

Habitat Suitability for Forage Fishes in Chesapeake Bay

Aug 2017 – Jul 2019



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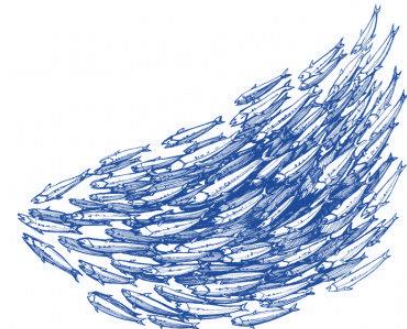
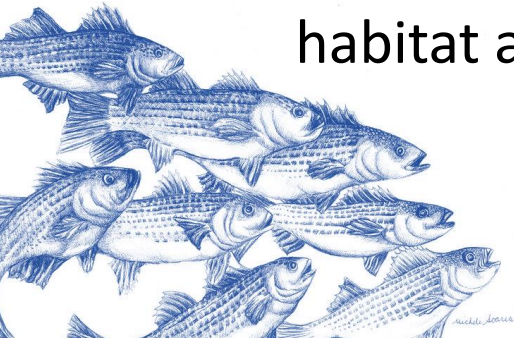
Michael L MacWilliams

21 June 2018

Photo: Chesapeake Bay Program

Motivation

- Production of sufficient forage fish is recognized as critical to advancing EBM
- Factors affecting local abundances and habitat conditions necessary to support forage production remain unexplored
- Objectives:
 - Quantify suitable habitat for forage species in Chesapeake Bay on a seasonal and annual basis
 - Assess the relationship between extent of suitable habitat and annual forage abundance



Habitat Suitability Models

- Numerically dominant forage species in Bay
 - Bay anchovy
 - Juvenile spot
 - Juvenile weakfish
 - Juvenile spotted hake
- Present year-round, occupy pelagic & benthic habitats
- Couple information from

- fishery surveys → catch

- spatio-temporally interpolated model → dO_2

- 3-D hydrodynamic model → temperature, salinity, current speed, sediment composition, depth

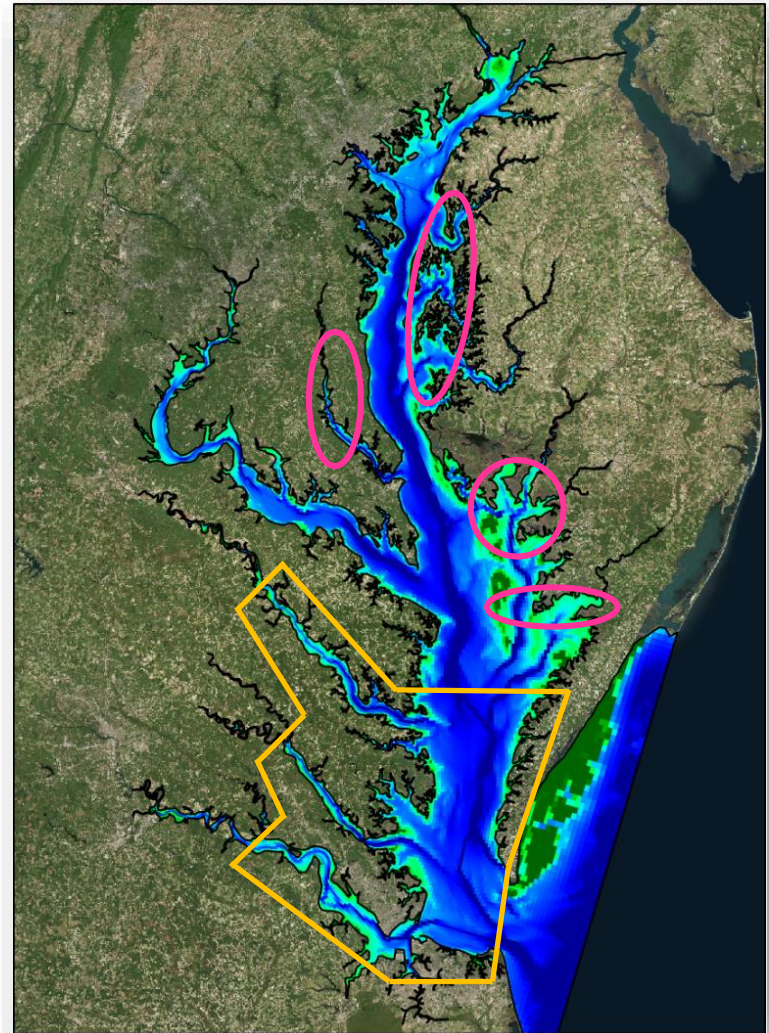
Allow us to extend the characterization of habitat beyond what is measured at the time of capture

The not-so-charismatic fauna:



Data Source: Fishery Surveys

- Bottom-trawl surveys
 - VIMS
 - Jan – Dec 111 sites/mon
 - MD DNR
 - May – Oct 53 sites/mon
- Monthly catches from 2000-2016

