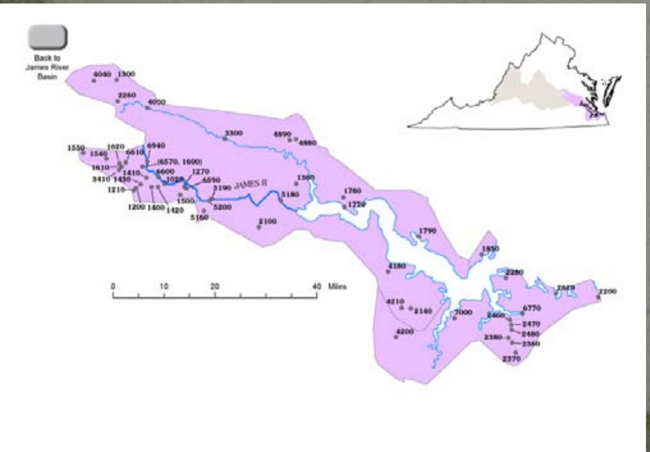
VA’s James River Chlorophyll Study

In Response To
Chesapeake Bay TMDL

STAC
Sept 11, 2012



Chesapeake Bay TMDL

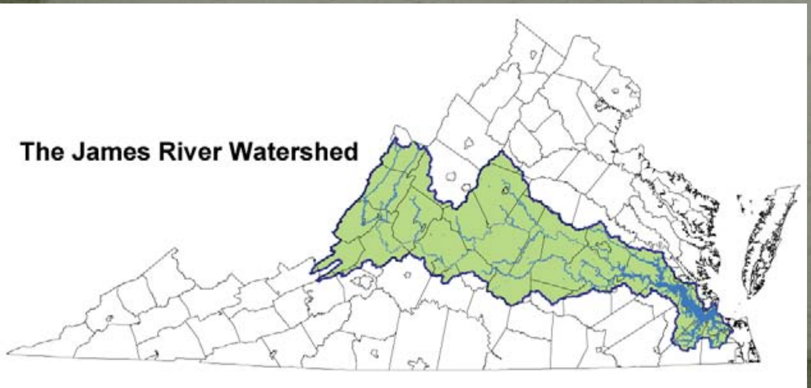
- Issued December 29, 2010
- Set Jurisdictional Allocations
  - VA
    - TN= 53.42 millions lbs/yr (mpy)
    - TP=- 5.36 mpy
    - Sediments = 2,578.9 mpy
  - James River Watershed (Appendix O)
    - TN=- 23.5 mpy (2003 cap loads = 26.4 mpy)
    - TP = 2.35 mpy (2003 cap loads = 3.41 mpy)
  - Appendix X – Staged Implementation
- Watershed Implementation Plan I
  - Study Plan for review and update of James River Site-specific Numeric Chlorophyll-a Water Quality Criteria (Appendix 2)

Impact of EPA TMDL Allocations

- Set nutrient load caps for all Bay river basins
- TMDL set cap much lower for James River basin than EPA approved with chlorophyll standard in 2005 (Appendix O & X)
- Impact estimated to add $1-2 billion to nutrient reduction costs
- VA conclusion: let's make sure first

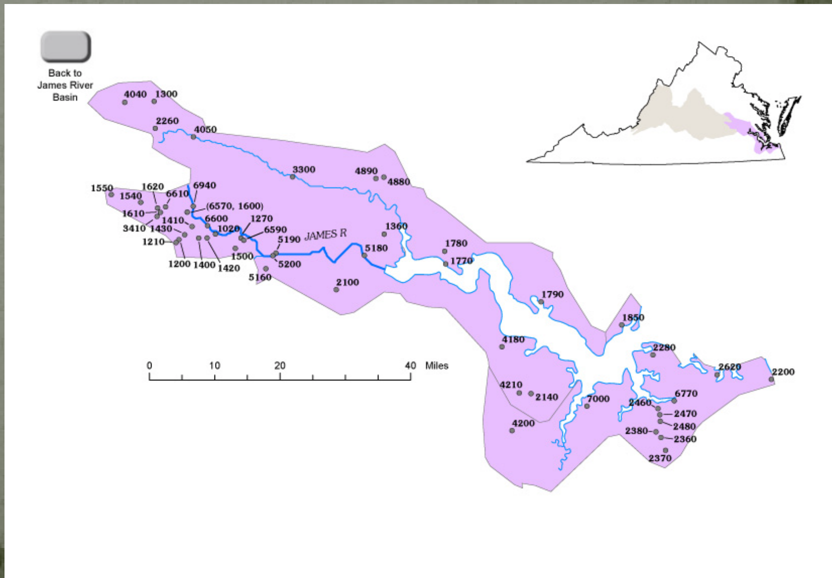
Study Goals

- Revisit the James River TMDL allocations (Appendix O & X, Bay TMDL)
  - Develop a site specific James River water quality model
  - Re-assess attainability of chl-a criteria
- Review and confirm/adjust James River chl-a standard (Appendix 2, WIP I)
  - Scientific Advisory Panel to make recommendations
  - Conduct scientific study to review basis for setting chlorophyll standard



Outline

- Background
  - Basis for Chlorophyll *a* Criteria – Summary of 2005 process
- Chesapeake Bay TMDL Process
  - Impact of EPA's TMDL Allocations
  - VA WIP/Bay TMDL Process
  - Issues
    - Critical Conditions
    - Assessment Process
    - Modeling
- James River Study
  - Modeling & Monitoring
- Schedule



Virginia Regulations

Existing Before 2005

- **Designated Uses -** 9 VAC 25-260-10
  "…balanced, indigenous population of aquatic life…"
- **General Criteria -** 9 VAC 25-260-20
  "…undesirable or nuisance aquatic plant life…"
- **Nutrient Enriched Waters -** 9 VAC 25-260-330
  "…undesirable growths of aquatic plant life in surface waters…"

Adopted in 2005 for All Bay Waters

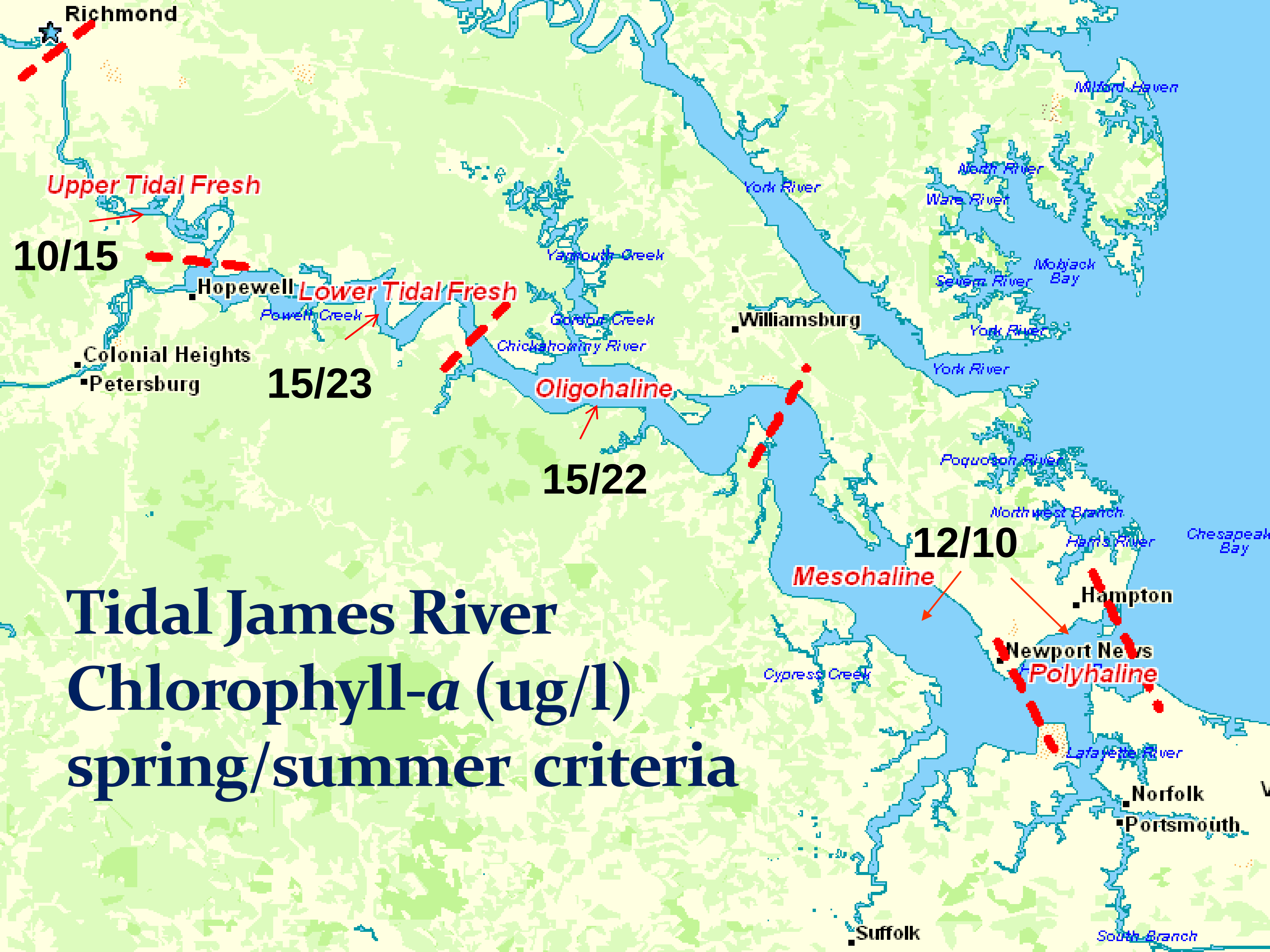
- **Narrative chlorophyll a criterion -** 9 VAC 25-260-185
  "concentrations of chlorophyll-a shall not exceed levels… undesirable… unsuitable… ecologically undesirable water conditions…"

Need for Numeric Chlorophyll-*a* Criteria

- Tidal James River is eutrophic
- Annual algal blooms
- High and increasing levels of undesirable algae
- Unbalanced community composition
- Listed as impaired under CWA § 303
- Dissolved oxygen or water clarity criteria not driving nutrient reductions

Attainability - Alternatives Analysis

- Alternative Loading Scenarios
- Levels of chlorophyll-a
- Attainability
- Environmental Benefits
- Modeling issues
  - Not sensitive to small loading changes
  - Calibrated seasonal averages over broad spatial and temporal domains
  - James River chlorophyll calibration highly variable



Tidal James River
Chlorophyll-*a* (ug/l)
spring/summer criteria
Richmond
Upper Tidal Fresh
10/15
Hopewell
Lower Tidal Fresh
Powell Creek
Colonial Heights
Petersburg
15/23
Oligohaline
15/22
Williamsburg
Mesohaline
12/10
Polyhaline
Hampton
Newport News
Norfolk
Portsmouth
Suffolk
York River
North River
Ware River
Mobjack Bay
Severn River
Milford Haven
Yarmouth Creek
Gordon Creek
Chickahominy River
Poquoson River
Northwest Branch
Chesapeake Bay
Cypress Creek
Lafayette River
South Branch

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VA WIP/Bay TMDL Process

- VA Phase I WIP – November 2010
  - Describe d VA concerns with allocations
  - Outlined need for study of existing chlorophyll criteria and review of modeling framework
  - Presented staged implementation approach for point source discharges in James Basin

- EPA Agreed with approach
  - Included Staged Implementation in Appendix X of Chesapeake Bay TMDL – December 2010
  - Tacit recognition that VA is reviewing chlorophyll criteria

Future Modifications to the Chesapeake Bay TMDL Section 10.3

- Based on possible updates to the model and on jurisdictions' WIPs, EPA will consider revising the Chesapeake Bay TMDL, if appropriate, in 2012 and 2017.
- EPA will also consider revising the TMDL based on other new or additional information provided by the jurisdictions.
- All revision requests from jurisdictions should be coordinated with EPA to fit within EPA's planned revision time frame.

James River Basin
Two Track Approach

Staged Implementation

- VA Phase I WIP outlines nutrient reduction actions to achieve TMDL Implementation 60% reduction target by 2017
- VA Phase III WIP with additional reductions scheduled after 2017

Scientific Study with Standards Review

- Conduct 3-4 year scientific study to review basis for setting chlorophyll standard & make recommendations
- Revise standard/TMDL by 2017, as appropriate

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Critical conditions (TMDL Appendix G)

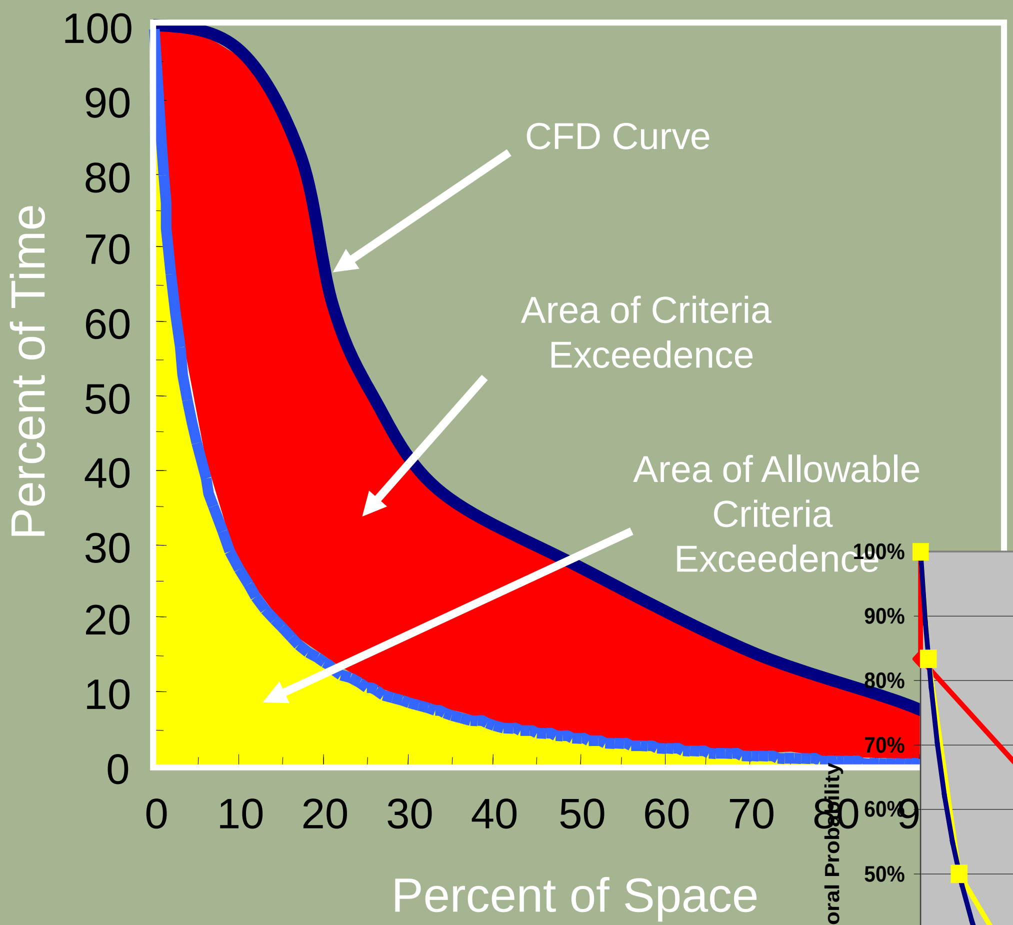
Critical Period –The WQGIT agreed that the critical period should be representative of an approximate 10-year return period. This was defined as the average period of time expected to elapse between occurrences of events at a certain site. For DO, the critical period was 1993-1995.

