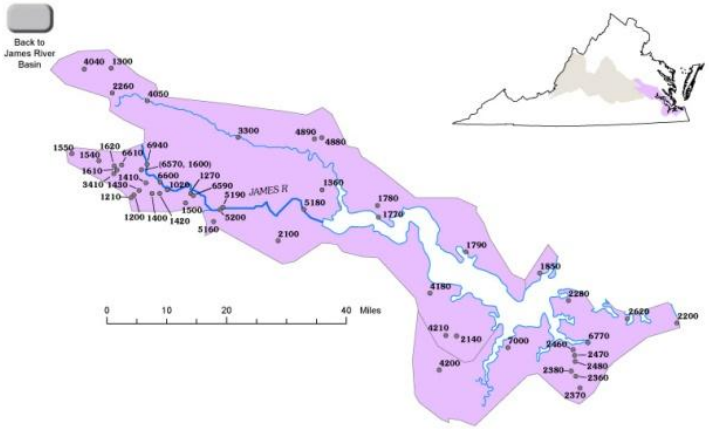
James River CHLa Study – 2012 Summary & 2013 Research



http://www.deq.virginia.gov/Programs/Water/WaterQualityInformationTMDLs/WaterQualityStandards/NutrientCriteriaDevelopment.aspx#James_R_CHLa_Study

http://wp.vcu.edu/jamesriver/

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..."

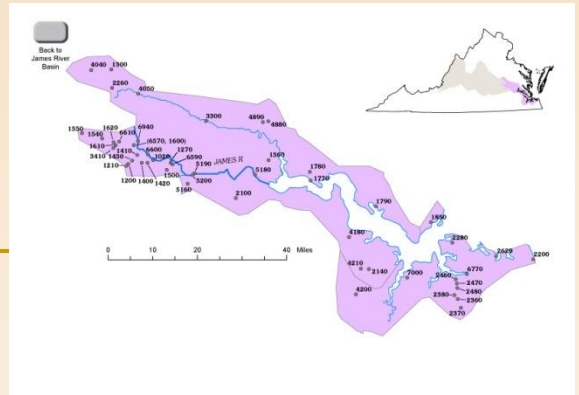
1999

James River Chlorophyll Criteria

- Tidal waters eutrophic
- High and increasing levels of undesirable algae
- Listed as impaired under CWA 303

Standards Based on

- Unbalanced community composition
- Attainment of Tribunary Strategy Loadings



Virginia Regulations

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…"

Designated Use	Chlorophyll a µ/l	James River Segment	Temporal Application
Open Water	10	JMSTF2	March 1 - May 31
	15	JMSTF1	
	15	JMSOH	
	12	JMSMH	
	12	JMSPH	
	15	JMSTF2	July 1 - September 30
	23	JMSTF1	
	22	JMSOH	
	10	JMSMH	
	10	JMSPH	

James River CHLa Study

Re-visit existing numeric CHLa criteria for the James. Are they protective of aquatic life?

Re-visit the JR TMDL loads with a site-specific water quality – HAB model.

Data Collection:

- When, where, why of algal blooms.
- Effects on water quality and aquatic resources

Modeling: James-specific linkages between nutrient inputs to the estuary and CHLa in the estuary

Designated Use	Chlorophyll a µ/l	James River Segment	Temporal Application
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	15	JMSTF1	
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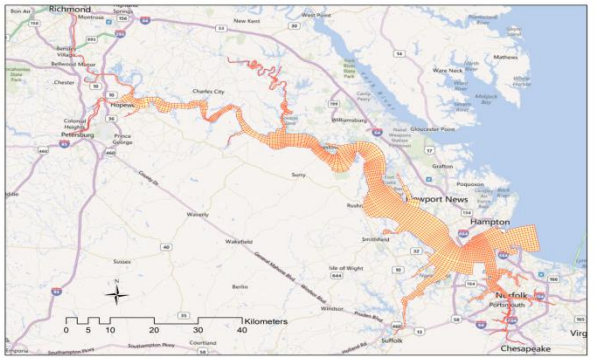
	15	JMSTF2	July 1 - September 30
	23	JMSTF1	
	22	JMSOH	
	10	JMSMH	
	10	JMSPH	



Science Advisory Panel

Clifton Bell (B&C)
Claire Buchanan (ICPRB)
Greg Garman (VCU)
Will Hunley (HRSD)
Winston Lung (UVA)
Kenneth Moore (VIMS)
Kimberly Reece (VIMS)
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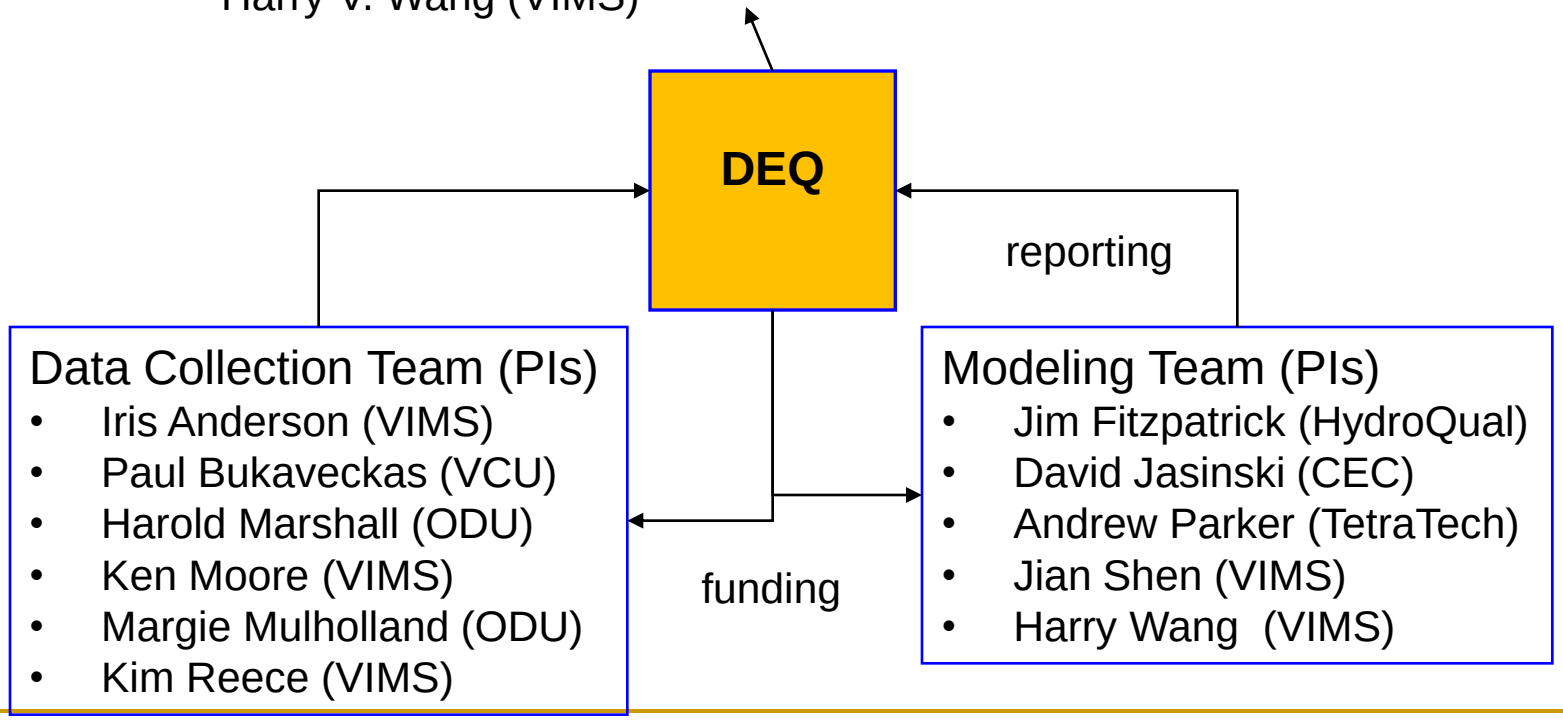
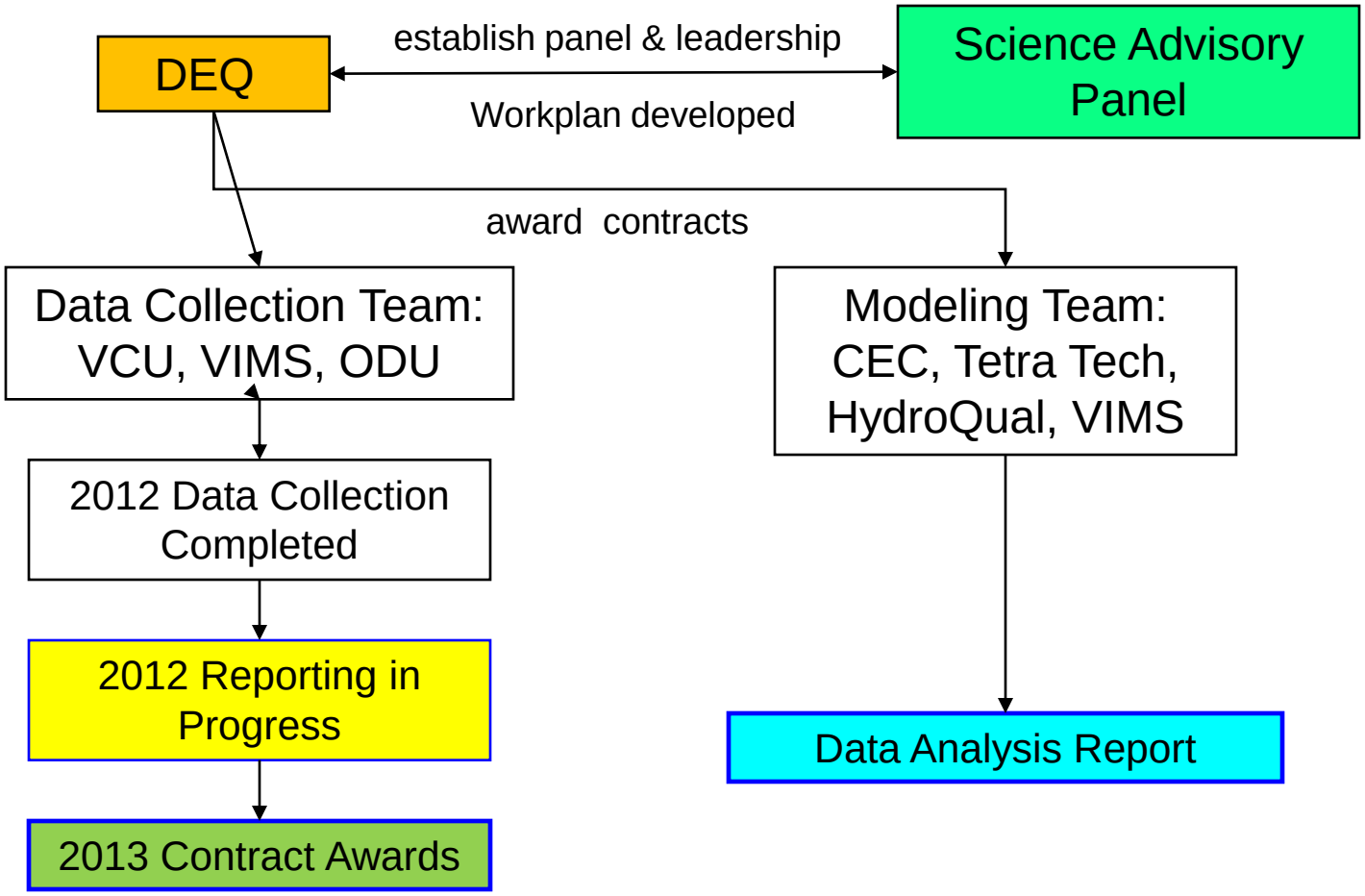
Eileen E. Hoffman (ODU)
Rebecca LePrell (VDH)
Harold G. Marshall (ODU)
Margaret Mulholland (ODU)
Peter Tango (USGS)



