Engineer Research and Development Center

Oyster Modeling for Ecosystem Restoration

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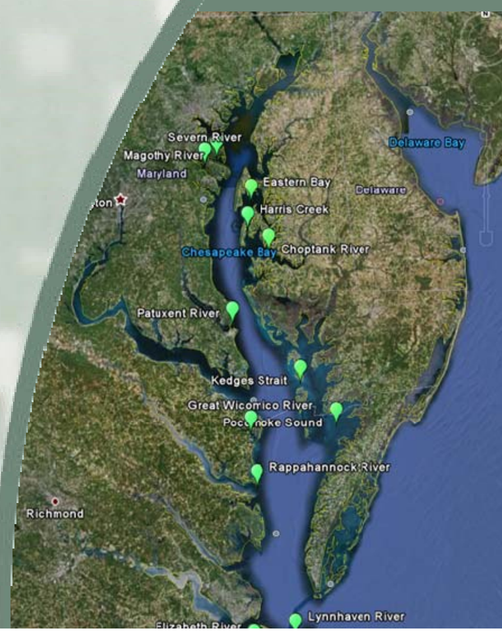
Integrated Ecological Modeling

Environmental Laboratory

28 January 2013



US Army Corps of Engineers®

Eastern Oyster Fishery

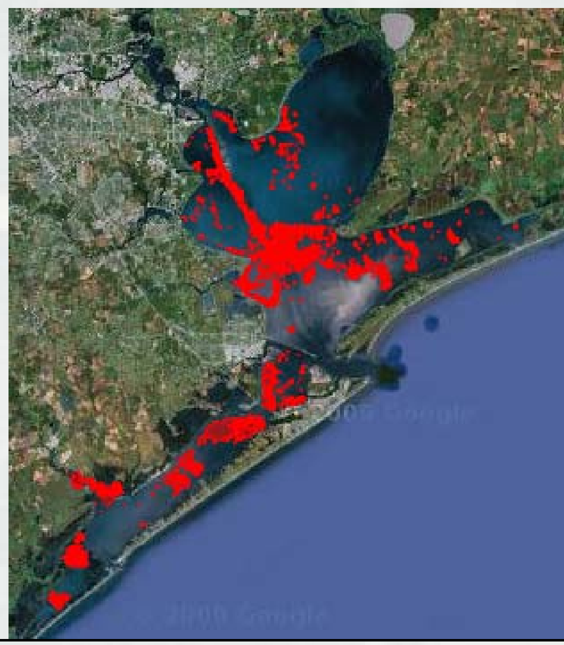
- Oyster abundance has changed
- Oyster reefs provide tremendous environmental and economic benefits
- Different viewpoints on how to restore oysters and maintain fishery

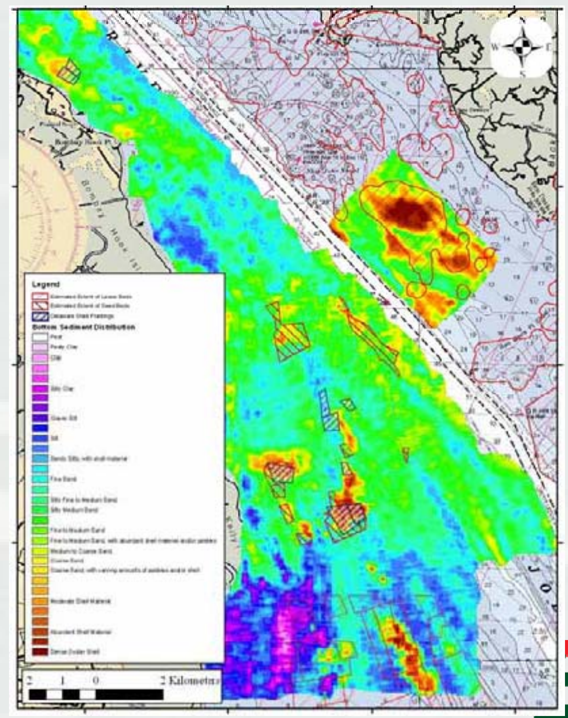
Oyster Restoration

- Oyster restoration becoming important throughout US waters
- Need to be able to plan restoration projects efficiently (i.e., need to be able to determine location of suitable habitats for oysters)
- Need to understand environmental benefits associated with restoration projects

Habitat Suitability

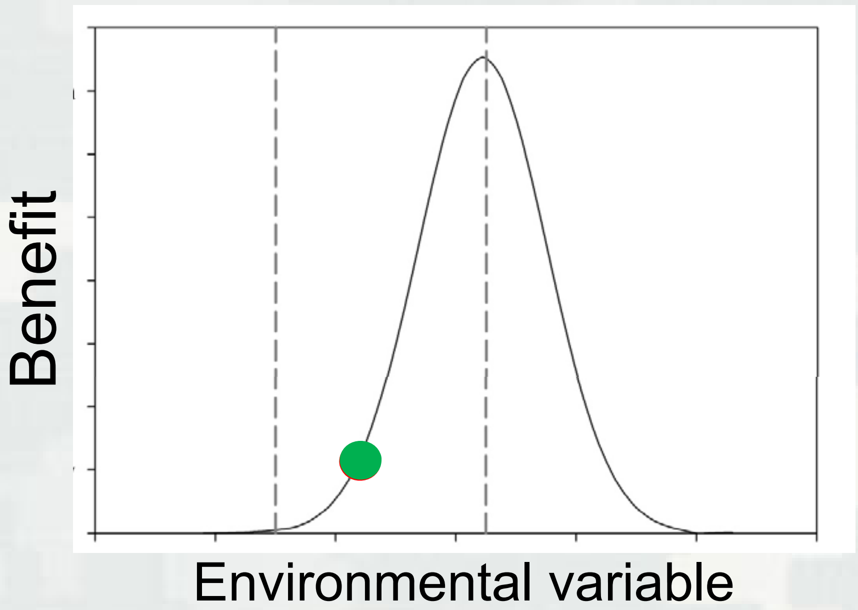
- Identify general relationships between species and environment
  - ► Determine potential locations for suitable habitats