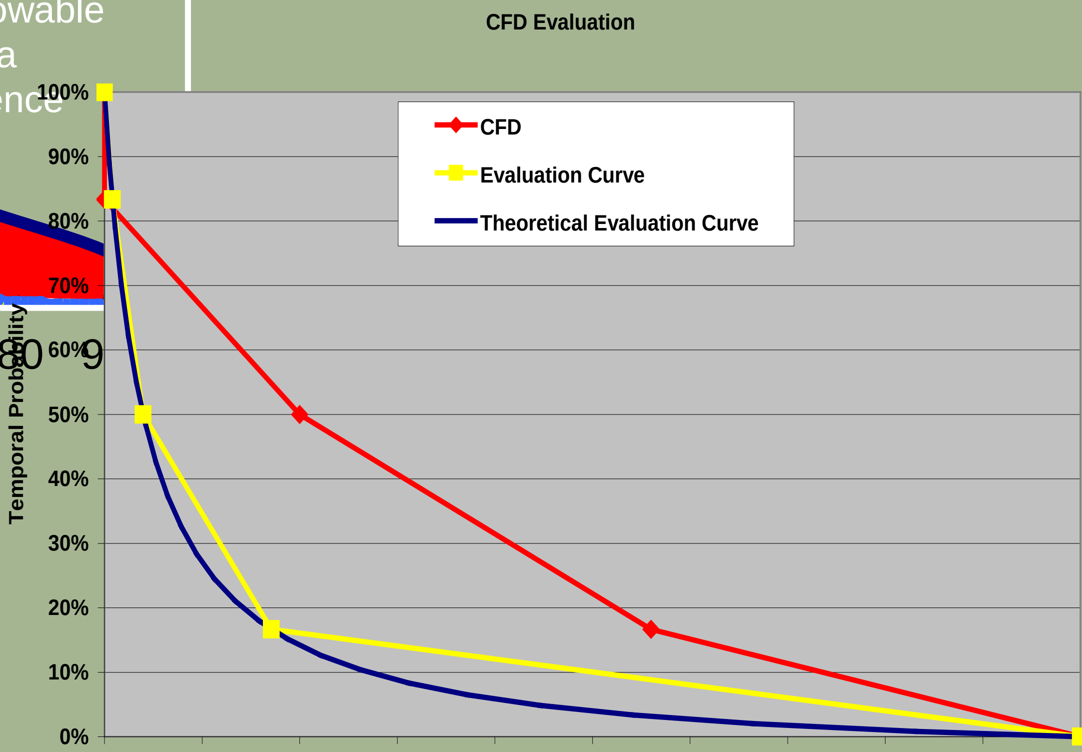
"Because the James River did not exhibit a correlation between high flow and chlorophyll-a violations, a critical period was not selected…"

Issues (con't)

- Assessment (TMDL Section 3.3.3)
  - CFD criteria assessment since no biologically based reference curve not available (USEPA 2007)
  - 10 percent default reference curve
  - Seasonal means of observed data; data transformed and then interpolated spatially within designated use area for each cruise. The interpolated value of each cell averaged in time across the entire season and then the spatial violation rate calculated as the fraction of interpolator cells failing the designated use (USEPA 2010)
  - Chlorophyll assessment was based on attainment over the 1991-2000 time series (Appendix O)

CFD-Based Attainment Assessment





Calibration Method

- Statistics
  - Mean difference
  - Absolute mean different
  - Relative difference
- Time comparison
- Longitudinal comparison

Comparison of calibration to DO and Chlorophyll-*a*

Parameter	Mainstem Bay Dissolved Oxygen (Level II)	James River Chlorophyll-a
Mean difference	0.3 mg/L	-0.78 ug/L
Absolute mean difference	0.94 mg/L	7.24 ug/L
Relative difference	19%	62%

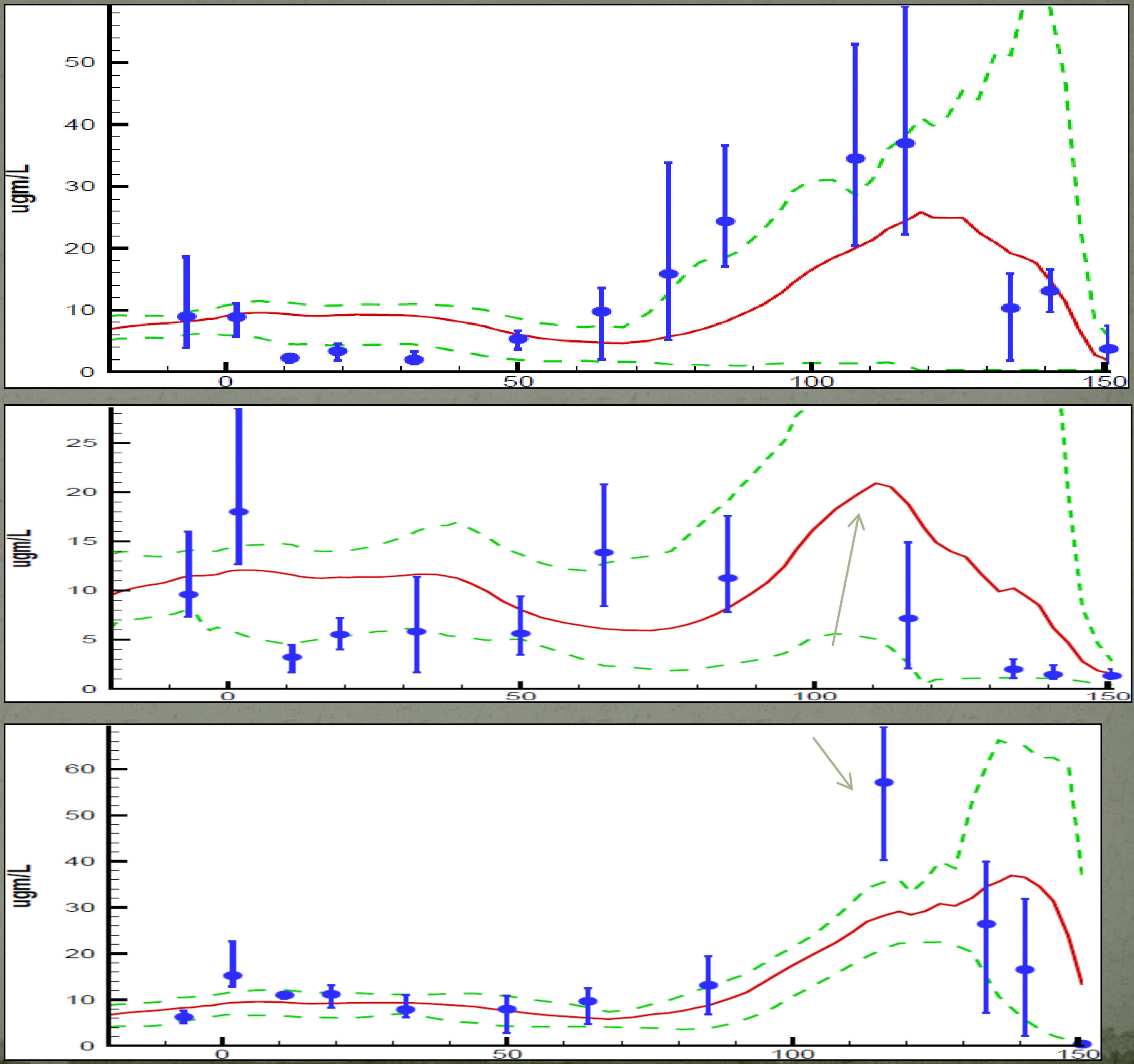
Source: Cerco and others, 2010

Summer

1994
Normal

1996
Normal but
very wet Aug

1999
Dry but wet Aug



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Science Advisory Panel

- Clifton Bell (VAMWA)
- Brian Benham (VT)
- Claire Buchanan (ICPRB)
- Paul Bukaveckas (VCU)
- Greg Garman (VCU)
- Eileen Hoffmann (ODU)
- Will Hunley (VAMWA)
- Rebecca LePrell (VDH)
- Winston Lung (UVA)
- Harry Marshall (ODU)
- Ken Moore (VIMS)
- Margie Mulholland (ODU)
- Kim Reese (VIMS)
- Peter Tango (USGS)
- Harry Wang (VIMS)

Guide and assist the Commonwealth in determining the approach, scope, design, and performance of a study to be performed over the next 3-5 years.

Panel Objectives

- Assessment of the modeling framework for linking CHLa in the estuary with nutrient loads to the estuary.
  - What changes can be incorporated to the model for better fit with observed CHLa (hydrodynamics, grazing, etc.)?
  - How do these changes affect attainability (nutrient load-CHLa relationship)?
- Evaluating existing numeric CHLa criteria for the James. Are these scientifically defensible?
  - What are the approaches that may be used to develop CHLa criteria?
  - What do we mean by "scientifically defensible"?

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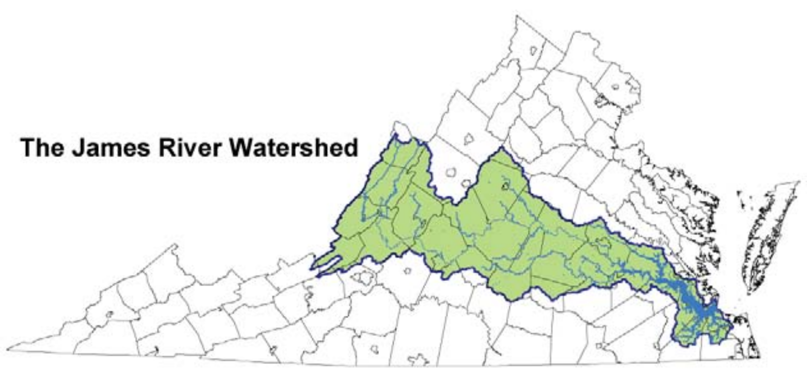

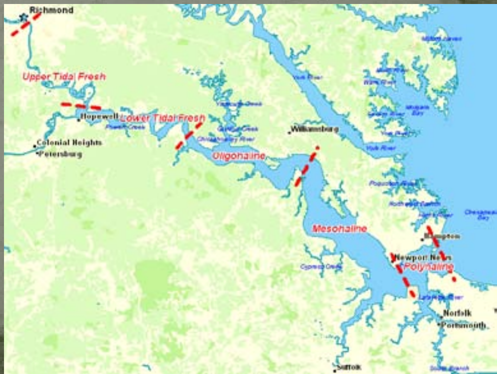

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Modeling Project Team

CEC

Dave Jasinski (Project Administrator) Data management & analysis.

VIMS

Roger Mann – (Project Manager) Fisheries scientist
Harry Wang – Hydrodynamic & Pollutant modeling
Jian Shen – Hydrodynamic, Water Quality, and Pollutant modeling
Bo Hung – Hydrodynamic & Water Quality modeling
Mac Sisson – GIS & Numerical modeling

HDR|HydroQual

James Fitzpatrick – Water Quality Modeling
Andrew Thuman – Water Quality Modeling
Thomas Gallagher – Water Quality Modeling

Tetra Tech

Andrew Parker – Hydrologic, Hydrodynamic, & Water Quality modeling
Peter von Lowe – Point & Non Point source pollution assessment
John Hamrick – EFDC Modeling
John Riverson – Watershed modeling
Sen Bai – Watershed & EFDC modeling

ODU

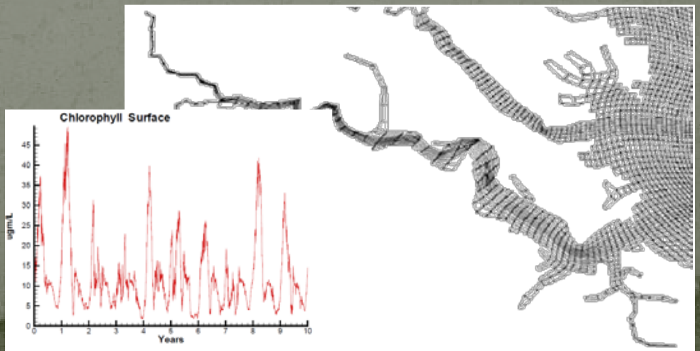
Margaret Mulholland – HAB expert

UNC

Hans Paerl – HAB/Plankton expert

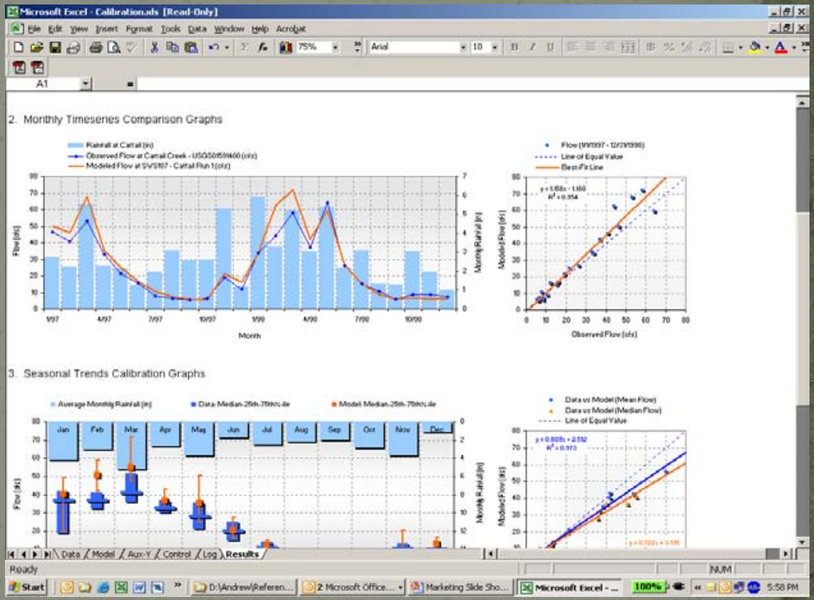
VCU

Paula Buckaveckas – Plankton Dynamics



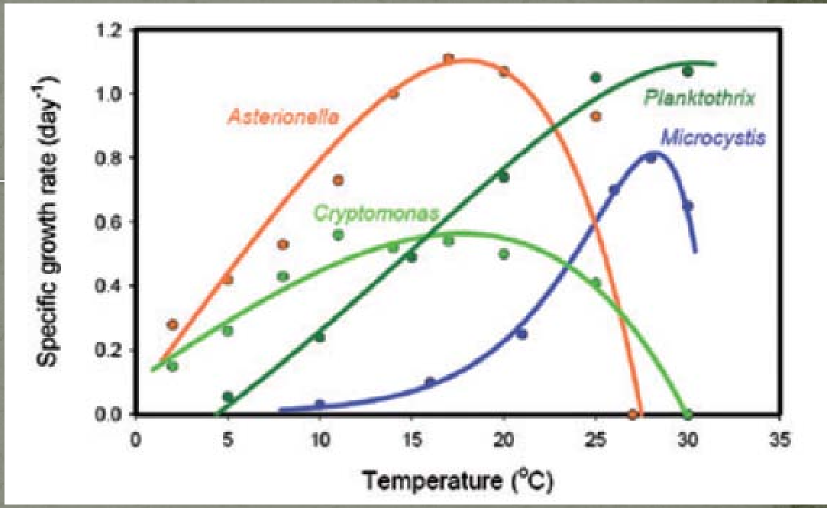
Flow & Nutrient Budget

- Estimates of nutrient loading and flow will be made based on a number of sources – USGS gage stations, water quality stations, 5.3 watershed model
- Use tools such as Hydrocal to assess nutrient and flow budgets



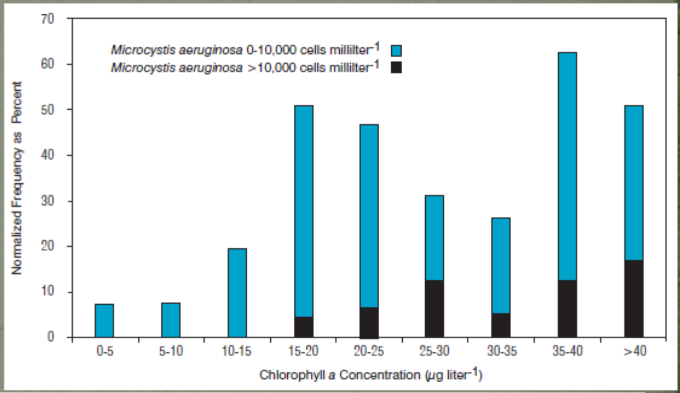
Critical Condition Assessment

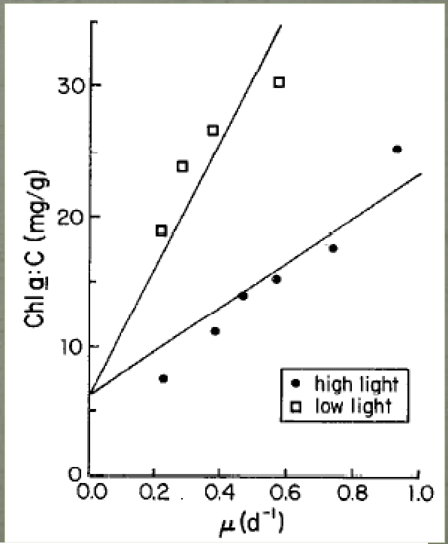
- Reassess USEPA analysis using information gathered from Subtask 2.1
- Expand analysis to include seasonally-averaged Qs and temperatures
- Look at drought/wet periods to see if they can explain the occurrence of HABs



Biological Reference Curves

- Site specific curves to be developed for fresh water to polyhaline regions of James River Estuary
- Unlike DO end-points, chl-a may be a challenge, but species diversity and/or likelihood of HAB bloom may be considered
- Conduct a Cumulative Frequency Distribution (CFD)-based assessment method
- Season specific due to changes in C:Chl ratio





