2018 Chesapeake Community Research and Modeling Symposium

June 12-14, 2018
Crowne Plaza Hotel
Annapolis, MD

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Welcome to the Chesapeake Community Research and Modeling Symposium 2018

Scope

The Chesapeake Community Modeling Program (CCMP) seeks to improve observational and modeling tools specific to the Chesapeake Bay and its surrounding environment by fostering collaborative, open source research. The purpose of the sixth biennial Chesapeake Community Research and Modeling Symposium is to identify and showcase existing observational and modeling research efforts and decision support tools using data.

While the Bay ecosystem is well-researched, many challenges remain. We need higher temporal resolution measurements and higher spatial resolution models, and better and models of physical, biological and chemical processes in the air-shed, watershed and estuary. We need more flexible sampling and modeling approaches to resolve management impacts on living resources. We need to link models to human and socio-economic impacts.

By bringing together managers, scientists, and stakeholders for a series of plenary talks, panel discussions, and special sessions, the 2018 Chesapeake Community Research and Modeling Symposium will highlight recent progress, challenges and prospects for research, monitoring and modeling efforts that are used to guide management and restoration efforts in Chesapeake Bay.

Planning Committee

Bill Ball - Chesapeake Research Consortium
Chris Duffy - Pennsylvania State University
Marjy Friedrichs - Virginia Institute of Marine Science
Courtney Harris - Virginia Institute of Marine Science
Raleigh Hood - University of Maryland Center for Environmental Science
Dave Jasinski - Chesapeake Research Consortium/Green Fin Studio
Kevin Sellner - Chesapeake Research Consortium
Gary Shenk - EPA Chesapeake Bay Program Office
Cecily Steppe - United States Naval Academy
Alexey Voinov - University of Technology Sydney
Claire Welty - University of Maryland Baltimore County

Sponsors

Three Decades of Using Science as the Foundation for Collaborative Bay and Watershed Restoration Decision-making–a Behind the Scenes Look at How the Partnership Works

Rich Batuik, Environmental Protection Agency

BIO

Rich Batiuk is the Associate Director for Science, Analysis, and Implementation at the United States Environmental Protection Agency's Chesapeake Bay Program Office located in Annapolis, Maryland. In his 33 years with EPA and the Chesapeake Bay Program partnership, he has led the integration of science into multi-partner policy-making and collaborative decision-making.

Rich is now focused on directing the partnership resources towards helping local partners understand their part in the Bay and watershed restoration efforts and getting the job done, restoring water quality to local waterways and the Bay.

He received his B.S. in Environmental Science from the University of New Hampshire in 1984 and his M.S. in Environmental Toxicology from American University in Washington D.C. in 1985.

ABSTRACT

Since the signing of the 1983 Chesapeake Bay Agreement, the state, federal, local, and academic Chesapeake Bay Program Partnership has built, added to, and continually expanded the scientific foundation on which the partners have based their collaborative, consensus-based decision-making processes. Two stories will be presented illustrating how the Partnership takes advantage of the continually evolving scientific understanding of the estuary and the surrounding watershed and incorporates that enhanced understanding into collaborative decision and policy making. One traces the 1985 through 2018 history of how an unprecedented set of Chesapeake Bay specific water quality criteria were derived through the joint efforts of the region's scientific and management communities became regulatory standards driving billions of dollars in investments and still evolved with time. The second walks through a unique approximately 7-year cycle of opening up well established goals and policies to reflect new science and data, adapts management actions to reflect that new understanding, and then locks back down for a prolonged period of focused implementation. Your tour guide/story-teller has been on the frontline of this intricate science/management dance for the past 33 years, watching and helping drive the evolution of how science influences policy and how policy seeks more certainty from science within this partnership we call the Chesapeake Bay Program.

Marjy Friedrichs, Virginia Institute of Marine Science

BIO

Dr. Marjorie Friedrichs is an associate professor at the Virginia Institute of Marine Science of the College of William & Mary. She received a BA in Physics from Middlebury College, a MS in Physical Oceanography from the Massachusetts Institute of Technology/Woods Hole Oceanographic Institution Joint Program, and a Ph.D. in Oceanography from Old Dominion University. Her interdisciplinary research interests focus on how physical processes affect biogeochemical properties in estuarine and coastal systems. She uses coupled hydrodynamic-biogeochemical models together with analyses of in-situ and satellite data to better understand how and why carbon and nitrogen cycling varies among diverse marine environments. Much of her current research investigates how human impacts, such as changes in global climate, atmospheric deposition, urbanization and land use affect carbon, biogeochemical and ecosystem dynamics in these systems. Friedrichs' current modeling projects involve forecasting hypoxia in the Chesapeake Bay (www.vims.edu/hypoxia) and inorganic carbon cycling (acidification). Another focus of her research involves the assessment of the relative skill of multiple models currently being used by the scientific community and techniques for optimally combining data and models including data assimilation and parameter optimization.

ABSTRACT

High-resolution mechanistic models with appropriate parameterizations for key physical, chemical, and biological processes are critical for predicting potential responses of shallow water ecosystems to future anthropogenic pressures. Shallow waters (< 3m deep) are of particular interest to Chesapeake Bay Program (CBP) managers, as these are some of the most difficult to simulate with the existing CBP modeling framework and because this is where some of the most significant initial effects of management efforts may be observed. As a result, in recent years the CBP has been directing efforts towards improving this component of their modeling framework. Specifically, they funded a multiple model intercomparison effort focused on the Chester River, a shallow tributary of the Chesapeake Bay. Results from multiple high-resolution model implementations were compared to those from the lower resolution Chesapeake Bay Program model. The models were all implemented for this system in a consistent manner, using identical forcing and boundary conditions to facilitate a comparison of the relative skill of the models. While all models were found to perform well in terms of representing temperature in this shallow water environment, only the high-resolution models were able to capture the upstream salinity gradient. Model results were very sensitive to concentrations used at the open boundary at the Chester River mouth, with model differences due to boundary condition adjustment occurring more than 45 km from the boundary. In contrast, model results were relatively insensitive to a 10% change in freshwater riverine inputs. In a second phase of the model intercomparison effort, a set of nutrient reduction strategies was applied to each of the models, representing three scenarios: "1985", "TMDL" and "All Forest". Comparison results indicate that in each case the TMDL scenario showed only relatively minor improvements in water quality compared to the 1985 scenario; in contrast, the "All Forest" nutrient reduction scenario resulted in large improvements in water quality throughout the Chester River. Overall, the high-resolution models behaved very similarly to the three nutrient reduction strategies tested here, leading to increased community confidence in our ability to manage water quality in the Chesapeake Bay.

Real Time ADCIRC Modelling for Coastal Zone Decision Support

Jason Fleming, Seahorse Coastal Consulting

BIO

Dr. Jason Fleming has served as the development coordinator for the ADCIRC coastal ocean model since 2005 and has worked on every part of the code during that time. In the aftermath of Hurricane Katrina, he was chosen to develop key ADCIRC features to support real time ADCIRC model guidance for tropical cyclones. Dr. Fleming is also the Lead Developer and Operator for the ADCIRC Surge Guidance System (ASGS), a software automation system for ADCIRC that he operated in real time for official decision support during the Deepwater Horizon event as well as Hurricanes Gustav, Irene, Isaac, Sandy, Harvey, Irma, and Maria. In 2010, Dr. Fleming founded the ADCIRC Boot Camp, an annual three day training event for teaching and learning in the ADCIRC model community.

ABSTRACT

The ADCIRC finite element coastal ocean model is used in real time decisions support services for coastal and riverine hydrodynamics, tropical cyclone winds, and ocean wave modelling for public sector agencies including NOAA, FEMA, Coast Guard, and the US Army Corps of Engineers, among others. Recent developments in ADCIRC's real time automation system, the ADCIRC Surge Guidance System (ASGS), have now enabled real time modelling of active flood control scenarios (manipulation of pumps and flood gates) for decision support during riverine floods and tropical cyclone events. During these events, the results are presented to official decision makers with the Coastal Emergency Risks Assessment (CERA) web application, an intuitive and interactive tool that integrates model data with measured data to provide situational awareness across the area of responsibility. Case study events will be described, including official decisions that have been made with the ASGS/CERA system in North Carolina (Irene 2011), Louisiana (Mississippi River flooding in 2016), and during the 2017 hurricane season for Harvey, Irma, and Maria.

Moderator: Scott Phillips, United States Geological Survey, Chesapeake Bay Program Office

BIO

Scott has over 3 decades of experience in conducting and directing scientific investigations related to the interdisciplinary studies of ecosystems. He began working on issues related to Chesapeake Bay in 1989 and since 1995 has served as the U. S. Geological Survey Chesapeake Bay Coordinator. He coordinates the scientific investigations of over 100 USGS projects on a broad range of related topics, including assessing the health of fish and wildlife; explaining water-quality conditions and trends, and forecasting the potential effects of land use and climate change. He works with scientists to synthesize major findings and provide ecosystem management implications. He interacts with the federal and state partners in Chesapeake Bay Program to consider the scientific information so they can make more effective decisions for ecosystem restoration and protection.

Greg Allen, Environmental Protection Agency

BIO

Greg Allen is an environmental scientist at EPA. Ten years in the analytical chemistry field led next to work in quality assurance and laboratory support for the Superfund program. Greg moved to the Chesapeake Bay Program to help lead the program's initiatives around reducing risk from toxic contaminants to the Bay's natural resources and users of the resources. Greg now helps to co-chair the Chesapeake Bay Program Toxic Contaminants Workgroup and facilitates the development and implementation of a management strategy that is intended to reduce risk from toxic contaminants. Greg is also active in the social sciences and conducts research on the organizational benefits of corporate social responsibility. One of his "whys" is to help people achieve extraordinary outcomes in their personal and professional lives through effective leadership.

Overview of Research Efforts to Address Toxic Contaminants in the Chesapeake System

By Scott Phillips and Greg Allen

ABSTRACT

The Chesapeake Bay Agreement has a goal to ensure that the Bay and its rivers are free of effects of toxic contaminants on living resources and human health. The two associated outcomes are (1) research and (2) policy and prevention. The research strategy will provide information about the occurrence, sources, and effects of toxic contaminants on fish and wildlife. The information will be used by the Toxic Contaminant Workgroup to consider policy and prevention approaches to reduce the effects of contaminants on living resources in the Bay watershed and make them safe for human consumption. The five issues being addressed in the research strategy (in order of priority) are:

- Supply information to make fish and shellfish safe for human consumption;
- Understand the influence of contaminants degrading the health, and contributing to mortality , of fish and wildlife;
- Document the occurrence, concentrations and sources of contaminants causing fish and wildlife degradation;
- Asses the relative risk of contaminants, and options for mitigation, to inform policy and prevention strategies,
- Gather information on issues of emerging concern.

The presentation will highlight some of the current research efforts being conducted to address the five issues in the strategy. The remaining science gaps will also be discussed to help inform future research efforts. We also anticipate additional abstracts on toxic contaminants and hoped they can be grouped together. We suggest this presentation could be an introductory talk and provide context for other presentations on the toxic contaminants and their effects on fish and wildlife.

Widespread Occurrence of Contaminants of Emerging/Increasing Concern in Chesapeake Bay Water, Sediment, and Oysters

Lee Blaney, University of Maryland Baltimore County

Co Authors: Ke He, Ethan Hain, Anna Feerick, Anne Timm, Mitchell Tarnowski

BIO

Dr. Lee Blaney received his BS and MS degrees in Environmental Engineering from Lehigh University. In 2011, he finished his PhD at the University of Texas at Austin and started as an Assistant Professor in the Department of Chemical, Biochemical, and Environmental Engineering at UMBC. He was recently promoted to Associate Professor. At UMBC, Lee has established a research program focused on (1) the occurrence, fate, transport, and toxicity of contaminants of emerging concern in natural and engineered systems and (2) resource recovery from agricultural waste. He is the recipient of the Maryland Outstanding Young Engineer Award, the NSF Career Award, and the AEESP Award for Outstanding Teaching in Environmental Engineering and Science.

ABSTRACT

The Chesapeake Bay is the nation's largest estuary, but the occurrence and distribution of contaminants of emerging concern (CECs) has not been investigated in this economically and ecologically important body of water. The input of CECs from urban and agricultural sources has not been spatially evaluated to identify trends in CEC occurrence in water or sediment with land-use characteristics. In addition, the accumulation of CECs into critical organisms, such as the eastern oyster (Crassostrea virginica), has not been assessed. As eastern oysters are consumed by humans and play a critical role in Chesapeake Bay restoration efforts, accumulation of CECs represents both public and ecological health concerns. These knowledge gaps were addressed by monitoring a suite of antibiotics, hormones, and sunscreen agents in water, sediment, and oysters from more than 50 sites in the Chesapeake Bay in spring/fall 2017. All analytes were measured using phase-specific extraction techniques coupled to liquid chromatography with tandem mass spectrometry. Fluoroquinolone, macrolide, and sulfonamide antibiotics were regularly detected in water samples. As both human- and animal-labeled antibiotics were detected, wastewater effluent and agricultural runoff were identified as potential sources. The estrogenic hormone, estrone, and five sunscreen agents, namely ethylhexylmethoxycinnamate, homosalate, octisalate, octocrylene, and oxybenzone, were frequently detected in water, sediment, and oyster tissue. These results provide the first comprehensive study of CECs in the Chesapeake Bay, confirm CEC bioaccumulation in oyster, and establish the need for improved CEC removal during municipal wastewater treatment and agricultural waste management.

Importance of Monitoring Sensitive, Resident Species for Assessing Effects of Exposure to Chemicals of Emerging/Increasing Concern

Vicki Blazer, United States Geological Survey

Co Authors: Heather Walsh, Cassidy Shaw, Luke Iwanowicz, Megan Schall

BIO

Dr. Blazer received her BS in Marine Biology from Southampton College of Long Island University and a PhD in Fisheries, Aquacultural Science and Pathology from the University of Rhode Island. After completing a postdoctoral position at the University of Georgia's College of Veterinary Medicine, she accepted the Assistant Unit Leader position at the Georgia Cooperative Fish and Wildlife Unit. In 1992 Vicki moved to the National Fish Health Research Laboratory, Leetown Science Center. She has been involved in fish health studies both nationally and internationally, most recently focusing on the Chesapeake and Great Lakes watersheds. Vicki is an adjunct professor at Penn State and West Virginia University, teaching and directing graduate student research. She is the recipient of numerous awards including the Distinguished Service Award from the Fish Health Section of the American Fisheries Society and the Protector of the Potomac award from the Potomac Riverkeepers Association.

ABSTRACT

The aquatic environment receives hundreds to thousands of chemical contaminants in complex mixtures. Those of emerging or growing concern include hormones, pharmaceuticals, chemicals in personal care products, plastics and other household products (such as flame retardants) and current use pesticides. Due to land use and climatic factors concentrations of individual chemicals can vary greatly throughout a year (or month). Chemical sampling is often a snapshot in time. Conversely, fish and other aquatic organisms are continually exposed to these complex mixtures of stressors. These mixtures may have chemicals with additive, synergistic or antagonistic activities. Exposures during important developmental periods can have significant effects later in life. Utilizing biomarkers of exposure, from the organism to the molecular level can provide indications of the types of chemicals an organism is being exposed to as well as the mechanisms (adverse outcome pathways). Adverse effects, including fish kills, intersex (testicular oocytes), lack of reproductive success (abnormal egg production), melanistic and other skin lesions, liver and skin tumors, population declines, have all been documented in the Chesapeake watershed. Different fish species show different sensitivities to various chemicals (or chemical mixtures) and so have different responses. Identifying adverse effects and understanding the risk factors (chemical concentrations, pathogens, other stressors) and timing of exposure are important for addressing management actions.

A Field-Based Approach to Understanding the Fate and Transport of Contaminants of Emerging Increasing Concern in the Environment

Heather Gall, Pennsylvania State University

BIO

Dr. Heather Gall received her B.S. degree in Civil and Environmental Engineering from Rutgers University in 2007. She then went to graduate school at Purdue University, where she received her MS and PhD in Civil and Environmental Engineering. In 2011, she began a post-doctoral research appointment at Purdue and joined the faculty at Penn State in 2013, where she is now an assistant professor of Natural Resources Engineering in the Agricultural and Biological Engineering Department. Her research seeks to understand the factors that affect the presence, fate, transport, and ecological impacts of contaminants of emerging concern (CECs) in the environment. Although her research efforts have largely focused on agricultural sources of CECs, she has recently expanded her research to include wastewater and drinking water treatment plants, as well as the presence of CECs in vernal pools and riparian buffers. Her research is funded by various funding agencies, including USDA, NSF, PA Sea Grant, and internal sources of funding at Penn State. She enjoys teaching two undergraduate classes and involving undergraduate students in her research programs. At Penn State, she has been honored with the Harbaugh Faculty Scholar Award as well as the College of Agricultural Sciences NACTA Teaching Award of Excellence.

ABSTRACT

Trace-level organic contaminants with endocrine disrupting properties are known to impact aquatic ecosystems at concentrations on the ng/L level. While many laboratory studies have been conducted to estimate physicochemical parameters (i.e., half-lives, sorption coefficients, etc.) that should predict their transport in the environment, these chemicals are found nearly ubiquitously in the environment and persist longer than laboratory studies would predict they should. My research group conducts field-based studies to understand how land management practices, biogeochemical processes, hydrologic transport pathways, and wastewater treatment technologies effect the occurrence, persistence, and potential impacts of emerging contaminants in aquatic environments. In an effort to engage the general public on this topic of emerging concern, we developed an "Emerging Contaminants Footprint Tool" to help empower people to reduce their footprint by making informed choices that can improve water quality for humans and aquatic ecosystems.

PANEL ABSTRACT

Status and Trends of Submersed Aquatic Vegetation (SAV) in Chesapeake Bay: A Synthesis

William Dennison[1], Jonathan Lefcheck[2], Robert Orth[3], Cassie Gurbisz[4]
1 University of Maryland Center for Environmental Science, Cambridge, MD 21613
2 Center for Ocean Health, Bigelow Laboratory for Ocean Science, East Boothbay, ME 04544
3 Virginia Institute of Marine Science, Gloucester Pt., VA 23062
4 St. Mary's College of Maryland, St. Mary's City, MD 20686

Chesapeake Bay has undergone rapid, profound changes since European settlement. Increases in human and livestock populations, associated changes in land use, increases in nutrient loadings, shoreline armoring, and depletion of fish stocks have altered the important habitats within the Bay. One such habitat, submersed aquatic vegetation (SAV), is foundational and provides numerous benefits and services to society. In Chesapeake Bay, SAV species are also indicators of environmental change due to their sensitivity to water quality and shoreline development. Here, we provide an overview of a two-year synthesis effort by a team of 14 scientists from a diversity of backgrounds and affiliations to assess the status and trends of SAV in Chesapeake Bay, and to develop management recommendations to insure healthy SAV populations in the future. Five products have been produced by this synthesis team that highlight these issues and will be briefly discussed here.

1. The first product, published in the journal BioScience, provided an overview of the importance of SAV in Chesapeake Bay as an indicator and ecosystem engineer, its integration into regional regulations and annual assessments of management outcomes, restoration efforts, the scientific literature, and popular media coverage, and emphasized both historical and emerging challenges for SAV persistence in the region.

2. The second product, published in Global Change Biology, focused on elucidating the patterns and drivers of eelgrass (Zostera marina) abundance in lower Chesapeake Bay. We showed that eelgrass cover had declined 29% in total since 1991, with wide-ranging and severe ecological and economic consequences. We identified an interaction between decreasing water clarity and warming temperatures as the primary driver of this trend. Declining clarity had gradually reduced eelgrass over the past two decades, primarily in deeper beds where light was already limiting. In shallow beds, however, reduced visibility exacerbated the physiological stress of acute warming, leading to recent instances of decline approaching 80%. We demonstrated a clear and rapidly emerging interaction with climate change.

3. The third product, recently published in the Proceedings of the National Academy of Sciences, united 30 consecutive years of watershed modeling, biogeochemical data, and comprehensive aerial surveys of Chesapeake Bay, USA to predict the cascading effects of anthropogenic impacts on SAV. We employed structural equation models to link land use change to higher nutrient loads, which in turn reduce SAV cover through multiple, independent pathways. We also showed through our models that high biodiversity of SAV consistently promotes cover, an unexpected finding that corroborates emerging evidence from other terrestrial and marine systems. Due to sustained management actions that have reduced nutrient concentrations in Chesapeake Bay by 23% since 1984, SAV has regained 17,000 density-weighted hectares to achieve its highest cover in almost half a century. Our study empirically demonstrated that nutrient reductions and biodiversity conservation are effective strategies to aid the successful recovery of degraded systems at regional scales, a finding which is highly relevant to the utility of environmental management programs worldwide.

4. The fourth product was a series of Fact Sheets for Resource Managers. The Fact Sheets focused on trends of SAV in each segment and whether they have attained the restoration goal established for that segment, key events influencing SAV, vulnerability and resilience of SAV, and management actions necessary to facilitate SAV growth and persistence.

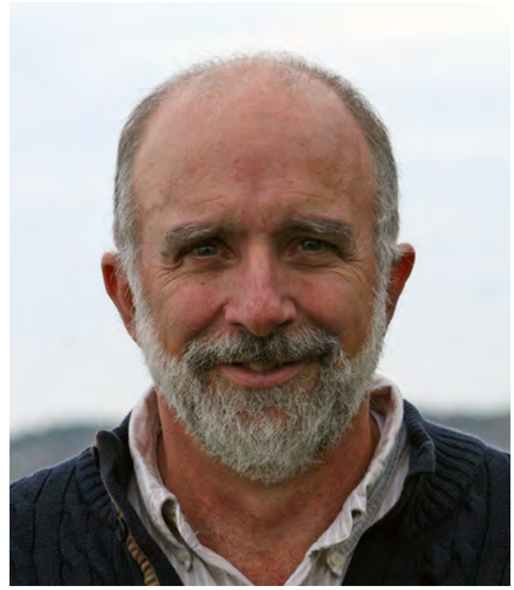
5. The fifth and final product, submitted to the journal Environmental Management, provided an overview of this extraordinary 30-year trajectory of SAV research, monitoring and management in Chesapeake Bay.

The productivity and contributions of this working group will provide not only rigorous science for the Bay, but also functions as a template for future groups focusing on other issues.

We also present results from an intensive case study of SAV dynamics in the Susquehanna Flats region of upper Chesapeake Bay to complement our broad-scale synthesis work. The primary goal of the case study was to investigate how internal ecosystem processes, such as plant-sediment and plant-nutrient interactions, may have influenced SAV recovery and stability. Through analysis of environmental monitoring data and observational field studies, we show that the plant bed stabilized bottom sediments, thereby limiting local sediment resuspension and enhancing water clarity. This likely increased the SAV bed's capacity to withstand and recover from high rates of sediment loading during a major flood event in September 2011. We also show that the SAV bed increased local water residence time. Because the plants and sediment were, then, in contact with the water for an extended period of time, denitrification and plant assimilation substantially decreased ambient water column nutrient concentrations. This limited phytoplankton production within the SAV bed and, again, improved water clarity. Moreover, this clear water often "spilled over" beyond the bed perimeter into adjacent unvegetated regions, increasing light availability for colonizing propagules. We suggest that this positive feedback process could enhance SAV recovery rates. Overall, this work demonstrates that internal ecosystem processes may complement nutrient load reduction to accelerate SAV recovery.

William Dennison, University of Maryland Center for Environmental Science

BIO



Dr. Dennison is a Professor of Marine Science and the Vice President for Science Applications at the University of Maryland Center for Environmental Science (UMCES). Bill rejoined UMCES in 2002 following a ten year stint at the University of Queensland in Brisbane, Australia. While there he developed an active Marine Botany group with strong links to the Healthy Waterways Campaign for Moreton Bay. Bill obtained his academic training from Western Michigan University (B.A., Biology & Environmental Science), the University of Alaska (M.S., Biological Oceanography), the University of Chicago (Ph.D., Biology), and the State University of New York at Stony Brook (Postdoc, Coastal Marine Scholar). Bill has published hundreds of papers and books and has presented at multiple international, national, and regional meetings, and at various universities, research institutions, and government agencies. Bill continues to serve and has served in the capacity of President, Chair, Co-Chair, Deputy Director, Leader and Member on more than three dozen separate environmental councils, committees, groups and societies. He has provided graduate student supervision to numerous "up and coming" scientists through the PhD, Masters and Honors programs at both the UMCES and the University of Queensland.

Cassie Gurbisz, St. Mary's College of Maryland

BIO

Cassie Gurbisz is an Assistant Professor of Environmental Studies at St. Mary's College of Maryland. Her research focuses on the restoration and resilience of coastal foundations species, such submersed aquatic vegetation (SAV) and marshes. Her dissertation work focused extensively on the recovery dynamics of SAV at Susquehanna Flats, an immense shoal in the upper Chesapeake Bay. Her current research focuses on understanding how SAV and marsh ecosystem functioning is changing in response to changing stressors, such as nutrient pollution, sea level rise, and storm events. Cassie also currently teaches an undergraduate course on Chesapeake Bay science and management, as well as interdisciplinary courses in environmental studies. She received her Bachelor's degree in Art and Environmental Science from Dickinson College in 2005 and her PhD in Marine Estuarine, and Environmental Science from University of Maryland Center for Environmental Science in 2016. Prior to her appointment at St. Mary's, Cassie worked as a postdoctoral fellow at the National Social Environmental Synthesis Center (SESYNC) in Annapolis, MD.

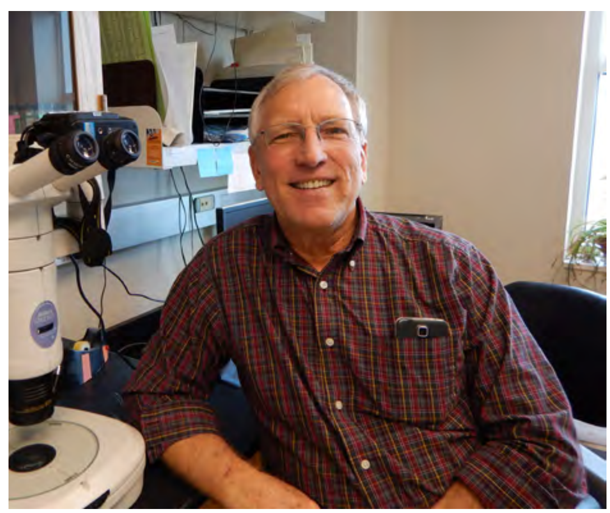
Jonathan Lefcheck, Center for Ocean Health, Bigelow Laboratory for Ocean Science

BIO

in 2015, completed post-doctoral research at the Virginia Institute of Marine Science in Gloucester Point, VA, and is currently based at the Bigelow Laboratory for Ocean Sciences in East Boothbay, ME. His interests include marine community ecology, biodiversity science, and biostatistics. He uses a combination of experiments and observation to understand how and why biodiversity matters to a range of coastal ecosystems, from seagrass beds to coral reefs to hydrothermal vents. He also develops statistical tools to help investigate the natural world and is an expert in the technique of 'structural equation modeling.' You can read

Robert "JJ" Orth, Virginia Institute of Marine Science

BIO



Bob (JJ) is a professor, and currently Chair, of Marine Science in the Department of Biological Sciences at the Virginia Institute of Marine Science, School of Marine Science, College of William and Mary. He received his bachelors from Rutgers University (1969), Masters in Marine Science from the University of Virginia (1971) and Ph.D. in Zoology from the University of Maryland (1975). He has been involved in seagrass research in the Chesapeake Bay region since 1969 and Australia since 1996. He. His current emphasis is on habitat restoration and conservation and understanding the principles and processes governing the persistence, alterations, and dynamics of these plant communities. One of his signature accomplishments has been leading a team of scientists in one of the largest and most successful seagrass restoration projects in the world in the seaside lagoons of Virginia's Delmarva Peninsula. Bob is also head of the VIMS program that maps underwater grasses baywide annually. Annual results from this mapping program are used by the federal government, as well as state entities in Virginia and Maryland, to help evaluate the success of Chesapeake Bay cleanup efforts. He is heavily involved with management agencies in the development of policies and laws governing the protection of these important underwater grasses in Chesapeake Bay and the Coastal Bays. He recently received the award as one of Virginia's Outstanding Scientists for 2018.

BIO

Larry Sanford serves as Interim Vice President for Education at UMCES and is also a Professor at UMCES Horn Point Laboratory. He maintains an active research program in fine sediment transport processes, coastal and estuarine physical oceanography, waves, and turbulence, with a special interest in interactions between fluid flow and estuarine ecology. Larry has served on the Chesapeake Bay Program Scientific and Technical Advisory Committee, the Bay Program Modeling Subcommittee and Sediment Workgroup, and various other Chesapeake Bay advisory committees. He also serves on the Steering Committee of the International Conference on Cohesive Sediment Transport Processes.

Larry earned his Ph.D. in Oceanographic Engineering in 1984 from the Joint Program in Oceanography and Oceanographic Engineering between the Massachusetts Institute of Technology and the Woods Hole Oceanographic Institution. He received his ScB in Mechanical Engineering from Brown University in 1978. He joined UMCES Horn Point Laboratory in 1984 and rose through the faculty ranks to Professor in 2001. He has authored or co-authored 65 peer-reviewed publications, served as major advisor for 12 graduate students, served on 75 other graduate committees, advised 12 undergraduate research interns, and taught 13 graduate courses.

At UMCES he has served on the Faculty Senate, chaired the Environmental Sustainability Council, and chaired a number of UMCES review committees. He has received the UMCES President's Award for Excellence in Application of Science, the Kirby Laing Fellowship of the School of Ocean Sciences, University of Wales, Bangor, and the USM MEES Program Teaching Award.

June 12th

8:30	8:45	Intro	**Introduction and Welcome [15 m] Arundel Ballroom**			
8:45	9:40	Plen-1	**Rich Batiuk, EPA, "Three Decades of Using Science as the Foundation for Collaborative Bay and Watershed Restoration Decision-making—a Behind the Scenes Look at How the Partnership Works" [55m]**			
9:40	10:35	Plen-2	**Marjorie Friedrichs, VIMS, "Shallow Water Management Models for Chesapeake Bay" [55m]**			
10:35	10:50		Break (15 minutes)			
10:50	11:45	Plen-3	**Jason Fleming, Seahorse Coastal, "Real Time ADCIRC Modelling for Coastal Zone Decision Support" [55m]**			
11:45	**12:40**		LUNCH (55 minutes)			
		Room	Arundel A	Arundel B	Arundel C	Prince George
12:40	**2:40**	**Tuesday Early Afternoon Session**	**A1. Change in the Chesapeake: Moving Toward Finer Scales In Watershed and Estuarine Modeling (Lewis Linker, Gary Shenk, Lisa Wainger, Rich Batiuk, Zach Easton, Andrew Sommerlot) [Part 1 of 4; Watershed 1: 2h]**	**B1. Biogeochemical and Ecological Forecasting: Challenges and Successes (Marjy Friedrichs, Raleigh Hood) [Part 1 of 2: 2h]**	**C. Sediment-Process Studies in the Chesapeake Bay Region, including Recent Studies from Conowingo Reservoir (Jim Fitzpatrick, Blake Clark, Cindy Palinkas, Courtney Harris) [2h]**	**E. Evaluating Current and Future Influences on James River Water Quality Condition (Jian Shen, Harry Wang, Richard Isleib) [2h]**
12:40	1:00	Tu-PM-1	***Peter Claggett,*** *Assessing fine-scale land cover and land use conditions in the Bay watershed: 1984 – 2025*	***Seann Reed,*** *D. Le, B. Sullivan, Assessing Freshwater Flow Impacts on NOS Chesapeake Bay Operational Forecast System (CBOFS) Salinity Simulations*	***Cindy Palinkas,*** *Sediment dynamics in Conowingo Pond from days to decades*	***Jian Shen,*** *Q. Qin, M. Sisson, R. Wang, Assessing the impact of uniqueness of water quality model kinetic parameter and model uncertainty on phytoplankton simulations in the tidal James River, Virginia, USA*
1:00	1:20	Tu-PM-2	***Zach Easton,*** *M. Wagena, A. Sommerlot, A. Collick, D. Fuka, Improved prediction of nutrient dynamics in complex landscapes using terrain models*	***Aijun Zhang,*** *J. Xu, L. Zheng, M. Peng, Performance, Challenges, and Opportunity for the Chesapeake Bay Operational Forecast System*	***Jeff Cornwell,*** *M. Owens, H. Perez, Z. Vulgaropulos, Biogeochemistry of Fluvial Particulates in Reservoirs and Chesapeake Bay Sediments*	***Qubin Qin,*** *J. Shen, The critical role of physical transport in the initiation of harmful algal blooms in the lower James River, Virginia*
1:20	1:40	Tu-PM-3	***Gopal Bhatt,*** *A. Sommerlot, G. Shenk, L. Linker, L. Li, C. Duffy, Towards a fine scale representation of the Chesapeake Bay Watershed*	***Chih-Hsien Lin,*** *Combining statistical time series models with mechanistic variable stoichiometry models to predict blooms of the harmful dinoflagellate Karlodinium veneficum in Chesapeake Bay under current and future warming conditions*	***Ken Staver,*** *Q. Zhang, W. Ball, Improving estimates of sub-scour storm flow loads to Chesapeake Bay from the Susquehanna watershed*	***Zhuo Liu***, *Y. Zhang, Harry Wang, F. Ye, H. Huang, Z. Wang, M. Sisson, The 3D SCHISM model application for studying impact of small-scale piling structures on circulation in the Lower James River*
1:40	2:00	Tu-PM-4	***Andrew Sommerlot,*** *Addressing the limitations of implementing watershed models at fine scales*	***Ben Davis,*** *J. Jacobs, A. DePaola, F. Curriero, Developing space-time prediction models for Vibrio parahaemolyticus in the Chesapeake Bay*	***Jim Fitzpatrick,*** *M. Velleux, N. Kogan, J. Hallden, B. Yadav, Long-term trends in deposition, resuspension and bioavailability of nutrients from Conowingo Pond*	***Derek Loftis,*** *A. Macias, M. Mullholland, D. Forrest, A Comparison of Tidewatch inundation predictions and citizen-science flood extent observations during the 2017 king tide in Tidewater Virginia*
2:00	2:20	Tu-PM-5	***Amy Collick,*** *D. Fuka, T. Veith, A. Buda, A. Allen, P. Kleinman, R. Bryant, Z. Easton, Employing fine resolution spatial information and extensive field research to evaluate best management practice (BMP) scenario evaluations across the Chesapeake Bay*	***Robert Daniels,*** *J. Jacobs, Vibrio predictive models and tools for the Chesapeake Bay*	***Emily Russ,*** *C. Palinkas, Spatial and temporal patterns of sediment geochemistry in upper Chesapeake Bay*	***Richard Isleib,*** *J. Fitzpatrick, N. Kim, N. Kogan, Assessing the water quality impacts in a tidal embayment from the closure of proposed storm surge barriers*
2:20	2:40	Tu-PM-6	***Moges Wagena,*** *Z. Easton, Agricultural conservation practices can help mitigate the impact of climate change*	***Marjy Friedrichs,*** *A. Bever, C. Friedrichs, S. Musick, R. Hood, Short-term hypoxia forecasts for the Chesapeake Bay*	***Danielle Tarpley,*** *C. Friedrichs, C. Harris, Temporal variability in sediment suspension and sediment-induced stratification related to freshwater discharge in the York River estuary, Virginia, USA*	***Andrew Thuman,*** *James Hallden, R. Isleib, R. Rugabandana, W. Hunley, James River overflow model: GUI development for model ease of use*
2:40	3:00		Break (20 minutes)			

June 12th con.

3:00	5:00 +	Tuesday Late Afternoon Session	A2. Change in the Chesapeake: Moving Toward Finer Scales In Estuarine and Watershed Modeling [Part 2 of 4; Watershed 2, Estuary 1: 1h 40m]	B2. Biogeochemical and Ecological Forecasting: Challenges and Successes [Part 2 of 2: 1h 40m]	D. Current State of Stormwater, Modeling, and Research (Scott Taylor, Seth Brown) [2h 40m]	F. Understanding Oyster Trajectories: Wild Population Dynamics, Restoration and the Role of Aquaculture (Ryan Carnegie, Jeff Cornwell) [2h 40m]
3:00	3:20	Tu-PM-7	***Kathleen Boomer,*** *Predicted and observed water quality benefits in reconnected floodplains of an outer coastal plain watershed, Maryland, USA*	***Meng Xia,*** *The development of a wave-current based ecological modeling system to Chesapeake Bay, Maryland coastal bays, and adjacent coastal ocean*	***Scott Taylor,*** *National Municipal Stormwater Alliance*	***M. Lisa Kellogg,*** *J. Cornwell, P. Ross, K. Paynter, M. Luckenbach, Quantifying the benefits of tributary-scale oyster reef restoration*
3:20	3:40	Tu-PM-8	***Lisa Wainger,*** *Using environmental economic models to support decision makers*	***Kyle Hinson,*** *M. Friedrichs, I. Irby, Evaluating responses of Chesapeake Bay hypoxia to 21st century temperature scenarios*	***Seth Brown,*** *To Green or not to Green: Modeling Incentive-Based Programs for Green Infrastructure Investment on Private Properties*	***Kevin Kahover,*** *L. Harris, J. Testa, L. Sanford, M. Forsyth, E. North, A high-resolution model of filtration, biodeposition, and nutrient dynamics on restored oyster reefs*
3:40	4:00	Tu-PM-9	***Gary Shenk,*** *Moving beyond total nitrogen and total phosphorus for the Chesapeake Bay TMDL*	***Wenfei Ni,*** *M. Li, A. Ross, R. Najjar, M. Wagena, Z. Easton, Climate downscaling projections for Chesapeake Bay hypoxia in the 21st century*	***Claire Welty,*** *M. Barnes, T. Lim, Assessing green infrastructure performance using a three-dimensional hydrologic modeling approach*	***Rasika Gawde,*** *E. North, R. Hood, Integrating and applying three-dimensional models to simulate oyster ecosystem services*
4:00	4:20	Tu-PM-10	***Lewis Linker,*** *R. Batiuk, L. Currey, D. Montali, Towards the next-generation multiple-scale models of the Chesapeake – what do the managers want?*	***Tal Ezer,*** *Sea level rise and variability in the Chesapeake Bay: Numerical modeling of the impact of climate change, hurricanes and the Gulf Stream*	***Michael Barrett,*** *Use of Permeable Friction Course for Stormwater Quality*	***Cecily Steppe,*** *A. Keppel, L. Wallendorf, L. Rodriguez, G. Pruden, Relating Severn River oyster reproduction to high-frequency water quality data*
4:20	4:40	Tu-PM-11	***Jesse O. Bash,*** *P. Campbell, T. Spero, D. Schwede, Future directions and the importance of scale in estimating atmospheric nitrogen loading to the Chesapeake Bay*	***Faye Duchin,*** *N. Springer, E. Hester, J. Little, An economic model of the Chesapeake Bay watershed for analysis of alternative scenarios about the future*	***Robert Traver,*** *B. Wadzuk, Advances in understanding the role of infiltration and evapotranspiration in Green Infrastructure*	***Ryan Carnegie,*** *L. Huey, R. Mann, Resistance and Tolerance to Diseases in the Eastern Oyster*
4:40	5:00	Tu-PM-12			***J. Michael Trapp,*** *Current topics in Quantitative Microbial Risk Assessment (QMRA)*	***Roger Mann,*** *M. Southworth, J. Wesson, R. Carnegie, K. Reece, C. Robison, Oyster populations in the Virginia Bay: Small steps to stability*
5:00	5:20	Tu-PM-13			***Nasrin Alamdari,*** *Comparing Tools for Integrating Cost Optimization with Simulation Modeling in Urban Watersheds*	***Carl Cerco,*** *Influence of oyster aquaculture on water quality attainment Chesapeake Bay: I. Model formulation and assessment of aquaculture activity*
5:20	5:40	Tu-PM-14			***P. Kanoko Maeda,*** *Linking Stormwater Best Management Practices to Social Factors in Two Suburban Watersheds*	***Richard Tian,*** *C. Cerco, L. Linker, Influence of oyster aquaculture on water quality attainment in Chesapeake Bay: II. Model implementation and application*
5:00	7:00		**Reception, Poster Session, Guardian Award**			

Bold names are the first author. Underlined names are presenters, if different than the first author.