Environmental Benefits

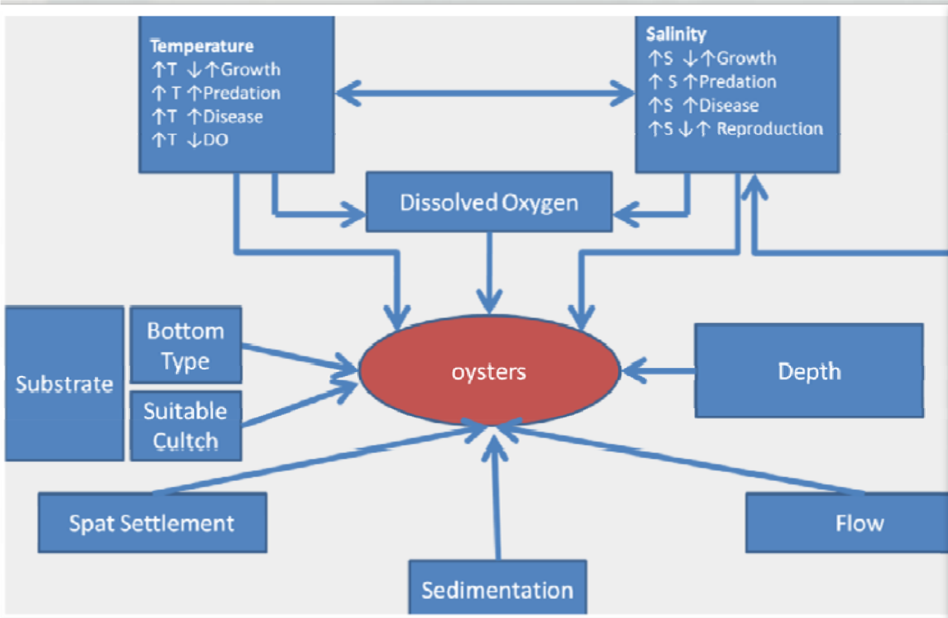
- What environmental benefits result from restoration?
  - Tool will identify potential benefits from reef restoration projects (water quality, etc)



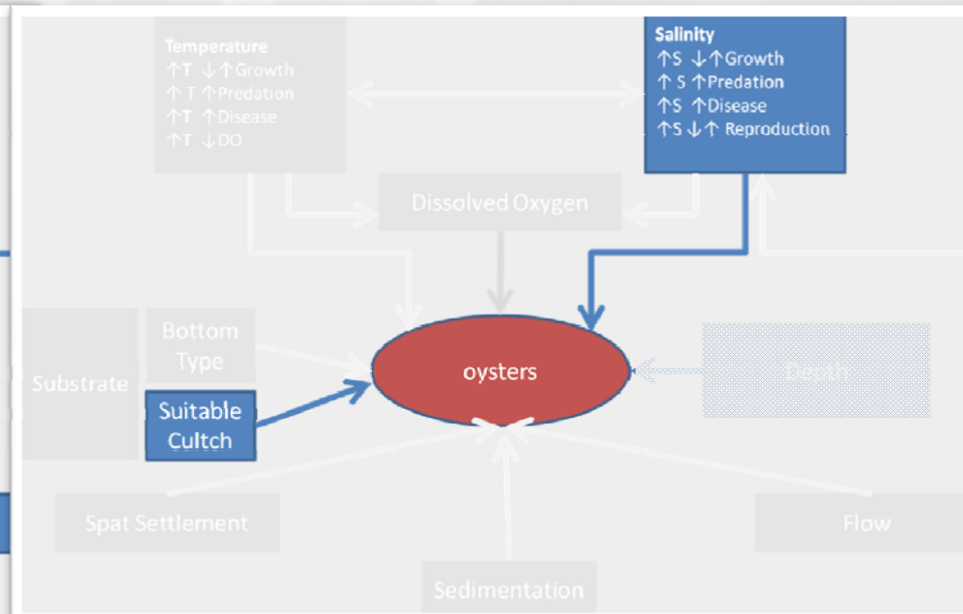
Approach

- Workshop with oyster experts throughout US in order to understand critical environmental factors for restoration
- Develop conceptual model for oyster ecology to serve as template for quantitative model
- Develop quantitative-based HSI model for oysters throughout their distribution
- Develop benefits algorithm to determine environmental benefits of proposed project alternatives

