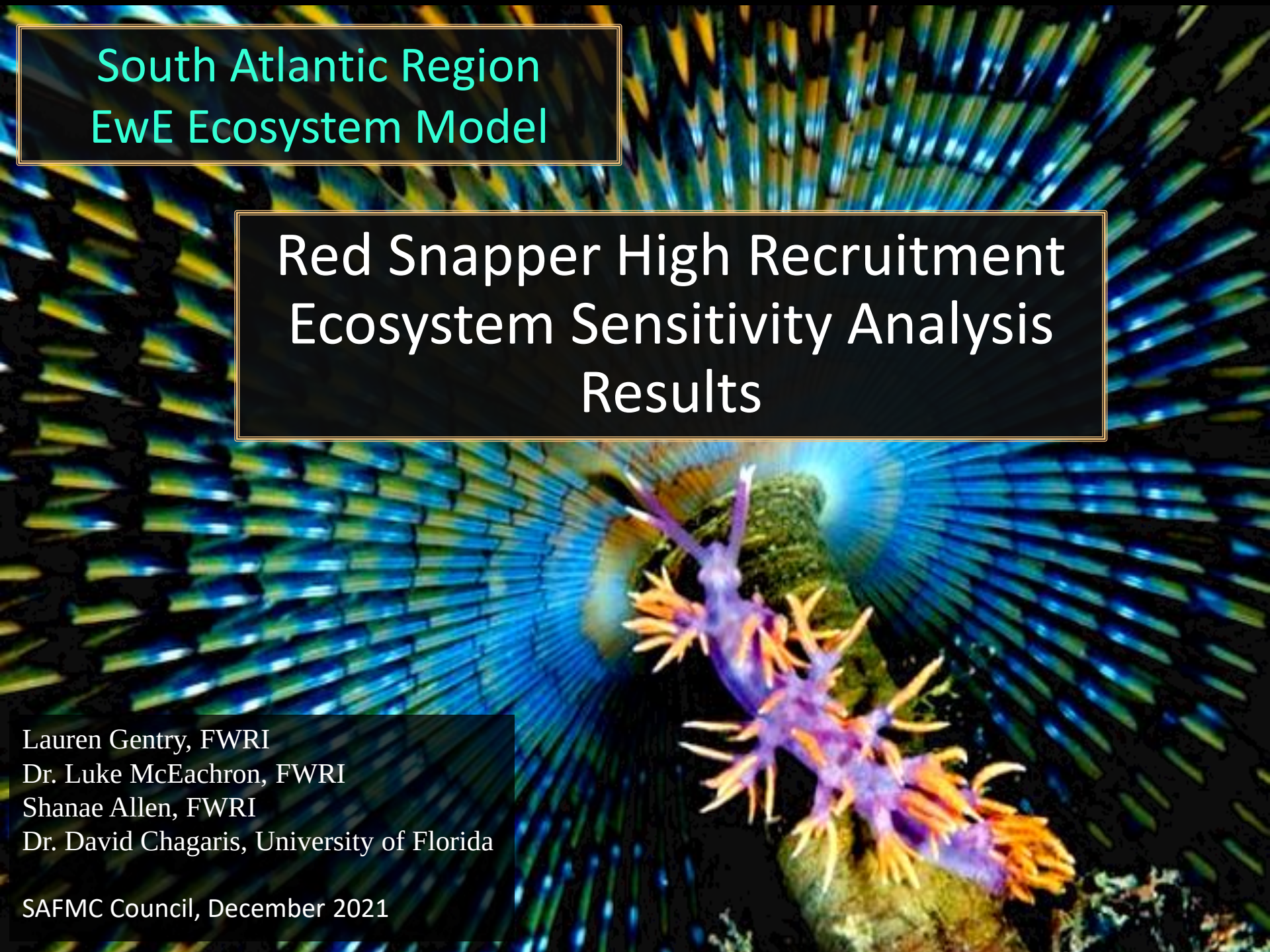
South Atlantic Region
EwE Ecosystem Model

Red Snapper High Recruitment Ecosystem Sensitivity Analysis Results



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SAFMC Council, December 2021

Ecopath with Ecosim

Ecopath: Mass-balanced snapshot of trophic dynamics

- Trophic groups are linked via diet
- Inputs: species, biomass, diets, growth parameters, landings, discards, etc.

