

Tidal Bay Past, Current, and Projected Water Temperature Changes, Influencing Factors, and Implications for Ecosystem Processes, Estuarine Health, Vulnerability, and Resilience

Presented by Rich Batiuk
Co-Founder, CoastWise Partners and
U.S. EPA Chesapeake Bay Program Office-Retired

Based on Contributions from
Kyle Hinson, VIMS; Rebecca Murphy, UMCES/CBPO;
and Richard Tian, UMCES/CBPO

Long-term Trends in Chesapeake Bay Surface and Bottom Water Temperatures

Per year, median surface increase = **0.024 °C.**

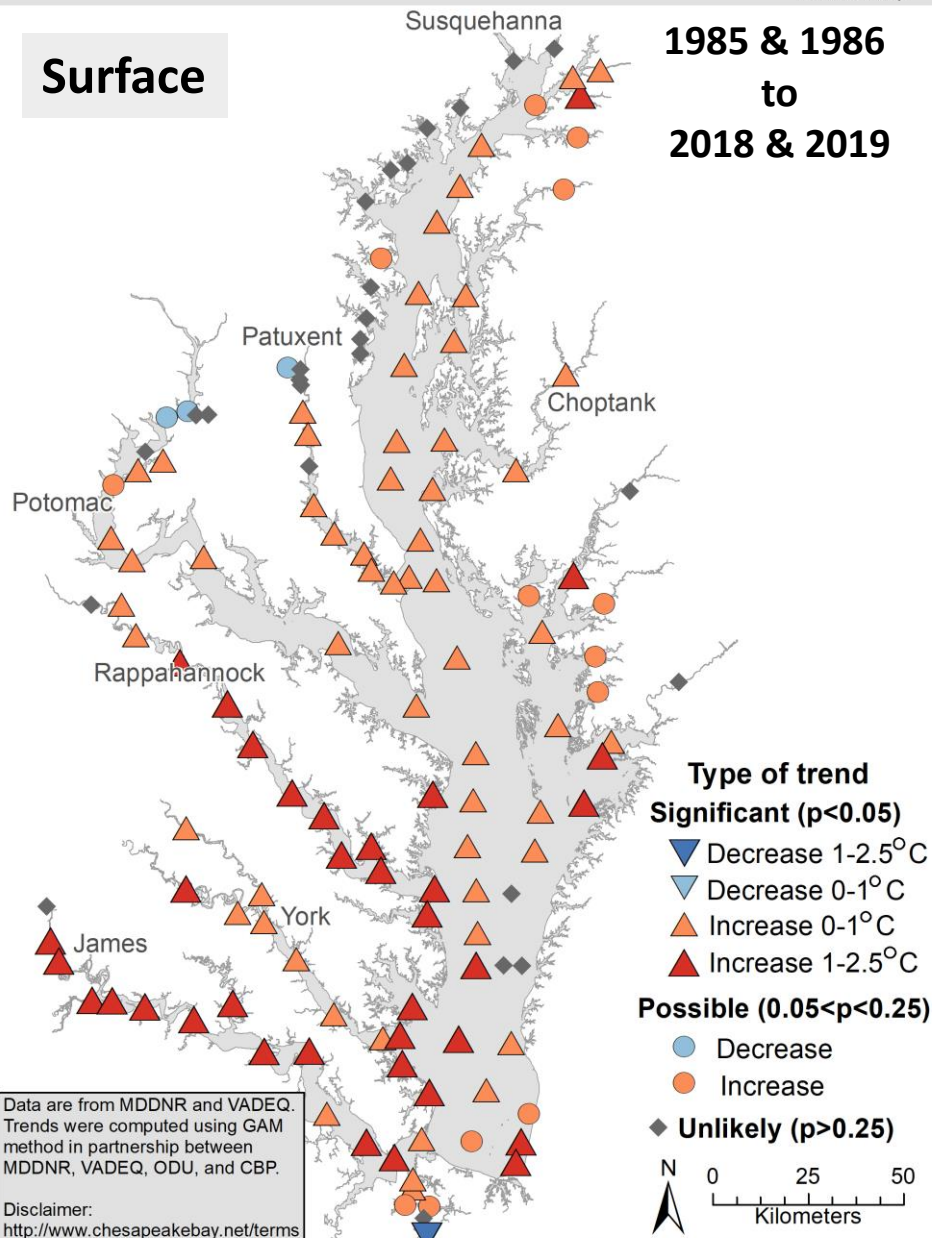
Baywide over 34 years, increase = **0.67 °C.**

