THE SOUTH ATLANTIC REGION ECOPATH MODEL

Advancing the Ecopath / Ecosim / Ecospace approach

Tom Okey, Ocean Integrity Research and the University of Victoria Roger Pugliese, South Atlantic Fishery Management Council

SAFMC Scientific and Statistical Committee Meeting 24-26 October 2017

FOOD WEB MODEL



FISHERY-ECOSYSTEM MODEL





PHASE 1- UPDATE SOUTH ATLANTIC ECOPATH MODEL

Activity 1

Refine South Atlantic Ecopath Model - Tom Okey

Activity 2

Data Assembly

- Marcel Reichert

PHASE 2 – CONNECT TO OTHER MODELS

Activity 3

Review of Estuarine Data and Models - Peter Sheng

Activity 4

A Coupled Marine Environmental Assessment and Prediction System for the Southeastern U.S. Coastal Ocean in Support of Effective Marine Ecosystem-Based Management

- Ruoying He

Grant 5

South Atlantic Fisheries Ecosystem Modeling & Prediction - Jerald S. Ault

THE UPDATED ECOPATH MODEL WILL:

- Support the SA Fishery Management Council's move to ecosystem-based management
- Advance and refine the LCC conservation blueprint
- Link to hydrodynamic oceanographic models and satellite data
- Provide more realistic predictions about spatial policy options
- Estimate impacts of episodic events that are limited in space (oil spills, red tides, upwelling)
- Meet the immediate needs of the SSC and the South Atlantic Council



ECOPATH WITH ECOSIM



No fish is an island

ECOPATH WITH ECOSIM

7000+ users in 150+ countries (google analytics) 800+ peer-reviewed publication (ISI Web of Knowledge)

ECOPATH / ECOSIM / ECOSPACE









ECOPATH



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

Diet composition e.g., for a tuna



Use volume or weight!

yPresSouthAtlar ticEcopathMod

HISTORY OF THE SAB MODEL

> 2001 - Strawman 48-group model constructed

> 2004 - Preliminary 98-group model developed

 2014 - Model refined to address forage fish questions (99 groups)

> 2017 – Model refinement to articulate the managed species (137 boxes)

ISSN 1198-6727

Preliminary SAS model

Sponsored by SAFMC 42-box model 98-box model



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

South 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 Kevs, 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 shear, and little doubt remains that the bookti Atle Oke considerably modified the continental sheaf. The

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)



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)







Attachment 10 Tab01_A10_Oke yPresSouthAtlan ticEcopathMod

NEW 99 BOX SAB MODEL (FORAGE)

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Forage version 2014

Sponsored by Pew Charitable Trusts

Forage groups articulated

99-box model

Fisheries Centre

The University of British Columbia



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.

Attachment 10

Tab01_A10_Oke yPresSouthAtlan ticEcopathMod

Articulated forage groups in the 2014 99-box South Atlantic Bight *EwE* model

Anchovies Atlantic menhaden Atlantic silverside Halfbeaks Mullets Sardines Scads Shad Thread herring Pelagic oceanic planktivores Squids Shrimps

