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

STAC Workshop Draft Findings

Local Government Advisory Committee Meeting
March 18, 2022

Presented by Julie Reichert-Nguyen
NOAA Chesapeake Bay Office, Climate Resiliency Workgroup Coordinator

Objectives

Pre-Workshop (June 2021)

Special Climate Resiliency Workgroup meeting—supported development of *state of science* synthesis papers

STAC Workshop DAY 1 (Jan 2022)

Goals:

- Discuss *drivers* of rising water temperatures
- Identify *ecological impacts*
- Identify *management implications* for living resources and habitats

STAC Workshop DAY 2 (March 15, 2022)

Goals:

- Identify management/policy *recommendations* related to implications from Day 1
- Identify *research, monitoring, or analyses* needed to support recommendations

See Synthesis Papers & Briefing Papers for More Information

BMPs – Forest Buffer

Fisheries – Brook Trout

Watershed

Mitigation
Lowering of Water Temps

Tidal

Adaptation
Minimize Impacts & Adjust

Submerged Aquatic Vegetation (SAV)

Oysters

Blue Crabs

Forage

(Menhaden, Bay anchovy, benthic invertebrates)

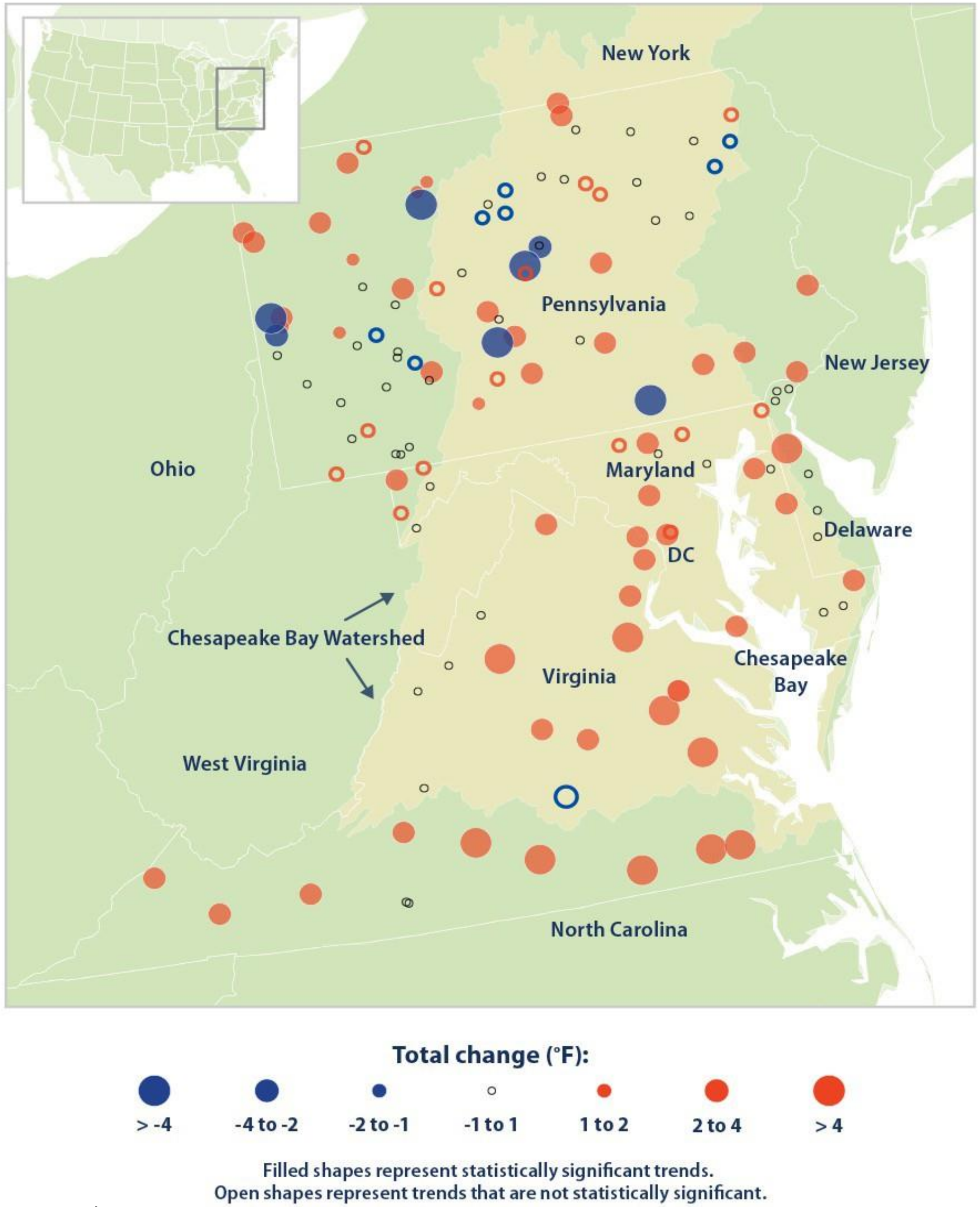
Striped Bass

Watershed

Trends, Drivers, Ecological Impacts, Management Implications & Draft Recommendations

Leads: Katie Brownson, U.S. Forest Service & Rebecca Hanmer, Forestry Workgroup Chair

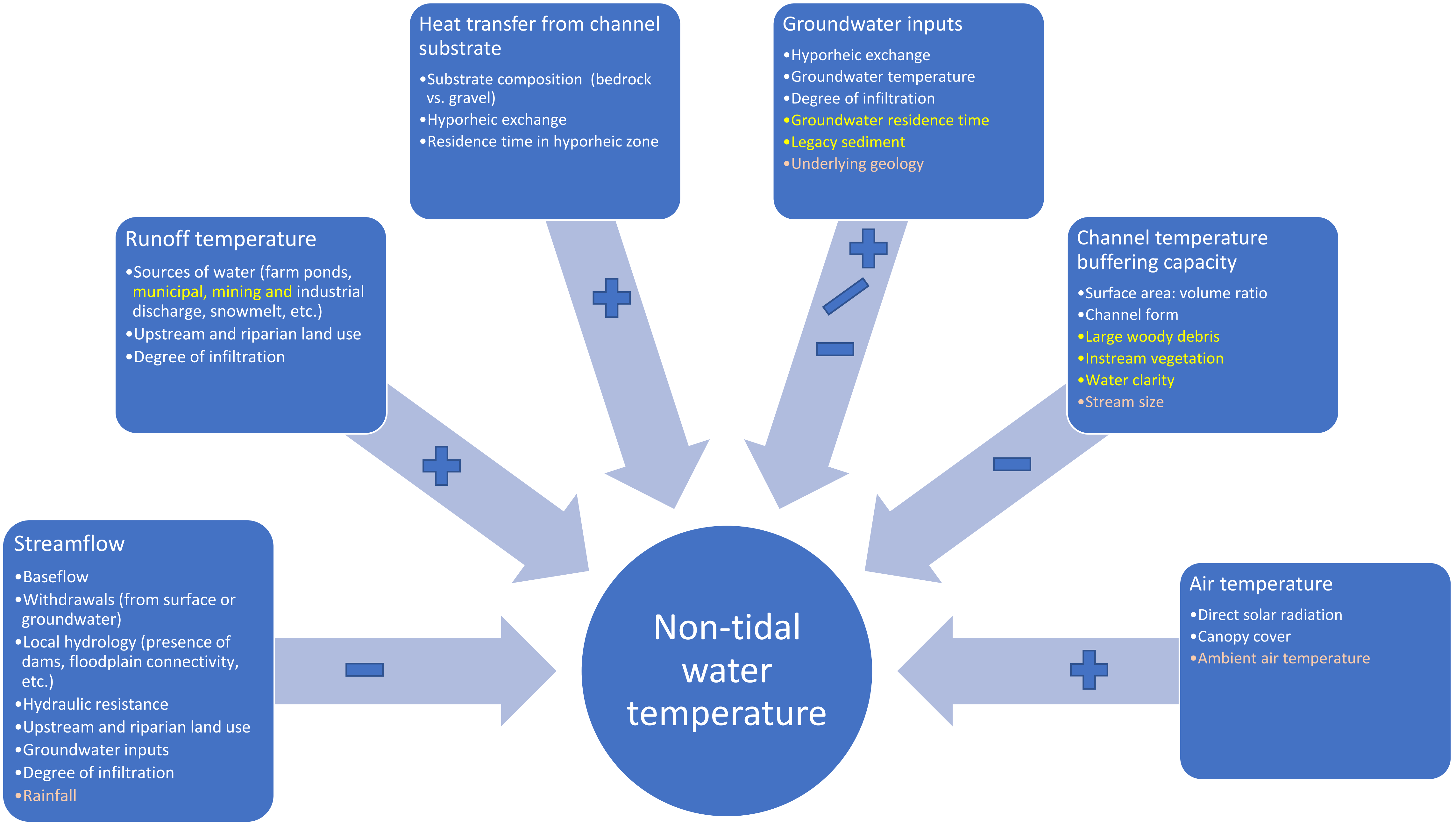
Water temperatures have been increasing in streams and rivers of the Chesapeake Bay watershed – even more than in the Bay's tidal waters



