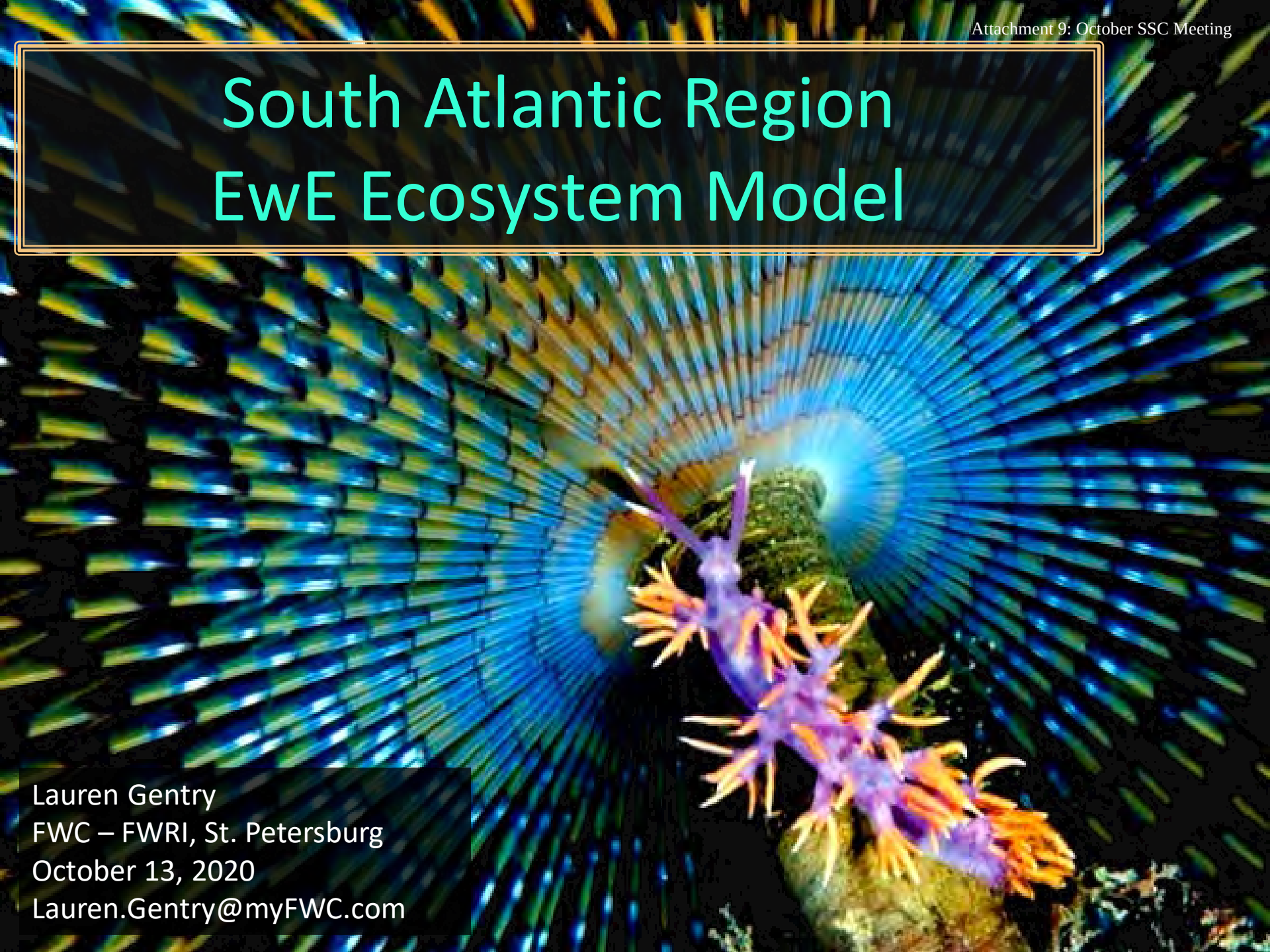
South Atlantic Region EwE Ecosystem Model



