

Evaluating Gulf Menhaden Reference Points with Ecosystem Models

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Gulf Menhaden Goals & Recommendations for Ecosystem Considerations

2015 Fishery Management Plan

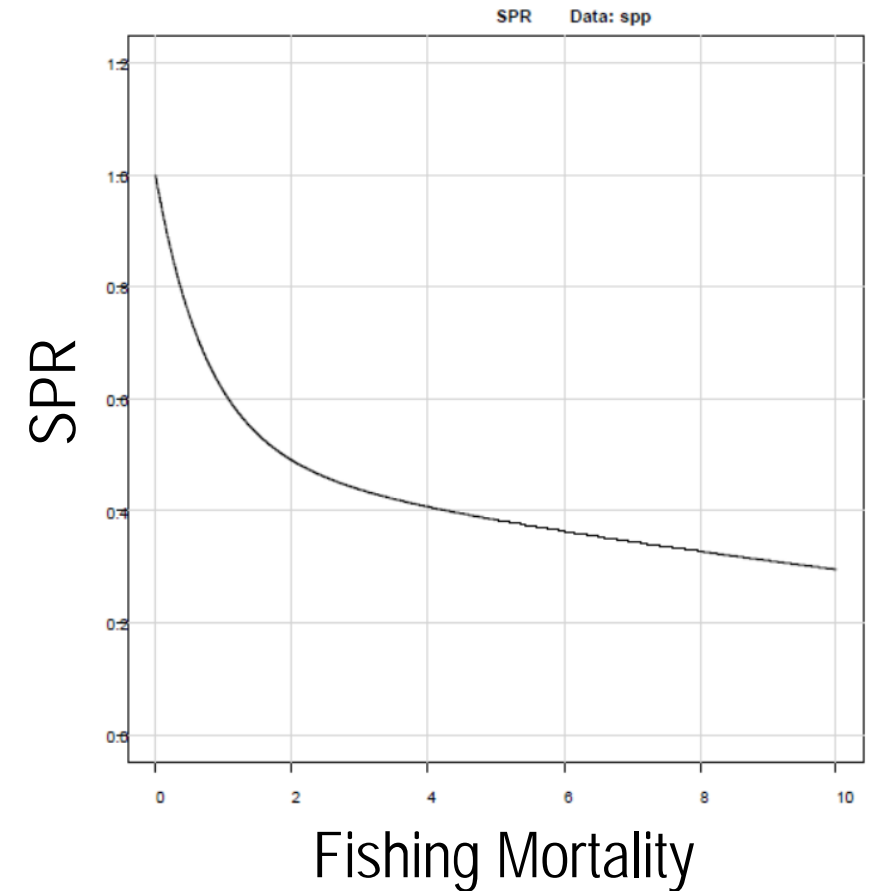
- Goal: Maintain the Gulf menhaden population at a level to [sustain their ecosystem role](#); and, to the extent practicable, maintain economically viable fisheries, with continued support for important social and cultural aspects of the associated fishing communities.

SEDAR 63 Recommendations

- Develop procedures to establish assessment benchmarks (e.g., F or proxies) that account for the [multiple priorities of ecosystem management](#) that could include predation mortality and ecological yield separate from other forms of natural mortality.
- Conduct additional research into [simulation models such as MSVPAs, Ecopath with Ecosim](#), etc.; results could produce better estimates of natural mortality as well as other fishery parameters.
- MAC discuss the goals and objectives for fishery management for Gulf Menhaden and recommend alternative reference points based on management needs

SEDAR 63 – 2018 Benchmark Assessment

- The quantities F_{MSY} , SSB_{MSY} , B_{MSY} , and MSY were inestimable and biologically implausible
- The assessment panel suggested the following benchmarks:
 - $F_{\text{threshold}} = M$
 - $F_{\text{target}} = 0.75M$
 - $SSB_{\text{threshold}} = 25\%$ equilibrium unfished SSB
 - $SSB_{\text{target}} = 50\%$ equilibrium unfished SSB
- Equilibrium landings associated with the fishing mortality rate threshold and target are 717,000 mt and 623,000 mt, respectively.