Model Review / Selection

- Subtask 3.1 – Watershed/Loading Model
- Subtask 3.2 – Hydrodynamic and Water Quality
- Models
- Subtask 3.3 – Phytoplankton/HAB Model
- Subtask 3.4 - Probabilistic – Empirical Model
- Subtask 3.5 – Predictive Accuracy

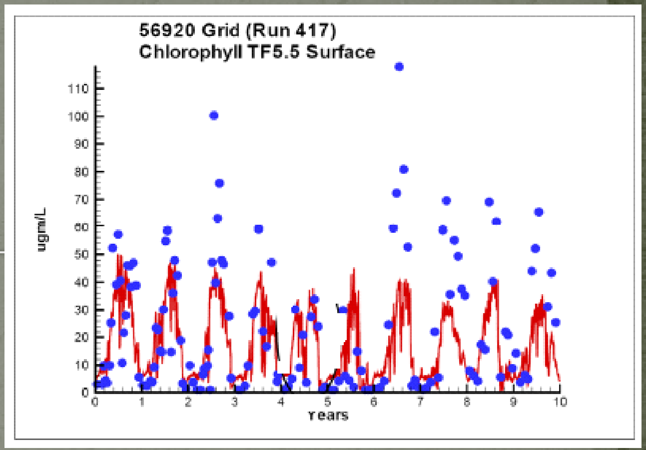
Subtask 3.1 Watershed Model

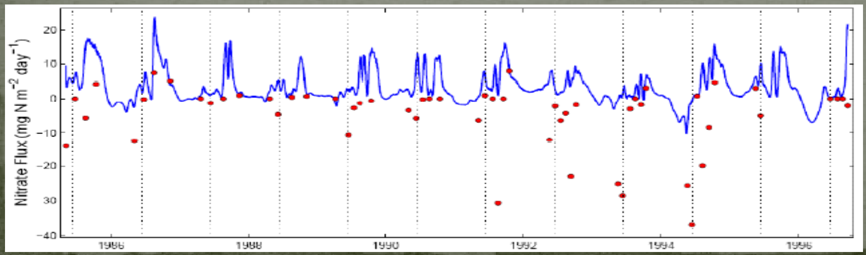
- Develop high resolution watershed model
  - Provide BCs for river models (flow and nutrient/ sediment loads)
  - Better represent local conditions
  - Mesh with existing Chesapeake Bay Watershed Model

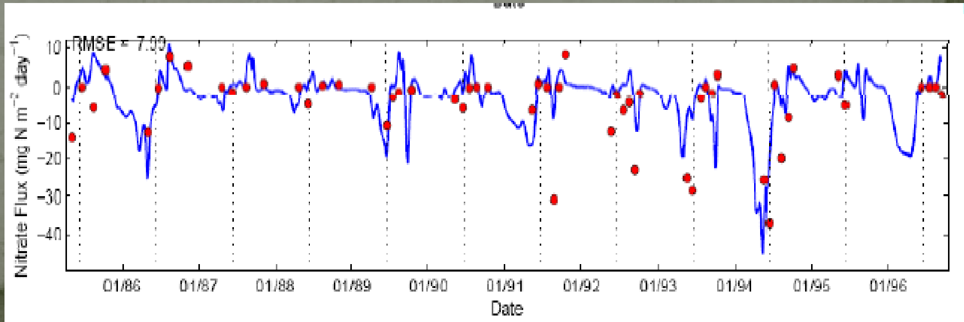
- Anticipate using EPA's LSPC
  - Loading Simulation Program- C++
  - Based on HSPF model algorithms (consistent with EPA Chesapeake Bay Watershed Model)
  - Benefits include previous application to criteria development, efficiency when running scenarios, streamlined model output, and seamless integration with river models

Subtask 3.2 – Hydrodynamic and Water Quality Models

- Review Chesapeake CH3D and CE-QUAL-ICM models
- Limitations imposed by grid resolution, processes and parameterization
- Importance of top-down control of phytoplankton
- Ongoing improvements to sediment-nutrient flux model
- Dual water quality model approach (EFDC/RCA)

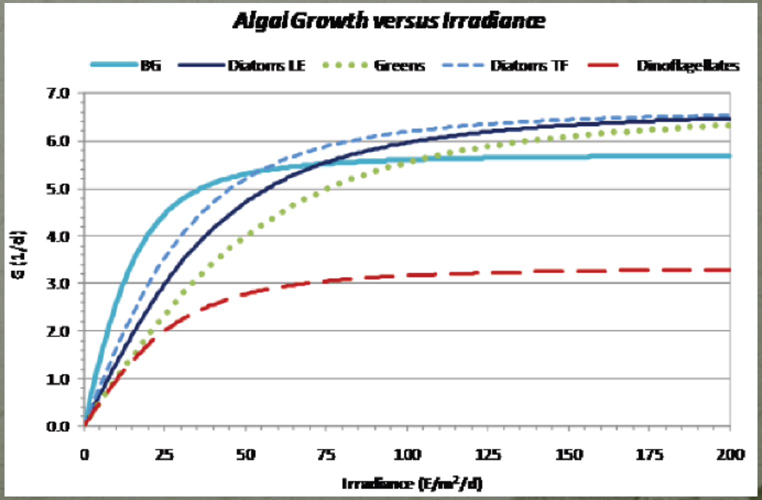






Subtask 3.3 – Phytoplankton/HAB Model

- Review existing CE-QUAL-ICM algal growth model and model coefficients
- Look to develop James River HABs model using guidance from Drs. Mulholland, Bukaveckas and Paerl
- Will considerer freshwater and marine (*C. polykrikoides*) HABs



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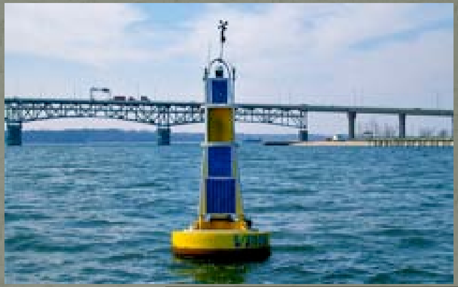
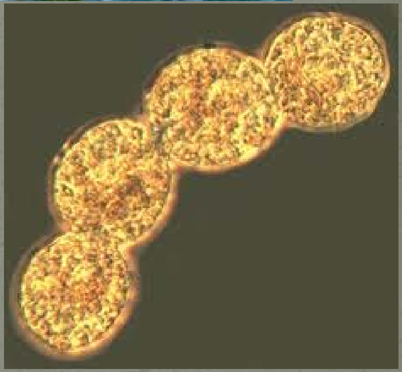
Monitoring Strategy – year 1



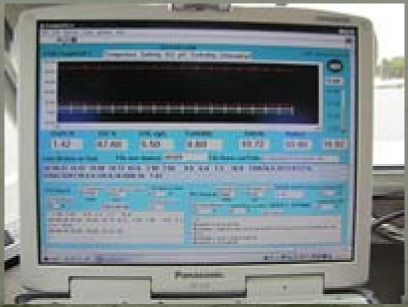
- Algal Bloom Characterization
  - Fixed stations
  - Continuous monitoring
  - Data flow
  - ID and numeration
  - Nutrient limitation & regeneration
- Designated Use Impairments
  - Bioassays
  - Microcystins
  - Literature review
- Model Development
  - All above
  - SONE

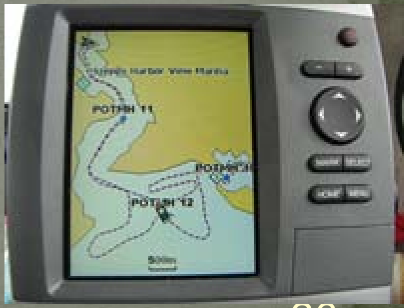


Monitoring Project Team

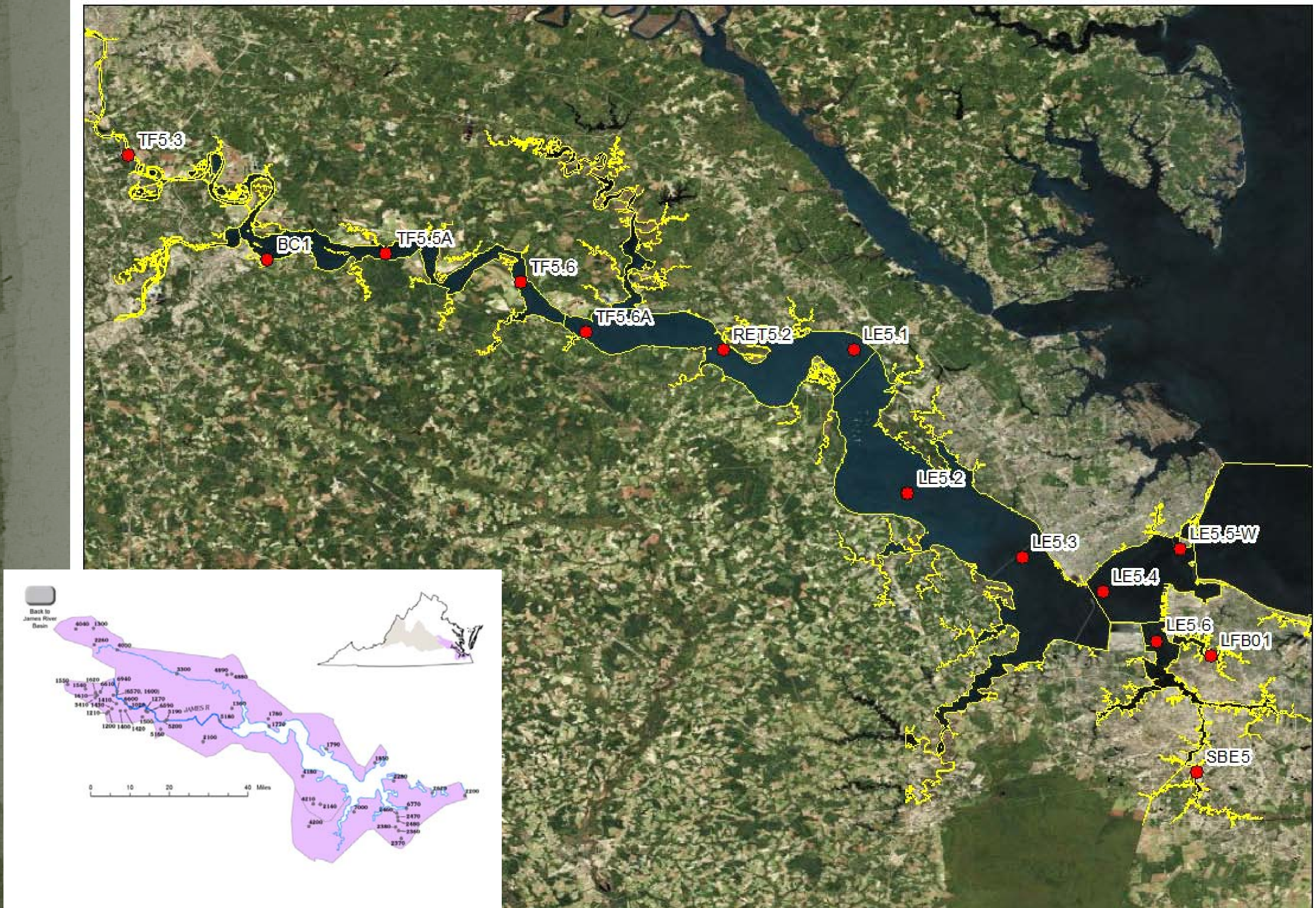
- ODU
  - *Margaret Mulholland* – HAB & nutrient regeneration
  - *Harry Marshall* – Phytoplankton & HAB IDs
- VCU
  - *Paul Buckaveckas* – Nutrient Dynamics
- VIMS
  - *Ken Moore* – Biological data and dataflow
  - *Kim Reece & Wolf Vogelbein* – HAB /genetics , aquatic toxicology and bioassays
  - *Iris Anderson* – Nutrient regeneration and SONE

- HRSD
  - Dataflow
  - Continuous monitoring
- City of Richmond

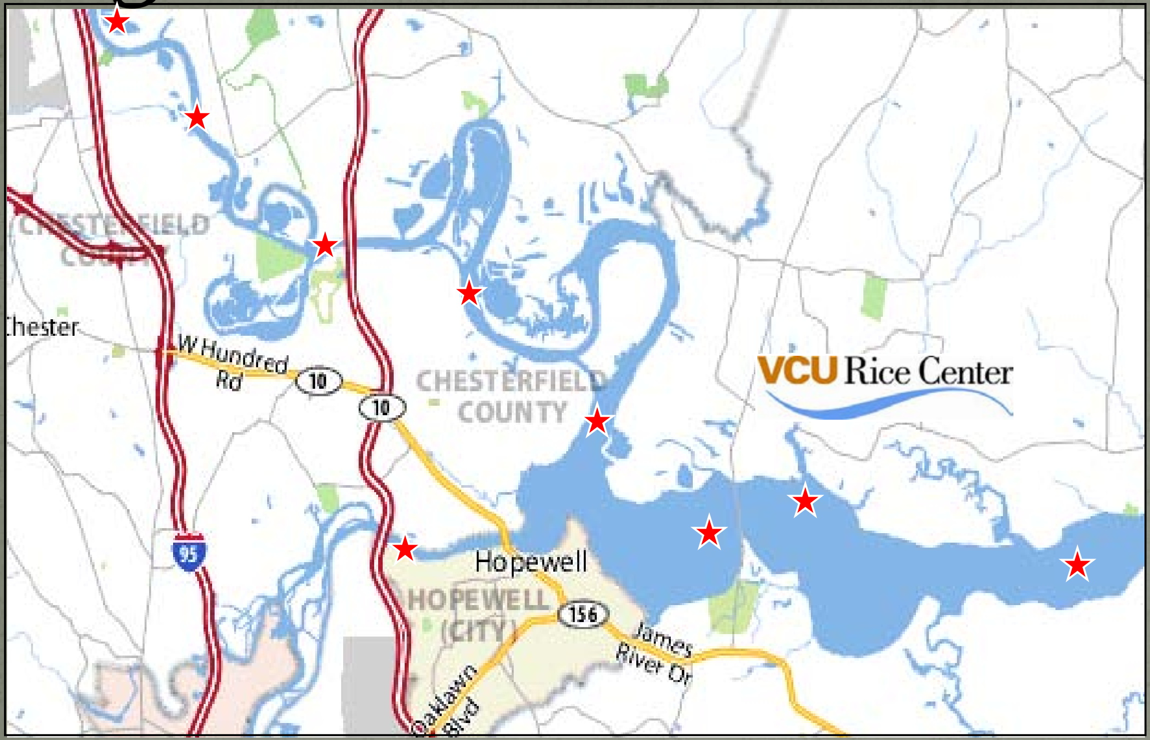




Fixed Stations



Algal Blooms in the Tidal-fresh James River

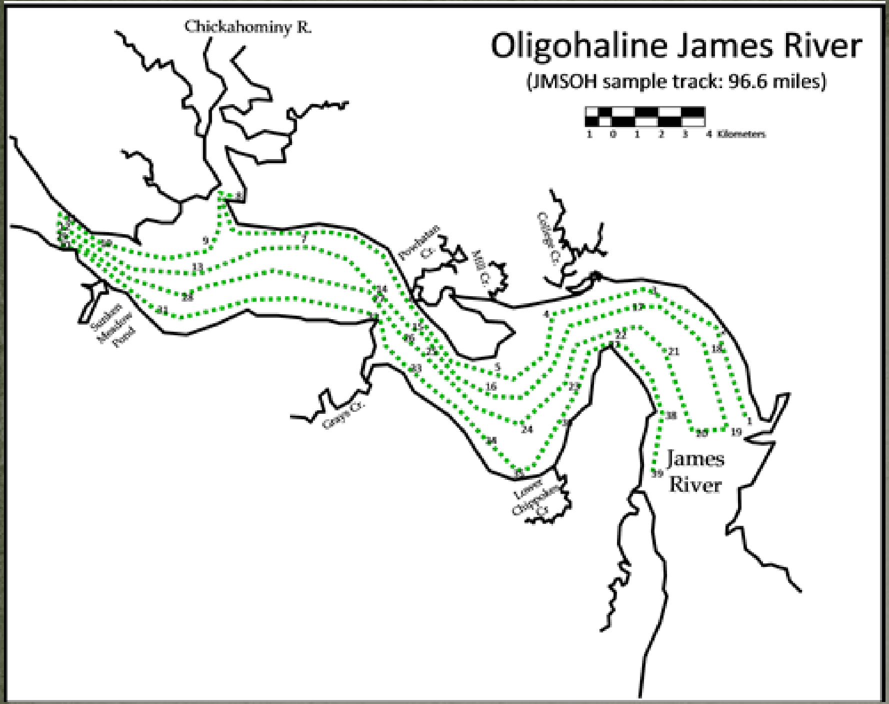


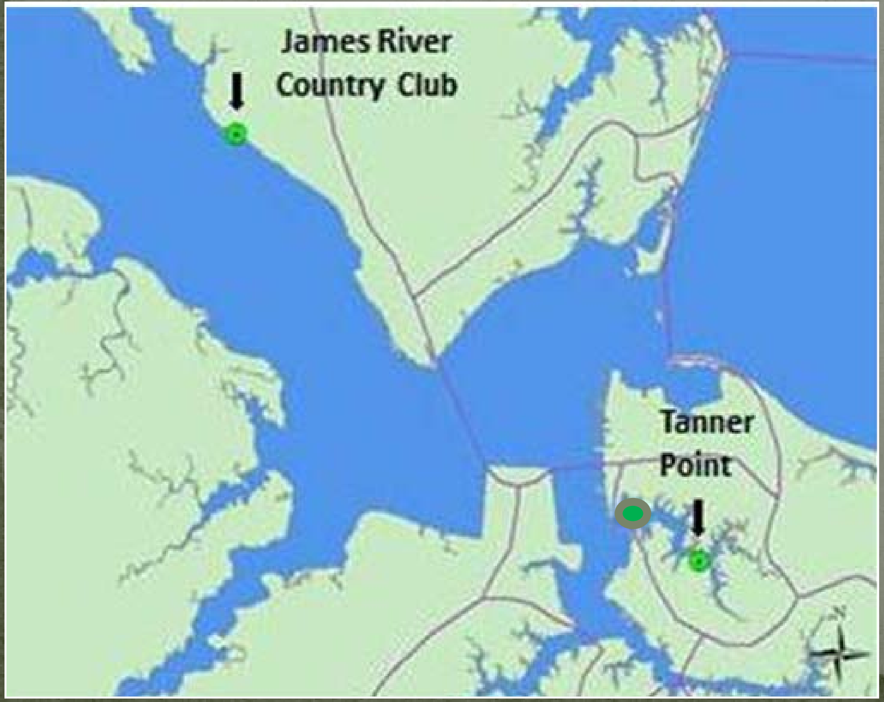
Weekly fixed-station monitoring of water quality, CHLa, nutrients and microcystin.

