

Gulf Menhaden Advisory Committee meeting



Gulf Menhaden
Brevoortia patronus



*Southeast
Fisheries
Science
Center*



RESTORE
SCIENCE PROGRAM



Tradeoffs between menhaden fishing effort and predator populations

UNIVERSITY
OF MIAMI
ROSENSTIEL
SCHOOL of MARINE &
ATMOSPHERIC SCIENCE



Igal Berenshtein , Skyler R. Sagarese, Matthew V. Laretta, David D. Chagaris

Overview/ Evolution

Introduction



Ecopath + Ecosim (EwE)



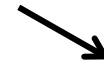
Calibration and diagnostics



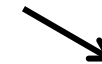
Natural mortality (M)



Ecological sensitivity



Ecological indicators



Management implications

Ecosystem Modeling for Fisheries Management in the Gulf of Mexico

- Funded by NOAA RESTORE FF0-2017, decision-support tool priority
- Goal: Integrate information on ecosystem stressors and predator-prey interactions into the assessment and management of fisheries in the Gulf of Mexico

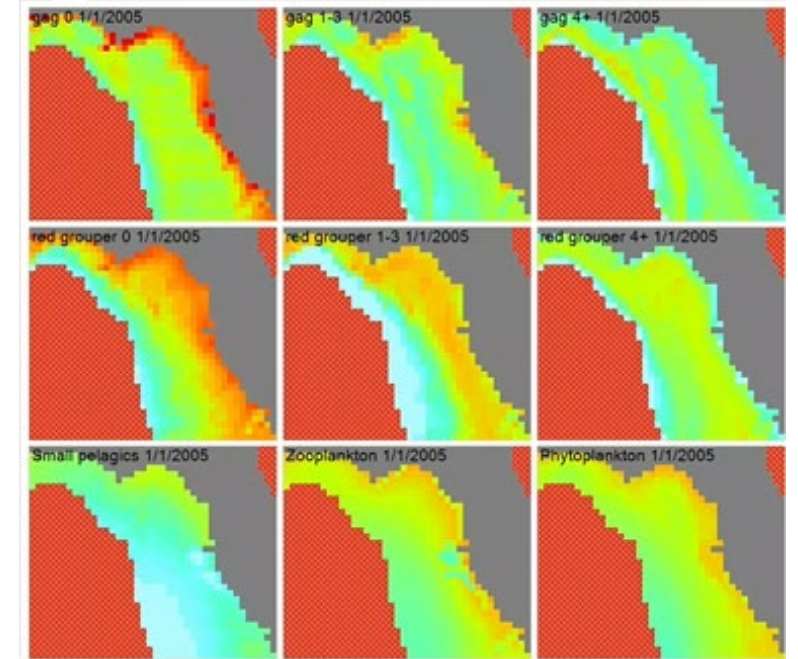
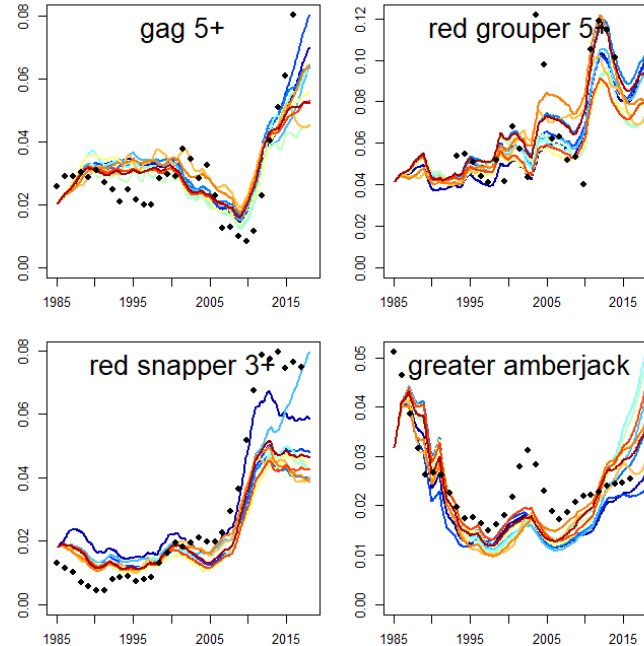
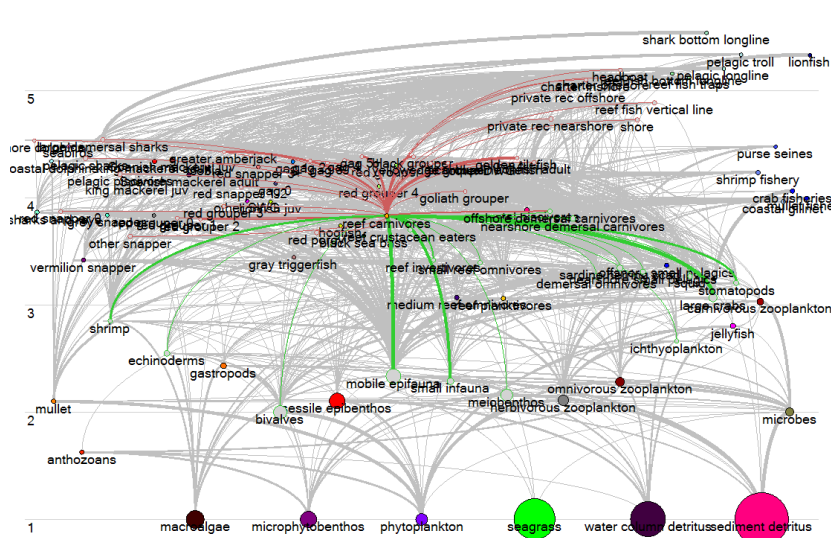




Ecopath with Ecosim

No fish is an island

www.ecopath.org



Ecopath

- Static snapshot of the ecosystem
- Input: biomass, mortality, consumption, diet, and fishery removals
- Requires mass balance
- Starting point for dynamic simulations

Ecosim

- Time dynamic simulations
- Environmental forcing
- Parameter estimation & time series calibration
- Future projection scenarios
- Policy analysis and tradeoffs

Ecospace

- Spatially explicit simulations
- Input: dispersal rates, habitat maps, habitat preferences, fishing areas, MPAs, port locations
- Spatial-temporal drivers
- Red tide mortality

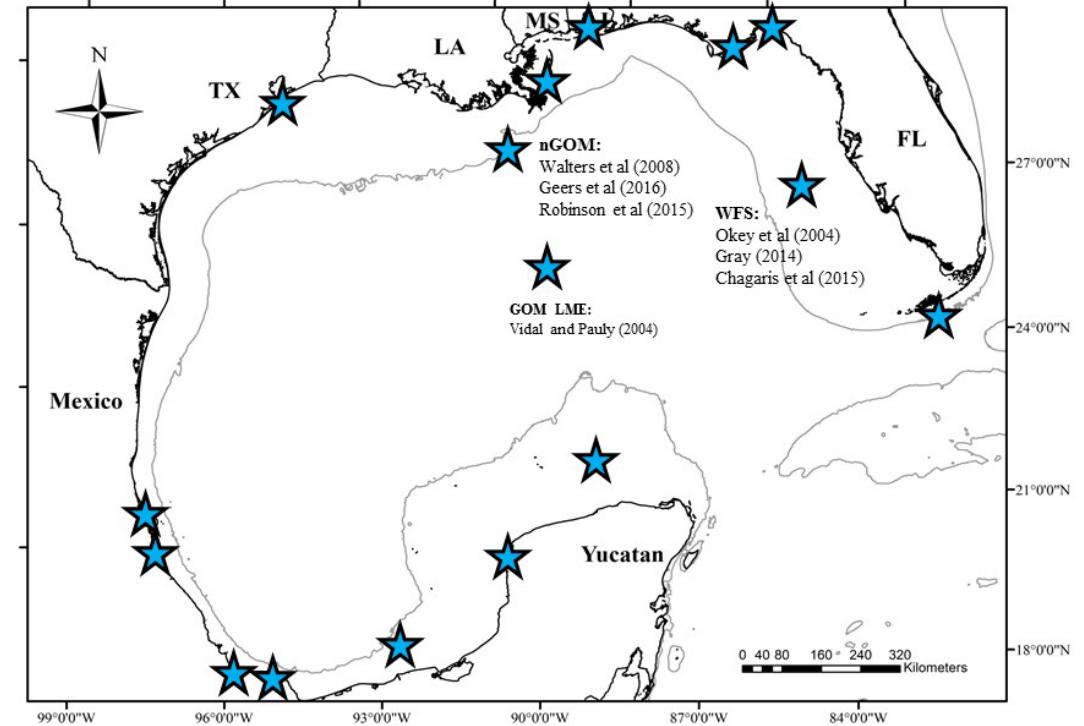
GOM EwE models

- Previous models
- Federally and internationally managed species
- Statistically-derived trophic interactions (Sagarese et al., 2016, Ainsworth et al., 2011)
- **Bycatch removals**
- Changes based on the scoping workshop
 - Revamp 1980
 - Age structure
 - Different partitioning



Ecopath with Ecosim

No fish is an island

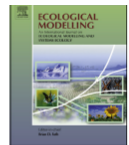


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Ecological Modelling

journal homepage: www.elsevier.com/locate/ecolmodel



Progress towards a next-generation fisheries ecosystem model for the northern Gulf of Mexico



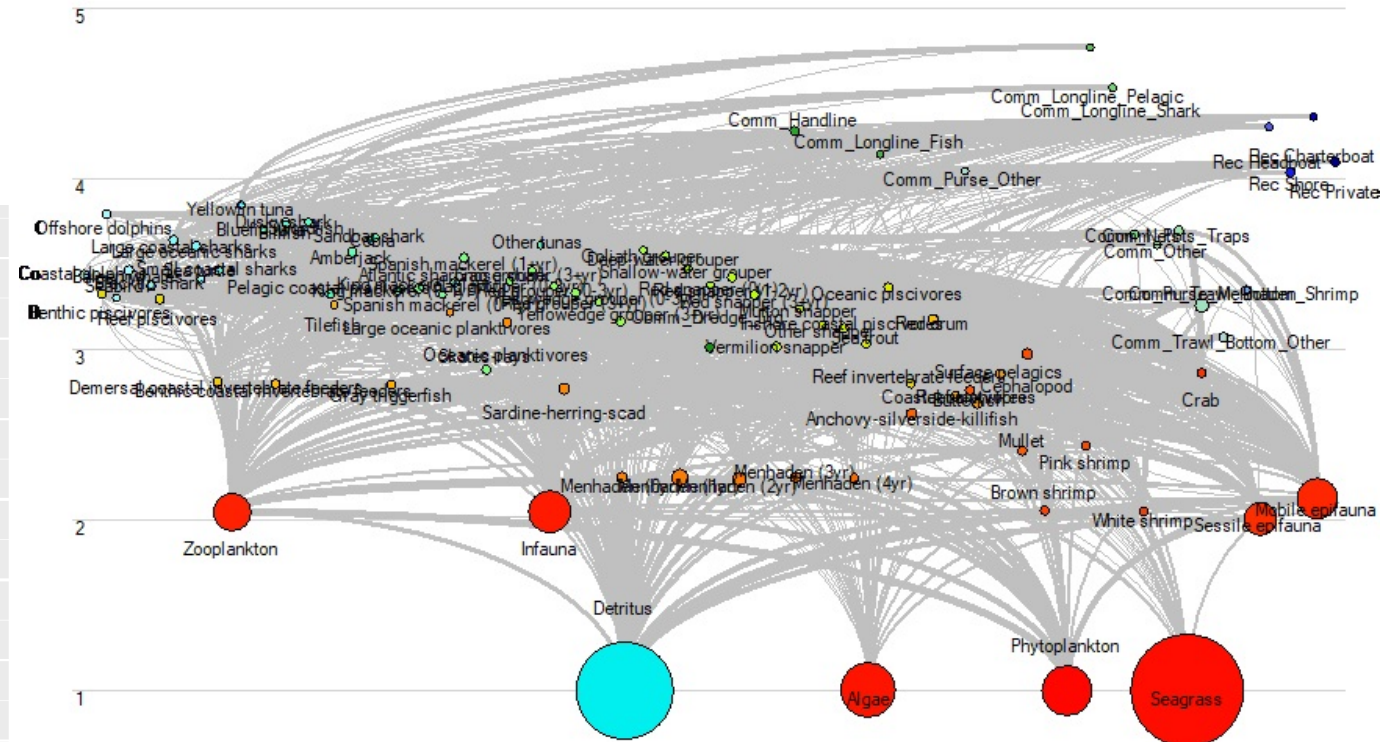
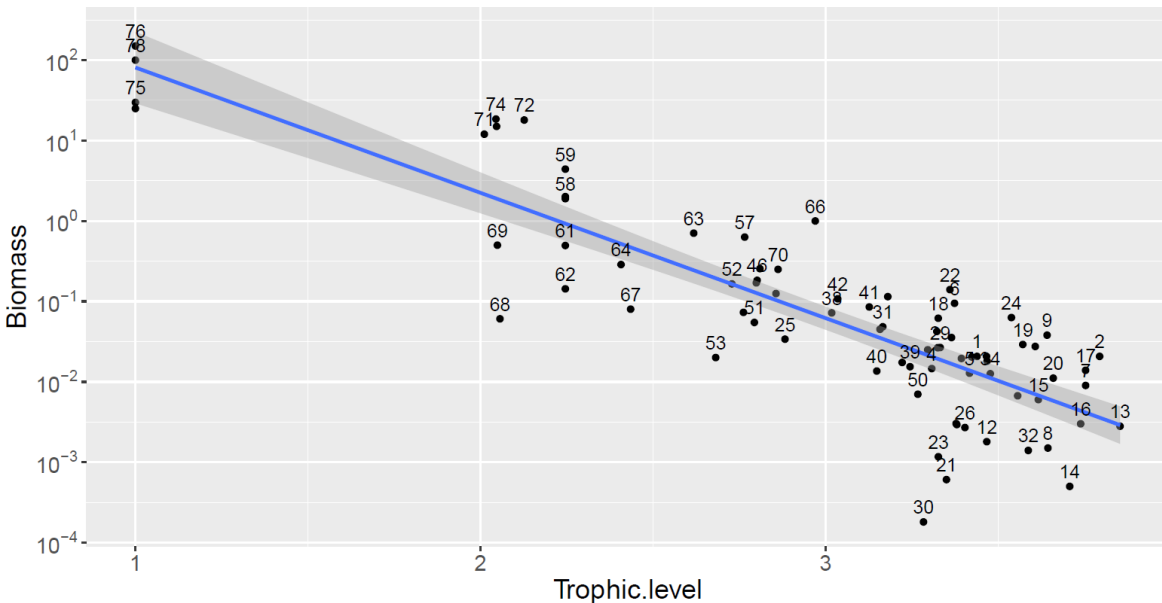
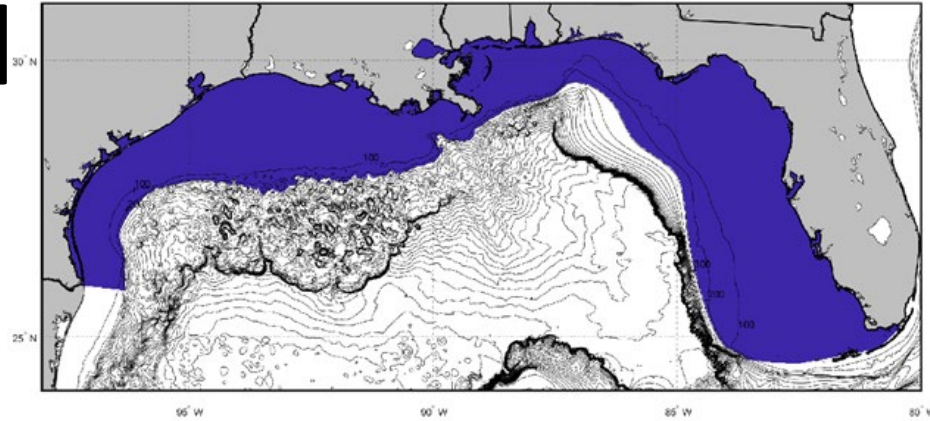
Skyler R. Sagarese^{a,*}, Matthew V. Laretta^b, John F. Walter III^b

^a Cooperative Institute for Marine and Atmospheric Studies, Rosenstiel School of Marine and Atmospheric Science, University of Miami, 4600 Rickenbacker Causeway, Miami, FL 33149, USA

^b Southeast Fisheries Science Center, National Marine Fisheries Service, 75 Virginia Beach Drive, Miami, FL 33149, USA

U.S. Gulf-wide Ecopath model

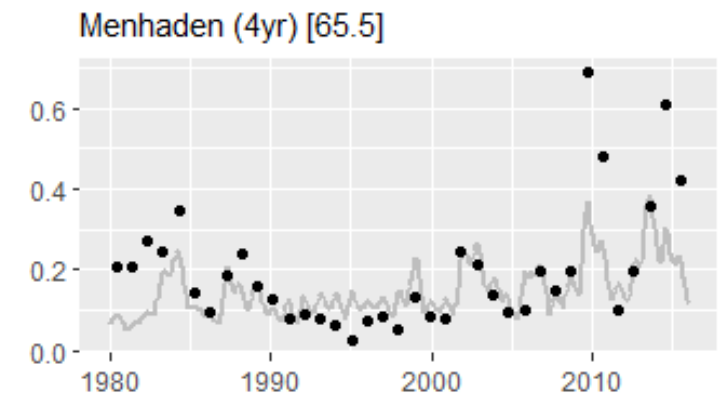
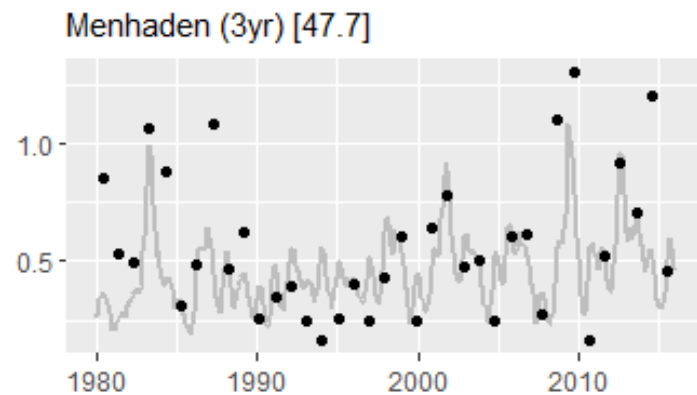
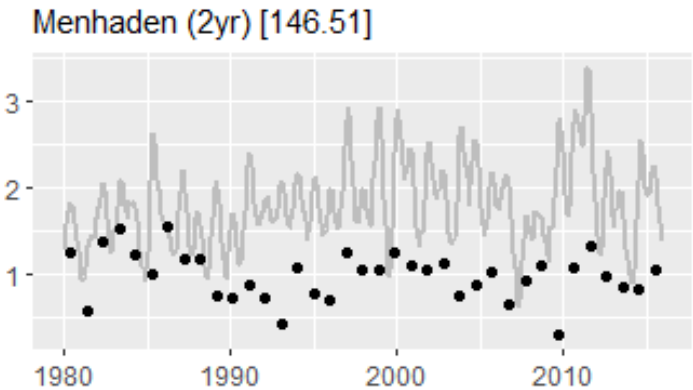
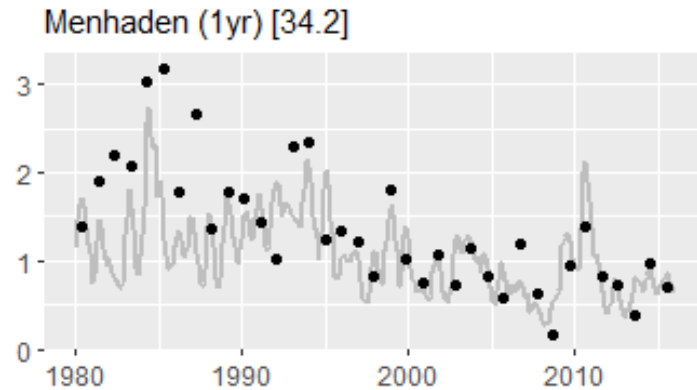
- Ecopath snapshot year: 1980
- Domain
- 78 functional groups
- 12 commercial fleets and 4 recreational fleets
- Pre-Bal diagnostics (Link 2010)
- Best practices (Heymans et al., 2016)