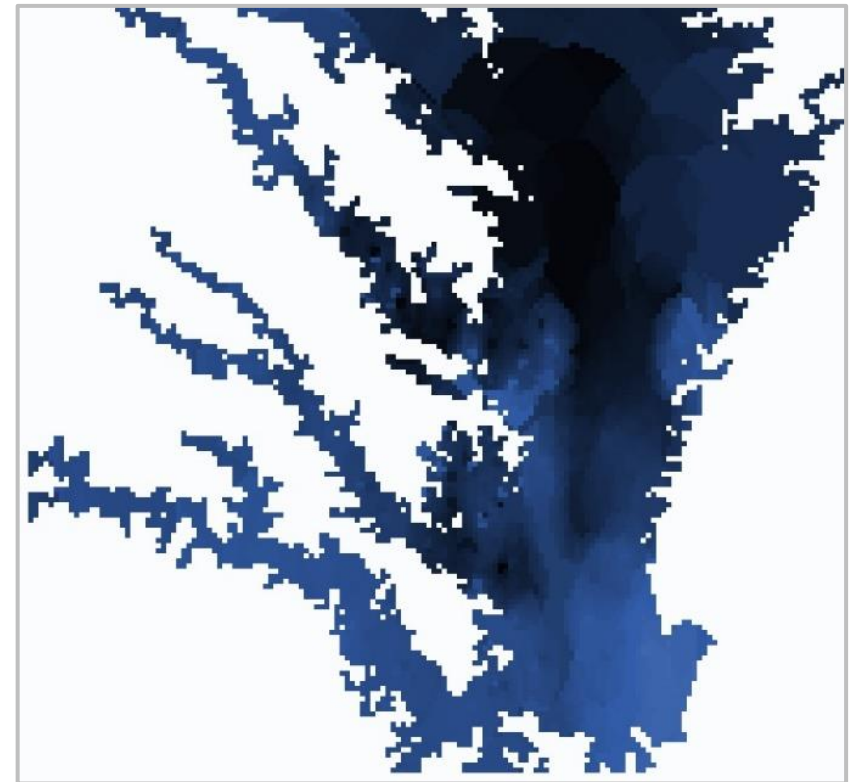


- VIMS trawl survey extent
- MD trawl survey extent

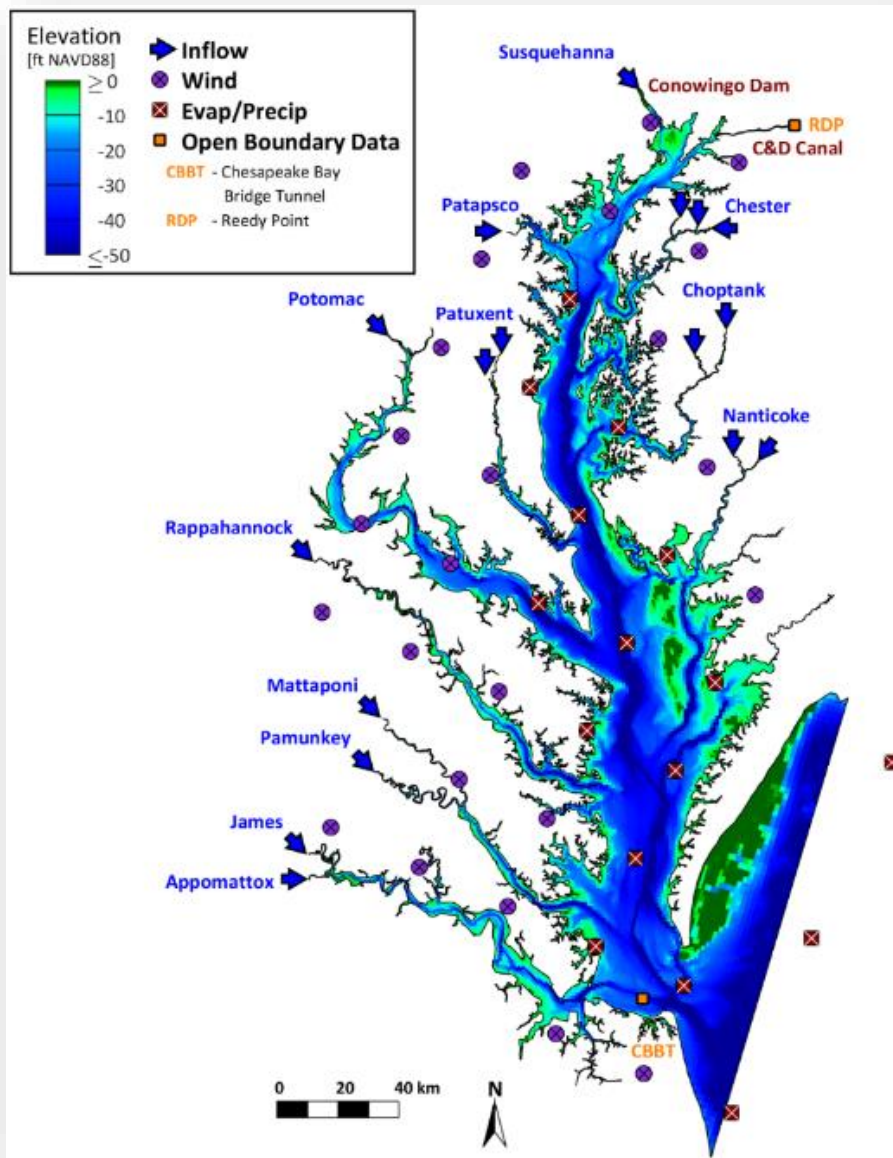
Data Source: Spatio-Temporal Model of dO₂

- dO₂ modeled in each 1-km² grid cell
 - 15-min records from VECOS and MD Eyes on the Bay
 - Monthly CBP water quality monitoring program
 - Monthly fisheries surveys
- Interpolations:
 - Spatial interpolation via inverse distance weighting
 - Temporal interpolation via linear models