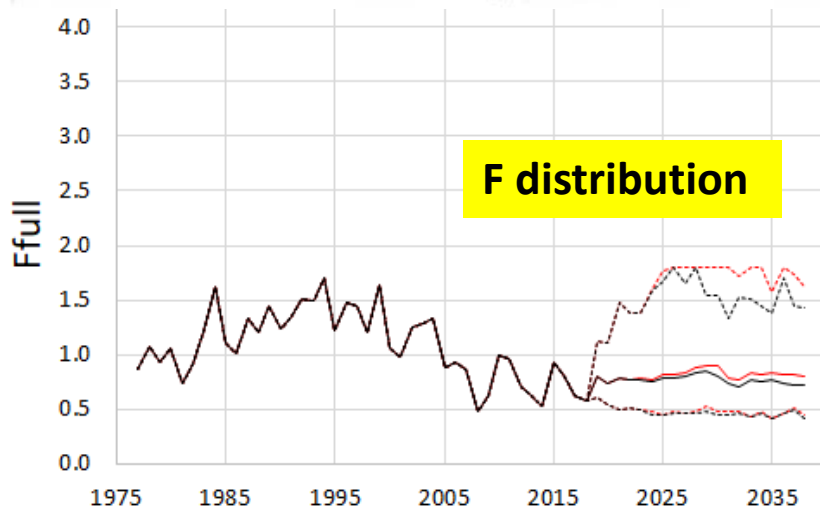
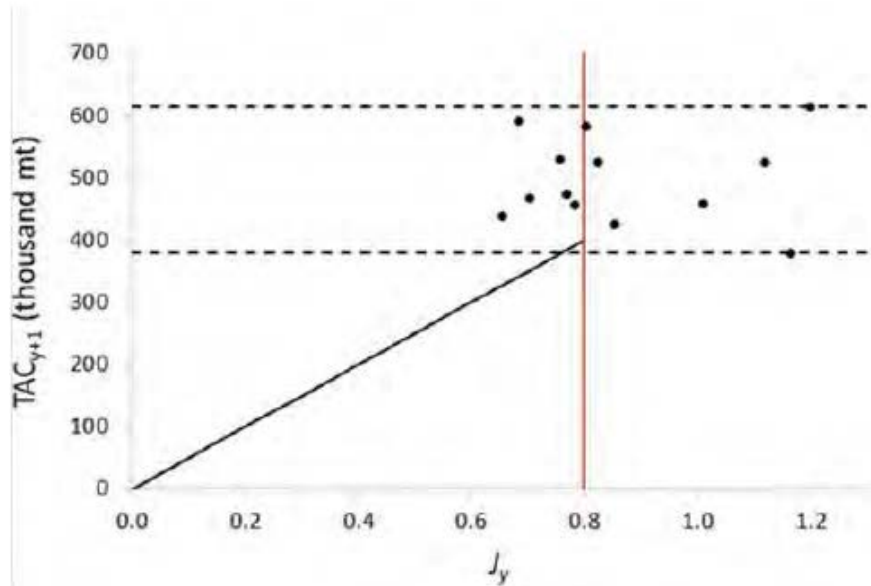
SEDAR 63 – 2018 Benchmark Assessment

SEDAR 63 Benchmark Options

Benchmarks	Estimate
R0	116.5
MSY	inf
$F_{2015-2017}$	0.78
$F_{30\%}$	>10
$F_{35\%}$	>10
$F_{F=M}$	1.32
$F_{F=0.75M}$	0.99
$F_{25\%SSB0}$	>10
$F_{50\%SSB0}$	4.71

