RISING WATER TEMPERATURES IN CHESAPEAKE BAY AND WATERSHED

Management Responses to Ecological Impacts

Management and Research Recommendations

Rethink Chesapeake restoration

The Chesapeake Bay Program's (CBP) management strategies and action plans to meet goals set by the 2014 Watershed Agreement need to take account of a critical, basic condition—water temperature—that has been changing and will continue to do so. The Scientific and Technical Advisory Committee (STAC) workshop was structured to initiate full consideration of rising water temperatures in nearly every restoration, conservation, education and public communication decision—made individually as well as collectively—by the CBP partners. The recommendations include many actions which can be initiated now, as well as actions in science, monitoring, modeling and program implementation which will help guide the Program in setting future goals.

Brook trout fishing in a tributary of Seneca Creek in Pendleton County, WV. Photo by Steve Droter/CBP.

Fishing Creek is protected by a riparian buffer as it flows past Schrack Farms in Loganton, PA. Photo by Will Parson/CBP.

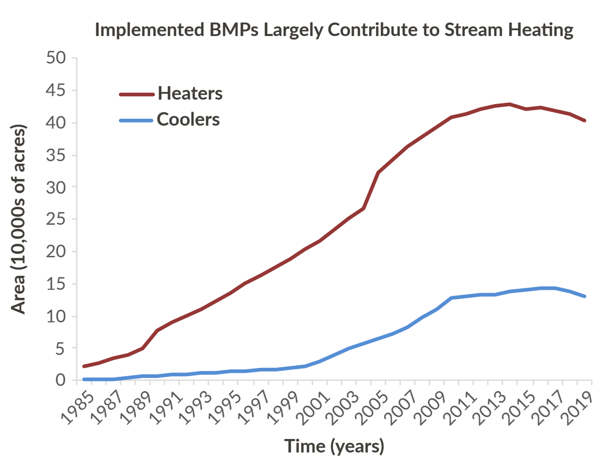


Figure 1. Trends in implementation of BMPs that may have an adverse impact on stream water temperature. Source: Synthesis Element Paper 7/8, Appendix K.

Protect coldwater fisheries

CBP partners need to accelerate conservation actions like maintaining and increasing intact forested watersheds to protect the coldwater streams now supporting healthy aquatic life, especially native brook trout, which are extremely sensitive to rising water temperatures, and continue analyses and mapping/modeling to identify stream reaches with thermally resilient groundwater inputs to focus habitat restoration efforts.

Restore aquatic habitats

CBP partners should work to strategically conserve and restore aquatic habitats, improving connectivity between healthy forested habitats and providing access to thermal refugia, both in sensitive rural watersheds and in urban streams.

Enhance "coolers" and reduce "heaters"

CBP partners should work to minimize the extent to which some water quality best management practices (BMPs) are further heating waterways and use forest buffers, good agricultural stewardship practices, stormwater infiltration, and other cooling BMPs to reduce the amount of heated runoff. Pay particular attention to expanding tree canopy coverage in historically under-served urban areas.

Modernize water quality standards

Given the vital role of Clean Water Act water quality standards (WQS) in protecting water quality and aquatic life, the states and EPA should review and update the components of current WQS systems that would strengthen their capability to address climate-related rising water temperatures and drive targeted protection and restoration strategies.

Apply Bay environmental thresholds to inform fisheries management

Establish fishing guidance based on temperature and dissolved oxygen thresholds to reduce vulnerability on key recreational fish species, such as striped bass and summer flounder, during periods of poor environmental conditions. Take actions to engage with fisheries stakeholders to explore strategic, long-term ways to advance ecosystem approaches to fishery management in the Bay that incorporate environmental thresholds influenced by climate change.

Communicate temperature risk

Better communicate the impacts of rising water temperatures and expected scenarios for existing Bay fisheries and fisheries moving into the Bay from the south between living resources managers, scientists, and stakeholders.

Create heat wave alert system

Convene an interdisciplinary team of scientists, resource managers, meteorologists, and communicators to design and create a publicly available marine heat wave alert system in connection with habitat preferences of key fisheries and underwater seagrasses.

Target nearshore projects

Develop common criteria and metrics to help target, site, and design natural infrastructure projects and implement in the nearshore, where ecological and climate resilience benefits are maximized across multiple habitat types, such as oyster reefs, underwater seagrass beds, and marshes.

