Forecasting the effects of climate change on Chesapeake Bay fisheries using physiologically informed habitat models

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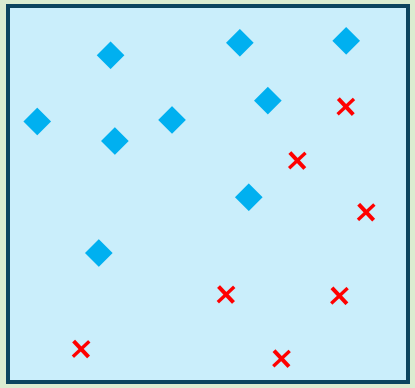
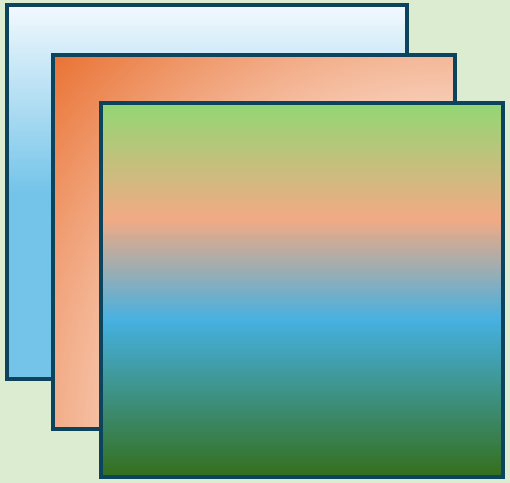
Correlative Habitat Suitability Models