Source: Rice and Jastrow 2015

- Sites differed, but across the watershed, water temperatures increased more than air temperatures
- USGS found an average increase of 1.98° F in air temperatures and 2.52° F in nontidal freshwater stream temperatures (from 1960 to 2010)
- Air to water temperature ratios at sites showed influence of land uses

Increasing stream and river temperatures have been driven by rising air temperatures, but other drivers have a strong influence



Ecological Impacts - Species

- **Strongest negative impacts** on coldwater species (e.g., trout, sculpin) and their habitats (esp. where streams aren’t driven by groundwater)

- Watershed-wide, warmwater aquatic species are most common. Although more tolerant to temperature increases, they are **sensitive to extreme temperatures** including rapid changes and to indirect effects (e.g., invasives, pathogens) from higher temps.

- **More study needed** of temperature effects on lower foodweb
    - Algae, biofilms, zooplankton
    - Macroinvertebrates
    - Freshwater mussels & host species
  - Life stages, & predator/prey interactions

Ecological Impacts - Other Stressors

- Co-occurring Stressors
  - Low dissolved oxygen
  - Invasive species
  - Algal blooms
  - Bacterial/viral outbreaks
  - Distribution & toxicity of other pollutants (e.g., heavy metals, pesticides, ammonia, etc.)
  - Expansion of invasives

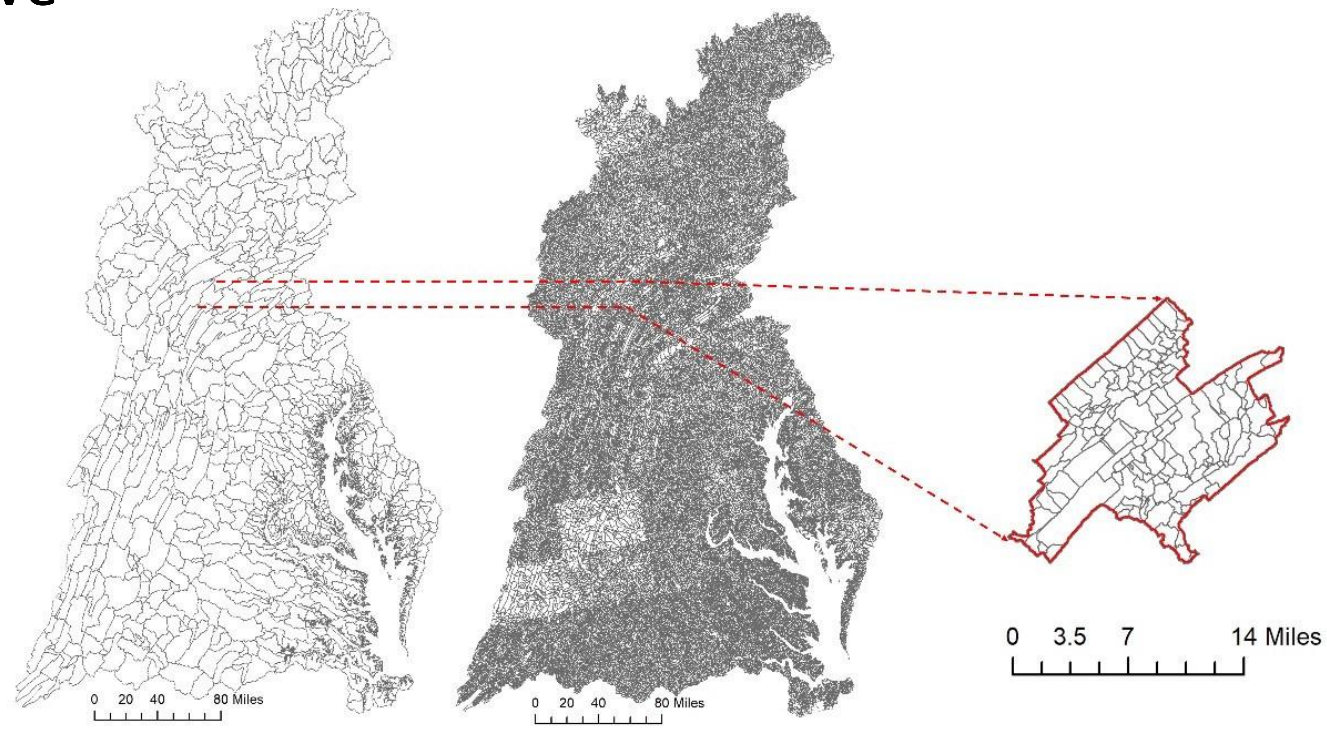
Photo credit: Driscol Drones

Management implications: policies and practices to address rising water temperatures

- Policies that promote the protection and maintenance of natural lands that provide cooling benefits, including forests, wetlands and healthy watersheds.
- Best Management Practices (BMPs) included in Watershed Implementation Plans (WIPs)

Management implications: Priority information needs

- Improved understanding of the relative influence of BMPs and habitat restoration on water temperature, including cost-effectiveness
- Additional data/modeling capacity to predict future changes in stream temperature
- Additional research to better understand how stream temperature and living resources will respond to management



Day 2 Themes for Discussion

- Coldwater fisheries and habitats
- Rural waters and habitats
- Urban waters and habitats
- Cross-watershed topics
  - State temperature water quality standards (WQS), monitoring and implementation
  - Monitoring and modeling

Photo credit: Joel Prince, NASF

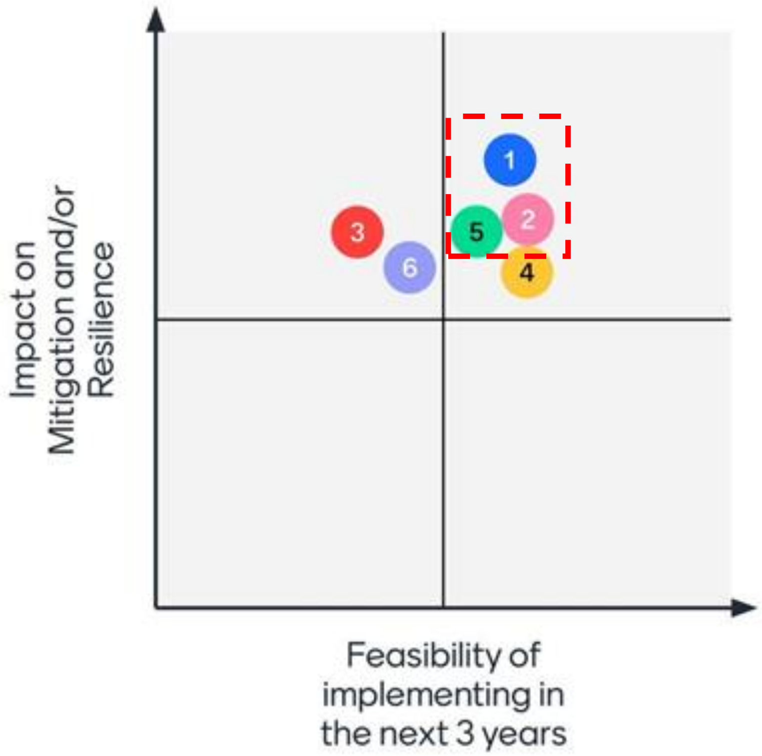
Management Recommendations (DRAFT)