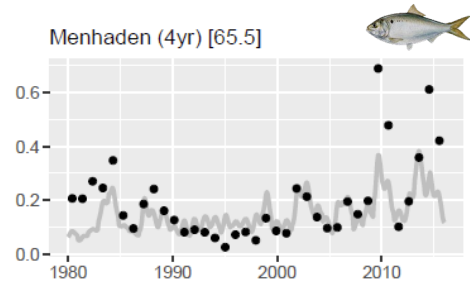
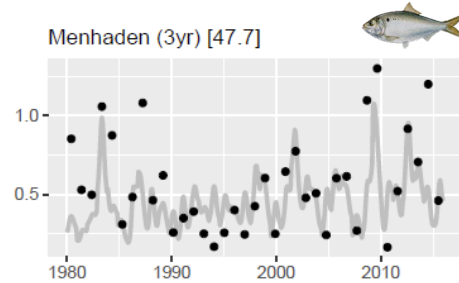
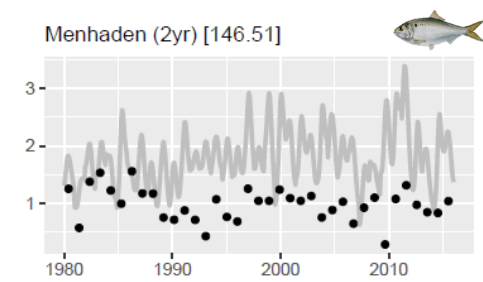
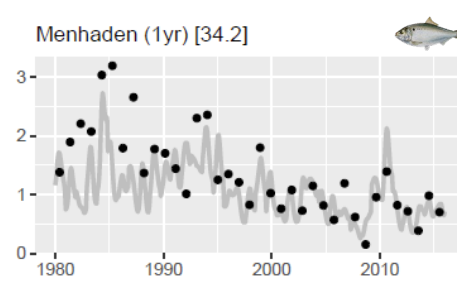
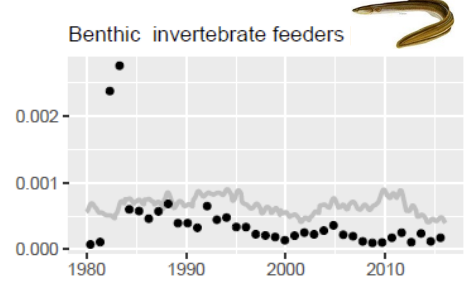
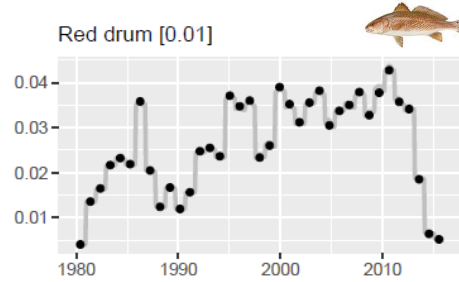
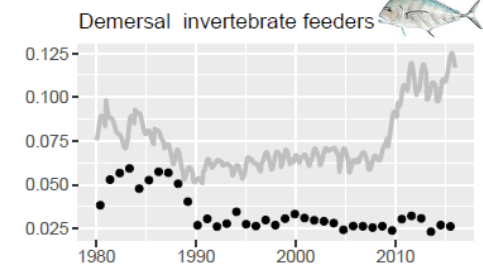
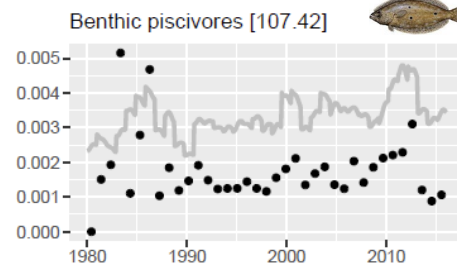
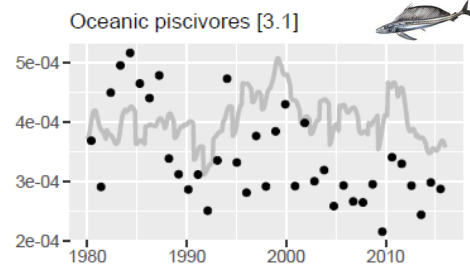
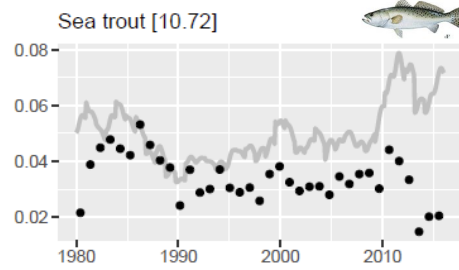
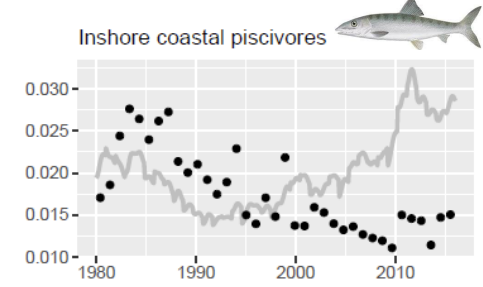
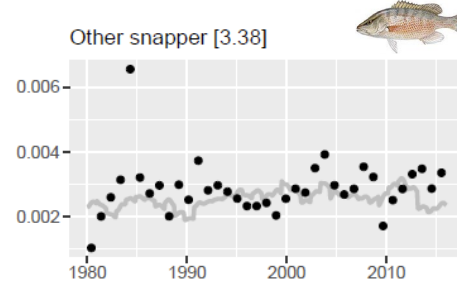
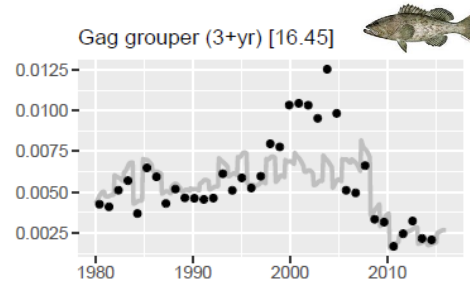
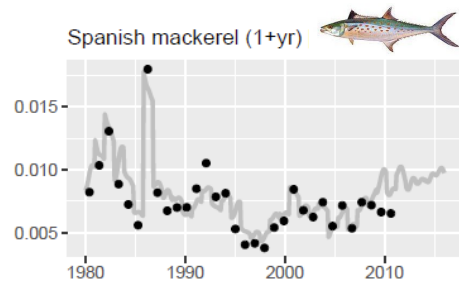
U.S. Gulf-wide Ecosim model

- Ecosim: 1980-2016
 - 160 input time series: biomass (B), catch (C), fishing mortality (F), fishing effort (E)
 - Data sources: SEDAR, SEAMAP, ICAAT, NOAA landings
 - Nutrient forcing: total Mississippi-Atchafalaya River Basin Loads
 - Fishing forcing: effort and mortality
 - Manual and automated calibration

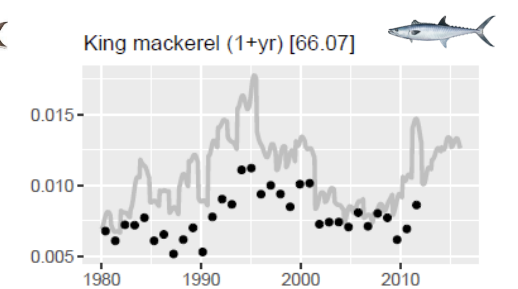
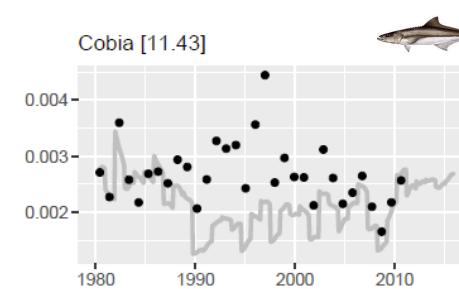
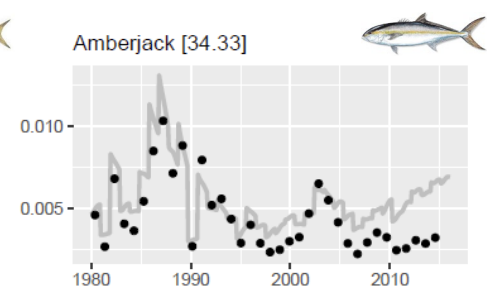
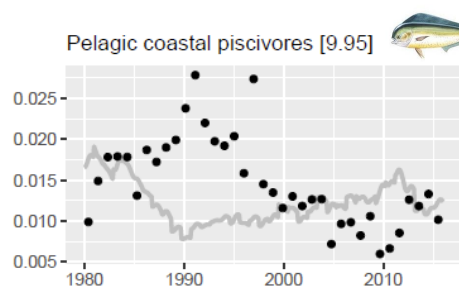
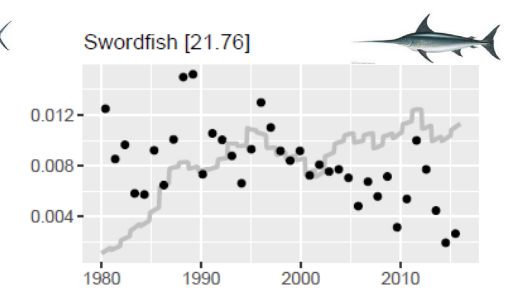
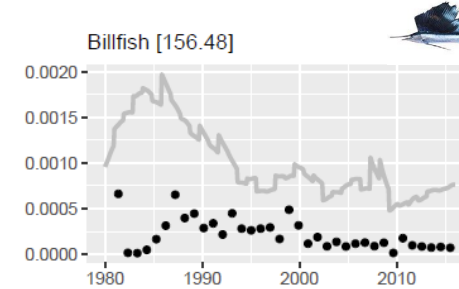
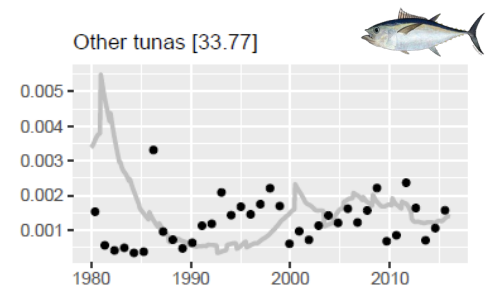
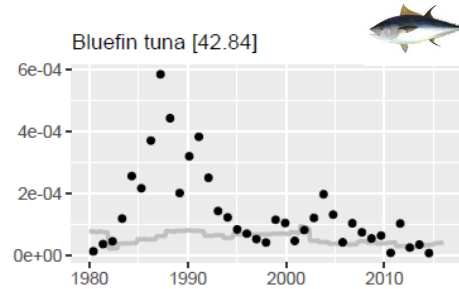
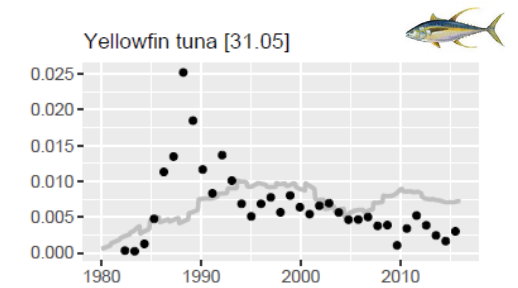
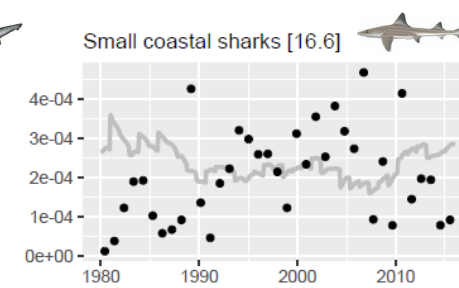
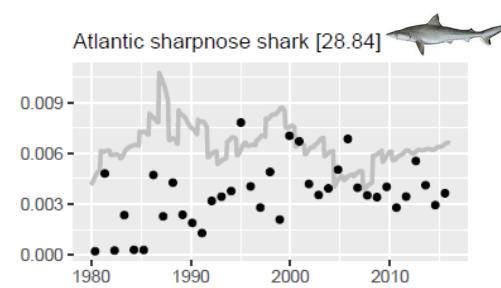
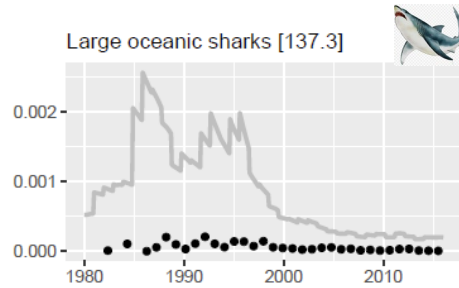
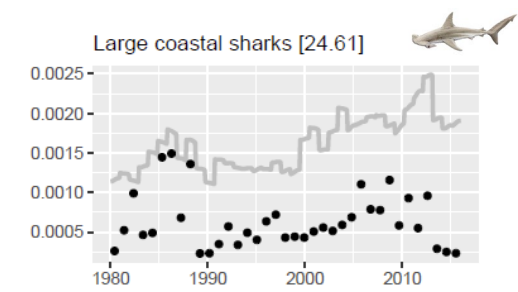
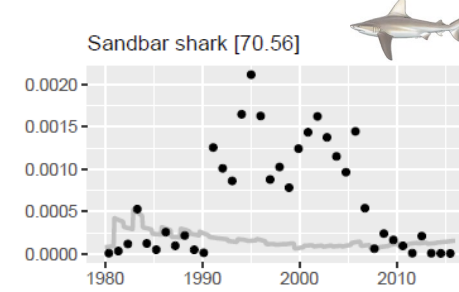
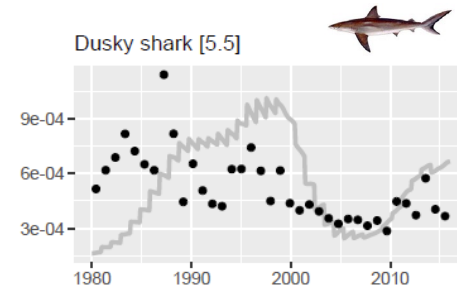
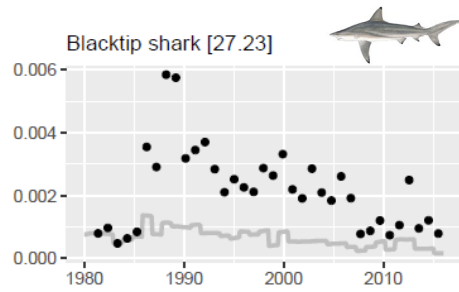
U.S. Gulf-wide Ecosim model – catch time series fits



