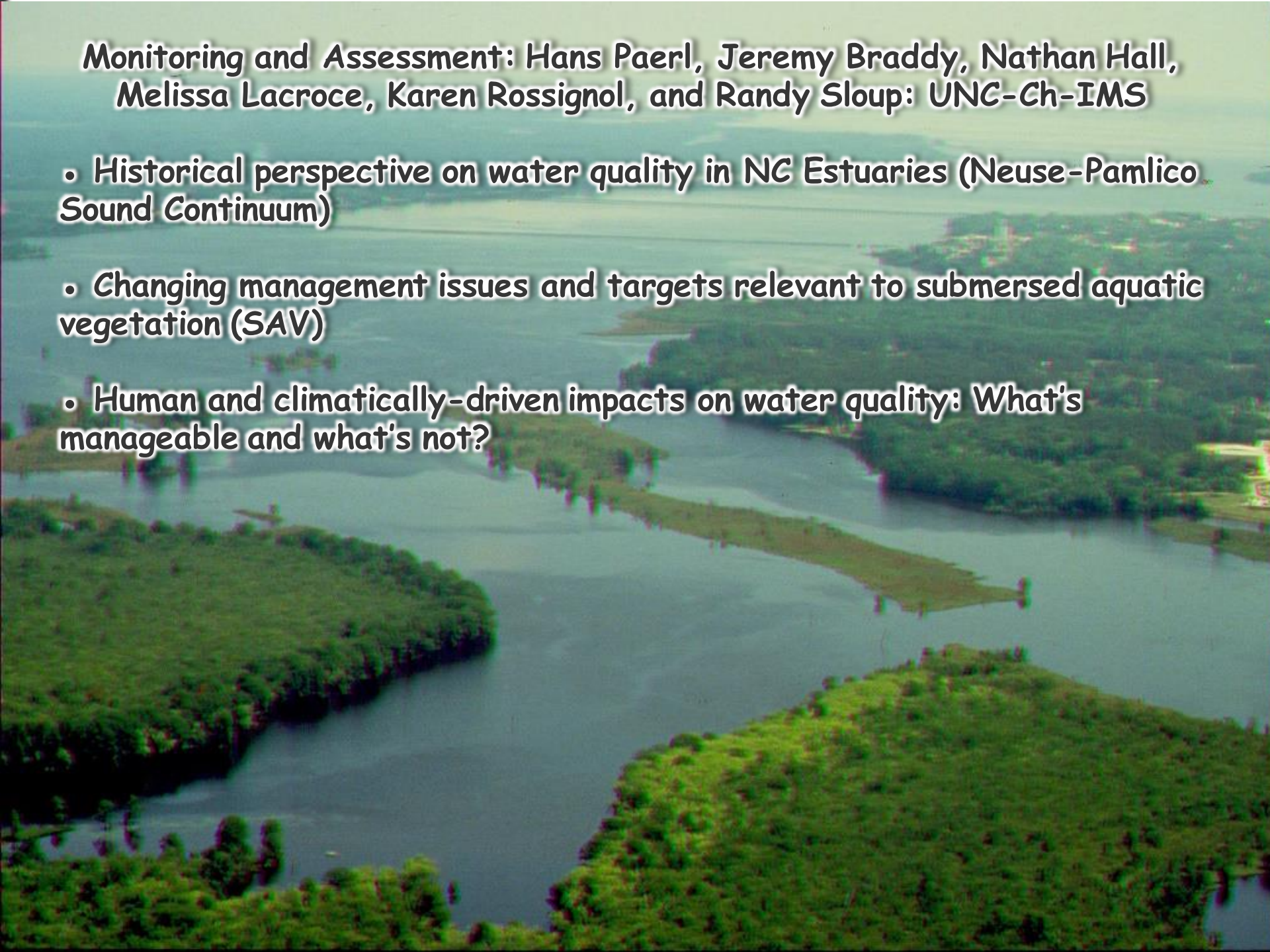


Monitoring and Assessment: Hans Paerl, Jeremy Braddy, Nathan Hall, Melissa Lacroce, Karen Rossignol, and Randy Sloup: UNC-Ch-IMS

- Historical perspective on water quality in NC Estuaries (Neuse-Pamlico Sound Continuum)
- Changing management issues and targets relevant to submersed aquatic vegetation (SAV)
- Human and climatically-driven impacts on water quality: What's manageable and what's not?

Data Sources: NC-DEQ, ModMon and FerryMon

Environmental Quality

Neuse River Estuary MODMON

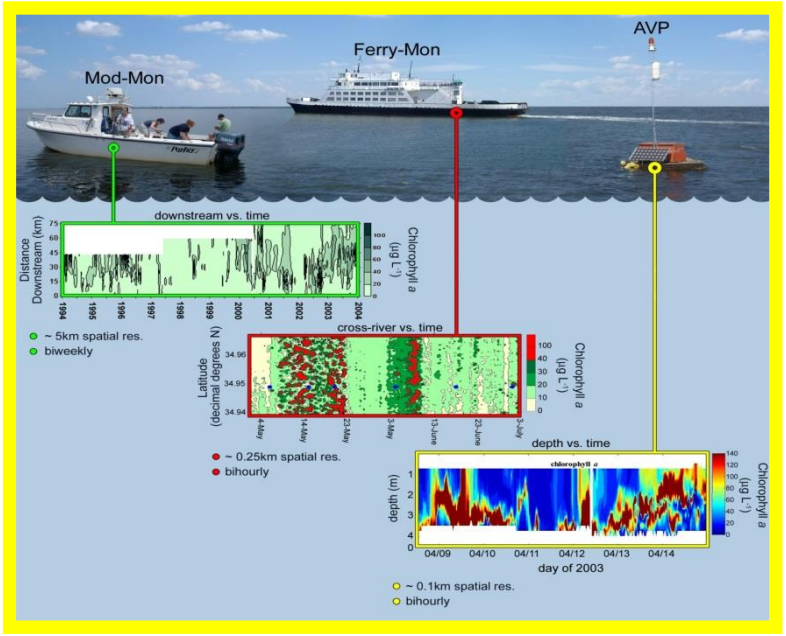
An Interdisciplinary Research Project

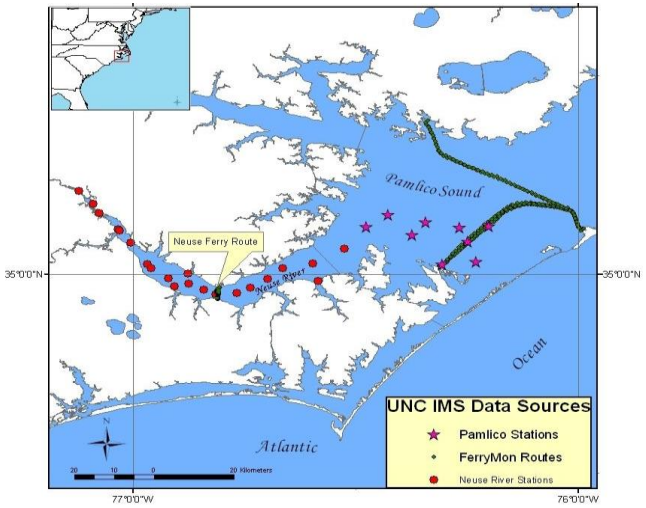
funded by

the North Carolina Department of Environment and Natural Resources and the Lower Neuse Basin Association/Neuse River Compliance Association

FerryMon

UNC-CH / DUKE / NCDENR / NCI





CRFL

Coastal Recreational Fishing License Reports, Plans, and Procedures

U.S. FISH & WILDLIFE SERVICE

NC forever

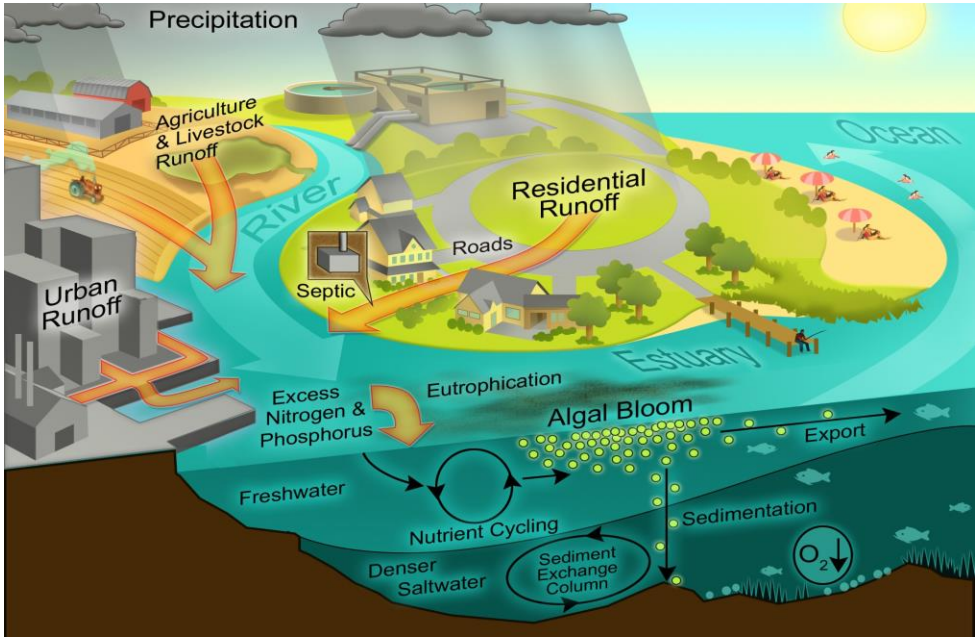
NSF

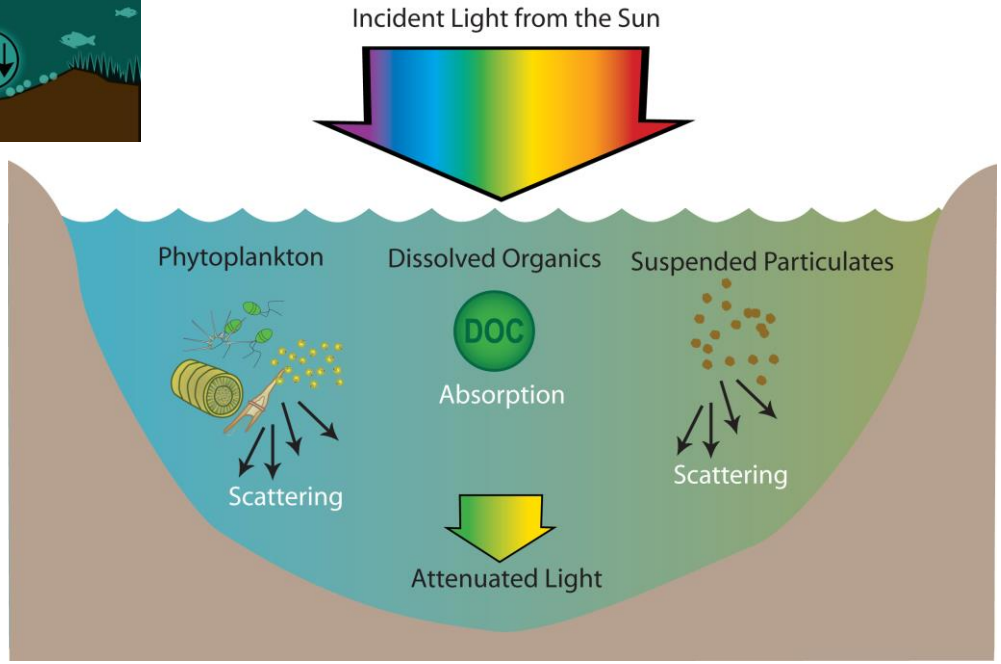
Sea Grant North Carolina

WRRI

LNBA

Key links between water quality and SAV's: Nutrients and Light Attenuation



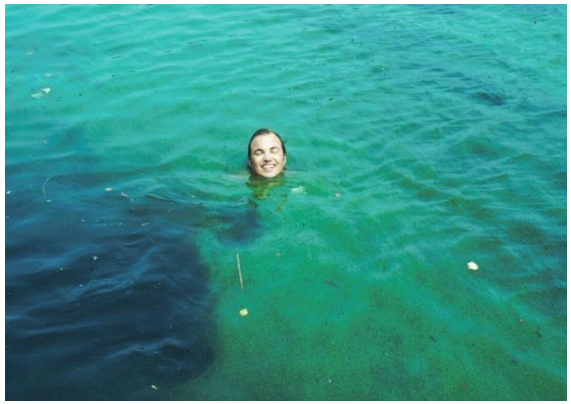


Clarifying impacts of nutrient loading on eutrophication of the Neuse R. Estuary

1. How did we get there?

2. Evaluating management actions

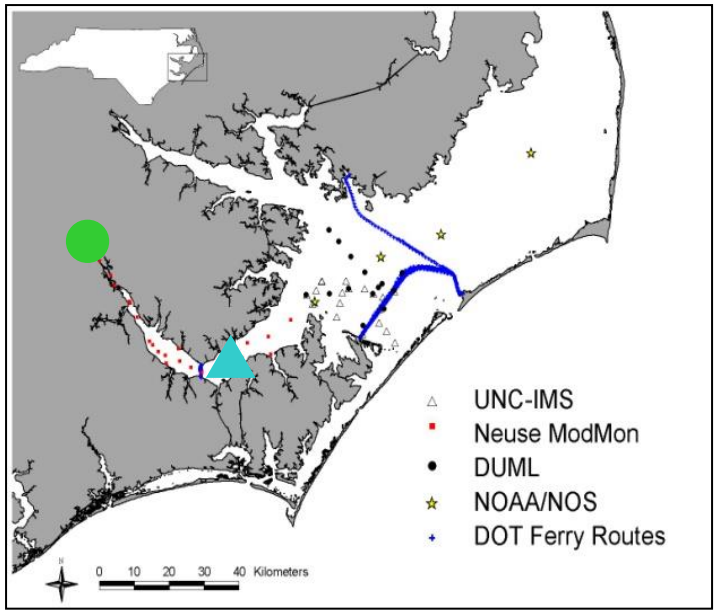
3. The rationale for N and P input controls