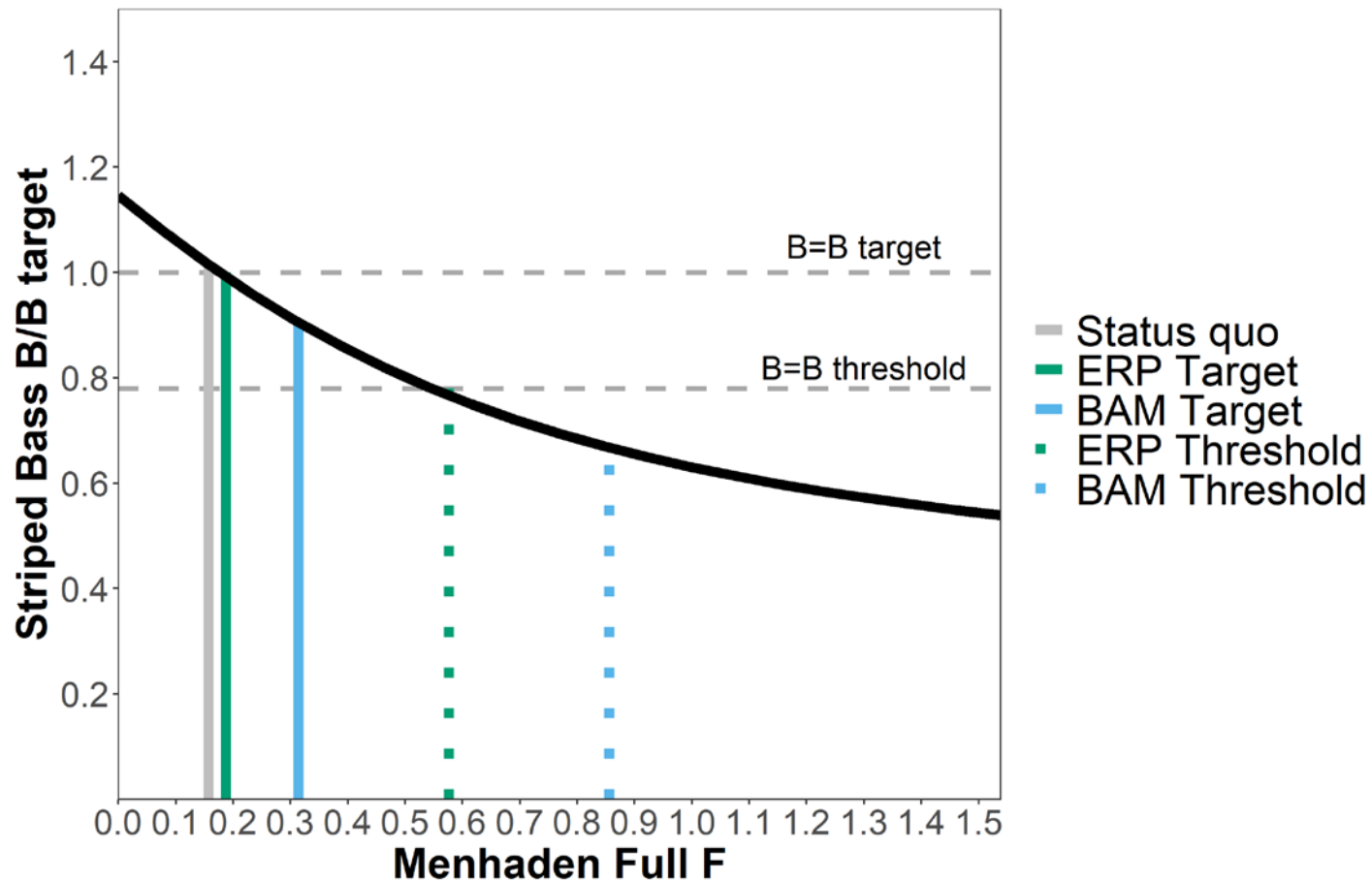
Benchmarks	Estimate
$SSB_{2015-2017}$	3,522,173
$SSB_{30\%}$	<2,074,992
$SSB_{35\%}$	<2,074,992
$SSB_{25\%SSB0}$	1,244,281
$SSB_{50\%SSB0}$	2,488,562
$SSB @ F_{F=M}$	3,212,045
$SSB @ F_{F=0.75M}$	3,408,847
$Y_{F=M}$	717,000
$Y_{F=0.75M}$	623,000

MSE Harvest Control Rule (Butterworth & Rademeyer)



- TAC is proportional to abundance, determined by a combined seine and gillnet index
- No TAC implemented when biomass is above J_y threshold of 0.8
- The dashed lines show the 2000-2017 minimum and maximum landing values used in simulation.
- Base MSE run resulted in F_{full} of appx. **0.5-1.5** (10-90 %tile)

Conceptual Approach to Gulf menhaden Ecological Reference Points (ERP)

