SEDAR 79: Mutton Snapper

Review Workshop – Day 2

Shanae Allen, Halie O'Farrell, Robert Muller

FWRI Stock Assessment Group, St. Petersburg, FL

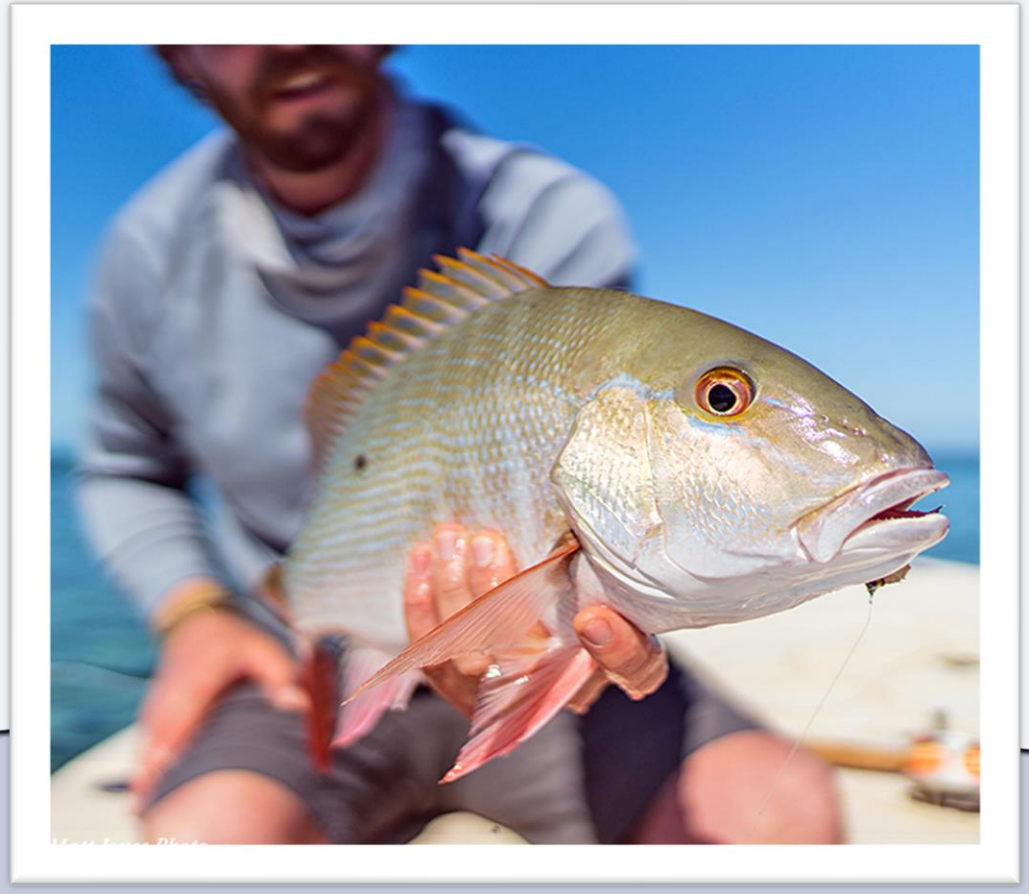
9/10-12/2024

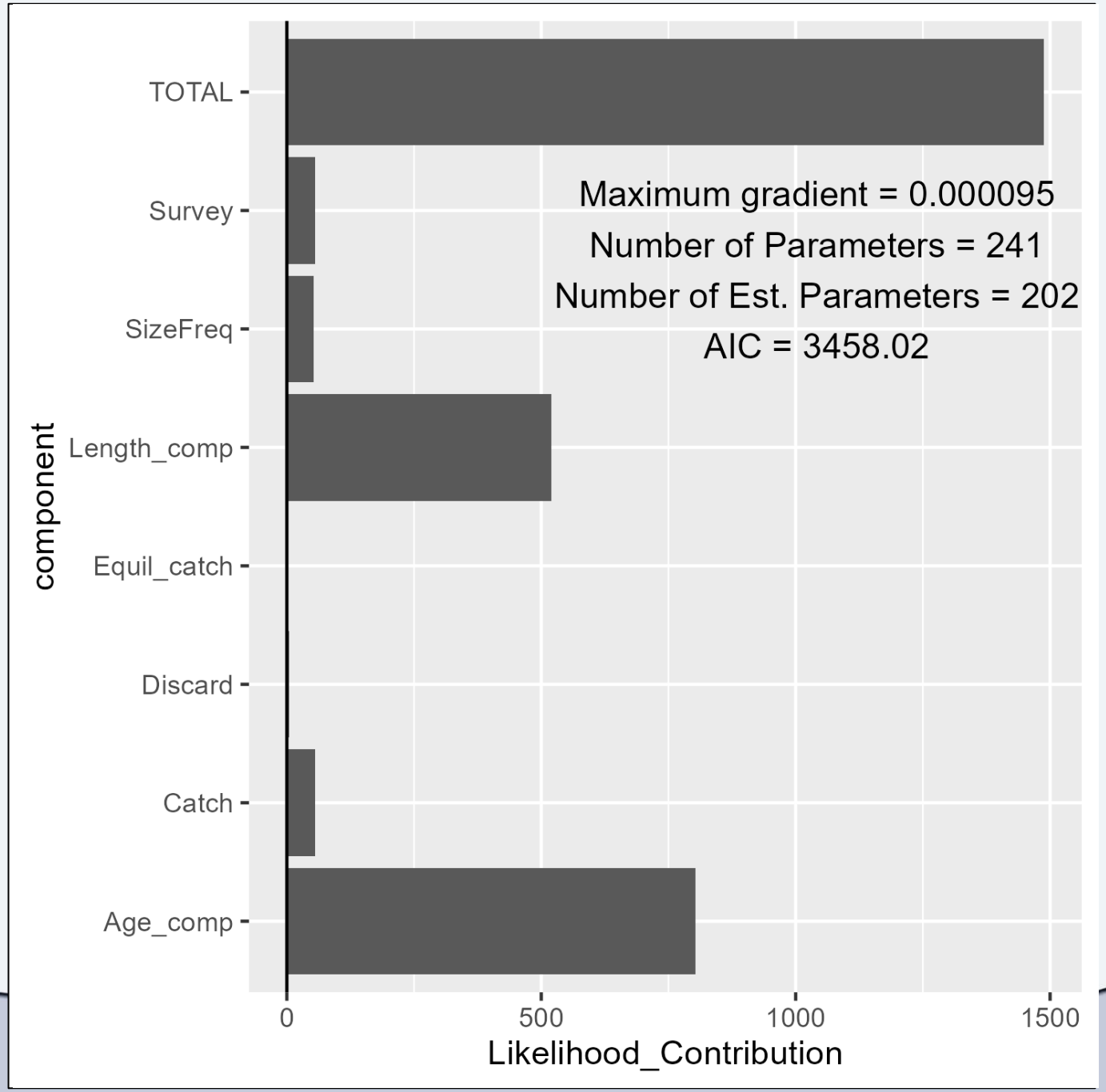
Goals

- Review Base Model Estimated Parameters & Results
- Uncertainty Analysis
- Comparison to SEDAR 15AU
- Base Model Diagnostics
- Sensitivity Runs
- Projections
- Model Bridging (Day 3)

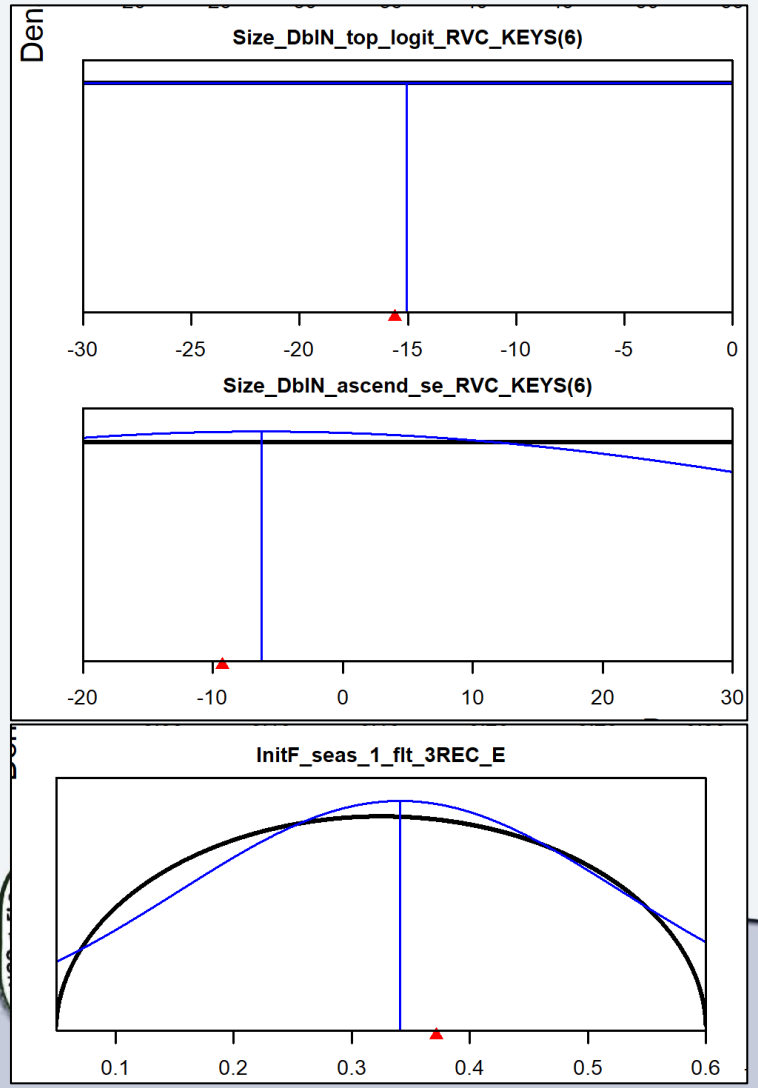
Base Model Estimated Parameters

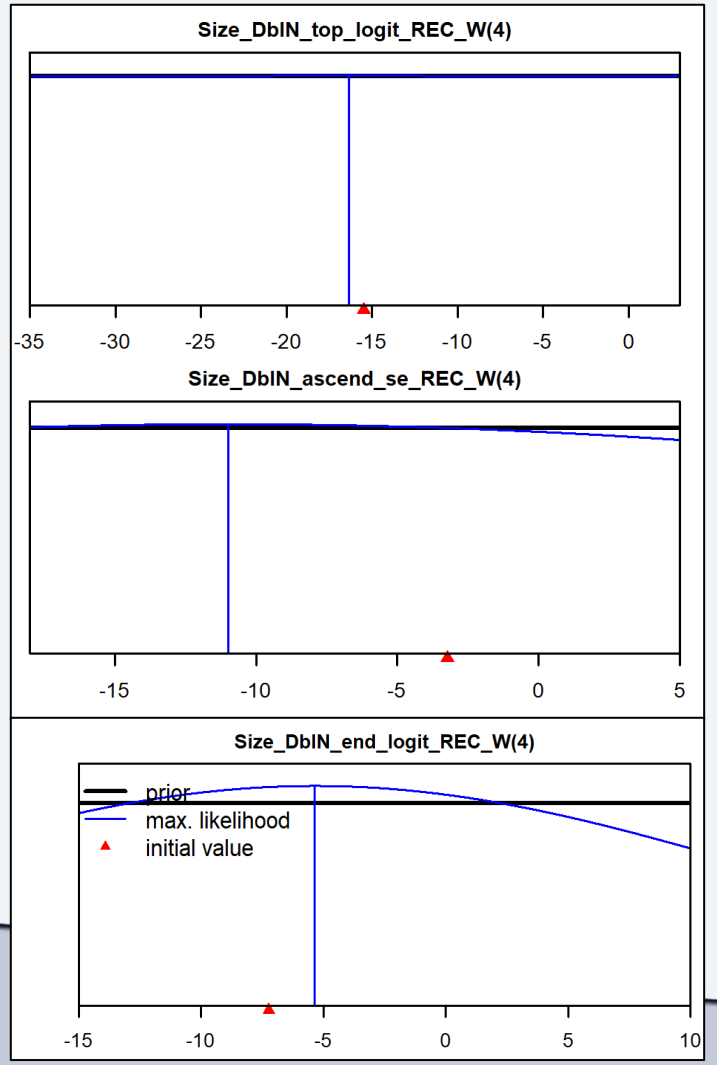
Log-Likelihood

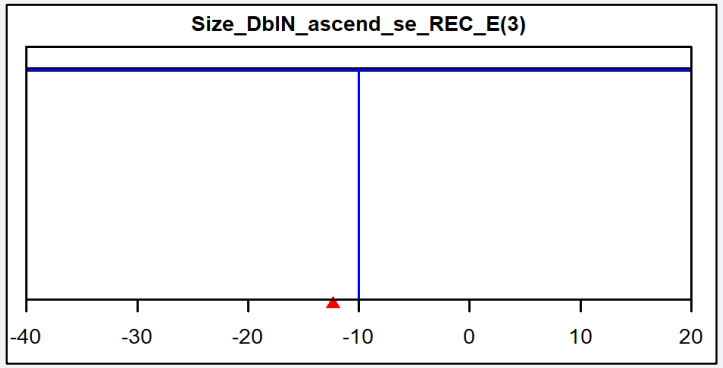


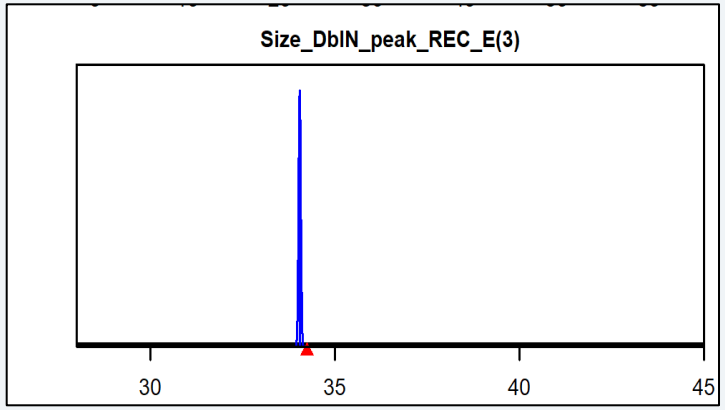


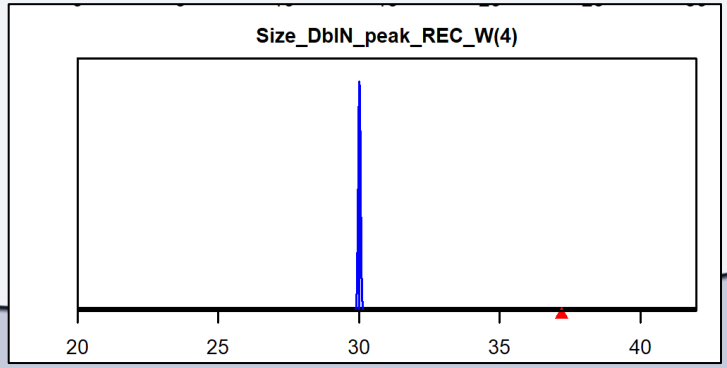
“Problem” Parameters







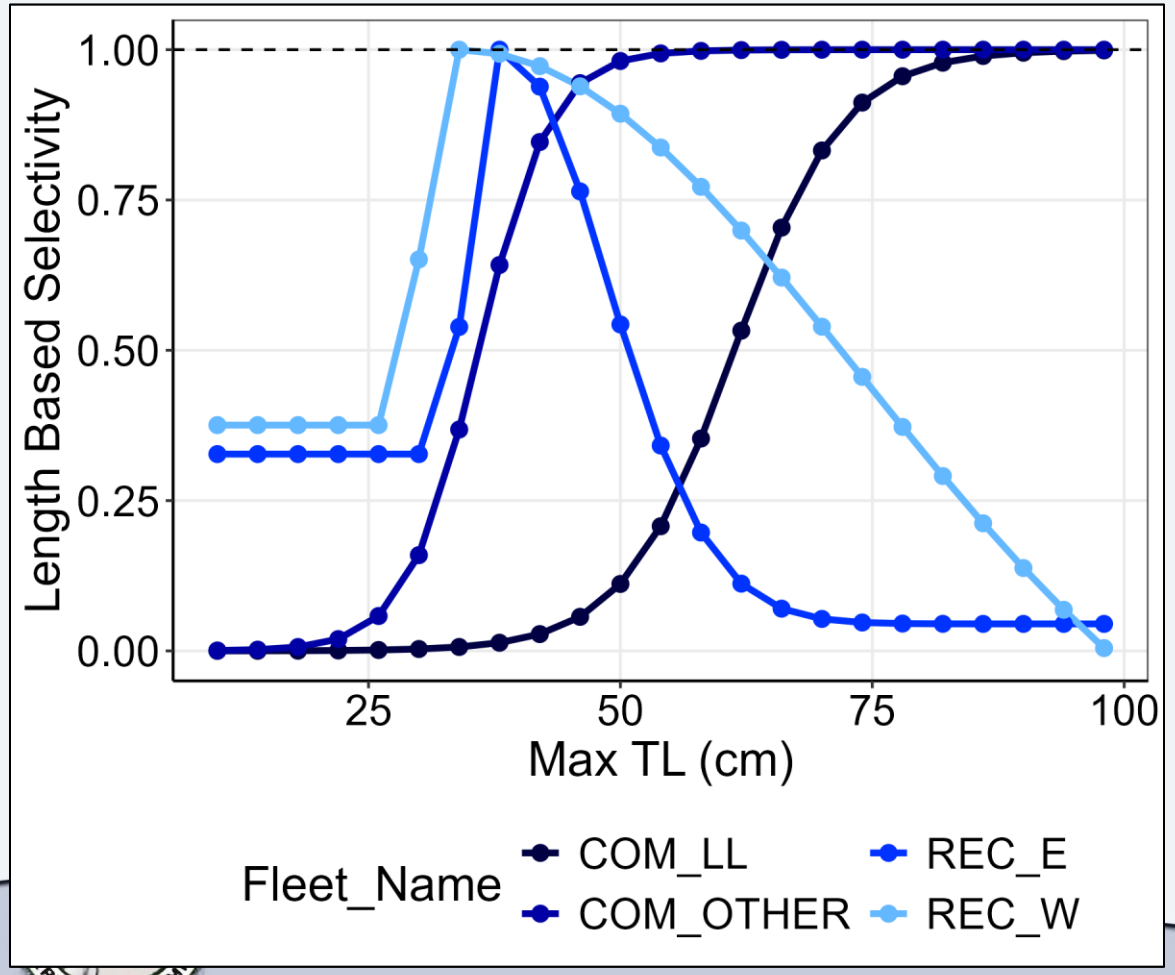


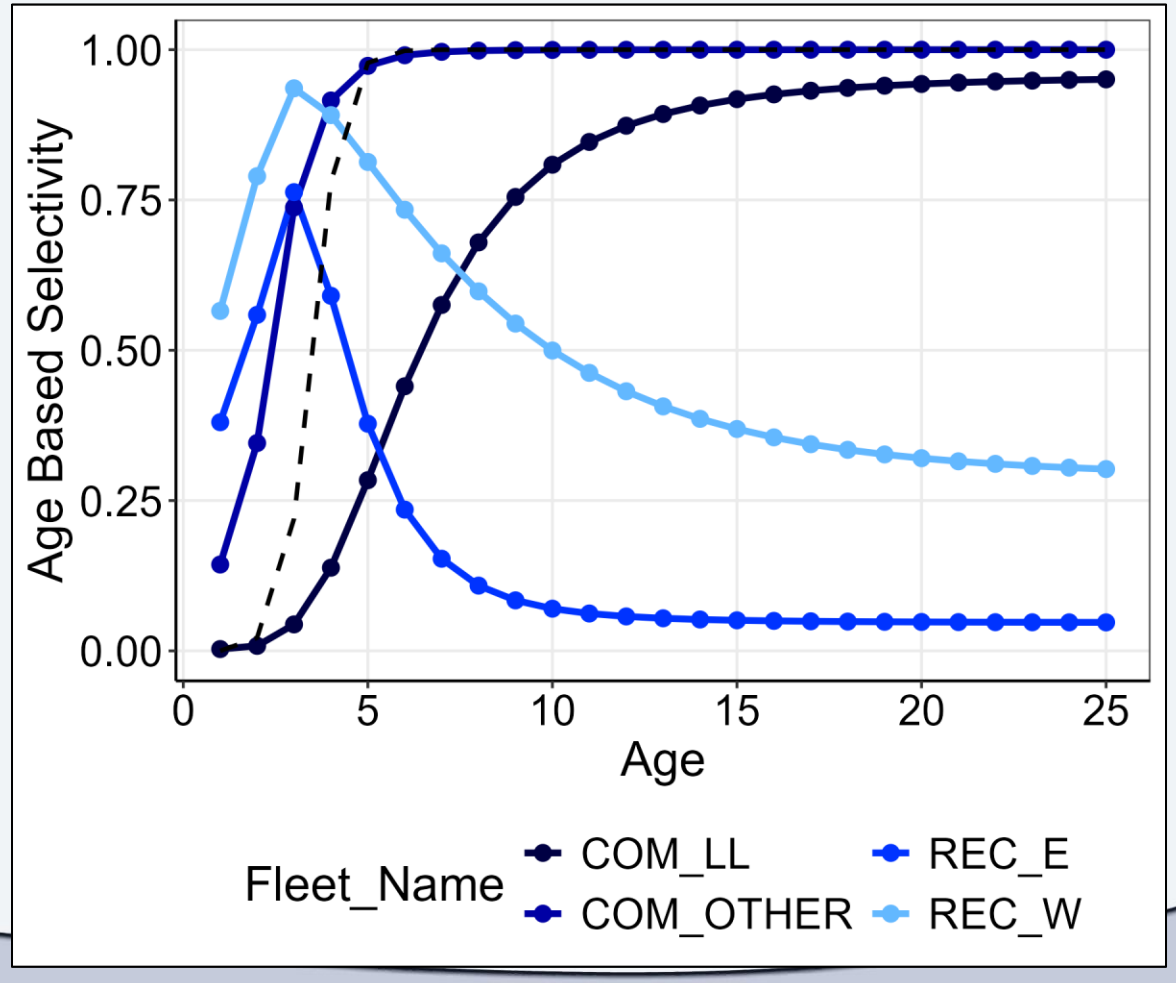


Correlated Parameters (correlation coefficient > 0.7)

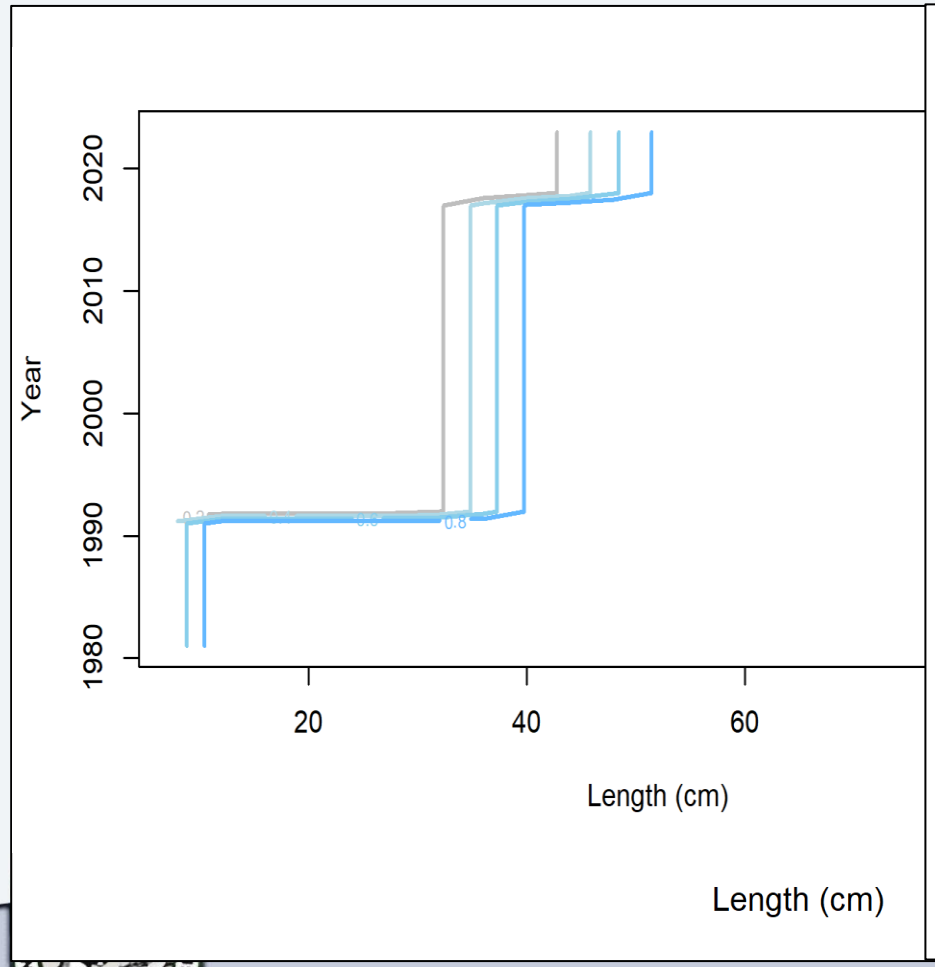
Parameter 1	Parameter 2	Correlation
Retain_L_infl_REC_E(3)_BLK2mult_1995	Retain_L_infl_REC_E(3)	-0.99
Retain_L_infl_REC_W(4)_BLK2mult_1995	Retain_L_infl_REC_W(4)	-0.95
Retain_L_width_REC_E(3)_BLK2mult_1995	Retain_L_width_REC_E(3)	-0.92
Size_DblN_ascend_se_RVC_DT(5)	Size_DblN_peak_RVC_DT(5)	0.91
Size_DblN_end_logit_RVC_KEYS(6)	Size_DblN_descend_se_RVC_KEYS(6)	-0.90
Size_DblN_descend_se_REC_E(3)	Size_DblN_top_logit_REC_E(3)	-0.89
Retain_L_infl_REC_W(4)_BLK2mult_2018	Retain_L_infl_REC_W(4)	-0.89
Retain_L_infl_REC_E(3)_BLK2mult_2018	Retain_L_infl_REC_E(3)	-0.89
Retain_L_infl_REC_E(3)_BLK2mult_2018	Retain_L_infl_REC_E(3)_BLK2mult_1995	0.88
Retain_L_width_REC_W(4)_BLK2mult_1995	Retain_L_width_REC_W(4)	-0.87
Retain_L_infl_REC_W(4)_BLK2mult_2018	Retain_L_infl_REC_W(4)_BLK2mult_1995	0.86
Size_95%width_COM_LL(1)	Size_inflection_COM_LL(1)	0.83
Size_DblN_end_logit_REC_W(4)	Size_DblN_descend_se_REC_W(4)	-0.82
VonBert_K_Fem_GP_1	L_at_Amax_Fem_GP_1	-0.82
Size_DblN_descend_se_RVC_DT(5)	Size_DblN_top_logit_RVC_DT(5)	-0.82
Retain_L_width_COM_OTHER(2)_BLK1add_2018	Retain_L_infl_COM_OTHER(2)_BLK1add_2018	0.81
Size_DblN_end_logit_RVC_DT(5)	Size_DblN_descend_se_RVC_DT(5)	-0.80
Size_95%width_GOM_VID(9)	Size_inflection_GOM_VID(9)	0.77
Retain_L_width_REC_E(3)_BLK2mult_2018	Retain_L_width_REC_E(3)	-0.76
Size_inflection_GOM_VID(9)	LnQ_base_GOM_VID(9)	0.76
SR_BH_steep	SR_LN(R0)	-0.72
Retain_L_width_REC_E(3)_BLK2mult_2018	Retain_L_width_REC_E(3)_BLK2mult_1995	0.71
CV_young_Fem_GP_1	L_at_Amin_Fem_GP_1	-0.70

