Chesapeake Community Research Symposium 2026

Poster Session

Cecily N. Steppe (U.S. Naval Academy Department of Ocean and Atmospheric Sciences), Trevor Chun

A preliminary study of the effects of anthropogenic noise and environmental factors on Oyster Toadfish (Opsanus tau) boat-whistle calls

Oyster Toadfish (Opsanus tau) is an ecologically important species found in estuaries along the U.S. East Coast. O. tau males send a characteristic boat-whistle mating call that may be masked by anthropogenic noise. In this study we used passive acoustic monitoring to determine whether the number of O. tau boat calls in a small tributary of Chesapeake Bay was related to the presence of anthropogenic noise or environmental variables. Two-minute recordings at 96kHz were taken every two hours from late June to the end of August, 2025. For each recording, boat-whistle calls were counted, and anthropogenic noise was classified as present or absent. Environmental parameters measured included water temperature, water level, and day-night classification. Because of the sharp decline in boat-whistle calls after a month, the data were split for analysis into an increased calling period (main call season, MCS), and a reduced calling period (post main call season, PMCS). Spectral analysis of the whole data set, MCS, and PMCS showed both similar dominant periods of boat-whistle calls at 24 and 12.2 hours likely related to diurnal and semidiurnal tides. PMCS also showed a dominant period of 14.2 days, potentially related to the spring/ neap cycle. Generalized linear regression performed on the entire data set, MCS and PMCS included anthropogenic noise (AN) presence, water level (WL), temperature (T), and day-night DN as factors. Different factors drove calls for the entire dataset, MCS, and PCS, suggesting that O. tau responds differently to environmental factors based on their need to vocalize. This study may facilitate understanding of how changes in the environment affect toadfish and their boat-whistle calls. Note: This work is made available for the purposes of discussion and does not necessarily reflect the views of the Department of the Navy or the Department of Defense.

Jeffrey Cornwell (UMCES Horn Point Laboratory)

Nutrient Mitigation Oysters: Advances and Suggestions for the Future

The certification of oysters as a nutrient-removal Best Management Practice (BMP) in the Chesapeake Bay added an important tool for nutrient mitigation. Rigorous review of relevant science was combined with a practical view towards implementation. In this presentation, I

review the scientific backbone of this management tool as applied to oyster aquaculture and reef restoration. The potential for nutrient removal on engineered surfaces (e.g. reef balls, oyster castles) is examined and suggestions made for their inclusion in nutrient balances. Research gaps, particularly in our understanding of oyster-related denitrification and biofouling organism biogeochemistry, will be identified.

Katherine H. Philipp(Virginia Institute of Marine Science, William & Mary), Mara F. Walters, Lauren S. Gregg, Meghan E. Capps, Amanda Chesler-Poole, Jessica M. Small, Bongkeun Song

Investigating microbial drivers of oyster larvae production in a research hatchery

The growing oyster aquaculture industry and oyster reef restoration efforts depend upon oyster hatcheries for seed and spat production. However, oyster hatcheries sometimes experience fluctuations in production success between years and within seasons of the same year. The causes of these fluctuations are often not well understood. This study aims to reveal if water microbiomes in hatchery systems relate to the success of larval survival and growth. At the VIMS Oyster Hatchery, total eyed oyster larvae production in 2024 far outpaced 2023 production, which was partially due to higher hatching rates and mean daily survival rates in 2024. We use 16S rRNA gene metabarcoding to assess differences in microbiome composition and diversity in hatchery water throughout and between the 2023 and 2024 hatchery seasons. Specifically, we investigate how water microbiomes were impacted by seawater management practices. Water treatment during the 2023 season included UV-sterilization and regular water tank cleaning and drying, while in 2024 UV sterilization was not used, water tanks were not consistently sterilized, and diatomaceous earth filters were introduced. We find that the microbiome community composition was different between the two years and that 2023 and 2024 did not share any dominant bacterial taxa. Throughout the 2024 season, the water microbiome's alpha diversity stayed relatively consistent, whereas the 2023 season had highly variable alpha diversity. Furthermore, the water microbiome's community composition changed at a faster rate in 2023 than it did in 2024. These findings show that the hatchery water's microbiome was more divergent in 2023, which suggests that hatchery water sterilization practices can shift water microbiomes in ways that may impact larval oyster health and survival. Managing microbiome stability, rather than simply reducing microbial loads, will be critical for improving hatchery production outcomes.

Alexandra Bijak (Virginia Institute of Marine Science, College of William & Mary), Mark Brush, Emily Rivest, Christopher Patrick

Clam addition impacts on seagrass sediment carbon content are highly variable across a Ruppia-Zostera mixed meadow

The practice of seagrass-bivalve co-restoration is rapidly expanding, but studies evaluating the effects of seagrass-bivalve interactions on meadow carbon cycling are limited. We conducted a hard clam (Mercenaria mercenaria) addition experiment in a natural mixed Ruppia-Zostera meadow in the lower Chesapeake Bay. We added juvenile hard clams (~2.5 cm width) to vegetated and unvegetated plots within both Ruppia- and Zostera-dominated zones in the summer of 2025. We quantified surface sediment (0-3 cm) percent organic matter as a proxy for organic carbon content both before and after clam additions. We found that the change in carbon content over the experiment varied widely across the meadow, ranging from ~50% decrease to ~75% increase. Carbon content did not significantly change in vegetated or unvegetated plots for either species after clam addition. However, Ruppia vegetated and Zostera unvegetated control (no clams) plots increased in carbon content by the end of the experiment, suggesting clam addition inhibited natural increases in carbon content over the summer that were observed in the unmanipulated plots. Hard clam addition may therefore limit sediment carbon accumulation in seagrass meadows, though the magnitude of clam effects varies by seagrass species.

William F. Schroer (Johns Hopkins University)

Microbial community response and phytoplankton bloom dynamics during disruption of aeration in a eutrophic estuary

Eutrophication driven hypoxia is an expanding threat to water quality in estuaries. Artificial aeration is used in freshwater and estuarine systems to mitigate the threat of hypoxia by directly oxygenating of the water column. Despite its expanding use, the impact of artificial aeration on the structure of microbial communities has not been well characterized, especially within estuarine ecosystems. Here we present a time series investigation of a microbial community's response to aeration and cessation of aeration in a eutrophic estuary. Our field site is a tributary of Chesapeake Bay, MD, USA, with a history of hypoxia and harmful algal blooms that has been seasonally aerated since 1988. Samples for 16S rRNA gene analysis and shotgun metagenomics were collected over a month-long period during which time the aerators transitioned from being “on” to “off/altered” to “on” again. Amplicon sequence variants (ASVs) of 16S rRNA genes were clustered based on their correlated abundance through the time series into representative modules. These modules demonstrate distinct temporal patterns of peak abundance (pre-disruption, disruption, post-disruption, recovery). The taxonomic make up of each module is distinct, demonstrating the community response patterns through time. The cessation of aeration caused a algal bloom that began as Synechococcus dominated and transitioned to domination by the ichthyotoxic algae Heterosigma akashiwo. Restoration of aeration led to rapid bloom termination. Disruption of aeration three years later resulted in a bloom of Gymnodinium, killing 800 fish, which again terminated upon restoration of aeration. Bloom termination may be triggered by the mixing effects of aeration, transporting populations out of the photic zone. Our results are consistent with as markers of community stratification break down during aerated periods. These findings demonstrate the complex community response to anthropogenic interventions and support the efficacy of aeration.

