Modeling Algal Dynamics in the Tidal Fresh Potomac River

Metropolitan Washington Council of Governments

Washington, DC
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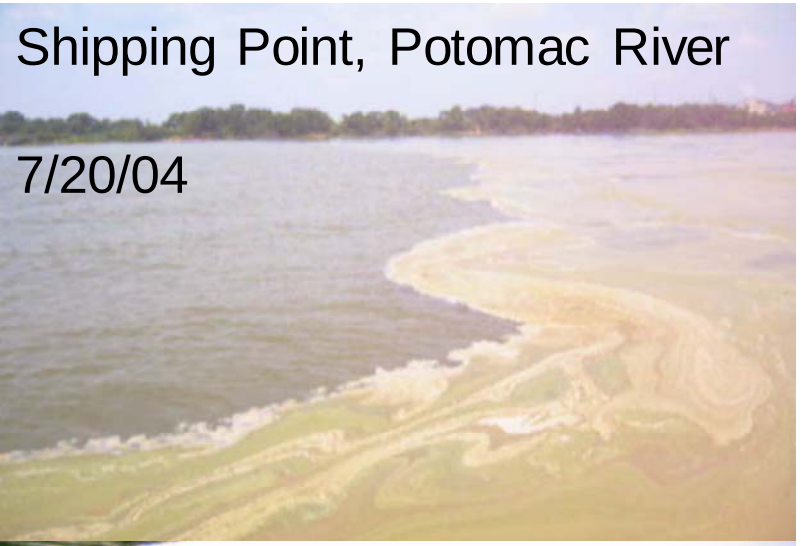
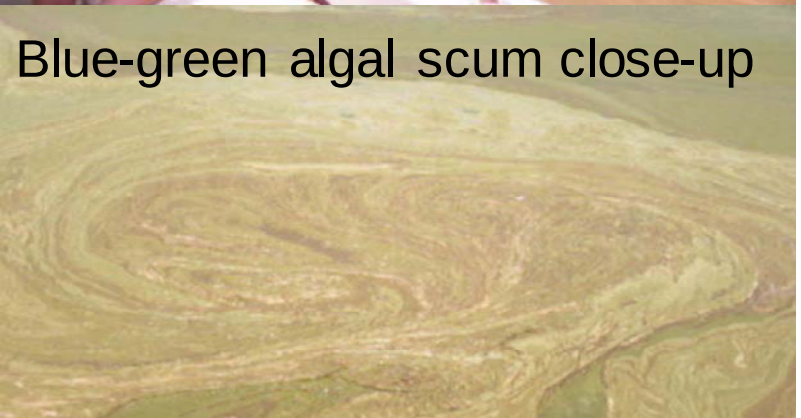
Potomac River Estuary

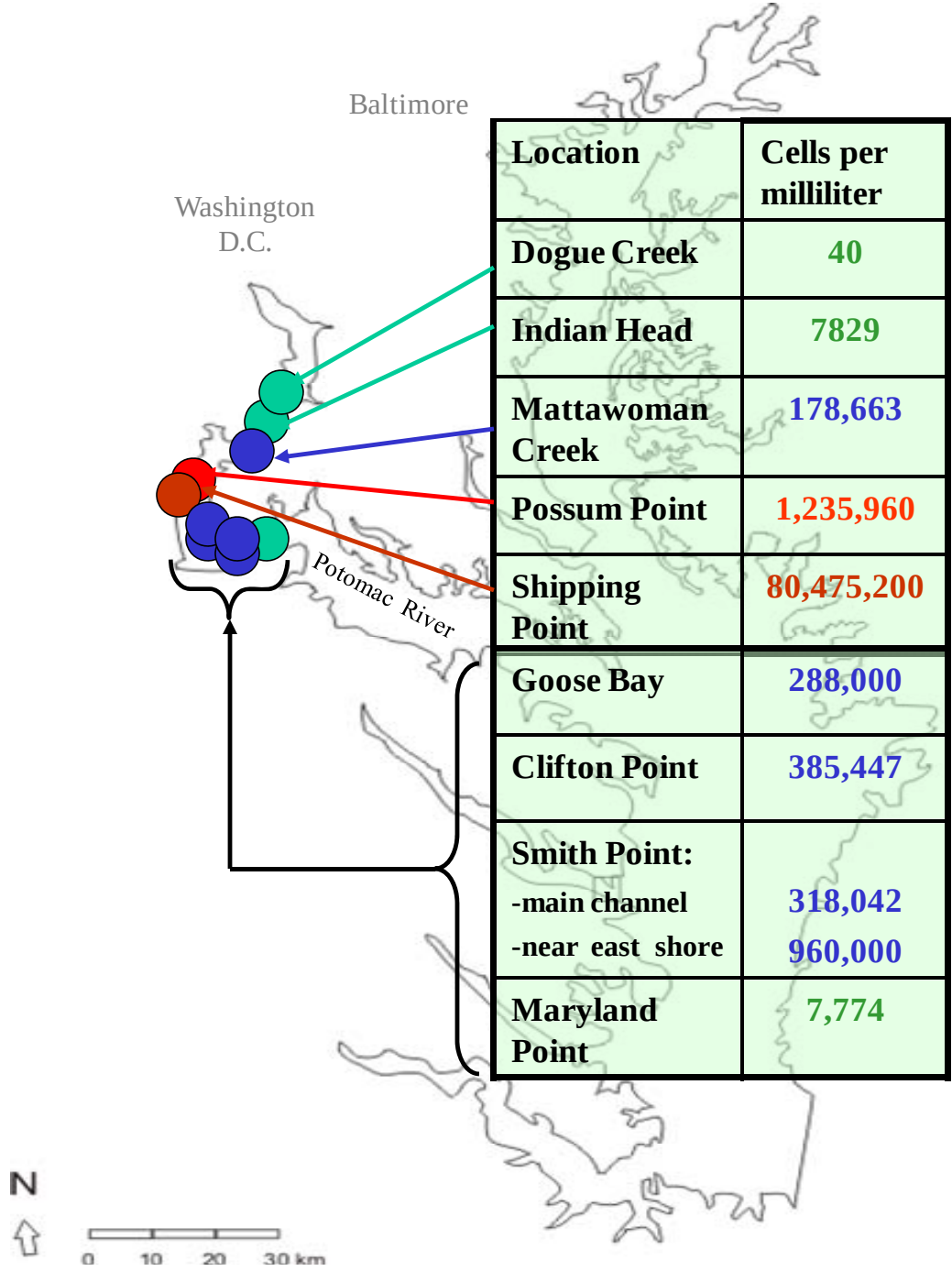
- Largest estuarine tributary to Chesapeake Bay
- 118 miles from head of tide to Chesapeake Bay
- Watershed area 2,537 mi^2
- Potomac basin population 5.8 million
- Oxygen depletion in bottom waters
- Excess chlorophyll concentrations
- Diminished living resources

Problems Unique to Potomac

- Blooms of blue-green algae
- Elevated pH
- P limitation in tidal fresh portion







Location	Cells per milliliter
Dogue Creek	40
Indian Head	7829
Mattawoman Creek	178,663
Possum Point	1,235,960
Shipping Point	80,475,200
Goose Bay	288,000
Clifton Point	385,447
Smith Point:	
-main channel	318,042
-near east shore	960,000
Maryland Point	7,774

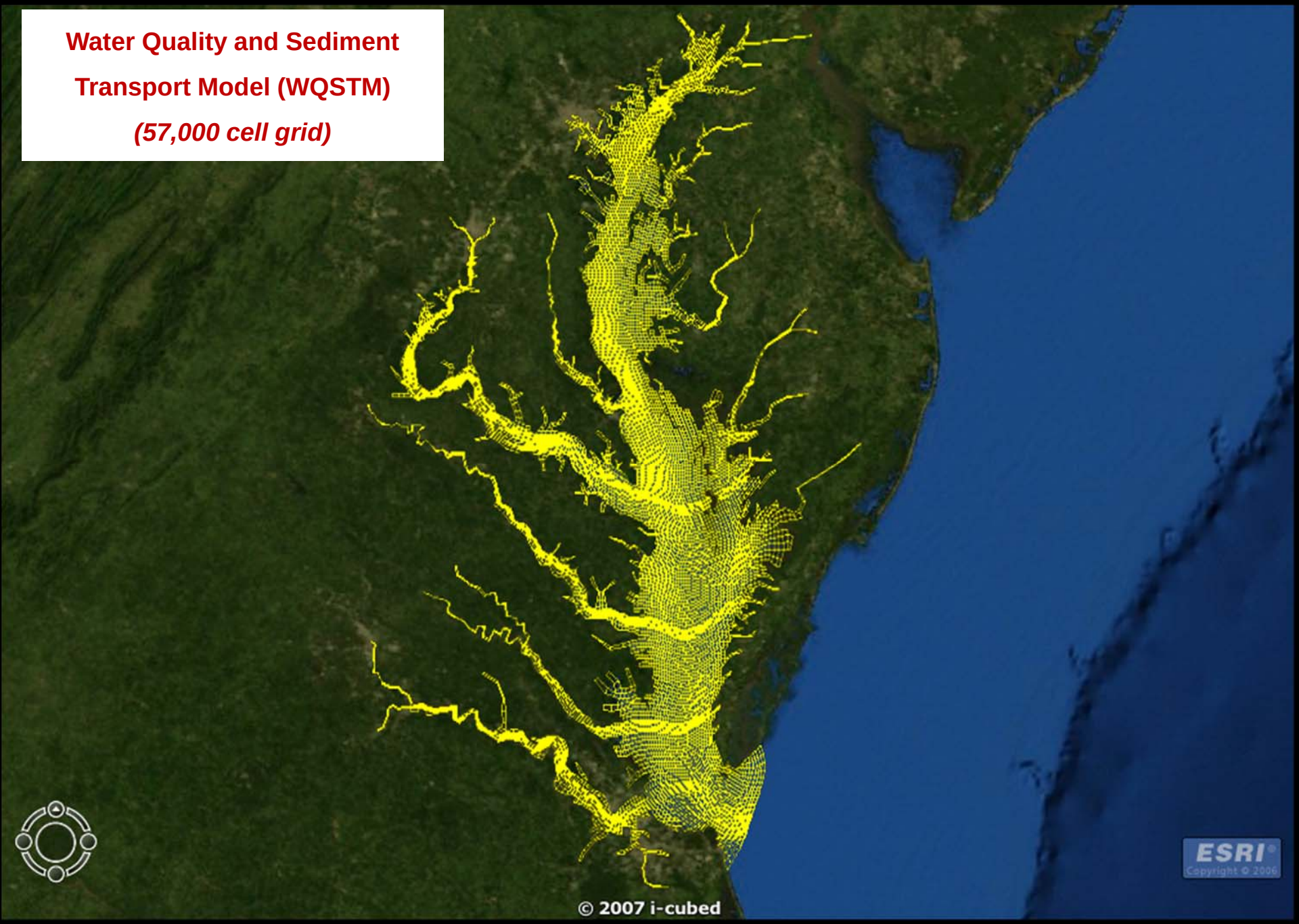
Original Study Objectives

- Refine algal groups in Potomac portion of the Chesapeake Bay Water Quality Model
- Calibrate the revised Potomac model