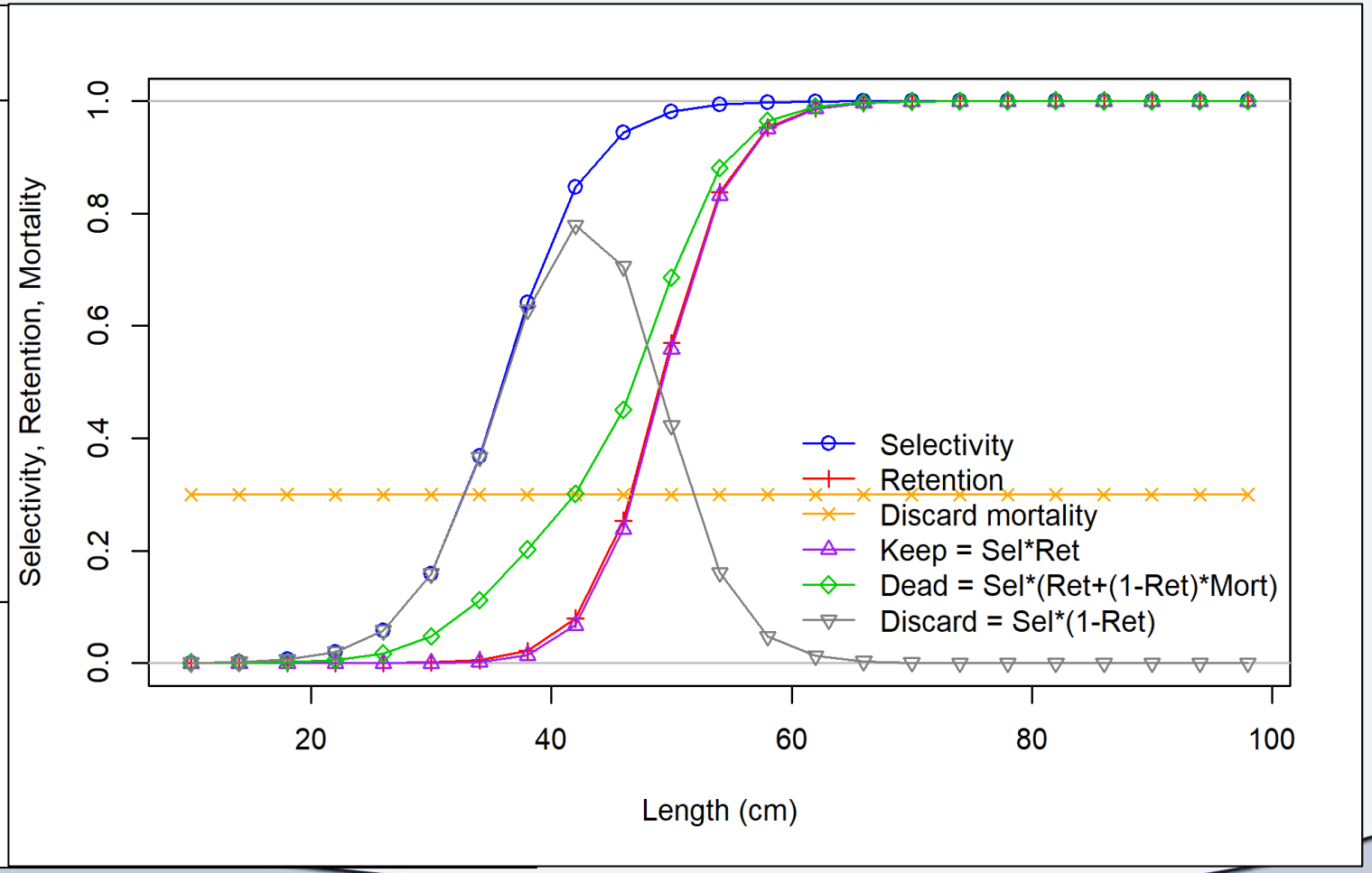
Fleet Selectivity



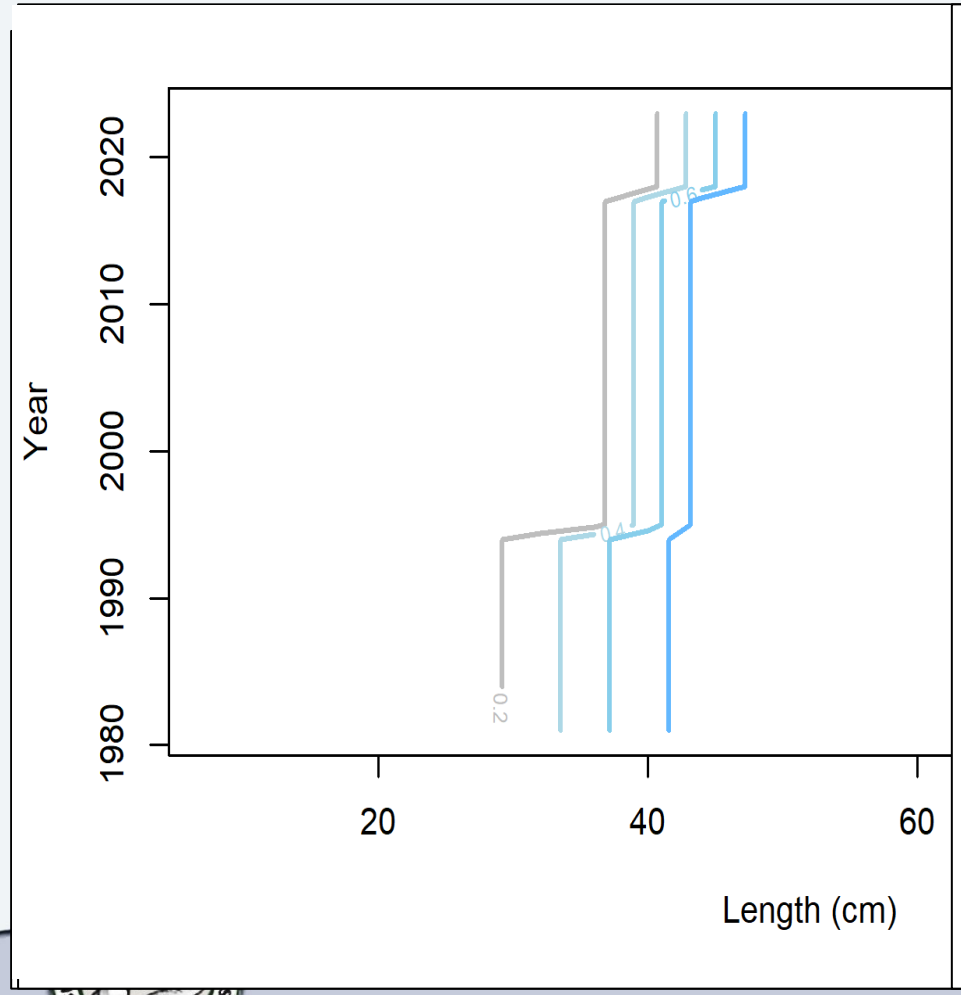


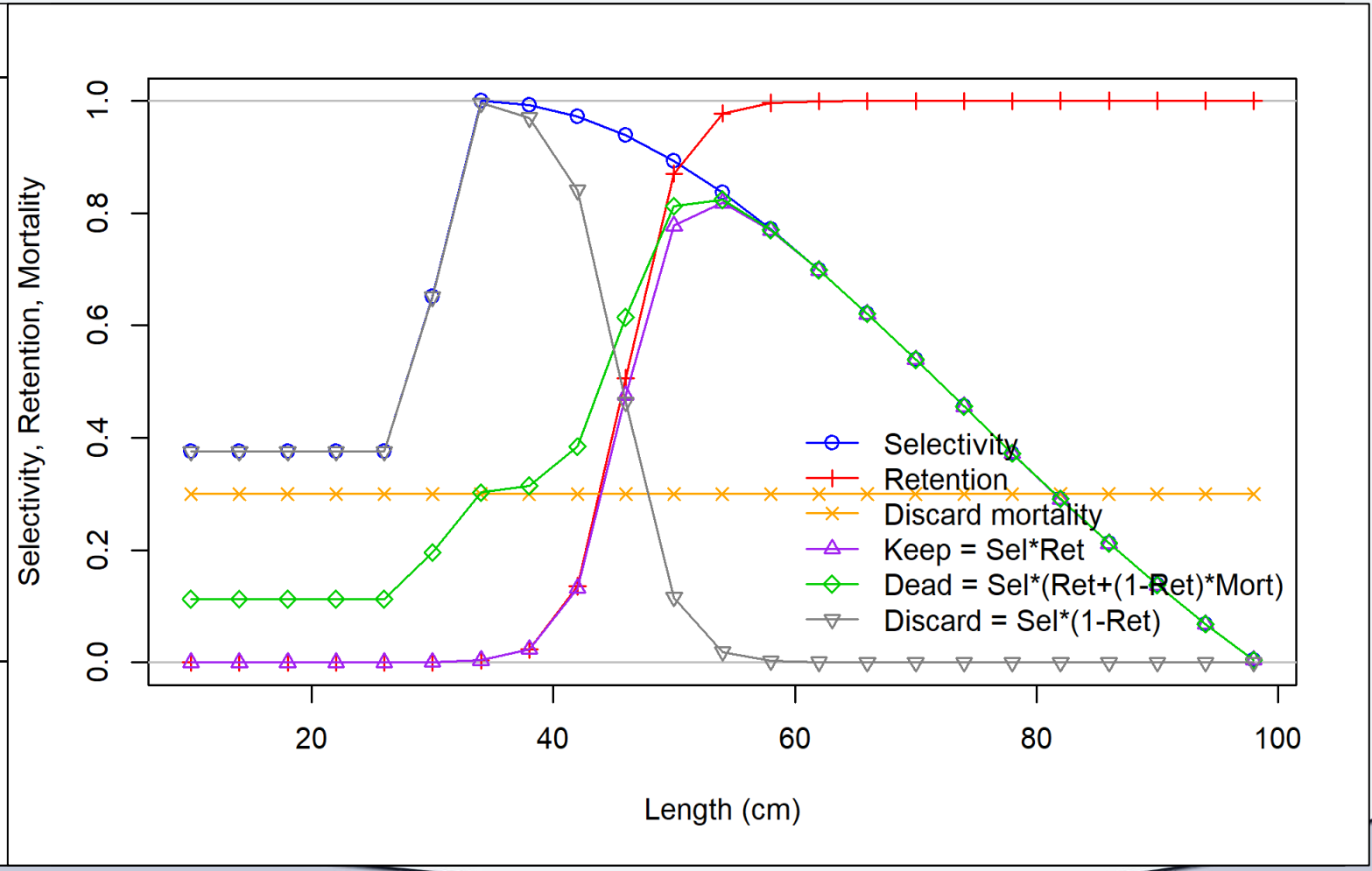
Com OTHER Retention



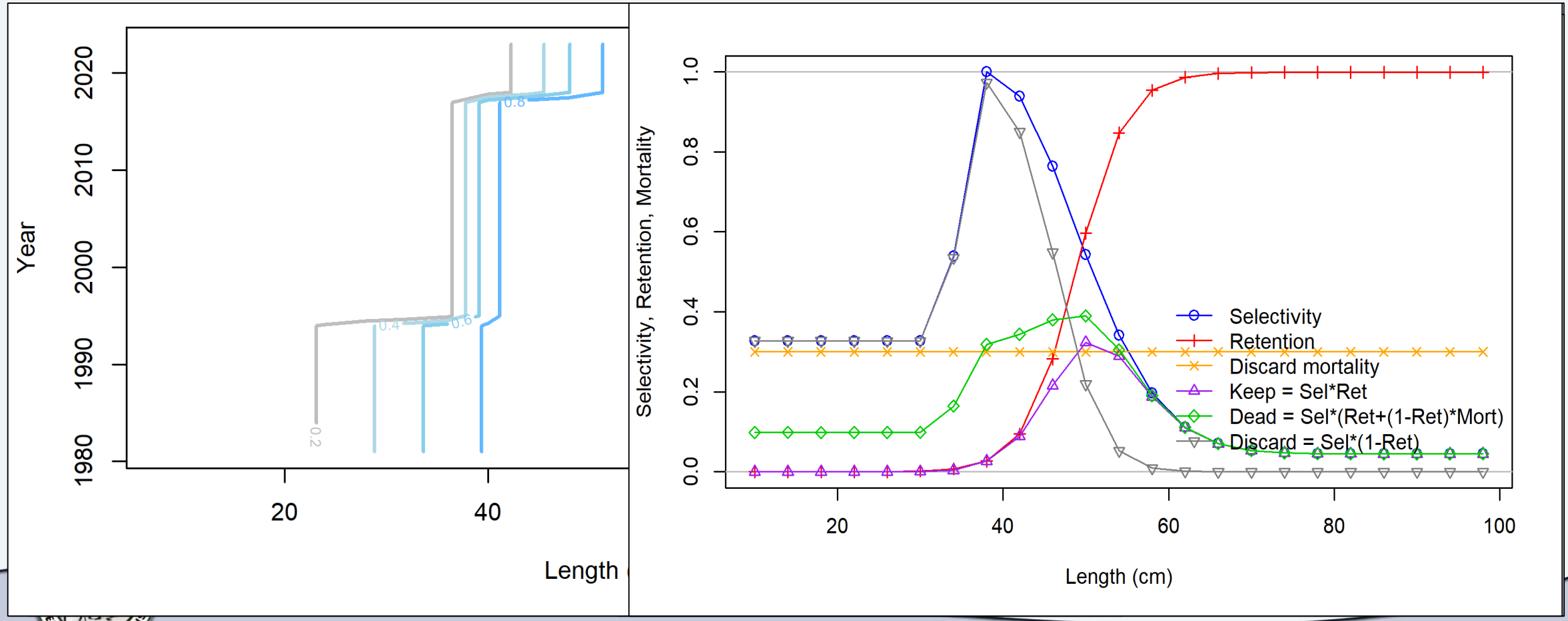


Rec WEST Retention

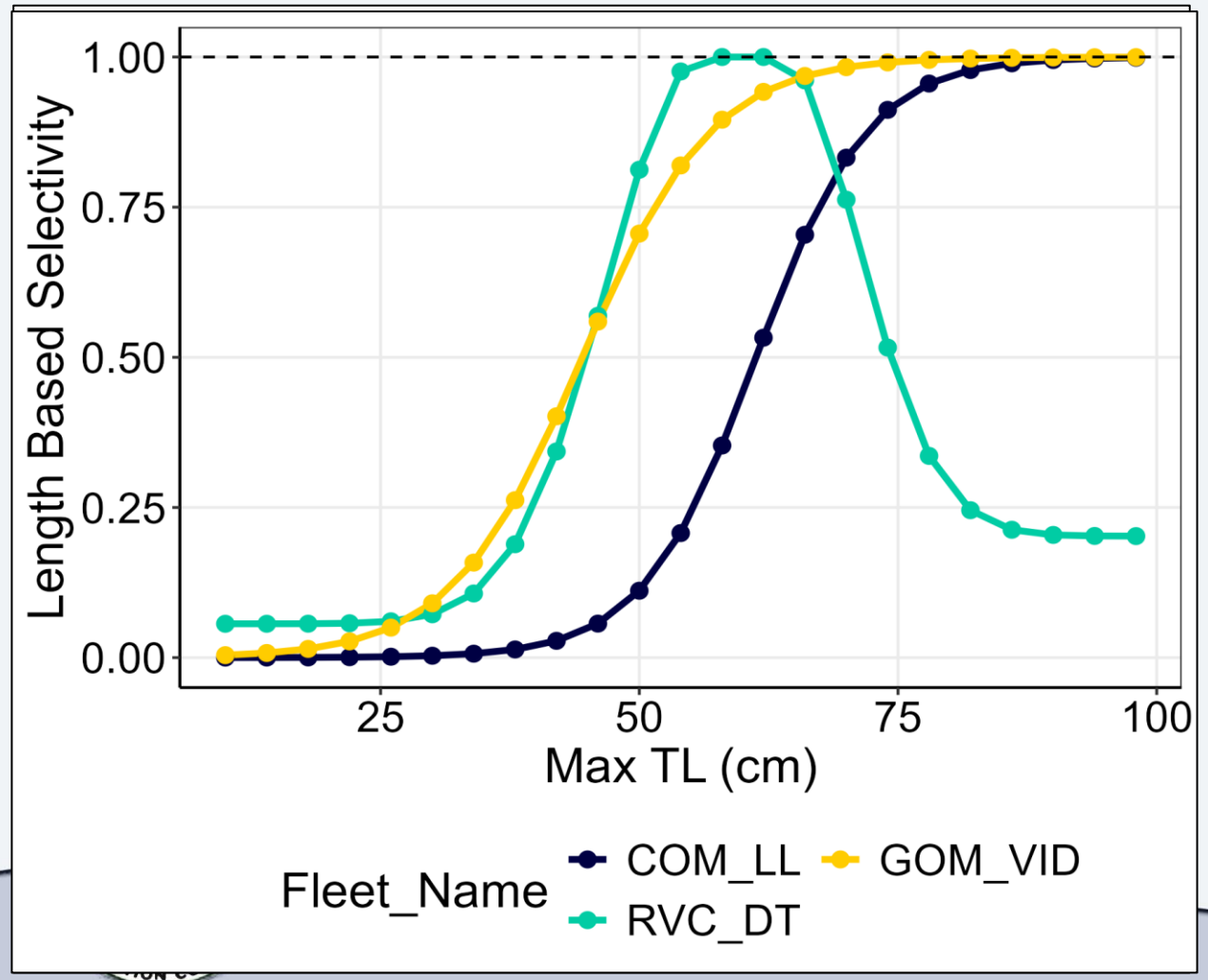


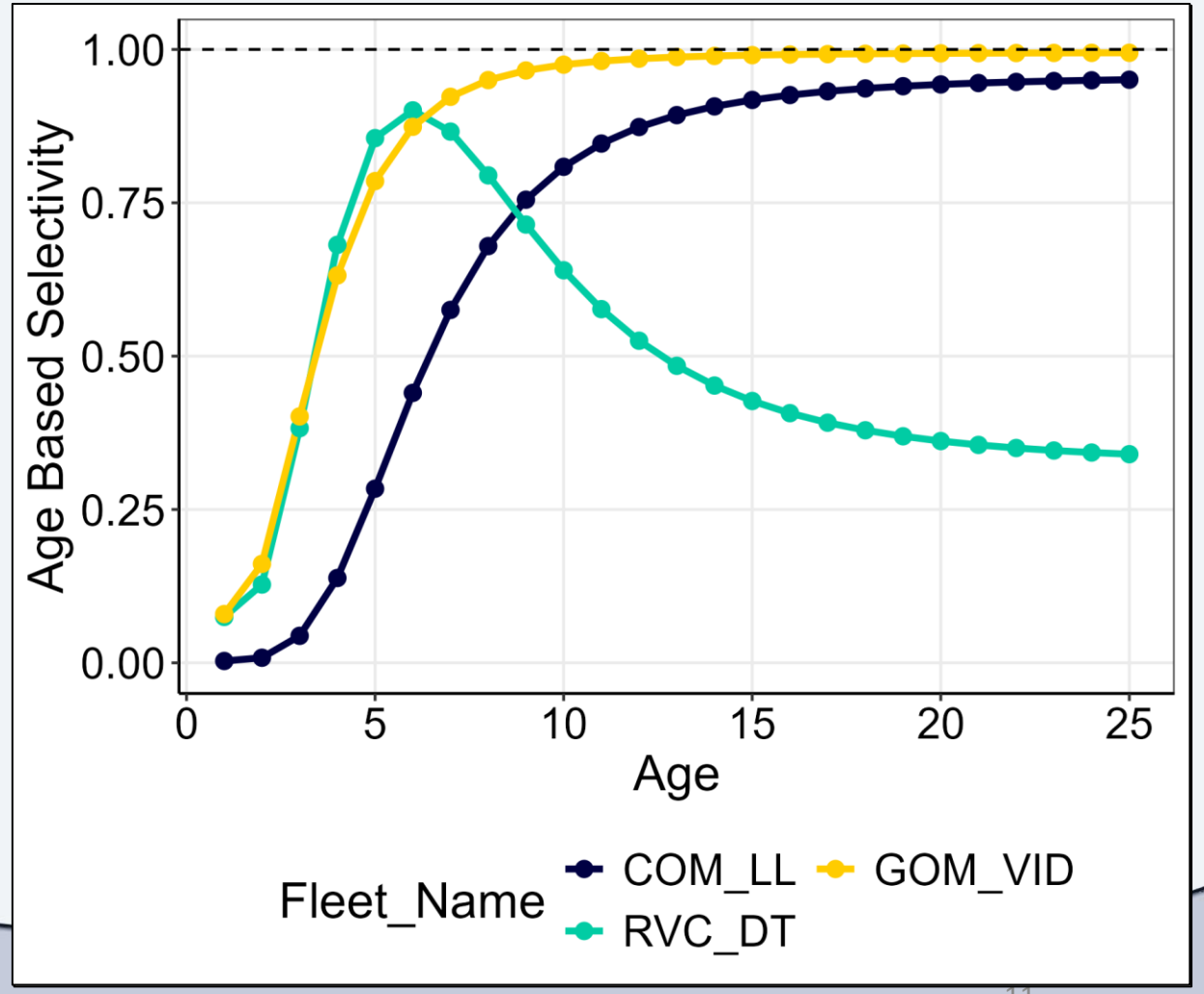


Rec EAST Retention

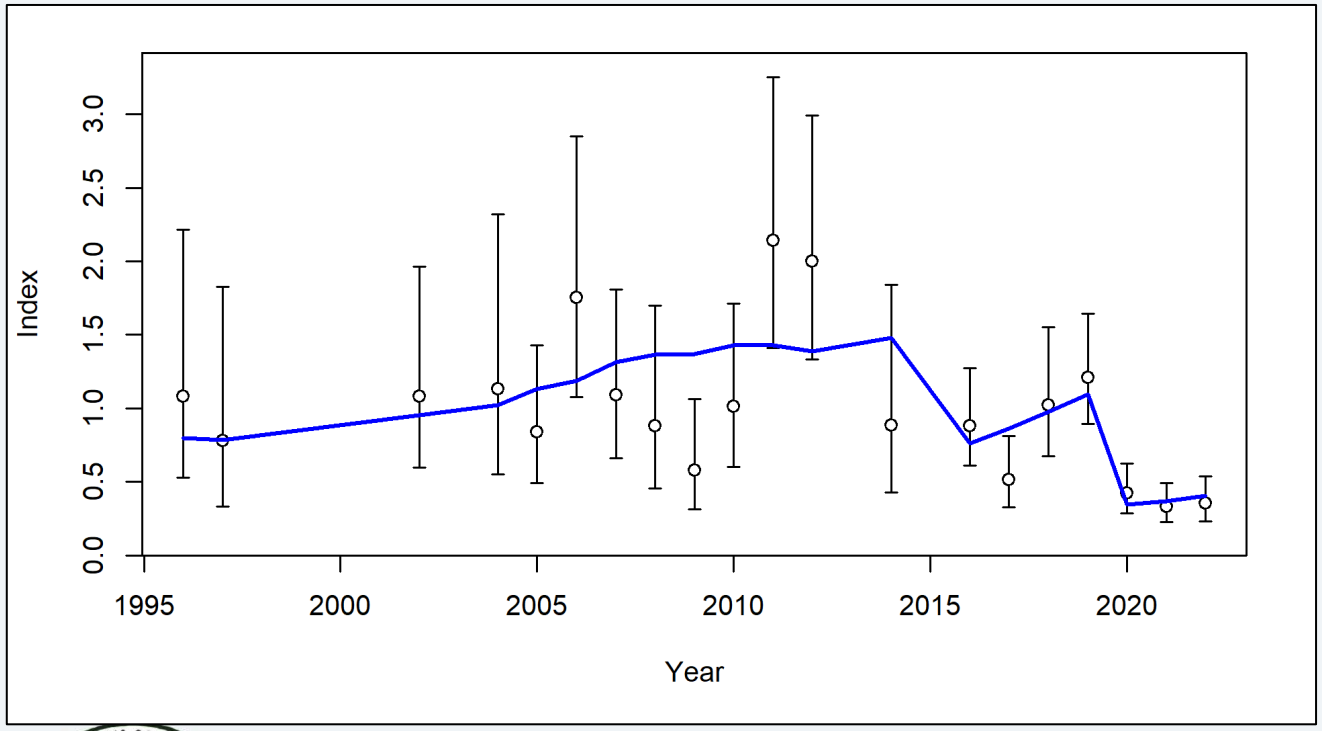


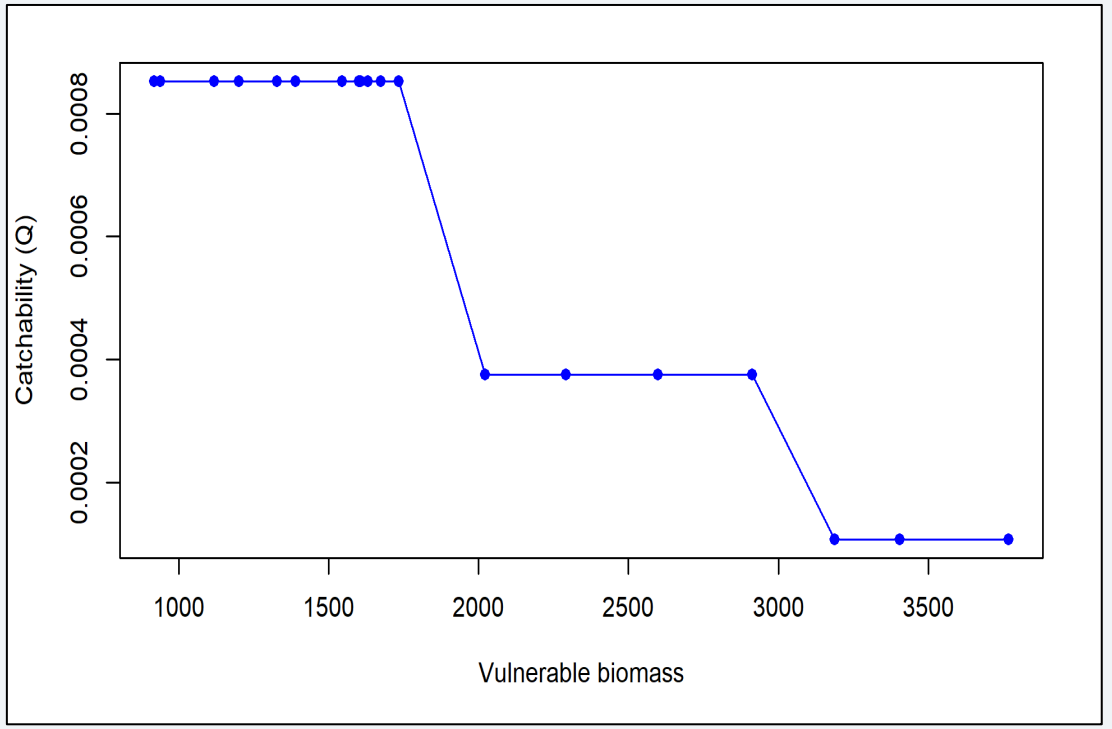
Index Selectivity (Gulf)



