Long-Term Trends in Nearshore Chlorophyll Concentrations Throughout Lake Michigan

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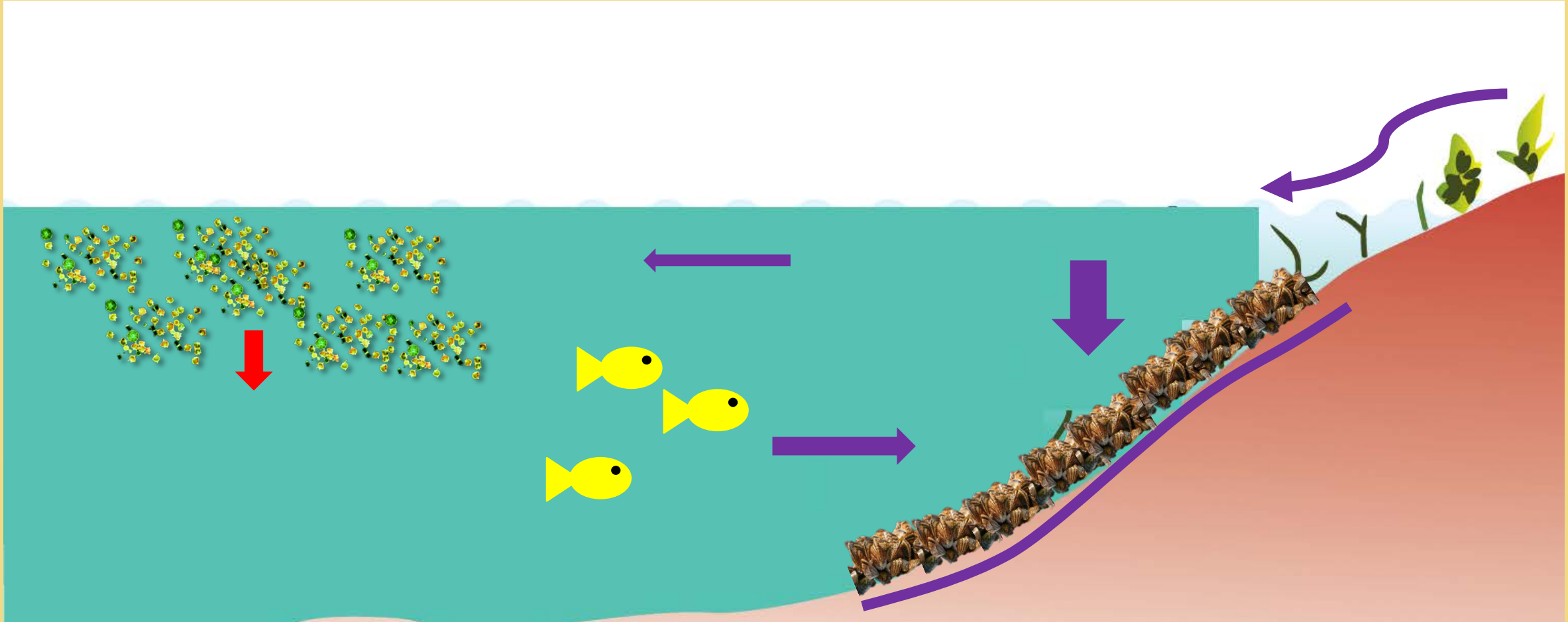
Chlorophyll *a* Concentrations: Decline Offshore and Nearshore Shunt

Declines Offshore

- Bunnell et al. 2014
- Fahnenstiel et al. 2010
- Mida et al. 2010
- Pothoven and Fahnenstiel 2013

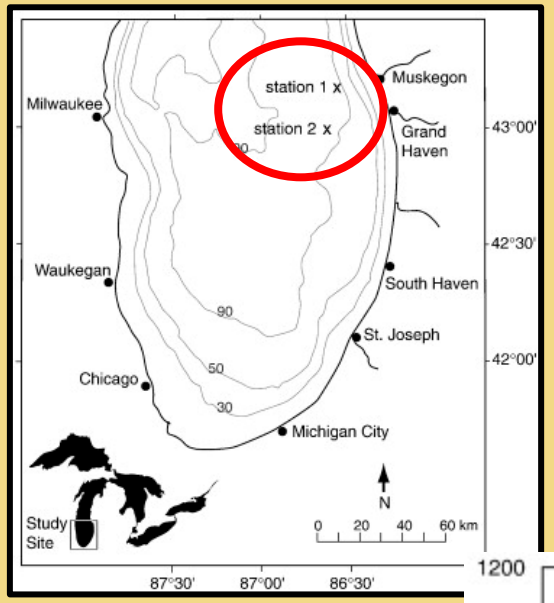
Nearshore Shunt

- Hecky et al. 2004
- Turschak et al. 2014
- Napela et al. 2014



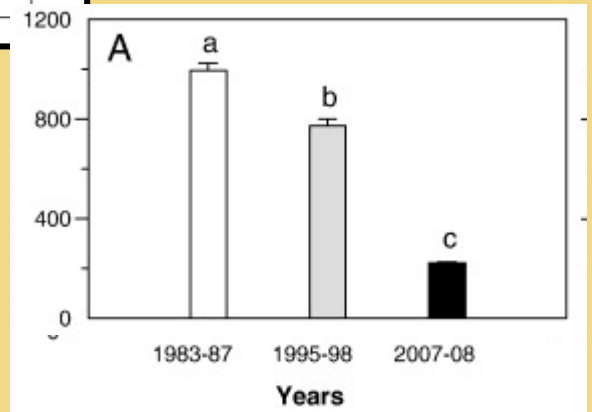
Chlorophyll *a* Concentrations: Long-Term Monitoring

