# Modeling Studies Providing Science-based Solutions for Sustainable Fisheries

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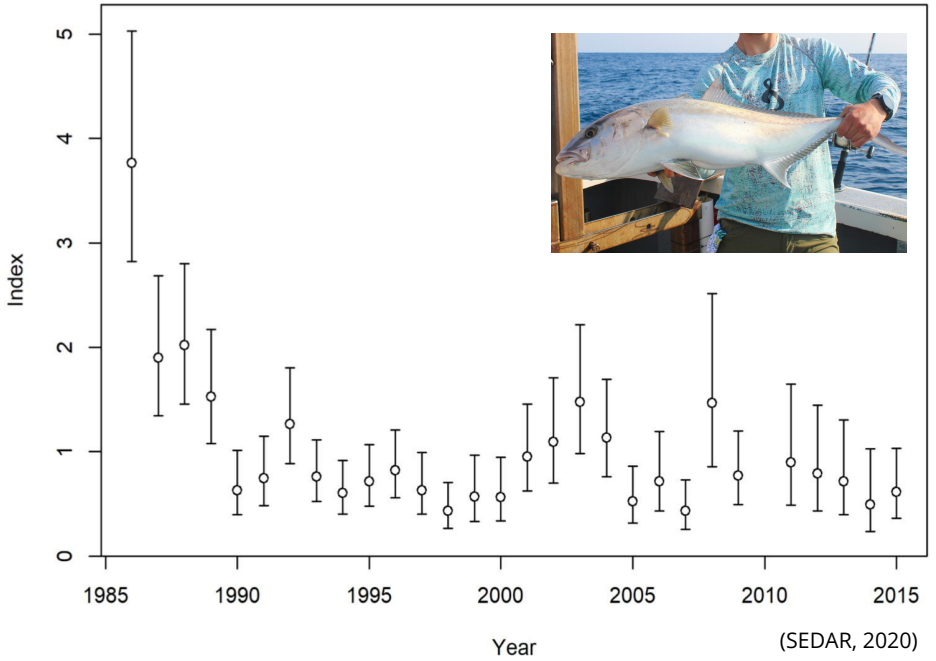
# Background

- The Gulf ecosystem is exposed to multiple stressors
- Management and restoration challenges
  - Not incorporating ecosystem process
  - Limited knowledge of larval dispersal and connectivity
- Effective management requires appropriate modelling approaches

