Presentation to Integrated Trends Analysis Team Meeting

November 12, 2016

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Two threads of underlying philosophy

John Tukey: Exploratory Data Analysis: it is "an attitude AND a flexibility AND some graph paper" -- "The picture-examining eye is the best finder we have of the wholly unanticipated"

Ralph Keeling: "The only way to determine what is happening to our planet is to measure it, and this means tracking changes decade after decade and poring over the records.

WRTDS – weighted regressions on time, discharge, and season

Build a statistical model for concentrations on every day in the period of record

Have it driven primarily by the data and not stuck in a “mathematical straight jacket”

Use this model to depict the amount and kind of change happening in concentration and in fluxes

Three topics

- **Status of WRTDS, EGRET, and uncertainty analysis**
- **Examples of uncertainty analysis applied to selected RIM data sets**
- **Encouragement for using various tools in EGRET to explore your data sets**

dataRetrieval

Retrieves water data for use in R from NWISWeb, the Water Quality Portal, and spreadsheets

EGRET: Exploration & Graphics for RivEr Trends

Retrieve data: from USGS, Portal, or Spreadsheets

Flow history analysis

Water quality graphics

WRTDS: Weighted Regressions on Time Discharge & Season: for water quality trends and fluxes

WRTDS for exploration

All the software and manuals for EGRET and dataRetrieval

https://github.com/USGS-R/EGRET/wiki

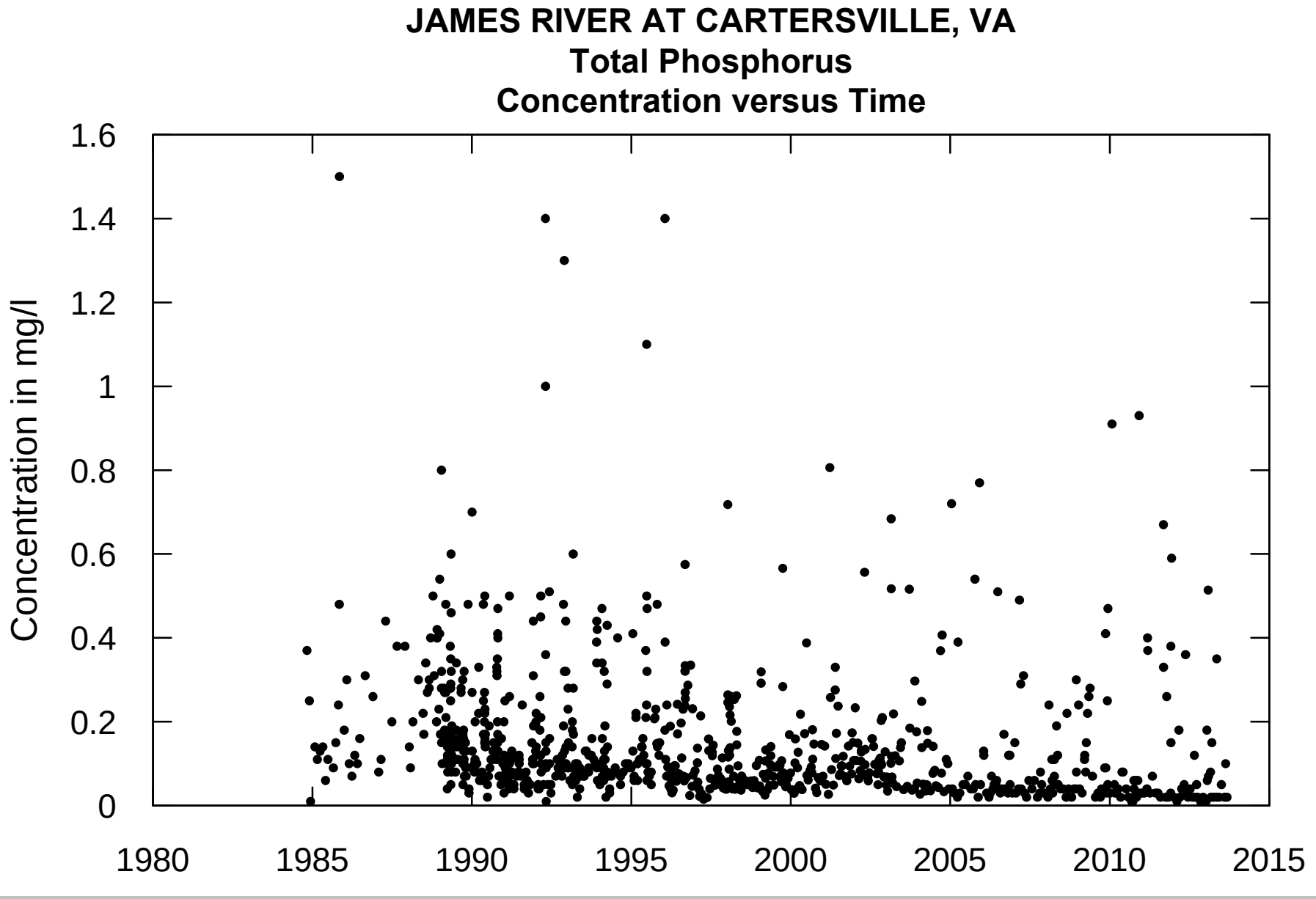
JAMES RIVER AT CARTERSVILLE, VA
Total Phosphorus
Water Year

Concentration trends

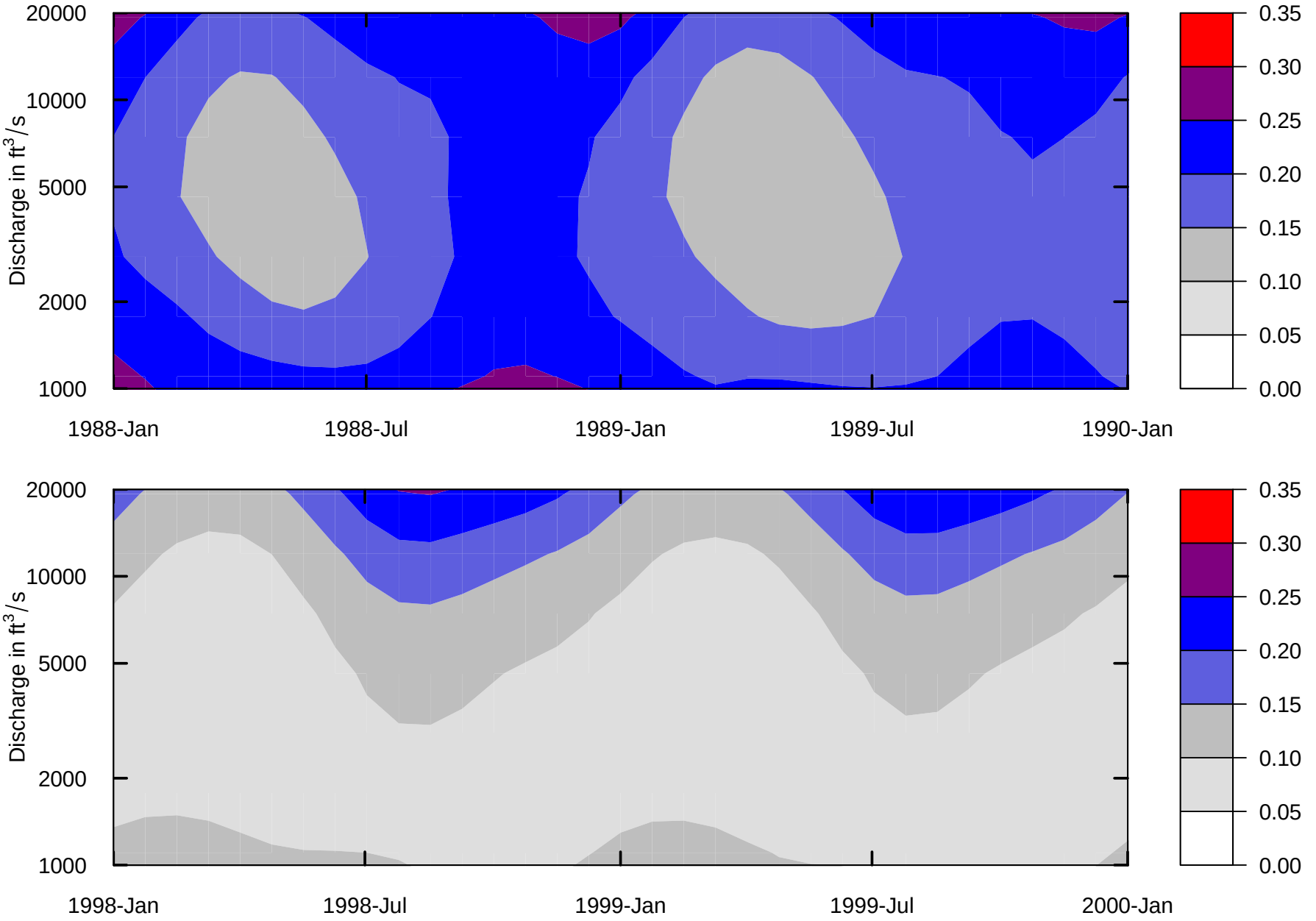
time span			change	slope	change	slope
			mg/L	mg/L/yr	%	%/yr
1985	to	2000	-0.17	-0.012	-63	-4.2
1985	to	2013	-0.2	-0.0073	-75	-2.7
2000	to	2013	-0.032	-0.0025	-32	-2.5