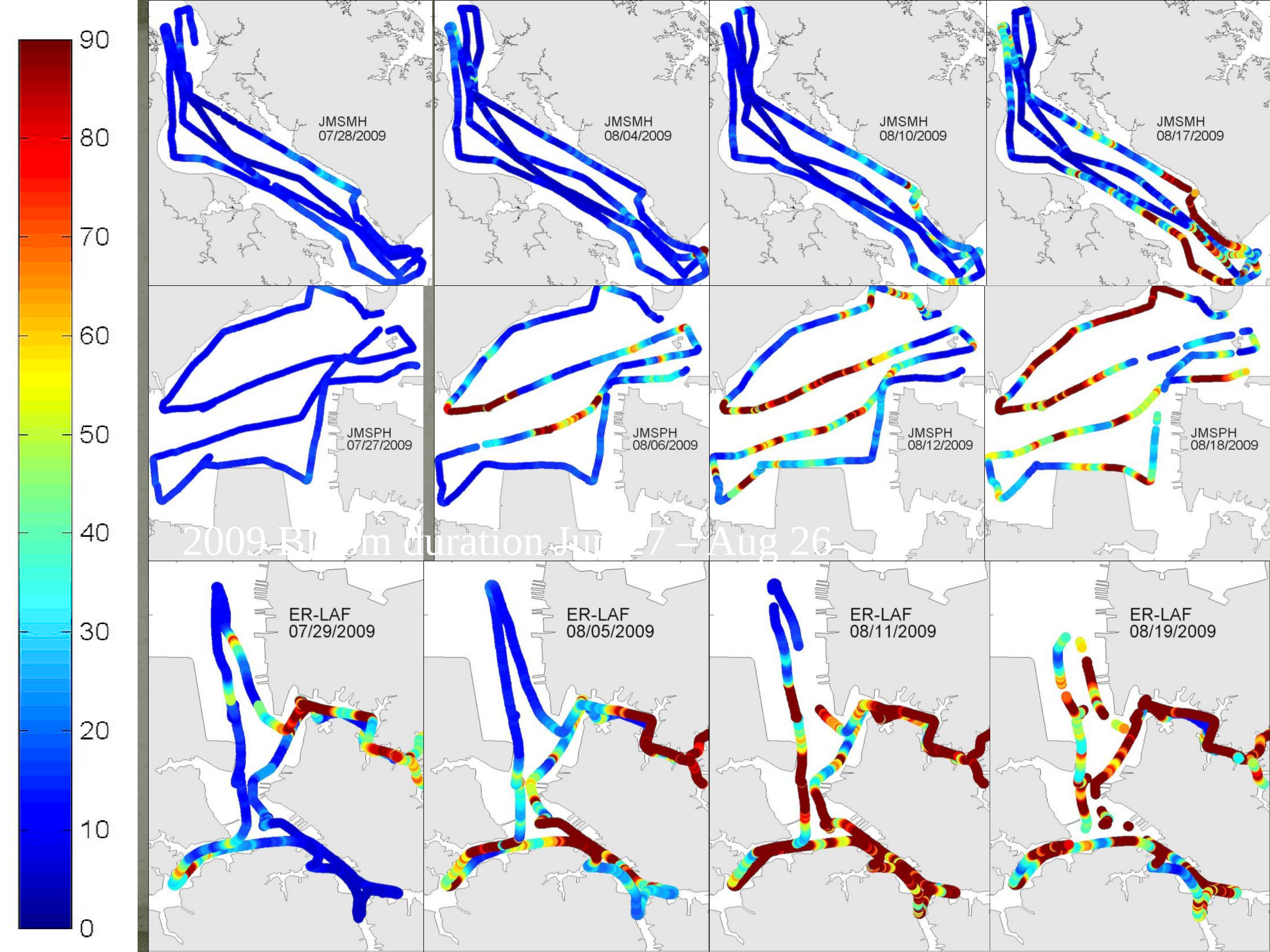
Continuous monitoring at VCU Rice Center for water quality, CHLa and phycocyanin.

Sampling locations for VCU-City of Richmond James River Monitoring Program.

Typical *Dataflow* cruise track illustrated for the for the oligohaline segment (**top left**). *ConMon* station locations (**bottom left**). Real time *ConMon* station at James River Country Club & 2 in Lafayette.







2009 Bl[illegible]m duration Ju[illegible]7 – Aug 26

DATA NEEDS FOR ASSESSING CHLa CRITERIA OF THE JAMES RIVER

Department of Biological Sciences: Old Dominion University

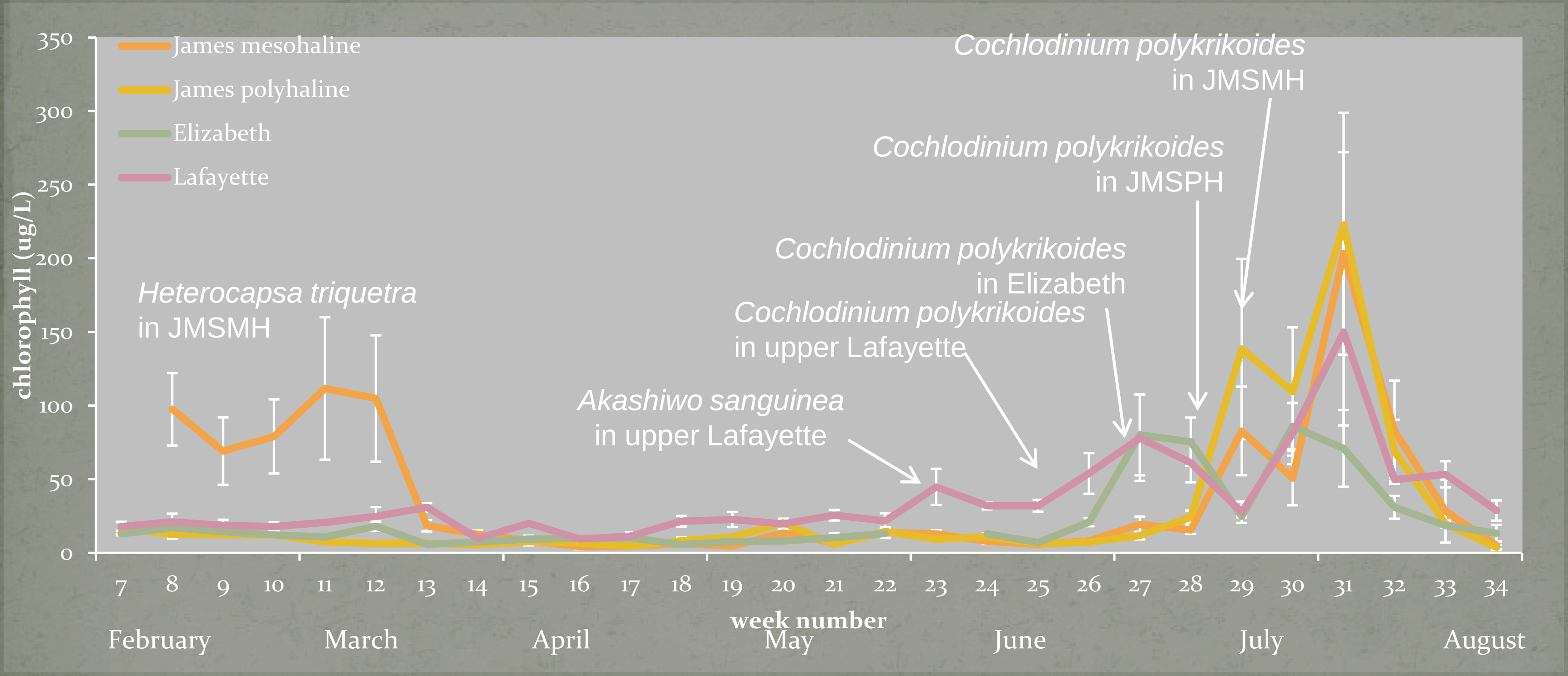
Major Objectives:

1. Identify phytoplankton species composition and abundance contributing to chlorophyll concentrations in the James, Elizabeth, and Lafayette rivers.

2. Monitor the status of HAB taxa throughout the study period when ever present, and not just during blooms development.

3. Identify river locations containing specific algal concentrations related to high chlorophyll levels and bloom development.

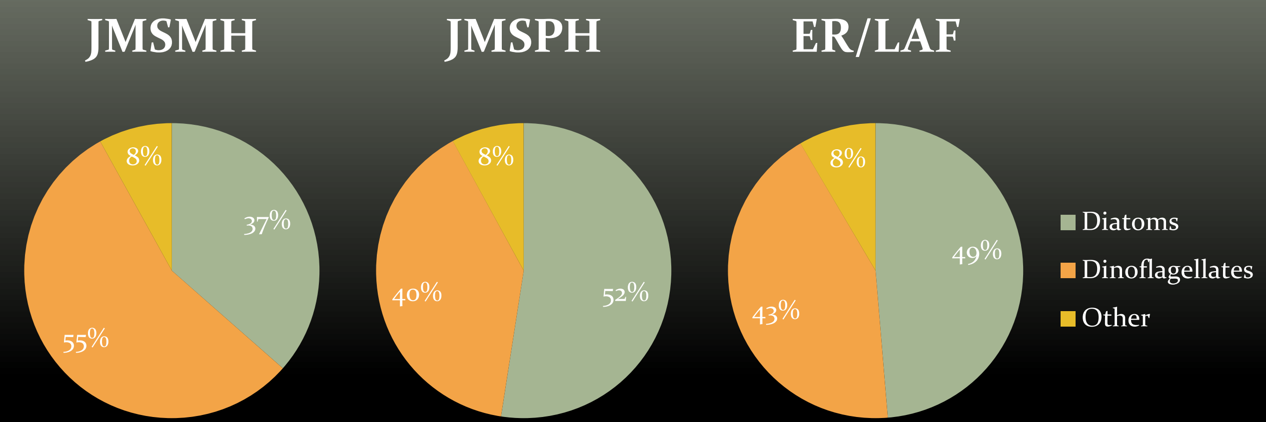
Results: James River Succession of Species Bloom Development With Hotspots and Transport



2012

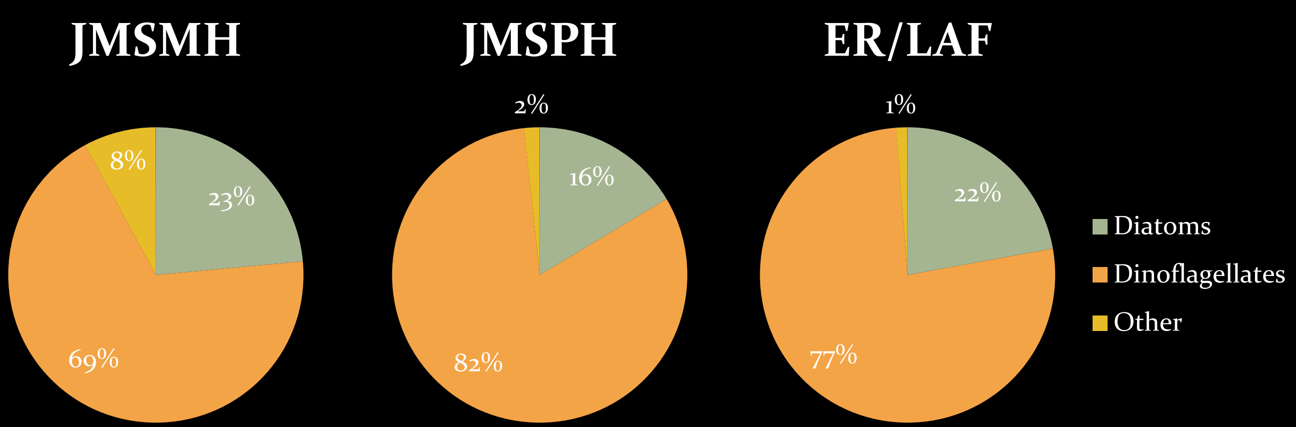
2012 winter/spring composition

- Abundance



Diatoms: 46%
Dinoflagellates: 46%
Other: 8%

- Biomass



Diatoms: 21%
Dinoflagellates: 76%
Other: 4%

Upper James – VCU (2012) Activities

- Characterizing algal blooms
  - Weekly monitoring of CHLa, nutrients, and phytoplankton.
- Algal Bioassay Experiments
- Grazer Effects
  - Monthly fish gut contents
  - Rangia Grazing Experiments
- Microcystin Monitoring
  - Weekly water
  - Monthly sediments & biota

Algal Bioassay Experiments in T-F James

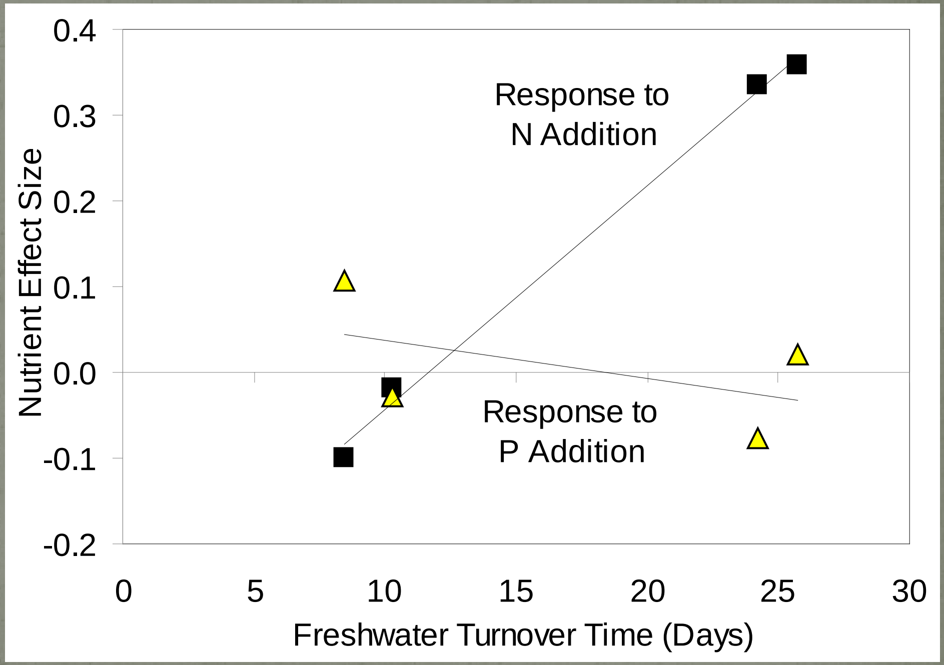
Light vs. Nutrient Limitation

N vs. P, NO_3 vs. NH_4 vs. DON

Monthly experiments (June–Oct) using water collected at Rice Pier & JMS75.

