Climate Resiliency Workgroup

August 17th, 2023

1:30-4:30 PM EST

Event webpage:

https://www.chesapeakebay.net/what/event/climate-resiliency-workgroup-meeting-august-2023

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

Workgroup Actions

- *Summarize recommendations from this meeting to share with Fish GIT at Summer Meeting on September 18th, 2023.*
- *Develop summary report of Marine Heatwave and Fish Impacts interviews and stakeholder meetings that were conducted.*
- *Coordinate with UMCES rare events project on which species can be evaluated for heat and cold events.*
- *Follow-up with Aaron Bever to discuss potential integration of marine heat waves and cold events in environmental forecast system.*

Partner-to-Partner Connections

- *Mary Fabrizio offered to connect with Kristen Saunders and folks at the Chesapeake Bay Program to share research results and products developed by her team at VIMS, which could support decision-makers. She offered to discuss sharing these products and the means of getting them in front of target audiences.*
- *Tom Parham offered to Mary Fabrizio that he could parse out the distribution of fish that inhabit the fishing sites analyzed in his research to better understand the seasonal patterns of habitat use at these locations.*
- *Nathan Shunk mentioned that he would connect with Bruce Vogt about how his research can potentially inform locations for the Chesapeake Bay Program buoys*
- *Tom Parham mentioned that he would be interested in talking with Nathan Shunk and Rebecca Murphy about if the water temperature trends from Rebecca's work align with Nathan's research findings.*

Minutes

1:30 PM **Welcome, Opening Remarks, and Announcements – Mark Bennett, Co-Chair (USGS), Jackie Specht, Co-Chair (MD Department of Natural Resources), and Julie Reichert-Nguyen, Coordinator (NOAA) [5 minutes]**

Focus of meeting:

- *Share tidal recommendations from the Rising Water Temperature STAC Workshop Report.*
- *Presentations on marine heatwave research and fish habitat research related to change in environmental conditions.*
- *Discuss ideas for a marine heatwave-fisheries alert indicator (addresses recommendation in workshop report).*

Workgroup Announcements:

- *NOAA's Office of Habitat Conservation is accepting proposals for their Transformational Habitat Restoration Funding, which prioritizes habitat restoration actions that rebuild productive and sustainable fisheries, contribute to the recovery and conservation of threatened and endangered species, use natural infrastructure to reduce damage from flooding and storms, promote resilient ecosystems and communities, and yield socioeconomic benefits. There will be up to $240 million available with individual projects funded between $1 to $25 million. For more information on previously funded projects, click here. Proposals are due November 17th, 2023.*
- *Letters of Intent for NOAA's Climate Resilience Regional Challenge are due August 21st, 2023. This opportunity offers approximately $575 million in grants for projects designed to build the resilience of coastal communities when faced with extreme weather and other impacts from climate change.*
- *The next Chesapeake Community Research Symposium will take place June 10-12, 2024 at the Crowne Plaza Hotel in Annapolis, Maryland. The scope of the symposium will include presentations on environmental research and science. The theme of the 2024 symposium is* ***Chesapeake Bay Restoration: Managing Water Quality for Living Resources in a Changing Climate.*** *The deadline for proposals is October 2, 2023. Proposals may be submitted to allison@greenfinstudio.com. Please keep the proposal length to 1000 words or less.*
- *The current Climate Monitoring and Assessment Indicators are officially updated with 2021 data on Chesapeake Progress. The two indicators track Total Annual Precipitation and Average Air Temperature throughout the Chesapeake Bay Watershed.*
- *USGS recently funded two separate projects that connect to climate change considerations:*
    - ***Coastal wetland vulnerability to climate change and sea-level rise: understanding ecological thresholds and ecosystem transformations*** *(Michael Osland, Kurt Kowalski, Glenn Guntenspergen, Joel Carr, Neil Ganju, Greg Noe, Eric Grossman,*

Kristin Byrd, Judith Drexler, Karen Thorne, Kevin Buffington, Jessica Lacy, Davina Passeri, Stephanie Romañach, Camille Stagg, Nicholas Enwright, Ken Krauss, James Grace)

- ***Thresholds in fluvial fish vulnerability to climate change-induced flow alteration.*** *(Taylor Woods, Kelly Maloney, Tim Counihan, Kenny Eng, James McKenna Jr., Kirk Rodgers, Daniel Wieferich, Tanja Williamson, Robert Zuellig)*

1:35 PM **Rising Water Temperature Tidal Recommendations (Jamileh Soueidan, CRC) [25 Minutes]**

Jamileh will present on the tidal findings from the STAC Rising Water Temperature Workshop. These findings include management implications, recommendations, and their associated science needs, which all aim to address increasing water temperatures in the tidal portions of the Chesapeake Bay.

