

# Accounting for Red Tide Mortality in Stock Assessments and Catch Projections in the Gulf of Mexico

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# Gulf of Mexico Red Tide

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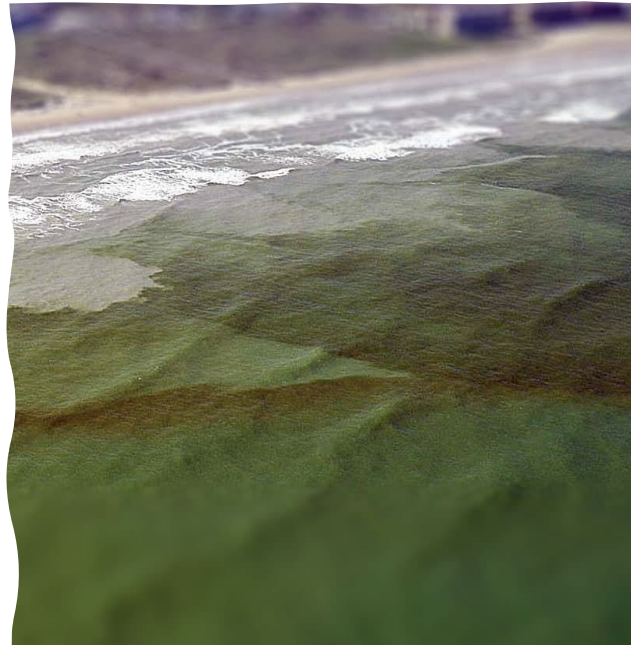
Red tide is caused by the toxic dinoflagellate *Karenia brevis*

They occur regularly on Florida's Gulf coast and are most frequent and severe in SW Florida during late summer and early fall.

Broad impacts across the ecosystem: mortality, movement, feeding, growth

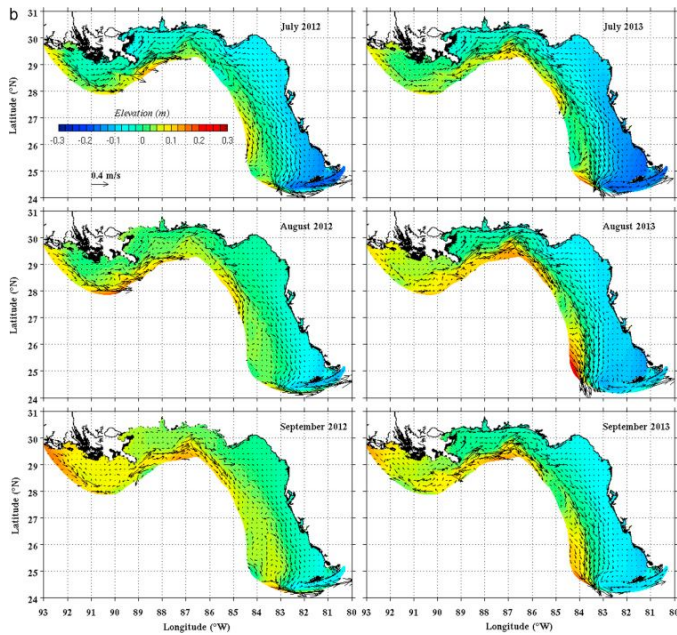
Respiratory distress in humans

Economic impacts on tourism and fisheries

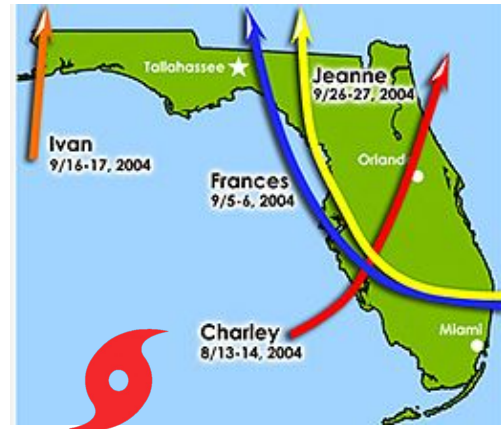


# Red Tide – Potential Causes

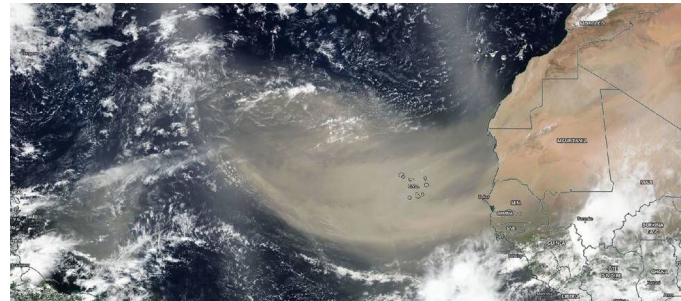
A combination of factors has been implicated in causing severe red tide blooms to occur.



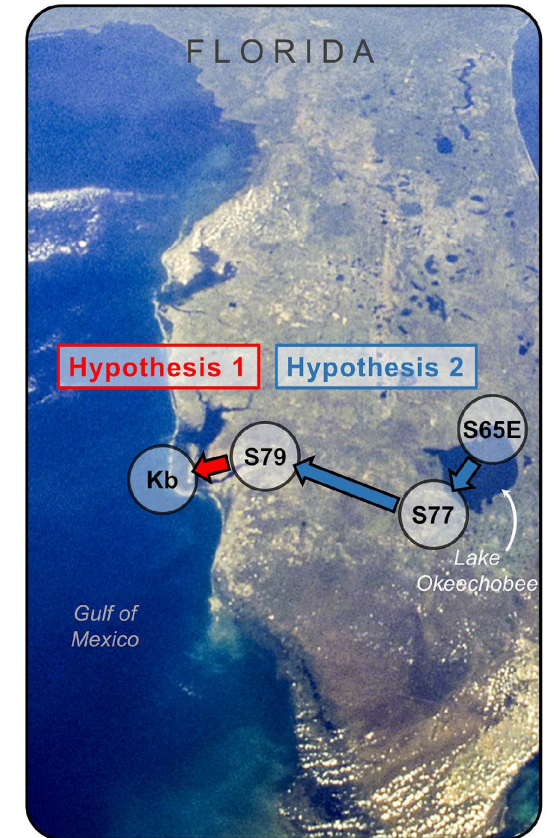
Wind-driven upwelling of inner shelf waters and coastal circulation (Weisberg et al 2014, 2016)



