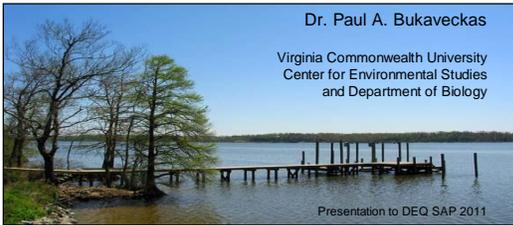


## Algal Blooms in the tidal-freshwater James River

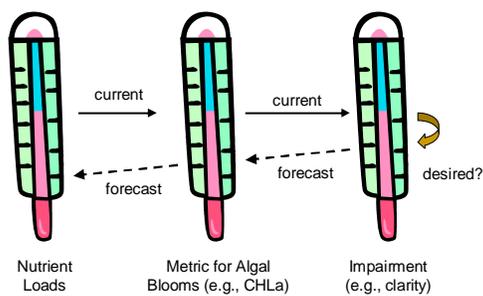


## Steps to Develop a Nutrient Management Strategy for the James

1. Characterizing the severity of algal blooms (magnitude, duration).
2. Identifying deleterious effects of algal blooms.
3. Establishing quantitative linkages between algal blooms, nutrient loads and water quality impairments.



## Conceptual Approach



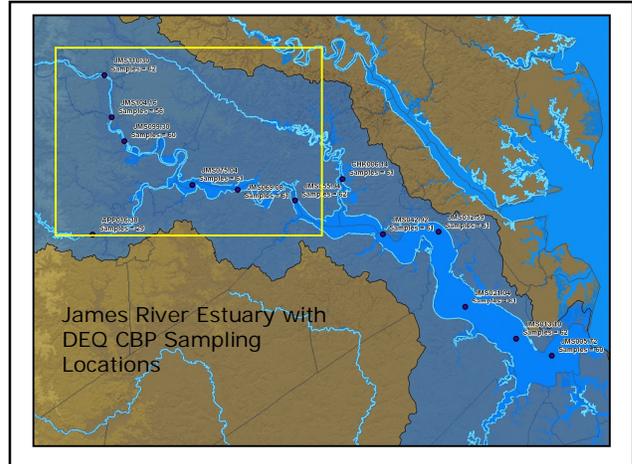
## Today's Presentation

- What we know and don't know about algal blooms in the tidal-freshwater James River
  - available data and recent findings
  - needs for future work



## Monitoring Algal Blooms in the James

- Chlorophyll a: pigment found in all types of algae including cyanobacteria.
  - concentrations easily and accurately measured
  - continuous monitoring by fluorescence probes
- Algal counts: identification and enumeration of cells.
  - provides information on community composition (e.g., harmful species)



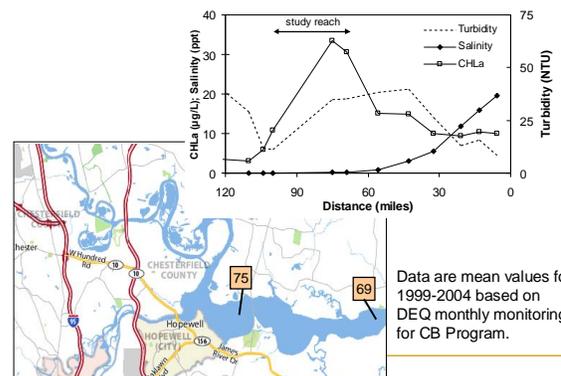
## Where, when, why do Algal Blooms occur in the Upper James?

Available data to address these questions:

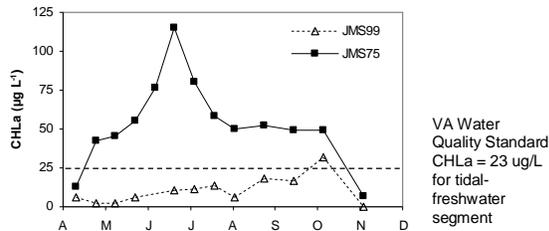
- DEQ CBP monthly monitoring (6 sites in t-f; 1980's – present)
- VCU study on causes of bloom formation (bi-weekly Apr-Nov 2007)
- RIC-VCU weekly monitoring (9 sites; 2009 – present)
- VCU Rice Pier continuous monitoring of CHLa and water quality (1 site; 2007 – present)



