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Three species of *Vibrio* pathogen in the Chesapeake Bay under future climate change scenarios

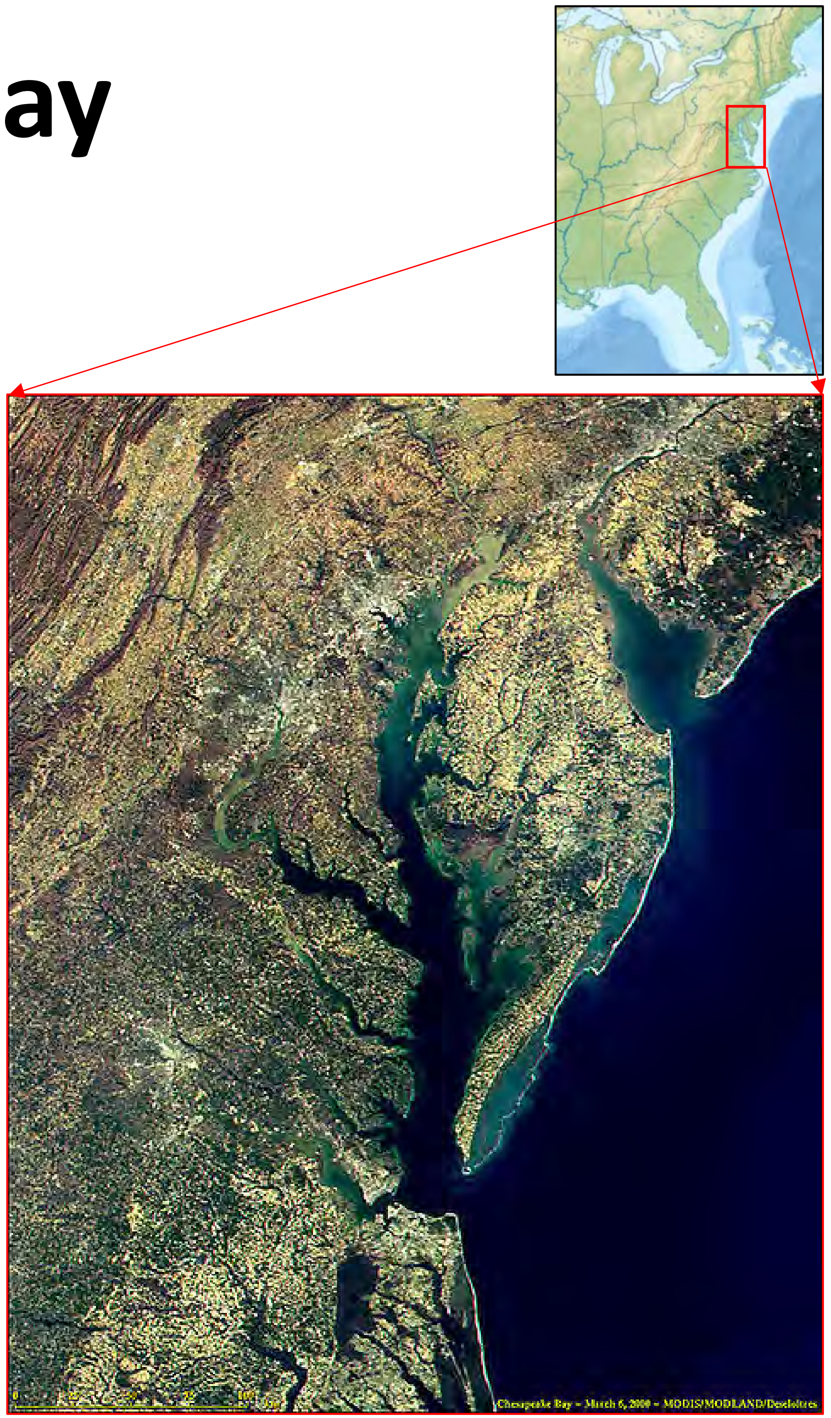
Barbara Muhling

John Jacobs, Charles Stock, Carlos Gaitan, Vincent Saba, Desiree Tommasi, Keith Dixon

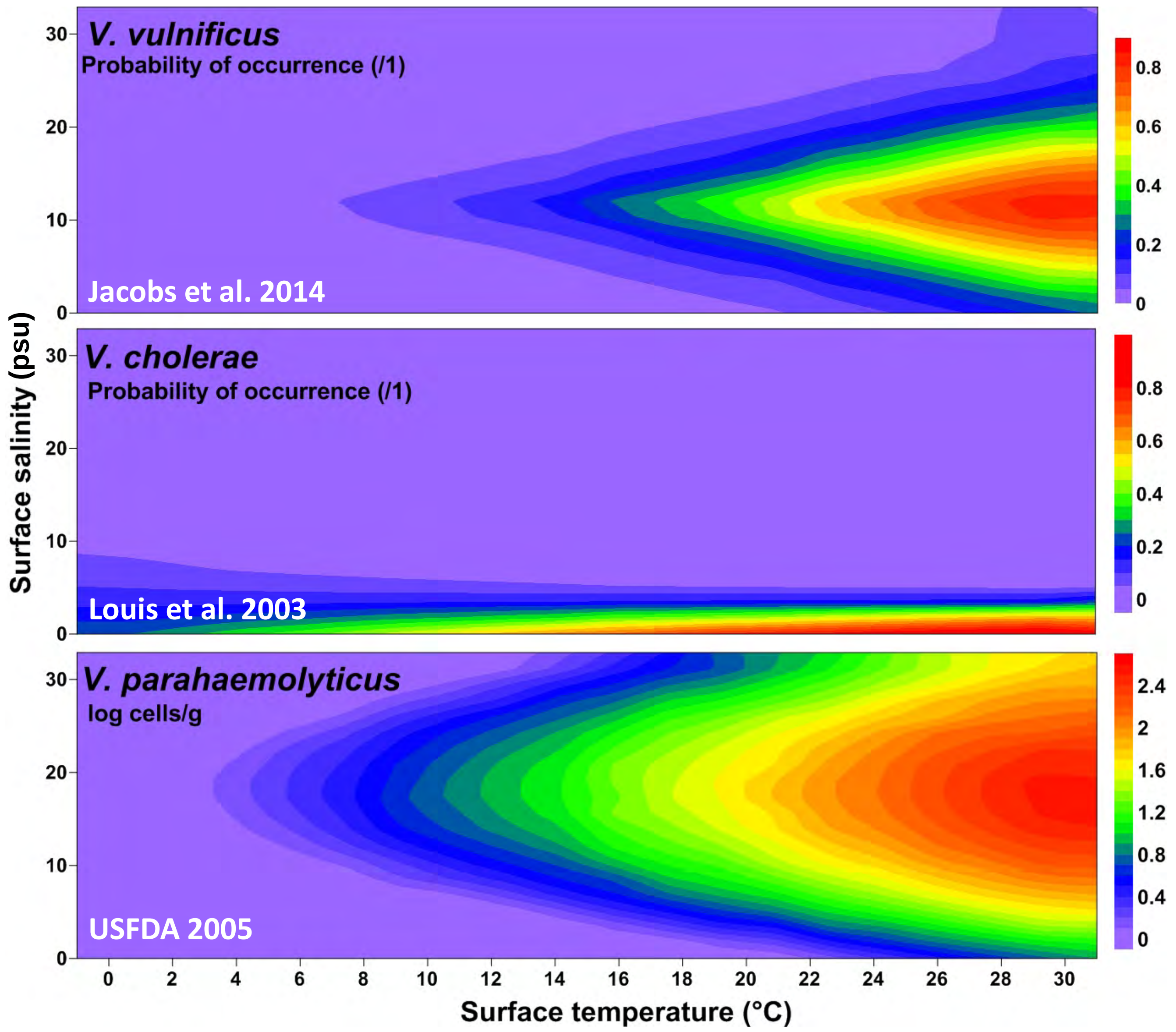


Vibrio in Chesapeake Bay

- Several species present naturally
- Vibriosis cases in warmer months
  - *V. parahaemolyticus* most common, *V. vulnificus* most severe
- Warmer waters associated with higher occurrence of bacteria in the water
- Species-specific salinity ranges