Precipitation & lagged submarine groundwater discharge (Hu et al. 2006)



Iron deposits from Saharan dust clouds (Walsh and Steidinger 2001)



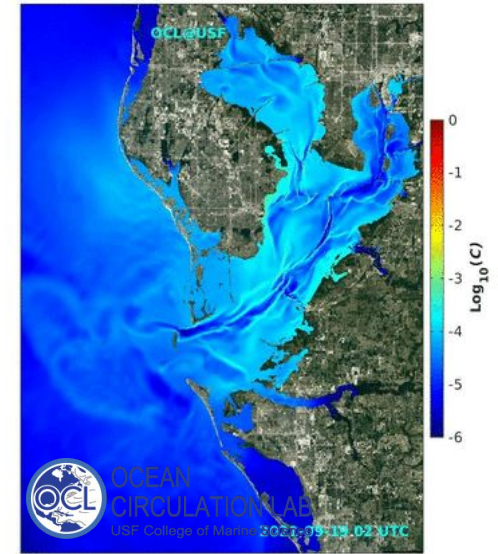
Water releases from Lake Okeechobee (Medina et al. 2022)

# Monitoring and Tracking Red Tides

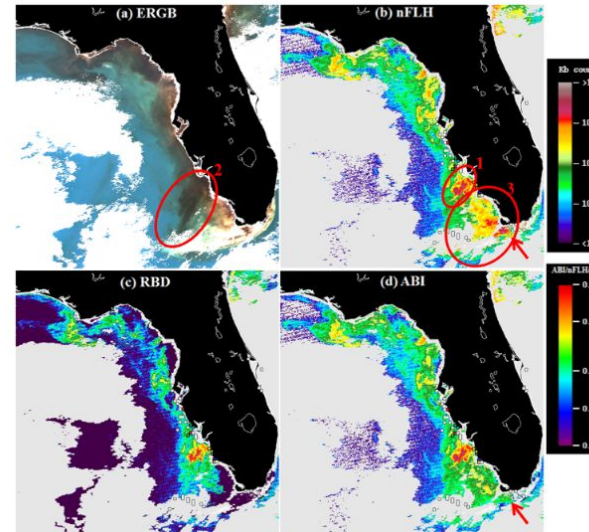
- Routine monitoring and event response sampling by FWC and collaborators
- Remote sensing of red tide blooms
- Circulation and trajectory modeling
- NCCOS respiratory and intensification forecasts



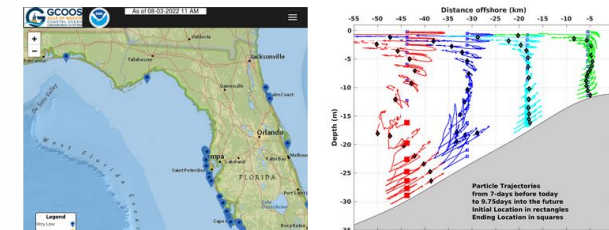
Routine monitoring



Circulation modeling



Satellite imagery



## Respiratory Forecast

Modeled forecast of respiratory irritation at individual beach locations, based on field samples of *Karenia brevis* concentration, wind speed, and direction.

[View Product](#)

## Intensification Forecast

Model results estimating the likelihood of bloom initiation or intensification along the coast of Southwest Florida, due to an accumulation of cells at the coast.

[View Product](#)

## Bloom intensity & respiratory forecasts

# Notable Red Tide Events in Florida

**Late 1940s:**  
SW FL from shore out to 14 mi.



**1994-1997:**  
Tampa Bay to FL Keys



**2014:**  
Isolated Bloom offshore NW Florida



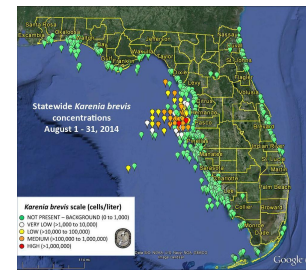
**2021:**  
Severe in and around Tampa Bay