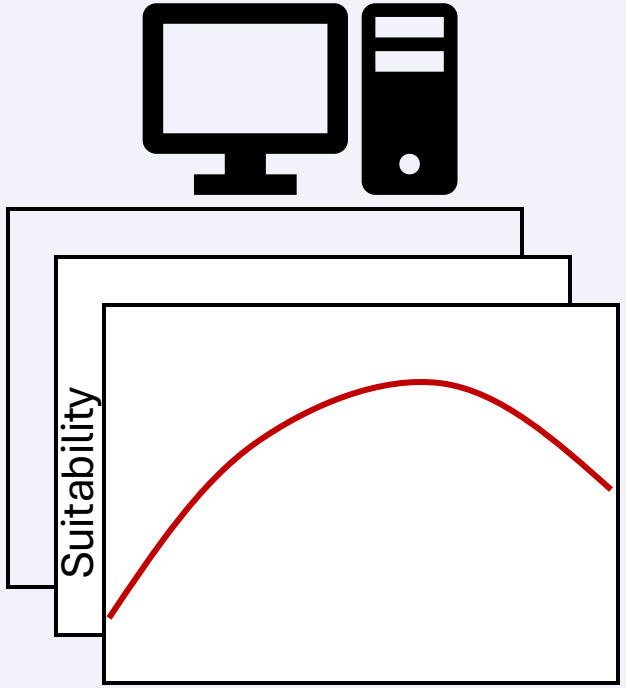
Current Range



Species field observations

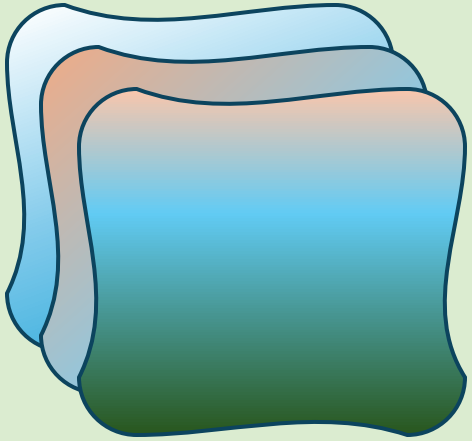


GIS environmental layers



Response curves

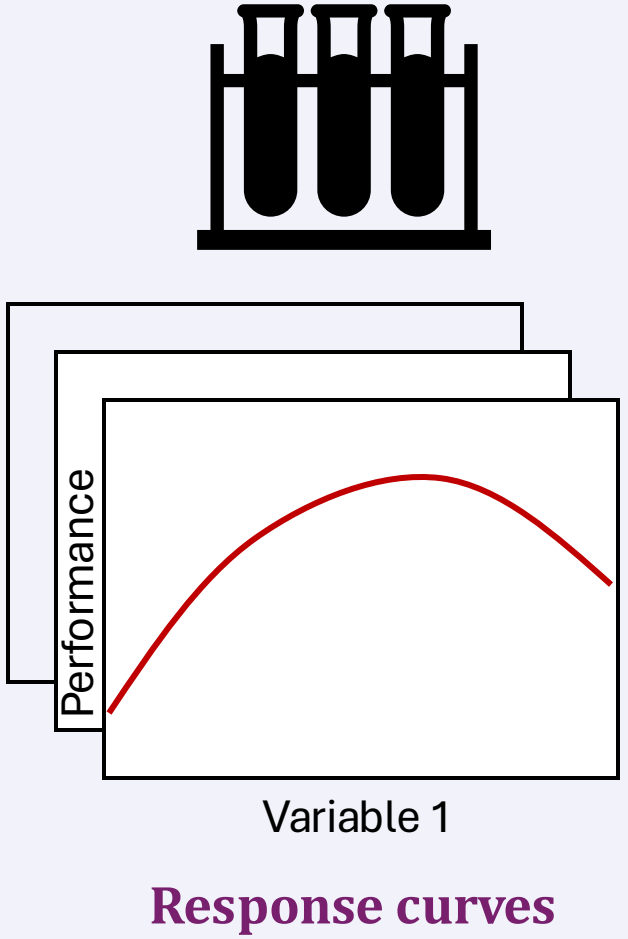
Future Range



GIS environmental layers

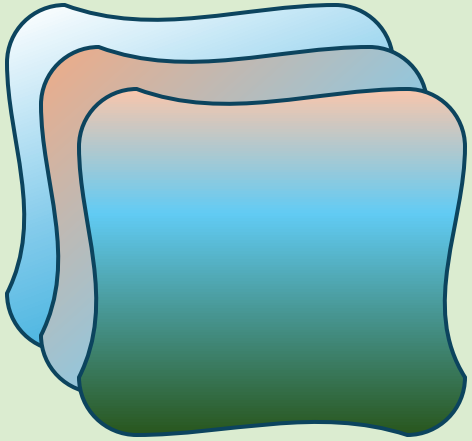
Invasion prediction

Mechanistic Habitat Suitability Models



Response curves

Future Range

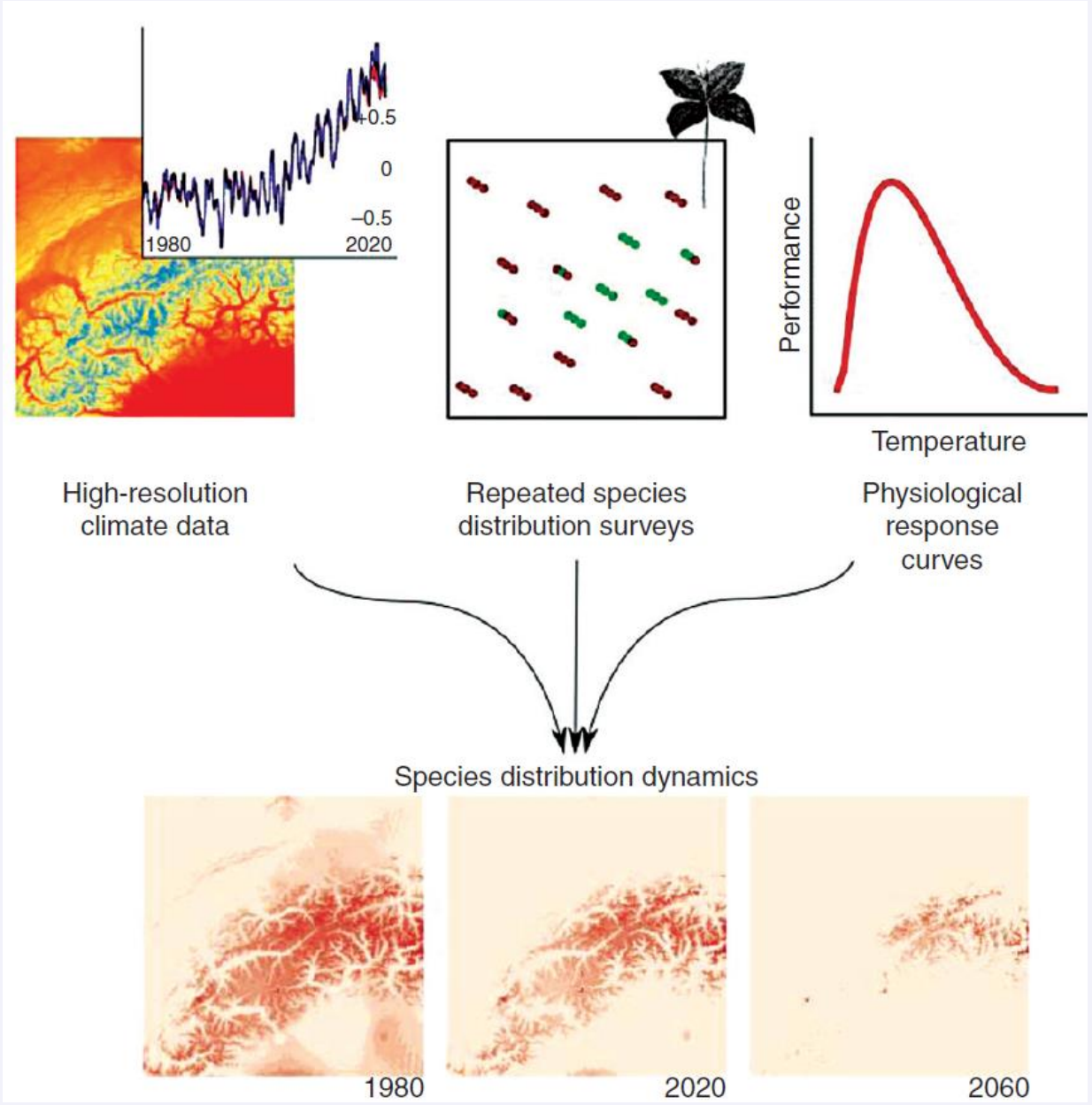


GIS environmental layers

Invasion prediction

“Holy Trinity” of Climate Change Ecology

- High-res climate data
- Repeated surveys
- Physiological response curves

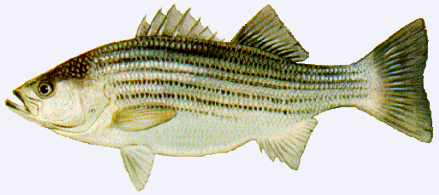


Lembrechts 2020

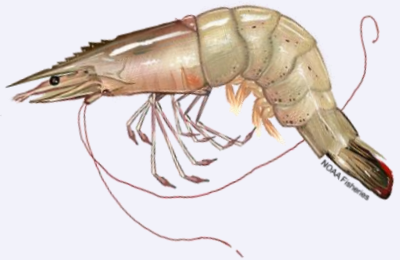
Objectives

- To quantify suitable habitats for five Chesapeake Bay species under historical and present-day climate conditions, and
- To project and quantify suitable habitats for study species under future climate conditions

