Estimates of red tide mortality on red grouper, 2002-2022, from the WFS FEM

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SEDAR 88 Red Tide Topical Workgroup Meeting

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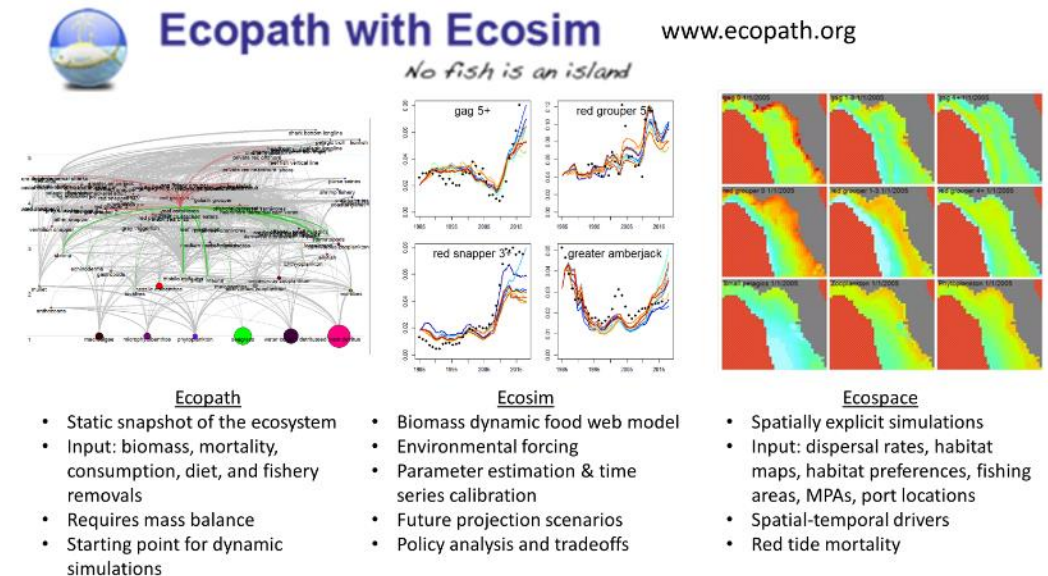West Florida Shelf
Fisheries Ecosystem Model

Overview

- WFS FEM model description and red grouper inputs

- Red tide mapping

- Model calibration

- Generating the red tide mortality index

- Future work

The West Florida Shelf *Fisheries* Ecosystem Model

A spatially dynamic food web model of the ecosystem, detritus to top predators, including fisheries.

- Developed using Ecopath with Ecosim (EwE) software

- Simulates spatial-temporal biomass and fishing dynamics over the WFS beginning in 1985 at a monthly timestep and 10-minute spatial resolution.

- Includes 83 functional groups and 18 fishing fleets with emphasis on reef fish and managed species.

- WFS-FEM Adapted from Okey et al. (2004) and Chagaris et al. (2013, 2015, 2017)

Ecopath with Ecosim www.ecopath.org
No fish is an island

Ecopath
- Static snapshot of the ecosystem
- Input: biomass, mortality, consumption, diet, and fishery removals
- Requires mass balance
- Starting point for dynamic simulations

Ecosim
- Biomass dynamic food web model
- Environmental forcing
- Parameter estimation & time series calibration
- Future projection scenarios
- Policy analysis and tradeoffs

Ecospace
- Spatially explicit simulations
- Input: dispersal rates, habitat maps, habitat preferences, fishing areas, MPAs, port locations
- Spatial-temporal drivers
- Red tide mortality

Static food web → time dynamics → spatial dynamics

WFS FEM – Red grouper Ecopath inputs

- Red grouper are included in the WFS FEM as a multistanza species, with 6 age stanzas.
  - Ages 0-5+ years old
  - Intended to capture ontogeny in diet, habitat, and fishery selectivity
- Initial (1985) inputs derived from SEDAR 61.
  - Biomass (mt/km^2), landings, discards, total mortality, growth, and maturity
  - Age 5+ biomass in 1986 = 15,824 mt
  - Age 0-4 biomass calculated by EwE assuming stable age distribution
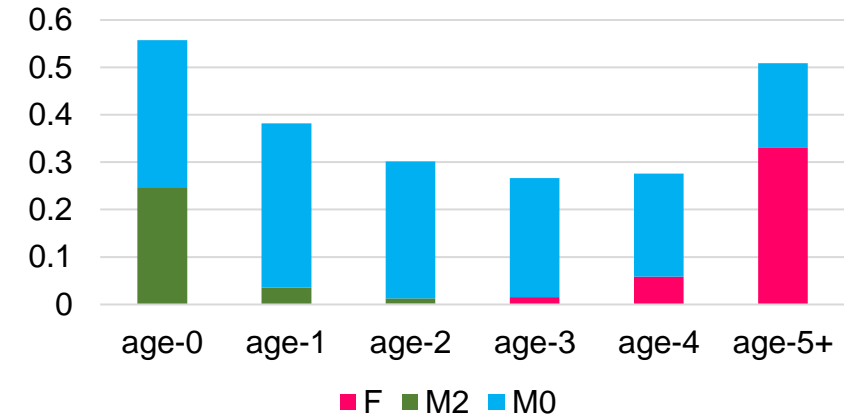
WFS FEM – Red grouper Ecopath diet

- Diet composition inputs derived from data collected by the FWC gut lab and other published studies (GoMexSI).

- Red grouper are primarily invertebrate feeders, until about age-3 when they start to consume more fish.
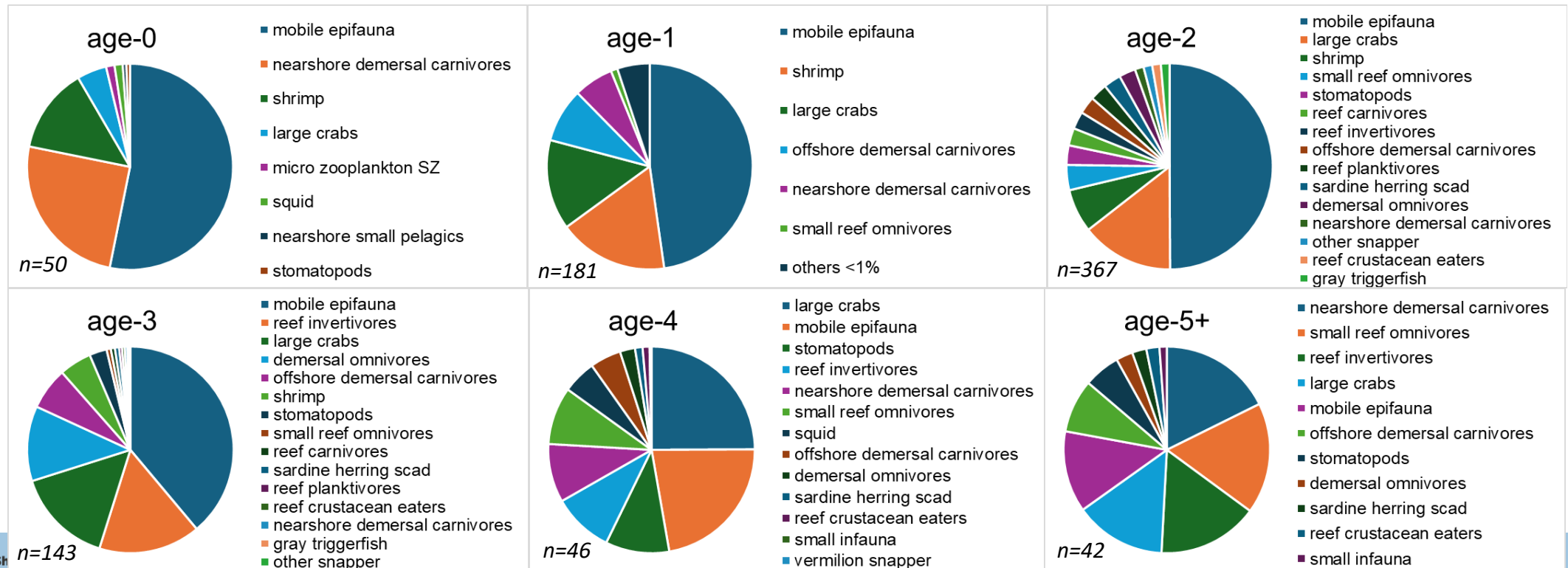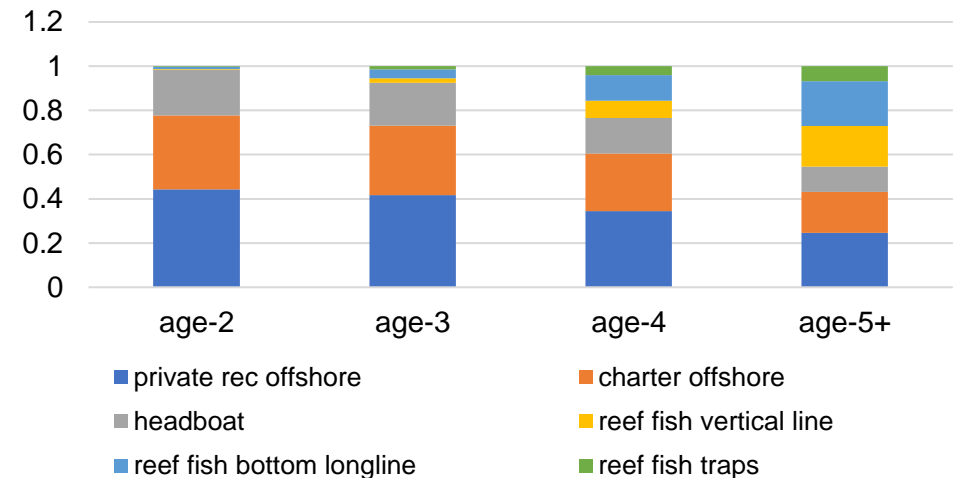
WFS FEM – Red grouper Ecopath mortalities