**1971:**  
West Central FL, offshore reefs



**2005-2006:**  
One of most severe blooms on record



**2017-2019:**  
SW FL, mass mortalities



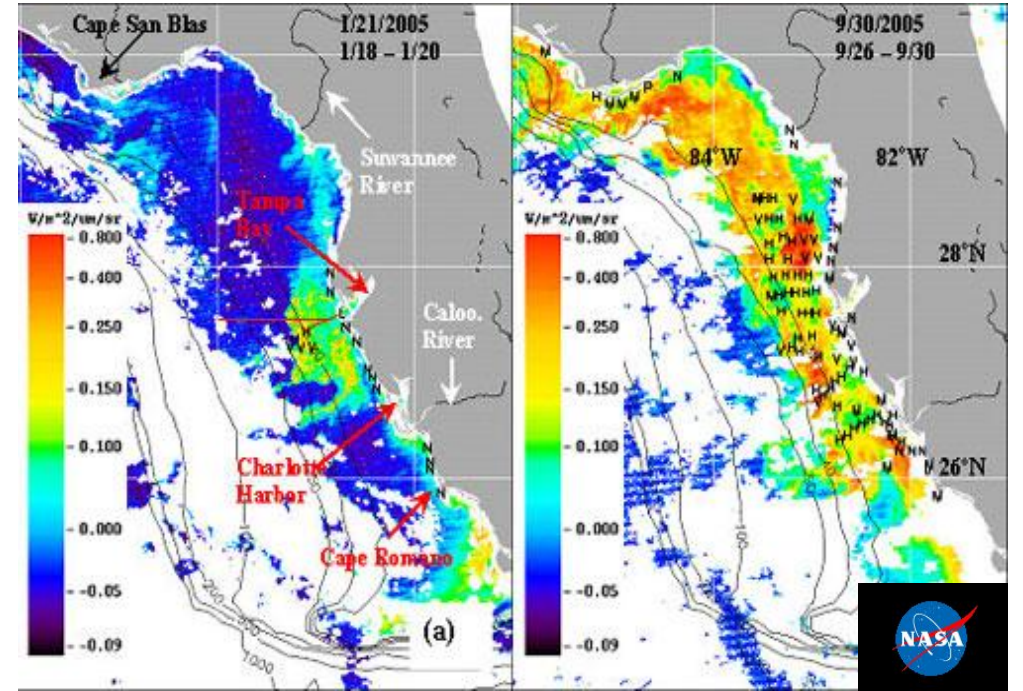
# The 2005 Red Tide

Red tide persisted from Jan 2005 – Feb 2006 and was expansive, inshore and offshore

Caused mass mortality of fish, manatees, dolphins, and sea turtles

Oxygen depletion resulted in extensive benthic mortality event between Tampa Bay and Sarasota

Diving, fishing charters, and research cruises reported dead fish and other reef animals



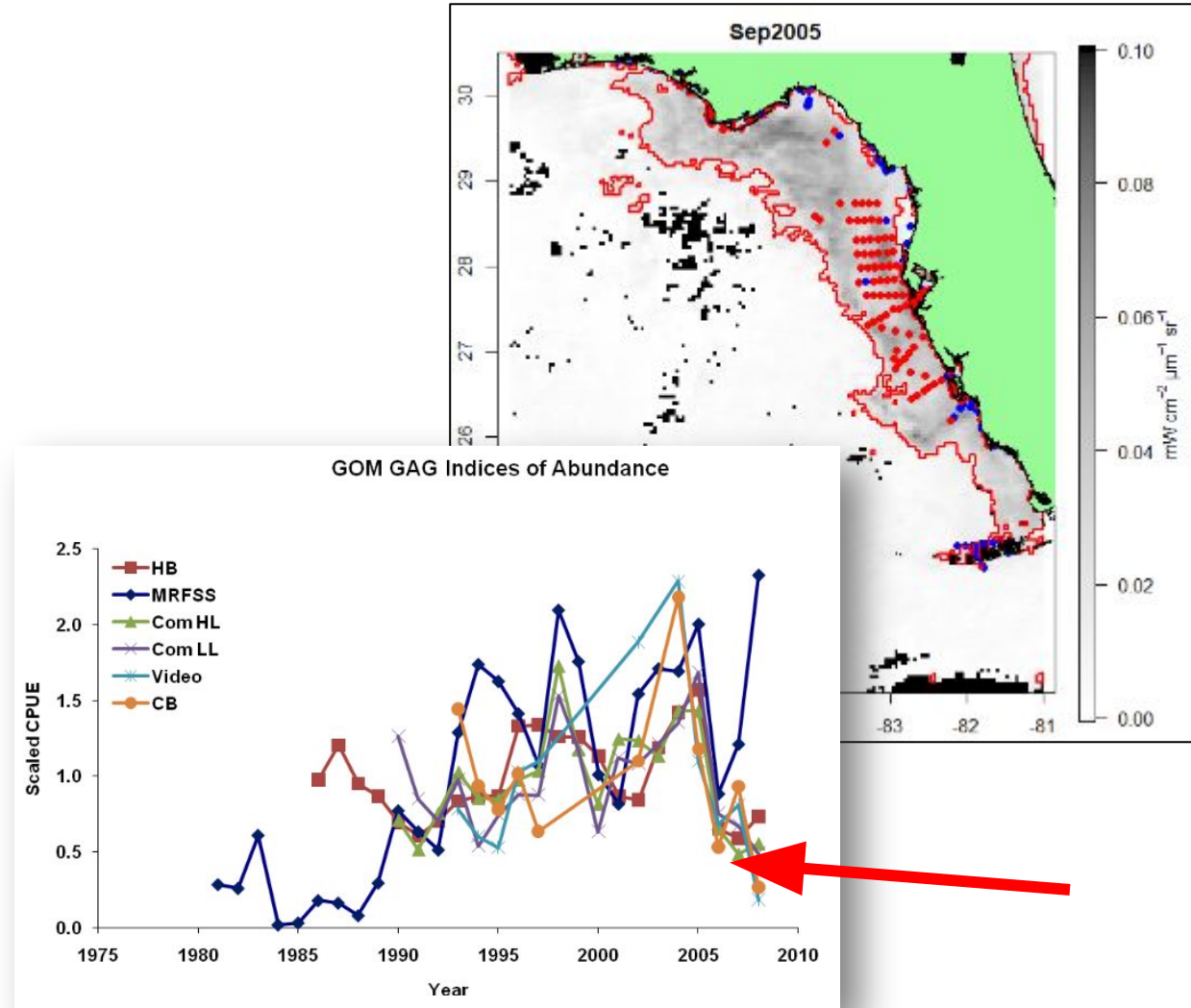
# Accounting for Red Tide in Stock Assessments

Sudden decline in abundance of gag and red grouper observed in multiple indices after 2005.

## 2009 SEDAR Update Assessments:

An episodic natural mortality rate term was added to the models (CASAL and ASAP) for 2005 and applied to all ages.

