Data Documentation

Dataset Information

Dataset Title:

NOAA RESTORE Science Program: Ecosystem Modeling to Improve Fisheries Management in the Gulf of Mexico: Model Inputs and Outputs for the US Gulf-wide Model, 1980-01-01 to 2016-12-31

Description:

This dataset is a collection of files containing the necessary inputs to, and relevant outputs from, the U.S. Gulf-wide ecosystem model, developed using the Ecopath with Ecosim (EwE) modeling software package. The spatial extent of the model is 25°-30.5° N and -81° to -97.3° W and hindcast simulations were run in Ecosim from 1980 (the Ecopath snapshot year) to 2016 at a monthly timestep. Input parameters for Ecopath include biomass, consumption, mortality, diet, landings, and discards for 78 functional groups included in the model. Each input or output parameter type is included as its own csv file with informative names.

Purpose:

The purpose of these datasets is to preserve all model inputs and model outputs generated by the US Gulf-wide ecosystem model used to estimate mortality rates and ecosystem indicators with special emphasis on Gulf menhaden (*Brevoortia patronus*). The EwE modeling software package can be downloaded from www.ecopath.org and the input files provided here can be used to reproduce the US Gulf-wide model.

The model was developed with funding from the NOAA Restore Science Program (FFO-2017), under the priority of developing scientific decision support tools. As such, this tool (the ecosystem model) was designed to evaluate tradeoffs between indirect and direct mortality caused by fisheries, among other things, for use in fisheries stock assessments and for providing management advice. This version of the US Gulf-wide model was updated from a previous version by parameterizing the Ecopath model for 1980 conditions and including additional age stanzas of key managed species. Further, this model was expanded into Ecosim by fitting to time series of biomass and catches via the manual and automatic calibration routines in the EwE software. The model was developed at the NOAA Southeast Fisheries Science Center and University of Miami (Cooperative Institute for Marine and Atmospheric Studies), in partnership with the University of Florida.

The data in this accession were funded by the NOAA RESTORE Science Program under award NA17NOS4510098 to the University of Florida.

Methods:

To model the US Gulf-wide ecosystem (out to about 400 meters), we used the EwE software (Christensen and Walters 2004). The EwE software suite is composed of three main components: *Ecopath*, *Ecosim* and *Ecospace*. *Ecopath* is the “mass-balanced” static version that provides a snapshot of the system. *Ecosim* is the time dynamic simulation module that allows

for predicting ecosystem and species changes over time. And lastly, *Ecospace* is the spatial component that predicts the distribution of biomass and catches of each functional group over a two-dimensional spatial grid at a monthly time step. The software is freely available at www.ecopath.org along with complete documentation of the model.

The first version of the US Gulf-wide EwE model was developed at the Southeast Fisheries Science Center to evaluate the ecosystem dynamics within the Gulf of Mexico, with particular emphasis on indirect effects of fishing (e.g., bycatch) and a comprehensive evaluation of predator-prey dynamics (Sagarese et al. 2016; 2017). The diet matrix input into the US Gulf-wide Ecopath model was based on a meta-analysis conducted on nearly 600 references (Sagarese et al. 2016). While previous Gulf of Mexico ecosystem models were available for different spatial zones of the Gulf of Mexico (e.g., Geers et al. 2016; Chagaris et al. 2015), this model was built with a focus on socioeconomically important federally and internationally managed species on a Gulf-wide scale, matching the spatial extent of U.S. management. In the current version, we updated the Gulf-wide Ecopath model from Sagarese et al. (2017) by parameterizing the model to reflect 1980 conditions, splitting functional groups, refining fishing fleets, and incorporating more age structure for species such as Gulf menhaden and red snapper (Berenshtein et al. 2021). Once the Gulf-wide Ecopath model achieved mass balance, we compiled and fit the Ecosim predictions to time-series of biomass and catches obtained primarily from SEDAR stock assessments or monitoring surveys. The current version of the US Gulf-wide EwE model includes 16 fishing fleets and 78 functional groups, and was calibrated to reference time series on abundance, catch, fishing mortality, and fishing effort from 1980 to 2016.

The primary objective of the current US Gulf-wide EwE model is to evaluate top-down (fishing and predation) processes in the Gulf of Mexico with a focus on Gulf menhaden. We used the US Gulf-wide Ecosim model calibrated for the years 1980-2016 to produce time- and age- explicit natural mortality estimates for five age classes of Gulf menhaden (*Brevoortia patronus).* These results were implemented in a sensitivity run during the most recent Gulf menhaden stock assessment update, which showed model outcomes and stock status similar to the base-run. Future analyses will include evaluating tradeoffs between menhaden harvest and predator biomass.