Objectives of ongoing work …

- Use calibrated, integrated model to investigate algal responses to different loading scenarios
  - 1985 Loads
  - TMDL Loads
- Scoping for potential application of integrated model to hindcast the 1983 algal bloom
  - Hydrometeorology
  - Alkalinity loads

Model Spatial Grid


Water Quality and Sediment
Transport Model (WQSTM)
(57,000 cell grid)
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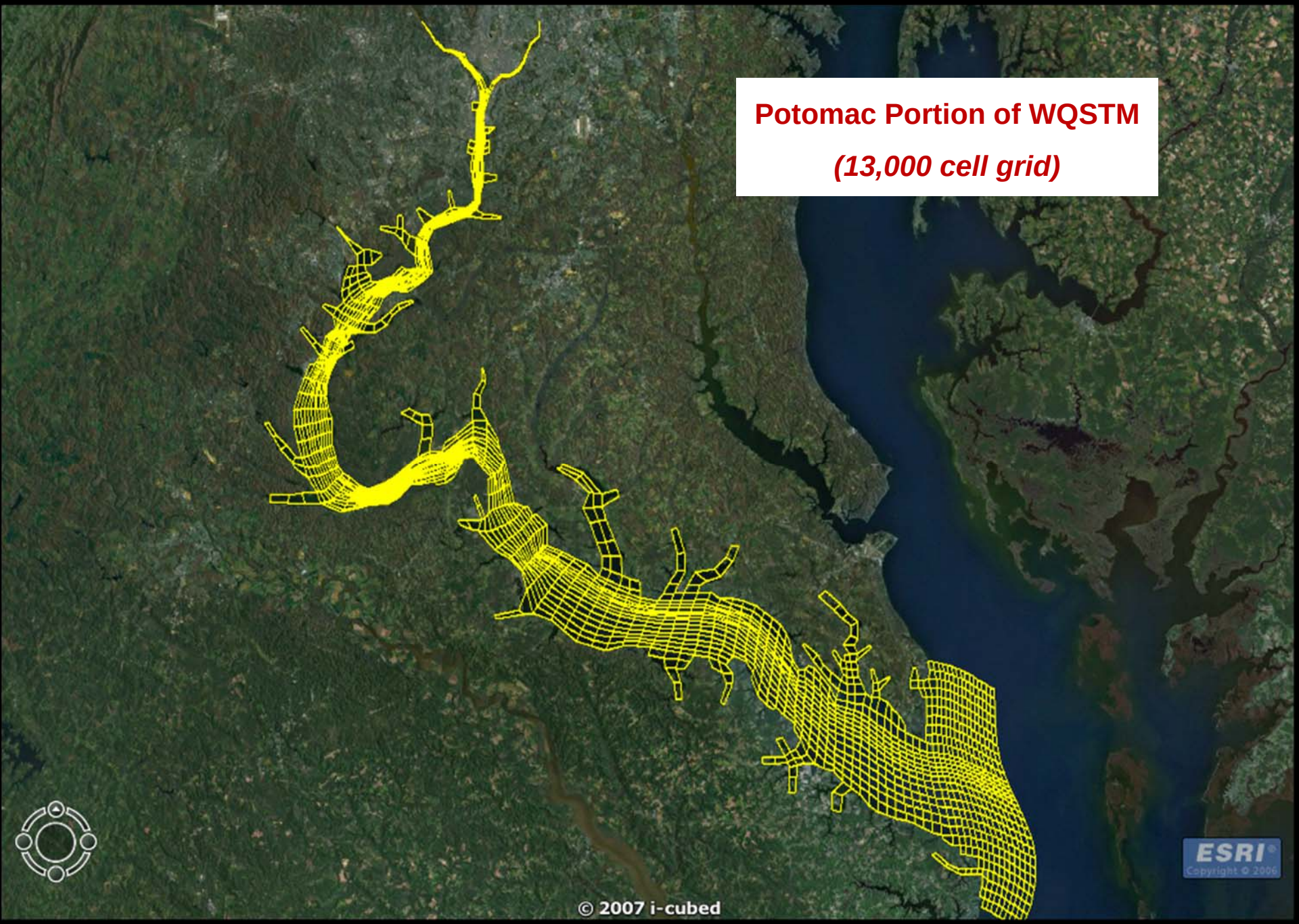
Potomac Portion of WQSTM
(13,000 cell grid)
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Monitoring Stations for
Potomac River and Estuary
Gunston Cove
GC 7
GC 9
TF 2.3
RET 2.2
LE 2.2
CB 5.2
symbol size is 300 m

Considerations for Revised Algal Model

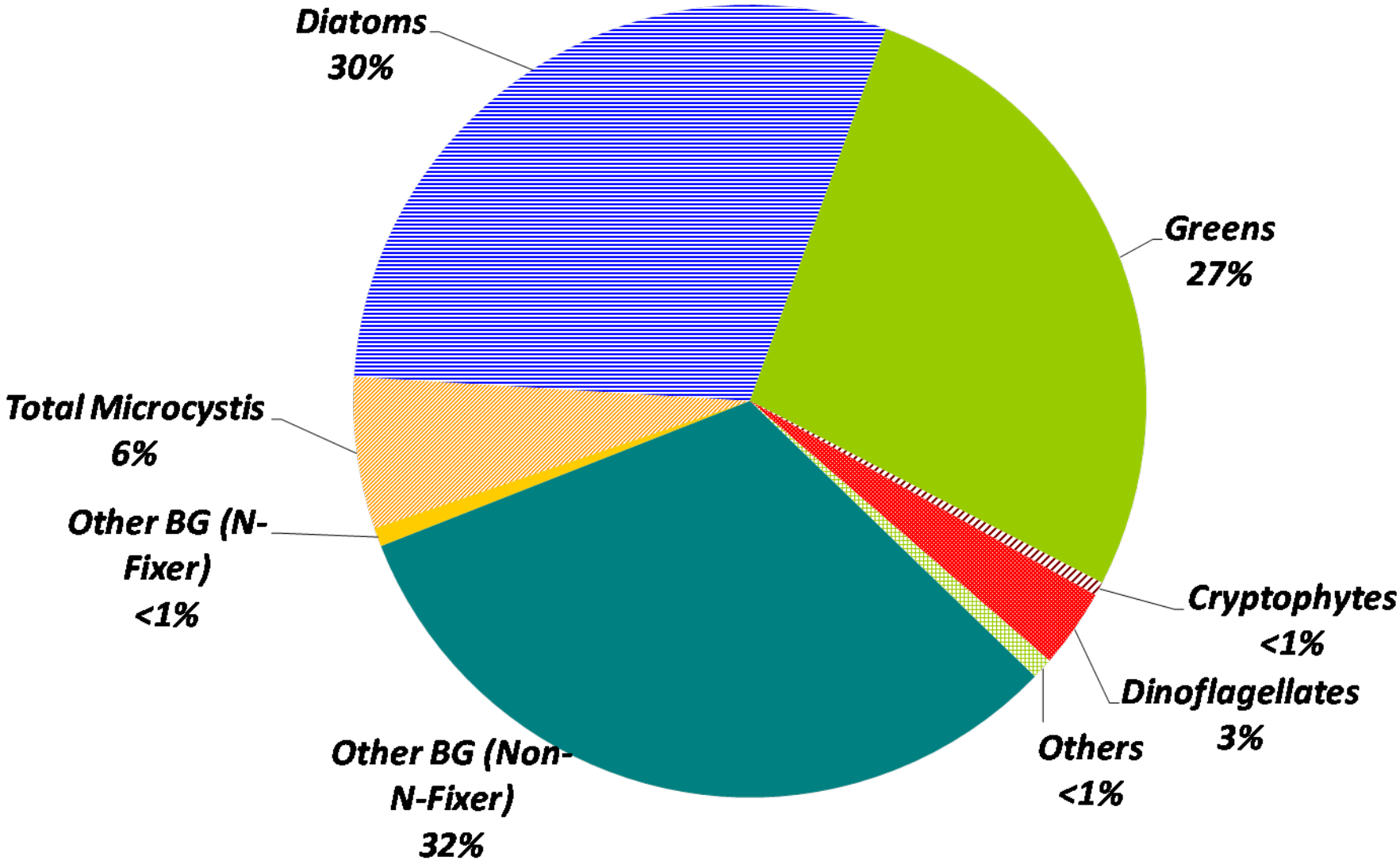
- Nutrient requirements
- Salinity tolerance
- Temperature requirements
- Susceptibility to grazing
- Water quality management issues
  - Microcystis blooms
- Model complexity
  - Difficult to model more than five groups
- Mass balance
  - Want to capture $\geq$ 95% of algal biomass

