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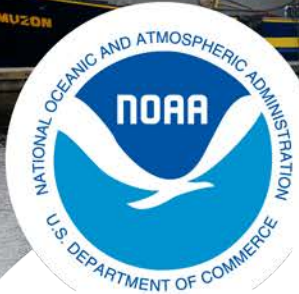
# Evaluation of the Effects of Alternative SPR Proxies on Gulf of Mexico Red Snapper ABCs and OFLs

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Gulf of Mexico SSC  
May 20, 2015  
New Orleans, LA

# Outline



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- Discussion of MSY concepts and proxies
- Requested work
  - Methods
  - ABCs and OFLs
- Summary



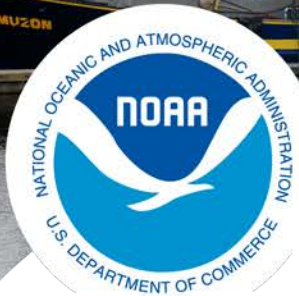
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# MSY Concepts



# MSY

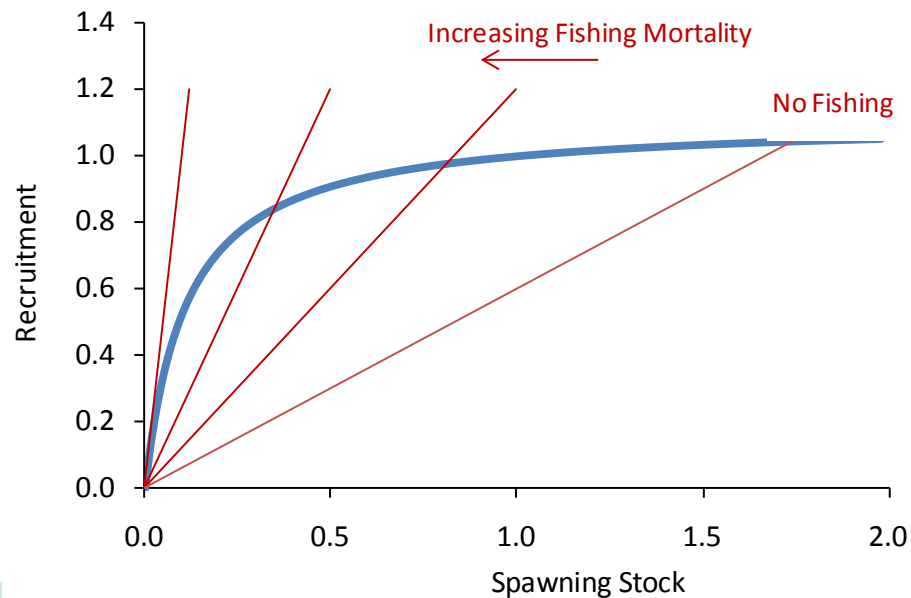


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- Depends on growth, natural mortality and the relationship between spawners and recruits
- Achieved when fishing is begun at an optimal age that balances production (growth, recruitment) with losses owing to natural mortality
- Achieving such "knife-edge" selection is often difficult in practice





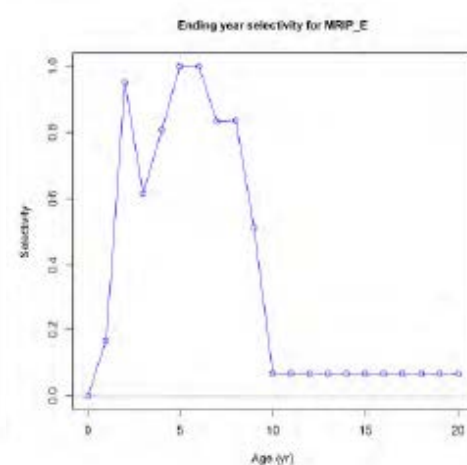
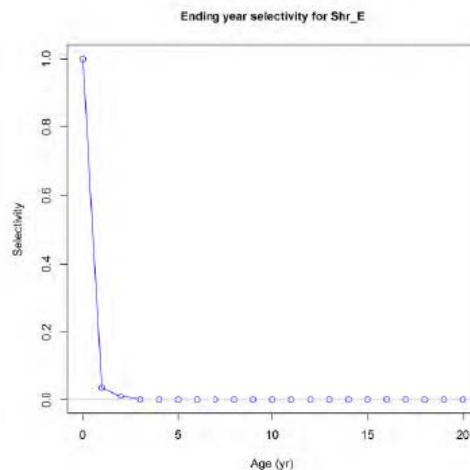
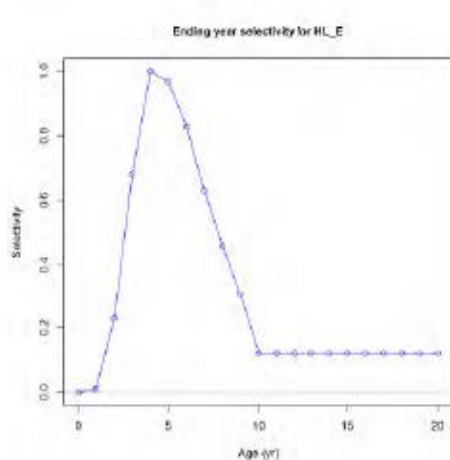


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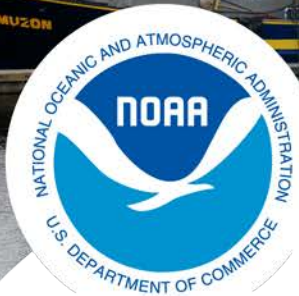
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# MSY for Red Snapper

- Determining MSY for red snapper is problematic because the stock-recruit function is not well-defined
- Several proxies for MSY have been proposed and much confusion has arisen largely because various fisheries that catch red snapper have inherently different selectivities
  - Yield Per Recruit (YPR)
  - Spawning Potential Ratio (SPR)



# YPR Proxies

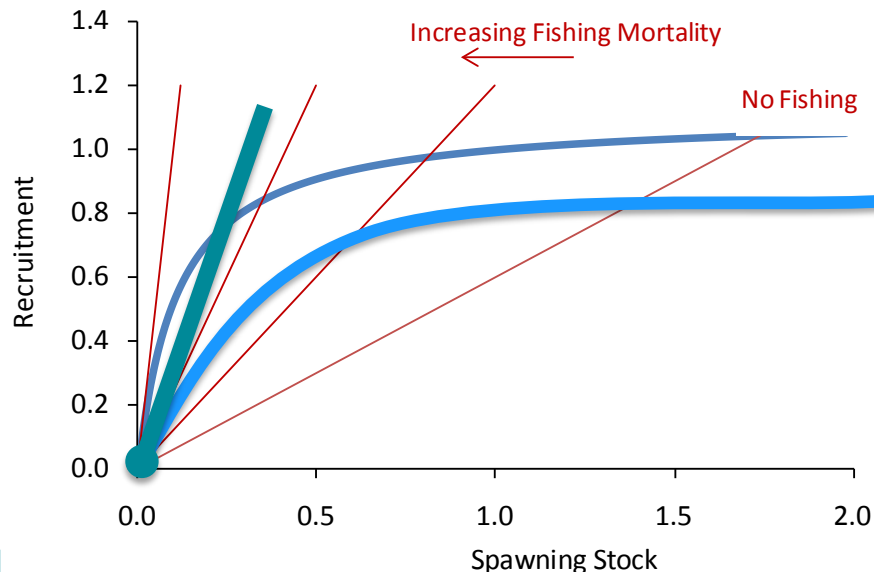


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- Maximum yield-per-recruit ( $YPR_{MAX}$ )
  - Maximizes yield from an 'average' fish at the time of capture
    - Optimal age at first capture balances gains in growth with losses due to natural mortality
    - Does not account for the relationship between spawners and recruits
- Policy based on maximum YPR will not produce the same yield as MSY unless recruits are truly independent of SSB
  - Can cause recruitment overfishing if S-R relationship does exist (i.e., if yield levels do not allow replacement)



