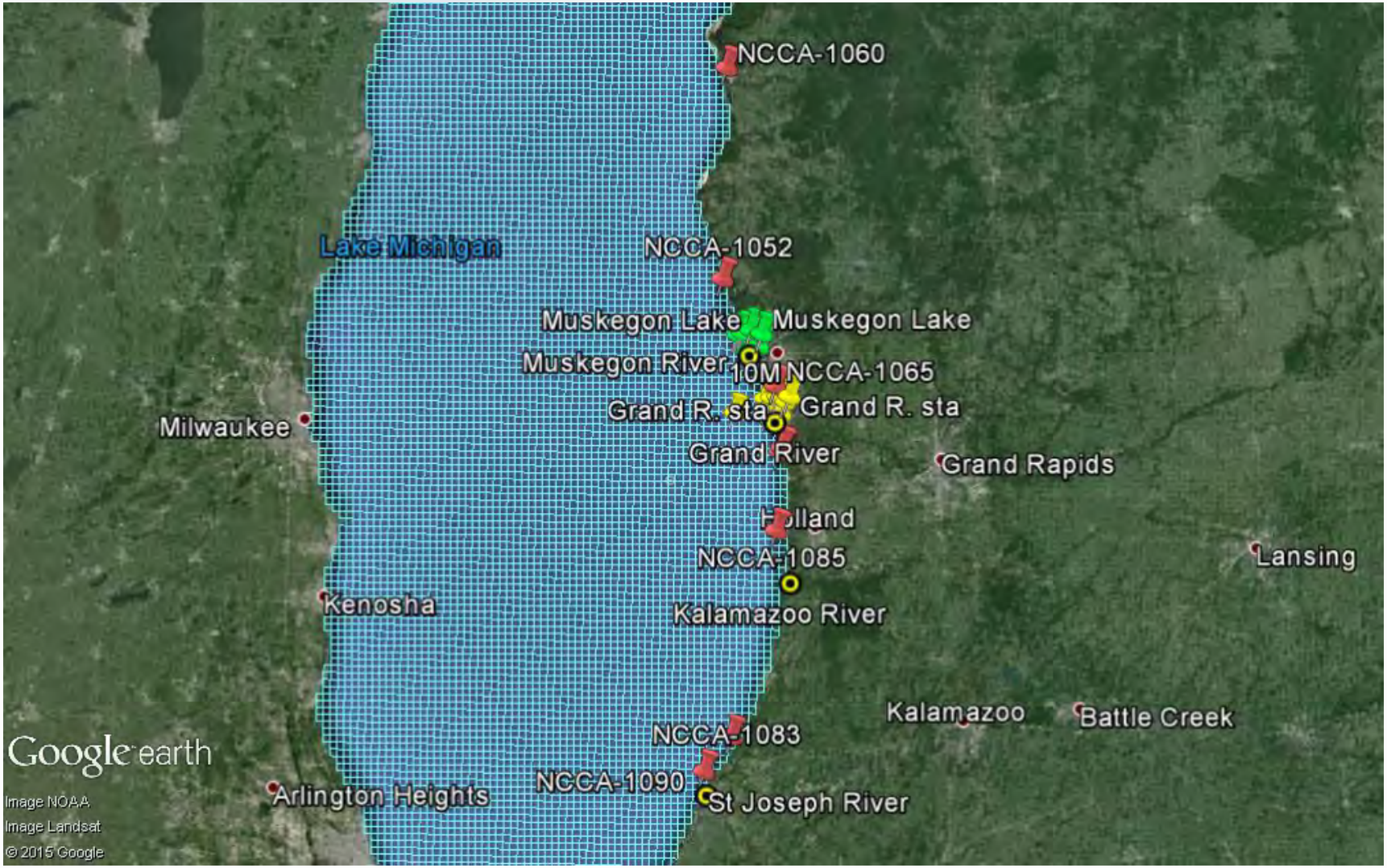
Very early stages of running a simple model

Lake Michigan Phosphorus Model Forecasts




2008 Great Lakes Tributary Total Phosphorus Loads (MTA) - Top 80 tributaries
Legend
Total Phosphorus: < 100 MTA
500
Total Phosphorus: > 100 MTA
100
Connecting Channel
506
61
77
575
62
239
28
195
74
98
41
210
100
29
240
43
40
240
120
32
86
658
90
396
69
34
136
637
67
124
52
201
601
107
28
58
42
241
132
81
121
28
57
443
156
325
137
189
137
502
3,812
2,040
1,105
475
59
80
35
45
41
83
64
279
264
49
28
32
366
59
206
202
452
179
105
79
41
37
UNIVERSITY of WISCONSIN GREEN BAY
UNITED STATES ENVIRONMENTAL PROTECTION AGENCY


Lake Superior
Green Bay
Georgian Bay
Lake Huron
NCCA-1060
Toronto
Lake Ontario
Lake Michigan
30M
20M
M1062
NCCA-1062
NCCA-1085
NCCA-1083
NCCA-1090
St Joseph River
Chicago
Lake Erie
Google earth
Image NOAA
Image Landsat
© 2015 Google