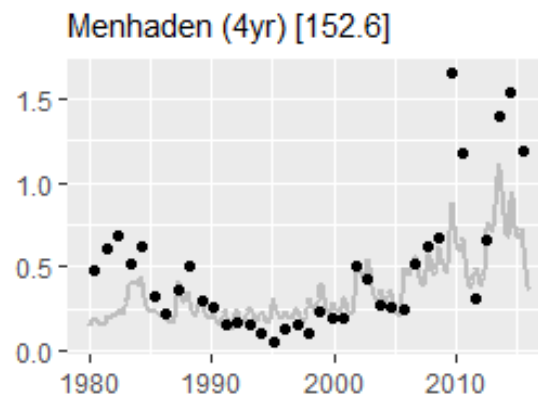
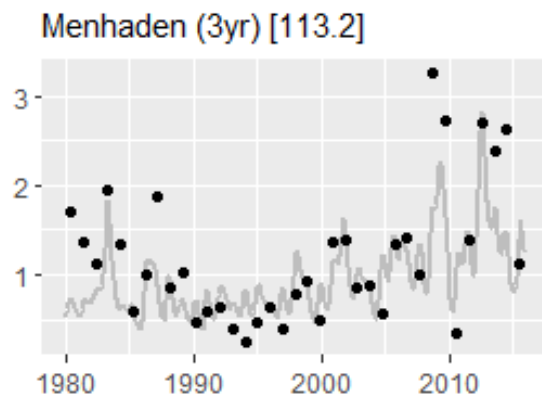
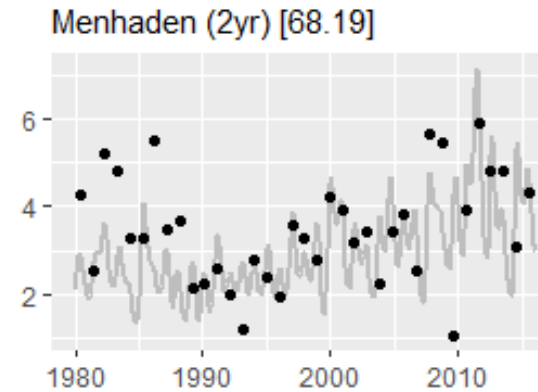
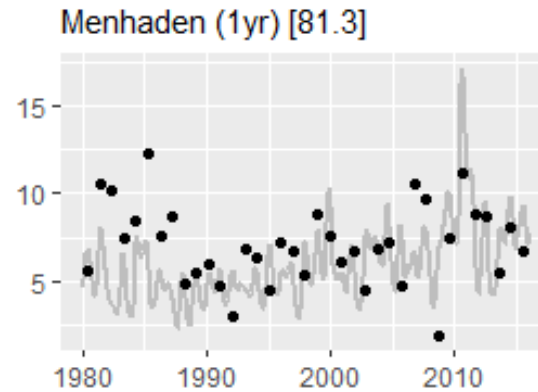
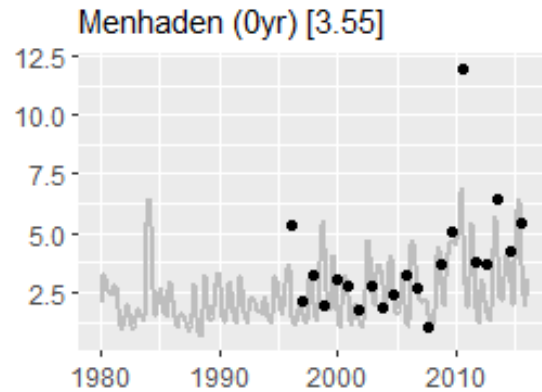
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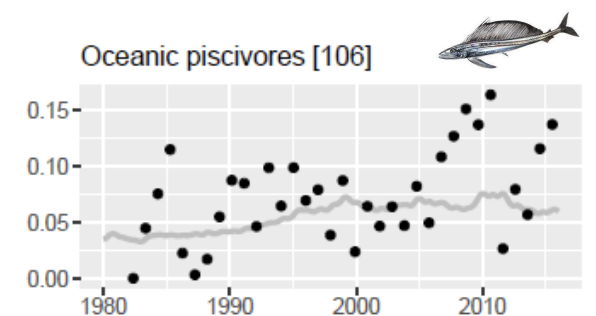
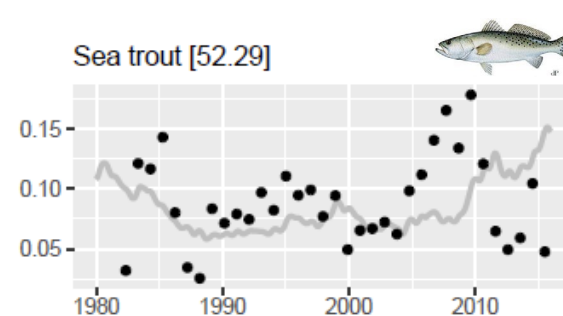
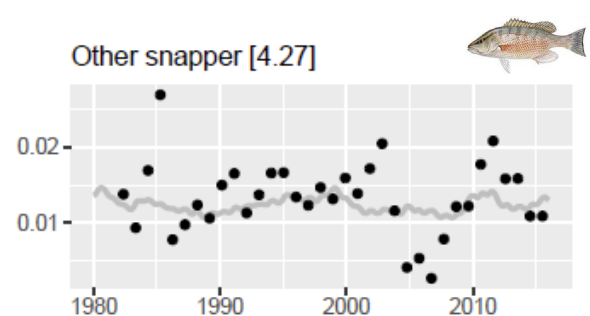
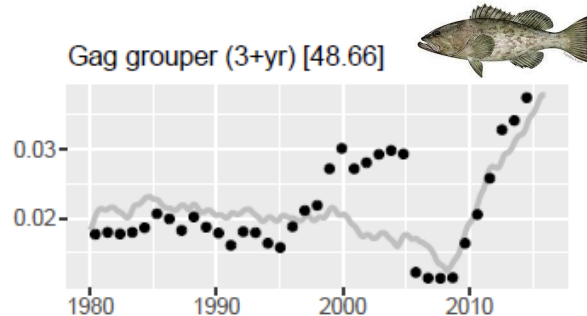
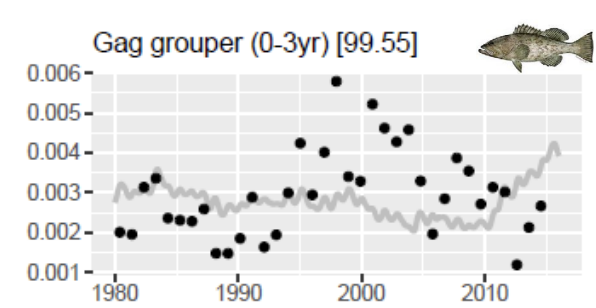
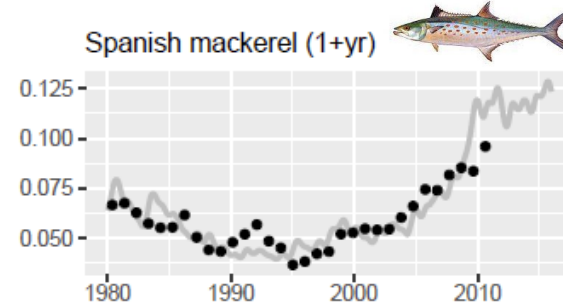
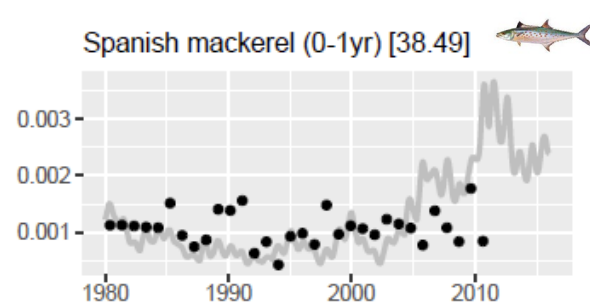
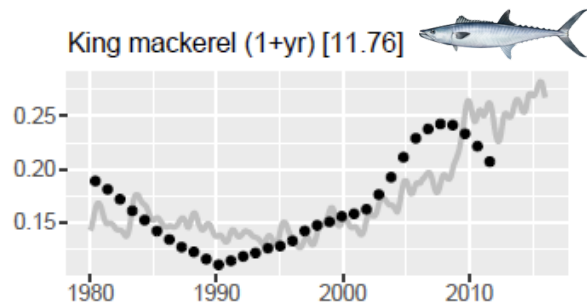
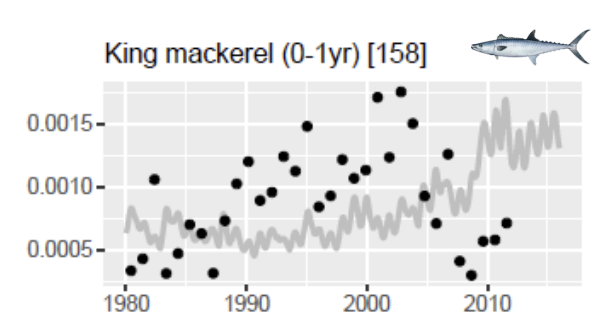
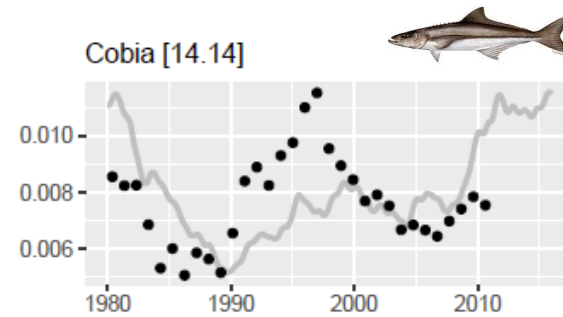
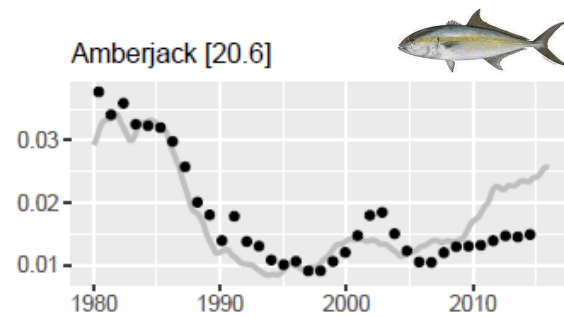
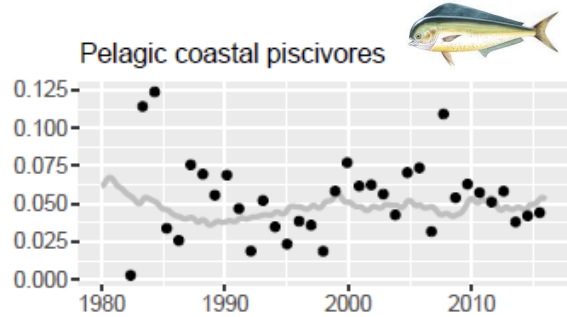
U.S. Gulf-wide Ecosim model – catch time series fits



U.S. Gulf-wide Ecosim model – biomass time series fits

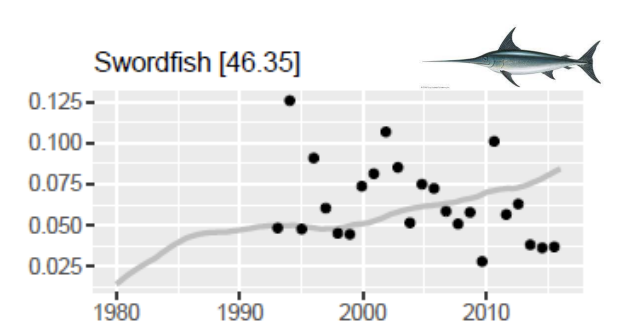
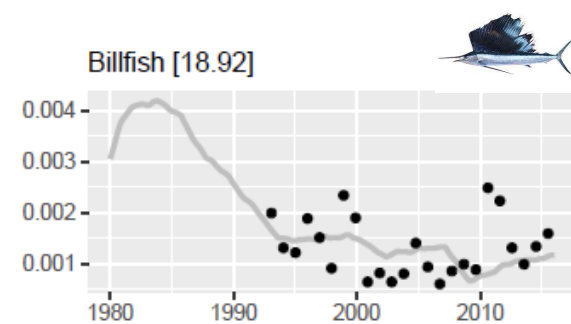
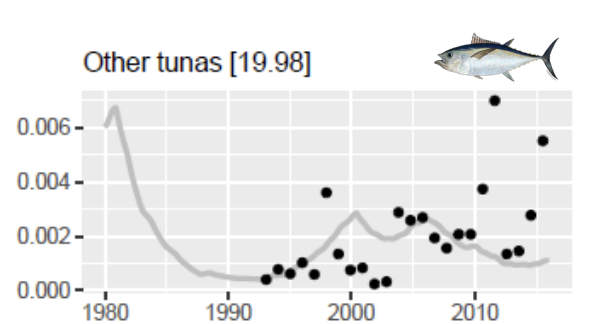
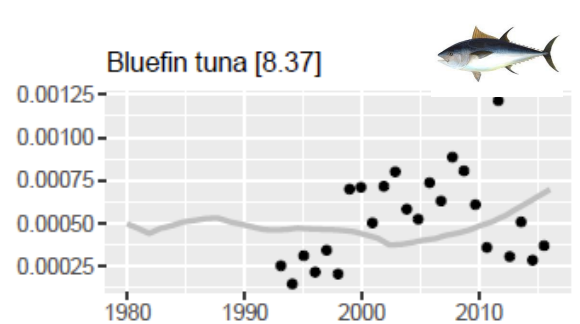
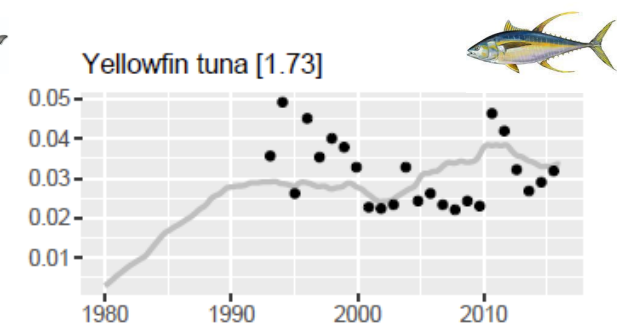
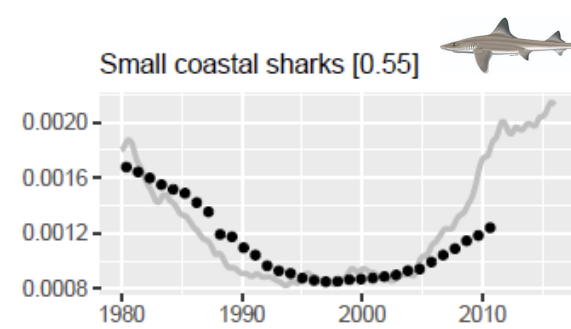
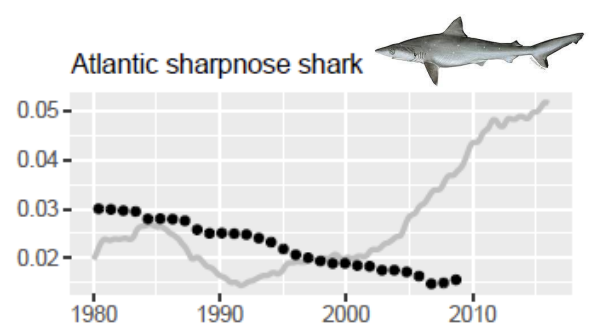
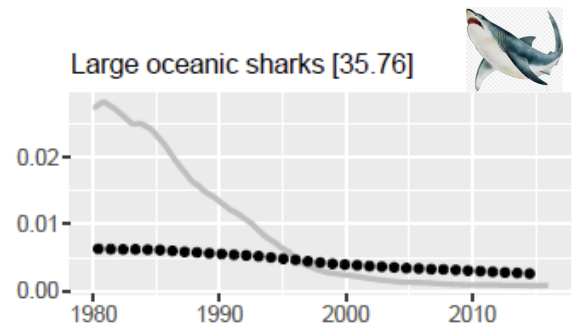
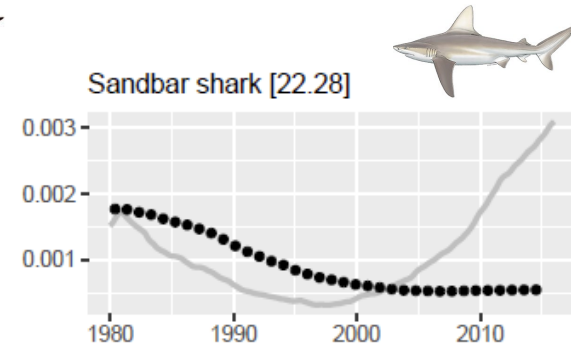
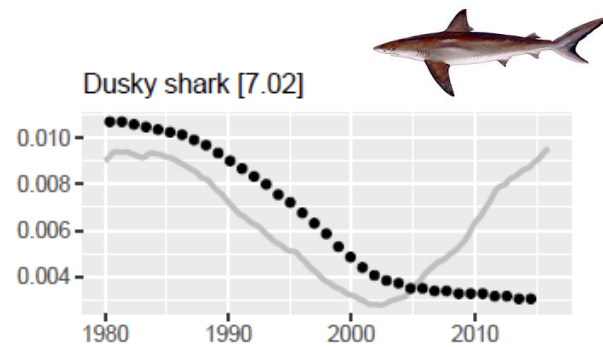
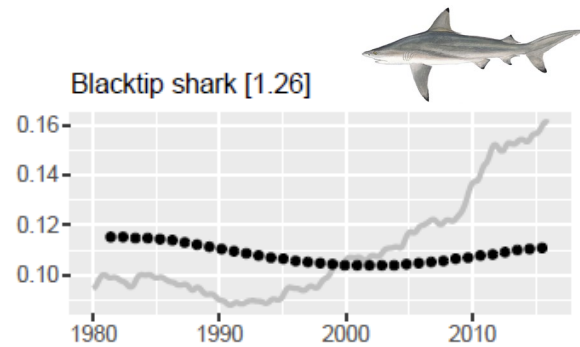


U.S. Gulf-wide Ecosim model – biomass time series fits

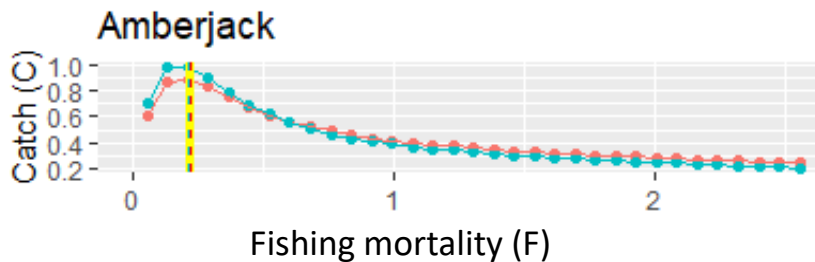
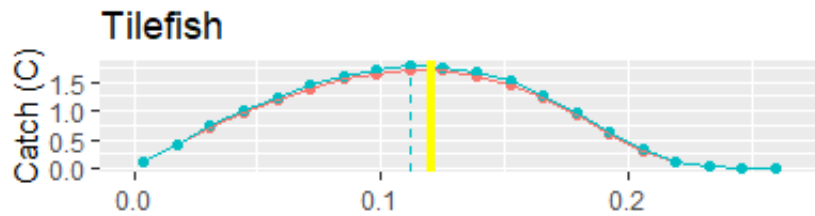
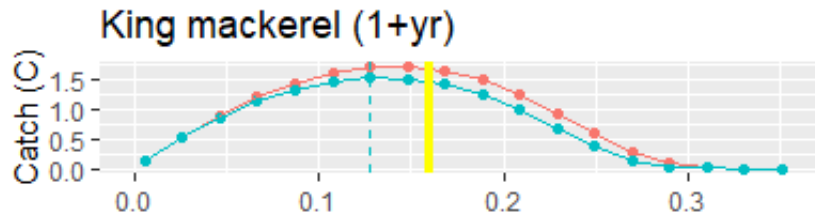
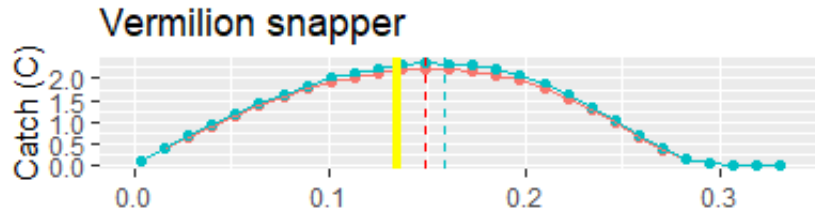


year

U.S. Gulf-wide Ecosim model – biomass time series fits



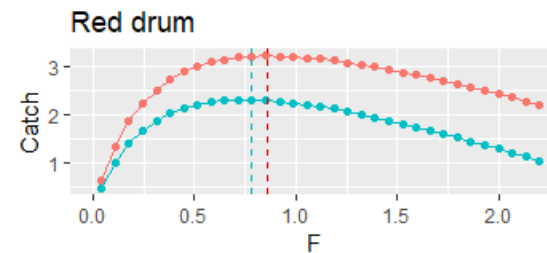
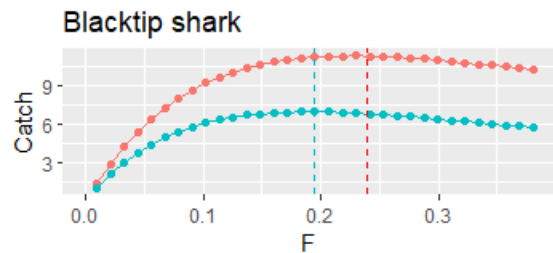
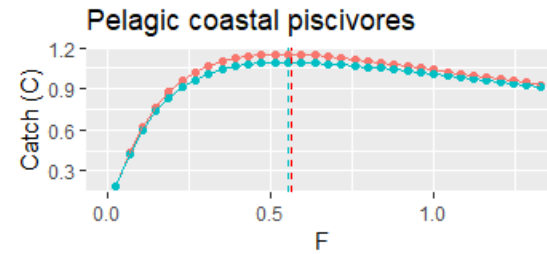
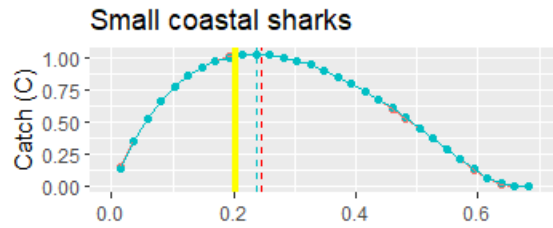
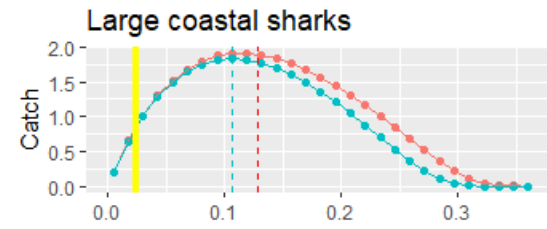
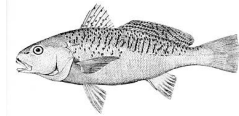
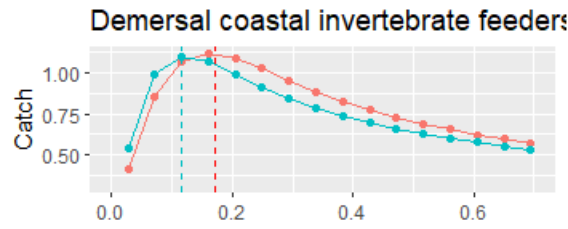
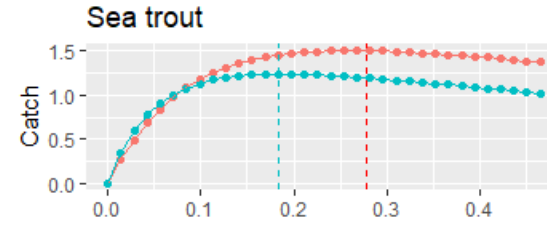
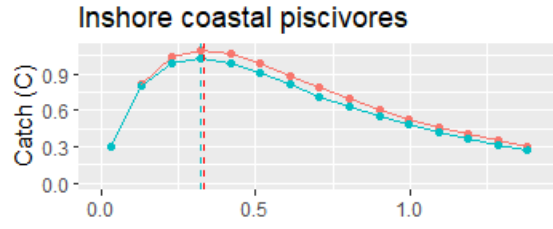
U.S. Gulf-wide Ecosim model – FMSY