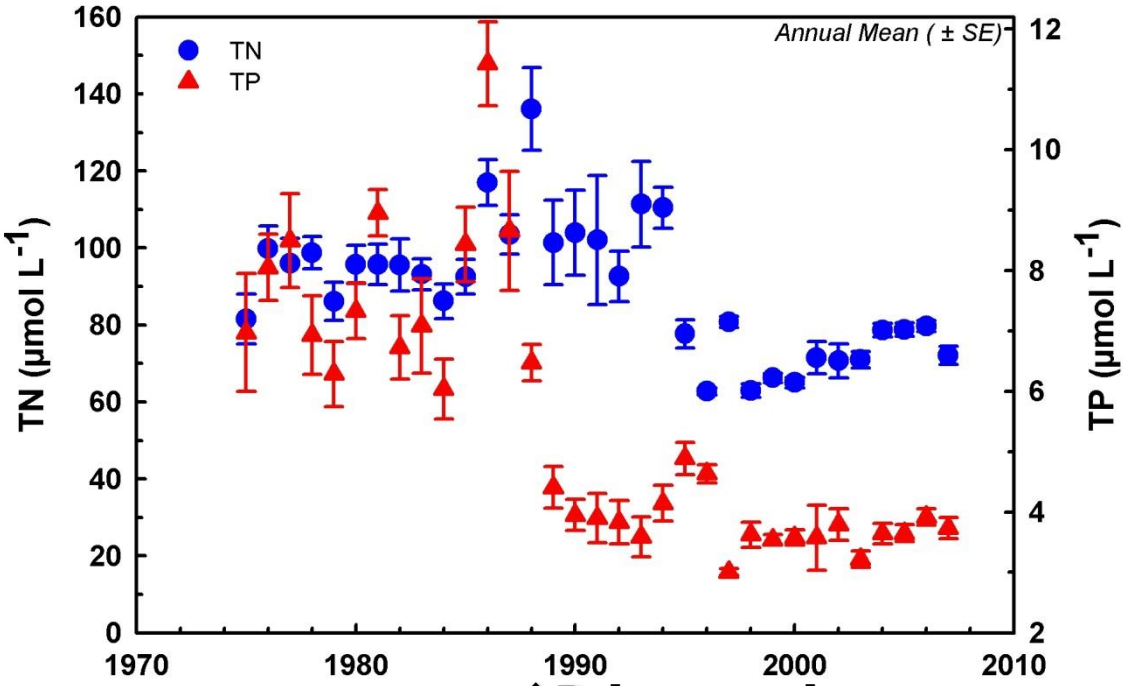


Some history

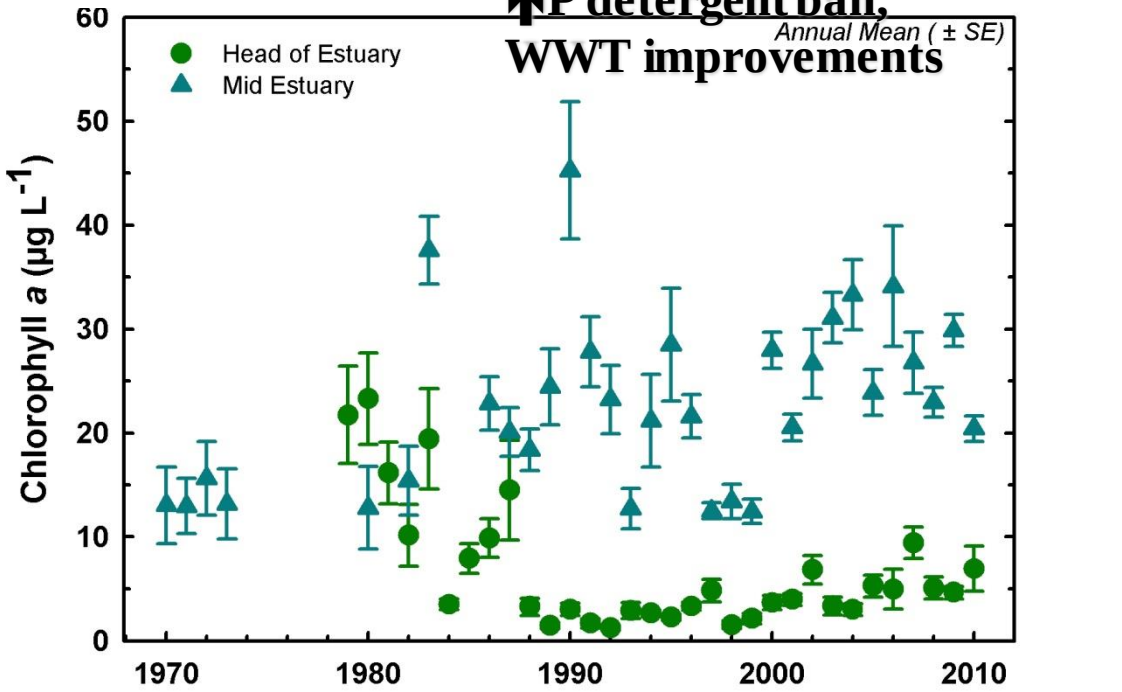
Late 1980's: Effects of upstream P reduction but no parallel N reduction on the Neuse River Estuary, NC

Phytoplankton biomass (Chl *a*)



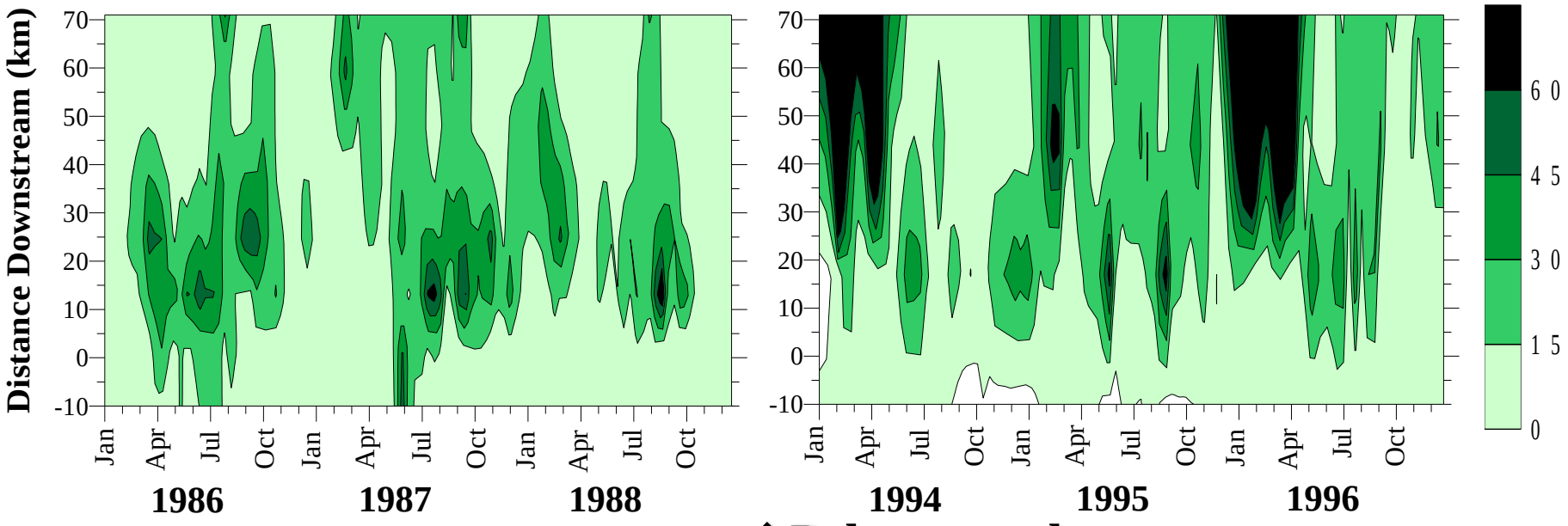


↑P detergent ban, WWT improvements



Chlorophyll *a*

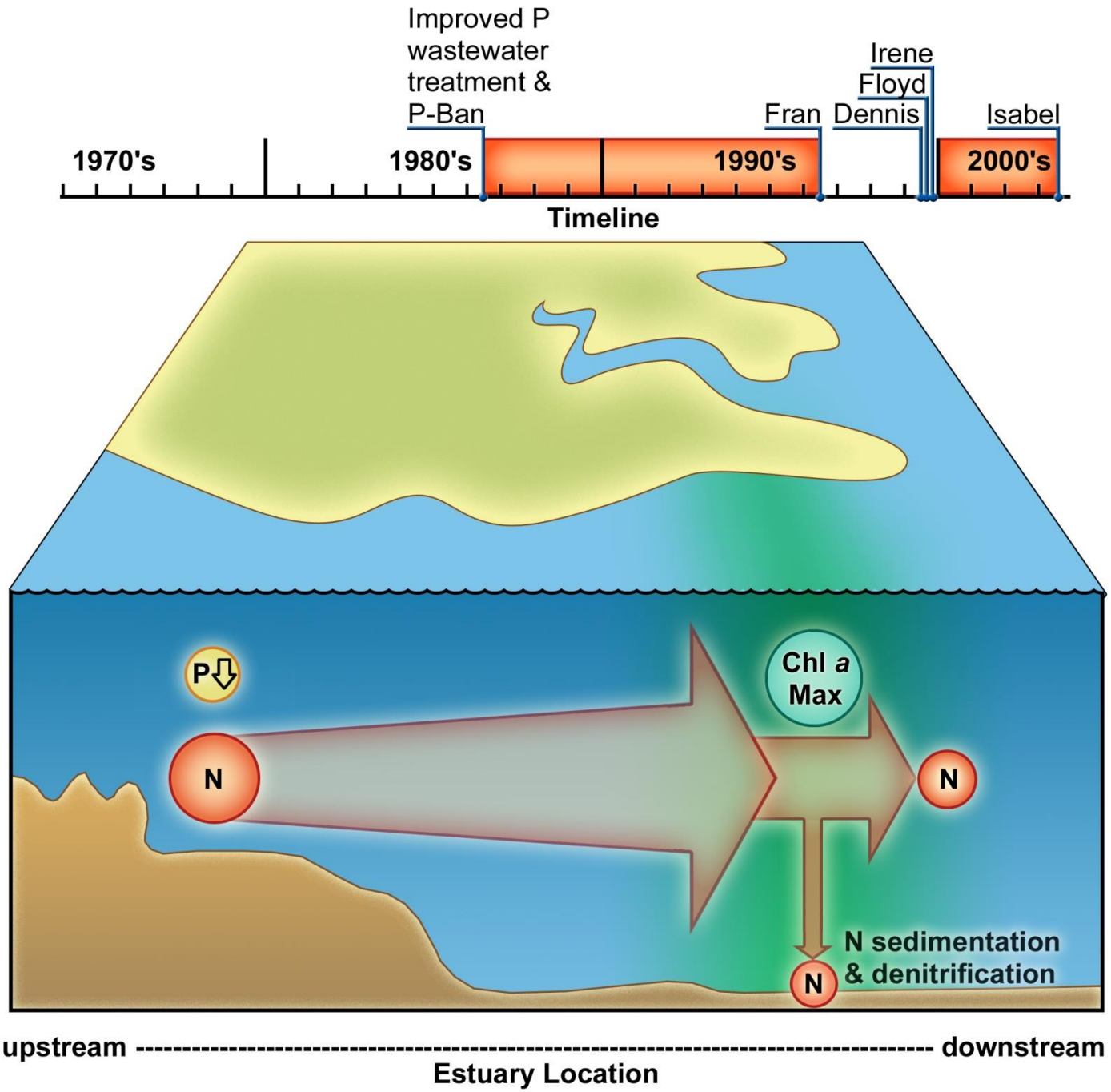
Neuse River Estuary



↑P detergent ban, WWT improvements

Freshwater P Reduction w/o Parallel N Reduction Exacerbated Estuarine Eutrophication