Cited Publications:

- Berenshtein, I., S.R. Sagarese, M.V. Lauretta, and D.D. Chagaris. 2021. Technical documentation of a U.S. Gulf of Mexico Ecopath with Ecosim Model. NOAA Technical Memorandum. NMFS-SEFSC-751, 229 p. https://doi.org/10.25923/zj8t-e656
- Chagaris, D.D., B. Mahmoudi, C.J. Walters, and M.S. Allen. 2015. Simulating the Trophic Impacts of Fishery Policy Options on the West Florida Shelf Using Ecopath with Ecosim. *Marine and Coastal Fisheries*, 7:44-58. https://doi.org/10.1080/19425120.2014.966216
- Christensen, V., and C. Walters. 2004. Ecopath with Ecosim: methods, capabilities, and limitations. *Ecological Modelling*, 172:109-139. https://doi.org/10.1016/j.ecolmodel.2003.09.003
- Geers, T.M., E.K. Pikitch, and M.G. Frisk. 2016. An original model of the northern Gulf of Mexico using Ecopath with Ecosim and its implications for the effects of fishing on ecosystem structure and maturity. *Deep Sea Research Part II: Topical Studies in Oceanography,* 129:319-331. https://doi.org/10.1016/j.dsr2.2014.01.009

- Sagarese, S.R., M.A. Nuttall, T.M. Geers, M.V. Lauretta, J.F. Walter III, and J.E. Serafy. 2016. Quantifying the trophic importance of Gulf menhaden within the northern Gulf of Mexico ecosystem. *Marine and Coastal Fisheries*, 8(1):23-45. https://doi.org/10.1080/19425120.2015.1091412
- Sagarese, S.R., M.V. Lauretta, and J.F. Walter III. 2017. Progress towards a next-generation fisheries ecosystem model for the northern Gulf of Mexico. *Ecological Modelling* 345:75-98. https://doi.org/10.1016/j.ecolmodel.2016.11.001

Data Sources:

- Gulf States Marine Fisheries Commission. SEAMAP trawl data. https://seamap.gsmfc.org/index.php
- SouthEast Data, Assessment, and Review. Gulf of Mexico fisheries stock assessments. http://sedarweb.org/

Associated Datasets:

- Chagaris, D., and D. Vilas. 2021. NOAA RESTORE Science Program: Ecosystem Modeling to Improve Fisheries Management in the Gulf of Mexico: Model Inputs and Outputs for the West Florida Shelf, 1985-01-01 to 2018-12-31 (NCEI Accession 0242339). NOAA National Centers for Environmental Information. Dataset. https://www.ncei.noaa.gov/archive/accession/0242339

People & Projects

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Funding:

- US DOC; NOAA; NOS; NCCOS; RESTORE Science Program
- US DOC; NOAA; NOS; National Centers for Coastal Ocean Science (NCCOS)

Associated Online Resources:

- Ecopath with Ecosim, https://ecopath.org/
- National Centers for Coastal Ocean Science. 2021. RESTORE Sponsored Research Project: Ecosystem Modeling to Improve Fisheries Management in the Gulf of Mexico. https://www.fisheries.noaa.gov/inport/item/65437
- RESTORE Project, Ecosystem Modeling to Improve Fisheries Management in the Gulf of Mexico, https://restoreactscienceprogram.noaa.gov/projects/fisheries-ecosystem-models

Extents

Start Date:	1980-01-01
End Date:	2016-12-31
Northern Boundary:	30.5
Southern Boundary:	24.9
Western Boundary:	-97.3
Eastern Boundary:	-80.9

Keywords

Sea Areas, Water Bodies, Marine Protected Areas:

- Gulf of Mexico

NCCOS Keywords:

- NCCOS Research Location > Region > Gulf of Mexico
- NCCOS Research Data Type > Model

File Information

Total File Size:	1.42 MB total, 15 files in 2 folders (unzipped), 848 KB (zipped)
Data File Compression:	n/a
Data File Resolution:	the model runs at a monthly timestep, part of the files are at a yearly resolution
Data File Format:	Comma-separated value (.CSV) – all input and output files

Data Files:

- Input Files (.CSV):
  - Input_Ecopath_diet_composition.csv
  - Input_Ecopath_fleets.csv
  - Input_Ecopath_group.csv
  - Input_Ecopath_landings_discards.csv
  - Input_Ecosim_forcing_functions.csv
  - Input_Ecosim_group_info.csv
  - Input_Ecosim_time_series.csv
  - Input_Ecosim_vulnerabilities.csv

Table 1: Data Dictionary for Input_Ecopath_diet_composition csv file.