Conceptual Model: HSI



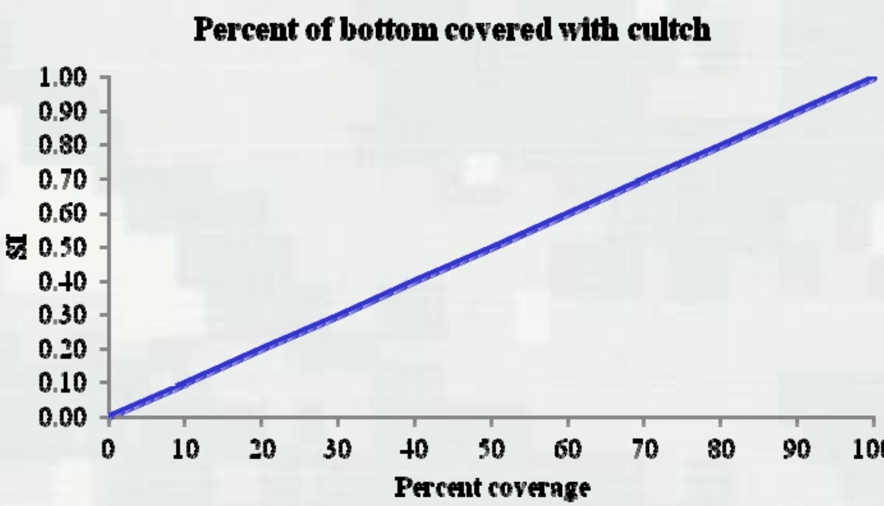
Full habitat requirements

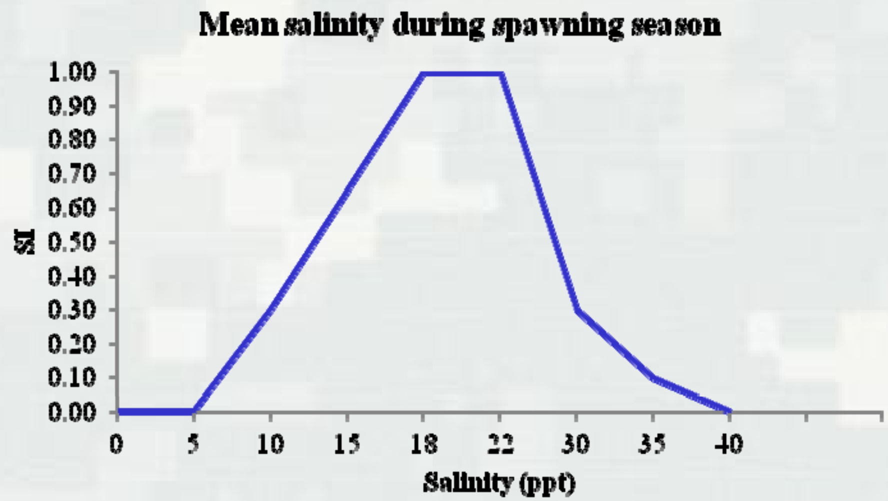


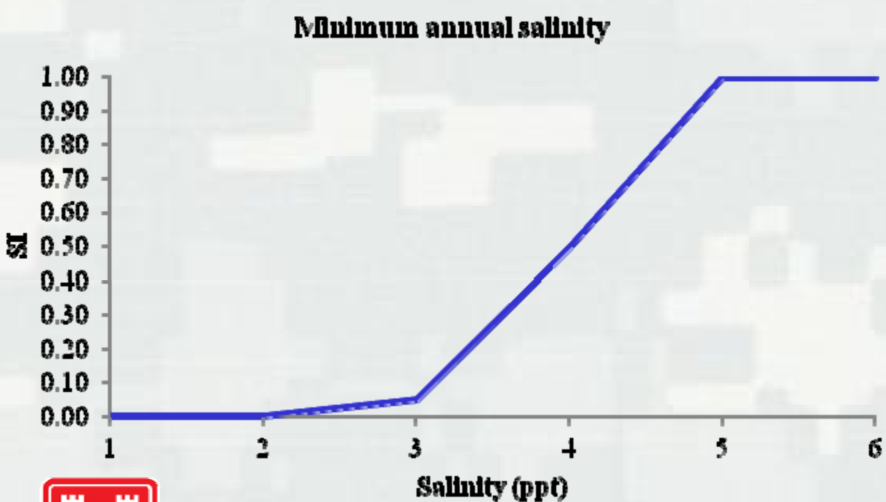
Simplified habitat requirements

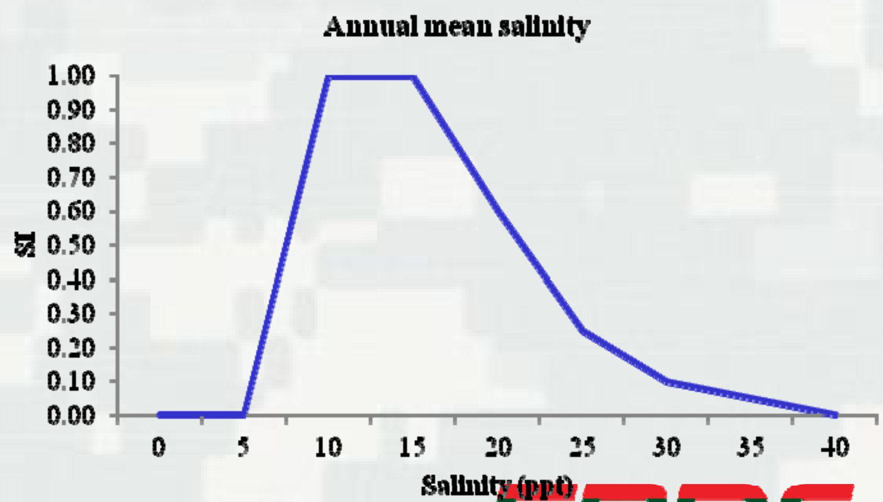
Conceptual modeling led by Dr. Tomma Barnes, Wilmington District