Phytoplankton Groups

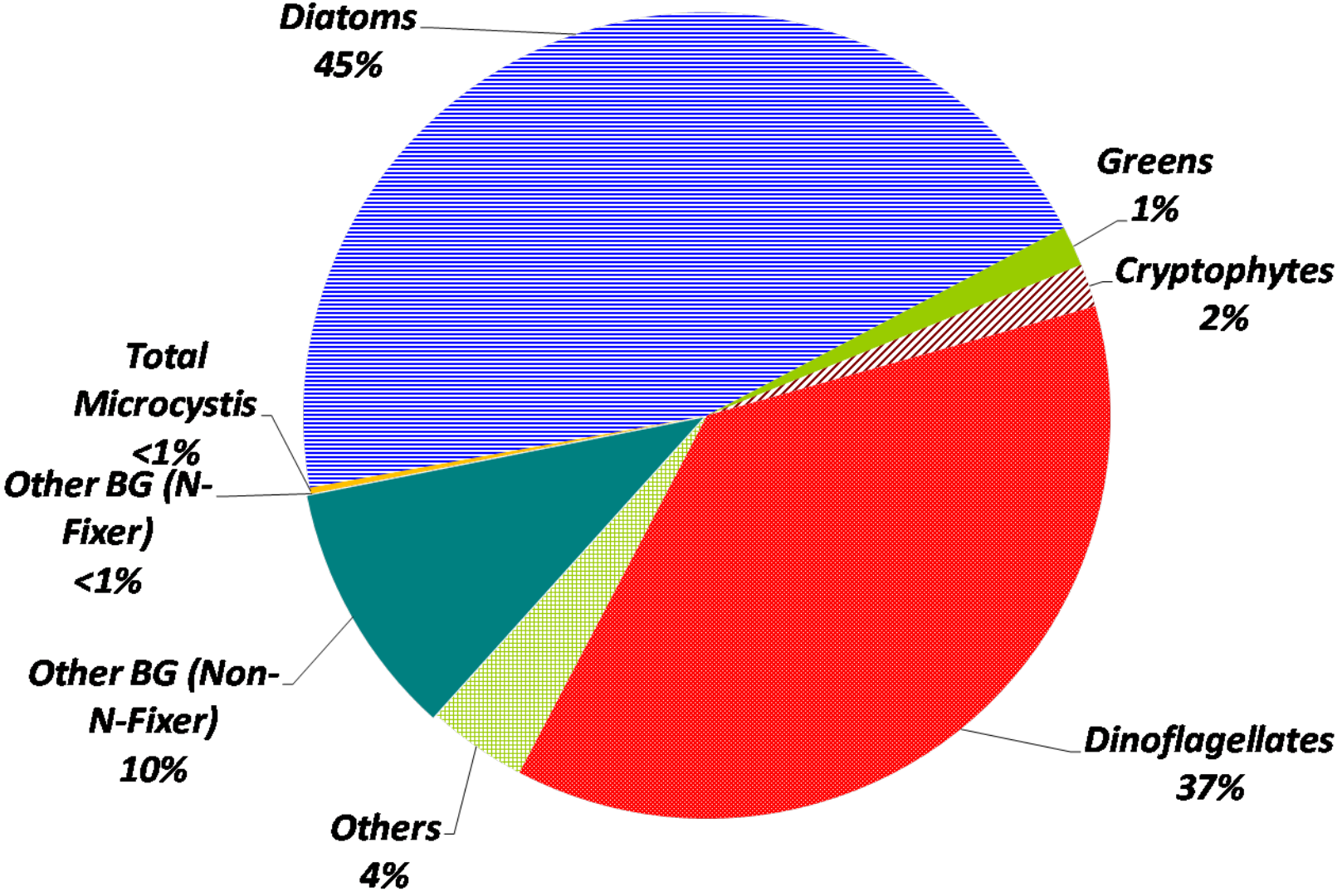
How to lump?

How to split?

Percent Composition as Organic Carbon
Tidal Fresh (1994-2000)



Percent Composition as Organic Carbon
Lower Estuary (1994-2000)



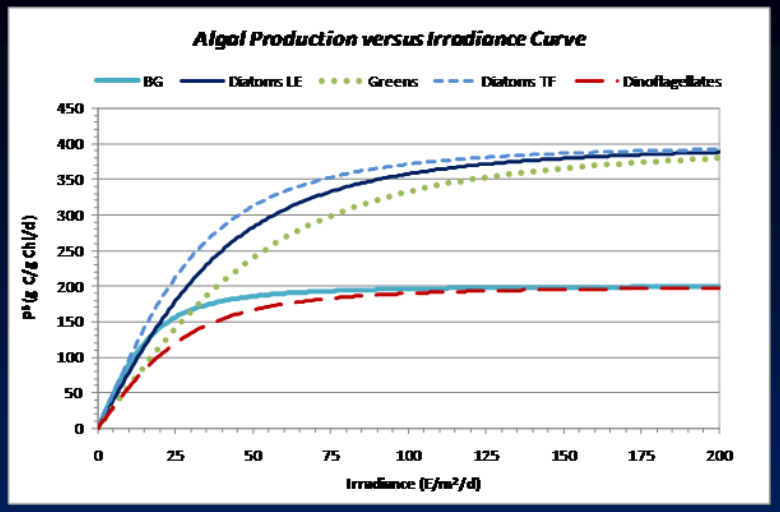
Five Algal Groups in Revised Model

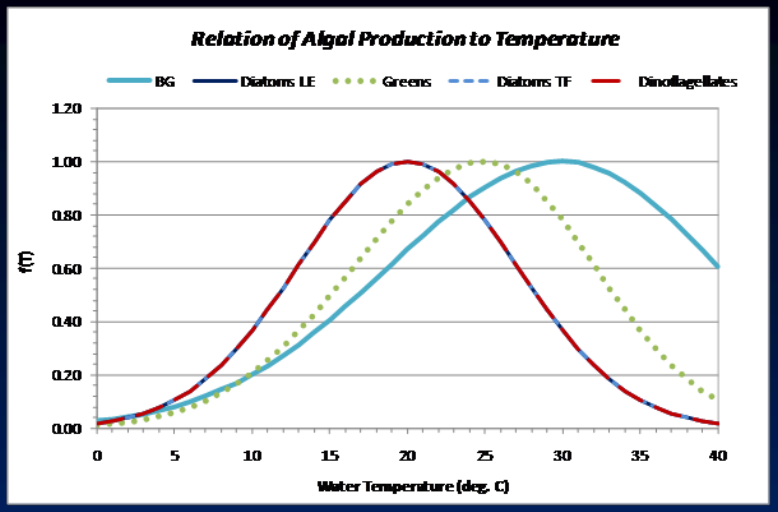
- Tidal Freshwater Diatoms
- Greens
- Blue-Greens

Dominant in Tidal Fresh

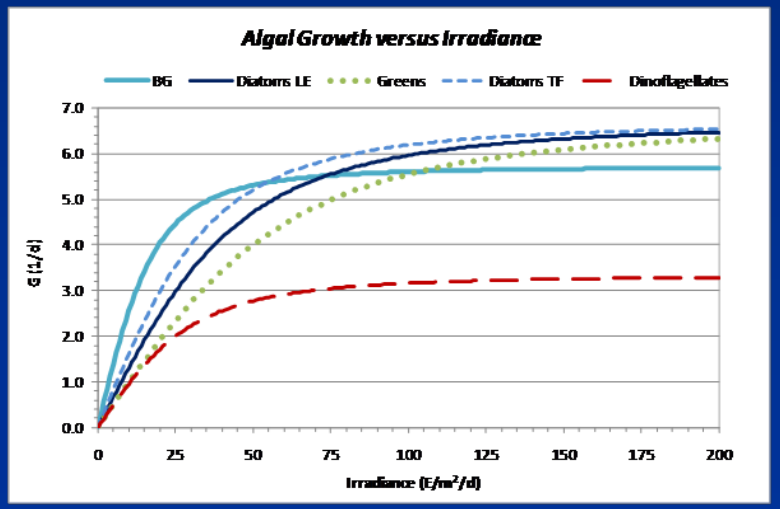
- Lower Estuary Diatoms
- Dinoflagellates

