EPA
United States
Environmental Protection
Agency

Increasing productivity amid stable nutrient regimes in Rhode Island Lakes and Reservoirs

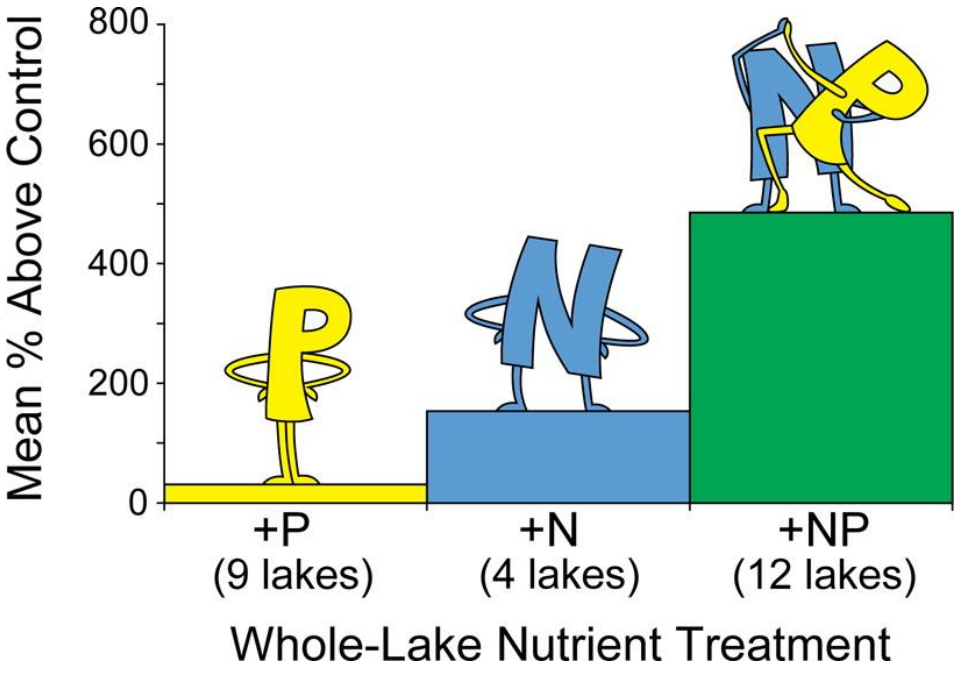
NALMS 2019
Burlington VT

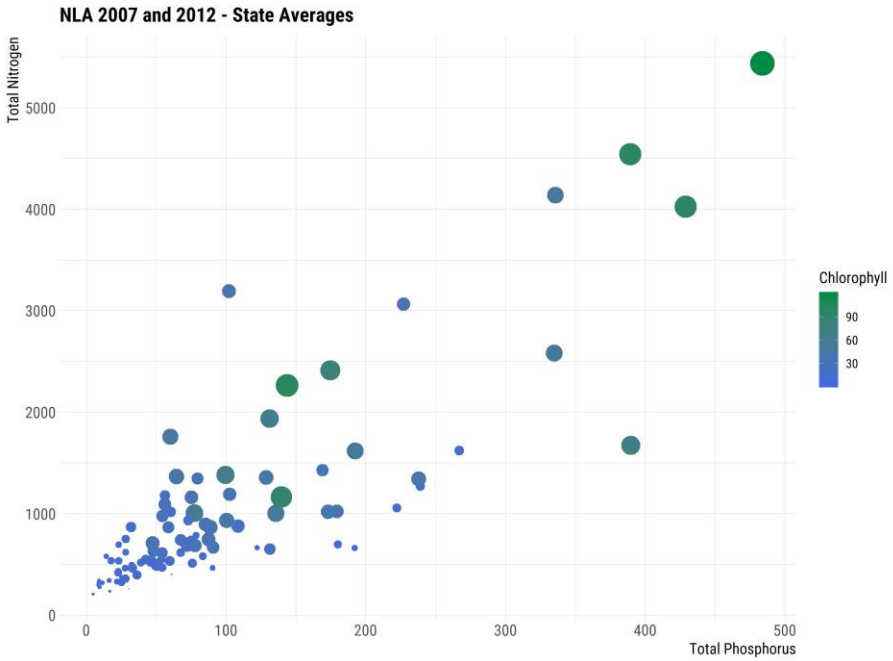
Jeff Hollister, Q Kellogg, Betty Kreakie, Stephen Shivers, Elizabeth Herron, Linda Green, Bryan Milstead, and Art Gold

Background

What drives changes in lake productivity?

