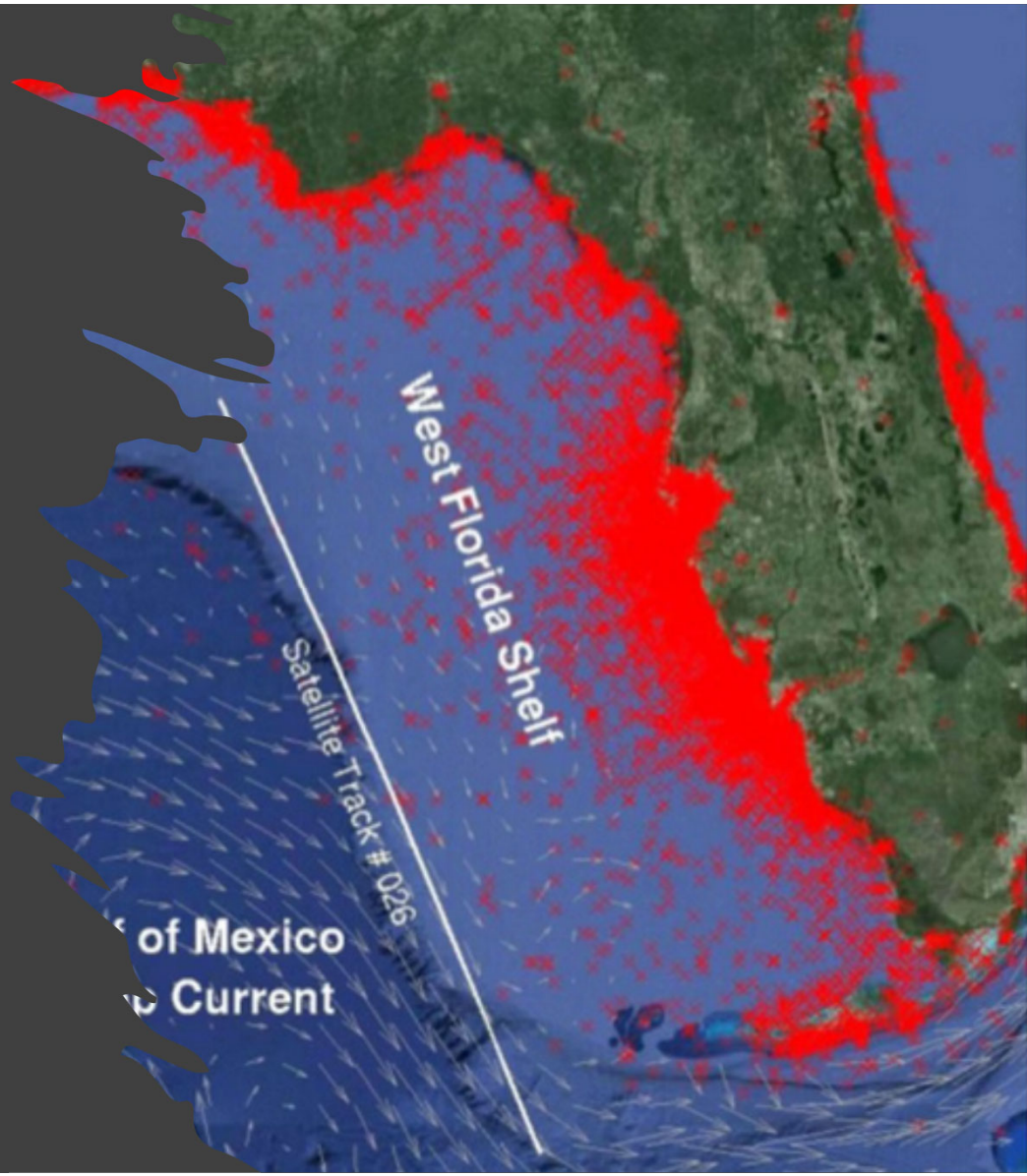
An update on the West Florida Shelf ecosystem model and red tide mortality estimation

David Chagaris
University of Florida

Gulf Council SSC Meeting

September 27-28



Presentation Overview

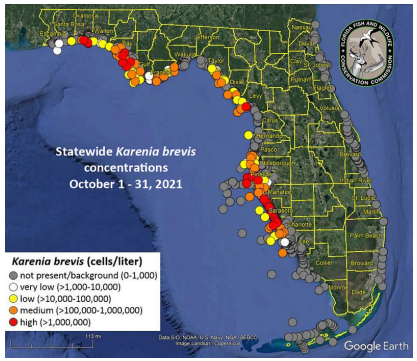
- Update on monthly red tide occurrence and severity since 2021
- Ongoing model development
- Future work

