Modeling Support for James River Chlorophyll Study

Presentation to the James River SAP, 5/3/2012

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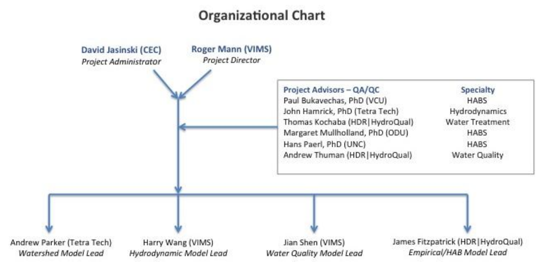
Project Team



Project Team

CEC
- *Dave Jasinski (Project Administrator)* Data management & analysis.

VIMS
- *Roger Mann – (Project Manager)* Fisheries scientist
- *Harry Wang* – Hydrodynamic & Pollutant modeling
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- *Mac Sisson* – GIS & Numerical modeling

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- *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

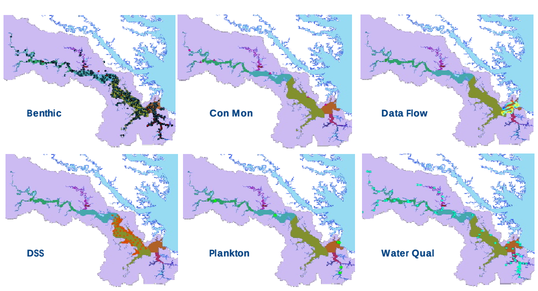
UNC
- *Hans Paerl* – HAB/Plankton expert

VCU
- *Paula Buckaveckas* – Plankton Dynamics

Task 1. Data Inventory and Integration

Data Type	Data Sub-type	Date Range	Physical Parameters	Chemical Parameters	Biological Parameters	Station Count
Benthic	Event	3/14/1991 - 9/24/2010				721
Benthic	Stations					721
Benthic	Biomass	03/14/1992 - 09/24/2010			biomass (g/sample)	657
Benthic	Taxonomic	03/14/1992 - 09/24/2010			species count (#/sample)	657
Department of Shellfish Sanitation		12/1984 - 03/2012	Tide Direction, Wind direction, Wind velocity, Water Temp, salinity, cloud cover, secchi (m), precip (inches)		Fecal Colliform (mpn/100ml)	118
Continuous Monitoring	Event	2/28/2006 - 12/4/2008	WTEMP, SPCOND, SAL, DO_Sat, DO, PH, Turb_NTU		CHL	6
Data flow Monitoring		3/15/2005 - 11/03/2011	WTEMP, SPCOND, SALINITY, DO_SAT, DO, PH, TURB_NTU		CHL	8 segments (APPTF, ELIPH, JMSMH, JMSOH, JMSPH, JMSTF1, YMSTF2, LAFMH)
Continuous Monitoring	Stations					6
Plankton	Pico Plankton	01/04/1993 - 12/22/1998			Count of Epiflourescent Picoplankton	6
Plankton	PicoStas	01/04/1993 - 12/22/1998				6
Plankton	Plankton	1/7/1991 - 9/23/2010			Counts by Species	6
Plankton	Plank_Sta	1/7/1991 - 9/23/2010				6
Plankton	Primary Productivity	1/7/1991 - 9/16/2009			Carbon fixation, CHLA, ASM_Ration	6
USGS	Concentration	2/21/1974 - 9/29/2010		TN, NO23, TP, Ortho P, SS		2
USGS	Uncensored Concentration	2/21/1974 - 9/29/2010		TN, NO23, TP, Ortho P, SS		2
USGS	Flow	1/1/1985 - 12/31/2010	Daily mean flow			11
USGS	station					11
Water Quality	Event	1/21/1991 - 12/21/2010	DO, DO_SAT_P, Salinity, Secchi, Sigma_T, SPCOND, SSC_$Fine, SSC_Fine, SSC_Sand, SSC_Total, WTEMP	CDOM_440, CDOM_Slope, CLW, COD, DIN, DOC, DON, DOP, FS, FSS, Hardness, KD, NH4, NH4W, NO23F, NO23W, NO2F, NO2W, NO3F, PC, PH, PIC, PIP, PN, PO4F, PO4W, POC, PP, SIF, SO4W, TALK, TDN, TDP, TKNW, TN, TOC, TON, TP, TSS, TURB_FTU, TURB_NTU,	BIOSI, BOD5W, CHLA, FCOLI_C, FCOLI_M, PHEO	87
Water Quality	Station					87

Task 1. Data Inventory and Integration



Task 2. Empirical Data Analysis

Subtask
- 2.1 – Data Review / Methodology Selection
- 2.2 – Flow and Nutrient Budget
- 2.3 – Critical Condition Assessment
- 2.4 – Biological Reference Curve

Subtask 2.1 – Data Review and Methodology Selection

Determine the distribution of phytoplankton, bloom frequency, and their extent in the James River

Correlation analysis – blooms and environmental variables:

- temperature, flow/residence time, nutrients, salinity, stratification/mixing, suspended solids/light
- seasonal and time-lag considerations
- include recent high frequency data
- consider internal loadings, i.e., benthic fluxes – VADEQ to support new field efforts