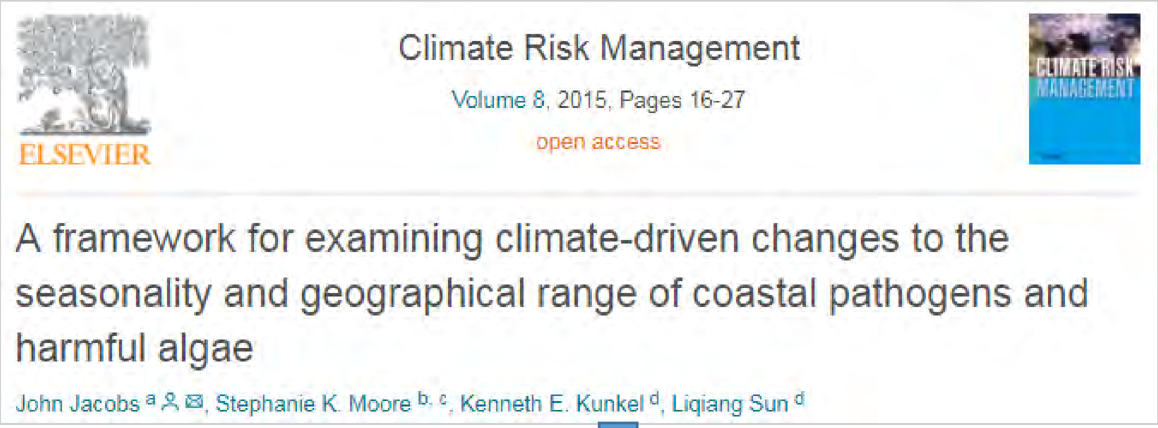


Vibrio in Chesapeake Bay
Habitat models



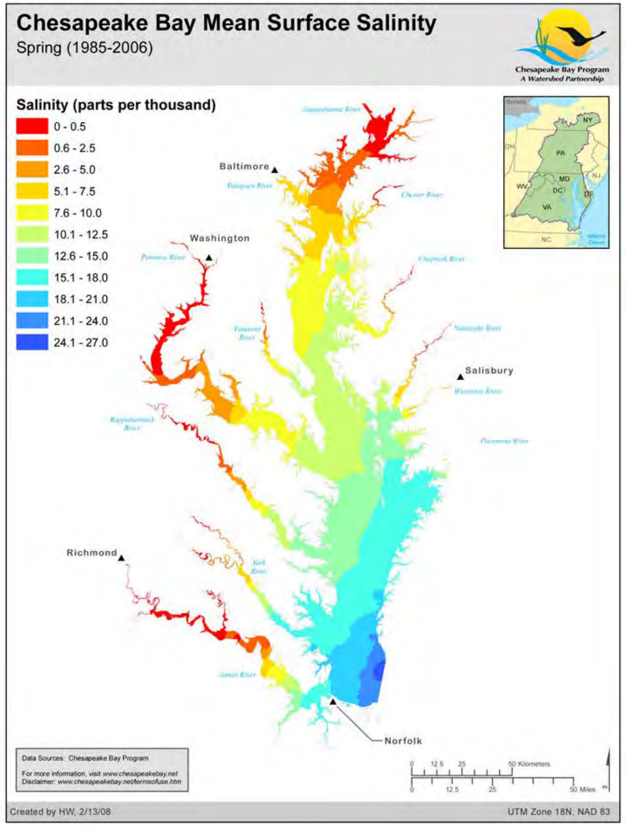
Vibrio and climate change in the Chesapeake Bay

- Jacobs et al. (2015) projected *V. vulnificus* in water and *V. parahaemolyticus* in oysters out to 2100
- Estimated water temperature from near-surface air temperatures
- But: modeled Chesapeake Bay as 1-dimensional
  - Salinity also held constant at 12 psu

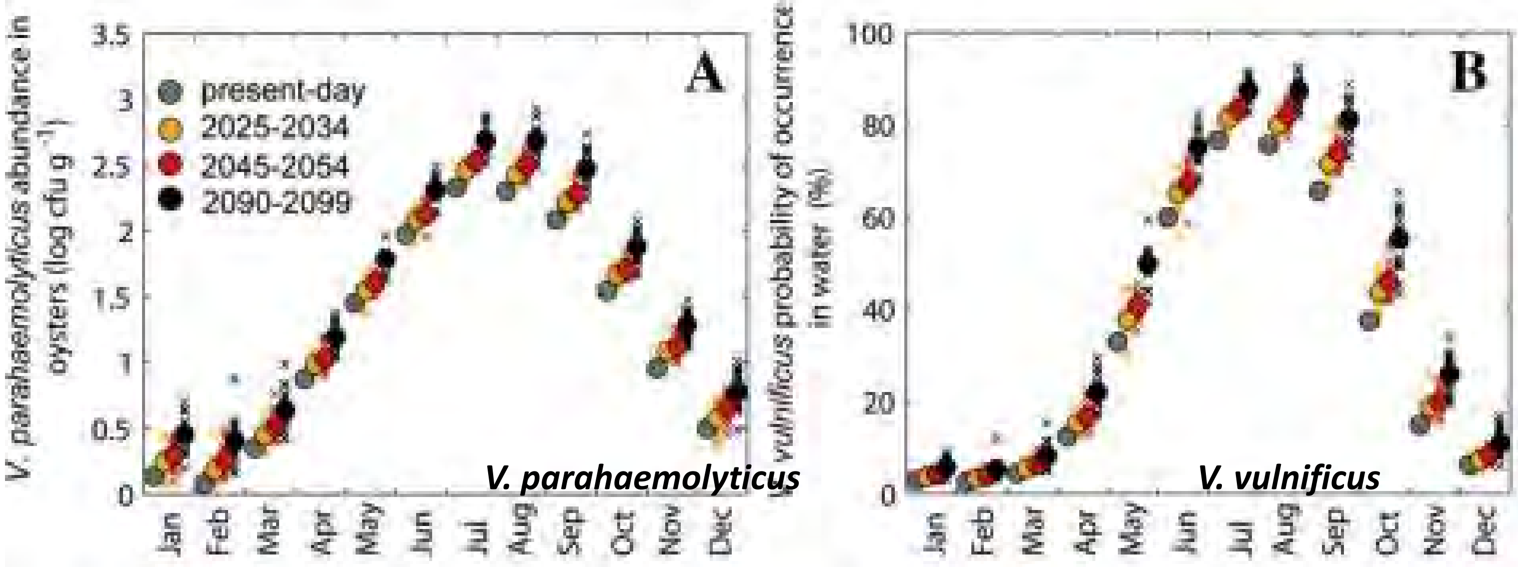

Climate Risk Management
Volume 8, 2015, Pages 16-27
open access
ELSEVIER

A framework for examining climate-driven changes to the seasonality and geographical range of coastal pathogens and harmful algae

John Jacobs [a], Stephanie K. Moore [b, c], Kenneth E. Kunkel [d], Liqiang Sun [d]

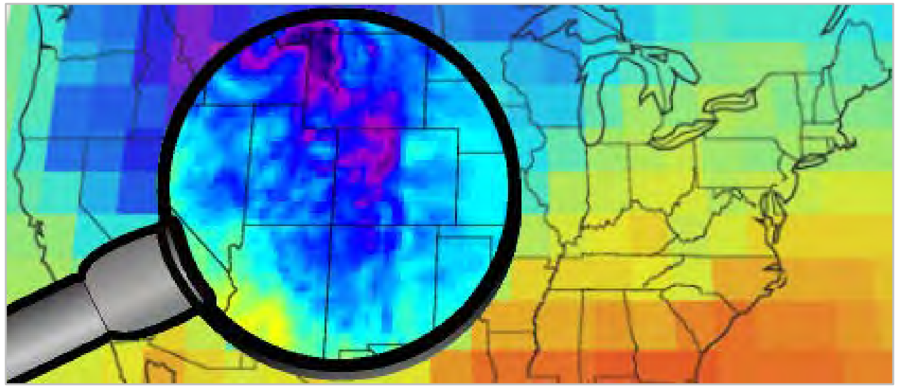


Ensemble of climate models, RCP 6.0



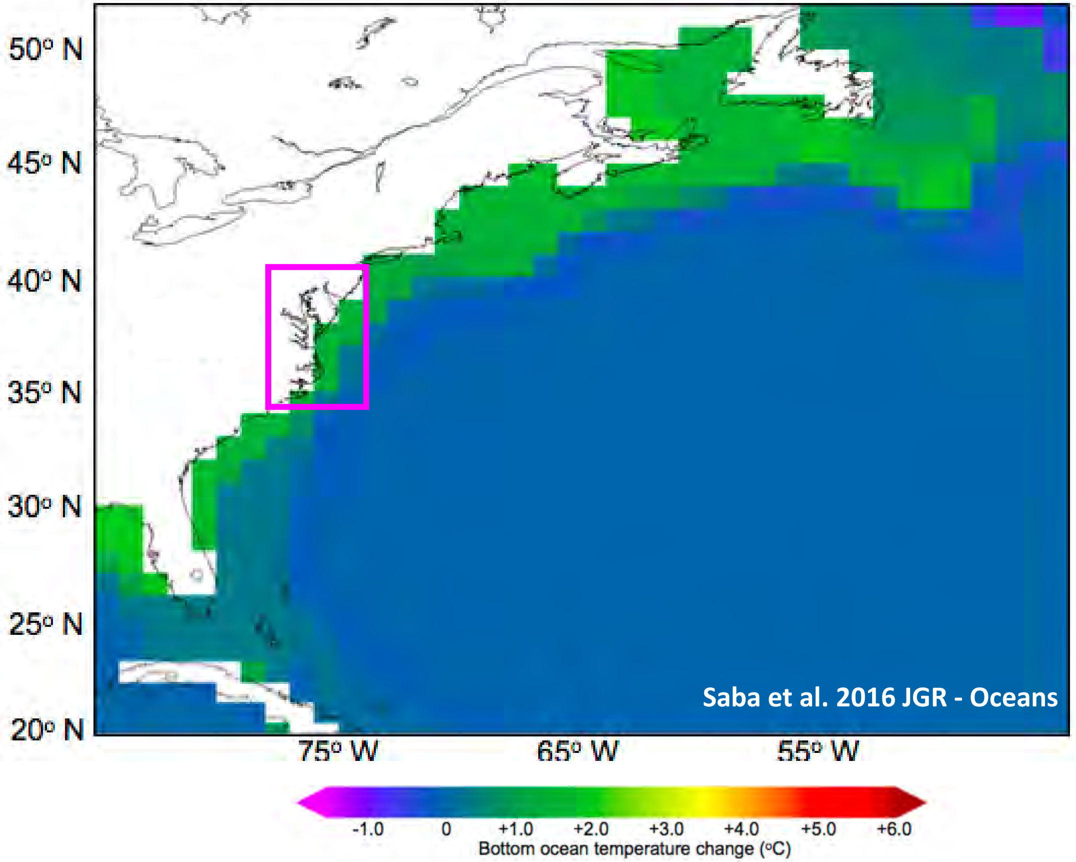
Climate model resolution and estuarine environments

