Chesapeake Bay Nontidal Network: Extension of Loads and Trends through WY2012

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USGS
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Outline for Today’s Discussion

- Where do we stand with implementation of WRTDS in the Nontidal Network?
- What are the latest trends in Nitrogen, Phosphorus, and Sediment concentrations and loads (with an emphasis on the 9-RIM stations)?
- What steps are we taking to explain the “nontidal” trends in loads?
- What steps are we taking to better link to estuarine responses/trends?

CB NTN Data Analysis through WY2012

- This is a unique year for determining nutrient and sediment loads and trends because this is the first time that we have two sets of models to perform our analyses across the CB NTN (ESTIMATOR and WRTDS)
- We have decided to use:
  - WRTDS as the primary approach for computing N, P, and S loads across the NTN
  - ESTIMATOR as the primary approach for determining changes in water-quality conditions (i.e. flow-adjusted concentration trends)
  - WRTDS will be used at the 9-RIM stations to determine the trends in N, P, and S "flow-normalized" loads
- By selecting WRTDS as our primary load determination tool, we are truly pioneering new applications in areas that have not been carefully researched (i.e. state-run ambient water-quality stations)

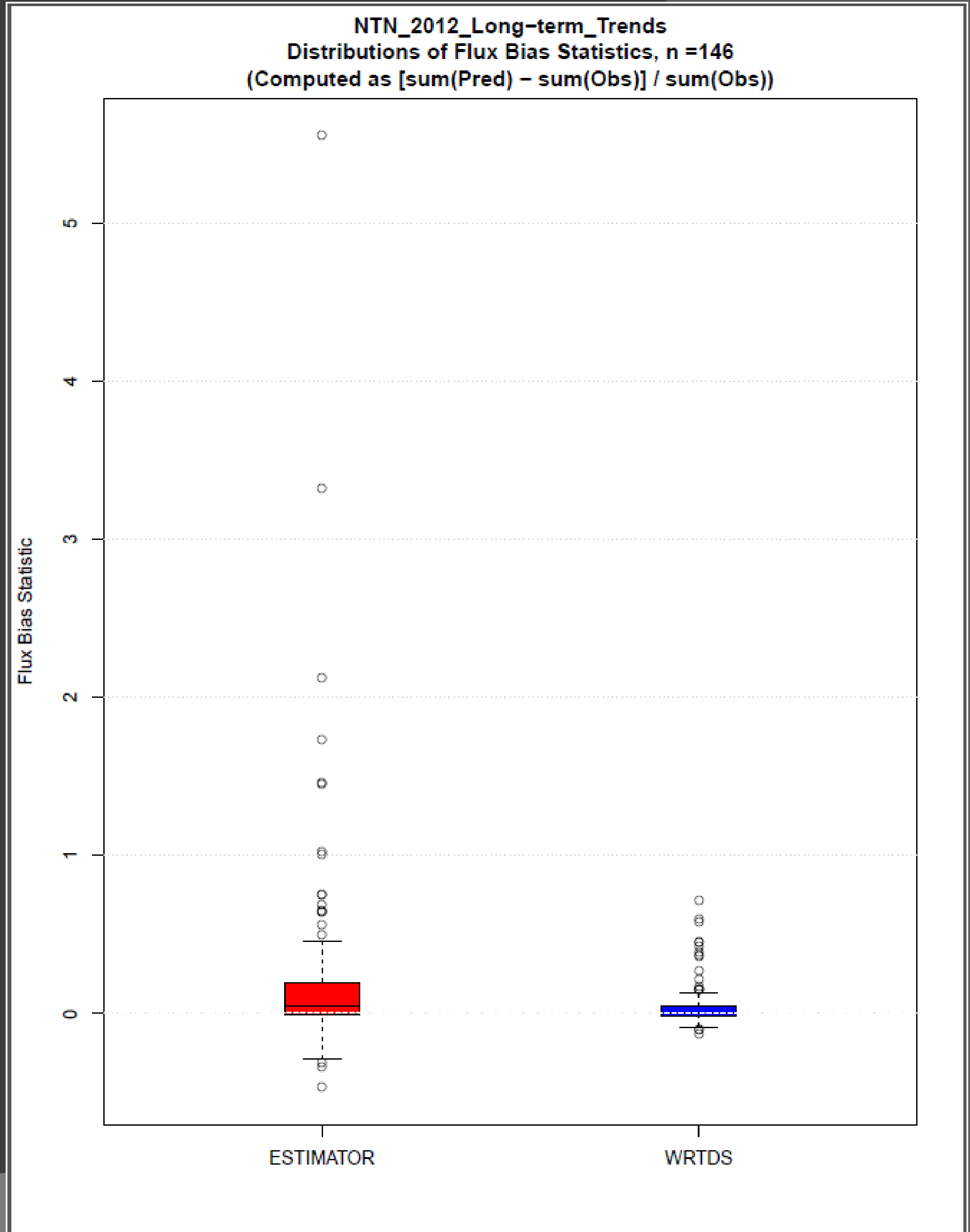
Where do we stand with incorporating WRTDS into our annual determination of loads and trends?

Why Use WRTDS?

- Moyer and others (2012) – found that WRTDS produced estimates of flux that were less biased than flux estimates obtained using ESTIMATOR (using high-quality, data-rich datasets)
- Hirsch, in review, *"Evaluating potential bias of regression-based flux estimates"*
  - Most detailed scientific study available addressing model selection, sample size, model diagnostics

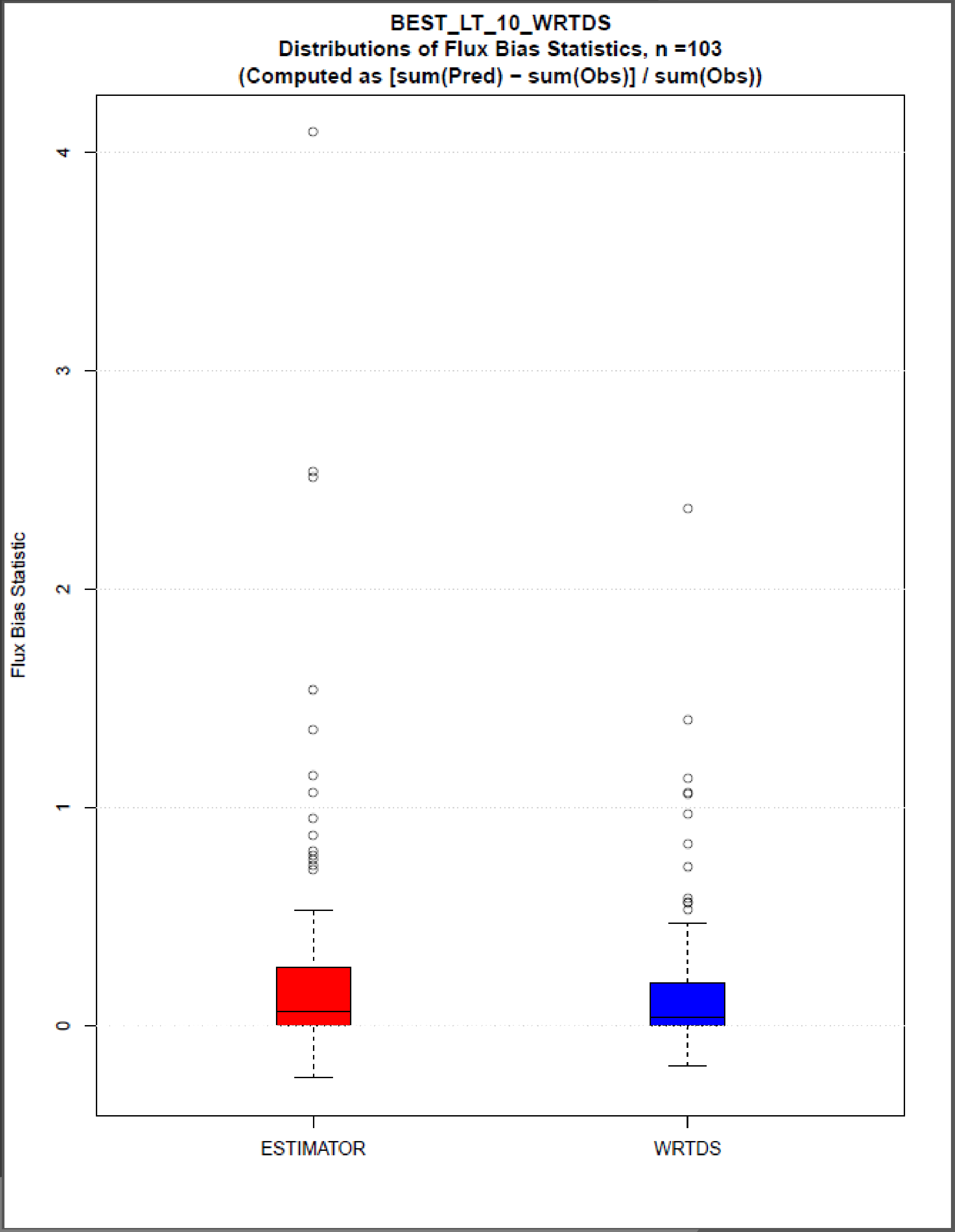
What Do Our WRTDS vs. ESTIMATOR FB Results Look Like?