Summary

Jamileh presented on the STAC Rising Water Temperature Workshop's tidal management recommendations and their associated science needs. Jamileh reviewed that water temperatures throughout the entire Chesapeake Bay tidal waters have been increasing over the past few decades. The main drivers of these rising water temperatures in the tidal waters of the Bay are primarily warming air and ocean temperatures. She highlighted that the tidal management recommendations are focused on adaptation as there would need to be a global focus on reducing greenhouse gasses to mitigate these trends. Jamileh then explained the ecological impacts that these rising water temperatures have on living resources (e.g., striped bass, seagrasses, blue crabs, oysters, and forage fish). These rising water temperatures are expected to cause range shifts with current Bay species shifting northward or exiting the Bay and new species (e.g., red drum, cobia, brown shrimp) from the south entering the Bay. These shifts have the potential to introduce new fisheries opportunities and new pathogens. Eelgrass, which was the dominant species of seagrass in the Bay, is likely to be extirpated due to its poor heat tolerance, while widgeon and certain ecotypes of freshwater and subtropical species are expected to dominate the Bay. For fisheries, blue crabs and some forage species may experience positive impacts as higher temperatures increases productivity, while oysters are expected to be negatively impacts due to combined stressors of overfishing and climatic impacts. Additionally, striped bass may experience positive or negative impacts depending on life stage and location in the estuary, which makes assessing vulnerability uncertain. Lastly, ecological impacts are compounded by extreme stressors such as marine heatwaves, which can cause negative impacts to habitat and species survival. Marine heatwaves are projected to increase in frequency and intensity as climate change progresses.

Jamileh stated that the bottom line is that the Chesapeake Bay of the future will not be the Chesapeake Bay of the past. Bay water temperatures are increasing and will continue to increase, which impacts all outcomes in the Chesapeake Bay Watershed Agreement. The Agreement focuses on climate resilience and adaptation, which guided the recommendations in this workshop report. The recommendations focus on building resilience with strategic restoration and management strategies to minimize the negative impacts and promote positive outcomes under changing climate conditions.

Jamileh then reviewed the recommendations that were developed during the workshop. They focus on four main themes: ecosystem based management, future climate conditions, nearshore habitats, and extreme stressors. For the ecosystem-based management, workshop participants proposed establishing fishing guidance based on environmental and habitat condition thresholds to reduce catch and release mortality during periods of poor environmental conditions. They also recommended hosting a workshop with fishery stakeholders to explore long-term strategies to advance ecosystem approaches that incorporate climate change considerations (e.g., potential for new fisheries and adaptation needs). For the future climate conditions recommendation, workshop participants proposed developing and implementing a strategy to improve communications around future climate conditions, which includes information on expected scenarios for impacts to existing species and on emerging species from the south. Additionally, they recommended social science research to inform targeted communications specific audiences (e.g., policymakers, managers, residents, and local partners). The nearshore habitats recommendation proposed that common criteria and metrics are developed to help target, site, and design natural infrastructure projects where multiple benefits can be optimized, which includes research investigating the co-location of restoration strategies to improve resilience (e.g., oyster reef and seagrass restoration). Lastly, the extreme stressors recommendation proposes convening an interdisciplinary team of scientists, resource managers, meteorologists, and communicators to design and create a publicly available marine heatwave alert system, and to tie this system to habitat preferences and environmental thresholds of key fisheries species.
Jamileh then highlighted key science and research needs that support these recommendations. For the ecosystem-based management recommendations, there were monitoring, modeling, and analyses needs that included increased monitoring of environmental and biological parameters, developing habitat suitability models for key fisheries species, ecosystem models that include improved information on climate impacts for key fisheries species, and assessing economic viability of emerging fisheries from the south. For the nearshore habitat recommendations, workshop participants identified the need for research into ecological impacts or benefits for natural infrastructure implementation under future climate conditions and developing criteria for targeting nearshore restoration where ecosystem services and benefits can be optimize. Lastly, science needs to support the extreme stressors recommendation includes relating current definitions of marine heatwaves with living resource thresholds, exploring real-time monitoring of marine heatwaves, and developing a marine heatwave indicator connected to living resource management and guidance to the public.

Jamileh ended the presentation by reviewing key takeaways and next steps to prepare for changing climate conditions. They include reducing climate change stress on key fisheries resource through minimizing other compounding stressors; facilitating discussions with managers on shifts in key fisheries resources; promoting the strategic use of natural infrastructure; and exploring options for siting different restoration efforts near each other to bolster climate resiliency.

Discussion

Julie mentioned that the STAC Rising Water Temperature Workshop Report and UMCES Summary Document can be found on the CRWG's webpage. She encouraged folks to read the report or summary document for more information about the effort and greater details about the recommendations.

