Atmospheric Nitrogen Deposition: An increasingly Important Source of "new" Nitrogen Supporting Coastal Eutrophication

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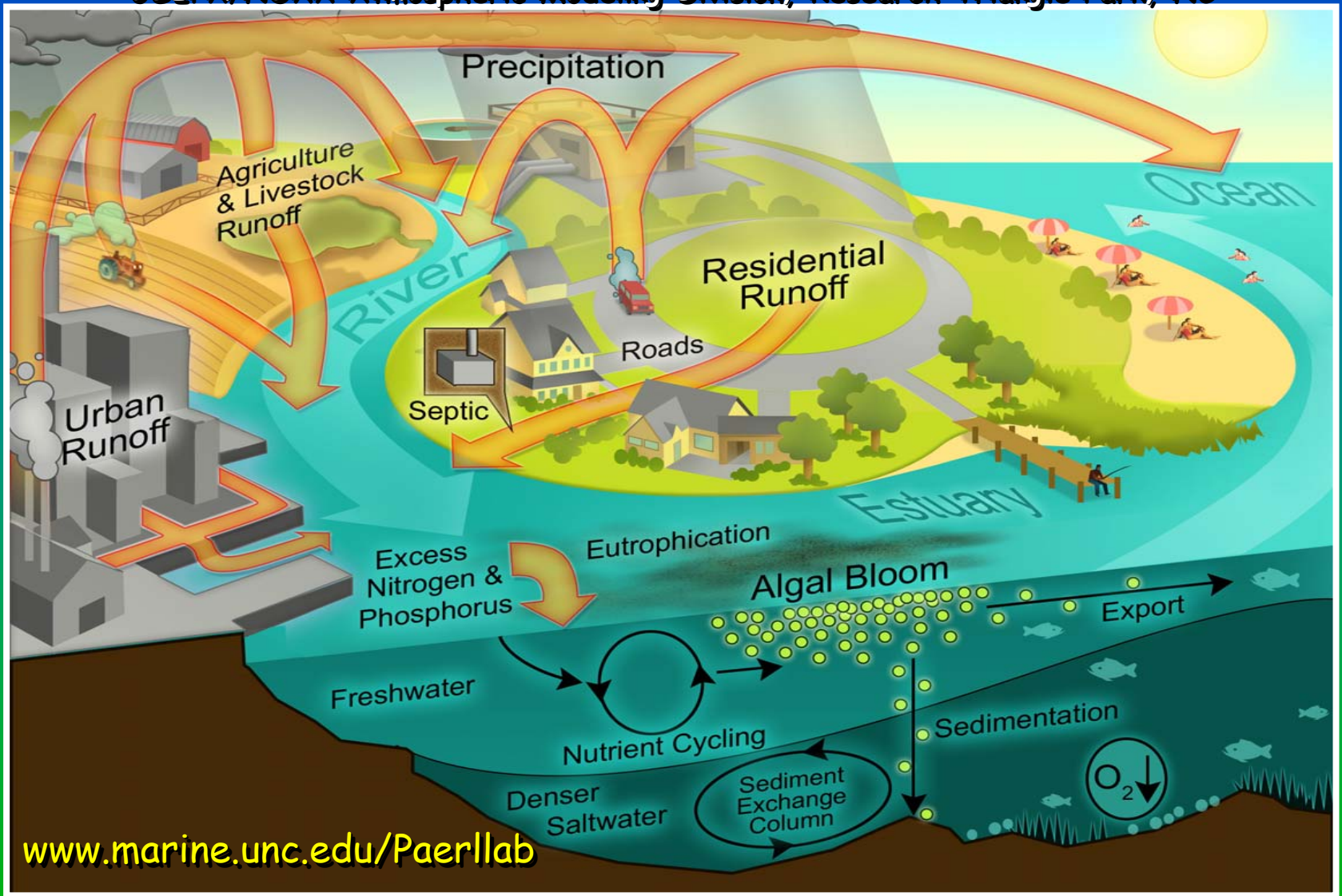
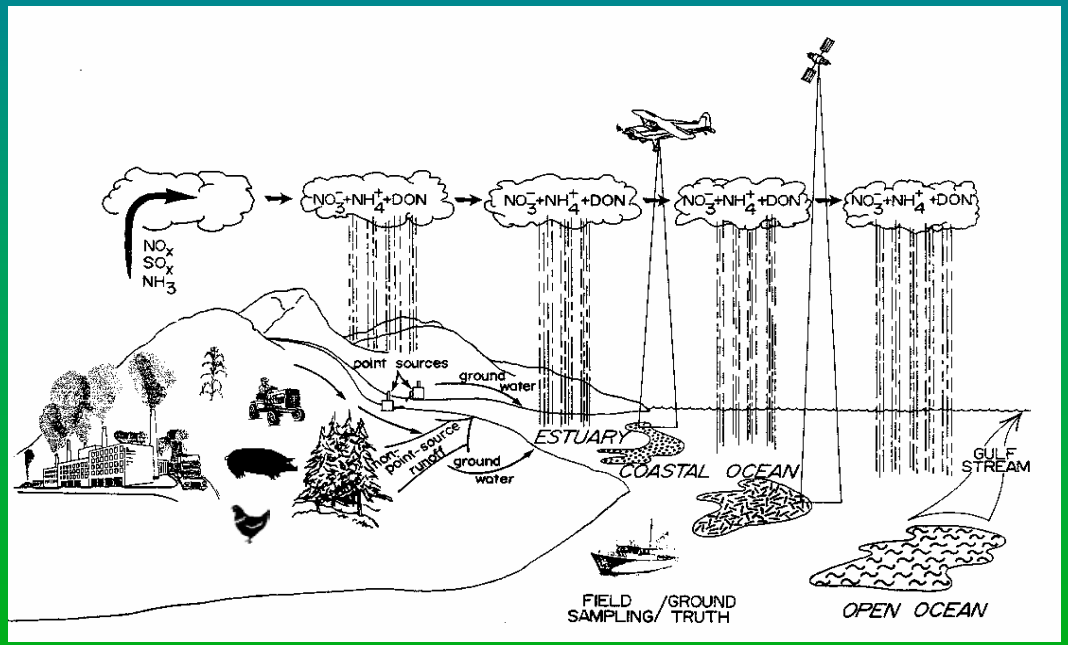


Why The Concern About Atmospheric Deposition of N (AD-N) in Coastal Waters?

- AD-N is a significant source of externally-supplied or "new" N to coastal waters
- N is the nutrient most often controlling primary production & eutrophication
- AD-N sources are biologically available
- N-sensitive waters are currently impacted by AD-N



- How important is AD-N as a "new" N source?
- What are the origins & chemical forms of AD-N?
- What are the ecological impacts on coastal ecosystems?

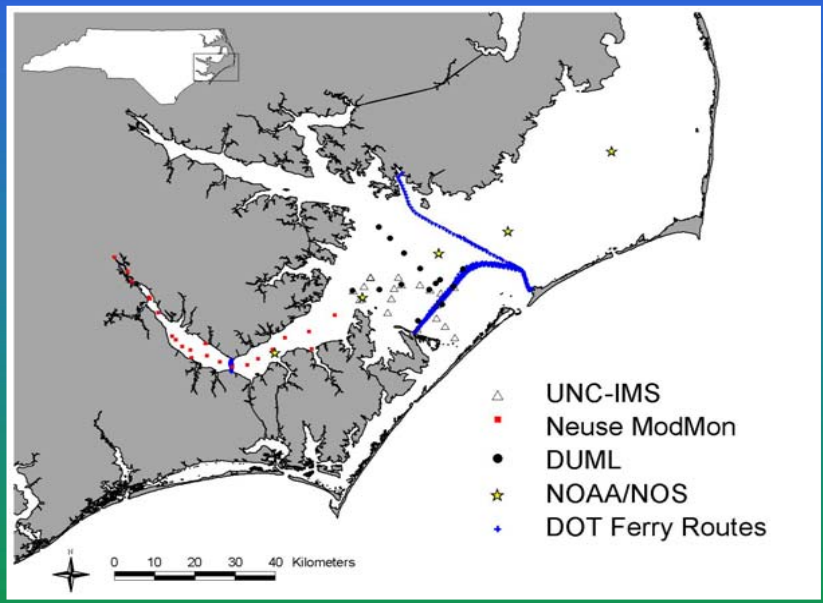
Estimated contributions of AD-N to "new" N inputs in estuarine, coastal and open ocean waters

• Baltic Sea	~30 %	Elmgren et al. 2001
• North Sea (Coastal)	20-40%	GESAMP 1989
• W. Mediterranean Sea	10-60%	Martin et al. 1989
• Waquoit Bay, MA	29%	Valiela et al. 1996
• Narragansett Bay	12%	Nixon 1995
• Long Island Sound	25%	L. I. Sound Study 1996
• New York Bight	38%	Valigura et al. 1996
• Barnegat Bay, NJ	~40%	Moser et al. 1999
• Chesapeake Bay	27%	C. B. Program 2001
• Rhode River, MD	40%	Correll and Ford 1982
• Neuse R., NC	~30%	Whitall and Paerl 2001
• Pamlico Sound, NC	20->40%	Paerl and Fogel 1994
• Sarasota/Tampa Bay, FL	25-30%	Sarasota Bay NEP 1996
• Mississippi River Plume	5 - ?? %	Goolsby et al. 2000