Forage Groups in the 99-box South Atlantic Bight model

| Group | Species included | B († [.] km [.] ²) | P/B (year [.] 1) | Q/B (year ⁻ 1) |
|---------------------------------|---|--|---------------------------------|---------------------------------|
| Anchovies | Bay (Anchoa mitchilli), striped (A. hepsetus), silver (Engraulis eurystole) | 3.75 | 1.45 | 17.50 |
| Atlantic menhaden | Brevoortia tyrannus (not B. patronus) | 7.05 | 1.70 | 7.84 |
| Atlantic silverside | Menidia menidia | 1.18 | 2.00 | 14.90 |
| Halfbeaks | Ballyhoo (Hemiramphus brasiliensis), balao (H. balao), common or Atlantic silverstripe (Hyporhamphus unifasciatus) | 1.22 | 2.60 | 11.70 |
| Mullets | Striped (Mugil cephalus), other (Mugil spp.) | 0.11 | 0.70 | 11.03 |
| Sardines | Spanish (Sardinella aurita), scaled (Harengula jaguana) | 1.93 | 1.11 | 11.82 |
| Scads | Round (Decapterus punctatus), rough (Trachurus lathami), bigeye (Selar crumenophthalmus) | 2.28 | 0.92 | 10.00 |
| Shad | Alosa spp. | 3.97 | 0.50 | 3.80 |
| Thread herring | Atlantic thread herring (Ophistonema oglinum) | 0.28 | 1.60 | 13.26 |
| Pelagic oceanic planktivores | Chub mackerel (Scomber japonicus), Ianternfish (Diaphus spp.), antenna codlet (Bregmaceros atlanticus), striated argentine (Argentina striata), flyingfish (Exocoetidae) | 3.95 | 0.87 | 11.71 |
| Squids | Shortfin (Illex illecebrosus), longfin (Loligo pealei) | 0.45 | 2.67 | 36.50 Attachme |
| Shrimps | Rock shrimps and penaeid shrimps | 2.53 | 5.38 | vPresSouth |

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Species / Groups in the 2014 SAB 99-box model

| Coastal bottlenose dolphin | Thread herring | Seabass | Estuarine infaunal crustaceans |
|---------------------------------|--------------------------------|----------------------------|----------------------------------|
| Manatees | Shad | Wreckfish | Estuarine polychaetes |
| Large coastal sharks | Anchovies | Other fishes | Bivalves/Oysters |
| Small coastal sharks | Atlantic silverside | Sea turtles | Offshore infaunal crustaceans |
| Baleen whales | Halfbeaks | Carnivorous jellies | Offshore polychaetes |
| Pelagic sharks | Pelagic oceanic invertivores | Birds oceanic piscivores | Small mobile epifauna |
| Rays and skates | Demersal coastal invertivores | Birds shorebirds | Calico scallops |
| Dogfish sharks | Demersal coastal omnivores | Birds shelf piscivores | Benthic meiofauna |
| Adult mackerel | Benthic oceanic piscivores | Birds herbivores | Deep-burrowing infauna |
| Juvenile mackerel | Benthic oceanic invertivores | Birds wading piscivores | Carnivorous zooplankton |
| Bluefish | Benthic coastal piscivores | Birds shelf invertivores | Aquatic and other insects |
| Weakfish | Benthic coastal invertivores | Birds raptors | Other zooplankton |
| Red drum | Benthic coastal planktivores | Encrusting fauna | Ichthyoplankton |
| Atlantic menhaden | Reef associated piscivores | Squids | Microbial heterotrophs |
| Mullets | Reef associated omnivores | Stomatopods | Phytoplankton |
| Other Drums & Croakers | Triggerfish | Octopods | Microphytobenthos |
| Striped bass | Shallow water grouper/tilefish | Blue crabs | Benthic macroalgae |
| Highly migratory pelagics | Goliath grouper | Horseshoe crabs | Pelagic macroalgae |
| Dolphinfish | Nassau grouper | Golden crabs | Seagrasses |
| Pelagic oceanic piscivores | Deep-water grouper/tilefish | Stone crabs | Marsh vegetation |
| Pelagic coastal piscivores | Shallow-water snapper | Spiny lobster | Estuarine benthic detritus |
| Nearshore piscivores | Mid-shelf snapper | Rock shrimps | Offshore benthic detritus |
| Pelagic oceanic planktivores | Jacks | Penaeid shrimps | Water-column detritus |
| Sardines | Red porgy | Megafaunal predators | Dead carcasses |
| Scads | Grunts and porgys | Echinoderms and gastropods | Tab01_A10_Oke yPresSouthAtlan |