- Total natural mortality declines with age, according to SEDAR 61.

- Predation mortality (M2) declines with age.

- There is a large amount of unexplained natural mortality (M0).

- Fishing mortality (F) increases with age, beginning with age-3.
  - ~75% of F on age-4 is recreational
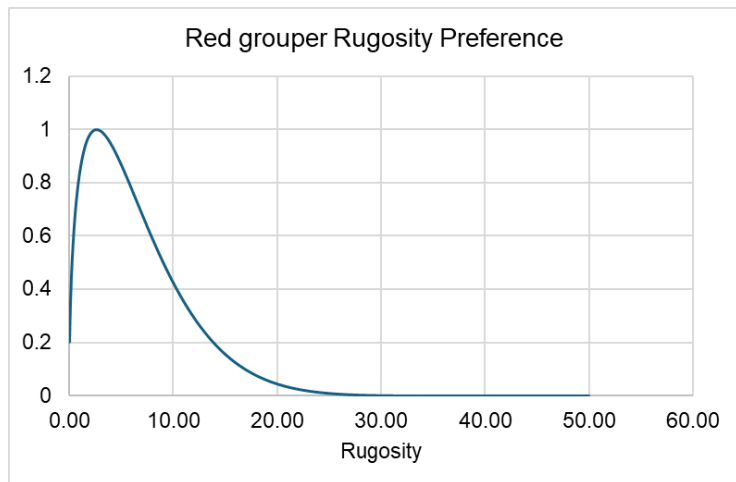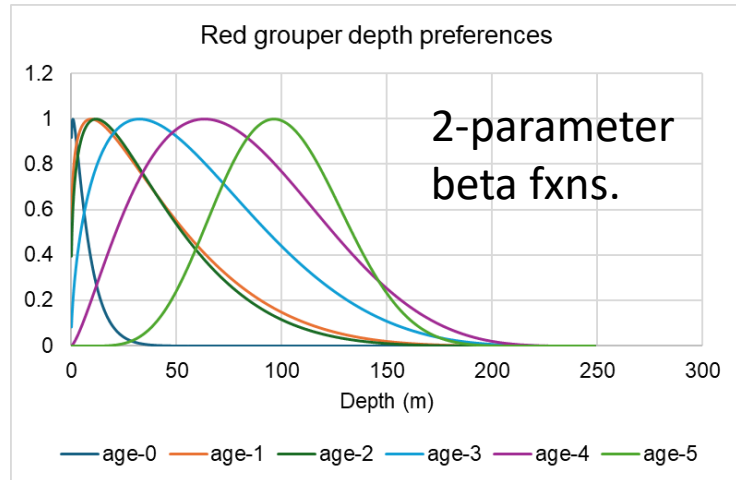 - ~50% of F on age-5+ is recreational

Red Grouper Ecopath Mortality Rates

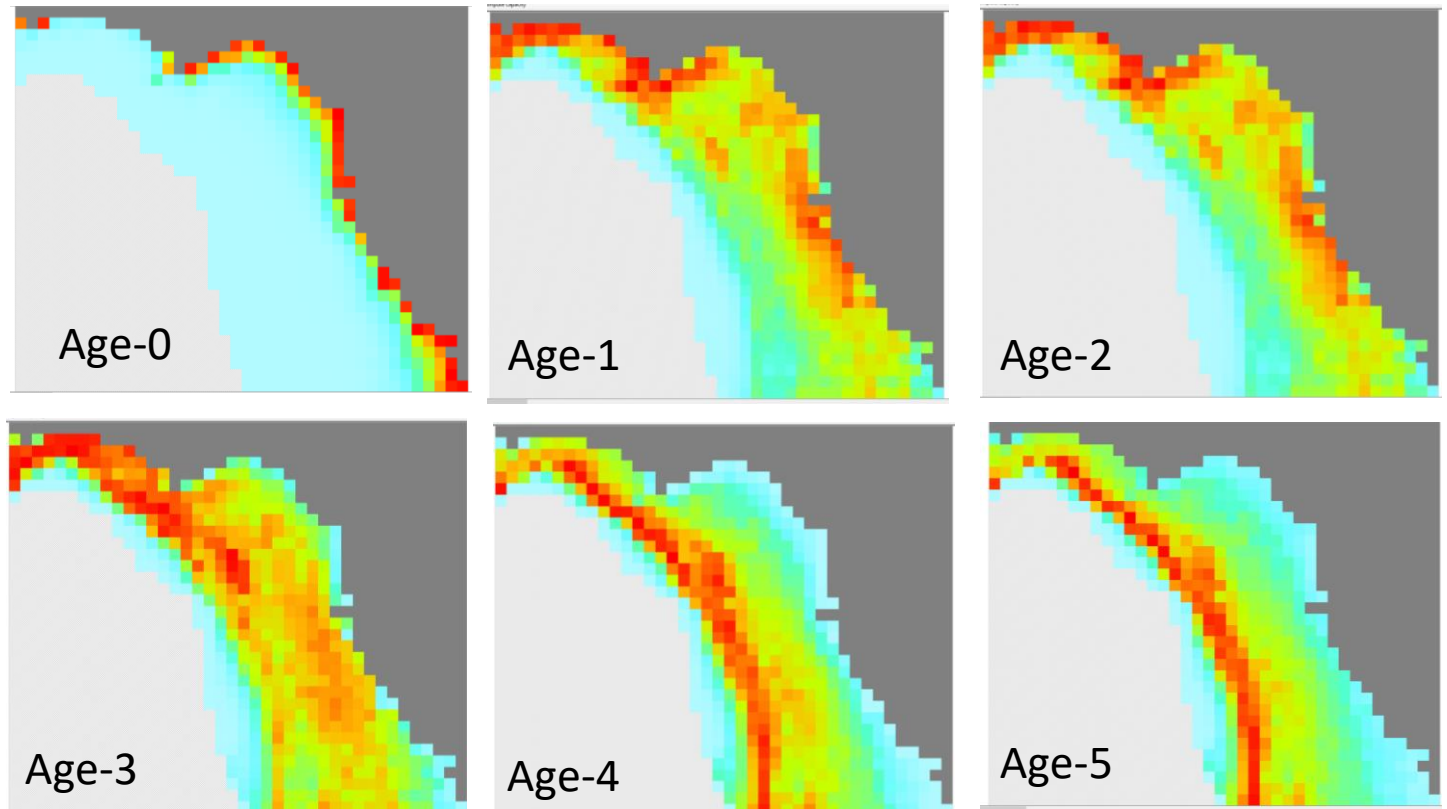F   M2   M0

Red Grouper Ecopath Proportion F by fleet

private rec offshore
charter offshore
headboat
reef fish vertical line
reef fish bottom longline
reef fish traps

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The WFS FEM – Red grouper Ecospace inputs

- Baseline dispersal rate: 54 km/yr

Red grouper depth preferences

2-parameter beta fxns.

Red grouper Rugosity Preference

Computed foraging capacity

Age-0

Age-1

Age-2

Age-3

Age-4

Age-5

WFS FEM - Red tide input maps

- WFS FEM requires monthly maps of red tide *intensity*, gridded over the geographic domain of the model.