- General circulation models (GCMs) too coarse to resolve local-scale dynamics in estuaries
- If we want to represent fine-scale features like estuaries, GCMs must be <u>*downscaled*</u> to area of interest
- *Statistical downscaling*: relies on present-day relationships between regional and local-scale processes
    - Low computational cost, can compare multiple GCMs
    - Needs long observational record (~30 years+)



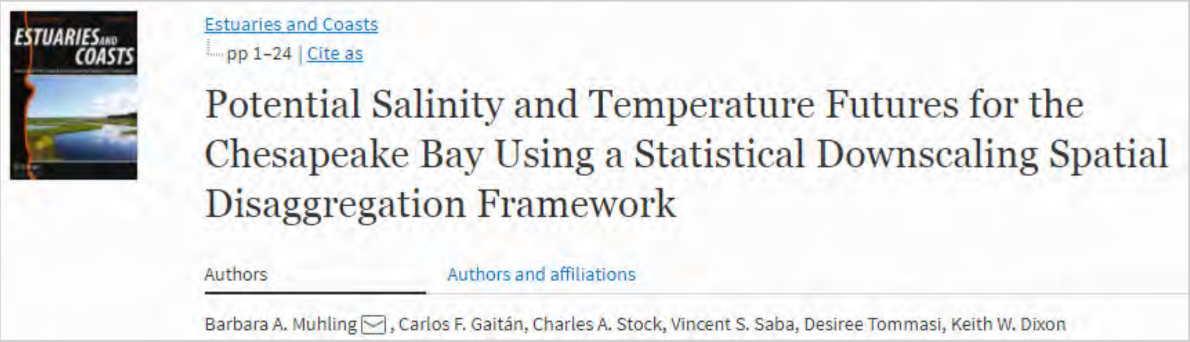
https://www.gfdl.noaa.gov/climate-model-downscaling/

GFDL CM2.1 General Circulation Model



Our modeling framework

- See Muhling et al. 2017 Estuaries and Coasts

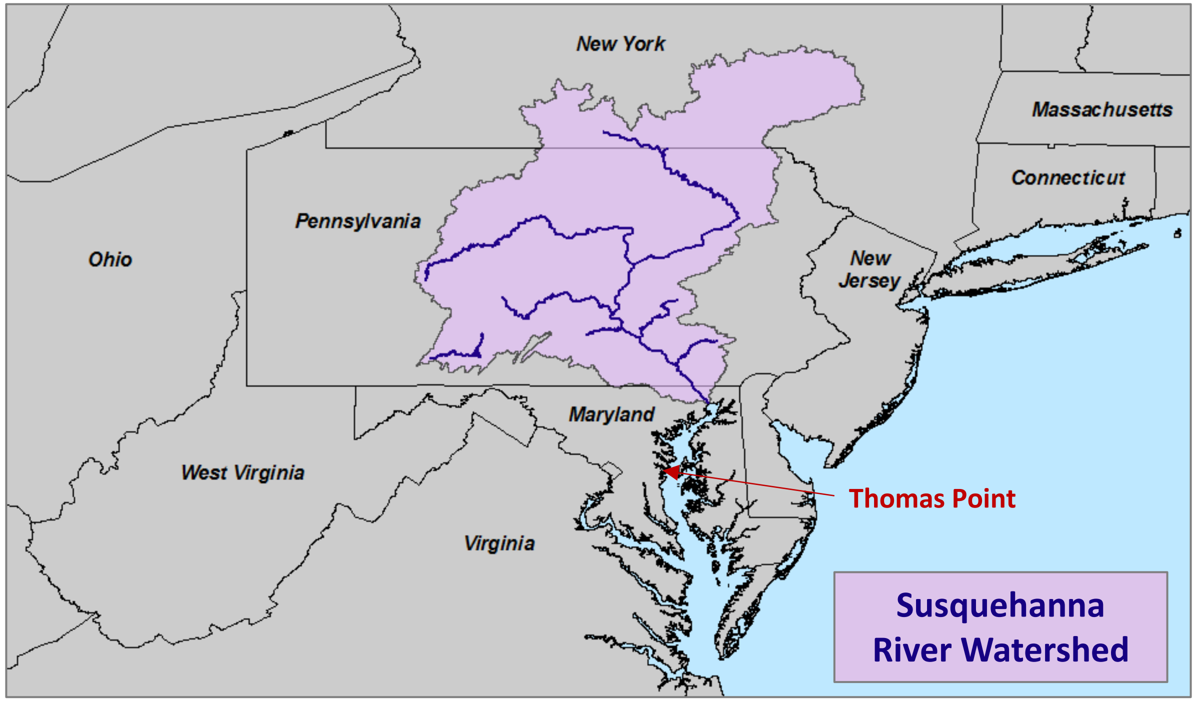

ESTUARIES AND COASTS

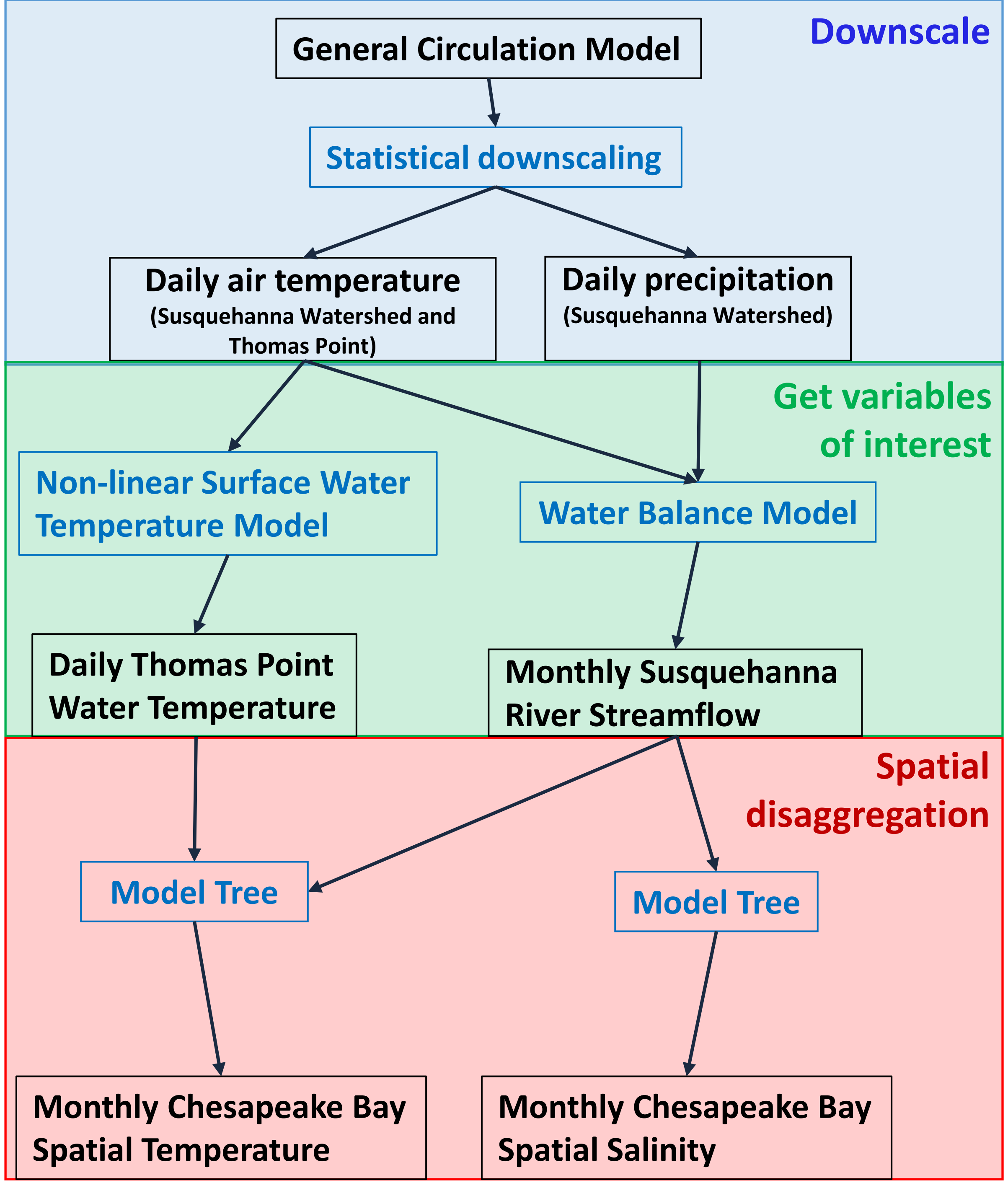
Estuaries and Coasts
pp 1–24 | Cite as

Potential Salinity and Temperature Futures for the Chesapeake Bay Using a Statistical Downscaling Spatial Disaggregation Framework

