Comprehensive Measurements of Rate Processes and Water Quality on the Potomac Estuary, August 2010

Lora Harris, Walter Boynton, Jeff Cornwall, Sujay Kaushal, Casey Sperling, Eva Bailey, Mike Owens, Melissa Day, Meghann Niesen, & Michael Pennino
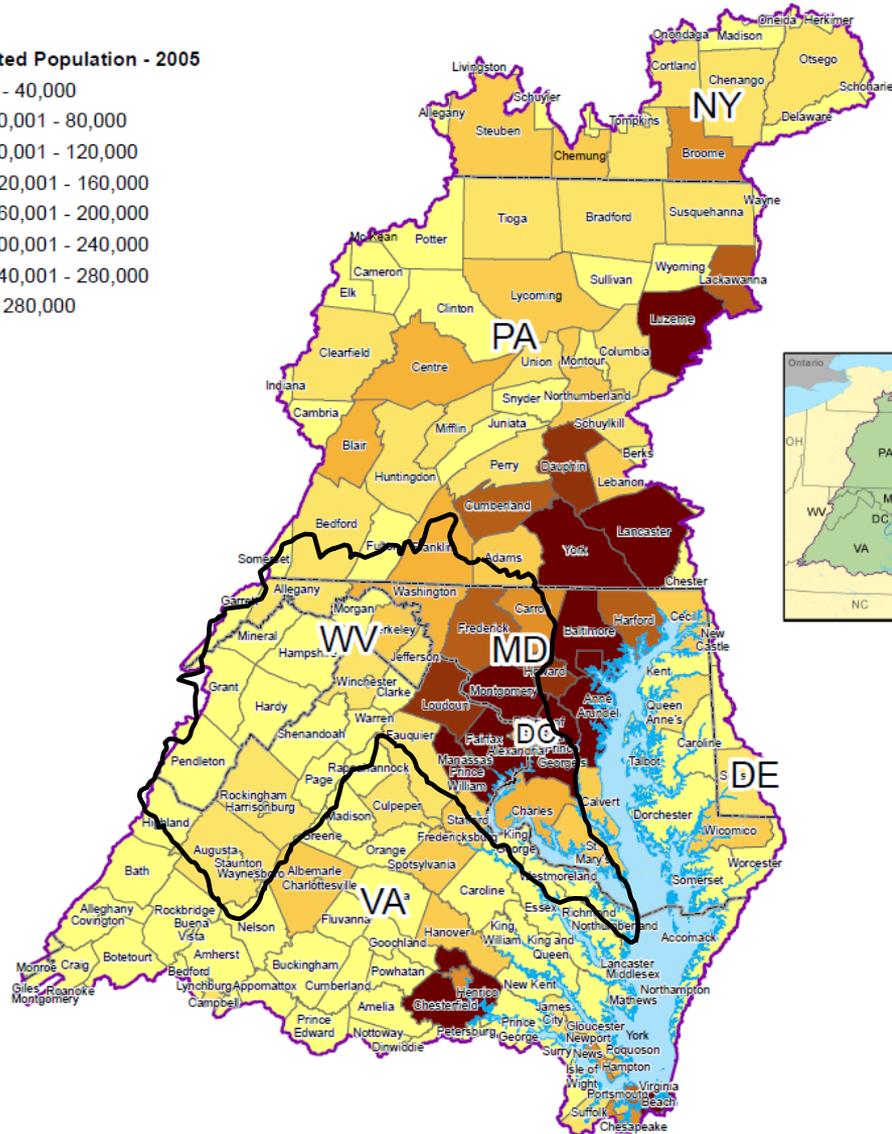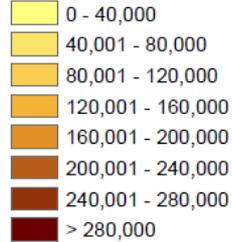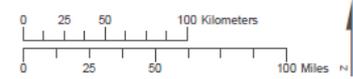
Population (2005)
Chesapeake Bay Watershed Counties

Chesapeake Bay Program
A Watershed Partnership

Estimated Population - 2005

- 0 - 40,000
- 40,001 - 80,000
- 80,001 - 120,000
- 120,001 - 160,000
- 160,001 - 200,000
- 200,001 - 240,000
- 240,001 - 280,000
- > 280,000

NY

PA

WV

MD

DC

DE

VA

Oneida Herkimer
Onondaga Madison
Livingston
Cortland Chenango Otsego
Schuyler Schoharie
Allegany Tompkins Delaware
Steuben Chemung Broome Wayne
Tioga Bradford Susquehanna
McKean Potter Sullivan Wyoming Lackawanna
Cameron Lycoming Luzerne
Elk Clinton Columbia
Clearfield Union Montour
Centre Snyder Northumberland
Indiana Mifflin Juniata Schuylkill Berks
Cambria Perry Dauphin Lebanon
Blair Huntingdon Cumberland Lancaster
Bedford Fulton Franklin Adams York Chester
Somerset Allegany Washington Carroll Harford Cecil New Castle
Garrett Mt. Morgan Berkeley Frederick Baltimore Kent
Mineral Hampsh. Jefferson Howard Queen Anne's
Grant Winchester Clarke Montgomery Anne Arundel Caroline
Hardy Warren Loudoun Talbot
Shenandoah Fauquier Fairfax Alexandria Prince Georges Calvert Dorchester
Pendleton Rappahannock Manassas Prince William Charles Wicomico
Page Madison Culpeper Stafford King George St. Mary's Worcester
Rockingham Harrisonburg Greene Orange Spotsylvania Westmoreland Somerset
Highland Augusta Albemarle Caroline Essex Richmond Northumberland Accomack
Staunton Waynesboro Charlottesville Fluvanna Hanover King William King and Queen Lancaster Middlesex Northampton
Bath Nelson Goochland Mathews
Alleghany Covington Rockbridge Buena Vista Amherst Buckingham Powhatan New Kent James City York
Monroe Craig Bedford Cumberland Henrico Charles City Gloucester Poquoson
Giles Roanoke Lynchburg Appomattox Amelia Chesterfield Prince George Newport News Hampton
Montgomery Campbell Prince Edward Nottoway Petersburg Surry Isle of Wight Portsmouth Virginia Beach
Dinwiddie Suffolk Chesapeake

Ontario
OH NY
PA NJ
WV MD DC DE
VA
NC
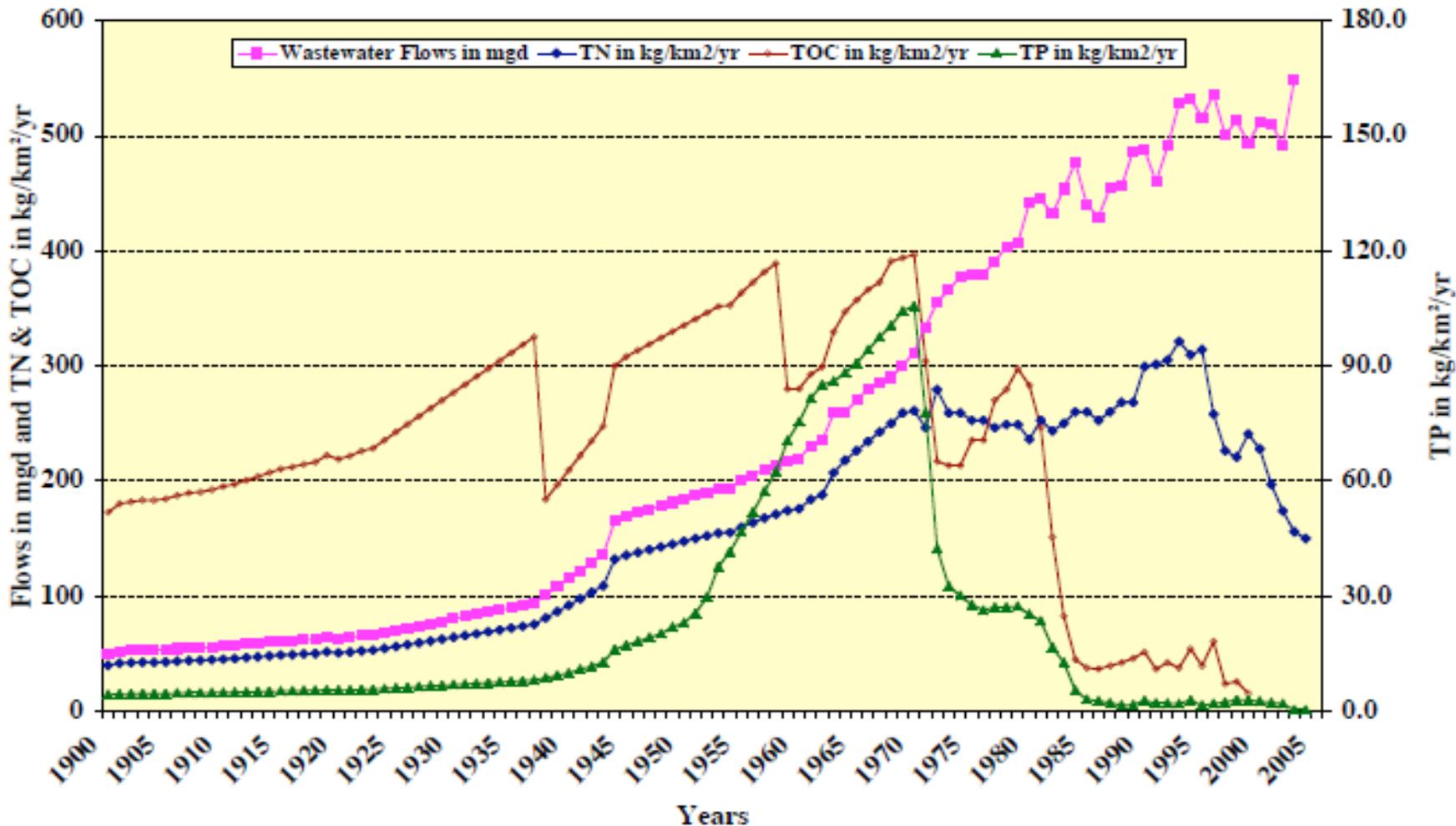Atlantic Ocean

Data Sources: US Census.

For more information, visit *www.chesapeakebay.net*
Disclaimer: *www.chesapeakebay.net/termsofuse.htm*

