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Participatory modeling and fisheries management: Overview of SEFSC applications

Gulf SSC meeting

February 24-26, 2026

UNIVERSITY OF MIAMI
COOPERATIVE INSTITUTE for
MARINE & ATMOSPHERIC STUDIES

Background: Participatory Methods in Resource Management

1970s: Critique of top down conservation and development

1970s-80s: Economic development and rural research
- e.g. Robert Chambers – Rapid and Participatory Rural Appraisal

1980s - 90s: Community-based conservation (1980s - 90s)
- Increased focus on stakeholder engagement/local knowledge
- Participatory mapping, stakeholder workshops, other methods

2000 - present: Co-management, Adaptive Management
- NGOs and agencies require stakeholder participation; co-production of knowledge
- Participatory GIS, monitoring and evaluation, participatory scenario planning

Participatory methods we have used

- Participatory mapping
- Participatory workshops
- Scenario planning
- Focus groups
- Oral histories

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Participatory Modeling

1980s - "Systems thinking" in ecology & socio-ecological systems research (e.g. Jay Forrester, Donella Meadows, Peter Senge)

1990s: Increased emphasis on co-management in conservation: stakeholder input to understand complex interactions

2000s: WWFs Measures of Success and Open Standards for Conservation: Conceptual models/results chains.

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Why participatory modeling?

- Genuine engagement helps overcome challenges with trust and buy-in from fishing community
- Prioritize key stressors, risks, or connections for ***EBFM implementation***
- Learn about supply chains, bottlenecks, and hardships *to* ***advance domestic seafood priorities***
- Supports transparent, inclusive, and participatory science and stewardship in recreational fisheries, *in accordance with* ***National Rec Fish Policy***
- Clarifies diverse objectives that exist across sectors and regions, ***relevant to Management Strategy Evaluation, defining Optimum Yield***
- In an era of rapid change fishermen often report anomalies before our science/data collection enterprise can detect them

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Case study 1: Application of participatory modeling to implementation of ecosystem-based fishery management

Participatory modeling for EBFM

- Workshop series initiated in 2018 amidst push to implement EBFM systematically
  - **Goal:** To increase information flow between scientists, managers, and stakeholders, in support of improved stock assessment and ecosystem assessment in the Gulf of Mexico
- Limited resources – where to start?
- Who gets to define priority issues?

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Participatory modeling for EBFM

What are the major factors affecting your fishery?

Where do the major risks in the fisheries system lie?

How do changes in ecosystems affect your businesses and communities?

What do you value in the ecosystem?

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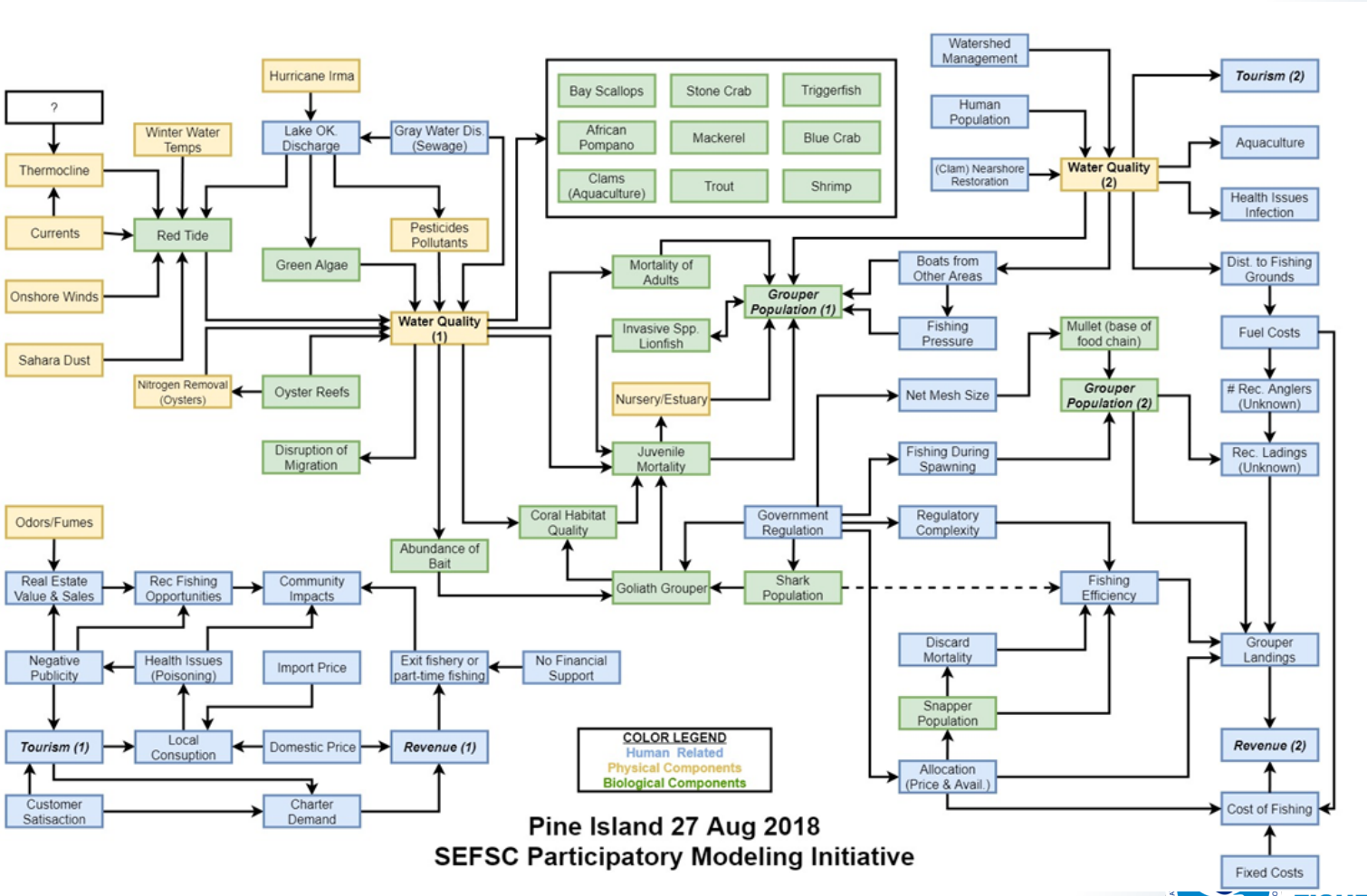
Participatory modeling for EBFM

Red tide impacts emerged as major driver

Concerns not only with impacts on target fish stocks, but also prey base, habitat, aquaculture, publicity, tourism, seafood demand, real estate, health…



Participatory modeling for EBFM

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Participatory modeling for EBFM

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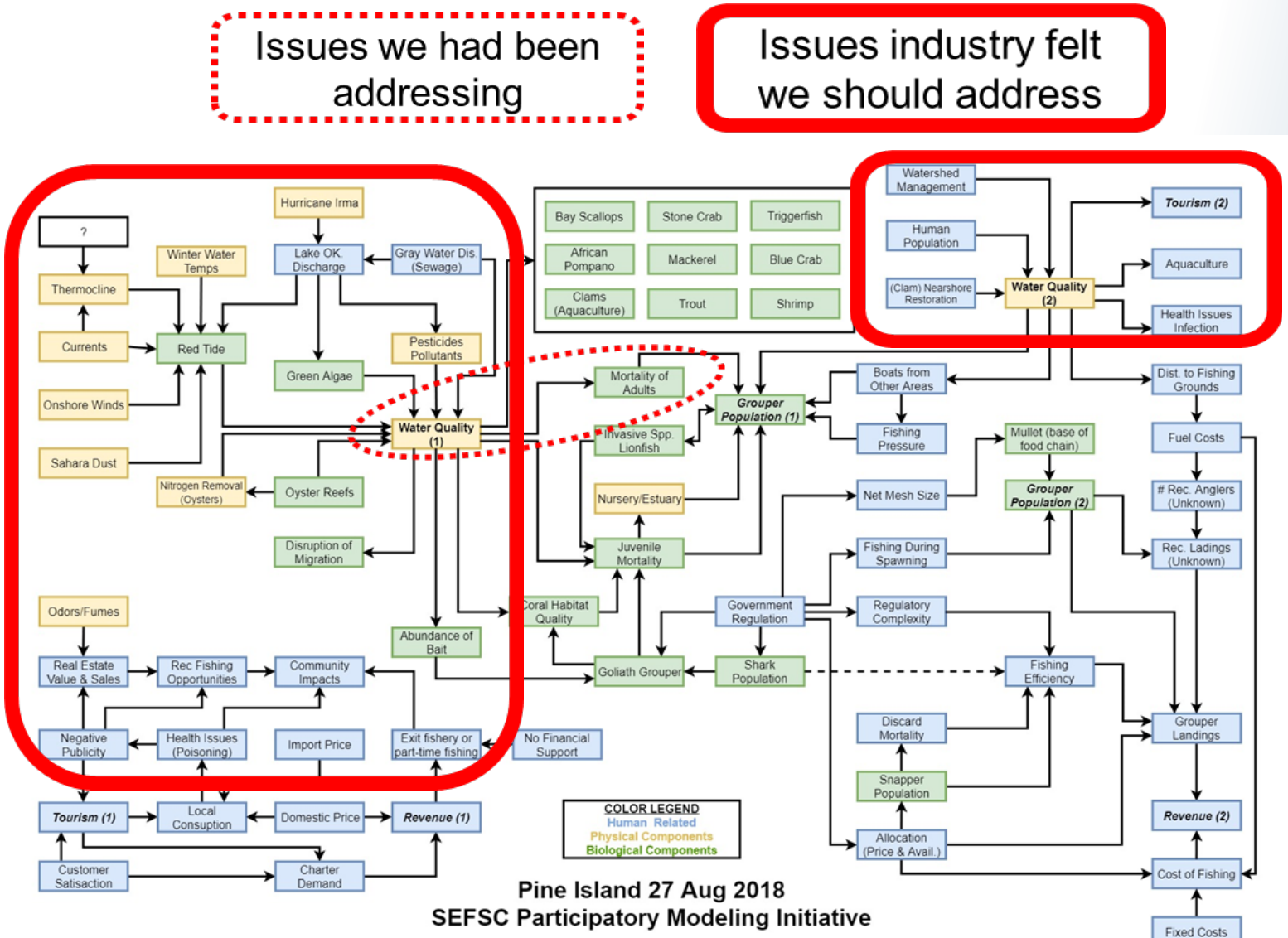


Red tide response efforts

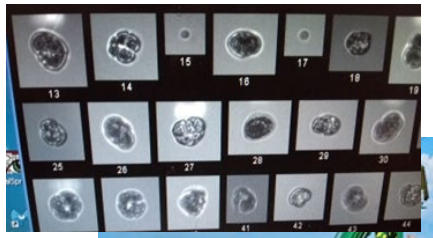
Spawned major new research initiatives to test hypotheses on ecological, social and economic impacts of red tide (with extensive external collaboration)

