South Atlantic Region
EwE Ecosystem Model

Red Snapper High Recruitment Ecosystem Sensitivity Analysis Results

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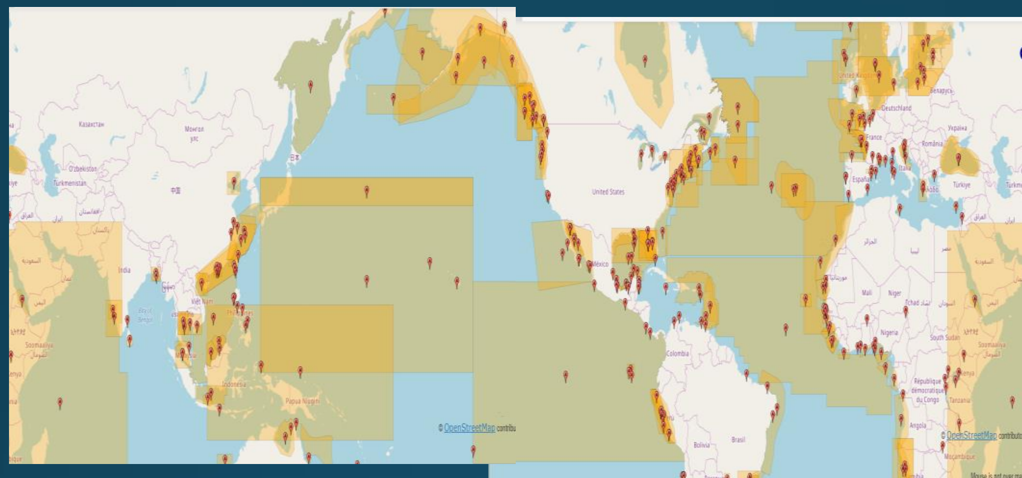
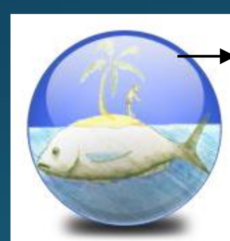
Model Background	Results	Workshop Conclusions
EwE/Model Intro Red snapper inputs Specific modifications	Ecopath insights Ecosim results Workshop scenarios	Overall Conclusions Improvements Future

Ecopath with Ecosim and Ecospace (EwE)

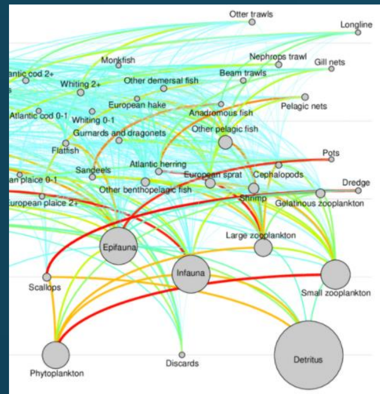




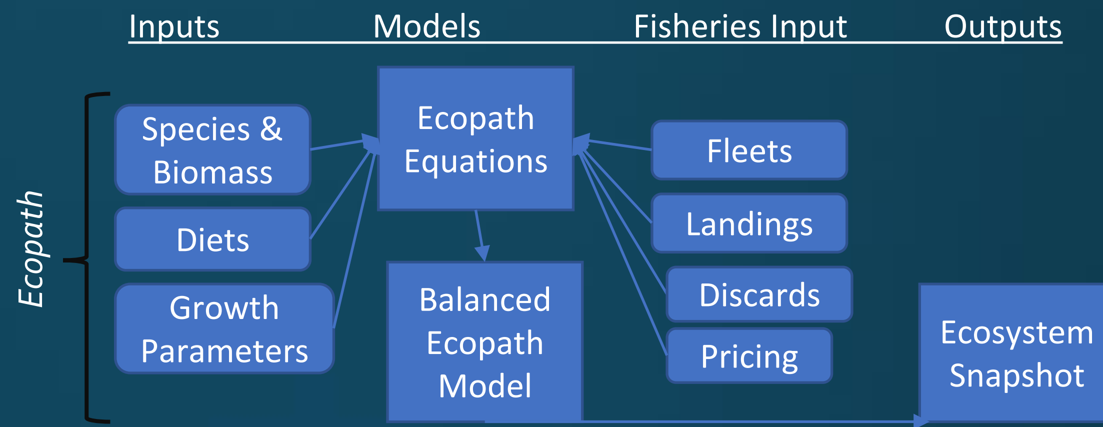
Ecopath
Mass-balance
Snapshot

Ecosim
Time
Dynamics

Ecospace
Space-Time
Dynamics



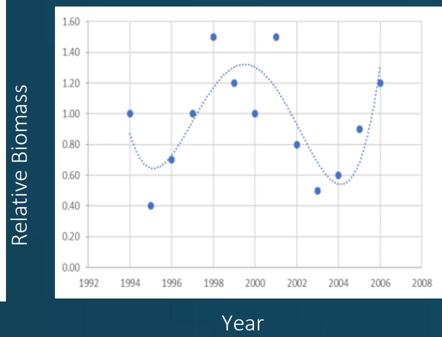
Bentley et al. 2019

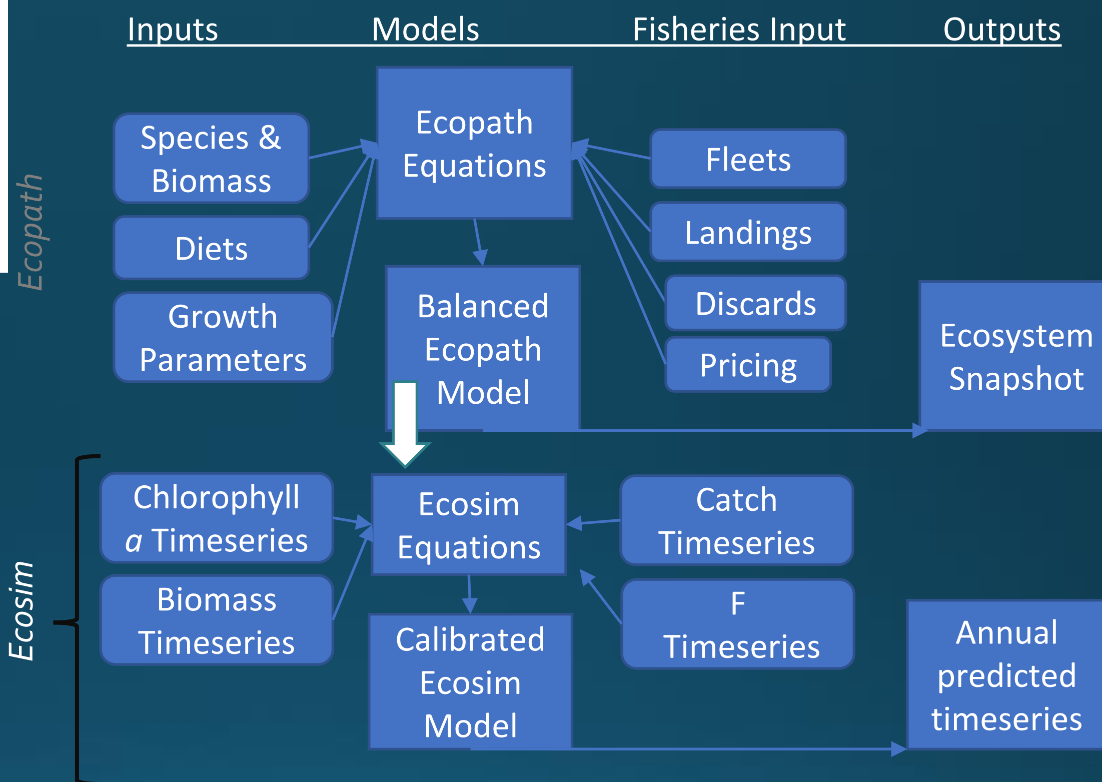


- Ecopath
  - Mass-Balance Snapshot
    - Prey mortality is predator consumption
    - Groups are linked via diet
  - Key groups, system size, flows
  - Best Practices (Link et al. 2010)
    - E.g., most biomass should be found at lower trophic levels
  - Builds the foundation for Ecosim and Ecospace

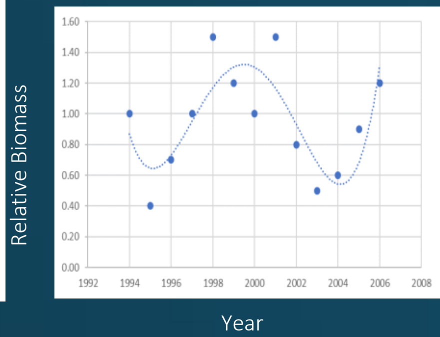
Table 1. Ecological and fisheries related indicators used in this comparison.

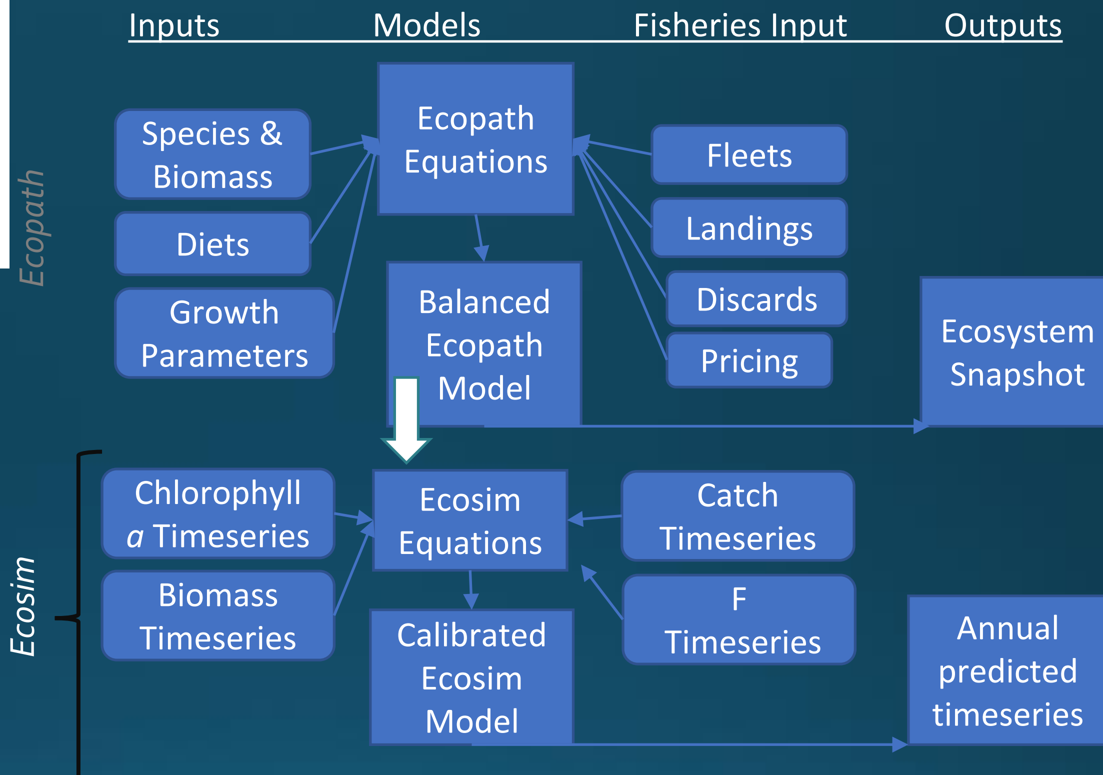
Acronym	Indicators	Units	Definition
Ecological indicators			
TST	Total System Throughput	$t \cdot km^{-2} \cdot y^{-1}$	The sum of all the flows through the ecosystem
PP/TST	Primary production/TST		Primary production over the sum of all the flows through the ecosystem
FD/TST	Flows to Detritus/TST		Flows to detritus over the sum of all the flows through the ecosystem
Q/TST	Total consumption/TST		Total consumption over the sum of all the flows through the ecosystem
R/TST	Total respiration/TST		Total respiration over the sum of all the flows through the ecosystem
Ex/TST	Total exports/TST		Total exports of the system over the sum of all the flows through the ecosystem
PP/P	PP/Total Production		Primary production over total production
MeanPz (MaxPz)	Mean (Max) proportion of total mortality due to predation		The mean (or Maximum) proportion of each group's total mortality that was accounted for by each predator
meanEE	Mean Ecotrophic Efficiency	%	Ecotrophic efficiency of a group is that proportion of the production that is utilized in the system.





- Ecopath
- Ecosim
    - Estimate time dynamics
    - Predator-prey interactions are not random and occur in ‘arenas’
    - Only a fraction of prey is available for consumption (i.e., vulnerable)





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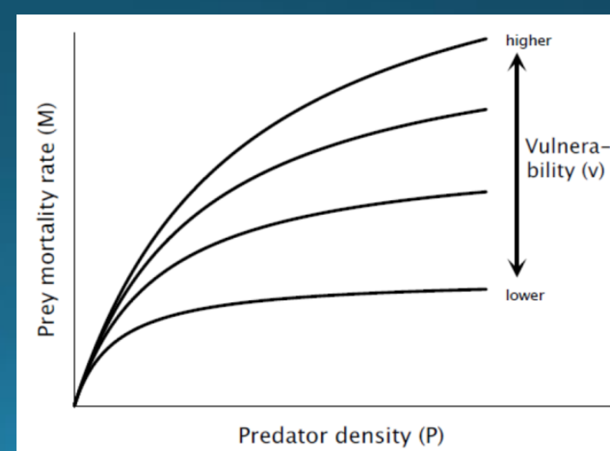


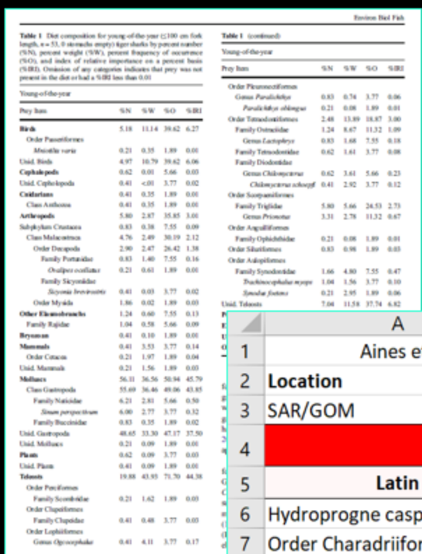
Ecopath Input Sources

Age Groups: Red Snapper Age 0 Red Snapper Age 1-3 Red Snapper Age 4+	Corresponded to ontogenetic shifts in habitat, diet, fecundity, and fishing mortality from SEDAR 73. TL (mm): <250 , 250-550 , >550 Weight (lbs): 0-1, 1-6, 6+
Biomass	SEDAR 73 1995
Total Mortality	• Estimated growth across monthly ages • Applied Lorenzen estimator scaled to $M_{target} = 0.13$ • Used mid-year M plus F for Z
Consumption rate	Fishbase

Diets

Primarily from SEAMAP, NOAA, and published literature

*Also found single predation events in BBC videos, Okeanos livestreams, photo catalogues, etc.



Published stomach contents - %W

	A	B	C	D
1	Aines et al 2017 "Feeding habits of the tiger shark, Galeocerdo cuvier, in the northwest A			
2	**Location**	**Sample size**	**Units**	**Factors**
3	SAR/GOM	169	% weight	Most were adults
4	**Original Data**			**Changes and Calculations**
5	**Latin**	**% W**	**Proportion**	**New Functional Group Decision**
6	Hydroprogne caspia	2.07	0.0207	**Shelf piscivores**
7	Order Charadriiformes	0.29	0.0029	**Shorebirds**
8	Teuthida	0.02	0.0002	**Squids**
9	Anthozoa	0.25	0.0025	**Encrusting fauna**
10	Ovalipes stephensoni	0.13	0.0013	
11	Sicyonia brevirostris	0.47	0.0047	
12	Stomatopods	0.16	0.0016	
13	Callinectes sapidus	0.4	0.004	

Example of final diet list

Functional Groups	Proportion of Diet
Highly migratory pelagics	0.144299
Sea turtles	0.1217
Demersal coastal omnivores	0.1072
Other deep grouper	0.0917
Echinoderms and gastropods	0.0626
Small coastal sharks	0.056
Pelagic oceanic piscivores	0.0516
Demersal coastal invertivores	0.045801
Offshore dolphins	0.0442
Birds - Wading piscivores	0.0418
Pelagic coastal piscivores	0.0417
Birds - Shelf piscivores	0.0228
Benthic coastal invertivores	0.0209
Benthic coastal piscivores	0.0199
Red snapper	0.0183
Auxis mackerels	0.0129
Pelagic rays	0.0115
Bluefish	0.0113
Birds - Shorebirds	0.0075
Other sciaenids	0.0069
Birds - Shelf invertivores	0.0067
Pelagic planktivores	0.0066
Encrusting fauna	0.0062
Rock shrimps	0.0047
Ocean triggerfish	0.00425
Gray triggerfish	0.00425
Blue crabs	0.004
Demersal rays/skates	0.002
Benthic oceanic invertivores	0.002
Bivalves/oysters	0.0018
Stomatopods	0.0016
Mega-invertebrate predators	0.0013
Marsh vegetation	0.0011

*Multiple species in a group are averaged together in the final matrix

Metadata Scoring

			Score (0-6)					
Group #	**Group Name**	**Individual species**	**Sample size**	**Year**	**Location**	**Diet richness**	**Detail**	**Ecological role?**
62	Red grouper	red grouper	1	5	6	1	4	Ecosystem engineer

Red Snapper Diets

Source	N (stomachs with food)	Location	Age Group
SEAMAP	219	SAR	Age 1-3, Age 4+
FWRI-FIM Gut Lab	244	SAR/GOM	Age 0
FWRI-FIM Gut Lab	171	SAR/GOM	Age 1-3, 4+
Szedlmayer and Lee 2004	789*	GOM	Age 0
Szedlmayer and Lee 2004	789*	GOM	Age 1-3
Tarnecki and Patterson 2015	343	GOM	Age 1-3, 4+

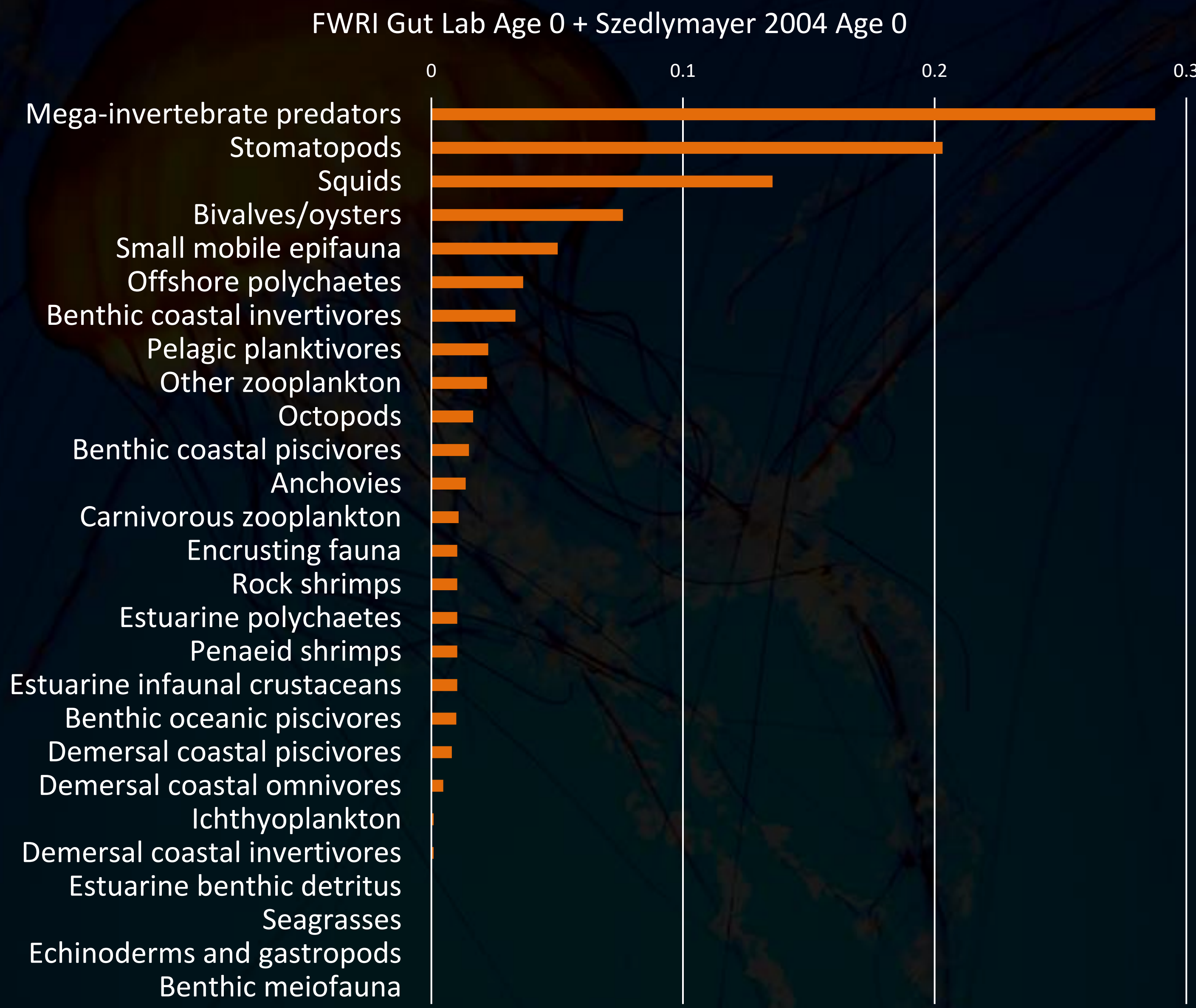
<u>Cross-referenced</u>

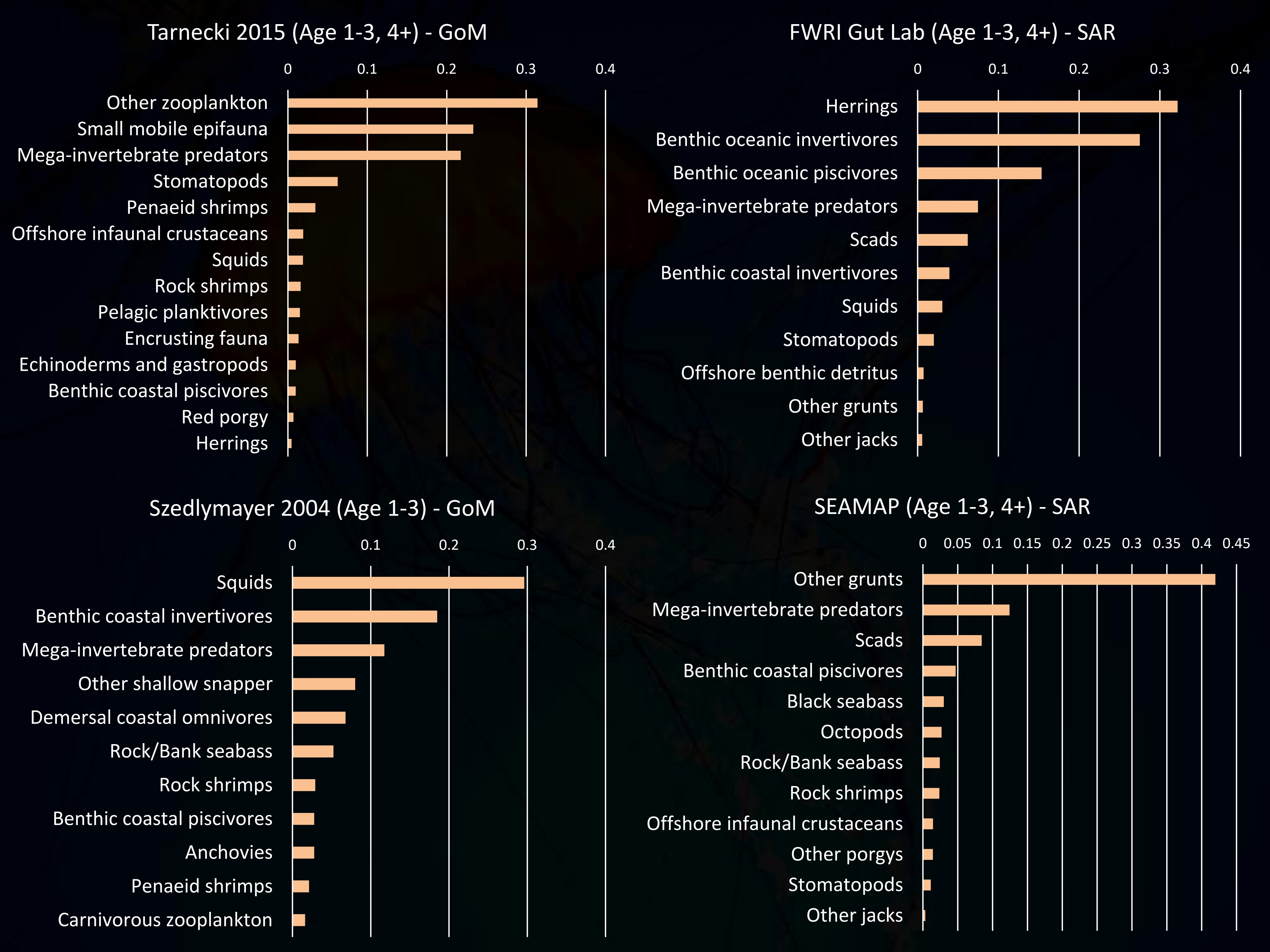
- Spanik, K. et al (2021) “Using DNA barcoding to improve taxonomic resolution of the diet of red snapper (Lutjanus campechanus) along the Atlantic coast of the southeastern United States” Fish. Bull. 119: 123-134
- Spanik, K. (2018) “Improving Diet Resolution for Reef-Associated Large Piscivorous Predators in the U.S. Southeast Atlantic Using Molecular Tools” Dissertation – College of Charleston
- McCawley, J. R., J. H. Cowan Jr. and R. L. Shipp (2006) “Feeding Periodicity and Prey Habitat Preference of Red Snapper, *Lutjanus campechanus* (Poey, 1860) on Alabama Artificial Reefs” Gulf of Mexico Science 24 (1).
- Wells, R.J.D., Cowan J.H., Jr , Fry, B. (2008) “Feeding ecology of red snapper *Lutjanus campechanus* in the northern Gulf of Mexico” Mar Ecol Prog Ser 361:213-225
- Ouzts, A.C. and S. Szedlmayer (2003) ”Diel Feeding Patterns of Red Snapper on Artificial Reefs in the North-Central Gulf of Mexico” Transactions of the American Fisheries Society, 132:6, 1186-1193
- Others

