Climate Resiliency Workgroup
Rising Water Temperature Cross-Workgroup Meeting
Monday, June 21, 2021; 9:30 AM – 4:00 PM

Meeting materials:
https://www.chesapeakebay.net/what/event/climate_resiliency_workgroup_crwg_june_2021_meeting

This meeting will be recorded for internal use to assure the accuracy of meeting notes.

Action Items:

- ✓ Denice Wardrop recommended using the CRC network to call for relevant research on these topics.
- ✓ Dan Goetz will share draft summary of most influential factors in brook trout streams.
- ✓ Need additional topic discussion on how to crosswalk the model and healthy watershed assessment.
- ✓ Session leads need to complete their draft synthesis papers by July 30th.

AGENDA

9:30 AM **Welcome, Meeting Overview and Introductions, *Julie Reichert-Nguyen (CRWG Coordinator, NOAA) and Scott Phillips (STAR Chair, USGS)***

- Special cross-workgroup meeting to share results from synthesis assignments in preparation for the Rising Water Temperature STAC Workshop.
- Overall goal of meeting is to share and assess what we know and don't know about the effects of rising water temperatures on habitats and living resources and potential management strategies to reduce vulnerability and increase resilience.
- From our discussions, we will see if there are emerging storylines about the effects of rising water temperatures on non-tidal and tidal resources and identify strong and weak points in information.
- The morning sessions focus on non-tidal watershed topics and afternoon on tidal Bay topics.

Materials:

Summary of STAC Project Proposal

9:40 AM **Past, Current, and Projected Water Temperature Changes in the Watershed and Implications for Ecosystem Processes Influencing Stream and River Health (#5)**

Synthesis Element Lead(s): Rich Batiuk (CoastWise Partners) and Nora Jackson (CRC)

Session Goal(s):

To road test whether our draft storyline on the past, current, and projected water temperature changes in the watershed is understandable and fully supported by the available data and scientific findings; and ensure we have a comprehensive listing of implications for ecosystem processes influencing stream and river health.

Presentation(s):

- Past, Current, and Projected Water Temperature Changes in the Watershed and Implications for Ecosystem Processes Influencing Stream and River Health, *Nora Jackson, CRC*

Discussion Question(s):

- Is our current draft storyline, described in our draft synthesis paper and highlighted in our presentation understandable and fully supported by the available data and scientific findings?
- Are we missing any important implications for ecosystem processes influencing stream and river health from our draft synthesis paper?

Materials:

Draft Synthesis Paper (5/6)

Presentation Notes:

- Implications for ecosystem processes: reduced DO, increased biological processes, increased remineralization rates, shifts in floral and faunal species, increased invasive species and pathogens, spawning impacts
- USGS is compiling publicly available data on water-temperature from multiple agencies and monitoring groups across the watershed
- Key findings: stream temperatures increased 1960s-2014; climate has the strongest natural influence on stream temperature; water temperature increases quicker than air temperature in agricultural areas without major dams; water temperature increases slower than air temperature in forested sites and in areas influenced by dams; increases in water temperature occurred at the greatest rates in the southern regions of the watershed

Discussion:

- Jamboard Questions & Answers (link to PDF on calendar event page here): Are we missing any important implications for ecosystem processes influencing stream and river health? (Pg. 1 of PDF)
- What is the mechanism that causes water temperature to increase faster than air temperature in ag areas?
    - Mixed land use? Ag land could also be residential
    - Peter Tango: Drain-tilling ag fields roughly equivalent to imperviousness?
    - Rebecca: Agree with the importance of analyzing closely the information about water temperatures increasing faster than air temperatures. Dig into this.
    - Scott: for projections on stream condition, suggest you include this https://www.usgs.gov/centers/cba/science/projecting-stream-conditions-under-future-land-use-and-climate-scenarios?qt-science_center_objects=0#qt-science_center_objects
    - Kristin Saunders: You may have touched on this Julie, but given that we are looking at non-tidal in morning and tidal in afternoon, is there any bridge between those two areas we need to investigate (meaning temp change in upstream nontidal areas' effect on tidal areas as water moves?); Rich: we will make connections between nontidal and tidal throughout the day; Julie: connections can also be made as we prepare for the STAC workshops in 2022.
    - Anne Hairston-Strang: factor in cold groundwater inputs from springs; Mike Kolian: Yes, groundwater is a major regulator of water temperature and often the dominate factor
    - Denice: Use CRC network to call for relevant research
    - Nicole Carlozo: Interested in what's different about the streams that are decreasing in temp (groundwater, land cover, vegetation?)
        - Rebecca Hanmer: Per Nicole's comment—Stream temp as integrator of what's happening on land. Relationship of land cover to groundwater to streams; relationship of water temp/air temp rises per above
        - Bill Dennison: Nicole's question will be important for helping us understand what management actions could be targeted
    - Anne Hairston-Strang: You mentioned impervious surface, but would also like to hear what people have to say about hydrologically connected impervious surfaces; Rich—that will be a topic in a later session that focuses more on the watershed and model; Nora—impervious surfaces and landscape factors will be addressed
    - Jonathan Leiman, MDE: Aquatic habitat connectivity to support fisheries populations is critical to making the case to conserve these cold-water resources. More spawning area, more fish, happier constituents.

- Dan Goetz: We are seeing elevation and forest cover as the most influential factors in brook trout streams; identified threshold of 65% forest cover, below that the odds of having brook trout go way down (Dan has a draft summary he can share with Rich)
- Kevin Du Bois: Do you account for differences between spring and non-spring creeks? Be careful with that characterization
- Dan: 37 variables used from land use, habitat, WQ, etc.; looked at paired air versus stream water temperature in June-August, seeing different slope and intercept relationships between brook trout and non-brook trout streams; groundwater is a major driver

10:05 AM **Water Temperature Effects on Fisheries and Stream Health in Non-Tidal Waters (#1)**

Synthesis Element Lead(s): Steve Faulkner (USGS) and Frank Borsuk (USEPA)

Session Goal(s):

Review current understanding of temperature sensitivities and vulnerabilities of key species/groups of species of watershed fish populations, macroinvertebrates, and mussels. Identify knowledge gaps, missing resources, and develop recommendations to mitigate detrimental impacts.