<u>Coldwater Fisheries & Habitats</u>

(1) Prioritize protecting forested watersheds with high quality brook trout habitat by maintaining and enhancing current forest cover

(2) Promote good agricultural stewardship, including better use of cooling BMPs, to minimize the impacts of agricultural land use in watersheds with high quality brook trout habitat

(5) Work with local governments to improve land use planning in high quality habitat areas and to better utilize new and existing programs for coldwater fisheries



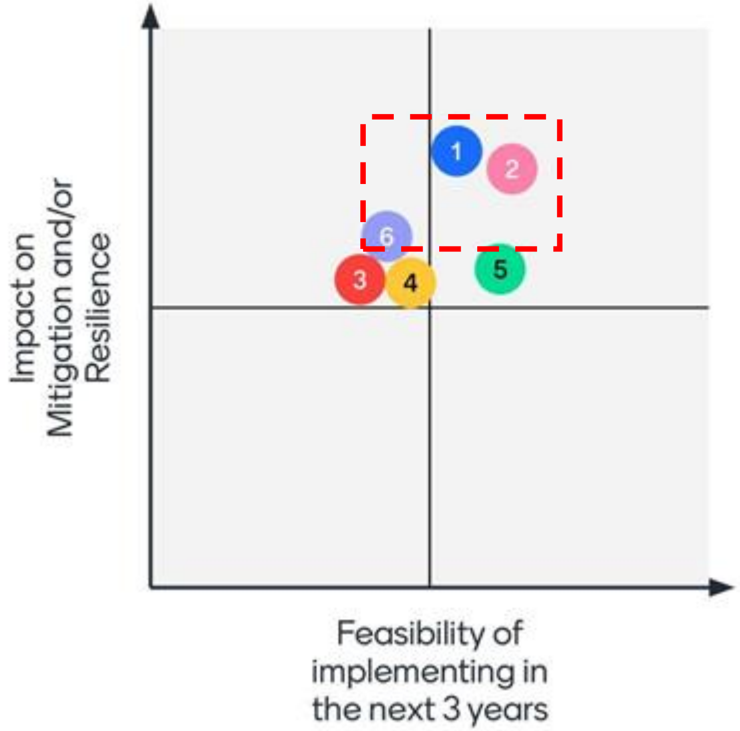
Management Recommendations (DRAFT)

<u>Rural Waters & Habitats</u>

(1) Improve forest cover throughout the landscape and ensure rivers and streams are well buffered

(2) Use the improved Bay watershed mapping capability to prioritize specific headwater stream reaches that are the most suited for riparian buffer plantings to exert the greatest cooling impact in rural watersheds

(6) Work with local government planning departments to modify codes and laws where appropriate to require conservation BMPs and cooling practices



Management Recommendations (DRAFT)

Urban Waters & Habitats

(1) Work with local governments to identify opportunities to incentivize stacking multiple stormwater “cooler” BMPs over “heater” BMPs in the Bay watershed for pollutant reduction going forward.

(4) Encourage the retention and expansion of urban tree cover (both in the riparian zone and upstream), especially in under-served urban areas which historically suffer the worst heating and human health outcomes.

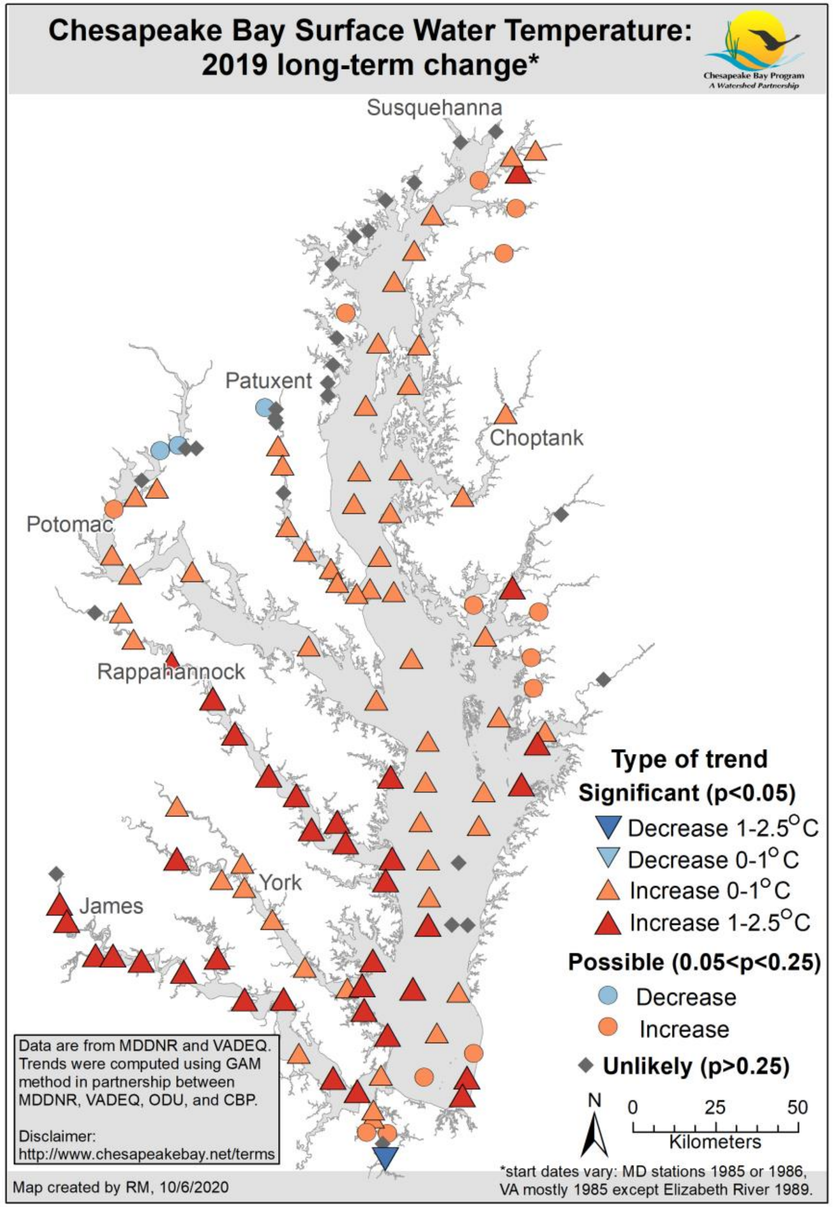
(6) Emphasize the multiple co-benefits of cooler BMPs beyond rising water temperatures and nutrient reductions to better communicate about these practices with residents and local governments and to access additional sources of funding