0 25 50 100 Kilometers
0 25 50 100 Miles

Created by JW, 2/13/08
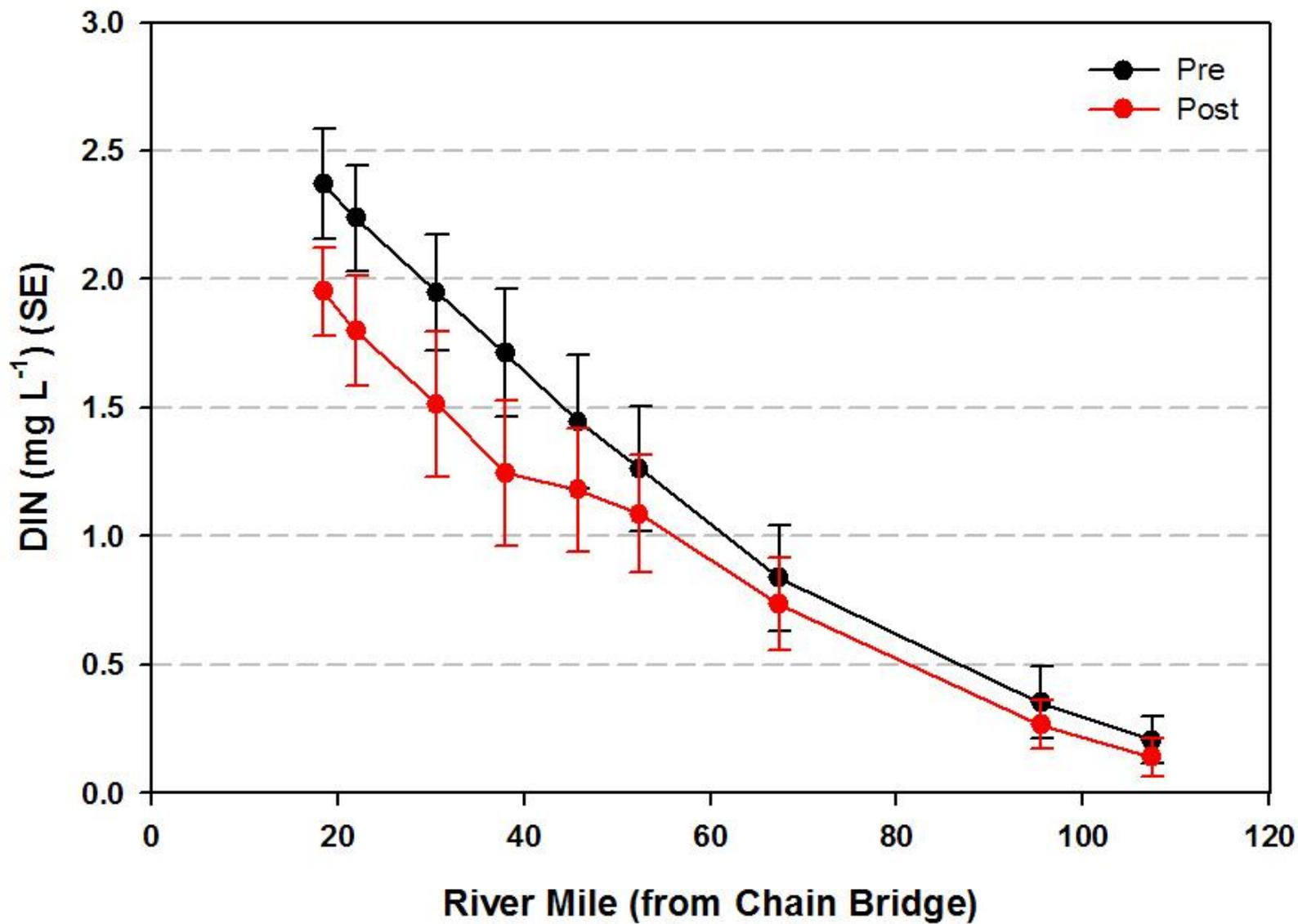
UTM Zone 18N, NAD 83

Courtesy Boynton Lab Group

Potomac Estuary Tidal WWTP Discharge Nutrient Trends

Jaworski Treatise

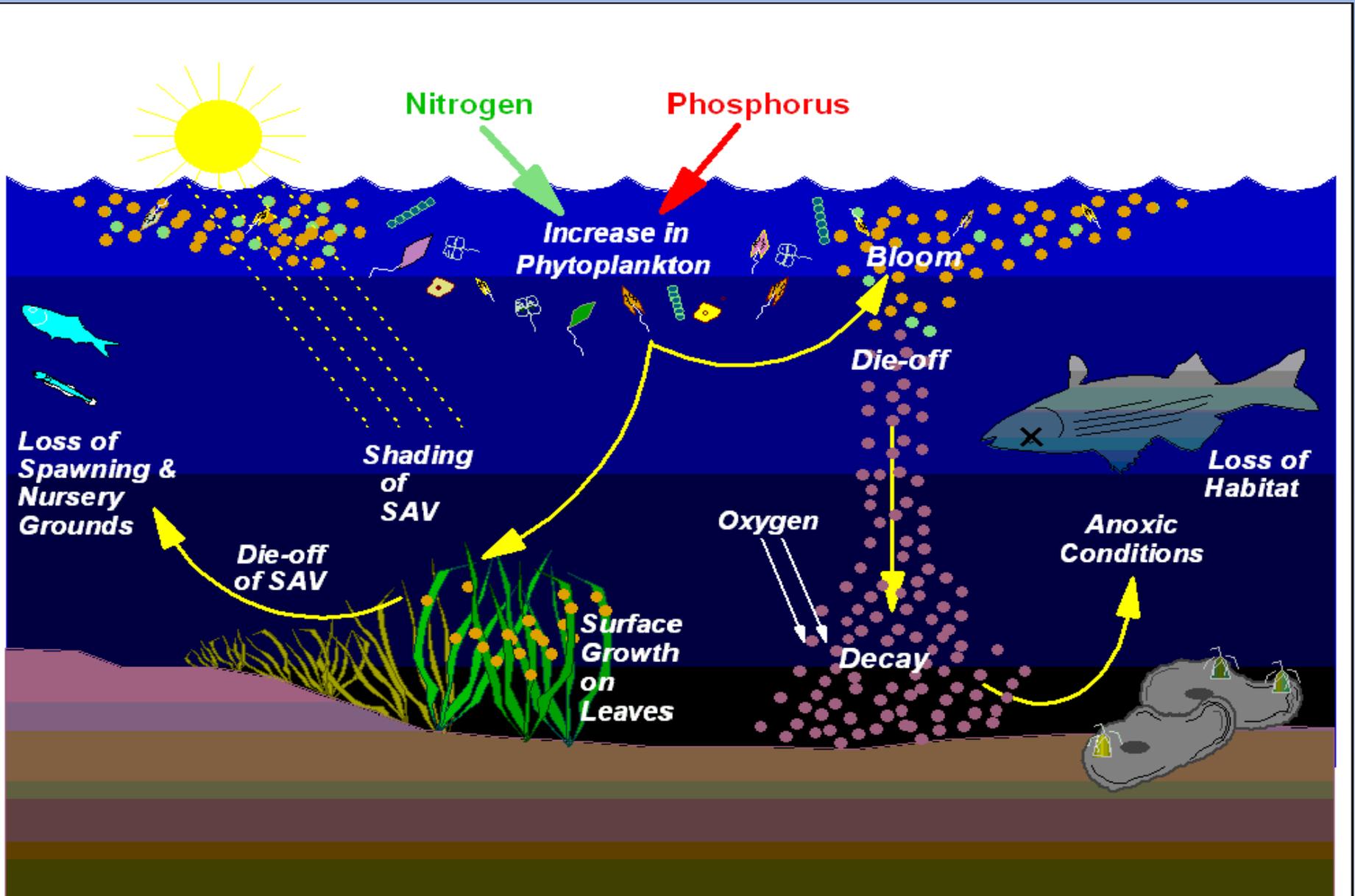# Comparison of Pre- and Post Denitrification at Blue Plains (1985 - 1996)
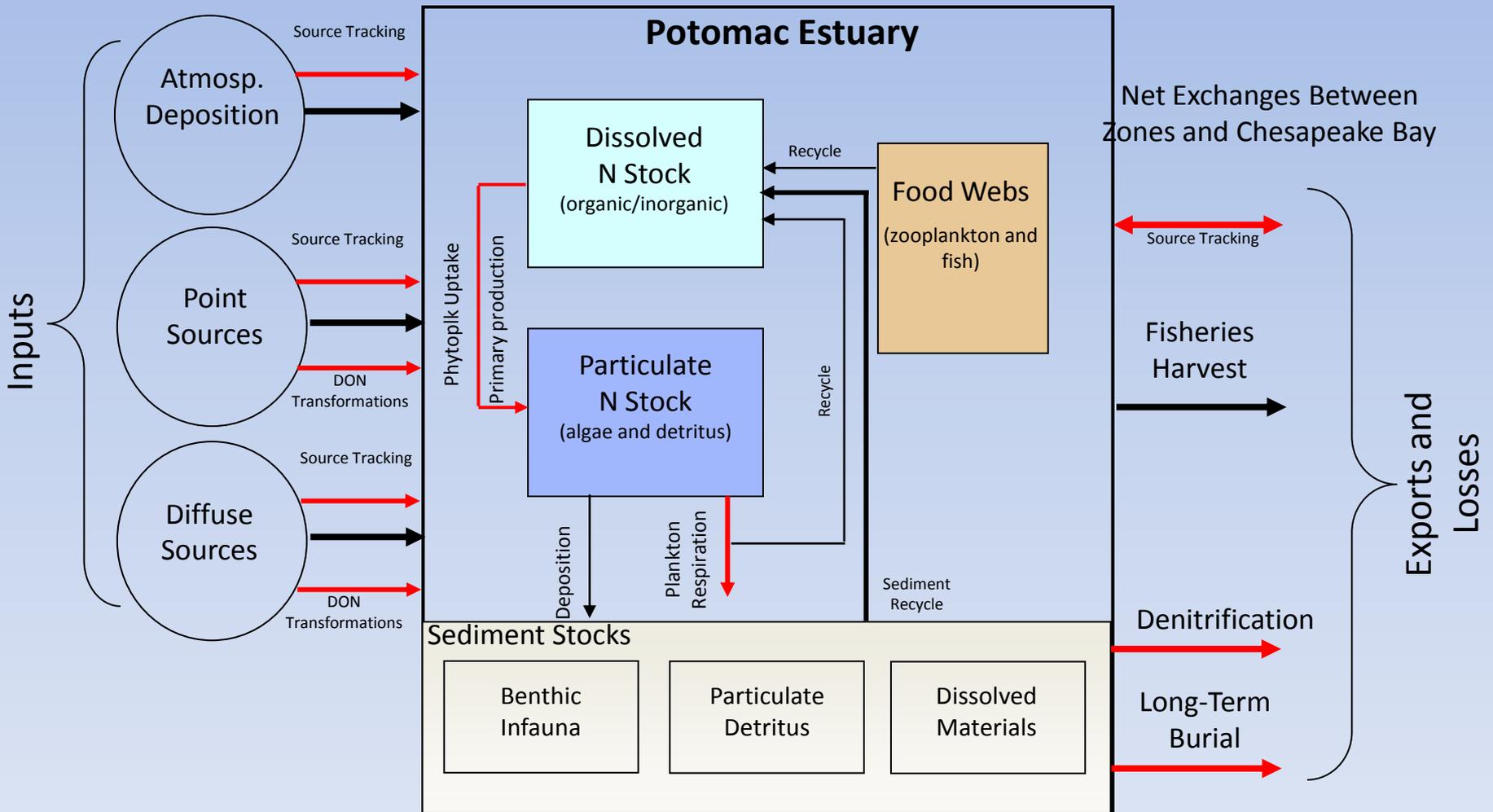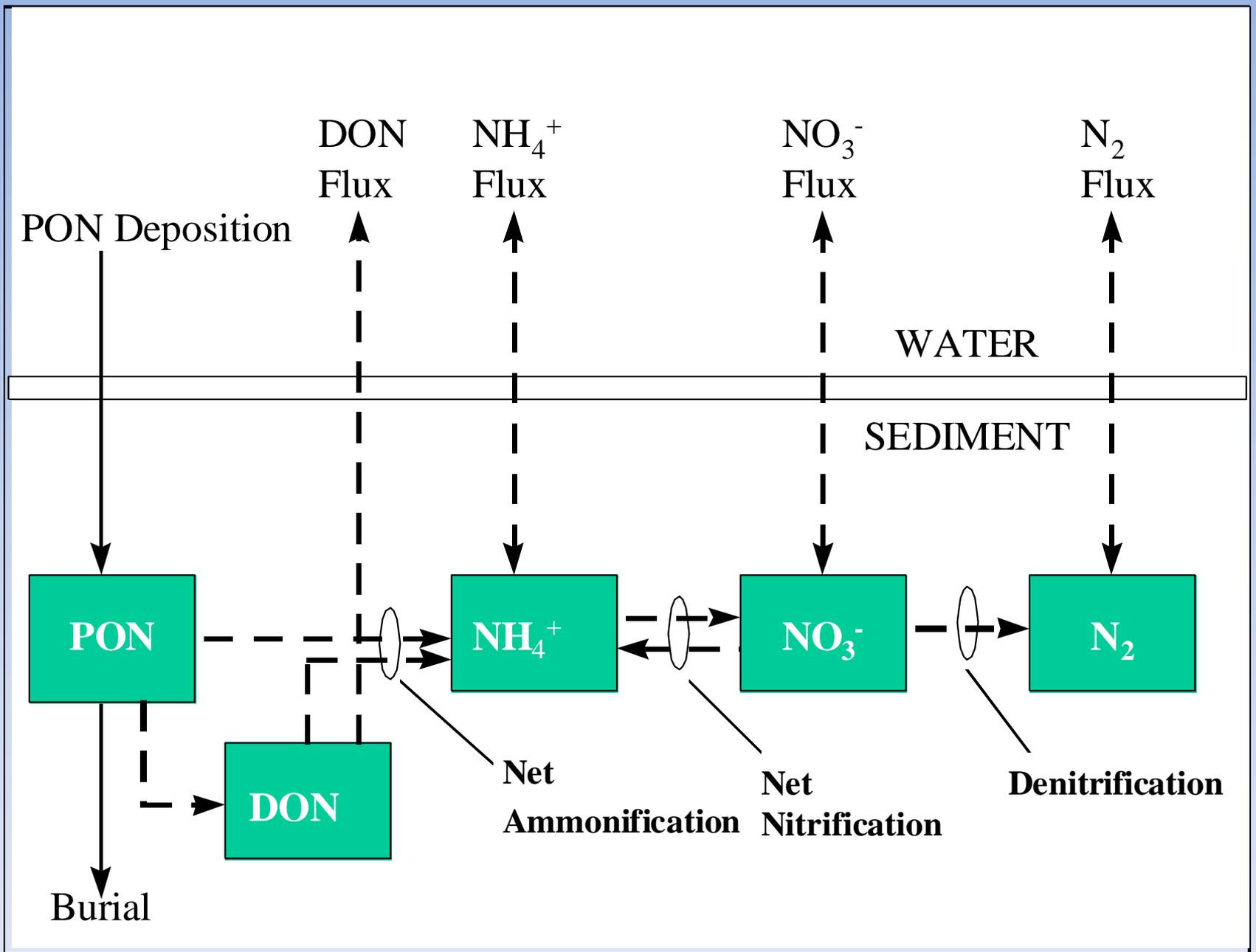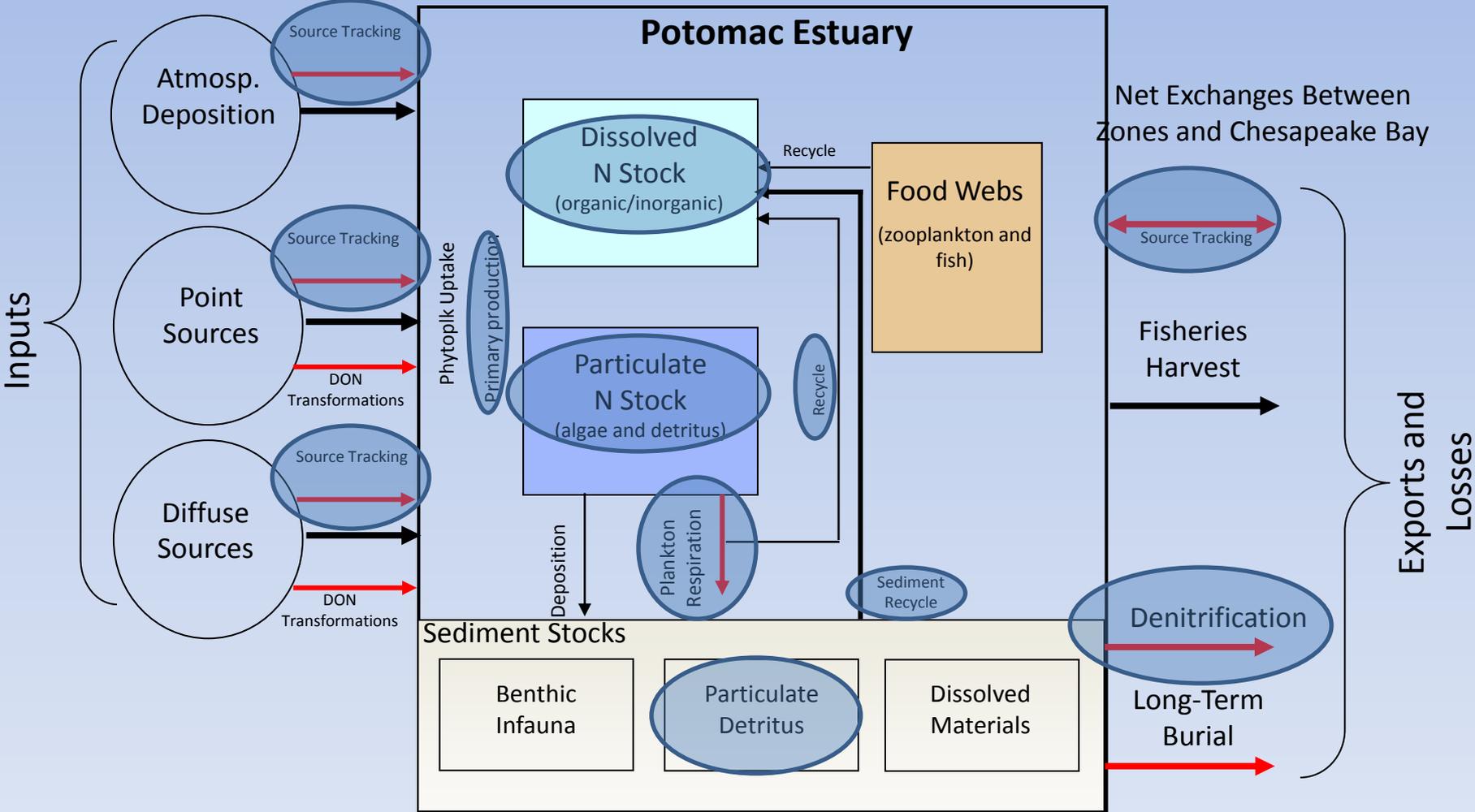