NTN Long-Term Stations



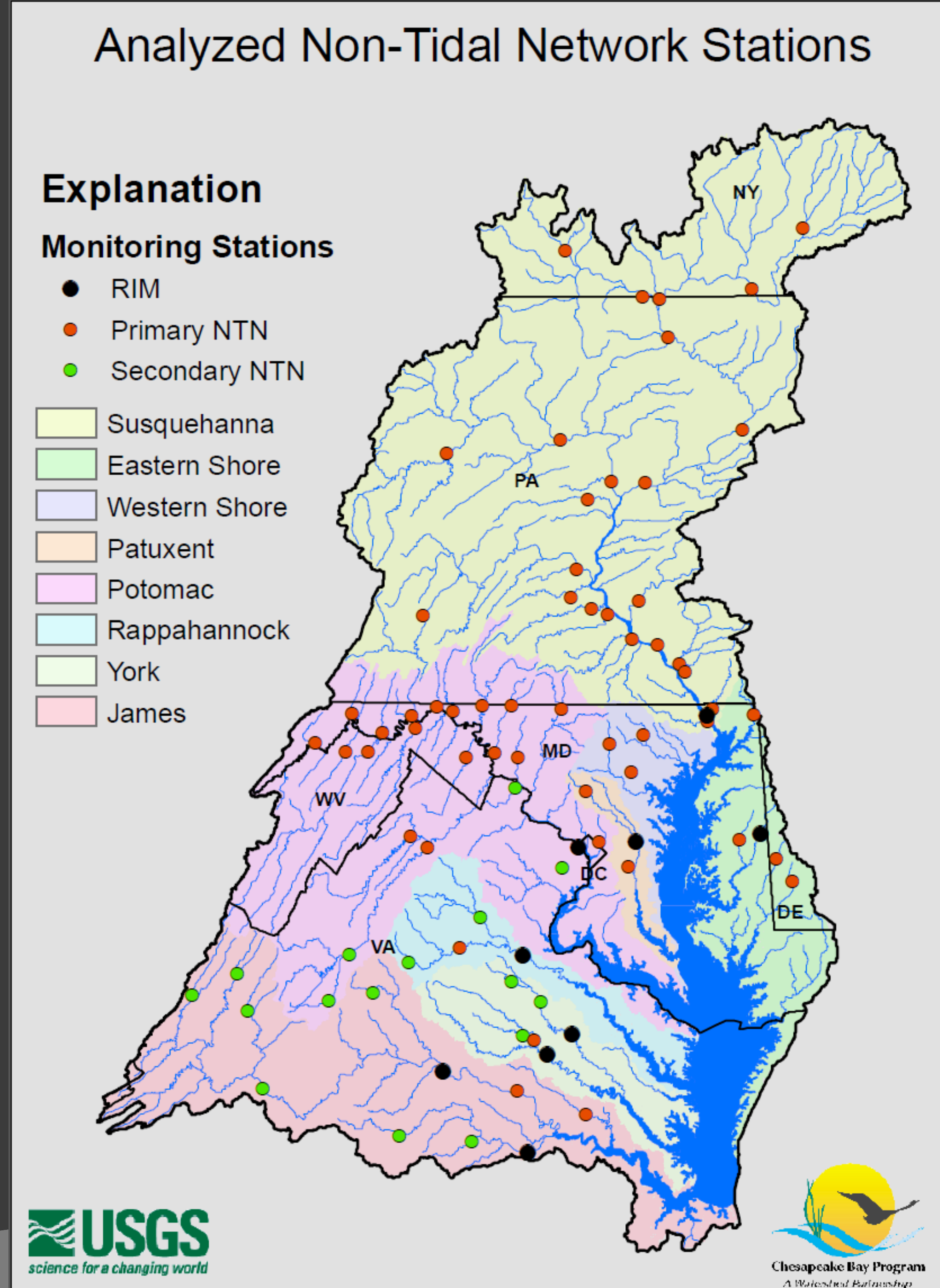
What Do Our WRTDS vs. ESTIMATOR FB Results Look Like?

NTN BEST scenario *(stations have greater than 120 observations)*



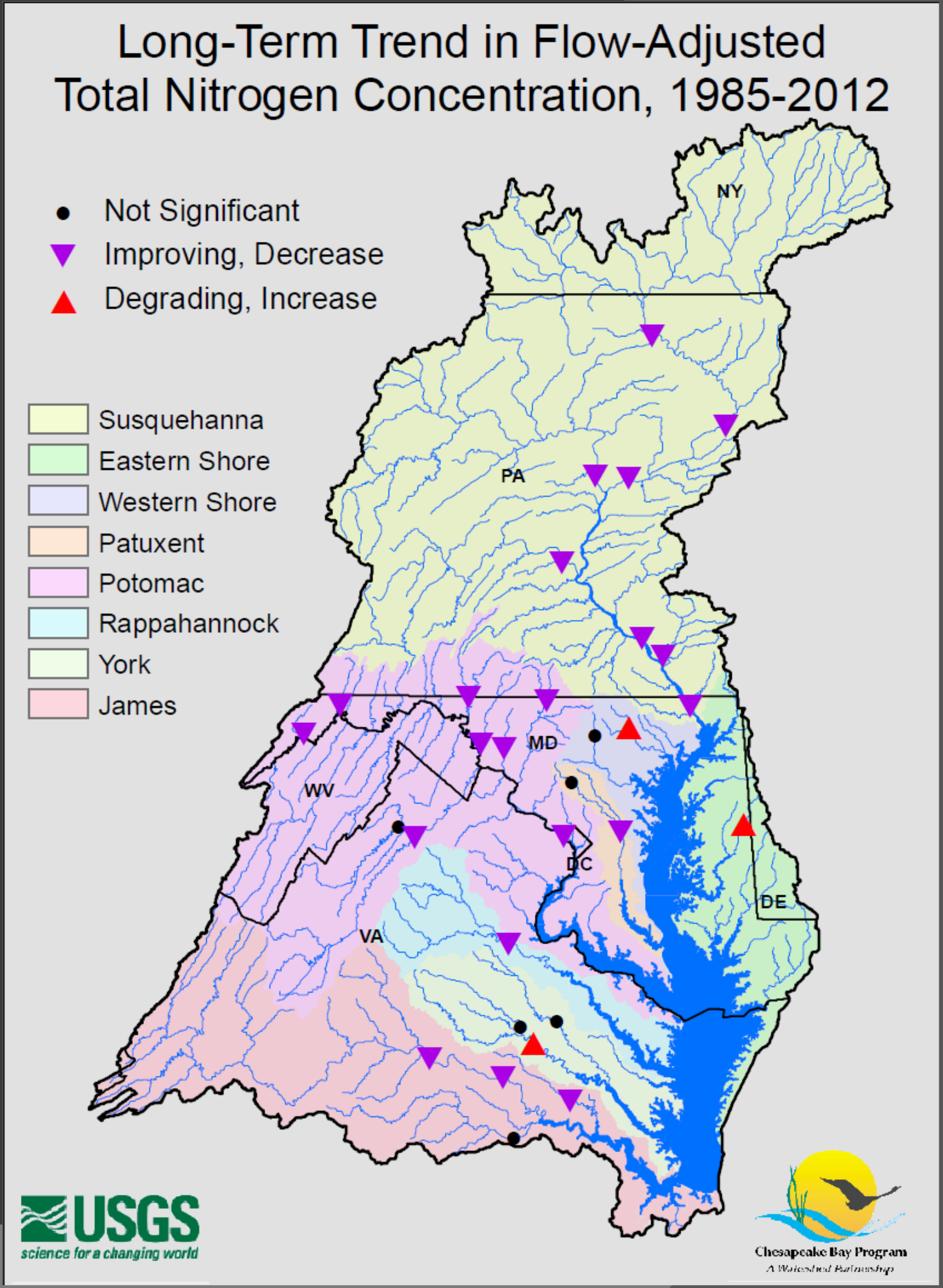
NTN Data Analysis

- WRTDS
  - Loads
    - All NTN stations with at least 120 observations in no fewer than 5 years
  - Trends
    - Flow-Normalized Loads at the 9-RIM stations
- ESTIMATOR
  - Loads
    - NTN stations with less than 120 observations in no fewer than 5 years
  - Trends
    - Flow-adjusted concentration trends at all NTN stations with at least 10 years of monitoring