Model Curves



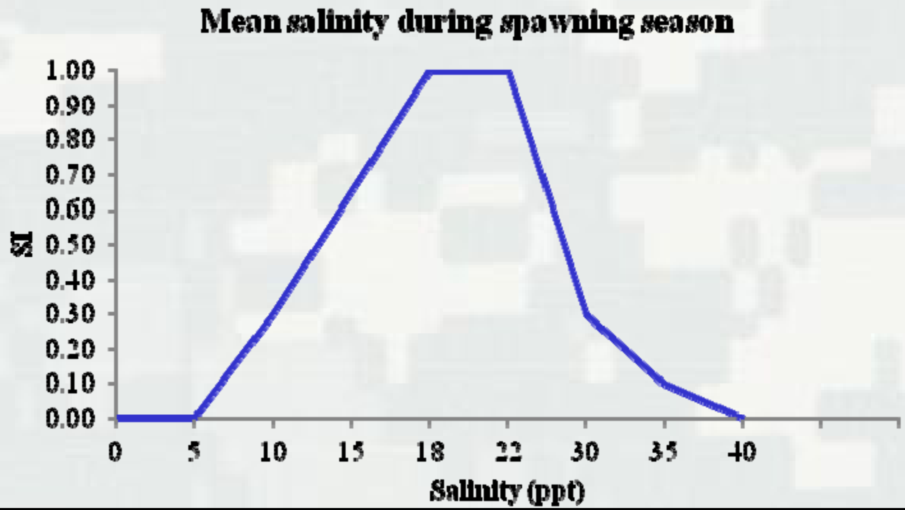






Equations

$MSSS \leq 5$ or $MSSS > 40$	$OSI_{MSSS} = 0$
$5 < MSSS \leq 10$	$OSI_{MSSS} = -0.3 + (0.06 * MSSS)$
$10 < MSSS \leq 15$	$OSI_{MSSS} = -0.4 + (0.07 * MSSS)$
$15 < MSSS < 18$	$OSI_{MSSS} = -1.1 + (0.1167 * MSSS)$
$18 \leq MSSS \leq 22$	$OSI_{MSSS} = 1$
$22 < MSSS \leq 30$	$OSI_{MSSS} = 2.925 - (0.0875 * MSSS)$
$30 < MSSS \leq 35$	$OSI_{MSSS} = 1.5 - (0.04 * MSSS)$
$35 < MSSS \leq 40$	$OSI_{MSSS} = 0.8 - (0.02 * MSSS)$



Overall HSI Equation

$$RSI = \left(\prod_{i=1}^{n} OSI_i \right)^{1/n}$$

Geometric mean of all variables

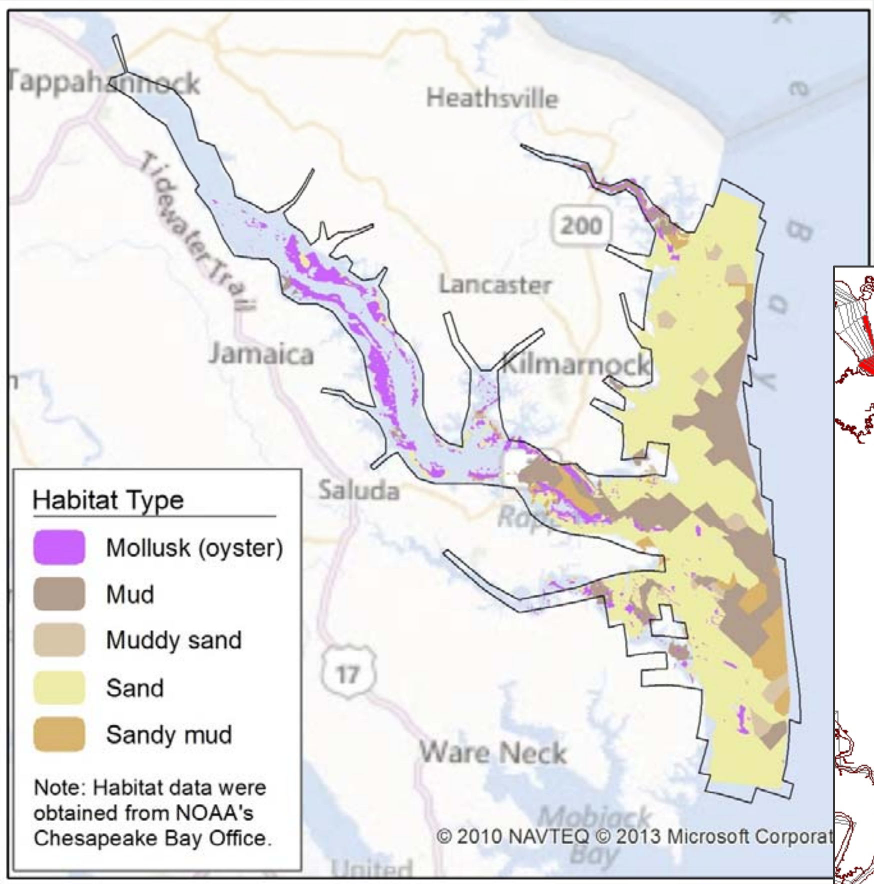
Case Studies

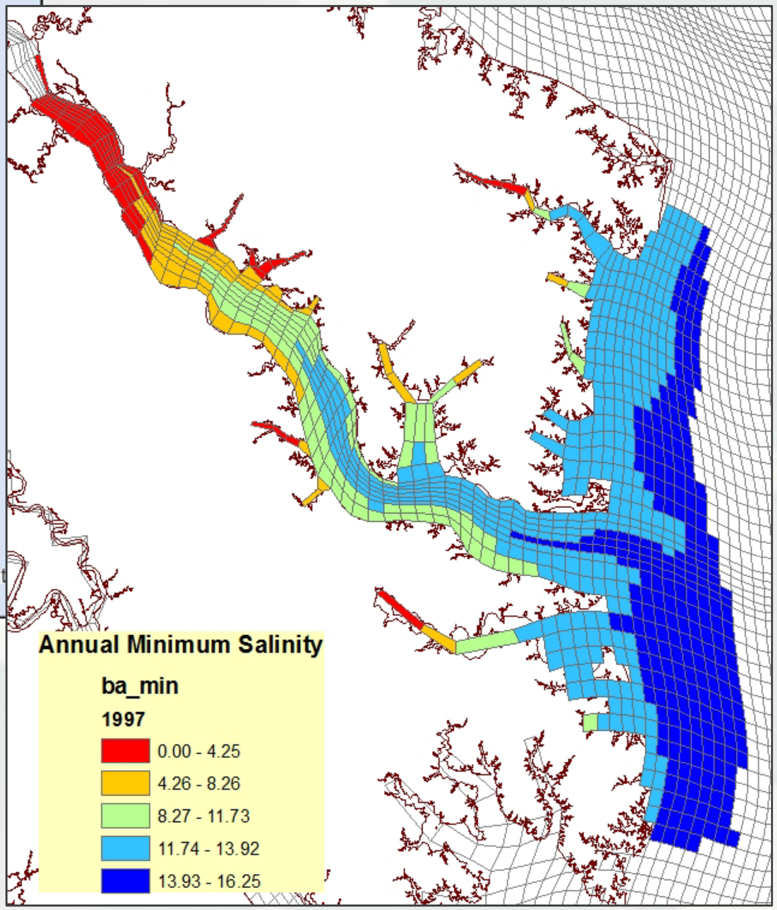
- Chose two locations: Lower Rappahannock River in the Chesapeake Bay, and Western Mississippi Sound in the Gulf of Mexico
  - Illustrate flexibility of model in 2 locations
  - Use of different data types, sources, and quality