Authors | Authors and affiliations

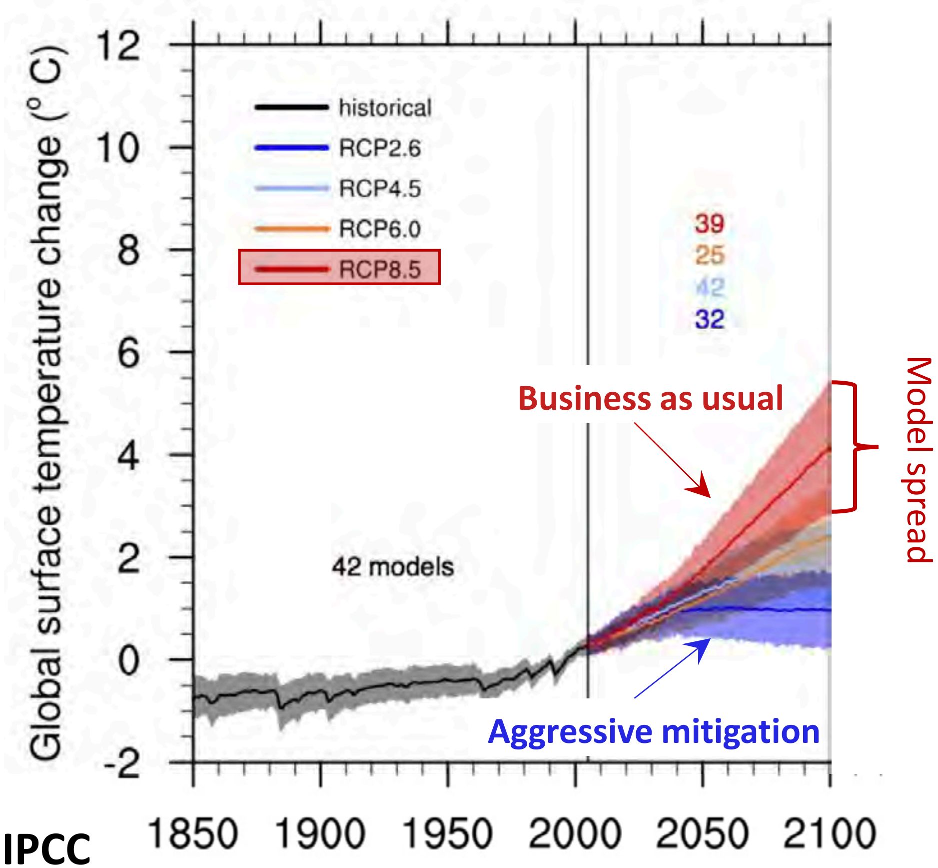
Barbara A. Muhling, Carlos F. Gaitán, Charles A. Stock, Vincent S. Saba, Desiree Tommasi, Keith W. Dixon





How will conditions change in the future?

- Two primary sources of uncertainty for long-range projections
  1. Representative Concentration Pathway (RCP): how much CO_2 will we emit?
     - We chose to consider the "business as usual" scenario, RCP8.5
  2. Variability in projections from different GCMs
     - We selected four GCMs with diverging but plausible temperature and precipitation futures



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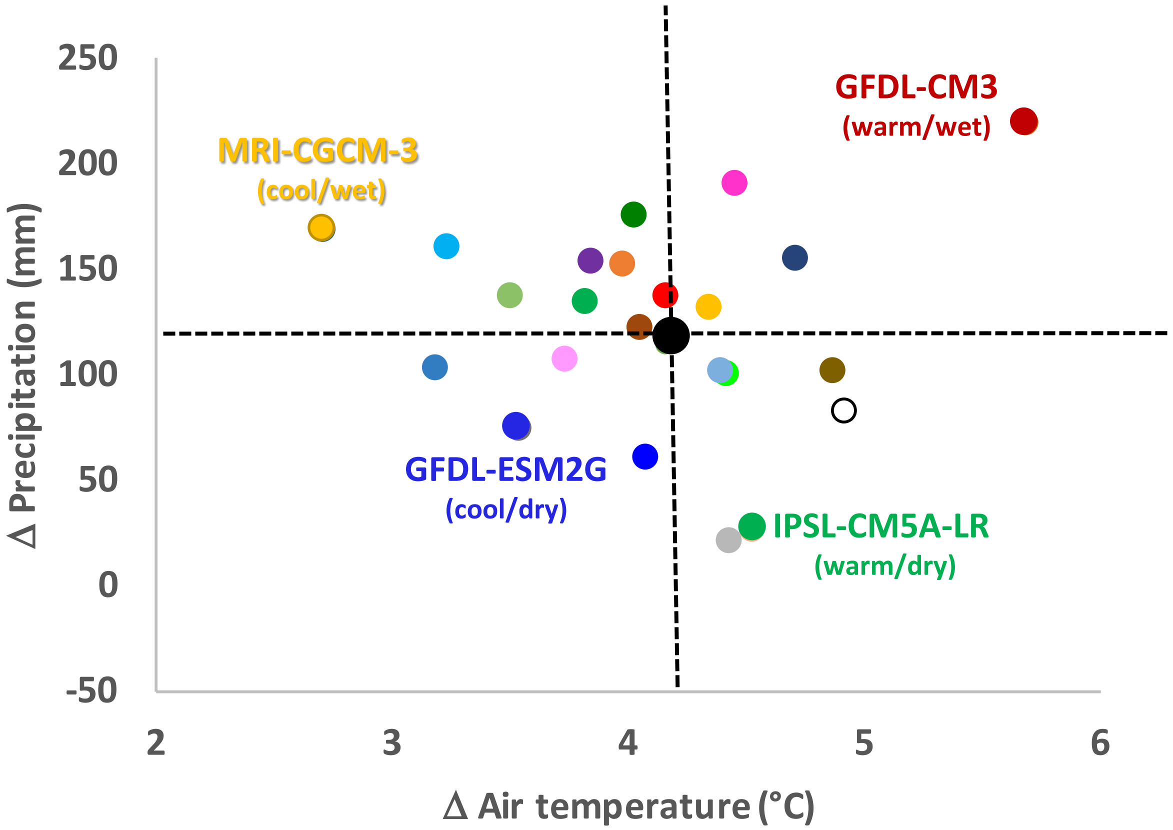
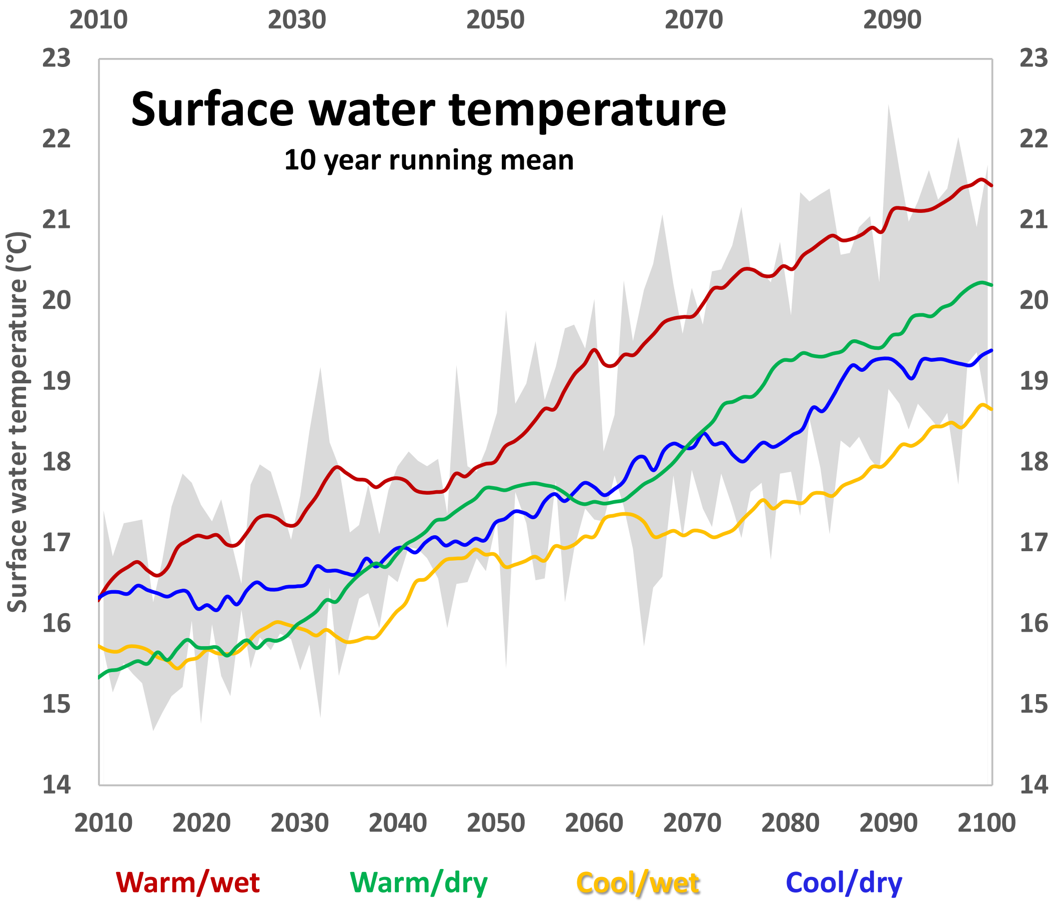
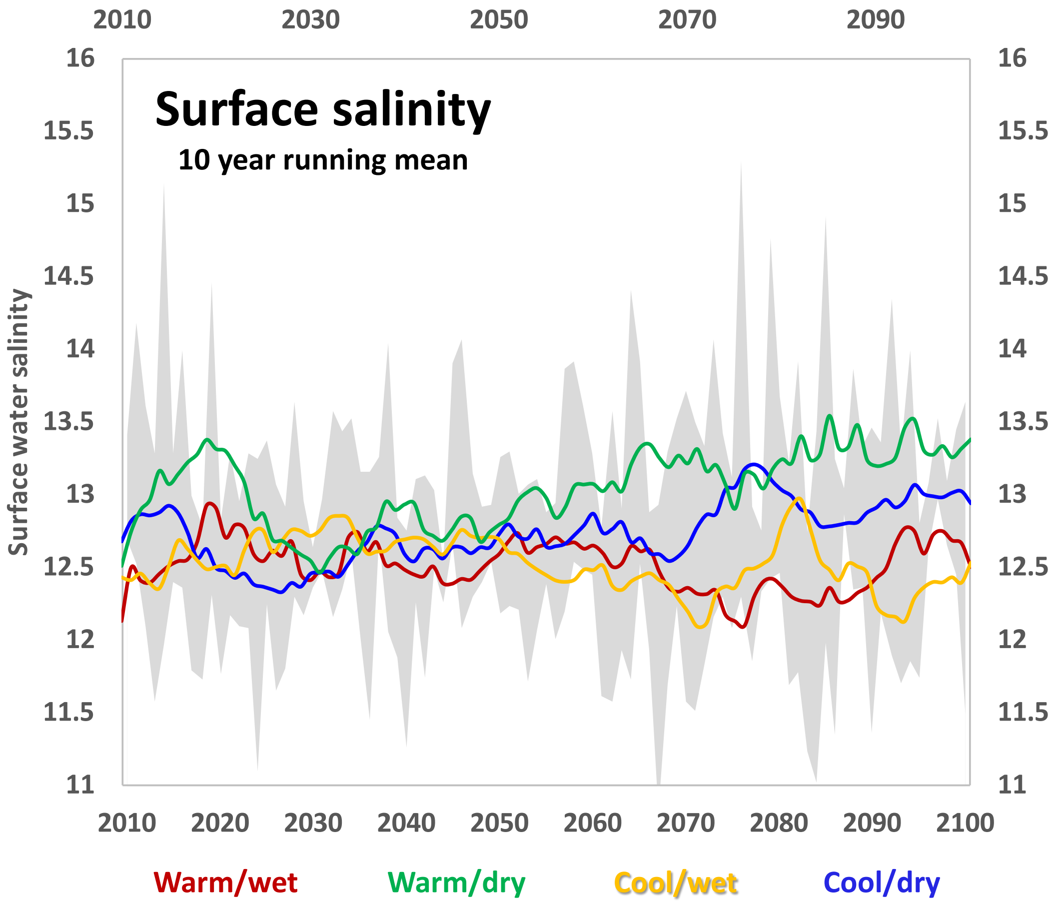