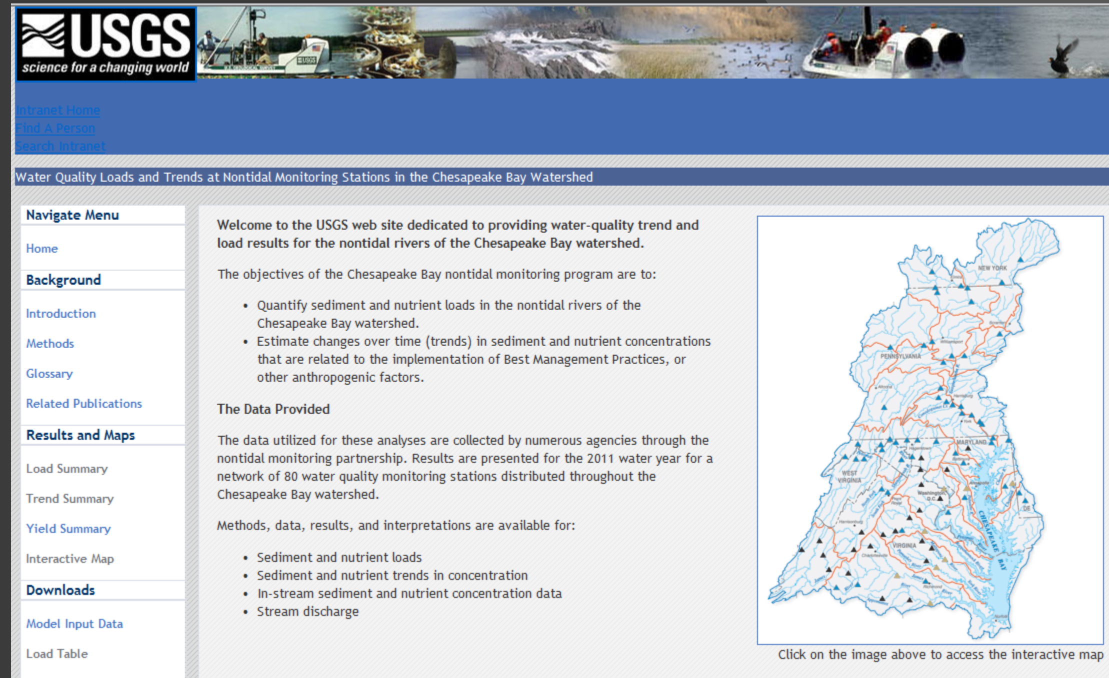
NTN Products

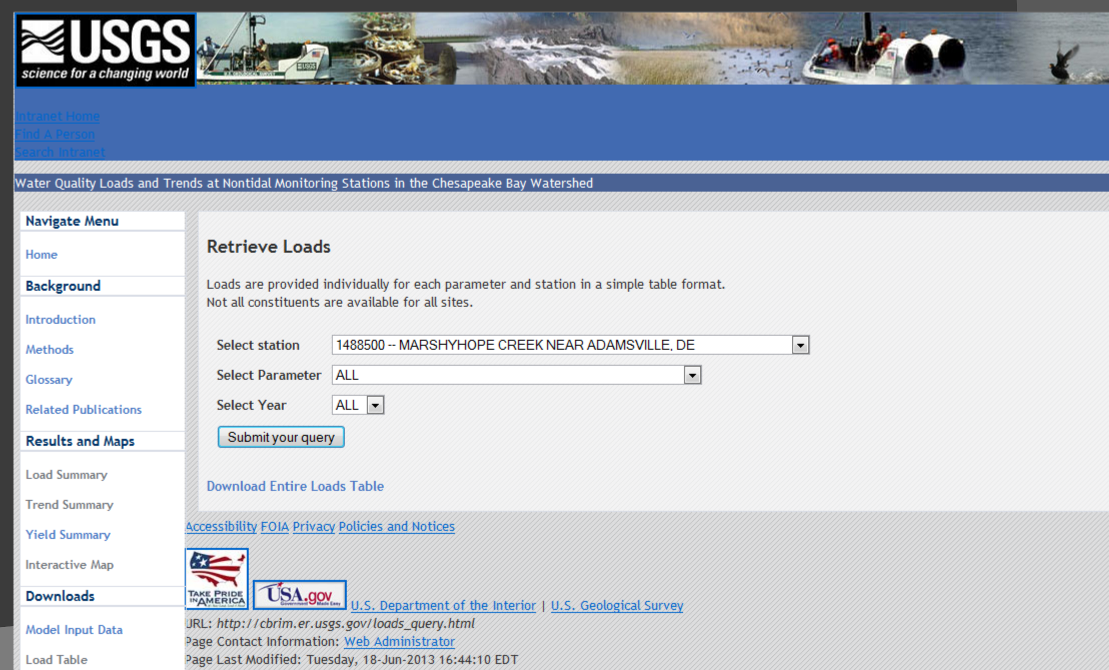
- Monthly and Annual N, P, and S Loads (80 NTN)
- 5-Year Mean Yields (80 NTN)
- Long-term trends in concentration (30 NTN) (ESTIMATOR)
- 10-year trends in concentration (31 NTN) (ESTIMATOR)
- Trends in load at the 9-RIM stations (WRTDS)



USGS NTN Web Page

- http://cbrim.er.usgs.gov/
- Update-to-date interactive maps (loads, yields, and trends)
- Download monthly and annual loads
- Summaries of current year’s loads and trends
- Unable to download WRTDS trends in flow-normalized loads





Latest Trends in Loads at the 9-RIM Stations

- Please understand that these latest results have not yet been published and are therefore provisional and not available for public consumption

Chesapeake Bay: River Input Monitoring Stations

Stations:

- Susquehanna
- Potomac
- James
- Rappahannock
- Appomattox
- Pamunkey
- Mattaponi
- Patuxent
- Choptank

Why these stations:

- Greater than 75% of the land area
- Vast majority of the total discharge from the nontidal areas passes these stations
- Robust datasets: nearly 30 years of monitoring with total observations ranging from 600 to 1,400

Constituents:

- Total Nitrogen
- Nitrate
- Total Phosphorus
- Orthophosphorus
- Suspended Sediment

