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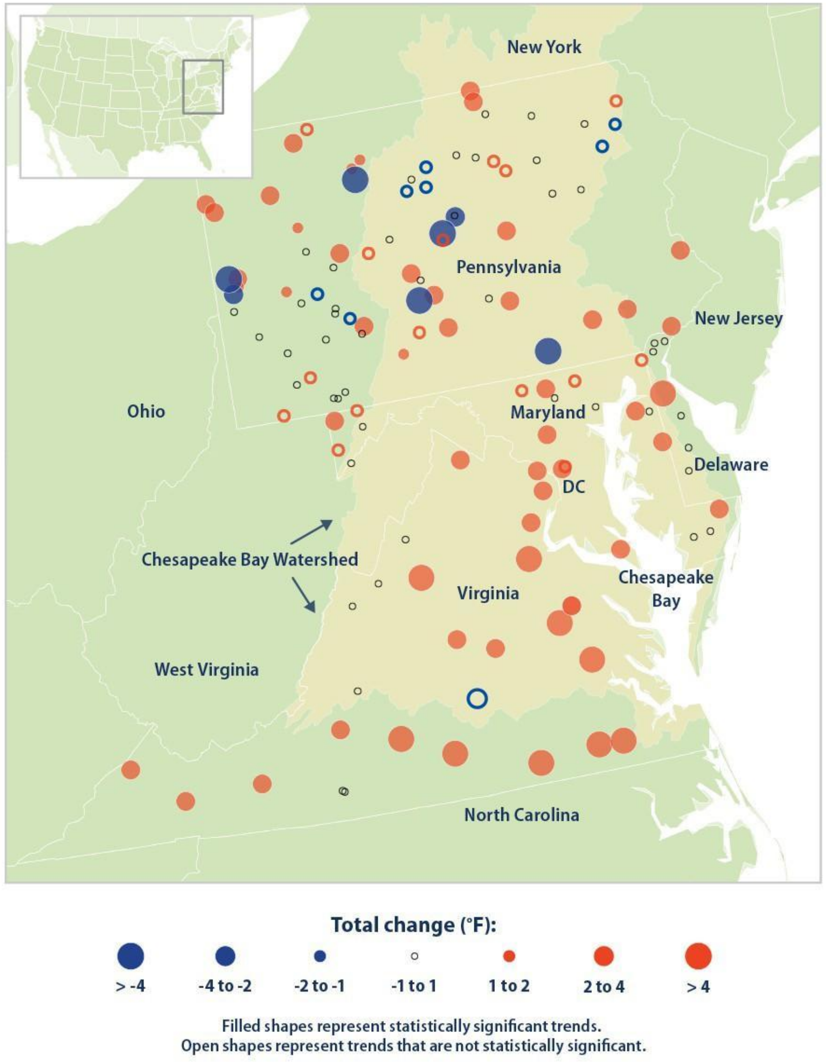
Chesapeake Bay Program
40 years of science, restoration and partnership.

# Climate Change Science to Inform Management Needs Identified by Stakeholders to Tackle Rising Water Temperatures in the Chesapeake Bay

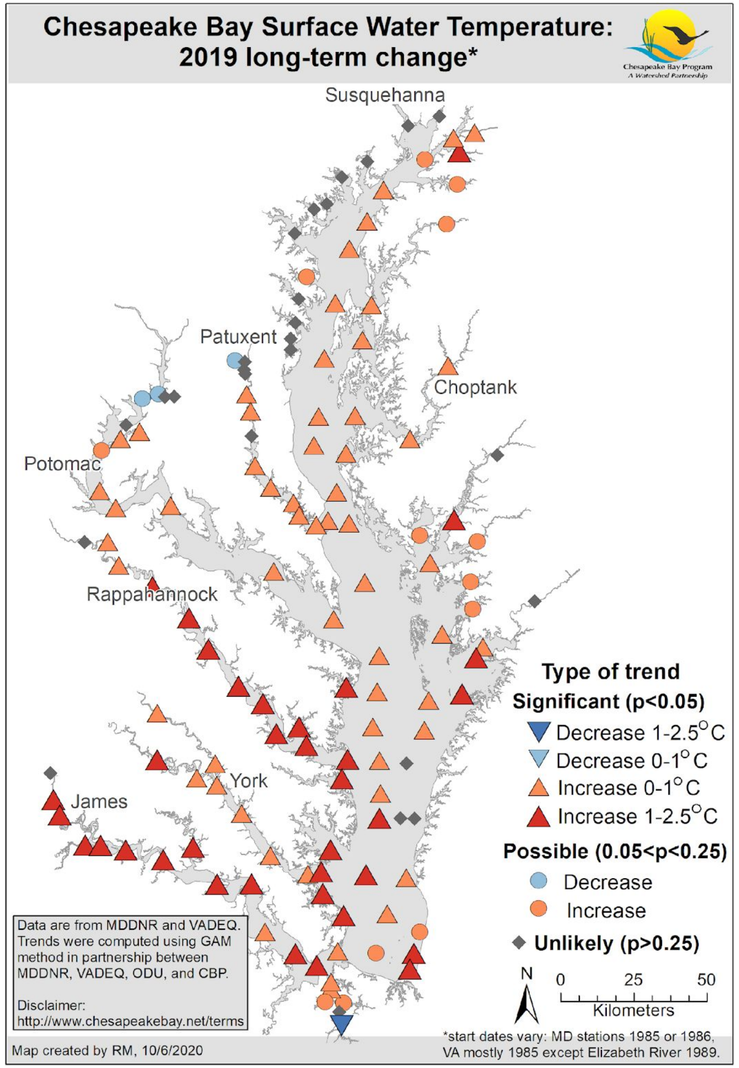
Sustainable Fisheries Goal Implementation Team Winter Meeting
March 2nd, 2023

Jamileh Soueidan, Chesapeake Research Consortium/NOAA Affiliate

# Climate Change Challenge: Rising Water Temperatures




(Rice and Jastram, 2015)



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# Call to Action: Chesapeake Bay Program


There is agreement across the Chesapeake Bay Program on the urgency to do more in preparing the region for the effects of rising water temperatures on water quality, habitat, and living resources goals.