Future projections: estuarine conditions

- Mean surface water temperatures increased >5°C in the warm/wet model, but only 2-3°C in the cool/wet model
- Salinity was strongly variable, reflecting high uncertainty with precipitation, but increased in the two dry models

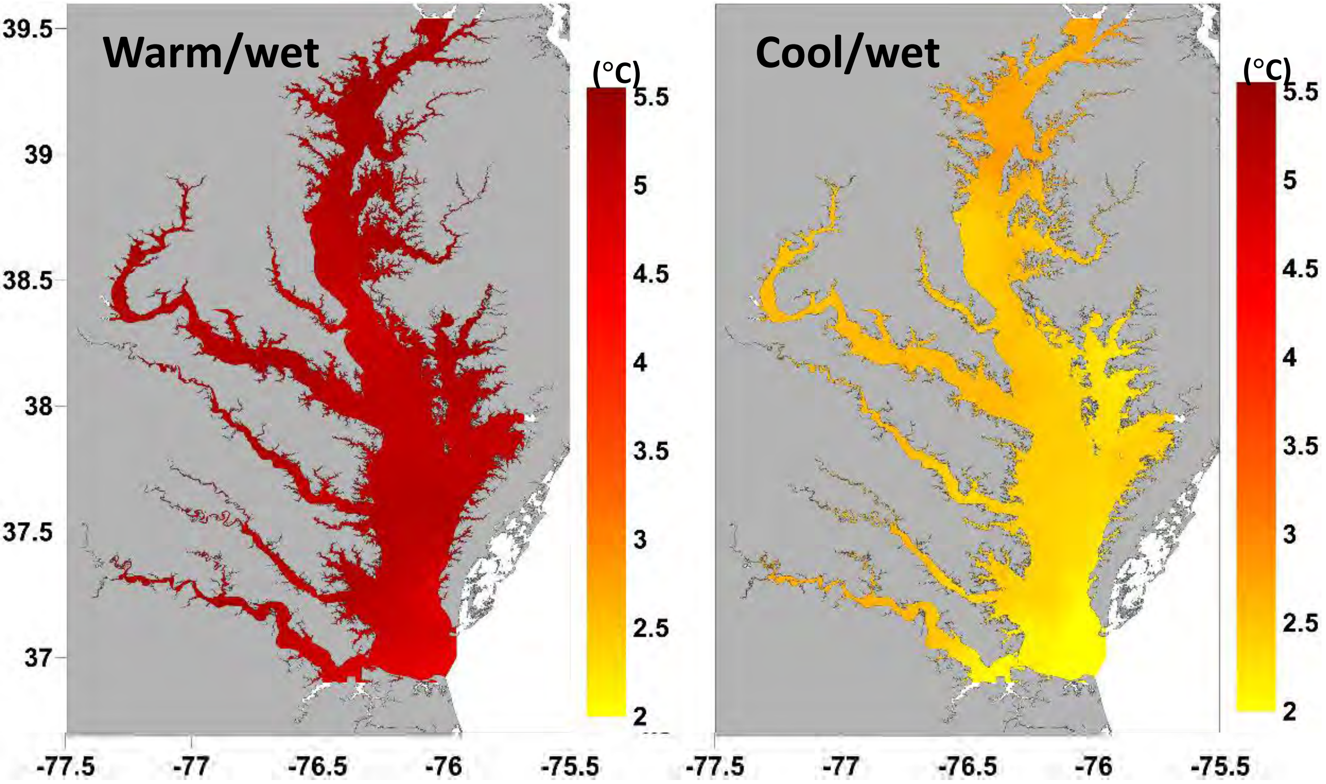




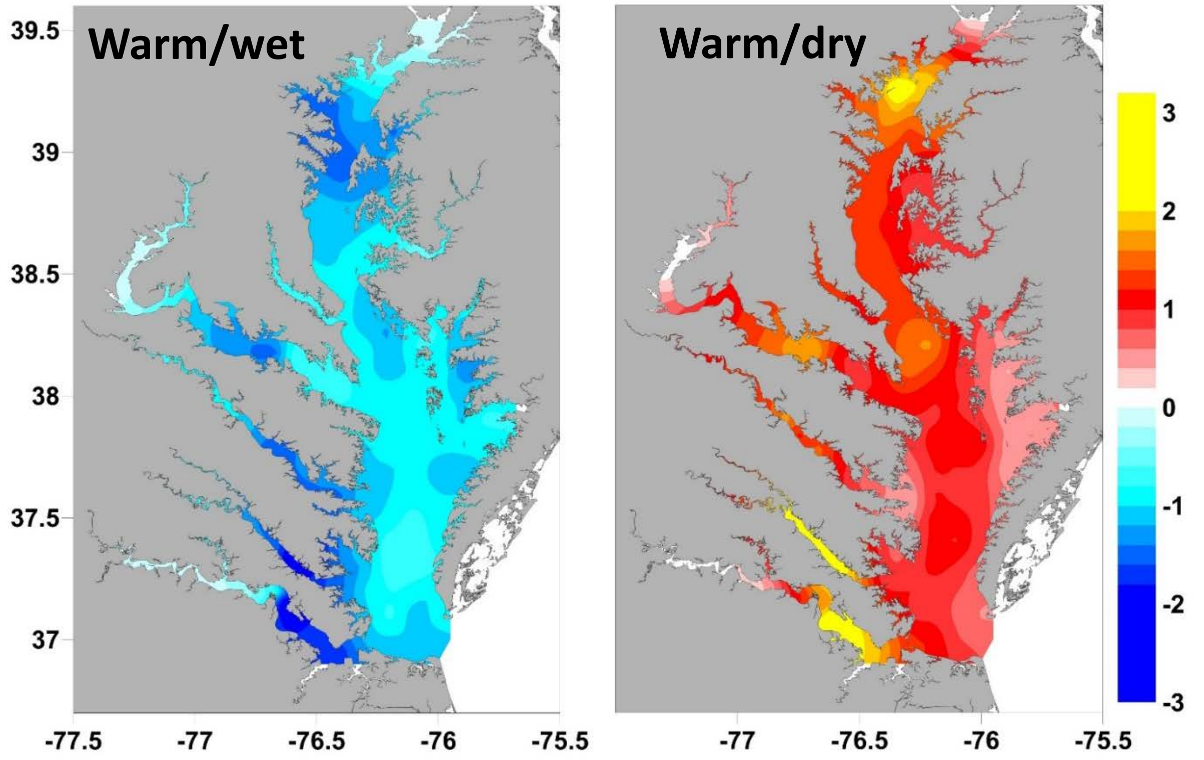
Future projections: estuarine conditions

- *Spatial variability* in warming was less than *inter-model variability*
    - Greatest warming in upper tributaries, less near continental shelf