NCCA-1060
Lake Michigan
NCCA-1052
Muskegon Lake
Muskegon Lake
Muskegon River
10M
NCCA-1065
Grand R. sta
Grand R. sta
Milwaukee
Grand River
Grand Rapids
Holland
NCCA-1085
Lansing
Kenosha
Kalamazoo River
Kalamazoo
Battle Creek
NCCA-1083
NCCA-1090
Arlington Heights
St Joseph River
Google earth
Image NOAA
Image Landsat
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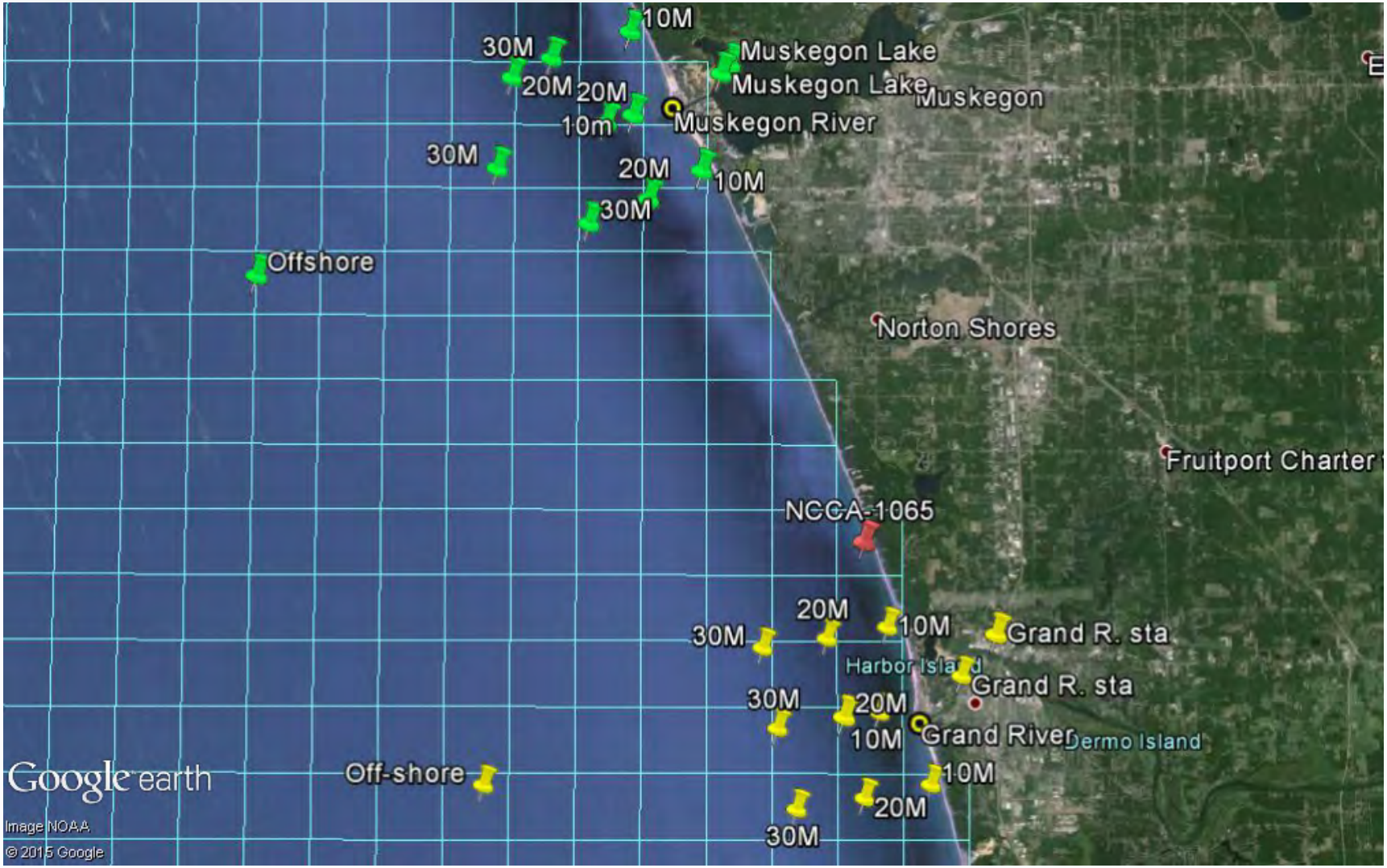
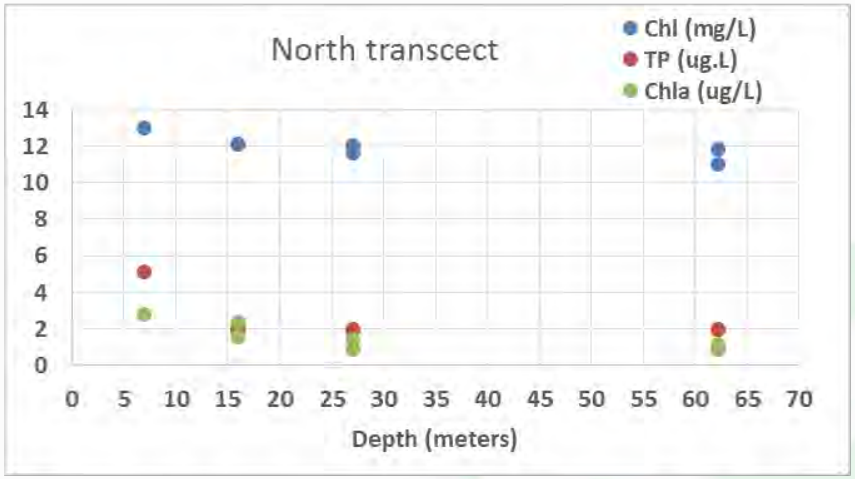
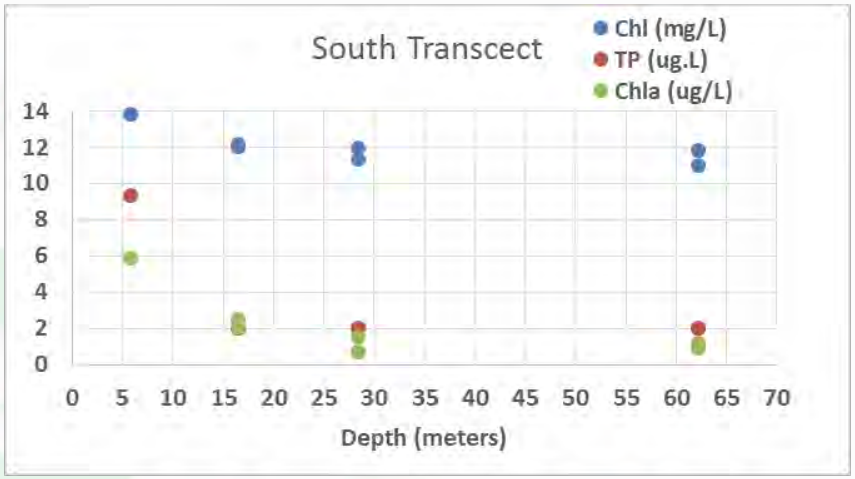
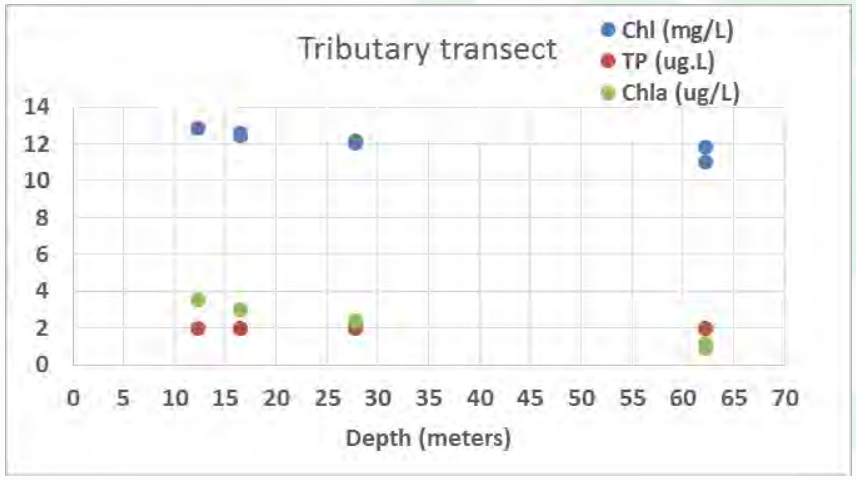
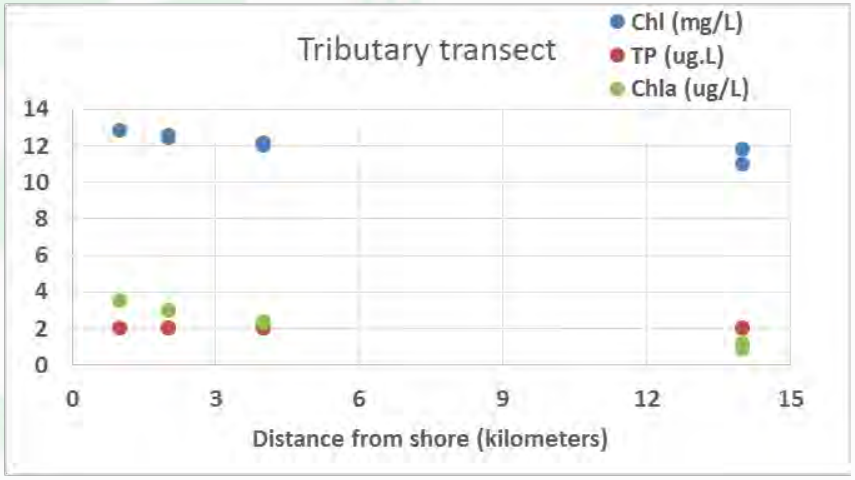

