Chesapeake Bay Program's
Scientific and Technical Advisory Committee Workshop

Rising Watershed and Bay Water Temperatures—
Ecological Implications and Management Responses

Findings and Emerging Storyline from the Tidal Syntheses

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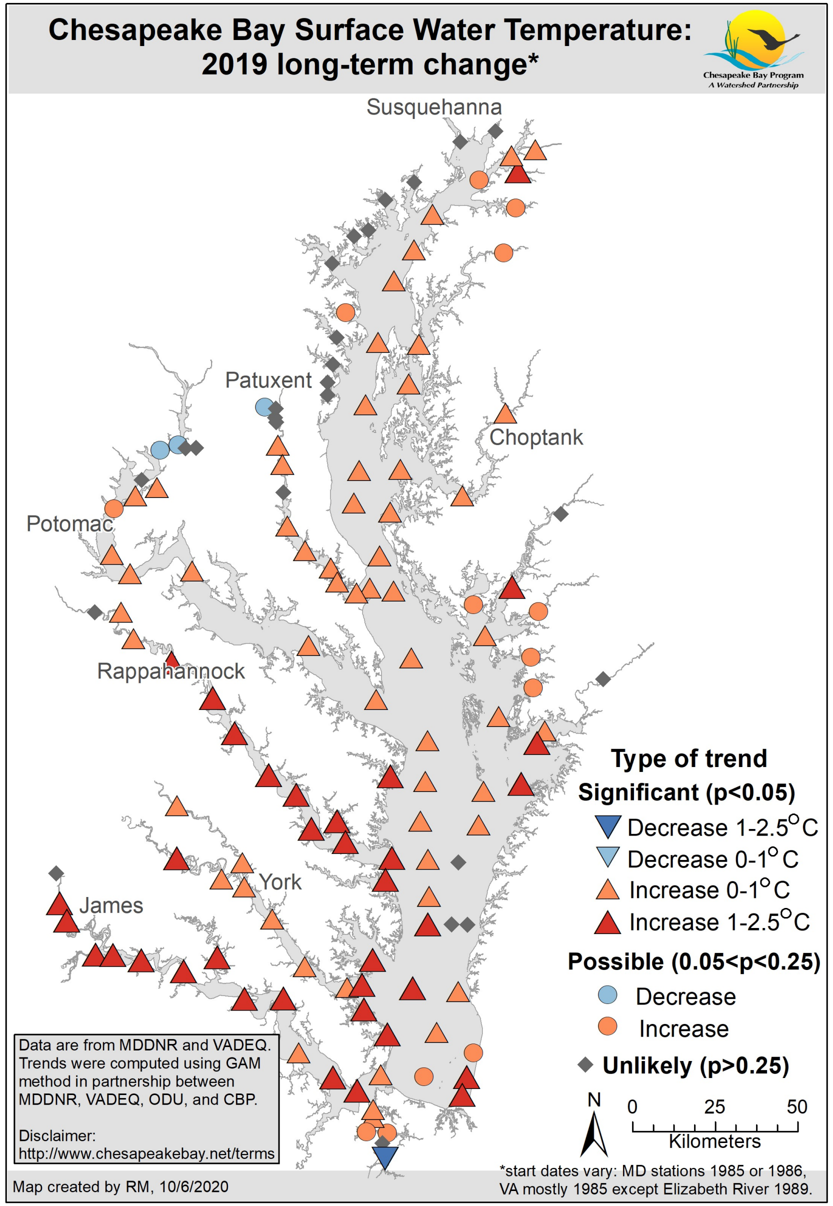
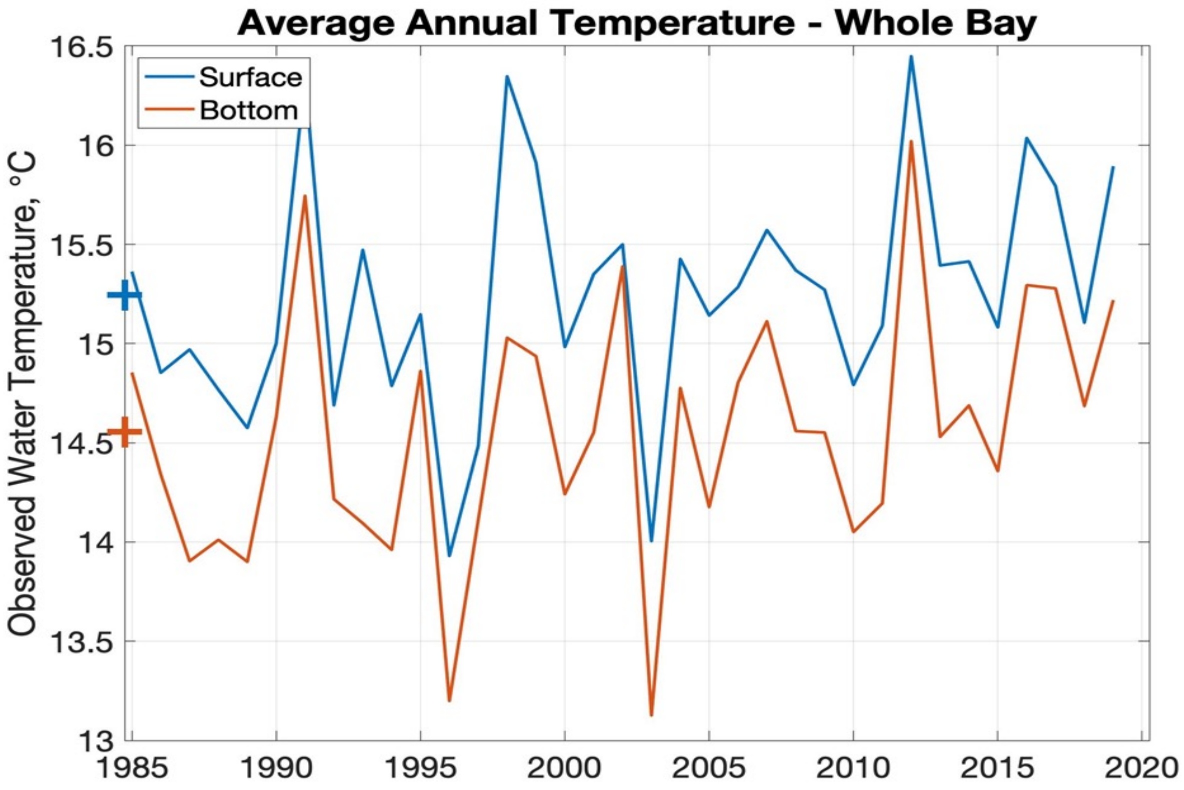
Chesapeake Bay tidal water temperatures have been increasing over the past three decades





