Habitat Suitability for Forage Fishes in Chesapeake Bay

Aug 2017 – Jul 2020

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21 August 2019

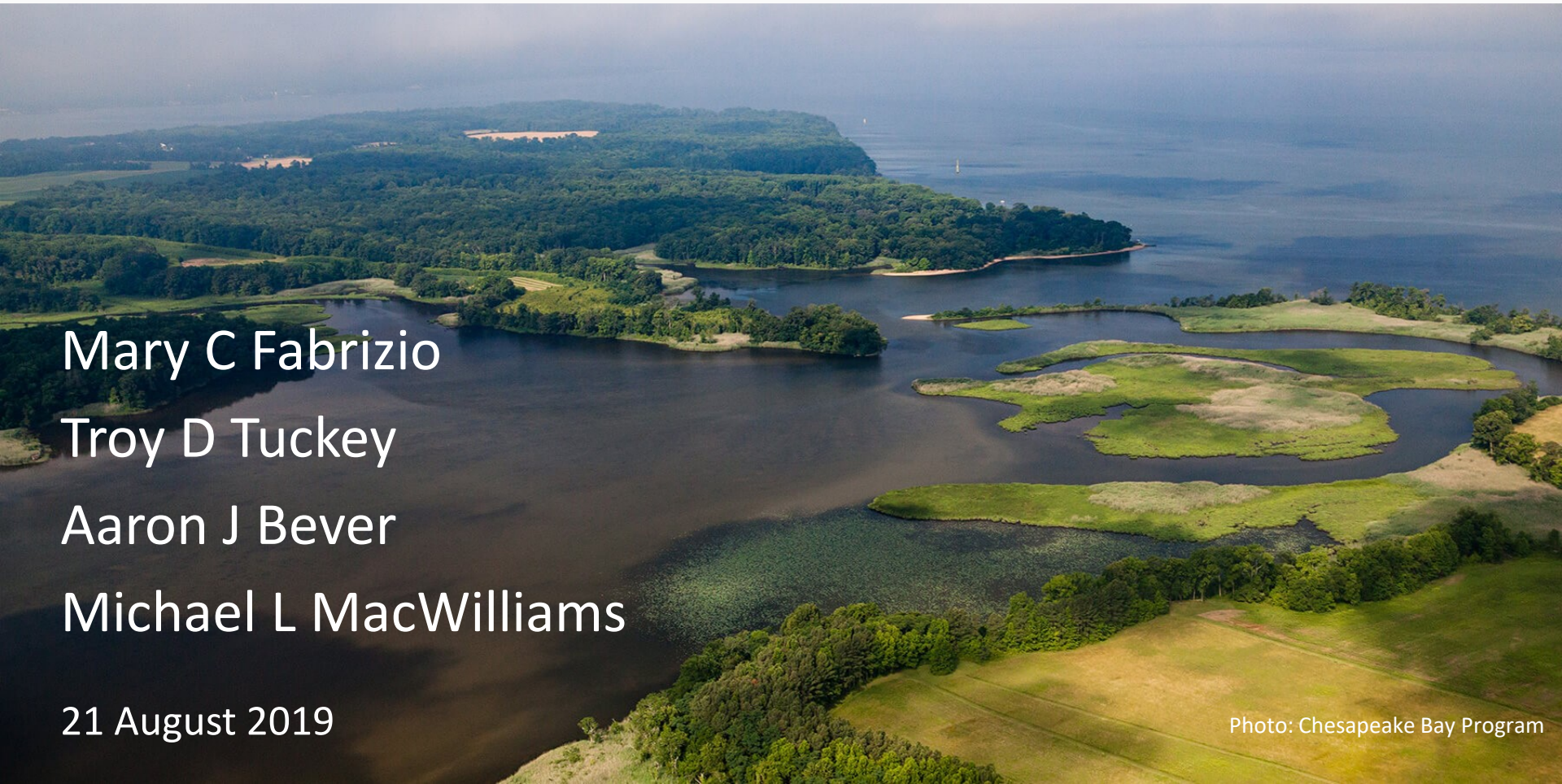
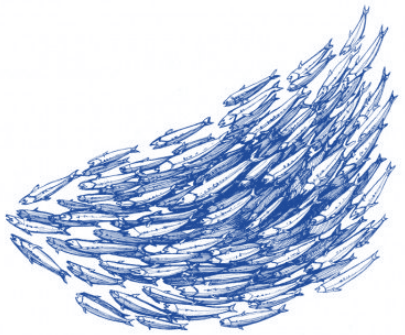


Photo: Chesapeake Bay Program

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

The not-so-charismatic fauna:

- 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

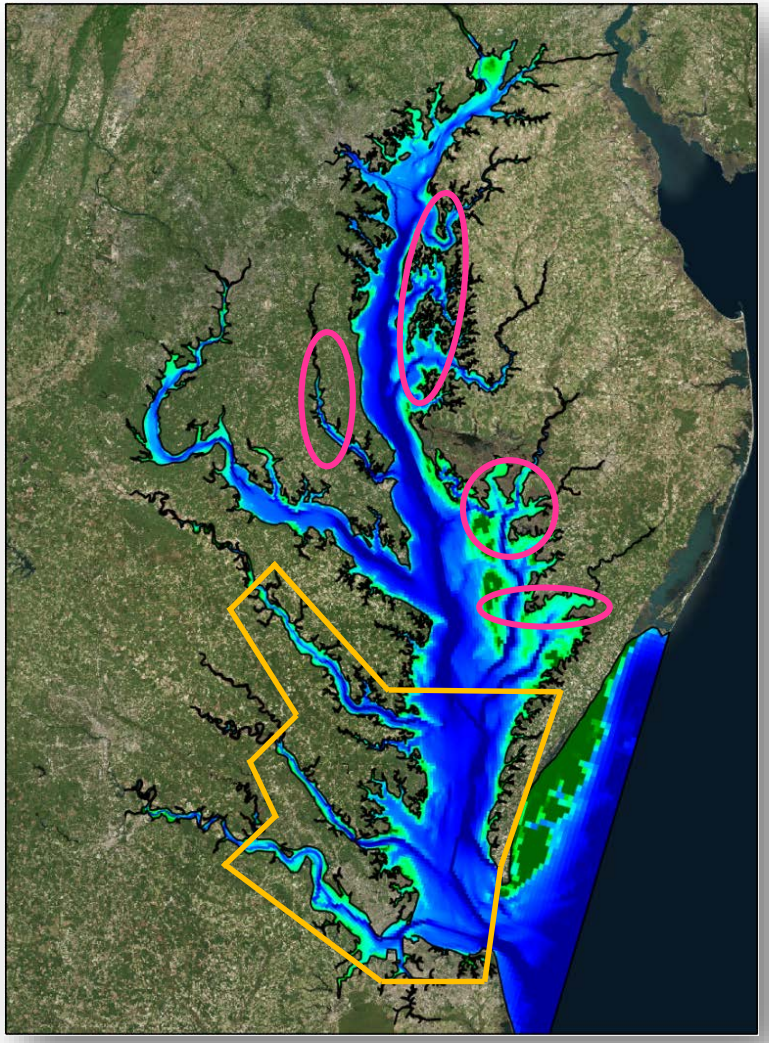
Allow us to extend the characterization of habitat beyond what is measured at the time of capture

