


South Atlantic Region Ecopath Model '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**
- 
- A series of white diagonal lines of varying lengths and thicknesses, located in the bottom right corner of the slide, creating a modern, abstract graphic element.

TALK OUTLINE

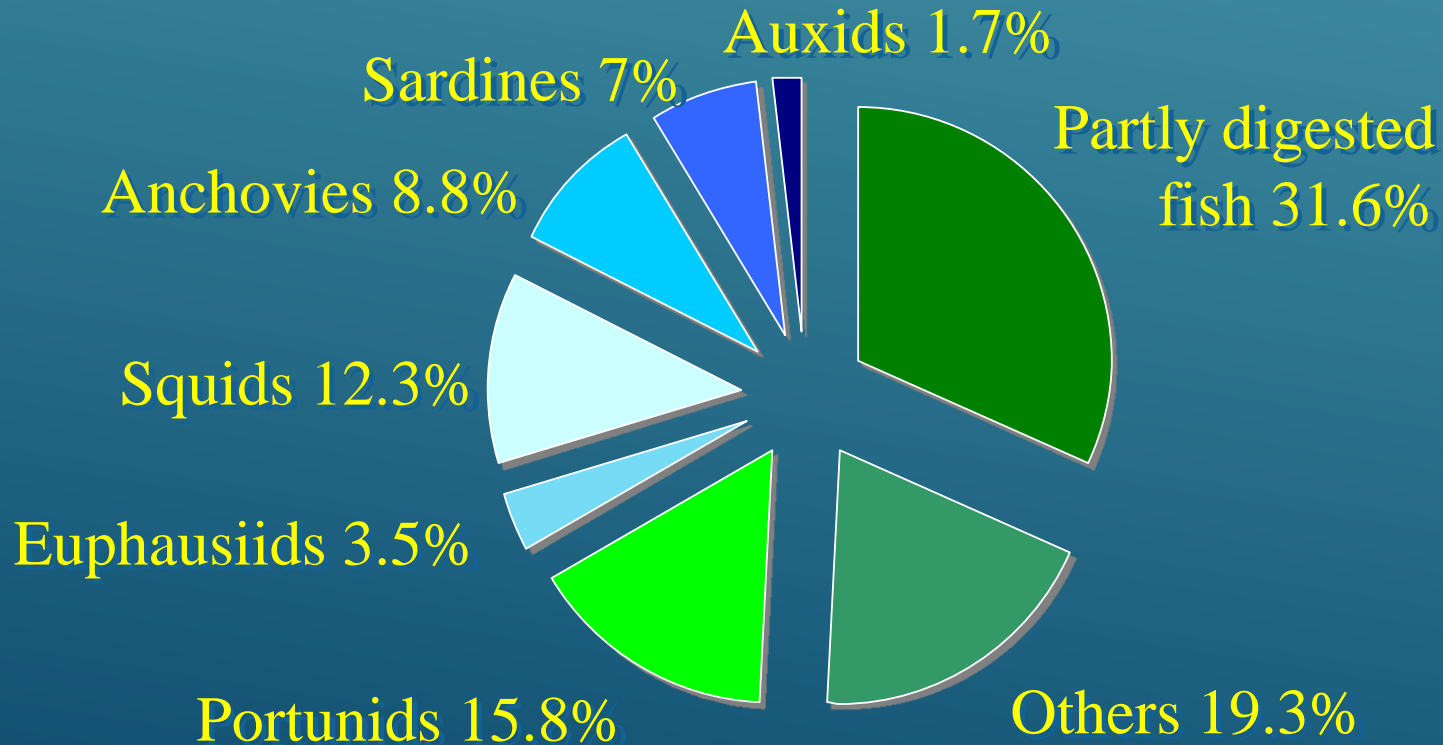
- Final assembly of the 143-box South Atlantic Region Ecopath model
- Examples of Explorations:
 - Reconstructing past ecosystem change
 - Red snapper and black sea bass interactions
 - Simulate varying fishing mortality on large coastal sharks and managed species response
 - Exploration of the ecosystem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

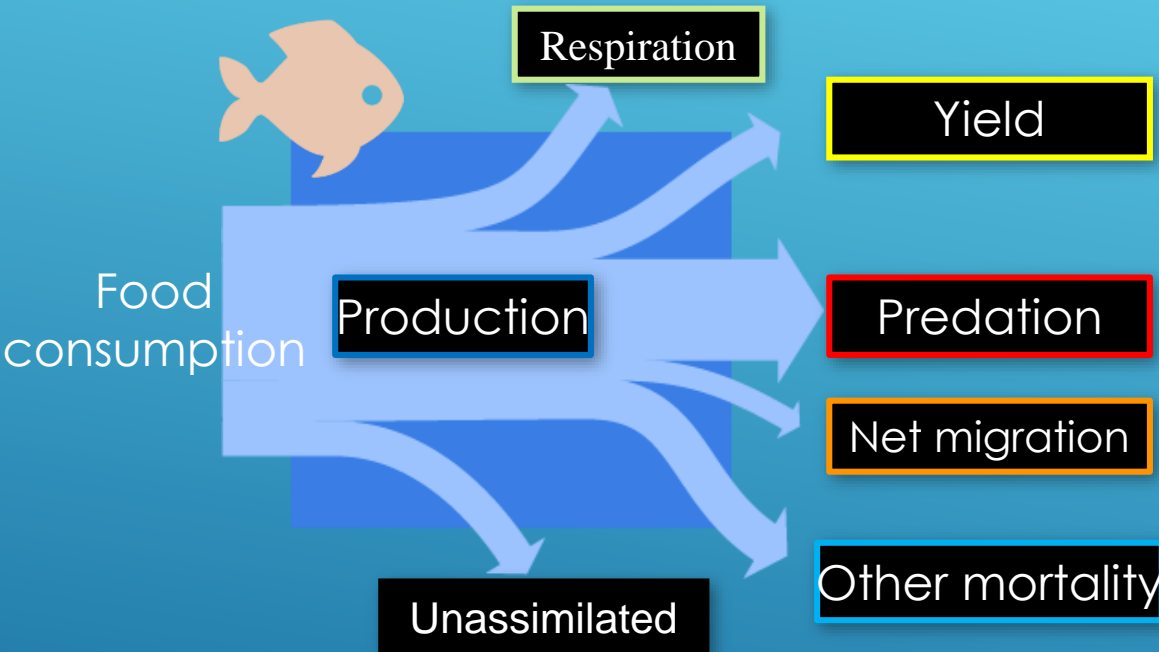
e.g., for a tuna



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
$B_i A_i$	Biomass accumulation
EE_i	Production used in the system
$1-EE_i$	Unexplained mortality

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

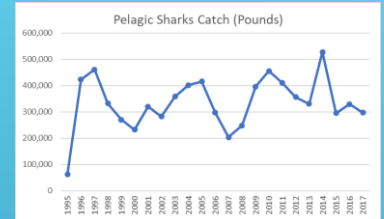
$$2. \left(\frac{P}{B} \right)_i \cdot B_i = \sum_{Pred_j=1}^n \left(\frac{Q}{B} \right)_j \cdot B_j \cdot DC_{ij} + E_i + Y_i + BA_i + \left(\frac{P}{B} \right)_i \cdot B_i \cdot (1 - EE_i)$$

Balancing Temptation 1:

Specify 1995-1998 Declines in Some Groups

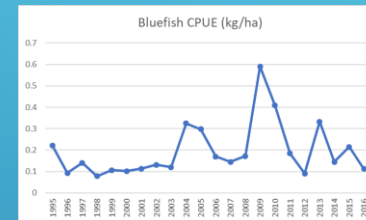
- Pelagic Sharks

Catch



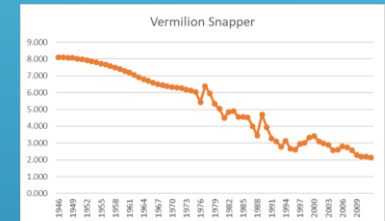
- Bluefish

CPUE



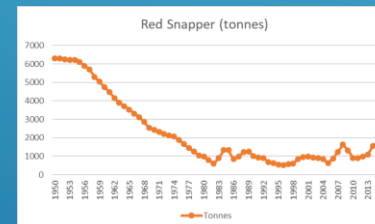
- Vermillion Snapper

Biomass



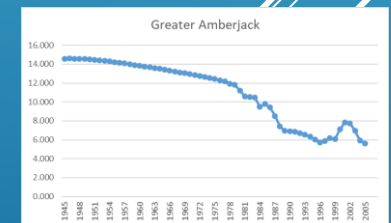
- Red Snapper

Biomass



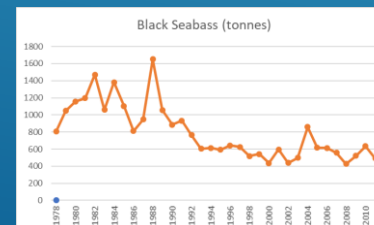
- Other Jacks

Biomass

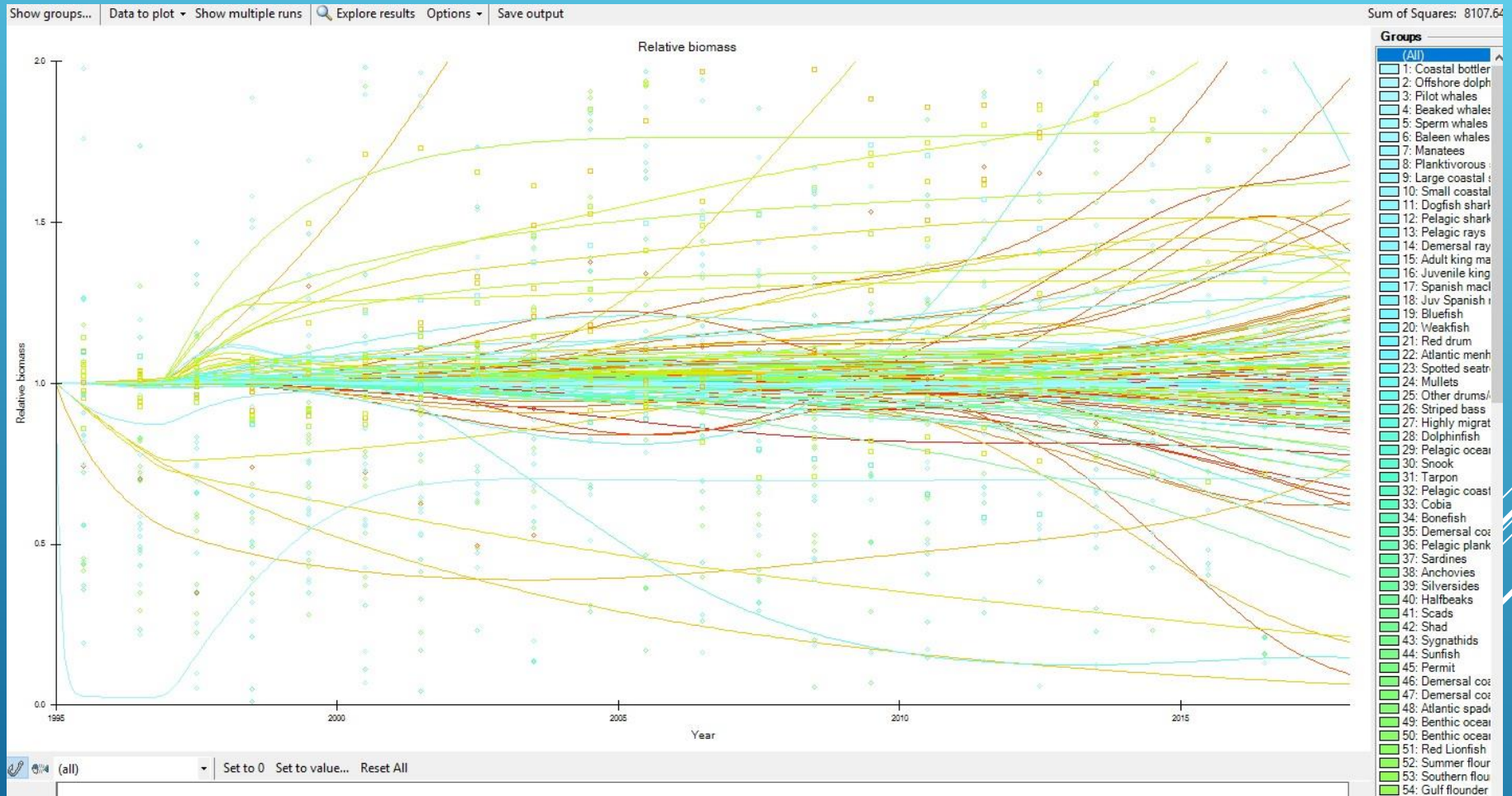


- Black Seabass

Biomass



The Overall Effects of Specified Declines



Fit to Time Series: Vulnerability Search

Search

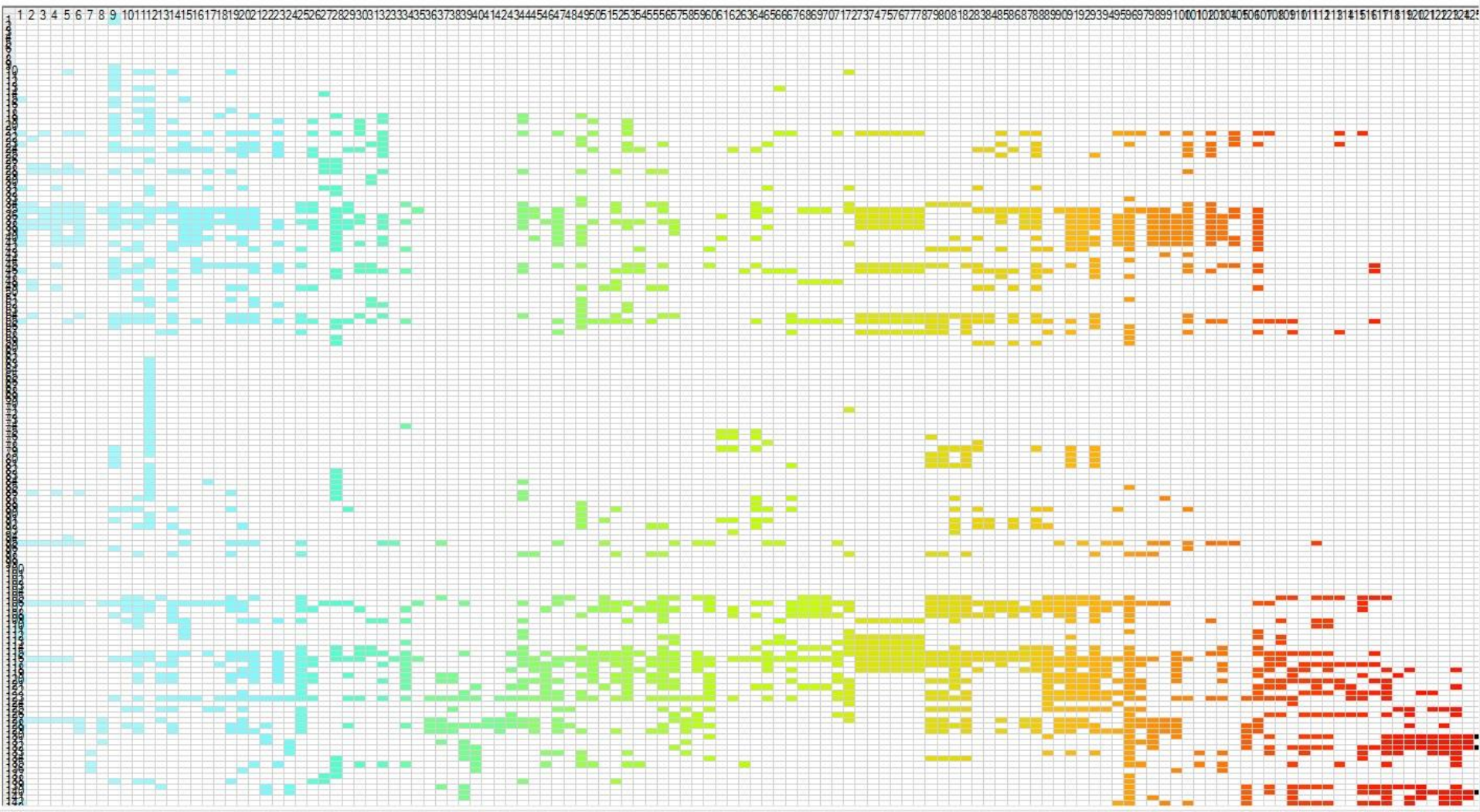
Vulnerability Search Anomaly Search

Search groups with time series

No. of blocks: 60

Selected: 60

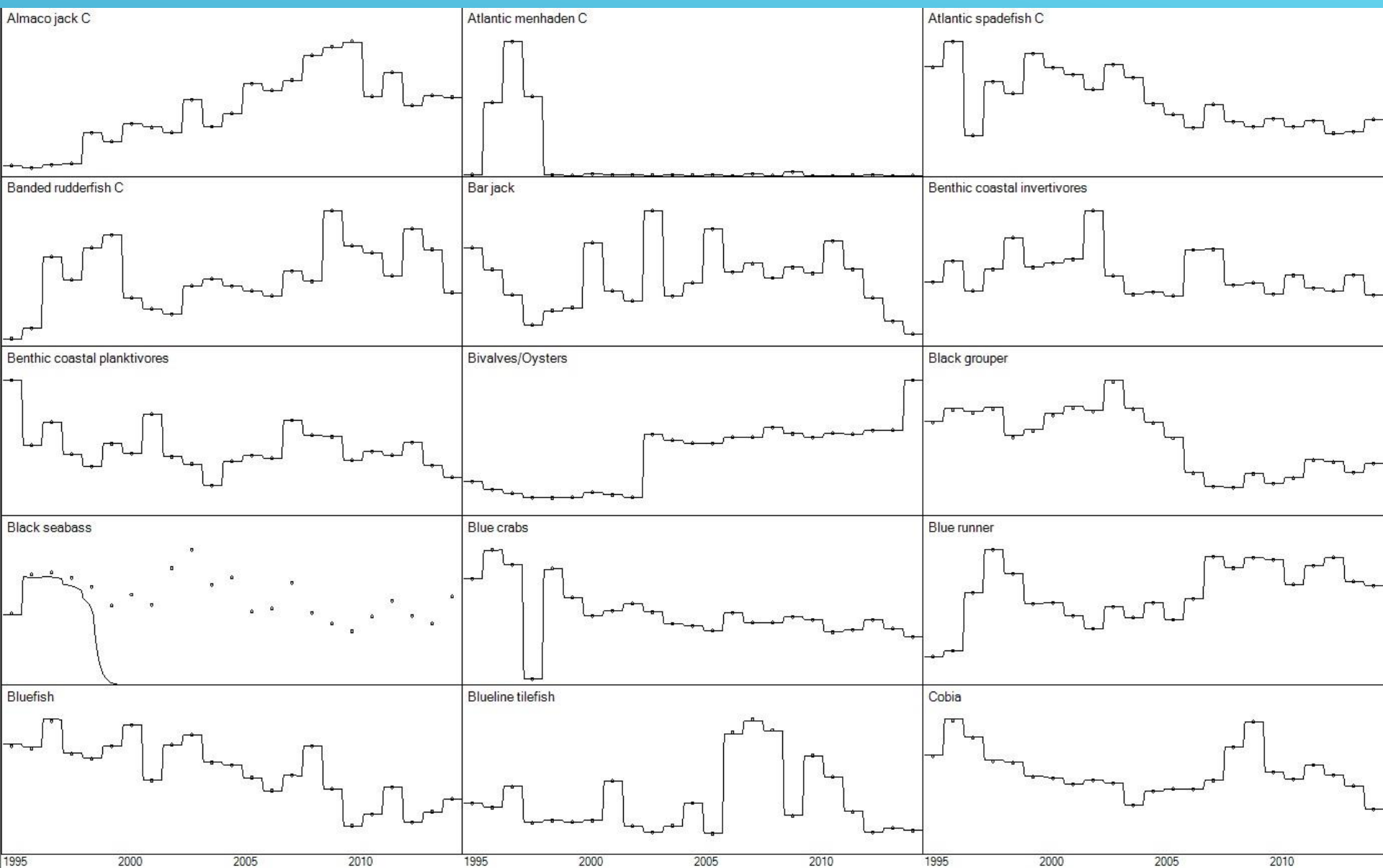
Variance: 10.000



Finding Vulnerability Parameters

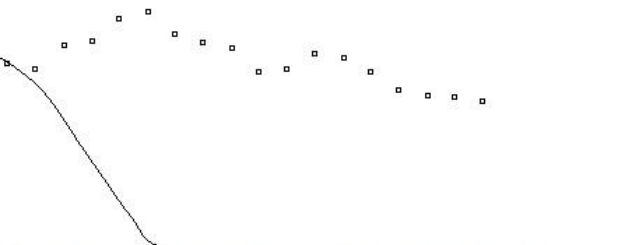
Estimate vulnerabilities																																Set:	Apply
	Prey \ predator	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
1	Coastal bottlenose dolphin									2.13846																							
2	Offshore dolphins									2.13846																							
3	Pilot 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																				1.94641
20	Weakfish									2.13846		2.13846	1.34551		2.51509																	1.94641	1.94641
21	Red drum									2.13846			1.34551																				
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					
23	Spotted seastrout		1.93648																														
24	Mulletts	1.93648								2.13846						2.39919																	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																																
27	Highly migratory pelagics												1.34551																				
28	Dolphinfish		1.93648	1.93648		1.93648																											
29	Pelagic oceanic piscivores		1.93648	1.93648	1.93648	1.93648				2.13846		2.13846			2.51509	2.39919		2.39919			1.34121												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																				