Ecosim: Ecopath with time dynamics

- Inputs: time series of primary productivity, catch, fishing mortality, WPUE, biomass, etc.

Many applications, but focus is often scenario testing

- Run multiple scenarios, compare outcomes for winners/losers
- Used in concert with single-species stock assessments
- Not used here for suggesting quotas/harvest/etc.

South Atlantic Region Model

Developed over 20+ years of refinements
140 functional groups
NC to FL Keys
800+ data sources
Calibrated for 1995-2016
Reviewed by SSC Workgroup, SSC, and Habitat AP
Endorsed for use by Council in 2020

Question from Council

What is the impact of recent high recruitment of Red Snapper on the snapper grouper complex?

Modifications

Red Snapper Age Stanzas (Ages 0, 1-3, 4+)
SEDAR 73 landings, discards, biomass projections
Recalibrated out to 2044

Direct/Indirect Impacts – Ecopath only

Prey Overlap

- Uses the fraction each prey contributes to the two predators' diets
- >50% is of interest (listed here)

RS Age 0	RS Age 1-3	RS Age 4+
Red Grouper	Dogfish	Red Grouper
Yellowtail Snapper	Red grouper	Dogfish
Dogfish	Yellowtail Snapper	Black seabass
Golden tilefish	Vermilion Snapper	Other porgies
Mutton Snapper	Snowy Grouper	Yellowtail Snapper
Black seabass	Nassau Grouper	Rays/Skates

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Mixed Trophic Impacts

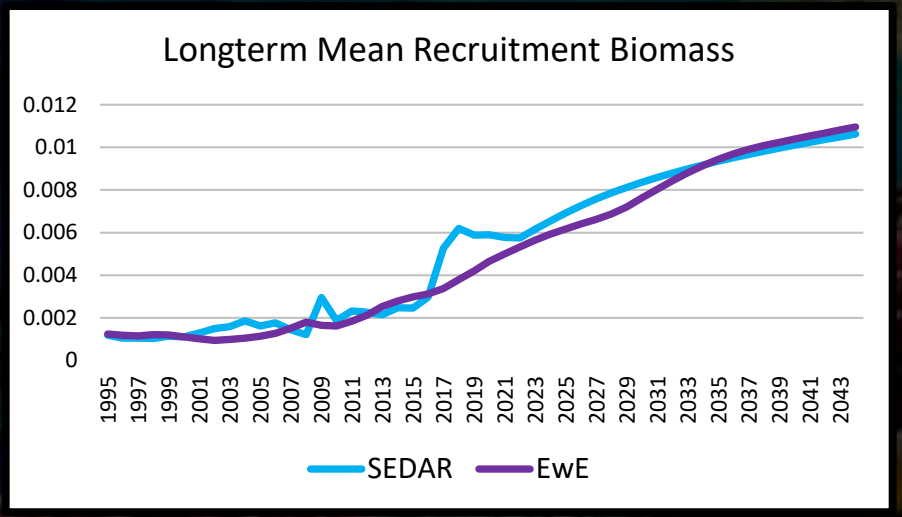
- Combines direct and indirect impacts
- Measures impact of infinitesimal increase of one group's biomass on other groups
- Includes trophic cascades
- Helps find species of interest
  - Impacts weren't very large

Winners	Losers
Golden Crabs	Black seabass
Nassau Grouper	Lionfish
Mutton Snapper	Red porgy
Gray Snapper	Rock/Bank seabass
Goliath Grouper	Other grunts (tomtate)
	Red Grouper
	Gag Grouper
	Scamp Grouper

Scenario Testing

Longterm Mean Recruitment

- Set low F from 2017 to 2044
- Follows SEDAR73 Longterm Mean Recruitment projection