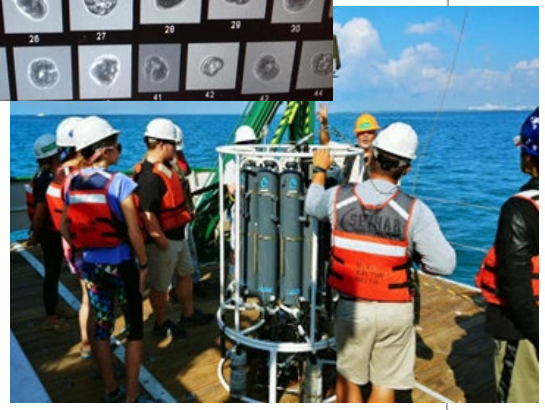
<u>Ecological impacts:</u>

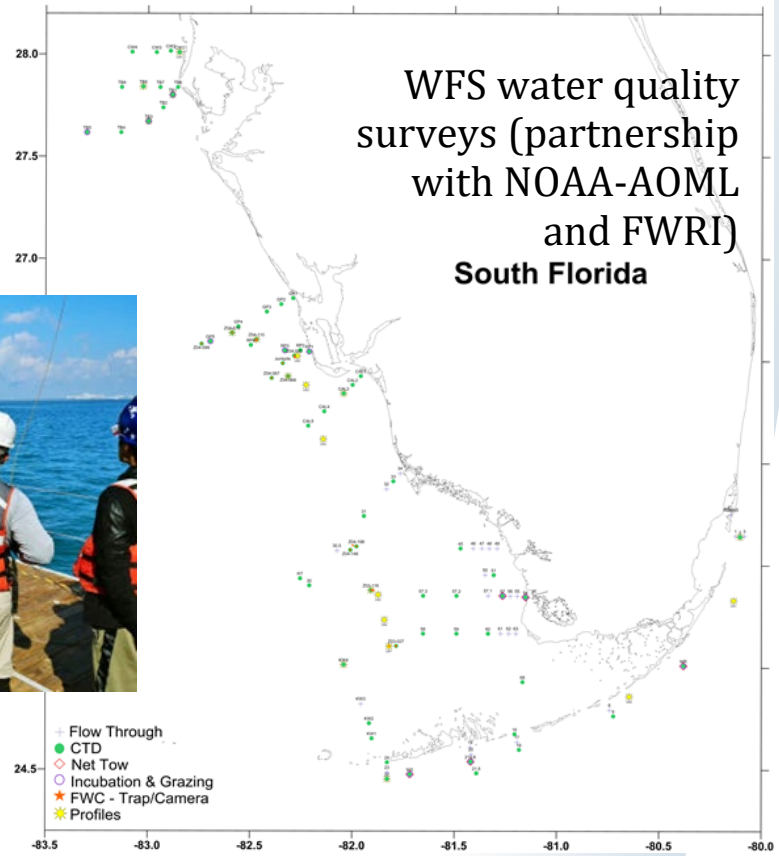
- collaborative monitoring
- analysis of historical survey data

<u>Social and economic impacts:</u>

- oral history project
- fleet behavior analysis
- economic impact analysis







62 interviews with industry members

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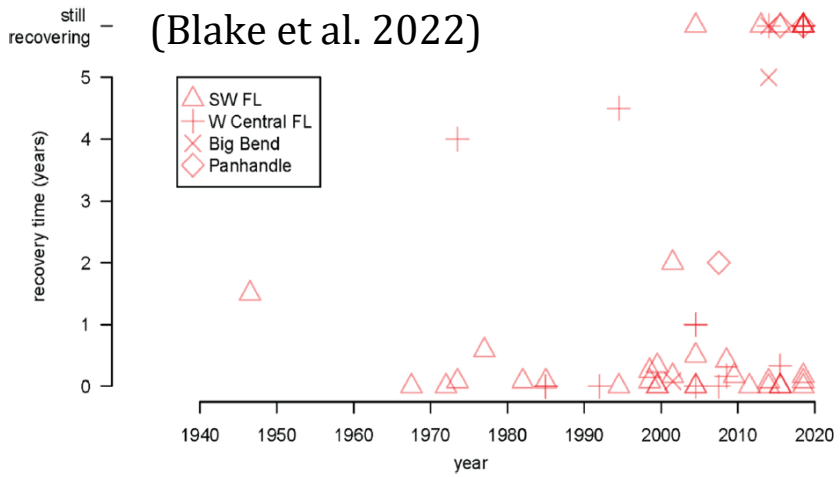
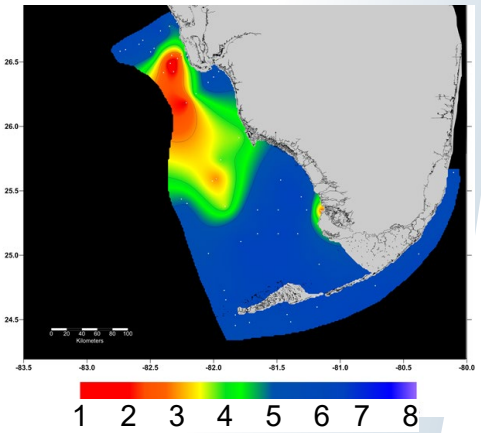
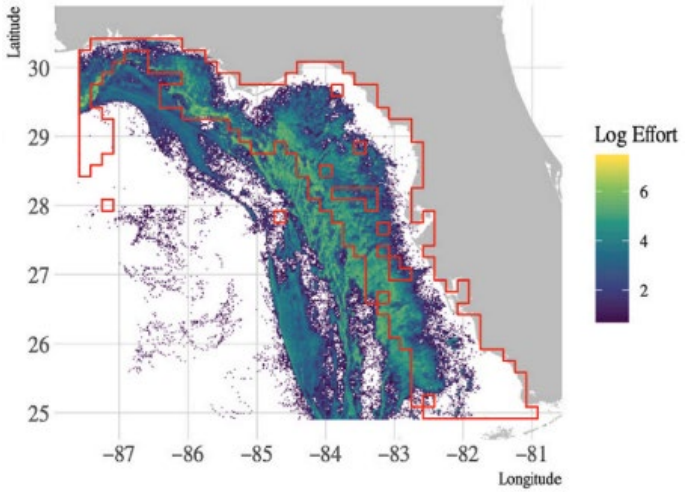
Red tide response - knowledge gained

- Perception of increasing red tide severity, duration, system recovery (Blake et al. 2022)
- Ecosystems most impacted by blooms associated with hypoxia; hypoxia forms in fall when blooms persist over summer (Turley et al. 2022)
- Red tide impacts at vessel level (displacement) but not fleet level (Perruso et al. in 2023)
- Decline in vacation rentals during 2018 event equating to losses of $184 million (Court et al. 2021)
- Local knowledge integrated into 2018 red grouper assessment projections (SEDAR 2018)

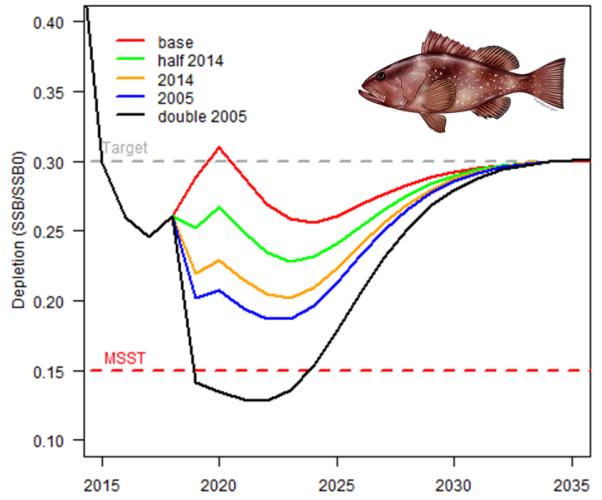


(Blake et al. 2022)





(Perruso et al. 2023)



(SEDAR 2018)

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Red tide response - knowledge gained

Adaptation to Typical Events

- Fish around patchy blooms
- Extended gear deployment, trial and error
- Move to fish offshore or inshore, north or south; temporarily change target species
- Temporarily delay harvesting clams and shellfish

Adaptation to Extreme Events

- Move fishing location (often very far from home port)
- Fish in deeper areas; redirect effort to other species
- Run charters to fish in the "backcountry"

resilience begins to break down…

- Stop fishing and get temporary job (construction, Uber, Home Depot)
- Get job as captain/crew in a different area of the country
- Switch from commercial to charter fishing, ecotourism, photo tourism

resilience gone

- Sell gear and equipment and leave the industry
- Retire
- Clam and shellfish harvests completely lost, aquaculture businesses shut down

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Pause for questions

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Case study 2: Application of participatory modeling to stock assessment

The need for holistic assessments

Kim et al. 2025 J. Mar. Sci. Eng.

The SocioEconomic Aspects in Stock Assessments Workshop (SEASAW) Report:

Recommendations for Increasing Assessment Accuracy and Improving Management Advice

Andrea N. Chan, Alan C. Haynie, Patrick Lynch, Skyler Sagarese, Kalei Shotwell, Lisa Pfeiffer, Scott Crosson, Melissa Krigbaum, Doug Lipton, Jeffrey Vieser, Aaron Mamula, John Walter, Richard Methot, Kristan Blackhart, Marysia Szymkowiak, Emily Markowitz, Stephanie Oakes, Michael Downs, Howard Townsend, T. Todd Jones, Diana Stram, Matthew McPherson

NOAA Technical Memorandum NMFS-F/SPO-232
June 2022

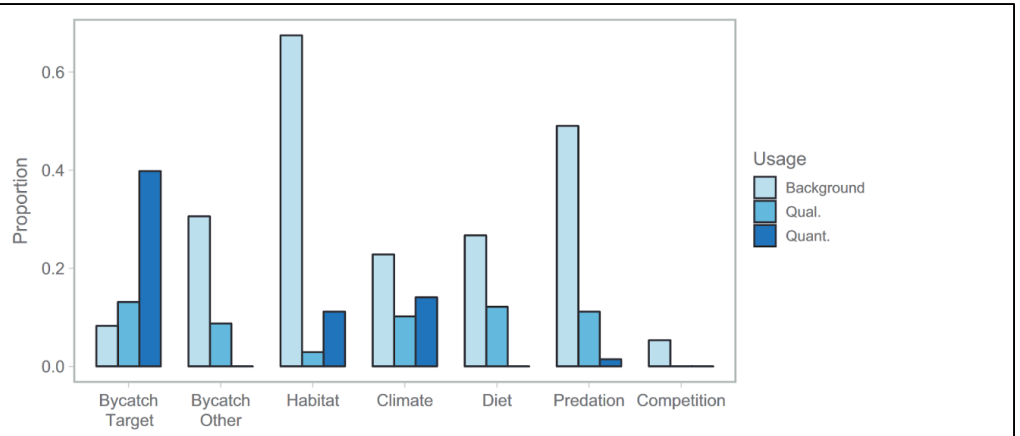
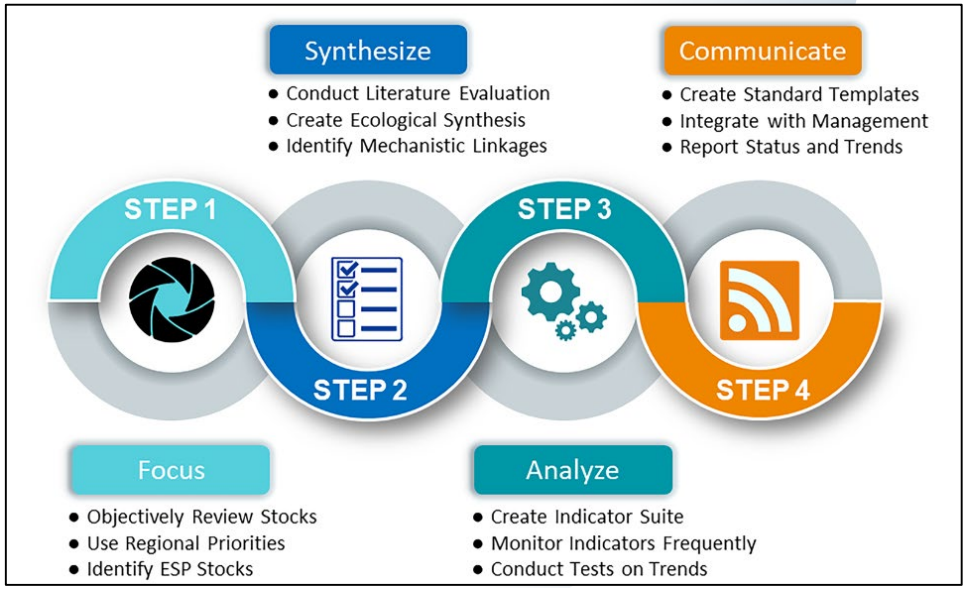


Figure 1. Inclusion of fishery and ecosystem interactions across interaction types. Each bar represents the proportion of assessment reports that received each score across topics ($n = 206$). Shading increases with scores: background information (1), qualitative inclusion of information (2), or quantitative inclusion (3).