Amy Freitag asked if the recommendations that supported social science research mention any particular type of research (e.g., discipline, topic, etc.) or detail specific needs associated with recommendations. Julie responded in the chat that recommendations focused on engagement with homeowners to understand behavioral drivers behind shoreline hardening decisions to create effective communication strategy. She added that these communication strategies revolved around promoting natural solutions for shoreline protection (e.g., living shorelines). Jamileh added that there were also needs around understanding behavior of anglers on the water, particularly as it relates to catch and release behavior, to better create communication strategies about key fisheries species and vulnerability to rising water temperatures. Kevin Du Bois commented that most anglers he knows do not target striped bass in particular, but will often catch them since they exist in the same areas where other species (e.g., speckled trout, red drum, etc.) also exist. He was wondering how these communication recommendation will address the co-location of multiple species and the function of non-species-specific fishing tackle. Jamileh responded that within these recommendations, there are points about bringing together these stakeholder groups (including recreational anglers) to better understand what type of alert or communications would be useful for them. She also mentioned that they can explore more regional/geographic communications, such as alerts for specific tributaries or regions of the Bay. Kevin mentioned that he would agree that geographic communications would be more useful, as communications directed at species specific fishing behavior is difficult in habitats where multiple species exist. Mary added that while there is a good amount of research around striped bass and temperature and how they react to catch and release, there is also growing evidence that other species are harmed as well, and could benefit from similar communication strategies and guidance. Kevin also mentioned that the mortality is likely linked to how the anglers are behaving with catch and release (e.g., length of time the fish is out of water). He mentioned another aspect to consider would be on catch and release tactics. Jim Uphoff highlighted that managing catch and release during recreational fishing is something that management has been focused on. He mentioned that they did a series of studies about the impacts of catch and release in the late 1990s to early 2000s, and they used that to communicate the impacts to anglers. He also mentioned that they are at a point where they have a closed catch and release season, where people are not supposed to target striped bass, and must use specific types of hooks. He says it is difficult in changing behavior around catch and release, especially as there is no legislation around it. Julie mentioned that these would be great points to share with the Sustainable Fisheries Goal Implementation Team.

2:00 PM **Considerations for Integrating Marine Heat Wave Information to Indicate Potential Impacts to Fisheries (Julie Reichert-Nguyen, NOAA) [20 Minutes]**

Julie will present recent efforts to support the Rising Water Temperature STAC Workshop recommendation focused on development of a Marine Heatwave Alert Indicator that incorporates living resource considerations. These efforts include: reviewing current research on defining and quantifying marine heatwaves and identifying environmental thresholds of key fisheries species; meeting with experts to discuss their perspectives on defining marine heatwaves in the Chesapeake Bay and considerations for relating to fish impacts; and working with existing definitions to identify marine heatwaves in NOAA's buoy data for integration in seasonal summaries.

Summary

Julie's presentation reviewed the current efforts to support the development of a marine heatwave alert, with connections to living resources and key fishery species. She wanted to set the stage for the rest of the meeting as presenters discuss their research around living resources and marine heatwaves. This effort has included reviewing different marine heatwave definitions, interviewing researchers about their work around marine heatwaves and environmental thresholds for key fishery species.

She reviewed the common definition for marine heatwave (developed by Hobday et al. 2016), which defines marine heatwaves as periods when water temperatures exceed the 90th percentile for five consecutive days. There are common marine heatwave descriptive characteristics, which include frequency (i.e., number of events that occur), duration (i.e., how long these events last), intensity (i.e., how hot the event is), and cumulative intensity (i.e., integral of marine heatwave intensities over a period of time). Recent research to characterize marine heatwaves in the Chesapeake Bay using this definition include the study by Mazzini and Pianca (2022), which found significant, increasing trends from 1986 to 2020 in marine heatwave frequency and yearly cumulative intensity. If trends persist, then the Chesapeake Bay will reach a semi-permanent marine heatwave state. Using the same definition, Wegener (2022) found that almost the entire Bay has experienced significant increases in the number of annual marine heatwave events. Additionally, findings indicated that the spatial structure of marine heatwave cumulative intensity is driven by increases in duration and that satellite analysis is consistent with buoy-wide analysis.

Julie reiterated the STAC Rising Water Temperature Report's Extreme Stressors recommendation that Jamileh reviewed in the previous presentation. She highlighted that there is stakeholder interest in the development of marine heatwave alert system, with connections to living resource considerations to help inform behavior change or when key species are approaching tipping points. She also reviewed the two actions (1.2a and 1.6a) in the CRWG's Logic and Action Plan that support this effort.

Julie then provided an overview of the recent efforts toward developing this marine heatwave indicator related to fish impact, which include: reviewing different marine heatwave definitions, conducting interviews with fisheries habitat and marine heatwave experts, and testing the marine heatwave analysis with current available data (CBIBS and satellite data). The two main definitions that folks use for marine heatwaves are the fixed baseline, which defines heat relative to historical temperature (Hobday et al. 2016) and the shifting baseline which defines heat relative to increasing average temperatures (Amaya et al. 2023). The interviews included individuals from VIMS, NOAA Physical Sciences Laboratory, MDNR, UMD, and Virginia Tech, and provided different insights and perspectives on how to characterize marine heatwaves in the Chesapeake Bay as it relates to living resources.

Data considerations include utilizing a 30-100 year dataset to establish climatological trends, which satellite data might have the greatest utility for this effort, how to ensure management utility of the end product, and integration of future climatology from climate change scenarios to inform tipping points in Chesapeake Bay habitats. Julie then highlighted some takeaways that related to connecting this work with fish impacts, which include: both marine heatwave definitions have utility for assessing fish impact depending on the question; determining the threshold and duration by which to categorize marine heatwaves for specific species; using ~28°F as a proxy for striped bass habitat squeeze conditions; impact of repeated marine heatwave events; engaging with fish physiologists to understand fish response to extreme events; and taking into consideration extreme events occurring throughout the year, not just the summer. Julie then discussed the inclusion of this marine heatwave work in the NOAA Chesapeake Bay Seasonal Summaries, which use existing data to craft narratives about impacts on living resources. She showed a simple example of how to include the striped bass habitat squeeze threshold on a figure depicting heatwave events. Julie also highlighted up and coming research that could inform these efforts and reviewed the incremental steps that have been made to develop a marine heatwave alert for the Chesapeake Bay as well as future considerations. Julie mentioned that she plans to develop a summary report of the information shared during the stakeholder meetings.