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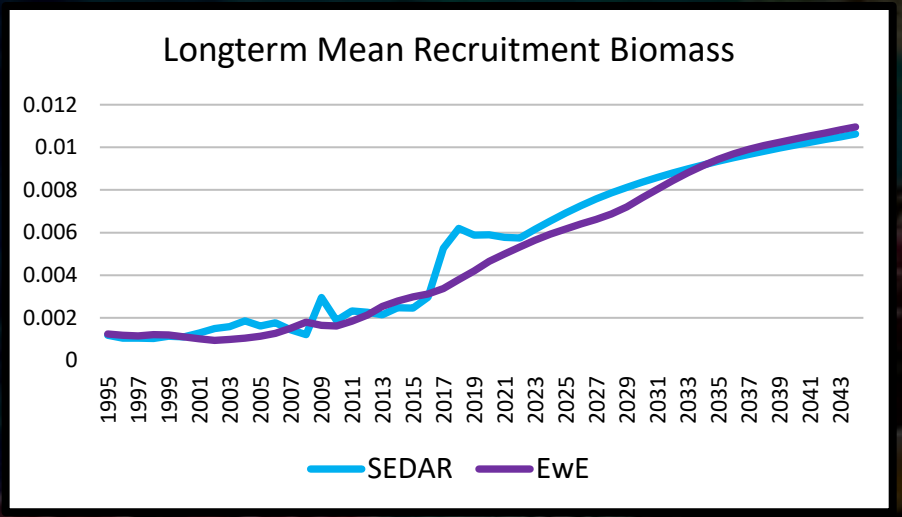

High Recent Recruitment

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AND

- Increased vulnerability of RS Age 0 prey to predation
- Simulates high recruitment of juveniles to older age groups
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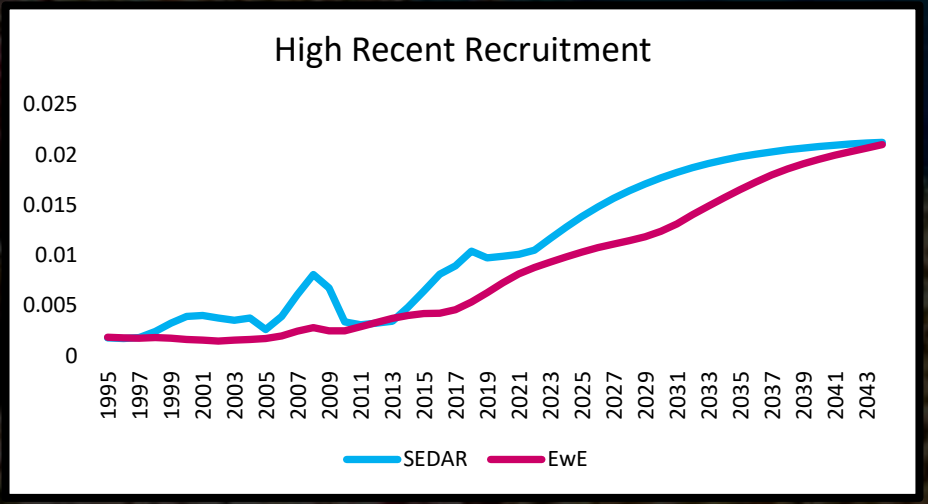

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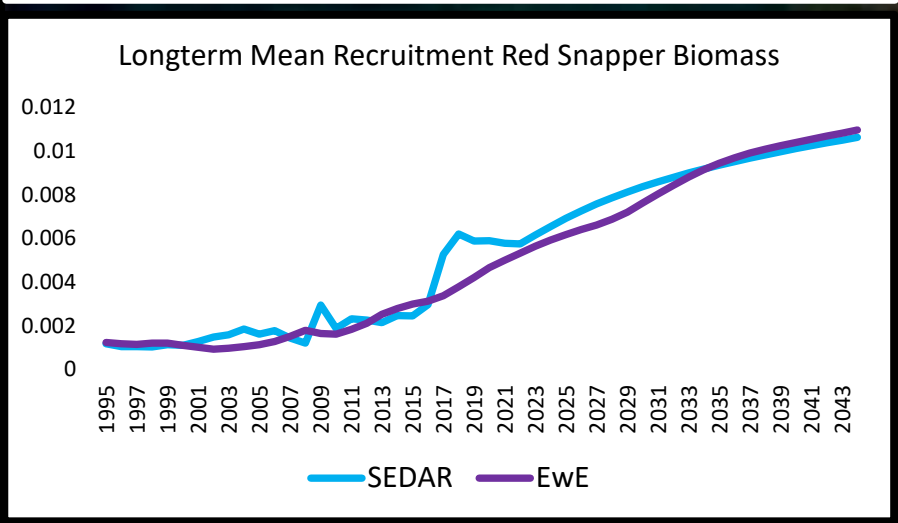