June 13th

8:30	10:00	Panel-1	***Research to Address Contaminants of Emerging and Increasing Concern for the Chesapeake Region*** **Moderator: Scott Phillips (USGS CBPO)** **Panelists: Greg Allen (US EPA CBPO), Vicki Blazer (USGS), Lee Blaney (UMBC), Heather Gall (Penn State)** **[1h 30m] Arundel Ballroom**			
10:00	10:15	Break (15 minutes)				
10:15	11:45	Panel-2	***Seagrass Recovery in Chesapeake Bay: A Success Story for Chesapeake Bay Research and Restoration*** **Moderator: Larry Sanford (UMCES)** **Panelists: Bill Dennison (UMCES), JJ Orth (VIMS), Cassie Gurbisz (St. Mary's College of MD), Jonathan Lefcheck (Center for Ocean Health)** **[1h 30m] Arundel Ballroom**			
11:45	12:40	Lunch (55 minutes)				
		Room	Arundel A	Arundel B	Arundel C	Prince George
12:40	**2:40**	**Wednesday Early Afternoon Session**	**A3. Change in the Chesapeake: Moving Toward Finer Scales In Watershed and Estuarine Modeling (Lewis Linker, Gary Shenk, Lisa Wainger, Rich Batiuk, Zach Easton, Andrew Sommerlot) [Part 3 of 4; Estuary 2: 2h]**	**H1. Other Current and Emerging Issues in Chesapeake Bay Science and Modeling (Bill Ball, Raleigh Hood, Dave Jasinski) [Part 1 of 2: 2h]**	**I1. Building useful decision support tools with monitoring and modeling data (Emily Trentacoste and John Wolf) [2h]**	**J1. Explaining conditions and trends: Integrated monitoring and modeling approaches to describe water-quality change in the watershed and estuary (Joel Blomquist, Qian Zhang, Jeremy Testa, Gary Shenk) [Part 1 of 2: 2h]**
12:40	1:00	Wed-PM-1	***Zhengui Wang**, Harry Wang, High resolution water quality modeling in the Chester River of the Upper Chesapeake Bay using unstructured grid SCHISM model*	***Moges Wagena**, A. Sommerlot, E. Buell, G. Bhatt, Z. Easton, Quantifying structural model uncertainty using a Bayesian multi-model ensemble*	***Allen Gellis**, Application of the Sediment Source Assessment Tool (Sed_SAT) to inform managers of sediment sources*	***Joel Blomquist**, R. Fanelli, J. Keisman, Q. Zhang, D. Moyer, M. Langland, A history of nutrient and sediment inputs to Chesapeake Bay: 1985-2016*
1:00	1:20	Wed-PM-2	***Richard Tian**, L. Linker, Impact of geomorphology and meanderings on saltwater intrusion, lateral advection, and hypoxia in the Chester River Estuary*	***Derek Loftis**, H. Wang, Z. Liu, L. Rogers, T. Allen, D. Forrest, D. Bekaert, Exploring communities at intensive risk in the lower Chesapeake Bay via reanalysis of 2011 Hurricane Irene with future sea level rise*	***Danny Kaufman**, O. Devereux, J. Rigelman, H. Ellis, A. Sommerlot, L. Linker, Development of a cost optimization scheme for Chesapeake Bay restoration*	***Scott Ator**, A. Garcia, G. Schwarz, J. Blomquist, A. Sekellick, Adapting SPARROW to disentangle the multiple drivers of nutrient trends in Chesapeake tributaries, 1992 - 2012*
1:20	1:40	Wed-PM-3	***Cuiyin Wu**, J. Keisman, L. Linker, G. Shenk, R. Tian, Diagnostic of nonattainment of water quality standard of Dissolved Oxygen of the Chesapeake Bay segments*	***Mac Sisson**, J. Shen, R. Wang, B. Joyner, Assessing the impact of floodgates to mitigate coastal flooding risks for the Lafayette River in Norfolk, Virginia, USA*	***Anton Kvit**, B. Davis, J. Bowers, A. DePaola, F. Curriero, Interactive spatiotemporal risk tool for vibrio parahaemolyticus in the Chesapeake Bay*	***Richard Smith**, A. Sekellick, W. Sanford, J. Blomquist, G. Schwarz, J. Brakebill, Delayed watershed response to management of Chesapeake Bay nitrogen sources caused by long-term storage of nitrogen in groundwater*
1:40	2:00	Wed-PM-4	***Yinglong Zhang**, H. Wang, F. Ye, K. Nunez, Z. Liu, Cross-scale modeling from sub-tributary to ocean: Implications for Chesapeake Bay*	***Guido Yactayo**, G. Busch, Stream Temperature Modeling for TMDL Development and Implementation in Nontidal Cold Water Streams in Maryland*	***Jonathan Czuba**, River network-based framework for understanding large-scale watershed functioning to guide sustainable landscape management*	***Wei Zhi**, A physically-based nutrient model for understanding controls on nitrate export in Chesapeake Bay*
2:00	2:20	Wed-PM-5	***Fei Ye**, The SCHISM Chesapeake Bay Model: 3D baroclinic simulations based on unstructured grid*	***Shreeram Inamdar**, G. Jiang, A. Lutgen, N. Sienkiewicz, D. Merritts, R. Walter, Freeze-thaw processes and intense rainfall-runoff events: Significant contributors of suspended sediment and nutrient loads from Chesapeake Bay watersheds*	***Lindsay Perez**, Scott Haag, R. John Dawes, Crossing watershed boundaries: Developing scalable tools for the Delaware and Chesapeake watersheds*	***Qian Zhang**, R. Murphy, R. Tian, M. Forsyth, E. Trentacoste, J. Keisman, P. Tango, Status and trends of the Chesapeake Bay water quality standards criteria attainment in 1985-2016: insights from assessment of thirty years of tidal water quality monitoring data*
2:20	2:40	Wed-PM-6	***Fei Da**, M. Friedrichs, P. St-Laurent, Impacts of direct atmospheric nitrogen deposition and coastal nitrogen fluxes on Chesapeake Bay hypoxia*	***Alexey Voinov**, Modeling for action: In search of new interfaces*	***David Saavedra, Adrienne Gemberling**, Using high-resolution data and web tools to enable precision conservation*	***Aaron Bever**, M. Friedrichs, M. Scully, C. Friedrichs, Estimating real-time hypoxic volume in the Chesapeake Bay using two vertical profilers*
2:40	3:00	Break (20 minutes)				

June 13th con.

3:00	5:00 +	Wednesday Late Afternoon Session	**A4. Change in the Chesapeake: Moving Toward Finer Scales In Watershed and Estuarine Modeling [Part 4 of 4; Estuary 3: 20m]**	**H2. Other Current and Emerging Issues in Chesapeake Bay Science and Modeling [Part 2 of 2: 1h 20m]**	**I2. Building Useful Decision Support Tools with Monitoring and Modeling Data [Part 2 of 2: 1h 20m]**	**J2. Explaining conditions and trends: Integrated monitoring and modeling approaches to describe water-quality change in the watershed and estuary [Part 2 of 2: 2h]**
3:00	3:20	Wed-PM-7	***Aaron Bever,*** *M. Macwilliams, M. Fabrizio, T. Tuckey, Quantifying habitat suitability for forage fishes in Chesapeake Bay: A coupled modeling approach using fishery surveys and a hydrodynamic model*	***Kelley Uhlig,*** *B. Song, Comparing Estuarine Microbial Community Composition of Conventional and Bio-Based Polymers*	***Zach Easton,*** *D. Fuka, A. Sommerlot, A. Collick, A Customizable Dashboarding System for Watershed Model Interpretation*	***Jaclyn Friedman,*** *E. Shadwick, M. Friedrichs, R. Najjar, Seasonal Variability of Carbonate Chemistry in the Chesapeake Bay*
			G. Practical Advances in Regional Land Change Modeling: What's Achievable Now? (Peter Claggett, Claire Jantz, David Donato) [1h 40m]			
3:20	3:40	Wed-PM-8	***Peter Claggett,*** *Can we ever get to version 2.0? Stepping off the dime*	***Eric Sakowski,*** *S. Preheim, Phage-host Interactions and Predation Strategies in the Chesapeake Bay*	***Dave Arscott,*** *A. Aufdenkampe, D. Tarboton, B. Evans, S. Haag, S. Kerlin, M. Daniels, A. Robbins, WikiWatershed: A public web app to model water quality and quantity, visualize monitoring data, and support conservation decisions*	***Elizabeth Shadwick,*** *M. Friedrichs, R. Najjar, M. Herrmann, New CO2 system observations in the Chesapeake Bay: high-frequency variability and long-term trends*
3:40	4:00	Wed-PM-9	***Labeeb Ahmed,*** *P. Claggett, F. Irani, R. Thompson, Faster, more flexible and stable models: Lessons learned on our way to the cloud*	***John Regan,*** *N. Locke, S. Saia, H. Carrick, A. Buda, M. T. Walter, Identification of Polyphosphate-Accumulating Organisms Contributing to Phosphorus Cycling in Stream Biofilms*	***Emily Trentacoste,*** *J. Wolf, A. Hoffman, Integrating 30 years of Chesapeake Bay data into a new decision support framework for Watershed Implementation Plan development*	***Wei-Jun Cai,*** *J. Su, Insights from spatial distributions of inorganic carbon parameters in the Chesapeake Bay: a bay-wide buffering mechanism via carbonate mineral precipitation and dissolution*
4:00	4:20	Wed-PM-10	***Scott Haag,*** *Geoinformatics methods and impacts on Regional Land Change Models*	***Sarah Preheim,*** *K. Arora-Williams, C. Holder, A. Gnanadesikan, Application of DNA- and RNA-sequence based techniques to inform biogeochemical models of the Chesapeake Bay dead-zone*	***John Wolf,*** *<u>Katherine Wares,</u> R. Thompson, S. Phillips, Mapping Geographic Areas that benefit Multiple Goals and Priorities for Conservation and Restoration Opportunities across the Chesapeake Bay Watershed*	***Chunqi Shen,*** *J. Testa, Modeling carbonate system dynamics and responses to nutrient loading changes in Chesapeake Bay*
4:20	4:40	Wed-PM-11	***David Donato,*** *F. Irani, D. Strong, Current computational options and challenges in land-change modeling*			***Ming Li,*** *X. Xie, C. Shen, B. Chen, W. Ni, W. Cai, J. Testa, Physically driven temporal and spatial variabilities in carbonate chemistry dynamics*
4:40	5:00	Wed-PM-12	***Claire Jantz,*** *S. Drzyzga, A. Yáñez, Improving the thematic resolution of urban land change modeling*			***Pierre St-Laurent,*** *M. Friedrichs, R. Najjar, E. Shadwick, Changes in Chesapeake Bay air-sea CO2 fluxes over the past century*
5:30	7:00		**Reception, Poster Session**			

Bold names are the first author. <u>Underlined</u> names are presenters, if different than the first author.

June 14th

		Room	Arundel A	Arundel B	Arundel C	Prince George
8:40	10:40	**Thursday Early Morning Session**	**K. Observations and Modeling of Chesapeake Bay Wetlands and Coupled Sub-estuaries: Advancing Understanding through Comparative Analyses (Patrick Neale, Maria Tzortziou, Raleigh Hood, Blake Clark) [2h]**	**M1. Water Clarity in Chesapeake Bay: trends, drivers, and research priorities (Jeni Keisman, Carl Friedrichs) [Part 1 of 2: 2h]**	**N1. Understanding Nutrient Transport in the Chesapeake Watershed: Legacies, Lag Times, Mechanisms, Drivers and Solutions (Daniel Wilusz, Bill Ball, Ciaran Harman, Karen Rice and Rosemary Fanelli) [Part 1 of 2: 2h]**	**O1. Using Environmental Biomarkers to Study Chesapeake Bay's Ecosystems (Christina Bradley) [2h]**
8:40	9:00	Thur-AM-1	***Alana Menendez,*** *M. Tzortziou, P. Neale, Temporal variability of fluorescent dissolved organic matter at a brackish, tidal marsh-estuary interface*	***Stephanie Barletta,*** *Suspended sediment variability in the surface layer of upper Chesapeake Bay*	***Kimberly Van Meter,*** *P. Van Cappellen, Q. Zhang, N. Basu, Landscape Legacies: Long-Term Nitrogen Trajectories in the Chesapeake Bay Watershed and Beyond*	***Matthew Ogburn,*** *R. Aguilar, K. Lohan, L. Plough, Applying Biomarkers to the Study of Trophic Dynamics and Connectivity*
9:00	9:20	Thur-AM-2	***Amanda Knobloch,*** *M. Brush, W. Reay, J. Zhang, E. Canuel, Sources and Fluxes of Dissolved and Particulate Carbon at the Marsh-Estuarine Interface*	***Carl Friedrichs,*** *J. Keisman, Describing and explaining Chesapeake Bay water clarity: A literature review*	***Shuyu Chang,*** *D. Wilusz, C. Harman, Effects of Climate Variability on Nitrate Export: SWAT Modeling in the Chesterville Catchment of the Eastern Shore, MD*	***Joseph Craine,*** *Environmental DNA reveals multi-assemblage eutrophication responses in the Potomac*
9:20	9:40	Thur-AM-3	***Patrick Neale,*** *K. Rose, M. Tzortziou, C. Gallegos, T. Jordan, Spectral model of light attenuation in the Rhode-River subestuary: Identifying drivers of spatial variability and long-term trends*	***Julia Moriarty,*** *M. Friedrichs, <u>Courtney Harris</u>, Effects of Seabed Resuspension on Primary Productivity and Remineralization in Chesapeake Bay*	***Daniel Wilusz,*** *D. Fuka, S. Chang, W. Ball, C. Harman, Using travel time data and a modified SWAT model to understand groundwater nitrate lag times in the Eastern Shore, MD*	***Nicole Hammond,*** *A. Nalesnik, C. J. Bradley, An analysis of nutrient concentration and marine signaling in a freshwater ecosystem pre- and post-removal of dams*
9:40	10:00	Thur-AM-4	***M. Karinna Nunez,*** *J. Zhang, W. Reay, C. Hershner, Cross-scale simulations: An innovative approach to evaluate the impacts of climate change on tidal marsh habitats*	***Elka Porter,*** *B. Johnson, L. Sanford, Effect of hard clam, Mercenaria mercenaria, density and bottom shear on sediment erodibility*	***John Schubert,*** *J. Czuba, Quantifying Sediment and Legacy Pollutant Residence-Time Distributions in Floodplains*	***Vicki Blazer,*** *H. Walsh, M. Schall, B. Keplinger, G. Smith, J. Mullican, K. Smalling, Importance of long term monitoring to understand impaired fish health*
10:00	10:20	Thur-AM-5	***Blake Clark,*** *R. Hood, Modeling of complex flow patterns across a large estuarine and tidal wetland complex in southern Dorchester County, MD*	***Qian Zhang,*** *<u>Joel Blomquist,</u> Watershed Export of Fine Sediment, Organic Carbon, and Chlorophyll-a to Chesapeake Bay: Spatial and Temporal Patterns in 1984-2016*	***James Pizzuto,*** *D. Karwan, K. Skalak, Sediment Storage Retards Benefits of Upland Sediment BMPs in Large Watersheds Drained By Alluvial Rivers*	***Heather Walsh,*** *V. Blazer, L. Iwanowicz, Testes Transcriptome Development and Molecular Identification of Intersex in Smallmouth Bass from Tributaries in the Chesapeake Bay*
10:20	10:40	Thur-AM-6	***Pamela Braff,*** *C. Hershner, K. Havens, Modeling the Distribution of Headwater and Isolated Wetlands in a Coastal Plain Watershed*	***Jeremy Testa,*** *V. Lyubchich, <u>Qian Zhang,</u> Patterns and Trends in Secchi Disk Depth over Three Decades in the Chesapeake Bay Estuarine Complex*	***Karen Rice,*** *A. Mills, R. Fanelli, A. Soroka, Thirty Years of Dissolved Phosphorus Dynamics in Nine Freshwater Tributaries to the Chesapeake Bay*	***Megan Schall,*** *V. Blazer, H. Walsh, G. Smith, R. Lorantas, T. Wertz, T. Wagner, Investigating occurrence of disease characteristics and trends in smallmouth bass abundance in rivers within the Chesapeake Bay Watershed*
10:40	11:00			Break (20 minutes)		

June 14th con.

11:00	1:00	Thursday Late Morning Session	**L. Modeling of Climate Change Consequences for Phase III Watershed Implementation Plans (Don Boesch) [2h]**	**M2. Water Clarity in Chesapeake Bay: trends, drivers, and research priorities [Part 2 of 2: 1h]**	**N2. Understanding Nutrient Transport in the Chesapeake Watershed: Legacies, Lag Times, Mechanisms, Drivers and Solutions [Part 2 of 2: 1h]**	
11:00	11:20	Thur-AM-7	*The Chesapeake Bay Program is challenged to address the many uncertainties in estimating nutrient load reductions needed to maintain water quality objectives as global and regional climate changes. **Lewis Linker** will present an overview of this challenge and modeling to date. Panelists **Lee Currey, Zach Easton, Maria Herrmann** and **Ray Najjar** will discuss recent reviews of the modeling efforts and offer recommendations on effective paths forward. Ample opportunity for audience participation will be provided.*	***Rebecca Murphy,*** *J. Keisman, Comparison of Secchi depth and Kd trends while adjusting for freshwater input variations*	***Rosemary Fanelli,*** *J. Blomquist, R. Hirsch, Drivers of orthophosphate trends in tributaries to Chesapeake Bay*	
11:20	11:40	Thur-AM-8		***Nicole M. Deluca,*** *B. Zaitchik, F. Curriero, Can multispectral information improve remotely sensed estimates of total suspended solids? A statistical study in the Chesapeake Bay*	***Qian Zhang,*** *D. Ha, H. Wei, W. Ball, Retrospective Analysis of Sediment-Associated Phosphorus Concentration in the Major Tributaries to Chesapeake Bay*	
11:40	12:00	Thur-AM-9		***Jeni Keisman,*** *C. Friedrichs, C. Buchanan, R. Batiuk, J. Blomquist, J. Cornwell, M. Lane, S. Lyubchich, K. Moore, R. Murphy, G. Noe, R. Orth, E. Porter, L. Sanford, J. Testa, M. Trice, Q. Zhang, R. Zimmerman, Examining trends in water clarity in the Chesapeake Bay: A synthesis of findings from recent STAC workshops*	***Aaron Cook,*** *J. Shortle, A second-best market design for lagged, persistent pollutants*	
12:00	12:20	Thur-AM-10				
12:20	12:40					
12:40	1:00					

Change in the Chesapeake: Moving Toward Finer Scales In Watershed and Estuarine Modeling

Session Leads: Lewis Linker, Gary Shenk, Lisa Wainger, Rich Batiuk, Zach Easton, Andrew Sommerlot
Date: June 12th Watershed Session, June 13th
Time: Estuary Session
Room: 12:40 PM

ABSTRACT

This session examines new approaches in Chesapeake Bay Program management taken to respond to finding solutions in watershed and estuarine modeling and decision making at fine scales. Ongoing advances in computational power, data availability, and the interest of decision makers to resolve pollution management at local scales is leading to higher spatial resolution models and analysis with attendant advances needed in Chesapeake watershed, estuarine, and social sciences. Modeling watersheds and estuaries at fine scales has the potential for providing improved insight into water quality processes, increased utility of pollution control estimates to decision makers, and improving understanding of the overall transport, processing, and attenuation of nutrients and other pollutants in the coastal watershed system. However, many current modeling paradigms still present challenges for building, running, and interpreting models of large watersheds at fine resolutions. Research addressing the computational, software, scientific, and data limitations of fine scale resolution watershed modeling will contribute to building effective solutions in the Chesapeake Bay. Additionally, work focused on the challenges of interpreting and communicating fine scale outputs of complex models, especially within a scenario context, could increase the potential for stakeholder participation. Social science research into outreach, communication, and approaches to building trust around advanced watershed modeling technology at the local scale will be explored.

JUNE 12 WATERSHED

12:40	Claggett	Assessing fine-scale land cover and land use conditions in the Bay watershed: 1984 – 2025
1:00	Easton	Improved prediction of nutrient dynamics in complex landscapes using terrain models
1:20	Bhatt	Towards a fine scale representation of the Chesapeake Bay Watershed
1:40	Sommerlot	Addressing the limitations of implementing watershed models at fine scales
2:00	Collick	Employing fine resolution spatial information and extensive field research to evaluate best management practice (BMP) scenario evaluations across the Chesapeake Bay
2:20	Wagena	Agricultural conservation practices can help mitigate the impact of climate change
3:00	Boomer	Predicted and observed water quality benefits in reconnected floodplains of an outer coastal plain watershed, Maryland, USA
3:20	Wainger	Using environmental economic models to support decision makers
3:40	Shenk	Moving beyond total nitrogen and total phosphorus for the Chesapeake Bay TMDL

ESTUARY

4:00	Linker	Towards the next-generation multiple-scale models of the Chesapeake – what do the managers want?
4:20	Bash	Future directions and the importance of scale in estimating atmospheric nitrogen loading to the Chesapeake Bay

JUNE 13 ESTUARY CON.

12:40	Wang	High resolution water quality modeling in the Chester River of the Upper Chesapeake Bay using unstructured grid SCHISM model
1:00	Tian	Impact of geomorphology and meanderings on saltwater intrusion, lateral advection, and hypoxia in the Chester River Estuary
1:20	Wu	Diagnostic of nonattainment of water quality standard of Dissolved Oxygen of the Chesapeake Bay segments
1:40	Zhang	Cross-scale modeling from sub-tributary to ocean: Implications for Chesapeake Bay
2:00	Ye	The SCHISM Chesapeake Bay Model: 3D baroclinic simulations based on unstructured grid
2:20	Da	Impacts of direct atmospheric nitrogen deposition and coastal nitrogen fluxes on Chesapeake Bay hypoxia
3:00	Bever	Quantifying habitat suitability for forage fishes in Chesapeake Bay: A coupled modeling approach using fishery surveys and a hydrodynamic model

Biogeochemical and Ecological Forecasting: Challenges and Successes

Session Leads:	Marjy Friedrichs, Raleigh Hood
Date:	June 12th
Time:	12:40 PM
Room:	Arundel B

ABSTRACT

Coastal biogeochemical and ecological forecasts are developed using knowledge of the hydrodynamics, biogeochemistry and ecology of a system and are used to predict how ecosystems will change in the future. Forecasts can be made for the short-term (hours to days), seasonally, or for the long-term (interdecadally) taking into consideration future climate change. In the Chesapeake Bay and other coastal ecosystems, multiple short-term modeling forecasts exist. For example, NOAAs Chesapeake Bay Operational Forecasting System (CBOFS) produces nowcasts and two-day forecasts of hydrodynamic variables such as water level height, temperature and salinity in the Bay. Forecasts of sea nettles, vibrio and hypoxia computed using a combination of logistic regressions and process-based models also exist for the Bay. Seasonal hypoxia forecasts are released each spring using empirical models, and mechanistic models are continually being used to predict what the future Chesapeake Bay will look like later this century. Ultimately, these forecasts will result in the availability of improved decision support products for the commercial and recreational use of the Chesapeake Bay. It is critical that such forecasts are generated through a process involving active engagement by stakeholders who are invested in Chesapeake Bay resources.

In this session we encourage researchers who are involved in generating and/or using coastal biogeochemical and ecological forecasts on any of these time scales. We also encourage contributions that explore how stakeholders can play a role in the generation, presentation and visualization of such forecasts and specifically invite presentations that link models with real-time data. Studies focusing on regions other than Chesapeake Bay are also welcome.

12:40	Reed	Assessing Freshwater Flow Impacts on NOS Chesapeake Bay Operational Forecast System (CBOFS) Salinity Simulations
1:00	Zhang	Performance, Challenges, and Opportunity for the Chesapeake Bay Operational Forecast System
1:20	Lin	Combining statistical time series models with mechanistic variable stoichiometry models to predict blooms of the harmful dinoflagellate Karlodinium veneficum in Chesapeake Bay under current and future warming condition
1:40	Davis	Developing space-time prediction models for Vibrio parahaemolyticus in the Chesapeake Bay
2:00	Daniels	Vibrio predictive models and tools for the Chesapeake Bay
2:20	Friedrichs	Short-term hypoxia forecasts for the Chesapeake Bay
3:00	Xia	The development of a wave-current based ecological modeling system to Chesapeake Bay, Maryland coastal bays, and adjacent coastal ocean

3:20	Hinson	Evaluating responses of Chesapeake Bay hypoxia to 21st century temperature scenarios
3:40	Ni	Climate downscaling projections for Chesapeake Bay hypoxia in the 21st century
4:00	Ezer	Sea level rise and variability in the Chesapeake Bay: Numerical modeling of the impact of climate change, hurricanes and the Gulf Stream
4:20	Duchin	An economic model of the Chesapeake Bay watershed for analysis of alternative scenarios about the future

Sediment-Process Studies in the Chesapeake Bay Region, including Recent Studies from Conowingo Reservoir

Session Leads: Jim Fitzpatrick, Blake Clark, Cindy Palinkas, Courtney Harris
Date: June 12th
Time: 12:40 PM
Room:

ABSTRACT

The importance of sediment transport and seabed processes in Chesapeake Bay and its many sub-environments has become increasingly recognized. Sediment transport and biogeochemistry can have a profound impact on geomorphology and water chemistry via nutrient and anthropogenic pollutant cycling within the sediment and across the sediment-water interface. Ecological restoration of the Chesapeake through the Chesapeake Bay total maximum daily load (TMDL) requires the reduction of nitrogen, phosphorus, and sediment loads in the Chesapeake watershed because of the water quality impairments and damage to living resources they cause. Understanding and quantifying these processes remain challenging, in part because much of the Chesapeake Bay is dominated by muddy sediment, whose cohesive nature often complicates attempts at numerical modeling and observation. Additionally, processes on or just above the seabed are difficult to observe and monitor, particularly during energetic conditions. However, recent advances in theoretical, observational, and numerical modeling techniques have led to increased understanding of these complex systems.

One example within the Chesapeake watershed, the Conowingo Reservoir, has been filling with sediment for almost a century and is now in a state of near-full capacity called dynamic equilibrium. The Chesapeake TMDL was developed in 2010 with the assumption that the Conowingo Reservoir effectively traps sediment and nutrients rather than the present state of dynamic equilibrium. Also, under high flow conditions, resuspended solids and nutrients from the Reservoir may be transported into the Bay's main channel, preventing achievement of water quality goals such as deep-channel dissolved oxygen standards. Within the past year a number of field, laboratory, and modeling studies have attempted to measure and quantify the bioavailability of these nutrients and the resulting impacts on water quality in Chesapeake Bay.

This combined session will highlight numerical models and field studies aimed at furthering our understanding of seabed, sediment-transport and depositional processes in Chesapeake Bay, its tributaries, and associated marsh systems. In particular, this session features studies related to the Conowingo Reservoir, from observations of nutrient flux and sediment diagenesis to modeling sediment transport and water quality, including projected impacts on Bay water quality.

12:40	Palinkas	Sediment dynamics in Conowingo Pond from days to decades
1:00	Cornwell	Biogeochemistry of Fluvial Particulates in Reservoirs and Chesapeake Bay Sediments
1:20	Staver	Improving estimates of sub-scour storm flow loads to Chesapeake Bay from the Susquehanna watershed
1:40	Fitzpatrick	Long-term trends in deposition, resuspension and bioavailability of nutrients from Conowingo Pond
2:00	Russ	Spatial and temporal patterns of sediment geochemistry in upper Chesapeake Bay Short-term hypoxia forecasts for the Chesapeake Bay
2:20	Tarpley	Temporal variability in sediment suspension and sediment-induced stratification related to freshwater discharge in the York River estuary, Virginia, USA

Current State of Stormwater, Modeling, and Research

Session Leads: Scott Taylor, Seth Brown
Date: June 12th
Time: 3:00 PM
Room: Arundel C

ABSTRACT

This Technical Session will provide an overview of the state of the art in Stormwater programs, modeling and research. It will highlight case studies, methods and programs from around the US as well as within the Chesapeake Bay watershed. The objective of this session is to support the conference theme by describing high performing Stormwater programs, monitoring approaches and research into BMP effectiveness. Improvement in water quality from MS4 discharges is a key element in the improvement of Chesapeake Bay.

3:00	Taylor	National Municipal Stormwater Alliance
3:20	Brown	To Green or not to Green: Modeling Incentive-Based Programs for Green Infrastructure Investment on Private Properties
3:40	Welty	Assessing green infrastructure performance using a three-dimensional hydrologic modeling approach
4:00	Barrett	Use of Permeable Friction Course for Stormwater Quality
4:20	Traver	Advances in understanding the role of infiltration and evapotranspiration in Green Infrastructure
4:40	Trapp	Current topics in Quantitative Microbial Risk Assessment (QMRA)
5:00	Alamdari	Comparing Tools for Integrating Cost Optimization with Simulation Modeling in Urban Watersheds
5:20	Maeda	Linking Stormwater Best Management Practices to Social Factors in Two Suburban Watersheds

Evaluating Current and Future Influences on James River Water Quality Condition

Session Leads:	Jian Shen, Harry Wang, Richard Isleib
Date:	June 12th
Time:	12:40 PM
Room:	Prince George

ABSTRACT

James River is a western tributary of the Chesapeake Bay. Harmful algal blooms (HABs) have frequently occurred in both its upstream tidal fresh region and its downstream polyhaline and mesohaline regions, which have been attributed to excessive nutrient inputs from the watershed. However, the James River does not have a dissolved oxygen (DO) impairment like other tributaries, although its nutrient loads are high among Virginian tributaries. To accommodate future development of the region and improve transportation and navigation, construction of new infrastructure, including a new bridge tunnel, storm surge barriers, and channel deepening, has been planned in the James River. Considerable research, including field observations, data analysis, and modeling, has been carried out in the James to investigate the interactions of physical processes, biochemical processes, and human impacts on the ecosystem. In 2014, the State of Virginia decided to revisit the James River TMDL allocations by developing a site-specific James River water quality model, and to reassess the attainability of the chlorophyll-a criteria. In addition, the State convened a Scientific Advisory Panel (SAP) to review and confirm or adjust the James River chlorophyll-a standards. Evaluating current and future influences on the water quality conditions of the James is important so that decision makers can effectively manage the James River. We solicit speakers for all research activities, including observation, data analysis, modeling, engineering channel modifications, and estuary management using science and policy related to the James River. Speakers will highlight how scientists and decision makers can engage to solve environmental problems through observations, research, modeling, and managing to help identify mechanisms for targeted management actions.

12:40	Shen	Assessing the impact of uniqueness of water quality model kinetic parameter and model uncertainty on phytoplankton simulations in the tidal James River, Virginia, USA
1:00	Qin	The critical role of physical transport in the initiation of harmful algal blooms in the lower James River, Virginia
1:20	Lui	The 3D SCHISM model application for studying impact of small-scale piling structures on circulation in the Lower James River
1:40	Loftis	A Comparison of Tidewatch inundation predictions and citizen-science flood extent observations during the 2017 king tide in Tidewater Virginia
2:00	Isleib	Assessing the water quality impacts in a tidal embayment from the closure of proposed storm surge barriers
2:20	Thuman	James River overflow model: GUI development for model ease of use

Understanding Oyster Trajectories: Wild Population Dynamics, Restoration and the Role of Aquaculture

Session Leads:	Ryan Carnegie, Jeff Cornwell
Date:	June 12th
Time:	3:00 PM
Room:	Prince George

ABSTRACT

Oyster biomass in the Chesapeake Bay region has decreased dramatically over the last 100 years, driven by intensive harvest, habitat degradation, and disease. The benefits of robust oyster populations include increased benthic diversity, improved water clarity, and nutrient retention and transformation, services which have been compromised by diminished oyster abundance. Increasing oyster abundance has been an objective of resource managers, yet the means by which this may best be effected, and the scope of potential impacts and benefits, for example increased N removal, is not fully understood. The purpose of this session is to identify current data sets and understanding and to compare and contrast these to current small and large scale modeling efforts. Topics could include controls on biomass and reproduction, effects of oysters on algal biomass and composition, use of oysters for nitrogen removal, and identification of the state of the art regarding oysters, oyster conservation and restoration strategies, and water quality.

3:00	Kellogg	Quantifying the benefits of tributary-scale oyster reef restoration
3:20	Kahover	A high-resolution model of filtration, biodeposition, and nutrient dynamics on restored oyster reefs
3:40	Gawde	Integrating and applying three-dimensional models to simulate oyster ecosystem services
4:00	Steppe	Relating Severn River oyster reproduction to high-frequency water quality data
4:20	Carnegie	Resistance and Tolerance to Diseases in the Eastern Oyster
4:40	Mann	Oyster populations in the Virginia Bay: Small steps to stability
5:00	Cerco	Influence of oyster aquaculture on water quality attainment Chesapeake Bay: I. Model formulation and assessment of aquaculture activity
5:20	Tian	Influence of oyster aquaculture on water quality attainment in Chesapeake Bay: II. Model implementation and application

Practical Advances in Regional Land Change Modeling: What's Achievable Now?

Session Leads:	Peter Claggett, Claire Jantz, David Donato
Date:	June 13th
Time:	3:20 PM
Room:	Arundel A

ABSTRACT

Model developers are intimately familiar with the strengths and limitations of their models and often maintain short-term and long-term wish lists of analyses they would like to do or data they would like to obtain to improve their models. This symposium is focused on discussing the short-term wish lists of regional land change modelers in the context of the seven models that have been developed and applied throughout or in parts of the Chesapeake Bay watershed: SLEUTH, CBLCM, SPRAWL, Dinamica, SILO, and FORE-SCE, MDP Land Use Model. Modelers will present on and discuss realistic and achievable ways of improving current models over the next 3-5 years with a focus on the following topics:

- Land change simulation: population migration, agricultural land abandonment, silviculture, infill/redevelopment
- Land change consequences: ecological integrity, water quality, ecosystem services
- Big and/or new data: Google API- travel accessibility, Census-PUMS, Census-LEHD, IRS-migration, high-res land use/cover, LCMAP annual land cover change
- Open source software and computer languages: Python, R, C, Java, QGIS, SAGA, Apache Hadoop

3:20	Claggett	Can we ever get to version 2.0? Stepping off the dime
3:40	Ahmed	Faster, more flexible and stable models: Lessons learned on our way to the cloud
4:00	Haag	Geoinformatics methods and impacts on Regional Land Change Models
4:20	Donato	Current computational options and challenges in land-change modeling
4:40	Jantz	Improving the thematic resolution of urban land change modeling

Other Current and Emerging Issues in Chesapeake Bay Science and Modeling

Session Leads:	Bill Ball, Raleigh Hood, Dave Jasinski
Date:	June 13th
Time:	12:40 PM
Room:	Arundel B

ABSTRACT

This session welcomes presentations describing new research, synthesis, or analysis on any topic that is of current or emerging relevance to the Chesapeake Bay system and that is not explicitly covered by other organized sessions for the 2018 Conference. Based on preliminary inquiries, some specific topics may include toxic contaminant fate and transport, chemicals of emerging concern (including pharmaceuticals and personal care products), plastics and microplastics, and sea level rise and other factors affecting coastal resiliency. Submittors should be prepared to consider poster presentations as a required possibility, depending on the number and nature of presentations submitted.

12:40	Wagena	Quantifying structural model uncertainty using a Bayesian multi-model ensemble
1:00	Loftis	Exploring communities at intensive risk in the lower Chesapeake Bay via reanalysis of 2011 Hurricane Irene with future sea level rise
1:20	Sisson	Assessing the impact of floodgates to mitigate coastal flooding risks for the Lafayette River in Norfolk, Virginia, USA
1:40	Yactayo	Stream Temperature Modeling for TMDL Development and Implementation in Nontidal Cold Water Streams in Maryland
2:00	Inamdar	Freeze-thaw processes and intense rainfall-runoff events: Significant contributors of suspended sediment and nutrient loads from Chesapeake Bay watersheds
2:20	Voinov	Modeling for action: In search of new interfaces
3:00	Uhlig	Comparing Estuarine Microbial Community Composition of Conventional and Bio-Based Polymers
3:20	Sakowski	Phage-host Interactions and Predation Strategies in the Chesapeake Bay
3:40	Regan	Identification of Polyphosphate-Accumulating Organisms Contributing to Phosphorus Cycling in Stream Biofilms
4:00	Preheim	Application of DNA- and RNA-sequence based techniques to inform biogeochemical models of the Chesapeake Bay dead-zone

Building useful decision support tools with monitoring and modeling data

Session Leads: Emily Trentacoste, John Wolf
Date: June 13th
Time: 12:40 PM
Room: Arundel C

ABSTRACT

Data visualization and decision support tools are an important bridge between the scientific, management, and practitioner communities. A vast amount of observational and modeling data is available to managers throughout the Chesapeake Bay watershed to inform decisions, including those on restoration efforts, priorities, and resources. However, information needs to be consolidated, distilled, and often visualized in order to be understandable and accessible to managers. Tools can guide decision-making, explain complex processes, tell stories with case studies, visualize varying spatial scales, allow interaction with data, and much more.

This session will focus broadly on both visualization and decision support tools developed for use in managing coupled watershed/receiving water systems and especially those with special relevance to the Chesapeake Bay and its watershed. The session welcomes presentations on tools developed for those who benefit from using the data to inform decisions, such as managers, local areas, conservation practitioners, etc. Ideally presentations will showcase ways to interact with, visualize, and use monitoring and observational data as well as modeling data, including inputs, outputs, model processes, or the running of models. Discussions will include identifying ways to distill and visualize complex data for various users, building decision-support frameworks for using data, incorporating storytelling and management-relevant information into tools, and identifying complementary tools by the various organizations in the Bay watershed.

12:40	Gellis	Application of the Sediment Source Assessment Tool (Sed_SAT) to inform managers of sediment sources
1:00	Kaufman	Development of a cost optimization scheme for Chesapeake Bay restoration
1:20	Kvit	Interactive spatiotemporal risk tool for vibrio parahaemolyticus in the Chesapeake Bay
1:40	Czuba	River network-based framework for understanding large-scale watershed functioning to guide sustainable landscape management
2:00	Perez	Crossing watershed boundaries: Developing scalable tools for the Delaware and Chesapeake watersheds
2:20	Saavedra, Gemberlig	Using high-resolution data and web tools to enable precision conservation

3:00	Easton	A Customizable Dashboarding System for Watershed Model Interpretation
3:20	Arscott	WikiWatershed: A public web app to model water quality and quantity, visualize monitoring data, and support conservation decisions
3:40	Trentacoste	Integrating 30 years of Chesapeake Bay data into a new decision support framework for Watershed Implementation Plan development
4:00	Wolf	Mapping Geographic Areas that benefit Multiple Goals and Priorities for Conservation and Restoration Opportunities across the Chesapeake Bay Watershed

Explaining conditions and trends: Integrated monitoring and modeling approaches to describe water-quality change in the watershed and estuary

Session Leads: Joel Blomquist, Qian Zhang, Jeremy Testa, Gary Shenk
Date: June 13th
Time: 12:40 PM
Room: Prince George

ABSTRACT

We encourage submissions that include:

- Applications of empirical and process models to understand watershed and estuarine responses to management actions
- Innovative use of monitoring data to capture finer-scale variability in time or space
- Establishment of linkages between: reduction strategies and measured changes, nutrient sources and watershed export, nontidal and tidal conditions

12:40	Blomquist	A history of nutrient and sediment inputs to Chesapeake Bay: 1985-2016
1:00	Ator	Adapting SPARROW to disentangle the multiple drivers of nutrient trends in Chesapeake tributaries, 1992 - 2012
1:20	Smith	Delayed watershed response to management of Chesapeake Bay nitrogen sources caused by long-term storage of nitrogen in groundwater
1:40	Zhi	A physically-based nutrient model for understanding controls on nitrate export in Chesapeake Bay
2:00	Zhang	Status and trends of the Chesapeake Bay water quality standards criteria attainment in 1985-2016: insights from assessment of thirty years of tidal water quality monitoring data
2:20	Bever	Estimating real-time hypoxic volume in the Chesapeake Bay using two vertical profilers
3:00	Friedman	Seasonal Variability of Carbonate Chemistry in the Chesapeake Bay
3:20	Shadwick	New CO2 system observations in the Chesapeake Bay: high-frequency variability and long-term trends
3:40	Cai	Insights from spatial distributions of inorganic carbon parameters in the Chesapeake Bay: a bay-wide buffering mechanism via carbonate mineral precipitation and dissolution
4:00	Shen	Modeling carbonate system dynamics and responses to nutrient loading changes in Chesapeake Bay
4:20	Li	Physically driven temporal and spatial variabilities in carbonate chemistry dynamics
4:40	St-Laurent	Changes in Chesapeake Bay air-sea CO2 fluxes over the past century

Observations and Modeling of Chesapeake Bay Wetlands and Coupled Sub-estuaries: Advancing Understanding through Comparative Analyses

Session Leads:	Patrick Neale, Maria Tzortziou, Raleigh Hood, Blake Clark
Date:	June 14th
Time:	8:40 AM
Room:	Arundel A

ABSTRACT

Involving complex dynamics, physical, chemical and optical properties, wetlands and sub-estuaries are among the most challenging components of the Chesapeake Bay ecosystem to model. Nevertheless, these areas are hot-spots of biogeochemical exchange and including them is necessary to accurately model and predict changes in the sources, quality and fate of carbon, nutrients and pollutants in the Bay. This challenge can be met by sustained interaction between model development and observational validation. Supporting this goal are recent technological advances enhancing observations in the temporal domain using in situ sensors, in the spatial domain using remote sensing, and enhanced computing resources for simulation modeling.

This session aims to encourage the interaction between scientists using observational and modeling approaches (either or both) to study wetland and sub-estuary hydrodynamics, water quality and biogeochemical processes. Particularly relevant would be presentations that combine modeling results with comparative observations from in situ sensors, field studies and/or remote sensing.

8:40	Menedez	Temporal variability of fluorescent dissolved organic matter at a brackish, tidal marsh-estuary interface
9:00	Knobloch	Sources and Fluxes of Dissolved and Particulate Carbon at the Marsh-Estuarine Interface
9:20	Neale	Spectral model of light attenuation in the Rhode-River subestuary: Identifying drivers of spatial variability and long-term trends
9:40	Nunez	Cross-scale simulations: An innovative approach to evaluate the impacts of climate change on tidal marsh habitats
10:00	Clark	Modeling of complex flow patterns across a large estuarine and tidal wetland complex in southern Dorchester County, MD
10:20	Braff	Modeling the Distribution of Headwater and Isolated Wetlands in a Coastal Plain Watershed

Modeling of Climate Change Consequences for Phase III Watershed Implementation Plans

Session Leads: Donald Boesch
Date: June 14th
Time: 11:00 AM
Room: Arundel A

ABSTRACT

Anthropogenic climate change is expected to result in warmer temperatures on land and in the Bay, increases in the amount and intensity of precipitation, and rising sea level. Some of these changes are already evident and will change inputs and processes in the watershed and the estuary in complex ways, quite likely requiring more nutrient load reductions to meet and sustain water quality improvements by 2025 and beyond. Over the past decade, the Chesapeake scientific community has been addressing aspects of this challenge through workshops, reports and modeling (both research and management models). However, in December 2017, the Chesapeake Bay Program's Principal Staff Committee decided not to adjust the nutrient load reductions required under the Phase III WIPs to accommodate the effects associated with climate change at this time. Rather, it directed the Partnership to address the uncertainties in current scientific understanding in order to develop improved estimates of pollutant load changes (nitrogen, phosphorus and sediment) and a better understanding of the BMP responses due to changing climatic conditions. In 2021, the Partnership will consider the results of updated methods, techniques and studies and revisit estimated loads due to climate change. Jurisdictions would be expected to account for additional load reductions needed in modified WIPs and/or in two-year milestones beginning in 2022.