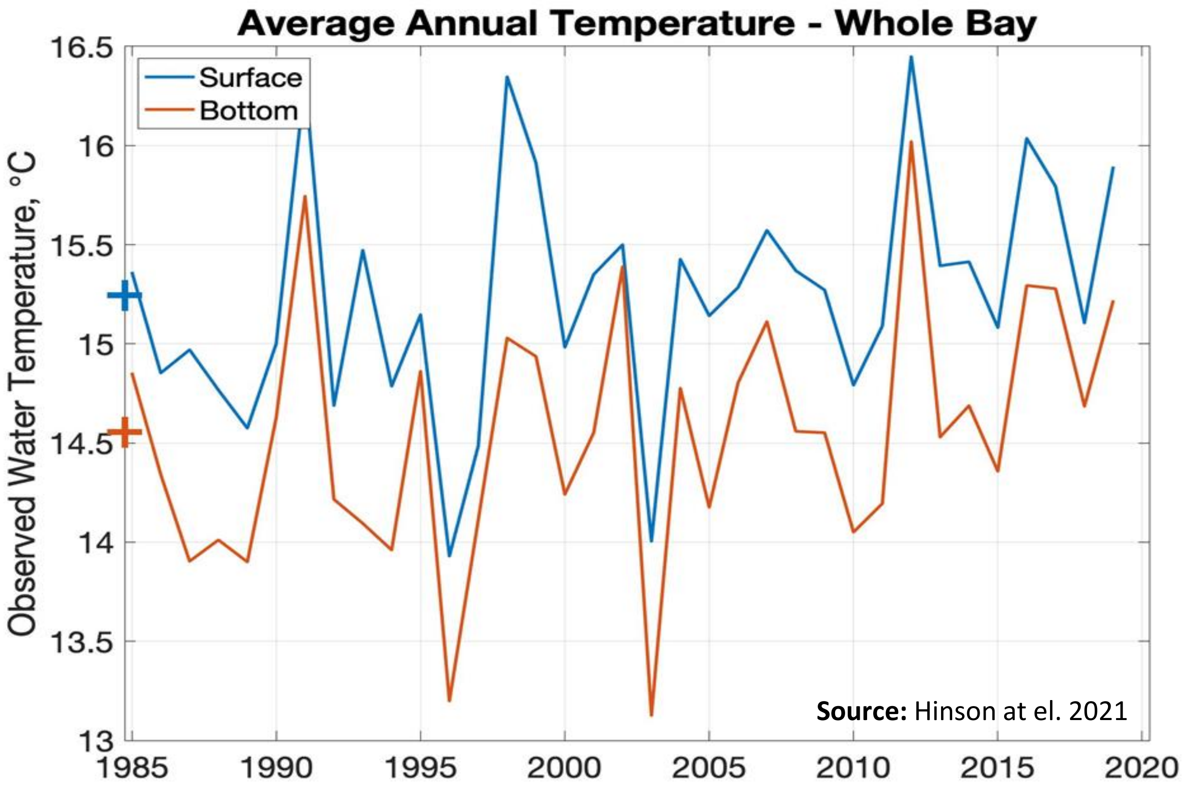
TIDAL

Trends, Drivers, Ecological Impacts, Management Implications & Draft Recommendations

Leads: Julie Reichert-Nguyen & Bruce Vogt, NOAA and Rich Batiuk, CoastWise Partners