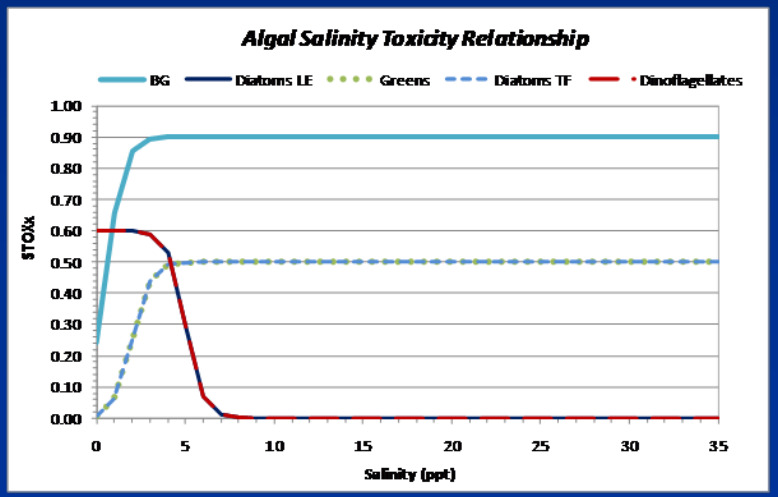
Dominant in Lower Estuary





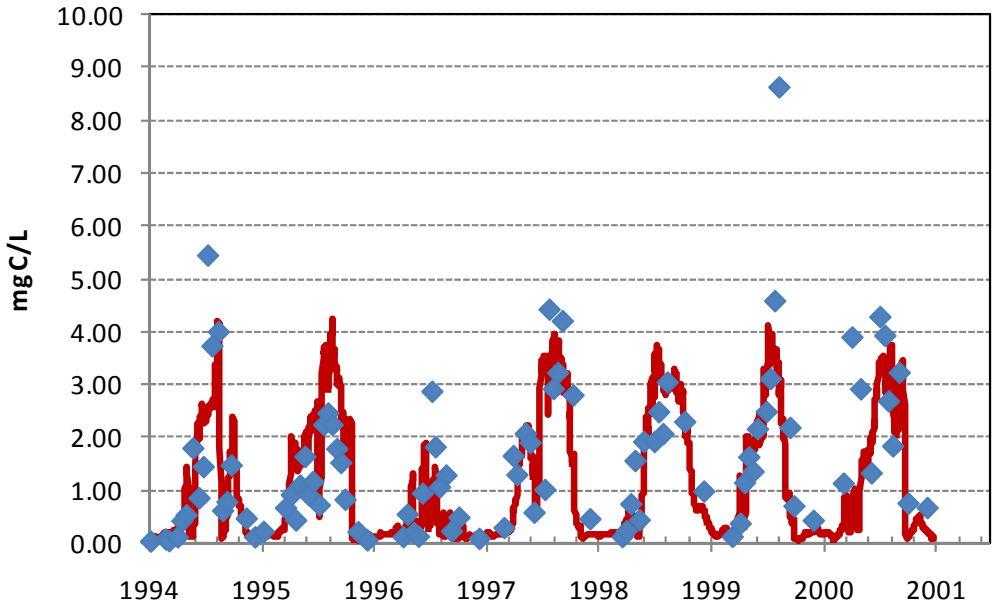
Light, temperature and salinity responses are principal drivers for algal differences