  1. Extrapolate the FWRI HAB water quality samples over the spatial grid.

  2. Use MODIS-Aqua satellite imagery to delineate possible red tides

  3. Clipped kriged data to satellite derived polygons

- Red tide maps available from 2002 - Sept 2023

- Work is ongoing to develop new satellite products from NOAA VIIRS and improve the extrapolation technique (anisotropy, VAST models)

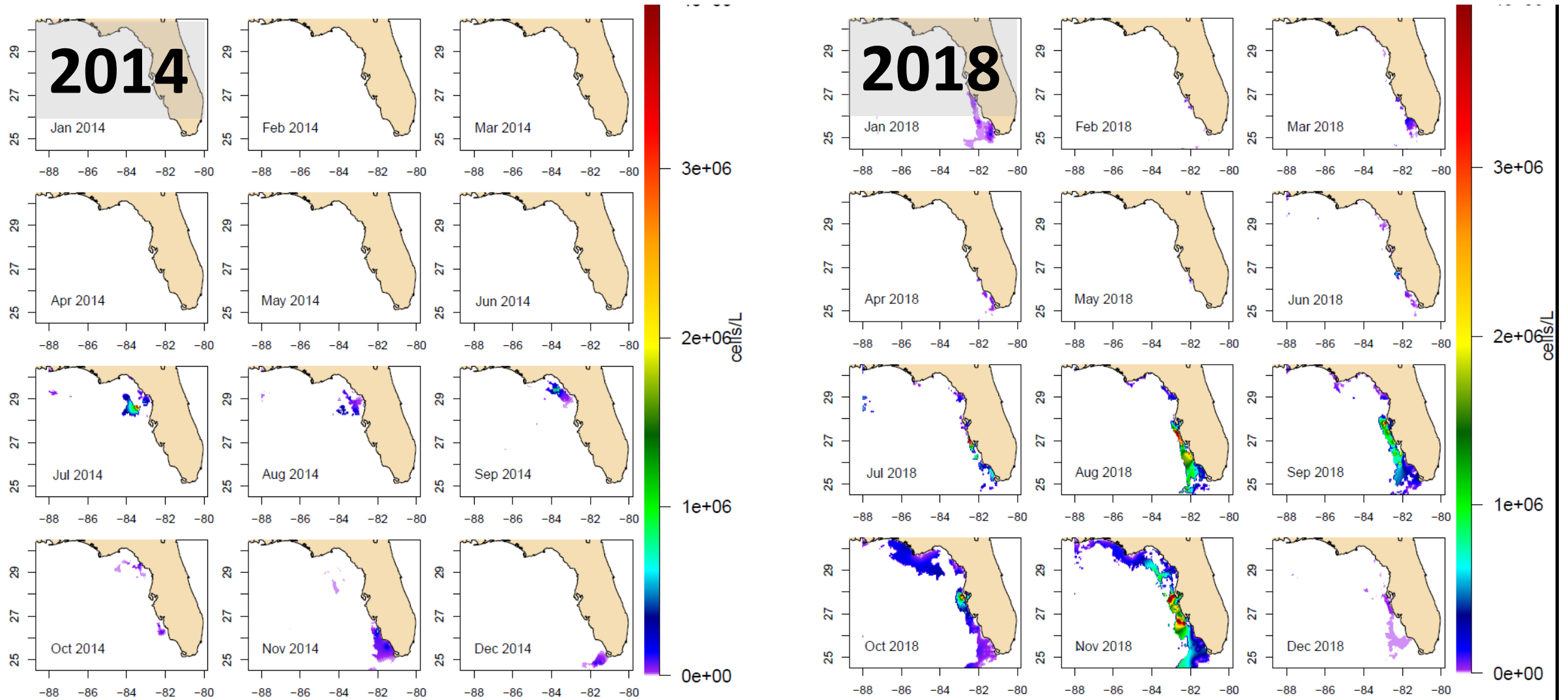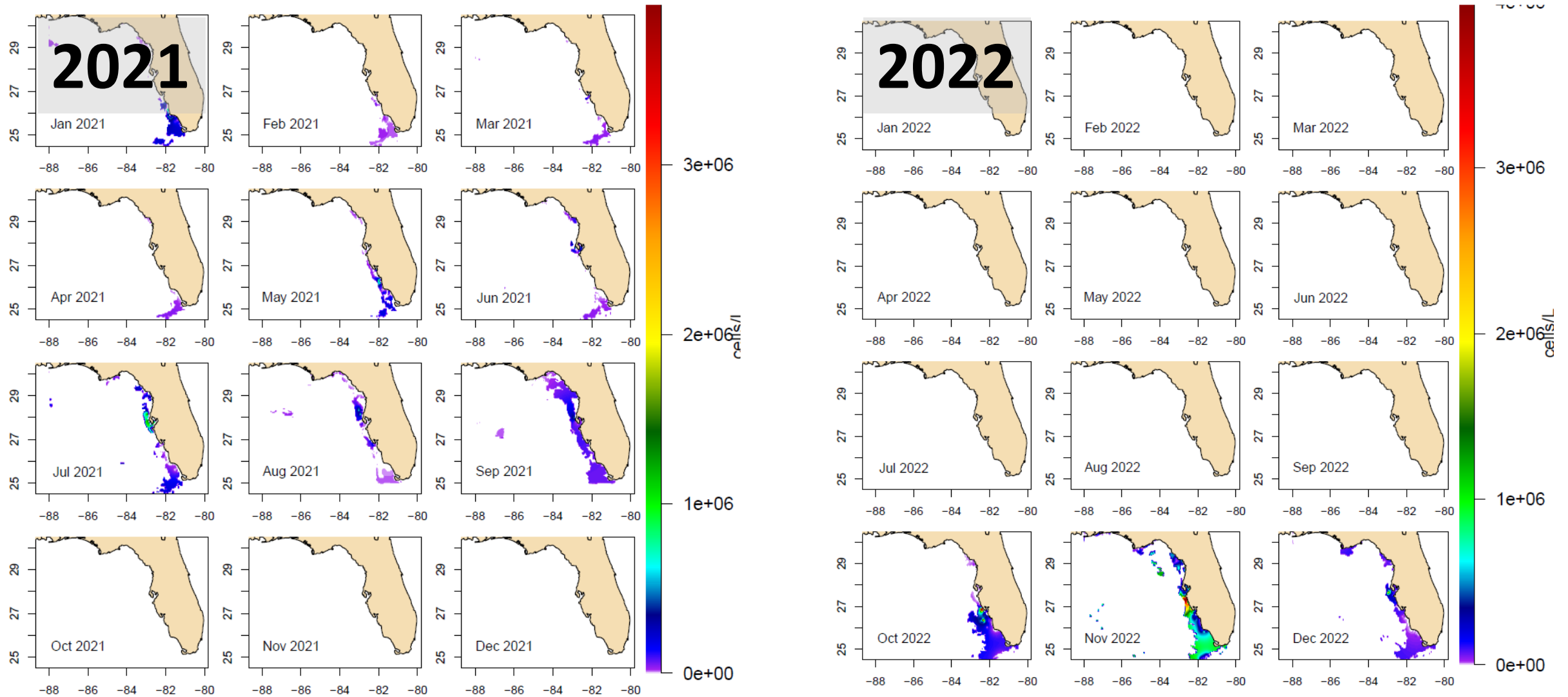West Florida Shelf
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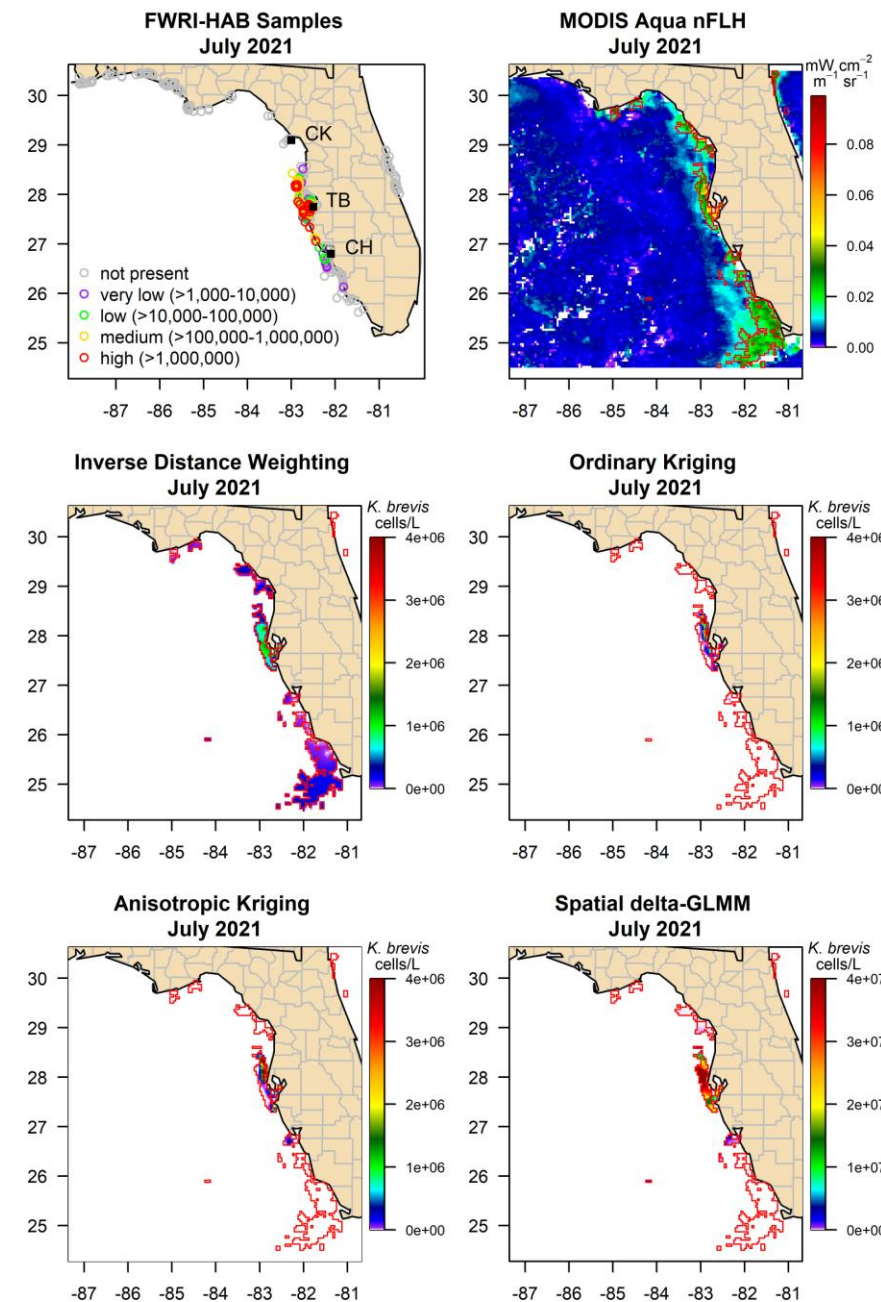
WFS FEM - Red tide input maps
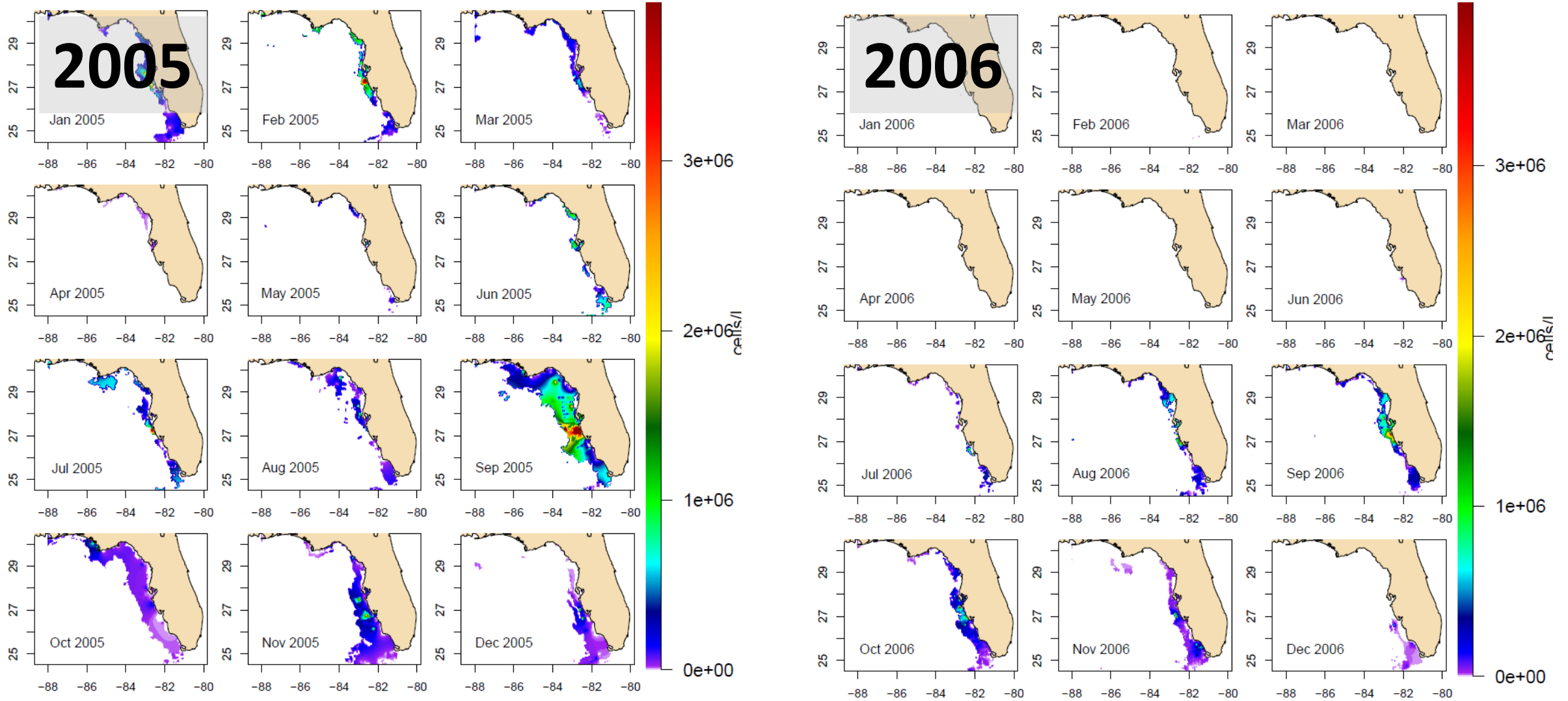
WFS FEM - Red tide input maps