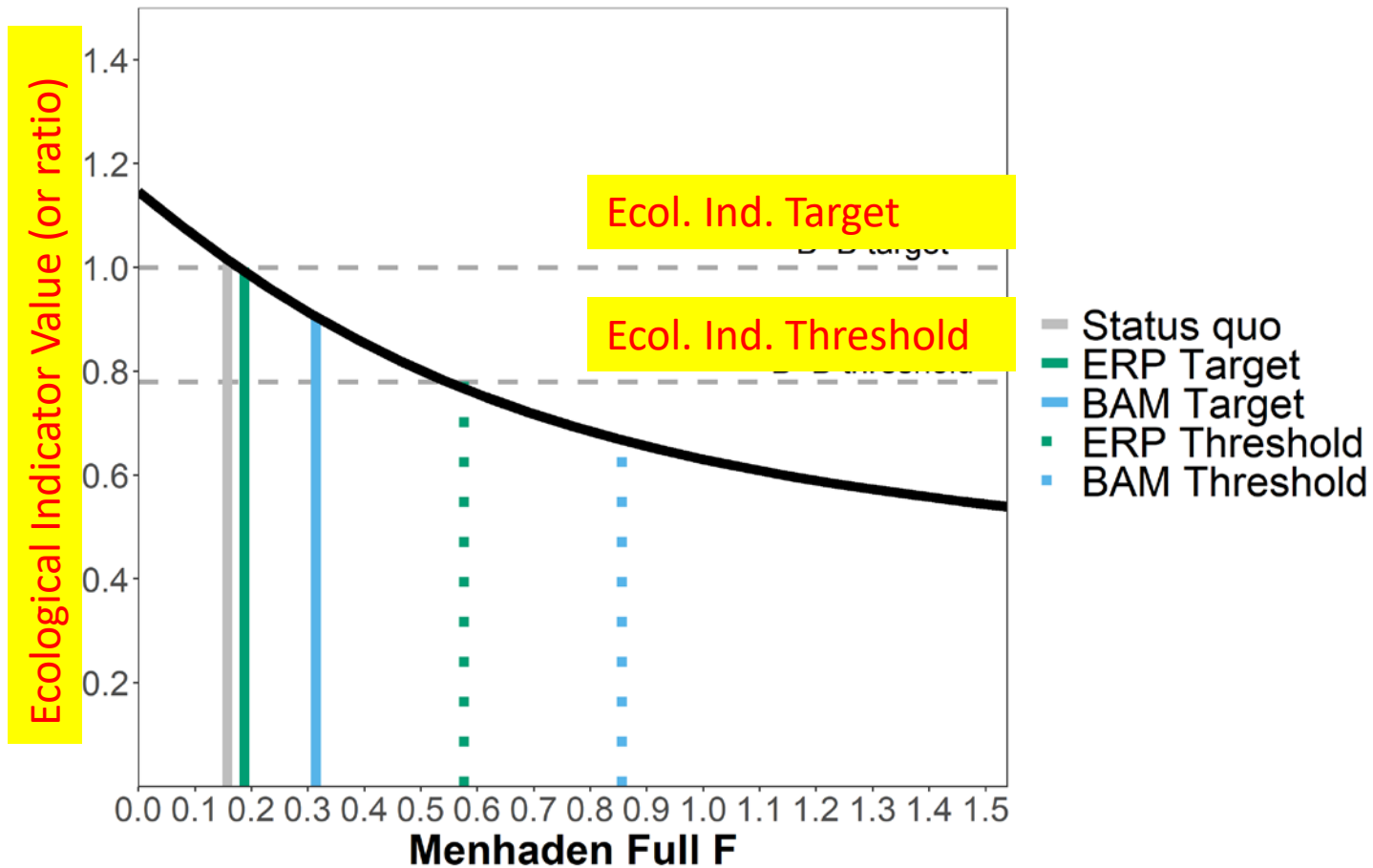


AM Ecological Reference Points

To establish reference points for Atlantic menhaden that take into account their role as a forage fish.