Courtesy Boynton Lab Group

Image courtesy Boynton Lab Group

Conceptual Diagram of Nitrogen Mass Balance for Potomac Estuary

Potomac Estuary

Inputs

Atmosp. Deposition

Source Tracking

Point Sources

Source Tracking

DON Transformations

Diffuse Sources

Source Tracking

DON Transformations

Phytoplk Uptake

Primary production

Dissolved N Stock (organic/inorganic)

Particulate N Stock (algae and detritus)

Recycle

Food Webs (zooplankton and fish)

Recycle

Deposition

Plankton Respiration

Sediment Recycle

Net Exchanges Between Zones and Chesapeake Bay

Source Tracking

Fisheries Harvest

Exports and Losses

Sediment Stocks

Benthic Infauna

Particulate Detritus

Dissolved Materials

Denitrification

Long-Term Burial

Image courtesy J Cornwell

Monitoring of Potomac Water Quality Supported by DC WATER Includes:

Monthly

- Local Cruises Between Gravelly Point and Fort Washington
- Measurements using MD DNR Monthly Cruise collected water
  - light attenuation, salinity, pH, temperature
  - dissolved and particulate nutrients, dissolved oxygen
  - primary production, respiration, chl a, HPLC pigments
  - DNA, taxonomy by microscopy
 - source tracking using eem's and stable isotopes

More intensive Source Tracking Stations
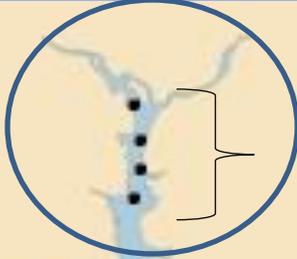
CBL 1 - 4

Long-term Biodiversity Monitoring

TF 2.1 – 2.4

RET 2.1, 2.2, 2.4

LE 2.1, 2.2
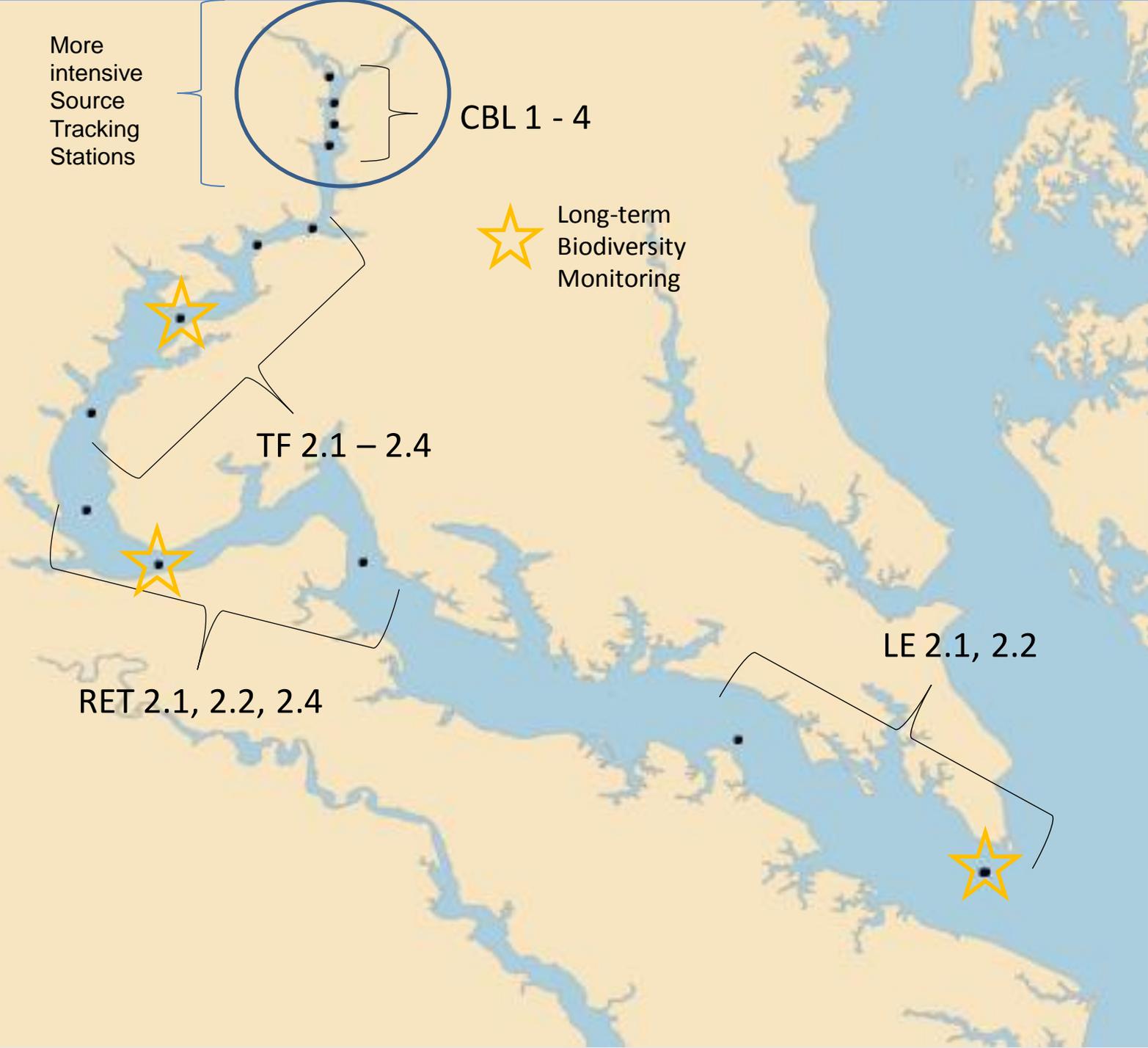
Monitoring of Potomac Water Quality Supported by DC WATER Includes:

Rachel Carson Cruise

- light attenuation, salinity, pH, temperature
- dissolved and particulate nutrients, dissolved oxygen
- primary production, respiration, chl a, HPLC pigments
- DNA, taxonomy by microscopy
- source tracking using fluorescence indicators and stable isotopes
- *Sediment flux measurements: denitrification, sediment oxygen demand, NH4+ and NO2/NO3 fluxes*
- *sediment nutrient concentrations, sediment*

Graduate Student Research

Meghann Niesen, M.S. candidate UMCES-CBL

1. *Are primary production rates influenced by biodiversity in the Potomac?*
2. *How do molecular approaches compare with microscopic identification when measuring metrics of biodiversity?*