The Neuse R. Estuary-Pamlico Sound

Excessive N loading → eutrophication →

hypoxia → WQ/habitat decline



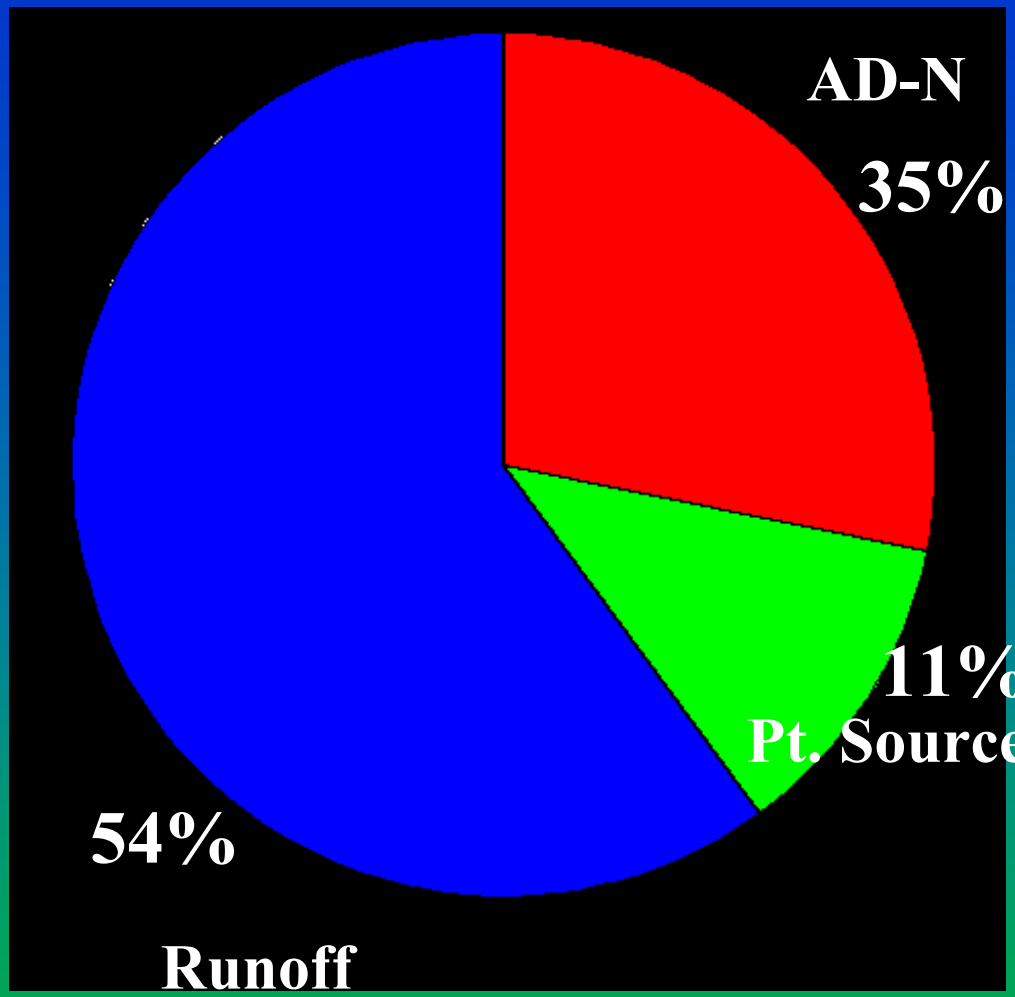
Neuse R Modeling & Monitoring Program (ModMon)

www.marine.unc.edu/neuse/modmon

Partners: UNC, ECU, Duke, NCSU, USGS, NCDENR, EPA,

Collaborators: NOAA-NOS, NASA, NADP, Weyerhaeuser

Neuse River Estuary N Sources (at head of estuary)



N Retention Values	
Forest	0.95
Pasture	0.90
Crop	0.70
Urban	0.70
Other	0.70

from Valigura et al. 1996

AD-N based on yearly averages from 1996-1999 data

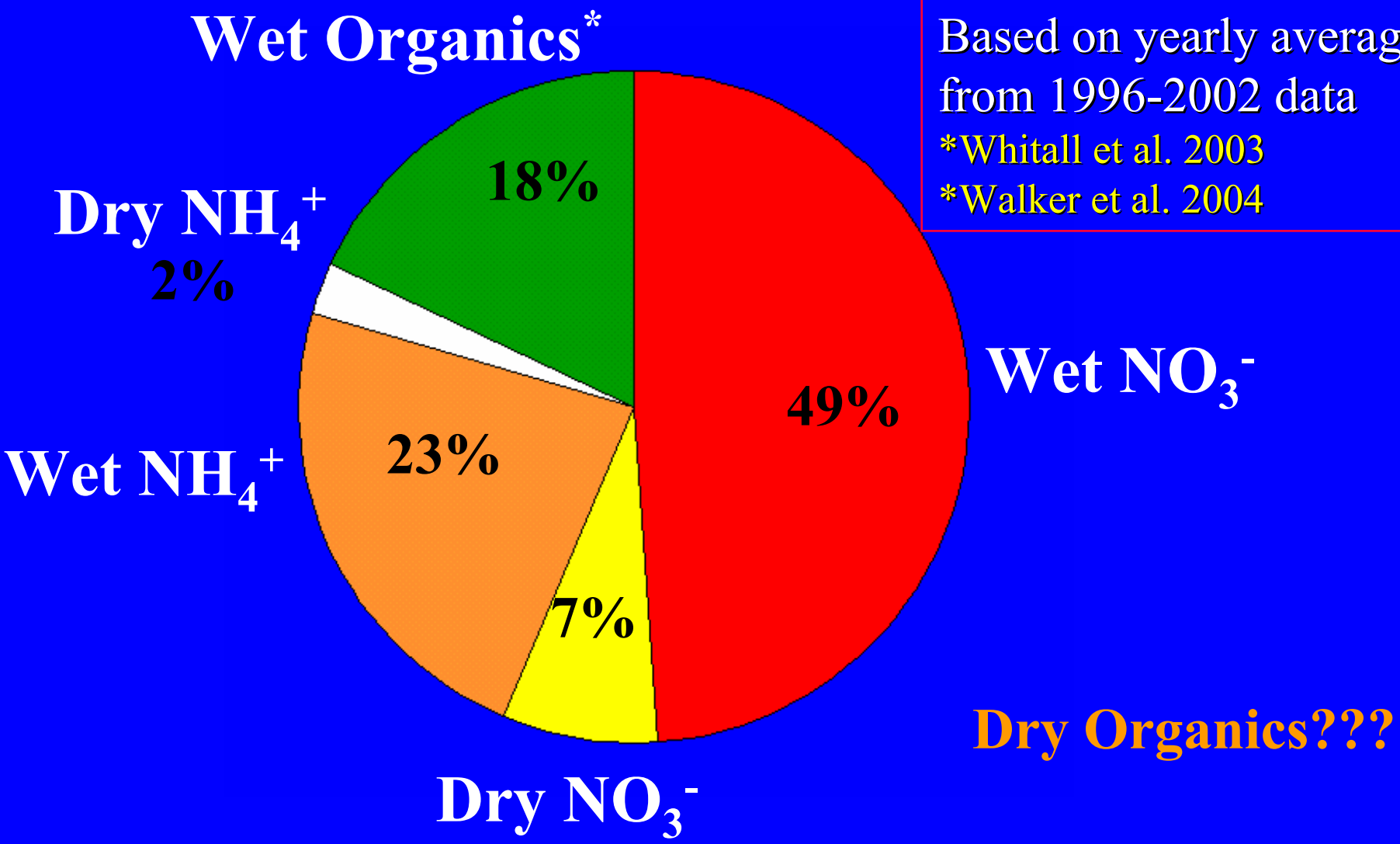
Runoff (excluding AD-N)and point source values from Dodd et al. 1992.

Total AD-N for Neuse R. Estuary

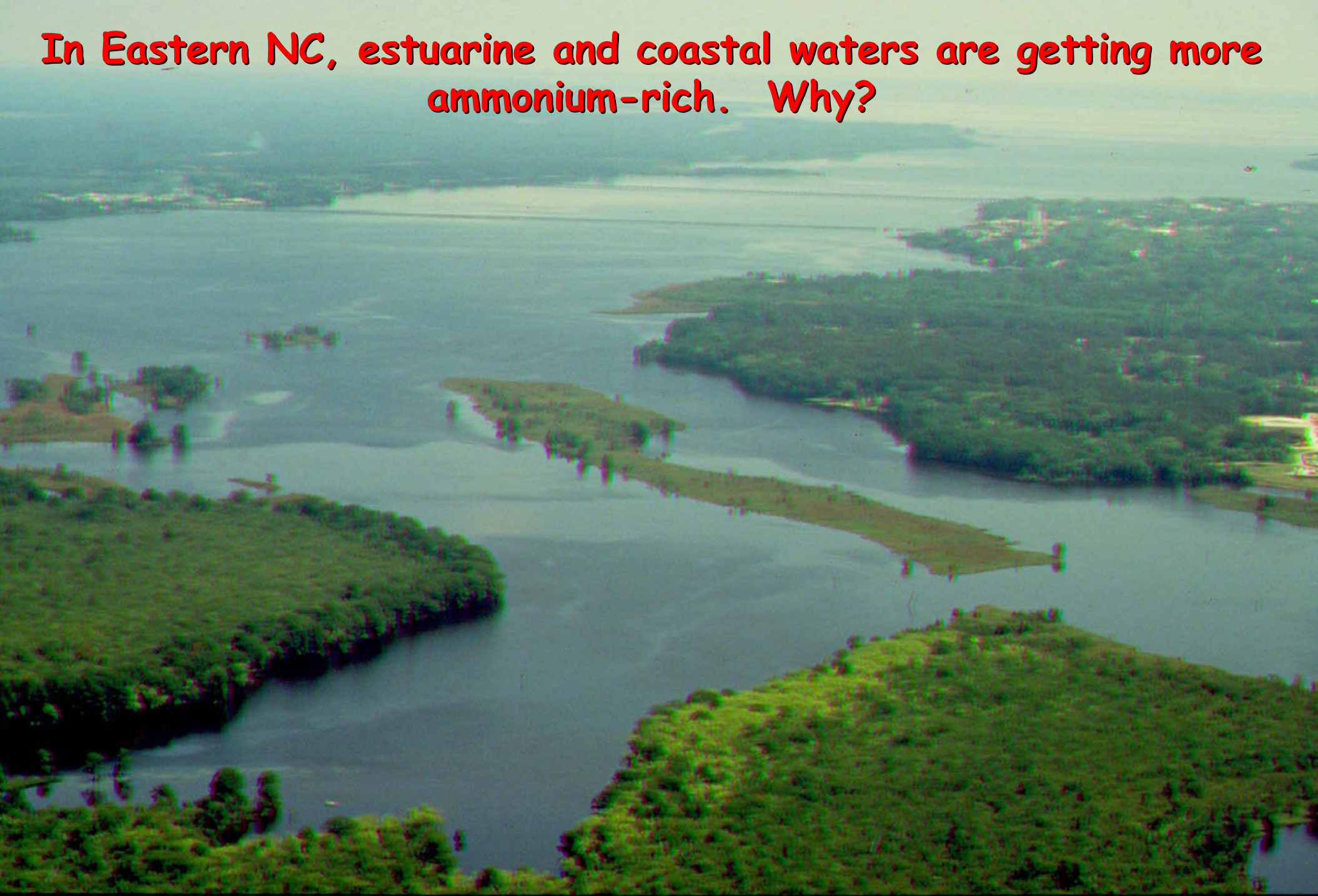
Based on yearly averages from 1996-2002 data

