Chesapeake Bay Program
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Climate Resiliency Workgroup

February 14, 2022
2:00-4:00 PM

Event webpage:
https://www.chesapeakebay.net/what/event/climate_resiliency_workgroup_meeting1

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

Agenda

2:00 PM **Welcome and Meeting Overview – Chair Mark Bennett (USGS) and Coordinator Julie Reichert-Nguyen (NOAA)**

Focus of meeting:

- Share research on marine heat waves in Chesapeake Bay.
- Debrief on Rising Water Temperatures STAC Workshop discussions.
    - Connect with workplan action related to Bay Water Temperature Change Indicator and identifying science needs related to rising water temperatures.
    - Get thoughts from CRWG members on the management implications of rising water temperatures related to habitats and living resources.

2:10 PM **Presentation on marine heatwave research in Chesapeake Bay – Dr. Piero Mazzini (Virginia Institute of Marine Sciences)**

The frequency, duration, and intensity of marine heatwaves (MWHs) have been observed to increase in global oceans, but little is known about their potential variability in estuarine systems. VIMS conducted a study to investigate the intensity, duration and frequency of MWHs in the Chesapeake Bay using over three decades of continuous temperature records. Observed trends suggest that the Chesapeake Bay will reach a semi-permanent MHW state, when extreme temperatures will be present over half the year. Given the detrimental impacts of MWHs on ecosystems and marine and estuarine economic activities, improving our basic understanding of MHWs is important to guide management decisions.

Summary

Piero began by explaining that marine heat waves garner a lot of attention and defined marine heat waves as when the sea surface temperature (SST) is greater than the 90th percentile threshold for five consecutive days. Piero shared some of the major impacts of marine heat waves, such as record breaking harmful algal blooms, global-scale coral bleaching, mortality of SAV, geographical species shifts and changes in species composition, and impacted commercial fisheries and aquaculture. Piero then explained why marine heatwaves in estuaries are relatively understudied due to the lack of adequate satellite resolution and *in situ* data. There are approximately 30 years of data for marine heat waves, but a shorter time series can also yield good results. The metrics studied for marine heat waves include duration, intensity, frequency, number of marine heat wave events, and cumulative intensity.

Next, Piero overviewed the available data on marine heat waves for the Chesapeake Bay (CB), like several long-term monitoring stations in CB that are not located perfectly but show similar statistics that are representative of the CB mainstem. The results of the analysis indicated that summertime has a longer occurrence of marine heat waves than other times of the years and aligns with problems of hypoxia. Results compared the overall CB to sub-regions, like the characteristics of the Upper Bay (0-8 events per year with most in current decade, duration of 5-20 days with no significant trend, but increasing in frequency), characteristics of the Lower Bay (significant trends, a few reaching 100-day marine heat wave event), and characteristics of the overall CB (no greater overall intensity like the global trend, but yearly cumulative intensity has been increasing). One aspect of the analysis looked at how events co-occur in different region of the Bay, where estimates of co-occurrence are measurements of similarity. The analysis also looked at lag events of co-occurrence and found typical lag was about 2 days where 40% occurred simultaneously with the open ocean. The analysis also observed temperature change for the mixed layer in the ocean and estuary, where the air-sea heat flux seemed to explain the co-occurrence of heat flux in the ocean and estuary.

The analysis related the data to climate indices and showed large spatial variability across the CB, with more influence shown in the lower CB and Mid-Atlantic Bight, but not so much in the Upper and Mid-CB. While there is a need for further studies to understand the cause of marine heat wave events, the main driver behind these marine heat waves is rising atmospheric temperatures. Piero concluded that if these trends persist, by 2100 the Chesapeake Bay will reach a state of semi-permanent marine heat waves. Piero provided a brief overview of the future work that is being done on this topic.

Discussion

Julie thanked Piero for presenting and commented on the importance of this research, especially considering the concerning nature of the main conclusion and how this fills some knowledge gaps around the impacts on aquatic life.

