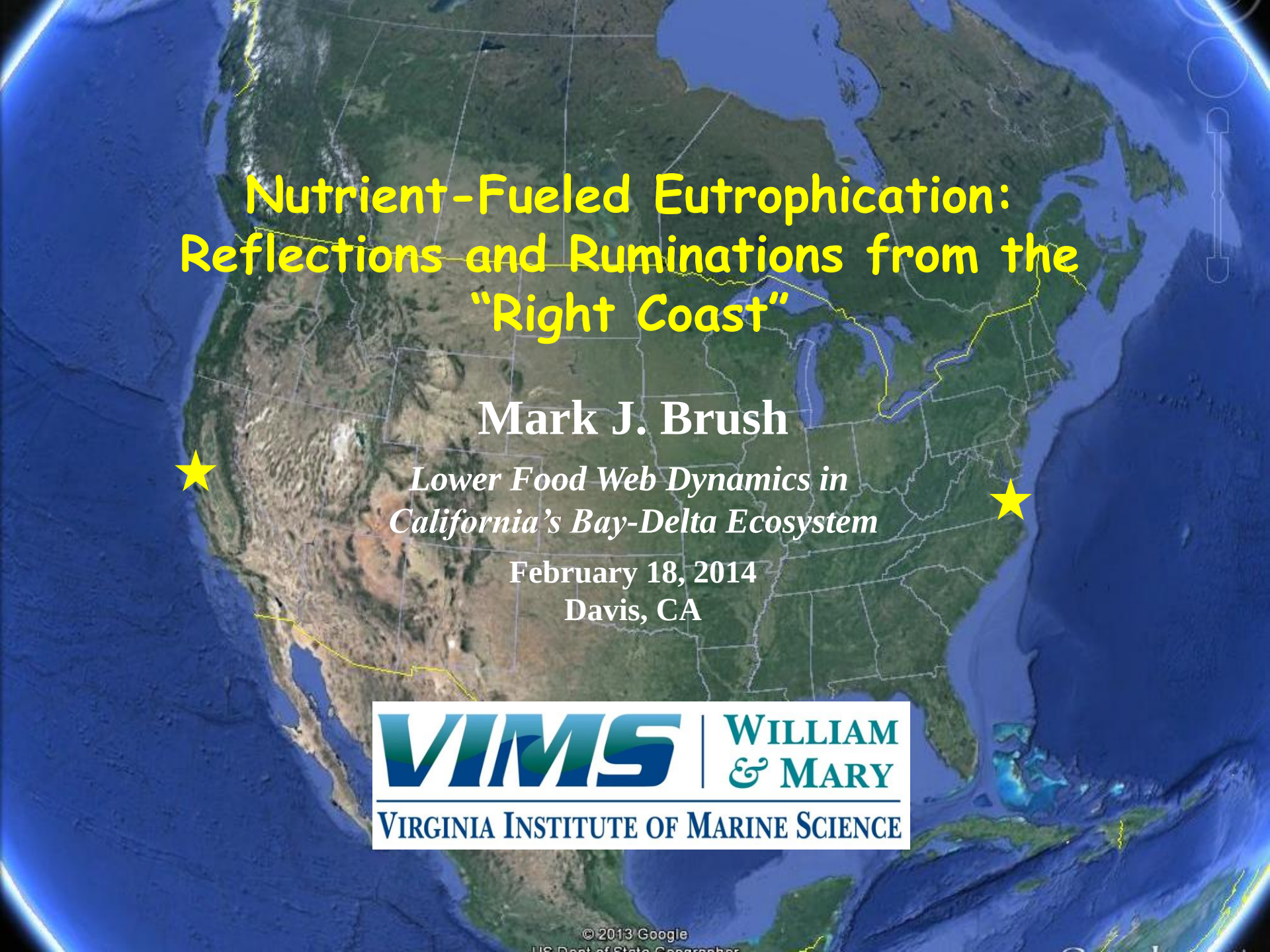


Nutrient-Fueled Eutrophication: Reflections and Ruminations from the "Right Coast"

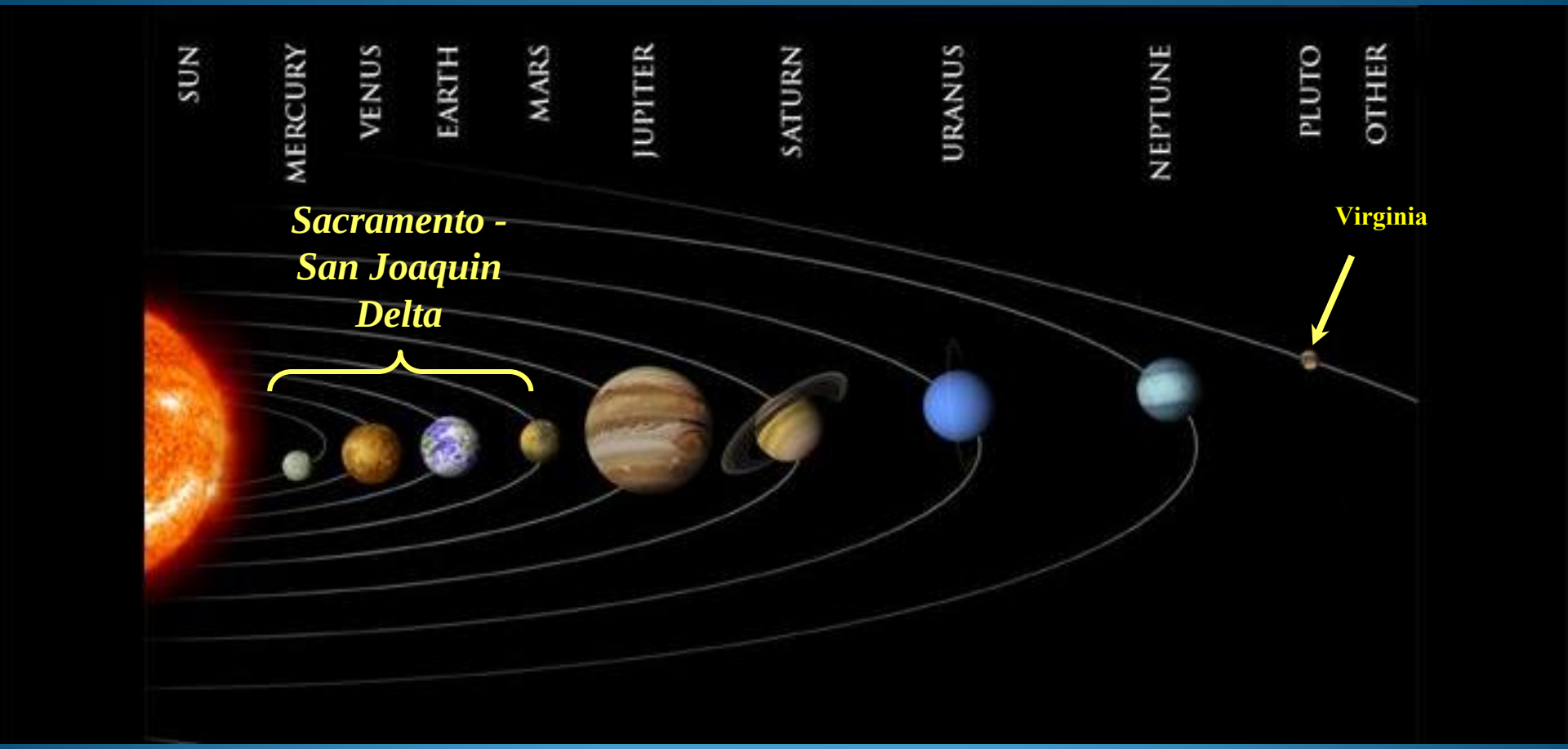
Mark J. Brush

Lower Food Web Dynamics in California's Bay-Delta Ecosystem

February 18, 2014
Davis, CA

VIMS | William & Mary
Virginia Institute of Marine Science


VIMS
Sacramento -
San Joaquin
Delta
© 2013 Google
US Dept of State Geographer
Image Landsat
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Google earth
Imagery Date: 4/9/2013 39°14'34.40" N 114°46'46.63" W elev 6240 ft eye alt 1065.13 mi


SUN
MERCURY
VENUS
EARTH
MARS
JUPITER
SATURN
URANUS
NEPTUNE
PLUTO
OTHER
Sacramento - San Joaquin Delta
Virginia

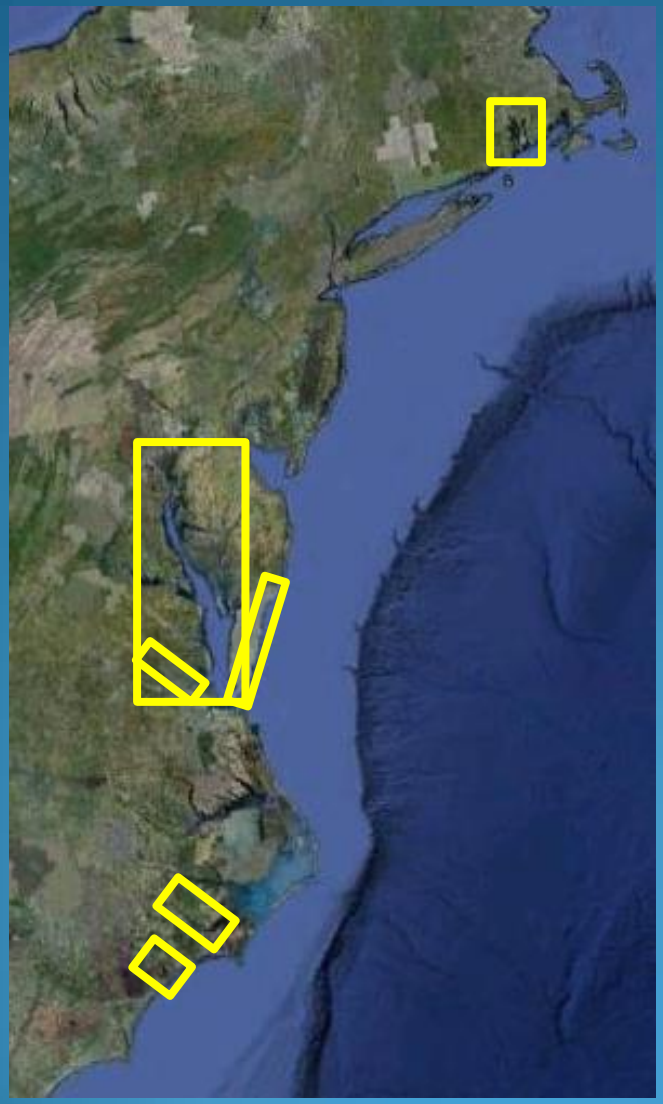
Objectives

- Provide a perspective from East Coast estuaries
- Highlight key processes from the East Coast that might also play a role in the Delta-Bay foodweb
- Highlight the merits of “reduced complexity” models

Key Topics

- Nutrient-fueled eutrophication
  - Role of interannual variability
  - Importance of transport processes
  - Nutrient reduction targets (TMDLs)
  - Dual N & P control
- Estuary/sub-estuary interaction and the role of advection
- The benthic filter
- Interactions with climate
- Oligotrophication
- Outwelling, NEM, and estuaries as carbon sources or sinks

The Estuaries



Narragansett Bay, RI

Chesapeake Bay, MD/VA

Delmarva lagoons, MD/VA

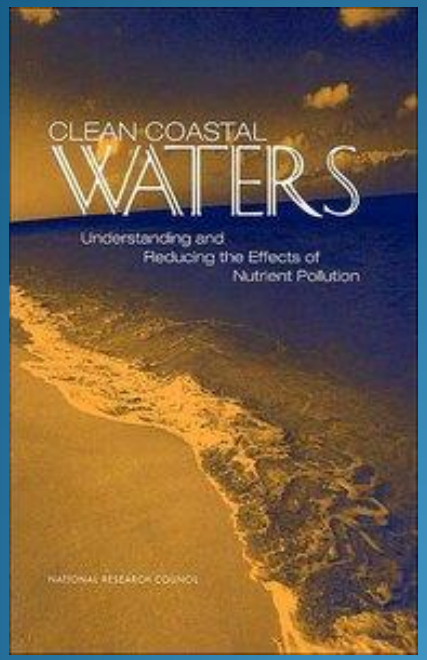
York River Estuary, VA

Neuse River Estuary, NC

New River Estuary, NC

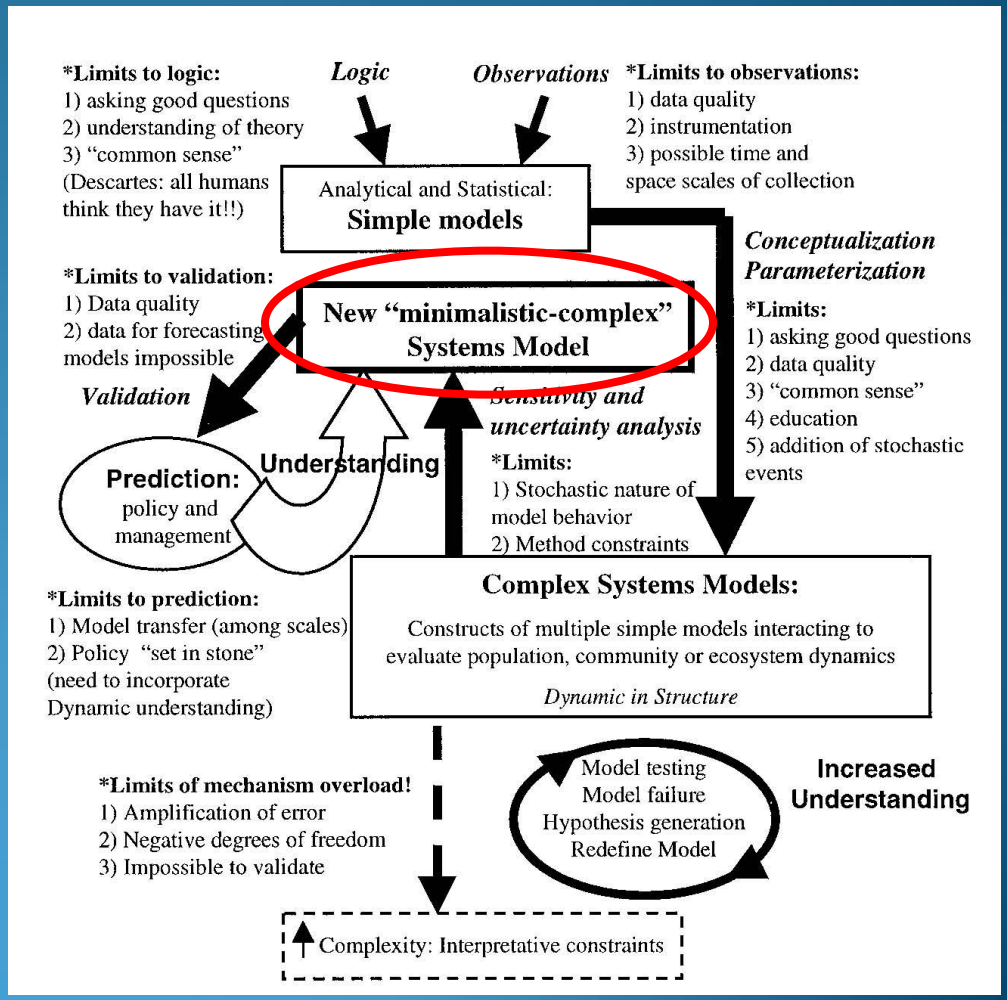
Modeling Approach

National Academy of Sciences' Committee on Causes and Management of Coastal Eutrophication (NRC 2000):

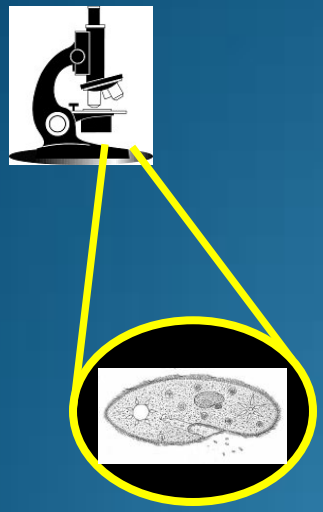


- Development of a reasonable accurate model accessible to managers to predict sources of nutrients in the landscape
- Simple frameworks for characterizing the sensitivity of estuarine response

Duarte et al. (2003)
"The limits to models in ecology"

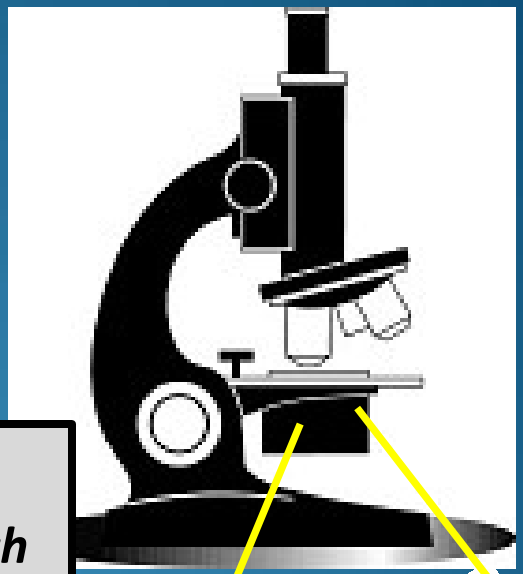


"Modeling Through the Macroscope"

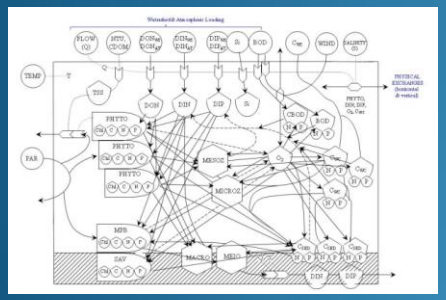


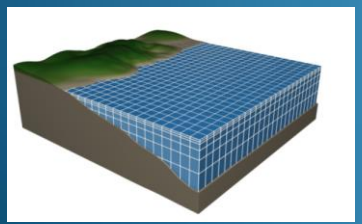
"The great ecologist H.T. Odum long argued that we need 'macroscopes' to help ecologists see the problems they study as they are embedded in the larger scales of nature and society."