# YPR Proxies

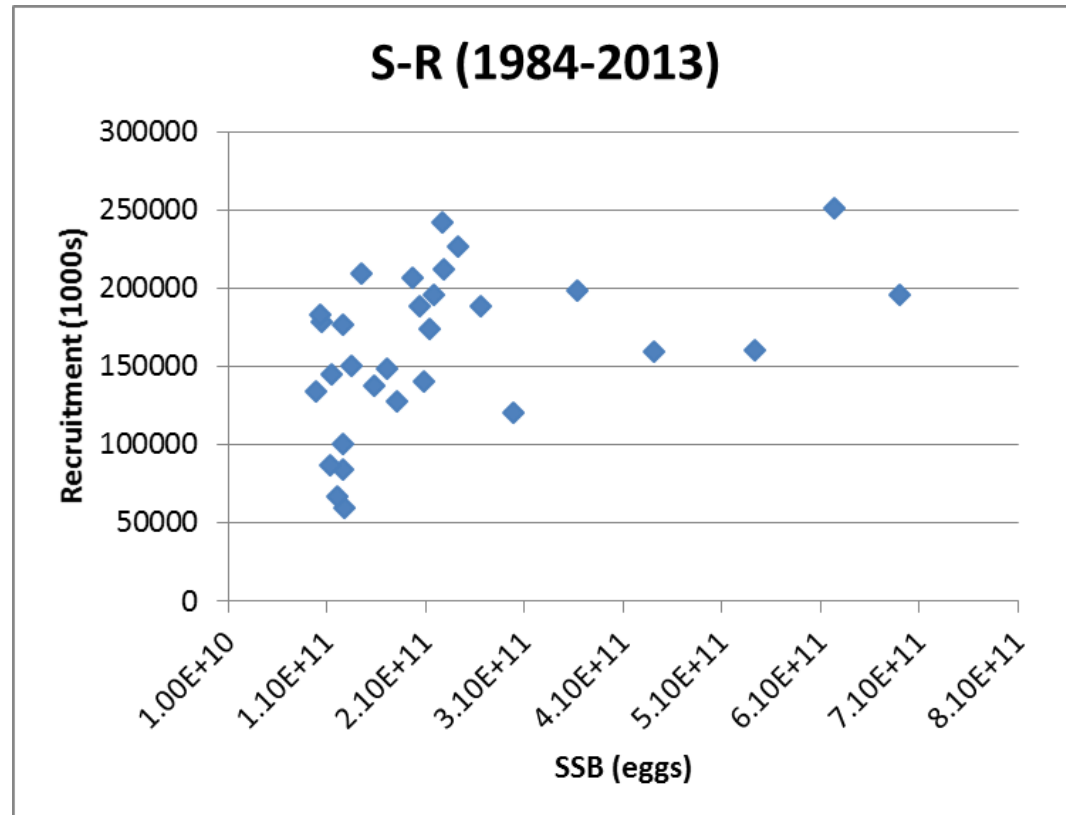


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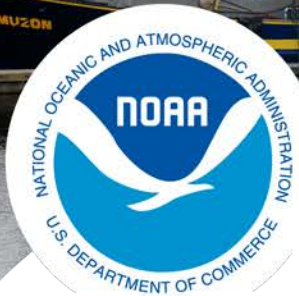
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- Considered for red snapper because there is no clear relationship between recruits and spawners
  - At some level it must exist (no parents = no offspring)



# SPR Proxies

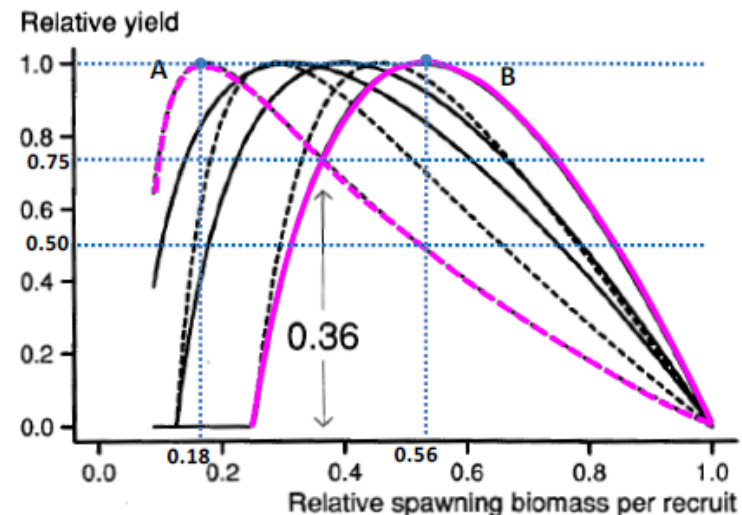


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- Spawning Potential Ratio (SPR) proxies
  - Based on life history (yield is not an explicit consideration)
  - Like YPR, does not account for a spawner-recruit relationship
  - Does not presume a prespecified selectivity pattern
  - Goal is to maintain spawning stock within safe biological limits based on meta-analysis of species with similar life histories
  - Typical values range from 20-60% of virgin SPR depending on the longevity of the species, natural mortality, and other important life history characteristics (Clark, 1993)
    - Typically achieve ~75% of MSY regardless of true stock-recruit relationship if biomass retained in this range







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# An Added Complication: Conditional MSY and YPR

- Management often chooses not to pursue a true MSY policy
  - Allow suboptimal selection patterns and bycatch from other fisheries (conditional yields)
  - The conditional MSY based on extant or prescribed selection patterns and bycatch levels tends to result in lower SSB and SPR than true MSY
  - Conditional maximum YPR tends to lead to *still lower* SSB and SPR

$$SSB_{MSY} \geq SSB_{MSY_{Conditional}} \geq SSB_{MaxYPR_{Conditional}}$$

- With conditional proxies SSB may decrease even though total landings have decreased
  - Depending on bycatch and discard rates total biomass killed can increase despite a decrease in directed fishing mortality



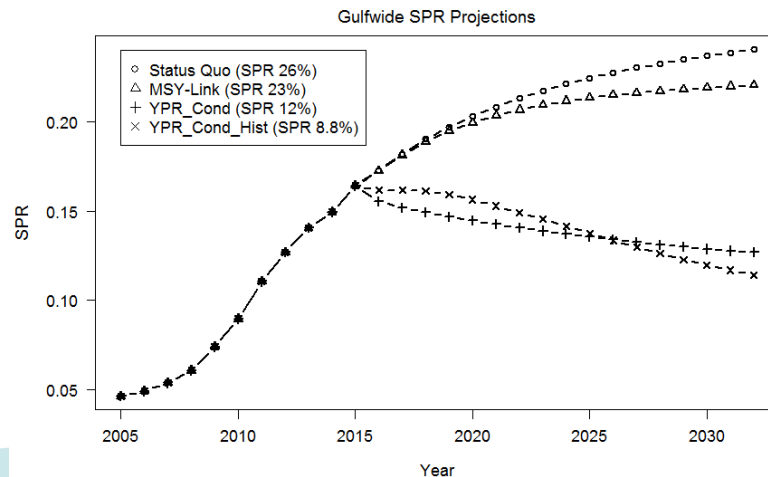
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# Maximum Conditional YPR