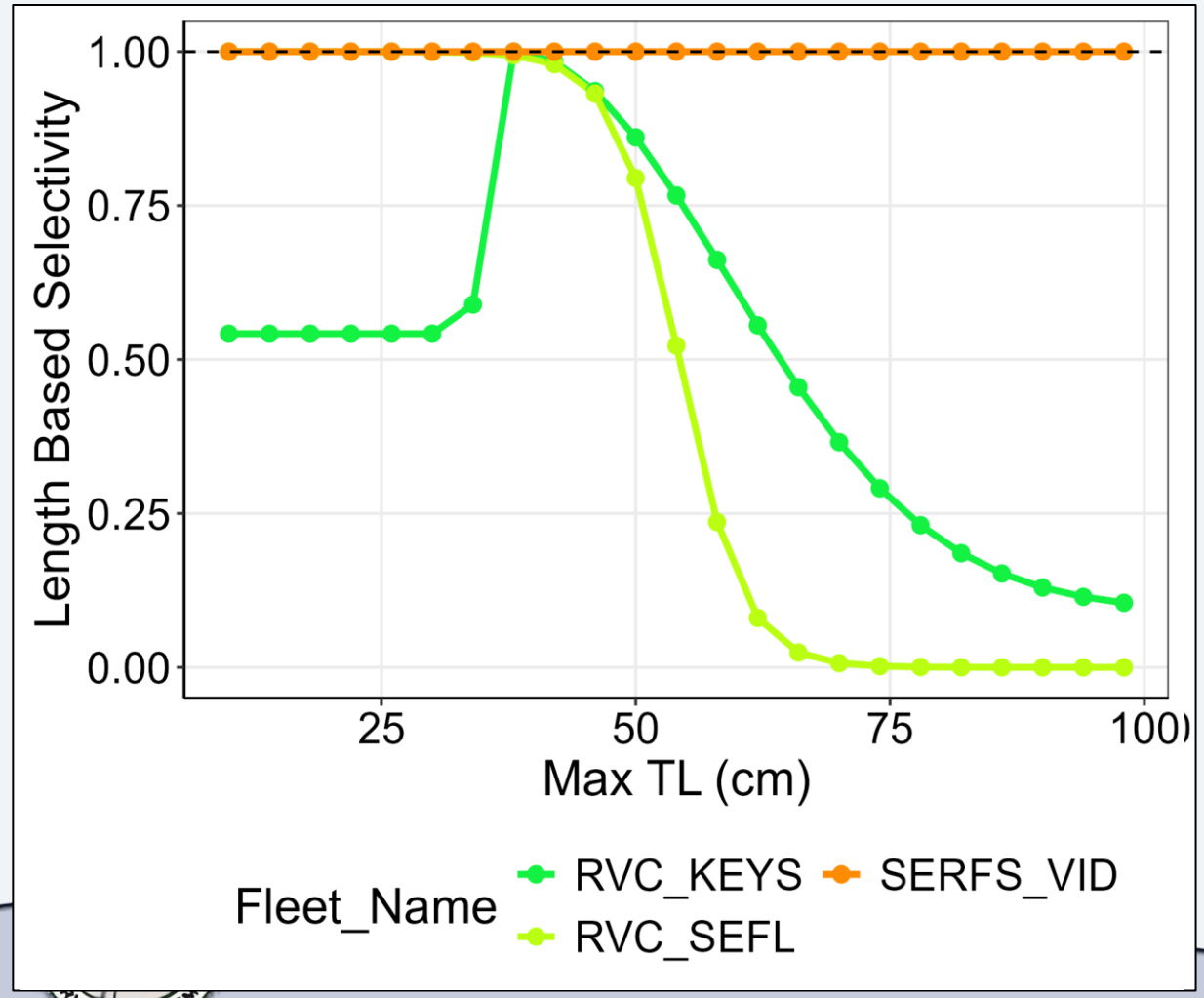


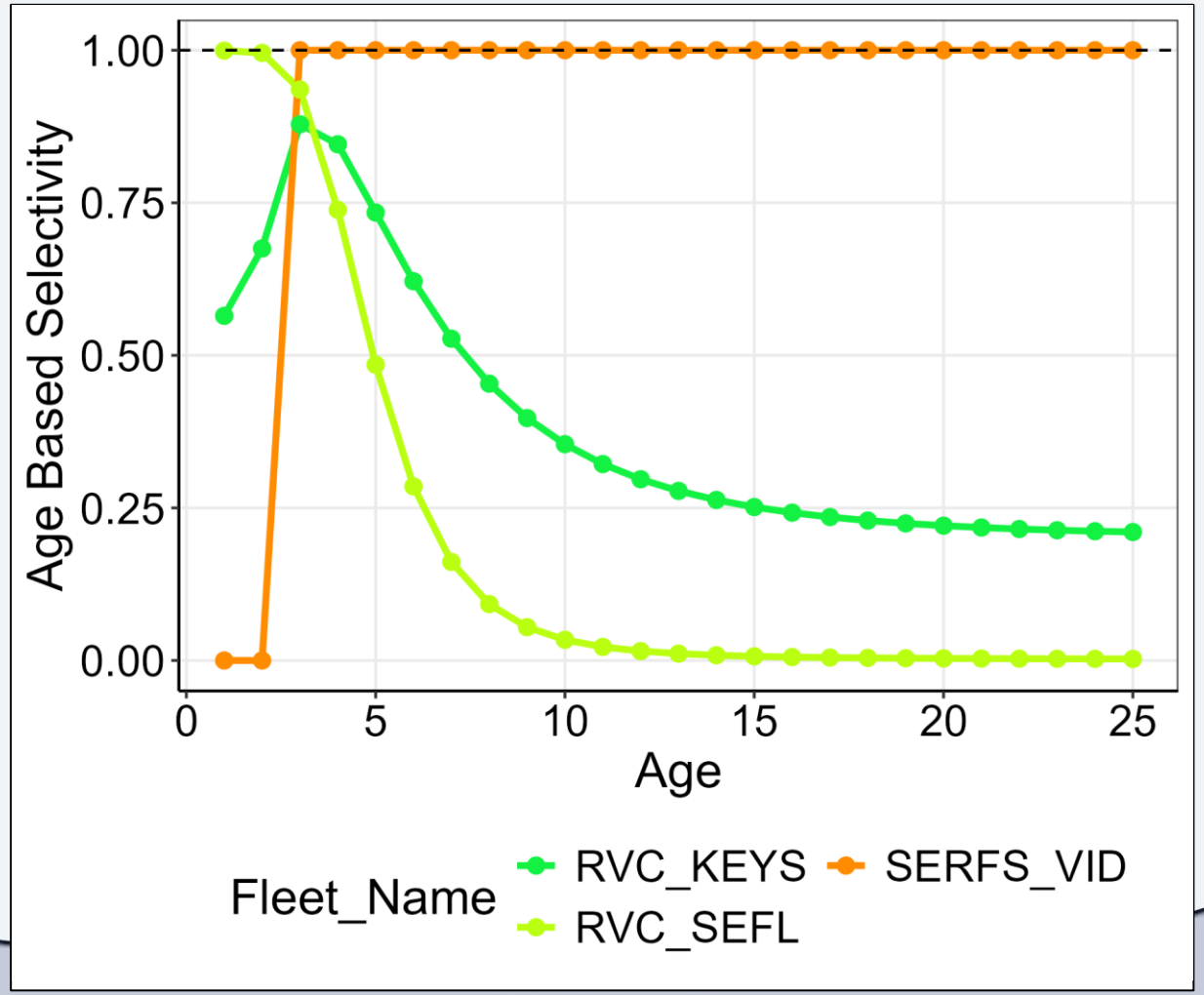
Gulf Combined Video Index Catchability



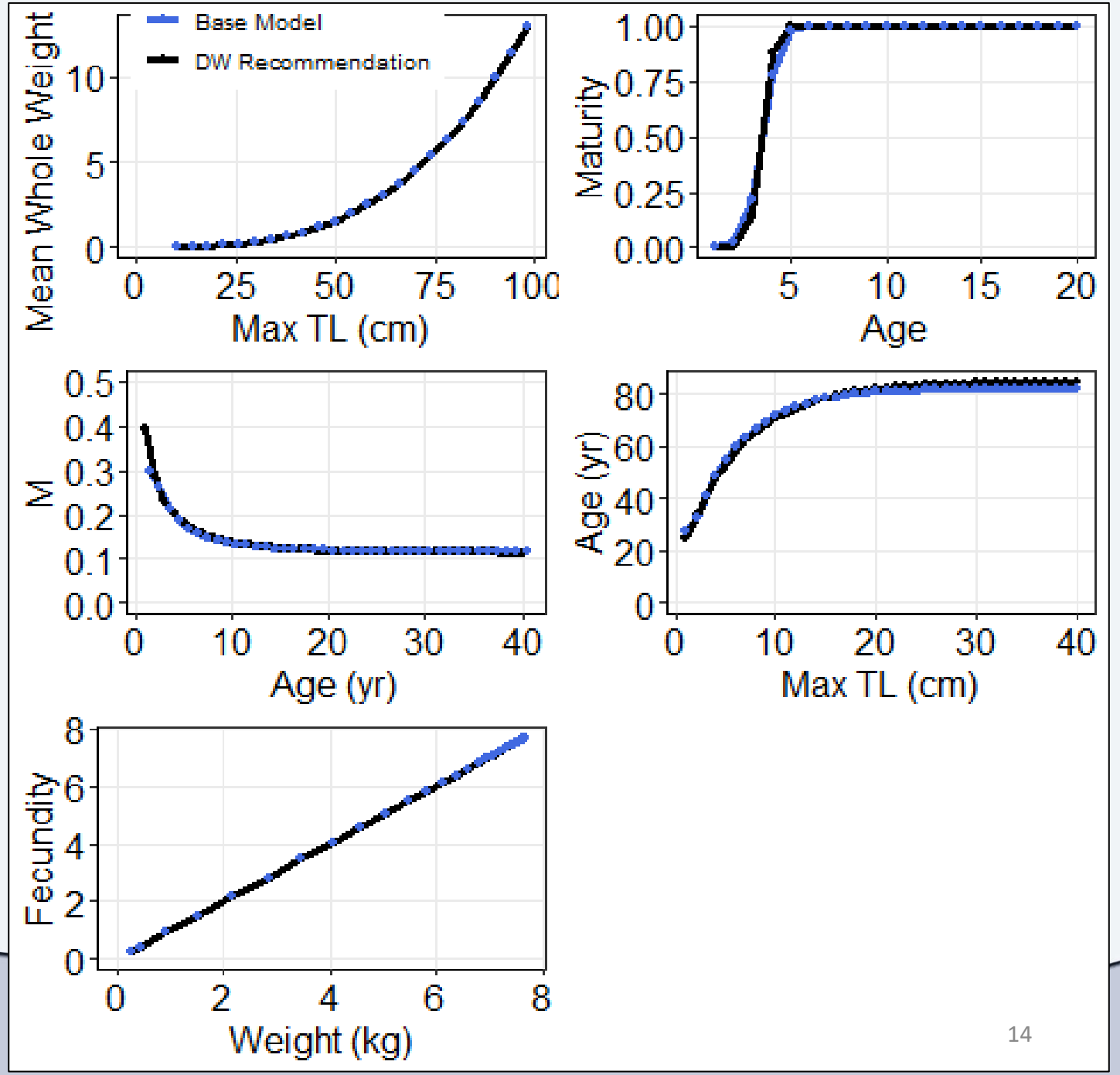


Index Selectivity (South Atlantic)

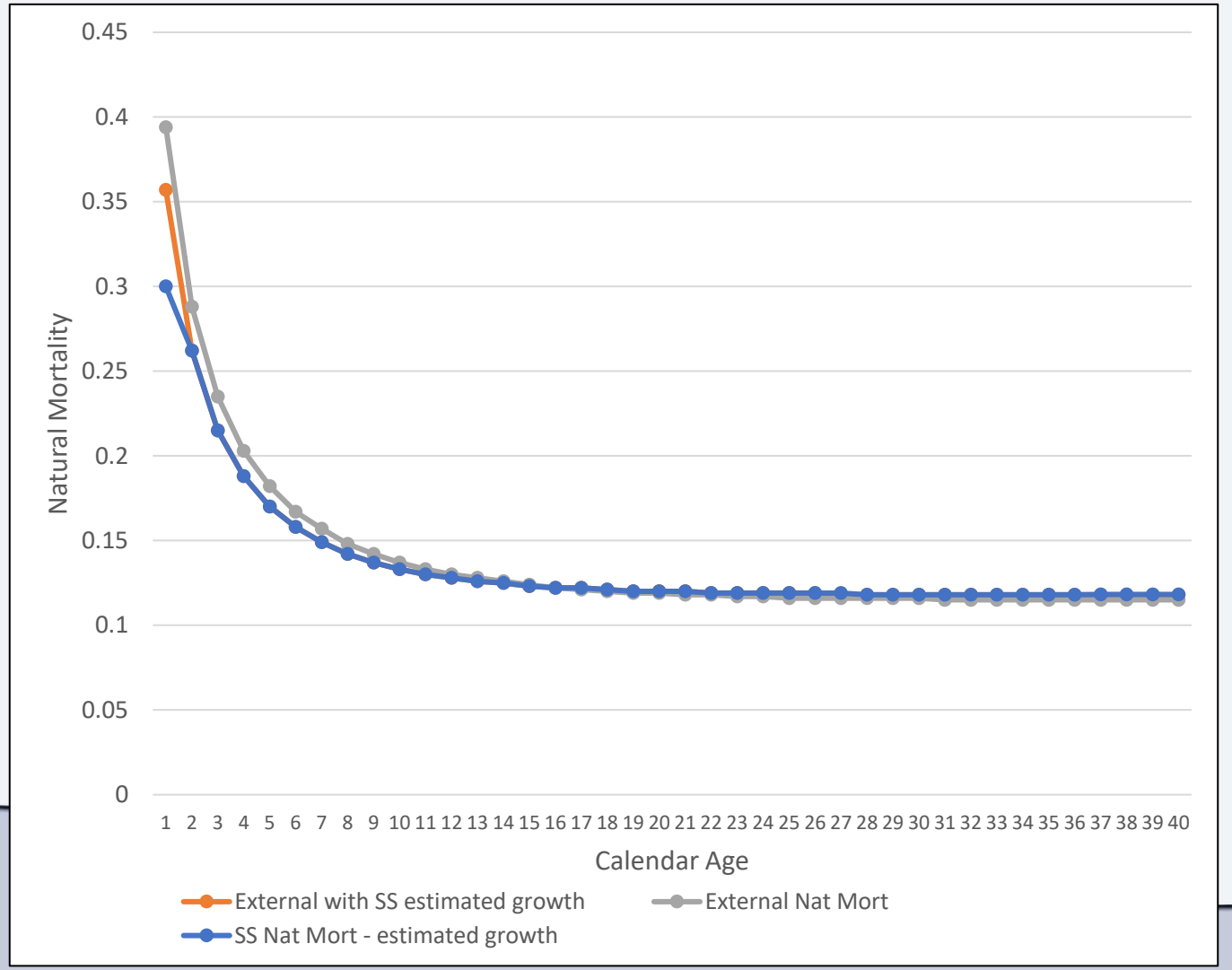




Life History



SS Natural Mortality vs External Model



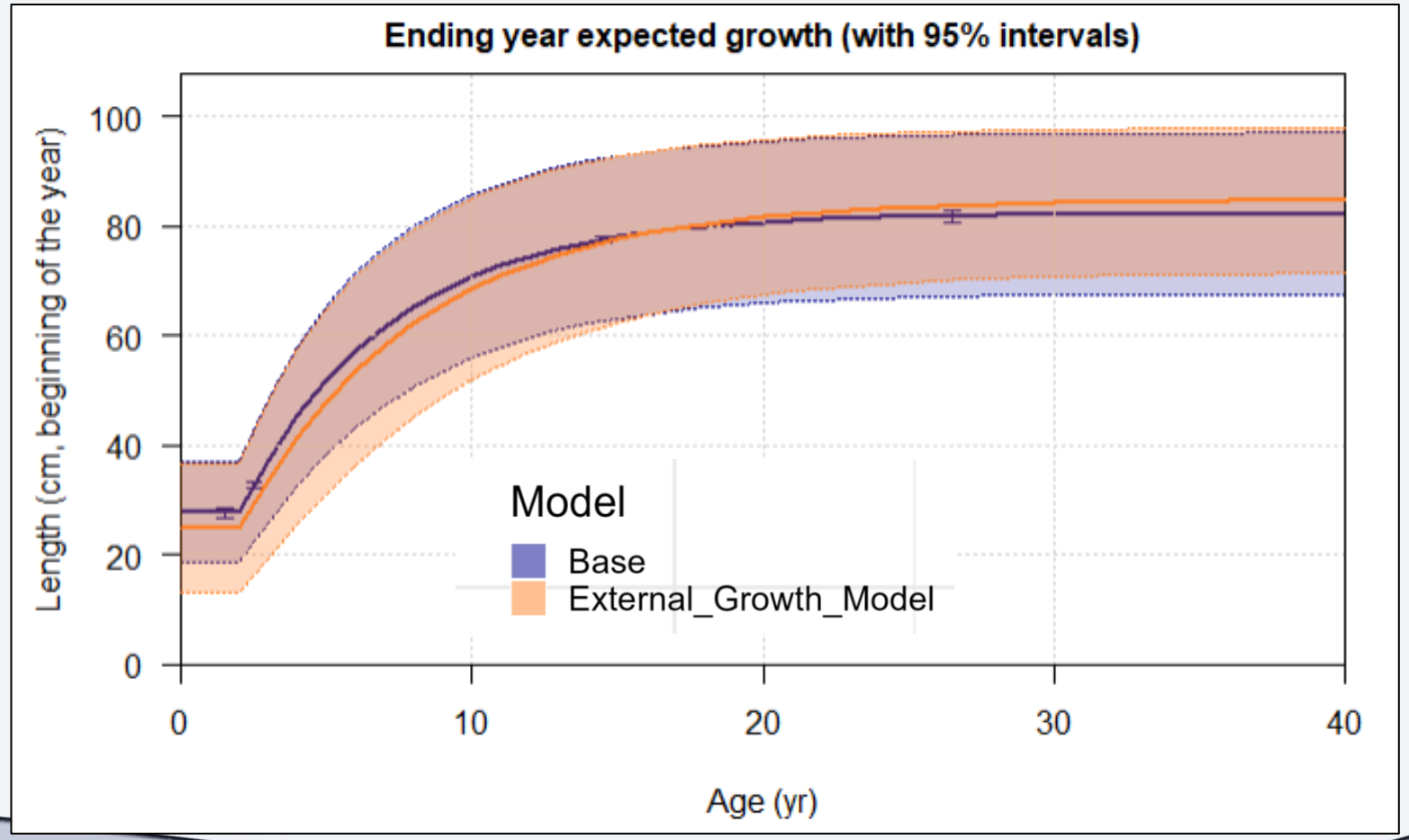
von Bertalanffy Growth Comparison

SS Model (blue)

- L_{inf}: 82.3 cm
- k: 0.195 year^{-1}
- CV_{young}: 0.17
- CV_{old}: 0.09

Size-truncated external model (pink)

