Neuse Estuary Monitoring and Research Program

Center for Applied Aquatic Ecology, NCSU

www.waterquality.ncsu.edu

NC STATE UNIVERSITY

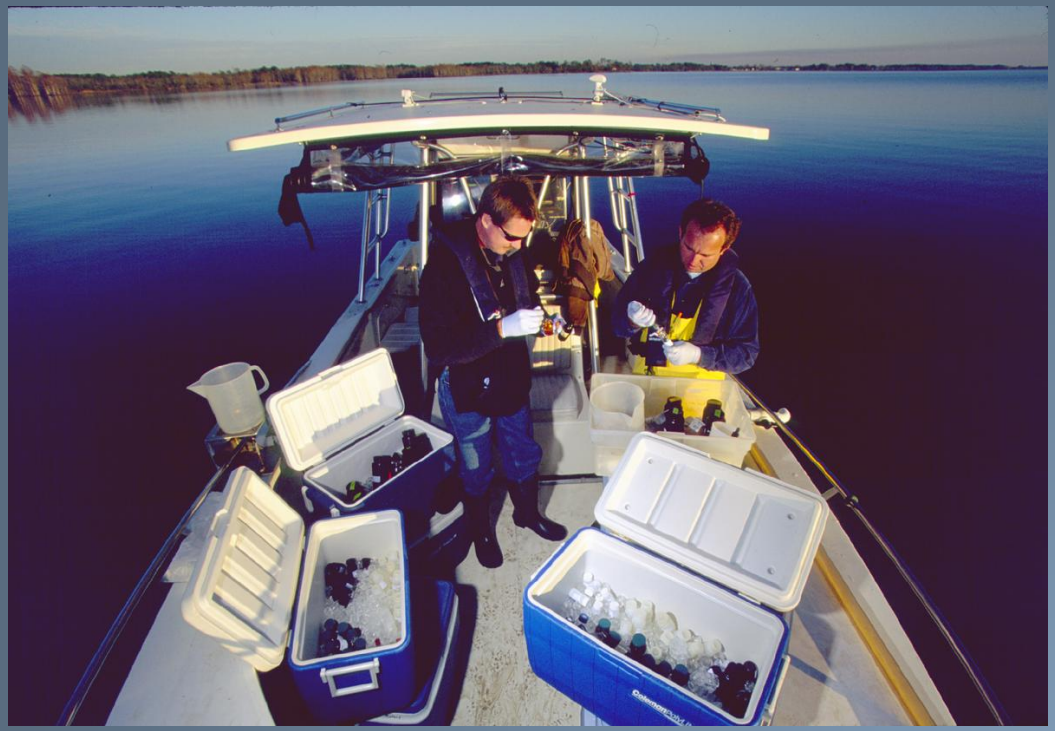
C A A E

More than 2/3 of coastal rivers and bays in the U.S. are moderately to severely degraded from cultural eutrophication. – Howarth et al. (2000)

- ***"Anthropogenic impacts on water quality are strong and the need for characterizing ambient conditions and temporal trends in these conditions is correspondingly urgent."*** **- Jassby et al. (1997)**

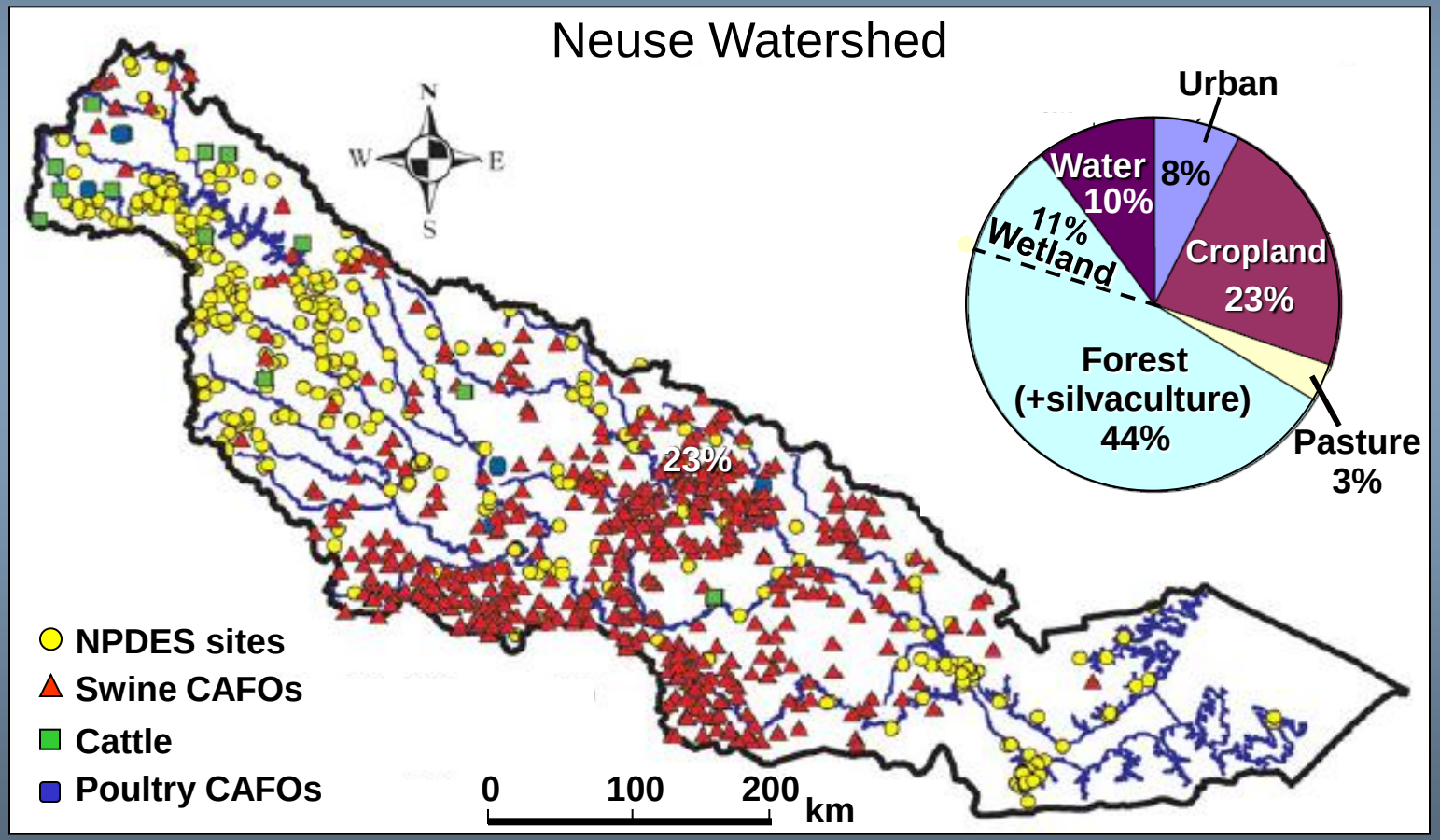
Program objective (ongoing)

Using a decadal+ dataset, characterize physical, chemical, biological trends in the Neuse Estuary



Thanks to: CAAE staff and students; statisticians D. Dickey, C. Brownie; collaborators in 16 agencies and academic institutions; funding from the NC General Assembly, EPA, private foundations

- **Inventoried and groundtruthed major sources of mammalian wastes (GIS); working to quantify sources of non-point pollutant loadings**



Watershed profile

Nutrient loading to the Neuse - past decade

- **Not well quantified –** non-point pollution from runoff (row crops, CAFOs), stormwater (impervious surfaces), industrial / residential lawn care; groundwater; atmospheric deposition (wet, dry).