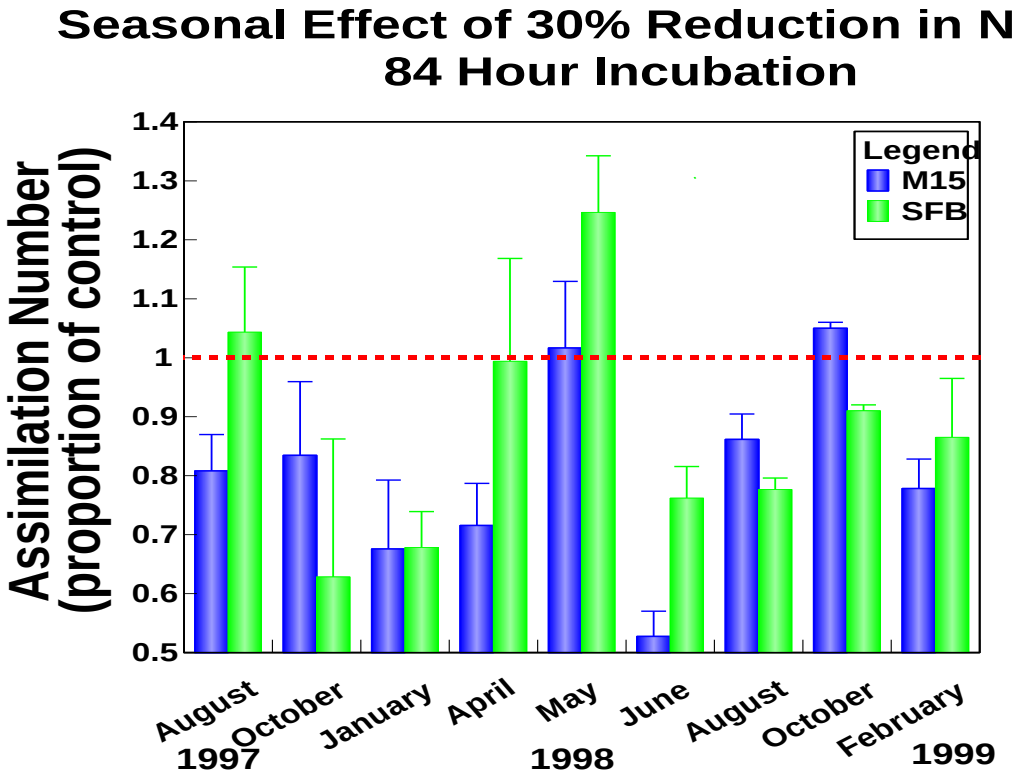
What's the mechanism?


Improved P wastewater treatment & P-Ban
Irene
Floyd
Fran
Dennis
Isabel
1970's
1980's
1990's
2000's
Timeline
P
N
Chl a Max
N
N
N sedimentation & denitrification
upstream
downstream
Estuary Location

Need: Reduce Estuarine Primary Production (Chl *a*) by Establishing an N Input Threshold

Recommendation: 30% N Input Reduction

Proof: Using dilution bioassays to evaluate mandated 30% N input reduction = TMDL)



Assimilation No. is an indicator of growth potential = Productivity / Chl *a*

The Metric

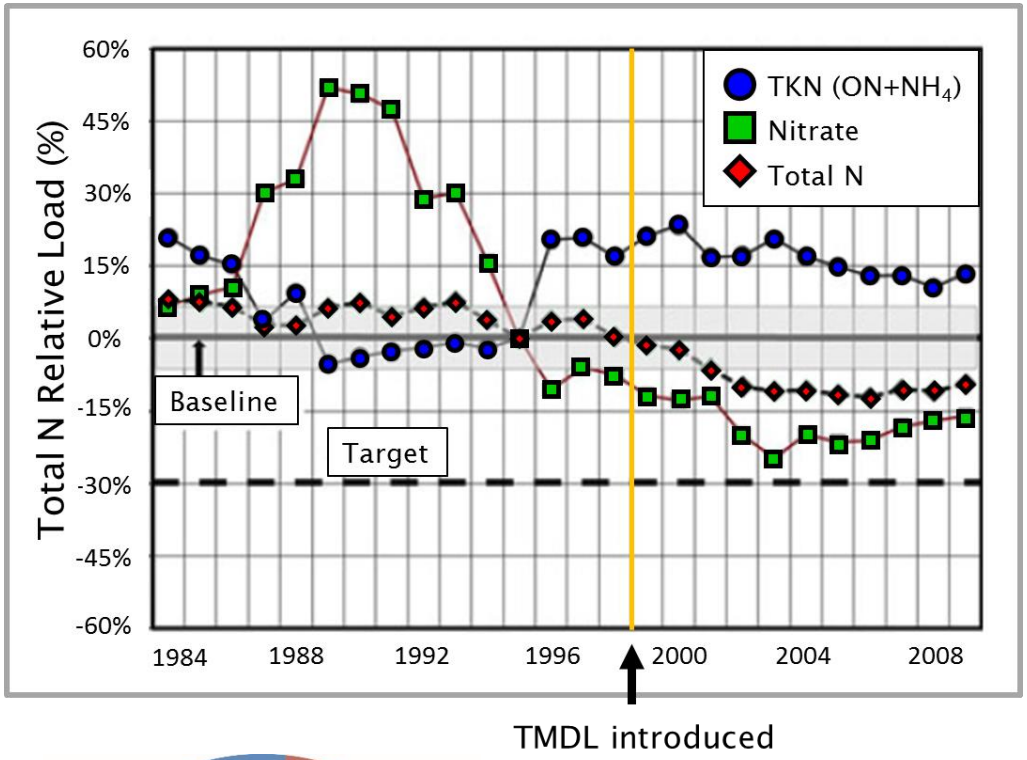
Chl a is the chosen metric for the TMDL
(nutrients ⇨ excessive algal growth)

10/40 criterion-- no more than 10% of samples
collected in a year can be over 40 μg Chl a / liter

Goal

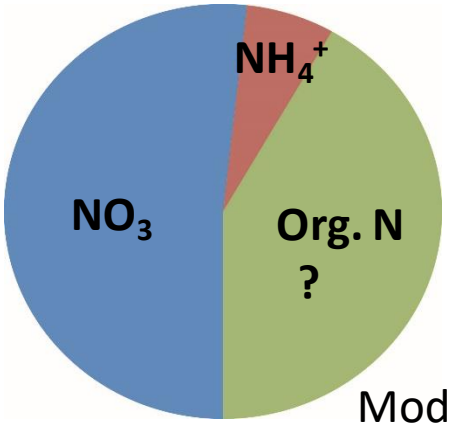
Provide NC-DENR (now DEQ) and stakeholders a scientifically sound, defendable determination of 10/40 criterion exceedances for the five use support areas of the NRE at annual time scales relevant to adaptation of the TMDL.

Total Maximum Daily N Load N-TMDL
(Initiated 1999)



- Reduction in inorganic nitrogen (nitrate)
- Increase in organic N (ON)
- **Role of ON in eutrophication?**

(subject of current research)



ModMon 1998-2018 data

Lebo et al., 2012; Pellerin et al., 2006; Osburn et al.. 2016; Paerl et al. 2018

Long-term trends in Chlorophyll *a*: What's evident?

✶ Upstream decrease following P reductions in late '80's

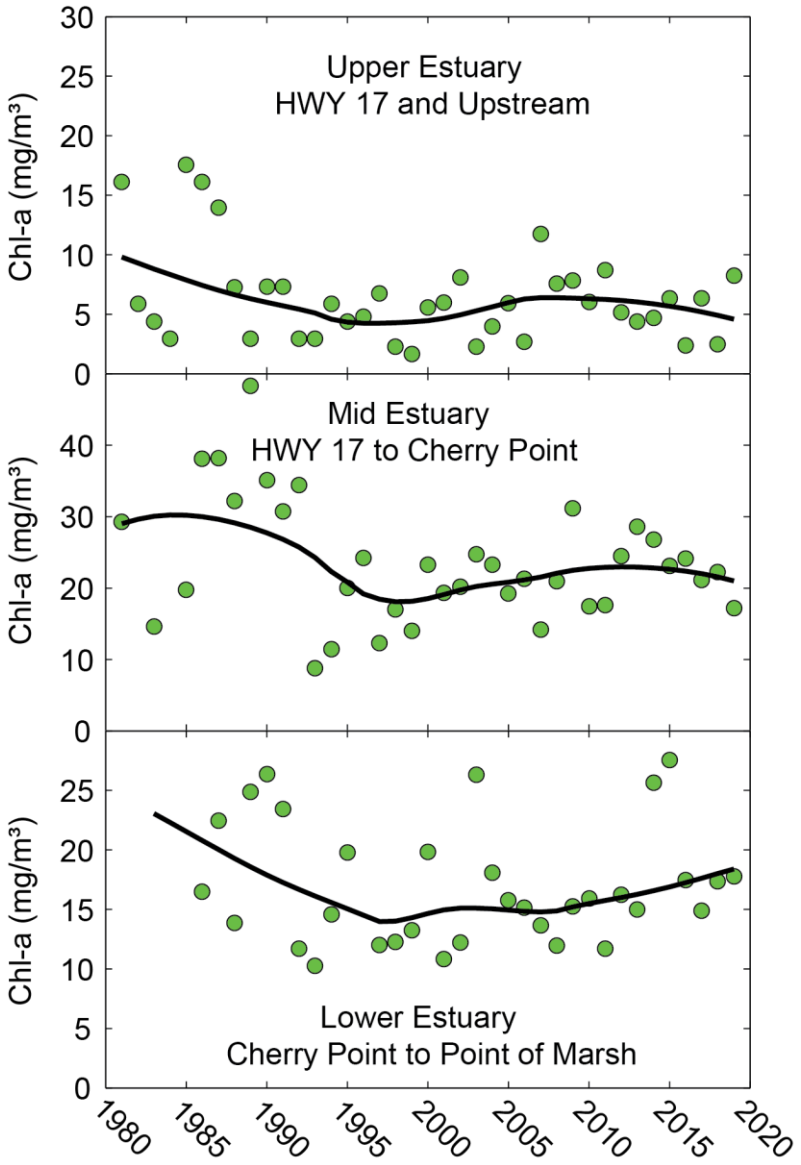
✶ No effect of P reductions on downstream, N-limited waters

✶ N-based TMDL initiated in late-1990's

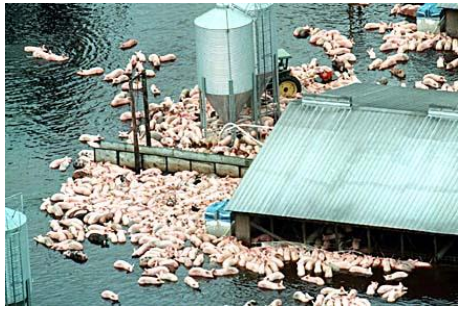
✶ Result: Reductions in DIN, but increases in DON: Overall, no net N decrease in TN

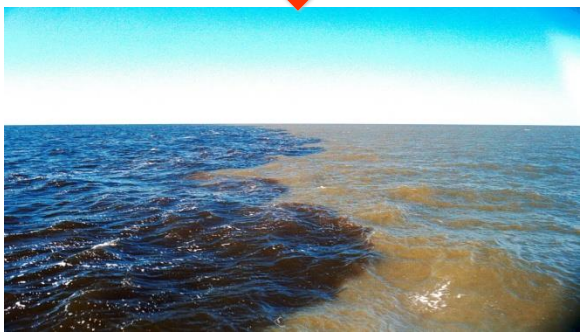
✶ Role of increasing DON in eutrophication?