- **ERP target:** maximum F on menhaden that sustains striped bass at their B target when striped bass are fished at their F target
- **ERP threshold:** maximum F on menhaden that keeps striped bass at their B threshold when striped bass are fished at their F target

Conceptual Approach to Gulf menhaden Ecological Reference Points (ERP)

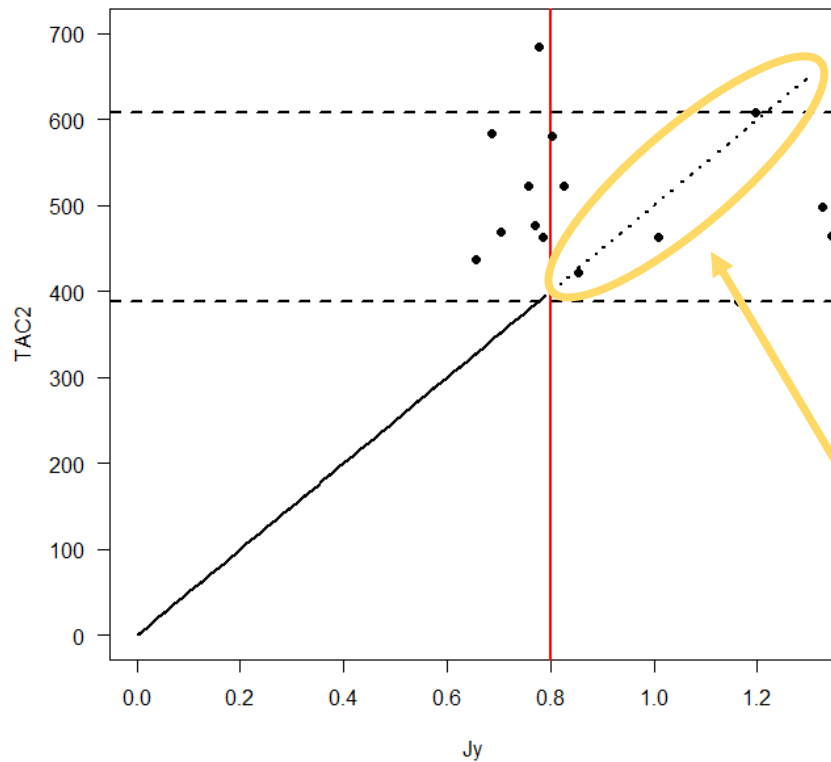


Proposed ERP indicator approach for Gulf menhaden

- Indicators TBD with input from MAC
- Should reflect interests of multiple stakeholder groups

Gulf Menhaden –Indicators from Ecosim HCR

Fixed exploitation rate HCR



- TAC is proportional to abundance (J_y)
- Convert J_y to Ecosim biomass-at-age, and calculate fixed exploitation rate for each age stanza

$$\hat{q}_y = J_y / \hat{v}B_y \qquad \hat{v}B_{J_y} = J_y / \hat{q}_y$$

$$U_{J_y} = TAC_{J_y} / \hat{v}B_{J_y} \quad \mathbf{F}_{full} \qquad U_{J_y,a} = U_{J_y} \cdot S_a$$

Age	1	2	3	4
Fixed U_a	0.15	1.03	0.90	0.90

- But, Ecosim cannot implement HCR threshold (i.e. TAC will always be proportional to B)
- Observation error & recruitment variability are also included in Ecosim HCR
- Generate distribution of indicators values

Ecological Indicators

Types of Indicators
<p>1) Ecosystem Structure</p> <ul style="list-style-type: none"> • Diversity • Aggregate biomass indices • Mean trophic level
<p>2) Trophic Utilization</p> <ul style="list-style-type: none"> • Primary Production Required to support fisheries • Trophic transfer efficiency • Energy cycling • Consumption ratios
<p>3) Ecosystem resilience</p> <ul style="list-style-type: none"> • Ecological network analysis • Ascendancy • Capacity

Indicator Selection Criteria	Importance		
	Technical Experts	Managers	Public
1) Concreteness - <i>based on reality</i>	1	2.5	3
2) Theoretical basis – <i>broad scientific support</i>	3	1	2
3) Public awareness – <i>communicable & of broad interest</i>	1	2	3
4) Cost – <i>requires tools/surveys that are available</i>	1	3	2
5) Measurement – <i>variance, bias, accuracy</i>	3	1	1
6) Historical context – <i>interpretation and ref points</i>	3	2	2
7) Sensitivity – <i>responds to fishing</i>	3	2	2
8) Responsiveness – <i>changes within 1-3 years</i>	2	3	1
9) Specificity – <i>disentangle fishing from other effects</i>	2	3	1.5