- **~ 2 million people, ~ 2 million pigs**

Human population ↑ 16%
Swine population ↑ 285%
Urban land cover ↑ 110%
Synthetic fertilizers ↑ 150%

Improvements – Neuse watershed

- **P banned from domestic detergents (1985-).**
- **Biological nutrient removal (BNR) at some major WWTPs (also reduced bypassing of raw sewage during moderate-major storm events) (2000-).**
- **Buffers (~17 m [50 ft.] along certain streams, 2000-).**
- **Cropland farmers signed agreement to reduce their use of N fertilizer by 40% (2003).**

Methods

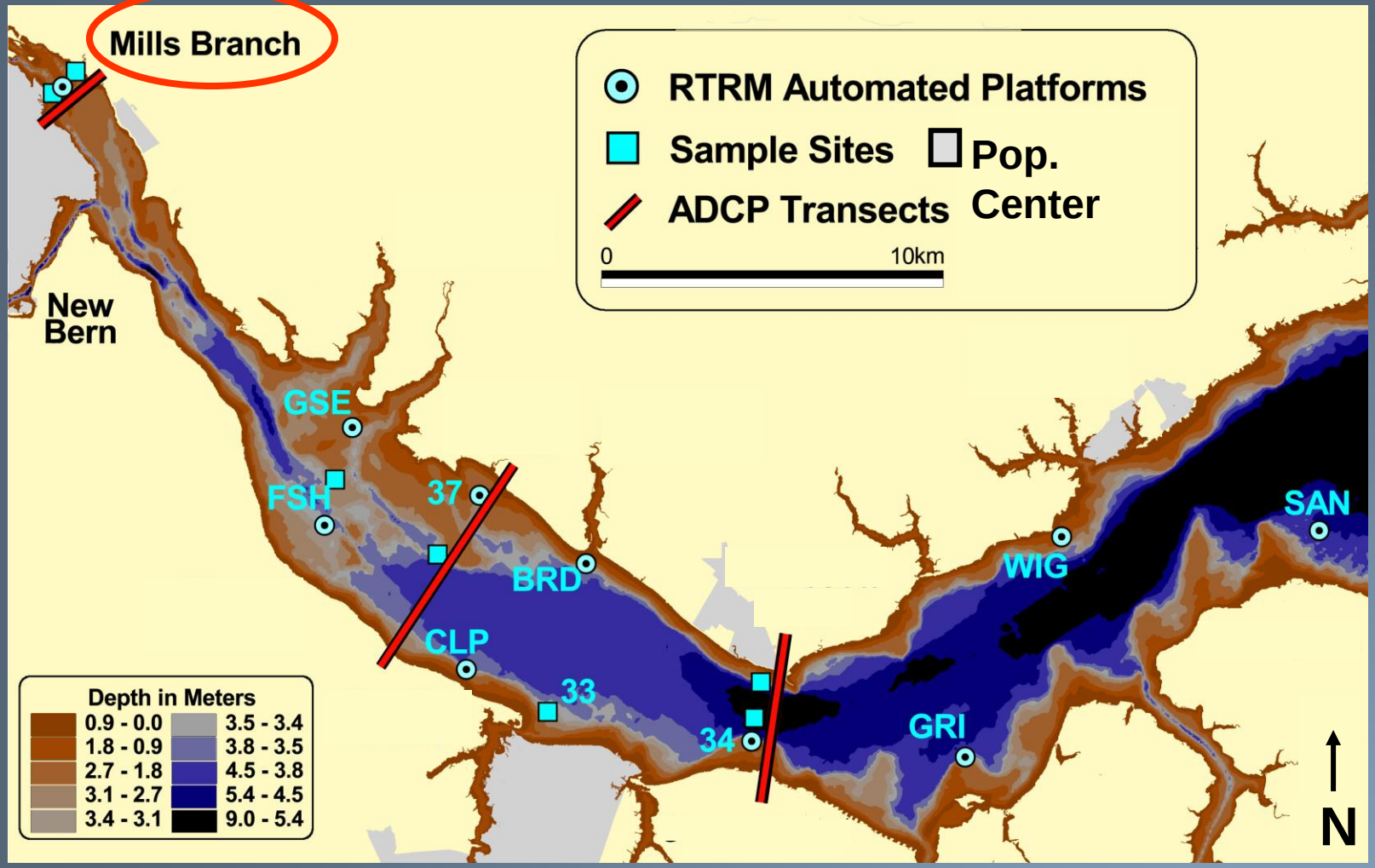
- **Collected water quality data (10 yr, ~40 variables**, weekly – biweekly April-Oct., monthly Nov.-March, more frequently during blooms, other events); also, **ADCP flow data**, augmented (past 4 yr) with RTRM platforms.

- **Calibrated time series models** (ARIMA; log-transformed data – then transformed back to the original units for graphs) to improve prediction of long-term trends in nutrient loadings.

- **Developed an ADCP-calibrated flow model** using a delivery gate at entrance of estuary, Mills Branch (previous models estimated flow from ~70 km upstream).

- **Developed a univariate model for dissolved oxygen** to evaluate long-term trends over time.