Focused on predatory fish of particular value in the 99-box SAB ecosystem model

Spanish/king mackerels

Vermillion snapper

Gag grouper

Dolphinfish

Black seabass

Greater amberjack

Cobia

Red snapper

Effects of Mullets and Squids on other groups



Effect of Menhaden on other groups



Striped bass Large coastal sharks Atlantic menhaden Small coastal sharks Highly migratory pelagics Weakfish Pelagic sharks Birds -- raptors Coastal bottlenose dolphin Reef associated piscivores Pelagic coastal piscivores Juvenile mackerel Dolphinfish Pelagic oceanic piscivores Benthic oceanic piscivores Wreckfish Birds -- shelf piscivores Adult mackerel Nearshore piscivores Dogfish sharks Shallow water grouper/tilefish Red porgy

Biomass change (year 10 / baseline)



Stomatopods Squids Reef associated omnivores Red porgy Calico scallops Seabass Dogfish sharks Small coastal sharks Megafaunal predators Red drum Sardines Other fishes Estuarine infaunal crustaceans Deep-water grouper/tilefish Shad Penaeid shrimps Mid-shelf snapper Thread herring Birds -- wading piscivores Scads Coastal bottlenose dolphin Deep-burrowing infauna Anchovies Pelagic sharks Pelagic oceanic invertivores Atlantic silverside Striped bass Carnivorous zooplankton Weakfish Grunts and porgys Highly migratory pelagics Aquatic and other insects Pelagic oceanic piscivores Wreckfish Shallow water grouper/tilefish Jacks Nearshore piscivores Nassau grouper **Bivalves/Oysters** Sea turtles Pelagic oceanic planktivores Spiny lobster Benthic coastal invertivores Large coastal sharks Benthic coastal piscivores Blue crabs Birds -- shelf piscivores Horseshoe crabs Demersal coastal invertivores Ichthyoplankton Benthic oceanic invertivores Benthic oceanic piscivores Octopods Benthic coastal planktivores

Effect of Squids on other groups

Effect of Pelagic Oceanic Planktivores on other groups

Pelagic oceanic planktivores Jacks Pelagic sharks Marsh vegetation Shallow-water snapper Birds -- oceanic piscivores Bluefish Wreckfish Highly migratory pelagics Shallow water grouper/tilefish Adult mackerel Pelagic coastal piscivores Juvenile mackerel Pelagic oceanic piscivores Weakfish Seagrasses Grunts and porgys Nearshore piscivores Other fishes Striped bass Dolphinfish Pelagic oceanic invertivores Other Drums & Croakers Carnivorous zooplankton Halfbeaks Dogfish sharks Mid-shelf snapper Birds -- wading piscivores Birds -- shelf piscivores Reef associated piscivores Seabass Shad Sardines Thread herring Red porgy Scads



Effect of anchovy on other groups



/PresSouthAtlan ticEcopathMod

Effect of halfbeaks on other groups



yPresSouthAtlar ticEcopathMoc

Effect of shrimps on other groups



Effect of all forage fish groups on other groups

Bluefish Juvenile mackerel Weakfish Adult mackerel Large coastal sharks Striped bass Highly migratory pelagics Atlantic menhaden Mullets Pelagic oceanic planktivores Sardines Scads Thread herring Shad Anchovies Atlantic silverside Halfbeaks Pelagic sharks Dolphinfish Small coastal sharks Jacks Reef associated piscivores Pelagic coastal piscivores Birds -- shelf piscivores Birds -- wading piscivores Birds -- oceanic piscivores Red porgy Coastal bottlenose dolphin Spiny lobster Shallow water grouper/tilefish Horseshoe crabs Stone crabs Wreckfish Birds -- raptors Benthic meiofauna **Bivalves/Oysters** Other Drums & Croakers Benthic oceanic piscivores Goliath grouper Demersal coastal omnivores Rays and skates Rock shrimps Triggerfish Golden crabs Birds -- shelf invertivores Offshore polychaetes Reef associated omnivores Stomatopods Nearshore piscivores Baleen whales Benthic coastal invertivores Seabass Red drum Shallow-water snapper Nassau grouper Deep-water grouper/tilefish Benthic coastal piscivores Pelagic oceanic piscivores Penaeid shrimps Birds -- herbivores Other zooplankton Carnivorous jellies Seagrasses Squids Carnivorous zooplankton Ichthyoplankton Birds -- shorebirds Benthic coastal planktivores Mid-shelf snapper Other fishes Aquatic and other insects Pelagic oceanic invertivores Dogfish sharks Marsh vegetation





