ECOLOGICAL & ECONOMIC IMPACTS OF LAND USE AND CLIMATE CHANGE ON COASTAL FOOD WEBS & FISHERIES

Simulating land-use and climate change scenarios in the Suwannee River Estuary

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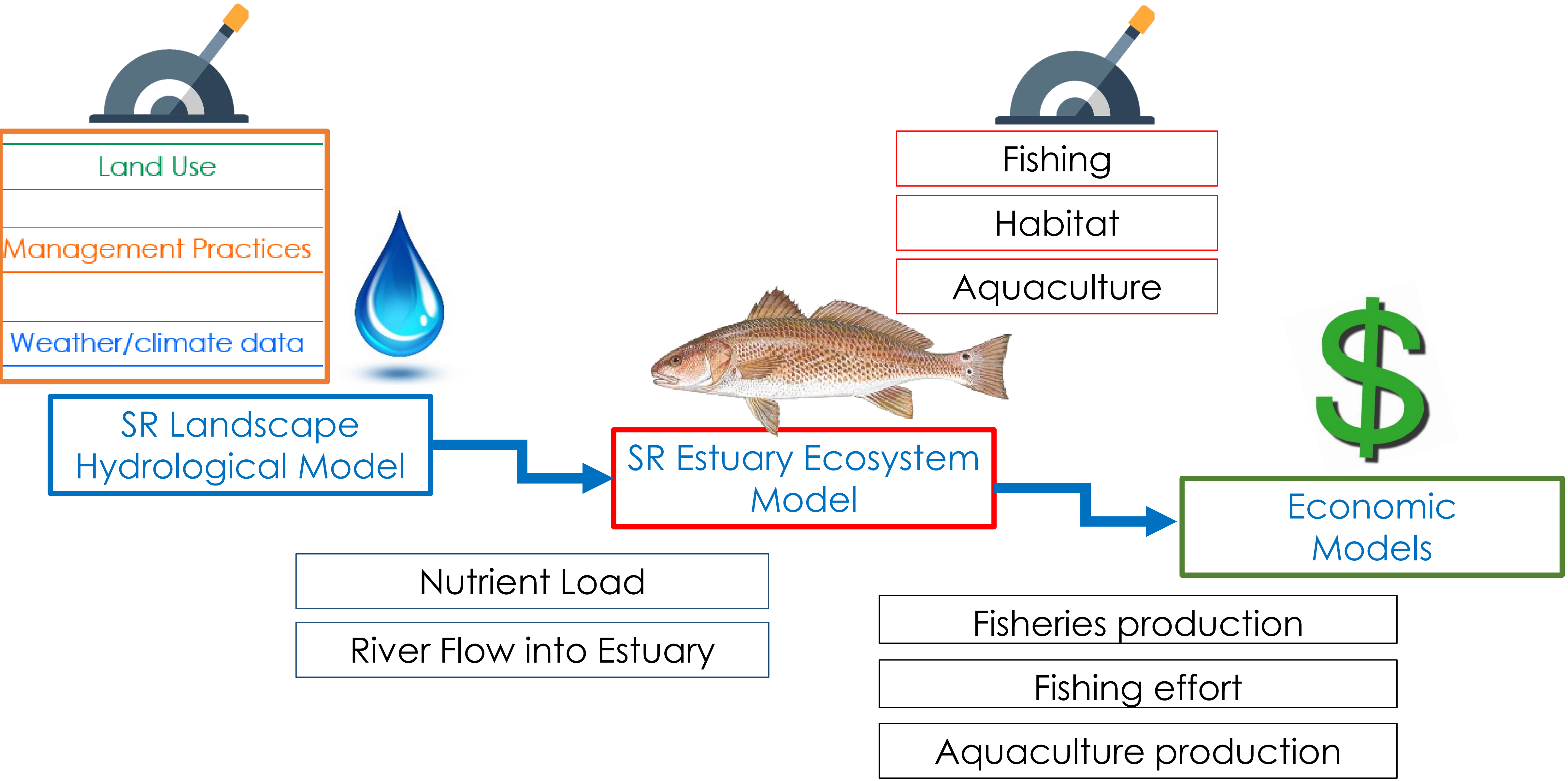


Scenario Framework

Ecosystem model developed to examine effects of land use and climate on estuarine productivity and natural resources

Natural resources

Environmental Drivers

Direct effects on feeding, movement, survival

Estuary Food Web

Effects on habitat and PP

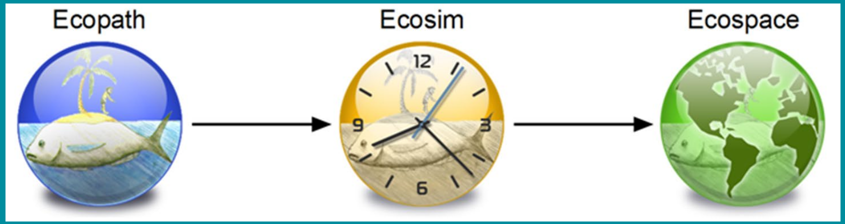
Habitat & Production

Changes in PP and habitat affect food availability, growth, survival, and movement

Changes in abundance affect fisheries production and fishing opportunities

The Suwannee River Estuary Model (SREM)