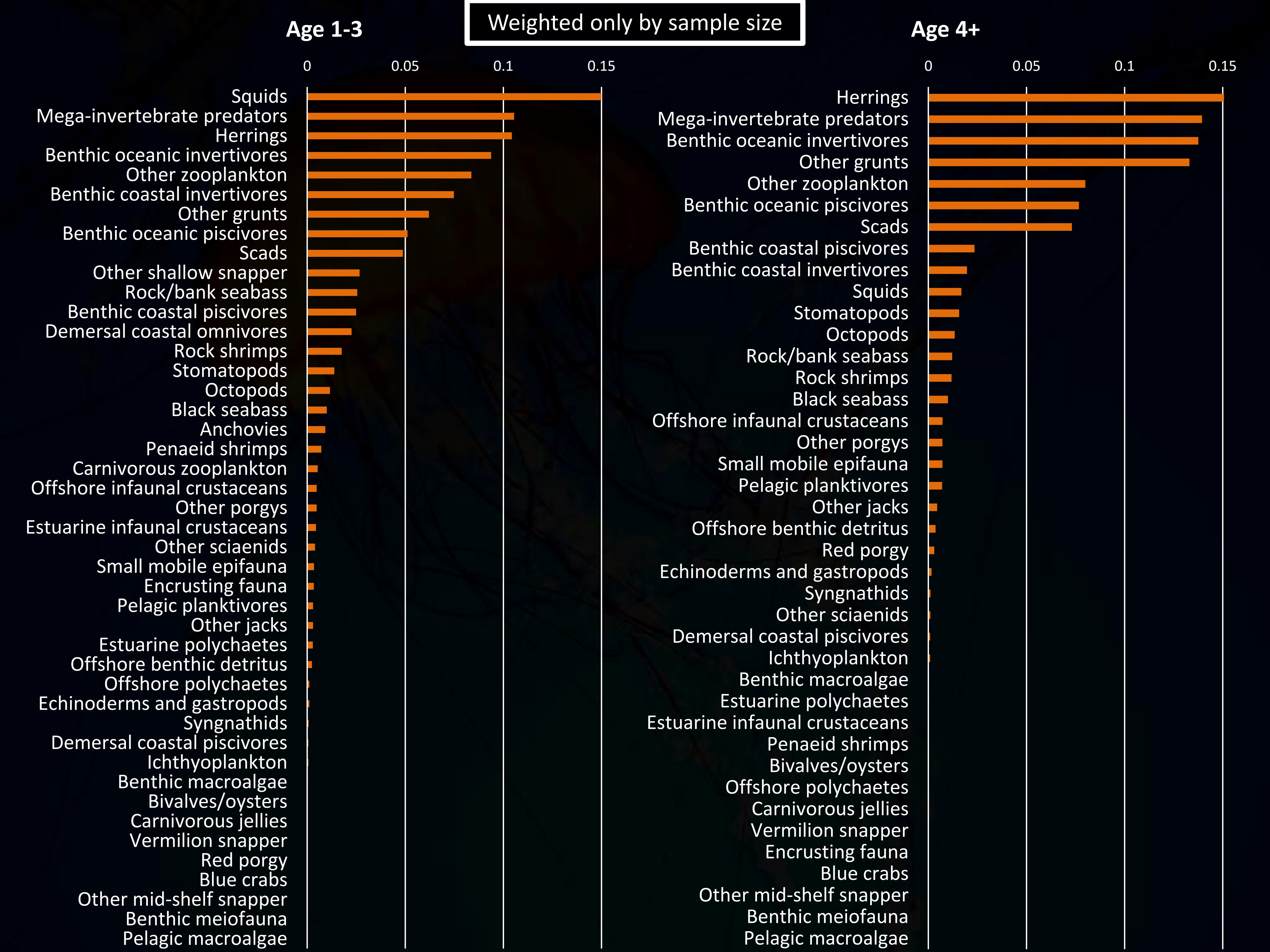
Szedlmayer, S. and J. Lee (2004) "Diet shifts of juvenile red snapper (Lutjanus campechanus) with changes in habitat and fish size“ Fish. Bull. 102: 366-375

Tarnecki, J and W. Patterson III (2015) ”Changes in Red Snapper Diet and Trophic Ecology Following the Deepwater Horizon Oil Spill”, Marine and Coastal Fisheries, 7:1, 135-147

Red Snapper Diets - Comparison



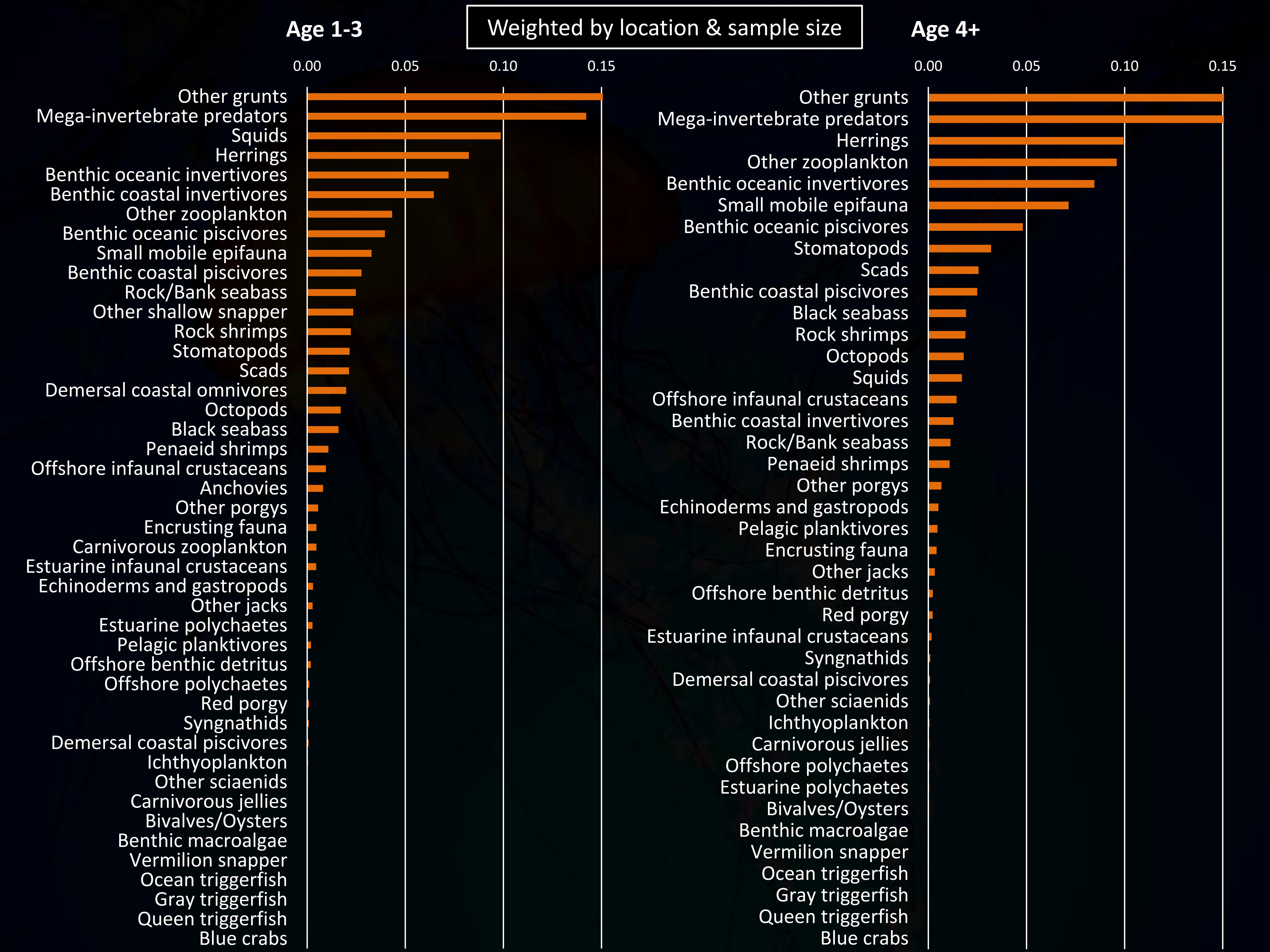

Tarnecki 2015 (Age 1-3, 4+) - GoM
0
0.1
0.2
0.3
0.4
Other zooplankton
Small mobile epifauna
Mega-invertebrate predators
Stomatopods
Penaeid shrimps
Offshore infaunal crustaceans
Squids
Rock shrimps
Pelagic planktivores
Encrusting fauna
Echinoderms and gastropods
Benthic coastal piscivores
Red porgy
Herrings
FWRI Gut Lab (Age 1-3, 4+) - SAR
0
0.1
0.2
0.3
0.4
Herrings
Benthic oceanic invertivores
Benthic oceanic piscivores
Mega-invertebrate predators
Scads
Benthic coastal invertivores
Squids
Stomatopods
Offshore benthic detritus
Other grunts
Other jacks
Szedlymayer 2004 (Age 1-3) - GoM
0
0.1
0.2
0.3
0.4
Squids
Benthic coastal invertivores
Mega-invertebrate predators
Other shallow snapper
Demersal coastal omnivores
Rock/Bank seabass
Rock shrimps
Benthic coastal piscivores
Anchovies
Penaeid shrimps
Carnivorous zooplankton
SEAMAP (Age 1-3, 4+) - SAR
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4
0.45
Other grunts
Mega-invertebrate predators
Scads
Benthic coastal piscivores
Black seabass
Octopods
Rock/Bank seabass
Rock shrimps
Offshore infaunal crustaceans
Other porgys
Stomatopods
Other jacks


Weighted only by sample size
Age 1-3
0
0.05
0.1
0.15
Squids
Mega-invertebrate predators
Herrings
Benthic oceanic invertivores
Other zooplankton
Benthic coastal invertivores
Other grunts
Benthic oceanic piscivores
Scads
Other shallow snapper
Rock/bank seabass
Benthic coastal piscivores
Demersal coastal omnivores
Rock shrimps
Stomatopods
Octopods
Black seabass
Anchovies
Penaeid shrimps
Carnivorous zooplankton
Offshore infaunal crustaceans
Other porgys
Estuarine infaunal crustaceans
Other sciaenids
Small mobile epifauna
Encrusting fauna
Pelagic planktivores
Other jacks
Estuarine polychaetes
Offshore benthic detritus
Offshore polychaetes
Echinoderms and gastropods
Syngnathids
Demersal coastal piscivores
Ichthyoplankton
Benthic macroalgae
Bivalves/oysters
Carnivorous jellies
Vermilion snapper
Red porgy
Blue crabs
Other mid-shelf snapper
Benthic meiofauna
Pelagic macroalgae
Age 4+
0
0.05
0.1
0.15
Herrings
Mega-invertebrate predators
Benthic oceanic invertivores
Other grunts
Other zooplankton
Benthic oceanic piscivores
Scads
Benthic coastal piscivores
Benthic coastal invertivores
Squids
Stomatopods
Octopods
Rock/bank seabass
Rock shrimps
Black seabass
Offshore infaunal crustaceans
Other porgys
Small mobile epifauna
Pelagic planktivores
Other jacks
Offshore benthic detritus
Red porgy
Echinoderms and gastropods
Syngnathids
Other sciaenids
Demersal coastal piscivores
Ichthyoplankton
Benthic macroalgae
Estuarine polychaetes
Estuarine infaunal crustaceans
Penaeid shrimps
Bivalves/oysters
Offshore polychaetes
Carnivorous jellies
Vermilion snapper
Encrusting fauna
Blue crabs
Other mid-shelf snapper
Benthic meiofauna
Pelagic macroalgae

Question from Workgroup: What would happen if you weighted SAR vs. GoM diets 80/20?

Q: What would happen if you weighted SAR vs. GoM diets 80/20?

% Diet Change with SAR vs. GOM weighted (>1% only)			
Age 1-3		Age 4+	
9%	Other grunts	5%	Other grunts
5%	Herrings	2%	Herrings
4%	Benthic oceanic invertivores	2%	Benthic oceanic invertivores
2%	Benthic oceanic piscivores	1%	Benthic oceanic piscivores
1%	Scads	1%	Scads
1%	Black seabass	-1%	Penaeid shrimps
1%	Octopods	-1%	Stomatopods
-1%	Anchovies	-1%	Mega-invertebrate predators
-1%	Rock/Bank seabass	-4%	Small mobile epifauna
-1%	Penaeid shrimps	-5%	Other zooplankton
-2%	Demersal coastal omnivores		
-2%	Other shallow snapper		
-3%	Small mobile epifauna		
-3%	Other zooplankton		
-4%	Benthic coastal invertivores		
-6%	Squids		



Weighted by location & sample size
Age 1-3
0.00
0.05
0.10
0.15
Other grunts
Mega-invertebrate predators
Squids
Herrings
Benthic oceanic invertivores
Benthic coastal invertivores
Other zooplankton
Benthic oceanic piscivores
Small mobile epifauna
Benthic coastal piscivores
Rock/Bank seabass
Other shallow snapper
Rock shrimps
Stomatopods
Scads
Demersal coastal omnivores
Octopods
Black seabass
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Other jacks
Estuarine polychaetes
Pelagic planktivores
Offshore benthic detritus
Offshore polychaetes
Red porgy
Syngnathids
Demersal coastal piscivores
Ichthyoplankton
Other sciaenids
Carnivorous jellies
Bivalves/Oysters
Benthic macroalgae
Vermilion snapper
Ocean triggerfish
Gray triggerfish
Queen triggerfish
Blue crabs
Age 4+
0.00
0.05
0.10
0.15
Other grunts
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Offshore polychaetes
Estuarine polychaetes
Bivalves/Oysters
Benthic macroalgae
Vermilion snapper
Ocean triggerfish
Gray triggerfish
Queen triggerfish
Blue crabs

Predators

Predator	Ages	Citation
Large coastal sharks	Age 0, 1-3, 4+	**Blacktip shark** Castro 1996 – SAR “Snappers” **Tiger shark** Aines et al 2017 – SAR/GoM, ID’d to species
Adult king mackerel	Age 0, 1-3	Saloman 1983 NOAA technical - SAR ID’d to species Had gray, lane, yellowtail, vermilion in stomach
Benthic oceanic piscivores	Age 0	Shortjaw lizardfish FWRI-FIM GoM “Lutjanidae”
Other shallow snapper	Age 0	Cubera Randall 1967 - Puerto Rico/Virgin Isles “Snappers such as lane, gray, muton, red”
Vermilion snapper	Age 0	SEAMAP Offshore - “juvenile snapper”
Black seabass	Age 0	SEAMAP Offshore - “Lutjanus sp.” Also had vermilion in stomach
Great barracuda	Age 0	Randall 1967 – Puerto Rico/Virgin Isles “Red snapper” Had 5 other snapper species in stomachs
Birds – shelf piscivores	Age 0	Lamb 2016 – GoM FL – ID’d to species Regurgitated fish found in chicks’ nests

Red Snapper Ecopath Input Sources

Landings

2020: Landings were collected independently from ACCSP, MRIP, and SRHS
Separated by fleet

Now: Used landings from SEDAR 73
-Estimates were slightly higher (only 6 tons more)
Used proportions from 2020 estimates to re-calculate fleet totals

Discards

2020: Released-alive discards from MRIP, with discard mortality rate applied by fleet
Commercial discards were 20% of landings

Now: SEDAR 73 already estimated released-alive discards, only reports Dead Discards
Ergo, discard mortality rate is 100%

Niche Overlap

Predicts values for Prey Overlap and Predator Overlap separately

- Uses a modified version of the Pianka 1973 method (arithmetic rather than geometric mean)
- Ranges from 0 (no overlap) to 1 (total overlap)
- **Prey Overlap:** uses the fraction each prey contributes to the two predators' diets
- **Predator Overlap**: uses the fraction a predator contributes to the total predation on two groups
    - Calculated using each predator's consumption (Q) and the proportion each prey contributes to the predator's diet

Prey Overlap

$$O_{jk} = \sum_{i=1}^{n}(p_{ji} \cdot p_{ki}) / (\sum_{i=1}^{n}(p_{ji}^2 + p_{ki}^2)/2)$$

O_{jk} = overlap of predators *j* and *k*
P_{ji} = proportion that prey *i* contributes to the diet of predator *j*
P_{ki} = proportion that prey *i* contributes to the diet of predator *k*

Predator Overlap

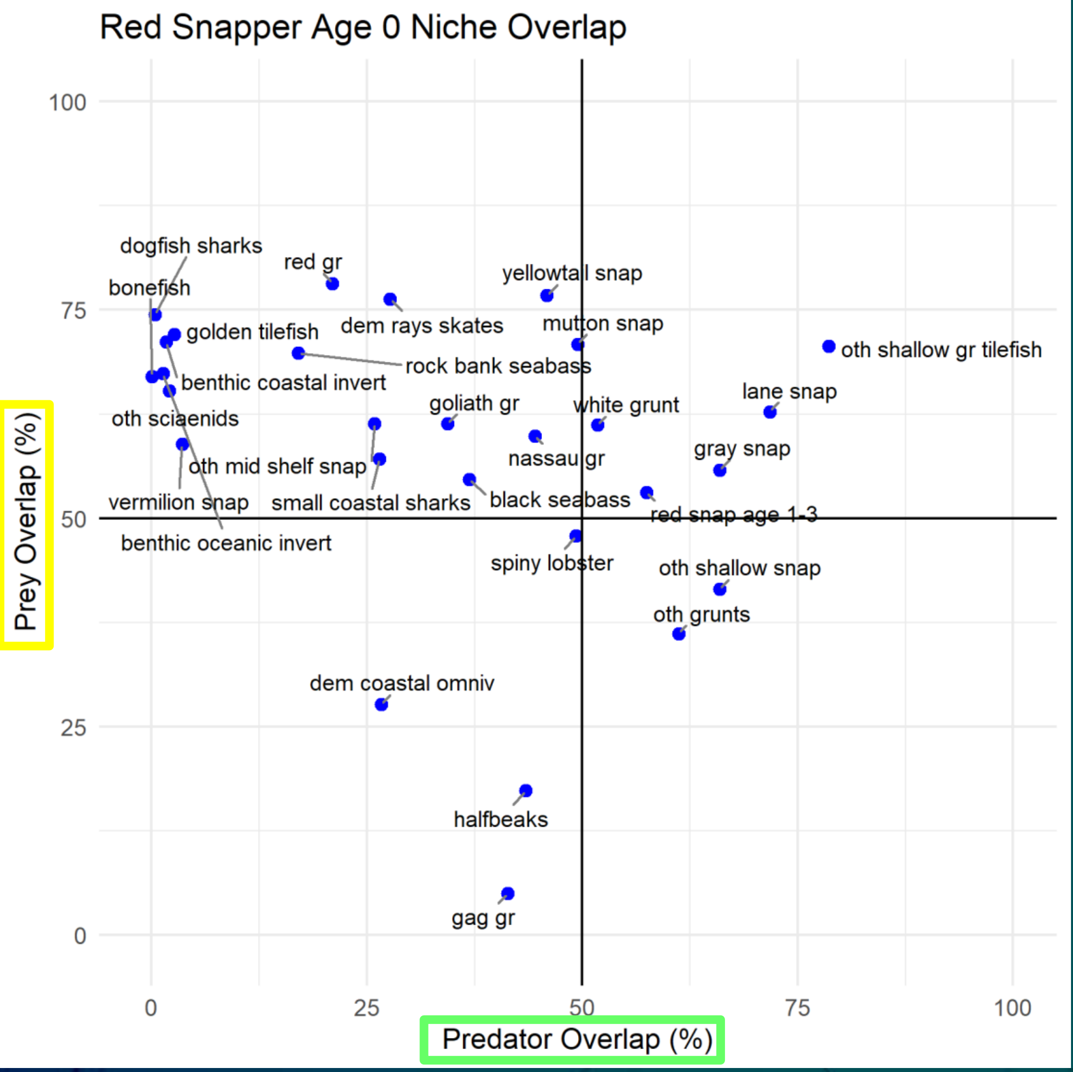
$$X_{nl} = Q_i P_{ln} / \sum_{l=1}^{n}(Q_l \cdot P_{ln})$$

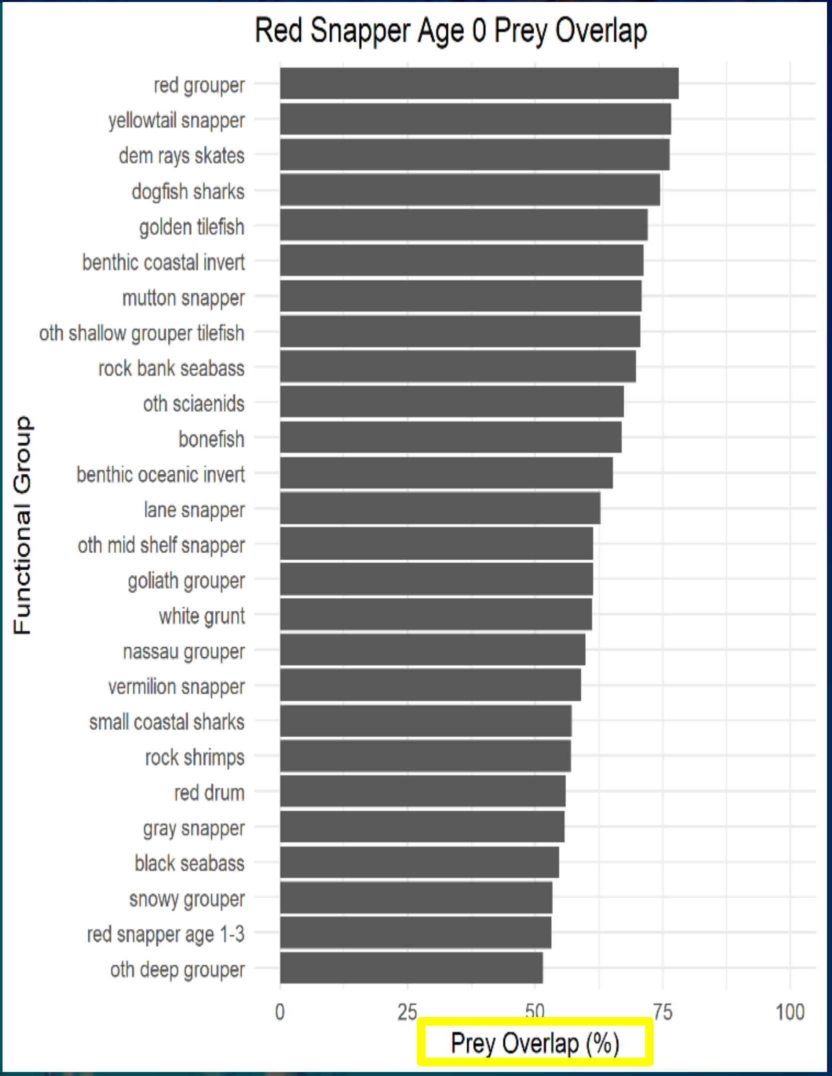
$$X_{ml} = Q_i P_{lm} / \sum_{l=1}^{n}(Q_l \cdot P_{lm})$$

$$P_{mn} = \sum_{i=1}^{n}(X_{ml} \cdot X_{nl}) / (\sum_{l=1}^{n}(x_{ml}^2 + x_{nl}^2)/2$$

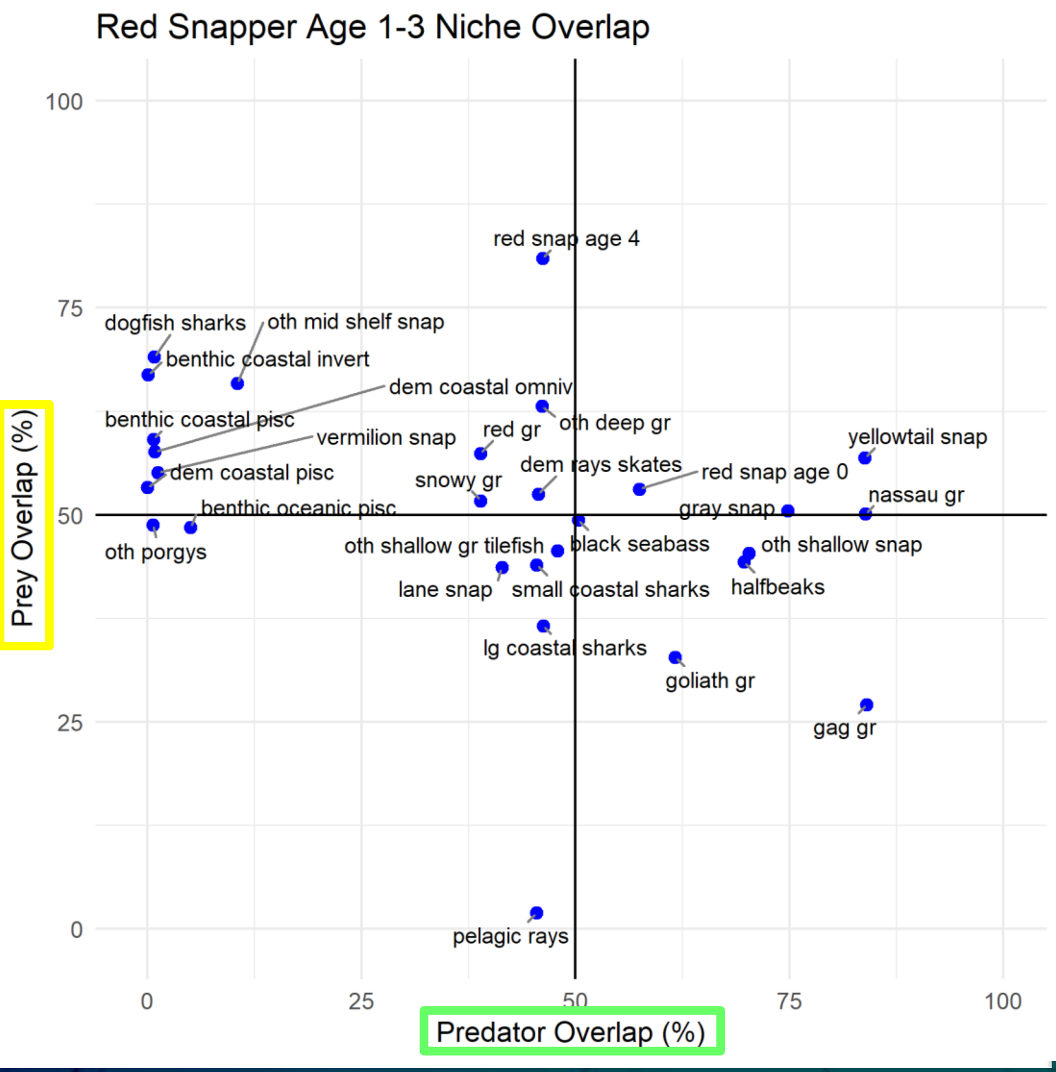
X_{nl} = fraction that predator *l* contributes to the total predation on prey *n*
X_{ml} = fraction that predator *l* contributes to the total predation on prey *m*
P_{mn} = Predator Overlap of preys *m* and *n*

