



WHAT'S TRENDING IN WAQUOIT BAY?

Jordan Mora, Spring 2018

Waquoit Bay NERR, MA

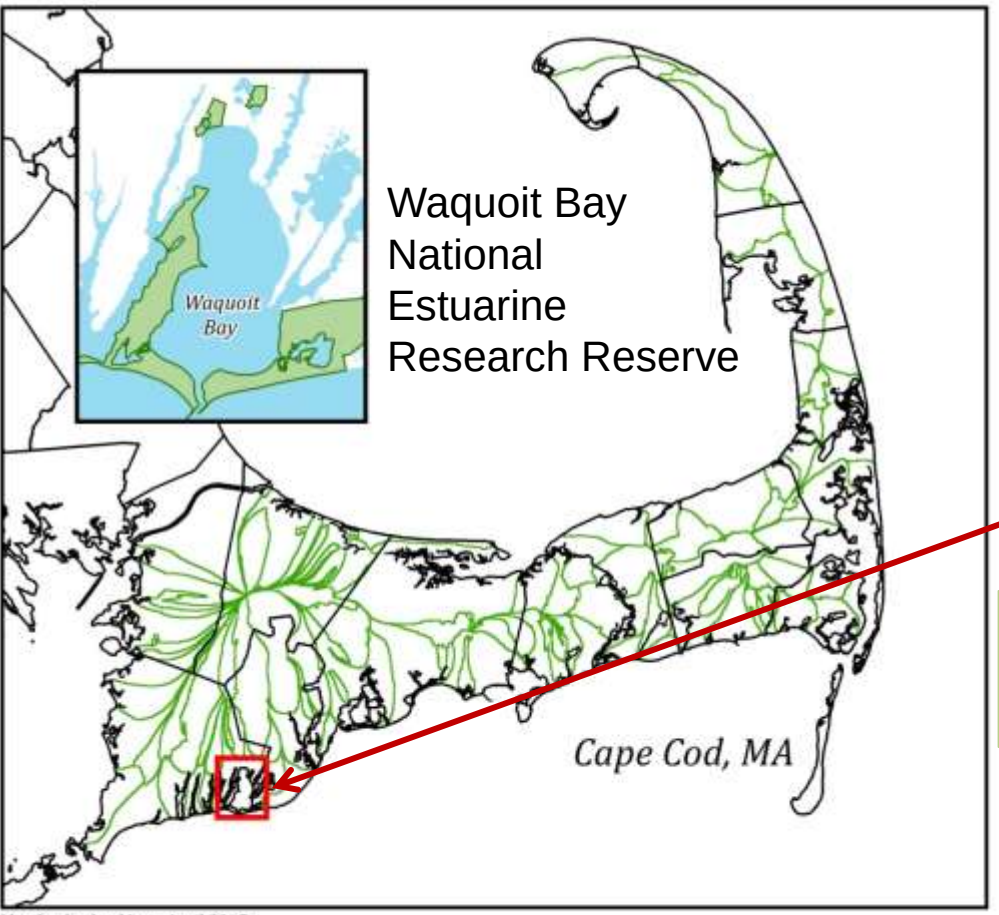

LAND
PRESS

Outline

- Intro to NERRS Waquoit Bay monitoring
  - Who/what/where are the players
- Trends and pulses
  - Temperature
  - Dissolved Oxygen
  - Nutrients & Chlorophyll + Pheophytin
  - Eelgrass & Macroalgae
- What's driving changes in Waquoit Bay
  - Nutrients
  - Macroalgae
- What's the take home?

Intro to Waquoit Bay monitoring

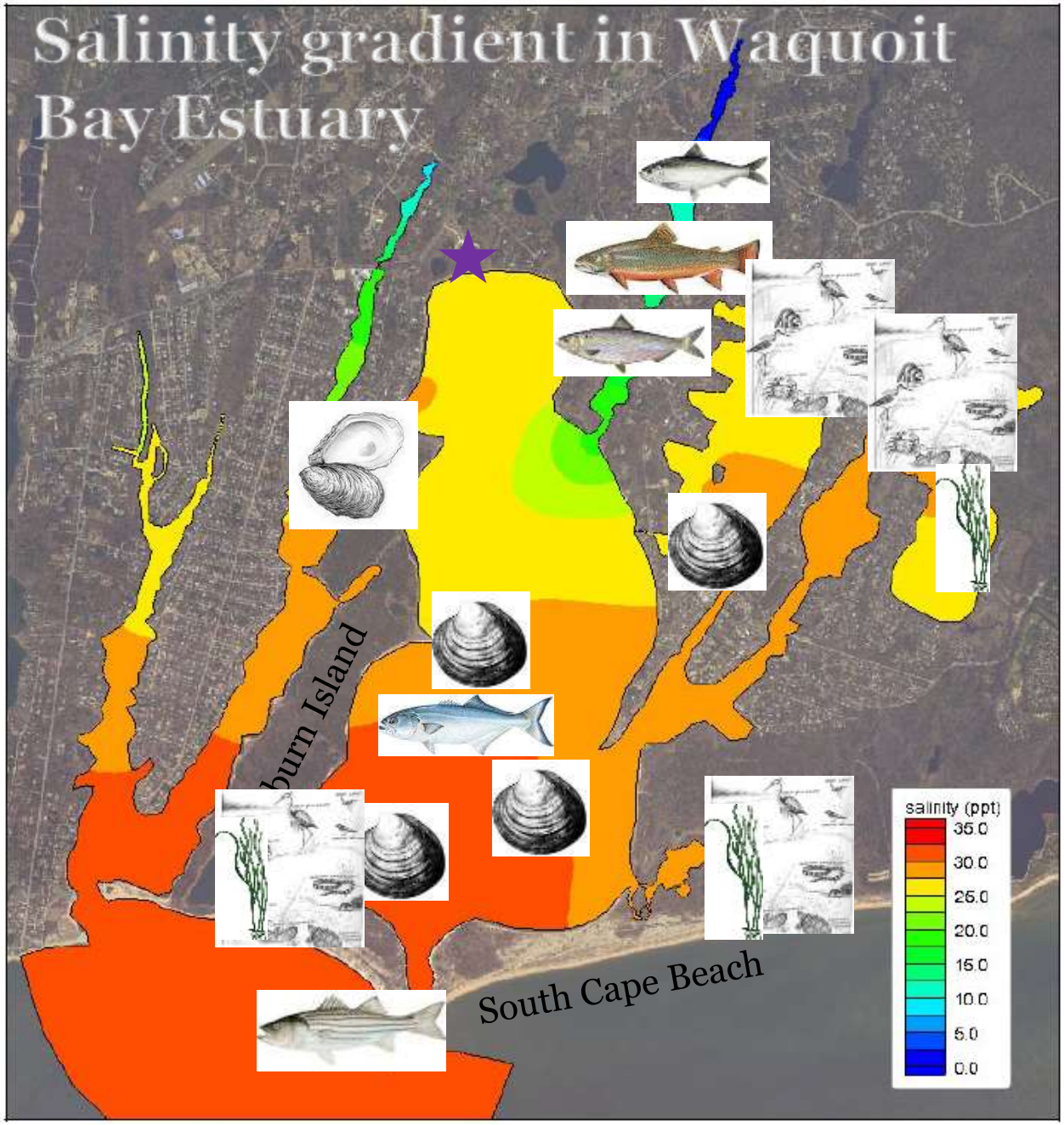
National Estuarine Research Reserve System



Map by: Jordan Mora, April 2015.
Data Sources: WBNERR (2004 Habitat Data & Property Boundary) and MassGIS (2009 USGS Orthos, 30cm res)

WAQUOIT BAY RESERVE FOUNDATION

http://www.mass.gov/eea/images/dcr/passport/passportcoverpetecircle462x286.gif



What's an Estuary?

<u>Significance</u>

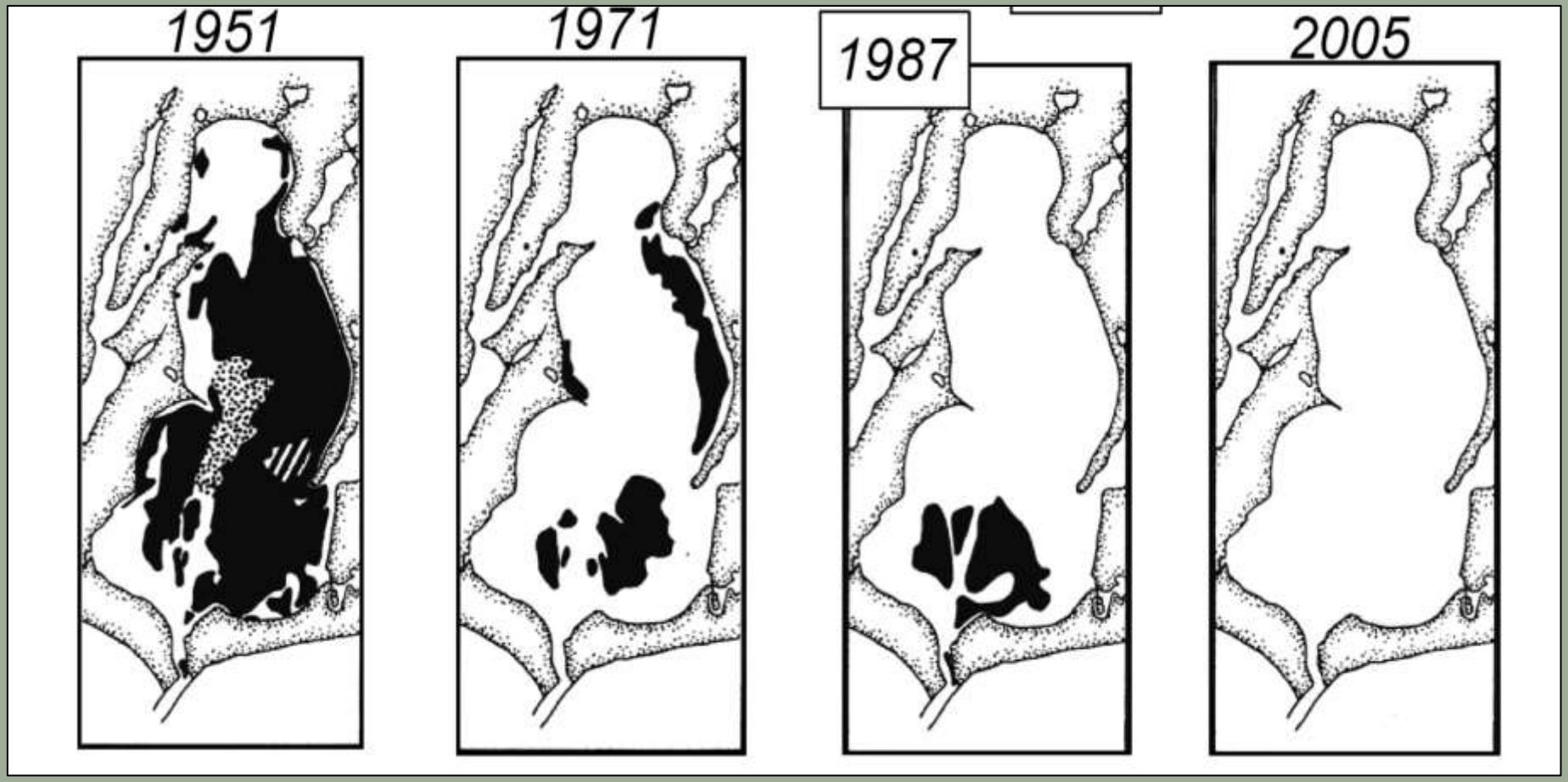
Productive systems with many ecosystem services to humans (filtering pollutants and excess nutrients, buffering storm impacts, and providing critical habitats) which help drive coastal economy (e.g., real estate values, infrastructural stability, fishing yields, eco-tourism, etc.).

MEP, May 2012

http://calvert.lib.md.us/calvertheritage/images/image017.png

Google-Data Image "Eelgrass", obtained on 07/07/2017

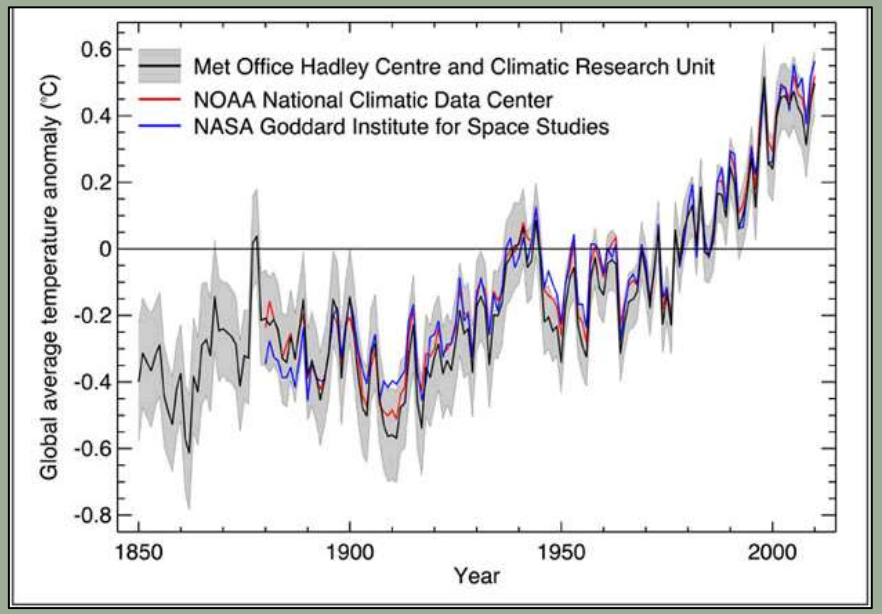
Background – Eelgrass Decline



Valiela, I., K. Foreman, M. LaMontagne, D. Hersh, J. Costa, P. Peckol, B. DeMeo-Anderson. C. D'Avanzo, M. Babione, Chi-Ho Sham, J. Brawley, K. Laitha. 1992. Couplings of Watersheds and Coastal Waters: Sources and Consequences of Nutrient Enrichment in Waquoit Bay, Massachusetts. Estuaries 15 (4): 43-457.

