South Atlantic Region Ecopath Mode

‘Finalized’

SAFMC SSC Meeting, 9-11 April 2019

Tom Okey, Ocean Integrity Research and the University of Victoria
Roger Pugliese, South Atlantic Fishery Management Council
Howard Townsend, NOAA/NMFS/ST/Ecosystems
Lauren Gentry, Florida Fish and Wildlife Conservation Commission

SAR Model Nicknames

- The Squid Model
- The Updated Fish Diets model
- The Who Eats Snappers/Groupers Model
- The Time Series Model
- The Most Articulated Ecopath Model for Fisheries Research
- The Model That Killed MSY

TALK OUTLINE

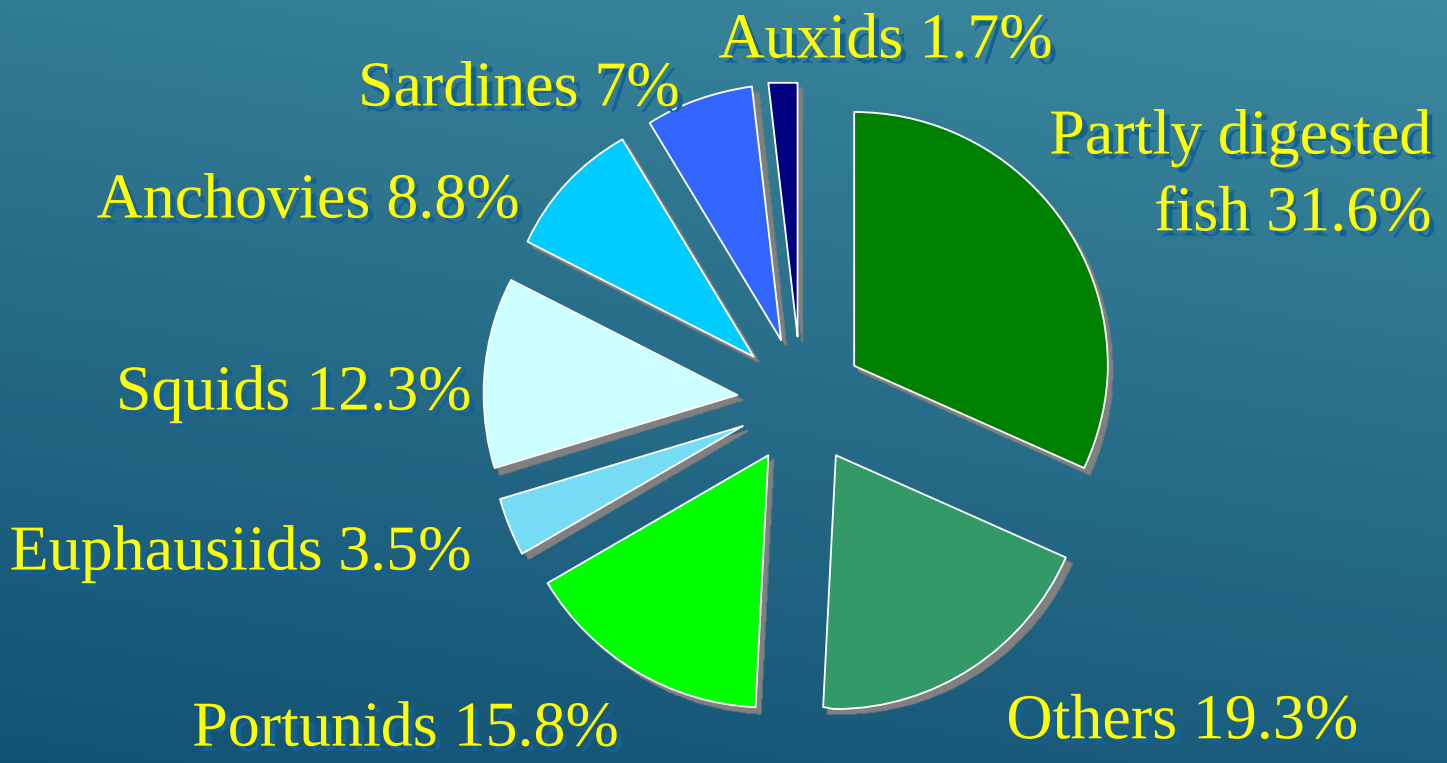
- **Final assembly of the 143-box South Atlantic Region Ecopath model**
- **Examples of Explorations:**
  - **Reconstructing past ecosystem change**
  - **Red snapper and black sea bass interactions**
  - **Simulate varying fishing mortality on large coastal sharks and managed species response**
  - **Exploration of the ecosystem effects of MSY for all managed species**

QUALITY DATA UNDERLYING THE SAR MODEL

Data	Contacts
Diets: Southeast Reef Fish Survey (SERFS): MARMAP/SEAMAP-SA/SEFIS …and other sources.	Tracey Smart, Kevin Spanik, Marcel Reichert
Diets: Refining diet matrix of the SAR model with Ecospecies data staff	Lauren Gentry, Kathleen Okeife
SERFS: MARMAP/SEAMAP-SA/SEFIS Abundance index data	Tracey Smart, Kevin Spanik, Marcel Reichert
SEAMAP-SA Coastal Trawl Survey biomass data	Tracey Smart, Kevin Spanik, Marcel Reichert
South Atlantic Commercial Landings 1995-2017	Julie Defilippi Simpson, Mike Rinaldi
Annual total biomass & catch from SA assessments (SEDAR)	Kevin Craig
Headboat recreational landings and Discards, SRHS_SA 1981-2016	Kelly Fitzpatrick
Recreational, non-headboat, MRIP – Marine Recreational Program	Online queries by Tom and Lauren
Spatial data from various sources	Rua Mordecai and other contacts

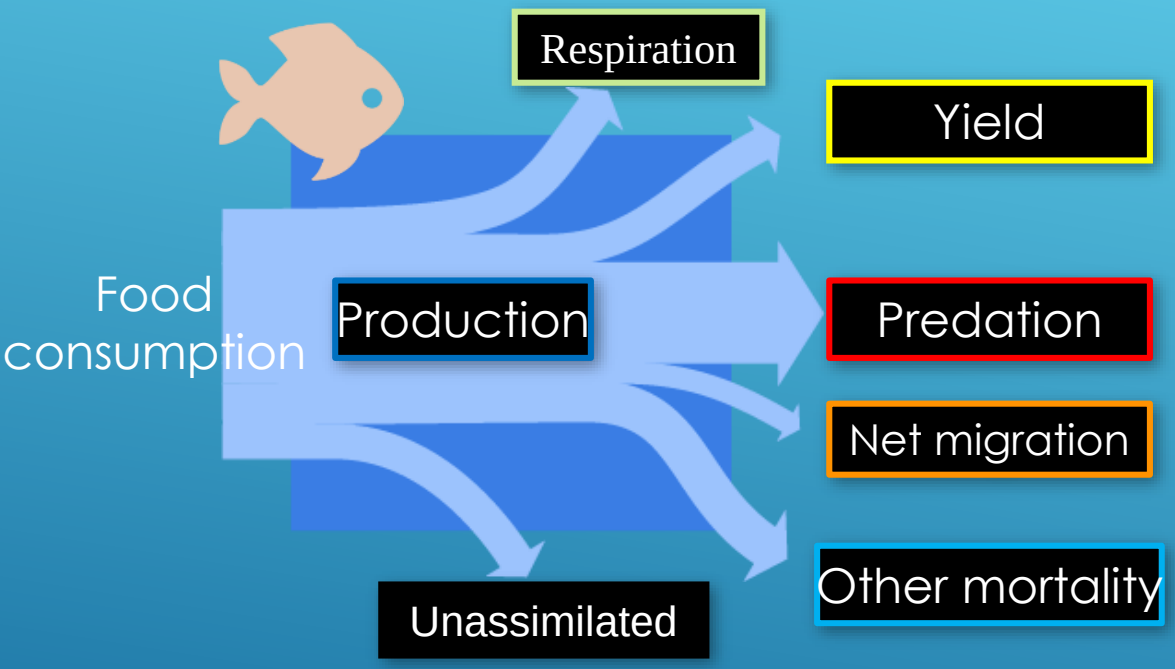
Diet composition

e.g., for a tuna



Use volume or weight!

INPUT PARAMETERS



B_i	Biomass
P_i/B_i	Production
Q_i/B_i	Specific consumption
DC_{ij}	Fraction of prey *i* in diet of predator *j*
B_iA_i	Biomass accumulation
EE_i	Production used in the system
$1\text{-}EE_i$	Unexplained mortality

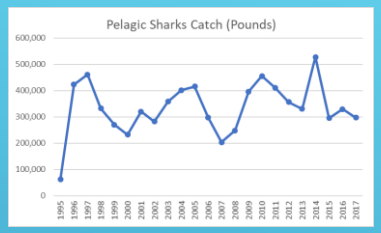
1. $$\left(\frac{Q}{B}\right)_i \cdot B_i = \left(\frac{P}{B}\right)_i \cdot B_i + R_i + UN_i$$

2. $$\left(\frac{P}{B}\right)_i \cdot B_i = \sum_{Pred\_j=1}^{n} \left(\frac{Q}{B}\right)_j \cdot B_j \cdot DC_{ij} + E_i + Y_i + BA_i + \left(\frac{P}{B}\right)_i \cdot B_i \cdot (1 - EE_i)$$

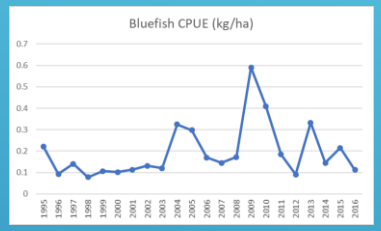
Polovina, J.J. 1984. Coral Reefs, 3:1-11; Pauly et al. 2000. ICES J. Mar. Sci., 57: 697-706; Christensen and Walters. 2004. Ecol. Model., 172(2-4): 109-139