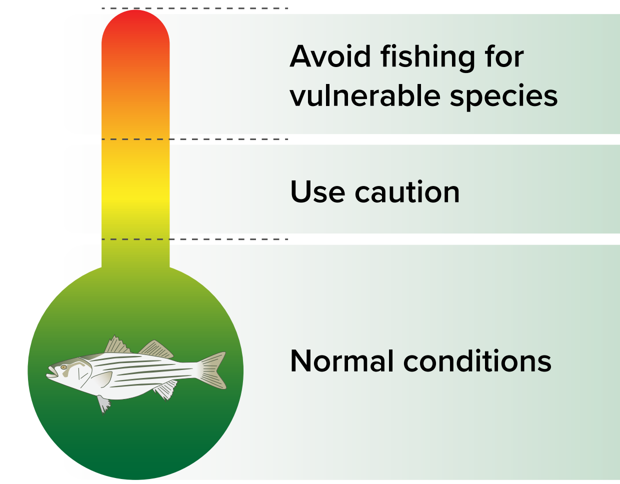


Figure 2. Defining temperature and dissolved oxygen thresholds for striped bass and other key species can minimize stress from fishing practices.

Striped bass fishing on the Chesapeake Bay. Photo by Steve Droter/CBP.

A yellow-crowned night heron hunts along a shoreline oyster reef on the Lafayette River in Norfolk, VA. Photo by Will Parson/CBP.

Causes and Effects of Rising Temperature

Counter water temperatures in the Chesapeake Bay watershed through cooling strategies

Water temperatures are rising in the Chesapeake Bay watershed

Water temperatures have been increasing in streams and rivers of the Chesapeake Bay watershed over the past several decades—even more than in the Bay's tidal waters. In many areas, water temperatures increased more than air temperatures, demonstrating that air temperature is not always the primary driver of water temperature in non-tidal waters.

Rising air temperatures and other drivers have a strong influence

Land use has a significant impact on temperatures of stream flow and precipitation-induced runoff from land surfaces. Trees and riparian forests play a central role in stream temperature moderation, through shading, evapotranspiration and facilitating infiltration. Conversely, exposed agricultural lands and developed areas with impervious surfaces contribute heated runoff to streams. Other landscape factors, like groundwater inputs, may help identify places that are more resilient to climate change to target for conservation, including healthy watersheds.

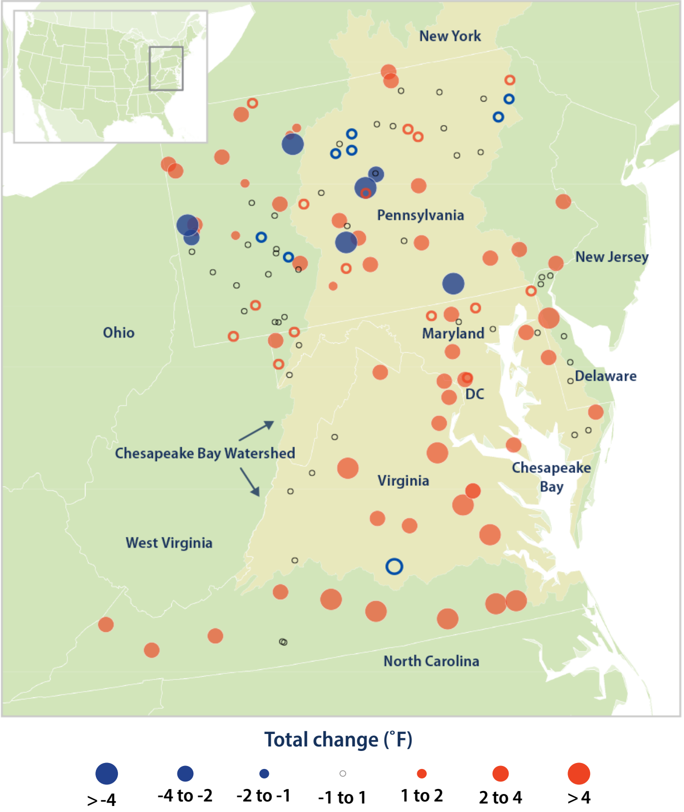


Figure 3. Changes in stream water temperatures in the Chesapeake Bay region, 1960-2014. Filled shapes and open shapes represent statistically significant and not statistically significant trends, respectively. Source: EPA, based on data from Jastram and Rice, 2015.