Subtask 2.1 – Data Review and Methodology Selection

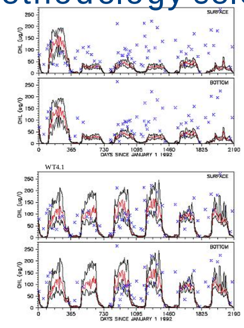
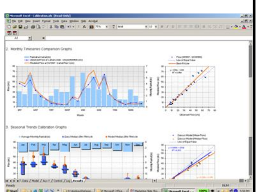


Fig. 57. The model results for chlorophyll a before (upper) and after (lower) implementing pH function at the station WT4.1 in Back River

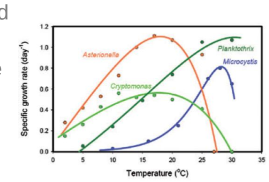
Subtask 2.2 – Flow & Nutrient Budget

- 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



Subtask 2.3 – 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



Subtask 2.4 – 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

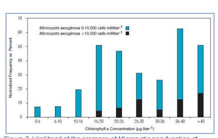


Figure 7. Likelihood of the presence of Microcystis as a function of total chlorophyll-a

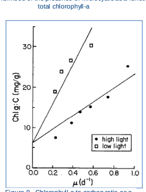


Figure 8. Chlorophyll-a to carbon ratio as a function of light

Task 3 – 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

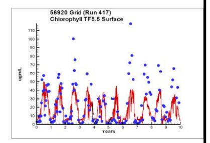
Subtask 3.5 – Predictive Accuracy

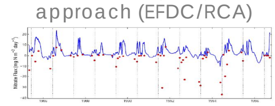
Subtask 3.1 Watershed Model

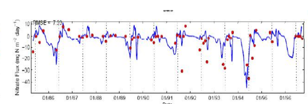
- Develop high resolution watershed model
  - Provide BCs for river models (flow and nutrient/ sediment loads)
  - Better represent local conditions
  - Mesh with existing Chesapeake Bay Watershed Model
- Basis for evaluating effects of watershed-based implementation strategies
- Anticipate using EPA's 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 sedimentnutrient flux model
- Dual water quality model approach (EFDC/RCA)

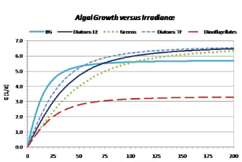






Subtask 3.3 – Phytoplankton/HAB Model

- 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



Subtask 3.4 – Probabilistic/ Empirical Analysis

- Seasonal timeframe of analysis may reduce variance and show importance of time lags

  Chl = 60 · Q-0.4 + 14.8 · TN · (1.52 · Season) - 1.60

  where Season is a variable (=0 for spring, =1 for summer)

  when a value is estimated for summer period, the seasonal effect is a 1.52 ug/L shift in the mean response (relative to spring) – captures effects of temperature and daylight length on algal biomass
- Will consider simple linear regression, non-linear regression and logistic regression models

Subtask 3.5 – Predictive Accuracy

- Will consider predictive accuracy for both deterministic and empirical models
- Will look at effectiveness of mixed deterministic/ empirical modeling approach
- The mixed approach may provide best management tool for predicting HABs

Task 4. – Model Calibration/ Validation

Dual model approach
- data from 1991-2000 will be used for calibration/validation of conventional eutrophication model (EFDC)
- data from 2007-2010 will be used for calibration/validation of the HAB model (RCA)
- then RCA will be applied to the 1991-2000 data record

Quantitative skill assessment – relative error, RMSE, correlation analysis (r^2), receiver operating characteristic (ROC)

Qualitative skill – graphics – time-series, spatial, and contour plots

Diagnostic mass balance analysis

Task 5 – Sensitivity and Uncertainty Analysis

- Model uncertainty analysis to consider model parameters, boundary conditions and loads
- Chlorophyll statistical analysis to consider magnitude, frequency and duration
- Focus on 3 high level chl-a areas and 5 key model coefficients
- Evaluate uncertainty using a dual model approach and comparison

Subtask 6 - Scenarios

Will consider 10 scenarios from:

- Baseline conditions
- VA tributary strategy
- VA TMDL allocations
- VA WIP I
- VA WIP II
- **VA WIP III
- Top-down controls
- Climate change
- James level of effort – Potomac River
- James ½ level of effort – Potomac River
- Combinations of above

Task 7 – Alternative Criteria Assessment

- Will work with VADEQ and SAP to consider one alternative set of chlorophyll-a criteria

Task 8 – Meet with VADEQ/SAP

- Meetings such as today
- SAP to provide first level of review
- Work together to deliver best scientifically defensible product to VADEQ
- Meet at a minimum of semi-annually

Task 9 – Modeling Report

Provide detailed information concerning:

- the choice of model(s) and model grid resolution,
- revised phytoplankton population algorithms, including functional groups and HABs,
- calibration and validation results, including model skill assessment,
- system-wide mass balances for nutrients,
- sensitivity and uncertainty analyses,
- results from the scenario evaluations, including assessment of criteria attainment by scenario,
- results from the assessment of alternative criteria