HSI – Chesapeake Bay

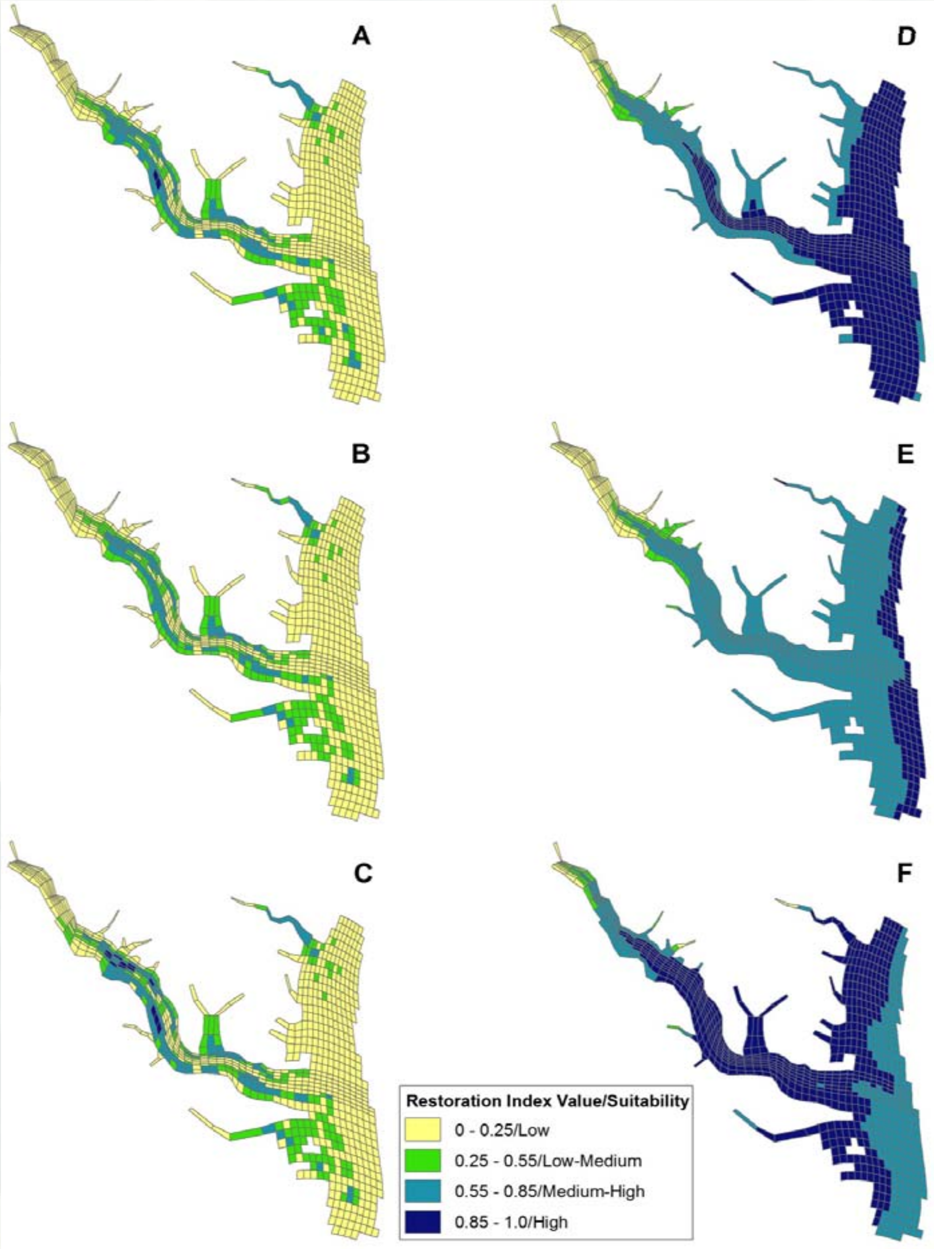
- **High Fidelity data**
  - Salinity (suitable salinity conditions)
    - Source: CH3D model output
    - Description: vector dataset of simulated surface salinity for 1997 – 1999 (3 years with wet, dry and average conditions) with varying grid cell resolution
    - Key variables extracted (monthly values):
      - Annual Mean Salinity
      - Mean Salinity During the Spawning Season (May – Sept)
      - Minimum Annual Salinity
  - Cultch (potential hard bottom substrate)
    - Source: NOAA's Chesapeake Bay Benthic Habitat Integration Dataset and USACE reefs
    - Description: combination vector dataset of historic acoustic surveys from Virginia and Maryland and more recent side-scan sonar and acoustic seabed classifications
    - Key variables extracted:
      - Mollusk (oyster) polygons
      - Reefs