# Larval Amberjack Dispersal

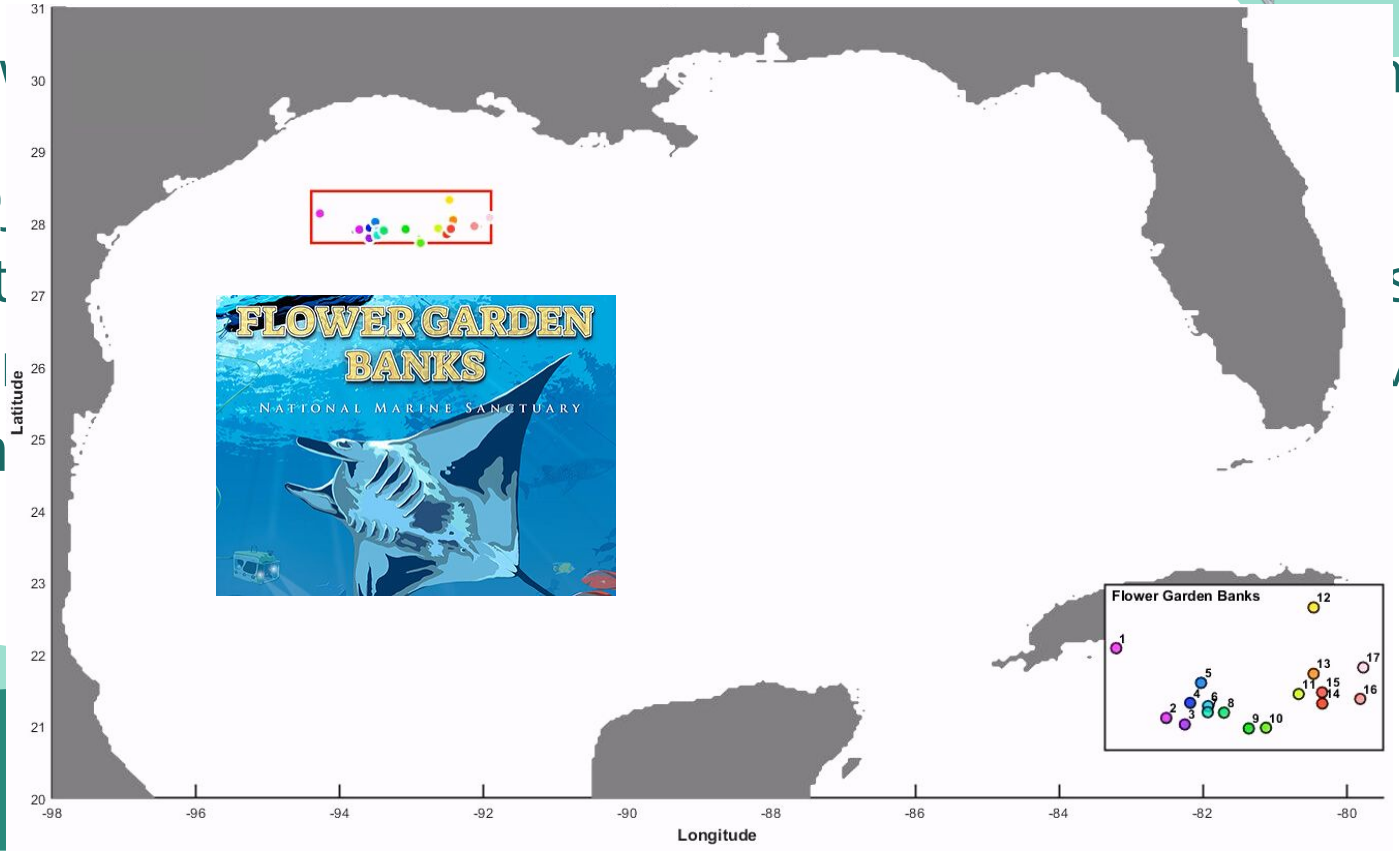
- Highly migratory, widespread reef fish
- Gulf stocks are currently overfished and subject to overfishing (SEDAR, 2020)
- Understanding larval dynamics is critical to improve stock assessment




(SEDAR, 2020)