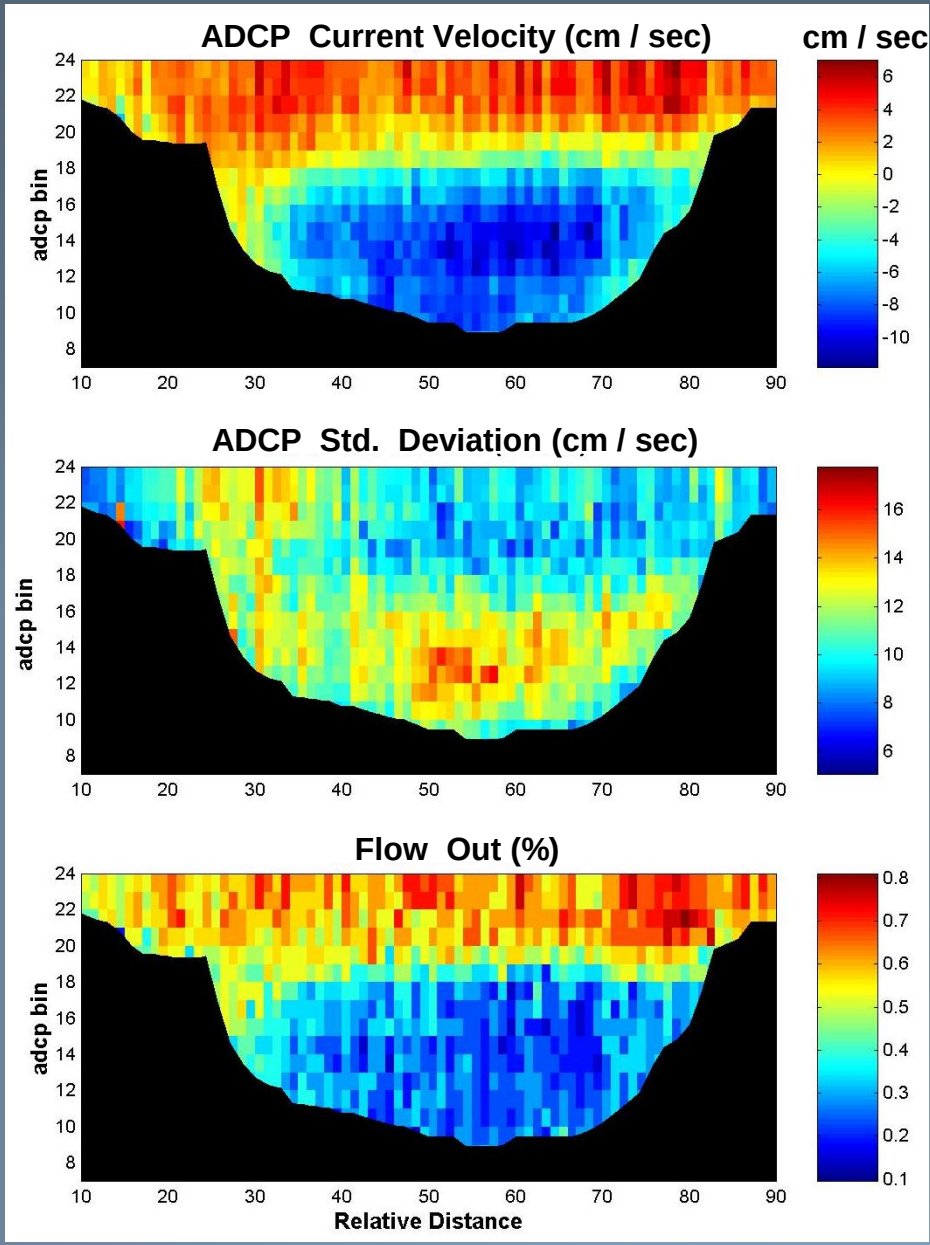
Neuse Estuary study area - CAAE



Most detailed data set on the Neuse Estuary for the past decade.

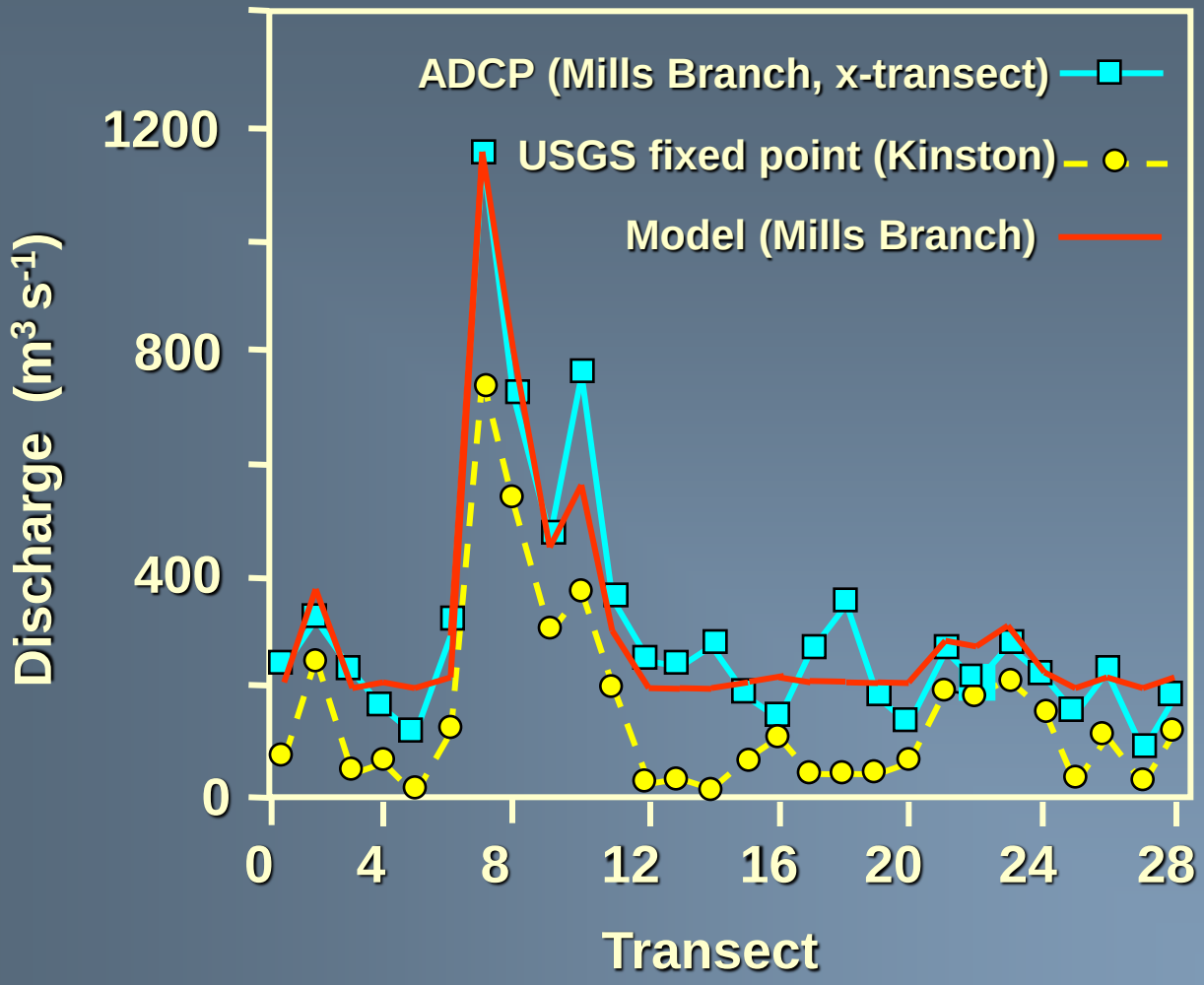
Mass Water Transport

Cross-transect ADCP detailed data set –included bottom-tracking capability for accurate bathymetry



Reed et al. (2004), *Estuarine and Coastal Shelf Science*

Modeled mass water transport, vs. measurements



Historical approach underestimates mass water transport (Mills Branch = better gate).

Burkholder et al. (2004), *Proceedings of the National Academy of Sciences*

CAAE's Remote Data Acquisition Platforms (1999-)

- **Meteorological measurements – wind speed / direction**, air temp., rel. humidity, barometric pressure, incident solar radiation, precip.

- **Hydrological measurements** – water level, water temp., salinity, DO, redox, pH, turbidity.

- **Discrete water samples** (ISCO sampler; short / long intervals); e.g, > 204,000 nutrient samples analyzed.