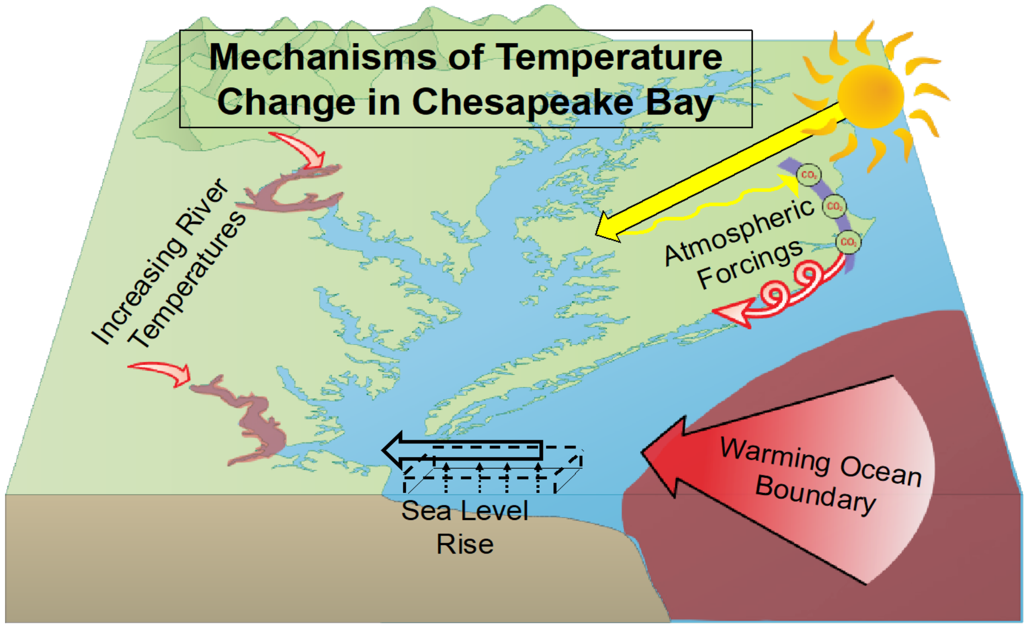
<u>Over the Past 30 Year Period</u>

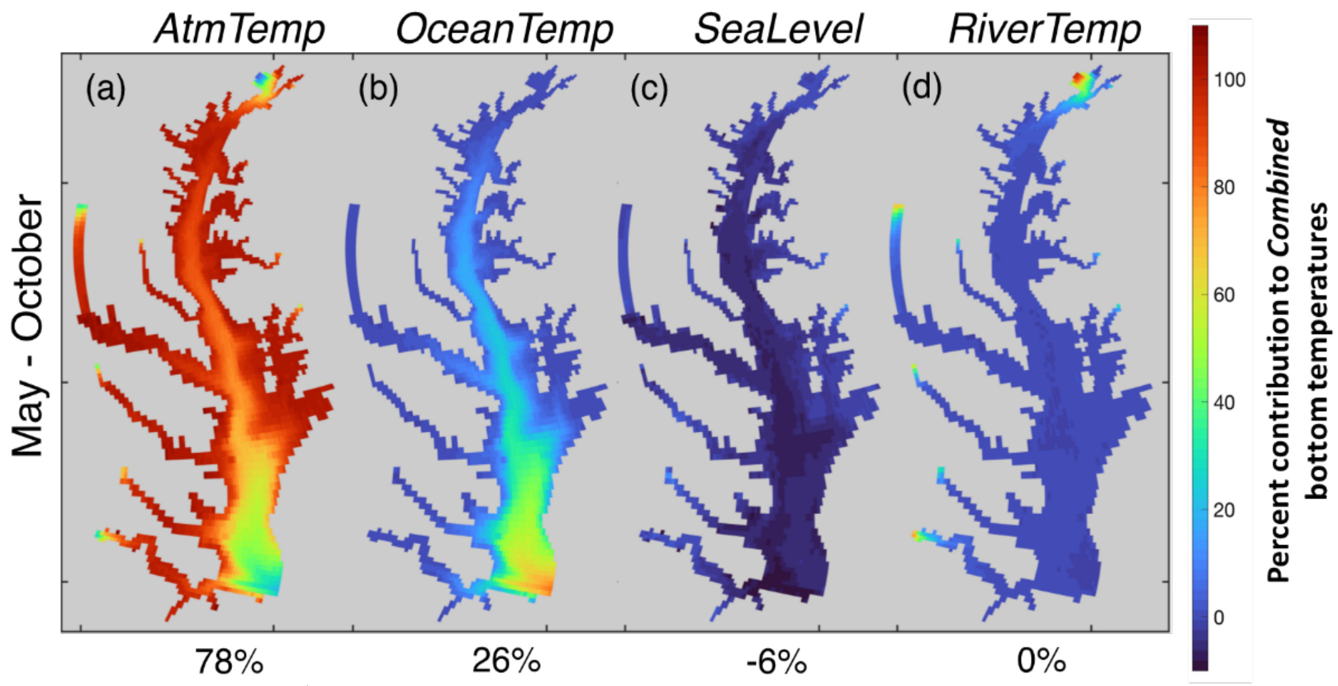
Annual average: +~0.7°C increase

Summertime: +1.0 °C increase

Wintertime: +0.3°C increase

Increasing tidal water temperatures have been driven largely by atmospheric forcings and the warming ocean boundary





1) Air temperatures ⬆
2) Ocean temperatures ⬆
3) Sea level rise ⬇
4) River temperatures ⬆

Source: Hinson at el. 2021

Tidal water temperatures have significant implications for the underlying biological and physical processes which directly influence habitat suitability

Higher water temperature — Lower oxygen solubility in water

Higher water temperature — Higher remineralization rate = more nutrients for algae growth

Higher water temperature — More stratified water column

All combined, these equal even lower dissolved oxygen!