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



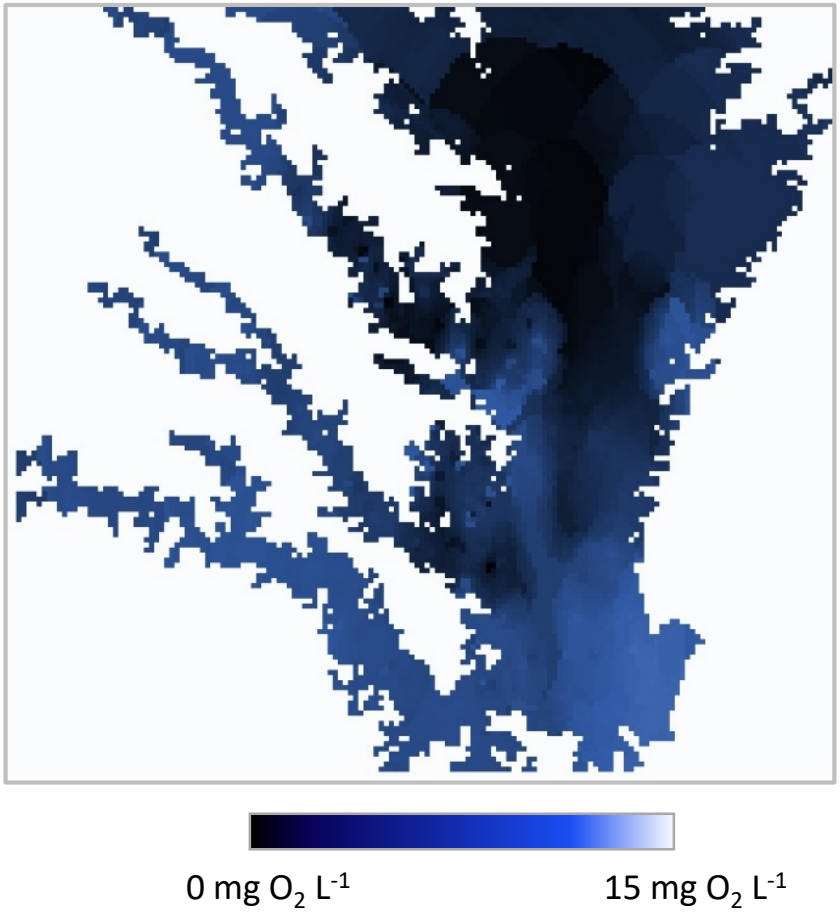
VIMS trawl survey extent

MD trawl survey extent

Data Source: Spatio-Temporal Model of dO_2

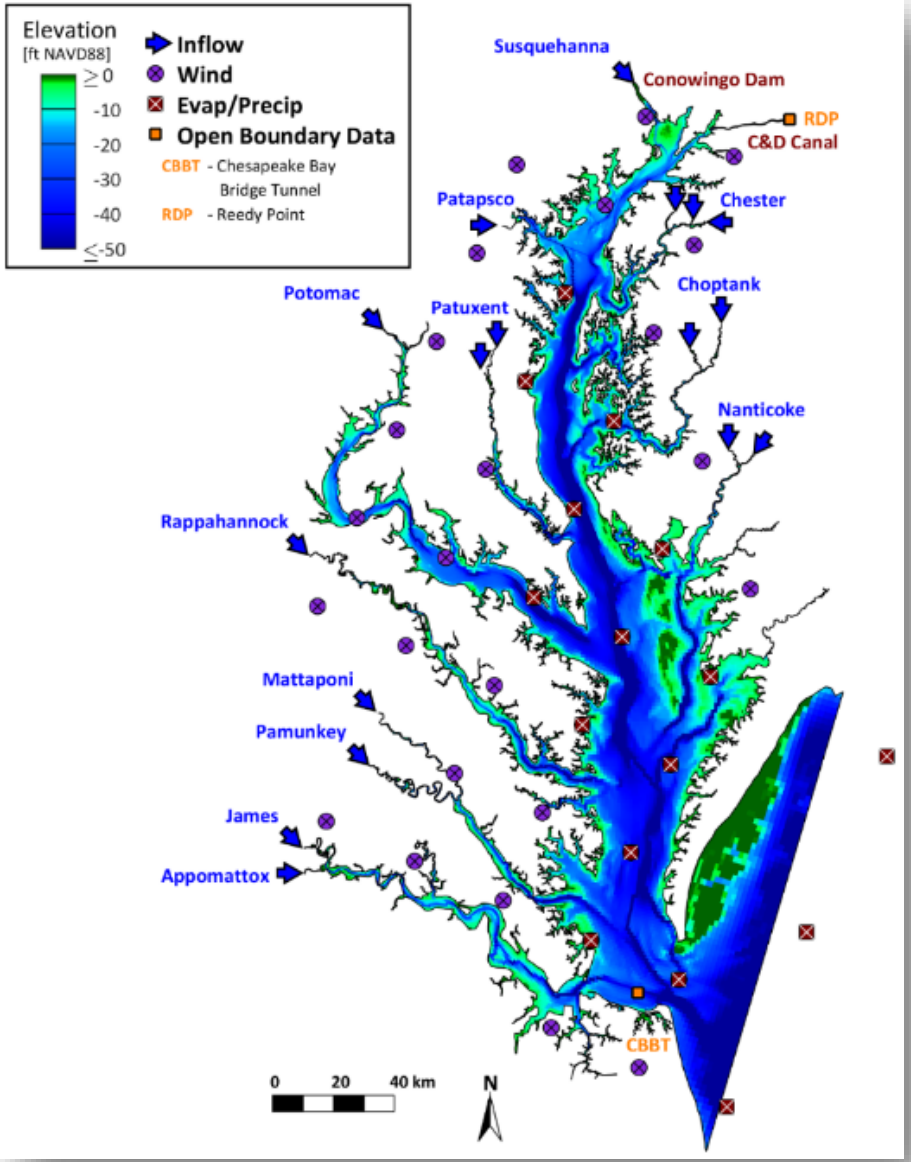
- dO_2 modeled in each 1-km^2 grid cell
  - 15-min records from VECOS and MD Eyes on the Bay
  - Monthly CBP water quality monitoring program
  - Monthly fisheries surveys
- Interpolations:
  - Spatial interpolation via inverse distance weighting
  - Temporal interpolation via linear models