Traditional Sampling



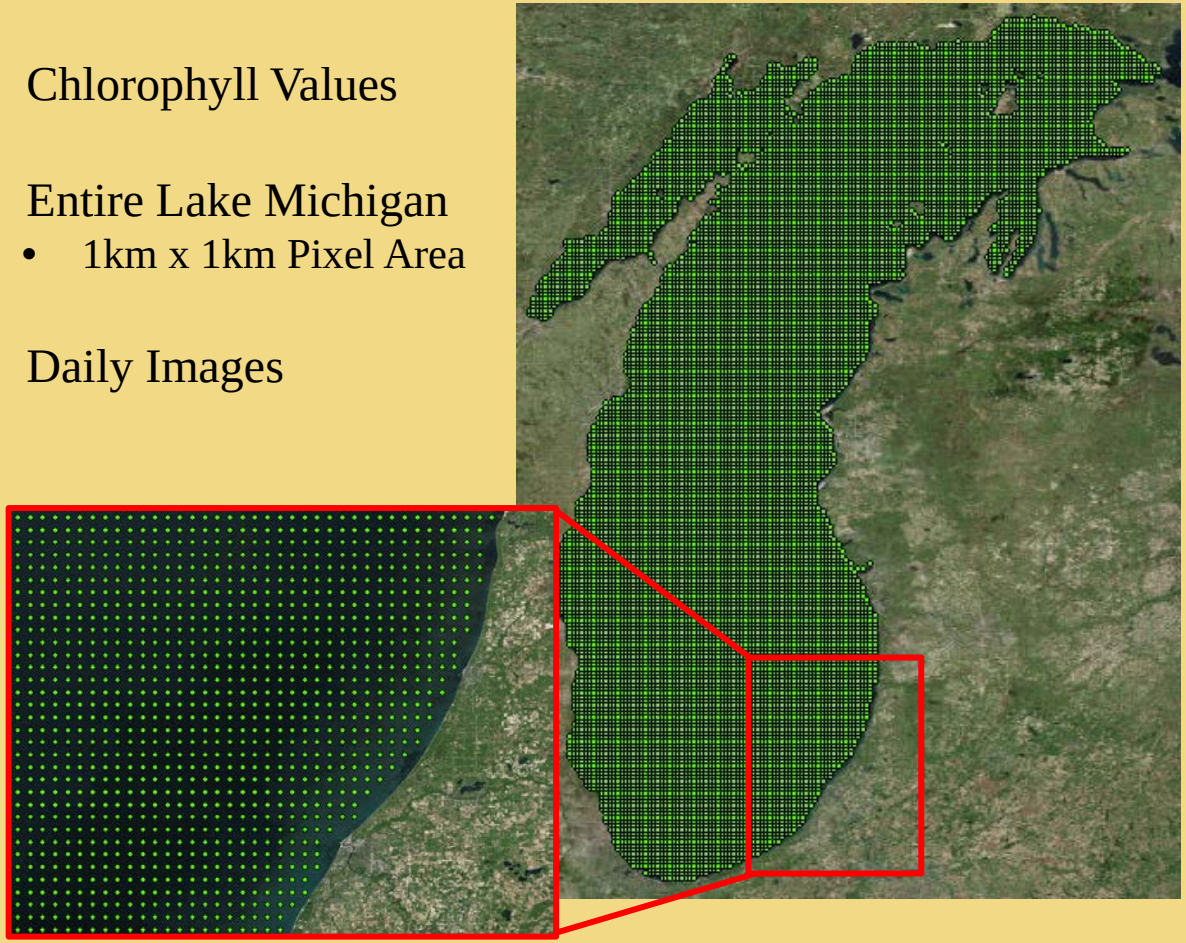
Fahnenstiel et al. 2010

- Water Samples
- Offshore
- Specific Time Periods



Satellite Imagery

- Chlorophyll Values
- Entire Lake Michigan
  - 1km x 1km Pixel Area
- Daily Images



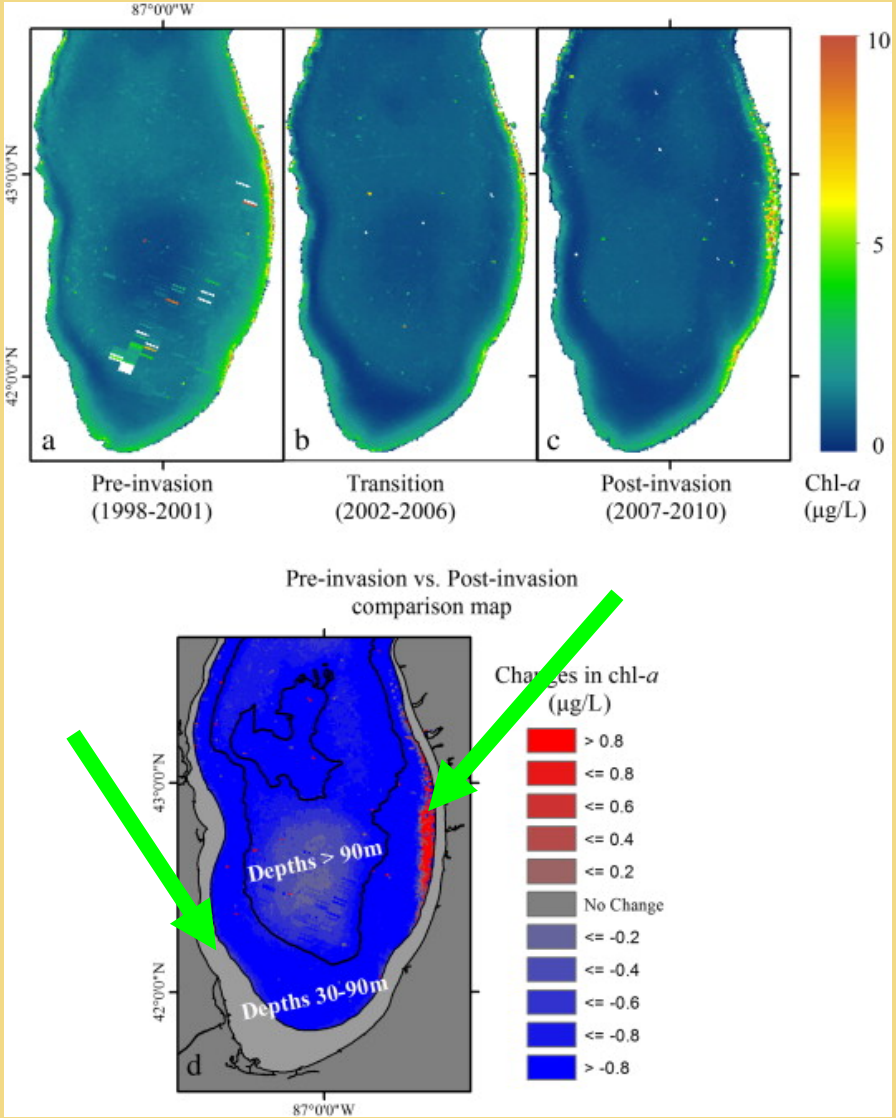
Satellite Imagery

- Similar Conclusions Offshore:
  - Declines in Chlorophyll *a* Concentrations
    - Yousef et al. 2014