Jeffery Jiao (IMET UMCES), Haoyu Chen

Physiological Plasticity and Halotolerance of Auxenochlorella protothecoides AS-1 Under Varying Trophic Modes and Salinity Stress

The green microalga Auxenochlorella protothecoides AS-1 exhibits remarkable environmental adaptability, positioning it as a versatile candidate for diverse biotechnological applications. This study evaluated the physiological responses of AS-1 to salinity stress, varying trophic modes, and antibiotic exposure. Cultures were maintained under autotrophic, mixotrophic, and heterotrophic conditions across a salinity gradient of 0 - 35 ppt, with extended tolerance testing up to 60 ppt. AS-1 demonstrated robust halotolerance, maintaining viability at 35 ppt for over 10 days, while optimal growth was observed at 5 ppt under autotrophic and mixotrophic conditions. Significant physiological plasticity was evidenced by salinity induced morphological changes, including increased lipid droplet accumulation, vacuole expansion, and the frequent formation of "glass ball" structures. Furthermore, salinity stress enhanced the production of exopolysaccharides, which were successfully isolated and fractionated via ion exchange and gel filtration chromatography. Spectinomycin was identified as the most effective antibiotic for culture purification, while AS-1 tolerated concentrations up to 2,000 μg/mL, growth inhibition became pronounced above 400 - 500 μg/mL. These findings highlight the high stress resilience of A. protothecoides AS-1, supporting its potential for large scale cultivation in saline environments and industrial wastewater systems.

Cheyenne Smith (USGS), Megan K. Schall, Kristina M. Gutchess, Heather L. Walsh, Geoffrey D. Smith, Timothy A. Wertz, Brandon Keplinger, John Mullican, Justin B. Greer, Tyler Wagner, Stephanie Gordon, Patricia M. Mazik, and Vicki S. Blazer

Bayesian Modeling Translates Fish Health, Contaminant, and Hydrologic Data into Chesapeake Bay Smallmouth Bass Management Insights

This study presents a management-oriented approach to investigating drivers of disease in wild smallmouth bass (Micropterus dolomieu) in the Chesapeake Bay watershed through a combination of fish health metrics, immune function assays, aquatic contaminants, hydrology, and land use data. Chronic health issues including disease outbreaks, endocrine disruption, and recruitment failures began in the early 2000s and differentially affected young of year in the Susquehanna River and adults in the Potomac River. Recruitment now appears to be rebounding in the Susquehanna River drainage but continues to lag in the Potomac River drainage despite overall improved water quality in the Chesapeake Bay. A total of 429 adult

bass were collected between 2016 and 2018 during spring and fall from four sites with different land use and chemical inputs. This study used Bayesian hierarchical models and multivariate analysis to evaluate relationships between immune variability and co-occurring stressors such as herbicides, altered flow regimes, parasite prevalence, and host traits including age, sex, and length. Key findings showed that adaptive immunity was more strongly influenced by predictors investigated than innate immunity, indicating long-term exposure effects. For example, adaptive immune function had significant relationships with agricultural land use in the immediate drainage, Palmer Drought Severity Index, and atrazine–flow interaction whereas innate immune response did not. This modeling framework provides transparent outputs to guide targeted monitoring and restoration. Recommended actions include monitoring contaminants in water after storm events or during droughts, timing pesticide applications to avoid extreme flow periods, and maintaining riparian buffers to reduce runoff. This study demonstrates that immune endpoints are influenced by multiple interconnecting factors and can provide insight into environmental drivers of fish health, which can then guide management decisions to promote healthy fish populations.

Yufeng Jia (Institute of Marine and Environmental Technology, University of Maryland Center for Environmental Science)

An alternative to synthetic fertilizer: Biofertilizer established with microalgae and soil bacteria for environmental sustainability and enhanced plant growth

The application of chemical fertilizers is a common practice in farming and it is essential for successful plant growth and crop yield. However, excess chemical fertilizer usage on farmland increases leaching that leads to nutrient runoff to the Chesapeake Bay, causing environmental issues like harmful algal blooms. Moreover, continuous application of conventional fertilizers resulted in low organic carbon content in the soil, which damages soil health and hampers agricultural sustainability. The main goal of this project is to develop a cost-effective microbe-based fertilizer that will substitute commercial synthetic fertilizers and reduce environmental impact. In addition to being environmentally friendly, it will promote the growth of agriculturally important plants and improve soil organic carbon content. We leveraged the microalgal strains in our lab and bacterial strains isolated from soil to establish a biofertilizer mixture for soil amendment. Our preliminary plant growth experiments showed that the mixture outperformed conventional synthetic fertilizers, as corn, soybean, and hot pepper plants amended with the microalgae and bacteria mixture had better net growth in height and biomass than those supplied with synthetic fertilizer. To evaluate the product’s effect on soil health, we analyzed the soil microbial communities via 16S rRNA sequencing. The microbial community structure shifted drastically in the amended soil compared to the control soil, as a suite of plant-growth-promoting bacterial taxa became more dominant. We further characterized the phytohormone content in our biofertilizer product and found that it is rich in a key plant-growth hormone, indole-3-acetic acid (IAA). The research conducted helped us better understand how microbial phytonutrients improve plant growth, help to improve soil environments, and reduce negative impact on the environment.

Abigail Sindelar (Old Dominion University), Alyssa Bucci, Peter Bernhardt, Margaret Mulholland

Examining Tidal Floodwaters as a Public Health Concern and Source of Nutrient Loading

Coastal communities within the Chesapeake Bay watershed are experiencing an increase in the severity and frequency of tidal flooding as a result of climate change and sea level rise. The City of Norfolk and the Hampton Roads region of Virginia are particularly vulnerable as, in addition to high rates of eustatic sea level rise, there are also high rates of local land subsidence and changes in ocean current dynamics that are causing the region to experience the second highest rate of local sea level rise within the United States. This study examined the extent of nutrient and contaminant loading to the Lafayette River, a sub-tributary of the Chesapeake Bay, during “king tide” flooding events. This study was enabled through two community science programs; Catch the King, focused on building public awareness about tidal flooding, and Measure the Muck, aimed at quantifying water quality impacts from tidal flooding. Previous years have shown that a single king tide event can input more than the entire annual load of nitrogen allocated for overland flow to the Lafayette River. Here, we report on the high Enterococcus abundance in the tidal floodwaters. Enterococcus, a fecal matter indicator, was found to be above the recreationally safe threshold within most floodwater samples collected pointing to a substantial threat to public health. This study highlights the need for monitoring of floodwaters to both update load allocations for nutrients and warn the public regarding potential health effects from contact with floodwaters.

Henry Kibuye (Penn State), Tamie Veith; Heather Preisendanz

Influence of Concentrated Flow Pathways on Nutrients and Pesticides Transport in Riparian Buffers

The occurrence of concentrated flow pathways (CFPs) within riparian buffers can undermine the achievement of water quality goals targeted by restoration programs. CFPs accelerate the movement of runoff through buffers, thereby reducing the retention of contaminants by buffer soil and vegetation. To evaluate the role CFPs play on the transport of nutrients (nitrogen and phosphorus) and pesticides (surface and sub-surface applied) to adjacent streams, soils samples were taken along the buffer gradient (edge-of-field, midpoint, and near stream), within CFPs and in areas of sheet flow (SF), and at 0-5 cm and 5-15 cm depths. Seven buffers across the agriculturally impaired Halfmoon Creek watershed, of the Chesapeake Bay, were identified for sampling in spring and summer 2025. Results indicate that surface-applied atrazine and

simazine, and sub-surface applied clothianidin were the most frequently detected pesticides. Concentrations in CFPs were not consistently higher than SF, with the Wilcoxon rank-sum test showing no statistically significant difference ($p > 0.05$). Also, concentrations tended to be lower at near stream in both CFP and SF suggesting that buffers generally reduced pesticide delivery into the stream. However, given the timing of sampling, higher concentration in CFPs along the buffer gradient indicates a potential increase in mobilization during subsequent runoff events. In wider, well-vegetated buffers, runoff collection points in the middle of the buffer prevented CFPs from connecting directly to the stream and resulted in locally elevated pesticide concentrations. For nutrients, there was no significant difference in concentration between SF and CFPs, while by depth, concentrations were higher at 0-5 cm. These results show that although buffers reduce contaminant transport, CFPs may accelerate delivery into the stream, particularly for pesticides. Additionally, buffer characteristics are key to mitigating CFPs, highlighting the need for buffer maintenance and utilization of tools, e.g., erosion and sediment control practices, to mitigate CFPs.