# Workshop Objectives

## Pre-Workshop (June 2021)

Special Climate Resiliency Workgroup meeting—supported development of *state of science synthesis papers*:

- Drivers

- Impacts to Fisheries, Habitat, Submerged Aquatic Vegetation

- Future Projections (Modeling)

- Monitoring and Assessment

## STAC Workshop DAY 1 (Jan 2022)

Goals:

- Discuss *drivers* of rising water temperatures

- Identify *ecological impacts*

- Identify *management implications* for living resources and habitats

## STAC Workshop DAY 2 (March 2022)

Goals:

- Identify management/policy *recommendations* related to implications from Day 1

- Identify *research, monitoring, or analyses* needed to support recommendations

Workshops funded through the Scientific Technical Advisory Committee

Synthesis papers located on the STAC Website

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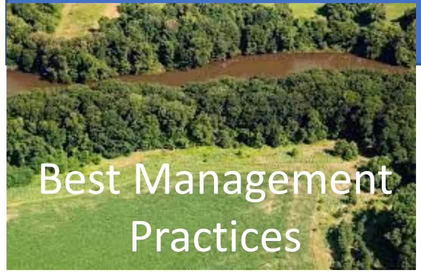
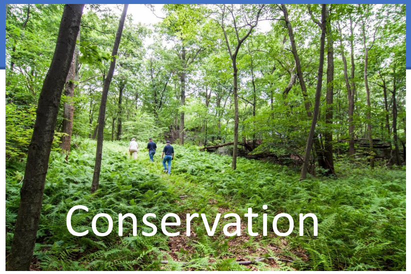
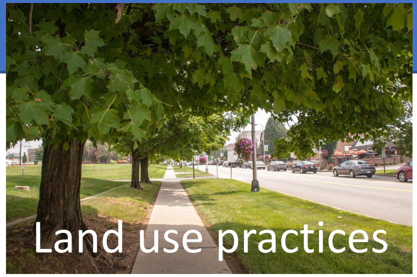
# Workshop Discussions