- A poor proxy for MSY
  - Treats bycatch and discards as an additional source of natural mortality
  - Directed yield is maximized AFTER bycatch/discard mortality has occurred (i.e., bycatch is not accounted for in the search for optimal total fishing mortality)
  - Assuming recruitment will stay constant even at extremely low SSB
  - As bycatch mortality increases, the resulting SPR tends to decrease
  - Often results in very low SPR



# SEDAR 7 proposition



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- MSY is hard to attain in practice because it is difficult to fish in a way that only removes the “optimal” age classes
- However, the spawning stock that supports the MSY ( $SSB_{MSY}$ ) can be achieved regardless of which age classes are removed (by adjusting the landings and bycatch appropriately)
- SEDAR 7 proposed way to compute OFL:
  - Assume fishing mortality rates from shrimp bycatch and closed season discarding will remain at recent levels (or levels prescribed by regulations)
  - Set OFL for directed fleets equal to the level that will achieve  $SSB_{MSY}$  (*not*  $SSB$  at conditional MSY)





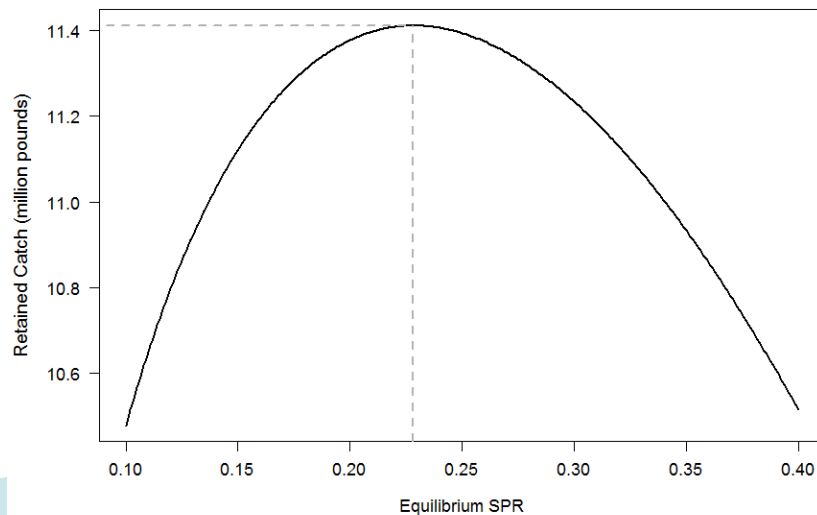
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# SEDAR 7: MSY-Linked

- Proposed by SEDAR 7 because the software available at the time could not compute the true MSY
  - Maximizes yield assuming all fleets (directed and bycatch) are equally scalable (i.e.,  $F$ s for each fleet are 'linked' in that they are increased or decreased by the same proportion)
  - Provides a better proxy for  $SSB_{MSY}$  than the  $SSB$  corresponding to an MSY conditioned on fixed levels of bycatch
  - The SPR corresponding to MSY-linked was 26% for SEDAR 7 (23% now)
  - Not practical because need to scale bycatch  $F$  in same proportion as directed  $F$





# Take-home Points



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- Unknown stock-recruit relationship
  - MSY indeterminable
- Can't enforce optimal selectivity
  - MSY impractical
- Maximum YPR can lead to overfishing if constant recruitment assumption violated
- SPR maintains biomass, but does not maximize yield
  - Maximum YPR is not an SPR proxy analysis
- Conditional YPR treats bycatch as additional  $M$ 
  - Even if bycatch is reduced to extent possible, it should not be treated as an inherent mortality source
- MSY-linked assumes all fisheries scalable
- Alternate proxy: SSB/SPR resulting from true MSY/Max YPR



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# Projection Methods



# Requested Work



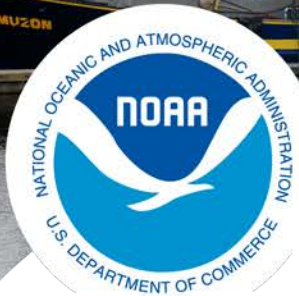
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- Determine assortment of MSY proxies based on spawning potential ratio ( $X\% \text{ SPR} = \text{SSBR} / \text{SSBR}_0$ ):
  - 40% SPR
  - 30% SPR
  - 26% SPR (Status Quo)
  - 24% SPR
  - 22% SPR
  - 20% SPR
  - SPR that maximizes ABC and OFL
- For each SPR proxy determine:
  - OFL
  - ABC
  - $\text{SSB}_{\text{Proxy}}$ ,  $F_{\text{proxy}}$ , and MSST
  - Time to reach  $\text{SSB}_{\text{Proxy}}$  and MSST (with and without fishing)
  - Optimum Yield (OY) where  $F_{\text{Direct}} = 0.75 * F_{\text{SPRtargetDirect}}$



# Methods



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- Based on 2014 update of SEDAR 31 assessment
- Projections performed with Stock Synthesis (SS)
- 60 year (2015-2074) forecast
- 8 directed fleets (each with an east and west component):
  - Commercial handline, commercial longline, recreational private (MRFSS/MRIP), and recreational headboat
- 6 bycatch fleets (each with an east and west component):
  - Shrimp, commercial without IFQ, and recreational closed season





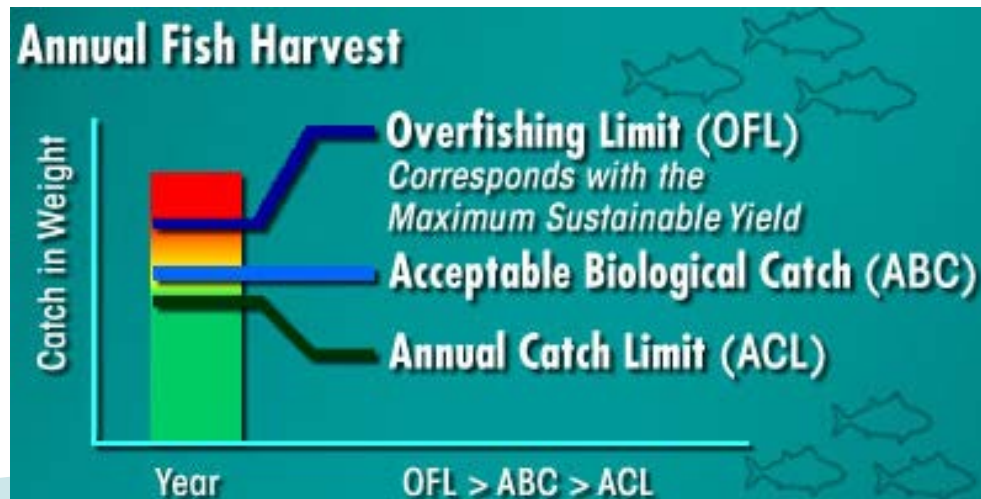
# Methods



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- OFL (millions of pounds whole weight): median yearly retained yield based on the  $F_{\text{Proxy}}$  that achieves the SPR target in equilibrium
- ABC (millions of pounds whole weight): 42.7<sup>th</sup> percentile ( $P^*$ ) of retained yield based on a  $F_{\text{Rebuild}}$  that achieves the SPR target in the terminal year (2032)
  - Less conservative SPR targets require a more stringent rebuilding date (2026)



