First Year Findings from James River CHLa Study

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Eutrophication – Setting Nutrient Targets

Dissolved O_2 standards are commonly used as the basis for establishing target nutrient loads (via water quality models linking nutrients, algae and hypoxia).

- Are DO-based standards sufficiently protective of eutrophication effects on living resources and human health?
- How do we establish nutrient targets where hypoxia does not occur (e.g., well-mixed estuaries)?

Managing Eutrophication (in context of CWA)

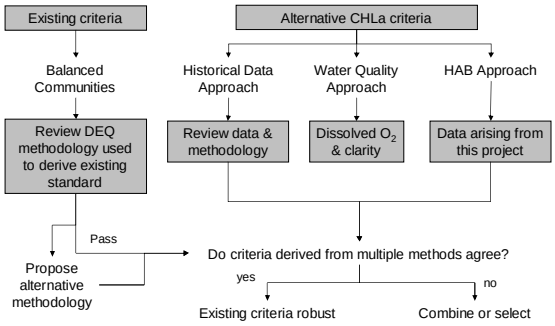
Impairments to Designated Uses from Algal Blooms

Designated Uses	Impairments
Swimmable	Transparency & Aesthetics, also algal toxins (e.g., Microcystin)
Drinkable	Taste & Odor compounds, algal toxins
Fishable	Hypoxia, transparency, algal toxins

How to develop algae-based water quality standards (metrics & rationale)?

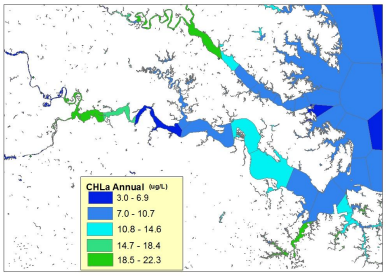
able
My Clean Water Act

Strategy & Roadmap



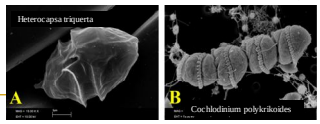
2012 Findings

- Magnitude, Duration and Composition of Algal Blooms
- Conditions Favoring Bloom Development
- Deleterious Effects of Algal Blooms



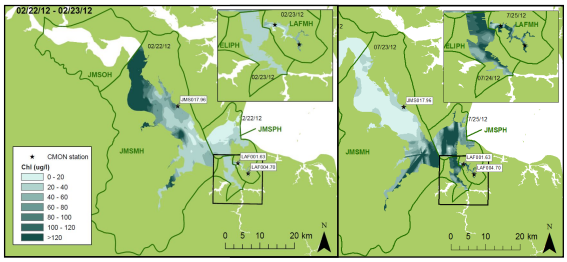
Magnitude, Duration and Composition of Blooms

Segment	2012 Bloom Events
Tidal-fresh	Summer lasting 26 weeks (May thru Oct) with CHLa > 20 µg/L - comprised of diatoms (76%), chlorophytes (16%) and cyanobacteria (6%).
Mesohaline	Spring lasting 5 weeks (Feb & Mar) by the non-HAB dinoflagellate *Heterocapsa triquetra with* CHLa >40 µg/L covering 18% of area.
Polyhaline	Summer lasting 13 weeks (June thru Sept) of *Cochlodinium polykrikoides* with CHLa >40 µg/L covering 60% of area.



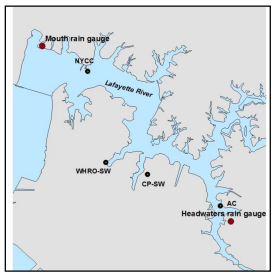
Algal Blooms in the Lower James

CHLa concentrations in the saline waters of the James River Estuary during the Spring *Heterocapsa* bloom (left) and the Summer *Cochlodinium* bloom (right).



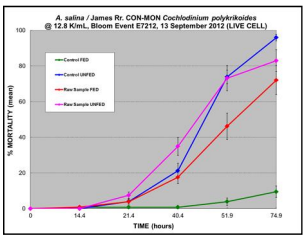
Algal Blooms in the Lower James

- Rain events result in localized nutrient inputs which can trigger blooms; these are not adequately captured by watershed and estuarine monitoring programs.
- An intensive monitoring and mapping program was conducted in 2011 and 2012 to identify the causal factors initiating and sustaining algal blooms.
- In both years blooms initiated in the Lafayette River, a sub-tributary of the lower James River, and extended into the Elizabeth and lower James River through August.



Algal Blooms in Lower James

- Samples were obtained during bloom events to assess adverse health impacts via laboratory toxicity assays using whole cells or lysates.
- Bioassays with *Artemia* were conducted using samples collected during the *Cochlodinium* bloom.
- *Artemia* mortality was directly related to *Cochlodinium* cell concentrations and CHLa levels in the samples.



Algal Blooms in the tidal-fresh James

- The natural geomorphometry of the channel and proximal nutrient inputs foster persistent algal blooms that exceed current CHLa standards.