A review of regional species climate vulnerability scores and bay-specific research, showed a range of positive and negative responses of living resources to water temperature

- **Positive impacts** are likely for blue crab and some forage species, as warmer temperatures support higher productivity and increased habitat range as species move northward

- **Negative impacts** are predicted for oysters due to their already depressed populations as a result of disease, overfishing and habitat loss

- Striped bass and Summer flounder may experience **both negative and positive impacts** at different stages of life (larval to adult) and habitat use (rivers and estuaries to marine)

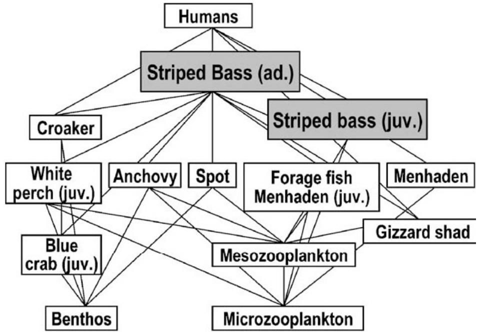
The impact of rising water temperatures on estuarine habitats have implications for the species that depend on those habitats

Habitat Name	Species	Importance of habitat by life stage (ACFHP)			
		Eggs/Larva	Juvenile/YOY	Adult	Spawning Adult
Estuarine emergent wetland	Striped bass		Moderate	Moderate	
	Blue crab		High	High	
	Summer flounder		High	Moderate	
	Winter flounder	High	Moderate		High
Estuarine submerged aquatic vegetation	Striped bass		Moderate	Moderate	
	Black sea bass		High		
	Blue crab	Very high	Very high		
	Summer flounder		High	Moderate	
Estuarine shellfish reef	Black sea bass		High	High	
	Blue crab	Moderate	Moderate	Moderate	
	Summer flounder		Moderate		
	Menhaden			Low	
Legend		*Very High Vulnerability*	*High Vulnerability*	*Moderate Vulnerability*	*Low Vulnerability*

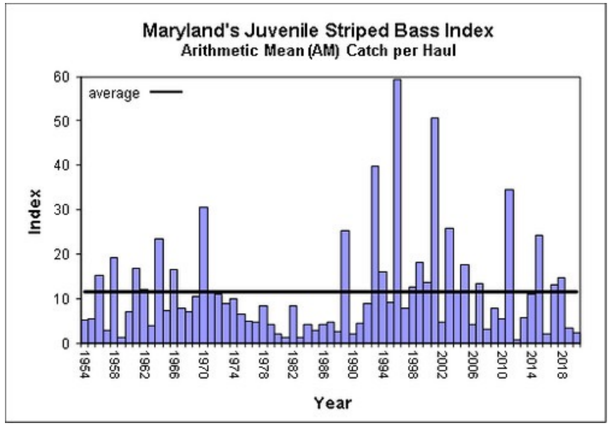
Habitat climate vulnerability rankings (Farr et al. 2021); species vulnerability rankings (Hare et al. 2016)

Shifts in species range and habitats are being documented

- Some Bay species' populations are shifting north while other species from the south are becoming more prevalent in the Bay



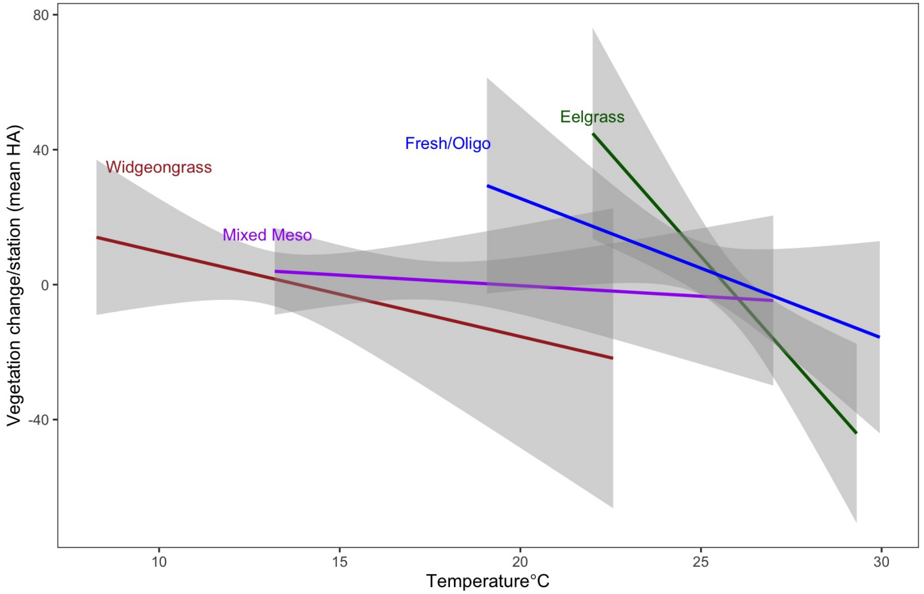
- These range shifts can result in changes to species abundance and distributions, food web dynamics, fishing behavior and new fisheries