- L_{inf}: 84.7 cm
- k: 0.16 year^{-1}
- CV_{young}: 0.14
- CV_{old}: 0.03



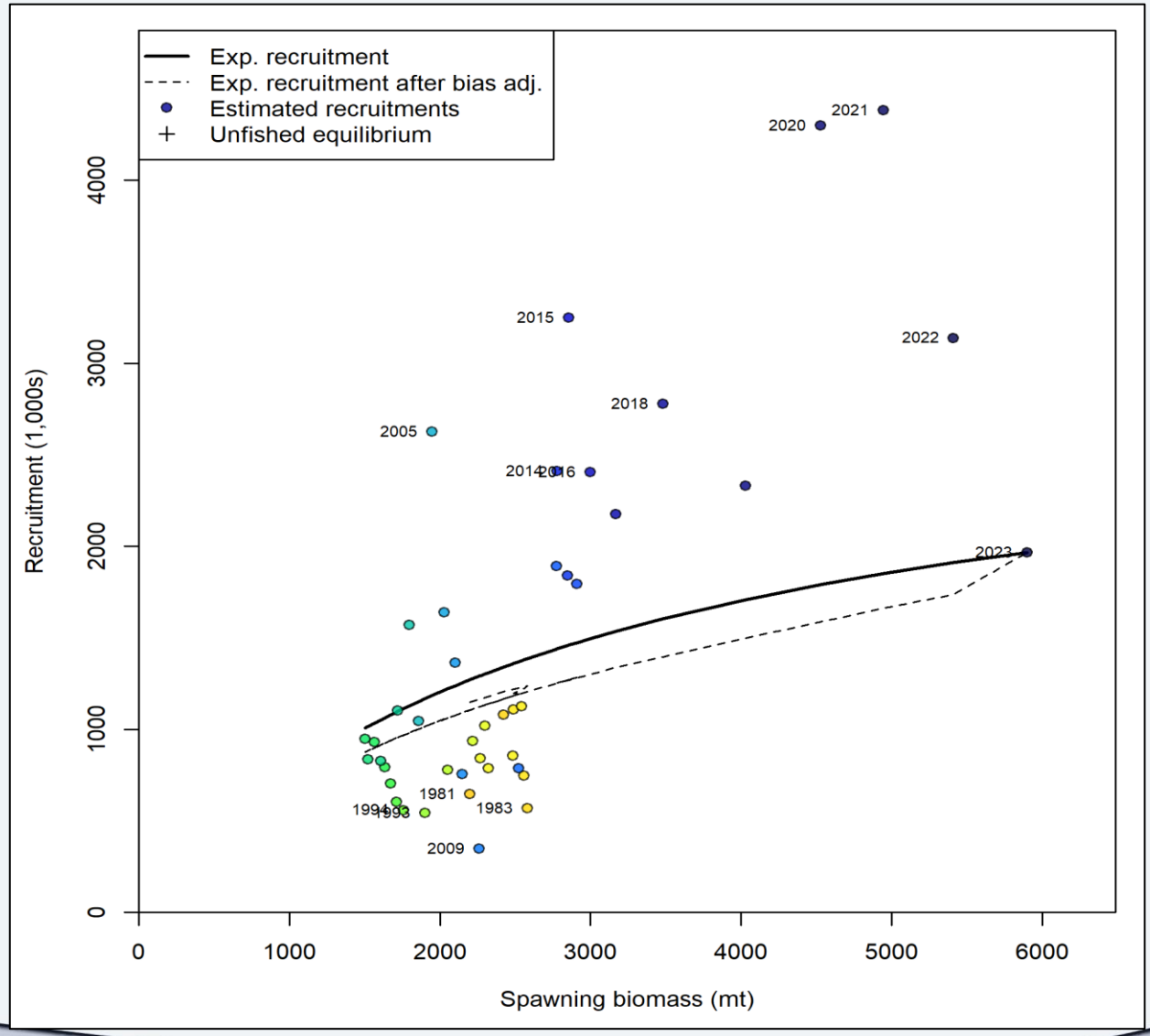
Stock Recruit Curve

SSB_0: 17,778 mt

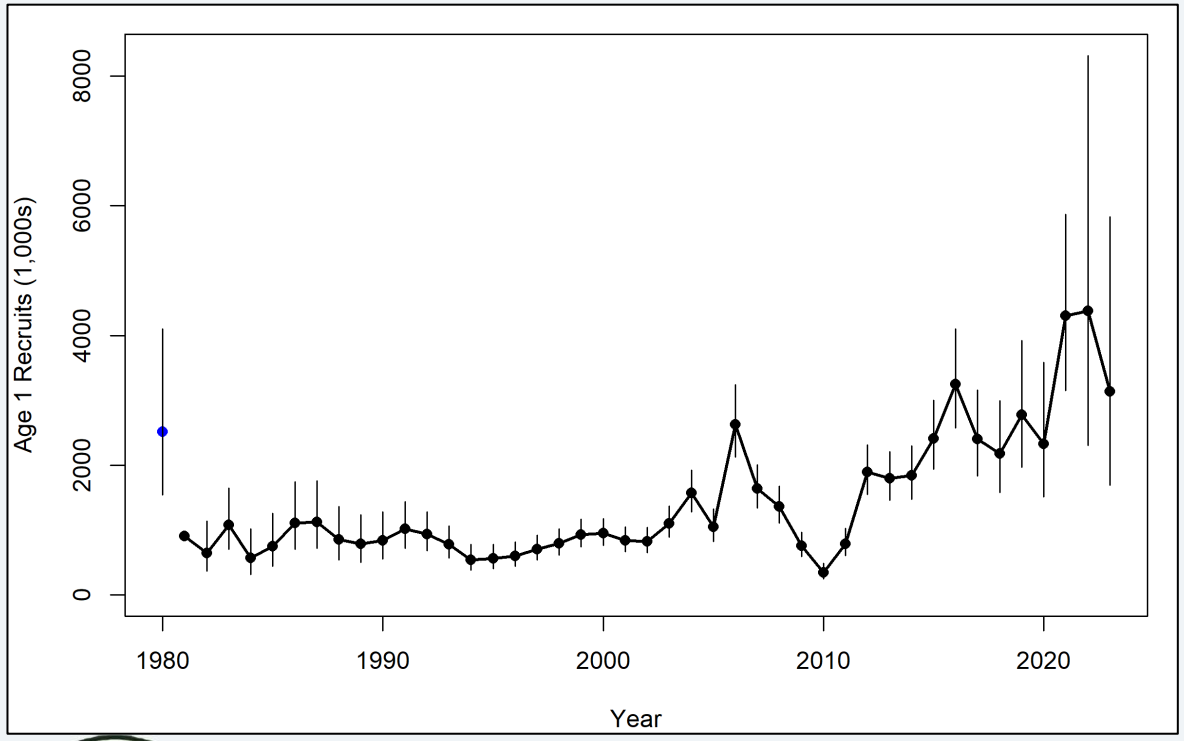
RO: 2.513 million

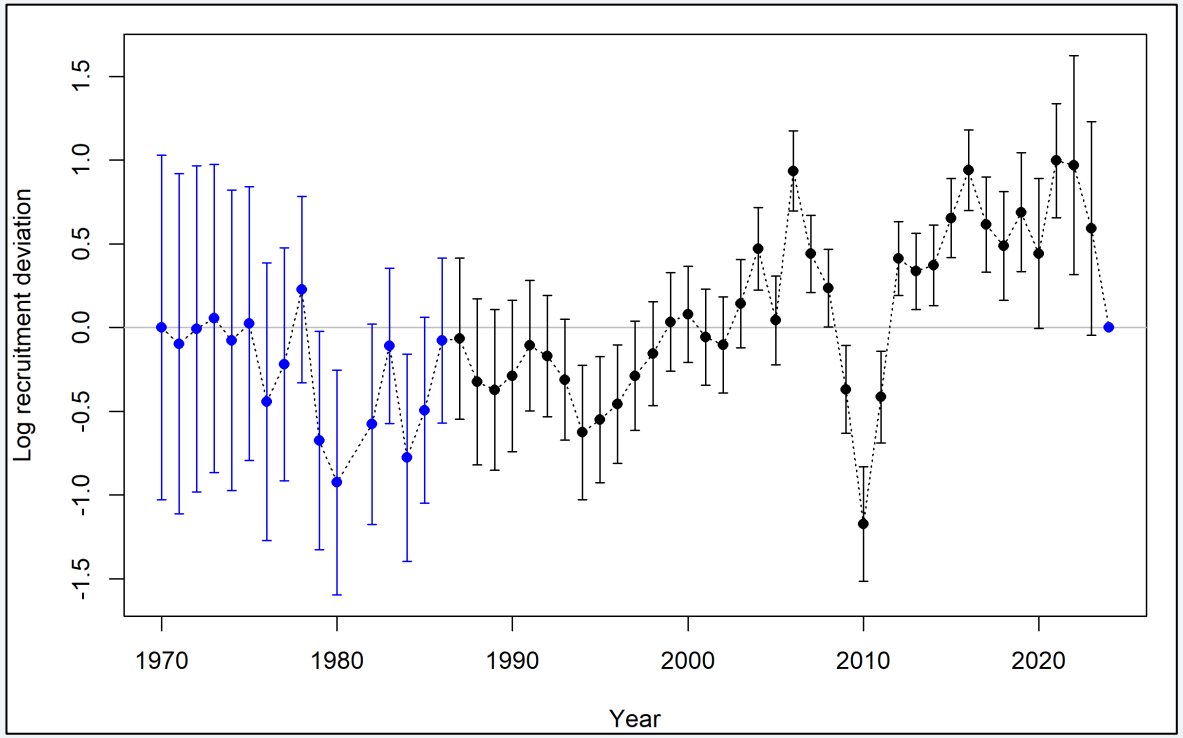
h: 0.64

σ_R: 0.55



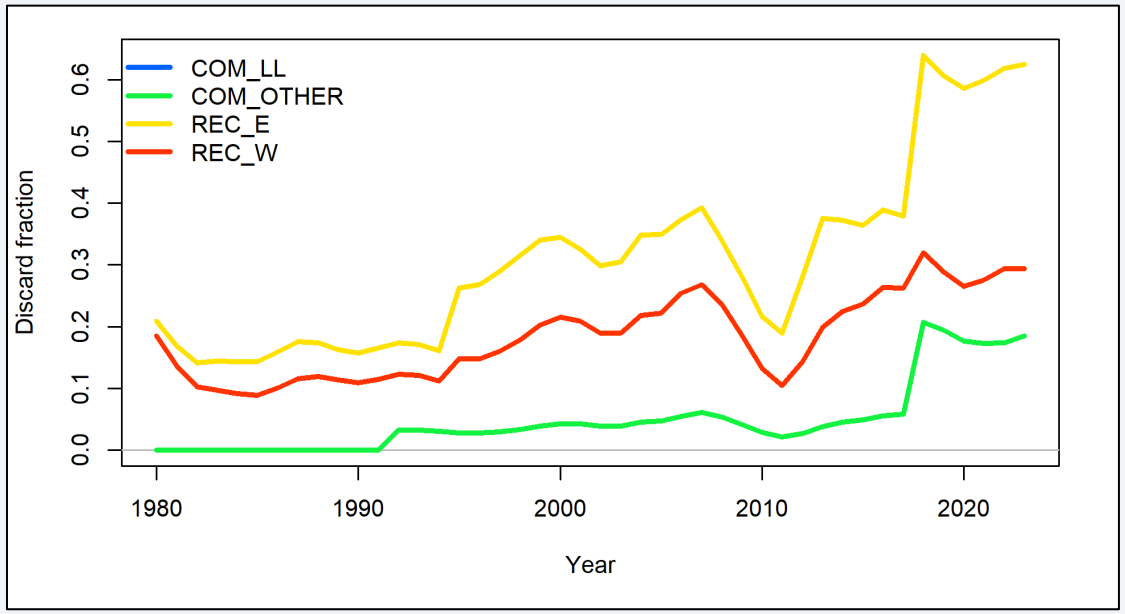
Recruits

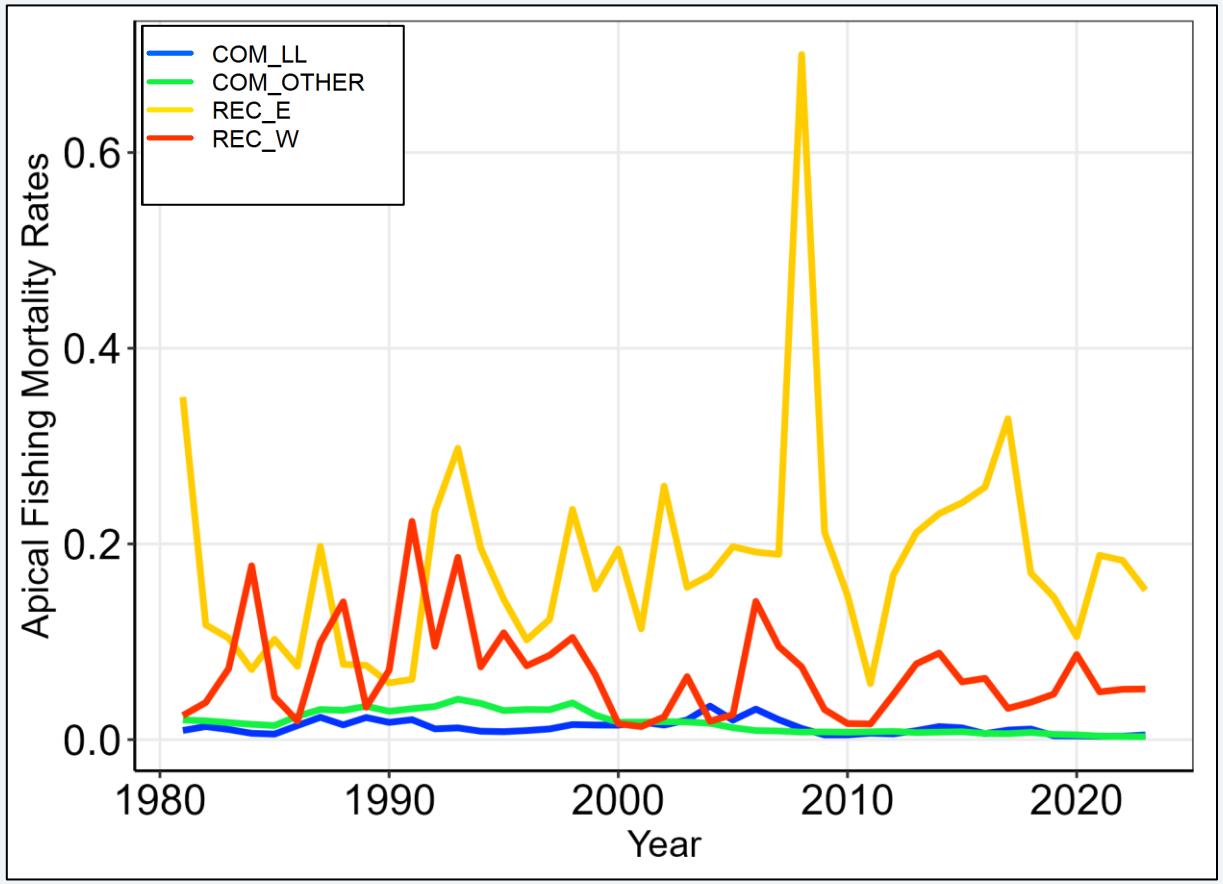

Age 1 Recruits (1,000s)
0
2000
4000
6000
8000
1980
1990
2000
2010
2020
Year


Log recruitment deviation
-1.5
-1.0
-0.5
0.0
0.5
1.0
1.5
1970
1980
1990
2000
2010
2020
Year