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	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			2.13846			1.34551			2.39919	2.39919	2.39919			1.34121	1.34121	1.34121								1.94641	1.94641	
38	Anchovies		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				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	Halibreaks		1.93648			1.93648	1.93648									2.39919	2.39919																
41	Scads		1.93648		1.93648	1.93648	1.93648									2.39919	2.39919	2.39919			1.34121	1.34121										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	Syngnathids				1.93648	1.93648	1.93648				2.13846	2.13846			2.51509								1.34121		1.99635		1.97818		2.22111		1.94641	1.94641	
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	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							1.99635					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

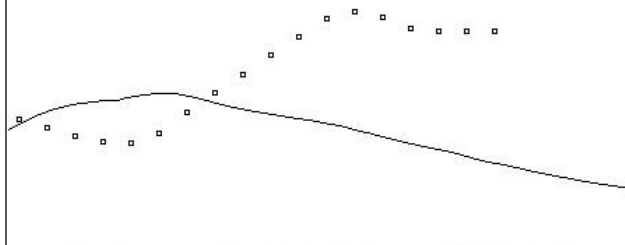


Fitting to Time Series (first try)

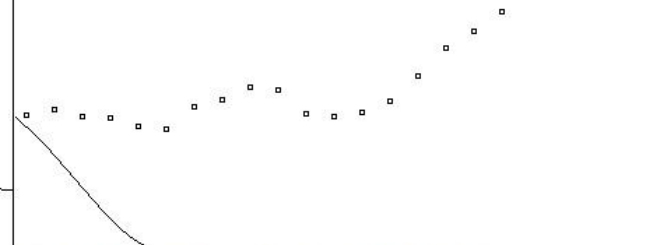
Vermilion snapper - Annual total biomass (t/km²) (1.00000): 8862.94



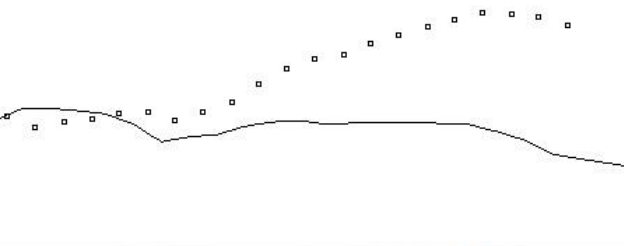
Red Porgy - Annual total biomass (t/km²) (1.00000): 5.00489



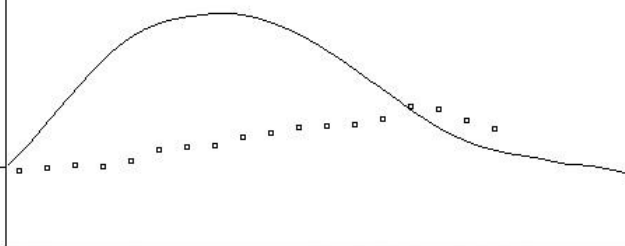
Black seabass - Annual total biomass (t/km²) (1.00000): 11871.2



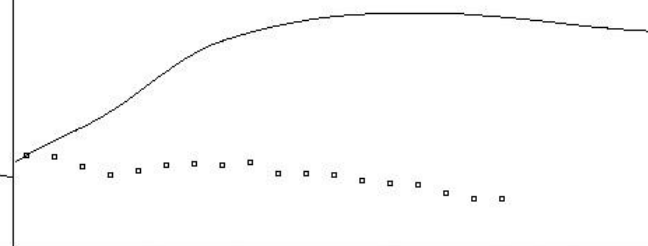
Golden Tilefish - Annual total biomass (t/km²) (1.00000): 4.31520



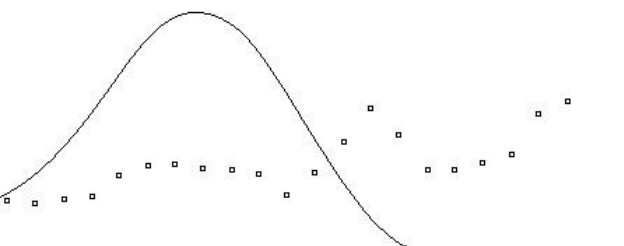
Spanish mackerel - Annual total biomass (t/km²) (1.00000): 5.82495



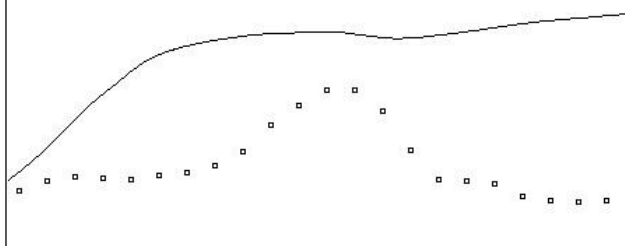
Cobia - Annual total biomass (t/km²) (1.00000): 19.1341



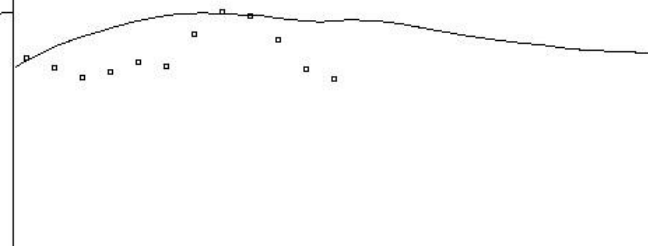
Red snapper - Annual total biomass (t/km²) (1.00000): 1169.32



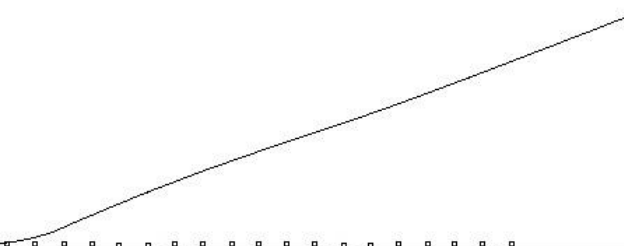
Red grouper - Annual total biomass (t/km²) (1.00000): 20.5057



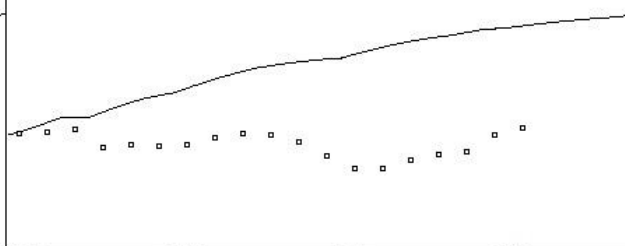
Greater amberjack - Annual total biomass (t/km²) (1.00000): 0.36722



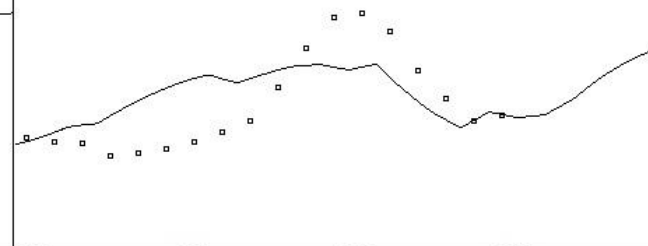
Gag grouper - Annual total biomass (t/km²) (1.00000): 148.550