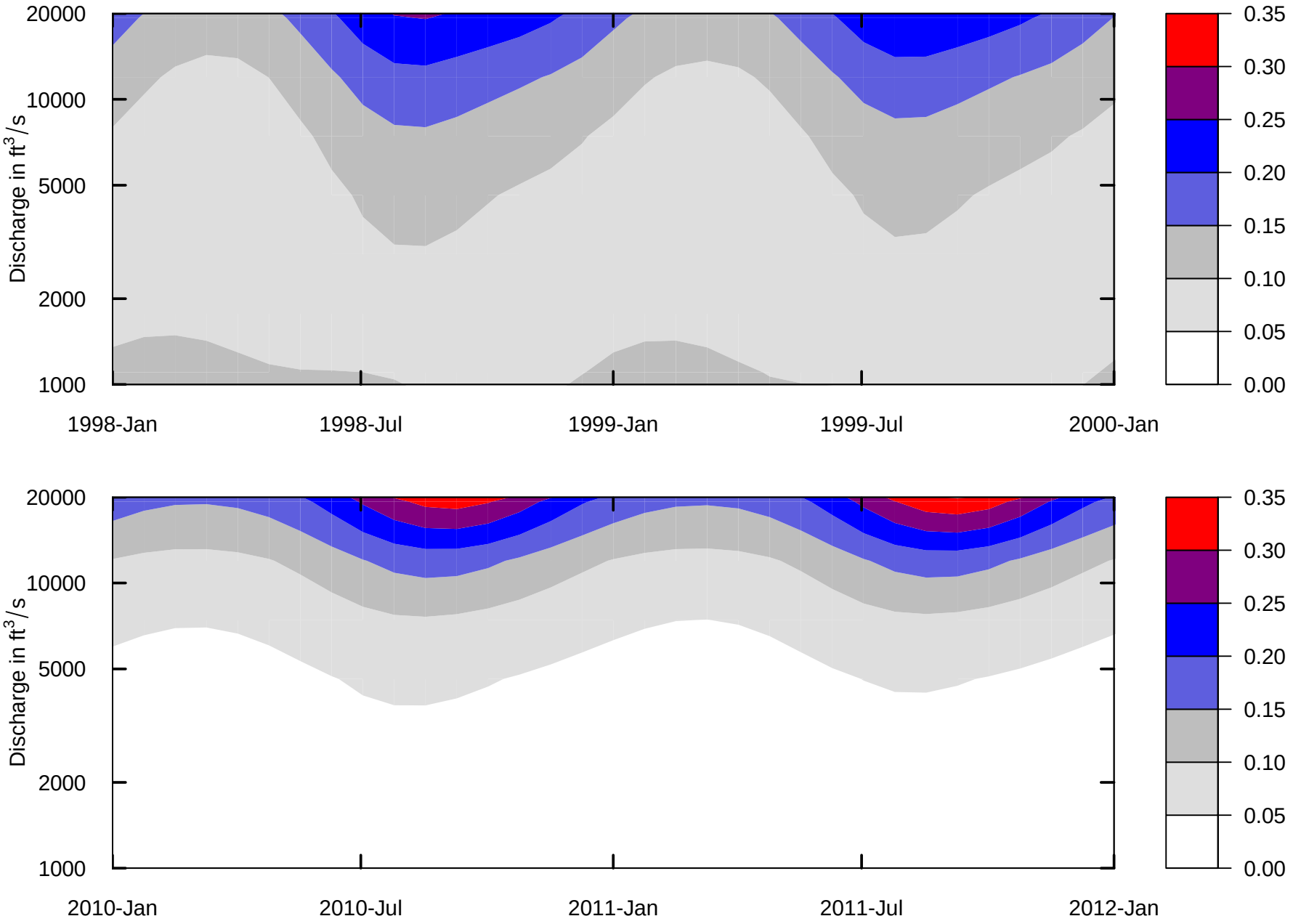
Flux Trends

time span			change	slope	change	slope
			10^6 kg/yr	10^6 kg/yr /yr	%	%/yr
1985	to	2000	-0.84	-0.056	-47	-3.1
1985	to	2013	-0.49	-0.017	-27	-0.97
2000	to	2013	0.35	0.027	38	2.9