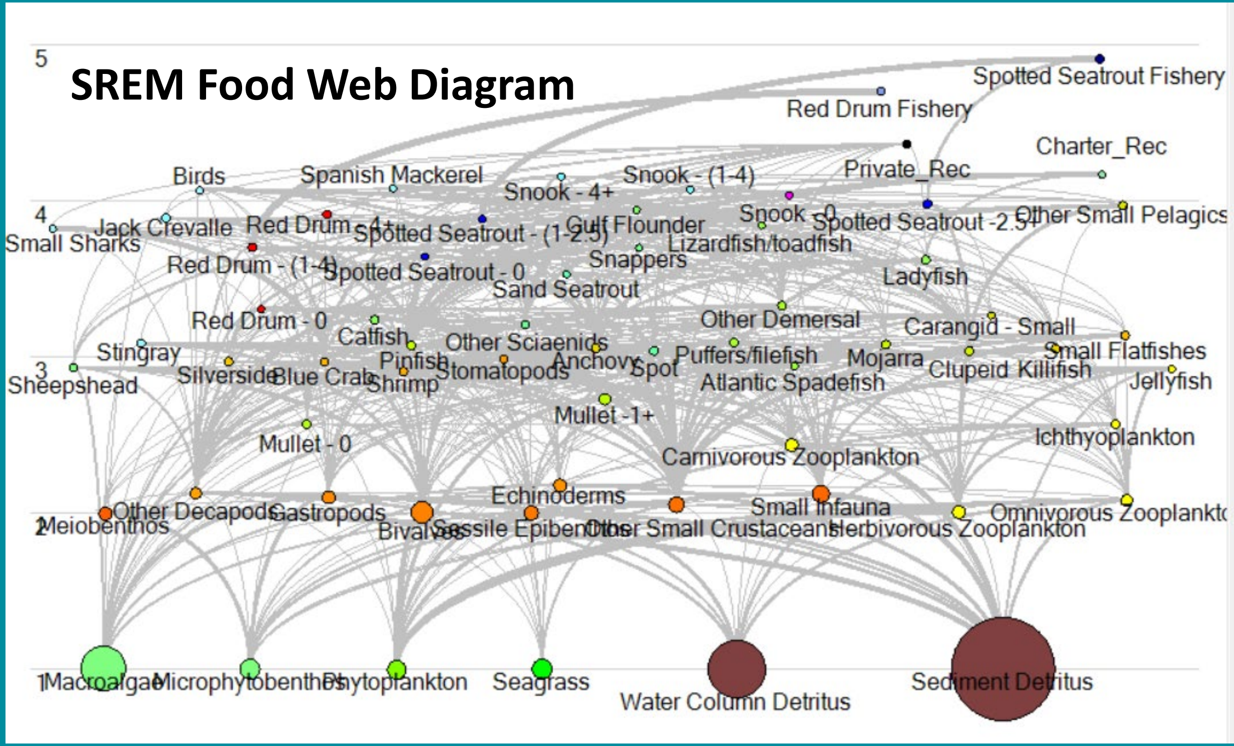
- Simulates biomass dynamics over space and time across all trophic levels
- Driven by changes in environmental conditions, habitat, fishing, and food web interactions



Ecopath with Ecosim (EwE) ecosystem modeling package (www.ecopath.org)

<u>SREM</u>

- 66 functional groups
  - PP to top predators
  - Focus on resident estuarine fish, sportfish, clam aquaculture, and oysters
- 8 fishing fleets
  - Recreational (charter, private, red drum, spotted sea trout, snook)
  - Commercial (oyster, stone crabs, clam aquaculture)



Sinnickson et al. 2021 Front. Mar. Sci

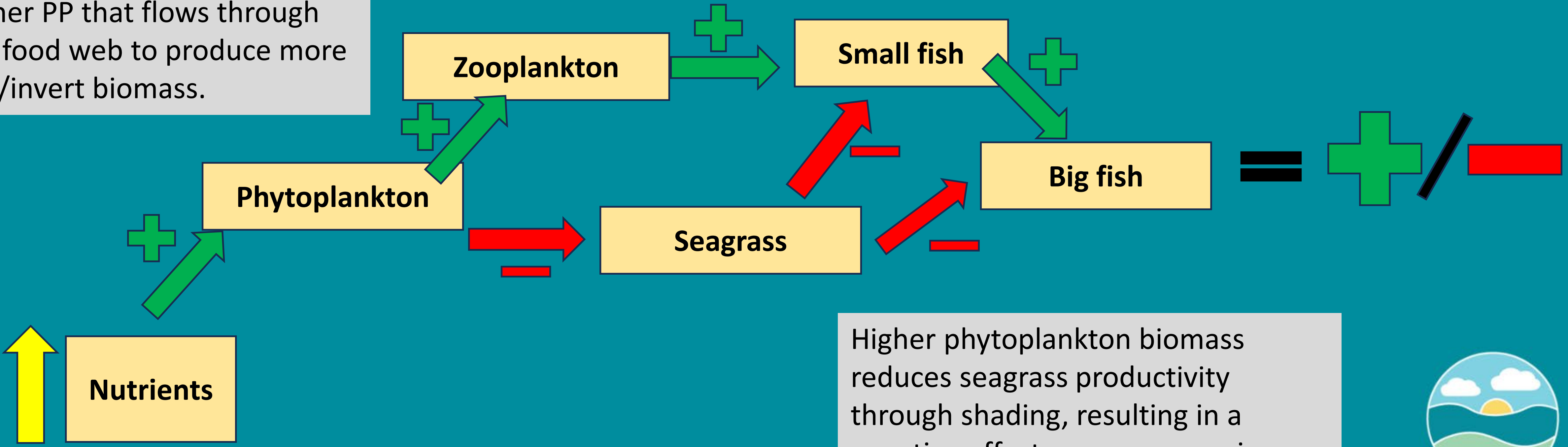
The Suwannee River Estuary Model (SREM)

- **Habitat types (3):** seagrass, marsh/mangrove, oyster
- **Environmental Drivers (3):** nutrients, temperature, salinity
- **Habitat affinities:** based on encounter probability models using FIM data
- **Environmental preferences:** – based on generalized additive models using FIM data
- **Mediation functions (2):** seagrass shading by phytoplankton; seagrass as foraging habitat
- Forcing function required to drive snook expansion
- ‘hatchery’ forcing used to seed clam aquaculture on lease sites

Simulating Land-use and Climate Change Effects in the Estuary

Nutrient additions/ reductions have simultaneous positive and negative effects in the model

More nutrients results in higher PP that flows through the food web to produce more fish/invert biomass.