Presentation(s):

- Water Temperature Effects on Fisheries and Stream Health in Non-Tidal Waters, *Steve Faulkner, USGS and Frank Borsuk, USEPA*

Discussion Questions:

- Can we identify at-risk species and prioritize mitigation recommendations?
- Can we tackle both filling in knowledge gaps (e.g., better knowledge of temperature sensitivities for at-risk species/habitats) and mitigation actions or should we prioritize one over the other?

Presentation Notes:

- 3 key elements of conceptual mode: exposure, sensitivity, adaptive capacity—combination of these factors indicate vulnerability
- Approach: initial literature review, expert opinion
- Key findings: multi-stressor lit review results; there are a lot of limitations of available literature
- EPA NRSA report: used this to develop dataset for sharing, cross-reference with NRSA data, and classified as cold or cool water species
- Key fish findings: categorical data available, lacking quantitative data; interaction of physiological stress and competitive stress caused by cooler temperature; impacts across food web—prey species may be more sensitive

- Species specific geospatial data that is scalable
- Incorporation of groundwater data into models
- Macroinvertebrates/mussels: many freshwater mussels are already living close to their upper thermal limit

Discussion:

- Menti Question
- Peter Tango: I seem to recall, for example, for many of the cold-water species, that "Fishes of New York" had life histories, thermal regime summarized under habitat preferences. I am digging deep into the gray matter but it is worth a look for some quantitative info.
- Mark Southerland: Has anyone looked at stream and streamside salamanders? Plethodontid (lungless) salamanders are sensitive to temperature and dissolved oxygen in the water.
    - Peter Tango: do you have some syntheses to reference on the herps?; Mark: Can look into it
- Jim George: Any sense of whether temp change might affect alkalinity, pH?
    - Marjy Friedrichs: Temperature can impact alkalinity and pH in a number of ways - both directly as well as through changing primary production and respiration. It may not be as large an effect as changing atmosphere CO2 concentrations however.
    - Marjy F: For impact of Temperature on alkalinity and pH, see brand new paper: https://agupubs.onlinelibrary.wiley.com/doi/full/10.1029/2021JC017239. Figures 7 and 8
- Denice: Does ICE model also include changes in hydrology with temperature increases?
    - Modeling hydrologic changes: difficult to integrate temperature?; some papers looking into some aspects, but full integration is not there yet; there is a flow component of brook trout research
- Peter Tango: Check in with Scott Stranko on benthic macros - I seem to recall there was 1 cold water obligatory PET species that lined up with temperature tolerances of brook trout for example. He may have more data on temperature tolerances across our macrofauna.
    - Dan Goetz: Maryland's Coldwater Resources Mapping Tool. https://maryland.maps.arcgis.com/apps/webappviewer/index.html?id=dc5100c0266d4ce89df813f34678944a
    - MD samples for macroinvertebrates; classified as protected cold water species, which allows protection of streams
- Mike Kolian: Are brook trout the keystone species?
    - Steve Faulkner: @MikeKolian - depends on what you mean by keystone, but yes, generally, and they are identified in the CBay Agreement with a specific Outcome.

10:30 AM **Factors and Geographies Most Influencing Water Temperatures in Local Waters throughout the Watershed (#6)**

Synthesis Element Lead(s): Rich Batiuk (CoastWise Partners) and Gary Shenk (USGS)

Contributor(s): Lew Linker (USEPA), Guido Yactayo (MDE)

Session Goal(s):

Initiate discussions on what are the most critical management questions and needs for information about the factors and geographies most influencing water temperatures in local waters and what the scales of those management questions are and information needs.

Presentation(s):

- Factors and Geographies Most Influencing Water Temperatures in Local Waters throughout the Watershed, *Rich Batiuk, CoastWise Partners*

Discussion Question(s):

- What are the most critical management questions and needs for information about the factors and geographies most influencing water temperatures in local waters?
- What are the scales of those management questions and information needs?

Presentation Notes:

- 1982: start of the model Phase 6—finer spatial scaling, decades worth of data, but this model doesn't have the geographic scale necessary to understanding temperature and climate in the way we need
- Phase 7 is under development, needs finer scaling to examine first and second order streams and the temperature response in those streams; important for living resources
- What are the questions? What scale is needed? How do we simulate that on the model?
- MDE: starting to get to the scale we are aiming for with the entire Chesapeake; modeling connections between smaller streams; at the small scale they are getting good calibrations for temperature for first and second order streams
- What management questions do we want to answer using modeling? What scale is needed to do that?

Discussion:

- Jamboard Questions & Answers (Link to PDF on calendar event page here): What are the most critical management questions/needs and scales for

information about factors/geographies most influencing water temperature in local waters? (Pg. 2 of PDF)

- Kevin Du Bois: Are the water temperature TMDLs required by EPA or are they a self-imposed goal to restore streams?
- Denice Wardrop: Could help to look into the type of information needed to support the temperature TMDLs for streams in the West.
- Gary: Steve presented a model for habitat that could help answer our question, but no management answers that we need; we need to add the management actions that partners can need; MDE has the model with management actions, but not the geographic extent needed for the partnership; interesting comparison
- Steve Faulkner: If anyone has karst streams they would be interested in including in our study, follow up with me or Than directly; Than Hitt: Feel free to contact me for more info on our karst/stream habitat study in the ChesBay headwaters: nhitt@usgs.gov
- James Martin: I don't see us being able to improve the scale of BMP reporting; BMP impact of local water temperature would be difficult
- Rich: When looking at what MDE is doing, we can increase monitoring; but I am talking about placement of BMPs—get landowners to place them in smarter locations; look at a TMDL perspective to cool water where cold water fisheries are important
    - Cold water mapping tool from Dan Goetz could be useful to assess placement: https://maryland.maps.arcgis.com/apps/webappviewer/index.html?id=dc5100c0266d4ce89df813f34678944a
- Kevin DuBois: DoD reports BMPs at the installation level; curious if it is reasonable to look at the implications
- Norm Goulet: need to make distinctions between urban and rural areas
- Anne Hairston-Strang: BMP reporting will be scale limited in many cases, but we are trying to get to shapefiles on buffers
- Kristin Saunders: It may be helpful to ask a set of local planners or leaders this same question. We may not be thinking of specific management questions they may have or scale they could advise on that may not be represented in the participants today.
- Renee Thompson: we may be able to utilize existing surveys and resources compiled by LGAC, the States and others to glean the scale needed for locals!