*Whitall et al. 2003

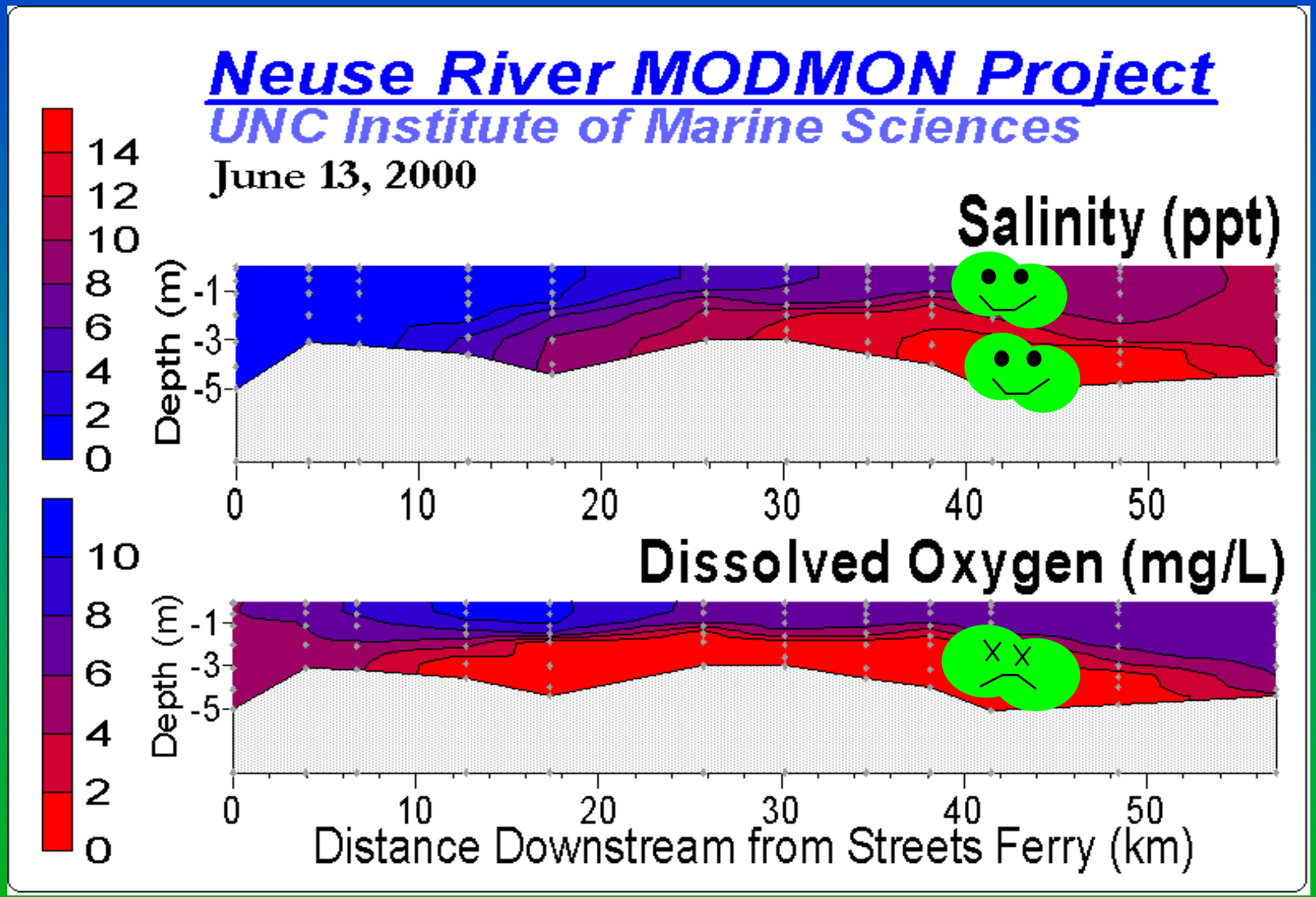
*Walker et al. 2004



* Estimate based on previous studies and limited data from this study; wet organics comprise approx. 20% of total wet N deposition


In Eastern NC, estuarine and coastal waters are getting more ammonium-rich. Why?

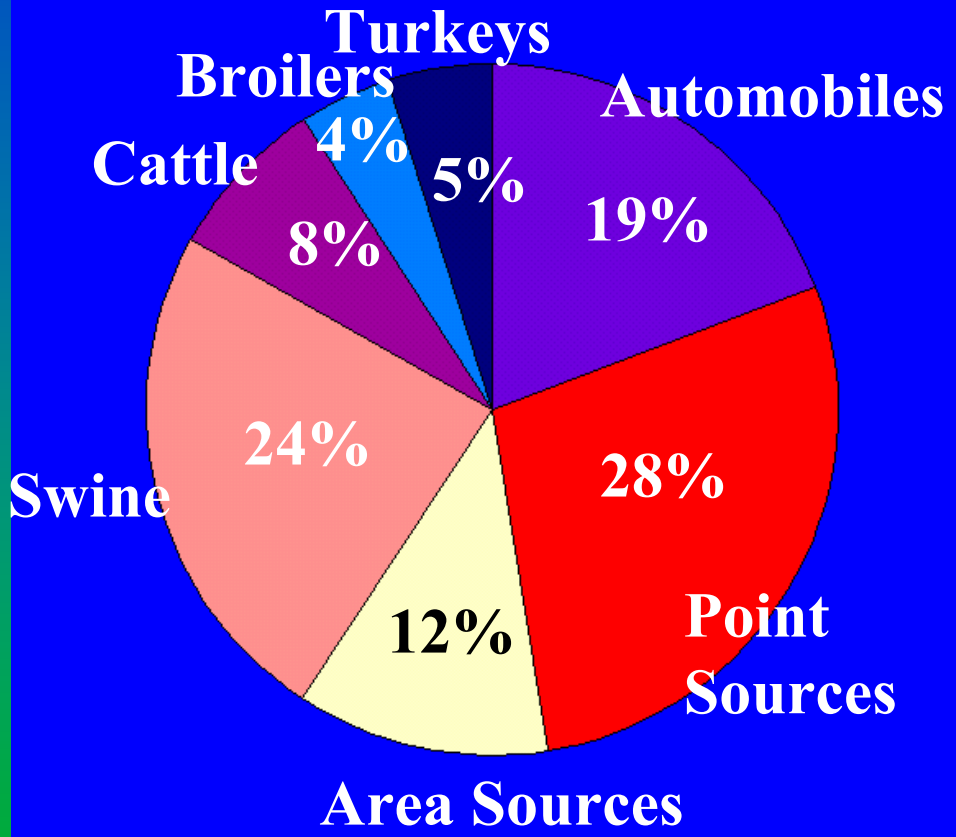
One reason: N-Driven Eutrophication, Increasing Hypoxia & Sediment Ammonium Release



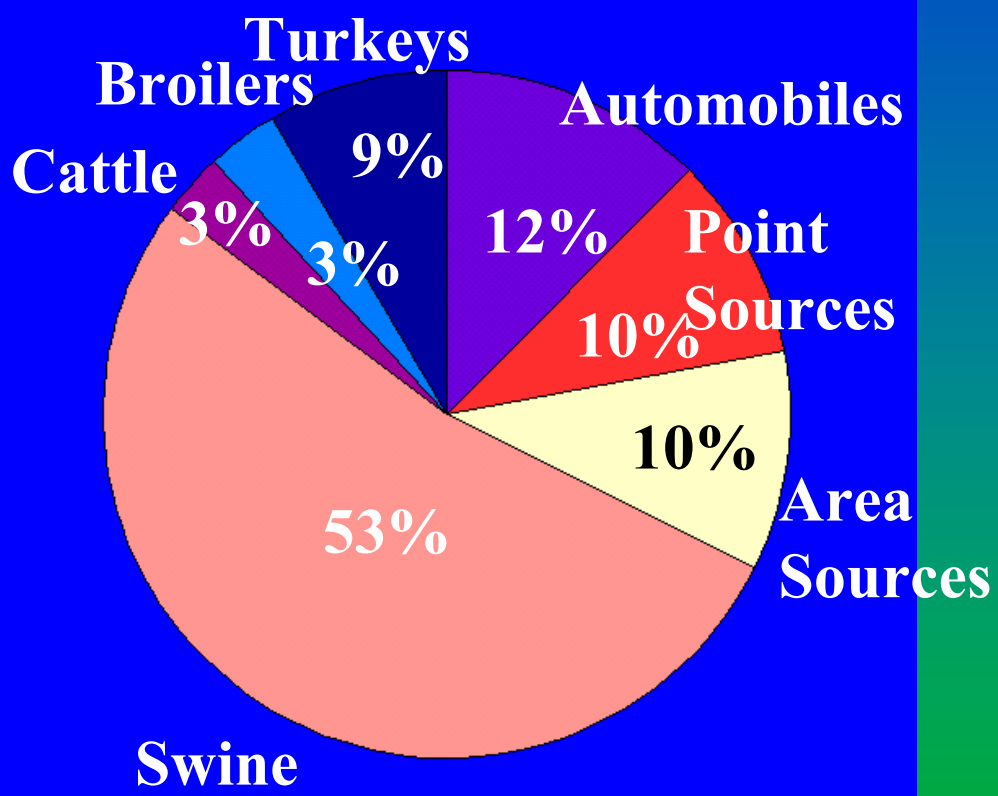
Another reason: More ammonia is being emitted locally and regionally

