Chesapeake Community Research Symposium 2024

Session 11: Tackling Ecosystem-Level Impacts from Rising Water Temperatures in the Tidal Waters of Chesapeake Bay

Julie Reichert-Nguyen, Jamileh Soueidan, Bruce Vogt, Brooke Landry

Summary of the Tidal Waters Recommendations from the Rising Water Temperature STAC Workshop Report

Rising water temperature trends in Chesapeake Bay prompted a call to action by the Chesapeake Bay Program (CBP) Partnership to synthesize knowledge and identify strategies to tackle the effects of increasing temperatures from climate change on key fisheries (e.g., striped bass, summer flounder) and habitats (e.g., marshes, submerged aquatic vegetation) in the Chesapeake Bay. There was the recognition that the continuation of long-term increases in water temperatures in the region would result in ecosystem-level changes affecting progress toward the water quality, habitat, and living resource goals in the 2014 Chesapeake Bay Watershed Agreement. Guided by scientific syntheses, a two-part Scientific, Technical, Advisory Committee (STAC) workshop in 2022 led to the development of actionable management, monitoring, and research recommendations. These recommendations focused on using ecosystem-based management; implementing nature-based adaptation strategies in the nearshore environment; addressing multiple pressures (e.g., overfishing, nutrient pollution) and extreme stressors (e.g., marine heatwaves); developing social strategies to reduce vulnerabilities (e.g., changing fishing behavior during extreme temperature events); and preparing for future climate conditions and associated ecosystem changes through targeted communication efforts with stakeholders. This presentation will serve as an opening for the session and provide an overview and summary of the Rising Water Temperatures STAC Workshop report's tidal management recommendations and the corresponding monitoring and research needs identified to promote better strategies to detect change and address increasing water temperature effects on tidal fisheries and habitats in the Chesapeake Bay.

Jamileh Soueidan, Julie Reichert-Nguyen, Ronald Vogel, Bruce Vogt

“Linking Marine Heatwave Events to Living Resource Considerations to Indicate Potential Impacts to Fisheries

The Chesapeake Bay is the largest and one of the most productive estuaries in the United States, with communities reliant on the ecosystem services provided by living resources found in the Bay. However, previous research indicates that marine heatwaves may threaten these important Bay species and habitats. These heatwaves are projected to increase in frequency and intensity due to global climate change. These extreme events are associated with a myriad of negative effects such as harmful algal blooms, increased unfavorable bacteria (e.g., Vibrio sp.), mortality of submerged aquatic vegetation, shifts in aquatic species distribution, composition, and abundance, and impacts to fisheries and aquaculture.

This presentation will focus on recent efforts by the NOAA Chesapeake Bay Office (NCBO) to integrate fisheries and fish habitat considerations into marine heatwave analyses to better understand how these extreme events are affecting key fisheries in the Bay. These efforts have included collaborating with marine heatwave and fisheries researchers to scope out a framework for detecting marine heatwaves in the data from the NOAA Chesapeake Bay Interpretive Buoy System supplemented by NOAA satellite temperature observations and drawing linkages between marine heatwave events and fisheries habitat considerations. This presentation will also highlight the effort to incorporate these analyses into NCBO's public-facing seasonal summaries—reports that are developed quarterly to analyze environmental impacts on key species. Efforts include the development of a special edition examining marine heatwave events from 2022-2023 and linking them to habitat condition thresholds for striped bass (Morone saxatilis). Next steps for this work will be to integrate marine heatwave analyses into future seasonal summaries, incorporate new fish physiology and environmental threshold research into the analyses, and scope out a framework for a marine heatwave forecasting system that can be used to inform fisheries management.

Nathan P. Shunk, Piero L.F. Mazzini; Ryan K. Walter; Kyle E. Hinson; Marjorie A.M. Friedrichs

Vertical Structure of Marine Heatwaves in Chesapeake Bay

Climate change-driven warming in Chesapeake Bay (CB) has increased the occurrence of extreme temperature events, known as marine heatwaves (MHWs), threatening key ecosystem functions. While previous studies have characterized surface MHWs in the CB main stem using in-situ observations, a three-dimensional characterization of MHWs throughout CB was not possible due to both limited horizontal coverage of data and lack of subsurface data with appropriate temporal resolution (daily) and record lengths (multidecadal). Thus, the vertical extent of MHWs is poorly understood, despite the potential ecosystem implications. This study uses a CB implementation of the Regional Ocean Modeling System (ChesROMS) with sufficient spatial and temporal resolution to characterize the vertical structure of MHWs in CB. We quantified: the surface and subsurface duration, mean and maximum intensity (temperature anomaly), cumulative intensity (a metric of total heat stress), and MHW area of events; the MHW depth fraction (percentage of water column in a MHW state); and the surface-bottom MHW synchronicity and the associated vertical propagation rates of synchronous events. In general, there were approximately twice the number of surface MHWs compared to bottom MHWs. Critical preliminary results suggest that throughout the year shallow areas (~5-10 m) had greater depth fractions and percentage of synchronous days than the deeper regions of the CB. While in deeper areas, there was greater synchronicity and depth fractions during the fall-winter "homogenous season," when vertical stratification is weaker in CB. Additionally, bottom MHW durations sometimes exceeded surface MHW durations, indicating that potentially stressful conditions can persist longer in the benthic environment. This is one of the first known studies to quantify the vertical structure of MHWs in an estuarine system and has major implications for the management of this ecologically significant system.