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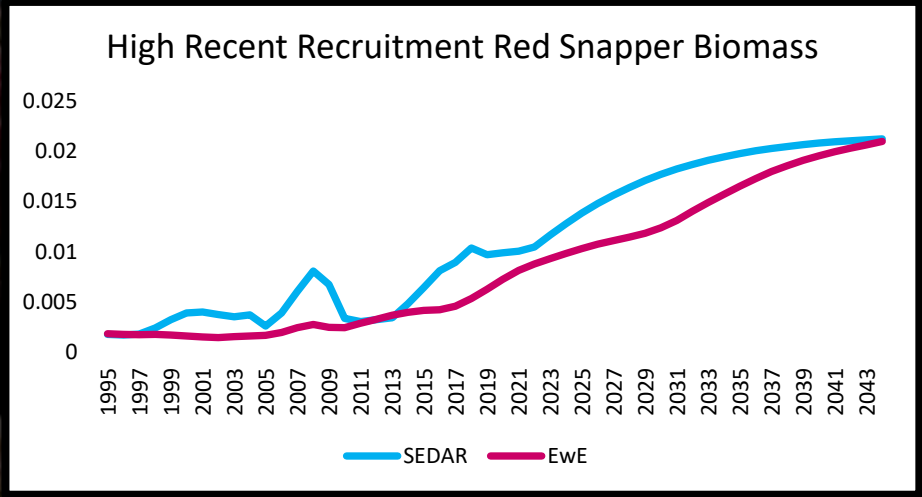