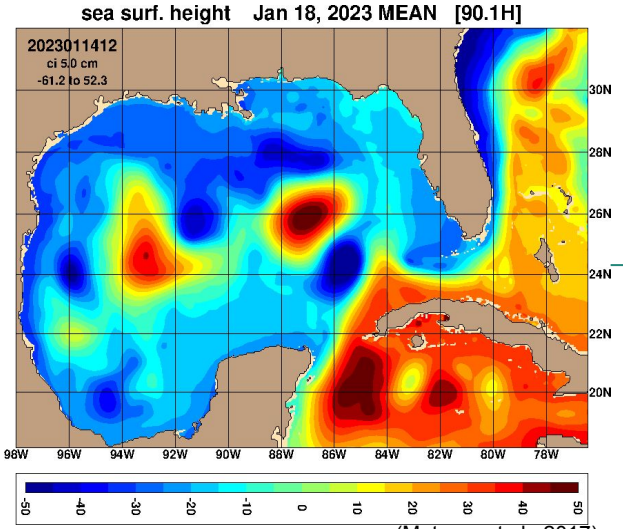
# Larval Amberjack Dispersal

- Flo… …e Gulf
- Ob… …to det… …s affect tra… …val am…



# Connectivity Modeling System

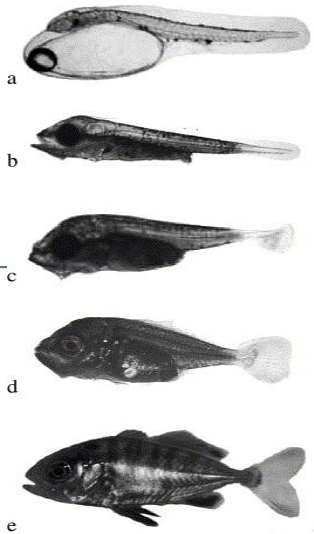
- CMS combines a stochastic biological model with an ocean circulation model (Paris et al. 2013)




(Metzger et al., 2017)

Environmental attributes
Water movement

Connectivity Modeling System
(Paris et al. 2013)




(Papandroulakis et al., 2005)

Early life history traits
Larval behaviors

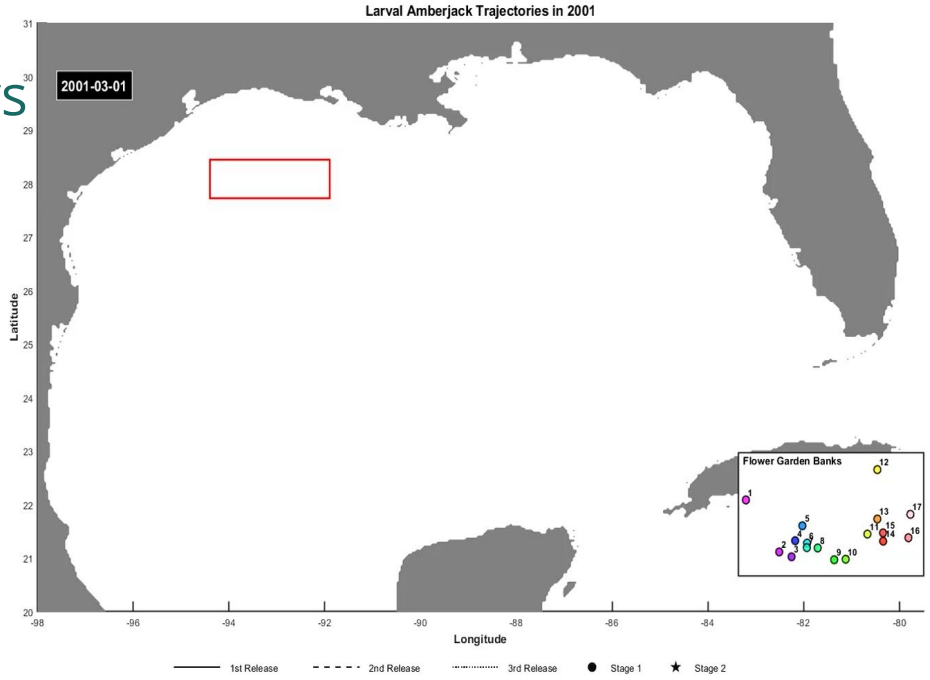
# Connectivity Modeling System

Information we have:

- Plegic Larvae Duration: 40 days
- Spawning time: March to June
- Spawning site: FGBNMS