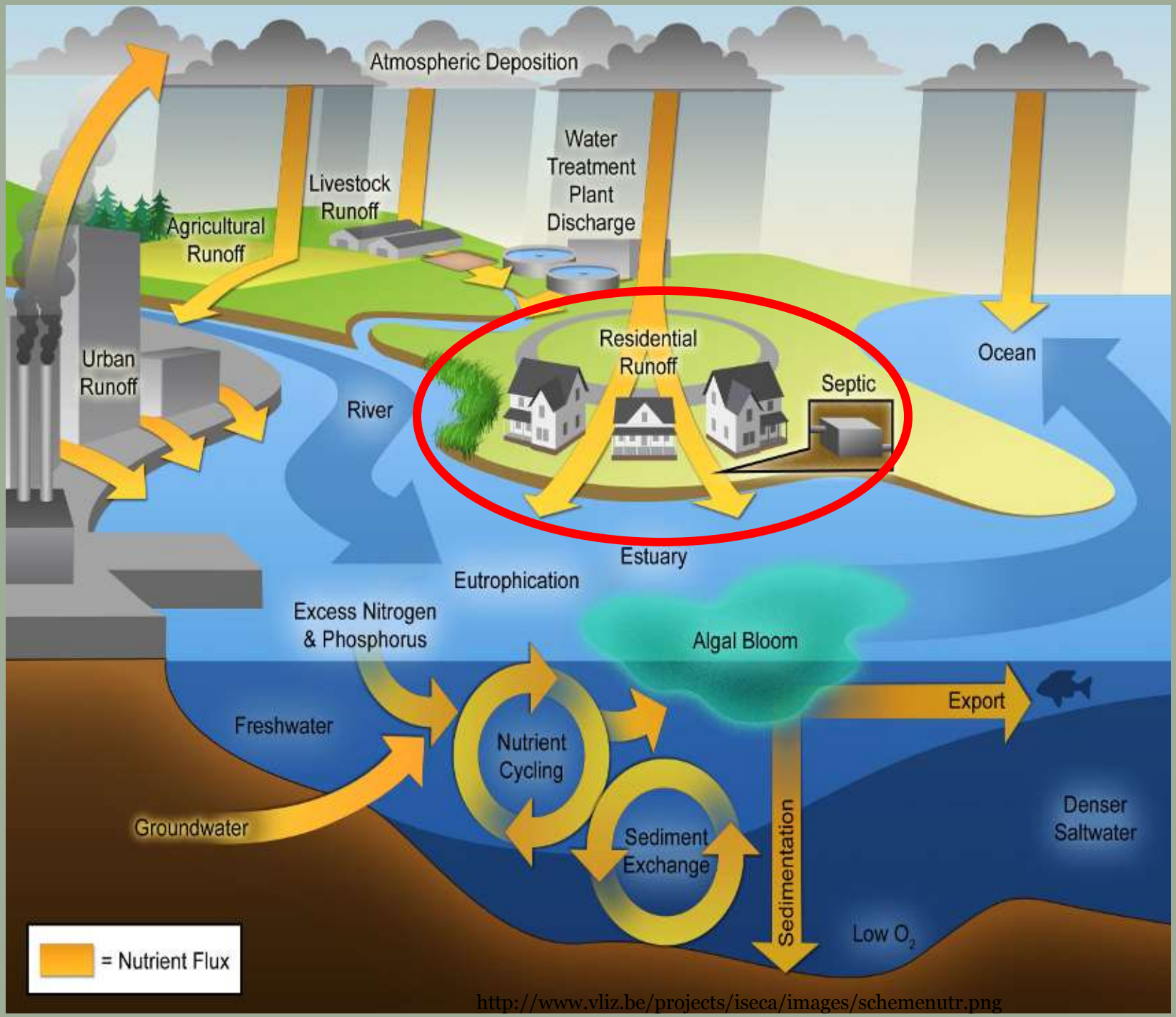
Threats to estuarine health

- Climate change



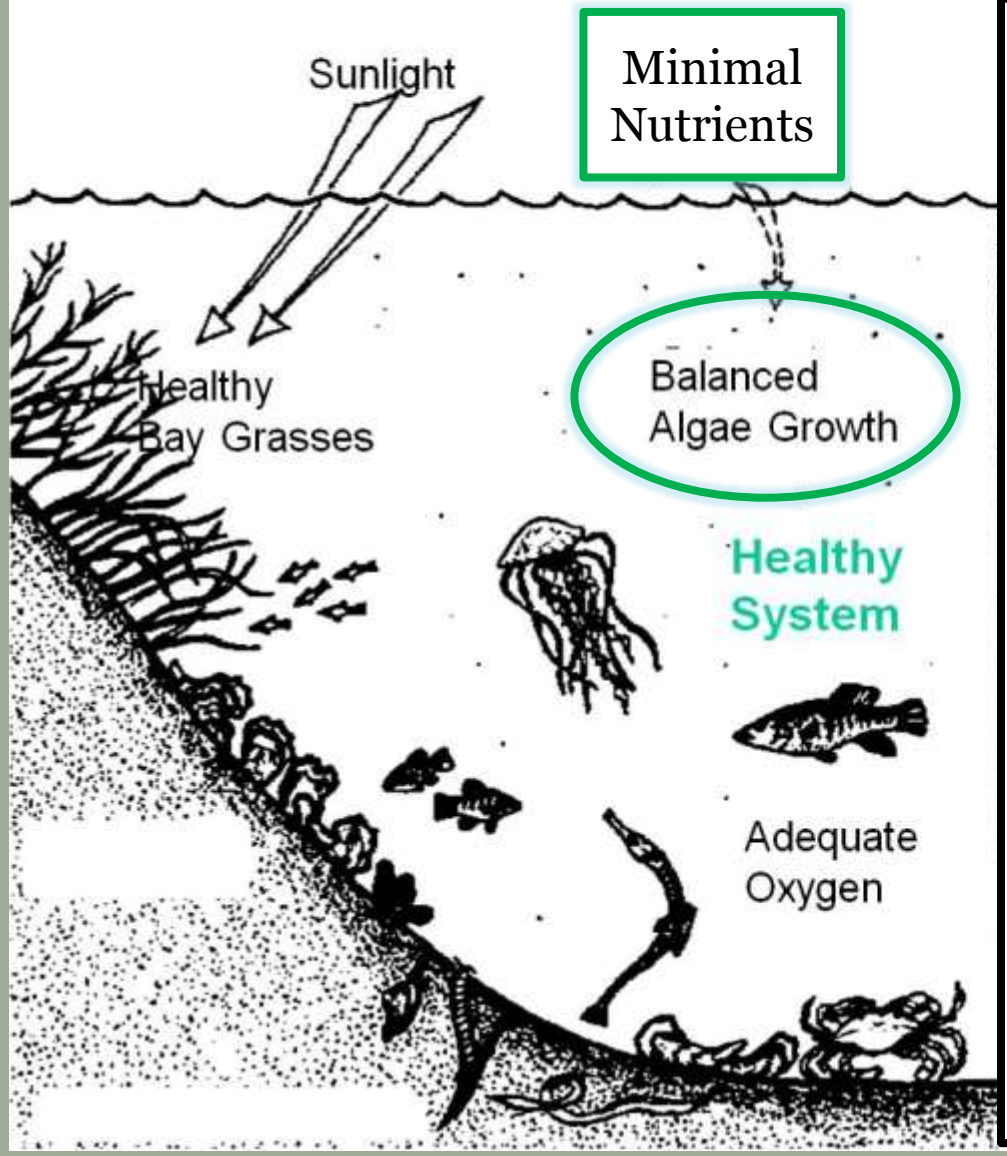
- Excess nutrient loading

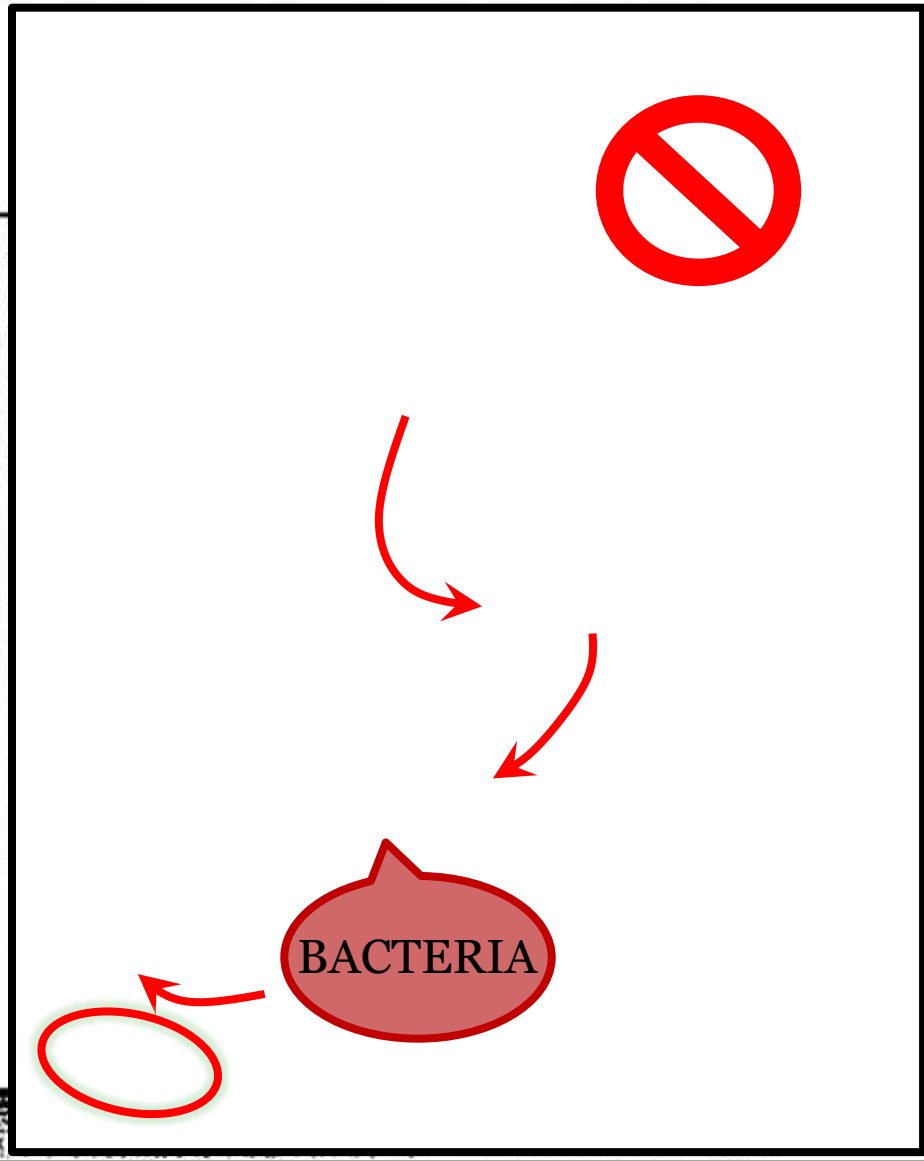

Waquoit Bay algal bloom, 2003



http://www.vliz.be/projects/iseca/images/schemenutr.png

EUTROPHICATION





http://www.inlandbays.org/wp-content/images/healthy_bay_eutrophication.jpg

The Mission

NERR System–Wide Monitoring Program (SWMP)

Established in 1995

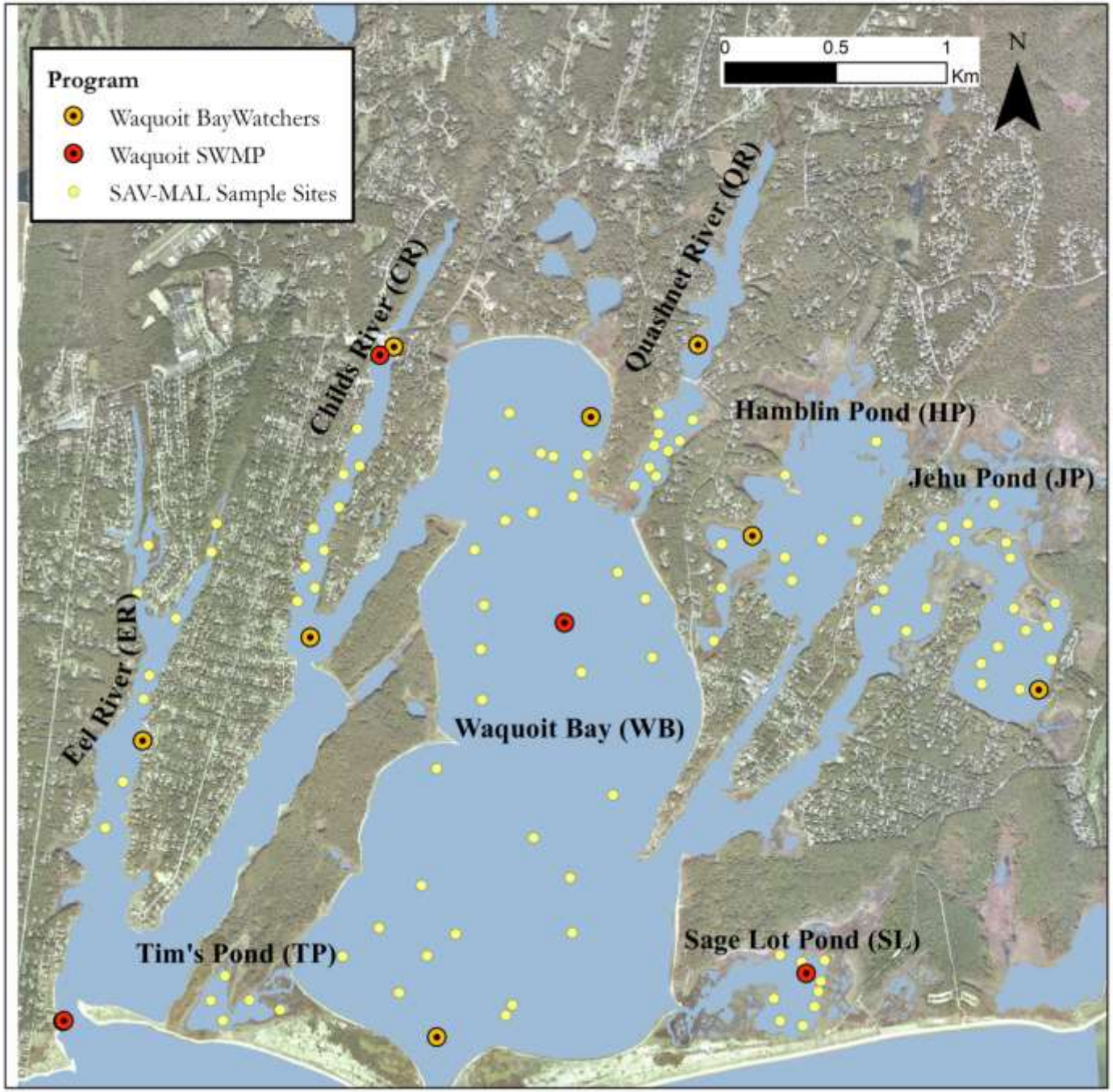
"Develop quantitative measurements of short-term variability and long-term changes in the water quality, biological systems, and land-use / land-cover characteristics of estuaries and estuarine ecosystems for the purposes of informing effective coastal zone management. "

The Process

- SWMP nutrient & water quality sampling
- SAV-MAL sampling

MBL Biological Discovery in Woods Hole

Waquoit Bay Monitoring Program



Trends and pulses

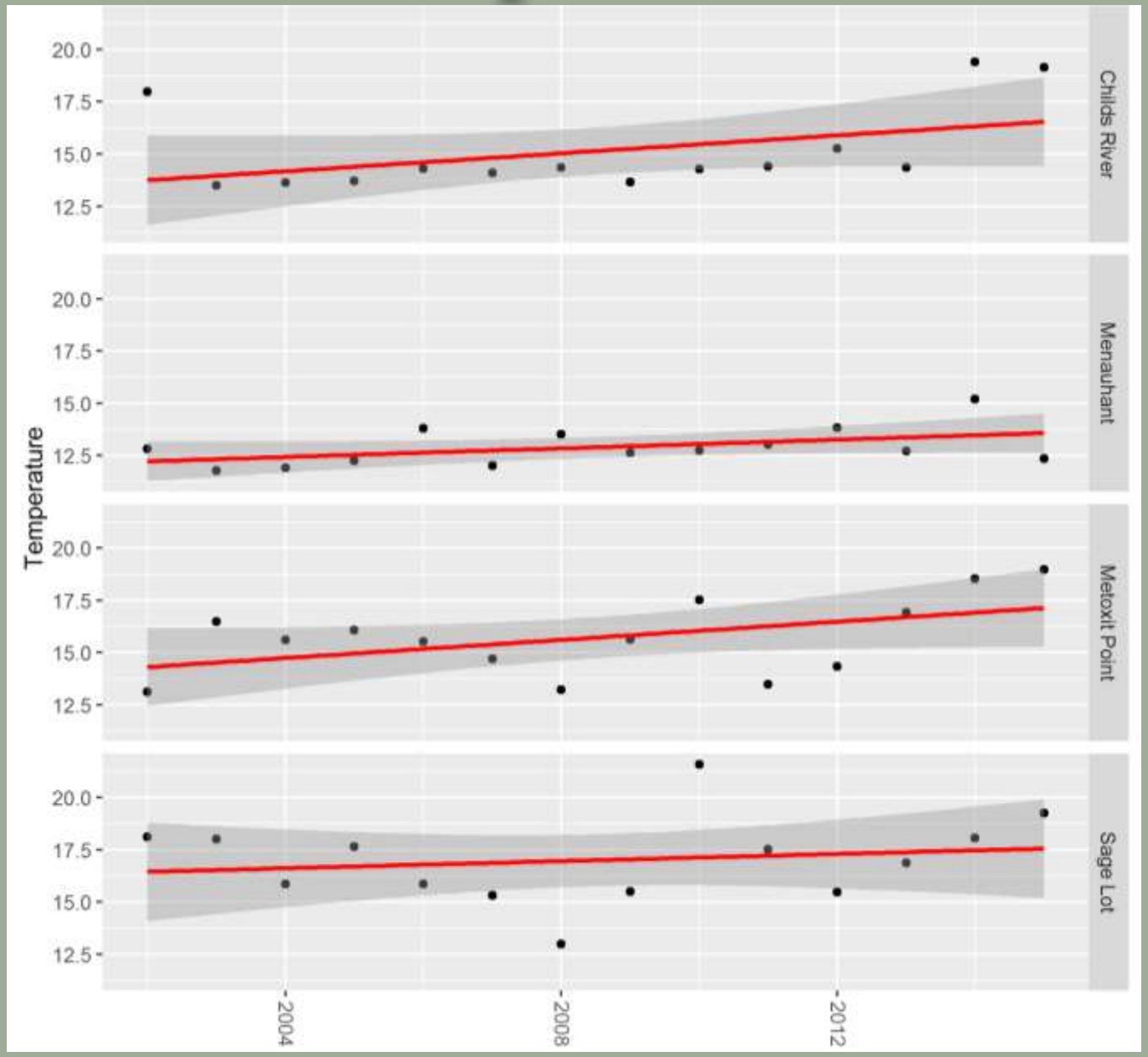
2017 Beach Erosion

2014 Shrimp Kill

2003 Algal Bloom

Temperature

Results from 15-minute SWMP sonde data



F = 2.79
P = 0.121

F = 3.352
P = 0.092

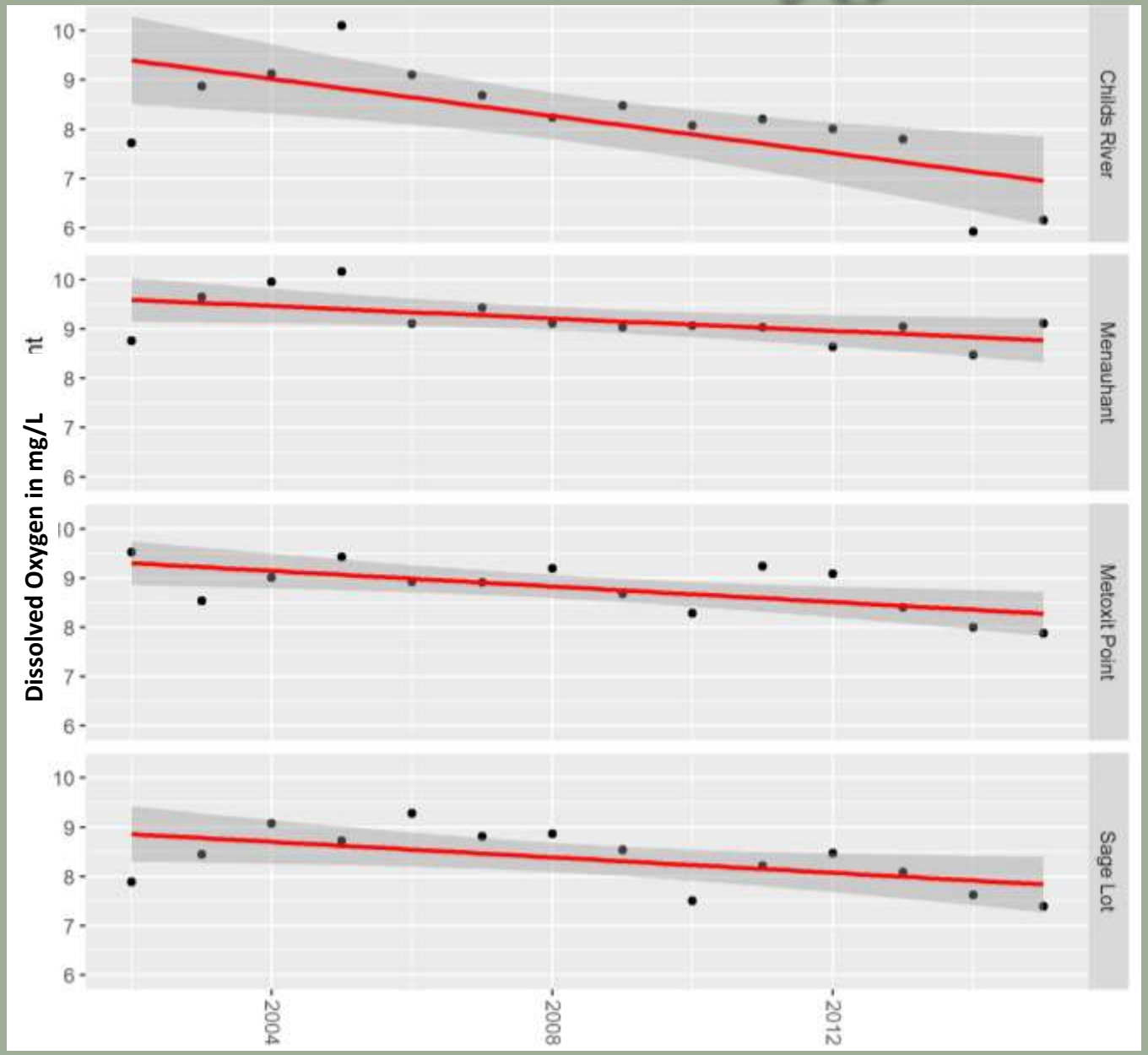
F = 3.78
P = 0.076

F = 0.363
P = 0.558

Grothues, T., and Owen Doherty, 2016., R-script training, JCNERR, & Eagle Rock Analytics