The Chesapeake Bay Program is challenged to address the many uncertainties in estimating nutrient load reductions needed to maintain water quality objectives as global and regional climate changes. **Lewis Linker** will present an overview of this challenge and modeling to date. Panelists **Lee Currey, Zach Easton, Maria Herrmann and Ray Najjar** will discuss recent reviews of the modeling efforts and offer recommendations on effective paths forward. Ample opportunity for audience participation will be provided.

Water Clarity in Chesapeake Bay: trends, drivers, and research priorities

Session Leads: Jeni Keisman, Carl Friedrichs
Date: June 14th
Time: 8:40 AM
Room: Arundel B

ABSTRACT

Water clarity is widely recognized as an important indicator of the health and trophic state of aquatic ecosystems. The propagation of light through water affects biogeochemical cycles, the distribution of aquatic organisms, and aesthetic human judgments regarding the suitability of water for different uses. Patterns in water clarity are generally understood to be a function of a suite of conditions and processes, such as bed resuspension, shoreline erosion and sediment runoff, nutrient loads driving planktonic algae, and additional feedbacks driven by biological communities. However, in spite of a general understanding of what drives water clarity, explaining patterns in water clarity within and across different physical habitats remains a challenge. The goal of this session is to build on recent discussions of water clarity trends and their drivers, to inform conceptual and numerical for explaining observed patterns in water clarity within and across diverse estuarine habitats of Chesapeake Bay. We anticipate that the session will include presentations on spatial and temporal trends in water clarity, as well as the value of various physical and biological drivers in explaining those trends.

8:40	Barletta	Suspended sediment variability in the surface layer of upper Chesapeake Bay
9:00	Friedrichs	Describing and explaining Chesapeake Bay water clarity: A literature review
9:20	Moriarty	Effects of Seabed Resuspension on Primary Productivity and Remineralization in Chesapeake Bay
9:40	Porter	Effect of hard clam, Mercenaria mercenaria, density and bottom shear on sediment erodibility
10:00	Zhang	Watershed Export of Fine Sediment, Organic Carbon, and Chlorophyll-a to Chesapeake Bay: Spatial and Temporal Patterns in 1984-2016
10:20	Testa	Patterns and Trends in Secchi Disk Depth over Three Decades in the Chesapeake Bay Estuarine Complex
11:00	Murphy	Comparison of Secchi depth and Kd trends while adjusting for freshwater input variations
11:20	Deluca	Can multispectral information improve remotely sensed estimates of total suspended solids? A statistical study in the Chesapeake Bay
11:40	Keisman	Examining trends in water clarity in the Chesapeake Bay: A synthesis of findings from recent STAC workshops

Understanding Nutrient Transport in the Chesapeake Watershed: Legacies, Lag Times, Mechanisms, Drivers and Solutions

Session Leads:	Daniel Wilusz, Bill Ball, Ciaran Harman, Karen Rice, Rosemary Fanelli
Date:	June 14th
Time:	8:40 AM
Room:	Arundel C

ABSTRACT

There is increasing evidence of widespread and significant accumulation of pollutants in the critical zone of anthropogenic landscapes, including excess nutrients from fertilizer and atmospheric deposition. Nitrogen (N) cycling has been well studied for decades, but little information is yet available in regard to transport times and storage within the watershed. Meanwhile, factors affecting the cycling and delivery of phosphorus (P) to streams and rivers have been less well studied and remain poorly understood, even while the transport, storage and residence time distributions of sediment-bound P (often a major portion of the load) are different and more complex than those for dissolved N species. This session includes presentations on the latest findings, empirical evidence and modeling approaches being used to understand and address mechanistic drivers and trends for N, P and other pollutants in the Chesapeake Bay watershed system.

8:40	Van Meter	Landscape Legacies: Long-Term Nitrogen Trajectories in the Chesapeake Bay Watershed and Beyond
9:00	Chang	Effects of Climate Variability on Nitrate Export: SWAT Modeling in the Chesterville Catchment of the Eastern Shore, MD
9:20	Wilusz	Using travel time data and a modified SWAT model to understand groundwater nitrate lag times in the Eastern Shore, MD
9:40	Schubert	Quantifying Sediment and Legacy Pollutant Residence-Time Distributions in Floodplains
10:00	Pizzuto	Sediment Storage Retards Benefits of Upland Sediment BMPs in Large Watersheds Drained By Alluvial Rivers
10:20	Rice	Thirty Years of Dissolved Phosphorus Dynamics in Nine Freshwater Tributaries to the Chesapeake Bay
11:00	Fanelli	Drivers of orthophosphate trends in tributaries to Chesapeake Bay
11:20	Zhang	Retrospective Analysis of Sediment-Associated Phosphorus Concentration in the Major Tributaries to Chesapeake Bay
11:40	Cook	A second-best market design for lagged, persistent pollutants

Using Environmental Biomarkers to Study Chesapeake Bay's Ecosystems

Session Leads: Christina Bradley
Date: June 14th
Time: 8:40 AM
Room: Prince George

ABSTRACT

Chesapeake Bay's ecosystems are complex systems structured by a wide array of natural and anthropogenic factors. This complexity results in spatially variable environmental conditions and biological communities whose characteristics determine the identity and strength of ecological processes at multiple spatial scales. Low frequency dynamics that manifest over multiple years to decades interact with seasonal dynamics, driving temporal variability in estuarine ecosystems. Further, long-term directional trends due to anthropogenic disturbance underlie and influence the timing and magnitude of annual process cycles. Describing and quantifying environmental or ecological relationships across relevant spatial and temporal scales in an estuary the size of Chesapeake Bay becomes logistically difficult using traditional methods. Environmental biomarkers (including biochemical markers) offer a powerful suite of tools that scientists at institutions throughout the Chesapeake Bay region are using in conjunction with more traditional approaches to understand ecological connectivity, hydrology and biogeochemistry. Environmental biomarker approaches include relatively well-established techniques such as bulk stable isotope measurements, fatty acid profiles, and bioaccumulating contaminants (e.g., PCBs, Hg) as well as emerging techniques that include compound-specific stable isotope analysis, DNA barcoding, and optical characterization of dissolved organic matter pool constituents. This special session will provide an opportunity for researchers currently using environmental biomarkers to study Chesapeake Bay to highlight their efforts to the modeling community. We hope that this session will facilitate a dialogue between researchers conducting empirical studies with biomarkers and researchers in the modeling community and, by doing so, foster collaborations that will ultimately support better parameterized and more informative models of Chesapeake Bay's ecosystems.

8:40	Ogburn	Applying Biomarkers to the Study of Trophic Dynamics and Connectivity
9:00	Craine	Environmental DNA reveals multi-assemblage eutrophication responses in the Potomac
9:20	Hammond	An analysis of nutrient concentration and marine signaling in a freshwater ecosystem pre- and post-removal of dams
9:40	Blazer	Importance of long term monitoring to understand impaired fish health
10:00	Walsh	Testes Transcriptome Development and Molecular Identification of Intersex in Smallmouth Bass from Tributaries in the Chesapeake Bay
10:20	Schall	Investigating occurrence of disease characteristics and trends in smallmouth bass abundance in rivers within the Chesapeake Bay Watershed

Posters

John Wolf	Leveraging Procedural Modeling to Visualize Chesapeake Landscapes
Hannah Morrissette, R. Hood	Using observational data to validate performance of sediment flux model formulations of increasing complexity
Sara Nason, T. Malchi, E. Miller, K. G. Karthikeyan, M. Shenker, B. Chefetz, J. Pedersen	Plant Accumulation of Carbamazepine and Lamotrigine: an Interspecies Comparison
Paul Stankiewicz, M. Kobilarov	Adaptive sampling of water nutrient concentrations utilizing autonomous underwater vehicles
Kelley Uhlig	Partitioning of Organic Contaminants to Conventional and Bio-based Polymers
Emily Block, K. Stephenson, Z. Easton	Opportunities and Challenges for Mitigating the Water Quality Impacts of Agricultural Drainage with Denitrifying Bioreactors in the Chesapeake Bay Watershed
Yuanzhi Yao	The representation of stream water temperature in the Dynamic Land Ecosystem Model (DLEM) and its applications to Chesapeake and Delaware Bay watersheds
Mahdad Talebpour, C. Welty	Building a comprehensive model for fully coupled urban atmospheric-hydrological processes
Yiyang Xu, M. Xia	Wave-Current interaction application in Chesapeake Bay
Charles Carlson, Jennifer Georgen, S. Hutt	Numerical models of submarine groundwater discharge in the southern Chesapeake Bay: Effects of variable recharge, permeability, salinity, and sea level
Ryan Woodland, C. Rowe, D. Quill, T. Murphy	Developing stable isotope trophic biomarkers for future diamondback terrapin habitat connectivity studies in Chesapeake Bay
Chris Holder, A. Gnanadesikan	Random forests and their applications in estuarine systems
Alfonso Macias, M. Mulholland, D. Loftis	Measure the Muck, a science-citizens engaging project for sea level rise
Shane Putnam, C. Harman	The Influence of Landscape Structure and Storage on the Hydrologic Response of a Piedmont Catchment in Northern Maryland
Arghajeet Saha, C. Raj	Identifying Nutrient Loading Hotspots in Susquehanna River Basin Using SWAT
Jianzhong Su, W. Cai, J. Brodeur, B. Chen, N. Hussain	A bay-wide self-regulated pH buffer mechanism in response to eutrophication and acidification in Chesapeake Bay
Talia Leventhal, L. Saporito, K. Elkin, H. Gall, P. Kleinman	Comparing the presence of antibiotics in soil and runoff following different dairy manure application methods

Ahmed, Labeeb, Peter R. Claggett, Fred Irani, Renee Thompson

Faster, more flexible and stable models: lessons learned on our way to the cloud

Type: Presentation

Abstract: *The Chesapeake Bay Land Change Model (CBLCM) is composed of code written in C++, Python and R. It was originally designed to forecast urban development throughout the Chesapeake Bay watershed. Currently, it is being used to evaluate the effects of planning and conservation actions as Best Management Practices to reduce pollution to the Chesapeake Bay. This requires simulating a large number (>10) of alternative future scenarios where each scenario takes approximately 4-5 days to complete and produces 0.8 TB of data. To improve model stability, efficiency, and flexibility, plans are underway to convert the code from Python 2 to Python 3 (integrating with ArcGIS Pro), optimize it for cloud computing, modularize and streamline the code structure using Python wrappers to call C++ and R, and to share the code on GitHub to facilitate collaboration on future improvements. The challenges and limitations experienced during this transition will be highlighted and discussed with consideration given to the potential role of open-source geospatial technologies such as QGIS and GDAL/OGR libraries in addressing these challenges.*

Alamdari, Nasrin

Comparing Tools for Integrating Cost Optimization with Simulation Modeling in Urban Watersheds

Type: Presentation

Abstract: *Restoring the hydrology, water quality, and aquatic habitat of urban watersheds requires selecting and sizing the most appropriate stormwater control measures (SCMs), often aided by the use of a hydrologic model. Models such as the Storm Water Management Model (SWMM) can simulate watershed conditions and SCM performance. Selection, sizing, and evaluation of SCMs can quickly become computationally difficult with increasing watershed size. An estimate of cost is also needed to identify the most cost effective options. This has led to the development of dedicated simulation-optimization tools. A promising alternative approach would be to develop an external control program for SWMM. An existing program known as R for Stormwater Management Model (RSWMM) was enhanced and integrated with a cost estimation spreadsheet for tallying costs of SCMs; and was integrated with a metaheuristic solver to optimize life cycle costs for SCMs. We used the program, RSWMM to generate a cost effectiveness curve for a small (123.4 ha) urban watershed (part of Difficult Run, Fairfax County, VA), and compared our results with other methods. Due to the widespread use of SWMM, the ability to use an existing models is a distinct advantage. Developing public domain tools such as RSWMM that combine a hydrologic model, cost estimation of SCMs, and optimization could help decision makers select the most cost-effective suites of SCMs. This could lower the costs of watershed restoration, speed up the process, and allowing more to be done for the same investment.*

Arscott, Dave, Anthony K. Aufdenkampe, David Tarboton, Barry Evans, Scott Haag, Steve Kerlin, Melinda Daniels, Arianna Robbins

WikiWatershed: A public web app to model water quality and quantity, visualize

monitoring data, and support conservation decisions

Type: Presentation

Abstract: *Model My Watershed® (MMW) is a free web application for modeling the influences of land use and best management practices on stormwater runoff and water quality. The public can access this tool at www.WikiWatershed.org. WikiWatershed is a toolkit designed to help citizens, conservation practitioners, municipal decision-makers, researchers, educators, and students advance knowledge and stewardship of fresh water. Any person with access to the internet can launch MMW and begin exploring landscape features within their watershed. Users can then run stormwater models to predict runoff, infiltration, evapotranspiration and water quality outcomes related to land use changes and implementation of best management practices for improving water quality and quantity in their watershed. MMW lets you: (1) visualize and analyze diverse geographic data layers of value in stormwater and water quality modeling; (2) define an area of interest for modeling and analysis by interactive drawing, selection within given dataset polygons, online watershed delineation, or uploading a file; (3) select a model to estimate storm runoff, infiltration, evapotranspiration, and nitrogen, phosphorus and sediment concentrations/loadings; and (4) modify features within your area of Interest by changing land use or implementing best management practices to run models and compare-contrast various modeled scenarios. A new feature within MMW, Monitor My Watershed®, allows users to search their area of interest for surface and ground water quality data archived with three data repositories (CINERGI, HydroShare, and CUAHSI Water Data Center).*

The two modeling approaches that are currently implemented within MMW are: the Site Storm Model, which simulates a single 24-hour storm event by applying a hybrid of the Source Loading and Management Model (SLAMM), TR-55, the simplest of the Food and Agriculture Organization of the United Nations evaporation models for runoff quantity and EPA's STEP-L model for water quality; and the Watershed Multi-Year Model, which simulates 30-years of daily weather, hydrology, nutrient, and sediment fluxes using the Generalized Watershed Loading Function-Enhanced (GWLF-E) model that was developed for the MapShed desktop modeling application (B.M. Evans, Penn State University). The GWLF-E model is also one of five watershed models available within EPA's BASINS multi-purpose modeling application.

Model My Watershed has been coupled to HydroShare (www.hydroshare.org), a web based hydrologic information system operated by the Consortium of Universities for the Advancement of Hydrologic Science Inc. (CUAHSI) that is available for use as a service to the hydrology community. HydroShare includes a repository for users to share and publish data and models in a variety of formats, and to make this information available in a citable, shareable, and discoverable manner. Results from MMW analyses may be directly exported to HydroShare for sharing with others.

WikiWatershed is an initiative of Stroud Water Research Center and is made possible through partnerships and contributions from individuals, organizations, and companies throughout the U.S., including: LimnoTech, Azavea, Penn State University, Utah State

University, University of Washington, and Drexel University. Development of WikiWatershed has been funded by the William Penn Foundation, National Science Foundation, and Stroud Water Research Center.

Ator, Scott, Ana Maria Garcia, Gregory E. Schwarz, Joel D. Blomquist, Andrew J Sekellick

Adapting SPARROW to Disentangle the Multiple Drivers of Nutrient Trends in Chesapeake Tributaries, 1992 - 2012

Type: Presentation

Abstract: *Understanding past trends in stream chemistry is critical to adaptive watershed management, but often complicated by multiple contaminant sources and watershed conditions that change over varying time scales. Where contaminant sources are limited, observed changes in water quality over time can often be attributed to known changes in inputs. Variable recent observed trends in nitrogen and phosphorus fluxes among Chesapeake Bay tributaries, however, reflect the multitude of nutrient sources and natural and human landscape conditions affecting nutrient fate and transport in the bay watershed. We adapted spatially-referenced regression (SPARROW) modeling to infer causes of observed trends in flow-normalized nitrogen and phosphorus fluxes in Chesapeake Bay tributaries and to estimate flux changes in unmonitored streams and to the bay between 1992 and 2012. The annual nitrogen flux to the bay from its watershed declined by 14 percent over this period from 147,000 Mg (metric tons) to 127,000 Mg. The majority (82 percent) of this decline is attributable to declining point-source inputs, while a further 12 percent is attributable to reduced atmospheric deposition. The remainder of the change is attributable to urban non-point sources, as decreasing average yields from urban areas possibly attributable to evolving management practices led to an overall decline in urban non-point fluxes between 1992 and 2012, even as urban areas increased by 27 percent. Inputs from agriculture contribute the majority of nitrogen to the bay from its watershed, but changed little between 1992 and 2012. Changing average nitrogen yields to streams from agricultural areas underlain by carbonate rocks, however, suggest possible effects of management practices that might be observed in the future in other geologic settings. Phosphorous contributions to local streams similarly changed little from non-point sources but declined substantially from point sources. Regardless of upstream trends, however, annual phosphorus delivery to the bay increased between 1992 and 2012 to 9,570 Mg due to substantially reduced removal and retention of phosphorus from the Susquehanna River in Conowingo Reservoir. Meeting nutrient flux targets mandated for 2025 by the Clean Water Act will require a reversal in phosphorus trends and accelerated nitrogen reductions over those observed between 1992 and 2012.*

Barletta, Stephanie

Suspended sediment variability in the surface layer of upper Chesapeake Bay

Type: Presentation

Abstract: *Episodic high flow events flush large loads of nutrients and suspended sediments down the Susquehanna River, over Conowingo Dam, and into the upper Chesapeake Bay, potentially exacerbating eutrophication in downstream areas of the estuary. Under low to moderate flow conditions, the Estuarine Turbidity Maximum (ETM) is thought to act like a particle buffer between the upper and lower Bay by trapping settling particles and promoting*

their accumulation in the bottom sediments, thus mitigating ecological damage downstream. Under high flow conditions, however, some surface layer sediments are thought to bypass the ETM. Relationships between flow, suspended sediment concentration, and particle settling characteristics have been uncertain due to suspected changes in suspended sediment properties under different flow conditions. To develop a better understanding of suspended sediment dynamics in the surface layer of upper Chesapeake Bay, several in-situ data sets under different flow conditions were examined, including long-term flow and concentration data at the Dam, flow dependent settling speed and grain size distribution data at the Dam, and upper bay axial surveys of particle concentrations and size distributions. Preliminary results indicate that particle size and settling speed do not change much before reaching the ETM, where significant aggregation and settling appear to occur. When examined in relation to surface layer salinity, significant loss of particle mass from the surface layer occurs up to salinities of approximately 2, above which an essentially non-settling particle population appears to maintain concentrations at a very low background level. These rapid transformations of sediment properties help to explain the overestimation of downstream sediment transport predicted by some existing Chesapeake Bay sediment transport models, which do not account for modification of suspended sediment characteristics in the water column. These modifications should be accounted for in future sediment transport models to better predict the fate of the Susquehanna's sediment loads and the implications of high flow events for the Chesapeake Bay ecosystem. A limitation of this study is that there were few observations under extreme flow conditions.

Barrett, Michael

Use of Permeable Friction Course for Stormwater Quality

Type: Presentation

Abstract: *Permeable Friction Course (PFC) is a thin lift porous asphalt overlay applied on top of conventional impermeable paving materials on highways to improve driving conditions in wet weather. This presentation will describe the degree to which PFC also provides substantial pollutant reduction for stormwater runoff in highways with this type of pavement. This paving material provides an innovative alternative for treating highway runoff, since no right-of-way is required for implementation.*

Bash, Jesse, Patrick Campbell, Tanya Spero, Donna Schwede

Future Directions and the Importance of Scale in Estimating Atmospheric Nitrogen Loading to the Chesapeake Bay

Type: Presentation

Abstract: *Atmospheric sources are one of the largest loadings of nitrogen to the Chesapeake Bay watershed. There has been active development of the Community Multiscale Air Quality (CMAQ) model to better estimate atmospheric deposition for terrestrial and aquatic ecosystem health applications. A new tiled, land use specific, dry deposition scheme developed for critical loads and total maximum daily load (TMDL) applications in the CMAQ model will be presented. In this study, we apply land use specific dry deposition and bulk grid cell deposition parameterizations to the Chesapeake Bay Watershed at 12 km and 4 km grid resolution to explore the impact that spatial scale and the parameterization of sub-grid cell processes have on estimates of*

nitrogen loading. Whether the parameterization of sub grid scale land use specific deposition estimates can partially compensate for higher spatial resolution will be evaluated. The impact on estimates evaluated against wet deposition and ambient concentrations observations and the mapping of deposition results to land use data will be discussed.

Bever, Aaron, Marjorie Friedrichs, Malcolm E. Scully, Carl T. Friedrichs

Estimating real-time hypoxic volume in the Chesapeake Bay using two vertical profilers

Type: Presentation

Abstract: *Although the measurement of in-situ dissolved oxygen concentration is possible with modern instruments, quantifying the total volume of water that is hypoxic (hypoxic volume) is a more difficult task, yet is critical for understanding the impact of low oxygen waters on living marine resources. This study uses a combination of field observations and numerical model results to demonstrate that the hypoxic volume in the Chesapeake Bay can be estimated using only 2 to 3 vertical profilers. Estimates of the hypoxic volume in the Chesapeake Bay calculated using a simple Geometric Hypoxic Volume (GHV) method were validated against traditional estimates based on interpolating many stations to the entire Bay, using both field collected data and three-dimensional numerical model results. The analysis demonstrated the location and thickness of the hypoxic water in the Chesapeake Bay was strongly constrained by the geometry of the embayment. Analyses examining the number of vertical profile locations needed for estimates of hypoxic volume indicated that using only two or three locations resulted in GHV estimates nearly as accurate as those calculated using up to thirteen locations and retained the quantified interannual severity in hypoxia. The analysis suggests a few automated vertical profilers in the mainstem of the Chesapeake Bay could be used to estimate the hypoxic volume in real time. This approach is likely applicable to other systems where hypoxic volume is constrained by bathymetry.*

Bever, Aaron, Michael Macwilliams, Mary C. Fabrizio, Troy D. Tuckey

Quantifying Habitat Suitability for Forage Fishes in Chesapeake Bay: A Coupled Modeling Approach Using Fishery Surveys and a Hydrodynamic Model

Type: Presentation

Abstract: *The continued production of sufficient forage fish is recognized as critical to advancing ecosystem-based management in Chesapeake Bay. Yet, factors that affect local abundances and habitat conditions necessary to support forage fish production remain largely unexplored. This study aims to quantify suitable habitat for forage species in the Chesapeake Bay and tributaries by combining information from 17 years of fisheries surveys with a 3-D hydrodynamic model to develop habitat suitability models in the Bay and tributaries and then map and quantify habitat area through time. The 3-D model developed by Anchor QEA is based on the Unstructured non-linear Tidal Residual Inter-tidal Mudflat (UnTRIM) hydrodynamic model and spans the entire Chesapeake Bay and major tributaries. The hydrodynamic model was validated throughout the Bay and tributaries using the spatially extensive environmental data collected at the time of fish sampling. The modeled salinity, temperature, and velocity results were subsampled at the exact times and locations of the fisheries survey data to provide dynamic habitat metrics that are not generally observed at the time of the* *fish sampling (e.g., velocity, stratification) for possible inclusion in fish habitat models. Based on the relationships between the hydrodynamic variables and fisheries catch data, the 3-D model will be used to map and quantify habitat through time. This approach demonstrates that numerical model hindcasts can be combined with long-term data sets to explore environmental conditions at different spatial and temporal scales in order to improve the understanding of observed biological data.*

Bhatt, Gopal, Andrew Sommerlot, Gary Shenk, Lewis Linker, Li Li, Chris Duffy

Towards a fine scale representation of the Chesapeake Bay Watershed

Type: Presentation

Abstract: *Understanding the spatial variability in watershed resources is critical for the effective management and protection of water recourses and ecosystem services. With the development of the EPA Chesapeake Bay Program's Phase 6 Model, the quality of data inventory for the Chesapeake Bay Watershed has significantly improved, land-cover land-use data being one such example. Significant human resources and financial investments in the development of these data products can benefit a new generation of spatially distributed models, and provide support for accurate fine scale representations of the watershed in the model. Although geospatial data inventories have significantly improved in recent years, serious data gaps remain a challenge for providing the information necessary for targeted planning and implementation of management practices. Spatially distributed watershed models such as Penn State Integrated Hydrologic Model (PIHM), which provides capabilities for multi-state, multi-scale, process based simulation of watershed processes, holds potential for overcoming such gaps through fine-scale simulations of regional river basins. Advances in the scale of computation, supported by a new generation of geospatial data inventories, now provide a practical basis for such numerical simulations of regional watersheds at significantly finer scales. In this work, high-resolution spatially distributed model prototypes for a number of test river basins (e.g. Juniata River Basin and Potomac River Basin) using high resolution geospatial data for topography, soil, land-use and land-cover are being developed. The spatially distributed model prototypes of the Chesapeake Bay Watershed can be used a discovery tool to test hypotheses, obtain new information, and improve linkages between the CBP partnership's models. In addition, these high-resolution model prototypes would offer research and discovery support for enhancing CBP's multiple-model strategy adopted with the development of Phase 6 Model. The high-resolution model outputs from these prototypes can also be used in the development of Meta-models for management applications, where simple numerical functions describing such Meta-model abstractions adequately describe the behavior of the local scales, as simulated by a complex process-based model. These steps are critical for eventually providing a more structured linkage among the fields, local, regional, and Bay Watershed scales.*

Blazer, Vicki Heather Walsh, Megan Schall, Brandon Keplinger, Geoff Smith, John Mullican, Kelly Smalling

Importance of long term monitoring to understand impaired fish health

Type: Presentation

Abstract: *Impaired fish health, such as skin lesions, skin and liver tumors, mortality events and reduced reproductive success have raised concerns of the public and*

resource managers. Smallmouth bass are an important sportfish and top predator in numerous watersheds of the Chesapeake Bay and we have used them as a sensitive indicator species. Intersex (testicular oocytes) and vitellogenin, two widely used indicators of exposure to estrogenic compounds, are commonly observed in bass. Additionally, mortality of adults in the Potomac and young of year in the Susquehanna have raised concerns about population declines. While numerous studies have been conducted to identify causes and/or risk factors for these health problems no one factor has been identified. In order to better understand associated risk factors adverse effects monitoring together with chemical contaminant monitoring and geospatial analyses has been used spatially and temporally at a number of sites. Adverse effects, ranging from organism (condition factor, gross lesions) to tissue (histopathology, plasma vitellogenin) and molecular (differential gene expression), have been measured for 4-5 years at sites with varying landuse. Temporal variability of the endpoints, including chemical concentrations, make cause and effect relationships difficult to document. However, having long term data (4-10 years) allows us to begin to evaluate exposures during key developmental or sensitive periods and identify long term effects.

Blomquist, Joel, Rosemary Fanelli, Jeni Keisman, Qian Zhang, Doug Moyer, Michael Langland

A History of Nutrient and Sediment Inputs to Chesapeake Bay: 1985-2016

Type: Presentation

Abstract: *The ecological condition of Chesapeake Bay and its numerous tributary embayments is largely determined by external inputs of freshwater and associated nitrogen, phosphorus, and suspended sediments. Since 2012, the U.S. Geological Survey has applied Weighted Regressions on Time Discharge and Season (WRTDS) at stream monitoring locations to report on progress on load reductions from the bay's contributing watershed. WRTDS results are particularly useful in describing long-term changes in stream loads while accounting for changes in flow, using a metric called flow-normalized load. Conditions in the estuary, however, do not respond to flow-normalized loads. Conditions in the estuary are regulated by actual nitrogen, phosphorus, and sediment inputs in the preceding days, weeks, and months. An ongoing examination of annual actual loads in relation to reported flow-normalized loads is providing a better understanding of the changes the bay has experienced over three decades. This analysis includes long term trends in annual river loads, changes in point sources, and atmospheric deposition as well as estimated contributions from unmonitored areas. The purpose of this effort is to provide resource managers and estuarine scientists with a clearer perspective of the magnitude of changes in water quality within the Chesapeake Bay Watershed relative to the actual changes that the Chesapeake Bay has experienced.*

Bock, Emily, Kurt Stephenson, Zach Easton

Opportunities and Challenges for Mitigating the Water Quality Impacts of Agricultural Drainage with Denitrifying Bioreactors in the Chesapeake Bay Watershed

Type: Poster

Abstract: *Artificial drainage enhances productivity of poorly drained soils but exacerbates nutrient export from agroecosystems, which supply a considerable portion of excess nutrient* *loading to the Chesapeake Bay. Opportunities to decrease nitrogen (N) and phosphorus (P) in drainage waters using a comprehensive drainage management approach were investigated as part of a multi-state, multi-institution project funded by an NRCS Conservation Innovation Grant. Denitrifying woodchip bioreactors and sawdust walls, practices utilizing biological N removal, were implemented on working and research farms with ditch and/or subsurface drainage networks in the Delaware, Maryland, and Virginia. Average N load removal efficiencies for seven woodchip bioreactors ranged from 9.5 to 72%, and concentration reduction efficiencies for the two sawdust walls were 74 and 88%. An economic analysis based on cost data from the bioreactor installations and empirically modeled performance suggested that woodchip bioreactors are cost effective compared to other agricultural best management practices to reduce M losses. Three adoption incentives were identified to encourage bioreactor implementation in Virginia that could be generalized to other jurisdictions: (i) development of NRCS practice standard for bioreactors in Virginia, which would then make bioreactors eligible for NRCS cost share funding (e.g. via EQIP, CREP); (ii) inclusion of bioreactors in a Virginia Resource Management Plan; (iii) use of bioreactors to produce tradable nutrient credits in Virginia. However, several regional factors with the potential to constrain bioreactor performance were identified: acid soils, shallow groundwater tables, sedimentation in ditches, and low N loading. In contrast to the extensive, patterned tile networks typical of the Midwest, drainage in the Mid-Atlantic is accomplished mainly with ditching and, to a small but increasing extent, subsurface tile drainage. The tile drainage systems that do exist tend to target saturated areas in the field rather than uniformly drain the entire field, and fields generally tend to be smaller. Smaller fields and drainage networks can translate into lower N loading, which could reduce cost-effectiveness of the practices due to loss of economy of size for the bioreactors and reduced efficiency due to N-limitation. Coastal Plain soils are also likely to be acidic, which suppresses the activity of denitrifiers responsible for removing excess N. Additionally, interfacing bioreactors with ditch systems requires refining system design, as the in-ditch bioreactor became clogged by significant sedimentation. Consequently, adapting bioreactors to the Mid-Atlantic is more complex than transplanting bioreactors designed to treat tile drainage. While bioreactor N removal efficiency is highly variable and their effectiveness relies on site-specific design, these regional difference in artificial drainage networks, cropping systems, soil types, and hydrologic regimes can inform assessment of bioreactor utility and cost-effectiveness in the Mid-Atlantic.*

Boesch, Donald, Lewis Linker, Lee Currey, Zachary Easton, Maria Herrmann, Ray Najjar

Modeling of climate change consequences for Phase III Watershed Implementation Plans

Type: Presentation

Abstract: *The consequences of global climate change are already evident in the Chesapeake Bay and watershed and will influence virtually every aspect of the structure and function of the ecosystem in the coming decades. The 2014 Chesapeake Watershed Agreement set a new goal for climate resiliency to withstand adverse impacts from changing climate conditions. Since then an important focus has been to estimate, using the suite of Chesapeake Bay*

Program's (CBP) management models, the effects of climate change on water quality and any adjustments that should be considered in nutrient load reductions included in Phase III Watershed Implementation Plans (WIPs) to achieve the Agreement's 2025 TMDL commitments. The models assumed specific projections of increased temperature, changes in precipitation, and a rise in mean sea level based on guidance from scientific community. Interpreting the model outcomes on the effects on hypoxia in the bottom-layer of the mainstem Bay, the CBP modeling team estimated that it would require additional load reductions of 9.1 million pounds (4.1 million kg) of nitrogen and 0.49 million pounds (0.22 million kg) of phosphorus per year to compensate for the effects of climate change by 2025.

In considering this advice, the CBP's Principals' Staff Committee (PSC) was struck by how rather small changes in assumptions affected these estimates. It also sought information on how modified "best management practices" could affect nutrient loads in the changing climate. The PSC directed the CBP workgroups to address the uncertainties in current scientific understanding so that in 2021, the Partnership can consider the results of updated methods, techniques and studies and revisit estimated loads due to climate change.

This unconventional session seeks to increase community awareness of the consequences of climate change and solicit its input toward addressing the particular challenge of adjusting WIPs. It will include an overview of the modeling efforts to date, the perspectives of a panel of three scientists familiar with both the climate modeling framework and the decision making process, and facilitated audience participation in the discussion. Outcomes of the session will help shape a subsequent workshop and the refinement of analyses.

Boomer, Kathleen

Predicted and Observed Water Quality Benefits in Reconnected Floodplains of an Outer Coastal Plain watershed, Maryland, USA

Type: Presentation

Abstract: *Reconnecting channelized rivers to adjacent floodplains presents a promising opportunity to address water quality concerns, abate downstream flooding, and expand vital wetland habitat. For example, the Chesapeake Bay Program's Phase 6 Watershed Model assumes that floodplains provide 150% greater water quality benefits compared to other wetland types, due to additional retention associated with riverine overbank flow. Few studies, however, explicitly assess restoration effects on the hydrologic regime of reconnected floodplains or confirm expected water quality benefits. We evaluated hydrologic functions in six floodplains along the Pocomoke River, a large Coastal Plain tributary of the Chesapeake Bay. Sites included a floodplain naturally connected to the mainstem, three reconnected floodplains, and two channelized sites. Within each wetland complex, a network of 5 to 12 water table wells was installed to evaluate the relative influence of river water, local discharge, and direct precipitation. Hourly water levels, recorded continuously for more than three years, were combined with synoptic water quality data to reveal varied challenges to restoring natural flooding regimes, depending on watershed position; but that floodplains provide critical buffers to impacts from local contributing*

areas. The observed extent of riverine overflow suggests that the modelled water quality benefit of floodplain restorations represents an appropriate upper limit estimate.

Braff, Pamela, Carl Hershner, Kirk Havens

Modeling the Distribution of Headwater and Isolated Wetlands in a Coastal Plain Watershed

Type: Presentation

Abstract: *Located at the interface between uplands and surface water networks, headwater systems play a critical role in maintaining the ecological integrity of downstream ecosystems. Headwater wetlands intercept surface runoff and shallow groundwater, acting as a natural filter to improve downstream water quality. Important functions provided by headwater wetlands include sediment retention, flood attenuation, and the removal of pollutants/excess nutrients. The loss and degradation of headwater wetlands has been linked to coastal eutrophication, loss of biodiversity, and decreased secondary production worldwide.*

The National Wetlands Inventory (NWI) is currently the best available resource reporting the distribution of tidal and non-tidal wetlands in the United States. NWI wetlands are mapped by aerial photo interpretation, which is well-suited for large herbaceous wetlands. However, in forested areas leaf canopy can obscure wetland detection. Studies have found that in the mid-Atlantic region NWI may miss more than half of small, forested wetlands, including headwater systems. A better understanding of wetland distribution in the Chesapeake Bay watershed is a critical need for both effective regulation of the public trust and efficient planning for private and public sector infrastructure.

We have developed a geospatial model to predict the extent and distribution of headwater and isolated wetlands in the lower York River watershed, extending from West Point to the Chesapeake Bay. Using lakes, rivers, and other waterbodies as indicators of the surface expression of the water table, we were able to interpolate the phreatic surface elevation throughout the study area. We then predicted wetland distribution based on the simulated depth to saturated soils.

Using this modeling approach, we identified an additional 13.73 km2 of potential wetland area previously unmapped by the National Wetlands Inventory. This represents a 22.5% increase in the 60.79 km2 of wetlands mapped by NWI in the lower York River watershed. Model predictions of additional wetland area were field verified following the U.S. Army Corps of Engineers wetland determination protocol at 20 randomly selected locations. Eighty percent of field verified sites were found to be true wetlands, suggesting that these results are a good indicator of additional wetland distribution in the study area.

This approach not only contributes to an improved understanding of headwater and isolated wetland distribution in the coastal plain, but it also provides a basis to evaluate the consequences of climate change. By incorporating the effects of precipitation, evapotranspiration, and sea level rise on the simulated depth to saturated soils, we can also apply the model to predict how headwater wetland extent may change and migrate in response to predicted changes in climate.

Brown, Seth

To Green or not to Green: Modeling Incentive-Based Programs for Green Infrastructure Investment on Private Properties

Type: Presentation

Abstract: *Communities are in need of cost-effective and innovative strategies for stormwater management infrastructure investments. This need is driven by the fact that stormwater pollution is the only major source of increasing water pollution across much of the country including sensitive waterbodies such as the Chesapeake Bay. In reaction to this significant and growing source of water pollution, regulations at the Federal, State and local level continue to become more stringent, the level of treatment for runoff continues to increase. This reaction by the regulatory sector is driving an increase in stormwater infrastructure investment needs. The use of green stormwater infrastructure (GSI) and retention-based standards is on the rise across the U.S., but it is still considered a novel or innovative approach in many areas. The basis of the interest in GSI from the stormwater and wet weather sector is based upon the premise that retaining water on-site is more cost-effective in addressing issues such as combined sewer overflows (CSOs), treats the pollution within runoff while replenishing groundwater resources, and provides co-benefits water quality and quantity treatment, such as improved air quality, enhanced property values, and improved social well-being.*

Considering that the goal of GSI is to retain runoff on-site, which is a decentralized approach to stormwater management that impacts significant segments of the landscape, the issue of treating stormwater on all types of properties, including private property is on the rise. This issue is multiplied for regulated entities who cannot meet regulatory requirements by implementing GSI on publically-owned land alone. For this reason, some municipalities are investigating the use of incentive-based programs to address the significant amount of stormwater runoff treatment required in permits. Understanding how incentive-based programs function requires a method of analysis reflecting the disaggregated and varying nature of decision-making by individuals, which can be irrational, inconsistent and driven by both monetary and non-monetary factors. Unlike idealized and mechanized systems, the dynamics associated with large populations of individual decision-makers is inherently non-deterministic. The field of computational social science has arisen to simulate how large populations of decision-makers behave, and what patterns emerge based upon varying initial conditions by using tools such as cellular automata and agent-based modeling (ABM). This approach is consistent with the investigation investment policies and strategies associated with the GSI adoption at the site level by private property owners, which is at the heart of the proposed research associated with this presentation.

The presentation will provide an overview of a methodology developed to simulate the amount and distribution of GSI investment in a given area based upon the use of incentive-based frameworks, such as a traditional fee/credit approach as well as non-traditional approaches, with an example being the Stormwater Retention Credit program established recently by the District Department of Environment (DDOE) that

proposes to trade retention credits across the District to take advantage of cost heterogeneity and generate GSI implementation in area that can stand to benefit the most from the environmental, economic and social benefits associated with this infrastructure.

Cai, Wei-Jun, Jianzhong Su

Insights from spatial distributions of inorganic carbon parameters in the Chesapeake Bay: a bay-wide buffering mechanism via carbonate mineral precipitation and dissolution

Type: Presentation

Abstract: *We present results from a full study of inorganic carbon parameters along the main stem Chesapeake Bay, allowing evaluation of the carbonate system behaviors and the acidification status in this large, urban, eutrophic, and coastal plain estuary. Ten cruises were conducted from March to December, 2016, and samples of pH, dissolved inorganic carbon (DIC), total alkalinity (TA) and calcium concentration were analyzed in order to describe spatial and seasonal patterns. In contrast to other estuarine studies where alkalinity is largely conservative, alkalinity was frequently non-conservative in the Chesapeake Bay, with large sinks in the upper bay and releases in the subsurface of the mid- and lower bays. The recovery of submerged aquatic vegetation (SAV) across the Susquehanna Flats in the upper bay where very high pH conditions must have promoted the precipitation of calcium carbonate may provide an important buffering resource via transport of the minerals to the low pH mid- and lower bays. This mechanism is interesting and important as it provides a bay wide shelf-regulated acid-buffering mechanism in response to eutrophication and acidification.*

Carlson, Charles, Jennifer Georgen, Sheila Hutt

Numerical models of submarine groundwater discharge in the southern Chesapeake Bay: Effects of variable recharge, permeability, salinity, and sea level

Type: Poster

Abstract: *Terrestrial and oceanic forces drive fluid flow within the coastal zone to produce submarine groundwater discharge (SGD). Groundwater flowing from the seabed serves as a significant pathway for contaminants and nutrients, producing an active biogeochemical reaction zone. This study has two primary goals: (1) to quantify the importance of SGD in geochemical and hydrologic budgets for the lower Chesapeake Bay, and (2) to investigate how SGD changes in response to sea level rise (SLR). Many factors affect relative SLR in the Mid-Atlantic coastal region, including eustatic sea level changes, postglacial rebound, groundwater withdrawal, and stratigraphic subsidence. The composite effect of these factors result in SLR rates of approximately 3.4 mm/yr - 5.8 mm/yr (e.g., Boon et al., 2010).*

Three coastal Virginia transects with different topographic gradients (southern Eastern Shore, Elizabeth River, and Ocean View beach) were modeled using similar treatments of boundary conditions and hydrogeologic layers. Each two-dimensional transect is approximately 5 km in the shore-perpendicular direction, with vertical elevations ranging from 10 m above sea level to 50 m below sea level. A pre-processing suite of code displays NOAA topography and bathymetry data, allows the user to delineate a desired transect, and outputs a cross-sectional numerical domain for a series

of steady-state calculations solved by a USGS program called SUTRA. SUTRA's hybrid finite element and finite difference method computes buoyancy-driven and variable-density flow, solves the coupled solute transport equation, and predicts areas of discharge and recharge across the nearshore coastal zone. Additionally, for the first goal of the investigation, a sensitivity study was performed on the variables of recharge rate, seawater density, and hydraulic permeability. Under the second objective, a series of models was run with sea level boundary conditions reflecting different SLR scenarios extending to the year 2100; results simulated the locations of the freshwater/saltwater interface at various future times for each of the three transects.