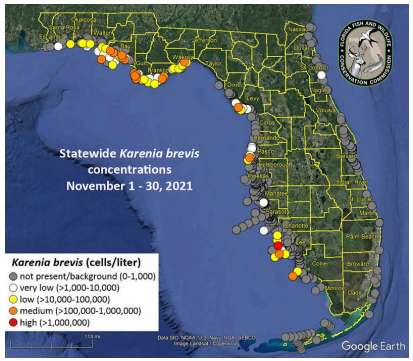
West Florida Red Tide: 2021

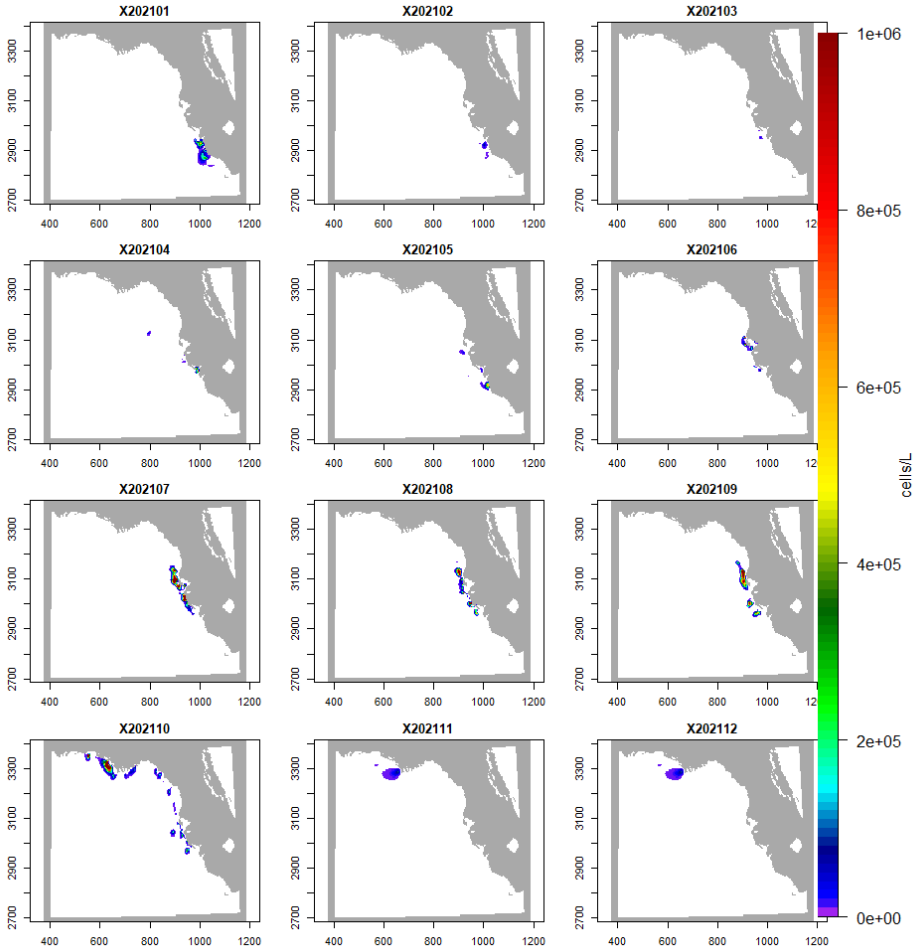
Piney Point wastewater dump “fed” red tide bloom around Tampa Bay

The 2021 red tide ended in October

Red tide mortality index was last updated for November 2021 SSC meeting, with data through October 2021