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





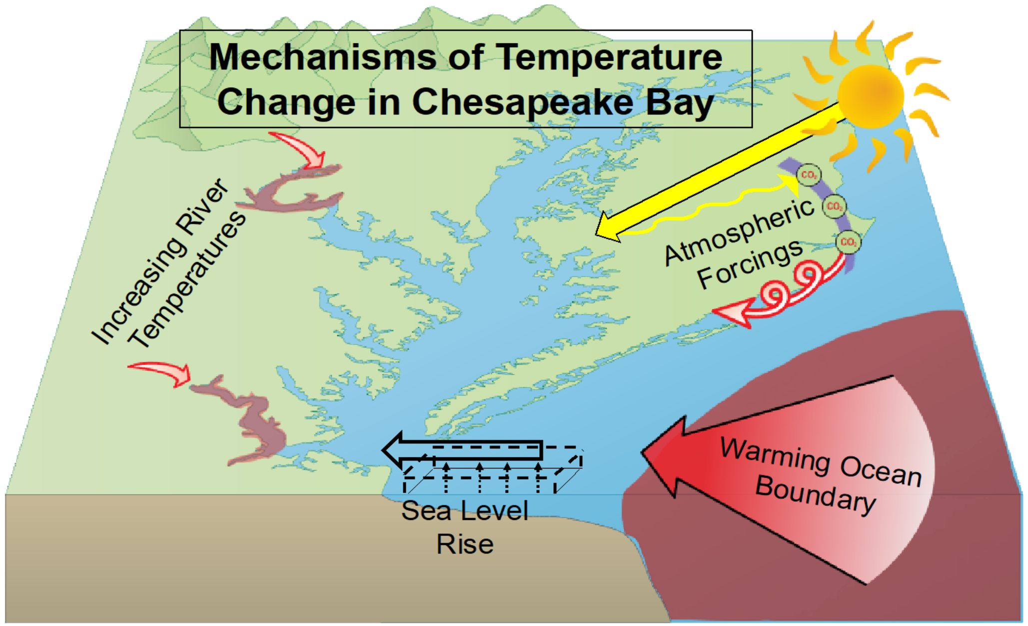
<u>Over the Past 30 Year Period</u>

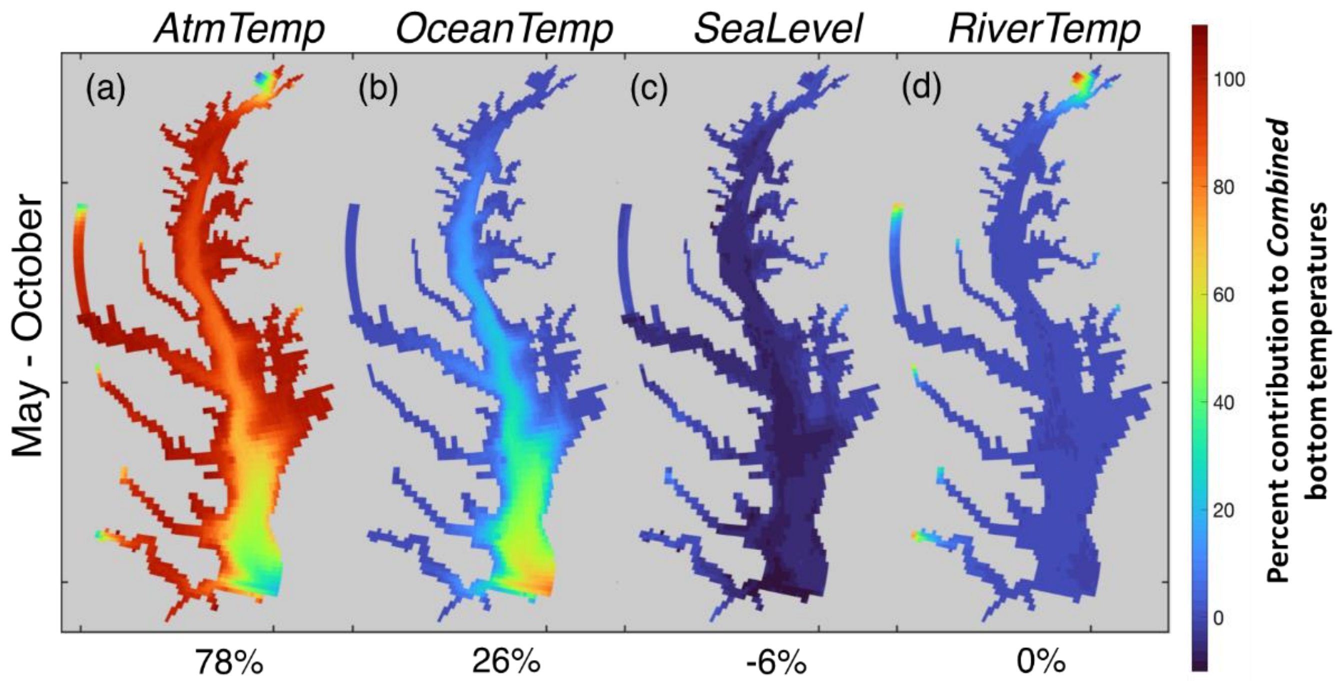
Annual average: +~0.7°C increase

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



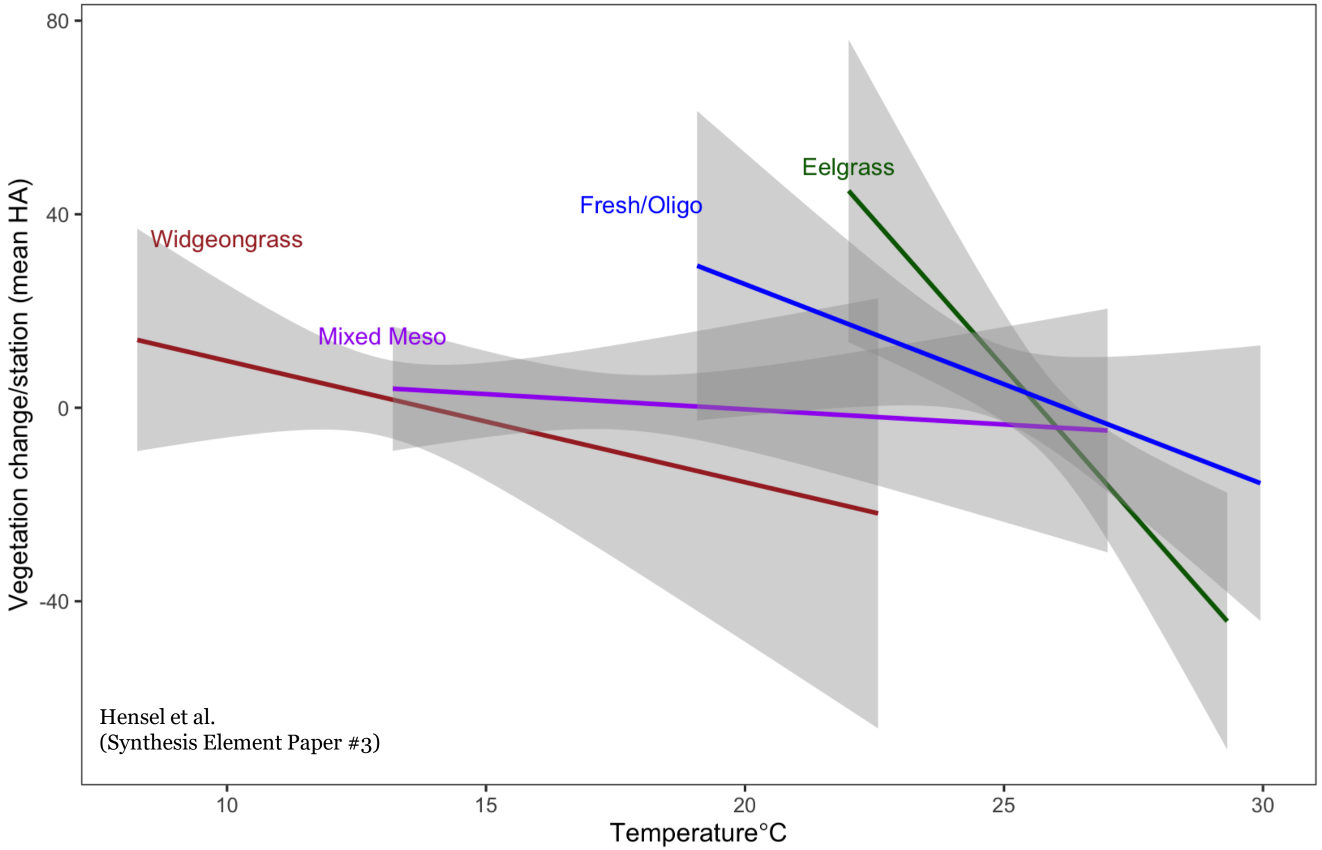


1) Air temperatures
2) Ocean temperatures
3) Sea level rise
4) River temperatures

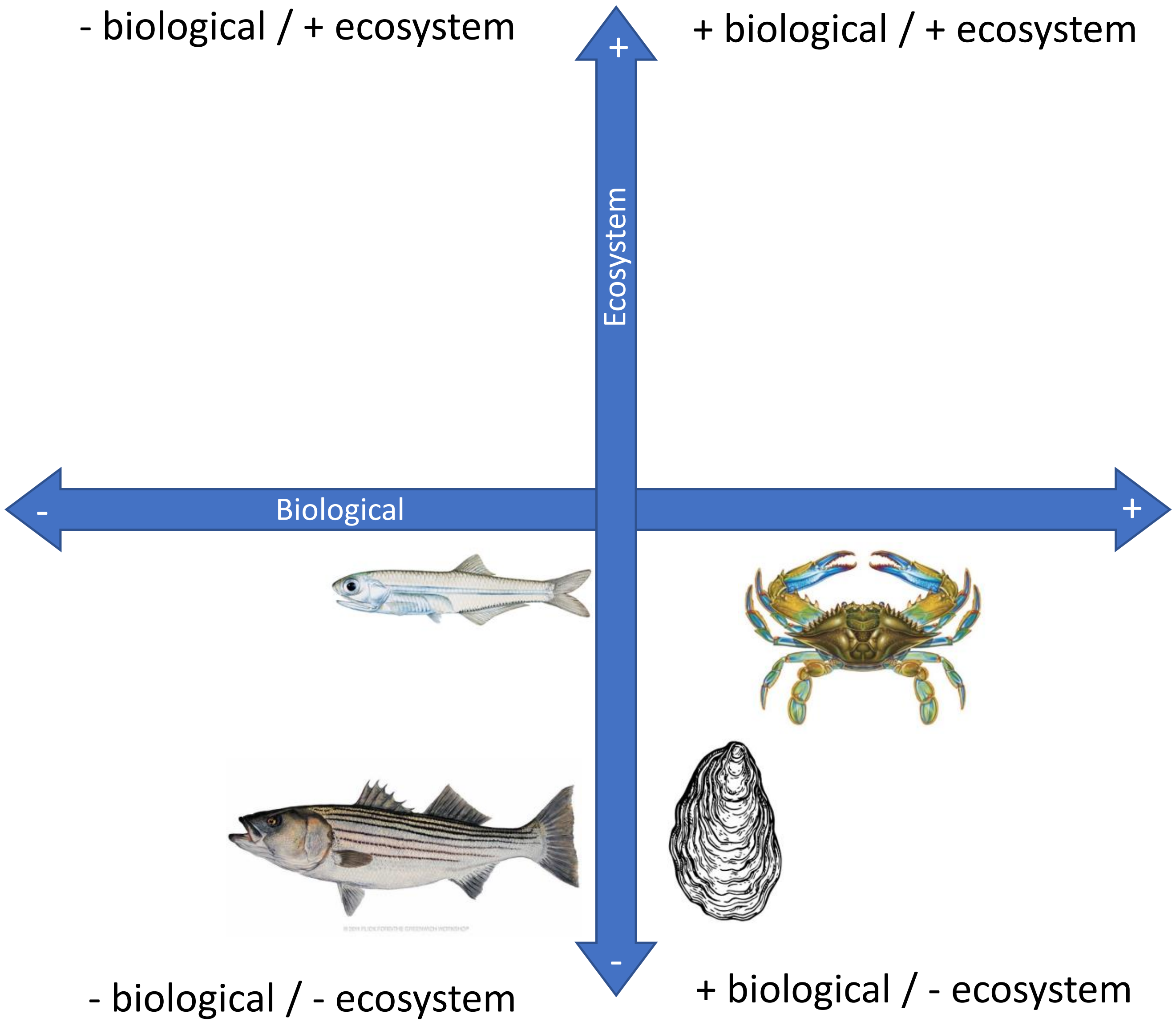
Source: Hinson at el. 2021

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

- Viable populations of eelgrass will likely be extirpated from Chesapeake Bay with increasing warming trends
- Temperature impacts to other Chesapeake Bay SAV species are not as well studied but appear to be less dramatic than those to eelgrass
- The CO_2 fertilization effect
  - may counterbalance some of the impacts from warming,
  - unknowns associated with invasive species, pathogens, cyanobacteria, etc. could counteract balance



Varying Effects and Sensitivities to Rising Water Temps for Chesapeake Bay Fisheries



POSITIVE
DIRECT
Increased growth rates & earlier maturation
Reduced winter mortality (blue crabs & oysters)
INDIRECT
Longer spawning and/or growing season
More algae/food (oysters)