FMSY

- - - Full comp.
- - - Stationary
- | Assessment

U.S. Gulf-wide Ecosim model – FMSY



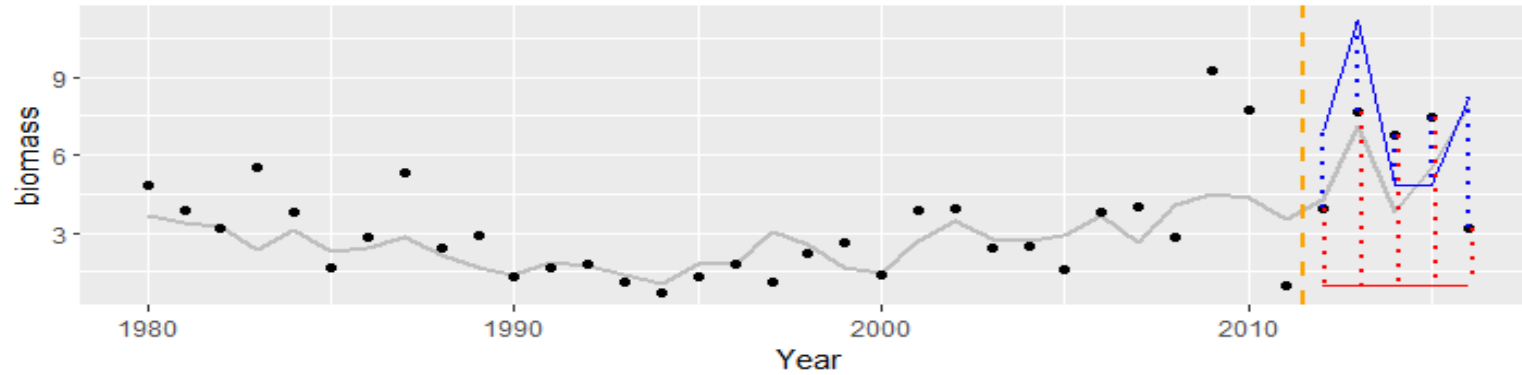
FMSY

- - - Full comp.
- - - Stationary
- | Assessment

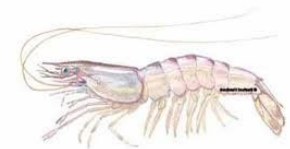
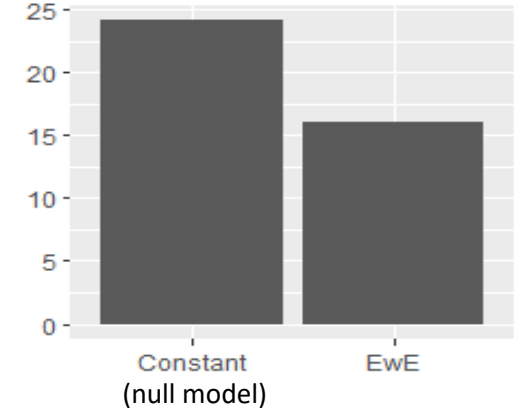
U.S. Gulf-wide Ecosim model – Forecast analysis



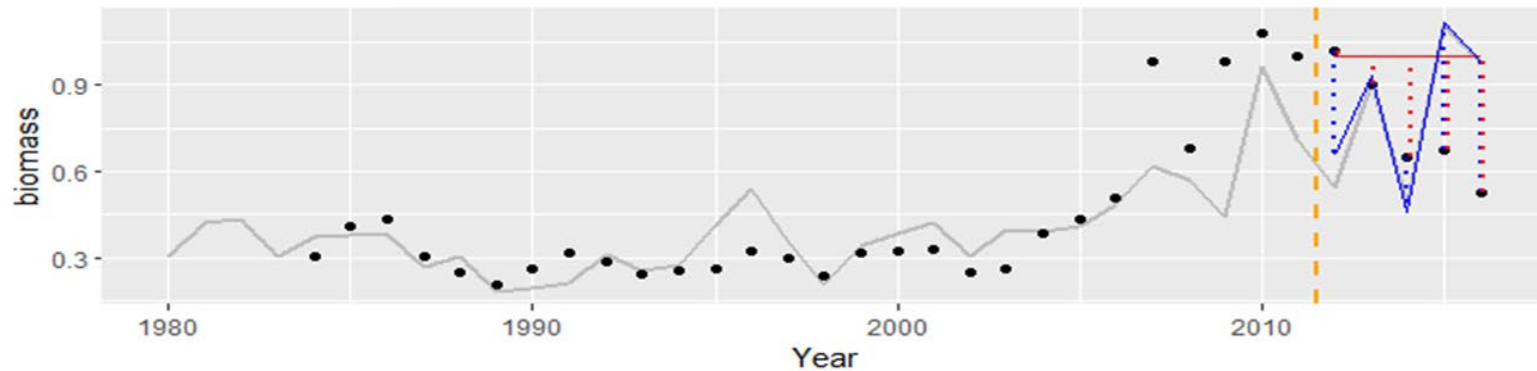
Menhaden (3 yr)



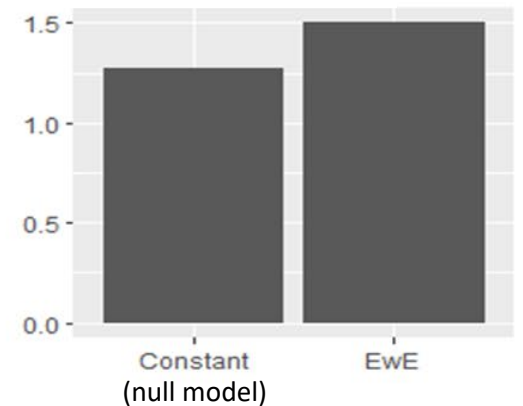
Errors sum



Brown shrimp



Errors sum



U.S. Gulf-wide EwE Forecast analysis results

- The Gulf-wide EwE model outperforms the null model
 - Modeling efficiency=0.5 (>0)
 - EwE errors $<$ null model errors
- Correct trend prediction
 - 74% of the groups
 - Spearman's rank correlation= 0.55 ($p < 0.001$)





GDAR

GULF DATA, ASSESSMENT, AND REVIEW

GDAR 03

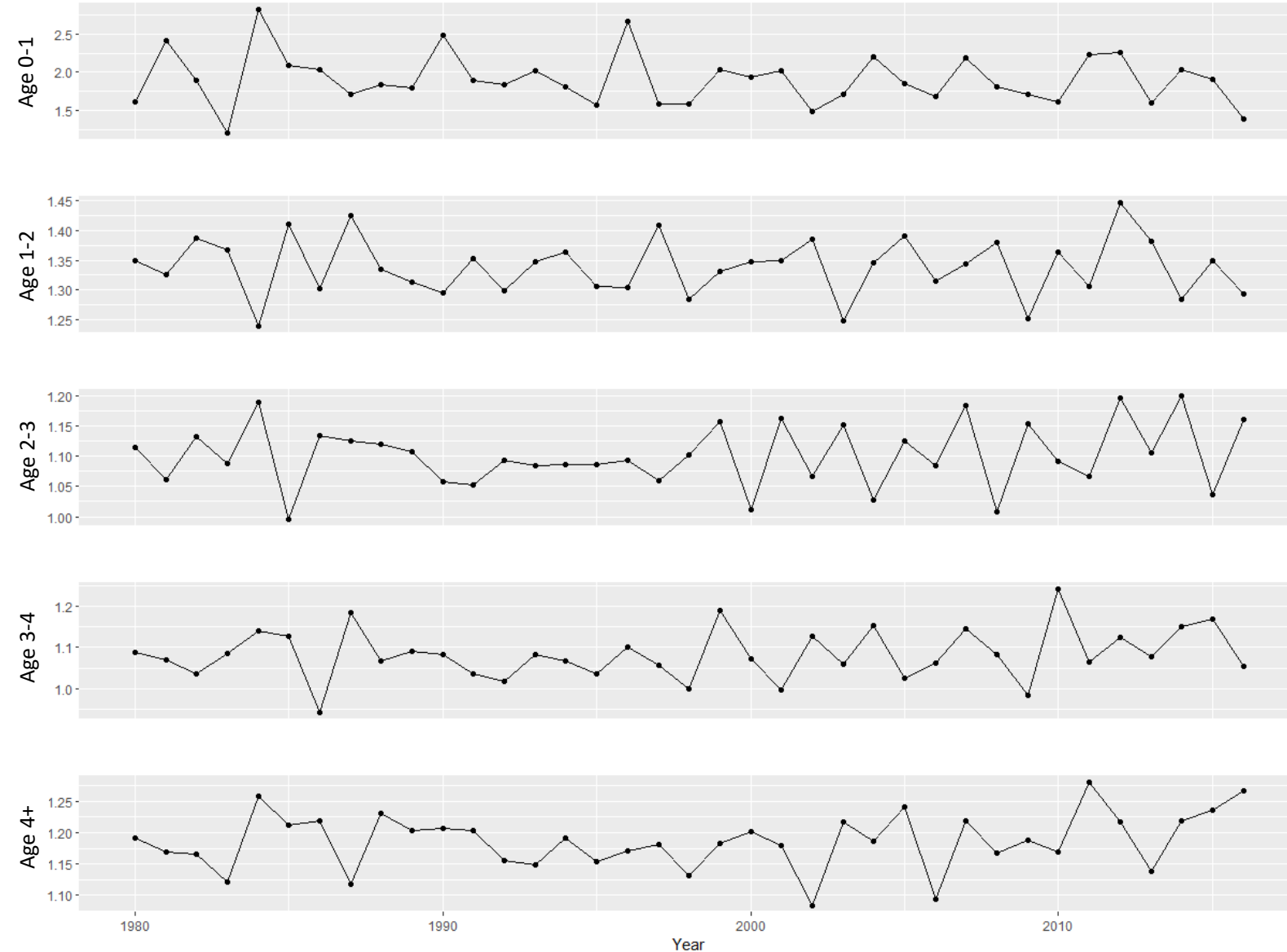
Gulf Menhaden Stock Assessment

2021 Update

October 2021

Sensitivity and Retrospective Analyses

Gulf menhaden natural mortality (M) estimates for stock assessment



GDAR

GULF DATA, ASSESSMENT, AND REVIEW

GDAR 03
Gulf Menhaden Stock Assessment

2021 Update

October 2021

Natural mortality (M) implementation in Gulf menhaden stock assessment



GDAR

GULF DATA, ASSESSMENT, AND REVIEW

GDAR 03 Gulf Menhaden Stock Assessment

2021 Update

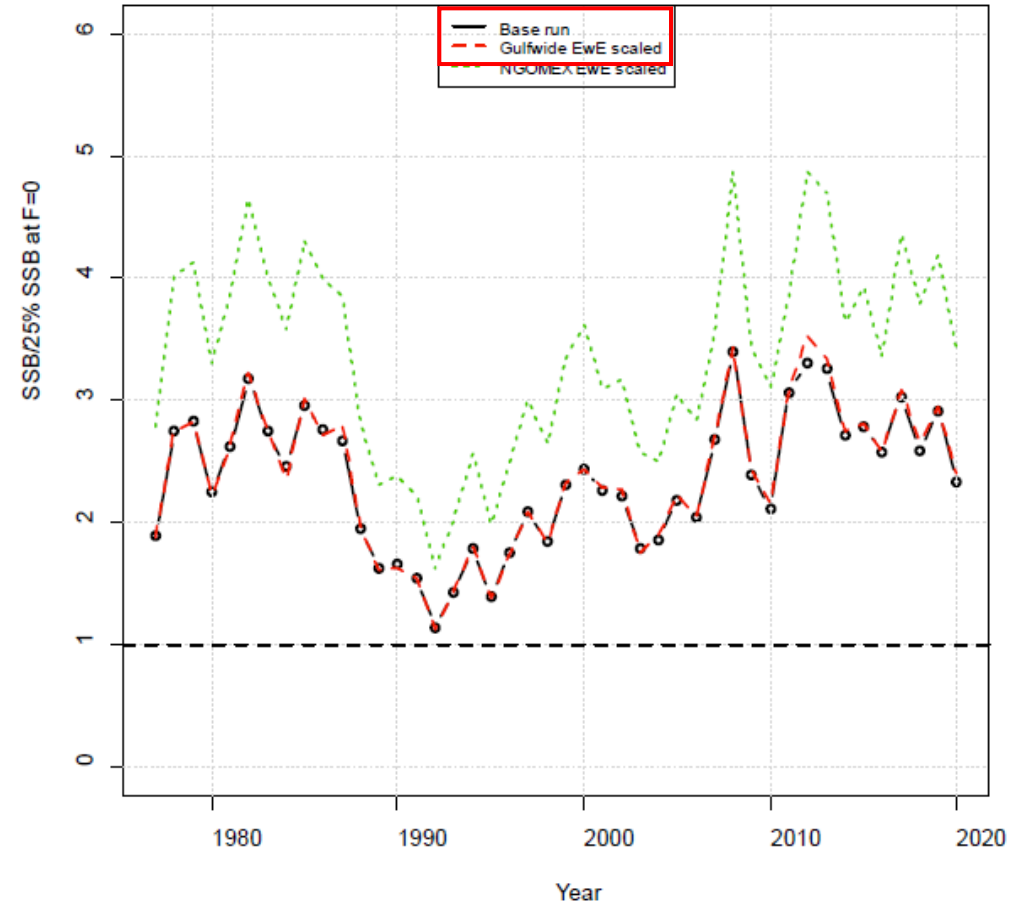
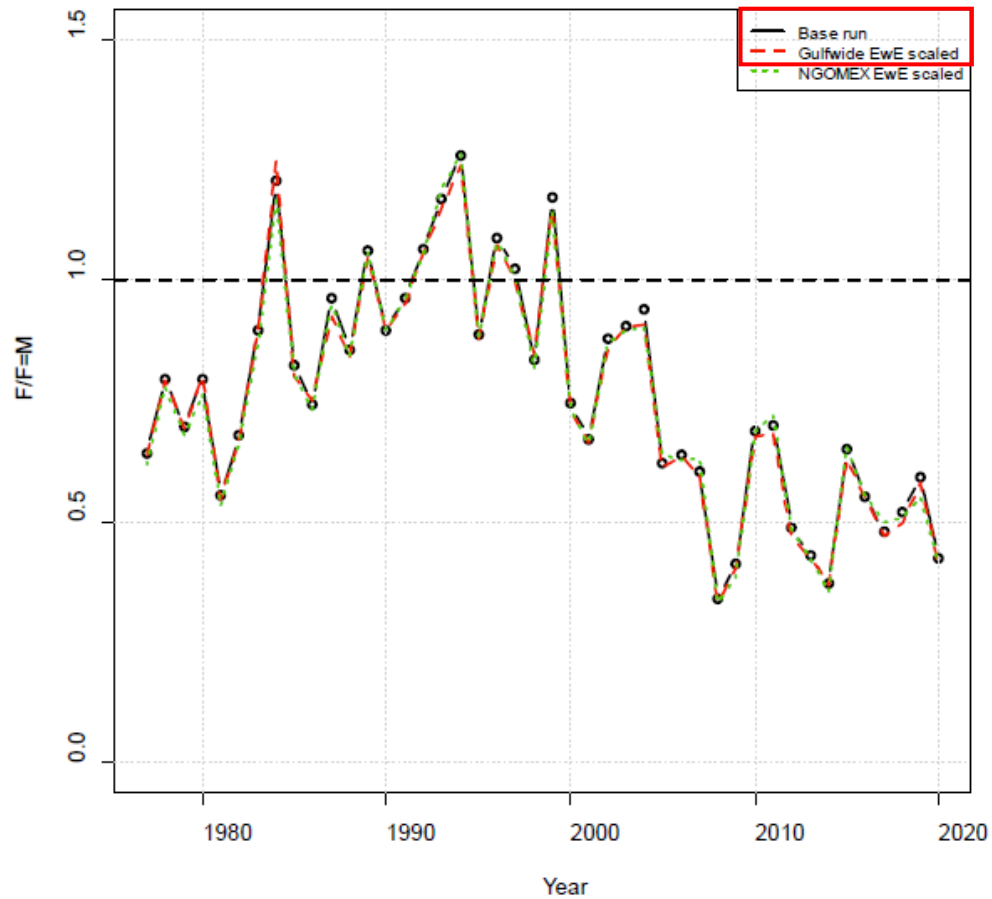
October 2021

Sensitivity and Retrospective Analyses

Run	$F_{F=M}$	$F_{F=0.75M}$	$SSB_{25\% \text{ at } F=0}$	$SSB_{50\% \text{ at } F=0}$	$F_{\text{Terminal 3 years}}/F_{F=M}$	$F_{\text{Terminal 3 years}}/F_{35\%}$	$SSB_{\text{Terminal 3 years}}/SSB_{30\%}$	$SSB_{\text{Terminal 3 years}}/SSB_{35\%}$
Base run	1.32	0.99	1,274,663	2,549,325	0.56	0.74	2.79	1.4
2016-2017 LA gillnet age comps	1.32	0.99	1,320,590	2,641,180	0.52	0.69	2.77	1.38
Pooled LA gillnet age comps	1.32	0.99	1,335,451	2,670,902	0.5	0.67	2.78	1.39
Gulfwide EwE scaled	1.32	0.99	1,284,590	2,569,180	0.55	0.73	2.82	1.41
NGOMEX EwE scaled	1.32	0.99	911,452.8	1,822,906	0.56	0.75	3.87	1.93
2020 age comps excluded	1.32	0.99	1,275,327	2,550,654	0.55	0.74	2.8	1.4
Retrospective 2019	1.32	0.99	1,240,673	2,481,346	0.62	0.83	2.42	1.21
Retrospective 2018	1.32	0.99	1,285,142	2,570,284	0.71	0.95	2.62	1.31
Retrospective 2017	1.32	0.99	1,241,641	2,483,281	0.41	0.54	2.54	1.27
Retrospective 2016	1.32	0.99	1,260,141	2,520,282	0.49	0.65	3.03	1.52
Retrospective 2015	1.32	0.99	1,256,415	2,512,831	0.56	0.75	3.08	1.54

Diagnostics and credibility summary

Sensitivity and Retrospective Analyses



Time series of $SSB/SSB_{25\% \text{ at } F=0}$ for sensitivity runs. The solid black line with open circles is the base run.