- Likewise habitats required by fish and shellfish species are shifting in range and experiencing impacts that lead to changes in fish abundance, distribution and reproduction success

Increasing tidal water temperatures negatively impact all Chesapeake Bay SAV communities to some extent

Without drastic improvements in water clarity or a reversal of warming trends, viable populations of eelgrass will likely be extirpated from Chesapeake Bay



Landry et al. (Synthesis Element #3 Paper)

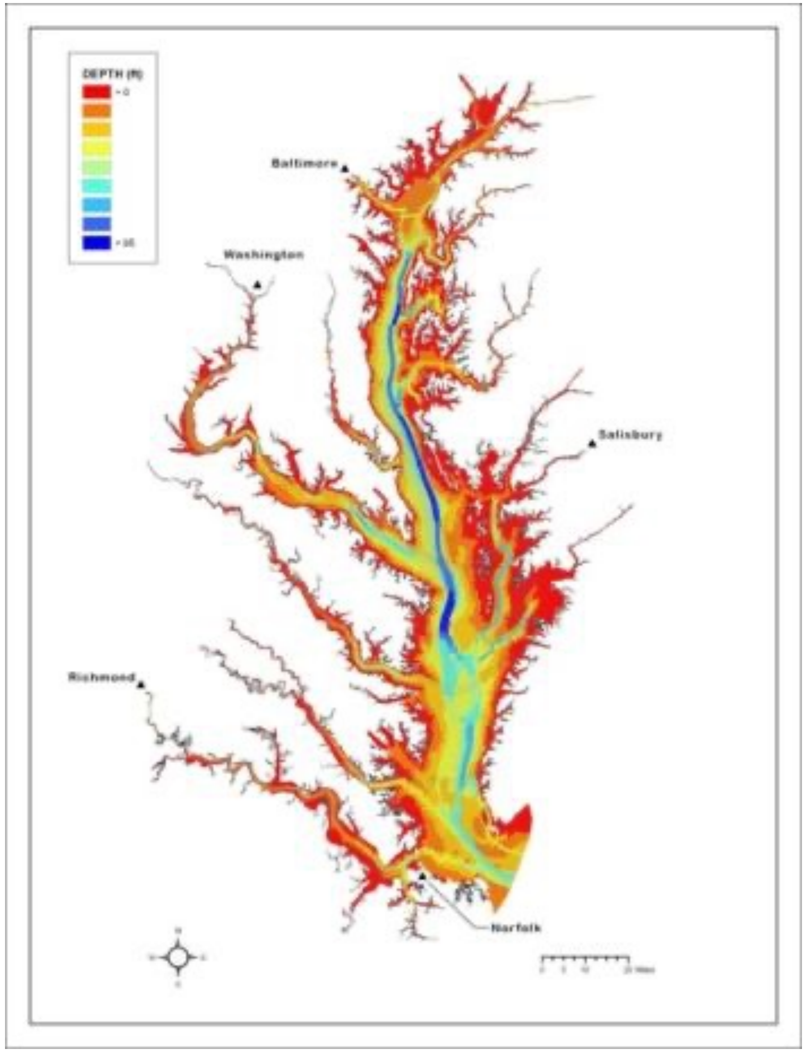
Temperature impacts to other Chesapeake Bay SAV species are not as well studied but appear to be less dramatic than those to eelgrass

The CO2 fertilization effect may counterbalance some of the impacts from warming, but unknowns associated with invasive species, pathogens, cyanobacteria, etc. may set that balance awry

