RISING TEMPERATURES AND CHESAPEAKE BAY

2022 STAC WORKSHOP PURPOSE

1. Summarize major findings on the ecological impacts of rising water temperatures, including science-based linkages between causes and effects.
2. Develop recommendations on how to mitigate these impacts and build climate resiliency into ongoing efforts, ranging from best management practices, habitat restoration, fisheries management, and land conservation to developing indicators and monitoring.

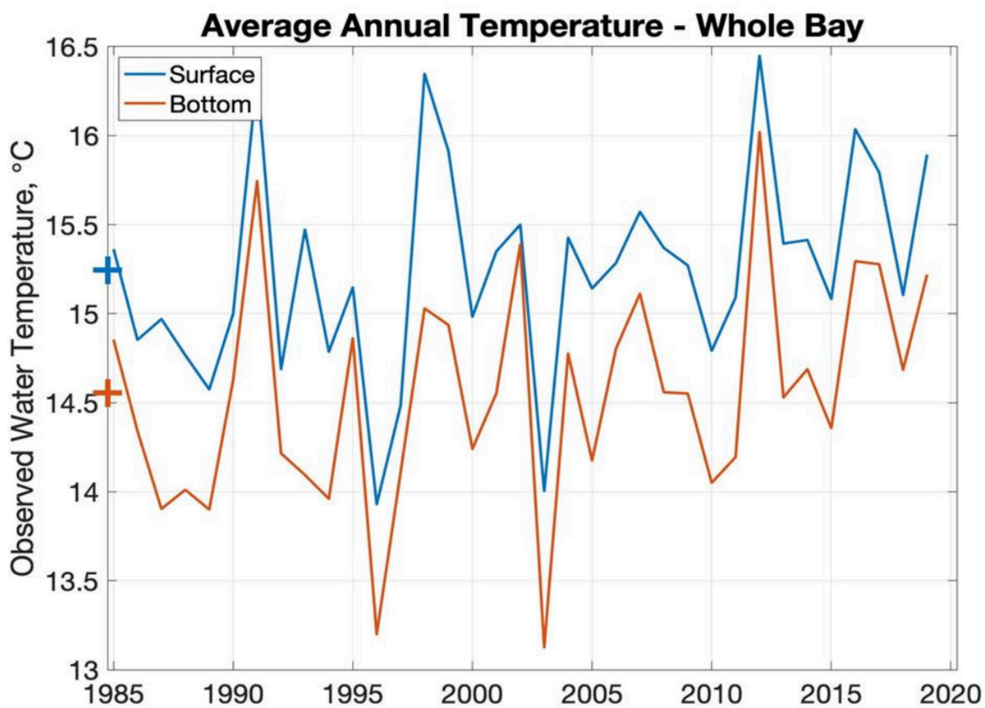
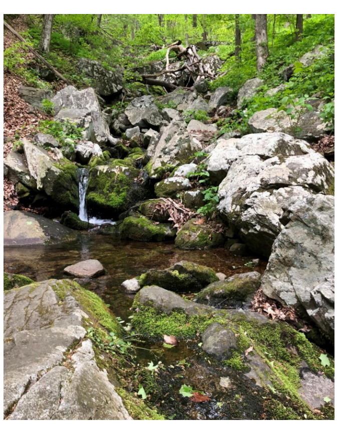


Figure 1. Temperature change over time in the Chesapeake Bay. Data from Hinson et al. 2021, Journal of the American Water Resources Association.

Water temperature is rising in Chesapeake Bay tidal waters and in streams and rivers across the Bay's watershed, and this is expected to continue. Water temperature increases have significant ecological implications for Bay and watershed natural resources, and could undermine progress toward Chesapeake Bay Program (CBP) Partnership goals for fisheries management, habitat restoration, water quality improvements, and protecting healthy watersheds. There is a critical need for insights into what the CBP Partnership might do now–within the scope of its current goals, policies and programs–to actively prevent, mitigate, or adapt to some of the adverse consequences.




CHESAPEAKE WATERSHED STREAMS ARE WARMING

Across the Chesapeake Bay watershed, stream temperature increased from 1960–2014 (Fig 2). Climate has the strongest influence on stream temperature. Water temperature rises faster than air temperature in open agricultural areas, and rises less than air temperature in forested sites and streams receiving cool water from major dams. Runoff from heated pavement adds to urban stream warming. Increases in water temperature are higher in the southern part of the watershed.

Rising water temperature speeds up biological processes and metabolism, increasing stress in living resources, and reduces dissolved oxygen. Warming can also shift species distributions, causing increases in invasive species and pathogens.