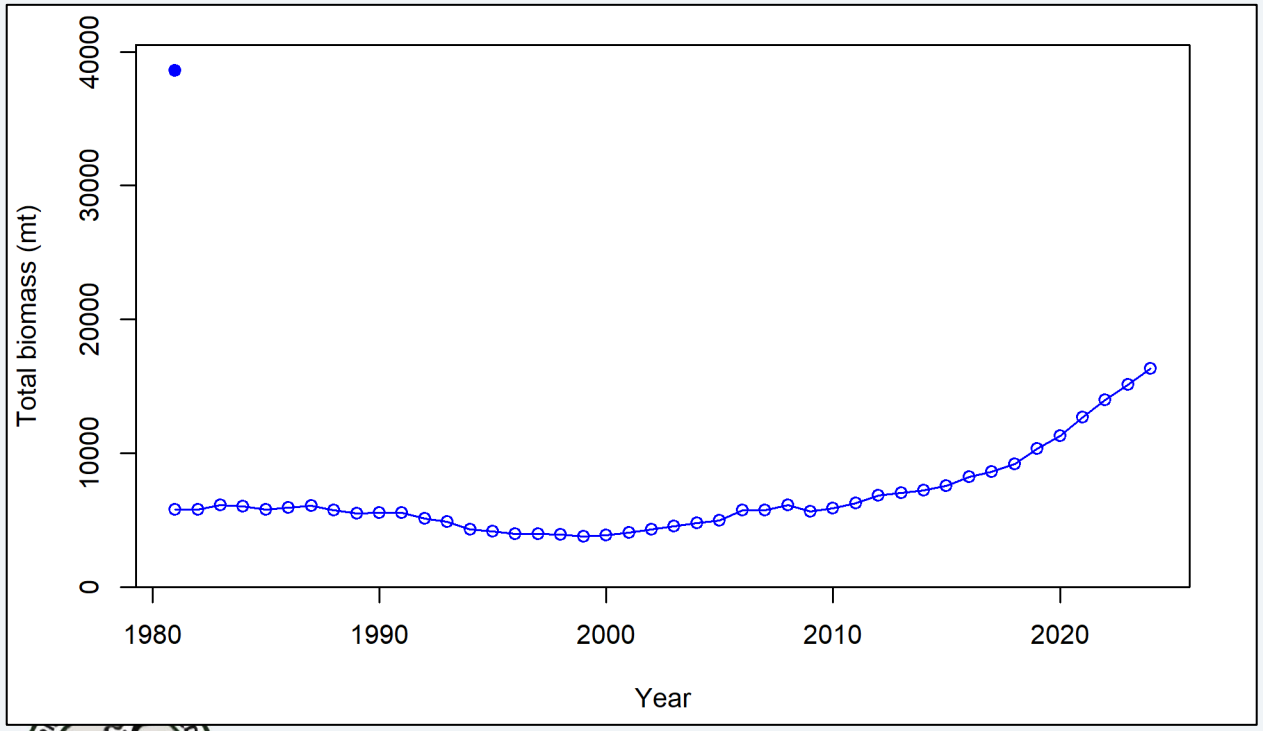
Base Model Results

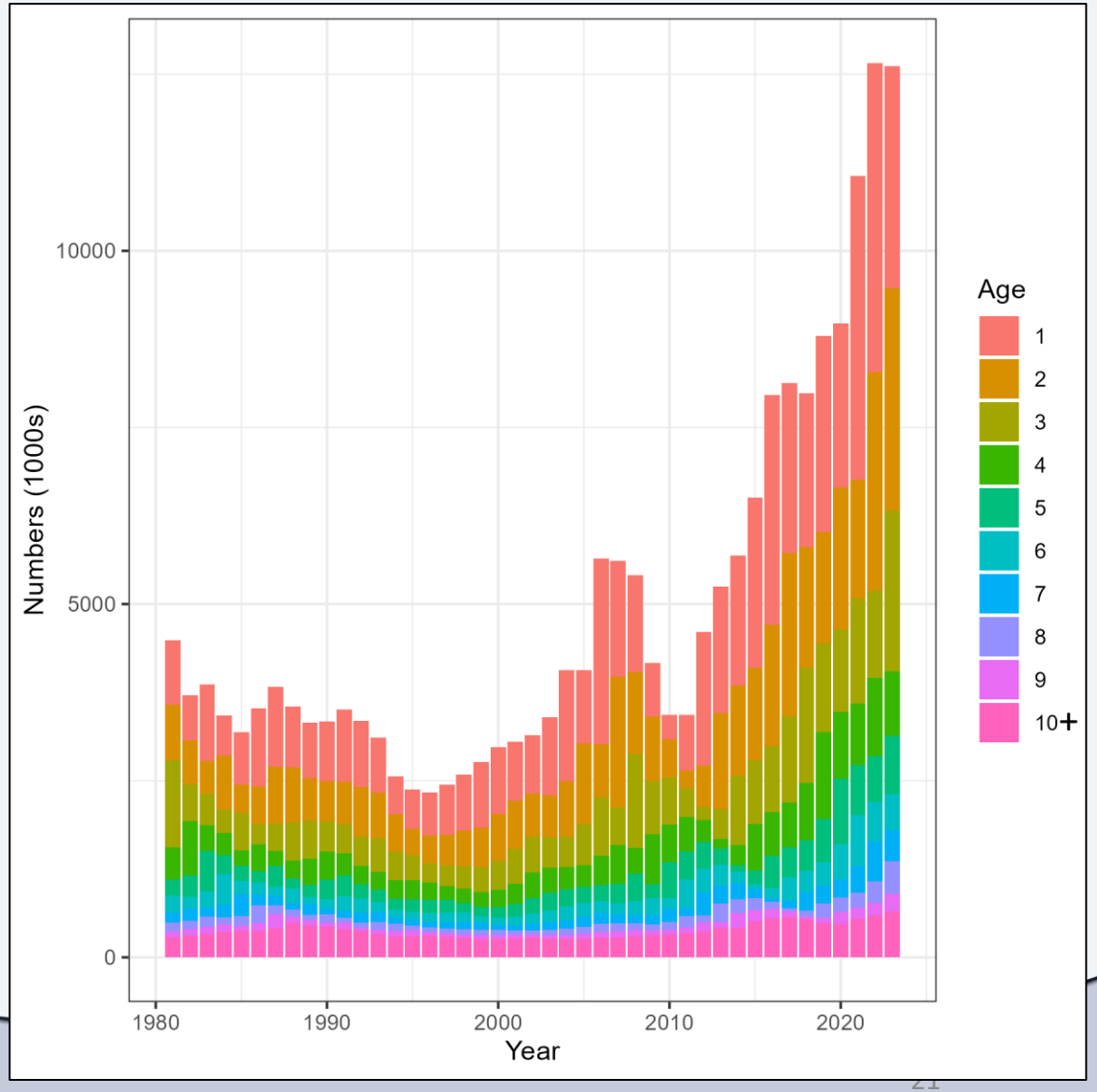
Discard Fractions and Apical Fs



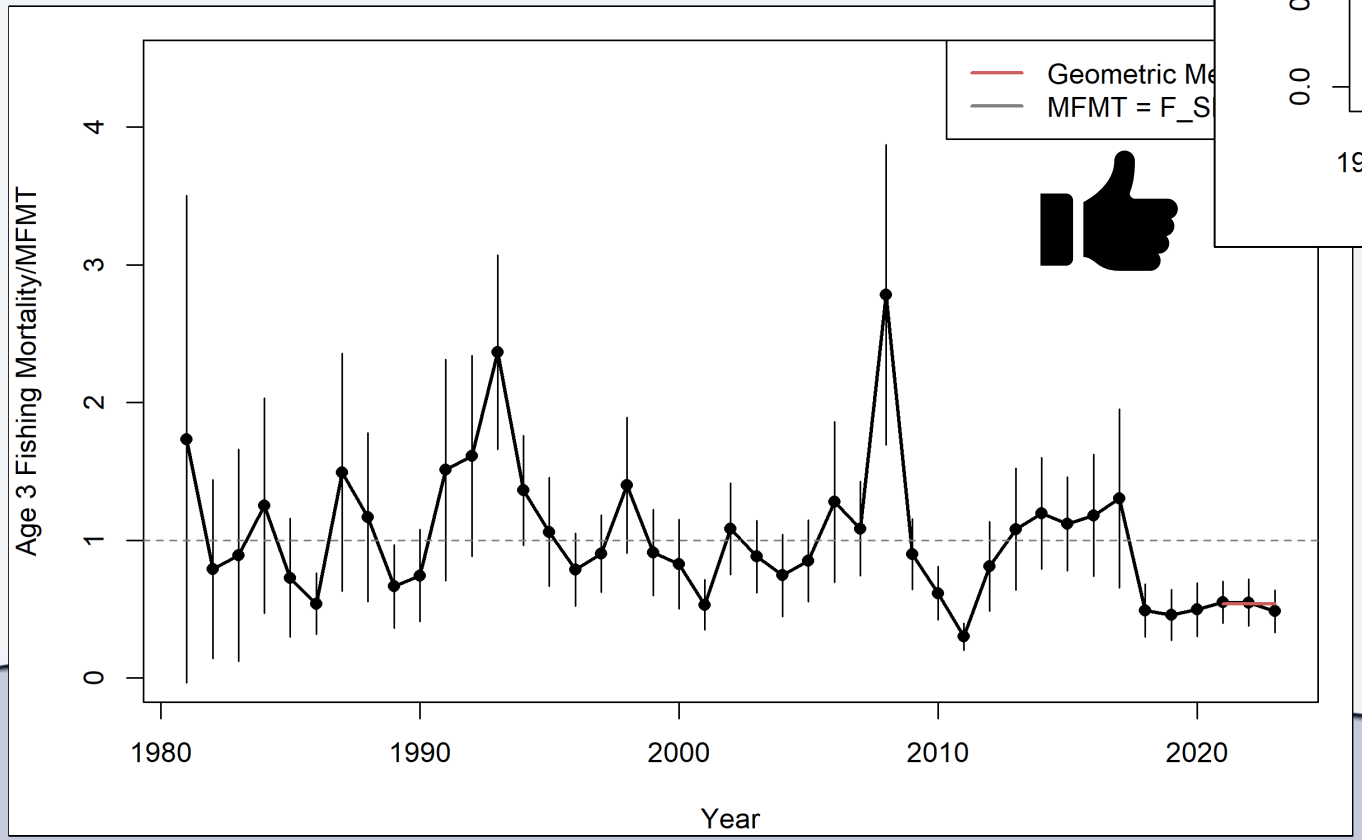


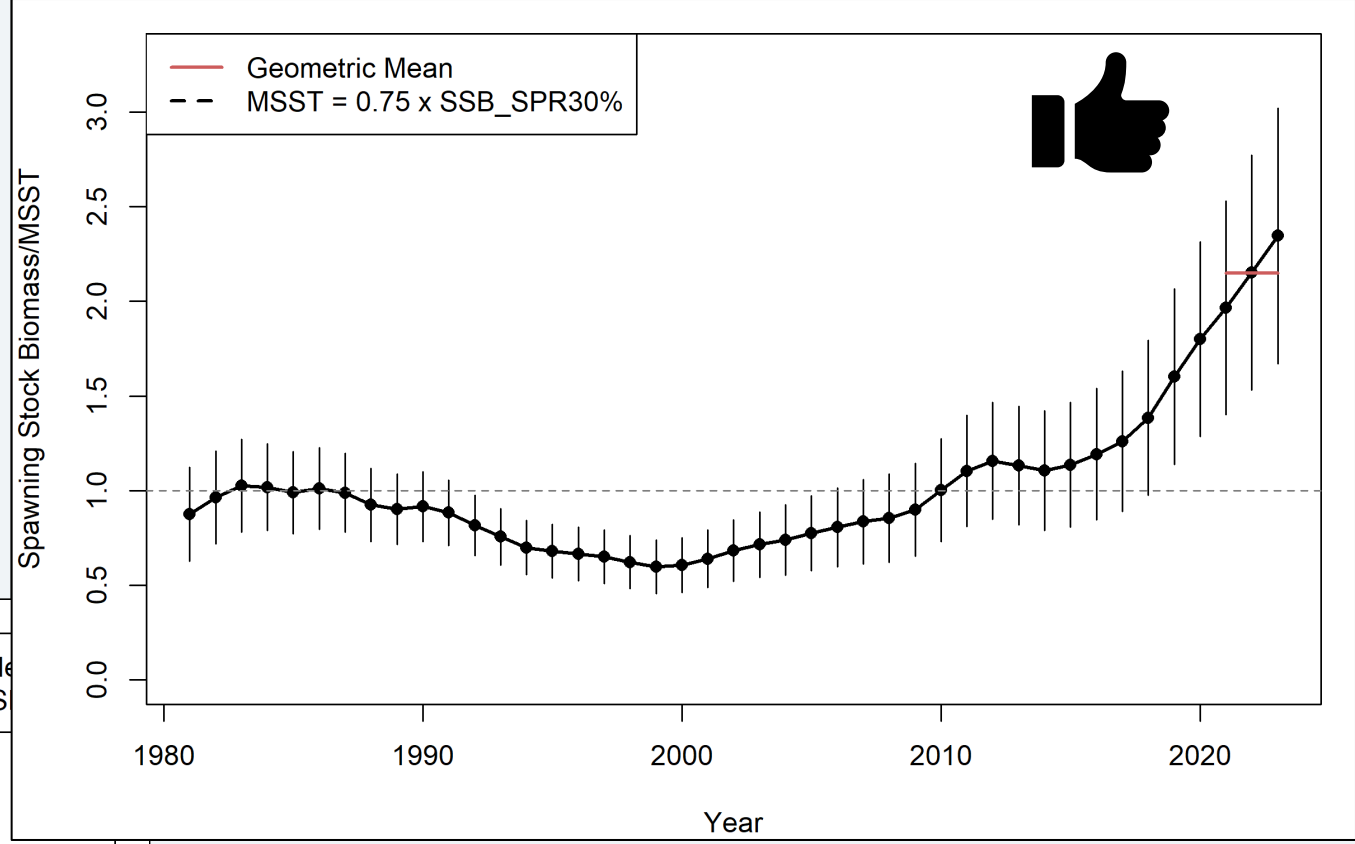
Total Biomass and Numbers at Age



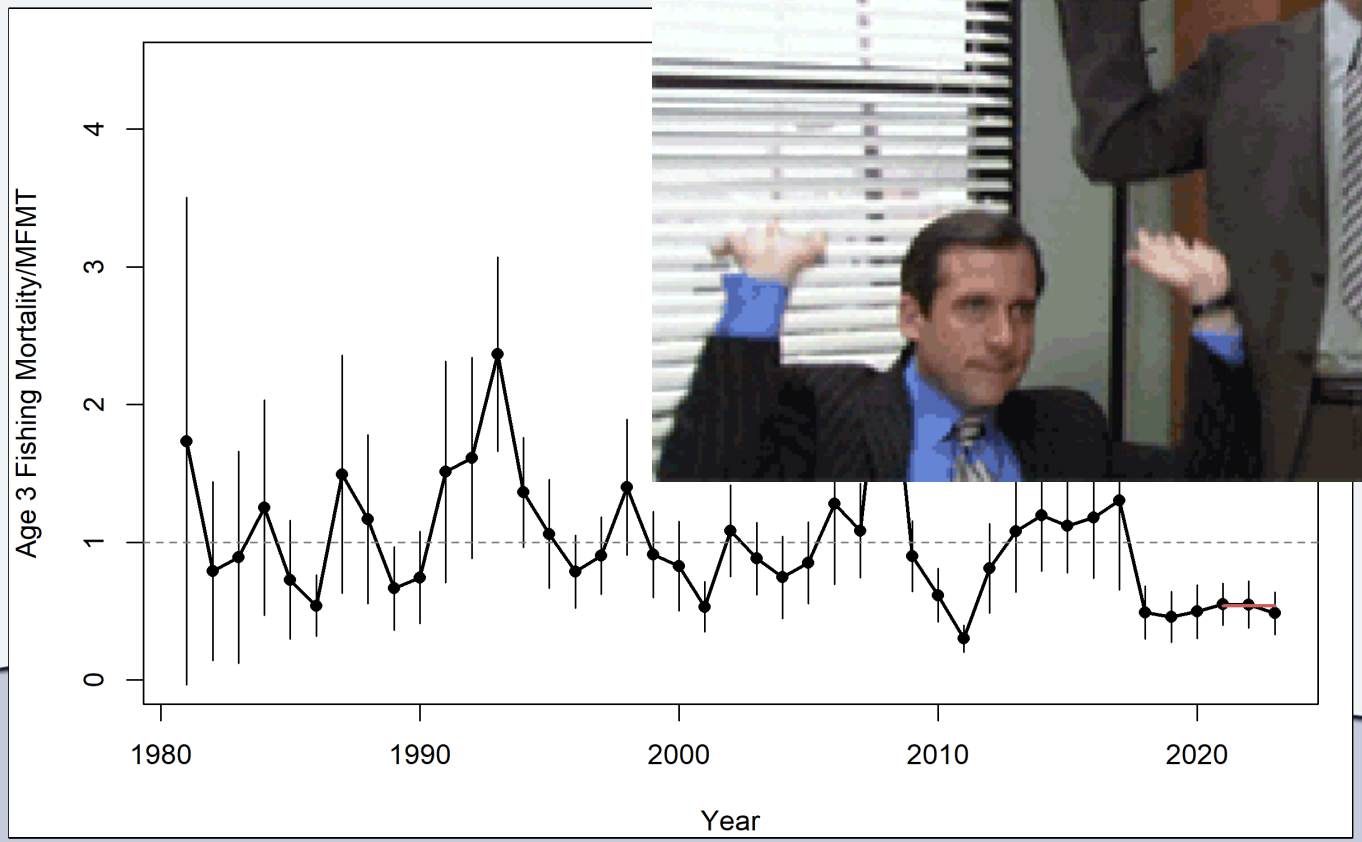


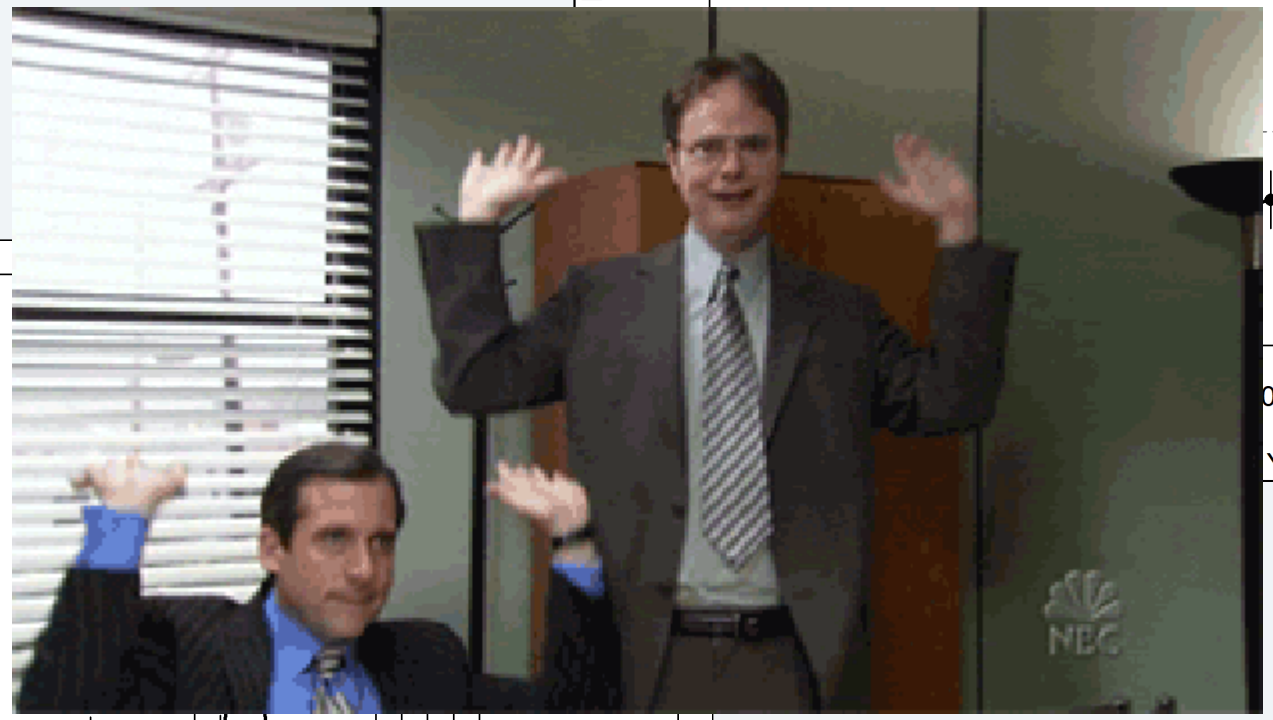
Results

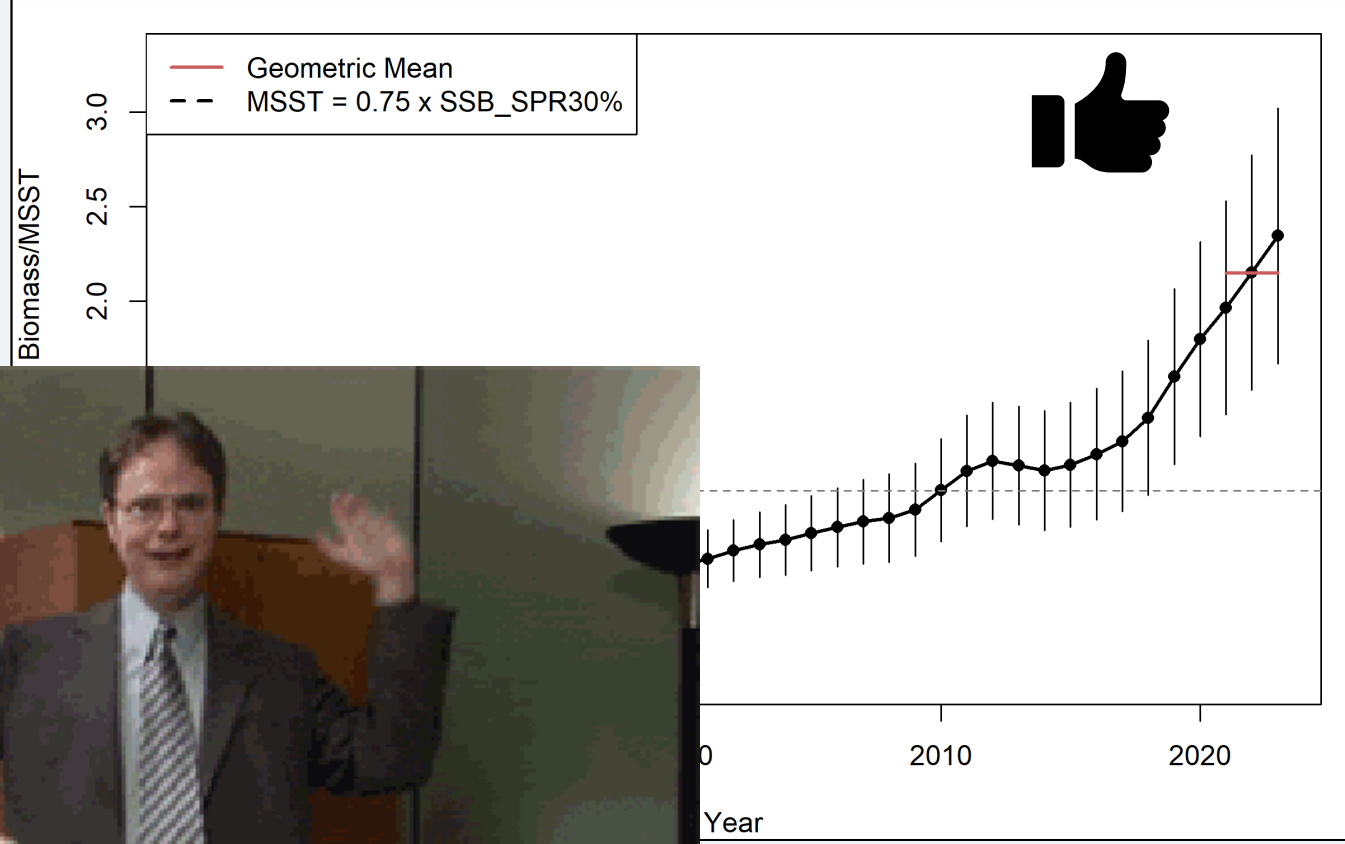

Geometric Me
MFMT = F_S
Age 3 Fishing Mortality/MFMT
0
1
2
3
4
1980
1990
2000
2010
2020
Year


Geometric Mean
MSST = 0.75 x SSB_SPR30%
Spawning Stock Biomass/MSST
0.0
0.5
1.0
1.5
2.0
2.5
3.0
1980
1990
2000
2010
2020
Year

Results


Age 3 Fishing Mortality/MFMT
0
1
2
3
4
1980
1990
2000
2010
2020
Year


NBC


Geometric Mean
MSST = 0.75 x SSB_SPR30%
Biomass/MSST
2.0
2.5
3.0
2010
2020
Year

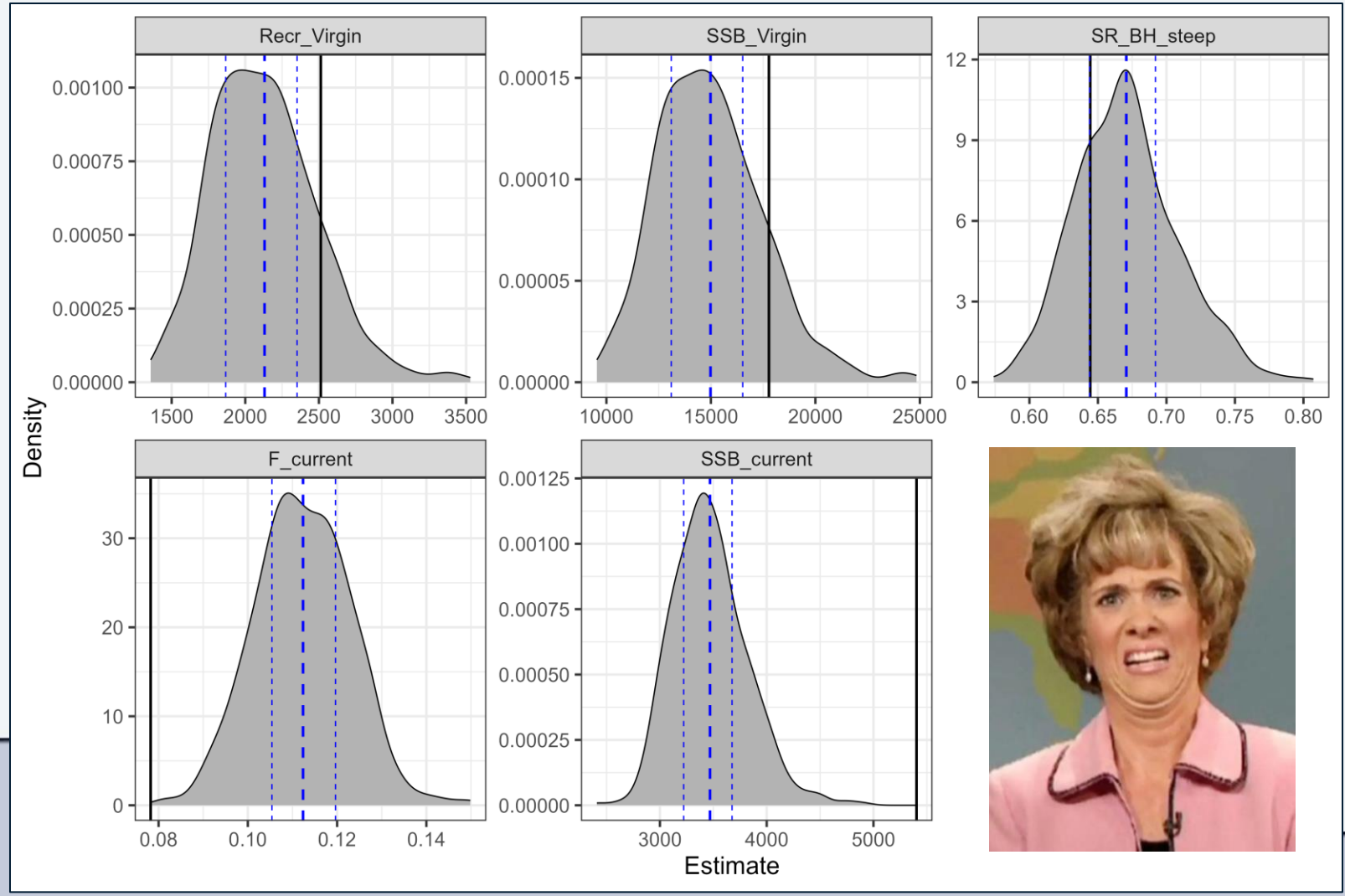
South Atlantic and Gulf of Mexico Fishery Management Councils		
Criteria	Definition	Base Model Value
$F_{30\%SPR}$	The fishing mortality rate associated with 30% SPR and the proxy used for F_{MSY}	0.149 yr^{-1}
$F_{40\%SPR}$	The fishing mortality rate associated with 40% SPR and the proxy used for F_{OY}	0.11 yr^{-1}
MFMT (Maximum Fishing Mortality Threshold)	$F_{30\% SPR}$	0.149 yr^{-1}
F_{OY}	$F_{40\%SPR}$	0.11 yr^{-1}
$F_{current}$ (recent average fishing mortality rate on age-3 fish)	The geometric mean of F on age-3 fish for 2021 - 2023	0.08 yr^{-1}
$SSB_{F30\%SPR}$	The estimated spawning stock biomass associated with F at 30% SPR	3,352 mt (7,389,895 lbs.)
MSST (Minimum Stock Size Threshold)	$0.75*SSB_{F30\%SPR}$	2,514 mt (5,542,421 lbs.)
$SSB_{current}$ (recent average of SSB)	The geometric mean of SSB for 2021 - 2023	5,403 mt (11,911,576 lbs.)
MSY proxy (Maximum Sustainable Yield Proxy)	Yield at $F_{30\%SPR}$	681.87 mt (1,503,266 lbs.)

MCMC Analysis

MCMC Analysis

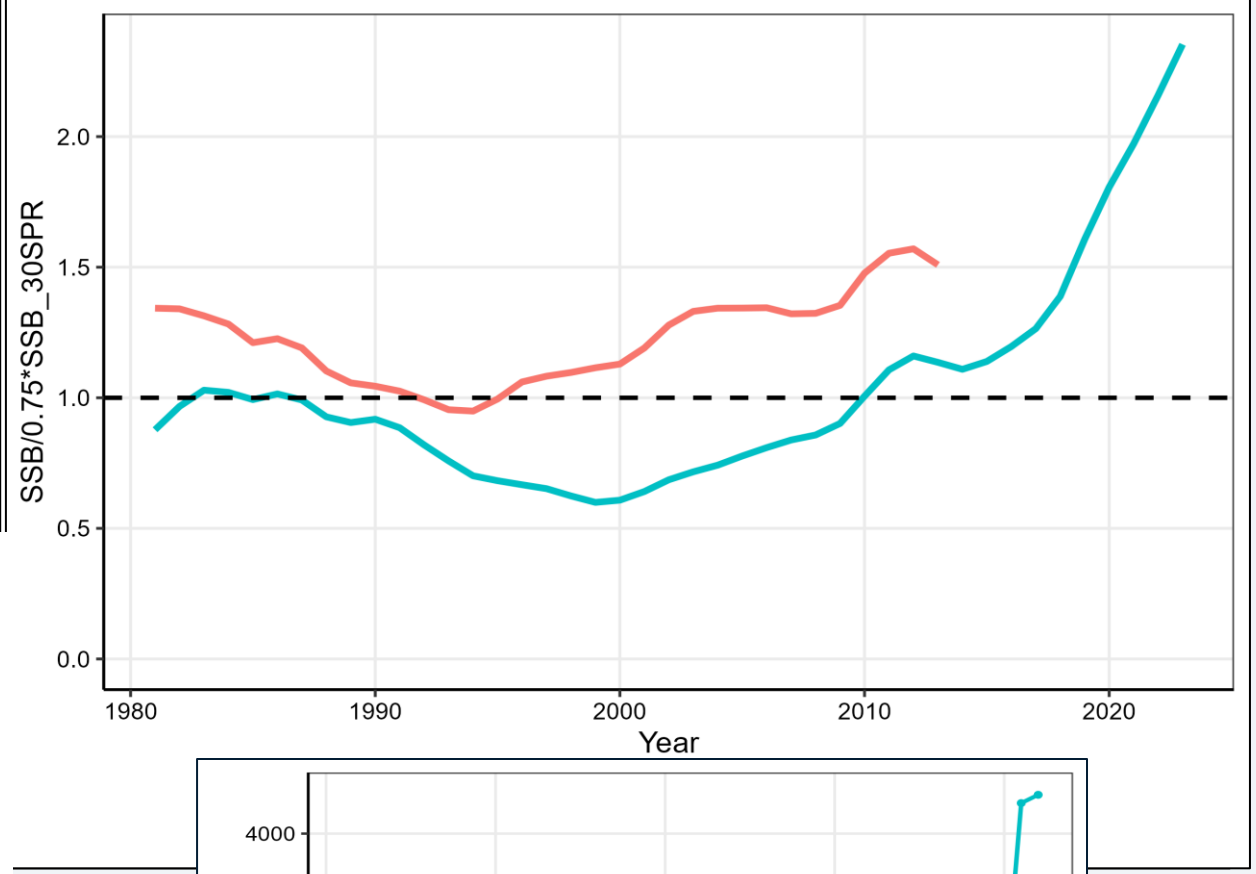
- Generate posterior distributions of model parameters and derived quantities
- Due to time constraints only a single converged chain of MCMC draws was produced
  - 563 iterations saved from 10,000,000 (500 burn in)
- Single-chain convergence assessed using Geweke's diagnostic to determine whether the mean of the first 10% of the chain is not significantly different from the last 50% of the chain. Also visually reviewed trace plots