Dissolved O₂ Conditions, July 2011

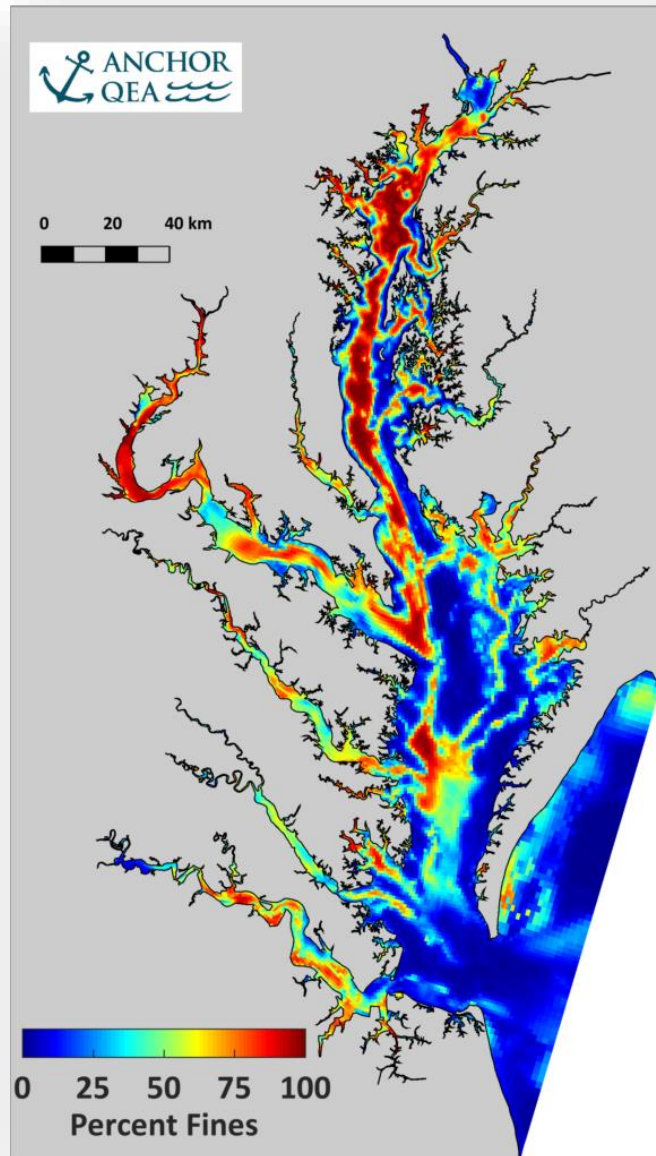


Data Source: 3D Hydrodynamic Model

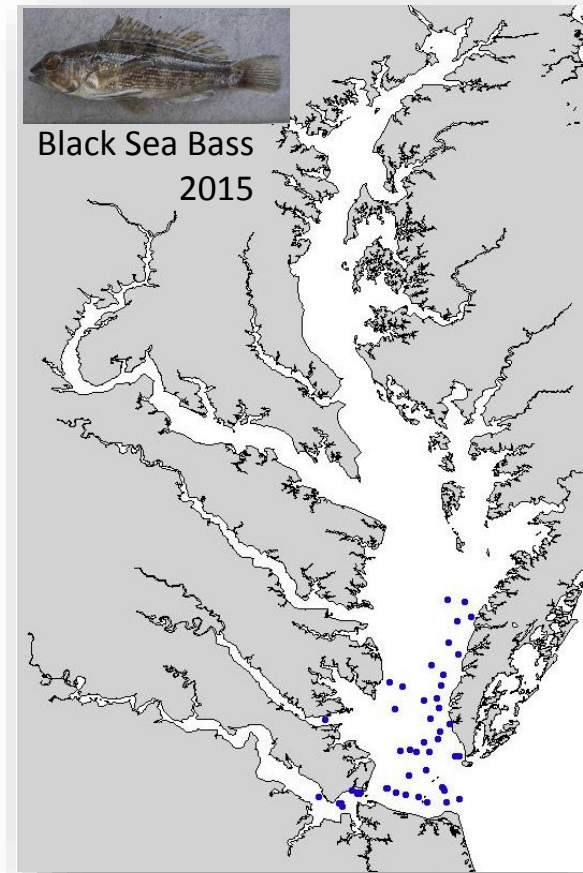


- Dynamic habitat features:
 - Near-bed salinity
 - Depth-averaged salinity
 - Salinity stratification
 - Percent of time that salinity is within a given range
 - Time- and depth-averaged current speed
 - And many more.....
- Static habitat features:
 - Depth
 - Sediment composition

Data Source: Sediment Composition



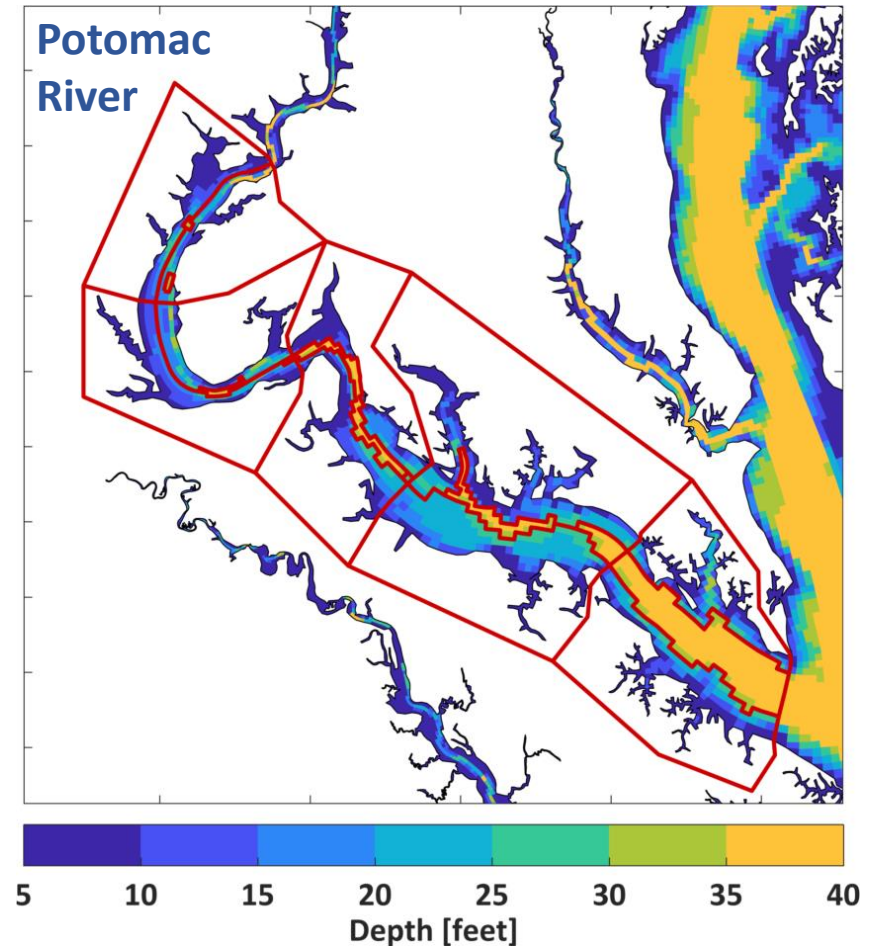
- First examination of relationship between forage fishes and sediments in the bay



Modeling Approach

1. Delineate contiguous polygons for habitat analysis

- Polygons = spatial units of analysis
- 15 polygons in Potomac River
 - 5 along the axis of the river
 - 3 from shore-to-shore (shoal, channel, shoal)
 - 30-ft contour is boundary between shoal & channel
- 15 polygons in each VA tributary
- Various polygons in each of the 9 subestuaries in MD
- 37 polygons in the bay
- **TOTAL = 142 polygons**



Modeling Approach

1. Delineate contiguous polygons for habitat analysis
2. Compute relative abundance of forage species in each polygon
3. Estimate dynamic & static habitat features in each polygon
4. Develop forage-fish habitat suitability models for the 4 species
5. Quantify and visualize suitable habitats seasonally & annually
6. Relate area of suitable habitat to forage abundance