10:55 AM **Break**

11:00 AM **Watershed Characteristics and Landscape Factors Influencing Vulnerability and Resilience to Rising Water Temperatures (#4)**

Synthesis Element Lead(s): Renee Thompson (USGS) and Nora Jackson (CRC)

Session Goal(s):

Provide an overview of the current healthy watershed framework, developed by the Healthy Watersheds Goal Implementation Team and how it can be related to stream temperature. Identification of initial metrics and how they are related to stream temperature as well as the connection to conservation, vulnerability of land conversion and resiliency. Discussion of how this element can complement other elements and reduce any duplication.

Presentation(s):

- Watershed Characteristics and Landscape Factors Influencing Vulnerability and Resilience to Rising Water Temperatures, *Renee Thompson, USGS, CBP*

Discussion Question(s):

- How is this element distinct from other elements?
- How can concepts of conservation of vital lands and healthy watersheds be woven into this framework?

Presentation Notes:

- Integrating co-benefit issues together
- How is this element distinct from other elements? (not reproducing past efforts, how is this supportive of those past efforts)
- How can concepts of conservation of vital lands and healthy watersheds be woven into this framework?
- All healthy watersheds are defined by the states, so they vary across the program
- Link to Healthy Watersheds Assessment: https://gis.chesapeakebay.net/healthywatersheds/assessment/
- Where are the pristine areas and where may they be getting degraded or resilient? Where are they supporting high value habitats despite stressors?
- Studies are pulling together relationships between hydrological processes and stream temperature and stream health; incorporation of high resolution hydrology data will broaden and inform understanding of processes
- Habitat: high resolution data on forest interior streams that have complex features; stream temperature is impacted by that
- Updating metrics related to watershed pollution; instead of 13 separate metrics, they will be using SPARROW
- Metrics impact stream temperature, which impacts stream health: make those 'backwards' relationships
- Vulnerability metrics: development, forest loss, protected lands
- Climate vulnerability index and climate change metrics, vulnerability to wildfire: how do we characterize these vulnerabilities and what are the thresholds associated with them?

Discussion:

- Kristin Saunders: Signals of change can also drive us to more closely investigate what changes are occurring and why at a smaller scale
- Steve: Challenge is how to synthesize very specific data and bring it back up to watershed index; some of it is very quantitative and needs to be for modeling and research, but also need generalized metrics for watershed metrics; identify key components
- Rich: the rest of the synthesis need to be where Renee is; healthy watersheds assessment, can put models and data into context; need a crosswalk between healthy watersheds and signal change meaningful output that provides direction; synthesis of the synthesis
- Gary: The model is not creating knowledge, but a tool that brings all knowledge together; ensure we are using the same information and providing it to the right people
- Kristin S: Gary, although not in person, the GIT Chairs meeting on June 30 will allow the conversation to continue on how to crosswalk the model and healthy watershed assessment
- Rebecca Hanmer: To see which cold and cool water fisheries as most vulnerable to water temp increases, can we answer question about % forest or % riparian forest buffers to conserve? How does this % fit with programs to meet Land Conservation outcome.
- Renee: Healthy Watershed Assessment has a filtering tool within it; you can look at catchments with specific classifications/characteristics; how do we do the crosswalk and that the tools are making connections for us
- Julie R-N: Map overlays will be important to make those connections
- Anne Hairston-Strang: The connectivity question is important, particularly for potential for reconnecting headwater populations that are thermally isolated right now.
- Kristin Saunders: Land protection is a really cost-effective preventive practice and allows us to NOT have to spend restoration dollars down the road - how do we get that message out to folks who might be using the model, and not the watershed assessment?

11:25 AM **Influence of BMPs and Habitat Restoration on Water Temperature (#7/8)**

Synthesis Element Lead(s): Katie Brownson, USFS coordinating and Tom Schueler, CSN

Contributors: Matt Ehrhart, Stroud; Jeremy Hanson, VT; Lucinda Power, EPA CBPO; Anne Hairston-Strang, MD DNR Forestry; Iris Allen, MD DNR Forestry; Judy Okay, J&J Consulting; Mark Dubin, UMD; Stephen Faulkner, USGS; Frank Borsuk, EPA; Katie Ombalski, Woods & Waters Consulting

Session Goal(s):

- Understand which Bay restoration BMPs have the potential to cool or warm stream and near-shore tidal water temperatures in the watershed
- Identify the mechanisms through which these BMPs are influencing water temperature and opportunities to enhance the cooling benefits or mitigate the heating impacts
- Define some key take home messages for managers, planners, and policy makers regarding the key opportunities to use BMPs more strategically to mitigate rising water temperatures
- Highlight areas for further investigation; for example, determining the cumulative water temperature impacts of historic BMP implementation and opportunities to use a better mix of BMPs to mitigate future stream warming.

Presentation(s):

- Summary of our Synthesis approach and findings for urban BMPs. *Tom Schueler, Chesapeake Stormwater Network*
- Special issues with forestry and habitat restoration BMPs. *Katie Brownson, US Forest Service*

Discussion Question(s):

- What are some key opportunities to use BMPs more strategically to mitigate rising water temperatures?
- What are some messages we could use to communicate about these opportunities to managers, planners, and policy makers?
- How can we further enhance the cooling benefits of forestry and habitat restoration practices?