- Conclusions Nearshore:
  - Declines in Chlorophyll *a* Concentrations

    BUT….
  - Very Broad Definition of Nearshore
    - >30 m in depth

  - Discuss Region and Seasonal Differences



Recent Breakthroughs

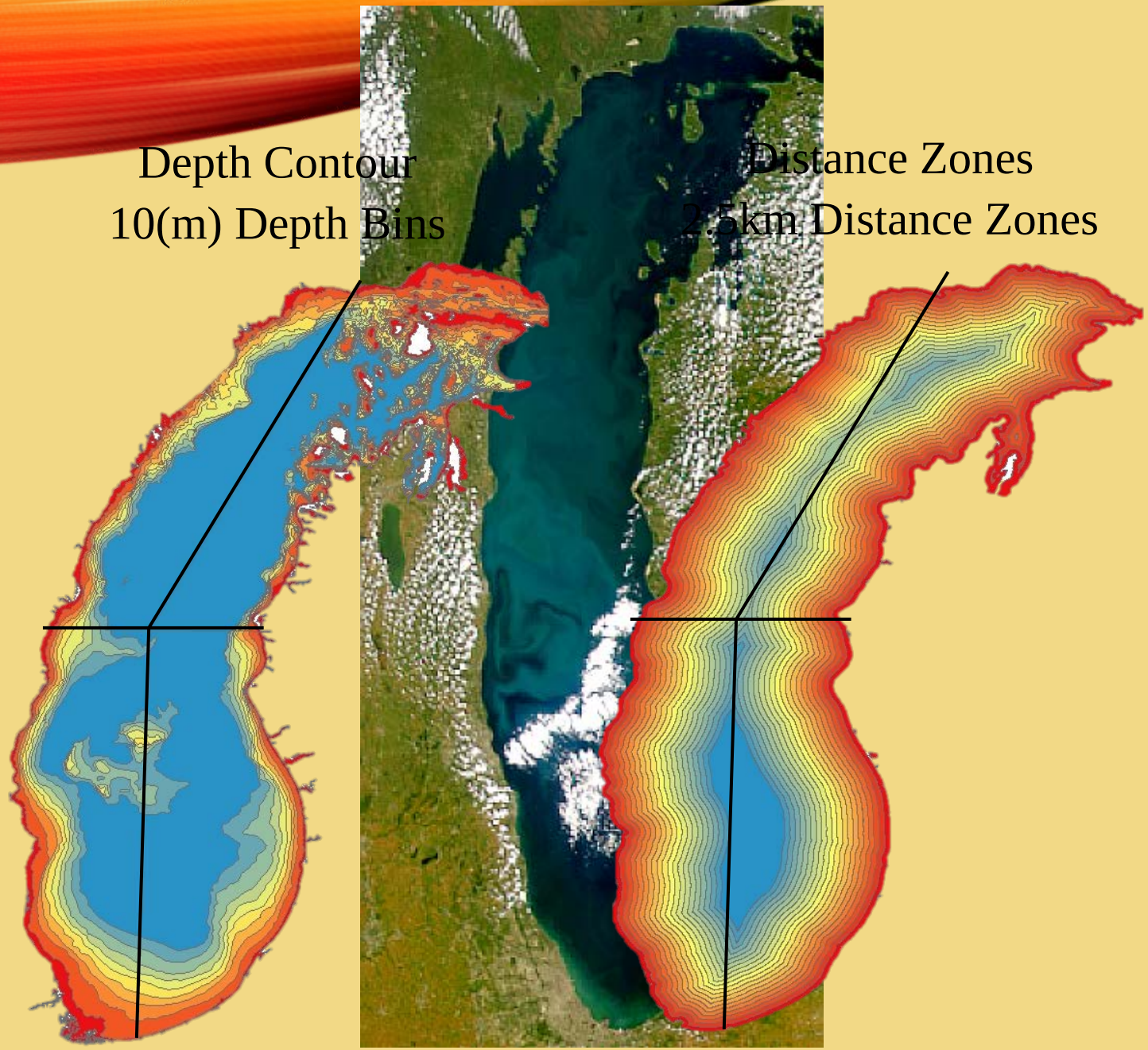
- New Algorithm (Lesht et al. 2013)
  - Cross Validated with EPA Long-Term Monitoring
  - More Accurate Than Previous Algorithms
  - Includes Nearshore Concentrations
- Standardize Both Satellites (Hutton et al. Unpublished)
  - Allows continued monitoring using both SeaWiFS and MODIS Satellites

Research Questions

1) Are Nearshore Chlorophyll *a* Concentrations Decreasing?
   a. Yearly Trends
   b. Seasonal Trends

2) Are Regional Trends Homogeneous Around Lake Michigan?

Methods



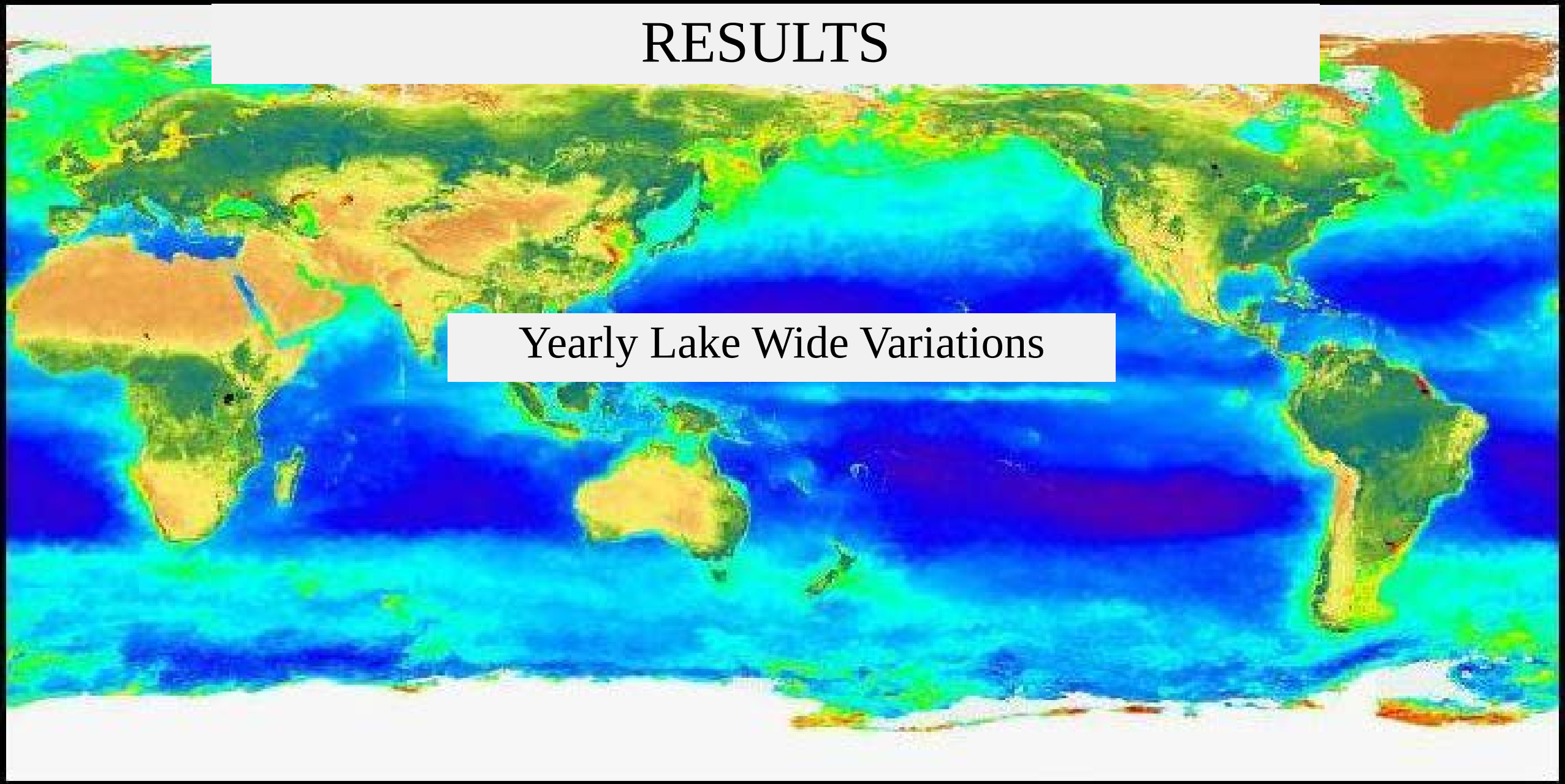
- Satellite Chlorophyll *a* Concentrations
  - Monthly Averages
  (Accounts for Days of No Data)

- 3 Representative Months
  - May (Spring Bloom)
  - July (Summer)
  - September (Fall Bloom)