Watershed

Mitigation - Lowering of Water Temps





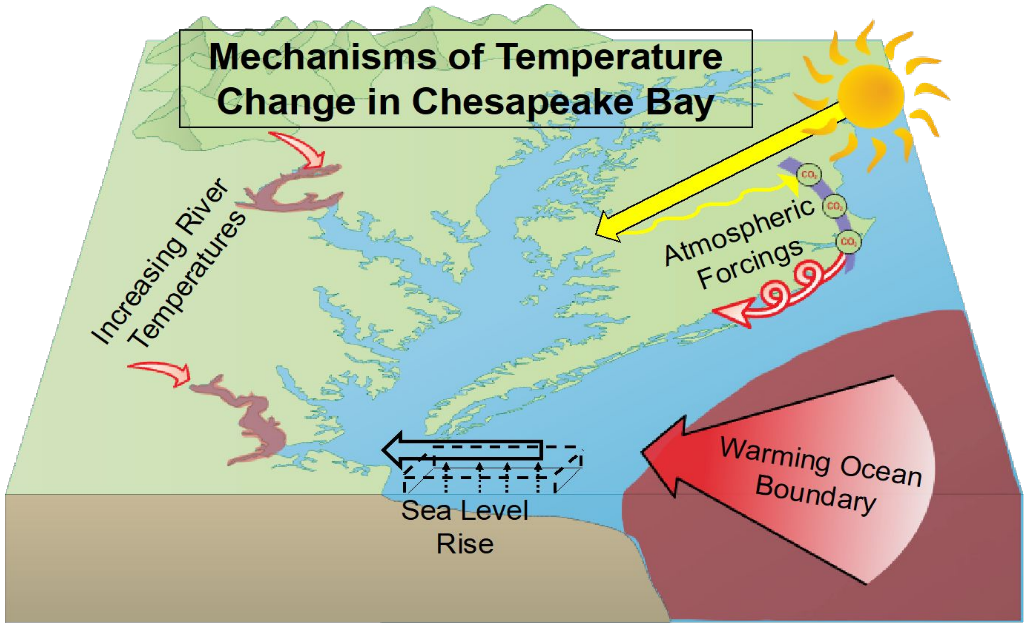
☆ Tidal

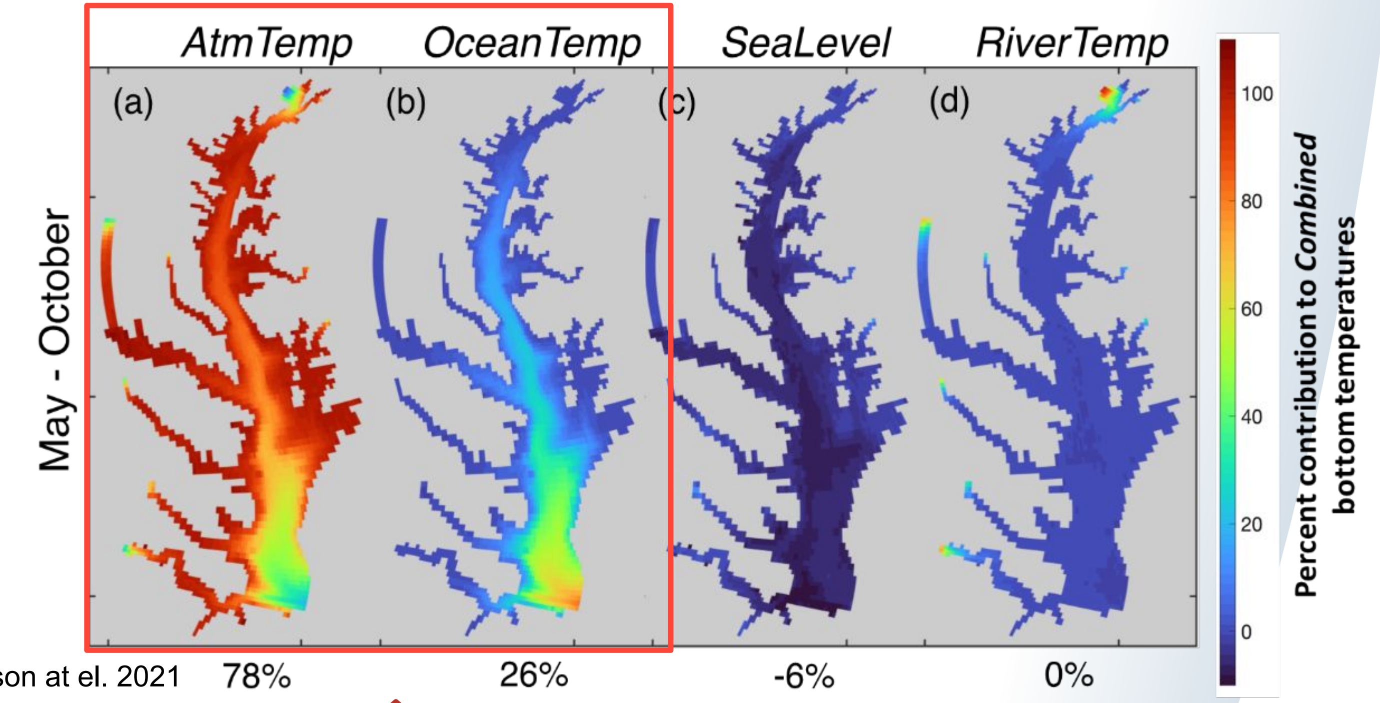
Adaptation - Minimize Impacts & Adjust





# Drivers of Rising Water Temperatures in the Chesapeake Bay




**Source:** Hinson at el. 2021

A. Air temperatures
B. Ocean temperatures
C. Sea level rise
D. River temperatures



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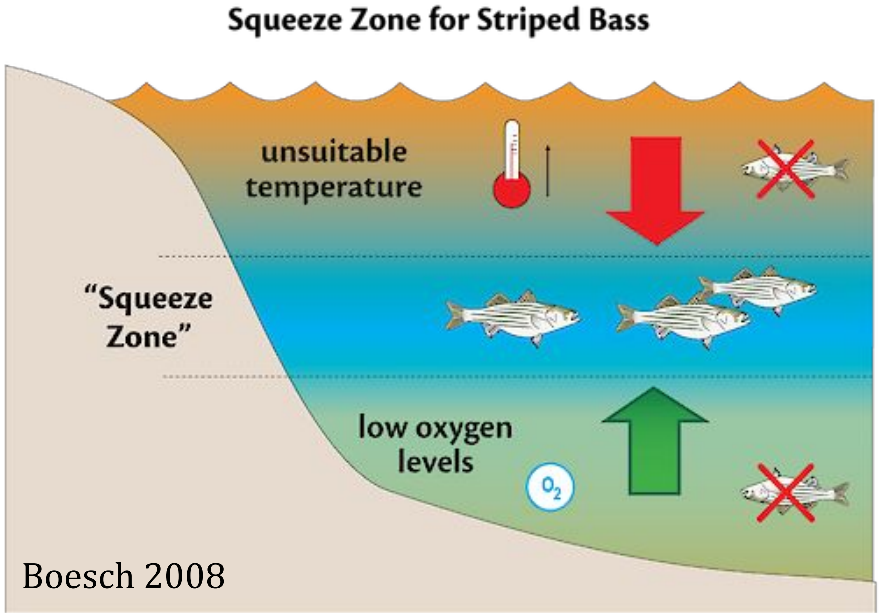
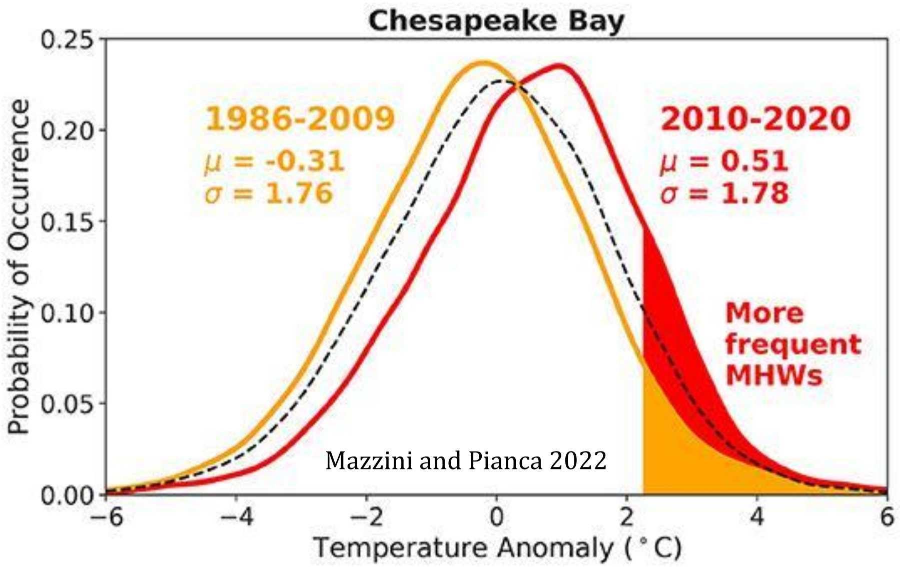
# Rising Water Temperatures: Compounding Impacts



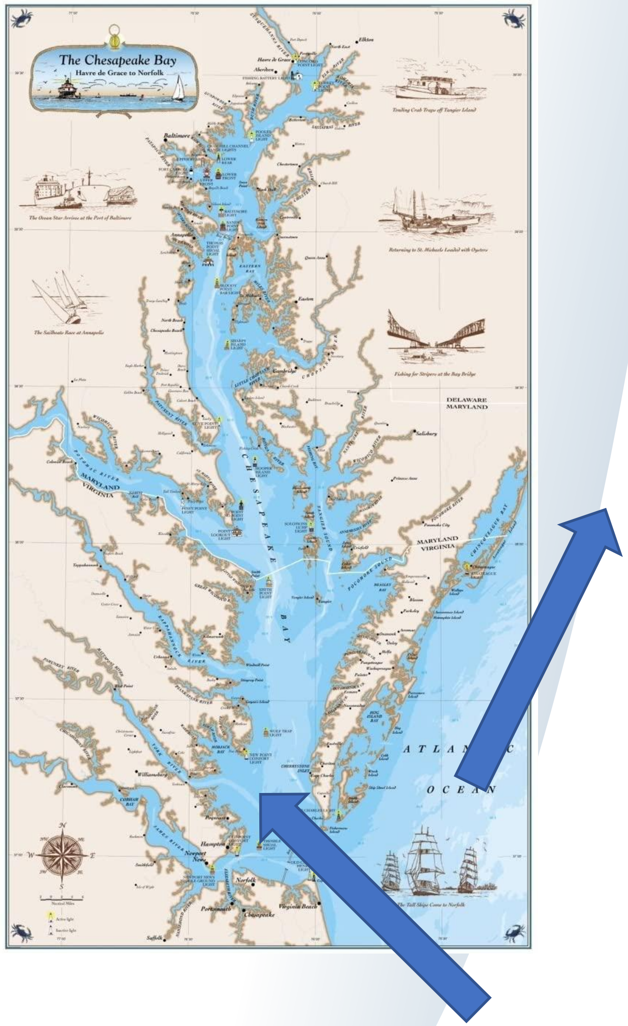

Changes in habitat suitability for vulnerable species (e.g., striped bass, eelgrass)

- Multiple stressors: With increases in water temperature, there are also decreases in bottom dissolved oxygen.
- Extreme Events: We are seeing increases in the intensity and frequency of marine heat waves (MHW).