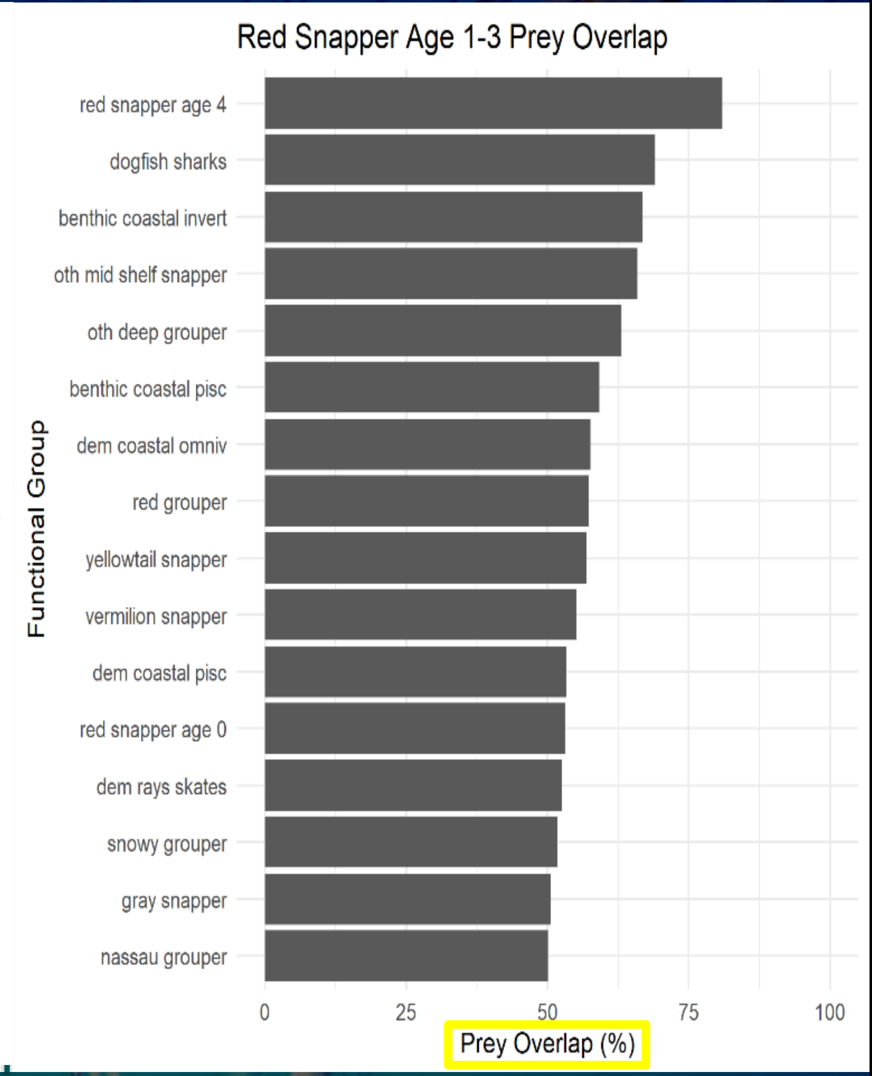
Niche Overlap



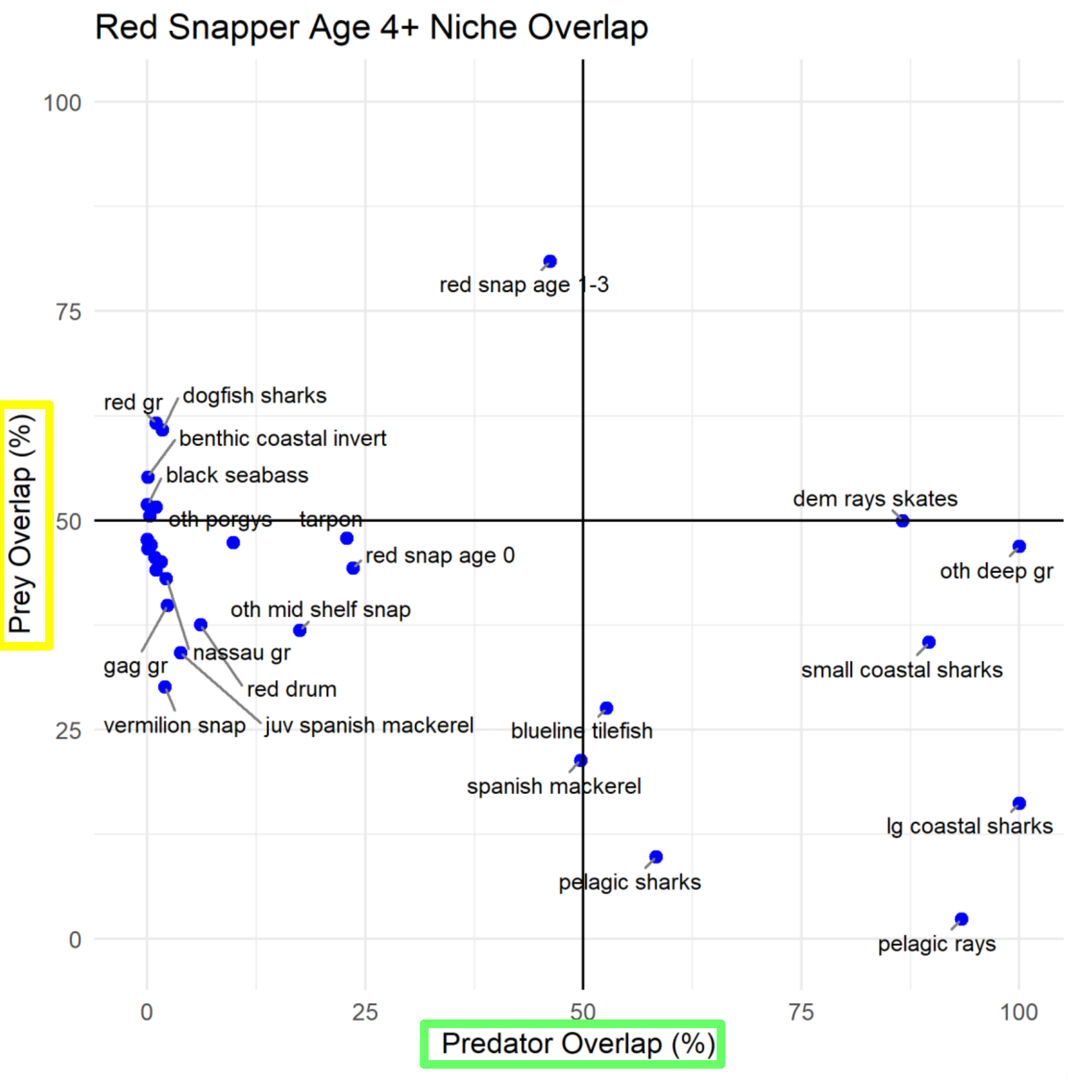


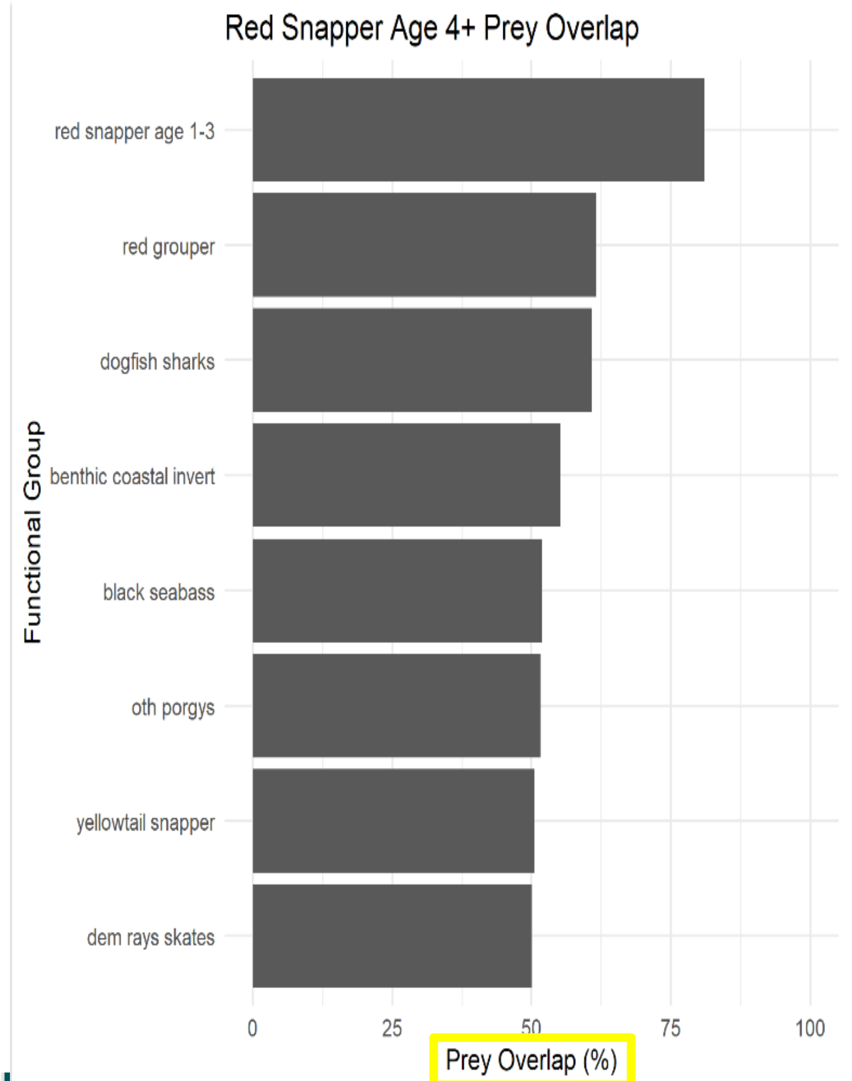
Niche Overlap





Niche Overlap

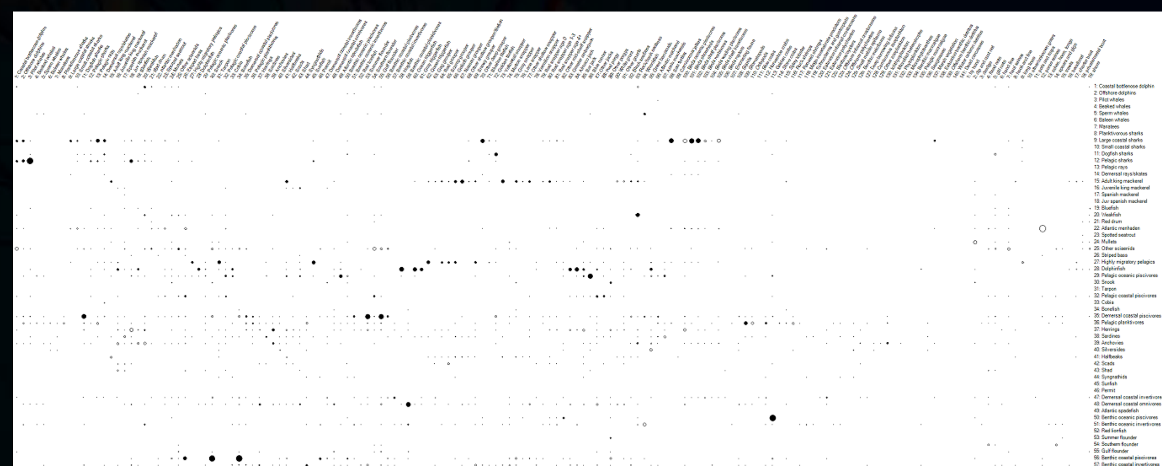




Mixed Trophic Impacts

Tool for exploring ecosystem structure

- Allows elements to interact in feedback loops
- Assesses the effect of a very small increase of one group's biomass on each other group's biomass
- Sum of direct and indirect impacts (predation, competition, etc.)
- Values are not concrete, but are relative and comparable across groups
- *Reflects impacts in a steady-state system*



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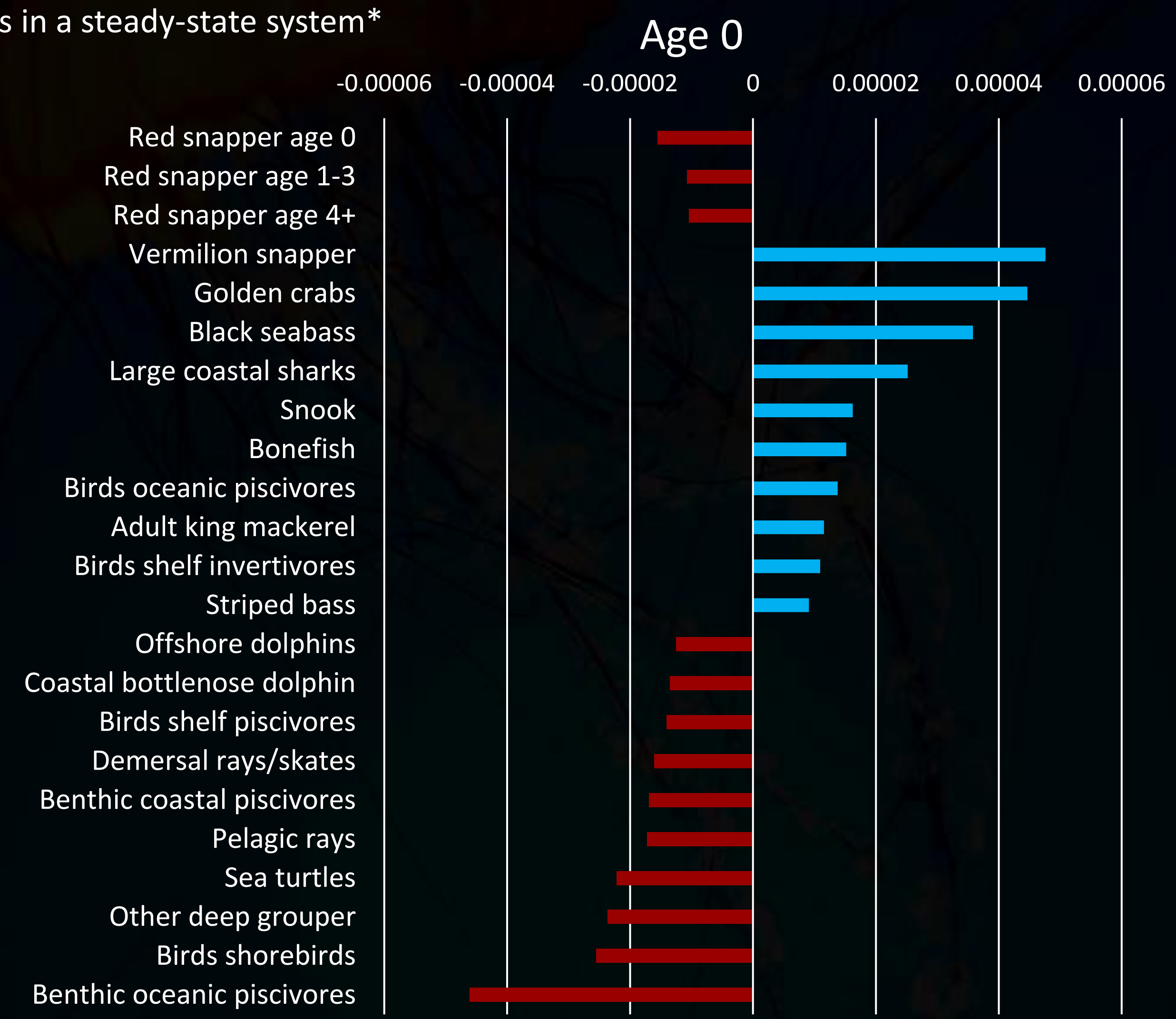
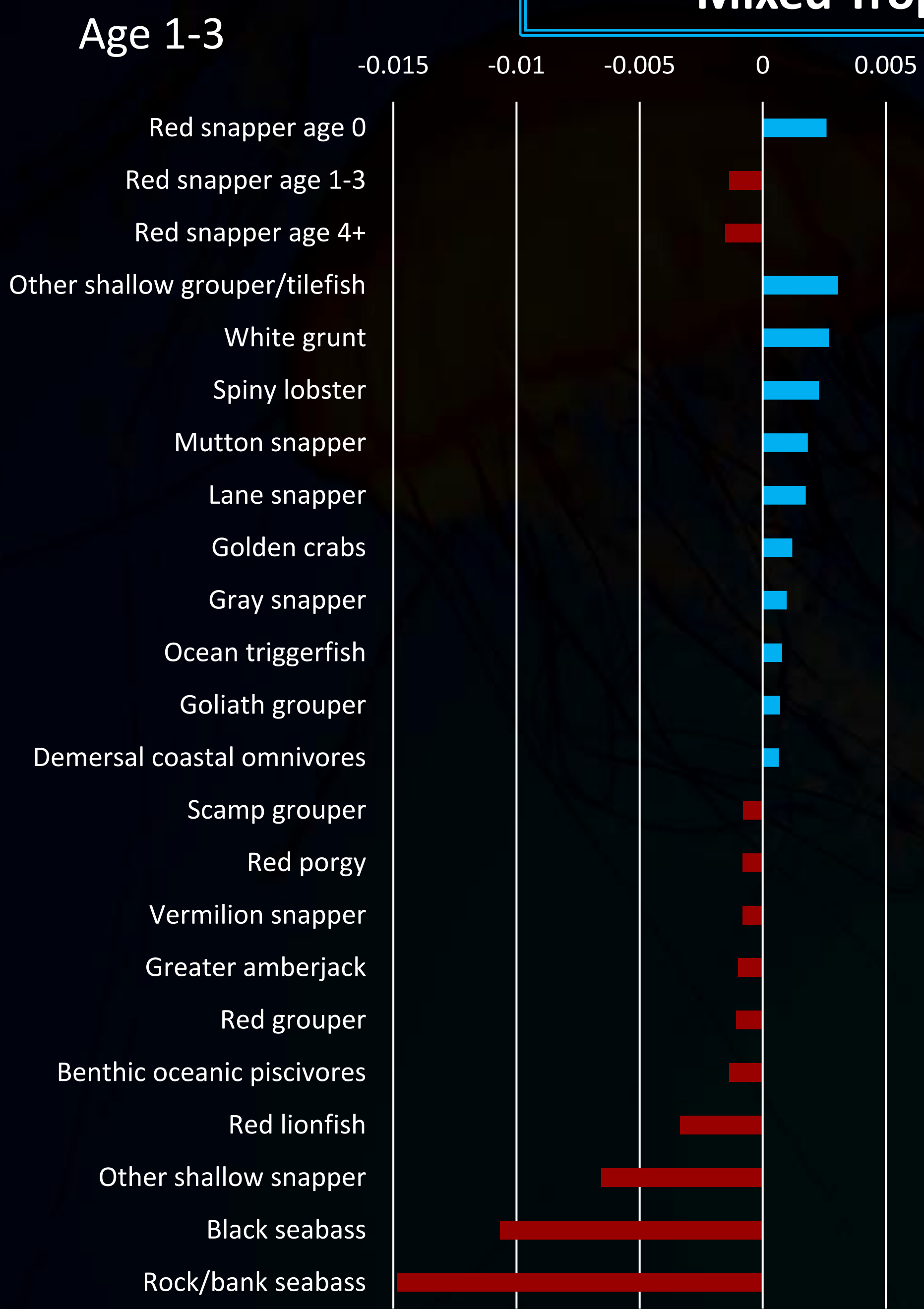
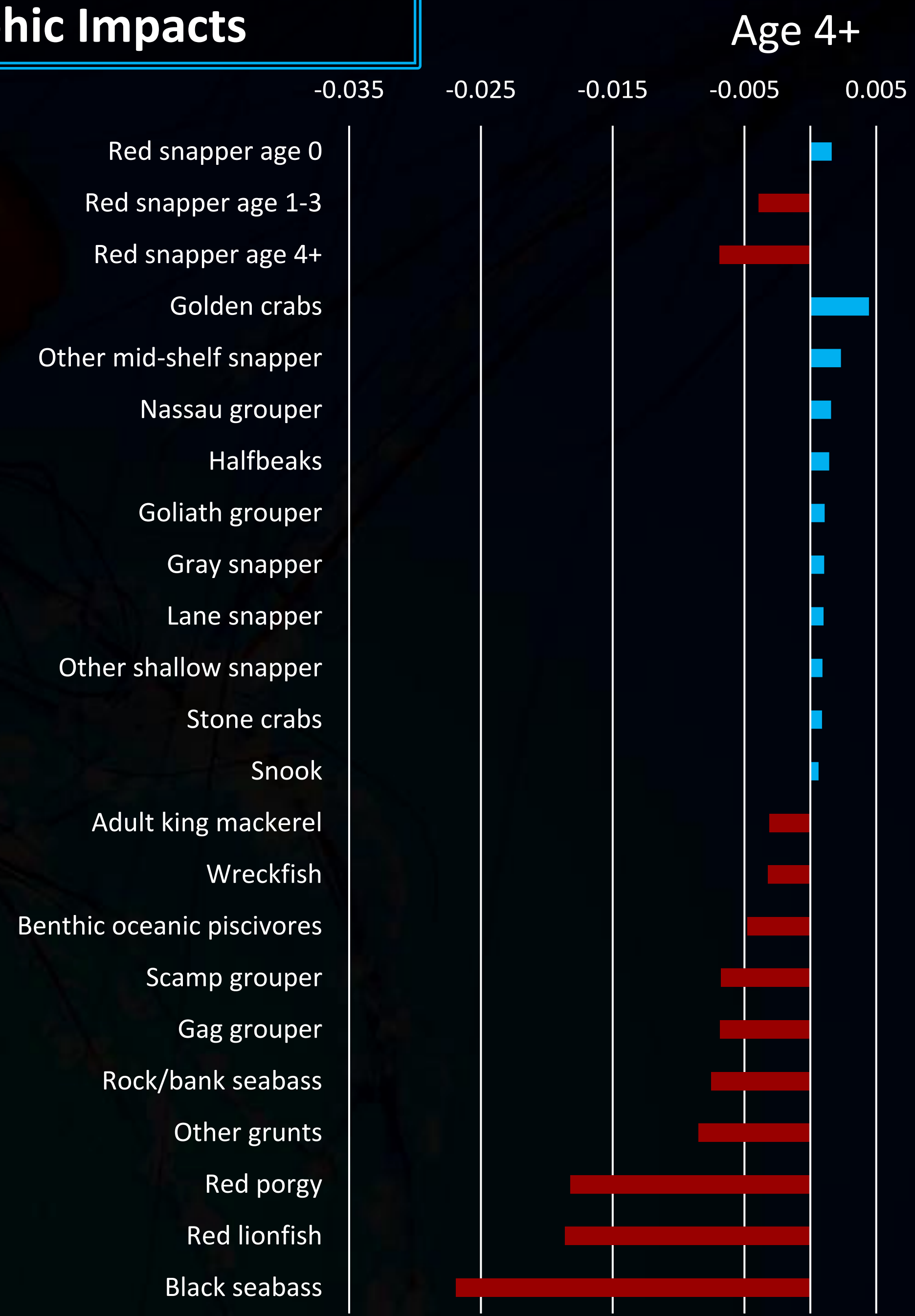
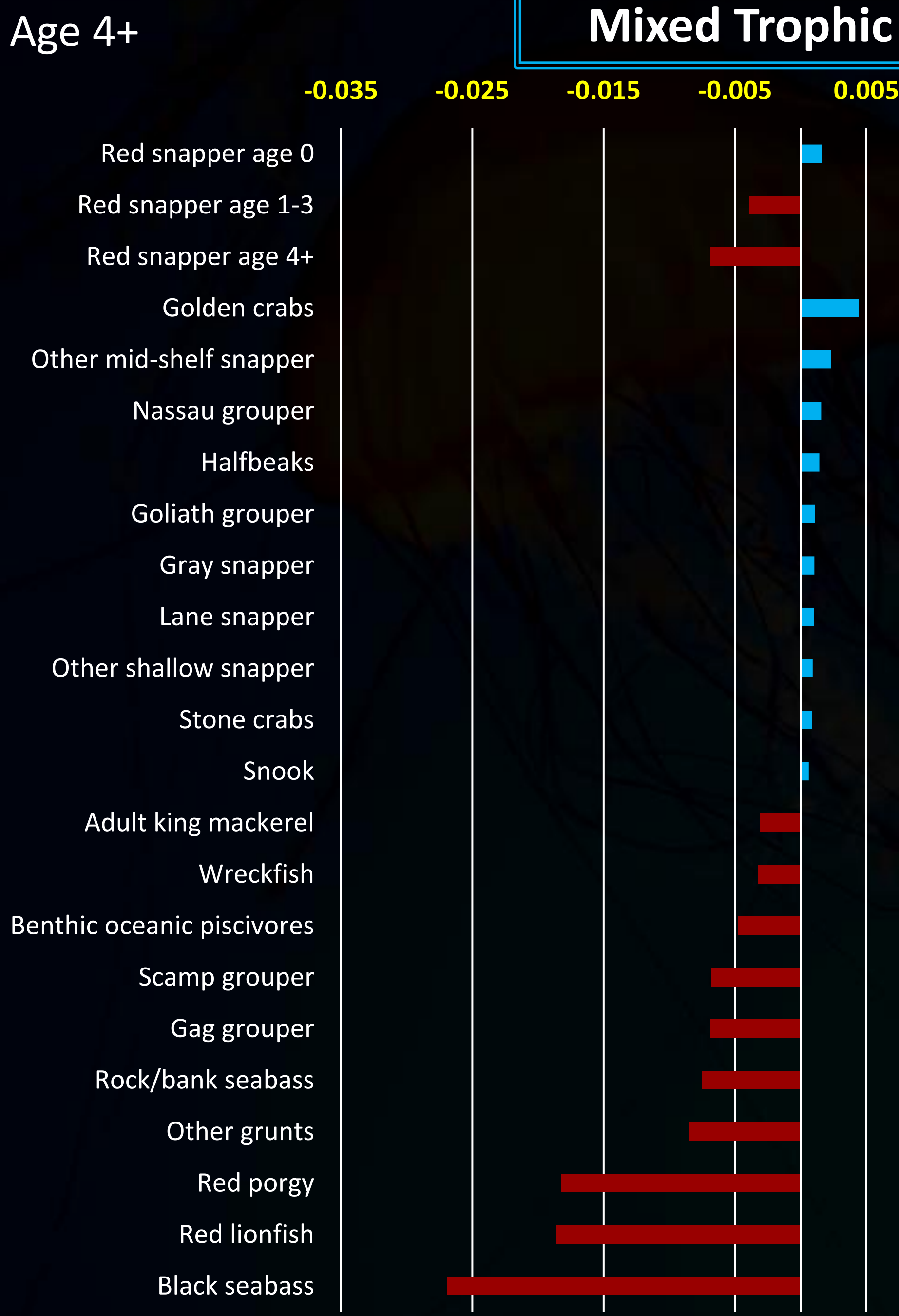