North Carolina Atmospheric Emissions, 1996

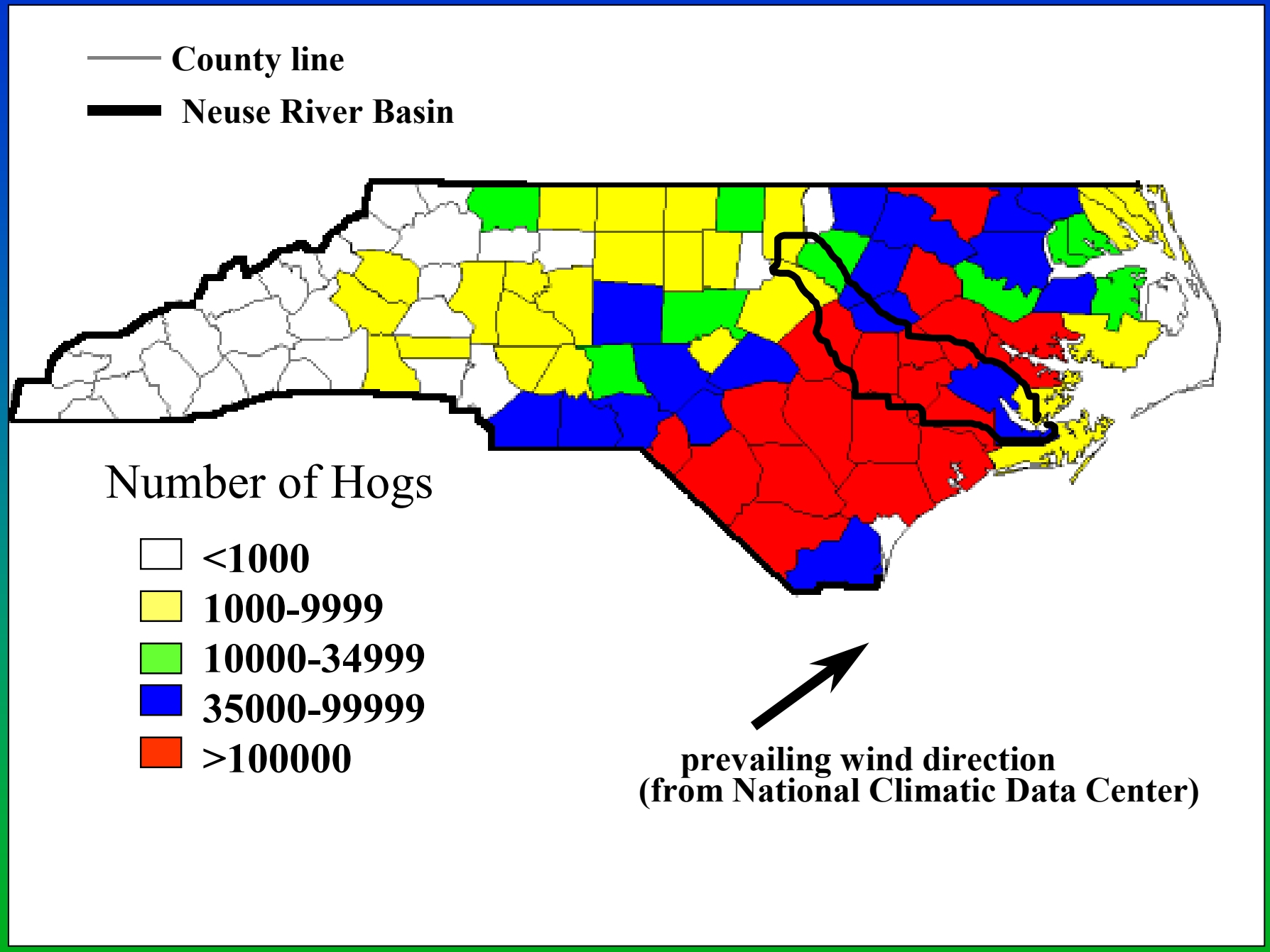
State N Emissions
(Total=325,322 Tons)

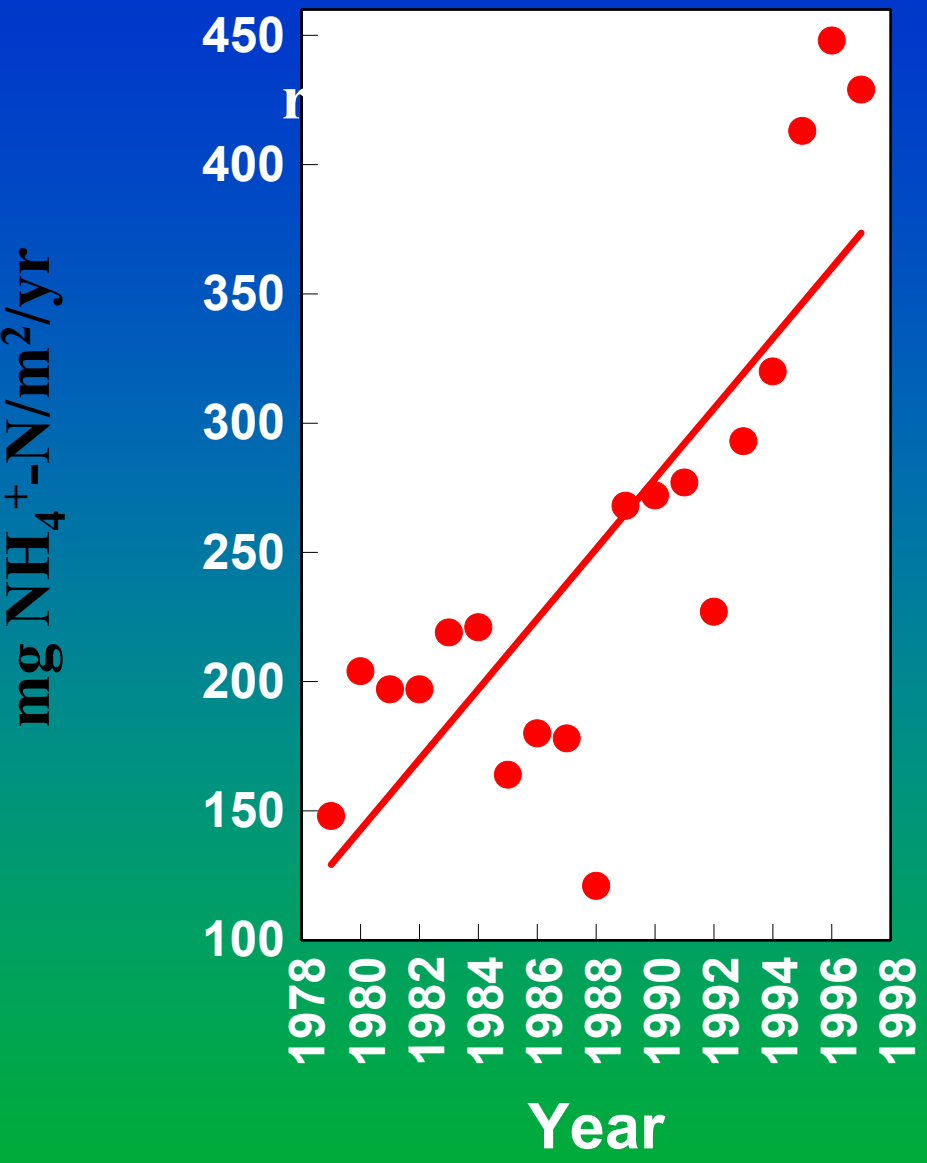


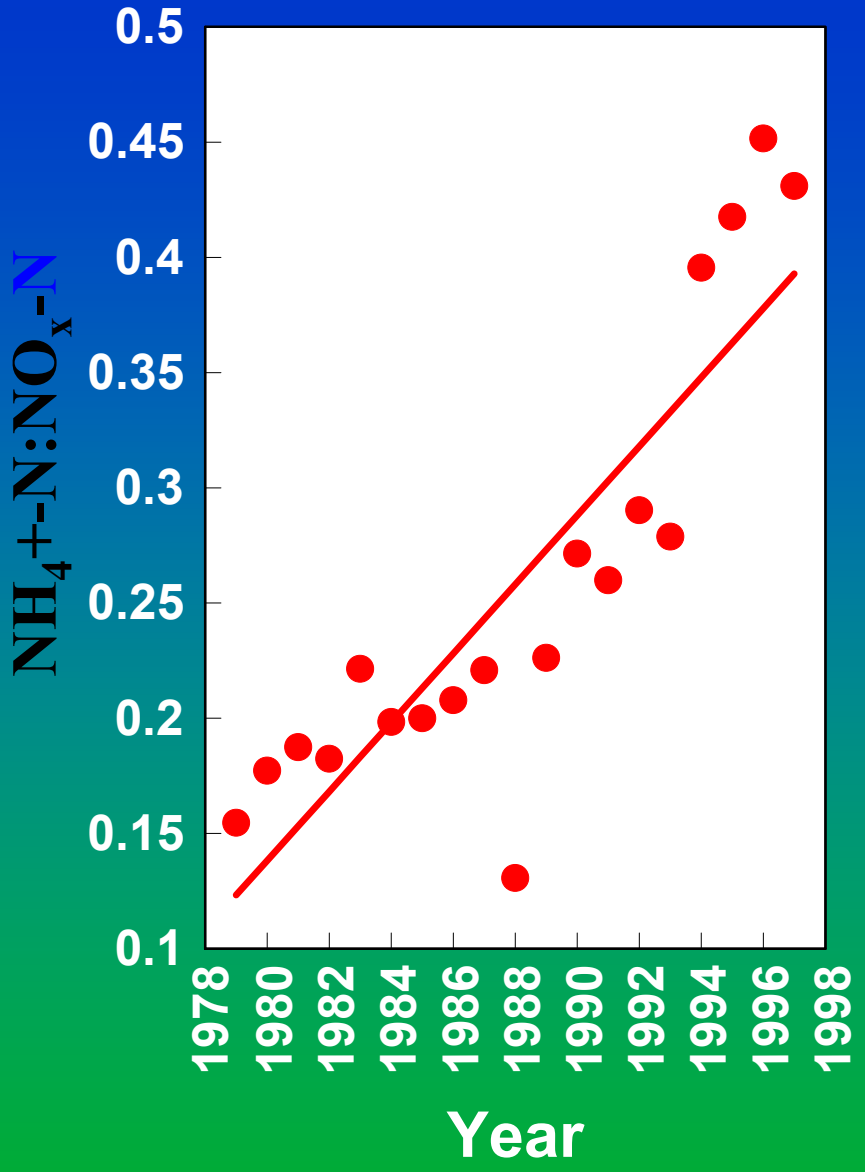
Coastal N Emissions
(Total=140,111 Tons)