# Ecological Impacts to Fisheries:

## Shifts in species range and habitats

- Some Bay species' populations are shifting north, while other species from the south are becoming more prevalent in the Bay.
- These range shifts can result in changes to species abundance and distributions, spawning, food web dynamics, fishing behavior, and new fisheries.
- Likewise, habitats required by fish and shellfish species are shifting in range and experiencing impacts that lead to changes in fish abundance, distribution, and reproductive success.



# Ecological Impacts to Fisheries:

## Species-specific impacts

- **Positive impacts** are likely for blue crab and some forage species, as warmer temperatures support higher productivity and increased habitat range as species move northward.

- **Negative impacts** are predicted for oysters due to their already depressed populations as a result of disease, overfishing, and habitat loss.

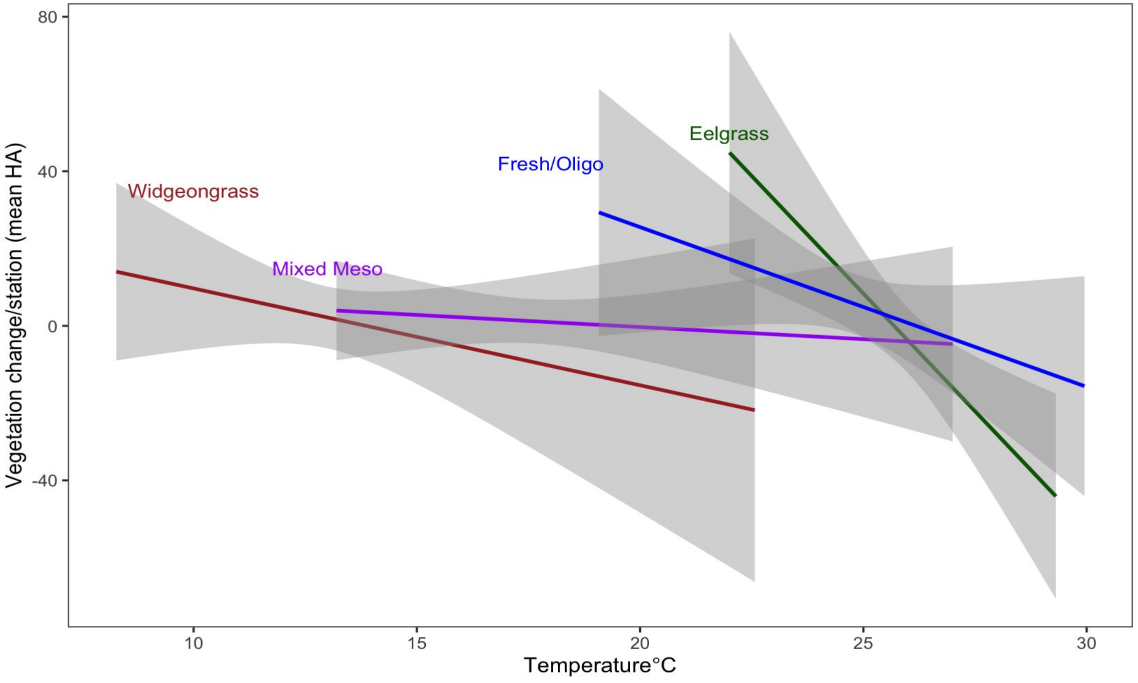
- Striped bass and Summer flounder may experience **both negative and positive impacts** at different stages of life (larval to adult) and habitat use (rivers and estuaries to marine).

| Negative |
|---|
| *Direct* |
| Reduced survival due to detrimental temperature ranges (more so during early life stages |
| *Indirect* |
| Increased hypoxic conditions |
| Ocean acidification |
| Increases in pathogens/disease occurrence |
| Alternation in food resources (abundance & quality |
| New non-native predators |

| Positive |
|---|
| *Direct* |
| Increased growth rates & earlier maturation |
| Reduced winter mortality (blue crabs & oysters) |
| *Indirect* |
| Longer spawning seasons and/or growing seasons |
| More algae/food (oysters) |

Northeast Fish and Shellfish Climate Vulnerability Assessment

# Ecological Impacts to Submerged Aquatic Vegetation




Hensel et al. (Synthesis Element #3 Paper, Appendix G)

- Viable populations of eelgrass are likely to be extirpated.
- Impacts to other SAV have not been as well studied.
- The $CO_2$ fertilization effect may provide some counterbalance to impacts of warming,

# Multiple Stressors on SAV Habitat

- Reduced SAV habitat from sea level rise and hardening of shorelines.
- Reduced water clarity and salinity from increased precipitation effects on SAV and oysters in addition to increases in temperature.
- SAV community change and effect on habitat use by fish and crabs.


Photo: Jay Fleming

# Management Implications

- Incorporating environmental conditions and multiple stressors in fisheries and SAV management frameworks.
- Assessing efficacy of current stock surveys.
- Including monitoring of fisheries prey and predator shifts and distributions.
- Promoting restoration siting and design for nearshore habitats to maximize ecological and resilience benefits.

# Themes for Actionable Recommendations

Ecosystem-Based Management

Multiple Stressors

New Temperature Regime

Nearshore Habitats

# Recommendations: Ecosystem-Based Management

- Establish fishing guidance based on temperature and dissolved oxygen and habitat condition thresholds to reduce catch and release mortality during periods of poor environmental condition.
- Hold workshop with fishery stakeholders to explore long-term strategies to advance ecosystem approaches that incorporate climate change considerations; include discussions on potential new fisheries and adaptation needs.