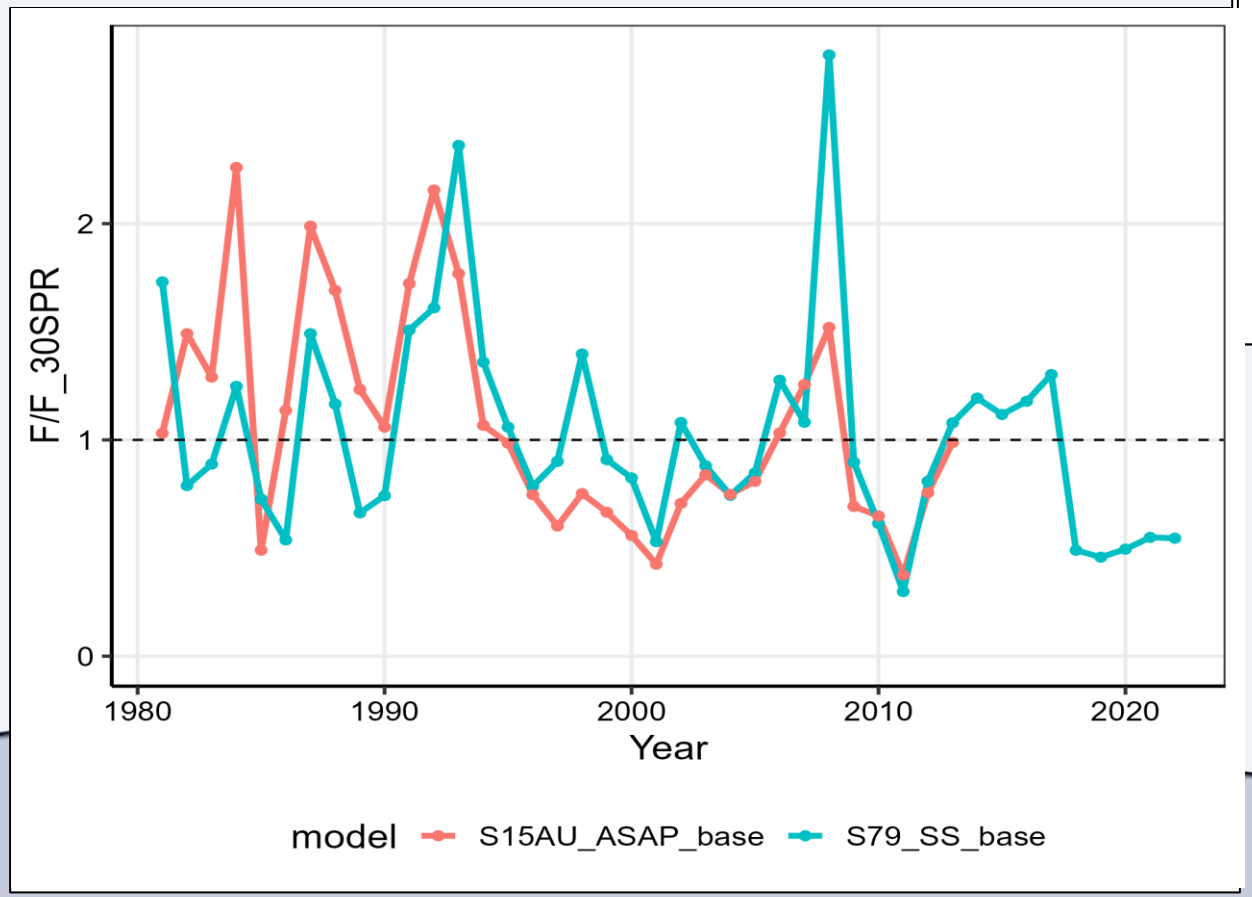
MCMC Analysis

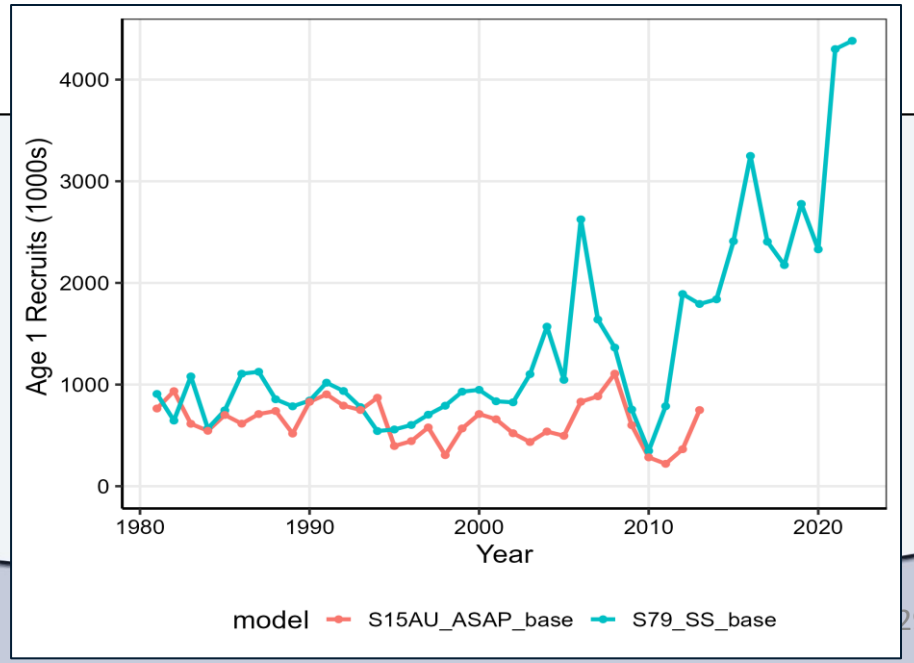


Comparison to SEDAR 15AU

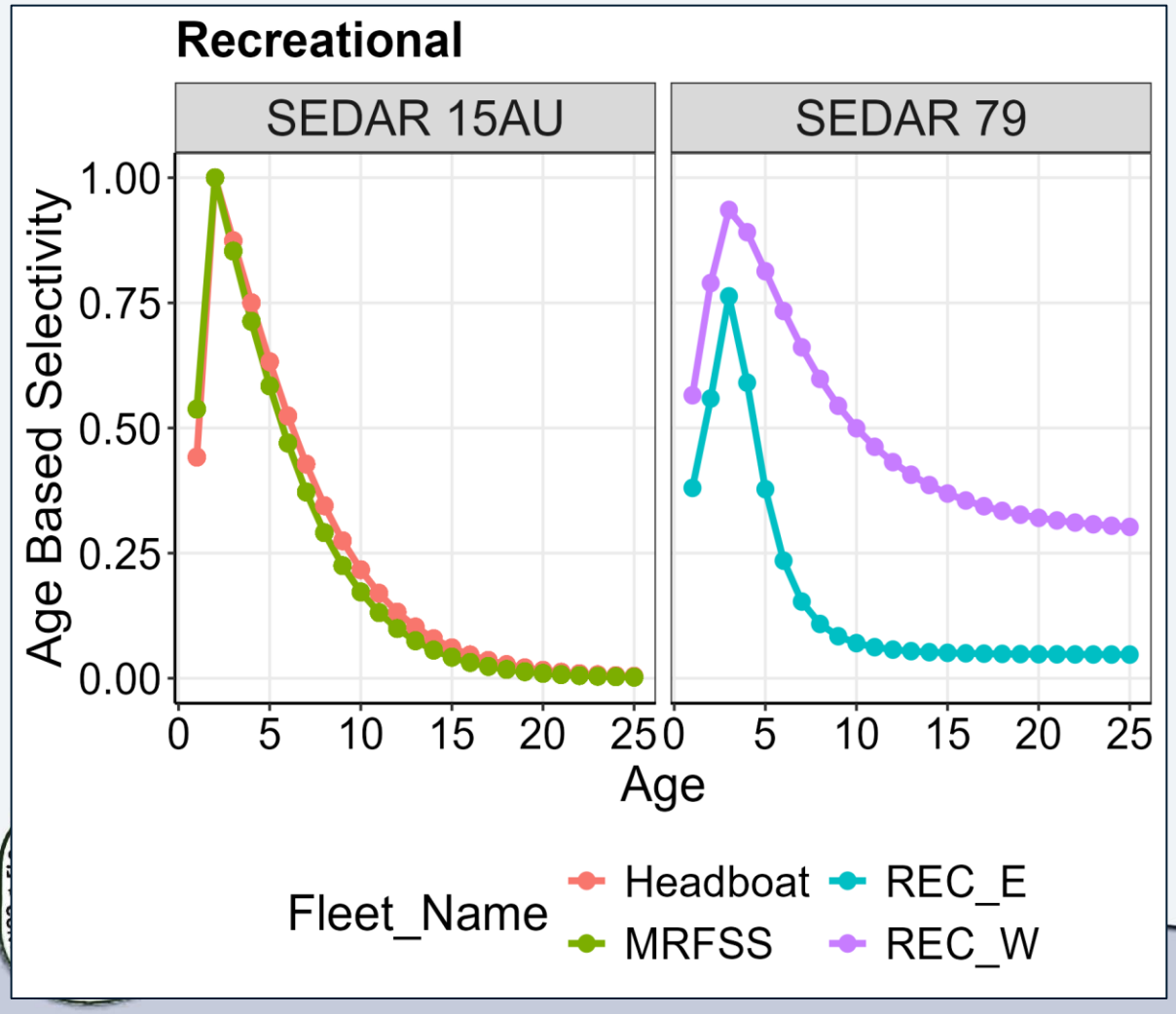
S79 Base Model vs S15AU

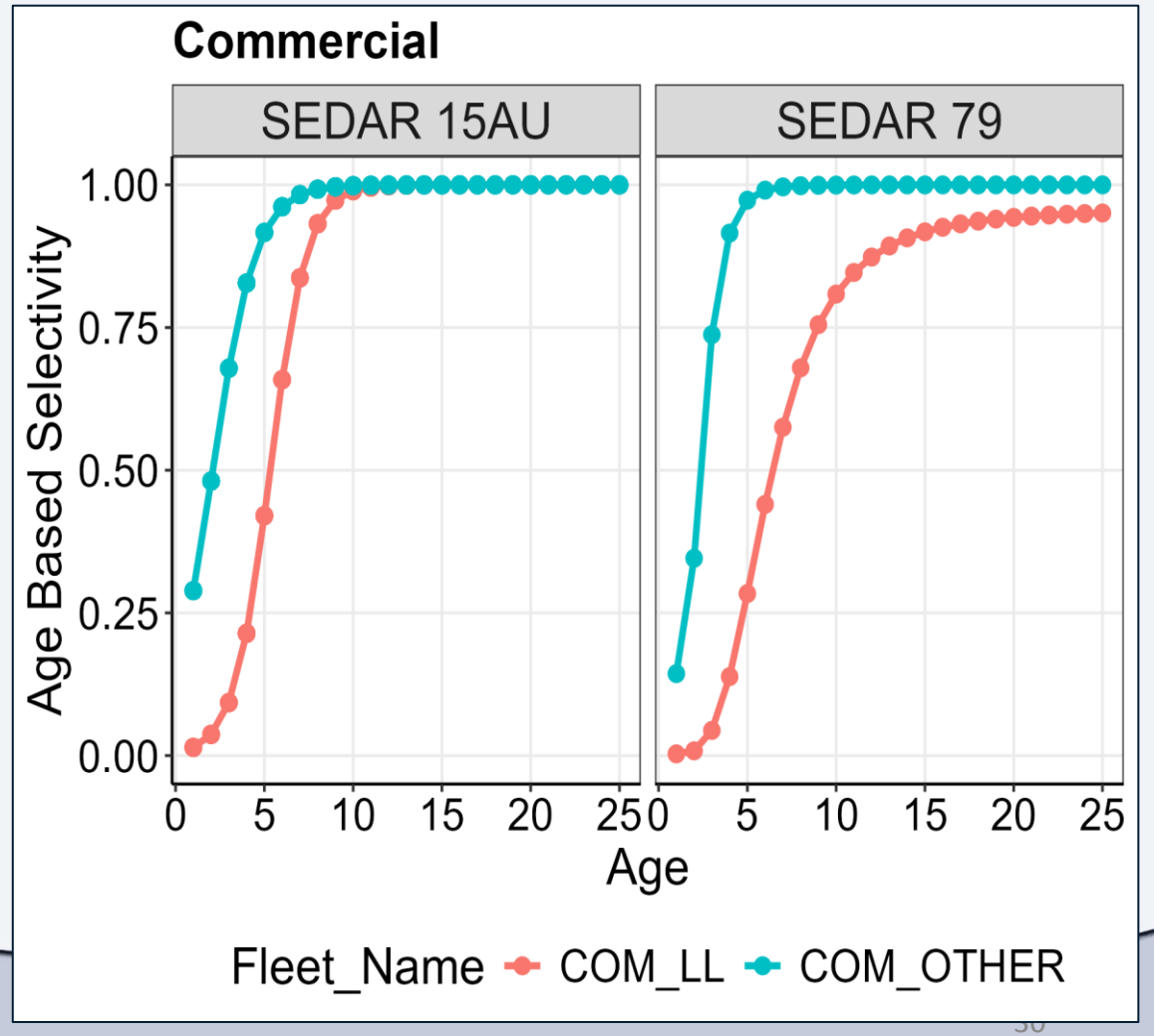






S79 Base Model vs S15AU Selectivity





Mutton Snapper Management Quantities			
Quantity	**Definitions**	**S15AU (CHTS)**	**S79 (MRIP-FES & SRFS)**
Log(R0)	Log(Unfished Recruitment)	6.568	7.83
h	Steepness	0.81	0.64
2013 Conditions	Spawning Stock Biomass in 2013	5.26 mp	6.27 mp
	age-3 F in 2013	0.18 yr-1	0.16 yr-1
$F_{30\%SPR}$	The fishing mortality rate associated with 30% SPR	0.18 yr^{-1}	0.14 yr^{-1}
$F_{40\%SPR}$	The fishing mortality rate associated with 40% SPR	0.13 yr^{-1}	0.11 yr^{-1}
$SSB_{30\%SPR}$	Spawning Stock Biomass associated with 30% SPR	4.65 mp	7.37 mp
Retained Yield @ $F_{30\%SPR}$	Equilibrium Value	0.91 mp	1.56 mp
Retained Yield @ $F_{40\%SPR}$	Equilibrium Value	0. 87 mp	?
MSST (Minimum Spawning Stock Threshold	$0.75*SSB_{30\%SPR}$		5.53 mp
	$(1-0.11)*SSB_{30\%SPR}$	4.14 mp	

Base Model Diagnostics

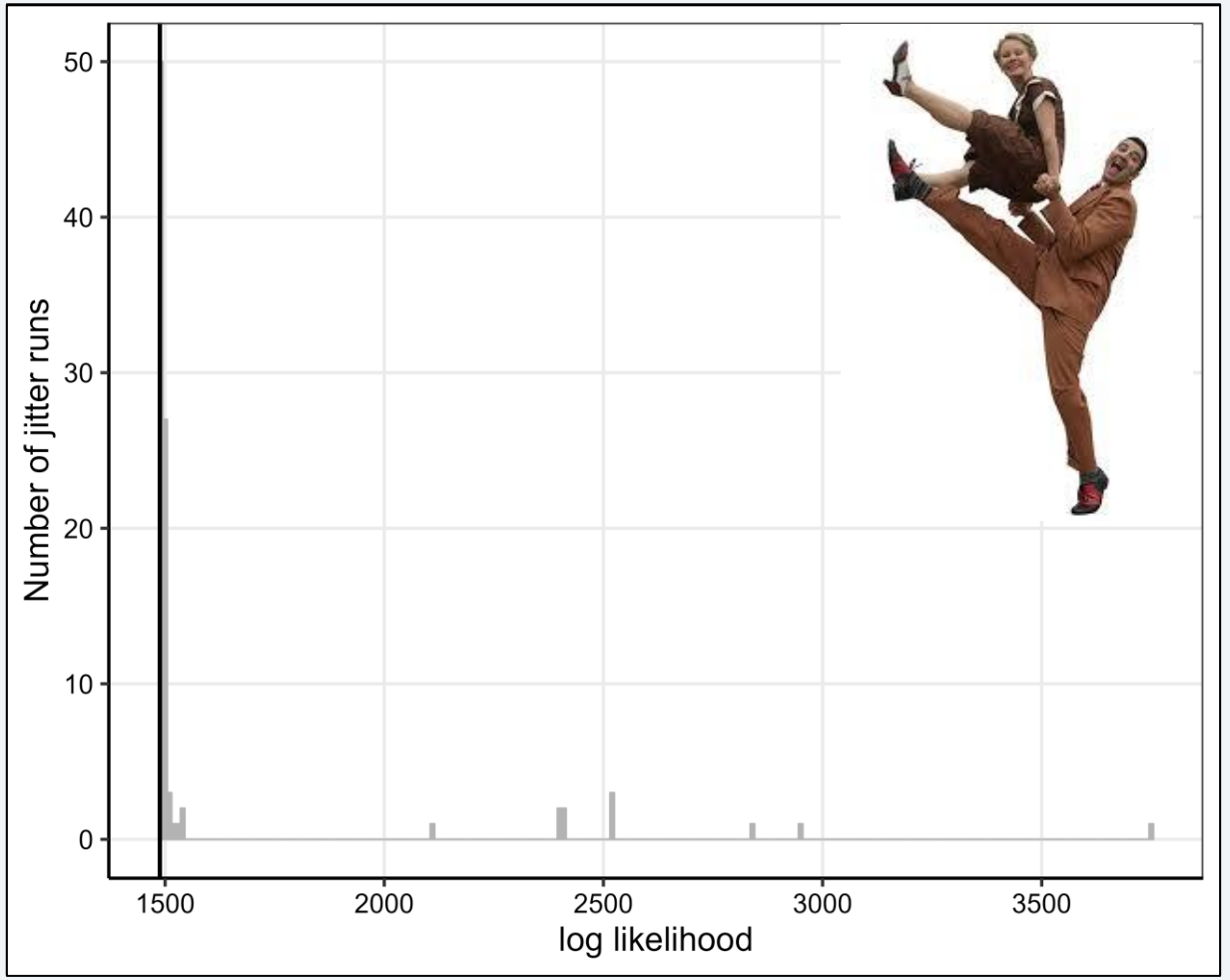
Model Diagnostics*

- Uncertainty and Correlation Analysis of Estimated Parameters
- Goodness of Fit and Residual Analysis (Runs Test)
- Model Convergence (Jitter Analysis)
- Model Consistency (retrospective analysis)
- Model Validation/Prediction Skill (via hindcast cross-validation)
- Likelihood Profiling on R0, Steepness, Base M
- Compare to an age-structured production model (ASPM)
- Sensitivity Runs
  - Release Mortality
  - Steepness=1
  - Jack-Knife Index Analysis (leave one index out)
  - MRIP-FES Rec Landings and Releases
  - Remove FIM YOY and COM LL
  - Start Year = 1986

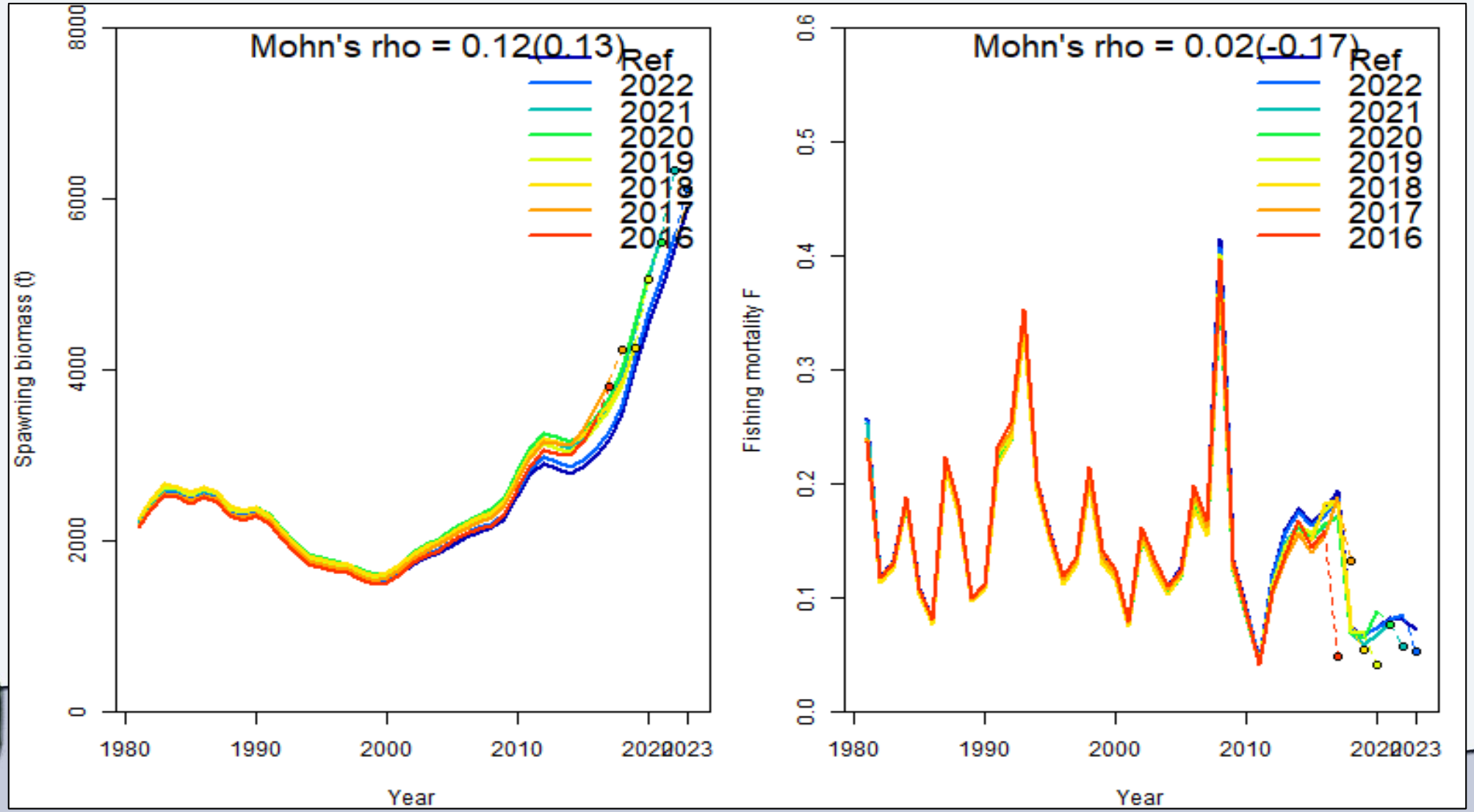
*Carvalho et al., 2021. A cookbook for using model diagnostics in integrated stock assessments. *Fisheries Research*, 240

Jitterbug Analysis

- Jittered starting values 10% for 200 runs
- Only 5 runs had max gradient < 0.0001
- 95 runs had max gradient < 0.05
- **No run had a LL value less than the base model**



Retrospective Analysis



Prediction Skill (9 yr hindcast cross validation)

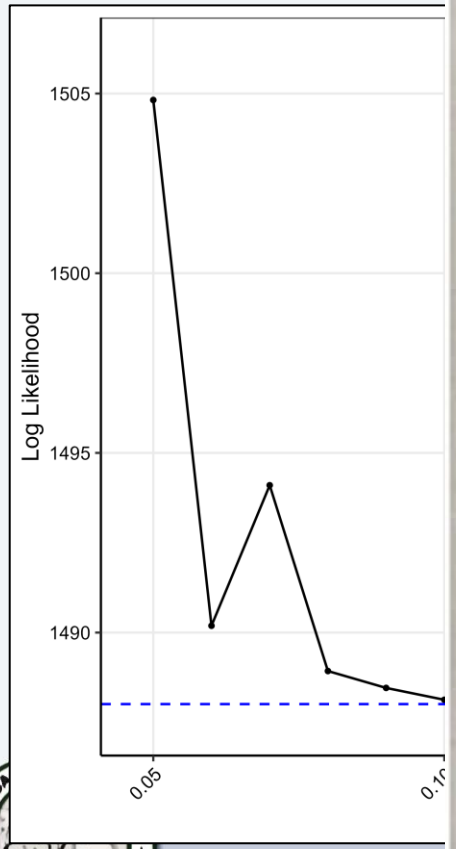
MASE (Mean Absolute Scaled Error) = Average of mean absolute error of prediction residuals (MAE.PR)/Naive Predictions (MAE.base)

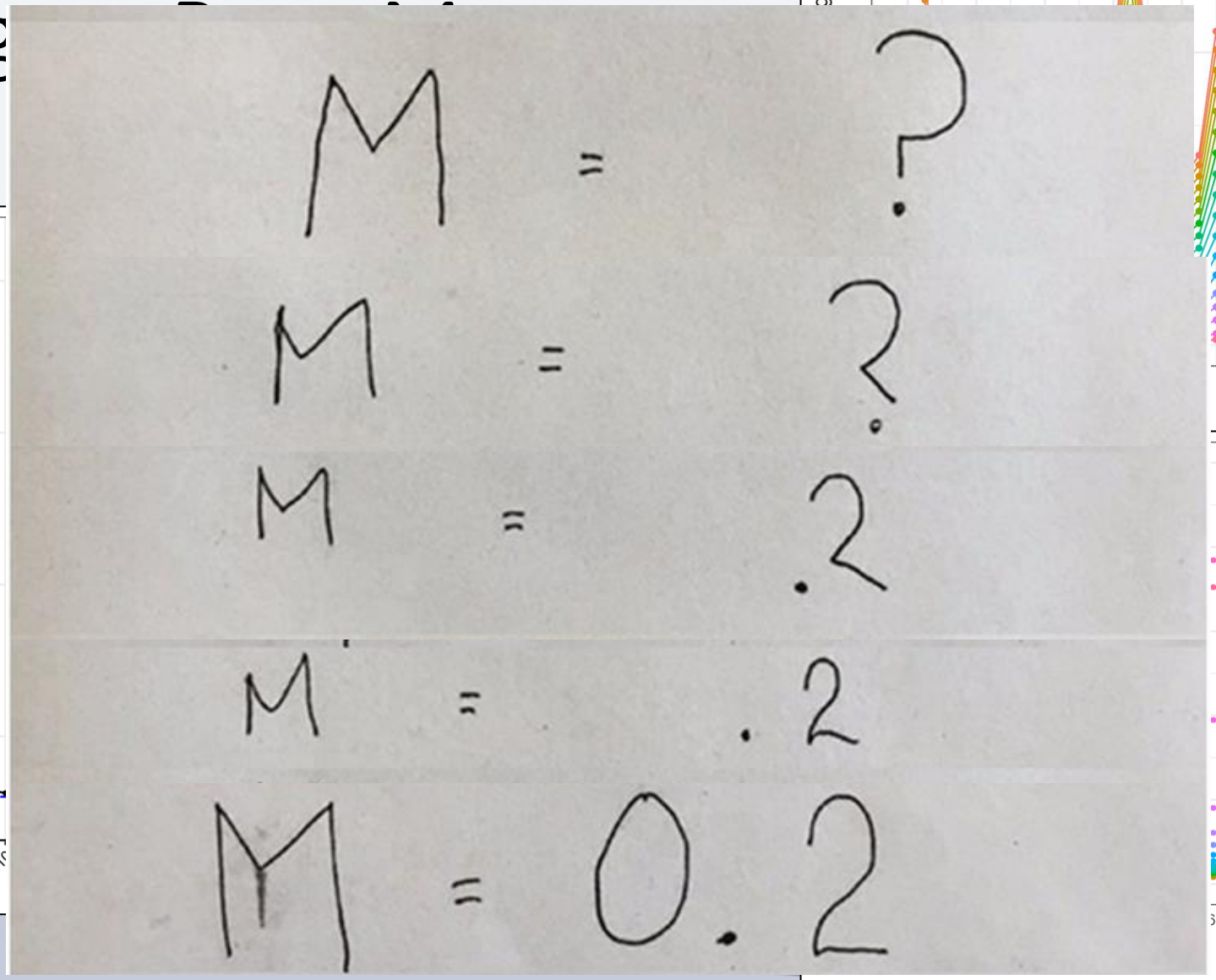
Index	MASE	MAE.PR	MAE.base	N_years
RVC_DT	0.47	0.22	0.48	4
RVC_KEYS	1.16	0.21	0.18	3
RVC_SEFL	1.88	0.60	0.32	5
FIM_YOY	0.54	0.48	0.88	8
GOM_VID	1.17	0.46	0.39	7
SERFS_VID	0.74	0.34	0.46	7
Joint	0.81	0.41	0.50	34

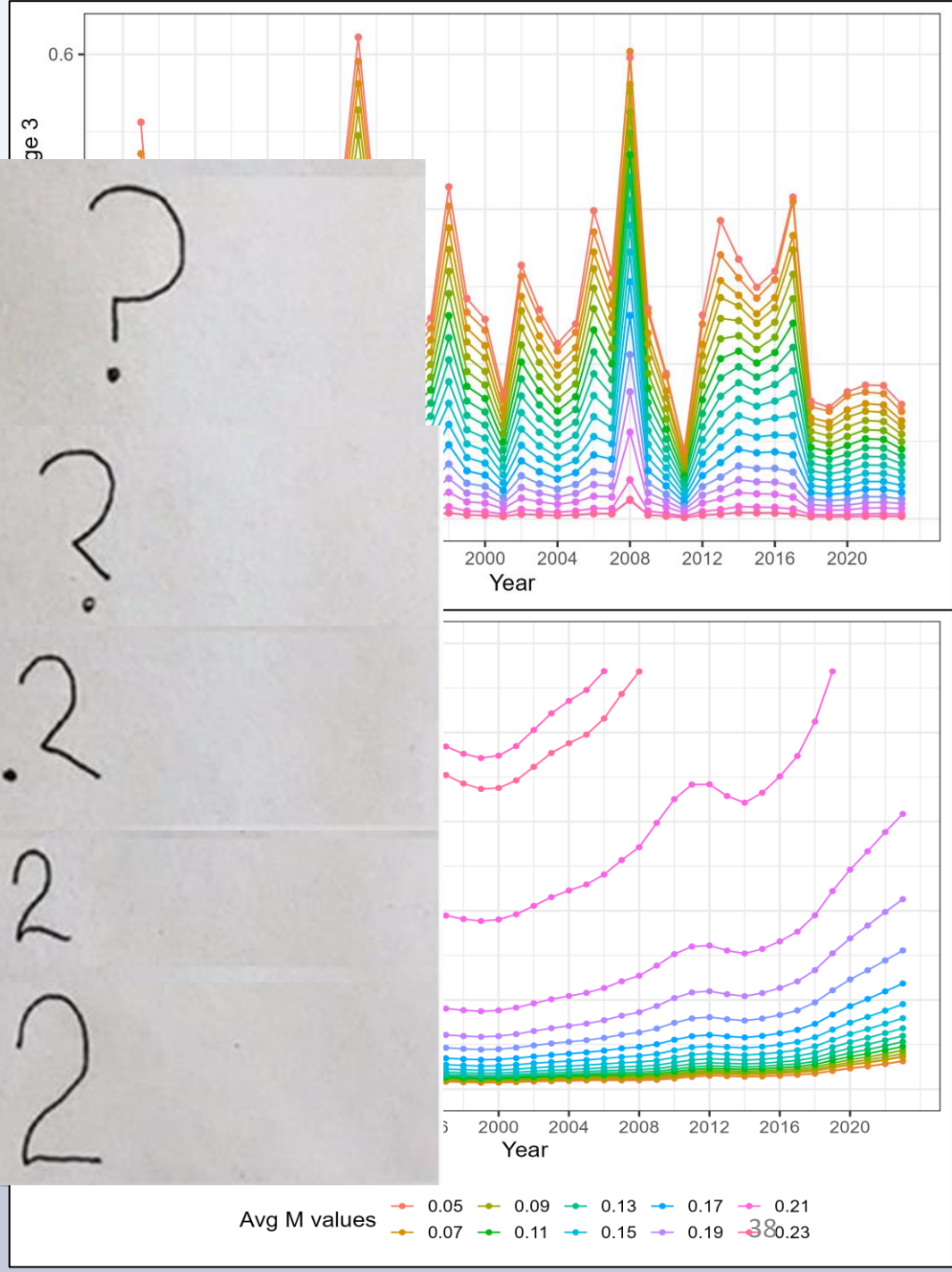
Parameter Profiling

- Hold a parameter value constant at a chosen value and estimate the remaining parameters
- All runs are presented, even those that had high gradients or positive definite hessians
- Fixed peak selectivity parameters for REC East and REC West fleets