<u>Discussion</u>

Jim Uphoff commented on using the 28°C striped bass threshold in the example marine heatwave figure, stating that it is a boundary that MDNR has used, but it could be more useful to utilize the four different categories developed by him and Tom Parham (MDNR), which categorize habitat condition (e.g., tolerable, intolerable). He also recommended using 30-31°C as the threshold for intolerable/unsuitable habitat for striped bass, as the lower threshold is still habitable by striped bass. Julie thanked Jim and mentioned that this is the type of feedback that she is looking for as this project is developed; she mentioned that the visualizations can show different ranges of habitat suitability.

Kevin Du Bois asked if there is a need to look into extended periods of cold too. He mentioned that they have seen some big freeze outs affecting speckled trout populations in VA. And he also asked why speckled trout have not been included in the upcoming Nesslage UMCES research. Julie mentioned that they could ask about the inclusion of other species in the UMCES research at the kick-off meeting. She mentioned that she believed it's based on the datasets that the research team has access to. She also mentioned that she believed that they did mention examining cold events in their research as well.

2:20 PM **Identifying environmental thresholds to predict suitable habitats for key species (Mary Fabrizio, VIMS) [30 Minutes]**

Mary will be reviewing her research focused on understanding the environmental thresholds and habitat suitability of key fisheries species in the Chesapeake Bay. She will be highlighting her recently funded proposal to build habitat suitability models using physiological thresholds for several species of fishes and white shrimp.

Summary

Mary Fabrizio presented on newly funded research focused on identifying environmental thresholds for predicting suitable habitats for key Chesapeake Bay species. She began by highlighting the significant changes that have occurred in important Bay fishery species (i.e., oysters, blue crabs, striped bass, Atlantic sturgeon, and American shad) and the implementation of the Total Maximum Daily Load (TMDL) by jurisdictions to improve water quality, conserve habitat, and prevent habitat degradation. This led to questions around how habitat condition affects these fishery species.

Her research will focus on species habitat models, which assumes that the distribution, abundance, and condition of organisms are determined by the local abiotic environment and tightly linked to the extent and quality of suitable habitat. She explained the two different types of models, which are correlative (e.g., species distribution and niche models) and mechanistic (e.g., based on processes, like physiology, that constrain demographics). When these models are used to understand what will happen to species under future climate change conditions, they are called habitat projections; correlative models have high uncertainty when applied to future climate conditions, while mechanistic models are more robust when examining future conditions. She highlighted the use of these physiology-based habitat models (i.e., mechanistic) to understand blue catfish salinity tolerance; through laboratory studies, they were able to estimate the probability of survival in certain salinities and relate that to spatial salinity trends in the Chesapeake Bay during wet and dry years. In physiology-based models, there are environmental predictors (e.g., temperature, dissolved oxygen, salinity) and physiological metrics (e.g., tolerance thresholds, hypoxia tolerance, consumption rates, growth rates, metabolic scope).

The approach they will be taking for this research is to build, verify, and apply physiology-based habitat models to project potential suitable habitats for key fisheries resources in the Chesapeake Bay, and examine responses to changing Bay conditions (e.g., rising water temperatures) across different life stages. Specific objectives of this research include: quantifying the suitable habitats for five species under historical and present-day climate conditions; and project and quantify suitable habitats for study species under future climate conditions. The research will be conducted by both fisheries scientists and physical oceanographers; the physical sciences portion will be using the Chesapeake Bay's environmental forecasting system (CBEFS) and the fisheries portion will utilize fishery survey data (i.e., VIMS juvenile fish trawl survey, MD small trawl survey, ChesMAPP survey, and menhaden stock assessment). The research will build response curves and then produce physiology-based habitat models combined with CBEFS to understand suitable habitat extent, as verified by fish survey results, and then project suitable habitat in 2050. Products from this research will include annual/seasonal maps depicting habitat model-based projects of potential suitable habitats, incorporation of habitat models into CBEFS, maps of suitable habitat extents in 2025 under different climate change scenarios, identification of climate change-driven changes in critical habitats, and identification of areas to prioritize for protection or restoration.

Discussion

Aaron Bever followed up Mary's presentation by introducing himself and the work he does with CBEFS. He explained that it is a computer model that is run every night to forecast environmental conditions (e.g., water temperature) in the Bay for two days into the future. He highlighted that it could be useful for the marine heatwave alert effort that was discussed earlier in the meeting. He shared a link in the chat to the current forecast. He also added that they have been working on building in automated alerts for when specific criteria are met by the forecast; the system will automatically email alerts if/when those criteria are met. Internally, they have tested this alert system for water temperature thresholds for speckled trout. He mentioned that marine heatwaves or striped bass thresholds could potentially be built into this alert system. Julie mentioned that this is something for the team to explore as the marine heatwave effort progresses.