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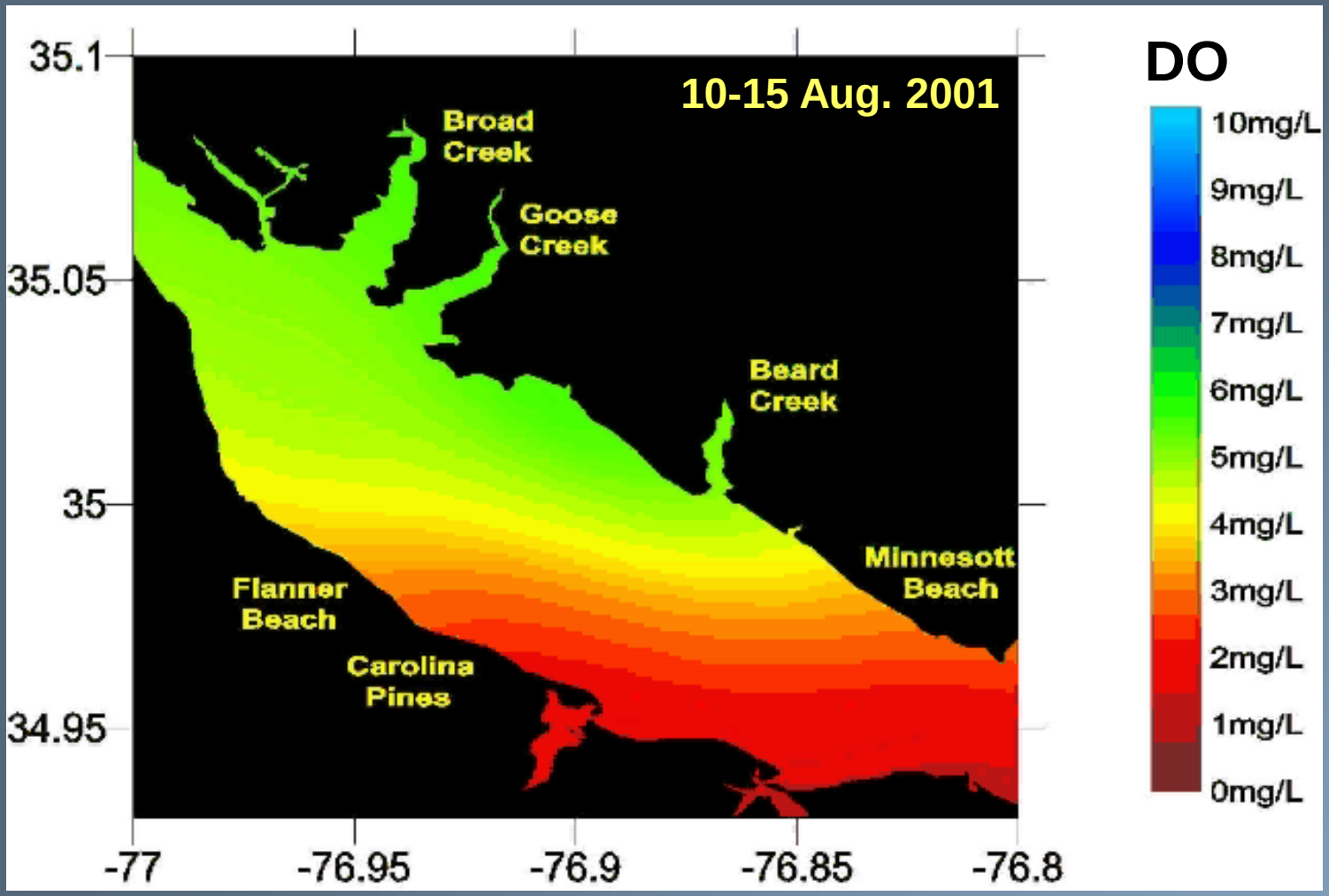
Glasgow et al. 2004 – *J. Exp. Mar. Biol. Ecol.*

Dissolved oxygen (example)



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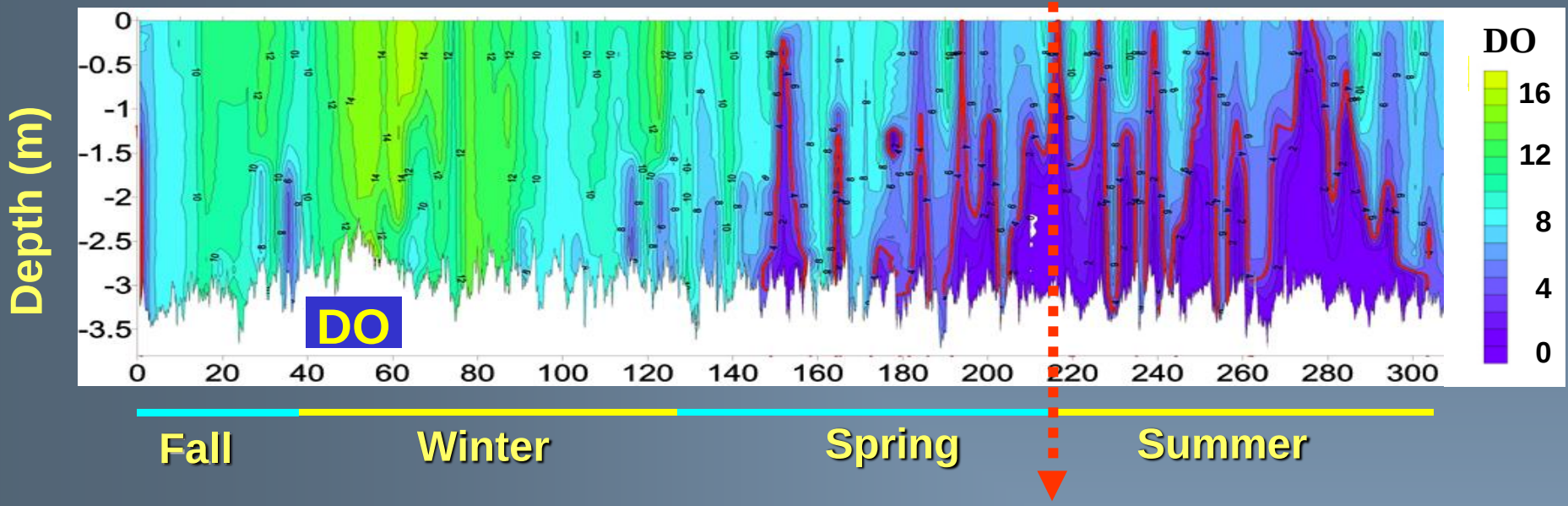
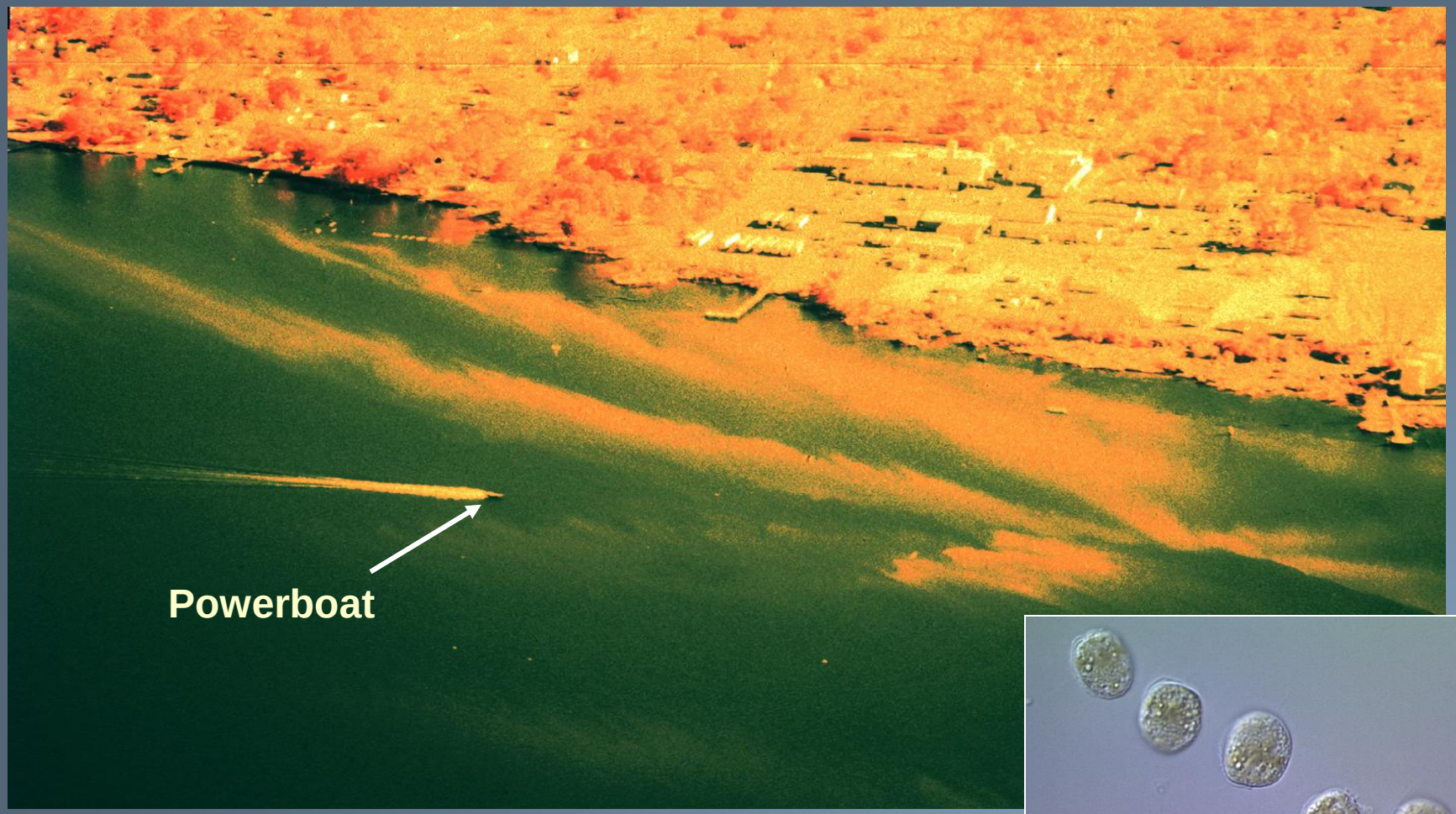
Profiler Record for DO (Carolina Pines, ~2,400 casts)