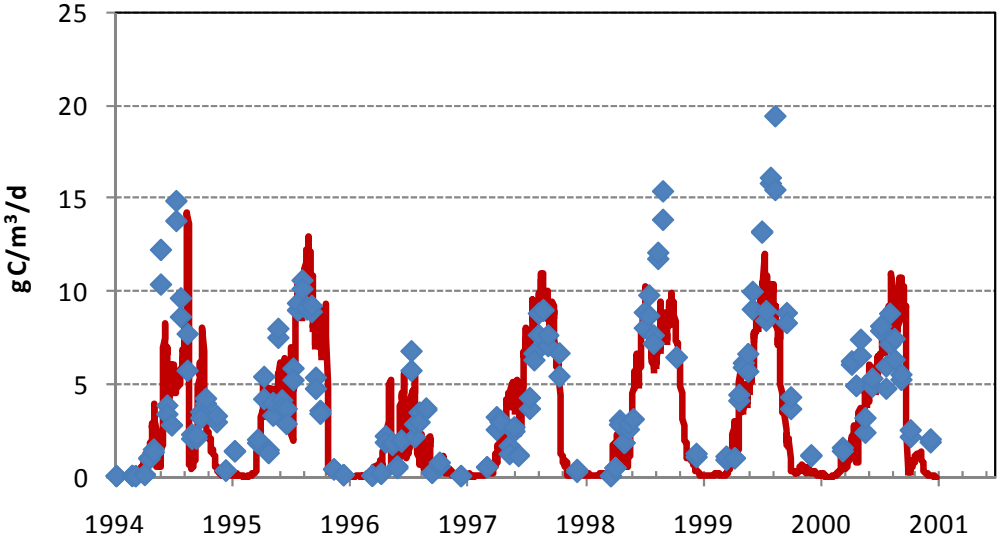


Selected Calibration Results

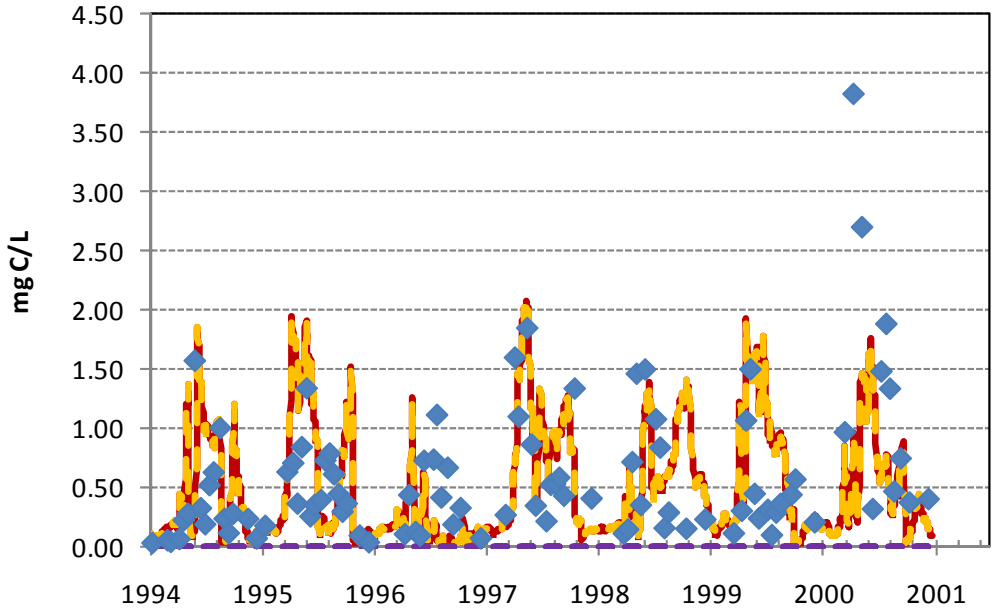
Tidal Fresh Potomac



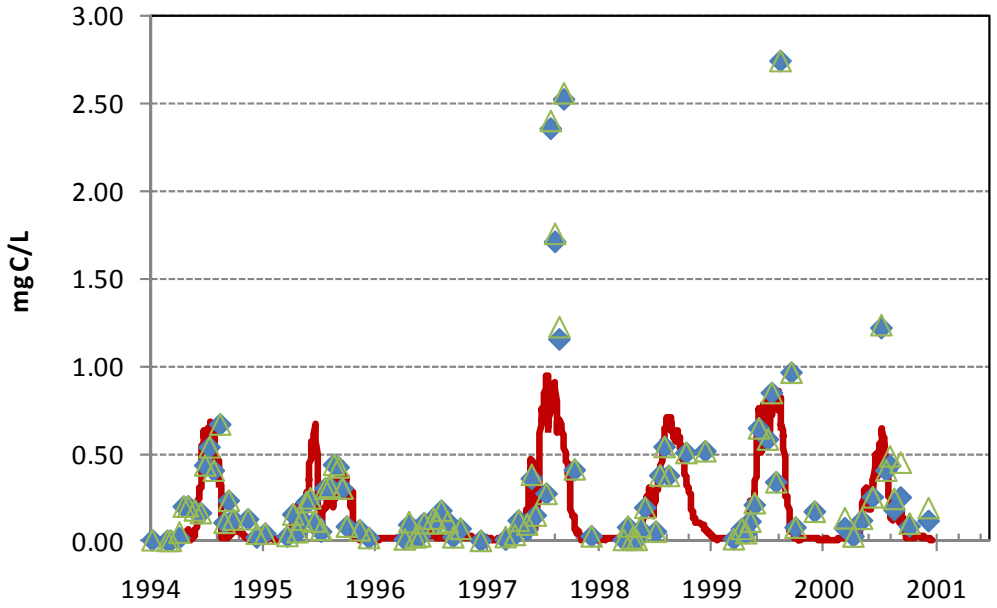
Total Biomass



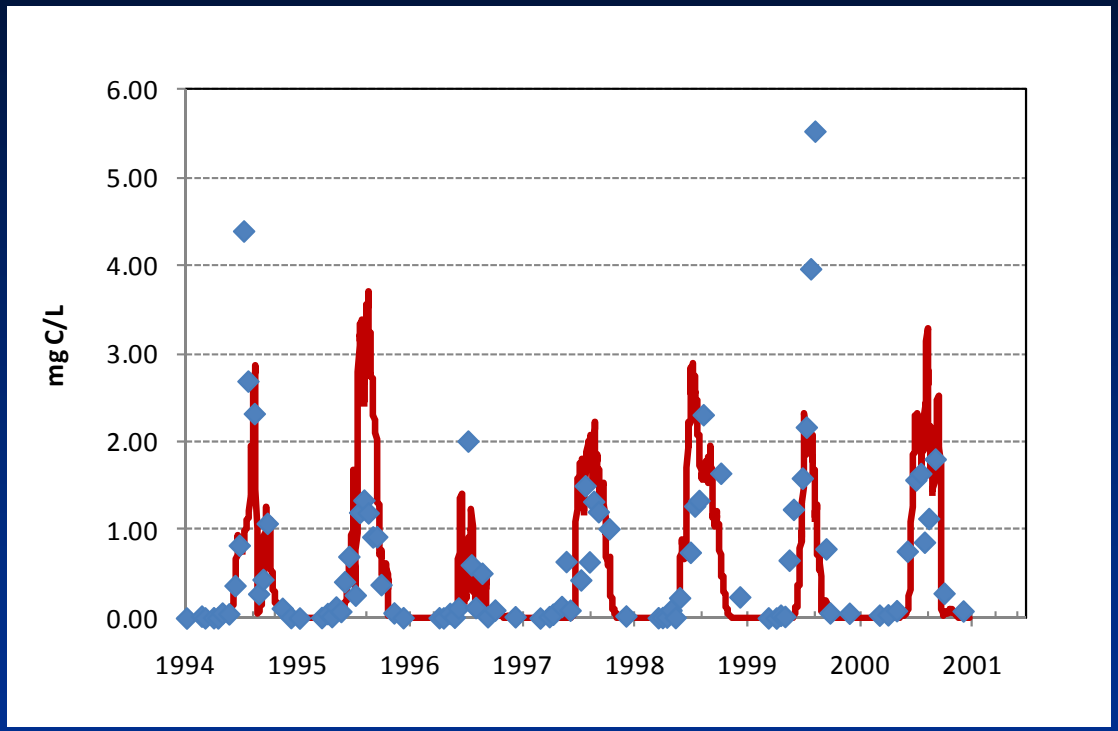
Carbon Fixation



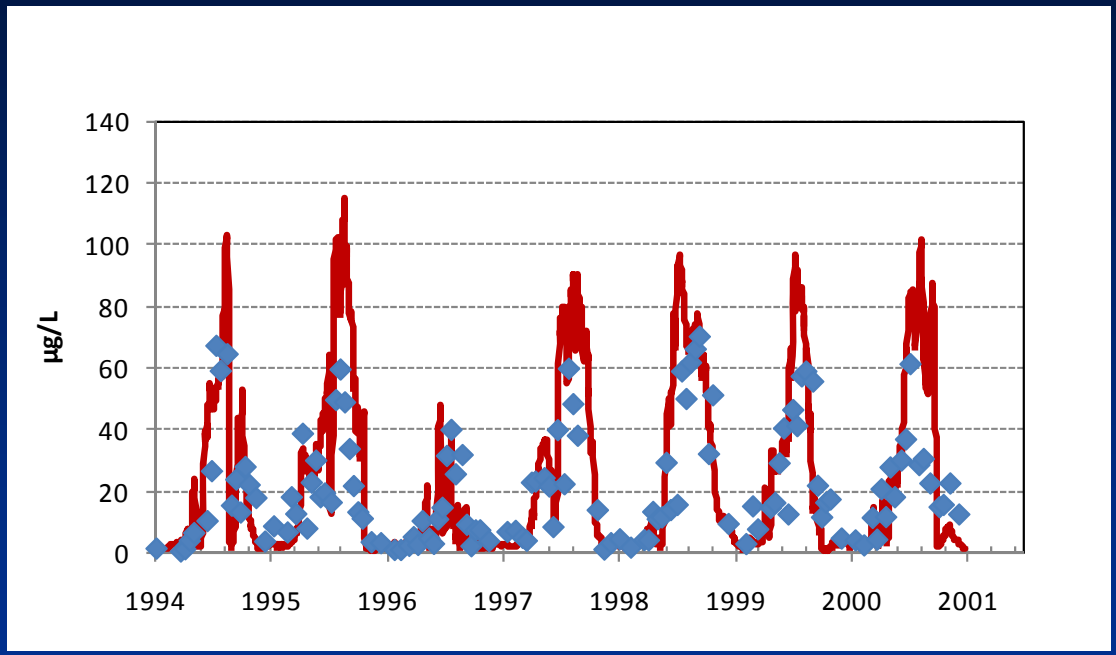
Diatom Biomass



Green Biomass

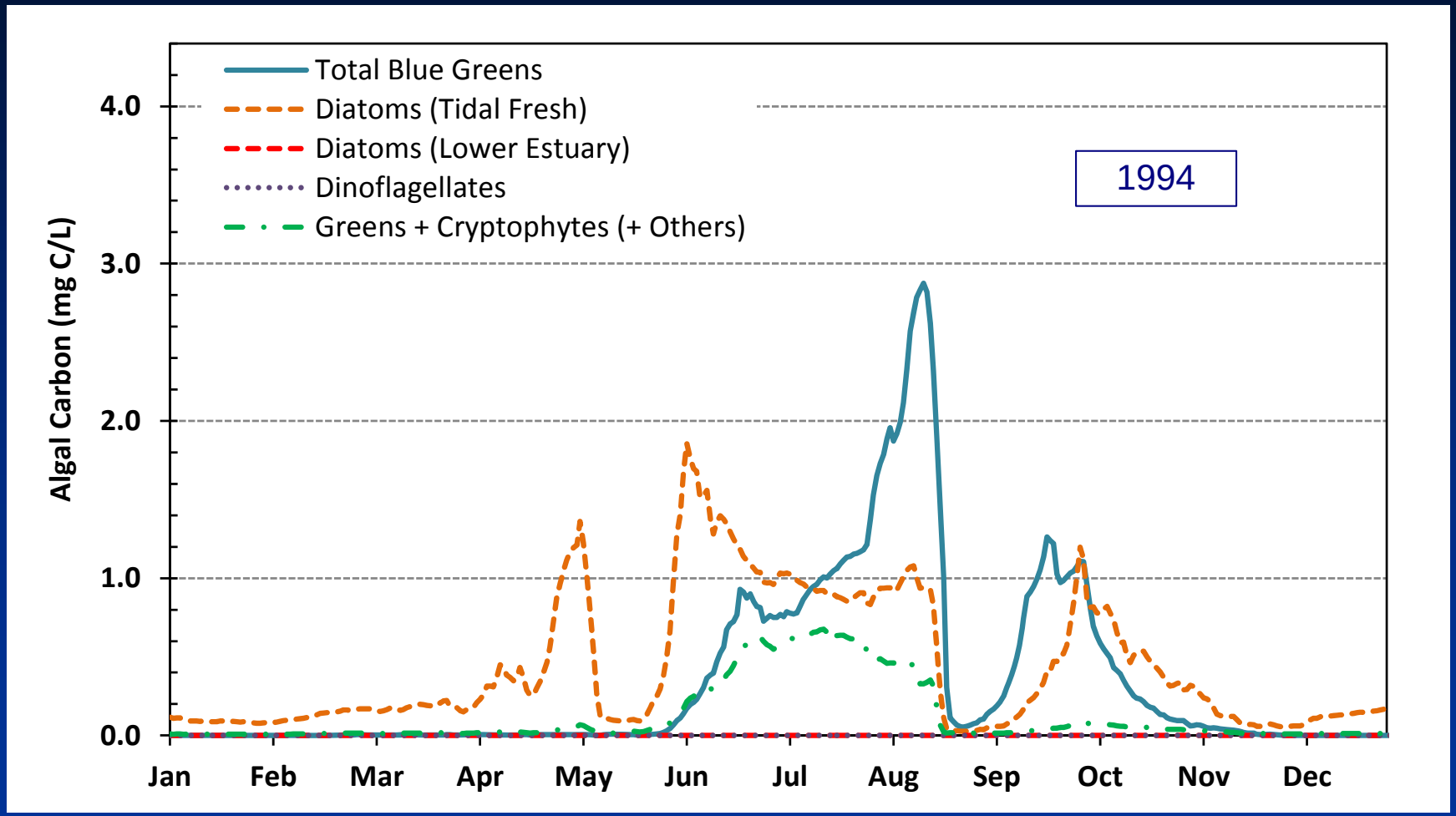


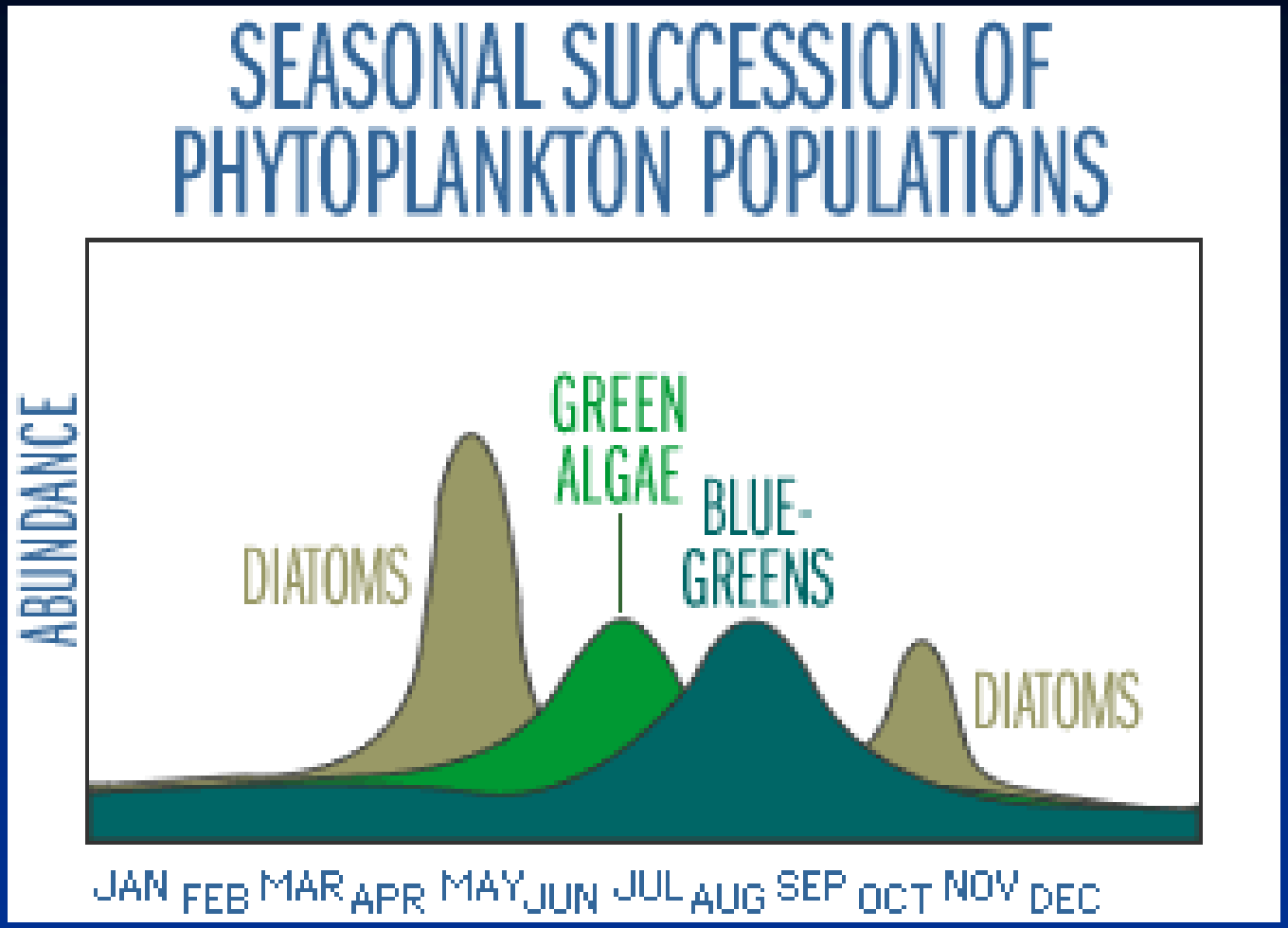
Blue-Green Biomass



Chlorophyll

Seasonal Succession Pattern





Water on the Web (2004)
http://www.waterontheweb.org/