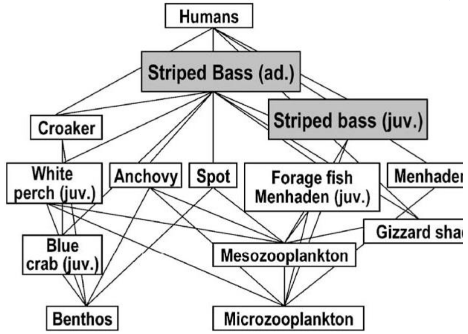
NEGATIVE
DIRECT
Reduced survival due to detrimental temperature ranges (more so during earlier life stages)
INDIRECT
Increased hypoxic conditions
Ocean Acidification (OA)
Increases in pathogens/disease occurrence (old & new)
Alteration in food resources (abundance & quality)
New non-native predators

Recruitment Concerns

Reduced water quality, greater sensitivities during early life stages, unfavorable changes in spawning timing & food resources (predator-prey mismatch), & fishing pressure could counteract any + biological effects

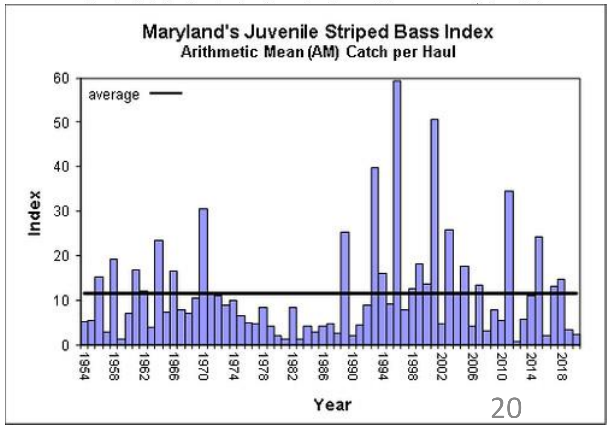
Shifts in species range and habitats are being documented due to rising water temperatures – need better understanding of species response in Chesapeake Bay

- Some Bay species' populations are shifting north while other species from the south are becoming more prevalent in the Bay (e.g., shrimp)



- Range shifts can result in changes to habitats and species affecting abundance and distributions, food web dynamics, fishing behavior; greater potential for new fisheries (e.g., cobia, red drum)

- Concerns of a new temperature regime allowing for new pathogens

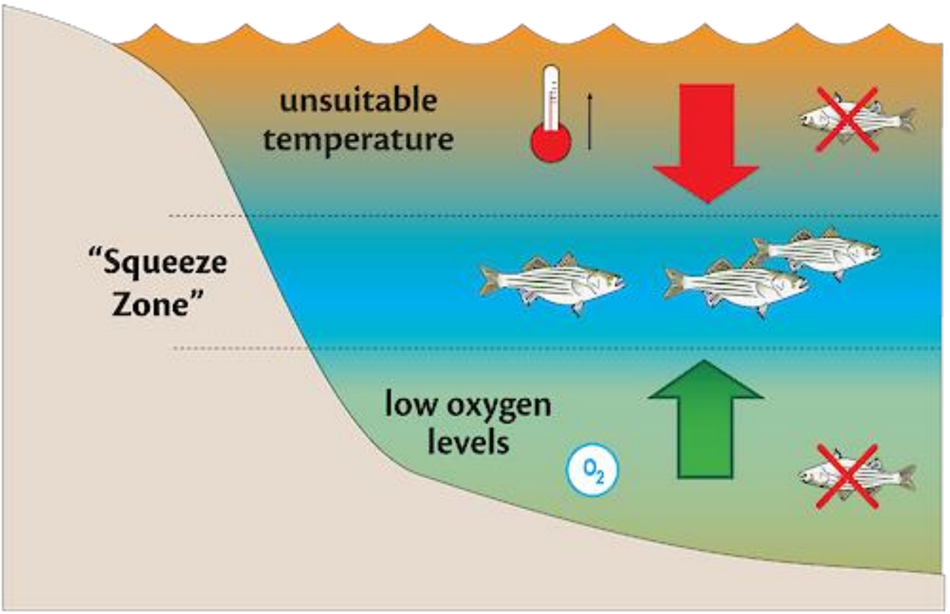


Science Needs – Better Understanding of Ecosystem-Level Effects, Multiple Stressors & Extreme Events on Survival & Habitat

Higher water temperature →
- Lower oxygen solubility in water
- Higher remineralization rate = more nutrients for algae growth
- More stratified water column

All combined = even lower dissolved oxygen

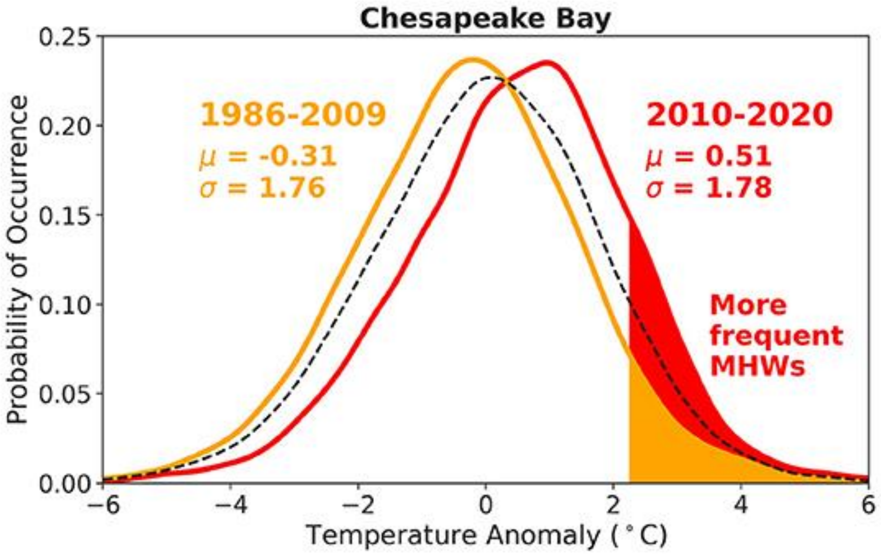
Squeeze Zone for Striped Bass



Conceptual diagram illustrating the compressed habitat of the striped bass from the low oxygen levels from the bottom, and the unsuitable unsuitiable tempatures on the top waters.
Diagram courtesy of the Integration and Application Network (ian.umces.edu), University of Maryland Center for Enviromental Science. Source: Boesch, D.F. (editor). 2008. Global Warming and the Free State: Comprehensive Assessment of Climate Change Impacts in Maryland. Report of the Scientific and Technical Working Group of the Maryland Commission on Climate Change. University of Maryland Center for Environmental Science, Cambridge, Maryland. This report is a component of the Plan of Action of the Maryland Commission on Climate Change, submitted to the Governor and General Assembly pursuant to Executive Order 01.10.2007.07.