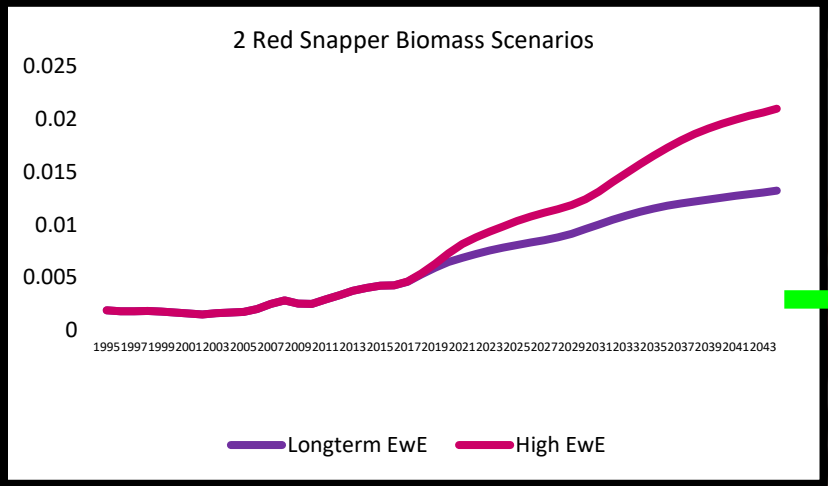
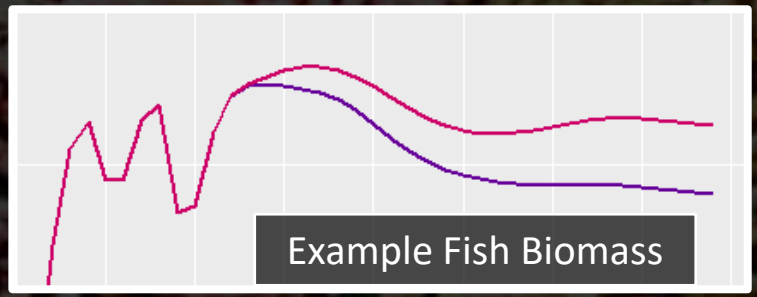
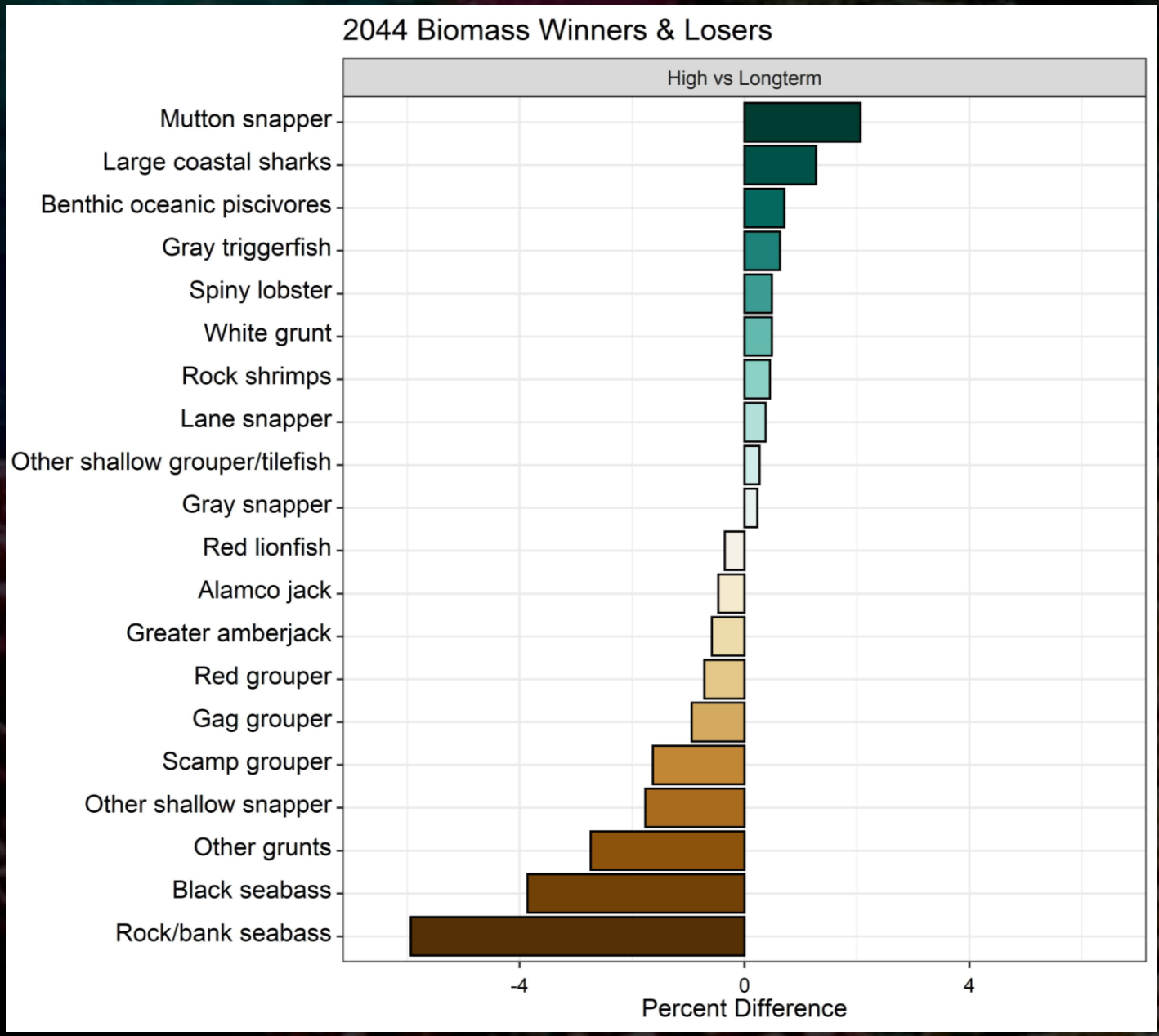