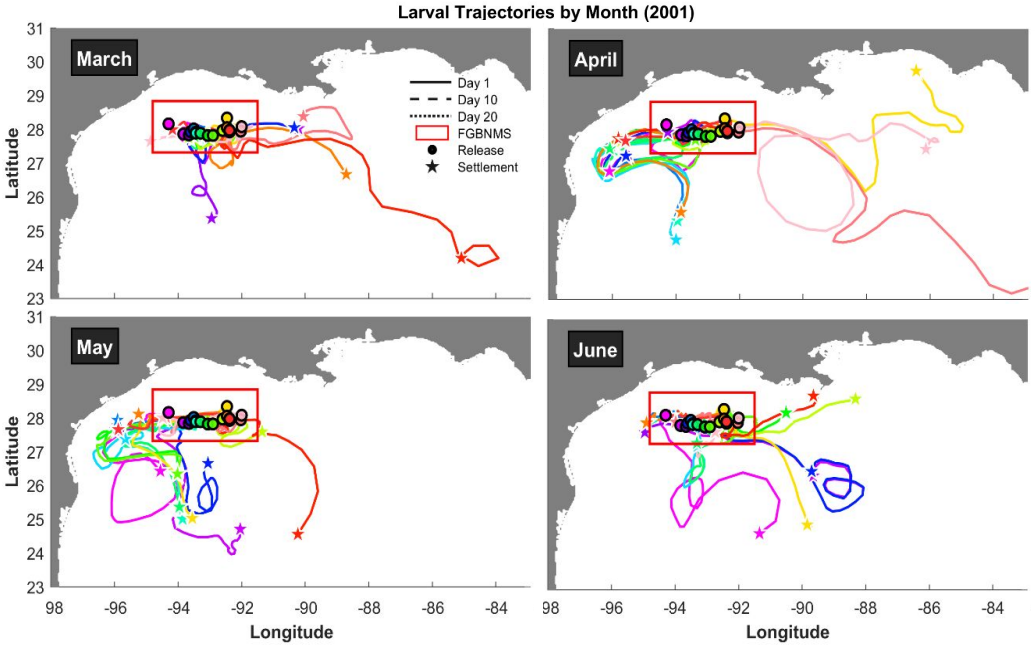
Problems to solve:

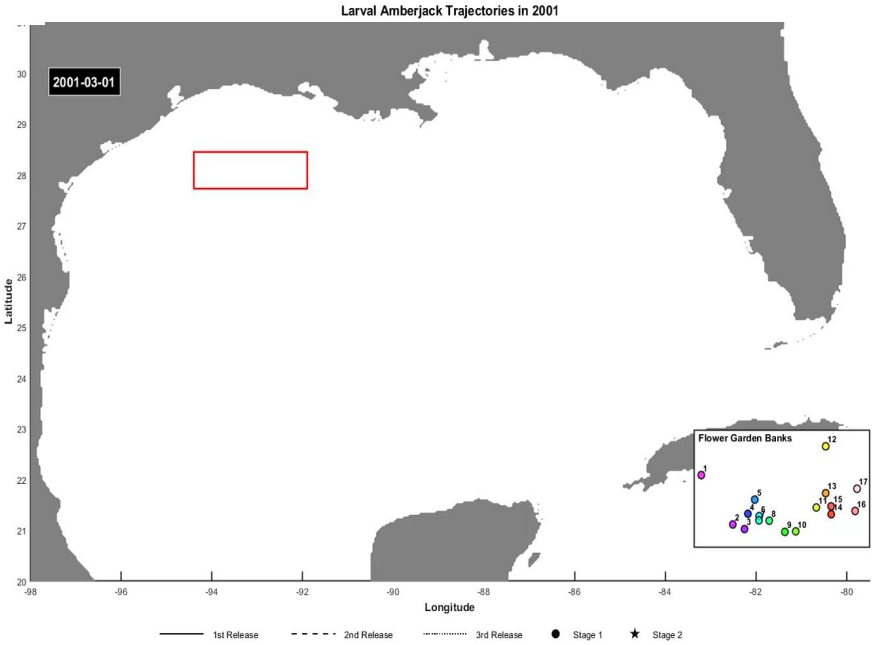
- How many larvae will survive?
- Where do they settle?
- How do currents influence their survival and settlement?