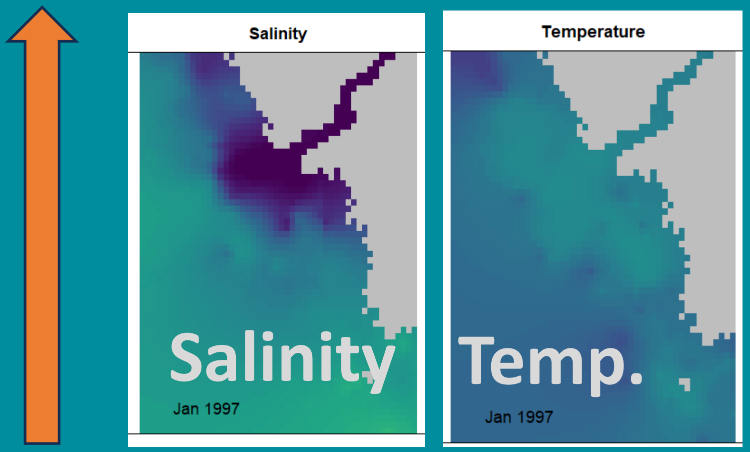


Higher phytoplankton biomass reduces seagrass productivity through shading, resulting in a negative effects on some species

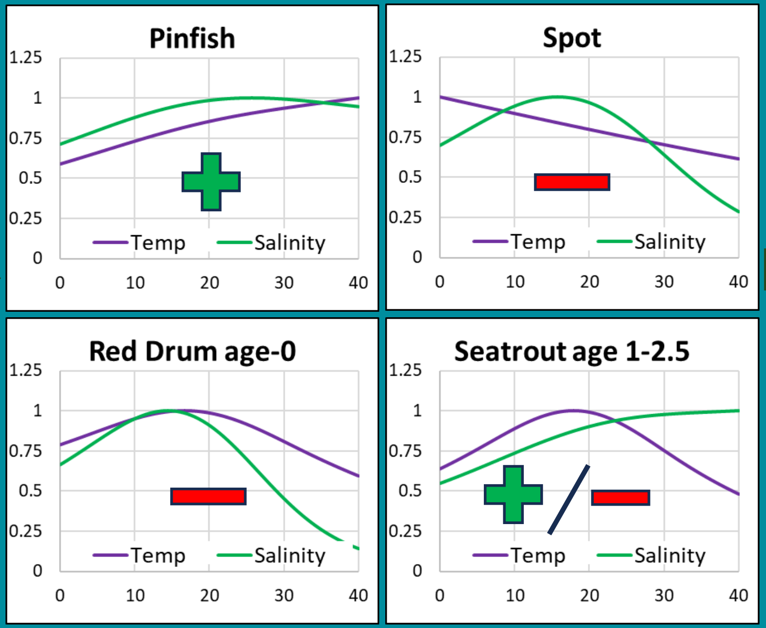
Simulating Land-use and Climate Change Effects in the Estuary

Temperature and salinity affect the foraging capacity in each grid cell, based on species-specific preference functions, which drive movement, feeding, and growth.

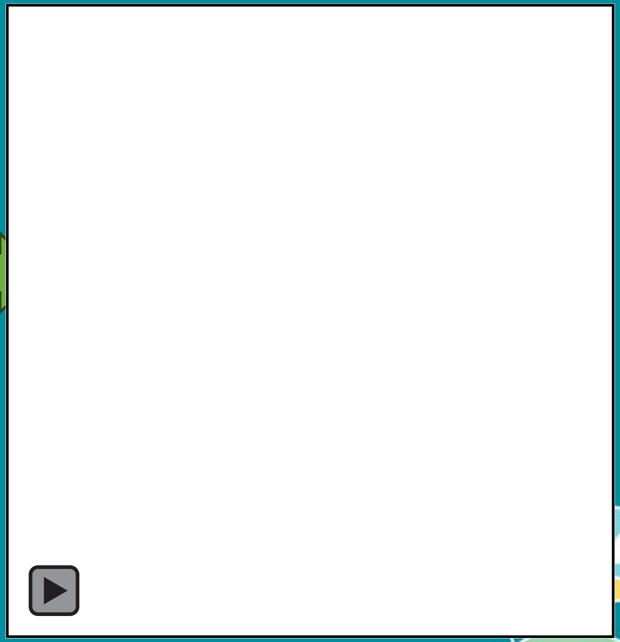
Scenario: Drier and Hotter



Environmental Preference Fxns.