Glasgow et al. (2004), *J. Exp. Mar. Biol. Ecol.*)

More intensive bloom sampling

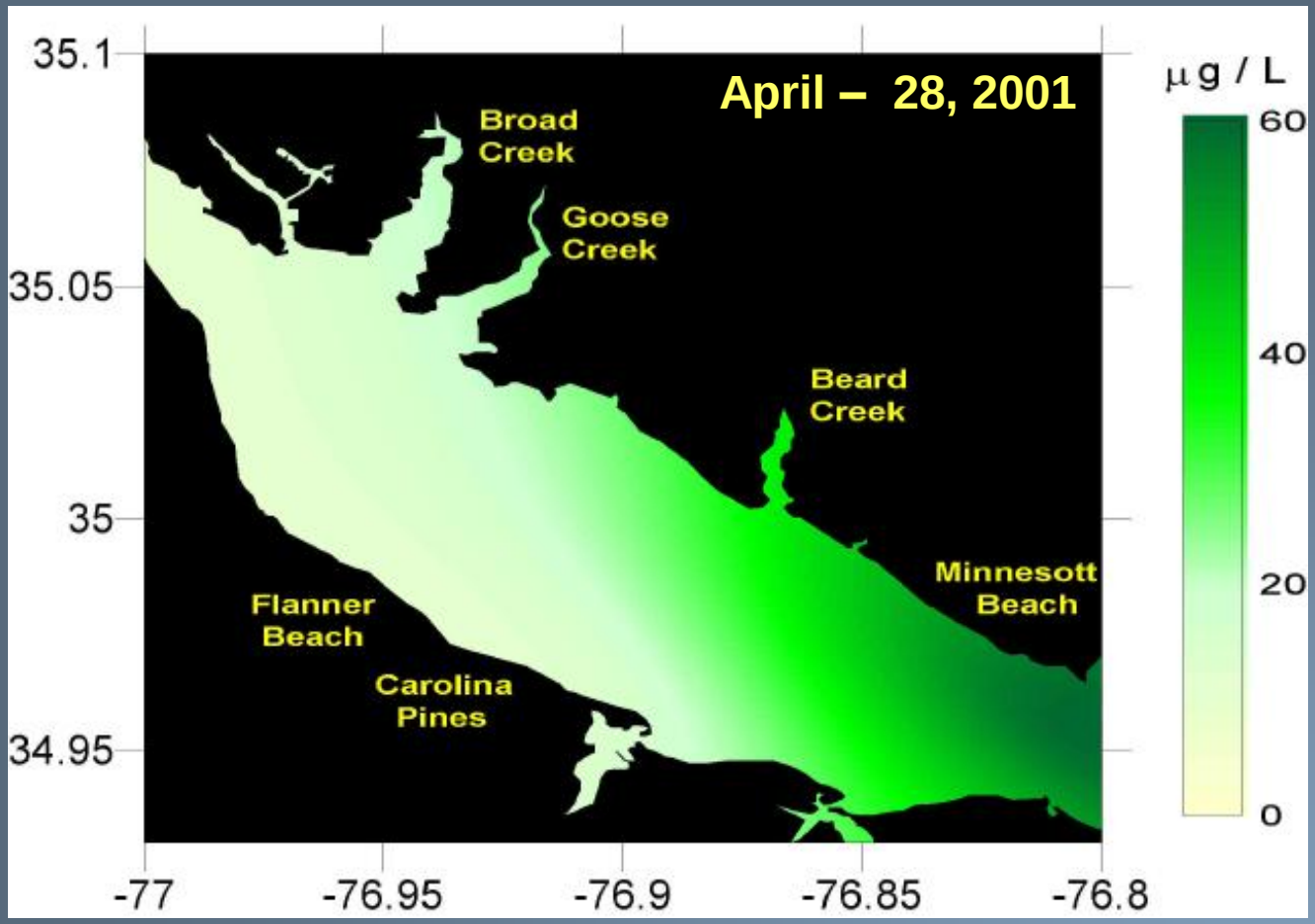
Neuse dinoflagellate bloom (*Prorocentrum minimum*) near south shore at Mills Branch, Dec. 2000