Scenario Testing Results
Winners/Losers under High Recent Red Snapper Recruitment



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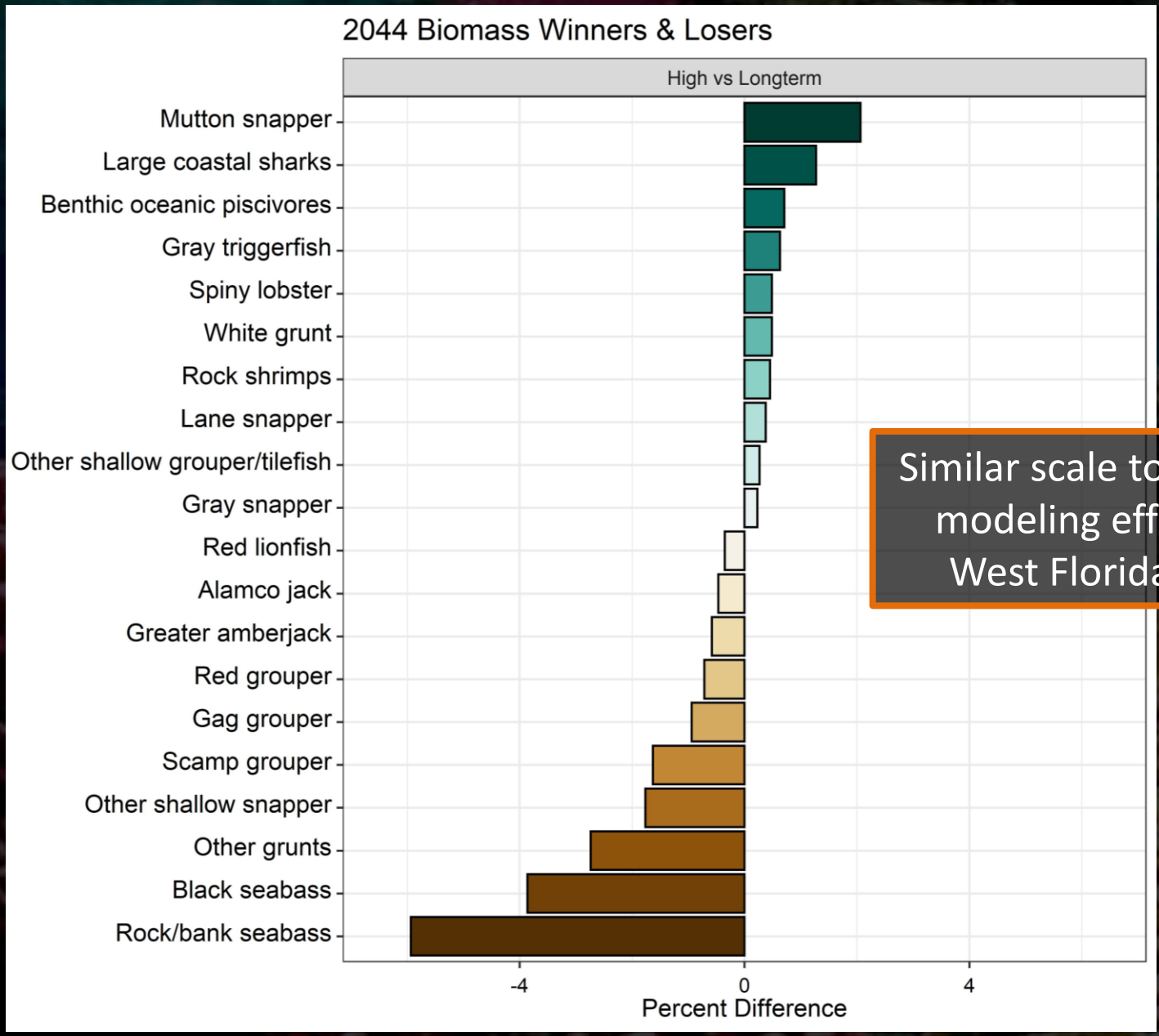