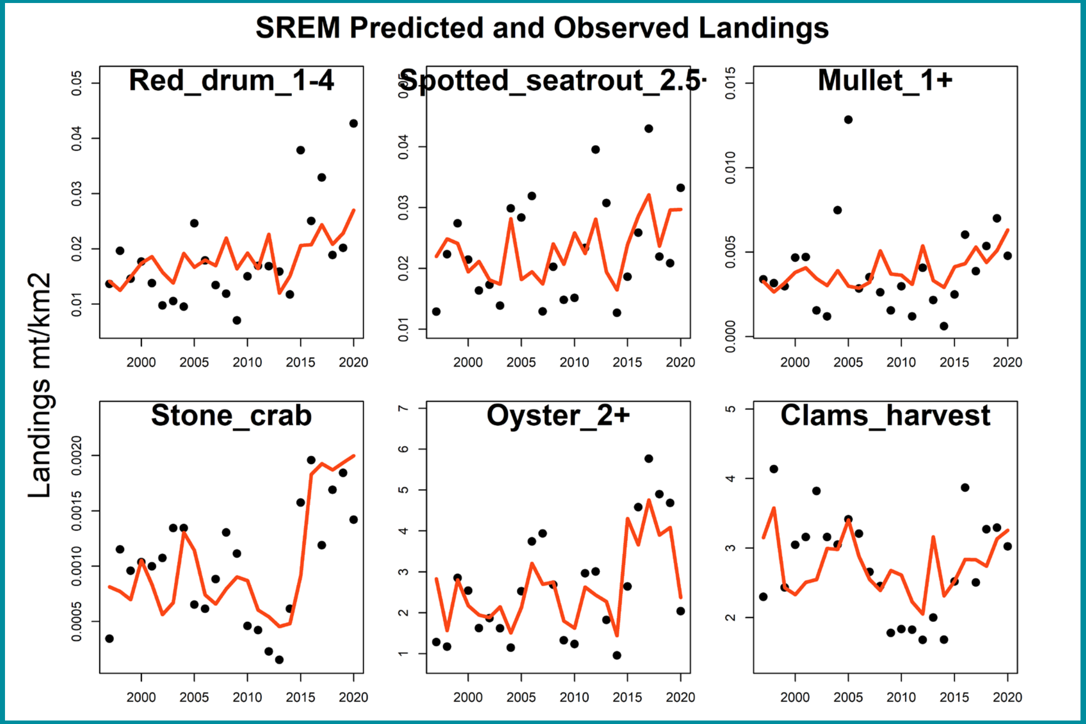
Computed Foraging Capacity Maps



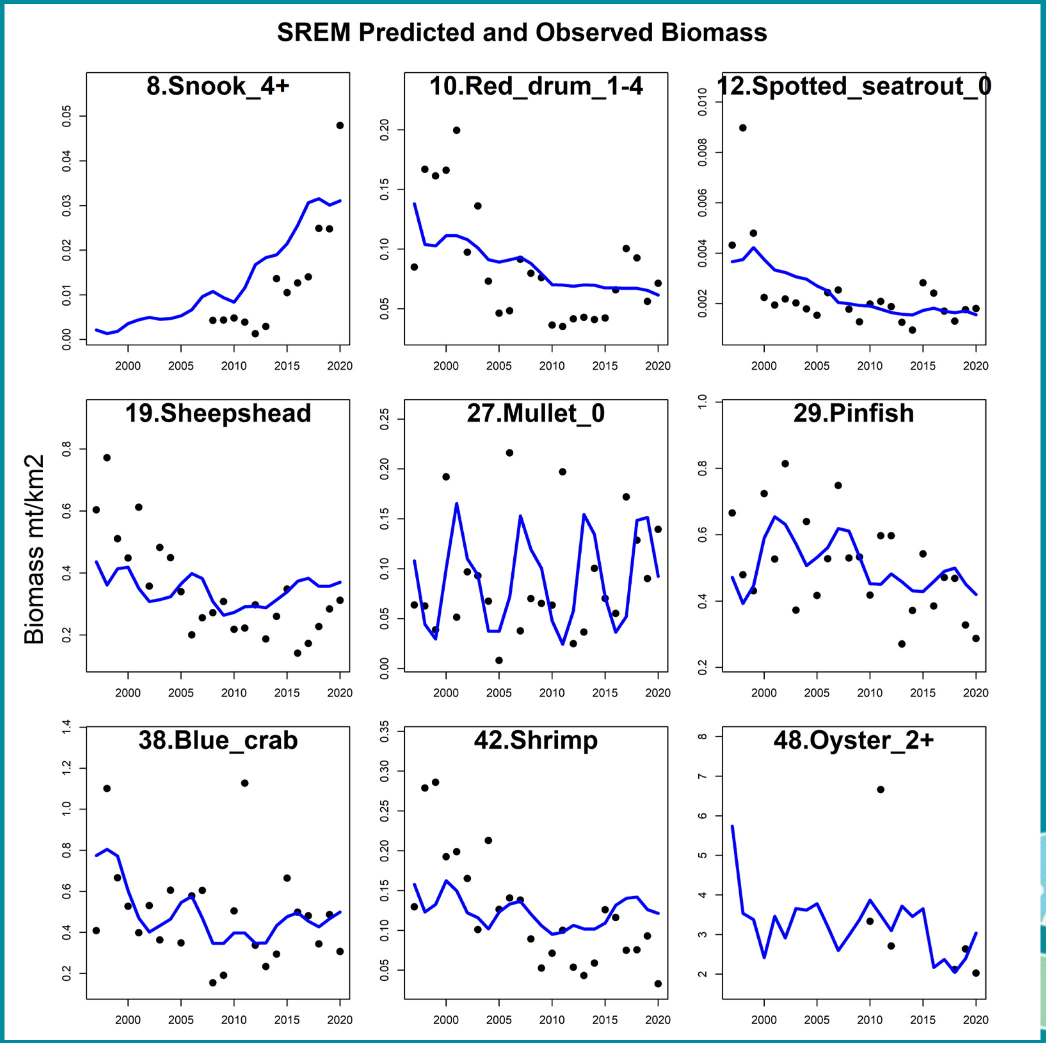
The Suwannee River Estuary Model (SREM)

The SREM was capable of reproducing many of the observed patterns in fish abundance from the FIM program and landings trends.