- Nutrients
- Temperature

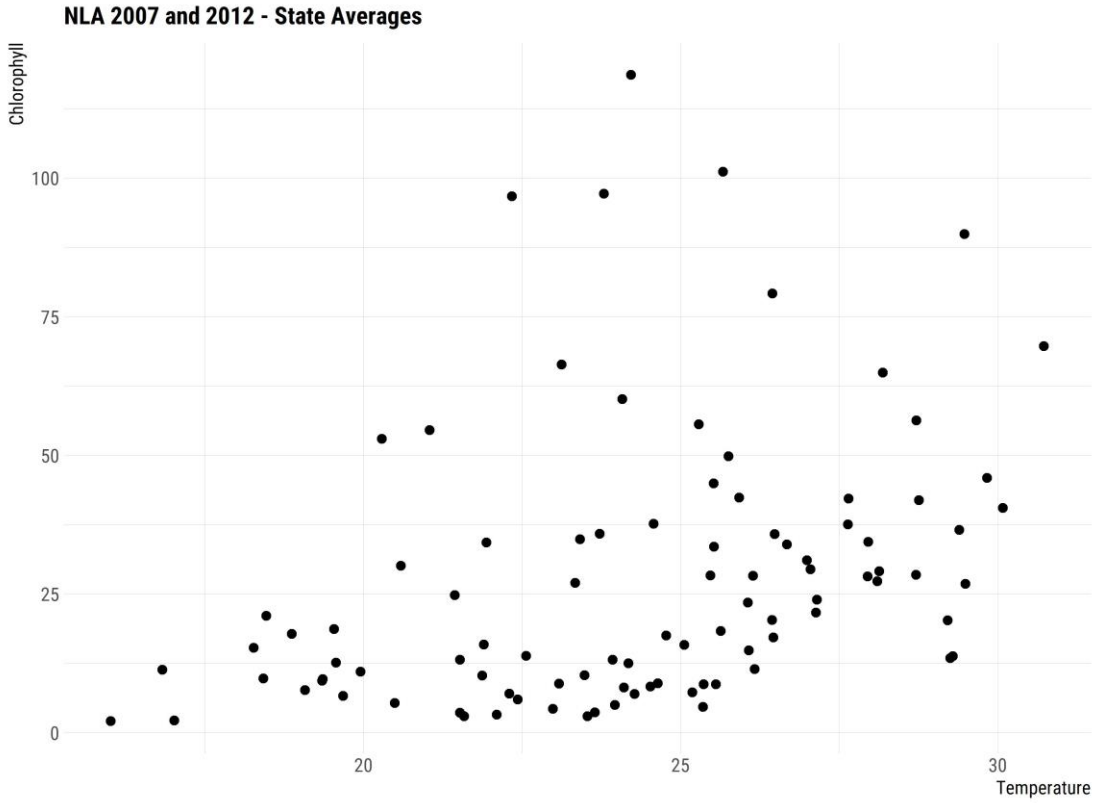




Paerl et al. 2016. It Takes Two to Tango: When and Where Dual Nutrient (N & P) Reductions Are Needed to Protect Lakes and Downstream Ecosystems. Environ. Sci. Tehnol. 50:20. https://doi.org/10.1021/acs.est.6b02575

What drives changes in lake productivity?

- Nutrients
- Temperature



The management problem

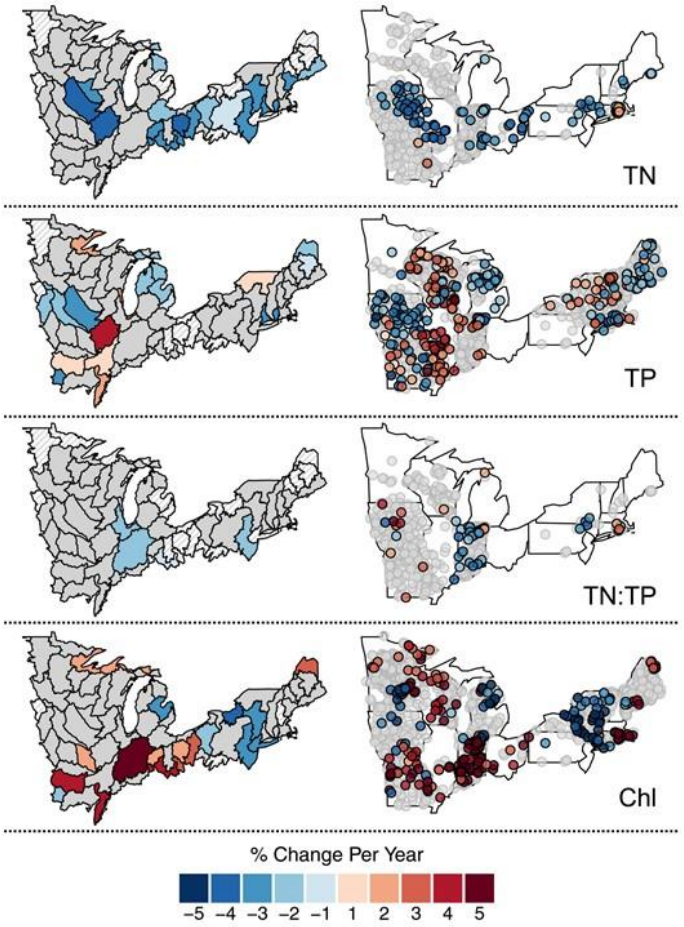
- Desire to reduce and manage nutrient pollution
- Phosphorus Bans
- Nutrient Criteria
- Enacted piecemeal over last ~20 years
- Do the data show any change?