Chesapeake Bay Surface Water Temperature: 2019 long-term change*



Surface

1985 & 1986
to
2018 & 2019



Map created by RM, 10/6/2020

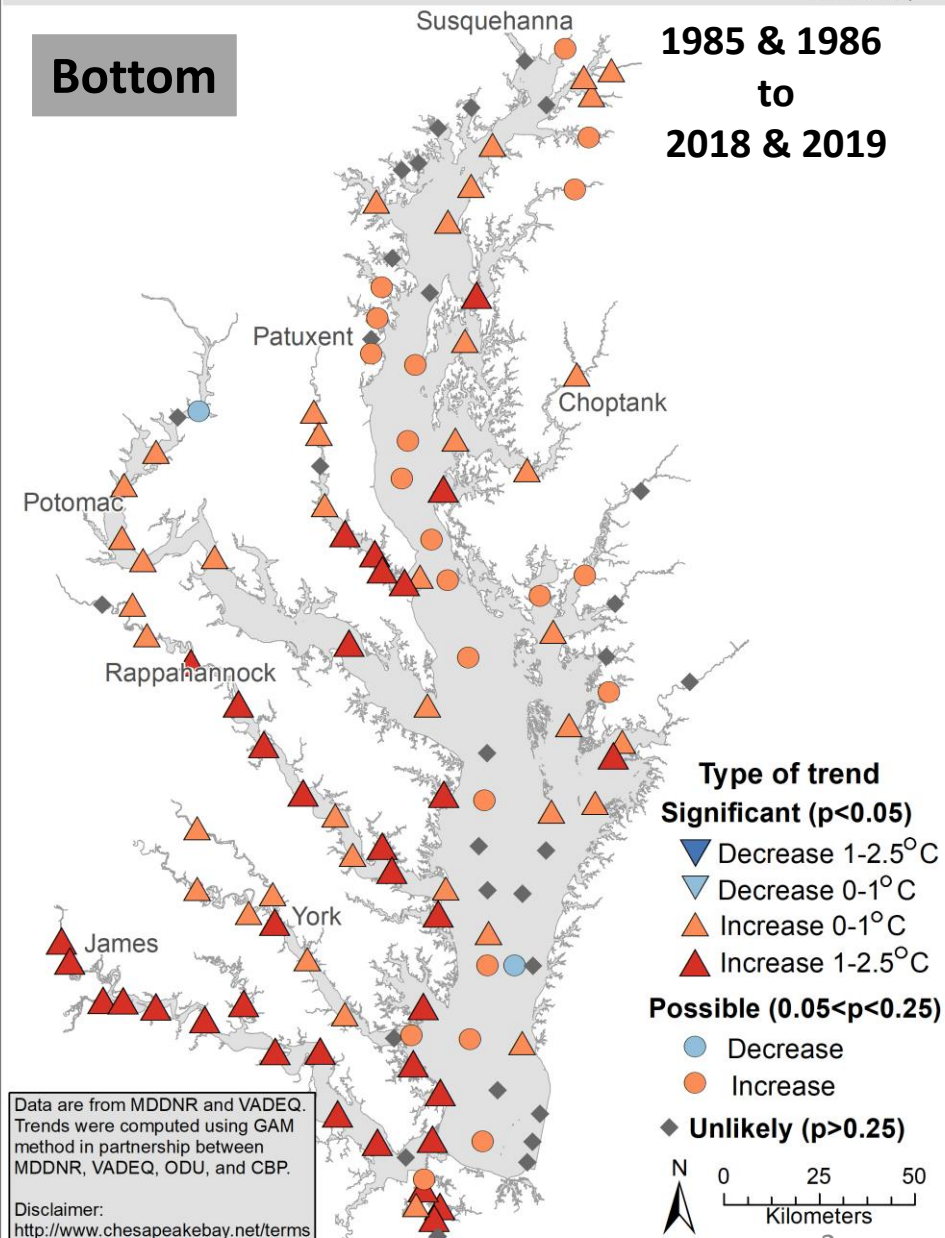
*start dates vary: MD stations 1985 or 1986, VA mostly 1985 except Elizabeth River 1989.