Dissolved O_2 Conditions, July 2011



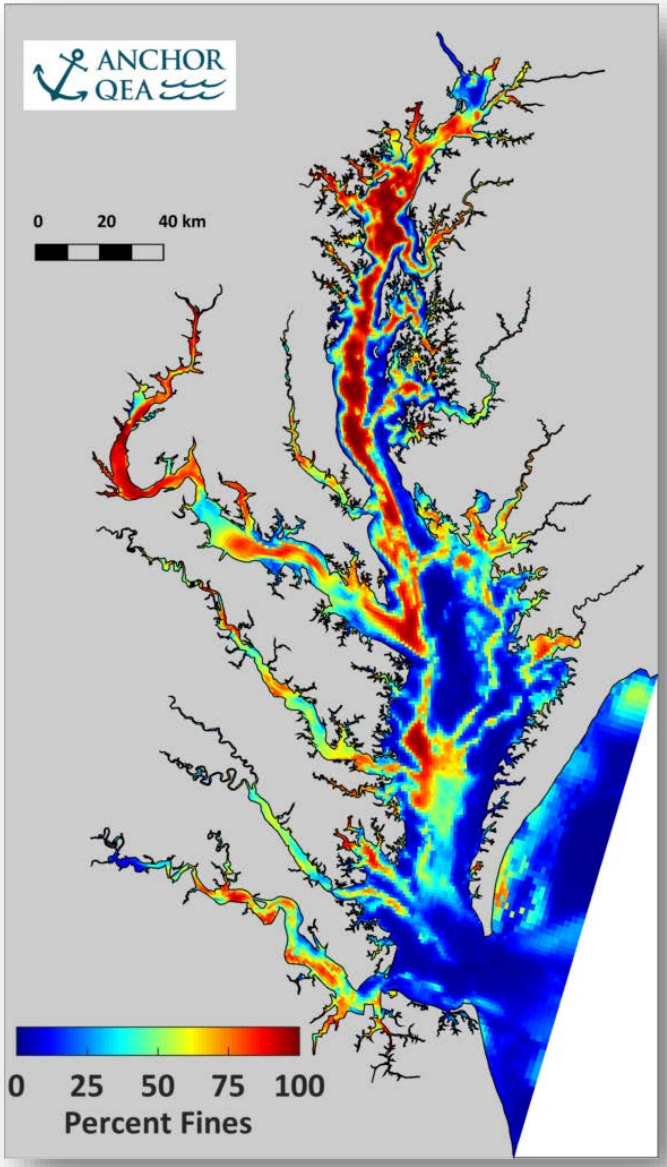
Marcek, Shen, & Fabrizio, unpubl data

Data Source: 3D Hydrodynamic Model

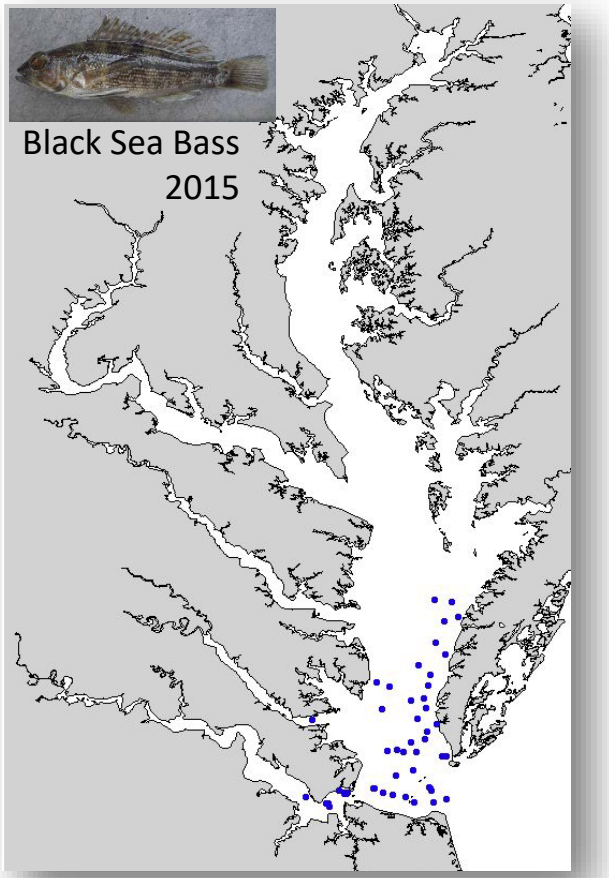


- Dynamic habitat features:
  - Near-bed salinity
  - Depth-averaged salinity
  - Salinity stratification
  - Tidal average bottom salinity
  - Time- and depth-averaged current speed
  - And many more…(34 total)
- Static habitat features:
  - Depth
  - Sediment composition