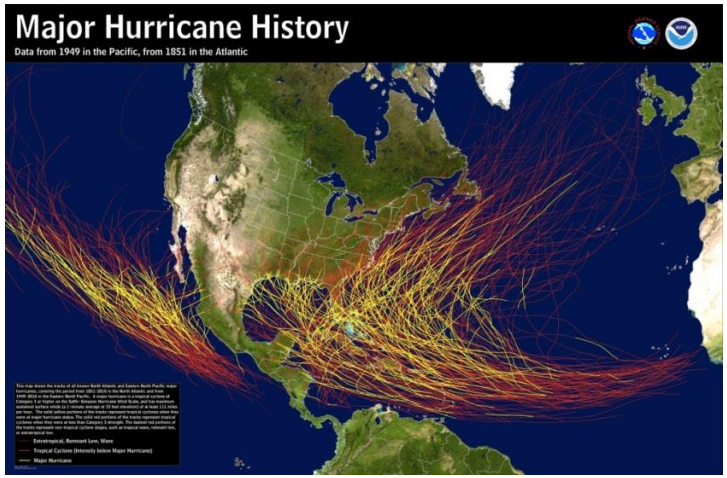
✶ Increasing variability in Chl a downstream: Storm/precipitation effects?

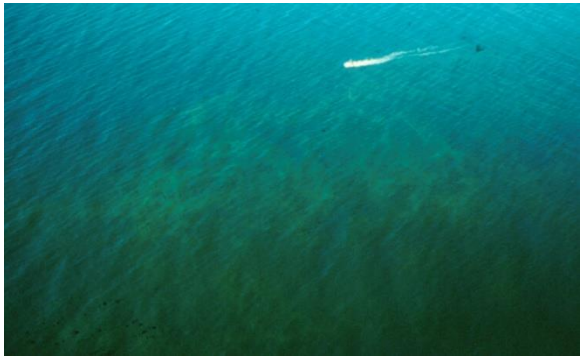


The 8000 lb Gorilla: Climate (change) and hydrologic perturbations interact with nutrient/sediment loads influencing water quality?









Why the concern about tropical cyclones?

(Besides the obvious!)

Large Hydrologic perturbations
(lots of water, quickly, and persistent flooding in low-lying areas)

Increased nutrient, organic matter and contaminant inputs

Changes in sediment dynamics (transport, deposition, resuspension)

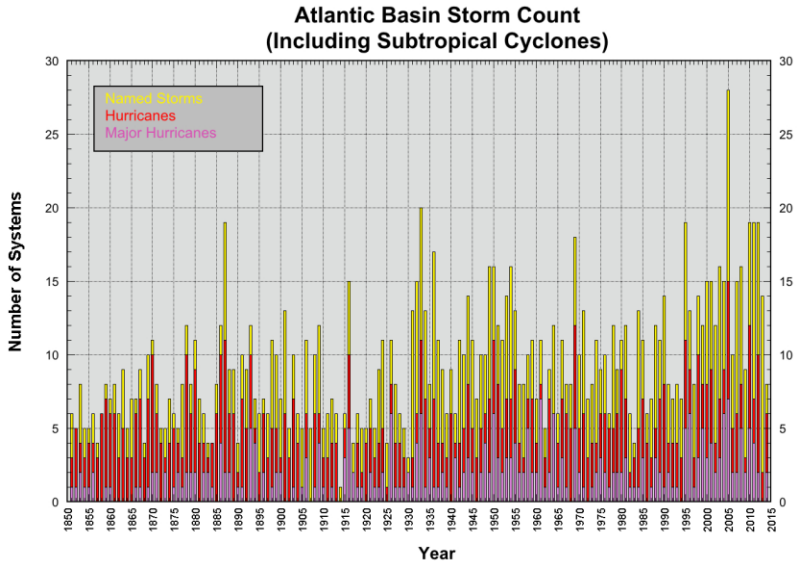
Biotic alterations (water quality, habitat, food webs)

Reason for concern……

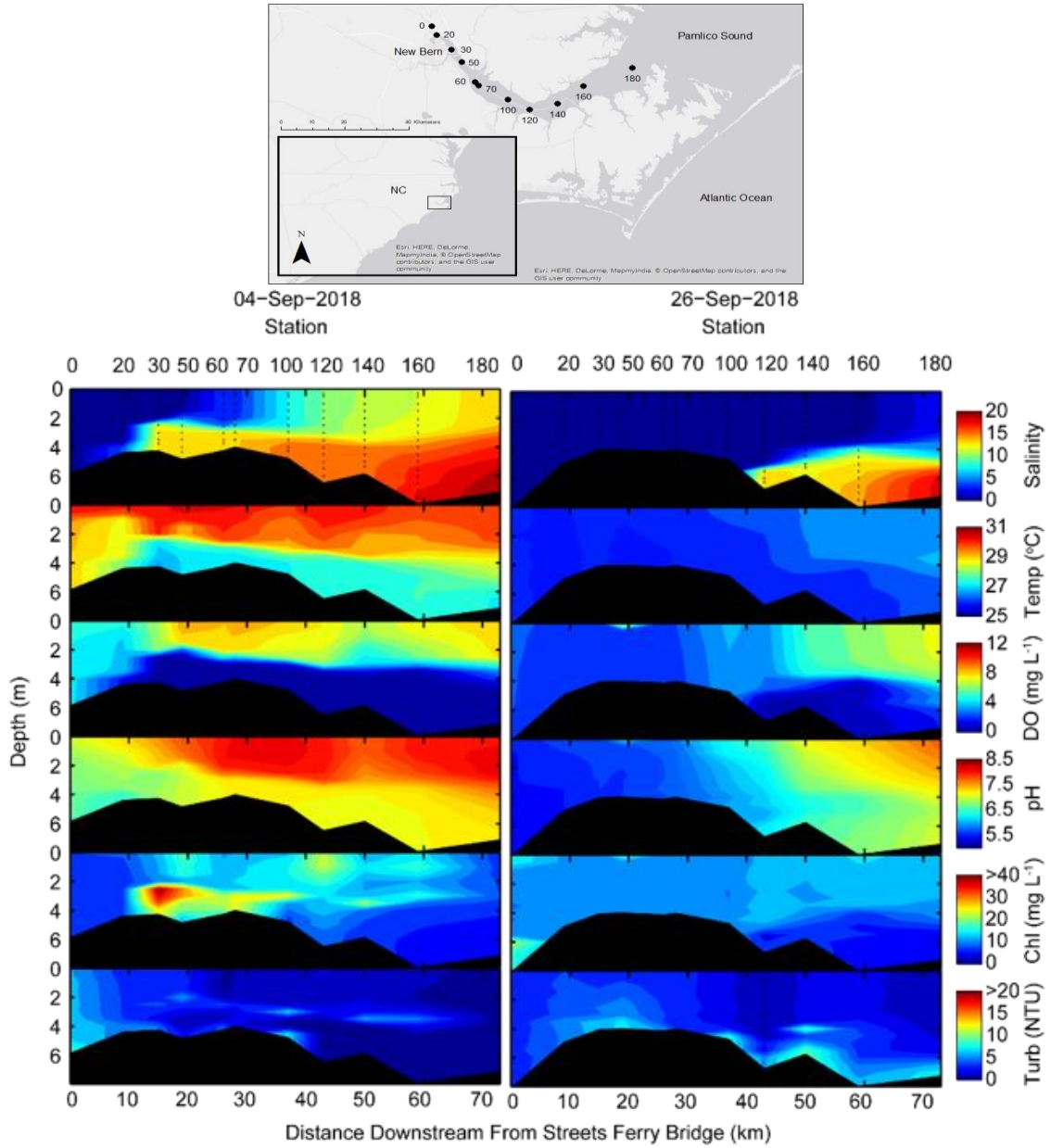
"We appear to be in a period of elevated tropical cyclone activity"

Emanuel 2005; Holland and Webster 2007; IPCC 2014; US Climate Change Report 2018

Hurricane Florence, Sept., 2018

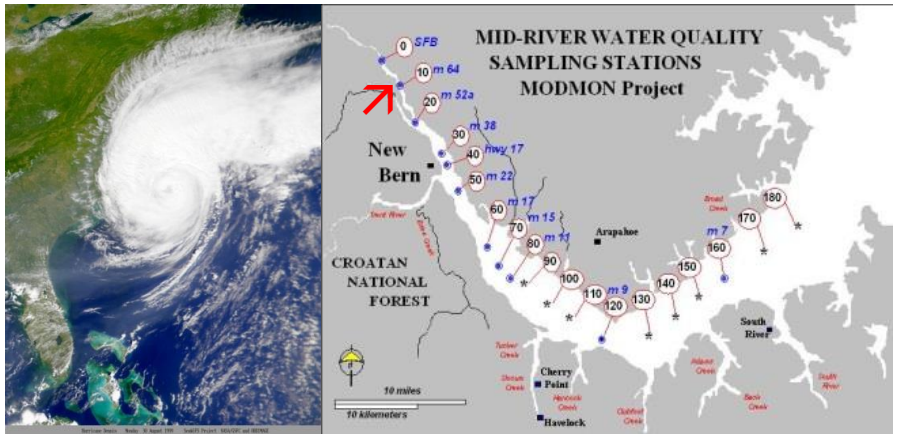


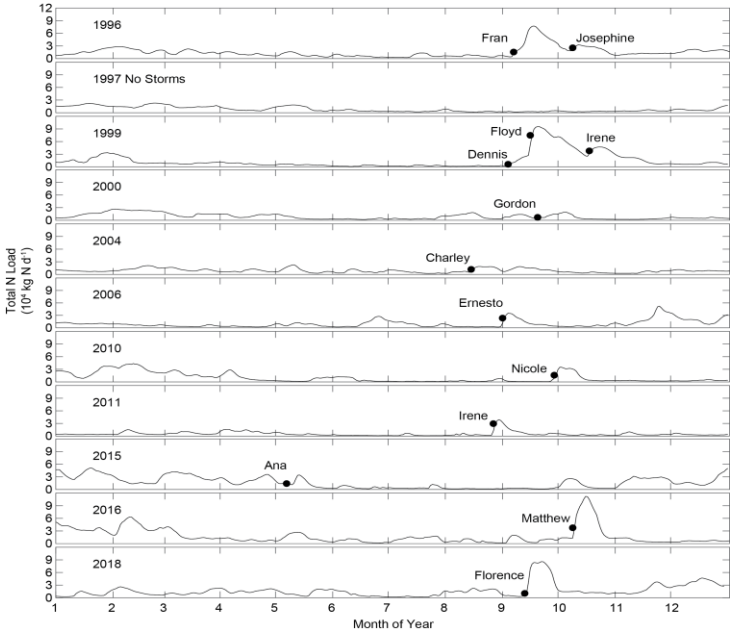
Impacts of hurricane Florence "freshet" on the Neuse River Estuary. The "pipeline" effect

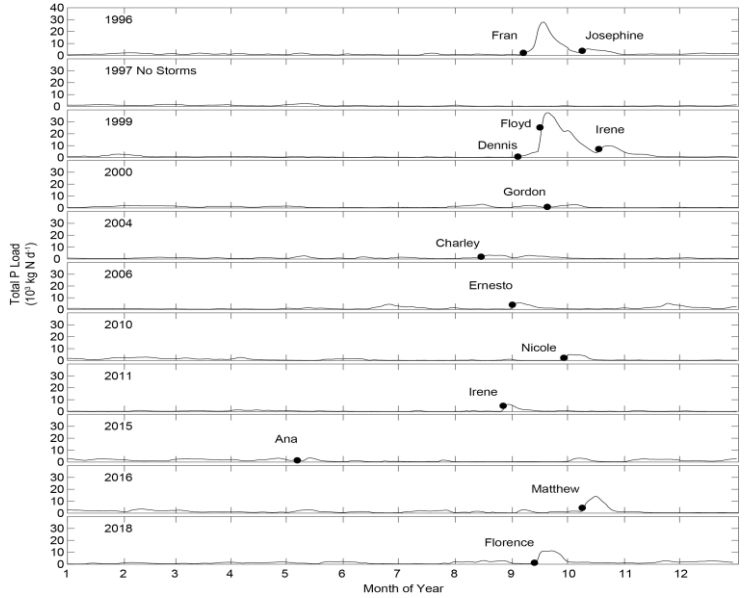


http://paerllab.web.unc.edu/modmon

N and P loading to the Neuse R. Estuary: Tropical cyclones are important relative to "normal" hydrologic patterns