Chesapeake Bay Bottom Water Temperature: 2019 long-term change*



Bottom

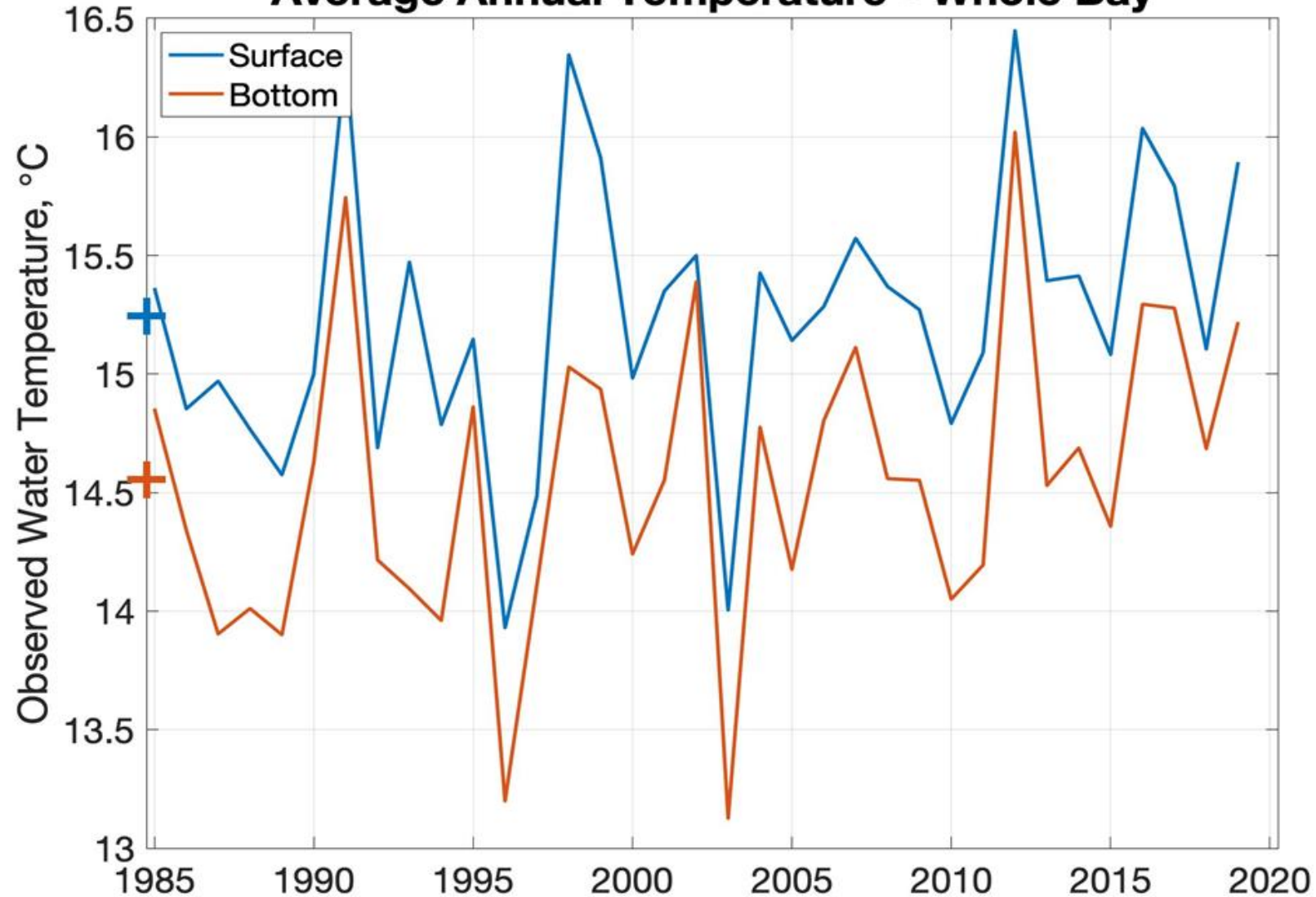
1985 & 1986
to
2018 & 2019



Map created by RM, 10/6/2020

*start dates vary: MD stations 1985 or 1986, VA mostly 1985 except Elizabeth River 1989.