Models suggest present-day SGD in all transects, with common flow pattern characteristics including freshwater discharging below the elevation of sea level, seawater recirculating in steep bathymetry, and intervening zones of relatively low flow. Although fluid velocity at the low tide mark was significantly dependent upon the slope of the transect, response to recharge rate was small over a reasonable range of modeled values. Permeability had the greatest effect on SGD; varying hydraulic conductivity over an order of magnitude produced at least a 50% change in discharge. Overall, this series of models identifies likely zones of high groundwater flow, reveals the variability of SGD rates between locations, and suggests where field measurements would be most valuable to better constrain the groundwater contribution to the coastal zone. Model runs that incorporate SLR also provide a general framework to better understand how changing sea levels could impact a range of idealized, present-day groundwater flow systems."

Carnegie, Ryan, Lauren Huey, Roger Mann

Resistance and Tolerance to Diseases in the Eastern Oyster

Type: Presentation

Abstract: *The eastern oyster Crassostrea virginica is foundational to the Chesapeake Bay ecosystem, and its relationships with protozoan parasites Perkinsus marinus (dermo) and Haplosporidium nelsoni (MSX) have been profoundly consequential. The emergence of MSX in the 1950s and the intensification of dermo in the 1980s dramatically reduced oyster abundance and longevity, compromising the myriad ecosystem services that oysters provide. It has long been thought that evolution of disease resistance was unlikely in Chesapeake Bay because predominant reproductive contributions came from oysters in low-salinity refuges from disease, an assumption supported by physical modeling of larval dispersal. Yet oyster populations have been expanding in recent years in areas even of high disease pressure. Population growth has occurred in unrestored areas with high disease pressure as well as in areas subject to intensive restoration efforts. These observations renewed questions about the possibility of an evolutionary response by oysters to disease.*

Resistance to MSX among wild oysters from mesohaline waters of Chesapeake Bay, while not complete, is now documented, and may partly explain the improvement in oyster performance. Infection with dermo, however, remains historically high. To look more closely at potential oyster responses to dermo in particular, we pursued analyses of archival data and histological materials at the VIMS Shellfish Pathology Laboratory on

two tracks. First, we used data from Fall Surveys of oyster diseases from 1988-2017 to determine whether changes occurred in P. marinus infection profiles over time that might suggest a modicum of resistance evolution. Second, we retrospectively evaluated archival histology to determine whether oyster reproductive measures (gonadal area fraction, oocyte density, and oocyte diameter, all measured at peak maturity in summer) may have changed over the period in a direction to indicate tolerance evolution. Results have been affirmative on most counts. While P. marinus infections remain highly prevalent, fewer infections today reach moderate or heavy intensities than in earlier years, indicating that contemporary oysters resist the development of the most intense and lethal infections. While no significant increasing or decreasing trend was observed in oocyte diameters across the period, both gonadal area fractions and oocyte densities increased beginning in 2003, following the extraordinarily intense 1999-2002 disease outbreak.

These observations provide the first substantive evidence of an evolutionary response by C. virginica to dermo disease in particular. While it may be obvious that managing the recovery and restoration of oyster resources requires a firm grasp of oyster biology and ecology, our results highlight how dynamic oyster biology can be over time, especially in regard to oyster interactions with the major pathogens. In a practical sense, these findings provide strong support for the concept of oyster sanctuaries in high- as well as low-disease areas as a tool for resource management. They indicate furthermore that changes in the biology of the oyster itself may be no less significant in driving the bay-wide population expansion of oysters than the intensive restoration activities in some of its tributaries.

Cerco, Carl

Influence of Oyster Aquaculture on Water Quality Attainment Chesapeake Bay: I. Model Formulation and Assessment of Aquaculture Activity

Type: Presentation

Abstract: *For several decades, the potential for oysters to improve Bay water quality, through their filter-feeding activity, has been promoted and investigated. Initial attention focused on restoration of the native oyster population. More recently, attention is being paid to the potential beneficial aspects of oyster aquaculture. In fact, the role of aquaculture is explicitly considered in the 2017 Midpoint Reassessment of the Chesapeake Bay TMDL. This presentation is the first of two that detail the incorporation of aquaculture into the Reassessment. Model formulation and determination of aquaculture activity are considered here. The second presentation focuses on the role of aquaculture in bay-wide nutrient budgets and effects of aquaculture on water-quality standards.*

The oyster model is based on the model used in the 2005 investigation of a ten-fold increase in native oyster population. Oyster population was predicted in the 2005 model. For use in evaluating aquaculture, however, the population is specified. Therefore, the 2005 model is modified to allow specification of the level of aquaculture activity. Most model parameters are the same as in the 2005 model.

While data exists, especially in recent years, on bay-wide aquaculture activity, little information is available to allow placement of aquaculture facilities and to quantify local

level of activity. Either the data does not exist or is proprietary. Location and activity were developed through predictive use of the model. First, aquaculture was restricted to locations of specific depth and salinity. The model was then run in predictive mode to find locations suited for oyster growth, based on food availability, dissolved oxygen, and other factors. Facilities were placed in these locations, consistent with available data on aquaculture by state and basin.

Chang, Shuyu, Daniel Wilusz, Ciaran Harman
Effects of Climate Variability on Nitrate Export: SWAT Modeling in the Chesterville Catchment of the Eastern Shore, MD
Type: Presentation
Abstract: *During the past several decades, human activity increased the input of nitrogen (N) to aquatic ecosystems through land clearing, application of fertilizer, discharge of waste water, etc. In the Chesapeake Bay watershed, a large portion of nitrogen originates from the Eastern Shore with highly agricultural land use. Climate change could have a significant effect on both the amount and seasonal loading of nitrate and total nitrogen in streamflow, which can be simulated by SWAT (Soil and Water Assessment Tool). SWAT is a long-term, continuous, watershed-scale simulation model that is designed to assess the impact of climate and different management practices on fluxes, nutrients, and agricultural chemical yields. The main objective of this research is to observe the seasonality of discharge and nitrate loads and look at how climate change affects nitrate export. The change of precipitation and temperature could alter several hydrological and N-Cycle processes, including lag time and transit time, streamflow and runoff generation, mineralization, and plant uptake. In this research, hydrological processes and the impact of climate change on N in Chesterville Branch watershed was modeled by SWAT. It was calibrated and validated by monthly stream gauge data and water quality monitoring data from USGS National Water Information System through SWAT-CUP. The sequential uncertainty domain parameter fitting algorithm (SUFI-2) in SWAT-CUP was performed to find the most sensitive streamflow and nitrate transport parameters and to calibrate them using multi-objective functions, namely the P-factor, coefficient of determination Nash-Sutcliff efficiency, etc. Climate sensitivity analysis is performed by running scenarios with extreme high and low changes in temperature and precipitation.*

Claggett, Peter
Can we ever get to version 2.0? Stepping off the dime.
Type: Presentation
Abstract: *The Chesapeake Land Change Model (CBLCM) is a pseudo-cellular automata stochastic model that simulates future growth of residential and commercial land uses. It is used operationally by the Chesapeake Bay Program Office to help jurisdictions account for future increases in pollution as required by the Chesapeake Bay Total Maximum Daily Load (TMDL) mandated under the Clean Water Act. Like all models, the CBLCM has issues and limitations that are shared by similar models and include how to represent and interpret: dynamic probabilities, spillover, development capacity, and the potential oversimplification of classes, trends, and historical observations of land cover/use change. Addressing these issues could take years or a lifetime depending on one's objectives and answer to the question: how good is "good enough"? This question will be*

discussed along with short-term (2-5 years) strategies to address each of the issues listed above as fodder for a broader discussion on the topics.

Claggett, Peter

Assessing Fine-Scale Land Cover and Land Use Conditions in the Bay watershed: 1984 - 2025

Type: Presentation

Abstract: *For the next generation of Chesapeake Bay Partnership models used to inform Bay restoration decisions mandated by the Bay Total Maximum Daily Load (TMDL), 1-meter-resolution land cover and land use (LULC) data for all counties intersecting the Bay watershed were developed for the year 2013. This fine-scale representation of watershed conditions was backcast to the year 1984 using historical satellite and Census data and forecast to the year 2025 using the latest version of the Chesapeake Land Change Model (CBLCM). The high-resolution land cover data provide critical contextual information needed to derive land use classes relevant to water quality such as turf grass and mixed open classes. The forecasts of future land use enable jurisdictions to account for future increases in pollution as required by the TMDL and enable the consideration of land use planning and land conservation actions as "Best Management Practices". Both land use conditions and forecasts of land use change will be updated every two years to ensure that management decisions are consistently informed with the best available data.*

Clark, J. Blake, Raleigh R. Hood

Modeling of complex flow patterns across a large estuarine and tidal wetland complex in southern Dorchester County, MD

Type: Presentation

Abstract: *The Blackwater, Transquaking, and Nanticoke River wetland-estuarine complex is one of the largest and most important tidal wetland ecosystems in Chesapeake Bay, MD, USA. The interconnectivity of each sub-basin, low surface elevation, and complex interactions between weather and tides make discerning dominant flow patterns and large scale water transport from sparse measurements alone difficult. In order to further explore water transport at different locations, the widely used FVCOM hydrodynamic model was implemented covering tidal marshes and subtidal estuarine waters in Dorchester County, MD, USA extending to the southern shore of the Nanticoke River. The modeling system (DoCoFVCOM) solves for tidal inundation in addition to salt and water transport, utilizing both tidal forcing and weather to predict the velocity field across the model domain. Using model derived flow across transects offers insight into the net flux of water in areas of interest, in addition to examination of event driven flow events.*

Collick, Amy, Daniela R. Fuka, Tamie L. Veith, Anthony Buda, Arthur Allen, Pete J.A. Kleinman, Ray Bryant, Zachary M. Easton

Employing fine resolution spatial information and extensive field research to evaluate best management practice (BMP) scenario evaluations across the Chesapeake Bay

Type: Presentation

Abstract: *Accurate representation of the hydrological and chemical processes governing nutrient mobility and transport in watershed models facilitates best management scenario evaluations and improves their reliability. In the Chesapeake Bay Watershed, the complex landscapes crossing different physiographic regions, complicate nutrient, specifically phosphorus*

(P), predictions because of a broad range of soils with and without restrictive layers, a wide variety of agricultural management, and variable hydrological drivers. The level of precision in the spatial input data layers can substantially impact the calculations of soil wetness indices and affect the ability to correctly predict hydrological and water quality events in models, such as SWAT-VSA. For example, many models have been developed for areas with variable topography as the primary drivers of surface runoff processes, thus they do not adequately address the Delmarva's, specifically the Eastern Shore's, flat terrain, which is dominated by subsurface hydrologic pathways connecting crop fields with local field ditches and streams, alt although there is long-term data from research (UMES Research and Teaching Farm) and commercial farms (some of whom we have collaborated with for over five years) include groundwater, ditch and stream monitoring (flow and water quality), soil characteristics, field management, and subsurface imaging (Electrical Resistivity Imaging (ERI)). Thus, interrelationships of hydrological monitoring and water quality are being fully evaluated to explain trends in water quality, with an emphasis on differentiating between the potential contributions of different management factors, and more recently, expand BMP modeling efforts in the challenging coastal plain landscapes. Similarly, extensive field management, fine-resolution spatial topographical and soil databases, as well as mixed-hydrological process representation, inform model initialization and support management scenario evaluations in watersheds in New York and Pennsylvania in efforts to improve P loss risk assessments in the Ridge and Valley physiographic region of the Chesapeake Bay Watershed. Challenges in interpreting results of BMP scenario evaluations at fine resolution and communicating them to diverse stakeholders will be covered as well.

Cook, Aaron, James Shortle

A second-best market design for lagged, persistent pollutants

Type: Presentation

Abstract: *There is significant interest in the use of water-quality trading to improve the economic efficiency of achieving nutrient and sediment pollution load reductions in the Chesapeake Bay and elsewhere. Trading between point and agricultural nonpoint sources is especially of interest given the low incremental costs of agricultural abatement compared to municipal and industrial point sources. Existing trading programs assume that nonpoint best management practices (BMPs) achieve the "credited" nutrient reductions as soon as they are implemented. However, changes in water quality in response to BMPs occur over time"from a few months to decades. In consequence, pollution reduction credits supplied by agricultural sources with lagged responses will not actually compensate contemporaneously for the avoided point source reductions. Credited agricultural nonpoint pollution reductions will overstate actual pollution reductions for some period of time depending on the structure of the lags corresponding to the credits traded.*

In theory, the optimal fix is to implement futures markets that explicitly date and trade realized pollution reductions. In this case, participants can only trade pollution reductions that are equivalent from the perspective of the receiving waters (i.e., those having the same delivery date). However, the high cost and complexity of water quality futures markets makes them

implausible. It is therefore desirable to consider "second best" market designs that retain the relative simplicity of current market designs with modifications to recognize and addresses lags. We propose such a design in this paper. This design would allow trades between any pair of sources (regardless of lag length disparity) provided that long-lagged sources compensate for their delays by providing load reductions that more than offset the increased loads of their trading partner. Whereas a futures market would require fixed load deliveries in every period, our system gives more flexibility by allowing short term load increases in exchange for long term reductions. In this paper, we develop a theoretical framework for evaluating this intertemporal tradeoff and for specifying the optimal rate at which long-lagged sources may substitute for short-lagged ones.

To compare the effects of pollution delivered at different points in time we use the concept of present value from standard economic theory, placing more weight on damages that occur earlier in time while placing less on those occurring later. Our trading system requires lagged sources to provide just enough additional load reduction such that the present value of environmental damages under some intertemporal reallocation are no higher than they would have been in the absence of the trade. We define the "trading ratio" as the pounds of nutrient reductions required from a lagged source in order to make up for a one-pound increase from a non-lagged source. In identifying the "correct" trading ratio, we solve for the smallest ratio that maintains environmental damages at status quo levels (in present value terms), thereby maximizing cost savings opportunities while preserving a given standard of environmental quality over time.

In practice, each source could be catalogued according to the speed of its deliveries and a trade ratio between two sources computed according to their lag differential. This system would make reductions from sources with rapid deliveries "cheaper" to provide, while implicitly increasing the costs for suppliers whose reductions whose effects may not be realized until years (or decades) later. A well-designed system of trading ratios will prevent excess environmental harm from trades, while maximizing opportunities to shift load reductions from high-cost sources to low-cost sources. We expect both the flexibility and simplicity of this market design will help achieve both nutrient reduction cost savings and acceptable water quality standards.

Cornwell, Jeffrey, Michael Owens, Hamlet Perez, Zoe Vulgaropulos

Biogeochemistry of Fluvial Particulates in Reservoirs and Chesapeake Bay Sediments

Type: Presentation

Abstract: *The infill of the Conowingo Reservoir has changed particulate dynamics in the lower Susquehanna River and likely has increased delivery of fluvial sediments to the upper Chesapeake Bay. The nutrients associated with these particulates, nitrogen and phosphorus, have very different biogeochemical cycles and subsequent downstream effects on the Chesapeake Bay. Reservoir sediments are very retentive of phosphorus, but in the estuary post-depositional mobility increases with salinity. Denitrification rates in the reservoirs are similar to the upper Chesapeake Bay and overall the rates of nitrogen remineralization are low. In this presentation, we describe the nature and reactivity of these particulates and describe the potential effects reservoir*

sediment scour on estuarine biogeochemical balances.

Craine, Joseph

Environmental DNA reveals multi-assemblage eutrophication responses in the Potomac

Type: Poster

Abstract: *Directly quantifying freshwater biotic assemblages has long been a proxy for assessing changing environmental conditions, yet traditional aquatic biodiversity assessments are often time consuming, expensive, and limited to only certain habitats and certain taxa. Sequencing aquatic environmental DNA via metabarcoding has the potential to remedy these deficiencies. Such an approach could be used to quantify changes in the relative abundances of a broad suite of taxa along environmental gradients, providing data comparable to that obtained using more traditional bioassessment approaches. To determine the utility of metabarcoding for comprehensive aquatic biodiversity assessments, we sampled aquatic environmental DNA at 25 sites that spanned the full length of the Potomac River from its headwaters to the Potomac estuary. We measured dissolved nutrient concentrations and also sequenced amplified marker genes using primer pairs broadly targeting four taxonomic groups. The relative abundances of bacteria, phytoplankton, invertebrate, and vertebrate taxa were distinctly patterned along the river with significant differences in their abundances across headwaters, the main river, and the estuary. Within the main river, changes in the abundances of these broad taxonomic groups reflected either increasing river size or a higher degree of eutrophication. The larger and more eutrophic regions of the river were defined by high total dissolved phosphorus in the water, a unique suite of bacteria, phytoplankton such as species of the diatom Nitzschia, invertebrates like the freshwater snail Physella acuta, and high abundance of fish including the common carp (Cyprinus carpio). Taxonomic richness of phytoplankton and vertebrates increased downriver while it consistently decreased for bacteria. Given these results, multi-assemblage aquatic environmental DNA assessment of surface water quality is a viable tool for bioassessment. With minimal sampling effort, we were able to construct the equivalent of a freshwater water quality index, differentiate closely-related taxa, sample places where traditional monitoring would be difficult, quantify species that are difficult to detect with traditional techniques, and census taxa that are generally captured with more traditional bioassessment approaches. To realize the full potential of aquatic environmental DNA for bioassessment, research is still needed on primer development, a geographically broad set of reference sites need to be characterized, and reference libraries need to be further developed to improve taxonomic identification.*

Czuba, Jonathan

River network-based framework for understanding large-scale watershed functioning to guide sustainable landscape management

Type: Presentation

Abstract: *Intensification of human actions on landscapes is altering their physical, chemical, and biological functioning, often with unintended environmental consequences that take years to reverse. Of particular interest are emergent hotspots of change, e.g., places and times of rapid river bank erosion, degraded water quality, and adversely impacted river biotic life.*

Management decisions are most effective when they can prevent or alleviate such consequences before they occur. However, predicting such locations over large space and time scales is difficult with fully distributed deterministic models that consider all the small-scale physics and interactions. Besides, climate change imposes non-stationary conditions, uncertainties abound, and nonlinearities in the system make it sensitive to small perturbations.

My approach has been to capture the most important features of the watershed system including transport pathways, travel times, and relevant process dynamics to identify emergent properties of the system such as hotspots of change, vulnerabilities, and critical thresholds for guiding sustainable watershed management. Specifically, the framework I have developed combines river-network configuration, local channel characteristics, and underlying process dynamics into time delays and transformations on a network.

The development and application of this framework thus far has focused on the dynamics of water, sediment, and nitrate on river networks. This framework applied to bed-material sediment transport on the 9,200 km2 Greater Blue Earth River Basin (within the Minnesota River Basin in southern Minnesota) has been used to identify locations of rapid channel migration due to local sediment accumulation. It also reveals sediment "bottlenecks" in river networks where local lows in transport capacity relative to sediment supply act as upstream controls on downstream sediment transport.

This framework also has been applied to nitrate and dissolved organic carbon cycling through a collection of remnant wetlands within the 2,800 km2 Le Sueur River Basin (also within the Minnesota River Basin). The model shows that the overall limits to nitrate removal rate via denitrification shift between nitrate concentration, organic carbon availability, and residence time depending on discharge, characteristics of the waterbody, and location in the network. Furthermore, the model results show that the spatial context of wetland restorations is an important but often overlooked factor because nonlinearities in the system, e.g., deriving from switching of resource limitation on denitrification rate, can lead to unexpected changes in downstream biogeochemistry. This framework can be used toward assessing where and how to restore wetlands for reducing nitrate concentrations and loads from agricultural watersheds.

Ongoing work is applying this framework to address questions related to mixed-size sand and gravel transport and storage dynamics, fine sediment transport and exchange between the channel and floodplain, and phosphorous dynamics. My hope is to start applying this framework to tributary watersheds of the Chesapeake Bay in the near future.

Da, Fei, Marjorie Friedrichs, Pierre St-Laurent

Impacts of direct atmospheric nitrogen deposition and coastal nitrogen fluxes on Chesapeake Bay hypoxia

Type: Presentation

Abstract: *Although rivers are the primary source of dissolved inorganic nitrogen (DIN) inputs to the Chesapeake Bay, direct atmospheric DIN deposition and DIN fluxes* *at depth coming from the continental shelf can also significantly impact Chesapeake Bay hypoxia. The relative role of these additional sources of DIN has not previously been thoroughly quantified. In this study, the three-dimensional Estuarine-Carbon-Biogeochemistry model embedded in the Regional Ocean Modeling System (ChesROMS-ECB) is used to examine the relative impact of these three DIN sources. Model simulations highlight that DIN inputs from the atmosphere have roughly the same impact on hypoxia as the same gram for gram change in riverine DIN loading. DIN inputs at depth from the shelf have a similar overall impact on hypoxia as those from the atmosphere (~0.2 mg L-1), however the mechanisms driving these impacts are distinct. While atmospheric DIN impacts dissolved oxygen (DO) primarily via the decomposition of autochthonous organic matter, coastal DIN impacts DO more via the decomposition of allochthonous organic matter entering the Bay from the continental shelf. The impacts of coastal and atmospheric DIN on estuarine hypoxia are greatest in the summer, and occur farther downstream (lower mesohaline) in wet years than in dry years (upper mesohaline). Integrated analyses of the relative contributions of all three DIN sources on summer bottom DO concentrations indicate that impacts of atmospheric deposition are largest in shallow near-shore regions, riverine DIN has dominant impacts in the largest tributaries and the oligohaline Bay, while coastal DIN fluxes are most influential in the polyhaline region. During the winter when estuarine circulation is strong and shelf DIN concentrations are relatively high, coastal DIN impacts bottom DO throughout the Bay.*

Daniels, Robert, John M. Jacobs

Vibrio Predictive Models and Tools for the Chesapeake Bay

Type: Presentation

Abstract: *Through the Ecological Forecasting Roadmap, NOAA has embarked on an effort to harness existing NOAA infrastructure (i.e.; observational platforms, ecosystem models, operational framework) for application to ecological issues. One focus area has been the distribution and concentration of Vibrio bacteria in surface waters and oysters. In the Chesapeake Bay, tools have been developed to predict the probability of occurrence of Vibrio vulnificus (Vv) in surface waters, and to help predict and reduce concentrations of Vibrio parahaemolyticus (Vp) in oysters both pre and post harvest. The Chesapeake Bay Vv model is being transitioned to operations at NOAA, through an intra-agency effort across several NOAA line offices. The model is based on a relationship between Vv and environmental variables at the NOAA/NCCOS/Cooperative Oxford Lab, and is being transitioned from NOAA/NWS/NCEP/Ocean Prediction Center to NOAA/NOS/CO-OPS where it will be run operationally. These tools that help predict and reduce Vibrio in oysters have been explored through a strong partnership with FDA and the states, where NOAA is using output of environmental variables from operational hydrodynamic models in the Chesapeake Bay and throughout the country to force FDA algorithms for growth of Vibrio spp. in oyster and post-harvest. Other tools have also been developed to demonstrate doubling time of Vp in oysters, and growing area scale best harvest window calculators. Vp doubling time and best harvest window*

tools have recently been developed for Delaware Bay and will be demonstrated.

Davis, Benjamin, John M. Jacobs, Angelo DePaola, Frank C. Curriero

Developing space-time prediction models for Vibrio parahaemolyticus in the Chesapeake Bay

Type: Presentation

Abstract: *Vibrio parahaemolyticus naturally occurs in brackish waters and is one of the leading causes of seafood-borne illness in the United States. Given the natural presence of the bacterium, it is necessary to develop robust and reliable ecological prediction tools in shellfish and in shellfish harvesting waters. Such predictions should be specific to a region of interest and also have adequate spatial and temporal resolution across the area of interest, as bacterium abundance can fluctuate significantly across space and intra-seasonally.*

Current efforts have identified environmental determinants of V. parahaemolyticus in the tidal waters of the Chesapeake Bay using a uniquely large data set (n= 1,385) collected from 148 monitoring stations between 2007-2010. Interval-censored regression models with splines were developed using water samples analyzed by qPCR for V. parahaemolyticus' abundance along with spatially- and temporally-indexed water quality data. Previously identified relationships with water temperature and turbidity were confirmed, while more complex and non-linear relationships were identified for many forms of nitrogen and phosphorus. Non-linear associations with salinity were determined to be a function of both low temperature and turbidity. Associations with dissolved oxygen and phosphate also appeared stronger when samples were taken near human developments.

This work has led to more sophisticated attempts to develop V. parahaemolyticus prediction models using time-indexed and 1- and 2-month lagged water quality measures. Tobit regression models were used to account for V. parahaemolyticus measures below the limit of quantitation and to simultaneously estimate presence and abundance of the bacterium. Models were evaluated using cross-validation along with a series of metrics to quantify prediction bias and uncertainty. The results were overall positive, indicating that in situ water quality data can provide adequate prediction for the presence and abundance of Vp in the Chesapeake Bay, and that lagged measures provide independent, and in some cases superior, predictive power when compared to time-indexed measures. Unexpectedly, models that contained only water temperature variables, the sole measure currently used in the U.S. V. parahaemolyticus risk calculator, performed poorly, indicating that more complex environmental models are necessary for adequate ecological forecasting.

Immediate future work will expand variable selection for prediction models and extend the spatial-temporal extent of such predictions by using geostatistical interpolation techniques. These modeling efforts will culminate in a prediction tool that will ideally provide real-time, as well as short- and long-term forecasts of V. parahaemolyticus, which could be visually summarized in space-time prediction maps. Overall, these predictions and forecast maps would better inform relevant stakeholders, including shellfish harvesters and regulators,

to the current and near-term risks of vibriosis from shellfish consumption, and could subsequently indicate when and where preventative food safety post-harvesting practices are necessary or whether shellfish harvesting grounds should be restricted for a period of time.

DeLuca, Nicole M., Benjamin F. Zaitchik, Frank C. Curriero

Can multispectral information improve remotely sensed estimates of total suspended solids? A statistical study in the Chesapeake Bay

Type: Poster

Abstract: *Water clarity in the Chesapeake Bay is an important environmental parameter to monitor due to its effects on submerged aquatic vegetation, pathogen abundance, and habitat damage for other aquatic life. The Chesapeake Bay is home to an extensive and continuous network of in situ water quality monitoring stations that include measurements of total suspended solids (TSS), which is a volumetric metric for water clarity. However, these in situ measurements can be limited spatially and temporally due to significant time and cost requirements. In addition, acquiring real-time data for some water quality parameters like TSS is difficult to achieve with in situ sampling because the water samples must be taken back to a laboratory for measurement, which can delay the reporting of data for weeks to months. Satellite remote sensing can fill gaps in space and time between in situ samples and has proven to be a valuable tool for monitoring water quality in open ocean, coastal, and estuarine systems. Most algorithms that derive TSS concentration in estuarine environments from satellite ocean color sensors utilize only the red and near-infrared bands due to the observed correlation with TSS concentrations. In this study, we investigate whether non-parametric statistical models that utilize additional reflectance bands from the Moderate Resolution Imaging Spectroradiometer (MODIS) can improve satellite-derived TSS estimates for the Chesapeake Bay. After optimizing the best performing statistical model, we compare its results to those from a commonly used single-band algorithm for the Chesapeake Bay on a holdout cross-validation dataset. We then evaluate the performance of each method above and below the 80th percentile of holdout TSS values and explore the generalizability of both methods throughout various partitions of space and time. Finally, we compare trends and variability from our statistical model to those from in situ TSS measurements.*

Donato, David, Fred Irani, David Strong

Current Computational Options and Challenges in Land-Change Modeling

Type: Presentation

Abstract: *Incremental and cumulative developments in scientific and technical computing over the past decade have gradually created new computational options for compute-intensive land-change modeling (LCM), though many of the fundamental requirements and challenges of LCM remain unchanged. Arguably, the past decade's advances in computational hardware and infrastructure have been more striking than general advances in software-development tools and techniques. With the processing speed of new processor cores apparently reaching a plateau, the leading strategy for faster turn-around of suitable LCM computations is parallel processing, that is, making more effective use of multiple processor cores and the multiple compute nodes of increasingly available high-performance computing (HPC) facilities. The* *growing accessibility of various technologies, OpenMP, virtual machines, containers, GPU-based computation, Hadoop, ZFS, Lustre, and others, has opened up new possibilities for LCM. GIS remains valuable for data preparation and visualization but generally unsuited for hosting complex models. New features in computer programming languages provide modest improvements in programmer efficiency and effectiveness. The challenge for LCM remains the development of a framework of concepts and software that enable rapid expression of models in the form of computationally tractable software.*

Duchin, Faye, Nathaniel Springer, Erich Hester, John Little

An Economic Model of the Chesapeake Bay Watershed for Analysis of Alternative Scenarios about the Future

Type: Presentation

Abstract: *We describe the design for a new model and database of the economic activities taking place within the Chesapeake Bay Watershed. The model explicitly accounts for the opportunities and constraints posed by the natural features of the landscape. It is structured for intimate integration with an existing hydrologic model of the watershed, with exchanges handled by a GIS module that translates between the spatial identifiers and temporal units of the two models and their databases. The resulting framework will be used to investigate alternative prospects for the future of the watershed that could meet the challenges and deliver on the aspirations that concern today's stakeholders. The first implementation will be for the Chesapeake Bay Watershed. The modeling framework is readily customizable for other watersheds with an existing hydrologic model and for which an adequate economic database has been constructed.*

Easton, Zachary, Moges Wagena, Andrew Sommerlot, Amy Collick, Daniel Fuka

Improved Prediction of Nutrient Dynamics in Complex Landscapes Using Terrain Models

Type: Presentation

Abstract: *Many water watershed models (e.g., SWAT, GWLF, HSPF, ANGPS) link runoff and pollutant concentrations almost solely to land use. As a result, we have sometimes dogmatically developed nonpoint source pollution control practices based too heavily on specific land uses and largely ignored the interaction between land management and physical, landscape scale processes. We contend that incorporating hydrologic complexity in the form of high resolution terrain models can reduce calibration needs, increase model parsimony, and better represent landscape pollutant loss. We demonstrate that by incorporating hydrologic complexity in the form of high resolution terrain models we can explain processes across scales, including: i) storage vs. discharge relationships, ii) storage vs. saturated area relationships, and iii) critical nutrient source areas. This has important consequences for using models to evaluate and guide watershed management because correctly predicting where runoff is generated is critical to locating best management practices to control non-point source pollution.*

Easton, Zachary, Daniel Fuka, Andrew Sommerlot, Amy Collick

A Customizable Dashboarding System for Watershed Model Interpretation

Type: Presentation

Abstract: *Stakeholders, including policymakers, agricultural water managers, and small farm managers, can benefit from the outputs of commonly run watershed models. However, the information that each stakeholder needs is typically different. While policy makers are often interested in the broader effects that small farm management may have on a watershed during extreme events or over long periods, farmers are often interested in field specific effects at daily or seasonal period. To provide stakeholders with the ability to analyze and interpret data from large scale watershed models, we have developed a framework that can support custom exploration of the large datasets produced. For the volume of data produced by these models, SQL-based data queries are not efficient; thus, we employ a "Not Only SQL" (NO-SQL) query language, which allows data to scale in both quantity and query volumes.*

We demonstrate a customizable Dashboarding system that allows stakeholders to create custom "dashboards" to summarize model output specific to their needs. Dashboarding is a dynamic and purpose-based visual interface needed to display one-to-many database linkages so that the information can be presented for a single time period or dynamically monitored over time and allows a user to quickly define focus areas of interest for their analysis. We utilize a single watershed model that is run four times daily with a combined set of climate projections, which are then indexed, and added to an ElasticSearch datastore. ElasticSearch is a NO-SQL search engine built on top of Apache Lucene, a free and open-source information retrieval software library. Aligned with the ElasticSearch project is the open source visualization and analysis system, Kibana, which we utilize for custom stakeholder dashboarding. The dashboards create a visualization of the stakeholder selected analysis and can be extended to recommend robust strategies to support decision-making.

Ezer, Tal

Sea level rise and variability in the Chesapeake Bay: numerical modeling of the impact of climate change, hurricanes and the Gulf Stream

Type: Presentation

Abstract: *Sea level in the Chesapeake Bay is rising faster than global sea level rise due to land subsidence and the rate seems to accelerate in recent decades. Studies also show that variations in the flow of the Gulf Stream can influence coastal sea level, so that weakening of this offshore current can cause elevated water levels and unpredictable flooding. Numerical ocean circulation models and observations are used for better understanding of the complex mechanism of remote influence on the coast and bay. For example, hurricanes can cause flooding not only due to precipitation and storm surge, but also through the disruption a storm can cause to the flow of the Gulf Stream which then remotely impact coasts far away from the storm. Local estuarine and storm surge models can be improved if remote influence from climate change and ocean currents can be modeled more accurately.*

Fanelli, Rosemary, Joel Blomquist, Robert Hirsch

Drivers of orthophosphate trends in tributaries to Chesapeake Bay

Type: Presentation

Abstract: *Orthophosphate (PO4) is the most bioavailable form of phosphorus (P) in aqueous systems, and excess PO4 may cause harmful algal blooms in lake and estuary ecosystems. A major restoration effort is* *underway for Chesapeake Bay (CB), with the goal of reducing P, nitrogen, and sediment loading from the watershed. However, spatial patterns in PO4 fluxes and trends in those fluxes over time remain poorly understood, because most of the scientific attention has been focused on total phosphorus to date. To address this research gap, we analyzed PO4 fluxes and trends over a 9-year period at 53 monitoring stations across the CB watershed to: 1) characterize the importance of PO4 to TP fluxes and trends; 2) describe spatial and temporal patterns of PO4 concentrations across seasons and stream flow; and 3) explore factors that may explain these patterns across time and space. Agricultural watersheds exported the most TP in the CB watershed, with PO4 comprising up to 50% of those exports. Although PO4 exports are declining at many sites, some agricultural regions are experiencing increasing trends at a rate sufficient to drive increases in TP. Regression modeling suggests that point source declines are likely responsible for the decreases observed in many of the watersheds, and that declining point sources may reduce concentrations at both low and high flows. Watersheds with higher enrollment in the Conservation Reserve Program had lower summer PO4 concentrations, highlighting the potential of that practice for mitigating the effects of agriculture on PO4 in streams. Manure inputs were a strong predictor of PO4 concentrations at high flows, and increasing manure applications may be contributing to increasing PO4 concentrations. Conservation tillage was also correlated with changes in PO4 concentrations at high flow, suggesting that this practice could contribute to increasing PO4 concentrations as well. Overall, this study highlights the success of point source reductions for reducing PO4 exports in many CB tributaries. These results also underscore the need for phosphorus management strategies to target dissolved PO4 and sediment-associated phosphorus in soils and biomass, particularly in regions with high manure inputs.*

Fitzpatrick, Jim, Mark Velleux, Nataliya Kogan, James Hallden, Badri Yadav

Long-term trends in deposition, resuspension and bioavailibility of nutrients from

Type: Presentation

Abstract: *Conowingo Pond appears to be at a point of dynamic equilibrium, i.e., sediments and nutrients are being trapped during low and moderate flow periods, but a fraction of the trapped sediments and nutrients may be resuspended and exported from the Pond during high flow and flood events. A question has arisen as to the bioavailability of the resuspended nutrients. This paper describes the model framework, application and findings from a stand-alone version of a sediment nutrient diagenesis and flux model (SFM), as well as an archive stack version of the SFM that has been linked to a coupled hydrodynamic/ sediment transport/water quality model of the Pond, in an effort to answer this question.*

Friedman, Jaclyn, Elizabeth Shadwick, Marjorie Friedrichs, Raymond Najjar

Seasonal Variability of Carbonate Chemistry in the Chesapeake Bay

Type: Presentation

Abstract: *As the largest estuary in the nation, the Chesapeake Bay has both an economic and ecological significance. The carbonate system in the Bay demonstrates seasonal complexities and has an important role in regulating changes driven by anthropogenic and natural carbon dioxide*

(CO_2) variability. Within the Bay, few measurements of two major carbonate system variables, dissolved inorganic carbon (DIC) and alkalinity, have been made. Declining water quality, in addition to hypoxia and eutrophication, may have a significant impact on the Chesapeake Bay's carbonate system. We present discrete DIC and total alkalinity data collected at 19 stations along the mainstem of the Bay on four cruises between June 2016 and May 2017, and an assessment of seasonal variability in the carbonate system. The distinct salinity gradient along the mainstem results in strong spatial variability in DIC and alkalinity, with elevated concentrations found at the mouth of the Bay associated with inflowing Atlantic Ocean waters; minimum concentrations of DIC and alkalinity, and suppressed pH and carbonate saturation state, are associated with fresher waters delivered mainly by the Susquehanna River. The Bay is partitioned into 5 subsections and the impact of physical (air-sea CO_2 exchange and mixing) and biological (photosynthesis and respiration) drivers on seasonality is examined. At the head of the Bay in summer we observed a maximum surface partial pressure of CO_2 (pCO_2) reaching over 880 atm in shallow waters with temperatures on the order of 27 C; in the same season the mouth of the Bay had surface partial pressure of 160 atm, with undersaturation with respect to the atmosphere driven primarily by biological processes. Finally, the trophic status of the entire mainstem is evaluated based on estimates of Net Community Production from a mass balance of DIC.

Friedrichs, Marjorie, Aaron Bever, Carl Friedrichs, Susanna Musick, Raleigh Hood
Short-term Hypoxia Forecasts for the Chesapeake Bay
Type: Presentation
Abstract: *The Estuarine Hypoxia component of the U.S. Integrated Ocean Observing System Coastal and Ocean Modeling Testbed (COMT) is evaluating existing hydrodynamic and water quality models used, or likely to be used, for operational forecasts for the Chesapeake Bay. As a proof-of-concept, an implementation of the Regional Ocean Modeling System in the Chesapeake Bay (ChesROMS) is presently linked to two short-term forecast models for dissolved oxygen: a Simple Respiration formulation for hypoxia (SRM), and a more complex Estuarine-Carbon-Biogeochemistry implementation (ECB). The mean output from ChesROMS-SRM and ChesROMS-ECB is being used to produce real-time nowcasts and short-term (48 hour) hypoxia forecasts for the Chesapeake Bay, which are currently available on the Virginia Institute of Marine Science website (at www.vims.edu/hypoxia). Meetings with Chesapeake Bay citizen stakeholders have been held in order to explore applications of the estuarine hypoxia nowcast/forecast products in support of recreational and commercial fishing. Interest in this product is high, particularly by recreational fishermen and charter boat captains, since lower catch per unit effort in the Bay is clearly associated with regions where dissolved oxygen is less than 4 mg/L. Work is currently underway to improve forecasts via the assimilation of in situ data (e.g. vertical profile cruise information) and to link these hypoxia forecasts with the Mid-Atlantic Regional Association Coastal Ocean Observing System (MARACOOS) OceansMap visualization software.*

Friedrichs, Carl, Jeni Keisman
Describing and explaining Chesapeake Bay water clarity: a literature review
Type: Presentation

Abstract: *Water clarity in the Chesapeake Bay region is most commonly assessed based on either (i) visual transparency, as measured by Secchi depth (Zsd), or (ii) incident light penetration, as determined by the diffuse attenuation coefficient (Kd). Although these parameters describe different optical properties, both of these measures are important. Zsd quantifies human perception of clarity and is closely related to aesthetic value, while Kd quantifies light available for photosynthesis. Transparency (and thus Zsd) is especially sensitive to the scattering of light by particles, which makes water look cloudy, whereas Kd is relatively more sensitive to the loss of light through absorption. To fully conclude that water clarity has increased (or decreased) at a given location, both of these two parameters should have improved (or gotten worse). If light penetration and transparency have trended in opposite directions, the story is more complicated.*

Previous work indicates that the most important component of Bay waters determining both Zsd and Kd is total suspended solids (TSS). However, TSS is not simply sediment from land. Except near riverine or local sources of sediment from runoff, TSS is highly influenced by resuspension and/or organic detritus. The composition of TSS is also important to its effect on water clarity. It is the total cross-sectional area of TSS that most directly blocks and scatters incident light, not its mass concentration, and (all else being equal) less dense, organic detritus has a larger cross-sectional area per unit mass than does inorganic mud. So an increase in the organic content of TSS tends to decrease water clarity. The effect of less dense organics is especially apparent for Zsd, since Zsd is very sensitive to scattering. Kd is additionally sensitive to absorption, and darker colored mud absorbs more light than less opaque organics. As a result, the total effect of organics versus inorganics is less significant for Kd.

Theoretically, increases in chlorophyll-a (Chl-a) should decrease water clarity because Chl-a absorbs light. Interestingly, in the Bay, high Chl-a is more strongly associated with degraded Zsd than with degraded Kd. The higher sensitivity of Zsd to Chl-a is somewhat surprising, given that Chl-a reduces clarity through absorption, and Kd is more sensitive to absorption than is Zsd. However, an increase in Chl-a is commonly associated with an increase in algal organic matter which, in turn, leads to more organic detritus. Thus the statistical association of decreased Zsd with increased Chl-a may often be due to an indirect association with increased organic solids.

Improvements in Kd and Zsd are also correlated to increased salinity, both spatially and temporally. A direct effect of salinity on clarity is not expected because dissolved salt is colorless and transparent. However, colored dissolved organic matter (CDOM), which does absorb light, is less prevalent in ocean water than in river water, so higher salinity should mean less CDOM. Although some efforts to relate dissolved organic matter to light attenuation in the Bay have been unsuccessful, higher salinity is further correlated to lower nutrient and sediment concentrations. Thus the correlation of Kd and Zsd to salinity may ultimately be related in part to salinity's relationship to suspended solids.