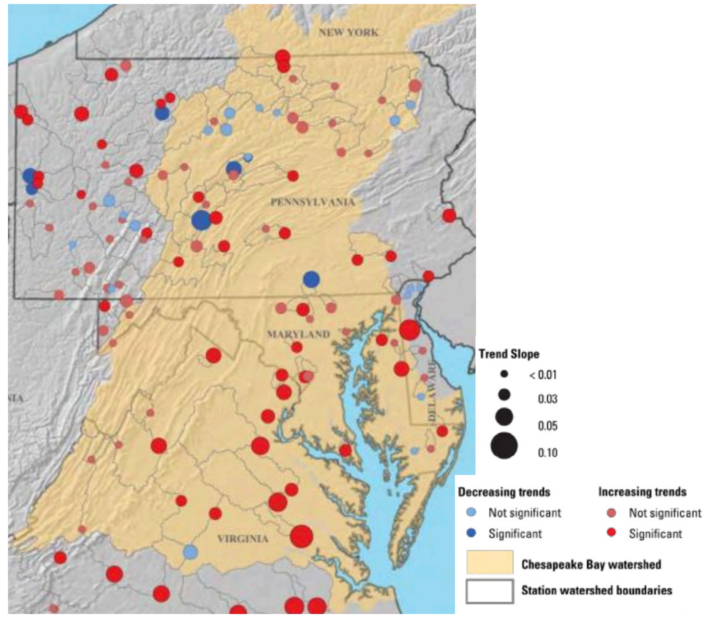


Figure 2. Locations of Chesapeake Research Consortium stream-water temperature measurement stations,1960–2014.

WEB TOOLS ARE AVAILABLE TO ASSESS HABITAT HEALTH

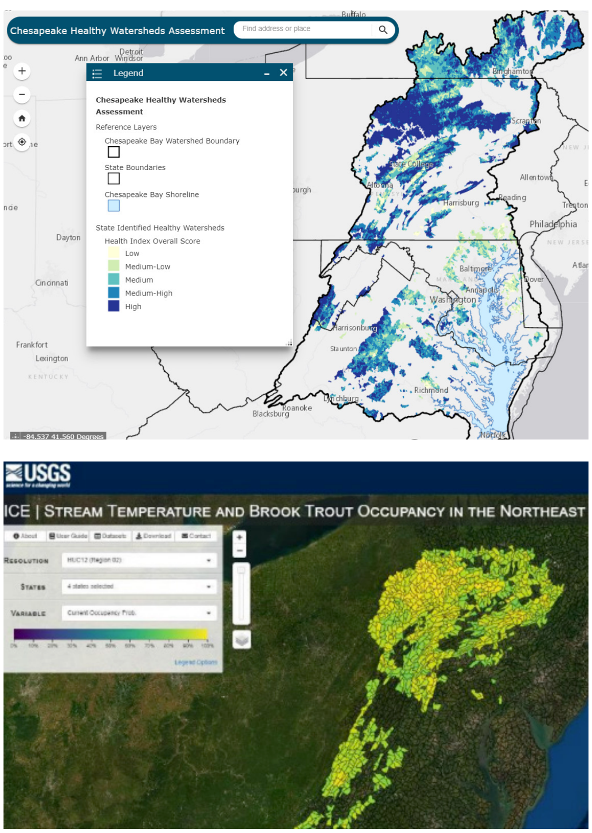


Figure 3. The Chesapeake Healthy Watersheds Assessment (Chesapeake Bay Program) and the Interactive Catchment Explorer (USGS) provide interactive online tools.

TEMPERATURE-SENSITIVE SPECIES LIVE IN SHADY STREAMS

Current stream temperature modeling occurs across the watershed, but only in streams of a certain size. Many of the most temperature-sensitive species in the watershed live in small, shallow streams; too small to be captured by the current scale of modeling. Modeling stream temperature on a finer scale will provide better, more accurate predictions about impacts on temperature-sensitive species.

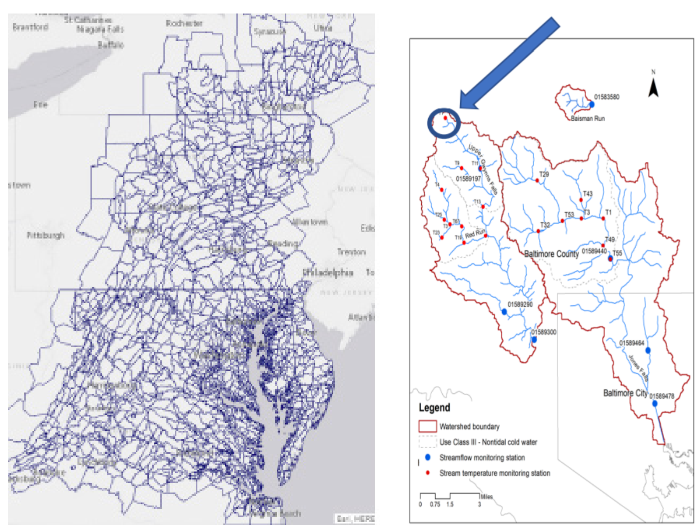


Figure 4. Spatial extent of stream temperature modeling in the Chesapeake watershed by the Chesapeake Bay Program.