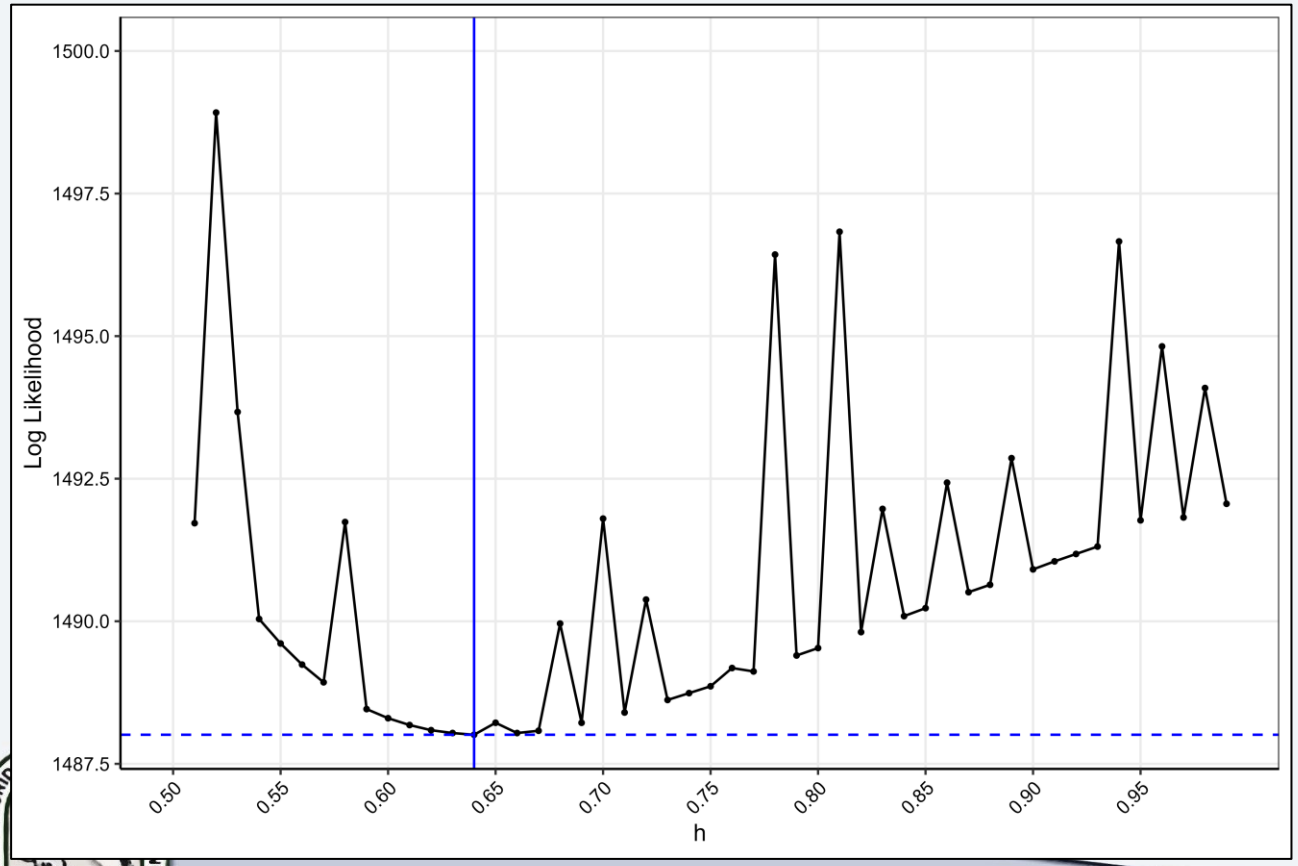
Profiling

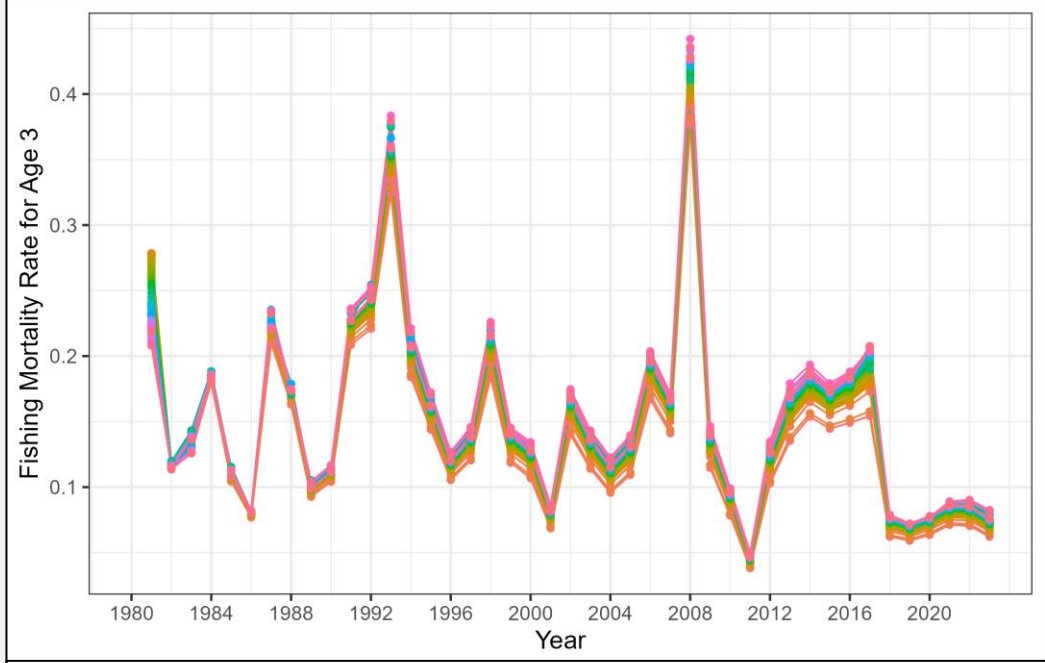

1505
1500
1495
1490
Log Likelihood
0.05

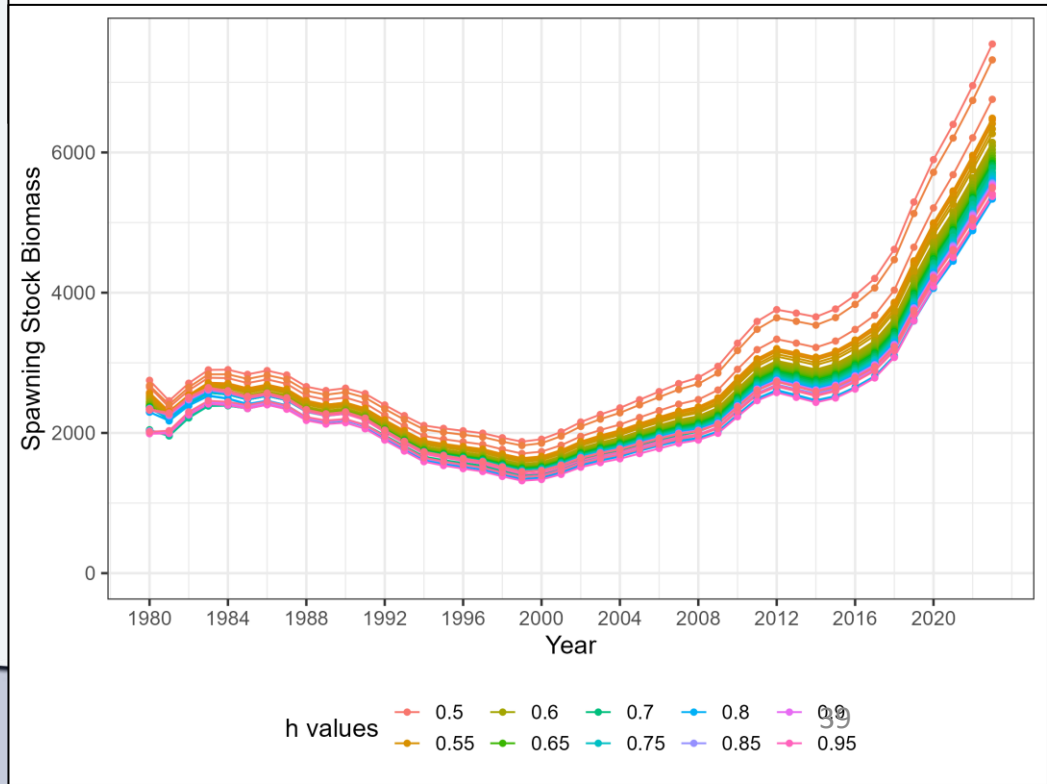

M = ?
M = .2
M = .2
M = .2
M = 0.2


0.6
2000
2004
2008
2012
2016
2020
Year
2000
2004
2008
2012
2016
2020
Year
Avg M values
0.05
0.07
0.09
0.11
0.13
0.15
0.17
0.19
0.21
0.23