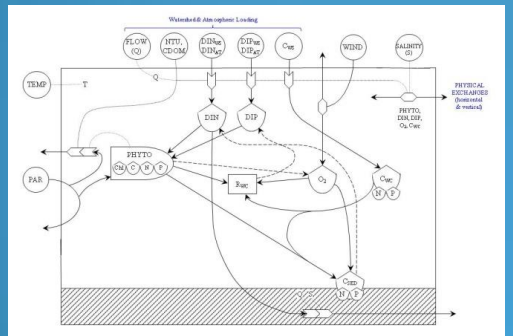
- Nixon (2009)

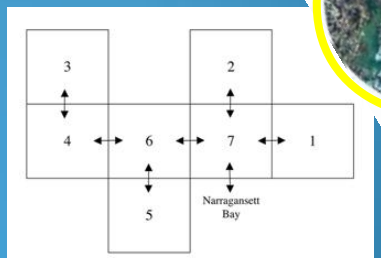


Can simple, holistic systems models serve as useful research & management tools in the age of reductionism?

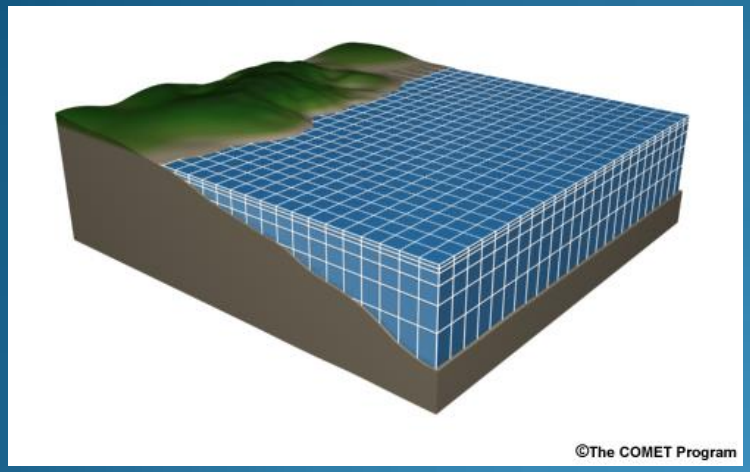


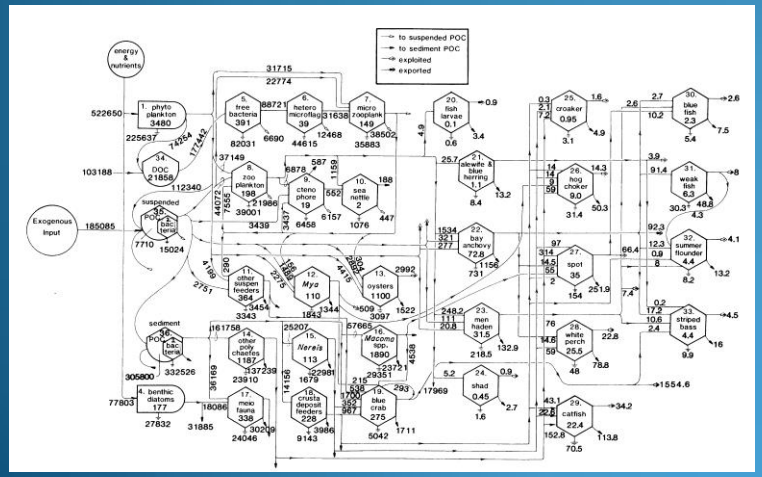






What this model isn't:

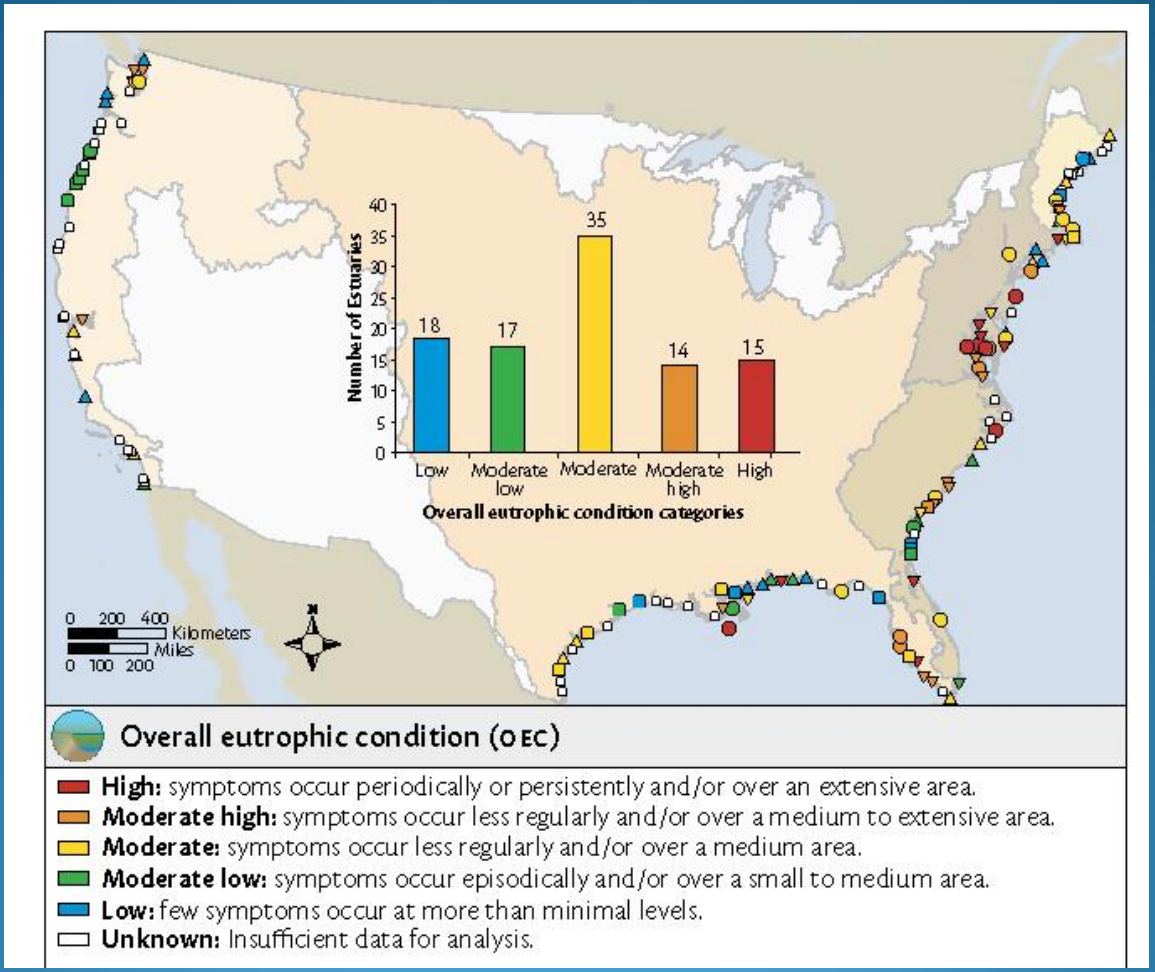




What this model is:

- Intermediate complexity
- Modular (easy addition of state variables)
- Management-focused
- Fast running (~ seconds to minutes)
- Quickly applied (~1.5-2 weeks per system)
- Accessible GUI, web-deployable

Nutrient-Fueled Eutrophication

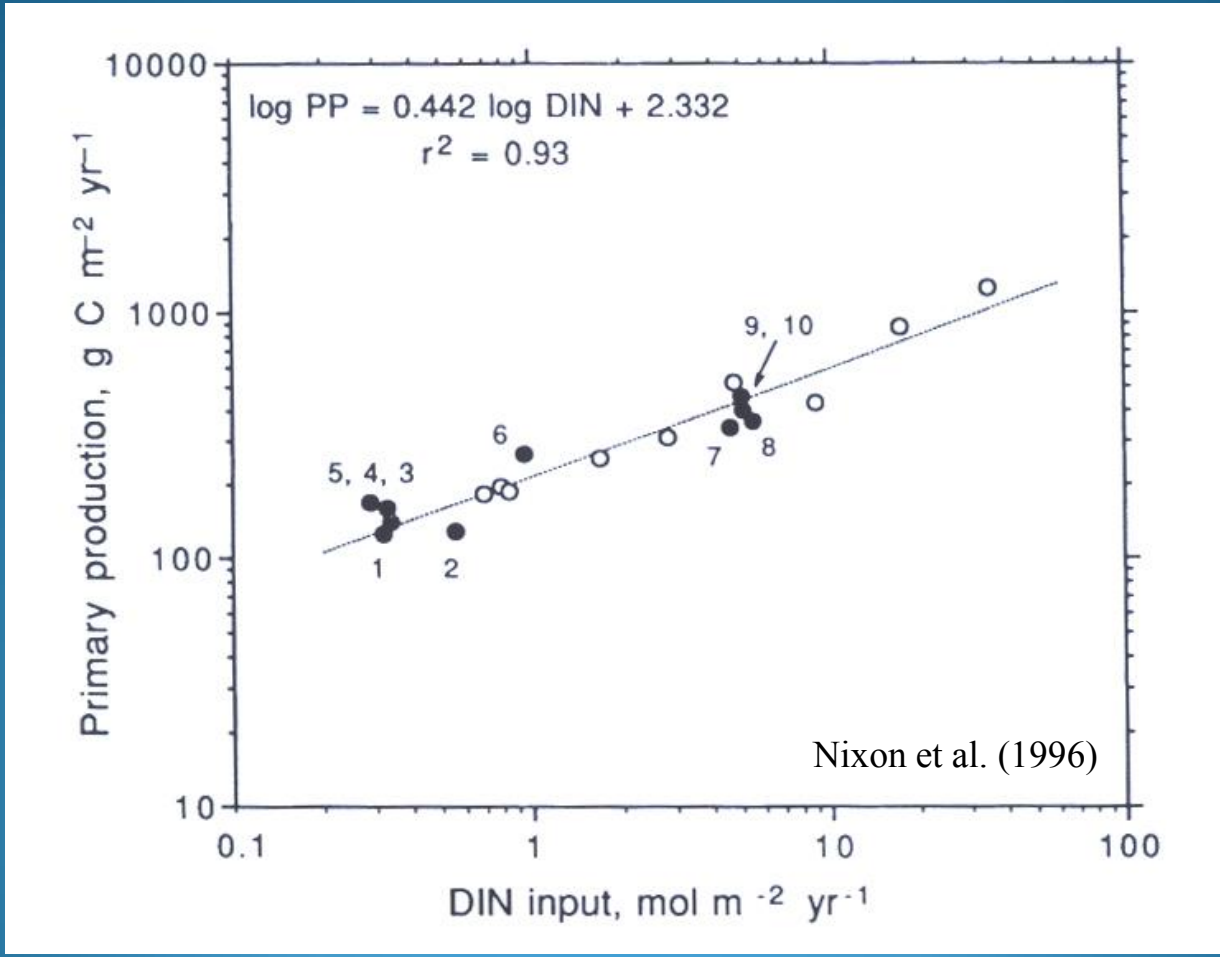


Bricker et al. (2007), NOAA National Estuarine Eutrophication Assessment Update

The root cause …

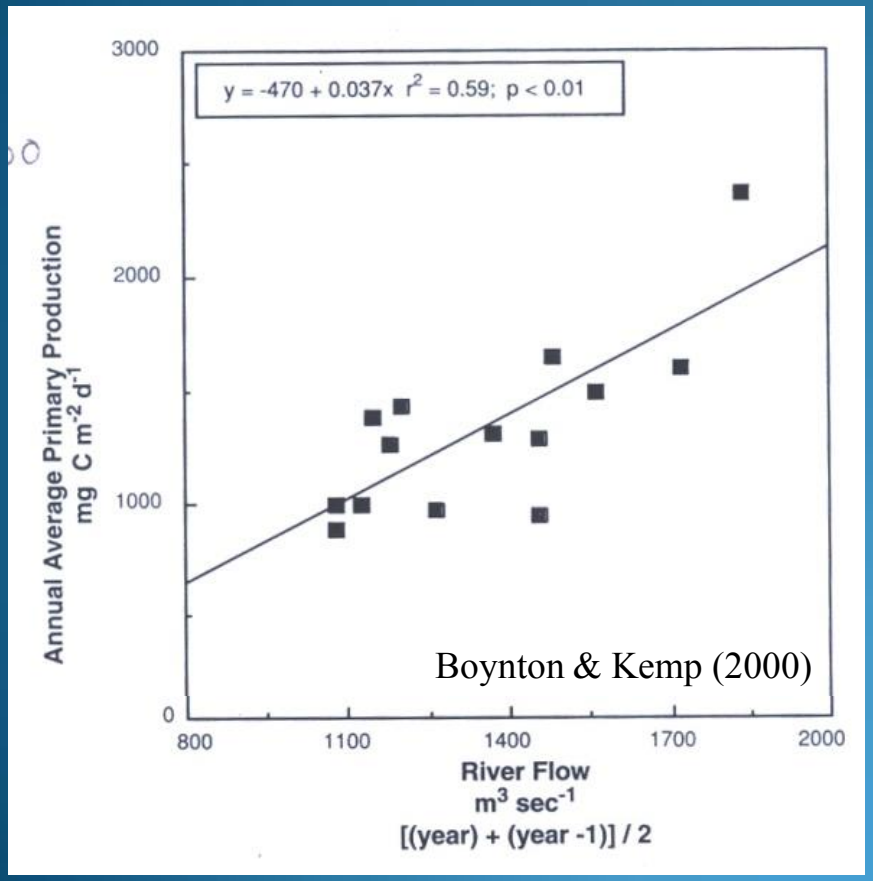
eutrophication (noun) – an increase in the rate of supply of organic matter to an ecosystem.