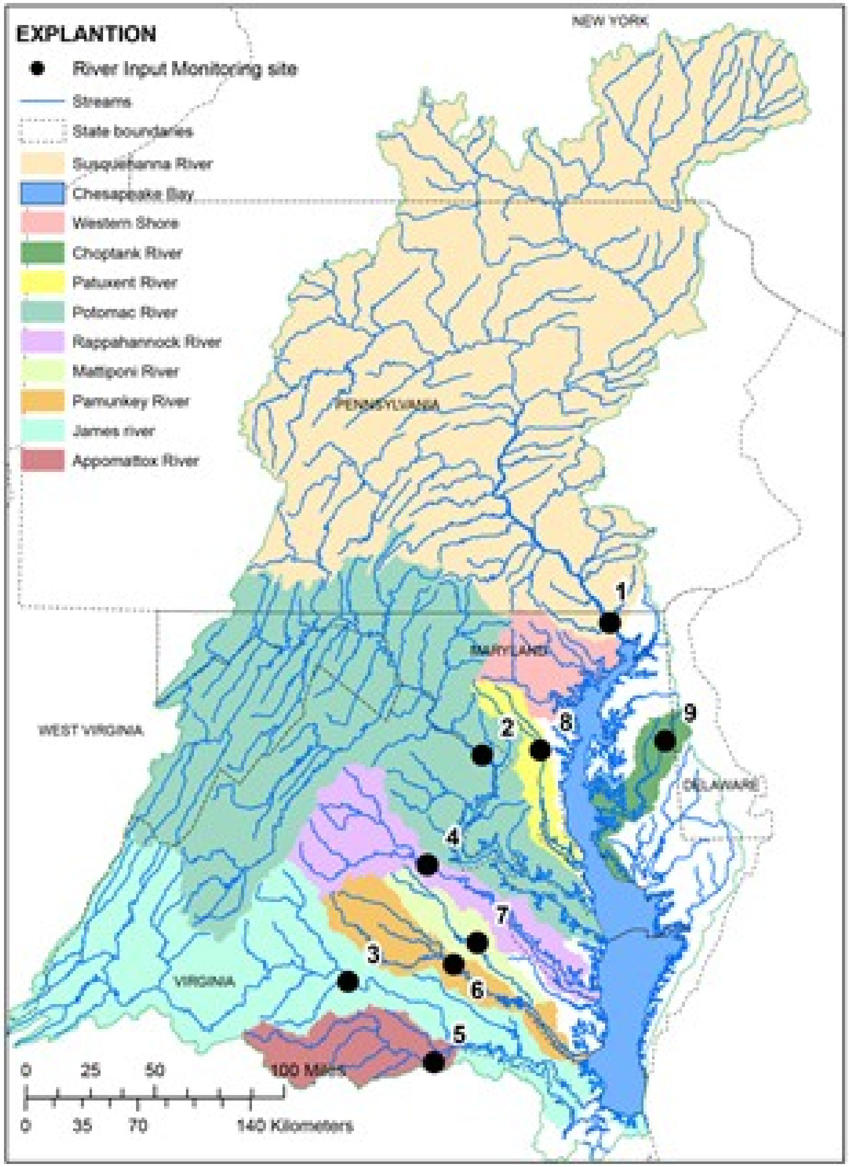


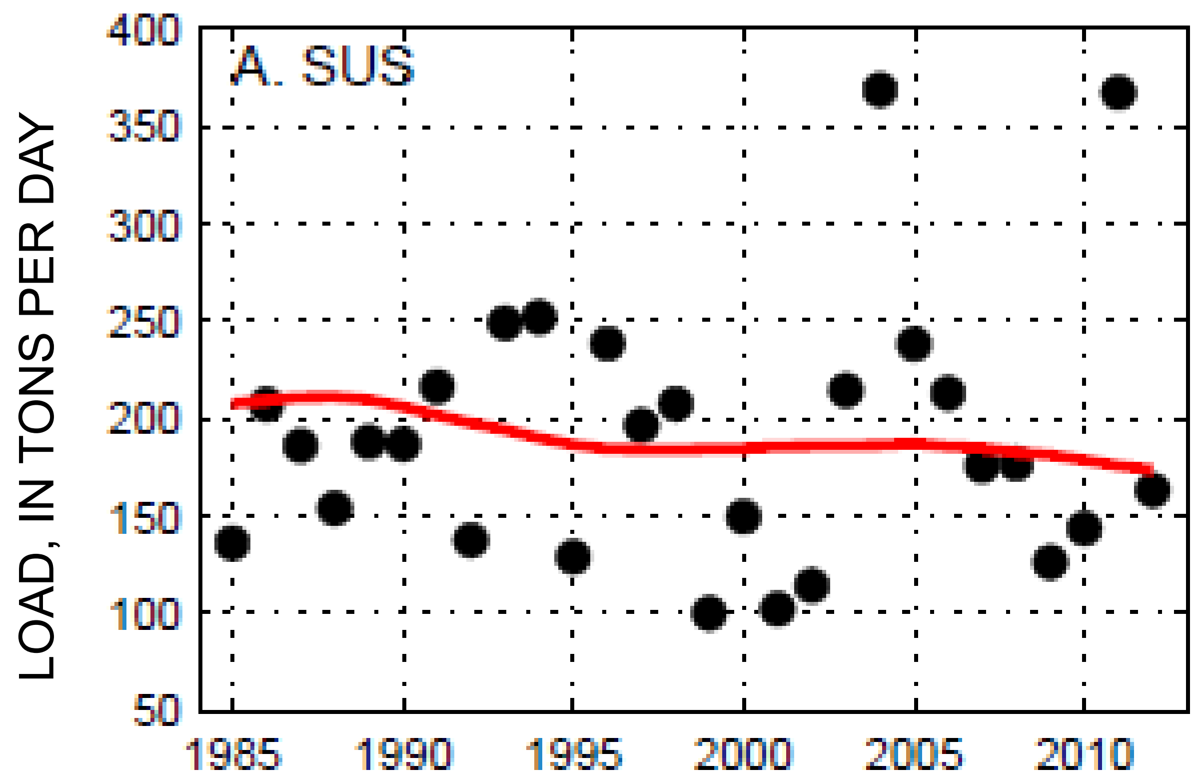
Figure 1. Map showing the location of the 9 River Input Monitoring (RIM) stations in the Chesapeake Bay watershed.

Trends in Total Nitrogen Annual Load

Total Nitrogen Load: Susquehanna (RIM)

- Influence of year-to-year variation in flow

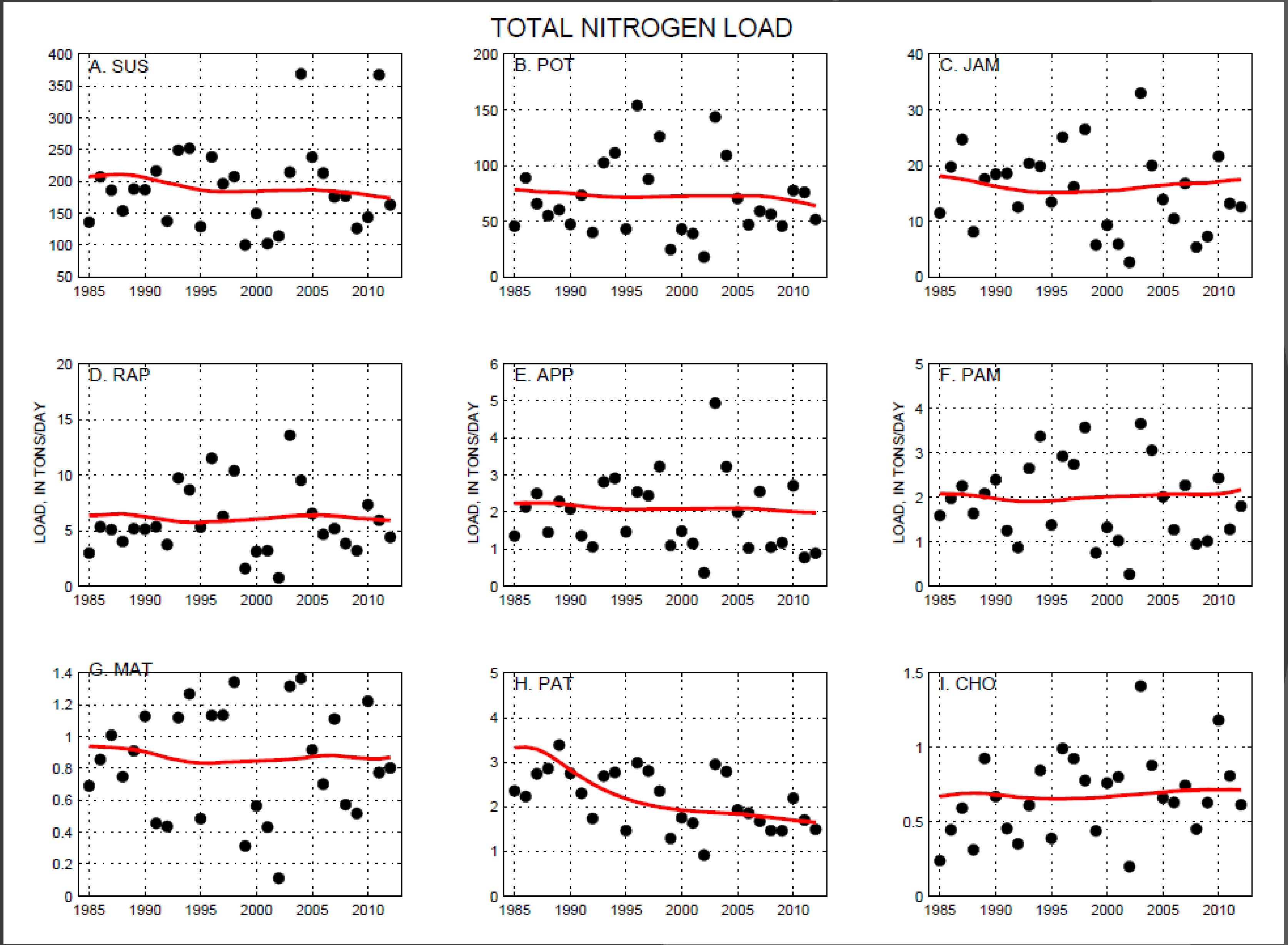
With WRTDS, we now can communicate how annual loads have changed once the year-to-year variation in Q has been removed



Trend in load for:
1985 to 2012 = Total reduction of 16%
2002 to 2012 = Total reduction of 7%