10M
30M
Muskegon Lake
20M
Muskegon Lake
Muskegon
20M
10m
Muskegon River
30M
20M
10M
30M
Offshore
Norton Shores
Fruitport Charter
NCCA-1065
20M
10M
Grand R. sta
30M
Harbor Island
Grand R. sta
30M
20M
10M
Grand River
Off-shore
10M
20M
30M
Google earth
Image NOAA
© 2015 Google

Grand River (late July 2003)

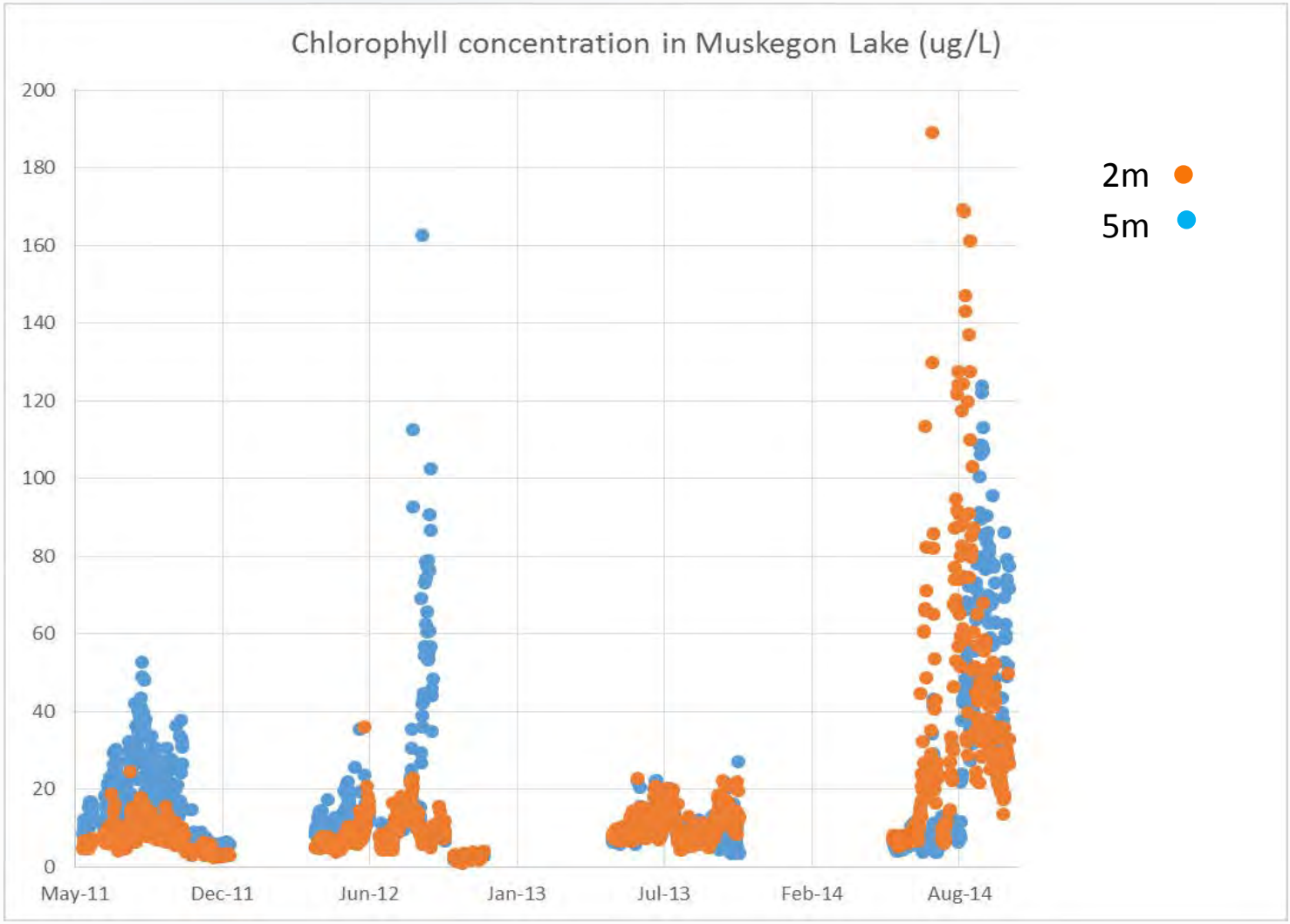


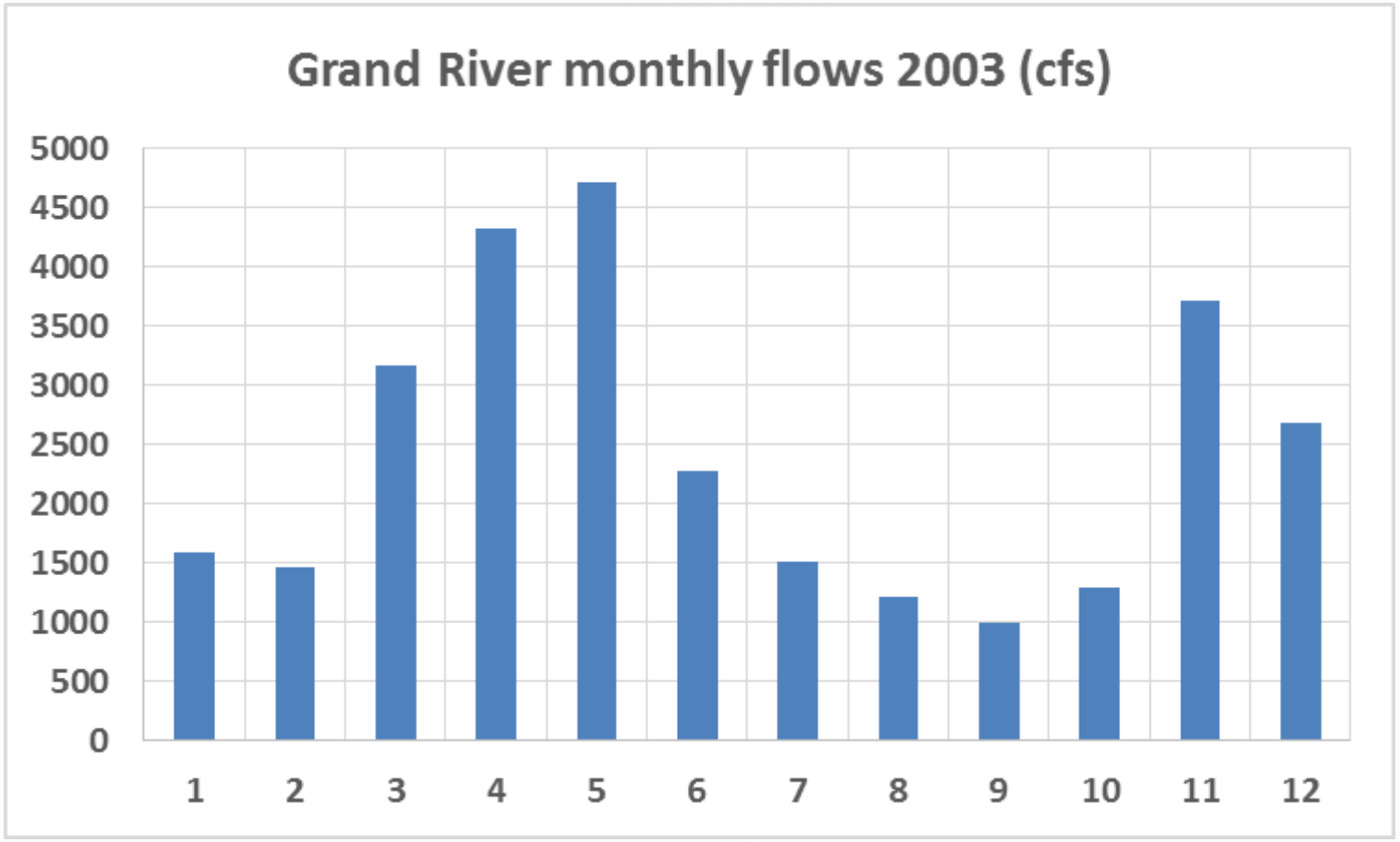


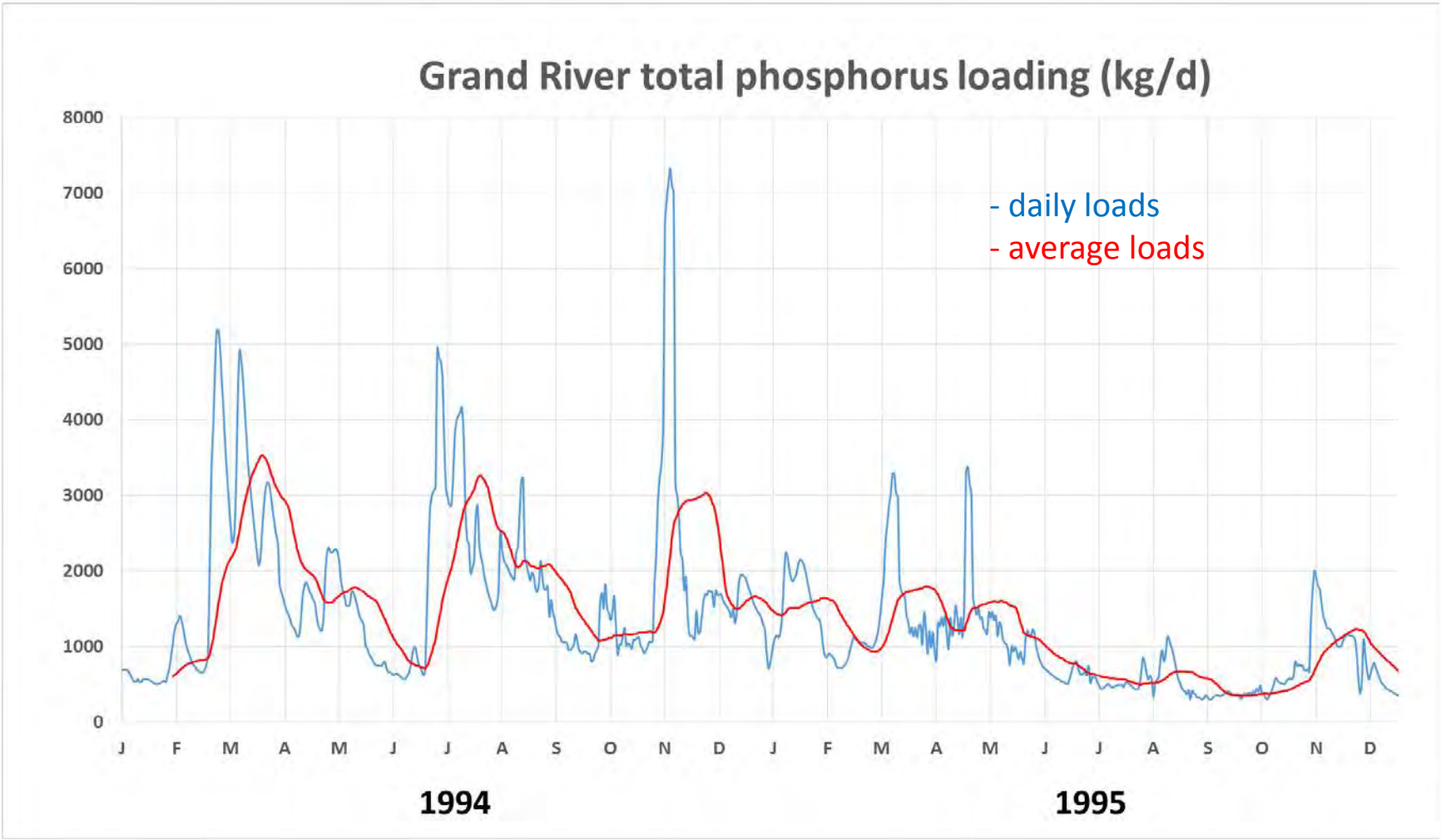


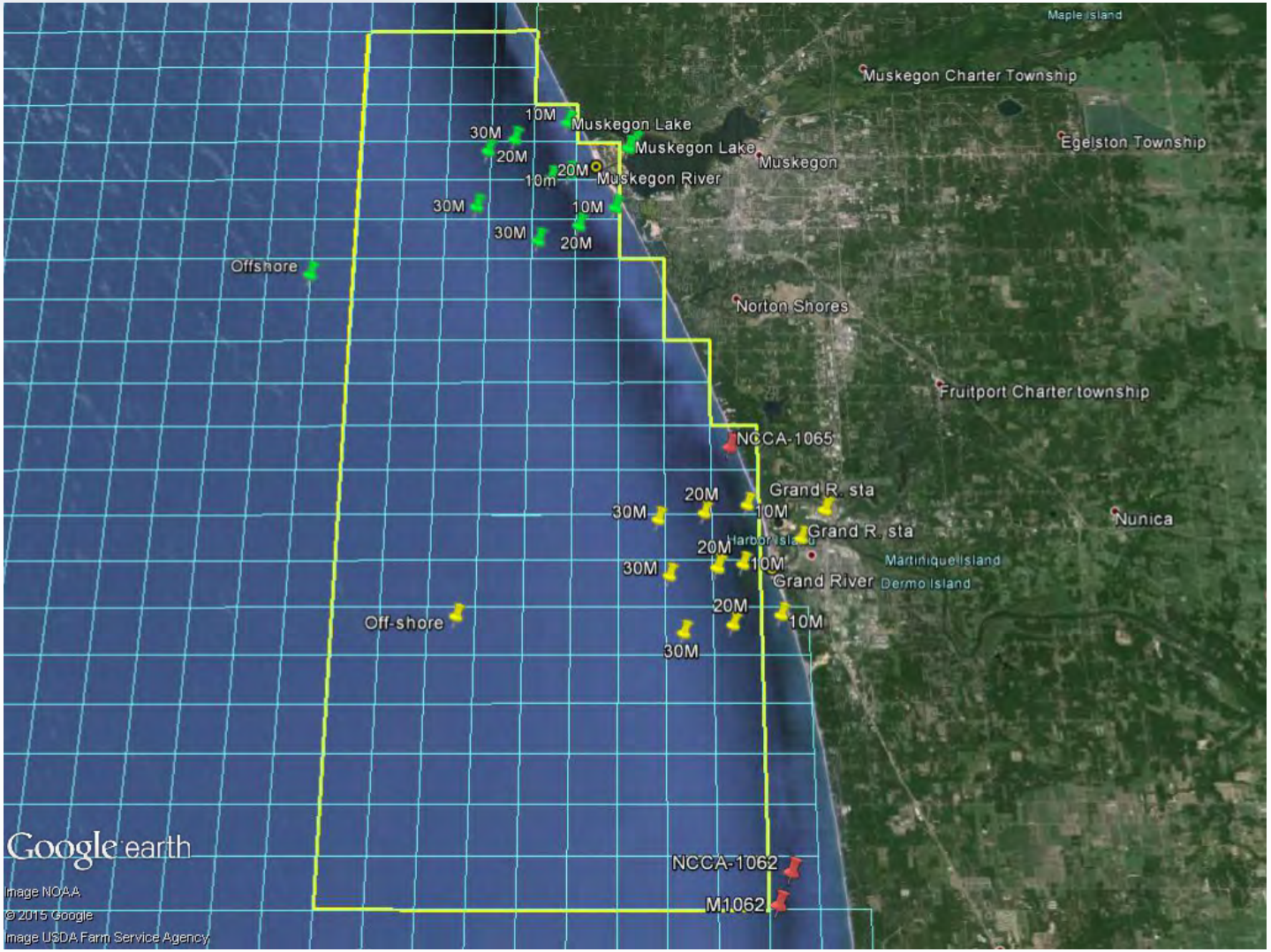


River concentrations: Chl-a = 109 ug/L chloride = 66 mg/L and TP = 106 ug/L