Lauren Gentry
FWC – FWRI, St. Petersburg
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Lauren.Gentry@myFWC.com

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)

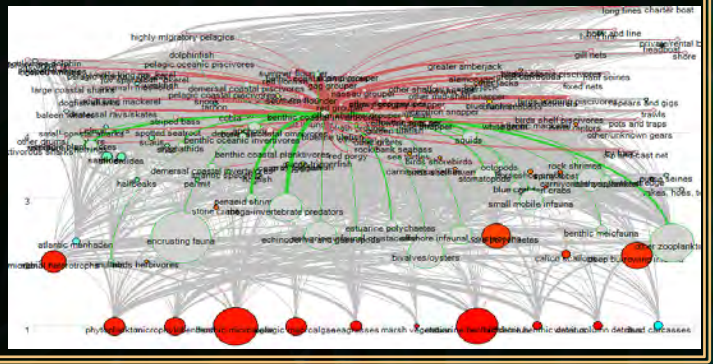
2020 - Model refinement to group together data-poor species (140 boxes, 700+ species)

EwE in a Nutshell

Ecopath – ecosystem structure and function as a snapshot in time

- Basic input: diets, production and consumption rates, biomasses, landings, discards (alive), discard mortality rates
- Mass-balanced model (mass in = mass out)
- Predator's consumption is prey mortality
- Trophic groups are connected via diet matrix

Starting point for simulations



Ecosim – time dynamic simulations to model catch and biomass

<u>Input</u>

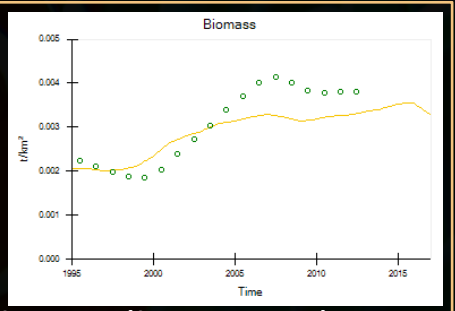
Time series (absolute biomass, relative biomass, landings, etc.)

Forcing functions (Chlor. A time series)

<u>Steps</u>

Use systematic process to calculate vulnerabilities of prey to predators (lowest SS)

Modify vulnerabilities/inputs to fit model predictions to time series of special interest



Ecospace – ecosystem in space and time

- Operates in a raster format
- Applies Ecosim model to each cell
- Biomass can move between cells in different time steps

Diets

April 2019 vs Oct 2020

April 2019

~70 diets for 60 species representing 40 groups

Species proxies for 30 groups

West Florida Shelf model data for 50 groups

Best guess data for 20 groups

October 2020

250 diets for 235 species representing 129 groups

0 Species proxies

West Florida Shelf model data for 17 groups (inverts)

0 Best guess data

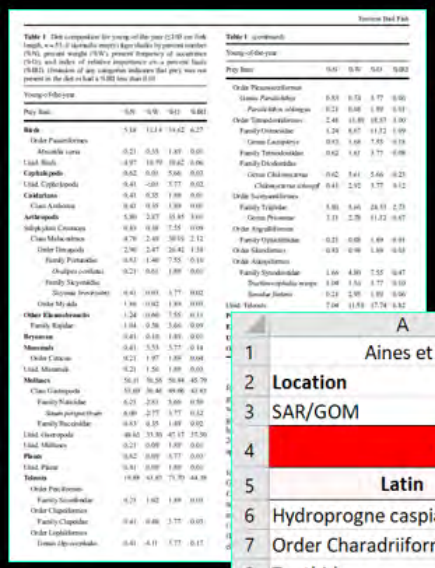
Diets

Primarily from SEAMAP, NOAA, and published literature

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

Origins

Quantitative detailed diet study (high quality)	36%
Quantitative detailed diet study (standard quality)	30%
Qualitative diet study	31%
General knowledge, expert consult	3%



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	0.164293
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
Mammal (neritic) 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