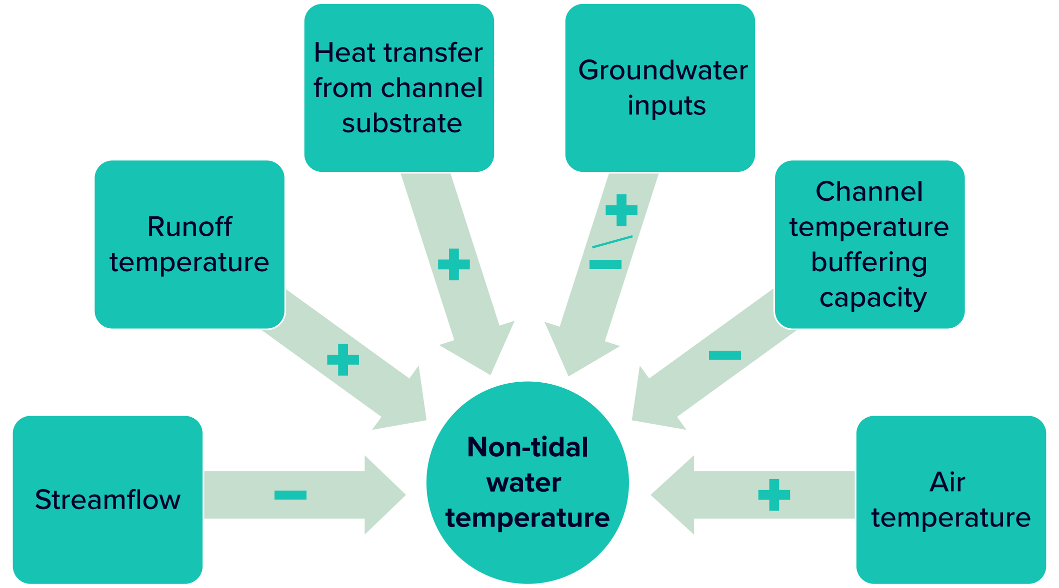


Figure 4. Major drivers of non-tidal water temperature and the direction of their influence. Source: Synthesis Element Paper 7/8, Appendix K.

Water temperatures can affect sensitive species

Warmer water temperatures, including shorter-term extreme heat events, will negatively impact aquatic habitats and threaten many ecologically and economically important aquatic species. Stream temperature has direct and indirect effects on many biological, physical and chemical processes in the freshwater environment. Rising water temperatures may increase the occurrence or co-occurrence of known stressors (such as harmful algal blooms) that negatively impact aquatic species and habitats.

Eastern brook trout (Salvelinus fontinalis) swim at the Virginia Living Museum in Newport News, VA. Photo by Will Parson/CBP.

Algae covers the surface of a pond in Warrenton, VA. Photo by Will Parson/CBP with aerial support by Southwings.

Stream temperature monitoring data is critical

In the past 70 years, stream temperature data has been collected at 31,142 sites by multiple agencies across the Chesapeake Bay watershed. The U.S. Geological Survey has begun compiling data from multiple agencies for assessing status and trends of stream temperature across the Chesapeake Bay watershed. Monitoring and analysis strategies need updating in the light of climate and land use change—for example, higher-frequency monitoring during critical periods to understand places and aquatic organisms most exposed and sensitive to pulsed heating events.