Photo: Eric Packard

 U.S. Department of Commerce | National Oceanic and Atmospheric Administration | National Marine Fisheries Service

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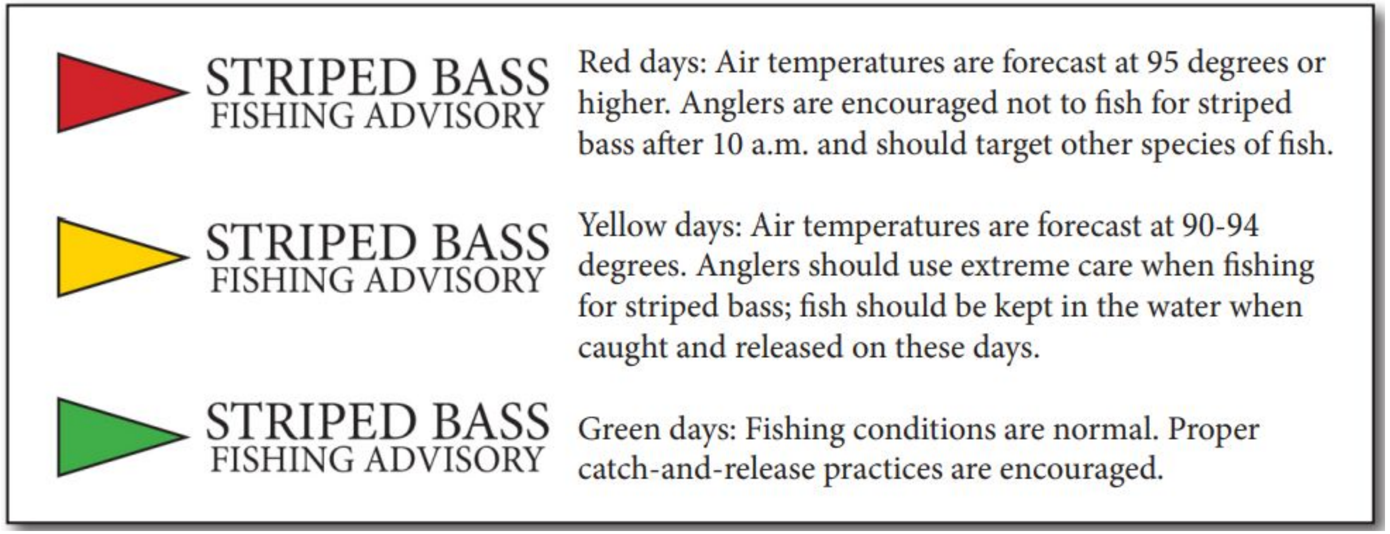
# Recommendations: New Temperature Regime

- Develop and implement strategy to improve communications on new temperature regime on expected scenarios for existing species and information on emerging species from the south.
- Support social science research and develop targeted communication for specific audiences (policymakers, managers, residents, local partners).

Photo: Dave Harp, *Bay Journal*

# Recommendations: Multiple Stressors

- Convene an interdisciplinary team of scientists, resource managers, meteorologists, and communicators to design and create a publicly available marine heat wave alert system.
- Connect alert system with habitat preferences of key species and guidance on fishing behavior; consider incorporating other key parameters (e.g., dissolved oxygen, salinity).




Example from Maryland Department of Natural Resources

# Recommendations: Nearshore Habitat

- Develop common criteria and metrics to help target, site, and design natural infrastructure projects where multiple benefits can be optimized.
- Support research to investigate co-location of restoration strategies to improve resilience (e.g., oyster reef and seagrass restoration).


Photo: Will Parsons, CBP



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# Identified Science Needs to Support Recommendations

- Ecosystem-Based Management - Monitoring, Analyses, and Modeling
- Extreme Climate Stressors (e.g., marine heat waves)
- Strategic Nearshore Habitat Restoration

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# Identified Science Needs:

## Ecosystem-Based Management—Monitoring

Photo: Doug Wilson

- Improve environmental monitoring of surface and bottom temperature, dissolved oxygen, and fish habitat condition.
- Consider establishing monitoring stations where there are significant fisheries habitat and spawning grounds.
- Evaluate needs for zooplankton monitoring at fish spawning and nursery areas to assess food web shifts.
- Explore the need for *in situ* monitoring of lower trophic organisms to better assess physiological response to changing conditions.



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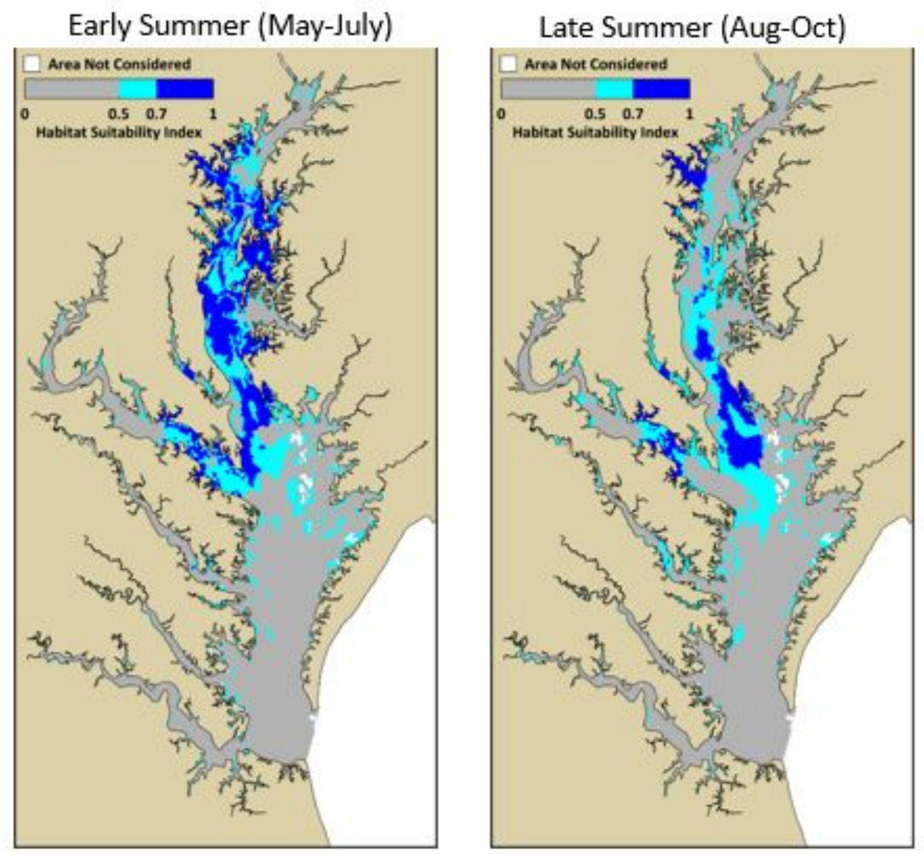
# Identified Science Needs:
## Ecosystem-Based Management—Analyses and Modeling