Julie asked if there is opportunity for native species to adapt to these extreme events, which seem to be increasing mostly in frequency and less so in intensity, or if the only option for species is to migrate out of the CB. Julie asked how this question might vary geographically

across the CB. Piero responded that the different sections of the CB are all under the influence of broad scale atmospheric forcing, which is similar to the ocean, and tend to exhibit similar responses. Piero said that the average across the Chesapeake Bay is 3 degrees Celsius higher than normal during marine heat waves and last for an average of 11 days. In relation to species tolerance, Piero noted he is not a biologist, but said it will depend on the particular species and likely biological studies will need to focus on each species individually. Julie replied that the similarity of changes across the CB in accordance with the ocean is an interesting point for species adaptation and agreed that there is a lot of research needed for understanding how different species respond to marine heat waves.

Joel Carr asked given shifts in sea level rise and water levels in the CB by 2100, how do you think flushing dynamics due to shifting tidal prism will affect these distributions? Will some areas get exacerbated and experience tidal flush? Piero said that for narrow estuaries one might see the invection rates driven by the ocean, but since the Chesapeake Bay is more akin to a narrow sea, the resonance time varies across the CB, such that the southern part of the bay may be about a month and the northern part may be closer to multiple months. Piero emphasized the role of the atmosphere as being the main driver of this warming. Joel responded this makes modeling easier.

Julie emphasized the importance of incorporating this research into Chesapeake Bay research and actions to protect living resources. She noted the connections with the future of this work and hypoxia.

2:40 PM **Debrief of Rising Water Temperatures STAC Workshop Phase 2, highlights on science findings, research gaps, and management implications**

2:40 PM *Tidal Subgroup - Julie Reichert-Nguyen (NOAA), Amy Goldfischer (CRC), Alex Gunnerson (CRC)*

Summary

Julie began by explaining the overall objectives of this STAC Workshop, the specific objectives of the first day, the Chesapeake Bay Program workgroups and partners supporting the effort, and the timeline from the start of funding to the completion of the report. Julie then emphasized that this presentation was a draft version of the storyline and species-specific impacts that will be finalized in the STAC report produced by this workshop. For the draft tidal storyline, Julie overviewed the physical direct and indirect effects of warming temperatures on living resources in addition to the broad implications for management. Julie provided the five guiding questions the Tidal Subgroup used to organize conversations throughout the first day of the workshop, which were: 1) What are the direct and indirect positive and negative effects of rising water temperatures on fisheries (e.g., blue crab, oysters, striped bass, summer flounder, forage) and submerged aquatic vegetation (SAV) resources?, 2) What do we know and not know about temperature sensitivities of the resource?, 3) What are key factors to consider for the resource to inform management action?, 4) What are the management implications across the different

fisheries and SAV resources?, 5) What temperature analyses would be useful for management purposes?

Amy and Alex then outlined the species-specific breakout room responses from the workshop, which corresponded with the questions asked throughout the tidal subgroup. Amy provided an overview of the ecological impacts, temperature sensitivities, key factors to consider for management decisions, and management implications for oysters and submerged aquatic vegetation. Alex provided an overview of the ecological impacts, temperature sensitivities, key factors to consider for management decisions, and management implications for blue crab, forage species, and finfish-predator species (in this case, striped bass). Julie concluded the presentation by identifying common themes across the tidal, species-specific breakout rooms. Examples of common themes include the direct versus indirect effects of temperature change, multiple stressors, extreme events, and ecosystem-based management.

3:05 PM *Watershed Subgroup – Katherine Brownson (USFS), Spencer Tassone (UVA)*

Summary

Katie Brownson began by explaining that this presentation is in draft form as well and is the result of work from many different individuals. The watershed portion of the workshop was organized differently and was not focused on particular species. One key finding was the largest driver of water temperatures was land use and land cover and that water temperatures increased more than air temperatures across the watershed. Another finding was that many Best Management Practices (BMPs) could be separated into warming and cooling categories based on their impact on water temperatures, but some could not be separated into those categories. Katie added how across the watershed, there has been substantially greater implementation of warming BMPs than cooling BMPs, with approximately three times as many warming BMPs being implemented than cooling BMPs in most years. Some examples of warming BMPs include stormwater retention ponds, floating treatment wetlands, and vegetated open channels. Some examples of cooling BMPs include riparian forest buffers, upstream tree planting, urban stormwater infiltration, and wetlands restoration. Runoff temperature, stream flow, and channel buffering capacity are some of the most relevant drivers to be considered by management.