CHESAPEAKE BAY WATER TEMPERATURE IS INCREASING

Temperatures are increasing across the Chesapeake Bay (0.7°C per year). Summer temperatures have increased more drastically (1.0°C per year) than winter temperatures (0.3°C per year), especially at the mouth of the Bay.

The impacts of increased Bay temperatures include higher metabolic rates for many species, and reduction in dissolved oxygen. Rising temperatures will also cause greater mineralization rates and increase water column stratification. Issues with hypoxia will be exacerbated by water column stratification, making vital oxygen unavailable for many species.

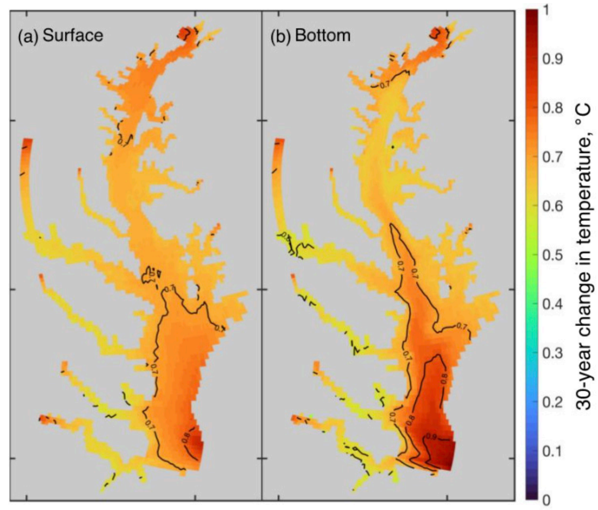


Figure 5. Chesapeake Bay water temperature change. From Hinson et al. 2021, Journal of the American Water Resources Association.

WARMING EFFECTS ON SPECIES VARY

Forage species like the blue crab will see increased productivity and habitat range as tidal waters warm. Oysters can survive higher temperatures and may experience habitat range expansion, but they are vulnerable to ocean acidification. Fishes may experience varying impacts at different life stages and across habitats. Submerged aquatic vegetation (SAV) communities will be affected by rising water temperatures; the severity of the effects will differ among communities and species. Eelgrass is particularly vulnerable to rising temperatures, and ecosystem services will be compromised as communities shift from eelgrass to widgeongrass. Given that temperature is not the sole predictor of annual fisheries and SAV change, all climate factors should be considered.

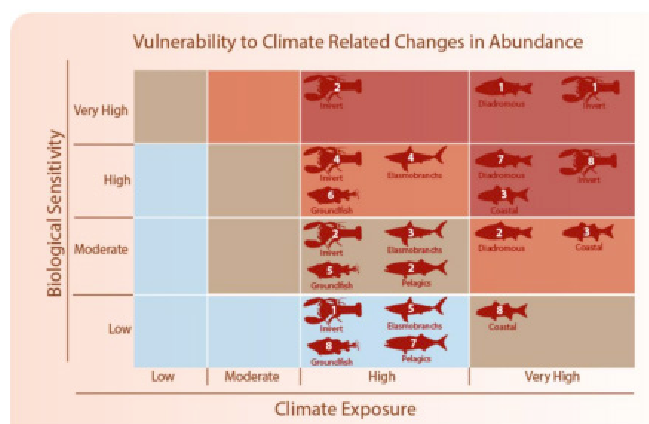


Figure 6. Temperature sensitivity among Chesapeake Bay species, from Northeast Fish and Shellfish Climate Vulnerability Assessment by NOAA.

INFLUENCES ON BAY TEMPERATURE

Air temperature is the main driver influencing Bay water temperatures year-round, but effects are lessened during summer. Warming ocean boundary effects are important in summer, but small during the rest of the seasons. Sea level rise slightly cools the Bay's main stem from April to September and warms bottom waters in winter. River temperatures produce little to no warming in the Chesapeake Bay's main stem. Increasing Bay water temperatures will result in increased volumes of low dissolved oxygen due to direct effects on oxygen solubility, biological process rates, and stratification.