Gawde, Rasika, Elizabeth North, Raleigh Hood

Integrating and applying three-dimensional models to simulate oyster ecosystem services

Type: Presentation

Abstract: *In addition to supporting an historically important commercial fishery, the eastern oyster, Crassostrea virginia, and the reefs that they create, provide ecosystem services, including improving water quality. Their role as ecosystem engineers has been recognized and extensively studied using two-dimensional and even three-dimensional (3D) models. Yet, the relationship between oyster abundance, their filtration rate, and associated ecosystem benefits has not been estimated at a scale fine enough to help guide spatial management of oyster populations and restoration efforts. To provide spatially-explicit estimates of these benefits, oyster ecosystem services were being modeled in a 3D hydrodynamic framework based on the Regional Ocean Modeling System (ROMS) as part of the OysterFutures program. This 3D framework, comprised of a coupled hydrodynamic-water quality model with an oyster filtration and biodeposition sub-model, was implemented over a fine-resolution model grid (120-150 m) that spanned the Choptank and Little Choptank Rivers on the eastern shore of Maryland. The model provided temperature and salinity predictions as well as estimates of biogeochemical variables (seston, chlorophyll, nitrate, ammonia, etc.) under alternative oyster abundances. These results were then applied to establish relationships between oyster abundance at individual reefs and their ecosystem services (seston reduction, light penetration, denitrification) in that region. The regression relationship that will be derived will be integrated with oyster larval transport, population dynamics, and economic considerations to identify how management actions like fishing regulations and restoration activities could affect oyster ecosystem benefits in the Choptank region. The future application of this tool for integrating spatial management, restoration, and water quality criteria will be discussed.*

Gellis, Allen

Application of the Sediment Source Assessment Tool (Sed_SAT) to Inform Managers of Sediment Sources

Type: Presentation

Abstract: *Sediment is one of the most common causes for the loss of stream-biologic integrity. Sediment impaired water bodies, usually coarsely identified by "fair" to "poor" macroinvertebrate index scores, are placed on the Impaired Waters 303(d) list where a sediment TMDL (total maximum daily load) is implemented. Information on the relative contributions of different watershed sediment sources is recognized as a key requirement in the design and implementation of targeted management strategies for sediment control. The ability to differentiate between sources (upland and channel) is important because management strategies to reduce sediment differ by source and require unique approaches. For this presentation, we will discuss the use of geochemical tracers or "fingerprints" associated with impervious surfaces, cropland, forests, or channel banks to identify sediment sources. The Sediment Source Assessment Tool (Sed_SAT), is a user-friendly tool designed to assist practitioners in assessing sediment sources using these geochemical fingerprints, and will also be discussed in this presentation.*

Gemberling, Adrienne, David Saavedra

Using high-resolution data and web tools to enable precision conservation

Type: Presentation

Abstract: *The Chesapeake Conservancy will open with an overview of its collaboration with conservation professionals in the Susquehanna River Watershed and a need for high-resolution planning datasets. The Conservancy and its partners mapped land cover for the entire Chesapeake Bay watershed at a one-meter resolution. In addition, Conservancy staff created a one-meter resolution water network dataset for the Susquehanna River watershed. These datasets enable conservation and restoration professionals to assess the landscape with greater precision than previously available and serve as vital planning tools. This talk will discuss the methods used to create our water network dataset and the application of our data to current conservation issues, including web-tools that:*

1) *Guide the implementation of forest riparian buffers across Pennsylvania for the WIP planning process.*

2) *Help to inform restoration professionals on where to install management practices in order to reduce the greatest sediment and nutrient inputs to our waterways, and*

3) *Provide landowners with on-demand parcel-specific printouts about restoration opportunities on their property.*

Haag, Scott

Geoinformatics methods and impacts on Regional Land Change Models.

Type: Presentation

Abstract: *As the amount of in situ and remotely sensed data increases concomitantly with the resolution of hydrodynamic models (nutrient, sediment, land cover and land use, buildout, temperature, contaminates, point sources, and other), the data processing and information retrieval complexities have created bottleneck for the incorporation of these dense data streams into actionable decision support tools. This presentation focuses on utilizing advanced data models, algorithms, and process workflows to incorporate high resolution data streams into hydrologic decisions support systems. In particular we discuss the development and implementation of an open source software stack to address the big-data issues related to hydrological decision support tools.*

Data models such as the Modified Nested Set (MNS), linked (adjacency) lists, identity matrices, Path Enumeration, and the log-reduced graphs can be used to represent the flow of water within computational systems. These differing data structures are all grounded in graph theoretical models where edges connect vertices inside of graphs G. We discuss pros and cons of these models in relation to a number of representational and retrieval problems with the hydrological domain.

Algorithms that operate on the data models described above are reviewed in the context of the information retrieval problem with a specific emphasis on the connections between dense data-streams and hydrologic decision support tools. As an example, we highlight the complexity of the HSM algorithm in comparison to other existing watershed delineation algorithms.

We will discuss implementation strategies in a wide variety of software applications from Relational Database Management Systems

(RDMBS) such as Postgres/PostGIS to software platforms such as python, and how to represent hydrological models within standard software environments. Standard metrics such as retrieval complexity are discussed.

Lastly, we show examples of decision support tools we have been working on (the Stream Reach Assessment Tool), along with nutrient hotpot modeling (Model My Watershed). These tools are being developed as endpoints within a robust full-stack architecture using tools like docker, swagger, python, binary memory maps, and cloud based web-services (i.e. AWS). We end our presentation by demonstrating several examples of real-time watershed delineation endpoint for the Chesapeake Watershed and nutrient hotspot modeling endpoint for the Chesapeake Bay and Delaware River Watershed.

Hammond, Nicole, Allison Nalesnik, C.J Bradley

An analysis of nutrient concentration and marine signaling in a freshwater ecosystem pre- and post-removal of dams

Type: Poster

Abstract: *Stable isotope analysis can be used as an indicator of the presence of marine derived nutrients from anadromous fish. Streams, in which anadromous fish spawn, are often nutrient poor and the spawning of the fish may be an important source of nutrients. The implementation of dams can splinter anadromous spawning habitats and instigate a shift in abiotic composition. Alternatively, dam removal allows anadromous fish to regain access to historical freshwater spawning habitats, potentially impacting food web dynamics and nutrient cycling in coastal freshwater systems. Marine material is generally more enriched in 15N and 13C than freshwater and terrestrial materials. By comparing the isotopes of nitrogen (14N and 15N) and carbon (12C and 13C), shifts in the presence of marine organisms and changes in abiotic factors, such as dissolved oxygen, pH, temperature, salinity, and nutrients can be documented as stream restoration efforts reconnect fish passages. We compared existing and post-removal dam sites on the eastern shore of Maryland, integrating abiotic factors at each location and concentrations of MDN (marine-derived nutrients). With this data, the effects of damming waterways and subsequent fragmentation of anadromous fish spawning environments can be modeled.*

Hinson, Kyle, Marjorie Friedrichs, Isaac Irby

Evaluating Responses of Chesapeake Bay Hypoxia to 21st Century Temperature Scenarios

Type: Presentation

Abstract: *Hypoxia is an increasingly potent stressor on living resources in the Chesapeake Bay, not only because of excess nutrient inputs, but also due to regional climate changes that are projected to affect the Bay's ecosystem. Specifically, estuarine temperature increases are anticipated throughout the 21st century based upon observed trends and downscaled Global Climate Models (GCMs). Here we use a 3-D hydrodynamic-biogeochemical model linked with a watershed model to simulate the impacts of warming temperatures on Chesapeake Bay hypoxia. Results suggest that the impact of increased temperature on biological rates and solubility can result in a substantial increase in the total volume of water with low oxygen concentrations, and can contribute to both an earlier onset and an earlier release of hypoxic conditions. Solubility drives a decrease in dissolved oxygen concentrations throughout the year*

and throughout the water column, while the impact of increased biological oxygen demand is most prevalent at depth in the spring and early summer. Further exploring the estuary's sensitivity to temperature increases can help identify changes in the spatial extent of hypoxia throughout the Bay. This study also demonstrates that increasing temperatures due to climate change have the potential to limit the effectiveness of ongoing nutrient reductions in reducing Chesapeake Bay hypoxia.

Holder, Chris, Anand Gnanadesikan
Random forests and their applications in estuarine systems
Type: Poster
Abstract: *Machine learning has been applied to numerous areas in the private sector and branches of science. However, there has been limited application of these techniques to oceanographic problems. A frequent criticism of these methods is their supposed "black-box" approach, in that it can be difficult to determine how a particular result was attained. Here, we evaluated whether we could decipher the pathways in which a particular machine learning technique produced its outcomes. This was accomplished by applying the machine learning algorithm known as random forest (RF) to model output where the relationships between biomass, light, and nutrients are known. The RF algorithm was able to capture a large amount of the variance leading to excellent accuracy of prediction. Through partial dependence plots, we were able to glimpse how the RF algorithm arrived at some of its results. However, the precise relationships that determined the ocean model were not observed in the standard partial dependence plots. Rather, it was necessary to use maximum values for some variables in the RF algorithm to acquire the original expected relationships. As our investigation continues, it is clear that machine learning techniques have a clear future in the work of oceanography with the added capability of unveiling new discoveries. Nevertheless, it is essential that the interpreter has a thorough understanding of the system and that the results of machine learning outputs are scrutinized to ensure accurate elucidation. As these techniques are applied to oceanography, their applications in estuarine settings will also play a vital role. As a preliminary investigation, we have begun applying the random forest algorithm to investigate aspects of the Chesapeake Bay's low oxygen regions.*

Inamdar, Shreeram, Grant Jiang, Alyssa Lutgen, Nathan Sienkiewicz, Dorothy Merritts, Robert Walter
Freeze-thaw processes and intense rainfall-runoff events: Significant contributors of suspended sediment and nutrient loads from Chesapeake Bay watersheds
Type: Presentation
Abstract: *Sediment and sediment-bound nutrients are among the leading causes of water quality and habitat impairment in the Chesapeake Bay. Hence, developing accurate budgets and identifying the key sources of suspended sediment are critical for Chesapeake Bay modeling and management strategies. Suspended sediment and nutrient input to streams can be particularly elevated during storms and can originate from upland sources (e.g., cropland and urban construction sites) and/or near-stream sources such as stream bank and bed erosion. While much attention has been given to suspended sediment export during large storms (such as hurricanes and tropical storms) and from upland sources, less attention is given to*

other types of storm events and stream bank sources of sediments. Our observations in mid-Atlantic watersheds for a range of drainage areas (0.12, 153 km2) show that winter rain storms following freeze-thaw cycles can generate substantial suspended sediment yields. Suspended sediment exports from the White Clay Creek (WCC) watershed (153 km2) following intense winter rain storms in 2016 generated 70% of the annual (2016) sediment yield in a fraction of the time (few days). Annual suspended sediment yields for WCC varied between 381 to 1180 kg/ha/year (2012-17) with selected winter storms exporting 173-497 kg/ha (2016-18). Similar magnitude of exports have been observed for watersheds in the Big Elk Creek drainage basin in Maryland. Further analyses is being conducted to determine how the frequency, magnitude, and duration of freeze-thaw cycles and the timing and intensity of rainfall events affect sediment yields. The availability of high-frequency (15 minute) turbidity-suspended sediment and discharge data makes this assessment possible. Initial sediment fingerprinting using geochemical and isotopic tracers indicate that stream bank legacy sediments constitute a substantial proportion of these winter/spring sediment yields. Freeze-thaw processes have been reported to destabilize stream bank sediments, making them vulnerable to erosion. Fine grained (silty) legacy sediments are particularly susceptible to this subaerial erosion processes. Given the considerable uncertainty regarding contributions of legacy sediments to annual sediment and nutrient yields, more attention needs to be devoted to understanding these events. These observations will help develop better mechanistic and numeric models for bank erosion and will provide valuable information that can be used to calibrate and refine bay model estimates of sediment yields, particularly in regards to contributions from legacy sediments. Future climate projections indicate increased intensification of storm events and increased variability of winter temperatures. Freeze-thaw cycles coupled with winter rain events could increase erosion and transport of stream bank sediments and nutrients with detrimental consequences for health of the Chesapeake Bay.

Isleib, Richard, James Fitzpatrick, Nicholas Kim, Nataliya Kogan

Assessing the Water Quality Impacts in a Tidal Embayment from the Closure of Proposed Storm Surge Barriers

Type: Presentation

Abstract: *When Superstorm Sandy hit New York and New Jersey it was accompanied by a large storm surge, which severely damaged areas along the coastal areas. Particularly hard hit by the storm surge and resulting flooding were areas in the Rockaways and Broad Channel communities in New York City. In response to this event and to help prevent such flooding in the future, the USACE is considering the construction of a storm surge barrier to be located near the Rockaway Inlet to Jamaica Bay, NY. This barrier could be closed during a storm event to prevent high tides associated with a storm surge from entering Jamaica Bay. In order to assess the potential impact of a barrier closure on water quality within the Bay, a modeling study was conducted using the Jamaica Bay Eutrophication Modeling system, known as JEM.*

The JEM model was used for a preliminary analysis to assess a series of scenarios that investigated the water quality impacts from a potential storm event and barrier closure. Three conditions were considered: (1) a base case, i.e., existing conditions with no storm

surge barrier in place, (2) the presence of a storm surge barrier, but with the storm surge barrier always open, and (3) the presence of a storm surge barrier but with the barrier being closed during storm events. The analysis included closures of 48 hour and 96 hour durations for the 1-in-10 and 1-in-25 year rainfall events. It was believed that a closure of 48 hours is perhaps the most reasonable closure period, but the analysis was extended to include a 96 hour closure, which was considered to be very conservative. The modeling analysis considered both long-term and short-term effects. The long-term effects analysis was meant to evaluate the potential impact of the storm surge barrier system itself, i.e., the physical structure, on water quality. In this case, the analysis compared water quality projections with the barrier in place, but with the gates of the storm surge barrier always in the open position, versus existing conditions, i.e., no storm surge barrier. The short-term effects were evaluated for conditions when the gates were closed. The evaluation considered water elevation, salinity, nutrients, dissolved oxygen and pathogens.

Lessons learned from this analysis can be applied to other areas such as the Chesapeake Bay. When considering the construction of a storm surge barrier, it is important to understand the ratio of the drainage area of a waterbody to the surface area of the waterbody, while also considering the percent imperviousness of the drainage area. Additionally, areas with poor circulation and vertical mixing can potentially be more severely impacted in terms of water quality when that mixing is further reduced through the closure of a storm surge barrier.

Jantz, Claire, Scott Drzyzga, Alfonso Yáñez

Improving the thematic resolution of urban land change modeling

Type: Presentation

Abstract: *Due to the complex environmental, social, economic, and technological factors that drive urbanization, most urban land change models focus on the simplest representation of urban form: urban land cover, represented as a single thematic category. While this allows for analysis and simulation of the 2-dimensional extent and pattern of urban form in the context of complex and interdependent drivers, it does not recognize the heterogeneity of the urban landscape in terms of its 3-dimensional form, intensity of impervious surfaces, and urban land uses. This presents limitations for understanding the full suite of social and environmental consequences of urban land change. Recent urban modeling in the Delaware River Basin (DRB2070) has generated maps of future urban land cover, but there is now a need to estimate the intensity of impervious surfaces so that consequences for water resources can be assessed. We will present a framework for estimating impervious surface intensity at different scales (i.e. for watersheds and for pixels), based on maps of future urban land cover.*

We base our approach on the National Land Cover Database (NLCD) land cover products, where urban land cover is represented as high intensity developed, medium intensity developed, low intensity developed, and developed open space. Because the NLCD land cover products are so widely used, these categories are often incorporated into water quality and hydrologic models to estimate runoff quality and quantity. Further, because they consistently measure change over time (2001, 2006, 2011), NLCD land cover products are often simplified and used to

drive urban land change modeling applications, including DRB2070, which was based on the extensively used SLEUTH model. In coupled land change-hydrologic modeling, it is not uncommon for scientists to face the question of how to incorporate simplified representations of urban land cover into hydrologic models that were calibrated on a more thematically complete representation of the urban landscape. This is especially true for local-scale or small watershed modeling.

We test a variety of approaches across scales. At the watershed level, relatively simple assumptions can be used to estimate aggregated land cover categories, but more complex modeling is required to estimate urban land cover classes for small watersheds/catchments and pixels - with commensurate tradeoffs in accuracy.

Kahover, Kevin, Lora Harris, Jeremey Testa, Larry Sanford, Melinda Forsyth, Elizabeth North

A High-Resolution Model of Filtration, Biodeposition, and Nutrient Dynamics on Restored Oyster Reefs

Type: Presentation

Abstract: *Oyster reefs create complex habitats that facilitate a variety of biogeochemical processes. For example, elevated rates of denitrification have recently been observed on restored oyster reefs, and have been attributed to the reef community itself, as opposed to the underlying sediment. Few models have been developed that describe these complex transformations at the spatial and temporal scale at which they occur. To better understand how oyster restoration affects local nitrogen dynamics, we have developed a high resolution model that incorporates the numerous hydrodynamic, physiological, and microbial processes specific to restored reefs. The model describes the advection and diffusion of chlorophyll across a reef, as well as its removal through oyster filtration. The environmental conditions that influence these processes are derived from the Regional Ocean Modeling System. Biodeposit production and resuspension are also incorporated into the model. Accumulations of biodeposits and other seston then serve as substrate for the sediment nutrient flux model, which simulates the diagenesis and transformation of nitrogen species on the reef. Model simulations, as well as implications for management, will be presented.*

Kaufman, Daniel, Olivia Devereux, Jessica Rigelman, Hugh Ellis, Andrew Sommerlot, Lewis Linker

Development of a cost optimization scheme for Chesapeake Bay restoration

Type: Presentation

Abstract: *The Chesapeake Assessment Scenario Tool (CAST), which supports the design of total maximum daily load (TMDL) programs in the Chesapeake Bay watershed, estimates nitrogen, phosphorous, and sediment load impacts and the financial costs of implementing best management practices (BMPs). This tool was developed through a stakeholder-driven process and is designed to help users identify management approaches that will achieve nutrient and sediment load targets and other management goals at an acceptable financial cost. However, due to the large number of decision variables (i.e. combinations of BMP types, placements and amounts) combined with the non-linear cascading effects of BMPs, it is not feasible for a user to conduct an exhaustive search of potential management scenarios in CAST. Analytical simplifications that could* *otherwise streamline the identification of optimal low-cost management approaches are inhibited by the complex BMP interactions that are essential for CAST to accurately reflect policy and management considerations of the Chesapeake Bay Program partnership. To overcome these challenges and enhance the functionality of CAST, a supplementary decision-support module is developed to rigorously analyze the space of potential management scenarios and identify low-cost BMP implementation options. This new software tool, the scenario optimization module, allows selection of geographies, agencies and sectors in the Chesapeake Bay watershed, and makes use of a hybrid approach for optimization. For a typical county, the approximately 200,000 potential decision variables make for a high-dimensional optimization challenge. The optimization module improves functionality of CAST by providing users an automated way to explore alternative BMP implementation scenarios and the trade-offs between them.*

Keisman, Jeni, Carl Friedrichs, Claire Buchanan, Richard Batiuk, Joel Blomquist, Jeff Cornwell, Mike Lane, Slava Lyubchich, Ken Moore, Rebecca Murphy, Greg Noe, Robert Orth, Elka Porter, Larry Sanford, Jeremy Testa, Mark Trice, Qian Zhang, Richard Zimmerman

Examining trends in water clarity in the Chesapeake Bay: a synthesis of findings from recent STAC workshops

Type: Presentation

Abstract: *In spite of documented reductions in nutrient loads to Chesapeake Bay over the past 30 years, trends in secchi disk depth , a visual measure of water transparency , declined (i.e. water became less transparent) in many regions of the estuary between 1985 and 2005. At the same time, trends in the diffuse attenuation coefficient, which quantifies light penetration, improved (i.e., Kd decreased) in some of the same locales. More recently, trends in both transparency and light penetration have begun to improve (i.e., Secchi depth increasing, Kd decreasing) in concert in recent years. Recognizing the importance of water clarity as an indicator of ecosystem health and aesthetic value, the Chesapeake Bay Program's Scientific and Technical Advisory Committee sponsored two consecutive workshops in 2017. These workshops brought together a multi-disciplinary group of subject experts to synthesize the current state of the science on factors affecting the optical properties of Chesapeake Bay waters, and to identify research priorities for advancing our ability to explain these trends. We present the findings from this workshop, and propose a conceptual framework to drive research priorities that address the management community's needs for evidence-based decision-making.*

Kellogg, M. Lisa, Jeffrey C. Cornwell, Paige G. Ross, Kennedy T. Paynter, Mark W. Luckenbach

Quantifying the benefits of tributary-scale oyster reef restoration

Type: Presentation

Abstract: *Recovery of ecosystem services provided by healthy oyster reefs has been an important factor motivating the conservation and restoration of these biogenic habitats. A state, federal and private partnership (MD-DNR, NOAA, ORP, USACE, and others) has undertaken a tributary-scale oyster reef restoration project in Harris Creek in the Maryland portion of Chesapeake Bay. An ongoing integrated research program is quantifying the ecosystem services provided by reefs*

encompassing a range of oyster biomass densities using three complimentary sampling programs to assess:
1) denitrification rates and nutrient fluxes, 2) macrofauna production, secondary production and nutrient assimilation, and 3) finfish utilization and trophic linkages. The two overarching goals of this research program are to quantify the ecosystem services provided by the Harris Creek restoration effort and to identify relationships between easily measured oyster reef metrics and ecosystem services that cannot be measured as part of most oyster reef restoration projects. Benefits calculated to date include enhanced denitrification, increased abundance and biomass of non-oyster macrofauna, and provision of prey for non-resident finfish species. Relationships between oyster tissue biomass density and oyster reef function range from highly correlated linear relationships, to non-linear relationships, to complex relationships that may be driven by factors outside the scope of our study. This range in possible relationships will be discussed in terms of its implications for quantifying the benefits of oyster reef restoration, developing adaptive management strategies, and developing reliable models of the ecosystem services provided by restored oyster reefs.

Knobloch, Amanda, Mark Brush, Willy Reay, Joseph Zhang, Elizabeth Canuel

Sources and Fluxes of Dissolved and Particulate Carbon at the Marsh-Estuarine Interface

Type: Presentation

Abstract: *The coastal ocean plays a critical role in the ocean carbon cycle due to the uptake and processing of carbon from terrestrial, atmospheric, and marine sources. However, the amount and composition of carbon exchanged throughout coastal habitats remain poorly constrained due to limited temporal coverage, few studies measuring multiple carbon pools simultaneously, and heterogeneity within and between systems. This study was designed to bridge gaps in our knowledge of the coastal ocean carbon cycle by measuring the amounts and composition of carbon exchanged at the marsh-estuarine interface. Beginning in October 2013, water was sampled monthly at 2.5-hr intervals over a 25-hr period and analyzed for particulate organic carbon (POC), dissolved organic carbon (DOC), and dissolved inorganic carbon (DIC). Composition and source proxies, such as carbon to nitrogen ratios and carbon and nitrogen stable isotopes, were also measured. These samples were collected from the mouth of Taskinas Creek, capturing exchange between a temperate marsh and the York River Estuary. Mean monthly concentrations of POC and DOC ranged from 1.59 to 6.98 mg/L and 4.16 to 7.11 mg/L, respectively. POC concentrations exhibited seasonal patterns with higher concentrations observed in the spring (Feb-Apr) while DOC concentrations did not vary seasonally. POC concentrations were generally higher during high tide while DOC and DIC were generally higher during low tide. This tidal variability suggests that the marsh acted as a sink for POC and a source for DOC and DIC. Carbon stable isotope values ranged from -31.16 to -16.88 per mil, indicating a mixture of sources; the most positive values occurred during spring (Feb-Apr), when primary productivity peaked. To calculate fluxes, water discharge was calculated using the Semi-Implicit Cross-scale Hydroscience Integrated System Model (SCHISM) and tidal prism volumes for water year 2014 (WY2014). Water volumes calculated using the two approaches were*

correlated ($r = 0.78$, $p < 0.0005$), indicating that the tidal prism method was suitable for the remainder of the timeseries when model data were unavailable. For WY2014 (October 2013-September 2014), POC showed net import into the marsh (77 g C m-2 yr-1) whereas DOC and DIC exhibited net export (21 and 301 g C m-2 yr-1, respectively). While each carbon pool was affected differently, tidal and seasonal variability interacted to control carbon concentrations and composition at the marsh-estuarine interface. This emphasizes the need for high frequency samplings that measure multiple carbon pools simultaneously as well as the importance of Taskinas Creek as both a source (DOC and DIC) and sink (POC) of carbon to the estuary. Data such as these are necessary to fill current gaps in knowledge of the coastal carbon cycle and allow accurate predictions of the effects of anthropogenic and climate change on the coastal ocean.

Kvit, Anton, Ben Davis, John Bowers, Andy DePaola, Frank Curriero

Interactive Spatiotemporal Risk Tool for Vibrio parahaemolyticus in the Chesapeake Bay

Type: Presentation

Abstract: *Vibrio parahaemolyticus is a naturally-occurring bacterium found in the Chesapeake Bay that can cause vibriosis in humans, leading to gastroenteritis and occasionally septicemia. Vibriosis most commonly occurs after eating raw or undercooked shellfish, such as oysters. However, certain precautions taken by shellfish harvesters, such as prompt icing and refrigeration, can significantly reduce bacterium concentrations within the shellfish.*

Bacterium abundance varies significantly throughout the Bay even across relatively short distances and time-periods. The distribution and abundance of V. parahaemolyticus in the water is highly affected by temperature, but salinity, turbidity, and other environmental factors have also been shown to be useful predictors. An improved understanding of these spatiotemporal variations and environmental associations is needed to better assist shellfish regulators and harvesters in their current food safety preventative efforts.

To address this issue, current research is actively developing pre-harvest V. parahaemolyticus abundance prediction models that consider many environmental factors and spatiotemporal relationships. These ecological models will be used in a risk model that expands upon the existing V. parahaemolyticus calculator developed by the USFDA by incorporating more recent data as well as the impacts of different harvesting practices.

In preparation to help harvesters and regulators more easily utilize these models, an interactive data tool, that will be accessible online, is being built using the Shiny package from the R statistical computing environment. This tool will map vibriosis risk distribution throughout the Chesapeake Bay and provide other relevant information such as short-term forecasts. The tool will allow the user to input the date, time of day, and location of a shellfish harvesting area, along with known harvest and refrigeration practices, in order to obtain the predicted distribution of vibriosis risk, expected number of vibriosis cases, as well as the prediction uncertainties for the given date and area. The tool will be able to incorporate current weather data, as well as predicted weather for the next few weeks via

an API, thus allowing the user to assess current and forecasted vibriosis risk. In order to provide more flexibility and accuracy, the user will have an option to input their own temperature measurements from their location of interest.

To help users plan for future shellfish harvesting and assess vibriosis risk, as well as assess the potential effects of climate change or other long-term trends on risk distribution, the tool will also considers several hypothetical scenarios, providing more general long term predictions. This interactive data mapping and visualization tool is intended for both shellfish harvesters and regulators, to help determine the precautions necessary to prevent vibriosis infections, and to assess the current and future spatiotemporal distribution of vibriosis risk.

Leventhal, Talia, L. Saporito, K. Elkin, Heather Gall, P. Kleinman

Comparing the presence of antibiotics in soil and runoff following different dairy manure application methods

Type: Poster

Abstract: *While use of manure as a nutrient source has many benefits for soil health, it has led to concerns of increased presence of antimicrobial resistance due to the large amount of antibiotics consumed and excreted by livestock. Given that some of the antibiotics used in livestock production are also used to treat humans, increased presence of antibiotic resistance elements (genes and bacteria) in the environment is a potential human health concern. However, different manure management practices may reduce the mobility of these elements in the environment. Therefore, the goal of this research is to evaluate the field-scale fate and transport of antibiotics in agroecosystems that receive manure via two application practices: surface broadcast and shallow disk injection. The field experiments will consist of 9 plots, with two treatments (surface broadcast and shallow disk injection), one control (no manure application) and three replicates of each. Rainfall simulator experiments will be conducted in the spring and fall seasons to determine the presence of antibiotics in the soil and surface runoff for little under two weeks following dairy manure applications. The simulated rainfall events will be conducted on days 1, 5, and 9 following the manure application on day 0. Composite runoff samples will be collected for a half-hour runoff duration at the following days following the manure application. Additionally, a composite runoff sample will be taken for the initial 5 minutes of runoff in order to determine the importance of the 'first-flush.' Soil samples will also be collected and analyzed for antimicrobial resistant elements at depths of 0-5 cm, 5-15 cm, and 15-25 cm as well as any present antibiotics. The data will be used to determine the differences in persistence and transport between the two dairy manure application methods. The results from this research will provide insights into the persistence, fate, and transport of antimicrobial resistance elements and the extent to which shallow disk injection or surface broadcast of manure may be able to reduce the transport of these elements in surface runoff.*

Li, Ming, Xiaohui Xie, Chunqi Shen, Baoshan Chen, Wenfei Ni, Wei-Jun Cai, Jeremy Testa

Physically driven temporal and spatial variabilities in carbonate chemistry dynamics

Type: Presentation

Abstract: *Recent observations in Chesapeake Bay revealed high frequency and large amplitude variations of pCO2, DIC and TA at time scales ranging from several hours to several days. Some of these variations were related to temporal variations in dissolved oxygen and were suggestive of a biological cause whereas others correlated with salinity time series and pointed to a physical driving mechanism. For example, an up-estuary (southerly) wind event deepened the surface layer, and mixed surface water and chemical species down to middle depths, significantly modifying the air sea CO2 flux and pH in the water column. On the other hand, a down-estuary (northerly) wind event drove upwelling on the eastern shore of the estuary and produced strong lateral gradient in pCO2 and air-sea flux of CO2. These short term signals are much stronger than long-term change in carbonate chemistry, and must be modelled and interpreted before the model can be used to predict long-term effects of ocean acidification on estuaries and coastal oceans. In this study we use a newly developed carbonate chemistry model (ROMS-RCA-CC) to simulate and interpret the observed temporal and spatial variabilities of pCO2, DIC and TA in Chesapeake Bay. Given the limited observational data currently available, we conduct a longer-term model integration to assess the integral effects of these short term mixing and advective processes on carbonate dynamics.*

Lin, Chih-Hsien (Michelle), Patricia M Glibert, Vyacheslav Lyubchich, Kevin J Flynn, Aditee Mitra

Combining statistical time series models with mechanistic variable stoichiometry models to predict blooms of the harmful dinoflagellate Karlodinium veneficum in Chesapeake Bay under current and future warming conditions

Type: Presentation

Abstract: *The Chesapeake Bay has been negatively affected by nutrient over-enrichment and this has been accompanied by increases in the frequency of harmful algal blooms (HABs). Of the many HAB species, dinoflagellate Karlodinium veneficum is of particular concern because of its toxigenic properties that can lead to both fish and shellfish mortality. In addition to the changing nutrient conditions that affect HABs, increased temperature and altered precipitation associated with nutrient delivery due to climate change also affect the frequency and timing of blooms. Many bloom-forming harmful algae depend not only on photosynthesis and dissolved nutrient uptake, but also consume particulate prey when nutrients are not available in the dissolved form, they are mixotrophs. While total prey availability is important for mixotrophs such as K. veneficum to feed, nutrient stoichiometry of the particulate prey as well as that of the dinoflagellate are also important factors affecting feeding behavior and growth. Statistical time series analysis of decadal trends in K. veneficum abundance in Chesapeake Bay show the predictive power of multiplicative factors (i.e., climate-related physical factors, nutrients, and prey) and the importance of temporal lags in some of these factors in bloom promotion. A conceptual model was developed of mid-Bay summer blooms of K. veneficum that incorporates the role of prey with a high N:P ratio originating from river inputs and a source inocula of K. veneficum from southern Bay waters with a lower N:P content. Therefore, prey that is N-rich likely play an important role in determining K. veneficum abundance at stations located in the mesohaline zone.*

Subsequent mechanistic modeling was undertaken, simulating the growth of dinoflagellate K. veneficum and its common algal prey, Rhodomonas based on laboratory data. This carbon-nitrogen-phosphorus model was run for 10 day growth periods under low N:P conditions (N:P=4), balanced N:P conditions (Redfield proportions of 16:1), and high N:P conditions (N:P=32) at various temperatures and showed that the modeled biomass of K. veneficum was highest when they consumed prey under high N:P conditions. When nutrients were in balanced proportions, the lower biomass of the mixotroph was attained at all temperatures in the model, suggesting that a system such as Chesapeake Bay might be more resilient for development of this HAB in warming temperatures if nutrients were in more balanced proportions. Both the conceptual model and the multi-nutrient simulation model underscore the importance of consideration of particulate prey in modeling HAB dynamics; it is insufficient to only consider dissolved nutrients. The simulations also imply that warmer, wetter springs that may bring more N may be more conducive to the development of these HABs. The integration of a fully dynamic model of land use, hydrodynamics, and models of HABs that appropriately incorporate their diverse nutritional strategies is a grand challenge, but would ultimately allow predictions of the spatial and temporal changes in HABs that may come with future nutrient changes under changing climate conditions.

Lindsay, Perez, Scott Haag, R. John Dawes

Crossing Watershed Boundaries: Developing Scalable Tools for the Delaware and Chesapeake Watershed

Type: Presentation

Abstract: *Since its inception, the Delaware River Watershed Initiative(DRWI) has sought to target restoration and protection efforts in local streams and waterways to maximize the impact of improving water quality across the greater Delaware River Watershed. Many of the challenges facing planners, conservationists, restorationists and planners in the Delaware cross watershed boundaries into the Chesapeake Watershed. One approach unique to the DRWI is broad targeted investment to specific HUC12 sized geographies. Each of these geographies, referred to as 'clusters', has a unique set of organizations facilitating planning and work happening on the ground , together these clusters function as a model for representing cumulative success. The DRWI has heavily invested in supporting planners and practitioners on the ground with model and science backed decision support tools. The Mapsheds model was implemented through the Stream Reach Assessment Tool (SRAT) and Wikiwatersheds , these tools were used to quantify TN, TP and TSS pollutant loading, landcover/landuse and protected lands within local stream catchments and their respective upstream watershed. We are now in the process of taking Mapsheds modeling data one step further by creating an open source front-end that summarizes the collective impact of BMPs on the ground to date and allows users to input and store new BMP data. Users will have the ability to understand goals and project impact taking place within their local watersheds where they are focused and cumulatively across the Delaware River Basin. While we are currently in the development phase of this project we are focusing on a multitude of functions that we believe create effective support tools: leveraging the accuracy and efficacy of modelling with collectively generated monitoring data, facilitating communication pathways between scientists and on the ground practitioners, building strong and* *fast APIs that facilitate small to large watershed delineations, and effectively communicating project impact across watershed scales.*

Linker, Lew, Rich Batiuk, Lee Currey, Dave Montali

Towards a Next Generation Multiple Scale Models of the Chesapeake What do the Managers Want?

Type: Presentation

Abstract: *This motivations of Chesapeake Bay Program (CBP) managers for decision making using fine scale watershed and estuarine model platforms are diverse, but primarily arise from the fortunate confluence of ongoing advances in computational power, data availability, and an interest in resolving pollution management at local scales. For the first time in the history of the CBP highly spatially resolved models are practical for water quality management. Modeling watersheds and estuaries at fine scales has the potential for providing improved insight into water quality processes, improved understanding of the overall transport, processing, and attenuation of nutrients and other pollutants in the coastal watershed system, as well as providing increased utility of pollution control estimates to decision makers. Nevertheless, computational and data constraints will continue to limit full application of a fine scale distributed watershed model throughout the entire Chesapeake basin, as well as fine scale unstructured grid models of the estuary. Therefore, a strategic approach is envisioned in order to achieve management objectives within the resource constraints.*

Liu, Zhuo, Yinglong J. Zhang, Harry V. Wang, Fei Ye, Hai Huang, Zhengui Wang, Mac Sisson

The 3D SCHISM model application for studying impact of small-scale piling structures on circulation in the Lower James River

Type: Presentation

Abstract: *We present a novel and challenging application of the 3D SCHISM model in an estuary-shelf setting in the Chesapeake Bay (and its vicinity) to study the collect effects of the bridge pilings on large-scale circulation. The specific bridge infrastructure, called the 3rd crossing, is designed to expand the size of the existing bridges across the lower James River and add a branch in parallel with the shore to link with Craney Island. It consists of 1000 small-scale bridge pilings with individual piling size of 1m – 2m in diameters. We first demonstrate that the model is capable of effectively transitioning grid resolution from ~400m down to ~1m near the pilings without introducing undue numerical artifact. We then show that despite their small sizes and collectively small area as compared to the total channel cross-sectional area, the pilings exert a noticeable impact on the large-scale circulation with on average 1.5 PSU salinity change in the near filed and 0.5 PSU in the lower James River. Pilings also create a rich structure of vortices and wakes around the fixtures. As a result, the water quality and local sedimentation patterns near the bridge piling area are likely to be affected as well. However, when evaluating over the entire waterbody of the project area, the near field effects are weighed with the areal percentage which is small compared to that for the larger unaffected area, and therefore the impact on the lower James River as a whole becomes relatively insignificant. The study highlights the importance of the use of high resolution in assessing the near-field impact of structures.*

Loftis, Derek, David R. Forrest

A Comparison of Tidewatch Inundation Predictions and Citizen-Science Flood Extent Observations during the 2017 King Tide in Tidewater Virginia

Type: Presentation

Abstract: *Tidewatch is a tidal prediction system developed by the Virginia Institute of Marine Science (VIMS) which provides forecasts at eight NOAA tide gauge locations and two of VIMS' own managed sites throughout tidewater Virginia. Prior to 2018, Tidewatch provided forecasts for 12 water level stations in the lower Chesapeake Bay. Since then, the predictions have expanded to include 18 new sensors installed by the USGS in 2016 and 28 new stations installed by StormSense in 2017 throughout Hampton Roads.*

'Catch the King' Tide was the world's largest simultaneous citizen-science GPS data collection effort. It coincided with the king tide on November 5, 2017, in Hampton Roads. Over 700 volunteers mapped the king tide's maximum flood extent to validate and improve predictive models and future forecasting of increasingly pervasive nuisance flooding. 59,006 high water marks and 1200+ geotagged pictures of inundation were captured using the 'Sea Level Rise' mobile app to trace the shape of the floodwaters using GPS location services. These data were then filtered for relative location accuracy and timing, interpolated with the use of digital elevation models to define estimated flood depths, and subsequently compared with elevation contours to develop a difference map to identify areas where VIMS' water level predictions over-predicted and under-predicted flooding prior to the king tide. The difference map provided valuable insights regarding hydro-correction for partially tidal water bodies that were not hydrologically connected to adjacent rivers and streams. This was found to be due to Lidar aerial data collection methods occasionally occluding culverts or bridges over waterways, and heavily canopied creek beds with thick tree cover. However, a geostatistical comparison between the model's maximum inundation extents and the volunteers' GPS observations yielded a mean horizontal distance difference of 19.3 ft. (5.9 m). Vertical accuracy of the model's predictions during the king tide were determined via comparison with 42 water level sensors to be within a root mean squared error of 1.4 in. (3.5 cm).

Loftis, Derek, Harry V. Wang, Zhuo Liu, Laura Rogers, Tom Allen, David R. Forrest, David Bekaert

Exploring Communities at Intensive Risk in the Lower Chesapeake Bay via Reanalysis of 2011 Hurricane Irene with Future Sea Level Rise

Type: Presentation

Abstract: *Strong cyclones along the U.S. eastern seaboard produce several unique coastal hazards that result from the combination of heavy inland rainfall and storm surge that accompany events ranging from strong Nor'easters to tropical storms and major hurricanes. Combined with longer-term challenges of rising sea levels attributed to coastal subsidence and steric expansion, impacts from these events are expected to increase, especially in coastal communities. In 2017, NASA's Earth Science Disasters Program hosted a regional workshop to explore these issues with particular focus on coastal Virginia and North Carolina, given impacts that NASA's Langley Research Center and the community of Hampton Roads had experienced from several past events. The workshop brought*

together regional partners in academia from VIMS, ODU, Hampton U, GMU, and U Alabama-Huntsville, emergency management, and scientists from NASA and partnering federal agencies to explore capabilities among the team that could improve understanding of the physical processes related to these hazards, their potential impact to these changing communities, and identify methodologies for supporting emergency response and risk mitigation.

A demonstration-based research initiative was developed to examine coastal hazards in a number of ways, including: 1) reanalysis of impacts from 2011 Hurricane Irene, using NASA and Europe's best numerical weather modeling approaches in combination with VIMS' large-scale and street-level hydrodynamic models to evaluate combined impact scenarios considering sea level rise, 2) remote sensing of flood extent from available optical and synthetic aperture radar useful for identifying storm impacts and as precursors for future response efforts, 3) adding value to remotely sensed flood maps through depth predictions and related efforts, and 4) examining coastal subsidence impacts on inundation from a similar strength hurricane in 2045 and 2075, as measured through time-series analysis of synthetic aperture radar observations. This presentation will highlight outcomes of the demonstration study's activities, as advised by NASA and VIMS' models, and describe opportunities for future collaborations within the NASA Earth Science Disasters Program with a vision towards examining and understanding coastal hazards through application of these concepts to other regions.

Maeda, P. Kanoko

Linking Stormwater Best Management Practices to Social Factors in Two Suburban Watersheds

Type: Presentation

Abstract: *To reduce nutrient pollution in urban watersheds, residents need to voluntarily practice a range of stormwater Best Management Practices (BMPs). However, little is known about the underlying social factors that may act as barriers to BMP implementation. The overall goal of this study was to better understand barriers to BMP implementation by exploring the links among resident demographics, knowledge, and behaviors so that appropriate education can be more effectively developed and targeted. In 2014-2015, a detailed questionnaire was administered door-to-door to 311 randomly selected households in two sub-watersheds of the Chesapeake Bay basin to test relationships among resident demographics, knowledge and attitudes towards water resources and BMPs, and BMP implementation. Multifactor regression models, which controlled for the effects of other key predictors, showed that respondents who had higher knowledge lived in households that implemented greater numbers of BMPs. In turn, resident BMP knowledge, or familiarity with BMPs, strongly varied with race and ownership status, with respondents who identified as Caucasian or within a collection of 'Other' races, and who were homeowners, having higher BMP knowledge than respondents who identified as African American and who were home renters, respectively. Overall, respondents preferred to receive educational materials on stormwater via pamphlets and YouTube videos. These results suggest that resident knowledge is important to determine the number of household BMPs, and that education outreach should*

probably target African American and renting households that have lower BMP knowledge using well-planned print and video educational media. Ongoing research is integrating the quantitative findings from this study with biodynamic hydrologic models in a GIS-based diagnostic decision tool that can identify nutrient pollution "hotspots" and prescribe appropriate BMPs under specific environmental and social conditions.