Data Source: Sediment Composition



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



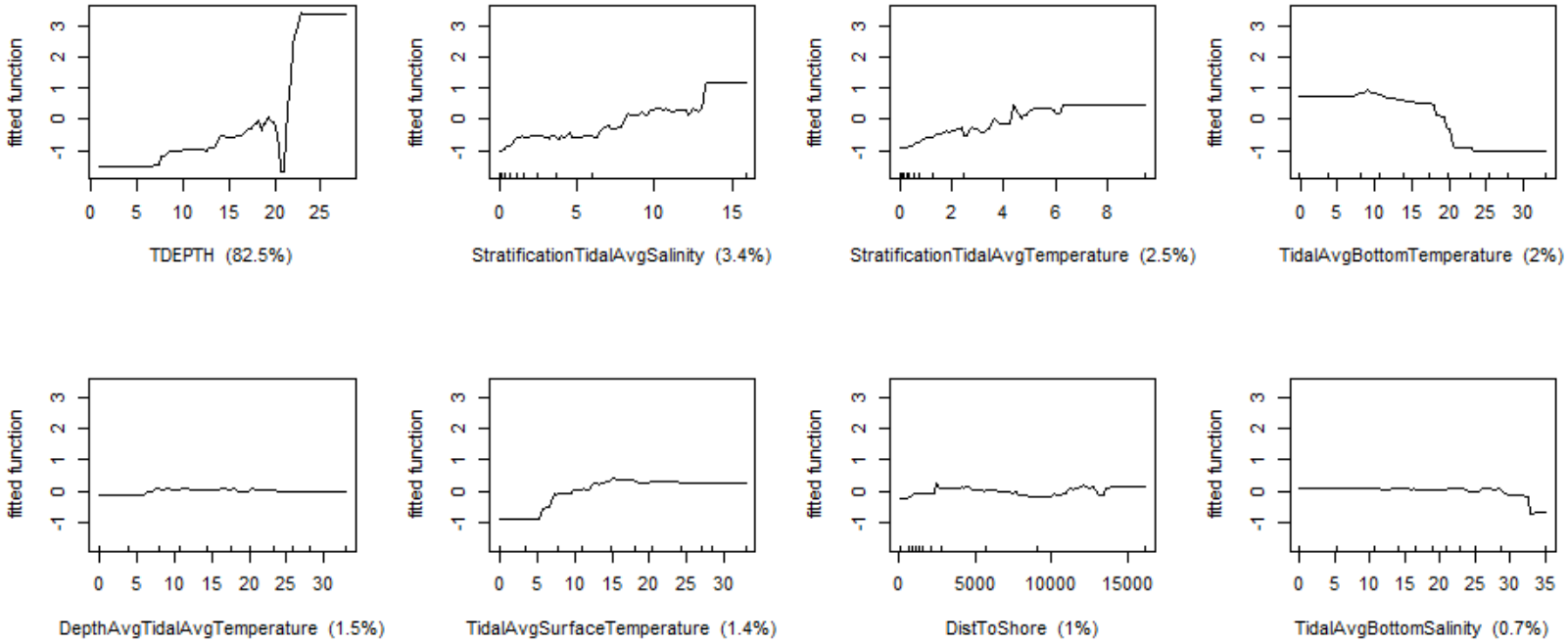
Modeling Approach

1. Estimate dynamic & static habitat features associated with catch data
2. Develop forage-fish habitat suitability models for the 4 species
3. Quantify and visualize suitable habitats seasonally & annually
4. Relate area of suitable habitat to forage abundance
5. Delineate contiguous polygons for local habitat analysis

Conceptual Habitat Model for Juvenile Spotted Hake

Predictor:	Relative Influence:
TDEPTH	82.5
StratificationTidalAvgSalinity	3.4
StratificationTidalAvgTemperature	2.5
TidalAvgBottomTemperature	2.0
DepthAvgTidalAvgTemperature	1.5
TidalAvgSurfaceTemperature	1.4
DistToShore	1.0

54.5 % of variation in catch explained by these 7 predictors through Regression Tree Analysis



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° C
- Bottom Temperature < 20° C