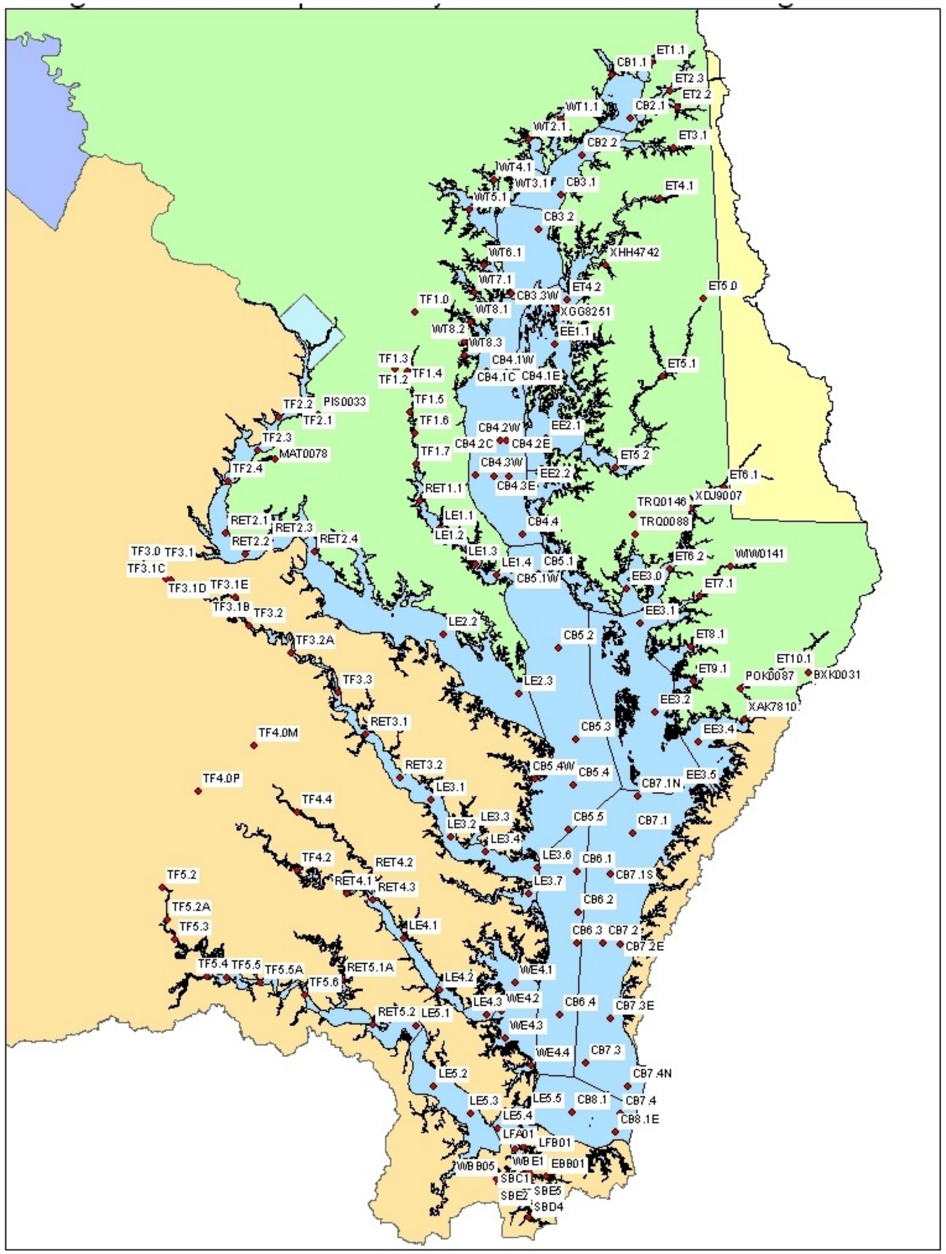
Better understanding of the influences of rising water temperatures on living resources and habitats will require enhancements to the Partnership’s current modeling tools

Assessment of open-water dissolved oxygen climate risk is needed in shallow waters. Going forward, a new Phase 7 Chesapeake Bay Water Quality and Sediment Transport Model is required which can:

1) Simulate shallow water at a finer scale
2) Allow for an unstructured model grid to fit complicated shorelines
3) Simulate wetting and drying of the intertidal region
4) Project tidal wetland and SAV migration with sea level rise
5) Estimate SAV responses to climate change
6) Assess living resource co-benefits
7) Provide a state-of-the-art assessment of the important interface between land and water in the Chesapeake Bay estuary