Source: NC DENR, Division of Air Quality

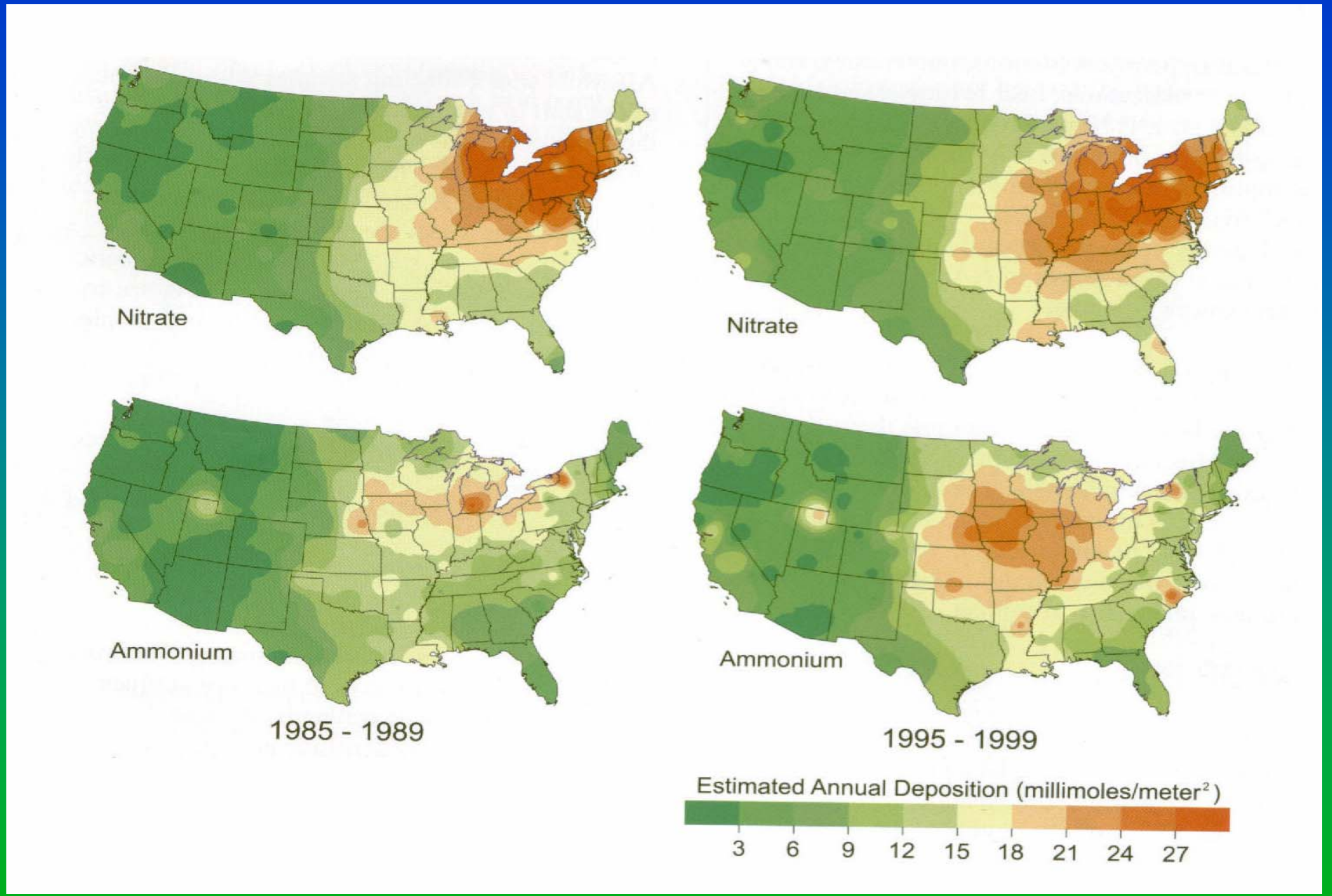

County line
Neuse River Basin
Number of Hogs
<1000
1000-9999
10000-34999
35000-99999
>100000
prevailing wind direction
(from National Climatic Data Center)





National Atmospheric Deposition Program Data
Sampson Co. North Carolina (NC35)

National Atmospheric Deposition Program 1999 Annual Summary

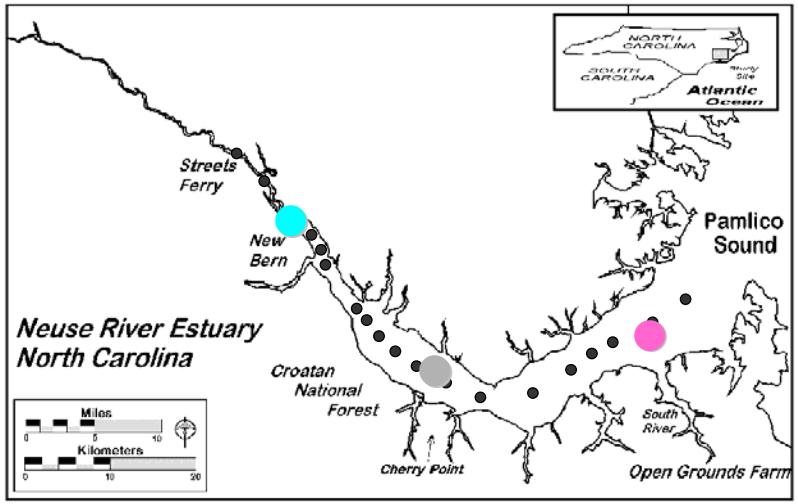


Why the Concern About Ammonium?