- Salinity changes greatest in winter – spring, responding to *changing snow melt*
    - Salinity decrease in wetter models, increase in dry models within mesohaline regions

Summer temperature change
1970 - 1999 vs. 2071 - 2100

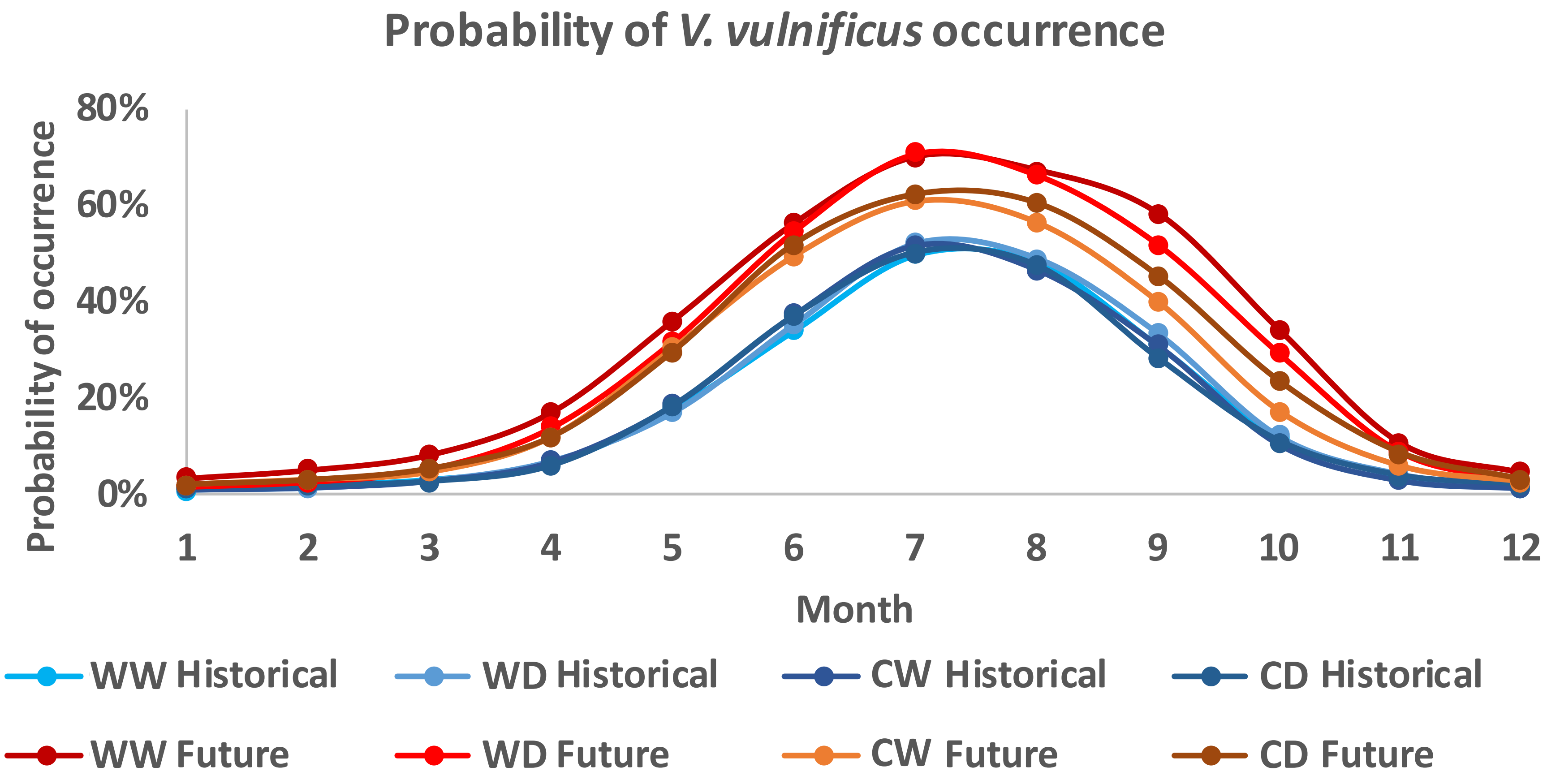


Winter salinity change
1970 - 1999 vs. 2071 - 2100



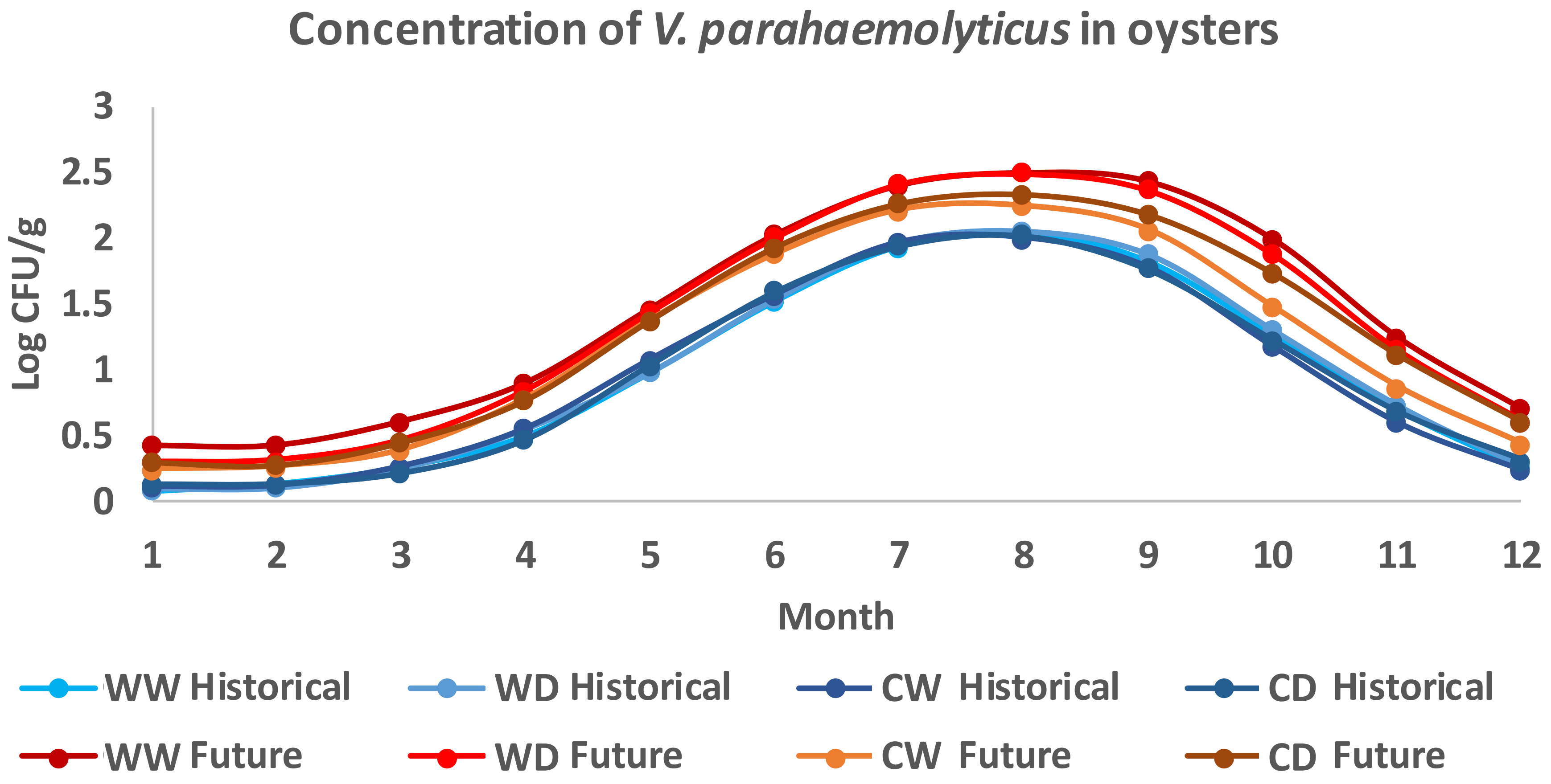
Effects on *Vibrio:*
V. vulnificus

- Increase in probability of occurrence from April through to November
- Summer to fall increases strongest in warmer models, weakest in cool/wet model