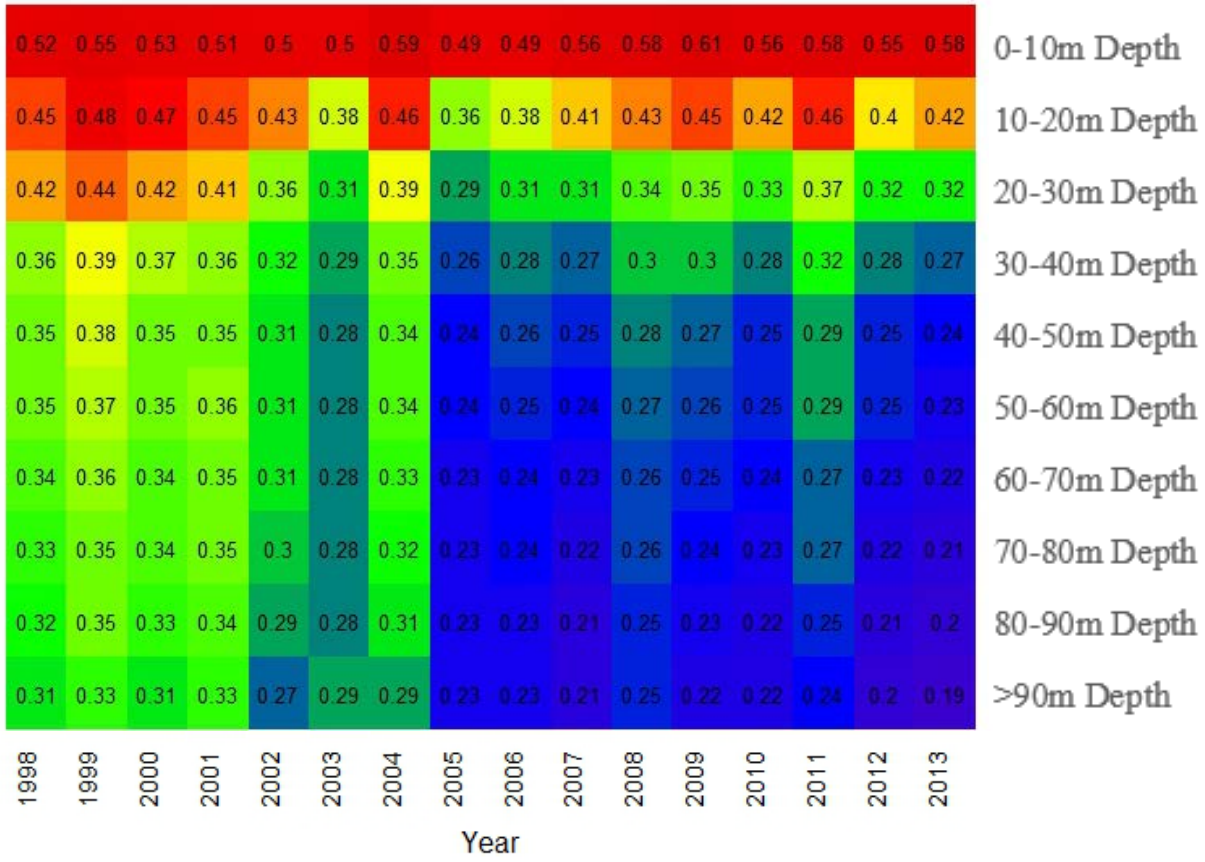
- Concentrations Averaged Per Location
  - Depth Contour
  - Distance Zones

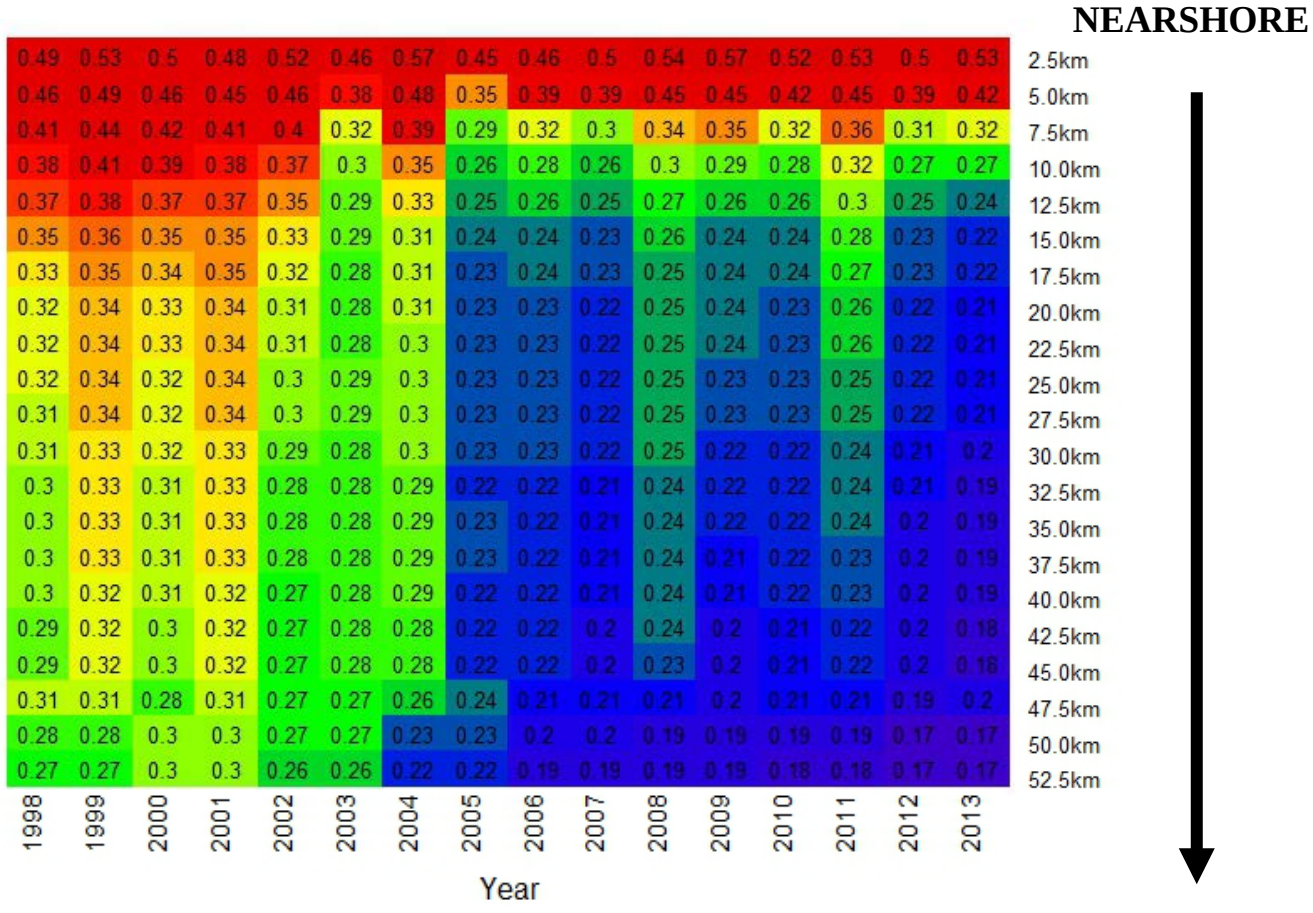
- Concentrations Averaged For Different Regions
  - Green Bay Not Included