Effect of all forage groups (including squids and shrimps) on other groups

Effects of menhaden on valued predatory fish



Tab01_A10_Oke yPresSouthAtlan ticEcopathMod

Effects of all forage fish on valued predatory fish



Effects of all forage on valued predatory fish



Articulated Managed Species / Groups in the 2017 SAB 137-box model

| Adult king mackerel | Red grouper | Vermilion snapper |
|---------------------------|--------------------------------|---|
| Juvenile king mackerel | Black grouper | Silk snapper |
| Spanish Mackerel | Scamp grouper | Red snapper |
| Juvenile spanish mackerel | Other shallow grouper/tilefish | Other mid-shelf snapper |
| Spotted seatrout | Snowy grouper | Greater amberjack |
| Snook | Yellowedge grouper | Almaco jack |
| Tarpon | Other deep grouper | Bar Jack |
| Cobia | Blueline tilefish | Banded rudderfish |
| Bonefish | Golden tilefish | Blue runner |
| Permit | Yellowtail snapper | Other jacks |
| Atlantic Spadefish | Mutton snapper | Other porgys |
| Hogfish | Gray snapper | White grunt |
| Ocean triggerfish | Lane snapper | Other grunts |
| Gray triggerfish | Cubera snapper | Black Seabass |
| Gag grouper | Other shallow snapper | Attachment 10 Bank/Rock seatoass10_Oke |

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Species / Groups in SAB 137-box model

| Coastal bottlenose dolphin | Nearshore piscivores | Gag grouper | Red porgy | Penaeid shrimps |
|----------------------------|-------------------------------|--------------------------------|--------------------------|--------------------------------|
| Manatees | Pelagic oceanic planktivores | Red grouper | Other porgys | Megafaunal predators |
| Large coastal sharks | Sardines | Black grouper | White grunt | Echinoderms and gastropods |
| Small coastal sharks | Scads | Scamp grouper | Other grunts | Estuarine infaunal crustaceans |
| Baleen whales | Thread herring | Goliath grouper | Black seabass | Estuarine polychaetes |
| Pelagic sharks | Shad | Nassau grouper | Rock/Bank seabass | Bivalves/Oysters |
| Rays and skates | Anchovies | Other shallow grouper/tilefish | Wreckfish | Offshore infaunal crustaceans |
| Dogfish sharks | Atlantic silverside | Snowy grouper | Other fishes | Offshore polychaetes |
| Adult king mackerel | Halfbeaks | Yellowedge grouper | Sea turtles | Small mobile epifauna |
| Juvenile king mackerel | Pelagic oceanic invertivores | Other deep grouper | Carnivorous jellies | Calico scallops |
| Spanish mackerel | Permit | Blueline tilefish | Birds oceanic piscivores | Benthic meiofauna |
| Juv Spanish mackerel | Demersal coastal invertivores | Golden tilefish | Birds shorebirds | Deep-burrowing infauna |
| Bluefish | Demersal coastal omnivores | Yellowtail snapper | Birds shelf piscivores | Carnivorous zooplankton |
| Weakfish | Atlantic spadefish | Mutton snapper | Birds herbivores | Other zooplankton |
| Red drum | Benthic oceanic piscivores | Gray snapper | Birds wading piscivores | Ichthyoplankton |
| Atlantic menhaden | Benthic oceanic invertivores | Lane snapper | Birds shelf invertivores | Microbial heterotrophs |
| Spotted seatrout | Red Lionfish | Cubera snapper | Birds raptors | Phytoplankton |
| Mullets | Summer flounder | Other shallow snapper | Encrusting fauna | Microphytobenthos |
| Other Drums & Croakers | Southern flounder | Vermilion snapper | Squids | Benthic macroalgae |
| Striped bass | Gulf flounder | Silk snapper | Stomatopods | Pelagic macroalgae |
| Highly migratory pelagics | Benthic coastal piscivores | Red snapper | Octopods | Seagrasses |
| Dolphinfish | Benthic coastal invertivores | Other mid-shelf snapper | Blue crabs | Marsh vegetation |
| Pelagic oceanic piscivores | Hogfish | Greater amberjack | Horseshoe crabs | Estuarine benthic detritus |
| Snook | Benthic coastal planktivores | Almaco jack | Golden crabs | Offshore benthic detritus |
| Tarpon | Reef associated piscivores | Bar jack | Stone crabs | Water-column detritus |
| Pelagic coastal piscivores | Reef associated omnivores | Banded rudderfish | Spiny lobster | Dead carcasses |
| Cobia | Ocean triggerfish | Blue runner | Rock shrimps | |
| Bonefish | Gray triggerfish | Other jacks | | Attachment 10 |