Katie identified some of the key knowledge gaps, such as the degree to which various drivers (and interactions between drivers) influence water temperature in specific sub-watersheds, regional/sub watershed models of groundwater inputs, and the relative influence of BMPs on water temperature. Some of the issues with the conceptual model include: accounting for variation in the importance of drivers depending on location within the watershed and the dominant land use; addressing issues of scale (both spatial and temporal); avoiding oversimplification- how to account for interrelationships and complex biological factors; and connecting drivers with management activities and land use decisions.

For the second part of the presentation, Spencer talked in detail about the effects of warming temperatures on non-tidal aquatic life. Spencer showed a conceptual framework of species and habitat vulnerability that integrates exposure, sensitivity, and adaptive capacity to understand the greatest relative vulnerability. As part of the workshop, participants identified Brook trout as being the most sensitive and exposed to rising water temperatures. For ecological impacts on species, participants identified the strongest negative impacts on cold-water species (e.g., trout, sculpin) and found that watershed-wide, warmwater aquatic species are most common. While warm-water species are more tolerant to temperature increases, they are sensitive to extreme temperatures including rapid changes and indirect effects (e.g., invasives, pathogens) from higher temperatures. Some key knowledge gaps for ecological impacts on species surround prey/food, life cycles, interactions with other stressors, and non-trout species, but specifically those lower in the foodweb.

For ecological impacts on habitats, participants identified that: the strongest negative impacts are on small, cold-water streams not driven by groundwater due to relatively low heat capacity; protecting native brook trout habitat, including watershed, is an urgent priority; and larger waterways with low forested watershed cover, riparian cover, heated urban runoff, and many "heater" BMPs are likely vulnerable as well. Some key knowledge gaps for ecological impacts on habitats includes which places are most susceptible to pulsed heating and how BMPs and stream restoration are impacting temperatures.

For the temperature aspects of ecological impacts, aspects were grouped by temporal (seasonality), spatial (landscape, aquatic connectivity), and event characteristics (long-term pressure, pulsed extreme warm water events – heatwaves). Many of the ecological impacts from other stressors include co-occurring stressors (low pH and dissolved oxygen, invasive species) and ecosystem shifts (species assemblages and predator/prey interactions).

Some overarching themes on management practices include the need to: ensure rivers and streams are well buffered; encourage the implementation of cooling and shading BMPs upstream; minimize the loss of existing forests; discourage implementation of heating BMPs, especially in cold-water habitats; and use habitat restoration to improve connectivity between suitable habitat patches and improve access to thermal refugia.

Some overarching themes on science support include the need to: improve understanding of the temperature impacts of BMPs; improve understanding of the ecological impacts of incorporating temperature refugia into stream restoration design; improve water temperature monitoring; and improve modeling and decision support tools.

3:30 PM **Discussion**

CRWG members discussed management implications and science needs related to assessing rising water temperatures and effects on natural resources (habitats, landscapes, fisheries, SAV).

Summary

Julie began by asking that CRWG meeting participants put their thoughts about the following questions in chat during the briefings from the tidal and watershed subgroups:

- Are there any findings or management implications that are missing?
- Are there any differing opinions on findings?
- Are there any research efforts you know of that can help inform knowledge gaps or management?

Judy Okay asked if they have been able to determine if some SAV are more tolerant to heat and turbidity and if increasing the tolerant species would be helpful even though the result may be less diversity. Breck Sullivan responded she was the notetaker in the SAV breakout group and as mentioned under Management Implications, the single most effective action is to accelerate improvements in water quality. Breck wondered if rising temperature is a factor the partnership should really be focusing on for some resources such as SAV and oysters. Nicole Carlozo responded, Maryland Department of Natural Resources (MD DNR) evaluated sea level rise impacts to future SAV habitat in Maryland's Ecological Effects of Sea Level Rise (EESLR) project and water quality was found to be the most important factor in the study, but water temperature was included as one of the significant factors, specifically summer and spring averages for bottom and surface. Breck replied it is good to know that we are going in the right direction with this workshop if temperature is a significant factor. Breck expressed there are still a lot of knowledge gaps surrounding temperature impacts on stable beds versus recovering or seedling beds. Nicole offered to share the report if that would be helpful.