Image credit: http://www.pca.state.mn.us/

Image credit: Elizabeth Herron

Stasis in Northeast

- Oliver et al (2017) Unexpected stasis in a changing world: Lake nutrient and chlorophyll trends since 1990. Global Change Biology. DOI: 10.1111/gcb.13810



But change at other scales

- Mathews et al (2018) Is Vermont losing its oligotrophic lakes?. LakeLine. 38-2.
- Rhode Island?

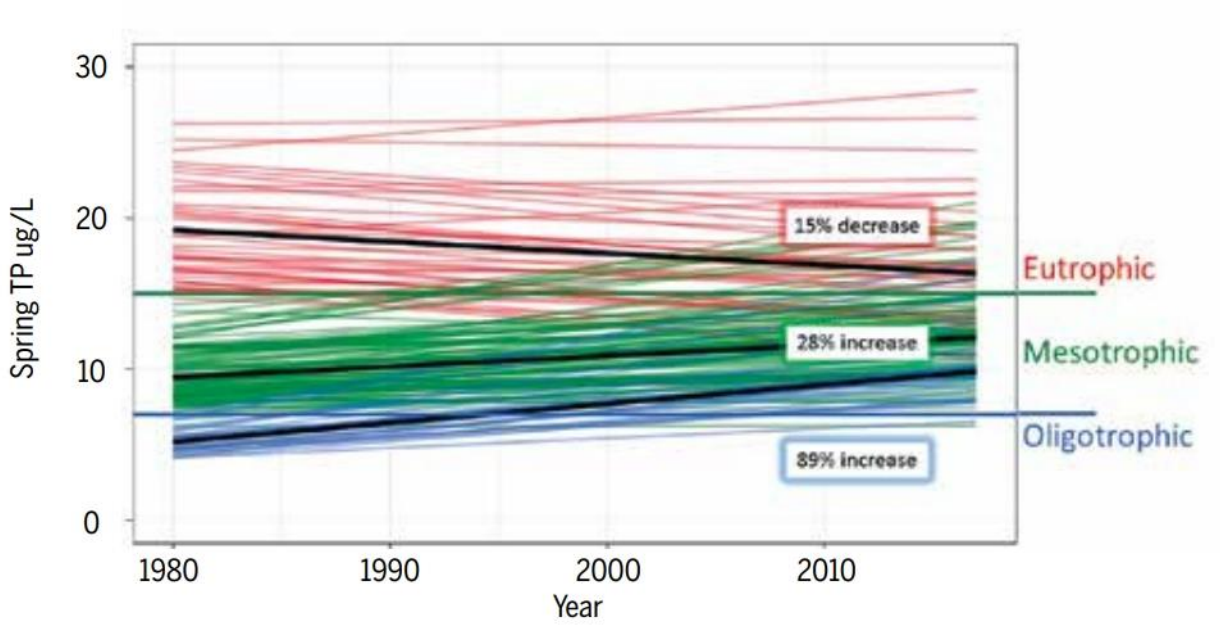


Figure 2. Linear mixed effects model showing the predicted changes in spring TP for individual lakes (solid colored lines, red = eutrophic, green = mesotrophic, blue = oligotrophic), and the overall predicted change in spring TP for each trophic category (solid black lines). Horizontal colored lines represent cut-offs between eutrophic and mesotrophic category (green), and between mesotrophic and oligotrophic category (blue).

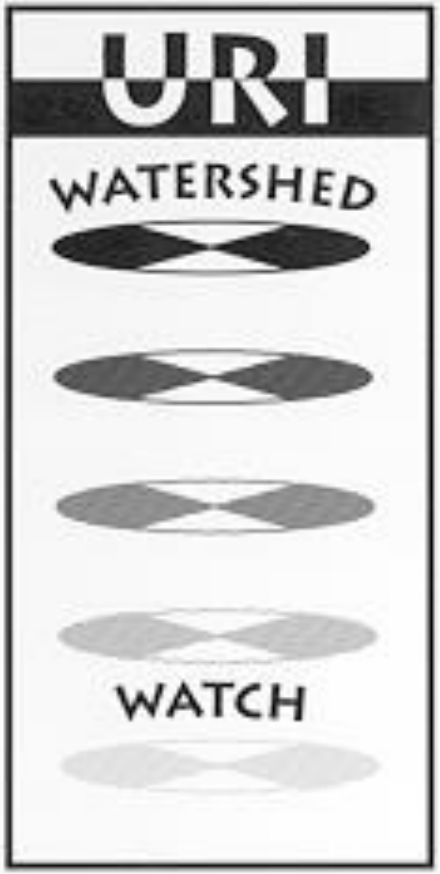
Research Questions

- What about changes in Rhode Island lakes and reservoirs?
- What analysis will highlight changes from long term datasets?