# Assumptions



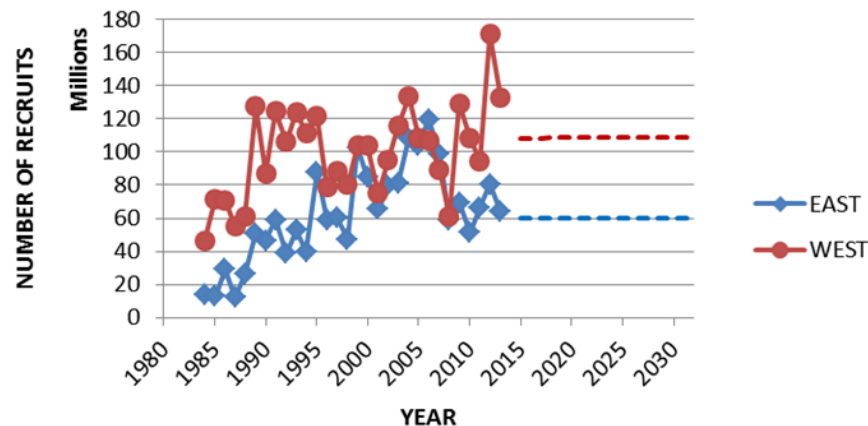
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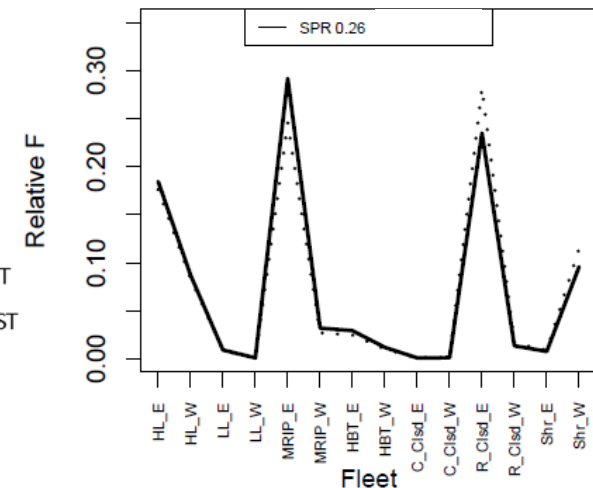
- 51% commercial, 49% recreational landings allocation
- Constant average recruitment (1984-2013)
- Selectivity, discarding, and retention constant (2011-2013)
- Relative fishing mortality by fleet in constant proportion (2011-2013)
- Shrimp bycatch and closed season discards constant at 2013 rates



**Age-0 Recruitment by Region**



**Relative F by Fleet at Equilibrium (F/Total F)**





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# Results: MSY Proxies





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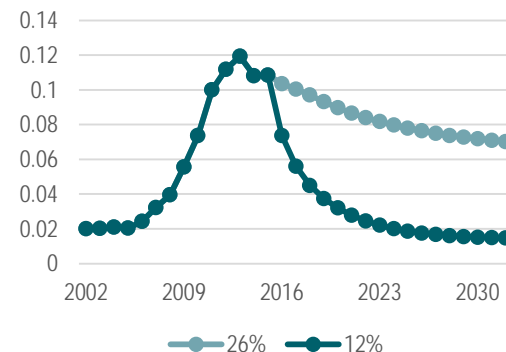
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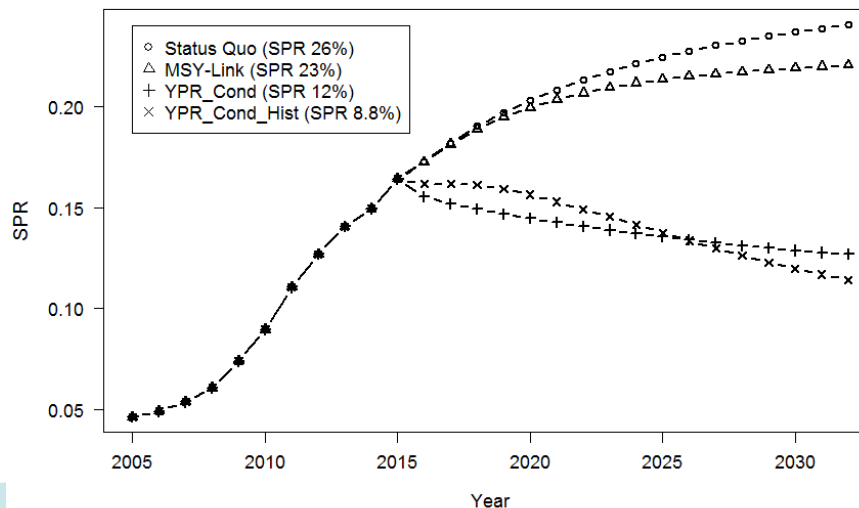
# Maximum Conditional YPR

- Maximum conditional YPR results in SPR 12% and ~SPR 2% in the eastern region
- For historical shrimp bycatch levels (5x current), the SPR at maximum conditional YPR would decrease to 8.8%

East GOM SPR



Gulfwide SPR Projections





# MSY-Linked

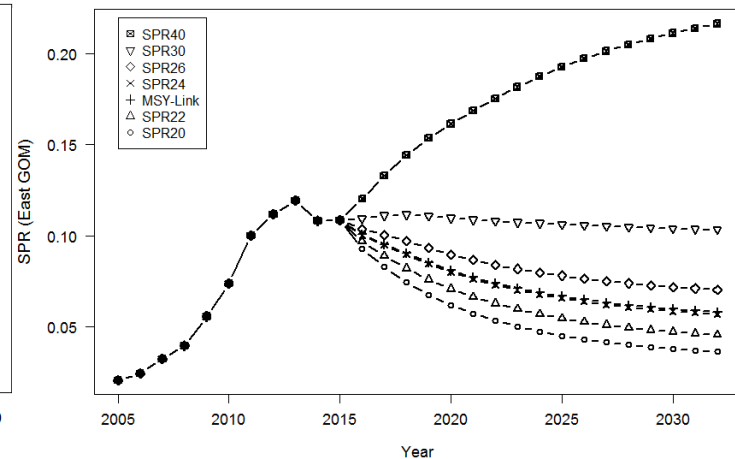
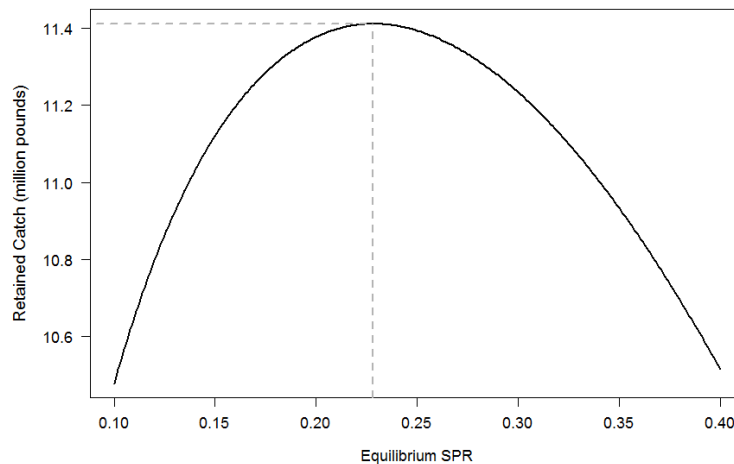