Column	Label	Definition	Units	Range
1	Group number	Functional group number	NA	1-78, import
2	Prey \ predator	Functional group name	NA	NA
3-76	1-74 (functional group number)	Diet proportion for each consumer functional group	proportion	0-1

Table 2: Data Dictionary for Input_Ecopath_fleets csv file.

Column	Label	Definition	Units	Range
1	Fleet number	Fleet number	NA	1-16
2	Fleet name	Fleet name	NA	NA
3	Fixed cost (%)	Cost of operating a fleet unit	percentage	0-100
4	Effort related cost (%)	Costs that are a function of effort per fleet	percentage	0-100
5	Sailing related cost (%)	Cost that are function of sailing for each fleet	percentage	0-100
6	Profit (%)	Profit of each fleet	percentage	-100-100
7	Total value (%)	Total value of each fleet	percentage	0-100
8	Discard_fate detritus	Discard fraction directed to detritus of each fleet	proportion	0-1

Table 3: Data Dictionary for Input_Ecopath_group csv file.

Column	Label	Definition	Units	Range
1	Group number	Functional group number	NA	1-78
2	Group name	Functional group name	NA	NA
3	Biomass in habitat area (t/km²)	The average biomass per unit area in the habitat area where the group occurs	$t \cdot km^2$	0<
4	Total mortality (/year)	Estimated total mortality rates for each stanza	$year^{-1}$	0<
5	Production / biomass (/year)	Production biomass ratio	$year^{-1}$	0<
6	Consumption / biomass (/year)	Consumption biomass ratio	$year^{-1}$	0<
7	Ecotrophic Efficiency	Fraction of the production that is used in the system	proportion	0-1
8	Unassim. consumption	Fraction of the food that is not assimilated	proportion	0-1
9	Detritus_fate detritus	Detritus left over fraction directed to detritus	proportion	0-1
10	Detritus_fate Export	Detritus fraction exported out of the system	proportion	0-1
11	Other_production Immigration (t/km²/year)	Migration into the modelled area	$t \cdot km^{-2} \cdot year^{-1}$	0<

Column	Label	Definition	Units	Range
12	Other_production Emigration (t/km²/year)	Migration out of the modelled area	$t \cdot km^{-2} \cdot year^{-1}$	0<
13	Other_production Emig. rate (/year)	Proportion of the population emigrating from the modelled area in a year	$year^{-1}$	0<
14	Other_production Biomass accumulation (t/km²)	Biomass difference between the beginning of the year and the beginning of the next year	$t \cdot km^{-2}$	0<
15	Other_production BA rate (/year)	Biomass rate difference between the beginning of the year and the beginning of the next year	$year^{-1}$	0<
16	K VBGF	Curvature parameter K for the Von Bertalanffy growth curve	$year^{-1}$	0<
17	BA/B	Relative biomass accumulation rate. Effect on the numbers at age of the population growth rate	NA	NA
18	Wmat/Winf	The mean weight at maturity/W_infinity	NA	0<1
19	Age start months	The start age in months of each stanza	months	0≤
20	Spawning proportion	Proportion of spawning biomass of each stanza	proportion	0-1
21	Leading stanza	Is multistanza group a leading stanza for biomass calculations?	Factor	Yes or No

Table 4: Data Dictionary for Input_Ecopath_landings_discards csv file.

Column	Label	Definition	Units	Range
1	Group number	Functional group number	NA	1-78
2	Group name	Functional group name	NA	NA
3-18	Landings-fleet	Landings of each functional group by each fleet	$t \cdot km^{-2} \cdot year^{-1}$	0≤
19-34	Discards-fleet	Discards of each functional group by each fleet	$t \cdot km^{-2} \cdot year^{-1}$	0≤
35-50	Discard mortality rate-fleet	Proportion of discards that die	NA	0-1

Table 5: Data Dictionary for Input_Ecosim_environmental_forcing_functions csv file.