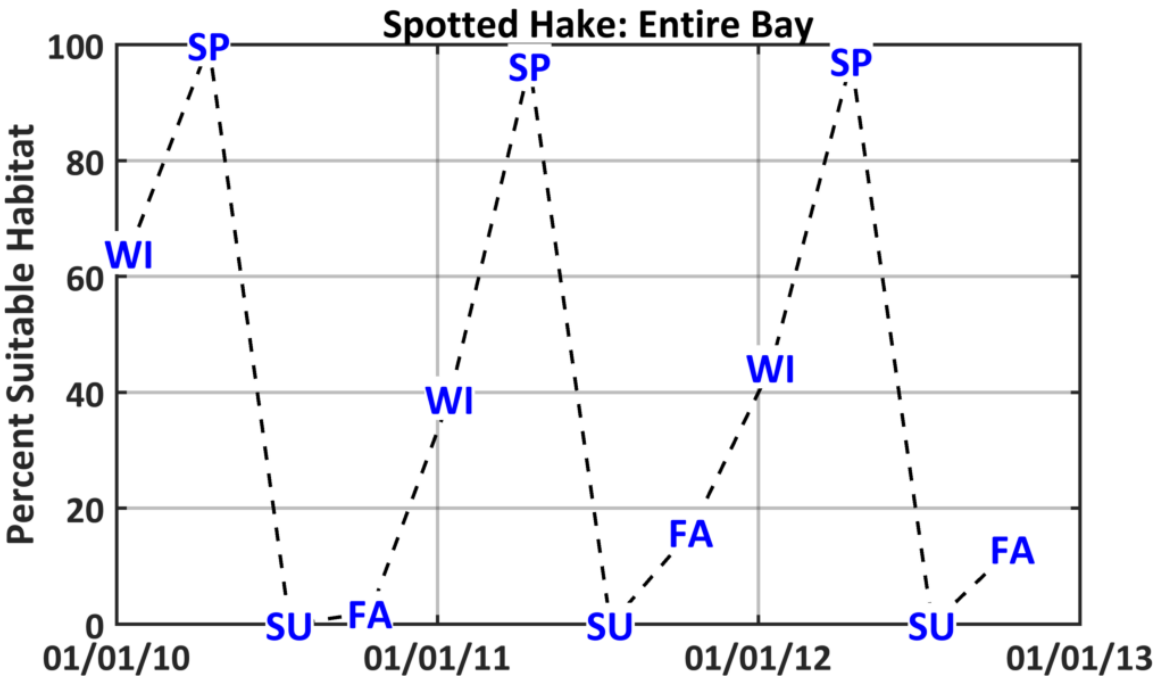
AND

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

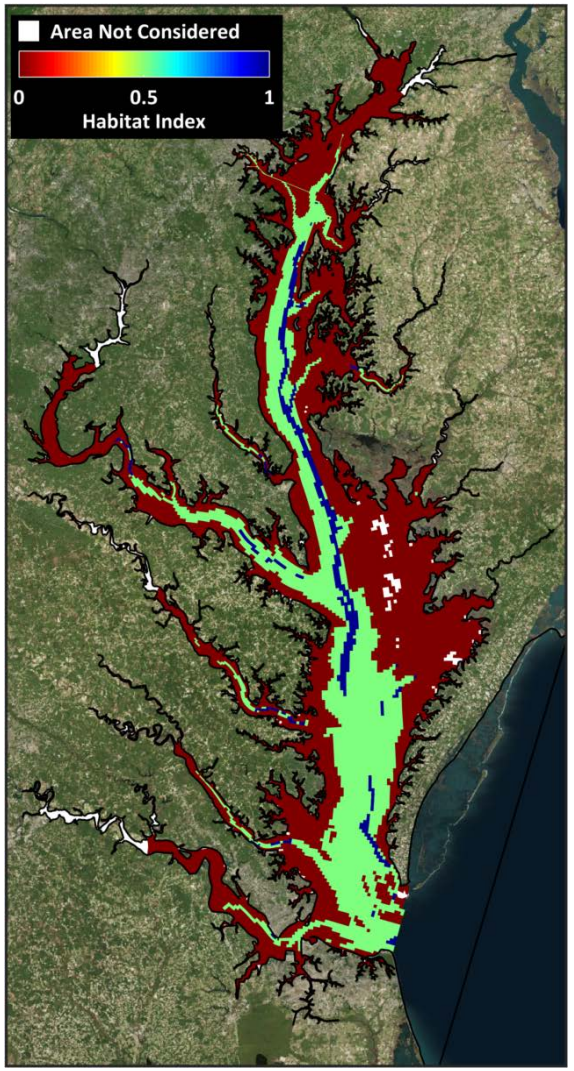
* Based on observed abundances in 2010, 2011, 2012

Seasonal Variation in HSI

- Habitat quantified using 3-mon averages



Mar 2010 – May 2010



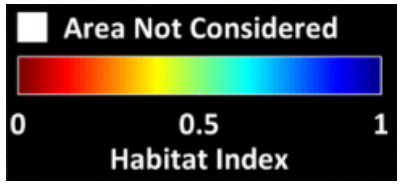
Relatively high abundance

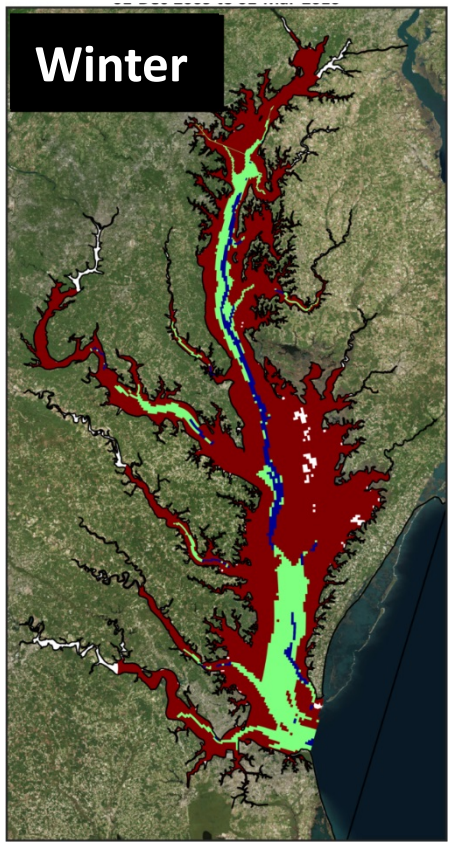
Average abundance

Relatively low abundance

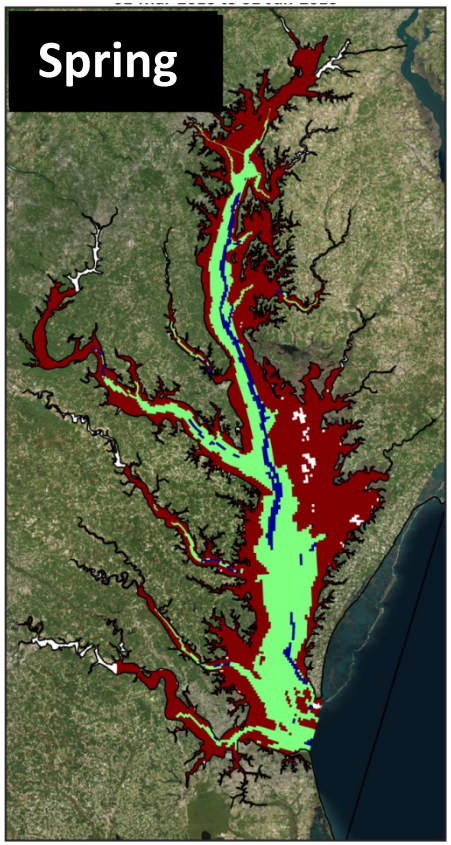
*Based on preliminary, simplified HSI model

Seasonal Variation in HSI (2010)