Balancing Temptation 1:
Specify 1995-1998 Declines in Some Groups

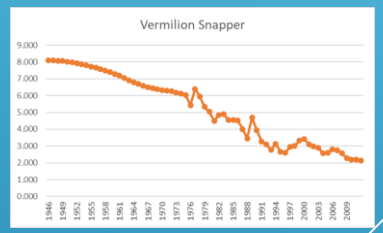
- Pelagic Sharks — Catch



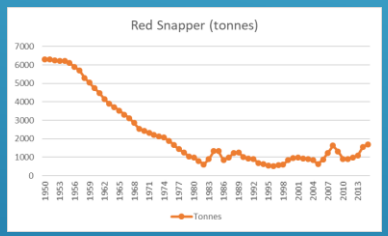
- Bluefish — CPUE



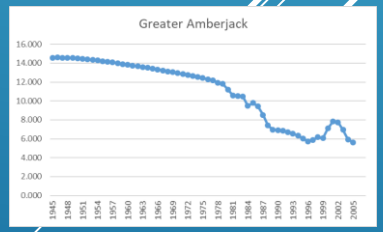
- Vermillion Snapper — Biomass



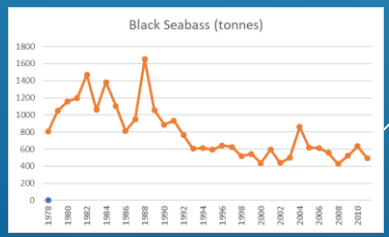
- Red Snapper — Biomass



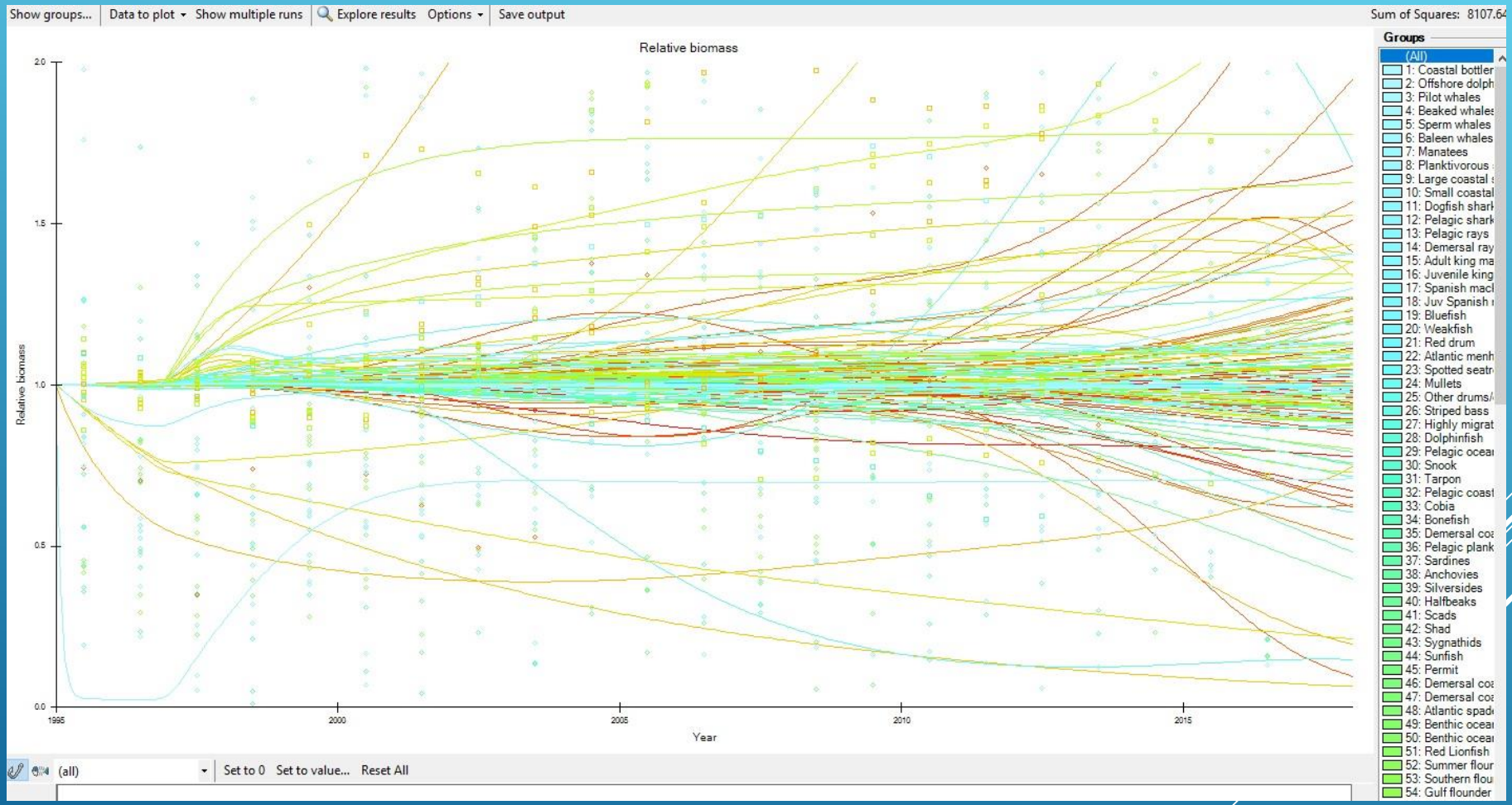
- Other Jacks — Biomass



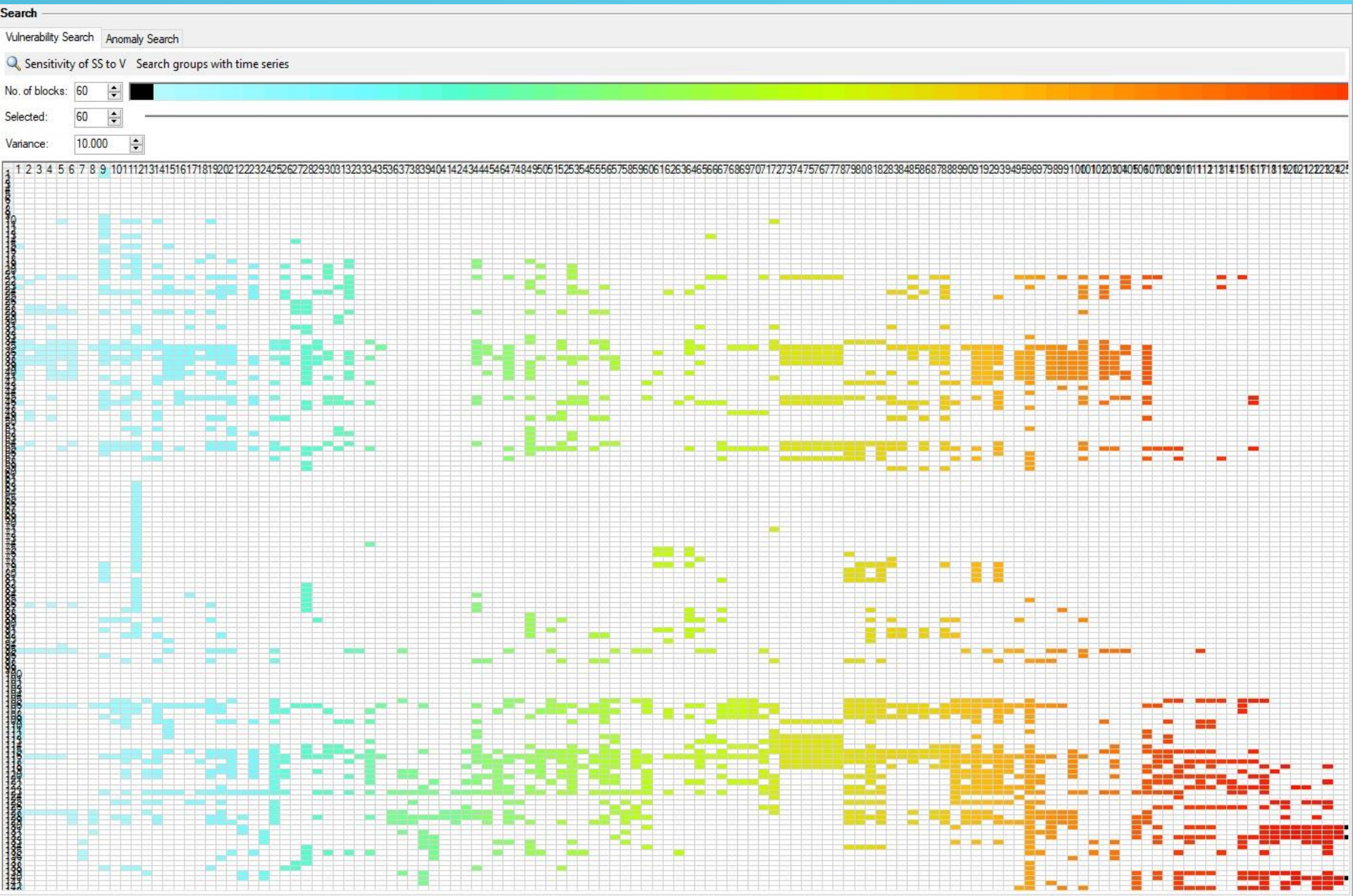
- Black Seabass — Biomass



The Overall Effects of Specified Declines



Fit to Time Series: Vulnerability Search



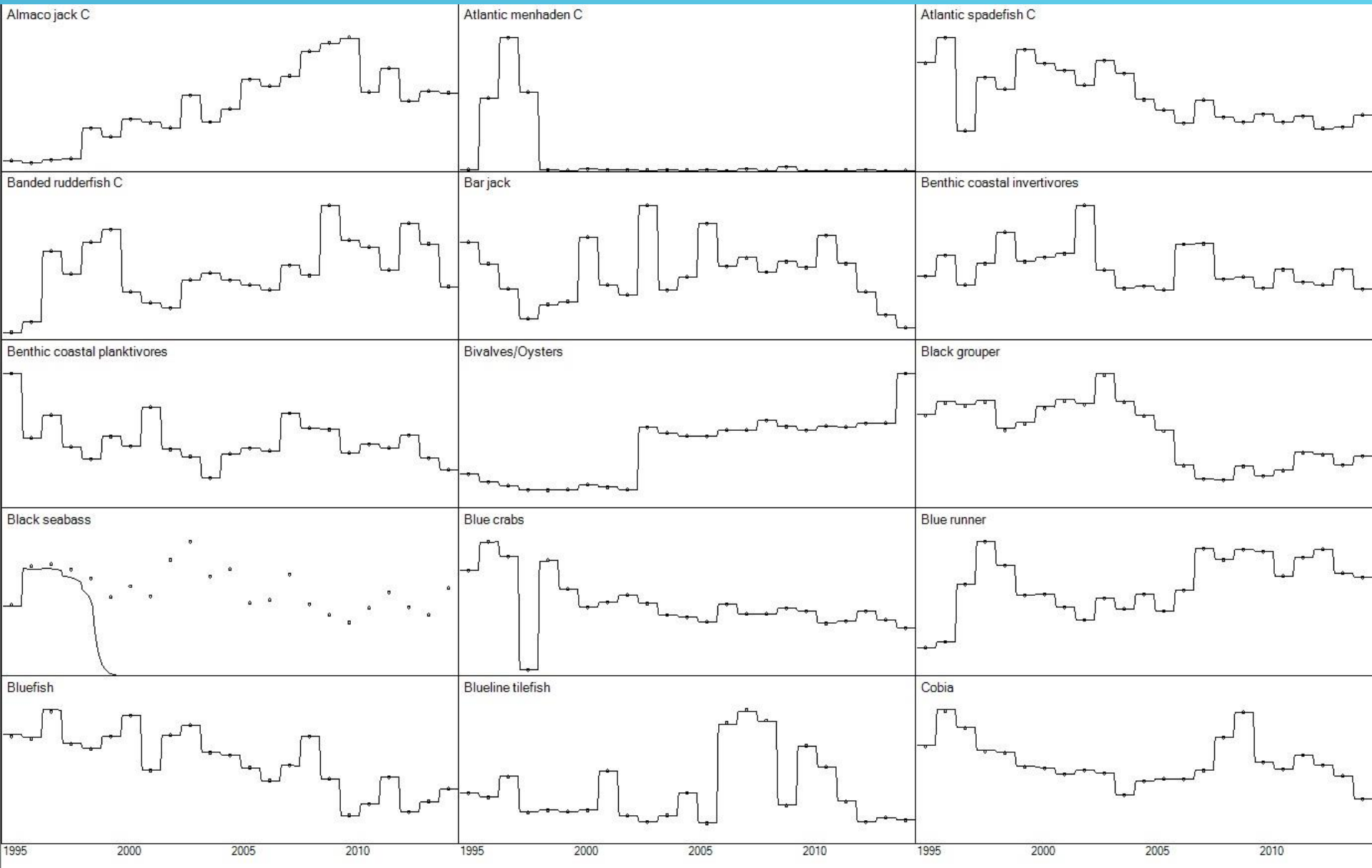
Finding Vulnerability Parameters

Estimate vulnerabilities

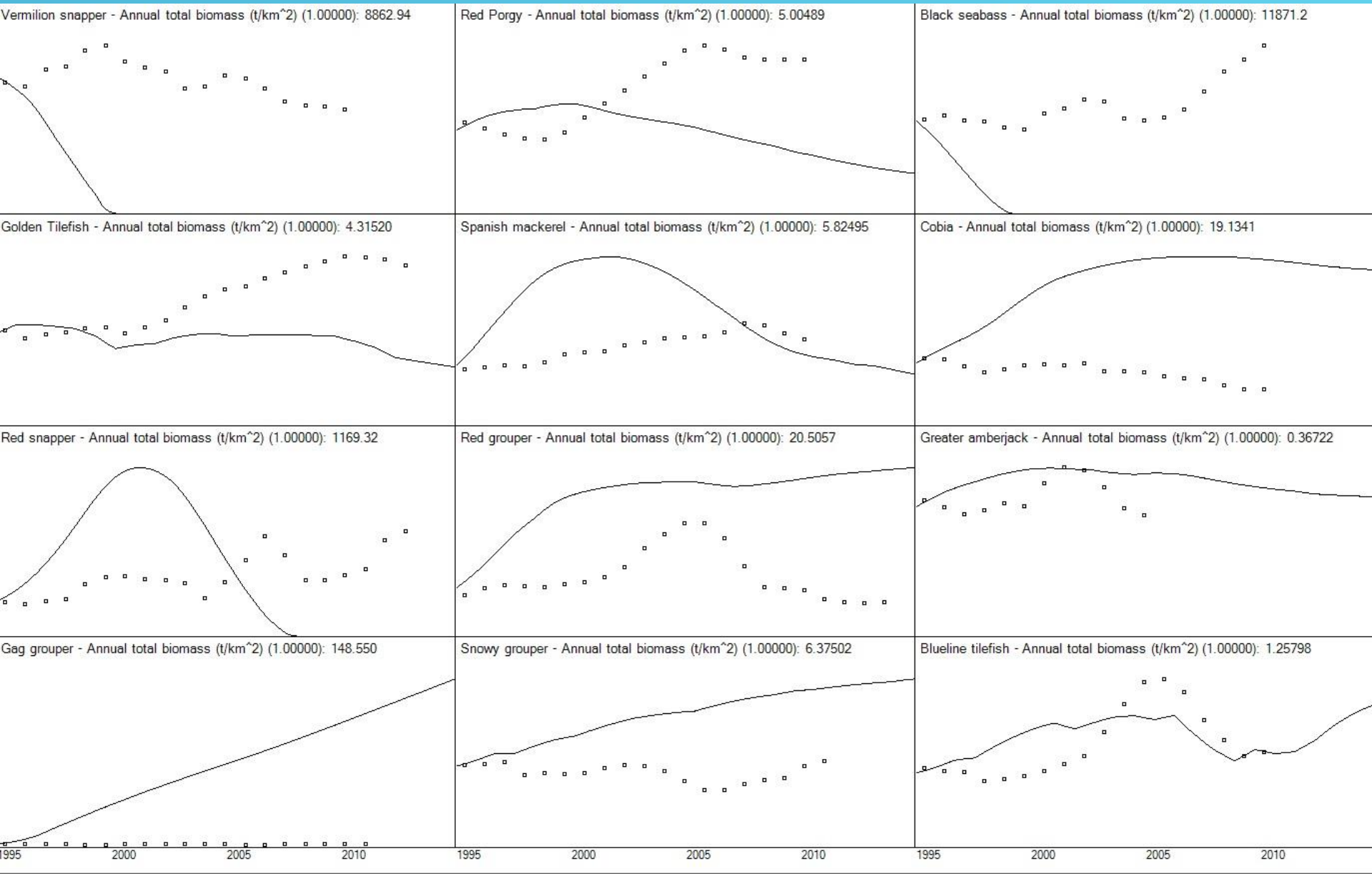
Set: Apply

	Prey \ predator	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
1	Coastal bottlenose dolphin									2.13846																							
2	Offshore dolphins									2.13846																							
3	Pilot whales																																
4	Beaked whales																																
5	Sperm whales																																
6	Baleen whales																																
7	Manatees																																
8	Planktivorous sharks																																
9	Large coastal sharks																																
10	Small coastal sharks									2.13846																							
11	Dogfish sharks					1.93648				2.13846		2.13846	1.34551		2.51509					1.34121													
12	Pelagic sharks									2.13846																							
13	Pelagic rays									2.13846																							
14	Demersal rays/skates									2.13846		2.13846	1.34551																				
15	Adult king mackerel																											2.22111					
16	Juvenile king mackerel	1.93648								2.13846		2.13846	1.34551			2.39919																	
17	Spanish mackerel									2.13846																							
18	Juv Spanish mackerel											2.13846	1.34551							1.34121													
19	Bluefish									2.13846			1.34551						2.39919			1.34121							2.22111				1.94641
20	Weakfish									2.13846		2.13846	1.34551		2.51509									1.99635			1.91007				1.94641		1.94641
21	Red drum									2.13846			1.34551																		1.94641		
22	Atlantic menhaden	1.93648		1.93648		1.93648	1.93648			2.13846		2.13846	1.34551		2.51509	2.39919		2.39919		1.34121	1.34121	1.34121		1.99635			1.91007		2.22111		1.94641		1.94641
23	Spotted seatrout		1.93648																														1.94641
24	Mullets	1.93648								2.13846						2.39919					1.34121	1.34121		1.99635								1.94641	1.94641
25	Other drums/croakers									2.13846	2.13846	2.13846	1.34551		2.51509	2.39919	2.39919	2.39919		1.34121	1.34121	1.34121		1.99635			1.91007			2.22111	1.94641		1.94641
26	Striped bass																				1.34121			1.99635			1.91007						1.94641