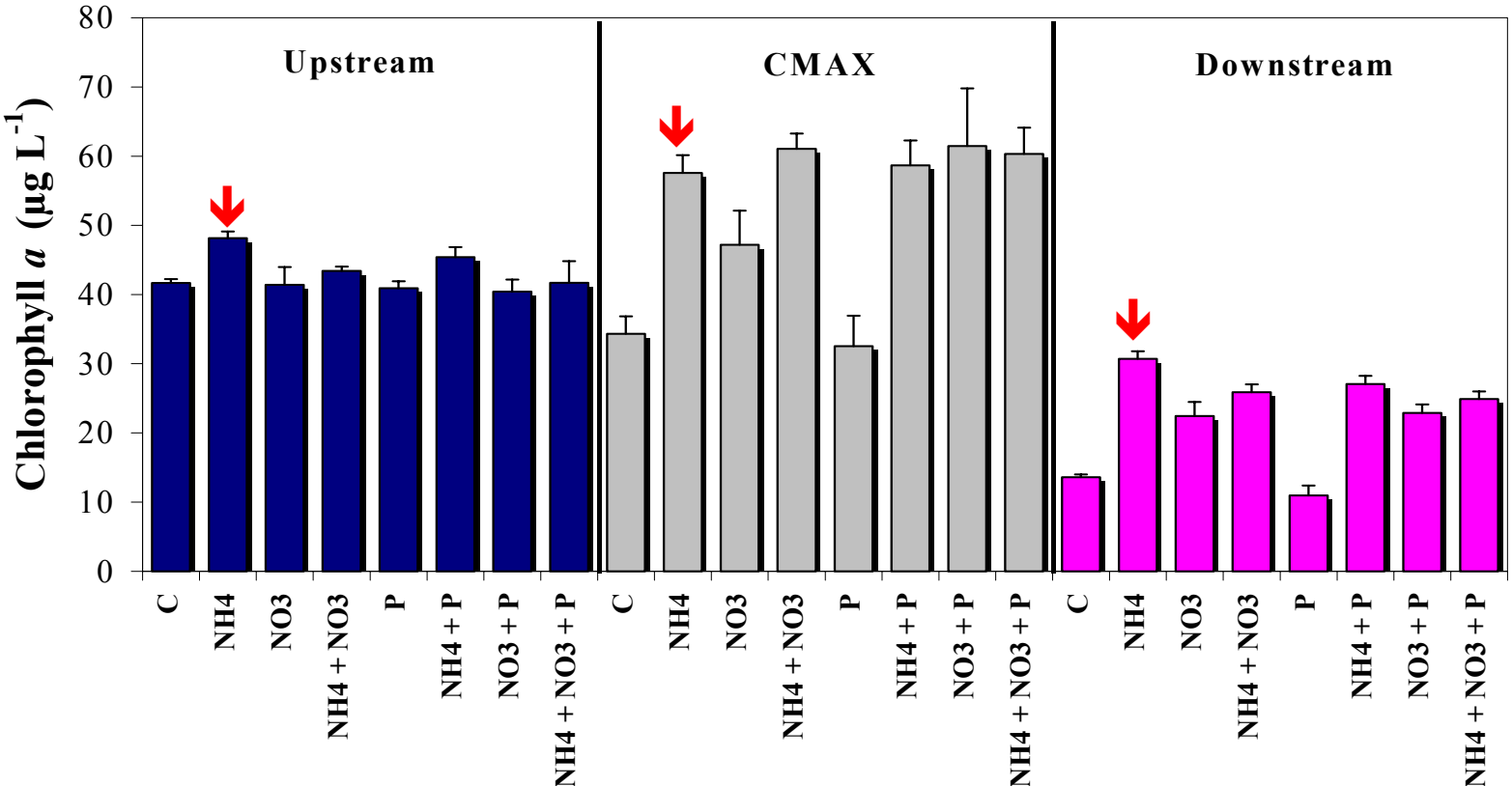
Not all forms of N are used equally

$NH_{3/4}^{+}$, NO_3^{-}, Organic N

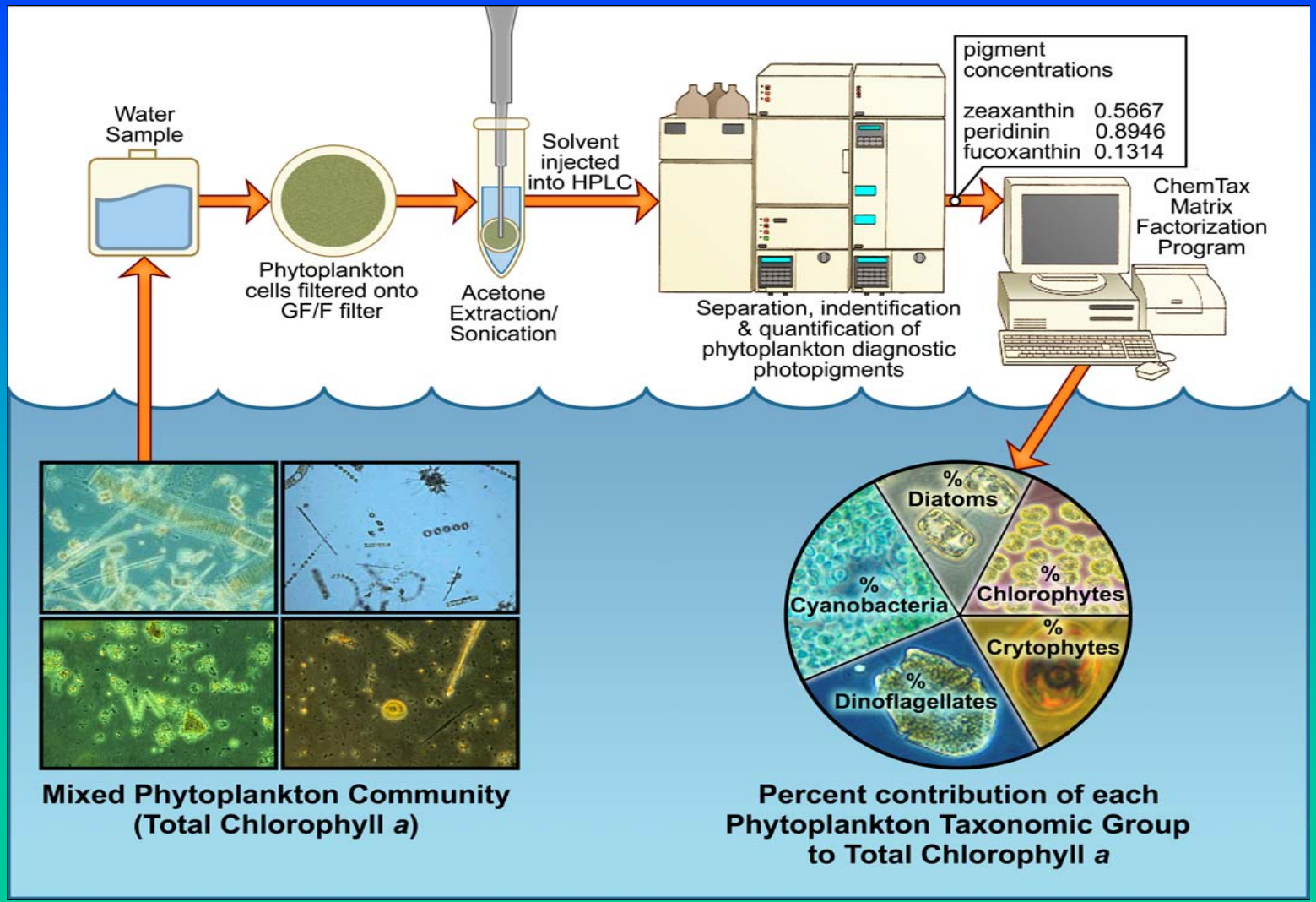
Ammonium is a Preferred N source



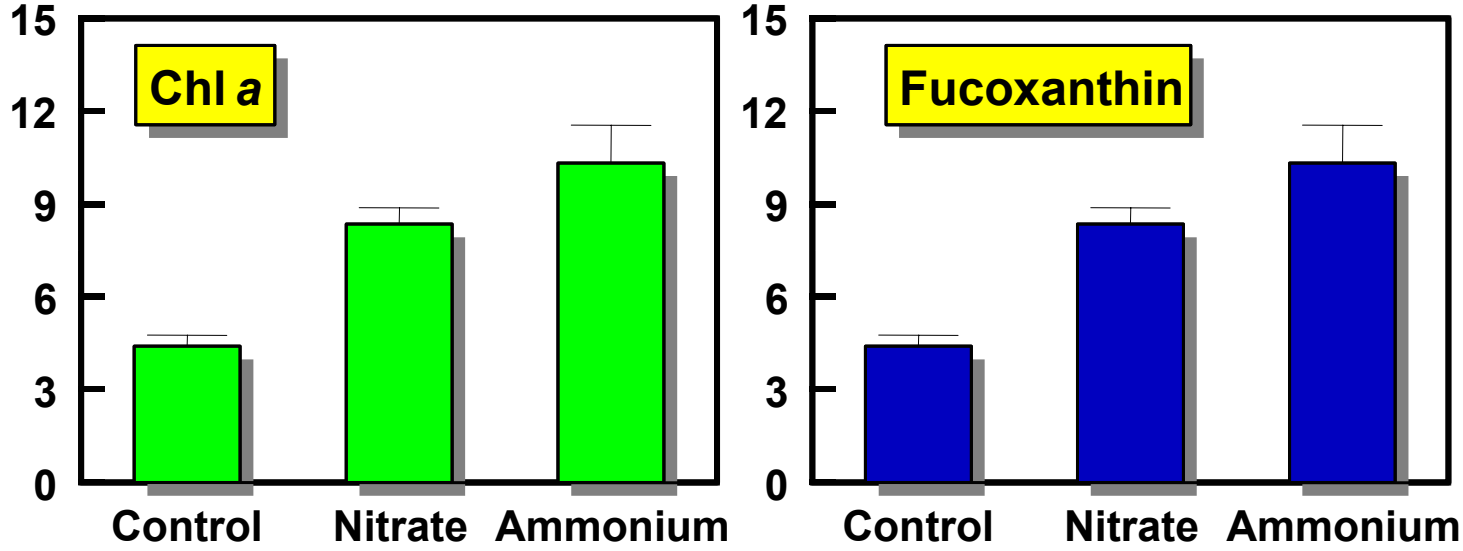
Nutrient Addition Bioassay Experiment, T1
Neuse River, July 2003



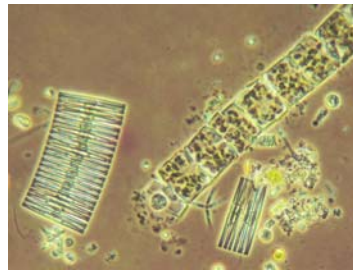
Looking into the green box: phytoplankton taxonomic group responses to specific forms of N enrichments by HPLC-ChemTax Analysis