Judy Okay asked about SAV and the tradeoffs surrounding diversity vs robustness of species in the bay. Brooke responded that this is already happening in the bay, specifically freshwater regions, due to temperature and water clarity. Brooke added this depends on salinity regimes and provided the example of eelgrass loss to widgeon grass in the Polyhaline region of the CB. Brooke explained there is already some self-selection going on with non-native species in the CB that provide some ecosystem services, but restoration activities are focused on species like eelgrass. Patrick suggested considering revising management and modeling accordingly to understand the new thresholds that exist for different compositions of taxa. We may need to think about a new regime and rethink everything we thought we knew.

Judy Okay asked if it look like SAV could have an advantage with extended Spring and Fall seasons. Joel Carr replied, it depends on the species, but likely the net carbon balance is too poor (high summer temperatures stress outweighs the longer season). Breck replied, based on what the experts in the SAV breakout group said that most likely there will be a longer growing season, but it will result in a change of species identity depending on which species can grow well with the higher temps.

Richard Tian commented that temperature and water quality stresses on spats and juvenile stage fishes may need more attention in future studies.

Scott Phillips commented, Julie, Amy, and Alex, did a nice job on organizing findings, gaps, and management implications into the "species summaries". Scott asked will the knowledge gaps be prioritized for each species to help develop associated recommendations to improve science. The management implications seem to be mix of what could be done (management options) and what needs to be learned (science recommendations). Scott recommended separating them since two different audiences on what could be done next. Judy Okay recommended ranking literature references as peer reviewed, CBP or other reports, non-journal papers, and annotated bibliographies to distinguish between references of most importance and varying accuracy. Stephen Faulkner replied, in the nontidal chapter they only cited peer-reviewed literature with the exception of maybe an unpublished thesis or two. Rich Batiuk replied, that management actions are needed before we know the full impact of higher temperature stress on organisms.

Breck asked Julie, given that Katie shared with us some monitoring needs that came up in the nontidal session, were you able to pinpoint any monitoring needs from the Tidal session we should reflect in the upcoming PSC report on how to improve CBP monitoring networks? Julie replied that for monitoring additional follow up is needed. Some expressed the need to monitor the actual organisms (fish, zooplankton, phytoplankton *in situ*) which is typically cut from monitoring programs. Breck thanked Julie for sharing, explaining the PSC report already includes needs for phytoplankton and fish monitoring, so this STAC workshop adds justification.

Rebecca Hanmer commented, the ranking of species exposure may have reflected the participants' expertise - as most worked with cold-water species. Very limited information was available on exposure of warmwater species.

Judy Okay asked if urbanization is acting as a surrogate for impervious surfaces? Katie replied, impervious surfaces are definitely an important component, but urbanization could also be a proxy for other interacting stressors, including other pollutants and invasive species.

Fredrika Moser asked, when thinking of management options, was much discussion given to how reducing greenhouse gas emissions (GGE) could be part of these strategies? Katie replied they didn't really discuss GGE reduction techniques with any sort of specificity and they are not taking a systematic approach to this issue as it is outside the scope of this workshop. They do expect there to be some co-benefits, from efforts around forest buffers.

Jim George asked if there were any thoughts or references on temp controls for construction sites. Katie replied that the watershed subgroup didn't address best practices for construction sites, but that could be something to look into for day 2 of the workshop.

Spencer Tassone commented, he is working on a nationwide assessment of heatwaves in riverine systems along with their relation to landscape features, and planning to submit for publication this month.

Renee Thompson commented, she appreciates the shout outs for vital land and complementary habitat conservation as well as improving habitat connectivity. She encouraged focusing on these themes in day 2 of the workshop.