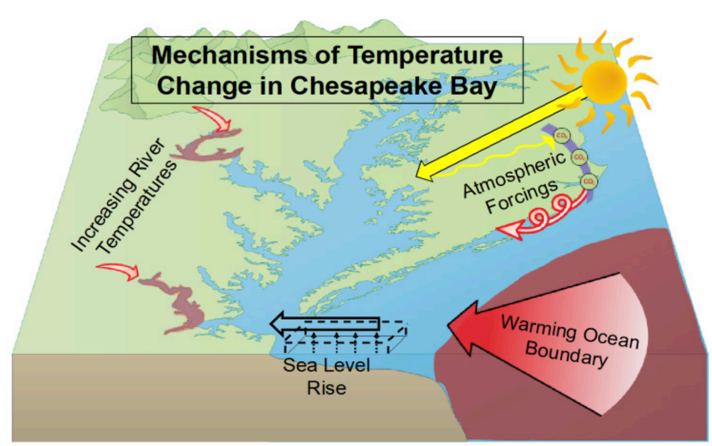


Figure 7. Temperature rise in the Chesapeake Bay is caused by atmospheric and ocean warming. Figure courtesy of Rich Batiuk.

RESEARCH AND MANAGEMENT

Best management practices (BMPs) can mitigate the effects of temperature increase. Certain elements of BMPs can be classified as heaters (like ponds), shaders (trees), and coolers (rain gardens) in terms of water temperature. Stagnant water is more susceptible to heating, while water that slowly infiltrates the water table has time to cool. Trees and forest conservation prevent solar water heating. Stream heat models enable further understanding of stream warming and management practices that can prevent it. Rising water temperatures in tidal Chesapeake Bay are driven largely by global air temperature increases and are therefore not likely able to be mitigated through watershed restoration strategies in the short-term. Existing fishery and SAV management approaches will need to adapt by better incorporating climate change impacts into their decision making for currently managed Bay species as well as additional species that are moving north into the Bay.

SLOW IT DOWN, SHADE IT, SOAK IT IN

MONITORING AND ASSESSMENT

Diverse data resources exist on water temperature measurements in the watershed and bay. Stream temperature data have been collected at 31,142 sites over 70 years by multiple agencies across the Chesapeake Bay watershed. The U.S. Geological Survey is compiling data to assess stream temperature status and trends across the watershed.

The current Chesapeake Bay tidal water quality monitoring network began sampling in 1985. There are 154 active stations sampled for physical, chemical, and biological parameters. Continuous surface monitoring is also available from NOAA buoys. An ongoing NOAA project aims to develop an estuarine surface water temperature product using daily satellite water temperature measurements.

Refined analyses will improve understanding of water temperature change to better assess affected watershed resources and tidal waters through the development of indicators with clear management applications.

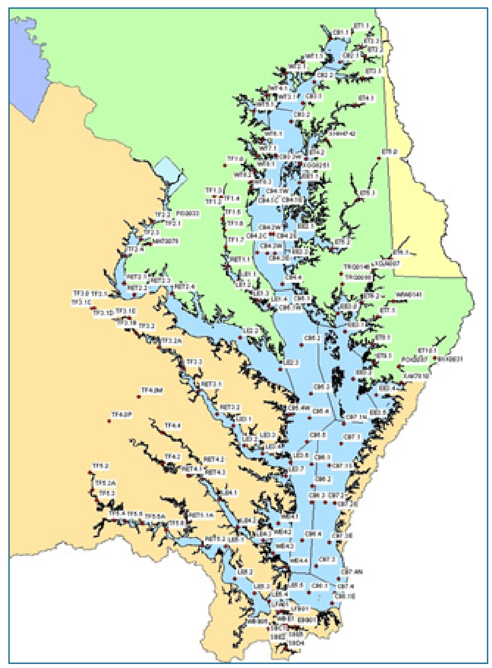


Figure 8. Tidal Chesapeake Bay Long-term Water Quality Monitoring Network.

WORKSHOP STEERING COMMITTEE MEMBERS

Rebecca Hanmer, co-chair (U.S. EPA retired; Chair, CBP Forestry Workgroup); Bill Dennison, co-chair, UMCES (Member, CBP STAC; and co-chair, CBP STAR Team); Matthew Ehrhart, Stroud Water Research Center (Member, CBP Citizens Advisory Committee); Julie Reichert-Nguyen, NOAA CBO (Coordinator, CBP Climate Resiliency Workgroup); Bruce Vogt, NOAA CBO (Coordinator, CBP Fisheries Goal Implementation Team); Renee Thompson, USGS (Coordinator, CBP Healthy Watersheds Goal Implementation Team); Frank Borsuk, U.S. EPA Freshwater Fisheries Biologist; Katherine Brownson, U.S. Forest Service; Scott Phillips, USGS (co-chair, CBP Scientific, Technical Assessment, and Reporting Team); Rich Batiuk, U.S. EPA retired (CoastWise Partners).

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