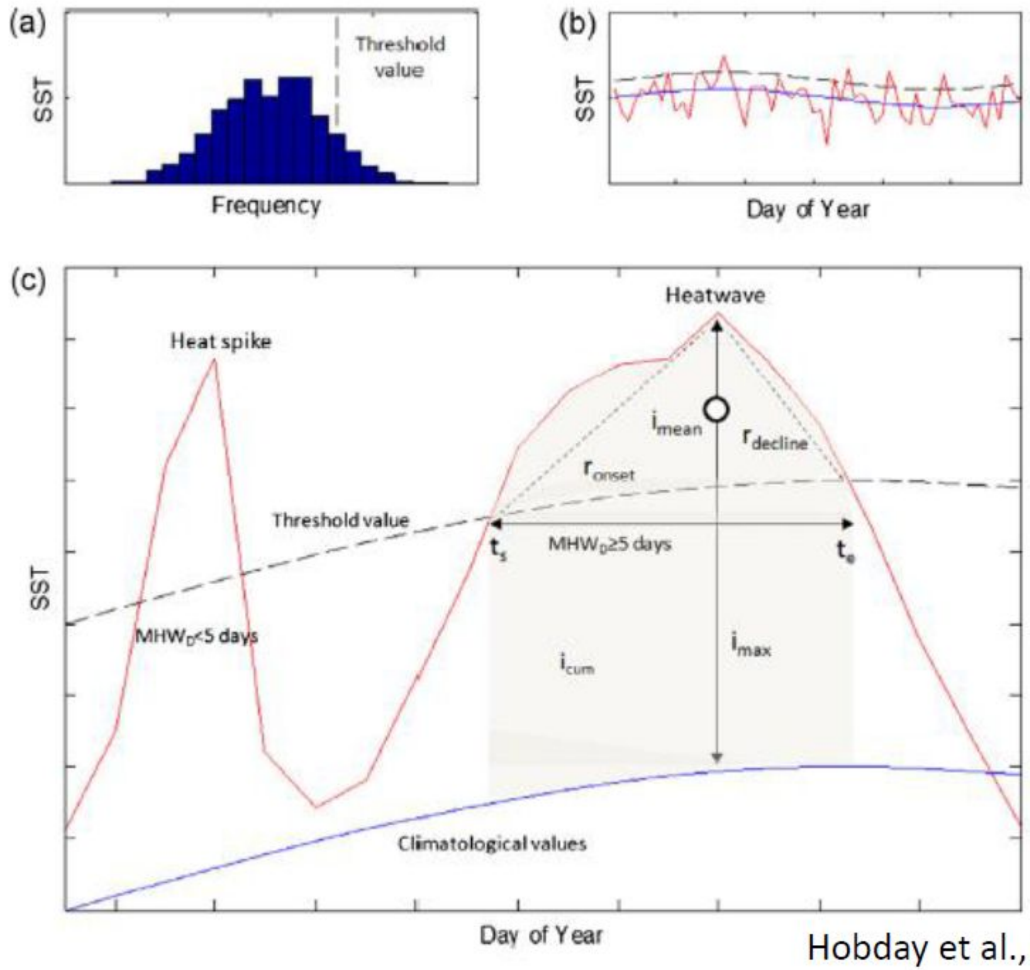
- Synthesize existing science to establish habitat condition thresholds based on temperature and dissolved oxygen for key fisheries species (e.g., striped bass, summer flounder).
- Develop habitat suitability models and indicators for key fisheries resources.
- Build into ecosystem models, improved information on drivers of natural mortality, recruitment success, and climate change impacts for key fishery species.
- Support assessments for emerging fisheries as climate change creates favorable conditions for these fisheries to be economically viable.
- Research how loss of late-winter/spring eelgrass habitat will affect blue crab populations.




Example from Striped Bass Habitat Suitability Study (Dixon et al. 2022)

# Identified Science Needs:

## Extreme Climate Change Stressors—Marine Heat Waves

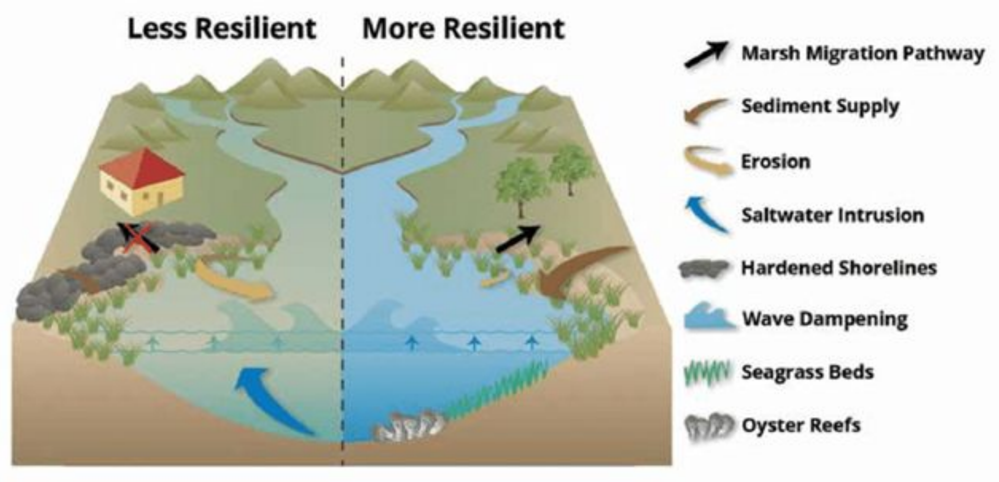



Hobday et al., 2016

- Relate current definitions of marine heat waves with living resource thresholds to determine an appropriate definition for Chesapeake Bay.
- Explore real time monitoring of marine heat waves and forecast products.
- Consider a marine heat wave indicator that connects with living resource management and guidance to the public.

# Identified Science Needs:
## Nearshore Habitat—Strategic Restoration

- Support threshold analyses to determine when ecological impacts or benefits occur from natural infrastructure implementation.
- Develop criteria for targeting nearshore restoration where multiple benefits and ecosystem services can be optimized.
- Increase understanding of watershed practices that can reduce local warming effects.
- Use models to increase understanding of habitat change from sea level rise to inform restoration strategies.