Macias, Alfonso, Margaret Mulholland, Derek Loftis

Measure the Muck, a science-citizens engaging project for sea level rise

Type: Poster

Abstract: *The lower Chesapeake Bay region has been impacted by human activities for approximately 400 years. These impacts come mainly from resource utilization and modification of the surface. Despite the great efforts that have been done to preserve this system, Nitrogen inputs keep increasing mainly due to increase in population, along with extensions of the agriculture industry and urbanization that support the demographic growth.*

A combination in long-term sea level rise, local subsidence, and natural climate variability, creates a higher impact in the coastal zone of the Hampton Roads region (VA, USA). This area has been recognized to be in the second place in the country in terms of vulnerability to flooding due to sea level rise increments.

There is a type of extreme tide caused by perigean spring tides that occur in this region. The periodicity of this type of tides is now know and they are publicly known as 'King Tides'. For the one occurring in fall of 2017, public and private organizations of the region organized a project called 'Catch the King'. The project pretended to gather scientist from local universities and organizations and public in general to delimit the scope of that years King Tide using a specific developed smartphone app.

The same event and app were used to perform a side project called 'Measure the Muck'. In this side project, water samples were recovered from flooding water at different areas of the Hampton Roads region (houses, schools, streets, parks, etc.). In total 213 samples were taken and transported to a laboratory in the Old Dominion University (VA), for analysis of salinity, particulate nitrogen and carbon, total suspended solids, ammonium, nitrate, nitrite, urea, and phosphate. Another 40 samples were taken in similar areas for Enterococcus analysis.
The most important of the preliminary results is the Enterococcus concentration in the water samples. Only 3 out of the 40 samples are below the swimming water quality standards (104 MPN/100mL). The rest of the samples are above this detection limits, whit some presenting values as high as 24,200 MPN/100mL.

The results for all the variables are being prepare in two types of maps. One form of the maps shows the specific sampling points, variables, and values in a dynamic interface using Google Earth™. The other type of map shows interpolations along the coastline of the Hampton Roads region were samples were taken during the 2017 event. These interpolations allow to identify hotspots for each variable (i.e. Ammonium) and help with developing new projects to reach nutrient inputs goals for restoration.

These calculations give a first order approach for a source of perturbation to the water

system that has been ignored. A basic scientific understanding of these interlinked physical and biological processes is paramount because storms and their 'flashiness' are projected to increase in the mid-Atlantic region in the future as a result of climate change and this will be superimposed on rising sea levels thereby increasing the incidence of flooding.

Mann, Roger, Melissa Southworth, James Wesson, Ryan Carnegie, Kimberly Reece, Clara Robison

Oyster Populations in the Virginia Bay: Small Steps to Stability

Type: Presentation

Abstract: *The role of the eastern oyster Crassostrea virginica in the Chesapeake Bay ecosystem in benthic pelagic coupling, complex habitat creation, alkalinity budgets and nutrient cycling has been well documented. That role has changed over historical time with post-colonial harvest, habitat degradation and disease among other challenges. Epizootics in the later part of the 20th century were particularly destructive, and by the early 2000s Virginia oyster populations were at a low ebb. Since 2006 we have observed a gradual but notable return of oysters to many locations in the Virginia portion of the bay, and while restoration efforts may have contributed locally the broad resurgence strongly supports the argument of natural changes in combination with conservative but sound management as the major drivers of recovery.*

The importance of both stable live populations and habitat (shell) to oyster recovery and perpetuation cannot be understated. We illustrate this relationship with data from long term, post epizootic (2006-2016) studies of seasonal recruitment (weekly shellstring deployment as settlement substrates) and fall stock assessment studies in the Virginia portion of the Bay. Recruitment has generally been strong since 2006, although early post settlement survival (from 1 to ~20mm YOY in the fall months) has been reduced compared to the 1998-2005 period. The driving cause for this reduced survival to YOY has not been definitively identified, although the role of emerging HAB events cannot be discounted. Survival from YOY, as estimated by fall surveys, to age classes 1-4, has increased and remained relatively stable over the 2006-2016 period. More year classes are now represented compared to pre-2005, although the population is still arguably age truncated compared to pre-colonial populations. The result of the 2006-2016 population stability is that shell budgets, that is the equilibrium between live oysters, exposed shell above the sediment water interface, buried shell, and shell loss to dissolution and biologically mediated degradation, can be generated for the western shore subestuaries in addition to the Pocomoke and Tangier Sounds. These budgets are somewhat location specific, being driven by the balance of recruitment, growth and mortality, and illustrate the influence of individual oyster shape (which in turn is reflective of local growth conditions) on the mass balance of the habitat creation and loss. Local restoration and repletion has very limited ability to alter the nature of these near equilibrium budgets, an observation commensurate with our understanding of the rates of formation and degradation of reef systems over geological and evolutionary time frames.

Conservative management in combination with targeted repletion offers the prospect of population stability in the near future;

however, two caveats are important. First, repletion will inevitably be limited by shell availability, and shell is a limited resource. Second, natural expansion of the resource remains limited by individual oyster longevity - we need oysters to live longer to provide more shell per individual at death in order to sustainably expand habitat.

Menendez, Alana, Maria Tzortziou, Patrick Neale

Temporal variability of fluorescent dissolved organic matter at a brackish, tidal marsh-estuary interface

Type: Poster

Abstract: *Tidal marshes are both terrestrial and aqueous, sitting at the interface between land and water. Previous studies, conducted mostly over a few individual tidal cycles, have demonstrated that most tidal marshes are net exporters of dissolved organic carbon (DOC) and net importers of particulate organic carbon (POC) to adjoining estuaries, however, there is need for continuous monitoring to better understand the temporal variability of this flux: tidally, seasonally, and during episodic storm events. Through use of an YSI EXO2 sonde, an in situ optical sensor at the interface of the brackish, tidal Kirkpatrick Marsh and Rhode River sub-estuary in Edgewater, Maryland (located on the northwestern shore of the Chesapeake Bay), we were able to continuously monitor fluorescent dissolved organic matter (FDOM) and fluorescent chlorophyll (FCHL). Corrections of FDOM due to temperature, absorbance, and particle scattering were developed for this sensor and evaluated. We assessed the capability of retrieving DOC concentrations based on in situ optical measurements and additional water physicochemical parameters across different seasons, years, and tidal stages. Results were combined with hydrological measurements to estimate fluxes of DOC and chlorophyll across this land-water interface, quantify temporal variability in carbon concentrations and marsh-estuary exchanges, and assess impacts of episodic events and high precipitation on wetland carbon export. Accurately estimating DOC stocks and fluxes from long-term, high-frequency in situ optical parameters is critical for understanding the role of tidal marsh ecosystems in estuarine and coastal ecology, and improving parametrizations of carbon transformation processes in coastal biogeochemical models.*

Moriarty, Julia, Marjorie Friedrichs, Courtney K. Harris

Effects of Seabed Resuspension on Primary Productivity and Remineralization in Chesapeake Bay

Type: Presentation

Abstract: *Observations in coastal environments show that resuspension can impact water quality and biogeochemical dynamics by vertically mixing sediment and water, and by redistributing material that has been entrained from the seabed into the water column. Yet, hydrodynamic ocean models that incorporate both sediment transport and biogeochemical processes are rare, and nearly all neglect the effect of resuspension on oxygen and nutrient dynamics. Accounting for such processes can be important in estuarine environments such as the Chesapeake Bay, where sediment resuspension and transport can affect development of summertime hypoxia by (1) transferring organic matter from the estuary's shoals to deeper regions; (2) increasing light attenuation, which affects primary productivity; and (3) altering fluxes of oxygen and nutrients between the seabed and water column.*

We investigated these issues by implementing a coupled hydrodynamic-sediment transport-biogeochemistry model for the Chesapeake Bay. Developed within the open-source Regional Ocean Modeling System (ROMS) framework and forced by output from the Chesapeake Bay Program's watershed model, the coupled estuarine model accounts for transport of sediment, oxygen, and nutrients; and processes including advection, resuspension, diffusion within the seabed and at the sediment-water interface, organic matter remineralization, and oxidation of reduced chemical species. Here, we implemented this coupled model in three dimensions for the Chesapeake Bay. Model results indicate that resuspension facilitated transport of particulate organic matter from shoals and the Upper Bay to the main channel in the Mid Bay, increasing remineralization there. Resuspension also increased turbidity and light attenuation in the Upper Bay, causing photosynthesis and primary production to decrease. Overall, these two effects caused bottom water oxygen concentrations to decrease and bottom water ammonium concentrations to increase throughout the main channel of the Bay.

Morrissette, Hannah, Raleigh R. Hood

Using observational data to validate performance of sediment flux model formulations of increasing complexity

Type: Poster

Abstract: *Particulate and dissolved organic matter processes within wetland sediments are extremely complicated and dynamic. Capturing the organic matter transformations and their complexities in the wetland sediment environment has proven difficult due to a lack of data and specific process observation to inform sediment flux models. The sediment flux model in this study originally encompassed only hydrolysis, the biotic degradation of particulates within the sediments, and remineralization of the dissolved organic matter pools. This research incorporates sorption processes between particulate and dissolved organic matter into the sediment flux model. By explicitly including sorption in theoretical increasing levels of complexity, we can quantify the effects of each individual new formulation on model performance. The new formulations were run under various forcing conditions and compared to thirteen-year base model runs without the additional complexity. The ability to reproduce the available observational data for compound concentrations and fluxes was statistically analyzed for each run. This research will provide insight into the ways to formulate more accurate model representations of sediment/water interactions and exchange of organic matter transport and transformation within wetland sediments and pore water.*

Murphy, Rebecca, Jeni Keisman

Comparison of Secchi depth and Kd trends while adjusting for freshwater input variations

Type: Presentation

Abstract: *Improved water clarity is a key goal for Chesapeake Bay because of its importance for underwater vegetation, as well as other benefits. Secchi disk depth and Kd are both used as measurements of water clarity in the Chesapeake Bay water column, but observations with a Secchi disk are based on light as seen by the human eye and Kd is the diffuse light attenuation coefficient, likely more relevant to underwater vegetation. Secchi depth is available since the mid-1980s at most of the long-term monitoring stations within the tidal waters,* *whereas Kd has a shorter monitoring record in many places. Both measures can be influenced by fluctuations in freshwater flow, for multiple reasons including flushing in tidal fresh areas and increased nutrient loads and sediment that are transported with freshwater. We present an approach for adjusting by freshwater flow or salinity in a Generalized Additive Model (GAM) structure. We evaluate trends in these two light measurements, both flow-adjusted and not, throughout the Chesapeake Bay tidal waters using sliding time scales in order to use as much data as possible, and compare trends between the two parameters. A comparison with trends for other relevant parameters, including TSS and chlorophyll-a, will be considered as well in an attempt to provide relevant information to stimulate an active discussion on these, sometimes disparate, trends.*

Nason, Sara, Tomer Malchi, Elizabeth Miller, K. G. Karthikeyen, Moshe Shenker, Benny Chefetz, Joel Pedersen

Plant Accumulation of Carbamazepine and Lamotrigine: an Interspecies Comparison

Type: Poster

Abstract: *Pharmaceuticals are common contaminants in wastewater treatment effluent and surface water systems where effluent is released. Direct use of effluent and use of effluent influenced water bodies for crop irrigation is an increasingly common practice, especially in arid regions. Therefore, crop plants intended for human consumption may be exposed to pharmaceuticals. Previous studies have found that the anti-epileptic drugs carbamazepine and lamotrigine can be taken up by plants under field conditions. However, variation among plant species is not well understood. We grew Arabidopsis thaliana, spinach, cucumber, and tomato plants and exposed them to carbamazepine and lamotrigine alone and in a mixture. We found that compound accumulation, mixture effects, and metabolism varied among species. Cucumber and tomato accumulated higher concentrations of carbamazepine metabolites and a significantly higher percentage of the initial compound provided was not detected in the nutrient solution or plants at the end of the exposure period when compared to spinach and A. thaliana. Water uptake by the plants correlated with carbamazepine and lamotrigine loss from solution across species, indicating that the loss of the compounds is likely due to transformation in planta. This hypothesis is supported by higher degree of similarity between human drug metabolism enzymes and those in tomato and cucumber than in spinach and A. thaliana. Our data demonstrate the importance of considering species differences when investigating plant accumulation and metabolism of pharmaceuticals, and caution that model species may not be representative of important crop species.*

Neale, Patrick, Kevin C. Rose, Maria Tzortziou, Charles L. Gallegos, Thomas E. Jordan

Spectral model of light attenuation in the Rhode-River subestuary: Identifying drivers of spatial variability and long-term trends

Type: Presentation

Abstract: *The attenuation of solar radiation controls many processes and characteristics of the Chesapeake Bay and is a key parameter needed to model Bay processes. While light attenuation is often modeled or measured as a single broad-band diffuse attenuation coefficient of photosynthetically active radiation (Kd PAR), attenuation can vary substantially across the solar spectrum and through time and space. Understanding*

this variability and its proximate causes may provide information to characterize large-scale environmental changes as well as potential water quality responses. We implemented a semi-analytical Kd model for four segments of the Rhode River sub-estuary of the Chesapeake Bay to examine spectral, spatial, and temporal variability in Kd across the ultraviolet (UV) to PAR wavelengths (290-710 nm) over the period 1986-2014. The model was validated using a detailed set of inherent and apparent optical properties of the Rhode River acquired during a two-year CISNET project (1999-2001). We used this model to identify wavelengths most sensitive to long-term change, the seasonal phenology of long-term change, and the optical constituents driving changes. The model included contributions by phytoplankton, non-algal particulates, chromophoric dissolved organic matter (CDOM), and water. Over the period of record, Kd increased (water transparency decreased) in both UV and PAR wavelengths, with the largest increases at the most upstream site, during summer months, and at short UV wavelengths. These increases were due primarily to an increase in total suspended solids particularly since 2005, however there was substantial seasonality in Kd and trends. The increase in total suspended solids was less in the segment bounded by high marshes with extensive networks of tidal creeks, consistent with a net filtering function of these marshes during tidal exchange. Overall, our results show that fundamental water quality parameters can be used to infer sub-estuarine light transmission over the full UV and PAR range, thus providing a key component needed by estuarine biogeochemical models and an enhanced tool to assist meeting transparency targets in Chesapeake Bay subestuaries.

Ni, Wenfei, Ming Li Andrew Ross, Raymond Najjar, Moges Wagena, Zachary Easton

Climate downscaling projections for Chesapeake Bay hypoxia in the 21st century

Type: Presentation

Abstract: *Climate change is expected to affect the Chesapeake Bay through higher temperature, rapid sea-level rise, and altered streamflow. A coupled hydrodynamic-biogeochemical model (ROMS-RCA) is used to project changes in Chesapeake Bay hypoxia by the mid-21st century under a medium-high greenhouse gas emissions scenario. ROMS-RCA is driven by bias-corrected atmospheric forcing and streamflow projections from three regional climate models included in the North American Regional Climate Change Assessment Program (NARCCAP) and relative sea level rise. Model results show that both the magnitude and timing of hypoxia are sensitive to the changing climate, with 20-30% increase in summer hypoxic/anoxic volumes and 2-10 days early onset. Additional idealized model runs driven by single climate change factors are conducted to discern the individual effect on hypoxia. It is found that the temperature increase is the main cause for the early increase of hypoxia, which can be accounted for by the decrease in oxygen solubility, and increased phytoplankton growth rate and respiration rate. Sea-level rise is primarily responsible for the increase in mid-late summer hypoxic volume, while the increased streamflow is found to mainly affect the seasonal progression of the hypoxia with little net effect on the annual hypoxic volume. Summer winds are projected to decline and contribute to an increase in hypoxic volume.*

Nunez, M. Karinna, Joseph Zhang, William Reay, Carl Hershner

Cross-scale simulations: an innovative approach to evaluate the impacts of climate change on tidal marsh habitats

Type: Presentation

Abstract: *Tidal marshes are facing growing threats from sea-level rise due to changes in global climate. Managing shoreline systems to sustain the capacity of these habitats to provide multiple ecosystem services requires an understanding of the conditions that will affect their survival. To evaluate the vulnerability of tidal marshes, different models have been developed to predict their spatial extent and future distribution. Current models provide useful information either for landscape scale at coarse resolution, or for site-specific scale, which limits the extrapolation of the results to larger areas. This study presents an advanced modeling framework that integrates the physical, and human components needed to simulate and assess the evolution and persistence of tidal marshes under different sea-level rise scenarios. Unlike existing marsh models, the Tidal Marsh Model (TMM) was generated using an unstructured grid. This type of grid allows multiple resolutions (cross-scale simulations) over the domain, overcoming scaling issues that current models present. Marsh areas are highly resolved at 1 meter cross-shore and 10-20 meters along-shore for fringe marshes. TMM is based on the SCHISM modeling system. The highly efficient and accurate semi-implicit finite-element/finite-volume method combined with the Eulerian-Lagrangian method are used to solve the hydrodynamic, sediment transport, and wave action equations relevant for marsh persistence. Historic and field data are used for calibration purposes. Results obtained in the York River, VA, show that the model captures processes important for marsh evolution, such as marsh inundation frequency, wave energy attenuation by marsh plants, erosion-deposition patterns in cross-shore marsh direction and around coastal structures, and marsh landward migration. TMM will advance the state of the science by modeling marshes in large areas, but with the kind of spatially explicit resolution currently only available from site-specific marsh evolution studies.*

Ogburn, Matthew, Robert Aguilar, Katrina P. Lohan, Louis V. Plough

Applying Biomarkers to the Study of Trophic Dynamics and Connectivity

Type: Presentation

Abstract: *Biomarkers have great potential to enhance our understanding of the structure and function of Chesapeake Bay ecosystems. The Smithsonian Environmental Research Center has been applying biomarkers to answer questions about trophic ecology and connectivity of important fishery resources. These studies include 1) using barcoding and metabarcoding to study diets of blue catfish and striped bass, 2) using environmental DNA analysis to understand broad-scale habitat use of river herring, and 3) using stable isotope and trace metal biogeochemistry to track the spawning migration of blue crabs and evaluate the relative importance of tributaries as spawning habitat. These tools open new windows into the lives of the species inhabiting Chesapeake Bay and provide new data for modeling efforts directed toward understanding and managing valuable natural resources.*

Palinkas, Cindy

Sediment dynamics in Conowingo Pond from days to decades

Type: Presentation

Abstract: *This study examines sediment dynamics in Conowingo Pond, the reservoir upstream of the last and largest dam on the Susquehanna River before it enters Chesapeake Bay. Conowingo Reservoir has recently reached dynamic equilibrium, resulting in reduced trapping of the fluvial sediment bound for the Bay. In addition, large flood events can scour much more than the average annual sediment load from the reservoir bottom, delivering exceptionally large sediment loads to the Bay within days. While there is much management interest in predicting the downstream impacts of both reservoir infill and scour events, predictions are limited by understanding of the complex spatiotemporal variability of sedimentation. To better quantify this variability, we have established sediment geochronologies throughout the Pond from days to decades with natural and anthropogenic radioisotopes (Be-7, Pb-210, Cs-137). These geochronologies are placed within the context of sediment loading to the Pond, as well as its geomorphology. We find that sedimentation rates generally scale with fluvial loads and reflect deposition of watershed-derived sediment. Along-river patterns of sedimentation follow those of river deltas incised by channels, while across-river patterns highlight the role of high-flow events and provide evidence for possible mechanisms of channel incision. Connection of these processes to upper Bay water quality are explored, particularly in light of recent changes in fluvial sediment loads. Thus, this study greatly improves understanding of sediment sources and transport through Conowingo Pond. These insights are critical for developing mechanistic models to guide and predict potential outcomes of future management decisions.*

Pizzuto, James, Diana L. Karwan, Katherine Skalak

Sediment Storage Retards Benefits of Upland Sediment BMPs in Large Watersheds Drained By Alluvial Rivers

Type: Presentation

Abstract: *Geomorphologists have long understood that storage delays the downstream delivery of sediment, but this process is rarely quantified and typically ignored in watershed sediment modeling. We use a stochastic sediment routing model to evaluate the time required to deliver benefits from best management practices (BMPs) that reduce sediment loading to all first order channels by 50%. The domain is an idealized 71,339 km2 watershed scaled to the Susquehanna River basin, with constant storage probability per unit channel length (0.015 km-1) and storage time distribution function (with values from <1 to >104 years), both representative of the mid-Atlantic region. Delivery times for BMP-induced benefits increase rapidly with watershed size, ranging from <1 year for a 57 km2 subwatershed to >104 years for the entire basin, where transient sediment budgets persist for 107 years. Storage processes and timescales should therefore be explicitly considered when assessing sediment BMPs in large watersheds.*

Porter, Elka, Barbara J. Johnson, Lawrence P. Sanford

Effect of hard clam, Mercenaria mercenaria, density and bottom shear on sediment erodibility

Type: Presentation

Abstract: *Bivalve suspension-feeders are widely known to reduce particulate concentrations in the water column through filtration. However, in a few previous studies infaunal bivalves have been found to increase sediment erodibility and thus* *potentially increase particulate concentrations in the water column. We investigated the effect of hard clam, Mercenaria mercenaria, density (50, 10, 0 clams m-2) and bottom shear velocity on muddy sediment erodibility in stepwise erosion experiments. We performed a series of short-term stepwise erosion experiments in 30 and 40 cm Gust microcosms over shear velocities of 0.288 to 1.39 cm s-1 where the shear velocity was held at a step for 20 minutes and turbidities were sampled every two minutes. In addition, we monitored sediment erodibility in two 1-month long ecosystem experiments with tidal resuspension and 0, 10 and 50 hard clams in 1 m3 shear turbulence resuspension mesocosm (STURM) tanks. We found that a low density of hard clams did not affect sediment erodibility, but a high density of hard clams destabilized sediments and led to higher turbidities at lower shear velocities. A high density of hard clams led to a significantly decreased critical erosional shear stress. In 1-month ecosystem experiments, 50 clams m-2 initially destabilized the sediment, leading to seston concentrations of about 200 mg L-1. However, the sediment stabilized over time and seston concentrations became similar (about 60 mg L-1) between treatments with different densities of hard clams. Thus, bioturbation by a dense bed of hard clams in interaction with infrequent high bottom shear due to storms may increase seston concentrations in the water column, but long-term effects between storms are not as clear.*

Preheim, Sarah, Keith Arora-Williams, Chris Holder, Anand Gnanadesikan

Application of DNA- and RNA-sequence based techniques to inform biogeochemical models of the Chesapeake Bay dead-zone

Type: Presentation

Abstract: *Nutrient pollution impacts the Chesapeake Bay by driving harmful algal blooms and subsequently creating low oxygen dead-zones that deteriorate the habitat for many aquatic animals. Although inhospitable for aquatic animals, the dead-zone promotes many unique microbial processes that could impact the size and duration of dead-zone, including processes impacting nutrient cycling. Recent work has suggested that microbial population and gene abundance, gene expression and genome content can be incorporated into reactive transport models of microbial processes which might benefit models of the dead-zone in the Chesapeake Bay. To investigate how best to use DNA- and RNA-sequence based observations in biogeochemical models of the Bay, we sequenced the microbial community in the Bay across a three-year period from multiple depths and sampling stations. We surveyed the microbial community with high-throughput amplicon sequencing to identify the spatiotemporal dynamics of specific populations and shotgun metagenomics to assess gene content. We also collected samples to assess gene expression profiles using RNA sequencing. We found microbial community structure is responsive to biogeochemical changes in the Bay, but that dispersal can act to homogenize the community in distinct biogeochemical zones. Dissolved oxygen levels were relatively high during sampling in June 2015, but became anoxic below 9 m and 15 m, in July and August respectively. Overall bacterial communities were more similar within a sample time point than between time points despite differences in water chemistry along depth profiles, highlighting that mixing promotes some degree of homogeneity across the entire community. However,*

specific populations have reproducible spatiotemporal dynamics, suggesting that population abundance could be predictive of conditions promoting their specific metabolic processes. Additionally, key genes involved in anaerobic metabolism are relatively more abundant where oxygen is depleted. The reproducible distribution of gene and population abundance in space and time will be used to guide biogeochemical model development, optimization and parameterization. Ultimately, the goal of this study is to determine whether incorporation of DNA- and RNA-sequence based observations into biogeochemical models improve predictions of the size and duration of dead-zone under changing environmental conditions.

Putnam, Shane, Ciaran Harman

The Influence of Landscape Structure and Storage on the Hydrologic Response of a Piedmont Catchment in Northern Maryland

Type: Poster

Abstract: *Many studies have sought to understand the influence of landscape structure on the storage and transport of water and contaminants, however, most of these studies have been conducted in relatively young landscapes where soils are thin and overlie an assumed impermeable bedrock layer. In contrast, relatively little research has been conducted in old landscapes, like those found in the Chesapeake Bay Watershed, where soils are thick and the bedrock is deeply weathered. In the Piedmont Physiographic Province of the Mid-Atlantic, previous research has suggested that this weathered bedrock has the potential to store large quantities of water, yet, its influence, as well as that of other landscape features on the quantity and composition of surface waters are not well understood. Here, the storage and release of water from individual landscape units within Pond Branch, a 37-hectare Piedmont catchment in northern Maryland, are quantified in order to test hypotheses relating landscape structure, storage, and flow pathways to the structure of the observed surface water discharge at the catchment outlet.*

Data from Pond Branch include hillslope spring and catchment discharge, hydrometeorological data, well water levels, and soil moisture measurements, as well as three years of high frequency precipitation and surface water stable water isotope data. Storage is estimated at the catchment scale and then decomposed into estimates of storage in the riparian area, soil, and weathered bedrock. The catchment hydrograph is deconstructed using hydrograph separation and the quantity of baseflow and quickflow is compared to the quantity of discharge that could be released or generated from hillslope and riparian landscape units. The results suggest that water stored and released from the hillslope landscape unit is the dominate source of baseflow, and that the hillslope response to storm events controls the quickflow response. However, this quickflow is likely composed of a combination of water that is rapidly released from the toe of the hillslope and from saturation excess overland flow from the riparian landscape unit. The role of the hillslope, including the weathered bedrock within, in controlling streamflow dynamics highlights the need to better understand the storage and release of water in deeply weathered catchments if we are to understand and model how contaminants are also stored and transported.

Qin, Qubin, Jian Shen

The critical role of physical transport in the initiation of harmful algal blooms in the lower James River, Virginia

Type: Presentation

Abstract: *The underlying mechanisms of the initiation of harmful algal blooms (HABs) are not fully known in estuaries due to the complex processes involved. Theoretical analysis in this study suggests that a relatively long period of time (weeks) is required for a successful HAB, and a HAB can occur independently from multiple unconnected locations, either in the main channel or a sub-tributary of an estuary, as long as those locations have a favorable condition for algal growth. In the lower James River, Cochlodinium polykrikoides bloom occurs almost every summer over the past two decades, and the Lafayette River, a sub-tributary, is suggested to be one primary originating location. Our study highlights the impact of physical transport, and results show that the unique circulation of the lower James River and relatively long residence time of Lafayette River are favorable for the first bloom to occur, regardless of the cyst distribution. A further investigation of various environmental conditions for the C. polykrikoides bloom reveals that physical transport also controls the interannual variability in the timing of its initiation, and southerly wind, heavy rainfall, and spring tide can cause strong flushing effect capable of interrupting, or even terminating, HAB initiation in the lower James River. In contrast, stratification may not be a necessary condition to trigger HABs. The crash of the short C. polykrikoides bloom observed in the Lafayette River in 2014 was mainly caused by strong flushing induced by wind and tide.*

Reed, Seann, Duc Le, Breck Sullivan

Assessing Freshwater Flow Impacts on NOS Chesapeake Bay Operational Forecast System (CBOFS) Salinity Simulations

Type: Presentation

Abstract: *There is an increasing interest in using model output from the Chesapeake Bay Operational Forecast System (CBOFS) to drive ecological models. We hypothesize that more accurate modeling of freshwater inputs will improve CBOFS salinity predictions, and hence the utility of CBOFS output for ecological applications. Improved salinity predictions would benefit NOAA's Sea Nettle Forecasting System, which uses CBOFS salinity and temperature output, and could also benefit other applications such as harmful algal bloom and oyster growth predictions.*

Currently, river inflows only enter CBOFS at 12 river locations. Inflows for nowcasting are derived from USGS streamflow observations while forecast inflows are derived through a simple persistence approach. The 12 inflow locations only drain about 75% of the Chesapeake Watershed, so approximate adjustments are made to account for ungauged flow. In simulation studies, we use gridded hydrologic model output in an effort to more accurately estimate ungauged flows. We also compare the baseline CBOFS configuration (12 inflow locations) to scenarios which use 22 and 55 locations, providing a more realistic representation of the river-estuary inflows. Our first analysis period from 2003-2005 is selected to coincide with the original CBOFS model validation (NOAA Technical Report CS 29). For this period, we validate salinity simulations using discrete salinity observations from the Chesapeake Bay Monitoring Program. Flow adjustments from our hydrologic model showed reductions in average salinity prediction error compared

to baseline runs and adding 22 inflow locations showed promise to improve salinity predictions near river-estuary interfaces. Future plans are to complete the analysis with 55 inflow locations and also validate the approach for a more recent period (2016), which will allow enhanced validation against continuous salinity observations from Chesapeake Bay Interpretive Buoy System (CBIBS) network. Lessons learned will guide future efforts in designing connections between NWS river models and the NOS estuary model. While the gridded hydrologic model used in this study was run at the NWS Middle Atlantic River Forecast Center (MARFC), concepts should be transferable to NOAA's National Water Model.

This work was made possible through the NOAA Chesapeake Bay Summer Internship program, along with collaboration between MARFC and the NOS Coastal Survey Development Laboratory. Two summer internships at the MARFC have focused on this project (2016 and 2017) and we anticipate continuing the project with another intern in the summer of 2018.

Regan, John, Nicholas Locke, Sheila Saia, Hunter Carrick, Anthony Buda, M. Todd Walter

Identification of Polyphosphate-Accumulating Organisms Contributing to Phosphorus Cycling in Stream Biofilms

Type: Presentation

Abstract: *Microbial activities can significantly affect the fate of phosphorus in both natural and engineered contexts, such as agricultural soils, streams, and biological wastewater treatment systems. Much of the research in these areas has occurred in parallel research communities, with relatively little exchange of ecological and phenotypic insights between different ecosystems. Polyphosphate-accumulating organisms (PAOs) provide a prominent example of this: PAO diversity, abundance, and mechanisms of P uptake and release are well studied among the wastewater treatment community, and their activity is central to the design and operation of enhanced biological P removal (EBPR) systems. However, there are very few studies on PAOs in natural freshwater contexts, and some of these even frame the occurrence of PAOs in the environment from the perspective of their introduction from EBPR system effluents to affected streams. Certainly there are PAOs in natural environments that are not derived from EBPR systems and that contribute to phosphorus mobility in natural contexts. PAOs directly take up or release phosphorus coupled with their processing of organics and as a function of cycling redox conditions. We hypothesized stream biofilms would provide microenvironments favorable for PAO enrichment through aerobic conditions created by oxygenic phototrophy and anaerobic conditions induced by net respiration following a diel cycle. We found phosphorus uptake and release occurred from stream biofilms during aerobic and anaerobic periods, with a higher abundance of polyP-containing cells following the aerobic periods, consistent with the known PAO metabolism. We also sampled stream biofilms derived from a range of trophic conditions across Pennsylvania. Using polyphosphate staining and fluorescence-activated cell sorting, we physically enriched PAO from these biofilm samples and then identified these putative PAOs using 16S rRNA gene sequencing. Results showed diverse PAOs that were distinct from the species typically enriched in EBPR systems (i.e., Candidatus Accumulibacter phosphatis). The predominant populations* *grouped according to trophic condition, suggesting various enrichment niches for different PAO populations. These data show an important role of PAOs in stream biofilms with respect to phosphorus storage and mobilization under diel conditions, and a considerable diversity of PAOs in stream biofilms distinct from those typically found in EBPR systems.*

Rice, Karen, Aaron L. Mills, Rosemary Fanelli, Alexander M. Soroka

Thirty Years of Dissolved Phosphorus Dynamics in Nine Freshwater Tributaries to the Chesapeake Bay

Type: Presentation

Abstract: *The 166,319-square kilometer (km2) basin that drains to the Chesapeake Bay (CB) has diverse land use and land cover, resulting in varying water quality of its freshwater tributaries. While nitrogen has been well studied in the CB basin, phosphorus has received less attention. We analyzed 30 years of dissolved phosphate (orthophosphate, OP) loads and concentrations at nine of the major tributaries to the CB. The watersheds are those designated as River Input Monitoring (RIM) stations, and include the Choptank, Susquehanna, Patuxent, Potomac, Rappahannock, Pamunkey, Mattaponi, James, and Appomattox Rivers. OP concentrations and loads varied among the watersheds with respect to their response to various climate, land-use, and hydrologic factors. Notably, cumulative fluxes of OP out of the watersheds were greater in the cooler part of the year, presumably due to increased discharge, in seven of the nine RIM watersheds. In contrast, the Patuxent River exported more OP during the warm season, and the Choptank River exported OP equally during the two seasons. The analysis suggests that the Choptank River watershed may be leaking OP, i.e., exporting phosphorus that is unable to be stored in the watershed because the sorption sites may be filled. The responses of OP transport to streamflow, land use, and water temperature differed among the watersheds. Therefore, management strategies should reflect the dominant factors accounting for changes in OP over time, so that phosphorus may be managed more effectively in the different watersheds.*

Russ, Emily, Cindy Palinkas

Spatial and temporal patterns of sediment geochemistry in upper Chesapeake Bay

Type: Presentation

Abstract: *Excess sediment input is among the main pollutants contributing to water quality degradation in the Chesapeake Bay. Previous sediment budgets identified two major sources of sediment to the upper Chesapeake Bay, the ~175 km span between the Susquehanna River and Potomac River Estuary mouths: 1) the Susquehanna River, the Bay's largest tributary; and 2) shoreline erosion. However, the relative contributions of these materials to the bottom sediments of the upper Bay are not well characterized. The objective of this research is to quantify geochemical differences in bottom sediments of the upper Chesapeake Bay over seasonal and decadal scales. Results from a principal component analysis indicate that the spatial variability in sediment geochemistry is highly correlated with distance from the Susquehanna River mouth. In contrast, changes in heavy metal concentrations explain much of the temporal variability. The spatial patterns in sediment geochemistry likely reflect changes in sediment source contributions, with greater fluvial contributions at sites closer to the Susquehanna River mouth, while the* *temporal patterns suggest changes in anthropogenic loadings of heavy metals to the upper Chesapeake Bay. Furthermore, this approach can be applied to quantify the amount of sediments supplied by fluvial and shoreline erosion in the upper Chesapeake Bay, which is critical to management efforts, especially with respect to recent Chesapeake Bay Total Maximum Daily Load (TMDL) reduction goals.*

Saha, Arghajeet, Cibin Raj

Identifying Nutrient Loading Hotspots in Susquehanna River Basin Using SWAT

Type: Poster

Abstract: *The nutrient loads in the Susquehanna River Basin (SRB) are influenced by wide-ranging prevalent natural and anthropogenic drivers. Notwithstanding having more than 30 years of research and funding invested in improving the water quality of the Chesapeake Bay, the overall health continues to remain degraded. Restoration of the bay to achieve the 2025 USEPA nutrient reduction goals are vital and require the use of inventive approaches to address the different factors which control the nutrient loadings at various spatial and temporal scales. Our research aims to develop a diagnostic decision support system to identify nutrient loading hotspots in the river basin. A comprehensive Soil and Water Assessment Tool (SWAT) model is developed for the SRB to estimate landscape nutrient loading and identifying the hotspots based on biophysical characteristics. The study is expected to help us better understand the optimum selection and placement of best management practices at watershed scale.*

Keywords: SWAT, nitrogen, phosphorus, Chesapeake Bay, Susquehanna River Basin

Sakowski, Eric, Sarah Preheim

Phage-host Interactions and Predation Strategies in the Chesapeake Bay

Type: Presentation

Abstract: *In aquatic environments, bacteriophage significantly contribute to bacterial mortality through infection and subsequent lysis. The Kill the Winner hypothesis predicts that the most competitive bacterial populations experience greater viral predation compared to their slower-growing counterparts. Therefore, phage predation is vital to the diversity and stability of aquatic bacterial communities. Cultivated phage fall along a spectrum of host specificity from broad (spanning genera) to narrow (strain specific), which may directly impact bacterial communities since specialist and generalist predators impact prey populations differently. Whereas specialist predators drive prey population cycles, generalist predators promote the stability of prey populations. Understanding the frequency, distribution, and relative impact of specialist (narrow host range) phage and generalist (broad host range) phage on bacterial communities will better enable predictions of bacterial community dynamics and biogeochemical cycling. However, the inability to readily cultivate most environmental bacteria and phage has hampered efforts to characterize natural phage-host interactions. In this study, we sought to leverage cultivation-independent metagenomics and single-cell amplification methods to characterize cyanophage-host interactions in the Chesapeake Bay. The Chesapeake Bay harbors many endemic phage populations that interact with the Bay's bacterial populations, and putative cyanophage were often more similar to other environmental viral sequences from the Bay than to reference phage. Overall, approximately*

two-thirds of the identified cyanophage had narrow host ranges, but several were linked to multiple hosts, while related hosts displayed different levels of phage susceptibility. This work begins to address how the interactions of bacterial populations with generalist and specialist phage influence the composition and stability of bacterial communities in the Chesapeake Bay by characterizing viral host ranges in the environment. Additionally, this work suggests that closely related bacterial populations may experience different levels of susceptibility to phage predation. Ultimately, this work will build toward better enabling researchers to tie phage-host interactions to important ecological shifts and biogeochemical processes in the Bay.

Schall, Megan, Vicki S. Blazer, Heather L. Walsh, Geoffrey Smith, Robert Lorantas, Timothy Wertz, Tyler Wagner

Investigating occurrence of disease characteristics and trends in smallmouth bass abundance in rivers within the Chesapeake Bay Watershed

Type: Presentation

Abstract: *Smallmouth bass (Micropterus dolomieu) are an important socioeconomic fish species in the Chesapeake Bay Watershed. There have been concerns for the health of many riverine fisheries throughout the Chesapeake Bay Watershed as a result of declines in smallmouth bass abundance, clinical signs of disease, and evidence for endocrine disruption. To evaluate possible declines in smallmouth abundance, we used a dynamic linear model to quantify trends and the probability of annual declines in abundance in major rivers in Pennsylvania, including areas with and without fish health concerns. Throughout the region, periods of decline in smallmouth bass abundance were present with the largest magnitude and probability of decline occurring in reaches within the Susquehanna River Basin. There was also evidence for variability in trends in smallmouth bass abundance in different sub-basins, which lead to questions about how fish health varies in areas with recovering populations when compared to populations that continue to decline or that have leveled off after a prolonged period of decline. In the same areas where fishery abundance surveys were completed, both juvenile and adult smallmouth bass were collected to assess fish health. We compared disease prevalence, specifically parasites and co-infections in young-of-year smallmouth bass, and intersex prevalence/severity in adults, with trends in abundance. This comparison attempts to link health observations made on individuals with potential population-level changes over time. When combined with environmental (water quality, chemical contaminants) and landscape factors it may also help direct and evaluate conservation and management actions.*

Schubert, John, Jonathan A. Czuba

Quantifying Sediment and Legacy Pollutant Residence-Time Distributions in Floodplains

Type: Presentation

Abstract: *Floodplains temporarily store and release sediment and adsorbed nutrients (such as phosphorous) and contaminants (such as mercury and PCBs) during the downstream progression of sediment movement from source to sink. A fraction of the sediment being transported by a river can be deposited in a given floodplain. Once deposited it may take tens to thousands of years before the river sweeps across the floodplain remobilizing that sediment. This creates potentially long lag times between upstream watershed management actions and downstream improvements in water*

quality. The major factors controlling the storage and release of sediment in floodplains include the: (1) temporal frequency of inundation, (2) spatial distribution of low-lying floodplain topography relative to the river channel, and (3) pathway by which the river sweeps across its floodplain.

To better understand the storage and release dynamics in floodplains, we first obtain high resolution lidar data that resolves the detailed floodplain topography. At this resolution, we see that typical floodplains are not flat featureless surfaces, but exhibit substantial topographic variability from oxbow lakes, natural levees, scroll bars, and floodplain channels , both adjacent to the river and across the floodplain, formed during previous channel occupation of that area. Next, we apply a 2-dimensional hydrodynamic model (HEC-RAS 2-D) to quantify where and how frequently the floodplain is inundated by water. Areas undergoing more frequent inundation are expected to have higher deposition rates and a greater accumulation of sediment/nutrients/contaminants.
Sometimes, these low-lying areas are not immediately adjacent to the river channel but farther across the floodplain. This is important to quantify because the spatial distance from the river to where deposition occurs contributes to setting the sediment residence time. Finally, using our best probabilistic estimates of how the river may sweep across the floodplain, we are able to quantify the temporal distribution of sediment released from individual floodplains. This is only part of the total source-to-sink lag time because once released that sediment can also temporarily deposit in downstream floodplains, thus greatly increasing the legacy of sediment delivered from watersheds.