Average Annual Temperature - Whole Bay



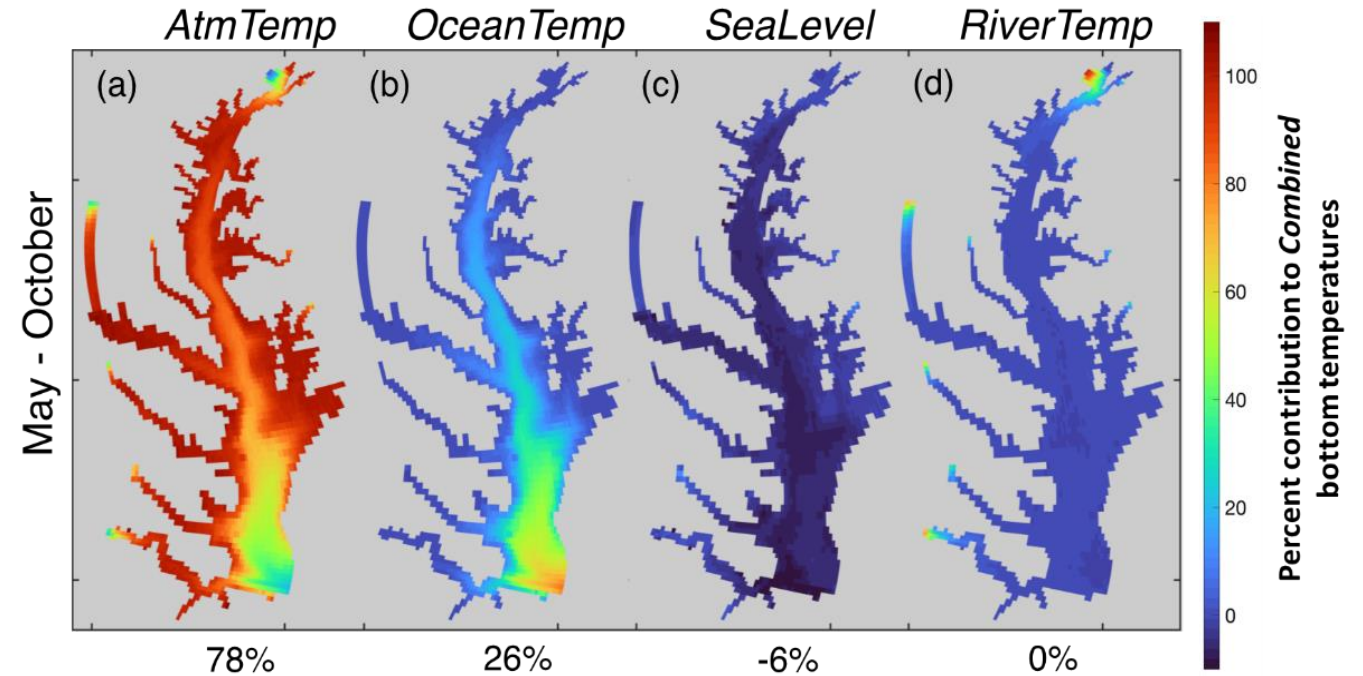
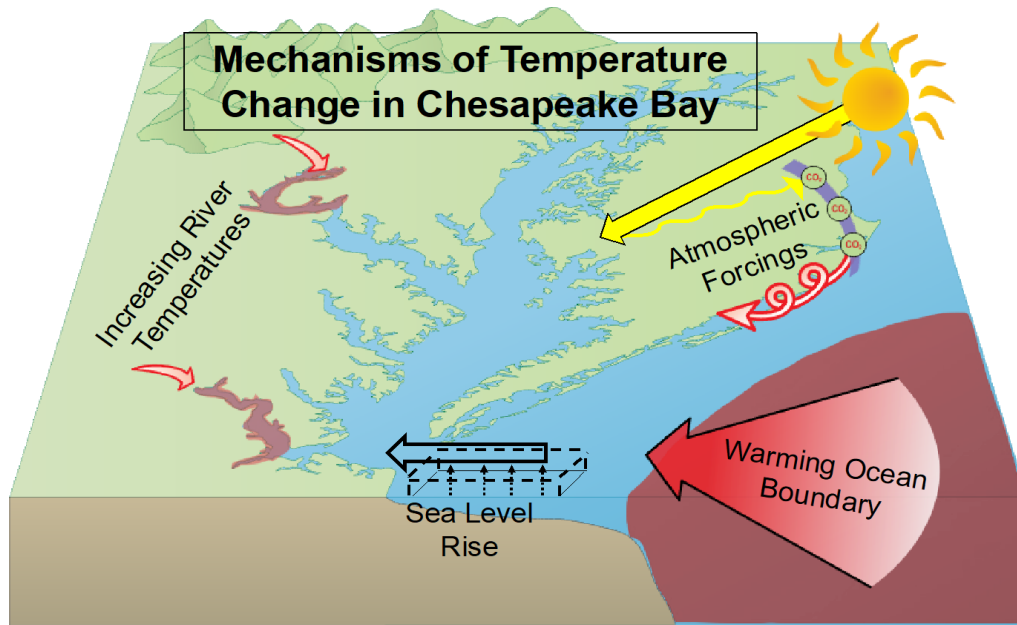
Over the Past 30 Year Period