Black Dots = Annual Load   Red Line = Flow Normalized Load

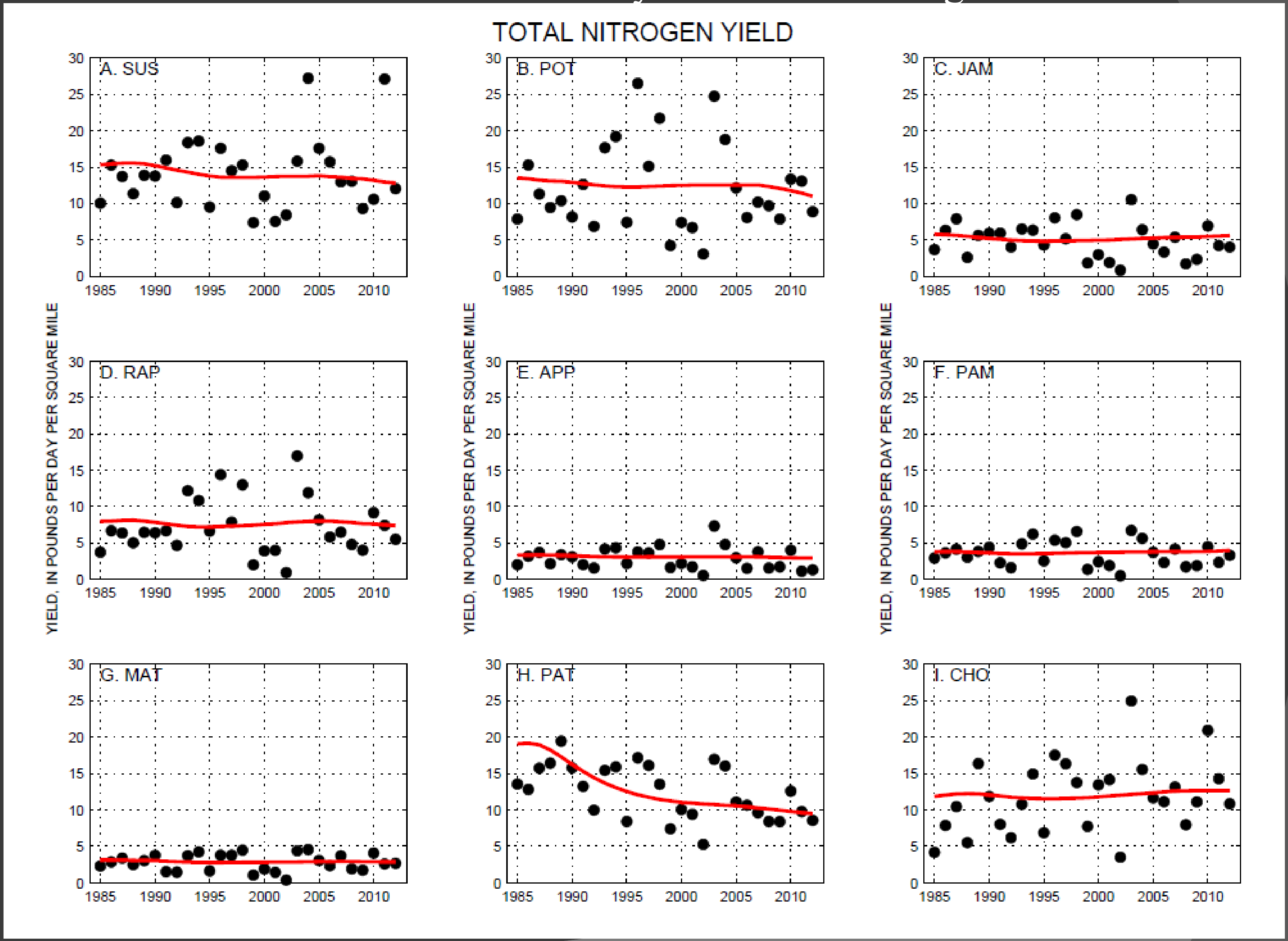
Trends in Total Nitrogen Load



Black Dots = Annual Load   Red Line = Flow Normalized Load

Trends in Total Nitrogen Yield

Yield = Load divided by the Basin Drainage Area



Black Dots = Annual Yield Red Line = Flow Normalized Yield

Trends in Nitrogen Loads

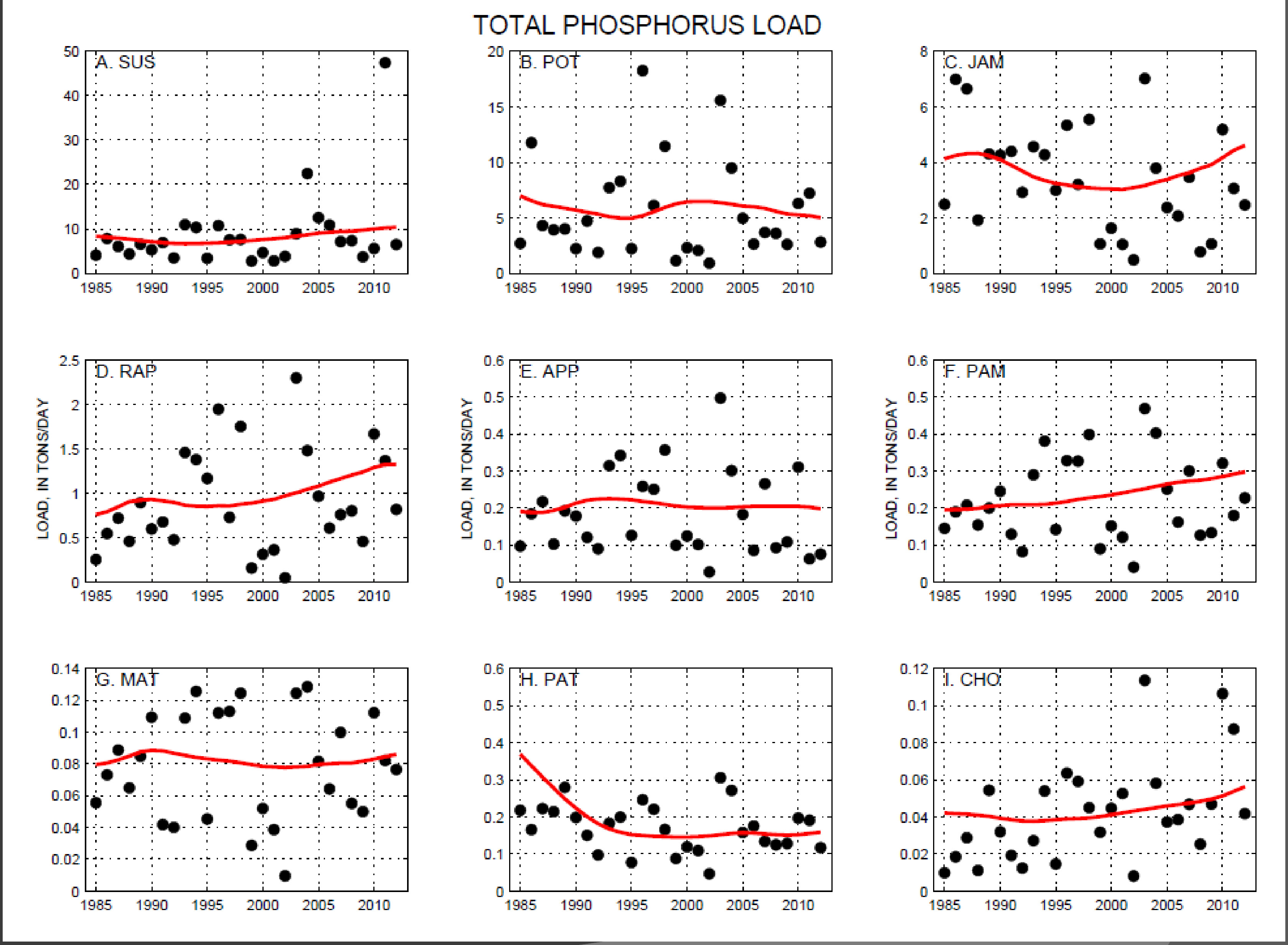
Station	Long-Term Trend (1985-2012)	
	Nitrate	Total Nitrogen
Susquehanna	Improving	Improving
Potomac	Improving	Improving
James	Improving	Minimal
Rappahannock	Improving	Minimal
Appomattox	Improving	Improving
Pamunkey	Minimal	Minimal
Mattaponi	Minimal	Minimal
Patuxent	Improving	Improving
Choptank	Degrading	Minimal

Minimal = total change less than or equal to |10%|

Improving = total load reduction greater than 10%

Degrading = total load increase greater than 10%

Trends in Total Phosphorus Load



Black Dots = Annual Load Red Line = Flow Normalized Load

Trends in Phosphorus Loads

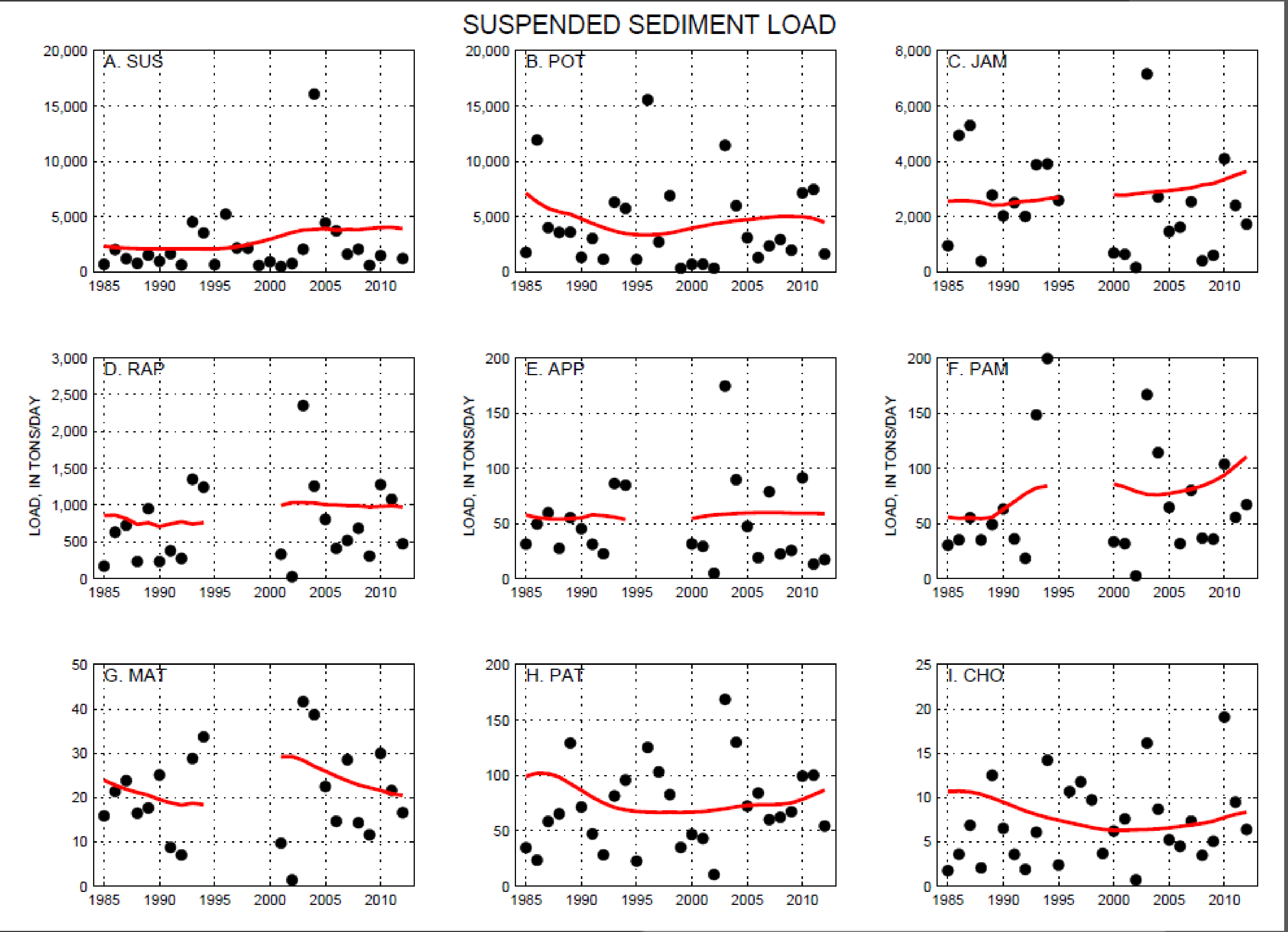
Station	Long-Term Trend (1985-2012)	
	Ortho-phosphorus	Total Phosphorus
Susquehanna	Improving	Degrading
Potomac	Improving	Improving
James	Improving	Degrading
Rappahannock	Improving	Degrading
Appomattox	Improving	Minimal
Pamunkey	Improving	Degrading
Mattaponi	Improving	Minimal
Patuxent	Improving	Improving
Choptank	Degrading	Degrading

Minimal = total change less than or equal to |10%|

Improving = total load reduction greater than 10%

Degrading = total load increase greater than 10%

Trends in Suspended Sediment Load



Black Dots = Annual Load   Red Line = Flow Normalized Load

Trends in Suspended Sediment Load

Station	Long-Term Trend (1985-2012)	Short-Term Trend (2002-2012)
Susquehanna	Degrading	Minimal
Potomac	Improving	Minimal
James	Not Available	Degrading
Rappahannock	Not Available	Minimal
Appomattox	Not Available	Minimal
Pamunkey	Not Available	Degrading
Mattaponi	Not Available	Improving
Patuxent	Improving	Degrading
Choptank	Improving	Degrading

Minimal = total change less than or equal to |10%|

Improving = total load reduction greater than 10%

Degrading = total load increase greater than 10%

What Steps are We Taking to Explain Water-Quality Trends in the Nontidal Portions of the Bay?