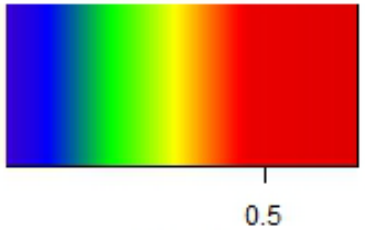
RESULTS



Whole Lake Yearly Average Depth Contour





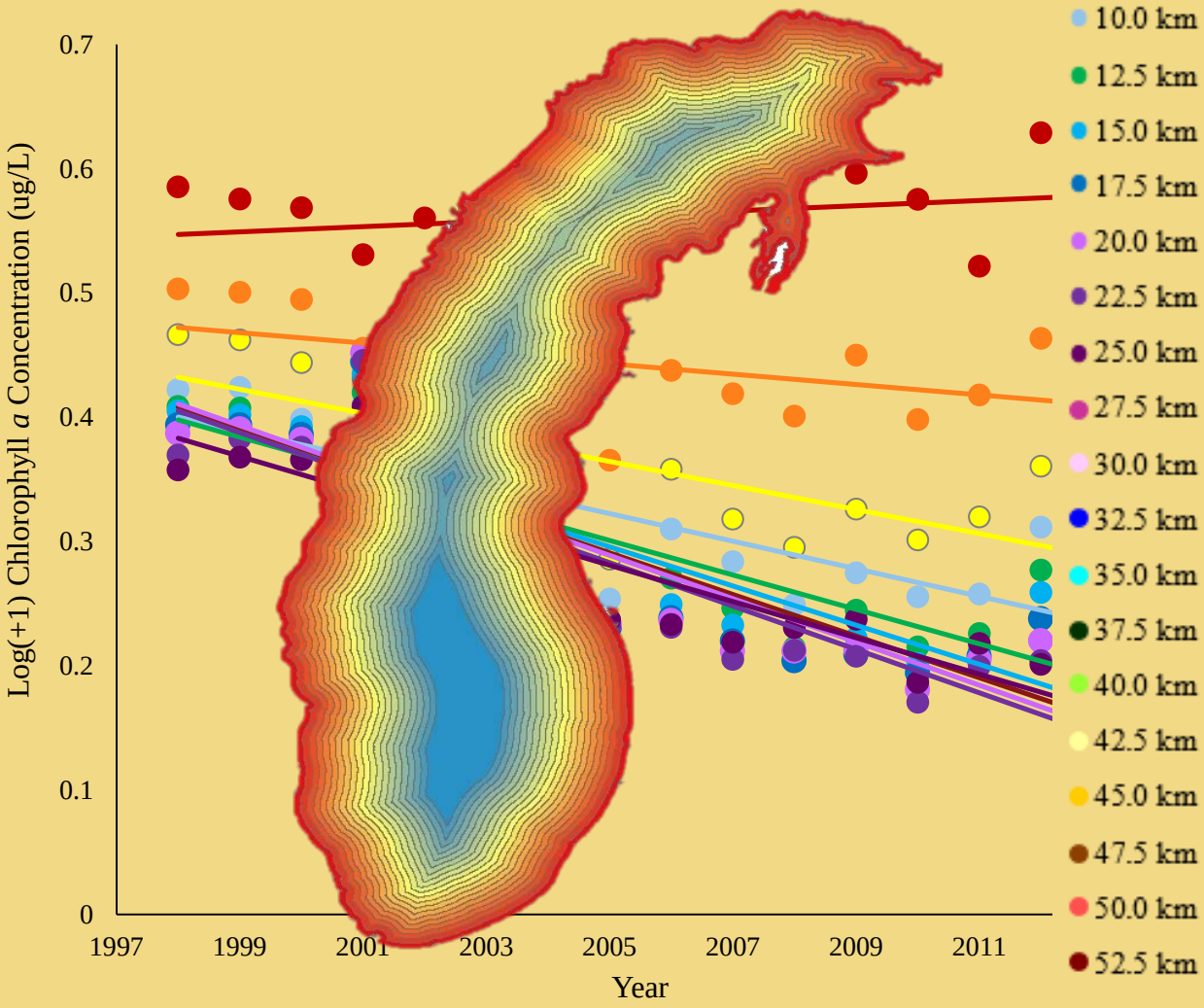


Log(+1) Chlorophyll *a* Concentration (ug/L)

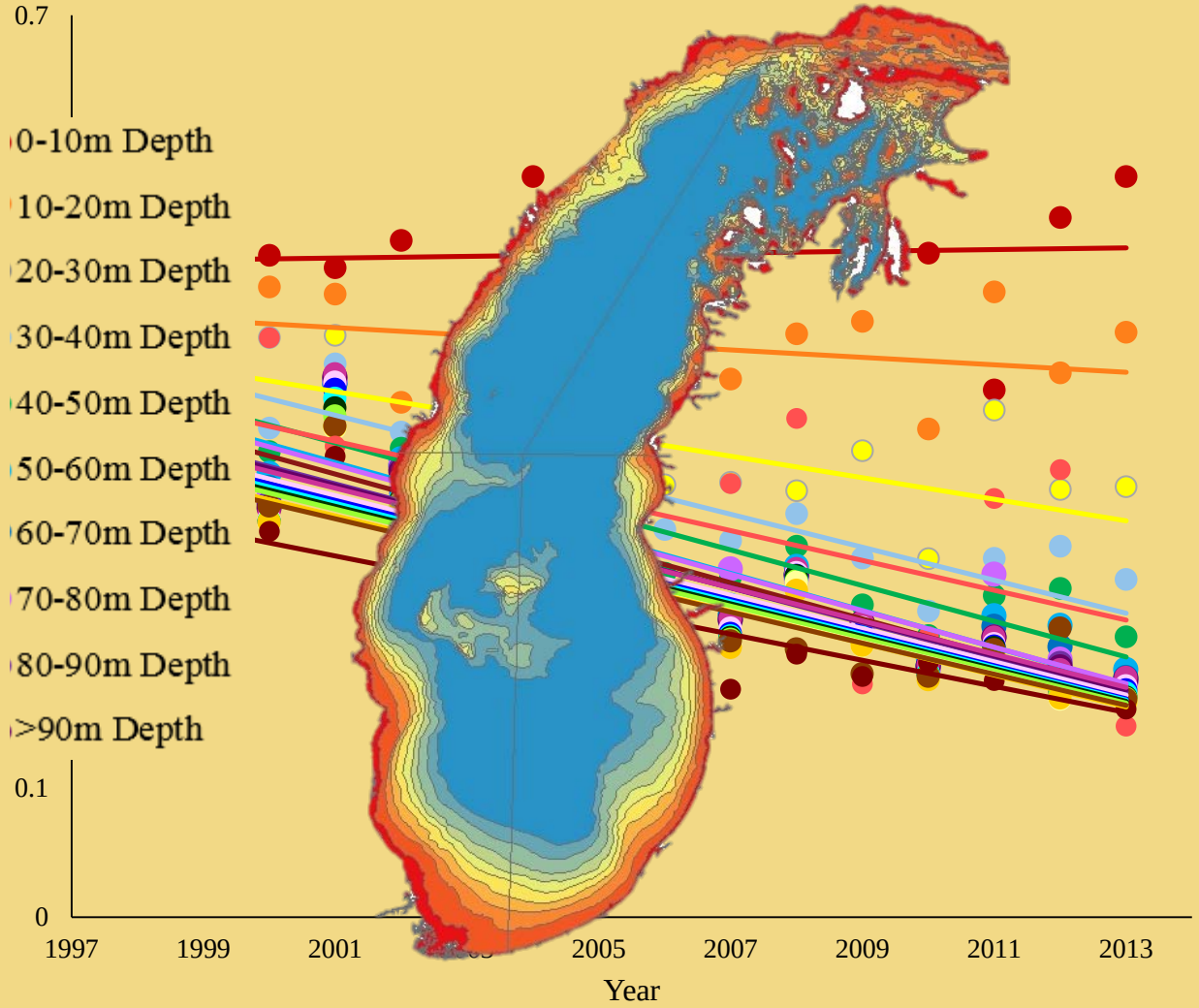
Lake Wide Seasonal Variations

Lake Michigan Seasonal May (Spring Bloom)