Similar scale to reef fish modeling efforts on West Florida Shelf

Visualizing results across tools

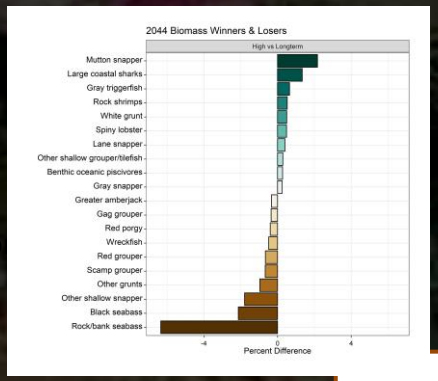
Diets (% wet weight)	Prey Overlap (%)	Mixed Trophic Impacts	Scenario Testing (%Δ B)
Age 4+	Age 4+	Age 4+	High vs Longterm
20 Other grunts	81 Red snapper age 1-3	0.004 Golden crabs	2.06 Mutton snapper
16 Mega-invertebrate predators	62 Red grouper	0.002 Nassau grouper	1.27 Large coastal sharks
10 Herrings	61 Dogfish sharks	0.001 Halfbeaks	0.71 Benthic oceanic piscivores
10 Other zooplankton	55 Benthic coastal invertivores	0.001 Other mid-shelf snapper	0.63 Gray triggerfish
8 Benthic oceanic invertivores	52 Black seabass	0.001 Goliath grouper	0.49 Spiny lobster
7 Small mobile epifauna	52 Other porgys	0.001 Gray snapper	0.49 White grunt
5 Benthic oceanic piscivores	51 Yellowtail snapper	0.001 Lane snapper	0.45 Rock shrimps
3 Stomatopods	50 Demersal rays/skates	0.001 Other shallow snapper	0.38 Lane snapper
3 Scads	50 Red lionfish	-0.003 Red grouper	0.27 Other shallow grouper/tilefish
2 Benthic coastal piscivores		-0.003 Adult king mackerel	0.23 Gray snapper
2 Black seabass		-0.003 Wreckfish	-0.40 Red lionfish
2 Rock shrimps		-0.005 Benthic oceanic piscivores	-0.47 Alamco jack
2 Octopods		-0.007 Scamp grouper	-0.58 Greater amberjack
2 Squids		-0.007 Gag grouper	-0.72 Red grouper
1 Offshore infaunal crustaceans		-0.007 Rock/bank seabass	-0.94 Gag grouper
1 Benthic coastal invertivores		-0.009 Other grunts	-1.63 Scamp grouper
1 Rock/Bank seabass		-0.009 Black seabass	-1.76 Other shallow snapper
1 Penaeid shrimps			-2.74 Other grunts
1 Other porgys			-3.86 Black seabass
1 Echinoderms and gastropods			-5.94 Rock/bank seabass
<1 Pelagic planktivores			
<1 Encrusting fauna			
<1 Other jacks			
<1 Offshore benthic detritus			
<1 Red porgy			

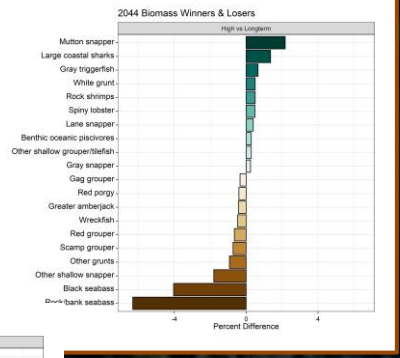
Repeated groups in purple

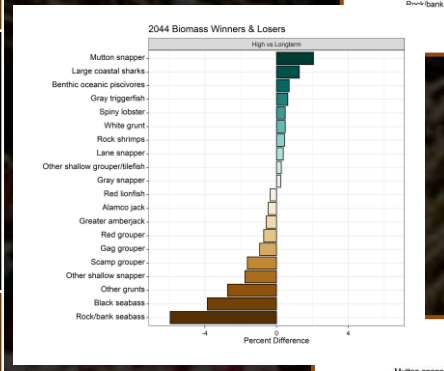
Full table available in report and briefing book

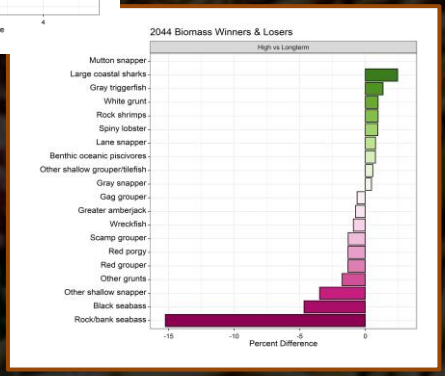
Workshop: Tested Sensitivity of Results

Tested sensitivity to:	Method	Results
High catch level of prey	Increased BSB catch 7x	<1% change in impact of RS on BSB biomass
Red snapper diet composition	Made BSB 25% of red snapper diet	<2% change in impact of RS on BSB biomass
South Atlantic vs. Gulf of Mexico RS diets	Weighted diets SAR:GoM by 80:20	Minor changes to final RS diets
Vulnerabilities of RS prey to predation	Doubled vulnerability of RS's prey	<3% change in impact of RS on BSB biomass









Results: Findings of the model are robust to realistic changes

Workshop Conclusions

1. Model properly addressed the question and demonstrated which species have positive and negative changes in biomass due to high Red Snapper recruitment.

Negative Effects	Minor Negative Effects	Positive effects
Bank Sea Bass	Red Grouper	Mutton Snapper
Black Sea Bass	Gag Grouper	Large Coastal Sharks
Grunts (tomtate)	Scamp	

2. The model provided insights on the impacts of Red Snapper management/recruitment on other species (EBFM)

3. These findings can be used to direct data collection needs and inform better monitoring of species with high management interest and negative impacts when Red Snapper is increasing, such as Black Sea Bass.