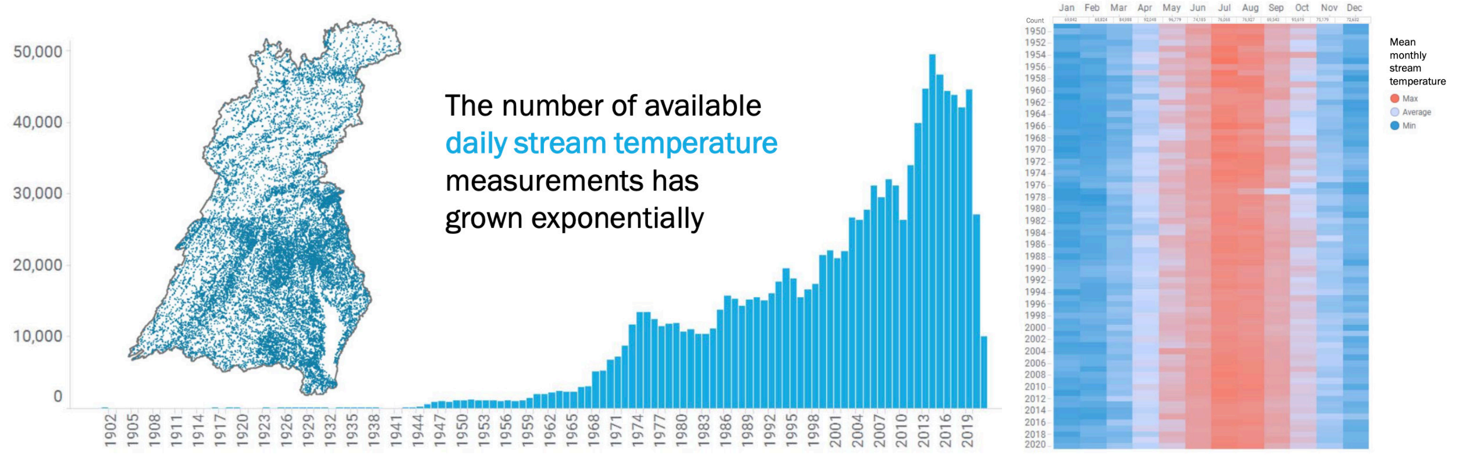


Figure 5. Available stream temperature data has increased over time (left), showing how average monthly temperatures change over time (right). Source: U.S. Geological Survey.

Minimize impacts to the Chesapeake Bay and adapt management

Water temperatures are rising in the Bay

Over the past three decades, the tidal water temperatures in the Chesapeake Bay have been increasing. These changes in tidal water temperatures are primarily driven by global atmospheric forcing (e.g., increasing surface air temperatures) and the influence of warming ocean waters entering the Bay. Warming ocean boundary effects are important in summer, but small otherwise 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 Bay's main stem. Other environmental factors are influenced by rising water temperatures, such as dissolved oxygen. 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.

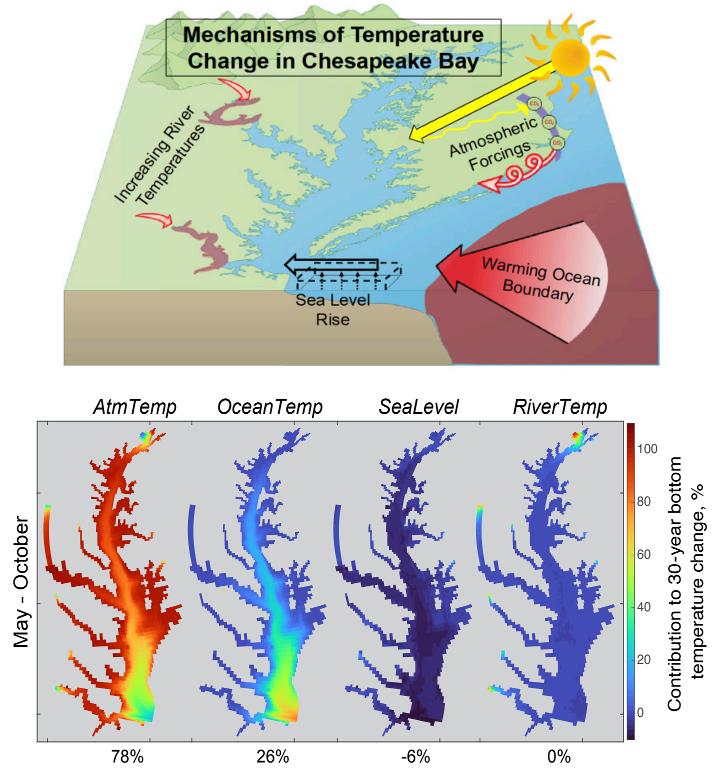
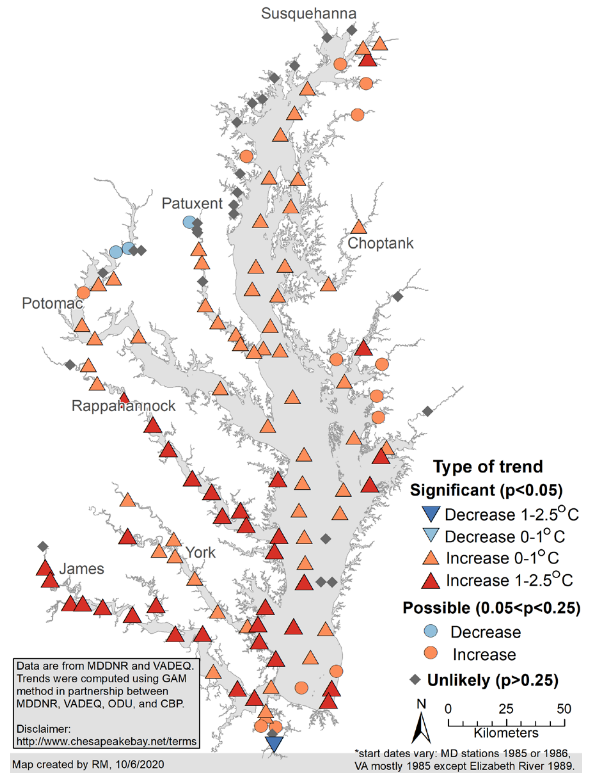


