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PROPOSAL FOR STAC REVIEW OF WATER TEMPERATURE INCREASES IN THE BAY AND ITS WATERSHED: ECOLOGICAL SIGNIFICANCE AND IMPLICATIONS FOR TIDAL WATER QUALITY STANDARDS, CURRENT BMPS AND HABITAT STRATEGIES, AND TIDAL AND NON-TIDAL MONITORING

For discussion by STAR on 11-19-20, and
preparation for WQGIT meeting on 11-30-20

[The format is based on an earlier example of a STAC Workshop proposal. STAR reviewers should concentrate on the key questions to be addressed, and the feasibility of a workshop in the proposed form + advance preparation. Editing to STAC's current format will be done by the project development team after agreement to go forward with the proposal.]

Workshop Title: Ecologically Significant Water Temperature Increases in the Bay and Watershed: Implications for Tidal Water Quality Standards, Indicators and Monitoring; and Mitigation or Adaptation BMPs in Phase III WIPs

Submitted by: Water Quality Goal Implementation Team (WQGIT), ...and Maryland DNR-Forestry, Climate Resilience WG, Brook Trout WG...?]
Endorsed by: [ ]

Workshop Steering Committee:
William Dennison (STAC, UMCES) [to be confirmed] +
Chair or Coordinator of CAC [to be confirmed]
Richard Batiuk (EPA-retired)
Members of the Project Development Team (PDT): Bill Dennison, Rich Batiuk, Anne Hairston-Strang MD DNR-Forestry, Gary Shenk USGS, Peter Tango USGS, Lew Linker EPA, Bruce Vogt NOAA, Julie Reichert-Nyugen NOAA, Sally Claggett USDA-Forest Service, Tom Schueler CSN, Judy Okay J&J Okay Consulting, Rebecca Hanmer EPA-retired
(Collaborators: Ellen Gilinsky STAC, Jessica Blackburn CAC, Jeremy Hanson VT, David Wood, CSN-USWG, Jonathan Leiman MDE, Julie Mawhorter, USDA-FS, Katherine Brownson, USDA-FS)
ADD Trout Unlimited? Other expert NGOs?

Workshop Description:
Water temperature increases caused by rises in air temperature are occuring in Bay tidal waters, and in nontidal streams and rivers in the Bay watershed. There is every reason to believe that temperatures will continue to rise over time. Water temperature increases have significant ecological implications for Bay and watershed natural resources, and could undermine the investment in Bay resource restoration. There are things which the Program might do – within the scope of its current programs – to prevent or mitigate some of the adverse consequences. The impact of climate change on Bay restoration is being monitored, modeled and studied, and much knowledge is being gained. This workshop will take advantage of available knowledge to

focus on major Bay Program instruments that could help to prevent or mitigate harmful effects from water temperature increases. The instruments are (1) Bay water quality standards, (2) Bay temperature indicator and (3) temperature-lowering BMPs in the Phase III WIPs [ADD any tidal habitat protection or fisheries management instruments that are not necessarily WQ BMPs?] What characteristics make these instruments beneficial, and where (spatial range)? Are modifications needed in these instruments? How much could they help? Are there corresponding changes to temperature monitoring, imagery and modeling which would make these key instruments more effective for management purposes?

The Water Quality Goal Implementation Team and its workgroups on Forestry, Urban Stormwater...[to be confirmed] plus the Climate Resilience Workgroup and [to be invited Habitat GIT, Brook Trout Workgroup, Stream Health Workgroup]...

...propose a two-1/2 day workshop. This is a broad agenda, and the proposal is to have four teams of about eight experts each working simultaneously. [NOTE: If STAR advises, it could instead be two teams of about 16 experts each: one for estuary one for watershed.]

- Two teams would address use of the estuary instruments, tidal WQS and Bay temperature indicator and if feasible, beneficial changes in habitat and fisheries management. The other two teams will focus on the Bay watershed, particularly on those BMPs in the WIPs that have the strongest co-benefits for preventing or mitigating water temperature rises.
- After one-1/2 days' discussion, each team will prepare its report and recommendations. The teams will then come together for ½ day to discuss each others' reports and prepare the joint report.