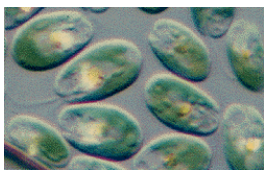
Bogue Sound Bioassay



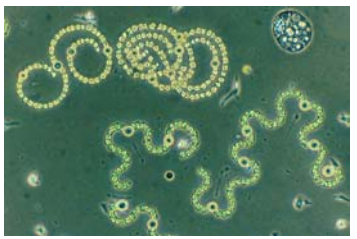
(mg m-3) Concentration



Diatoms



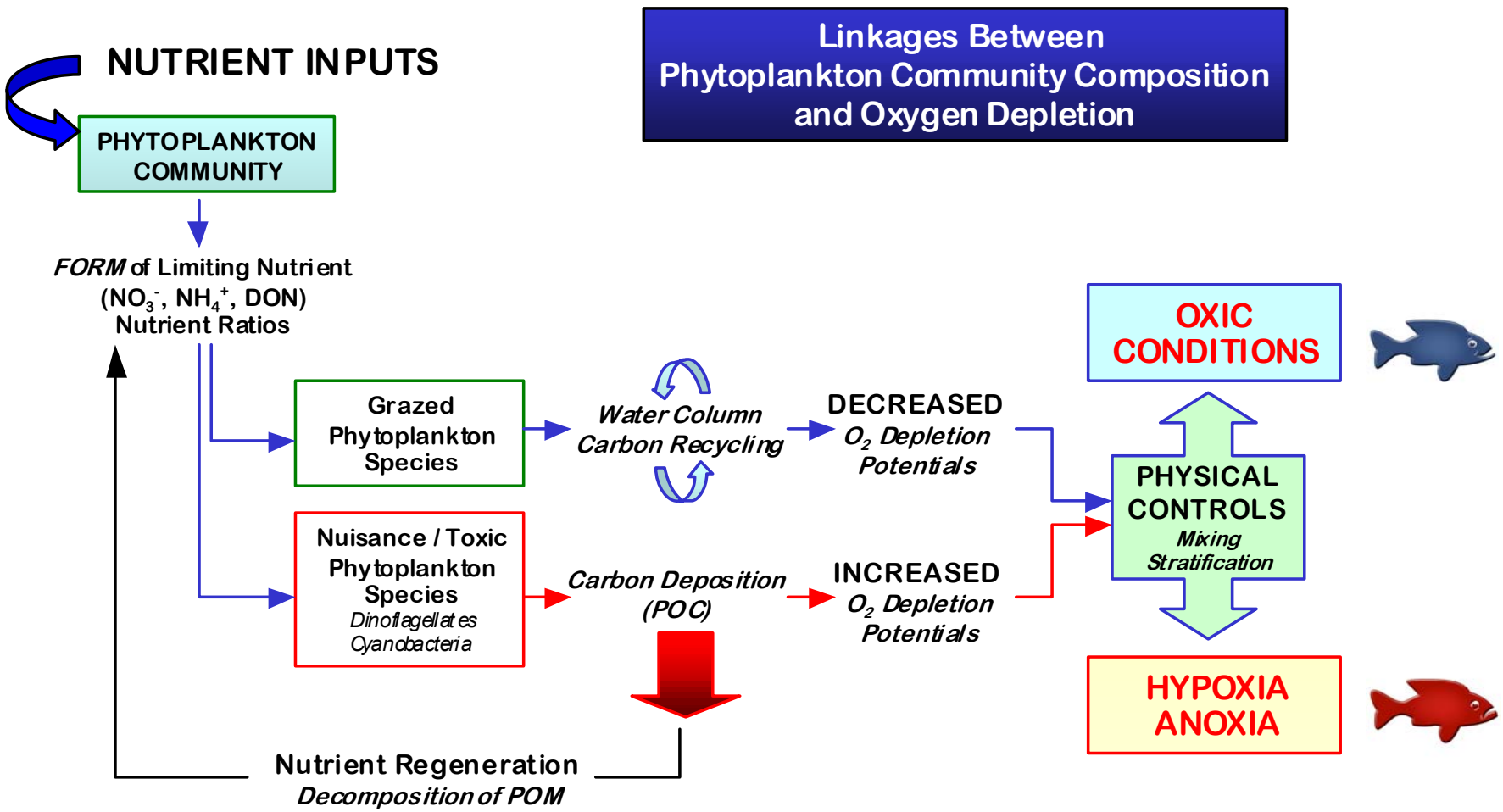
Cryptomonads



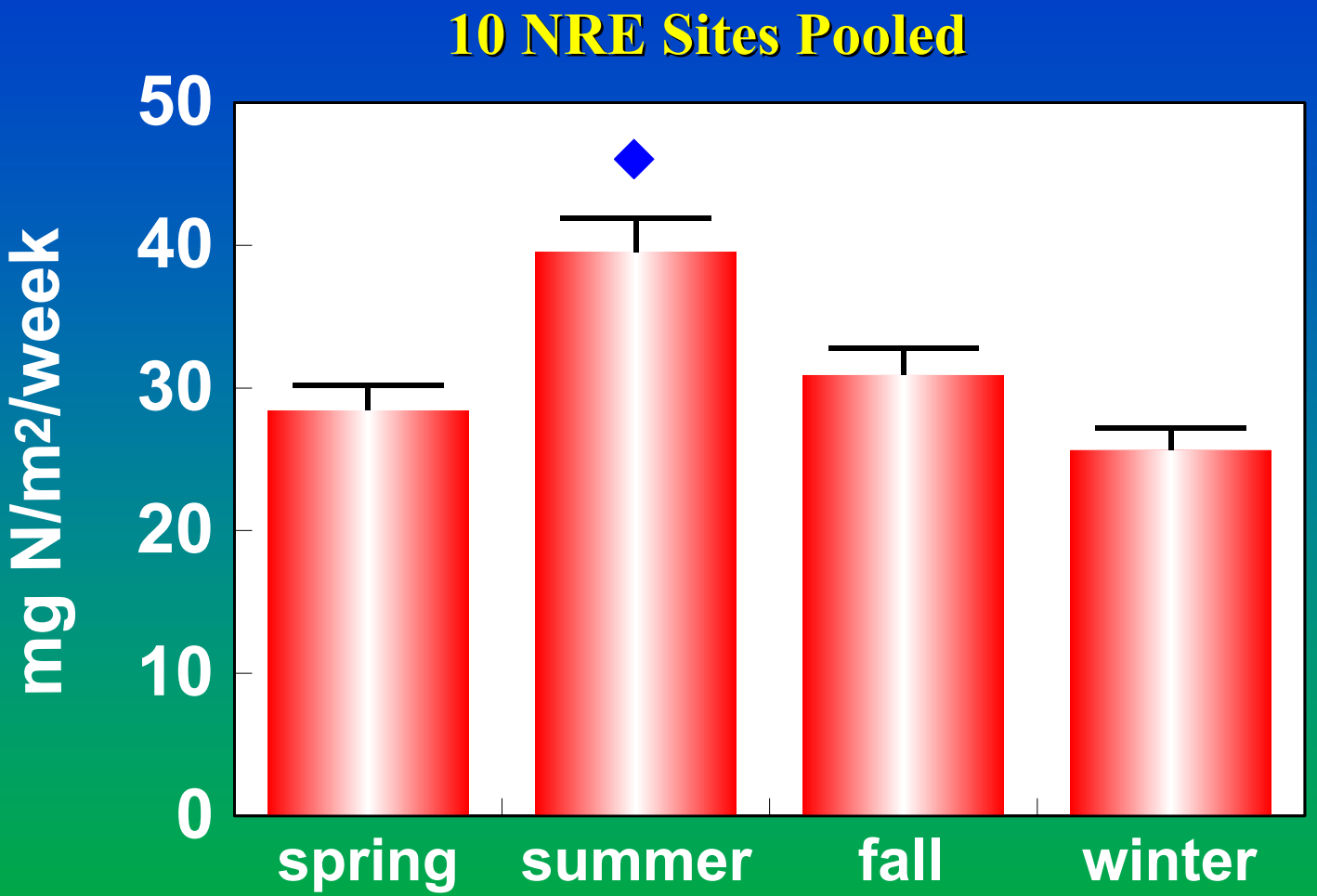
Cyanobacteria

Treatment

Impacts on Ecosystem Biogeochemical cycling and trophodynamics

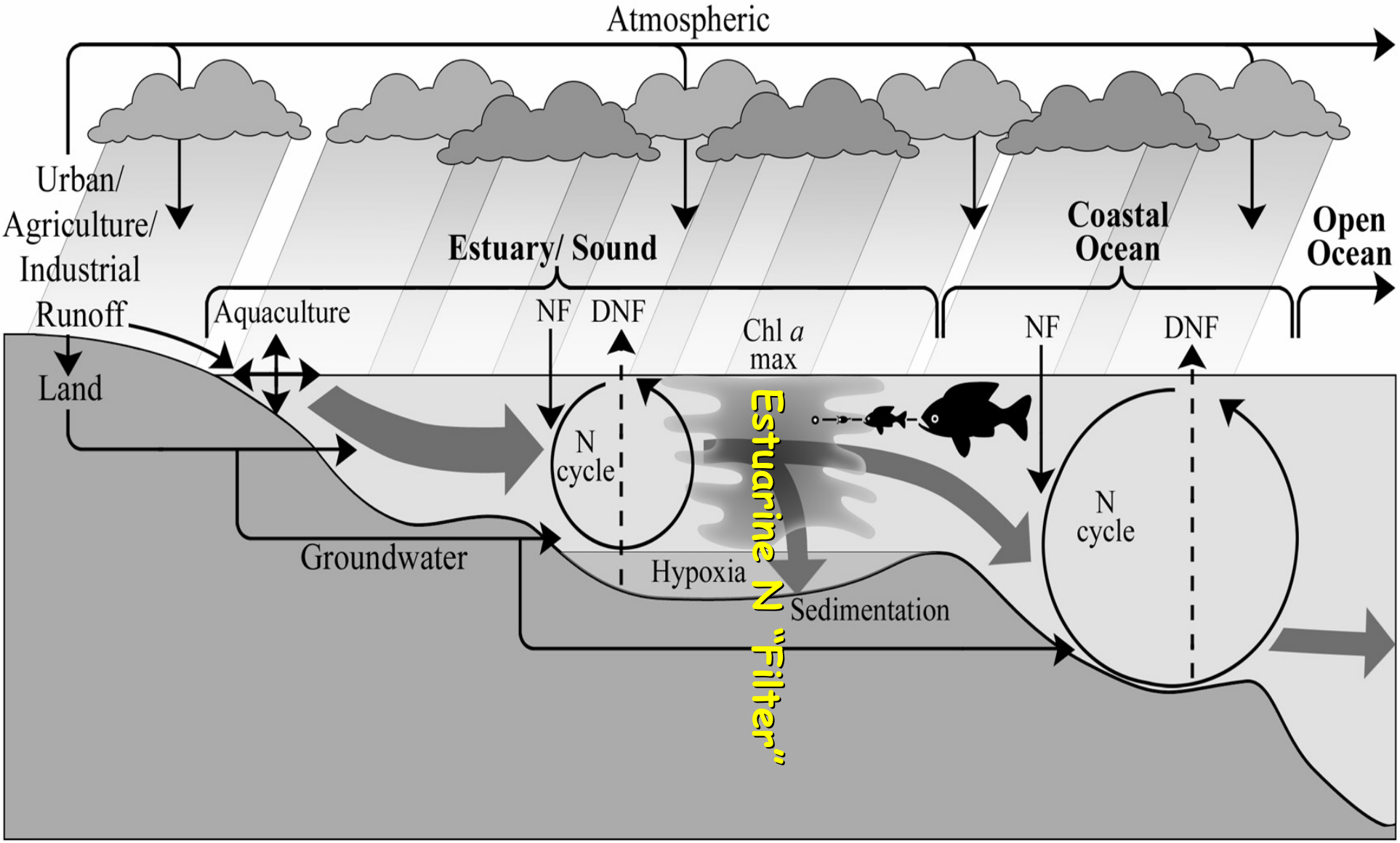


Seasonal Variability in ADN is also important

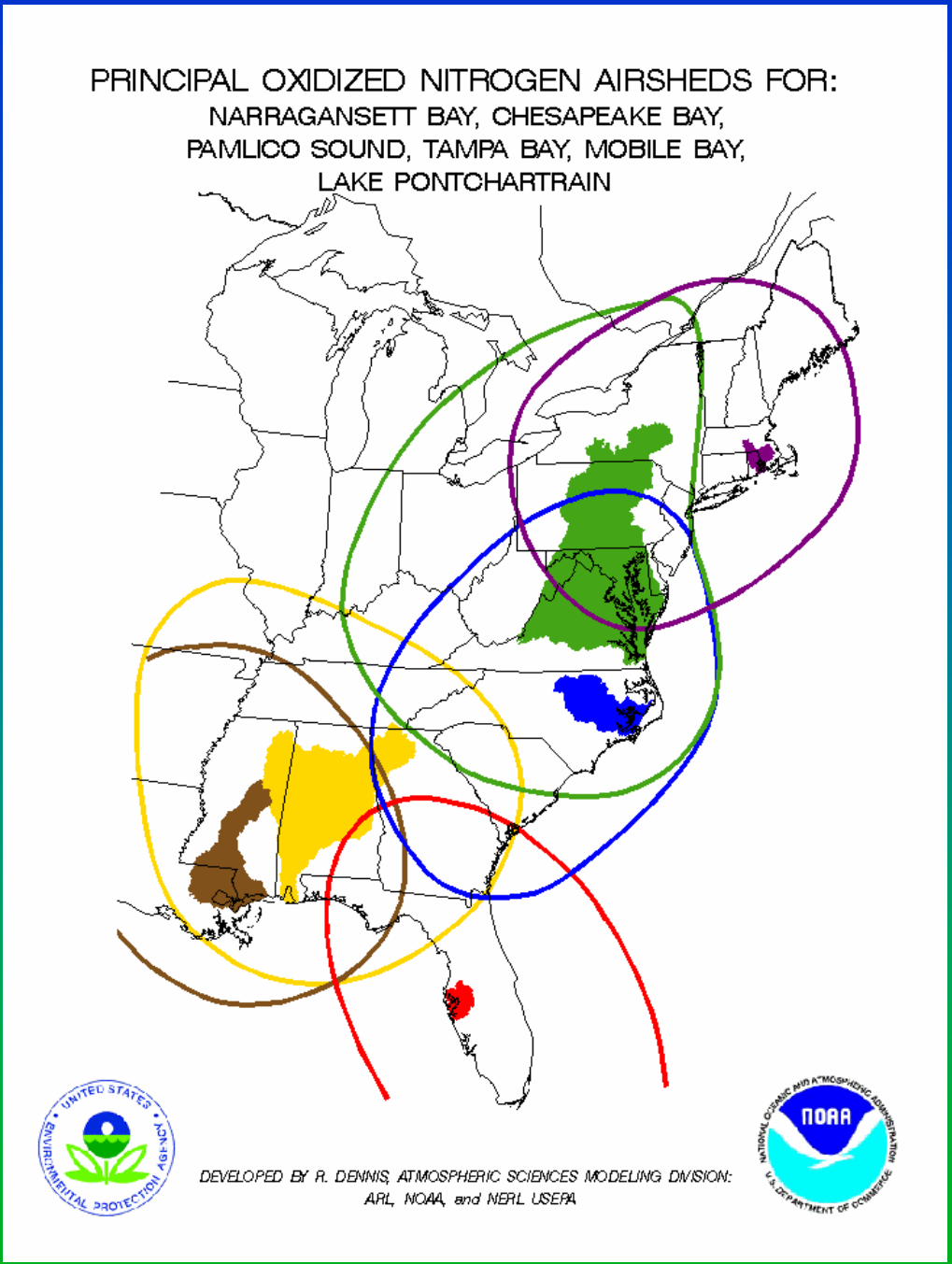


◆ Significantly higher than spring, fall and winter at α=.01

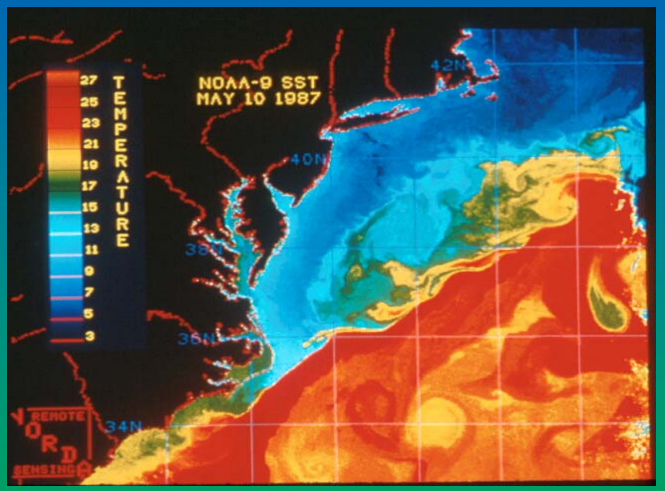
Atmospheric N inputs can bypass the estuarine N "filter"