Annual average:
+~0.7°C increase

Summertime:
+1.0 °C increase

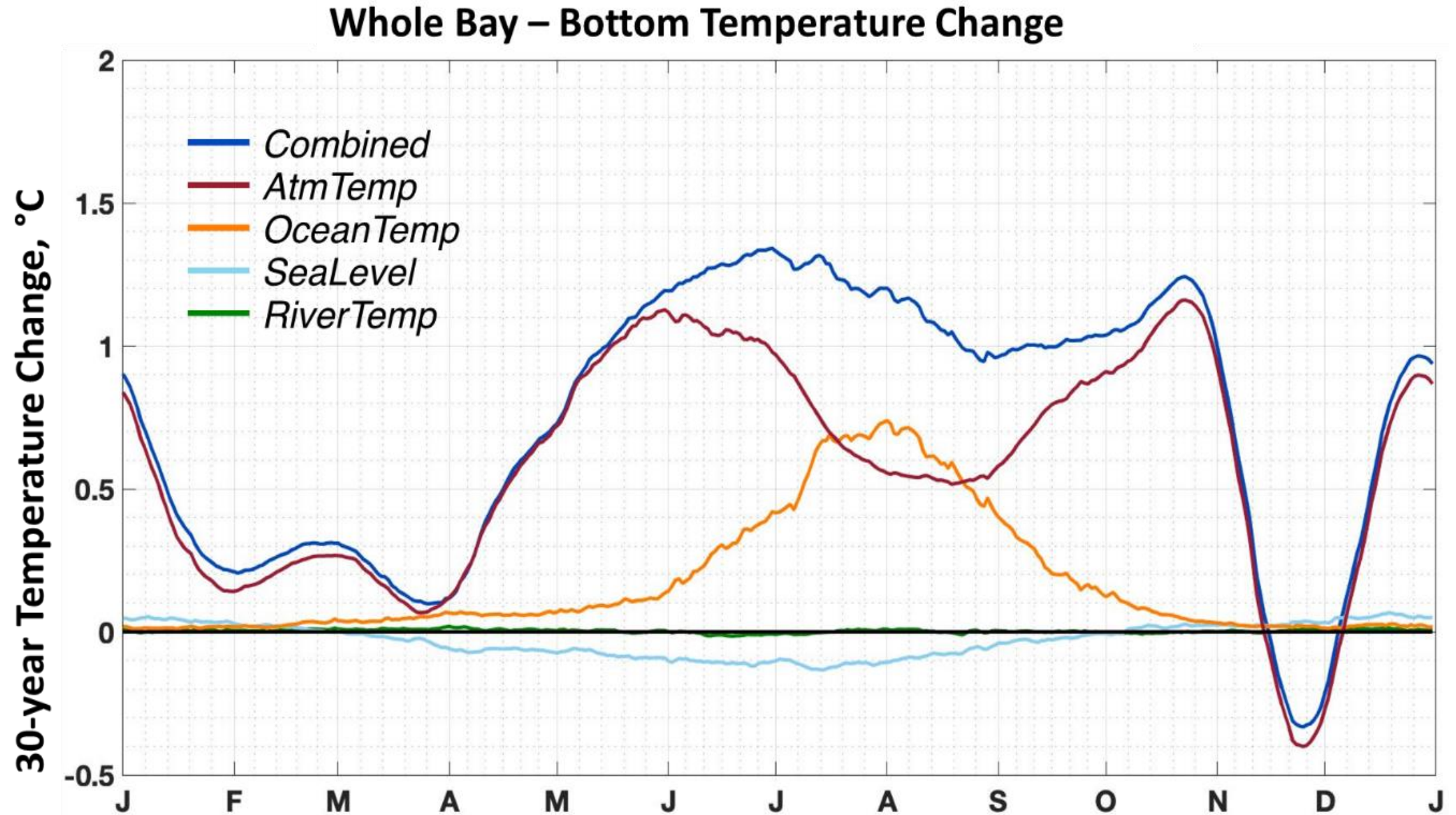
Wintertime:
+0.3°C increase

Driving Forces Behind Warming of