Bay Anchovy



Striped Bass

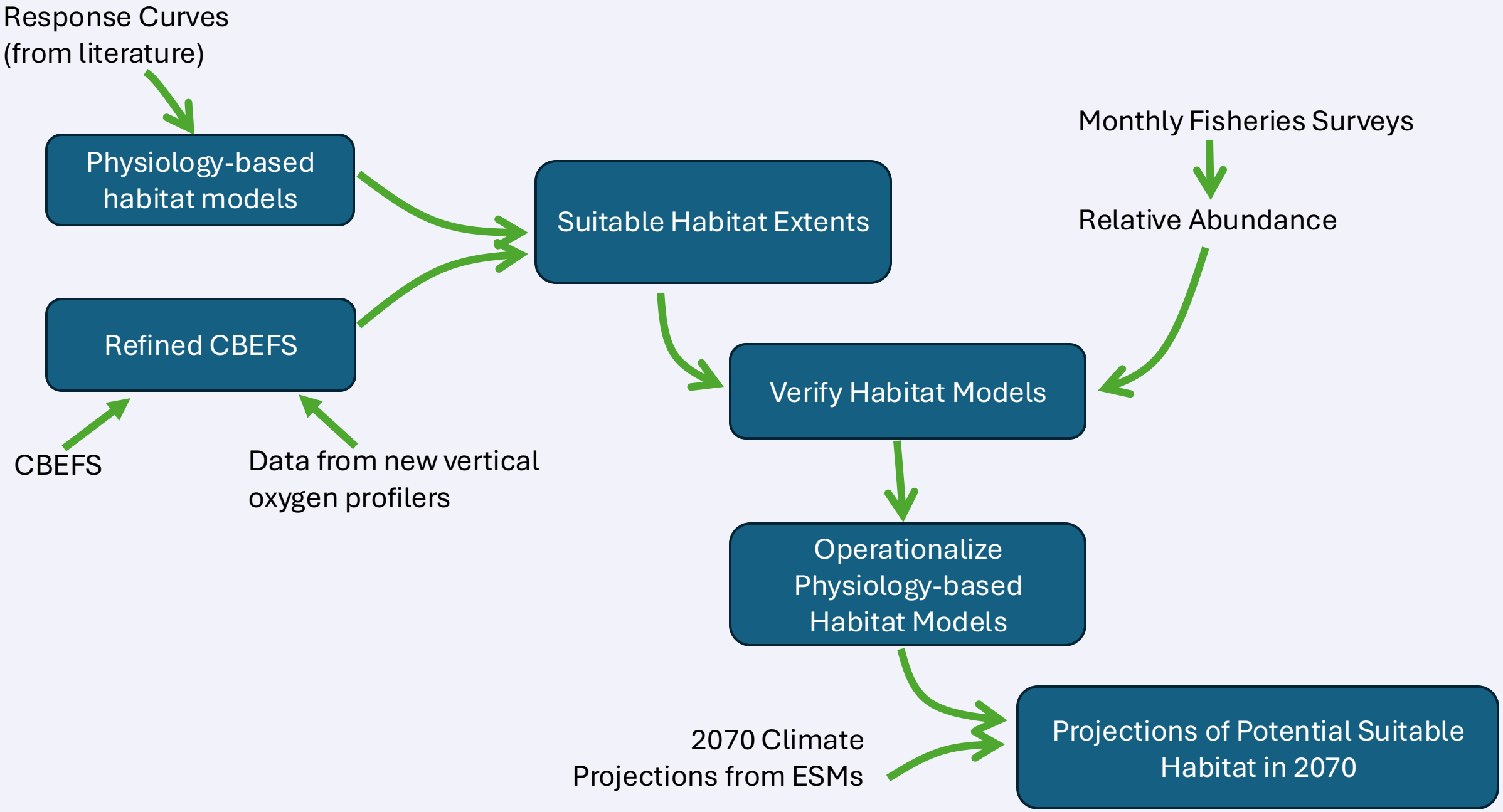


White Shrimp

Atlantic Menhaden

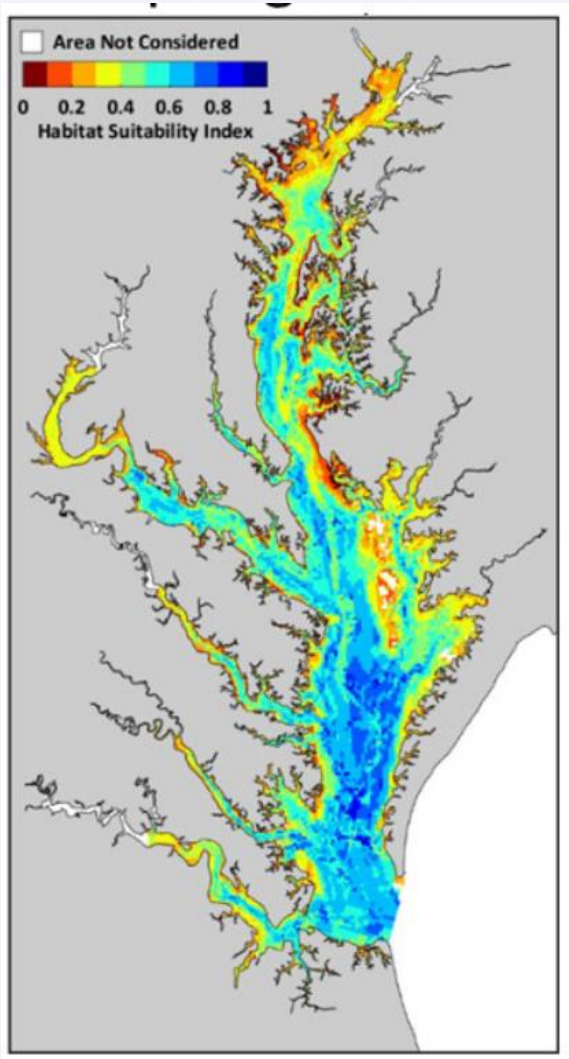
Atlantic Croaker

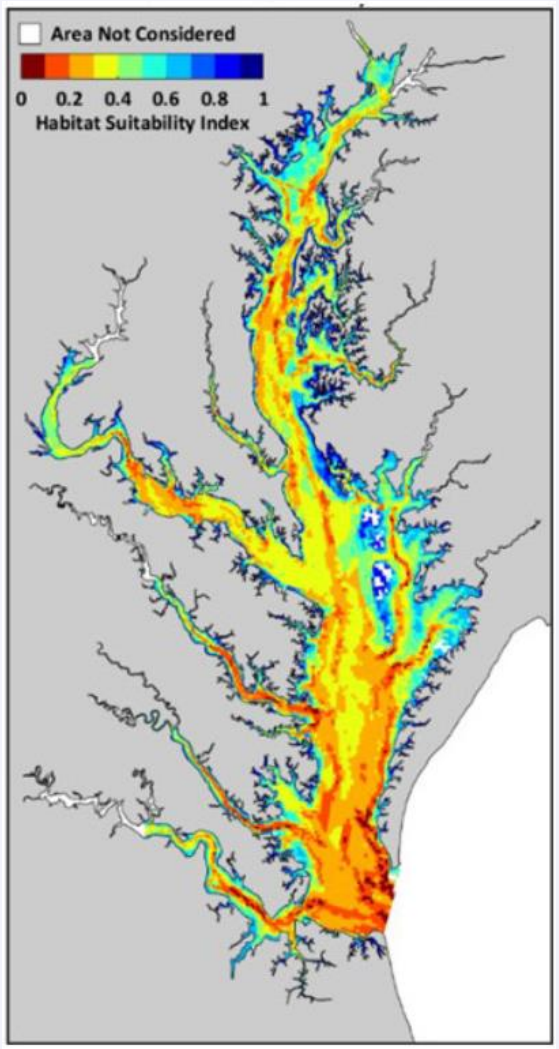
Spot


Response Curves
(from literature)
Physiology-based
habitat models
Refined CBEFS
CBEFS
Data from new vertical
oxygen profilers
Suitable Habitat Extents
Monthly Fisheries Surveys
Relative Abundance
Verify Habitat Models
Operationalize
Physiology-based
Habitat Models
2070 Climate
Projections from ESMs
Projections of Potential Suitable
Habitat in 2070