Snowy grouper - Annual total biomass (t/km²) (1.00000): 6.37502

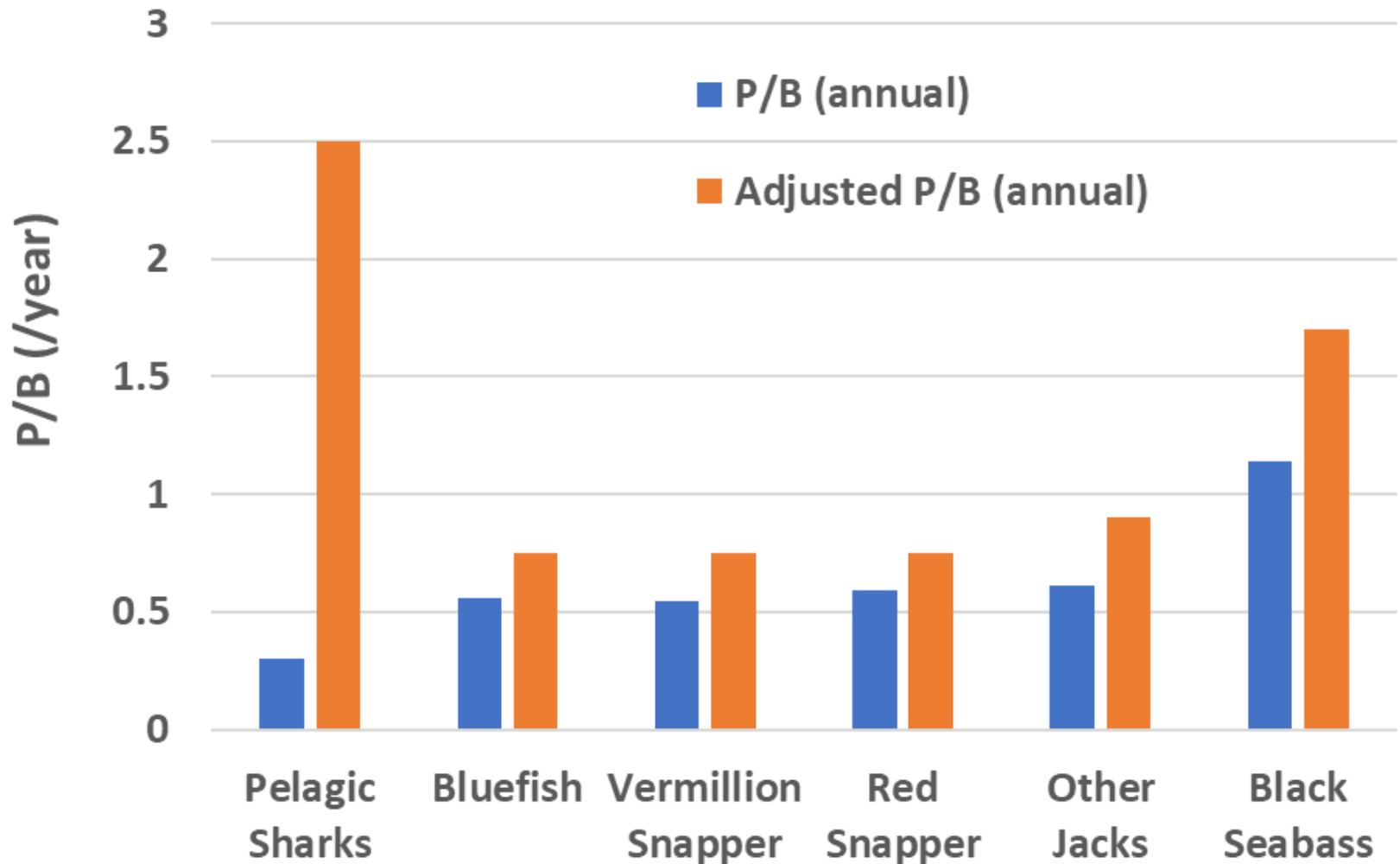


Blueline tilefish - Annual total biomass (t/km²) (1.00000): 1.25798



Balancing Temptation 2

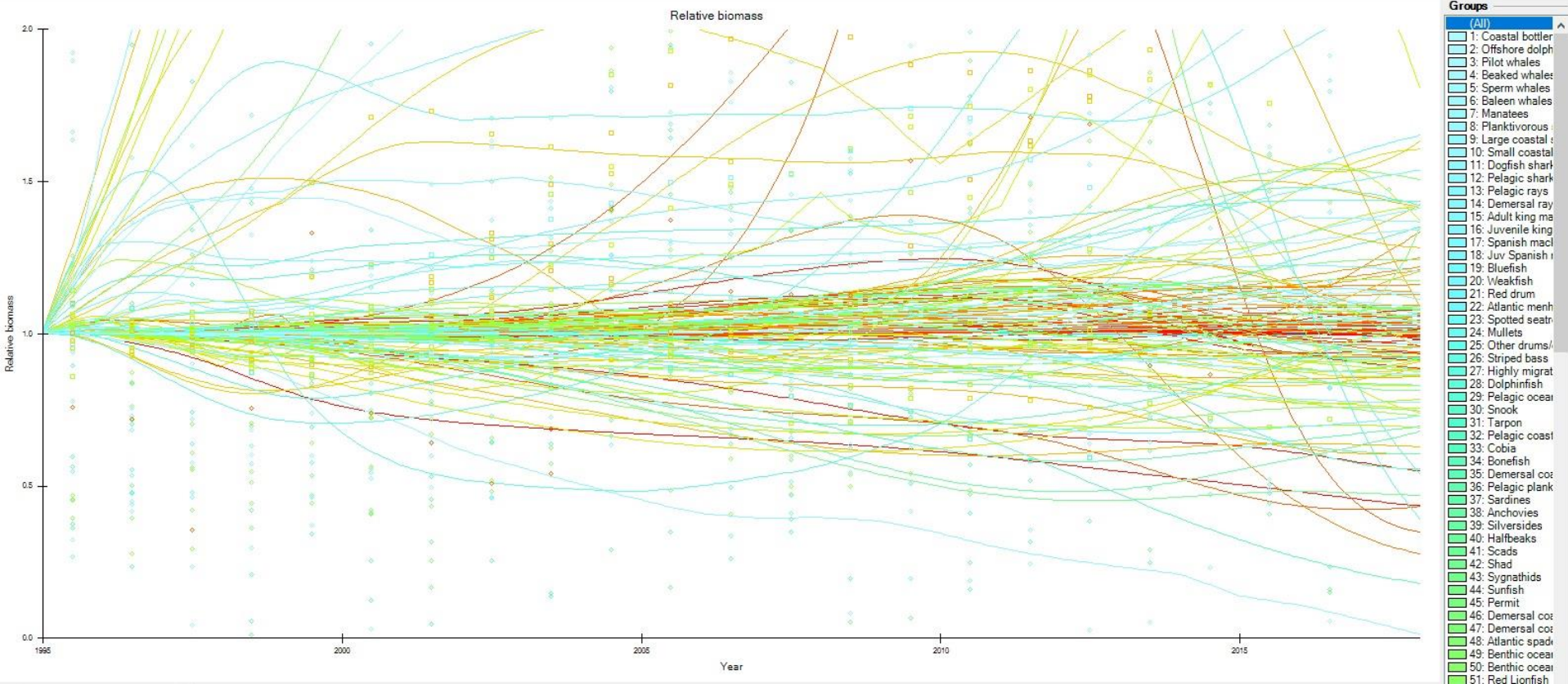
Increase Production Rates



The Overall Effects of Elevated P/B Values

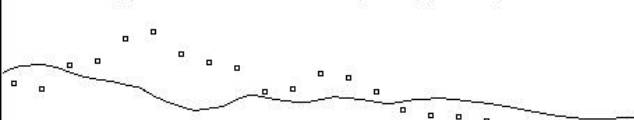
Show groups... Data to plot Show multiple runs Explore results Options Save output

Sum of Squares: 576.236

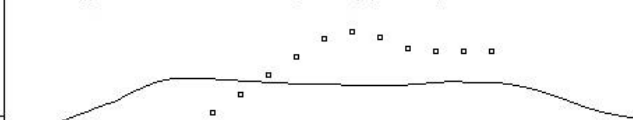


Fitting to Time Series (second try)

Vermilion snapper - Annual total biomass (t/km²) (1.00000): 0.43859



Red Porgy - Annual total biomass (t/km²) (1.00000): 1.21751



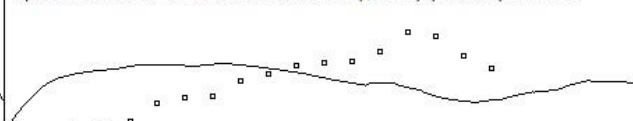
Black seabass - Annual total biomass (t/km²) (1.00000): 1.10277



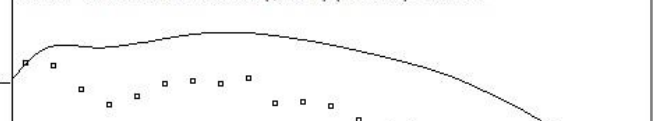
Golden Tilefish - Annual total biomass (t/km²) (1.00000): 1.71527



Spanish mackerel - Annual total biomass (t/km²) (1.00000): 0.85043



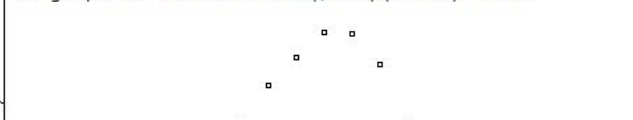
Cobia - Annual total biomass (t/km²) (1.00000): 1.87239



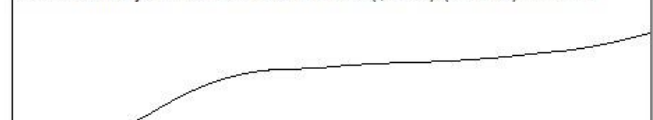
Red snapper - Annual total biomass (t/km²) (1.00000): 3.12077



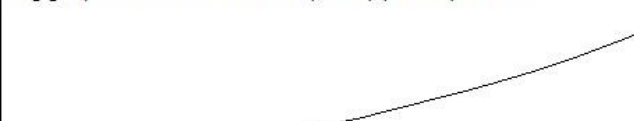
Red grouper - Annual total biomass (t/km²) (1.00000): 4.23407



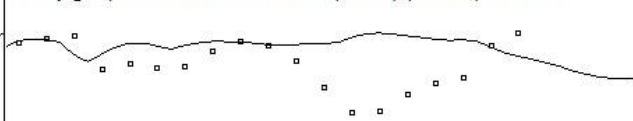
Greater amberjack - Annual total biomass (t/km²) (1.00000): 2.55006