Kister 2016 (Reprinted with permission from the Integration & Application Network, 2013)

# Current Efforts that could Support Recommendations

- Development of seasonal summaries of environmental trends and relating to potential fish impacts (NCBO)
- Fish habitat suitability studies; e.g., shallow water habitat utilization by summer flounder and black sea bass (VIMS)
- Development of shoreline hardening thresholds related to blue crab and forage fish habitat use (CBP)
- Funded research on siting and design of natural infrastructure projects in the nearshore to enhance ecological and climate resilience benefits
    - Marsh Adaptation (CBP Climate Resiliency Workgroup)
    - Oyster structures (VIMS)

# NOAA Chesapeake Bay Office: Future Goals

- Exploring the development of a state of the ecosystem report for the Chesapeake Bay for use by managers that tracks how climate change is progressing related to fisheries.
- Incorporating marine heat wave trends in fish habitat risk analyses.
- Reviewing locations for monitoring of multiple stressors (e.g., dissolved oxygen and temperature) related to significant fish habitat.
- Improving monitoring with new dissolved oxygen profilers and telemetry receiver platforms.
- Supporting science to understand the effects of changing environmental conditions on fish.

# Key Takeaways

- Tidal waters in the Chesapeake Bay are rising as a result of global climate change/increasing air temperatures.
- There are steps we can take now to better prepare for changing conditions:
  - Reduce climate change stress on key fisheries resources by minimizing other stressors (e.g., nutrient pollution, fishing pressure, hardened shorelines), especially during periods or areas of high vulnerability (e.g., marine heat waves).
  - Facilitate discussions with managers and industry on shifts in key fishery resources, for both existing and emerging fisheries.
  - Promote strategic use of natural infrastructure and living shorelines to maximize multiple benefits, including enhancing fish habitat and resilience.
  - Explore options for siting different restoration efforts, such as oyster and seagrasses, near each other to bolster climate resiliency.

# Acknowledgements: Tidal Coauthors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- Breck Sullivan, United States Geological Survey (USGS)
- Rich Batiuk, Coastwise Partners

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Rising Water Temperature Workgroup Report Link:
www.chesapeake.org/stac/events/session-2-rising-watershed-and-bay-water-temperatures-e2-80-94ecological-implications-and-management-responses/

# Thank You

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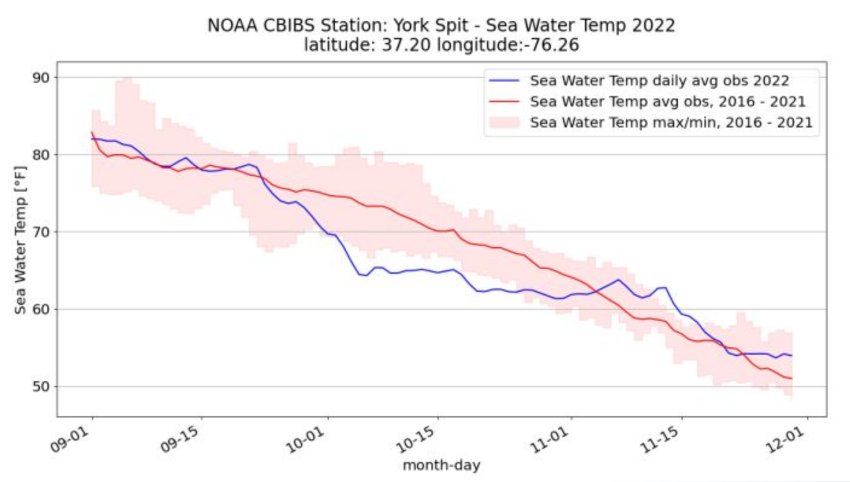
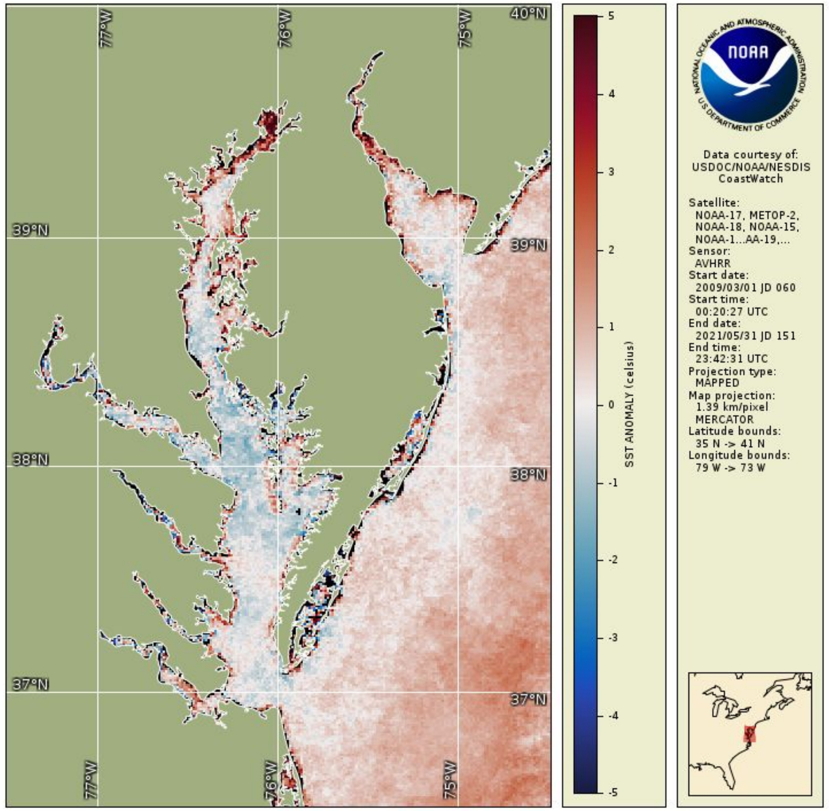
# References