Data

URI Watershed Watch

- Volunteer monitoring program
- Started in 1988 with 14 lakes
- Now
  - ~400 volunteers
  - 250+ sites
  - 120+ waterbodies
- Rigorous QA/QC
- Data used by RI DEM and US EPA



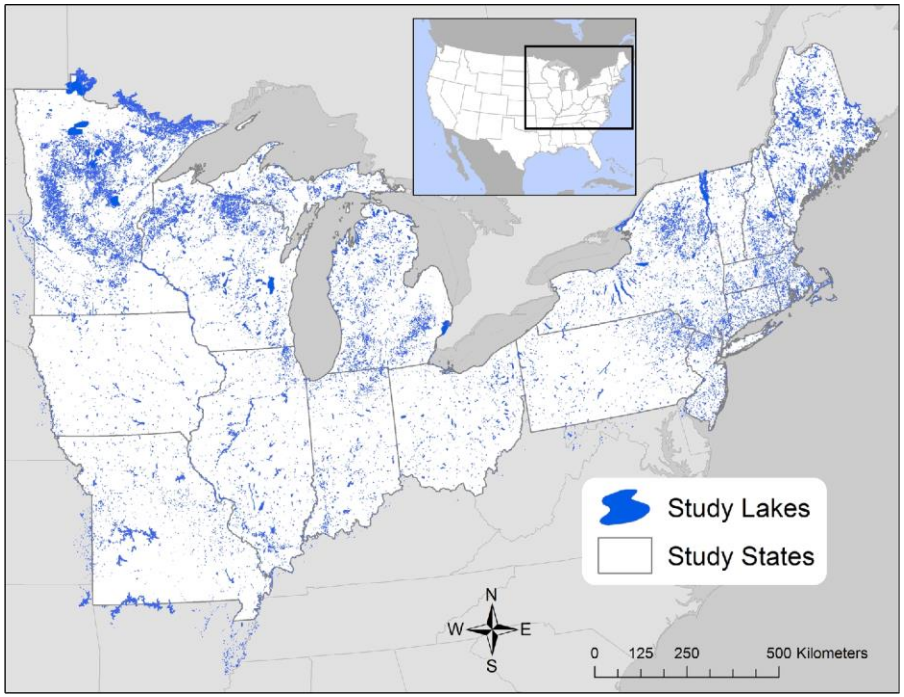
URI Watershed Watch: Lake Sampling

- May to October
- Weekly
  - Water Clarity
  - Temperature
- Every Other Week
  - Chlorophyll
  - Dissolved Oxygen
- 3 Times per Season
  - Nutrients
  - Alkalinity
  - pH
  - Bacteria

LAGOSNE: LAke multi-scaled GeOSpatial and temporal database

- Soranno et al (2017). LAGOS-NE: a multi-scaled geospatial and temporal database of lake ecological context and water quality for thousands of US lakes. Gigascience, 6(12)
- Stachelek and Oliver (2017). LAGOSNE: Interface to the lake multi-scaled geospatial and temporal database. R package version 1.1.0. https://cran.r-project.org/package=LAGOSNE

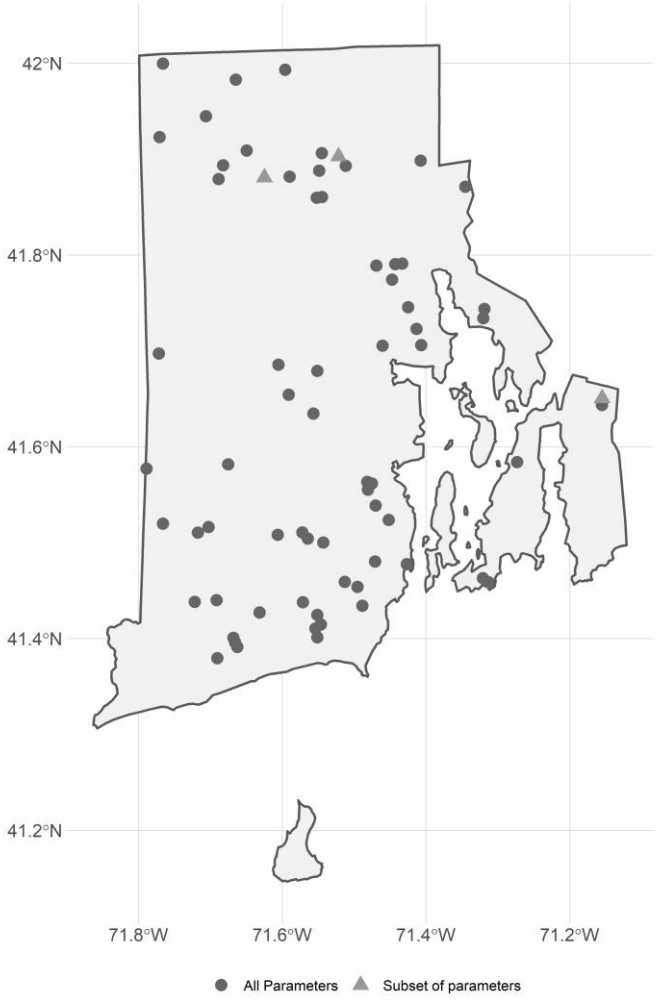
- 17 States:
  - CT, IL, IN, IA, ME, MA, MI, MN, MO, NH, NJ, NY, OH, PA, RI, VT, WI
- ~ 50,000 Lakes