Mixed Trophic Impacts





Mixed Trophic Impacts - context



Ecosim inputs

Time series of primary productivity

- Satellite-derived Chlorophyll *a*
- Calibrated by NASA from both MODIS and SeaWiFS satellites

Catch time series

- SEDAR for red snapper – reference only
- ACCSP, MRIP, SRHS for other species (104 groups) - forced

Biomass time series – reference only

- SEDAR stock assessments for assessed species (12 groups)

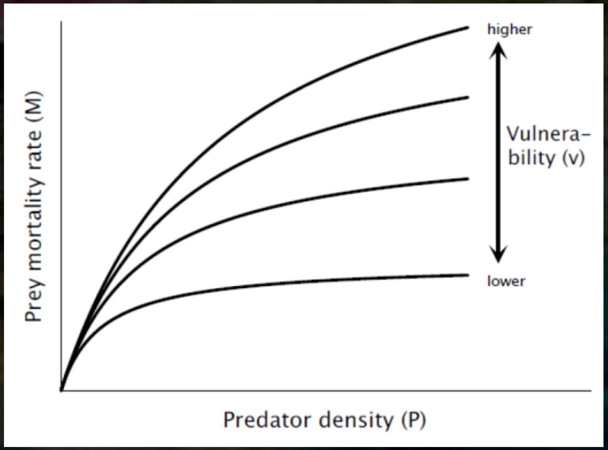
WPUE time series

- SEAMAP (33 groups)

Fishing Mortality time series (Red snapper only)

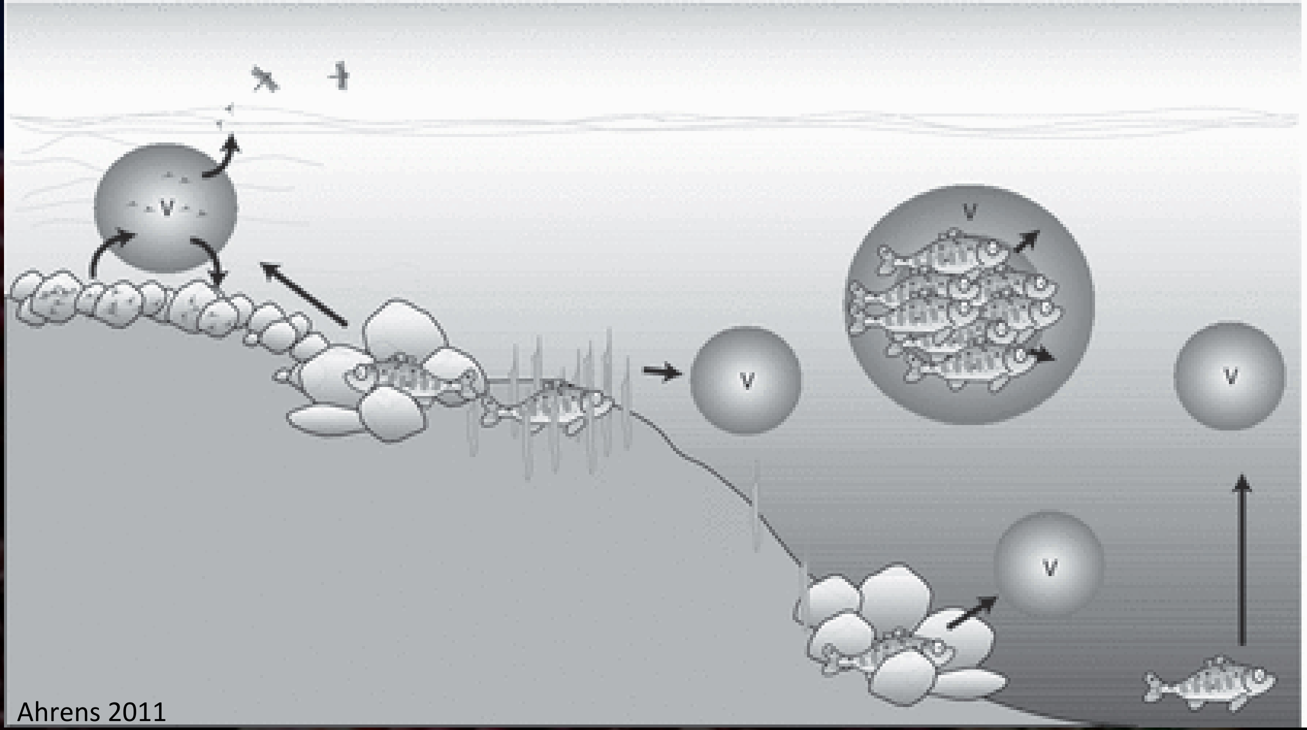
- SEDAR 73: Catch/Biomass by age group
- Forcing time series drives the estimates

Vulnerability fitting



Systematic process to calculate vulnerabilities of prey to predators (lowest SS)

- Vulnerabilities scale prey mortality to predator density
- Modify vulnerabilities/inputs to fit model predictions to time series of particular interest

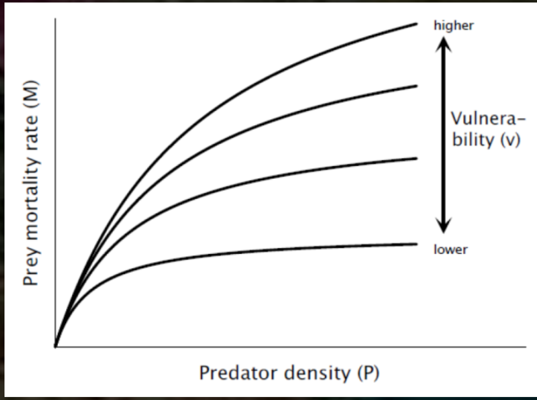


Age 4+

Vulnerability fitting

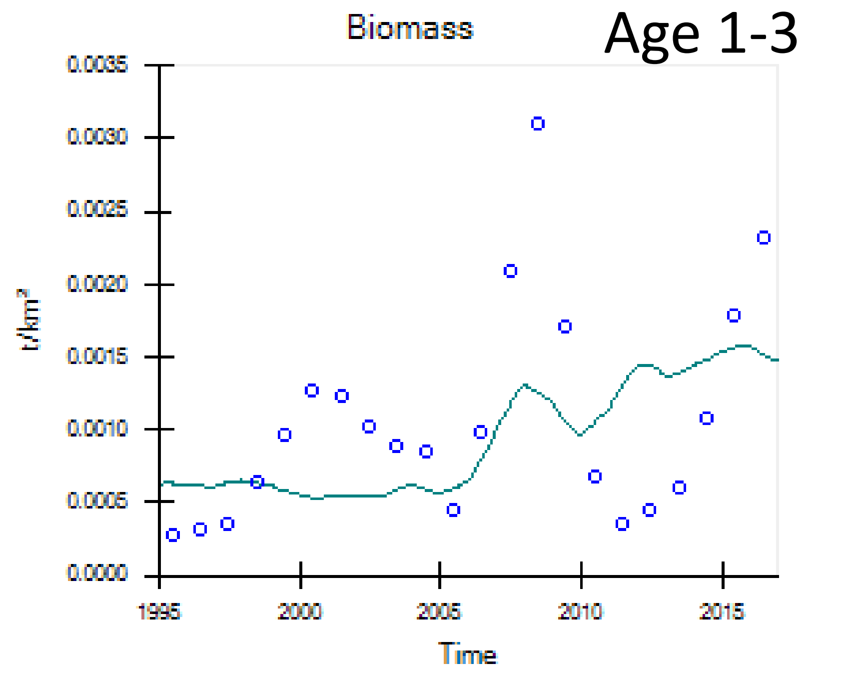
Systematic process to calculate vulnerabilities of prey to predators (lowest SS)

- Vulnerabilities scale prey mortality to predator density
- Modify vulnerabilities/inputs to fit model predictions to time series of particular interest

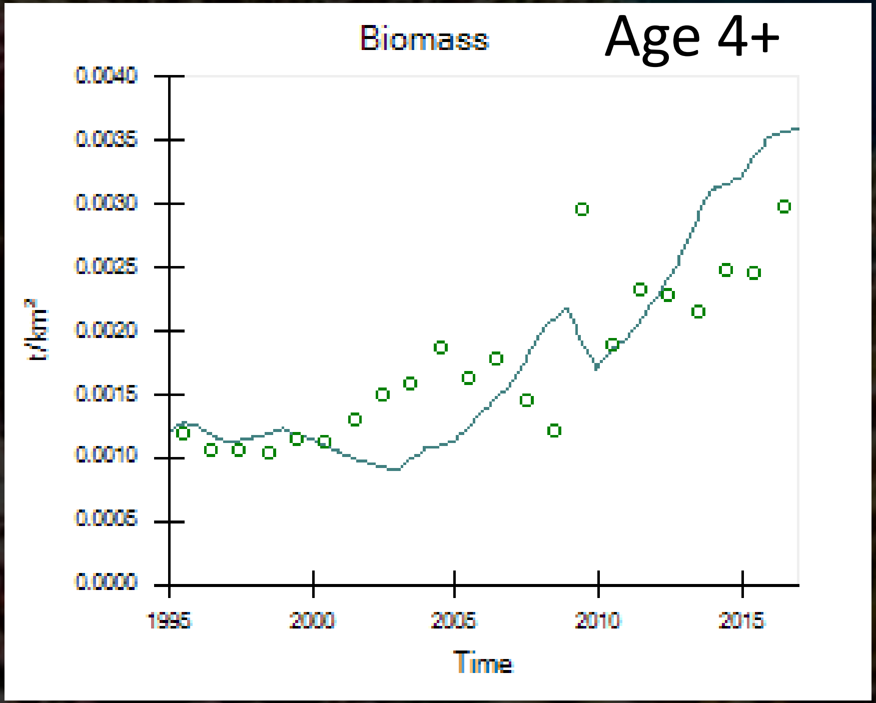


Red Snapper Fits

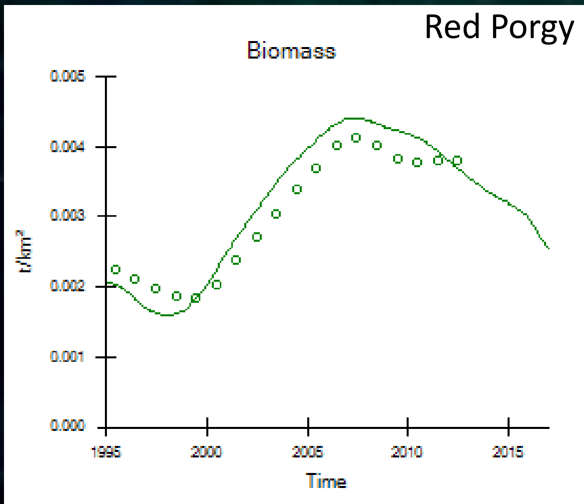
Age 1-3

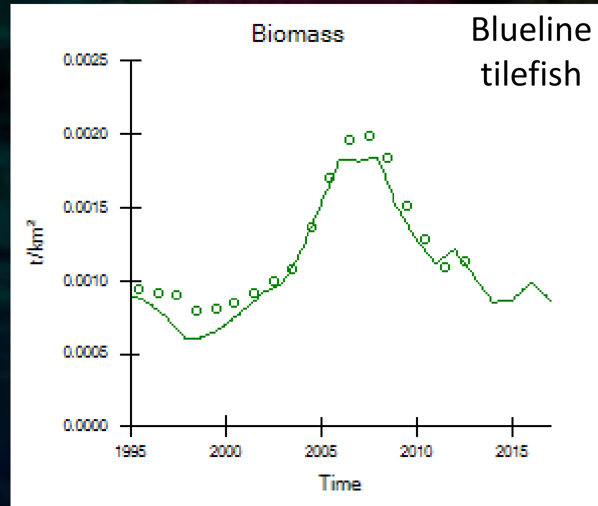


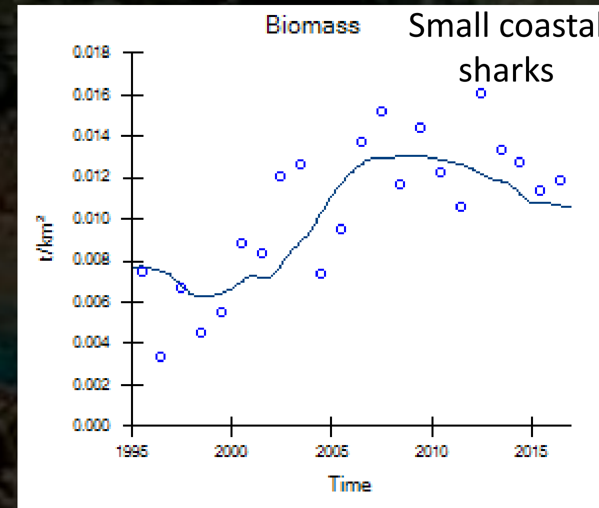
Age 4+

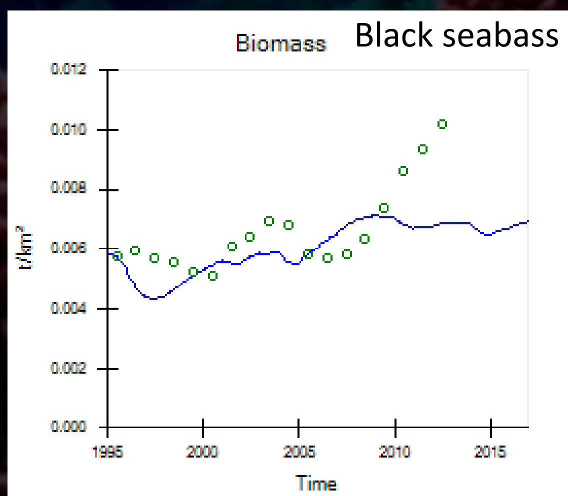


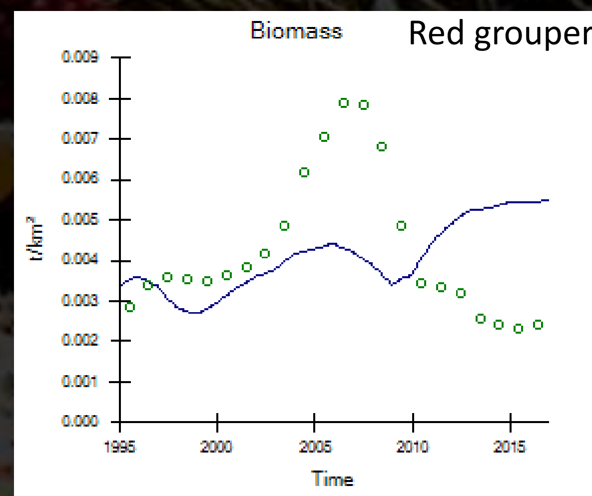
Other Species' Fits







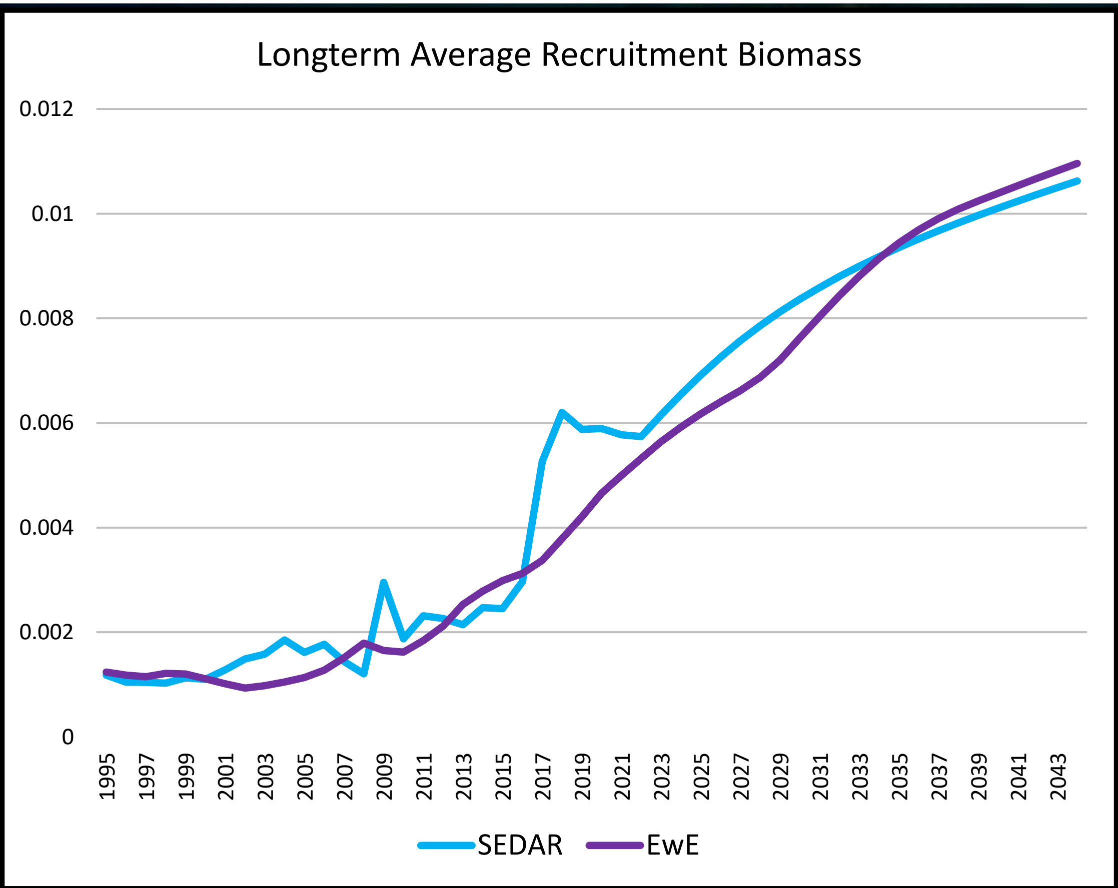




Simulating The Future

Long-term Average Recruitment

- Set F to 0.0188 from 2017 to 2044
  - Both Age 1-3 and 4+
  - Allows red snapper to recover
  - Total 2044 biomass = SEDAR predicted 2044 biomass under long-term recruitment (Scenario 7 from July SSC presentation)



Simulating The Future

High Recent Recruitment

- Set F to 0.0188 from 2017 to 2044

AND

- Added forcing function to vulnerabilities of Age 0 Red Snapper's prey
    - Increasing vulnerability makes prey mortality more closely linked to predator density
    - Increases vulnerability of their prey to predation
    - Used biomass estimates from SEDAR73 to direct the shape
    - Simulates high recruitment of juveniles to older age groups

Total 2044 biomass = SEDAR predicted 2044 biomass under high recent recruitment (Scenario 13 from July SSC presentation

Simulating The Future

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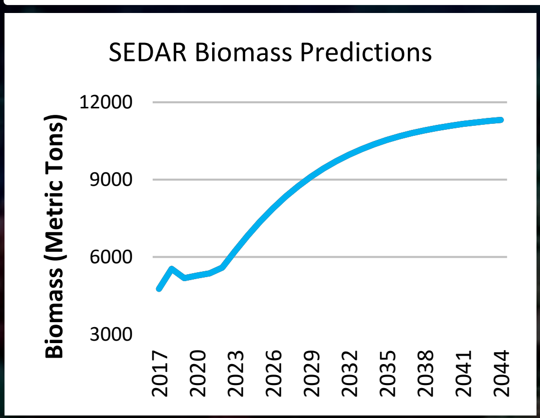

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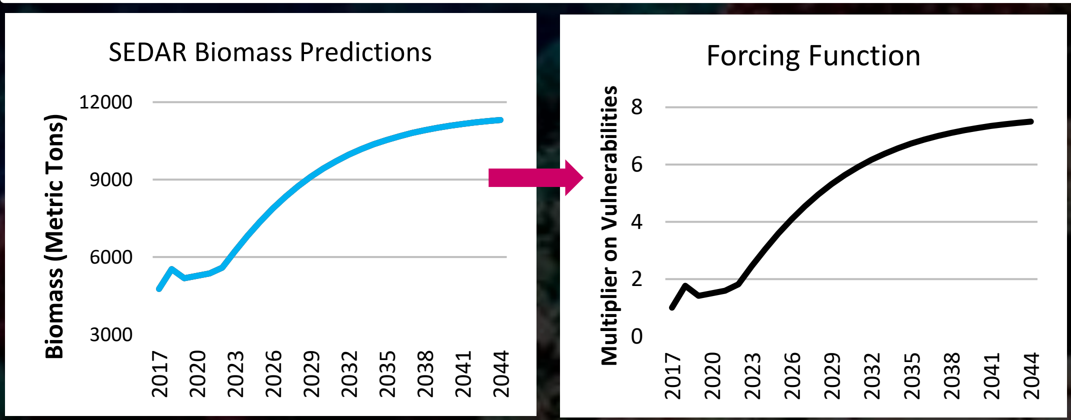

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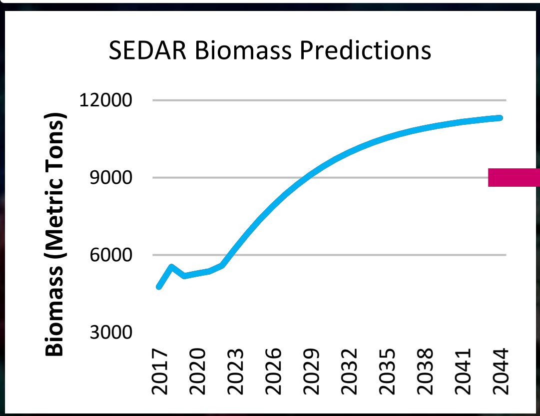
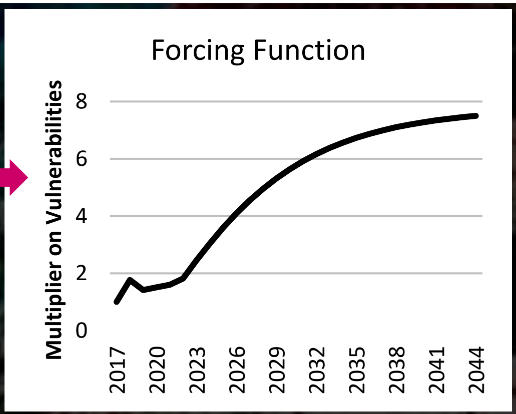
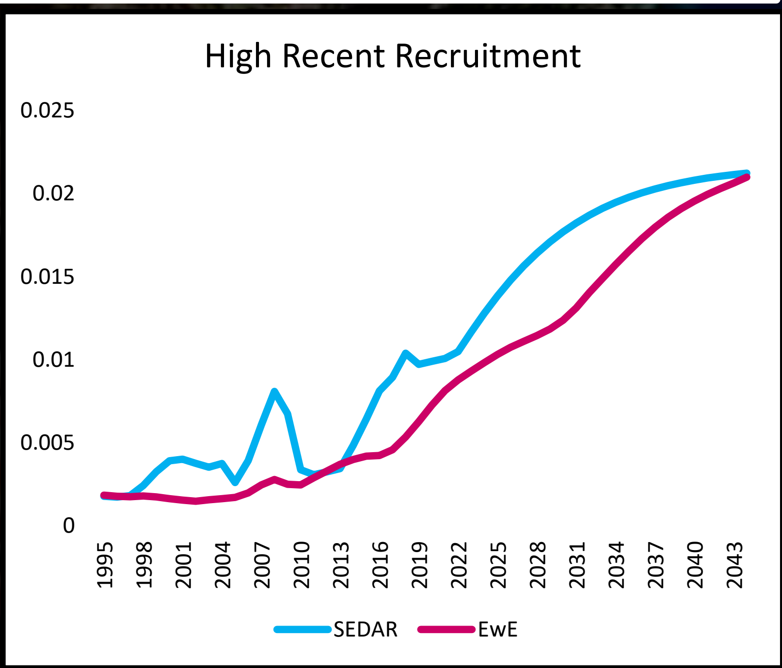