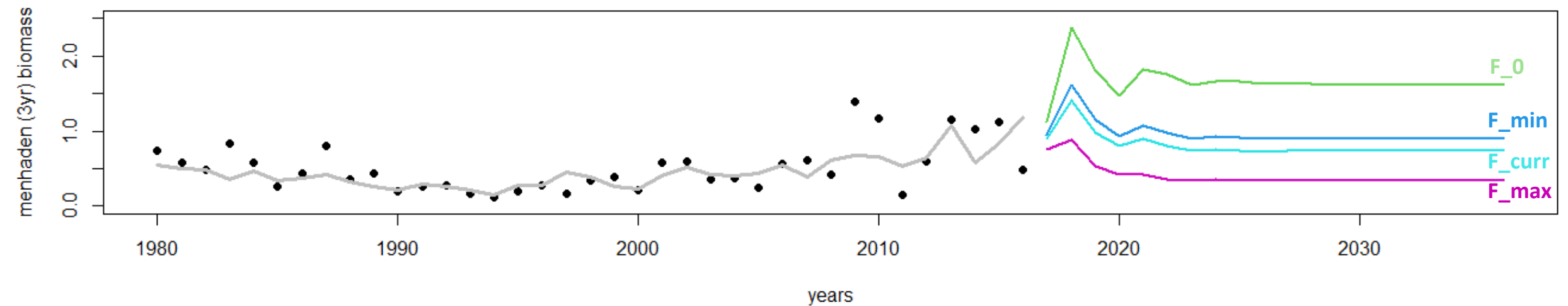
Ecological sensitivity: Gulf menhaden + predators

Four management scenarios of fishing mortality (F) and effort (E)



- F_0: F and E equals zero
- F_min: F and E equals historical minimum
- F_current: F and E equals last model year (2016) value
- F_max: F and E equals historical maximum

*All other species held constant at terminal year 2016 F rates



Gulf menhaden– case study

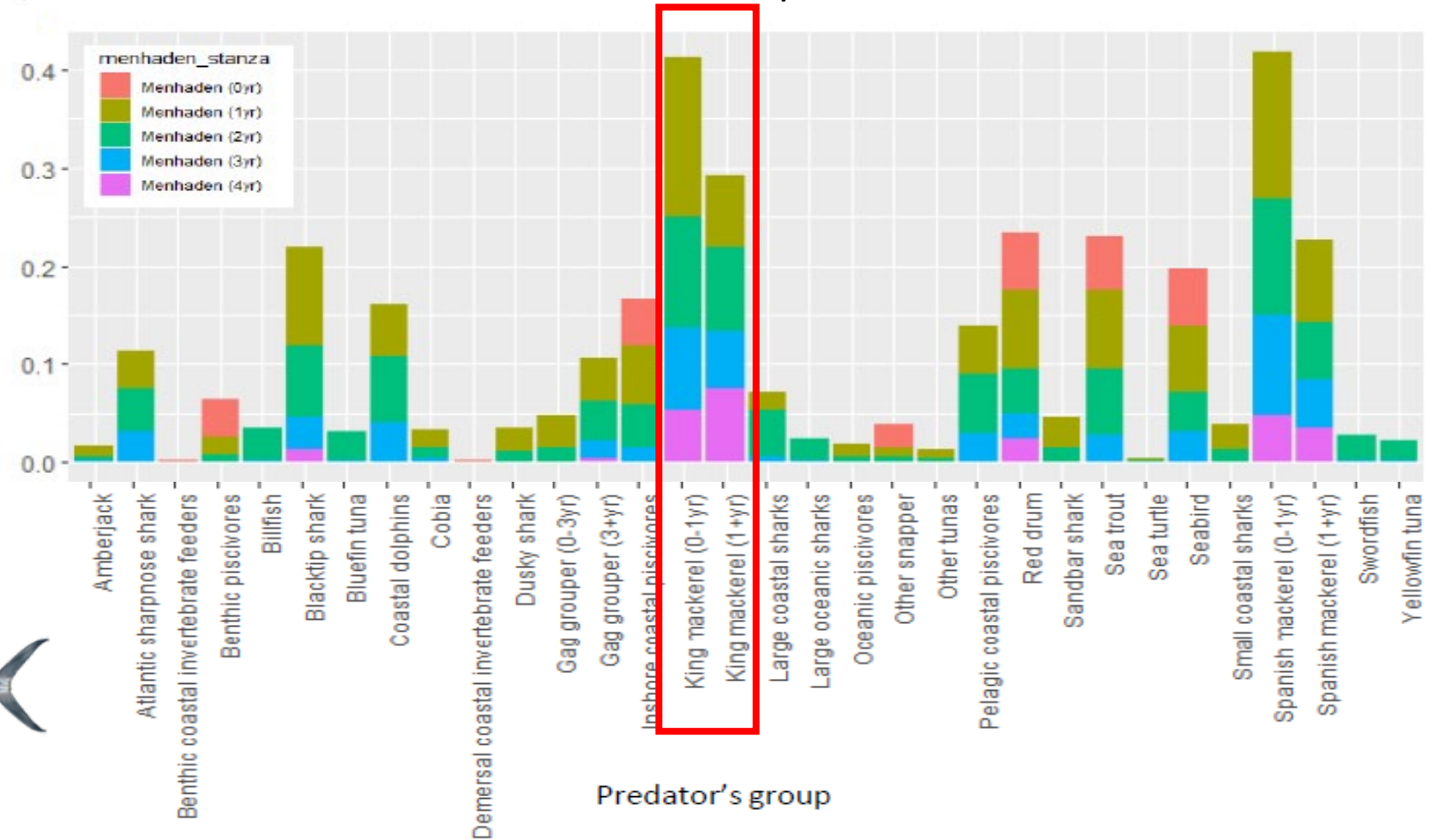
- Ecological Reference Points
- F Scenarios: F_0 , F_{min} , $F_{current}$, F_{max}



vs.



Fraction of menhaden in predator's diet



Gulf menhaden– case study

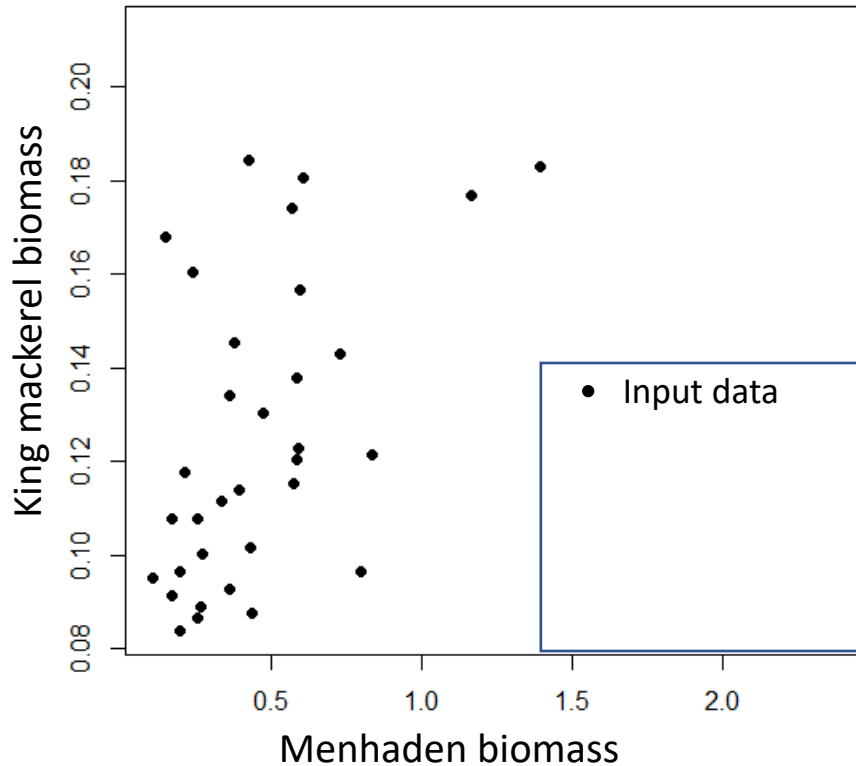


vs.



Diagnostics

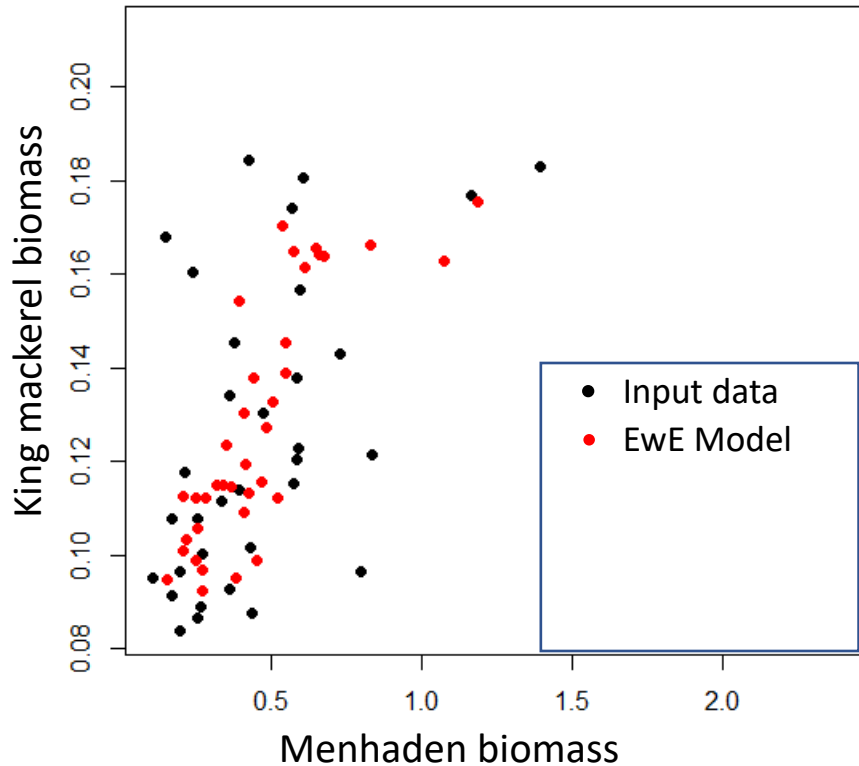
- Input data – realistic relationship



Gulf menhaden– case study



vs.



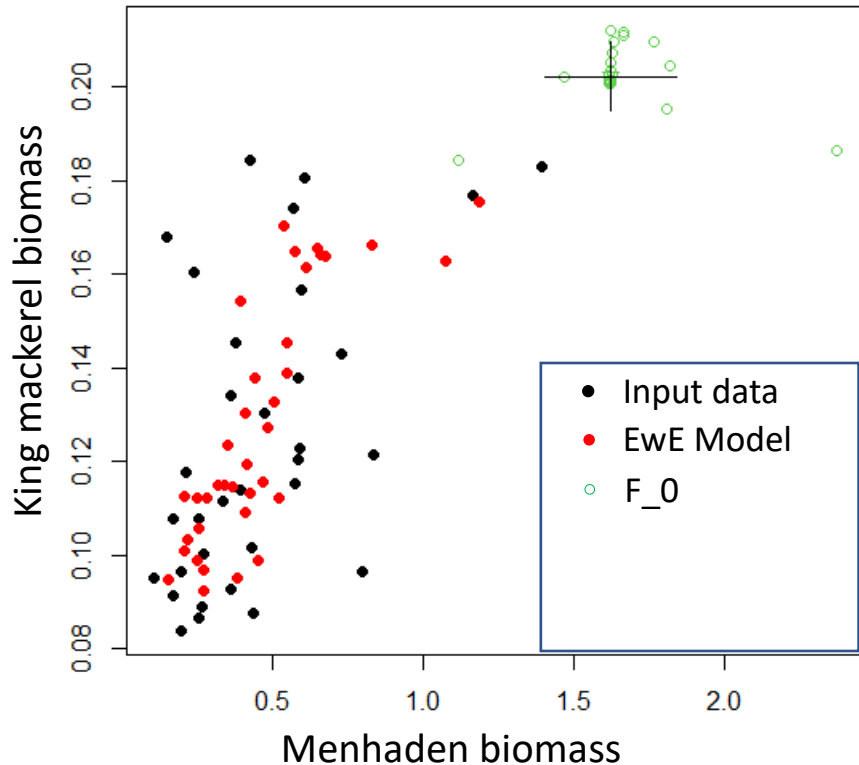
Diagnostics

- Input data – realistic relationship
- Model recreates observed pattern

Gulf menhaden– case study



vs.



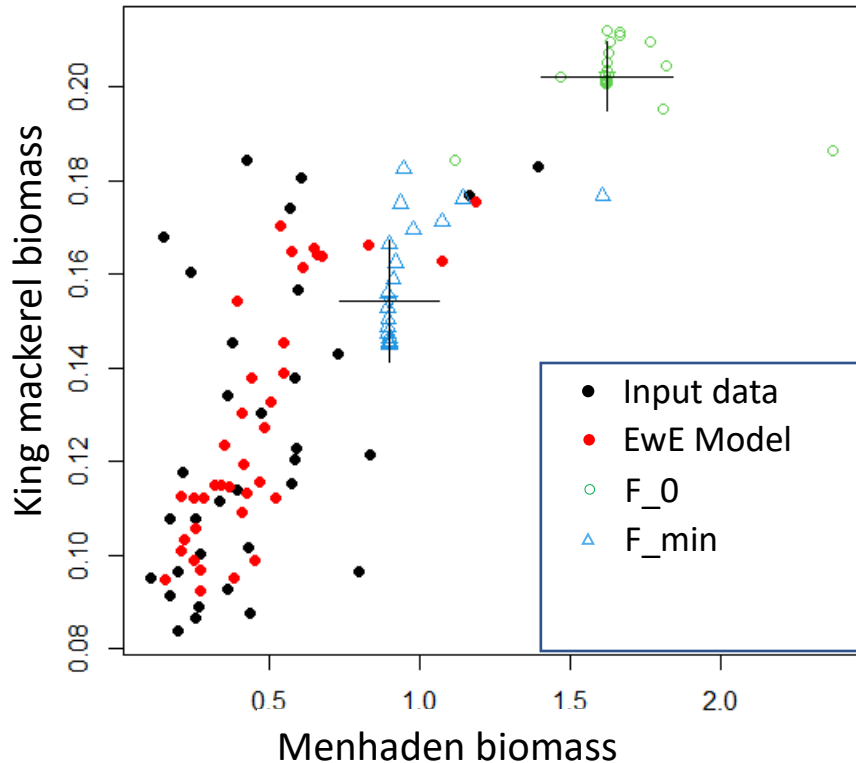
Diagnostics

- Input data – realistic relationship
- Model recreates observed pattern
- Scenarios:
 - F_0

Gulf menhaden– case study



vs.



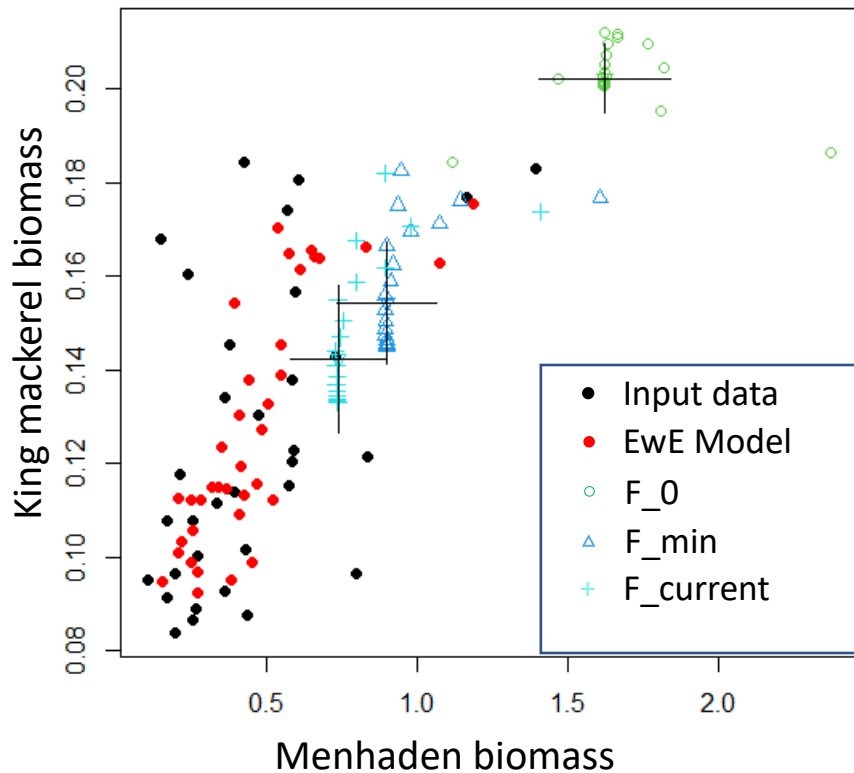
Diagnostics

- Input data – realistic relationship
- Model recreates observed pattern
- Scenarios:
 - F_0
 - F_min

Gulf menhaden– case study



vs.