WFS FEM - Red tide input maps

WFS FEM – model calibration

It's impossible to evaluate all possible parameter combinations in Ecospace, therefore a subset of parameters are selected for calibration.

Spatial biomass distributions are most sensitive to *habitat preference functions* and *dispersal rates*.

Temporal biomass predictions are most sensitive to predator-prey *vulnerability parameters*, as they determine how species respond to harvest and changes in predator/prey abundances.

Landings trends are sensitive to all of the above, plus *parameters that govern spatial fishing effort*. (*not evaluated here*)
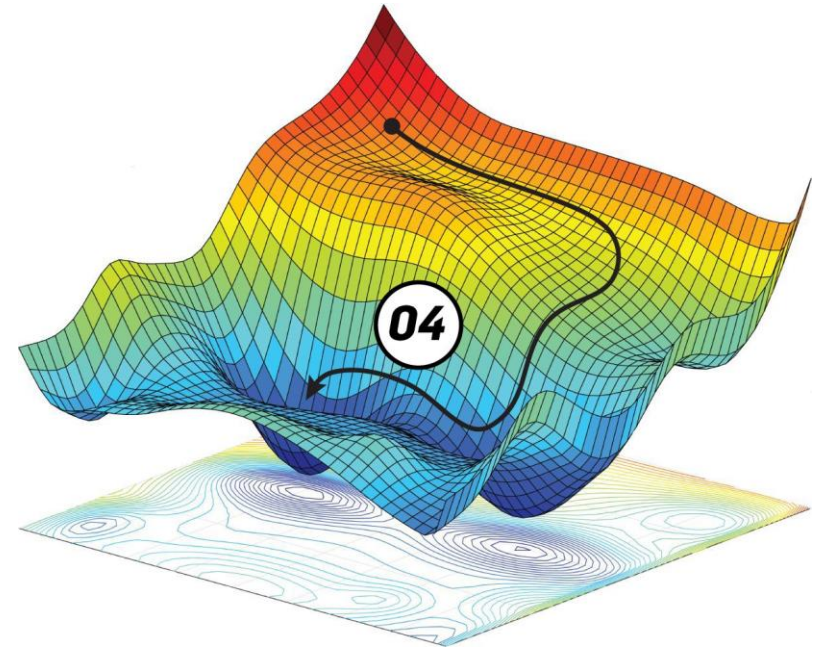
This is a work in progress!