Data preparation and analysis

URI Watershed Watch: Filtered for Trend Analysis

- Parameters:
  - Total Nitrogen, Total Phosphorus, N:P, Temperature, Chlorophyll
- Years:
  - 1993 to 2016
- Months:
  - May through October
- Depths:
  - <= 2 meters
- Sites:
  - At least 10 years of data
- Total of 69 Sites



LAGOSNE: Filtered for Trend Analysis

- Parameters: Total Nitrogen, Total Phosphorus, N:P, Chlorophyll
  - Temperature data not currently available
- Years: 1993 to 2016
- Months: May through October
- Depths: <= 2 meters
- Sites: At least 10 years of data
- Total of 1482 Sites

Analysis: Site-specific z-scores and yearly trends

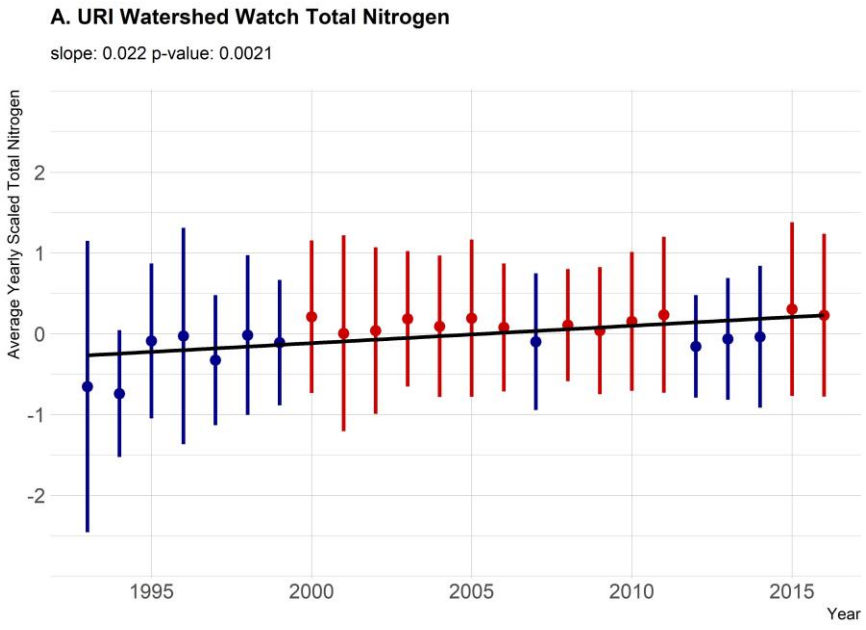
- Similar to temperature anomalies used to look at global temperature change
- Calculate average yearly z-score
- Look for monotonic yearly trend
  - Slope of regression line

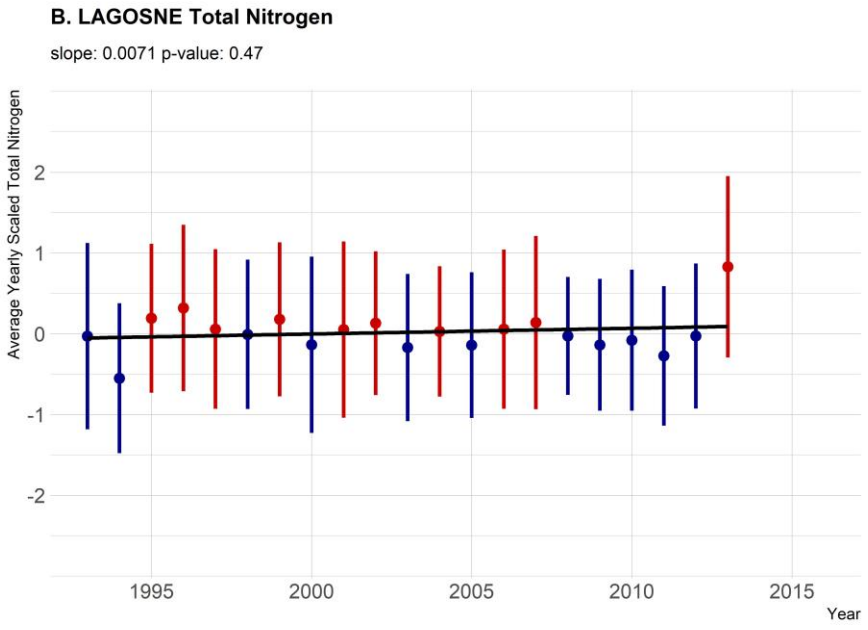
	Year 1	Year 2	Year 3
Station 1 Long-term mean = 7.06 Long-term s.d. = 1.42	data: 5, 4, 8 Site and Year mean: 5.67 Site and Year Z-score: $\frac{(5.67 - 7.06)}{1.42} = -0.98$	data: 6, 9, 6 Site and Year mean: 7 Site and Year Z-score: $\frac{(7 - 7.06)}{1.42} = -0.04$	data: 8, 9 Site and Year mean: 8.5 Site and Year Z-score: $\frac{(8.5 - 7.06)}{1.42} = 1.01$
Station 2 Long-term mean = 3.66 Long-term s.d. = 0.94	data: 2, 3, 3, 4 Site and Year mean: 3 Site and Year Z-score: $\frac{(3 - 3.66)}{0.94} = -0.71$		data: 4, 3, 6 Site and Year mean: 4.33 Site and Year Z-score: $\frac{(4.33 - 3.66)}{0.94} = 0.71$
Station 3 Long-term mean = 12.44 Long-term s.d. = 1.90	data: 11, 15 Site and Year mean: 13 Site and Year Z-score: $\frac{(13 - 12.44)}{1.90} = 0.29$	data: 14 Site and Year mean: 14 Site and Year Z-score: $\frac{(14 - 12.44)}{1.90} = 0.82$	data: 10, 12, 9 Site and Year mean: 10.33 Site and Year Z-score: $\frac{(10.33 - 12.44)}{1.90} = -1.11$
Mean Z-scores	mean z-scores = **-0.47** s.d. z-scores = 0.67 n = 3	mean z-scores = **0.39** s.d. z-scores = 0.61 n = 2	mean z-scores = **0.21** s.d. = 1.15 n = 3