Materials:

Draft Synthesis Paper (7/8)

Presentation Notes:

- Simple stream warming model
    - looks at the impact of exogenous factors on local stream temperature
    - land use is influenced by the heat island effect: hypothesized the impact of urban land is greater than suburban>pasture>crops vs. forests
        - upland BMP effect to reflect how ponding, infiltration, filtration or storage runoff modifies base flow or runoff temperatures (+/- or no change relative to land use baseline)

        - stream corridor effect: riparian cover
            - class of corridor BMPs (stream restoration, forestry practices)
        - riverine or reservoir effect: increase of stream temperature as it goes from headwater to head of the Bay (mostly warm but can be cold)
- Classified BMP-temperature effect
    - known heaters, suspected heaters, shaders, shade-removers, known-coolers, suspected coolers, thermal, neutral (may not have data to make an assessment)
        - most urban BMP practices are known and suspected heaters
        - gives an example of 2 completed stream restoration projects – 1990s stream restoration project caused stream temperature increase due to tree clearing
    - Legacy BMPs (1980s-2000s): e.g. surface stormwater ponds, created wetlands, dry extended detention ponds
        - 2-10°F heating effect compared to land use baseline
        - Not many engineering techniques to mitigate heating effect once it occurs
    - Known and suspected coolers: e.g. bioretention and permeable pavement
        - many required
        - improvement to move surface runoff back into shallow groundwater where it may reside for hours or days before reaching stream
        - cooling effect can range 2-5°F depending on soils and underdrains
        - not refrigerators -- cannot compensate entirely for landuse effect and instead designed to treat the impervious cover; cannot meet cold water temperature standards **better to utilize landuse and corridor practice
- Modeling Questions:
    - Historic BMP implementation from 1970s to present, has either increased, decreased or had no impact on stream temperatures, discharge to the Bay
    - Would a different mix of BMPs built in future years mitigate storm warming due to climate change after 2022 or compensate for any heating by historic practices built prior to 2020?
- Evaluation: how good is the data?
    - decent data for urban and forestry practices
    - little temperature data for Ag and habitat practices
    - lack detail data to accurately model future changes on stream temperature

- Urban BMPs have a mixed effect but historically can still have more heaters than coolers, and when combined with non-BMP practices (upland and corridor tree clearing) exacerbates the warming
- Shaders (riparian buffers, corridor practices, potential benefits of upland forestry practices) and shade-removers (land development):
    - riparian forests effectively cool streams
        - reduce incoming shortwave and evapotranspiration benefits
        - can shade smaller, narrower streams
        - species of tree and vegetation can be important
            - area for further research! some shaders are so effective, they can shade out other vegetation; tradeoffs between shading and habitat benefits
        - scale: even small pockets of riparian benefits can be beneficial but may take 10-15 years from planting to mature forests
    - upland practices: less data
        - some studies suggesting upland tree planting can be helpful cooling water downstream
        - floodplain forests are also shown to reduce water temperature by reducing ambient air temp
        - by encouraging more infiltration, upland practices can provide benefits for mitigating extreme heat associated with summer low flow conditions
        - Iris Allen (WVU) looking at the impacts of forest harvesting on water temperature can be effectively mitigated by maintaining riparian forest buffers
- What else needs to be done before the workshop?
    - more research on the temperature impacts on Ag, forestry, and habitat restoration practices
    - will look into the BMP databases to if there is any more urban BMP temperature efficiency data
    - may use input data from Phase 6 to see heaters vs. coolers in the watershed
    - will use existing mapping data to calculate the total headwater stream mileage of the Bay watershed that potentially could be reforested

Discussion:

- Jamboard Questions & Answers (Link PDF on calendar event page here):
    - What are some key opportunities to use BMPs more strategically to mitigate rising water temperatures? (Pg. 3 of PDF)
    - What are some messages we could use to communicate about these opportunities to managers, planners, and policy makers? (Pg. 4 of PDF)
    - How can we further enhance the cooling benefits of forestry and habitat restoration practices? (Pg. 5 of PDF)

- Kristen Saunders: Wondering out loud if there is a way to reflect the classifications and related ecosystem service values and connect this work to the RESES project which is attempting to put quantification on certain BMPs into CAST....work ongoing.
- Peter Tango: https://www.bbc.com/news/world-48395221 how can painting a roof white cool it? Examples in India, NY City, etc.
- Julie Reichert-Nguyen: Interesting article in Nature about using nature-based watershed BMPs to mitigate air temperature increases: https://www.nature.com/articles/d41586-021-01241-2
- Rebecca Hanmer: Going back to data about water temperatures rising faster than air temperatures in certain areas: if you dig into the specific areas, could that inform BMP analysis?
- Katie Ombalski: Regarding messaging - making the connection between increased infiltration to reduced risk or magnitude of flooding.
    - Katie Brownson: Great idea Katie- I like the idea of making the infiltration/flooding/stream temperature connection more explicit
- Rebecca Hanmer: BMP expert panels: incorporate temperature impact in analysis?

11:50 AM **Needs for Enhancing Monitoring Networks for Watershed Water Temperature Change Impacts (#10)**

Synthesis Element Lead(s): Scott Phillips and Peter Tango (USGS)

Session Goal(s):

The goals of this session are to (1) present progress in the USGS compilation of stream -temperature data, and (2) get feedback how these data can be used to address stream-temperature monitoring needs for the watershed synthesis elements above.

Presentation(s):

- Stream Temperature in the Chesapeake Bay Watershed, *John Clune, USGS*

Discussion Question(s):

- Does the presentation by John Clune provide the appropriate amount of detail needed for this synthesis topic?
- What are the primary stream-temperature monitoring needs of the other watershed synthesis elements?