# Connectivity Modeling System

## Preliminary results: Larval dispersal trajectories



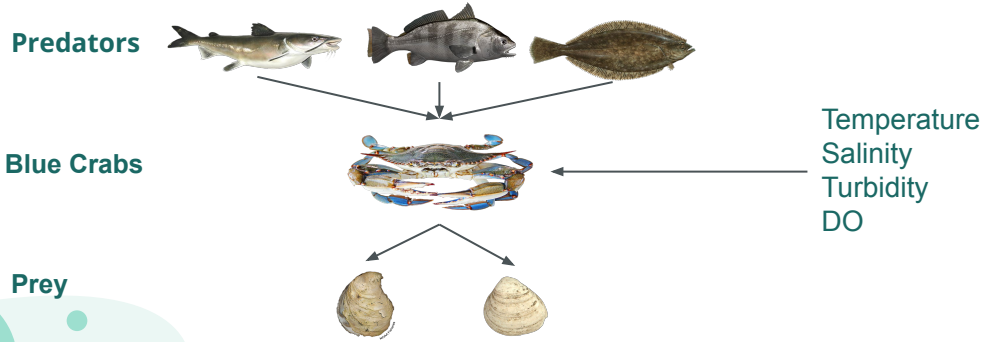
# Blue Crab Population Decline

- Blue crabs support important commercial fisheries in Texas estuaries
- Their populations have declined significantly over the past 40 years
- The cause of the decline remains unclear

# Blue Crab Population Decline

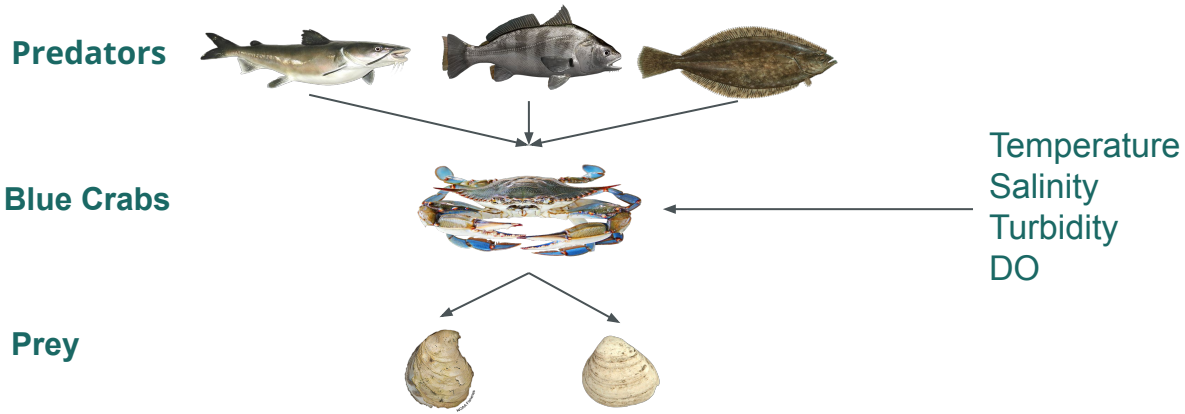
Approaches and Objectives:

- State space model (Box and Jenkins, 1970)
- Assess how trophic interactions and environmental factors influence population dynamics and identify potential drivers contributing to the decline
- Forecast short-term population trends to support management decisions