OBJECTIVES – Explaining Water-Quality Conditions:

1. Produce water-quality results (to the highest degree possible) at all Chesapeake Bay nontidal network stations

2. Link changes in water-quality conditions to Natural/Anthropogenic alterations to the watershed during recent (< 10 years) and/or historic (> 10, 25, 50, 100 ... years ago).

3. Compare “observed” water-quality results (loads and trends) to the CB Watershed model and assist in identifying ways to improve/reduce uncertainty in these modeled results.

8 Steps for Highly Effective Explanation of Changes in Water-Quality Conditions

1) Identify “defendable” water-quality response
2) Watershed mass balance
3) Time-series analysis
4) Identify natural and anthropogenic changes in the watershed
5) Define transport and storage processes
6) Understand the role of climate change
7) Make tidal connections
8) SYNTHESIZE Results

8.) Synthesis of Results

- We will communicate our results to the CBP along the way.
- We must synthesize these results into a coherent document that 1) describes the most likely factors governing water-quality conditions at the regional scale and 2) highlights gaps (e.g. data, tools, …) that confound linking water-quality response to an action in the watershed.

Where will these study elements occur?

- Eastern Shore (Ator and others – Draft 2013).
- Potomac Watershed (ongoing - "complete" 2015)
- Susquehanna Watershed (Currently formulating plan)
- Virginia Tributaries (??)

Goal for completing study element pubs and each watershed synthesis

- Prior to the 2017 CBP Mid-Point Assessment

What Steps are being Taken to Better Link Nontidal and Tidal Water-Quality Patterns?

Linking Nontidal and Tidal Water-Quality Responses

- Relating nutrient loads and flow to the extent of Bay hypoxia
- Trends in Seasonal Loads
  - USGS
  - JHU

Relating Loads and Flow to Bay Hypoxia

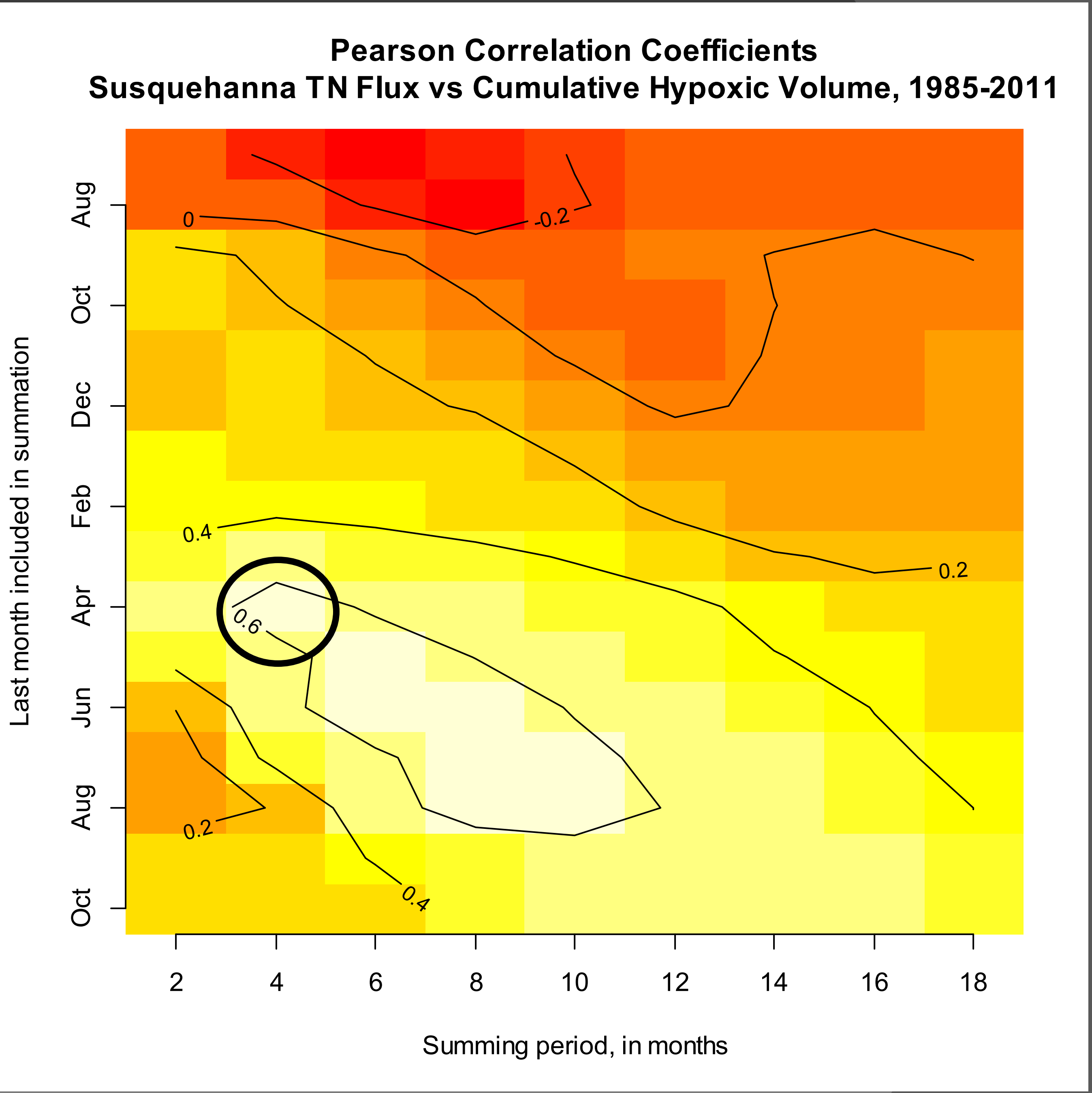
(Jeff Chanat and Doug Moyer)

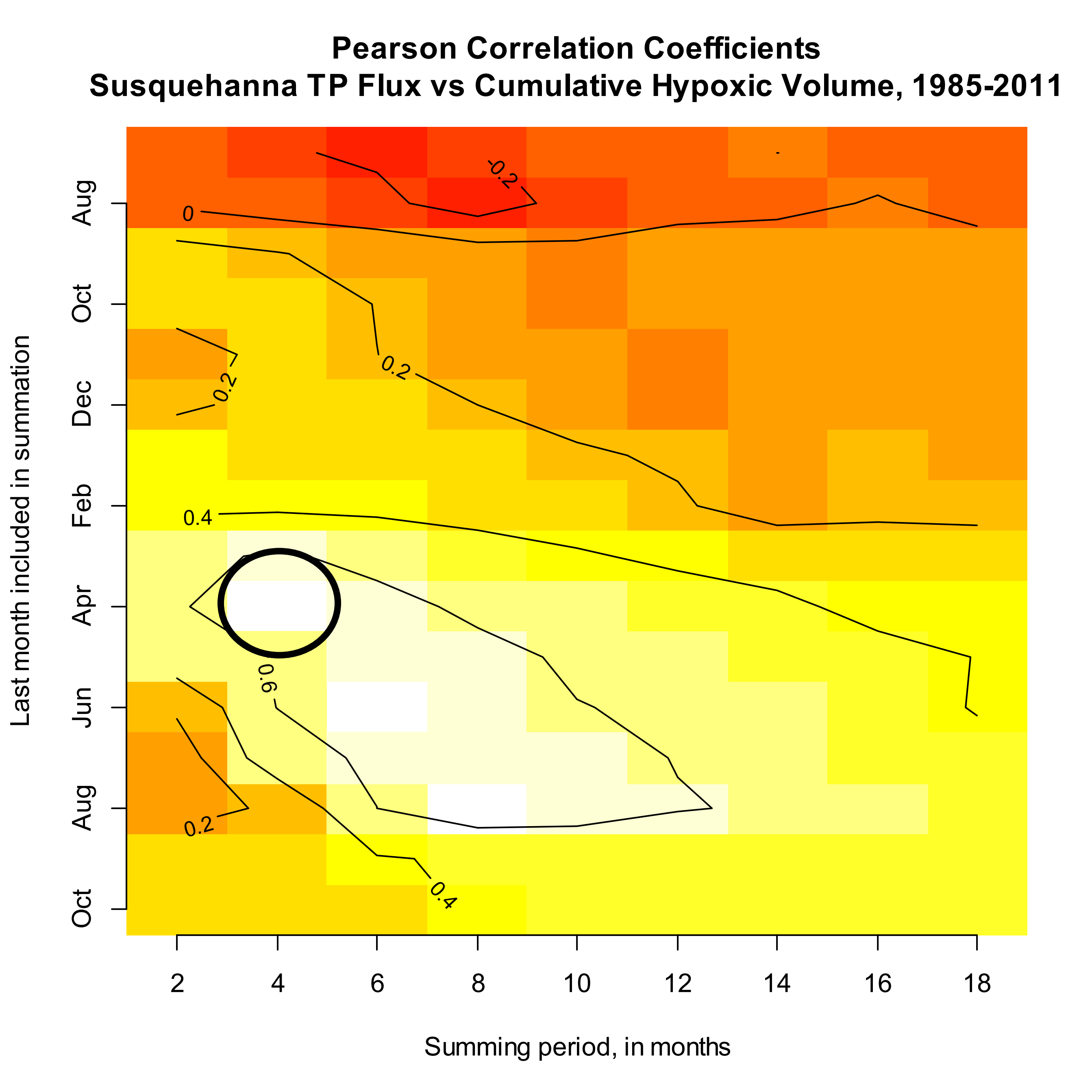
- VERY Preliminary!!
- Can we predict annual cumulative hypoxic volume using monthly load or flow from the RIM stations?
- Time series of annual cumulative hypoxic volume km^3d (Bever et al. 2013)
- Monthly load and flow from each of the 9-RIM stations
  - Experiment with lag, where lag zero = October *(identify earliest period in a given year with the strongest relation to hypoxic volume)*
  - Experimented with summing monthly load or flow for a range of 2 to 18 months *(identify the fewest number of months with the strongest relation to hypoxic volume)*
- Pearson correlation matrix