- Gag: CASAL model estimated  $M_{rt}=0.35$ , 18%-29% mortality
- Red grouper: ASAP model estimated  $M_{rt} = 0.32$



2009 SEDAR 10 Update Assessment for gag grouper

# Accounting for Red Tide in Stock Assessments

Subsequent stock assessments using SS accounted for red tide as a fishing mortality term, ***with equal selectivity across all ages.***

A red tide mortality term ( $F_{y, \text{red tide}}$ ) was estimated in years ***when red tide was presumed severe enough to impact the stock.***

## Gag Grouper

$$Mrt_{2005} = 0.35 \text{ (2009 SEDAR 10U)}$$

$$Mrt_{2005} = 0.71 \text{ (2014 SEDAR 33)}$$

$$Mrt_{2005} = 0.73 \text{ (2016 SEDAR 33U)}$$

$$Mrt_{2005} = 0.72 \text{ (2021 SEDAR 72)}$$

$$Mrt_{2014} = 0.47 \text{ (2021 SEDAR 72)}$$

$$Mrt_{2018} = 0.20 \text{ (2021 SEDAR 72)}$$



$$M = 0.159$$

## Red Grouper

$$Mrt_{2005} = 0.32 \text{ (2009 SEDAR 12U)}$$

$$Mrt_{2005} = 0.55 \text{ (2015 SEDAR 42)}$$

$$Mrt_{2005} = 0.34 \text{ (2019 SEDAR 61)}$$

$$Mrt_{2014} = 0.26 \text{ (2019 SEDAR 61)}$$



$$M = 0.144$$



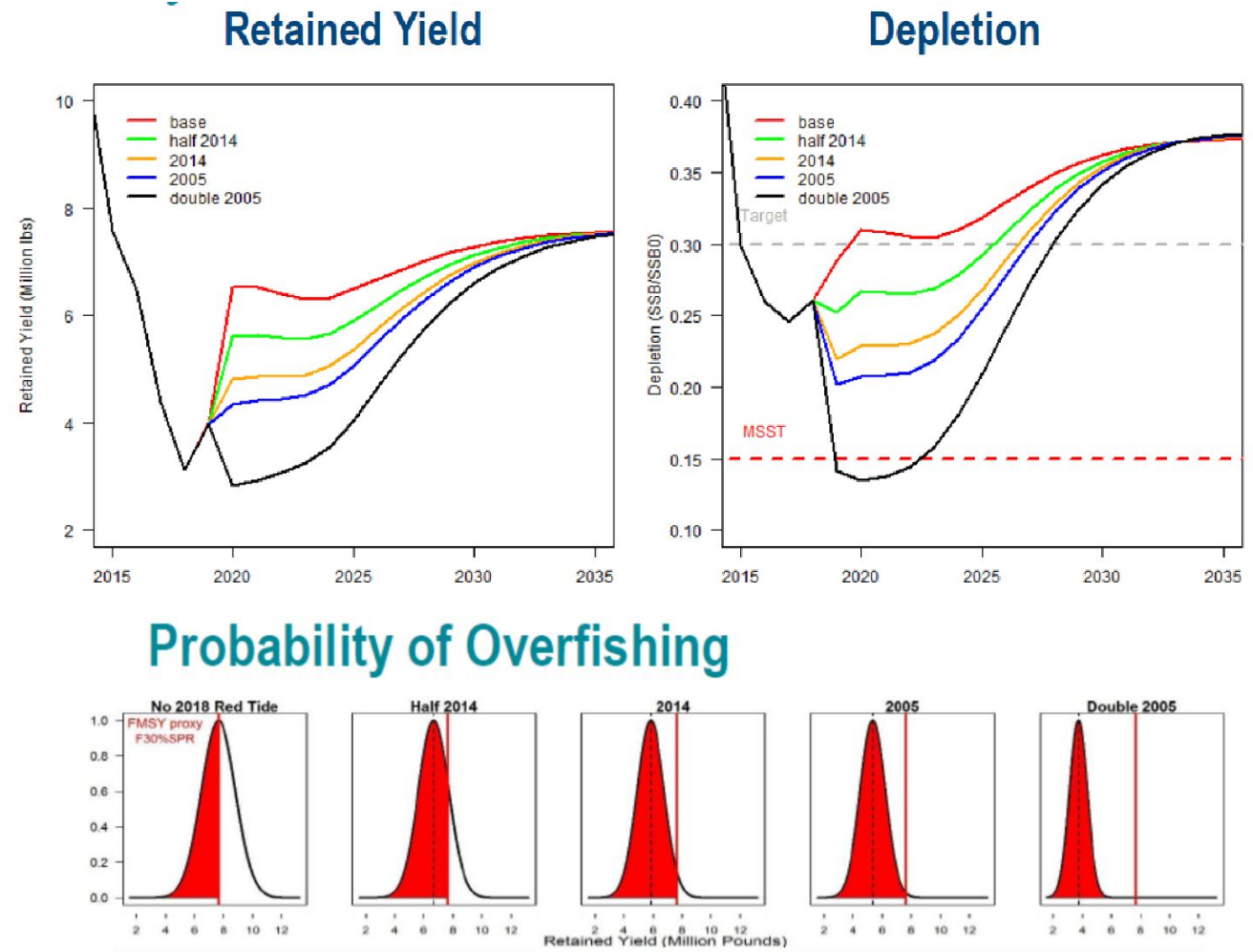
# Accounting for Red Tide in Catch Projections

If a red tide occurs during a projection year, a mortality rate must be specified.

Projections and catch advice are sensitive to assumptions about recent and ongoing red tides.