Year-1 Objectives:
-measuring nutrient limitation,
-HABs and cyanotoxins.

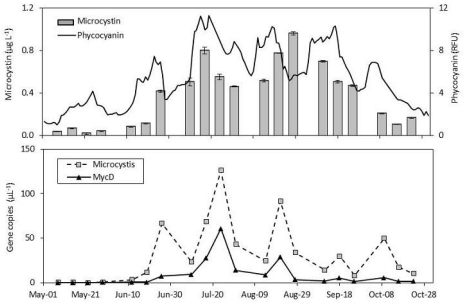
Bukaveckas et al. 2011 *Estuaries & Coasts;* Bukaveckas & Isenberg 2013 *Estuaries & Coasts*

Phytoplankton Nutrient Limitation

	1992-93*	2012**
No. experiments	11	12
Nutrient limitation detected	0	11
Dissolved inorganic N (mg/L)	0.45	0.25
Phosphate (mg/L)	0.022	0.013

Algal bioassay experiments provide evidence for increasing severity of nutrient limitation associated with reductions in point source nutrient inputs to the tidal-fresh James. Data from Fisher et al. 1999* and Wood & Bukaveckas (*Estuaries & Coasts*, in review)**.

Cyanobacteria blooms in tidal-fresh James

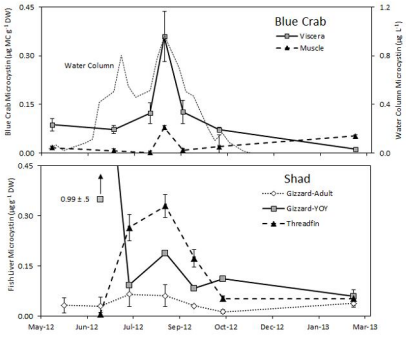


Wood et al. *Environmental Science & Technology* (in review)

Microcystin in tidal fresh James 2012

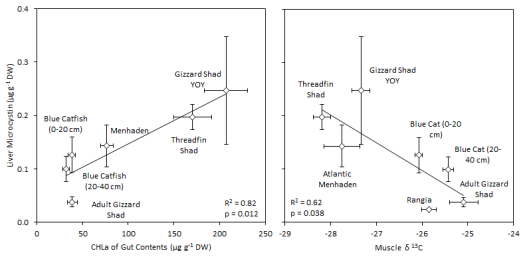
- 104 of 105 water samples (May-October); max = 1 µg/L.
- 11 of 60 sediment samples (peak in August).
- 254 of 379 (67%) fish and shellfish.
  - Highest incidence of MC in blue crabs (viscera = 100%; muscle = 64%).
  - Blue crab tissues exceeded WHO safety guidelines in August.

Microcystin in the Food Web of the James



Wood et al. *Environmental Science & Technology* (in review)

Microcystin in the Food Web – Why are some taxa more vulnerable than others?

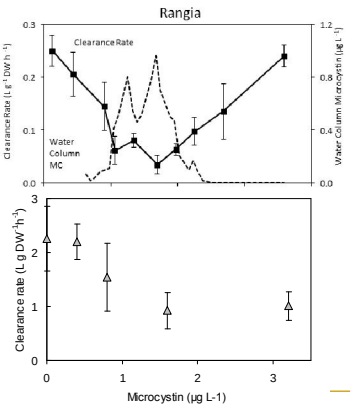


Autochthonous contributions to diet predict MC accumulation in tissues.

Toxin effects on ecosystem services

-filtration rate of wedge clams drops from 28%/d to 10%/d.

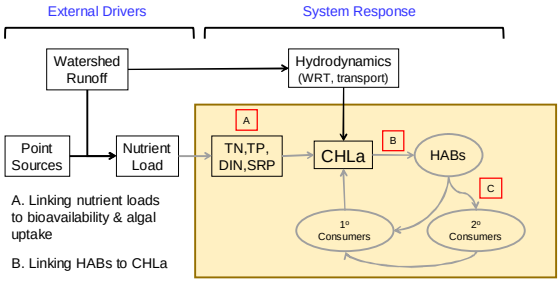
Rangia cuneata



What have we learned?

- Tidal Fresh:
  - Reductions in point source inputs correspond to lower nutrient concentrations and greater severity of nutrient limitation.
  - Ubiquitous presence of Microcystin in James River Estuary - implications for human health (blue crab consumption), living resources (crabs, pelagic fishes) and ecosystem services (benthic filter-feeders).
- Lower James:
  - An expanded monitoring effort in 2012 provided enhanced spatial and temporal resolution to characterize the magnitude, duration and composition of algal blooms.
  - Bloom initiation was linked to local rainfall events and subsequent transport of algae from shallow tributaries of the James.

Three Key Data Needs



A. Linking nutrient loads to bioavailability & algal uptake

B. Linking HABs to CHLa

C. Linking HABs to effects on living resources