WFS FEM – model calibration
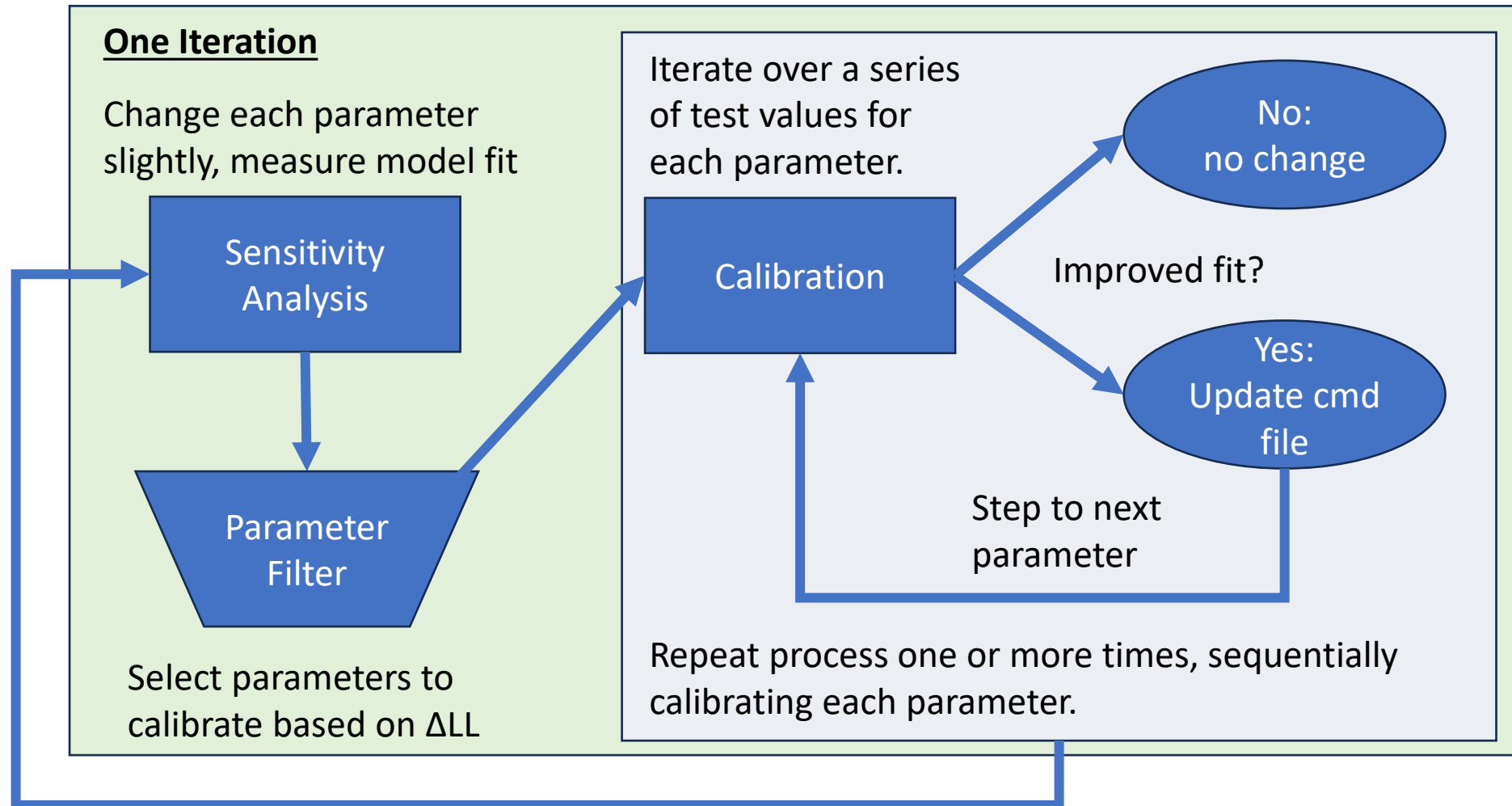
Observed data for red grouper

- Estimated biomass-at-age timeseries from SEDAR 61

- CPUE indices used in SEDAR 61 and 88
    - SEAMAP summer groundfish trawl (2009-2022)
    - Charter/Private CPUE (1986-2017)
    - SEAMAP Video (1993-2017)
    - Com HL index (1993-2009)
    - Com LL index (1993-2009)
    - NMFS BLL index (2001-2022)

- Spatially averaged CPUE
    - NMFSS BLL
    - SEAMAP trawl
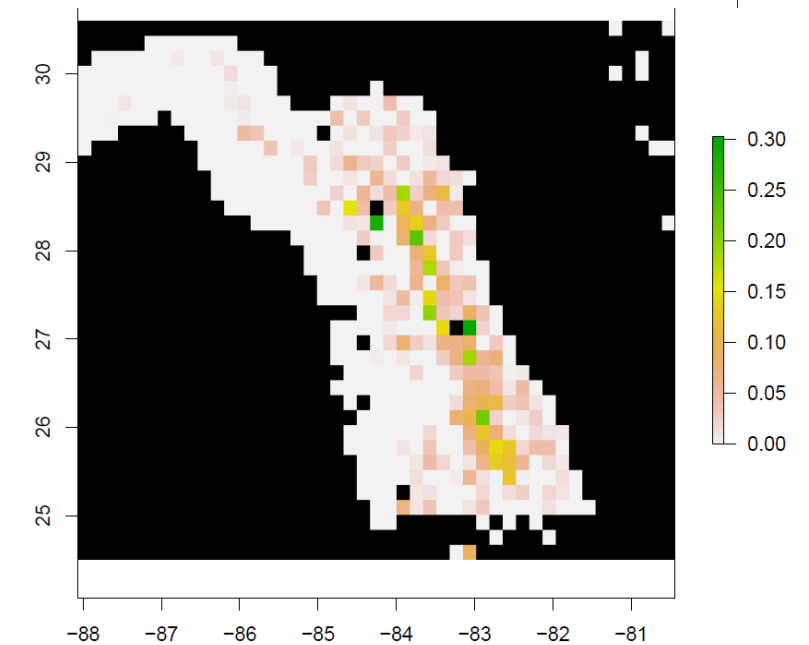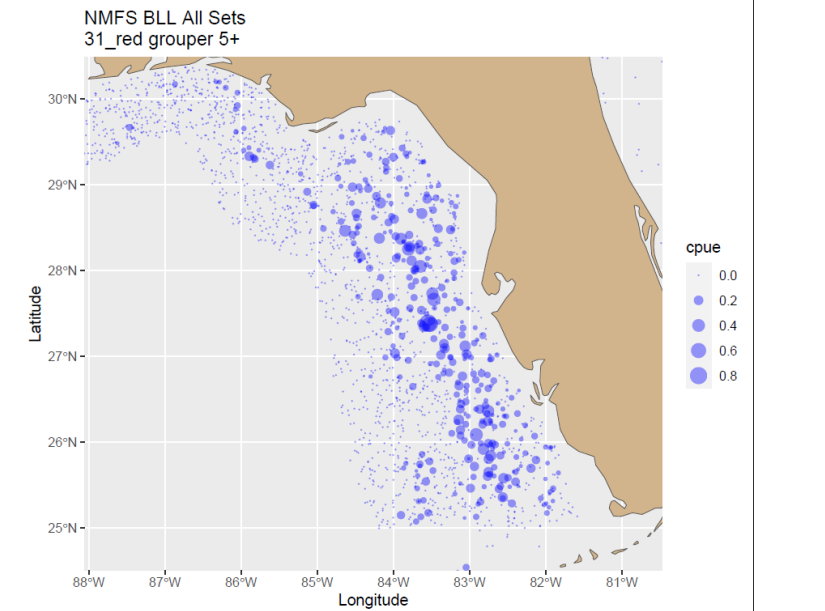
Ecospace Calibration Procedure

The calibration procedure consists of a series of iterations, with different parameters calibrated in each iteration.

Within each iteration, parameters are 'calibrated' sequentially, beginning with the most sensitive parameter.

One Iteration

Change each parameter slightly, measure model fit

Sensitivity Analysis

Parameter Filter

Select parameters to calibrate based on ΔLL

Iterate over a series of test values for each parameter.

Calibration

Improved fit?

No: no change

Yes: Update cmd file

Step to next parameter

Repeat process one or more times, sequentially calibrating each parameter.

After all parameters have been evaluated, re-run sensitivity analysis. Repeat N times or until no improvement in model fit.

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Ecospace Calibration Procedure

The calibration procedure consists of a series of iterations, with different parameters calibrated in each iteration.

Within each iteration, parameters are 'calibrated' sequentially, beginning with the most sensitive parameter.

This can be done in phases, to focus on key aspects of model behavior.