6 Metadata Categories and Scores

	Sample Size
6	n = 2000+
5	n = 1000 - 2000
4	n = 500 - 1000
3	n = 300 - 500
2	n = 100 - 300
1	n = 10 - 100
0	n = 0 - 10

	Diet richness
6	60+ groups in diet
5	50-60
4	40-50
3	30-40
2	20-30
1	10-20
0	0-10

	% of group found
6	200% (two diets)
5	100%
4	75-99%
3	50-75%
2	25-50%
1	10-25%
0	0-10%

	Year
6	1995-1998
5	1998 - 2019
4	1985 - 1995
3	1975 - 1985
2	1965 - 1975
1	Before 1965
0	No date given

	Detail
6	No unknown material, species level ID
5	0-10% unknown material, excellent ID
4	10-30% unknown, some higher taxons
3	30-40% unknown, entirely grouped taxons
2	40-50% unknown, only functional groups
1	50-60% unknown, phylum-level ID only
0	60%+ unknown, most vague (ex. fish and crabs)

	Location
6	SAR
5	SAR + else
4	GOM/North ATL
3	Caribbean/Puerto Rico
2	Other Atlantic
1	Other oceans
0	Unspecified

Analyses – Sensitivity

EwE Monte Carlo simulation routine for testing uncertainty in diet data

Results correlated (40%) with diet richness scores

Thus isolated groups with high sensitivity adjustments **and** normal/low diet richness