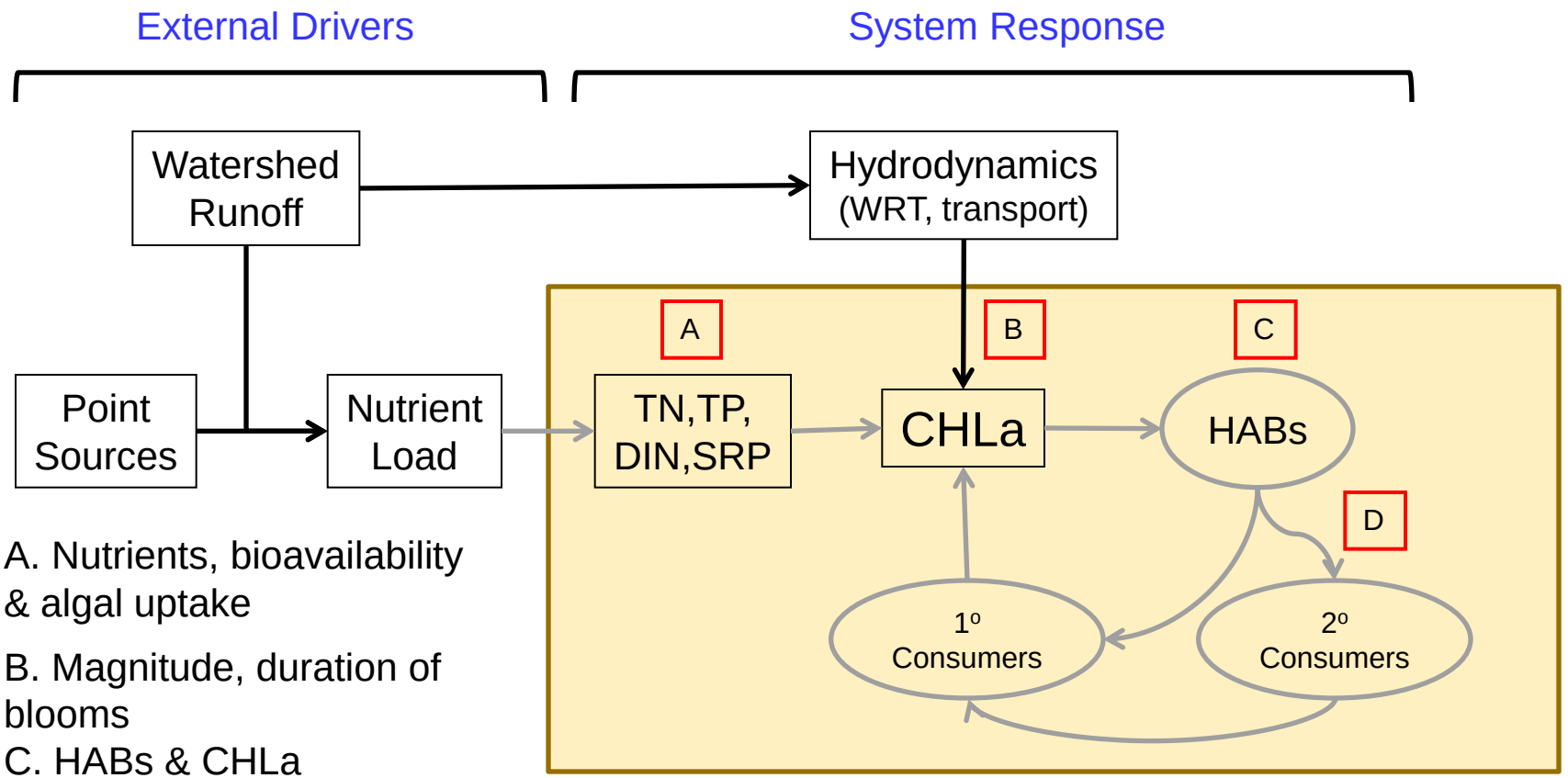
Project Status



Panal Priorities: Spring 2013

- Evaluate results from 2012 data collection
- Assess 2013 data collection activities
- Evaluate progress in modeling effort