Chlorophyll concentration in Muskegon Lake (ug/L)
200
180
160
140
120
100
80
60
40
20
0
May-11
Dec-11
Jun-12
Jan-13
Jul-13
Feb-14
Aug-14
2m
5m


Grand River monthly flows 2003 (cfs)
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
1
2
3
4
5
6
7
8
9
10
11
12


Grand River total phosphorus loading (kg/d)
8000
7000
6000
5000
4000
3000
2000
1000
0
- daily loads
- average loads
J F M A M J J A S O N D J F M A M J J A S O N D
1994
1995


Maple Island
Muskegon Charter Township
Egelston Township
Muskegon
Muskegon River
Muskegon Lake
Muskegon Lake
10M
30M
20M
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10m
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10M
30M
20M
Offshore
Norton Shores
Fruitport Charter township
NCCA-1065
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Grand R. sta
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Harbor Isl
Martinique Island
Dermo Island
20M
30M
10M
Grand River
20M
10M
Off-shore
30M
NCCA-1062
M1062
Google earth
Image NOAA
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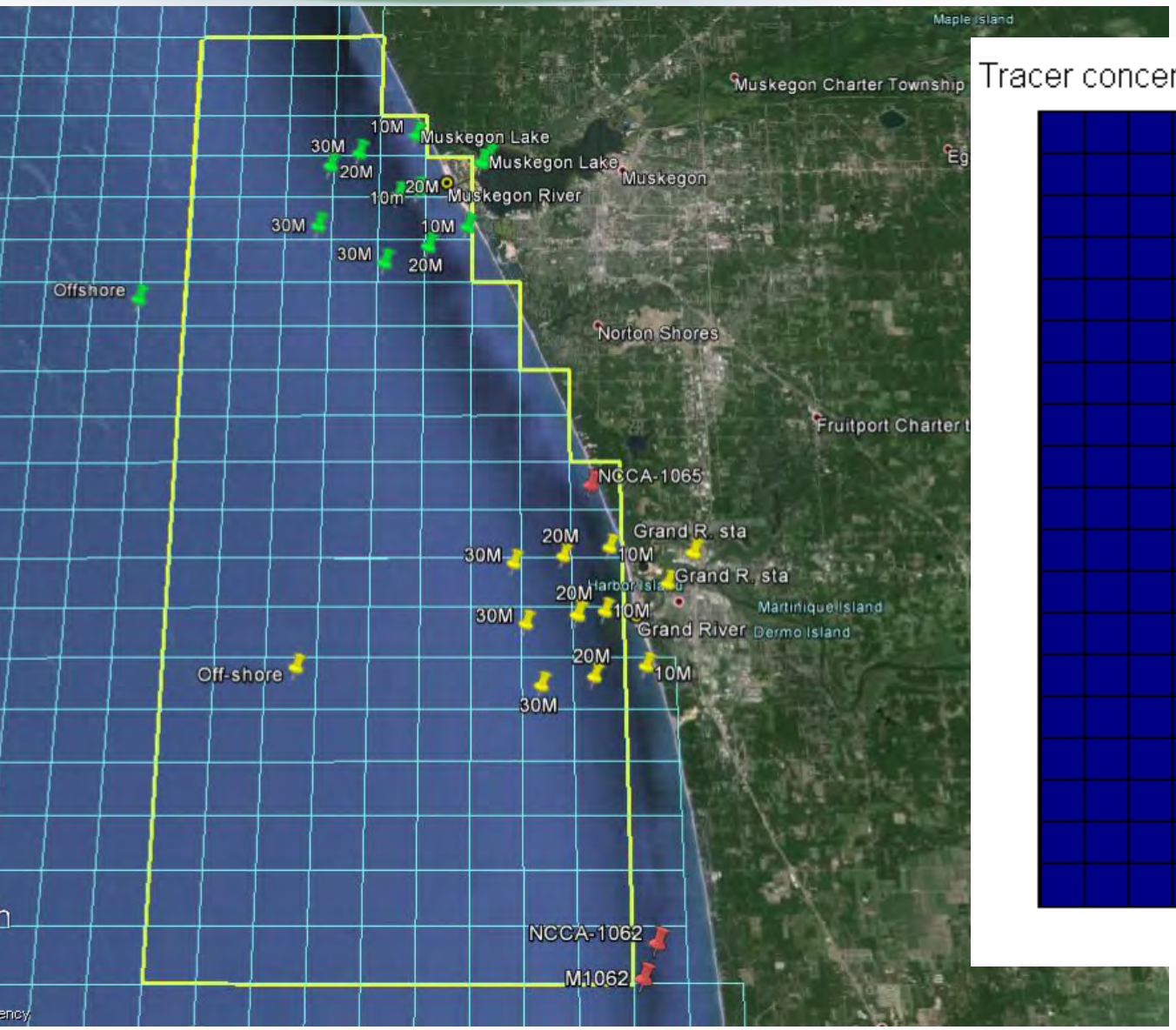
Image USDA Farm Service Agency