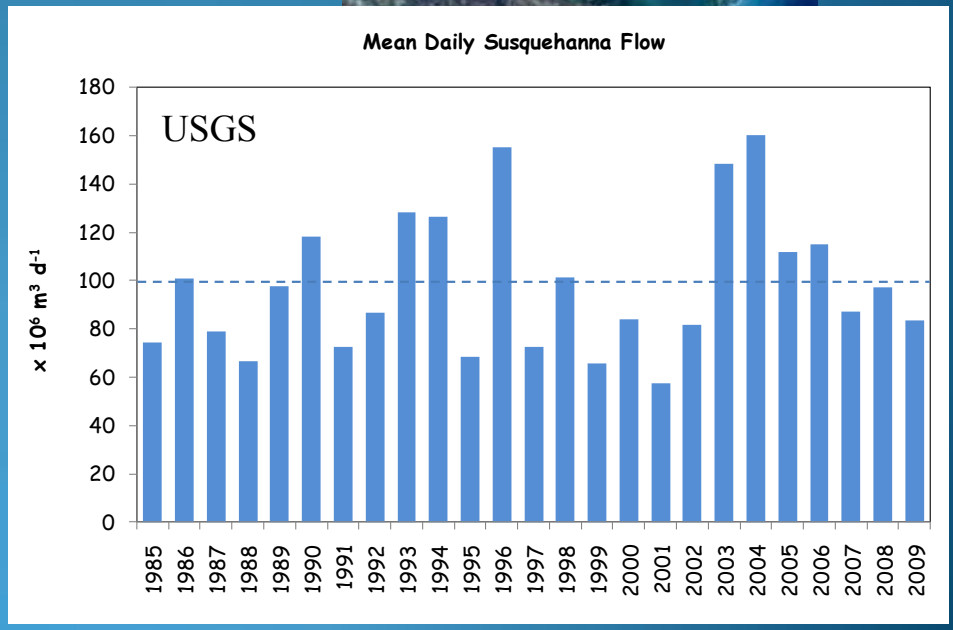
Nixon (1995)



Complicated by interannual variability …

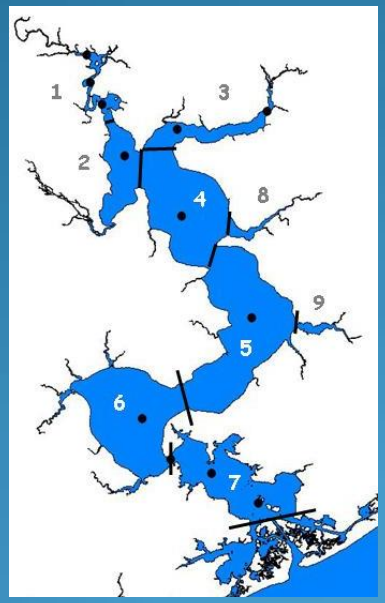
Chesapeake Bay

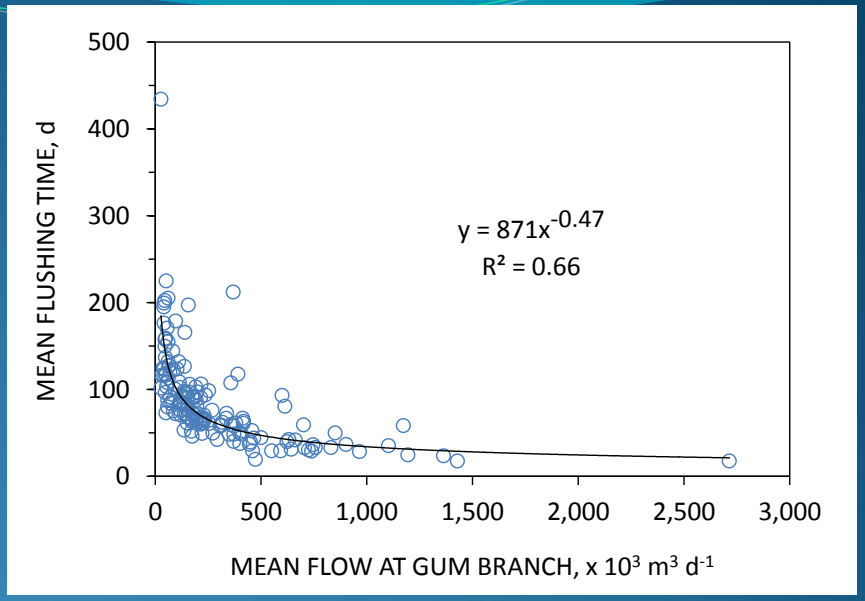


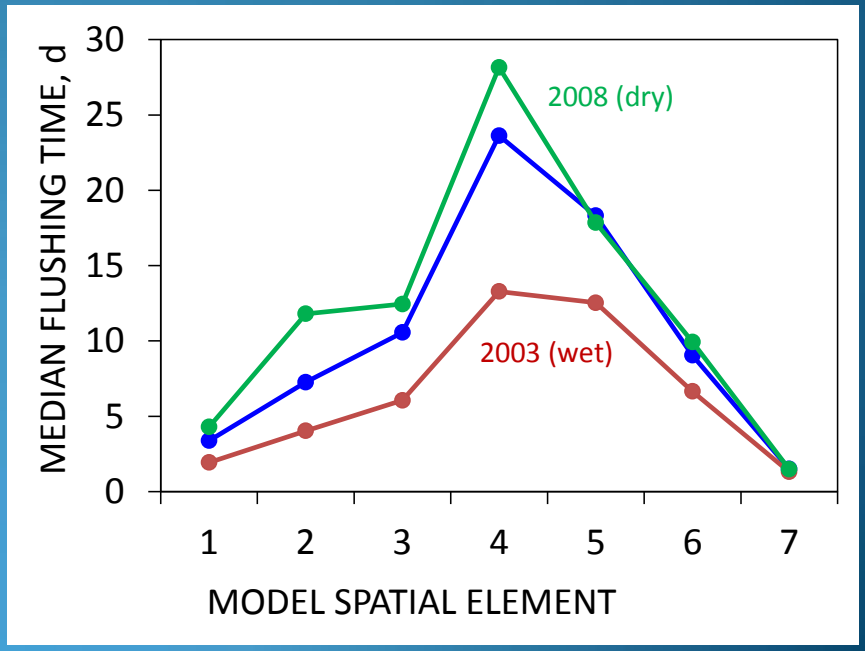


… and by transport time scales

New River Estuary, NC

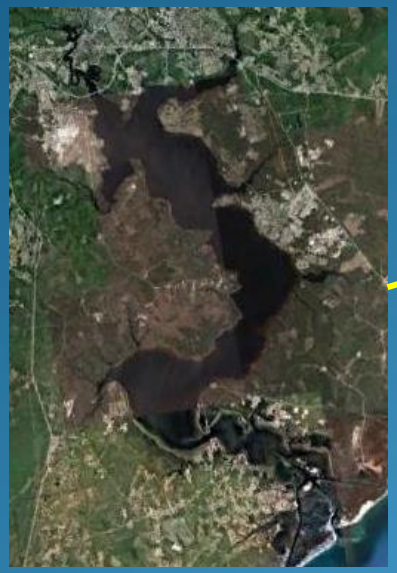


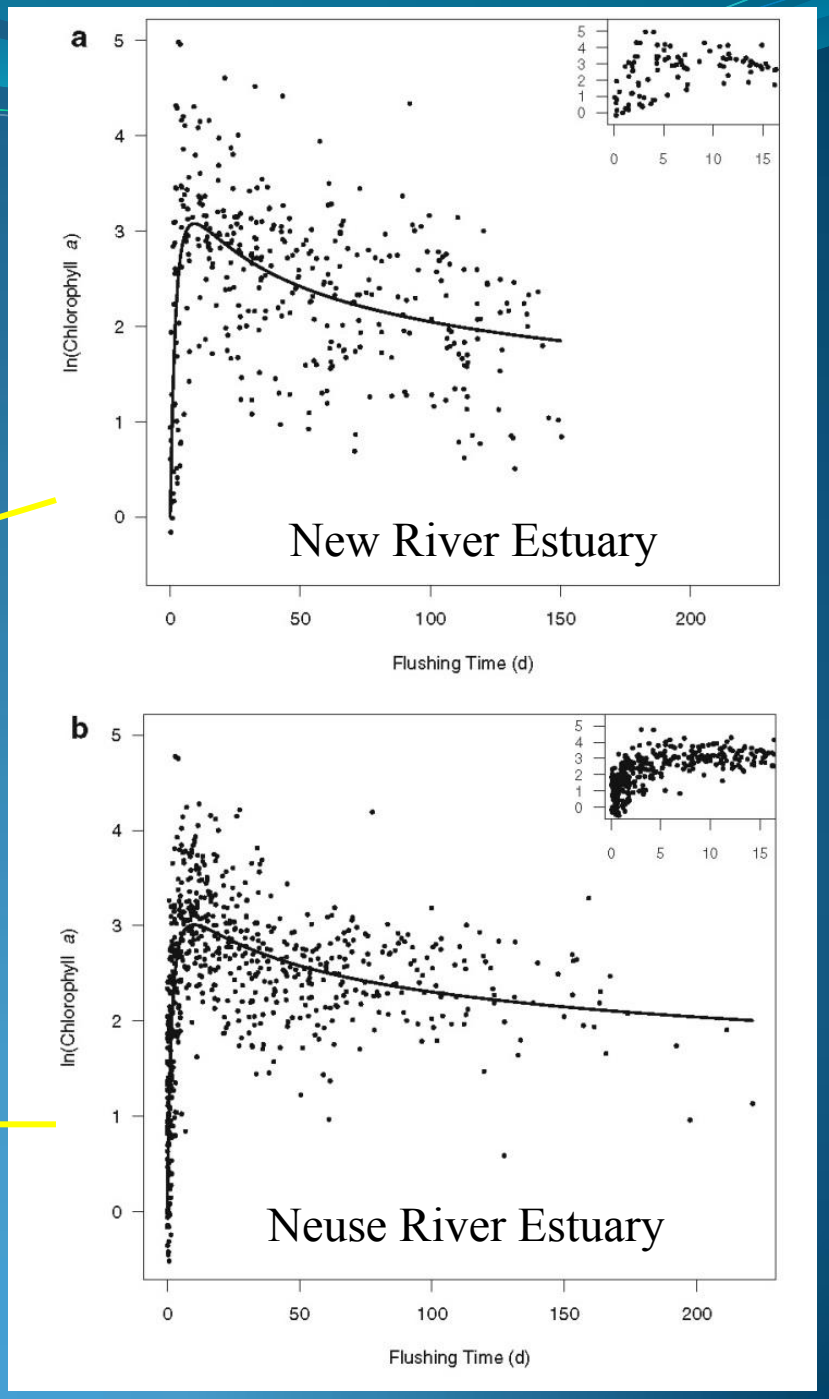




Brush (2012)

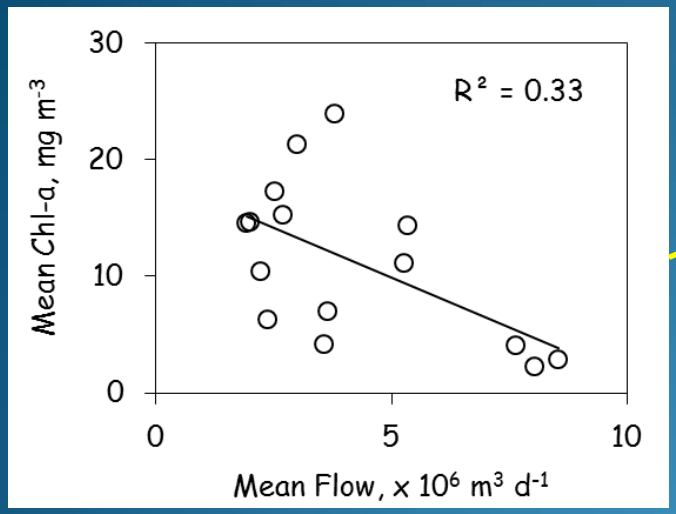
Transport time scales continued …

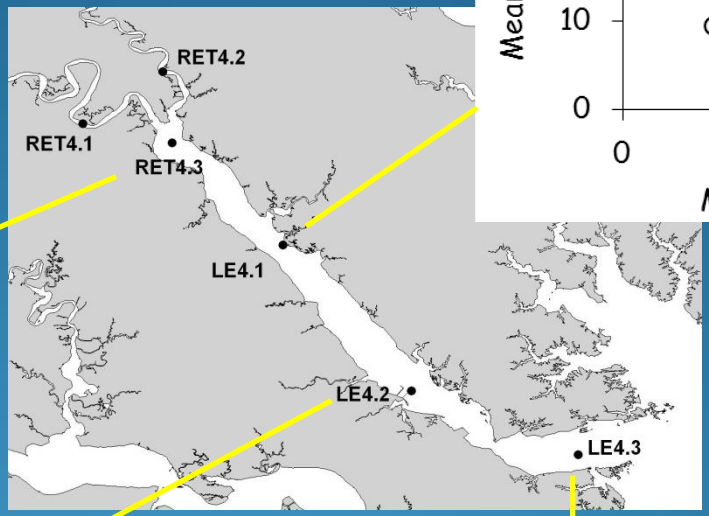


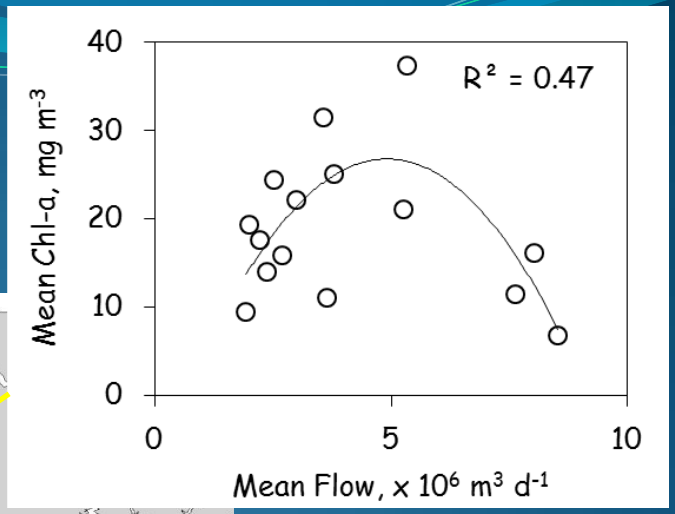


Peierls et al. (2012)

