FerryMon & ModMon: Keeping a watchful eye on water and habitat quality in the Pamlico Sound System

Dr. Hans W. Paerl, Kenan Professor of Marine & Environmental Sciences

UNC Institute for Marine Sciences, Morehead City, NC

Monitor Track
Berne Room
2:00 – 2:30pm

Albemarle-Pamlico Ecosystem Symposium
Embarking on a New Voyage

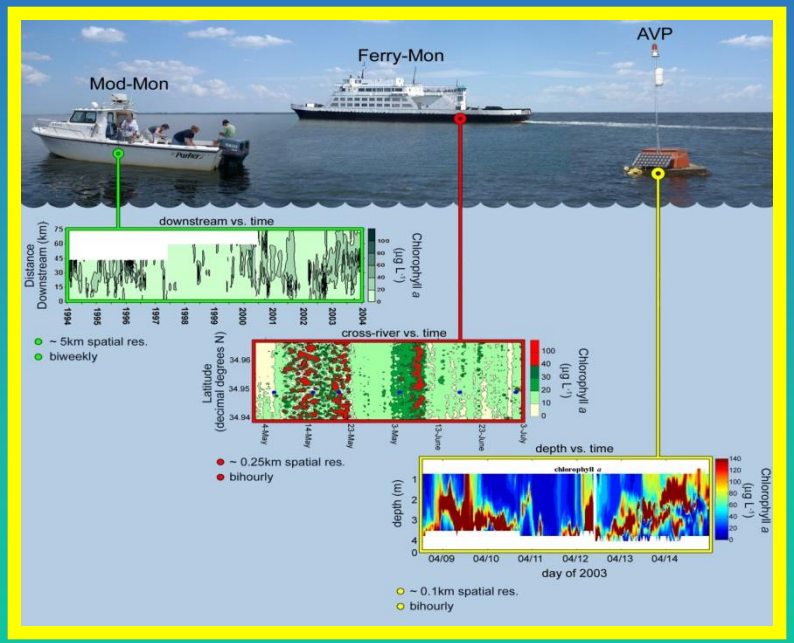
FerryMon
UNC-CH / DUKE / NCDENR / NCDOT

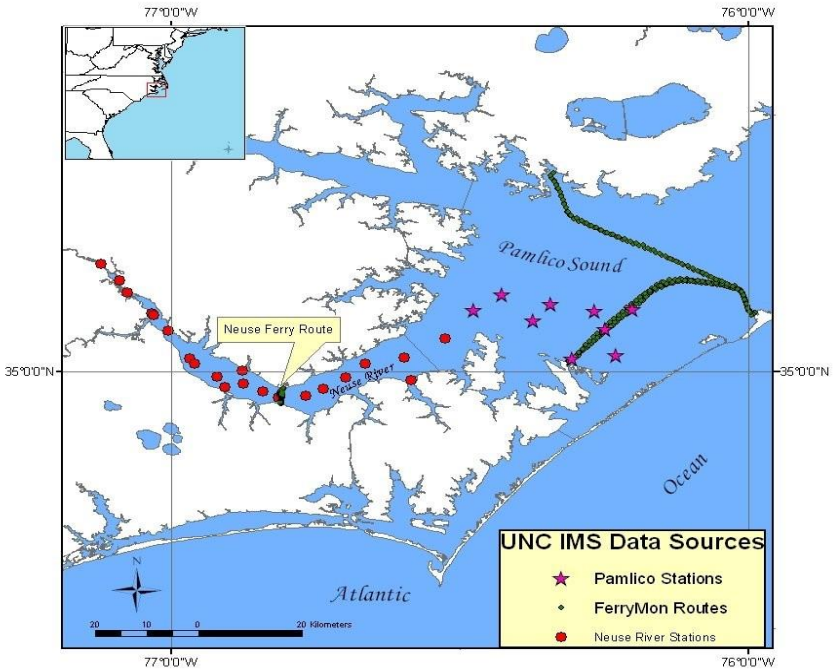
Neuse River Estuary
MODMON

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





CRFL
Coastal Recreational Fishing License Reports, Plans, and Procedures

NSF

This research is funded by U.S. EPA - Science To Achieve Results (STAR) Program
Grant # 82667701

NCDENR

Sea Grant North Carolina

WRRI

LNBA

The Albemarle/ Pamlico Sound Estuarine System

- Second largest estuary and largest lagoonal estuary in US
- Most important US SE fisheries nursery
- Watershed includes most of eastern NC & southern VA
- Poorly flushed ($\tau \sim 1$ Yr), with oligo-mesohaline conditions
- History of WQ problems in tributaries
- Impacted by climate change (storms, SLR)

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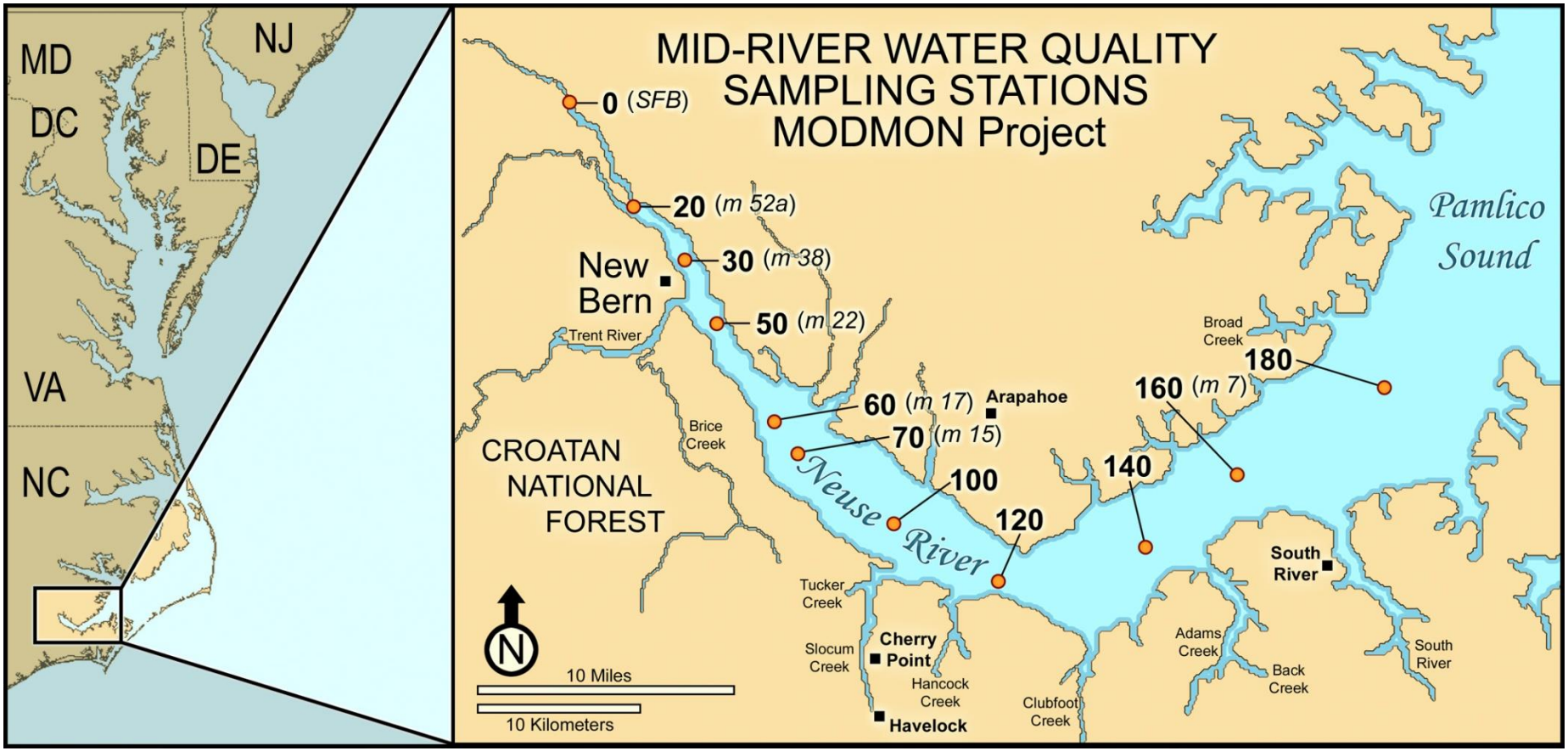
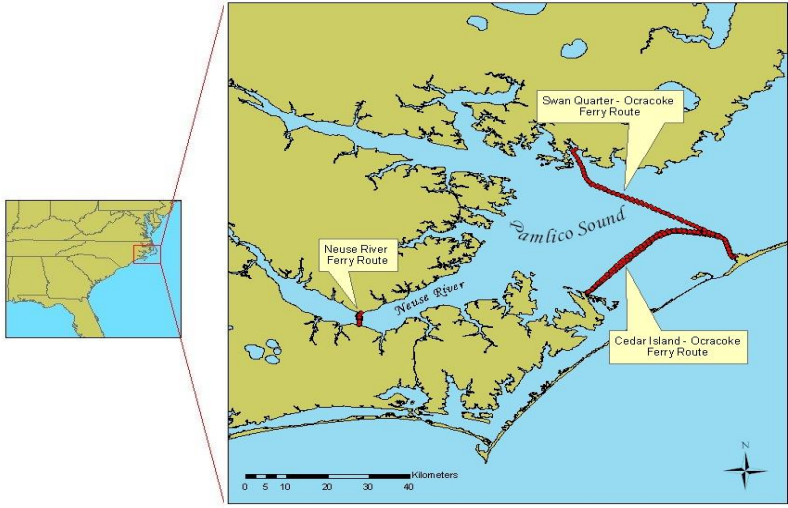
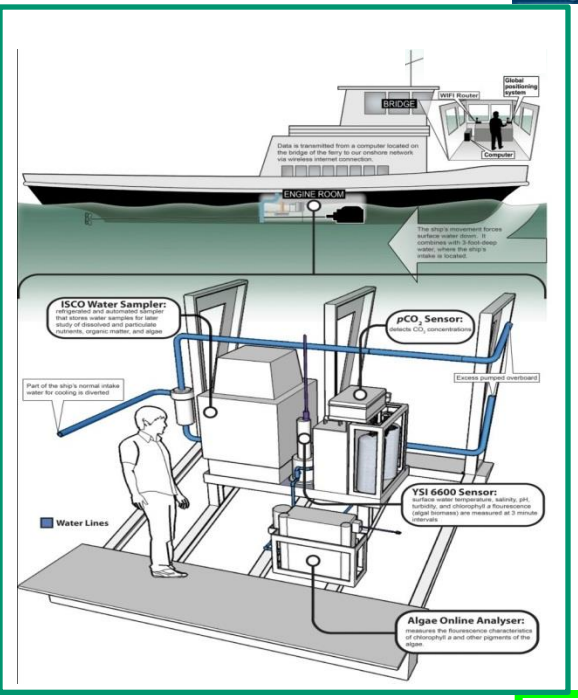


www.marine.unc.edu/neuse/modmon

Here's how FerryMon works

www.ferrymon.org





Raw Data Sent via Internet to UNC-IMS Marine Lab
Raw Data Stored at IMS
Raw Data Text Files QA/QC'ed
QA/QC'ed Data added to Microsoft Access Database

Ferry Bridge Equipt

- Date/Time
- DGPS Latitude / Longitude
- Data Modem / Data Logger

YSI sonde

- *in-situ* Chl*a*
- Salinity
- Temperature
- Turbidity
- pH, DO, pCO_2
- Date/Time