27	Highly migratory pelagics												1.34551															2.22111	2.22111				
28	Dolphinfish		1.93648	1.93648		1.93648																						2.22111	2.22111				
29	Pelagic oceanic piscivores		1.93648	1.93648	1.93648	1.93648	1.93648			2.13846		2.13846			2.51509	2.39919		2.39919		1.34121								2.22111	2.22111				1.94641
30	Snook																															1.94641	
31	Tarpon																															1.94641	
32	Pelagic coastal piscivores	1.93648			1.93648								1.34551					2.39919			1.34121							2.22111	2.22111				
33	Cobia												1.34551																2.22111				
34	Bonefish																																
35	Demersal coastal piscivores	1.93648	1.93648		1.93648	1.93648	1.93648			2.13846		2.13846			2.51509											1.97818	1.91007			2.22111			
36	Pelagic planktivores	1.93648	1.93648	1.93648	1.93648	1.93648	1.93648		2.00000	2.13846	2.13846	2.13846	1.34551	1.34551	2.51509	2.39919	2.39919	2.39919	2.39919	1.34121	1.34121	1.34121				1.97818	1.91007		2.22111	2.22111			
37	Sardines	1.93648		1.93648	1.93648	1.93648	1.93648			2.13846			1.34551			2.39919	2.39919	2.39919		1.34121	1.34121	1.34121							2.22111		1.94641		1.94641
38	Anchovies	1.93648	1.93648	1.93648	1.93648	1.93648	1.93648			2.13846	2.13846	2.13846	1.34551		2.51509	2.39919	2.39919	2.39919	2.39919	1.34121	1.34121	1.34121		1.99635		1.97818	1.91007		2.22111	2.22111	1.94641		1.94641
39	Silversides	1.93648	1.93648	1.93648	1.93648		1.93648			2.13846		2.13846				2.39919	2.39919	2.39919			1.34121	1.34121		1.99635			1.91007		2.22111	2.22111			1.94641
40	Halfbeaks	1.93648			1.93648		1.93648									2.39919	2.39919												2.22111				
41	Scads	1.93648			1.93648	1.93648	1.93648									2.39919	2.39919	2.39919		1.34121	1.34121								2.22111				1.94641
42	Shad	1.93648			1.93648	1.93648	1.93648			2.13846		2.13846			2.51509	2.39919	2.39919				1.34121			1.99635					2.22111		1.94641		1.94641
43	Sygnathids										2.13846	2.13846			2.51509							1.34121			1.97818				2.22111			
44	Sunfish																																
45	Permit									2.13846			1.34551				2.39919																
46	Demersal coastal invertivores				1.93648					2.13846		2.13846	1.34551				2.39919	2.39919	2.39919	1.34121	1.34121	1.34121		1.99635		1.97818						1.94641	1.94641	
47	Demersal coastal omnivores	1.93648								2.13846	2.13846	2.13846			2.51509		2.39919					1.34121		1.99635					2.22111		1.94641	1.94641	1.94641
48	Atlantic spadefish									2.13846																			2.22111				
49	Benthic oceanic piscivores		1.93648									2.13846			2.51509																		
50	Benthic oceanic invertivores		1.93648		1.93648							2.13846			2.51509					1.34121	1.34121					1.97818	1.91007						
51	Red Lionfish																																
52	Summer flounder											2.13846	1.34551		2.51509					1.34121		1.34121										1.94641	