Other deep groupers
Blue runner
Auxis mackerels
Herrings
Menhaden

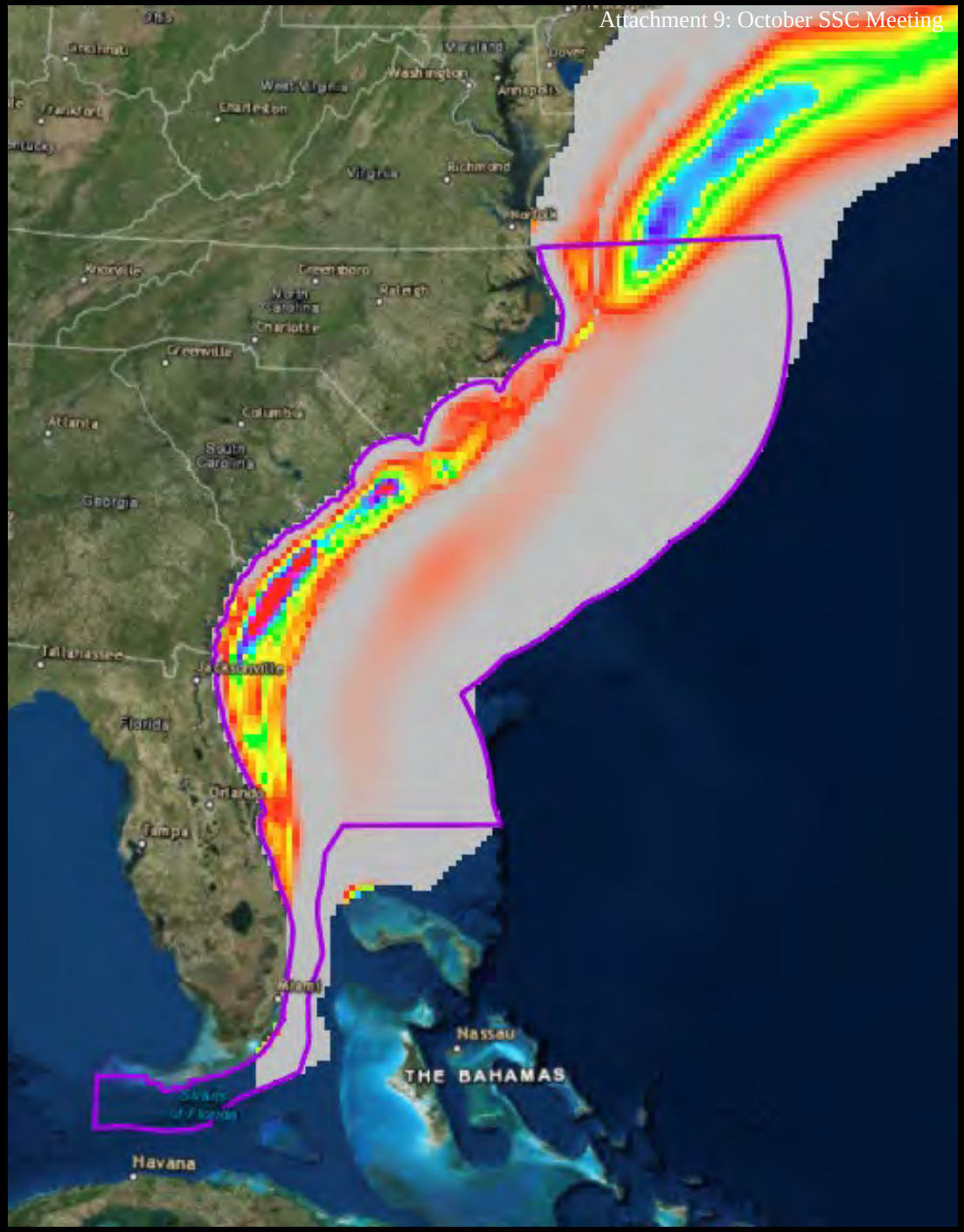
Analyses – Sensitivity

Can use large adjustments to single predator/prey pairs to identify outliers for closer scrutiny

Predator --- Prey	Solution
Halfbeaks --- Seagrass	Incidental ingestion
Hogfish --- Echinoderms & gastropods	Low detail diet
Red snapper --- Black seabass	Net feeding, added more diets
Coastal bottlenose dolphin --- Weakfish	Confirmed by other diets
Shortfin mako --- Bluefish	High quality data – no change
Bluefin marlin --- Auxis mackerels	High quality data – no change

Biomasses

- Primarily from stock assessments
- Others calculated by FWRI staff (manatee surveys, GIS, etc.)
- 61 of 140 input, Ecopath is estimating the rest



Cetacean biomasses

Habitat-based cetacean density models for the U.S. Atlantic and Gulf of Mexico

Developed by Marine Geospatial Ecology Laboratory - Duke University

Landings

Worked with ACCSP to update commercial landings input

- Gear-specific landings for 1100 species from 1995-2019
- Allocated higher taxonomic groups
- Reallocated 90 million pounds of “unknown” landings (seaweed and inverts)
- Examined outliers
- Fixed large coastal shark/dogshark query reversal
    - Solved the misbalanced issue Tom Okey mentioned to the SSC in April 2019

Added recreational/headboat landings to time series that formerly contained only commercial landings

- Found expanded list of MRIP species - added 400+ new species’ landings
- Now have 153 total time series (formerly 131)
- Quality control on outlying values
    - Contacted NOAA, MRIP, GA DNR, etc. (via Wilson Laney)
    - Scamp, cownose ray outliers a result of extrapolation from <5 catches, removed

Other inputs

Added all discard mortalities currently used by SEDAR stock assessments

- Also added newly published/in-press discard mortalities for deep groupers and gray triggerfish from NCSU

Added time series of primary productivity

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

Checked outputs again best practices and thermodynamics rules

Created pedigree for all basic inputs

- Ecopath uses these pedigrees to track estimates
- Also helps drive Monte Carlo sensitivity analyses

Value in the process

Use of diet matrix in other applications

-NOAA Climate Change Vulnerability Assessment
-Ecospecies Database (also long-term repository)
-Comprehensive prey lists for other applications

- SAFMC discussions of new ecosystem component sp.

Identifying data gaps and outliers for future research

- Diet data poor species from metadata (locality, modernity, sample size, etc.)
- Biomass for species with large impacts on model outputs
- Outliers in catch data records – blueline tilefish is next?