Phase 1:
Fit spatial patterns
(environmental responses)

Phase 2:
Fit temporal patterns
(vulnerabilities)

Phase 3:
Fit other patterns
(M0 forcing)

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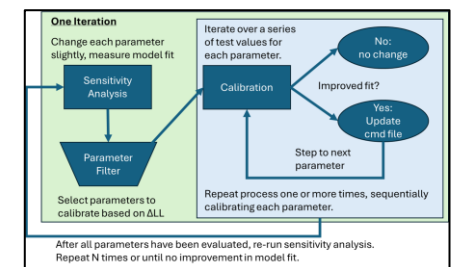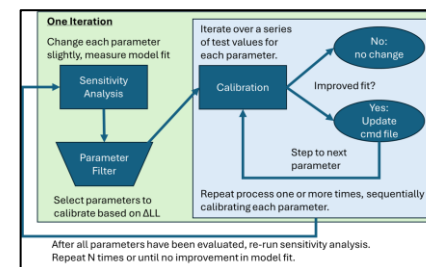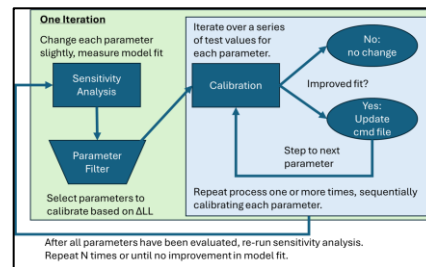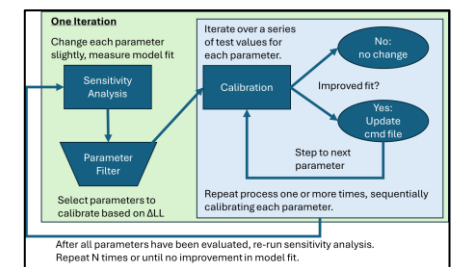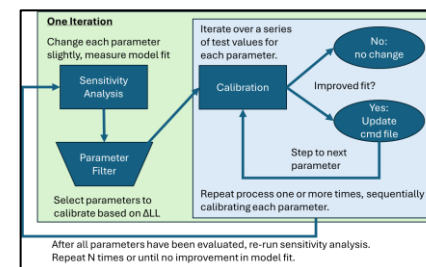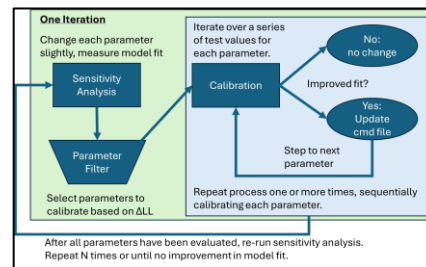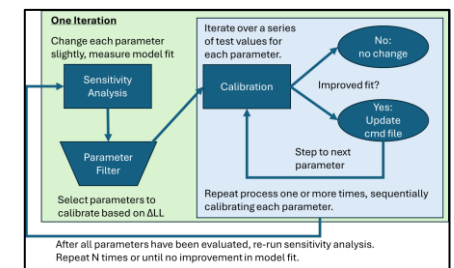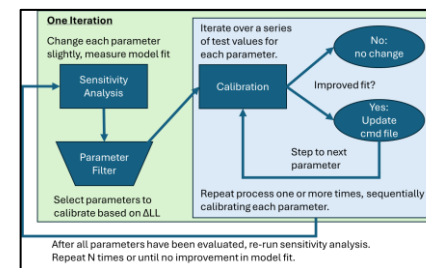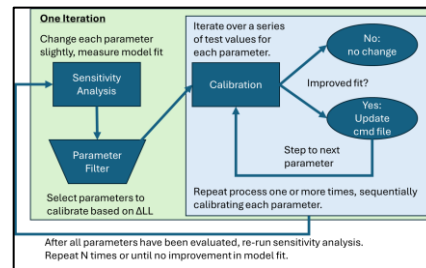
Model 1 → Model 2 → Model 3

WFS FEM – model calibration

Age-5 red grouper 'habitat capacity' and BLL CPUE

Initial   Observed   Calibrated

Age-1 red grouper 'habitat capacity' and SEAMAP trawl CPUE
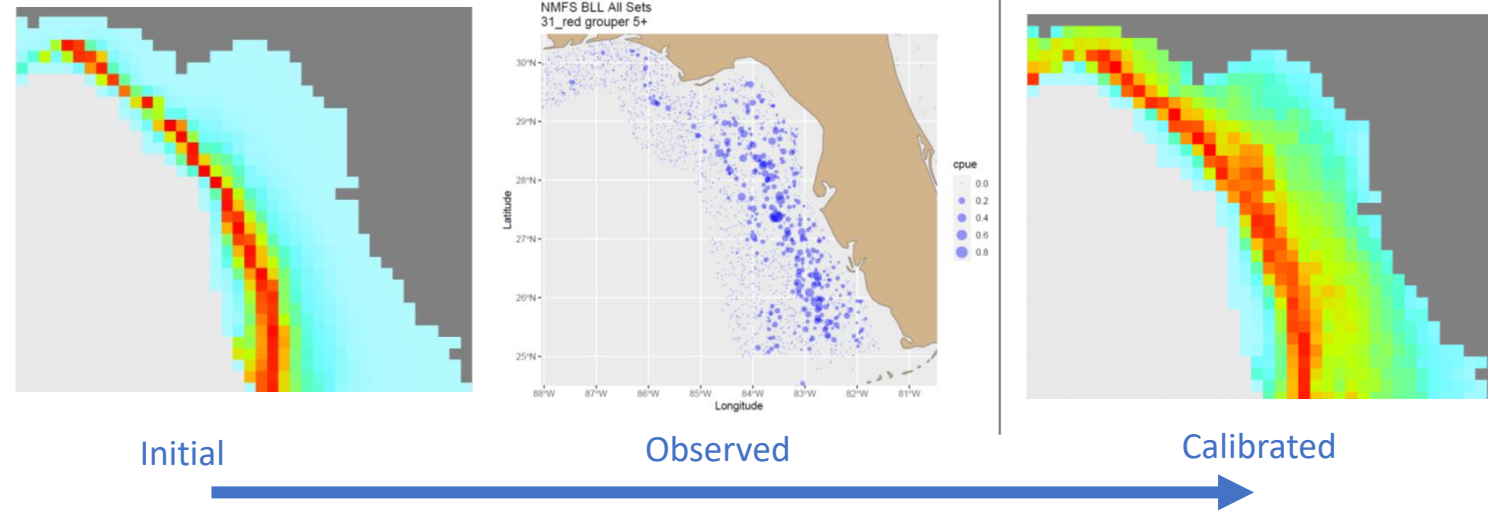

Depth & rugosity functions were slightly adjusted during calibration process to improve fits to spatial data.
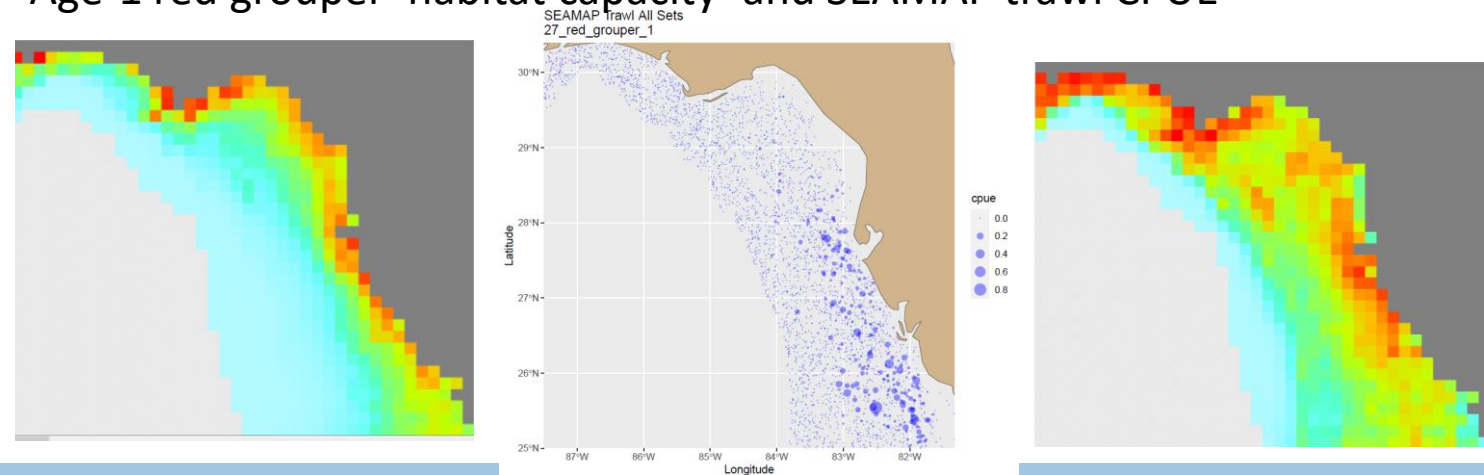
WFS FEM – model calibration

The new calibration procedure failed to produce reasonable fits to timeseries for red grouper.