Conceptual Habitat Model for Juvenile Spotted Hake

- Habitat suitability index (HSI)
 - 0=relatively low abundance
 - 1=relatively high abundance



Regression Tree Analysis

- Salinity Stratification > 2 psu
- Temp. Stratification $> 1^{\circ}$ C
- Bottom Temperature $< 20^{\circ}$ C

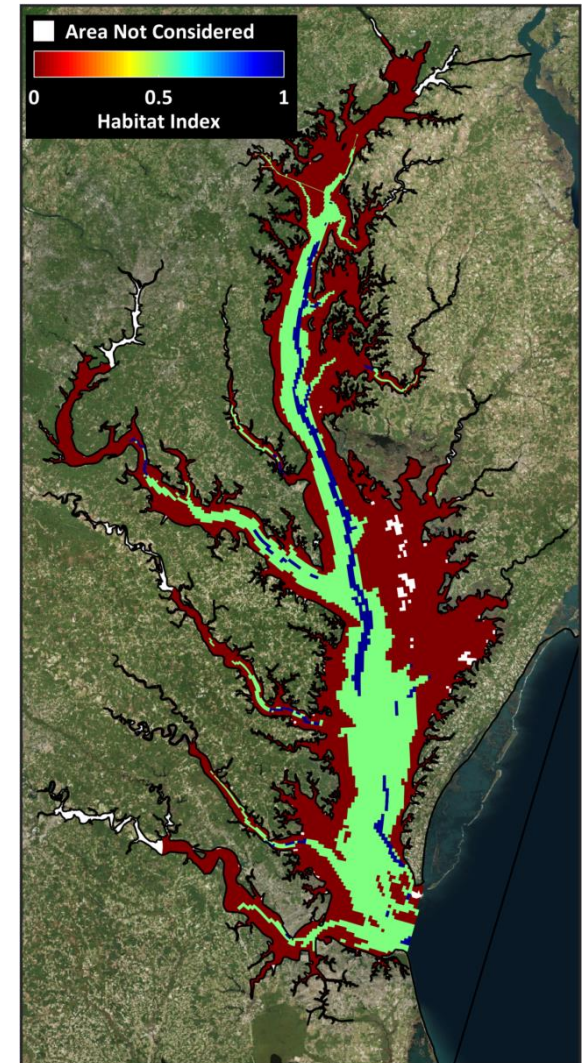
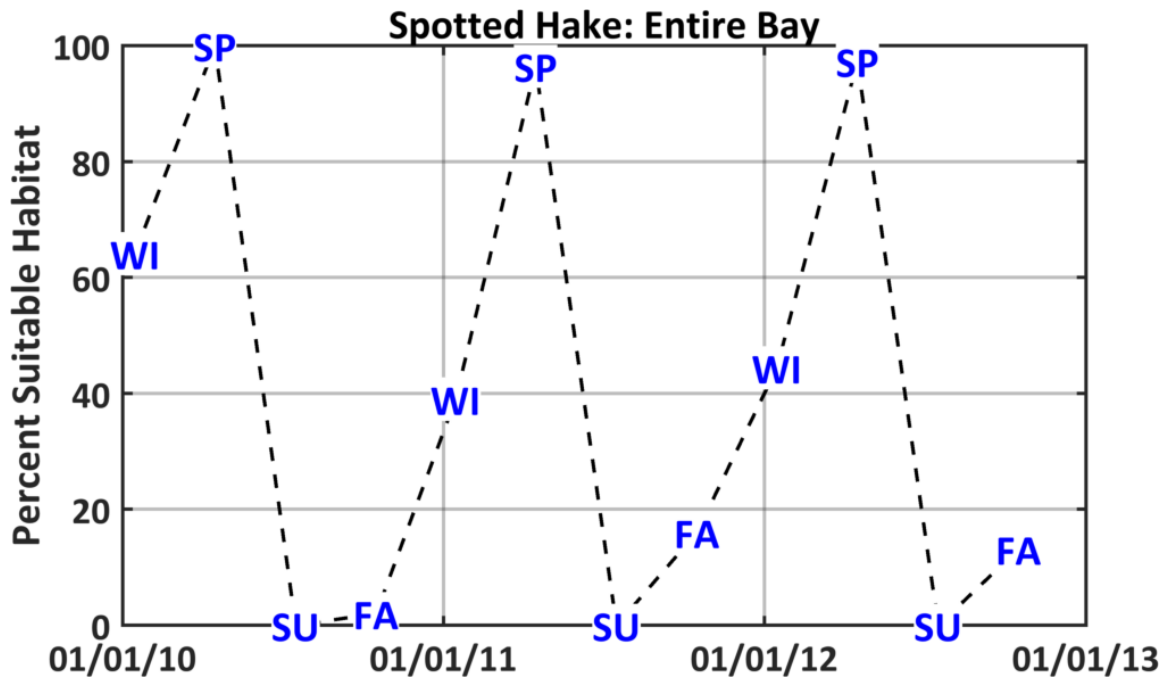
AND

- Depth < 7.5 m \rightarrow HSI = 0.0
- Depth between 7.5 and 20 m \rightarrow HSI = 0.5
- Depth > 20 m \rightarrow HSI = 1.0

Mar 2010 – May 2010

Seasonal Variation in HSI

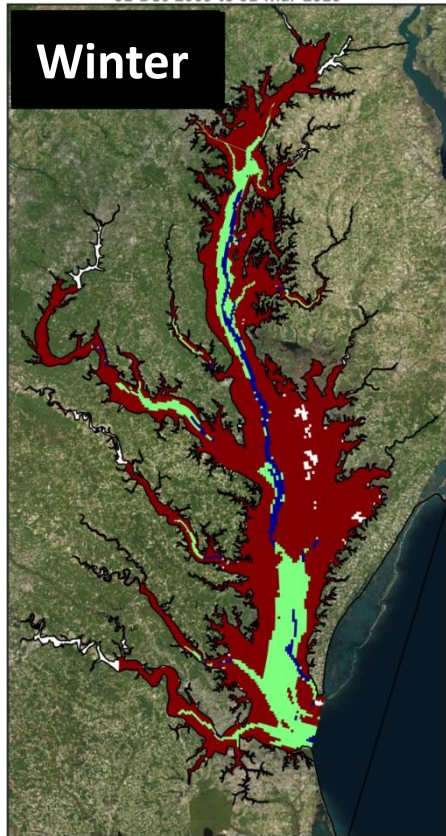
- Habitat quantified using 3-mon averages