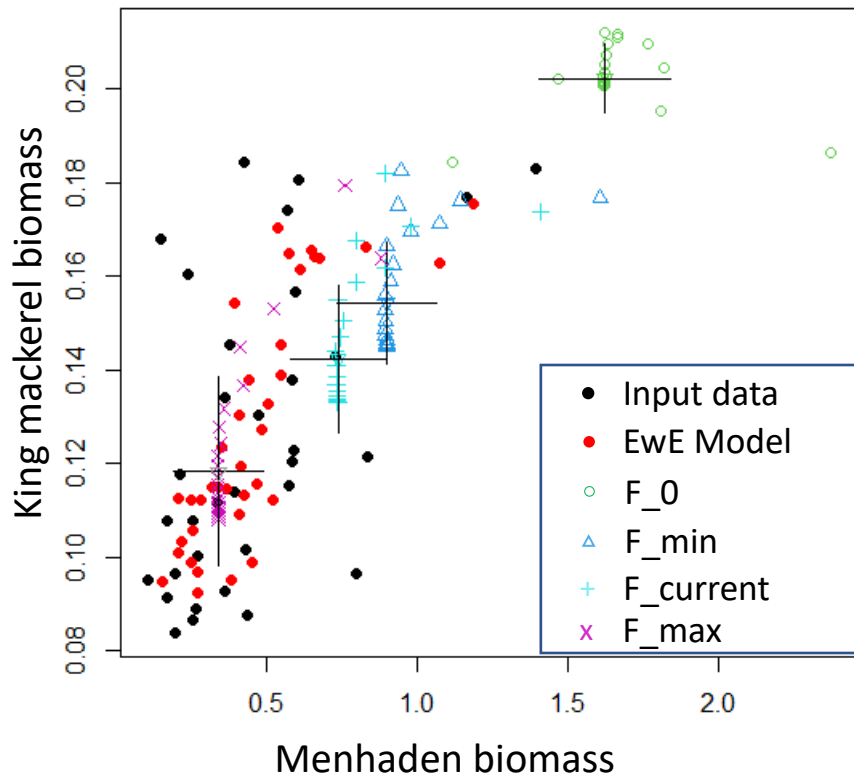
Diagnostics

- Input data – realistic relationship
- Model recreates observed pattern
- Scenarios:
 - F_0
 - F_min
 - F_current

Gulf menhaden– case study

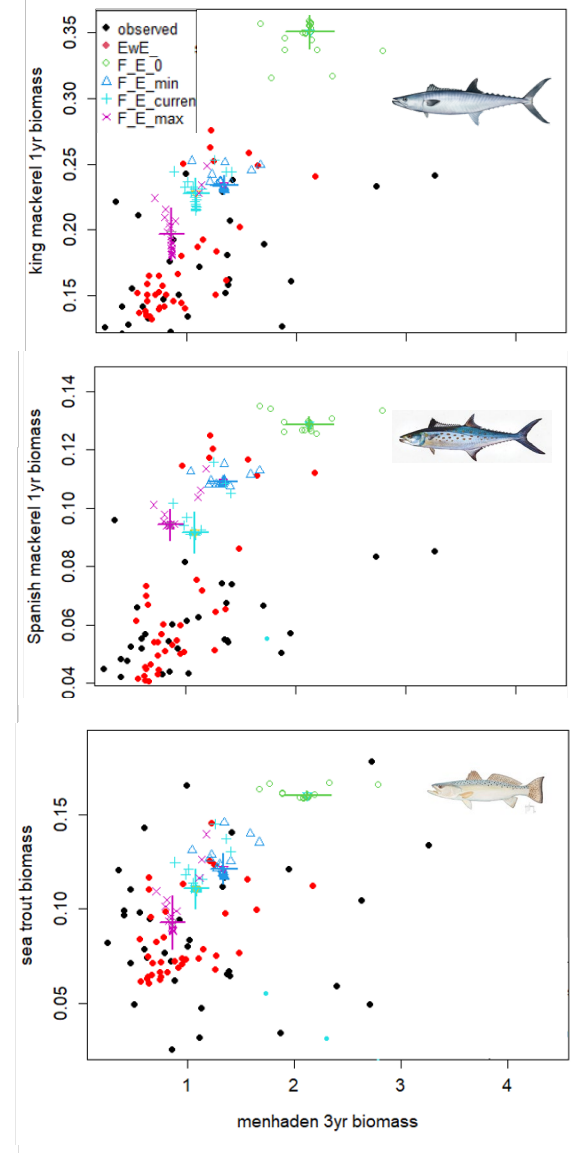
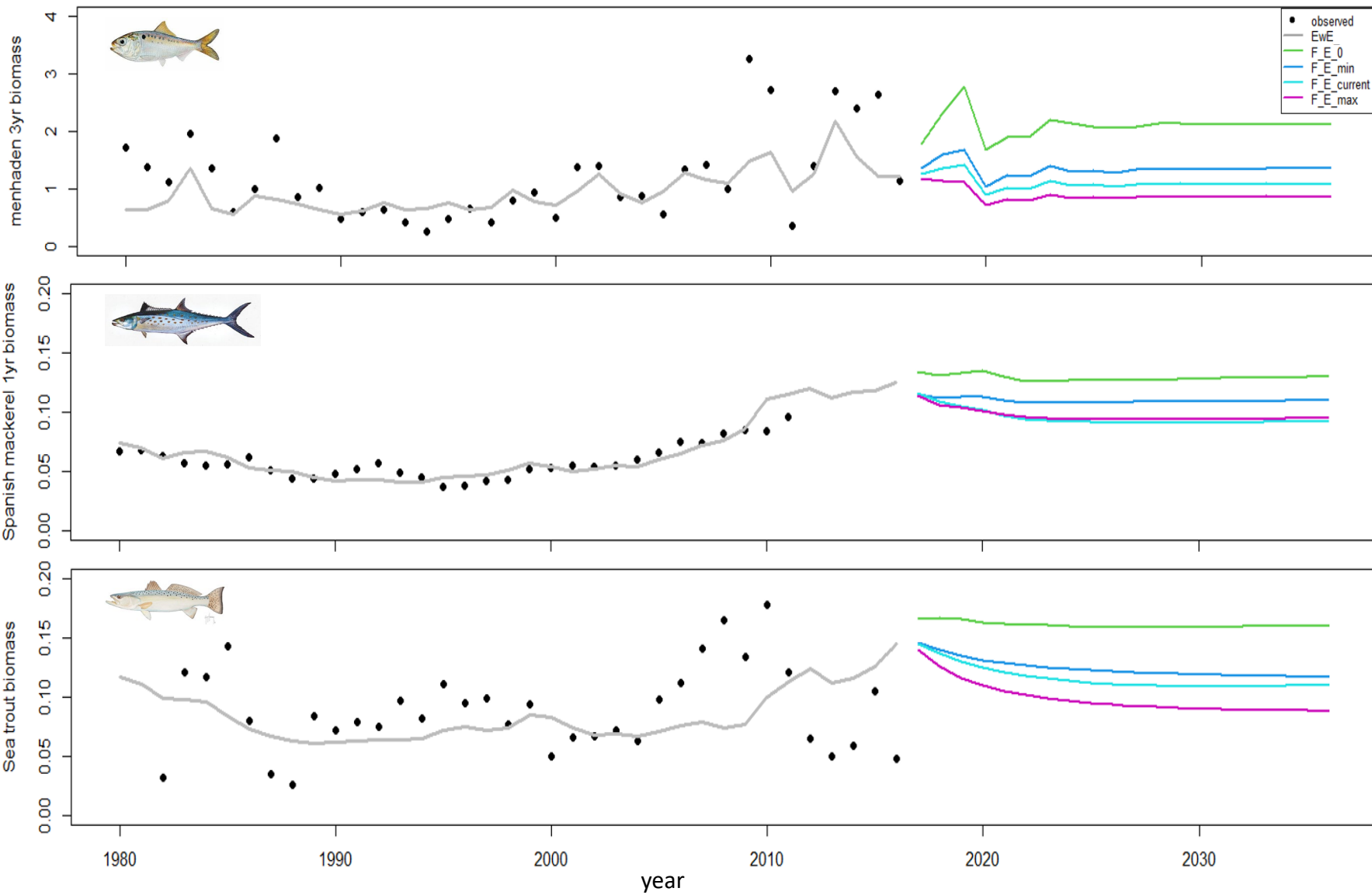


vs.

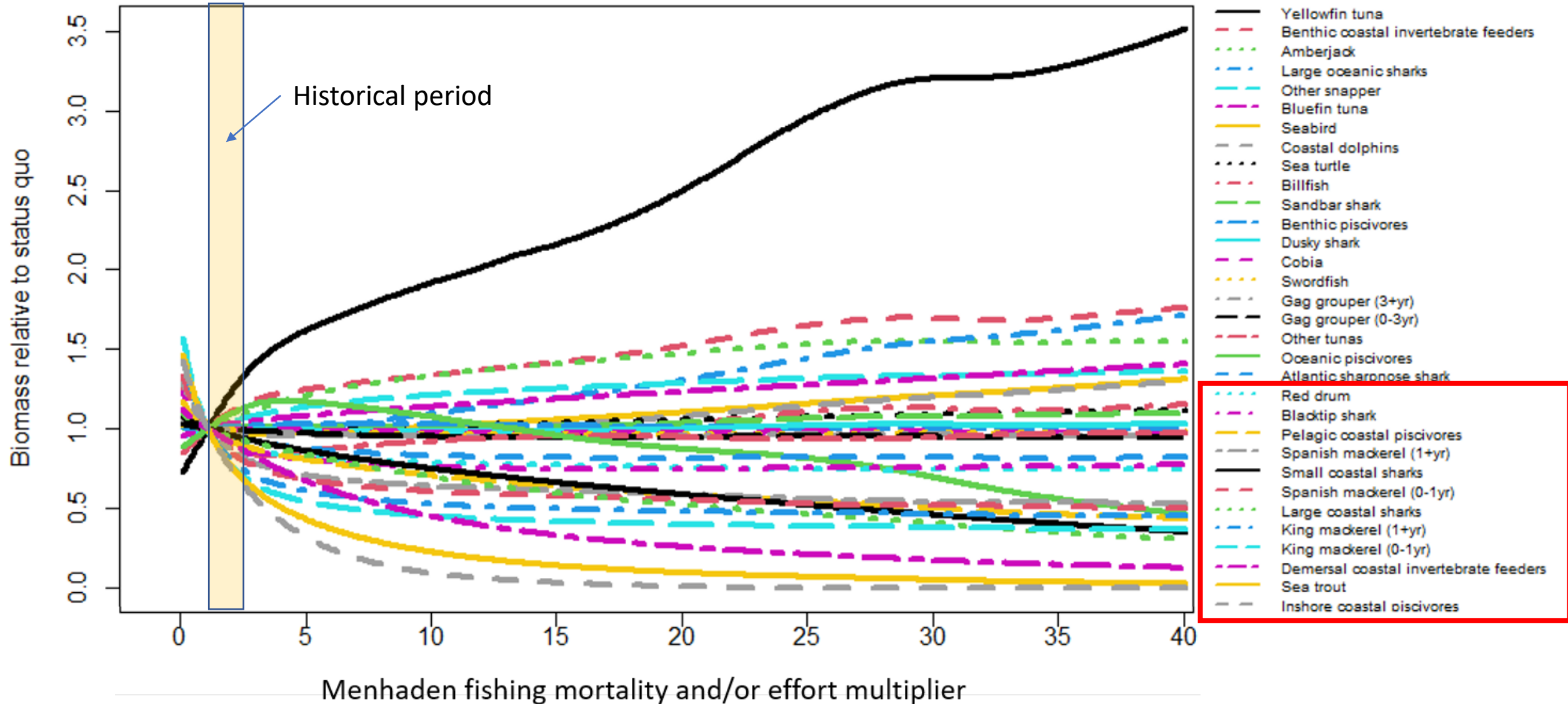


Diagnostics

- Input data – realistic relationship
- Model recreates observed pattern
- Scenarios:
 - F_0
 - F_min
 - F_current
 - F_max



Gulf menhaden– the effect of F & E on predators



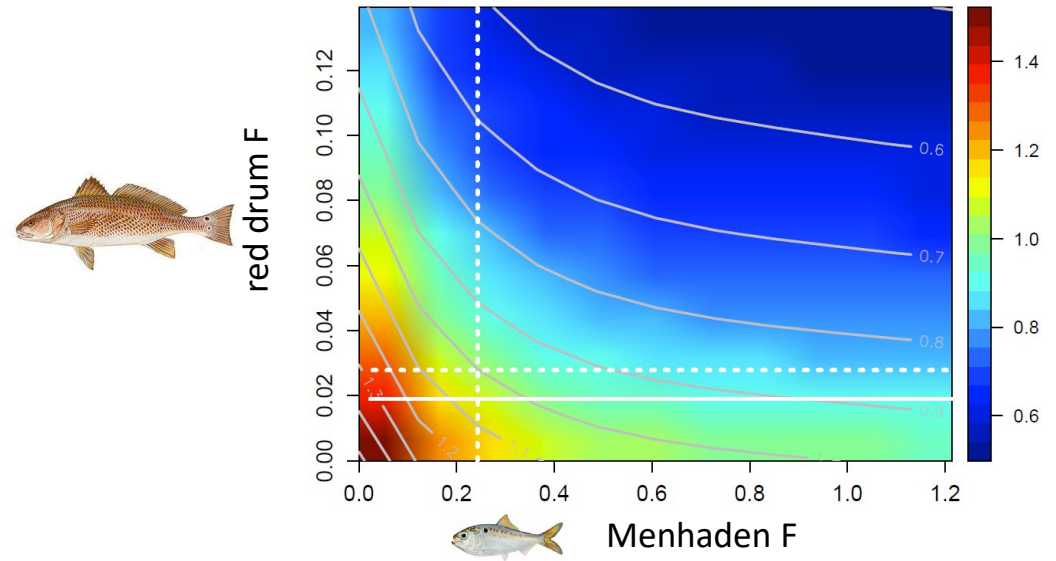
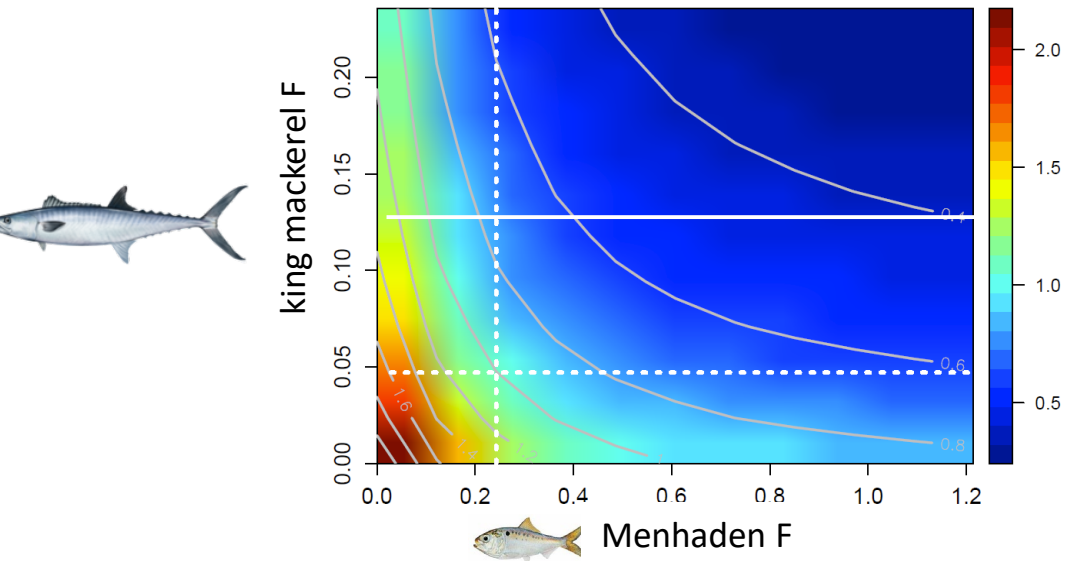
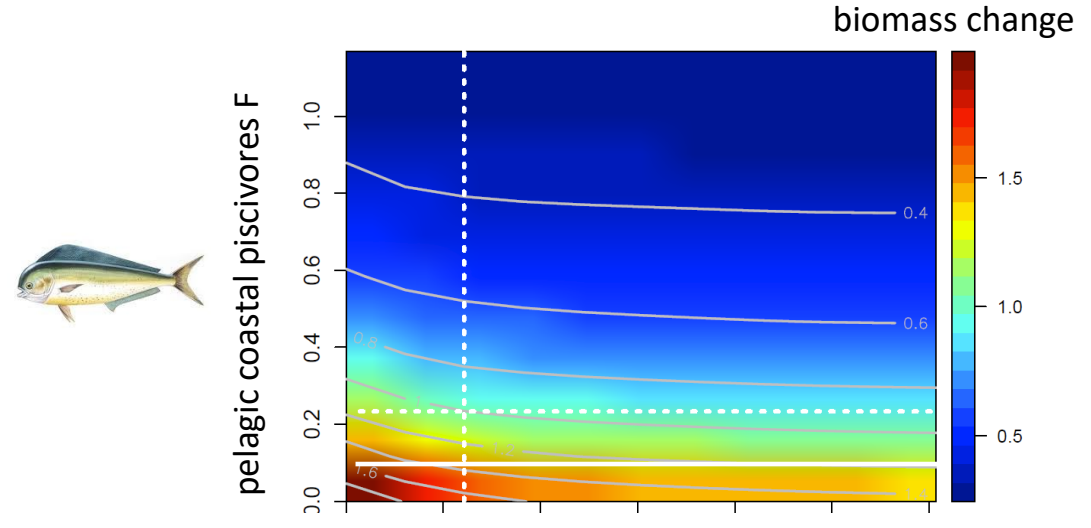
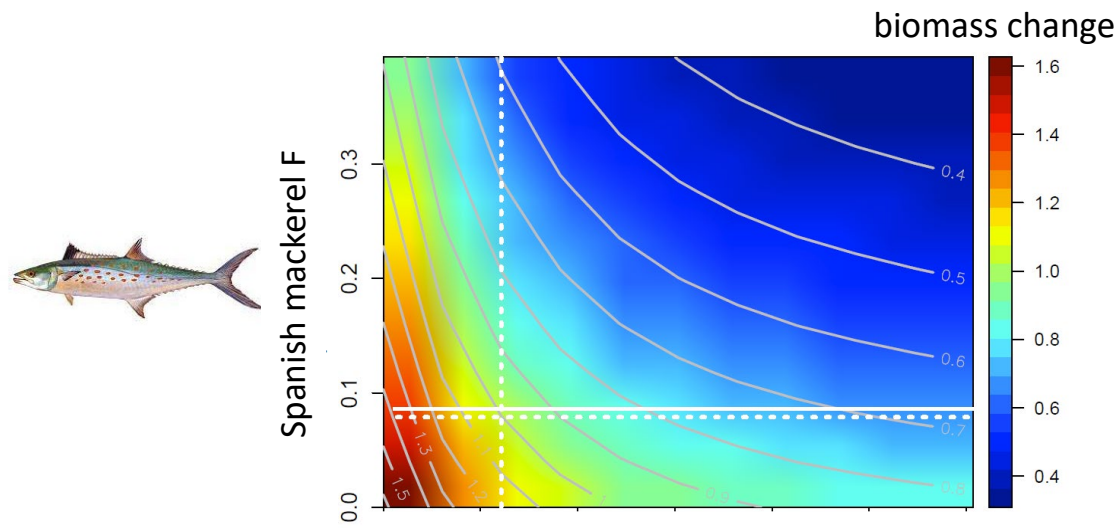
Gulf menhaden– possible pathways of effect