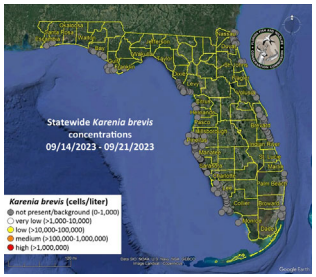


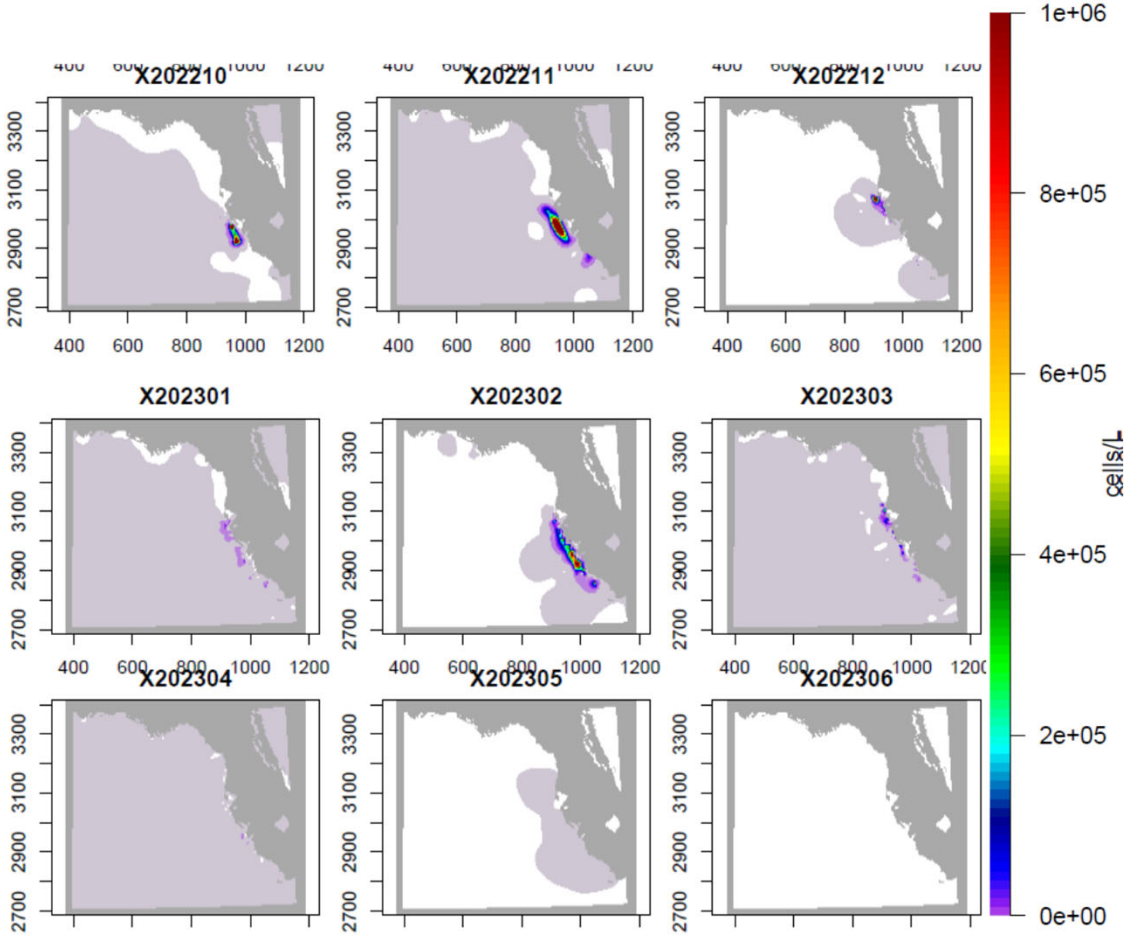




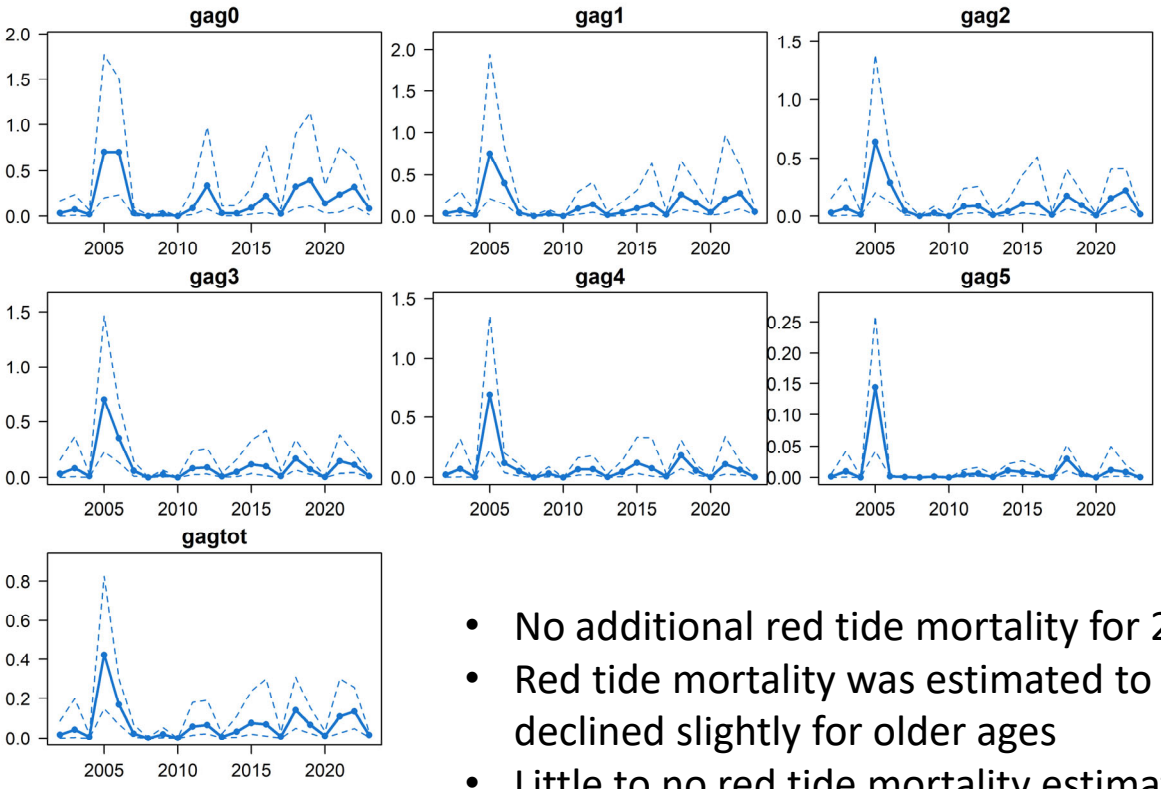
West Florida Red Tide: 2022-2023

- In 2022, a bloom formed off Lee County after Hurricane Ian
- Expanded along SW FL and became more severe in November
- Lingered through Feb-Mar 2023
- Restricted to nearshore areas of SW Florida
- No red tide since March 2023