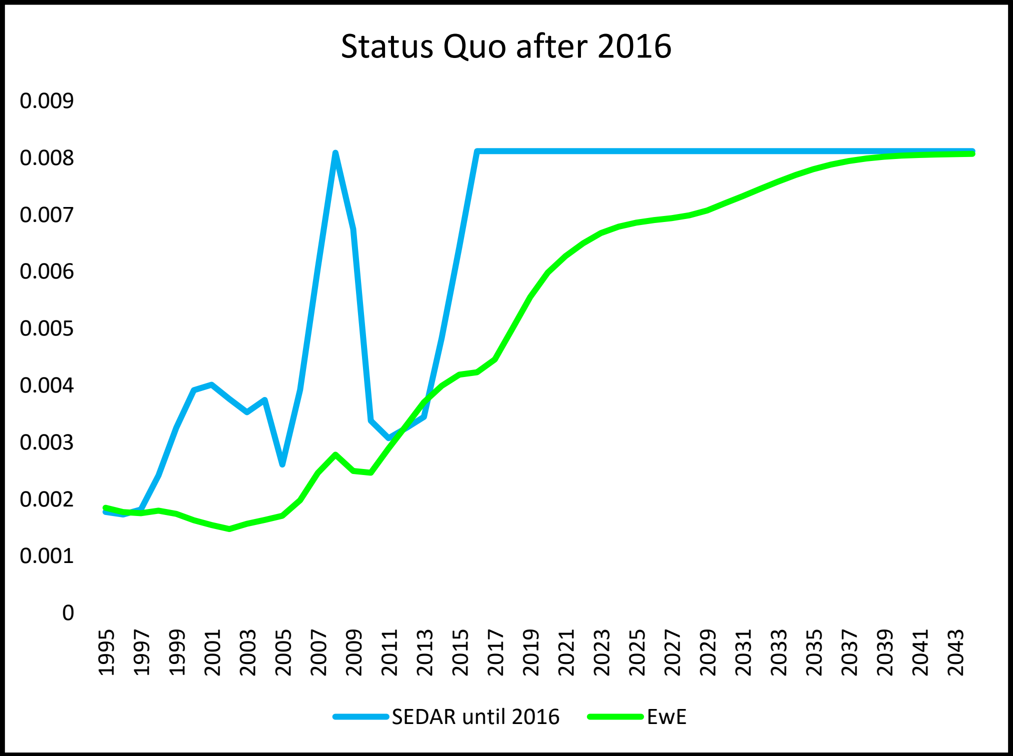




Simulating The Future

Status Quo

- Arbitrary low biomass
- Set F to 0.1 for 2017-2044
  - Age 4+ only
  - Keeps total populations around the 2016 biomass
  - Allows us to see the impacts of 3 levels of Red Snapper biomass

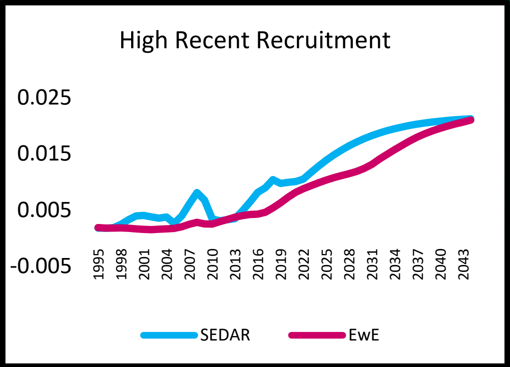


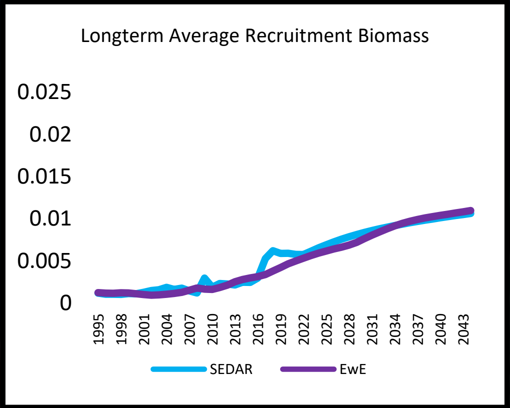
Simulating The Future

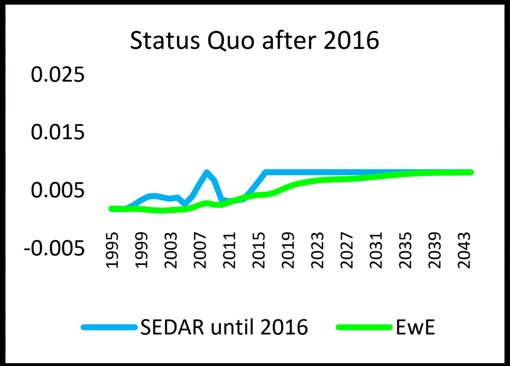
High Recent Recruitment

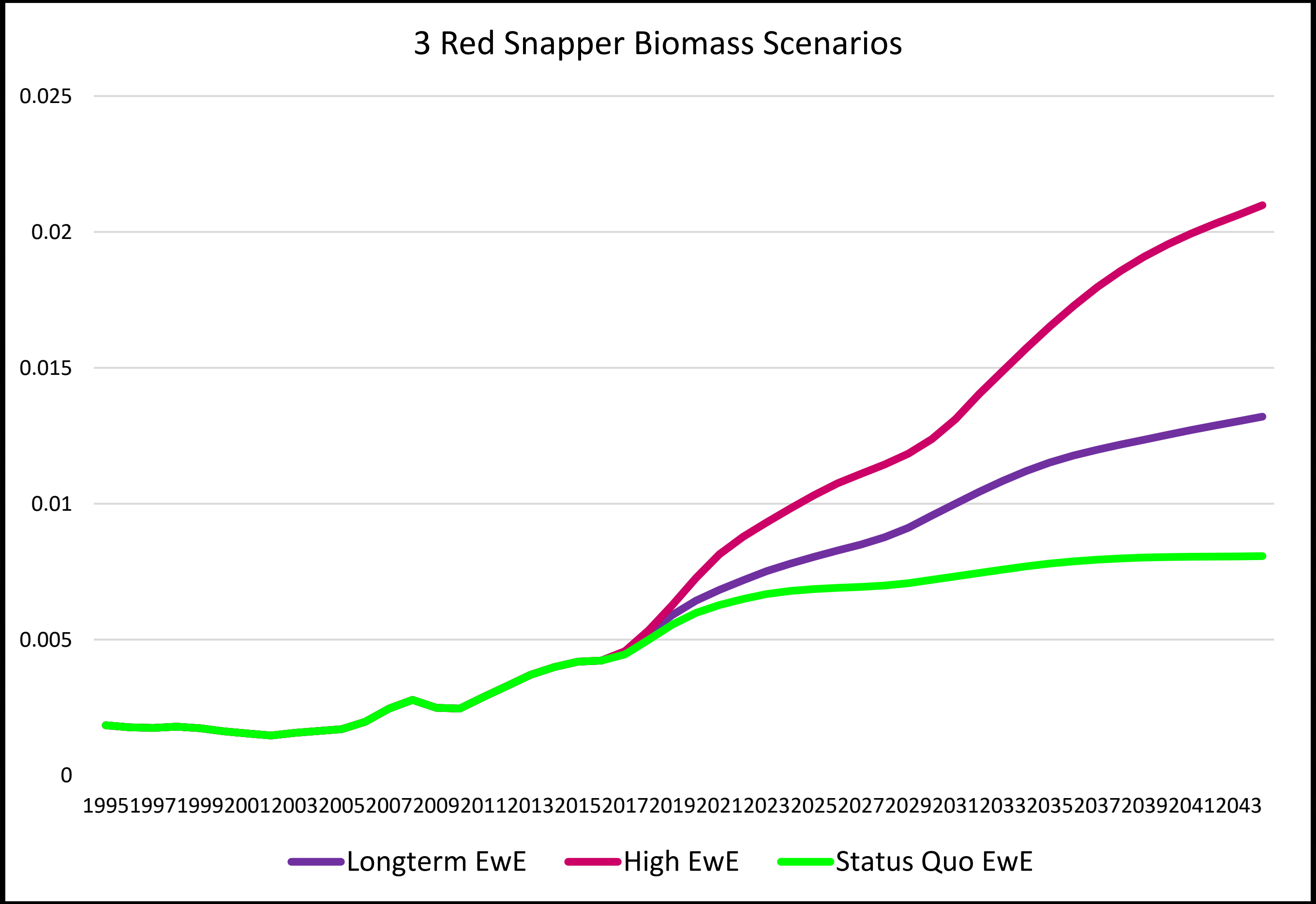
Long-term Average Recruitment

Status Quo







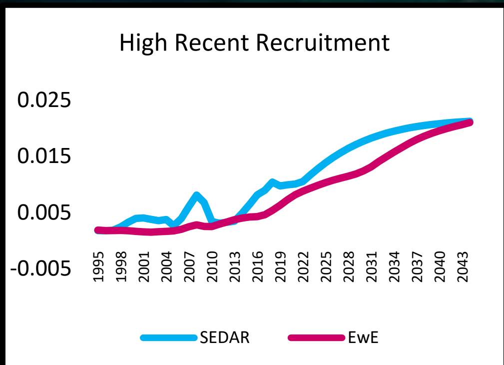


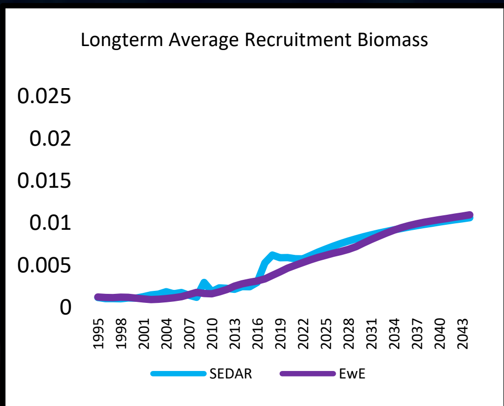
Simulating The Future

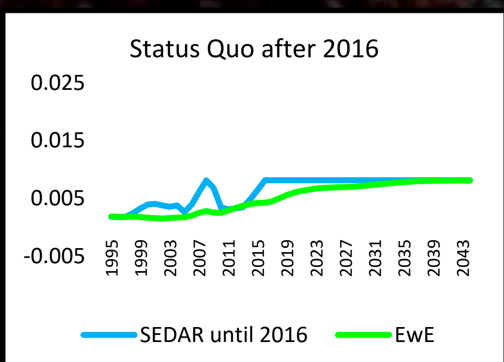
High Recent Recruitment

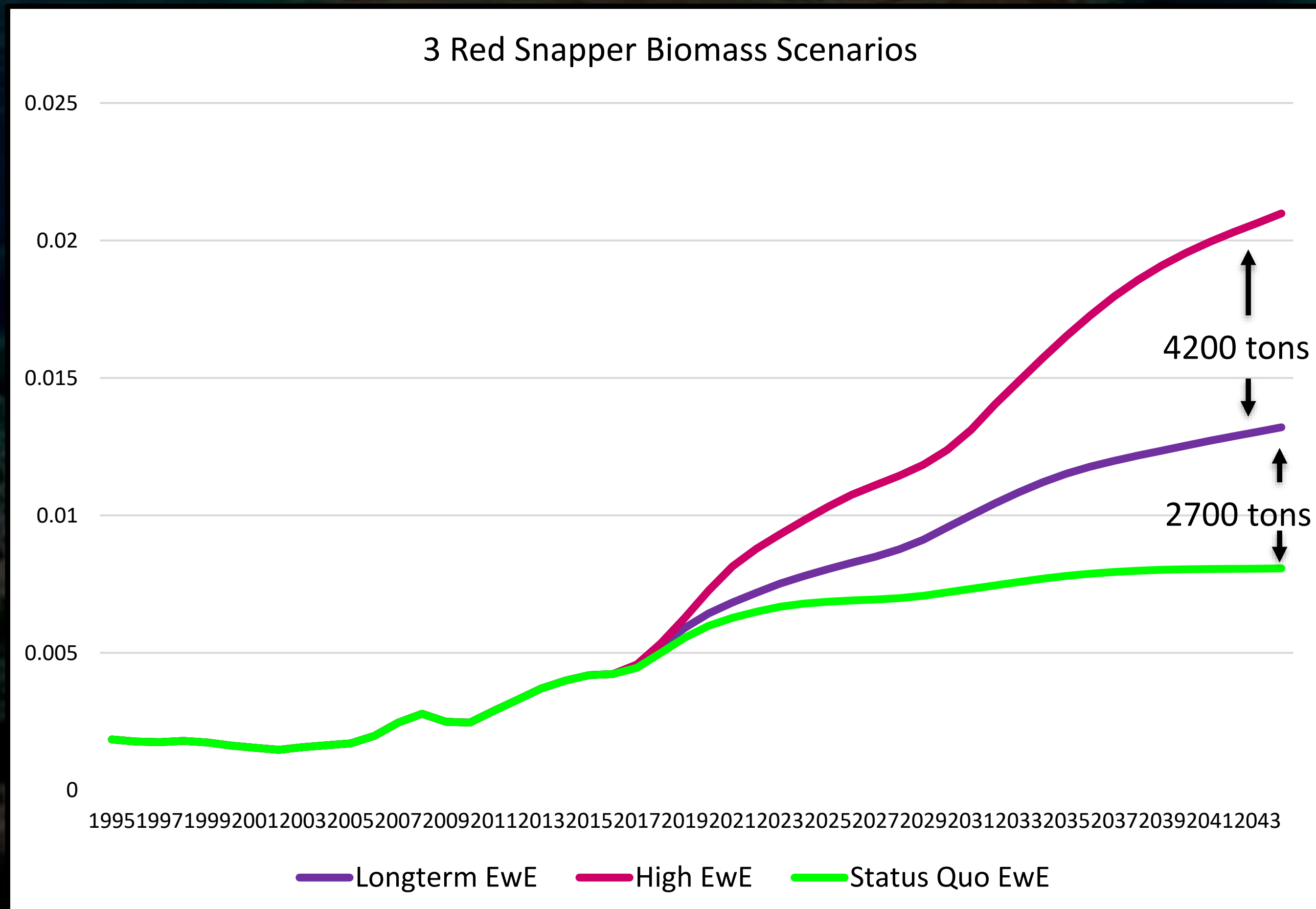
Long-term Average Recruitment

Status Quo

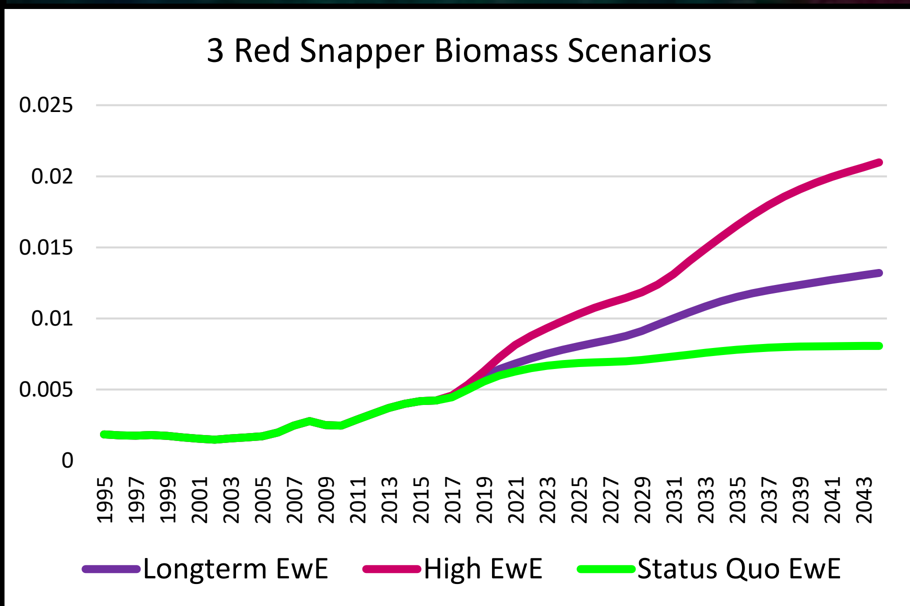


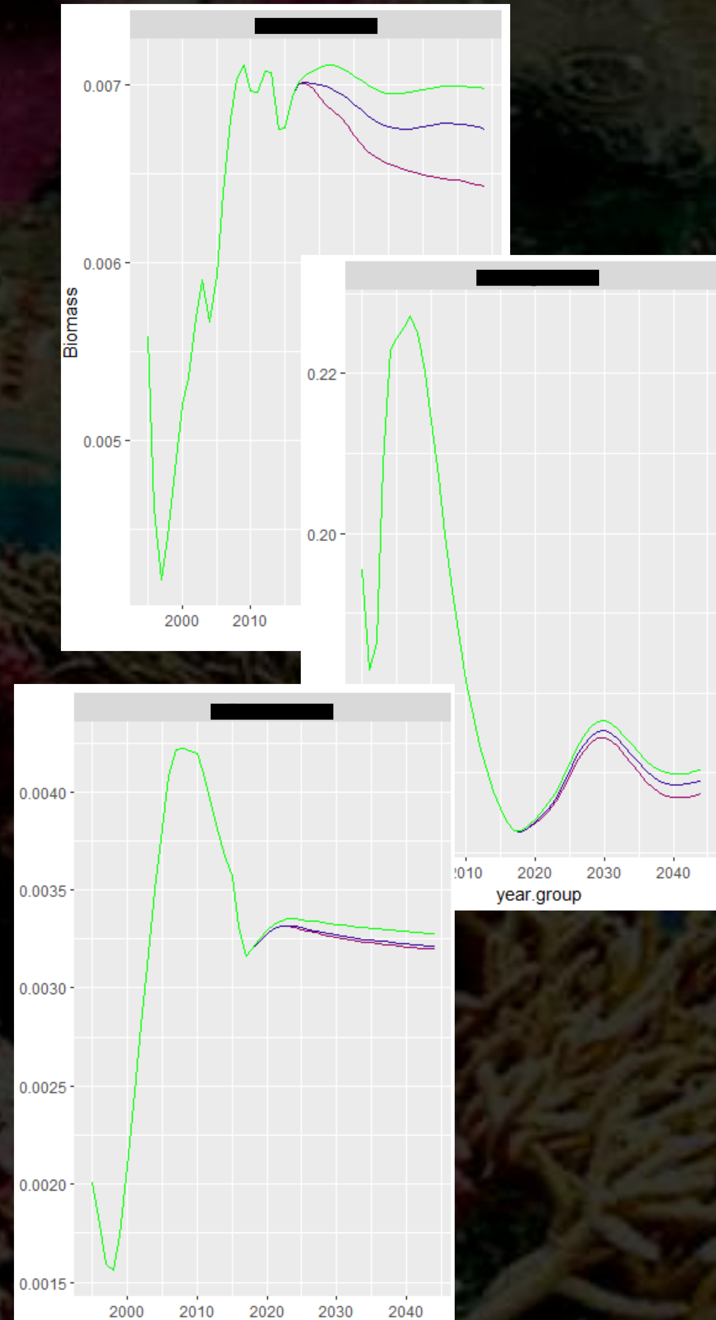




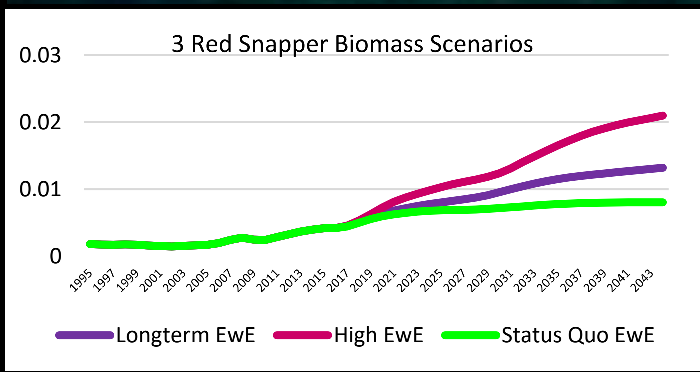


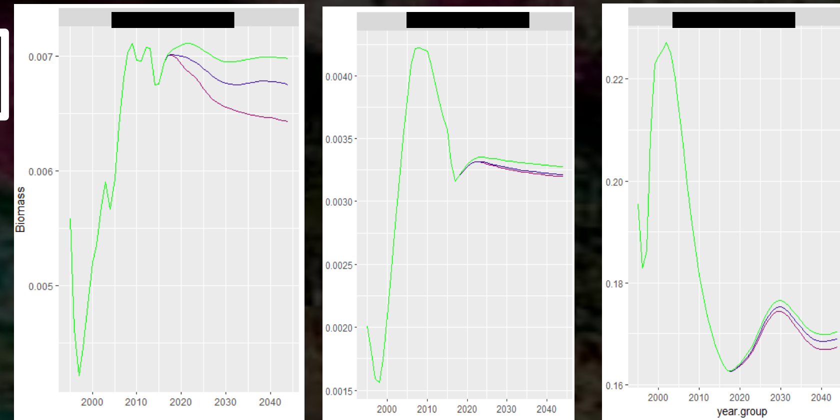
Scenario Testing (Example only)



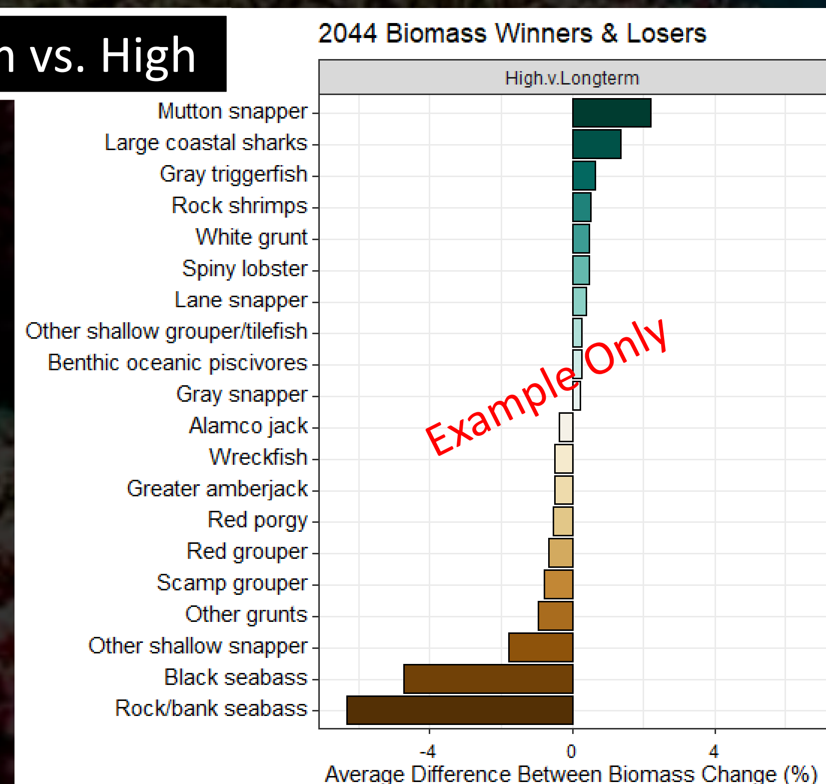


Scenario Testing (Example only)