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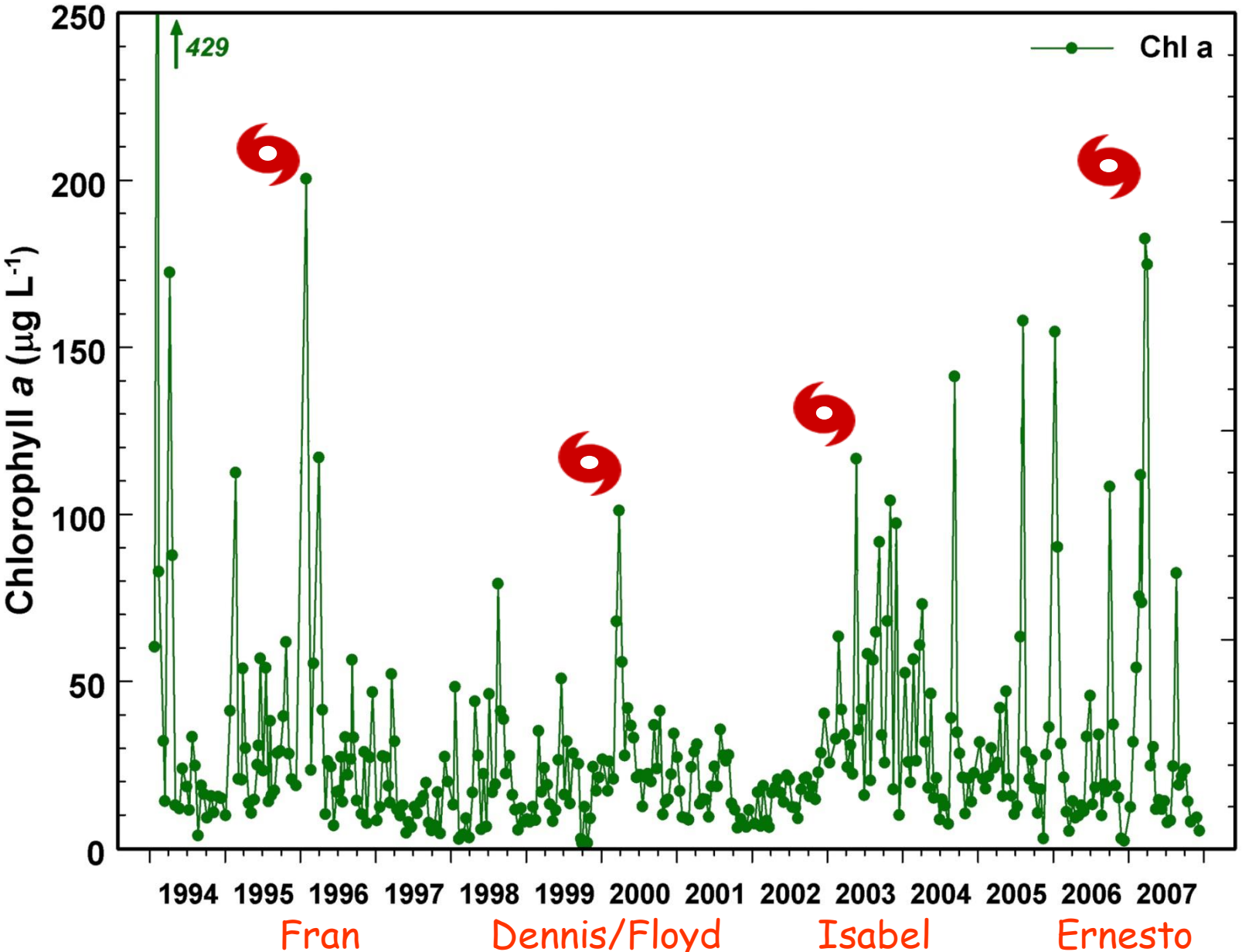
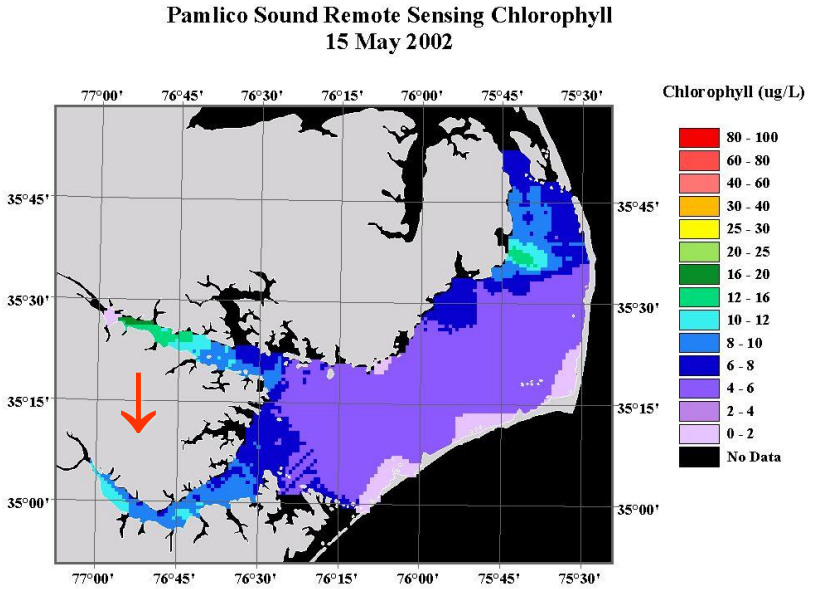
PN	16.0	18.2
TP	21.5	25.7
SRP	26.0	32.8
DOC	21.2	25.6
POC	17.0	19.6
DIC	14.1	15.7

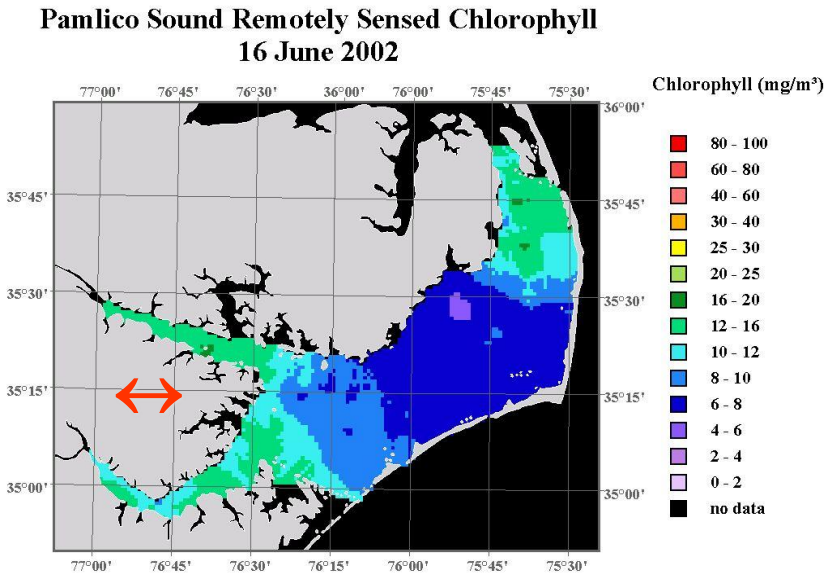
Hall et al., 2013; Peierls et al., 2012; Paerl et al., 2014, 2018, in prep.

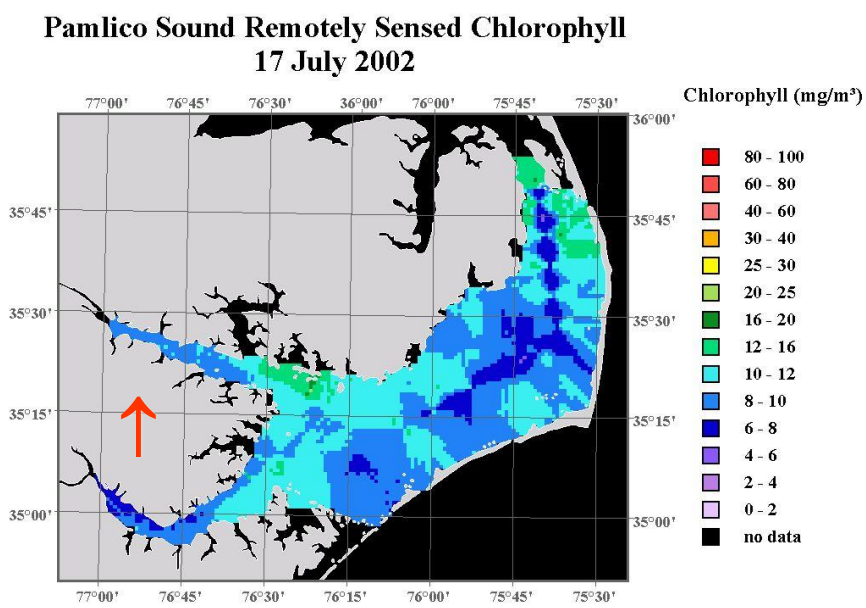
Major hurricanes/tropical storms & phytoplankton biomass (Chl *a*) responses in the Neuse R. Estuary, NC