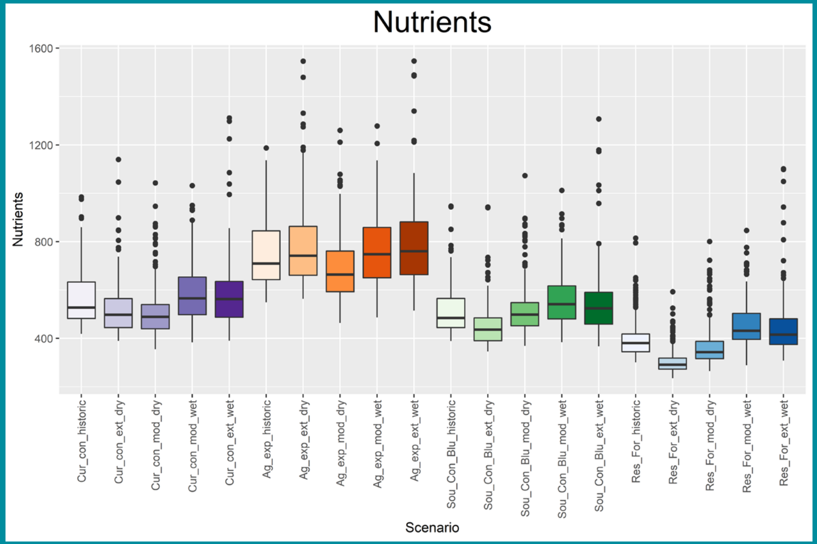
Catch

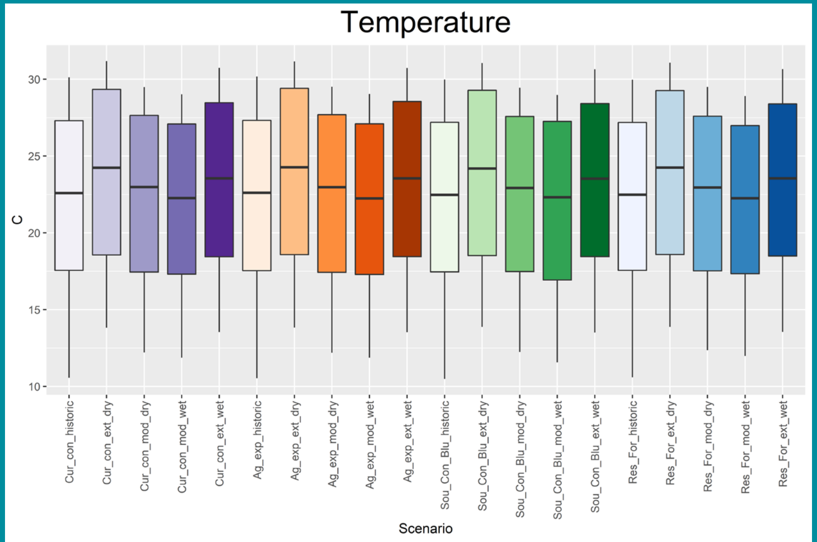


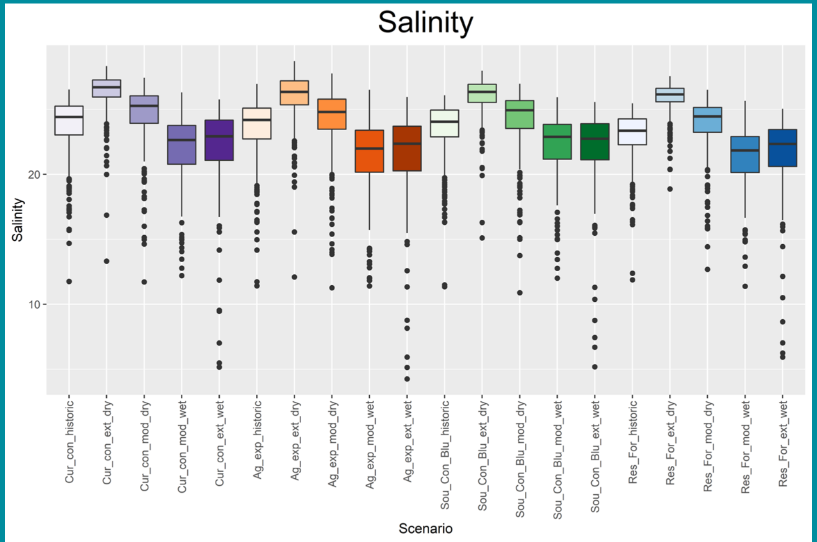
Biomass



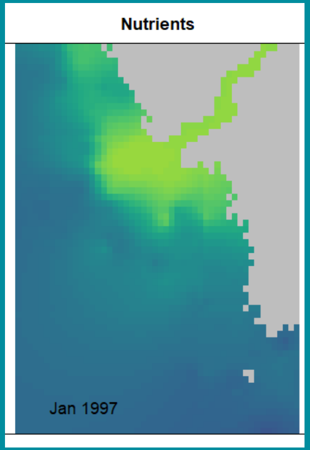
Future Land Use and Climate Scenarios in the Suwannee River Estuary



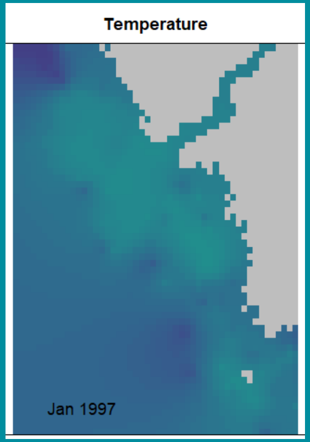




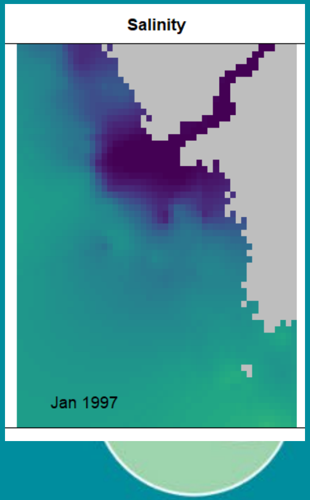
Nutrient loading is driven largely by changes in land use. Ag expansion has the highest nutrient inputs while restoration forestry has the lowest.