Algal Responses to Changes in Loads

Tidal Fresh Potomac

Approach

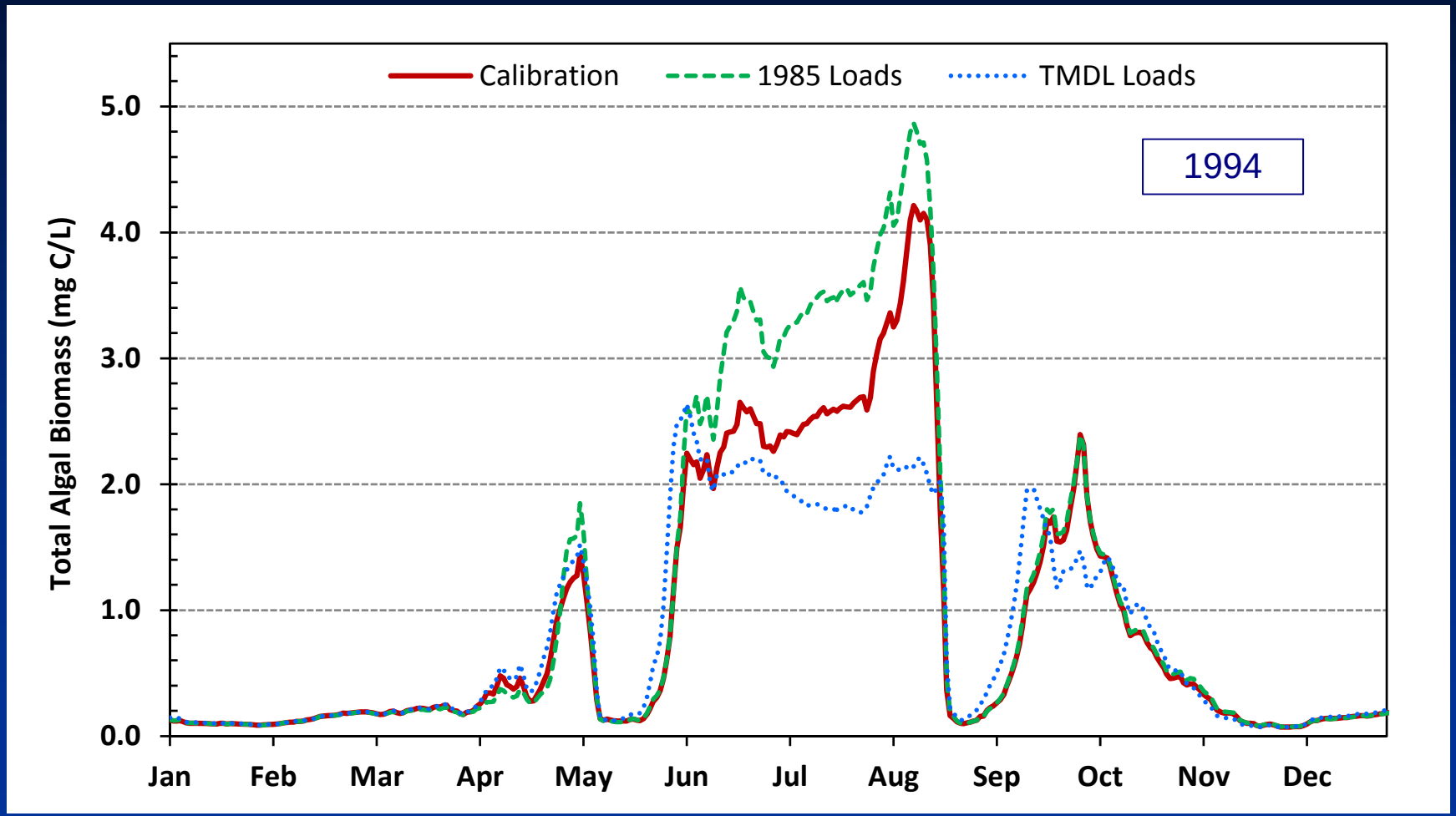
- All simulations use 1994-2000 hydrology
- Three loading scenarios
  - Base calibration (1994-2000)
  - 1985 Loads
    - 1985 land uses
    - 1985 point sources
  - TMDL Loads
- Compare results for:
  - Tidal fresh portion (Station TF2.3)
  - Average water year (1994)

Potomac Scenario Loads

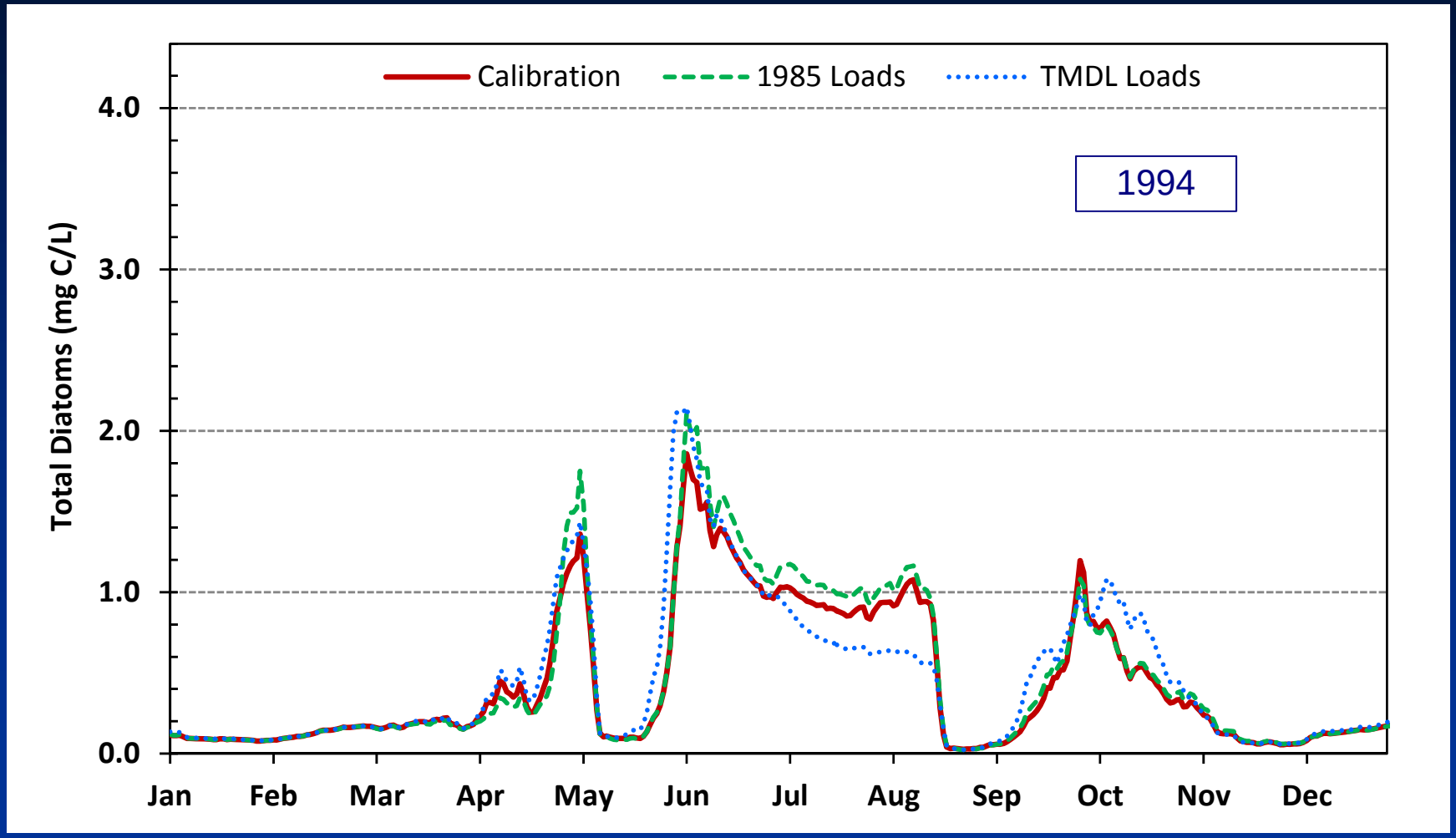
Scenario	Total N Load (million lbs/yr)	Total P Load (million lbs/yr)
1985	81.2	5.18
Calibration	75.5	4.88
TMDL	44.9	3.65