Red Tide Mortality on Gag Grouper Jan 2002- June 2023

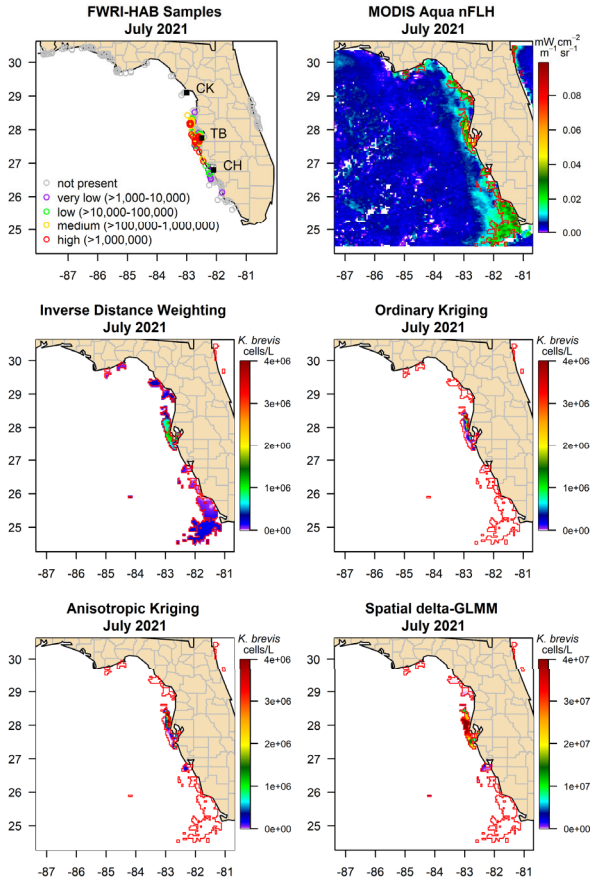


Year	age-0 mean	combined ages mean
2005	0.707	0.424
2006	0.706	0.168
2012	0.338	0.067
2016	0.228	0.070
2018	0.328	0.140
2019	0.395	0.068
2020	0.141	0.013
2021	0.242	0.109
2022	0.324	0.133
to June 2023	0.084	0.017

- No additional red tide mortality for 2021 after the November SSC meeting
- Red tide mortality was estimated to be higher in 2022 than 2021 ages 0-2, but declined slightly for older ages
- Little to no red tide mortality estimated for 2023

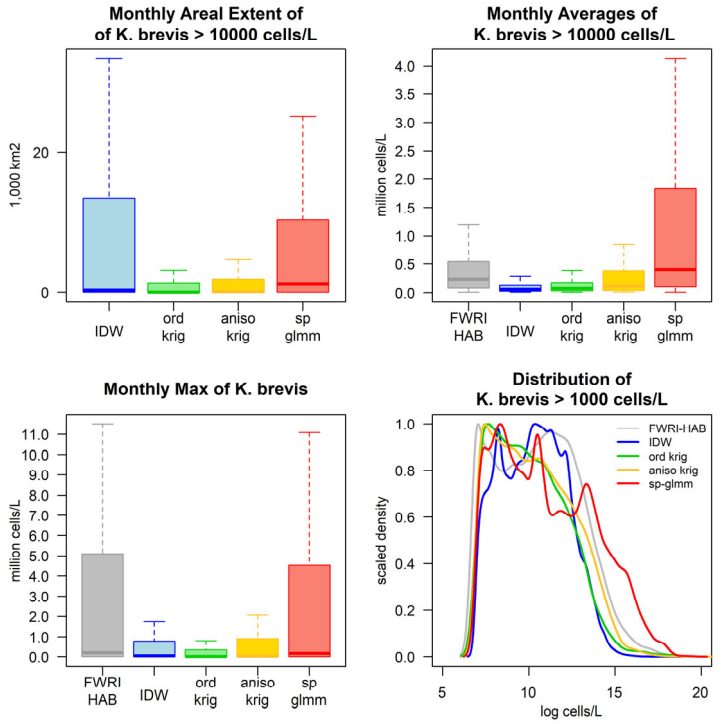
Recent Updates: evaluating alternative spatial extrapolation approaches for mapping red tide

- FWRI HAB data are kriged and then clipped to satellite data
  - Inversed Distance Weighting (simplest)
  - Simple Ordinary Kriging
  - Anisotropic Kriging (non-symmetrical variance structure)
  - Spatial delta-GLMM (i.e. VAST)



Recent Updates: evaluating alternative spatial extrapolation approaches for mapping red tide

- FWRI HAB data are kriged and then clipped to satellite data
  - Inversed Distance Weighting (simplest)
  - Simple Ordinary Kriging
  - Anisotropic Kriging (non-symmetrical variance structure)
  - Spatial delta-GLMM (i.e. VAST)
- Transition to Anisotropic and VAST models for extrapolation
  - More computationally intensive but distribution is more similar to observed data