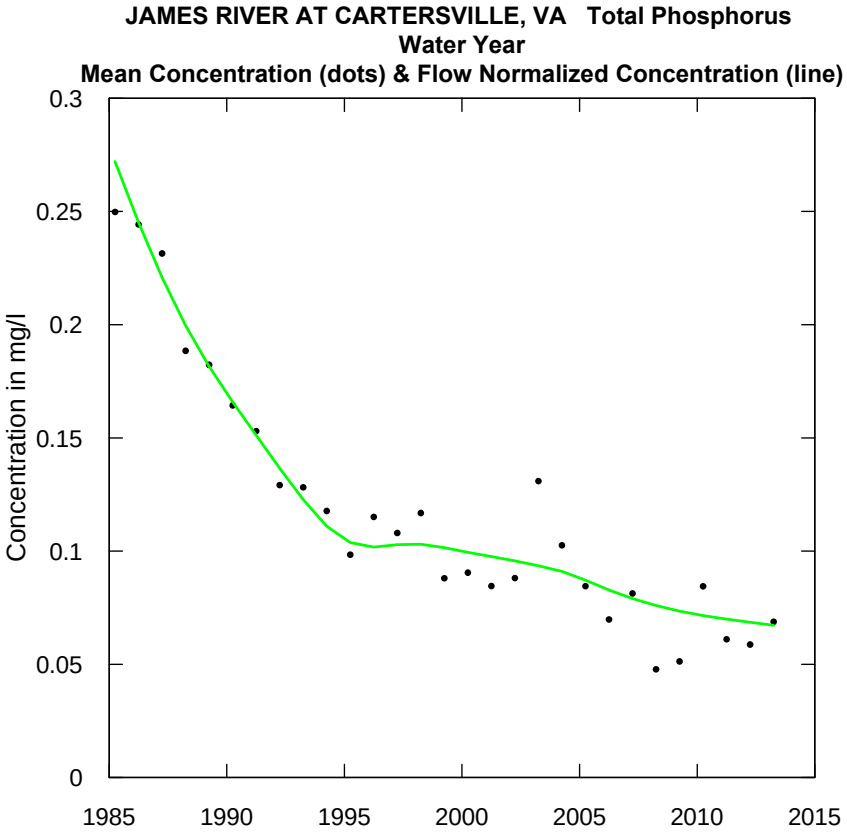


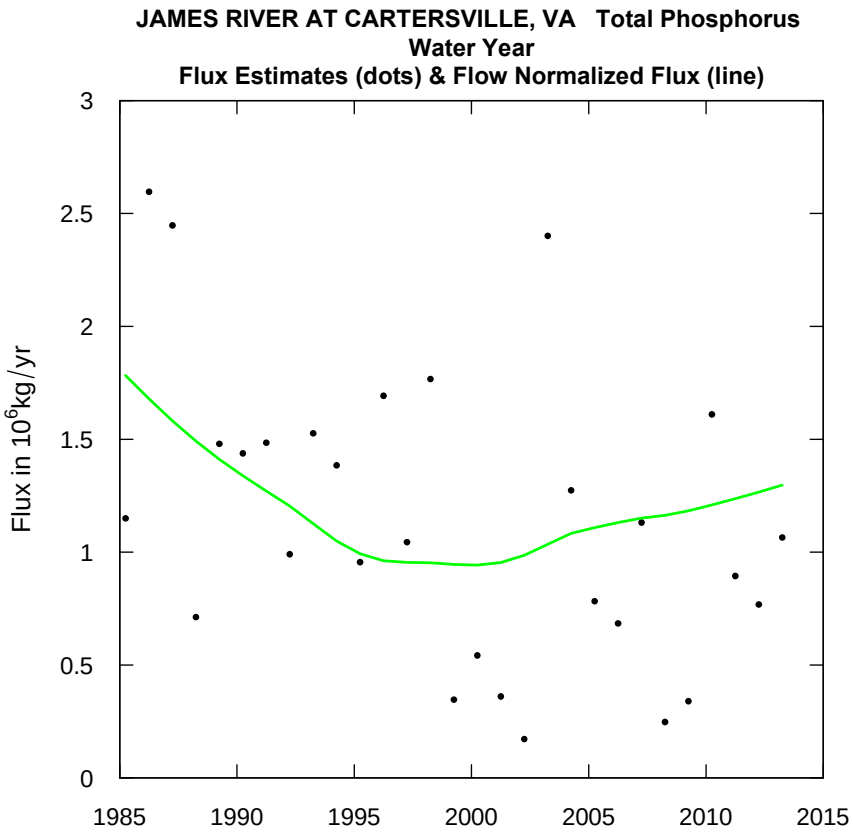
JAMES RIVER AT CARTERSVILLE, VA Total Phosphorus
Estimated Concentration Surface in Color





James River, TP trends





Uncertainty analysis: Code is written to do the following

- Accept or reject H_o (no trend) at $\propto = 0.1$ for FN Concentration and FN flux for any given start & end year (extensive Monte Carlo testing of method, more to come)
- Estimate the 90% CI on trend over that period (in real units or percent change)
- Display a 50% CI on the whole FN Concentration record and FN Flux record

Bootstrap Results James River TP

Results for the period 1985 - 2013

For Flow Normalized Concentration, Reject H_o: p < 0.03
For Flow Normalized Flux , Do not reject: p = 0.41

90% Confidence Interval for Slope of Concentration -109% to -19%
90% Confidence Interval for slope of Flux -75% to +42%

Results for the period 2000 – 2013

For Flow Normalized Concentration, Reject H_o: p = 0.01
For Flow Normalized Flux, Reject H_o: p = 0.07

90% Confidence Interval for Slope of Concentration, -51% to -16%
90% Confidence Interval for Slope of Flux, 3% to 72%

Bootstrap Results James River TP

Results for the period 1985 - 2000

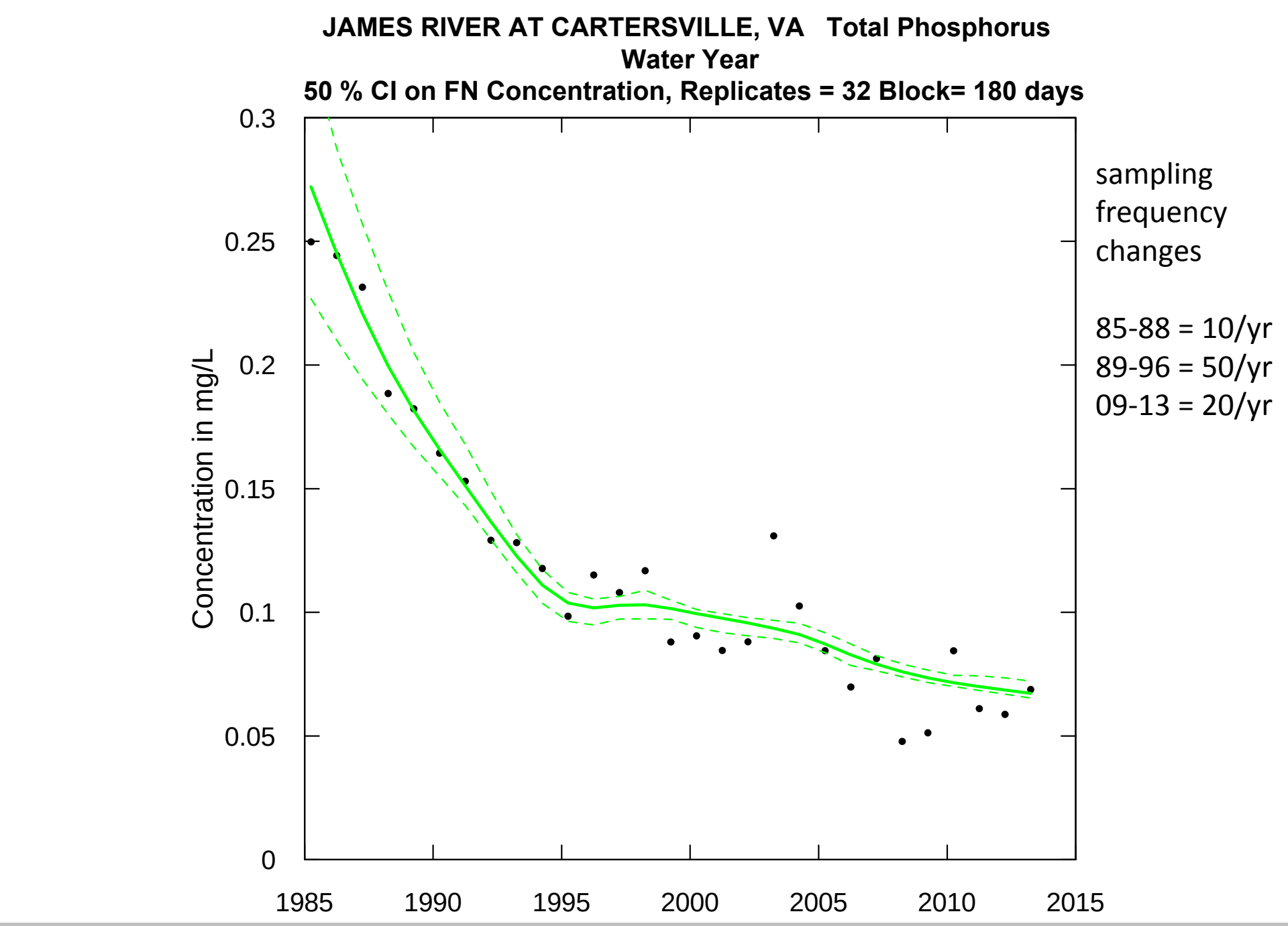
For Flow Normalized Concentration, Reject Ho: p = 0.02
For Flow Normalized Flux , Reject Ho: p = 0.06