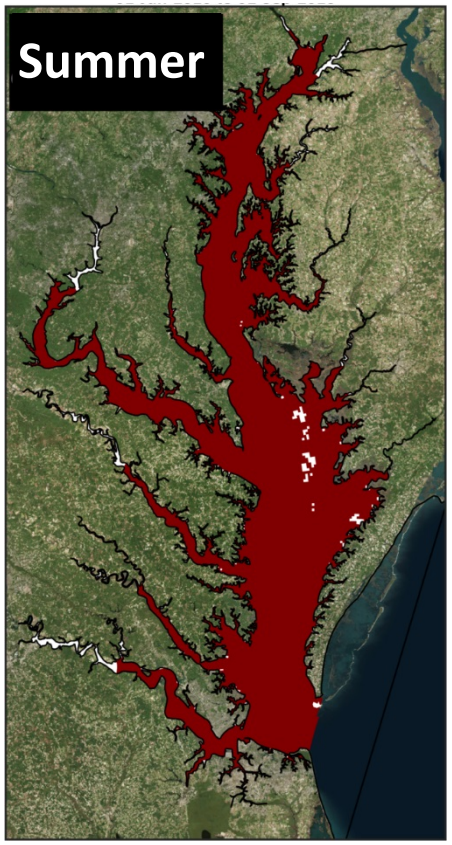




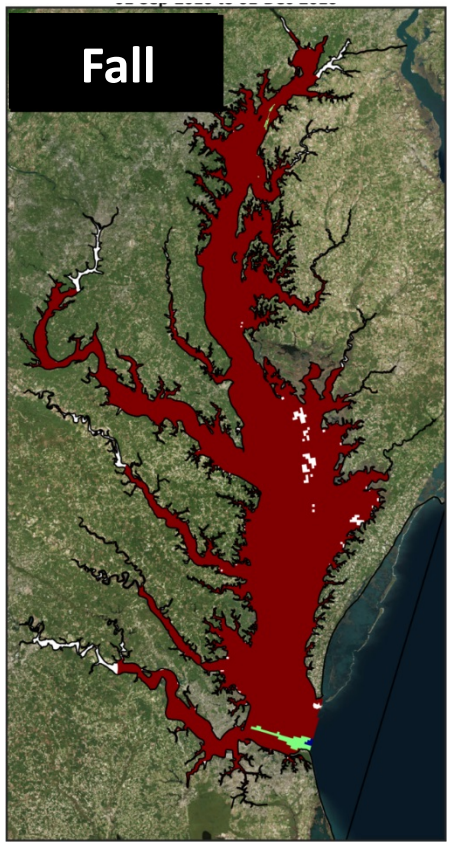
Dec - Feb



Mar - May



Jun - Aug



Sep - Nov

Relatively high abundance

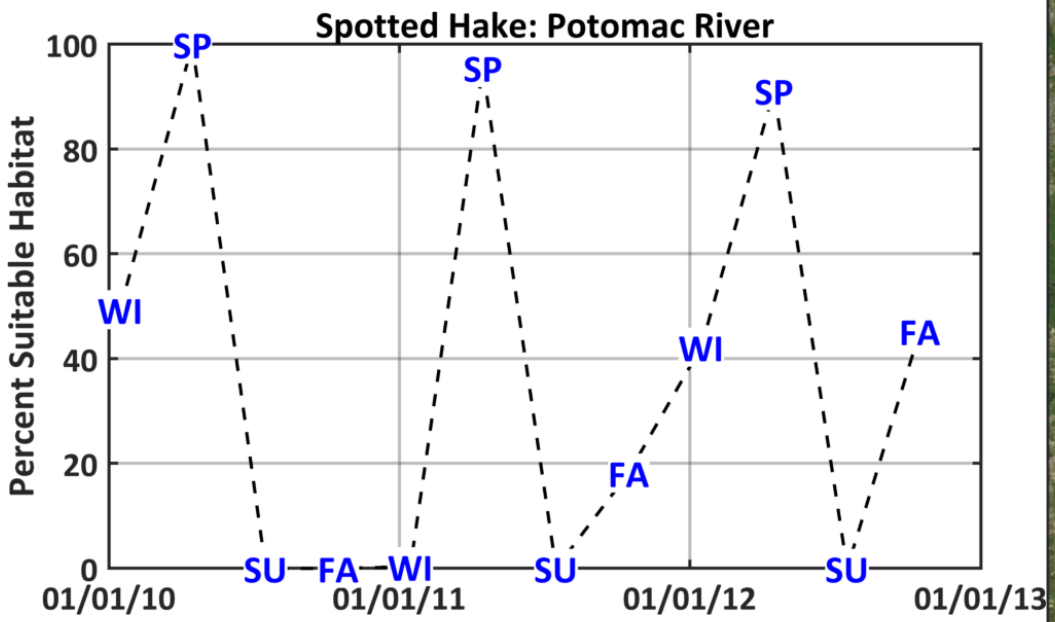
Average abundance

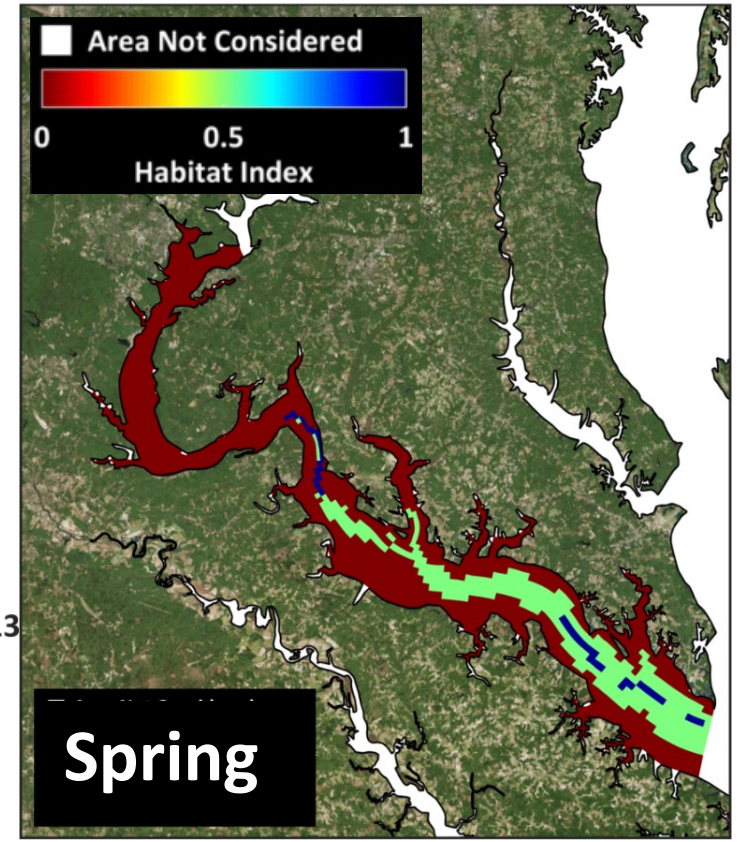
Relatively low abundance

*Based on preliminary, simplified HSI model