Kristin Saunders added that she is excited to explore how to get the resulting products into the hands of local implementers and decision makers so that critical habitat protection and restoration priority areas can be factored into local and state land-use decisions. She asked Mary if there was a timeline for these products now that they were funded for this work. That way folks at the CBP could start thinking about target audiences for these products. Mary responded that as soon as the funding comes in, the project is planned to take three years, but might have some findings ready to share around two years into the project. She added that there are other projects through her lab that have yielded results that could be helpful for decision-makers, and she offered to discuss sharing those products and means of getting them in front of target audiences. Mary also highlighted that these awards are cooperative agreements so they will be working closely with NOAA on this effort.

Kevin Du Bois asked if they are concerned that the habitat suitability maps might be used to concentrate efforts, which has the potential to impact species population. Mary asked if he is focused on the future project models and maps. Kevin was wondering more if recreational anglers might use the maps to focus on specific areas. Mary responded that it is a good thought and a potential unintended consequence that they need to think about. Julie mentioned that this might be something that Bailey Robertory and Bruce Vogt could raise with the Sustainable Fisheries Goal Implementation Team.

2:50 PM **Incorporating Environmental Thresholds into Fishing Guidance (Tom Parham and Jim Uphoff, Maryland DNR) [30 Minutes]**
Tom will be presenting his work focused on incorporating environmental thresholds for striped bass into fishing guidance. This research utilizes dissolved oxygen and water temperature data to characterize suitable habitat for striped bass.

Summary
Tom Parham presented on a collaborative effort at Maryland DNR to assess how climate change and summertime conditions impact striped bass habitat in the Chesapeake Bay. He highlighted that the Bay's tidal water temperature has been increasing over the last three decades, with marine heatwaves becoming more frequent. He reviewed the striped bass habitat squeeze hypothesis, where in warmer summer months, elevated surface water temperatures and decreasing oxygen levels in the bottom waters force some or many striped bass into a band of cooler water with adequate oxygen levels.

To determine summer habitat thresholds for striped bass in the Bay, they developed dissolved oxygen and water temperature requirements for a "typical" harvestable resident fish during the worst habitat conditions. They were able determine these requirements using results from scientific literature (e.g., bioenergetics models direct observations, tagging, telemetry, and literature reviews). They categorized resident striped bass habitat condition into four categories (i.e., suitable, tolerable, marginal, and unsuitable) based on dissolved oxygen and temperature thresholds. They then mapped the suitability of the Bay using cruise data from 1986 to 2020. Using this data, they assessed how habitat conditions have changed in Maryland during that time period; the results showed consecutive months of degraded conditions in recent years, which is an increase in severity, frequency, and duration. When looking at dissolved oxygen and temperature separately over this time period, they saw that dissolved oxygen patterns did not change much over time, potentially due to the nutrient and sediment reductions, however temperature increases are causing declining habitat conditions over time. The data showed that the Bay is shifting from suitable towards tolerable and marginal habitat conditions. To understand habitat conditions where striped bass are found, they examined how habitat in popular fishing locations have changed since 1986 in Maryland. They see a similar pattern in habitat conditions at these locations, with increasing frequency and duration of degrading conditions, however while unsuitable habitat Maryland-wide is 10% to 15%, at these fishing locations it is ~30%. They plan to publish this information in their weekly Maryland Fishing Report, with a section focused on current Bay conditions and a forecast for the next week at these fishing locations. Through this targeted communication, they hope to reach recreational anglers about the state of the Bay.

Tom provided key takeaways at the end of the presentation. Essentially, since 1986, striped bass habitat has degraded, mainly in the past 10-20 years. In Maryland, suitable habitat has decreased between 1% and 10%. In popular fishing areas, conditions follow a similar pattern of increasing frequency, intensity, and duration but with a higher percentage of habitat degradation. Lastly, increasing water temperature is the major driver of this degradation.

Future conditions include more frequent, longer lasting, and more degraded striped bass habitat conditions. Next steps in this work include collaborating with the Chesapeake Bay Program to examine changes in future striped bass habitat using various climate change and Bay cleanup scenarios. Lastly, despite increasing water temperatures being the primary driver to impacting striped bass habitat, it is still extremely important to continue nutrient and sediment reduction actions.

Discussion
Julie mentioned that the findings showing that temperature are the major driver of degradation and not dissolved oxygen were interesting in that they show that the nutrient reduction strategies are keeping dissolved oxygen stable. She highlighted the importance of continuing the work with nutrient reductions as it is integral in dealing with the impacts of climate change.

Mary Fabrizio inquired about the areas where fishing is concentrated, and wanted to know more about why they might be seeing a greater percentage of unsuitable habitat in those locations relative to the rest of the Bay. Tom responded that some of those sites have a seasonal pattern to them, where striped bass might traverse the regions in the early springtime when there is higher dissolved oxygen levels, so those areas are more popular during those times. However, they might not be popular areas during the summer time. Tom mentioned that these sites include everything from shallow water locations to deep shoals. He mentioned he could probably parse out the distribution of the different polygons to better understand these patterns. Jim Uphoff also highlighted that the sites located in the shallows will be more susceptible to degradation caused by temperature, while the sites that are located in the deeper waters might be more impacted by hypoxia.