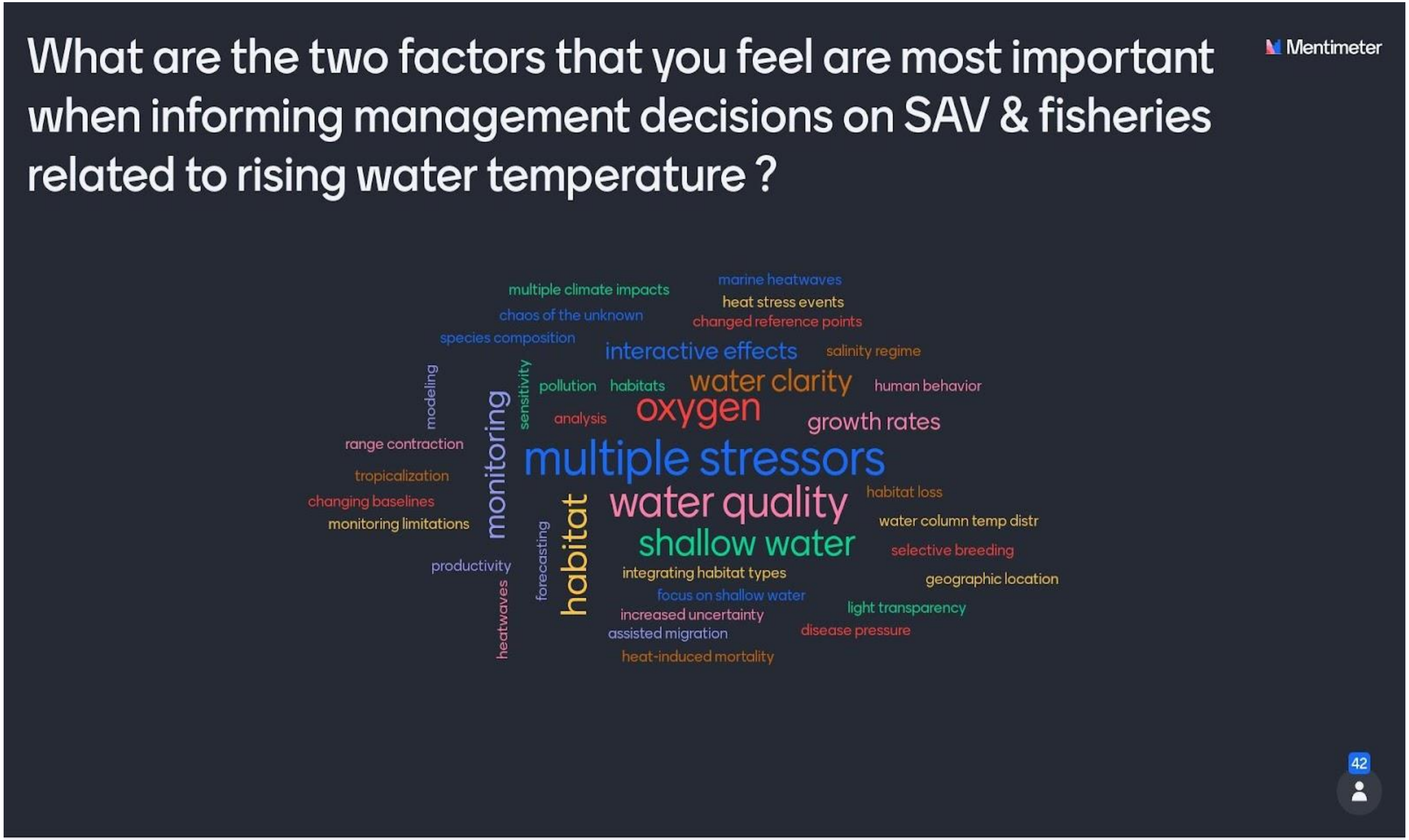
- Reduced water clarity & salinity from increased precipitation effects on SAV & oysters
- SAV community changes & effect on habitat-use by fish and crabs

- Reduced SAV habitat from sea level rise and hardening of shorelines
- Changes in the intensity, duration, & frequency of marine heat wave events & effects on survival



Source: Mazzini and Pianca 2022

Factors to Consider for Decision-Making



Day 2 Themes for Discussion: Top-Ranking Tidal Management Implications from Pre-Workshop Survey (~18 Participants)

Ecosystem-Based Management

- Changes in restoration locations & techniques
- Factoring in rising water temps in recruitment estimates
- Incorporating environmental conditions (temp & habitat) in fisheries management frameworks
- Efficacy of current stock surveys
- Using nowcast & forecast models for forage species to manage predator stocks accordingly

Multiple Stressors

- Maximizing improvements in water quality & clarity to build resilience
- Incorporating habitat squeeze considerations in fisheries management decisions
- Including shoreline development & other climate stressor effects when assessing SAV recovery
- Building in buffers for ecosystem uncertainty in catch quotas

Nearshore Habitats

- Co-locating oysters & SAV with one another and/or riparian forest buffers
- Limiting use of hardened shorelines that negatively affect nearshore resources; promote green infrastructure solutions for shoreline protection and habitat

New Temperature Regime

- Changes in spawning success, recruitment, & adult mortalities
- Monitoring threats from shifting predator distributions & new tropical parasites
- Temp-driven changes on oyster BMP effectiveness

Management Recommendations (DRAFT)

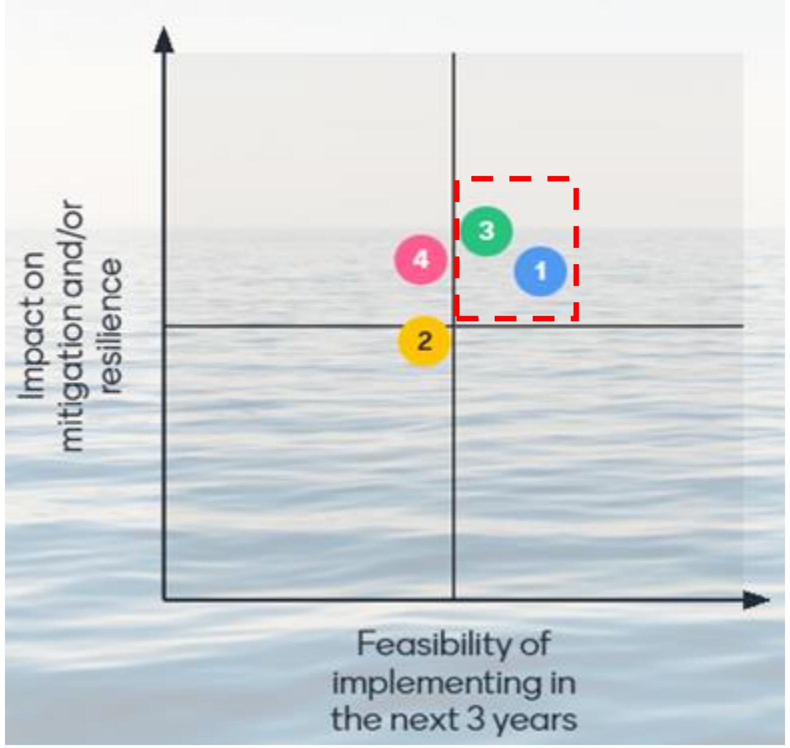
<u>Ecosystem-Based Management</u>

(3) Continue water quality improvement to support SAV essential fish habitat – enhancing water clarity increases resilience to warming temperatures

(1) Adjust within same season fisheries catch limits using two prong approach:

1) develop management triggers based on temperature thresholds for determining seasonal closures and

2) Incorporate an educational/human behavioral warming tool to communicate when fish are most stressed/vulnerable & how to modify fishing behavior outside of closures



Management Recommendations (DRAFT)

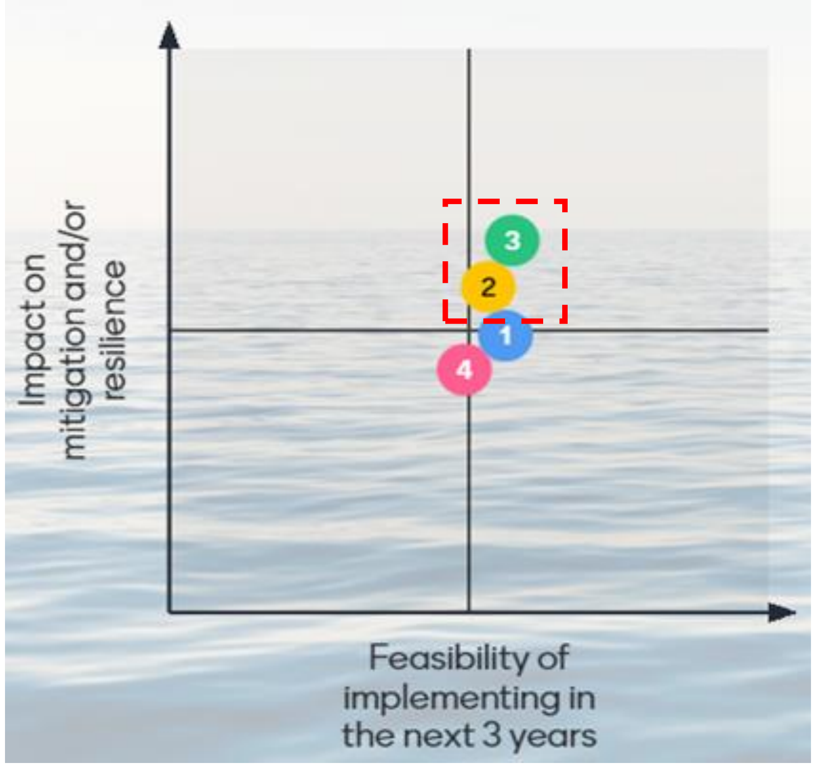
Nearshore Habitats

(3) Target use of natural/green infrastructure where ecological & climate resilience benefits are highest