Materials:

Draft Synthesis Paper (10)

Presentation Notes:

- USGS is compiling multi-agency data for assessing status and trends, and modeling stream temperature across the Chesapeake Bay
    - number of available temperature stream sites has increased exponentially
        - data pulled from 31, 142 sites collected since 1970s
        - aggregating the sites into a daily value; 1.2 million+ temperature points
- Data Sources:
    - USGS endless (continuous temperature sites, ~30 across the watershed), citizen monitoring data, USGS Aquarius data
    - asterisks on slide next to data sources that are still collecting data
- Compiling data through a coordinated framework
    - will be publicly available by end of 2021
    - information: site ID, date, daily min/max/mean, source of the data, any important notes
- Currently developing methods that can be used for routine compilation cycles (every 2 years, etc.)
- Develop procedures for cleaning up data and can be repeated
- Developing a synthesis of good status and trends methods to publish within a USGS SIR. Will include more than temperature (conducts, geomorphology, etc.)
    - methods on doing status and trends
    - resources: Sam Oliver (national data set on machine learning and precision-guided techniques), WRTDS, etc.
- Evaluating models to predict temperature where we don't have observations (USGS SPARROW, Ecosheds, Bay Model, EPA SSN Models)
- Timeline:
    - bringing new advances across the watershed to understanding stream temperature
    - next year: publishing status and trends methods
    - 2013-beyond: having the status and trends model

Discussion:

- Jamboard Questions & Answers (Link PDF on calendar event page here):
    - What are the primary stream-temperature monitoring needs of the other watershed synthesis elements? (Pg. 6 of PDF)
- Answers to Menti Question: *Does the presentation by John Clune provide the appropriate amount of detail needed for this synthesis topic?*
- Anne Hairston-Strang: What is the distribution of headwater to large-order streams in the dataset?
    - Some metadata has drainage data with it but would need to delineate the 31,000+ data. Don't have that information at this point.

    - Rebecca Hanmer: would be useful to evaluate data sufficiency in geographic areas of most sensitive species
- Dan Goetz: John, has the daily stream data been paired with air temp? This analysis would provide great insight into thermally resilient watersheds across the entire watershed?
    - not within this project's scope but could incorporate that into future work plans
- How does the data represent different areas? Land use?
    - Peter Tango: I like the idea of representativeness - site locations by geography (pie chart), stream order, latitude, longitude. A few key summaries like that.
- Bill Dennison: What about satellite augmentation of the data set?
    - Peter Tango: no, but interested to talk after
- Dan Goetz: Can't this thermal modeling and watershed resiliency work be translated into larger initiatives to policy makers? Thinking planting trees for net carbon emissions.
    - Peter Tango: Dan G "The Berkeley Lab says the worldwide use of reflective roofing could produce a global cooling effect equivalent to offsetting 24 gigatonnes of carbon dioxide - the equivalent of taking 300 million cars off the road for 20 years." So yes to managing temperature as a policy target linked with carbon management.
    - Dan Goetz: Worldwide assuming 100% implementation? Or on smaller scale?; Peter Tango: Need to go back to the Berkeley work for more details.

12:15 PM **Wrap Up—Non-Tidal Watershed Synthesis Presentations**

Moderators: Bill Dennison (UMCES) and Rich Batiuk (CoastWise Partners)

Session Goal(s):

- Summarize emerging storyline about effects of rising water temperatures on non-tidal aquatic resources and habitat in the watershed and possible responses.
- Identify strong and weak points in the information to date.

Next Steps:

- Take what we learn today to finish information synthesis papers (turn in drafts by July 30th and finalize by early September)
- Based on information synthesis findings, structure questions for STAC workshop in January 2022.

Wrap Up – Summary of key points made in sessions

Answers to *Menti Cloud: What words come to mind when reviewing rising water temperatures on nontidal waters?*

12:30 PM **Lunch**

1:00 PM **Welcome and Review of Meeting Objectives, *Julie Reichert-Nguyen (NOAA) and Scott Phillips (USGS)***

1:10 PM **Tidal Bay Past, Current, and Projected Water Temperature Changes, Influencing Factors, and Implications for Ecosystem Processes, Estuarine Health, Vulnerability, and Resilience (#5/6)**

Synthesis Elements Lead(s): Rich Batiuk (CoastWise Partners) and Nora Jackson (CRC)

Contributor(s): Gary Shenk (USGS) and Lew Linker (USEPA)

Session Goal(s):

To road test whether our draft storyline on the past, current, and projected water temperature changes and factors influencing them in the tidal waters is understandable and fully supported by the available data and scientific findings; and ensure we have a comprehensive listing of implications for ecosystem processes influencing estuarine ecosystem health.

Presentation(s):

- Tidal Bay Past, Current, and Projected Water Temperature Changes, Influencing Factors, and Implications for Ecosystem Processes, Estuarine Health, Vulnerability, and Resilience, *Rich Batiuk, CoastWise Partners*

Discussion Question(s):

- Is our current draft storyline, described in our draft synthesis paper and highlighted in our presentation understandable and fully supported by the available data and scientific findings?
- Are we missing any important implications for ecosystem processes influencing estuarine ecosystem health from our draft synthesis paper?

Materials:

Draft Synthesis Paper (5/6)

Presentation Notes:

- Across the entire Bay, temperatures are rising to differing degrees.
- We are starting to see effects on the living resources.
- There is a 0.7-degree Celsius increase in annual average temperature.
- The biggest driver of the increase is air temperature, as well as ocean temperature, sea level rise, and river temperatures (in order of importance).
- There is (relatively) even warming from the surface to bottom of the Bay.
- We have got a wealth of information on temperature change in the Bay.
- Key processes/implications: increase biological processes, reduce oxygen saturation, increase water stratification, and increase remineralization rates. The factors lead to algae blooms and die offs.
- Projected temperatures predict a 1.09 degree Celsius increase in the air and 0.9 degree increase in the water.
- No matter how land is altered or how much nutrients are pulled out of the system, there will still be an opposing force leading to hypoxic volume increase.
- Summary: air temperature is the leading driver, sea level has a cooling effect in the summer, rivers produce little to no warming, and increasing Bay water temperatures will result in increased volumes of low dissolved oxygen.

Discussion:

- Jamboard Questions & Answers (Link to PDF on calendar event page here).
    - Are we missing any important implications for ecosystem processes influencing estuarine ecosystem health? (Pg. 1 of PDF)
- Julie: Tidal waters may require different adaptations and management strategies.
- Jim George: The coastal acidification (carbonate system) is an interesting storyline, when we consider SAV is serving as a buffering system (not strongly connected to temperature but might be worth a footnote).
    - Brooke Landry: ocean acidification considerations as they relate to SAV will be covered in the SAV chapter
- Bill Dennison: Would addressing the use of Ches Bay for power plant cooling water be relevant?
    - Brooke Landry: Interestingly, some of the known temperature thresholds for SAV were determined in power plant thermal plumes.
- Rebecca Murphy: There is additional data, looking at shallow water data.
- Marjy Friedrichs: The southern Bay is warming particularly fast because the ocean water is warming faster than the atmosphere. This is because the Gulf Stream has moved and blocked cool waters.