Results

Results: Nitrogen trends

- RI: Increasing but driven by low years in 1993 and 1994
  - Without those years slope = 0.01 and p-value = 0.06
- LAGOSNE: Static

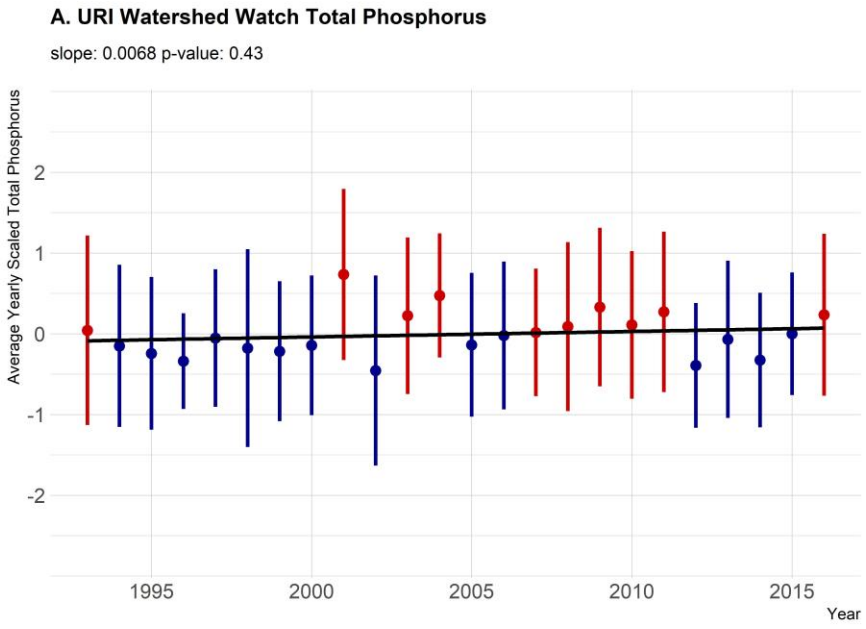


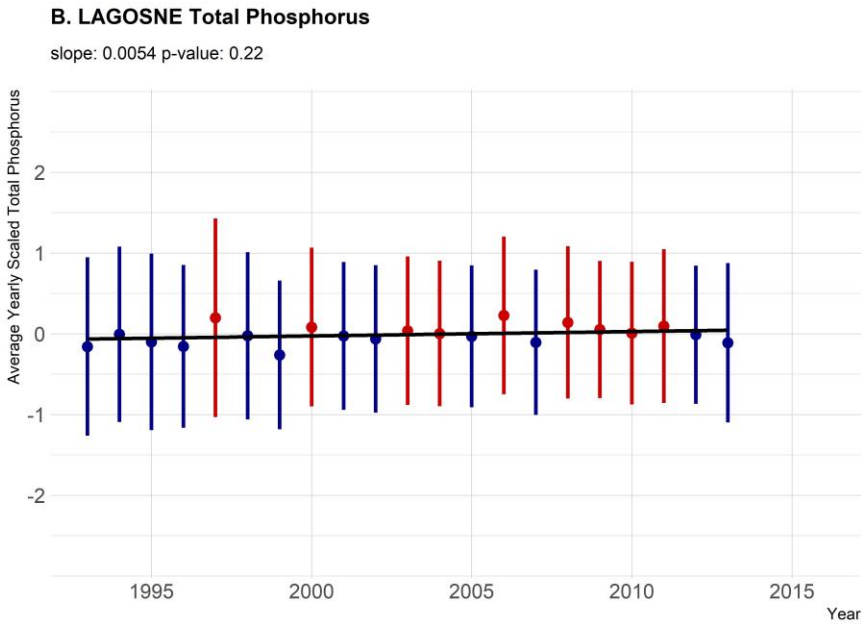


Points are averages and ranges are standard deviations with blue indicating an average below the long-term mean and red indicating an average above the long-term mean.