Maple Island
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Muskegon Lake
30M
Muskegon Lake
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Martinique Island
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Grand River
Dermo Island
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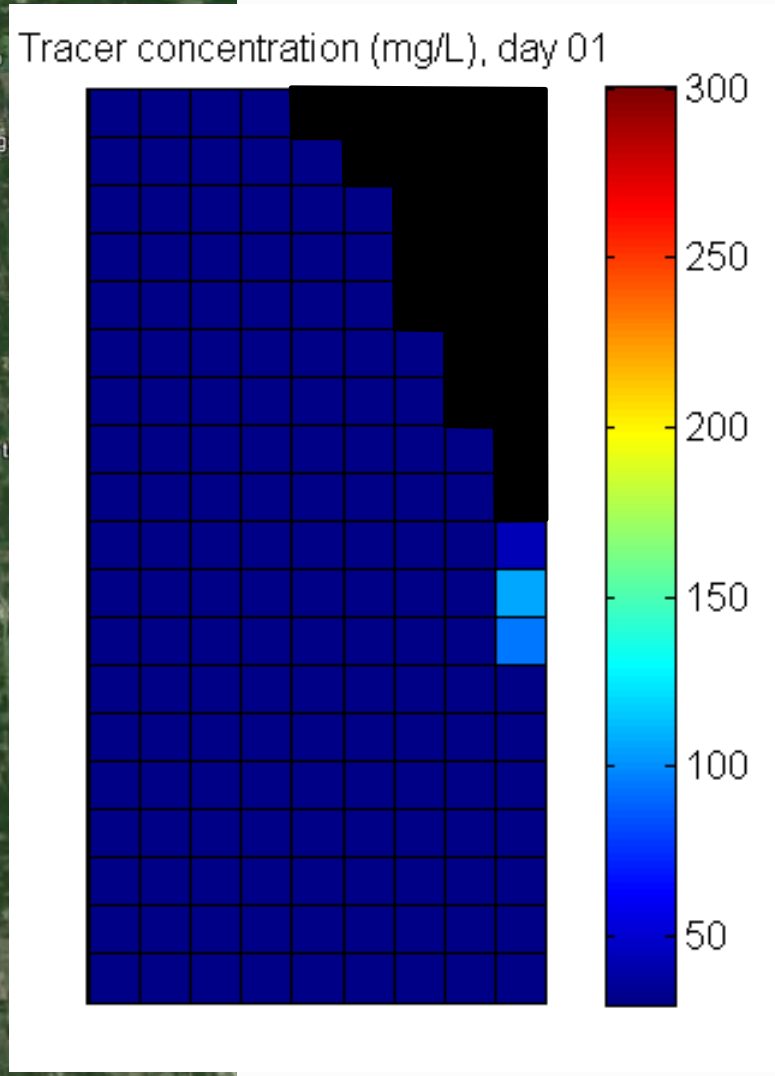
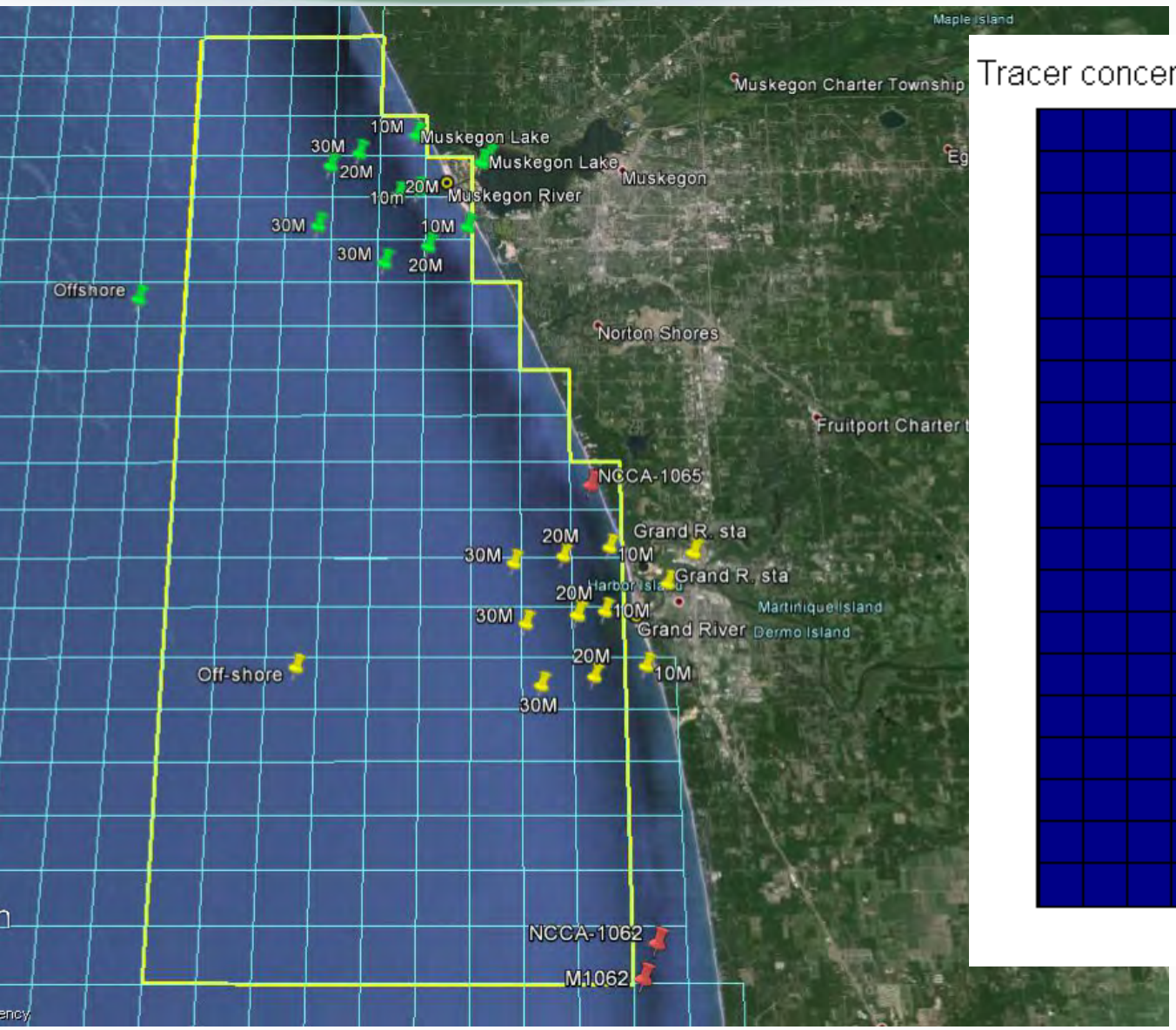