Temperature in the estuary is driven by climate change. The extreme climate scenarios are slightly warmer on average, by 1-2 °C.



Salinity is largely driven by precipitation under the future climate change scenarios. Higher salinity in extreme dry secnarios.

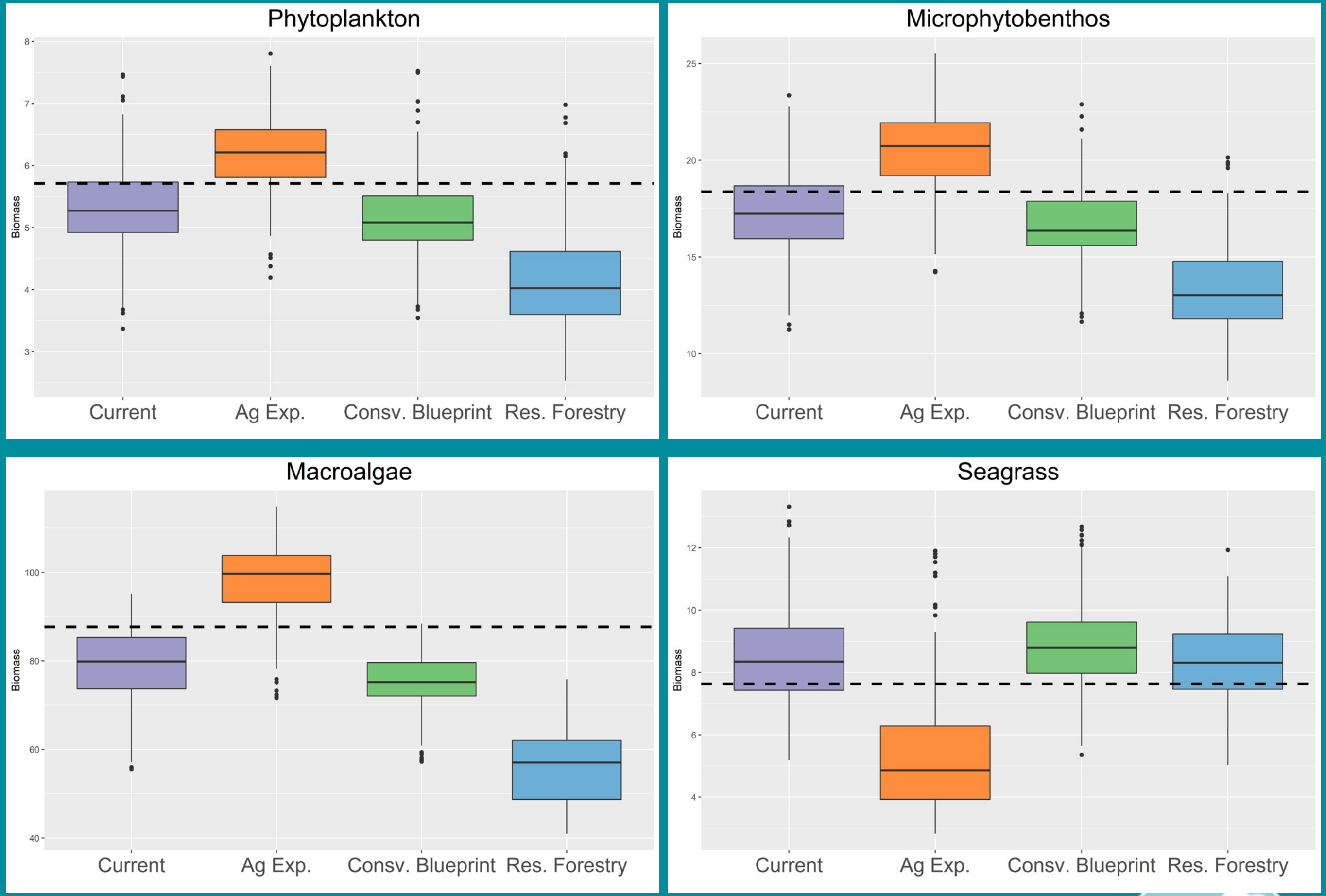


SREM Land Use and Climate Scenario Predictions

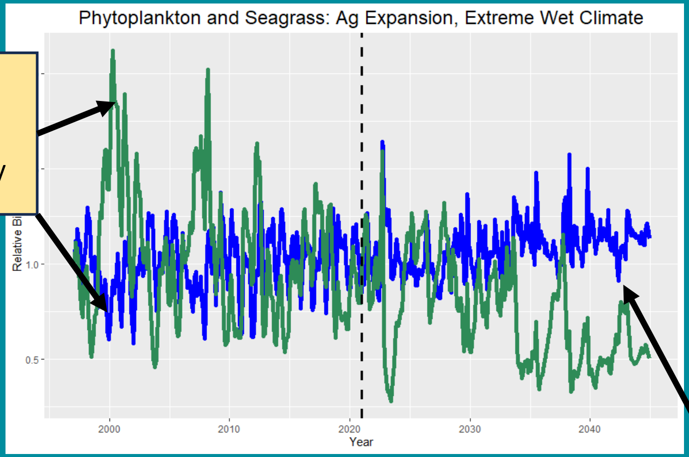
Primary Producers

Future phytoplankton and algae biomass varies with nutrient inputs.