Data Collection and Modeling Framework



A. Nutrients, bioavailability & algal uptake

B. Magnitude, duration of blooms

C. HABs & CHLa

D. HABs & living resources

Historical changes

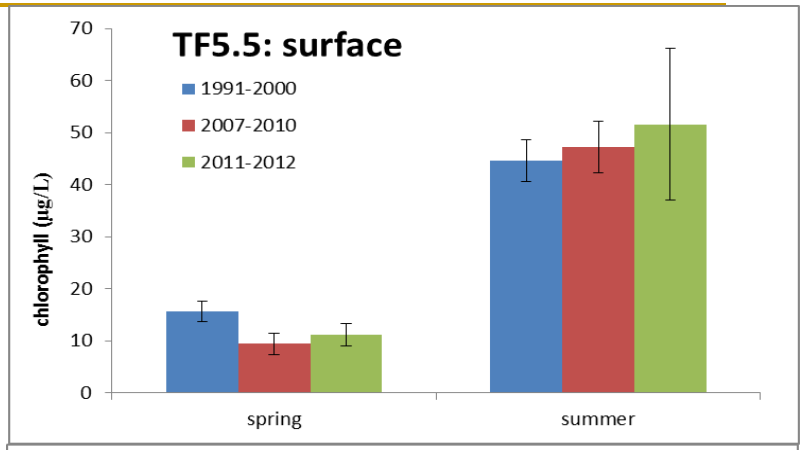
1991-2000 – WQ Model

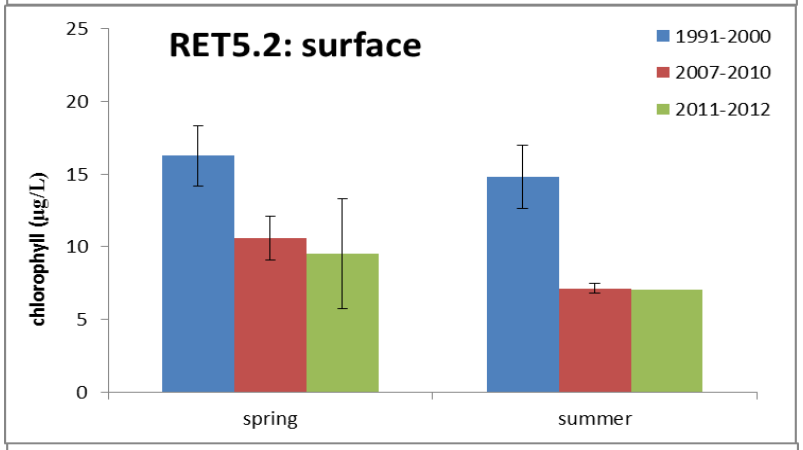
2007-2010 - HAB

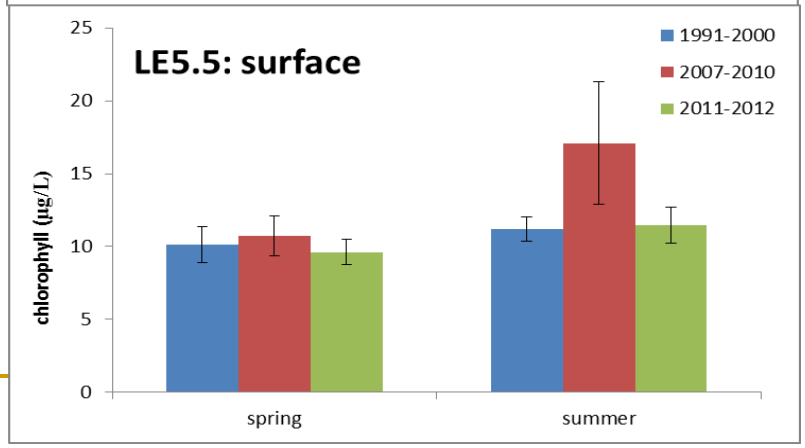
2011-2012 – JR Study

No significant differences between time periods.

Spring (March-May) and summer (July-September) surface chlorophyll concentrations at the three James River phytoplankton monitoring stations during three time periods. No significant differences between time periods.







Bloom duration, frequency, & magnitude

Tidal fresh

- Summer ***abundance pulse*** (May thru Oct) lasting 26 weeks (183 days) with mean conc. = 39,000 cells/ml for CHLa > 20 µg/L - comprised of diatoms (76%), chlorophytes (16%) and cyanobacteria (6%).

Mesohaline

- Spring **bloom** (Feb & Mar) lasted 5 weeks by the non-HAB dinoflagellate *Heterocapsa triquetra with conc.* > 190,000 cells/ml and CHLa >300 µg/L.

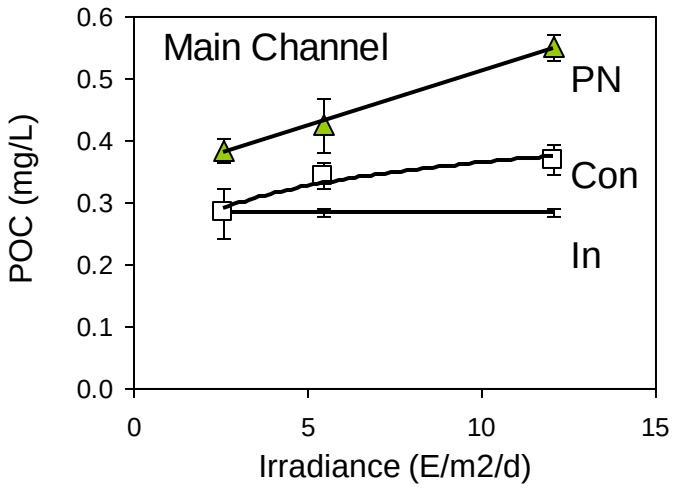
Polyhaline

- Summer **bloom** (late Jun to mid-Sept) of *Cochlodinium polykrikoides* lasted 13 weeks and reached up to 75,000 cells/ml with CHLa >300 µg/L. Major biomass and chlorophyll sources were diatoms and chlorophytes during spring and dinoflagellates (70%) and diatoms (25%) during summer

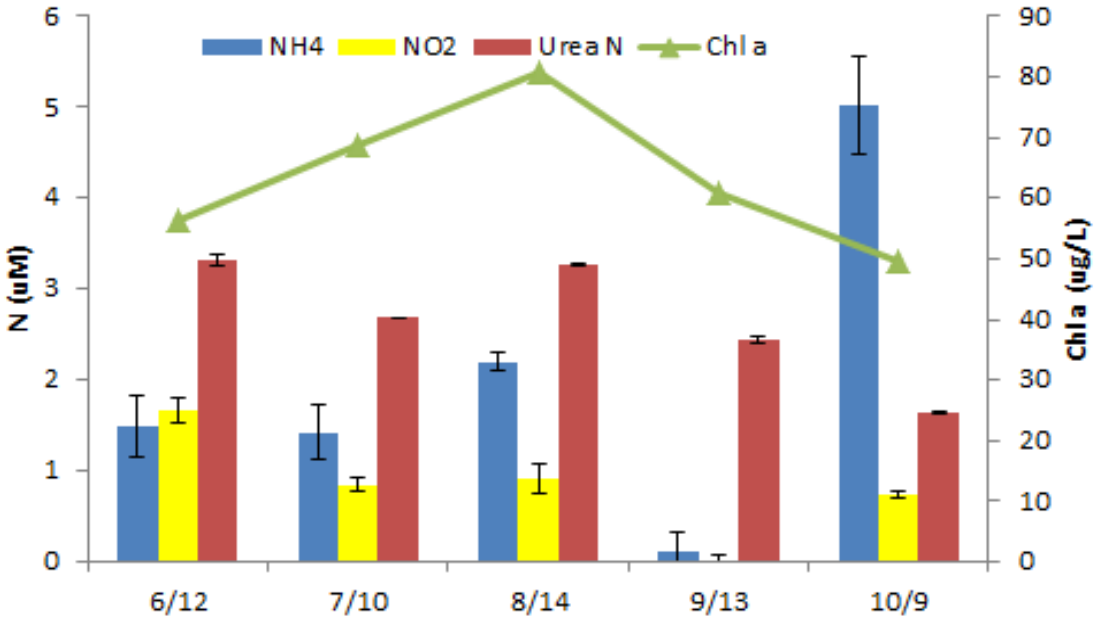
Nutrients, bioavailability & uptake

	P	N	PN	Light
Fisher et al. 1999	0	0	0	11
This study - 2012	0	2	11	12

Results from algal bioassay experiments performed at JMS75 in 1989-1994 (Fisher et al. 1999) and 2012 (this study).