We apply our methodology to the South River in Virginia where historical mercury contamination has accumulated in the floodplain. Eventually, this mercury-contaminated sediment will move downstream through the Shenandoah River to the Potomac River before reaching the Chesapeake Bay.

Shadwick, Elizabeth, Marjy Friedrichs, Ray Najjar, Maria Herrmann

New CO2 system observations in the Chesapeake Bay: high-frequency variability and long-term trends

Type: Presentation

Abstract: *Understanding the vulnerability of estuarine ecosystems to anthropogenic impacts requires a quantitative assessment of the dynamic drivers of change to the estuarine carbonate (CO2) system. We report new high-frequency CO2-system observations from the Chesapeake Bay. An autonomous (SeapHOx) sensor was deployed on a surface buoy at the York River Spit in November 2016. The instrument makes hourly measurements of pH, along with dissolved oxygen, temperature and salinity, which are validated roughly monthly with discrete CO2 system samples. Using an empirical relationship between salinity and alkalinity for this specific location, the full CO2 system is resolved with hourly resolution. These observations yield insight into the natural high-frequency variability at this estuarine location. The sensor data are complimented by seasonal surveys in the Chesapeake Bay mainstem, which indicate large spatial and temporal variability in pH and carbonate saturation state throughout the region. The broader scale context of these new observations is assessed through* *comparison with an existing 30-year (1984 , present) time-series from a water-quality monitoring program and outputs from high-resolution hydrodynamic-estuarine-biogeochemical model for the Chesapeake Bay.*

Shen, Jian, Qubin Qin, Mac Sisson, Rico Wang

Assessing the impact of uniqueness of water quality model kinetic parameter and model uncertainty on phytoplankton simulations in the tidal James River, Virginia, USA

Type: Presentation

Abstract: *Eutrophication models have often been used to evaluate the impact of changes of environmental conditions on estuarine water quality, such as improvements to stormwater runoff conditions, nutrient reduction, channel deepening, installation of a storm surge barrier, etc. For a water quality model addressing complex biochemical processes, the accuracy of model simulations depends highly on the formulation of biochemical processes and kinetic parameters used for the model. As there is no unique solution for kinetic parameters and high correlations exist among parameters, the uncertainties of model simulations are difficult to quantify. It is unknown if the model response to the change of environmental conditions, such as a reduction of nutrients, will be different when conducting model scenario simulations with the use of different sets of model kinetic parameters. In this study, we used the 3D water quality model of the James River as an example to study the impact of the uniqueness of model parameters and its impact on the model performance and uncertainty associated with model response to the nutrient reductions. Multiple model simulations have been conducted. Correlations between model parameters and the uniqueness of model parameters and different formulations for algal growth are investigated. It is found that the model calibration based on statistics for chlorophyll-a is not sufficient to evaluate the model accuracy of model skill. Using different model parameters can often yield similar model skill scores based on statistics, while a large uncertainty can be associated with model response to the change of environmental conditions. Caution should be exercised when conducting model calibration.*

Shen, Chunqi, Jeremy Testa

Modeling carbonate system dynamics and responses to nutrient loading changes in Chesapeake Bay

Type: Presentation

Abstract: *Despite decades of research related to dissolved oxygen dynamics, organic carbon cycling, and nutrient biogeochemistry in Chesapeake Bay, studies of the carbonate system have been generally lacking until recently. With an increasing interest in the interaction between ocean acidification and eutrophication in estuaries worldwide, filling gaps in our lack of understanding of the carbonate system in Chesapeake Bay is particularly timely. To begin to address these gaps, we implemented a coupled hydrodynamic-biogeochemical model in Chesapeake Bay to investigate carbonate system dynamics, identify key contributors to carbonate system variations, and simulate the impact of altered nutrient loading on oxygen depletion and dissolved inorganic carbon cycling. The simulations realistically reproduced recent seasonal measurements of pH, total alkalinity, dissolved inorganic carbon (DIC), and surface water pCO2 made via vertical profiles spanning the entire*

salinity gradient in Chesapeake Bay. Model results reveal that eutrophication in Chesapeake Bay is associated with the development of hypoxia and the acidification of subsurface waters. Aerobic respiration contributes more than 50% of DIC production at hypoxic area, while calcium carbonate dissolution, sediment fluxes, and sulfate reduction account for the other fractions of DIC production. According to model simulations, the upper Bay is a strong source of CO2 to the atmosphere, while the middle bay is a net sink because of high primary phytoplankton production, which agrees with previous research in this area. Our model also suggests that acid water (pH <7.5) volume can be reduced as much as 25% assuming a 50% nutrient loading reduction from the Susquehanna River and Bay tributaries.

Shenk, Gary

Moving beyond total nitrogen and total phosphorus for the Chesapeake Bay TMDL

Type: Presentation

Abstract: *The 2010 Chesapeake Bay TMDL and subsequent planning targets have set limits on the nitrogen and phosphorus that the Bay can assimilate while still meeting water quality standards. During the 2010 TMDL process, it was recognized that nitrogen and phosphorus loads reaching the bay from northern and eastern tributaries had a greater impact than loads reaching the Bay from southern and western tributaries. It also was recognized that the relative influence of nitrogen and phosphorus varied throughout the Bay, with phosphorus decreasing in importance in the southern part of the Bay. In the 2017 Midpoint Assessment of the Chesapeake Bay TMDL, this concept was again used and expanded to consider differential effects of organic and inorganic nitrogen and phosphorus and the flow dependence of nitrogen and phosphorus for two major management decisions: accounting for climate change effects and accounting for Conowingo infill effects. The effects on attainment of water quality standards of dissolved oxygen is used in all cases as a common currency to determine the relative effects of nutrient species, timing, and spatial patterns of release into the Chesapeake Bay. The infill of the Conowingo reservoir is estimated to add more than ten million pounds of nitrogen and more than one million pounds of phosphorus per year. However, since the majority of the nitrogen and phosphorus increase is estimated to be scoured less-bioavailable organic material in large storms, the overall effect is only estimated to be equivalent to about six million pounds of nitrogen and a quarter million pounds of phosphorus delivered at normal times and species. An analysis of climate change effects on the Chesapeake TMDL showed that the change in total nitrogen and total phosphorus is estimated to be negligible in the short term. However, since a significant increase in more-bioavailable inorganic nitrogen, such as nitrate and ammonia, and inorganic phosphorus, or phosphate, will be offset by a decrease in organics, the overall effect is equivalent to approximately a nine million pound increase in nitrogen and a half million pound increase in phosphorus. That is, the change in load due to the infill of the Conowingo reservoir is greater than the change in load due to climate change, but due to differential effects of nitrogen and phosphorus forms and timing, the effect of climate change is estimated to be greater than the effect of Conowingo infill.*

Sisson, Mac, Jian Shen Rico Wang, Brian Joyner

Assessing the impact of floodgates to mitigate coastal flooding risks for the Lafayette River in Norfolk, Virginia, USA

Type: Presentation

Abstract: *The City of Norfolk (City) and the Norfolk District, U.S. Army Corps of Engineers (USACE), are partnering to conduct a Flood Risk Management Study (FRMS) to determine the Federal interest and feasibility of alternatives to mitigate coastal flooding risk in the City. The FRMS is in the Feasibility Study (FS) phase in which alternatives are proposed and developed to conceptual/preliminary design level, benefit/cost analyses are conducted, and environmental studies are completed to comply with the National Environmental Policy Act (NEPA). The magnitude of the feasibility study will require an Environmental Impact Statement (EIS). The purpose of the modeling is to support the determination of whether the proposed alternatives will have significant impacts on circulation and water quality, and if so, to what degree and what potential mitigation actions may be applied/required. Numerous simulations were conducted to assess changes to both hydrodynamics and water quality conditions, due to either the presence of the floodgates or how they are configured. Model results will be presented and assessed impacts on salinity and dissolved oxygen will be discussed.*

Smith, Richard, Andrew Sekellick, Ward Sanford, Joel Blomquist, Gregory Schwarz, John Brakebill

Delayed Watershed Response to Management of Chesapeake Bay Nitrogen Sources Caused by Long-term Storage of Nitrogen in Groundwater

Type: Presentation

Abstract: *Attributing observed trends in estuarine water quality to changes in nitrogen loading is a difficult watershed management problem due, in large part, to varying lags in the response of tributary water quality to controls on multiple sources. We describe the construction and application of an integrated modelling system that accounts for seasonal to multi-decadal lags in watershed response to total nitrogen (TN) source changes in two contrasting riverine systems in the Chesapeake Bay (US) watershed, the Potomac and Choptank. Groundwater is a dominant vector for TN transport from upland source areas to surface waters in these systems, and response lags are primarily the result of transient groundwater storage. The wide range in response times stems from variations in aquifer thickness and porosity. The modelling system involves a 5-step calibration process: (1) Compilation of historical (1950 , 2012) data on TN sources (housing density, fertilizer use, manure production, and atmospheric inorganic nitrogen deposition), nitrogen control practices, hydrology, and climate; (2) Development of a 60-year MODFLOW-based groundwater age-distribution model for the watersheds; (3) Use of the historical source data and groundwater age-distribution model to project groundwater nitrogen transport to 12,615 stream segments for the period 2002-2008; (4) Calibration of a dynamic SPARROW model of base-flow TN flux using source-specific estimates of groundwater inputs from Step 3, and base-flow load observations from 22 stream monitoring stations in the basin; (5) Calibration of a dynamic SPARROW model of total stream flux in the watershed using base-flow model predictions from Step 4 as 'groundwater' inputs along with records of contemporaneous surface and point sources for 2002-2008. Predicted response times following hypothetical reductions in surface*

sources range from less than one year to several years in the Potomac Basin, while response times can range to decades in the Choptank Basin. Lags in transport of nitrogen will make water quality improvements in many parts of the Chesapeake watershed difficult to detect and attribute to controls in the absence of integrated ground and surface water modeling.

Sommerlot, Andrew

Addressing the Limitations of Implementing Watershed Models At Fine Scales

Type: Presentation

Abstract: *Over the past few decades, much research has been published concerning the implementation of watershed models used to estimate the impacts of human actions on water quality. Multiple semi-distributed and distributed schema for processed based tools have emerged as one main category of watershed models used in studying the interaction of the agricultural landscape and management practices with water quality at fine scales. Although these models have made analysis and scientific study more accessible and easier overall, their continuing effectiveness is challenged by limitations. These limitations are highlighted in the case of the Chesapeake Bay Program, where watershed modelling is paramount to the creation of decision making tools designed to guide policy makers and stakeholder decisions toward meeting water quality criteria. No single processed based model has been satisfactory to adopt as a end-to-end solution. This is due to both scientific limitations including difficulties in performing multi-site calibrations effective at all local and sub-global levels in the Bay watershed, and engineering limitations, such as the inability to scale a fine resolution model up to the whole Bay. Thought leadership has steered modelling towards a combined approach, using multiple models and modelling techniques to address these, as well as other limitations, constraints, and goals. The result is a custom estimation tool on a platform accessible to non-technical interest groups, which utilizes well known science and satisfies the engineering constraints of actual implementation under high levels of scrutiny. This method has its own limitations, and a main guiding principle for the Chesapeake Bay Program in developing future watershed modelling techniques is to use finer-scale tools. An effective, fine scale watershed model for the Chesapeake Bay Program will have to address the scientific and engineering limitations present in modern tools, allow for flexible use in analyzing the watershed at multiple manager-and-stakeholder-based scales, and hold a high standard for fine scale outputs, all while being fully scalable to the complete Bay area. The work pilots early-stage adjustments and additions to existing modelling techniques, and experiments briefly with new frameworks, all focused on meeting these criteria. This study attempt to address, and also to and demonstrate the specific problems that building a fine resolution, large scale model in support of the Chesapeake Bay TMDL brings to light.*

Stankiewicz, Paul, Marin Kobilarov

Adaptive sampling of water nutrient concentrations utilizing autonomous underwater vehicles

Type: Poster

Abstract: *One of the most practical and influential applications of the recent advances in autonomous systems is in the environmental monitoring realm. For a given measurement of interest, i.e. dissolved oxygen or nitrates, localizing regions that contain either (1) high variability or (2)*

extreme values can help authorities identify potential abnormalities and address the problem. Traditional techniques for gathering this type of data typically rely on stationary buoys or human-operated vessels. More recently, autonomous underwater vehicles (AUVs) are being used in these scenarios; however, their data collection routines are typical constrained to following a predefined sampling trajectory, i.e. a lawnmower pattern. These strategies are highly inefficient when the overall goal is to locate and characterize small areas of highly concentrated data. Rather, autonomous systems now have the capability to adapt their trajectories based on in-situ data to focus sampling efforts on higher-level goals. Giving an AUV these higher-level goals such as locating, tracking, or mapping environmental phenomena lets the system execute this objective with greater efficiency due to the ability to adapt in response to measurements collected during the mission. In this way, much more information can be gathered about the measurement of interest than is currently available through static buoys or pre-planned trajectories. With regards to monitoring the health of the Chesapeake Bay, these systems allow precise hypoxic volume estimation by augmenting static buoys and ship-based sampling with multiple autonomous vehicles. Additionally, information-seeking adaptive sampling is capable of detecting and tracking nitrate hotspots from ground water aquifers and run-off.

This research provides optimal adaptive sampling strategies for AUVs to be deployed in an environment where limited operator interaction is available. In particular, this effort combines the areas of surrogate modeling, adaptive sampling, and optimal trajectory generation. Autonomous systems can leverage real-time surrogate models of the surrounding environment by using the models to inform the selection of new sampling points. A delicate tradeoff then must be balanced between densely sampling a region of interest, while also continuing to consider unexplored areas.

The proposed strategy of solving this problem is to combine Gaussian processes with optimal path planning. Gaussian processes have become the status-quo for surrogate modeling of environmental phenomena due to their ability to characterize both spatial correlations and measurement uncertainty within the model. Gaussian process regression is a Bayesian, non-parametric modeling technique where model uncertainty can be exploited to guide sampling to high-information areas. Trajectory optimization can then utilize these models by choosing the sampling paths that have the highest reward with respect to the desired mission. Steps to the proposed sampling algorithm include the following: (1) Perform Gaussian process regression to model the environment based on collected measurements. (2) Use the Gaussian process upper confidence bound algorithm to choose subsequent sampling locations in a multi-armed bandit setting. (3) Perform receding horizon cross-entropy trajectory optimization for path planning between sampling locations. The advantages of the proposed sampling routine are shown both in simulation data and initial field testing results on an Iver3 AUV.

Staver, Ken, Qian Zhang, William Ball
Improving estimates of sub-scour storm flow loads to Chesapeake Bay from the Susquehanna watershed
Type: Presentation

Abstract: *Storm flow delivers the majority of sediment and phosphorus to Chesapeake Bay. The Susquehanna is the single largest tributary of the Bay and plays a central role in Bay water quality, especially the main stem. A handful of large storms are unique in the Susquehanna record, because in addition to having delivered large loads from the watershed, they also scoured sediment from the lower Susquehanna reservoir system which resulted in the highest sediment concentrations measured by the USGS at the outfall of the Conowingo Reservoir. The two tropical storms (Ivan in 2004; Lee in 2011) that led to reservoir scour in the modern water quality record (1978-present) generated peak sediment concentrations that were considerably higher than any measured in other storms, and Lee also generated sub-scour sediment concentrations that stood out from samples collected at sub-scour flows in lesser storms. This suggests the possibility that including tropical storm data in load estimation approaches can result in overestimates of loading that occurs during very high but sub-scour storm flows. The 'Weighted Regressions on Time, Discharge, and Season' model (WRTDS) has been used extensively, and almost exclusively in recent times, to generate concentration values in the Bay watershed for days when sample data are not available, and to generate daily and annual loads to the Bay. Comparison of WRTDS output with sample data for the final monitoring point on the Susquehanna before discharge into the Bay indicates that sub-scour storm flow concentrations tended to be overestimated in the time and season windows influenced by tropical storms Ivan and Lee. This suggests that sub-scour storm loads to the Bay from the Susquehanna were overestimated in this period which covers from the year 2000 to the present, particularly for moderately high discharges in and near the month of September. This presentation will describe these issues and consider options for improving the accuracy of estimates of sub-scour storm concentrations. The goal is to increase accuracy of overall load estimates, particularly for sub-scour storm loads which dominate sediment inputs to the Bay from the Susquehanna in most years when scour flows do not occur.*

Steppe, Cecily, Andrew Keppel, Louise Wallendorf, Luis Rodriguez, Grace Pruden

Relating Severn River oyster reproduction to high-frequency water quality data

Type: Poster

Abstract: *Chesapeake Bay oyster populations (Crassostrea virginica) have been decimated over the last century by a combination of anthropogenic and natural factors. To alleviate the loss of oysters and associated ecosystem services, substantial efforts have been made over the last decade to restore Chesapeake Bay's oyster populations. Much of this work has focused on small tributaries. For example, since 2000 the National Oceanic and Atmospheric Administration and the U.S. Army Corps of Engineers have built and supplemented oyster reefs in the Severn River, a sub-estuary of Chesapeake Bay near Annapolis, Maryland USA. To most efficiently allocate economic resources to Chesapeake Bay restoration, however, it is important to consider whether or not a restoration site is favorable for reef maintenance via self-seeding. Historically, the Severn River has shown minimal annual spat set, and this has been attributed to low salinities that could reduce gamete production. However, recent work has demonstrated that oysters in the Severn River do undergo gametogenesis, suggesting that timing of spawning and or*

larval survival could limit oyster recruitment. To this end, in 2013 we sampled oysters grown in cages in the Severn River every two weeks from June to October for histological analysis (n=180). For each oyster we both calculated a gonadosomatic index, and assigned a gametogenetic stage. We compared the results to high-frequency data from a nearby continuous water quality monitoring station to determine whether salinity, temperature, or hypoxia could be limiting gamete development. Well-developed gonads and gametes were found throughout most of the spawning period, with apparent spawning occurring in late August. This result suggests that other factors, such as insufficient spawning stock for successful fertilization, unfavorable water quality for larval development, or advection from the parental stock causes the low recruitment observed in the Severn. We suggest that continued high frequency water quality monitoring, larval sampling, and applying physical models of Severn River hydrodynamics be used to determine the potential for oyster recruitment to, and efficient restoration of Severn River reefs.

St-Laurent, Pierre, Marjorie Friedrichs, Raymond G. Najjar, Elizabeth Shadwick

Changes in Chesapeake Bay air-sea CO2 fluxes over the past century

Type: Presentation

Abstract: *Over the past century, the population of the Chesapeake Bay region has almost quadrupled, greatly modifying land cover and management practices within the watershed. Simultaneously, the region has been experiencing a high degree of climate change, including increases in temperature and precipitation intensity. Together, these shifts have resulted in dramatic changes in carbon cycling within Chesapeake Bay. To better understand these changes on a variety of time scales, we use a linked land-estuarine-ocean modeling system that includes both inorganic and organic carbon cycling, and compare two multi-year simulations: one from the first decade of the 1900s and one from the first decade of the 2000s. The changes between these two periods caused the Bay to become increasingly net autotrophic in the spring season, and this shift was accompanied by an increase in spring uptake of CO2 and a corresponding decrease in annual net outgassing of CO2. In this presentation, we examine how four environmental drivers have contributed to these overall changes: (1) riverine inputs of inorganic carbon/alkalinity, (2) riverine inputs of inorganic nitrogen, (3) atmospheric CO2, and (4) temperature. The contribution of these four drivers varies considerably. Despite dramatic variations in the alkalinity and inorganic carbon inputs of the Susquehanna River over the past century, these variations are found to have a fairly small effect on the net outgassing of the whole Bay. In contrast, the two-fold increase in riverine inputs of inorganic nitrogen over the last century had a profound impact on the Bay. This increase is responsible for the shift toward a more autotrophic bay and it caused, in turn, the substantially higher CO2 uptake during the spring season. The last two drivers (atmospheric CO2 and temperature) have a significant effect on the net air-sea CO2 flux of the Bay but not to the same extent as changes in the riverine inputs of inorganic nitrogen. Our findings support the hypothesis that changes in land use and climate substantially alter carbon cycling and air-sea CO2 fluxes in estuaries.*

Su, Jianzhong, Wei-Jun Cai, Jean Brodeur, Baoshan Chen, Najid Hussain

A bay-wide self-regulated pH buffer mechanism in response to eutrophication and acidification in Chesapeake Bay

Type: Poster

Abstract: *Additions of CO2 and acid from the atmosphere, biological respiration, and oxidation of reduced chemical species have led to severe acidification in estuarine and bay waters. However, it is not known how eutrophic and seasonally hypoxic water bodies resist anthropogenic forcing. Using calcium and carbonate chemistry data from the Chesapeake Bay and geochemical model analysis, we reveal a bay-wide self-regulated pH buffer mechanism via calcification and CaCO3 dissolution to resist coastal eutrophication and acidification. In summer, the submerged aquatic vegetation in the shallow upper bay and longshore assimilates considerable nutrients via intensive photosynthesis, and provides a super high-pH environment, which facilitates CaCO3 crystal formation by calcifying epiphytes and plants. In the subsurface water of the mid and lower bay, CaCO3 particles from the bay shores dissolve to buffer the pH decrease caused by CO2 from aerobic respiration, providing relatively stable pH conditions. This study presents a previously undocumented pH buffer mechanism as a result of nutrient load reductions and SAV recovery. These results demonstrate that coastal ecosystems can further promote their own recovery in complex, sometimes unpredictable ways as we release the pressures exerted by anthropogenic stressors.*

Talebpour, Mahdad, Claire Welty

Building a comprehensive model for fully coupled urban atmospheric-hydrological processes

Type: Poster

Abstract: *This study aims to build a fully coupled atmosphere-land surface-subsurface hydrological model for urban areas. Previous regional-scale urban models have not been fully coupled as they have either neglected groundwater dynamics or atmospheric dynamics. Such models have focused either on atmosphere-land surface coupling, representing groundwater dynamics as boundary conditions, or on groundwater-land surface coupling, using atmospheric processes as boundary conditions. Moreover, urban areas are characterized by fine-scale heterogeneous landscape features, compared to natural landscapes. The urban canopy (composed of a complex array of surfaces) can cause substantial alteration of atmosphere-land surface processes, including evapotranspiration, atmospheric boundary layer formation, and sensible heat flux. Groundwater dynamics are also altered by urban features, where impervious surfaces affect locations and rates of infiltration to the subsurface and rate of evaporation from the vadose zone. In addition, other anthropogenic urban features (lawn irrigation, stormwater and wastewater infrastructure) typically alter water balances in urban areas. In some cases, it may be critical to include these processes in urban hydrologic-atmospheric models. Here we present results of simulations of a new version of WRF.Noah.ParFlow, where the new component is incorporation of the Princeton Urban Canopy Model (PUCM), to simulate urban atmosphere-land surface-groundwater processes. Our longer-term goal is to apply this model to three metropolitan areas of distinctly differing in climate characteristics (Baltimore, Denver, Portland), as part of the Urban Water Innovation Network project supported by National Science Foundation. The purpose of*

the project is to evaluate coupled water-energy scenarios where the impacts of the coupling on the water cycle may be important. Here we present a test run of the coupled model for a small urban watershed, with the caveat that the model is intended for applications at much larger scales where spatial variability in atmospheric dynamics would be relevant. The illustrative test case is for Dead Run, a highly urbanized watershed located in the Baltimore, MD metropolitan area. We utilized a 256 km2 domain centered on Dead Run watershed for the simulations. We compare soil moisture and temperature outputs at the land surface from the two models to identify the differences caused by underrepresentation of groundwater flow in WRF.Noah.PUCM. Further modifications of the model are in progress to enable representation of highly-resolved land cover and hydrologic processes (Noah.ParFlow grids) within coarser- gridded representation of atmospheric processes (WRF).

Tarpley, Danielle, Carl T. Friedrichs, Courtney K. Harris

Temporal variability in sediment suspension and sediment-induced stratification related to freshwater discharge in the York River estuary, Virginia, USA

Type: Presentation

Abstract: *The factors governing suspended sediment concentration (SSC) in cohesive environments, such as tidal estuaries, are complex. Sediment-induced stratification inhibits the upward diffusion of sediment, which effects light penetration and biogeochemistry throughout the water column. The York River is a moderately energetic, partially-mixed tidal estuary whose sediment bed is dominated by mud. Previous studies that explored tidal variability in near-bed SSC in the York River have shown that the largest concentrations (a few 100 mg/liter) directly follow peak tidal flow, and that high SSC is associated with reduction of the bottom drag coefficient, which is an effect of sediment-induced stratification. The availability of sediment for suspension in York River has been characterized using bed erodibility, which has been shown to vary with sediment bed composition and the presence or absence of a discharge-related secondary turbidity maximum. To further examine the influence of hydrodynamic conditions on SSCs and sediment-induced stratification, instrumentation was deployed in the middle reaches of the York River in the fall of 2016 under low river discharge (August 25 - September 13) and the late spring of 2017 under elevated river discharge (May 8 - June 6). Instrumentation included a downward looking Sontek® Pulse-Coherent Acoustic Doppler Profiler (PC-ADP), multiple Acoustic Doppler Velocimeters (ADVs), Laser In-Situ Scattering Transmissometry (LISST), multiple conductivity-temperature-depth sensors and an upward looking current profiler. These instruments provided measures of suspended sediment concentration, velocity profiles, turbulence characteristics, and stratification. The deployments covered a range of conditions including flood/ebb tides, the spring/neap cycle, and seasonal changes in river discharge.*

Flow velocities and SSCs vary over a range of timescales; at the seasonal timescale they are higher during elevated river discharge. On tidal timescales they are higher during the flood and spring tides. At first glance, seasonal differences in suspended sediment concentrations are stronger than either flood/ebb or spring/neap tidal variations. Estimates of Reynold's stress from 20 cm *above the bed are lower under heightened river discharge, in spite of the higher flow velocities, which may be attributed to sediment-induced stratification. Additionally, when river discharge is elevated, the erodibility of the bed is greater, and finer sediment is seen in suspension. SSC profiles, calculated gradient Richardson number, and upper water column hydrodynamics provide further insights on the impacts of sediment-induced stratification on sediment distribution in the water column. Both a tower of ADVs and upward looking current profiles show temporal variations in velocity shear. Near the bed, downward looking current profilers and point measurements show variability in SSC determined from acoustic backscatter, and in the resulting gradient Richardson number.*

Taylor, Scott

National Municipal Stormwater Alliance

Type: Presentation

Abstract: *Discussion of new national non-profit corporation, National Municipal Stormwater Alliance*

Testa, Jeremy, Vyacheslav Lyubchich, Qian Zhang

Patterns and Trends in Secchi Disk Depth over Three Decades in the Chesapeake Bay Estuarine Complex

Type: Presentation

Abstract: *Water clarity is an important ecosystem indicator of Chesapeake Bay, the largest estuary in the United States. Understanding both the long-term degradation and the recent improvements is critical to targeting management actions that support continued improvements in water clarity. We conducted a comprehensive analysis of Secchi disk depth in Chesapeake Bay and its tributaries over the last thirty years to better understand the spatiotemporal patterns of Secchi depth as well as key controlling mechanisms. The nature of long-term change in Secchi depth is dependent on both season and location along the salinity gradient. Our results support previous findings related to particulate matter controls on light attenuation, but reveal new details related to the spatial and temporal patterns of these relationships. Although watershed nutrient, sediment, and freshwater inputs did not correlate with Secchi depth, water-column variables that represent the consequences of those inputs were important, such as total suspended solid (TSS) and chlorophyll-a concentrations. The inconsistency of these two findings may be explained by controls on chlorophyll-a and TSS that are not directly related to watershed input, such as grazing and resuspension, and by lags of several months between watershed input and water-column concentrations. Regardless of the specific mechanism, we were able to associate long-term changes in Secchi depth with changes in TSS and chlorophyll-a concentrations, and infer that the particular driver of change was region-specific and associated with salinity regimes. These findings reinforce the value of watershed restoration actions designed to limit nutrient and sediment inputs to Chesapeake Bay and its tributaries and the potential of achieving co-benefit in improving water clarity in the Bay estuarine complex.*

Thuman, Andrew, James Hallden, Richard Isleib, Ruta Rugabandana, William Hunley

James River Overflow Model: GUI Development for Model Ease of Use

Type: Presentation

Abstract: *The Hampton Roads Sanitation District (HRSD) owns and operates six (6) treatment plants (TP) that discharge to the*

tidal James River or its tributaries. These TPs include: Williamsburg; James River; Boat Harbor; Nansemond; Virginia Initiative Plant (VIP); and Army Base. In addition, there are pump stations and conveyance systems that are not owned by the HRSD that can also potentially contribute to overflows to the James River. As part of an overflow assessment for the James River TP in 2003, HDR developed a refined model of the James River for use in assessing the potential water quality impacts in the river associated with the overflow (HydroQual, 2003). Since development of this model, there have been a number of other overflows to the James River that could be assessed with the James River Overflow Model (JROM). The goal of HRSD was to develop a model graphical user interface (GUI) for the JROM to allow HRSD staff to easily and quickly complete assessments for future overflows to the river, if they occur.

The transport of a constituent associated with an overflow (i.e., bacteria) is controlled by the circulation in the river and by bacterial die-off rates that are affected by solar radiation, temperature and salinity. The circulation in the river is calculated with a hydrodynamic model (ECOMSED), which requires the assignment of model inputs for: freshwater flow (upstream James River and tributaries); downstream Chesapeake Bay and Atlantic Ocean tidal conditions (water elevation, salinity and temperature); and meteorological conditions (e.g., wind speed/direction, solar radiation, air temperature). The water quality model (RCA) uses the hydrodynamic model circulation output to calculate the ultimate fate of the overflow constituents given the assigned magnitude and duration of the event and bacterial die-off rates. This linkage of the water quality and hydrodynamic models is completed through the GUI, which allows the user to assign various characteristics of an overflow event: model grid cell where the overflow enters the river; flow and duration of the overflow event; start time of the overflow event (e.g., month/day/year/hour); and overflow concentration of bacteria; and base bacterial die-off rates. In addition, the user can select a hydrodynamic circulation pattern to use and enter observed bacteria concentration data for comparison to the model calculated bacteria levels.

The GUI provides information about the model study area in GIS-based shape files such as: model grid; TP locations; pump stations and conveyance system; beach areas; shellfish harvesting areas; water bodies; counties; and land marks. The GUI also provides a means for presenting the results of an overflow assessment through time-series graphs of bacteria concentrations and also through mapping/animation of the model output over time to present the spatial influence of a particular overflow event. Model output is also saved to an MS Access database and GIS-based shape files.

The model results provide a means for quickly assessing the spatial impact of an overflow, magnitude of the resulting bacteria concentrations and an ability to relay any potential impacts on sensitive areas to utility managers or stakeholders.

Tian, Richard, Carl Cerco, Lewis Linker

Influence of Oyster Aquaculture on water quality attainment in Chesapeake Bay: II. Model implementation and application

Type: Presentation

Abstract: *Oyster aquaculture is on a trajectory of exponential expansion in*

Chesapeake Bay, by 1,000 percent from 2012 to 2016 in Maryland waters, and it is even more established in the Virginia portion of the Bay. The primary goal of oyster aquaculture is for economic revenue, but there is also an environmental co-benefit that oysters help to clean up the Bay through the filtration and removal of organic and inorganic particles in the water column. Two specific mechanisms lead to the environmental benefit. First, oyster harvest from aquaculture represents a net nutrient removal from the Bay. Secondly, oyster filtration conveys particulate organic and inorganic substances from the water column to the sediment through biodeposition, followed by burial and denitrification for nitrogen, and sequestration of phosphorus in sediments with overlaying aerobic water. An expert panel has been formed to guide the Bay Program in assessing the environmental benefit of oyster aquaculture to the Bay. Based on data and trends, the oyster expert panel projected that oyster aquaculture will reach to 112 million oysters harvest in 2025 in Maryland waters and 280 million oysters harvest in the Virginia portion of the Bay, equivalent to an annual removal of 466x103 lbs carbon, 78x103 lbs nitrogen, and 8.6x103 lbs phosphorus. This paper presents model estimates of the potential impact of oyster aquaculture on water quality attainment using the projected aquaculture activities and the 2017 version of the Chesapeake Bay Program's Bay Model (Water Quality and Sediment Transport Model , WQSTM). In Maryland, approximately 80% of the oyster aquaculture are on the bottom and 20% are suspended in the water. In Virginia, 20% are on the bottom and 80% are suspended in the water. Water column cultured oysters grow faster and reach to commercial size in two years, whereas bottom cultured oysters need three years to reach to harvest size. As such, 1.5 times the harvest is used as oyster biomass in the model for water column culture and 2 times for on-bottom culture. The model simulates the biogeochemical processes related to the oyster like filtration, respiration, and deposition of organic substances, and the net nutrient removal was reduced from the watershed loading at the appropriate locations based on oyster aquaculture fields. Six scenarios were simulated, three based on the TMDL scenario (without oyster aquaculture, with oyster nutrient removal only and with both nutrient removal and biogeochemical processes, respectively) and the other three based on the calibration. In the deep trench in the middle of the Bay where hypoxia occurs the most frequently, dissolved oxygen attainment is estimated to be improved 5 percent by the oyster nutrient removal, and by 13 percent when both nutrient removal and biogeochemical processes are taken into account. This is equivalent to 1.2 million pounds of nitrogen and 22 thousand pounds of phosphorus removal from the watershed. Our study shows that oyster aquaculture has the potential to be an effective BMP for the Bay restoration. Detailed analysis on nutrient fluxes, biogeochemical processes, and impact on local waters will be presented at the conference.

Tian, Richard, Lewis Linker

Impact of geomorphology and meanderings on saltwater intrusion, lateral advection, and hypoxia in the Chester River Estuary

Type: Presentation

Abstract: *Extensive data have been collected over the years in the Chester River Estuary by the Chesapeake Bay Monitoring Program (CBP) and an application of the coupled FVCOM-ICM model has been carried out using the observations from 2001 to 2010. The FVCOM-ICM application*

was part of a mult-model assessment of Chester River Estuary. The assessment of the forcing data at the fall line, including river discharge and nutrient loading, were provided from the Chesapeake Bay partnership Watershed Model (Phase 5.3.2) and open boundary conditions at the mouth of the Chester were specified with the output of CH3D-ICM model (2010 version). Wind forcing, air temperature, and pressure were from the Thomas Point Lighthouse monitoring station. Other surface forcing data were from the NOAA North Atlantic Regional Reanalysis. The models were first spun up for 5 years using 2001's forcing data and then continuously run from 2002 to 2010, calibrated and validated against the CBP monitoring data. The Chester River Estuary is characterized with several submerged river meanders and the model shows discontinuous spatial distribution of hypoxia at these curvatures. Low Brunt-Väisällä frequency and strong lateral circulation are also simulated at these curvatures, which can be explained by the helical circulation theory caused by centrifugal force at estuary meanderings. The simulation shows that the gravitational circulation and saltwater intrusion are also subject to the geomorphology and meanders in the Chester River Estuary.

Trapp, J. Michael

Current topics in Quantitative Microbial Risk Assessment (QMRA)

Type: Presentation

Abstract: *The US faced with a growing number of regulatory water quality impairments, the most prevalent of these issues involve fecal bacterial contamination (>13% nationwide). Bacterial contamination is not only the most prevalent, but the most complex as a result of the diverse nature of sources, sinks, and reproduction in the environment. To further confound the issues the bacteria used for regulatory compliance are not the organisms that directly pose the public health concerns. Rather they are indicators of pathogens which epidemiology studies have shown relationships to human health concerns.*

Over the past decade, there have been significant advancements in the identification of sources of bacteria pollution in surface waters which include the use of host specific genetic (qPCR) markers to target source control activities and remediation. However, due to nature of these bacteria indicators to survive in the environment in many cases these efforts do not result in achieving water quality objectives.

The development of quantitative microbial risk assessment (QMRA) aims to change the focus of regulatory compliance from achieving a numeric target to focusing on the threat posed to the public. The basis of this is that bacteria from human waste contains the highest concentration of human pathogens and thus poses a greater threat for illness than from other sources or environmental bacteria. QMRA can involve a number of steps ranging from very precise sampling to determine pathogen concentrations to site specific epidemiological studies. Data produced in this process is used to calculate a site specific profile that determines an associated public health risk for different levels of bacterial concentrations. Based on this profile a bacterial water quality standard can be set for that location which represents an acceptable illness rate and risk level.

Traver, Robert, Bridget Wadzuk

Advances in understanding the role of infiltration and evapotranspiration in Green Infrastructure

Type: Presentation

Abstract: *Our understanding of the roles of infiltration and evapotranspiration have grown dramatically over the last two decades. These components are the fundamental basis of all green infrastructure systems in one form or the other. As our knowledge base expands through research, an opportunity is created to improve performance and resilience of these systems by applying our expanded understanding of infiltration and evapotranspiration.*

Trentacoste, Emily, John Wolf, Aera Hoffman

Integrating 30 years of Chesapeake Bay data into a new decision support framework for Watershed Implementation Plan development

Type: Presentation

Abstract: *In 2018, the jurisdictions in the Chesapeake Bay watershed are beginning development of their final Watershed Implementation Plans (WIPs) for the Chesapeake Bay TMDL. An overwhelming amount of new and updated data and information is available to help understand changes in water quality and inform management decisions that go into the WIP. However, this information currently exists in disparate places and is difficult to visualize or utilize. Additionally, jurisdictions are engaging local areas during WIP development to strategize restoration planning efforts at a finer resolution, so information is necessary at smaller scales such as counties or subwatersheds. We have been developing a decision support tool for managers at both the jurisdictional and local level, that provides visualization, access, and guidance on use of integrated Chesapeake Bay watershed data such as water quality monitoring and trends, modeling inputs and outputs, BMP implementation, and geospatial information. The tool has been developed with extensive upfront research on user needs to ensure its utility, specifically for Phase III WIP development. Here we present the tool, the process by which it was developed, and the decision-support framework that it provides.*

Uhlig, Kelley, Robert C. Hale, Drew Luellen

Partitioning of Organic Contaminants to Conventional and Bio-based Polymers

Type: Poster

Abstract: *With ever-rising amounts of plastic pollution in coastal waters including the Chesapeake Bay, there are concerns over the potential for microplastics (sub-5 mm particles) to concentrate and transfer hydrophobic organic contaminants (HOCs) through aquatic food webs. Greater awareness regarding the pervasiveness and potential dangers of plastic debris has led to increasing adoption of more degradable "bioplastics," which are polymers derived from biological processes. It is predicted that market share of bio-based plastic products will rise in the coming years, yet no studies to date have addressed the potential for these plastics to concentrate HOCs. The objective of this study was to determine the partitioning coefficients for representative HOCs to two bioplastics, polyhydroxyalkanoate (PHA) and polylactic*

acid (PLA), compared to two conventional plastics, high-density polyethylene (HDPE) and polyvinyl chloride (PVC). To investigate this, we performed batch sorption experiments with each polymer/HOC combination. Experiments were conducted by combining each polymer type with autoclaved 35ppt salt water and adding varying amounts of the HOC of interest. Reaction vessels were mixed continuously for 48 hours until they reached equilibrium, at which time the polymer was separated from the water. Extracts of water and plastic pairs were analyzed by gas chromatography-mass spectrometry and the partitioning coefficients for each polymer/HOC combination calculated. Preliminary results indicate that the partitioning of HOCs to bio-based polymers is less than the partitioning to conventional polymers, potentially due to the differences in surface hydrophobicity and crystallinity of the polymer types.

Uhlig, Kelley, Bongkeun Song

Comparing Estuarine Microbial Community Composition of Conventional and Bio-Based Polymers

Type: Presentation

Abstract: *Plastic debris provides a unique habitat for microbial fouling communities. Colonization by microorganisms affects the fate of plastic debris by way of altering the density of floating plastics, initiating biodegradation, and facilitating ingestion by organisms. Furthermore, pathogenic and invasive species have been found to colonize plastic debris. Marine-borne plastics are more persistent than natural particles and debris found in coastal and open-ocean systems, potentially allowing for greater transport and distribution of any colonizing microbes. The current literature regarding microbial communities on plastic debris mainly concerns debris found in the open oceans, though most debris originates in coastal environments including estuaries. This study compared the estuarine microbial colonizers of five polymer types using next-generation sequencing. The five polymers chosen include two conventional polymers, high-density polyethylene (HDPE) and polyvinyl chloride (PVC), two bio-based polymers, polyhydroxyalkanoate (PHA) and polylactic acid (PLA), and naturally present chitin. Polymers were deployed for up to four weeks in the lower York River, a major tributary of the Chesapeake Bay. Initial results indicate distinct differences between conventional and bio-based polymer microbial communities, which can have implications for transport of pathogens.*

Van Meter, Kimberly, Philippe Van Cappellen, Qian Zhang, Nandita Basu

Landscape Legacies: Long-Term Nitrogen Trajectories in the Chesapeake Bay Watershed and Beyond

Type: Presentation

Abstract: *Global flows of reactive nitrogen (N) have increased significantly over the last century in response to land-use change, agricultural intensification and elevated levels of atmospheric N deposition. Despite widespread implementation of a range of conservation measures to mitigate the impacts of N-intensive agriculture, N concentrations in surface waters are in many cases remaining steady or continuing to increase. Such lack of response has been attributed to legacy N stores in subsurface reservoirs that contribute to time lags between conservation measures implemented on the landscape and water quality benefits realized in receiving water bodies. It has remained unclear, however, what the magnitudes of such stores might be, and how they are partitioned between*

shallow soil and deeper groundwater reservoirs. In the present work, we have synthesized data to develop a comprehensive, 214-year trajectory of N inputs to the land surface of the Mississippi River Basin (MRB) as well as the Susquehanna and other watersheds draining into the Chesapeake Bay. Based on this dataset, we have used the ELEMeNT model - which pairs a simulation of soil nutrient dynamics with a travel time-based approach - to reconstruct historic nutrient yields at the outlets of these watersheds and to model future N-loading under a range of scenarios. Our results show significant N loading above baseline levels in both watersheds before the widespread use of commercial N fertilizers, largely due to 19th-century conversion of natural forest and grassland areas to row-crop agriculture. By quantifying the magnitudes of legacy N accumulation in soil and groundwater pools, the model results also highlight the dominance of soil N legacies in MRB and groundwater legacies in Chesapeake watersheds. Our modeling of future scenarios indicates that even if agricultural N use were to become 100% efficient, it would take on the order of decades to meet policy goals for improving water quality. Our results suggest that significant time lags should be anticipated when aiming to reduce N export, and that both long-term commitment and large-scale changes in agricultural management practices will be necessary to meet such goals.