- Gag in 2014 (SEDAR 33U) and 2021 (SEDAR 72)
- Red grouper in 2019 (SEDAR 61)

Calls for independent, and timely estimates of red tide mortality for the SSC to provide catch advice

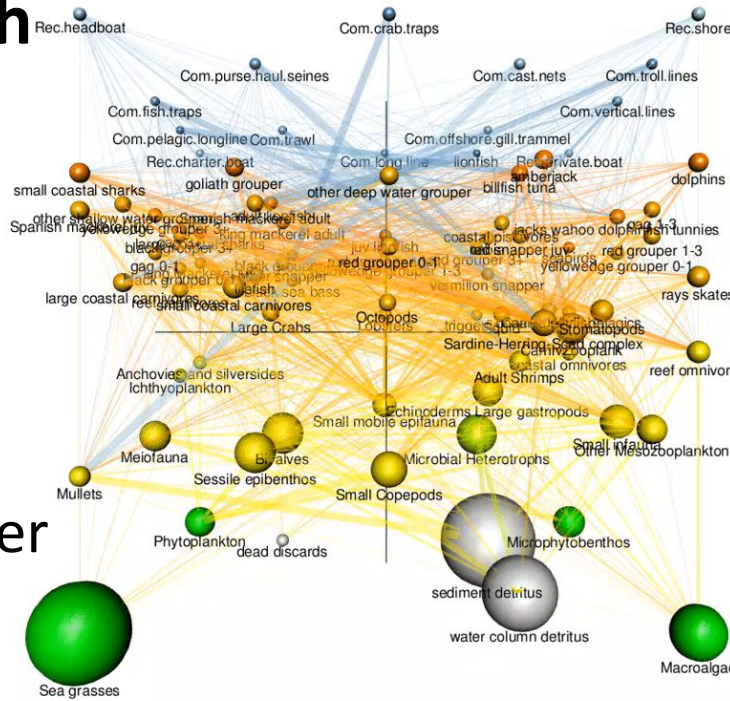


Credit: Skyler Sagarese

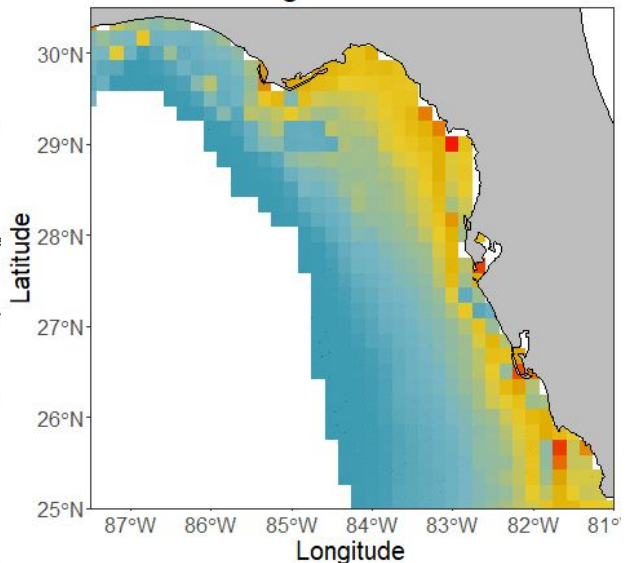
# An Ecosystem Modeling Approach to Estimate Red Tide Mortality

## The West Florida Shelf Ecopath with Ecosim and Ecospace Model (EwE)

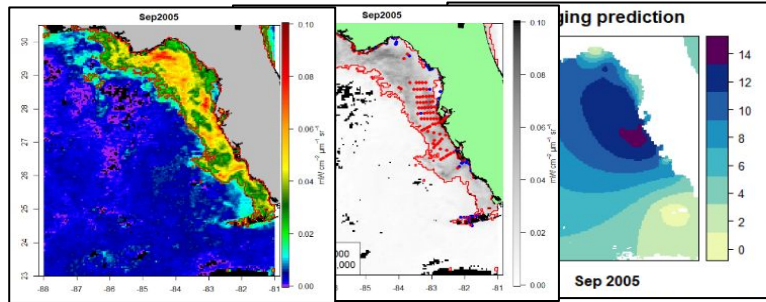
- Adapted from Okey et al. (2004) and Chagaris et al. (2013, 2015, 2017)
- 83 functional groups, 18 fishing fleets
- Simulates spatial-temporal dynamics over the WFS from 1985-2021
- monthly timestep and 10-min spatial resolution