Michael O'Brien, Ashlee Horne, Ian Park, Chuck Stence, David Secor

Impacts on Atlantic sturgeon spawning phenology following heat waves and large storms

Increased Mid-Atlantic summer warming and fall storms caused by climate change are hypothesized to affect the timing of fall-spawning Atlantic sturgeon within the Chesapeake Bay. Spawning by endangered Atlantic sturgeon occurs in the early autumn as temperatures fall to between 25 and 20 C, the onset of which is delayed by higher temperatures during August . Further, adults spawn in the midst of hurricane season in the narrow and shallow spawning reaches of the Nanticoke River and Marshyhope Creek, and the aftermath of storms expose them to rapid drops in temperature and increases in flow. Utilizing an eight-year biotelemetry and observing system dataset, we report the duration and end date of Atlantic sturgeon spawning runs in the Nanticoke River and their relation to summer warming and large storm events, culminating with the recent mass-exodus associated with Tropical Storm Ophelia in September 2023.

Jim Uphoff

Spawning season temperature conditions associated with the recent declines in year-class success of Striped Bass in Maryland spawning areas

Maryland’s Striped Bass spawning areas are important to fisheries along the Atlantic coast that are dependent on strong year-classes produced here. Year-class success in Maryland’s portion of Chesapeake Bay has not been consistently high since the late 2000s and has been very poor since 2019. Management’s attention has focused on increasing spawning stock, but temperature and river discharge during late winter–spring and their influence on survival of eggs and larvae are major influences. We compiled spawning season temperature records from egg and larval surveys conducted in two rivers during 1954-2023 to examine changes before and after 1999. Early temperature milestones (days that a first egg collected and when 12ºC was reached) exhibited little or no change on average, but later milestones (16ºC and 20ºC) were progressively earlier. The temperature span when most eggs were collected (12ºC to 16ºC) has shortened and lethally high temperatures (indicated 20ºC) were reached 6-12 days earlier. Asymmetric patterns of milestones that reflect very rapid warming have increased in frequency. Below average flow conditions increased after 2011, increasing odds that a lesser year-class will form. The combination of a shortened spawning season and less favorable flow conditions may complicate management’s attempt to increase recruitment by increasing spawning stock.

Andrew G. Keppel, Tom Parham, Jim Uphoff, Renee Karrh

Changes in summer habitat conditions for resident Chesapeake Bay striped bass determined from interpolated historic water quality data

Long term water quality monitoring data were interpolated to create monthly three-dimensional datasets of Chesapeake Bay water temperature and dissolved oxygen (DO) conditions. These interpolated datasets were then used to evaluate historic changes in striped bass (Morone saxatilis) habitat conditions. Habitat criteria applicable to mature fish were developed from studies of Chesapeake Bay and southeastern United States reservoir striped bass. Fish likely to be Chesapeake Bay residents in summer when temperature and DO would be stressful are primarily 3- to 6- year-old males and some immature females and are not participants in the Atlantic coast migration. This group of resident fish forms the basis of a major recreational fishery as well as an important commercial fishery in Maryland.
Four habitat conditions were defined based on combined water temperature and DO conditions and applied to interpolated water quality data to estimate volumes of water suitable (occupied without stress), tolerable (occupied with some stress long-term), marginal (high stress under short-term occupancy), and unsuitable for resident striped bass. There has been an increase in the frequency and severity of summertime habitat stress, particularly since 2010. This habitat decline is primarily driven by water temperature increases due to climate change. The impact of temperature increases has become more important to striped bass habitat quality than improvements in oxygen conditions resulting from nutrient reductions; however, the population level impact of these habitat changes is unknown.