Color infrared photograph

Springer et al. 2004, *Harmful Algae*

Phytoplankton chlorophyll *a*



Springer et al. (2004), *Harmful Algae*

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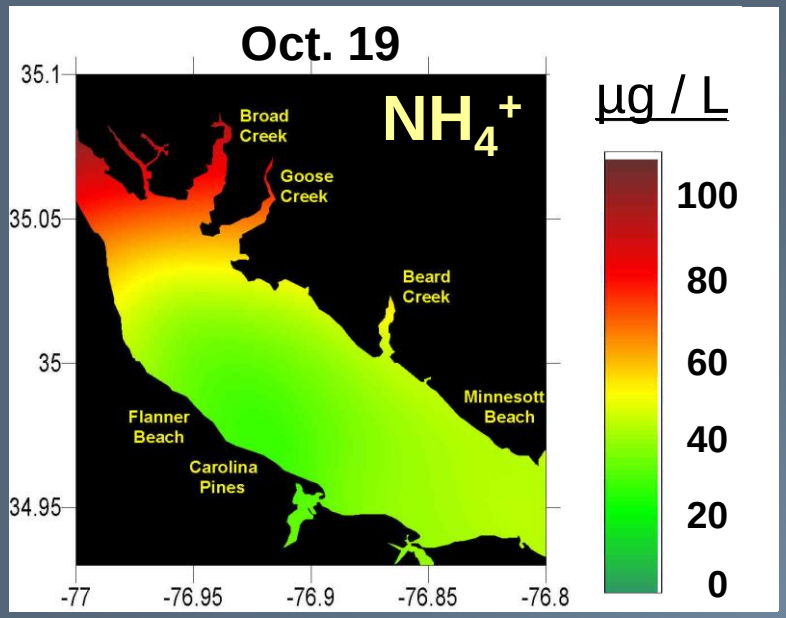
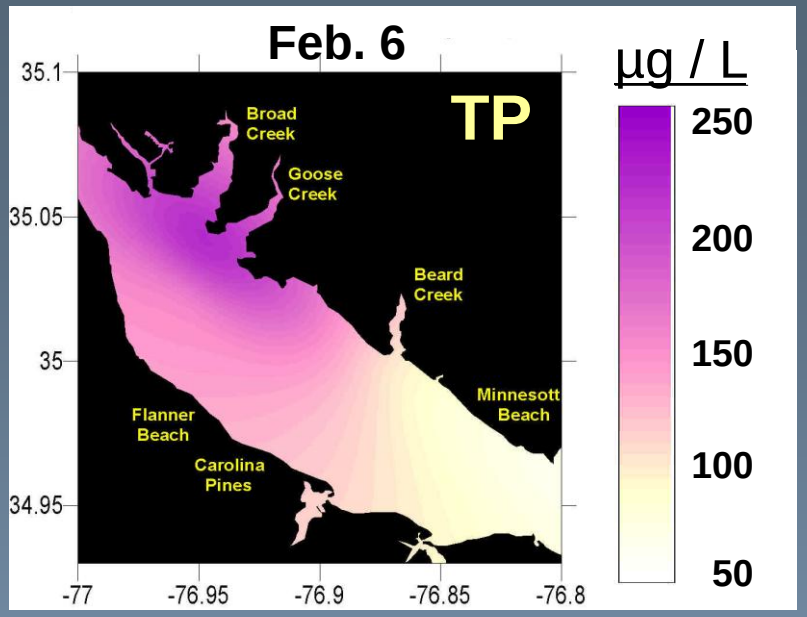
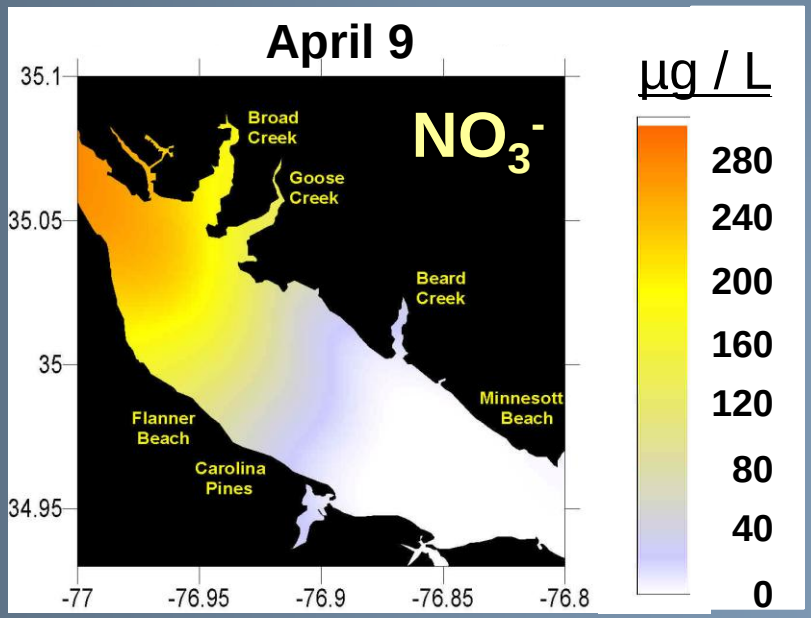
Related to nutrient pulses