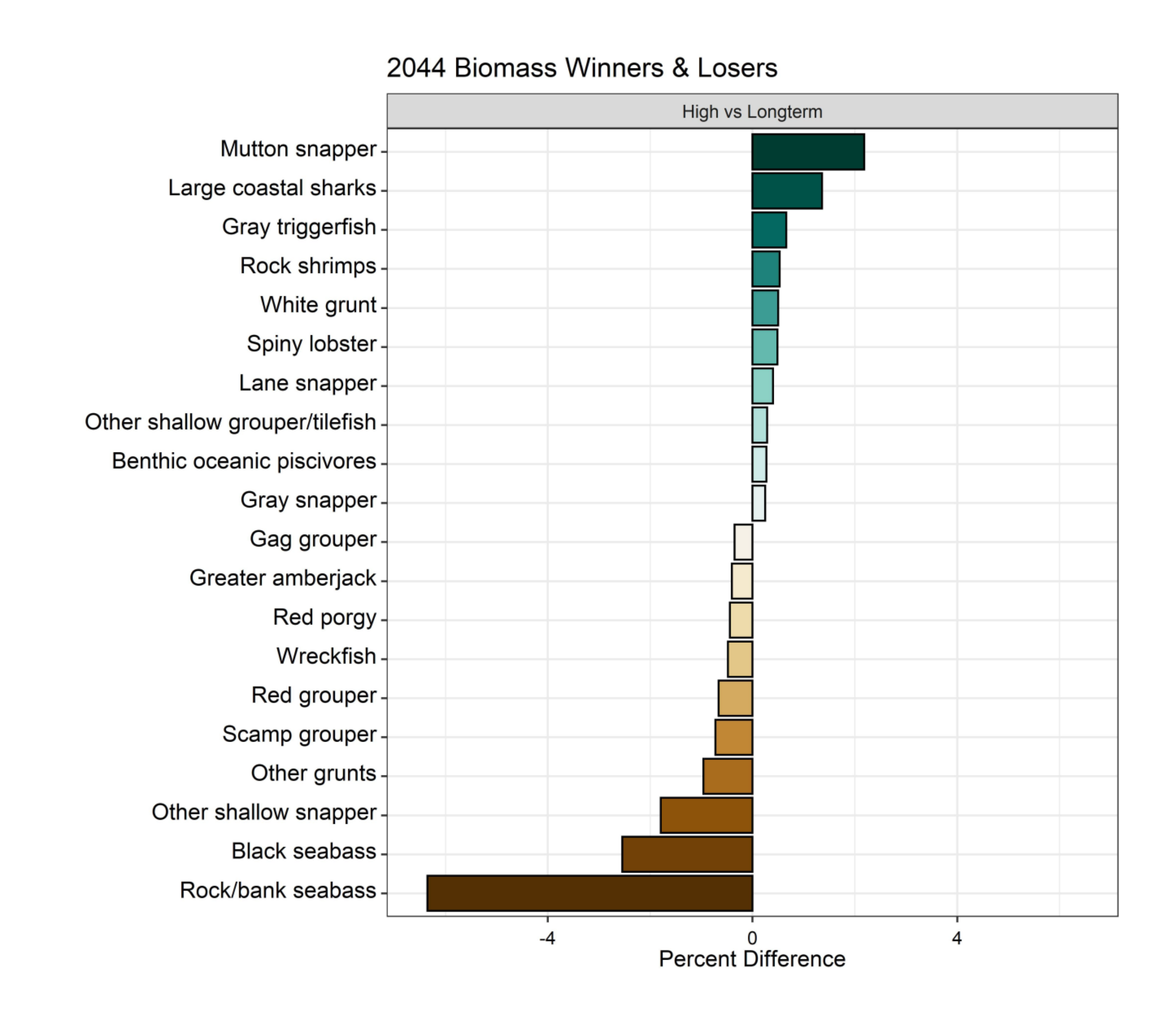
Longterm vs. High



Scenario Testing Results

High Recent Recruitment

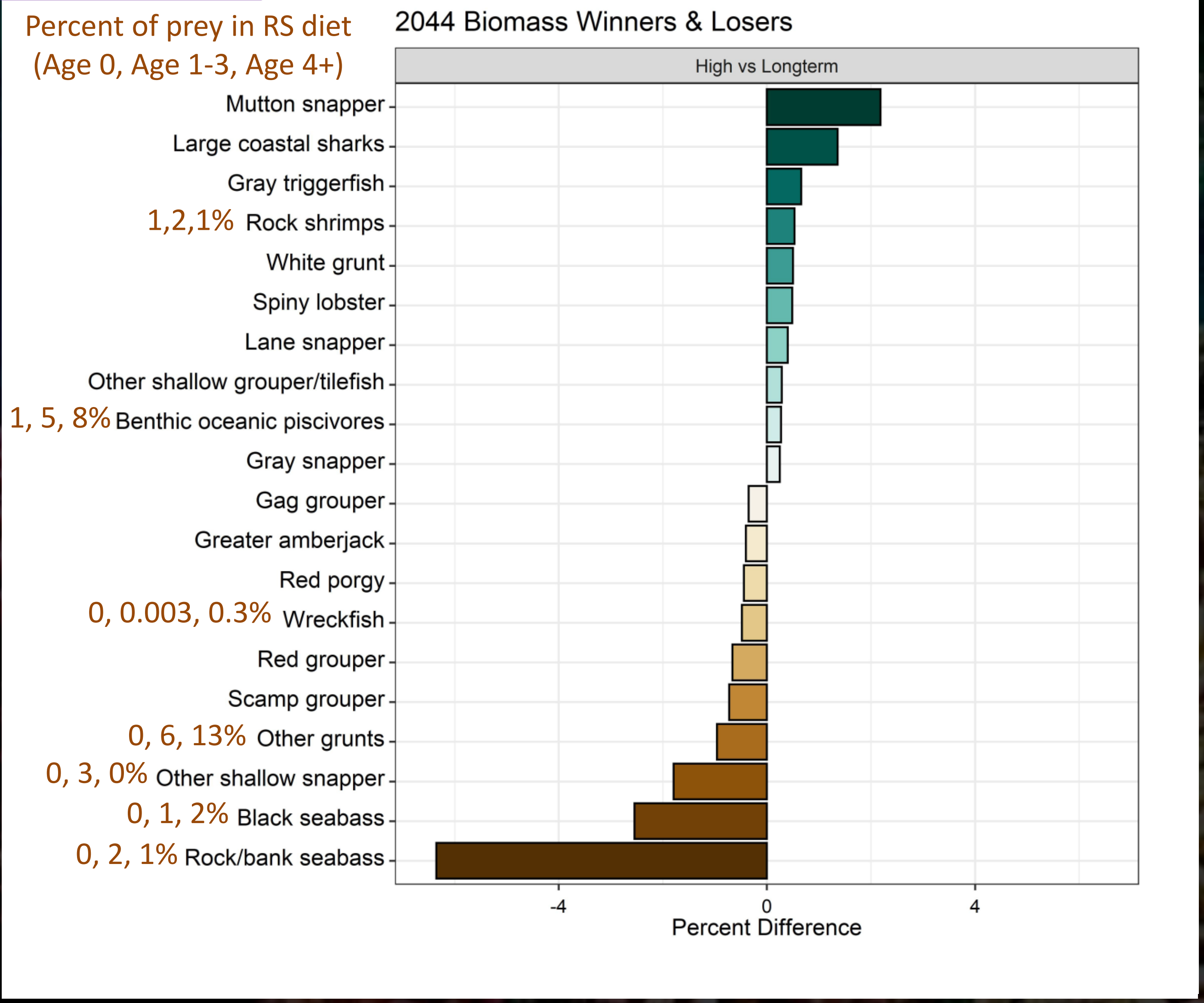
Long-term Average Recruitment



Scenario Testing Results

High Recent Recruitment

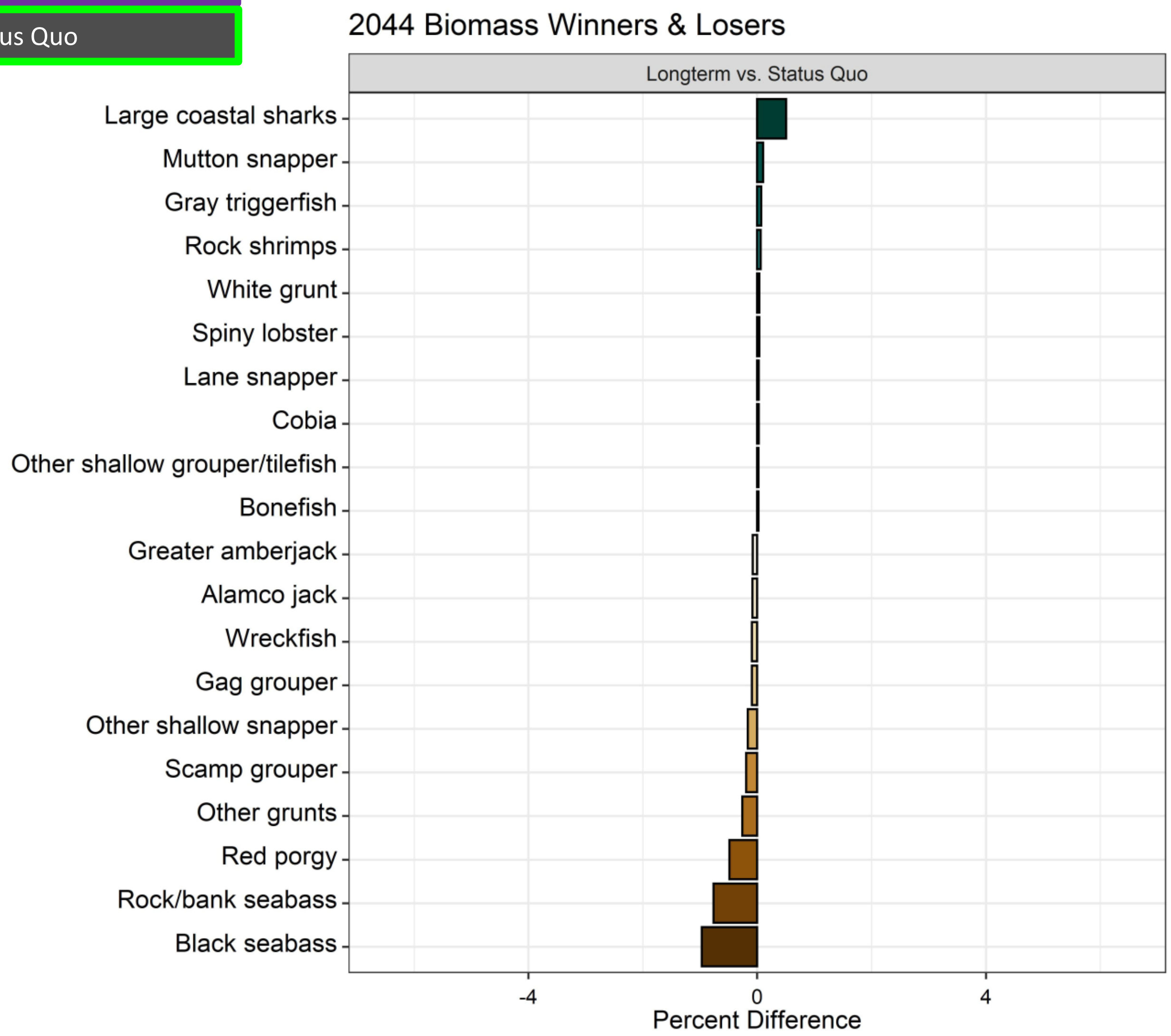
Long-term Average Recruitment



Scenario Testing Results

Long-term Average Recruitment

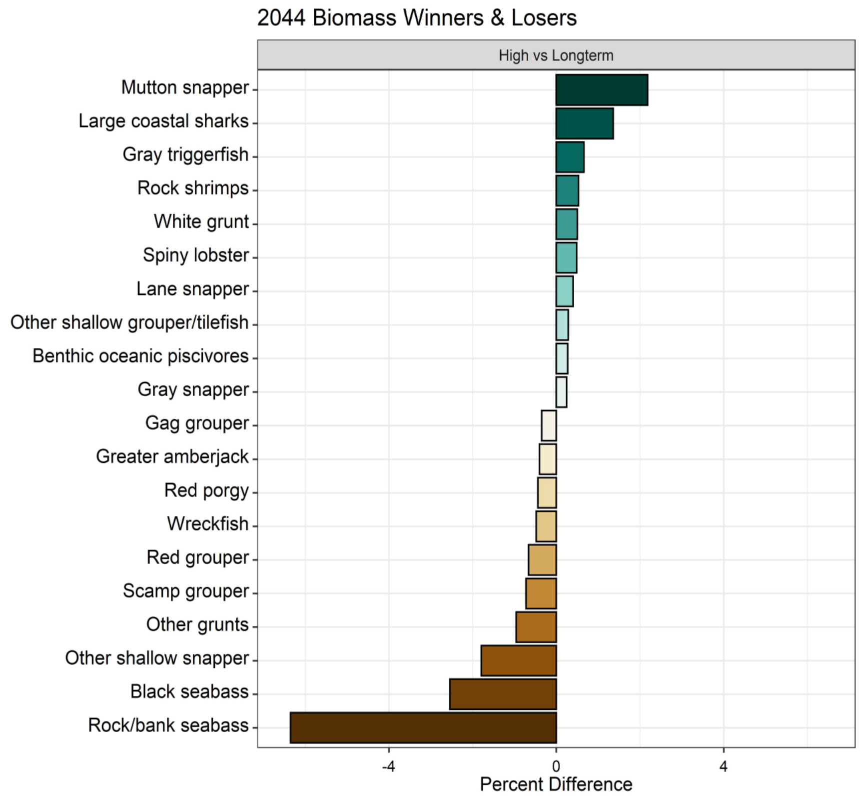
Status Quo



Scenario Testing Results

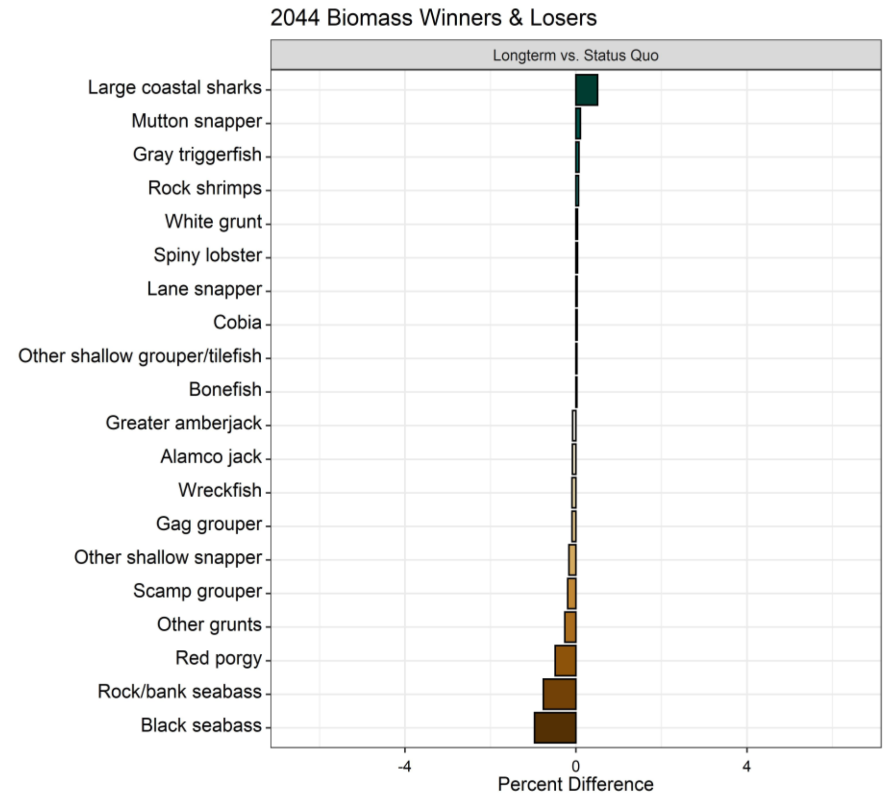
High Recent Recruitment

Long-term Average Recruitment



Long-term Average Recruitment

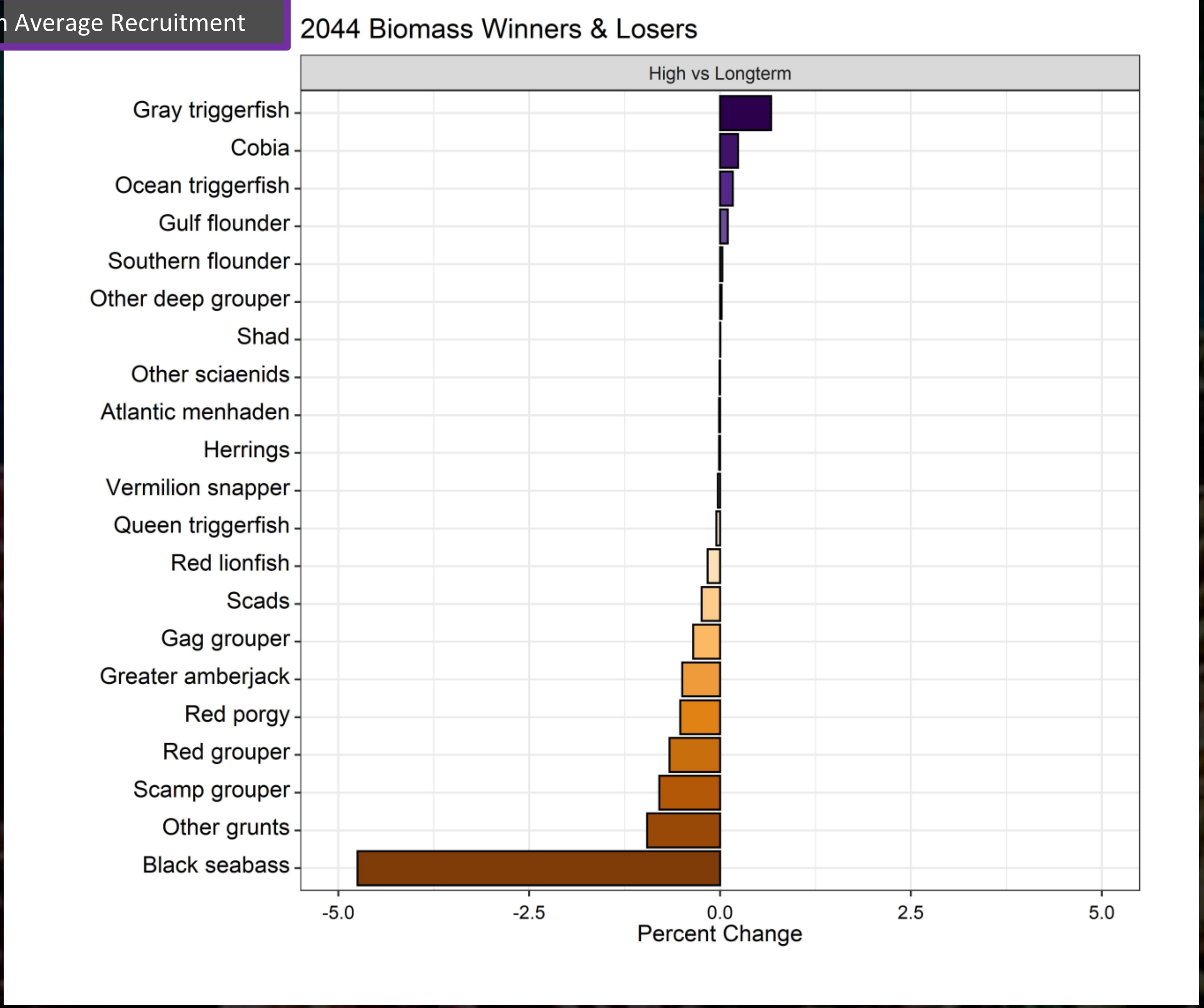
Status Quo



Scenario Testing Results – Important Species for Management

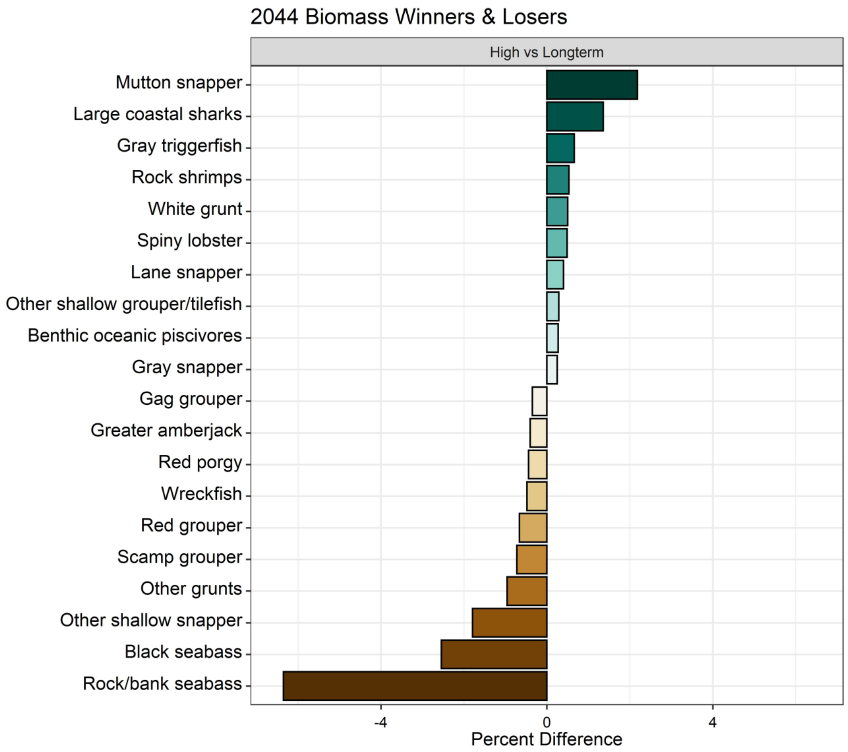
High Recent Recruitment

Long-term Average Recruitment

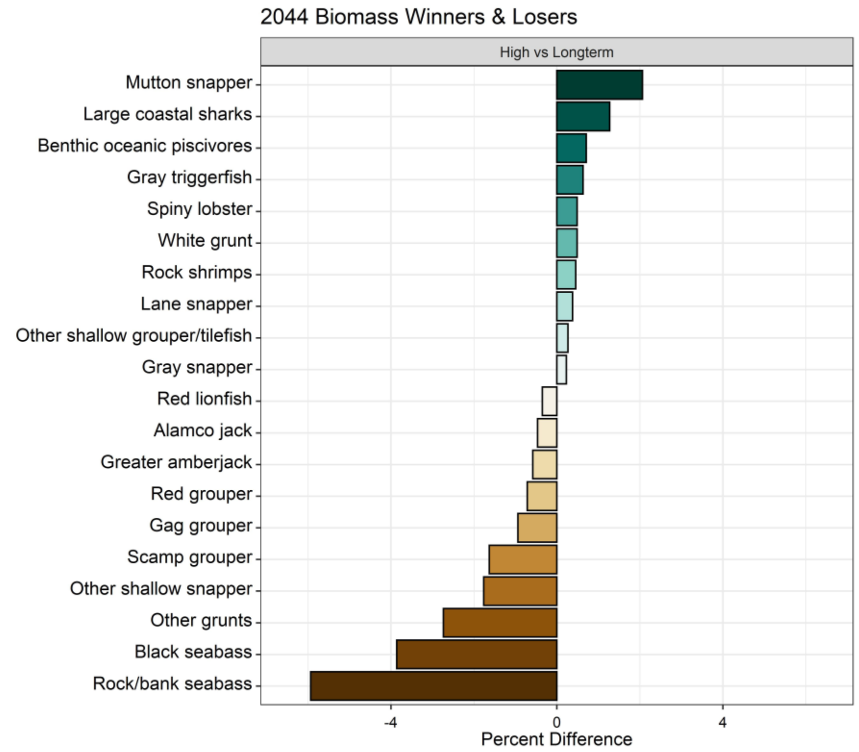


Question from Workgroup: What would happen if you weighted SAR vs. GoM diets 80/20?

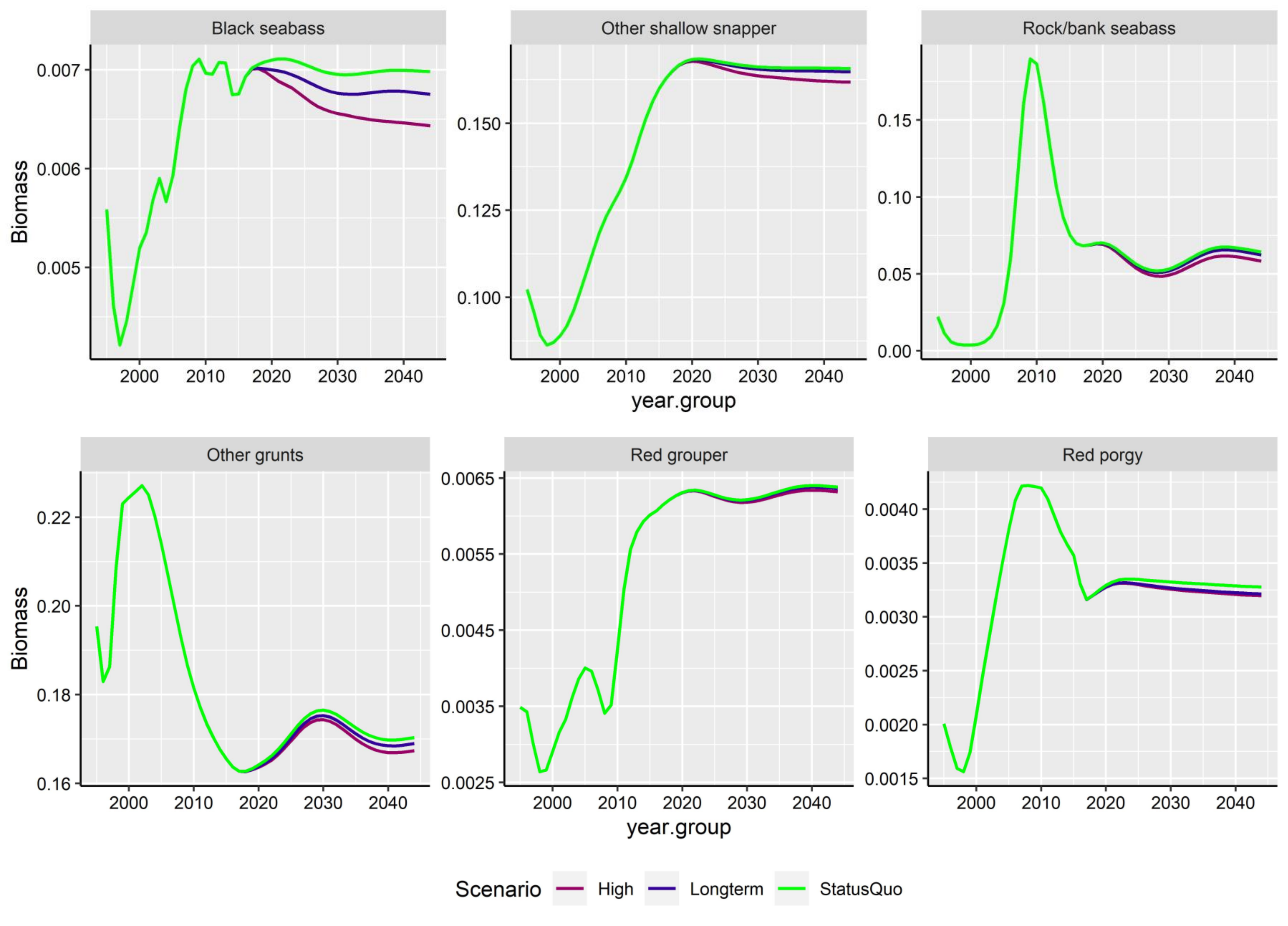
Previous: Weighted only by sample size



Weighted by sample size
and
Weighted SAR 80% : GoM 20%



Preliminary Results



1520 tons 4300 tons

Question from Workgroup:
Are there any interacting effects of catch level on a prey with the impact of high red snapper recruitment on that prey?