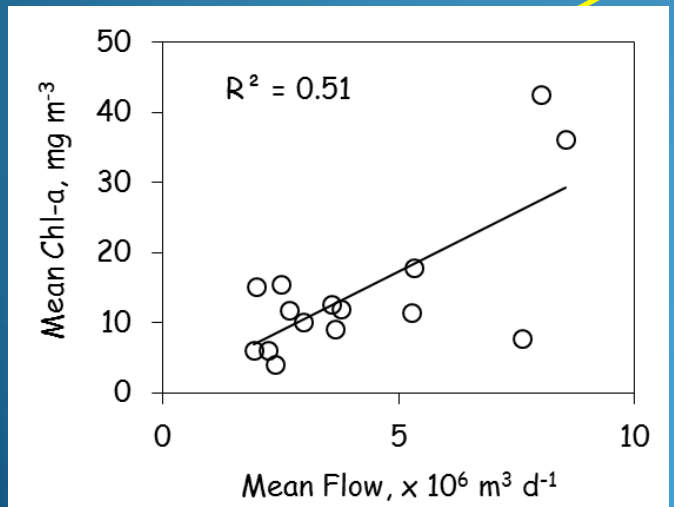
Transport time scales continued …

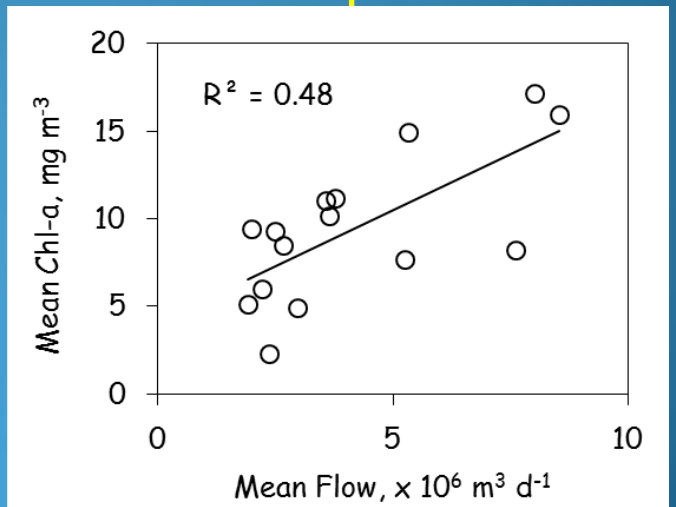






York River Estuary, VA

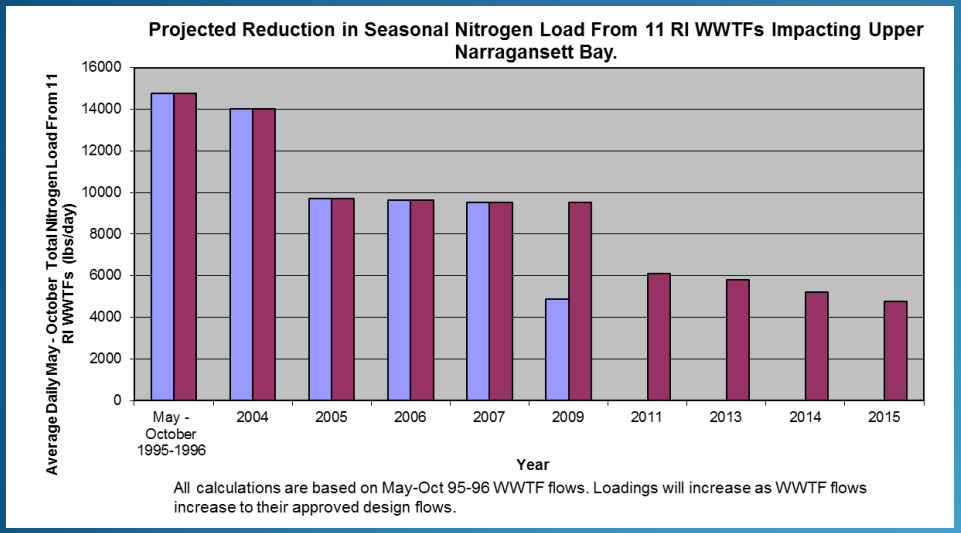




Data: EPA Chesapeake Bay Program

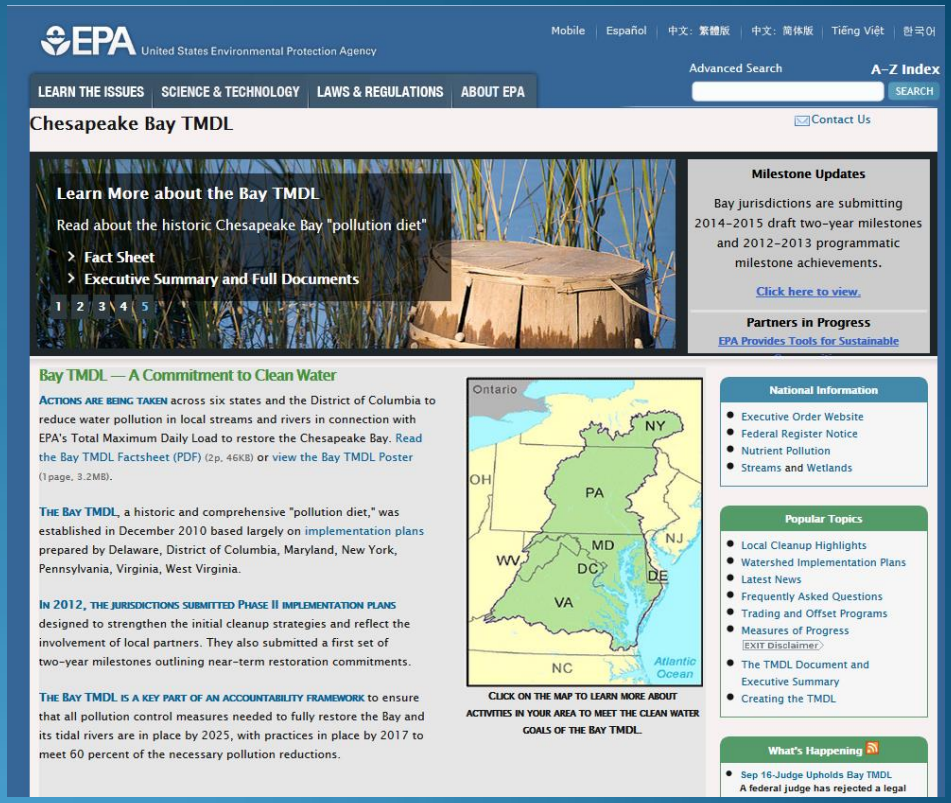
Nutrient reductions:

Narragansett Bay



Liberti et al. (RI DEM)

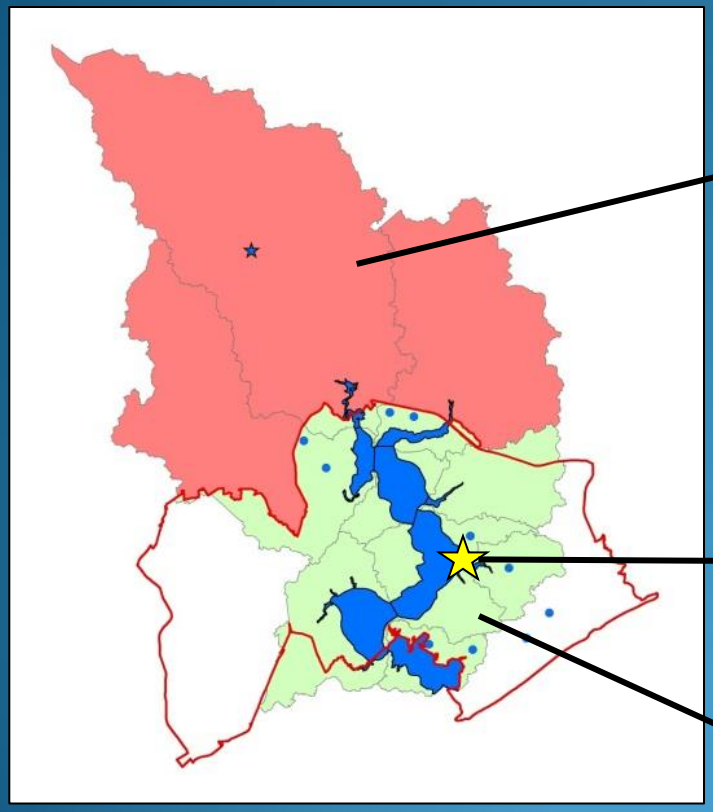
Chesapeake Bay TMDL



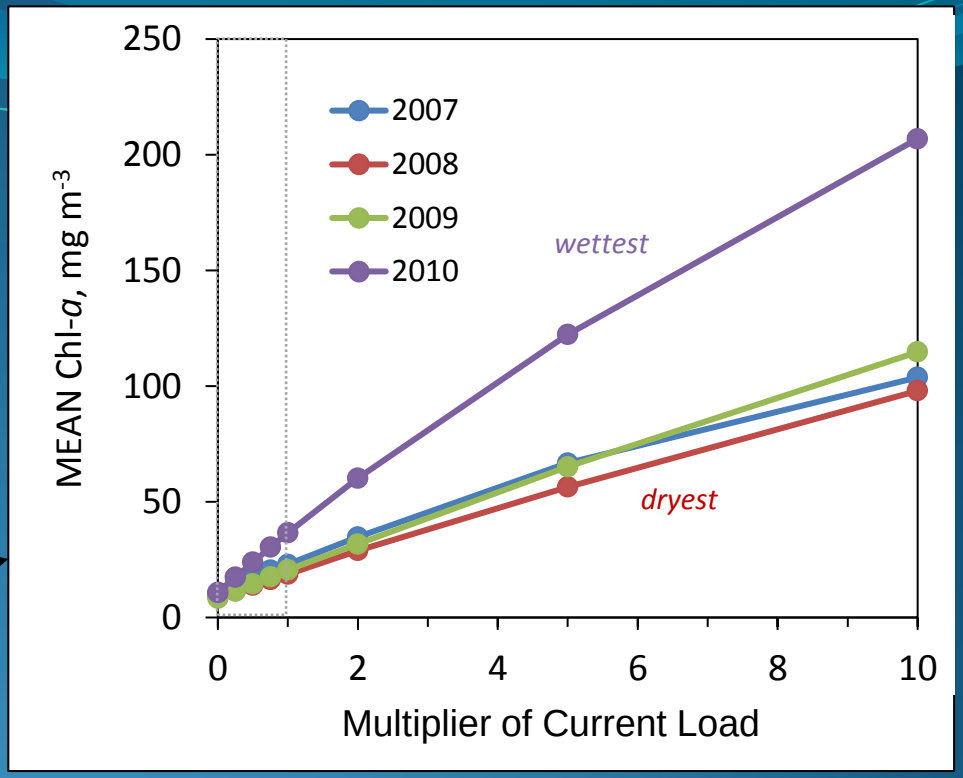
RI WWTF Reductions:

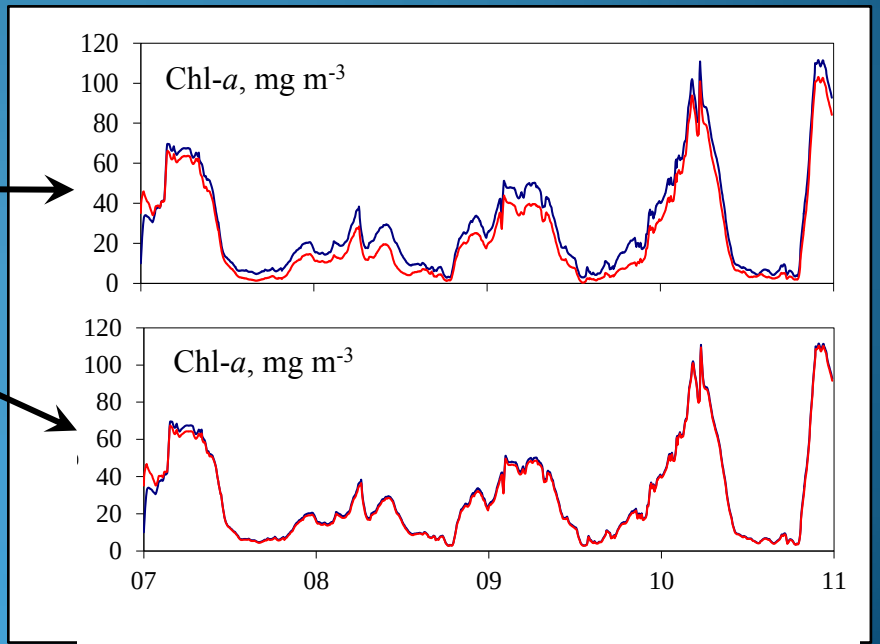
- CSO system online
- 30% WWTF reduction as of 2005
- ≥ 50% WWTF reduction by 2014

Using simple models:



Brush (2012)

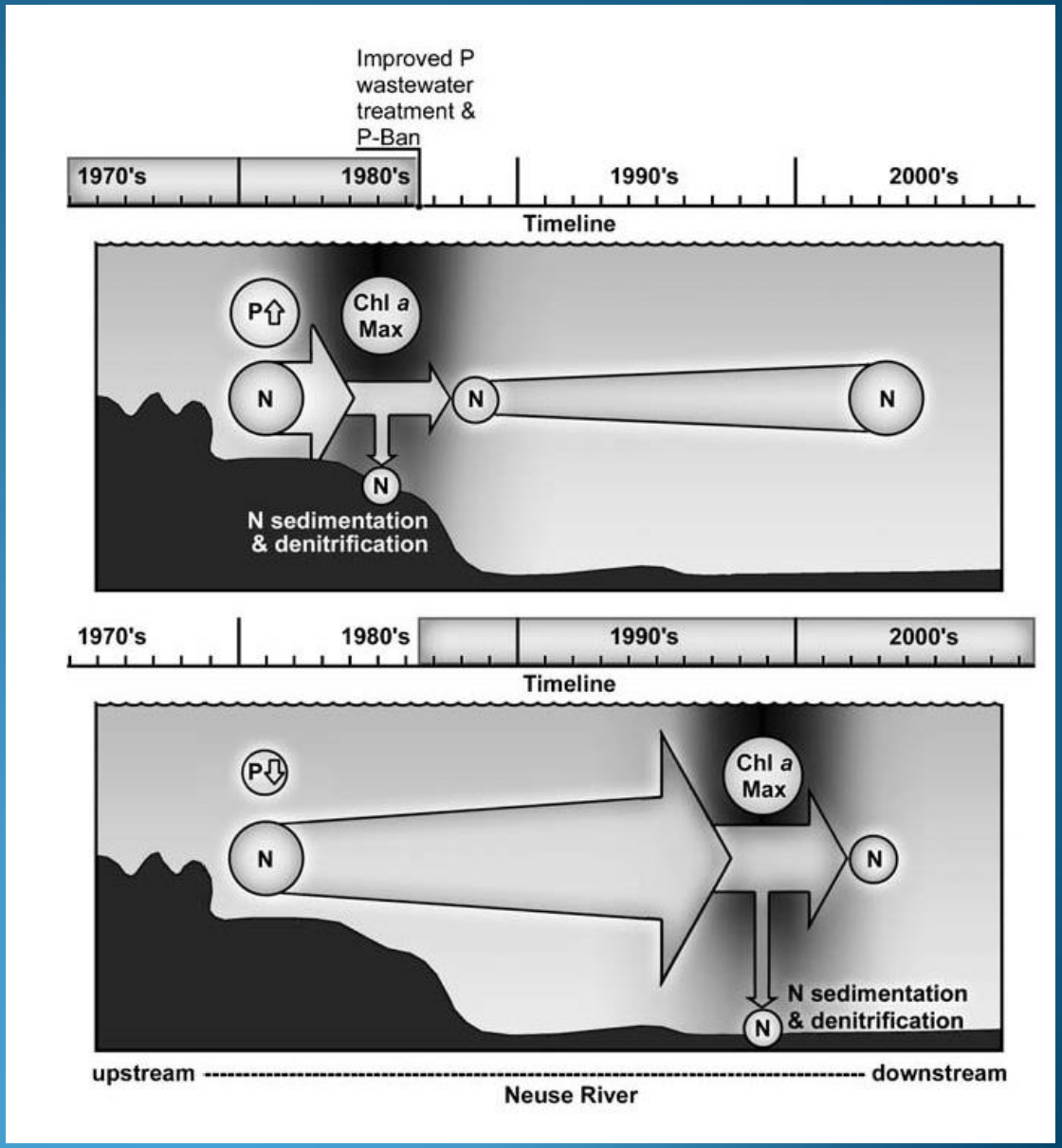




Dual nutrient control:

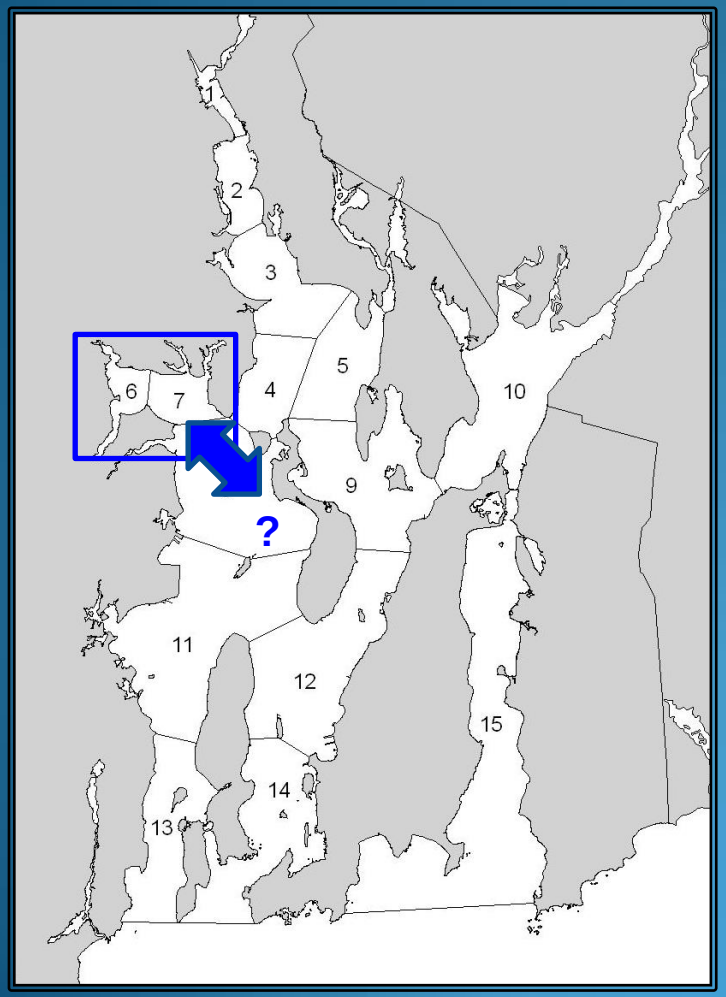
Neuse River Estuary, NC

Paerl et al. (2004); Paerl (2009)