Marshall et al. 2019 ICES J. Mar. Sci.

Table 1. Description of variables Used in the generalized additive model (GAM) for CPUE standardization of red snow crab (*Chionoecetes japonicus*).

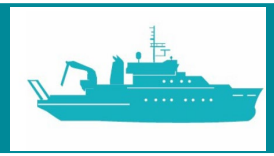
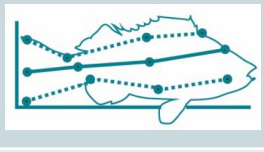
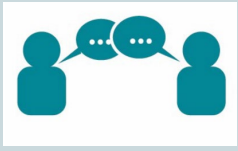
Category	Variable	Type	Description	Source
Fishery–spatiotemporal factors	Year	Categorical (15 levels)	15 years from 2009 to 2023	TAC internal records [36]
	Month	Categorical (10 levels)	10 months, excluding the closed season (July–August)	TAC internal records [36]
	Area	Categorical (2 levels)	Fishing areas; Gangwon (GW), Gyeongbuk (GB)	TAC internal records [36]
	GT	Categorical (3 levels)	Gross tonnage of fishing vessels; 8–20 tons, 20–40 tons, over 40 tons	TAC internal records [36]
	s(Lat, Long)	Continuous	Interaction term capturing the average spatial distribution of CPUE based on latitude and longitude	TAC internal records [36]
Socioeconomic Factors	COVID	Categorical (2 levels)	Indicator variable representing the impact of the COVID-19 pandemic; 0 = pre-COVID, 1 = post-COVID	WHO [37], De Silva et al. (2023) [38]
	s(GP)	Continuous	Global export price of red snow crab (USD per ton)	KATI [39]
	s(OP)	Continuous	Crude oil price (USD per barrel), representing fluctuations in fuel costs	KNOC [40], KOSIS [41]
	s(LP)	Continuous	Proportion of live catch in the total red snow crab harvest (%)	TAC internal records [36]
	s(LP, by = Area)	Continuous	Interaction term capturing the effect of live catch proportion by fishing region (GW and GB)	TAC internal records [36]



Shotwell et al. 2023 Coast. Mgmt.

Purpose of this research

- Develop a standardized methodology for incorporating socio-economic & ecosystem information into the stock assessment process
- Better understand feedback loops and unintended consequences relevant to managing fisheries

	Data collection
	Data processing
	Stock assessment models
	Projections
	Harvest control rules
	Communication with managers and stakeholders

Adapted from Chan et al. 2022 SEASAW report

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Case Study

Gulf of America Red Snapper

Photo from Capt. Brian Rowe

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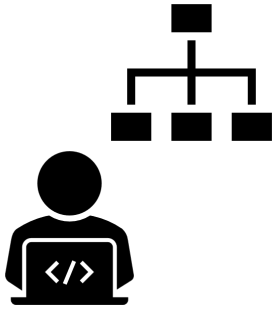
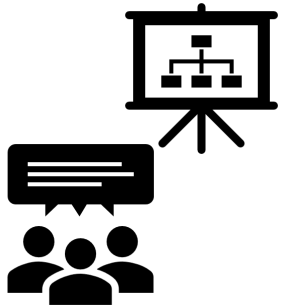
Methods

Phone conversations with individual stakeholders



Researchers create conceptual model



Model validated with in-person workshop

Identify components linked to stock assessment

Develop standard protocols

Identify future applications and improvements

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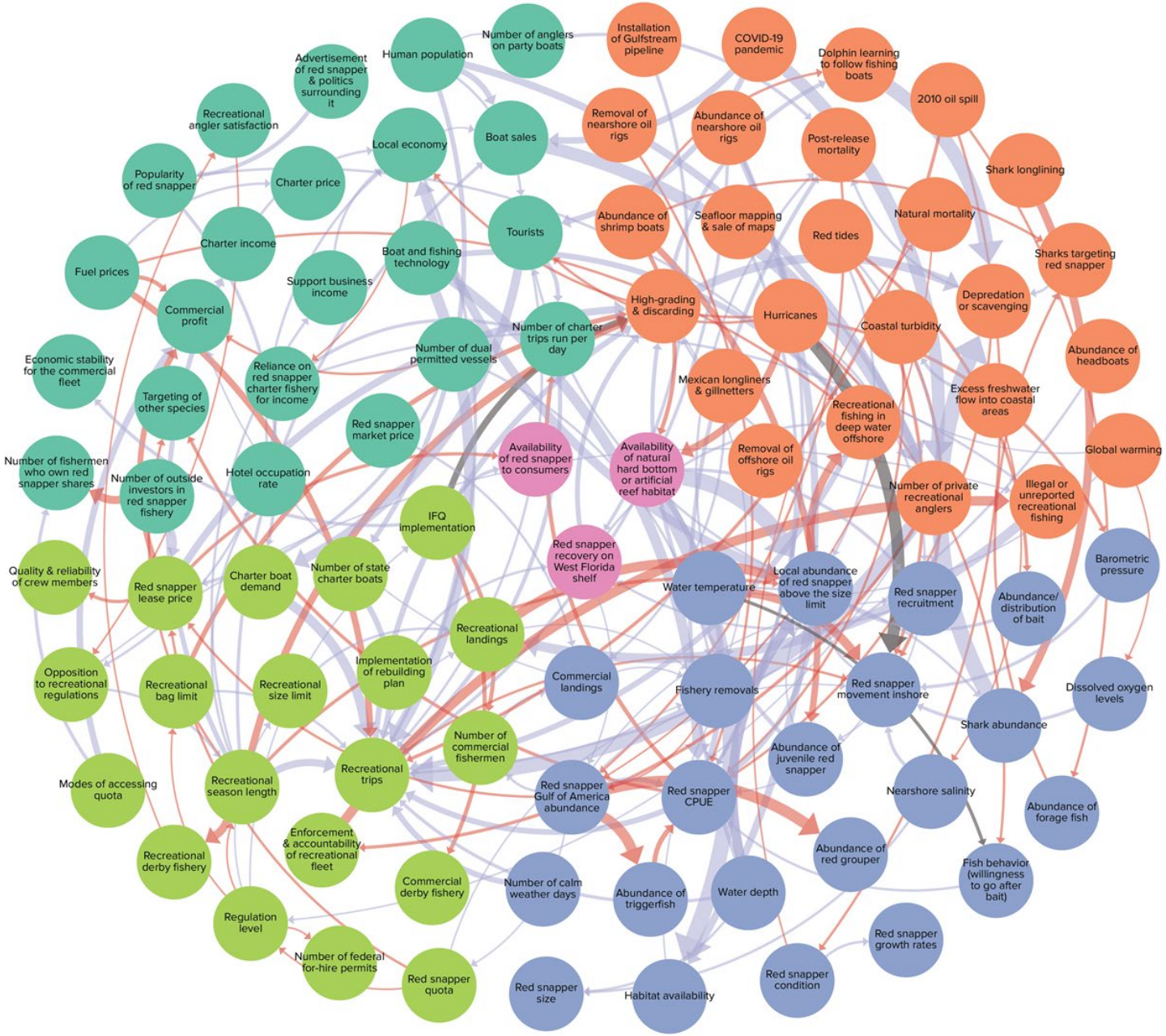
Gulf model

*based on interviews with 53 fishermen



Legend

- Positive connections
- Negative connections
- Number of anglers
- Unknown connection
- Driver
- Pressure
- State
- Ecosystem Service
- Response

Interactive model available at:
https://gulf-iea.kumu.io/gulf-red-snapper-participatory-model

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What can participatory modeling help us do?

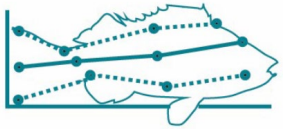
Stock assessment process

Data collection

Data processing

Stock assessment models

Projections



Harvest control rules

Communication

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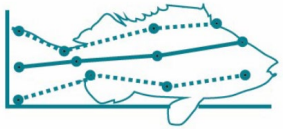
What can participatory modeling help us do?

[Stock assessment process](#)	Data collection	Data processing	Stock assessment models	Projections	Harvest control rules	Communication
						
[Benefit of participatory modeling](#)	Identify driving variables	ID factors to consider during data processing	Improve model parameterization	ID changes to consider when running projections	ID management objectives	Examine unintended consequences of management

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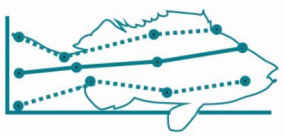
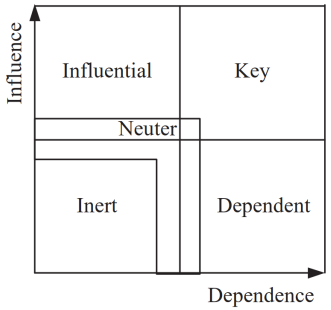
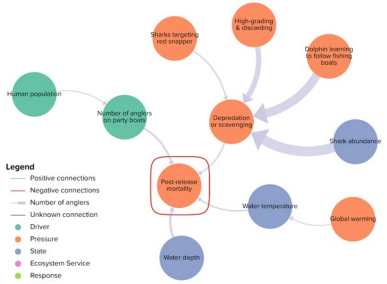
What can participatory modeling help us do?

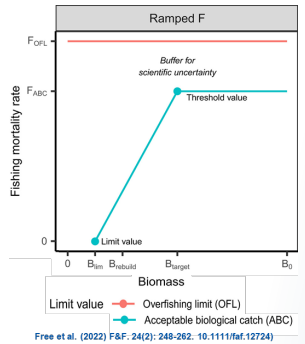
	Data collection	Data processing	Stock assessment models	Projections	Harvest control rules	Communication
Stock assessment process						
Benefit of participatory modeling	Identify driving variables	ID factors to consider during data processing	Improve model parameterization	ID changes to consider when running projections	ID management objectives	Examine unintended consequences of management
Method	Social network analysis & node categorization	ID in arrows to CPUE & discard mortality	ID nodes related to model parameters	Examine perceived changes in fishery dynamics	Manage for Optimum Yield	ID out arrows from management actions



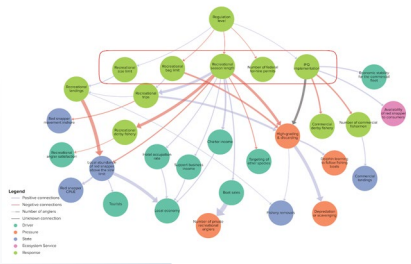


Parameter category	Related nodes in SD model
Fishing mortality	Fishery removals
Stock-recruit deviations	Red snapper recruitment
Stock-recruit relationship	Red snapper recruitment
Recruitment apportionment	Red snapper recruitment
Selectivity	Recreational fishing in deep water offshore, Derby fishery
Retention	High-grading & discarding
Catchability	Red snapper CPUE
Length/age composition weightings	Red snapper size

Derived quantity
Recruitment (R)
Growth Curve
Weight-Length Relationship
Fecundity-at-Age (Fec)
Selectivity (S)
Retention (Ret)
Discard Mortality (DM)
Natural Mortality (M)
Directed Fishing Mortality (F_{Dir}) by Fleet
Directed Discard Fishing Mortality (F_{Disc}) by Fleet
Total Directed Fishing Mortality (F_{Tot_Dir}) by Fleet



Free et al. (2022) F&F. 24(2): 248-262. 10.1111/faf.12724



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What can participatory modeling help us do?