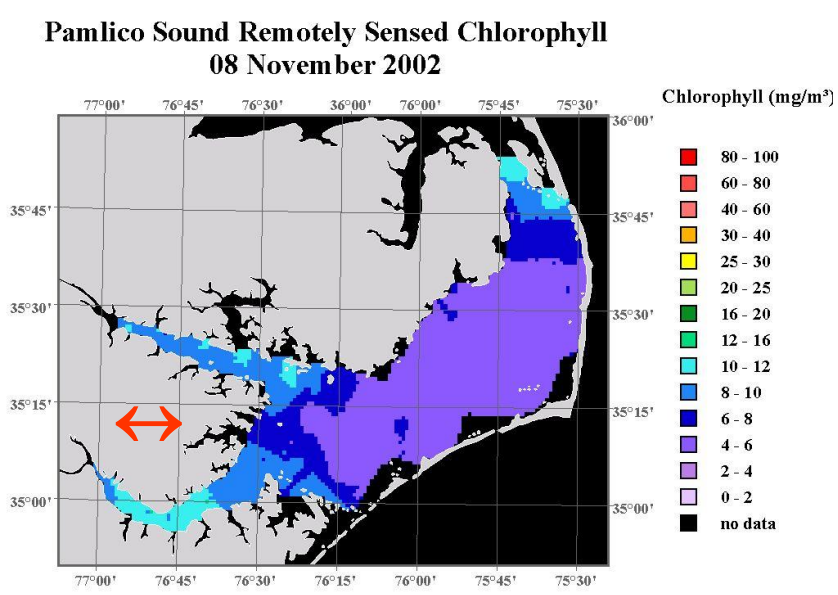


Freshwater Discharge affects algal production (Chl *a*) in Pamlico Sound, NC







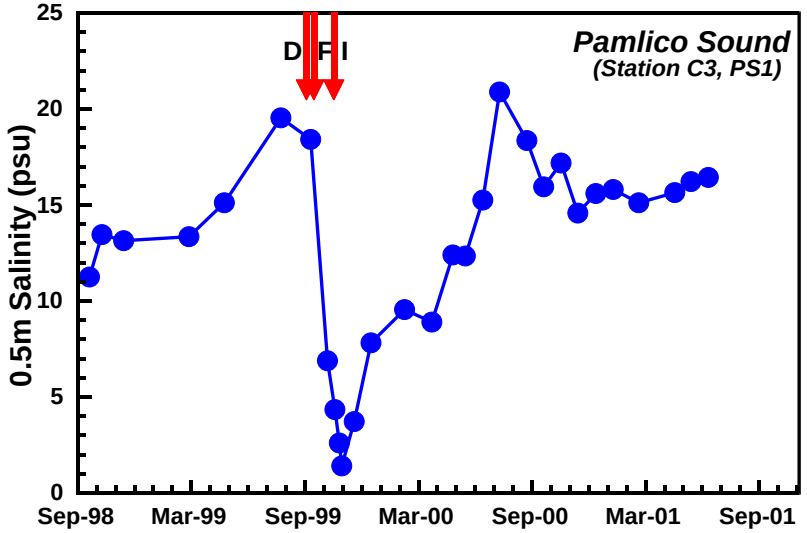


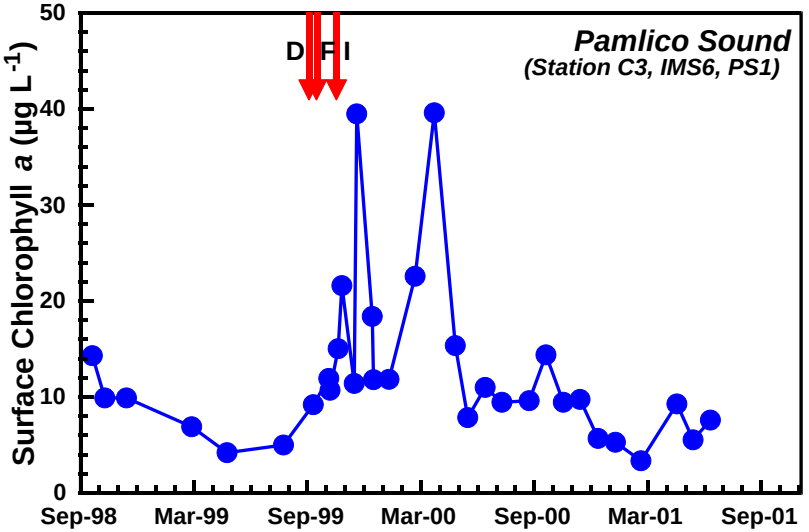
Flow: high↑, low↓, moderate↔

Harding et al., 2017

Hurricanes Dennis, Floyd & Irene ('99)

Salinity and Chlorophyll *a* responses in the Pamlico Sound

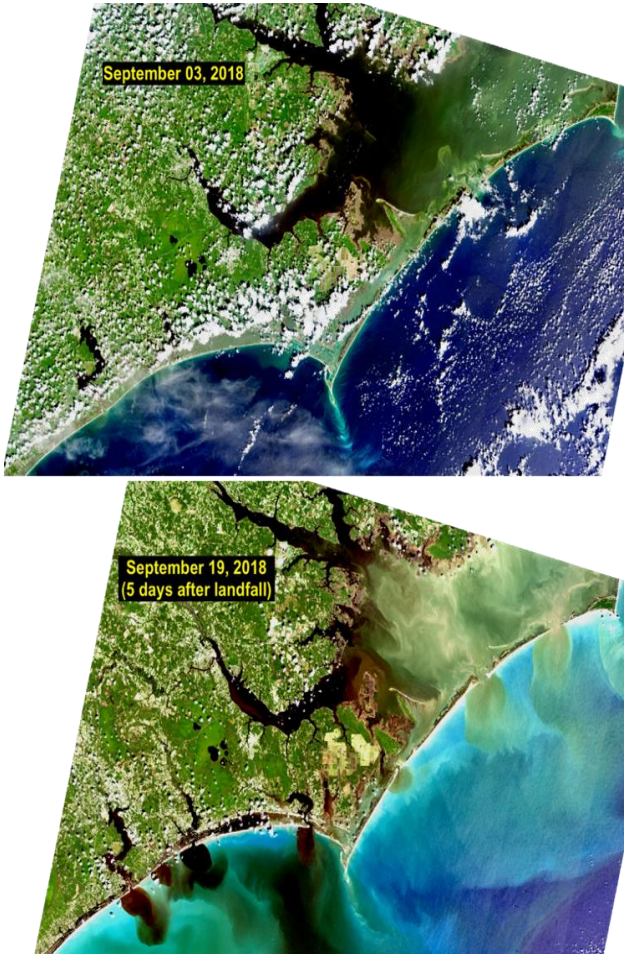


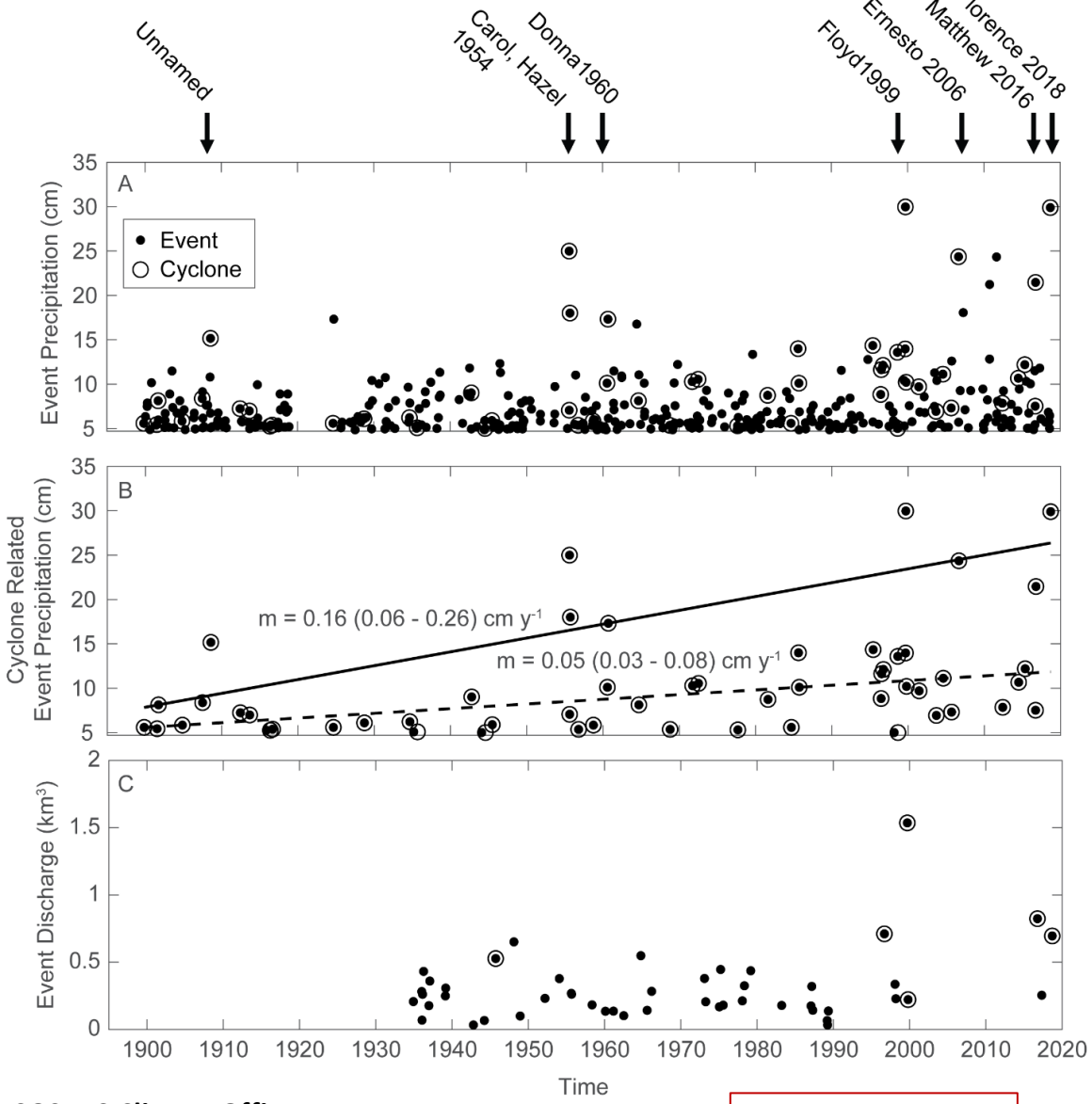


Paerl et al., 2001; 2006

The future??

We appear to be experiencing a "new normal" with regard to tropical cyclone frequency and rainfall intensity/flooding

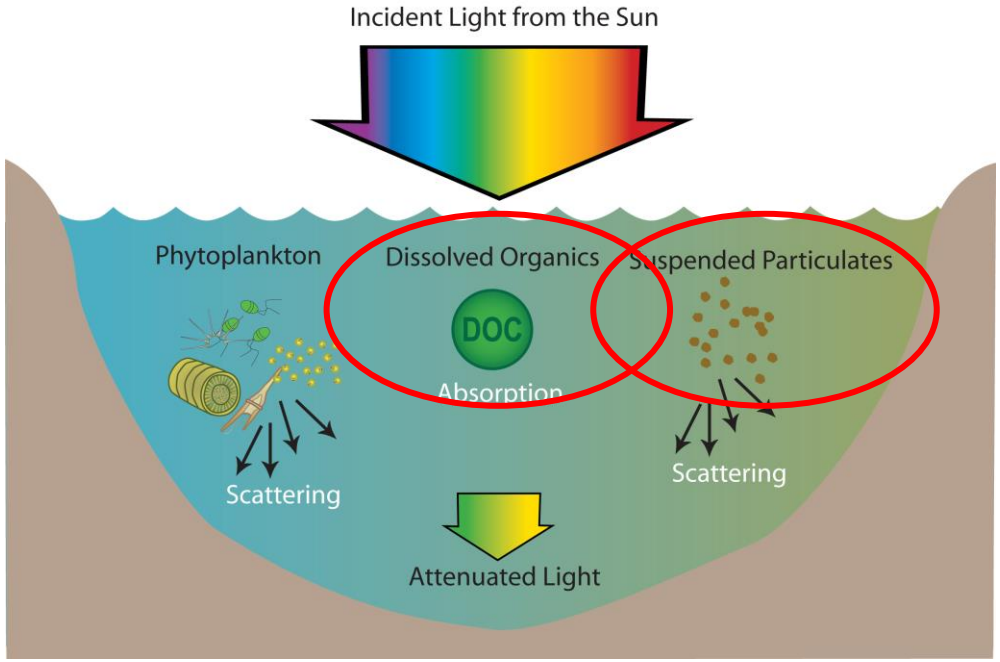




Data sources: NOAA-National Hurricane Center, USGS, NC Climate Office

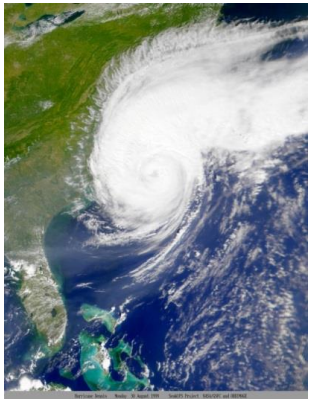
Paerl et al., 2019

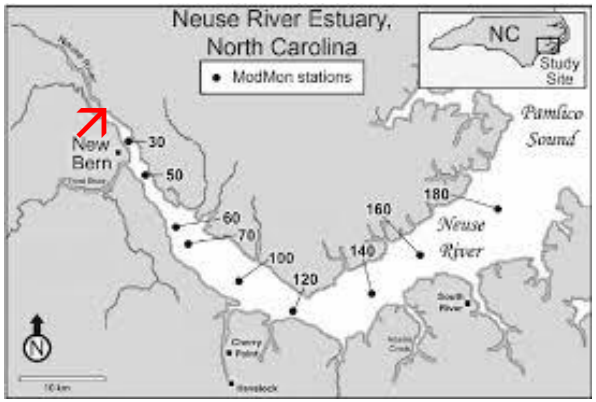
Suspended sediments and CDOM: Important light attenuation components



Freshwater discharge from Hurricane Florence (Sept. 2018)
Lower frame has been processed to emphasize CDOM.
Photo courtesy of Landsat Data Webpage (USGS).

DOC loading to the Neuse R. Estuary: How important are tropical cyclones relative to "normal" hydrologic patterns ? Answer, VERY!