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- MSY-linked results in ~SPR 23% and equilibrium yield of 11.41mp
- Unreliable proxy
  - MSY-linked < Max Conditional YPR
    - True MSY would have greater landings than any YPR proxy, because directed F can be increased at expense of bycatch (conditional YPR may have higher killed biomass)
  - Increases bycatch F (compared to status quo SPR 26%), because all Fs linked and MSY is attained by increasing short-term yield





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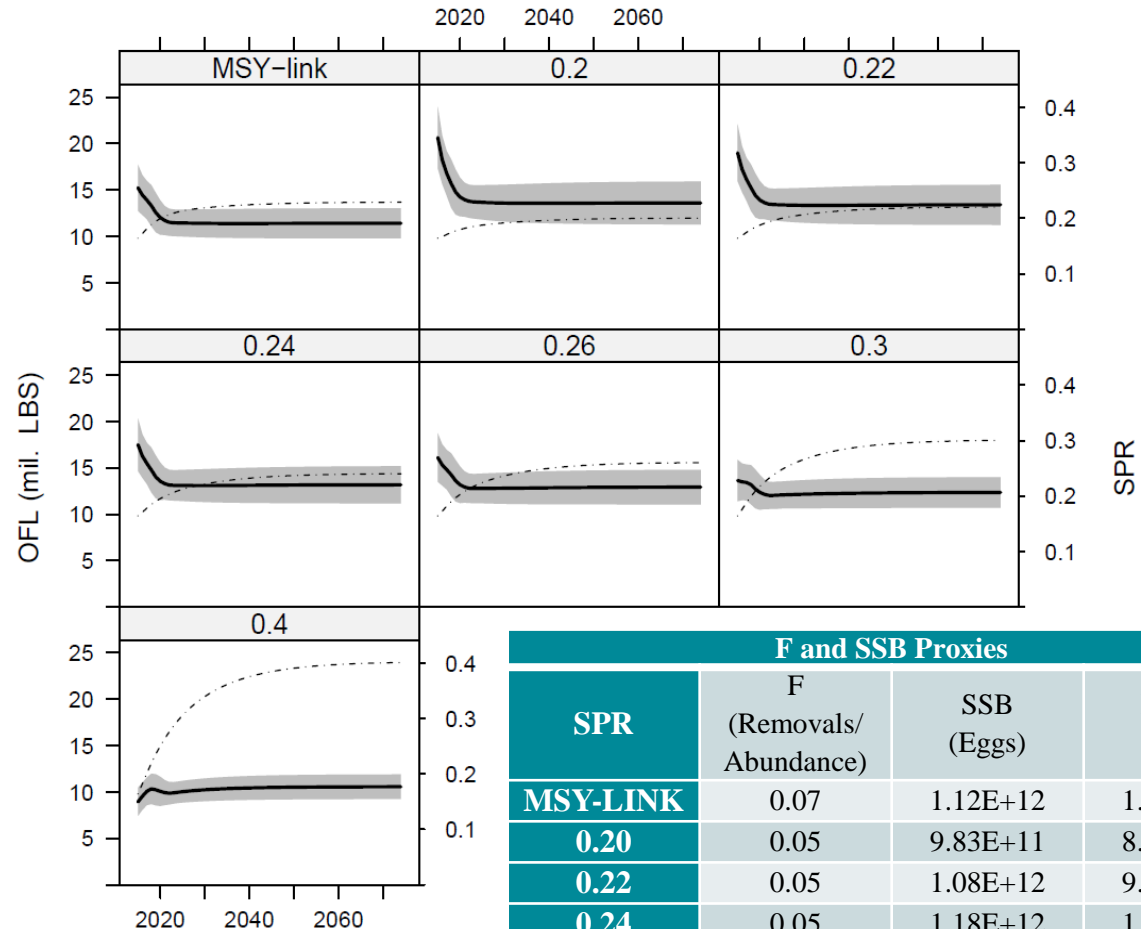
# Results: ABCs and OFLs



# OFLs and Proxies

Long-term Overfishing Limits (OFL)  
for Various Equilibrium SPR Targets

OFL ———  
SPR - - - -



F and SSB Proxies			
SPR	F (Removals/ Abundance)	SSB (Eggs)	MSST (Eggs)
<b>MSY-LINK</b>	0.07	1.12E+12	1.03E+12
<b>0.20</b>	0.05	9.83E+11	8.98E+11
<b>0.22</b>	0.05	1.08E+12	9.88E+11
<b>0.24</b>	0.05	1.18E+12	1.08E+12
<b>0.26</b>	0.05	1.28E+12	1.17E+12
<b>0.30</b>	0.05	1.47E+12	1.35E+12
<b>0.40</b>	0.04	1.97E+12	1.80E+12



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# ABCs (2032)