Stock assessment process

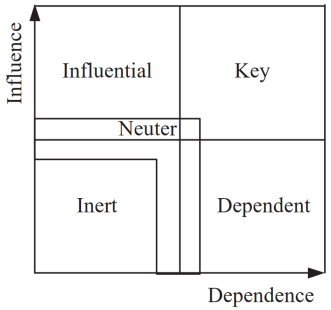
Benefit of participatory modeling

Method

Data collection

Identify driving variables

Social network analysis & node categorization



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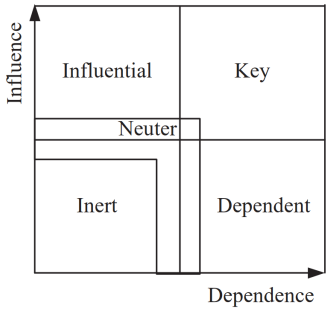
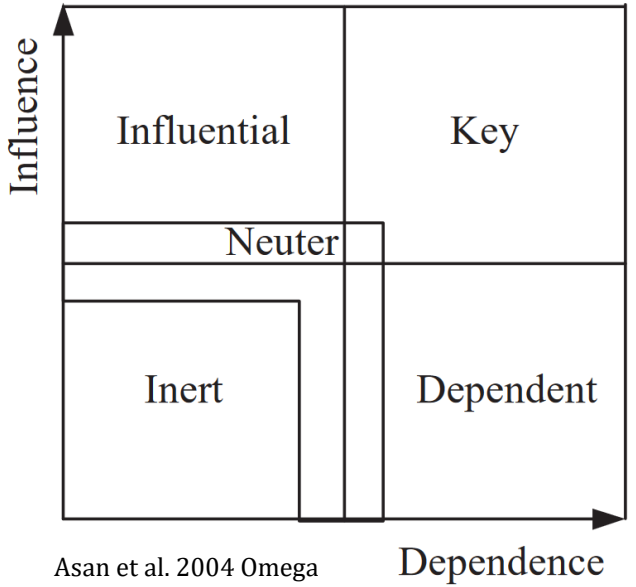


How do we identify important ecosystem and socioeconomic drivers?

1. Social network analysis (SNA)
2. Categorize factors using EBM-DPSER framework

MICMAC influence-dependence diagram



Asan et al. 2004 Omega

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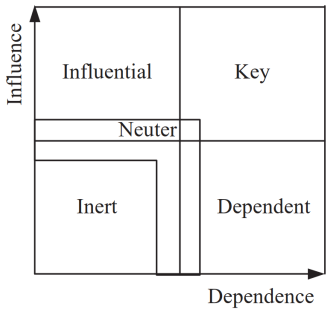

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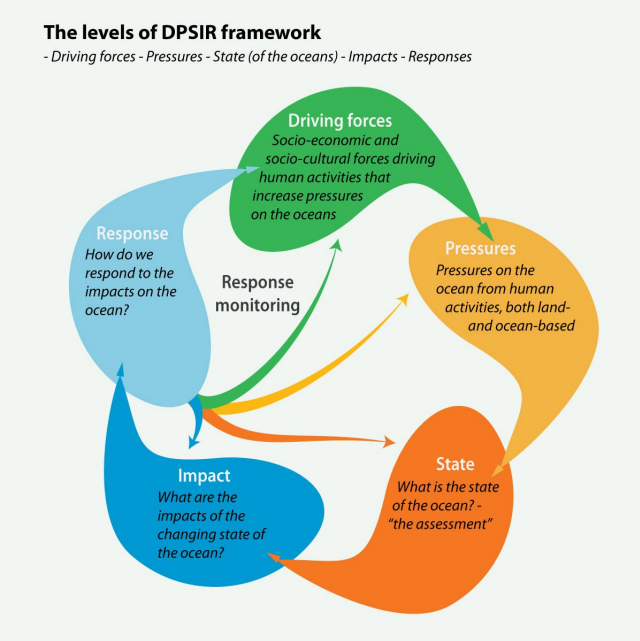

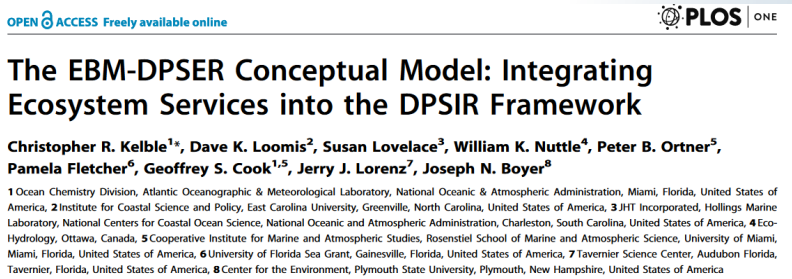
OPEN ACCESS Freely available online PLOS ONE

The EBM-DPSER Conceptual Model: Integrating Ecosystem Services into the DPSIR Framework

Christopher R. Kelble[1]*, Dave K. Loomis[2], Susan Lovelace[3], William K. Nuttle[4], Peter B. Ortner[5], Pamela Fletcher[6], Geoffrey S. Cook[1,5], Jerry J. Lorenz[7], Joseph N. Boyer[8]

1 Ocean Chemistry Division, Atlantic Oceanographic & Meteorological Laboratory, National Oceanic & Atmospheric Administration, Miami, Florida, United States of America, 2 Institute for Coastal Science and Policy, East Carolina University, Greenville, North Carolina, United States of America, 3 JHT Incorporated, Hollings Marine Laboratory, National Centers for Coastal Ocean Science, National Oceanic and Atmospheric Administration, Charleston, South Carolina, United States of America, 4 Eco-Hydrology, Ottawa, Canada, 5 Cooperative Institute for Marine and Atmospheric Studies, Rosenstiel School of Marine and Atmospheric Science, University of Miami, Miami, Florida, United States of America, 6 University of Florida Sea Grant, Gainesville, Florida, United States of America, 7 Tavernier Science Center, Audubon Florida, Tavernier, Florida, United States of America, 8 Center for the Environment, Plymouth State University, Plymouth, New Hampshire, United States of America

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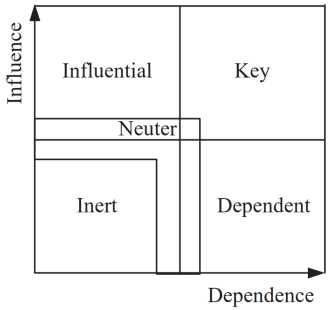

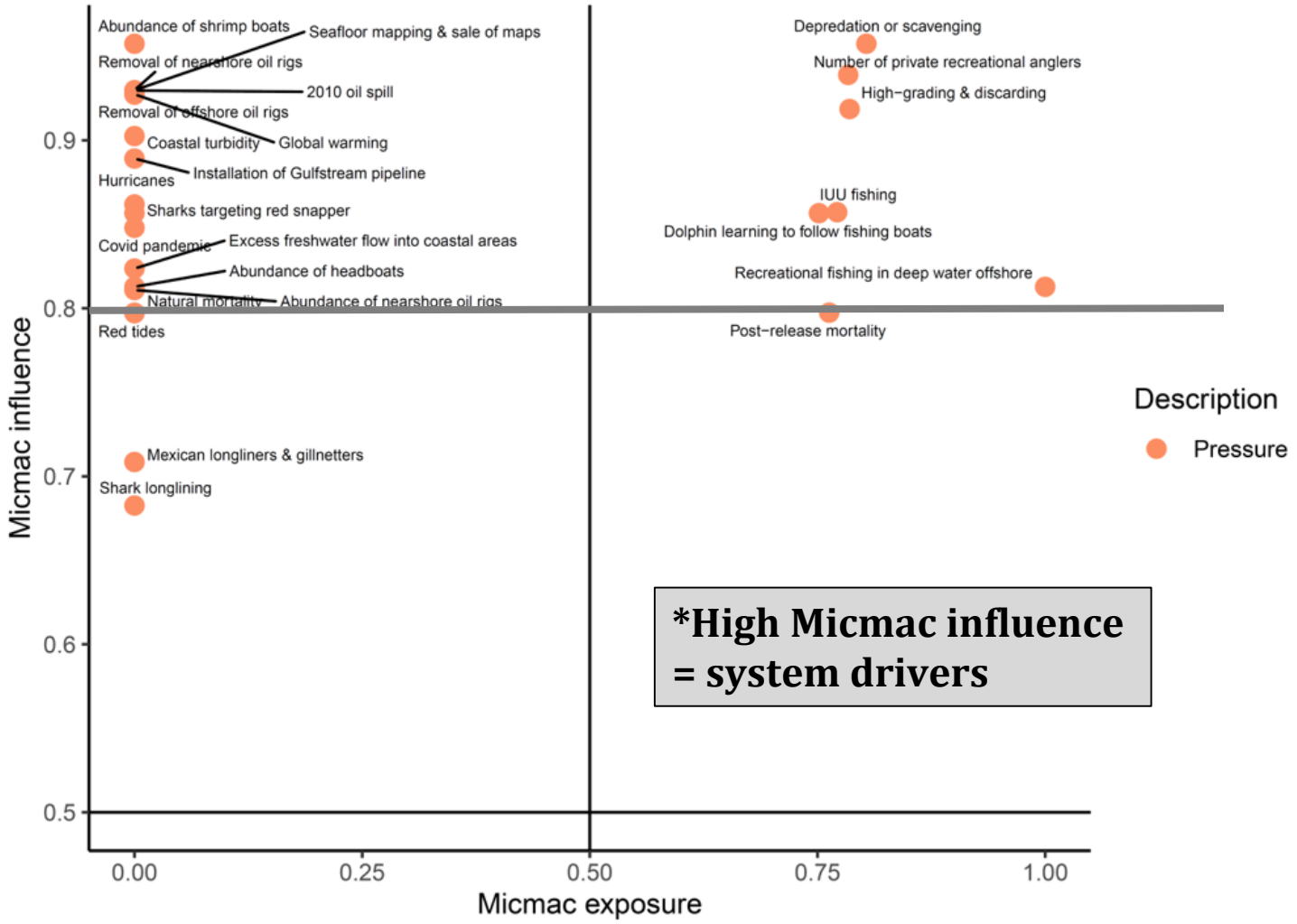

***High Micmac influence = system drivers**

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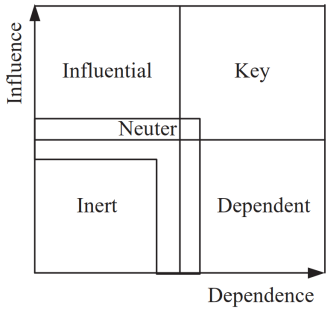
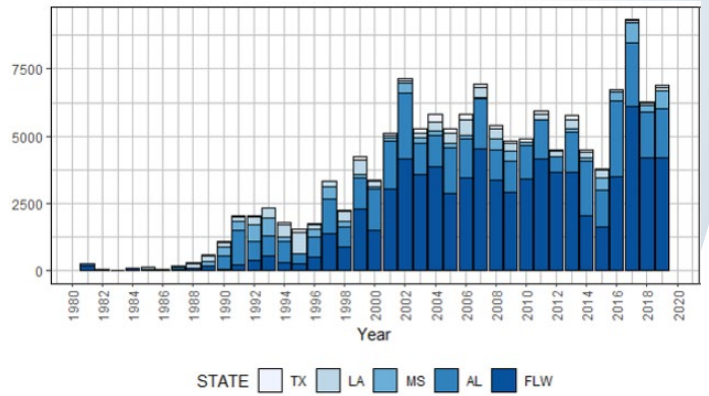


Credit: Hannah Aycock

Depredation [dep-ri-**dey**-sh*uh*n]: The complete or partial removal of a hooked fish by a predator before it can be retrieved by a fishing vessel.
(Mitchell et al., 2018 Rev. Fish Biol. Fish.)

What is the fate of these discarded fish?

Recreational discards



SEDAR74-DW-01

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What can participatory modeling help us do?