- Relatively high abundance
- Average abundance
- Relatively low abundance

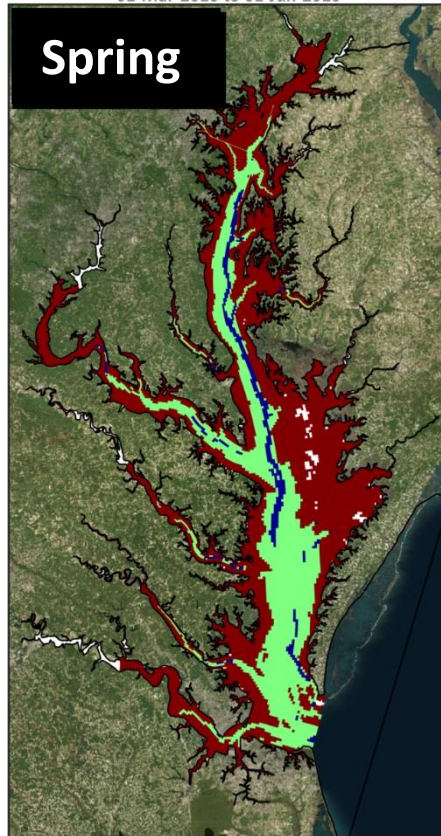
*Based on preliminary, simplified HSI model

Seasonal Variation in HSI (2010)



Winter

Dec - Feb



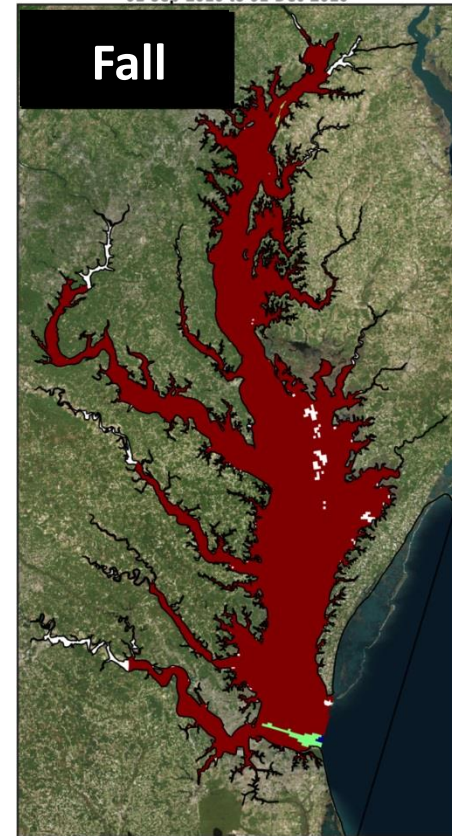
Spring

Mar - May



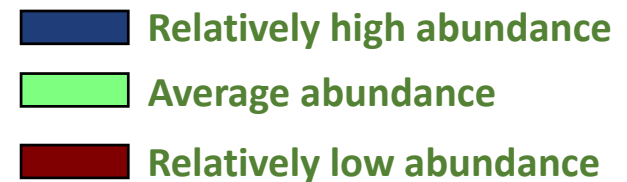
Summer

Jun - Aug



Fall

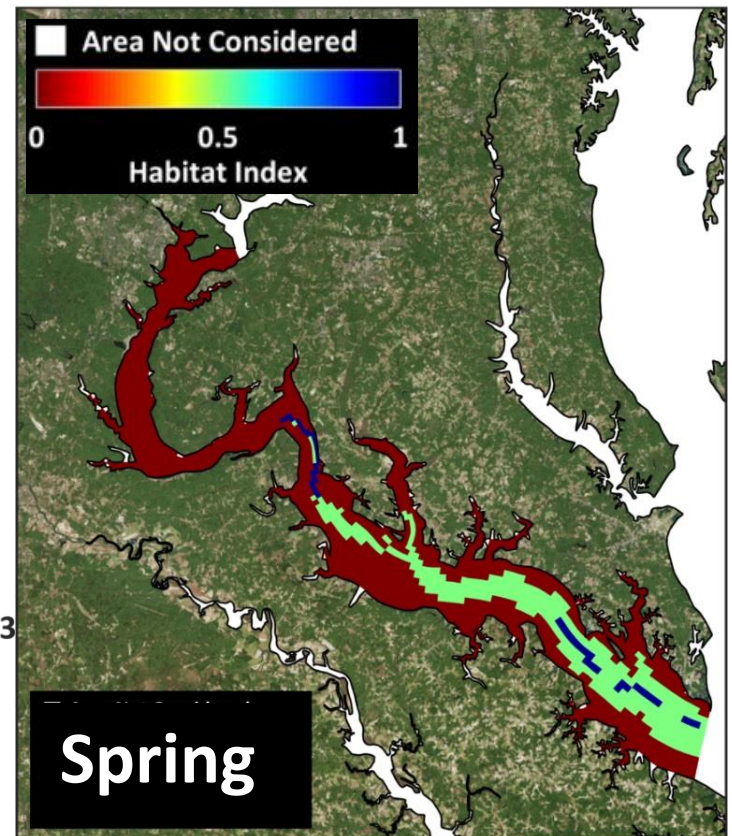
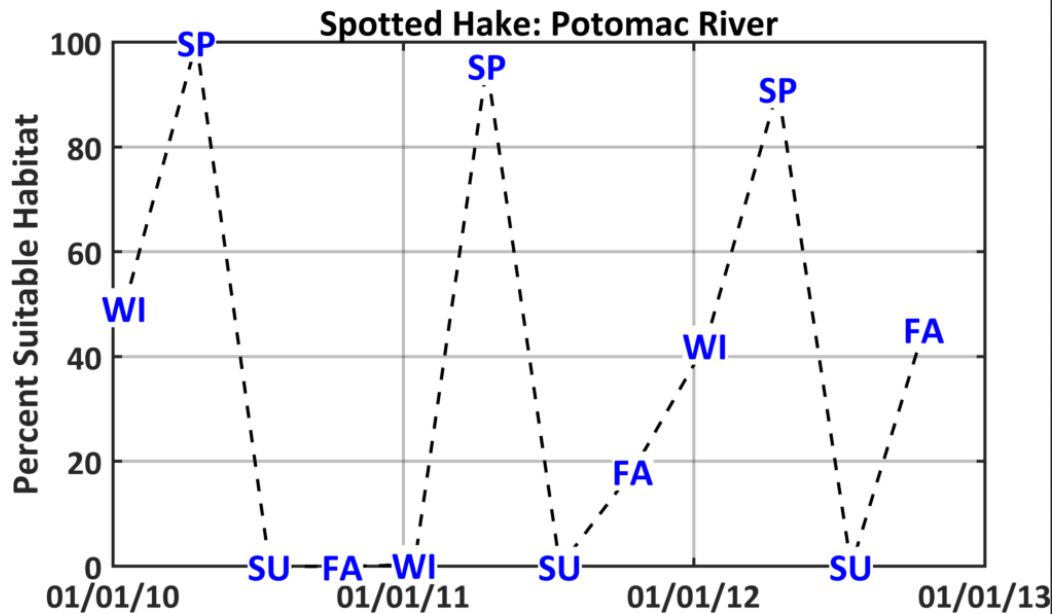
Sep - Nov