Tab01_A10_Oke yPresSouthAtlan ticEcopathMod

Choosing the newly articulated groups

| | A | В | C | D | E | F | G | Н | 1 | J | |
|----|-------------|--------------|---------------------|-----------------------------|--------------|---------------|---------------|-------------------------------|-------------|------------|--|
| 1 | | | Status De | etermination | Stock | Status | Fishing Leve | Recomme | | | |
| 2 | s | tock | Cr | iteria | SLOCK | Stock Status | | lbs ww unless otherwise noted | | | |
| 3 | | | Overfishing | Overfished | Overfishing? | Overfished? | OFL | ABC | Year | | |
| 4 | | | MFMT | MSST | | | | | | | |
| 5 | Alm | aco Jack | F _{30%SPR} | (1-M)*SSB _{30%SPR} | UNK | UNK | UNK | 302,517 | 2013 | 302,517 | |
| 6 | | | UNK | UNK | 2.288.92**** | 0-2-200712345 | | | 0000000000 | 0 | |
| 7 | Atlanti | c Spadefish | F _{30%SPR} | (1-M)*SSB _{30%SPR} | UNK | UNK | UNK | 189,460 | 2013 | 189,460 | |
| 8 | | | UNK | UNK | 03-465.03 | | Devision set | | 12/2/2016-0 | 0 | |
| 9 | Banded | Rudderfish | F _{30%SPR} | (1-M)*SSB _{30%SPR} | UNK | UNK | UNK | 145,434 | 2013 | 145,434 | |
| 10 | | | UNK | UNK | | | | | - | 0 | |
| 11 | Ba | r Jack | F _{30%SPR} | (1-M)*SSB _{30%SPR} | UNK | UNK | UNK | 24,780 | 2013 | 24,780 | |
| 12 | | | UNK | UNK | | | | 88 | | 0 | |
| 13 | Black | Grouper | F _{30%SPR} | (1-M)*SSB _{MSY} | No | No | 627,552 GM/SA | 256,430 | 2013 | 256,430 | |
| 14 | | | 0.216 | 5.92 mp | | | 294,949 SA | | | 0 | |
| 15 | Black | Sea Bass | F _{MSY} | (1-M)*SSB _{MSY} | No | No | 2 296 000 | 2 133 000 | 2013 | 2,133,000 | |
| 16 | Diden | | 0.610 | 256E10 eggs | | 110 | 2,250,000 | 2,155,000 | 2015 | 0 | |
| 17 | Black | Snannar | F _{30%SPR} | (1-M)*SSB30%SPR | LINK | LINK | LINK | 382 | 2013 | 382 | |
| 18 | Diack | эпарреі | UNK | UNK | UNK | UNK | ONK | 302 | 2015 | 0 | |
| 19 | Blackfi | n Snanner | F _{30%SPR} | (1-M)*SSB30%SPR | LINIZ | LINK | LINK | 3 665 | 2012 | 3,665 | |
| 20 | ыаскт | n Snapper | UNK | UNK | UNK | UNK | UNK | 3,005 | 2015 | 0 | |
| 21 | pl | Dunna | F _{30%SPR} | (1-M)*SSB30%SPR | | | | 1 125 720 | 2012 | 1,125,729 | |
| 22 | Diue | Kunner | UNK | UNK | UNK | UNK UNK | | 1,125,725 | 2015 | 0 | |
| 23 | pl | | F _{MSY} | (1-M)*SSB _{MSY} | Vee | Maria | | 624.244 | 2012 | 631,341 | |
| 24 | Bluell | ne i lietish | 0.302 | 221.9 mt | res | res | UNK | 631,341 | 2013 | 0 | |
| 25 | | | F _{30%SPR} | (1-M)*SSB30%SPR | LINIZ | | | 2 740 | 2012 | 2,718 | |
| 26 | C C | oney | UNK | UNK | UNK | UNK | UNK | 2,/18 | 2013 | 0 | |
| 27 | | 127 | F3096SPR | (1-M)*SSB30965PR | | | | | | 24,680 | |
| 28 | Cuber | a Snapper | UNK | UNK | UNK | UNK | UNK | 24,680 | 2013 | 0 | |
| 29 | - | | FROMER | (1-M)*SSB30%SPR | | | | | | 3,285 | |
| 30 | Dog Snapper | | UNK | UNK | UNK | UNK | UNK | 3,285 | 2013 | 0 | |
| 31 | 1 | | Fanesepp | (1-M)*SSBMev | 2 | 0 | | | | 805,000 gw | |
| 32 | Gag | 0.21 | 6.82 mp | Yes | No | 1,095,000 gw | 805,000 gw | 2013 | 0 | | |
| | | | | | | | | | | | |
| 1 | Attac | | | | | | | | | | |