- Boesch, D.F. (editor). 2008. Global Warming and the Free State: Comprehensive Assessment of Climate Change Impacts in Maryland. Report of the Scientific and Technical Working Group of the Maryland Commission on Climate Change. University of Maryland Center for Environmental Science, Cambridge, Maryland. This report is a component of the Plan of Action of the Maryland Commission on Climate Change, submitted to the Governor and General Assembly pursuant to Executive Order 01.10.2007.07.
- Dixon, R. L., Fabrizio, M. C., Tuckey, T. D., & Bever, A. J. (2022) Extent of Suitable Habitats for Juvenile Striped Bass: Dynamics and Implications for Recruitment in Chesapeake Bay. Virginia Institute of Marine Science, William & Mary. doi: 10.25773/v87b-6b43.
- Fabrizio, M. C., Tuckey, T. D., Smith, S. C., Ross, P. G., Snyder, R. A., Wang, H. V., & Bever, A. J. (2022) Characterization of Nursery Habitats used by Black Sea Bass and Summer Flounder in Chesapeake Bay and the Coastal Lagoons. Virginia Institute of Marine Science, William & Mary. doi: 10.25773/PJCC-RG41.
- Hinson, K. E., Friedrichs, M. A., St-Laurent, P., Da, F., & Najjar, R. G. 2021. Extent and causes of Chesapeake Bay warming. JAWRA Journal of the American Water Resources Association.
- Hobday, A. J., Alexander, L. V., Perkins, S. E., Smale, D. A., Straub, S. C., Oliver, E. C., et al. 2016. A hierarchical approach to defining marine heatwaves. Progress in Oceanography. 141, 227–238. doi: 10.1016/j.pocean.2015.12.014.
- Mazzini, P. L., & Pianca, C. 2022. Marine Heatwaves in the Chesapeake Bay. Frontiers in Marine Science, 8(750265).
- Rice, K.C., and Jastram, J.D., 2015. Rising air and stream-water temperatures in Chesapeake Bay region, USA: Climatic Change, v. 128, p. 127-138 https://doi.org/10.1007/s10584-014-1295-9.

# NCBO Seasonal Summaries

- Quarterly reports using existing environmental observational data to craft narratives about impacts on living resources (e.g., water temperature/SST anomalies, salinity, flow)
- NCBO is planning to expand this product to include:
  - More observational data and insights from fisheries research
  - New research from 2023 funding opportunity
  - Species-specific risk assessment to increase utility for Bay/regional managers



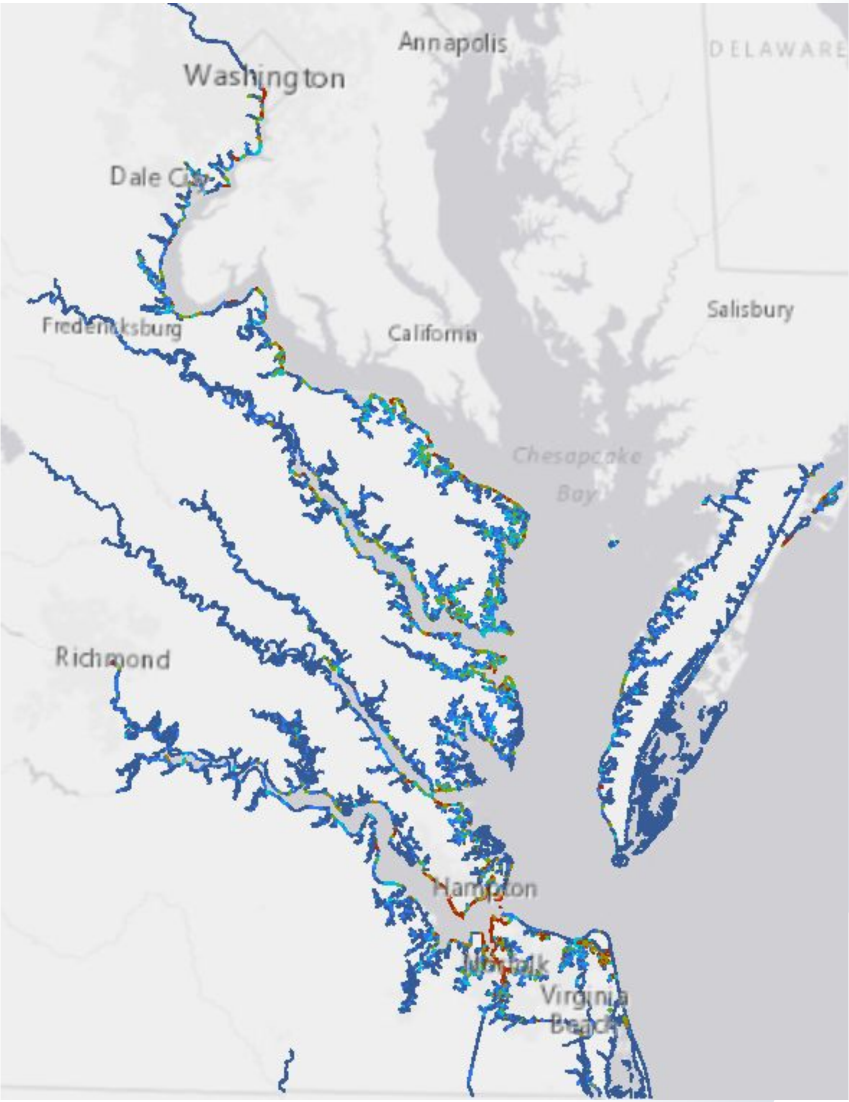
# Habitat Suitability:
## Characterizing Nursery Habitat Use of Juvenile Fishes
(Fabrizio et al. 2022)

- **Purpose of Study**: Understanding the dynamic nature of spatial nursery habitats for managed species (i.e., summer flounder & black sea bass)
- Investigated structured habitat use (e.g., use of oyster reefs, marsh, sea grass, and soft bottom use in western and eastern shore tributaries of Chesapeake Bay)

- **Key Findings**
  - Summer flounder relative abundance is highest in marsh habitat.
  - Juvenile flounder were larger in Choptank system. This is potentially connected to significant oyster restoration investment.
  - Thermal conditions—temperature and salinity—were important predictors of fish relative abundance and growth.
  - Temperatures below 25.9 C were established as suitable for summer flounder.
  - Suitable conditions are down by more than 50% over last two decades.

# Shoreline Hardening Threshold

- 2015 NOAA/Smithsonian Environmental Research Center Study
  - The study looked at 85 sites and quantified influences of shoreline change on ecosystem health. Shoreline development was linked to decline in a number of species.
- Mapping layers for Maryland and Virginia based on study: “Threshold effects of altered shorelines and other stressors on forage species in Chesapeake Bay” (Virginia Institute of Marine Science)
  - Shoreline hardening of 10-30% (17% mean) was found to be a threshold number for species decline of six analyzed forage fish species.
  - Juvenile blue crab showed general decline with an increase in shoreline development.



# Siting and Design of Natural Infrastructure Projects:
## Oyster Structures and Shoreline Protection

- Ongoing NOAA-funded project with Virginia Institute of Marine Science
- Goal: Provide siting options in Mobjack Bay, Virginia, and its tributaries where nearshore oyster structures can be most effective in protecting shorelines (reduced wave energy and erosion) while promoting oyster growth.


Photo: Chesapeake Bay Foundation