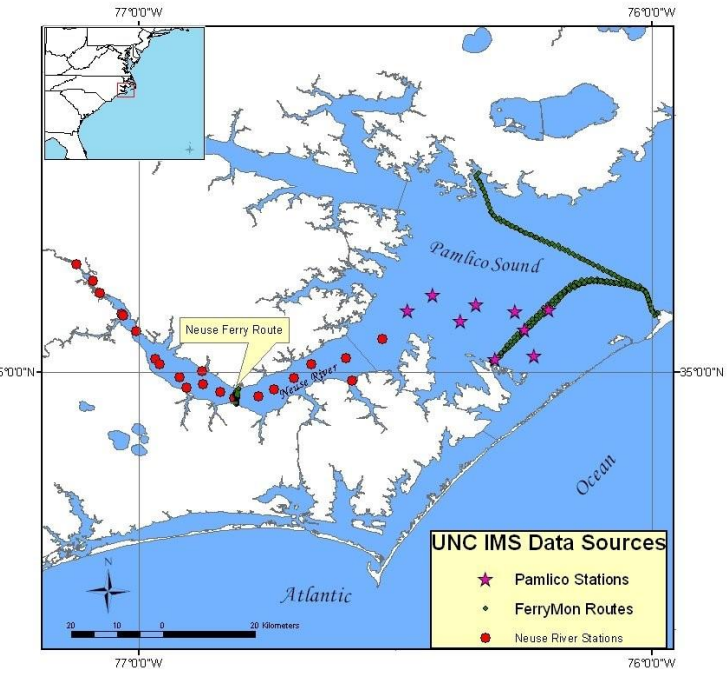
ISCO discrete sampler

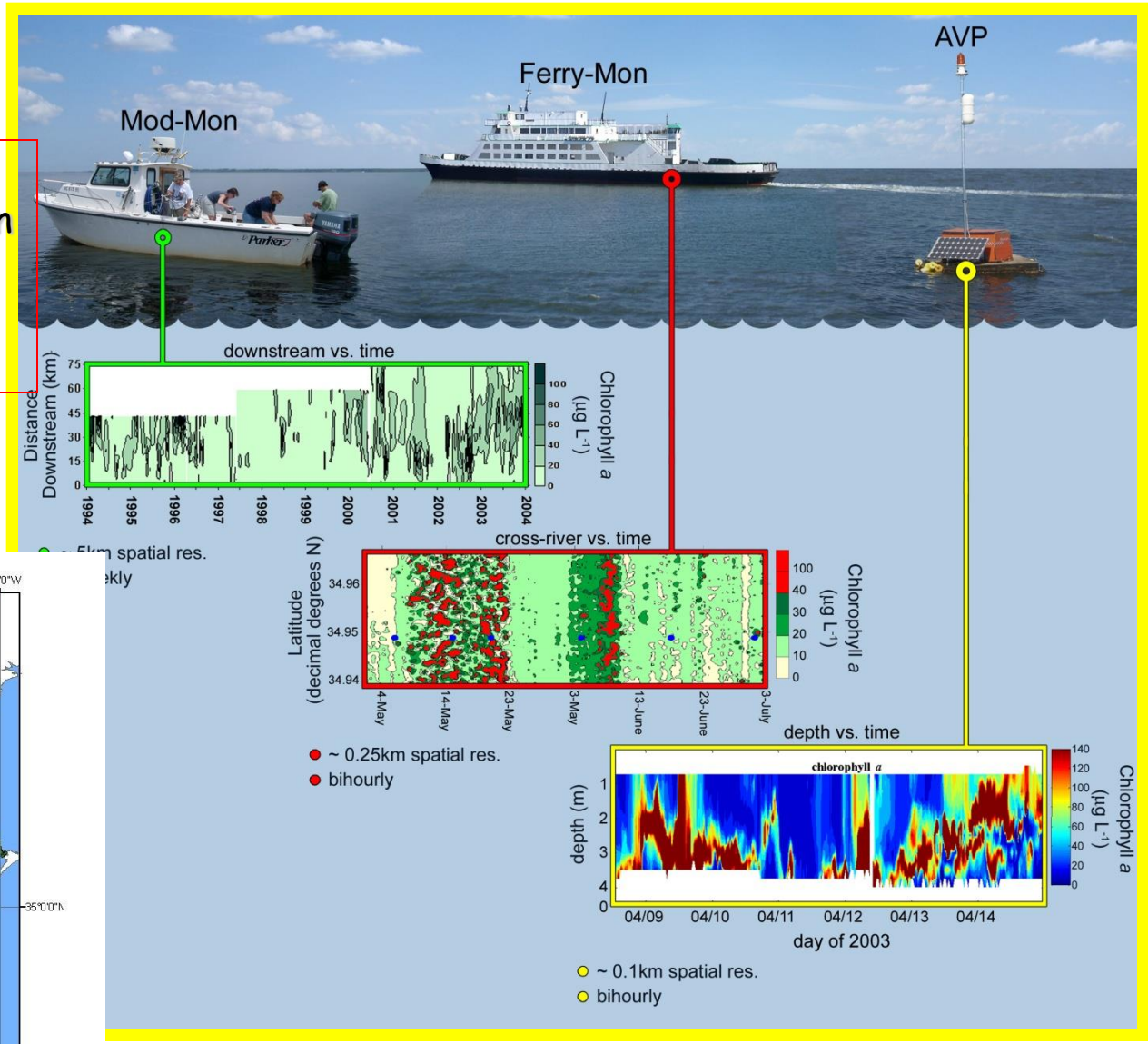
- *in-vivo* Chl*a*
- Diagnostic Pigments
- Nutrients
- E. Coli / viruses
- Date/Time

ModMon and FerryMon: space-time intensive monitoring to assess human and climatic impacts on water quality in the Albemarle-Pamlico Sound System (APS)

ModMon: Since 1994
www.unc.edu/ims/neuse/modmon

FerryMon: Since 2000
www.ferrymon.org



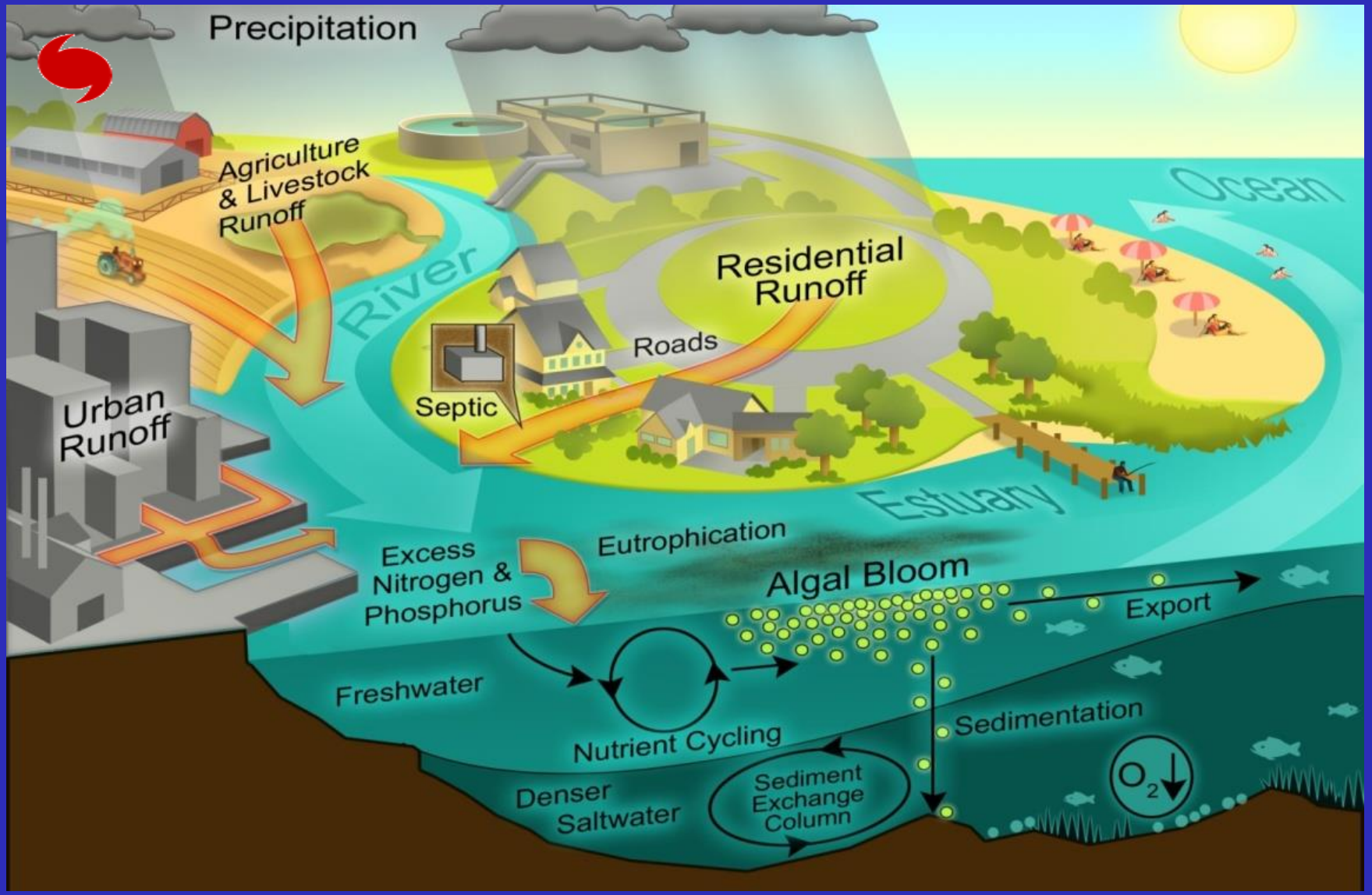


FerryMon ModMon Products/ Applications

- Provide baseline of multiple WQ indicators for Pamlico Sound
- Assess compliance with NC WQ standards
- Determine human & climatic drivers of WQ
- Determine patterns of WQ variability→ event scale!
- Provide data for WQ & circulation models
- Provide ground-truthing for remote sensing
- Provide infrastructure for complementary instrumentation
- Enhance public awareness of WQ issues

The Challenge: Assessing Synergistic Impacts from Multiple Stressors in APS

Land use and Nutrient Loads, Climate Change, storms and SLR



The Nutrient-Eutrophication Problem

- Excessive nutrient inputs (largely N) stimulate algal growth & degrade water quality throughout APS
- Excess algal production causes hypoxia, disrupts food chain, and adversely affects fisheries
- Evaluate nutrient-sensitive waters and TMDL's
- Climate change (warming, storms) influence these effects

Evaluating Total Maximum Daily Load (TMDL) for the Neuse R. Estuary

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

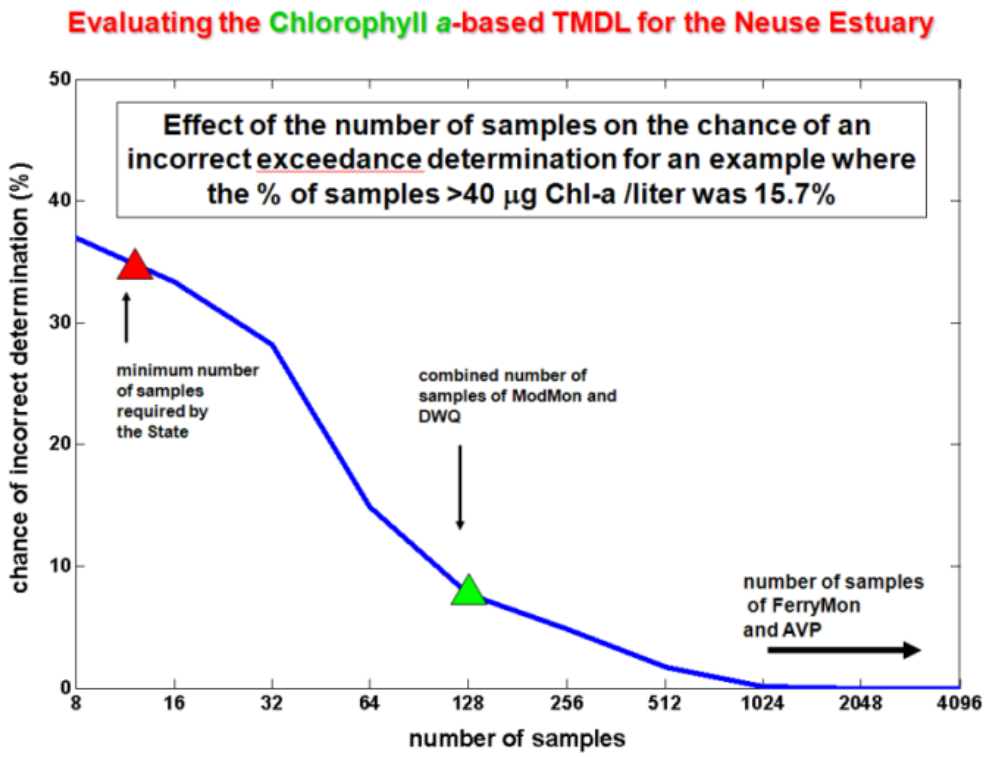
10/40 criterion-- no more than 10% of samples
collected in a year can be over 40 μg Chl a / liter