Ron Vogel, Kim Couranz

Exploring the Effects of Anomalous Conditions in Tidal Water Column Habitat on Chesapeake Bay Species via Seasonal Summaries

Following the end of each meteorological season, the NOAA Chesapeake Bay Office issues a report that discusses how that season's environmental conditions may have affected key species in the Chesapeake Bay. These "seasonal summaries" illustrate spatial and temporal changes in water quality and habitat compared to long-term averages. Environmental observations include water temperature, salinity, dissolved oxygen, precipitation, and streamflow. Species discussed include striped bass, blue crab, oyster, bay anchovy, and summer flounder. Additional observations and species may be added in the future.

The seasonal summaries link changes in environmental conditions to effects on living resources; these links can inform ecosystem-based management at state and regional levels. As temperatures in Chesapeake Bay rise due to climate change, routine reporting of current conditions and how they are changing will allow fishery managers to make informed decisions as they consider new regulations and guidelines under shifting environmental regimes.

This session will discuss the information included in the seasonal summaries—from the acquisition of data from NOAA Chesapeake Bay Interpretive Buoy System, NOAA satellites, and other sources; to images and graphs that manifest any anomalies; to analysis of those anomalies and how they may affect species, This information is presented in a scientific seasonal summary that is distributed to scientists, resource managers, and other experts around the Chesapeake Bay watershed. The session will also discuss how the scientific seasonal summaries are "translated" into a version that is more readily digestible by a broader audience to support a wider understanding on how climate change will affect the Chesapeake Bay ecosystem.

Christopher J. Patrick, Marc Hensel; David Wilcox; Jon Lefcheck; Brooke Landrey

Outlook Hazy, Please Try Again: Contrasting futures of Chesapeake SAV under different climate and nutrient management scenarios

Temperature rise and successful nutrient reductions over the last two decades have facilitated a shift in the identity of the dominant SAV species throughout the Chesapeake Bay from eelgrass to widgeon grass as well as shifts in the community composition of tidal fresh/oligohaline communities. Mechanistic predictions on how both climate change and regional management will affect each SAV community are required to update restoration plans and prepare for a warmer and stormier future. We built a series of structural equation models, one for each of the four major SAV communities in Chesapeake Bay, to understand the factors that control temporal dynamics in SAV from 1984 to 2020. We then applied those models to forecast simulated futures from the Chesapeake Bay Modeling Workgroup future climate and nutrient management scenarios. We found that continued nutrient reductions are essential to ensure a vegetated Chesapeake Bay under climate change. Continued nutrient reductions will most benefit widgeon grass and tidal fresh/oligohaline communities that currently make up ~70% of all SAV, while nutrient reductions will also maintain eelgrass populations through 2060 and beyond. Current nutrient reduction targets will foster the maintenance and expansion of SAV in Chesapeake Bay under climate change conditions but, to reach SAV restoration targets within this century, nutrient reduction targets must be significantly expanded and designed to benefit the new dominants. Species-specific monitoring and management combined with experimental investigations on the effect of species shifts on food webs, fisheries, and blue carbon is an essential next step in predicting the future.

Amanda Bevans

Modeling the Effects of Habitat Changes in the York River Ecosystem, Chesapeake Bay

Eastern Oyster (Crassostrea virginica) and Eelgrass (Zostera marina) are foundational habitats in the Chesapeake Bay. A 200-acre oyster restoration effort has recently been completed in the York River, the 5th largest tributary of the Chesapeake system. Concurrently, the Eelgrass population continues to decline due to increasing water temperatures. Ecosystem modeling allows for the integration of many different lines of the best available data and subsequent visualization of ecological states that cannot be observed directly, such as varying degrees of habitat loss and restoration. Model simulations quantify the impacts of separate and joint habitat scenarios for regional fisheries and serve as a science-based approach to communicate benefits of invested resources to stakeholders. An ecosystem model of the York River was developed that integrates available biomass, predator-prey interactions, fisheries, and environmental conditions. Changes to oysters and seagrass were modeled separately and in combination to improve our understanding of the synergistic effects of simultaneous habitat changes. The York River model was projected over time under eleven habitat scenarios. Oyster-specific scenarios simulated pre-restoration biomass, young reef (current status), and mature reef; Eelgrass-specific scenarios simulated declining Eelgrass, current Eelgrass status, and Eelgrass restored to the management goal. Additional scenarios incorporated different combinations of changes to both habitats. Model results suggest that fisheries harvest increases substantially when eelgrass is restored to the management goal, producing an ecological environment that may no longer be attainable with climate change. Ecosystem conditions that simulate Eelgrass restored to recently observed maximal coverage are believed to be more feasible than historical records of coverage that the management goal is based on. Fisheries harvests increased with “mature” restored oyster reef modeled to account for expected growth, but increases were somewhat moderated as aquaculture and natural recruitment already support a relatively large biomass of oysters in the York River system.