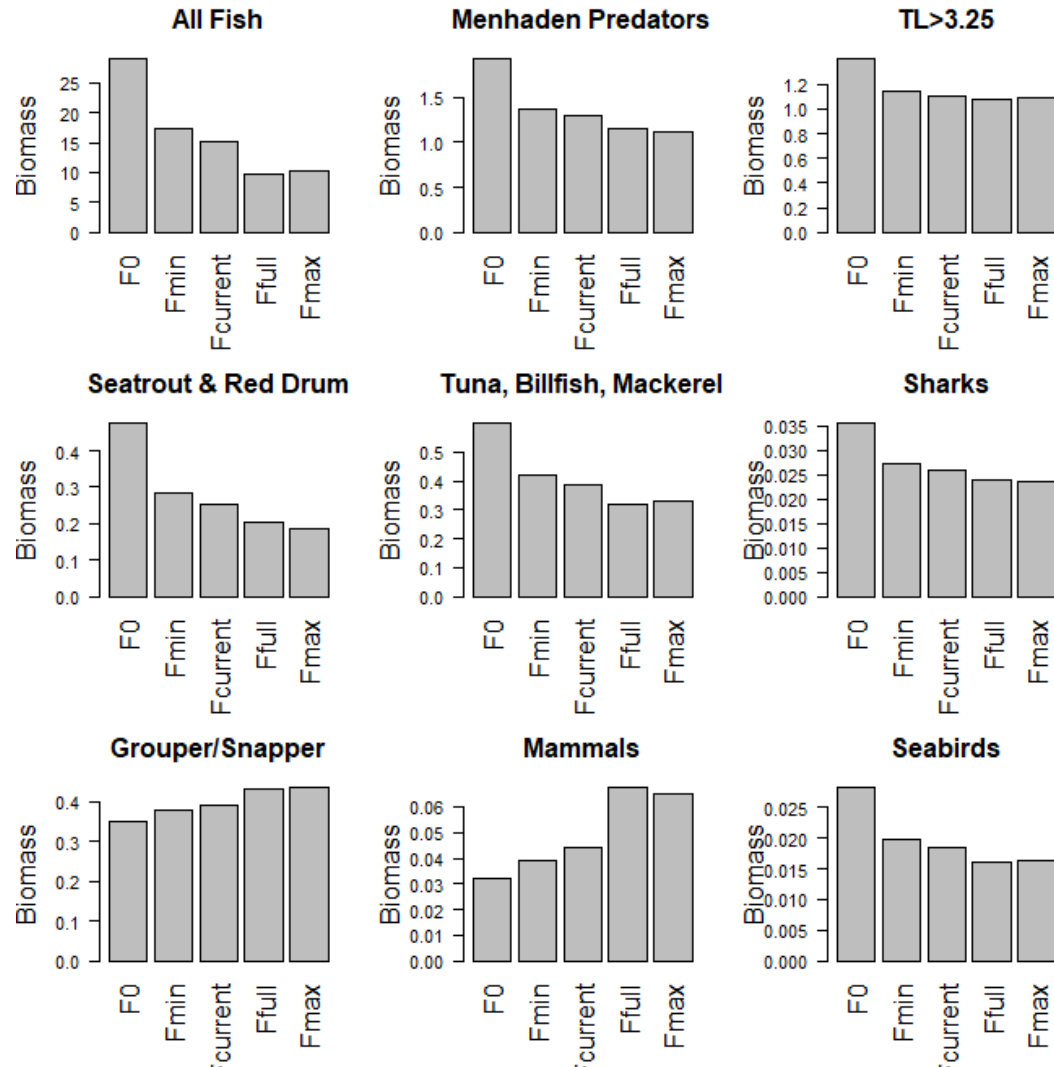
Minor	Minor/Mod	Moderate	Mod/High	High
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Rice, J. C., & Rochet, M. J. (2005). A framework for selecting a suite of indicators for fisheries management. ICES Journal of Marine Science, 62(3), 516-527.