Extend to Areas Not Sampled: Potomac River

March – May 2010



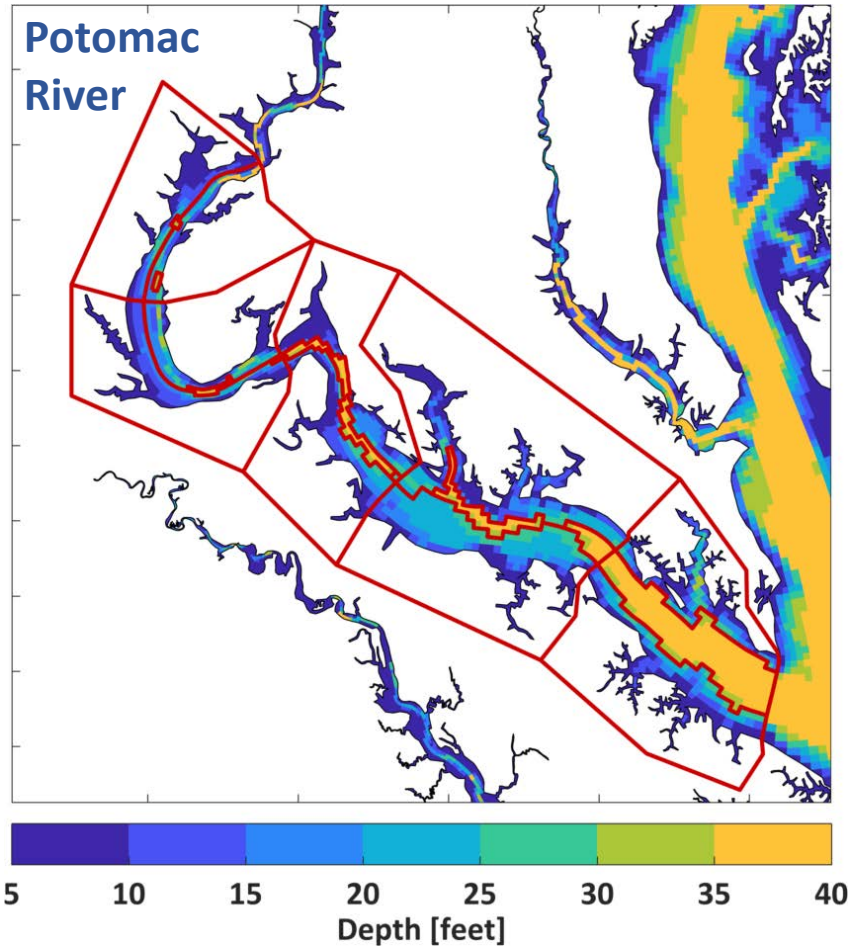


*Based on preliminary, simplified HSI model

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**



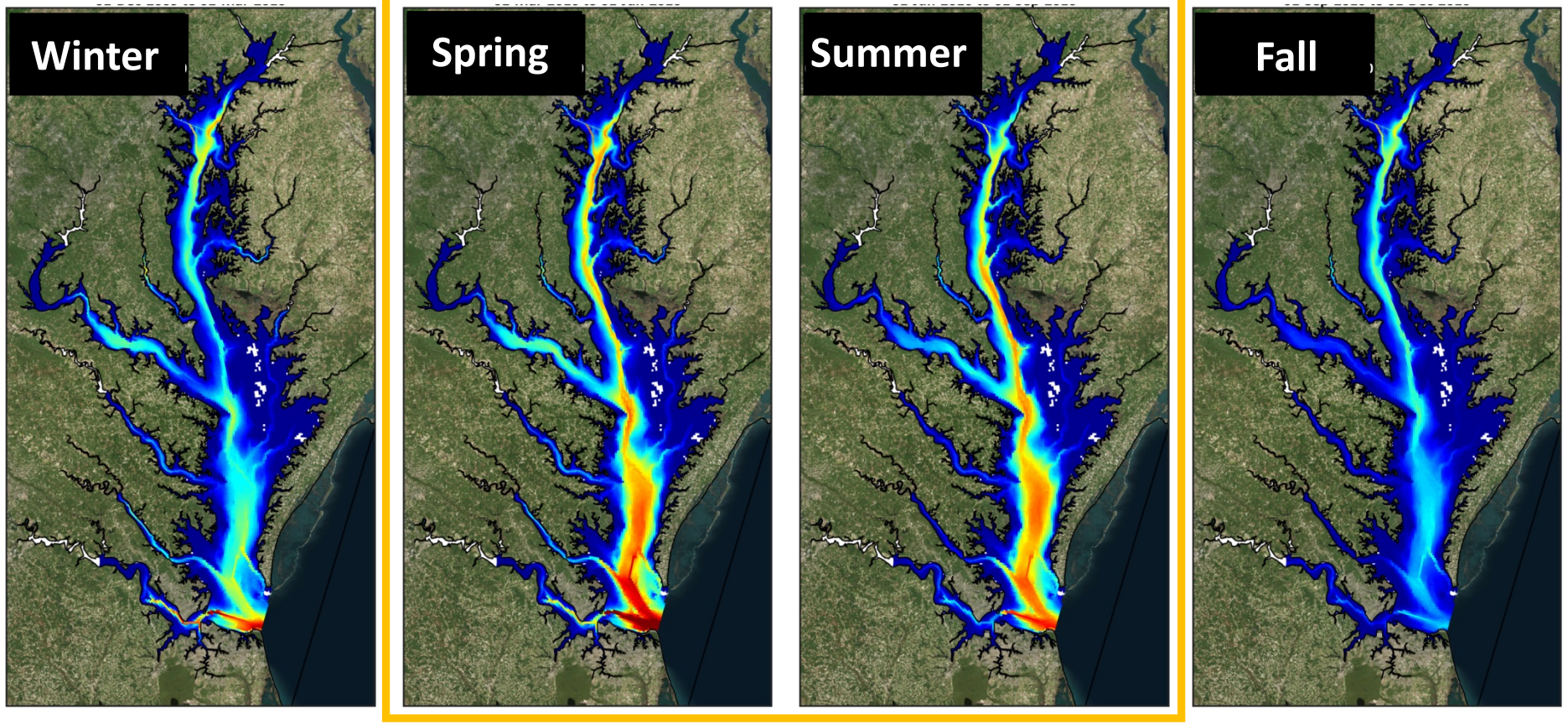
Next Steps

- 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)