- Small error discovered in console file, some parameters may not have loaded properly along the way
- EwE Software updates changed how spatial-temporal driver maps were indexed. Some possibly loaded incorrectly
- Producing results with partially updated model
- Flawed calibration procedure

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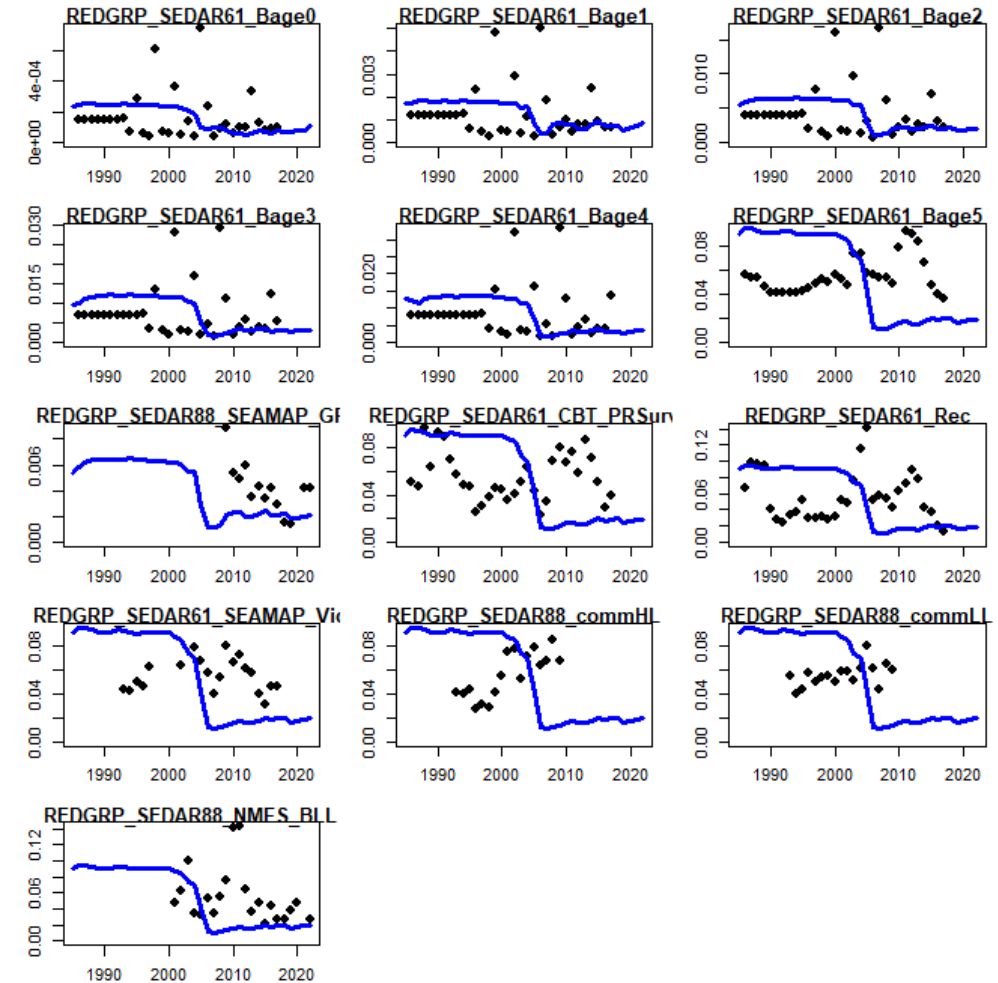
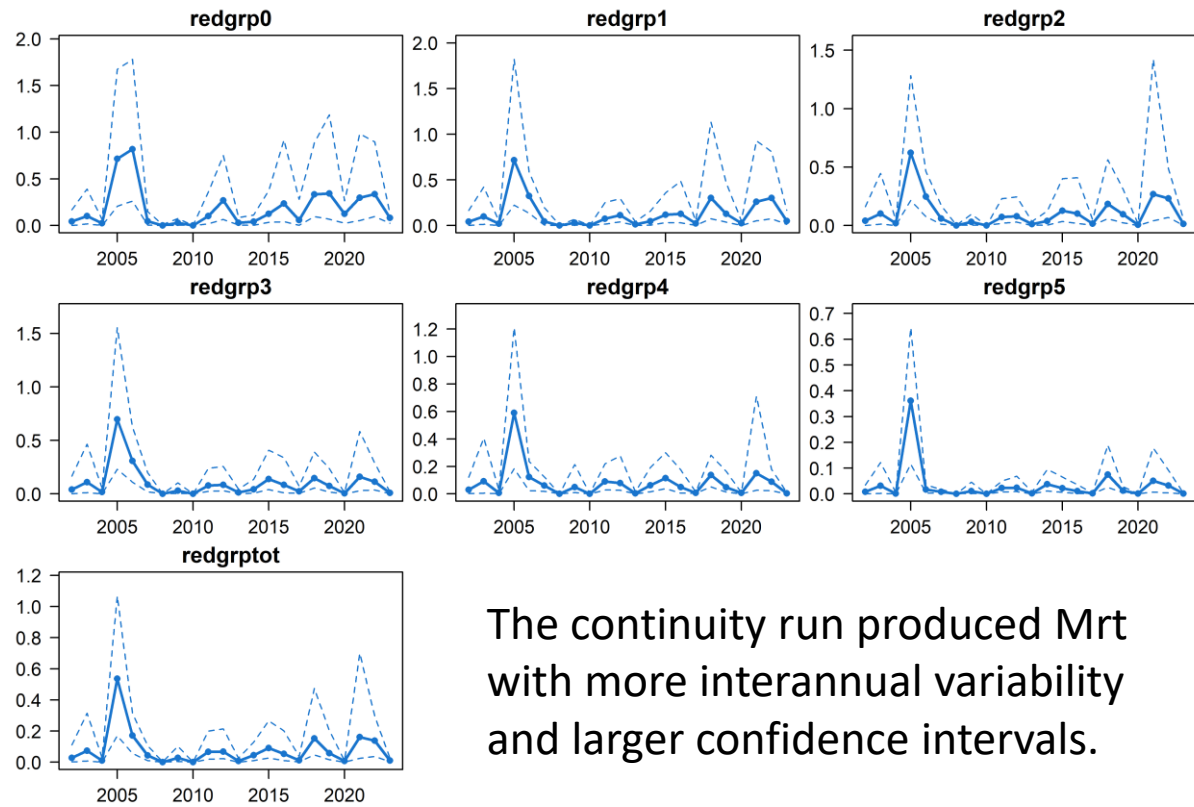# WFS FEM – model calibration

Option: Revert back to previous model configuration, which was used for gag grouper in SEDAR 72 and presented to SSC in September 2023.