# State Space Model

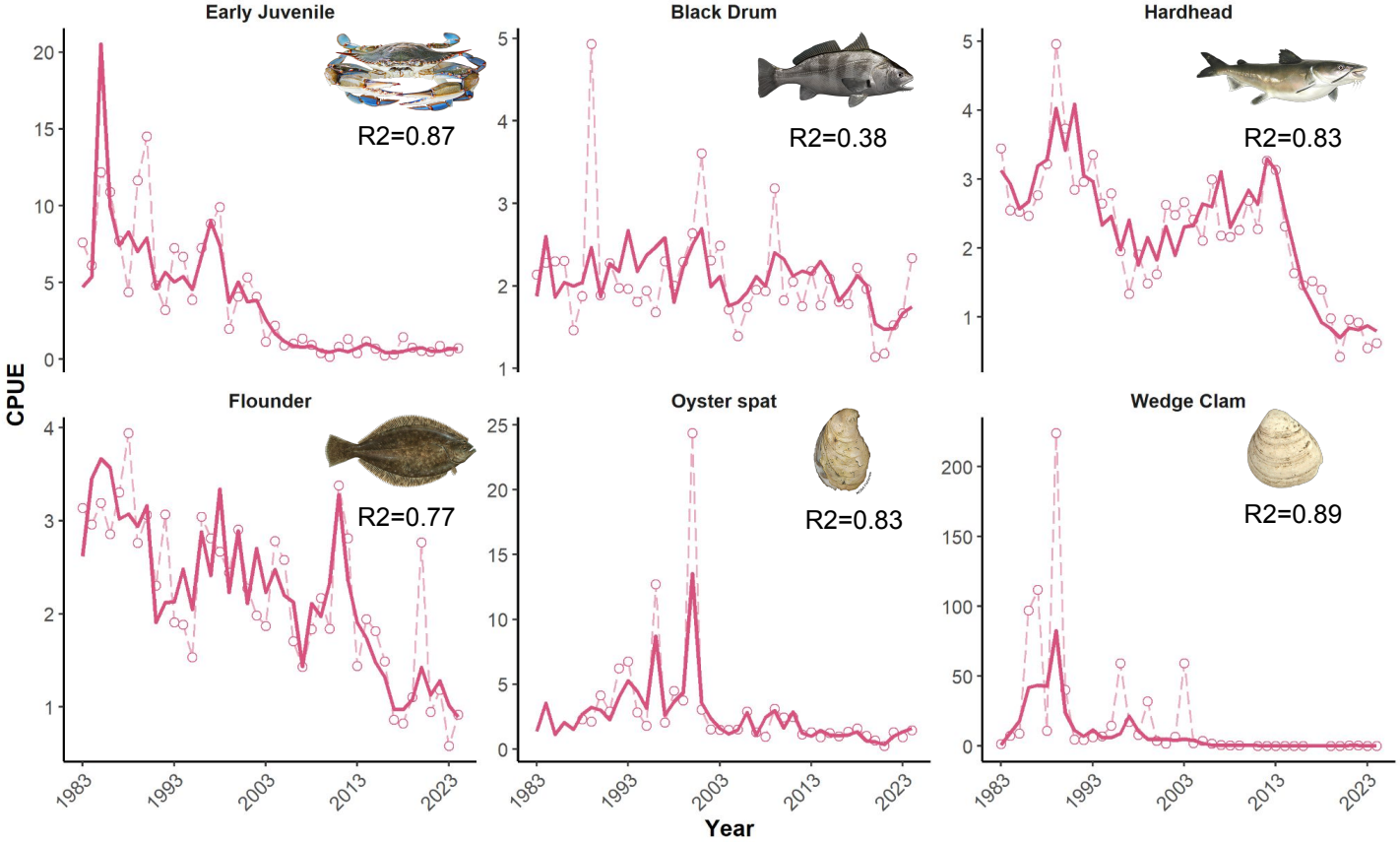
- Construct a simplified ecosystem that includes both abiotic and biotic factors with time-series data over the past 40 years (TPWD)
- Capture both internal species interactions and external covariate effects on the current state of the system