Casey L. S. Hodgkins (UMCES Chesapeake Biological Lab), Jeremy M. Testa, Allison D. Dreiss, Walter R. Boynton

Synthesizing the Patapsco River Estuary: From Nutrient Reductions to Wastewater Treatment Failures.

The Patapsco River estuary is a highly urban and eutrophic system. During the past 40 years the estuary has experienced large reductions in point-source nitrogen (N) and phosphorus (P) loading as a result of a shift from industrial point sources to municipal sources that have implemented nutrient removal processes. To assess the impact of these reductions on the Patapsco River estuary this study examined long term water quality data, ecosystem metabolism (computed with continuous monitoring data), non-point and point source nutrient loads (Phase 6 watershed model), and sediment-water fluxes. Point source N and P loads decreased from 1985-2020, followed by a brief increase in 2021-2022 associated with wastewater treatment plant (WWTP) failures. Loads returned to pre-failure values in 2023. Water column N, P, and chlorophyll concentrations decreased with load reductions. Sediment N and P fluxes and sediment oxygen consumption were generally reduced in 2023 compared to rates measured in the 1990s (pre-ENR). However, P fluxes were much higher in the Inner Harbor in 2023, than in the 1990s. These findings indicate that while nutrient load reductions have contributed to a decline in overall water column nutrient and chlorophyll concentrations, sediment water fluxes, and ecosystem metabolism, localized conditions such as bottom water hypoxia, can significantly alter some estuarine processes such as sediment P fluxes.

Matt Robinson (Chesapeake Bay Program Office, EPA Mid-Atlantic Region), Kelly Somers (Water Division, EPA Mid-Atlantic Region)

Updates from the Chesapeake Bay Program Plastic Pollution Action Team

Following recommendations from a 2019 Scientific and Technical Advisory Committee (STAC) workshop on microplastic pollution in the Chesapeake Bay and watershed, the Chesapeake Bay Program (CBP) Management Board created the Plastic Pollution Action Team (PPAT). The PPAT was tasked with four objectives: providing oversight to the development of preliminary ecological risk assessments of microplastics for Bay subwatersheds; use ecological risk assessment results to develop a science strategy that identifies and prioritizes gaps in information concerning the effects of plastic pollution on the Bay ecosystem; present results from the ecological risk assessments to the Management Board to guide future action on addressing plastic pollution; and monitor policy advances at the state and federal level that could potentially impact, advance, or complement this work to inform the science strategy and identify potential policy or management options that could be utilized for source reduction strategies. This presentation will provide an update on the progress of the PPAT and future plans.

Tejaswini Ronur Praful (ODU), Meredith Evans Seeley, Margaret Mulholland

Assessing 'Microplastide' – Microplastics riding the tide, during King Tide flooding event in Norfolk, Virginia

Microplastics (MPs) are pervasive contaminants in marine and terrestrial environments, with increasing evidence of ingestion, accumulation, and potential ecological impacts across trophic levels. Accurate identification and quantification of MPs remains technically challenging due to their heterogeneous polymer compositions, variable morphologies, and environmental degradation. In the lower Chesapeake Bay, critical data gaps persist regarding MP abundance, transport pathways, resuspension dynamics, and long-term environmental fate. Existing studies on MPs are largely constrained to the upper Bay, and primarily focus on organismal ingestion rather than system-level processes. These uncertainties are particularly pronounced in the Elizabeth and Lafayette Rivers, two tidal sub-estuaries draining densely urbanized and industrialized watersheds in southeastern Virginia. Despite global MP documentation, no integrated dataset quantifies MP concentrations or exchange processes in the lower Chesapeake Bay. This study investigated the abundance, size distribution, and polymer composition of MPs in tidal floodwaters associated with King Tide flood events that occurred on September 13, 2025, and October 11, 2025, in Norfolk, Virginia, USA. Baseline samples were collected one, three, and five days prior to each flooding event to assess temporal variability. Water samples were filtered onto stainless-steel membranes, followed by oxidative digestion of organic matter using 30% hydrogen peroxide. Post-digestion residues were re-filtered, suspended in 190-proof ethanol, and analyzed using an Agilent 8700 Laser Direct Infrared (LDIR) chemical imaging system for polymer identification and particle characterization. Preliminary findings indicate the presence of multiple synthetic polymers such as rubber, polytetrafluoroethylene (PTFE), polyurethane, acrylonitrile butadiene styrene (ABS), and polyethylene terephthalate (PET). The majority of detected particles ranged between 50 and 100 µm, suggesting dominance of fine microplastic fractions during tidal inundation. This study provides foundational MP data for the lower Chesapeake Bay and highlights the need for standardized analytical workflows capable of resolving MPs within complex, matrix-rich environmental samples.

Kaleea Korunka (Virginia Institute of Marine Science)

A Pilot Investigation of Microplastics and Tire Wear Particles in Virginia's Elizabeth River

The Elizabeth River, a major tributary of the Chesapeake Bay, has played a central role in regional ecological, industrial, and United States history. Its environmental condition closely reflects the health of surrounding communities. While the river has been extensively monitored for traditional water quality indicators through the Elizabeth River Project, microplastics and tire wear particles remain largely uncharacterized. Nonetheless, these persistent contaminants are likely to be present due to the highly urbanized watershed, posing potential ecological impacts. This pilot investigation aims to establish microplastic and tire wear particle abundance across several water quality grades in the northern Elizabeth River. Sites were selected to represent industrial, military, residential, and mixed-use water inputs. Monthly sampling sites include the main stem (Plum Point Kayak launch dock or 'The Jetti'), Eastern Branch (Grandy Village Pier/Learning Barge), Broad Creek (private dock) and Lafayette (Ryan Resilience lab dock). A peristaltic pump combined with an inline filtration apparatus filtering at 300 µm, 100 µm, 10 µm will capture particulate tire and microplastic particles encompassing both surface (0.5 m below the surface) and near-sediment (0.5 m above the sediment) samples of 10–20 L. Collected particles will be analyzed using pyrolysis–gas chromatography/mass spectrometry (Py-GC/MS), providing mass of different plastic polymer types and tire wear. Preliminary results will be presented and integrated with historical water quality data from the Elizabeth River Project to evaluate potential relationships between microplastics and established indicators of river health. Findings from this study will provide the first targeted assessment of microplastics as emerging contaminants in the Elizabeth River. This can be used to establish a baseline for future monitoring, management strategies, and community-focused restoration efforts.