HSI Chesapeake Bay

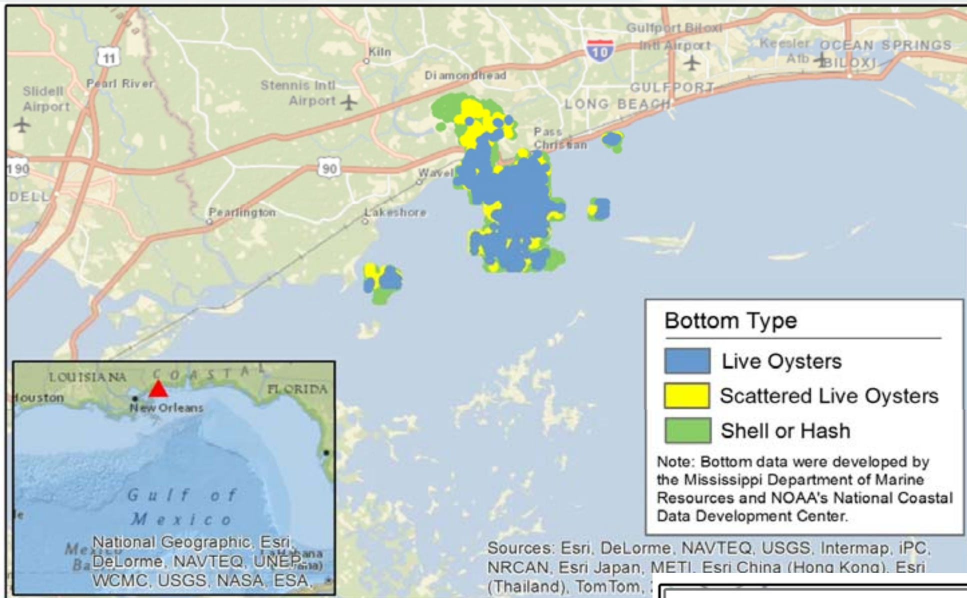


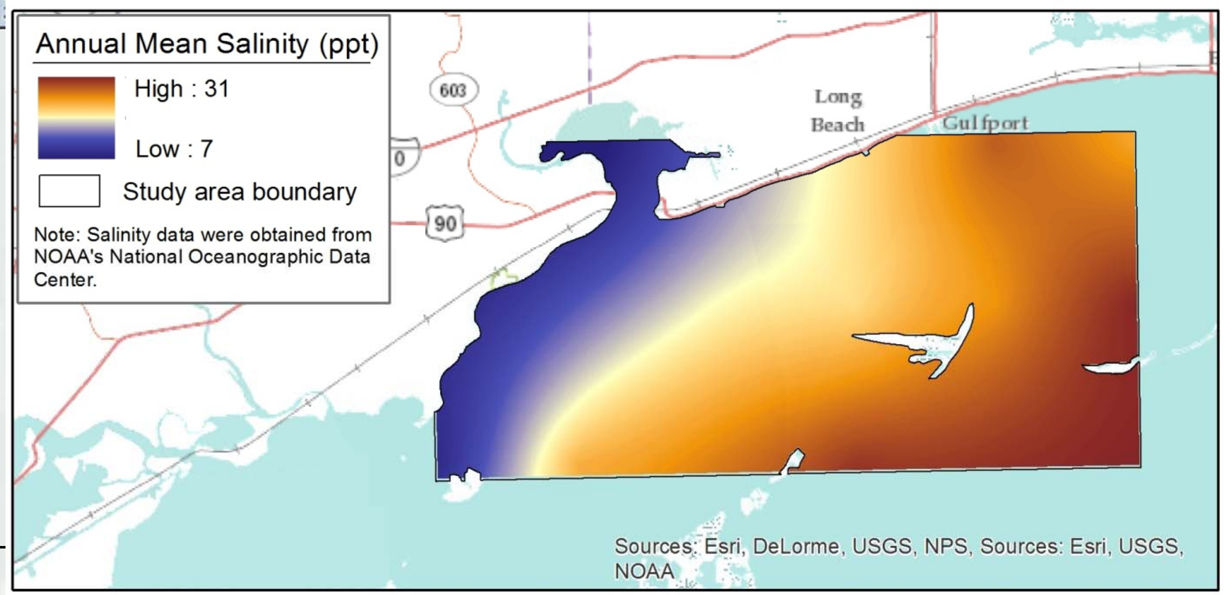


Chesapeake Bay HSI Results

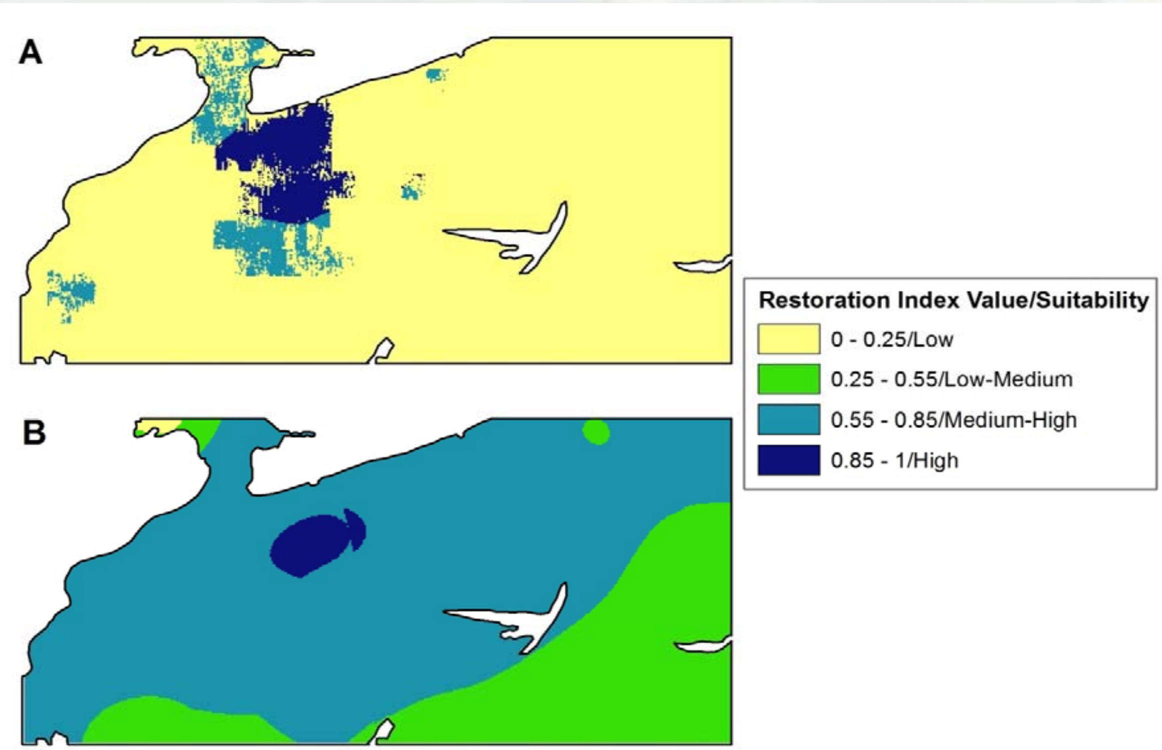


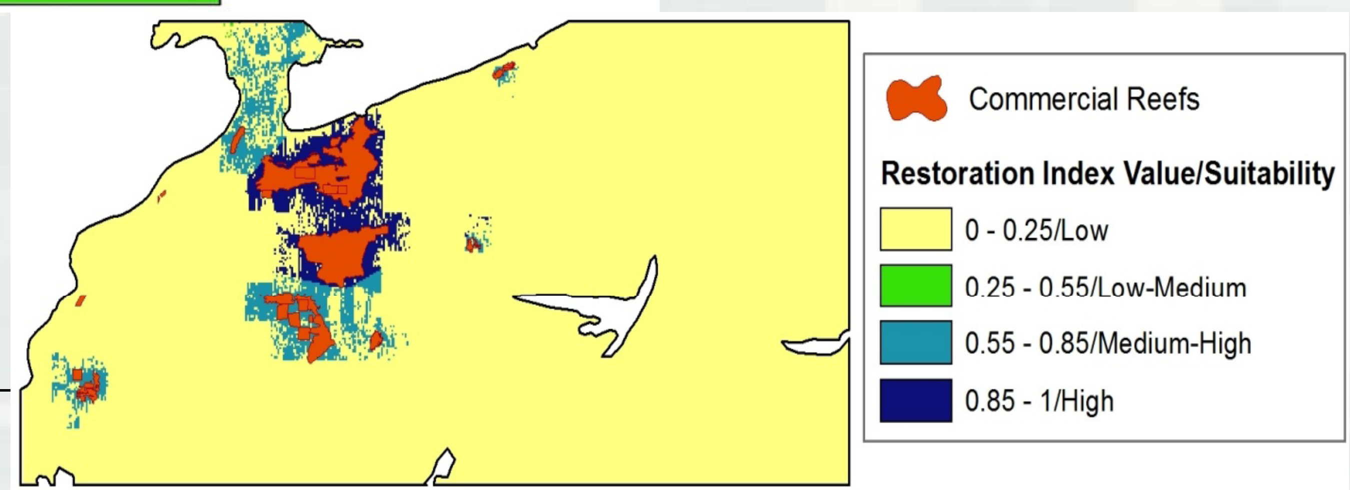
HSI Gulf of Mexico





Gulf of Mexico HSI Results

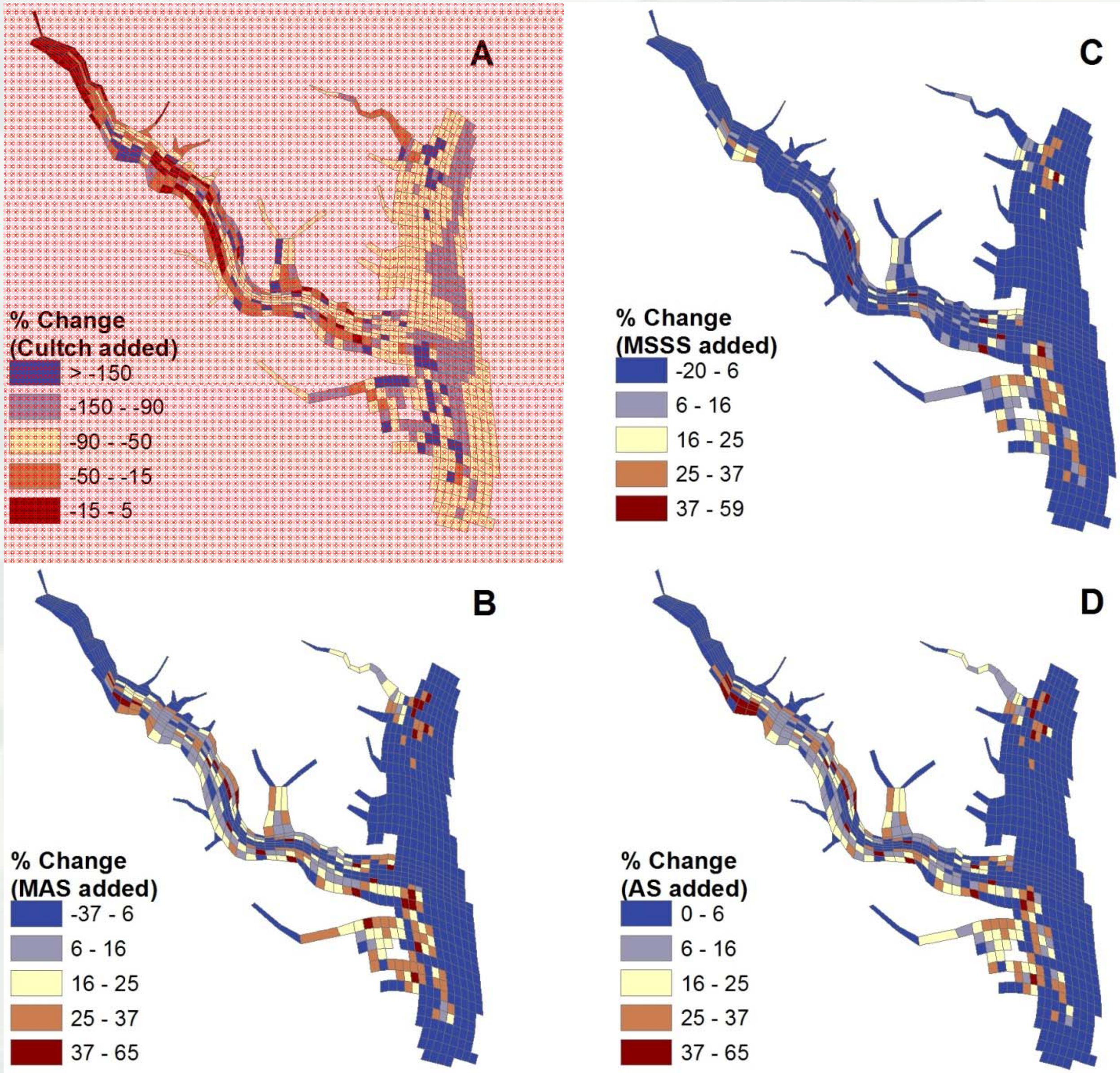




HSI Results – General

- Results for both Chesapeake Bay and Gulf of Mexico indicated that results were highly influenced by the *% Cultch* variable
- Model needed to be evaluated more thoroughly to quantify effects of each variable
- Ran sensitivity analyses for each site