- Accelerate preferred designs, provide information on funding opportunities & provide technical drafting assistance for implementation proposals

(2) Amplify the urgency to manage shoreline development & condition based on ecological thresholds already established for SAV, blue crab and fish

- Improve the delivery and communication of the ecological threshold to local planners
- Explore incentives for private landowners to promote use of living shorelines
- Develop a pipeline for integrating thresholds into regulatory language



Management Recommendations (DRAFT)

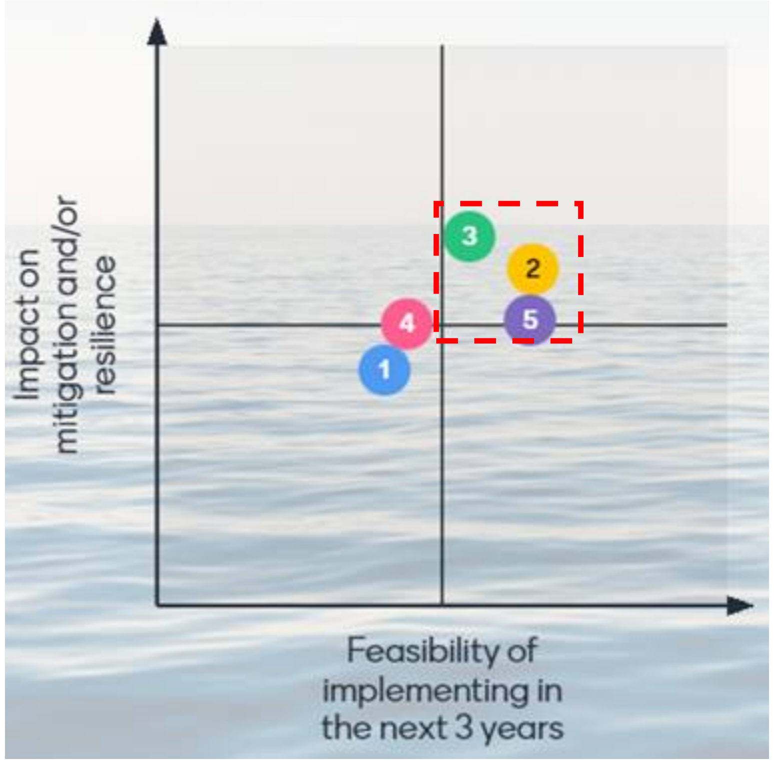
Multiple Stressors

(3) **Implement TMDL to its fullest potential** & better connect to living resource outcomes

(2) Develop a **public facing heat wave warning system** that incorporates dissolved oxygen and is linked to habitat preferences of key species such as striped bass, blue crabs, oyster, and SAV

- Partner with meteorological community to incorporate into weather forecast and warnings

(5) **Education of the public to manage expectations** of what the regulation of living resources can accomplish given the external stressors



Management Recommendations (DRAFT)

New Temperature Regime

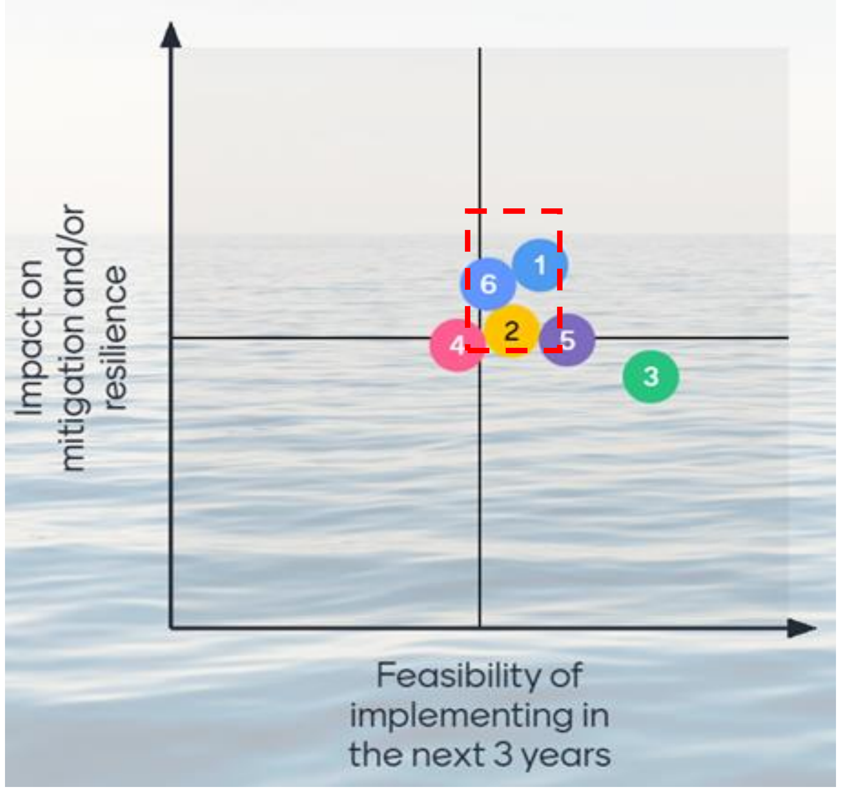
(1) **Improve long-term monitoring networks** to **better connect to managing living resources**

- E.g., allow for assessment of striped bass under heat stress in summer, blue crab winter mortality, oyster biomass
- Consider strategic siting in shallow waters & spawning habitat

(6) Explore ways to support fisheries in the **development of more strategic, long-term climate predictions for management**

(2) **Examine impacts of temperature change on fish stock survey designs (e.g., blue crab winter dredge survey catchability estimates)**

- Assess whether shifts in temperature ranges/seasons are accounted for



Next Steps

- Steering Committee will review & synthesize information, including management recommendations and associated science needs, from synthesis papers and both workshop days and draft final report

- Participant review of draft report (~April-June 2022 timeframe)

- Release final report (~summer 2022 timeframe)

- Conduct outreach with Bay Program and partners to discuss strategies to implement the report's recommendations

Watershed Acknowledgements

- **Synthesis Element #1 Paper (Water Temperature Effects on Fisheries and Stream Health in Nontidal Waters):** Stephen Faulkner, Kevin Krause, Rosemary Fanelli, Matthew Cashman, Than Hitt and Benjamin Letcher, USGS; Frank Borsuk and Greg Pond, EPA
- **Synthesis Element #1 Addendum (Temperature Criteria in CBP Jurisdictions' Water Quality Standards and Information on Warmwater Species):** Rebecca Hanmer, EPA-retired; Jonathan Leiman, Maryland Department of the Environment; Daniel Goetz, Maryland Department of Natural Resources; Robert Breeding, Virginia Department of Environmental Quality; and Matthew Robinson, DC Department of Energy and Environment
- **Synthesis Element #4 Paper** (Watershed Characteristics and Landscape Factors Influencing Vulnerability and Resilience to Rising Stream Temperatures): Renee Thompson, USGS; Nora Jackson, CRC/CBP; Judy Okay, J&J Consulting; Nancy Roth, Tetra Tech; Sally Claggett, USFS
- **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 #7/8 Paper (Impacts of BMPs and Habitat Restoration on Water Temperatures): Katie Brownson and Sally Claggett, USFS; Tom Schueler, CSN; Anne Hairston-Strang and Iris Allen, Maryland Department of Natural Resources-Forestry; Frank Borsuk and Lucinda Power, EPA; Mark Dubin, UMD; Matt Ehrhart, Stroud; Stephen Faulkner, USGS; Jeremy Hanson, VT; Katie Ombalski, Woods & Waters Consulting
- **Synthesis Element #10 Paper (Monitoring)**: Peter Tango, Breck Sullivan, John Clune, and Scott Phillips, USGS

Tidal 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, Maryland DNR; 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
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- **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