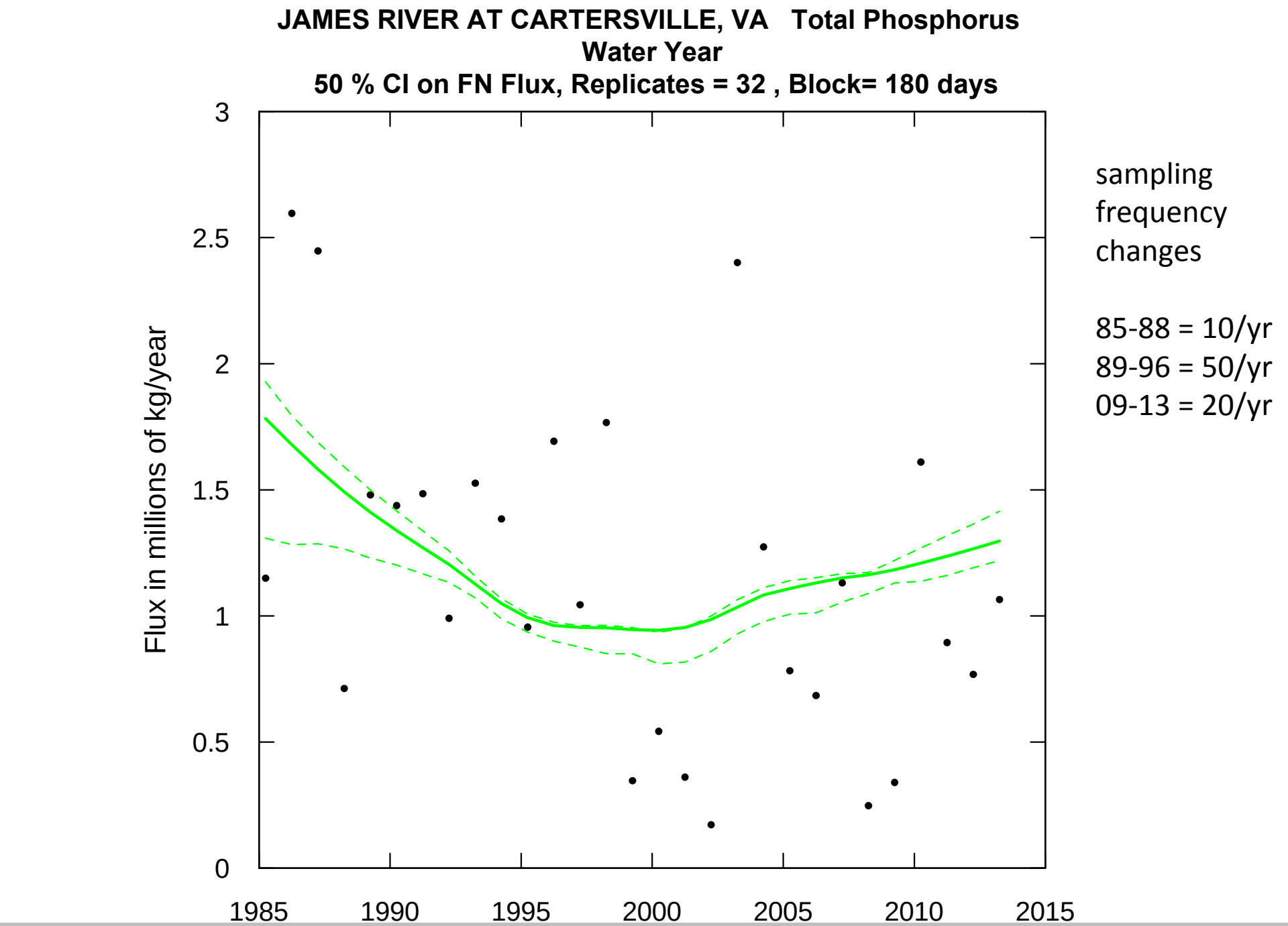
90% Confidence Interval for Slope of Concentration -90% to -26%
90% Confidence Interval for slope of Flux -76% to -9%

Results for the period 2000 – 2013

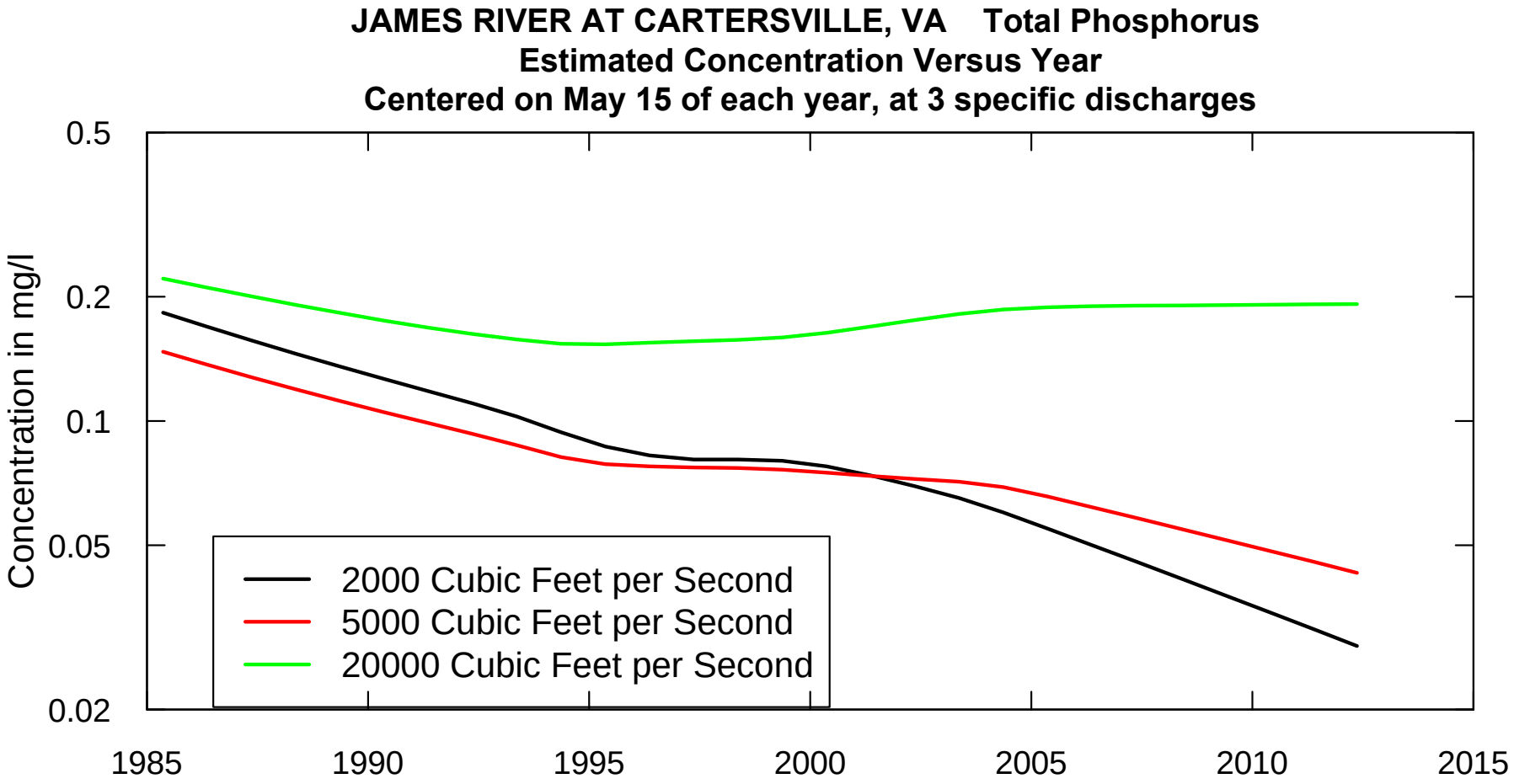
For Flow Normalized Concentration, Reject Ho, p = 0.01
For Flow Normalized Flux, Reject Ho, p = 0.07

90% Confidence Interval for Slope of Concentration, -51% to -16%
90% Confidence Interval for Slope of Flux, 3% to 72%