Chesapeake Bay Tidal Waters

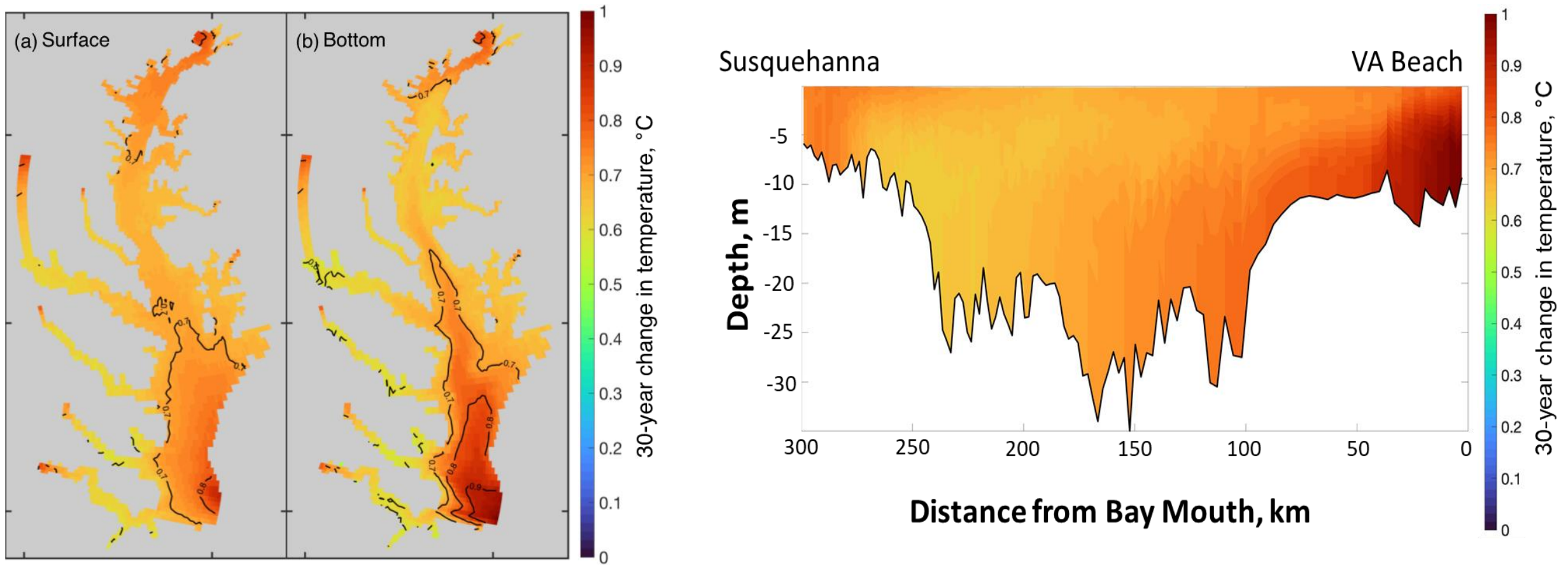


- 1) Air temperatures 
- 2) Ocean temperatures 
- 3) Sea level rise 
- 4) River temperatures 