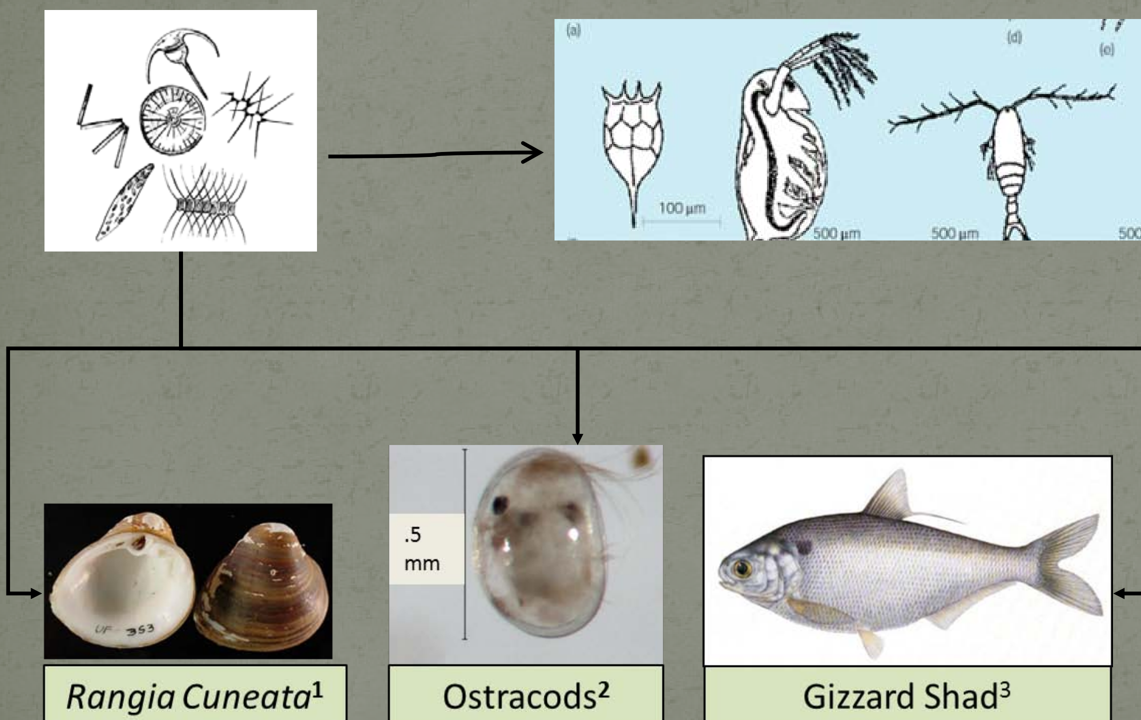
Response variables: algal growth rates (CHLa, POC), and Microcystin production.

Results used to model nutrient utilization = f(WRT).



Top-down Controls on Algal Blooms

Year 1 Objective: Who are the important consumers of suspended and sedimented CHLa in the tidal freshwater James River?



Prior work showed that zooplankton grazing rates were low.*

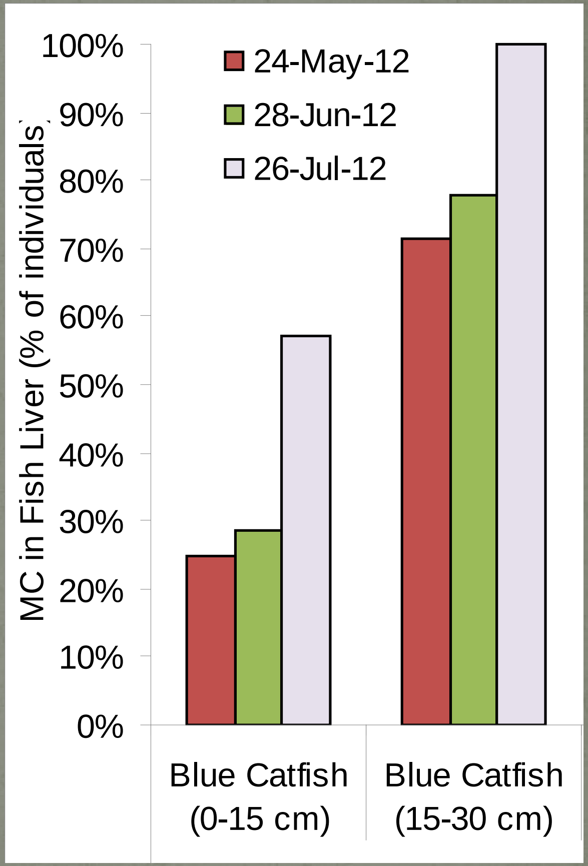
Measuring filtration rates by wedge clams (abundance data available from CBP benthic surveys).

Measuring CHLa in gut contents of benthic- and pelagic-feeding fish.

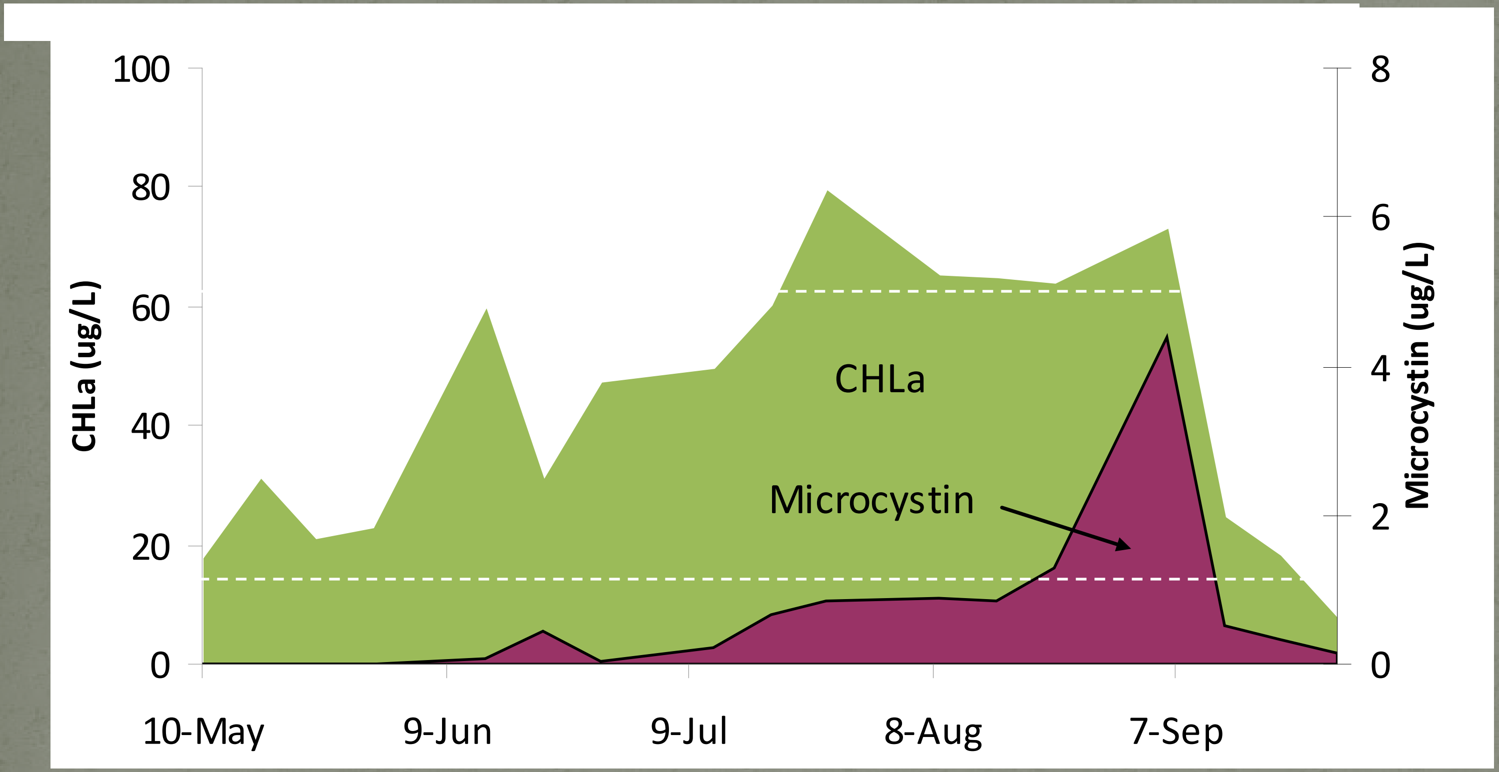
*Bukaveckas et al. (2011) *Estuaries & Coasts*

Impairments Associated with Algal Blooms

- Monthly monitoring (June-Oct) of Microcystin accumulation in target species that are important components of the food web:
  - Macroinvertebrates: Rangia, blue crabs.
  - Fish: Atlantic menhaden, gizzard shad, juvenile and adult catfish.
- 10 individuals per group per month (as available); analyses include liver and muscle.



HABs in the Tidal-fresh James River



Contact standard

Drinking standard

CHLa and cyanotoxins in the James River (JMS 75) during 2011.

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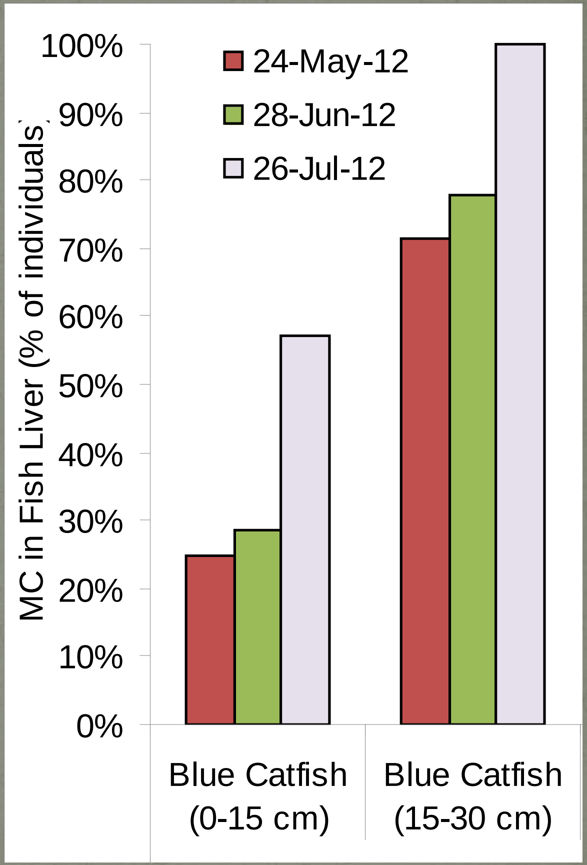


Sample processing in Reece Lab

Two 100 ml water samples collected at each site

?

Bloom/species composition

3 um filtration

Visual diagnosis via light microscopy

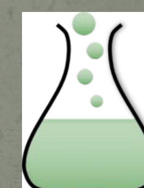
?

?

DNA extraction

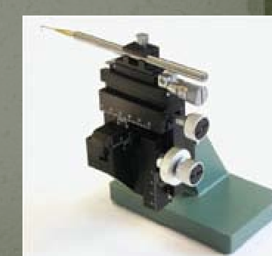
Bioassay (2.1)

Establish cultures



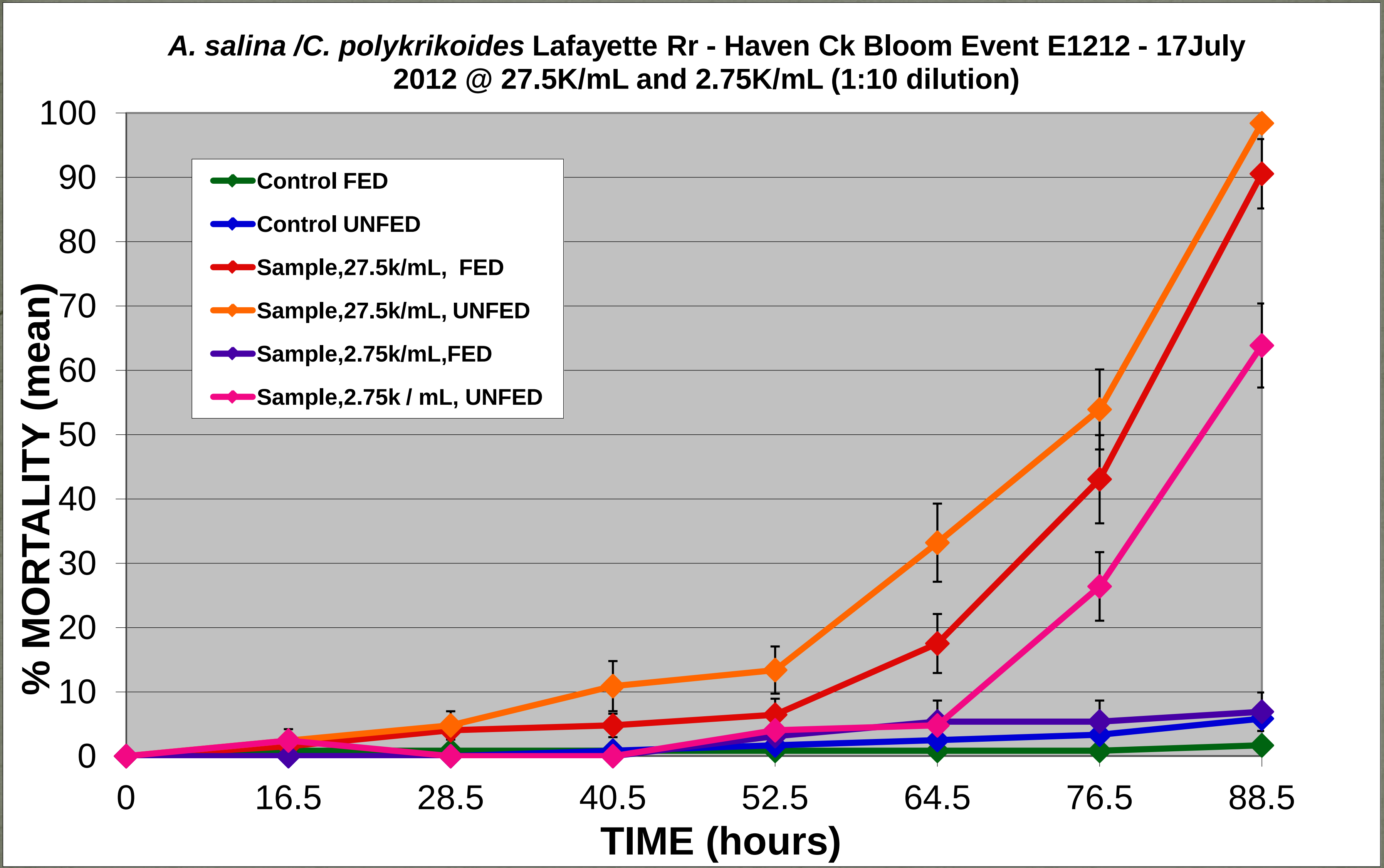
PCR assays: *C. polykrikoides*, *K. veneficum*, *P. piscicida*, *P. shumwayae*, *Luciella* spp., *A. monilatum*. *Prorocentrum* spp., Raphidophytes