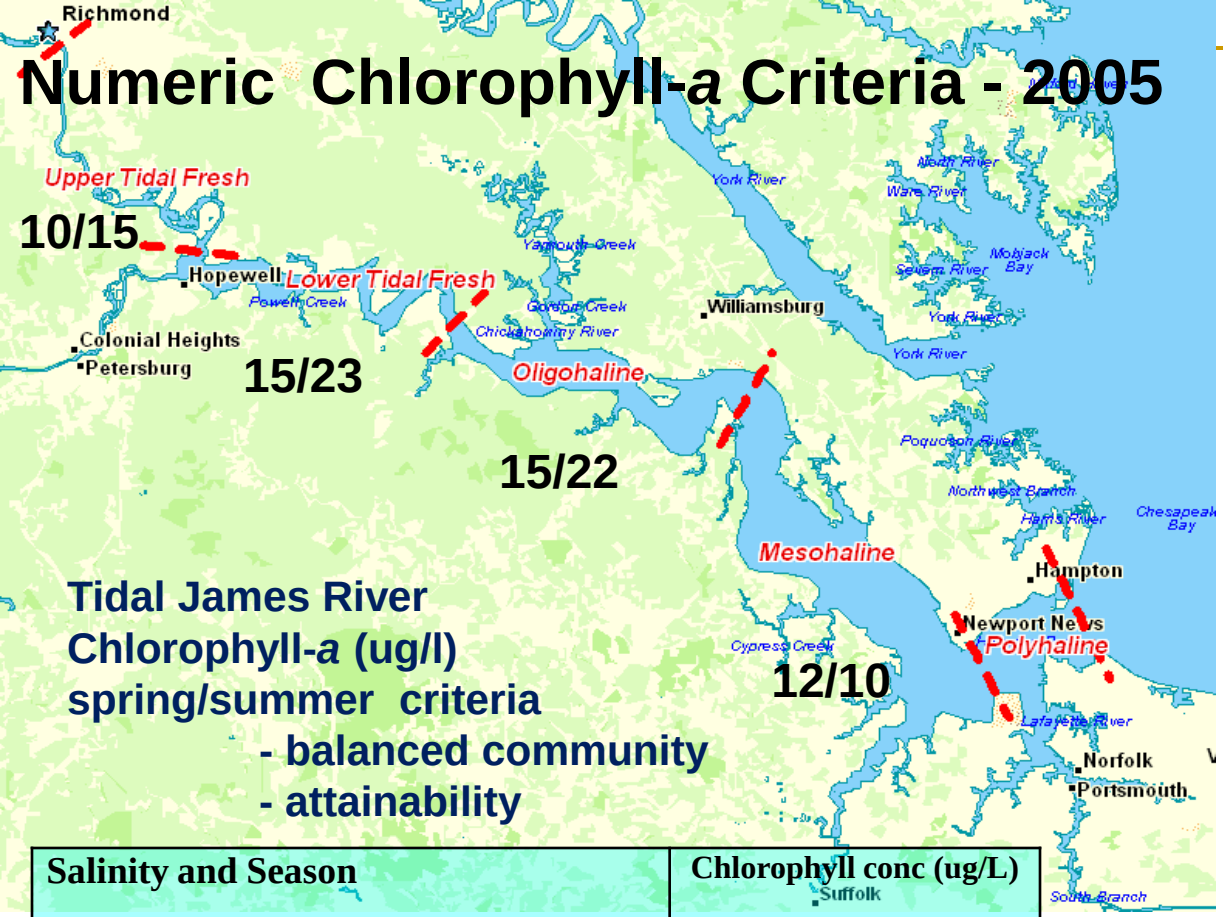


Nutrients, bioavailability & uptake

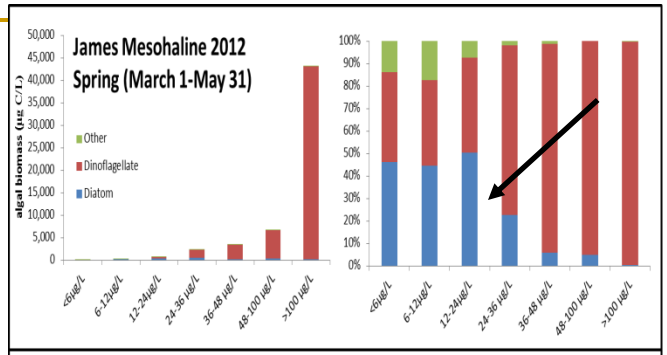


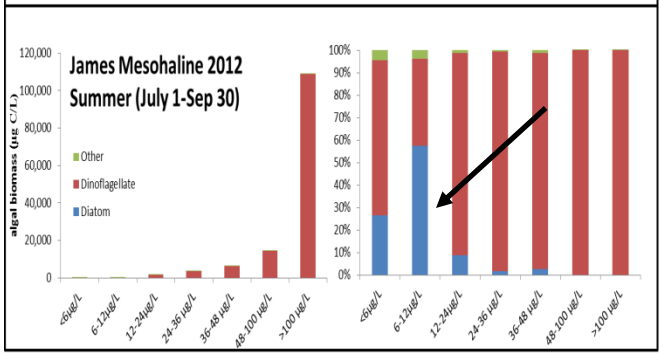
Urea and NH4+ were the dominant forms of N taken up (e.g., ~90% of total N uptake during *Cochlodinium* bloom). These results suggest that wastewater (tf) and regenerated N were important for fueling phytoplankton growth.

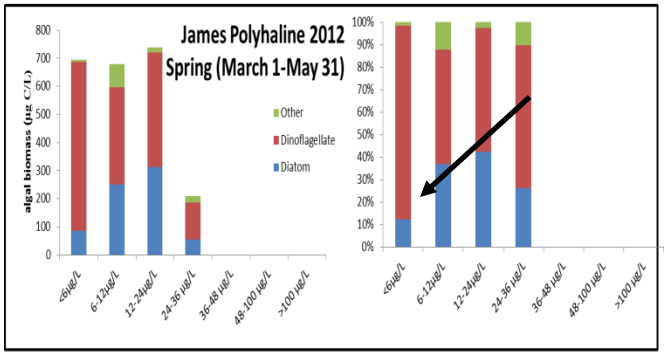
Numeric Chlorophyll-*a* Criteria - 2005

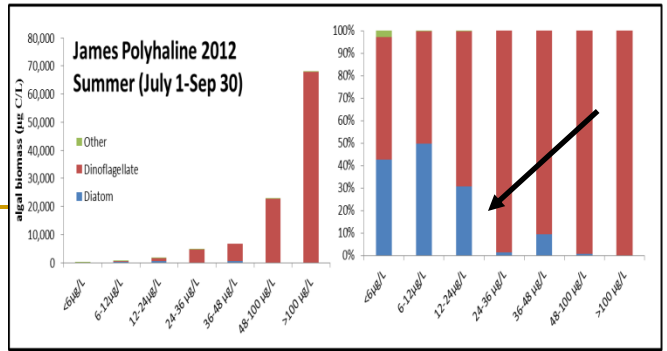


Salinity and Season		Chlorophyll conc (ug/L)
Mesohaline	Spring	12-36
	Summer	6-12
Polyhaline	Spring	6-12
	Summer	< 24