Species Overlap

Species A



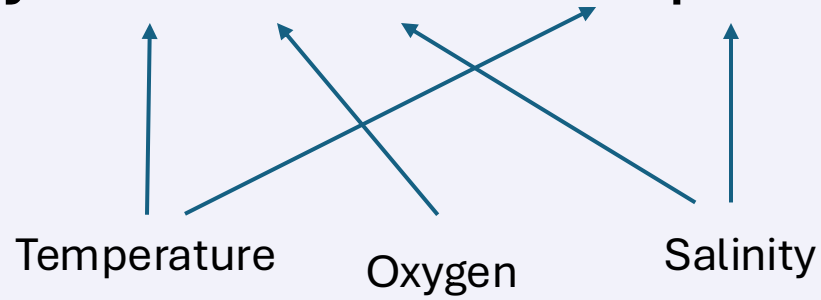


Species B

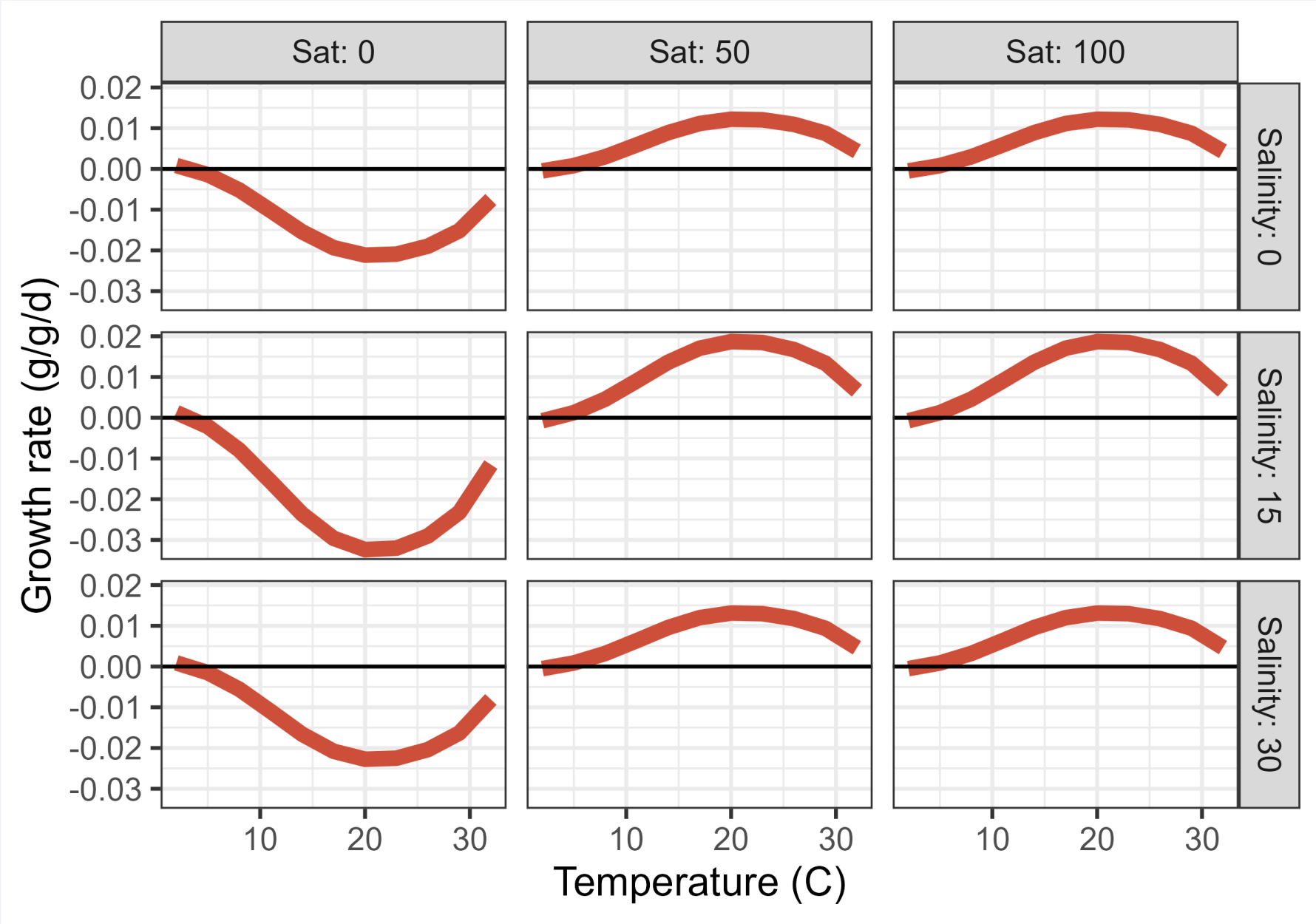
HSI from literature: Bioenergetics

Energy Consumed = Respiration + Waste + Growth

Growth = Energy Consumed - Respiration - Waste