Julie mentioned that the way they categorized suitability is clear from a communication's standpoint, as people can relate to what suitable can be like versus unsuitable. She asked if they have received feedback about these categorizations. They have not had this used in an official communication yet, but it is going to be included in the next official report. However, they modeled after Eyes on the Bay, with being as non-technical as possible to communicate habitat conditions throughout the Bay.

3:20 PM **BREAK**

3:25 PM **Subsurface Structure and Impacts of Marine Heatwaves in the Chesapeake Bay (Nathan Shunk, VIMS) [30 Minutes]**
Nathan will present his research investigating spatial and temporal patterns of marine heatwaves in the Chesapeake Bay and how they are connected to water quality parameters (e.g., dissolved oxygen).

Summary
Nathan Shunk presented his Master's thesis research focused on subsurface temperature and dissolved oxygen anomalies during marine heatwave events in the Chesapeake Bay. He provided an overview of marine heatwaves in the coastal and global oceans; these events occur

globally and range in size, intensity, and duration. Research indicates that these events are increasing in frequency, intensity, duration, and spatial extent as a result of atmospheric warming. Impacts from these events include coral bleaching, mass benthic die offs (e.g., seagrasses, mussels, scallops, crabs), and biogeographic shifts, harmful algal blooms, and fishery and aquaculture declines. Additionally, he highlighted the compound events, which occur when marine heatwaves occur in conjunction with other environmental events (e.g., low dissolved oxygen, low pH, or low light).

Nathan then reviewed characteristics of marine heatwaves in the Chesapeake Bay. Research shows that these events are increasing in frequency and annual cumulative intensity, which is a metric of annual cumulative heat stress on the environment. These trends match the global trends and the mean Bay warming trends. Most marine heatwaves occur in the summer, however marine heatwave events do occur year-round. Additionally, there is a large co-occurrence of these events throughout the mainstem of the Bay. He added that they use the Hobday et al. (2016) definition that was reviewed in previous presentations. To identify marine heatwaves using this definition, there needs to be daily data for ~30 years.

The objectives of this research include characterizing spatiotemporal variability of subsurface temperatures and dissolved oxygen during marine heatwave events; identifying extent of warming prior to and following events; and evaluating role of air-sea heat flux in onset and decline of events. However, he only shared the results from the first two objectives in this presentation. For the subsurface analysis, they used six different surface temperature time series datasets (spatially averaged into one dataset), subsurface data (i.e., temperature, salinity, dissolved oxygen, and chlorophyll A), and Susquehanna River discharge data. They split the Bay into four regions (i.e., the upper Bay, upper channel, lower channel, and lower Bay). They used the surface dataset to identify marine heatwave events, and used the subsurface dataset to calculate buoyancy frequency squared and the mixed layer depth and to calculate the daily climatology and anomalies in the subsurface data. Lastly, they identified profiles preceding, during, and following marine heatwave events.

They identified 84 marine heatwave events, evenly distributed through time. Of these events, ~36% were partially captured across the entire length of the mainstem and ~24% of the events were fully captured across the entire length of the mainstem. For the subsurface data, ~30-40 marine heatwave profiles were captured per station. Approximately 7% of profiles were sampled in a wet or dry year; they removed the trend of wet or dry years by removing the linear trend between the variability in salinity and the variability of the factors they were interested in.

For temperature they found that, in the winter, anomalies penetrate to the bottom and are larger than anomalies present in the summer. While in the summer, there is thermal stratification, with smaller anomalies, that are horizontally consistent across the surface of the mainstem. During the spring, the patterns are similar to summer, however anomalies are larger in the upper Bay and upper channel; in March, waters are stratified in the upper channel and homogeneous in the lower channel. In the fall, the patterns of temperature anomalies are consistent with winter. They inferred that there are two seasonal regimes: a stratified regime from April to August, where temperature anomalies do not penetrate below the mixed layer depth, and homogenous regime from September to March, where temperature anomalies are present throughout the water column. During the stratified season, there is strong density stratification, preventing temperature anomalies to penetrate to the bottom of the deep channel. He highlighted a few exceptions to these regimes: in the upper Bay, temperature anomalies are homogenous year-round due to depth and influence from the Susquehanna River; in the lower channel, they see at one station, temperature anomalies penetrating to the bottom due to downwelling; and in the lower Bay, they see a muted seasonal cycle, due to saltwater intrusion. They also noted anomalies present before and after marine heatwave events in both surface and subsurface data, indicating that there may be a preconditioning of the water leading up to events.

Nathan then reviewed the seasonal differences in dissolved oxygen: in the winter, they saw low levels concentrated in the deep channel, with the greatest negative anomalies in the upper Bay and upper channel; in the spring, they saw notable negative anomalies in the upper channel and upper Bay, with slight positive anomalies at the surface; in the summer, there is absence of notable anomalies, with slightly positive anomalies at the surface; and for fall, there were few notable anomalies. This indicates that there is greater dissolved oxygen variability spatially, with more complex drivers controlling dynamics during marine heatwave events. He highlighted the seasonal variability in how slight changes in dissolved oxygen can influence hypoxic conditions depending on the month/season. When relating dissolved oxygen to temperature, they conducted a correlation analysis; in the upper Bay and lower Bay, the two factors are slightly negatively correlated, in the upper channel, the two factors are positively correlated at the surface, while negatively correlated at the bottom. The region that experienced positive correlation, also experiences positive temperature anomalies in the spring and summer and positive chlorophyll anomalies.