Results: Phosphorus trends

- RI: Static
- LAGOSNE: Static

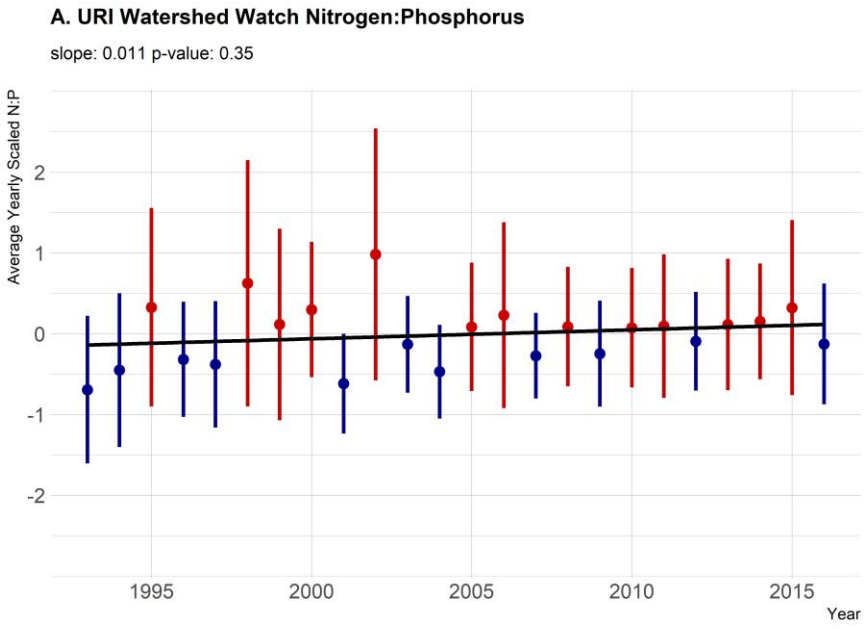


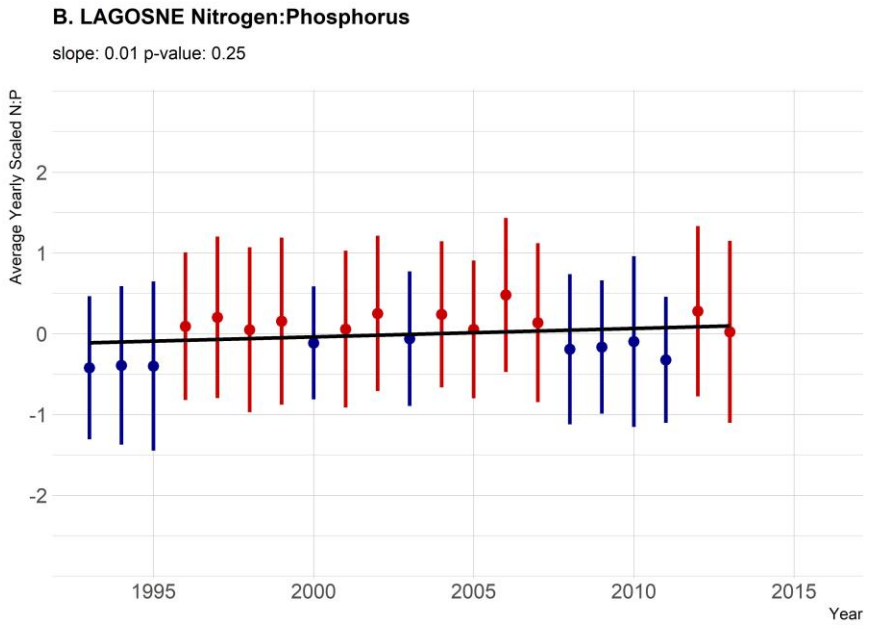


Points are averages and ranges are standard deviations with blue indicating an average below the long-term mean and red indicating an average above the long-term mean.