Damien Taylor (Old Dominion University), Richard Zimmerman, Victoria Hill, Brooke Landry

Investigating the 2023 dieback of SAV in the Gunpowder River, Maryland

Submerged aquatic vegetation (SAV) is a critical indicator of estuarine health in the Chesapeake Bay, yet localized declines continue to occur despite regional recovery trends. In 2023, a substantial dieback of SAV was documented in the Gunpowder River, Maryland, raising concerns regarding sediment runoff from nearby construction. This study looked at the potential drivers of the SAV dieback using satellite-derived SAV metrics from Planet satellite imagery (2021-2025) with in situ water quality data and freshwater discharge data. In 2021 and 2022 summertime maximum satellite retrieved SAV extent was ~8.2 km2, with a sharp decline to ~1.5 km2 in 2023. While the overall extent of SAV declined, the leaf area index (LAI) remained relatively stable (~1.7 m2 m-2), indicating that the seagrass density remained constant within the remaining beds. Time series analysis of total suspended solids (TSS), Secchi depth, and chlorophyll a showed no abnormal changes that aligned with the SAV dieback, suggesting that sediment runoff was not the primary driver. In contrast, salinity increased dramatically beginning in July 2022 from 0.09 PPT all the way to 5.09PPT in November 2022. This spike in salinity was strongly negatively correlated with the cumulative freshwater discharge from the Conowingo Dam. The temporal correspondence between increased salinity and declining SAV area indicates that reduced freshwater input and associated salinity stress were the most likely drivers of the SAV dieback.

SAV in the Gunpowder River has made a gradual recovery since 2023, expanding to 2.5 km2 in 2025, however this is still far below the extent of 2021 and 2022. If salinity in this region does not decline then the oligohaline SAV species may be succeeded by more mesohaline species, or this could be a longer-term pattern in salinity due to wet or dry years that produces cyclical patterns.

Ashley B. Dann (Department of Geological, Environmental, and Planetary Sciences, University of Maryland, College Park)

Freshwater Salinization Impacts the Quality and Decomposition of Dissolved Organic Matter in Streams of the Chesapeake Bay Watershed

Anthropogenic salt inputs and saltwater intrusion due to sea-level rise have led to the salinization of freshwater ecosystems. Dissolved organic matter (DOM) is a key energy source in freshwater food webs, acting as a vector for sorption, transport, and transformation of metals and organic contaminants. Salinization can affect the quality of organic matter, nutrient cycling, and microbial communities. The chronic salinity levels experienced by microbial communities during baseflow conditions may influence their ability to adapt to acute salinity pulses (e.g., road salt applications). Our study examined how acute salinity pulses impact DOM quality and biological oxygen demand (BOD) by simulating road salt application through the experimental addition of pure NaCl to stream water samples in incubation experiments. Our stream study sites, located in the Chesapeake Bay Watershed, included Hickey Run (acute and chronic salinity risks, median specific conductivity [SPC]=971 μS/cm) and Rock Creek in Washington D.C. (moderate salinity risk, median SPC=526 μS/cm), and Paint Branch in Maryland (lower salinity risk and extensively restored, median SPC=402.5 μS/cm). Additionally, multiple longitudinal synoptic surveys were conducted at Hickey Run and Paint Branch between August 2024 and December 2025 to examine relationships among BOD, DOM quality, and SPC (a proxy for salinity) along flowpaths, as indicated by fluorescence indices. Results from the incubation experiments show that DOM quality shifted from proteinaceous, labile, and fresh toward more humic and aromatic material in response to acute salinity pulses. Furthermore, surveys revealed significant relationships ($p < 0.05$) between salinity and DOM quality, and between DOM quality and BOD ($p < 0.05$). Therefore, acute salinity pulses affect DOM quality, which in turn affects BOD and may ultimately affect dissolved oxygen in the Chesapeake Bay. Our findings aim to inform BMPs for stream restoration and stormwater management in urban ecosystems by emphasizing the effects of salinization on stream biogeochemistry.

Allison Welch (Chesapeake Research Consortium)

Growing Chesapeake Bay Tidal Trends with Participatory Science Data

Tracking change in estuarine water quality is necessary to identify responses to management actions aimed towards reducing eutrophication in tidal waters. In Chesapeake Bay, a collaborative trend analysis program exists between state, federal and academic partners with annual products including water quality trends based on fitting Generalized Additive Models (GAMs) to monitoring data. Currently, these trends are published by the Chesapeake Bay Program (CBP) using state and federal data.

By partnering with Chesapeake Monitoring Cooperative (CMC), we aim to analyze high quality participatory science data using the same methods. CMC partners, including Blue Water Baltimore (BWB), have been collecting geographically dense participatory science data for over a decade. For example, CBP currently maintains one tidal station in the Patapsco River, while BWB monitors 24 stations. This poster will showcase various trends utilizing BWB's data and CBP GAM method, which is a novel presentation of participatory science data shown in conjunction with data from state and federal partners. By utilizing the unique and diverse data provided by groups, like BWB, with our existing analysis technique, we can fill monitoring gaps, inform restoration, and provide a clear pathway for aligning participatory science with decision-making.

Megan Ladds (Old Dominion University), Margaret Mulholland

Integration of Imaging FlowCytobot into Chesapeake Bay Program monitoring cruises

The Chesapeake Bay Program has been continuously sampling for a variety of parameters within the Chesapeake Bay since 1988. The Chesapeake Bay Program cruise in cooperation with the Water Quality lab at ODU goes out and samples the mainstem at designated sites over the course of three days each month (except in July and August when it is twice a month). One of the sample types that is taken is planktonic samples. These are then preserved with Lugol's solution and analyzed by microscopy. The data analysis for these samples takes anywhere between weeks to months to analyze and upload requiring many hours of manpower and years of taxonomic experience. In October 2025 an Imaging FlowCytobot (IFCB) was added to the cruises. The IFCB continuously takes high quality images of plankton (10-150 μm) using flow cytometry paired with a camera where a 5 mL sample can be run every twenty minutes. This addition enables continuous plankton sampling across the entire cruise track, widening the area analyzed within the lower bay. The images are then uploaded into the online classification program EcoTaxa which enables machine learning and easier classification after only a small portion of images are manually classified. Each cruise generates 45-75 samples that are each connected to a GPS coordinate along the cruise track. Manual classification of these images is currently in progress with hopes of full classifier automation with only periodic checks within the next two years. The IFCB addition will not only provide plankton data from a wider area but can also detect species that may be emergent or patchy, such as present or emergent harmful algal blooms, as well as capture other ecological aspects that are difficult to detect in the field such as lifecycles, parasitism, and grazer interactions.

Greg Silsbe (University of Maryland Center for Environmental Science), Emily Brownlee, Xiaoxu Guo, Catherine Wazniak

Phytoplankton Image Classification: Overview and application to Chesapeake Bay Imaging Flow Cytobot Data

High-throughput microscope imaging systems such as Imaging FlowCytobot (IFCB), FlowCam, and the low-cost PlanktoScope are being rapidly adopted by stakeholders and researchers to aid in the monitoring Harmful Algal Blooms (HABs) in the Mid-Atlantic region. Taxonomic classification of high-throughput imagery is performed using machine learning algorithms built upon expertly trained image libraries, ideally these libraries contain 102 -103 images of a given taxa. This diverse array of automated imaging platforms and the growing but highly fragmented image libraries in the Mid-Atlantic region has resulted in a critical need for a harmonized and flexible data management approach on a regional scale. While many independent efforts are underway to create these image libraries, there are no centralized mechanisms for collecting and disseminating this information systematically across users so as not to duplicate efforts. This presentation will provide an overview of a recently funded project that seeks to create an image library data portal hosted through the Mid-Atlantic Regional Association Coastal Ocean Observing System (MARACOOS). A key component of this project is the creation of state-of-the-art pipelines for near-real time image classification. This presentation will provide an overview of these data pipelines, and provide examples of image classification at PhytoChop, a coastal observatory that provides continuous IFCB imagery.