Stock assessment process

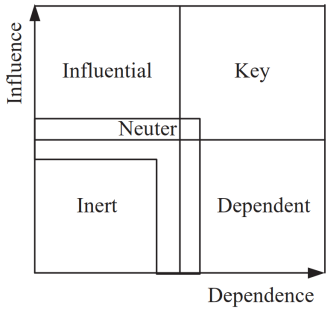
Benefit of participatory modeling

Method

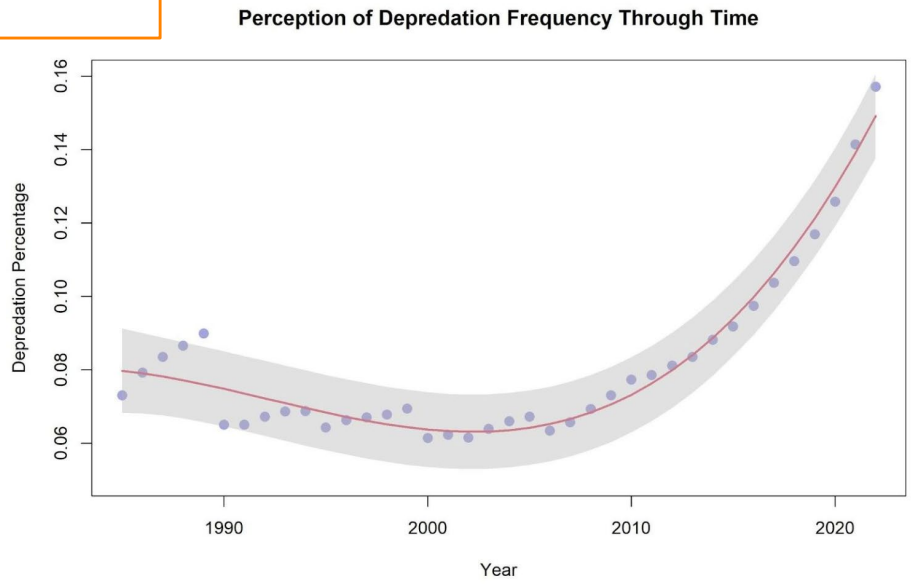
Data collection

Identify driving variables

Social network analysis & node categorization



"Currently, in my industry, my bite-catch discard rate is somewhere around 20%, give or take how deep we're fishing. When the dolphin packs show up – and they're everywhere on every boat multiple times a day – follow you around, take 100% of the fish off your string; you don't even get them to the boat, and if you do get them to the boat and you throw them back they keep them and they follow you around and they surf your wake and it's gotten worse and worse and worse and worse and worse and worse."- FL charter captain



Evan Prasky, Northeastern University

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What can participatory modeling help us do?

[Stock assessment process]

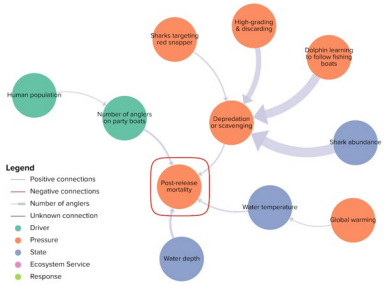
[Benefit of participatory modeling]

[Method]

Data processing

ID factors to consider during data processing

ID in arrows to CPUE & discard mortality



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What can participatory modeling help us do?

[Stock assessment process]

[Benefit of participatory modeling]

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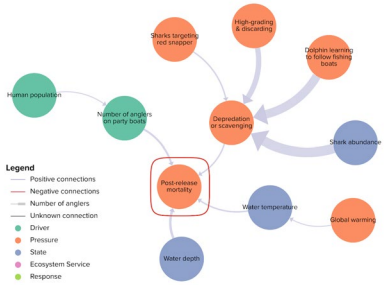

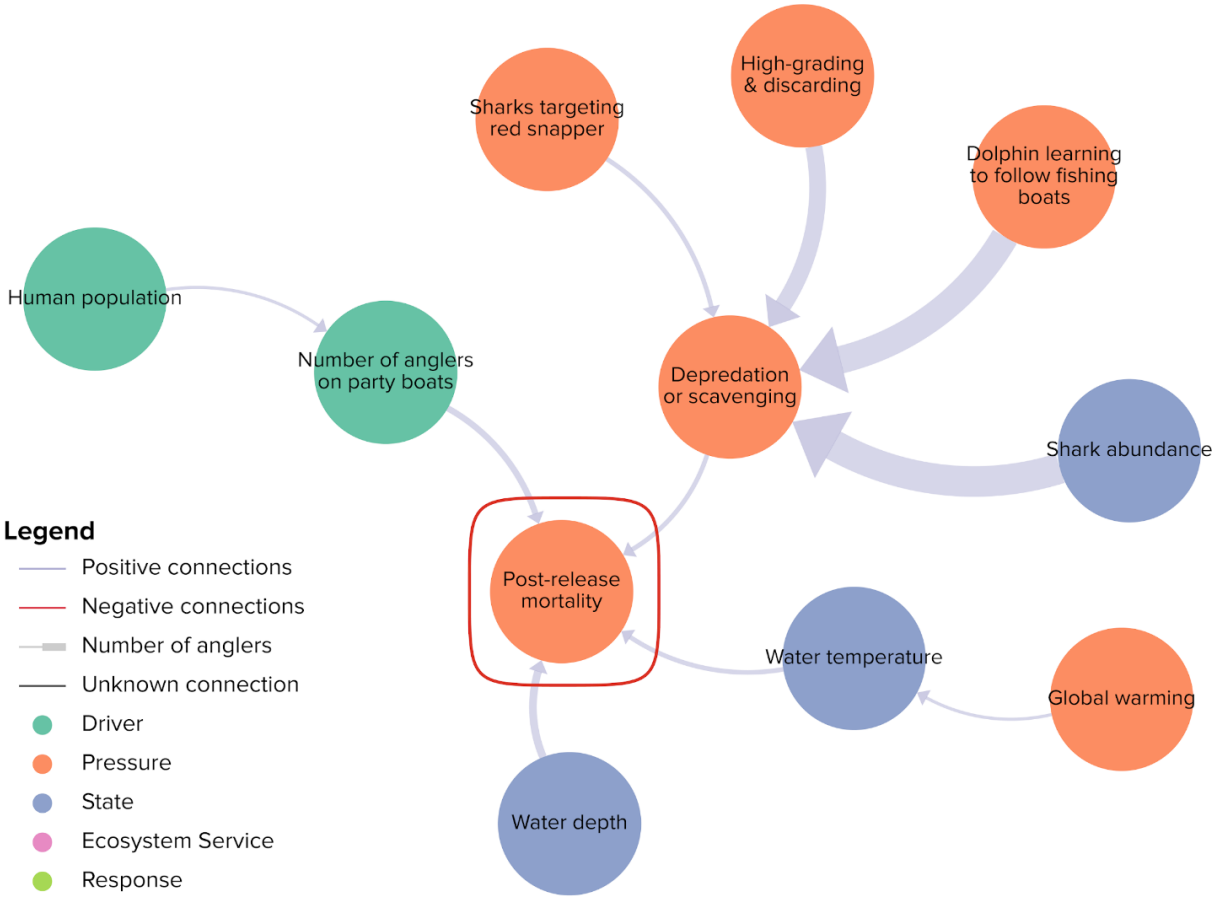

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What can participatory modeling help us do?

Stock assessment process

Benefit of participatory modeling

Method

Stock assessment models

Improve model parameterization

ID nodes related to model parameters

Parameter category	Related nodes in SD model
Fishing mortality	Fishery removals
Stock-recruit deviations	Red snapper recruitment
Stock-recruit relationship	Red snapper recruitment
Recruitment apportionment	Red snapper recruitment
Selectivity	Recreational fishing in deep water offshore, Derby fishery
Retention	High-grading & discarding
Catchability	Red snapper CPUE
Length/age composition weightings	Red snapper size

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What can participatory modeling help us do?

[Stock assessment process](#)

[Benefit of participatory modeling](#)

[Method](#)

Stock assessment models

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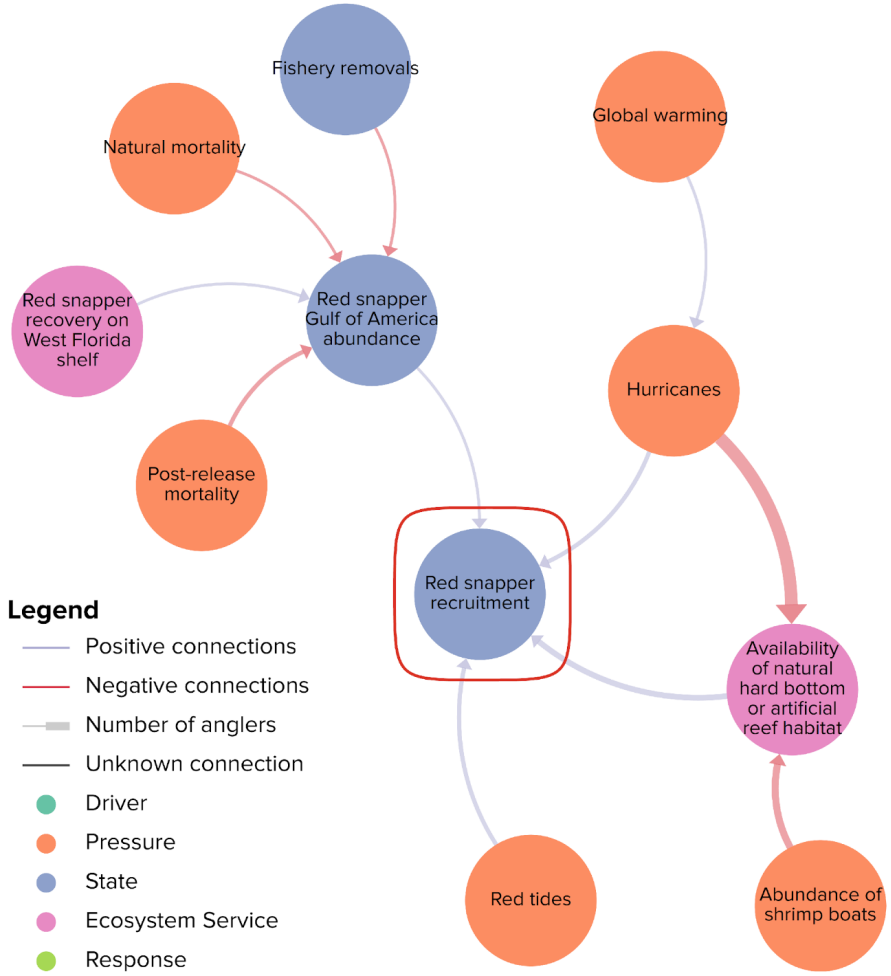