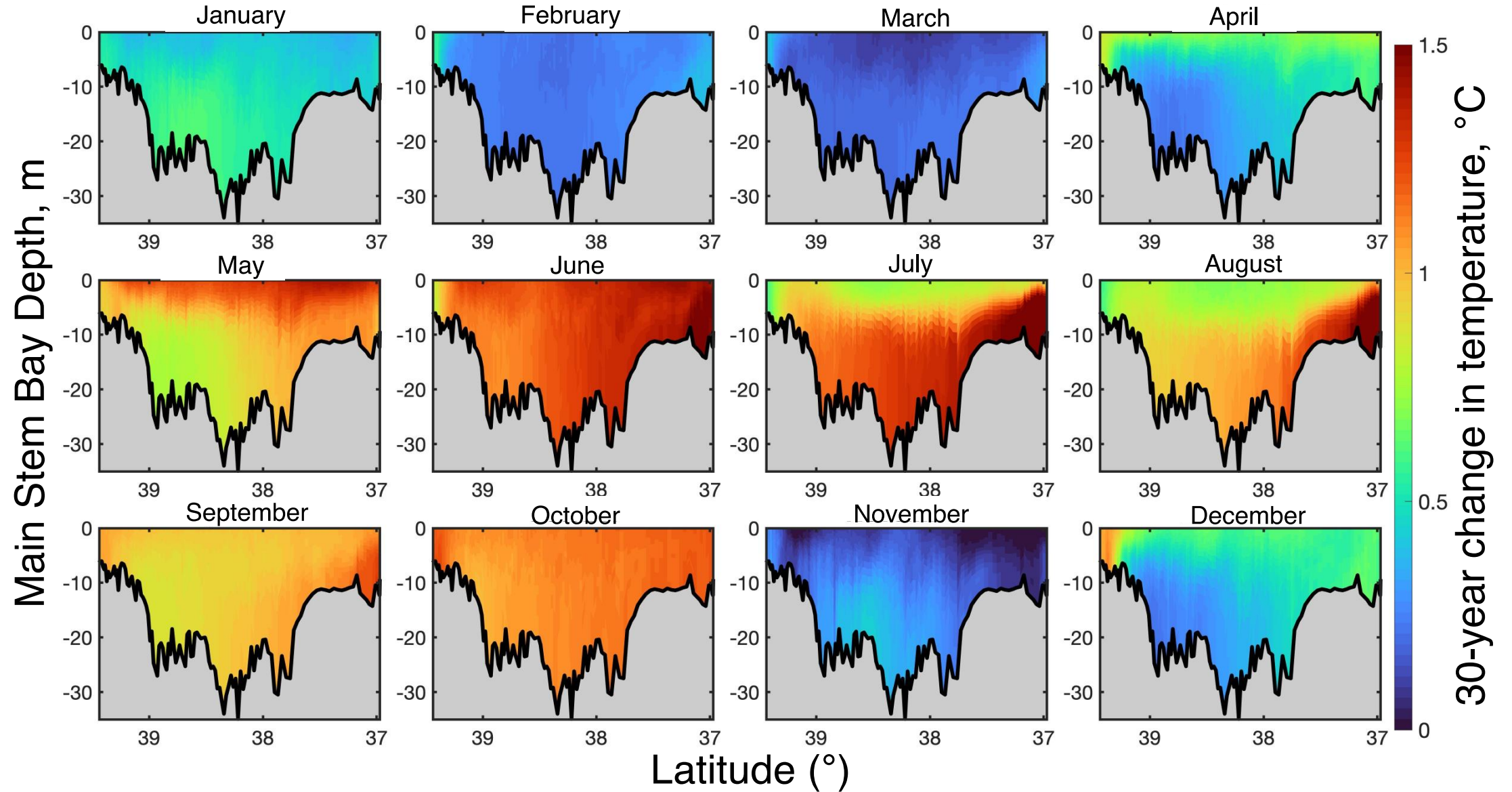
Driving Forces Behind Warming of Chesapeake Bay Tidal Waters