Tracer concentration (mg/L), day 01
300
250
200
150
100
50


Maple Island
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Muskegon Lake
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Muskegon
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Muskegon River
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Offshore
Norton Shores
Fruitport Charter
NCCA-1065
20M
Grand R. sta
30M
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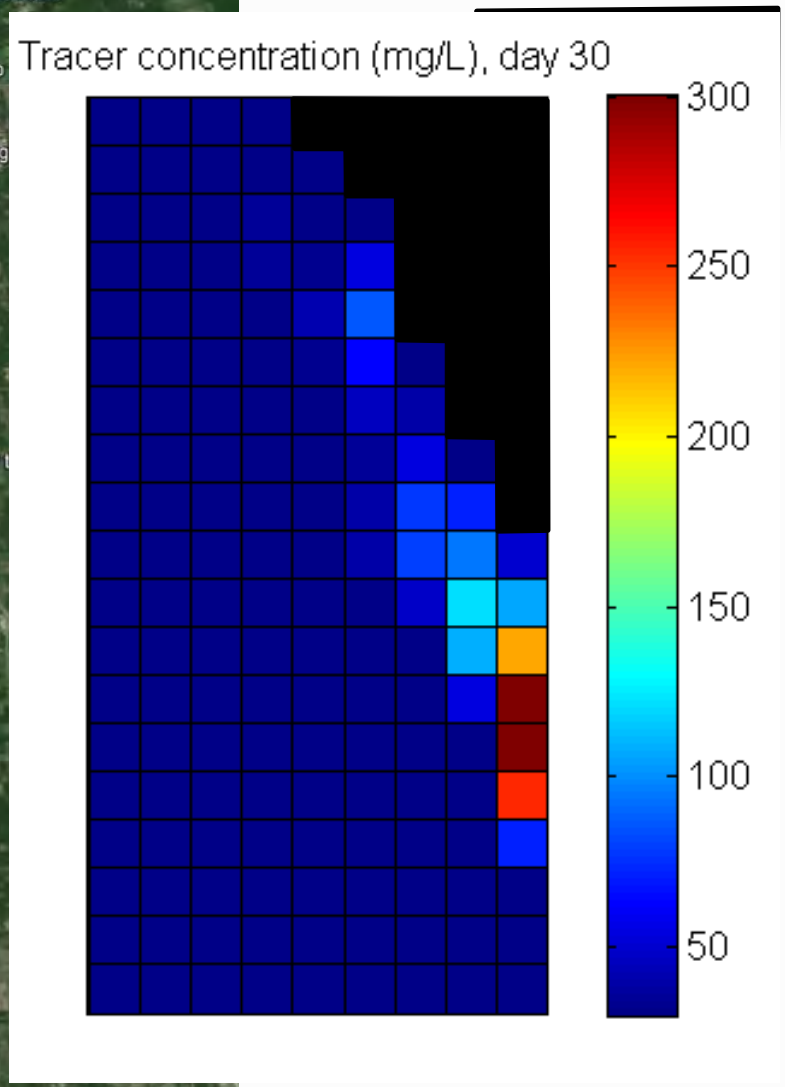
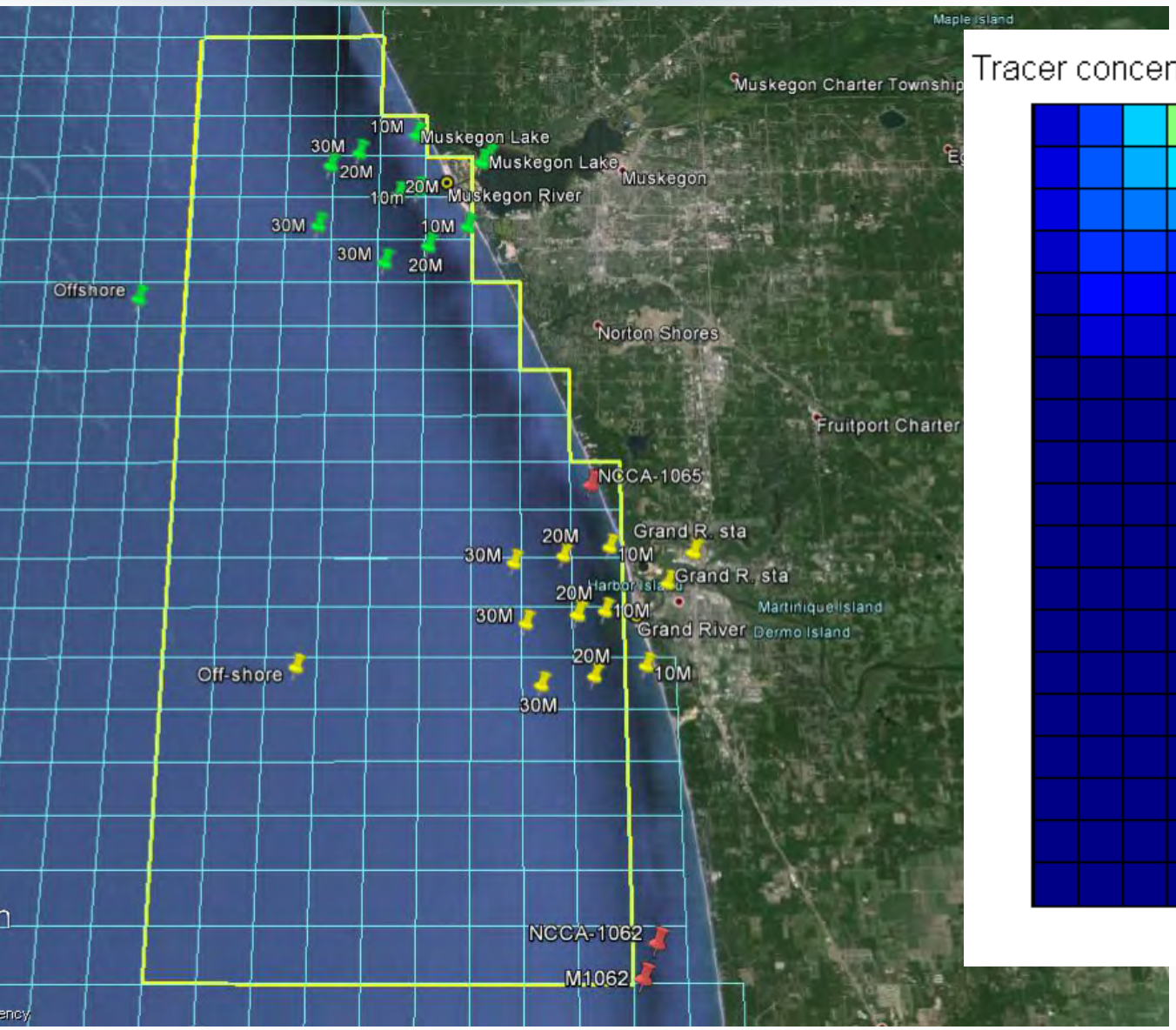
Grand R. sta
20M
Harbor Island
10M
Martinique Island
30M
Grand River
Dermo Island
20M
Off-shore
10M
30M
NCCA-1062
M1062