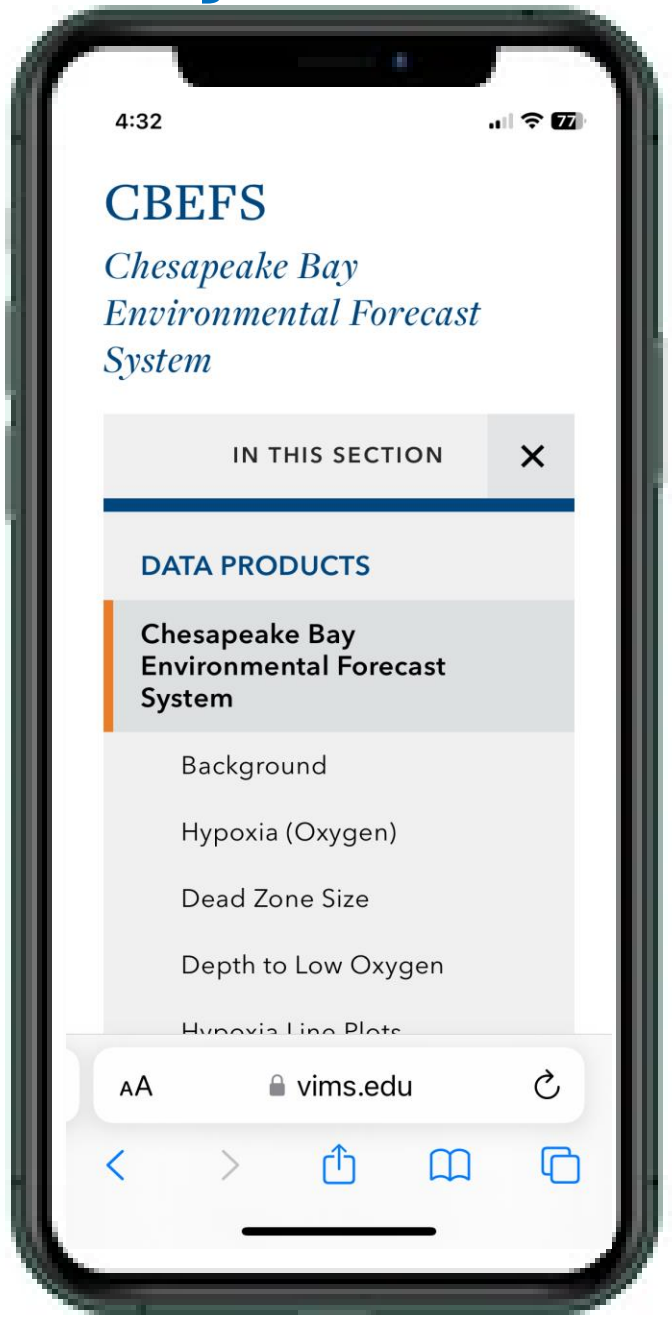


Example: Atlantic Croaker

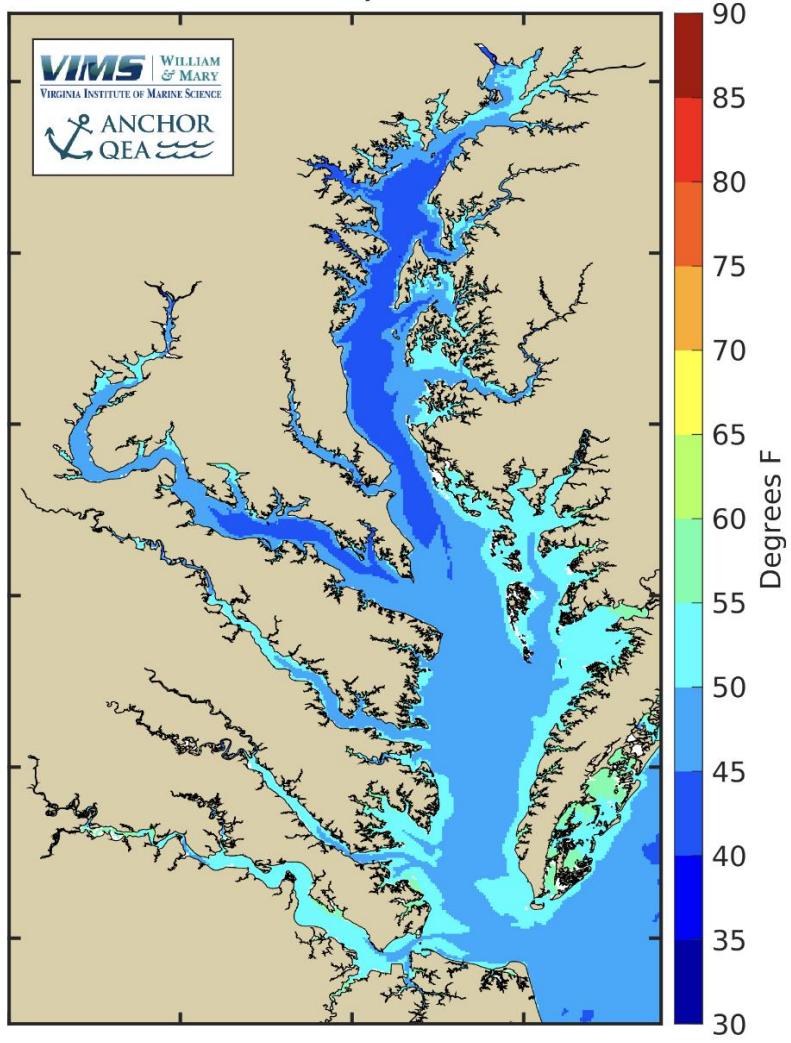


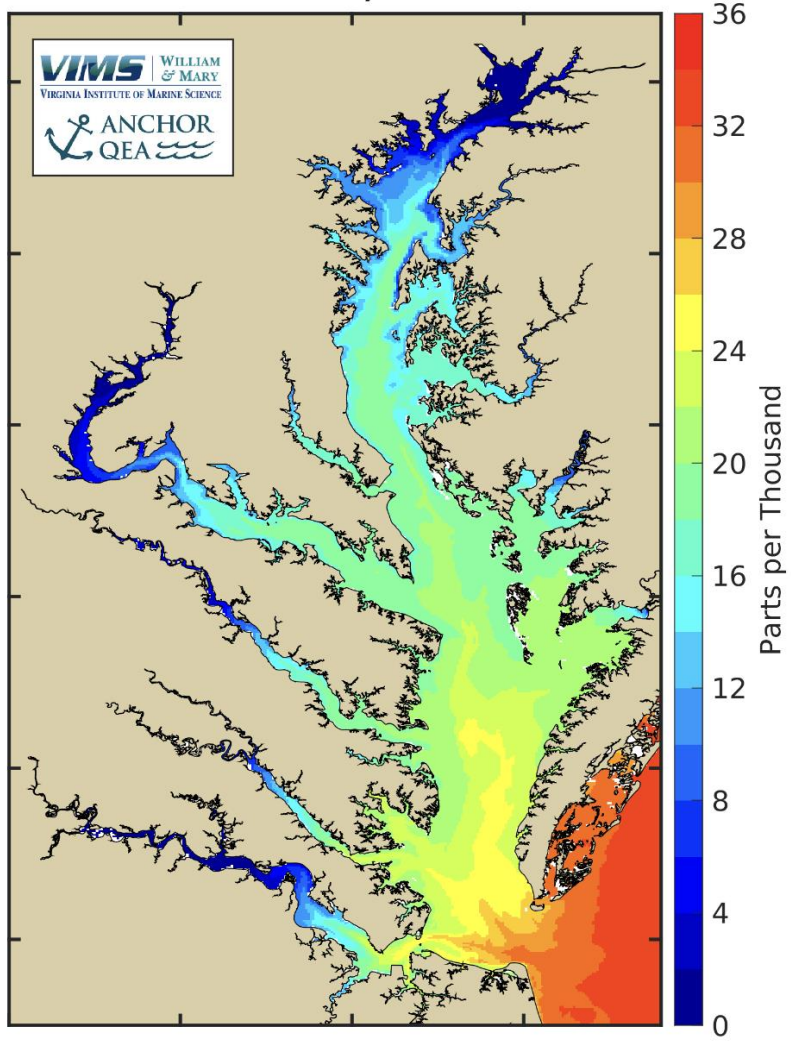
Chesapeake Bay Environmental Forecast System (CBEFS)