## Highest CHLa occurs in Upper James River

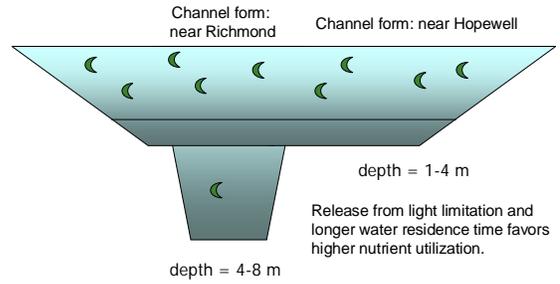


## Persistent Algal Blooms at JMS75

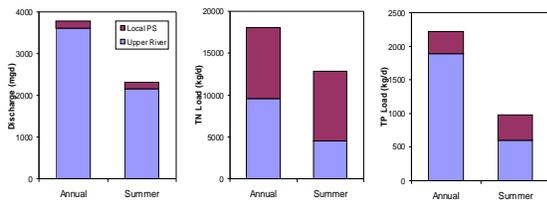


JMS99 = Osborne Landing; JMS75 = near Hopewell, VA  
Data for 2007 from Bukaveckas et al (2011) E&C

## Why Here? Depth, Light and CHLa in the James River



## Daily Nutrient Loads to t-f James River



Data are average values for 2007-2010  
Point Sources (PS) include WWTPs, Industry and Richmond CSOs.  
Summer = May - September

## Algal Blooms in the Upper James

The natural geomorphometry of the channel and proximal nutrient inputs foster persistent algal blooms in the region of river mile 69-75. These exceed current water quality standards.



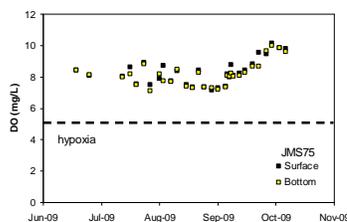
## Algal Blooms in the James - Key Unknowns

- What are the impairments arising from algal blooms?
- What level of CHLa is permissible to protect against impairments?
- What level of nutrient load reduction is needed to attain desired CHLa?

## Algal Blooms: Deleterious Effects

- Oxygen Depletion – decomposition of algal biomass can lead to oxygen depletion (hypoxia)
- Reductions in water clarity – restrict growth of submerged aquatic vegetation.
- Harmful Algal blooms – toxin-producing strains of algae

## Dissolved Oxygen in the James River



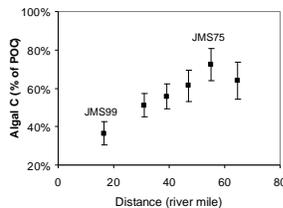
Daytime dissolved oxygen concentrations at the site of the CHLa maximum (JMS75). Data from VCU City of Richmond Monitoring Program.

## Algal Blooms: Deleterious Effects

- Oxygen Depletion ✓
- Water clarity
  - Data on water clarity can be used in conjunction with measurements of TSS, POM and CHLa to quantify algal contributions to light attenuation.



## Algae & Water Clarity



Algae account for on average 70% of particulate organic matter at the site of the CHLa maximum (JMS75).

But note that POM accounts for only ~25% of total suspended particulate matter.

Average values for April-November 2007 from Bukaveckas et al. (2011).  
Algal C estimated from CHLa based on empirical relationship for James River.

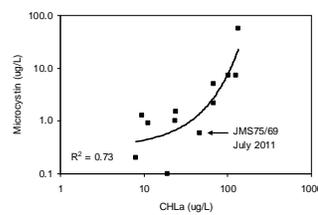
## Algal Blooms: Deleterious Effects

- Oxygen Depletion ✓
- Water clarity ✓
- Harmful Algal blooms
  - Certain types of algae produce chemical defense compounds (phytotoxins). In freshwaters, the most common are from cyanobacteria (cyanotoxins; e.g., Microcystin).
  - Not all cyanobacteria produce toxins, and those that are capable of producing toxins do not always produce toxins.

## Cyanotoxins in the James

- In late summer, algal blooms at JMS75 are dominated by cyanobacteria including known toxin-producing species (Microcystis).
- Microcystin exposure can result from drinking contaminated water or ingestion of fish (MC is biomagnified).
- Weekly monitoring of MC in water initiated in June 2011.

## Microcystin in tidal-fresh James River



MC is predicted to exceed WHO Drinking Water Standard (1 µg/L) at:

CHLa = 37 µg/L

MC is predicted to exceed WHO Contact Standard (20 µg/L) at:

CHLa = 130 µg/L

Data from James River shown in comparison to African and North American lakes surveyed by Poste et al. (2011) ES&T.

## Summary

- What we know:
  - When, where, why algal blooms occur
  - No dissolved oxygen impairment
- What we don't know:
  - Microcystin in algae and food web
  - N vs. P limitation of algal growth
  - Forecasting CHLa (e.g., in response to load reductions)
  - Top-down controls on CHLa (or, lack thereof)