Ollie Gilchrest (Old Dominion University)
Monitoring suspended sediment concentrations in the tidally influenced James River using high-frequency satellite imagery

The lower James River in coastal Virginia is tidally influenced for ~70 km, extending from its mouth in the southern Chesapeake Bay to a dam just south of Richmond. Salinity in this area ranges from >20 PSU near the mouth, to <1 around Jamestown, located ~50 km up river. Previous research using in-situ instrumentation has identified that salinity exerts a strong control on suspended-sediment concentration (SSC), with high turbidity in the fresh river water and considerably less suspended matter in the more-saline areas, which has important implications for sediment trapping, and the deposition of associated organic carbon, nutrients, and other pollutants. The dynamics of fluvial and marine waters meeting (the fluvial front) result in enhanced sediment trapping due to flow convergence and salinity-induced particle aggregation. As a result, the location of the fluvial front can be inferred using ocean color information correlated to SSC.

This study maps the location of the fluvial-estuarine boundary using images collected by the Planet satellite constellation. This commercial product collects frequent imagery (~daily) at high resolution (3-m), across 8 spectral bands. For this research, I analyzed ~10 images to establish the location of the river-estuary front during different seasons and different tidal cycles. The images were classified into clear and sediment-laden water using both unsupervised and supervised classifications. During the wet season (spring), the fluvial front moves ~15-km further seaward than during the dry season (summer). I also calculated a Normalized Suspended Material Index (NSMI) for each image to determine the relative amount of sediment suspended in the water. There was overall higher SSC in the spring than in the summer months, likely due to the higher river discharge in the spring. This study builds on previous research using traditional oceanographic and hydrologic data collection methods, and highlights the potential of novel remote sensing tools.

Marina Metes (US Geological Survey), Kristina Hopkins, Nathaniel Rosenbloom, Nicholas Santoro

Remote Mapping and Assessment of Stormwater Storage in the Chesapeake Bay Watershed

There is currently no regional, comprehensive database of urban stormwater best management practices (BMP) that includes stormwater storage estimates for the Chesapeake Bay watershed. Existing databases have several issues, including inconsistent nomenclature, limited information on size and storage capacity, and BMP inclusion sometimes limited to those on public lands. A new method has been developed to remotely map the shape of stormwater ponds and roadside swales in Clarksburg, Maryland, using 1-meter (1m) resolution lidar data and a deep learning model. Inputs to the model include various landscape metrics derived from the 1m lidar that emphasize topographic depressions, along with a digitized dataset of polygons representing the extent of stormwater ponds, roadside swales, and stormwater storage from as-built engineering designs.

A U-Net convolutional neural network deep learning model was trained using the input datasets to remotely map these targeted stormwater features within a small urban watershed in Clarksburg, Maryland. A separate set of training data was excluded to test accuracy of the model, which currently performs with over 79% accuracy. The 1m lidar was then used to characterize each stormwater feature with metrics on depth, area, and volume to estimate the potential stormwater storage of each stormwater facility. Storage estimates were then compared with the storage volume that each stormwater facility was originally engineered to hold.

This pilot study will be expanded to 30 urban and suburban basins within the Chesapeake Bay watershed to support other USGS efforts related to enhanced understanding of the effects of BMP implementation on aquatic ecosystems. The results of this study could also be used to improve runoff and flood frequency estimates and better account for BMP density at larger scales across the Chesapeake Bay watershed.

David Die (University of Maryland Eastern Shore), Heather Luedke, Shana Miller

Bridging the Communication Gap in Management Strategy Evaluation: Lessons for Chesapeake Bay

Management Strategy Evaluation (MSE) is increasingly recognized as a powerful framework for testing alternative management procedures that support the sustainable use of marine resources, including those within the Chesapeake Bay. By generating quantitative performance indicators, MSE enables managers to evaluate tradeoffs among ecological, economic, and social objectives while explicitly simulating ecosystem dynamics, feedback processes, and key sources of uncertainty. This holistic approach makes MSE especially relevant for complex systems where management decisions must balance multiple priorities.
Despite these advantages, MSE also presents challenges—particularly the need to ensure that stakeholders understand the method and can interpret its outputs. Communicating MSE results in ways that are transparent, intuitive, and accessible is critical for building trust and fostering informed participation in management decisions.
Tuna Regional Fishery Management Organizations (tRFMOs) have grappled with these same challenges for more than a decade. In response, there have been investments in targeted capacity building efforts, including training programs, participatory workshops, and the development of multimedia educational materials and specialized visualization and decision support tools. These initiatives have significantly improved stakeholder engagement and facilitated more robust and inclusive management discussions.

In this presentation, we share lessons learned from the tRFMO experience and highlight how similar investments in communication and stakeholder capacity could enhance the application and impact of MSE in the Chesapeake Bay restoration context.

Jessie Turner (Old Dominion University), Fei Da, Molly Mitchell

Unintended consequences within the trajectory of recovery: Examples from the Chesapeake Bay

Managing estuarine systems often involves interventions to regulate sediment and nutrient inputs with the goal of improving water quality; however, these management strategies can produce unintended consequences. The Chesapeake Bay is an estuary recovering from eutrophication which provides clear case studies for these patterns. In the Chesapeake Bay, decreased sediment inputs, resulting from shoreline stabilization and watershed modifications, can impair marsh resilience to sea level rise and disrupt sediment-light-algal interactions affecting water clarity. Likewise, reductions in riverine nutrient inputs, while beneficial for mitigating eutrophication, may contribute to surface water acidification. These outcomes complicate assessments of restoration success. Throughout other estuaries' recovery journeys from historical nutrient pollution, similar patterns have been observed in several other systems worldwide. Effective long-term estuarine management requires integrating diverse monitoring approaches, adaptive decision-making, and ecosystem-based strategies to balance environmental and economic objectives. Understanding both the intended and unintended effects of management actions is crucial to ensuring sustainable outcomes and representative assessments of success along the non-linear path of recovery from eutrophication.

Meredith Lemke (Chesapeake Research Consortium)

Visualizing and Strengthening Networks with Mapping

Learn how to increase network connections, grow collaborative capacity, and leverage data visualization with network mapping by exploring a case study of the Chesapeake Steward Map! How does it work? Map users opt-in, fill out a questionnaire, and indicate their level of connection to other users. Questionnaire data is then displayed on the interactive data visualization platform Kumu. Data can be filtered and configured by areas of expertise, location, and many other ways leading to a variety of use cases for the Map by different audience types. Network mapping is a particularly useful tool for managers of networks, coalitions, partnerships, and organizations looking for collaborative opportunities. The foundational background of this tool is the network theory of change which describes methods of relationship building and collaboration to achieve greater collective impact in complex, anarchic systems.

Matthew Baker (UMBC)

The geomorphic signature of urbanizing landscapes

Urbanization leaves a persistent geomorphic imprint through systematic terrain modification. Anthropogenic changes typically occur at fine spatial scales and accumulate over time to reshape landforms in characteristic ways. High-resolution topographic data enable detection of these signatures independently of land cover or other remote-sensing proxies. We developed a new terrain-based metric, the SlopeCV Index, to quantify the geomorphic signature of modern urban development from 1-m LiDAR data. The index measures local slope variability and aggregates it over broader scales to distinguish patterns and intensities of development. Applied to the Maryland Piedmont (USA), the SlopeCV Index effectively characterized terrain modification across a gradient of urbanization, capturing both the extent and intensity of anthropogenic alteration. It tracked temporal changes in surface form across development types, from suburban expansion to regraded uplands, and revealed systematic reductions in low-order flowpath lengths and hillslope-to-channel distances—alterations that may accelerate hydrologic response during storms. This simple, topographic approach offers a quantitative means to map and interpret the geomorphic consequences of urbanization independent of impervious surface. The SlopeCV Index may provide a transferable framework for assessing landscape transformation and its hydrologic implications across diverse physiographic and climatic settings.