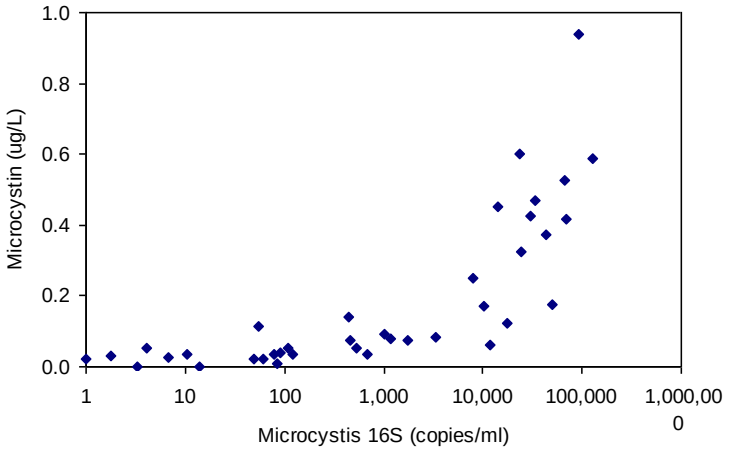


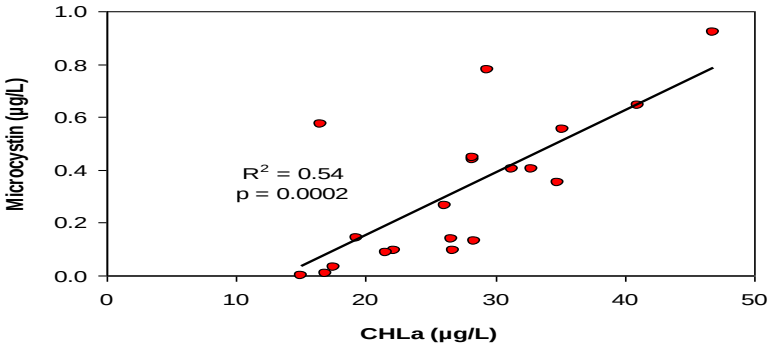


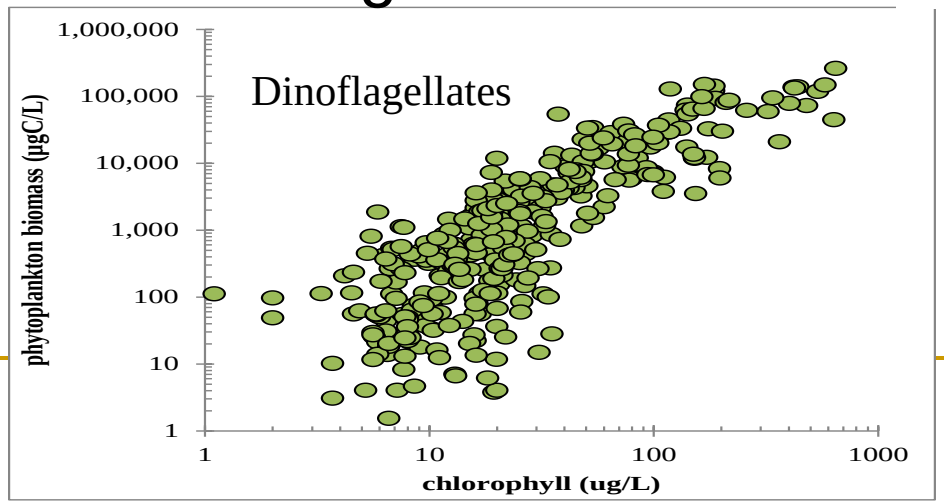
Relationships between chlorophyll concentrations and algal composition by season and salinity regime.

CHLa & HABs

- Tidal-fresh: significant relationships between CHLa and Microcystin
- Meso- and poly-haline: significant positive relationship between CHLa and dinoflagellate biomass.

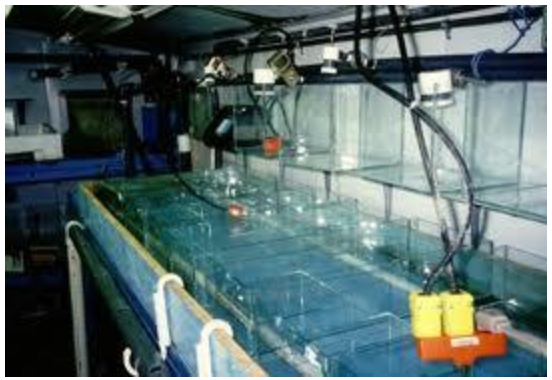


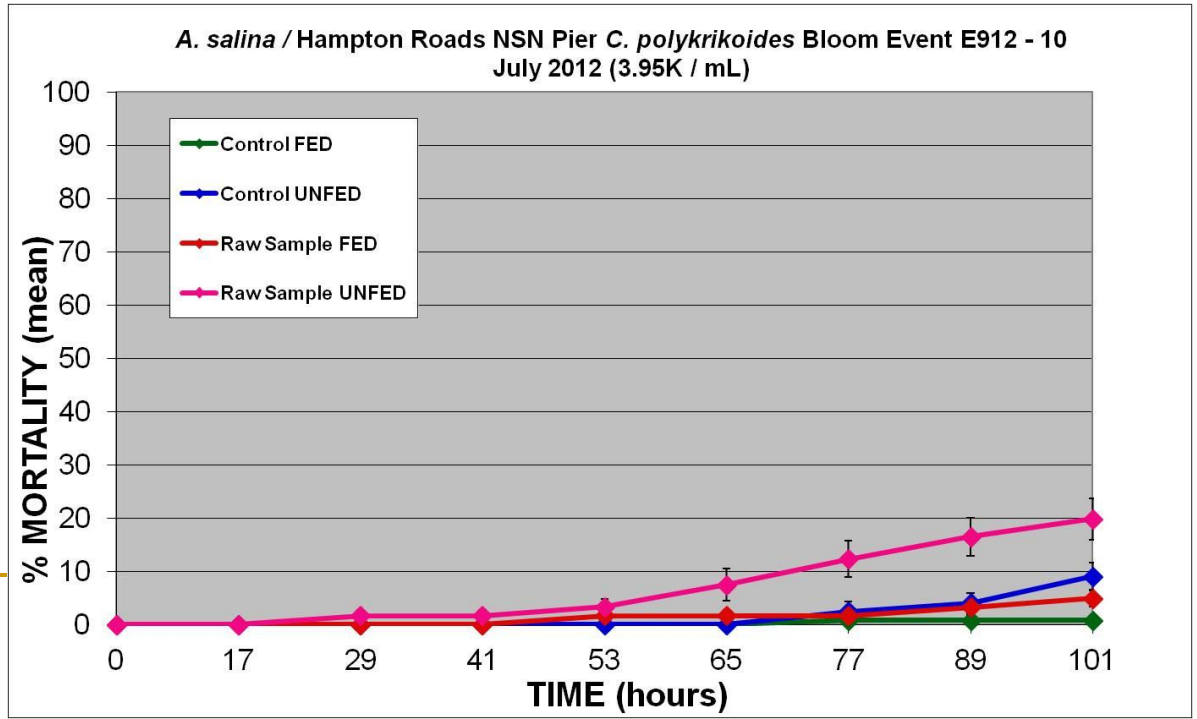




Linking algal blooms & adverse effects on aquatic live

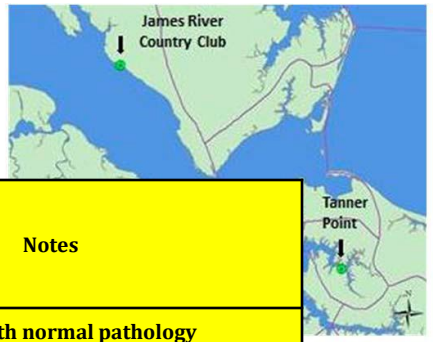
- Bioassays of *C. polykrikoides with Artemia*
  - Chl-a > 150 ug/L = 60-100% mortality
  - Chl-a < 120 ug/L = < 20% mortality





Bloom Exposure with mature oysters - Oysters exposed to chlorophyll levels spiking above 20 ug/L for 6 or more days exhibited some pathological effects. Most notably, gill erosion was evident in several animals. Following 5 or more days with spikes above 30 ug/L mortalities were observed in samples. **Oysters recovered following several weeks with little to no bloom activity.**

Note: the study was conducted during a time when disease pressures from *Perkinsus marinus* (aka Dermo) were heavy and mortalities cannot be unequivocally attributed to the bloom activity.