Gag grouper - Annual total biomass (t/km²) (1.00000): 53.2295



Snowy grouper - Annual total biomass (t/km²) (1.00000): 0.58463



Blueline tilefish - Annual total biomass (t/km²) (1.00000): 1.31664



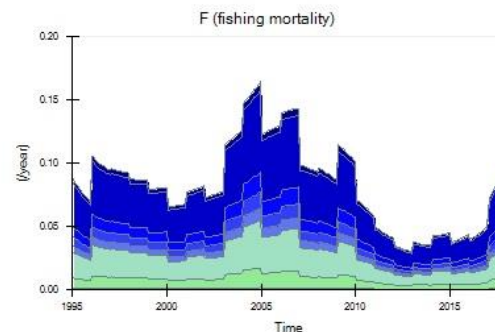
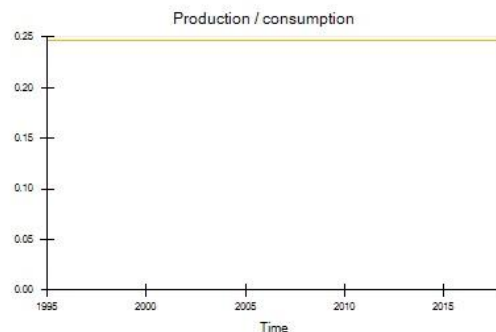
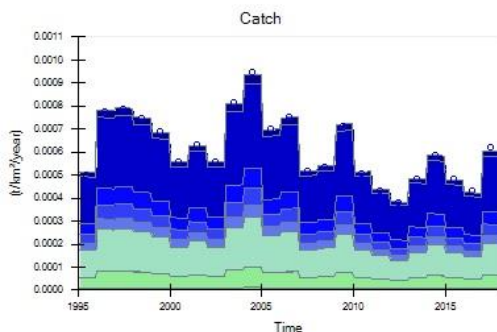
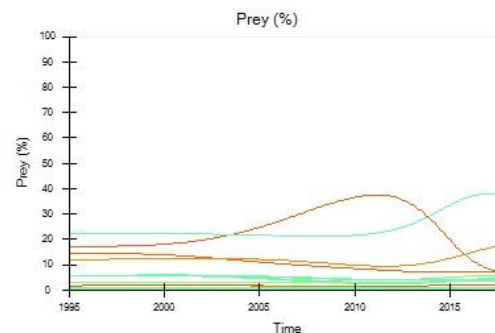
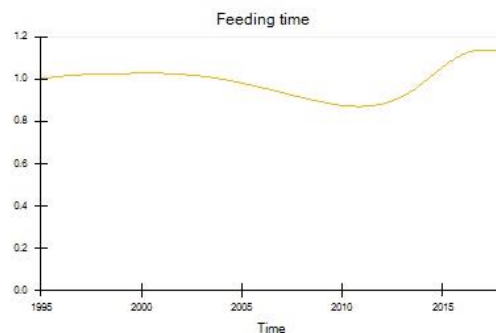
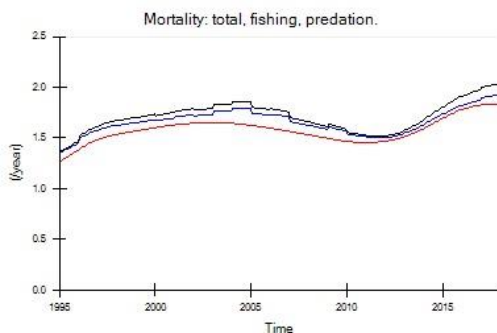
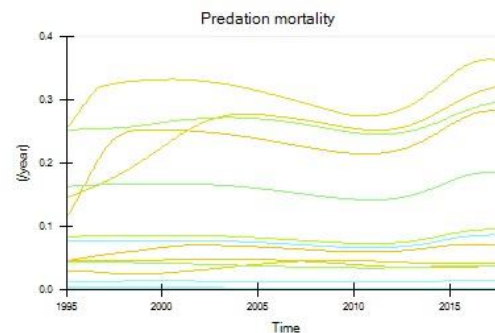
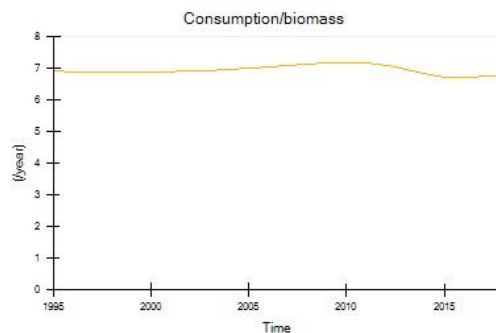
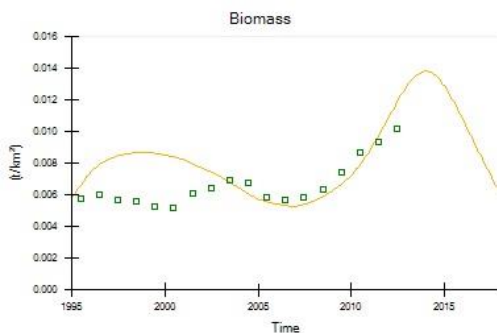
1995 2000 2005 2010

1995 2000 2005 2010

1995 2000 2005 2010

Ecosim Group Plots – Black Seabass

Black seabass



Show plots

Group

- 77: Cubera snapper
- 78: Other shallow snapper
- 79: Vermilion snapper
- 80: Silk snapper
- 81: Red snapper
- 82: Other mid-shelf snapper
- 83: Greater amberjack
- 84: Almaco jack
- 85: Bar jack
- 86: Banded rudderfish
- 87: Blue runner
- 88: Other jacks
- 89: Red porgy
- 90: Other porgys
- 91: White grunt
- 92: Other grunts
- 93: Black seabass**
- 94: Rock/Bank seabass
- 95: Wreckfish
- 96: Other fishes
- 97: Sea turtles
- 98: Carnivorous jellies
- 99: Birds -- oceanic piscivores
- 100: Birds -- shorebirds
- 101: Birds -- shelf piscivores

Predators ranked

- 81: Red snapper
- 56: Benthic coastal invertivores
- 83: Greater amberjack
- 88: Other jacks
- 49: Benthic oceanic piscivores
- 64: Scamp grouper
- 20: Weakfish
- 89: Red porgy
- 86: Banded rudderfish
- 55: Benthic coastal piscivores
- 84: Almaco jack
- 14: Demersal rascals/krill

Prey ranked

- 36: Pelagic planktivores
- 118: Echinoderms and gastropods
- 106: Encrusting fauna
- 117: Megafaunal predators
- 42: Shad
- 38: Anchovies
- 37: Sardines
- 39: Silversides
- 46: Demersal coastal invertivores
- 121: Bivalves/Oysters
- 109: Octopods
- 107: Crustaceans

Fleets

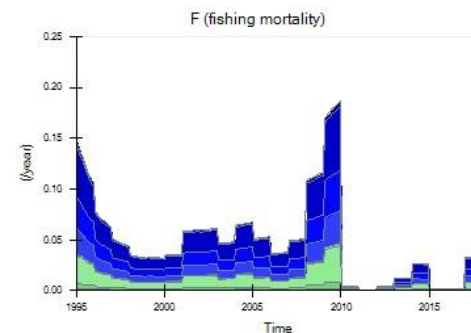
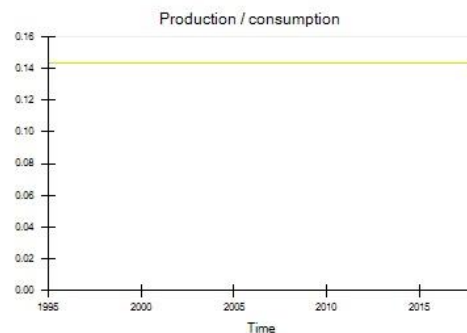
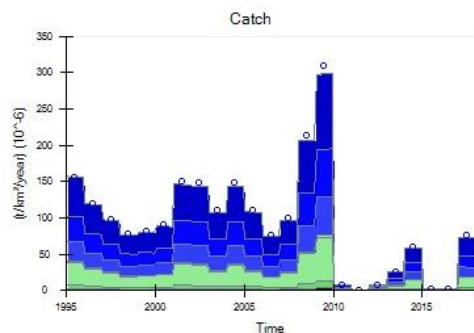
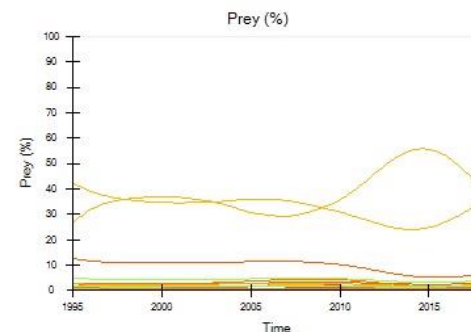
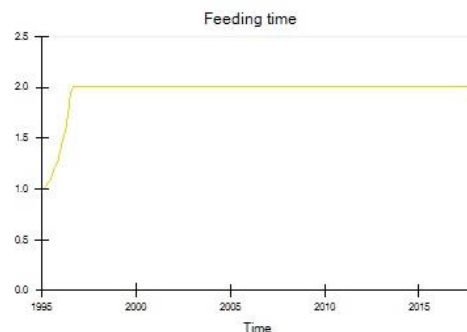
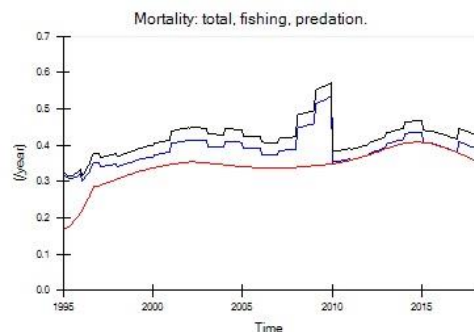
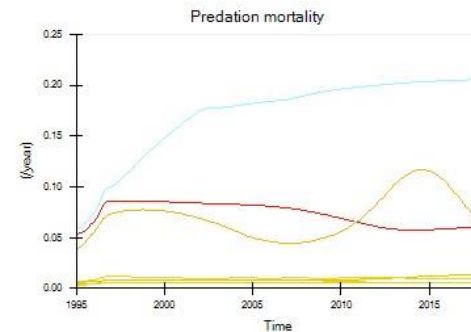
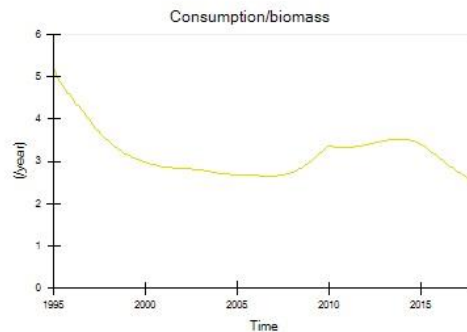
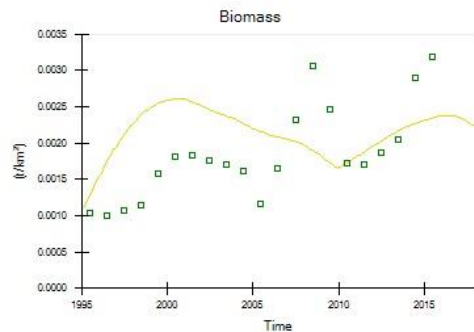
- 18: Private/Rental boat
- 11: Pots & Traps
- 8: Hook and line
- 17: Charter boat
- 16: Headboat
- 15: Trawls
- 19: Shore
- 6: Hand Line
- 5: Gill Net