Leonardo Pecora (University of Maryland, Baltimore County), Dr. Matthew Baker

Automated extraction of stream geomorphic metrics using digital data in the Gunpowder-Patapsco

Geomorphic measurement of fluvial landforms provides valuable information for characterizing stream setting and contextualizing measures of condition. Geomorphic assessments have historically been derived from field-based measurements and more recently with manual interpretation of digital datasets. However, field surveys have been limited in spatial coverage and it is unclear whether digital approaches capture similar variation. With the availability of high-resolution digital elevation, hydrography, and geomorphometry data, multiple geomorphic metrics can be continuously, remotely, and efficiently computed across a large stream network. As a proof of concept, we present methods for automated extraction of a suite of GIS-based geomorphic metrics including entrenchment ratio, valley confinement, bank height ratio, channel slope, and sinuosity for mapped stream reaches of the Gunpowder-Patapsco HUC12. Continuous and extensive spatial coverage of these metrics facilitated comparisons among similar streams and analyses of patterns related to metric interrelationships, stream order, land cover, and physiographic province. The coverage extent enabled detection and identification of locations exhibiting abnormal conditions for comparison with field assessments and biotic assessments. Such comparisons may provide insight into the types and magnitude of disturbances affecting individual stream reaches and their interaction with stream setting across physiographic provinces. Future work will extend this approach to the entire Chesapeake Bay watershed and incorporate additional geomorphic metrics to support watershed health assessment, identification of restoration priorities, and evaluation of modern and historical anthropogenic impacts.

Kachapond Chettanawanit (Integrated Coastal Sciences Program, East Carolina University), Qubin Qin

Relative Effects of Freshwater Flushing and Wind Forcing on Freshwater Age in a Large Lagoonal Estuary

The Albemarle–Pamlico Estuarine System, or APES, is the largest shallow coastal lagoon system in the United States. APES exchanges water with the Atlantic Ocean through multiple inlets and receives freshwater input from major tributary rivers. Its hydrodynamics are primarily controlled by river discharge, wind forcing, and tides. River inflow introduced new water and dissolved and particulate elements, while wind influences circulation patterns and transport pathways within the estuary and lagoon network. Understanding the spatial and temporal distributions of key physical variables, including salinity and temperature, is essential for quantifying transport processes, including freshwater age. Freshwater age is the time elapsed since water entered the system. This metric is useful for assessing travel times from upstream river sources to downstream lagoon regions and for characterizing flushing behavior. Seasonal wind regimes in APES, with predominantly northerly winds in winter and southerly winds in summer, are expected to produce contrasting salinity structures and transport responses. Previous studies have examined APES hydrodynamics using numerical models, but the combined effects of flushing processes and wind driven circulation on freshwater age remain insufficiently resolved. This study evaluates the freshwater age in APES using the SCHISM hydrodynamic modeling framework. Model experiments were designed to isolate and compare the relative influences of freshwater discharge and wind forcing on water age distributions. The results improve understanding of transport times for newly introduced water from river and ocean boundaries and provide information relevant to future estuarine management and restoration planning.

Jian Shen (Virginia Institute of Marine Science), Julia A. Teixeira, and Qubin Qin

Development of A Coupled High-Resolution Dynamic and Particle Tracking Model to Assess Cumulative Impacts of Surface Water Intakes on Ichthyoplankton in Virginia Tributaries

The increasing number of surface water intake projects across the Chesapeake Bay watershed raises significant concerns about their cumulative impacts on migratory finfish species, aquatic fauna, and water quality. While individual intake structures have been evaluated during permitting processes, particularly for their effects on ichthyoplankton and benthic organisms, there remains a critical gap in understanding the broader, system-wide consequences of these developments. To address this gap, the Virginia General Assembly has approved a budget amendment supporting a comprehensive study led by the Virginia Institute of Marine Science. This initiative will assess the cumulative impacts of surface water withdrawals on ichthyoplankton dynamics and water quality across the Bay. The findings will inform science-based decision-making to safeguard aquatic ecosystems, fisheries, and water resources.

We will present the modeling framework and approach used in this study. A 3D unstructured grid model with <1 m resolution near the intakes is being developed to directly estimate intake induced mortality. A preliminary analysis using forward and backward particle tracking to assess intake impacts on ichthyoplankton will also be shown. By coupling the high resolution hydrodynamic model with a particle tracking module, we quantified both total and maximum daily particle removal rates and used these metrics to estimate ichthyoplankton mortality.

Meng Xia (University of Maryland Eastern Shore), Long Jiang, Haoran Liu, Seyedeh Fardis Pourreza Ahmadi, Yiyang Xu, Bishnupriya Sahoo, Sakib Bin Rafi, Adnan Khairullah, Sreelakshmi Sreenivasan

The Integrated Atmospheric-Physical-biochemical-Groundwater Modeling System for the Chesapeake Bay

Chesapeake Bay stands as one of the largest and most productive estuaries on the North American continent. In our research, we employed a 3-D hydrodynamic-biogeochemical-Lagrangian particle-tracking model, utilizing the offline linked Finite Volume Coastal Ocean Model (FVCOM), the Integrated Compartment Model (CE-QUAL-ICM) and particle trajectory model. The model demonstrated satisfactory skill in simulating total suspended solids (TSS), nutrients, dissolved oxygen (DO), and chlorophyll-a, including various phytoplankton groups over a decade-long period from 2003 to 2012. Our integrated modeling framework proved to be a robust tool for analyzing the spatiotemporal variations of key water quality parameters and identifying their primary physical drivers. This comprehensive approach allowed us to evaluate microbial dynamics, sediment transport, and the impacts of released dredged sediments. Furthermore, we investigated the bio-physical plume dynamics in Chesapeake Bay and examined the potential climatic impacts on phytoplankton variability and biochemical plumes within the estuarine ecosystem.

In addition, an integrated groundwater and hydrological modeling system was applied to the Chesapeake Bay region, specifically coupling groundwater flux simulations from ParFlow hydrological model (Professor Maxwell, Princeton University). This approach identified the vulnerabilities of both Chesapeake Bay and surrounding areas to storm surges and coastal flooding, which are influenced by variables such as precipitation, river discharge, and groundwater flux. The atmospheric model called Regional Climate–Weather Research and Forecasting Model (C-WRF, by Professor Liang, University of Maryland College Park), alongside the Congestion Mitigation and Air Quality (CMAQ) framework, are under development to drive this modeling system, thereby providing crucial air quality inputs and realistic atmospheric force essential for the study of the Chesapeake Bay ecosystem.

Sakib Bin Rafi (MEES Program, Department of Natural Science, University of Maryland Eastern Shore), Meng Xia

Linking Lagrangian Transport Pathways to Seasonal Environmental Exposure in Chesapeake Bay

Environmental conditions in Chesapeake Bay change throughout the year and across different parts of the estuary due to tides, winds, river inputs, and seasonal stratification. As water moves through the Bay, temperature and mixing conditions shift along the way. Because microbial communities respond to the environmental conditions they experience during transport, quantifying exposure histories provides a useful framework for interpreting spatial variability in estuarine microbial habitats.