- Predation
- Bycatch
- Competition
- Trophic effects

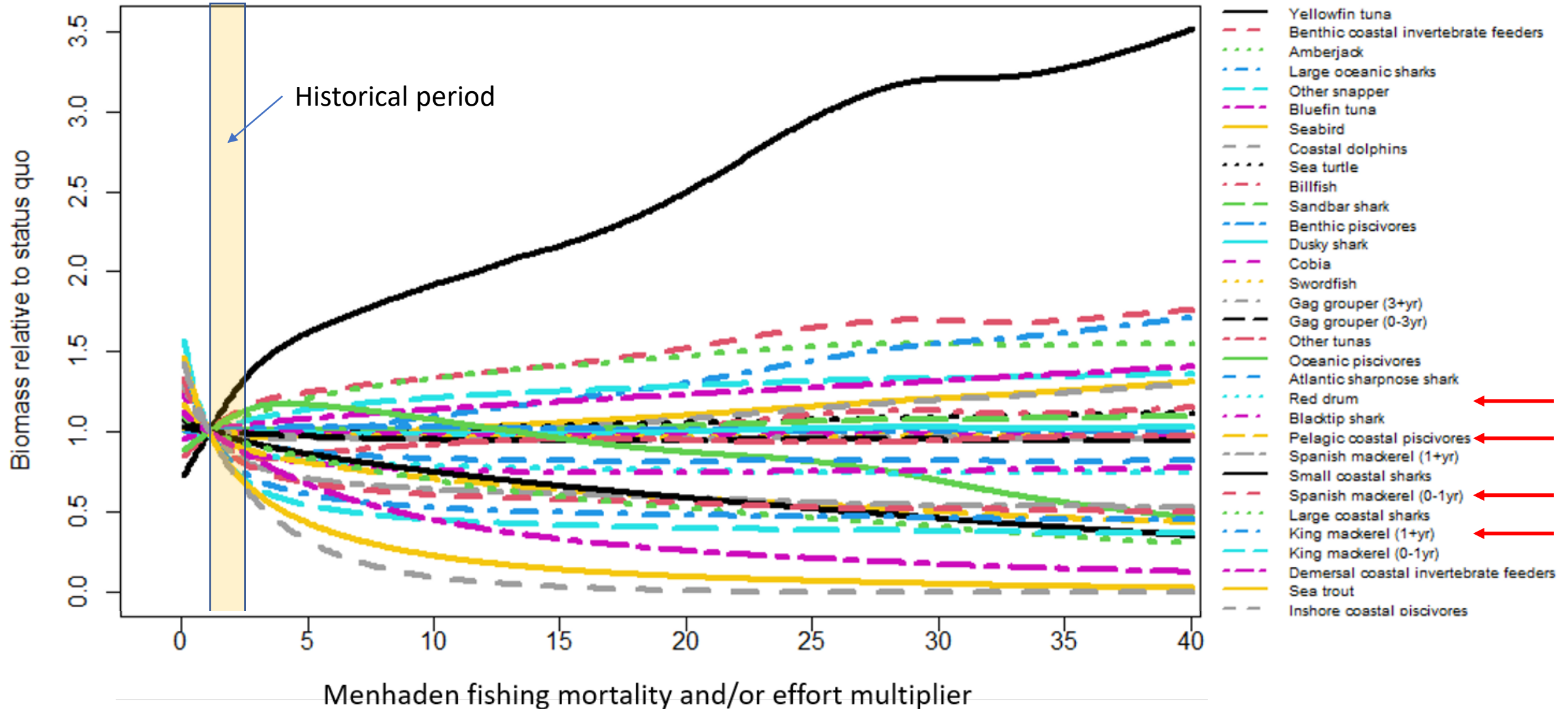


(influence on group's prey or predator)

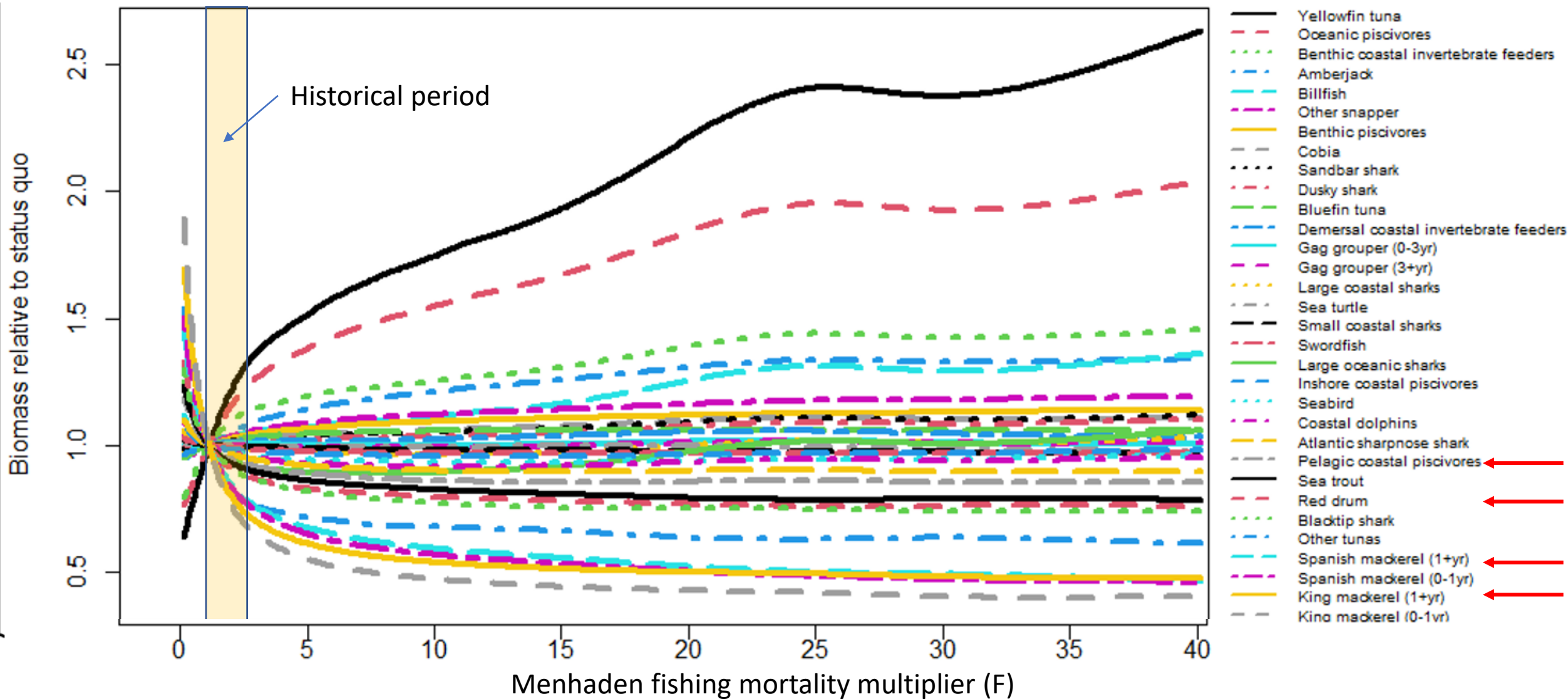
Gulf menhaden– the effect of F on predators



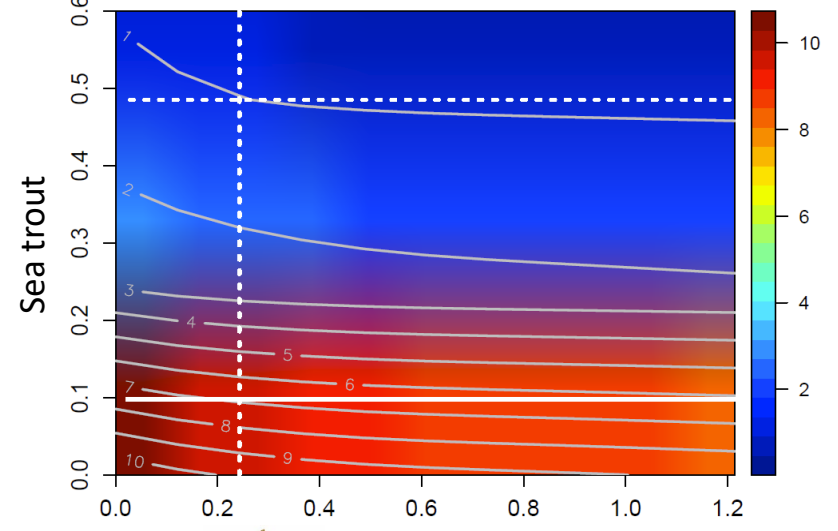
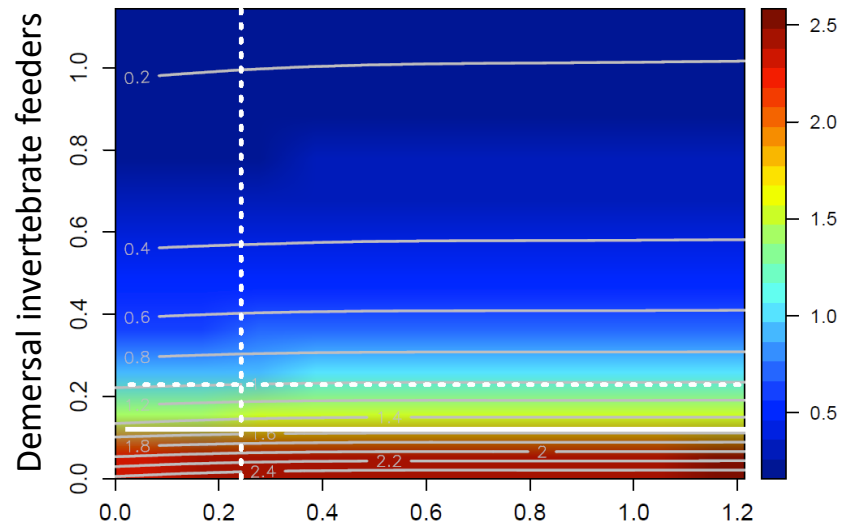
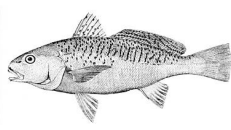
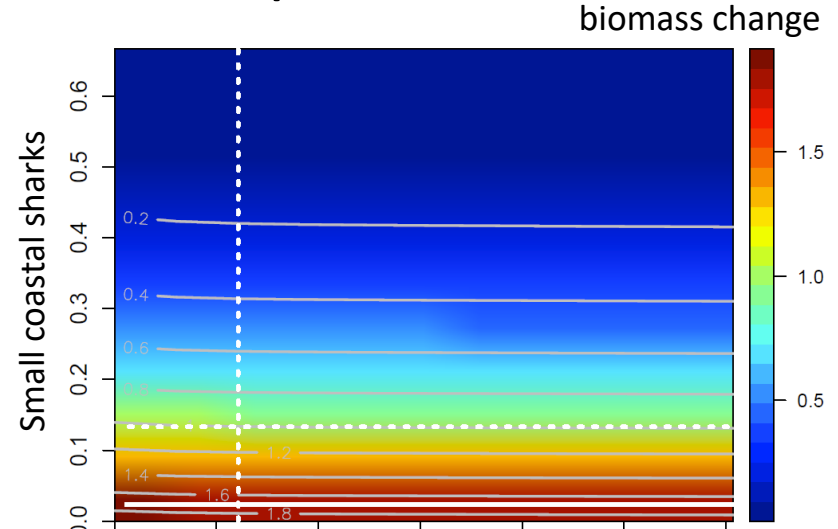
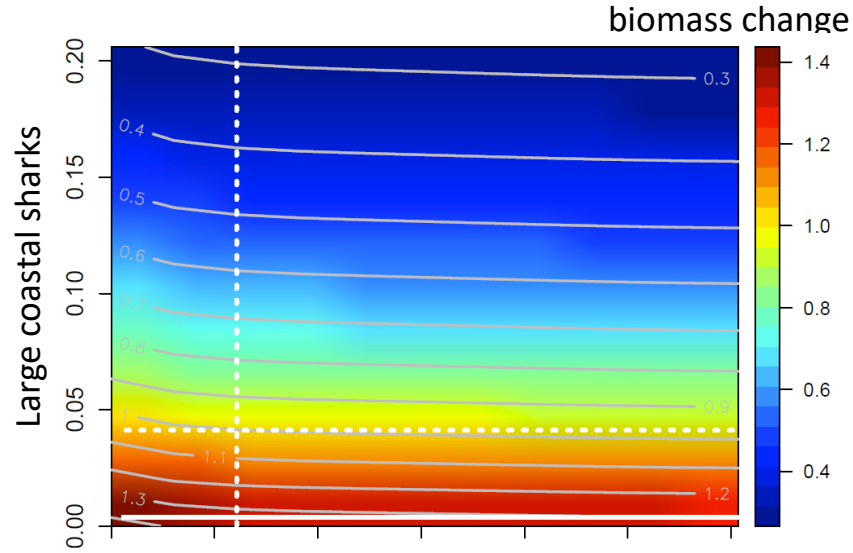
Gulf menhaden– the effect of F & E on predators




Gulf menhaden– the effect of F on predators



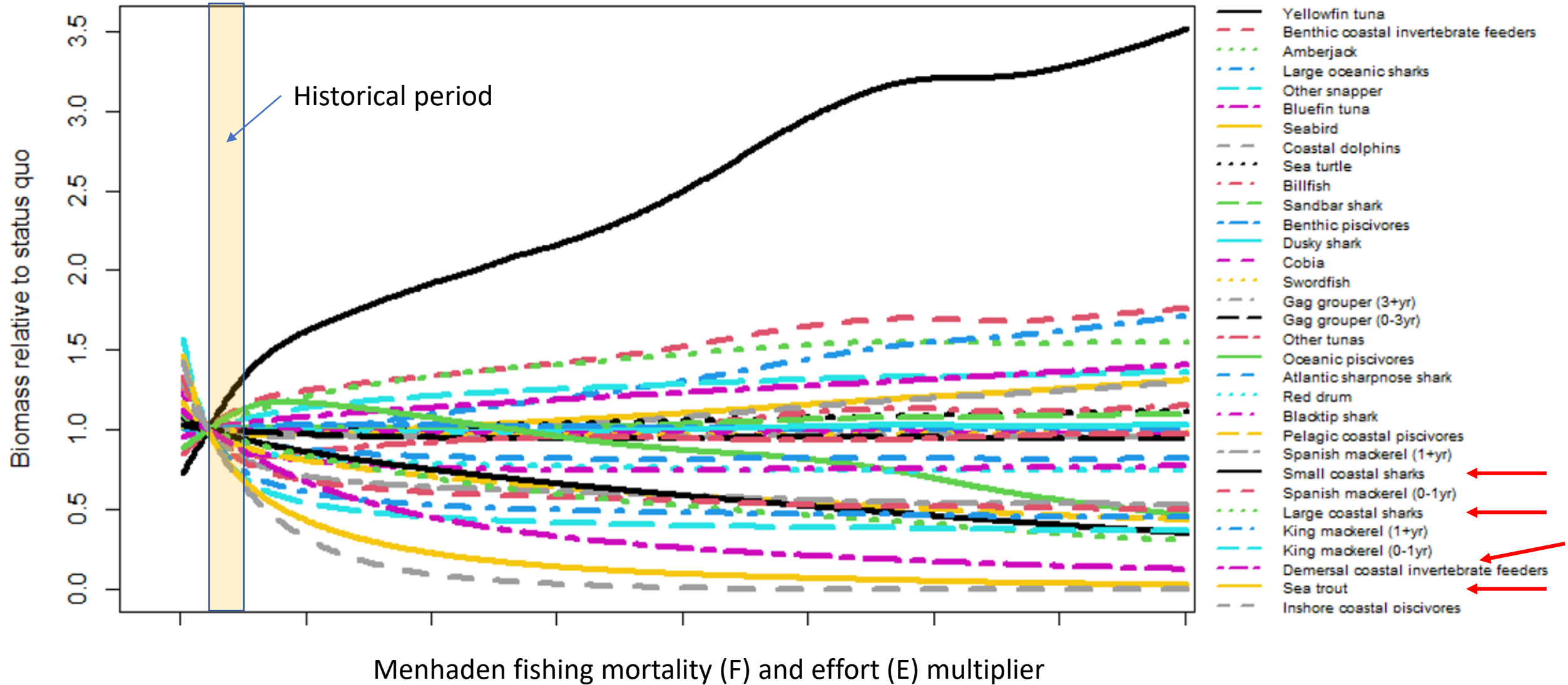
Gulf menhaden– the effect of F on predators