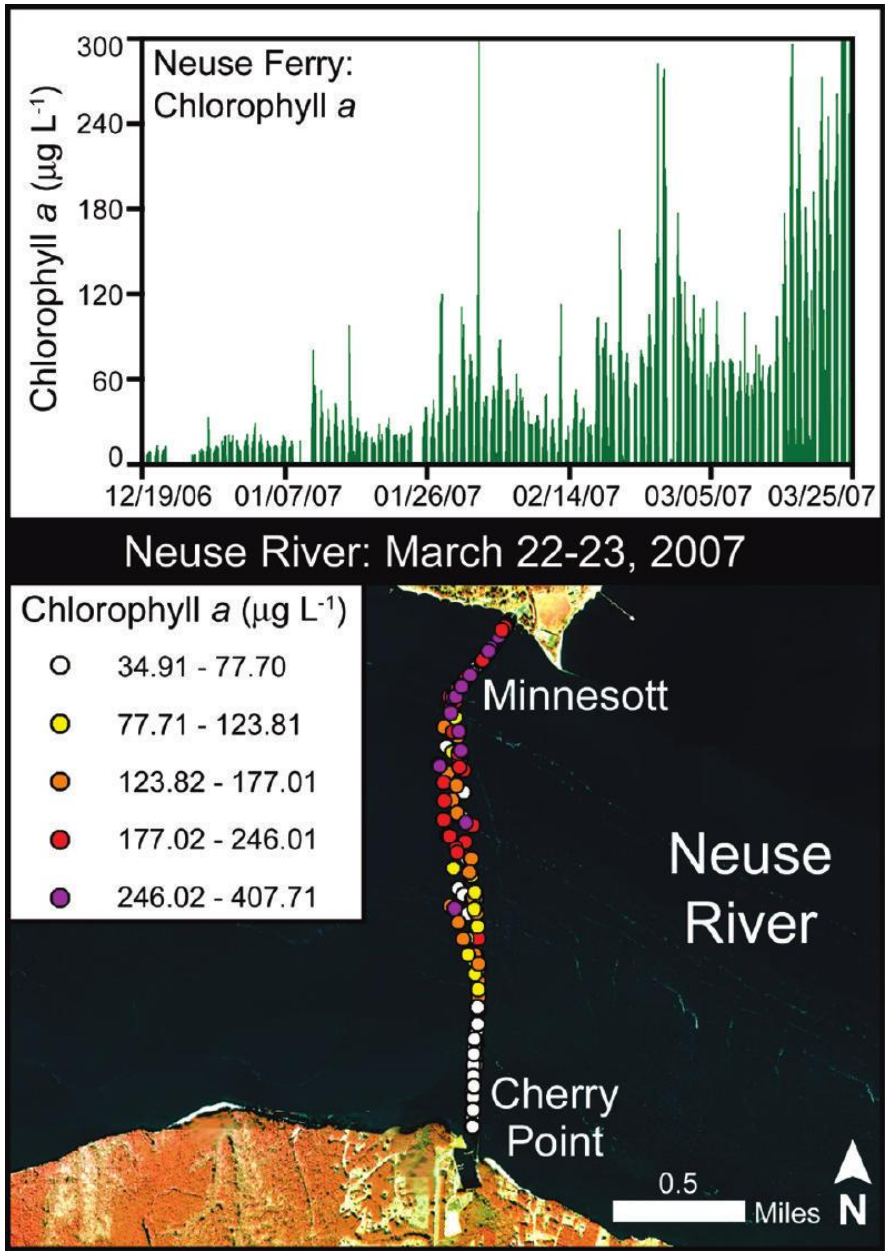
The TMDL is only as strong as our ability to assess the 10/40 criterion!

Goal

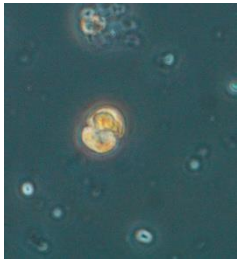
Provide NC-DENR and stakeholders a scientifically sound, defendable determination of 10/40 criterion exceedances for the five use support areas of the NRE at annual time scales relevant to adaptation of the TMDL.

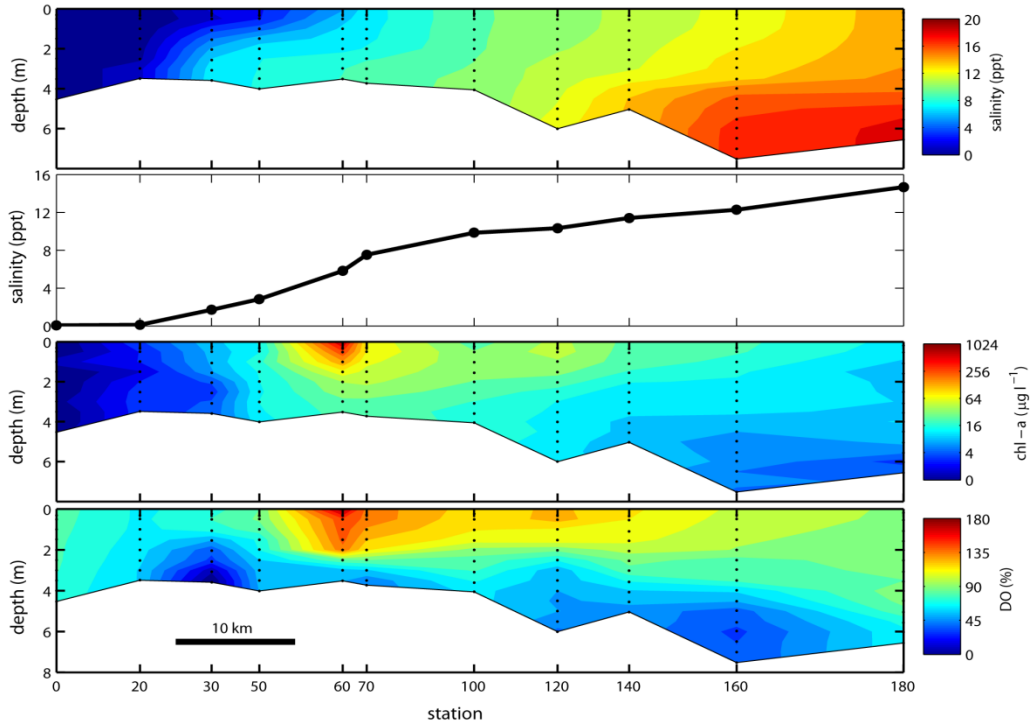
Assessing the Chlorophyll *a*-based TMDL for the Neuse R. Estuary

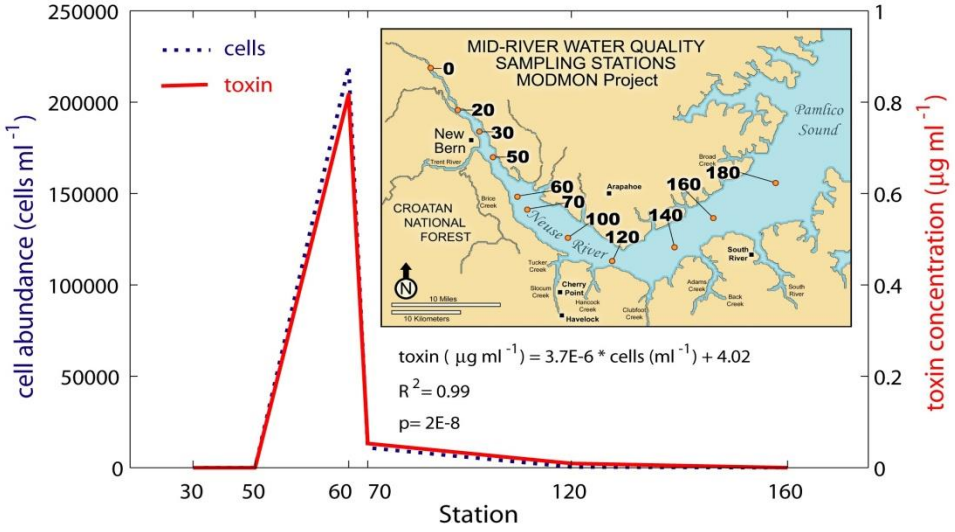




Detecting a toxic dinoflagellate (*Karlodinium)* bloom following nutrient-enriched runoff from Tropical Storm Ernesto, Oct. 2006







- **Runoff associated with Ernesto contained nutrient load and set up strong salinity stratification**
- **Favorable light and temperature conditions created ideal conditions for an algal bloom.**
- **Near-surface stratification was favorable for motile dinoflagellates; *Karlodinium* prefers these conditions in fall.**

Hall et al. 2008

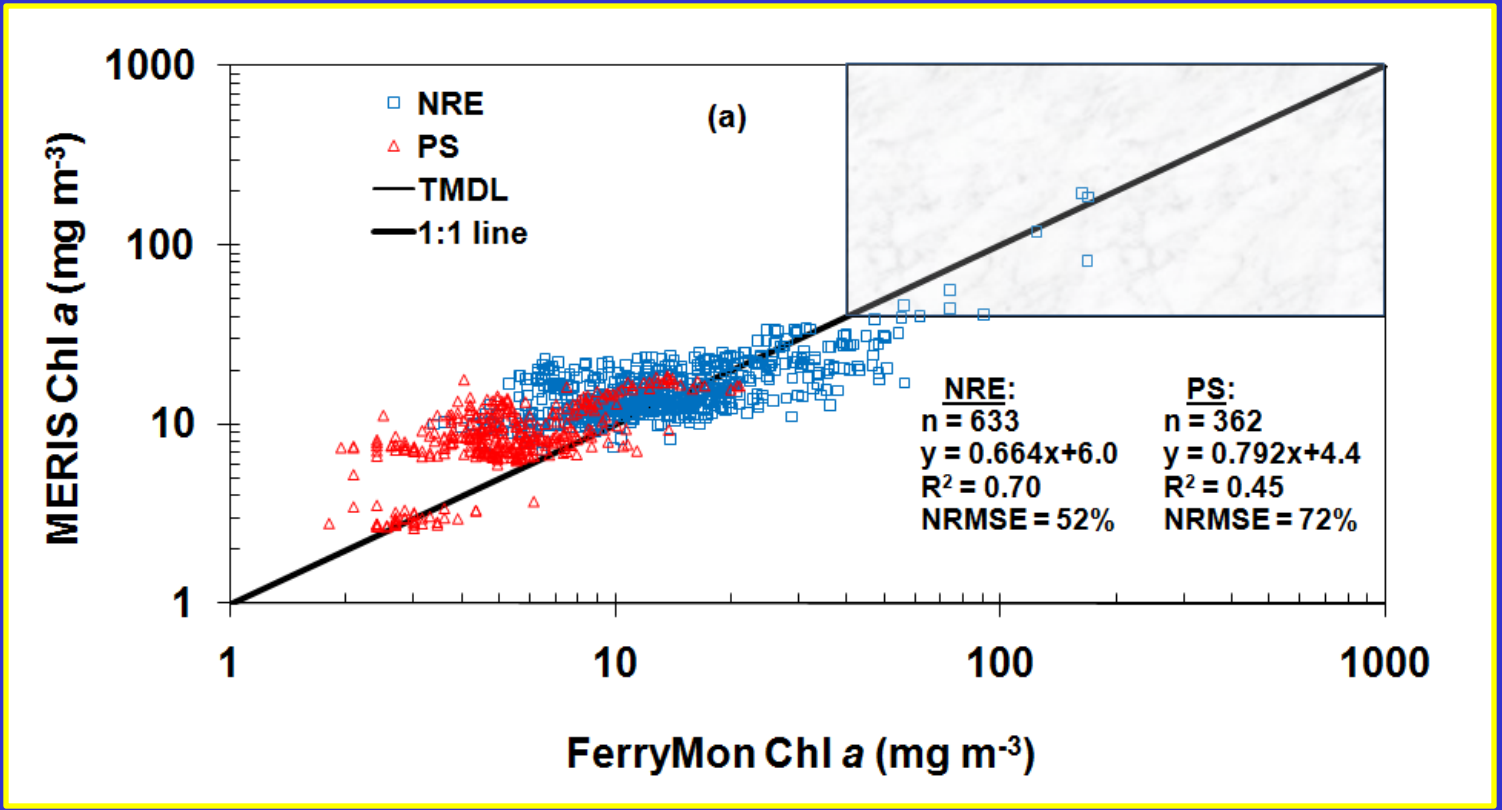
Scaling Up: using MERIS, SeaWiFS and AVIRIS imagery