To enable workshop discussions to focus on the instruments and how they might best be employed by the Bay Program, participants will have to be fully prepared. All workshop participants will be briefed in advance on what the Bay Program knows already: data and modeling water temperature rises: observations and trends, future forecasts; implications for living resources and studies of the most vulnerable species; already-developed issues and options for a Bay temperature indicator; available studies of temperature impacts of BMPs; management actions to ameliorate temperature impacts in the watershed; available reports on management responses to increased tidal temperature. (This preparatory information will also be useful for informing others in the Program, and the public.)

[YOU ASK!!! HOW CAN ALL THIS PREP WORK BE DONE? Mechanisms:

- The Workgroups who are now sponsoring and collecting studies in their area that speak to water temperature impacts, e.g, Brook Trout, Urban Stormwater, Forestry, Climate Resilience, Stream Health, etc. agree to help, by summarizing the results of their work and presenting it in a short video. That is:
"What have we learned about water temperature impacts in our studies, and (if they have discussed it) what can be done?"
- The Steering Committee would collect these short abstracts of study findings from the Workgroups, and organize their videos into e.g. one or two webinars.
- Bill Dennison also suggested various water temperature issues could be discussed in advance, in several STAR meetings.

- The STAC experts would then review the science and deepen the insights in the workshop.

Management Need:
Among the body of climate studies in the Bay Program, there is an emphasis on possible impacts of climate-related changes, such as how BMPs might function in light of changing precipitation patterns. The ecological effects of temperature increases are relatively well-known or predictable.
Need: Both to highlight opportunities for preventive actions and adaptation, it is timely to focus on water temperature increases in Bay tidal and nontidal waters, caused by rises in air temperature, and ways in which major Bay Program tools might best be used to prevent and mitigate their effects. Also, an indicator for non-tidal stream temperature has been established, but a tidal Bay water temperature indicator is still needed.

Background:
Climate change poses serious risks for the natural resources of the Chesapeake Bay and its watershed. The 2014 Chesapeake Watershed Agreements includes the goal of "increas[ing] the resiliency of the Chesapeake Bay watershed, including its living resources, habitats, public infrastructure and communities, to withstand adverse impacts from changing environmental and climate conditions." The two Outcomes are for Monitoring and Assessment, and Adaptation.

In the ten years since STAC published *Climate Assessment and the Bay*, a large body of monitoring information, modeling studies and scientific assessments has been assembled. Scientific assessment has concentrated on the effects of climate change on the Chesapeake Bay restoration program, in areas such as (1) ability to achieve the Bay criteria for dissolved oxygen; (2) effectiveness of BMPs for restoring Bay water quality; (3) changes in submerged aquatic vegetation; (4) and impacts on brook trout and other fisheries habitat.

With this growing body of scientific understanding, it is timely to sharpen the lens specifically on water temperature increases caused by rises in air temperature. There are uncertainties about the exact nature and timing of climate changes affecting the Bay region, but increasing air temperatures are comparatively predictable and detectible, and the relationship of increased air temperatures to water temperature increases is well-established.

Water temperature has been rising in the Bay, and already impacts on eelgrass are apparent. USGS monitoring of nontidal waters shows the alarming ratio of water to air temperature increases [footnote: Rebecca Chilrud, paper posted 01-07-20 cites from USGS data that average non-tidal stream temperatures increased 2.52 degrees F from 1960 to 2010, while air temperatures increased 1.99 degrees F.] and further significant air/water temperature increases are predicted.

Water temperature affects all chemical and biological processes of aquatic organisms, as well as being directly linked to survival for temperature-sensitive organisms like brook trout. Water temperature integrates what is happening on the land (e.g. forested, open, urban impervious), and affects the way nutrients and other pollutants behave in the water column.

Key instruments:

(1) Water quality criteria and standards (WQS), including spatial and temporal use zone designations and other interpretative mechanisms.