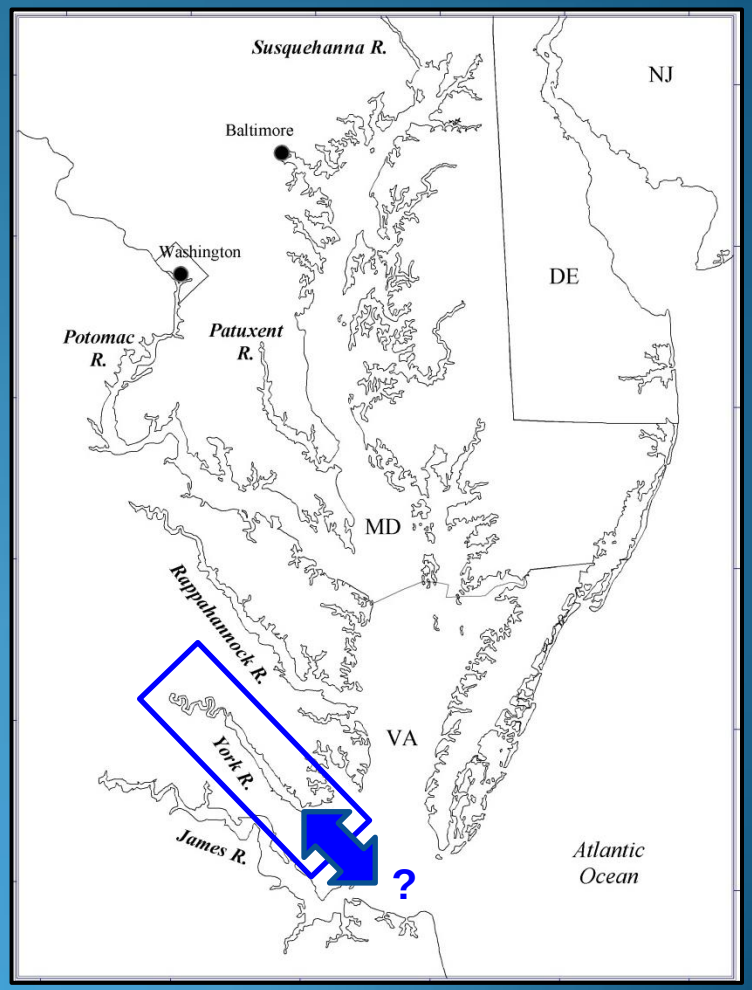


Estuary/Sub-Estuary Interaction & the Role of Advection

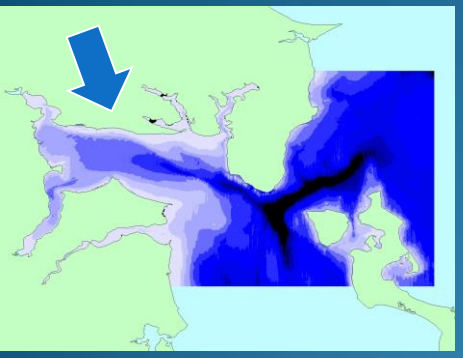
Greenwich Bay,
Narragansett Bay, RI



York River Estuary,
Chesapeake Bay, VA



0% of inputs from the watershed

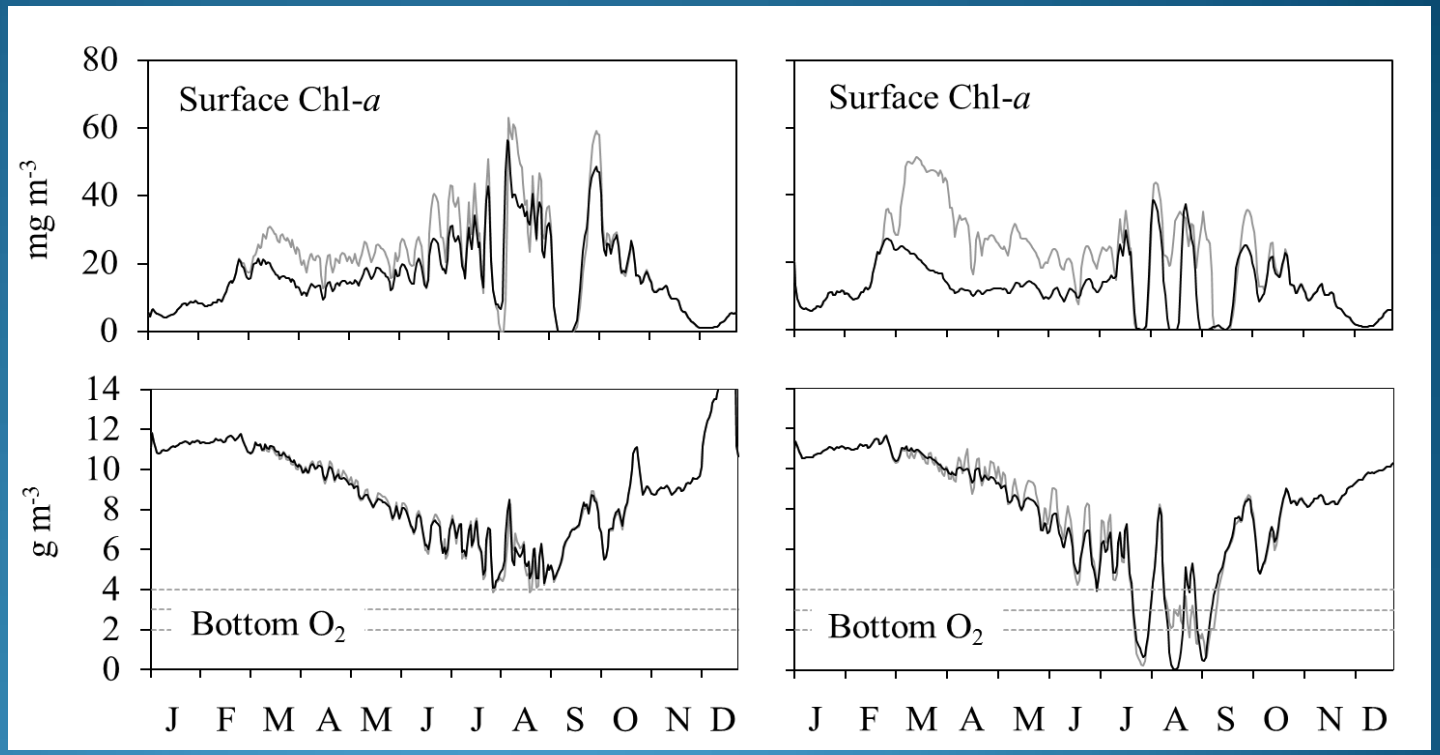


Greenwich Bay, RI

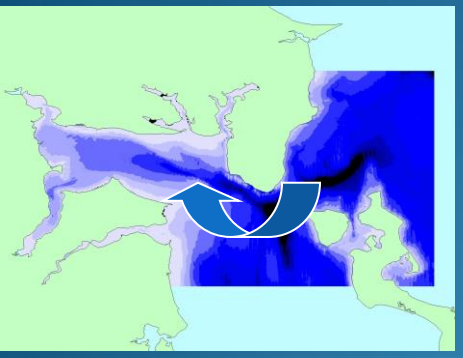
Brush (2002, 04)

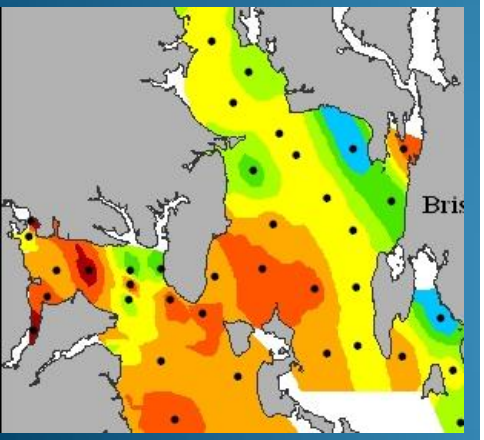
Apponaug Cove

Greenwich Cove



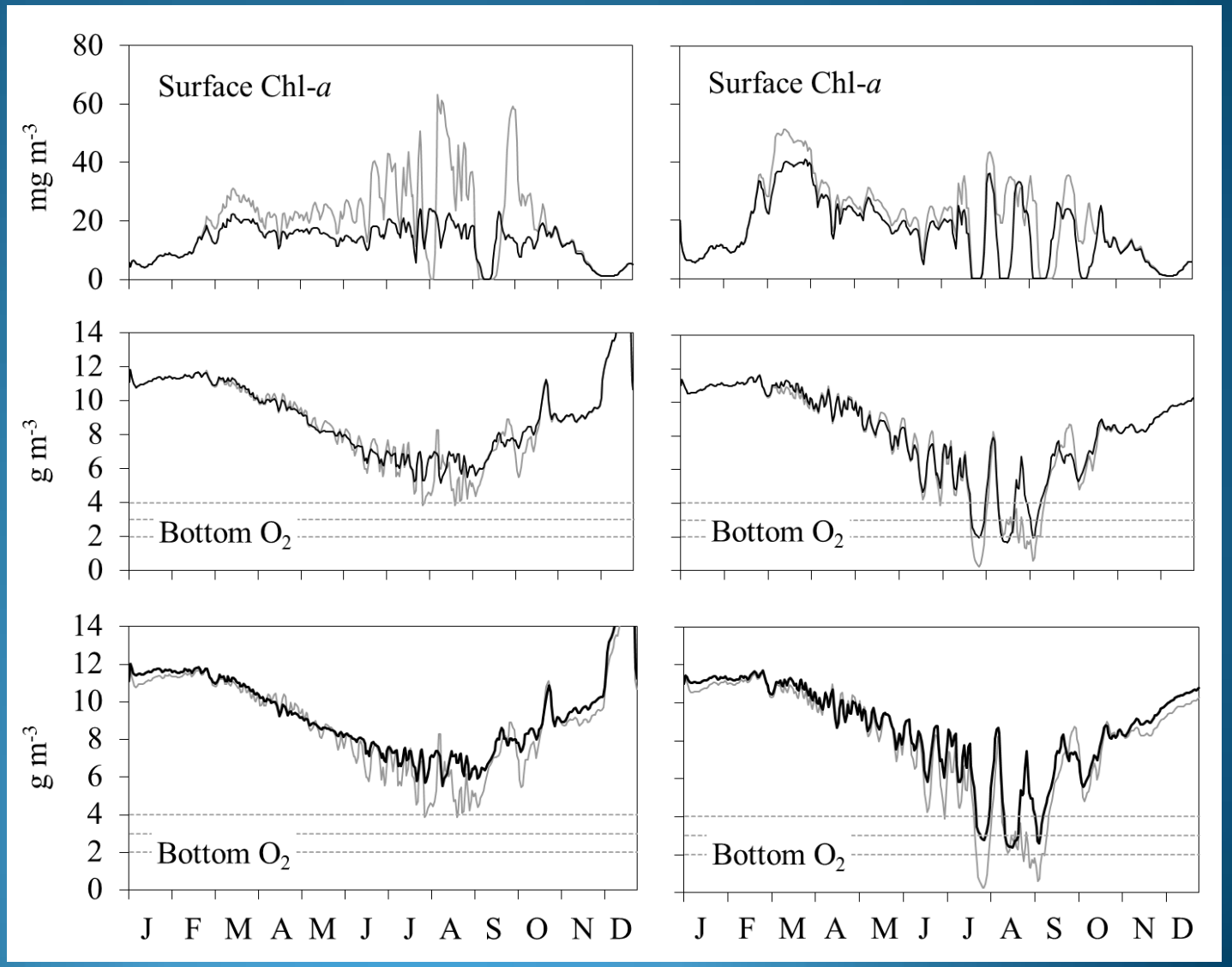
0% of inputs from Narragansett Bay





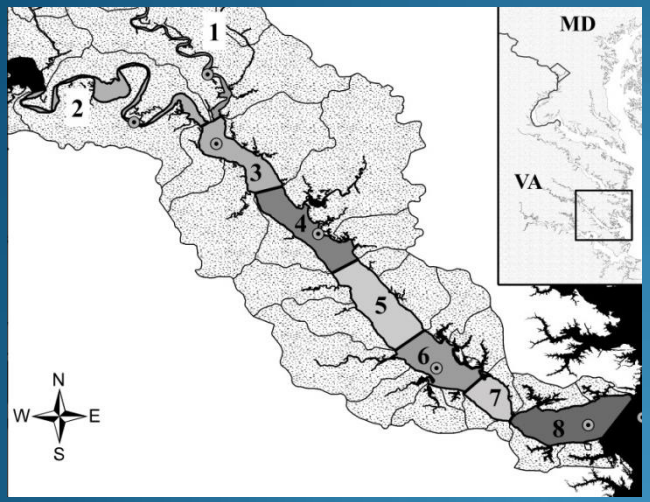
Apponaug Cove

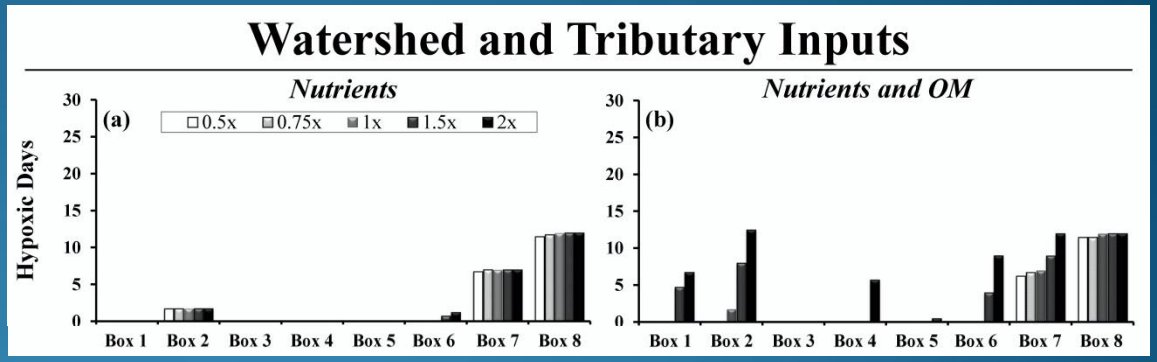
Greenwich Cove

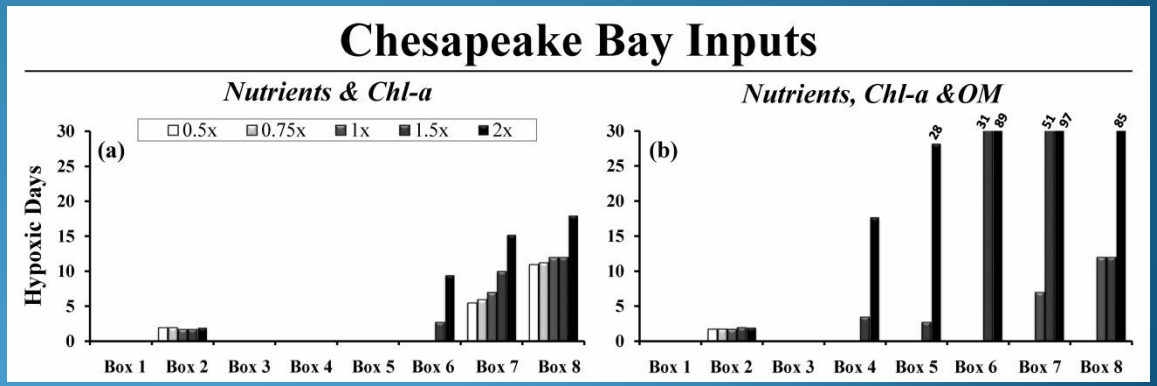


York River Estuary, VA

Lake (2013)