The model predicts seagrass decline under the Agricultural Expansion scenarios due to increases in phytoplankton and algae.



Phytoplankton decline and seagrass recovery



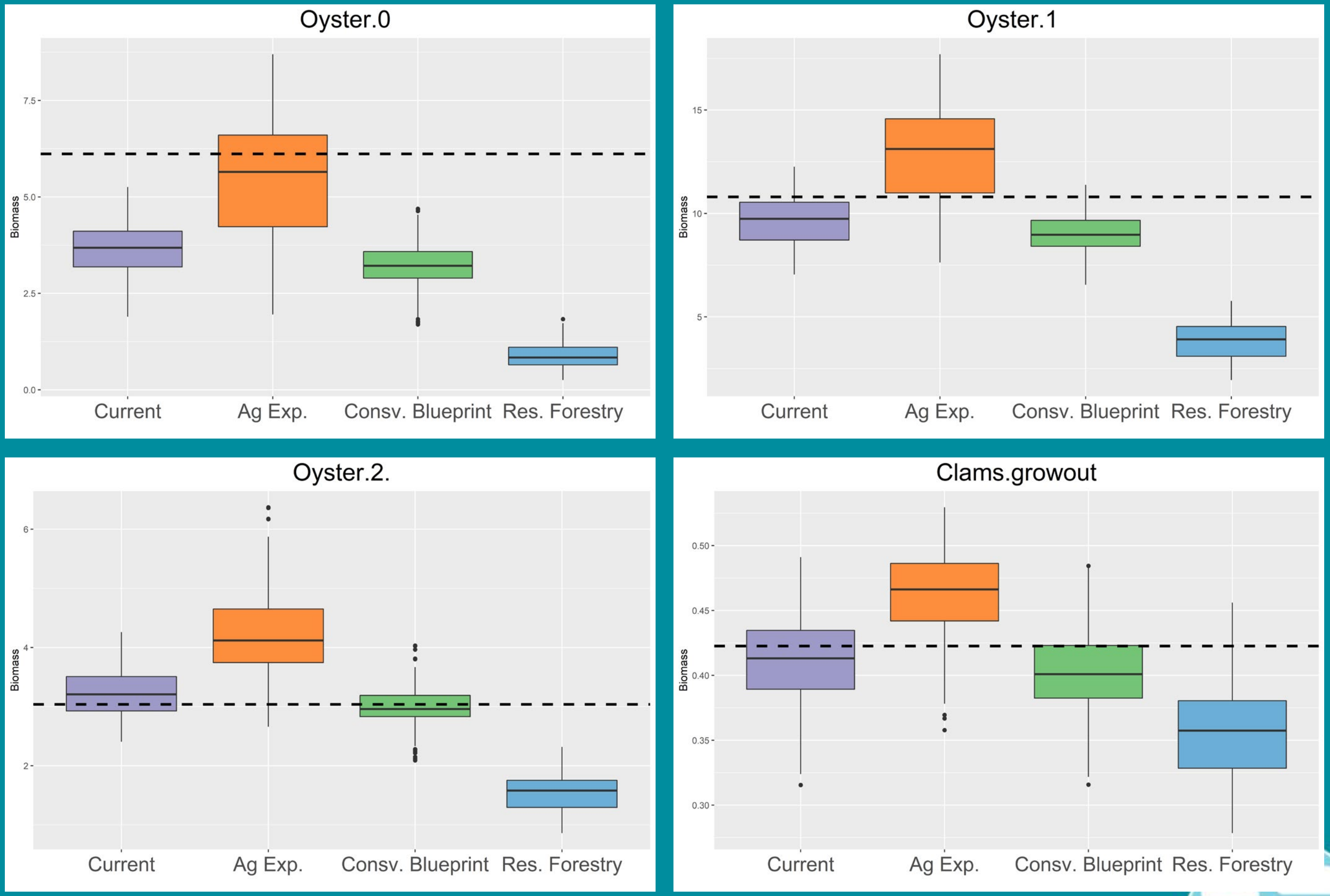
Persistent seagrass loss in future ag expansion scenario