August 2004 Flight Paths
NASA / EPA Modified U2 Aircraft

FerryMon Ground Truthing Routes

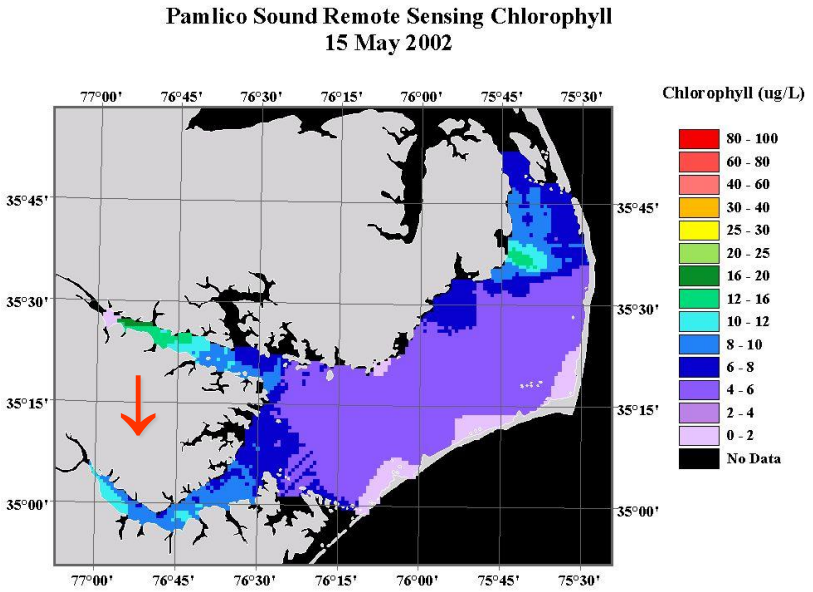
Calibrating Satellite Based Remote Sensing

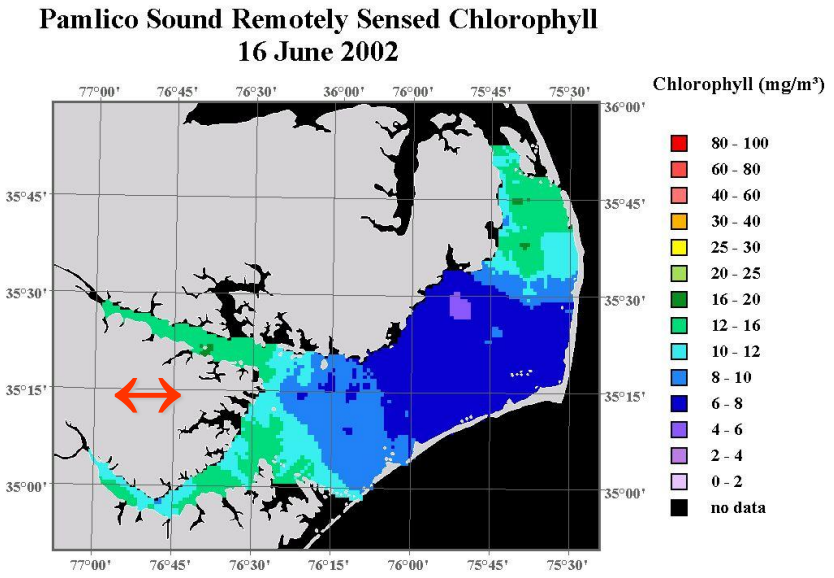
FerryMon and ModMon Ground Truth Data Used To Calibrate/ Validate Algorithms (MERIS Imagery, European Space Administration- Envisat Satellite)

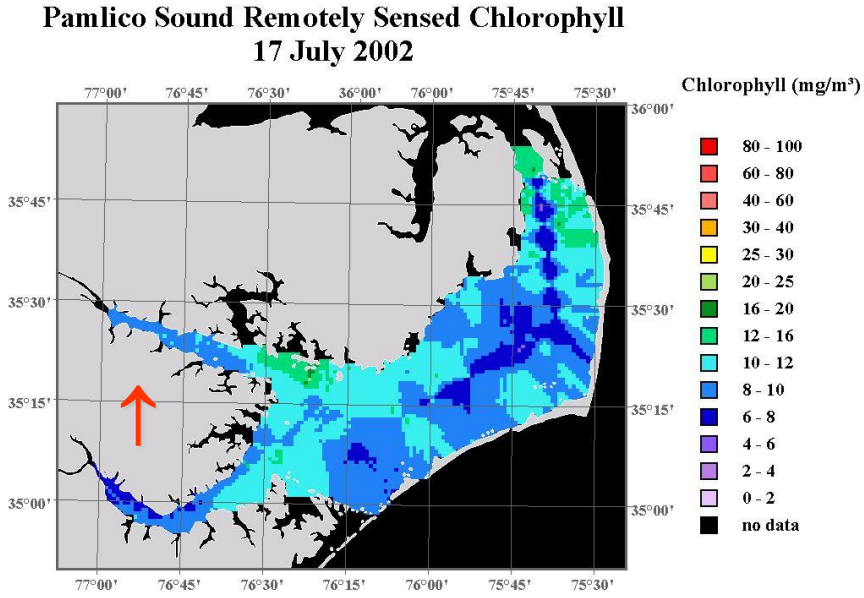


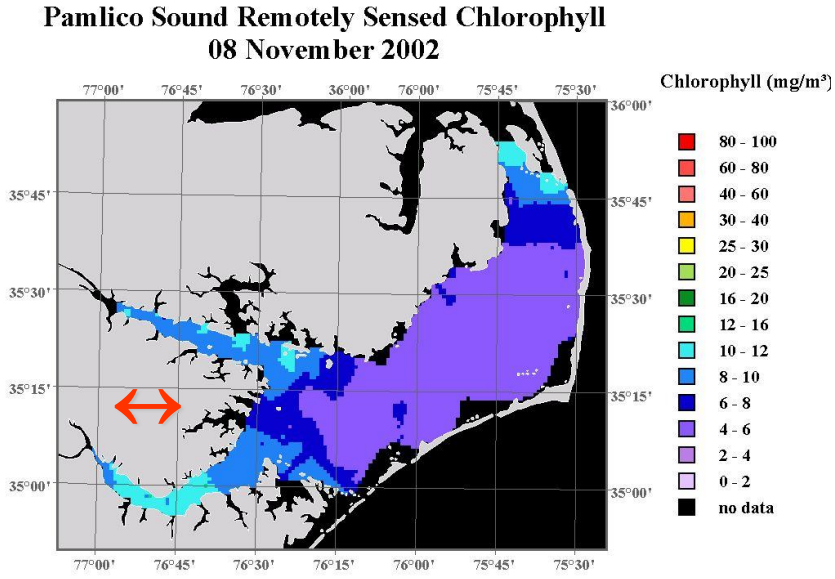
Sokoletsky et al. 2011

FerryMon/ModMon & Aircraft based SeaWiFS: FW discharge effects on algal production (Chl *a*)