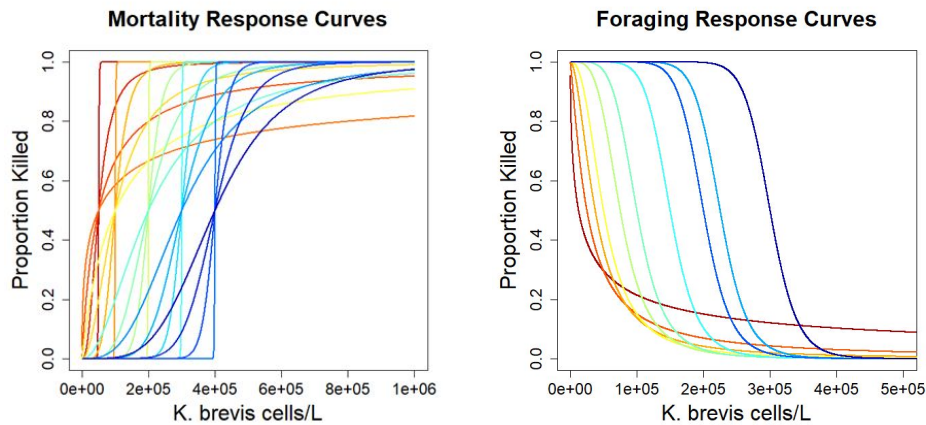
sardine herring scad Jan2004



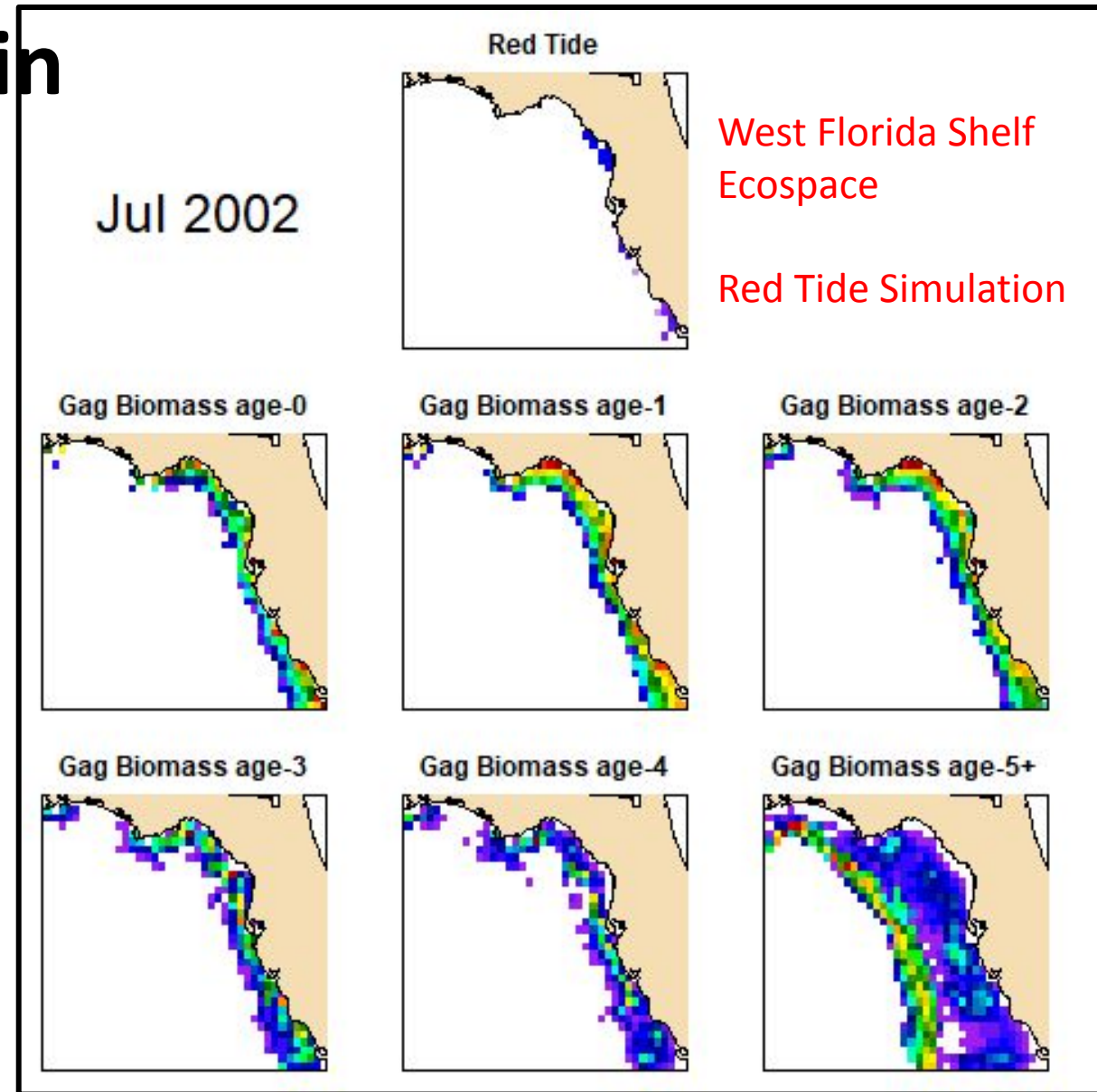
# Simulating Red Tide Effects in WFS Ecospace Model



Monthly red tide maps (cells/L) derived from nFLH satellite imagery and FWC HAB sampling. Input as spatial driver into WFS Ecospace Model.