Column	Label	Definition	Units	Range
1	Time	Monthly timestep for the time period simulation (where decimal refers to month, e.g., 1980.1 is January of 1980)	Decimal year	January 1980 – December 2016
2	Total N&P monthly	Total nitrogen and phosphorus at monthly step, scaled to mean of 1	NA	0<
3	PPanomaly	Model estimated primary production anomaly at monthly step	NA	0<

Table 6: Data Dictionary for Input_Ecosim_group_info csv file.

Column	Label	Definition	Units	Range
1	Group number	Functional group number	NA	1-77
2	Group name	Functional group name	NA	NA
3	Max rel. P/B	Maximum increase in production allowed for primary producers	NA	0<
4	Max rel. feeding time	Multiplier to limit how much the feeding time may increase	NA	0<
5	Feeding time adjust rate [0,1]	Factor to determine how fast organisms adjust feeding times	proportion	0-1
6	Fraction of other mortality sens. to changes in feeding time	Proportion of the unexplained natural mortality rate that is assumed to be sensitive to changes in feeding time	proportion	0-1
7	Predator effect on feeding time [0,1]	Factor to determine the response of feeding time to changes in predator abundance	proportion	0-1
8	Density-dep. catchability: Qmax/Qo [>=1]	Allows for increase in catchability at low stock sizes	NA	1=<
9	QBmax/QBo (for handling time) [>1]	Factor that limits prey consumption rates per predator	NA	1<
10	Switching power parameter [0,2]	Factor that determines the ability to switch from one prey to another	NA	0-2

Table 7: Data Dictionary for Input_Ecosim_time_series csv file. The first four rows of the table are header information including the time series index number, the time series name, the time series weight multiplied to the sum of squares, and the time series type. The remaining rows contain annual time series information.

Column	Label	Definition	Units	Range
1	Target	Years in the time period simulation	years	1980-2016
2-161	Functional group number: Functional group name or Fleet number: fleet name	Catches, fishing mortality, relative fishing effort or relative biomass by fleet or functional group	NA	0<

Table 8: Data Dictionary for Input_Ecosim_vulnerabilities csv file.

Column	Label	Definition	Units	Range
1	Group number	Functional group number	NA	1-78
2	Prey \ predator	Functional group name	NA	NA
3-76	1-74 (functional group number)	Vulnerability exchange rate parameter for each predator prey interaction	NA	1<

- Output Files:
    - Output_Ecopath_basic_estimates_mortalities.csv
    - Output_Ecopath_predation_mortality_rates.csv
    - Output_Ecosim_biomass_monthly.csv
    - Output_Ecosim_catch_monthly.csv
    - Output_Ecosim_predation_mortality_rates.csv

Table 9: Data Dictionary for Output_Ecopath_basic_estimates_mortalities csv files.

Column	Label	Definition	Units	Range
1	Group number	Functional group number	NA	1-78
2	Group name	Functional group name	NA	NA
3	Trophic level	Effective trophic level	NA	1<
4	Biomass in habitat area (t/km²)	Input or computed biomass density	$t \cdot km^2$	0<
5	Total mortality (/year)	Input total mortality for multistanza groups	$year^{-1}$	0<
6	Production / biomass (/year)	production to biomass ratio	$year^{-1}$	0<
7	Consumption / biomass (/year)	Consumption to biomass ratio	$year^{-1}$	0<
8	Ecotrophic Efficiency	Fraction of the production that is used in the system	proportion	0-1
9	Production / consumption (/year)	Production to consumption ratio	proportion	0-1
10	Biomass accumulation (t/km²)	Relative biomass accumulation	$t \cdot km^{-2}$	NA
11	BA rate (/year)	Proportion of accumulated biomass of the total biomass	$year^{-1}$	NA
12	Fishing mort. rate	Fishing mortality rate	$year^{-1}$	0=<
13	+ Predation mort. rate (/year)	Predation mortality rate	$year^{-1}$	0=<
14	+ Other mort. rate (/year)	All mortality not elsewhere included (e.g. disease)	$year^{-1}$	0=<
15	Fishing mort. / total mort.	Proportion of total mortality that is fishing	proportion	0-1
16	Proportion natural mort.	Proportion of total mortality that is natural mortality	proportion	0-1

Table 10: Data Dictionary for Output_Ecopath_predation_mortality_rates csv files.

Column	Label	Definition	Units	Range
1	Group number	Functional group number	NA	1-77
2	Prey \ predator	Functional group name	NA	NA
3-76	Predators functional group number	Predation mortality rate by predator and prey	$year^{-1}$	0=<

Table 11: Data Dictionary for Output_Ecosim_biomass_monthly csv file.