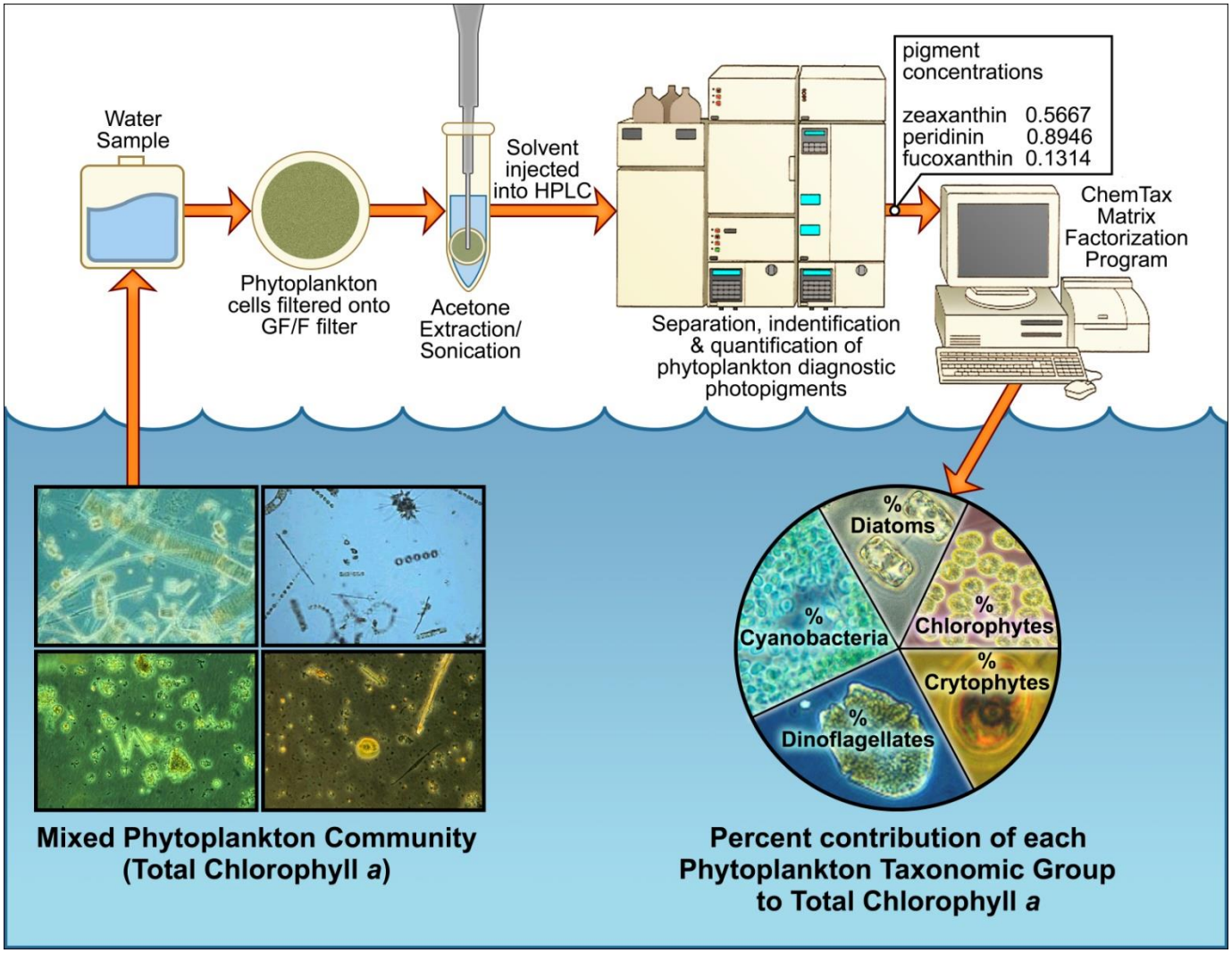




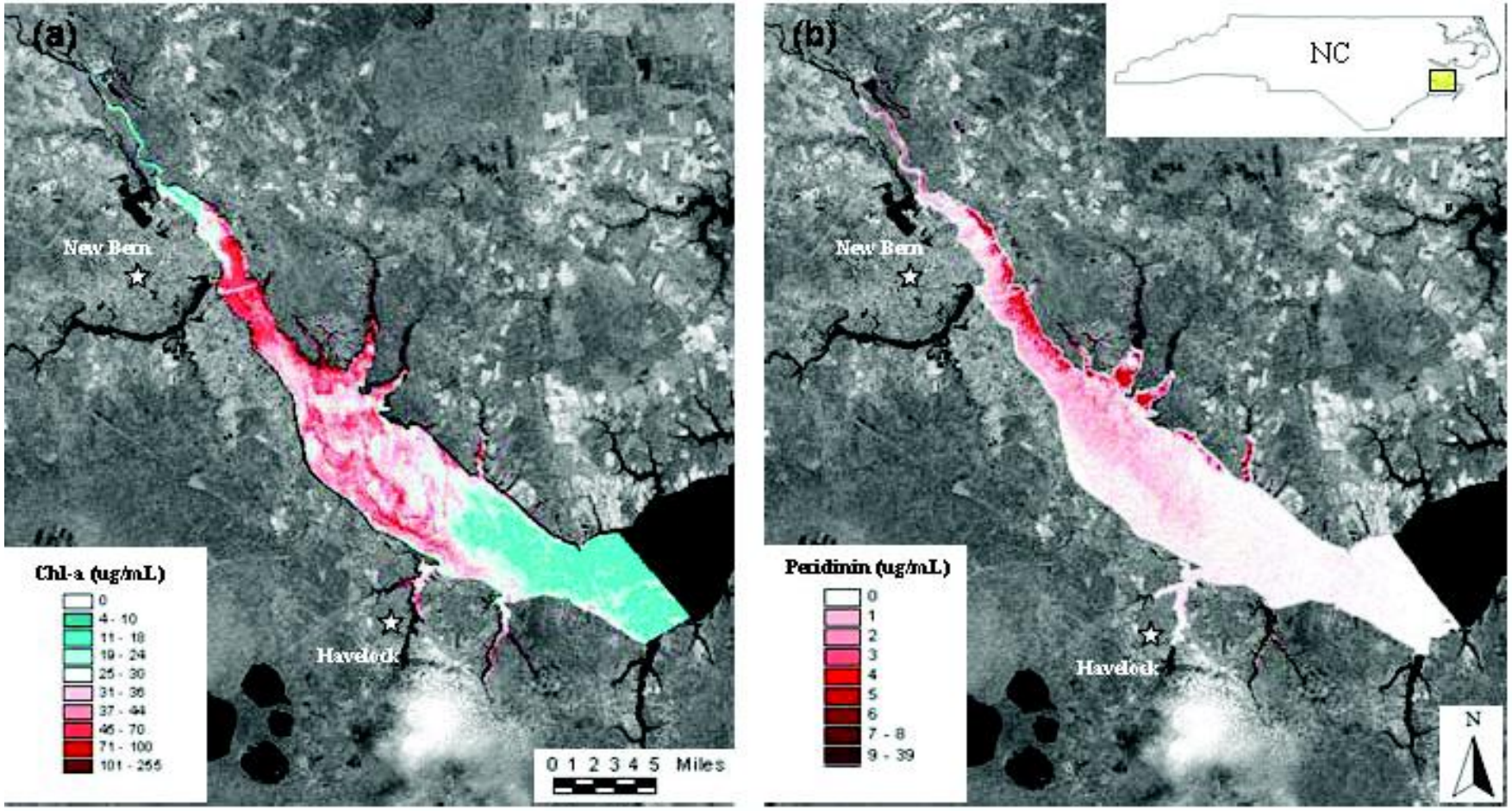
Flow: high↑, low↓, moderate↔

Harding et al. 2009; Paerl et al., 2007

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



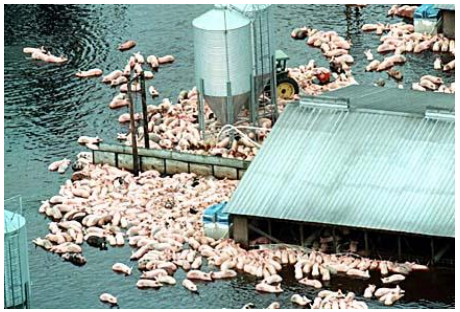
Diagnostic Microalgal Indicators and Remote Sensing

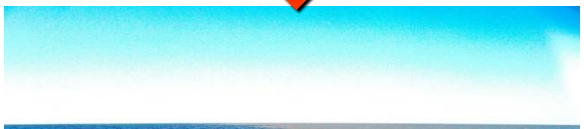


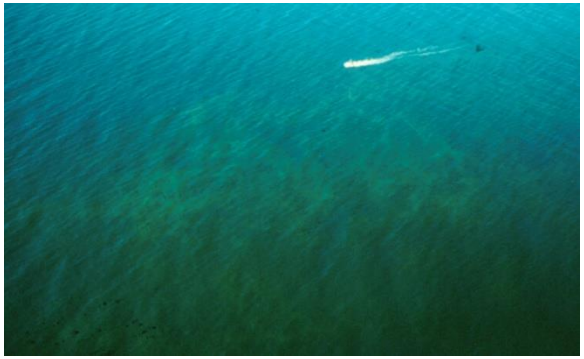
Estimated Chlorophyll-a and Peridinin concentrations in the Neuse R. Estuary 15 May 2004 as determined with AVIRIS, FerryMon and ModMon data. (Lunetta et al 2006)

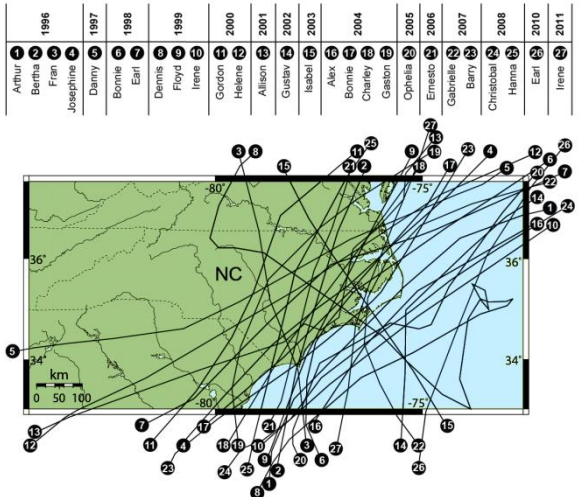
Users: EPA, NASA, NOAA, NC DENR-DWQ

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









Why the concern about tropical cyclones?

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

Increased Nutrient and other contaminant inputs

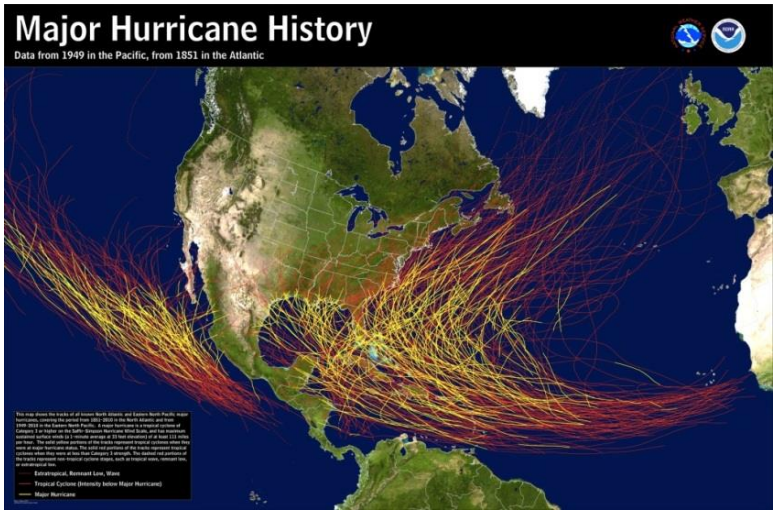
Changes in sediment dynamics (transport, deposition, resuspensi

Biotic alterations (water quality, habitat, food webs)