Restoration of the Bay has been spurred by the development of the Chesapeake Bay TMDL and resulting WIPs. In turn, the TMDL is based on achieving the Bay tidal WQS. The jurisdictions used water quality criteria guidance developed by the Bay Program for dissolved oxygen, clarity/SAV and chlorophyll-a (issued in 2003), and technical support guidance on establishing the designated uses. The criteria and associated guidance have been updated periodically.

In the 2003 Chesapeake Bay water quality criteria guidance, the dissolved oxygen (DO) criteria protective of shortnose sturgeon are based on temperature. When water column temperatures are higher than a specific temperature, a higher dissolved oxygen criterion applies to the waters in that segment. This is a specific example of how WQS can effectively address temperature effects.

The CBPO modeling team has factored in simulation of temperature changes on watershed processes and tidal water biological rates and processes anticipating the need to better simulate the effects of climate change on the Bay ecosystem. Increasing tidal water column temperatures could have the following implications for Maryland, Virginia, Delaware and the District of Columbia's existing Chesapeake Bay WQS regulations:

- Changes in the numerical DO criteria due to either species-specific sensitivity to higher temperatures (e.g. temperature-based sturgeon DO criteria) or changes to oxygen saturation at higher water column temperatures;
- Changes in the season definitions in the states' designated uses (e.g. what constitutes the summer season or the spring migratory period);
- Changes in the spatial delineation of the states' designated uses (e.g. temperature increases changing water column stratification which defines the open water vs. deep water vs. deep channel designated use boundaries; and
- Changes in the water clarity criteria due to temperature-induced stress on SAV resulting in the need for increased light availability to the plants' leaves to offset temperature stress.

Findings from STAC would be a solid foundation for getting the Partnership's full attention on addressing temperature.

Note that Bay watershed jurisdictions have also adopted WQS for their nontidal rivers and streams, and established anti-degradation policies in their WQS for protecting especially high quality waters, such as cold-water fish habitat. As an example of management use of the temperature WQS in nontidal waters, MDE is currently preparing a TMDL and implementing guidance for protection of naturally-reproducing wild trout fishery.

(2) Bay Water Temperature Indicator

Development of indicators is a key element in meeting the Climate Resiliency goal in the 2014 Agreement, and the Climate Resiliency Workgroup gives high priority to establishing a Bay temperature change indicator (there is already a temperature indicator for nontidal water). A

useful Bay indicator needs to relate to fisheries and habitat impacts of increasing tidal water temperatures, and to decision-making.

Recent reviews indicate that there could be a mismatch of the temporal and spatial scales of datasets, e.g. using monthly grab samples, to answer management questions. STAC discussion and recommendations would be very valuable about (a) what types of data, including temporal and spatial scales, are needed to address management questions around fisheries and SAV, and (b) whether any of the Program's existing monitoring can fulfill those needs.

(3) Best management practices incorporated into the jurisdictions' Watershed Implementation Plans (WIPs).

While these BMPs are designed and promoted for meeting the TMDL and tidal WQS, some have the co-benefit of combating stream temperature increases caused by rises in air temperature. They may cool (shade) streams and protect sensitive species, or cool runoff or discharges that would otherwise harm aquatic life in receiving waters.

Within the prime mission of achieving the Bay TMDL, the Water Quality GIT has a strong interest in encouraging implementation of BMPs which have co-benefits. For example, co-benefits of BMPs can improve the cost-effectiveness of Bay water quality restoration and address local needs. More fundamentally, unchecked water temperature increases associated with continuing rises in air temperature jeopardize the very aquatic benefits which the Bay's Water Quality program is seeking to protect.

The Bay Program needs a clear understanding of the vulnerabilities associated with rising water temperatures: which are the most vulnerable species, which are the most vulnerable locations, which BMPs in the Phase III WIPs have the potential to prevent or mitigate adverse water quality impacts of temperature rise, and where/how are they best applied. There are many studies of BMPs and BMP characteristics that can be tapped, but this general information needs to be related specifically to the Bay watershed. STAC expert review would be invaluable on how to apply the general knowledge about BMP characteristics to the specific landscapes in the Bay watershed.

(4) Monitoring strategies for tidal and nontidal waters, and associated modeling. As an outcome of the STAC discussions of instruments (1)-(3) above, what are identifiable needs for changing temperature monitoring strategies and modeling.
? - should we add Habitat strategies?