Biodiversity and Production in the Potomac River

- ◆ Tidal Fresh
- ▲ River Estuarine Transition
- ○ Lower Estuarine
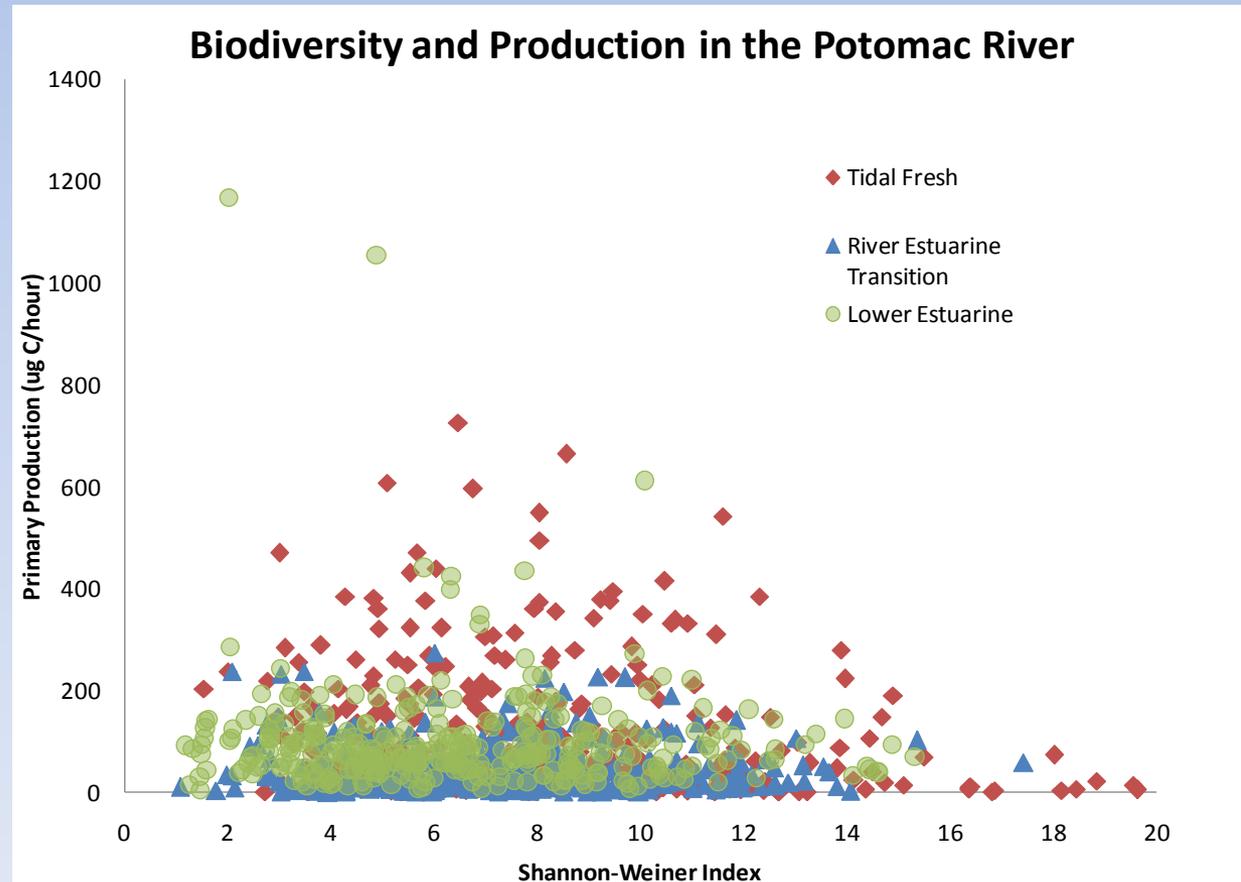
Graduate Student Research

Katherine Ziombra, M.S. candidate UMCES-CBL

1. *What models of primary production are effective in the tidal fresh Potomac?*
2. *How have patterns of water column nitrogen concentrations changed in the context of management actions at the Blue Plains Wastewater Treatment Plant?*
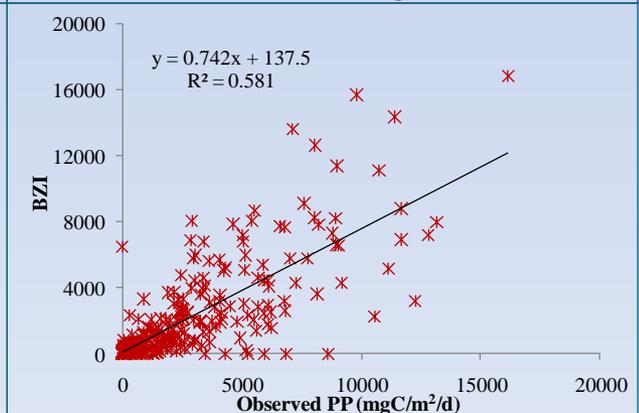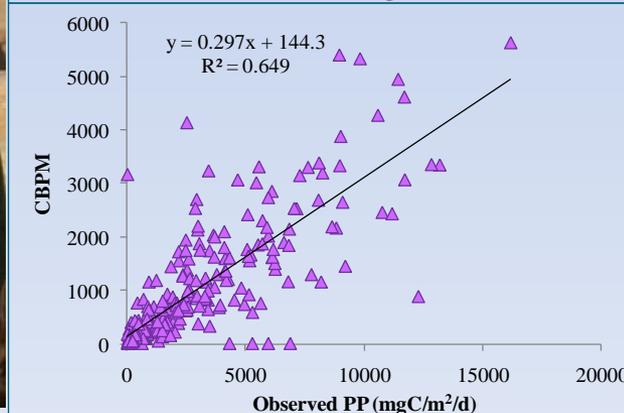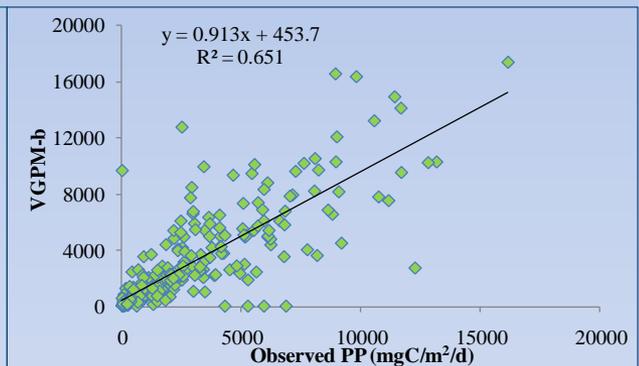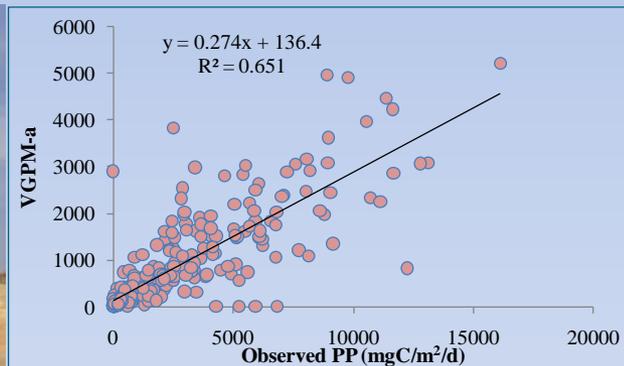
Graduate Student Research

Michael Pennino, *PhD candidate UMBC*

1. *Can a combination of δN15 and δO18 stable isotopic tracers be used for source tracking of Blue Plains wastewater effluent in the Potomac?*
2. *Will excitation emission matrices and associated fluorescence indices complement isotopic tracers for improved modeling of effluent plumes?*

Forest, Agricultural, and Suburban Watersheds
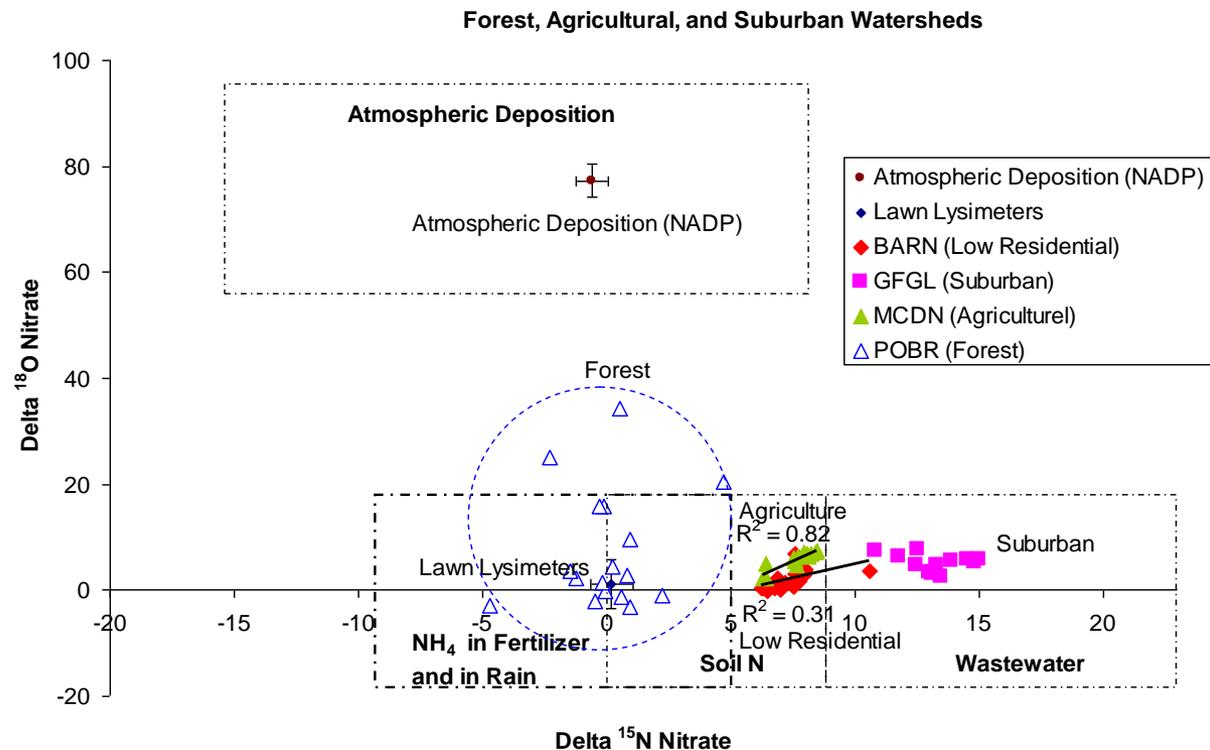
Graduate Student Research