Dissolved Oxygen

Results from 15-minute SWMP sonde data



F = 17.61
P = 0.001

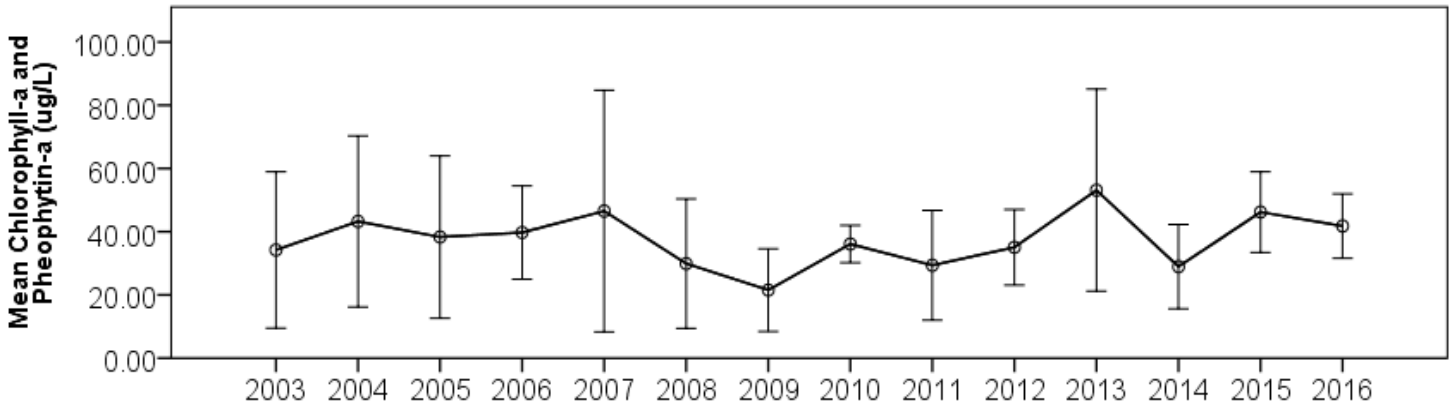
F = 0.7725
P = 0.397

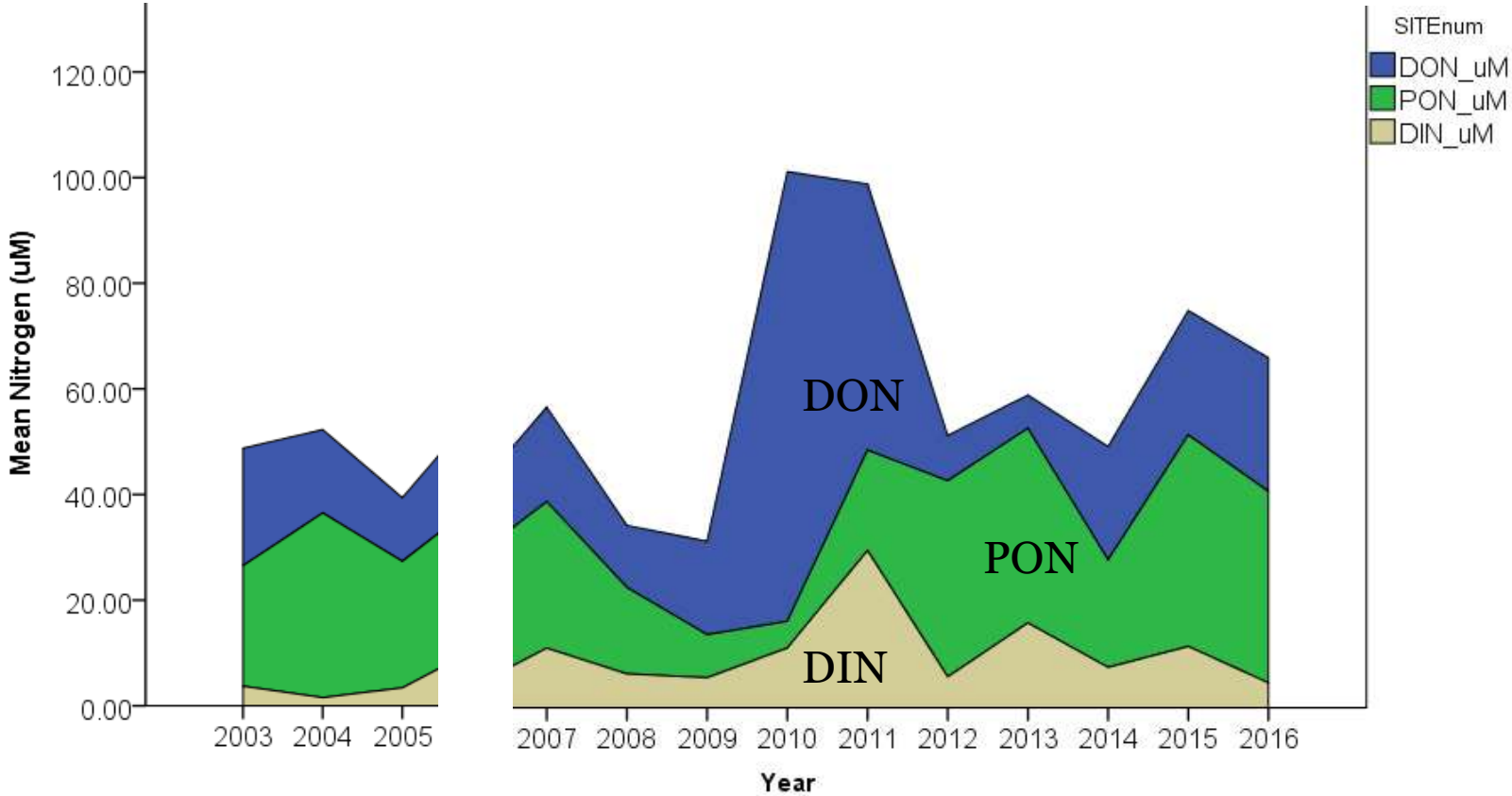
F =11.38
P = 0.006

F =11.28
P = 0.006

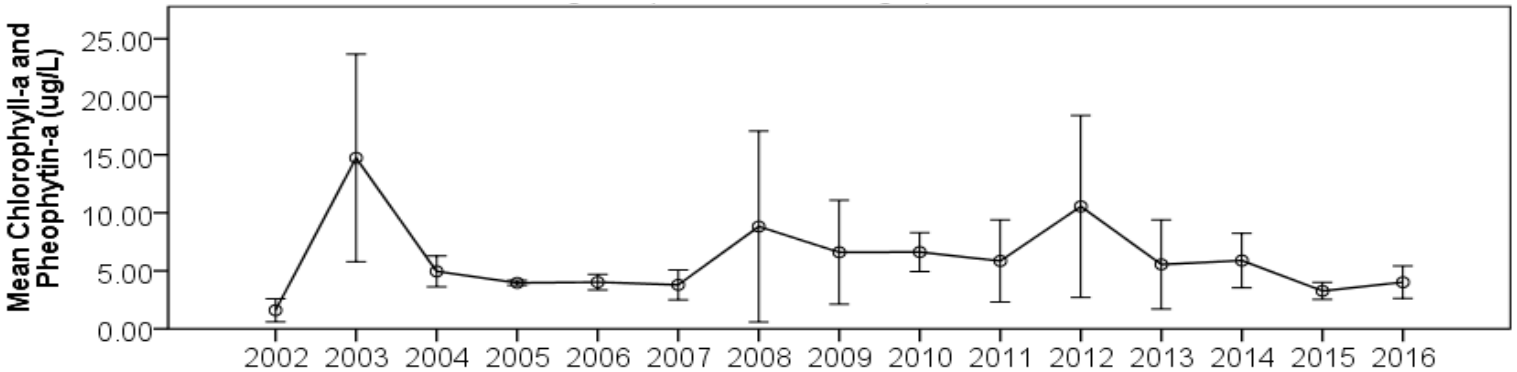
Grothues, T., and Owen Doherty, 2016., R-script training, JCNERR, & Eagle Rock Analytics

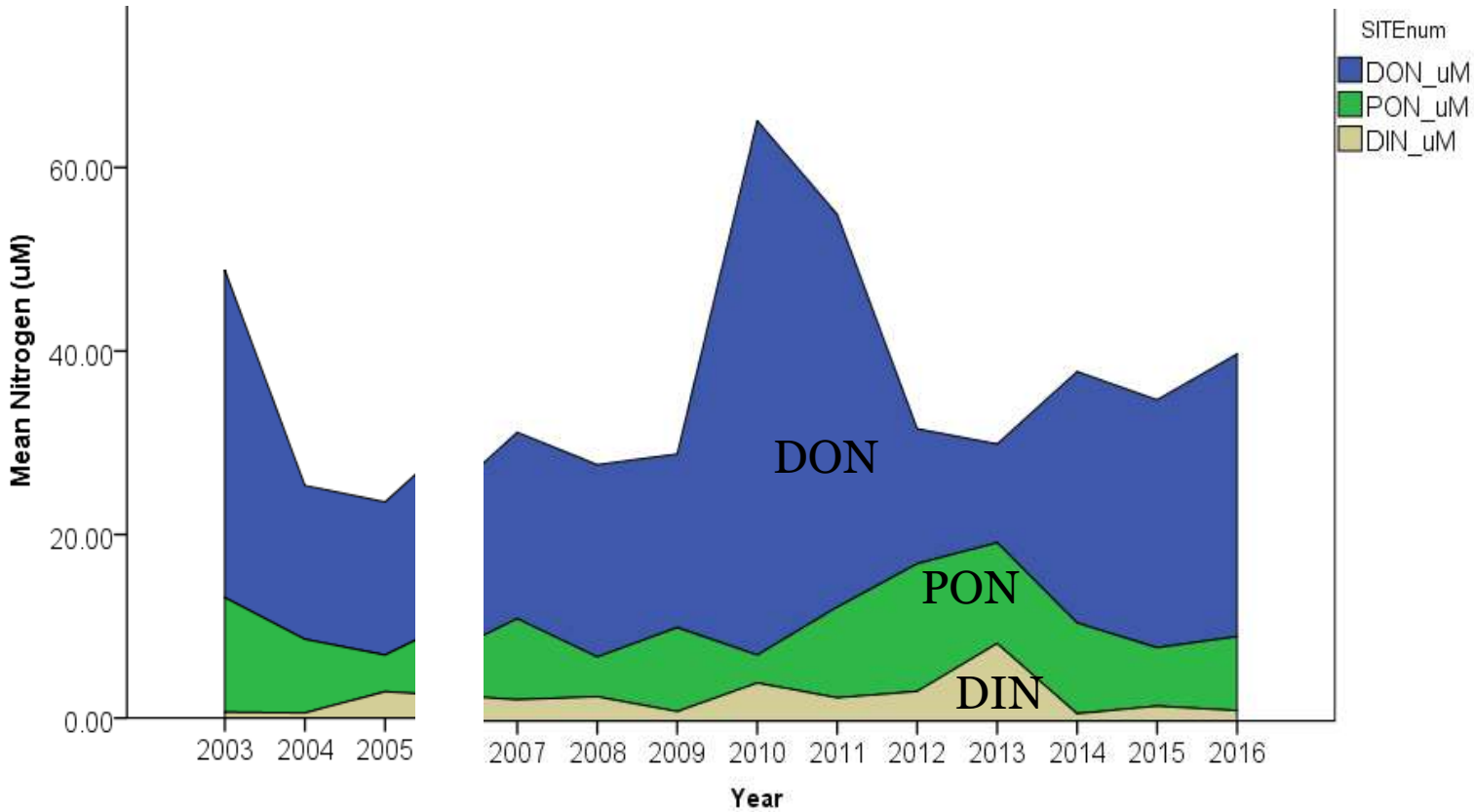
Childs River: Summer (June-August)



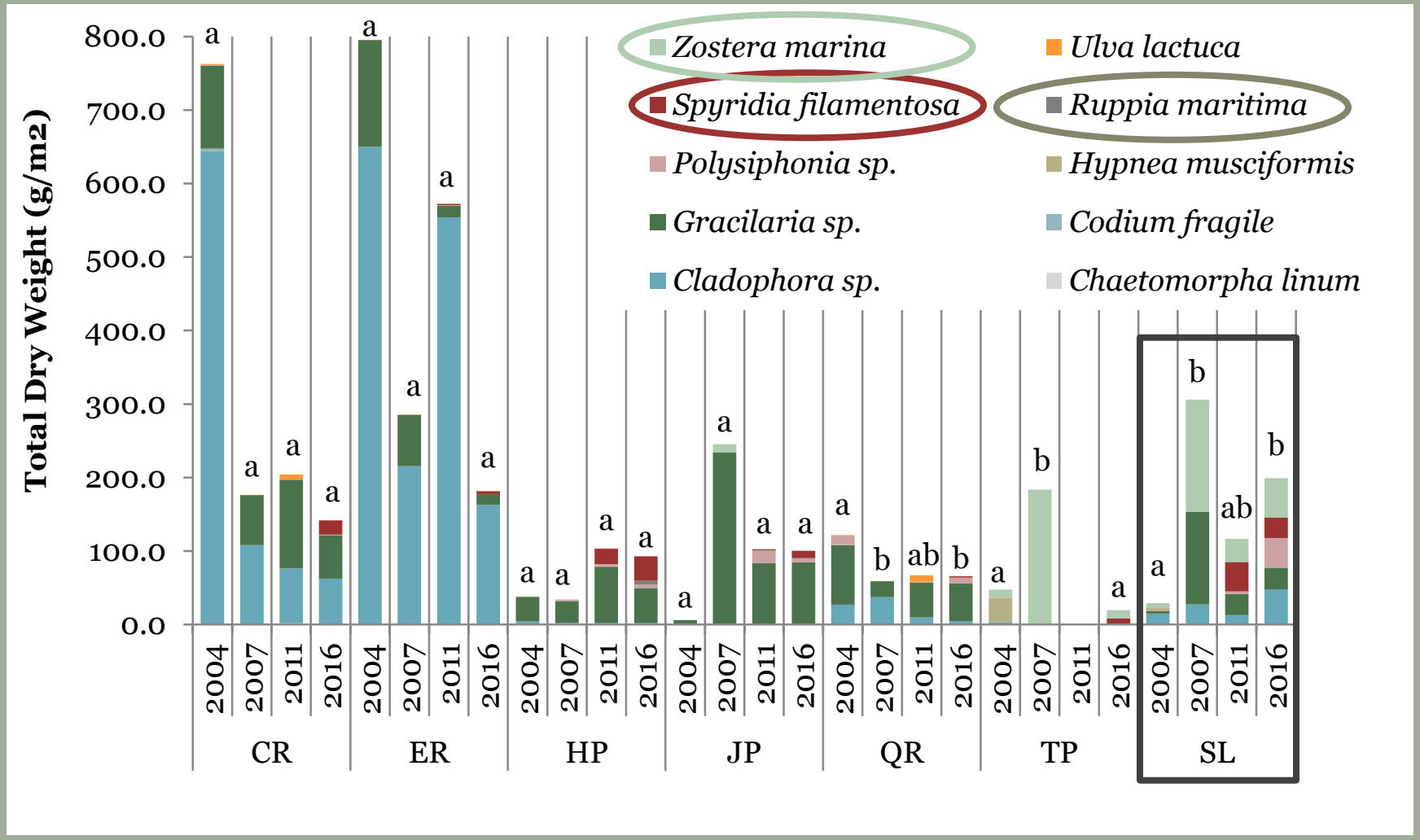


Sage Lot: Summer (June-August)