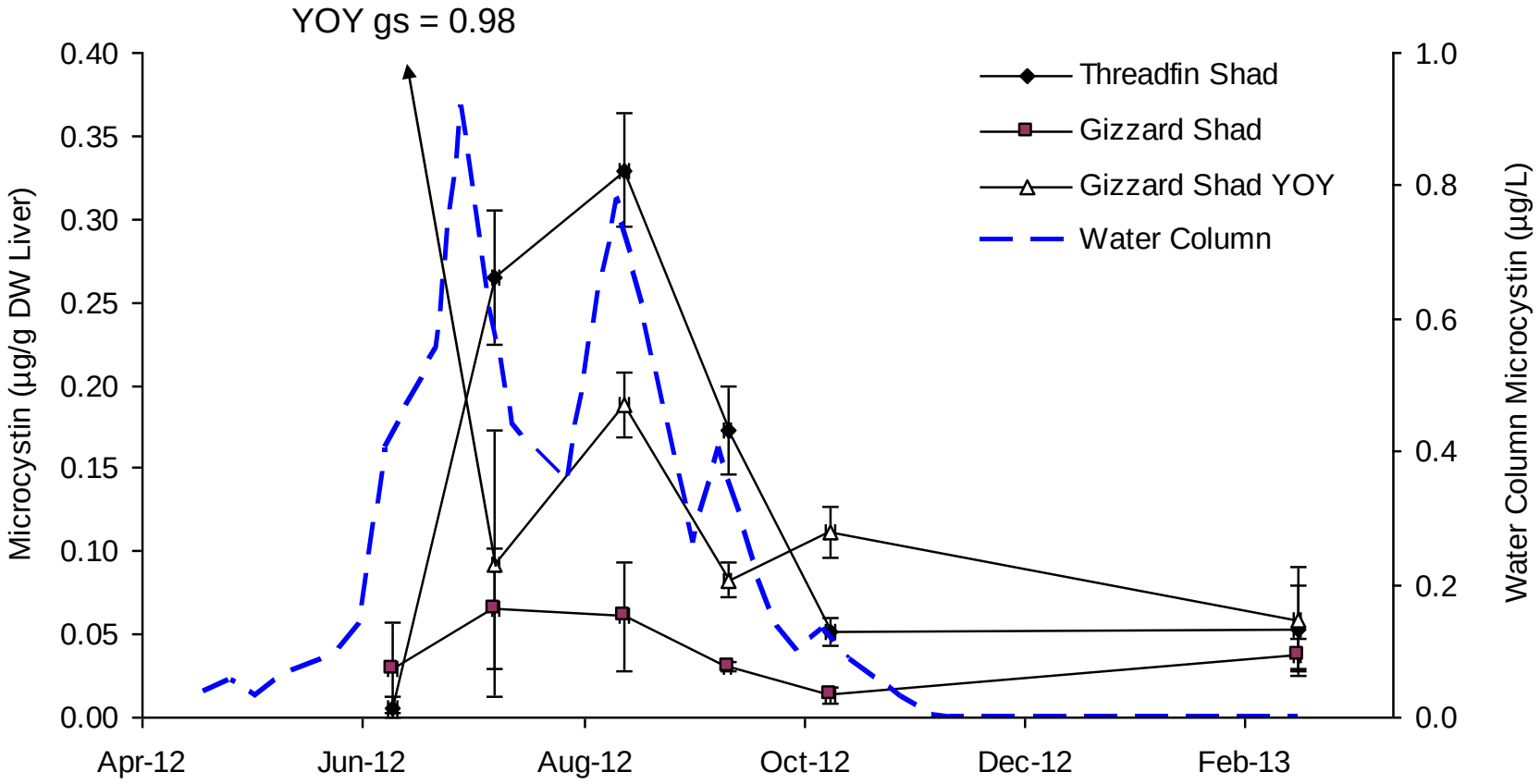


collection date (2012)	# oysters sampled (live/dead)	# days since deployment	# days exposed to max >20ug/L	# days exposed to max >30ug/L	# days exposed to max >40ug/L	range of daily mean CHLa levels during exposure	Notes
June 13	5/0	16	0	0	0	3.28 – 12.96	Baseline sample with normal pathology
July 25	15/0	56	6	1	0	2.61 – 16.27	Increased hemocytosis and some gill erosion was observed in all animals
Aug. 8	15/0	70	10	4	0	2.61 – 16.27	2 animals had minor gut epithelial disruption, with metaplasia in one of them. 2 animals had increased hemocytosis in the gills
Aug. 23	13/2	85	10	4	0	1.14 – 16.27	1 animal with gill erosion, 2 animals in the sample were dead
Sept. 13	11/4	106	14	10	2	1.14 – 25.77	Maximum CHLa levels spiked to 103.93 ug/L. One animal was moribund with extensive gill erosion and 4 animals were dead
Nov. 12	13/2	167	17	12	4	0 – 25.77	CHLa monitoring ended 10 days before the collection date and levels had remained low for almost 8 weeks except for 2 days in late October when average levels were 8-9 ug/L. Pathology was normal in 13 animals and 2 animals were dead.

Microcystin in tidal fresh James 2012

- Detected in 104 of 105 water samples during May through October.
- Detected in 11 of 60 sediment samples during same period.
- Detected in 254 of 379 (67%) individuals for fish and shellfish. Highest incidence of Microcystin contamination in blue crabs (viscera = 100%; muscle = 64%). Microcystin in blue crab tissues exceeded WHO safety guidelines in August.

HABS & Living Resources



Microcystin concentrations in water and fish tissues.

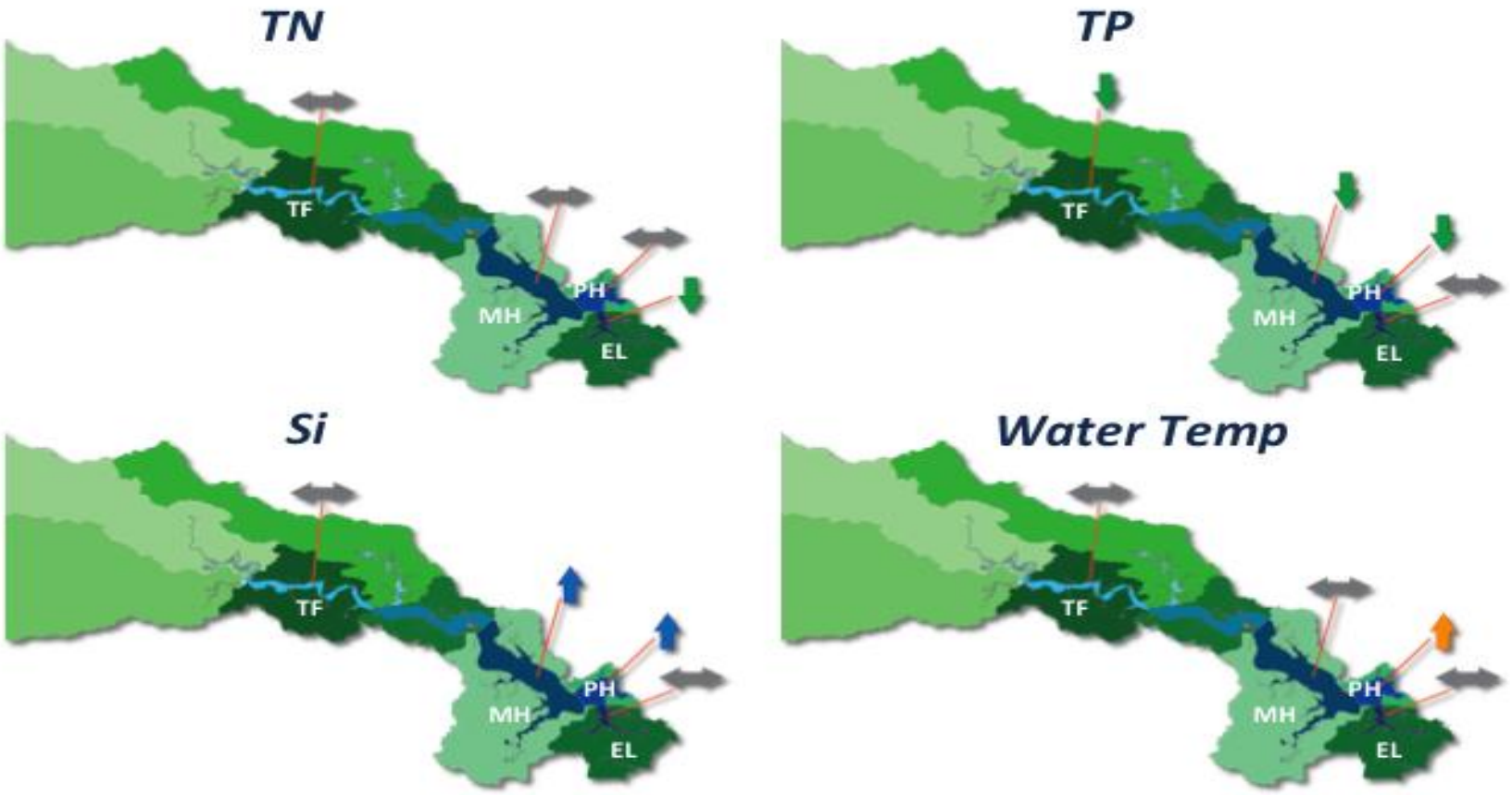
James River Chl-a Study Research for 2013

- Algal characterization
  - Fixed Station in TF
  - DATAFLOW in OH, MH, PH, ER, LAF
  - Top-down controls in TF
- Algal Bloom Triggers
  - Daily and diel monitoring
  - Storm events
  - SONE
  - Nutrients
- Potential Impacts to Aquatic Life
  - Shellfish
  - Zooplankton
  - Fish
  - Oysters