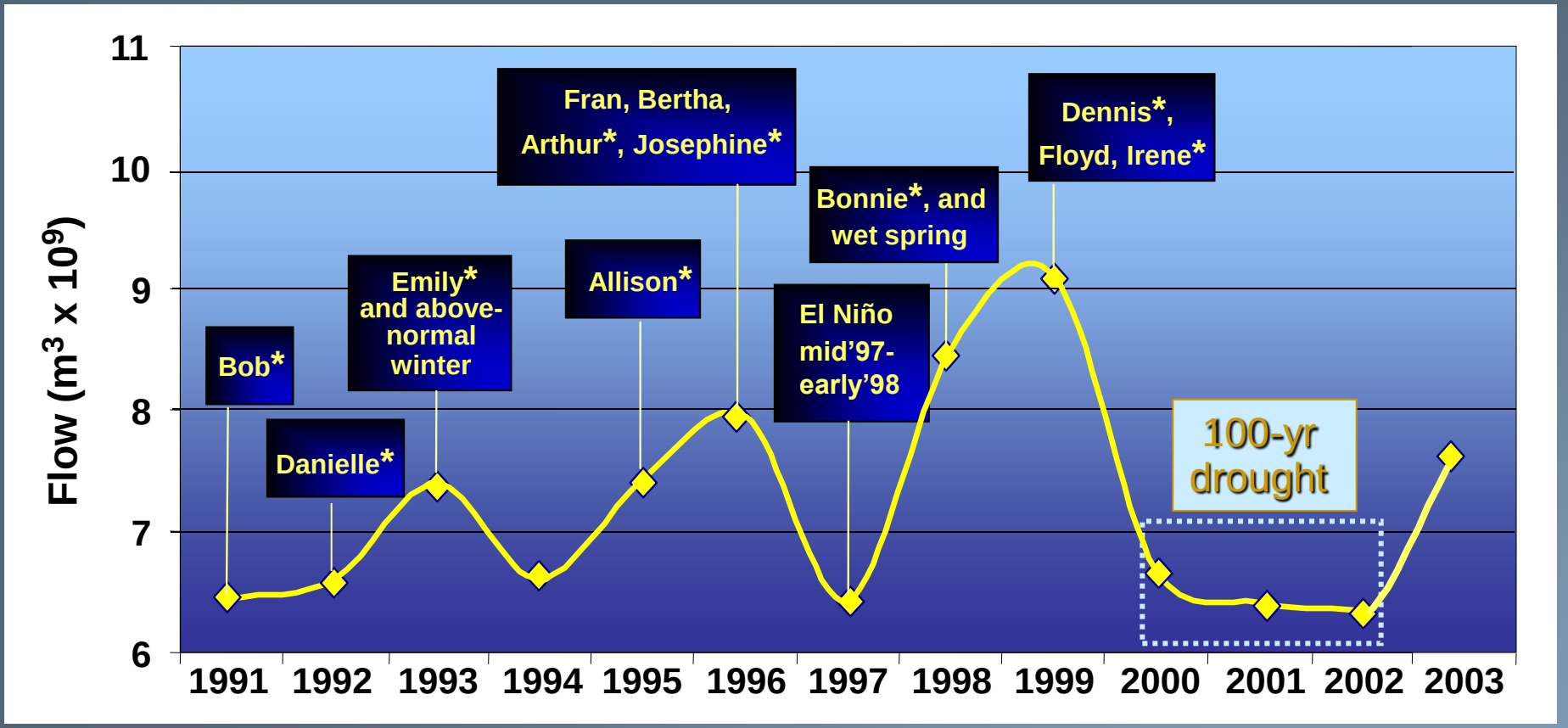






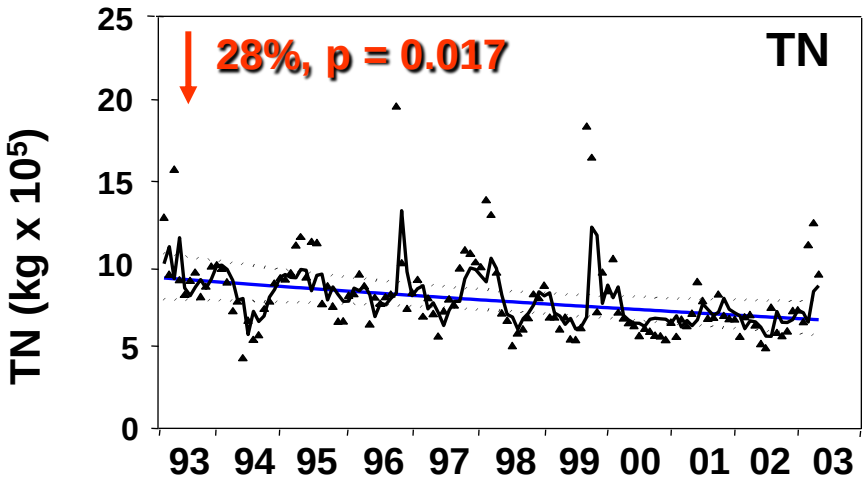
Springer et al. (2004),
Harmful Algae

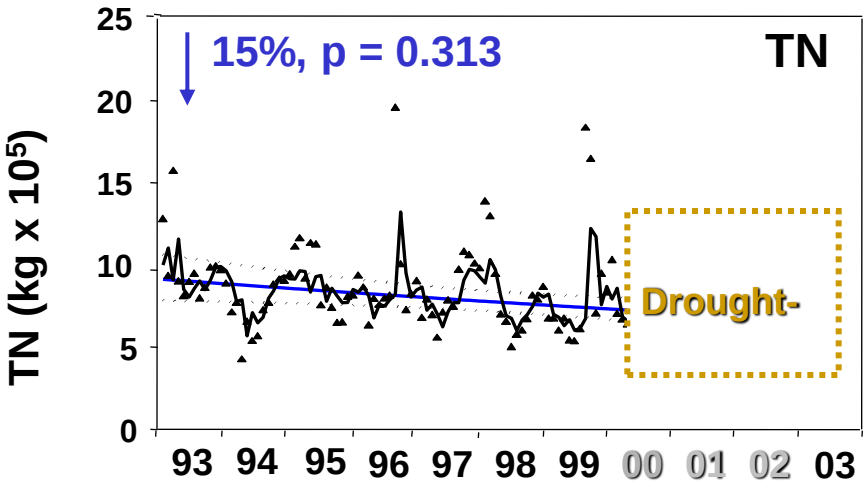
Annual Water Delivery Volumes at Mills Branch



Burkholder et al. (2004), Proceedings of the National Academy of Sciences

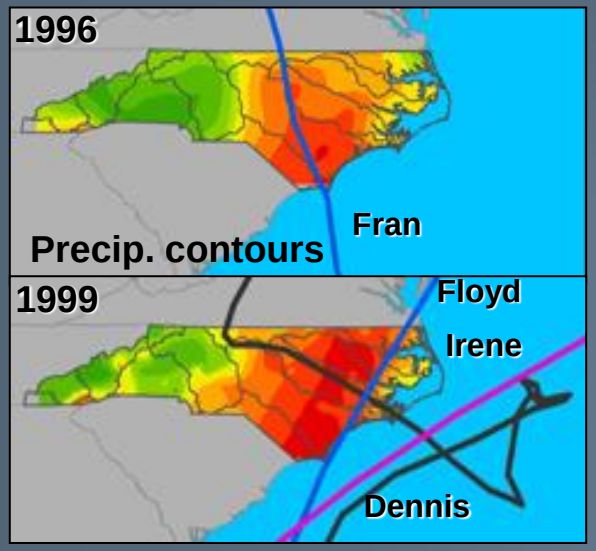
TN loading – Neuse Estuary

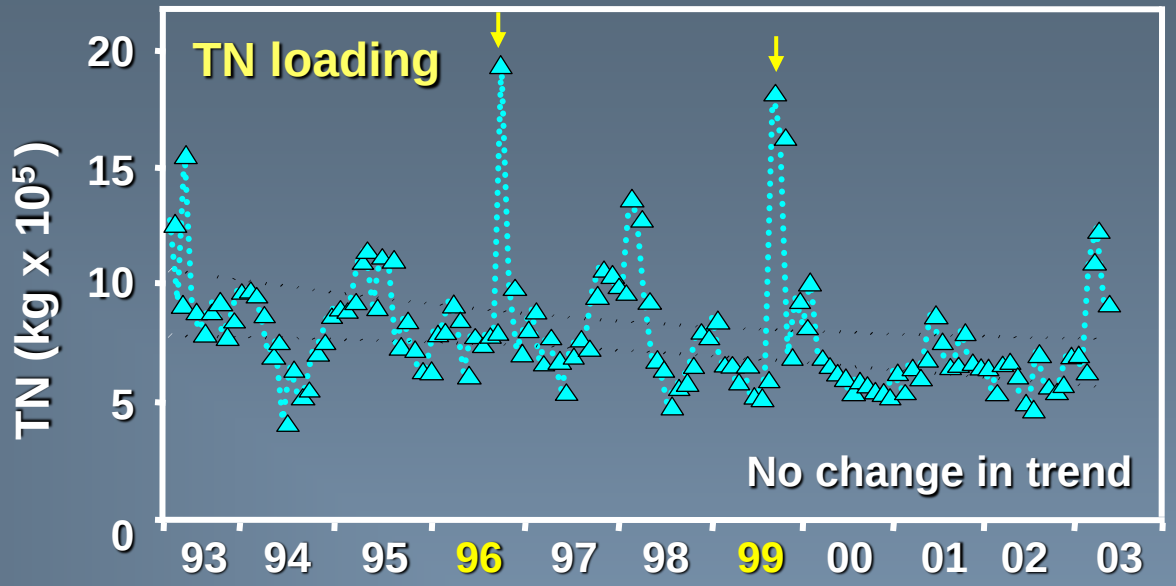




- Parametric PROC ARIMA, non-parametric Seasonal Kendall Tau models agreed: **Significant decrease** (~**28%**) in TN loading. **However**, drought years drove the trend.