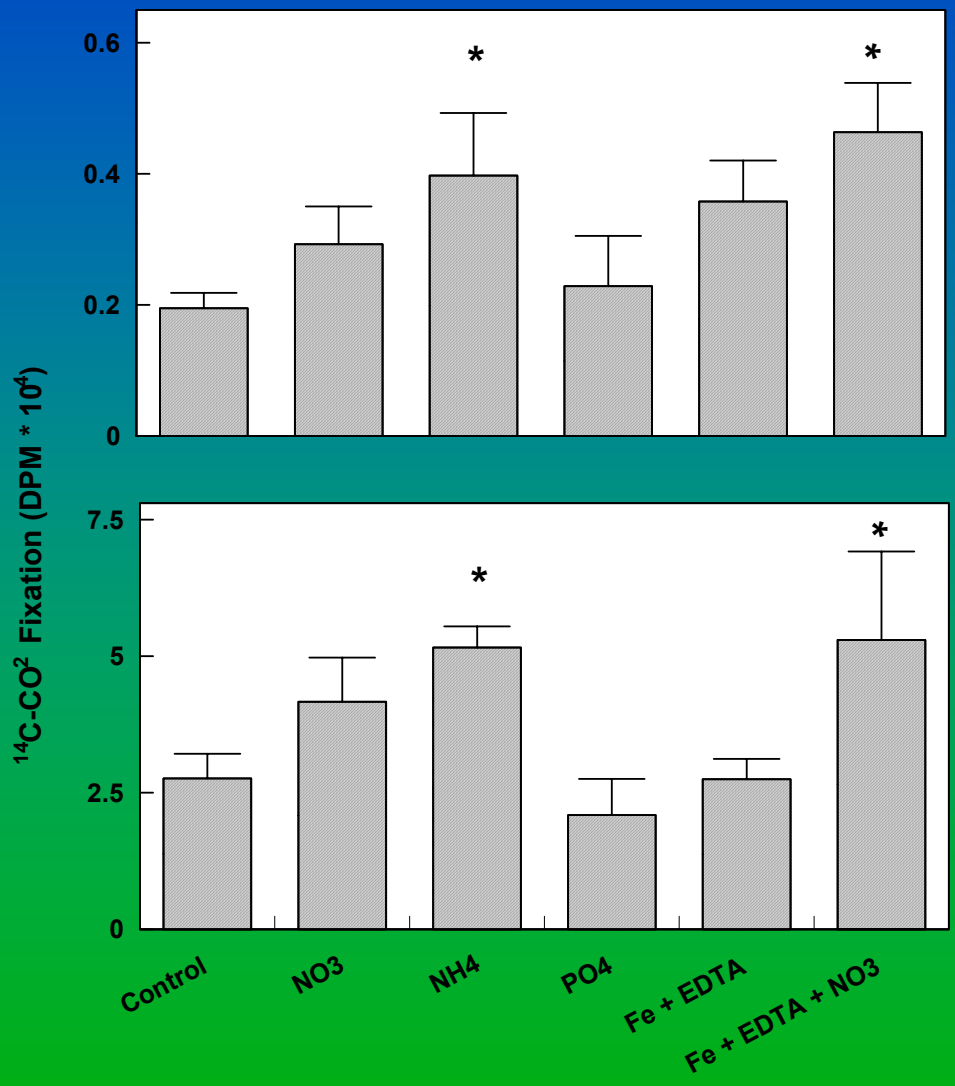


The Airshed Scale: Bypassing the Estuarine Filter & Influencing the Coastal Zone



Nutrient stimulation of primary production in the W. Atlantic Ocean (Gulf Stream vs. Coastal)



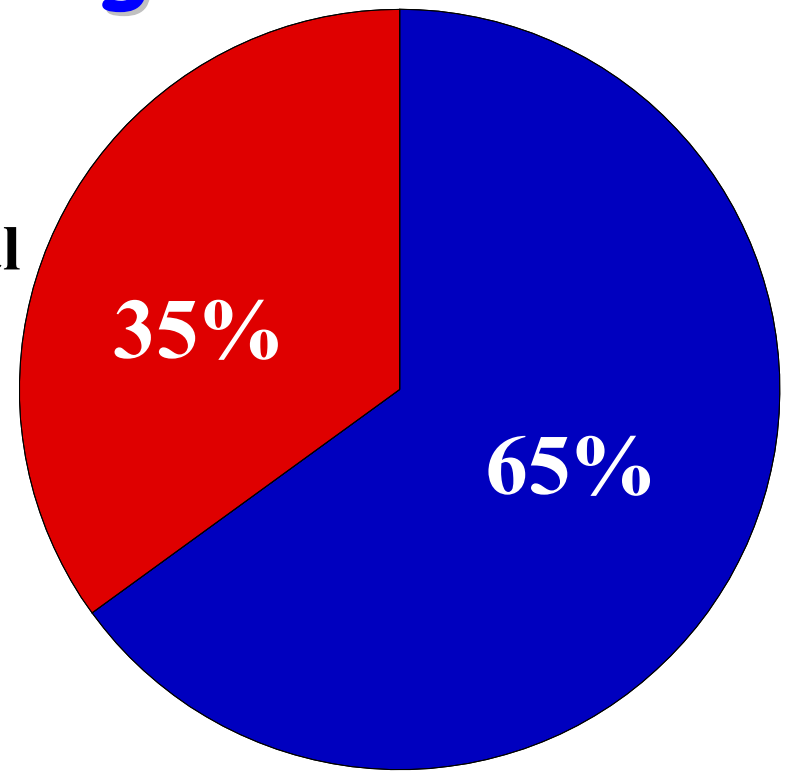


Gulf Stream

Coastal

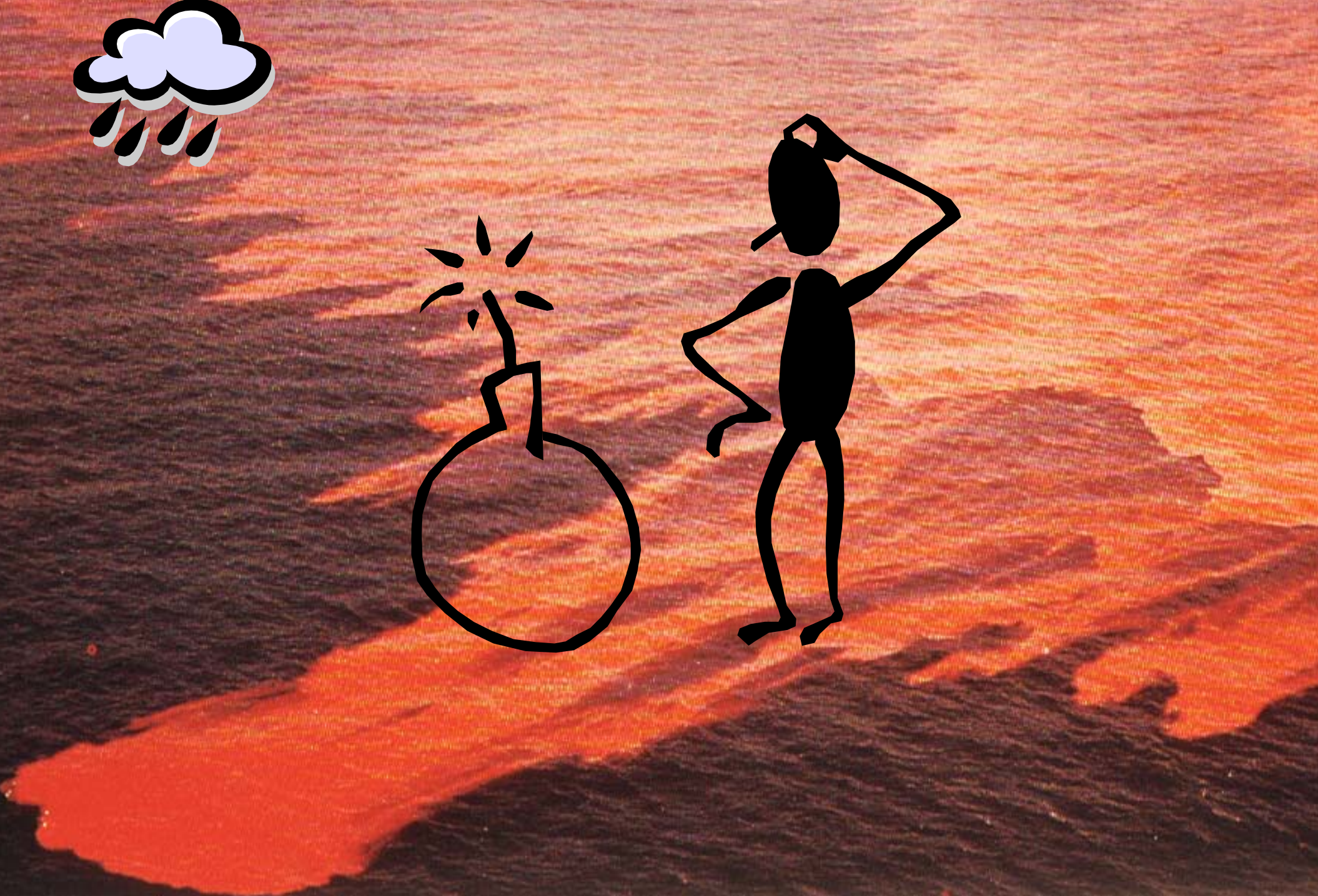
Relative Importance of AD-N Flux to the Annual N Budget of NC Coastal Waters

Direct Deposition of AD-N to Coastal Waters (903 kg N/km^2/yr)



Land Based N Flux to Coastal Waters (1877 kg N/km^2/yr)

Land Based DIN Flux values for Southeastern U.S. region include AD-N deposition to land (Howarth et al. 1996), AD-N values from UNC-IMS 1990-2000 data (DIN+DON; where DON is estimated at 20% of DIN flux)



Conclusions

- AD-N is a significant source of N enrichment to coastal waters downwind of emission sources.
- AD-N impacts production and composition of phytoplankton. AD-N plays a role in eutrophication dynamics of these waters.
- Chemical forms of AD-N are important and ammonium is of growing concern
- Impacts are both local and regional.
- Management of AD-N will include local, regional, and potentially, global efforts


Thanks to: US EPA STAR/EaGLe Program, NC Sea Grant, National Science foundation, USDA-NRI, Environmental Defense, NC DENR/DWQ/DAQ