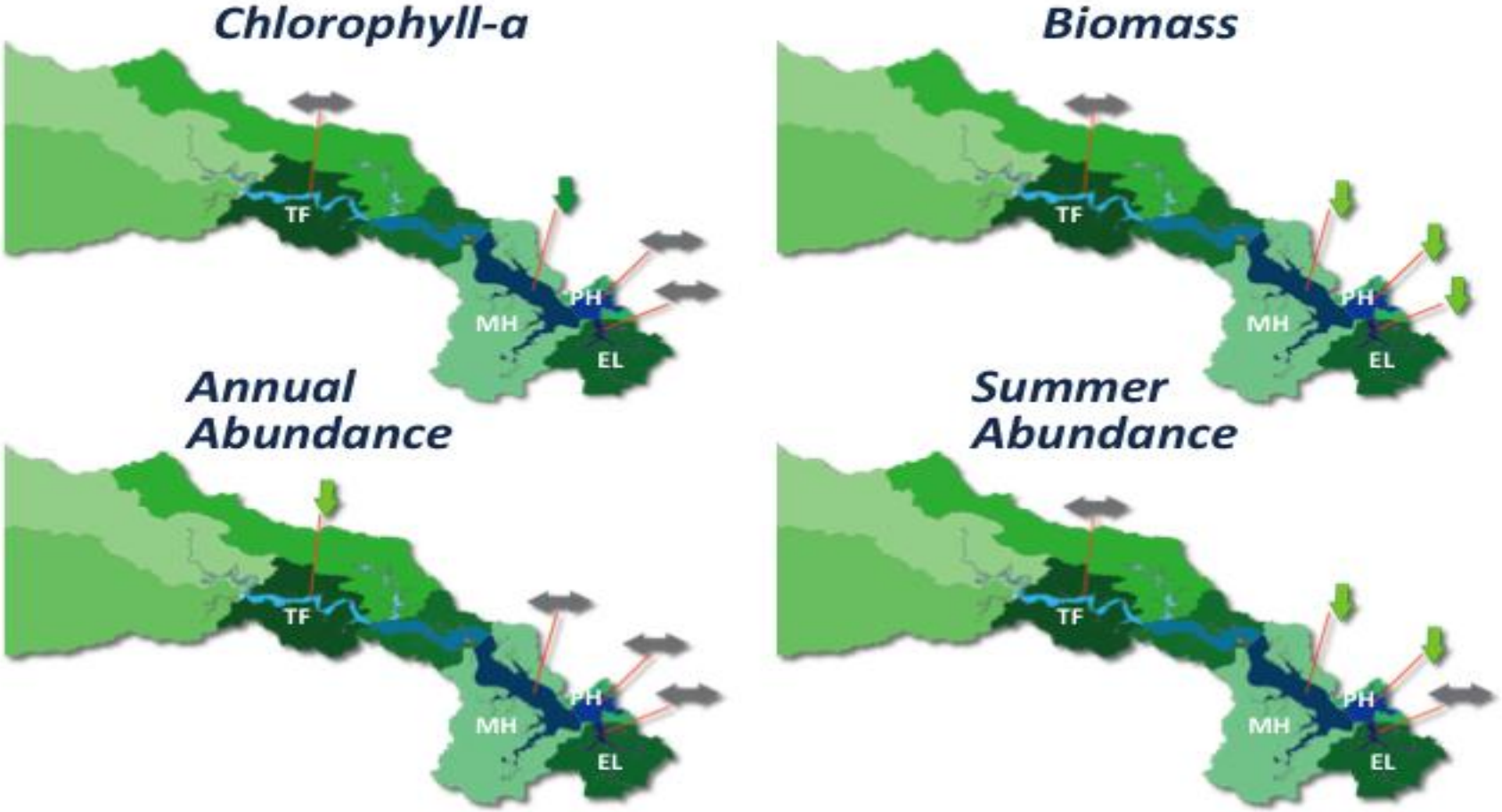
Dose Response Bioassays

- Toxicity species
  - *Cochlodinium polykrikoides*
  - *Prorocentrum minimum*
  - *Gymnodinium spp.*
  - *Karlodinium veneficum*
  - *Microcystis aeruginosa*
- Test organisms
  - *Crassostrea virginica*
  - *Bosmina*
  - *Cyprinodon variegates*

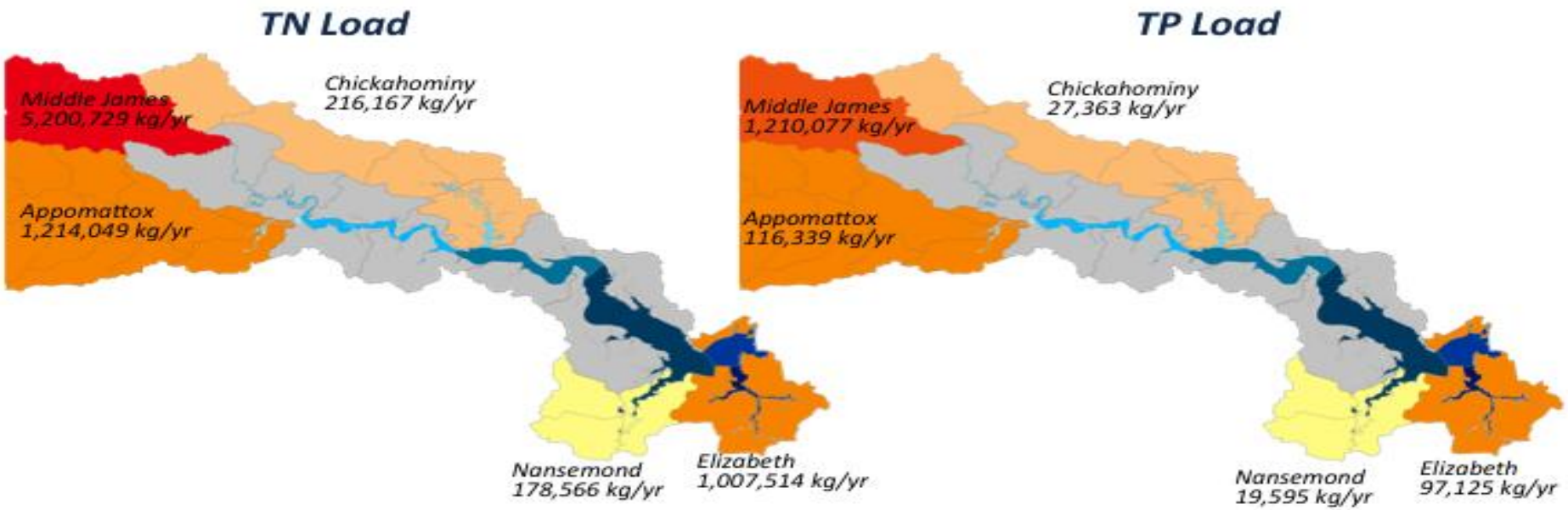
Modeling: Empirical Data Analysis
Long term trends (1995-2010)



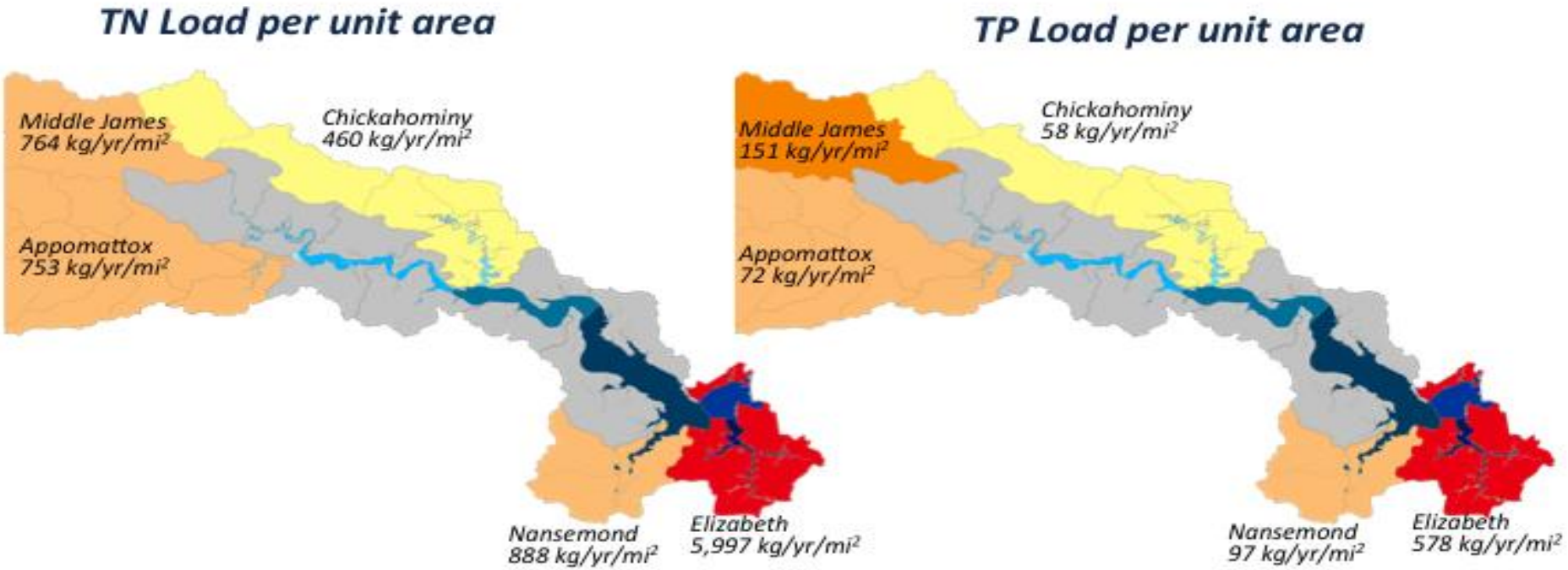
Long-term trends 1995-2010)