Melinda Forsyth, M.S. candidate UMCES-CBL

1. *Do oyster morphology and orientation affect particle capture and, ultimately, oyster growth?*
2. *Can an individual-based bioenergetic oyster model incorporating morphology inform restoration efforts on the Potomac?*
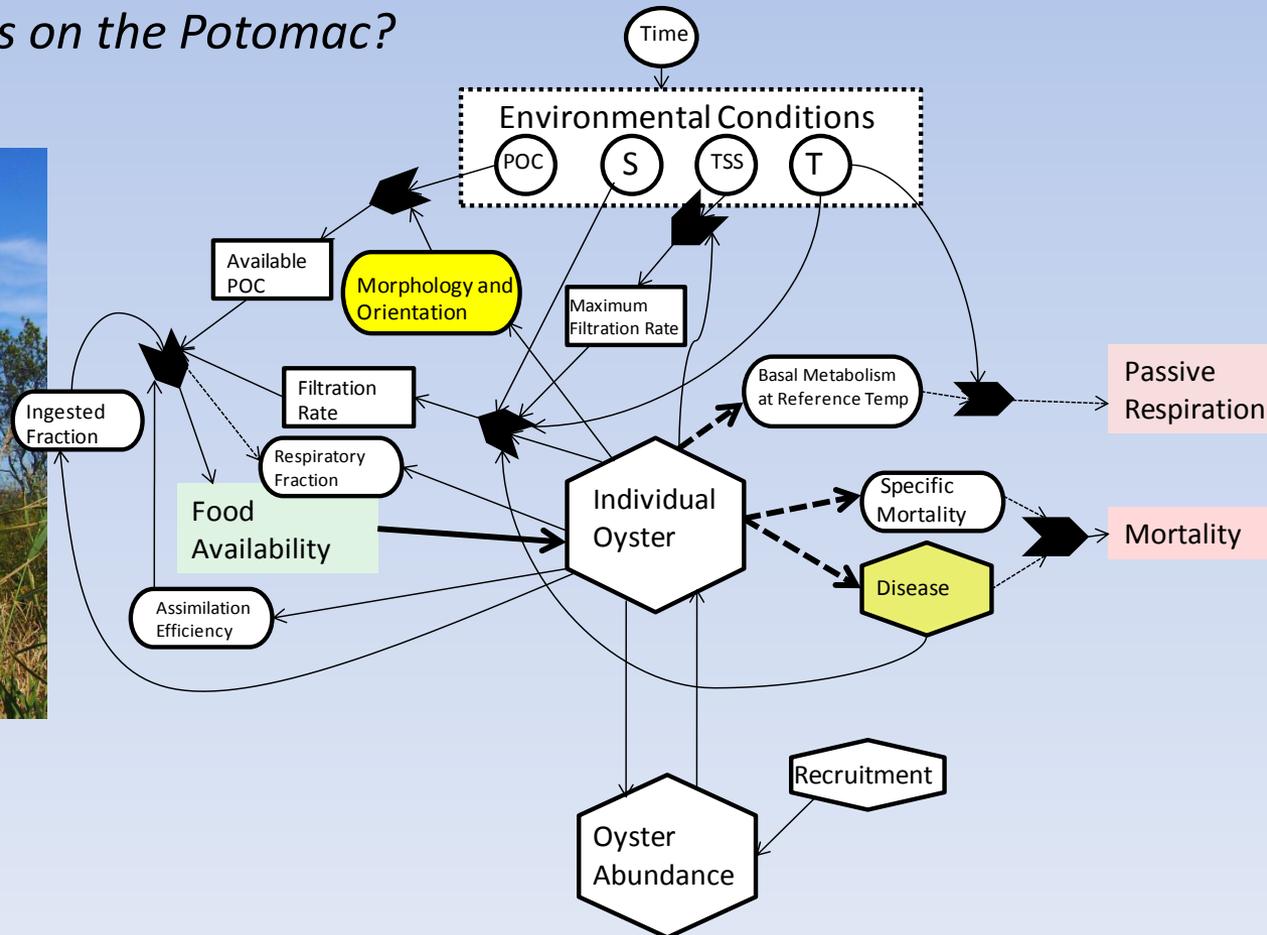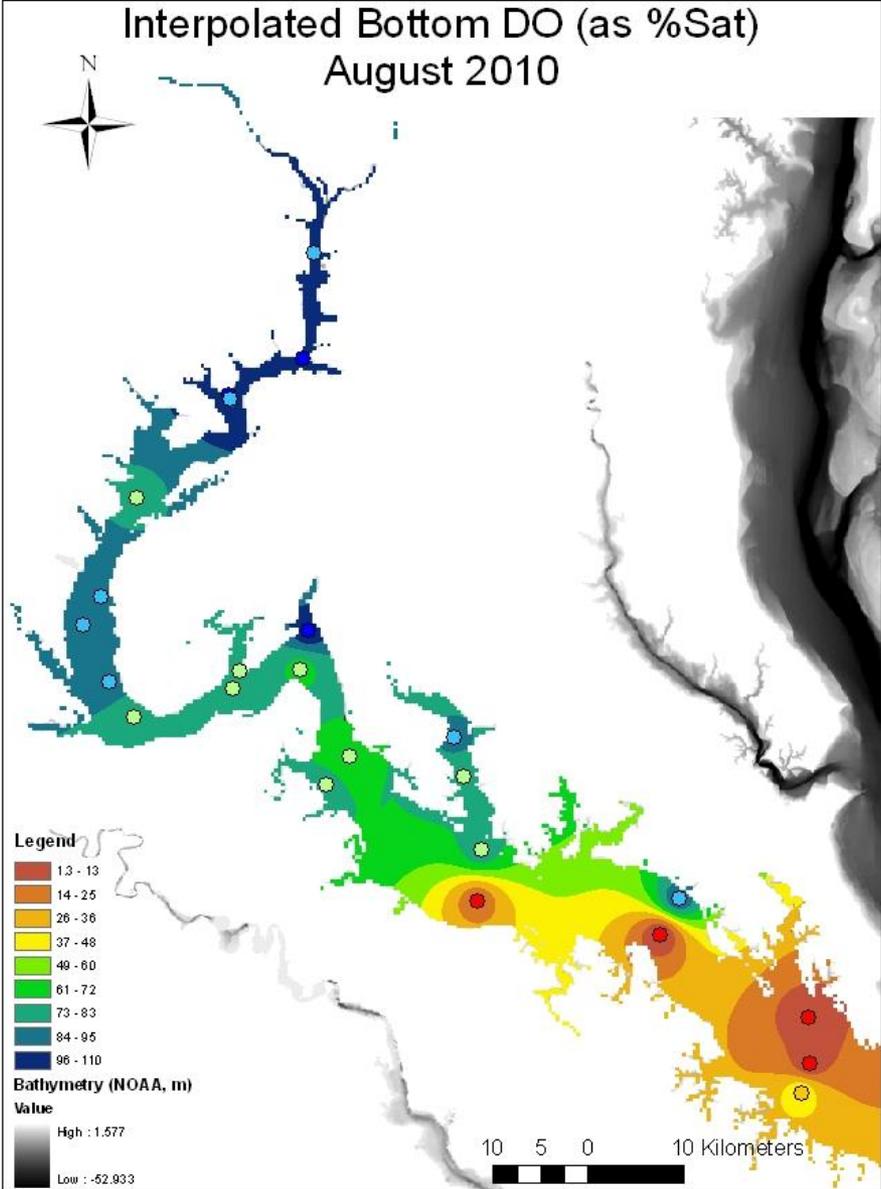
- Four Principal Investigators: Harris, Boynton, Kaushal, Cornwell

- Most comprehensive measurements of estuarine rate processes and water quality made at one time

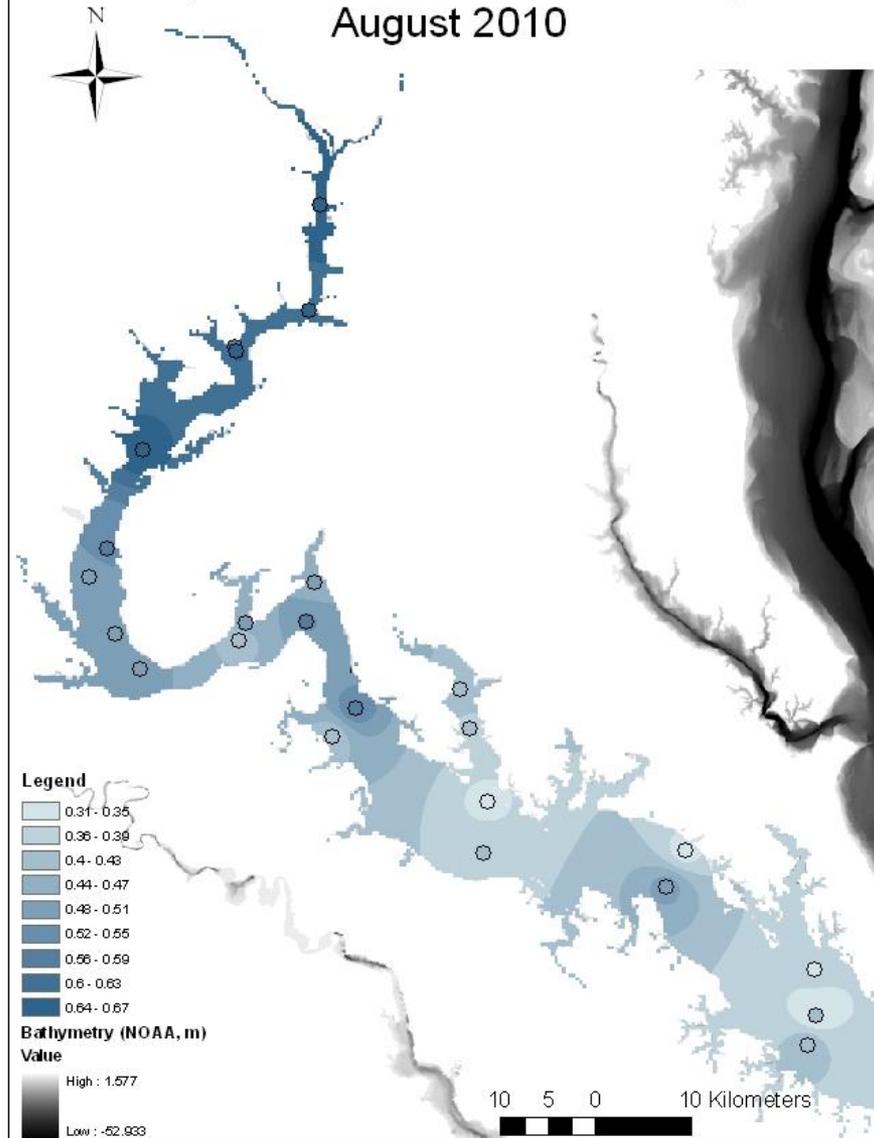- Successful measurements and execution of all cruise objectives
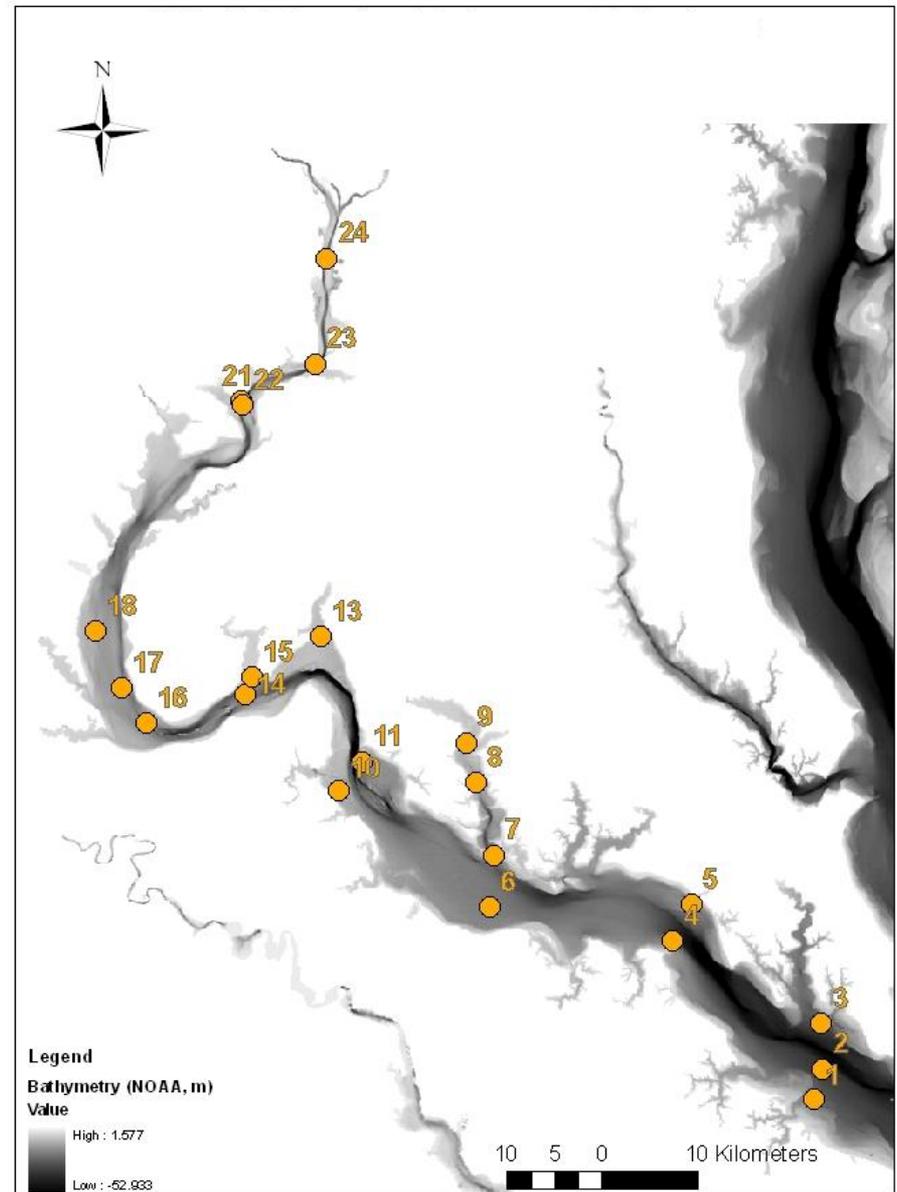
Preliminary Results August 2010 Cruise