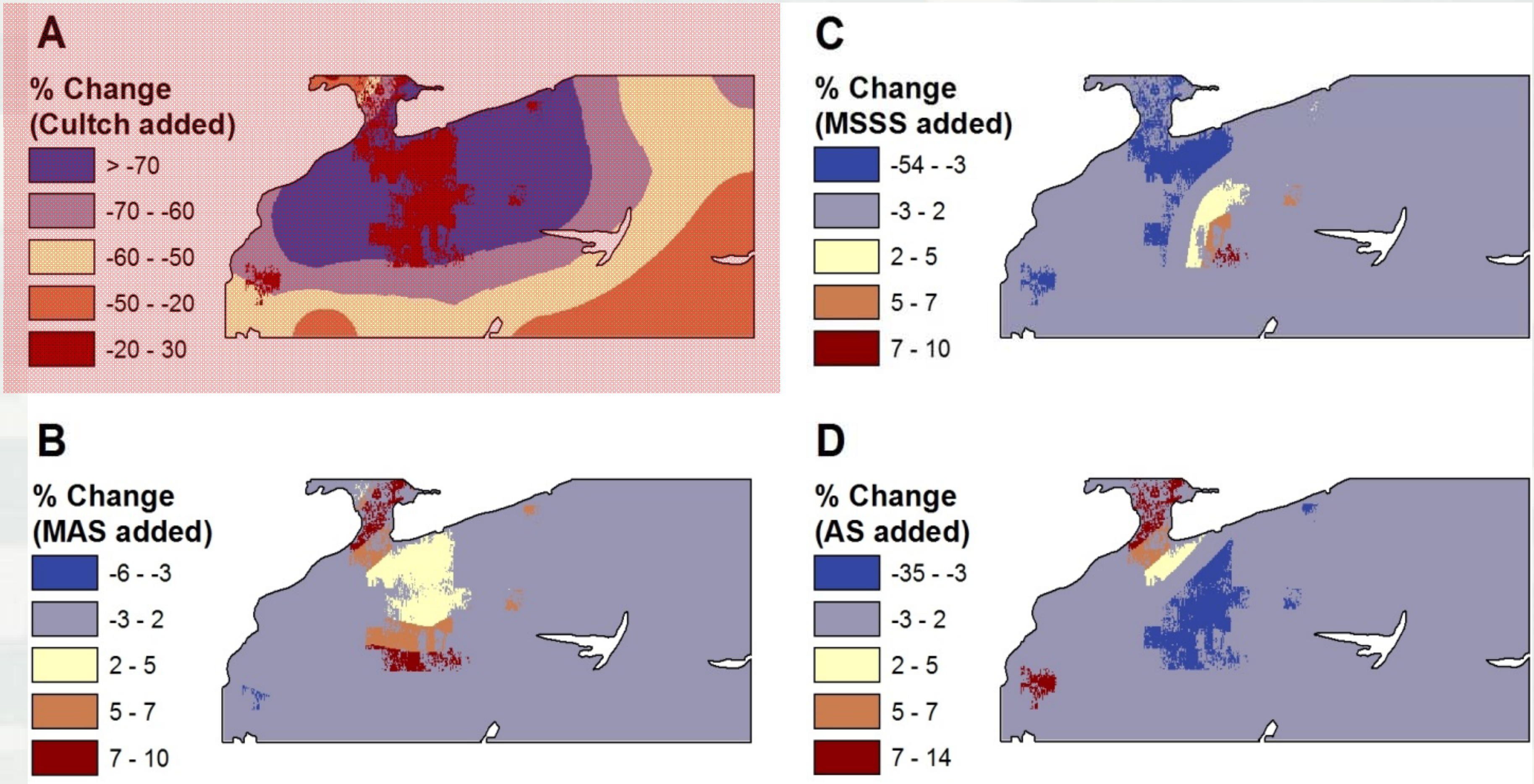
Sensitivity analysis of Chesapeake Bay



Variables added one at a time, then model was rerun

Then calculated % Change of results

Sensitivity analysis of Gulf of Mexico



Conclusions

- This approach was successful for identifying suitable locations for oyster restoration

Conclusions

- Oyster habitat is dynamic
  - Changes from year-to-year

- Simplified model with salinity and substrate captured general trends in oyster habitat
  - Wet years (lower salinity) were worse for oysters compared to moderate years
  - Emphasizes that simple models can reflect natural conditions

Conclusions

- Model is sensitive to *% Cultch*
  - ► Parameterization was a simple linear relationship, so areas without hard substrate were considered unsuitable
  - ► In order to apply the model for restoration planning in areas without hard substrate, a polygon representing potential reef areas would need to be added to *% Cultch* layer to determine overall suitability

Conclusions

- HSI-GIS approach is flexible and adaptable
  - ► Multiple data types can be used
  - ► Model is flexible and can be adapted as new information is available

- Important to fully evaluate model
  - ► Sensitivity analysis allows for deeper understanding of model results
  - ► Helps quantify uncertainty and make more informed decisions

Future Work

- Modeling oyster benefits from potential restoration work
  - Water quality parameters, among others (led by Carl Cerco and Mark Noel)

- Different functional forms of model equations should be evaluated