Save results to .csv

☐ Save data for visible plots only

Red Snapper Plots

Red snapper



Show plots

Group

- 73: Yellowtail snapper
- 74: Mutton snapper
- 75: Gray snapper
- 76: Lane snapper
- 77: Cubera snapper
- 78: Other shallow snapper
- 79: Vermilion snapper
- 80: Silk snapper
- 81: Red snapper**
- 82: Other mid-shelf snapper
- 83: Greater amberjack
- 84: Almaco jack
- 85: Bar jack
- 86: Banded rudderfish
- 87: Blue runner
- 88: Other jacks
- 89: Red porgy
- 90: Other porgys
- 91: White grunt
- 92: Other grunts
- 93: Black seabass
- 94: Rock/Bank seabass
- 95: Wreckfish
- 96: Other fishes
- 97: Sea turtles

Predators ranked

- 9: Large coastal sharks
- 138: Great barracuda
- 93: Black seabass
- 79: Vermilion snapper
- 91: White grunt
- 82: Other mid-shelf snapper
- 80: Silk snapper

Prey ranked

- 93: Black seabass
- 92: Other grunts
- 117: Megafaunal predators
- 55: Benthic coastal piscivores
- 109: Octopods
- 115: Rock shrimps
- 94: Rock/Bank seabass
- 122: Offshore infaunal crustaceans
- 88: Other jacks
- 90: Other porgys
- 41: Scads
- 138: Great barracuda

Fleets

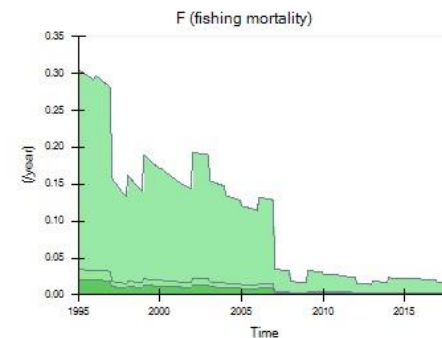
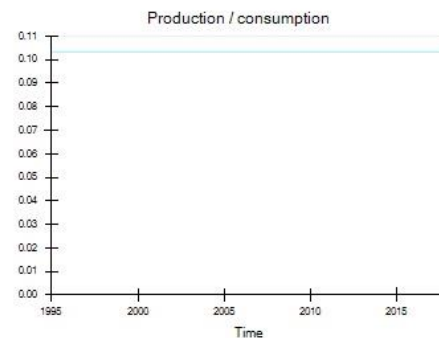
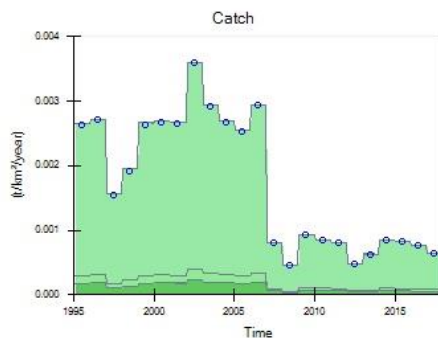
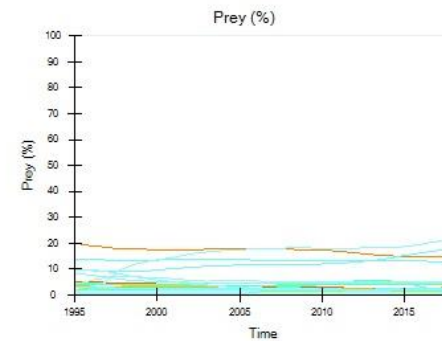
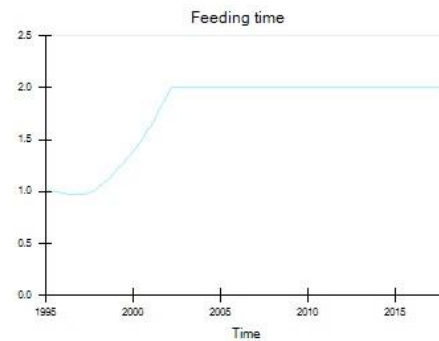
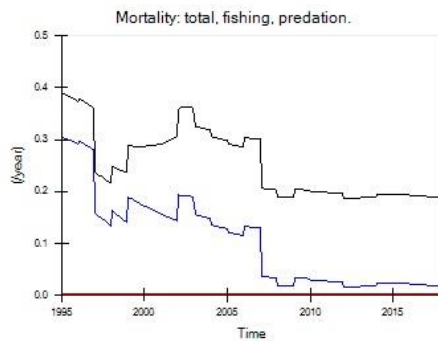
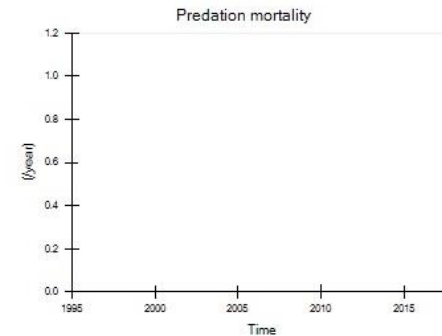
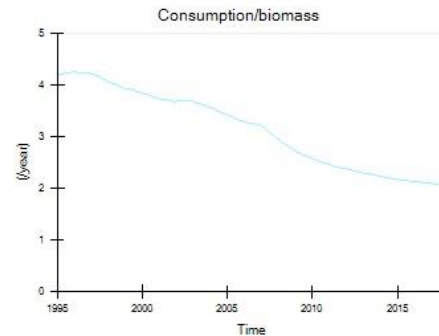
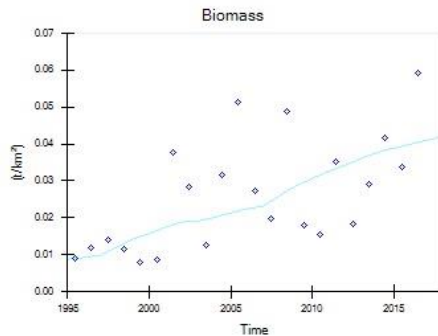
- 18: Private/Rental boat
- 17: Charter boat
- 8: Hook and line
- 16: Headboat
- 6: Hand Line
- 9: Long Lines
- 1: By Hand
- 11: Pots & Traps
- 15: Trawls

Save results to .csv...

☐ Save data for visible plots only

Large Coastal Sharks Plots

Large coastal sharks



Show plots

Group

- ☐ 1: Coastal bottlenose dolphin
- ☐ 2: Offshore dolphins
- ☐ 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
- ☐ 11: Dogfish sharks
- ☐ 12: Pelagic sharks
- ☐ 13: Pelagic rays
- ☐ 14: Demersal rays/skates
- ☐ 15: Adult king mackerel
- ☐ 16: Juvenile king mackerel
- ☐ 17: Spanish mackerel
- ☐ 18: Juv Spanish mackerel
- ☐ 19: Bluefish
- ☐ 20: Weakfish
- ☐ 21: Red drum
- ☐ 22: Atlantic menhaden
- ☐ 23: Spotted seatrout
- ☐ 24: Mulletts
- ☐ 25: Other drums/croakers

Predators ranked

Prey ranked

- ☒ 107: Squids
- ☐ 12: Pelagic sharks
- ☐ 25: Other drums/croakers
- ☐ 22: Atlantic menhaden
- ☐ 10: Small coastal sharks
- ☐ 14: Demersal rays/skates
- ☐ 36: Pelagic planktivores
- ☐ 46: Demersal coastal invertivores
- ☐ 29: Pelagic oceanic piscivores
- ☐ 117: Megafaunal predators
- ☐ 11: Dogfish sharks
- ☐ 20: Other sharks

Fleets

- ☒ 9: Long Lines
- ☐ 5: Gill Nets
- ☐ 8: Hook and line
- ☐ 15: Trawls
- ☐ 7: Haul Seines
- ☐ 1: By Hand
- ☐ 10: Other Gears