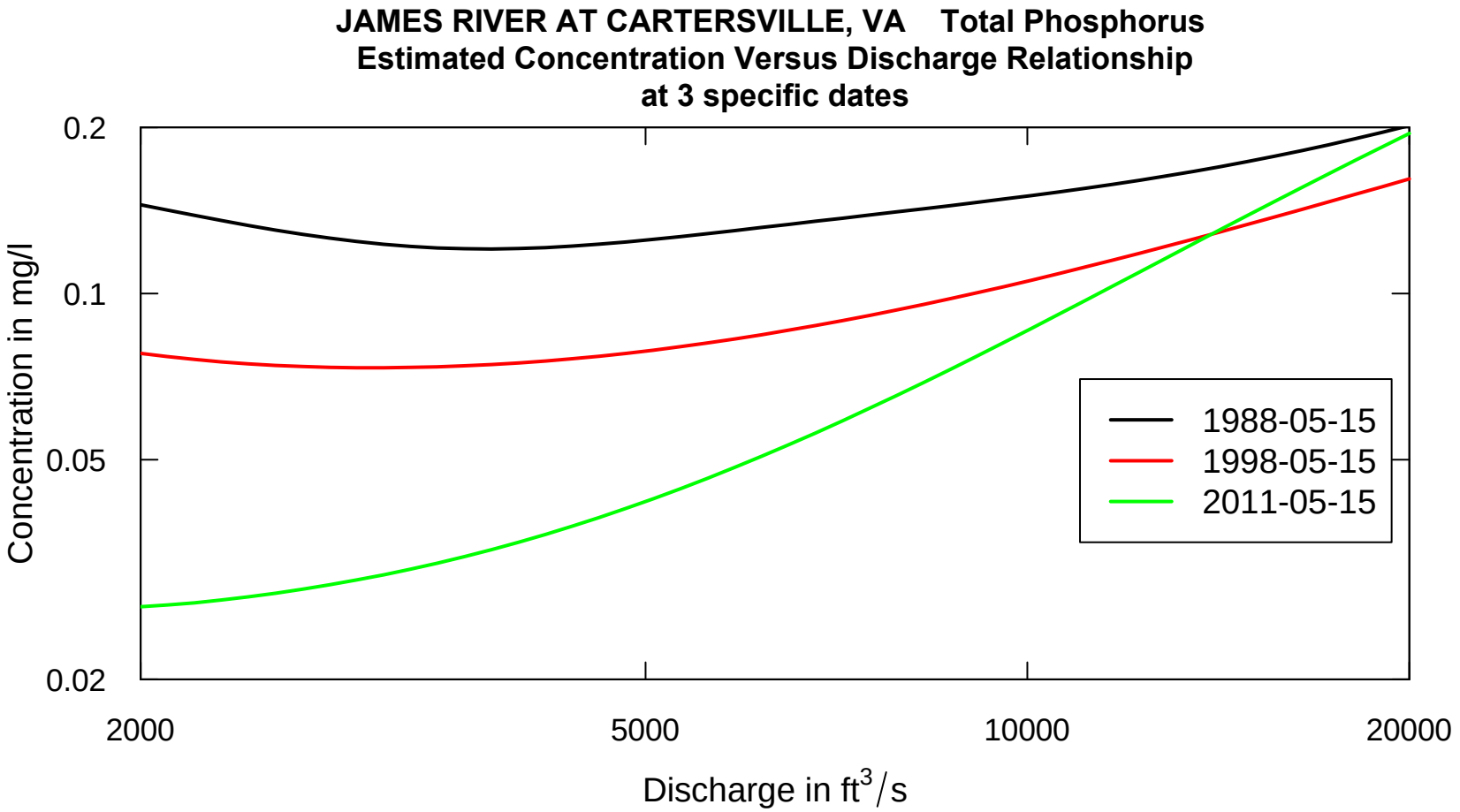


plotConcTimeSmooth(2000,5000,20000,"05-15",1985,2013,qUnit=1,logScale=TRUE)



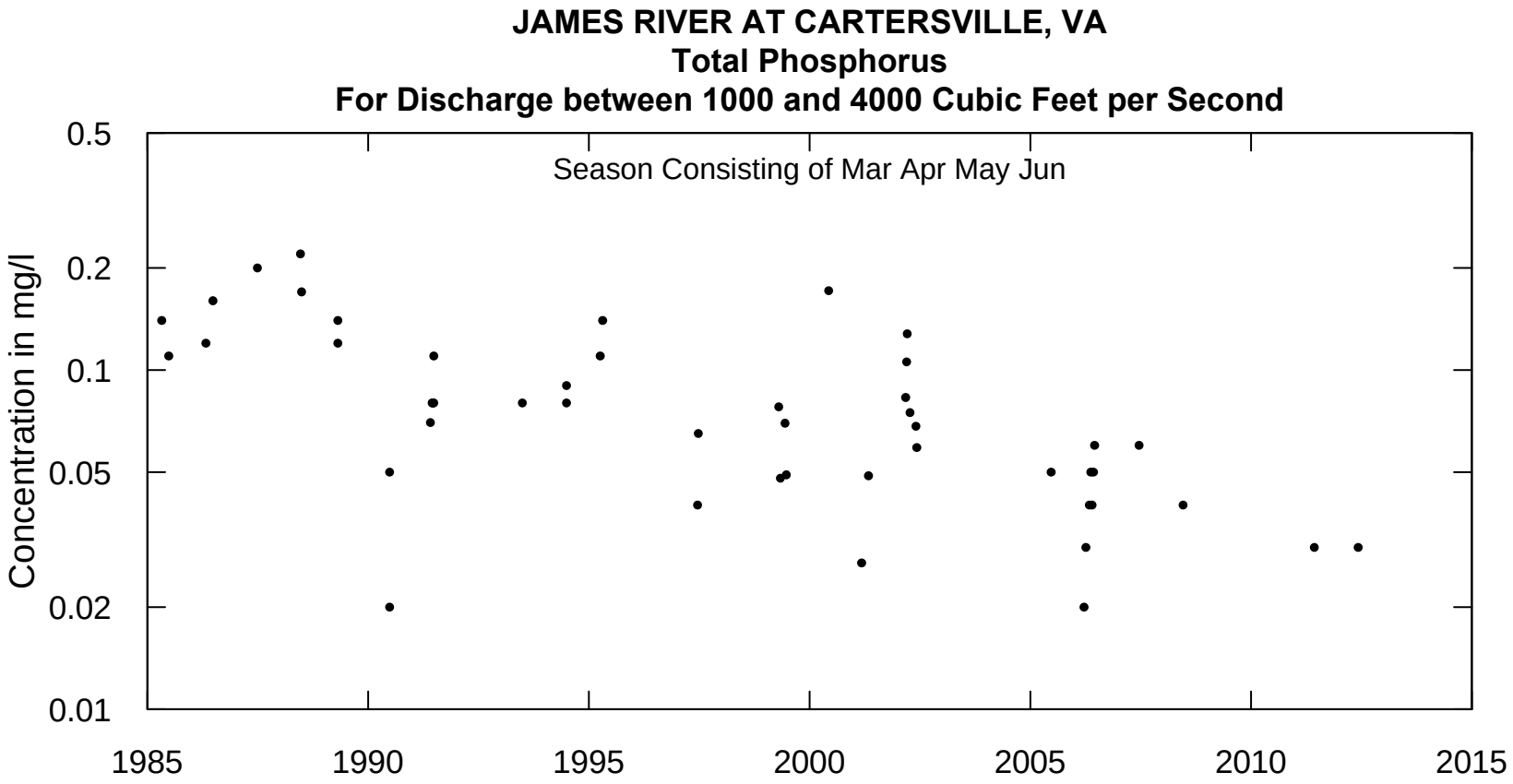
Note: Estimator requires that these curves all be linear or quadratic and that they all have the exact same shape and they never cross

plotConcQSmooth("1988-05-15","1998-05-15","2011-05-15",2000,20000,qUnit=1, legendLeft=11000,legendTop=0.07,logScale=TRUE,concMax=0.2)



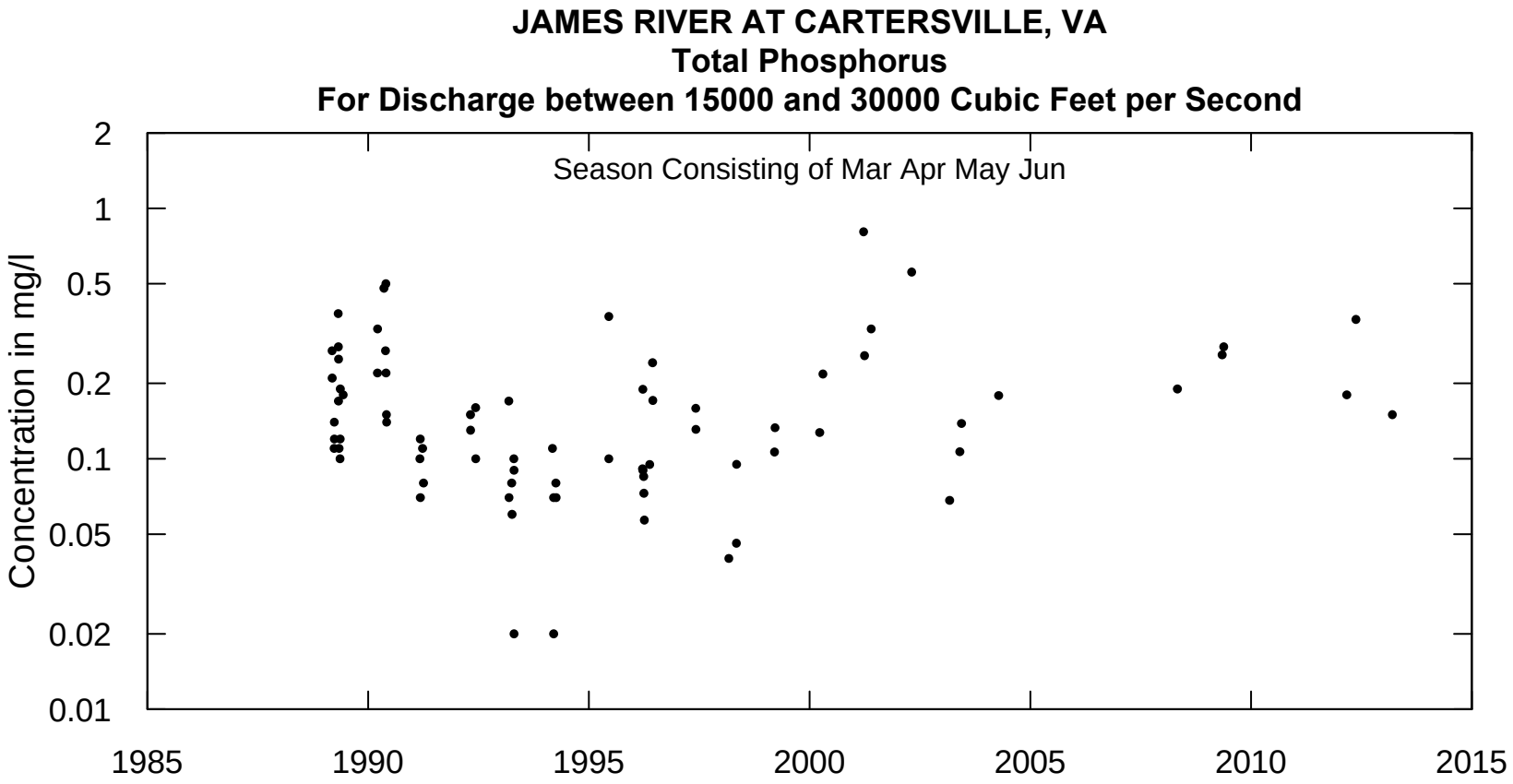
Note: Estimator requires that these curves all be linear or quadratic (not too bad here) and that they all have the exact same shape and they never cross

```
INFO<-setPA(paStart = 3,paLong = 4)
plotConcTime(qUnit=1,qLower=1000,qUpper=4000,logScale=TRUE)
```