Depth Contour

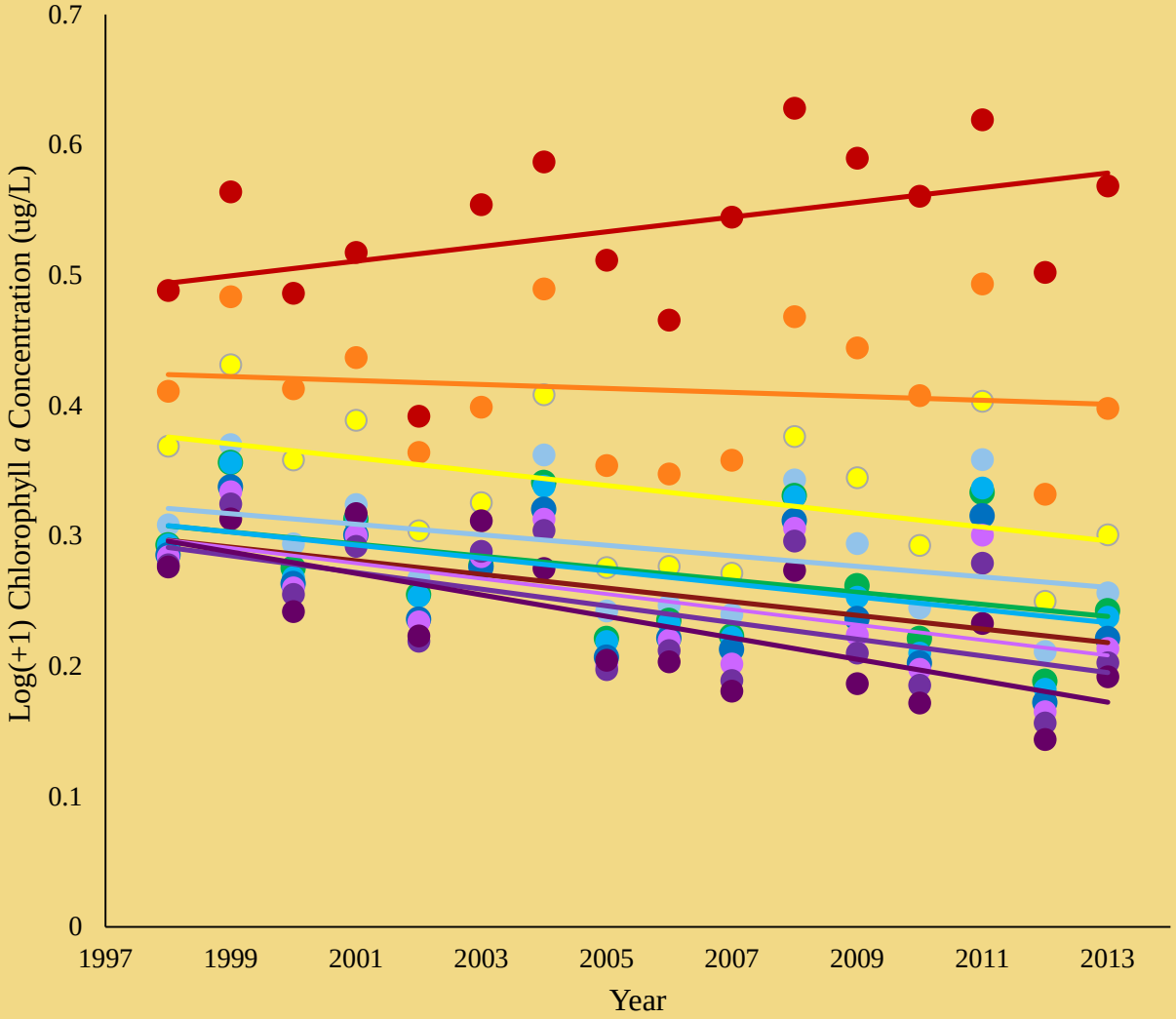


Distance Zones

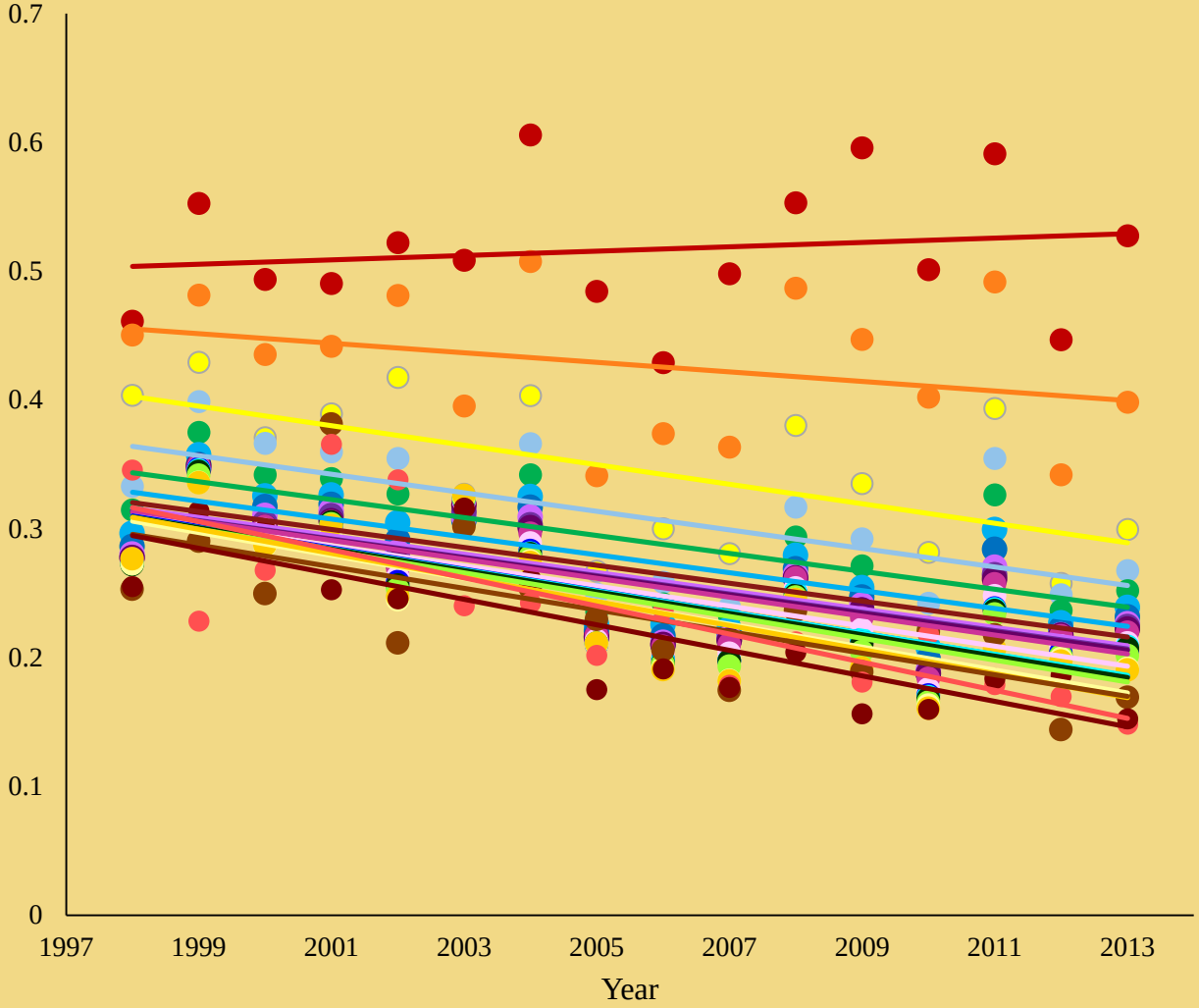


Lake Michigan Seasonal July (Summer)