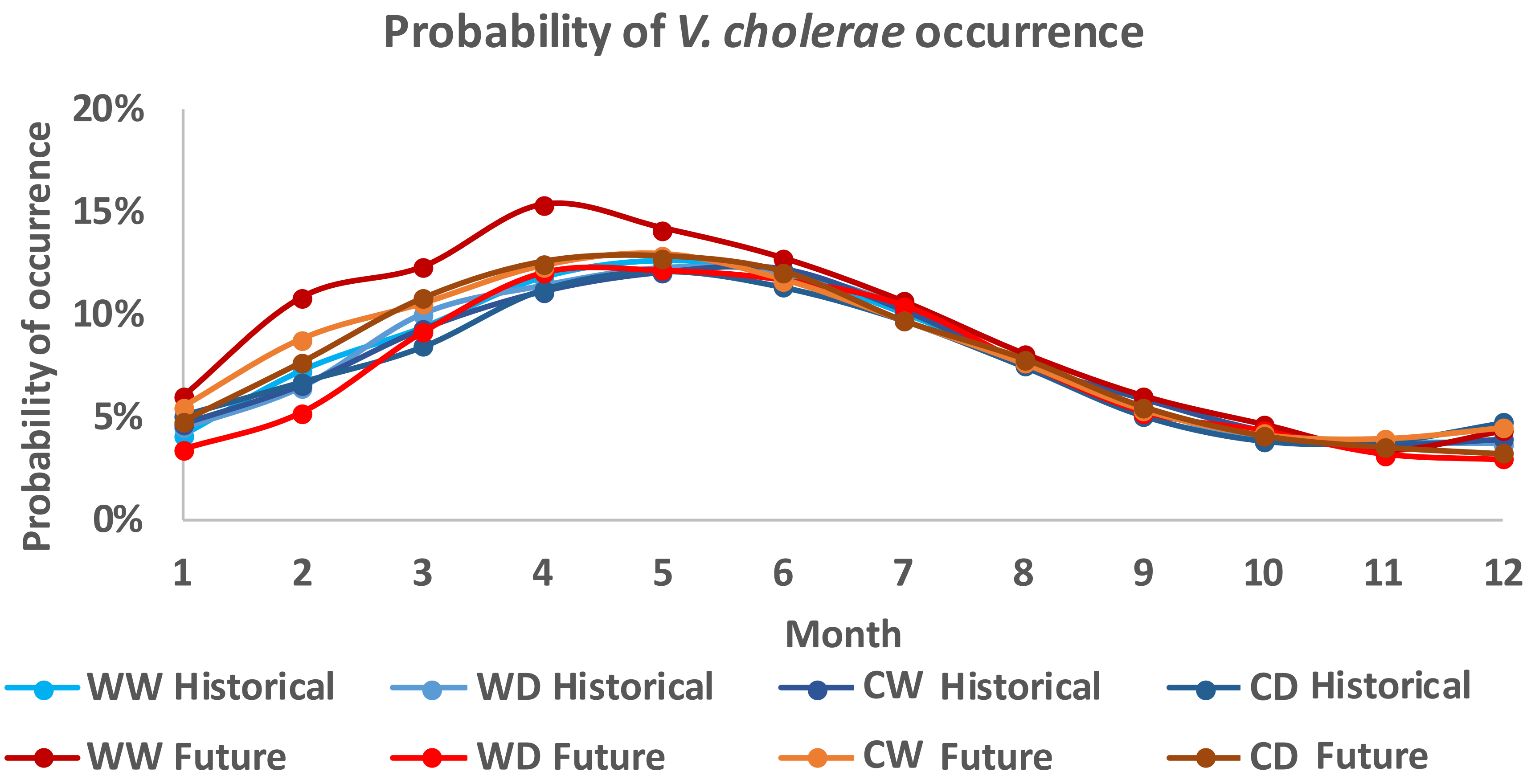
Effects on *Vibrio:*
V. parahaemolyticus

- Increase in predicted concentration in oysters throughout the year
- Models give similar results winter – spring, warmer models associated with higher risk summer - fall



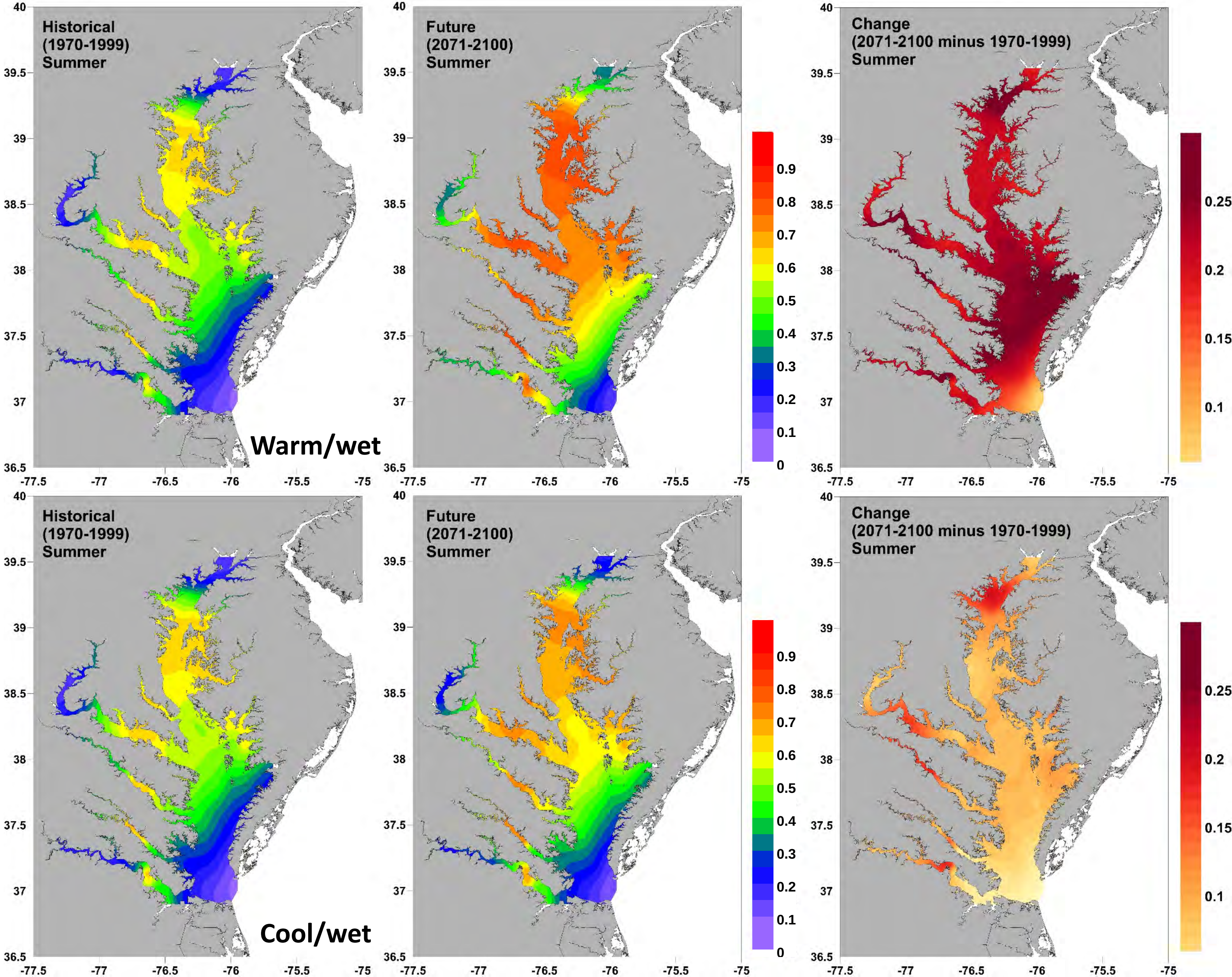
Effects on *Vibrio:*
V. cholerae

- Both wet models projected an increase in probability of occurrence in winter – spring
- Warm/dry model projected a decrease compared to the recent historical period