MORE? CITE Specific outcomes benefited? One is Riparian Forest Buffer. 2025 Water Quality? any Habitat?

Workshop Synthesis: Workshop discussions and outcomes will be documented in a final workshop report that will be distributed to the CBP and interested parties. The final report will be released within 90 days following the workshop. Products [detailed on pg x] will focus on the use of existing data and modeling, and include recommendations to develop ....[metrics?] where data are lacking. The final report will provide guidance on how the identified factors can be addressed, and the significance these factors play in the evaluated.... The Chesapeake Bay

Citizens' Advisory Committee [CAC] coordinator is a member of the steering committee [to be confirmed]; this will help ensure the workshop products will be useful....

Pre-workshop Preparation: The Steering Committee will reach out to appropriate scientists and experts when designing the workshop to ensure necessary expertise is available and all relevent information, research and data sets are identified, compiled and sent to the workshop participants in advance of the workshop.

There is an important body of information available on patterns and trends in temperature in the Chespeake Bay region, and expected impacts. The Steering Committee will utilize existing reports and literature to inform the workshop. See Appendix 1 for available studies and those in progress.

The cooperation CBP Workgroups will prepare synopses of the results of their studies to date which shed light on the questions to be addressed in the workshop, and 5-10 minute presentations. The Steering Committee will organize the synopses and presentations into one or two preparation webinars for participants in the STAC workshop.

Workshop Speakers and Attendees: The Steering Committee will identify and convene experts in (1) monitoring and modeling climate change-induced water temperature increases in Bay tidal and non-tidal waters, and evaluating likely ecological changes associated with those increases and predicting areas of emphasis; (2) in developing Bay tidal water quality standards, (3) in assessing the usefulness of datasets to establish a useful Bay water temperature change indicator, and (4) in evaluating best management practices, the characteristics of BMPs for preventing or mitigating water temperature increases, and probable approaches for using these BMPs and/or modifying them to be more effective at addressing effects of temperature increases.

Questions to address:

- What Bay watershed species and habitats are most likely to be endangered by climate-induced water temperature changes?
- What changes to the Bay tidal water quality WQS, use designations, and attainment methodoloties might be most useful to address climate-induced water temperature increases?
- Can CBP use current tidal water temperature monitoring and modeling to create a Bay water temperature change indicator? Or will monitoring and modeling need to be changed to produce an indicator that is useful for management decisions?
- What characteristics of BMPs are most likely help mitigate or avoid harmful aquatic ecosystem effects of climate-induced water temperature increases, and what beneficial BMPs are in the Phase III WIPs? How could this co-benefit fit into WIP implementation? What feasible modifications could make these and perhaps other BMPs more effective?
- What strategy should be adopted for focusing application of these BMPs on the Bay watershed landscape?
- Are modifications in nontidal water monitoring and modeling strategies indicated?

Workshop Products

Recommendations for Water Quality Criteria/Standards program development - for followup by Water Quality GIT, Bay tidal water jurisdictions.
[What about SAV?]

Recommendation for Bay Water Temperature Indicator - for followup action through the Climate Resiliency WG (ref. Outcome); + possible changes in temperature monitoring and modeling.

Recommendations on BMPs with Important Water Temperature Co-benefits - for followup by State WIP Programs, WQGIT and Technical Workgroups + possible recommendations for monitoring and modeling.

[What about the Brook Trout WG? no response yet]

Communications products for WIP Programs and WQGIT, CAC

Rationale: This workshop will bring together experts from across disciplines to assemble basic information about climate-induced water temperature increases and ecological sensitivity to water temperature impacts in the projected ranges of increase. Also experts concerning the characteristics of BMPs mostly likely to be beneficial in mitigating stream and tidal water temperature increases, along with experts in the selected BMPs to be assessed immediately.

