# Watershed temperature impacts

Workshop purpose:
1) Share tidal and nontideal results
2) Explore potential management strategies
3) Develop storylines about effects of rising temperatures

Multiple implications of rising temperatures:
Dissolved oxygen, flora/fauna shifts, biogeochemical processes, invasives & pathogens, spawning

Watershed map: Overall rising temperatures, increases in southern watershed more pronounced, land use (forest cover and agriculture) affects rate of rising temperature

Working with USGS to produce a more comprehensive picture of long term trends in stream and river water temperature working from not only the existing CBP Partnership Nontidal Network but also bringing in a wealth of data from other agencies and institutions

# Watershed temperatures: Fish impacts

Interactive Catchment Explorer tool--valuable tool for use and application by the partners to run 'scenarios' based on information drawn from the other synthesis elements

Thermal habitat forecasting tool

Macroinverts and f/w mussels: thermal tolerance limits not well known, many f/w mussel spp. near upper thermal limit

Partners will need to make decisions on what are the best metrics to use to evaluate which temperatures are causing impacts on target fish species--existing data and published studies focus on critical thermal maxima

Need to fill knowledge gaps as well as ID effective mitigation strategies

# Watershed Temperatures: Modeling

Work is underway to integrate the impacts from changes in stream hydrology with the thermal impacts, but further work is needed to really quantify these interactions and their combined effects and impacts

Phase 6 CBP model not sufficent: Model scaling to look at temperature effects needs to be finer scale

Key questions:
1) critical management questions & information needs: streamside land cover, karst/spring sources, types of buffers, thresholds of landscape factors, infiltration & groundwater, stream locations,

2) at what scales?: finer scale needed, BMP reporting at county scale, model dependent scaling, living resource scaling, avoid compromising TMDL modeling

# Watershed Characteristics and Landscape Factors

Interactive website; gis.chesapeakebay.net/healthywatersheds/assessment

The CBP Partnership's Chesapeake Healthy Watershed Assessment could be used to integrate a number of the different factors influencing water temperature and the resultant effects on the resiliency of the watershed to climate change and development trends--could be a great tool for synthesizing findings from many of the other synthesis elements

Context: conceptual diagram of healthy watershed/healthy stream vs. unhealthy watershed/unhealthy stream

Healthy Watershed Assessment could be used to translate model scenario outputs and other more technical data into information land managers and public can relate to.

Need to better understand how local managers and other local decision makers can use the outputs from the Healthy Watershed Assessment to enhance their decision making

## Influence of BMPs and habitat Restoration on Water Temperatures

Heaters (ponding), shaders (trees, riparian buffers), coolers (infiltration)

Developed a "stream warming model" which could be useful in developing the next generation of watershed models directed toward better simulating effects of BMPs and landscapes on local and downstream stream temperatures

The combination of classification cooler and heater BMPs and the stream warming model was used to develop two scenarios based on BMPs implemented to date and what future BMP implementation might mean for stream temperature

There is good temperature effects data for urban and forestry BMPs, but limited to no temperature effects data for agricultural and habitat BMPS

There is a growing understanding of the benefits of riparian forest buffers, but less data on upland practices like tree planting

Excellent list of actions to be taken prior to the workshop, including making several evaluations of implementation of heaters vs coolers over the past decades

# Enhancements to the Partnership's Nontidal Monitoring Networks

USGS compiling status, trends and modeling; need future coordinated network

To date, have compiled 70 years of water temperature data from 31,142 sites, aggregating into daily temperature data where there are multiple direct measures at the same station, resulting in millions of data points across the entire Chesapeake Bay watershed

Developed and implementing a quality control procedure for addressing known error and outliers within the diverse array of compiled data sets

Developing a USGS publication compiling information on a range of the different status and trends statistical analysis techniques

Data release (2021) followed by status and trend methods (2022) followed by status and trends model (2023)

Recommendation for pairing these stream temperature data with air temperature data and conduction side by side status and trend analyses

## Tidal Temperature Changes Overview

Rich talking . . . blah . . . blah . . .