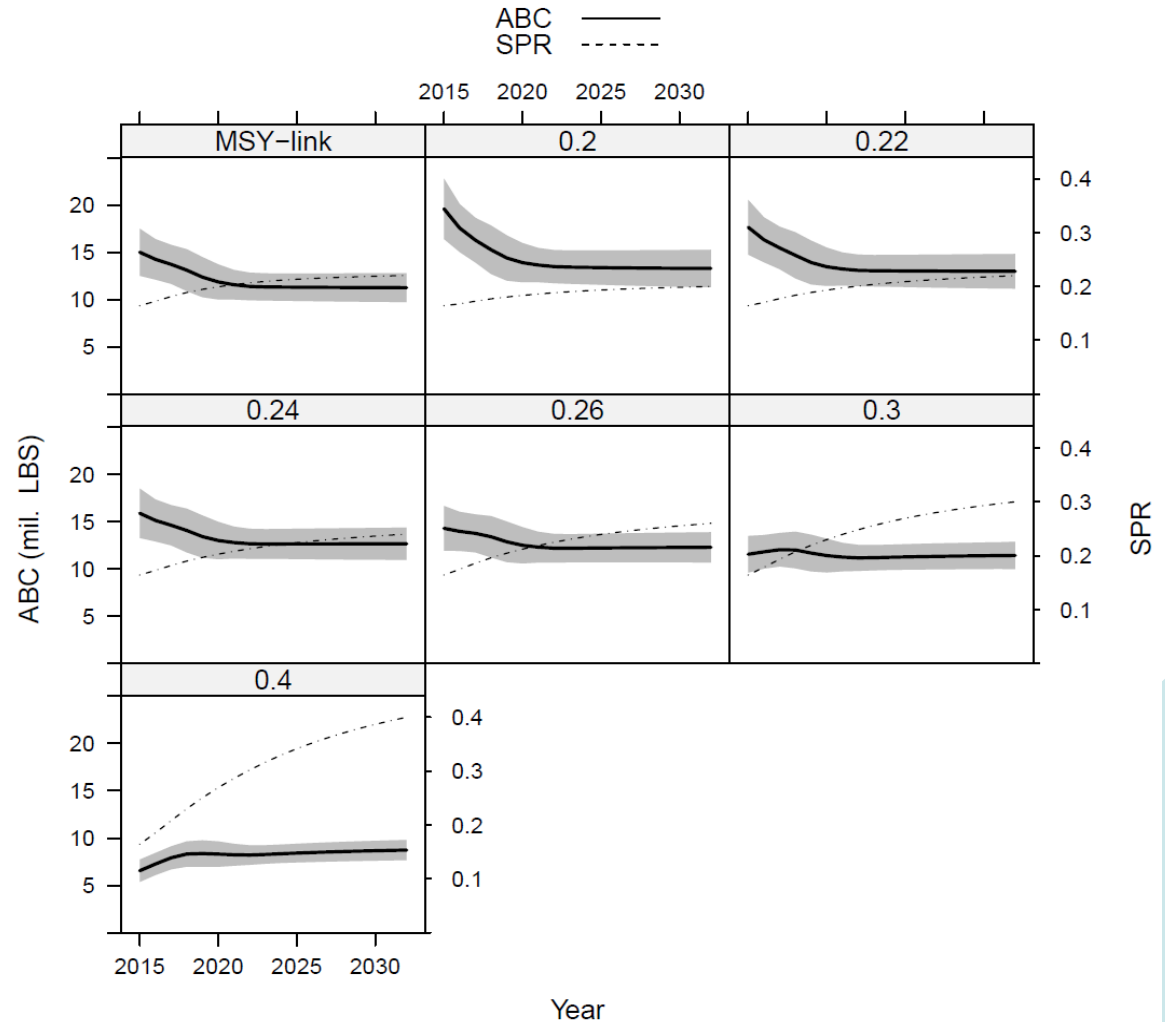


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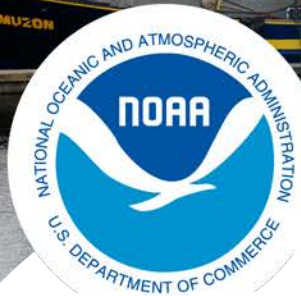


Acceptable Biological Catch (ABC)  
for Various SPR Targets (2032 Rebuilding)





# ABCs (2032)

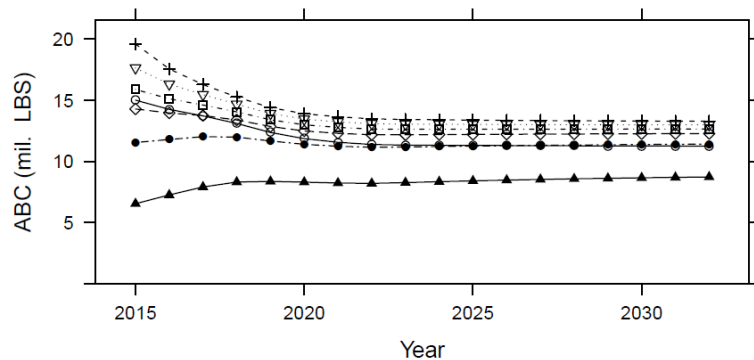


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MSY-link ○  
0.2 +  
0.22 ▽  
0.24 □  
0.26 ◇  
0.3 ●  
0.4 ▲

Acceptable Biological Catch (ABC)  
for Various SPR Targets (2032 Rebuilding)



ABC (Retained Yield Million Pounds Whole Weight)

YEAR	SPR 40%	SPR 30%	SPR 26%	SPR 24%	SPR 22%	SPR 20%	MSY- LINK
2015	6.55	11.54	14.28	15.87	17.63	19.59	15.00
2016	7.26	11.79	13.96	15.11	16.31	17.55	14.25
2017	7.91	12.02	13.74	14.61	15.45	16.28	13.72
2018	8.32	11.99	13.38	14.05	14.67	15.26	13.10
2019	8.37	11.67	12.85	13.40	13.91	14.39	12.36
2020	8.31	11.40	12.49	12.99	13.46	13.90	11.86
2021	8.24	11.24	12.29	12.78	13.23	13.64	11.56
2022	8.21	11.15	12.18	12.65	13.08	13.48	11.38
2023	8.27	11.17	12.17	12.62	13.04	13.42	11.33
2024	8.35	11.22	12.19	12.63	13.03	13.40	11.31
2025	8.41	11.25	12.21	12.63	13.02	13.37	11.30
2026	8.47	11.29	12.22	12.63	13.01	13.35	11.29
2027	8.53	11.31	12.23	12.64	13.00	13.34	11.28
2028	8.58	11.34	12.24	12.64	13.00	13.32	11.28
2029	8.62	11.36	12.25	12.64	12.99	13.31	11.27
2030	8.66	11.38	12.26	12.64	12.99	13.30	11.26
2031	8.70	11.40	12.26	12.65	12.99	13.29	11.26
2032	8.73	11.41	12.27	12.65	12.99	13.29	11.25
Equil	9.05	11.61	12.40	12.74	13.04	13.30	11.26

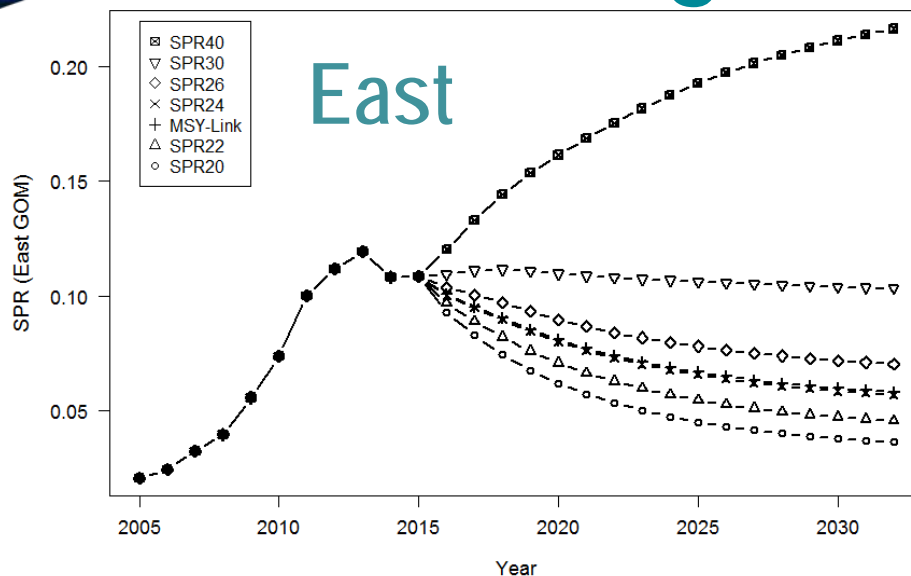


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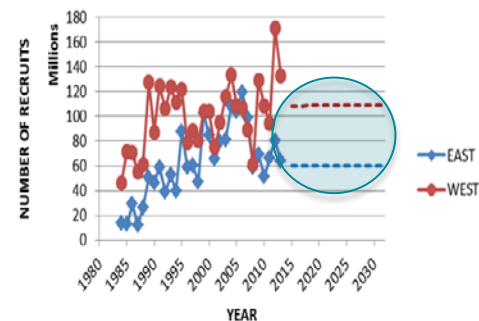
# Regional SPR