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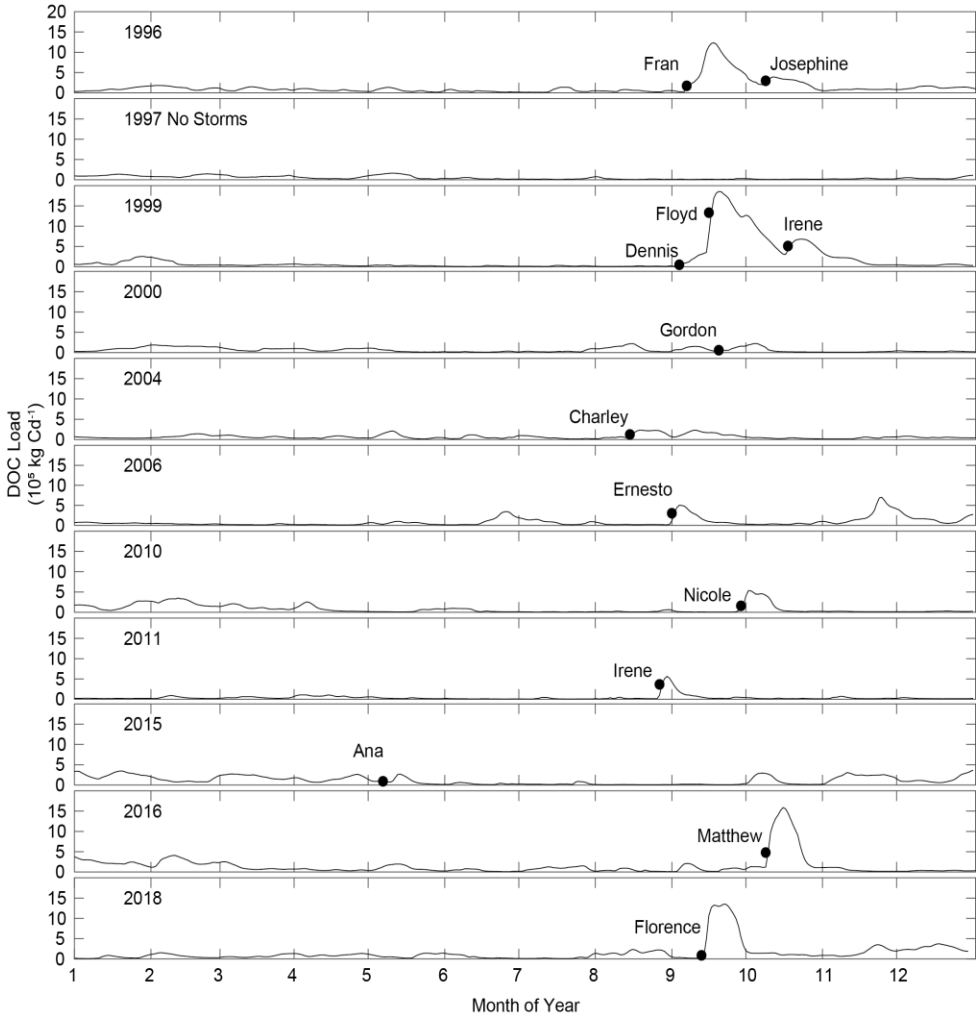
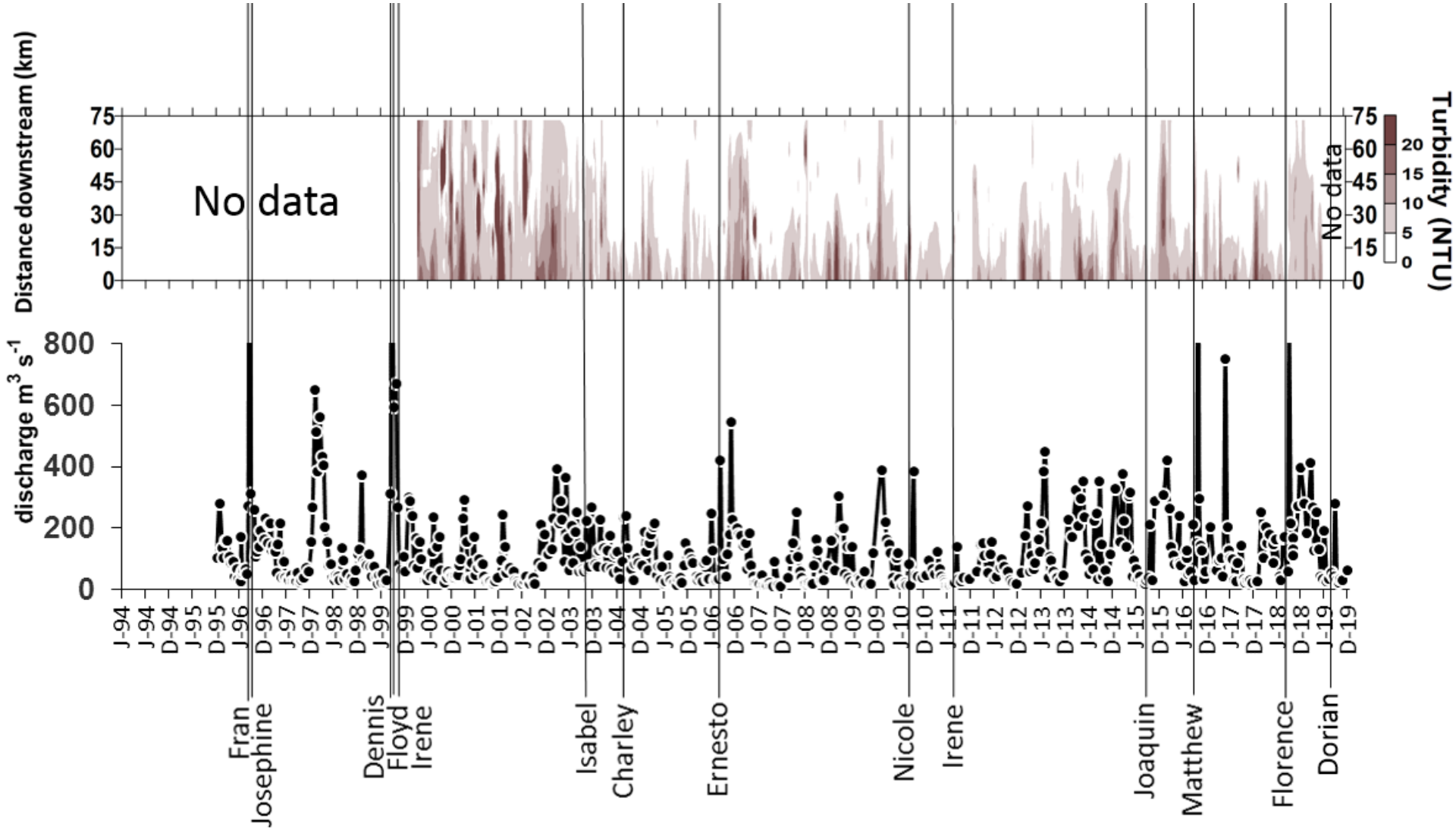


Hall et al., 2013; Peierls et al., 2012; Paerl et al., 2014, 2018

Major Precipitation events, discharge and turbidity



Determining upstream sources of DOC and DON

ENVIRONMENTAL Science & Technology

Article

pubs.acs.org/est

ES&T 50:8473-8484

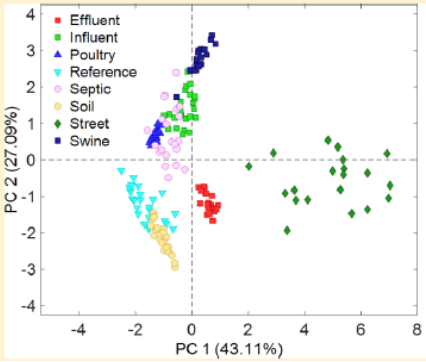
Predicting Sources of Dissolved Organic Nitrogen to an Estuary from an Agro-Urban Coastal Watershed

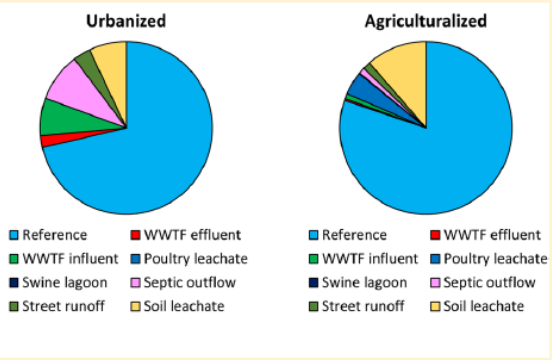
Christopher L. Osburn,*[,†] Lauren T. Handsel,[†,§] Benjamin L. Peierls,[‡] and Hans W. Paerl[‡]

[†]Department of Marine, Earth, and Atmospheric Sciences, North Carolina State University, Raleigh, North Carolina 27695 United States

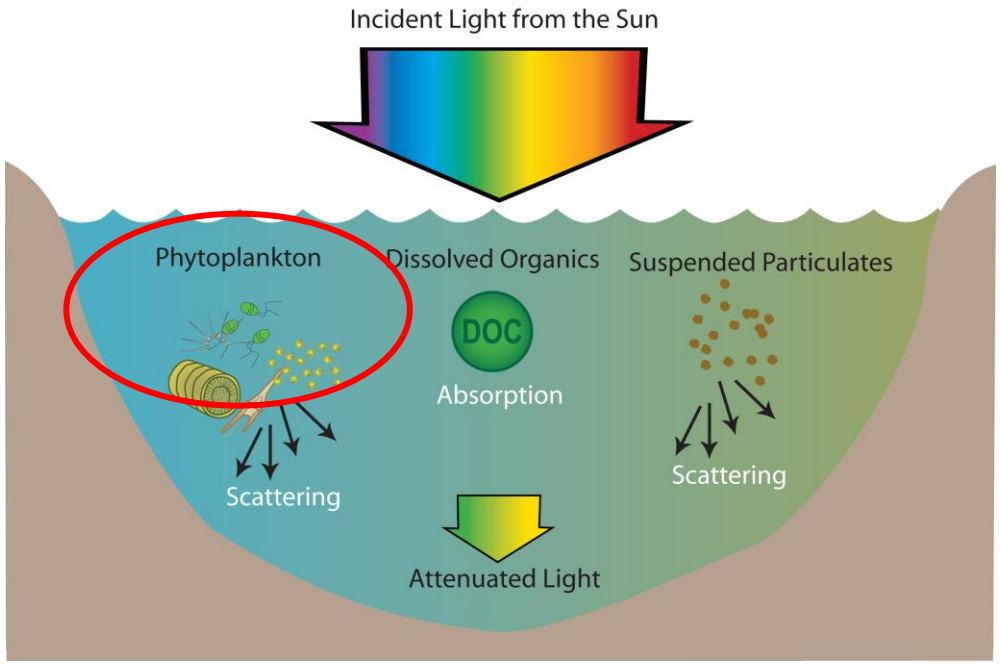
[‡]Institute of Marine Sciences, University of North Carolina at Chapel Hill, Morehead City, North Carolina 28557 United States