Clone cultures



Quantify cells/ml via Real-Time PCR

Bioassay Results

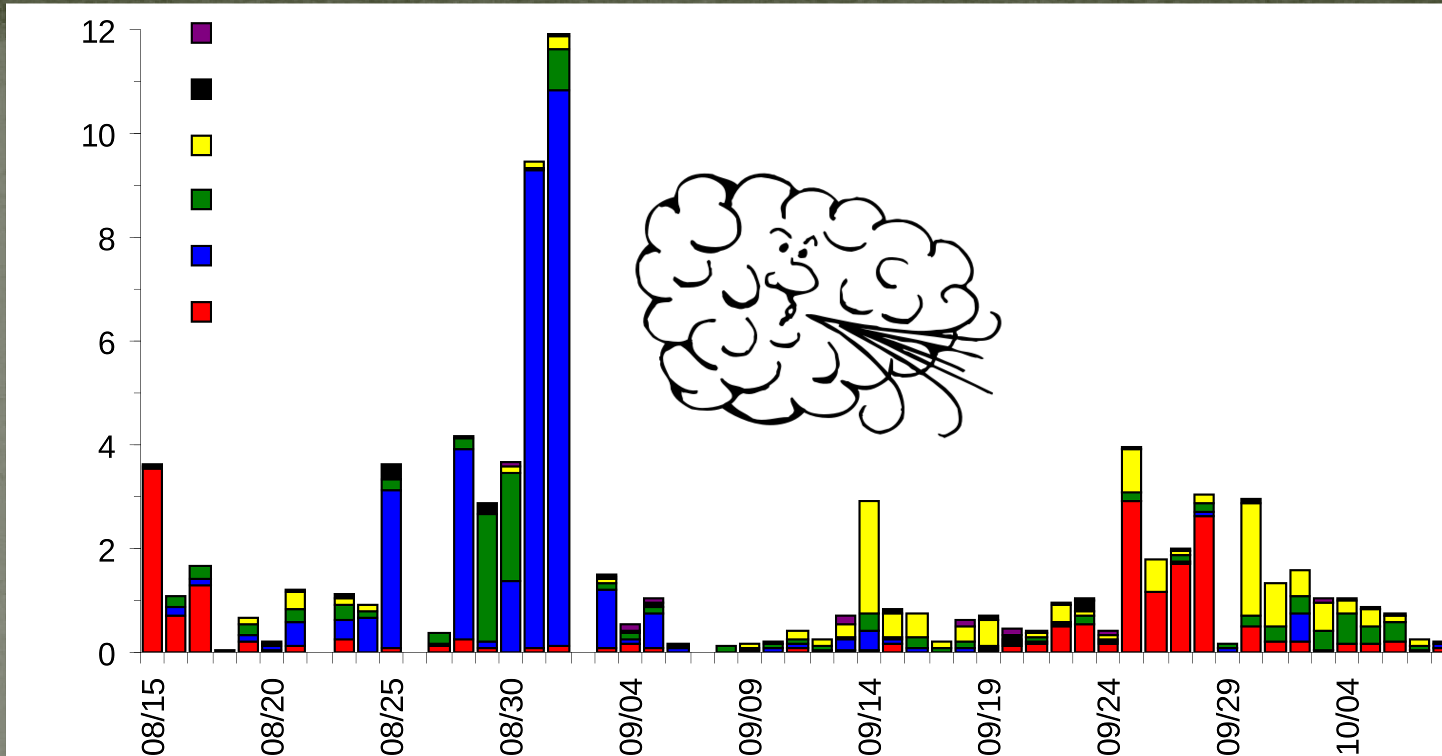


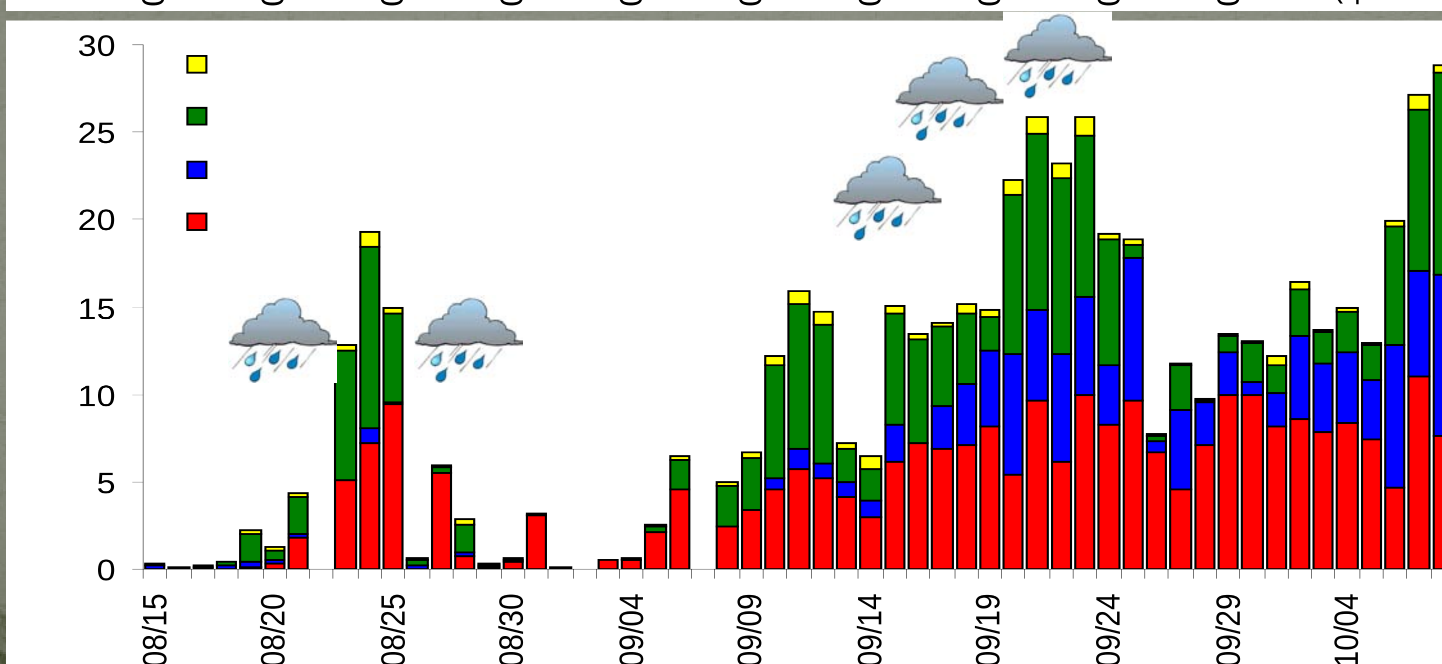
CHLa – 422 ug/L

To identify bloom triggers -

at relevant timescales for bloom initiation
HRSD CMAP platform has been successful for *Cochlodinium*

- Sample before, during, and after a bloom to better understand bloom initiation with respect to nutrient uptake dynamics and ambient nutrient concentrations on short timescales
- To identify triggers and controls on bloom formation


12
10
8
6
4
2
0
08/15
08/20
08/25
08/30
09/04
09/09
09/14
09/19
09/24
09/29
10/04


30
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09/14
09/19
09/24
09/29
10/04

Analytes

- Nutrient mapping – NO_3, NO_2, NH_4, urea, TDN, TDP, DIP
- Diagnostic pigments – paired with chl and taxonomic identifications-develop functional groups for modeling
- Continuous monitoring in Lafayette at fixed sites – near mouth and up river
- Nutrient mapping – HRSD
- Relate to local and regional meteorology
- Storm sampling – Lafayette
  - Continuous monitoring coupled with dataflow

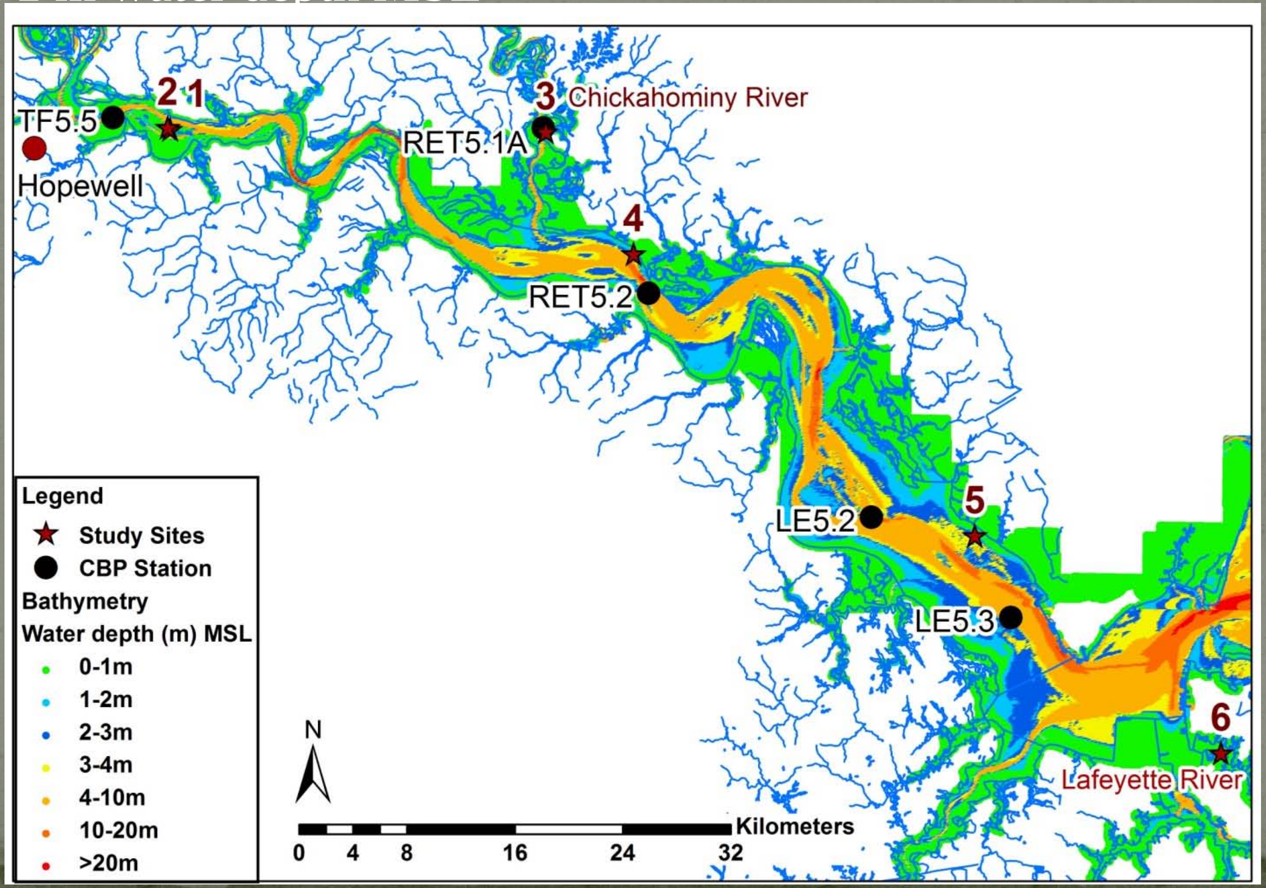
SONE Objectives

- Perform measurements of sediment : water and water column nutrient fluxes, metabolic rates and sediment characteristics at six sites along the James River during August 2012 and March/April 2013. The following data will be used to calibrate the James River water quality model:
  - Sediment : water fluxes of DIN, DIC, DIP, DON, DOC, SiO_2.
  - Metabolic rates (gross primary production, respiration, net community production, sediment oxygen demand)
  - Sediment characteristics: grain size, bulk density, organic content, benthic chlorophyll *a*, extractable nutrients (DIN, DIP), organic carbon, total nitrogen, total phosphorus.

Site Selection

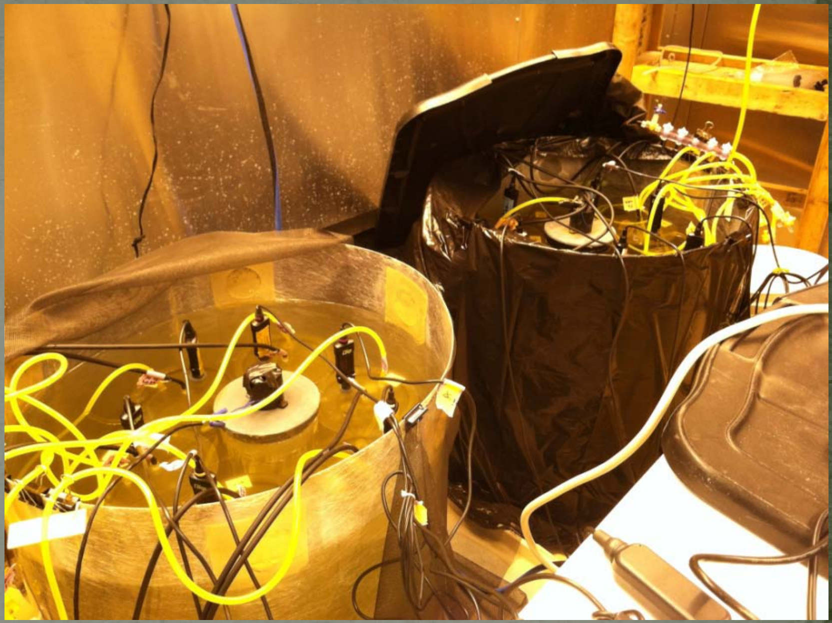
Six sites were selected based on modeling requirements (consulted with Jian Shen, Jim Fitzpatrick) and to leverage data collections by Paul Bukaveckas, Ken Moore, and Kim Reece in the James River and Margie Mulholland in the Lafayette River.

- 3 sites at 2m water depth MSL
- 3 sites at 1 m water depth MSL



Methods – Flux Measurements

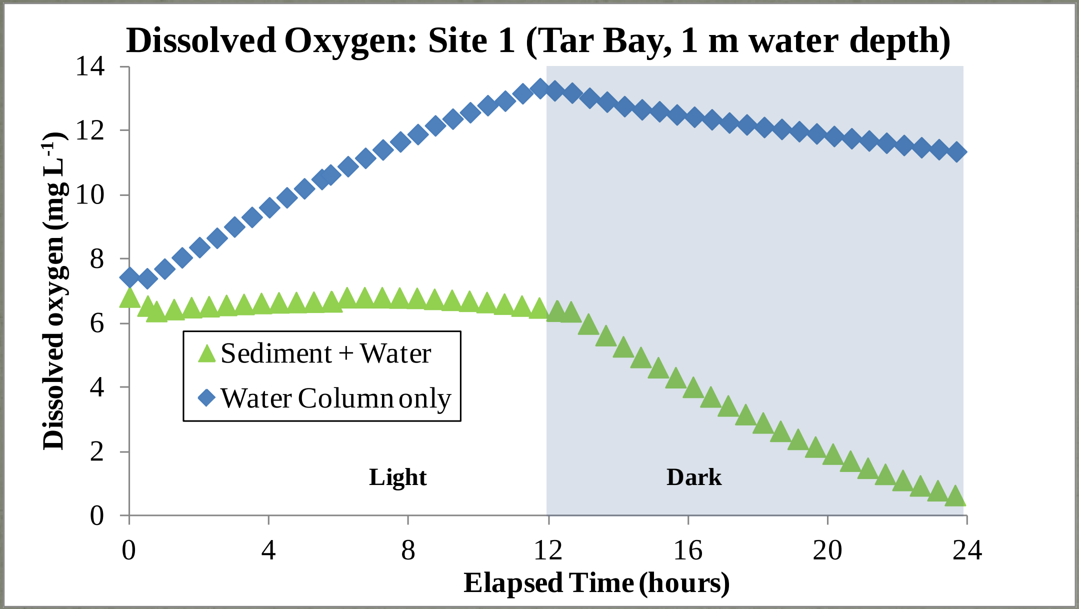
- Sediment cores (13.3 cm i.d x 40 cm tall) were collected at 3 randomly selected stations, along with water, from each site.
- Cores were returned to VIMS and incubated uncapped overnight in site-specific bottom water at in-situ temperature in environmental chamber.
- Next morning metabolism and nutrient flux experiments were initiated at in situ light levels after capping the sediment+water and water column only cores (n=3 each).
- Water samples for DIC, DIN, DIP, DON, DOC, SIO_2 were collected at dawn, mid-day, dusk, and the following dawn.
- Cores were instrumented with Hach DO sensors for continuous measurements of DO.