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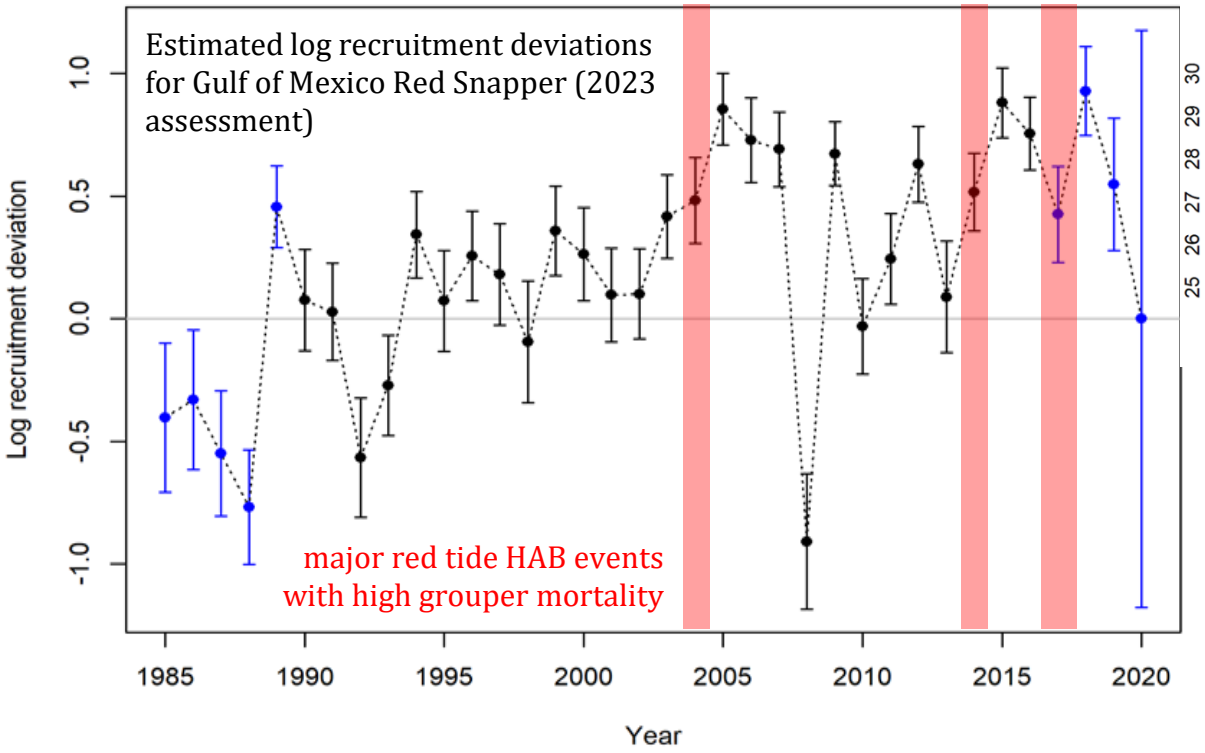
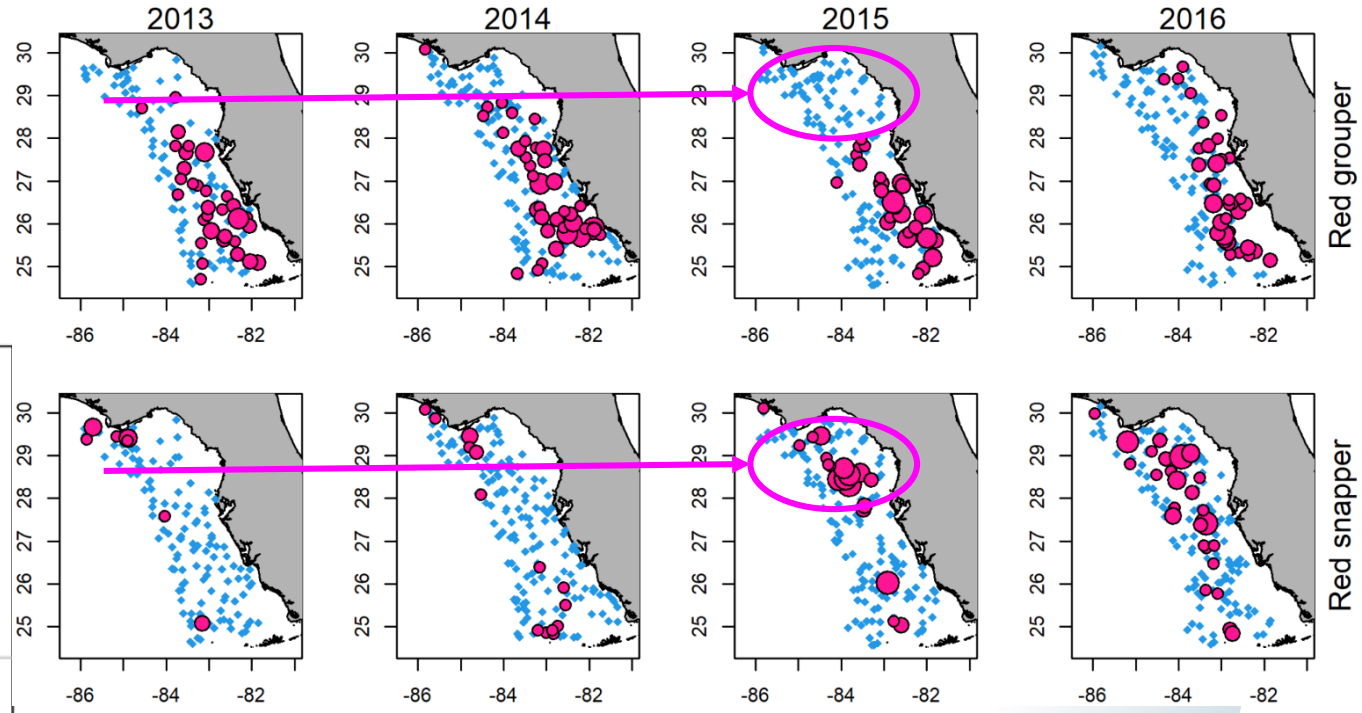
Hypothesis: increased recruitment post-red tides





pink = CPUE
blue = zeros
2014 RT associated with
↓RG and ↑RS in 2015 in FL Big Bend

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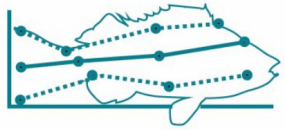
What can participatory modeling help us do?

Stock assessment process

Benefit of participatory modeling

Method

Projections



ID changes to consider when running projections

Examine perceived changes in fishery dynamics

Derived quantity
Recruitment (R)
Growth Curve
Weight-Length Relationship
Fecundity-at-Age (Fec)
Selectivity (S)
Retention (Ret)
Discard Mortality (DM)
Natural Mortality (M)
Directed Fishing Mortality (F_{Dir}) by Fleet
Directed Discard Fishing Mortality (F_{Disc}) by Fleet
Total Directed Fishing Mortality (F_{Tot_Dir}) by Fleet

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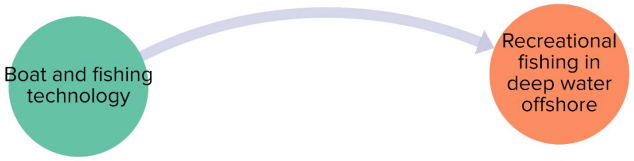
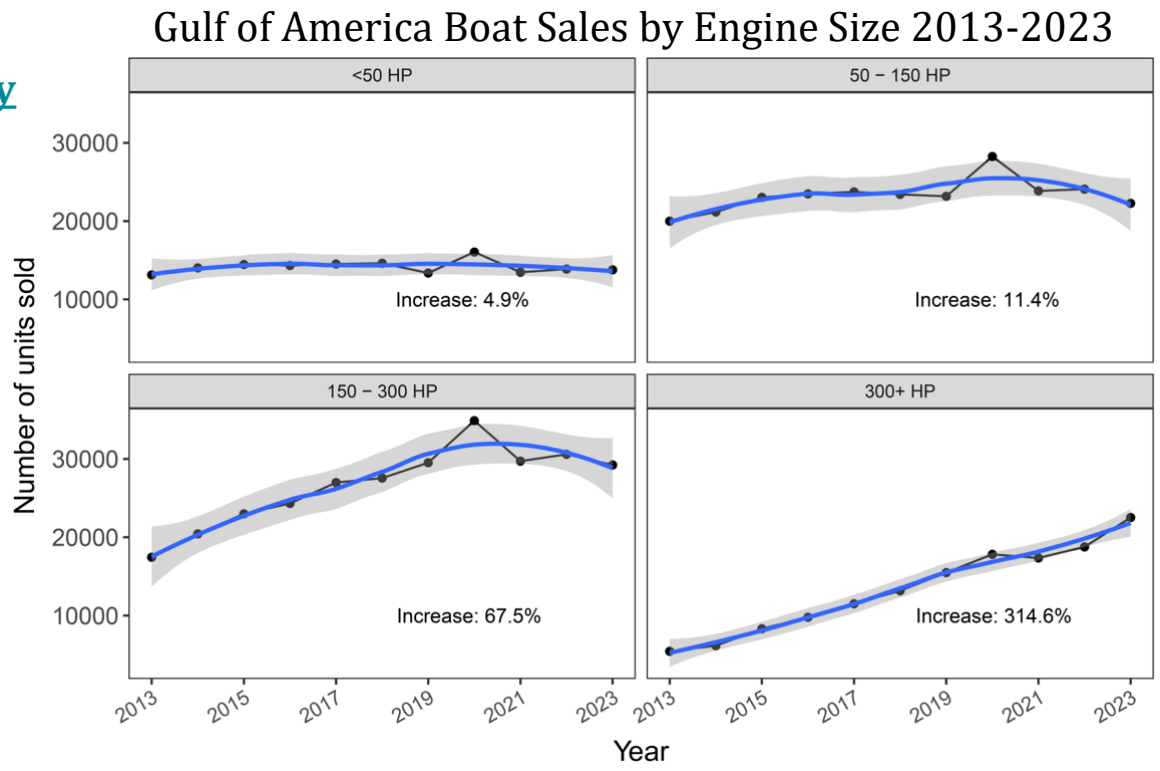
Hypothesis: changing spatial distribution of rec effort

Stock assessment process

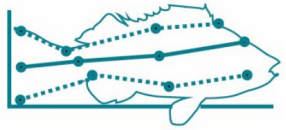


Benefit of participatory modeling



Method

Projections



ID changes to consider when running projections

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Growth Curve
Weight-Length Relationship
Fecundity-at-Age (*Fec*)
Selectivity (*S*)
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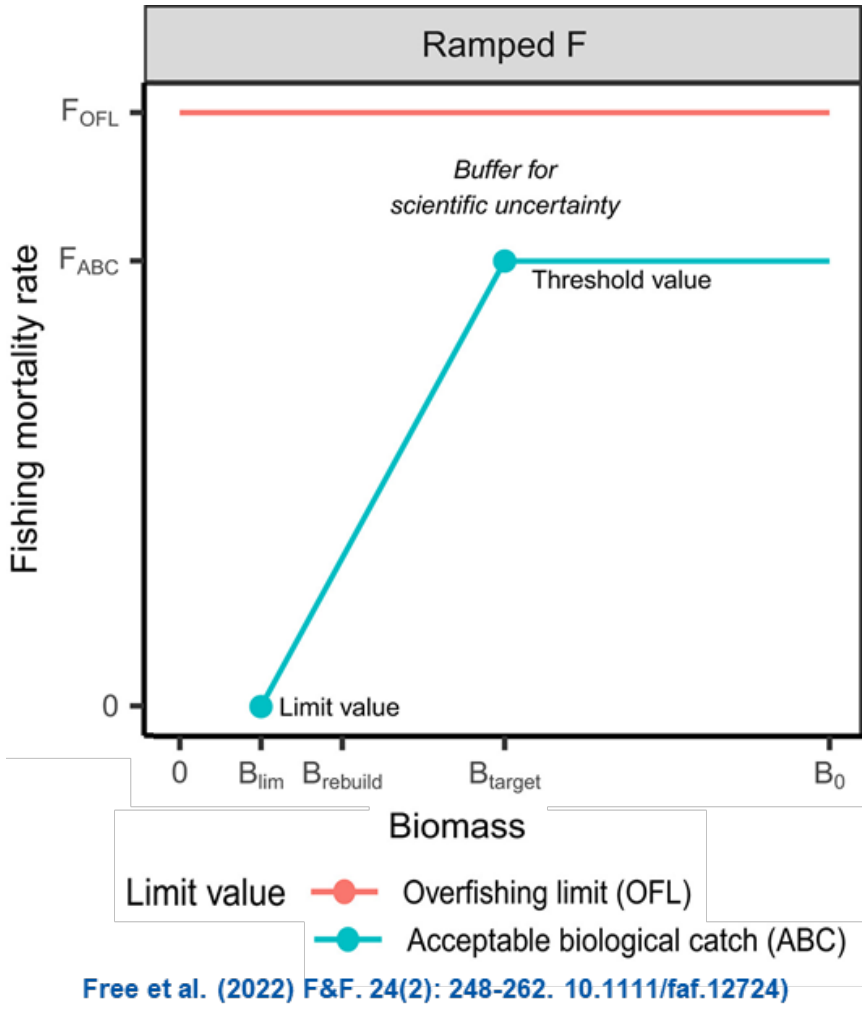
Directed Fishing Mortality (F_{Dir}) by Fleet
Directed Discard Fishing Mortality (F_{Disc}) by Fleet
Total Directed Fishing Mortality (F_{Tot_Dir}) by Fleet
Bycatch/Closed Season Discard Fishing Mortality (F_{Byc}) by Fleet
Total Fishing Mortality (F_{Tot})
Total Mortality (*Z*)
Abundance-at-Age (*N*)
Spawning Stock Biomass (*SSB*)
Retained Catch-at-Age (*C*) by Fleet
Retained Yield (*Y*) by Fleet
Spawning Potential Ratio (SPR)

What can participatory modeling help us do?