Column	Label	Definition	Units	Range
1	timestep\group	Monthly time step of simulation	NA	1-444
2-79	Functional group number	Monthly absolute biomass by functional group predicted by Ecosim	$t \cdot km^{-2}$	0<

Table 12: Data Dictionary for Output_Ecosim_catch_monthly csv file.

Column	Label	Definition	Units	Range
1	timestep\group	Monthly time steps	NA	1-444
2-79	Functional group number	Monthly absolute catch (landings and dead discards) by functional group predicted by Ecosim	$t \cdot km^{-2} \cdot year^{-1}$	0=<

Table 13: Data Dictionary for Output_Ecosim_predation_mortality_rates csv file.

Column	Label	Definition	Units	Range
1	year	Annual time step	NA	1980-2016
2-9	Menhaden age 0 predation mortality by predator	Menhaden age-0 predation mortality by predator	NA	0<
10-36	Menhaden age 1 predation mortality by predator	Menhaden age-1 predation mortality by predator	NA	0<
37-68	Menhaden age 2 predation mortality by predator	Menhaden age-2 predation mortality by predator	NA	0<
69-100	Menhaden age 3 predation mortality by predator	Menhaden age-3 predation mortality by predator	NA	0<
101-132	Menhaden age 4 predation mortality by predator	Menhaden age-4 predation mortality by predator	NA	0<

List of Model Functional Groups:

- Algae
- Amberjack
- Anchovy-silverside-killifish
- Atlantic sharpnose shark
- Baleen whales
- Benthic coastal invertebrate feeders
- Benthic piscivores
- Billfish
- Blacktip shark
- Bluefin tuna
- Brown shrimp
- Butterfish
- Cephalopod
- Coastal dolphins
- Coastal omnivores
- Cobia
- Crab
- Deep-water grouper
- Demersal coastal invertebrate feeders
- Detritus
- Dusky shark
- Gag grouper (0-3yr)
- Gag grouper (3+yr)
- Goliath grouper
- Gray triggerfish
- Infauna
- Inshore coastal piscivores
- King mackerel (0-1yr)
- King mackerel (1+yr)
- Large coastal sharks
- Large oceanic planktivores
- Large oceanic sharks
- Menhaden (0yr)
- Menhaden (1yr)
- Menhaden (2yr)
- Menhaden (3yr)
- Menhaden (4yr)
- Mobile epifauna
- Mullet
- Mutton snapper
- Oceanic piscivores
- Oceanic planktivores
- Offshore dolphins
- Other snapper
- Other tunas
- Pelagic coastal piscivores
- Phytoplankton
- Pink shrimp
- Red drum
- Red grouper (0-3yr)
- Red grouper (3+yr)
- Red snapper (0yr)
- Red snapper (1-2yr)
- Red snapper (3+yr)
- Reef invertebrate feeders
- Reef omnivores
- Reef piscivores
- Sandbar shark
- Sardine-herring-scad
- Sea trout
- Sea turtle
- Seabird
- Seagrass
- Sessile epifauna
- Shallow-water grouper
- Skates-rays
- Small coastal sharks
- Spanish mackerel (0-1yr)
- Spanish mackerel (1+yr)
- Surface pelagics
- Swordfish
- Tilefish
- Vermilion snapper
- White shrimp
- Yellowedge grouper (0-3yr)
- Yellowedge grouper (3+yr)
- Yellowfin tuna
- Zooplankton

Documentation Files:

- BrowseGraphic.JPG
- DataDocumentation.PDF

Parameter Information

Parameter Description:

Parameters: Biomass
Property Type: calculated
Units: mt/km^2
Observation Category: model output
Sampling Instrument: Models/Analyses > Data Analyses > Environmental Modeling
Sampling and Analyzing Method:

Biomass was calculated using the Gulf-wide EwE model (Berenshtein et al. 2021). Biomass dynamics were simulated at a monthly timestep. Biomass in each month is calculated as a function of consumption of prey minus losses to predation, fishing, and natural mortality.

Data Quality Method:

Model simulations were checked for stability and outputs were compared with observational data. These outputs are from the best run scenario where deviations between predicted and observed data were minimized.

Document Information

Date:	2021-11-02
Resource Provider:	NCCOS Data Manager, nccos.data@noaa.gov, US DOC; NOAA; NOS; National Centers for Coastal Ocean Science (NCCOS)
Comment:	This data documentation describes data files archived as a NOAA NCEI data accession, and is intended to provide dataset-level metadata for the purposes of discovery, use, and understanding.
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