Response functions used to drive mortality, foraging, and movement

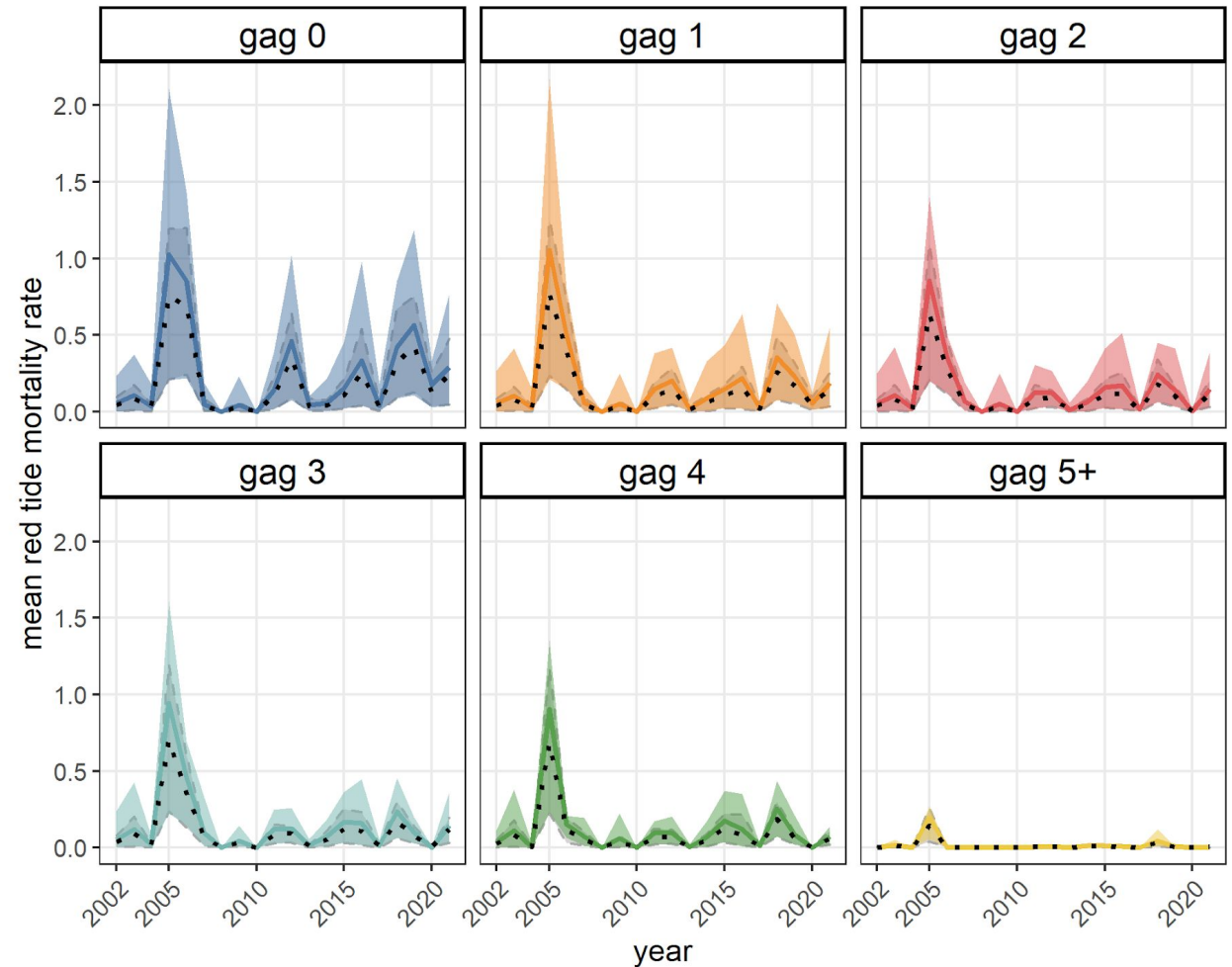


- ✓ Spatial overlap
- ✓ Bloom duration and severity
- ✓ Direct mortality

# Estimated red tide mortality rates for Gag 2002- 2021

- Highest  $M_{RT}$  in 2005
  - Followed by 2006, 2018, and 2021
- Higher  $M_{RT}$  for younger ages due to occurrence of blooms nearshore
- Uncertainty due to red tide lethal and sub-lethal response curves

Red Tide Mortality Rates Gag - All Ages Combined			
Year	mean	Low95	Upp95
2005	0.428	0.148	0.833
2006	0.164	0.067	0.277
2014	0.034	0.006	0.112
2018	0.139	0.050	0.318
2021	0.103	0.027	0.290

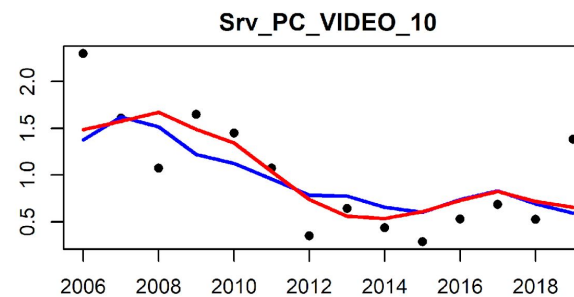
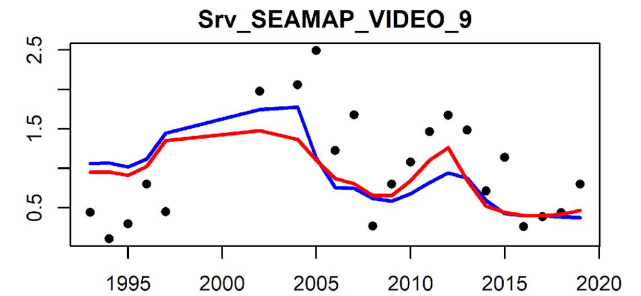
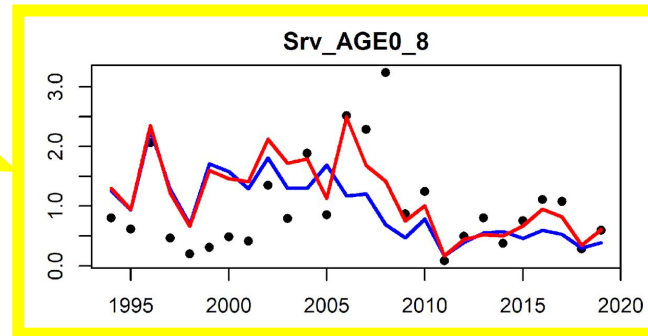
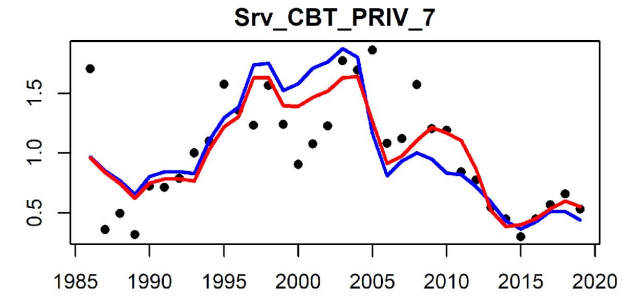
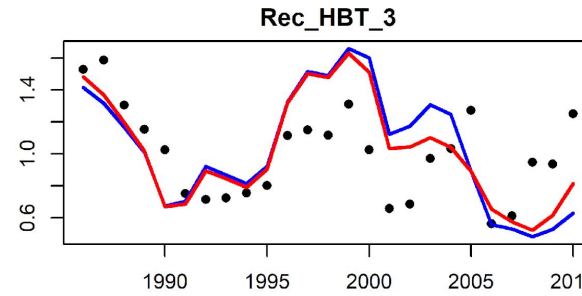
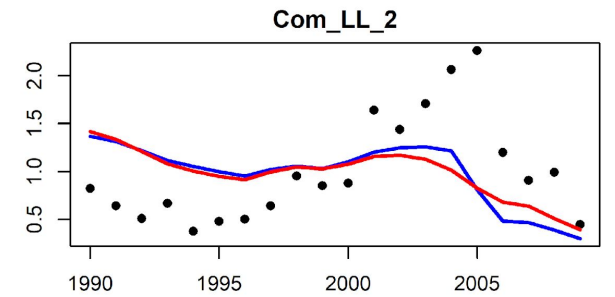
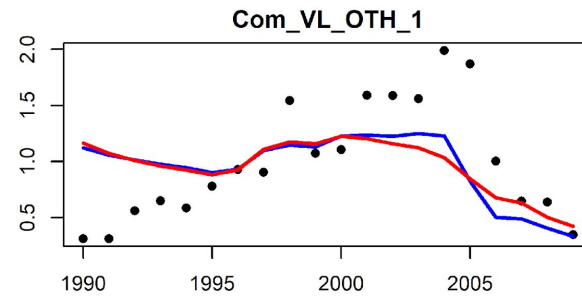