Temporal-dynamic module of EwE, initialized from Ecopath Includes biomass and size structure dynamics Requires only a few extra parameters

Used, among others, to assess Quantify combined effect of species dynamics, fishing impacts, and environmental impacts on a food web over time Replicate past scenarios (time series fitting) Explore future scenarios Explore fishing policy alternatives Test model robustness







Walters et al 1997 RFBF, Ahrens et al 2012 Fish and Fisheries

Tab01_A10_Oke yPresSouthAtlan ticEcopathMod

CALIBRATING THE MODEL



TIME PREDICTIONS FROM THE STRAIT OF GEORGIA MODEL, 1950-2000









Spatial temporal component of EwE, executes Ecosim for every 'water' cell in a grid

Requires extra inputs, related to movement, habitat, fishing, environment

Groups and fleets try to move to nearby optimal conditions





| File Vie | | | | SCatSea | model 1978 - | Ecopath with | Ecosim | 6.5.10838 | .0 – | |
|-----------------------------------|---|---|--|--|--------------|--------------|--------|-----------|---|--------------------------------|
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| Navigator | | | Danie i | nnut Mane | | | | _ | | • X |
| | | | Ecospace | fishery | | | | × | 📑 📑 Edit map details | |
| | | | | | <u>S</u> et | : 1 | Apply | 📑 💕 | 🖃 🕲 MPAs (1) | 1 |
| Fleet \ habitat use: | All 0- | 50 50-150 sand | 50-150 mud | 50-150 rock | 150-400 sand | 150-400 mud | >400 | MPA1 | / @ MPA1 | |
| wling fishery | | | | | | | | | 🗄 💭 Fishing (2) | |
| se seine fishery aline fishery | | | | | | | | | 🖃 🧔 Reference (1) | 1 |
| ll bait fishery | | i 🗹 | | | | | | | 🔒 💭 Reference | |
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ticEcopathMod