Results: N:P trends

- RI: Static
- LAGOSNE: Static

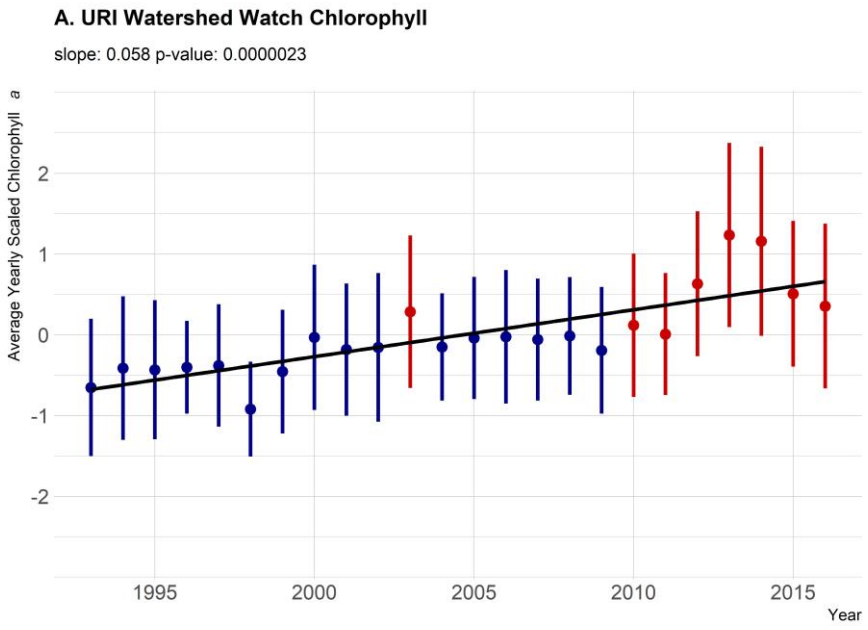


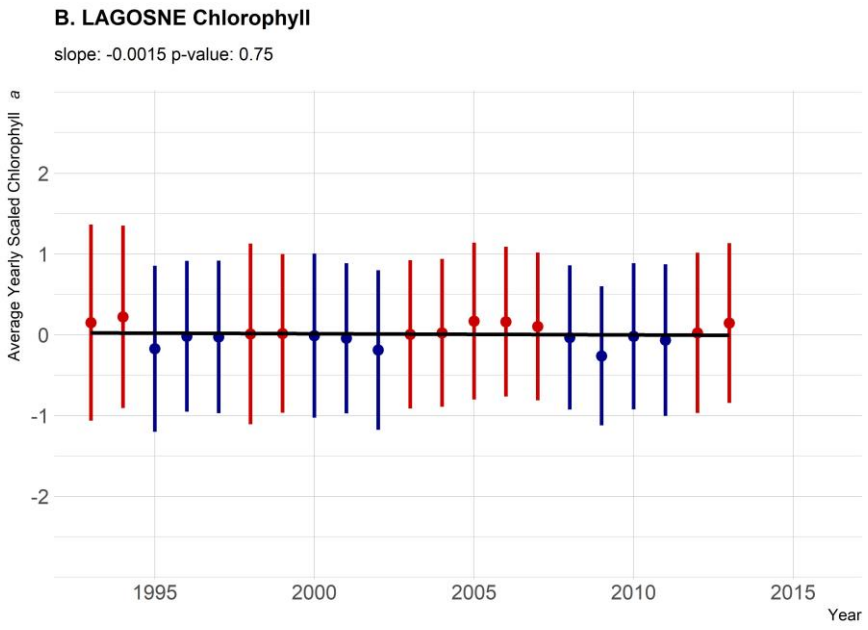


Points are averages and ranges are standard deviations with blue indicating an average below the long-term mean and red indicating an average above the long-term mean.

Results: Chlorophyll trends

- RI: Increasing
- LAGOSNE: Static

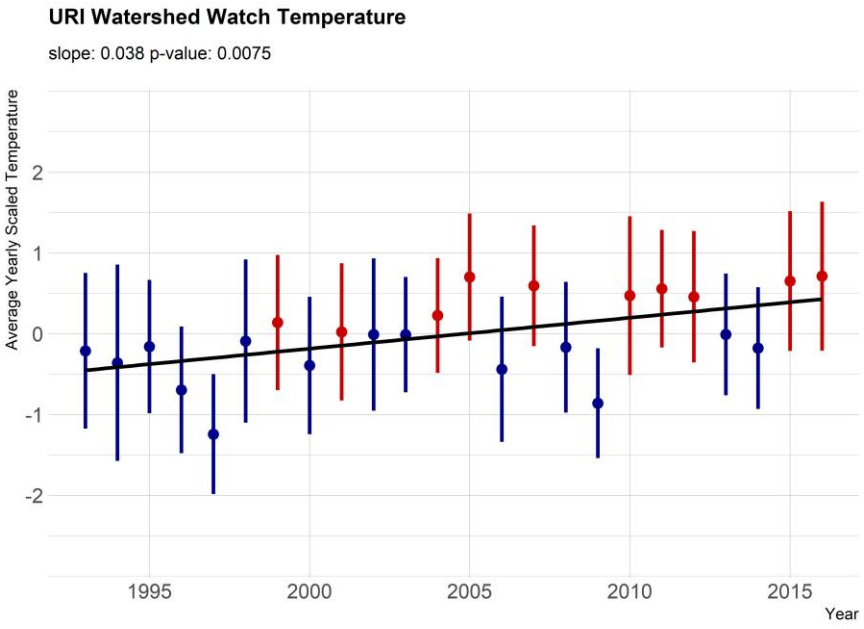




Points are averages and ranges are standard deviations with blue indicating an average below the long-term mean and red indicating an average above the long-term mean.

Results: Temperature trends

- RI: Increasing
- LAGOSNE: NA



Points are averages and ranges are standard deviations with blue indicating an average below the long-term mean and red indicating an average above the long-term mean.

Conclusions

Conclusions

In Rhode Island

- More chlorophyll
- More heat
- Nutrients not changing much

Within the Northeast

- Stasis
  - Our results concur with Oliver et al. (2017)

URI Watershed Watch

- Volunteer monitoring data is indispensable for long-term monitoring

Thank you and Questions

Jeff Hollister
hollister.jeff@epa.gov
401 782 9655
@jhollist