Forcing the Historical Catch

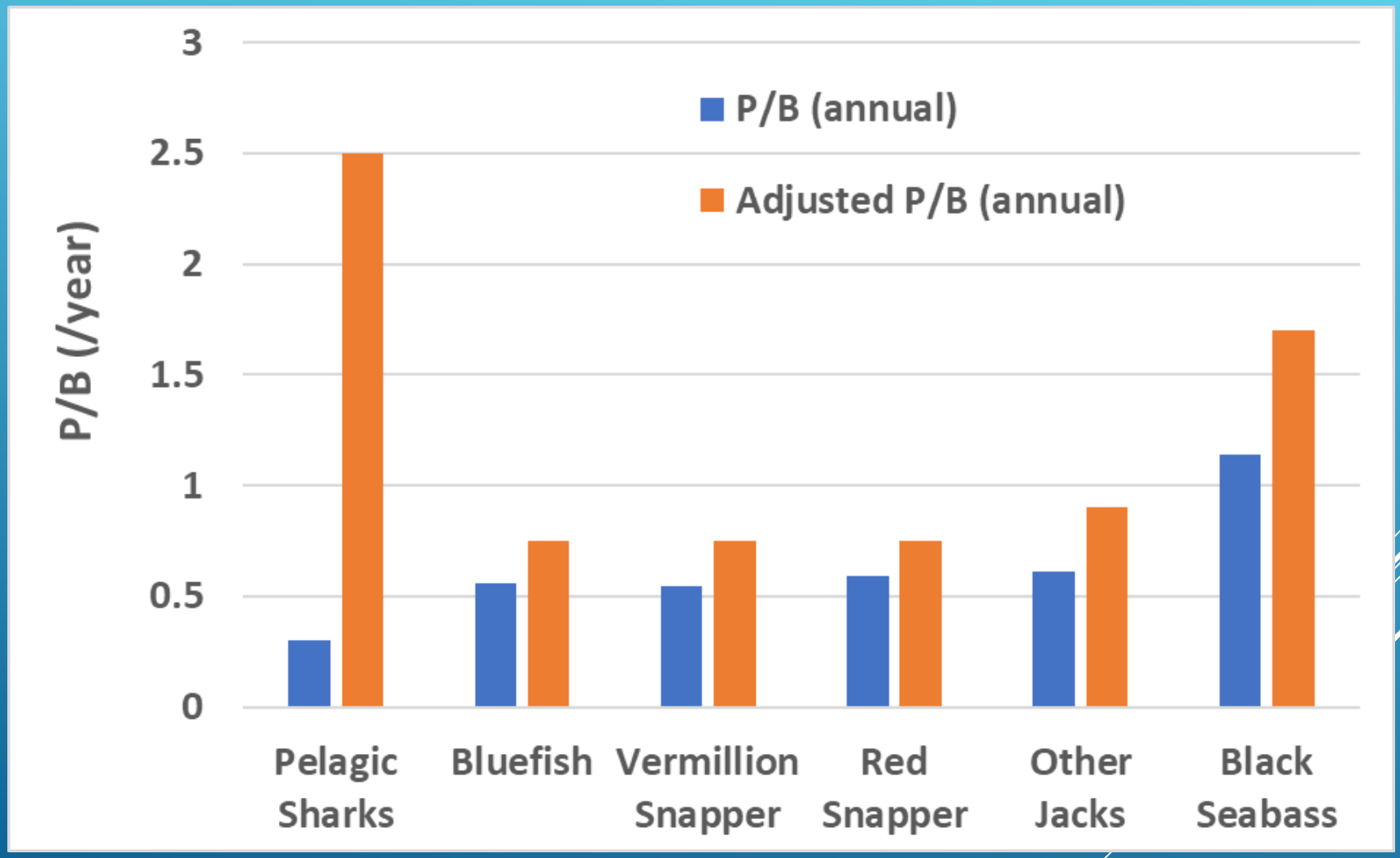


Fitting to Time Series (first try)