SREM Land Use and Climate Scenario Predictions

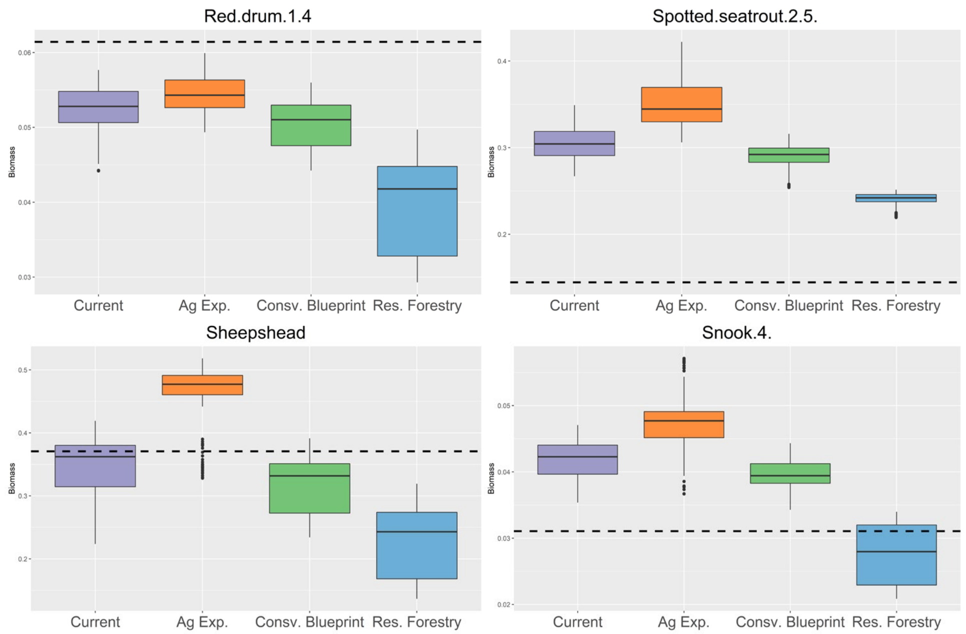
<u>**Shellfish Resources**</u>

Nutrient inputs from Ag. Expansion enhance production of wild oysters and cultured clams, compared to current land use.

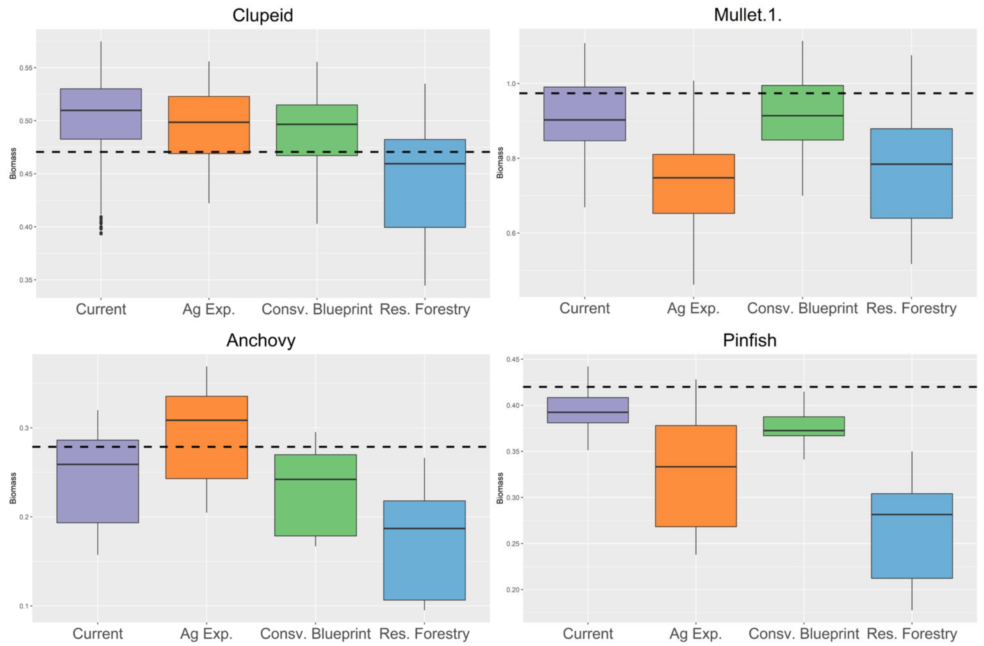
Fishing effort and clam seeding held constant at current levels. Oysters decline in all scenarios under this assumption.



SREM Land Use and Climate Scenario Predictions



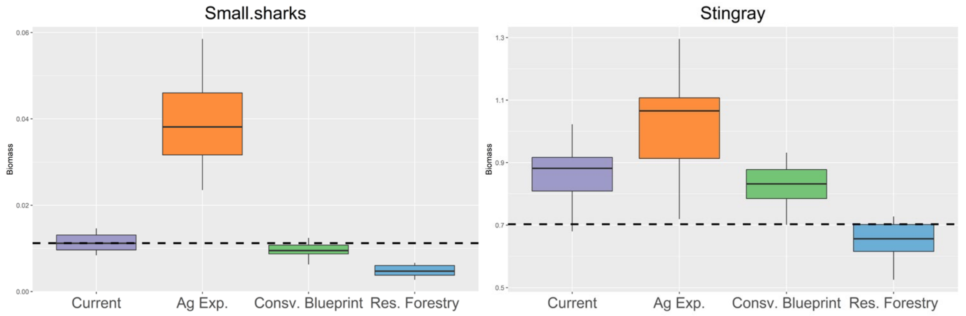
Sportfish stocks have moderate affinity to seagrass, and are influenced more by nutrient signal, with biomass ending either below or above current levels.



Small pelagic baitfish respond to nutrients.

Pinfish & mullet respond more strongly to seagrass.

Increase in small sharks and rays under higher nutrient scenarios.



Impacts on fish community

SREM Land Use and Climate Scenario Predictions

Summary of Results

- Scenarios that increase discharge and/or nutrients increase primary production in the estuary, which cascades to higher trophic levels, including fisheries.
- Seagrass loss is predicted under the agricultural expansion scenarios, which has negative effects on associated fish species.
- The restoration forestry scenario lowers the overall productivity in the estuary
- Fishing effort was held constant at current levels, contributing to declines in sportfish and oysters in many scenarios, with economic implications.

Model Sensitivities and Uncertainties

- The model was sensitive to parameters regulating nutrient uptake by PP and transfer efficiency to secondary producers.
- Seagrass and water quality relationships are more complex than modeled, and many groups were sensitive to the shape and strength of seagrass mediation functions.
- Oysters were highly unstable under certain scenarios and parameter configurations.
- Additional 'tipping points' need to be explored that may lead to alternative stable states.