Water Column Sampling:
Surface
Below pycnocline
Bottom water

Sediment Cores for
Nutrient fluxes
Denitrification
Sediment Oxygen Demand

Interpolated Bottom DO (as %Sat)
August 2010

Legend
13 - 13
14 - 25
26 - 36
37 - 48
49 - 60
61 - 72
73 - 83
84 - 95
96 - 110
Bathymetry (NOAA, m)
Value
High : 1.577
Low : -52.933

10   5   0   10 Kilometers

Interpolated Total Dissolved Nitrogen
August 2010

Legend
0.31 - 0.35
0.36 - 0.39
0.4 - 0.43
0.44 - 0.47
0.48 - 0.51
0.52 - 0.55
0.56 - 0.59
0.6 - 0.63
0.64 - 0.67
Bathymetry (NOAA, m)
Value
High : 1.577
Low : -52.933

10   5   0   10 Kilometers

Interpolated Particulate Nitrogen
August 2010

Legend
0.12 - 0.14
0.15 - 0.15
0.16 - 0.17
0.18 - 0.19
0.2 - 0.2
0.21 - 0.22
0.23 - 0.24
0.25 - 0.25
0.26 - 0.27

Bathymetry (NOAA, m)
Value

High : 1.577

Low : -52.933

10 5 0   10 Kilometers
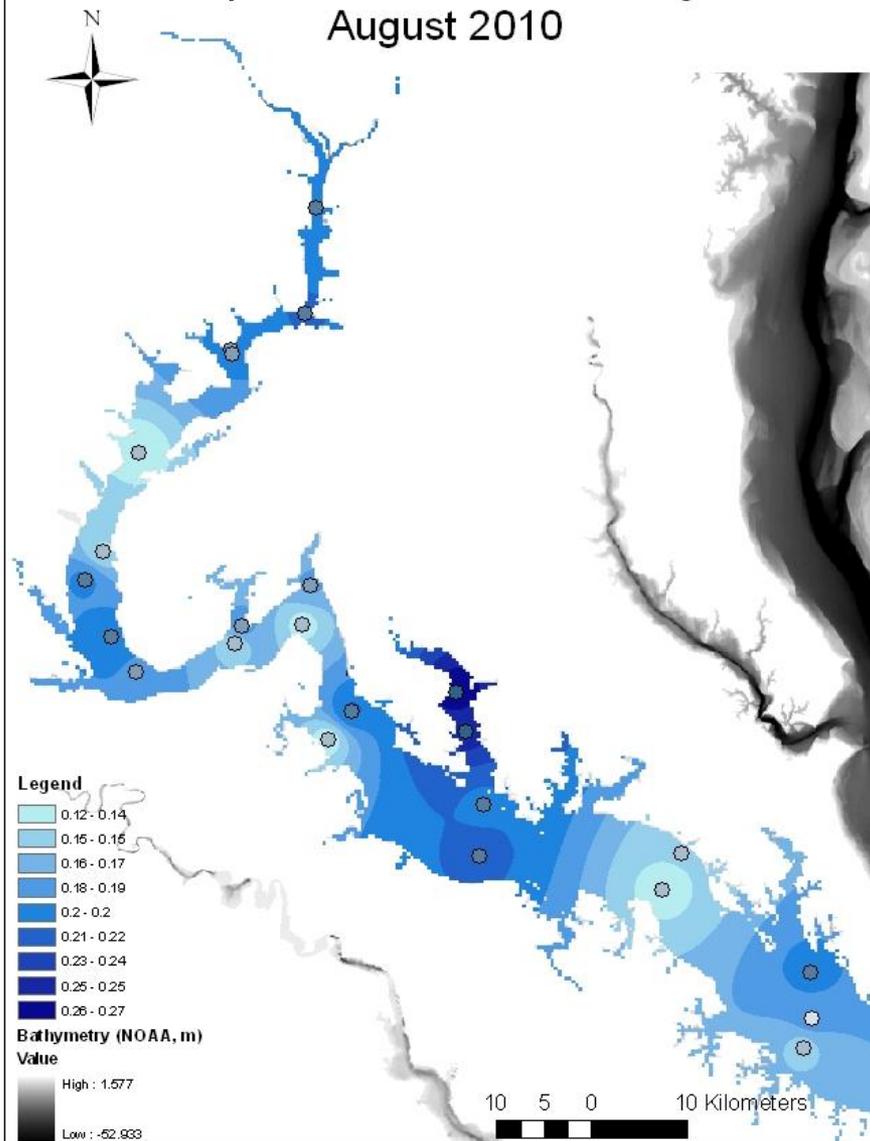
Interpolated Particulate Phosphate
August 2010

Legend

- 0.014 - 0.021
- 0.022 - 0.027
- 0.028 - 0.034
- 0.035 - 0.04
- 0.041 - 0.047
- 0.048 - 0.053
- 0.054 - 0.06
- 0.061 - 0.067
- 0.068 - 0.073

Bathymetry (NOAA, m)
Value

High : 1.577

Low : -52.933

10   5   0   10 Kilometers
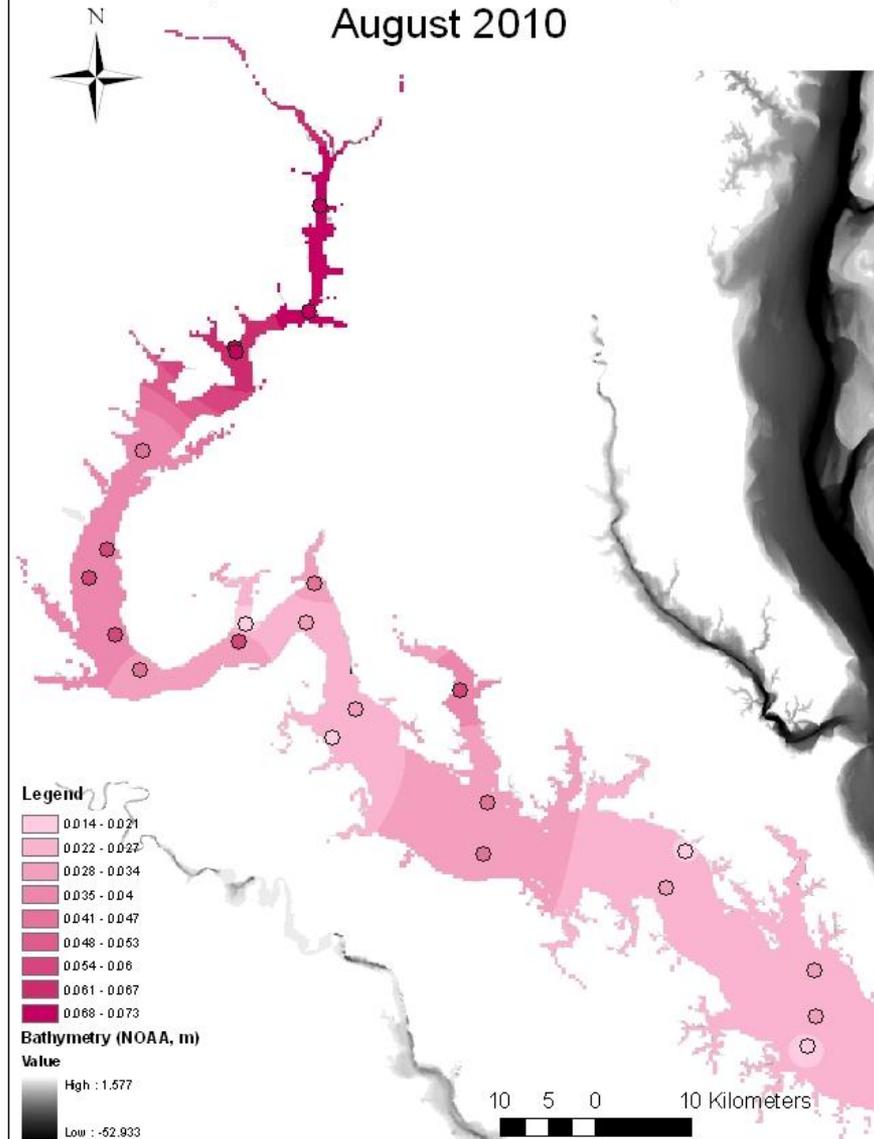
Interpolated Surface Water Fluorescence
August 2010

Legend
0.62 - 6.2
6.3 - 12
13 - 17
18 - 23
24 - 28
29 - 34
35 - 39
40 - 45
46 - 51
Bathymetry (NOAA, m)
Value
High : 1.577
Low : -52.933

10   5   0   10 Kilometers
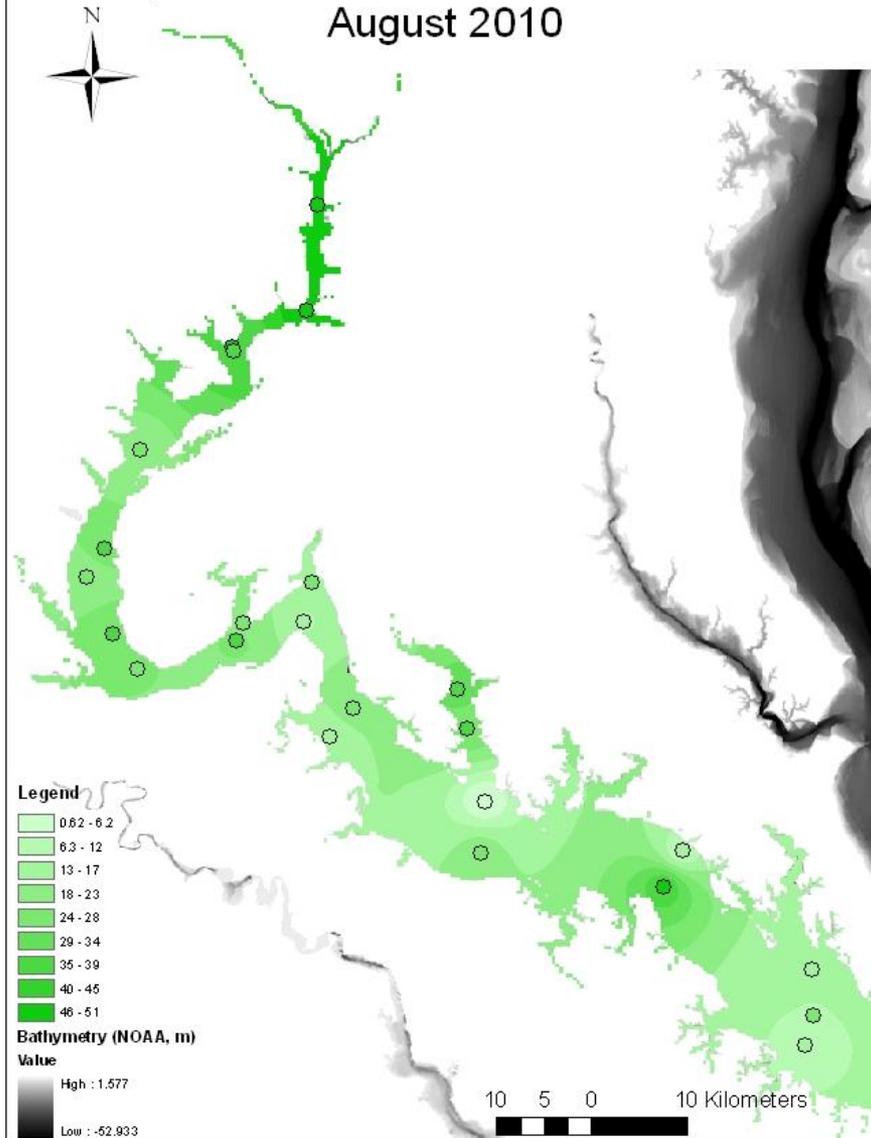
Interpolated Sediment Chlorophyll
August 2010