The Benthic Filter

FEATURE ARTICLE: REVIEW

MEPS, 2007

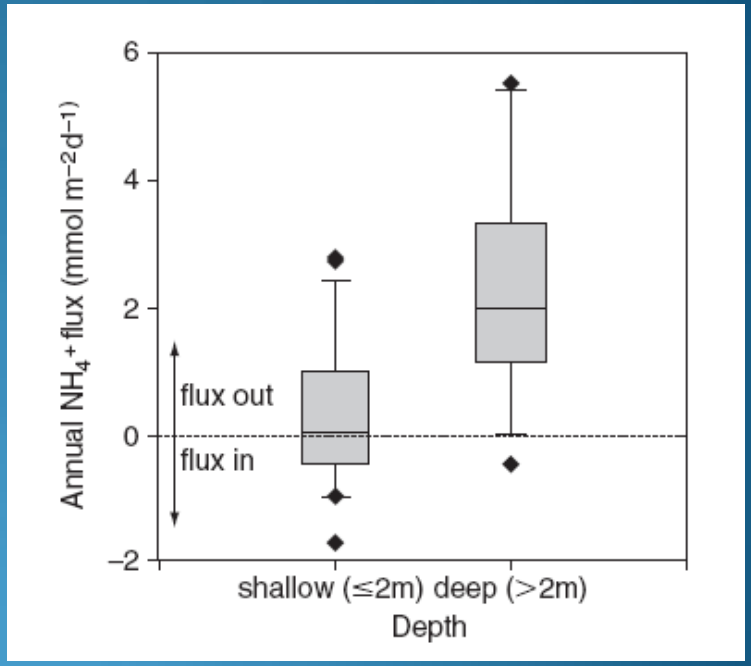
Eutrophication in shallow coastal bays and lagoons: the role of plants in the coastal filter

Karen J. McGlathery[1,*], Kristina Sundbäck[2], Iris C. Anderson[3]

[1]Department of Environmental Sciences, University of Virginia, 291 McCormick Road, PO Box 400123, Charlottesville, Virginia 22903, USA
[2]Department of Marine Ecology, Marine Botany, Göteborg University, PO Box 461, 40530 Göteborg, Sweden
[3]School of Marine Science, Virginia Institute of Marine Science, College of William and Mary, Gloucester Point, Virginia 23602, USA

ABSTRACT: Nutrient loading to coastal bay ecosystems is of a similar magnitude as that to deeper, river-fed estuaries, yet our understanding of the eutrophication process in these shallow systems lags far behind. In this synthesis, we focus on one type of biotic feedback that influences eutrophication patterns in coastal bays—the important role of primary producers in the 'coastal filter'. We discuss the 2 aspects of plant-mediated nutrient cycling as eutrophication induces a shift in primary producer dominance: (1) the fate of nutrients bound in plant biomass, and (2) the effects of primary producers on biogeochemical processes that influence nutrient retention. We suggest the following generalizations as eutrophication proceeds in coastal bays: (1) Long-term retention of recalcitrant dissolved and particu-

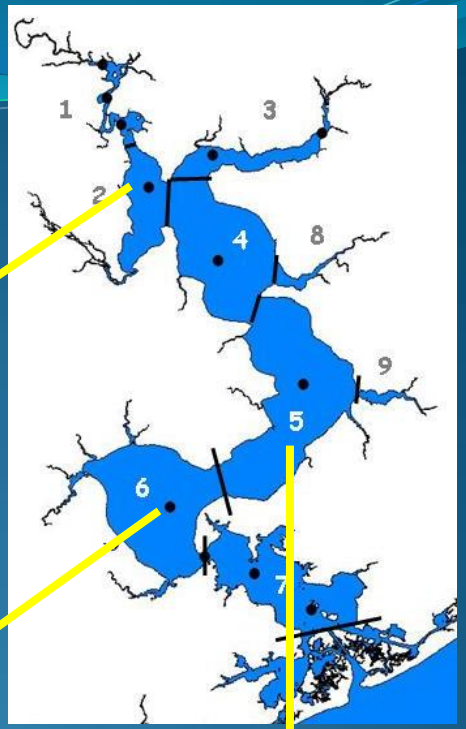
Joye & Anderson (2008)



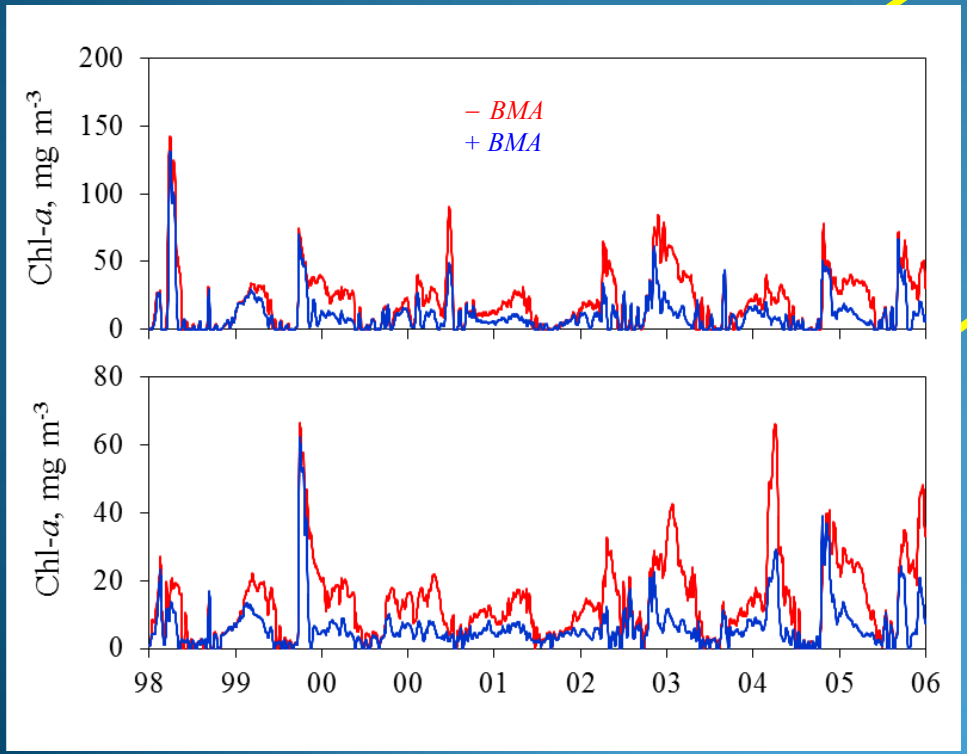
F. Parker

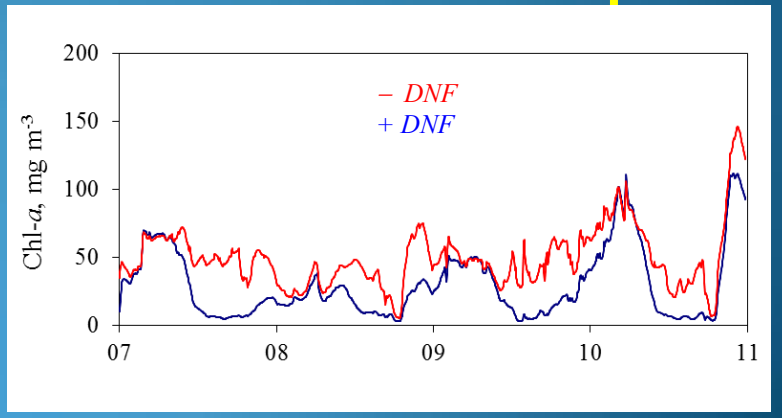
New River Estuary, NC

Brush (2012)

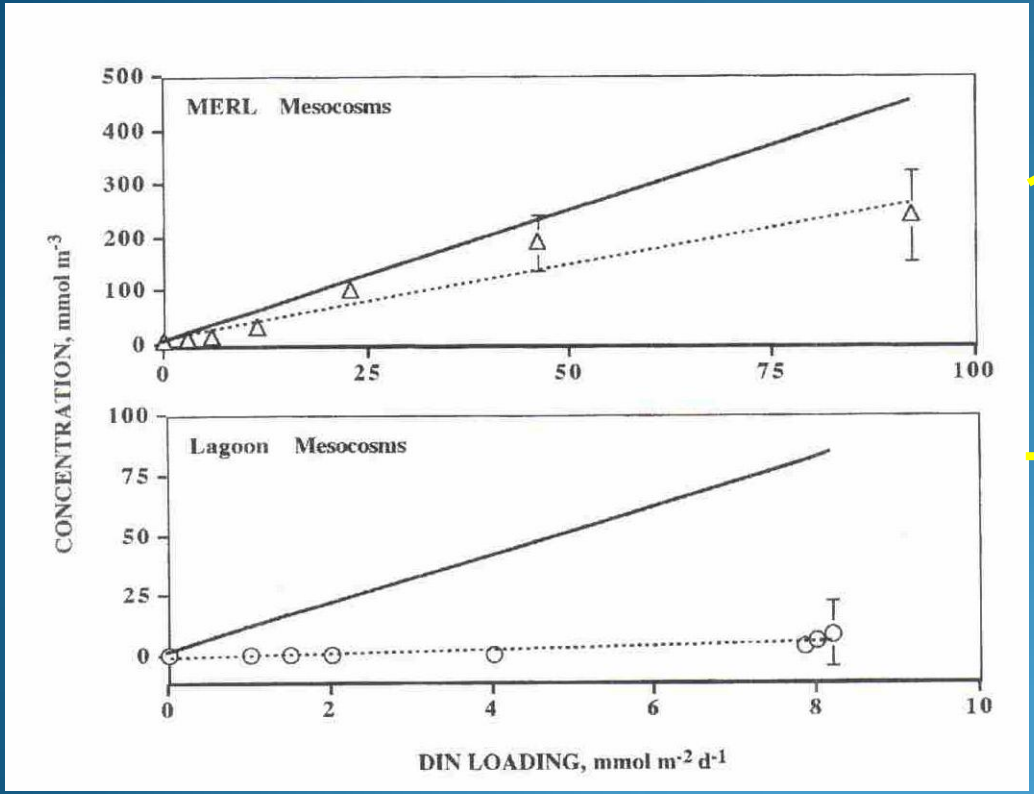


Simulated Chl-*a*, mg m^{-3}

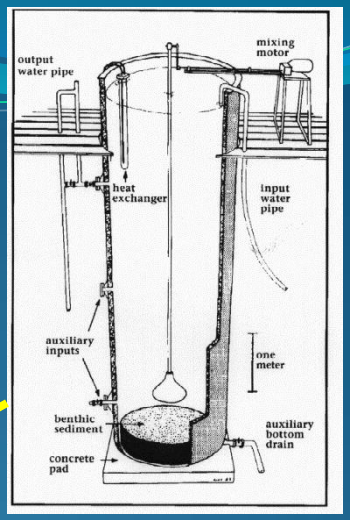


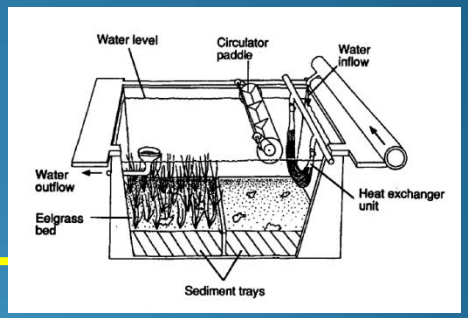


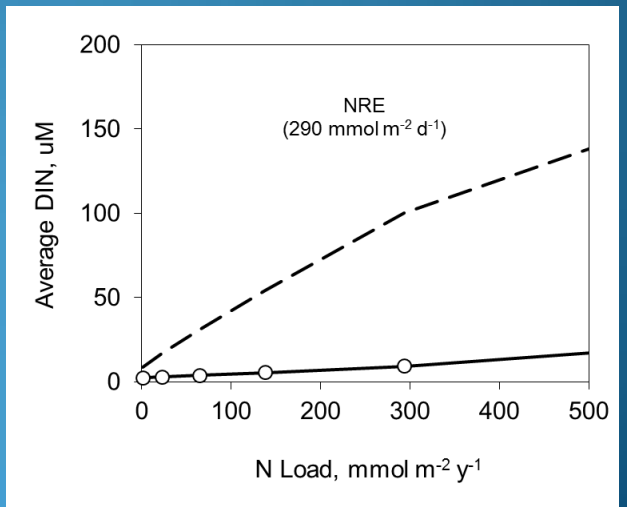
Nutrient concentration can be a poor indicator in shallow systems:



Nixon et al. (2001)

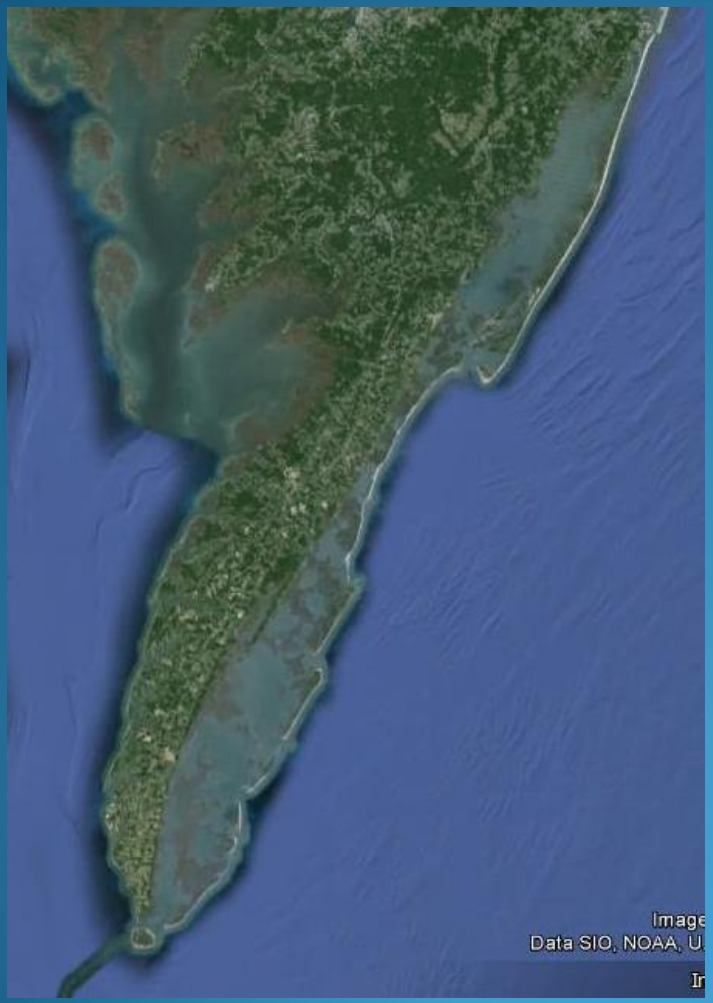


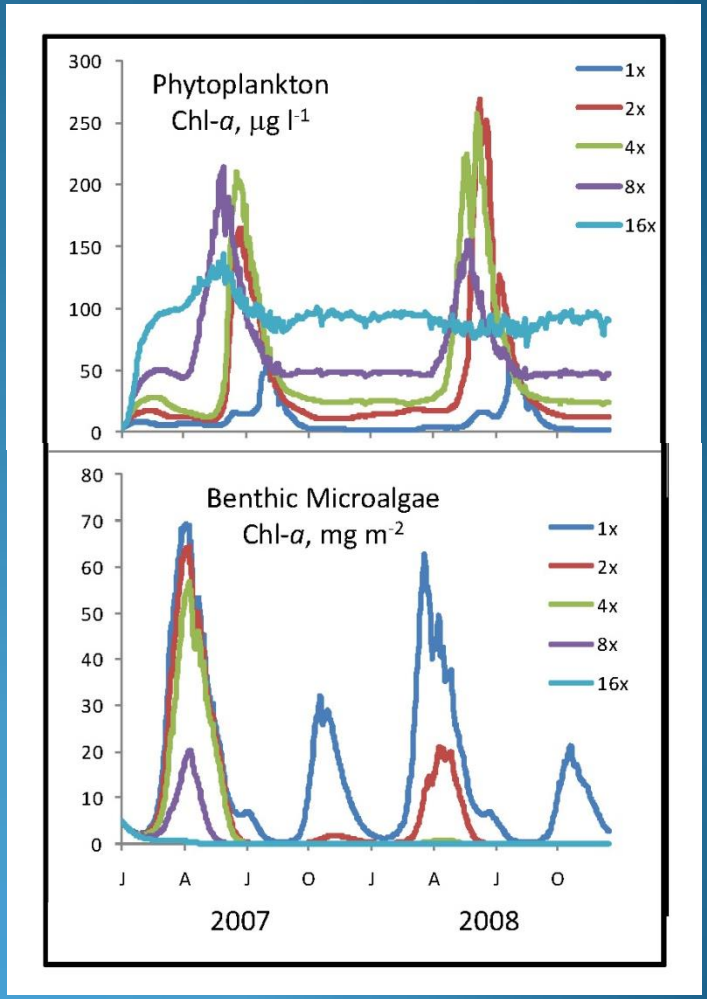




Brush (2012)