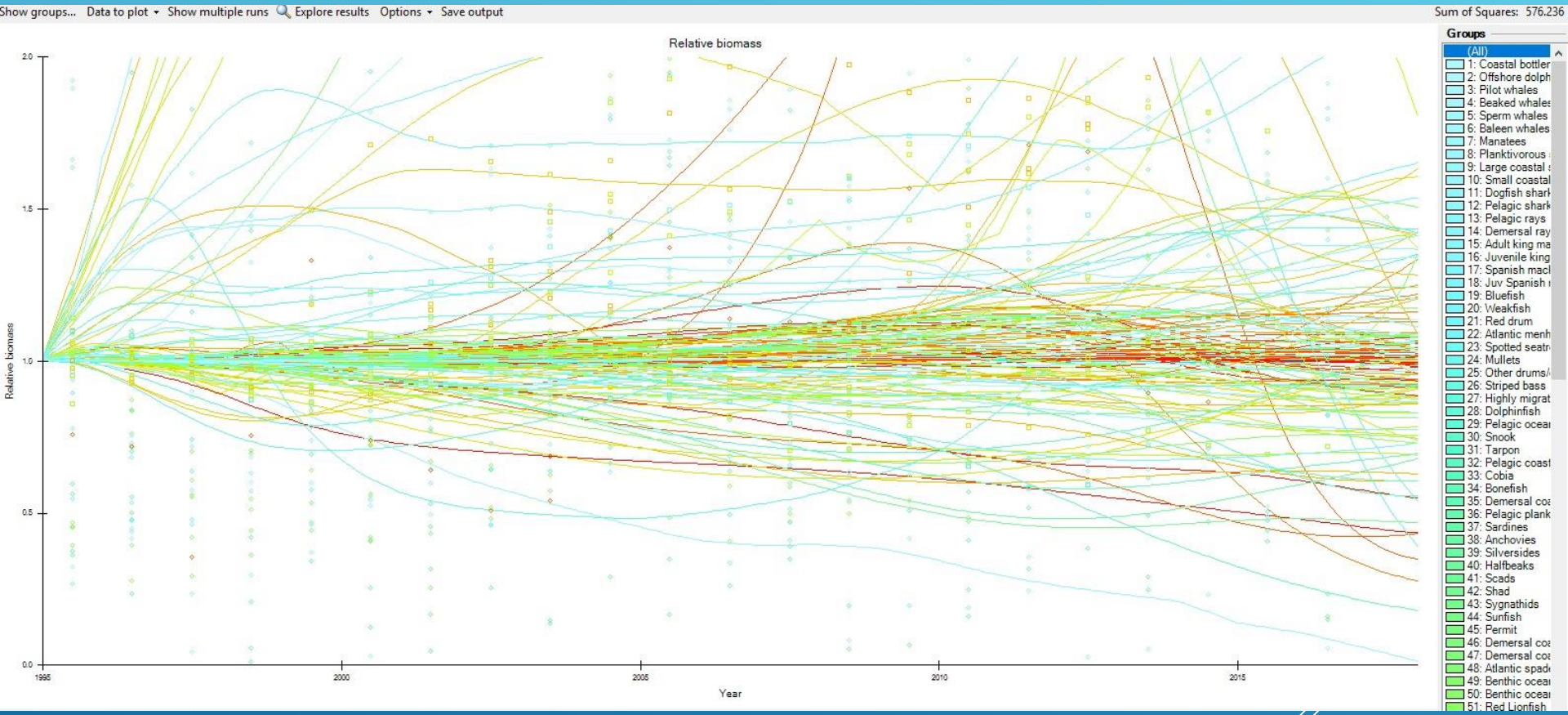


Balancing Temptation 2

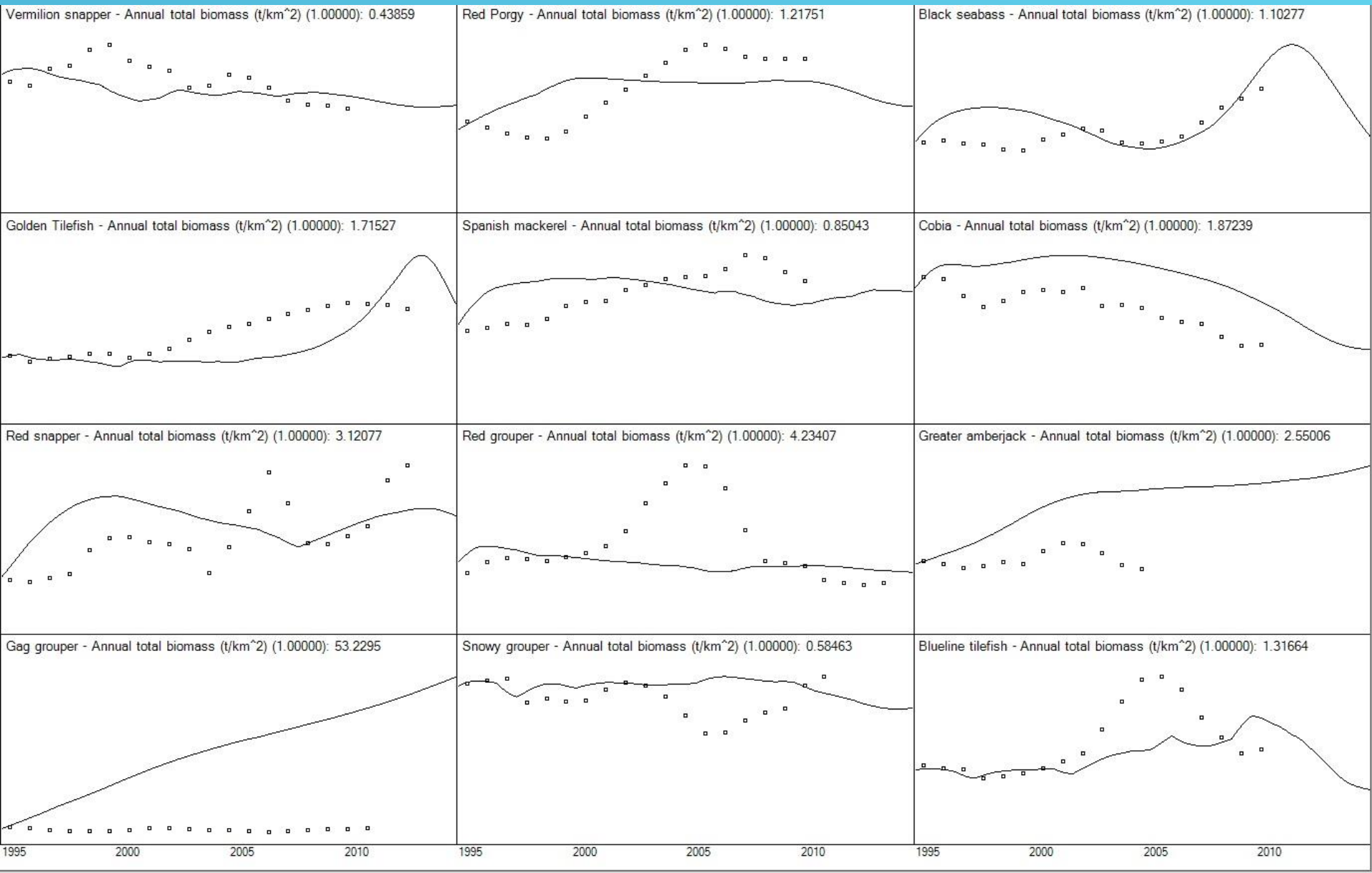
Increase Production Rates



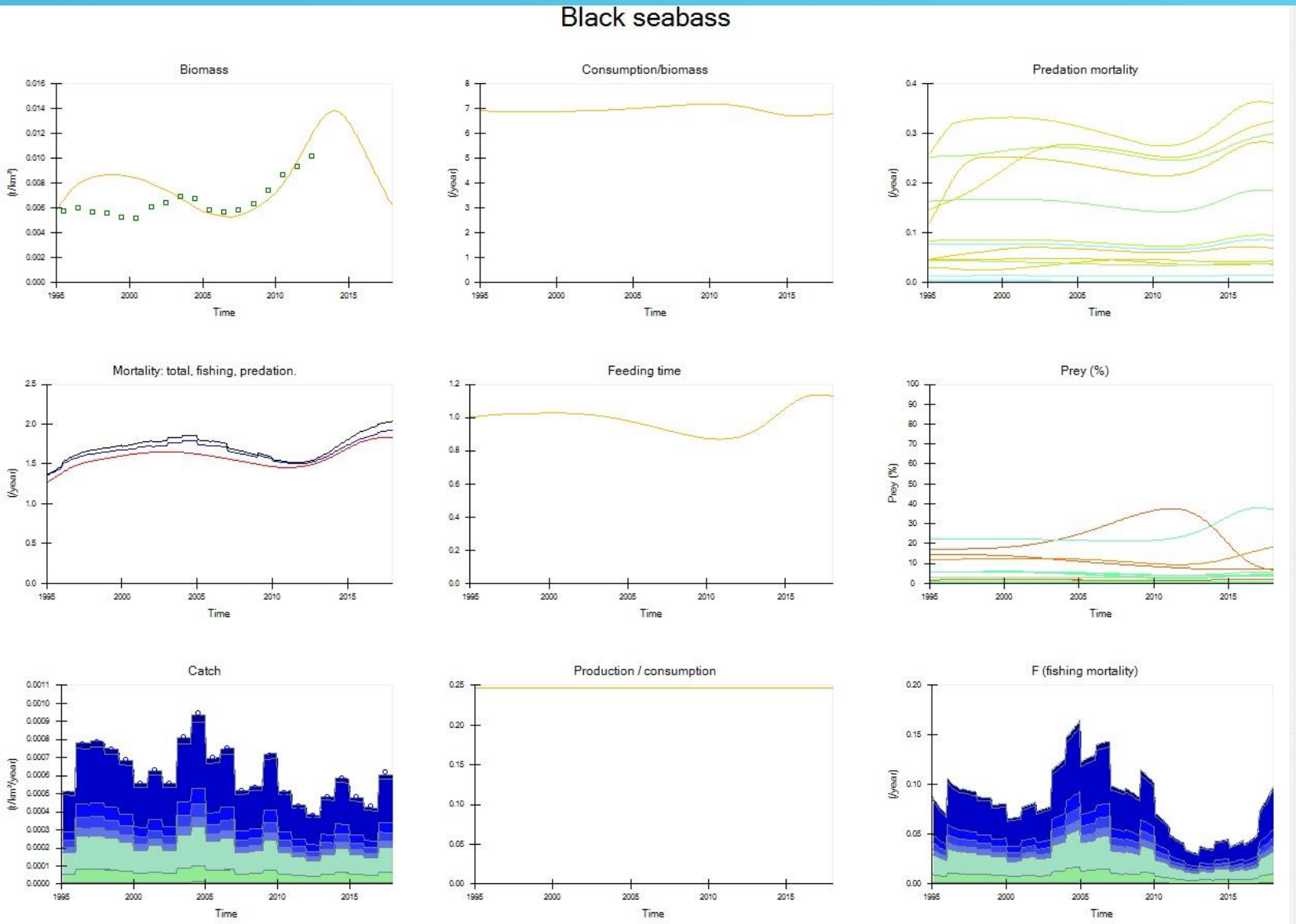
The Overall Effects of Elevated P/B Values



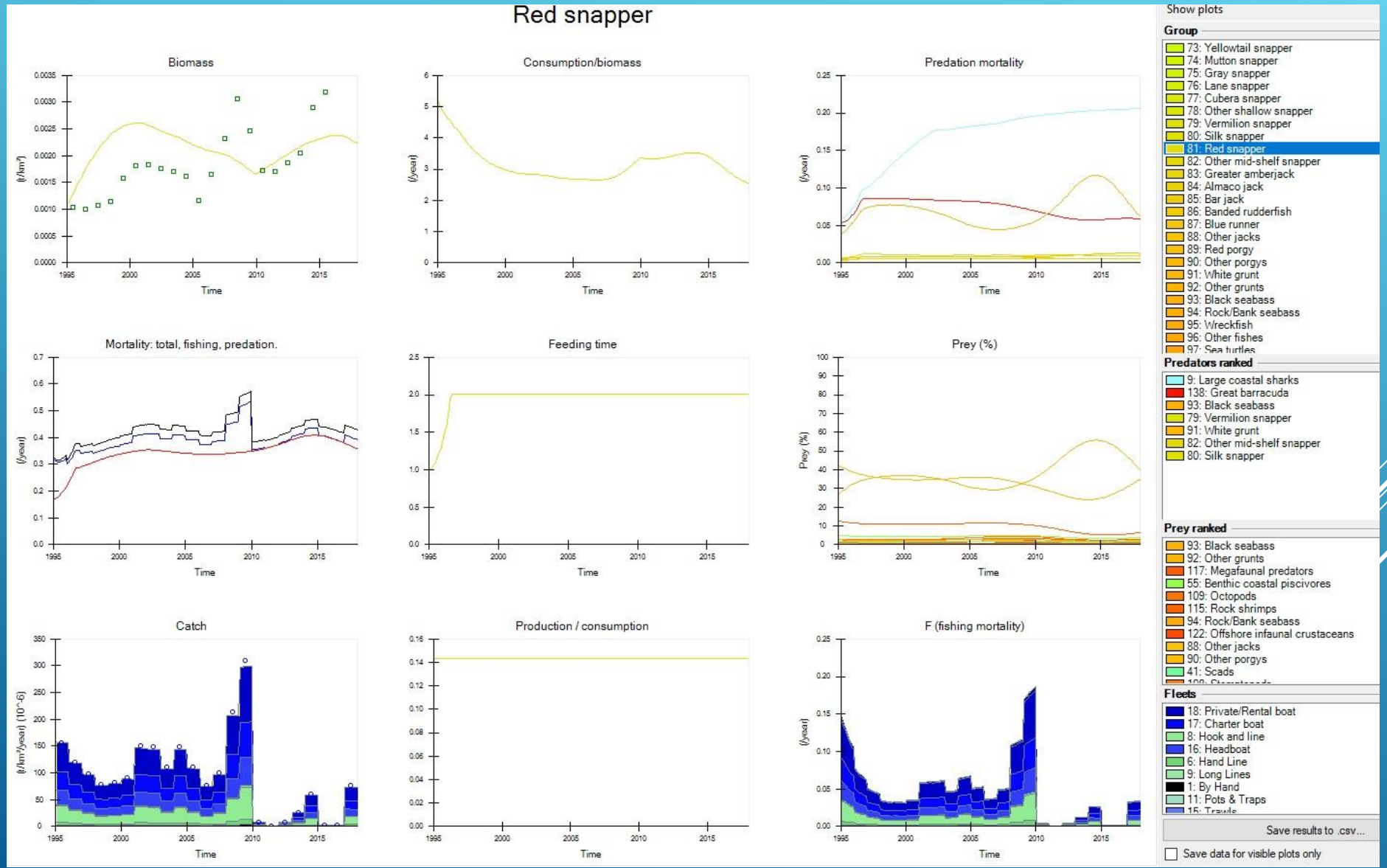
Fitting to Time Series (second try)