Timeline: The Steering Committee will begin [bi-monthly?] meetings in [January?] 2021 to plan the [webinar and] workshop, gather existing information and data, and identify experts. In [ ], participants and key partners will be invited to the workshop. The workshop will be conducted and the steering committee will have a follow-up meeting in [ ] 2021. The report will be submitted to STAC [90 days after the workshop]

Budget Justification and Logistics: The workshop will be held over [two days?] between ?September and December 2021. Workshop participations will be by invitation only and target [30?] participants. Estimated costs for venue, catering and travel are included below:
[Venue - $4000] [Catering - $3000] [Travel for participants - $3000] Total:

APPENDIX 1

a. Chesapeake Progress - multiple indicators tracking air temperature, stream temperature: https://www.chesapeakeprogress.com/climate-change/climate-monitoring-and-assessment
b. Integrated Trends Action Team - annual updates on Bay temperature trends at monitoring stations
c. NOAA - satellite-based Baywide estimates of temperature trends (Ron Vogel NOAA resource)
d. UMCES, VIMS - single state records for bay temperature
e. Changing Chesapeake website - tropical nights index, frost-free days index and more: http:///www.chesapeakedata.com/changingchesapeake/

f. USDA - recently updated plant hardiness zone maps which essentially integrate information about temperature patterns through time to show how zonal boundaries are shifting northward: https://planthardiness.ars.usda.gov/PHZMWeb/AboutWhatsNew/aspx. See section on Climate Change and maps online showing old zones, new and where change has occurred e.g. Annapolis area shifted a half-zone closer to tropical.

g. 4th National Climate Assessment - this has northeast and southeast summaries of climate effects, often temperature focused on land, sea, air, society and more: https://nca2018.globalchange.gov/

h. NOAA State of the Ecosystem (mid-Atlantic to New England) water conditions and fish community responses to climate/temperature shifts: https://www.fisheries.noaa.gov/new-england-mid-atlantic/ecosystems/state-ecosystem-reports-northeast-us-shelf

i. STAC 2010 Climate Assessment of the Bay (journal publication): https://www.nrs.fs.fed.us/pubs/jml/2010/nrs_2010/najjar_001.pdf

j. Chesapeake Bay Watershed Brook Trout Habitat and Climate Change Vulnerability Assessment, 2015. Clingerman, Jason and Boettner, Fritz, Downstream Strategies and Petty,Todd West Virginia University. https://www.downstreamstrategies.com/wp-content/uploads/2015/04/ches-bay-brook-trout-report_final.pdf

k. Habitat Requirements for Chesapeake Bay Living Resources, Second. Edition, 1991.[check if available online]

l. Chesapeake Bay Water Quality Criteria, 2003 [find exact ref. to temperature-dependent DO criteria for shortnose sturgeon]

m. USFS best current refs. climate change and forests

n. NOAA regional synthesis of multiple climate change factors on many species: https://www.fisheries.noaa.gov/new-england-mid-atlantic/climate/northeast-vulnerability-assessment

o. Ding, Haiyong and Andrew J. Elmore. "Spatio-temporal patterns in water surface temperature from Landsat time series data in the Chesapeake Bay, U.S.A.", Remote Sensing of Environment, journal homepage: www.elsevier.com/locate/rse

In preparation

-- Maryland Department of Natural Resources, Department of Forestry: Review of "Relationship between stream temperature and riparian forest buffers" (Anne Hairston-Strang, Jenny Katz, October 2019)

-- Maryland Department of Environment, Integrated Water Planning Program: Temperature TMDL (focused on loadings, which essentially dictate habitat suitability for designated uses) and companion guidance for Maryland jurisdictions (Jonathan Leiman, September 2020)
+ proposed Temperature Symposium at September 2021 conference of the American Fisheries Society whose results could be summarized for workshop

-- Chesapeake Stormwater Network: Series of four memoranda on "Maintaining the Resiliency of Stormwater and Restoration Practices in the Face of Climate Change in the Chesapeake Watershed" (David Wood and Tom Schueler, 2020)

-- Virginia Tech: "A Systematic Review of Chesapeake Bay Climate Change Impacts and Uncertainty: Watershed Processes, Pollutant Delivery, and BMP Performance"

(Committee- Zach Easton, Raymond Najjar, Julie Shortridge, Kurt Stephenson, Lisa Wainger, with Jeremy Hanson)