1991-2000 Scenario Loads, Appendix J, Chesapeake Bay TMDL Report

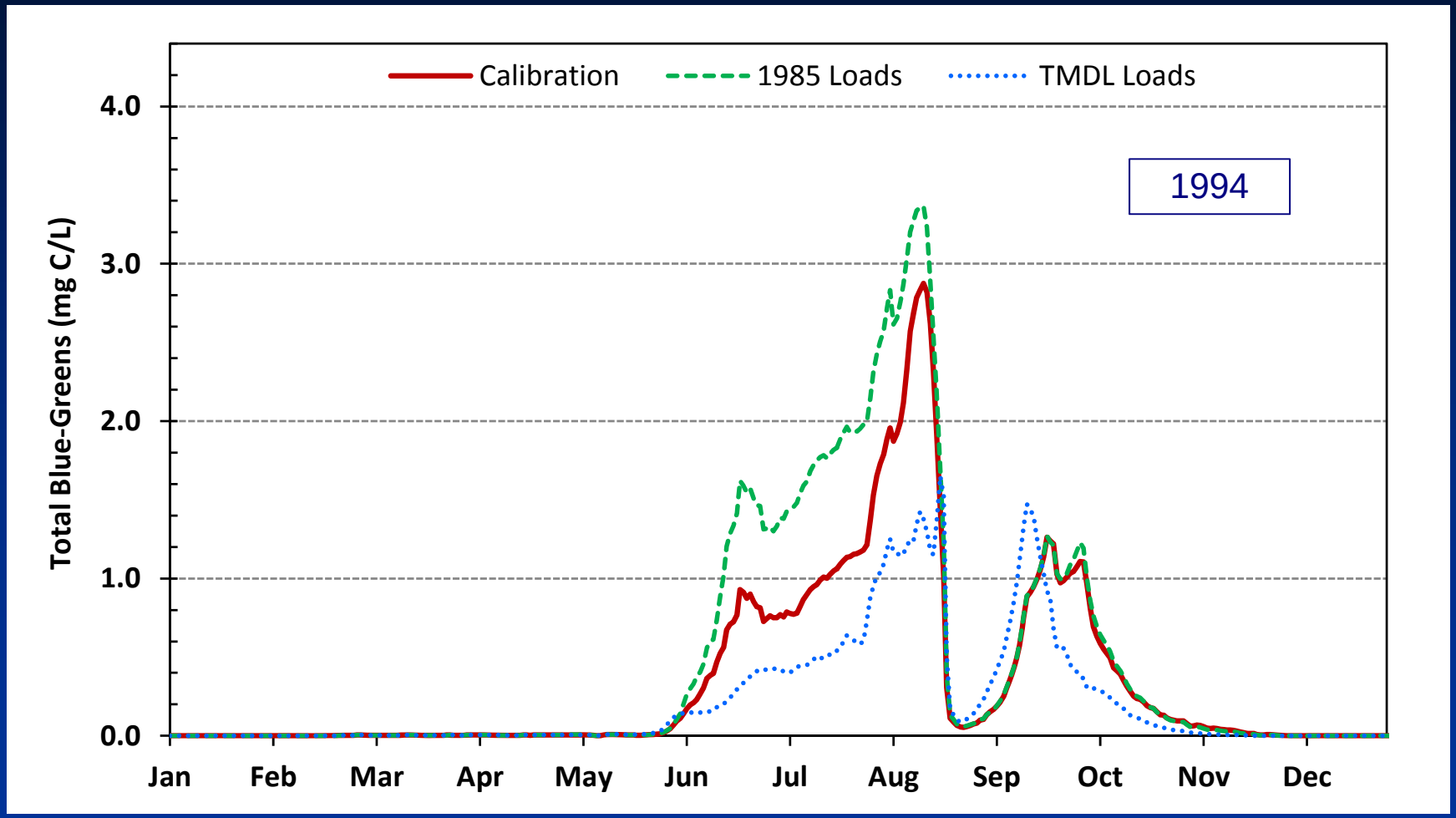
Total biomass responds to loads …



Diatom response is muted …



Blue-green response is much larger …



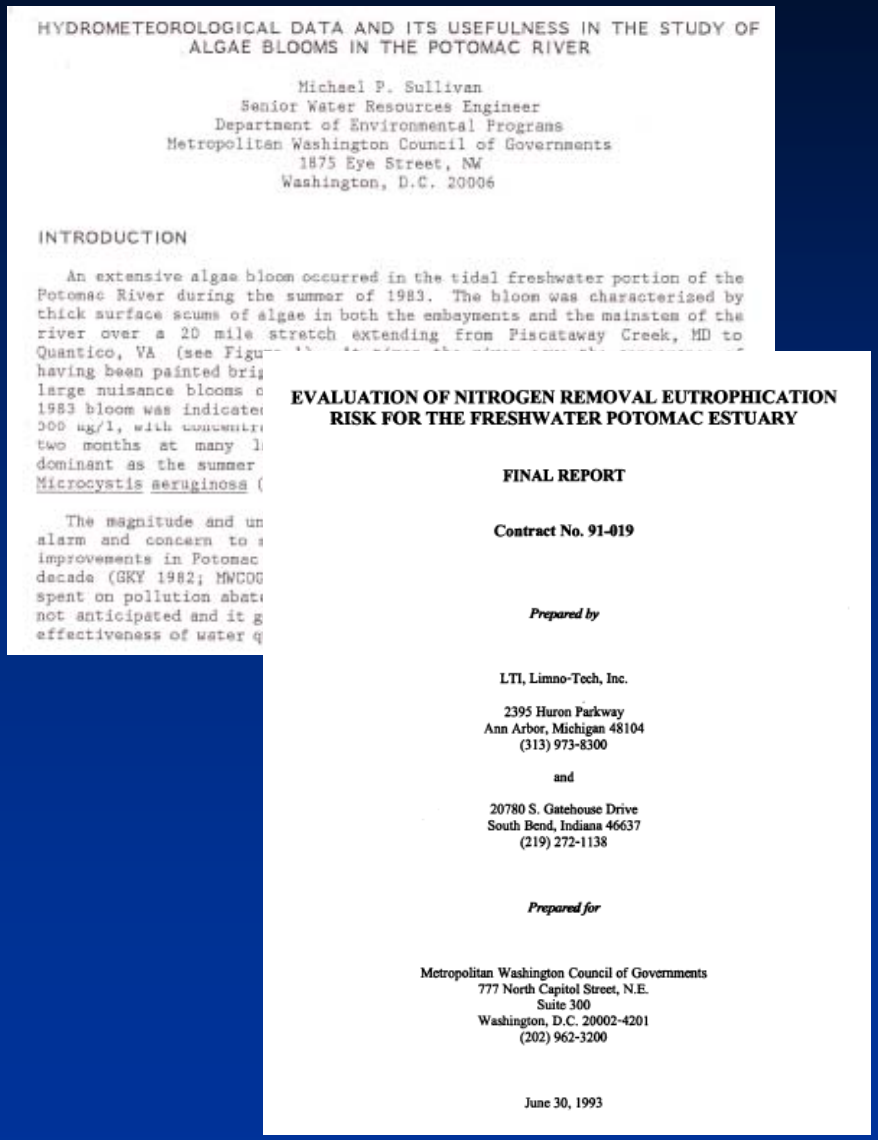
Conclusions

- The feasibility of a regional-scale application of an independent model extracted from the larger Chesapeake Bay Model was demonstrated
- The feasibility of an integrated model for that represents pH, alkalinity, TIC and multiple algal functional groups was demonstrated
- Nuisance blue-green algae in the tidal fresh Potomac appear more responsive to changes in nutrient loads than more desirable algal groups

Next Steps with Integrated Model?

- Use to develop pH TMDL for DC waters
- Support the load allocation process for the nutrient TMDL
- Use as diagnostic tool to investigate the 1983 algal bloom
  - Does model reproduce the large blue-green bloom?
  - Is pH-dependent sediment phosphorus release important?
  - How important is alkalinity?
    - Fall line
    - Blue Plains

It is not just about nutrients …



HYDROMETEOROLOGICAL DATA AND ITS USEFULNESS IN THE STUDY OF ALGAE BLOOMS IN THE POTOMAC RIVER

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INTRODUCTION

An extensive algae bloom occurred in the tidal freshwater portion of the Potomac River during the summer of 1983. The bloom was characterized by thick surface scums of algae in both the embayments and the mainstem of the river over a 20 mile stretch extending from Piscataway Creek, MD to Quantico, VA (see Figu

having been painted brig

large nuisance blooms o

1983 bloom was indicate

300 ug/l, with concentr

two months at many l

dominant as the summer

Microcystis aeruginosa (

The magnitude and un

alarm and concern to s

improvements in Potomac

decade (GKY 1982; MWCOG

spent on pollution abat

not anticipated and it g

effectiveness of water q

EVALUATION OF NITROGEN REMOVAL EUTROPHICATION RISK FOR THE FRESHWATER POTOMAC ESTUARY

FINAL REPORT

Contract No. 91-019

Prepared by

LTI, Limno-Tech, Inc.