Legend
65 - 83
84 - 100
110 - 120
130 - 140
150 - 160
170 - 170
180 - 190
200 - 210
220 - 230
Bathymetry (NOAA, m)
Value
High : 1.577
Low : -52.933

10   5   0   10 Kilometers

Fluorescence Index
August 2010

Legend
1.5 - 1.5
1.6 - 1.5
1.6 - 1.5
1.6 - 1.5
1.6 - 1.5
1.6 - 1.5
1.6 - 1.6
1.7 - 1.6
1.7 - 1.6
Bathymetry (NOAA, m)
Value
High : 1.577
Low : -52.933

10   5   0   10 Kilometers
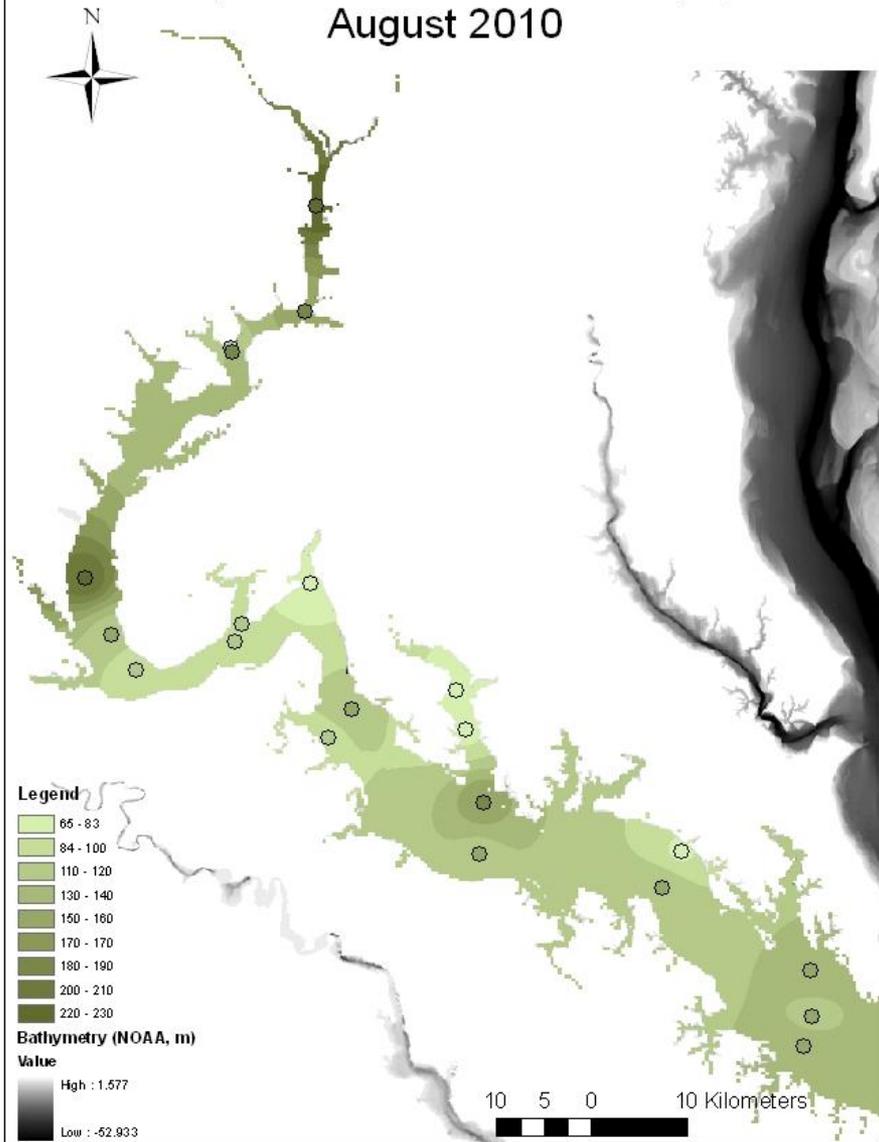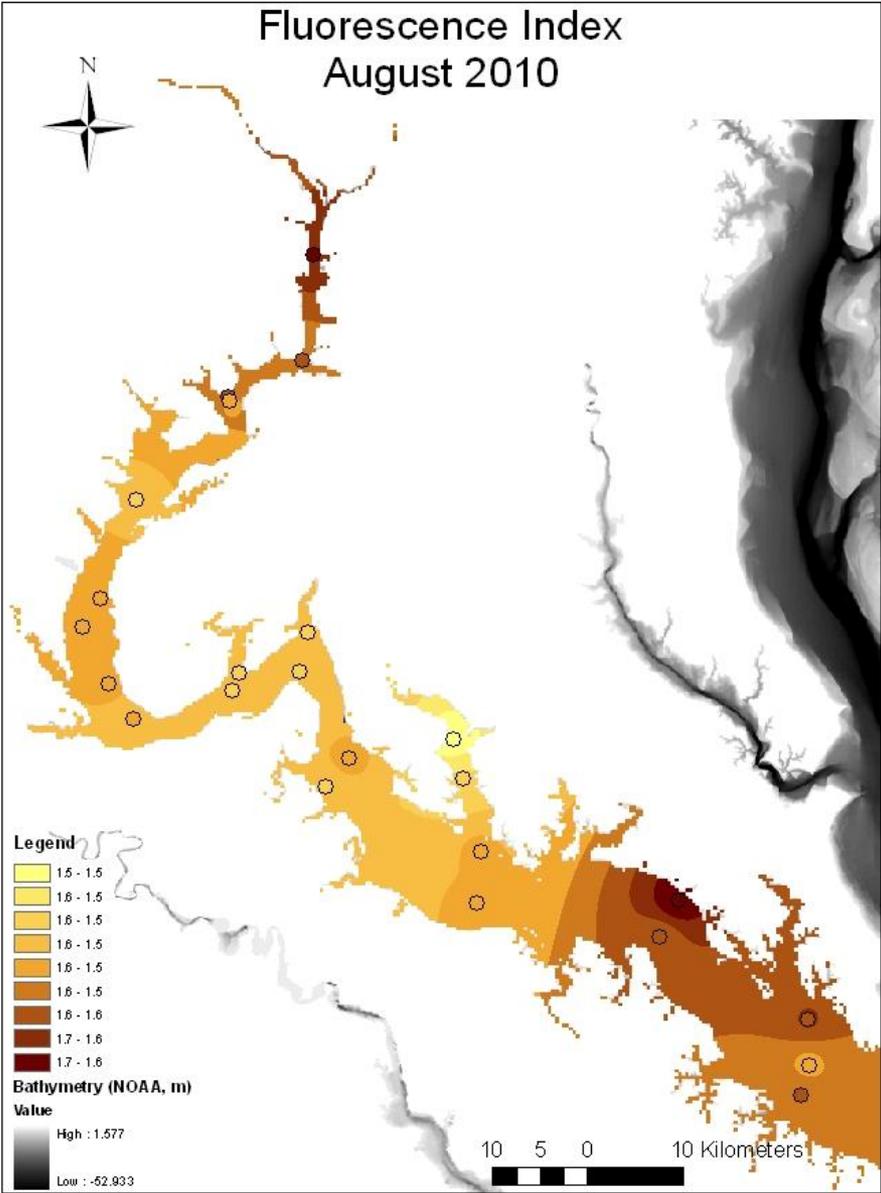
N2-N Flux for Potomac Tributary
August 2010
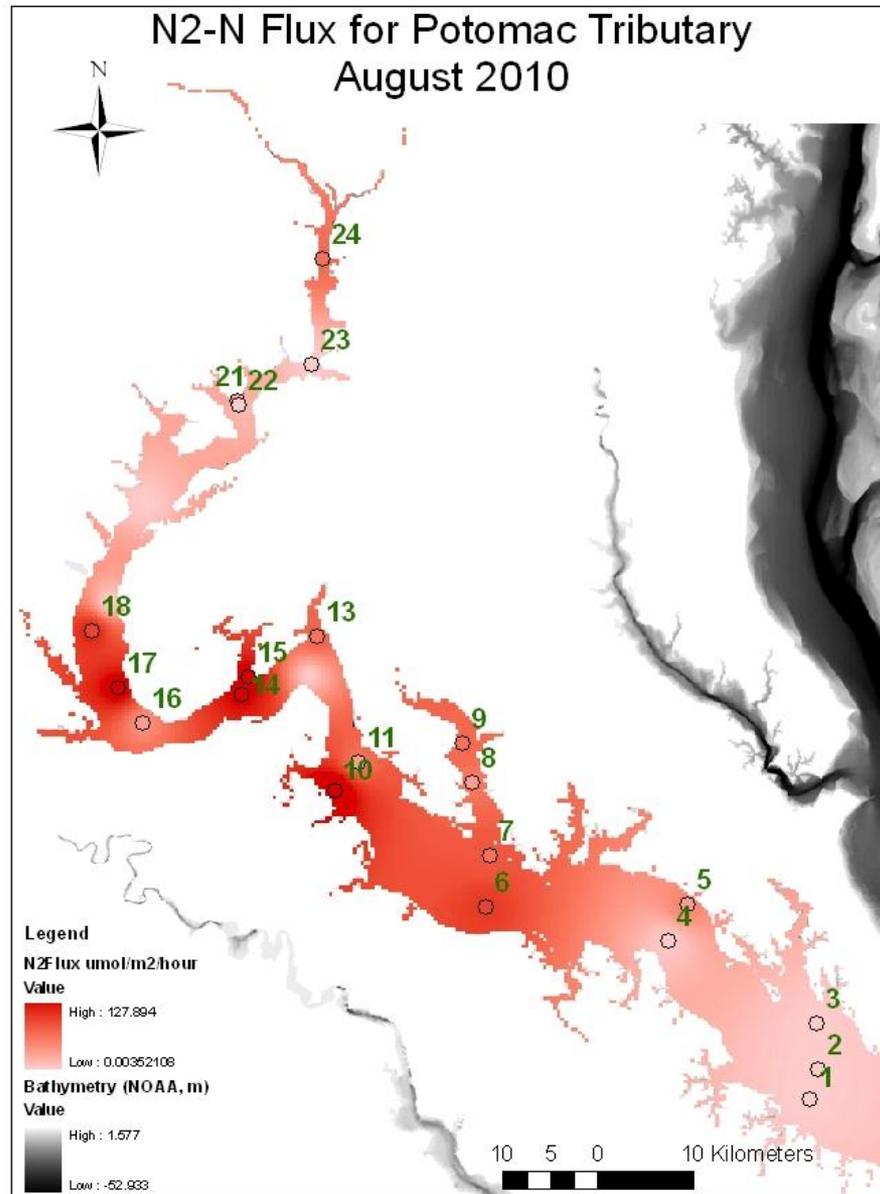
Estimates of Denitrification