Development of alternative stable states:





Brush et al. (2010)

Interactions with Climate

Estuarine, Coastal and Shelf Science 86 (2010) 1–20

Contents lists available at ScienceDirect

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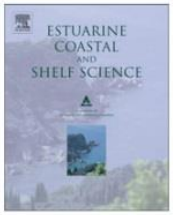
journal homepage: www.elsevier.com/locate/ecss



Invited feature

Potential climate-change impacts on the Chesapeake Bay

Raymond G. Najjar[a,*], Christopher R. Pyke[b], Mary Beth Adams[c], Denise Breitburg[d], Carl Hershner[e], Michael Kemp[f], Robert Howarth[g], Margaret R. Mulholland[h], Michael Paolisso[i], David Secor[j], Kevin Sellner[k], Denice Wardrop[l], Robert Wood[m]

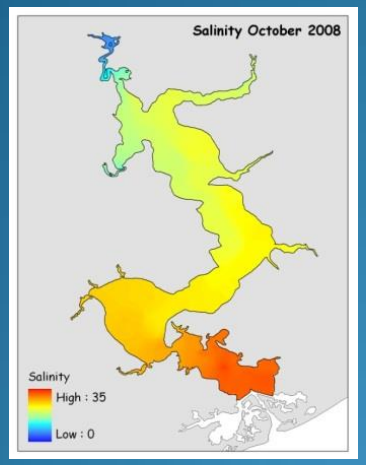
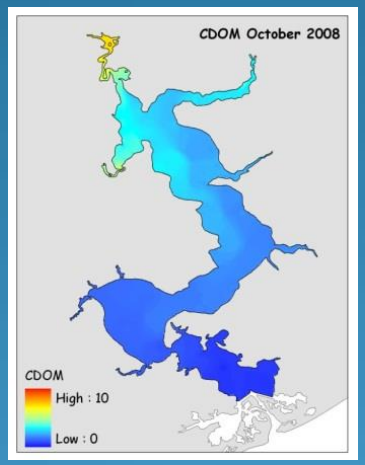
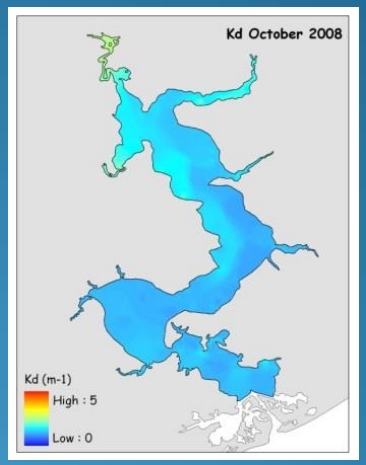
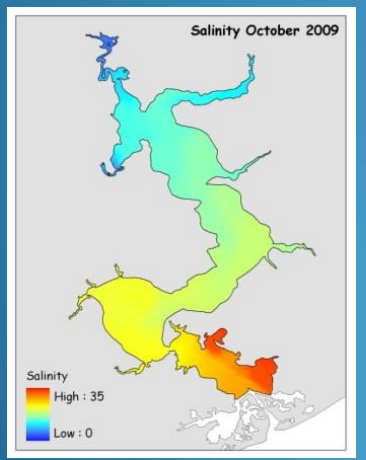
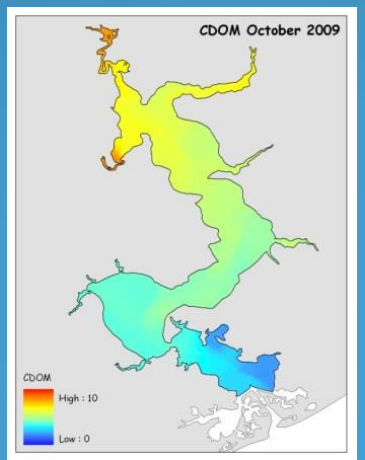
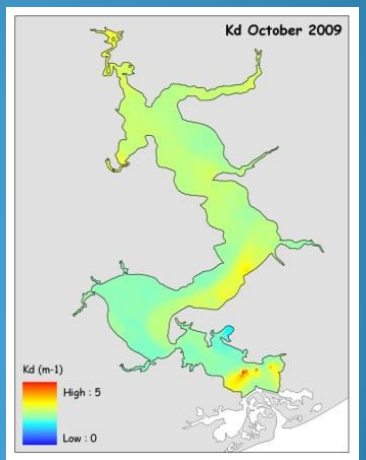
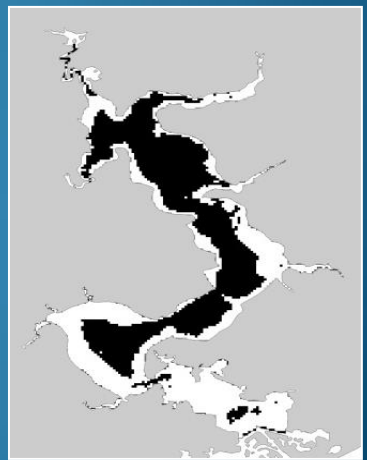
In the Mid-Atlantic, we expect a climate that is…

- Warmer
- Wetter (more precipitation → flow?)
- Stormier
- With higher sea levels

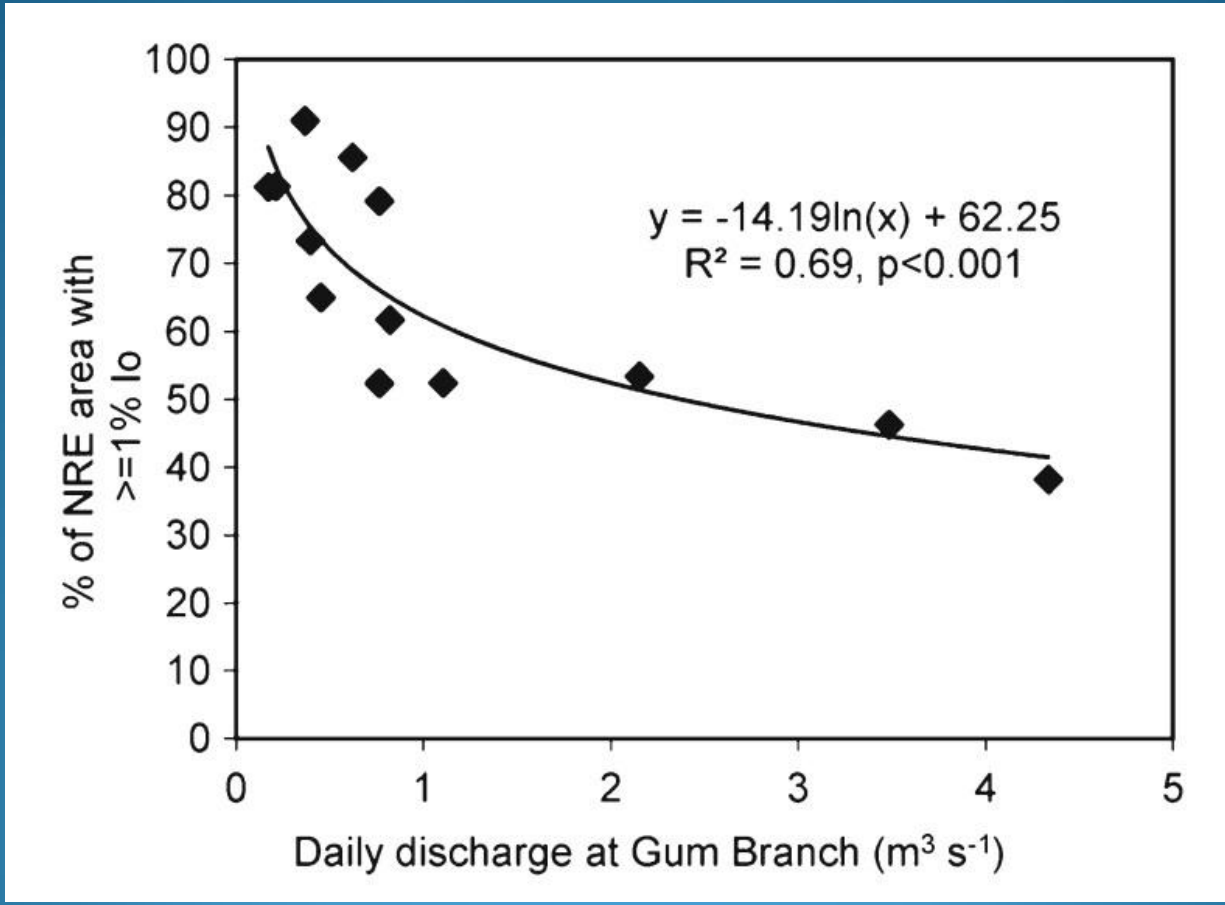
Wet vs. dry periods:

New River Estuary, NC

Anderson et al. (2012)

	Salinity (PSU)	CDOM (ABS_{440}, m^{-1})	K_d (PAR) (m^{-1})	1% I_o
Oct 2008 (drought):				
Oct 2009 (wet fall):				

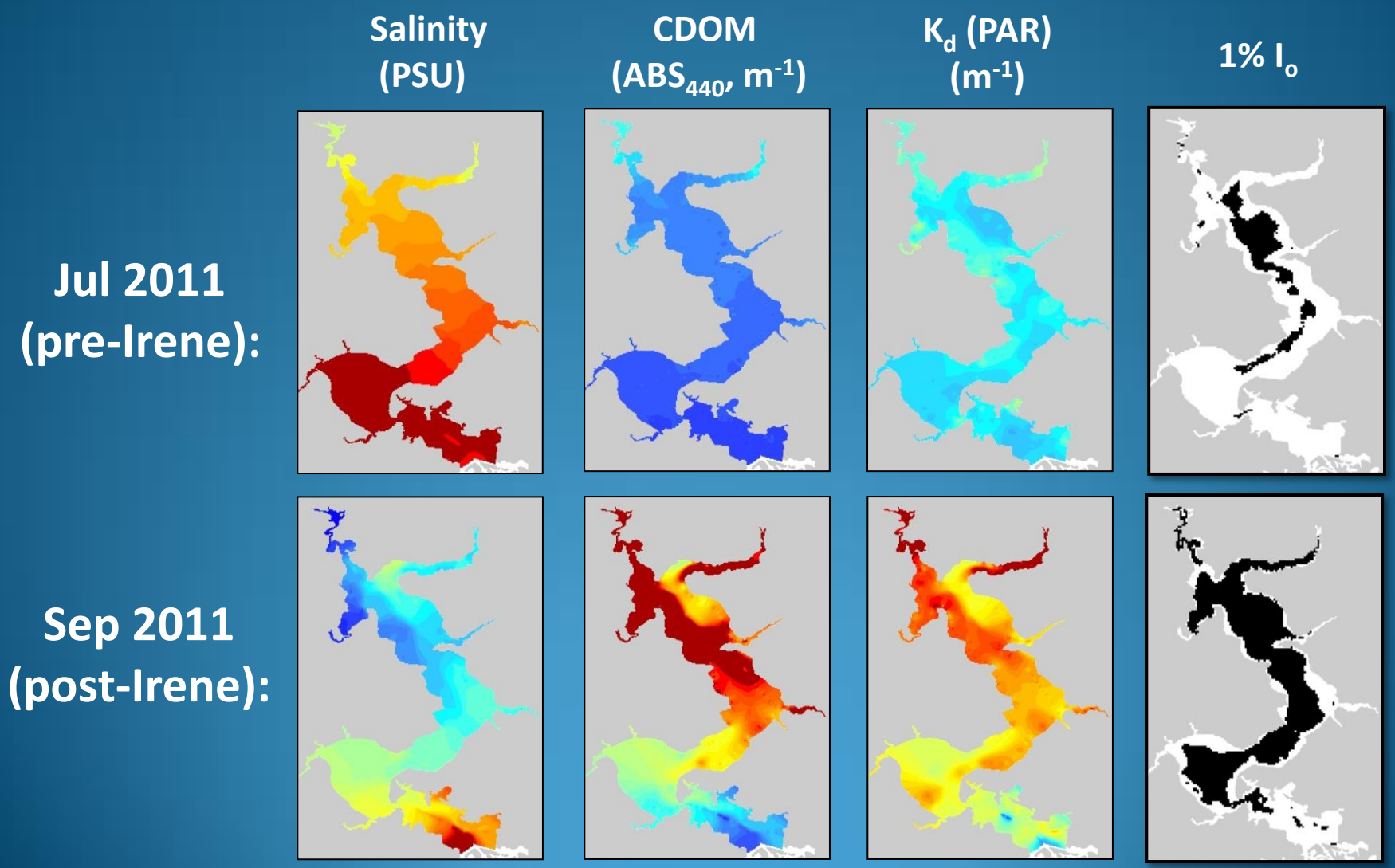
Wet vs. dry periods:



Anderson et al. (2013)

Role of storms (Hurricane Irene):

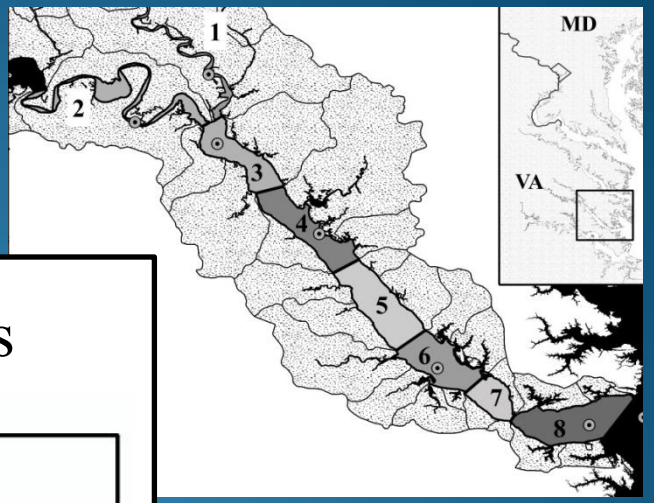
Anderson et al. (2012)