TN loading estimates (Neuse Estuary)

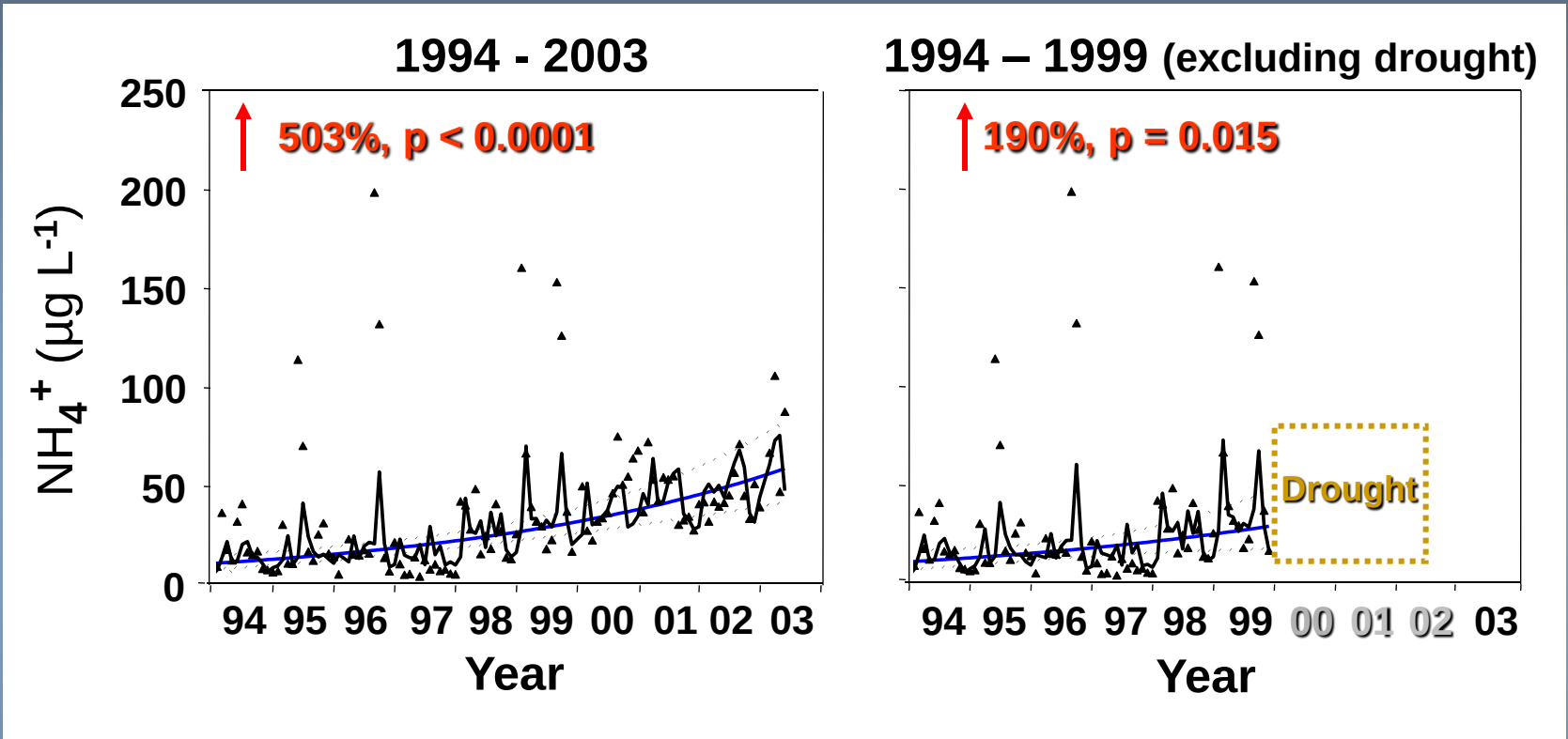




- PROC ARIMA (parametric), Seasonal Kendall Tau (non-parametric) trend analyses: trends (± drought) were not affected by the hurricanes.

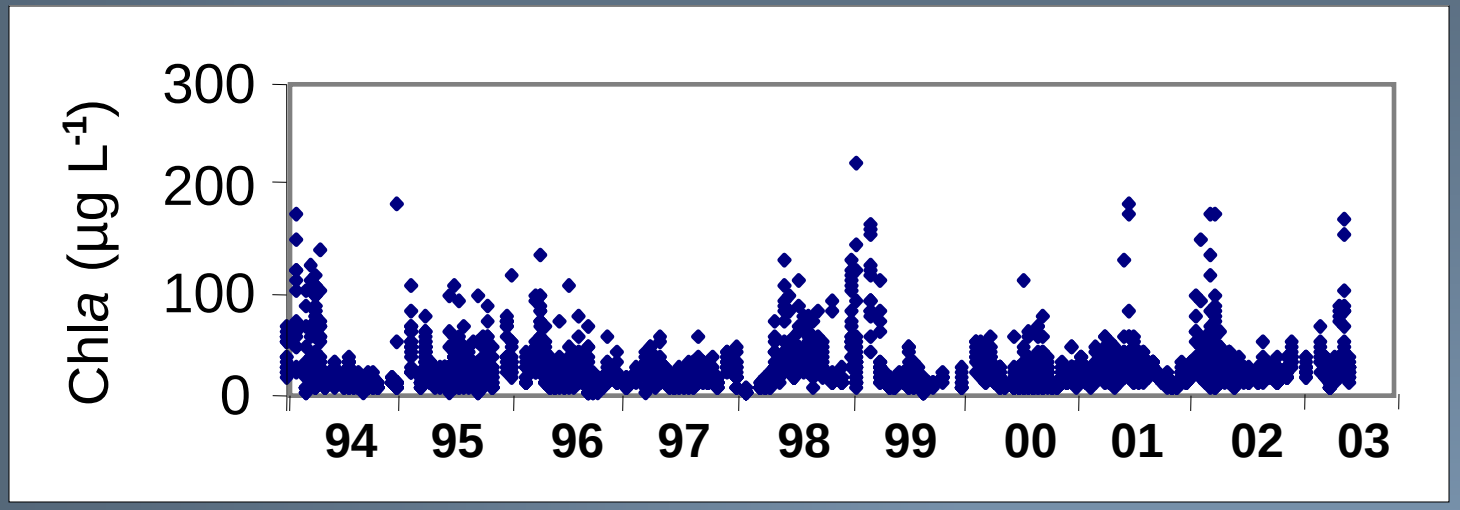
- No significant change in TN loading over the past decade – "running to stand still".

NH_4^+ concentrations - Neuse Estuary



➢ **~200 – 500% increase** (significant, with or without the sustained drought). Potential drivers: changes in land use and waste inputs, regeneration etc. [NO_3^- concs. increased 120%, but not significant].

Chlorophyll *a* – Neuse Estuary (1994 – 2003)



- No significant trend for all stations considered collectively, but significant increases (up 60%) at some stations.

Summary (Neuse, 1993 – 2003)

- **TN loading ↓ 28% (significant; but drought-related [2000-2002]. Loading is again increasing). TN trend highly sensitive to $T_{initial}$ (no change from 1994-). No change in TP loading ± drought.**

- **NH_4^+ concentrations ↑ 200 – 500%; significant ± drought.**

- **Chl*a* ↑ in localized areas, but no change overall.**

From analysis of this decadal database

- Drought-related TN loading decrease (loading again increasing.

- Highly significant increase in NH_4^+ concentrations, related to non-point sources. Improved treatment of some major point sources (sewage);

Overall, these analyses point to the need to control additional non-point sources, as in many estuaries throughout the world.

Ongoing and Future Plans – Neuse Monitoring and Research Program (CAAE and partners)

- Assess factors controlling harmful algal blooms (meteorology, nutrient fluxes, grazing);
- Improve quantification of nutrient loading, and examine the role of non-point sources on algal blooms (RTRM);
- Finish validating the U.S. EPA EFDC/WASP models to improve prediction of phytoplankton chlorophyll, harmful algal blooms.

Ongoing and Future Plans (CAAE and partners)

- Environmental education outreach (various secondary schools, high schools, colleges)

Floating Classroom Program – *RV Humphries*