Color Range

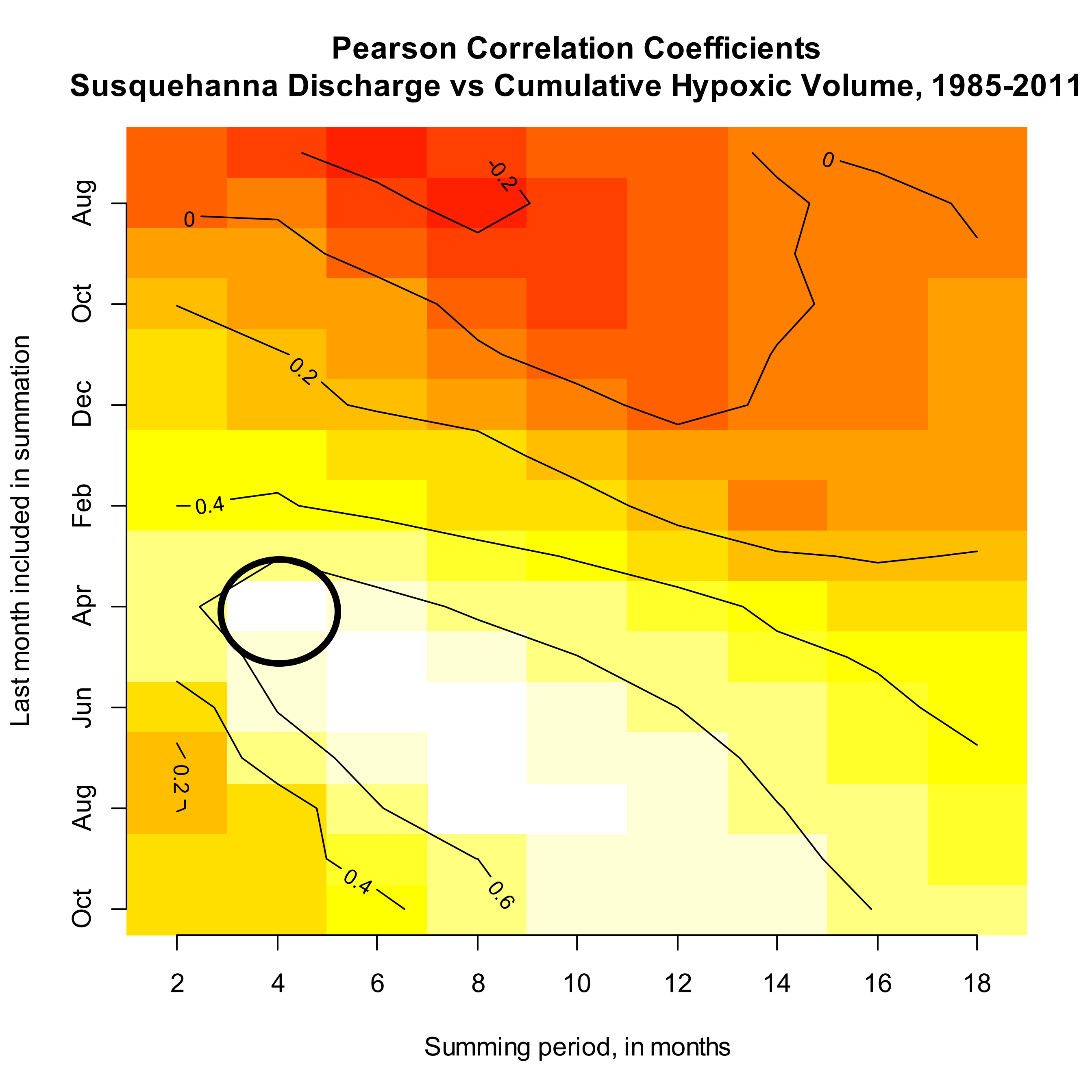
- Red = weakest relation
- White = strongest relation

- Critical period identified = January, February, March, and April





Pearson Correlation Coefficients
Susquehanna TP Flux vs Cumulative Hypoxic Volume, 1985-2011
Last month included in summation
Aug
Oct
Dec
Feb
Apr
Jun
Aug
Oct
-0.2
0
0.2
0.2
0.4
0.6
0.2
0.4
2
4
6
8
10
12
14
16
18
Summing period, in months



Pearson Correlation Coefficients
Susquehanna Discharge vs Cumulative Hypoxic Volume, 1985-2011
Last month included in summation
Aug
Oct
Dec
Feb
Apr
Jun
Aug
Oct
Summing period, in months
2
4
6
8
10
12
14
16
18
0
-0.2
0
0.2
0.4
0.2
0.4
0.6