Used, among others, to assess

- Distribution of marine species and fishing effort
- Spatial impact of fishing
- Management options, e.g. impact of MPAs
- Impact of environmental change (EwE version 6.3+)

Running model has been linked to Marxan & Atlantis Includes an IBM approach

SPATIAL DISTRIBUTION OF SPECIES



SETTING UP THE HABITAT FORAGING CAPACITY MODEL

1. SELECT GROUP CAPACITY MODEL

| Anchovy Bay - Ecopath with Ecosim 6.5.14149.0 − □ > | | | | | | | |
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| Navigator 🕴 😂 Basic input 😵 Group capacity model 🗸 🗸 | | | | | | | |
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| > 🖏 Output | Group name | Use habitat | Use environmental responses | Both | | | |
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| Ecospace | 2 Seals | | | | | | |
| Er Input | 3 Cod | <u> </u> | M | | | | |
| Maps | 4 Whiting | | | | | | |
| Habitat based foraging | 5 Mackerel | | | | | | |
| 🗔 Apply foraging responses | 7 Shrimo | | | | | | |
| 🗔 Group capacity model | 8 Benthos | | | | | | |
| 🔄 Habitat foraging usage | 9 Zooplankton | | | | | | |
| Functional responses grid | 10 Phytoplankton | | | | | | |
| Dispersal | 11 Detritus | | | | | | |
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| Marine Protected Areas | | | | | | | |
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ticEcopathMod

2. DEFINE ENVIRONMENTAL DRIVERS

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3. POPULATE ENV. DRIVER MAPS



4. DEFINE ENV. RESPONSE CURVES

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Foraging habitat capacity model case study

Full Mediterranean EwE model

90+ functional groups, assigned to 4 MSFD zones

Time frame 1950 – 2010 Entire basin at 0.167 dd grid





1. Define environmental drivers

Primary production

Salinity (surface and bottom)

Temperature (surface and bottom)

Depth MSFD area restrictions



2. Define environmental responses

Here we are using a plug-in to import environmental responses from AquaMaps species envelopes



4. Ecospace computes capacity (cetaceans - depth)

| General Med model - Ecopath with Ecosim 6.5.10321.0 | |
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4. More capacity (Western sardine - depth, MSFD W)



4. Run

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| gato | <u> <u> </u> </u> | Piscivores feeding | Others feeding | Pinnipeds W | Seabirds W | Sea turtles | High | | |
| P | Eishing effort | Large Pelagics | Medium pelagics W | European pilchard | European anchovy | Other small | í 📕 🛛 | | |
| | © Catch | Large demersals W | European hake W | W Medium demersals | W Small demersals W | Deep fish W | | | |
| | Catch/biomass 2 Legend max. | Sharke W | Dave and skatos W | W Conhalonada W | Crustanoans W/ | Lolly firsh W | | | |
| | | Slidiks W | Rays and skales W | Cepilalopods V | Ciusiaceansiv | Jenularive | | | |
| | | Benthos W | Zoopiankton W | Phytoplankton W | Seagrass W | Piscivores feeding cetaceans A | | | |
| | Show all | Pinnipeds A | Seabirds A | Medium Pelagics A | European pilchard | European anchovy | | | |
| | Selected groups/fleets: Choose | Other small | Large demorsals A | European hake A | Medium demersals | Small demensals A | í 🔤 🛛 | | |
| | Show single group/fleet: | pelagics A | Sharks A | Rays and skates A | A Cephalopode A | Crustaceans A | | | |
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| | ✓ Show IMB packets | European anchovy | Other small | Large demorsals I | European hake I | Medium demersals | | | |
| | 🗄 Labels ———— | Small demensals I | Deep fish L | Sharks | Rays and skates I | Cephalopods I | í 🔤 🛛 | | |
| | Run | Crustaceans I | Jellyfish | Benthos | Zooplankton | Phytoplankton I | | | |
| | Run Multi-stanza 💌 | Soarrang | Disciplation fooding | Dinningde E | Soshirds E | Modium Polagios E | | | |
| | Resume Stop | Sedgrass | cetaceans E | Filmpeus C. | Seablids E | Medidini Felagics L | | | |
| | | European pilchard | European anchovy | Other small pelagics E | Large demorsals E | European hake E | ttachr | | |
| | Graph options | Medium demersals | Small demorsals E | Deep fish E | Skarks E | Rays and skates E | | | |
| | | Cephalopods.E | | | | | | | |