Warming of Tidal Waters By Depth and Geographic Location



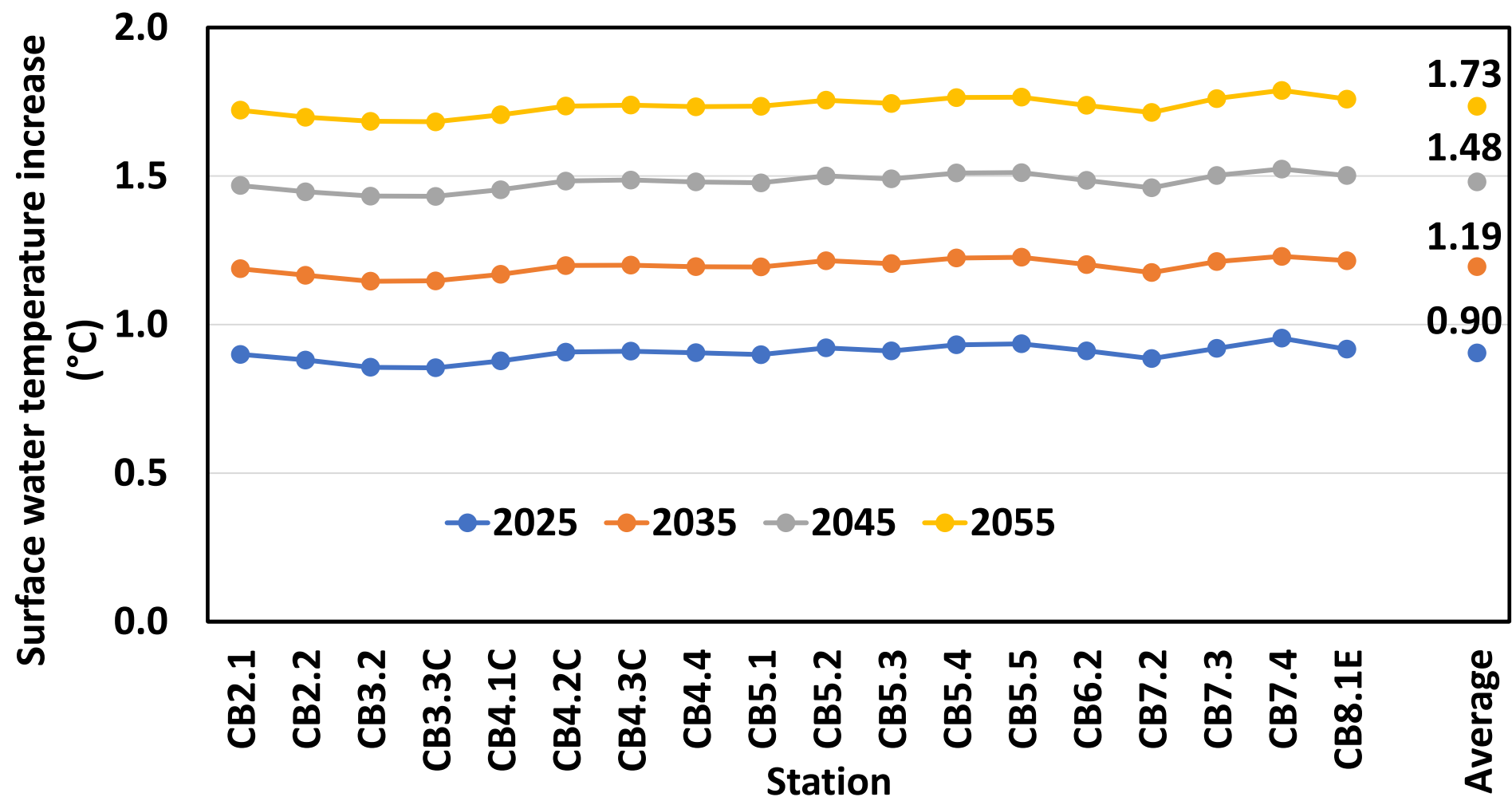
Warming of Tidal Waters By Season



Implications for the Estuarine Ecosystem's Ecological Processes

- Increases in biological processes and metabolism
 - Higher algal production rates
 - Higher stress on organisms at higher temperatures
- Reduced oxygen saturation
 - Water able to hold less oxygen
- Increased water column stratification
 - Lower oxygen levels in deeper waters
- Increased remineralization rates
 - More recycling of nutrients, more available for algae growth

Modeled Chesapeake Bay Summer Surface Water Temperature Increase under Future Climate Conditions from 1995 Baseline



Future Projections for Tidal Waters

- Average hypoxic volume in the summer would increase by 9% from 1995 to 2025 as air temperature increases by 1.06°C and water temperature by 0.9°C
- Of the three major drivers of water temperature change impacts, the percent contribution to projected the change in hypoxic volume is:
 - 55% due to the change in dissolved oxygen solubility
 - 33% due to increased biological rates
 - 11% due to increased stratification

Tidal Water Temperatures-Key Findings

- Air temperature is the main driver influencing Bay water temps year-round, but effects lessened during summer
- Warming ocean boundary effects are important in summer (influenced \geq 50% warming), but small otherwise during the rest of seasons
- Sea level rise slightly cools main stem from April-September and warms bottom waters in winter
- River temperatures produce little to no warming in the Chesapeake Bay's mainstem
- Increasing Bay water temperatures will result in increased volumes of low dissolved oxygen due to direct effects on oxygen solubility, biological processes rates and stratification

Discussion Questions

Is our current draft storyline, described in our draft synthesis paper and highlighted in our presentation, understandable and fully supported by the available data and scientific findings?

Are we missing any important implications for ecosystem processes influencing estuarine ecosystem health from our draft synthesis paper?