Voinov, Alexey

Modeling for action: in search of new interfaces

Type: Presentation

Abstract: *Perhaps one of the reasons why we often fail to take action based on the scientific knowledge we already have is because we cannot synchronize the understanding of systems gained from models, with human perceptions, beliefs, values and preconceived notions about the system that already exist. The modeling results may go contrary to our preferences and priorities. We find it difficult to act based on the models and the logic of Kahneman's system 2 slow type of thinking involved, when it clashes with the intuitive system 1 fast type of thinking. Engaging stakeholders in the modeling process in a participatory process can help resolve some of these contradictions, though in many cases it is still difficult to organize and conduct the process properly. New technologies inspired by social media and wide access to the Internet deliver opportunities for broad democratic engagement of the public in science and decision making. However the process is easily compromised by increasing uncertainties associated with information production and sharing, group thinking, and clustering along cultural, educational or party lines.*

Integrated modeling is seen as a way to connect modeling efforts across disciplines and developers, including on-going model development and existing legacy models. So far most of the integration is happening at the level of software, when models are presented as software components, which are further connected applying various programming tools. However there is a large category of models that come in form of concepts, the so-called conceptual models. In some cases these are just the first stage of developing more detailed models that eventually do end up as software, however some conceptual or mental models never get any further developed, providing important services as is, in the form of conceptual diagrams, cognitive maps, stories, scenarios.

For examples in participatory research, the stage of conceptualization may prove to be sufficient for finding consensus and helping to make the best decision.

We see a lot of potential in taking model integration beyond the software coupling, and considering mental models developed by stakeholders in addition to computer models. Model integration should then deal with coupling of all sorts of models, including software components and conceptual models produced by stakeholders. However appropriate coupling tools, or interfaces are still missing. Such interfaces are essential to assist stakeholder interaction, helping stakeholders communicate knowledge and information among themselves, by providing a common framework and language to express their individual mental models, ideas and data.

Wagena, Moges, Zach Easton

Agricultural Conservation Practices Can Help Mitigate the Impact of Climate Change

Type: Presentation

Abstract: *Agricultural conservation practices (CPs) are commonly implemented to reduce diffuse nutrient pollution. Climate change can complicate the development, implementation, and efficiency of agricultural CPs by altering hydrology, nutrient cycling, and erosion. This research quantifies the impact of climate change on hydrology, nutrient cycling, erosion, as well as the effectiveness of agricultural conservation practices in the Susquehanna River Basin within the Chesapeake Bay Watershed, USA. We set up, calibrate and test the Soil and Water Assessment Tool-Variable Source Area(SWAT-VSA) model using weather, soil, and land use data and select four BMPs, buffer strips, strip crop, no-till, and tile drainage, to test their response to climate change. We force the calibrated model with six downscaled global climate models (GCMs) for a historic period (1990-2014) and two future scenario periods (2041-2065) and (2075-2099) and quantify the impact of climate change on hydrology, nitrate-N (NO3-N), total N (TN), dissolved phosphorus (DP), total phosphorus (TP), and sediment export with and without BMPs. We also tested prioritizing BMP installation on the 30% of agricultural lands that generate the most runoff (e.g., critical source areas-CSAs). Compared against the historical baseline and excluding the impact of BMPs, the ensemble model mean predictions indicate that climate change would result in annual increases in flow (4.5→7.3%), surface runoff (3.5→6.1%), sediment export (28.5→18.2%) and TN (9.5→5.1%), but decreases in NO3-N (12→12.8%), DP (14→11.5), and TP (2.5→7.4%) export. When agricultural BMPs are simulated most do not appreciably change the overall water balance, however, tile drainage and strip crop decrease surface runoff generation and the export of sediment and DP/TP, while buffer strips reduce N export substantially. Installing agricultural CPs on CSAs results in nearly the same level of performance for most practices and most pollutants. These results suggest that climate change will influence the performance of agricultural CPs and that targeting agricultural CPs to CSAs can provide nearly the same level of performance as more widespread adoption*

Wagena, Moges, Andrew R. Sommerlot, Elyce Buell, Gopal Bhatt, Zachary M. Easton

Quantifying Structural Model Uncertainty using a Bayesian Multi-Model Ensemble

Type: Presentation

Abstract: *Watershed models are essential tools to understand, quantify, and predict hydrologic processes and nutrient. However,* *the reliability of watershed models in a management context depends largely on associated uncertainties. The objective of this study is to quantify structural uncertainty of flow, sediment, total nitrogen (TN), and total phosphorus (TP) predictions using three models: the Soil and Water Assessment Tool-Variable Source Area model (SWAT-VSA), the standard Soil and Water Assessment Tool (SWAT-ST), and the Chesapeake Bay watershed model (CBP-model). We initialize each of the models using weather, soil, and land use data and analyze outputs of flow, sediment, TN, and TP for the Susquehanna River basin at the Conowingo Dam in Conowingo, Maryland. Using these three models we fit Bayesian Generalized (Non-) Linear Multilevel Models (BGMM) for flow, sediment (log), TN, and TP (log) and obtain estimated outputs with 95% confidence interval. We compare the BGMM results against the individual model results and straight model averaging (SMA) results using a split time period analysis (training period and testing period) to assess the BGMM in a predictive fashion. The BGMM provided better predictions of flow, sediment, TN, and TP compared to individual models and the SMA during the training period. However, during the testing period the BGMM was not always the best predictor, in fact, there was no clear best model during the testing period. Importantly, the BGMM provides estimates of prediction uncertainty, which can enhance decision making and improve watershed management by providing a risk-based assessment of outcomes.*

Wainger, Lisa

Using Environmental Economic Models to Support Decision Makers

Type: Presentation

Abstract: *Environmental economics has much to offer decision makers by providing a framework for 1) establishing values of environmental changes, 2) comparing costs, benefits and risks of alternative actions, and 3) maximizing cost-effectiveness of environmental restoration. In addition, new understanding of behaviPresentation biases generates opportunities to design programs that nudge people to improve their well-being, instead of assuming that information alone will be sufficient to generate action. However, any application of environmental economics depends on a solid foundation of ecological and social science. This talk will use case studies to highlight emerging understanding of how ecosystem service bundles are generated through management practices and how such information can be integrated to support different types of decision makers. For example, results from an effort by an interdisciplinary group of government and academic researchers addressed the question: Can the public water quality benefits of USDA programs be measured with existing data, methods, and information? The team's goal was to assess the state of the science and demonstrate a process for valuing a representative suite of ecosystem service benefits with monetary or non-monetary benefit metrics. Using the lessons learned from the case studies, the talk will present options for generating information at spatial and temporal resolutions useful for tailoring management to real-world choices.*

Walsh, Heather, Vicki Blazer, Luke Iwanowicz

Testes Transcriptome Development and Molecular Identification of Intersex in Smallmouth Bass from Tributaries in the Chesapeake Bay

Type: Presentation

Abstract: *Intersex, the presence of testicular oocytes (TO), was first described in male smallmouth bass from the Potomac River basin in 2003 and in the Susquehanna River basin in 2007. The presence of intersex was discovered during fish health assessments which were conducted after smallmouth bass experienced disease and mortality events and prevalence reached as high as 100%. Intersex has been widely studied in fish and is used as a biomarker of exposure to estrogenic endocrine disrupting chemicals (EDCs) released in wastewater treatment plant effluent, agricultural runoff, and industrial effluent. Reproductive effects such as reduced sperm motility and abundance have been observed in smallmouth bass; however, population-level effects and time of induction remain unknown. Historically, histology has been used to visually identify the presence of TO, however techniques which incorporate molecular identification of genes associated with intersex are becoming more widely accepted. The use of Next-Generation Sequencing (NGS), particularly RNA-Seq, with non-model fish for transcriptome development and biomarker gene discovery is highly valuable since the existence of sequence data is low. Unlike the abundance of sequencing data available for model fish species there is very limited data available for smallmouth bass. In this study, a partial testes transcriptome was sequenced with NGS for the identification of intersex biomarker genes. Differential gene expression was conducted on the Nanostring nCounter® platform. Intersex and non-intersex males were compared from sites in the Potomac and Susquehanna River drainages in order to determine genes that were differentially regulated. At some of these sites, characterized as integrator sites, water quality, total estrogenicity and contaminant data were collected. Correlations with geospatial data and landuse associated with these sites were also examined.*

Wang, Zhengui, Harry Wang

High resolution water quality modeling in the Chester River of the Upper Chesapeake Bay using unstructured grid SCHISM model

Type: Presentation

Abstract: *As part of an EPA's shallow water demonstration project, a high resolution unstructured water quality modeling was implemented in the Chester River of the Upper Chesapeake Bay. The Chester River is a tributary in the eastern side of the Upper Bay with a length of about 69 km beginning at Millington, MD and ends at the Chesapeake Bay in a very wide mouth between Love point and Swan Point. The tidal range is about 2 feet and the main tributaries include Langford Creek and Morgan Creek on the north side and Corsica River and Southeast Creek on the south side. The watershed loads were divided into 28 sub-basin and provided by EPA HSPF model. The hydrodynamics were characterized by a large bend almost 135 degree turn between lower and mid-Chester, and, along with it, the presence of an 18 m deep hole in an otherwise shallow estuary. The summer DO can reach hypoxia and anoxia in the deep hole. Further up In the Upper Chester, the blue green algae dominated the summer phytoplankton bloom and the peak chlorophyll can reach 50 - 70 ug/l in a basin confined by two major spits. Modeling watersheds and estuaries at fine (local) scales has the potential for providing improved insight into water quality processes, increased utility of pollution control estimates to decision makers, and improving understanding of the overall transport, processing, and attenuation of*

nutrients and other pollutants in the coastal watershed system. The setup of a coupled hydrodynamic eutrophication model with high resolution, unstructured grid SCHISM (Semi-implicit Cross-scale Hydroscience Integrated System Model) in the Chester shows an example in which the local features such as large river bend and sand spits off the shoreline can be modeled explicitly. As a results, both hydrodynamics and water quality condition bear the signature of the secondary circulation (by the bend) and trapping mechanism at both forward and backward side of the spit (by the eddies) . The revealing of these features was benefit from the high resolution, unstructured grid modeling and the results were supported by the observations.

Welty, Claire, Michael L. Barnes, Theodore Lim

Assessing green infrastructure performance using a three-dimensional hydrologic modeling approach

Type: Presentation

Abstract: *We have applied the three-dimensional, coupled groundwater-surface water-land surface model ParFLow.CLM at scales ranging from small watersheds to metropolitan regions to quantify groundwater-surface water interactions and groundwater storage in urban areas. We have recently extended this approach to quantifying the hydrologic budget at site and neighborhood scales at green infrastructure installations.*

For a permeable pavement GI site in Philadelphia, we quantified the temporally-variable nature of the infiltration process as affected by precipitation and evapotranspiration. Simulation and groundwater monitoring results for 2016 indicate that during winter months, snow and snowmelt play an important role in the water balance. Snowmelt can be significant on an inter-monthly time scale, with infiltration from snowmelt contributing to the peak winter infiltration rates. During summer months when evapotranspiration exceeds precipitation, water captured by the GI contributing area during precipitation events enhances recharge to groundwater. This is a deviation from expected seasonal behavior at the site scale, when summer months would typically see reductions from storage resulting from evapotranspiration. Model results indicate that the site discharges to regional groundwater throughout the year.

At the neighborhood scale, we evaluated changes in hydrology of a residential urban sewershed in Washington DC resulting from retrofitting with a network of GI installations between 2009 and 2015. The model was used to test nine additional GI and imperviousness spatial network configurations for the site and was compared with monitored pipe-flow data. Results from the simulations show that GI located in higher flow-accumulation areas of the site intercepted more surface runoff, even during wetter and multiday events. However, a comparison of the differences between scenarios and levels of variation and noise in monitored data suggests that the differences would only be detectable between the most and least optimal GI/imperviousness configurations.

These modeling results at both GI and sewershed scales provide illustrative examples of how coupled modeling can be used to quantify hydrologic budgets for components that cannot easily be monitored beyond the point scale. The approach can be

applied to any geographic location where meteorologic, topographic, vegetative, and hydraulic conductivity data are available.

Wilusz, Daniel, Daniel Fuka, Shuyu Chang, William P. Ball, Ciaran J. Harman

Using travel time data and a modified SWAT model to understand groundwater nitrate lag times in the Eastern Shore, MD

Type: Presentation

Abstract: *In the Eastern Shore, MD, intensive agriculture and atmospheric deposition have increased nitrogen inputs to the landscape. These inputs leach as nitrate into the region's thick, porous, unconfined aquifer. Here nitrate is stored and slowly released over decades, resulting in long nitrate travel times (i.e., lag times) to the Chesapeake Bay that must be accounted for in management plans. A commonly-used, open-source model to simulate the storage and release of groundwater nitrate is the Soil and Water Assessment Tool (SWAT) or an enhanced version that accounts for topographically-driven variable source areas (TopoSWAT). The ability of SWAT or TopoSWAT to simulate nitrate lag times in the Eastern Shore is limited because (1) SWAT implicitly simulates travel times by assuming that groundwater is well-mixed, which could be a poor assumption in many parts of the Eastern Shore, and (2) SWAT does not calculate simulated travel times, which precludes calibration against available data. To overcome these limitations, we demonstrate proof-of-concept of a modified version of TopoSWAT that (1) allows the user to relax the well-mixed groundwater assumption using the recently developed theory of rank StorAge Selection (rSAS) functions, and (2) calculates and outputs groundwater nitrate travel times to facilitate interpretation and evaluation. The resultant TopoSWAT-rSAS model is tested at the small, intensively studied Chesterville Branch watershed on the Eastern Shore. Compared with the unmodified model, we show the modified TopoSWAT-rSAS model can simulate lag times that are much more consistent with available tracer-derived travel time data. We use the TopoSWAT-rSAS model to make first-order estimates of the sensitivity of catchment travel times to climate variability and catchment characteristics. We conclude that TopoSWAT-rSAS is a promising new tool for understanding groundwater nitrate transport in the Eastern Shore, MD, and similar physiographic regions.*

Wolf, John

Leveraging Procedural Modeling to Visualize Chesapeake Landscapes

Type: Poster

Abstract: *The 2014 Chesapeake Bay Watershed Agreement contains 10 goals and 31 outcomes that collectively address a wide variety of ecosystem conservation and restoration issues. The topics addressed in these goals and outcomes often relate to place-based management of fisheries, habitats, water quality, and watersheds. Many of these issues have been communicated through a combination of scientific illustrations and conceptual diagrams, but illustrating the potential impacts of local, geographically specific management decisions has relied primarily on static, two-dimensional maps. Although mapping and geographic information systems have been used to address these topics for many years, three-dimensional (3D) GIS has not gained traction to communicate the complexity of these issues.*

In GIS, procedural modeling enables the creation of 3D features from 2D map layers based on data-driven algorithms. In the

Chesapeake Bay Watershed, 3D landscapes can be generated from high-resolution land cover, LIDAR, building footprints, and procedural rules. High-resolution land cover can be used to categorize existing natural and human-made features. LIDAR point clouds are used to create elevation and surface (ground and first return) models at local scales. Building footprints are based on existing planimetric data, high-resolution land cover, and/or man-made features digitized from imagery. Derived data layers are then rendered in 3D based on procedural rules at various levels of detail (LOD).

Procedurally derived landscapes can be generated from GIS data and exported to web formats, enabling the development of interactive 3D web scenes. The resulting scenes can be explored by the end user to better understand real-world management issues at a local scale.

This poster will (1) highlight the process for deriving 3D landscapes, (2) illustrate examples of procedurally defined landscapes at local land and water management scales, and (3) discuss their potential to communicate management practices relevant to The Chesapeake Bay Watershed Agreement.

Wolf, John, Katherine Wares, Renee Thompson, Scott Phillips

Mapping Geographic Areas that benefit Multiple Goals and Priorities for Conservation and Restoration Opportunities across the Chesapeake Bay Watershed.

Type: Presentation

Abstract: *The Chesapeake Bay Watershed Agreement recognizes that 'to be successful in achieving its goals and outcomes, progress must be made in a strategic manner, focusing on efforts that will achieve the most cost-effective results.' It further acknowledges that using place-based approaches will help produce recognizable benefits to local communities while contributing to larger ecosystem goals. The Goal Implementation Teams (GITs) at the Chesapeake Bay Program (CBP) have started to more effectively collaborate on inter-related outcomes.*

The cross-GIT mapping project illustrates an approach to identify places where the CBP and other partners can make progress on complementary priorities. These locations represent areas that potentially provide the greatest benefit to living resources considering outcome-specific restoration and conservation goals, future threats, and current and prospective partner priorities and efforts.

This presentation will present results of our composite suitability modeling exercise for identifying high ranking conservation and restoration areas based on data resources identified by CBP GITs and Workgroups. The aim of this project is to more effectively share resources to make progress on inter-related outcomes, identify areas where efforts can be concentrated, align partner activities, enhance effectiveness, and communicate multiple conservation and restoration values.

After reviewing the initial background composite conservation and restoration maps, one or more example management questions will be presented to demonstrate how the cross-GIT mapping products are being used by the CBP Management Board to identify cross-outcome conservation and restoration opportunities. Ultimately, the cross-GIT mapping will be used as a decision-

support tool by managers to incorporate multiple outcomes into their restoration planning and better target their implementation efforts.

Woodland, Ryan, Chris Rowe, Danielle Quill, Theresa Murphy

Developing stable isotope trophic biomarkers for future diamondback terrapin habitat connectivity studies in Chesapeake Bay

Type: Poster

Abstract: *Human-induced alteration of fringing coastal habitats will continue in Chesapeake Bay due to coastal development, shoreline hardening and global climate change. For example, global sea level rise will significantly alter coastal landscapes through inundation and erosion of low-lying areas in Chesapeake Bay. These activities and processes will change the mosaic of shoreline and littPresentation habitats available to Bay fauna. Animals that display area fidelity and rely on fringing coastal habitats during multiple life stages, such as diamondback terrapins (Malaclemys terrapin Schoepff 1793), are likely to be particularly vulnerable to coastal disturbance. Stable isotope analysis of both inert and metabolically active tissues offers a powerful tool to investigate trophic connectivity of fringing and nearshore habitats to better understand the contribution of coastal habitats to the diet of key consumers. Nondestructive sampling of tissue stable isotope composition is critical for threatened and endangered species or those with unknown population status such as diamondback terrapin. Here, we provide initial results from an ongoing validation experiment to assess the viability of using the natural carbon, nitrogen and sulfur stable isotope composition of diamondback terrapin claws (keratin) as an indicator of trophic niche. Diamondback terrapins maintained at the Calvert Marine Museum in Solomons, MD, were used as experimental animals in this study (n=9). Diet amount and composition was tightly controlled and included four potential prey types (smelt [Osmeridae], hake [Merlucciidae], shrimp [Penaeidae], scallops [Pectinidae]). Claw growth was measured each month and clipped if sufficient growth had occurred. Trophic enrichment factors (TEF, offset between stable isotope composition of a consumer's tissue and its prey) were calculated for C, N and S of diamondback terrapin claw keratin. Tissue- and consumer-specific TEFs are critical for the robust application of mixing models, an important analytical tool for estimating consumer diet from stable isotope data collected in the field. Similarly, growth rates of claws provide information on the time interval over which field-collected claws integrate dietary information. Results from this study will enable future studies into the effect of shoreline disturbance on trophic connectivity diamondback terrapins in Chesapeake Bay.*

Wu, Cuiyin, Jeni Keisman, Lewis Linker, Gary Shenk, Richard Tian

Diagnostic of nonattainment of water quality standard of Dissolved Oxygen of the Chesapeake Bay segments

Type: Poster

Abstract: *There is a need for higher resolution in the Chesapeake Bay Program's estuarine model. In an analysis of the estimated water quality standard of Dissolved Oxygen (DO) criteria attainment results in Chesapeake Bay (CB) segments with the 2017 Water Quality and Sediment Transport Model (WQSTM), it was observed that in a limited number of Chesapeake Bay segments, poor dissolved oxygen conditions persisted even under scenarios of*

dramatically reduced nitrogen and phosphorous loads. Preliminary analysis identified ten out of 92 segments which were insensitive to nutrient reductions: eight of them were in the Open Water DO designated use, one in Deep Water, and one in Deep Channel. Many of the CB segments insensitive to nutrient reductions have a model segment scale that is insufficient to adequately simulate DO. This study is to explain the anomalous results in these segments and to determine whether the Chesapeake Bay Water Quality and Sediment Transport Model (WQSTM) effectively simulated historical conditions and improvement in those conditions with reduced loads. If the WQSTM is determined to be nonresponsive in the affected Bay segments, additional lines of evidence will be explored to determine whether the apparent nonattainment represented an area of real concern, or whether those segments could reasonably be expected to show sufficient improvement to attain water quality standards given the nitrogen and phosphorous load reductions. Each Bay segment was evaluated to determine the following: 1) whether the Chesapeake Bay WQSTM effectively simulated historical conditions and improvement in those conditions with reduced loads; 2) whether nearby Bay segments also exhibited persistent or widespread hypoxia (low to minimal DO levels). The analysis will help decision makers and stakeholders to refine the draft Watershed Implementation Plan 3 planning targets. The analysis will also examine scale issues, particularly with respect to the 57,000 cells of the 2017 WQSTM, which are on average about a kilometer by a half kilometer in size and if a finer resolution scale could resolve the issue.

Xia, Meng

The development of a Wave-Current based Ecological Modeling system to Chesapeake Bay, Maryland Coastal Bays and adjacent Coastal Ocean

Type: Presentation

Abstract: *It is critical to improve our understanding to a series of biophysical questions to Chesapeake Bay (CB) and Maryland Coastal Bays (MCBs), such as phytoplankton outflow plume in the CB and Harmful Algae Blooms at the MCBs. UMES Estuarine and Coastal Ocean Modeling lab lead by Dr. Xia has implemented a three-dimensional (3-D) Wave-Current hydrodynamic-biogeochemical model by linking Finite Volume Community Ocean Model (FVCOM)-Surface Wave Model (SWAVE) and Integrated Compartment Model (CE-QUAL-ICM) to the CB and MCBs. The model showed acceptable model skill in simulating hydrodynamics (e.g. temperature, salinity), total suspended solids (TSS), nutrients (carbon, nitrogen, phosphorus and silicon), dissolved oxygen (DO) and chlorophyll-a (including diatoms, dinoflagellates and cyanobacteria) in a 10-year simulation period from 2003 to 2012. Using this modeling system, the simulated historical Chesapeake Bay Outflow Plume (CBOP) was classified into five types based on the orientation, shape, and size along with the available satellite imagery from 2003-2012. It was also found that streamflow and wind magnitude were responsible for the seasonal variability in surface plume area and thickness, respectively, and that streamflow explained most of the interannual variability in both surface plume area and thickness. Biogeochemical simulations help determine the dominant environmental drivers of primary production in the plume region during the ten-year simulation, and the growth of phytoplankton showed severe nitrogen limitation. With the* *help of the modeling system, a variety of numerical experiments were conducted to test the sensitivity of simulation results to model settings including winds, tides, river discharge, riverine and non-point-source nutrient loadings, and underwater light climate. Our coupled modeling package turned out to be a robust tool to analyze the spatiotemporal variation of key water quality parameters and determine their key physical drivers.*

Applying the biophysical framework, we investigated the potential climatic impacts on phytoplankton variability and the bio-chemical plume in the CB in the future. Based on the hindercast model and with the help of a robust climate model(s) and watershed model, a downscaling method was applied to project the possible future physical and biological CBOP structure. How the effect of climate change to the CB and its plume until year 2090 was given, and results displayed an increasing trend in surface area in the coming decades. Ideal experiments were then performed to explore the response of the plume signatures to ambient salinity, sea level rise, and sea temperature, as projected by the Coupled Model Intercomparison Project Phase 5 (CMIP5) models.

A 3-D unstructured-grid based numerical model was used to investigate its response of the MCBs to Hurricane Sandy, one of the most dangerous storm surges. This modeling system could be useful to study the hurricane induced storm surge, meteotsunami besides the ecological modeling/forecasting.

Xu, Yiyang, Meng Xia

Wave-Crrent Interaction Application in Chesapeake Bay

Type: Poster

Abstract: *The mass, energy and momentum exchanges between surface waves and underlying mean flow have been defined and intensively studied in the last 50 years. The most interesting idea among these interactions is the concept of surface wave radiation stress. It has been proven useful in many scenarios, including wave-induced "set down" outside the surf zone and "setup" inside as waves shoal and break; and the interaction of freely propagating long and short surface waves. The three-dimensional unstructured Finite Volume Coastal Ocean Model was implemented for Chesapeake Bay and its coastal oceans to delineate the realistic Chesapeake Bay Outflow Plume (CBOP). We coupled the wave model and included the processes of wave-current interactions in the model to investigate the influence of wave-current interactions on CBOP. In order to fully address this issue, wave dynamics are demonstrated under different wind directions and speed.*

Yactayo, Guido, Greg Busch

Stream Temperature Modeling for TMDL Development and Implementation in Nontidal Cold Water Streams in Maryland

Type: Presentation

Abstract: *Stream temperature is an important measure of water quality and a key parameter for protecting aquatic life (MDE, 2013). Aquatic species, such as macroinvertebrates and fish, are sensitive to dissolved oxygen content of streams, which is influenced by stream temperature (George et al., 2011). As a consequence, if the thermal tolerance of a fish species is exceeded in a stream reach, it can result in direct fish mortality (MDE, 2013). According to George et al. (2011), stream water temperature is spatially and temporally dynamic and controlled by a complex and interacting set of factors, such as local air*

mass characteristics, solar radiation, shading, channel characteristics, and the hydrologic regime. Anthropogenic stressors, including increased watershed imperviousness, destruction of riparian vegetation, and changes in climate, can also influence the thermal regime of streams causing changes in the biological community (MDE, 2013; Nelson and Palmer, 2007). Management practices that affect these factors can have the potential to secondarily affect stream temperature dynamics.

The Maryland Department of the Environment (MDE) assigns a Use Class to each of the State's waterbodies following the Code of Maryland Regulations (COMAR), which defines designated uses that should be supported including the protection and propagation of fish, shellfish, and wildlife, and for recreation in and on the water. Use Class III(-P) , Nontidal Cold Water streams are suitable for the growth and propagation of trout and other coldwater obligate species, and capable of supporting self-sustaining trout populations and their associated food organisms (MDE, 2013). Maryland has adopted the numeric temperature criteria associated with Use Class III(-P). The assessment methodology uses observations taken between June and August, to determine whether water quality standards are being met in Use Class III(-P) streams. The 90th percentile temperature of a Use Class III(-P) stream must be equal to or less than 68° F/20° C, outside of any mixing zone established by the Department, to be considered not impaired (MDE, 2013).

Quantitative tools are needed not only to assess the thermal regimes of Use Class III(-P) , Nontidal Cold Water in the State of Maryland, but also to explore scenarios where best management practices can moderate stream thermal conditions. Here, we assessed the appropriateness of the Soil Water Assessment Tool (SWAT) model for simulating stream temperature dynamics in an urban catchment in Maryland and the impact of management actions, such as riparian shading and stormwater retrofitting. Our modeling results, which are in agreement with field studies in the region, indicate that watershed imperviousness and stormflow are significant predictors of Use Class III(-P) summer temperature exceedance percentage. Even though the percent of forested riparian buffer is not a significant predictor, it was negatively correlated with the summer temperature. The contributions of the current work are 1) to develop a stream temperature TMDL methodology that can be applied to temperature impaired Use Class III (-P) , Nontidal Cold Waters in the State of Maryland and 2) to facilitate implementation by providing modeling information and restoration activities instructions to watershed managers & other stakeholders.

Yao, Yuanzhi

The representation of stream water temperature in the Dynamic Land Ecosystem Model (DLEM) and its applications to Chesapeake and Delaware Bay watersheds

Type: Poster

Abstract: *Water temperature is a key factor influencing the biogeochemical processes of stream ecosystems. Simple empirical equations are the most commonly used method for predicting stream temperature, which based on the relationship between air temperature and water temperature. However, empirical equations are limited by its lacking of ability in separating the contribution of each factor (such as climate, landuse change) to the stream temperature. Meanwhile, physical based models are hard*

to simulate water temperature of intermittent water ways because the effective surface area in headwater area is hard to predict. To solve these problems, we incorporate a new water transport scheme into our fully physical based land ecosystem model. The water transport process in this new model is scale adaptive that helps extend water temperature calculation into tributaries and headwater areas. We applied our new water temperature model to 4-km resolution dataset in Chesapeake Bay and Delaware Bay watersheds from 1960- 2015. The preliminary results show that water temperature increased significantly in the downstream area, but remain steady in the upstream mountainous area. Our study further indicates that landuse change significantly affected the surface water temperature in downstream areas. While climate change is the dominant factor contribute to water temperature in the upstream area. We compared the difference of inland water CO2 degassing driven by both empirical- and physical-model based model estimation of water temperature, respectively, finding the difference in main channel CO2 degassing being about 4.86%. However, the total difference in upstream subnetworks reached to 14.86%, which may significantly affect the carbon budget estimation.

Ye, Fei

The SCHISM Chesapeake Bay Model: 3D baroclinic simulations based on unstructured grid

Type: Presentation

Abstract: *Despite the successful application of unstructured-grid (UG) models in coastal systems, obstacles in maintaining efficiency and accuracy still exist when moving towards finer scales. Efficiency bottlenecks (especially for baroclinic simulations) arise when large contrasts in spatial resolutions are present in the domain of interest, which is common because management often demands local refinements; in addition, a faithful representation of the underlying bathymetry is an under-studied issue.*

This study aims to improve the cross-scale capability for the baroclinic simulation of the Chesapeake Bay, which has a complex bathymetry and close connection to processes in both the smaller-scale tributaries and the larger-scale coastal ocean. To achieve this goal, recently developed numerical techniques in the hydrodynamic model SCHISM (schism.wiki) are utilized, including an implicit vertical transport solver that maintains efficiency under large scale contrasts and a flexible vertical grid that faithfully follows bathymetry while reducing pressure gradient error and unphysical diapycnal mixing. The model generally exhibits high skill for major baroclinic processes, such as the salt intrusion, periodic stratification, and the three-layer circulation found in some parts of the Bay. Most importantly, high accuracy is achieved through an accurate representation of the underlying bathymetry without any artificial smoothing. Sensitivity tests show that bathymetry smoothing can lead to misrepresentations of system dynamics by reducing the channel-shoal contrast. Therefore, bathymetry smoothing should be avoided as much as possible. The flexibility and efficiency of SCHISM are also illustrated by real applications that demand locally very high resolution in certain Bay tributaries. These characteristics make SCHISM ideal for investigating the interrelated processes occurring in the Chesapeake Bay's mainstem, shallow waters, and adjacent coastal ocean.

Zhang, Yinglong, Harry Wang, Fei Ye, Karinna Nunez, Zhuo Liu

Cross-scale modeling from sub-tributary to ocean: implications for Chesapeake Bay

Type: Presentation

Abstract: *Modeling watersheds and estuaries at fine (local) scales has the potential for providing improved insight into water quality processes, increased utility of pollution control estimates to decision makers, and improving understanding of the overall transport, processing, and attenuation of nutrients and other pollutants in the coastal watershed system. However, significant challenges remain in building, running, and interpreting models of large areas at fine resolutions due to the limitation of the current modeling paradigms.*

We seek to advance the state of science in Chesapeake Bay estuarine modeling by enabling 'resolution on demand' through the application of a next-generation modeling framework, grounded on hybrid grids in both the horizontal (unstructured-structured) and vertical (flexible terrain-following with shaved cells) dimensions. This talk will focus on the overall capability and applications of SCHISM (Semi-implicit Cross-scale Hydroscience Integrated System Model) modeling system, and other companion talks will address its applications to circulation (Ye et al.), water quality (Wang et al.) and marsh migration (Nunez et al.). We highlight some recent new developments that include: (1) a new vegetation module that is fully integrated into the implicit framework of SCHISM and accounts for the vegetation impact on current, waves, and thus sediment transport; (2) a marsh module that is aimed at simulating marsh migration on decadal scale. We will also briefly present a sister model (MPAS-OI: Model Prediction Across Scales-Ocean Implicit) that can be effectively used to simulate fine-scale inundations using a fully conservative nonlinear implicit solver in conjunction with a sub-grid representation of underlying bathymetry. The latter would be particularly useful for local planning that demands very high resolution. The efficiency of the two models running on modern high-performance computing platforms will also be discussed.

Zhang, Qian, Joel Blomquist

Watershed Export of Fine Sediment, Organic Carbon, and Chlorophyll-a to Chesapeake Bay: Spatial and Temporal Patterns in 1984-2016

Type: Presentation

Abstract: *Chesapeake Bay has long experienced nutrient enrichment and water clarity deterioration. This study provides new quantification of loads and yields for sediment (fine and coarse grained), organic carbon (total, dissolved, and particulate), and chlorophyll-a from the monitored nontidal Chesapeake Bay watershed (MNTCBW), all of which are expected to drive estuarine water clarity. We conducted an integrated analysis of nine major tributaries to understand spatial and temporal export patterns over the last thirty years (1984-2016). In terms of spatial pattern, export of these constituents from the MNTCBW was strongly dominated (~90%) by the three largest tributaries (i.e., Susquehanna, Potomac, and James). Among the nine tributaries, the ranking of constituent export generally follows the order of their watershed sizes, with other factors such as land use and reservoir playing important roles in some exceptions. In terms of partitioning, suspended sediment (SS) export was dominated by fine-grained sediment in all nine tributaries; overall, ~90% of the MNTCBW SS is fine sediment. Total organic carbon (TOC) export was dominated by dissolved organic carbon (DOC) in all*

tributaries except Potomac River; overall, ~60% of the MNTCBW TOC is DOC. A comparison with literature shows that the MNTCBW SS and TOC yields were ~80% and ~60% of the respective medians of worldwide watersheds. In terms of temporal pattern, flow-normalized yields from the MNTCBW show overall increases in SS (both long-term [1984-2016] and short-term [2004-2016]), fine SS (long-term and short-term), TOC (long-term), and chlorophyll-a (short-term). The rises in SS, fine SS, and TOC were largely driven by Susquehanna River where Conowingo Reservoir's trapping efficiency has greatly diminished in the last twenty years. Overall, these new results on the status and trends of sediment, organic carbon, and chlorophyll-a provide the foundation for building potential linkages between riverine inputs and estuarine water clarity patterns.

(These results have been published in Science of the Total Environment [https://doi.org/10.1016/j.scitotenv.2017.10.279] and the estimated annual loads are available for download through the associated online supplementary materials.]

Zhang, Qian, Di Ha, Hengchen Wei, William Ball

Retrospective Analysis of Sediment-Associated Phosphorus Concentration in the Major Tributaries to Chesapeake Bay

Type: Presentation

Abstract: *Control of riverine phosphorus flux has been a principal focus of the Chesapeake Bay watershed management. Typically, a substantial proportion of phosphorus is transported with suspended sediment (SS), known as sediment-associated phosphorus (SAP). In this work, we conducted a comprehensive analysis of multi-decadal SAP concentrations for nine major rivers in the non-tidal Chesapeake Bay Watershed to better understand its temporal and spatial variability. The SAP concentrations (mass based ratio of particulate phosphorus to SS) were calculated based on estimates of SS and phosphorus concentrations estimated from monitoring data using the WRTDS (Weighted Regression of Time, Discharge, and Season) method. Preliminary results revealed a consistent effect of flow on SAP concentrations: most rivers showed higher SAP concentration at lower discharge, which may be due to the higher affinity of finer sediment (e.g., silt and clay) that is more mobile at low discharge. The observed temporal effects were less consistent among the various tributaries: four rivers (James, Rappahannock, Mattaponi, and Patuxent) showed decreased SAP concentrations in recent years (1996-2012) in comparison with the earlier period (1979-1995), implying cleaner sediments in recent years. In contrast, four other rivers (Susquehanna, Potomac, Appomattox, and particularly Choptank) showed increased SAP concentrations in recent years. Such inconsistent temporal trends across the rivers may be related to spatial heterogeneity in the watersheds (e.g., geology, soil type, sediment size distribution, and land use changes), which warrants further investigation.*

Zhang, Qian, Rebecca Murphy, Richard Tian, Melinda Forsyth, Emily Trentacoste, Jeni Keisman, Peter Tango

Status and Trends of the Chesapeake Bay Water Quality Standards Criteria Attainment in 1985-2016: Insights from Assessment of Thirty Years of Tidal Water Quality Monitoring Data

Type: Presentation

Abstract: *To protect the aquatic living resources of Chesapeake Bay, the*

Chesapeake Bay Program partnership has developed a guidance framework of ambient water quality criteria with designated uses (DUs) and assessment procedures for dissolved oxygen (DO), water clarity/underwater grasses, and chlorophyll-a. For measuring progress toward meeting the respective states' water quality standards, a multimetric attainment indicator approach has been recently documented by the partnership that estimates their combined attainment. We applied this indicator approach to three decades of monitoring data of DO, water clarity/underwater bay grasses, and chlorophyll-a data on moving 3-year periods to track the progress in all 92 management segments of Chesapeake Bay. In 2014-2016, 40% of tidal water-DU combinations in the Bay are estimated in attainment of water quality criteria, which marks the best 3-year status in the entire record. Since 1985-1987, the indicator has followed a nonlinear trajectory, consistent with impacts from extreme weather events and subsequent recoveries. Over the record (1985-2016), the indicator exhibited a positive and statistically significant trend ($p < 0.05$), indicating that the Bay has been recovering since 1985. This improvement in attainment was statistically linked to total nitrogen, indicating responsiveness of attainment status to the reduction of nitrogen load through various management actions since the 1980s. In addition, we extracted information from the assessment procedures to quantify the 'attainment deficit' for a particular segment and DU to better understand how far away it is from the desired status of 'attaining.' These new results on attainment deficit provide more detailed information about how the estuarine water quality changes in space, time, and across different DUs, which can inform managers of progress in water quality improvement at various locations of the Bay ecosystem.

Zhang, Aijun, Jiangtao Xu, Lianyuan Zheng, Machuan Peng

Performance, Challenges, and Opportunity for the Chesapeake Bay Operational Forecast System

Type: Presentation

Abstract: *NOAA's National Ocean Service operates and maintains the Chesapeake Bay Operational Forecast System (CBOFS) . CBOFS uses a three dimensional Regional Ocean Modeling System (ROMS) to provide the maritime community with nowcast and forecast guidance of the physical conditions of the Chesapeake Bay. Recurring skill assessment results of CBOFS have demonstrated technical weaknesses and performance deficiencies in its forecast parameters, especially salinity. Modeled salinity is generally over-predicted compared with observations, and is over-mixed vertically. While CBOFS' salinity forecast meets mariners' requirements for assessing buoyancy, it is insufficient to support ecological forecasting requirements, such as sea settle or pathogen forecasting. To satisfy these additional mission requirements, it is urgent and vital to improve the accuracy of CBOFS forecast guidance. Challenges that need to be addressed to improve CBOFS include: 1) real time observations, especially vertical profile and transect measurements of salinity and water temperature; 2) the development of innovative methodologies and parametrizations of vertical and horizontal mixing processes to resolve over-mixing and horizontal movement of salt fronts; and 3) the evaluation and validation of coupling solutions with the National Water Model to improve river forcing conditions for forecast cycles. Continued engagement with the external modeling*

community is needed to help resolve these challenges.

Zhi, Wei

A physically-based nutrient model for understanding controls on nitrate export in Chesapeake Bay

Type: Presentation

Abstract: *Water quality remains a challenging issue for the Chesapeake Bay Watershed despite decades of efforts to protect water resources. Although nitrate is one of the most commonly monitored nutrient species, its export behaviors at the watershed scale are not fully understood. The concentration-discharge behavior of nitrate has exhibited dilution (stream concentrations decrease with discharge), chemostatic (constant), and enrichment behavior (concentrations increase with discharge), while the underlying cause remains largely elusive.*

In this work, we develop a physically-based nutrient module on the basis of the bioRT-Flux-PIHM, a watershed-scale hydrobiogeochemistry model taking into account of hydrological processes, land-surface interactions, and multicomponent reactive transport processes. This new nutrient model enables simulation of coupled water and aqueous biogeochemical processes to understand controls of nutrient export under dynamic hydrologic conditions, including the shift between different nitrate sources and flow pathways. The bioRT module has been verified against the widely used reactive transport code CrunchTope. The application of the nutrient model is demonstrated at two sub-watersheds in the Chesapeake Bay, the Chesterville Branch and the Conewago Creek Watershed. The Chesterville Branch Watershed exhibits a dilution concentration-discharge (CQ) while the Conewago Creek Watershed shows a contrasting enrichment behavior.

Model results show that hydrologic conditions determine the dominant nitrate source and flow pathway connected to the stream. Under baseflow conditions, stream nitrate is close to groundwater nitrate concentration as groundwater is the dominant source. As water increases, the lateral flow becomes the dominant flowpaths and shallow soil interflow largely determines the stream nitrate concentration. For the two sub-watersheds, groundwater is the key component to reproduce their stream nitrate dynamics. Specifically, groundwater at the Chesterville Branch Watershed has higher nitrate concentration and is diluted large interflow during big precipitation events, leading to a dilution CQ behavior. In contrast, groundwater at Conewago Creek has lower nitrate concentration and the stream is enriched by interflow with high nitrate concentration during large precipitation events, leading to flushing behavior. In summary, the new model offers physics-based modeling capabilities that potentially unify different nutrient observations in different watersheds.