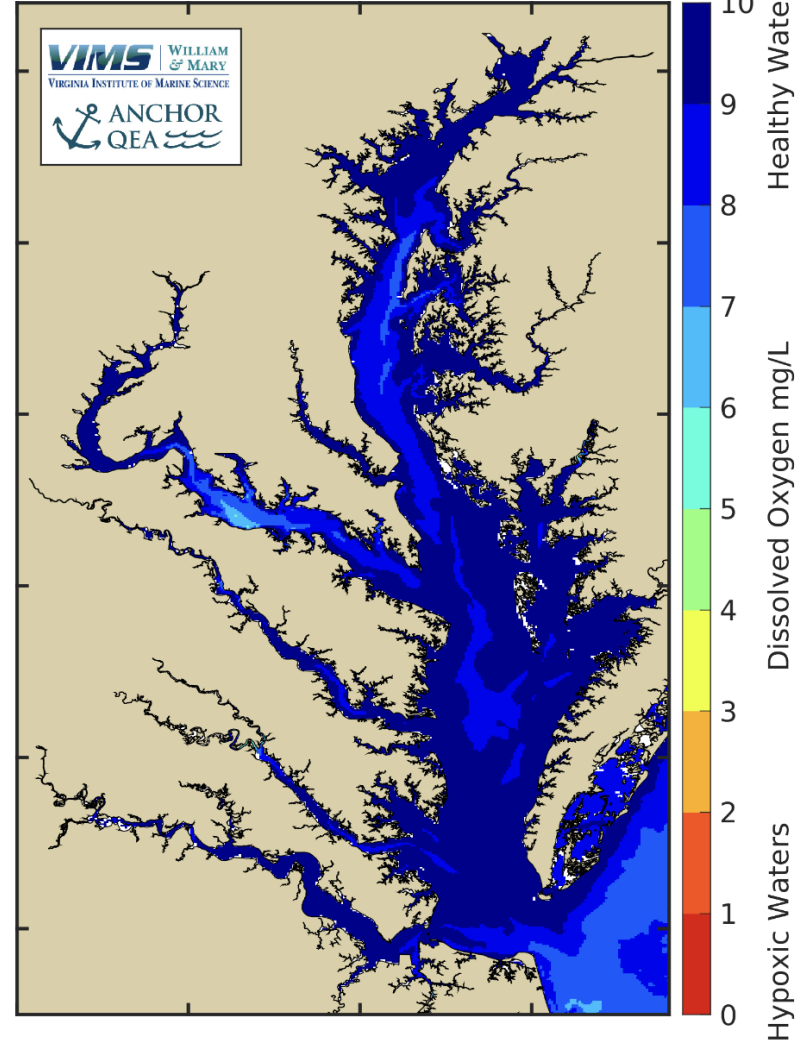
vims.edu/cbefs



CBEFS forecasts for today: March 25th, 2025







ROMS-ECB – coupled hydrodynamic-WQ model

Feng et al, 2015; St-Laurent and Friedrichs, 2024

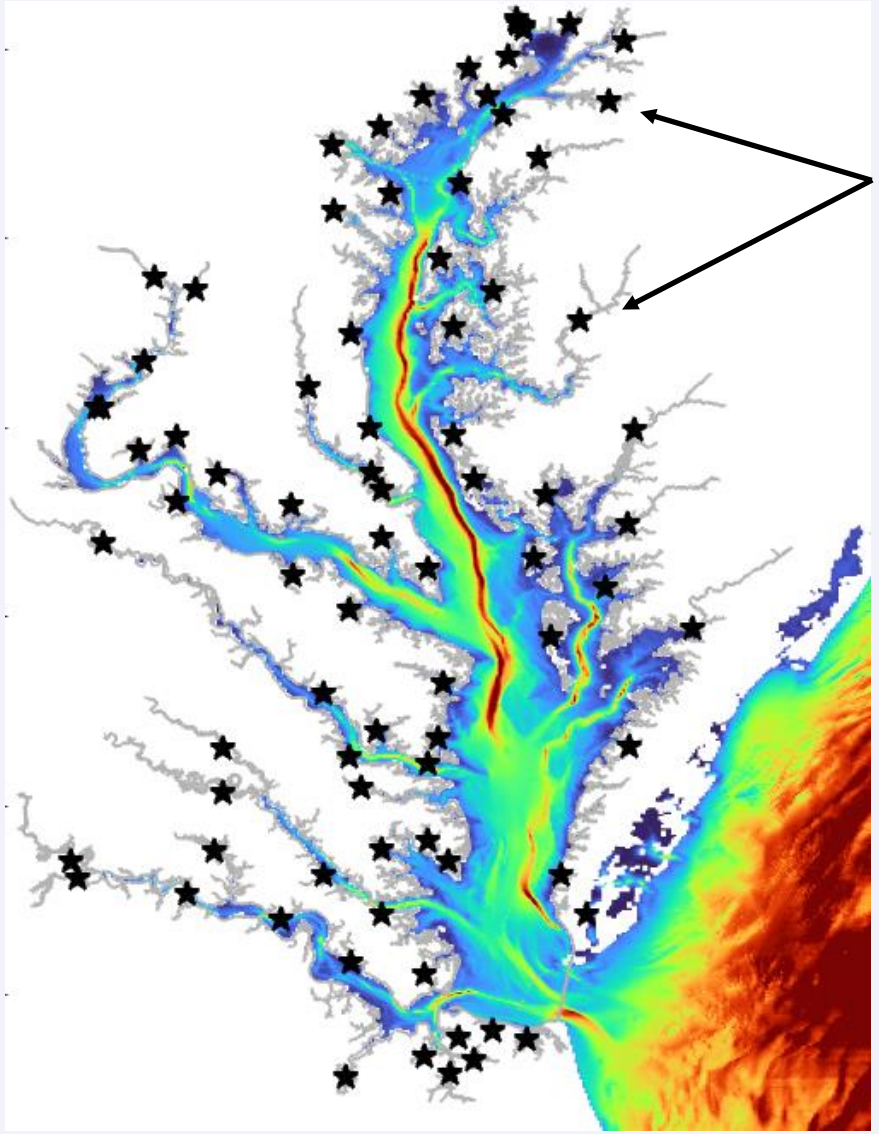
Modeling System:

Regional Ocean Modeling System (ROMS)

600m x 600m resolution
20 vertical layers

Estuarine Carbon and Biogeochemistry (ECB)

Full carbon & nitrogen cycles
Sinks & sources of O_2
Air/sea exchanges
Wetting & drying
Biogeochemical fluxes at bed
Sediment transport module



Forcing:

Terrestrial ★

CBP's Phase 6 watershed model & USGS data

Atmospheric

ERA5 Reanalysis; NAM forecasts

Oceanic

In situ data climatologies

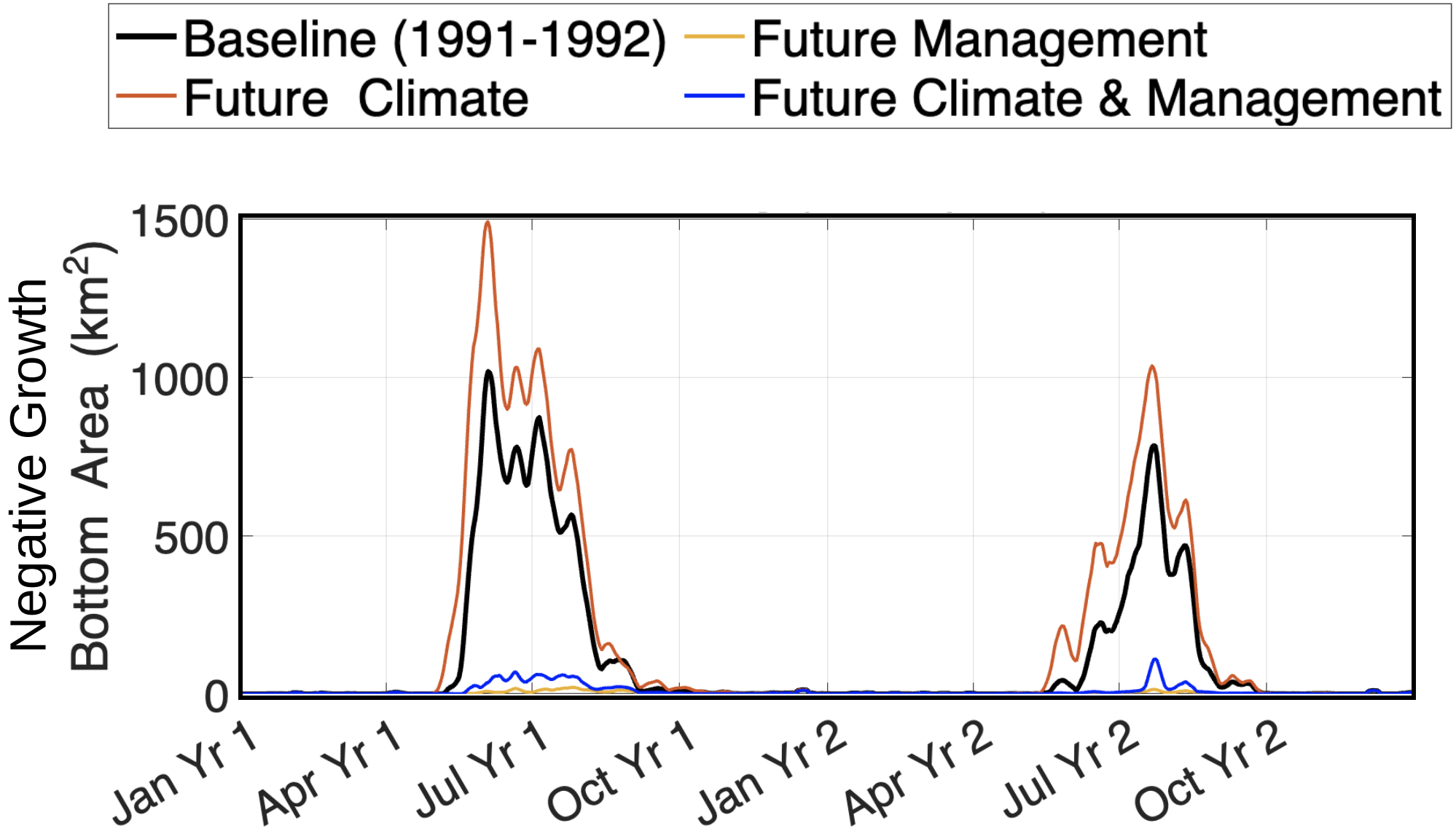
Data collected from stations throughout the Bay from 1985 to present were used to develop and evaluate the model