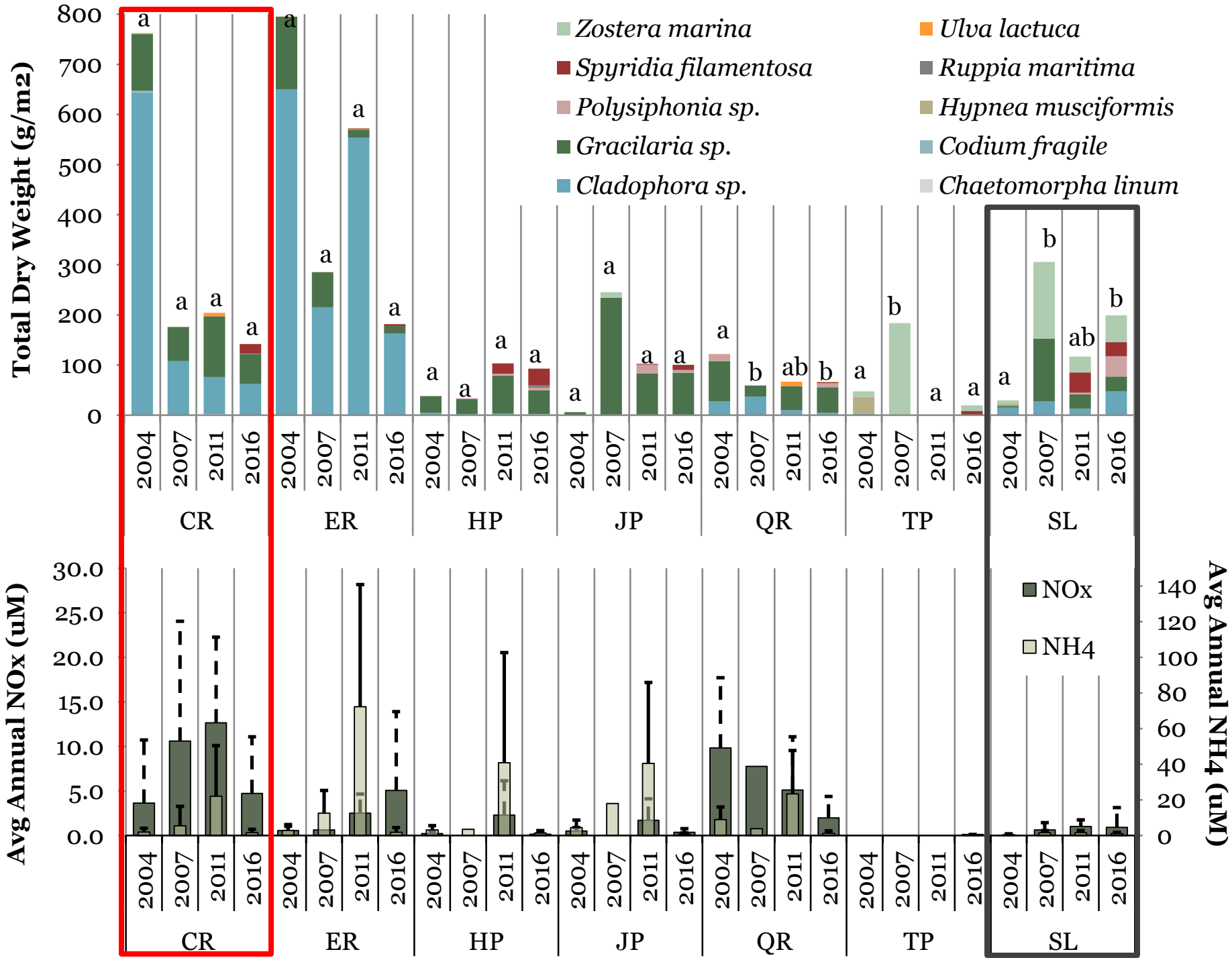




Eelgrass & Macroalgae



$\alpha = 0.09$


Total Dry Weight (g/m2)
Zostera marina
Ulva lactuca
Spyridia filamentosa
Ruppia maritima
Polysiphonia sp.
Hypnea musciformis
Gracilaria sp.
Codium fragile
Cladophora sp.
Chaetomorpha linum
CR
ER
HP
JP
QR
TP
SL
2004
2007
2011
2016
Avg Annual NOx (uM)
Avg Annual NH4 (uM)
NOx
NH4

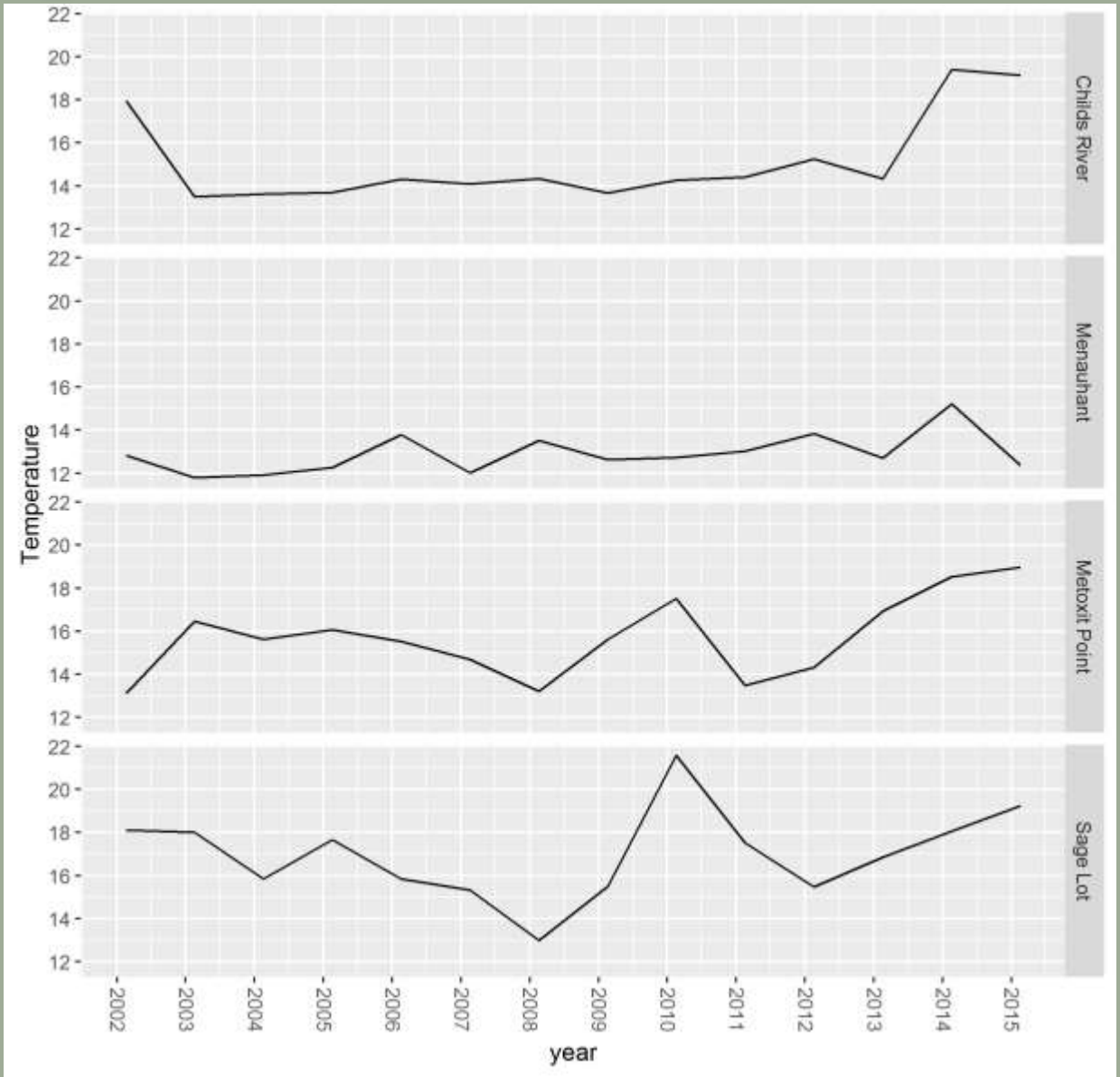
Who's Driving?

Why are 2010-2013 N levels elevated?

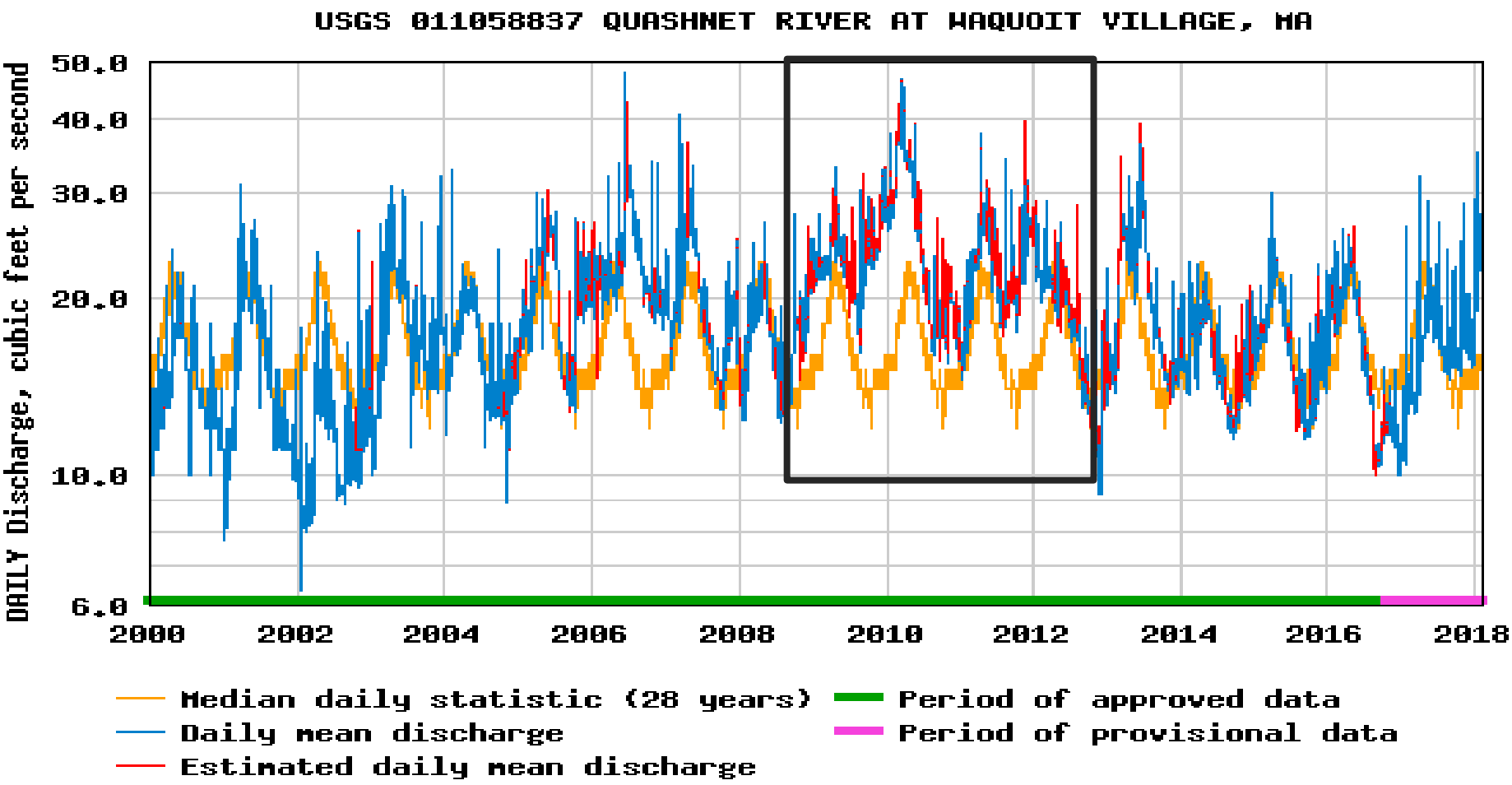
- IS IT REAL?
  - Regional trend supported by other databases:
    - Waquoit BayWatchers (more subdued 2010 event due to difference in sampling time; incoming vs. outgoing tide)
    - Buzzards Bay Coalition BayWatcher's online data
- Speculate climate drivers for regional impact
  - Temperature
  - Precipitation & Discharge
  - Storms