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Are there any interacting effects of catch level on a prey with the impact of high red snapper recruitment on that prey?

Levels of BSB Catch extended from 2017 to 2044

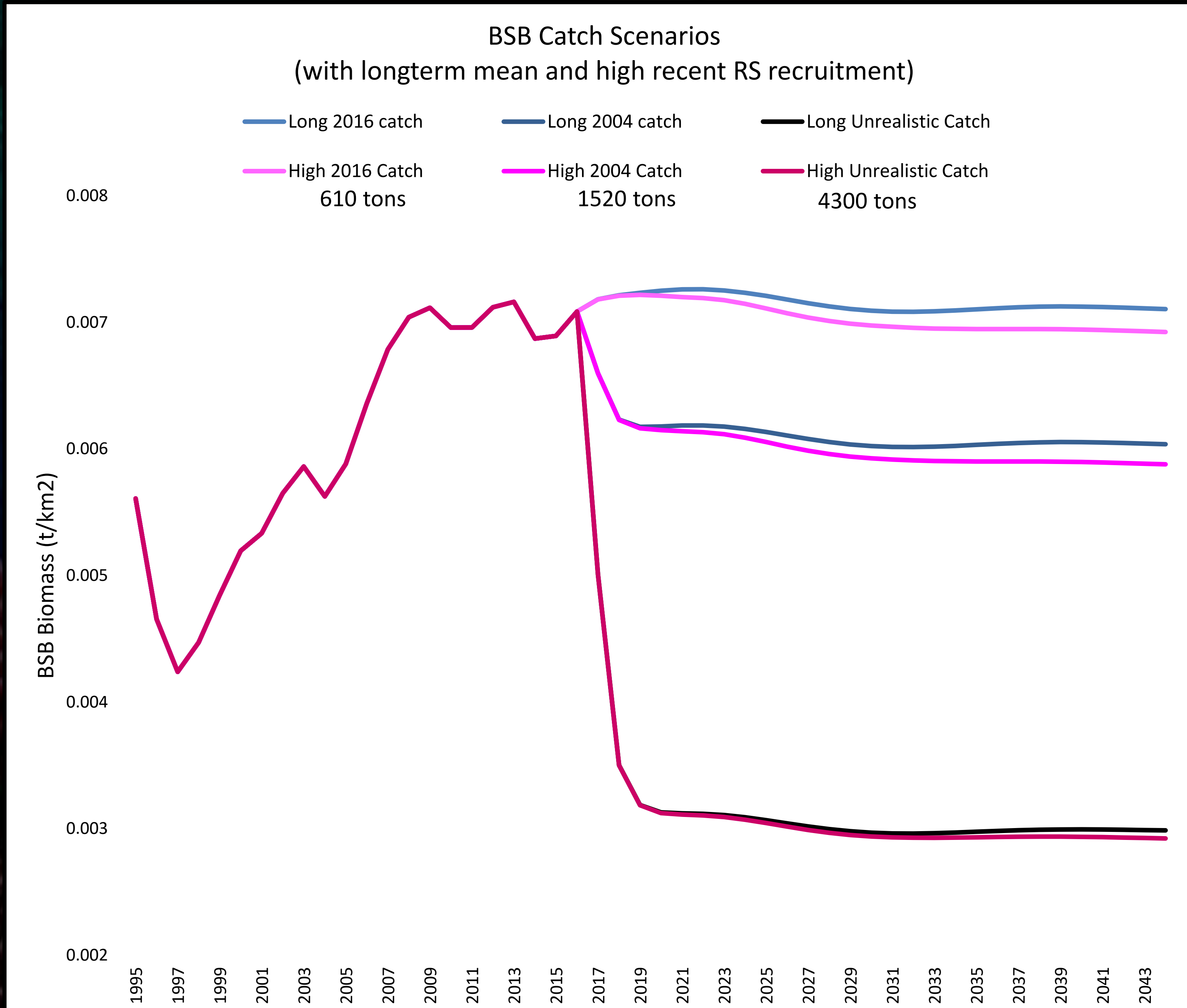
Normal
2016 BSB Catch
610 tons

Large
2004 BSB Catch
1520 tons

Unrealistically Large
BSB Catch
4300 tons

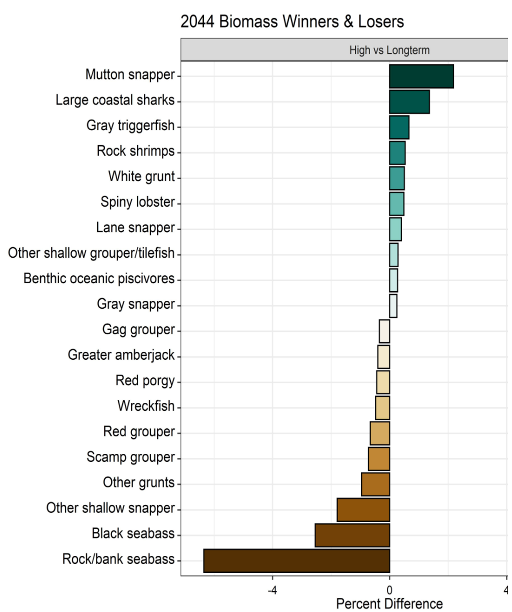
BSB Higher Catches Scenarios

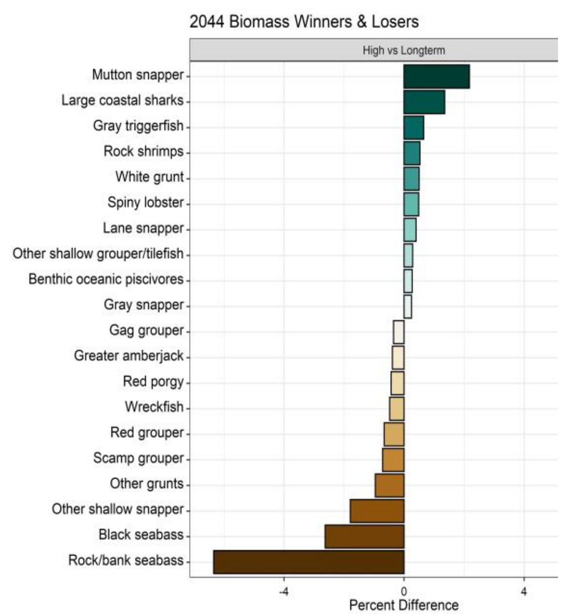
Q: Are there any interacting effects of catch level on a prey with the impact of high red snapper recruitment on that prey?

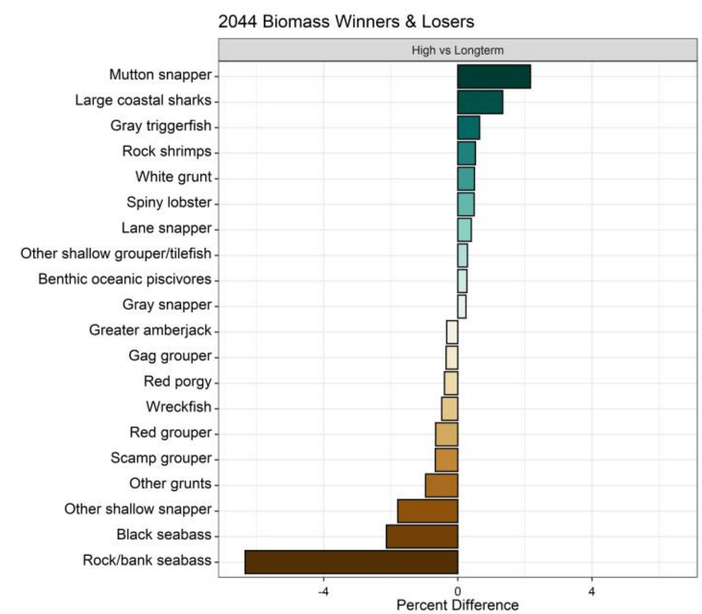


Winners/Losers Under BSB Bigger Catch Scenarios

Normal 2016 BSB Catch 610 tons	Large 2004 BSB Catch 1520 tons	Unrealistically Large BSB Catch 4300 tons







BSB loss -2.36	BSB loss -2.34	BSB loss -2.13

Q: Are there any interacting effects of catch level on a prey with the impact of high red snapper recruitment on that prey?

Question from Workgroup:
If we change the vulnerabilities of Red Snapper (and thus the biomass of red snapper) do the impacts on other species change in magnitude?

What would it take to get to a 10% decrease in black seabass?

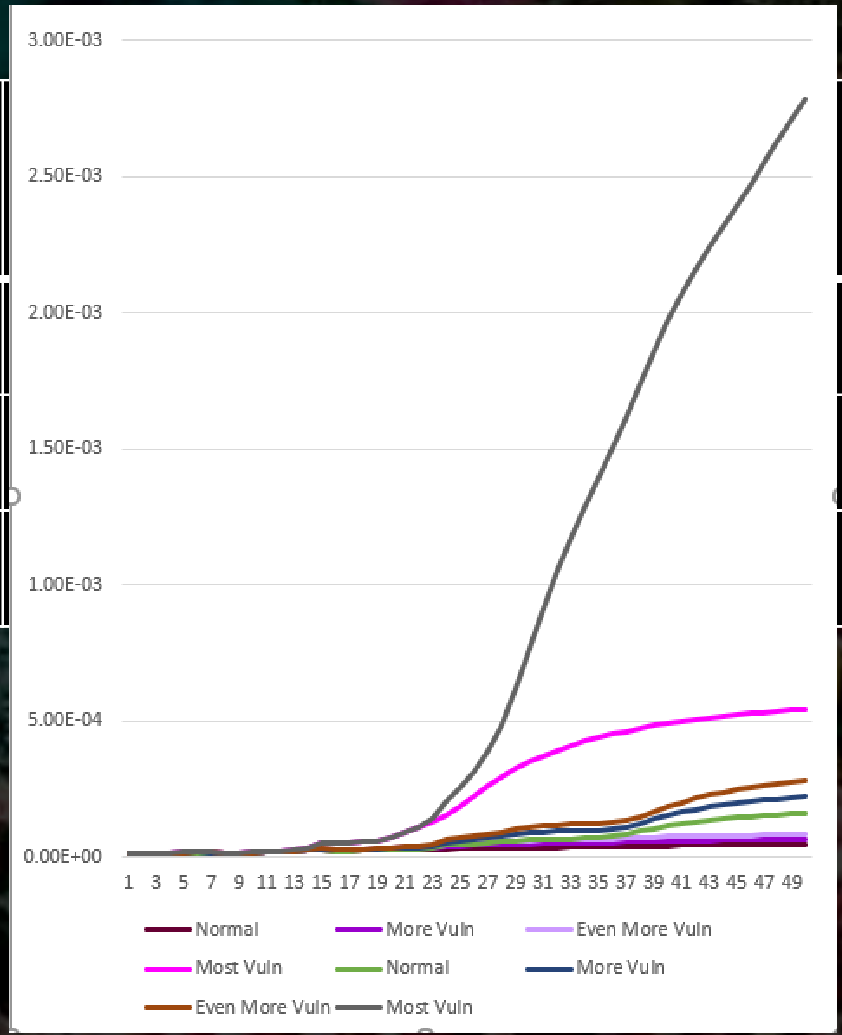
RS Biomass w/ Different Vulnerabliities

	Normal (1x)	1.5x	2x	10x
Age 0	5	7.5	10	50
Age 1-3	10	15	20	100
Age 4+	3.5	5.25	7	350

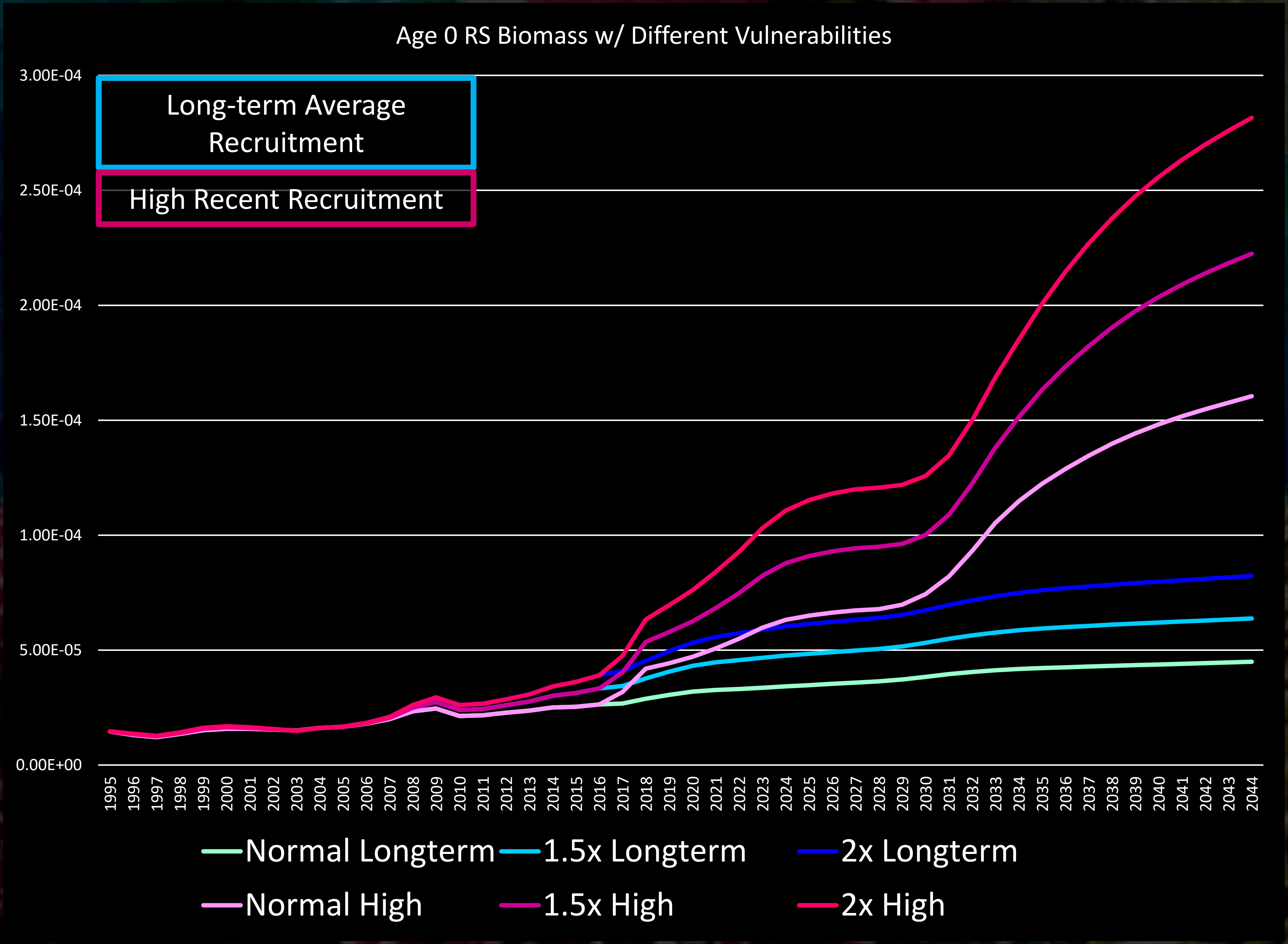
Q: If we change the vulnerabilities of Red Snapper (and thus the biomass of red snapper) do the impacts on other species change in magnitude? What would it take to get to a 10% decrease in black seabass?

RS Biomass w/ Different Vulnerabliities

	10x
Age 0	50
Age 1-3	100
Age 4+	350



“10x” put red snapper biomass off the charts, so it’s not included in the next slides


Age 0 RS Biomass w/ Different Vulnerabilities
Long-term Average Recruitment
High Recent Recruitment
3.00E-04
2.50E-04
2.00E-04
1.50E-04
1.00E-04
5.00E-05
0.00E+00
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
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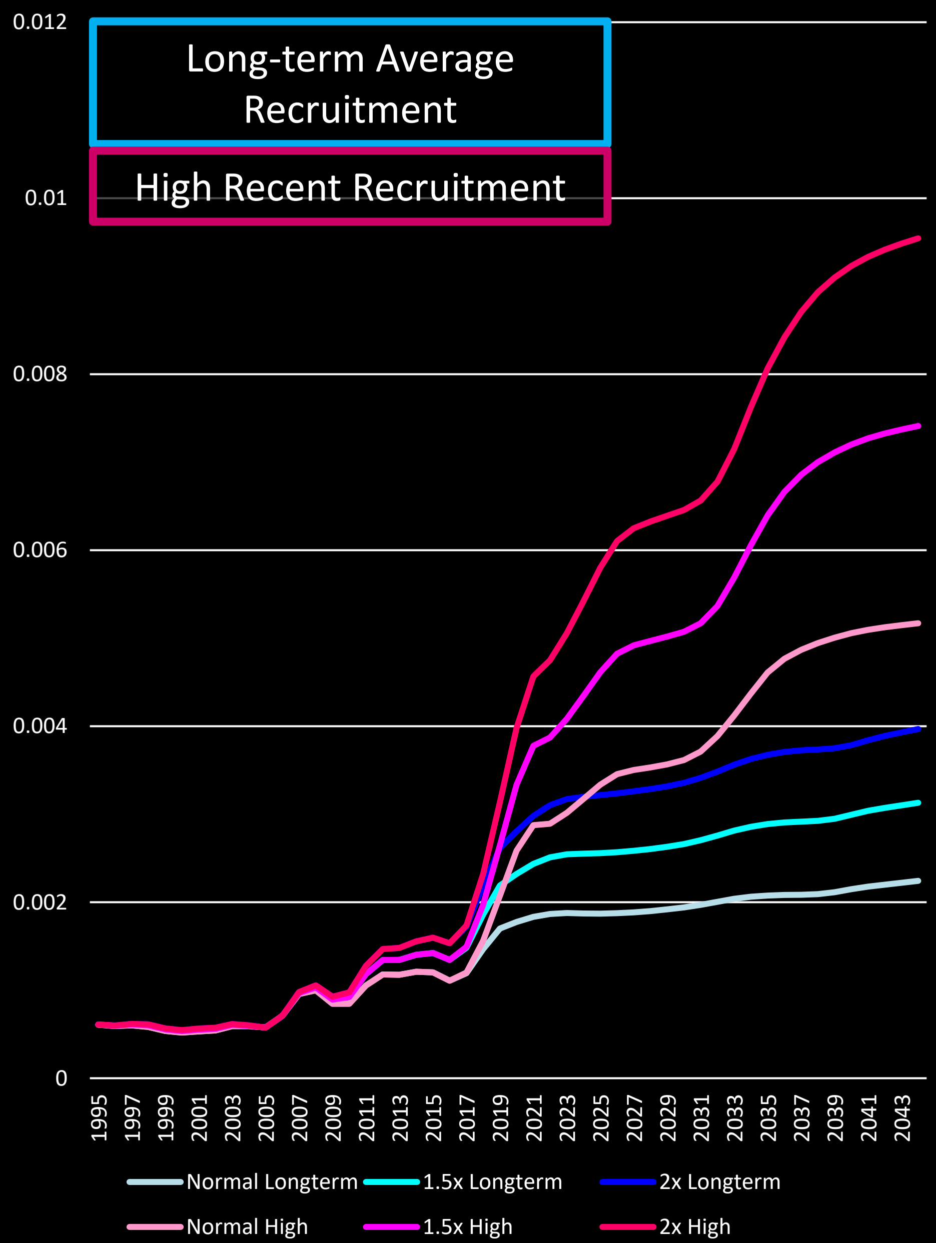
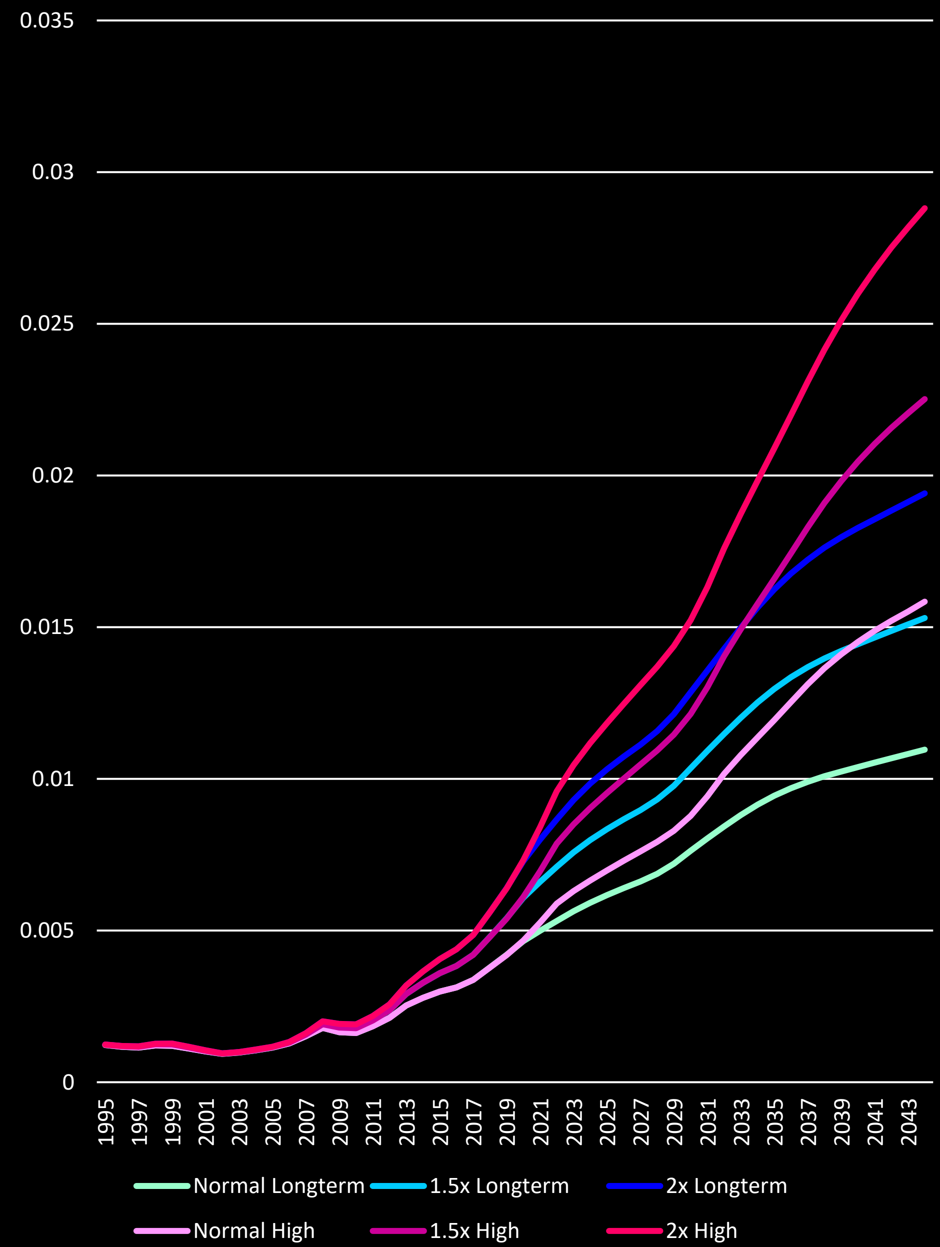
2030
2031
2032
2033
2034
2035
2036
2037
2038
2039
2040
2041
2042
2043
2044
Normal Longterm
1.5x Longterm
2x Longterm
Normal High
1.5x High
2x High

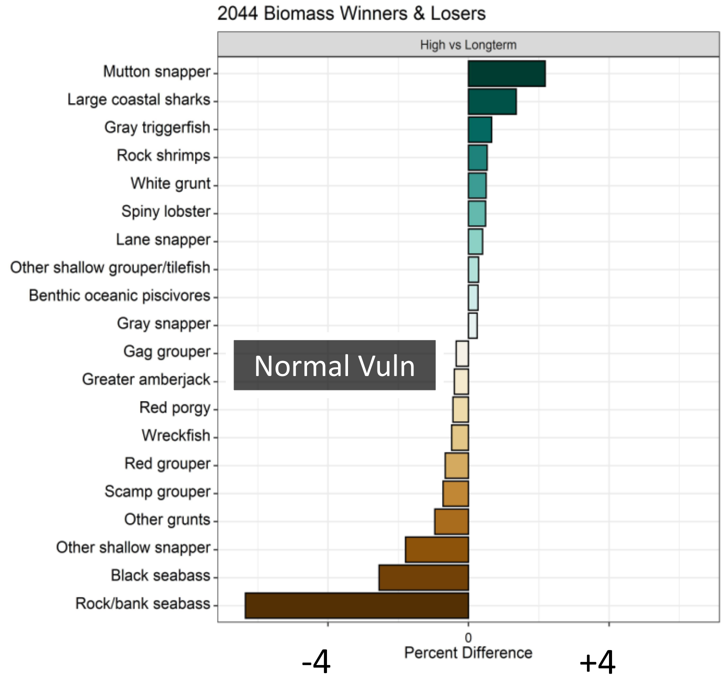
Age 1-3 RS Biomass w/ Different Vulnerabilities