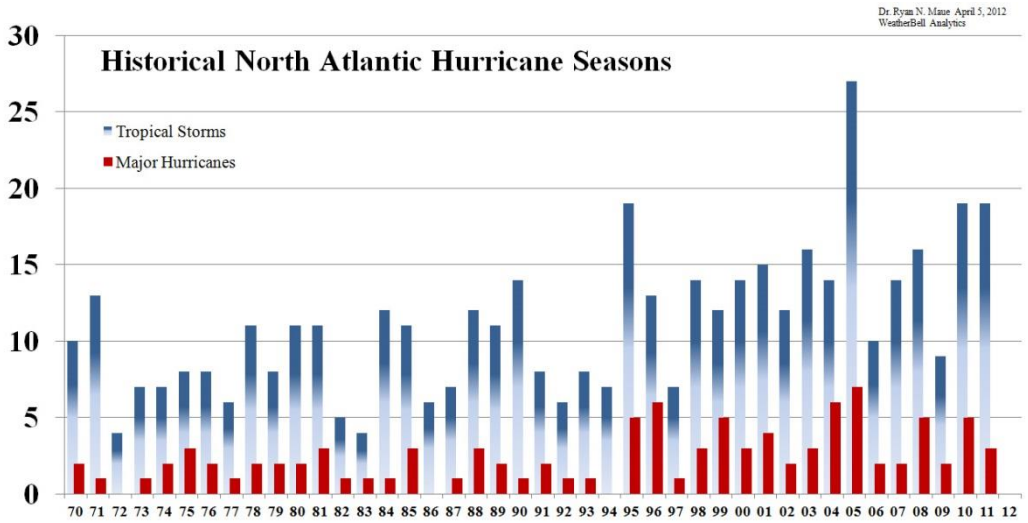
Reason for concern……

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

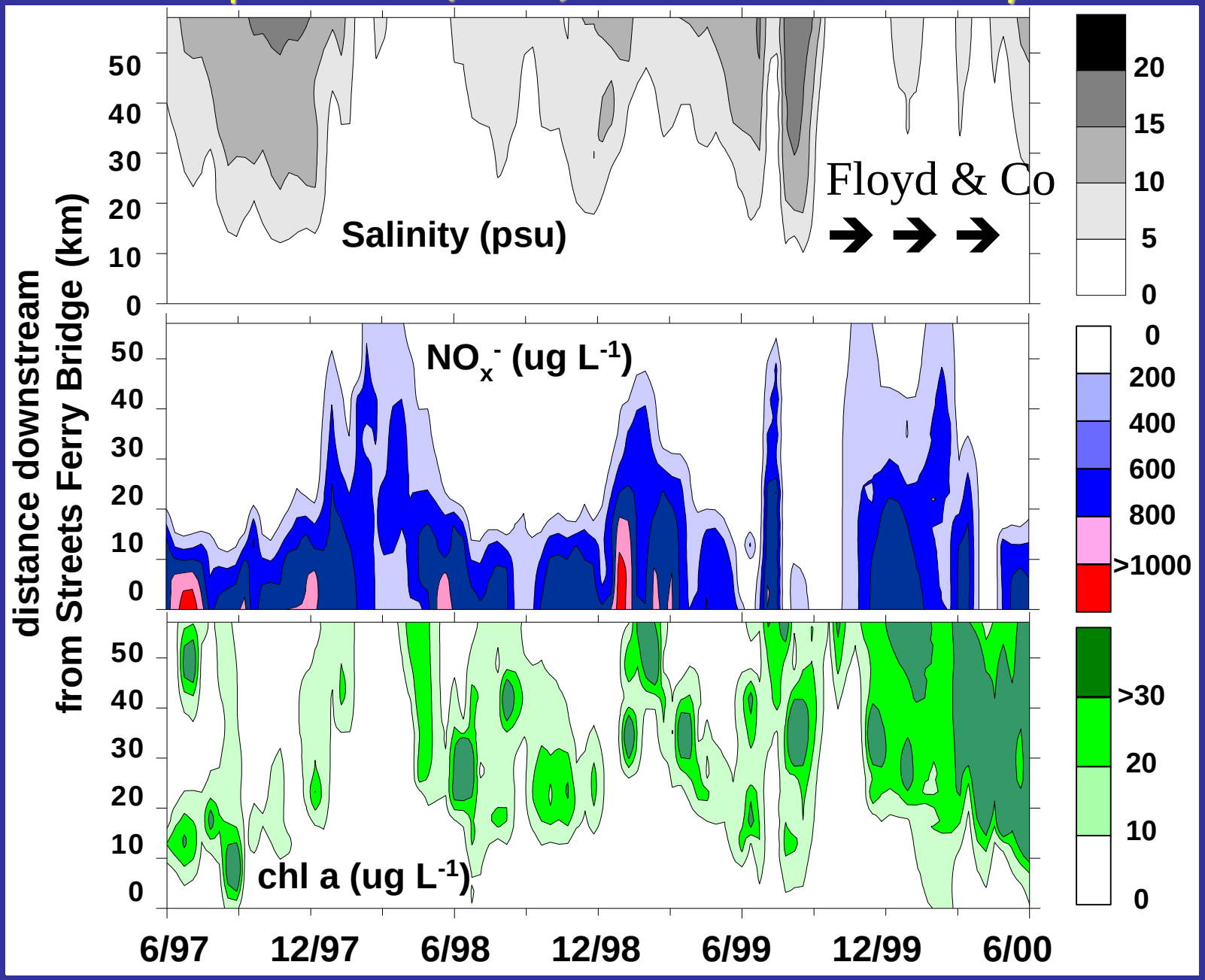
Emanuel 2005; Holland and Webster 2007



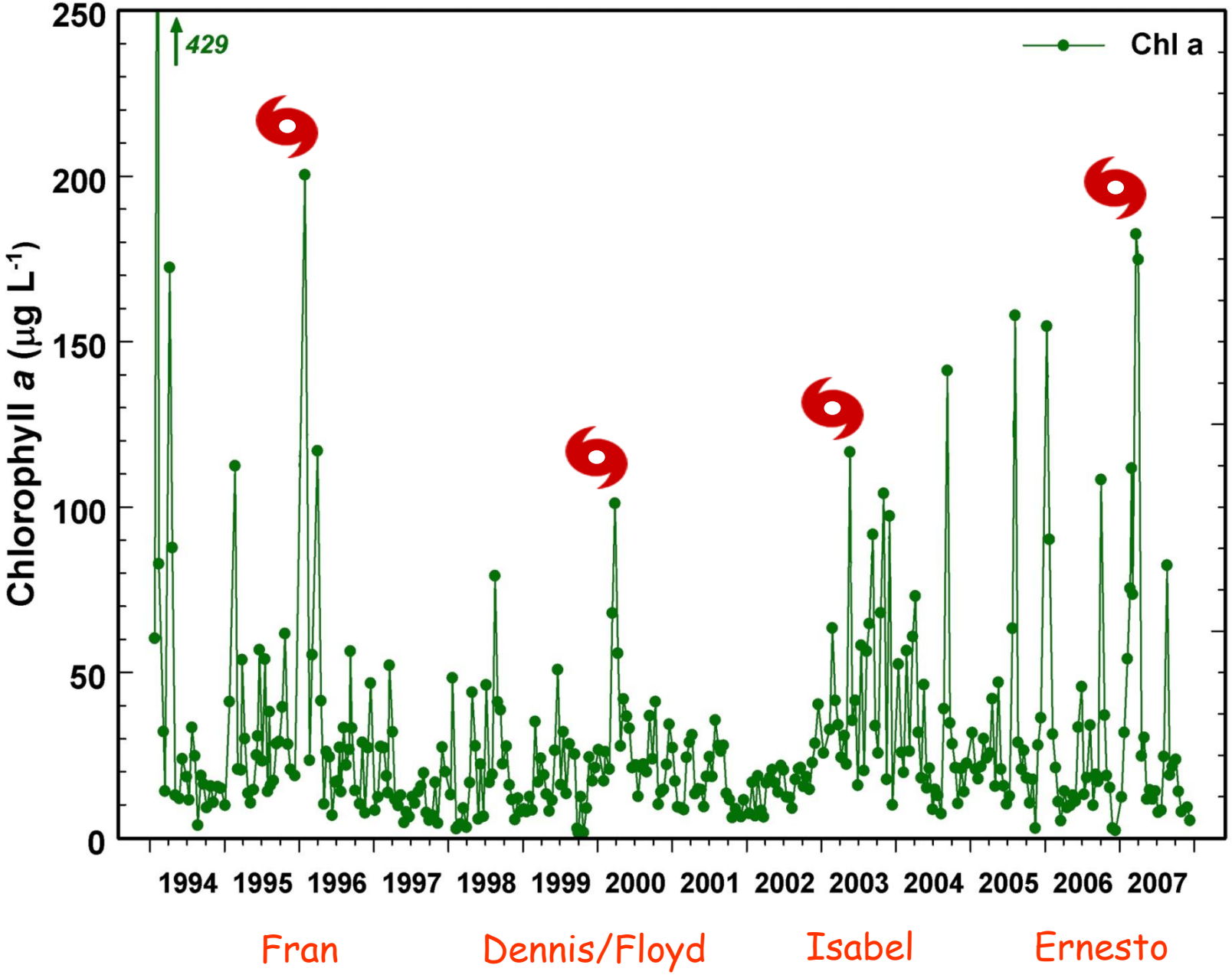
Source: NOAA, Natl. Hurricane Center



Effects of Hurricanes Floyd & Co (1999) on N inputs and algal production (Chl *a*) in the Neuse R. Estuary

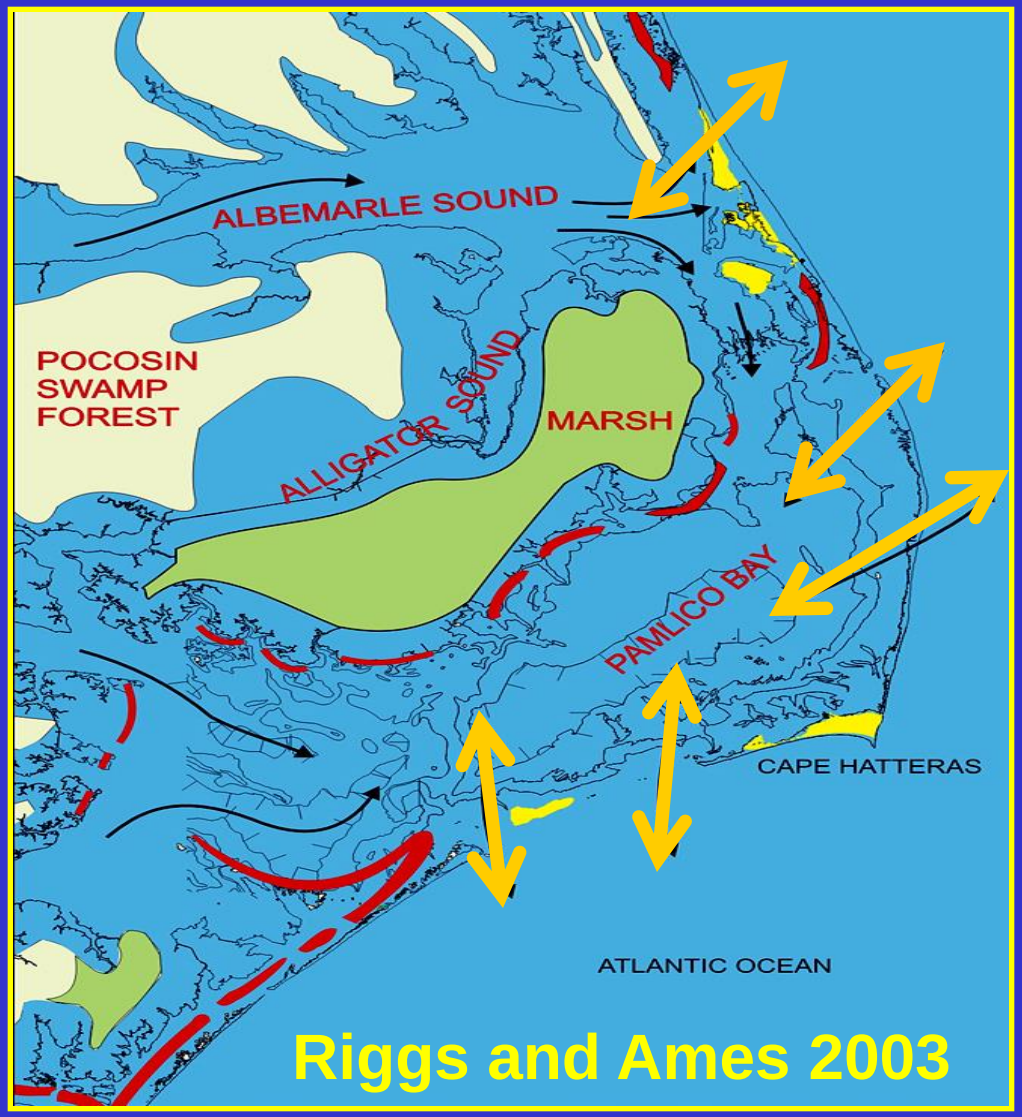


Major hurricanes/tropical storms & phytoplankton biomass (Chl *a*) responses

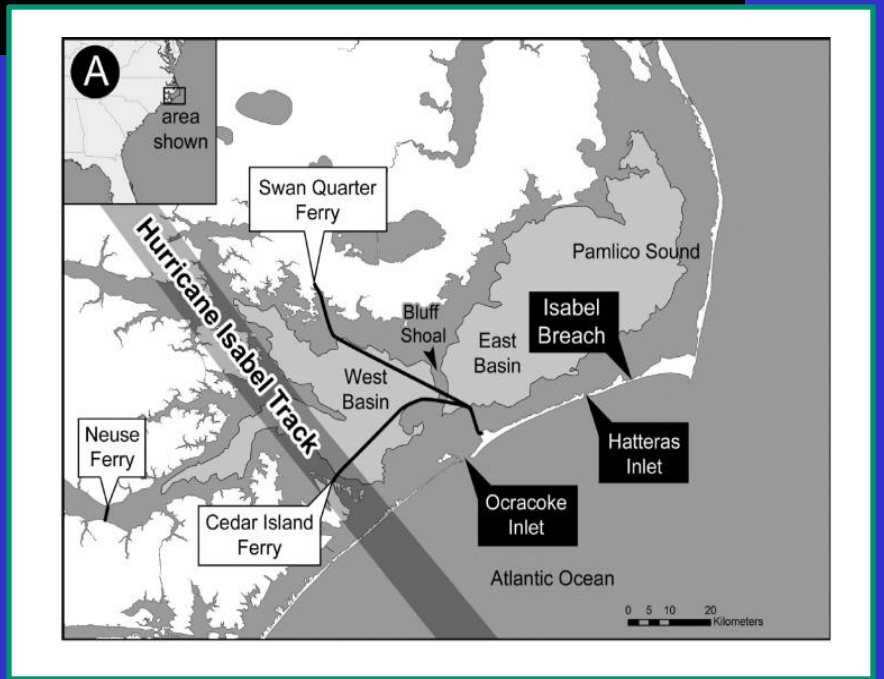


Increasing storms and sealevel rise: Assessing impacts on APES

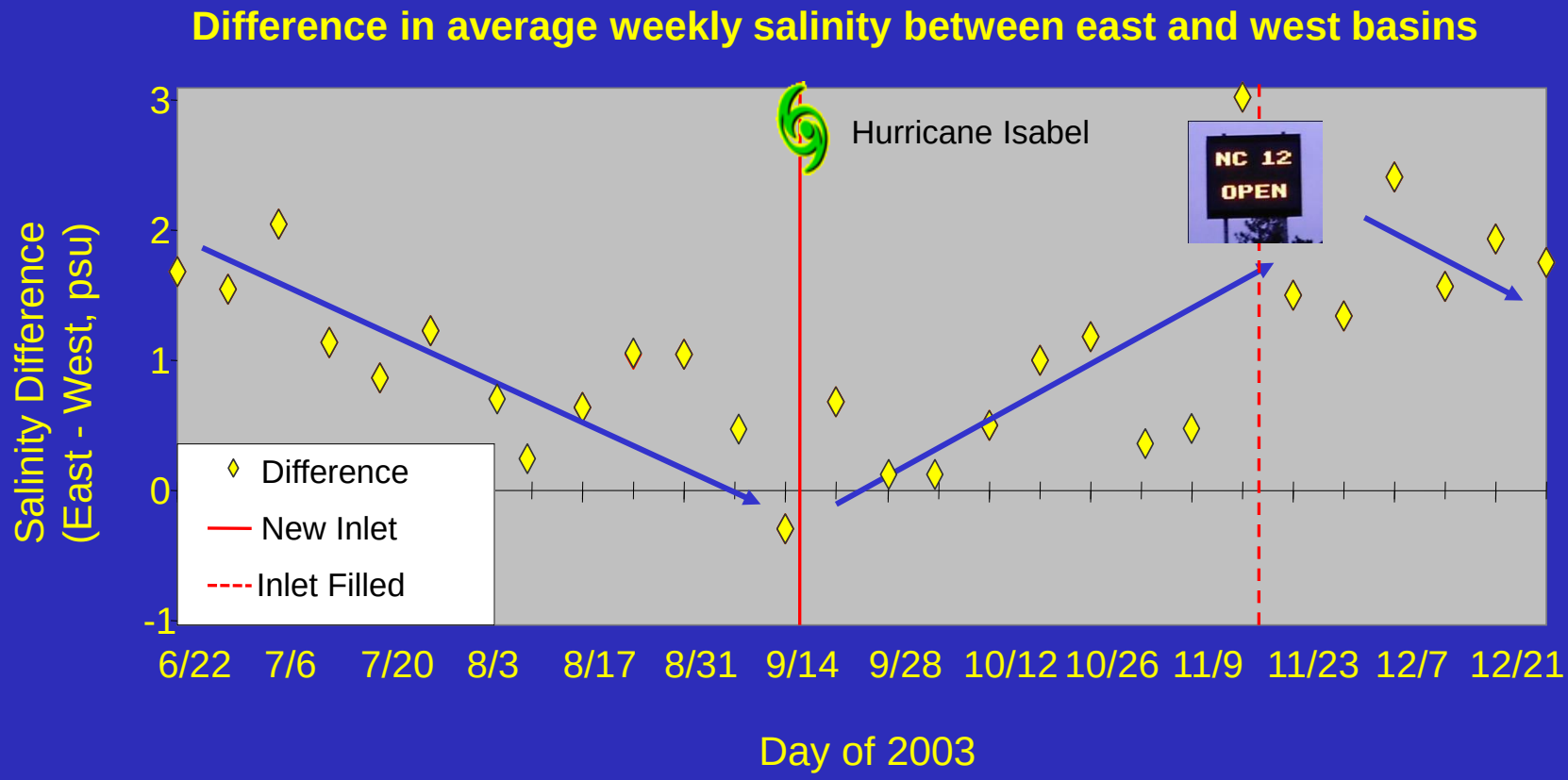
Now & Later?