Tracer concentration (mg/L), day 30
300
250
200
150
100
50


Maple Island
Muskegon Charter Township
10M
Muskegon Lake
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Muskegon Lake
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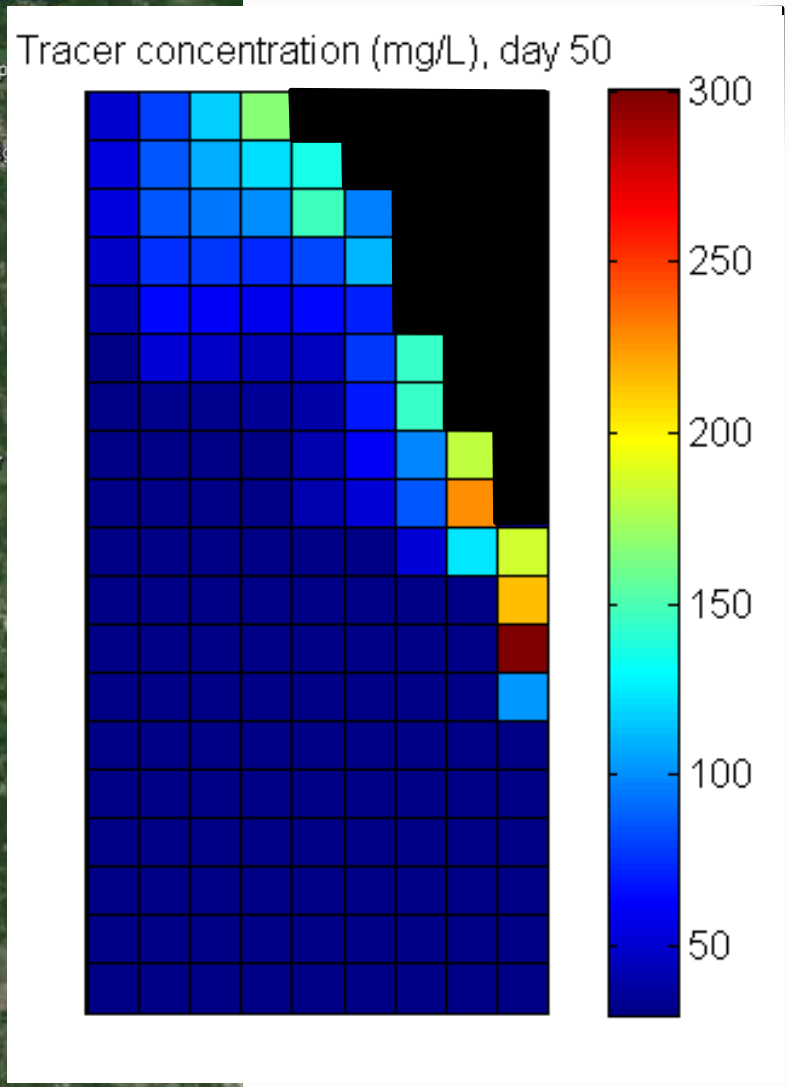
Tracer concentration (mg/L), day 50
300
250
200
150
100
50

What have we learned so far and what is next

The watershed signal (in the form of a river discharge) is diluted very quickly – not surprising

20 meters it is approaching off shore waters, although there is a distinct watershed signal

20 m is likely strongly affected by season, likely higher in spring

Still unclear where to sample to quantify the nearshore – a big part of this work

We need to go beyond a snapshot of the nearshore and attempt to describe it for a season/year

Tracer show of how quickly the nearshore signal gets diluted and almost disappear


NCCA-1065
20m contour
10M
20M
30M
Ferrys
Grand R. sta
Grand R. sta
Grand Haven
Grand River
10M
20M
30M
10M
Off-shore
20M
30M
Google earth
Image NOAA
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As part of the Lake Michigan CSMI USEPA in collaboration with NOAA, USGS and other partners will collect samples around the major Michigan rivers

Plan to collect samples in May, July and September. At minimum TP, chloride and chlorophyll-a

See if we can model chloride (other conservatives), nutrients and perhaps chl-a

If the model can simulate the data, we can apply it to learn something about how dynamic the system is and how changes in load/climate can Impact the nearshore

Perhaps insight into where to sample to represent the nearshore of Lake Michigan/Great Lakes?