*Credit: Daniel Vilas*



# Effects on the Stock Assessment Model

- SEDAR 72 sensitivity run incorporated mortality estimates as age-specific additive deviations on natural mortality
- Resulted in better fits to the indices (lower RMSE), especially recruitment!
- Suggests that ecosystem model output is consistent with observed trends in abundance
- Also indicates that recruitment devs and fishing mortality alone may not explain population dynamics

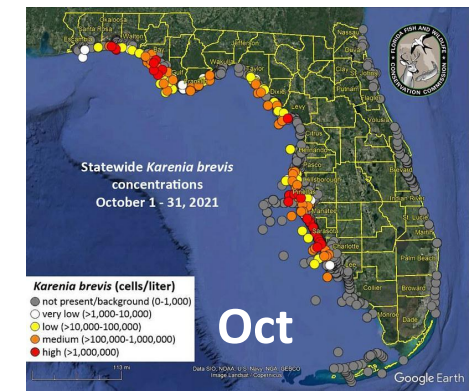
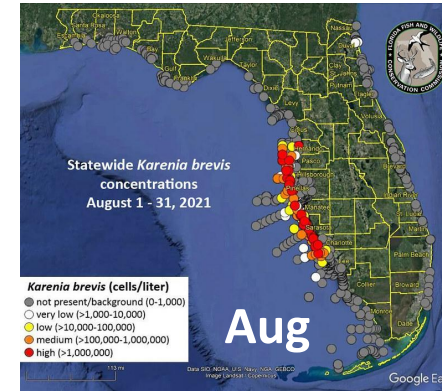
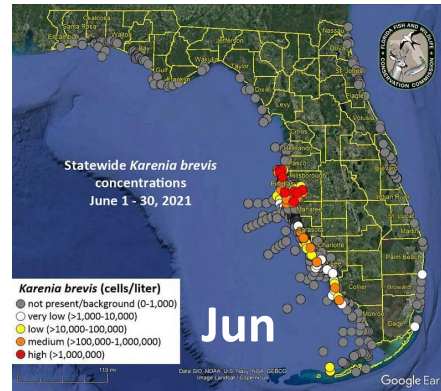


— SEDAR 72 Base  
— SEDAR 72 Mblock  
● Obs

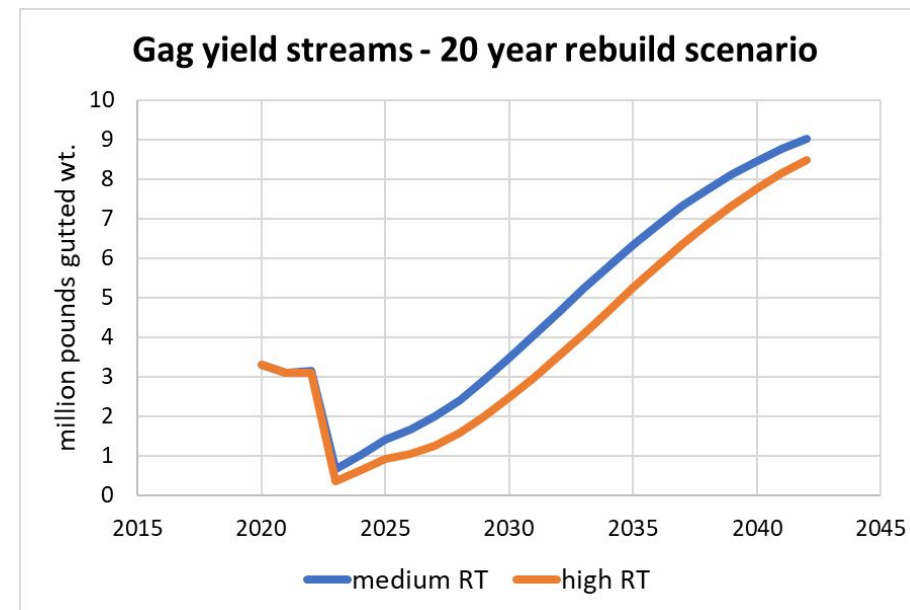
*Credit: Lisa Ailloud*

# Near-real time estimates of red tide mortality for catch projections

June – Oct 2021: A severe red tide occurred throughout the summer, expanded north, and began to dissipate at the end of October



- November 18, 2021: The SSC convened to set the ABC for gag grouper
- The ecosystem model was updated with data from FWC and NOAA ERDDAP through October (2-week lag)
- Projected yield streams and rebuilding plans were influenced by the 2021 Mrt estimate.
- The SSC selected the medium severity red tide scenario (median estimate)



# Addressing red tides through a Fishery Ecosystem Plan

## FEP Guiding Principals

Fishery Ecosystem Issues (FEIs)

Stakeholder Engagement

Regional Subdivisions

Conceptual and Ecosystem Modeling

Ecosystem Status Reports and Indicators

Management Integration

Addressing Extra Jurisdictional Issues

## Gulf of Mexico Fishery Ecosystem Plan



*Submitted to:*

**Gulf of Mexico Fishery Management Council**

*Submitted by:*

**LGL Ecological Research Associates, Inc.**



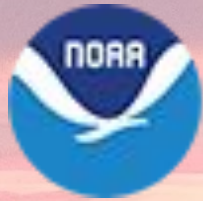
**March 2022**

# Summary

- Red tides often occur on the WFS and can cause mass mortality of marine life
- Red tide mortality has been incorporated into stock assessments of gag and red grouper since 2009
- Ongoing red tide blooms can create challenges when providing catch advice
- A spatial-temporal ecosystem model was developed to quantify red tide mortality, inform stock assessment models, and help provide management advice
- In the future, this will be formally integrated into the stock assessment and FEP process







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SCIENCE PROGRAM



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Ecopath  
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**Sea Grant**  
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