A glimpse of a more “connected” Pamlico Sound



Salinity Patterns in Pamlico Sound Demonstrate Storm Driven Changes in Connectivity to Coastal Ocean



Paerl et al. 2009. Environ. Sci. Technol. 43:7609-7613.

How will sea level rise impact the Sound?

Changes in circulation, flushing, salinity regimes?

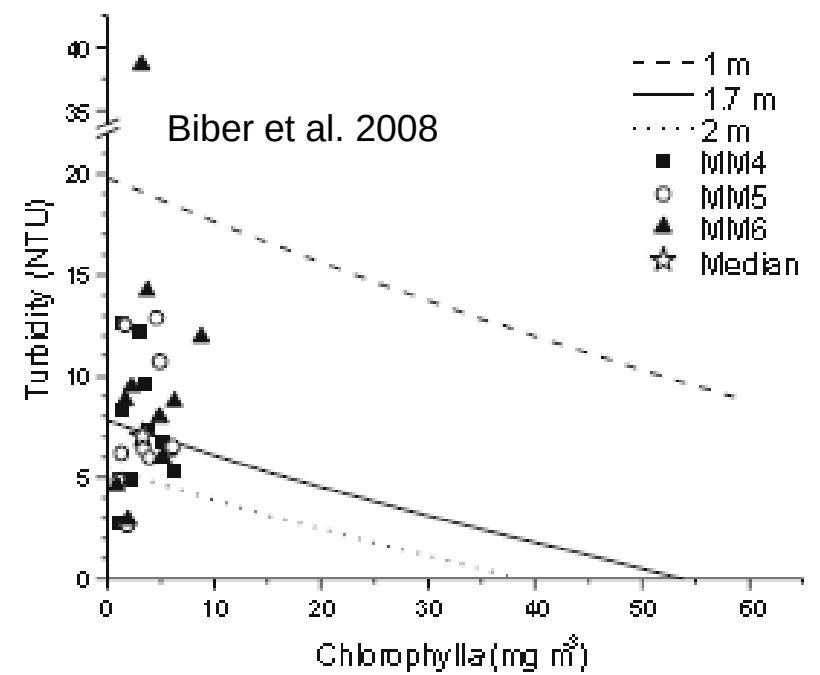
Water clarity?

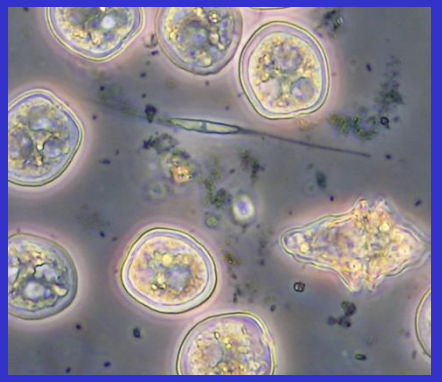
Changes in community structure?

FerryMon & ModMon provides data to detect & understand these changes & inform science based management.

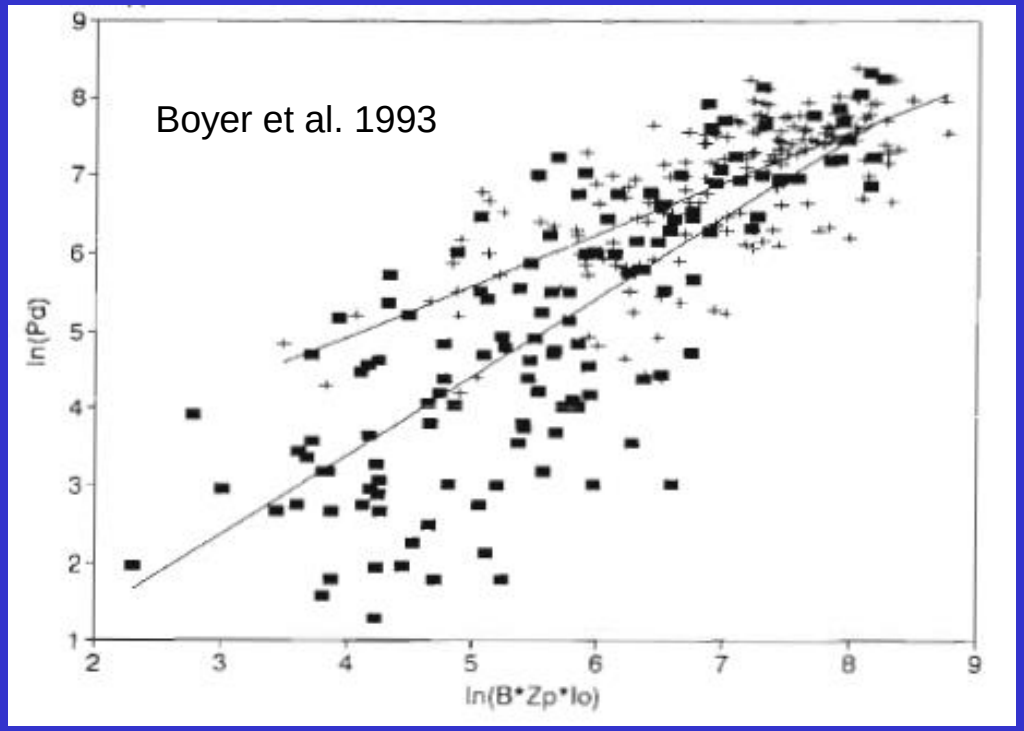
Water clarity:
Defining the structure of the base of the food web