1. Rate measurements of N2-N fluxes interpolated across lower Potomac

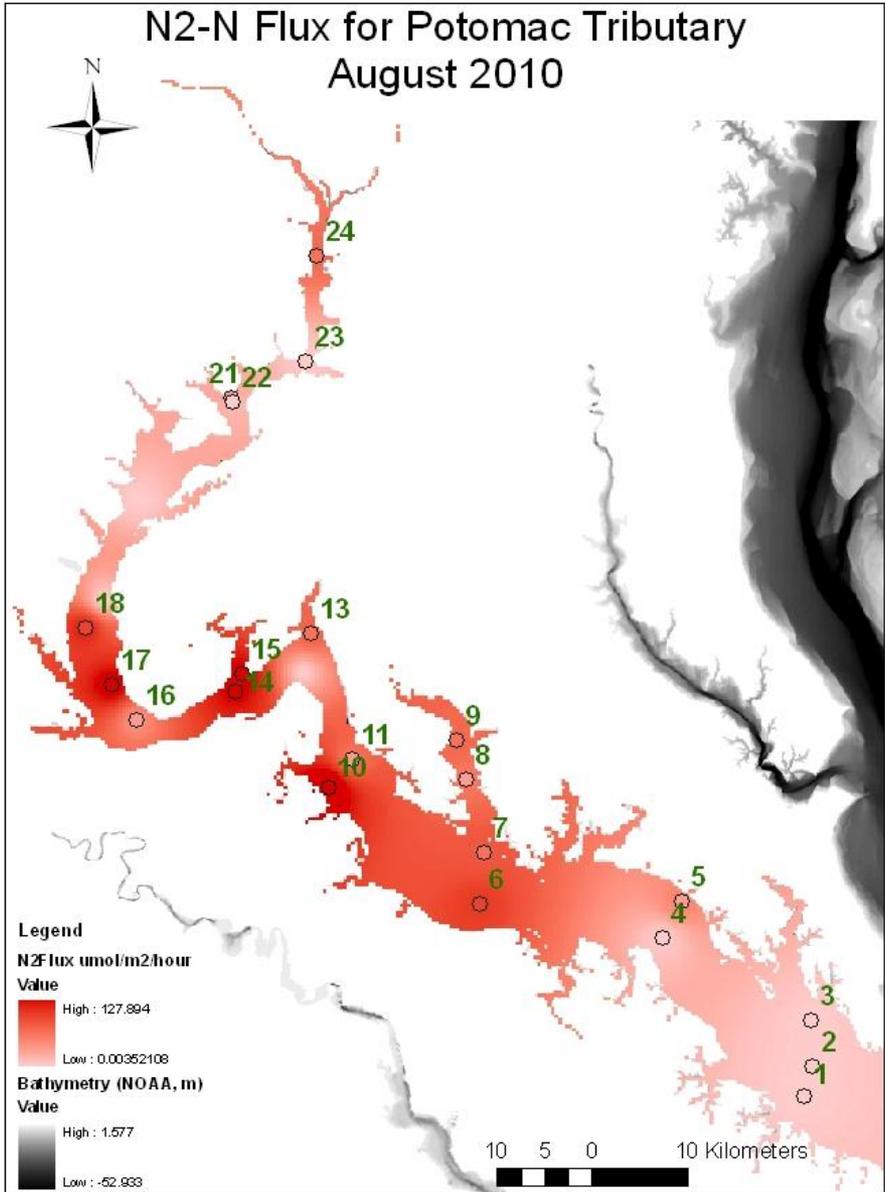2. Raster dataset exported fromArcGIS, predictions summed to estimate total denitrification rate for Potomac.

   ~15,900 kg N per day

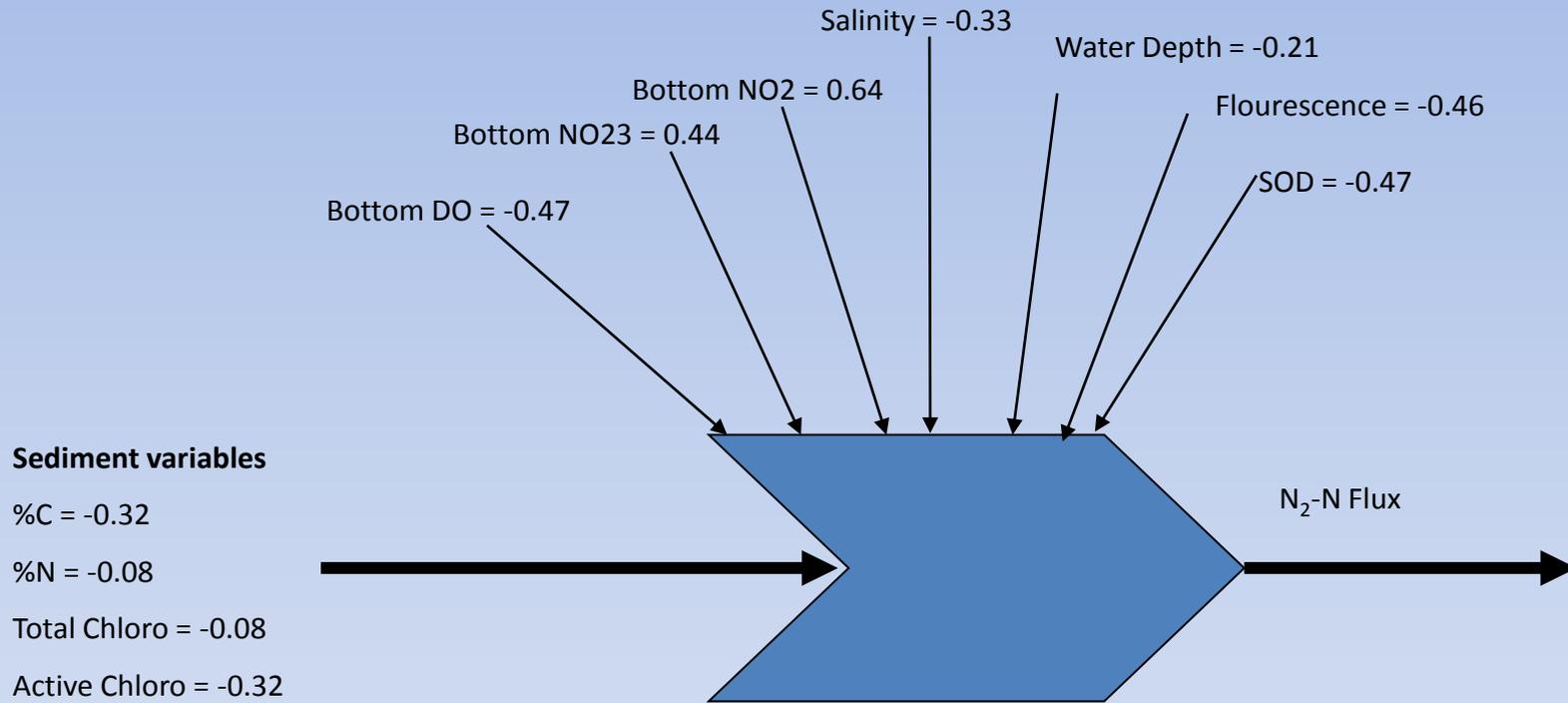3. Inputs of N from upper Potomac averaged for July and August, 2009

   8695 kg N per day

4. Inputs of N from Blue Plain averaged for July and August, 2007

   6976 kg N per day

N2-N Flux for Potomac Tributary August 2010

Legend
N2Flux umol/m2/hour
Value
High : 127.894
Low : 0.00352108
Bathymetry (NOAA, m)
Value
High : 1.577
Low : -52.933

Statistical Modeling

Salinity = -0.33

Water Depth = -0.21

Bottom NO2 = 0.64

Flourescence = -0.46

Bottom NO23 = 0.44

SOD = -0.47

Bottom DO = -0.47

Sediment variables

%C = -0.32

%N = -0.08

Total Chloro = -0.08

Active Chloro = -0.32

N_2-N Flux

All results are simple, linear r values. The n in this analysis was about 24

N2N Flux= 824*NO2(conc) - 0.0293*SOD - 0.800*Fluorescence + 26.0
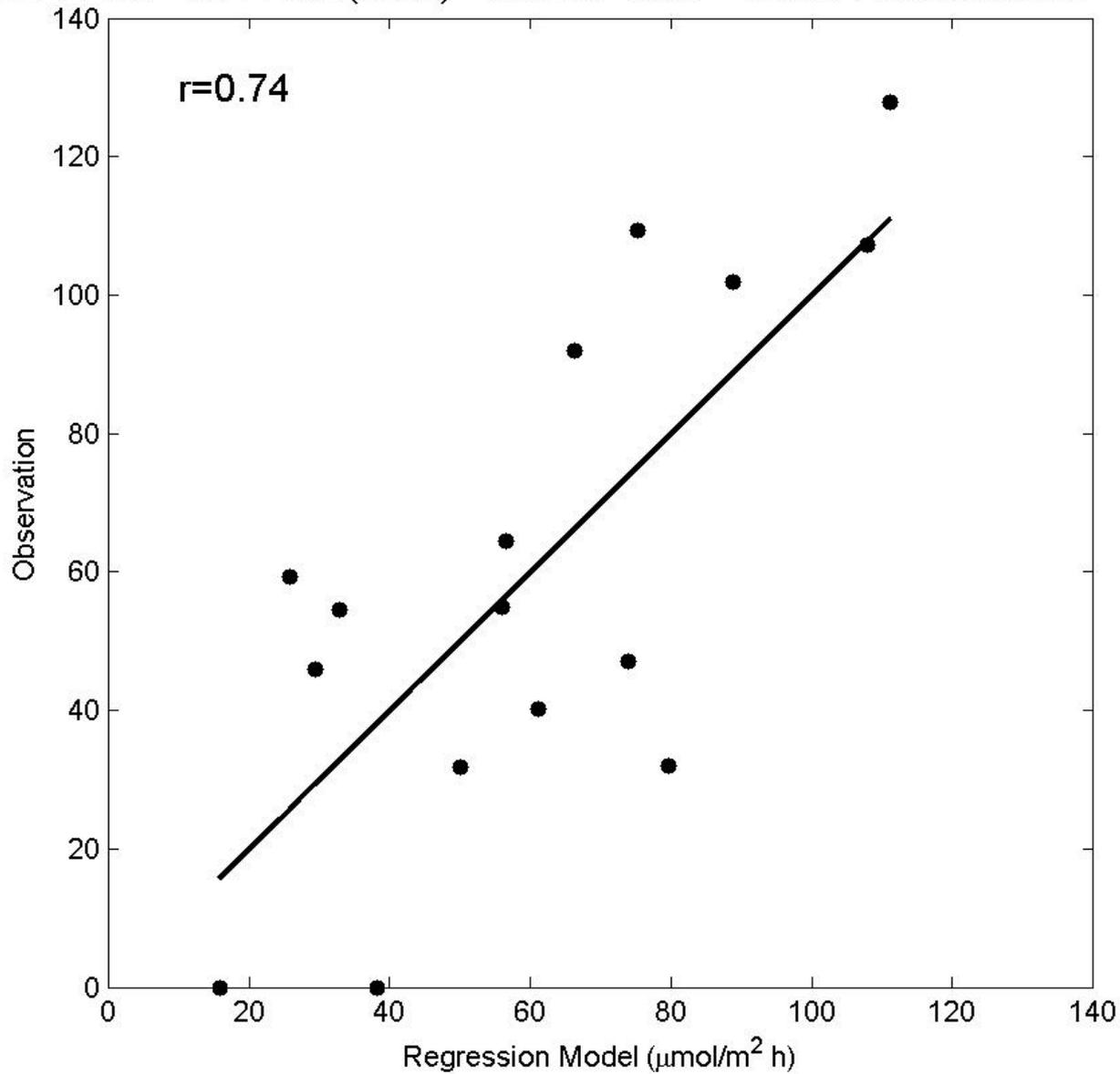
Missing Pieces:

Seasonal Variability:
Spring: High Nitrate, High Oxygen, Spring Bloom

Fall: Low Nitrate, High Oxygen,

Winter: Low Temp, High Nitrate, High Oxygen

Measured Parameters:
Nutrient Burial

SAV Denitrification/Nitrification

DON Bioavailability

Modeling:
Ideally incorporate into Potomac version of Bay Model to improve formulation of rate processes.

Acknowledgements

J Cornwell & M Owens (UMCES-HPL)

S Kaushal & M Pennino (UM-College Park, UMBC)

W Boynton, E Bailey, C Sperling, M Day

M Niesen, M Forsyth, K Ziombra (UMCES-CBL)

A Bayard & L Wainger

Sally Bowen & Mark Trice

S Murthy, W Bailey, M Siddique