Supporting Information

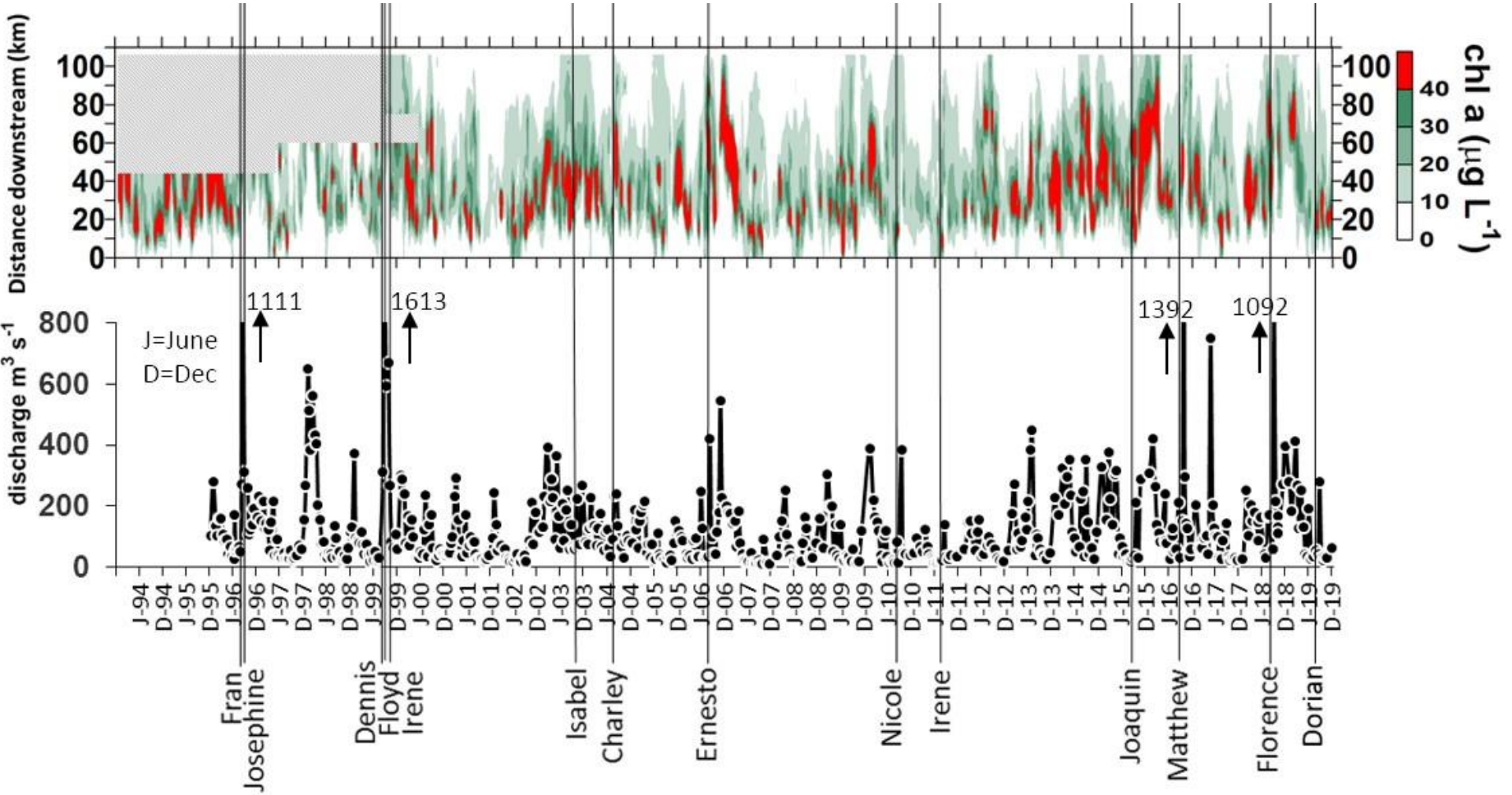




Chl a: another light attenuation component



Major Precipitation events, discharge and Chlorophyll *a*



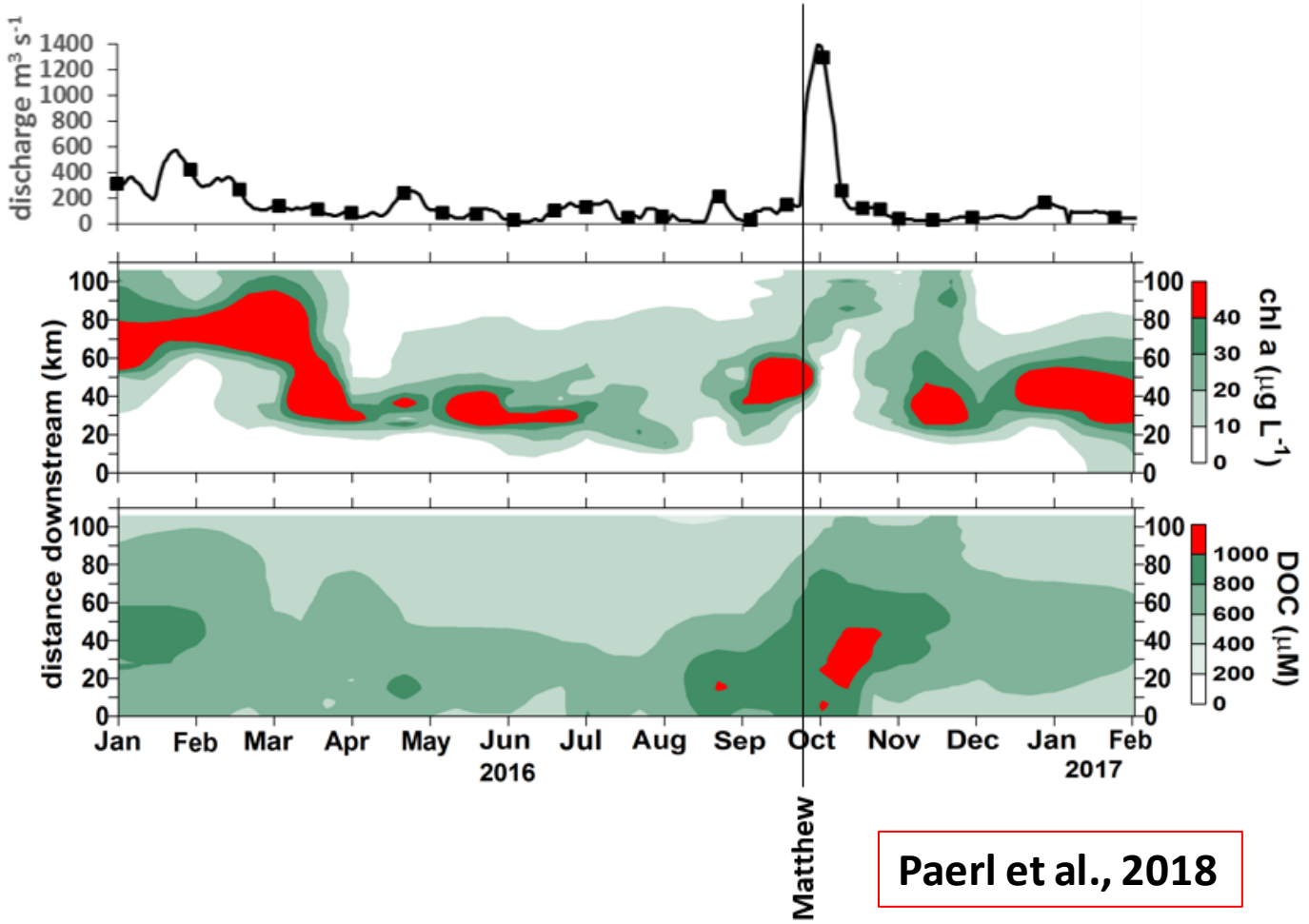
Interactions of Chl a and DOC as light attenuating factors

Impacts of Hurricane Matthew's (Fall 2016) "500 year" floodwaters on the Neuse River Estuary, NC.

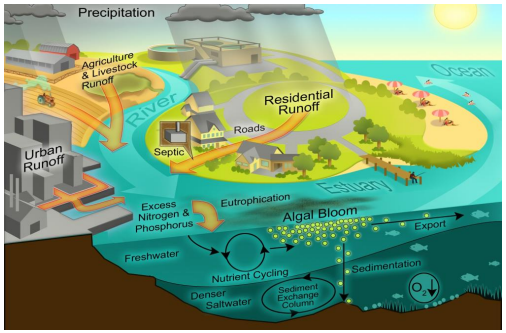
1. First a big flush of organic matter delivered from the watershed….
2. Then an algal bloom (as chlorophyll *a*) response

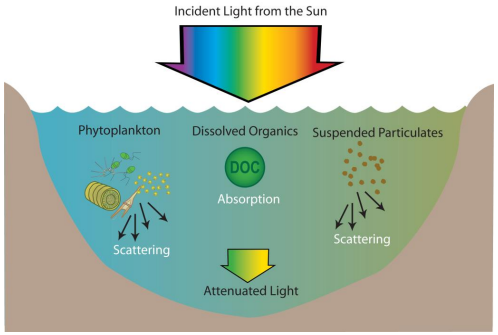
Before

After



Paerl et al., 2018

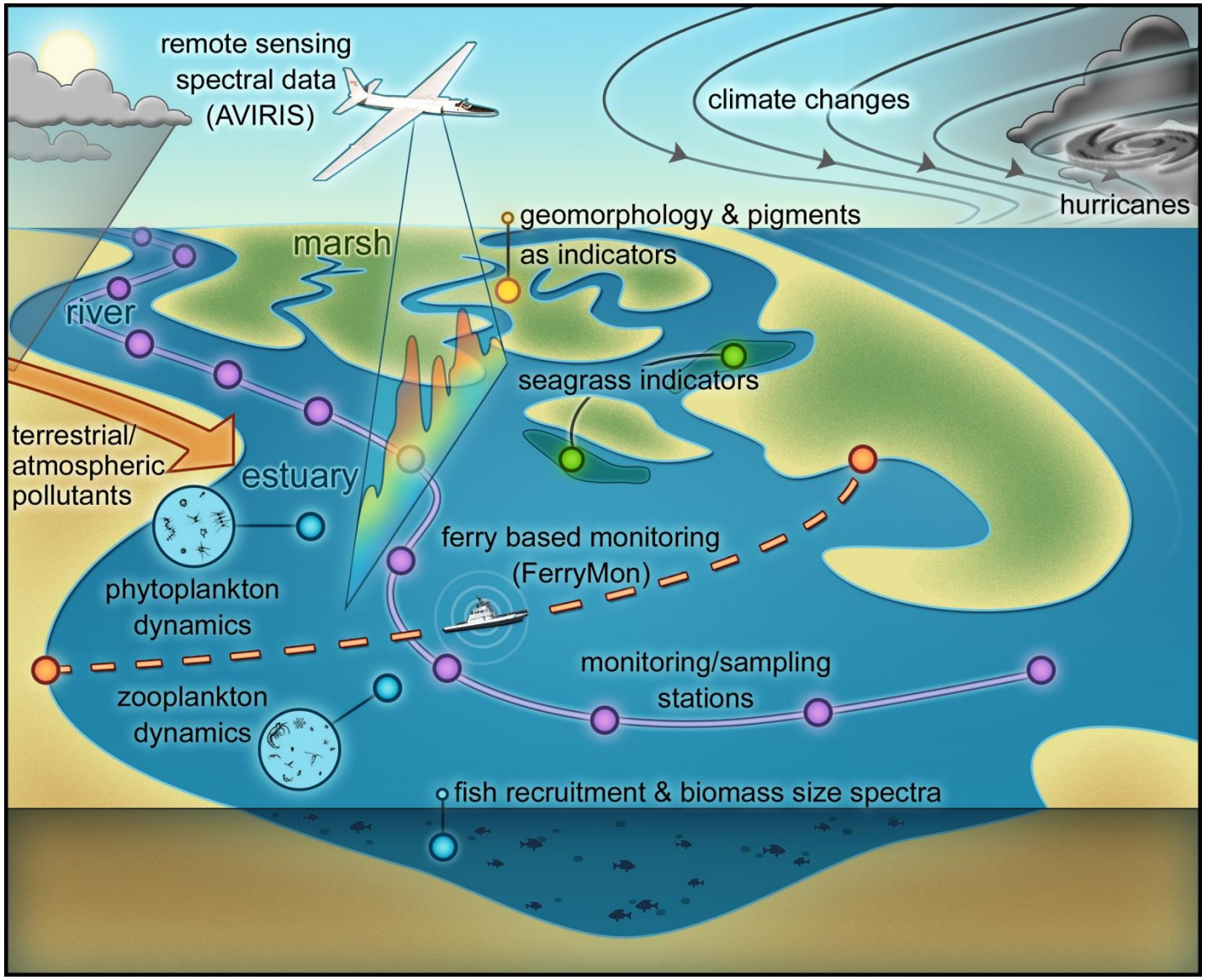




Conclusions

- Eutrophication of Neuse (and other tributaries of APES) linked to N and P availability/loads
- Historically, upstream P reductions decreased riverine primary production (PP), but still need N reductions to control downstream PP
- N-based TMDL (30% N load reduction) has led to decreased DIN loading, but DON has gone up: Net effect, no decrease in TN loading, and downstream Chl *a* may be increasing
- Increase in high rainfall TC's impacting episodic and annual nutrient/OM loads, salinity regimes
- Event scale important in nutrient, DOC/CDOM loading and phytoplankton growth responses
- Need to assess effects of episodic vs. seasonal/annual/multi-annual drivers on optical and habitat conditions that affect SAV health and distributions in APES
- Lastly, lesson from Chesapeake Bay: One major TC (Agnes, 1972) can impact SAV's with multiple year recovery needed

ModMon and FerryMon: Gauging human and climatic impacts on APES



Environmental Quality

U.S. Fish & Wildlife Service

NSF

Sea Grant North Carolina

WRRI

LNBA

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