Identifying unusual/valuable interactions

- Shortfin makos consume 80% bluefish
- Blue marlin consume 80% Auxis mackerels

Hypothetical Scenario Testing

Black sea bass discard mortality rates

- Ruderhausen et al. 2019 found that descending devices/venting increases survivability by 1.5x vs no intervention
- Reduced recreational discard mortality rate from 14% to 9%
- Model behaved as expected

Biggest Winners and Losers

↑ Biomass

Black seabass
Pelagic planktivores
Encrusting fauna
Squids
Bivalves

↓ Biomass

Anchovies
Shad
Demersal coastal invertivores
Stomatopods
Mega-inverts (crabs)

Prey overlap (%)

	Red snapper	Red porgy	Red lionfish	Red grouper	Black sea bass
Red snapper					
Red porgy	41				
Red lionfish	65	17			
Red grouper	66	67	41		
Black sea bass	43	62	20	65	

Top overlapping diets

Red snapper		Red porgy		Red lionfish		Black sea bass	
Red lionfish	65	Spiny lobster	93	Scamp	75	Golden tilefish	75
Red grouper	65	Queen triggerfish	85	Gag	73	Dogfish sharks	74
Scamp	58	Golden tilefish	80	Red snapper	65	Demersal rays/skates	65

Contributors

SAFMC
FWC – FWRI
NOAA
NMFS
SCDNR
NCDENR
GADNR
ASMFC
UF
UNF
UNC
NCSU

Questions?

Lauren.Gentry@myfwc.com

Appendices

140 groups (part 1)

MAMMALS

Coastal bottlenose dolphin

Offshore dolphins

Pilot whales

Beaked whales

Sperm whales

Baleen whales

Manatees

ELASMOBRANCHS

Planktivorous sharks

Large coastal sharks

Small coastal sharks

Dogfish sharks

Pelagic sharks

Pelagic rays

Demersal rays/skates

TAXONOMIC GROUPS

Mullets

Other sciaenids

Sardines

Anchovies

Silversides

Halfbeaks

Scads

Shad

Sygnathids

Other shallow grouper/tilefish

Other deep grouper

Other shallow snapper

Other mid-shelf snapper

Other jacks

Other porgys

Other grunts

Herrings

FUNCTIONAL GROUPS

Highly migratory pelagics

Pelagic oceanic piscivores

Pelagic coastal piscivores

Demersal coastal piscivores

Pelagic planktivores

Demersal coastal invertivores

Demersal coastal omnivores

Benthic oceanic piscivores

Benthic oceanic invertivores

Benthic coastal piscivores

Benthic coastal invertivores

Benthic coastal planktivores

AVES

Birds -- oceanic piscivores

Birds -- shorebirds

Birds -- shelf piscivores

Birds -- herbivores

Birds -- wading piscivores

Birds -- shelf invertivores

Birds -- raptors

REPTILES

Sea turtles

PHOTOSYNTHETICS

Phytoplankton

Microphytobenthos

Benthic macroalgae

Pelagic macroalgae

Seagrasses

Marsh vegetation

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	Golden crabs	Carnivorous zooplankton
Spotted seatrout	Gray triggerfish	Greater amberjack	Spiny lobster	Other zooplankton
Striped bass	Gag grouper	Almaco jack	Rock shrimps	Ichthyoplankton
Dolphinfish	Red grouper	Bar jack	Penaeid shrimps	Microbial heterotrophs
Snook	Scamp grouper	Queen triggerfish	Megafaunal predators	**DEAD**
Tarpon	Goliath grouper	Blue runner	Echinoderms and gastropods	Estuarine benthic detritus
Cobia	Nassau grouper	Red porgy	Estuarine infaunal crustaceans	Offshore benthic detritus
Bonefish	Snowy grouper	White grunt	Estuarine polychaetes	Water-column detritus
Sunfish	Black seabass	Vermillion snapper		Dead carcasses
Wreckfish	Rock/Bank seabass			
Great barracuda	Atlantic mackerel			