Temperature

Results from 15-minute SWMP sonde data

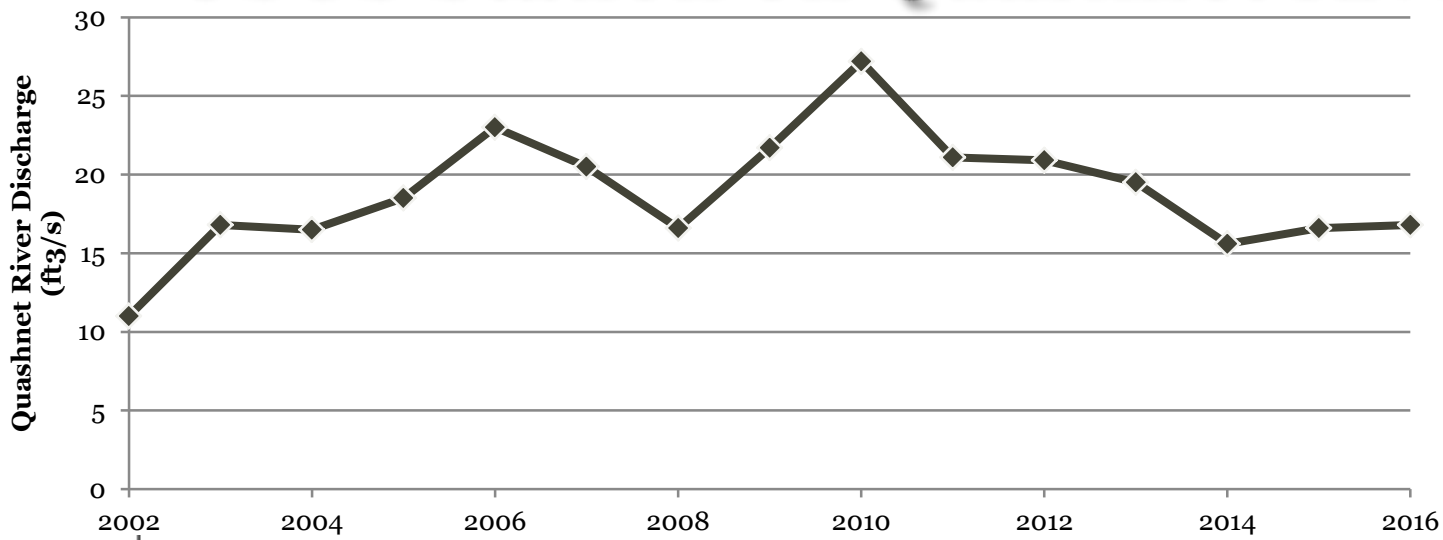


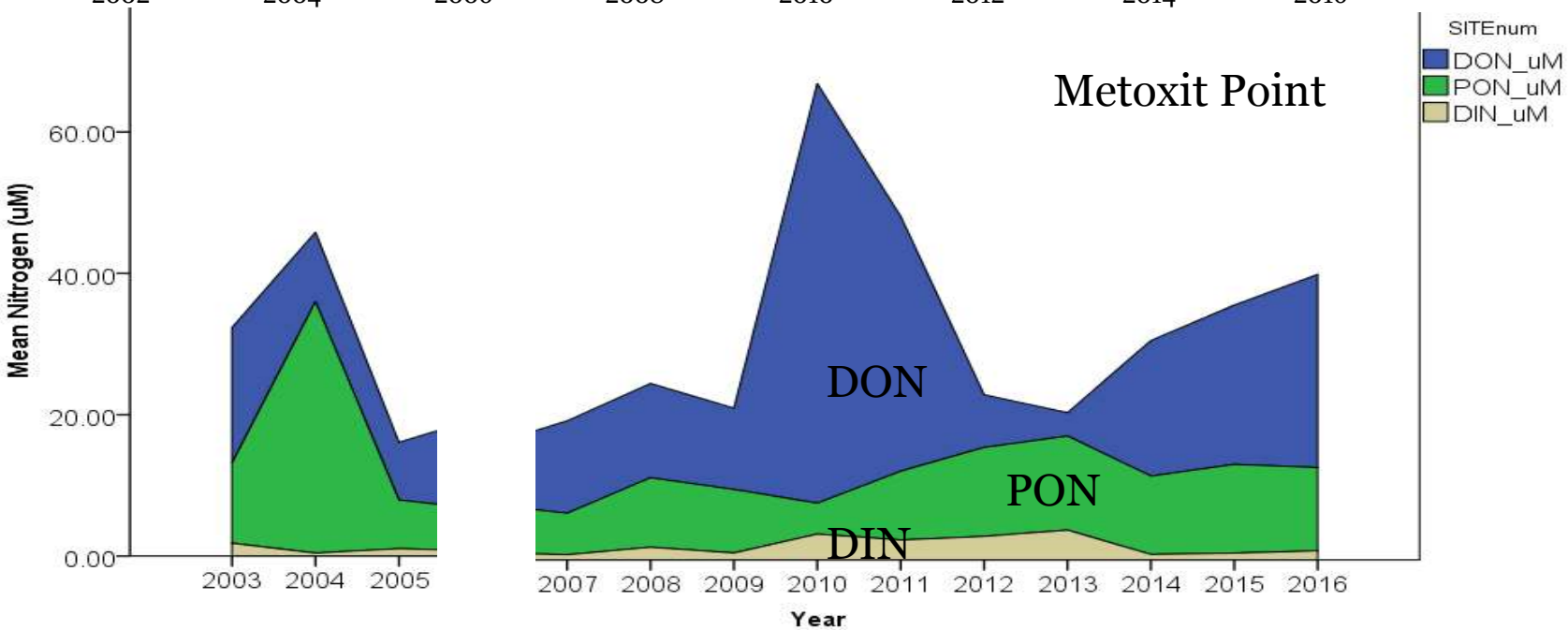
Discharge – USGS Water Gauge



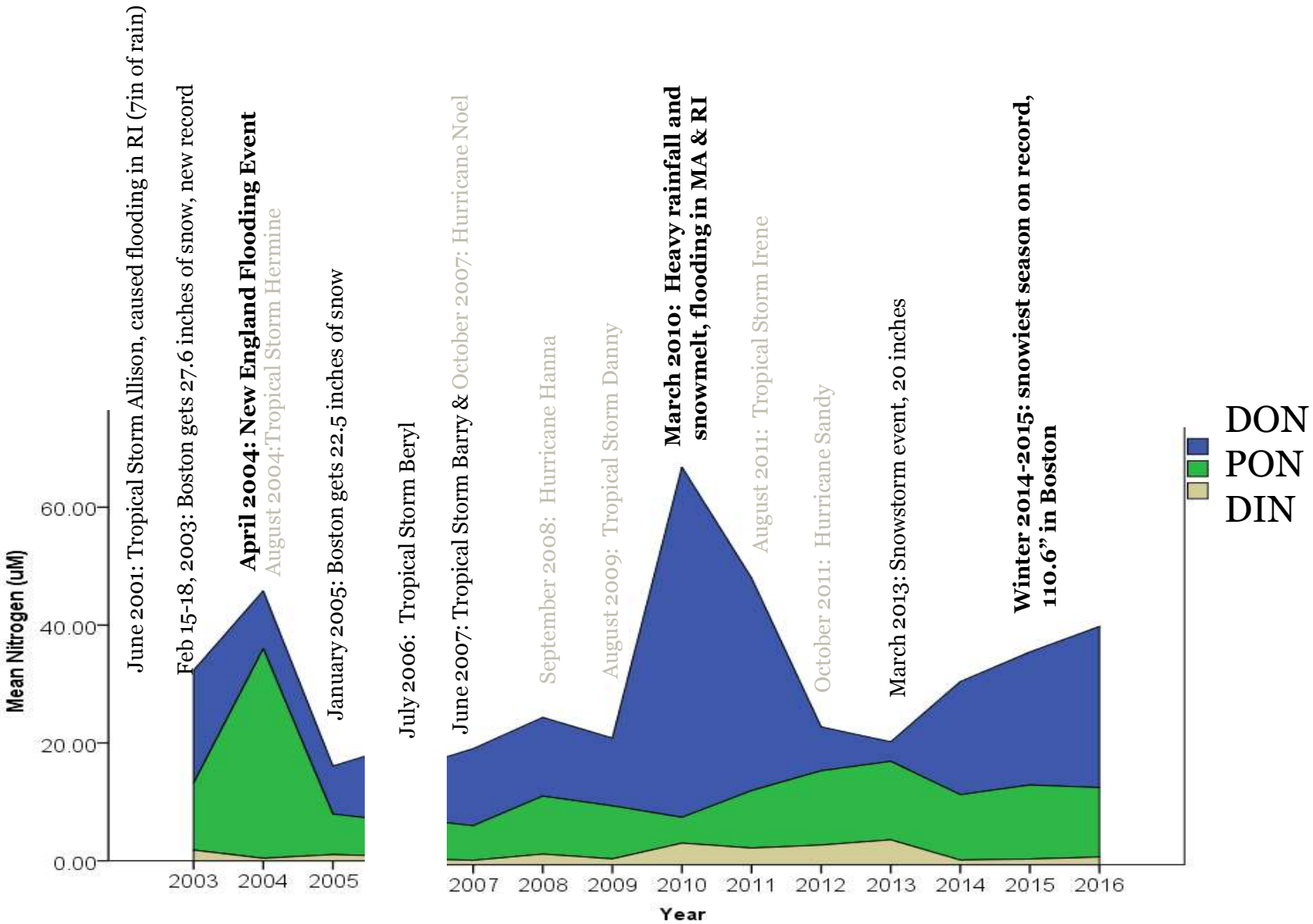
Discharge

USGS Station on Quashnet River

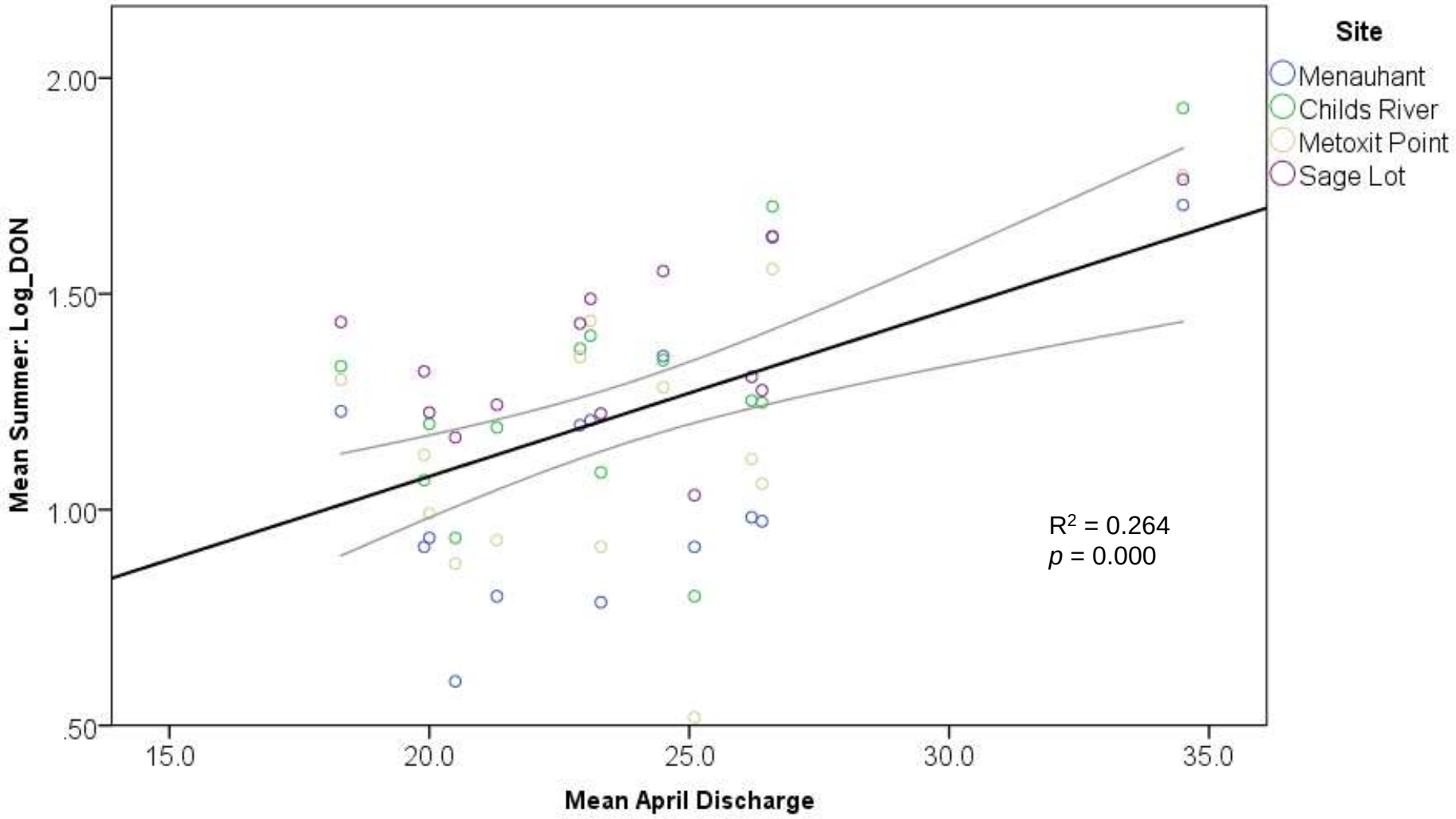




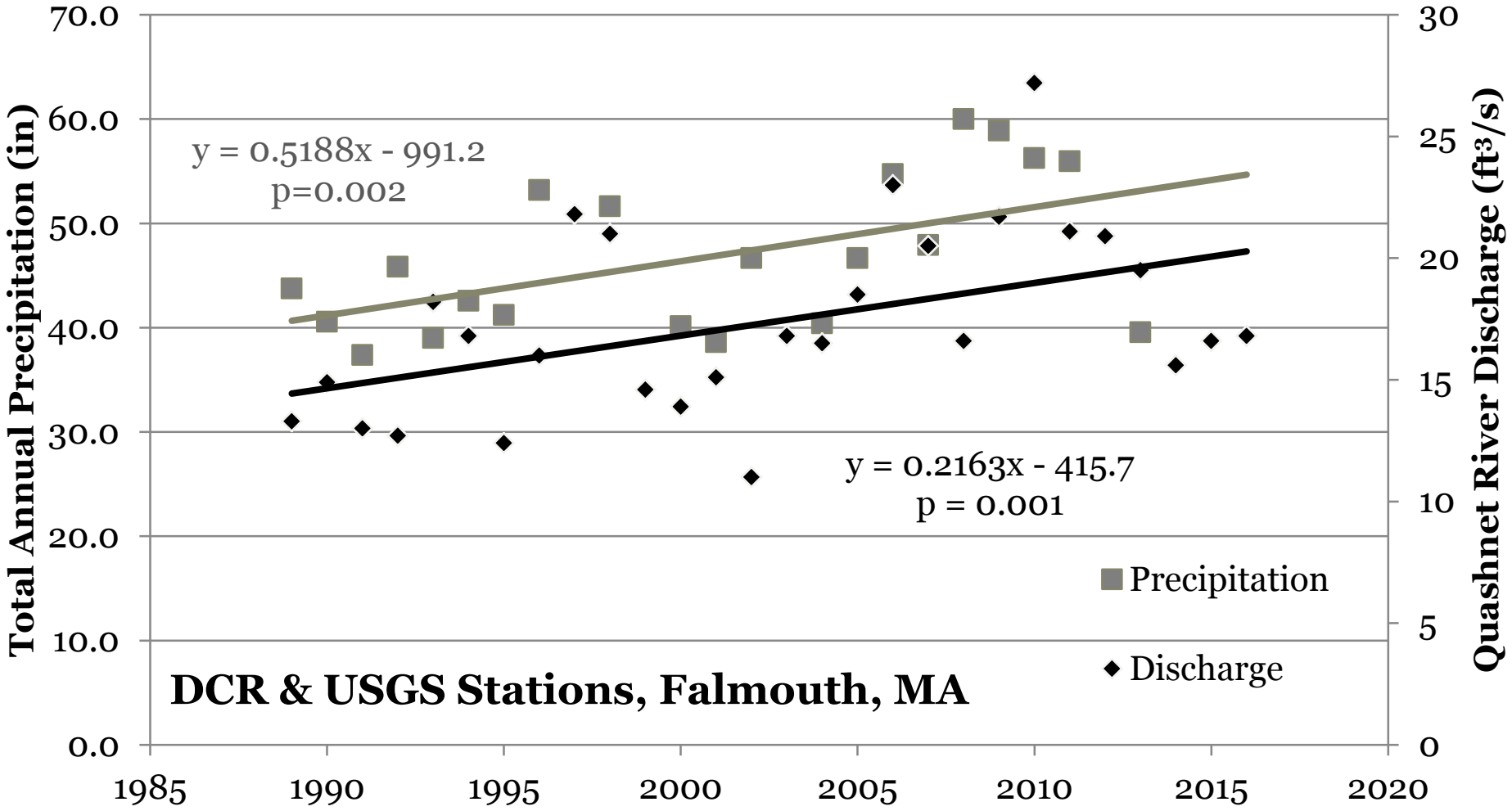
Storms


June 2001: Tropical Storm Allison, caused flooding in RI (7in of rain)
Feb 15-18, 2003: Boston gets 27.6 inches of snow, new record
April 2004: New England Flooding Event
August 2004:Tropical Storm Hermine
January 2005: Boston gets 22.5 inches of snow
July 2006: Tropical Storm Beryl
June 2007: Tropical Storm Barry & October 2007: Hurricane Noel
September 2008: Hurricane Hanna
August 2009: Tropical Storm Danny
March 2010: Heavy rainfall and snowmelt, flooding in MA & RI
August 2011: Tropical Storm Irene
October 2011: Hurricane Sandy
March 2013: Snowstorm event, 20 inches
Winter 2014-2015: snowiest season on record, 110.6" in Boston
Mean Nitrogen (uM)
0.00
20.00
40.00
60.00
2003
2004
2005
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
Year
DON
PON
DIN

When is discharge most influential?



Climate Change Impacts



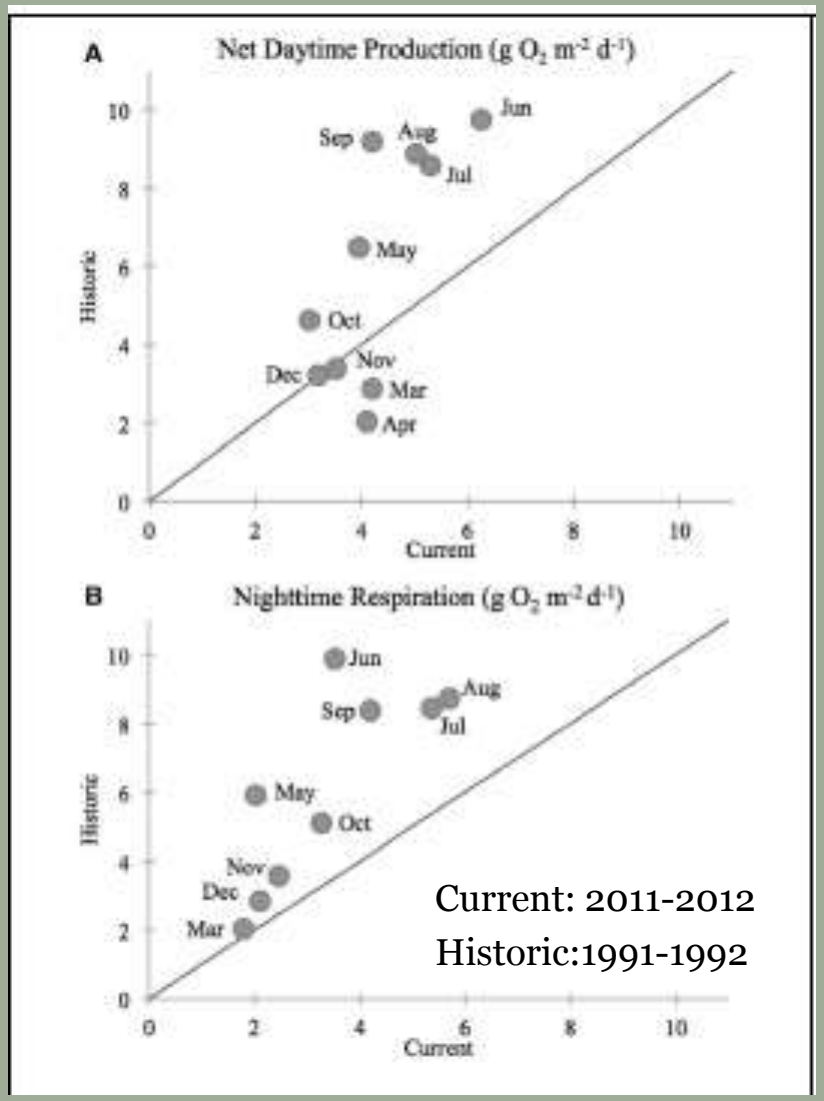
Why is macroalgae biomass decreasing at Childs River?

- IS IT REAL?
  - Corroborating trends documented:
    - Foster & Fulweiler (2014) in Childs River, Waquoit Bay
    - Nixon and others (2009) in Narragansett Bay
    - Fulweiler and others (2007) in Narragansett Bay

Foster & Fulweiler crew sampling in Waquoit Bay

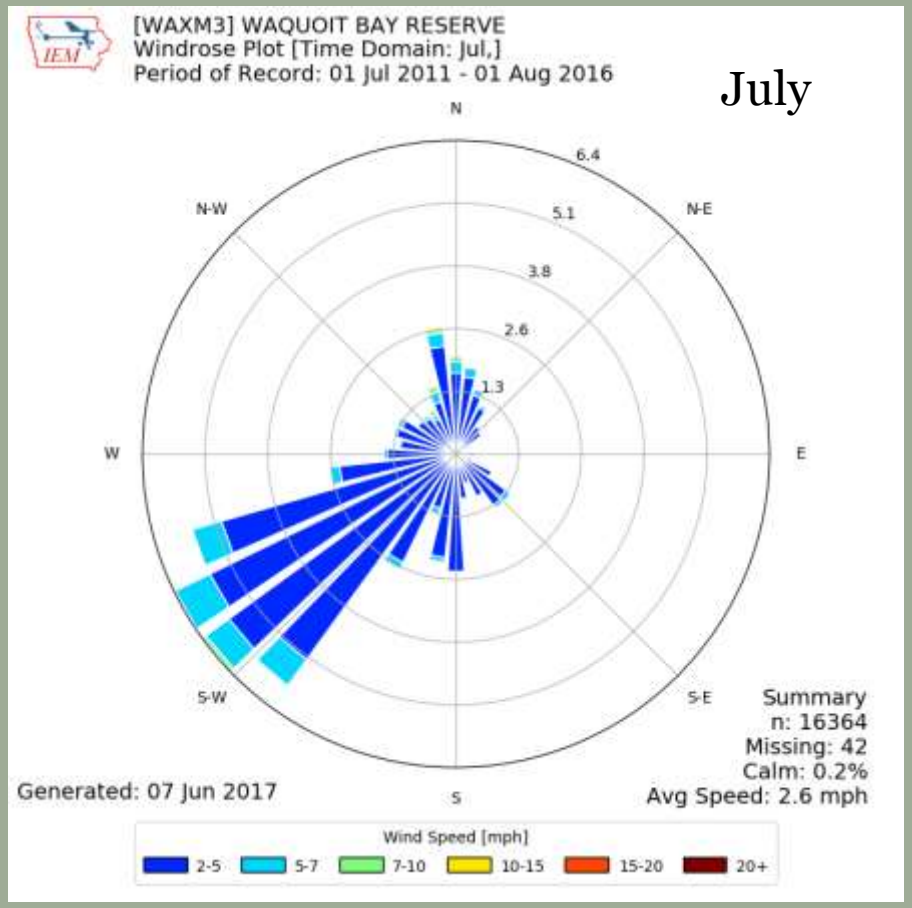
Why is macroalgae biomass decreasing at Childs River?