- Jim George: Could someone quickly speak to near term changes, or does the data support saying anything?
    - Rebecca Murphy: In our analysis of 10-year change vs 34, it's hard to say if there is a difference. There is a lot of variability in the 10-year changes simply due to the variability in flow and that impact. Probably some additional analysis efforts would be needed.

1:35 PM **Water Temperature Effects on Fisheries and their Habitats in Tidal Bay Waters and Management Considerations (#2, #7/8)**

Synthesis Element Lead(s): Bruce Vogt (NOAA) and Justin Shapiro (CRC)

Contributor(s): Emily Farr and Jay Lazar (NOAA) and Mandy Bromilow (NOAA Affiliate)

Session Goal(s):

Share information on the vulnerability and impacts for increasing temperatures on representative species and their habitats. Consider key factors when choosing representative species such as, ecological importance, economic value, cultural significance, biological diversity, and differing anticipated responses to increasing temperatures. Introduce the climate science and management frameworks NOAA has developed to reduce impacts and increase resilience.

Presenters: *Bruce Vogt and Emily Farr, NOAA*

- Water Temperature Effects on Fisheries and their Habitats in Tidal Bay Waters and Management Considerations*, Bruce Vogt and Emily Farr, NOAA*

Discussion Questions:

- Are there additional representative species or habitats that were missed in our presentation/synthesis?
- Are there other management frameworks that exist/or are being considered that could be applied to tidal systems?

Presentation Notes:

- Addressing what we know: Using the NOAA Climate Vulnerability Assessment
    - Northeast assessment weighing species vulnerability by calculating sensitivity and exposure scores (Including biological information, life history, etc.)
    - Along with scores were directional impacts and data uncertainty scores to accompany each species
    - The fisheries team analyzed five “key” species representing a wide range of vulnerability scores and temperature sensitivities
- Species Narratives:
    - Blue Crab

        - Overall narrative: Likely climate "winner" from decreased winter mortality with rising temperature
    - Oyster
        - Likely to be negatively affected from climate impacts
        - Many stressors beyond temperature play a role
    - Striped bass
        - Complicated narrative surrounding rising temperatures because of life history
            - Summer warming will reduce habitat
            - Cooler winters may help recruitment
    - Summer Flounder
        - Bay is very important for juveniles
        - Again, a mixed bag and uncertainty for climate impacts - unsure if distribution shifts are attributed to temperature or fishing restrictions
    - Forage species
        - Overall narrative for these two species (anchovy and menhaden): Climate change winners as increased temp will increase range and productivity
- Habitat Vulnerability Assessments:
    - Similar to assessment addressed above, but focused on habitat types in northeast
    - Important note - there is no "sensitivity to temp" rank, but rather sensitivity composite score of a number of abiotic factors
- Specific habitats of interest:
    - Salt marsh
        - Very vulnerable to climate change: Changes in photosynthetic rate, decay rate,
    - SAV
        - Highly vulnerable to climate change: Striped bass and blue crab are highly dependent
        - SAV will be talked about in more detail later
    - Shellfish reef
        - Intertidal is very highly vulnerable
        - Subtidal is highly vulnerable
- Existing information Gaps:
    - Need for finer resolution (bay-specific) models and spatial products
    - Better quantifying links between climate change and species decline
    - Identifying threshold numbers
- Management Responses/Approaches:
    - NOAA has a Climate Science Strategy
        - NOAA Northeast creates a State of the Ecosystem product that compiles observational/biological data to help guide managers and commissions

- Ecosystem Based Fisheries Management
  - Each region of NOAA has an ecosystem-based fisheries management (EBFM) plan to help inform science-based management
  - Important because temperature increases in tidal waters likely can't be mitigated, so understanding how to respond is key

Discussion:

- Jamboard Questions & Answers (Link to PDF on calendar event page here; Pg. 2 and 3 of PDF).
- Peter Tango: asks about oyster temperature sensitivity since they are found in Gulf
  - Bruce: responds that they have low sensitivity to temp, but important variables beyond temperature are the major concern (acidification for example)
- Steve Faulkner: asks about additional management frameworks
  - Look into state wildlife action plans

2:10 PM **Water Temperature Effects on Submerged Aquatic Vegetation (#3)**

Synthesis Element Lead(s): Brooke Landry (MDNR)

Session Goal(s):

Provide a brief overview of the state of the science regarding water temperature effects on SAV communities in Chesapeake Bay, and the management implications associated with potential significant loss.

Presentation(s):

- Water Temperature Effects on Submerged Aquatic Vegetation in Chesapeake Bay, *Brooke Landry, MDNR*

Discussion Question(s):

Chesapeake Bay SAV can be divided into three main communities based on their salinity tolerance: the polyhaline community, the mesohaline community, and the tidal fresh/oligohaline community. It's likely that each community will respond to rising water temperatures differently (and that species within each community will respond differently as well).

- From a management perspective, looking at how integral SAV is to so many other systems, how do we prioritize research needs and management actions with limited time and funding?

- Which community type gets highest priority?
- How do we balance conservation and restoration?

Presentation Notes:

- There are 20 commons species of SAV.
- Their distribution is based primarily on salinity. The southern Bay has the greatest salinity content.
- Direct impacts to SAV include temperature increase, sea level rise, and salinity changes. This will affect survival, however the increase in carbon dioxide will help photosynthesis and counteract other stresses.
- Warming is not uniform, with the shallows warm faster where SAV content is high.
- Most species are considered "temperate." A change in temperature effects photosynthesis and respiration, germination, and spread disease.
- Eelgrass has been significantly lost in the Southern Bay.
- Widgeon grass is temperature tolerant and has spread in the regions of eelgrass loss.
- Data gaps for other species, such as a redhead grass and horned pondweed.
- Freshwater species impacts vary depending on tolerances. Unlike marine seagrass beds, freshwater beds consist of a diversity of SAV species.
- Indirect impacts and complicating factors include increases in rainfall, eutrophication, higher sediments sulfide levels, etc.
- To fill the data gaps there is a GIT funded project to model climate impacts – both outcomes and potential recovery trajectories. There is also a proposal to study cyanobacteria overgrowth in the SAV beds.
- Management implications include the loss of eelgrass in the lower bay impacting SAV goals and tributary goals. While Widgeon grass can fill the niche, it may still impact the species dependent on it.