Figure 7. The four major mechanisms driving changes in water temperature throughout the Chesapeake Bay's main stem, tidal tributaries and embayments (top). Percent contribution to the total change in main stem bottom temperatures from each sensitivity experiment for May through October based on a 30-year timeframe (late 1980s-late 2010s, bottom). Source: Hinson et al. 2021.



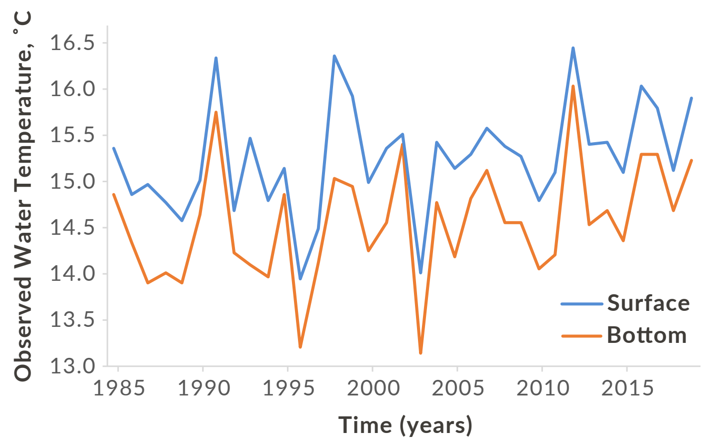


Figure 6. Long term trends in surface water temperatures at the Chesapeake Bay Mainstem and Tidal Tributary Water Quality Monitoring Program stations from a start date of 1985 or 1986 to an end date of 2019 (left). Temperature change over time in the Chesapeake Bay (right). Sources: CBP 2020; Hinson et al. 2021.

Ecological implications predicted at a Bay scale

Rising water temperature in the Chesapeake Bay is already affecting many key species, such as striped bass, eastern oyster, eelgrass, and blue crab, contributing to future ecosystem changes. Research focused on assessing climate vulnerability shows both positive and negative responses of living resources to temperature and other climate change related factors depending on species, life stage, and location within the estuary.