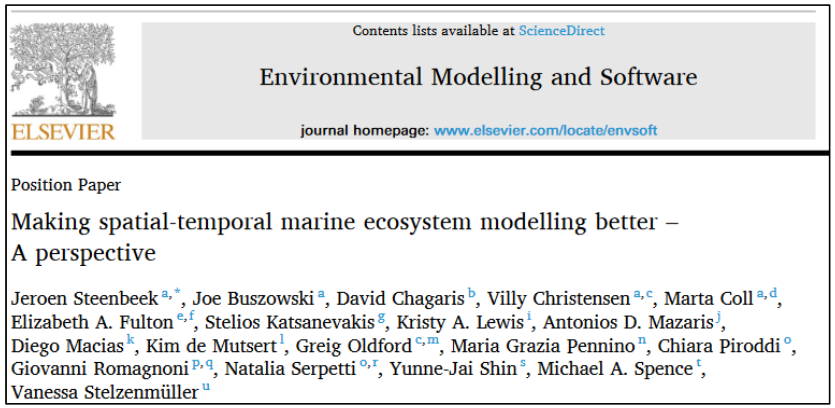


Recent Updates: Improving model predictions

Developing Systematic Assessments of Marine Ecosystem Model Performance

- Parallel processing Ecospace runs
  - First used in WFS red tide gag application
  - Expanded to include other parameters
    - pred-prey vulnerabilities, habitat preferences, dispersal rates
  - Monte-Carlo runs on initial model conditions
  - Characterize uncertainty due to spatial-temporal drivers
  - From this, we can develop ensemble modeling approaches.

- Model Calibration
  - Regional time series in biomass, catch, effort
  - Map-map comparisons
  - Age compositions
  - Develop a composite objective function for evaluating model fit to multiple data types/sources



Contents lists available at ScienceDirect

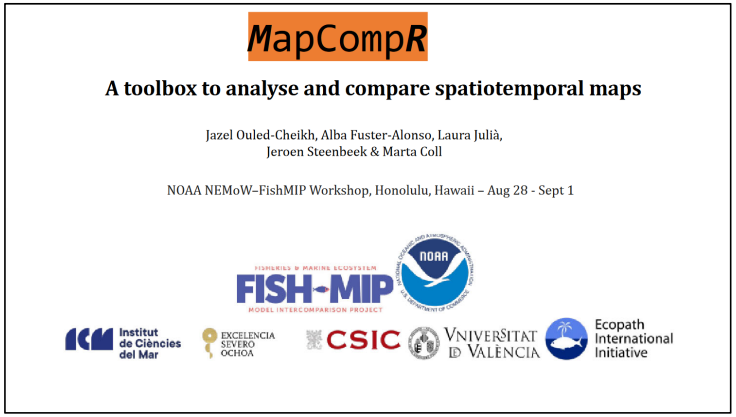
Environmental Modelling and Software

journal homepage: www.elsevier.com/locate/envsoft

Position Paper

Making spatial-temporal marine ecosystem modelling better – A perspective

Jeroen Steenbeek [a,*], Joe Buszowski [a], David Chagaris [b], Villy Christensen [a,c], Marta Coll [a,d], Elizabeth A. Fulton [e,f], Stelios Katsanevakis [g], Kristy A. Lewis [i], Antonios D. Mazaris [j], Diego Macias [k], Kim de Mutsert [l], Greig Oldford [c,m], Maria Grazia Pennino [n], Chiara Piroddi [o], Giovanni Romagnoni [p,q], Natalia Serpetti [o,r], Yunne-Jai Shin [s], Michael A. Spence [t], Vanessa Stelzenmüller [u]



MapCompR

A toolbox to analyse and compare spatiotemporal maps

Jazel Ouled-Cheikh, Alba Fuster-Alonso, Laura Julià, Jeroen Steenbeek & Marta Coll

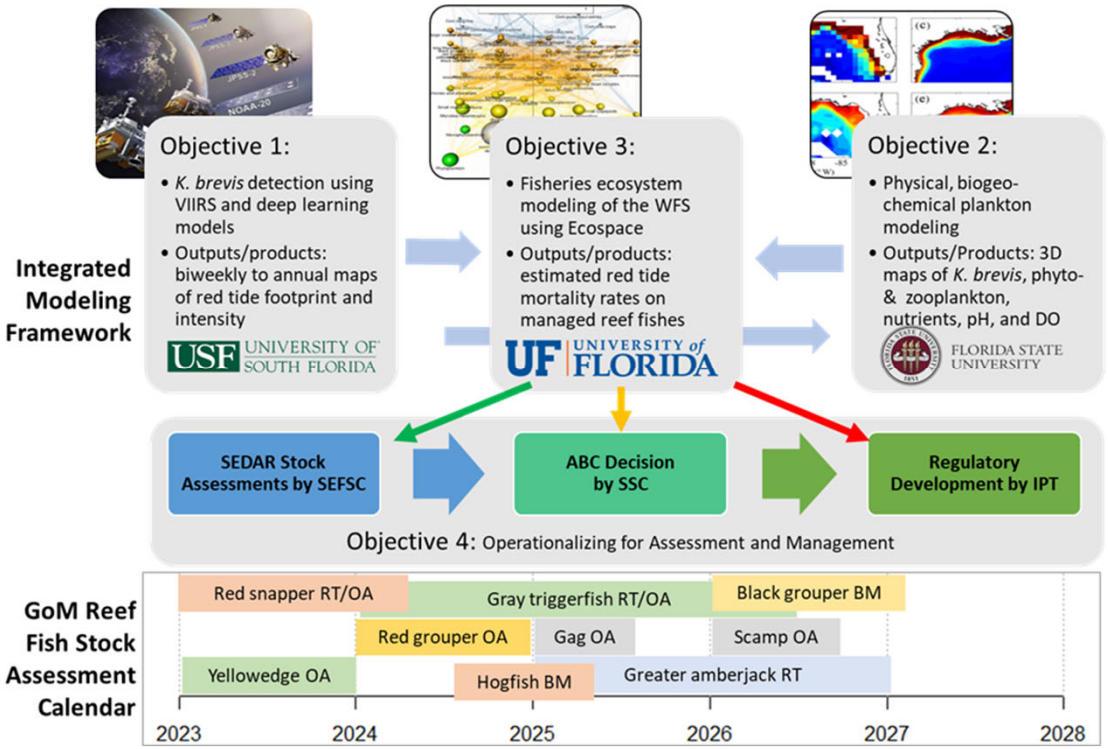
NOAA NEMoW–FishMIP Workshop, Honolulu, Hawaii – Aug 28 - Sept 1