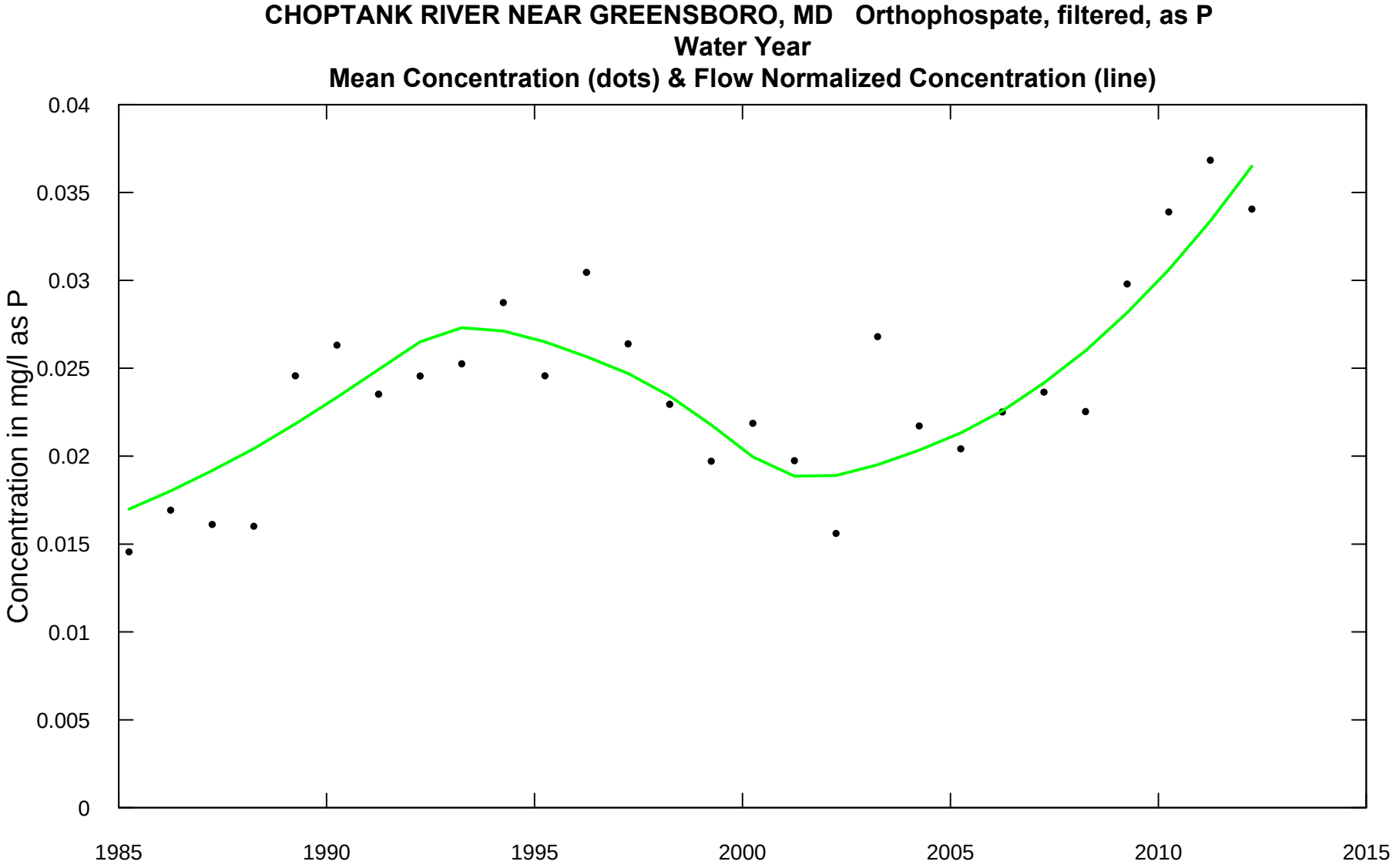
At low discharge, rather large long-term decline in concentration

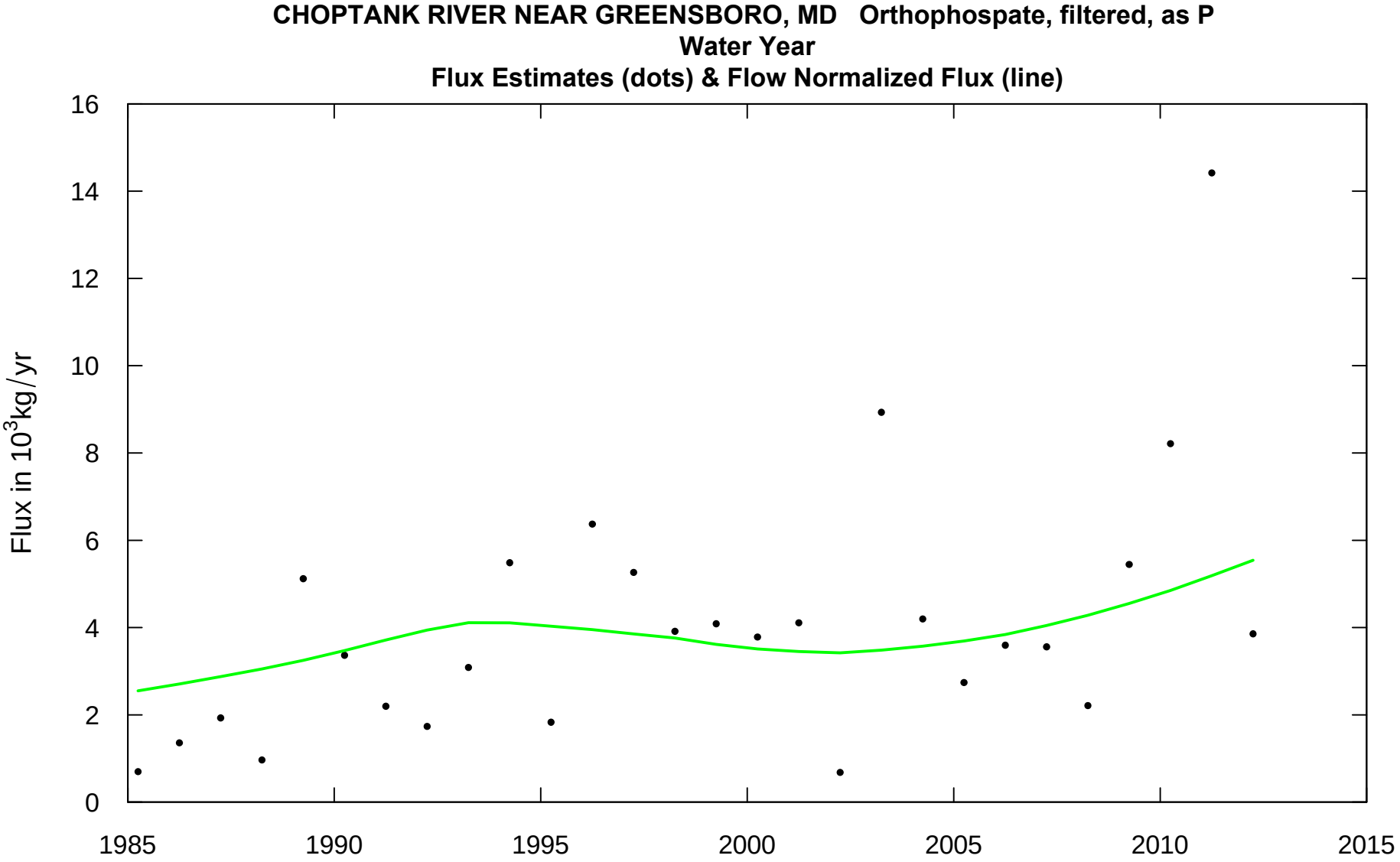
plotConcTime(qUnit=1,qLower=15000,qUpper=30000,logScale=TRUE,concMax=2)