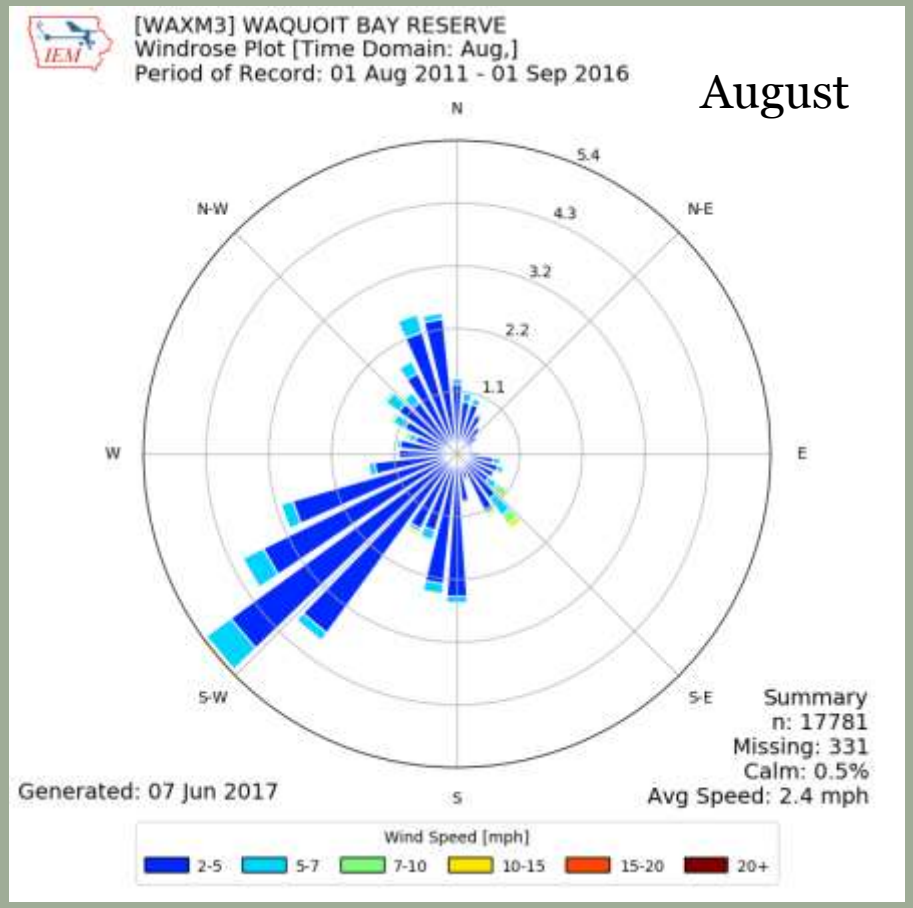
- Foster & Fulweiler (2014)
  - Working theories:
    - Sulfide concentration buildup
    - Environmental factors:
      - increased temperature
      - decreased wind speed
      - changes in timing of phytoplankton blooms



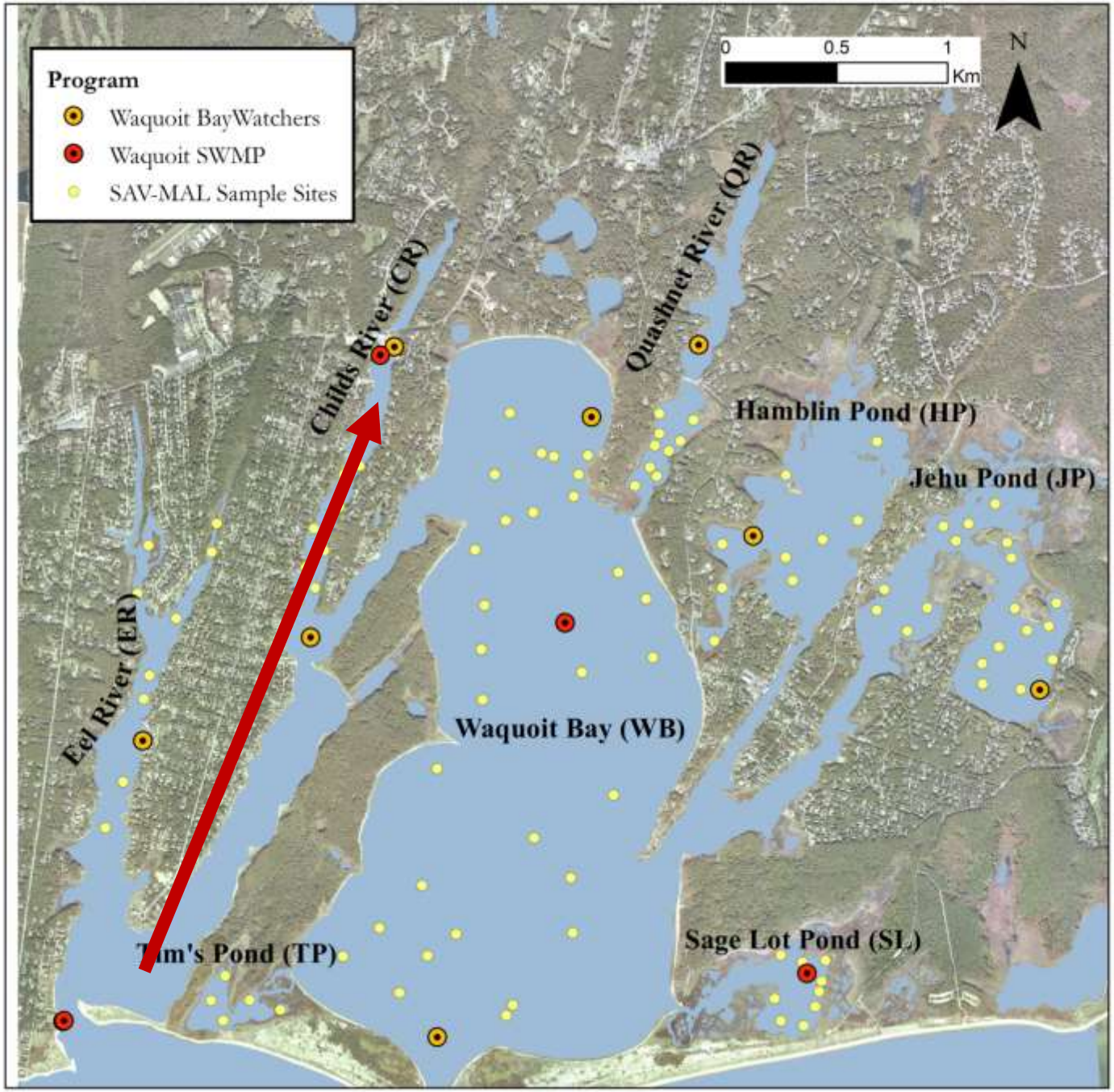
July & August Wind Roses

WBNERR Carriage House Data



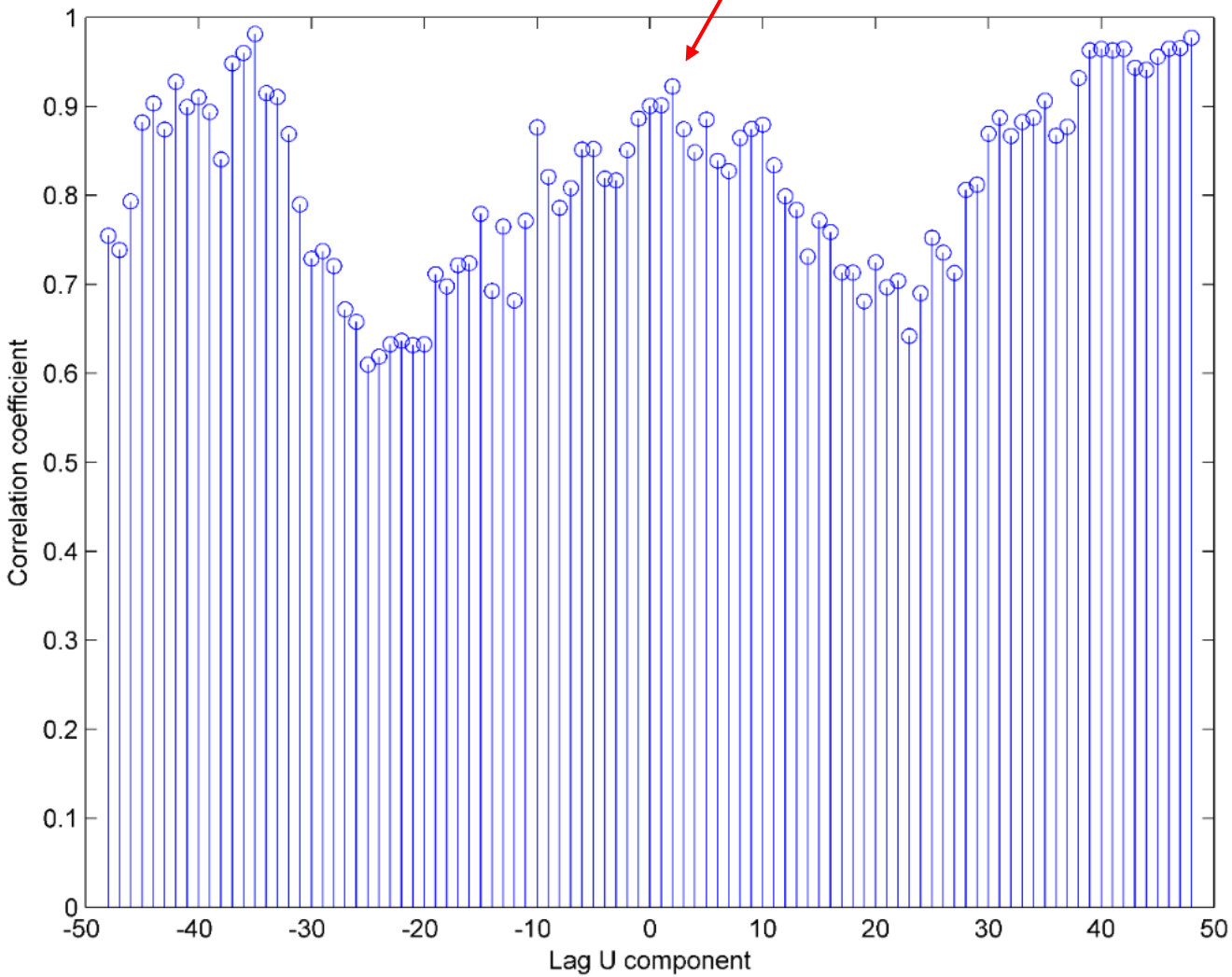


Iowa State Environmental Mesonet:
http://mesonet.agron.iastate.edu/sites/dyn_windrose.phtml?network=WI_ASOS&station=MSN


Program
Waquoit BayWatchers
Waquoit SWMP
SAV-MAL Sample Sites
0
0.5
1
Km
N
Childs River (CR)
Quashnet River (QR)
Hamblin Pond (HP)
Jehu Pond (JP)
Eel River (ER)
Waquoit Bay (WB)
Tim's Pond (TP)
Sage Lot Pond (SL)

Impact of wind on DO at Childs River

2 hr lag, correlation coefficient = 0.92



West Wind

Grothues, T., 2018, JCNERR

Wind's Role in our Estuary

- Foster & Fulweiler (2014) found a significant drop in summer wind speeds (May-October; p=0.016) based on WBNERR Carriage House data.

- Since we know that wind increases DO in Childs River, reduced wind speeds would result in more prolonged hypoxic conditions.

- Prolonged hypoxia may result in benthic microbes shifting to anaerobic respiration (increasing sulfide concentrations), decreased macrofauna activity, and reduced benthic nitrogen fluxes (i.e., denitrification).

- Combined, eutrophication and climate change impacts are likely causing decreased productivity in Childs River.

What's the take home?

- **Heavy spring rain and discharge events appear to play a significant role** in nutrient dynamics in the estuary**,** and **with increased precipitation from climate change, we may see more frequent spikes in summertime total nitrogen.**

  Note: Although residential development has continued to grow over the last two decades, the heightened nitrogen load from the increased residential development may be balanced by decreased atmospheric nitrogen from improved air quality policy (Valiela et al. 2016).

- The **decline of macroalgae in Childs River may be a reflection of prolonged eutrophication exacerbated by climate change impacts** (i.e., reduced summer wind speeds, increased precipitation, and increased temperature). This part of our estuary is essentially becoming **a dead zone**.

- Changes to nutrient levels through improved **coastal management must take climate change factors into account.**

Relevant or Cited Literature

- Benson, J. L., Schlezinger, D., & Howes, B. L. 2013. Relationship between nitrogen concentration, light, and *Zostera marina* habitat quality and survival in southeastern Massachusetts estuaries. *Journal of Environmental Management*, *131*, 129–137.

- Burkholder, J., Glasgow, H., & Cooke, J. 1994. Comparative Effects of Water-Column Nitrate Enrichment on Eelgrass Z*ostera-Marina*, Shoalgrass *Halodule-Wrightii*, and Widgeongrass *Ruppia-Maritima*. *Marine Ecology Progress Series*, 105(1-2), 121–138.

- Foster, S.Q., and R.W. Fulweiler. 2014. Spatial and historic variability of benthic nitrogen cycling in an anthropogenically impacted estuary. *Frontiers in Marine Science*, 11(56): 1-16.

- Fox, S.E., M. Teichberg, I. Valiela, L. Heffner. 2012. The relative role of nutrients, grazing, and predation as controls on macroalgal growth in the Waquoit Bay estuarine system. *Estuaries and Coasts,* 35: 1193-1204.

- Fulweiler, R.W., S.W. Nixon, B.A. Buckley, and S.L. Granger. 2008. Net sediment N2 fluxes in a coastal marine system-experimental manipulations and a conceptual model. *Ecosystems* 11: 1168-1180.

- Johnson, M. R., Williams, S. L., Lieberman, C. H., & Solbak, A. 2003. Changes in the Abundance of the Seagrasses *Zostera marina* L. (Eelgrass) and *Ruppia maritima* L. (Widgeongrass) in San Diego, California, Following an El Niño Event. *Estuaries*, 26(1), 106–115.

- Marsh, J.A., W.C. Dennison, and R.S. Alberte. 1986. Effects of temperature on photosynthesis and respiration in eelgrass (*Zostera marina*). *Journal of Experimental Marine Biology and Ecology*, 101(3): 257-267.

- Nixon, S. W., R.W. Fulweiler, B.A. Buckley, S.L. Granger, B.L. Nowicki, and K.M. Henry. 2009. The impact of changing climate on phenology, productivity, and benthic-pelagic coupling in Narragansett Bay. *Estuarine Coastal Shelf Science* 82: 1-18

- Teichberg, M., S.E. Fox, C. Aguila, Y.S. Olsen, and I. Valiela. 2008. Macroalgal responses to experimental nutrient enrichment in shallow coastal waters: growth, internal nutrient pools, and isotopic signatures. *Marine Ecology Progress Series,* 368: 117-126.

- Valiela, I., K. Foreman, M. LaMontagne, D. Hersh, J. Costa, C. D'Avanzo, M. Babione, P. Peckol, B. DeMeo-Anderson, C. Sham, J. Brawley, K. Lajtha. 1992. Couplings of watersheds and coastal waters: Sources and consequences of nutrient enrichment in Waquoit Bay, MA. *Estuaries*, 15(4): 443-457.

- Valiela, I., Owens, C., Elmstrom, E., & Lloret, J. 2016. Eutrophication of Cape Cod estuaries: Effect of decadal changes in global-driven atmospheric and local-scale wastewater nutrient loads. *Marine Pollution Bulletin*, 110(1), 309-315.

Acknowledgements

- Interns & Volunteers
- Rick York, Town of Mashpee
- Ivan Valiela Lab, Marine Biological Laboratory
  - Jeff Metcalf Summer Undergraduate Research Fellowship
  - WHOI Sea Grant
  - EPA SNEP
  - Brown LINK Award Program
- Waquoit Bay Reserve Foundation
- Former and current WBNERR staff

Questions?