## East



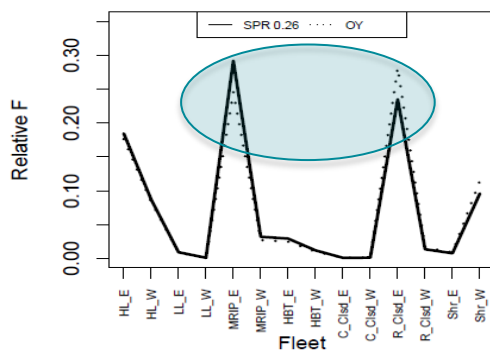
## Growth

Age-0 Recruitment by Region

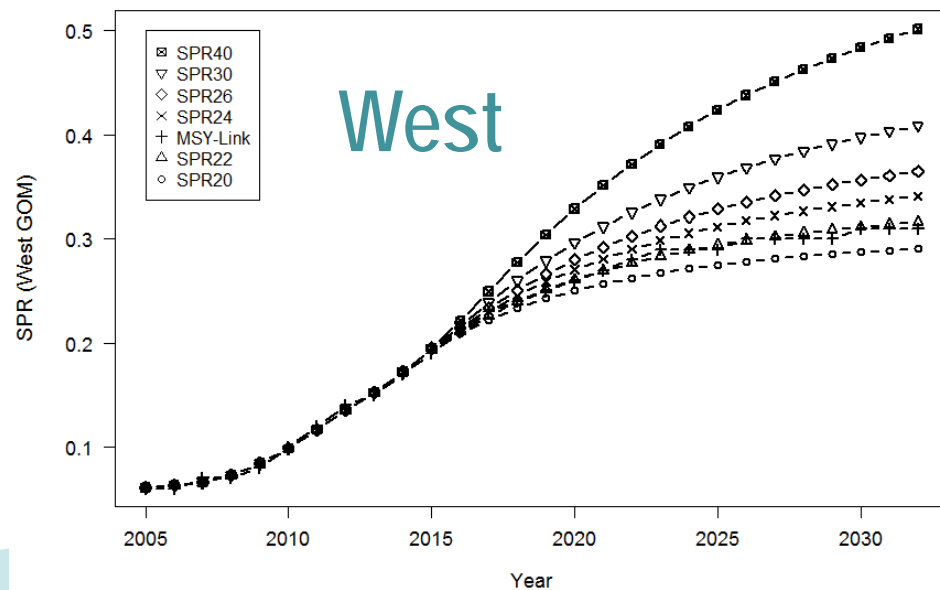


## Removals

Relative F by Fleet at Equilibrium (F/Total F)



## West



# ABCs (2026)

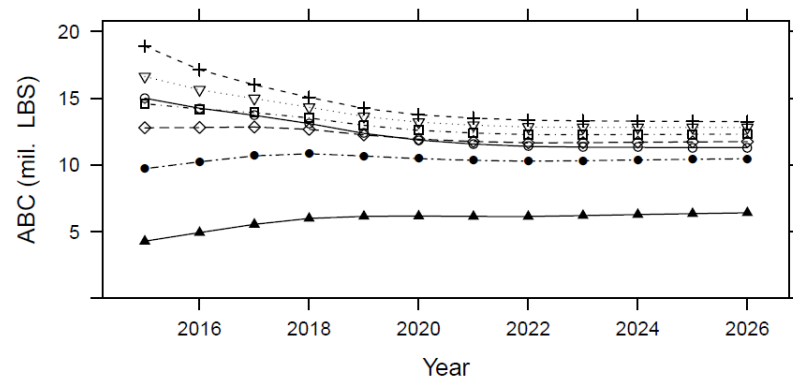


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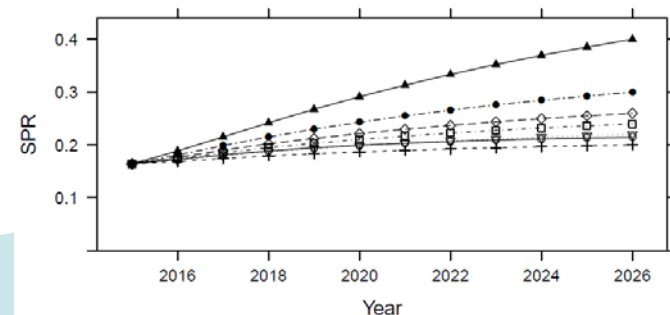
MSY-link ○  
0.2 +  
0.22 ▽  
0.24 □  
0.26 ◇  
0.3 ●  
0.4 ▲

Acceptable Biological Catch (ABC)  
for Various SPR Targets (2026 Rebuilding)

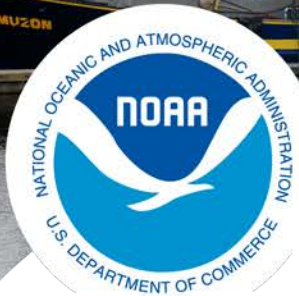


ABC (Retained Yield Million Pounds Whole Weight)							
YEAR	SPR 40%	SPR 30%	SPR 26%	SPR 24%	SPR 22%	SPR 20%	MSY-LINK
2015	4.27	9.71	12.78	14.59	16.63	18.91	15.00
2016	4.92	10.23	12.80	14.19	15.64	17.14	14.25
2017	5.54	10.67	12.84	13.92	14.98	16.01	13.72
2018	5.98	10.84	12.67	13.52	14.33	15.07	13.10
2019	6.14	10.66	12.25	12.97	13.63	14.24	12.36
2020	6.16	10.47	11.93	12.59	13.20	13.76	11.86
2021	6.13	10.34	11.75	12.39	12.98	13.51	11.56
2022	6.13	10.27	11.66	12.28	12.84	13.35	11.38
2023	6.19	10.31	11.67	12.27	12.81	13.30	11.33
2024	6.27	10.37	11.70	12.28	12.81	13.28	11.31
2025	6.34	10.42	11.72	12.30	12.81	13.26	11.30
2026	6.40	10.46	11.75	12.31	12.81	13.24	11.29
Equil	7.03	10.88	12.00	12.47	12.88	13.22	11.26

Spawner Potential Ratio (SPR)  
for Various SPR Targets (2026 Rebuilding)



# Optimal Yield

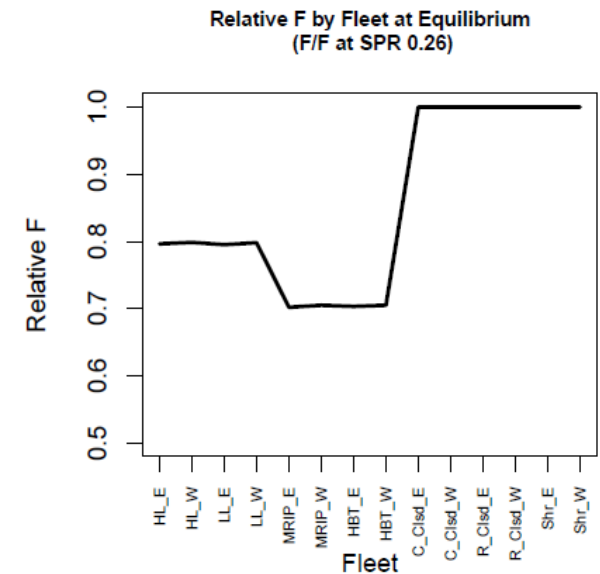


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Retained Yield Million Pounds Whole Weight			
YEAR	SPR 26%	Retained Yield (mp)	Yield Proportion
2015	16.10	12.49	0.78
2016	15.31	12.59	0.82
2017	14.80	12.70	0.86
2018	14.26	12.60	0.88
2019	13.60	12.22	0.90
2020	13.17	11.90	0.90
2021	12.93	11.71	0.91
2022	12.79	11.60	0.91
2023	12.77	11.61	0.91
2024	12.77	11.65	0.91
2025	12.78	11.68	0.91
2026	12.78	11.71	0.92
2027	12.79	11.73	0.92
2028	12.79	11.75	0.92
2029	12.79	11.77	0.92
2030	12.80	11.79	0.92
2031	12.80	11.81	0.92
2032	12.81	11.82	0.92
Equil	12.91	12.00	0.93