- Keep new depth response functions
- Better fits to data, especially for younger age stanzas
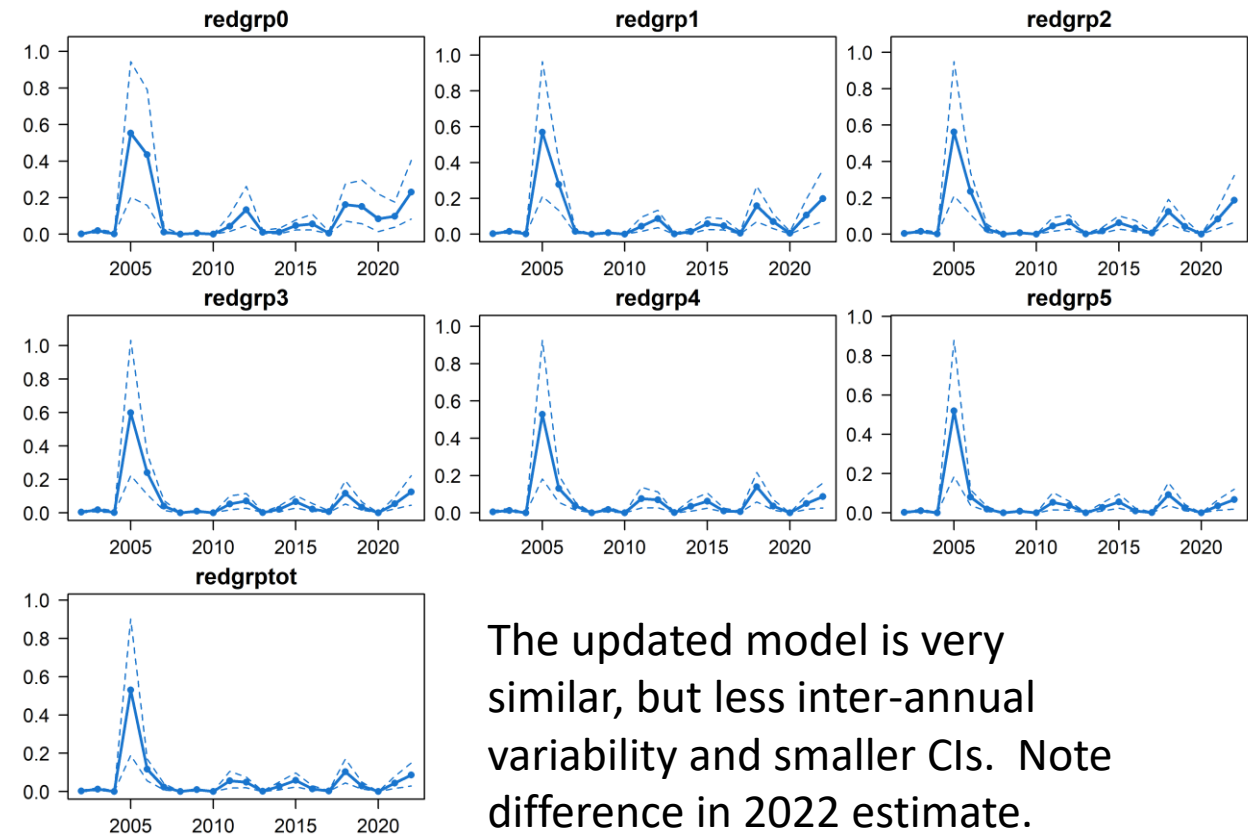
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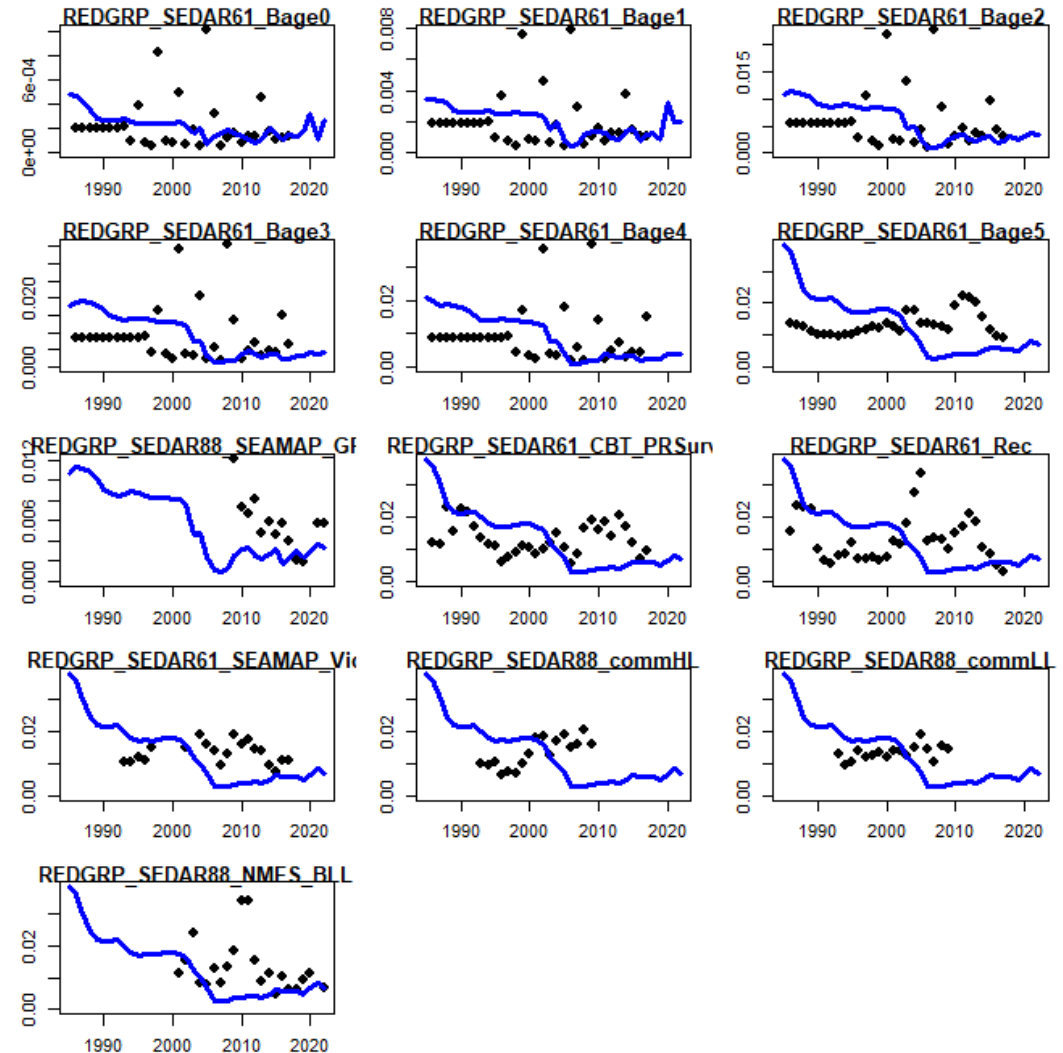
WFS FEM – red tide mortality index

Continuity Run (Sept 2023)

The continuity run produced Mrt with more interannual variability and larger confidence intervals.

## Partially Updated Model (calibration attempt)

The updated model is very similar, but less inter-annual variability and smaller CIs. Note difference in 2022 estimate.

WFS FEM – red tide mortality index for red grouper

Key Takeaways

- More work is needed to diagnose and calibrate the current version of the model.

- The red tide mortality index is very similar to the continuity run, despite diverging trends and poor fit to data.

- The resulting Mrt is not so sensitive to the updates and calibrations made thus far.

Red tide mortality
Red grouper all ages combined
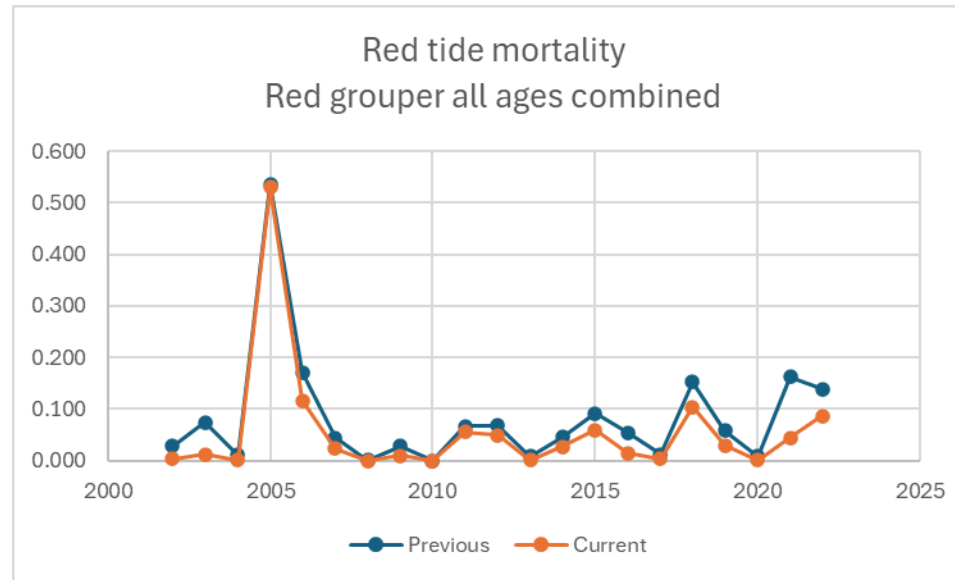
Year	Previous	Current
2002	0.028	0.003
2003	0.074	0.012
2004	0.010	0.001
2005	0.537	0.531
2006	0.171	0.117
2007	0.044	0.024
2008	0.000	0.000
2009	0.028	0.010
2010	0.000	0.000
2011	0.067	0.056
2012	0.068	0.049
2013	0.008	0.001
2014	0.045	0.027
2015	0.092	0.059
2016	0.054	0.014
2017	0.012	0.003
2018	0.153	0.104
2019	0.058	0.029
2020	0.008	0.000
2021	0.162	0.044
2022	0.138	0.087

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