Depth Contour

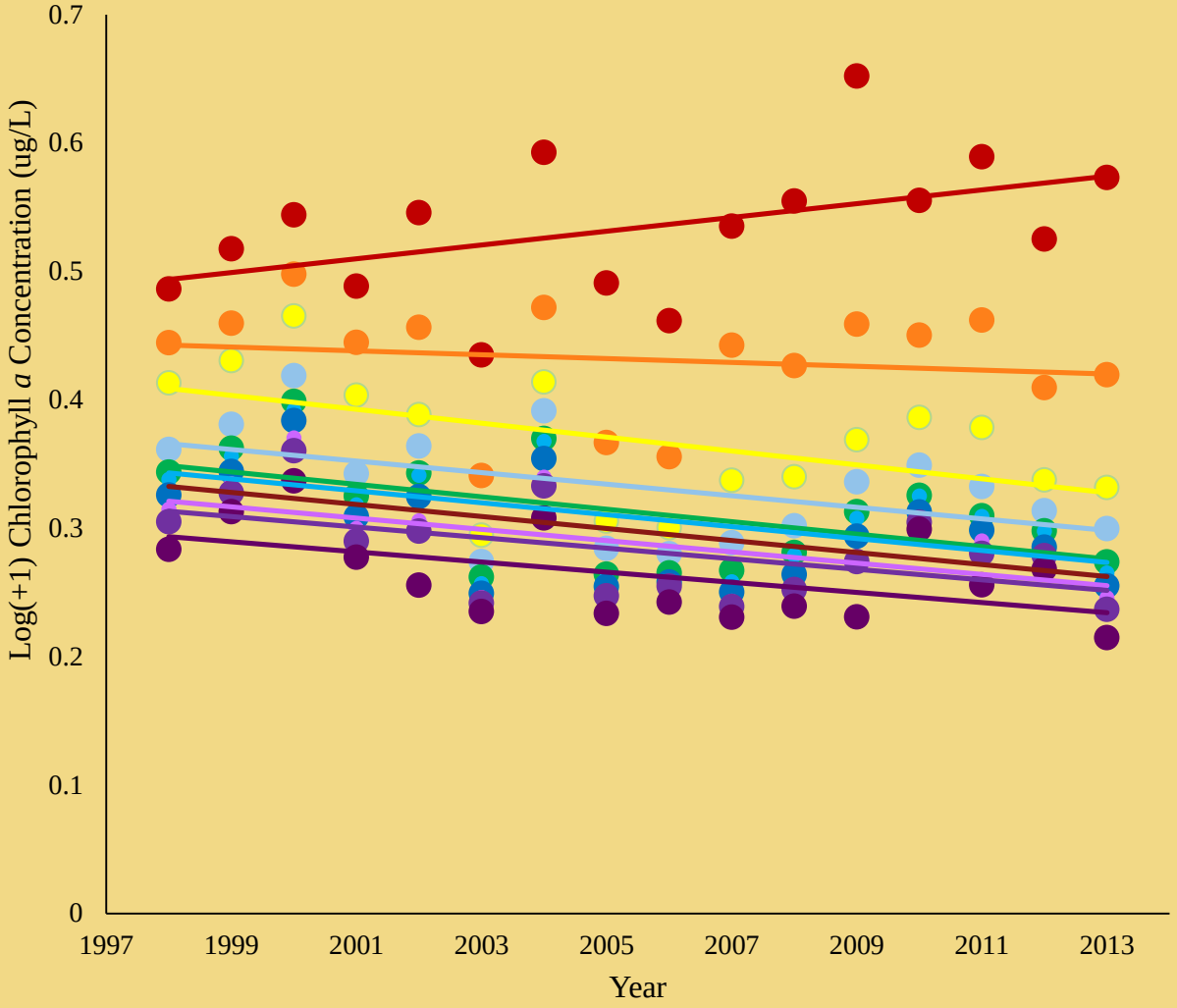


Distance Zones

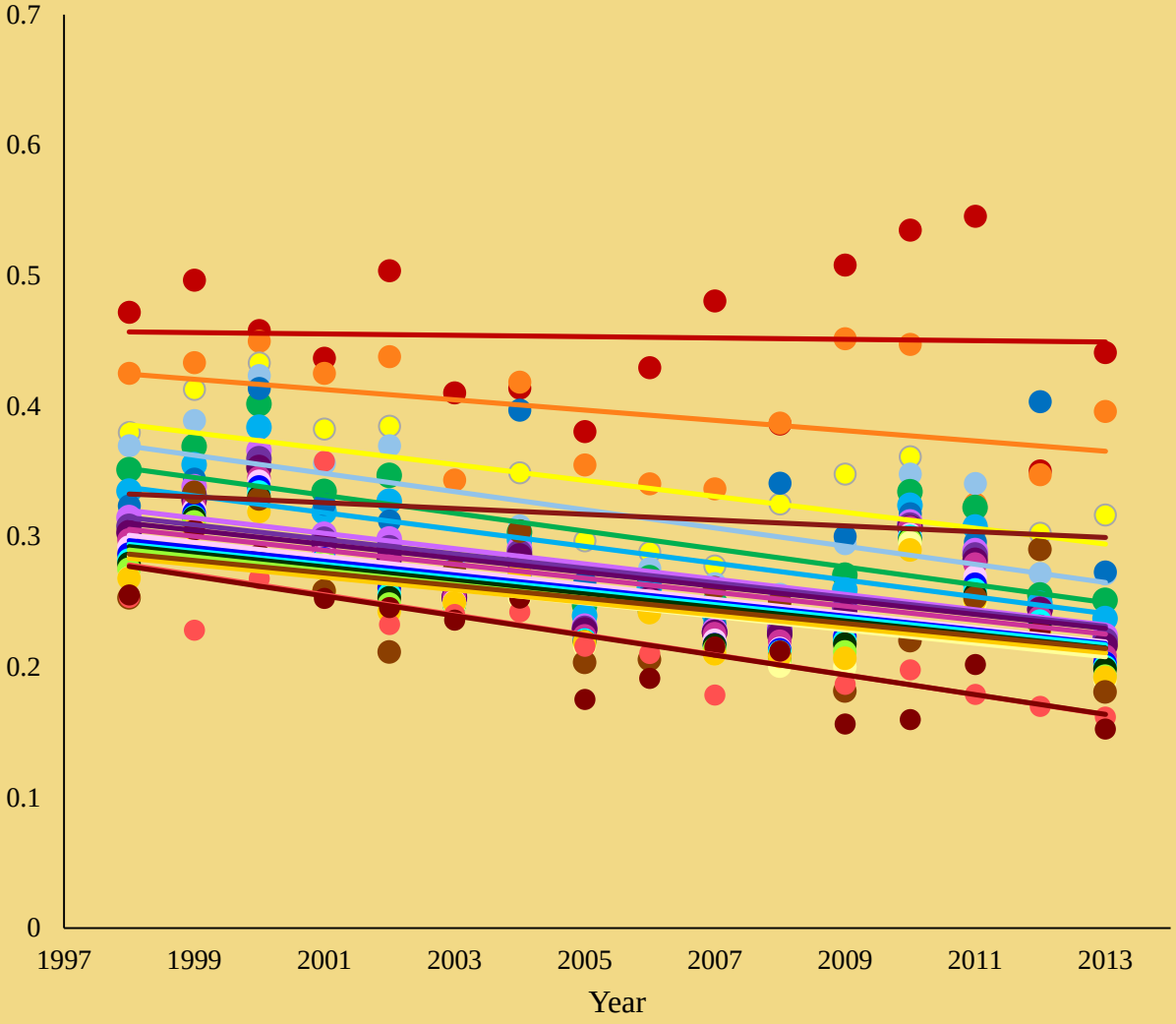


Lake Michigan Seasonal September (Fall Bloom)