Future Work: Operationalizing WFS Ecospace

Overall goal is to account for red tide mortality when assessing GoM reef fishes and setting their ABCs.

- 4 Objectives
  1) Remote Sensing - Chuanmin Hu, USF
  2) Biogeochemical modeling – Mike Stukel, FSU
  3) Ecosystem modeling and 4) Operational management application – David Chagaris, UF (lead PI)
- NOAA Restore Funding: October 2023-September 2028

RESTORE SCIENCE PROGRAM

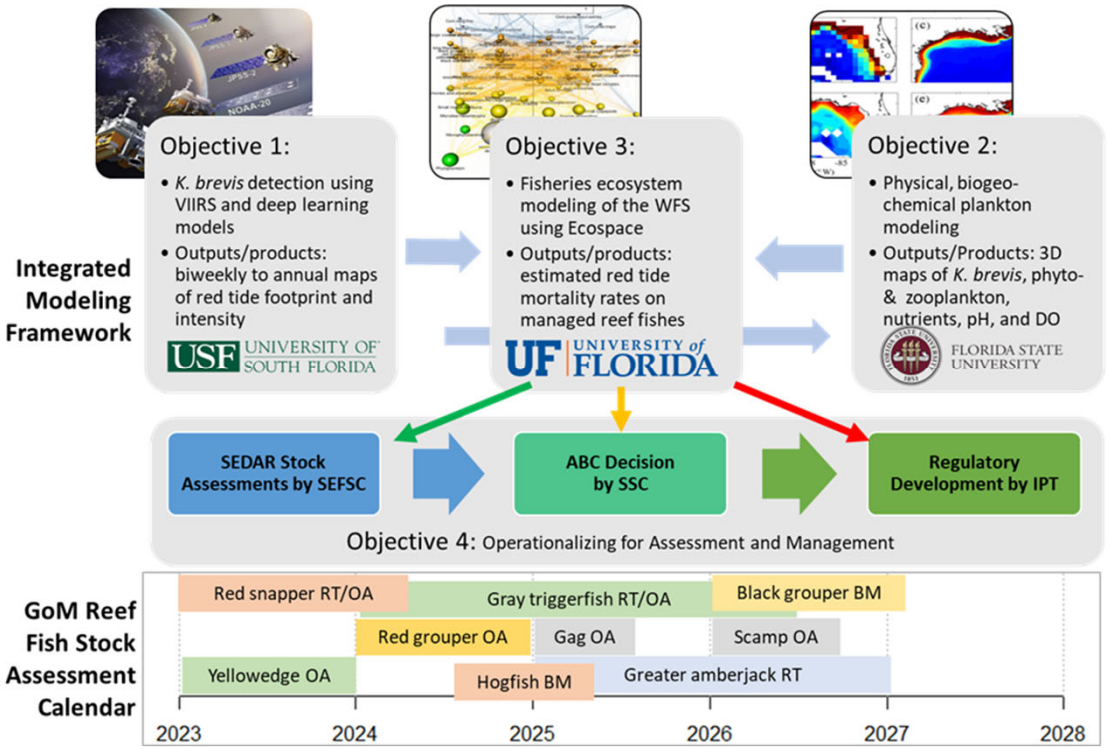


Future Work: Operationalizing WFS Ecospace

Project Team:

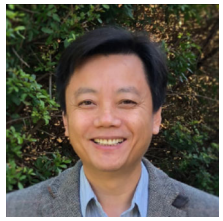
- Modeling: David Chagaris (UF, lead); Chuanmin Hu (USF), Mike Stukel & Sven Kranz (FSU)
- Collaborators: Ted Switzer (FWC); Kate Siegfried, Mandy Karnauskas, Skyler Sagarese (SEFSC)
- Resource Managers: Ryan Rindone (Gulf Council); Daniel Luers (SERO)
- Stakeholder Engagement: Mike Sipos (UF/FSG), Casey Streeter, Dylan Hubbard

RESTORE SCIENCE PROGRAM



Operationalizing WFS Ecospace

Objective 1: Develop red tide maps using NOAA's Visible Infrared Imager Radiometer Suite (VIIRS)