There are data gaps for monitoring of temperature thresholds important to living resources



Tidal Chesapeake Bay Long-Term Water Quality Monitoring Network

These gaps include high temporal frequency data at the reach-scale in the watershed and for nearshore, shallow tidal waters in the bay

There is interest in coincident air temperature monitoring

Tidal water indicator requires input from managers on their application needs

- Assessment methods exist, but we **lack the connections** between physical parameter changes and ecological impacts (e.g., habitats, living resources)
- We **need input from managers** on their intended management applications for the indicator
- **No single data source** meets all the desired criteria—accuracy, spatial resolution, temporal extent—to address management questions
- A **multi-source data approach** could allow for a more robust indicator (e.g., combining satellite data and monitoring data)
- Important to **consider indicator longevity** to ensure reliability of the indicator for decision-making needs

Rising Tidal Water Temperatures Storyline

- Chesapeake Bay tidal waters temperatures are rising, largely influenced by atmospheric and ocean temperatures.

- Rising tidal water temperatures directly influence physical, chemical, and biological processes that can have direct and indirect effects on the Bay's living resources and habitats.

- The Bay's fish, crab, shellfish, benthic and pelagic forage, and SAV communities have varied sensitivities to temperature will result in direct and indirect responses from rising tidal water temperatures.

Rising Tidal Water Temperatures Storyline

- Rising tidal water temperatures create new spatio-temporal habitat niches allowing for species not endemic to the Bay to extend their range into the Bay (e.g., cobia, red drum) and thrive (e.g., shrimp). SAV - warm water pathogens

- Better understanding of the influences of rising water temperatures on living resources and habitats will require enhancements to the Partnership’s current modeling tools.

- Having the right monitoring and tidal water temperature change indicators in place to collect and organize data in response to management needs will be critical to inform improved decision-making for managers and policy-makers.

Rising Tidal Water Temperatures Storyline

- Given global scale forces as significant drivers of temperature change in tidal waters (e.g., greenhouse gas emissions), management options targeting adjustments to fisheries catch, seasons, and quotas, and SAV community expectations to account for warming habitats will be needed.

- BMPs reducing hot water plumes in urban-influenced tidal tributaries could minimize exacerbated warming for some nearshore habitats in the short to mid-term timeframe.

- Actions utilizing nature-based, habitat-forming, carbon sequestering BMPs could mitigate or reduce vulnerabilities of temperature increases within a mid to long-term timeframe (end of century).

Acknowledgements

- **Synthesis Element #2 Paper (Tidal Fisheries and Habitat Impacts)**: Bruce Vogt, Jay Lazar, and Emily Farr, NOAA; Mandy Bromilow, NOAA Affiliate; Justin Shapiro, CRC
- **Synthesis Element #3 Paper (SAV Impacts)**: Brooke Landry and Becky Golden, CBP; Marc Hensel and Chris Patrick, VIMS; Dick Zimmerman and Rhianne Cofer, Old Dominion University; Bob Murphy, TetraTech
- **Synthesis Element #5 Paper (Trends)**: Rich Batiuk, CoastWise Partners; Nora Jackson, CRC/CBP; John Clune, USGS; Kyle Hinson, VIMS; Renee Karrh, Maryland Department of Natural Resources; Mike Lane, Old Dominion University; Rebecca Murphy, University of Maryland Center for Environmental Science/CBP; and Roger Stewart, Virginia Department of Environmental Quality
- **Synthesis Element #6 Paper (Model Projections)**: Rich Batiuk, CoastWise Partners; Gopal Bhatt, Pennsylvania State University/CBP; Lewis Linker, U.S. EPA CBP; Gary Shenk, USGS/CBP; Richard Tian, University of Maryland Center for Environmental Sciences/CBP; and Guido Yactayo, Maryland Department of the Environment
- **Synthesis Element #9 Paper (Indicators)**: Julie Reichert-Nguyen and Bruce Vogt, NOAA; Mandy Bromilow, NOAA Affiliate; Ron Vogel, UMD for NOAA Satellite Service; Breck Sullivan, USGS; Anissa Foster, NOAA-CRC Internship Program
- **Synthesis Element #10 Paper (Monitoring)**: Peter Tango, Breck Sullivan, John Clune, and Scott Phillips, USGS

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