*Based on preliminary, simplified HSI model

Extend to Areas Not Sampled: Potomac River

March – May 2010



*Based on preliminary, simplified HSI model

Next Steps

- Complete interpolation of dO_2 observations
- Include MD trawl data in regression tree analysis
- Consider P/A data in regression tree analysis
- Develop forage-fish habitat suitability models for 4 species
 - Quantify & visualize suitable habitats seasonally & annually
 - Relate area of suitable habitat to abundance of forage fishes
- Validate our coupled modeling approach using
 - estimates of salinity from the hydrodynamic model and observations of salinity from the trawl surveys
 - fishery data from areas not currently sampled (Mobjack Bay)

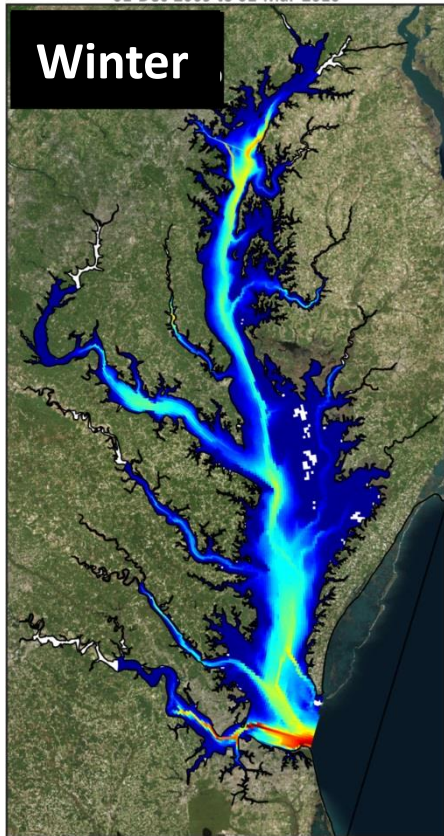


Thank You



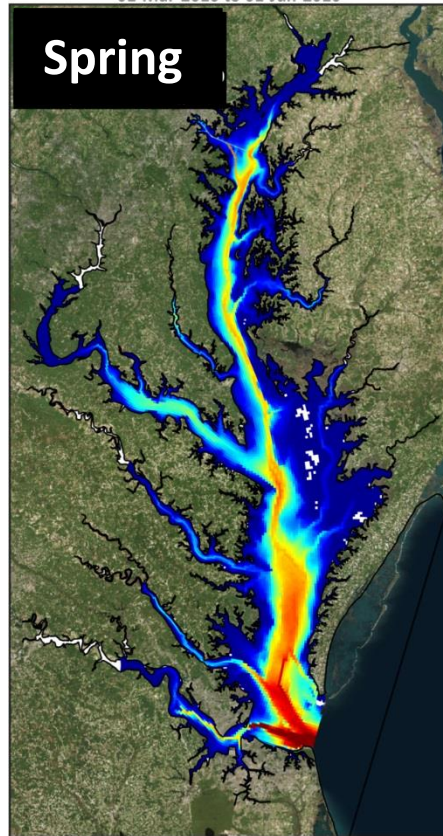
Salinity Stratification (2010)