Retained Yield Million Pounds Whole Weight							
YEAR	MSY-LINK	SPR 40%	SPR 30%	SPR 26%	SPR 24%	SPR 22%	SPR 20%
Equil	11.41	10.57	12.34	12.91	13.17	13.40	13.60
Equil OY	11.2	9.29	11.29	12.00	12.33	12.64	12.93



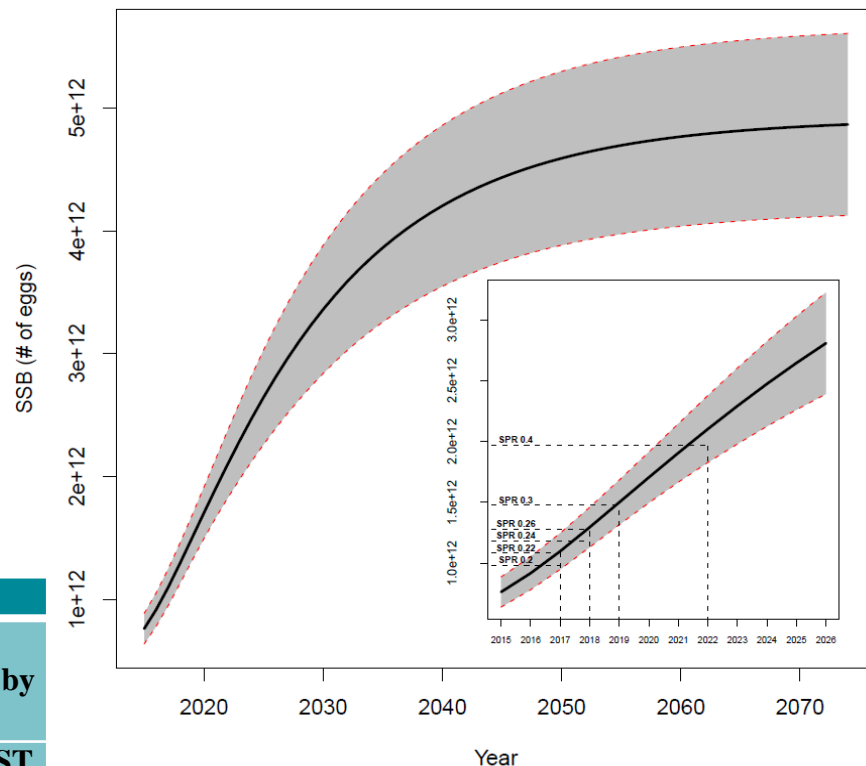
# Rebuilding Times

Spawning Stock Rebuilding with No Fishing Mortality



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Year that Rebuilding Target is Reached

SPR	F=0		OFL (Reach SPR by 2074)		2032 (Reach SPR by 2032)		2026 (Reach SPR by 2026)	
	SSB	MSST	SSB	MSST	SSB	MSST	SSB	MSST
MSY-LINK	2018	2017	2070	2023	NA	NA	NA	NA
0.2	2017	2016	2070	2022	2032	2020	2026	2019
0.22	2017	2017	2070	2026	2032	2023	2026	2021
0.24	2018	2017	2070	2029	2032	2024	2026	2022
0.26	2018	2018	2070	2031	2032	2025	2026	2023
0.3	2019	2019	2070	2034	2032	2026	2026	2023
0.4	2022	2021	2070	2037	2032	2028	2026	2024



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# Summary



# Summary

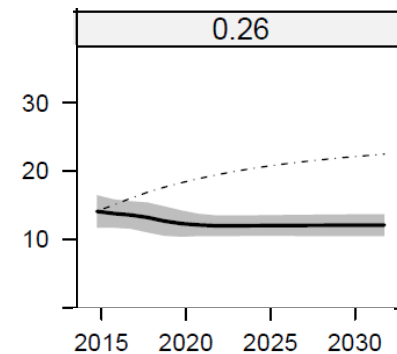


**NOAA**  
**FISHERIES**

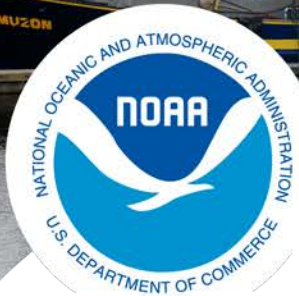
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- ABCs decrease as SPR targets become more conservative
- Status quo (SPR 26%) leads to ABCs of:
  - 2015: 14.28 mp
  - 2016: 13.96 mp
  - 2017: 13.74 mp
- Multiple possibilities for defining OY fishing mortality when multiple directed and bycatch fleets exist:
  - $0.75 * F_{\text{Direct}}$
  - $0.75 * F_{\text{total}}$
  - $0.75 * \text{Harvest Rate (Removals/Abundance)}$



# Summary



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- Is there a best proxy for MSY?
  - MSY indeterminable and unobtainable in practice
  - Conditional MSY treats bycatch and discards as natural mortality
  - MSY-link relies on scaling  $F$  on all fleets proportionally and may 'require' increasing bycatch mortality
  - Appropriately chosen SPR proxies can maintain SSB, but may forego potential yield
- SSB at TRUE maximum YPR is attainable even though associated yield is not
  - Calculate assuming optimal selectivity, but achieve SSB by scaling directed fisheries
  - Without knowledge of the stock-recruit relationship and given the complexities of red snapper, this may be the closest to MSY that is achievable



# Summary



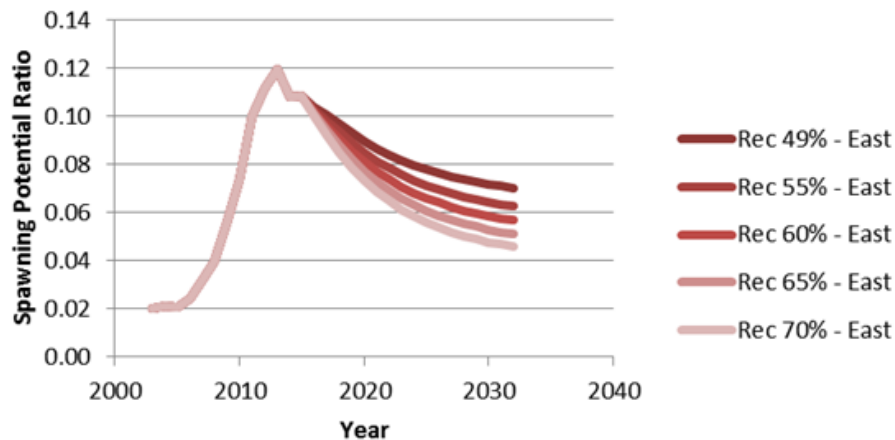
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- Gulfwide proxies ignore finer scale regional dynamics
  - Status quo management is projected to lead to depletion of eastern unit to SPR 7% by 2032
  - Assumptions drive projections especially recruitment and relative fishing mortality
- A change in SPR target in combination with a change in allocation will lead to more severe SPR implications than either action individually

**Effect of Allocation on SPR**





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# Questions?



Gulf of Mexico SSC  
May 20, 2015  
New Orleans, LA