Gulf menhaden – Proposed Indicators

- Calculated with the Gulfwide and NGOMEX models to capture effects on different suite of species
- Indicators represent the equilibrium value after 20 year projection of menhaden F rate
 - F_{\min} and F_{\max} are observed max and min F rates, by age, over the calibration time period (1980-2017)
 - Additional runs will explore full range of F values to generate tradeoff plots
 - Alternative scenarios for nutrient loading and predator harvest rates
- These indicators are not intended to be tracked over time, but rather to evaluate long-term (equilibrium) ecosystem impacts of proposed menhaden reference points

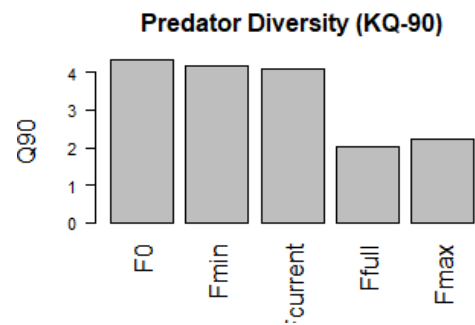
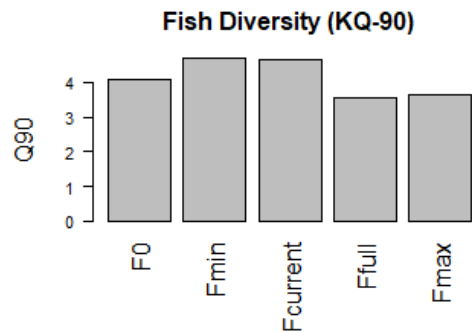
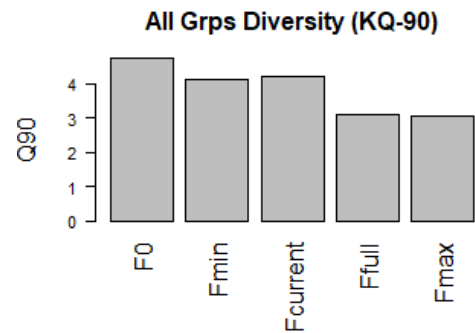
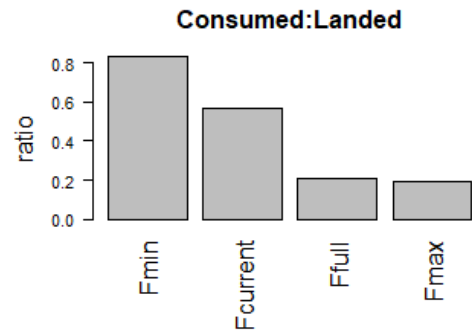
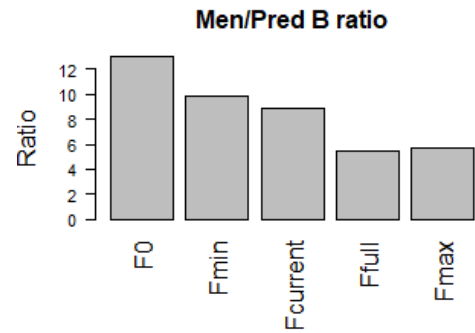
Gulf menhaden – Proposed Indicators



Aggregate Biomass Indicators

- All fish
- All menhaden predators
- Upper trophic levels
- Seatrout & Red Drum
- Tuna, Billfish, Mackerel
- Sharks
- Grouper/Snapper
- Mammals
- Seabirds

Gulf menhaden – Proposed Indicators



Trophic Utilization Indicators

- Menhaden Consumed:Menhaden Landed
- Primary Production Required (PPR)

Ecosystem Structure Indicators

- Predator/Prey biomass ratios
 - Prey biomass should be roughly 10X higher than predator¹
- Kempton's Q90 diversity index
 - Exclusion threshold = 0.9
 - Groups removed from diversity calculation if biomass drops below *Ecopath* by 10%
 - Higher thresholds are more sensitive to fishing

¹Hatton, Ian A., et al. 2015. The predator-prey power law: Biomass scaling across terrestrial and aquatic biomes. *Science* 349.

Questions for Discussion

- Will the MAC be making future recommendations on reference points?
- Are the proposed indicators useful and easy to understand?
- Are there additional indicators to consider?
- What are the key sensitivities/uncertainties to evaluate?
- Is the Ecosim HCR implementation close enough to proceed?