Bay wide long term trends; rising temperatures; surface and bottom waters
0.7 deg C increase;  summer > winter

Mostly due to air temperatures as well as ocean temperatures during the summer, but not due to sea level rise or river temperature

Seasonal changes: near mouth of Bay in summer months highest increase

Impacts: increased biological processes, reduced DO, increased stratification, increasing remineralization rates

Model projections +1.73 deg C by 2055

Rising temp will increase hypoxic volume due to DO solubility, incr biol rates & incr stratification

Ocean acidification/SAV buffering sidebar

Position of Gulf Stream influencing ocean temps, leading to southern Bay warming

## Tidal temperature effects on fisheries

The NOAA Climate Vulnerability Species Assessment used expert input to score the sensivity to a number of climate variables for 82 species--directly applicable to Chesapeake Bay species

Chesapeake Bay Representative Species Winners and losers:
Blue crabs: sensitive and likely benefit from incr temps

Oysters: less sensitive but likely negative effects of climate (not just temp)

Striped bass: multiple life stages in the Bay result in both positive and negative effects on the species, but overall high vulnerability to climate change/rising temperatures

Summer flounder: changes in populations could be due to both harvest pressure as well as changes in climate and specifically temperature

Bay anchovy and Atlantic Menhaden (as representative of larger group of forage fish): low impacts and likely to continue to expand their ranges

## Tidal Temperature Effects on Fisheries-Habitat Vulnerability (Con't)

Developed cross walks between critical fisheries habitats and the species and their life stages dependent on these habitats to illustrate the vulnerability of each habitat to climate change/rising temperatures and their interactions: salt marsh, SAV beds, intertidal shellfish reefs

Science Gaps:
Finer scale modeling and assessment of Bay species impacts specific to the Chesapeake Bay needed working from larger scale assessments by NOAA

Need to identify species specific temperature thresholds

Management Responses:
NOAA's State of the Ecosystem Reports are shared with the regional fisheries management councils and can be used to inform management of fisheries within Chesapeake Bay and adapting to rising water temperatures

Recognize new species are coming into Chesapeake Bay (e.g., shrimp, red drum)

# SAV Impacts Due to Increasing Temperatures

State of science: Increase spp. diversity in low salinity reaches, only Zostera and Ruppia in polyhaline

Impacts on SAV: temp increase, sea level rise, incr carbon dioxide; Incr CO2 beneficial to SAV

Shallow water warming important

Most SAV temperate; 11.5-26 C optimum

Loser: Zostera distribution shrinking; impact of heat events with turbid water

Winner: Ruppia tolerant of wider range of conditions, but potential impact on seedlings

Data gaps for other Chesapeake SAV, particularly Zannicellia, other freshwater spp.

Freshwater SAV more diverse, potentially.providing ecosystem resilience

Indirect impacts and complicating factors (e.g., rainfall, eutrophication, epiphytes, shoreline armoring, invasives, pathogens)

Workgroup funded project on SAV climate impacts

Pending proposal to investigate Lyngbya impacts on upper Bay SAV

# Tidal Bay Water Temperature Change Indicator

Connecting change to restoration goals: Fish habitat, forest buffers, SAV

Moving from physical indicators (trends analysis, NEP indicator) to ecological impact indicators (fish spawning habitat) to climate resilience indicators

Various data sources available: long term monitoring stations, bouy data, CBL pier, Thomas Pt lighthouse, citizen data, satellite data

No one data set meets all criteria-all have advantages and limitations

Existing gaps: 1) understanding of management needs; 2) synthesis of indicator methologies; 3) linkages between physical change and ecological inpacts; and 4) incorporation of climate change projections

Forage indicator; developing habitat suitability index using fisheries suvey data and modeling environ. conditions (e.g., springtime warming impact on bay anchovy)

Need to further flesh out management actions which might respond to the indicator findings

## Enhancing Tidal Monitoring Network to Address Temperature Changes

We have a wealth of long term tidal monitoring networks, many in place for going on four decades, with additions of citizens monitoring and others along the way

Our monitoring networks provide insights on current status, magnitude, frequency and duration of events, trends through time and addressing critical management issues--e.g, losses of eelgrass during extreme summer temperatures

Existing investments in diverse data resources; can be enhanced with further data analyses

Regional and connected impacts--ocean and more global influences on Chesapeake Bay

Enhanced monitoring opportunities working within the Partnership's existing tidal monitoring networks--new technologies, increase frequency/density of sampling, apply new assessment tools