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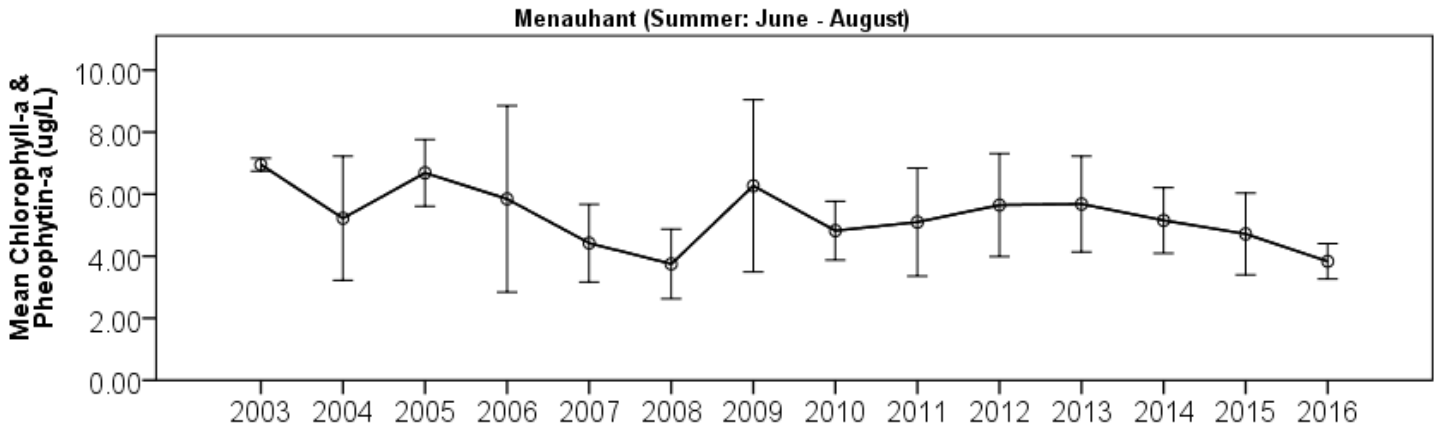
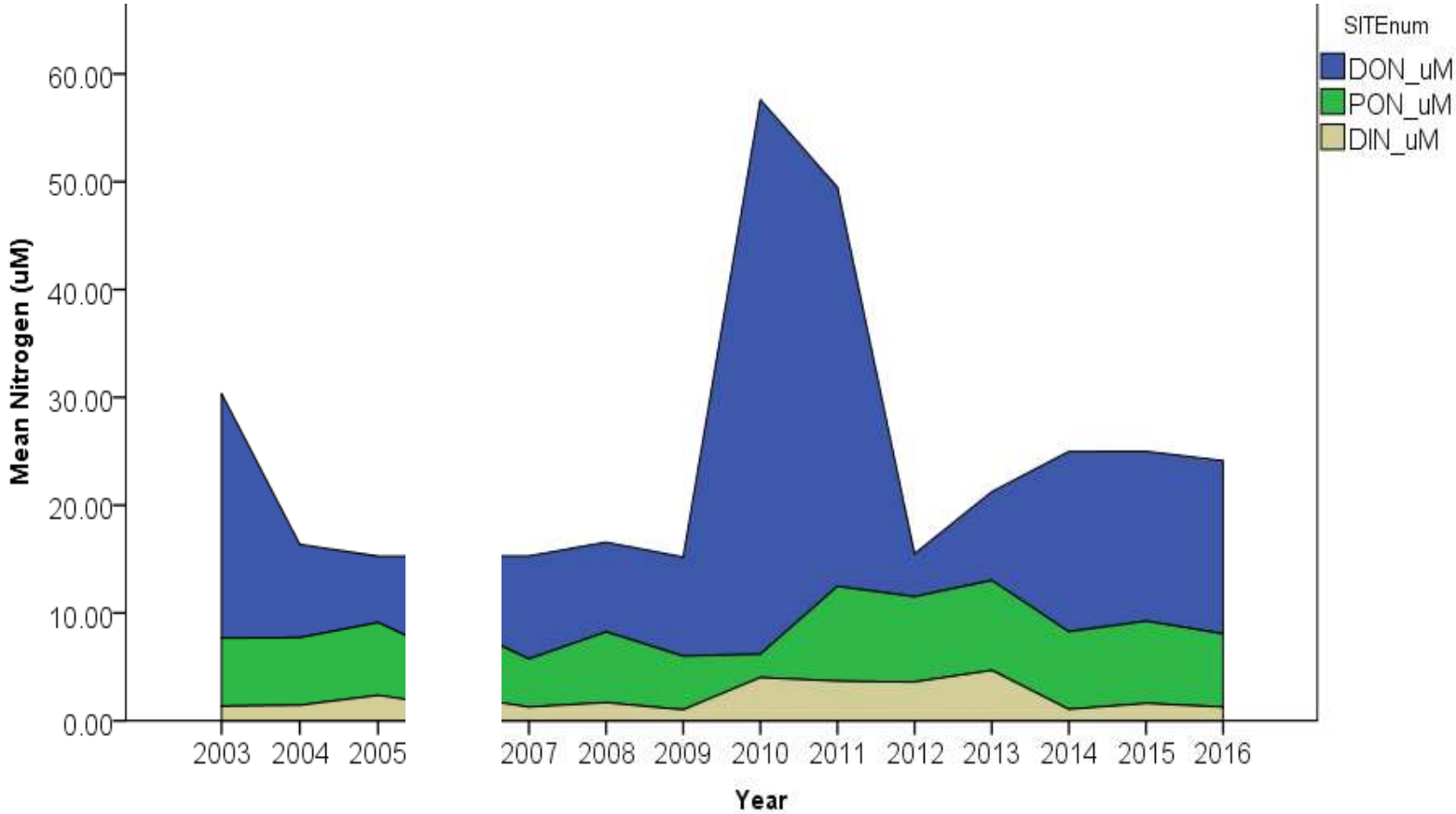
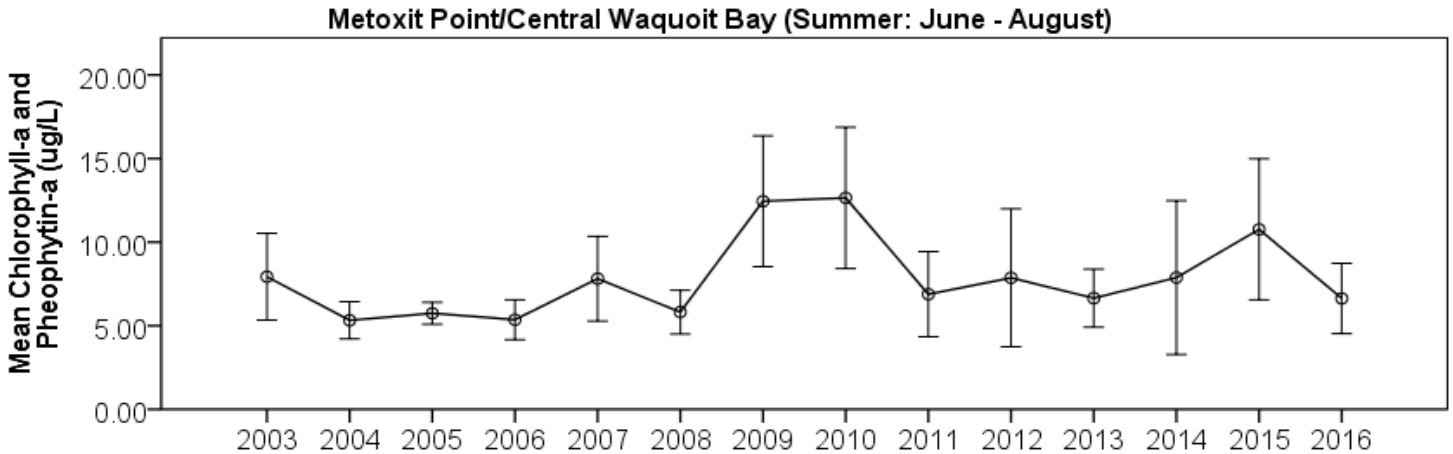
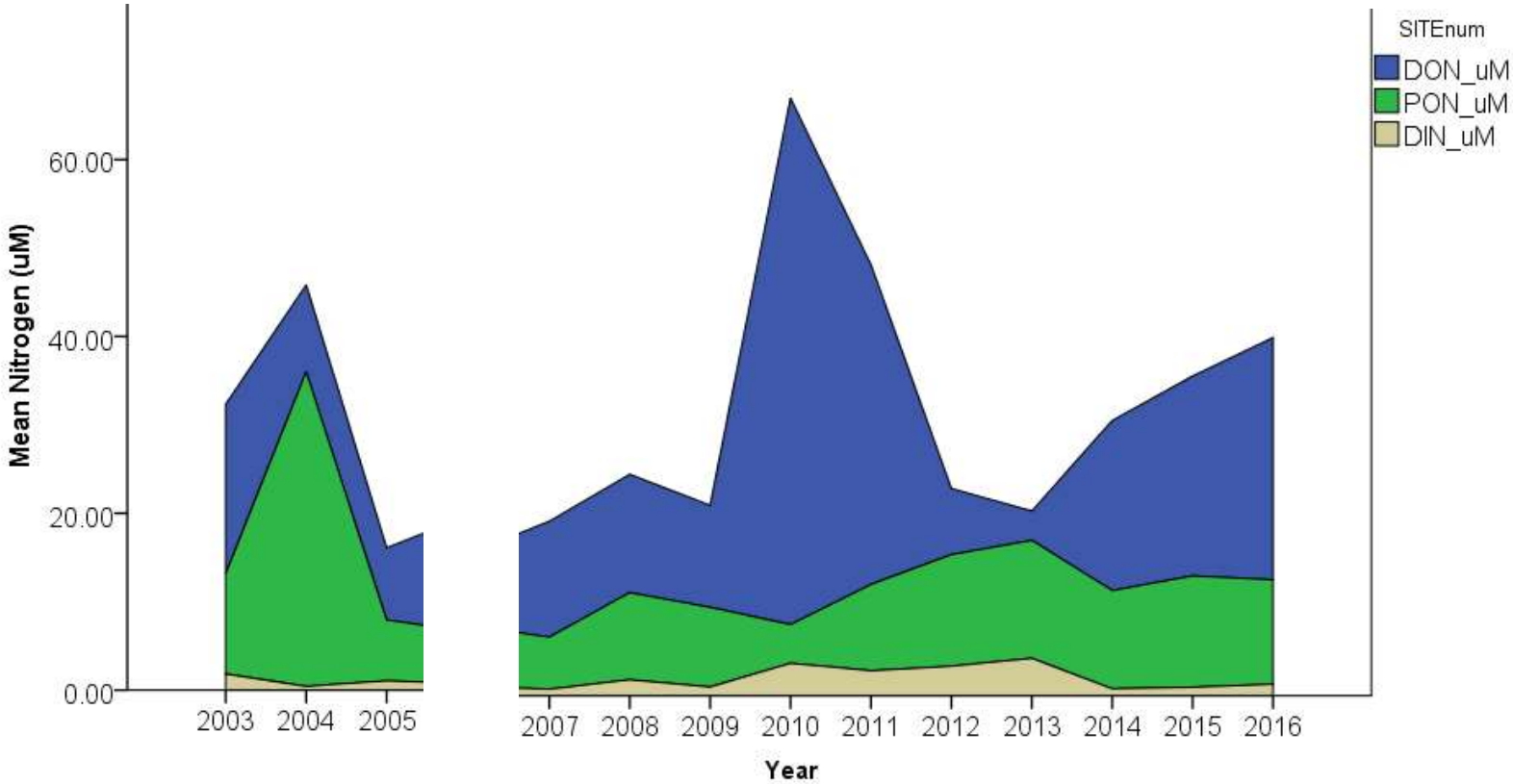
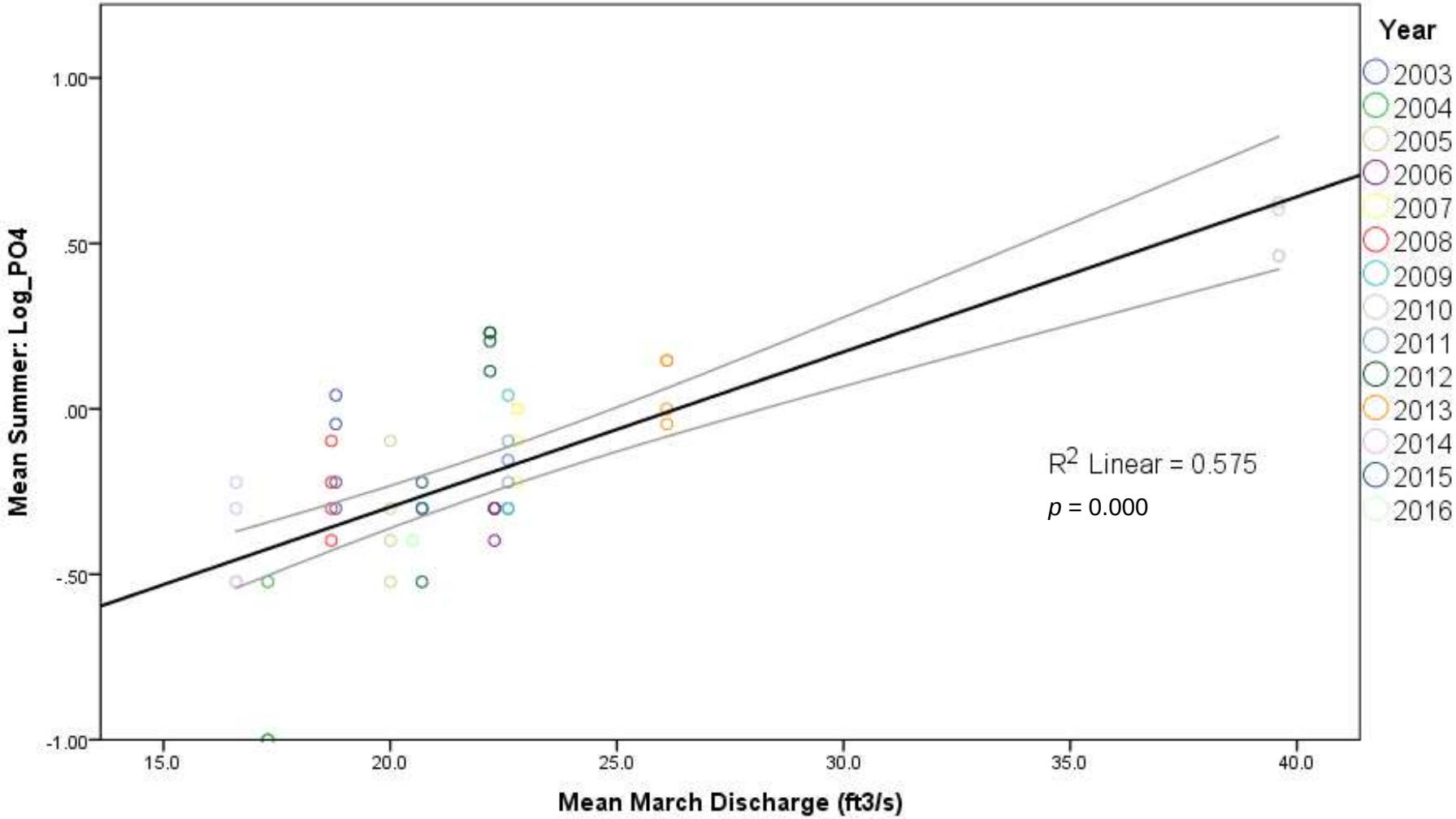

Menauhant (Summer: June - August)
Mean Chlorophyll-a & Pheophytin-a (ug/L)
10.00
8.00
6.00
4.00
2.00
0.00
2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016


SITEnum
DON_uM
PON_uM
DIN_uM
Mean Nitrogen (uM)
60.00
50.00
40.00
30.00
20.00
10.00
0.00
2003 2004 2005
2007 2008 2009 2010 2011 2012 2013 2014 2015 2016
Year

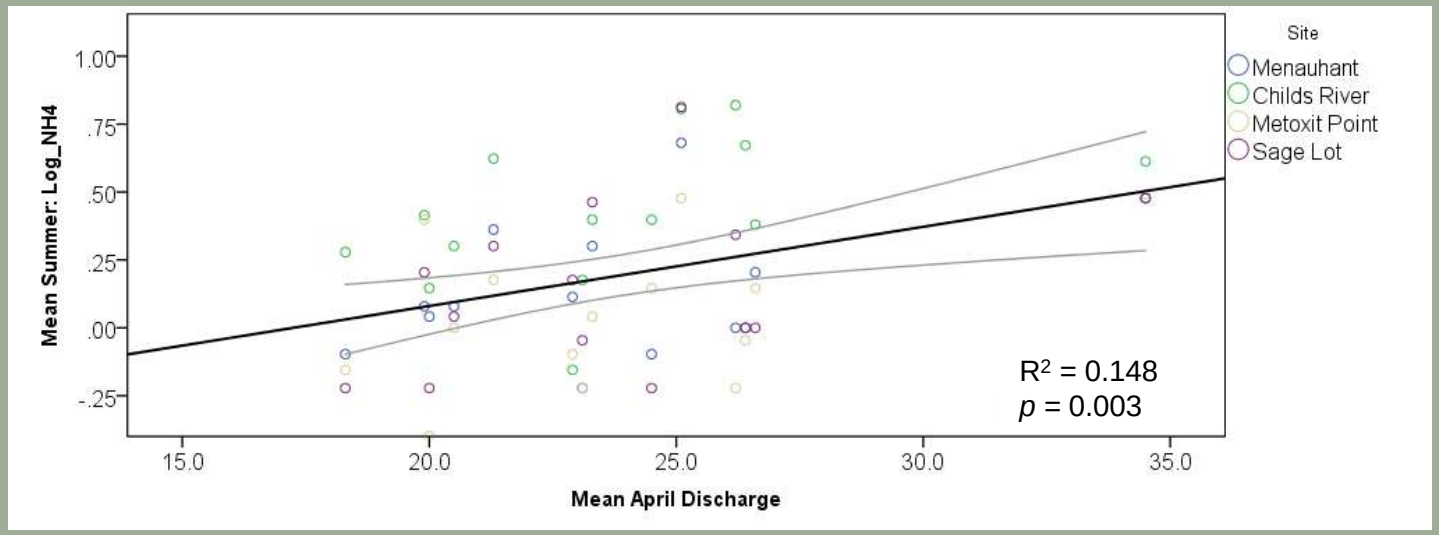

Metoxit Point/Central Waquoit Bay (Summer: June - August)
Mean Chlorophyll-a and Pheophytin-a (ug/L)
20.00
15.00
10.00
5.00
0.00
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016

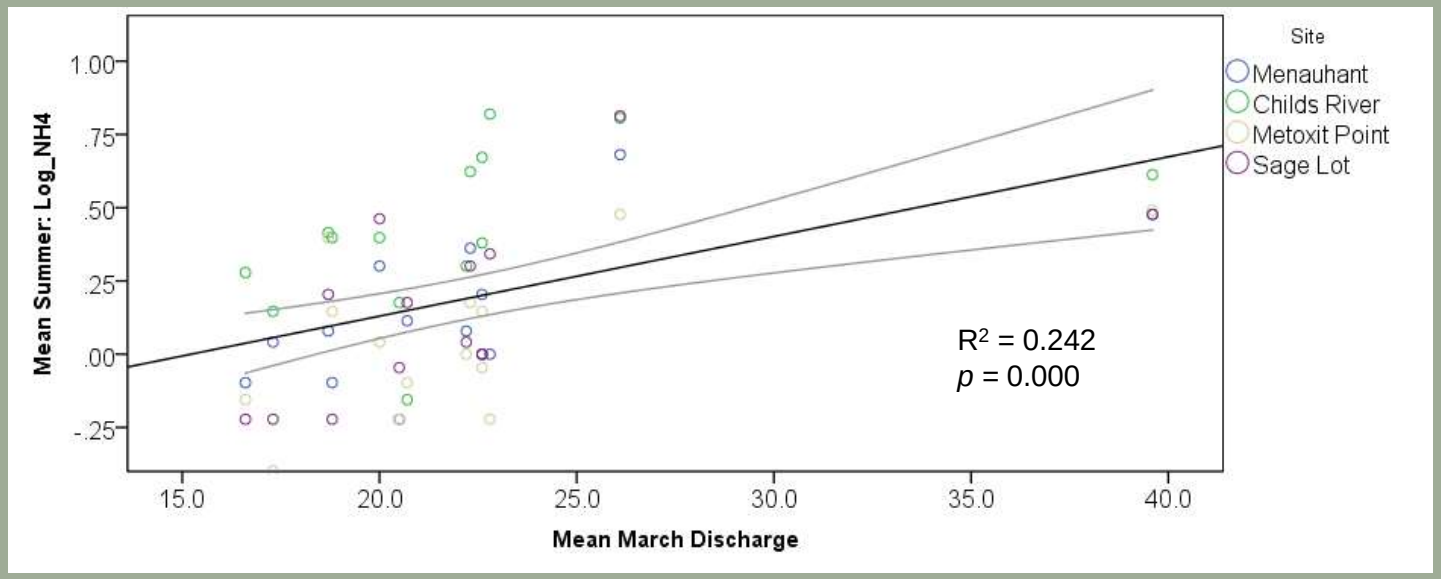

Mean Nitrogen (uM)
60.00
40.00
20.00
0.00
2003
2004
2005
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
Year
SITEnum
DON_uM
PON_uM
DIN_uM

When is discharge most influential?