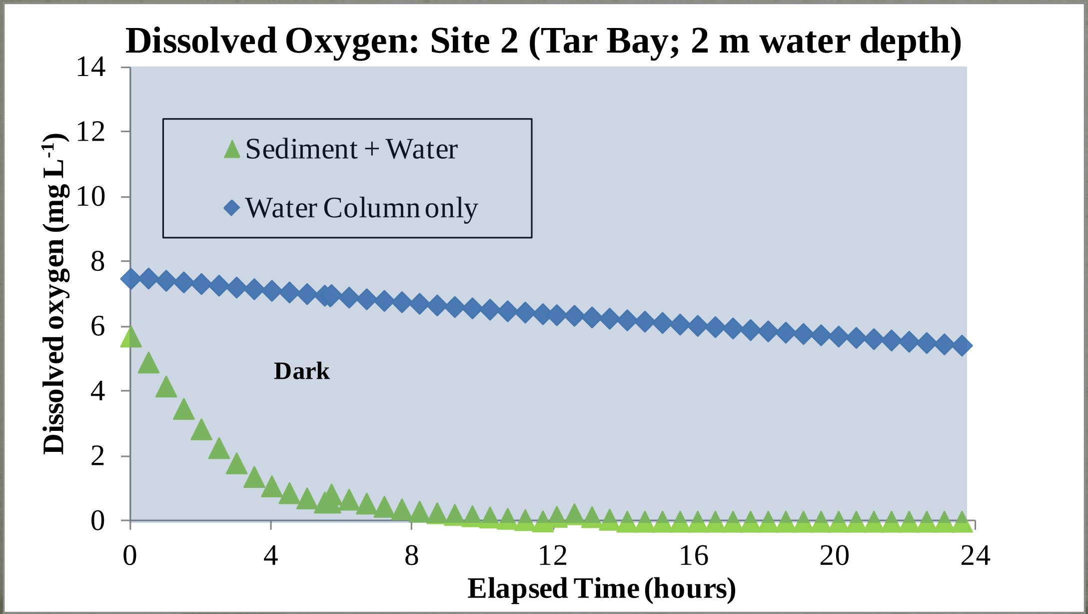


Methods - Site Characterization

- Sediment collected concurrently with the flux sediment cores were analyzed for:
  - Bulk density, organic content, grain size, organic C content, TN , TP, DIP in the 0 – 1 cm and 1 – 5 cm sediment depth horizons.
  - Benthic chl *a* and phaeophytin was measured in the 0 – 1 cm sediment depth horizon.
- The water column was characterized at the time flux cores were taken by:
  - YSI 6600 profiles (temperature, salinity, turbidity, in vivo chl *a*, and DO)
  - Grab samples for concentrations of DIN, DIP, DON, DOC, silicate, extractable chl *a*, phaeophytin
  - LiCor for photosynthetically active radiation (PAR) and light attenuation.

Preliminary Results – August 2012





- For Tar Bay 1 m water depth cores:
  - In the light (at in-situ level level): DO increased in the water column, but remained relatively constant in the sediment+water cores
  - In the dark: DO decreased at a faster rate in the sediment+water cores than in the water column cores.
- For Tar Bay 2 m water depth cores:
  - Cores kept in the dark throughout 24 hours to match in-situ level level
  - DO decreased at a faster rate in the sediment+water cores than in the water and 1 m cores.

Outline

- Background
- Chesapeake Bay TMDL Process
- JR Modeling & Monitoring
- Schedule

Schedule

2011	Workplan Developed Notice of Intended Regulatory Action (NOIRA)
2012	Workplan Implementation
2012-14	Monitoring and Modeling
2015	Panel Recommendations and Assessment Review
2016	Develop Regulatory Proposal (DEQ, if warranted)
2017	Regulatory Review (if necessary) Complete WIP III

http://www.deq.virginia.gov/wqs/rule.html#James_Chl_A_study

Questions
&
Discussion

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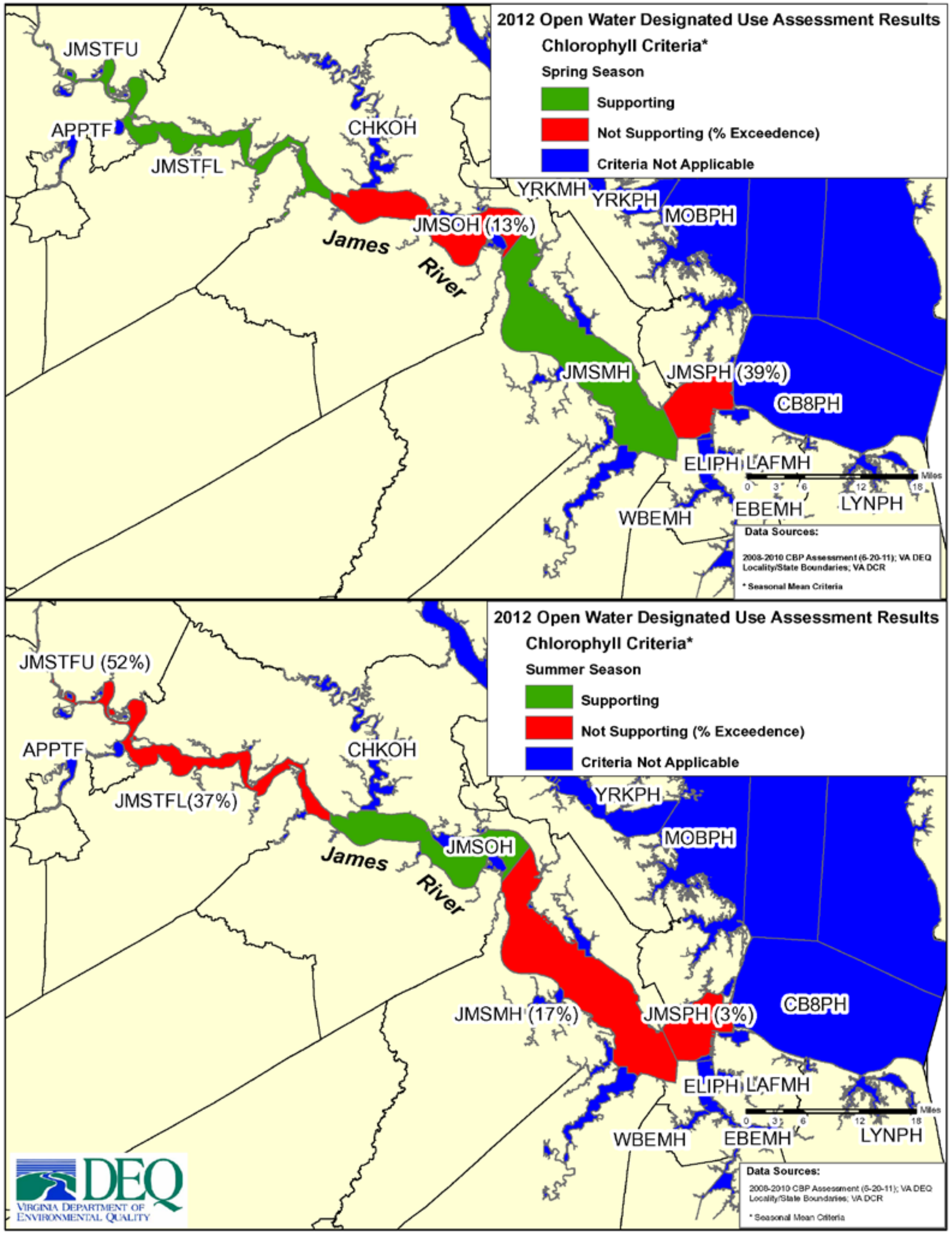
VA DEQ
(804) 698-4314
arthur.butt@deq.virginia.gov

Ches. Bay and Tidal Tributaries:

- Numeric Chlorophyll criteria only apply to the James River
- Criteria were met in:
  - Upper & Lower James during the spring season
  - Middle James during the summer season



Status: Scientific Review

- Scientific study to review basis for setting final nutrient allocations
  - VCU contracted to assist in managing study and Science Advisory Panel
- Completed detailed monitoring & modeling work plan
  - James River Study
    - Modeling contract (awarded 3/12)
      - Re-assess chlorophyll attainability
    - Monitoring contracts (awarded 5/12
      - focus on algal bloom characteristics and
      - linking blooms to designated uses
- Initiate Rulemaking process – NOIRA issued; Regulatory Advisory Panel (TBD)

Alternatives Analysis Example

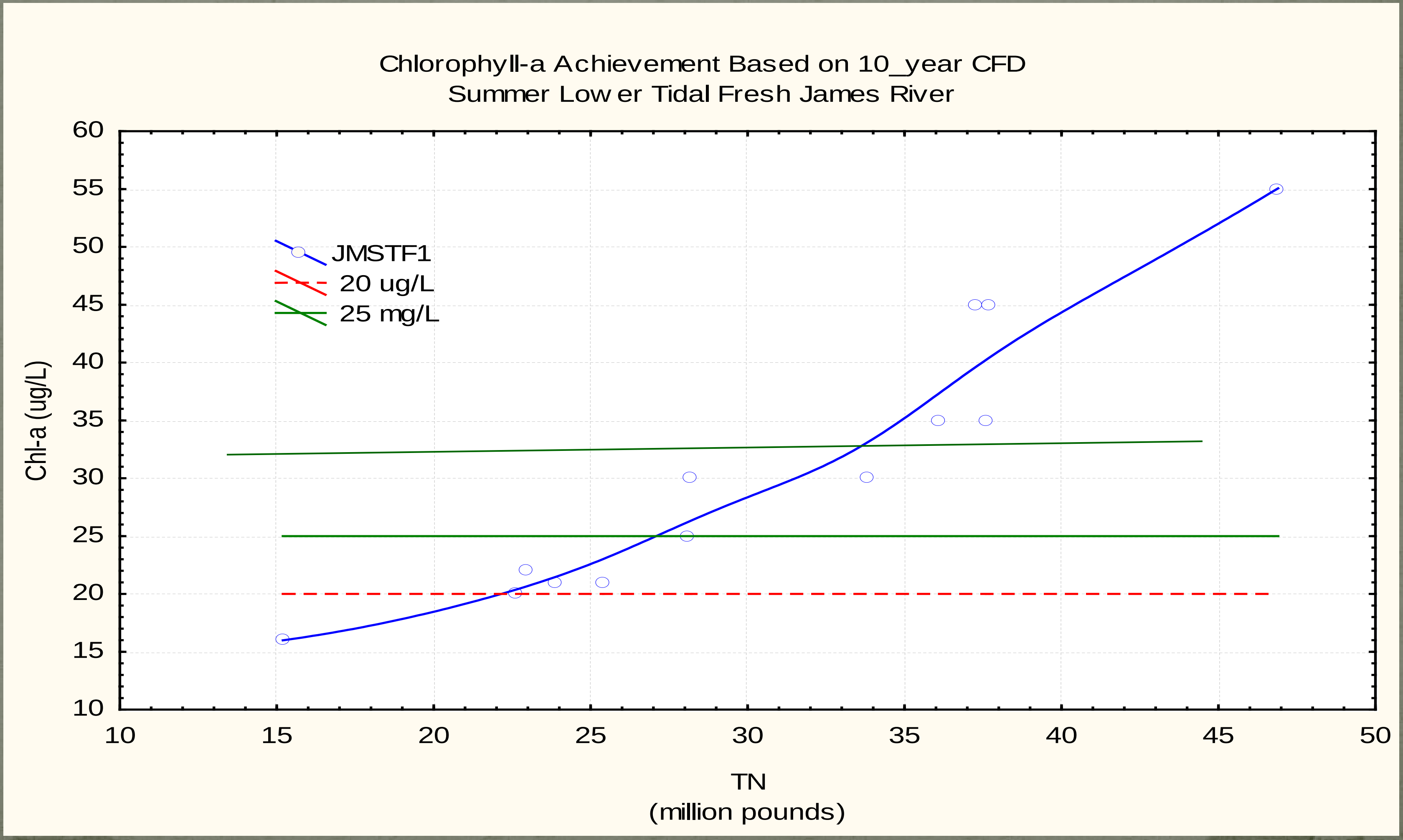


Figure O-4. Attainment of numeric chlorophyll *a WQS in the James River at the Chesapeake Bay basinwide loading level of 170 mpy TN and 11.3 mpy TP.*

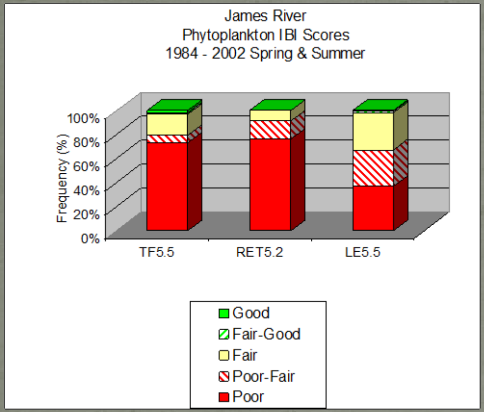
Cbseg	170 Loading Scenario 25.5 TN, 2.5TP '91-'93 CL Spring Seasonal	170 Loading Scenario 25.5 TN, 2.5TP '92-'94 CL Spring Seasonal	170 Loading Scenario 25.5 TN, 2.5TP '93-'95 CL Spring Seasonal	170 Loading Scenario 25.5 TN, 2.5TP '94-'96 CL Spring Seasonal	170 Loading Scenario 25.5 TN, 2.5TP '95-'97 CL Spring Seasonal	170 Loading Scenario 25.5 TN, 2.5TP '96-'98 CL Spring Seasonal	170 Loading Scenario 25.5 TN, 2.5TP '97-'99 CL Spring Seasonal	170 Loading Scenario 25.5 TN, 2.5TP '98-'00 CL Spring Seasonal
JMSTFL	0%	0%	1%	1%	1%	0%	0%	0%
JMSTFU	0%	0%	0%	0%	0%	0%	0%	0%
JMSOH	0%	0%	0%	2%	2%	2%	0%	2%
JMSMH	2%	0%	0%	0%	0%	0%	0%	0%
JMSPH	0%	0%	0%	0%	0%	0%	0%	0%
Cbseg	CL Summer Seasonal	CL Summer Seasonal	CL Summer Seasonal	CL Summer Seasonal	CL Summer Seasonal	CL Summer Seasonal	CL Summer Seasonal	CL Summer Seasonal
JMSTFL	0%	0%	0%	0%	4%	11%	11%	4%
JMSTFU	0%	0%	0%	0%	0%	0%	0%	0%
JMSOH	0%	0%	0%	0%	0%	0%	0%	0%
JMSMH	0%	0%	0%	0%	0%	0%	12%	12%
JMSPH	0%	0%	0%	0%	0%	0%	9%	9%

For this scenario, the James River Basin allocation is 25.5 mpy TN and 2.5 mpy TP. Failure to attain WQS is shown in red text as percent nonattainment.

Public Comment Received (in 2005)

- **Environmental** – must have numerical criteria; prefer the originally proposed criteria or close to the original criteria; no more delays.
- **Citizens** – reflect environmental comments.
- **Regulated** – concerns with scientific basis of criteria particularly in lower James; prefers upward adjustments of criteria; cost too high; benefits not clear or measurable.

Basis for Chlorophyll *a* Numeric Criteria



- Balance = Phytoplankton Index of Biotic Integrity (IBI), Diversity Indices
- Undesirable or nuisance aquatic plant life… = HAB, food quality issues
- Natural characteristics
- Attainability

Scientific Study & Review

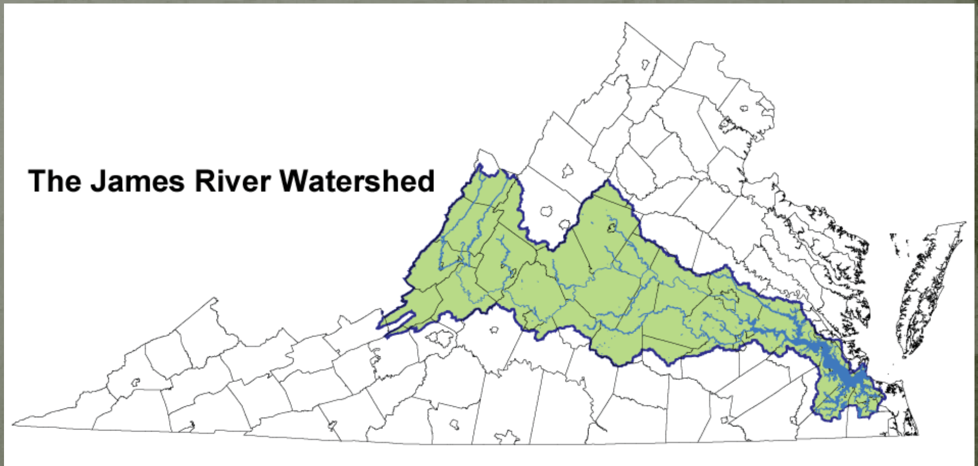
- Scientific study to review basis for setting final nutrient allocations
  - VCU contracted to assist in managing study and Science Advisory Panel
- Completed detailed monitoring & modeling work plan
  - James River Study
    - Modeling contract (awarded 3/12)
      - Re-assess chlorophyll attainability
    - Monitoring contracts (awarded 5/12)
      - focus on algal bloom characteristics and
      - linking blooms to designated uses
- Initiate Rulemaking process – NOIRA issued; Regulatory Advisory Panel (TBD)

DEQ Responses / Conclusions

- Set numerical criteria in the tidal James River.
- Setting chlorophyll criteria is not as quantitatively precise as the dissolved oxygen or water quality recommendations.
- Attainability can be used to focus in on a criterion value that will remain protective of designated uses based on the available scientific findings