Habitat suitability for sea grasses

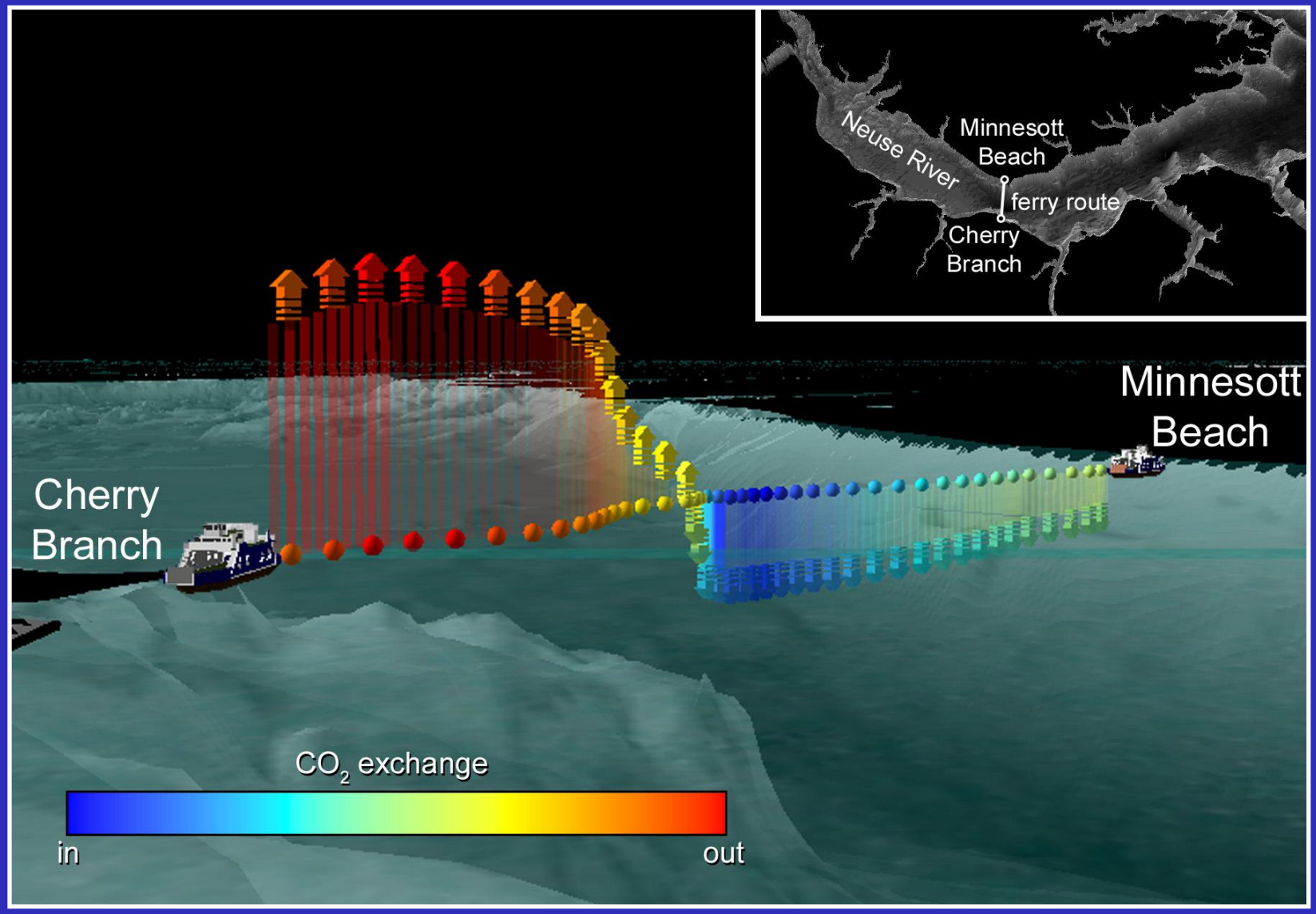




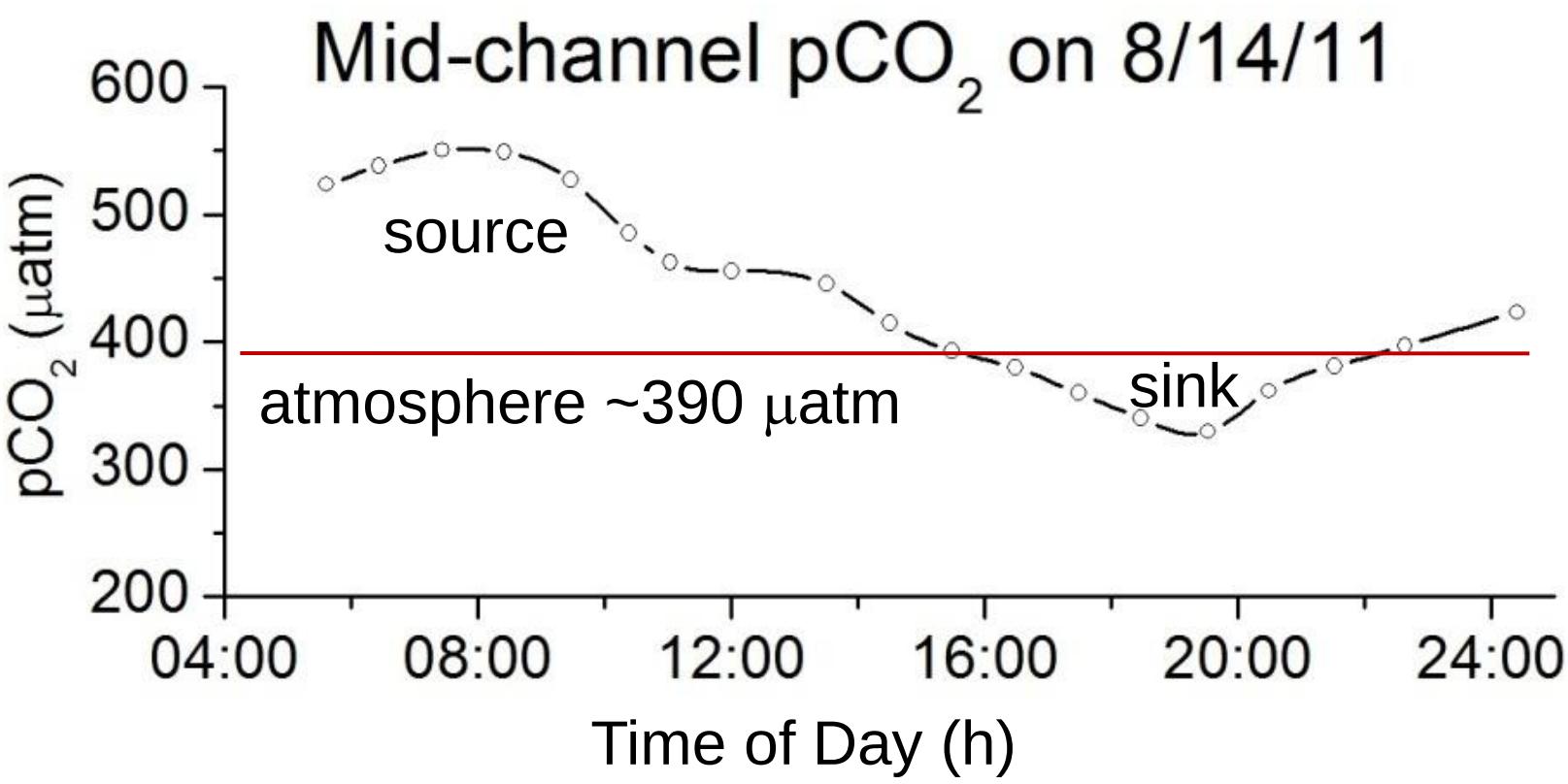
BZI models of phytoplankton production



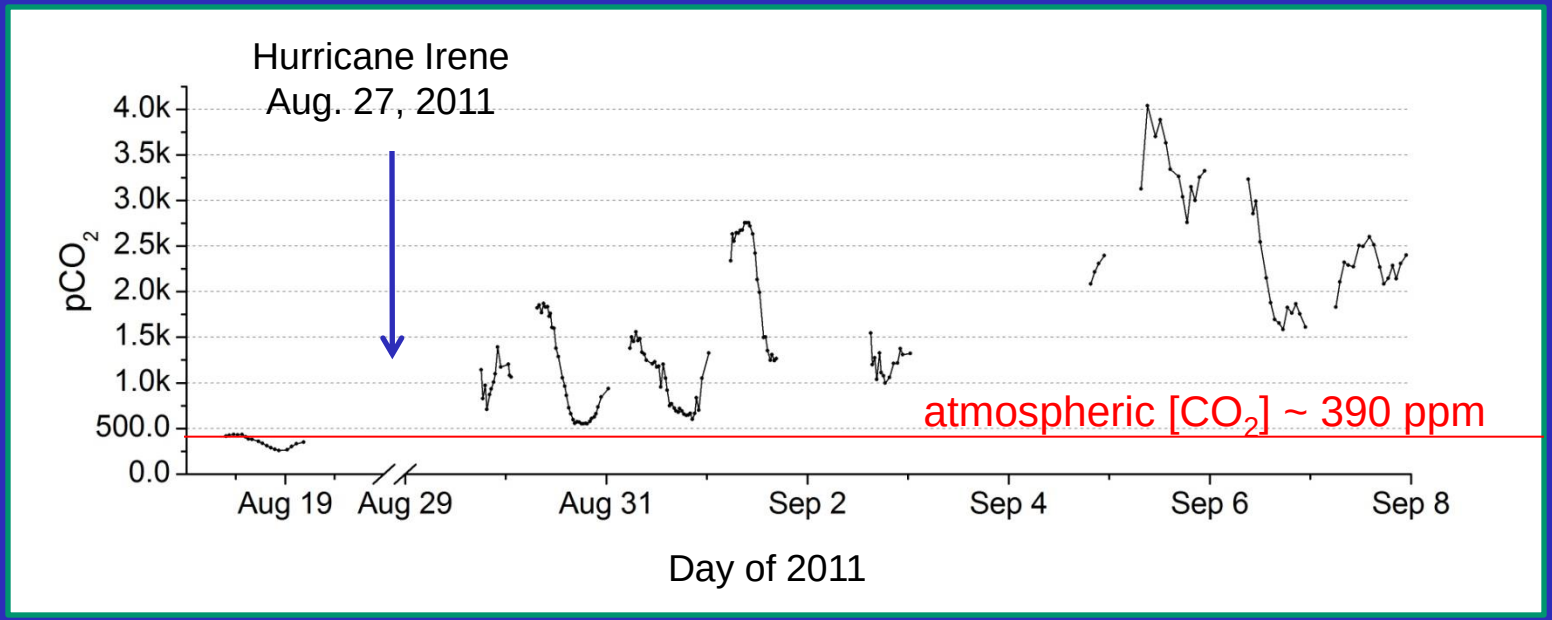
Assessing the role of APS in regional CO_2 dynamics

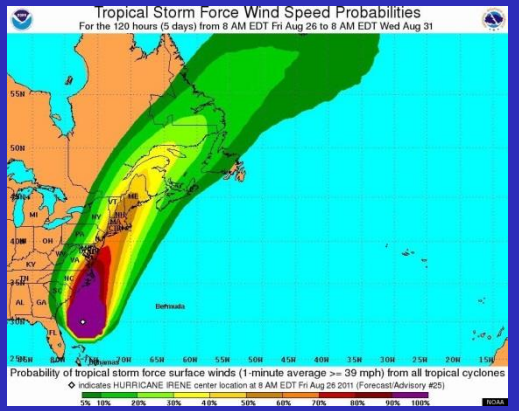


Influence of Phytoplankton Production / Respiration Diel Fluctuations in pCO_2 Revealed by FerryMon



Impact of Hurricane Irene on CO_2 Dynamics in the Neuse River Estuary





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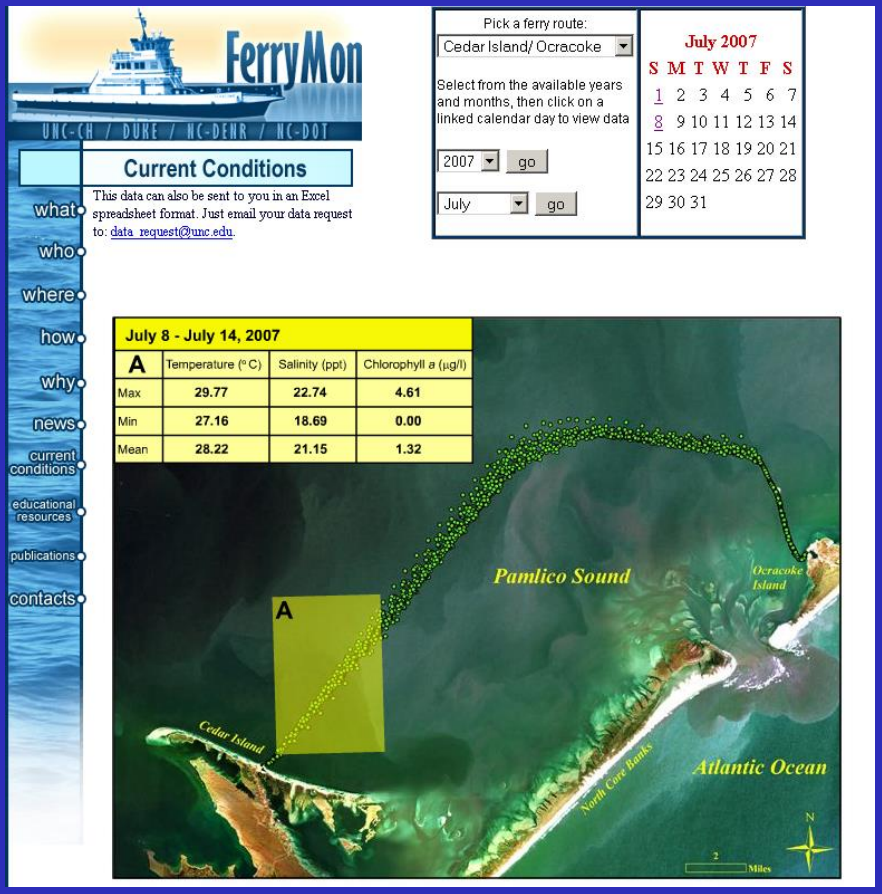
Outreach and Education



On the Web

Weekly Summaries

K-12 Lesson Plans

On the Ferries and websites

Educational Posters

Out and About

Museum Exhibits, PBS videos, etc.

Websites: www.ferrymon.org
www.unc.edu/ims/neuse/modmon/index.htm

Ecological Indicators as Management Tools in Response to Human and Climatic Change

This research is funded by
U.S. EPA - Science To Achieve Results (STAR) Program
Grant # 82667701

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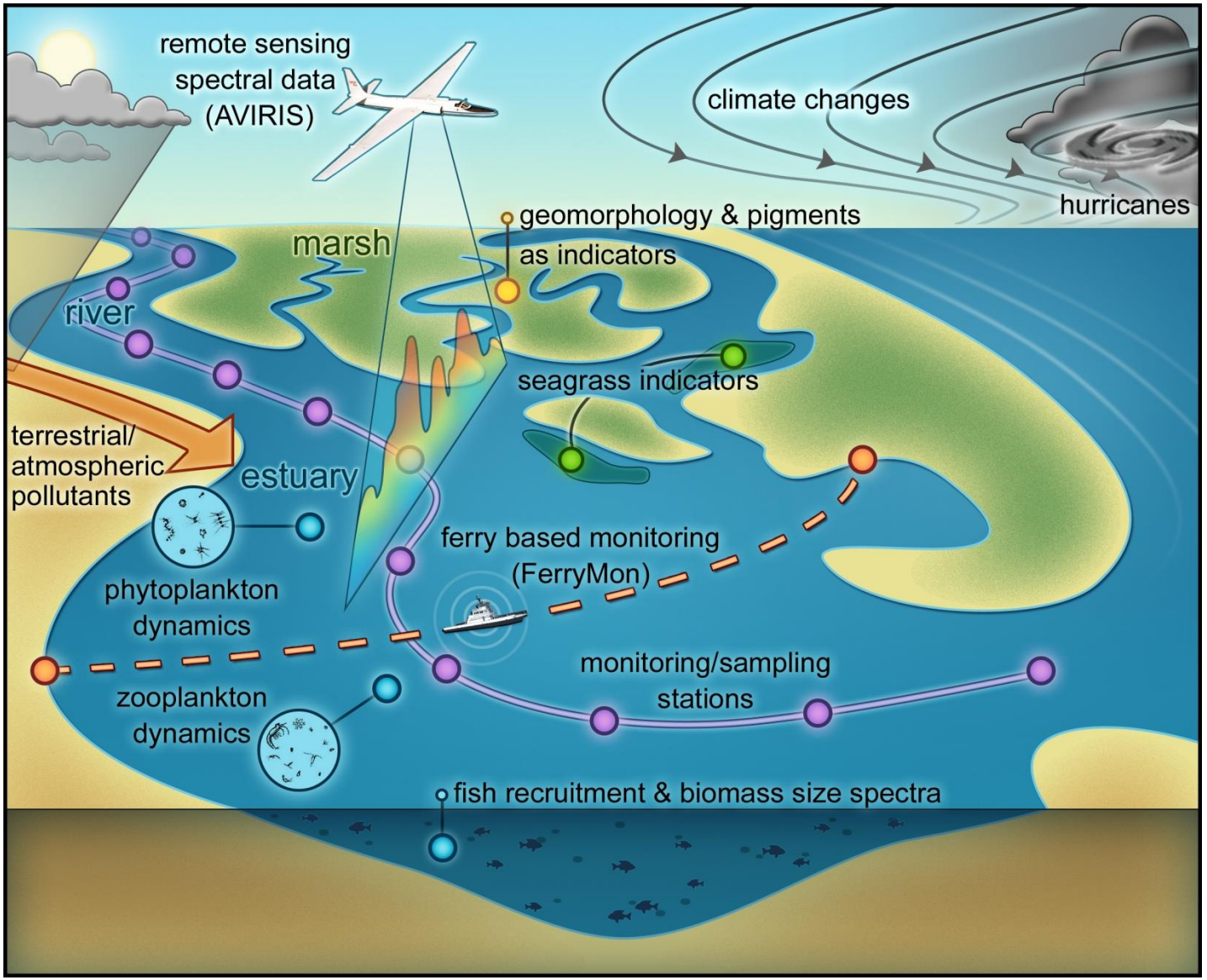
CRFL
Coastal Recreational Fishing License Reports, Plans, and Procedures



Special Thanks to:

Lower Neuse Basin Assoc./Neuse River Compliance Assn.

Water Resources Research Institute

NC Sea Grant

http://www.unc.edu/ims/paerllab/