4. Exploration in the model of direct vs. indirect impacts can help figure out what might be the driving factor for impacts (e.g., competition vs. predation) or even ways to improve populations (e.g., habitat restoration).

Take-away Points

Red Snapper are not likely to cause >5% decline in other species/groups

- Red snapper is a generalist predator, switches prey according to availability, and has a diverse diet of fish, crustaceans, plankton, and other inverts.

Keep an eye on Black Sea Bass and Red Porgy as Red Snapper recover

- If recruitment were to increase further or if we've underestimated recruitment, impacts could be larger for groups already in peril.

Questions?

Model Team

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Appendix

142 groups (part 1)

MAMMALS

Coastal bottlenose dolphin

Offshore dolphins

Pilot whales

Beaked whales

Sperm whales

Baleen whales

Manatees

ELASMOBRANCHS

Planktivorous sharks

Large coastal sharks

Small coastal sharks

Dogfish sharks

Pelagic sharks

Pelagic rays

Demersal rays/skates

TAXONOMIC GROUPS

Mullets

Other sciaenids

Sardines

Anchovies

Silversides

Halfbeaks

Scads

Shad

Sygnathids

Other shallow grouper/tilefish

Other deep grouper

Other shallow snapper

Other mid-shelf snapper

Other jacks

Other porgys

Other grunts

Herrings

TROPHIC GROUPS

Highly migratory pelagics

Pelagic oceanic piscivores

Pelagic coastal piscivores

Demersal coastal piscivores

Pelagic planktivores

Demersal coastal invertivores

Demersal coastal omnivores

Benthic oceanic piscivores

Benthic oceanic invertivores

Benthic coastal piscivores

Benthic coastal invertivores

Benthic coastal planktivores

AVES

Birds -- oceanic piscivores

Birds -- shorebirds

Birds -- shelf piscivores

Birds -- herbivores

Birds -- wading piscivores

Birds -- shelf invertivores

Birds -- raptors

REPTILES

Sea turtles

PHOTOSYNTHETICS

Phytoplankton

Microphytobenthos

Benthic macroalgae

Pelagic macroalgae

Seagrasses

Marsh vegetation

142 groups (part 2)

SINGLE SPECIES GROUPS	SINGLES SPECIES CONT.	SINGLE SPECIES CONT.	INVERTS	INVERTS CONT.
Adult king mackerel	Permit	Auxis mackerels	Carnivorous jellies	Bivalves/Oysters
Juvenile king mackerel	Atlantic spadefish	Blueline tilefish	Encrusting fauna	Offshore infaunal crustaceans
Spanish mackerel	Red Lionfish	Golden tilefish	Squids	Offshore polychaetes
Juv Spanish mackerel	Summer flounder	Yellowtail snapper	Stomatopods	Small mobile epifauna
Bluefish	Southern flounder	Mutton snapper	Octopods	Calico scallops
Weakfish	Gulf flounder	Gray snapper	Blue crabs	Benthic meiofauna
Red drum	Hogfish	Lane snapper	Horseshoe crabs	Deep-burrowing infauna
Atlantic menhaden	Ocean triggerfish	Red snapper Age 0	Golden crabs	Carnivorous zooplankton
Spotted seatrout	Gray triggerfish	Red snapper Age 1-3	Spiny lobster	Other zooplankton
Striped bass	Gag grouper	Red snapper Age 4+	Rock shrimps	Ichthyoplankton
Dolphinfish	Red grouper	Greater amberjack	Penaeid shrimps	Microbial heterotrophs
Snook	Scamp grouper	Almaco jack	Megafaunal predators	**DEAD**
Tarpon	Goliath grouper	Bar jack	Echinoderms and gastropods	Estuarine benthic detritus
Cobia	Nassau grouper	Queen triggerfish	Estuarine infaunal crustaceans	Offshore benthic detritus
Bonefish	Snowy grouper	Blue runner	Estuarine polychaetes	Water-column detritus
Sunfish	Black seabass	Red porgy		Dead carcasses
Wreckfish	Rock/Bank seabass	White grunt		
Great barracuda	Atlantic mackerel	Vermillion snapper		