Nathan highlighted the potential ecosystem impacts which include seasonal effects on organisms (e.g., exceeding thermal tolerances, impacts on organisms at the larval stage, changes in migration patterns). Also, these events limit thermal refuges for organisms in the Bay. Lastly, he finished his presentation by underscoring some main takeaways. For temperature, there are two seasonal temperature regimes, air-sea heat flux is a primary driver of marine heatwave events, and persistent anomalies leading up to events may serve a precondition of the waters. For dissolved oxygen, decreased levels are greatest in the upper Bay an upper channel during winter and spring and the impacts to the hypoxic zone. Future work can focus on investigating the cross-stem structure and connection with the tributaries and plume, other drivers, cumulative impact of these events on water quality, and other biogeochemical parameters during these events.

Discussion

Julie thanked Nathan for his presentation and reviewed the discussion that was occurring in the chat during the presentation. Bruce Vogt had commented that they had not really thought about marine heatwaves as a winter phenomenon but wondered what impacts they could be having on blue crab overwintering and burrowing behavior and oyster feeding and growth. Aaron Bever responded that this year, the water temperature this late winter/early spring was relatively warm; he read somewhere in a seasonal summary that oysters may have become more active earlier with the water warmer than the historical average, and it could benefit the oyster population. Jim Uphoff added that winter temperatures have been found to be important influences on year-class success of temperate fishes. Some species require a cool period for their eggs to develop properly. Additionally, it can affect the timing of copepod blooms in relation to striped bass spawning. Mary Fabrizio commented that warming temperatures in winter have implications for catchability of blue crabs in the dredge survey, as they are more active and less vulnerable to the gear. Warming temperatures in winter can also decrease blue crab burial behavior thereby increasing vulnerability to predation (e.g., by blue catfish). Aaron Bever also mentioned that he would be interested in discussing the incorporation of marine heatwaves into CBEFS modeling system as related to habitat or automated email alerts.

3:55 PM **Discussion: Ideas for a Marine Heatwave Fisheries Alert Indicator [30 Minutes]**
This discussion will focus on brainstorming how to include fish impact considerations when developing a marine heatwave-fisheries alert indicator.

Discussion

Julie began the discussion by highlighting that the recommendations that were developed during the STAC Rising Water Temperature workshop, and how the participants and stakeholders were interested in extreme events such as marine heatwaves. She mentioned that there was interest in developing a marine heatwave indicator or alert related to fishery impact.

She highlighted the discussion in the chat during the presentations, which raised interesting points on looking into how resilience efforts could be a place for this. Bruce Vogt had asked in the chat if Mary Fabrizio or Tom Parham had seen a targeted multi-tiered habitat restoration (e.g., oysters, seagrasses, marsh, WQ BMPs, combined) as a means to mitigating temperature, dissolved oxygen and other impacts on fishery resources. He was wondering if they could bolster climate resilience and create refuge for fish species via better targeted and designed habitat improvements. He was asking in light of the Comprehensive Evaluation of System Response (CESR) report, which suggests a shift to shallow water targeting of actions to achieve better outcomes for living resources. And if so, he asked about how would they identify the right places to target these efforts. Mary Fabrizio responded that she thinks that creating climate resilience and refuges for fishes via better targeted and designed habitat improvements is a great idea and is much needed. She is not sure that they have enough information to propose something just yet but should definitely move in this direction. Shifting to focus on shallow habitats will not address the other issues that Tom Parham presented today, as it seems that temperature is a major driver of suitability and shallow areas are generally warmer, so there needs to be a broader approach. Tom Parham added that he wanted to think more about this question and get back to Bruce. He said he would speculate that size, number of actions and magnitude of impact of these restoration actions would be increasingly important and as the Bay ecosystem continues to warm. Breck Sullivan commented that the question Bruce raised was interesting and will be a part of the STAR August meeting discussion, which will be focused on how to implement the recommendations from the CESR report; they plan to focus on how best to identify target areas for shallow waters and what criteria need to be considered in that targeting. Julie mentioned that Denice Wardrop will be presenting the findings of the CESR report at the CRWG's September meeting (September 25th, 2023 from 10:00 AM – 11:30 AM).