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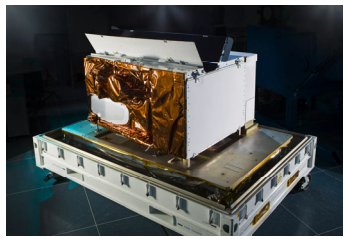
Chuanmin Hu, USF

- Maintain continuity of red tide model after planned MODIS Aqua stoppage in 2023
- VIIRS has more valid observations than MODIS
- But, not equipped with sensor used to detect red tide
- Deep learning models will be developed to detect red tide using VIIRS
- Maps of bloom frequency, footprint and intensity at biweekly, monthly, seasonal, and annual intervals



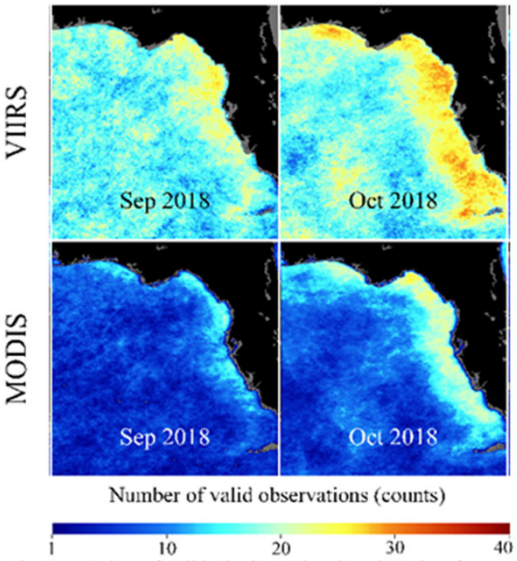


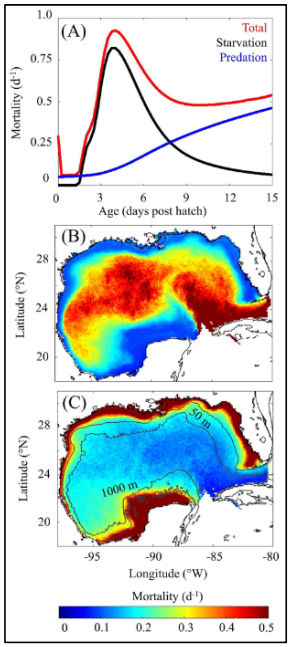
Fig 3. Number of valid obs in each 1-km location from VIIRS and MODIS.

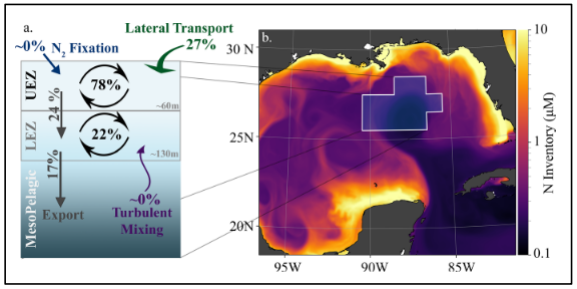
Operationalizing WFS Ecospace

Objective 2: Incorporate oxygen and *K. brevis* dynamics into a physical biogeochemical model

- $NEMURO_{GOM}$: A physically coupled model of GoM biogeochemistry and plankton food web
  - Previously developed for application to GoM nutrient dynamics and Atlantic bluefin tuna larvae
  - Simulates 3-d time varying dissolved oxygen, pH, phytoplankton and zooplankton biomass
- Add K. brevis to NEMUROGOM, conduct data assimilation and ensemble modeling
- One-way coupling with WFS Ecospace to improve lower trophic level dynamics and incorporate bottom layer DO and K. brevis

Mike Stukel, FSU





Operationalizing WFS Ecospace

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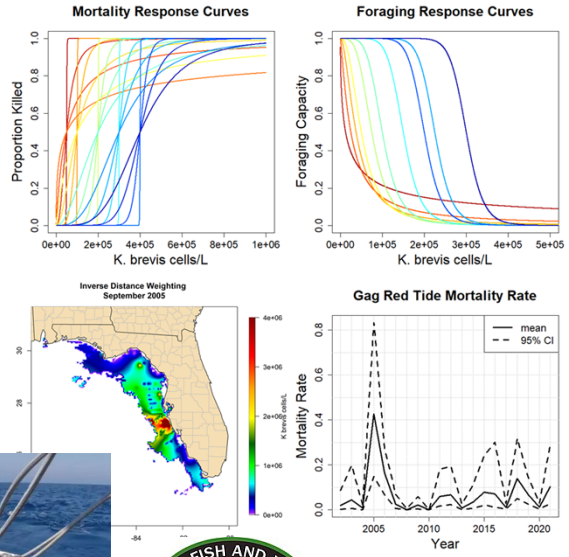
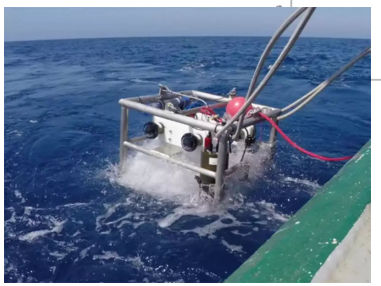
NATURE COAST BIOLOGICAL STATION

Objective 3: Update and calibrate the WFS Ecospace model.