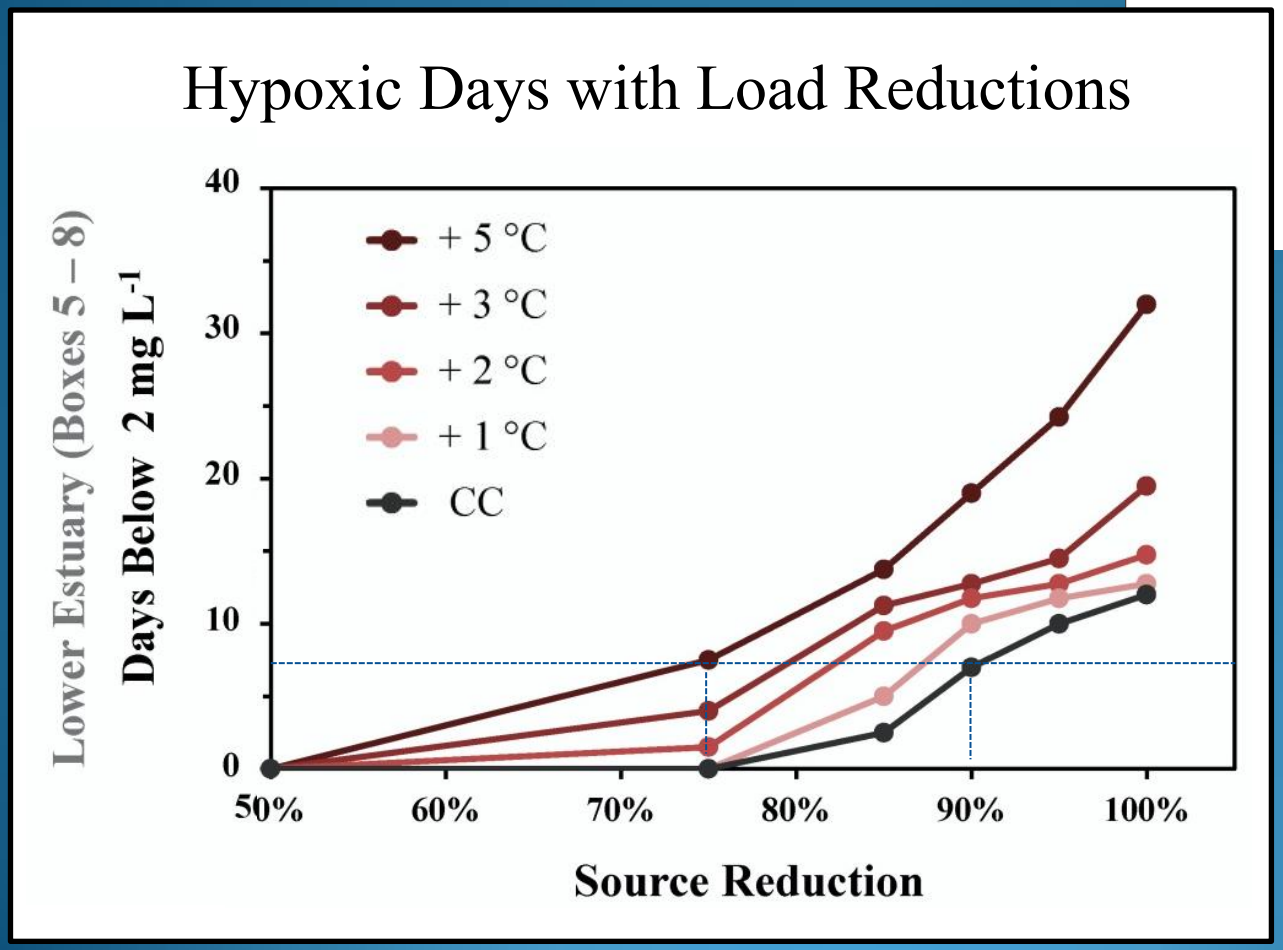


York River Estuary, VA

Lake (2013)

Effect on nutrient reduction targets:

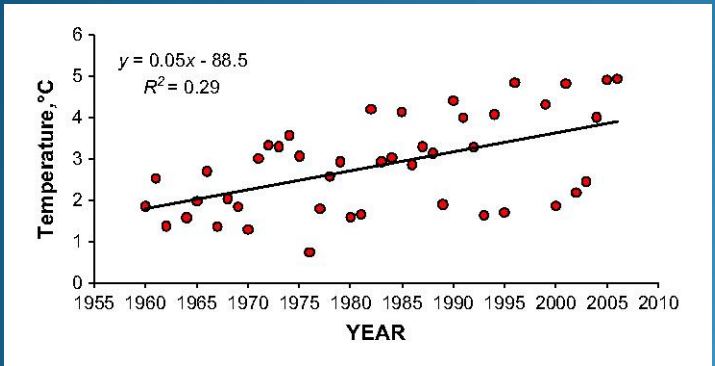


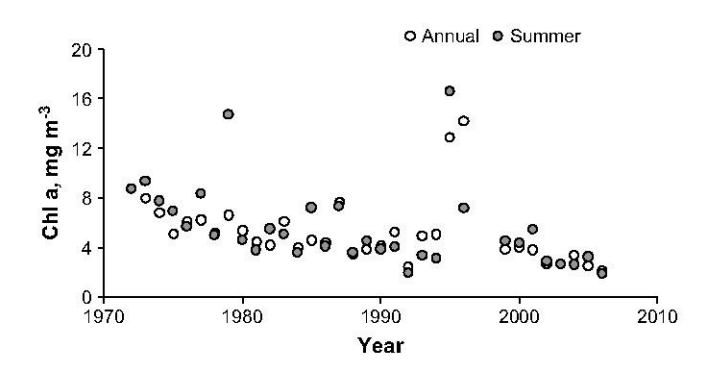


Oligotrophication

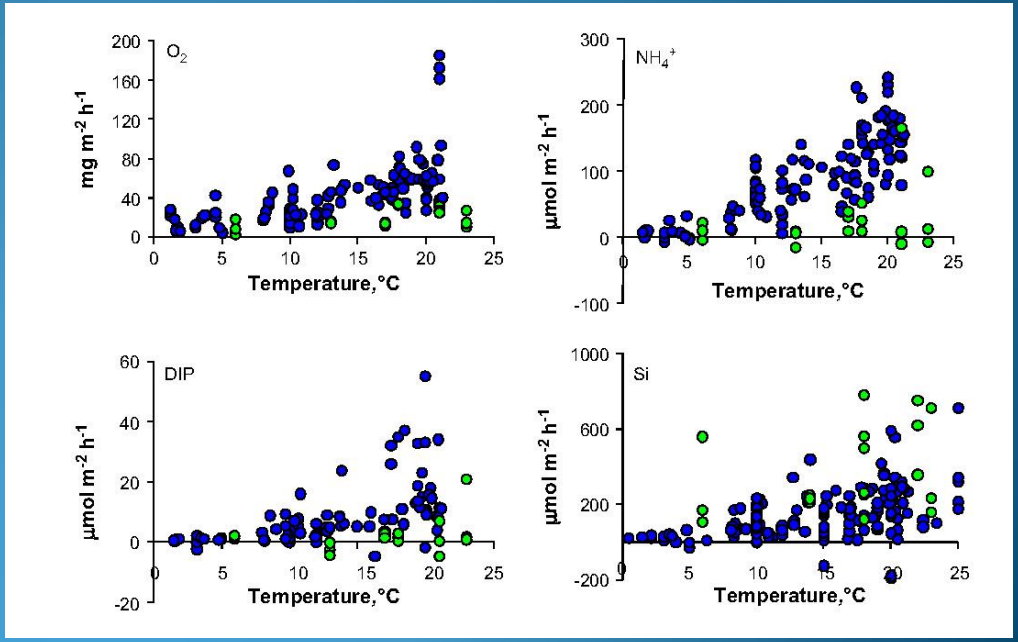
Oligotrophication (noun) – a decrease in the rate ofsupply of organic matter to an ecosystem.

Nixon (2009)



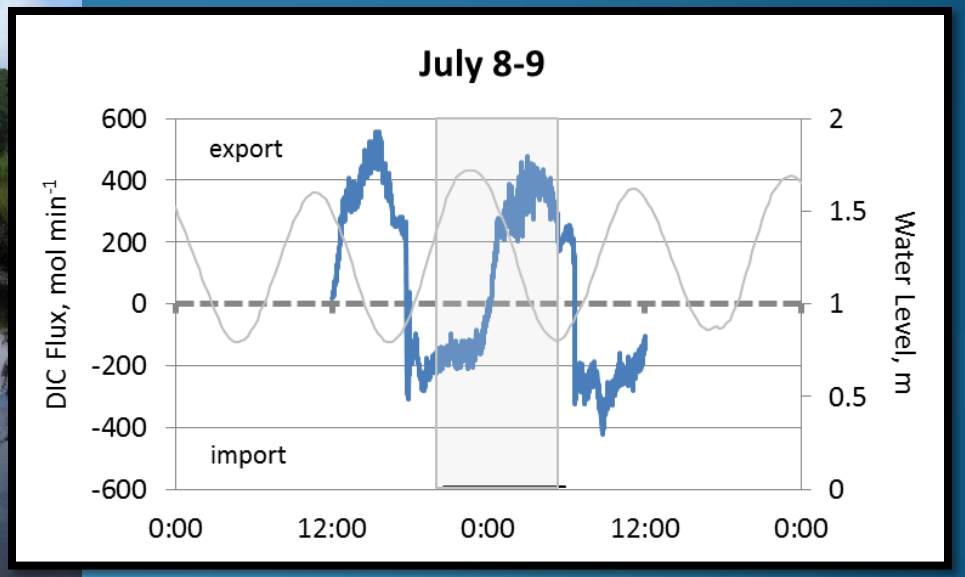


Narragansett Bay
Nixon et al. (2009)



Outwelling, NEM, and Estuaries as C Sources/Sinks

Photo: J. Radcliffe

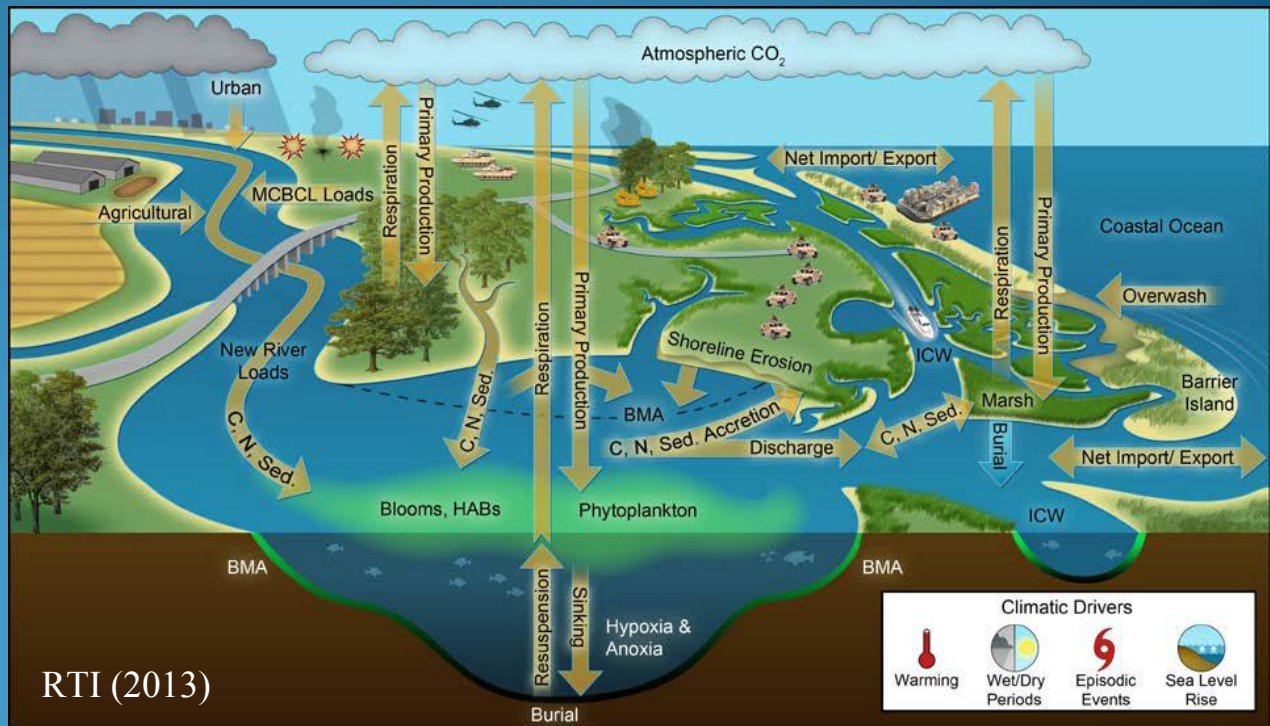


Brush, Ramirez-Velez, & Lake

grida.no/publications/rr/blue-carbon

Phase 2

2013 – 2017
https://dcerp.rti.org/

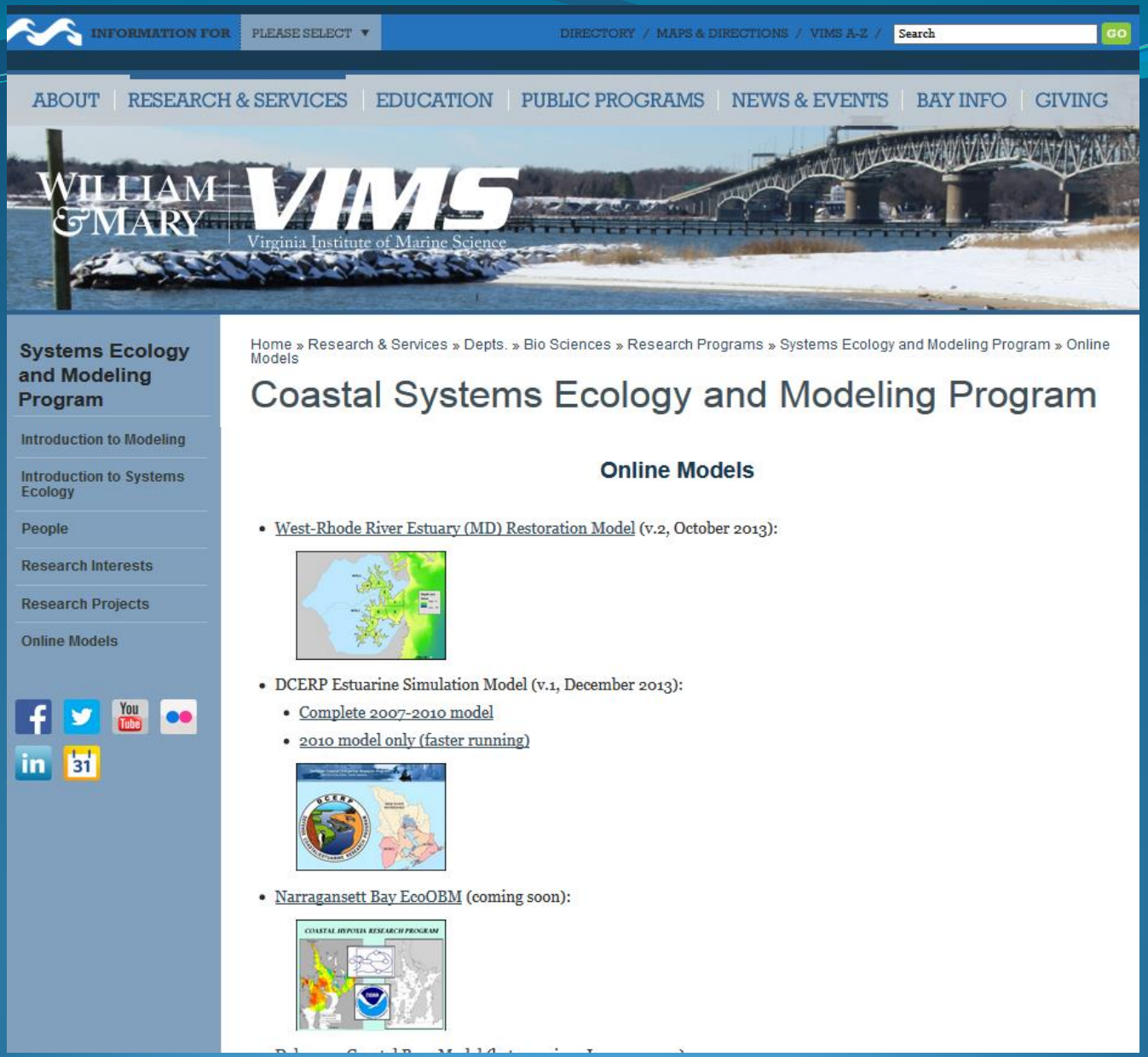


RTI (2013)

Summary

- Nutrient-fueled eutrophication
  - Role of interannual variability
  - Importance of transport processes
  - Nutrient reduction targets (TMDLs)
  - Dual N & P control
- Estuary/sub-estuary interaction and the role of advection
- The benthic filter
- Interactions with climate
- Oligotrophication
- Outwelling, NEM, and estuaries as carbon sources or sinks

Simple models



www.vims.edu/research/departments/bio/programs/semp/models/index.php

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VA/MD Collaborators:

Lora Harris
Sam Lake
Alma Ramirez-Velez

NC Collaborators:

Iris Anderson
Carolyn Currin
Sam Lake
Hans Paerl
Mike Piehler
Jen Stanhope

RI Collaborators:

Scott Nixon

Wally Fulweiler
Jim Kremer
Candace Oviatt