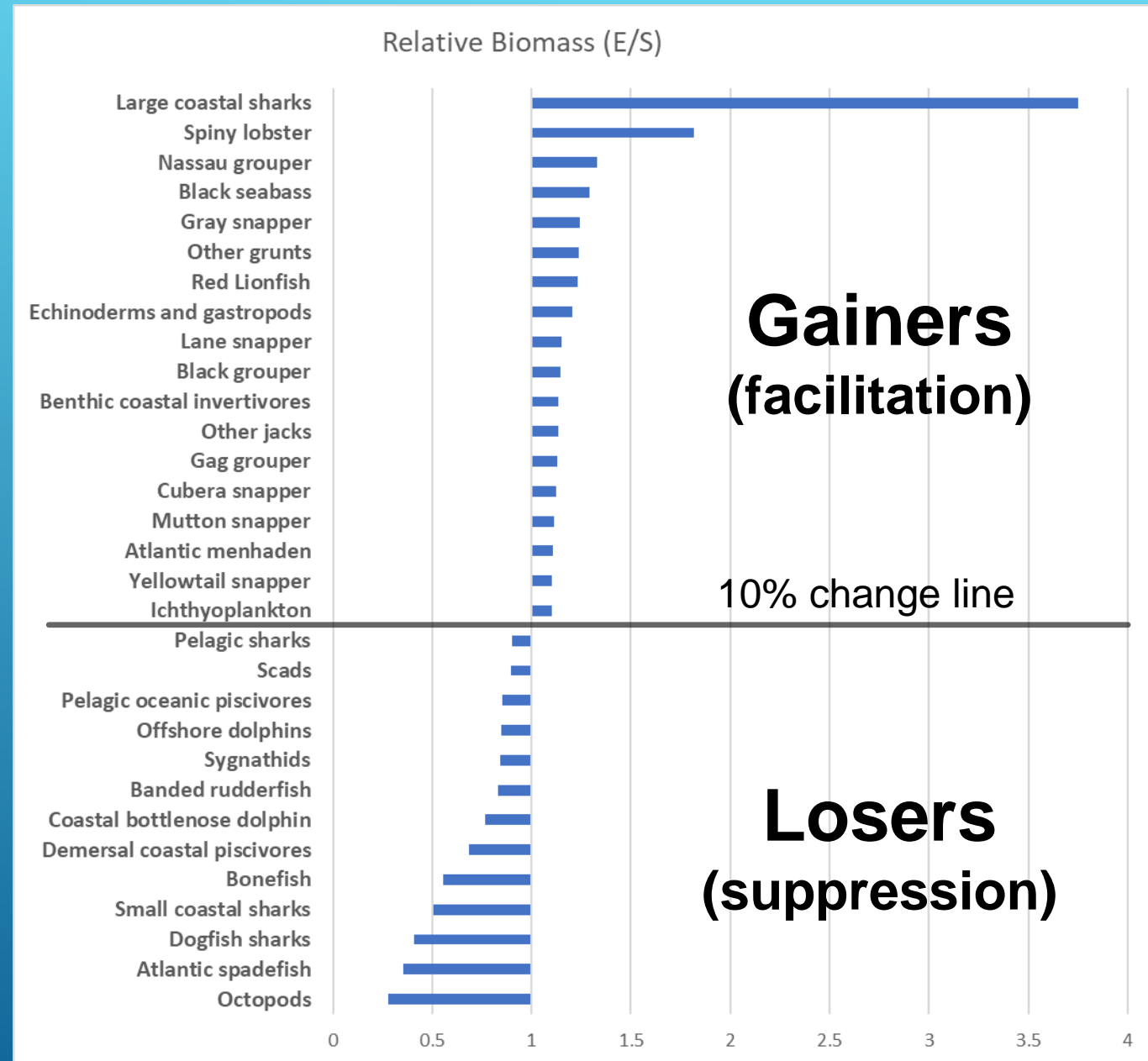
Save results to .csv...

☐ Save data for visible plots only

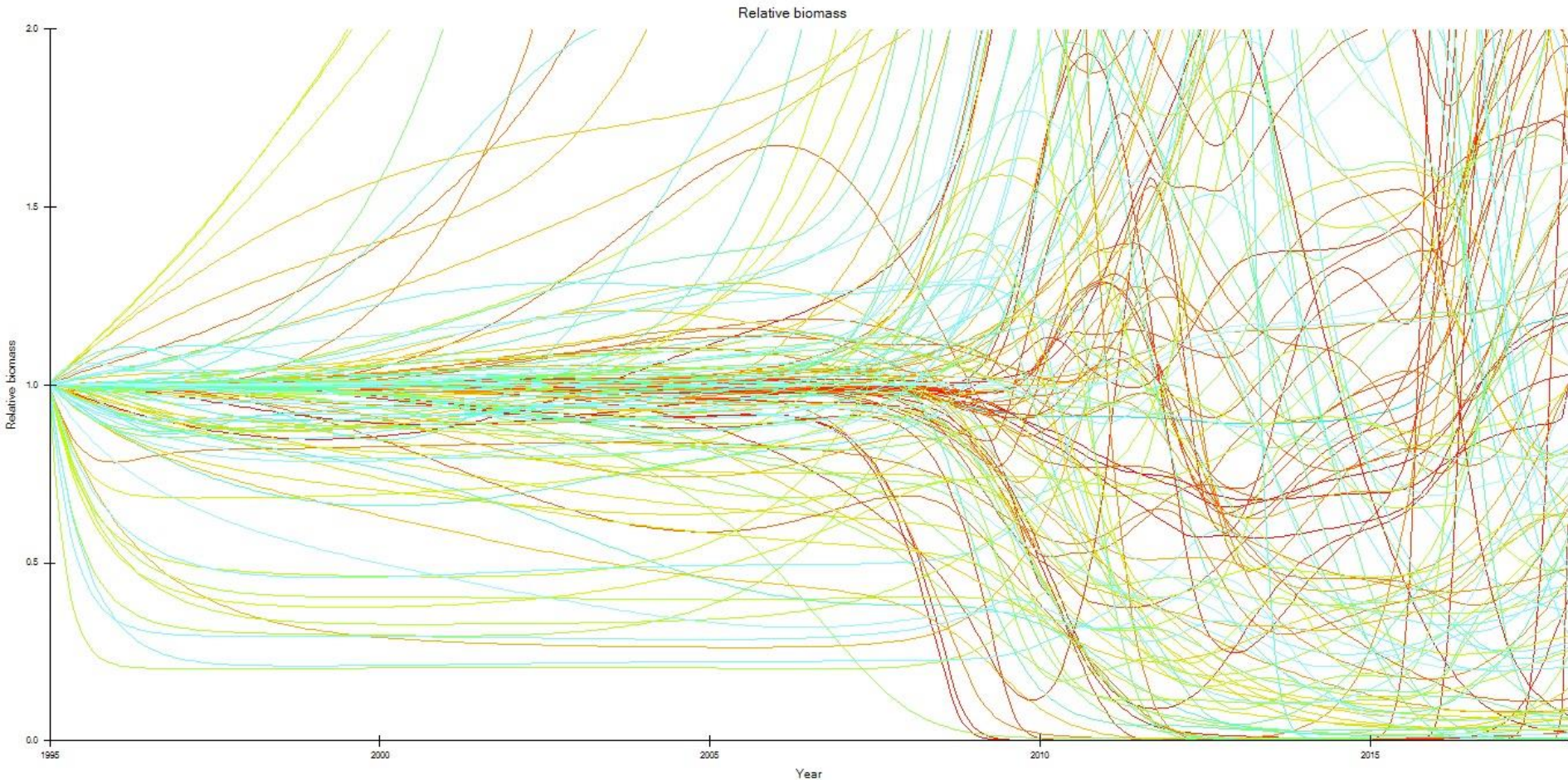
Large Coastal Sharks Make Black Seabass, Snappers, Groupers, Lobster, etc.

(23-year simulation)

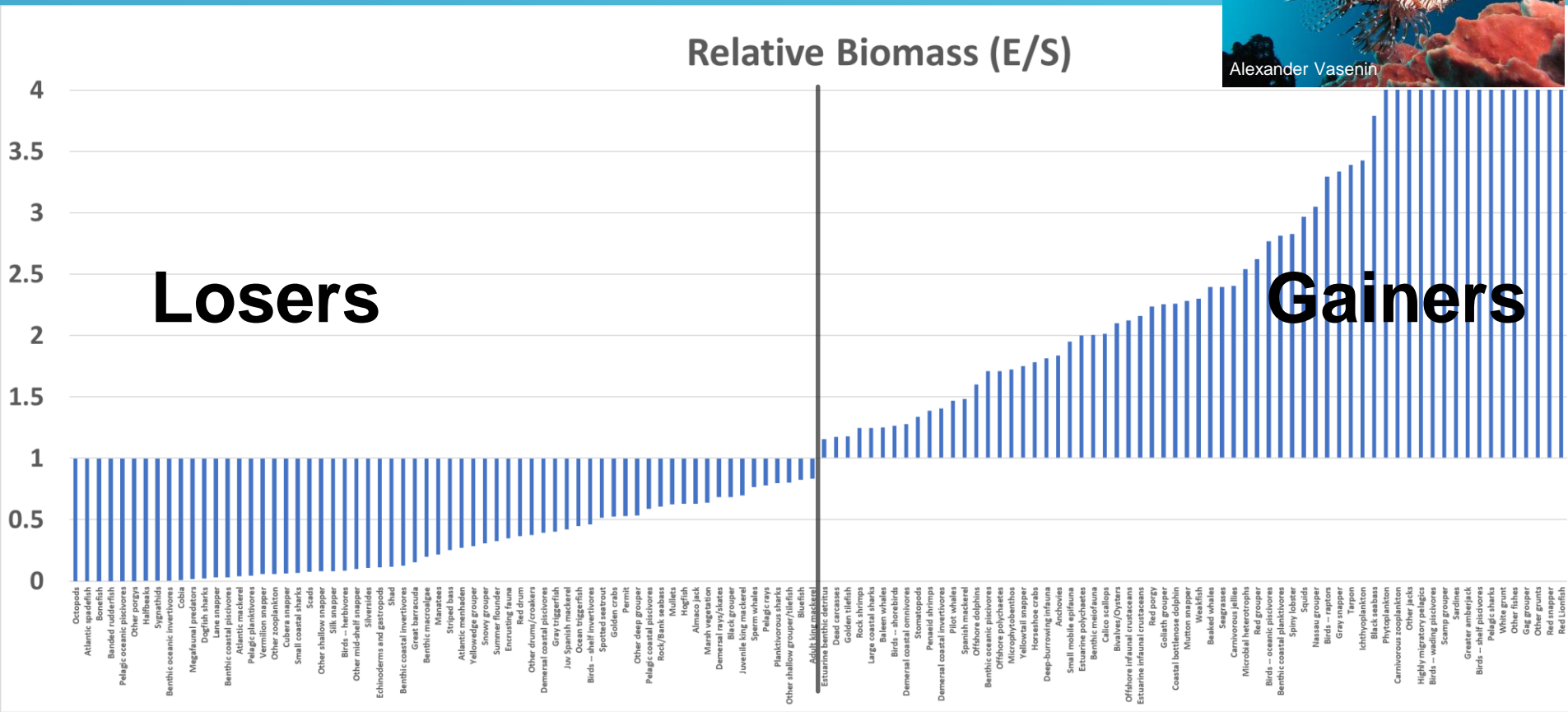
Is this a counterintuitive result?