Baseline and future experiments

Model Runs	Forcing Conditions
Baseline	Realistic 1990's conditions
Future Climate	Climate deltas applied • Representative of 2070s • One Earth System Model & downscaling; one emissions scenario - Warmer air temperatures and higher sea level
Future Management	Assume nutrient reductions (TMDLs) have been achieved
Future Climate & Management	Climate deltas applied • Representative of 2070s • One Earth System Model & downscaling; one emissions scenario - Warmer air temperatures and higher sea level Assume nutrient reductions (TMDLs) have been achieved

Ongoing dissertation work by Colin Hawes (VIMS)

Bottom Area of Negative Growth for Small (8g) Croaker



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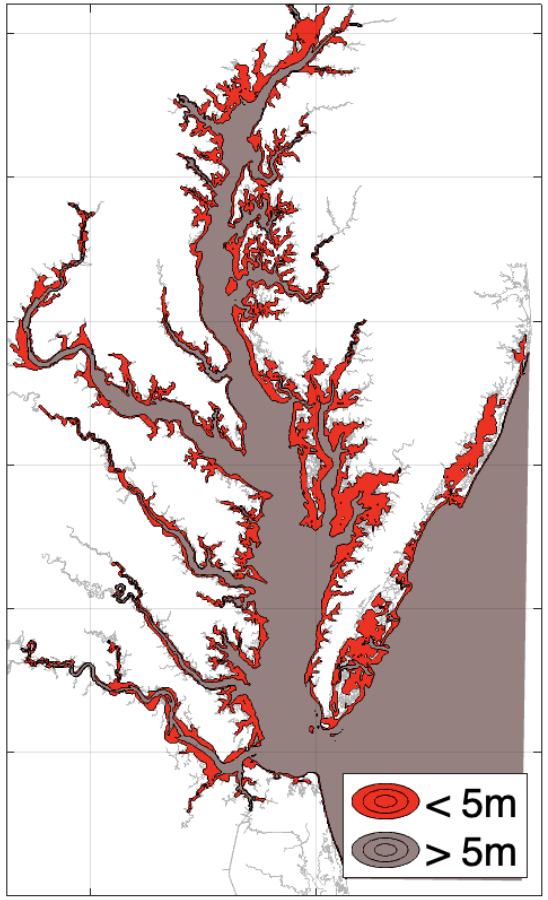

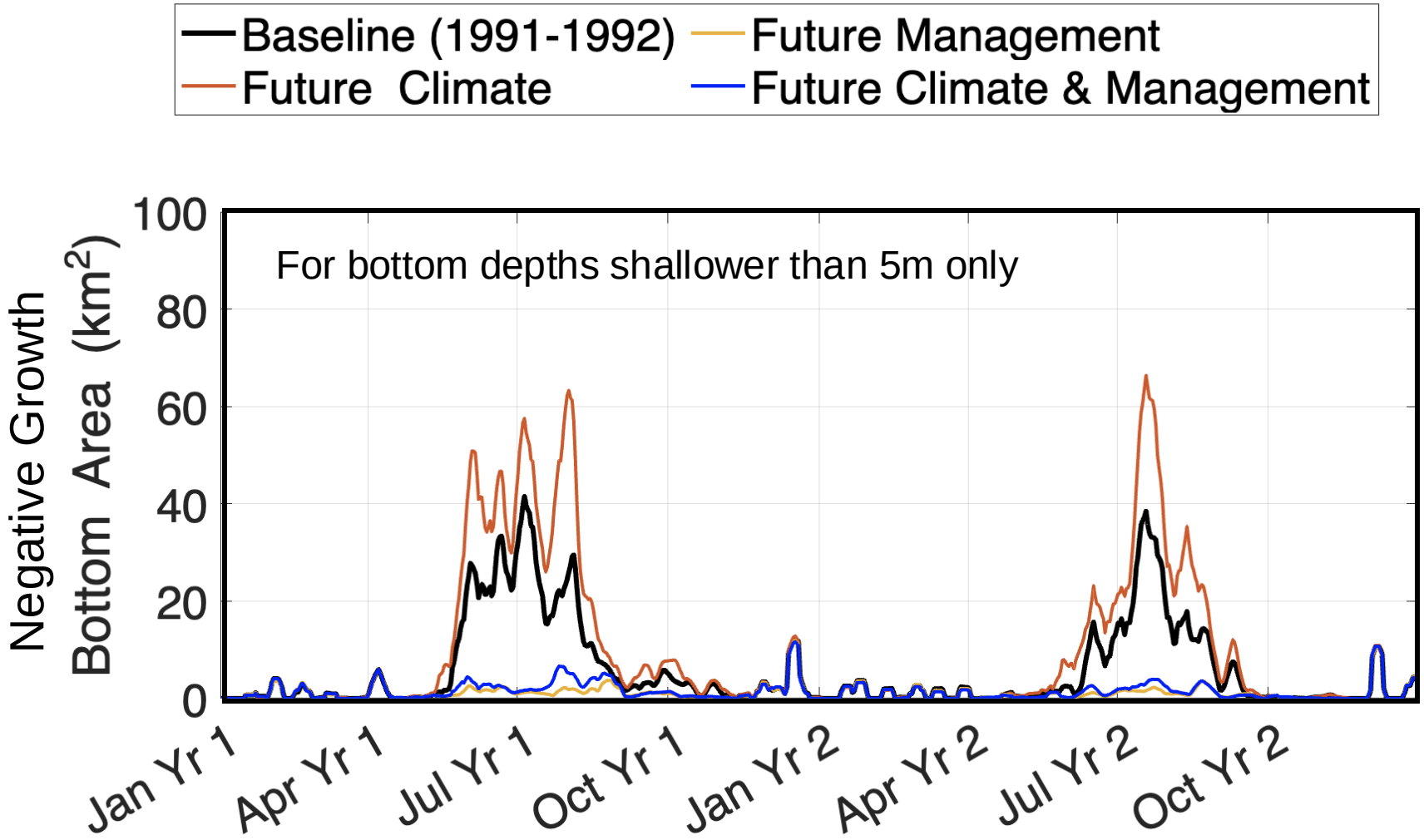

Summary

- Small croaker (8g) are impacted most by hypoxia
  - Future management dramatically improves habitable area
  - Future climate slightly decreases habitable area
- Lots to do!
  - Additional Earth System Models (ESMs)
  - Addition years (wet vs. dry)
  - Additional emission scenarios
  - Define an appropriate habitat suitability index (0 to 1)
  - Examine larger croaker
  - Examine other species (volume rather than area)