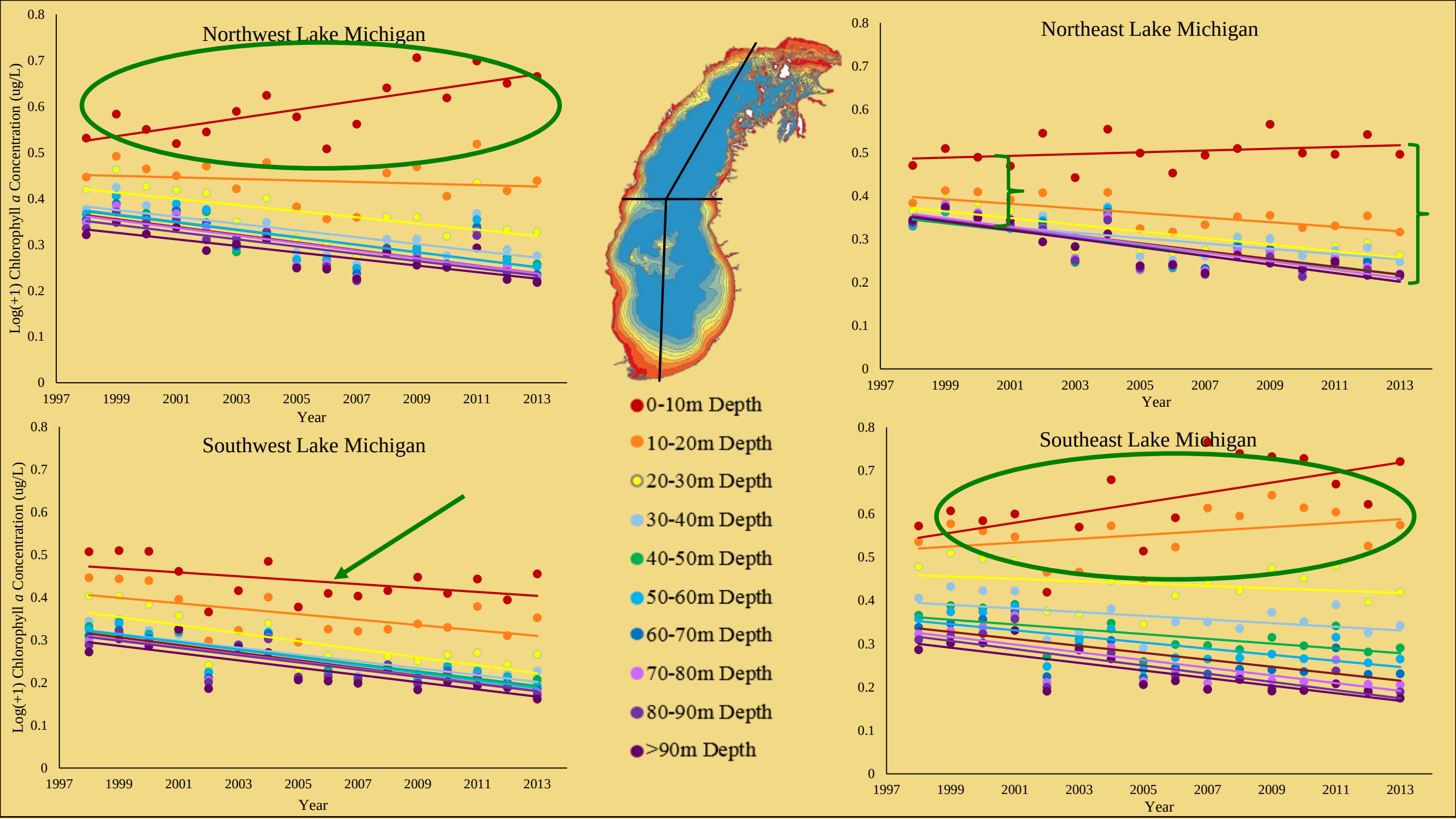
Depth Contour



Distance Zones



Yearly Regional Variations


Northwest Lake Michigan
Northeast Lake Michigan
Southwest Lake Michigan
Southeast Lake Michigan
Log(+1) Chlorophyll a Concentration (ug/L)
Year
0-10m Depth
10-20m Depth
20-30m Depth
30-40m Depth
40-50m Depth
50-60m Depth
60-70m Depth
70-80m Depth
80-90m Depth
>90m Depth

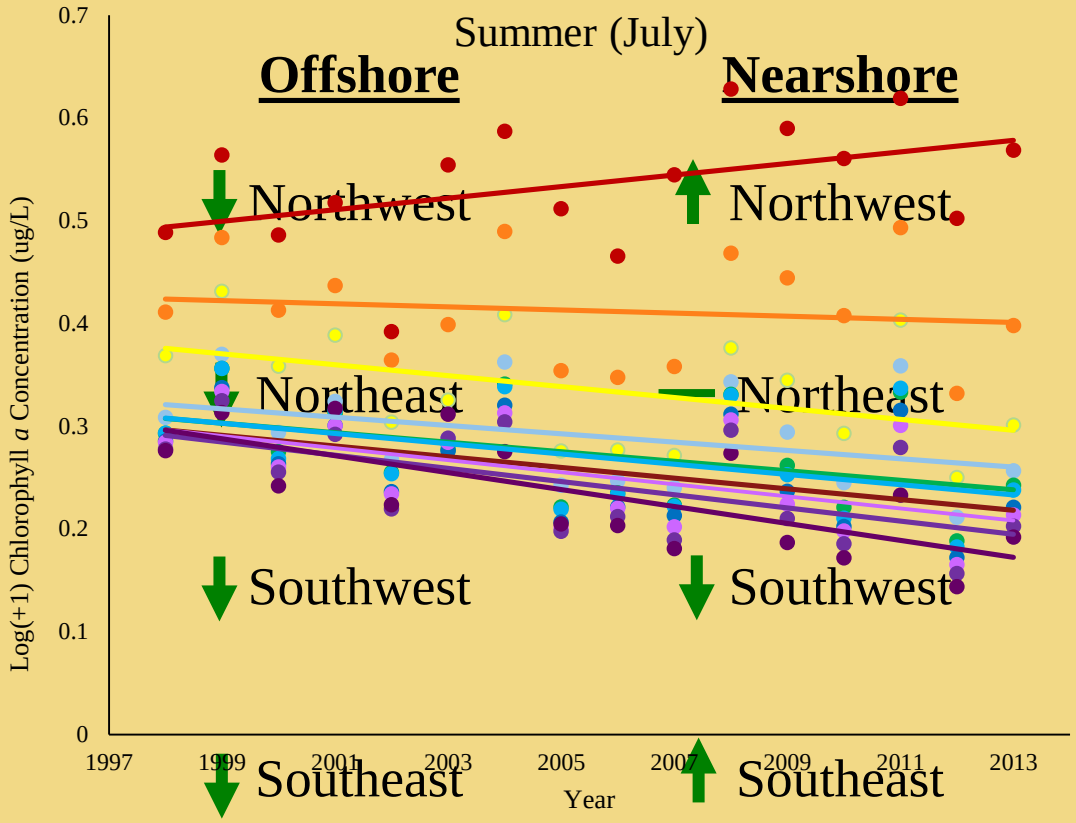
Conclusions

1) Are Nearshore Chlorophyll *a* Concentrations Decreasing?
   a. Yearly Trends
   b. Seasonal Trends

No

2) Are Regional Yearly Trends Homogeneous Around Lake Michigan?

No



- Green Bay Concentrations
- Fox River Nutrient Input

- Fewer Watersheds
- Colder Temperatures

- Larger Watersheds
- More Agriculture
- Warmer Temperatures

QUESTIONS???