Discussion:

- Answers to Menti Question #1: From a management perspective, how do we prioritize research needs and management action with limited time and funding?
- Answers to Menti Question #2: How do we balance conservation and restoration?
- Frank Borsuk: What are the effects of the soft algae on the distribution of SAV?
- Brooke: The macroalgae that accumulate smother SAV. They can also shade out SAV.

- Julie: I heard a lot about multiple stressors and differing responses to rising temperatures. While a species may not be negatively impacted individually by increasing temperature, the impacts to the overall habitat can lead to negative impacts on the species.
- Brooke: We really do not have research on individual species. Without knowing individual tolerances, it is hard to begin. Should we start with freshwater, because they have turning out so resilient, or seek to save marine beds.
- Julie: Some of these species may also provide protection from storm surge.
- Brooke: Yes, for example, eelgrass is much more resilient for storm surge in comparison to Widgeon grass. Eelgrass also peaks at a specific time providing a winter habitat, which changes as widgeon grass fills its niche causing a seasonal loss of ecosystem services.
- Brooke: There is a big debate right now on whether to focus on restoration or conservation.
- Bruce Vogt: For management and restoration, more work around how co-locating oysters and SAV can mitigate climate impacts on each.

2:40 PM **Break**

2:45 PM **Information Supporting the Development of and Options for a Tidal Bay Water Temperature Change Indicator(s) (#9)**

Synthesis Element Lead(s): Julie Reichert-Nguyen (NOAA)

Contributor(s): Breck Sullivan and Anissa Foster (CRC), Ron Vogel (NOAA) and Mandy Bromilow (NOAA Affiliate)

Session Goal(s):

Share information and discuss indicator concepts for a Bay Water Temperature Change Indicator, including available data sources, initial indicator considerations to connect with ecological impacts, and preliminary identification of data strengths and limitations.

Presentation(s):

- Information Supporting the Development of and Options for a Tidal Bay Water Temperature Change Indicator(s), *Breck Sullivan (CRC) and Julie Reichert-Nguyen, NOAA*
    - Identification of tidal water temperature data sources (e.g., satellite, buoy, monthly monitoring)

    - Preliminary big picture data considerations for connecting physical water temperature change to ecological impacts.
- Forage Indicator Efforts Connecting Water Temperature to Living Resources, *Mandy Bromilow, NOAA Affiliate*
    - Forage fish springtime warming indicator effort
    - Habitat suitability index effort

Discussion Question(s):

- What are management applications that a Bay Water Temperature Change Indicator could be useful for related to the effects of changing temperature conditions on living resources and/or habitats?

Presentation Notes (Julie Reichert-Nguyen and Breck Sullivan):

- The climate resiliency workgroup is responsible for climate monitoring and assessment as well as climate adaptation. To do that, they need indicators that can track resilience.
- If climate change is going to have a multidisciplinary impact, we need multidisciplinary indicators—have physical change indicators that can connect with ecological impacts and resilience decisions.
- We have various data sources for water temperature: in situ monitoring stations, buoy data, and satellite sources.
- No data set meets the best-of-all criteria (spatial and temporal scales, accuracy, record length, institutional support, etc.).
- Stations are Bay wide and can capture the vertical profile but have a low spatial and temporal interval.
- Buoy data provides a high temporal interval, but a low spatial interval.
- Satellite data is bay wide, with a high spatial and temporal interval, but is surface only.
- Indicator examples related to water temperature include the integrated trends analysis of Bay water temperature change and the indicator for the National Estuary Program based on satellite data.
- The integrated trends and analysis team analyzes trends using GAMs, producing maps to portray physical change.
- Satellite data is not available in the narrow tributaries; however, it fits the need for daily data.
- In summary, we need to work towards connecting physical water temperature change with ecological impacts. Given limitations, using a multi-source data approach (e.g., observed data and satellite data) could allow for a more robust indicator to address management applications. Next steps for indicator development—prioritize/select the management application need(s) and assess appropriate indicator methodologies to address the need(s).

Presentation Notes (Mandy Bromilow):

- The forage indicators seek to identity if there is enough prey, how prey availability changes, and develop an indicator to track it.
- They identified the most important prey using gut contents of predators.
- The indicator plan includes an abundance timeseries, incorporation of environmental factors, and considering predator consumption.
- They focused on springtime warming and a habitat suitability index.
- To identity a useful indicator, they had to identify the key species and habitat relationships.
- To address fishery priorities and interests, it must connect to climate change and habitat conservation.

Discussion:

- Jamboard Questions & Answers (Link to PDF on calendar event page here; Pg. 4 of PDF)
- Julie: What are management applications that a Bay Water Temperature Change Indicator could be useful for related to the effects of changing temperature conditions on living resources and/or habitats?
- James Martin: Indicators are only useful for things that change quickly, otherwise it would remain static. What management options would be guided by this indicator?
    - Julie: For management considerations, indicators could help identify vulnerable habitats and where adaptation decisions are necessary. Management options could involve changing regulations to protect vulnerable species/habitats.
    - Bruce Vogt: James, for tidal fisheries we are trying to shift management from single species stock assessments to including climate and other ecosystem factors affecting fish productivity and distributions. This means developing indicators that link species and climate variables that can be considered by management bodies such as the Mid Atlantic Fishery Management Council and Atlantic States Marine Fisheries Commission in their decisions.
- Kristen Saunders: another example of a management action could be to change our goals for certain outcomes
    - Brooke Landry: don't want to give up or change goals—interested in figuring out if we can implement strategies to fix the problem (clean up the water so that our SAV can tolerate higher temps).