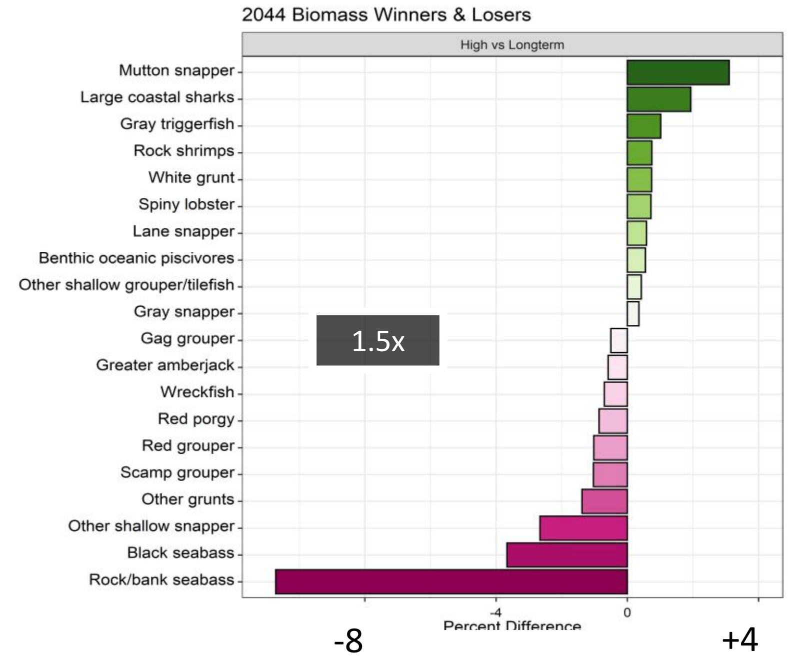


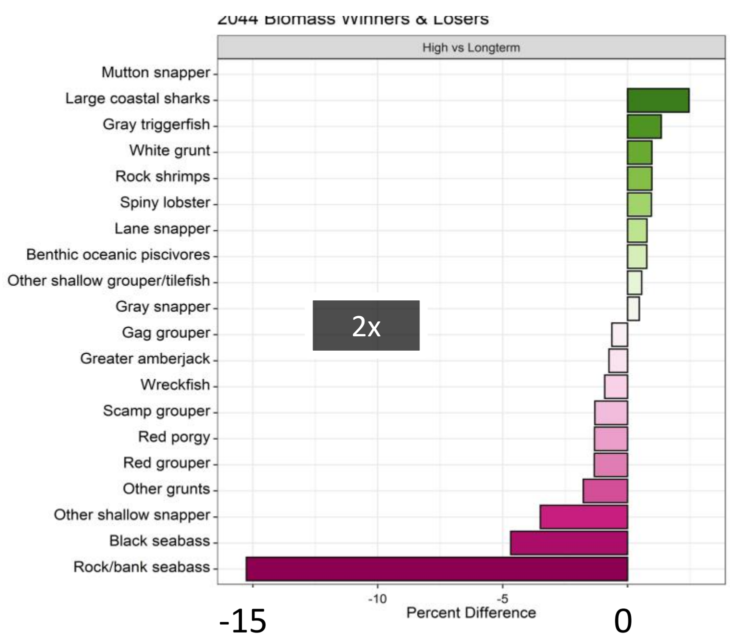
Age 4+ RS Biomass w/ Different Vulnerabilities

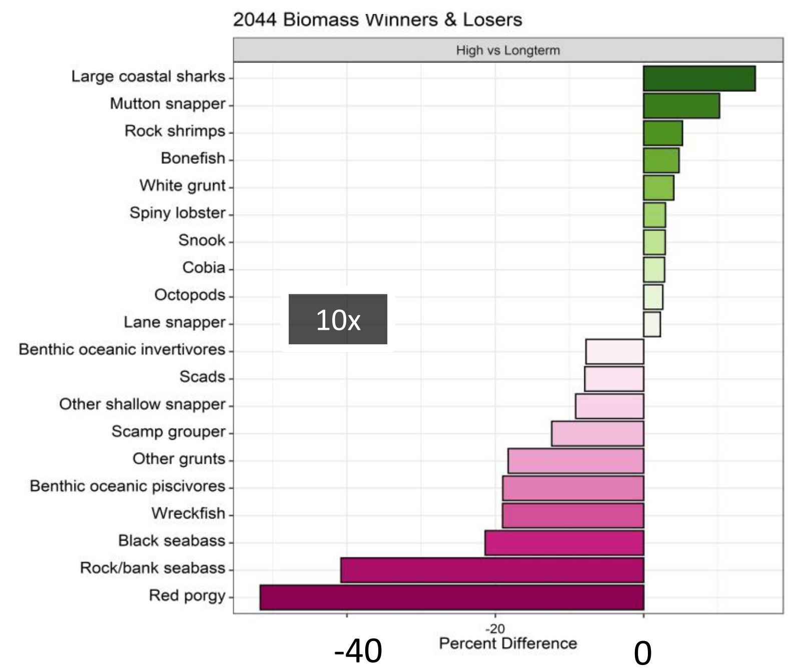


Winners/ Losers Under Different RS Vulnerabilities



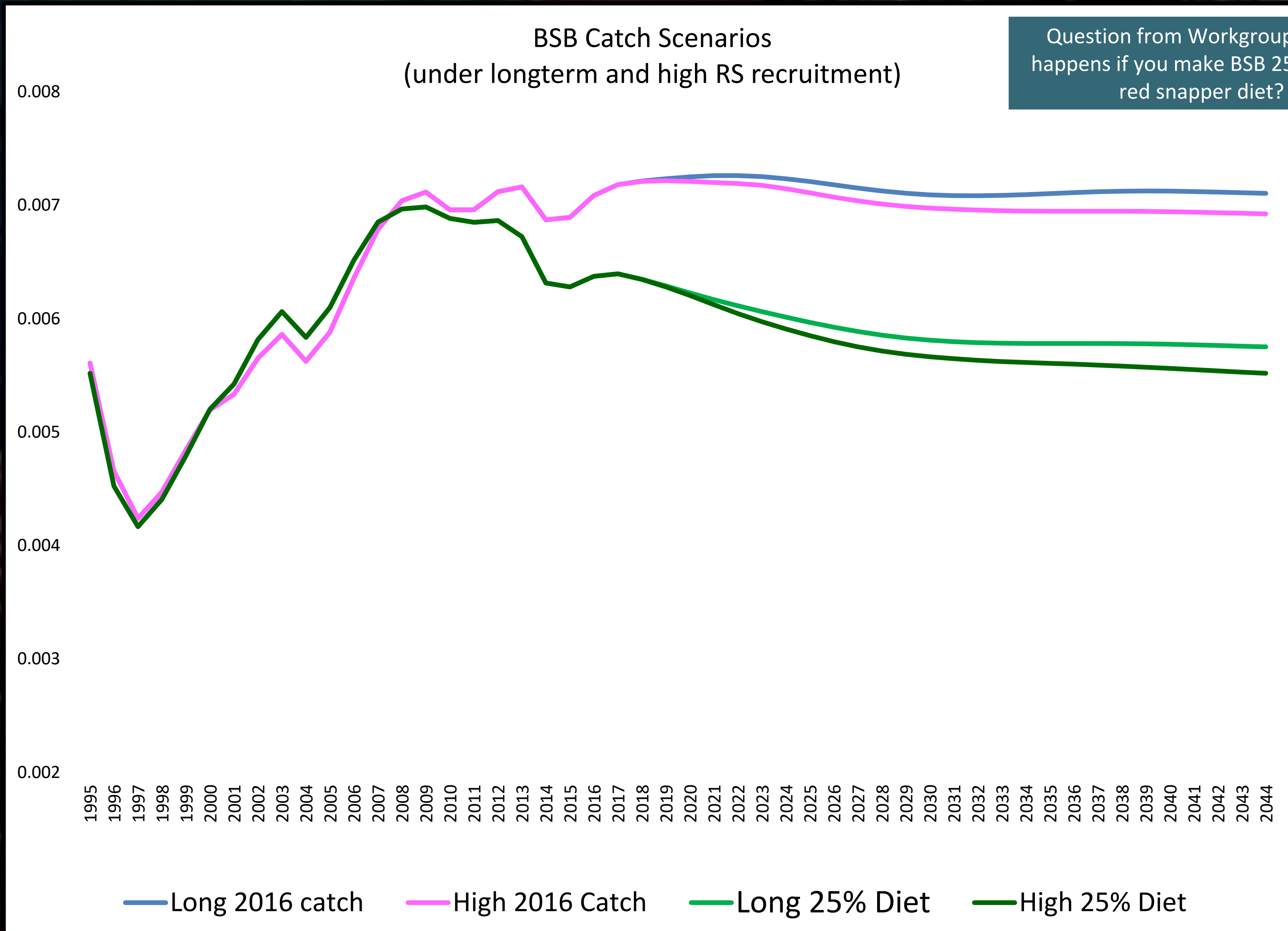






Question from Workgroup:
What happens if you make BSB 25% of the red snapper diet?

Increase BSB to 25% of Age 4+ RS Diet



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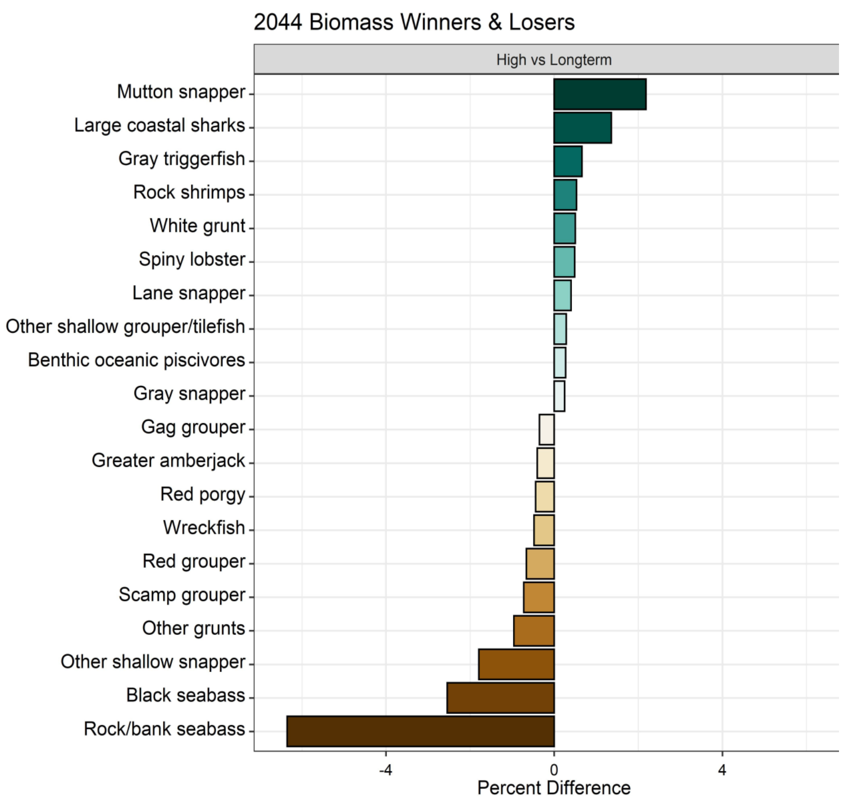
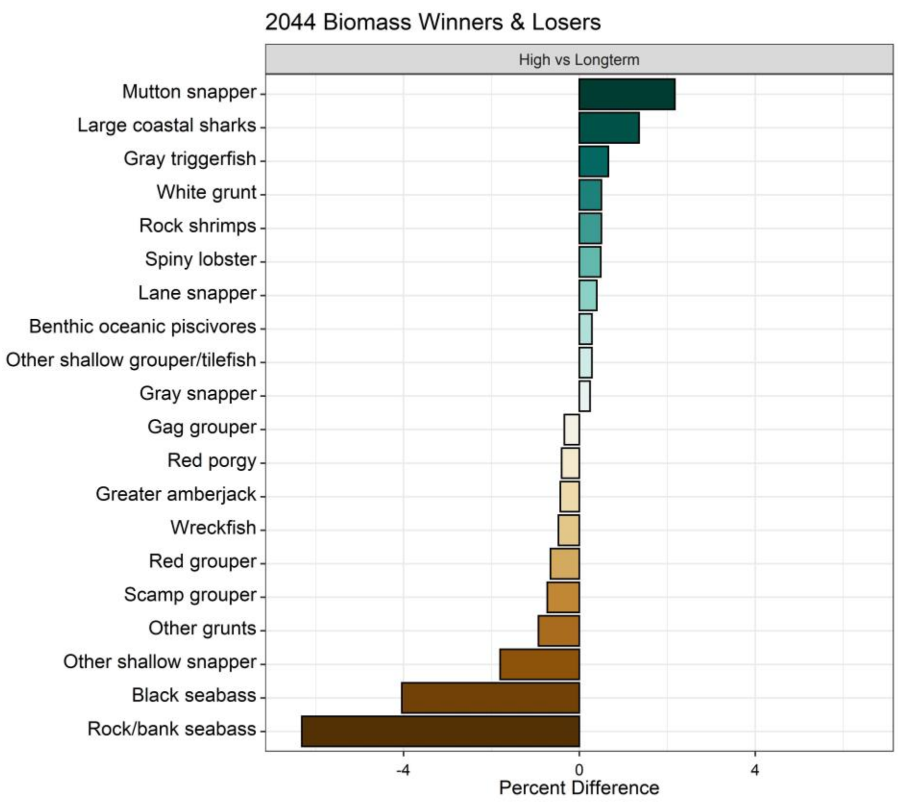
Increase BSB to 25% of Age 4+ RS Diet





Question from Workgroup: Can we see all winners/losers together?

Diets (% wet weight)			Prey Overlap (%)			Mixed Trophic Impacts		Scenario Testing (%Δ B)
Age 0	Age 1-3	Age 4+	Age 0	Age 1-3	Age 4+	Age 1-3	Age 4+	High vs Longterm
29 Mega-invertebrate predators	16 Other grunts	20 Other grunts	78 Red grouper	81 Red snapper age 4+	81 Red snapper age 1-3	0.003 Other shallow grouper/tilefish	0.004 Golden crabs	2.06 Mutton snapper
20 Stomatopods	14 Mega-invertebrate predators	16 Mega-invertebrate predators	77 Yellowtail snapper	69 Dogfish sharks	62 Red grouper	0.003 White grunt	0.002 Nassau grouper	1.27 Large coastal sharks
14 Squids	10 Squids	10 Herrings	76 Demersal rays/skates	67 Benthic coastal invertivores	61 Dogfish sharks	0.002 Spiny lobster	0.001 Halfbeaks	0.71 Benthic oceanic piscivores
8 Bivalves/oysters	8 Herrings	10 Other zooplankton	74 Dogfish sharks	66 Other mid-shelf snapper	55 Benthic coastal invertivores	0.002 Mutton snapper	0.001 Other mid-shelf snapper	0.63 Gray triggerfish
5 Small mobile epifauna	7 Benthic oceanic invertivores	8 Benthic oceanic invertivores	72 Golden tilefish	66 Greater amberjack	52 Black seabass	0.002 Lane snapper	0.001 Goliath grouper	0.49 Spiny lobster
4 Offshore polychaetes	6 Benthic coastal invertivores	7 Small mobile epifauna	72 Red porgy	63 Other deep grouper	52 Other porgys	0.001 Golden crabs	0.001 Gray snapper	0.49 White grunt
3 Benthic coastal invertivores	4 Other zooplankton	5 Benthic oceanic piscivores	71 Benthic coastal invertivores	59 Benthic coastal piscivores	51 Yellowtail snapper	0.001 Gray snapper	0.001 Lane snapper	0.45 Rock shrimps
2 Pelagic planktivores	4 Benthic oceanic piscivores	3 Stomatopods	71 Mutton snapper	58 Summer flounder	50 Demersal rays/skates	0.001 Ocean triggerfish	0.001 Other shallow snapper	0.38 Lane snapper
2 Other zooplankton	3 Small mobile epifauna	3 Scads	71 Other shallow grouper/tilefish	58 Demersal coastal omnivores	50 Red lionfish	0.001 Goliath grouper	0.001 Stone crabs	0.27 Other shallow grouper/tilefish
2 Octopods	3 Benthic coastal piscivores	2 Benthic coastal piscivores	70 Rock/bank seabass	57 Red grouper	49 Halfbeaks	0.001 Demersal coastal omnivores	0.001 Mullets	0.23 Gray snapper
1 Benthic coastal piscivores	2 Rock/Bank seabass	2 Black seabass	67 Other sciaenids	57 Yellowtail snapper	48 Tarpon	0.001 Nassau grouper	0.001 Snook	-0.40 Red lionfish
1 Anchovies	2 Other shallow snapper	2 Rock shrimps	67 Bonefish	55 Vermilion snapper	48 Greater amberjack	0.0004 Large coastal sharks	0.001 Sunfish	-0.47 Alamco jack
1 Carnivorous zooplankton	2 Rock shrimps	2 Octopods	66 Cobia	54 Almaco jack	48 Almaco jack	0.0003 Bonefish	0.0005 Bonefish	-0.58 Greater amberjack
1 Encrusting fauna	2 Stomatopods	2 Squids	65 Benthic oceanic invertivores	53 Demersal coastal piscivores	47 Golden tilefish	0.0003 Gray triggerfish	0.0004 Pilot whales	-0.72 Red grouper
1 Rock shrimps	2 Scads	1 Offshore infaunal crustaceans	63 Lane snapper	53 Red snapper age 0	47 Other grunts	0.0003 Halfbeaks	0.0004 Bar jack	-0.94 Gag grouper
1 Penaeid shrimps	2 Demersal coastal omnivores	1 Benthic coastal invertivores	61 Other mid-shelf snapper	53 Demersal rays/skates	47 Other deep grouper	-0.0005 Sea turtles	-0.001 Other deep grouper	-1.63 Scamp grouper
1 Estuarine infaunal crustaceans	2 Octopods	1 Rock/Bank seabass	61 Goliath grouper	52 Snowy grouper	47 Red porgy	-0.001 Blueline tilefish	-0.001 White grunt	-1.76 Other shallow snapper
1 Estuarine polychaetes	2 Black seabass	1 Penaeid shrimps	61 White grunt	51 White grunt	46 Rock/bank seabass	-0.001 Adult king mackerel	-0.002 Blueline tilefish	-2.74 Other grunts
<1% Benthic oceanic piscivores	1 Penaeid shrimps	1 Other porgys	60 Nassau grouper	50 Gray snapper	46 Other shallow snapper	-0.001 Scamp grouper	-0.002 Greater amberjack	-3.86 Black seabass
<1% Demersal coastal piscivores	1 Offshore infaunal crustaceans	1 Echinoderms and gastropods	59 Queen triggerfish	50 Nassau grouper	45 Goliath grouper	-0.001 Red porgy	-0.003 Red grouper	-5.94 Rock/bank seabass
<1% Demersal coastal omnivores	1 Anchovies	<1% Pelagic planktivores	59 Vermilion snapper	49 Black seabass	44 Red snapper age 0	-0.001 Wreckfish	-0.003 Adult king mackerel	
<1% Ichthyoplankton	1 Other porgys	<1% Encrusting fauna	57 Small coastal sharks	49 Other porgys	44 Scamp grouper	-0.001 Gag grouper	-0.003 Wreckfish	
<1% Demersal coastal invertivores	<1% Encrusting fauna	<1% Other jacks	57 Rock shrimps	48 Benthic oceanic piscivores	43 Nassau grouper	-0.001 Greater amberjack	-0.005 Benthic oceanic piscivores	
<1% Estuarine benthic detritus	<1% Carnivorous zooplankton	<1% Offshore benthic detritus	56 Red drum	48 Pelagic oceanic piscivores	43 Other shallow grouper/tilefish	-0.001 Vermilion snapper	-0.007 Scamp grouper	
<1% Seagrasses	<1% Estuarine infaunal crustaceans	<1% Red porgy	56 Gray snapper	48 Offshore dolphins	43 Cobia	-0.001 Red grouper	-0.007 Gag grouper	
<1% Echinoderms and gastropods	<1% Echinoderms and gastropods	<1% Estuarine infaunal crustaceans	55 Black seabass	47 Wreckfish	42 Bonefish	-0.001 Benthic oceanic piscivores	-0.007 Rock/bank seabass	
<1% Benthic meiofauna	<1% Other jacks	<1% Syngnathids	53 Snowy grouper	46 Other shallow grouper/tilefish	42 Gray snapper	-0.004 Red lionfish	-0.009 Other grunts	
	<1% Estuarine polychaetes	<1% Demersal coastal piscivores	53 Red snapper age 1-3	45 Other shallow snapper	41 Mutton snapper	-0.006 Black seabass	-0.009 Black seabass	
	<1% Pelagic planktivores	<1% Other sciaenids	52 Other deep grouper	45 Beaked whales	40 Snowy grouper	-0.007 Other shallow snapper	-0.018 Red porgy	
	<1% Offshore benthic detritus	<1% Ichthyoplankton	49 Octopods	44 Halfbeaks	40 Gag grouper	-0.015 Rock/bank seabass	-0.020 Red lionfish	

Diets (% wet weight)						Prey Overlap (%)						Mixed Trophic Impacts				Scenario Testing (%Δ B)	
Age 0		Age 1-3		Age 4+		Age 0		Age 1-3		Age 4+		Age 1-3		Age 4+		High vs Longterm	
29	Mega-invertebrate predators	16	Other grunts	20	Other grunts	78	Red grouper	81	Red snapper age 4+	81	Red snapper age 1-3	0.003	Other shallow grouper/tilefish	0.004	Golden crabs	2.06	Mutton snapper
20	Stomatopods	14	Mega-invertebrate predators	16	Mega-invertebrate predators	77	Yellowtail snapper	69	Dogfish sharks	62	Red grouper	0.003	White grunt	0.002	Nassau grouper	1.27	Large coastal sharks
14	Squids	10	Squids	10	Herrings	76	Demersal rays/skates	67	Benthic coastal invertivores	61	Dogfish sharks	0.002	Spiny lobster	0.001	Halfbeaks	0.71	Benthic oceanic piscivores
5	Small mobile epifauna	7	Benthic oceanic invertivores	8	Benthic oceanic invertivores	72	Golden tilefish	66	Greater amberjack	52	Black seabass	-0.001	Adult king mackerel	-0.005	Benthic oceanic piscivores	0.49	Spiny lobster
4	Offshore polychaetes	6	Benthic coastal invertivores	7	Small mobile epifauna	72	Red porgy	63	Other deep grouper	52	Other porgys	-0.001	Scamp grouper	-0.007	Scamp grouper	0.49	White grunt
3	Benthic coastal invertivores	4	Other zooplankton	5	Benthic oceanic piscivores	71	Benthic coastal invertivores	59	Benthic coastal piscivores	44	Red snapper age 0	-0.001	Red porgy	-0.007	Gag grouper	0.45	Rock shrimps
2	Pelagic planktivores	4	Benthic oceanic piscivores	3	Stomatopods	55	Black seabass	58	Summer flounder	44	Scamp grouper	-0.001	Benthic oceanic piscivores	-0.007	Rock/bank seabass	-1.63	Scamp grouper
2	Other zooplankton	2	Demersal coastal omnivores	3	Scads	53	Snowy grouper	58	Demersal coastal omnivores	43	Nassau grouper	-0.004	Red lionfish	-0.009	Other grunts	-1.76	Other shallow snapper
2	Octopods	2	Octopods	2	Benthic coastal piscivores	53	Red snapper age 1-3	50	Nassau grouper	43	Other shallow grouper/tilefish	-0.006	Black seabass	-0.009	Black seabass	-2.74	Other grunts
1	Benthic coastal piscivores	2	Black seabass	2	Black seabass	52	Other deep grouper	49	Black seabass	42	Gray snapper	-0.007	Other shallow snapper	-0.018	Red porgy	-3.86	Black seabass

Question from Workgroup:
Can we see all winners/losers together?

The full table is available as page 22 of the EwE Workshop Report, and as a high-resolution PDF in the briefing book

Workshop Conclusions

Overall model conclusions

1. Model properly addressed the question and demonstrated which species have positive and negative changes in biomass due to Red Snapper recruitment.
   - Higher red snapper biomass led to negative changes in biomass to Bank Sea Bass, Black Sea Bass, and other grunts (Tomtate).
   - Minor negative changes in biomass were observed for Red Grouper, Gag Grouper, and Scamp
   - Positive effects were observed for Mutton Snapper and large coastal sharks

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

3. Increasing Red Snapper recruitment could increase abundance of some species and lead to decreases for other. Higher Red Snapper recruitment could reduce biomass of black sea bass, but the scale of the impacts is minor (less than 5%).

Workshop Conclusions

4. These findings can be used to direct data collection needs such as Red Lionfish, which has minimal biomass in the model in and shows negative impacts. These results could also inform better monitoring of species with high management interest and negative impacts when Red Snapper is increasing, such as black sea bass.

5. 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).

6. These results are on a similar scale to modeling efforts on reef fish from West Florida Shelf. This is likely due to the generalist nature of the species in question.

Workshop Conclusions

7. Operationalizing the model could be based on regular data updates which will require re-fitting (1-2 months for very large changes).

8. Development of EwE models is an iterative process and the more the model is explored, the better it will become

Model Team

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Contributors

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Appendix

142 groups (part 1)

MAMMALS	TAXONOMIC GROUPS	TROPHIC GROUPS	AVES
Coastal bottlenose dolphin	Mullets	Highly migratory pelagics	Birds -- oceanic piscivores
Offshore dolphins	Other sciaenids	Pelagic oceanic piscivores	Birds -- shorebirds
Pilot whales	Sardines	Pelagic coastal piscivores	Birds -- shelf piscivores
Beaked whales	Anchovies	Demersal coastal piscivores	Birds -- herbivores
Sperm whales	Silversides	Pelagic planktivores	Birds -- wading piscivores
Baleen whales	Halfbeaks	Demersal coastal invertivores	Birds -- shelf invertivores
Manatees	Scads	Demersal coastal omnivores	Birds -- raptors
ELASMOBRANCHS	Shad	Benthic oceanic piscivores	**REPTILES**
Planktivorous sharks	Sygnathids	Benthic oceanic invertivores	Sea turtles
Large coastal sharks	Other shallow grouper/tilefish	Benthic coastal piscivores	**PHOTOSYNTHETICS**
Small coastal sharks	Other deep grouper	Benthic coastal invertivores	Phytoplankton
Dogfish sharks	Other shallow snapper	Benthic coastal planktivores	Microphytobenthos
Pelagic sharks	Other mid-shelf snapper		Benthic macroalgae
Pelagic rays	Other jacks		Pelagic macroalgae
Demersal rays/skates	Other porgys		Seagrasses
	Other grunts		Marsh vegetation
	Herrings		

140 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		