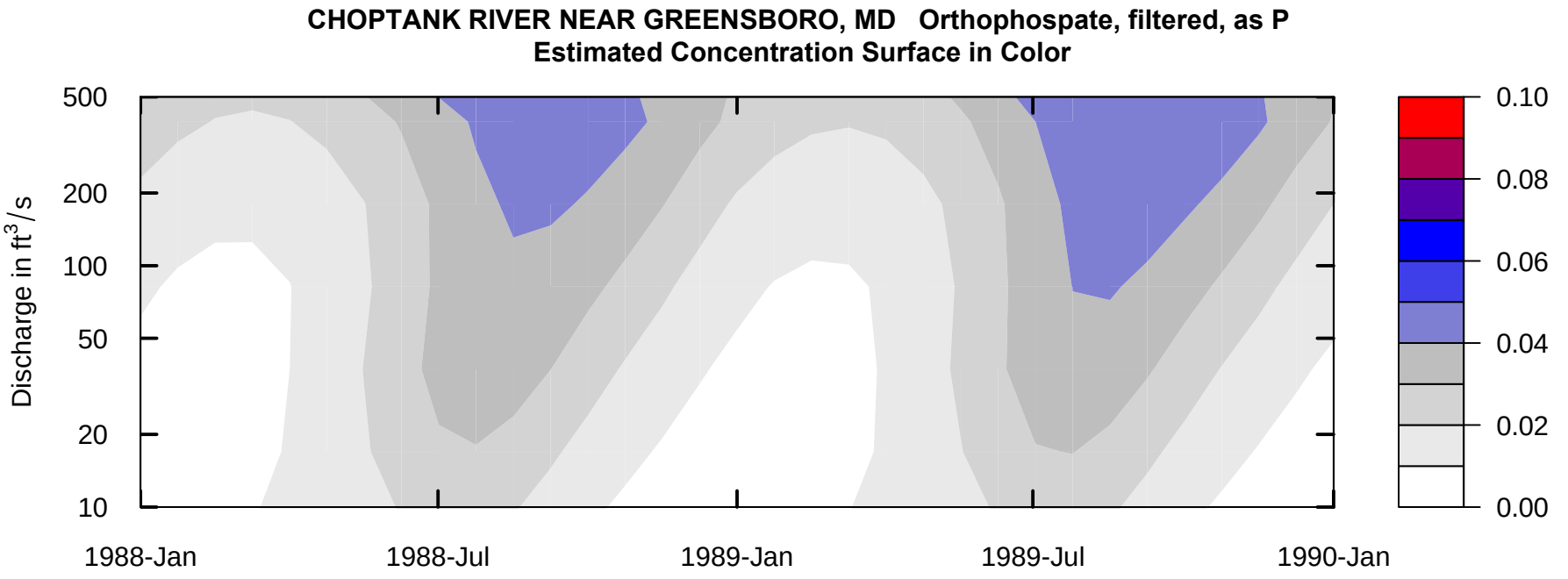
At high discharge, some ups and downs, more recently up, but no major long-term decline as is seen at low discharge

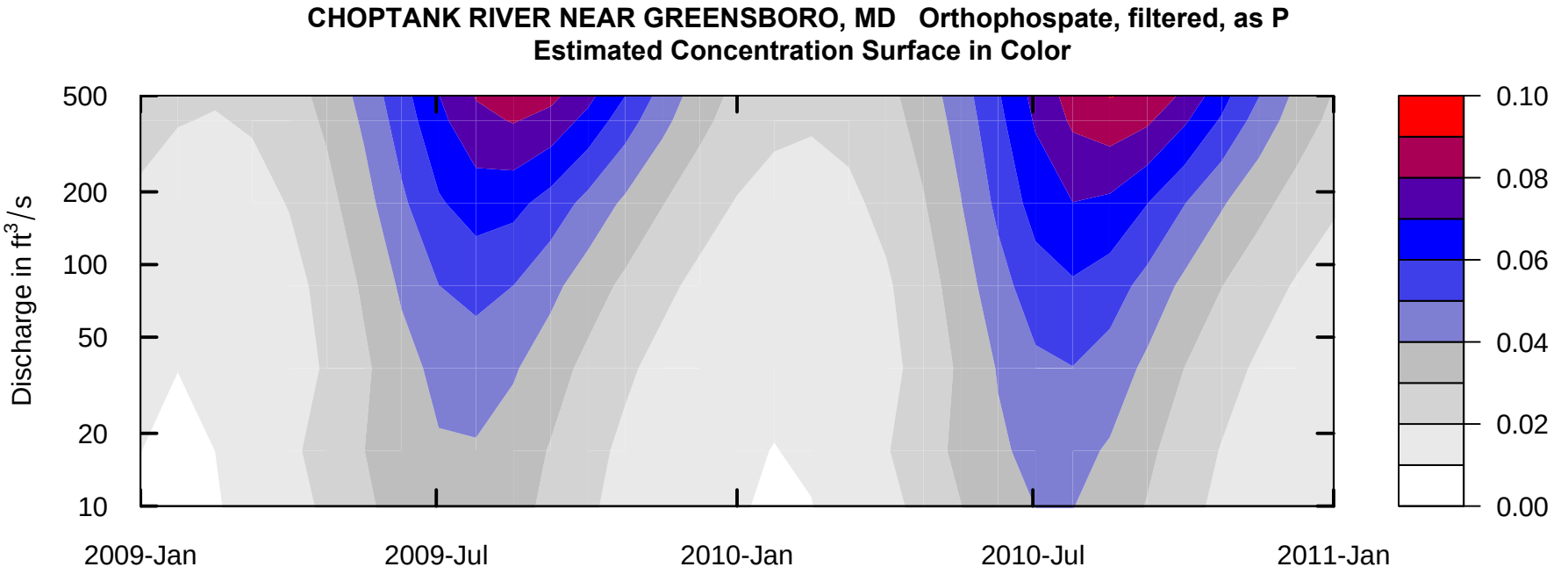
A quick look at Choptank River, Dissolved Orthophosphorus, 1985 - 2012





```
tableChange(fluxUnit=8,yearPoints=c(1985,2000,2012))

  CHOPTANK RIVER NEAR GREENSBORO, MD
  Orthophospate, filtered, as P
  Water Year

          Concentration trends
  time span        change      slope     change      slope
                     mg/L    mg/L/yr          %       %/yr

1985  to  2000      0.003      2e-04         17        1.2
1985  to  2012      0.019    0.00072        115        4.3
2000  to  2012      0.017     0.0014         83        6.9


                Flux Trends
  time span          change          slope        change          slope
                  10^3 kg/yr    10^3 kg/yr /yr         %          %/yr
1985  to  2000          0.96          0.064           38           2.5
1985  to  2012             3           0.11          117           4.3
2000  to  2012             2           0.17           58           4.8
```