3:15 PM **Needs for Enhancing Monitoring Networks for Tidal Bay Water Temperature Change Impacts (#10)**

Synthesis Element Lead(s): Peter Tango (USGS)

Contributor(s): Breck Sullivan (CRC) and Scott Phillips (USGS)

Session Goal(s):

- Share data sources commonly used to reflect temperature conditions and tracking change in the tidal waters of the bay and tributaries. A core set of data is being discussed within STAR-related workgroup activities of the Hypoxia Collaborative, Climate Resiliency Workgroup and the 4D Water Quality Estimator project.
- Discuss information needs for bay water temperature related to the other synthesis elements (e.g., fisheries and SAV impacts, habitat vulnerability, management applications).
- Begin discussion to help identify opportunities for use of existing data to improve analysis, recommending enhancements needed for tidal water temperature monitoring.
- Get input on the prioritization of monitoring/data investments.

Presentation(s):

- Needs for Enhancing Monitoring Networks for Tidal Bay Water Temperature Change Impacts, *Peter Tango, USGS*

Discussion Questions:

- For your changing temperature-related decision-support purposes, what data needs do you have, where, and for what purpose beyond the existing networks and programming?
- Do you need more data resources or do you need better tools for analysis and reporting using the diversity of existing data collections?
- If you are investing in enhanced information gathering, where do you need the most relevant monitoring information?

Materials:

Draft Synthesis Paper

Presentation Notes:

- Original networks:
    - 123 stations on nontidal network
    - 1985 tidal-monitoring network: largely in tact
        - shallow water, continuous monitoring
    - SAV/benthic monitoring
- Recent monitoring networks:
    - Chesapeake Monitoring Cooperative: citizen monitoring program

- Water temperature monitoring data provides insight on spatial-status of present conditions, magnitude of measurements (e.g. heat waves), frequency and duration of events, SAV monitoring, trends over time
- Data is showing that Bay temperatures are rising
- Strong set of investment on diverse data sources (local-scale, Bay-wide scale)
- Regional and global effects are influencing SLR and thermal water expansion
    - seeing warming in near-shore off-shore zones impacting migratory species (recreational and fishery species)
- Tool box used to enhance monitoring efforts:
    - increase frequency of measurements and time
    - density of measurements
        - data flow or other technologies
        - citizen's monitoring
        - satellite-based data
    - adopting to new technologies
        - hypoxia collaborative
        - drone, aerial, satellite technologies
    - developing a 4D water quality estimator in the tidal Bay: can help integrate new forms of data sources into a high-frequency high-resolution manner

Discussion:

- Jamboard Questions & Answers (Link to PDF on calendar event page here; Pg. 5 and 6 of PDF).
- Answers to Menti Question #1: Do you need more data resources or do you need better tools for analysis and reporting using the diversity of existing data collections?
- Answers to Menti Question #2: If you are investing in enhanced information gathering, where do you need the most relevant monitoring information?
- Scott Phillips: would rising temp in marshes help with processing of nutrients?
    - Joel Carr: Scott, it also would affect decomp rates, carbon cycling etc.
    - Scott Philips: @joel Carr--what media (water, soil) should be measured for temp change?; Joel Carr: both, but in reality water (wells) is probably the simplistic

3:40 PM **Wrap Up—Tidal Bay Synthesis Presentations**

Moderator(s): Bill Dennison (UMCES) and Rich Batiuk (CoastWise Partners)

Session Goal(s): Summarize emerging storyline about effects of rising water temperatures on tidal resources and habitat in the Chesapeake Bay and possible

responses. Identify strong and weak points in the information to date. Next steps for the STAC Workshop can be found in the project proposal.

Next Steps:

- Take what we learn today to finish information synthesis papers (turn in drafts by July 30th and finalize by early September)
- Based on information synthesis findings, structure questions for STAC workshop in January 2022.

Wrap Up—summary of key points made during sessions

Answers to *Menti Cloud: What words come to mind when reviewing rising water temperatures on tidal waters?*

4:00 PM Adjourn

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Next CRWG Meeting:

- Monday, August 16, 2021, 1:30 – 3:30 PM (No July Meeting)

Participants: Breck Sullivan (CRC), Julie Reichert-Nguyen (NOAA), Alexis Park, Alison Santoro, Annabelle Harvey (CRC, STAC Coordinator), Anne Hairston-Strang (MD DNR Forest Service), Brad Fink (VA Dept. of Wildlife Resources), Brooke Landry (MD DNR), Bruce Vogt (NOAA_, Carl Friedrichs, Charles Sandusky, Dan Goetz (MD DNR), David Wood (Chesapeake Stormwater Network), Debbie Herr Cornwell (MD Dept. of Planning), Denice Wardrop, Elizabeth Andrews, Emily Farr (NOAA), Fran Borsuk (US EPA Region 3), Gary Shenk (USGS@CBPO), Greg Golden, Greg Noe, Iris Allen, Isabella, Jackie Pickford (CRC), James Colgin (USGS PA Water Science Center), James Martin (VA DEQ), Joel Carr (USGS), Jennifer Starr (Alliance for the Chesapeake Bay, LGAC Coordinator), Jim George (MD Dept. of Environment), John Clune (USGS), Jonathan Leiman (MDE), Karl Blankenship (Bay Journal), Katie Brownson (US Forest Service), Katie Ombalski, KC Filippino, Kevin Du Bois (DoD), Kevin Hess (PA DEP Coastal Program), Kirstin Underwood, Kristin Saunders (UMCES), Kyle Hinson (VIMS), Mandy Bromilow (NOAA Affiliate), Marek Topolski (MD DNR), Marjy Friedrichs (VIMS), Mark Southerland (Tetra Tech/supports CBP Healthy Watersheds effort), Matt Konfirst, Matt Lawrence (MD DNR Fishing and Boating), Matthew Cashman (USGS), Meg Cole (CRC), Mike Kolian (US EPA), Nicole Carlozo (MD DNR), Nora Jackson (CRC), Norm Goulet, Peter Tango (USGS), Rebecca Hanmer, Rebecca Murphy (UMCES), Renee Thompson (USGS), Rich Batiuk, Richard Tian, Sara Weglein, Scott Phillips (USGS), Steve Faulkner (USGS), Tammy Zimmerman, Than Hitt (USGS), Thomas Muradaz

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