In this study, we use a three-dimensional FVCOM hydrodynamic simulation together with an offline Lagrangian particle tracking (LPT) framework to quantify environmental exposure along transport pathways in Chesapeake Bay. Particles are advected throughout the full sigma-layer water column and sample temperature and vertical mixing intensity through time. For each trajectory, we calculate cumulative thermal exposure, residence time, and vertical excursion characteristics to characterize the integrated environmental history associated with transport. Winter and summer conditions produce very different exposure patterns. In summer, stratification keeps surface waters in place longer, leading to greater cumulative warming along transport pathways. In winter, stronger mixing spreads water more evenly and reduces prolonged exposure to any single set of conditions. These seasonal differences create distinct physical environments that may influence microbial processes in Chesapeake Bay.

This framework connects patterns of water movement in Chesapeake Bay to changes in environmental conditions that are relevant to microbial communities. By analyzing how temperature, light exposure, stratification and mixing vary along transport pathways, it provides a practical way to examine how physical circulation shapes habitat variability across the estuary. This approach also creates a clear starting point for future work that incorporates biological or biogeochemical processes into the modeling framework.in the Chesapeake Bay.

Cassia Pianca (Virginia Institute of Marine Science - Chesapeake Bay National Estuarine Research Reserve of in Virginia), Piero Mazzini; David Parrish, Ryan Walter, Erin Shields, Willy Reay and Carl Friedrichs

Marine heatwaves in the York River Estuary: Spatial coherence and thermal exposure across a Chesapeake Bay tributary

Marine heatwaves (MHWs) are increasing in frequency globally, yet their dynamics within estuarine regions remain poorly characterized compared to the open ocean. The York River Estuary (YRE) provides a unique opportunity to examine extreme warming across a full salinity gradient spanning over 70 km using long-term, high-frequency monitoring data. Here, we analyze 22 years (2003–2025) of in situ temperature observations from five CBNERR-VA stations spanning tidal fresh, mesohaline, and polyhaline regions of the YRE. Using the Hobday et al. (2016) marine heatwave framework, we quantify event frequency, duration, intensity, cumulative thermal exposure, and spatial coherence of MHW events across the estuary. Despite differences in salinity and mean water depth (0.9–2.1 m), MHWs exhibit strong spatial coherence, with events occurring nearly synchronously across stations and showing comparable mean durations (6–11 days) and intensities (~2.5–3.5 °C above seasonal climatology). Post-2015 years display elevated cumulative MHW intensity and more frequent multi-station events, suggesting a shift toward a higher thermal baseline. The extreme summer of 2025 ranks among the highest cumulative-intensity years in the 22-year record and was characterized by multiple severe-category events affecting all stations. These findings indicate that shallow Chesapeake tributaries can experience estuary-wide extreme warming. By resolving the temporal structure and spatial coherence of MHWs in a tributary setting, this study provides a regional physical framework for understanding thermal exposure in vulnerable Chesapeake Bay habitats under continued climate warming.

Nathan P. Shunk (Virginia Institute of Marine Science, William & Mary), Piero L. F. Mazzini; Ryan K. Walter; Pierre St-Laurent; Marjorie A.M. Friedrichs

The Importance of Subsurface Temperature Monitoring: Vertical Structure of Marine Heatwaves in Chesapeake Bay

Discrete and prolonged periods of extremely warm waters in oceans and estuaries, known as marine heatwaves (MHWs), have increasingly garnered the attention and concern of the scientific community over the last decade. These extreme events have impacted marine ecosystems globally, and have been associated with mass die-offs of foundational species—including seagrass in CB—adult fish and invertebrate kills, reduced recruitment, and reduced water quality. Yet, data scarcity limits our understanding of their subsurface extent,

particularly in estuaries. Therefore, developing effective management strategies for Chesapeake Bay living resources experiencing MHWs will require a more comprehensive perspective of water column impacts. Using a high-resolution regional ocean model (ROMS-ECB), we characterized the horizontal extent and subsurface structure of MHWs in the main stem and tributaries of Chesapeake Bay. Additionally, we developed a supplementary definition for local climatology identified MHWs, "Vertical MHWs," to quantify their vertical structure and propagation. Surface MHWs were generally shorter, more frequent and intense, and impacted ~5% of the Bay surface area, while the deepest MHWs were generally longer, less frequent and intense, and regularly occupied >50% of deep-water areas. Synchronous MHWs—a class of vertical MHWs which occur simultaneously in the surface and bottom sometime during their duration—were predominant across ~75% of the Bay, primarily in shallow regions (isobaths <10 m). Conversely, asynchronous MHWs, which indicate surface-bottom discontinuity, dominated in deeper regions (isobaths >10 m) and occurred primarily during the highly stratified spring-summer season. High synchronicity in the shallow regions indicates a surface MHW signal likely reflects a concurrent bottom one within days, potentially impacting benthic communities. Analyses of asynchronous events suggest surface MHWs are inconsistent predictors of subsurface warming, especially in the deeper regions of CB, highlighting the need for expanded monitoring to better understand, predict, and manage MHW impacts on coastal and estuarine ecosystems.

Pierre St-Laurent (W&M's Batten School & VIMS), J.L. Wilkin, M.A.M. Friedrichs

A data-assimilative model forecast of biogeochemistry for the Mid-Atlantic Bight: Doppio-BGC

The Mid-Atlantic Bight (MAB) and its estuaries are impacted by multiple stressors including acidification, warming, and sea level rise. These stressors have the potential to negatively affect local fisheries and aquaculture industries, but the variable nature of the MAB environment makes the monitoring of such stressors (and their impacts) difficult. For example, water mass mixing in the coastal MAB was recently identified as one of the most significant drivers of carbonate system variability. In order to address these challenges, we propose a new model forecast of biogeochemistry in the MAB: Doppio-BGC. This effort is supported by MARACOOS and leverages an existing 4D-Var data-assimilative model of hydrodynamics (Doppio, operated by the Rutgers University Ocean Modeling Group) which is being extended to include a 3-day prognostic forecast of biogeochemical variables based on the Estuarine-Carbon-Biogeochemistry module (ECB). The biogeochemical variables cover both the nitrogen and carbon cycles and provide additional information relevant to a suite of species that depend on the MAB and its estuaries. A major asset of Doppio-BGC over other modeling systems is its ability to accurately capture stochastic events such as Gulf Stream-induced warm core ring intrusions at the shelf break, which recent studies have suggested could be mitigating acidification on the shelf. We anticipate that Doppio-BGC will become a valuable tool for resource managers, the fishing industry, and academic researchers who need to understand these ongoing changes and their impacts in the MAB and its estuaries.

Zhengui Wang (Virginia Institute of Marine Science), Yinglong J. Zhang, Jian Shen

Development of Machine Learning based inundation model in Chesapeake Bay

Although traditional numerical models have achieved stunning progress in simulating estuarine and oceanic processes, their rapidly increasing computational cost poses significant challenges because of the growing demand for higher spatial resolution and large ensembles of simulations under different scenarios. Recent advances in artificial intelligence provide an alternative approach to ocean modeling by leveraging the high computational efficiency of machine learning (ML) models once they are properly trained. In this talk, we present our recent work on simulating total water levels in the Chesapeake Bay using an ML-based approach. Unlike many existing studies that focus on a limited number of stations, our goal is to develop a water-level model for the entire Chesapeake Bay. The ML model is trained, validated, and tested using 36 years of output from a traditional numerical model, SCHISM, rather than relying solely on observations from several tide gauge stations. SCHISM employs an unstructured grid with spatially varying resolution, which presents significant challenges for direct integration into ML frameworks. By carefully designing the ML architecture, we demonstrate that unstructured grid model outputs can be effectively used for training. The trained ML model successfully reproduces both tidal and subtidal water-level variability, and shows promise in physically sensible response to changes in forcing conditions.