Bootstrap results 2000 – 2012
Choptank, Dissolved Ortho P

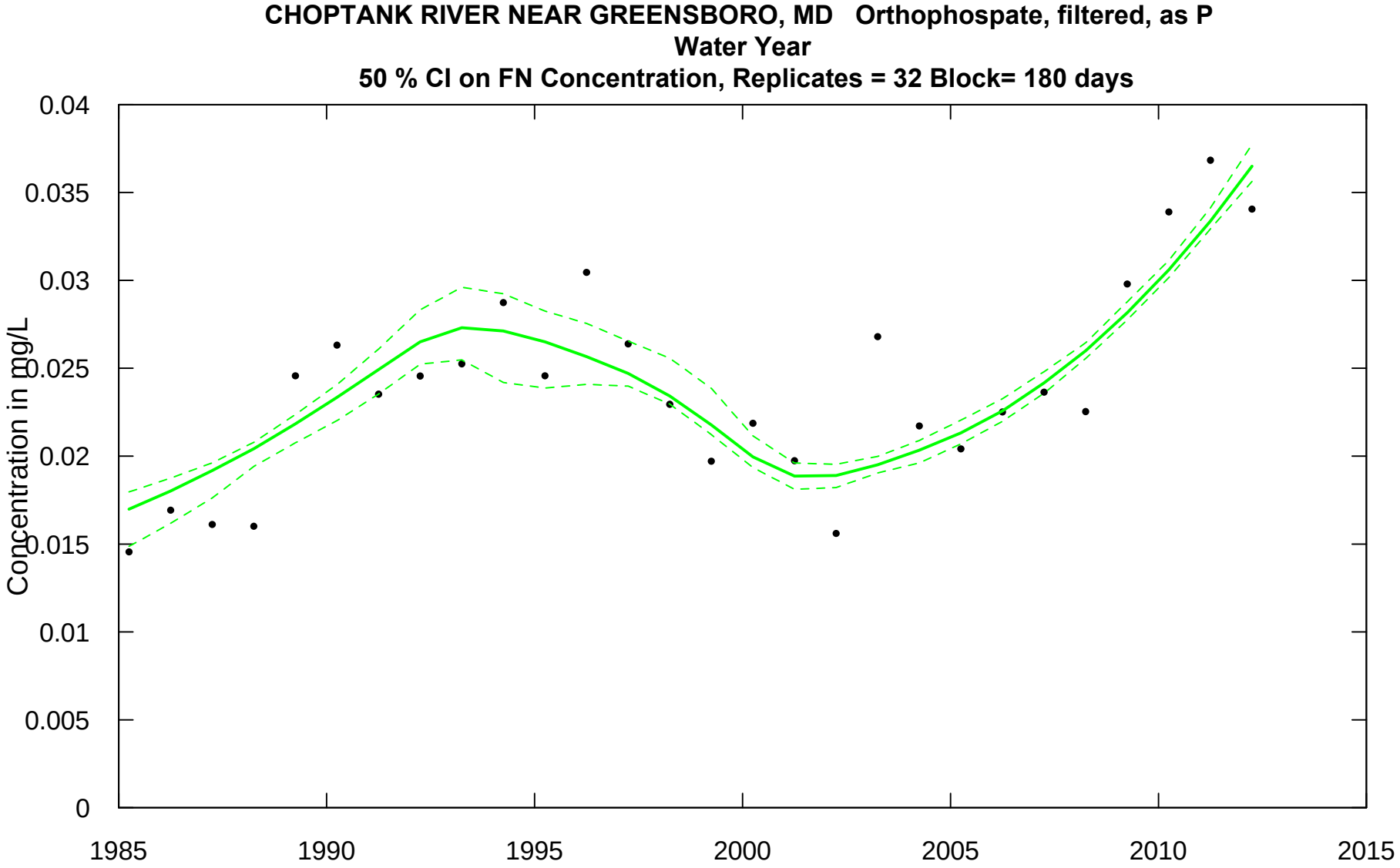
Reject H_o for FN Concentration: $p < 0.024$

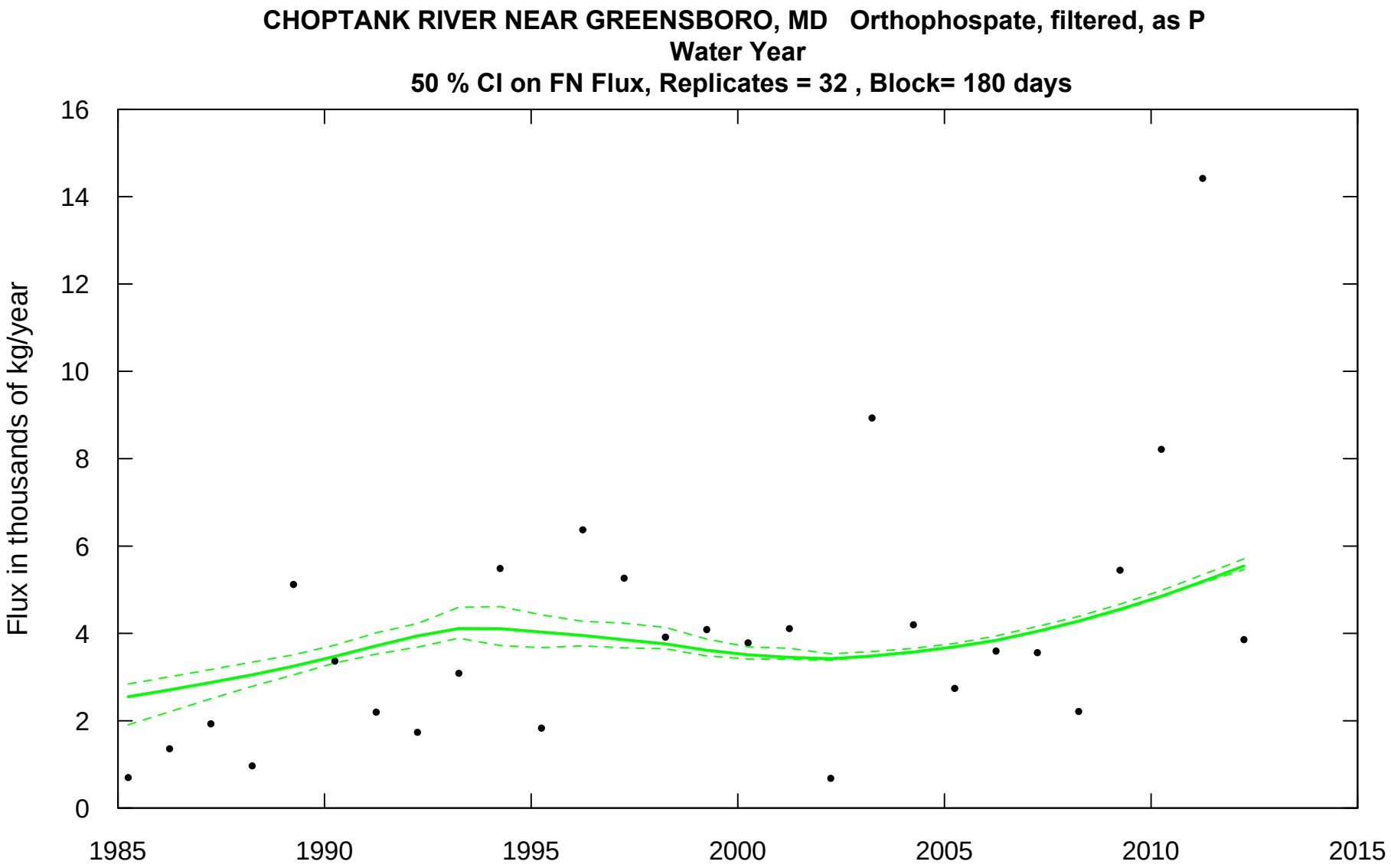
Reject H_o for FN Flux: $p < 0.024$

Estimated change over the period 2000 - 2012

Concentration 0.0165 mg/L, 90% CI (0.0107,0.0209)

Flux 2.03 10^3 kg/yr, 90% CI (1.50, 2.60)





My reaction

- The phosphorus story on the Eastern Shore is a big issue: because of proximity to the Bay and intensity of the agriculture.
- This Choptank example and an earlier look I took at the Nanticoke at Bridgeville both suggest substantial upwards trends since 2000.
- One of the big nutrient management questions for the Bay watershed is the growing amount of stored P in soils (particularly from animal waste) that this stored P is moving increasing amounts of P to streams in runoff events.

When all is said and done:

The only way to figure out what is happening to our planet is to measure it,

and this means tracking changes decade after decade

and poring over the records.

dataDelivery and EGRET

- Information and software available at: https://github.com/USGS-R/EGRET/wiki

dataRetrieval and EGRET give you a toolbox to help you pore over the records. I hope you will use those tools.