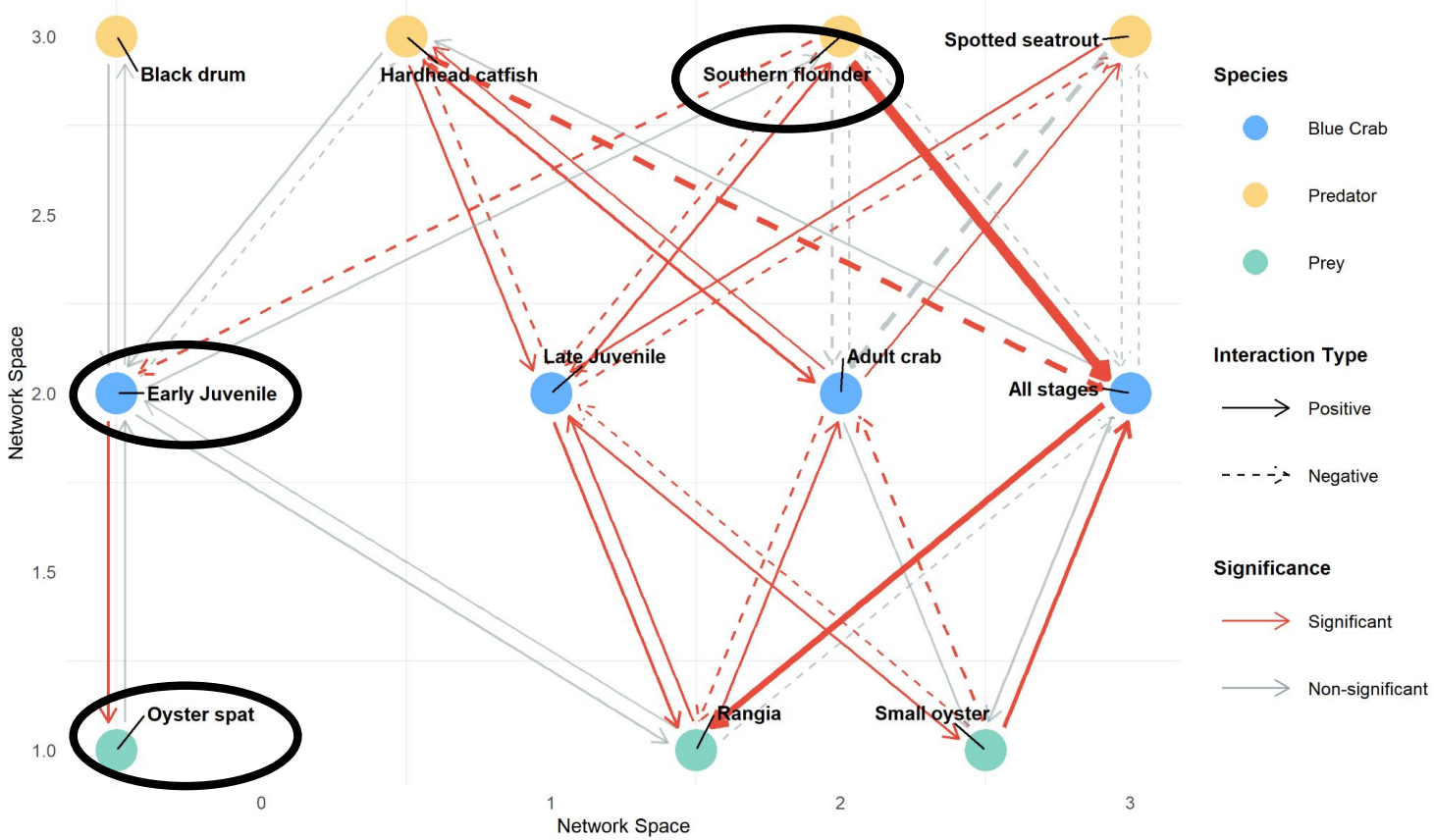

$$a_{(t)} = B * a_{(t-1)} + C * U_{(t-h)} + E_{(t)} \quad \text{(Prediction)}$$

$$Y_{(t)} = Z * a_{(t)} + V_{(t)} \quad \text{(Describe the observed data)}$$

# Predicted Population Trends



# Species Interaction Network



# Potential Solutions for Sustainable Fisheries

- By integrating biological and hydrodynamic models, we can simulate larval transport and evaluate spatial connectivity

- Applying time series modeling allows us to explore the combined influences of predation, prey availability, and environmental drivers on population dynamics

- Modeling approaches form the scientific basis for nature-based solutions to restore fisheries, enhance habitat resilience, and support effective management

# Acknowledgements

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Thank you! Any questions?