> 2 psu



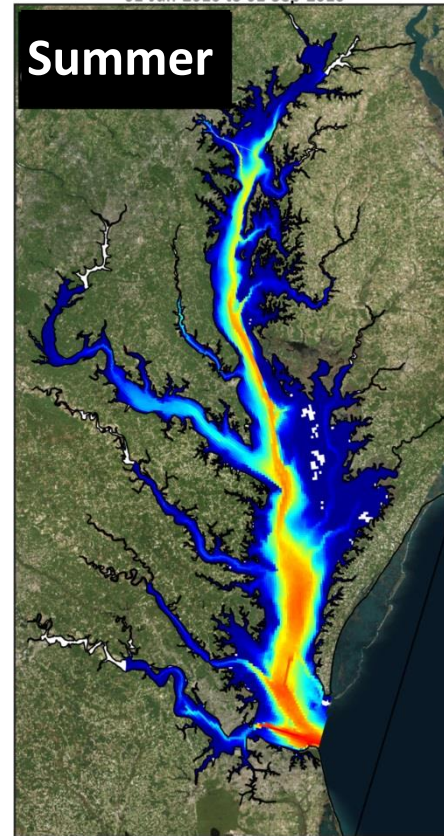
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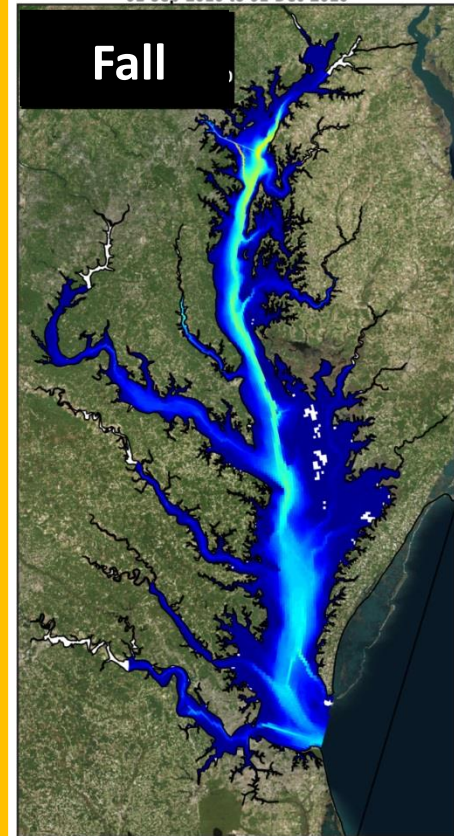
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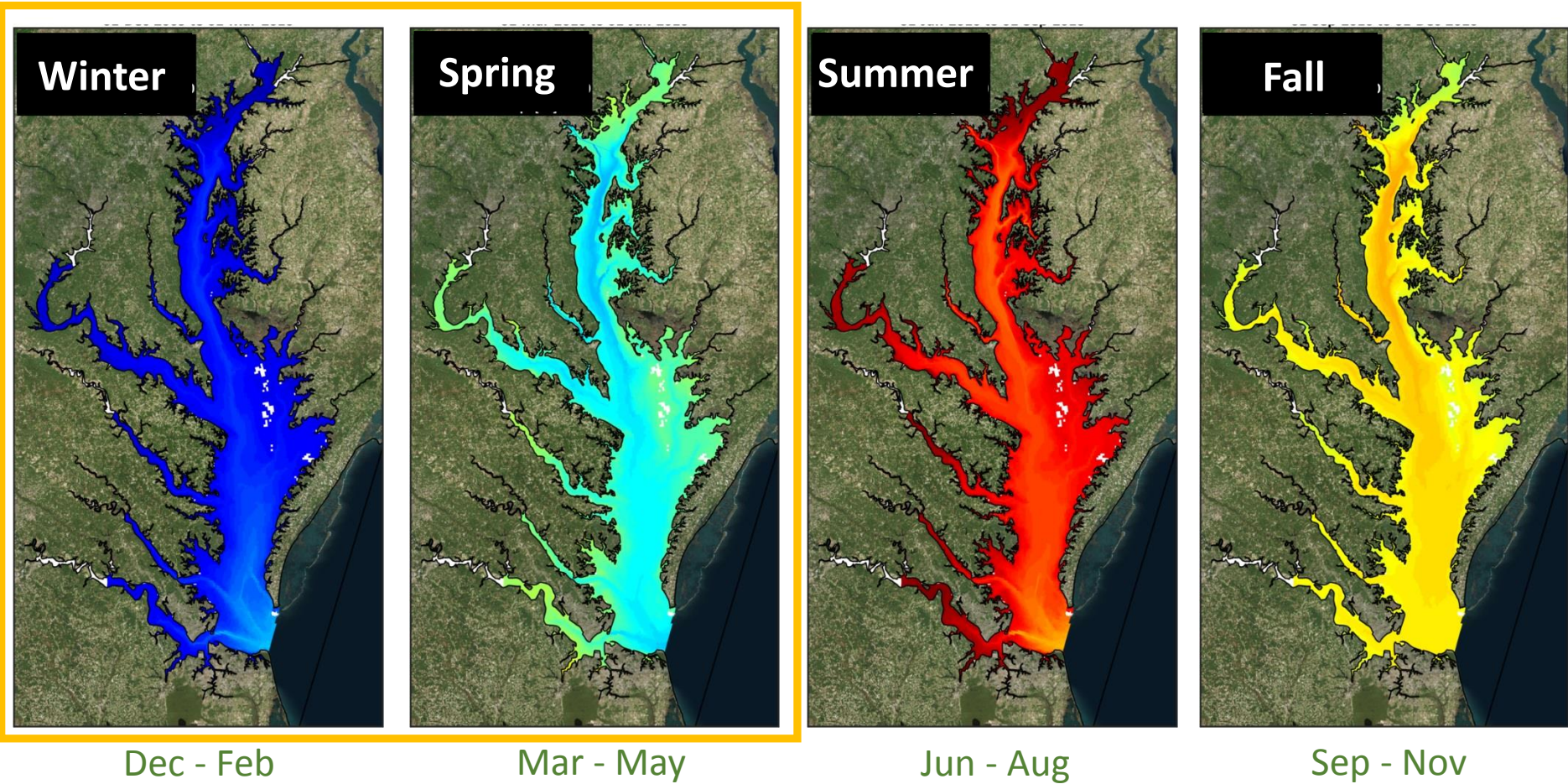
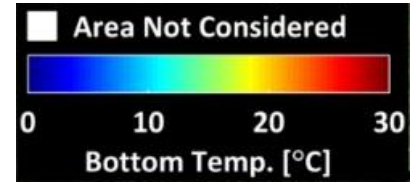
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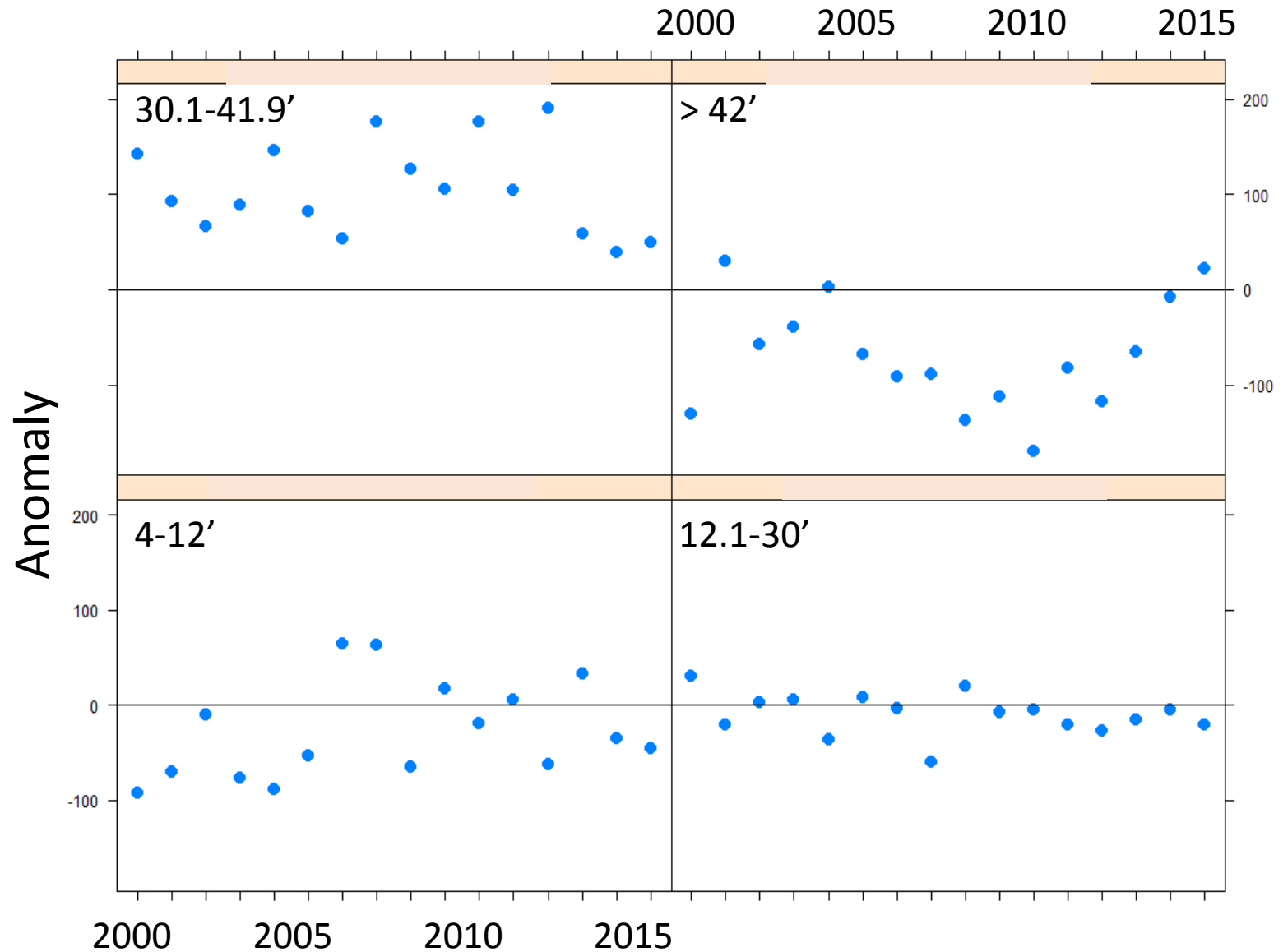
Bottom Temperature (2010)