[Stock assessment process]

[Benefit of participatory modeling]

[Method]

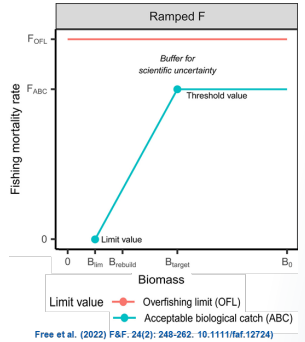


Free et al. (2022) F&F. 24(2): 248-262. 10.1111/faf.12724

Harvest control rules

ID management objectives

Manage for Optimum Yield



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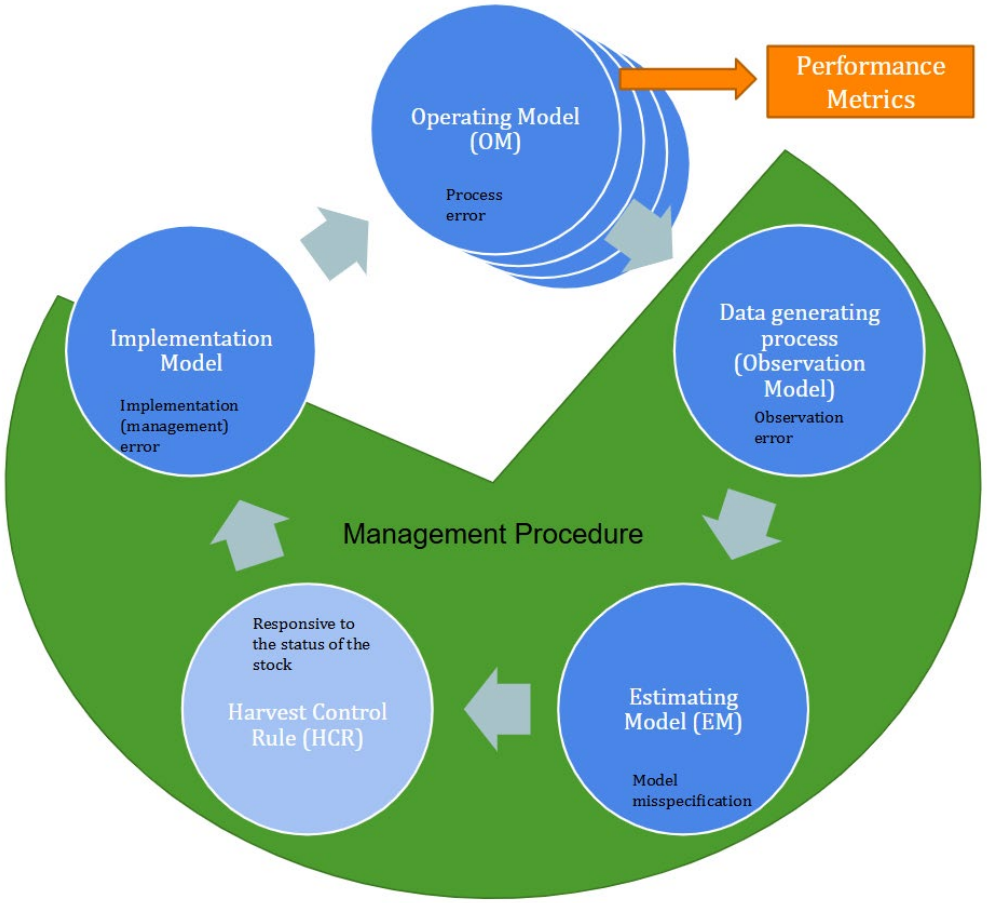
What can participatory modeling help us do?

[Stock assessment process]

[Benefit of participatory modeling]

[Method]

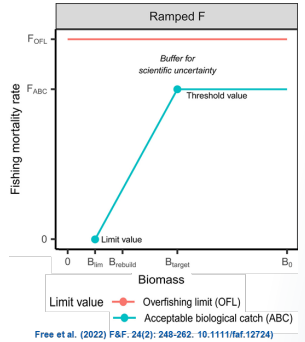
Management Strategy Evaluation



Harvest control rules

ID management objectives

Manage for Optimum Yield



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What can participatory modeling help us do?

Stock assessment process

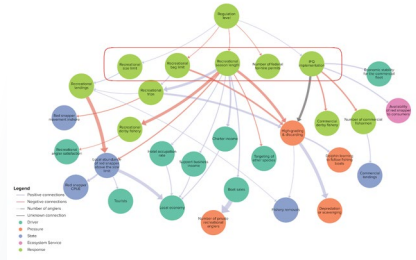
Benefit of participatory modeling

Method

Communication

Examine unintended consequences of management

ID out arrows from management actions



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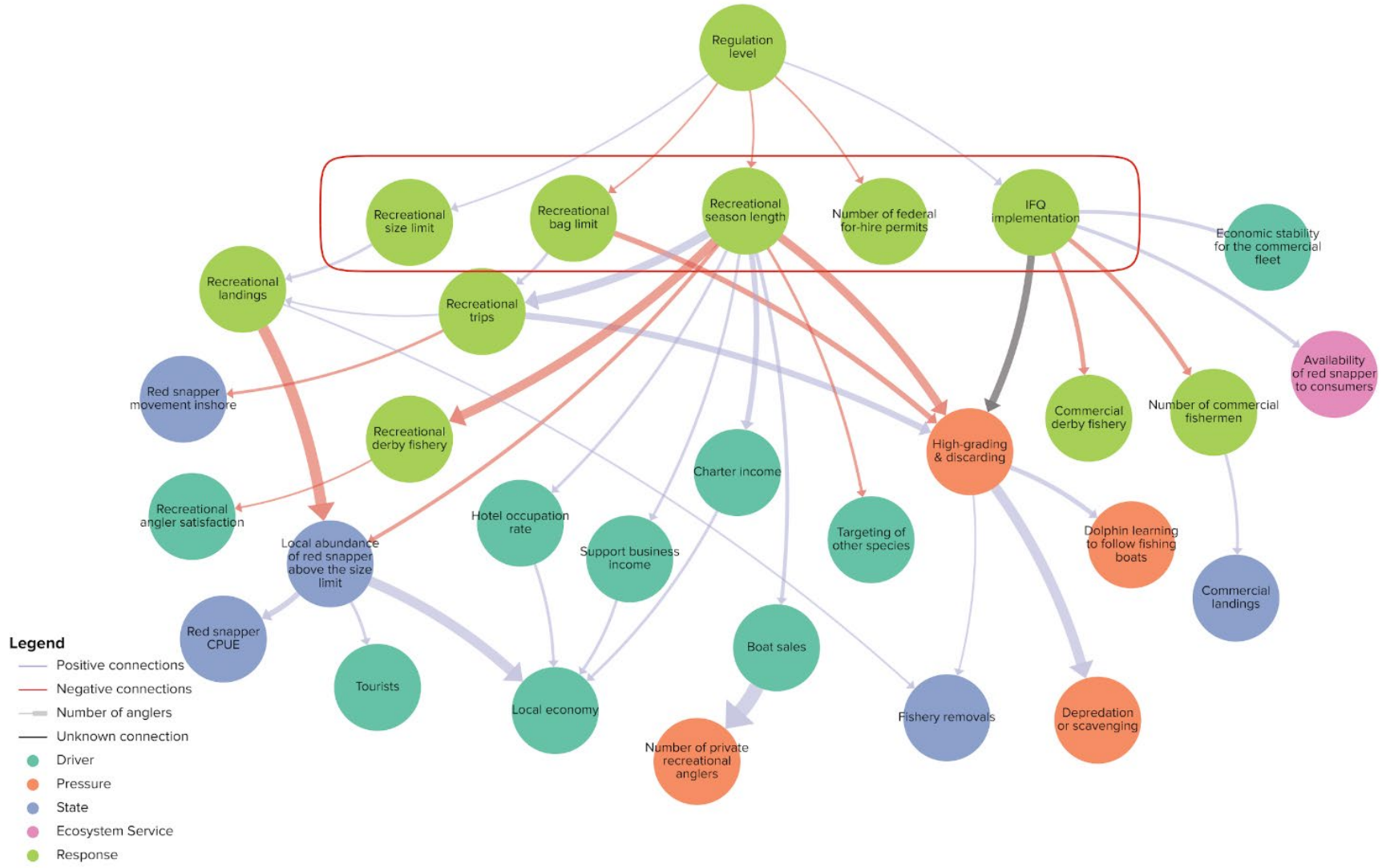
What can participatory modeling help us do?

Stock assessment process

Benefit of participatory modeling

Method



Communication

Examine unintended consequences of management

ID out arrows from management actions

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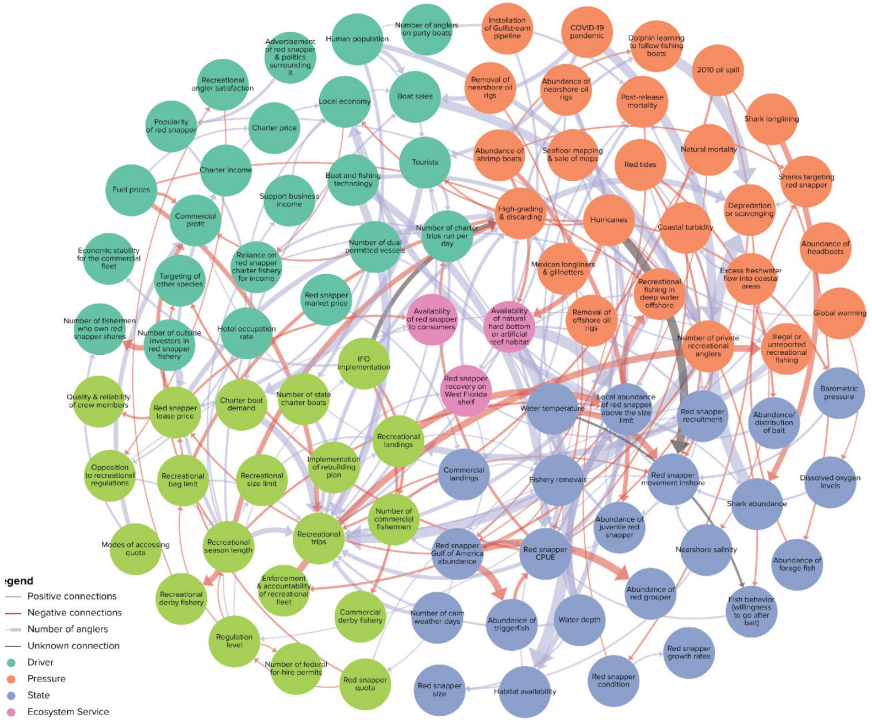
Summary



	Data collection
	Data processing
	Stock assessment models
	Projections
	Harvest control rules
	Communication with managers and stakeholders

System dynamics of red snapper populations in the Gulf of Mexico to support ecosystem considerations in the assessment and management process