OUR WORKING GROUP

- Roger Pugliese South Atlantic Fishery Management Council
- > Dr. Rua Mordecai, SALCC, Dr. Simeon Yurek, USGS
- Dr. Marcel J. Reichert Marine Resources Research Institute, South Carolina Department of Natural Resources (Tracey Smart, Wally Bubley)
- > **Dr. Howard Townsend –** NOAA/NMFS/ST/Ecosystems
- Dr. Luiz Barbieri Florida Fish and Wildlife Conservation Commission, FWRI
- Dr. Ruoying He Department of Marine, Earth and Atmospheric Sciences, North Carolina State University
- Dr. Peter Sheng Professor and Director, Coastal and Oceanographic Engineering Program, University of Florida
- > Dr. Thomas Okey Ocean Integrity Research, Victoria, BC, Canada
- Dr. Jerald S. Ault Rosenstiel School of Marine and Atmospheric Science, University of Miami
- > Dr. Jeroen Steenbeek Ecopath Research and Development Consortium
- > Dr. Patrick N. Halpin Director, Geospatial Analysis Program Duke University

Tab01_A10_Oke yPresSouthAtlan ticEcopathMod

3. EXCHANGING DATA WITH THE OUTSIDE WORLD

GIS DATA FOR MANY ECOSPACE LAYERS Connected to existing Ecospace driver layers

Primary production

Environmental drivers

Habitats

Fishing cost

MPA layouts

Contaminants

Migration

Computed foraging capacity

Coming soon

Advection



SPATIAL TEMPORAL DATA FRAMEWORK



Attachment 10 Tab01_A10_Oke yPresSouthAtlan ticEcopathMod

Steenbeek et al. 2013. Ecological Modelling 263, 139-151.

SPATIAL TEMPORAL DATA FRAMEWORK



SPATIAL TEMPORAL DATA FRAMEWORK CASE STUDY



ADVECTION

Current Advection model in EwE, which computes advection flow fields from wind, mixed layer depth, and upwelling, does not work

Work-around (EwE version 6.5+) Applying advection flow fields does work: flow layer content can be entered or driven by spatial temporal framework

Ongoing developments

New Advection model only requires depth and / wind input to calculate advection and upwelling

1. CALCULATE ADVECTION

| Anchovy Bay - Ecopath with Ecosim 6.5.14149.0 | | | | | | | | |
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| Ecospace parame | Name: Wind map | | | | | | | |
| Maps | Max value: 29.34146 | | | | | | | |
| Apply foraging | Min value: 10.55253 | | | | | | | |
| A Group capaci | <u>C</u> ursor: | | | | | | | |
| Functional res | Value: 40.000 | | | | | | | |
| Advection | Smooth 💋 | | | | | | | |
| Ecospace fishery Marine Protected | Month: January ~ 🗈 | | | | | | | |
| External data Advection map Upwelling | Model parameters | | | | | | | |
| > X Tools | Upwelling 30.00 | | | | | | | |
| Tools | PP upwelling 0.01000 | | | | | | | |
| | Compute advection velocities | | | | | | | |
| | <u>C</u> ompute <u>Stop</u> | | | | | | | |
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| Status 🛃 Remarks | | | | | | | | |
| 🚍 Anch | ovy Bay 🥝 New Ecosim scenario 🚳 BayOfAn&htorietame | | | | | | | |

Tab01_A10_Oke yPresSouthAtlan ticEcopathMod