Kelly O. Maloney (U.S. Geological Survey, Eastern Ecological Science Center at the Leetown Research Laboratory), Benjamin P. Gressler, Lindsey J. Boyle, Alexander H. Kiser

Long-term predictive modeling of stream biological condition indicates wide-spread changes within the Chesapeake Bay watershed, U.S.A.

Regional analyses of stream conditions in the Chesapeake Bay watershed have been constrained by sparse spatial and temporal data, particularly for extended time scales, hindering efforts to assess changes through time. To address this need, we developed random forest machine learning models to predict annual biological condition for 360,893 small, nontidal streams in the Chesapeake Bay watershed from 1985–2023. Four biological response metrics reflecting different aspects of the macroinvertebrate community were assessed: percent Ephemeroptera, Plecoptera, and Trichoptera excluding Hydropsychidae (EPT-H), percent Ephemeroptera, percent clinger functional group, and the Chesapeake basin-wide index of biotic integrity (Chessie BIBI). Predictors included natural landscape features, land cover, and climate variables. We calculated trends in predictions for each of the 360,893 streams to identify those likely to have degraded or improved over this time. For the Chessie BIBI we further

calculated the percentages of stream length in different biological condition categories (e.g. Fair vs Poor) across the 39 years to examine how conditions have changed. Biological condition was predicted to be poorer near Washington, D.C. and Baltimore, Maryland, with declining trends across all metrics in these urbanized areas. Spatial heterogeneity was evident with Chessie BIBI scores and clinger percentages predicted to increase in many southern streams but decline in northern streams, while EPT-H and Ephemeroptera were predicted to decrease watershed wide except in the Southeastern Plains bioregion. By 2021, watershed wide Chessie BIBI improvements were predicted for only 0.9–1.1% of total stream length, falling short of management goals. Overall, results demonstrate the utility of long-term data and machine learning for predicting stream condition, identifying key stressors, and guiding restoration and conservation site selection.

Leonardo Bruni (Horn Point Laboratory, University of Maryland Center for Environmental Science), William Nardin, Giulia Franchi, Matthew Houser

Eco-Morphodynamic Response and Sediment Budget Analysis of Coastal Maryland: A 50-Year Numerical Simulation of Marsh Migration and Cropland Inundation

Our study develops an idealized numerical model using the Delft3D suite to simulate and evaluate the long-term morphodynamic response of a representative coastal section near Cambridge, Maryland. The model utilizes a schematized domain divided into four distinct ecological zones, such as, open water, low marsh, high marsh, and cropland, each characterized by a specific, linearly increasing slope designed to represent the characteristic topographic profile of the Chesapeake Bay shoreline. A central focus of this research is the mechanistic role of sediment transport in governing coastal evolution. By implementing a coupled hydrodynamic-morphodynamic approach, we analyze how suspended sediment concentrations and bedload transport interact with tidal currents to dictate the accretion or erosion rates across the profile. The research focuses on a 50-year projection, integrating real tidal dynamics with sea level rise (SLR) scenarios to determine if vertical accretion can keep pace with rising waters. Utilizing this idealized geometry, we isolate the effects of marsh migration and the subsequent saline inundation of agricultural land. We specifically examine the lack of sediment, where insufficient mineral input may accelerate the conversion of high marsh into low marsh or open water. Anticipated outcomes include the identification of critical geomorphic thresholds for cropland conversion and a deeper understanding of the vulnerability of the Maryland coastal landscape. These findings provide a quantitative basis for assessing whether natural sediment supply is sufficient to sustain inland wetland expansion or if anthropogenic intervention is required to prevent total land loss.

Evelyn Page (James Madison University), Tejaswini Ronur Praful, Peter Bernhardt, Margaret Mulholland

Investigation of Nutrient Release under Turbulent Shear – Driven Sediment Resuspension Processes
Eutrophication is a principal driver of harmful algal blooms (HABs) in aquatic systems, leading to hypoxia and consequential ecological and economic losses, including impacts on fisheries, aquaculture, water recreation, and restoration efforts, collectively amounting to billions of dollars. While nutrient inputs from urban and agricultural runoff and wastewater effluents, are widely recognized as primary contributors, internal nutrient loading from sediment resuspension also plays a significant role. Sediment-derived nutrient release can be triggered by hydrodynamic forces such as waves, tides, and wind events, particularly in shallow, micro-tidal, mesohaline systems like the Lafayette River, a shallow tributary of the lower Chesapeake Bay. Dormant algal cysts within the sediments further amplify bloom initiation potential when resuspension occurs. Accurately quantifying these processes is challenging due to the difficulty of sampling water parcels immediately before and after natural resuspension events. Laboratory simulations of sediment resuspension offer a controlled approach to investigate nutrient and cyst dynamics. In this study, twelve sediment cores were collected along with the overlying water from the Lafayette River. Samples were incubated at 12 °C or 28 °C under a 14:10 light: dark cycle. Sediment resuspension was induced in the treatment cores using a homogenizer, disturbing the top 0.5–1 cm of sediment for 30 minutes. Water samples were collected approximately 10 cm above the sediment surface immediately after resuspension and subsequently at daily intervals for the first five days, then every other day until day 14. Nutrient concentrations (nitrate, phosphate, ammonium), total chlorophyll, and particle characteristics were measured. Preliminary results indicate that resuspended sediments significantly increased concentrations of nitrate, phosphate, ammonium, and chlorophyll in the overlying water with elevated levels persisting longer in the high temperature treatments. These findings underscore the critical contribution of non-point, sediment-derived nutrient release to eutrophication dynamics and highlight its relevance in informing nutrient management and restoration strategies in the Chesapeake Bay.

Maryam Rishehri (University of Maryland, Baltimore County (UMBC))

Comparative Analysis of Simulated Subsurface Flow Paths and Residence Time Patterns in Urban Piedmont Watersheds

As part of the Critical Zone Collaborative Network, we use three-dimensional coupled groundwater–surface water flow modeling and Lagrangian particle tracking to evaluate subsurface transport and solute source dynamics in urban Piedmont watersheds along a U.S. East Coast gradient. Understanding how basin geometry and stream network structure influence subsurface flow organization is essential for interpreting streamflow age composition and solute delivery. We applied the integrated ParFlow-CLM hydrologic model coupled with EcoSLIM backward particle tracking to four watersheds spanning a size gradient: Dead Run (smallest), Swift Creek, Anacostia River Northwest Branch, and Difficult Run (largest). Models were constructed at 40-m resolution with consistent vertical stratigraphy (31 m depth, 15 layers) to compare subsurface transport behavior across watersheds that differ in geometry, land cover, and climate.

Particles were released uniformly across stream network cells and tracked backward to recharge locations over 50 years. Subsurface flow paths varied systematically among watersheds, reflecting differences in basin size, elongation, and drainage configuration. The elongated Anacostia NWB domain exhibited longitudinally aligned flow paths converging toward a dominant main stem, whereas Difficult Run displayed a more radial drainage configuration. Swift Creek showed a moderately elongated dendritic network with mixed pathway organization, while Dead Run exhibited a compact flow structure.

Residence times were evaluated using discrete time bins to characterize particle ages exiting each watershed. Swift Creek, Anacostia NWB, and Difficult Run exhibited bimodal residence time distributions, with the largest fraction of particles exiting within 0–2 years and the second largest within 20–50 years, reflecting the coexistence of rapid shallow pathways and deeper long-storage pathways. In contrast, Dead Run is dominated by intermediate residence times (10–20 years), indicating more spatially clustered contributing distances and reduced pathway diversity.

The findings suggest that watershed geometry and stream network structure influence subsurface connectivity and residence time patterns across basins.

Mary McWilliams (UMBC)

Assessment of stream chemistry of storms from newly deployed high-frequency sensors at Baltimore Ecosystem Study field sites