Carissa Gervasi, Matthew McPherson, and M. Karnauskas

SEDAR74-DW-16

Using stakeholder knowledge to better understand uncertainty in the Gulf of Mexico red snapper stock assessment model

Carissa L. Gervasi, Matthew McPherson, Mandy Karnauskas, J. Marcus Drymon, Evan Prasky, Hannah Aycock

SEDAR74-RW-01

24 November 2023

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Pause for questions

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Case study 3: Application of participatory modeling to management strategy evaluation

Background - South Atlantic dolphin/wahoo

- SAFMC manages dolphin & wahoo along the entire U.S. Atlantic coast; highly migratory but no international governance
- Different perceptions on the state of the fishery regionally
- Species support very important fisheries but limited data available (no stock assessment)
- Council at a nexus on management decisions
- Recreational allocation is 93% (dolphin); 97.55% (wahoo)

PC: Chris Page

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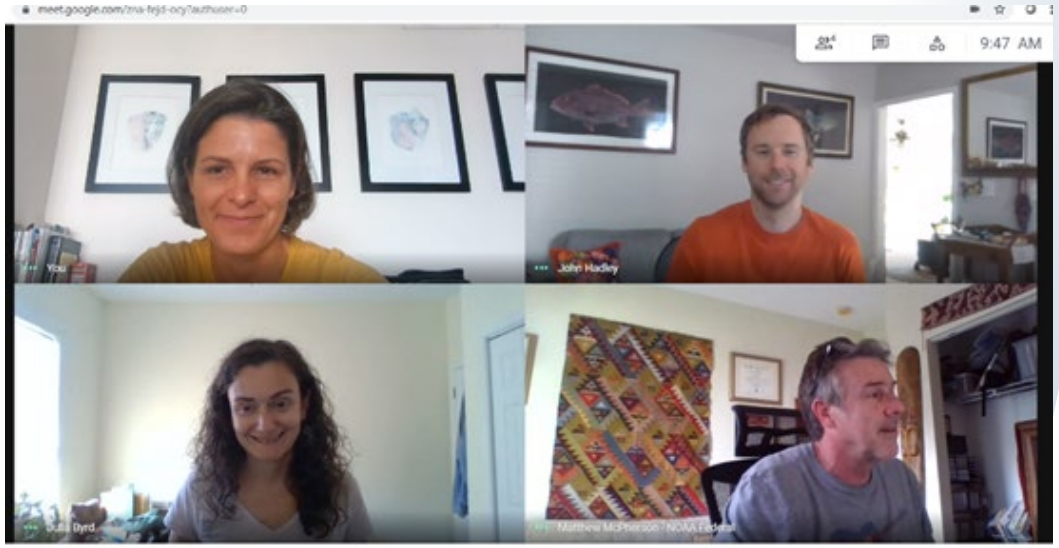
Participatory modeling for dolphin/wahoo



- Project initiated with SAFMC in 2020
- Focus on comparing divergence of perspectives on fishery from North Carolina / Virginia versus Florida
- Three workshops with fishing communities in NC and VA
- Due to COVID, shift to virtual method for Florida

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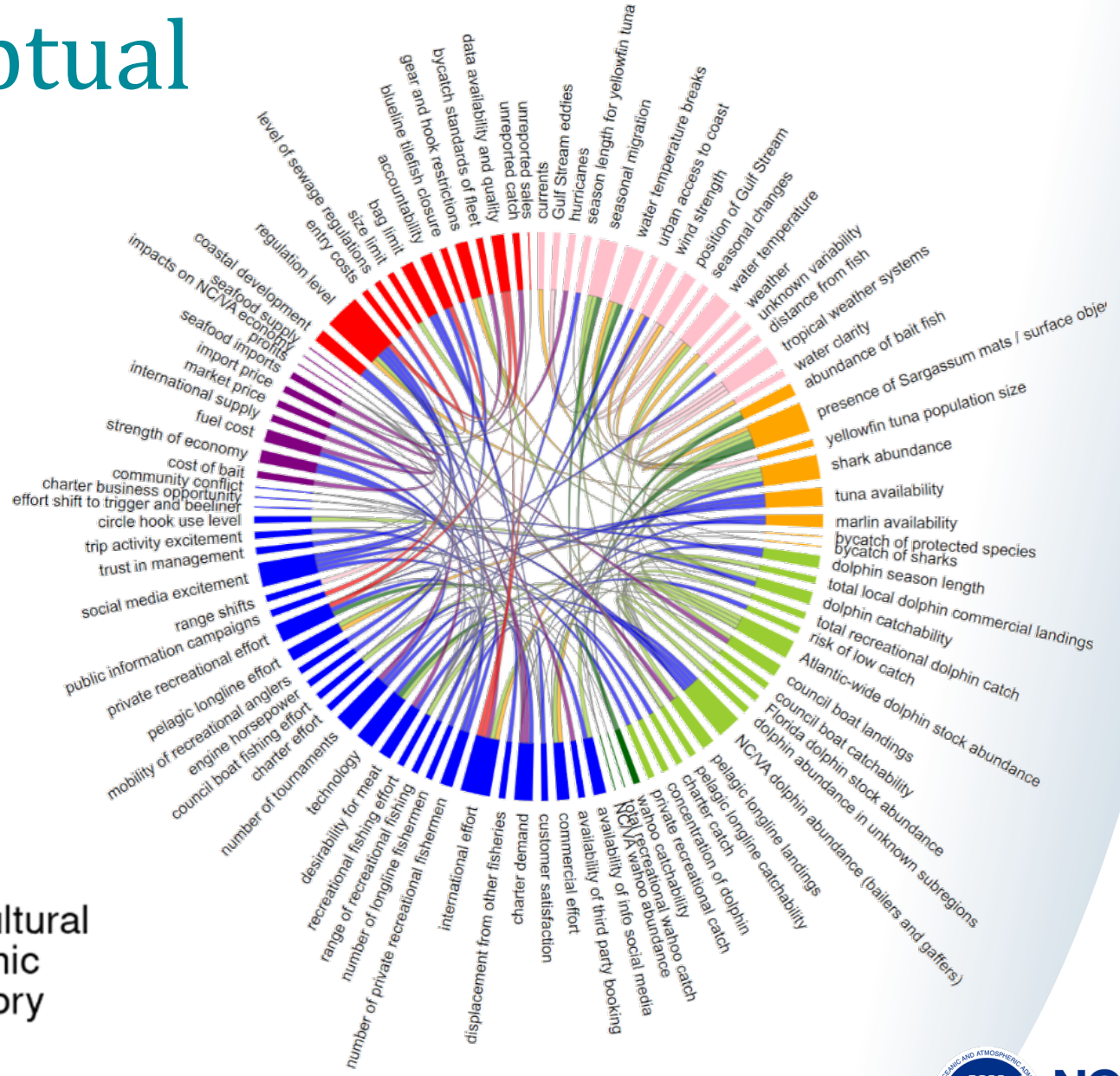
Participatory conceptual models

Nodes with high centrality → major system influencers

End points → stakeholder preferences

Linkages → testable hypotheses



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Main findings for dolphin / wahoo

- Dolphin and wahoo play different roles in the fisheries and were modeled separately; dolphin of primary importance
- Heavy emphasis on social and economic dimensions of the fishery; relatively little knowledge of biological stock drivers
- Factors driving local dolphin abundance are outside of domestic management control
- Considerable variation among the sub-regions with regard to the role of the species, effort shifts, and preferences
- Perceived conflicts at local and regional levels

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Management solution for dolphin?

1 - predict the amount of dolphin the SAFMC will have each year

and

2 - maximize the usage of those fish across sectors and region

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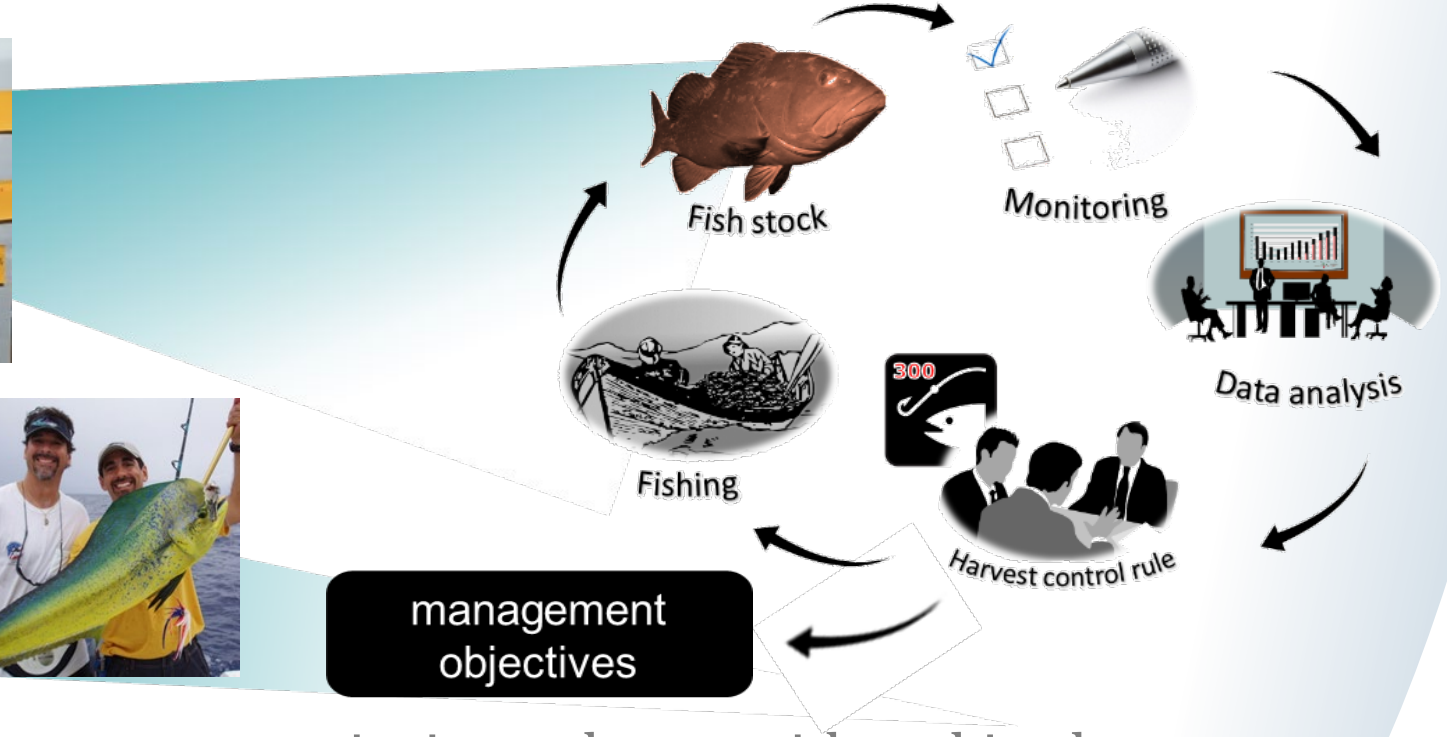
Management Strategy Evaluation

Management strategy evaluation used to test management procedures that will best achieve desired outcomes



Participatory modeling informs uncertainties to be considered in the simulation and the conceptual management objectives

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Discussion

1. Are there ways that the information gathered from participatory modeling provide a useful accompaniment to the catch advice from stock assessments?
2. What other pathways exist for participatory modeling to be integrated in the management process?
3. What other opportunities are there for integrating participatory research in the stock assessment and management process?

Acknowledgements

Thank you to all of the industry and community members who participated in these projects, for their time and insights.

Thank you to the numerous internal and external collaborators who have assisted with the workshops and subsequent outcomes.

MREP and PECASE Awards funded the in-person workshops.

Interactive red snapper model available at: https://gulf-iea.kumu.io/gulf-red-snapper-participatory-model

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