TN & TP Loads by sub-watershed



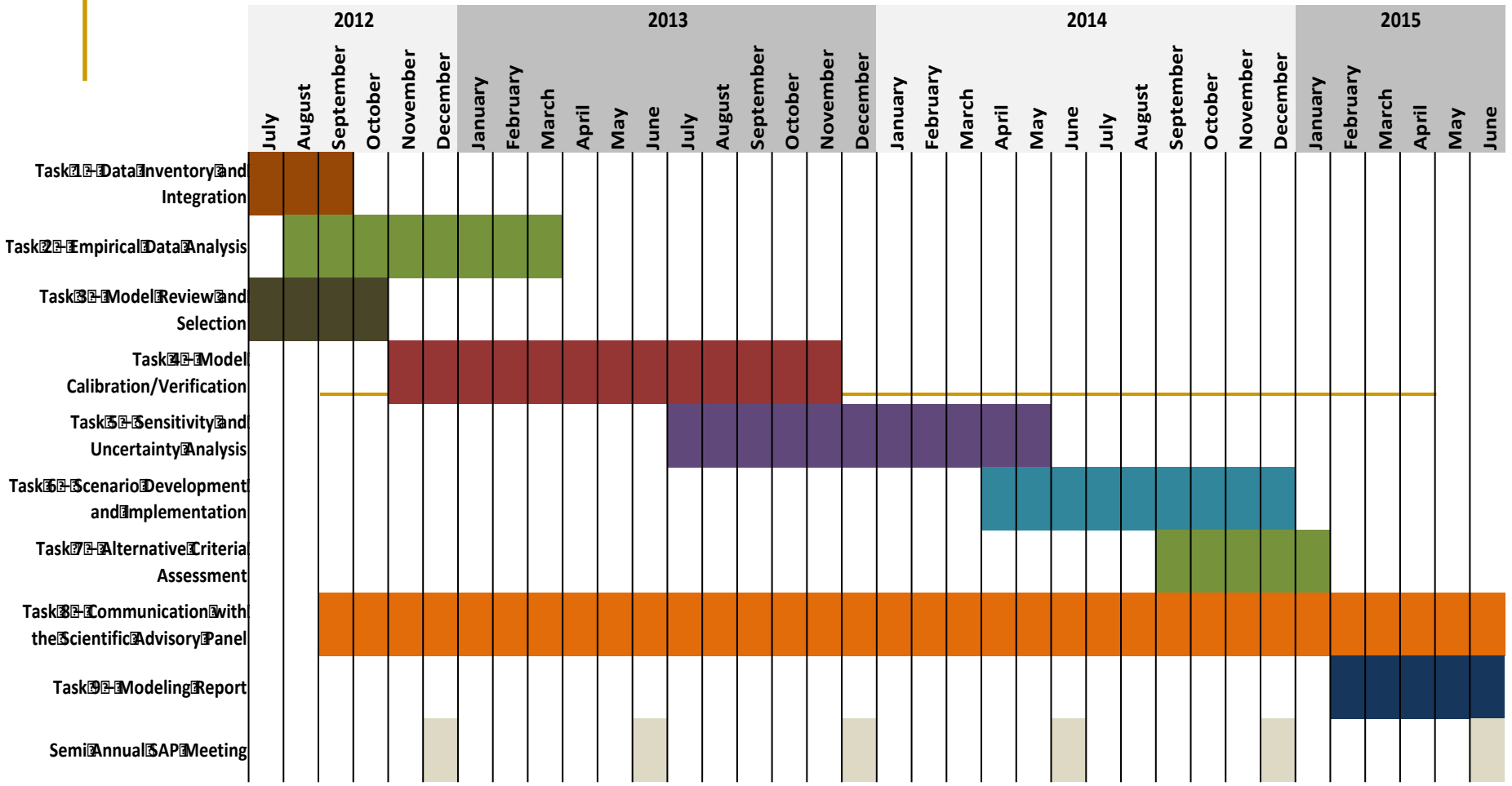
TN & TP Loads per Unit Area



JR Chl-a Study Schedule

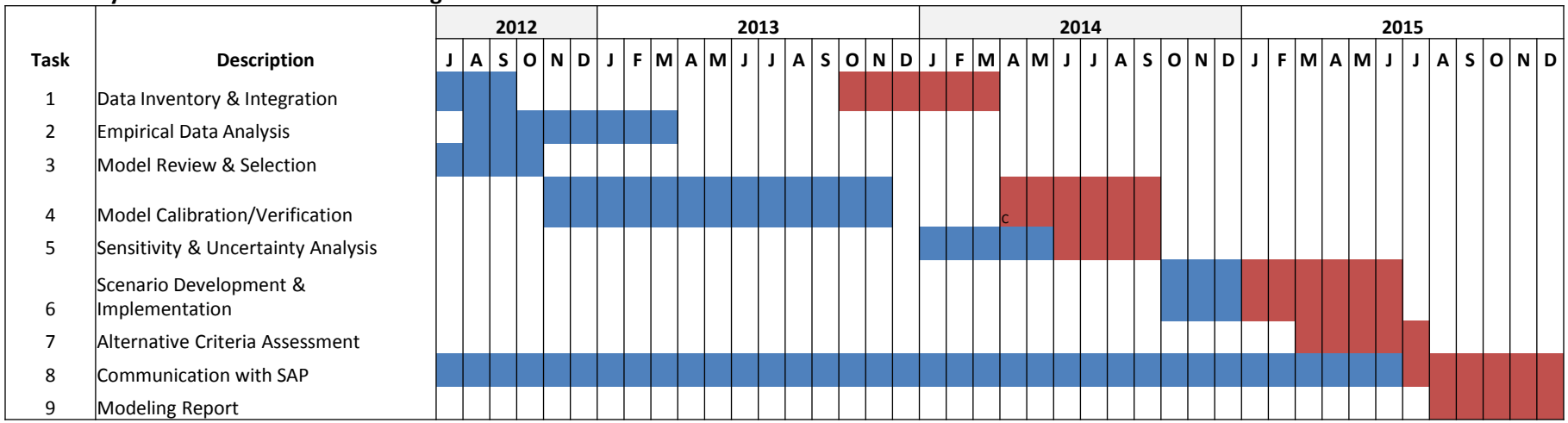
2011 - - - - - - Workplan Developed
Notice of Intended Regulatory Action (NOIRA)
2012 - - - - - - Workplan Implementation
2012-14 - - - - Monitoring and Modeling
2015 - - - - - - Assessment Review and Science Panel Recommendations
2016 - - - - - - Develop Regulatory Proposal (if appropriate)
2017 - -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

CEC Model Timeline



Proposal to extend model calibration to include 2011-13

Potentially Modified Schedule - Modeling



James River CHLa Study – More to come in 2013 & 2014

http://www.deq.virginia.gov/Programs/Water/WaterQualityInformationTMDLs/WaterQualityStandards/NutrientCriteriaDevelopment.aspx#James_R_CHLa_Study

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