Bruce raised a question for Nathan regarding the placement of the Chesapeake Bay Program Buoys. They currently have three buoys deployed, taking real-time measurements of salinity, temperature, and oxygen throughout the water column every 10 minutes. They are trying to scope out sites for the buoys they are planning to deploy next; there are 10 additional buoys they are planning to deploy over the next couple of years. Currently, they have buoys in the Choptank River, mid-Bay, and at the mouth of the Potomac River. They are interested in targeting locations where they can connect the observations that the buoys are collecting with living resources. He was curious if Nathan had thoughts on locations for the new buoys that can help inform the future research that was mentioned in his presentations. Nathan mentioned that he does not have a specific answer at the moment but would think about it and reach out to Bruce offline. Julie commented that she would be curious to see what is occurring with marine heatwaves in the fishing locations that Tom mentioned in his presentation, using the data that Nathan compiled. She asked if Tom and Nathan had any insights about potentially overlaying these data at these fishing sites to inform the placement of the buoys Bruce mentioned. Tom responded that a good number of the popular fishing areas are located in the mainstem of the Bay, and targeting restoration or resiliency projects in those locations will need to be large-scale to make an impact on the temperature and dissolved oxygen conditions. Jim Uphoff mentioned that they have quite a bit of experience working in the shallow water, and when discussing restoration or resiliency projects; implementing sediment and nutrient reduction activities in these areas and then expecting a reaction from living resources and habitat is going to be different from implementing strategies that directly target the specific living resources. To help provide insights, he mentioned that he needed to better understand what strategies they are looking at implementing, such as shifting the same nutrient reduction strategies to smaller watersheds or will different, more comprehensive strategies be considered. Bruce commented that the points that Jim raised are salient, especially as they are thinking about the opportunity or potential for restoration to create thermal refuge for species or maintain habitat conditions that a suitable to species. An example he was thinking about was whether they can maintain or improve spawning habitat conditions for striped bass in the most productive spawning regions of the Bay.

Tom also mentioned to Nathan that Rebecca Murphy ran a series of water temperature trends throughout the Bay and she examined temperature at different depths; he said it would be interesting to see how these trends line up with the work that Nathan conducted. Tom said he would be interested in talking about this further offline. Rebecca would be interested in chatting as well; she mentioned that they annually compile the surface and bottom trends at fixed stations across the Bay, and they can pull the trends apart to look at the most recent results.

Mark Bennett commented that he was interested in understanding what is meant by a marine heatwave alert indicator. He mentioned that indicators are usually long-term data that indicate change, and he highlighted that an earlier presentation mentioned not having long-term data (>30 years) to develop the climatology to detect marine heatwaves. He also commented that an alert is a different thing. Julie responded that they are trying to sort this out. She mentioned that there are ways to build that longer timeframe by pulling from various data sources and model data. She commented that first, they are hoping to understand if marine heatwaves are coinciding with periods of increased vulnerability for fish species, and second, the stakeholders from the STAC Rising Water Temperature Workshop are wanting an alert for when these extreme events are going to happen, which would include forecasting. She mentioned that Nathan's work is interesting as there may be this preconditioning of warming waters that could serve as an early warning signal for marine heatwave events. She mentioned that there are still research gaps that need to be filled to get to this point and that Mary's research and the research at UMCES will help start informing these gaps. Mark commented that this describes more of an alert system, and Julie mentioned that this could be converted to an indicator, such as percent of habitat experiencing a marine heatwave conditions, which can be published on Chesapeake Progress.

Julie summarized some of the main points from the presentations and discussions. She commented that looking at things geographically is going to be important if they want to connect with fish impacts. She mentioned that seasonal differences exist, so it will be import to look at the seasonality as well, especially how temperature can penetrate the water column during a marine heatwave event. She heard that it is important to set the appropriate ranges for fish vulnerability and that they need to communicate these ranges in a thoughtful manner as to not be misleading. These thresholds can focus on environmental condition or fish physiology or a combination of both. Lastly, she heard that extreme cold events should also be examined as they have impacts on living resources at different life stages as well.

4:25 PM Partner Announcements and Wrap-up [5 Minutes]

- Funding Announcement: New MARISA Small Grants Program available. Focuses on using available decision support tools to integrate climate change information in hazard mitigation or climate adaptation plans.

4:30 PM Adjourn

Participants

First Name	Last Name	Affiliation
Aaron	Bever	Anchor QEA

Adrienne	Kotula	CBC
Amanda	Small	MD DNR
Amy	Freitag	NOAA
Andrew	Keppel	MD DNR
Andrew	Szwak	Land Trust Alliance
Angie	Wei	UMCES
August	Goldfischer	CRC
Bailey	Robertory	CRC
Breck	Sullivan	USGS
Bruce	Vogt	NOAA
Chris	Moore	CBF
Chris	Guy	USFWS
Chris	Feinman	
Debbie	Herr Cornwell	MDP
Doug	Bell	EPA
Efeturi	Oghenekaro	MD Sea Grant
Hannah	Nisonson	NOAA
Jamileh	Soueidan	CRC
Jian	Zhao	UMCES
Jim	Uphoff	MD DNR
Joel	Carr	USGS
Julie	Reichert-Nguyen	NOAA
Kate	Allcock	EPA
Kevin	Du Bois	DOD
Kristin	Saunders	UMCES
Mandy	Bromilow	NOAA
Marek	Topolski	MD DNR
Marie	Panday	MDE
Mark	Bennett	USGS
Mary	Fabrizio	VIMS
Molly	Mitchell	VIMS
Nathan	Shunk	VIMS
Nicole	Carlozo	MD DNR
Qian	Zhang	UMCES
Rebecca	Murphy	CBP
Renee	Karrh	MD DNR
Rikke	Jepsen	ICPRB
Taryn	Sudol	MD Sea Grant
Taylor	Woods	USGS
Tom	Parham	MD DNR
Will	Isenberg	VA CZM