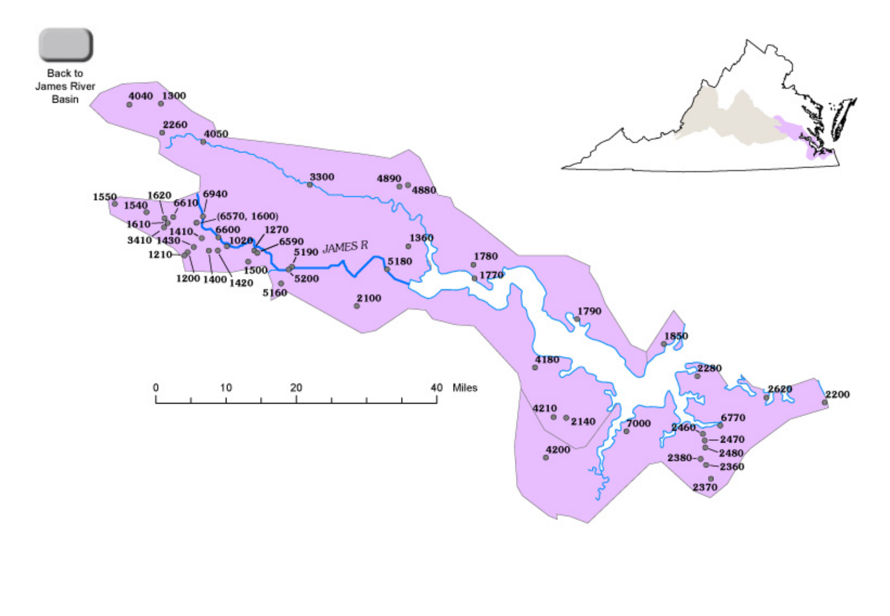
James River Watershed

- Third largest tributary to Chesapeake Bay
- Virginia's largest river
- Over 10,000 square miles (about 25% of the state)
- Home to 1/3 of all Virginians (2.5 million with half living in the lower section)
- Land-use
  - 71% forest
  - 16% agriculture
  - 5% urban
  - 8% other



Lower James River

- Land-use*
  - 31% forest
  - 54% urban/suburban/mixed open
  - 12% agriculture
  - 3% other
- Water residence time
  - 36 days – high flow
  - 74 days – low flow

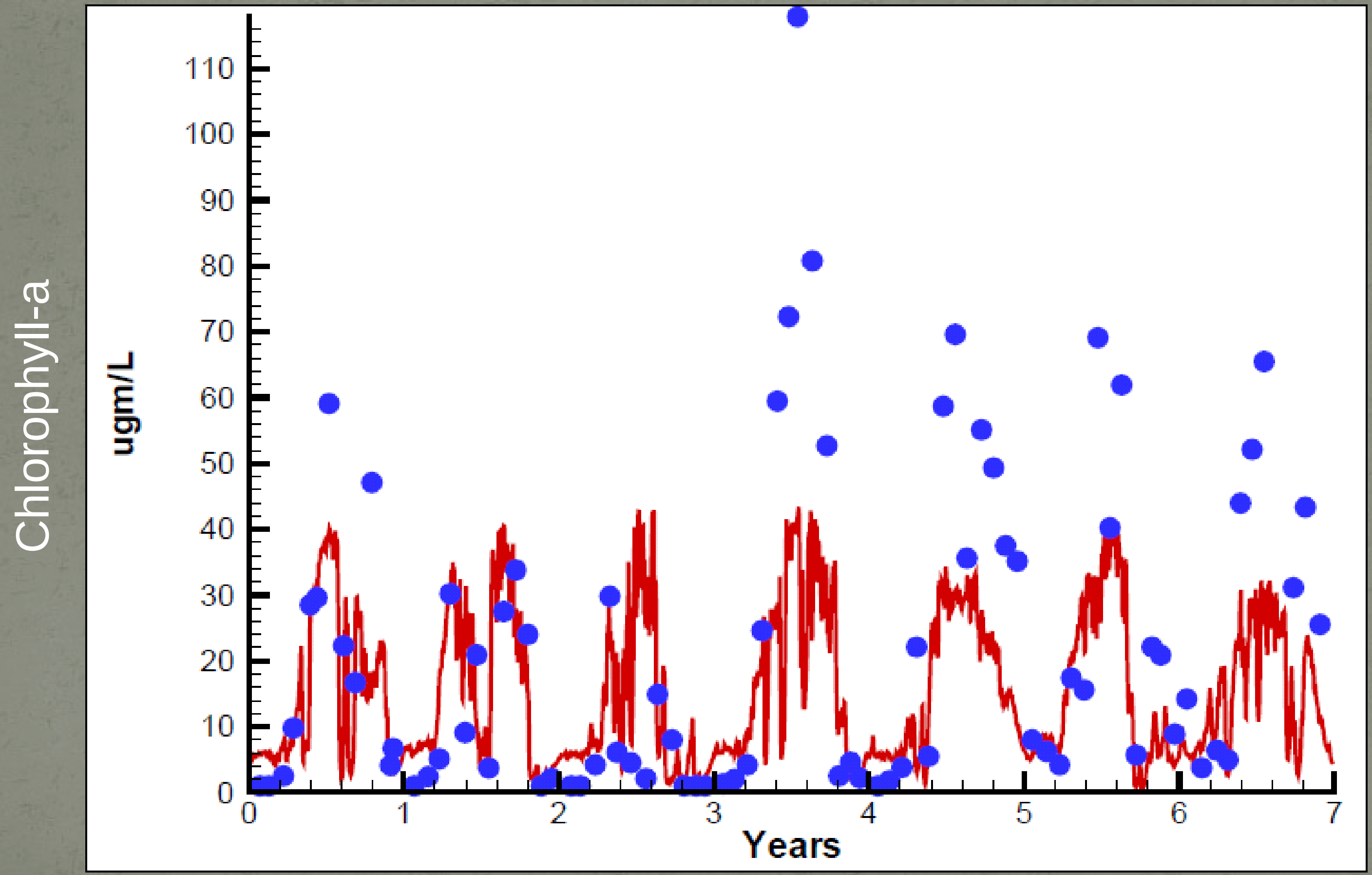


* (James River Tributary Strategy, 2005)

Watershed Model – James River: Explanatory power for concentration

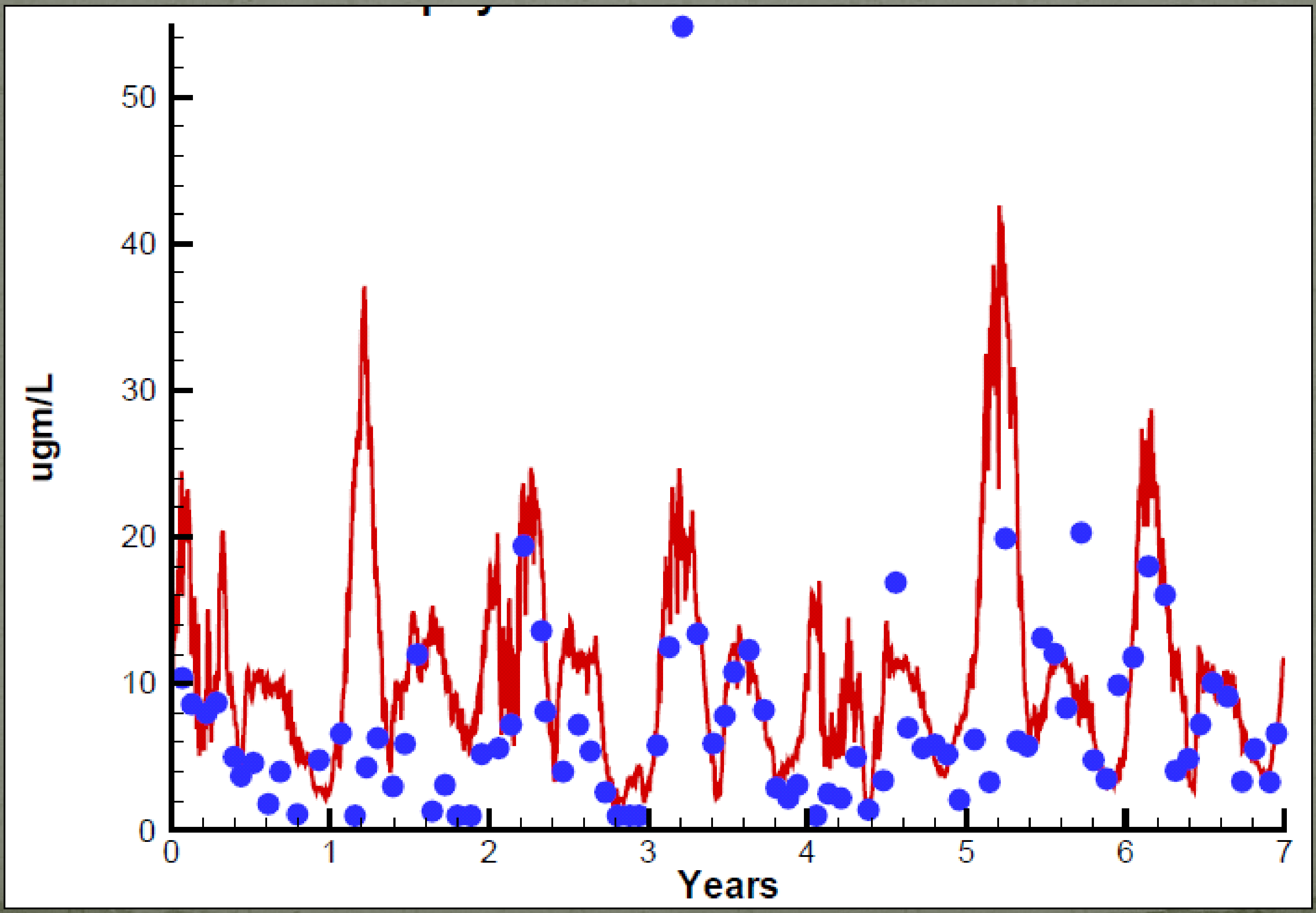
Parameter	Model Efficiency	R^2
Flow	**0.84**	**0.88**
Total N conc.	**-0.15**	**0.18**
Total P conc.	**0.13**	**0.09**

Tidal Freshwater James River calibration



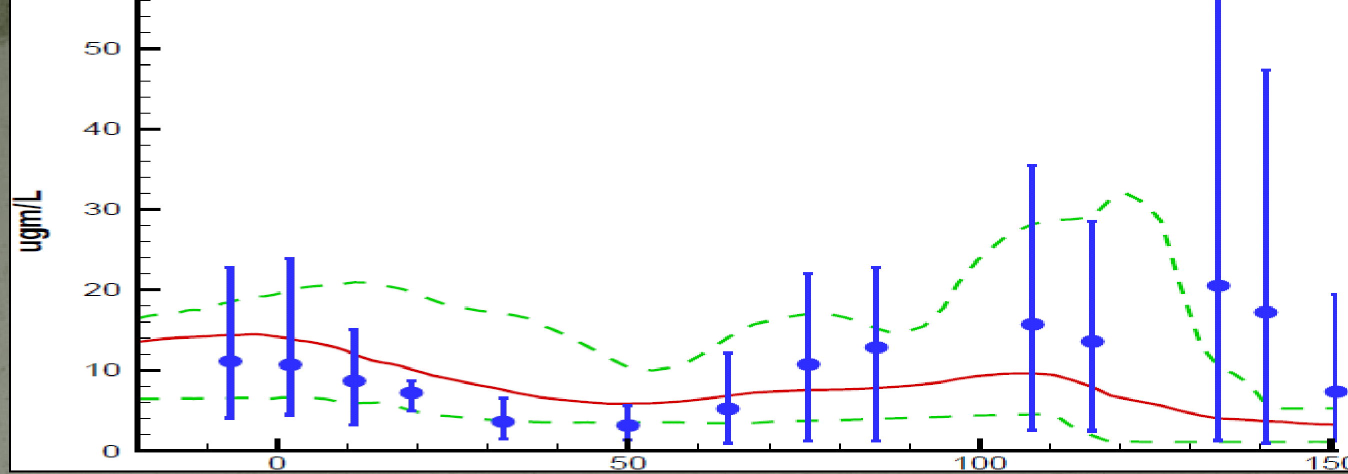
Lower James River calibration

Chlorophyll-a

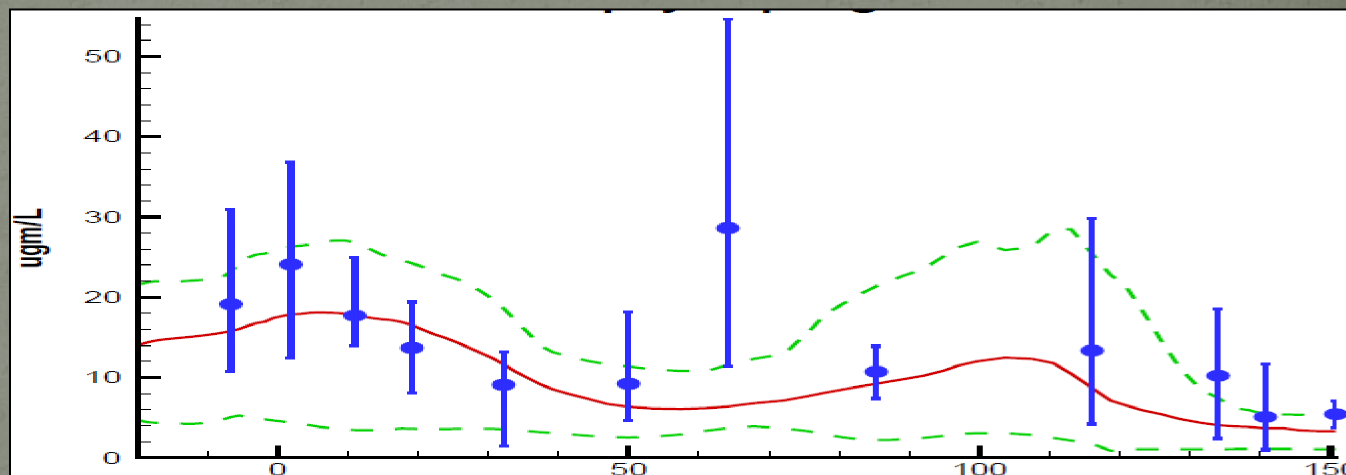


Spring

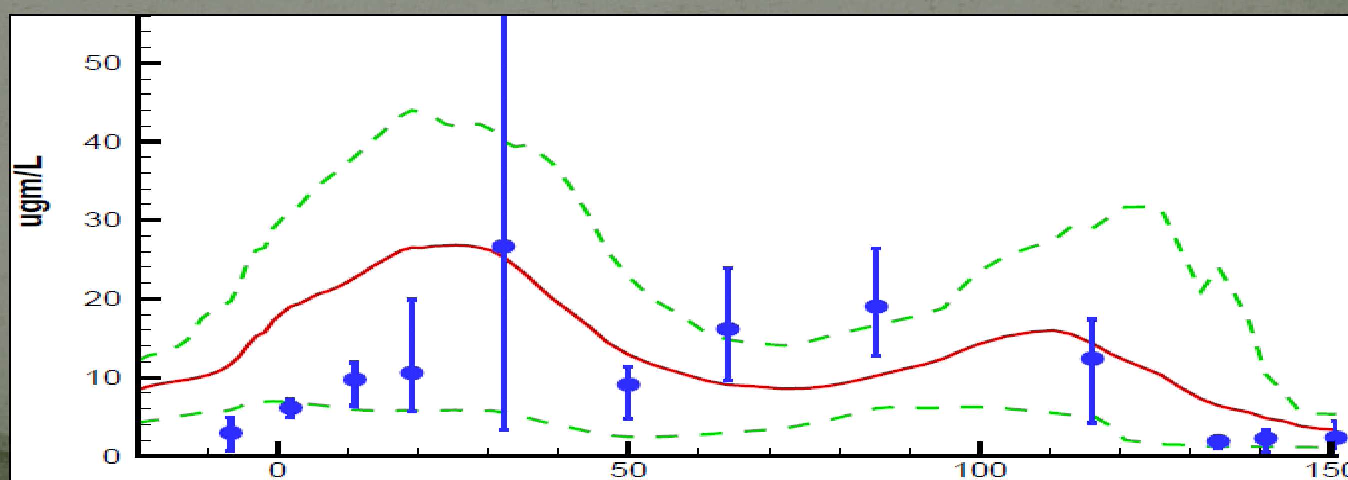
1994
Wet early Spr
Dry late Spr



1996
Normal



1999
Dry



Data Collection Activities 2012

- Upper James Estuary (VCU, ODU)
  - Expanded monitoring of CHLa & phytoplankton.
  - Algal bioassay & grazing experiments
  - Monitoring Microcystin in water, sediments, biota.
- Lower James Estuary (VIMS, ODU, HRSD)
  - Expanded dataflow cruises including oligohaline
  - Continuous monitoring of CHLa & nutrients
  - Dinoflagellate toxicity tests