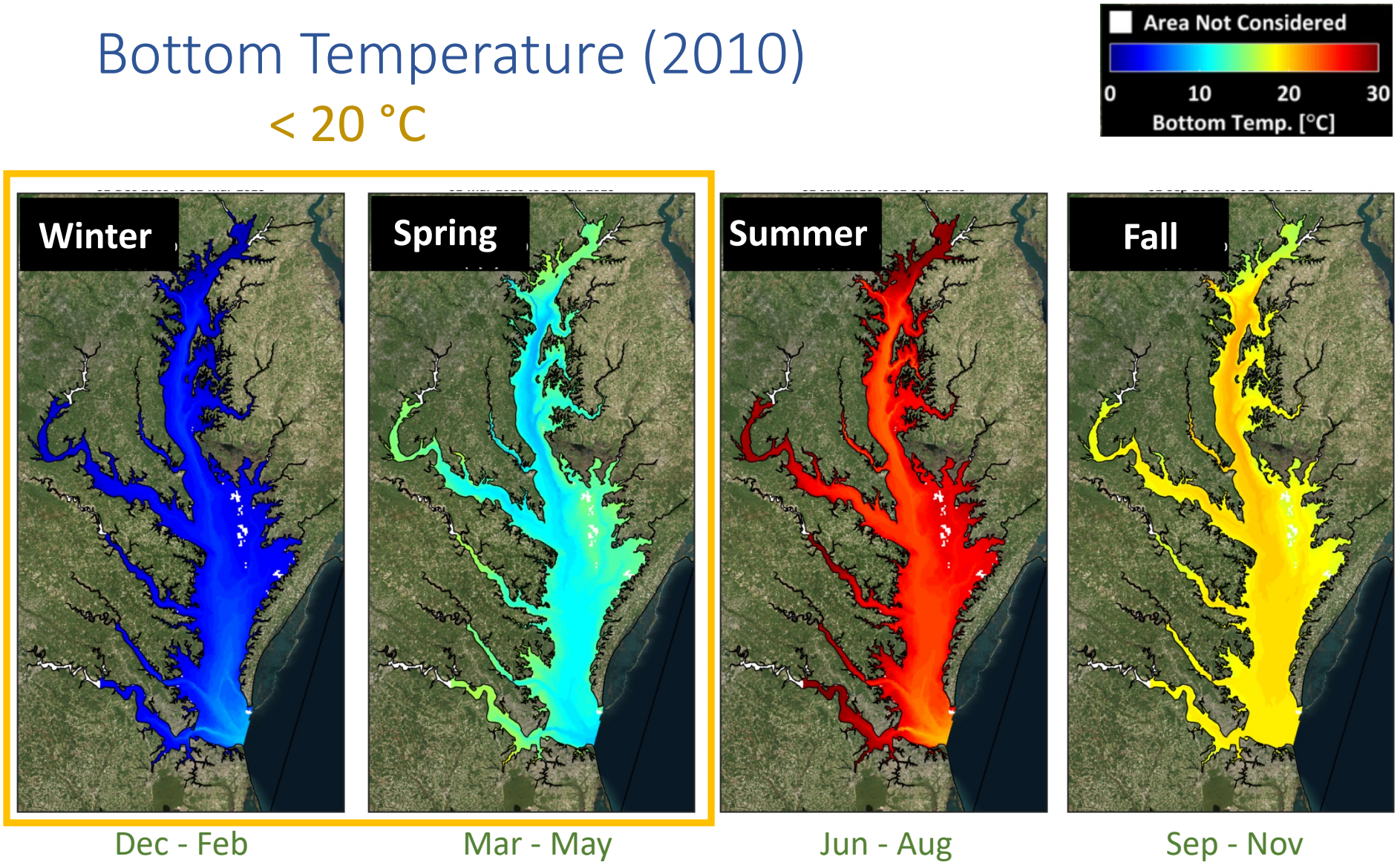
> 2 psu



*Based on preliminary, simplified HSI model

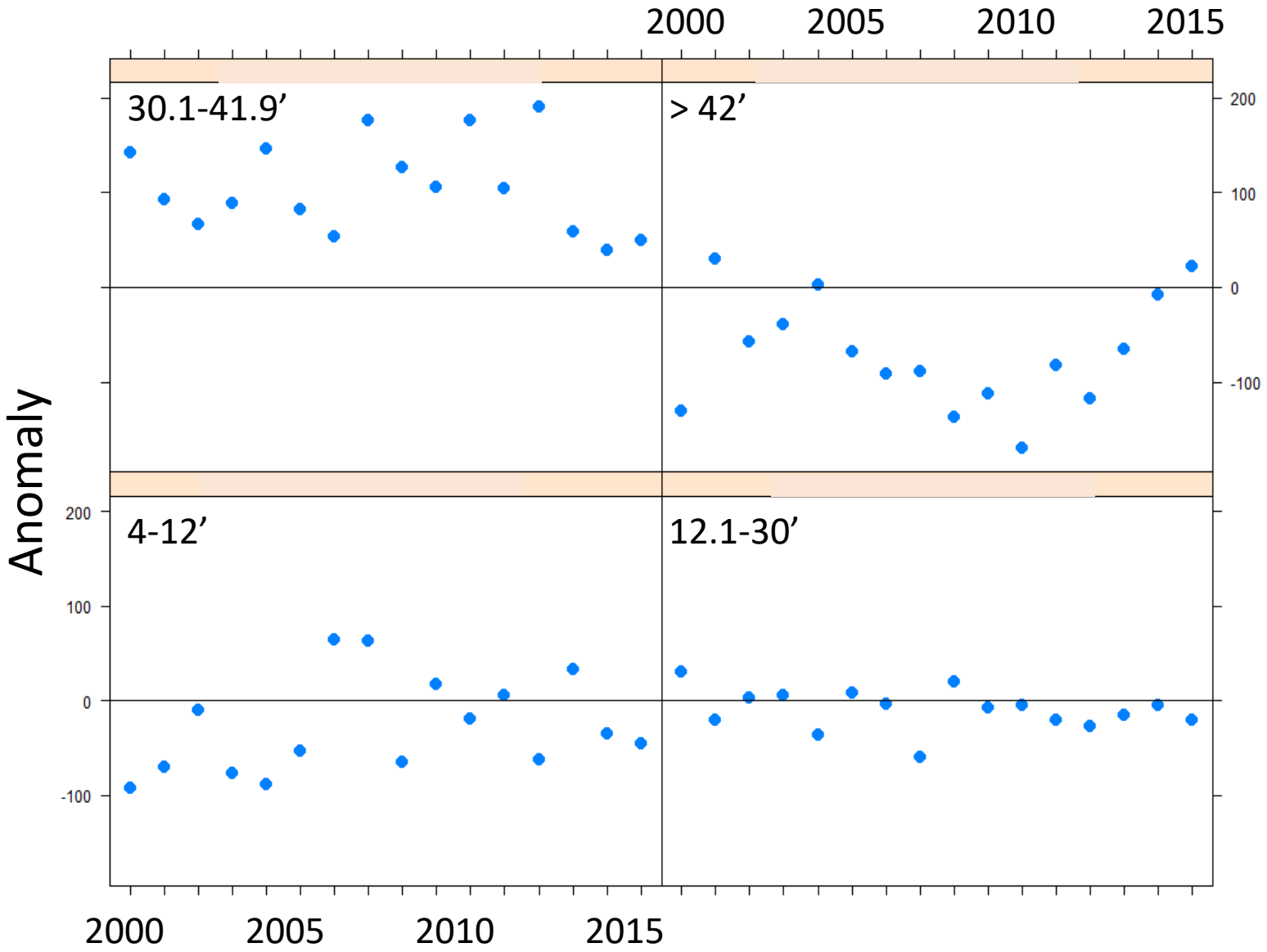
Bottom Temperature (2010)

< 20 °C



*Based on preliminary, simplified HSI model

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