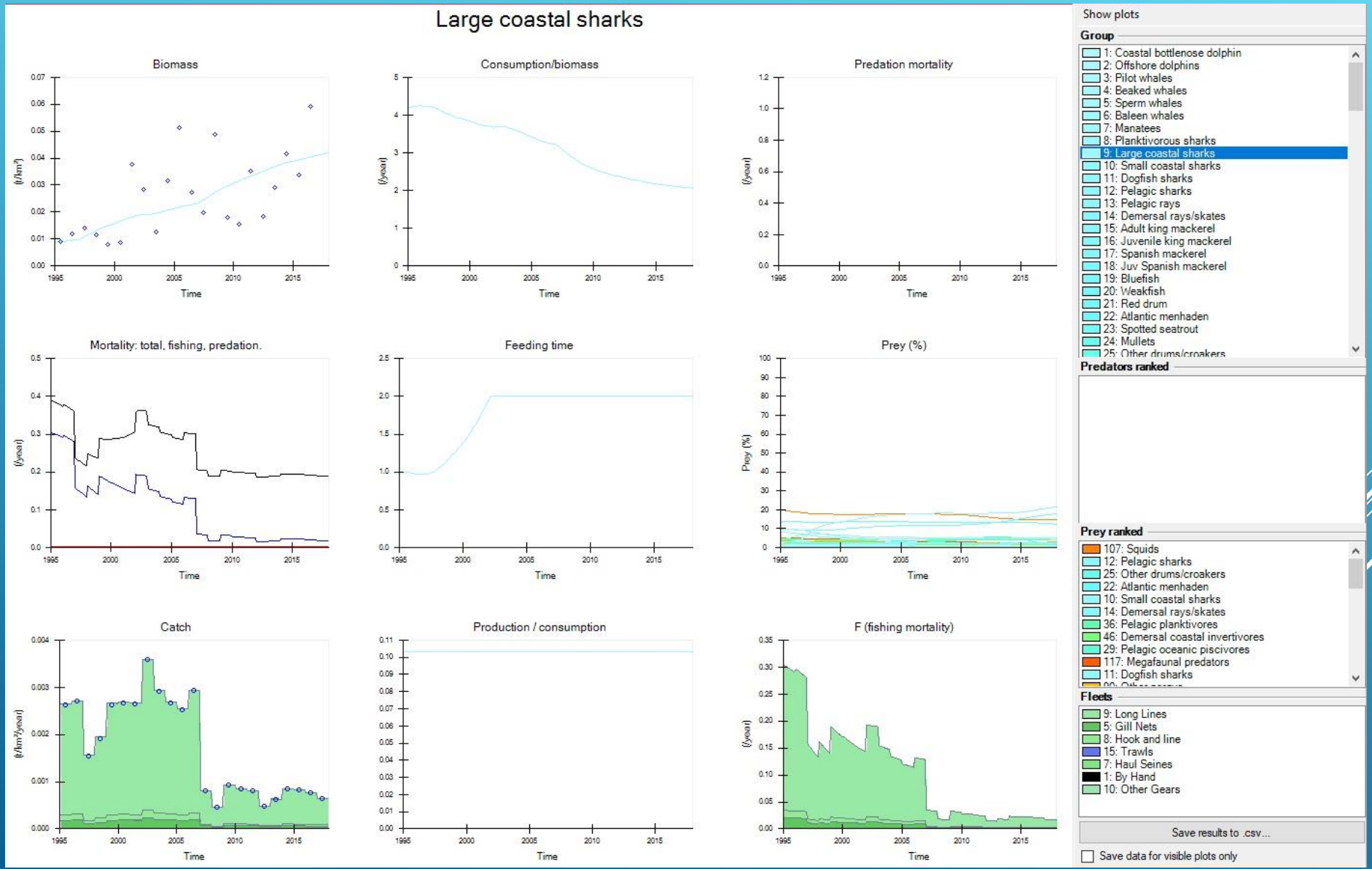
Ecosim Group Plots – Black Seabass



Red Snapper Plots



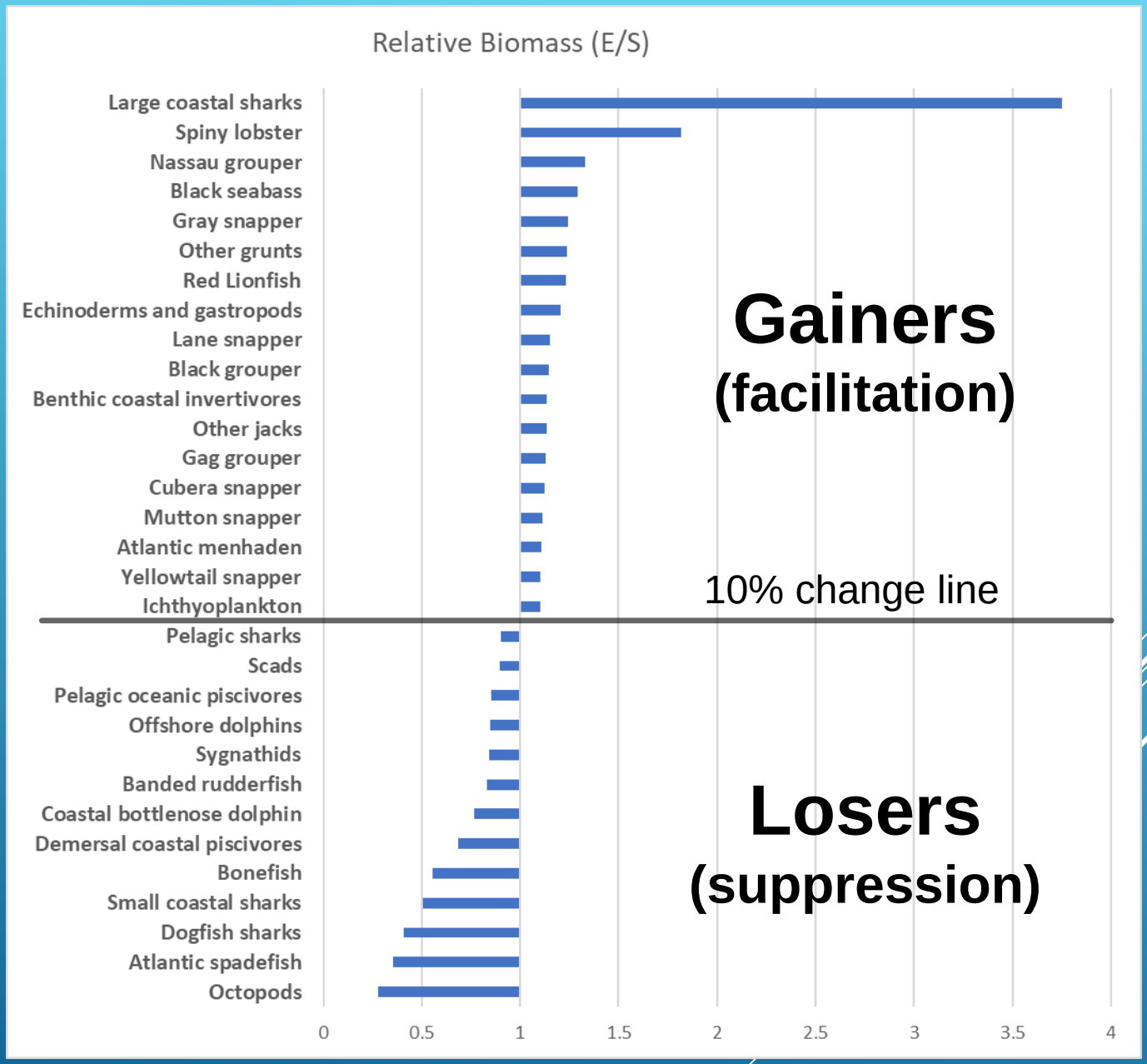
Large Coastal Sharks Plots



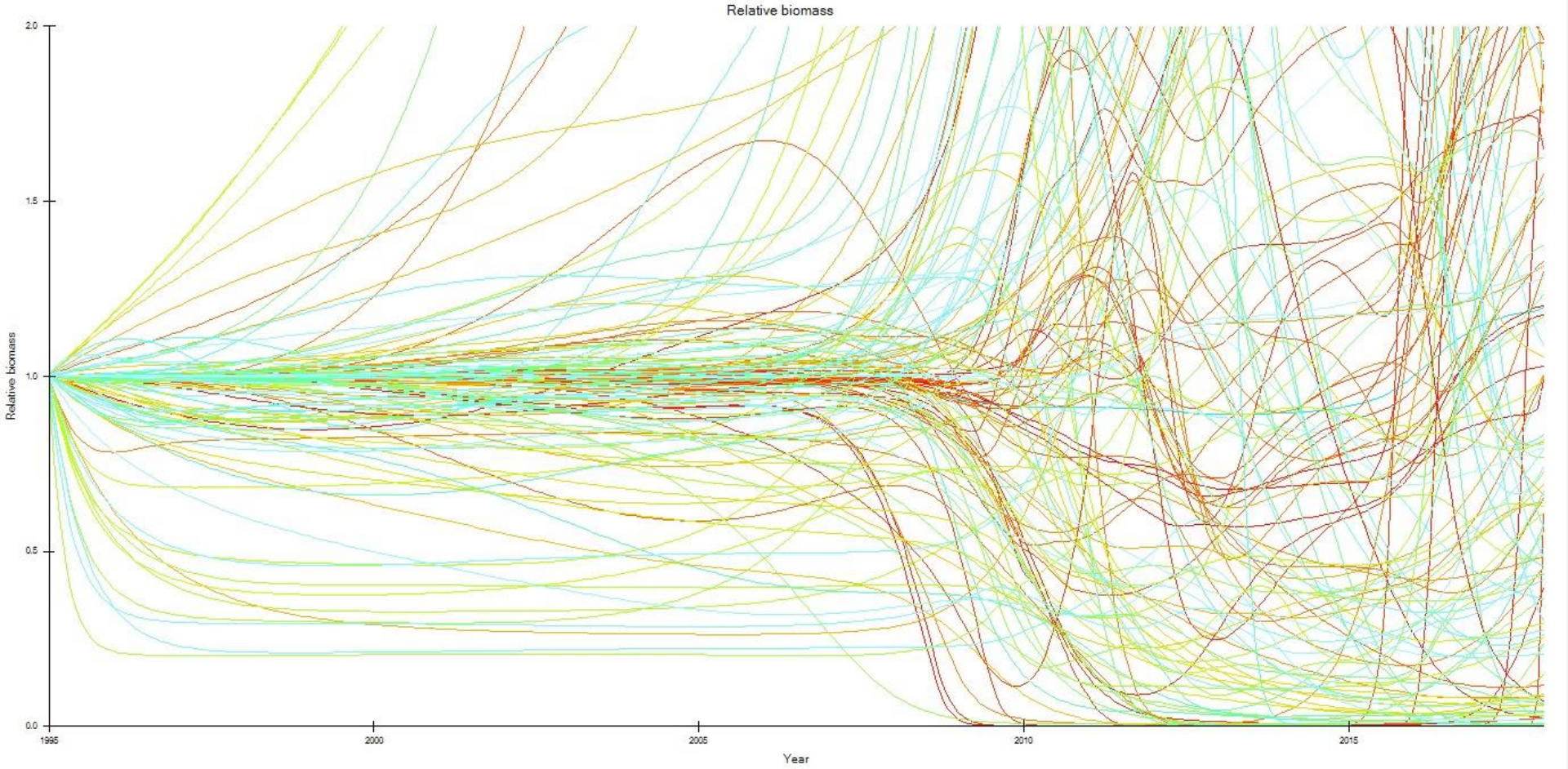
Large Coastal Sharks Make Black Seabass, Snappers, Groupers, Lobster, etc.