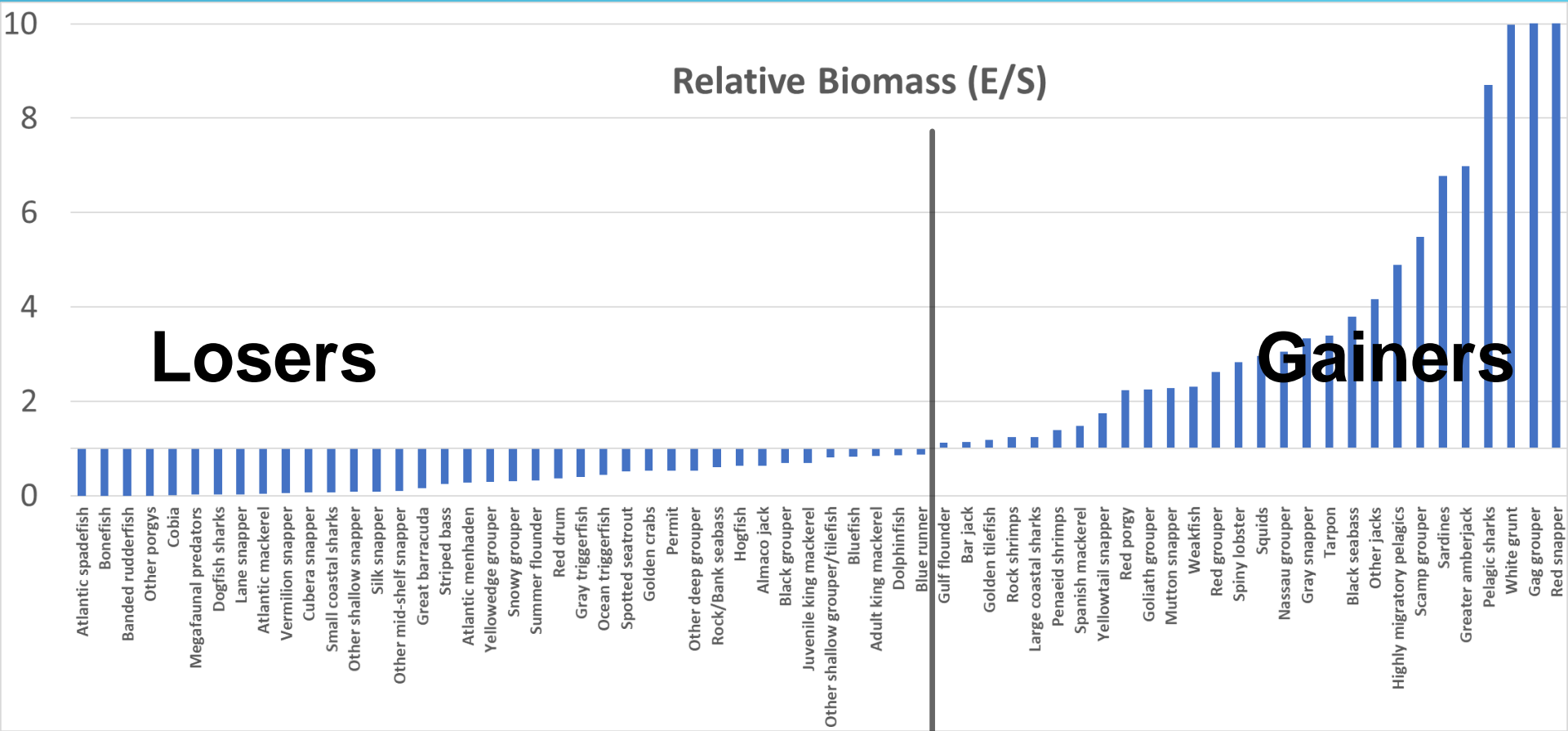
MSY for all = Chaos



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

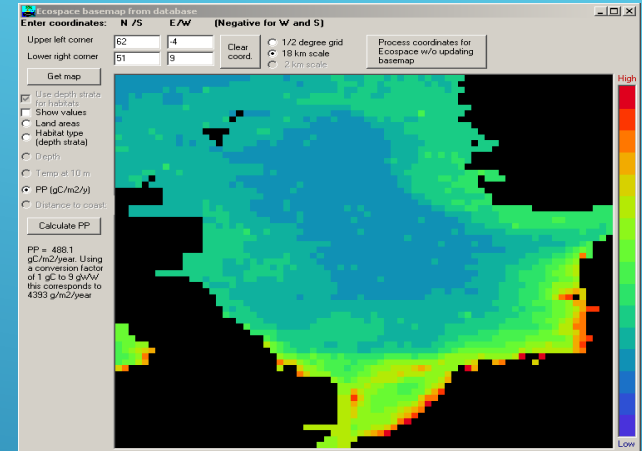
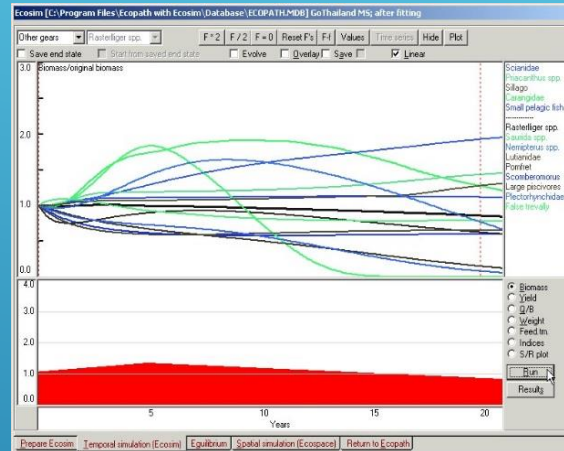
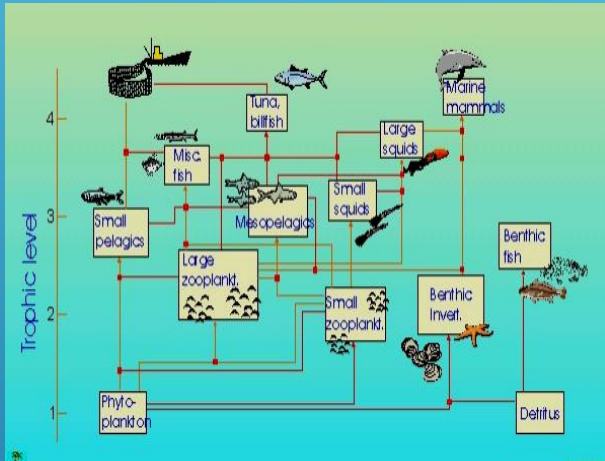
- Identify SSC members to participate on an Ecopath Model Subgroup composed of FWRI/SAFMC staff and members of modeling workgroup.
- Highlight SAFMC/FWRI strategy to collaboratively provide long-term repository for model inputs/outputs and a team approach to maintain and regularly run the models.

Tom Okey


Thomas.Okey@gmail.com



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)
- 

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- 42-box Strawman
- 98-box Preliminary



Fisheries Centre Research Reports

ISSN 1198-6727

2001 Volume 9 Number 4

Southeastern United States, Atlantic Shelf, Page 167

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

Thomas A. Okey¹ and Roger Pugliese²

¹Fisheries Centre, University of British Columbia,
2204 Main Mall, V6T 1Z4, Vancouver BC Canada
email: t.okey@fisheries.ubc.ca

²South Atlantic Fishery Management Council, One
Southpark Circle, Suite 306, Charleston SC 29407 USA

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 continental shelf of the southeastern United

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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

Thomas A. Okey, Andrés M. Cisneros-Montemayor,
Roger Pugliese, Ussif R. Sumaila

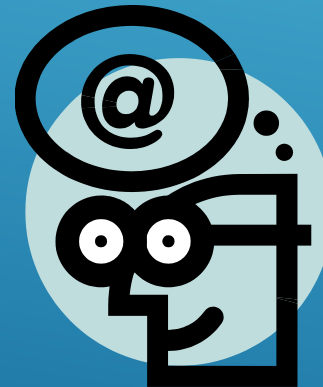
Year: 2014

Email: thomas.okey@gmail.com

This working paper is made available by the Fisheries Centre, University of British Columbia, Vancouver, BC, V6T 1Z4, Canada.

Early primary contributors

- Behzad Mahmoudi (FMRI)
- Bob Feller (USC)
- David Whitaker (SCDNR)
- Doug Vaughan (NMFS)
- Marty Levissen (SCDNR)
- Jack McGovern (NMFS)
- Larry DeLancey (SCDNR)
- Bill Sharp (FMRI)
- Whit Gibbons (UGA)
- Joan Browder (NMFS)
- John Carlson (NMFS)
- Larry Cahoon (UNC)
- Galen Johnson (UNC)
- Megan Gamble (ASMFC)
- Brad Spear (ASMFC)
- Toni Kearns (ASMFC)
- Peter Verity (SKIO)
- Wilson Laney (USFWS)



Early secondary contributors

- Elizabeth Wenner (SCDNR)
- Robert George (GIBS)
- Carolyn Currin (NOAA)
- Chuck Hunter (USFWS)
- Craig Watson (USFWS)
- Damon Gannon (Mote Lab)
- Desmond Kahn (DEDNR)
- Enric Cortez (NMFS)
- George Sedberry (SCDNR)
- Greg McFall (GRNMS)
- Hans Paerl (UNC)
- Jennifer Wheaton (FMRI)
- Jenny Purcell (WWU)
- Jim Nance (NMFS)
- John Merriner (NOAA)
- Doug Forsell (USFWS)

- Jon Hare (NOAA)
- Jose Castro (Mote Lab)
- Ken Lindeman (ED)
- Mark Epstein (USFWS)
- Martin Posey (UNC)
- Paul Carlson (FMRI)
- Steve Ross (UNC)
- Buddy Powell (WT)
- Alan Bolten (UFL)
- Karen Bjorndal (UFL)
- Bob Noffsinger (USFWS)
- Sean McKenna (NCDENR)
- Pat Tester (NOAA)
- Lance Garrison (NMFS)
- Myra Brower (SEFMC)