Chris Patrick commented, another issue to consider is shifts in system state in terms of composition and dynamics and how this will change management strategies. For example, in SAV work data is showing that water quality targets required to sustain a specific taxon, like widgeon grass, has very different sensitivities than other taxa like eelgrass. Changes in relative abundance, new taxa moving in from North Carolina controls, and stressor responses, may require management to revisit what they consider to be certain given new temperature regimes. Chris emphasized that these concepts can transfer to other species as well. Katie talked about the need for different strategies for different species and that some species may require different approaches within the Resist-Adapt-Direct framework. Katie gave the example of certain cold-water species like Brook trout are already at the limits of their thermal tolerances, so a resist strategy is paramount. Julie and Katie concluded that a "one-size fits all" approach would not be appropriate based on this understanding.

In relation to concepts that should be emphasized in day 2 of the workshop, Joel Carr and Scott Phillips recommended multiple stressors and how rising temperatures influence them. Rebecca Hanmer emphasized the importance of dealing with interrelationships.

Spencer Tassone commented, he found heatwaves in one estuary of CB co-occurred with low dissolved oxygen events about 25% of the time. That's to say that 25% of estuarine heatwaves in CB co-occur with a low DO event. (https://link.springer.com/article/10.1007/s12237-021-01009-x#article-info). Stephen Faulkner replied, in addition to dissolved oxygen, heatwaves in small cold-water streams can dry them out and kill fish so we should include that as another indirect effect.

Mark Bennet commented, infiltration does not cool the water - groundwater really is not cooling water down, it is just buffering against warming. Katie and Stephen Faulkner agreed, commenting it is difficult to capture those nuances, but we will need to be clear in the report. Matt Ehrhart emphasized the need to be thoughtful in the language of the report. Matt said many of the comments spoke to reduced heated overland flow and increased baseflow support for the stream, which can be significant during the summer heat.

Anyone who has comments or questions can reach out to Julie Reichert-Nguyen at (julie.reichert-nguyen@noaa.gov) for the tidal subgroup or Katie Brownson at (katherine.brownson@usda.gov) for the watershed subgroup.

3:55 PM Wrap-up and announcements

Julie announced that the status of the March CRWG meeting has yet to be decided due to the upcoming second day of the STAC Rising Temperatures workshop on March 15th. After the meeting, it was decided that there will not be a March meeting since the CRWG staff are

helping organize the Day 2 Rising Water Temperature STAC Workshop. The next CRWG meeting will be April 18, 2022.

4:00 PM Adjourn

Participants: Alex Gunnerson, Amy Goldfischer, Anna Hamilton, Anna Kasko, Anne Hairston-Strang, Amanda Poskaitis, Allison Breitenother, Annabelle Harvey, Becky Golden, Bill Jenkins, Ben McFarlane, Breck Sullivan, Briana Yancy, Brooke Landry, Bruce Vogt, Calle Biles, Chris Patrick, Carl Friedrichs, Debbie Herr Cornwell, Elizabeth Andrews, Erin Garnaas-Holmes, Frank Borsuk, Fredrika Moser, Lisa Doseman, George Onyullo, Gina Hunt, Jefferson Flood, Jennifer Starr, Jess Blackburn, Jessica Rodriguez, Jeremy Hanson, Jim George, Joel Carr, John Denniston, Jonathan Leiman, Judy Okay, Julie Reichert-Nguyen, Justin Shapiro, Katherine Brownson, Kristin Saunders, Laura Cattell Noll, Marjy Friedrichs, Matt Konfirst, Meg Cole, Matt Ehrhart, Molly Mitchell, Mark Bennet, Nathan Shunk, Nicole Carlozo, Nora Jackson, Piero Mazzini, Rebecca Hanmer, Rebecca Murphy, Renee Karrh, Renee Thompson, Rich Batiuk, Richard Tian, Rikke Jepsen, Roberto Llanso, Ron Vogel, Sally Claggett, Scott Phillips, Sophie Waterman, Spencer Tassone, Stephen Faulkner, Susan Minnemeyer, Taryn Sudol, Todd Lutte, Yi Liu.