(23-year simulation)

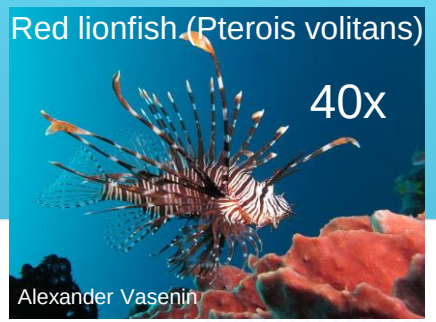
Is this a counterintuitive result?

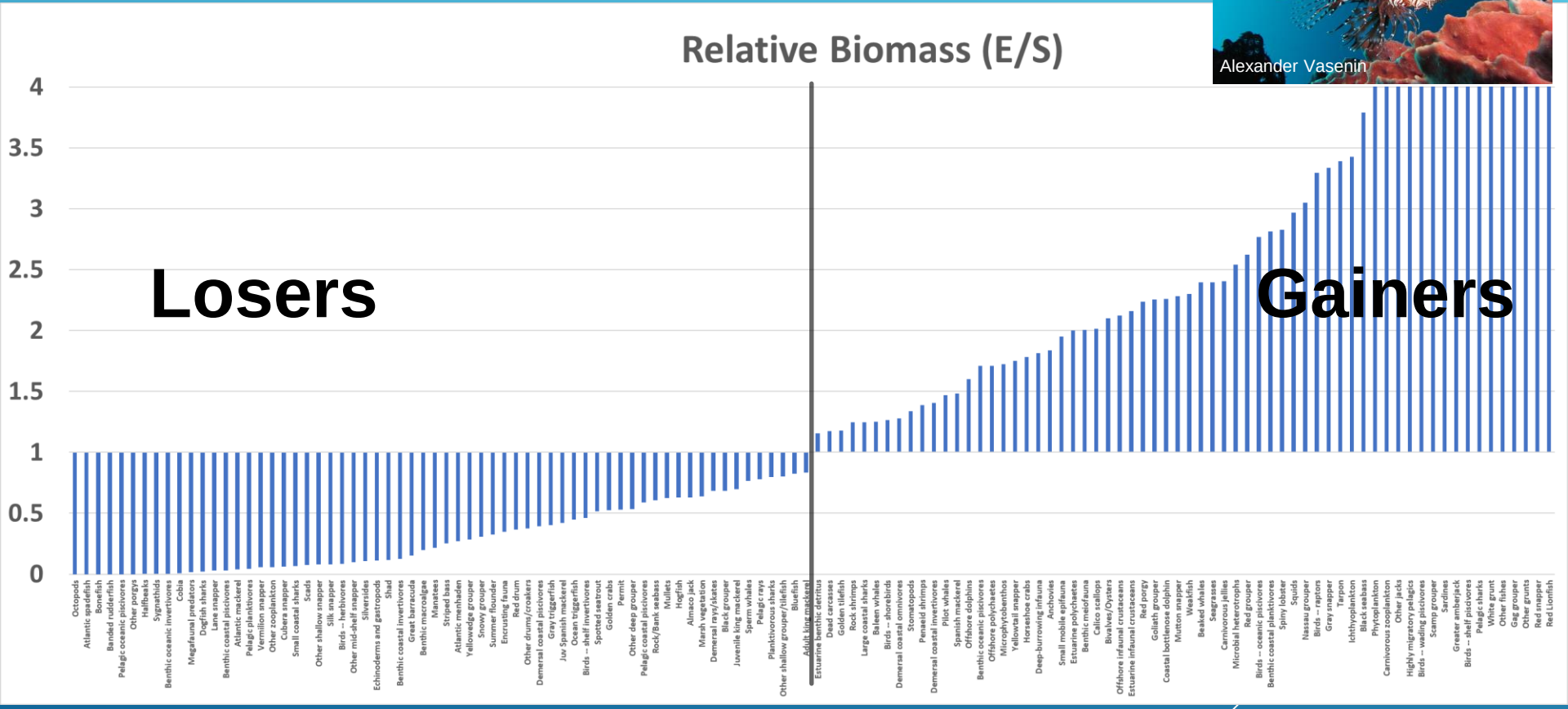


MSY for all = Chaos

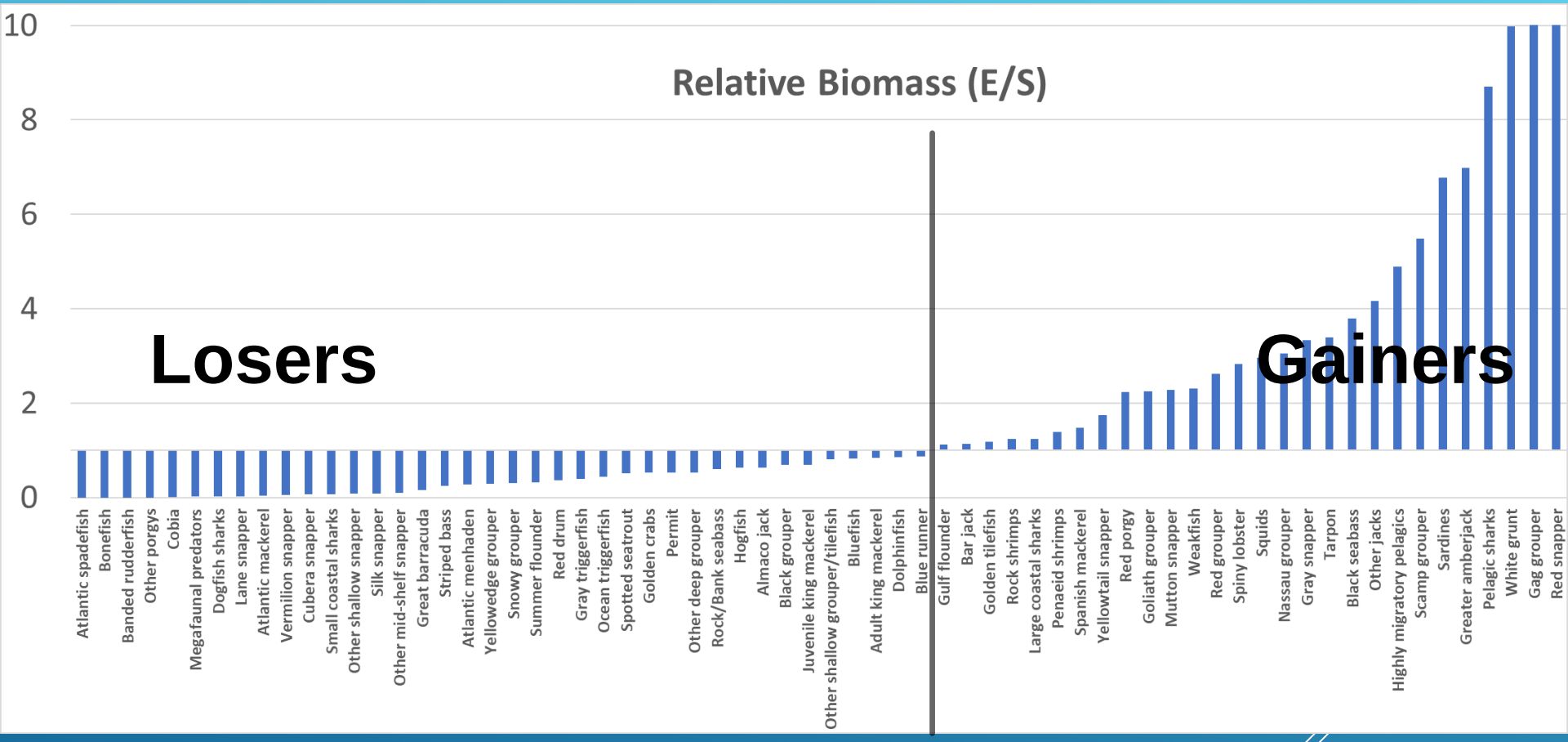


MSY for all captured species





MSY-ALL: Species of Interest



MSY-All: Top 20 Losers and Gainers of Biomass

Biggest Losers	Biggest Gainers
Atlantic spadefish	Red snapper
Bonefish	Gag grouper
Banded rudderfish	White grunt
Other porgys	Pelagic sharks
Cobia	Greater amberjack
Megafaunal predators	Sardines
Dogfish sharks	Scamp grouper
Lane snapper	Highly migratory pelagics
Atlantic mackerel	Other jacks
Vermilion snapper	Black seabass
Cubera snapper	Tarpon
Small coastal sharks	Gray snapper
Other shallow snapper	Nassau grouper
Silk snapper	Squids
Other mid-shelf snapper	Spiny lobster
Great barracuda	Red grouper
Striped bass	Weakfish
Atlantic menhaden	Mutton snapper
Yellowedge grouper	Goliath grouper
Snowy grouper	Red porgy

SUMMARY AND FUTURE DIRECTION

- **First Phase (Ecopath)** - A snapshot of SA ecosystem - SAFMC species, relevant prey & predators, and the lower trophic levels. Continually refined.
- **The Second Phase (Ecosim)** - Model is calibrated with quality time series of catch and biomass. Example simulations are presented, including some relevant "what-if" scenarios.
- **The Third Phase (Ecospace)** – Spatially-related questions can be addressed including spatial management and spatial expression of environmental change.