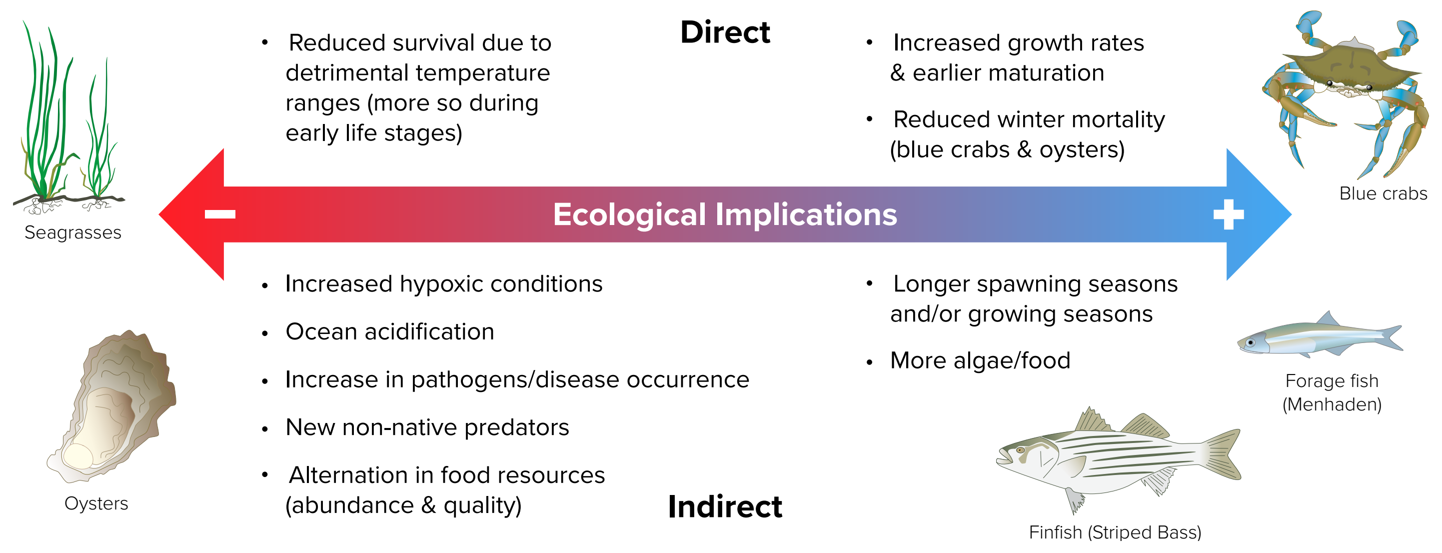


Figure 8. There are a range of positive and negative responses of living resources and habitats (e.g., forage fish, finfish, benthic organisms, and submerged aquatic vegetation) to rising water temperature and other climate change related factors.

Ecological shifts expected at an ecosystem-level

Rising water temperatures have resulted in northward shifts in several Bay species' ranges, while new species from the south are becoming more prevalent in the Bay. These shifts can impact species abundance and distributions, food web dynamics, fishing behavior and the potential for new fisheries. Likewise, habitats required by fish and shellfish species, such as underwater grasses, are also shifting in range and experiencing temperature-driven impacts on area and composition that can affect fish abundance, distribution and reproduction success.

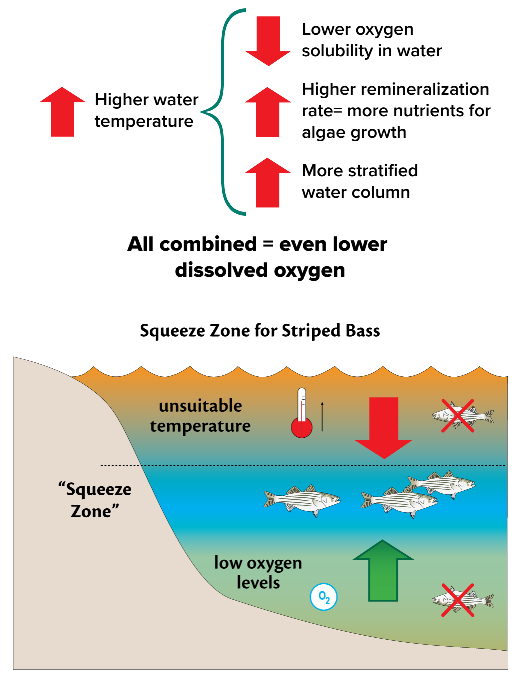


Figure 9. Conceptual diagram illustrating the compressed habitat of the striped bass from the low oxygen levels from the bottom, and the unsuitable temperatures from the surface. Diagram courtesy of the Integration and Application Network (ian.umces.edu), University of Maryland Center for Environmental Science. Source: Boesch 2008.

Moving Forward

Stay focused
Focus on the Chesapeake Bay TMDL and consider stream temperatures in the context of existing goals.

Keep positive
Despite changes to the watershed and Bay, we must push forward and tell our story as changes unfold.

Prioritize BMPs
Implement cooling BMPs/natural infrastructure that reduce heated runoff from developed areas, farms, & forests.

Integrate monitoring
Link smaller streams, groundwater, living resources and air temperature with water temperature monitoring.

Communicate
Help people to understand why water temperatures are rising and what they can do about it.

Increase trees
Better communicate the benefits of conserving mature trees and don't just rely on new tree planting.

Update standards
State water quality standards need to address climate-related changes to water temperature.

Adapt fisheries
Future management and monitoring of fisheries must adapt as fisheries change with rising water temperatures.

Target restoration
Factor rising water temperatures into our tools for targeting the lands to conserve and where to apply BMPs.

Land-sea opportunities
Consider shorelines/nearshore environments for restoration and habitat protection of at-risk species.

About the workshop

The project began with preparation of background papers summarizing current information about rising water temperatures. Two one-day workshops were held in early 2022 and were structured with parallel sessions focused on the watershed and tidal waters. One focused on the ecological impacts and management implications and the other focused on development and refinement of management recommendations.

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

Cover photo: Brook trout by Will Parson/CBP

Chesapeake Bay Program
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