< 20 °C



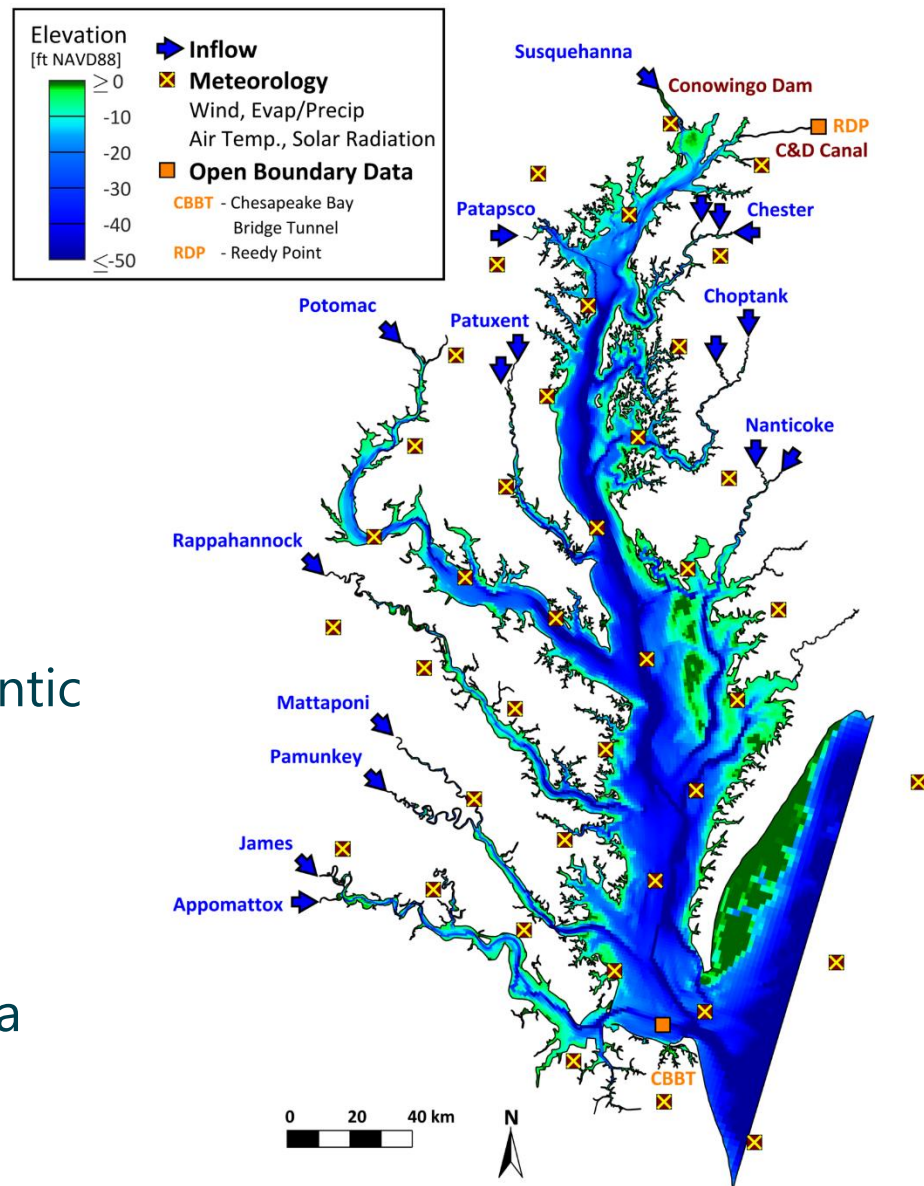
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Annual Catch Anomalies for Bay Anchovy



Numerical Model

- Bathymetry
 - FEMA Region III DEM
 - USACE navigation channel surveys
- Open Boundaries
 - NOAA water levels
 - World Ocean Atlas 2013 Atlantic Ocean
 - USGS Data at C&D Canal
- Meteorology
 - NARR gridded reanalysis data
- USGS tributary inflows



Reviewers' Suggestions

- Incorporate measures of physical habitat (eelgrass, oyster reefs) in the modeling and mapping
- Provide maps of suitable habitat to anglers
- Others?