Linking Nontidal and Tidal Water-Quality Responses

- Relating nutrient loads and flow to the extent of Bay hypoxia
- Trends in Seasonal Loads
  - USGS
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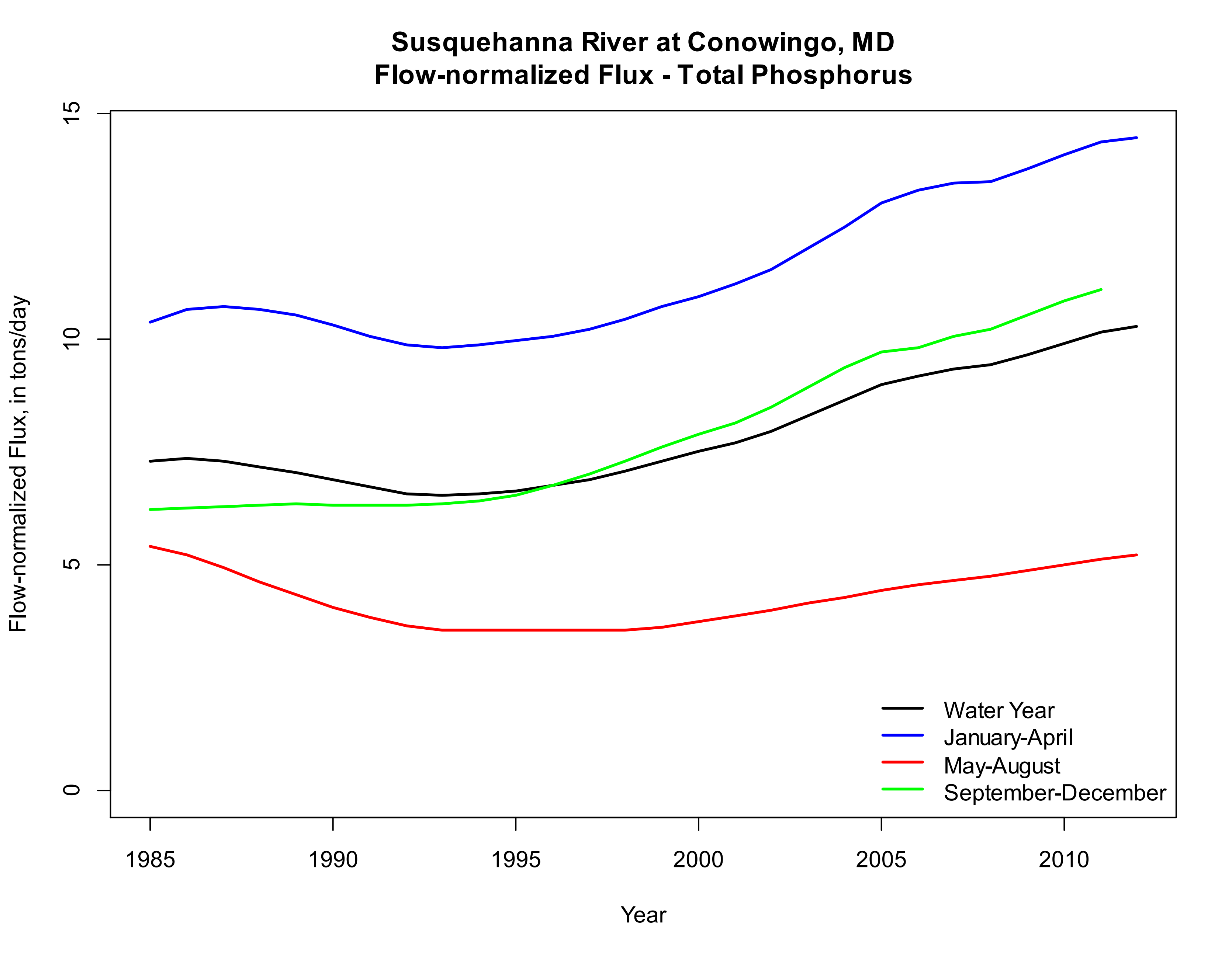
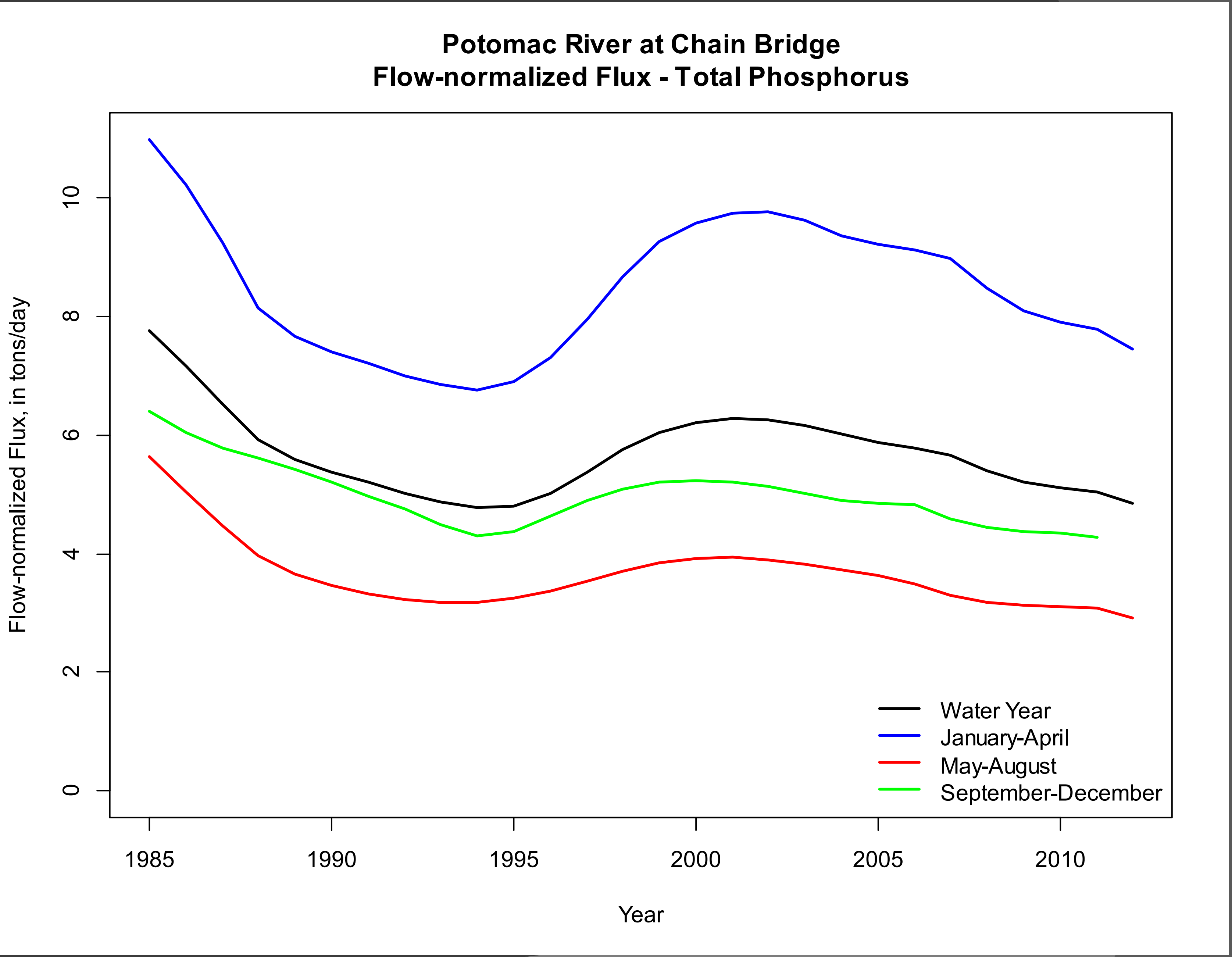


Susquehanna River at Conowingo, MD
Flow-normalized Flux - Total Phosphorus
Flow-normalized Flux, in tons/day
0
5
10
15
1985
1990
1995
2000
2005
2010
Year
Water Year
January-April
May-August
September-December


Potomac River at Chain Bridge
Flow-normalized Flux - Total Phosphorus
Flow-normalized Flux, in tons/day
0
2
4
6
8
10
1985
1990
1995
2000
2005
2010
Year
Water Year
January-April
May-August
September-December

Seasonal Loading Patterns

- Johns Hopkins University – Bill Ball and Qian Zhang

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Long-term seasonal trends of nitrogen, phosphorus, and suspended sediment load from the non-tidal Susquehanna River Basin to Chesapeake Bay

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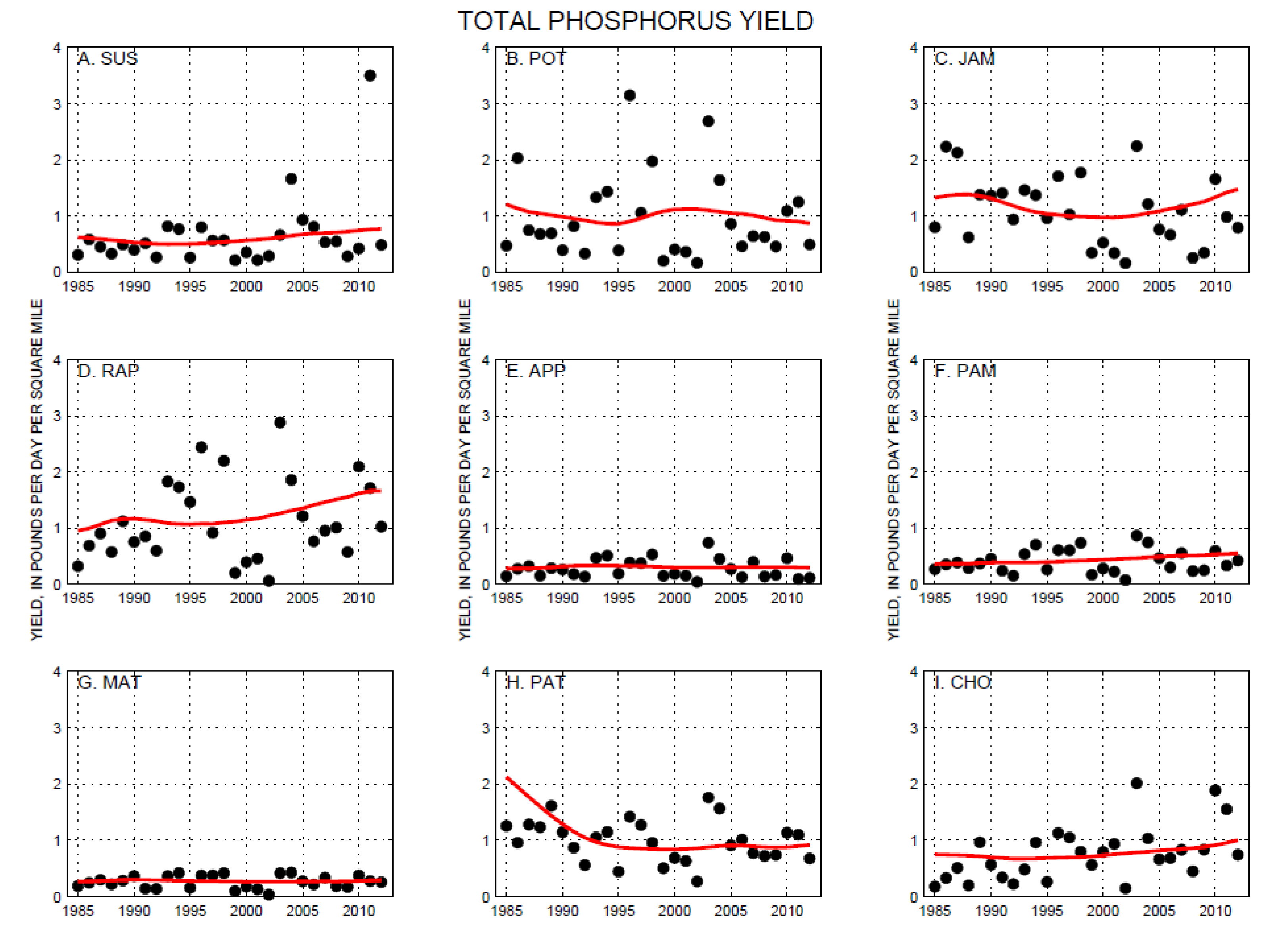
HIGHLIGHTS

- Flow-normalized loads of N, P, and SS from the Susquehanna River were evaluated.
- SS and particulate-bound P and N from the Susquehanna to Chesapeake Bay are rising.
- N, P, and SS loads have declined in the Susquehanna River above its major reservoirs.
- The Conowingo Reservoir has neared its capacity to trap SS and particulate P and N.
- The reservoir will pose challenges to attainment of nutrient and sediment reduction.

Trends in Total Phosphorus Yield

Yield = Load divided by the Basin Drainage Area



Black Dots = Annual Yield Red Line = Flow Normalized Yield