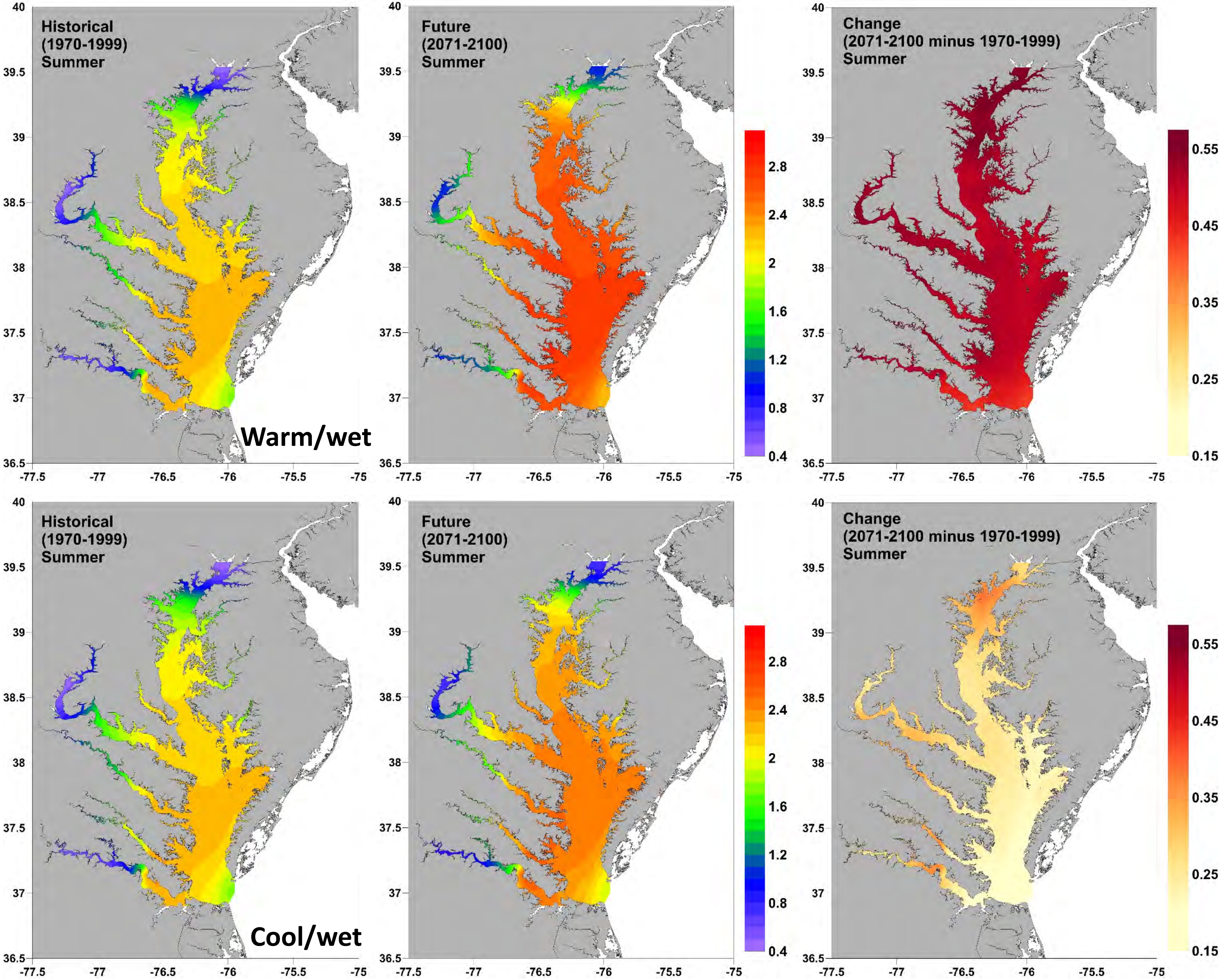
V. vulnificus

- Strongest increases in probability of occurrence in mesohaline regions
- Overall increase in high-risk area



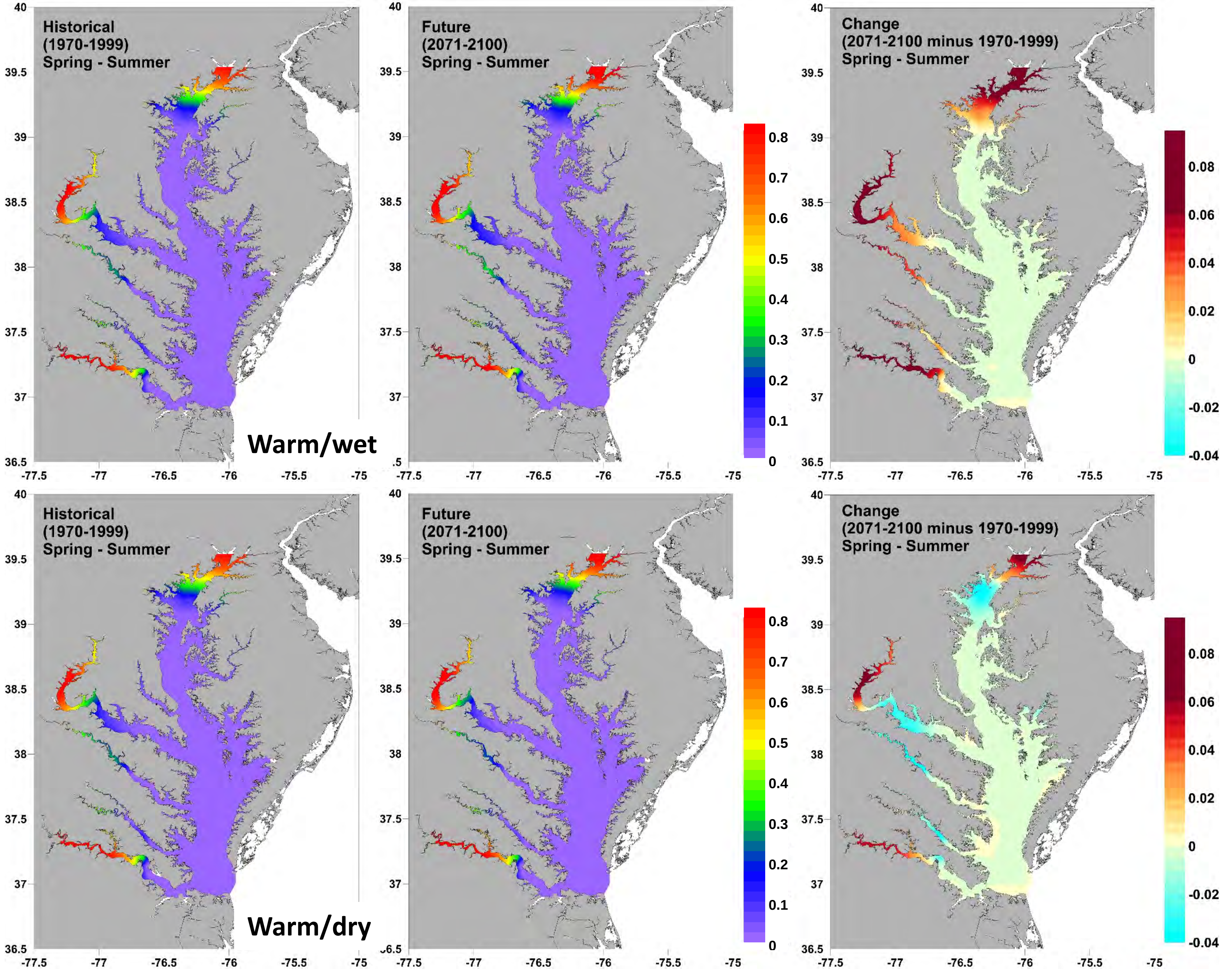
V. parahaemolyticus

- Increases in predicted concentration in oysters throughout most of the Bay
- Except regions where salinity remains < 5 psu



V. cholerae

- High-risk areas remain restricted to low salinity areas
- Warming increases probability of occurrence within these areas
- Dry models project contraction of high-risk areas upstream



Conclusions

- Likely increase in occurrence of *V. vulnificus* in the Chesapeake Bay and increase the mean concentration of *V. parahaemolyticus* in oysters by the end of the 21st century
- In contrast, occurrence for *V. cholerae* may increase only in wetter future, high-risk areas are restricted to low salinity zones of the bay
- The length of the high-risk summer season for *V. vulnificus* and *V. parahaemolyticus* is projected to increase
- Implications for future recreational use and seafood extraction from the Chesapeake Bay, with the potential for considerable economic costs as a result
- Downscaled projections are available for other studies and uses

Future work

- High resolution seasonal forecasts of *Vibrio* risk (Gonzalez-Taboada et al.)

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Questions?

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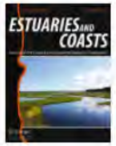

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Research Article

Projections of the future occurrence, distribution, and seasonality of three *Vibrio* species in the Chesapeake Bay under a high-emission climate change scenario

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