- Add or refine age structure for assessed species; modify phytoplankton and zooplankton to match $NEMURO_{GOM}$
- Integrate with G-FISHER camera survey data
  - Habitat mapping & metrics, habitat preferences, indices of abundance (regional, spatial)
- Model calibration and ensemble modeling
- MICE models (models of intermediate complexity) developed as needed



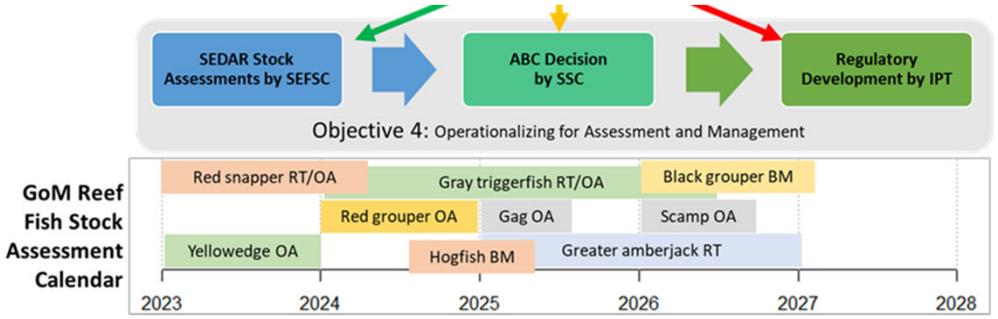


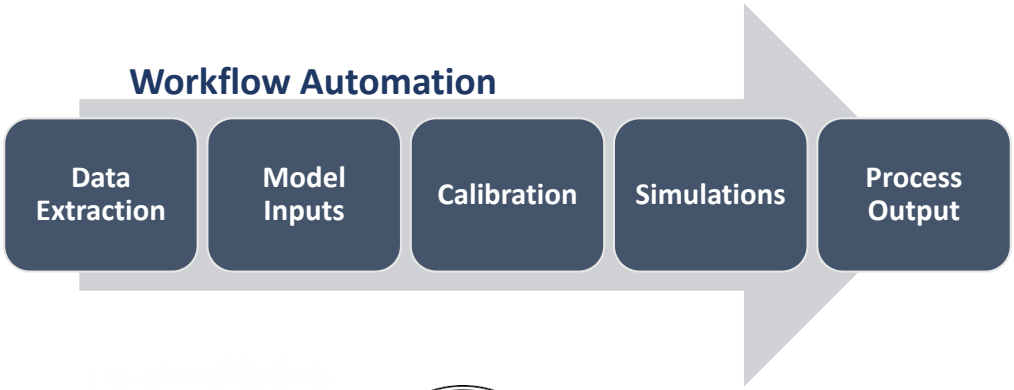
FLORIDA FISH AND WILDLIFE CONSERVATION COMMISSION

Operationalizing WFS Ecospace

Objective 4: Operationalizing the WFS ecosystem model for routine stock assessment and management.

- Establish protocols, procedures, and I/O formats that enable routine updates and reproducible model runs.
- Developed and refined over time through application to multiple stock assessments
- Code library (Github)
- rShiny application, visualizer and simulation front-end





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Stakeholder Engagement

Gathering local ecological knowledge (LEK)

- Identify set of stakeholders – commercial/recreational fishers, dive operators, eco-tour guides, natural resource professionals
- Online questionnaire or forum to solicit information on fish kills, water quality, catch, and effort as red tides are occurring
  - Information will complement model predictions, and serve as reality checks
- In-person meetings with participating stakeholders
  - compare model against LEK (when/where and what species affected)
  - Help develop outreach and communication products that are useful to the fishing community

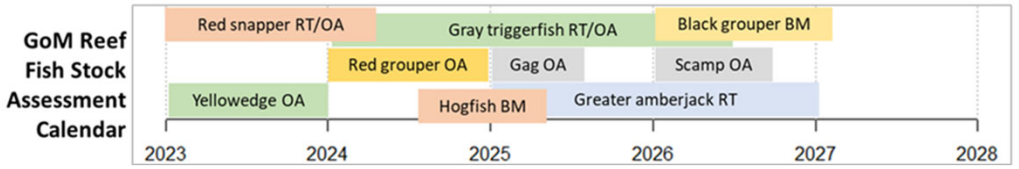
Sea Grant FLORIDA

Mike Sipos, Collier County

Timeline

- Model developments will be phased-in with each stock assessment
- Goal: VIIRS -> WFS Ecospace integration operational for red grouper OA and ABC determination
- Goal: Fully operational by 2026
- Model will be updated routinely and upon request, for other species and concerns

	2023	2024	2025	2026	2027	2028
Remote sensing of red tide	Data Acquisition	Model Update & Develop	Operational			
Biogeochemical modeling	Data Acquisition	Model Update & Development		Operational		
WFS ecosystem modeling	Data Acquisition	Model Update & Development			Operational	



Thank You

For more Information, please visit the project page

https://sites.google.com/ufl.edu/dchagaris-fisheries-lab/research/wfs-ecosystem-model

David Chagaris

UF Nature Coast Biological Station

dchagaris@ufl.edu

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