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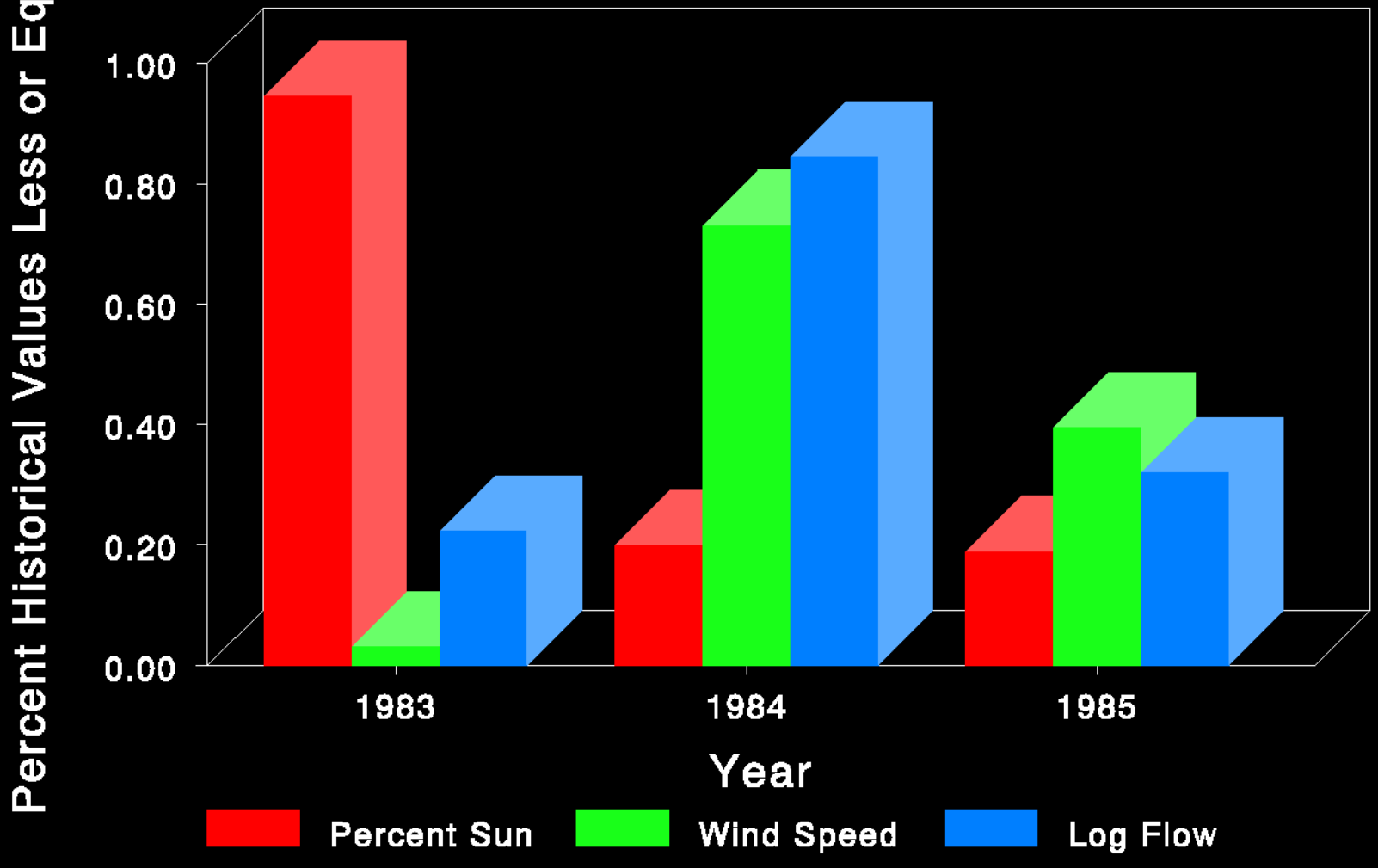
June 30, 1993

- Algal Encouragement Index (AEI)
- Flow, percent sunshine, wind speed
- AEI in 1983 was 100-year high

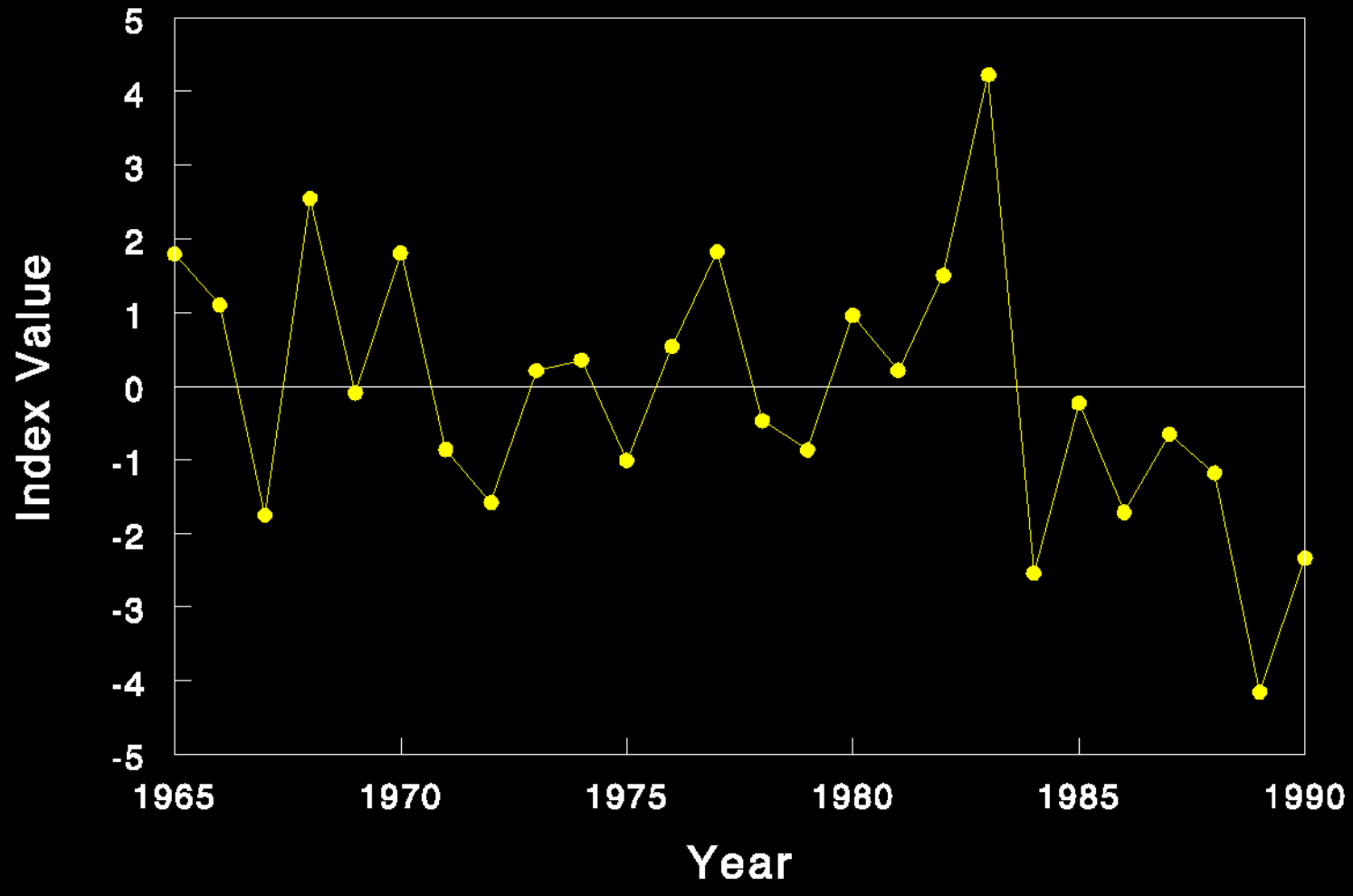
Freshwater Potomac Estuary

Summer Average Meteorological Conditions

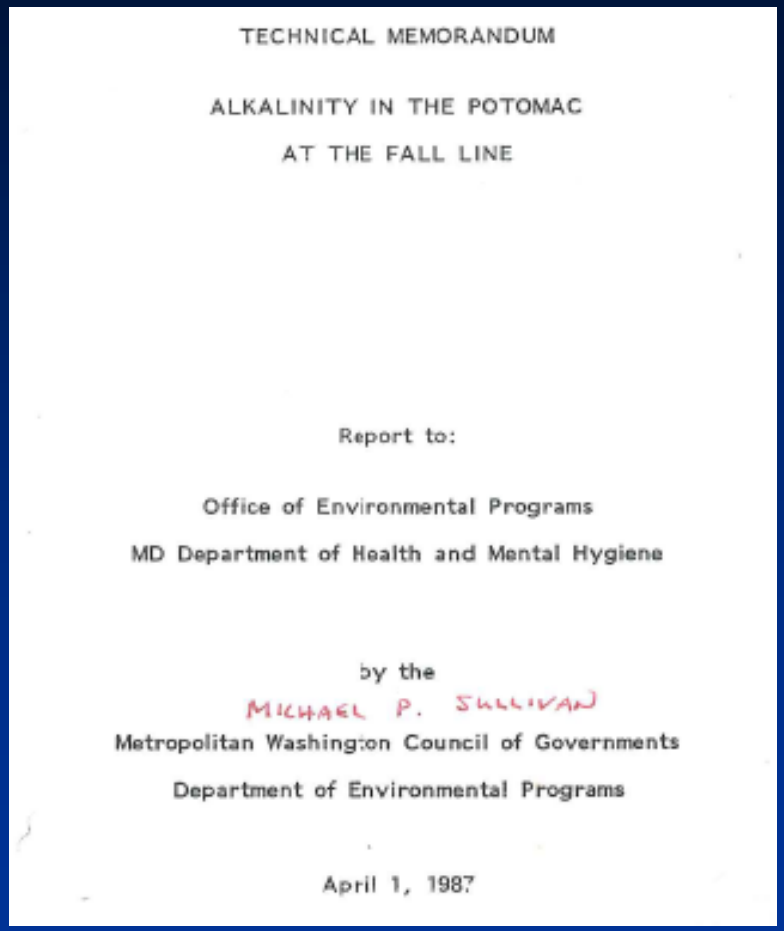


Freshwater Potomac Estuary

Summer Algal Encouragement Index



Then there is alkalinity …



TECHNICAL MEMORANDUM

ALKALINITY IN THE POTOMAC

AT THE FALL LINE

Report to:

Office of Environmental Programs

MD Department of Health and Mental Hygiene

by the

MICHAEL P. SULLIVAN

Metropolitan Washington Council of Governments

Department of Environmental Programs

April 1, 1987

- Specific hydrologic conditions in 1983 caused very low alkalinity in the tidal fresh Potomac
- Fall line alkalinity load in 1983 dominated the Blue Plains load

How to Hindcast 1983 Conditions?

- Model actual 1983 hydrodynamics
- Get the sunlight and temperature right
- Get the nutrient loads right
  - Watershed Model (nonpoint sources)
  - Point sources
  - Atmospheric sources
- Get the alkalinity loads right
  - Fall line
  - Blue Plains

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