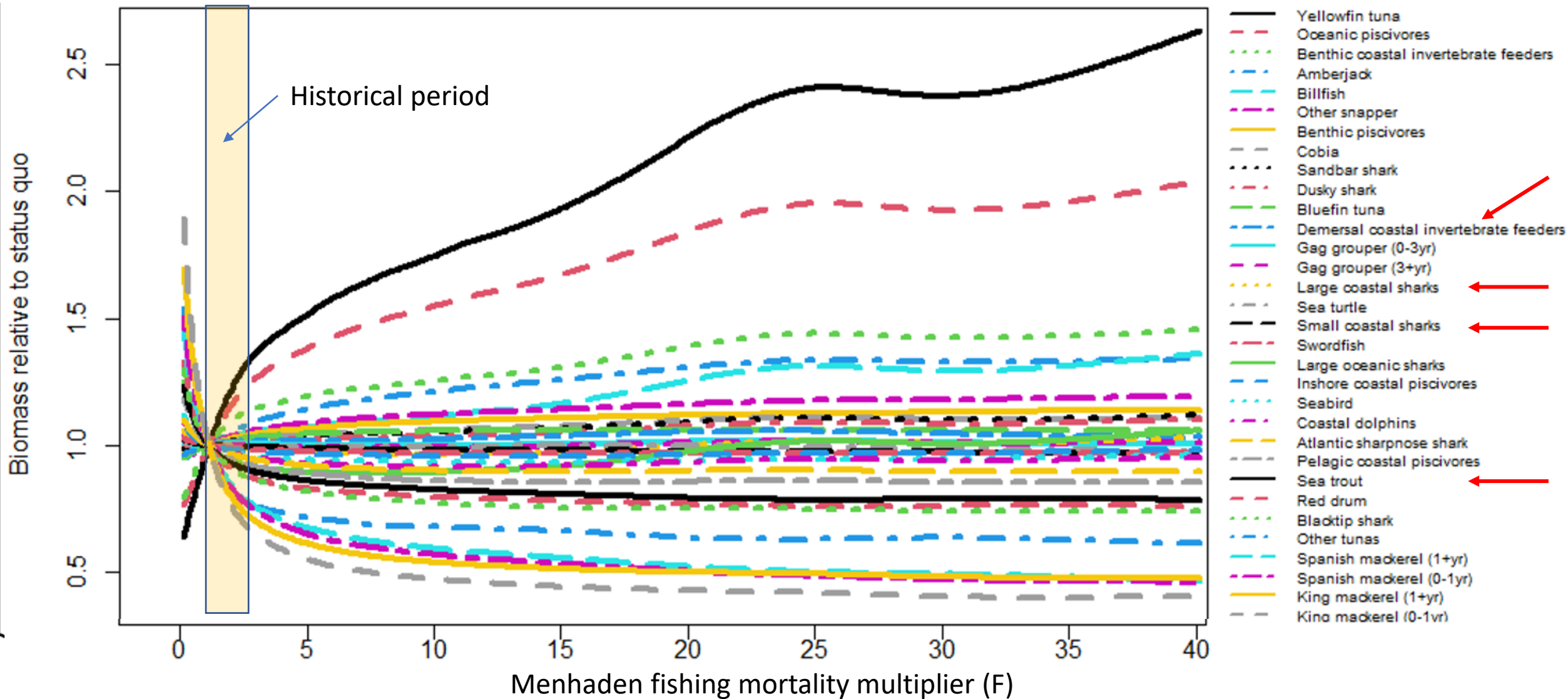
 Menhaden F

 Menhaden F

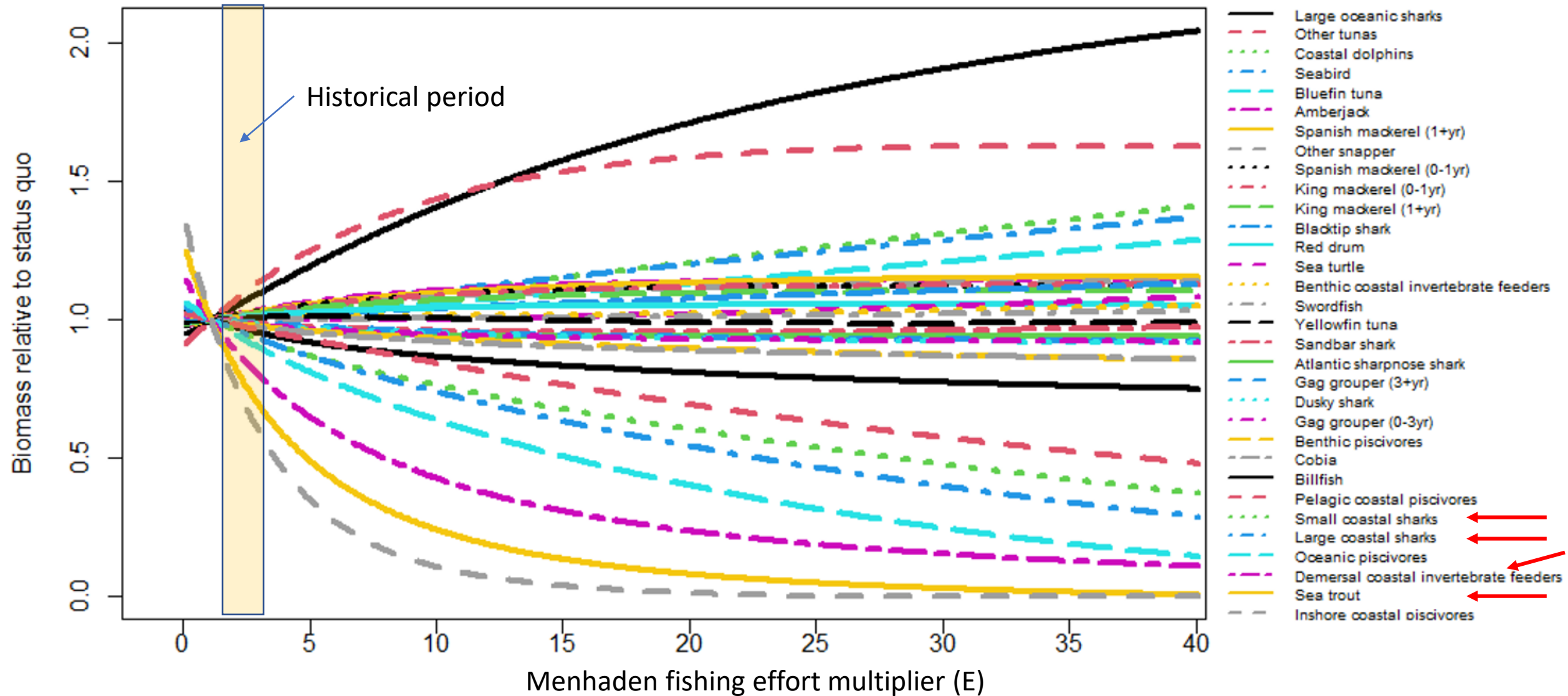
Gulf menhaden– the effect of F & E on predators



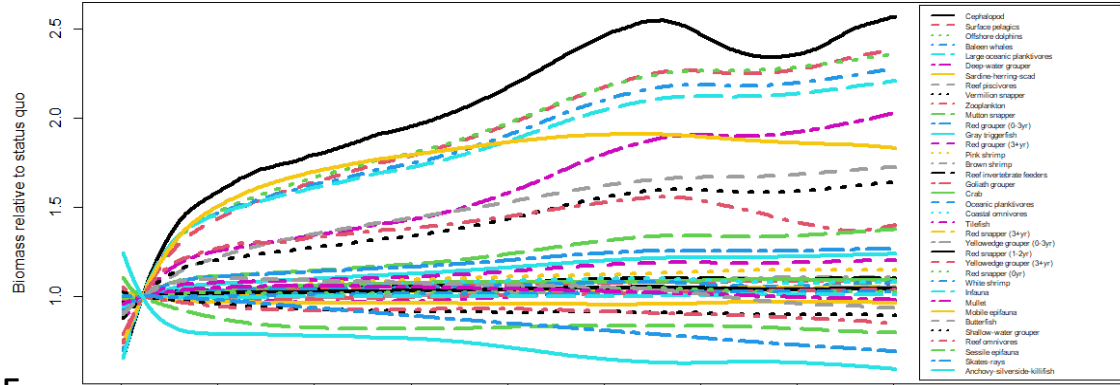
Gulf menhaden– the effect of F on predators



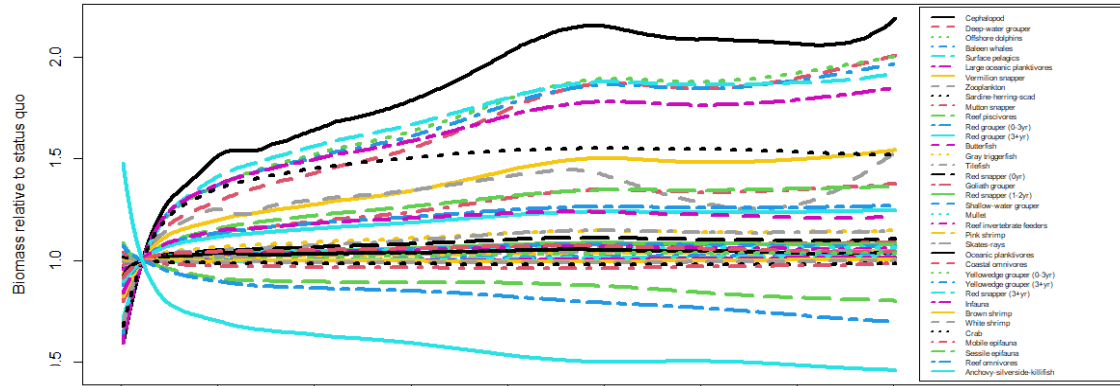
Gulf menhaden– the effect of E on predators



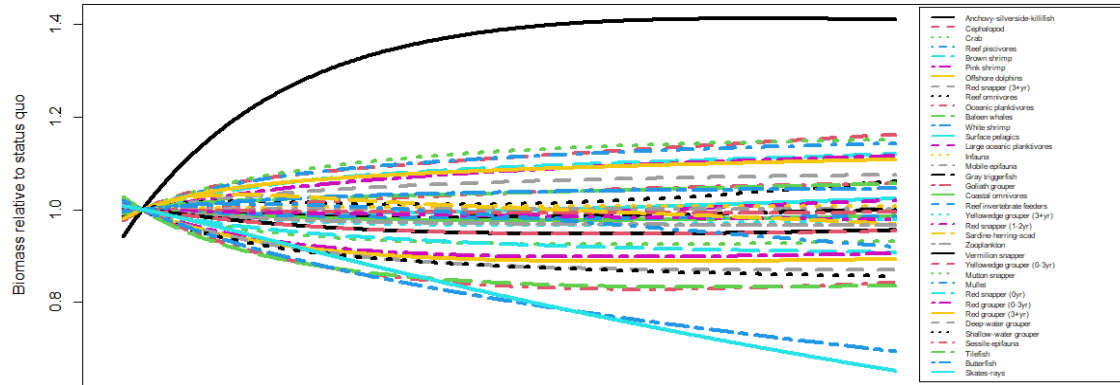
E+F



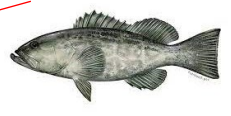
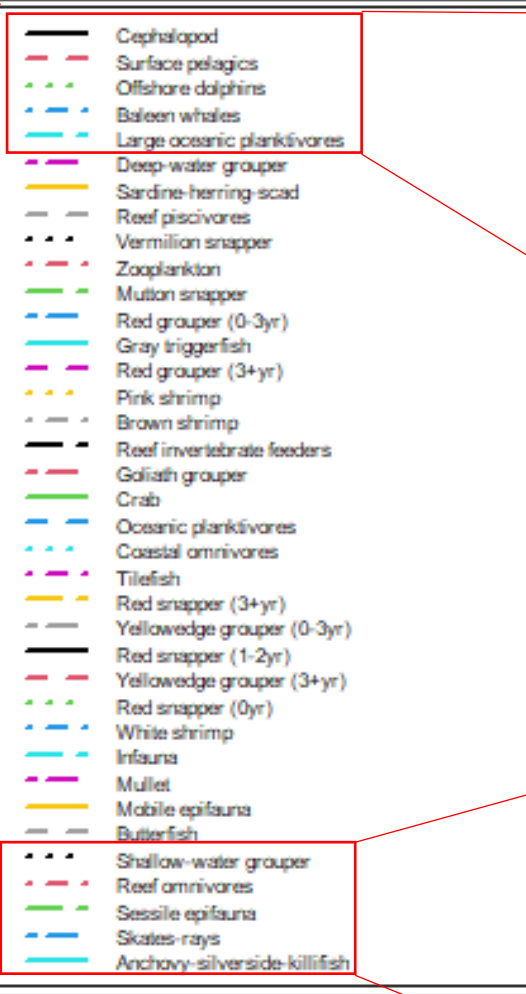
F



E



Gulf menhaden fishing pressure multiplier



Further group-specific investigation

- Creating Ecopath models from Ecosim projections
- Comparing Ecopath models to investigate the mechanism (x1 vs. x40)

Why cephalopods increase when menhaden fishing increase?



Cephalopod predators' biomass (t/km²)

Group	x1	x40
Inshore coastal piscivores	0.105	0.000
King mackerel (1+yr)	0.224	0.087
Sea trout	0.114	0.003
Spanish mackerel (1+yr)	0.108	0.023
Demersal coastal invertebrate feeders	0.302	0.036
Oceanic piscivores	0.035	0.027
Blacktip shark	0.121	0.075
Large coastal sharks	0.040	0.013
Pelagic coastal piscivores	0.075	0.032
Red drum	0.145	0.109
Total	1.267	0.406

Cephalopods' prey biomass (t/km²)

Group	x1	x40
Zooplankton	12.005	17.976
Anchovy-silverside-killifish	1.013	0.561
Mobile epifauna	18.515	17.827
Cephalopod	0.684	1.668
Reef omnivores	0.019	0.035
Sardine-herring-scad	0.411	0.833
Reef invertebrate feeders	0.179	0.194
Demersal coastal invertebrate feeders	0.302	0.036
Total	33.128	39.130

- Food availability and/or bycatch

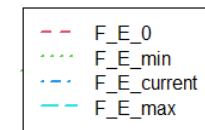
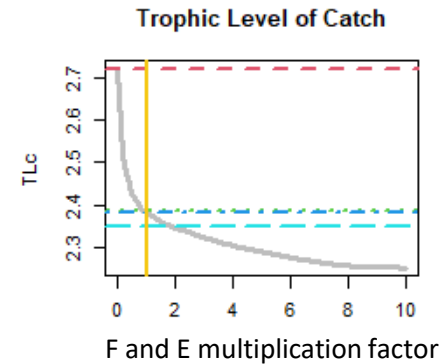
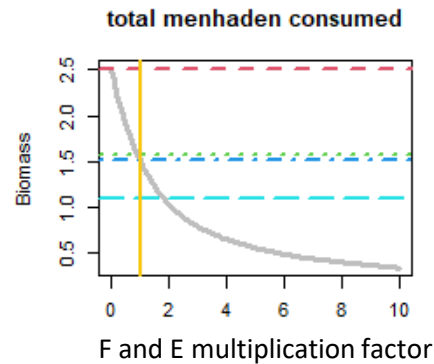
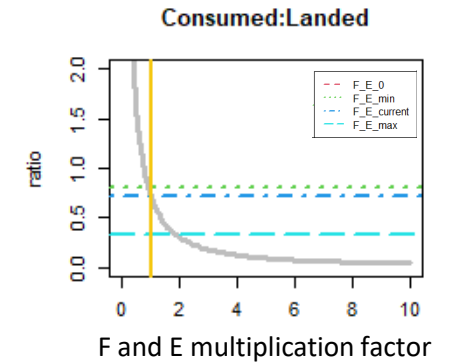
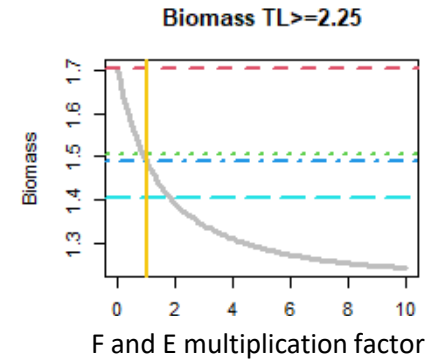
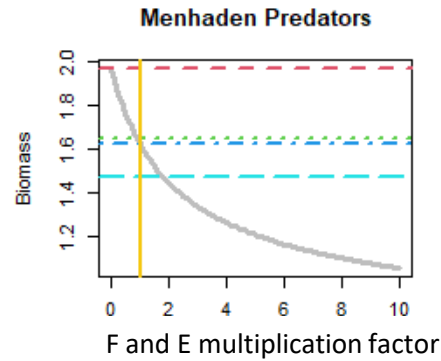


Cephalopod fishing mortality

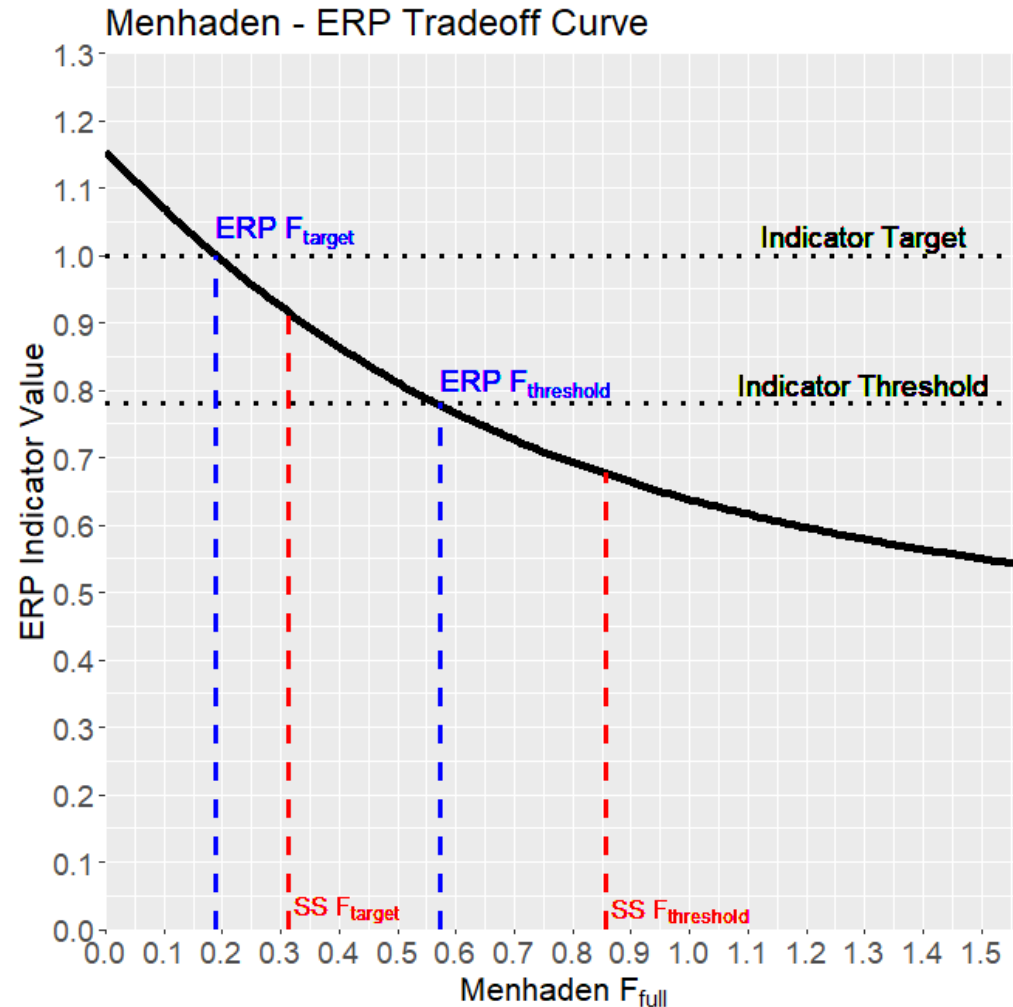
Fleet	x1	x40
Comm_Purse_Menhaden	4.00E-05	0.00160162
Comm_Trawl_Bottom_Other	4.56E-05	4.56E-05
Comm_Trawl_Bottom_Shrimp	4.52E-05	4.52E-05

Ecological indicators

- Gulf menhaden predators
- Biomass (TL>2.25)
- Consumed: landed
- Total menhaden consumed
- Trophic level of the catch



Conceptual Approach to Gulf menhaden Ecological Reference Points (ERPs)



Proposed ERP indicator approach for Gulf menhaden

- Indicator approach adapted from [ERPs for Atlantic menhaden](#)
- Indicators TBD with input from MAC
- Should reflect interests of multiple stakeholder groups

Overview/ Evolution

Introduction



Ecopath + Ecosim (EwE)



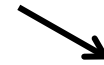
Calibration and diagnostics



Natural mortality (M)



Ecological sensitivity



Ecological indicators



Management implications

Summary

- Main takeaways:
 - Model construction & diagnostics
 - Menhaden fishing tradeoffs
 - Other applications
- Limitations
- Future work + research recommendations



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Acknowledgments

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Dr. Matthew Nuttall

Dr. Kim de Mutsert



Gulf Menhaden Advisory
Committee meeting

Any questions ?



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