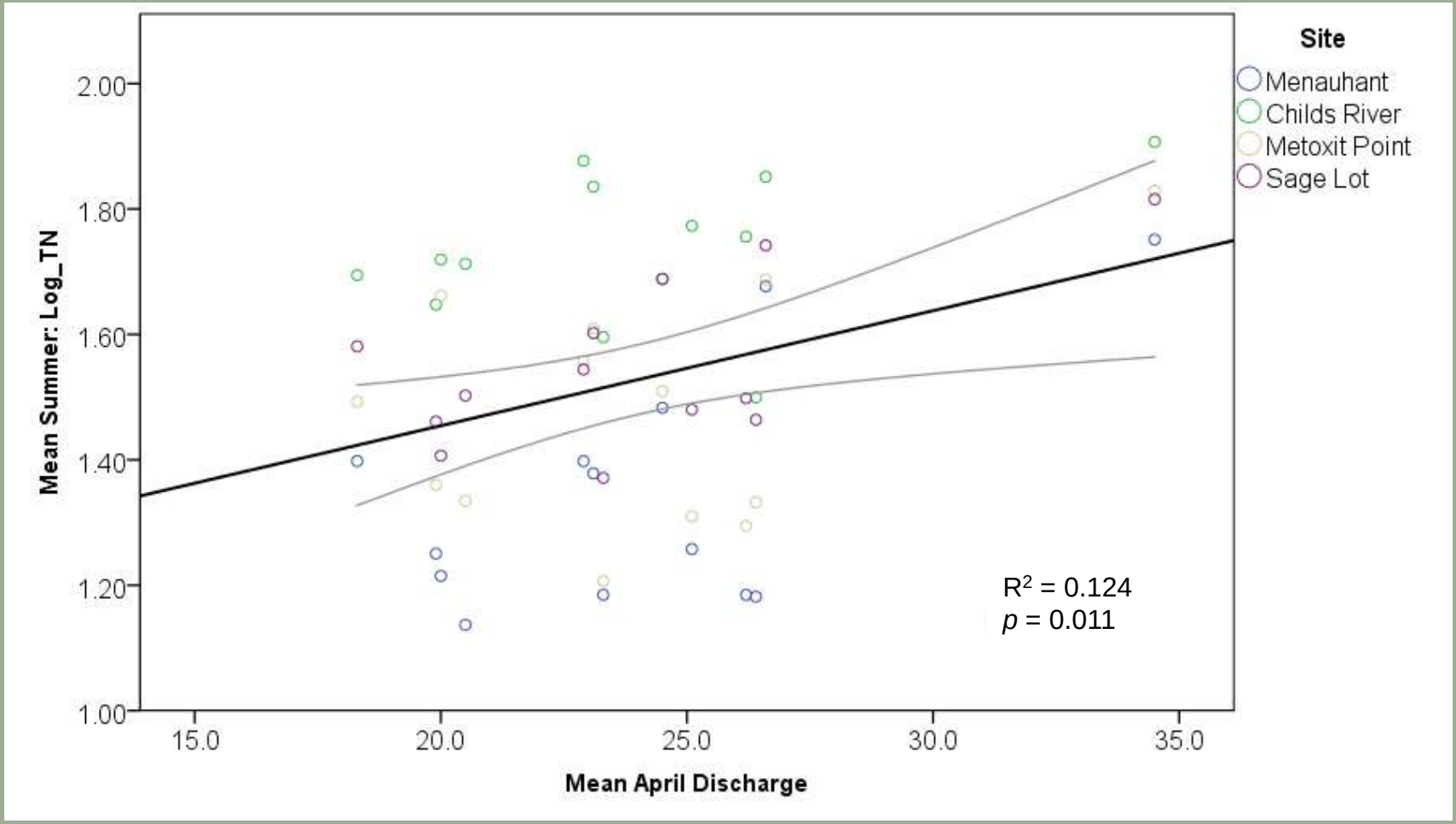


When is discharge most influential?

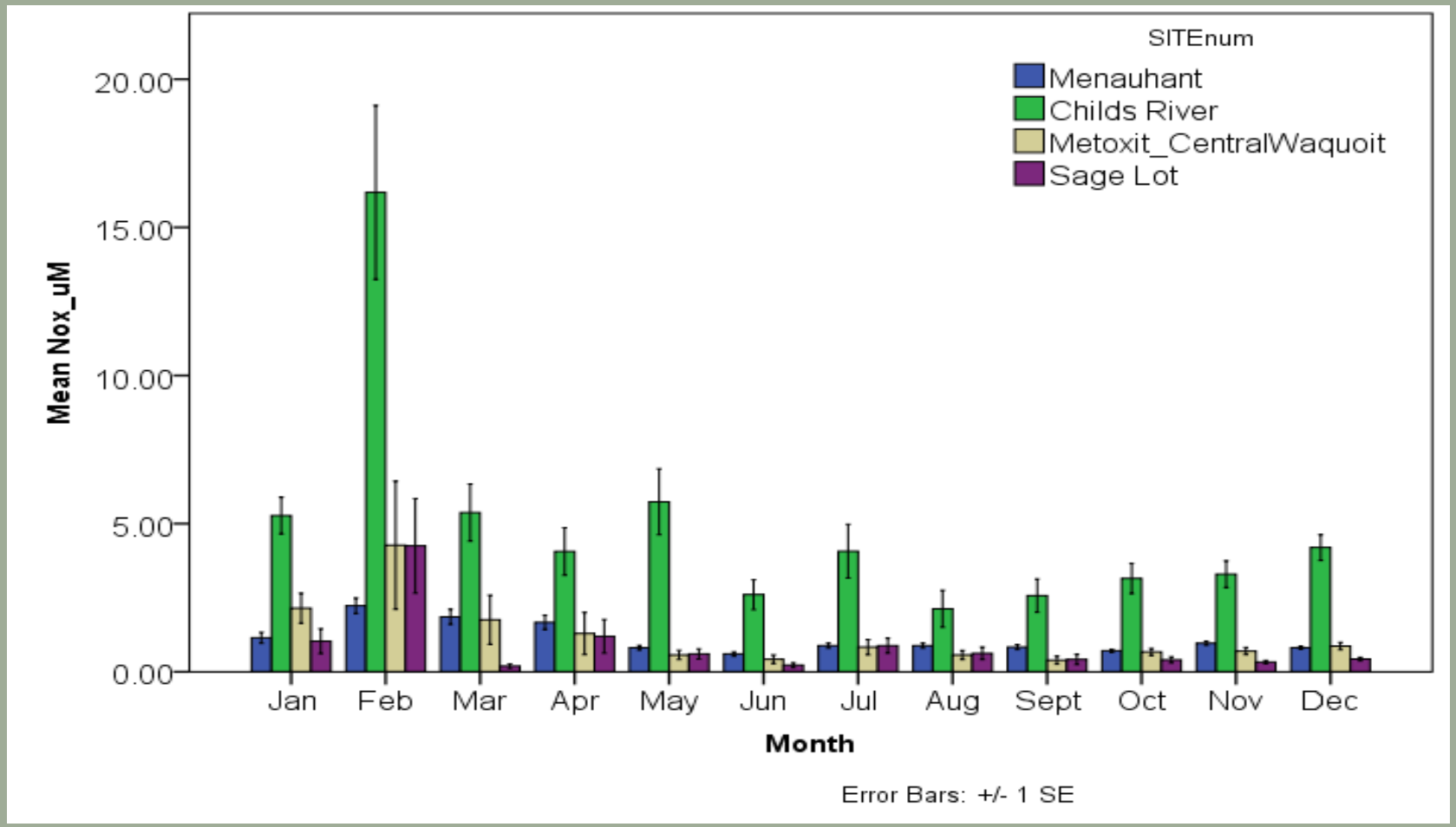




When is discharge most influential?

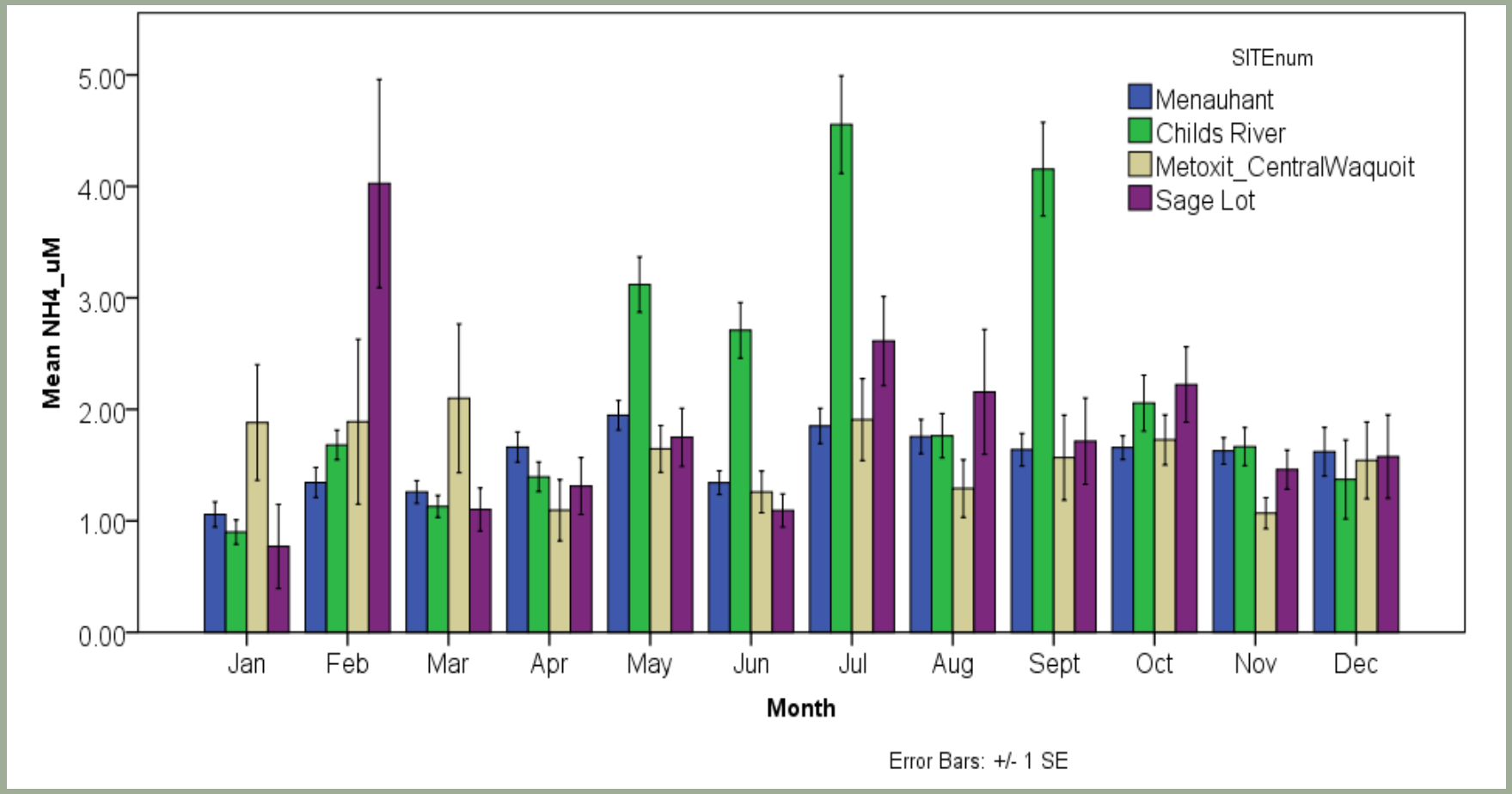


The "Nitrogen Gradient"



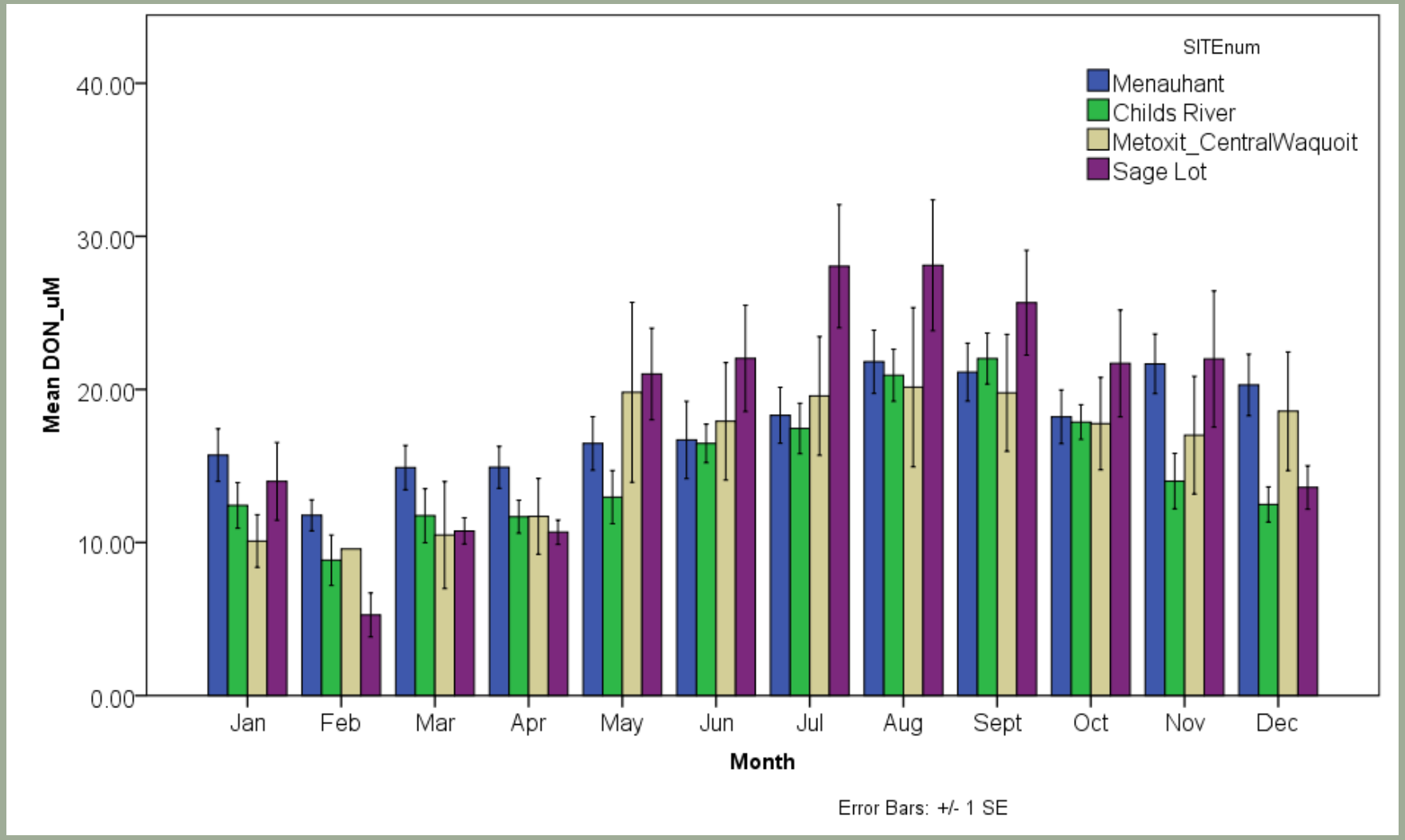
Average of all years (SWMP only)

The "Nitrogen Gradient"



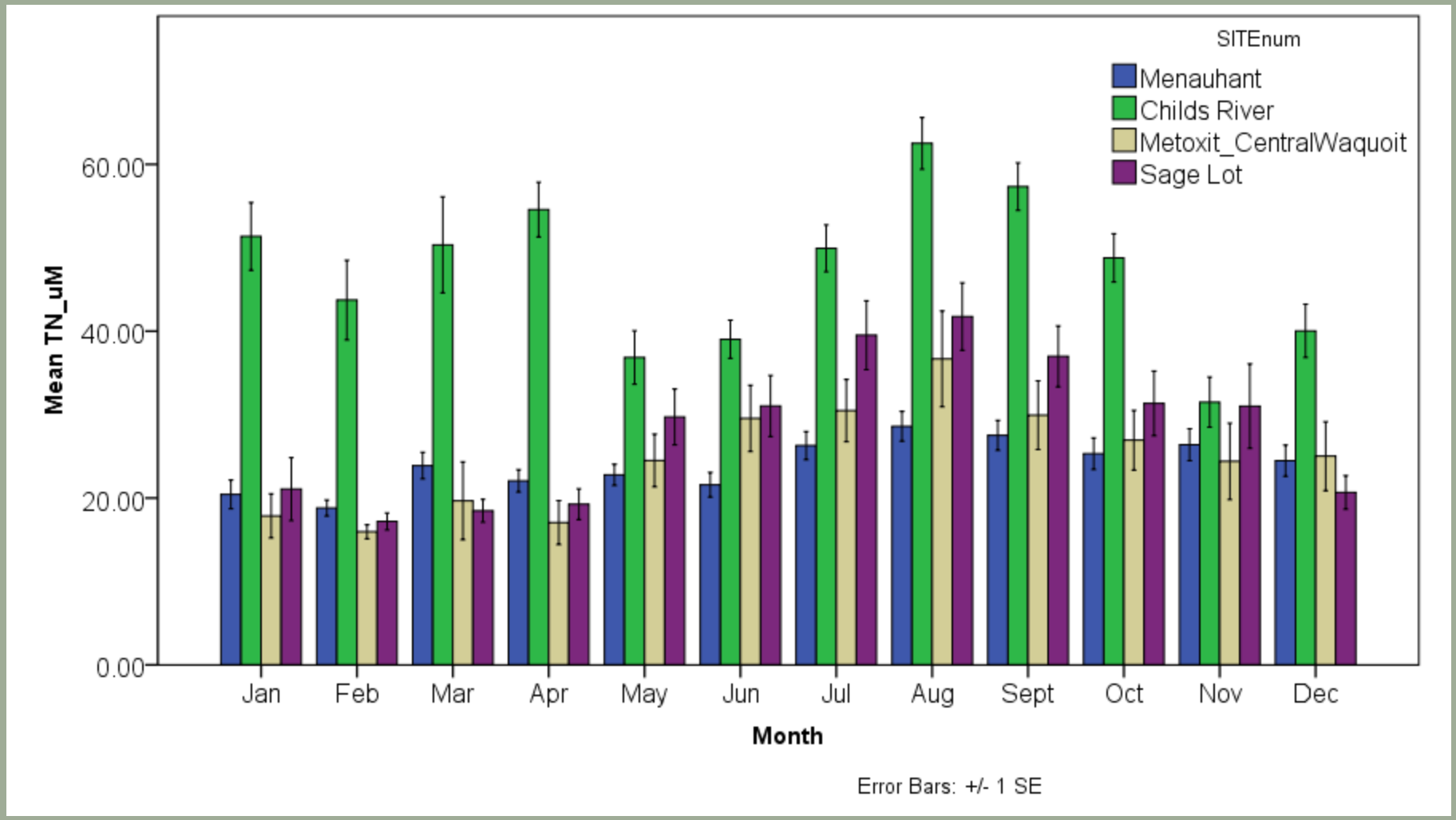
Average of all years (SWMP only)

The "Nitrogen Gradient"



Average of all years (SWMP only)

The "Nitrogen Gradient"



Average of all years (SWMP only)

Seasonal Phosphate Trends