A PATH FORWARD

- Identify SSC members to participate on an Ecopath Model Subgroup composed of FWRI/SAFMC staff and members of modeling workgroup.
- Highlight SAFMC/FWRI strategy to collaboratively provide long-term repository for model inputs/outputs and a team approach to maintain and regularly run the models.

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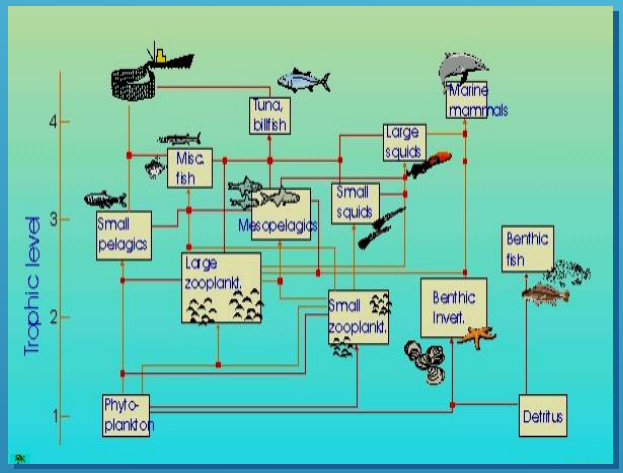
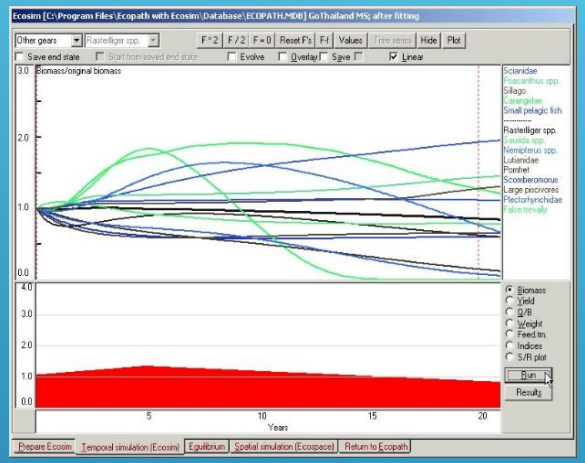
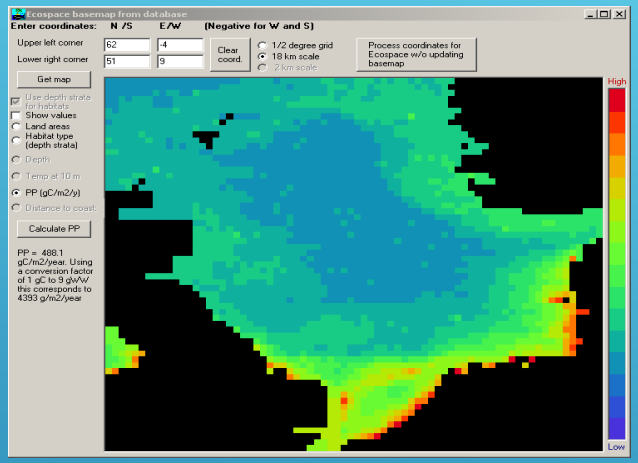
ECOPATH / ECOSIM / ECOSPACE







HISTORY OF THE SOUTH ATLANTIC MODEL

- 2001 - Strawman 48-group model constructed
- 2004 - Preliminary 98-group model developed
- 2014 - Model refined to address forage fish questions (99 groups)
- 2019 – Model refinement to articulate managed species (143 boxes)

Sponsored by SAFMC

- 42-box Strawman
- 98-box Preliminary

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A PRELIMINARY ECOPATH MODEL OF THE ATLANTIC CONTINENTAL SHELF ADJACENT TO THE SOUTHEASTERN UNITED STATES

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ABSTRACT

The biological communities of the Atlantic continental shelf adjacent to the southeastern United States are well known, but this knowledge is not integrated into a cohesive description of that region. We constructed a preliminary food web model of this area using Ecopath with Ecosim, as a way to initiate a long-term process of integrating this knowledge, learning more about the structure and resiliency of the system, and helping to guide research priorities in the future. The current model is considered to be a first iteration that can be used as a vehicle to stimulate a more rigorous refinement effort in the near future. The ecologically defined area covered by this model extends from Cape Hatteras, North Carolina to the easternmost extent of the Florida Keys, and from the intertidal zone (or the entrance of estuarine systems) to the 500 m isobath. The time period characterized by this preliminary model is the four years from 1995 to 1998.

the Gulf Stream advect the underlying nutrient rich slope waters onto the shelf (Mallin *et al.* 2000).. This region as a whole supports a diverse assemblage of marine organisms, as it is somewhat of an ecological interface, or gradient, between warm-water and cold-water species assemblages. We refer the reader to Mallin *et al.* (2000) for a general description of the ecological setting, processes, and related research. A brief overview of special habitats is presented below.

Human activities along the east coast of the southeastern United States have influenced the adjacent continental shelf ecosystem for thousands of years, as native Americans conducted some limited artisanal fisheries and modified fire regimes and the vegetation in upland watersheds (e.g., Cronon, 1983). Modifications to the ecology of the continental shelf ecosystem accelerated soon after the arrival of Europeans, who began fishing coastal waters (e.g., Mowat, 1984; Reeves *et al.*, 1999) in addition to introducing domesticated livestock, weed plants, disease, and new kinds of agriculture (e.g., Crosby, 1986).

Other profound anthropogenic modifications to this continental shelf occurred during the 20th century with the widespread use of powered fishing and whaling vessels, and coastal urbanization and industrialization. One particularly destructive type of fishing is bottom trawling, which destroys biogenic seafloor habitat in addition to simply removing fishes (Watling and Norse, 1998; Turner *et al.*, 1999).

Trawling activity is intense in this area, and little doubt remains that these activities have considerably modified the continental shelf. The

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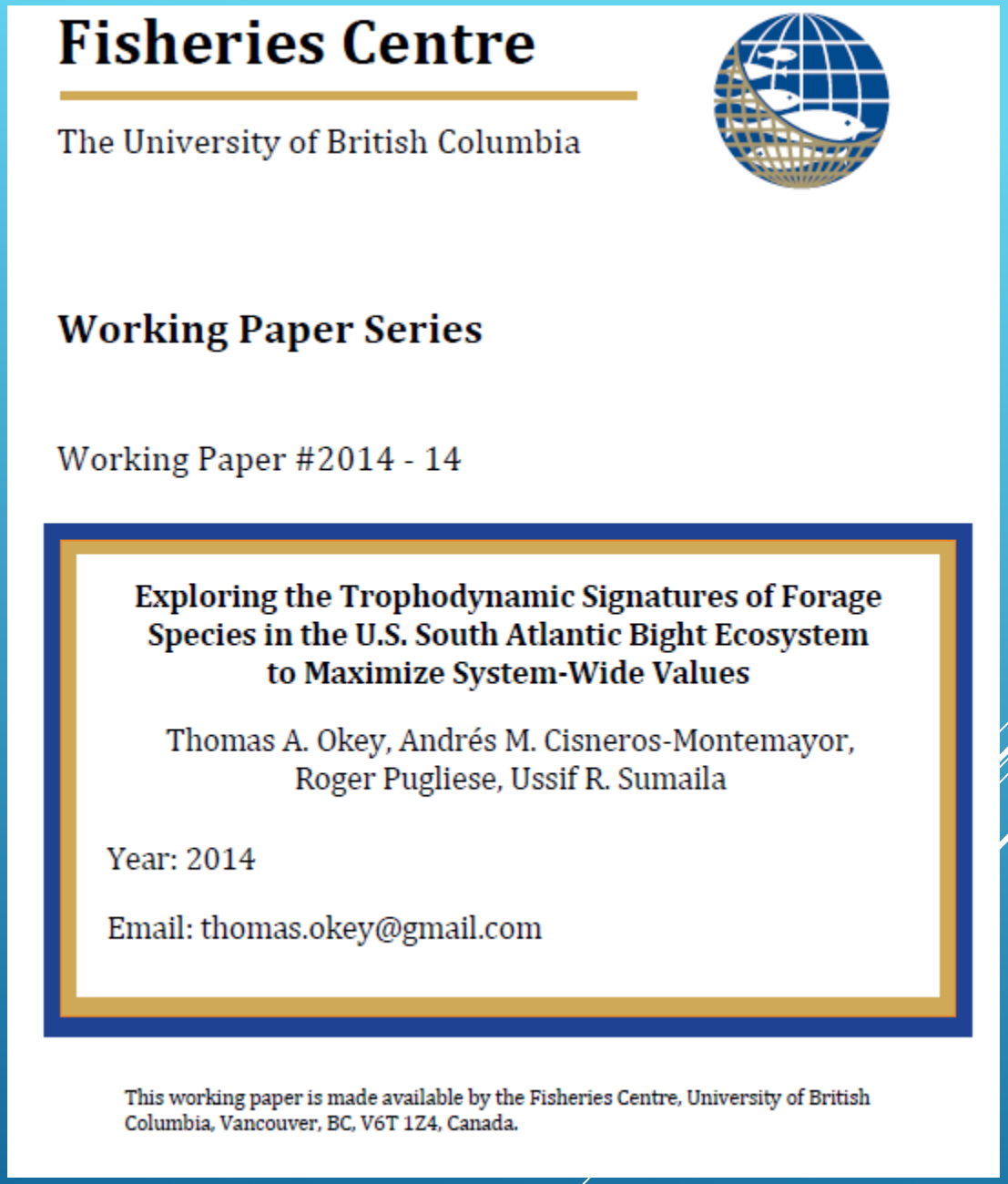
- 99-box Forage model



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Working Paper Series

Working Paper #2014 - 14

Exploring the Trophodynamic Signatures of Forage Species in the U.S. South Atlantic Bight Ecosystem to Maximize System-Wide Values

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