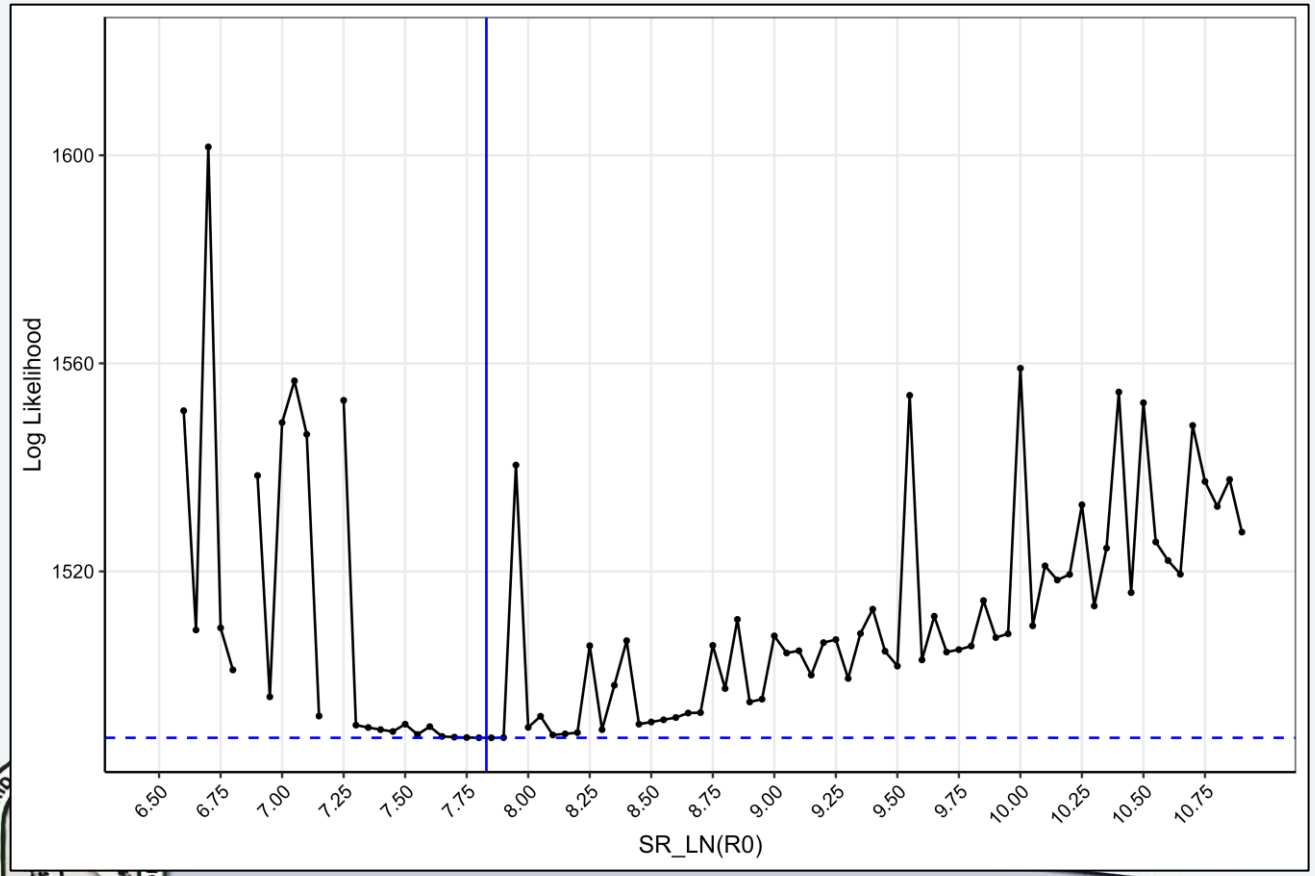
Profiling on Steepness

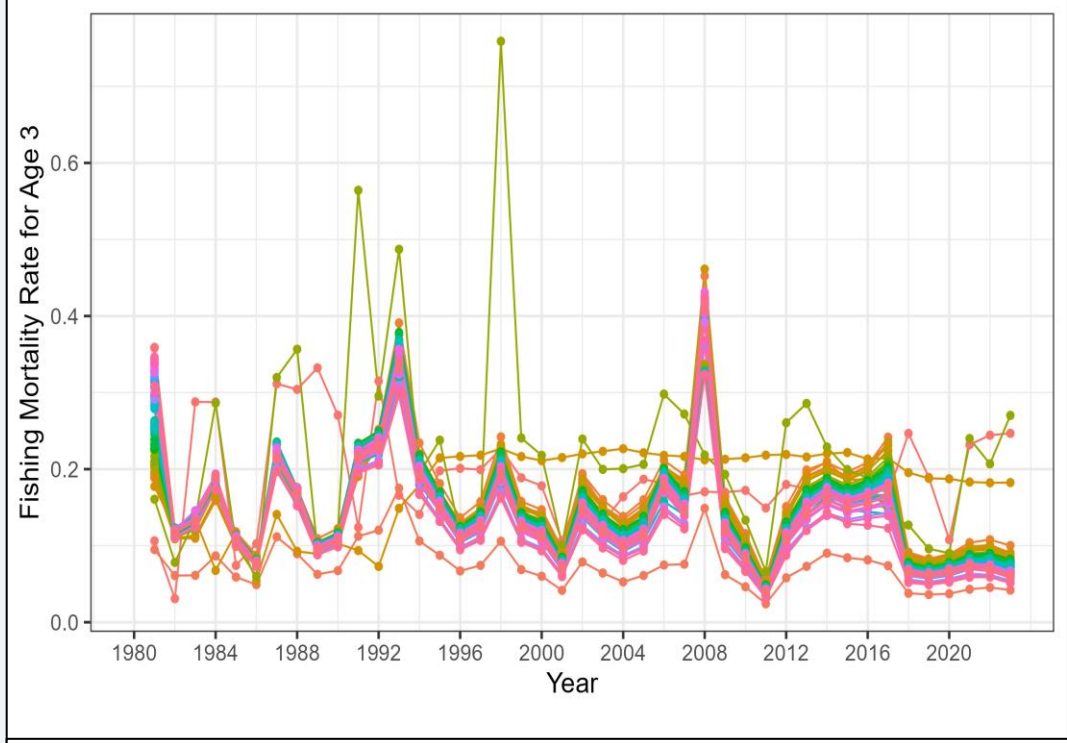


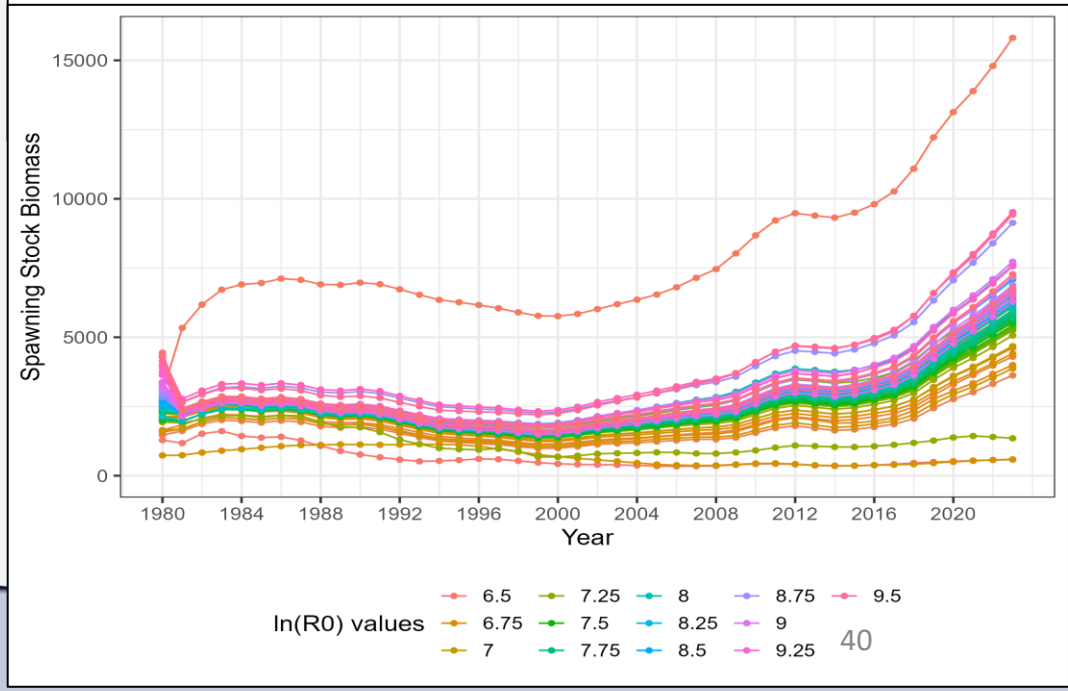




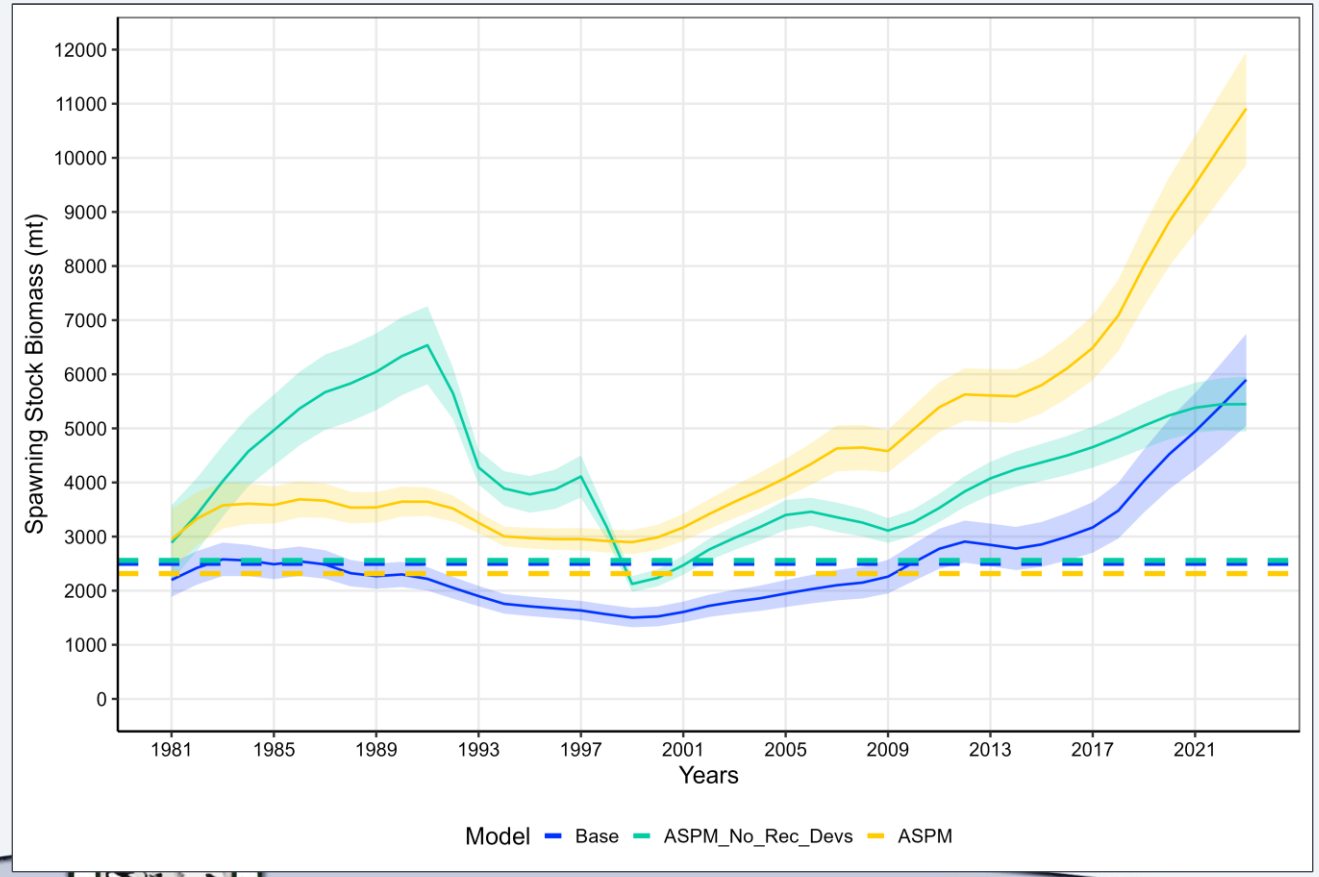
Profiling on R0

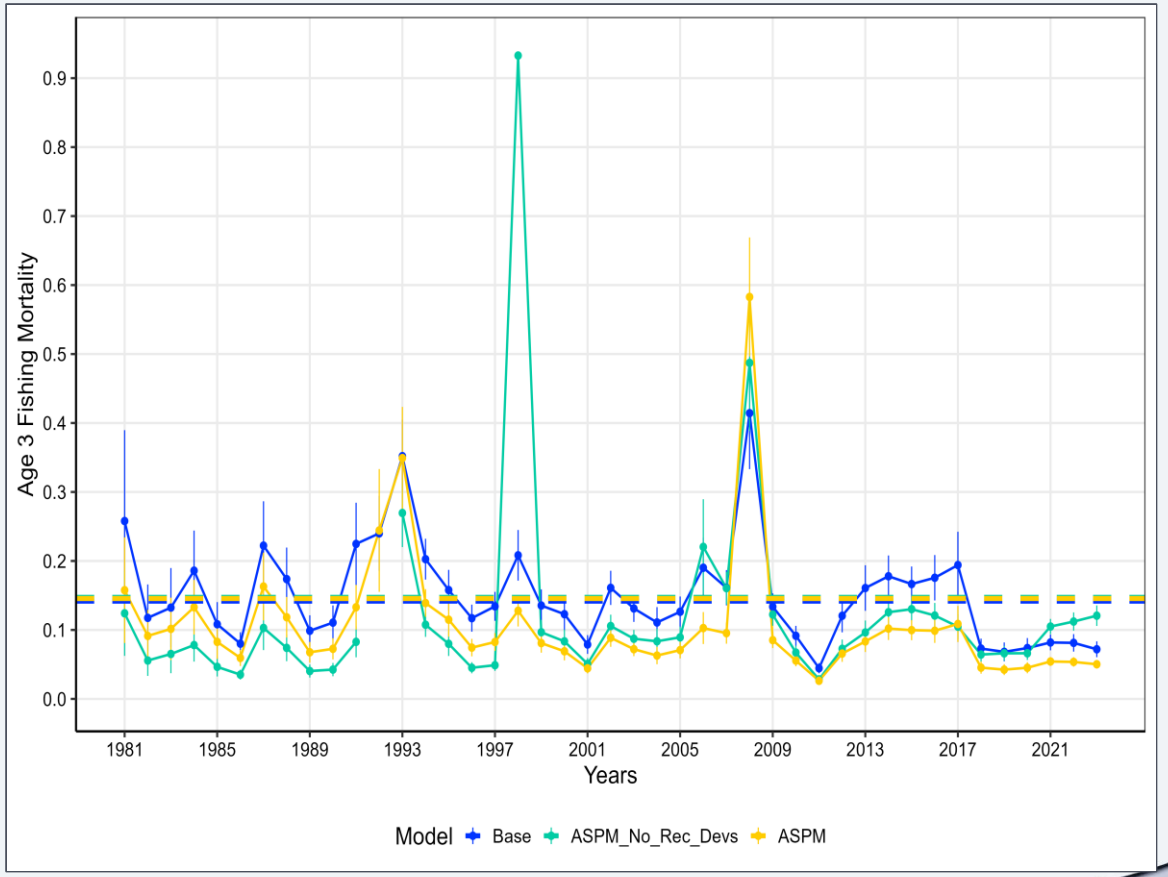




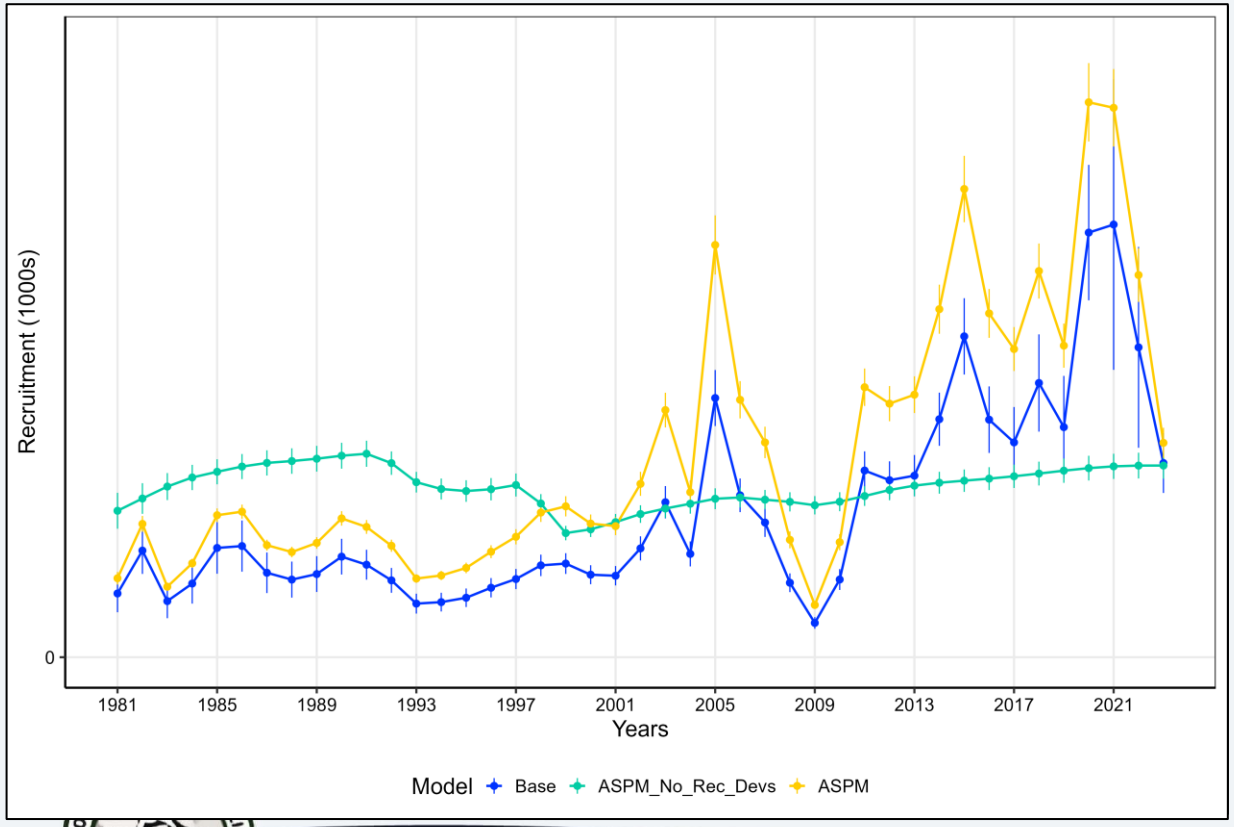


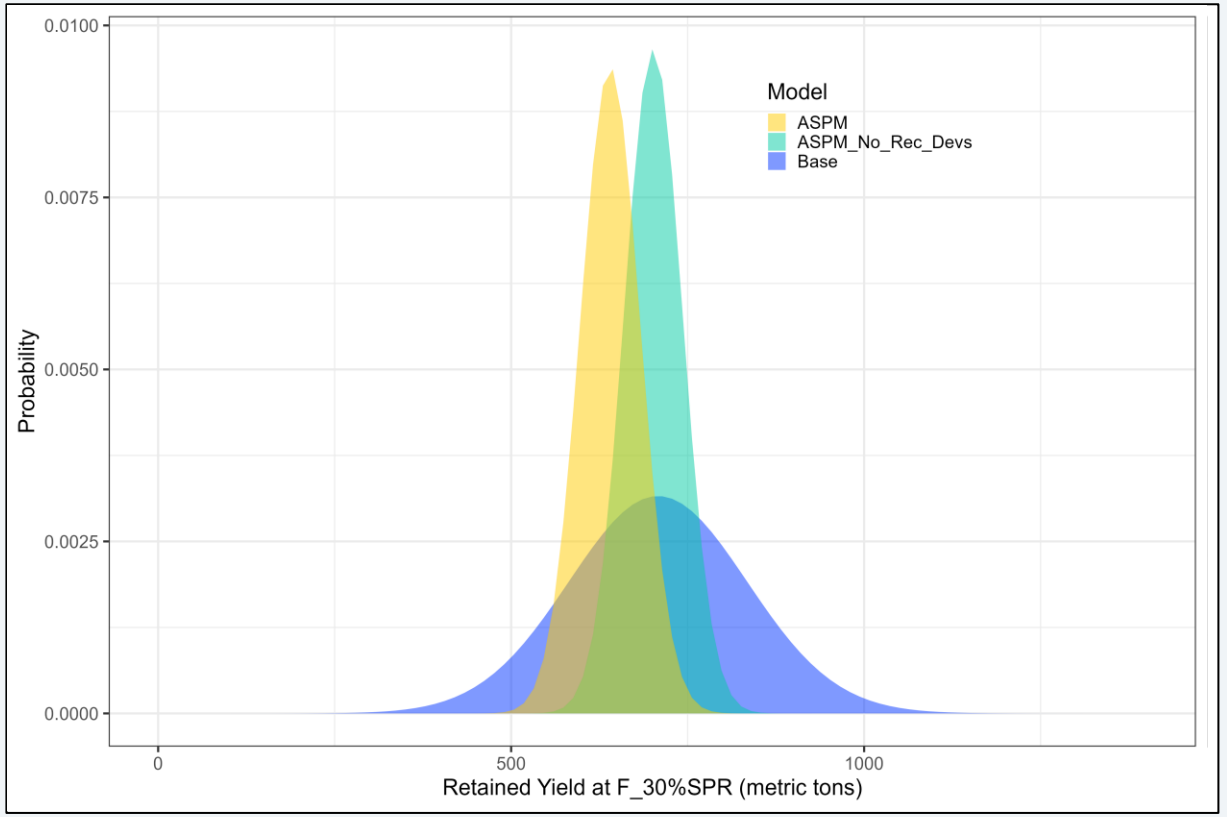
Age-Structured Production Model



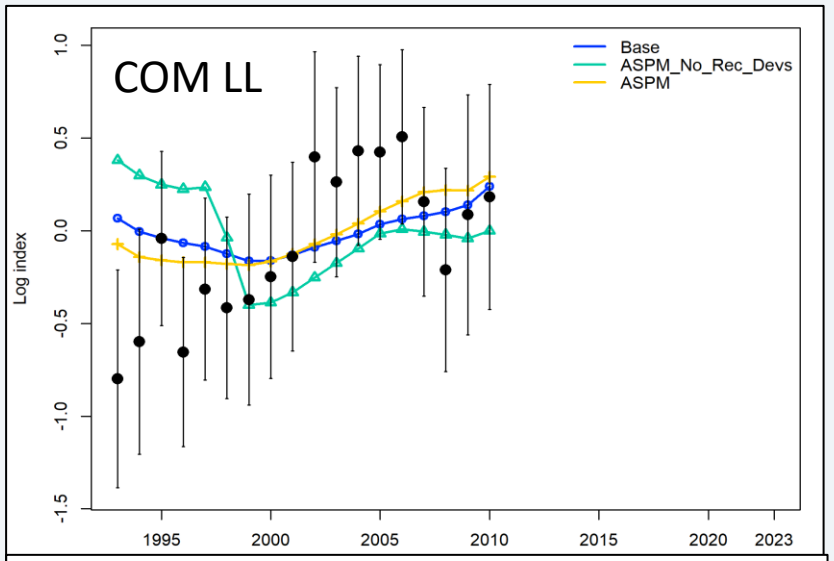


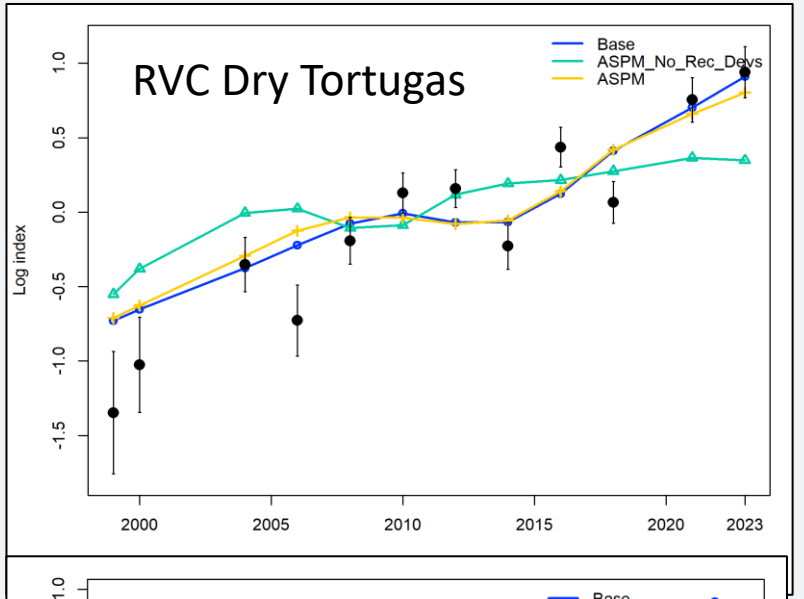
Age-Structured Production Model

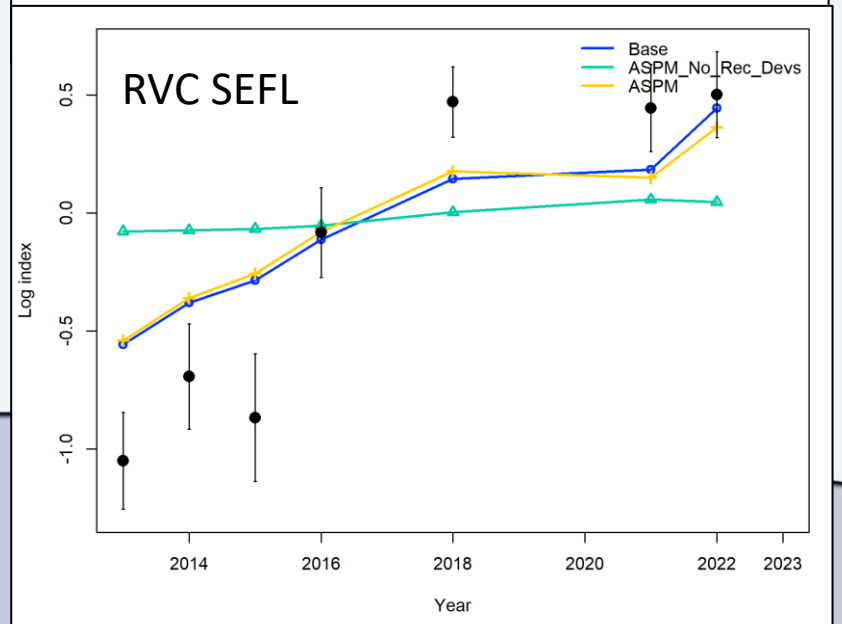


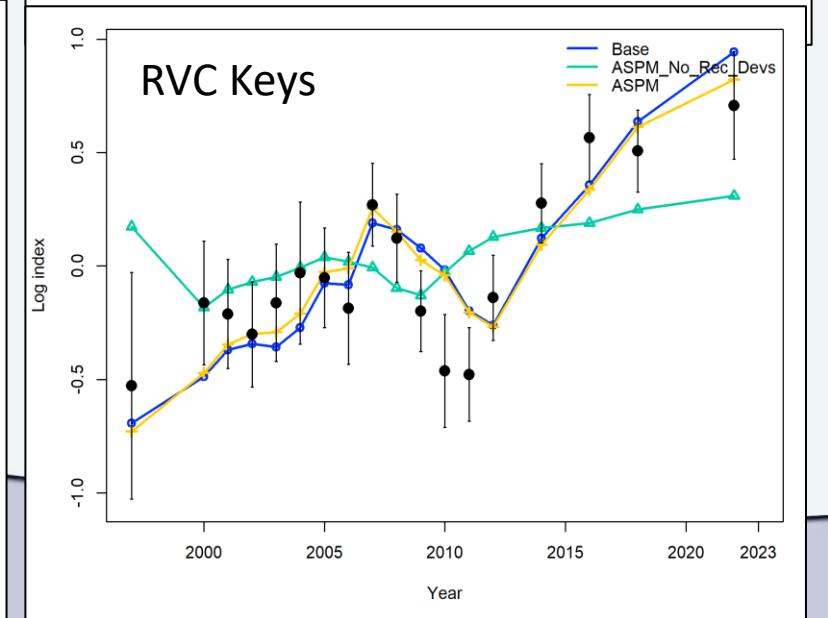


Age-Structured Production Model

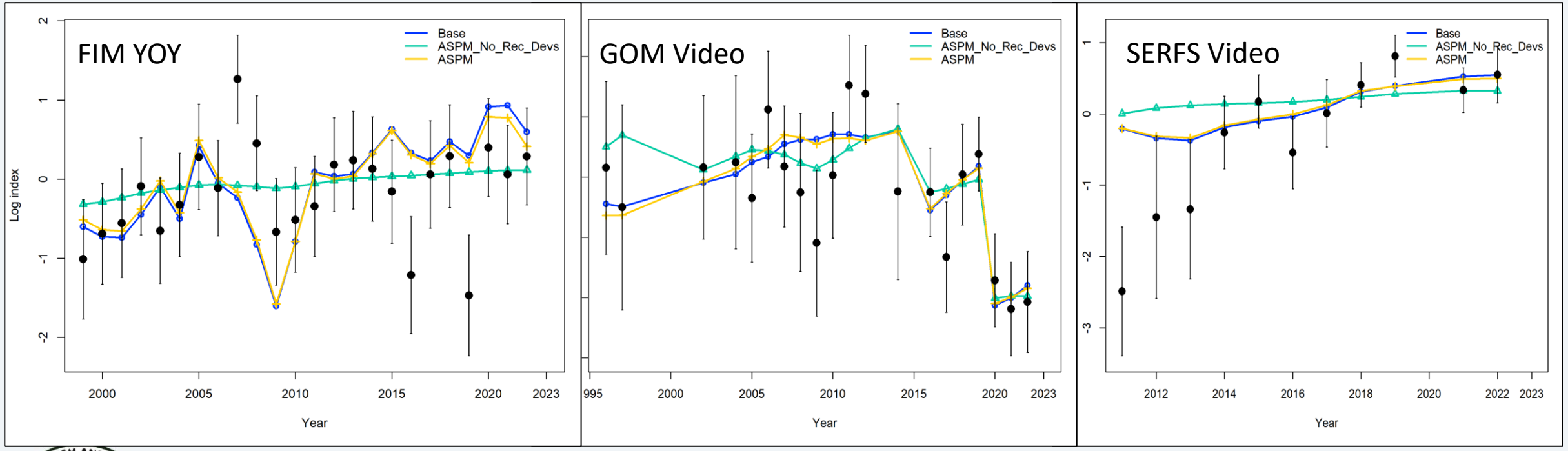








Age-Structured Production Model

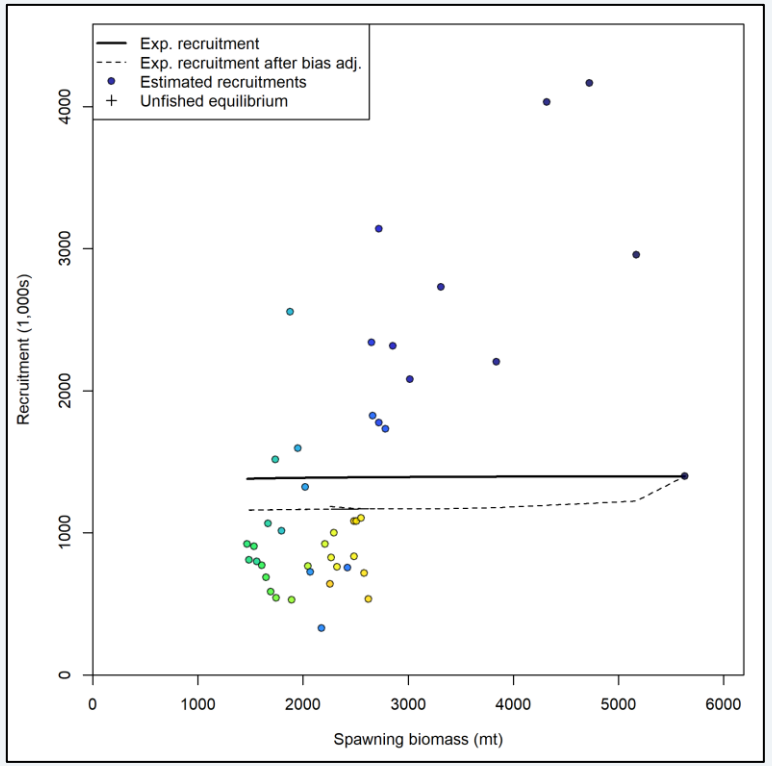


Base Model Sensitivity Runs

Steepness ≈ 1

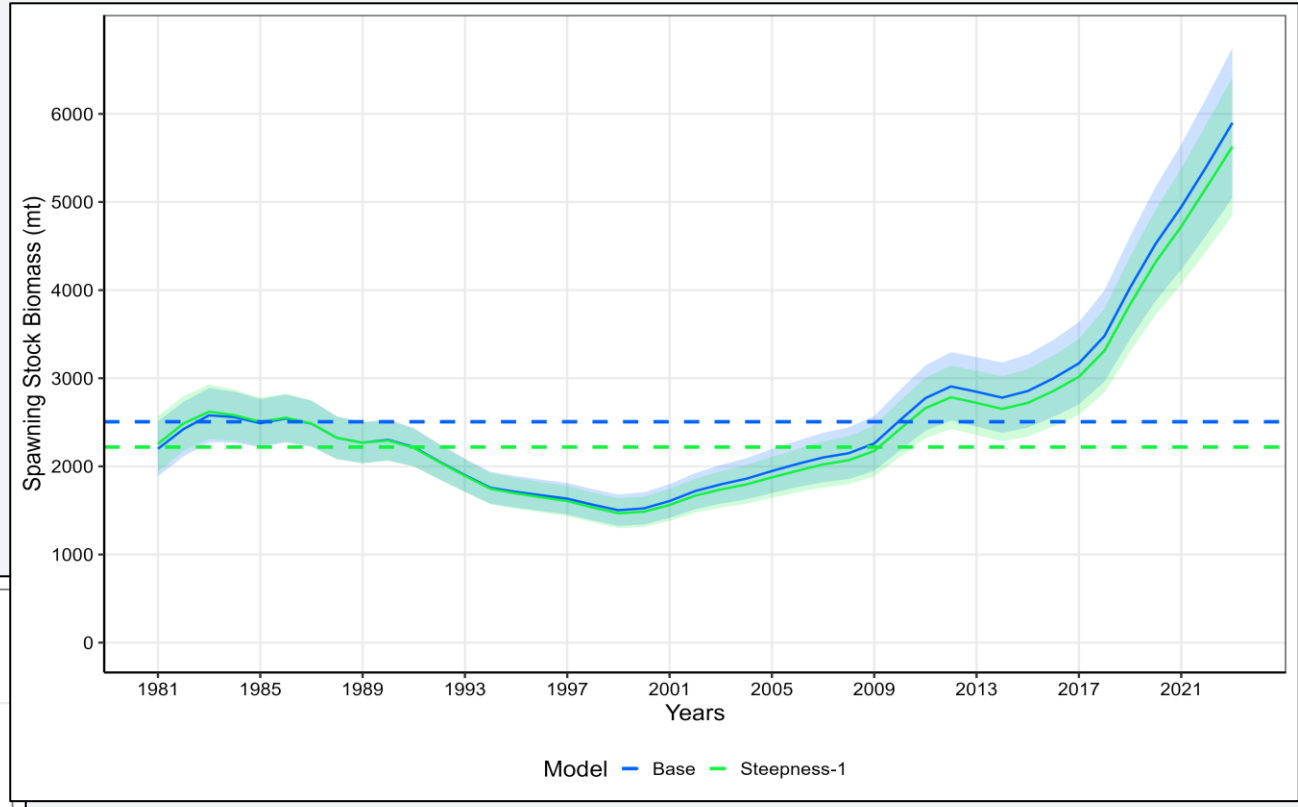
*fixed peak for REC EAST selectivity

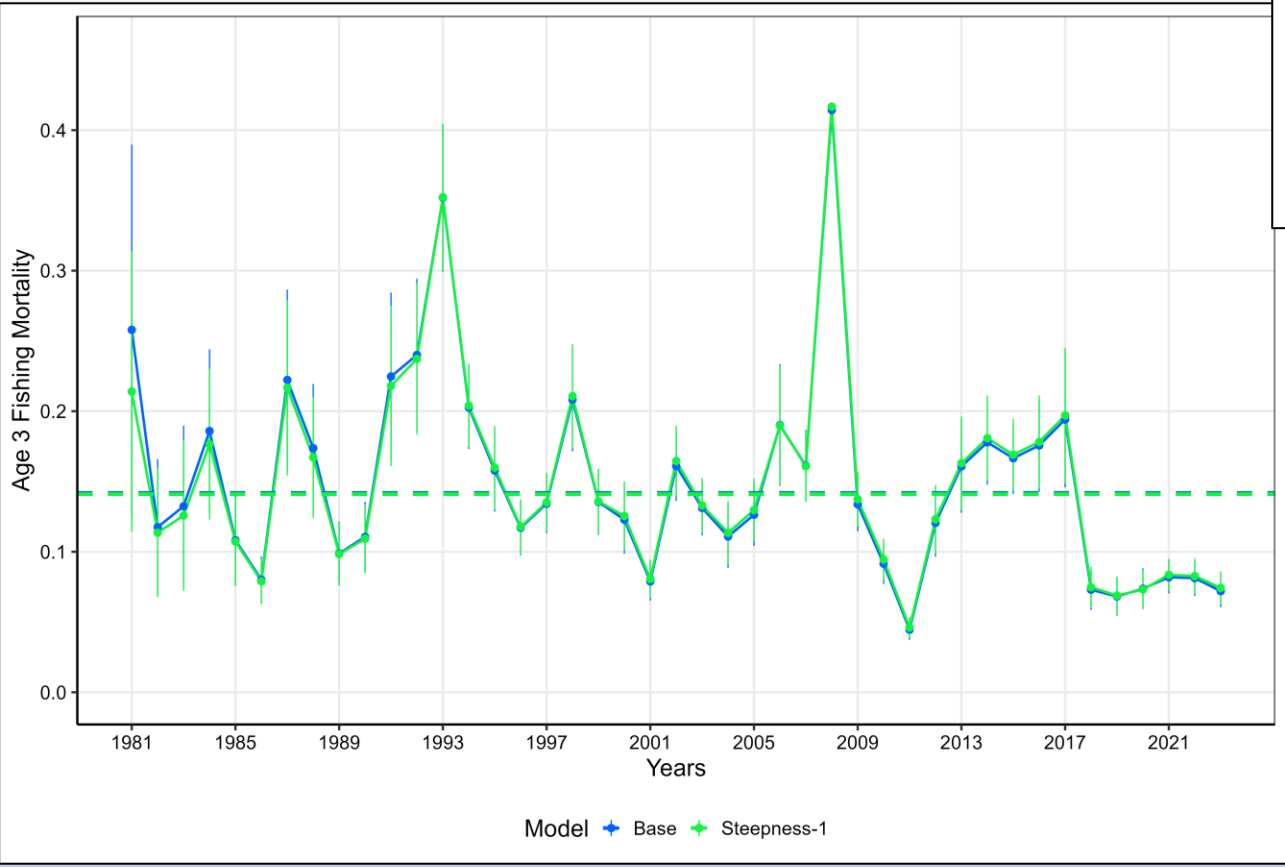
Parameter	Base	Steepness-1
TOTAL_likelihood	1488	1495
Survey_like	55	56
Length_comp_like	519	526
Age_comp_like	803	804
SR_BH_steepness	0.64	0.99
SR_LN(R0)	7.83	7.25
Virgin Recruits (millions)	2.51	1.40
SSB unfished (1000 mt)	17.78	9.92

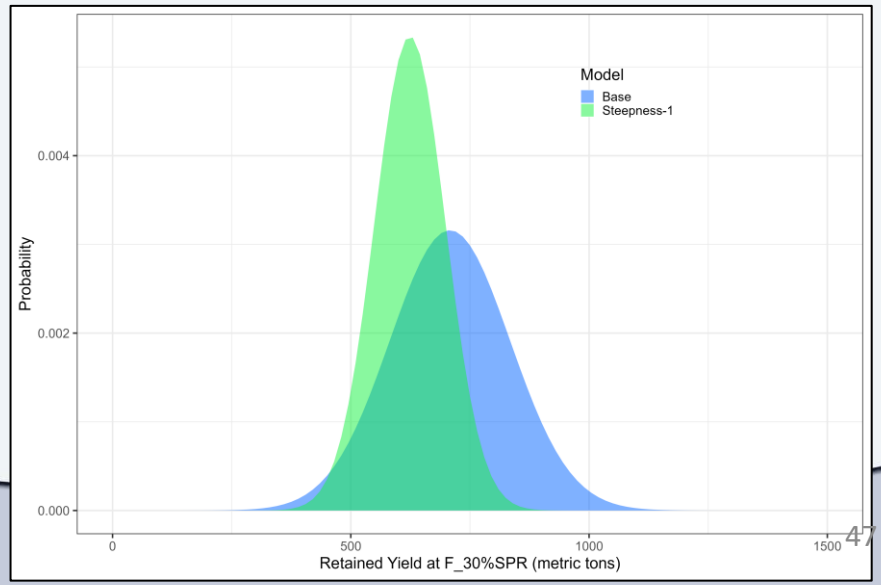


Steepness ≈ 1

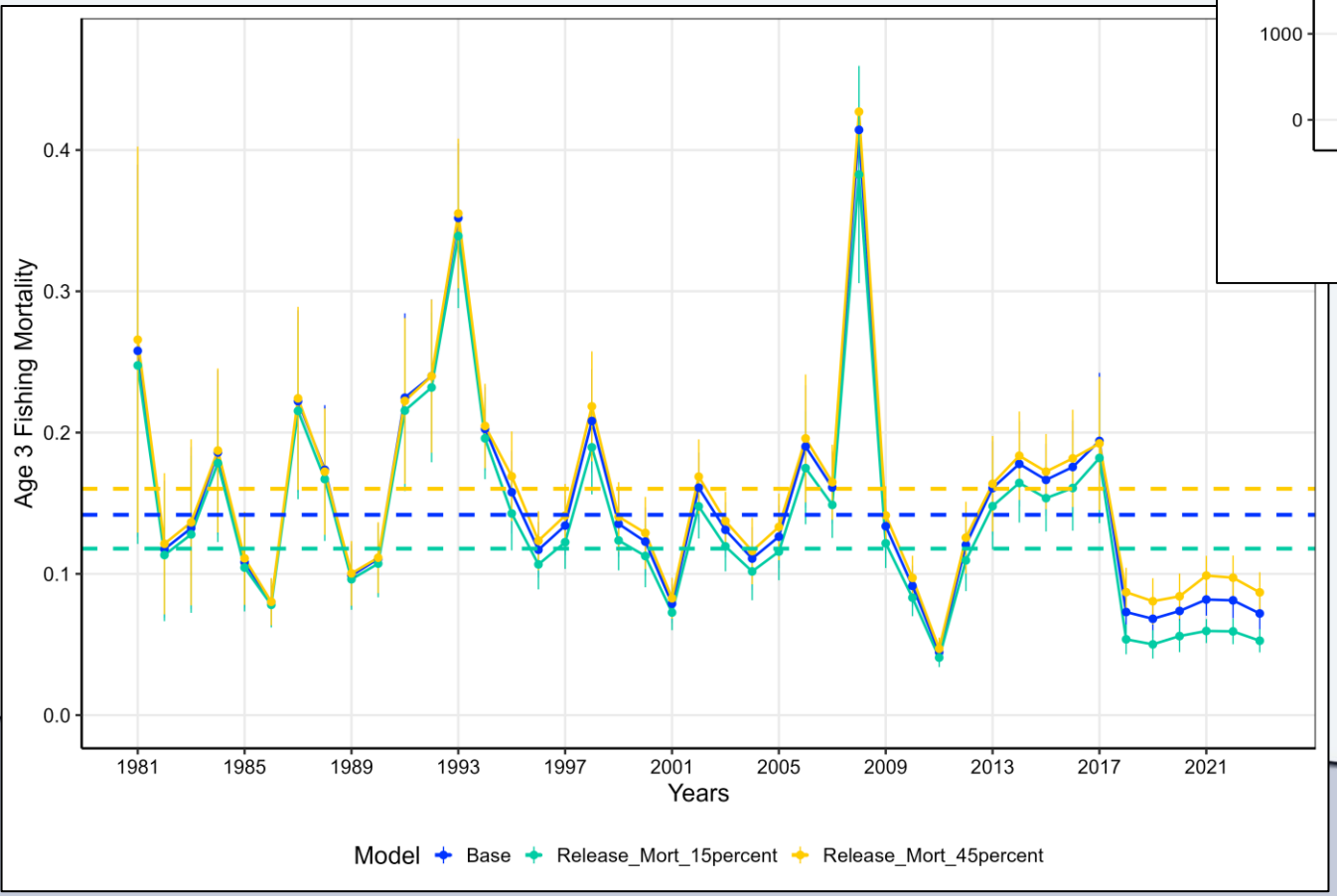
*fixed peak for REC EAST selectivity

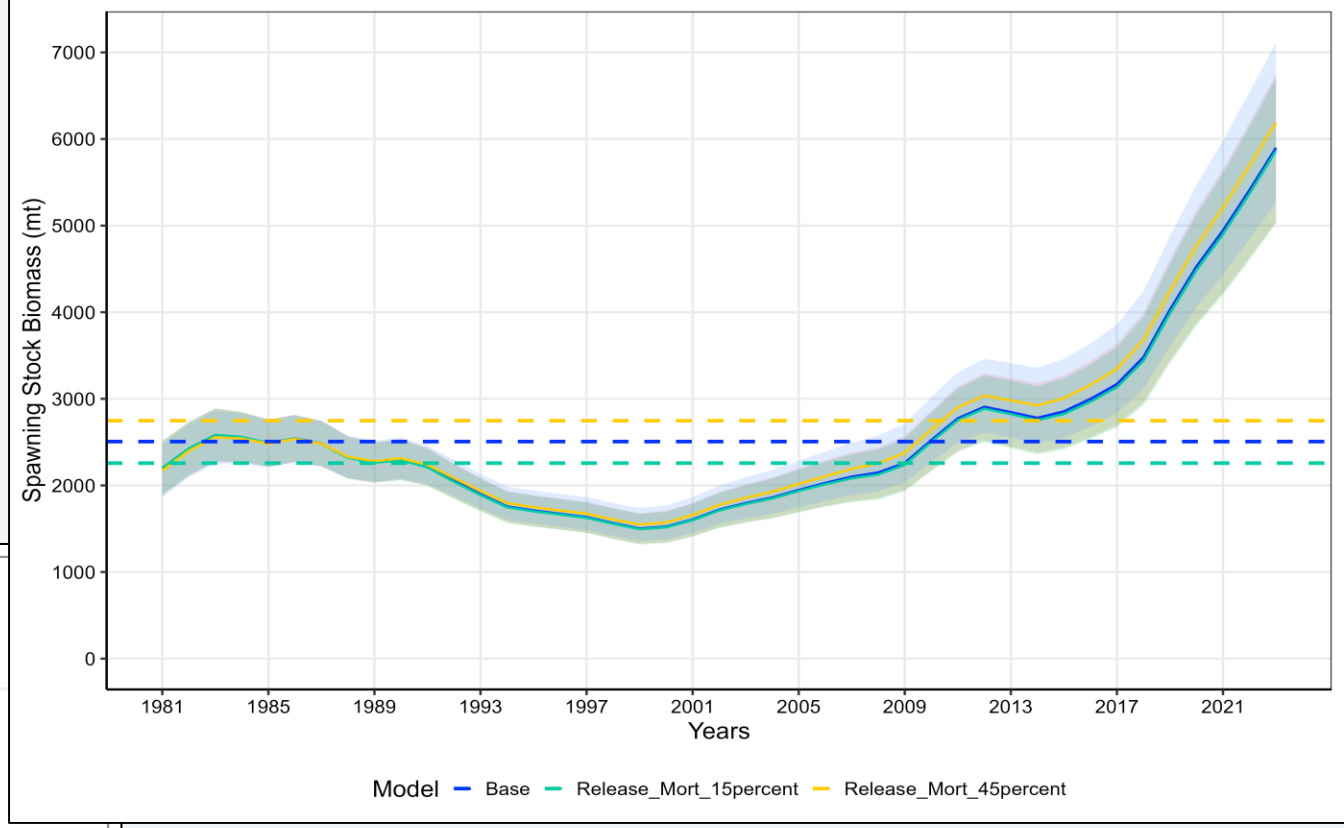


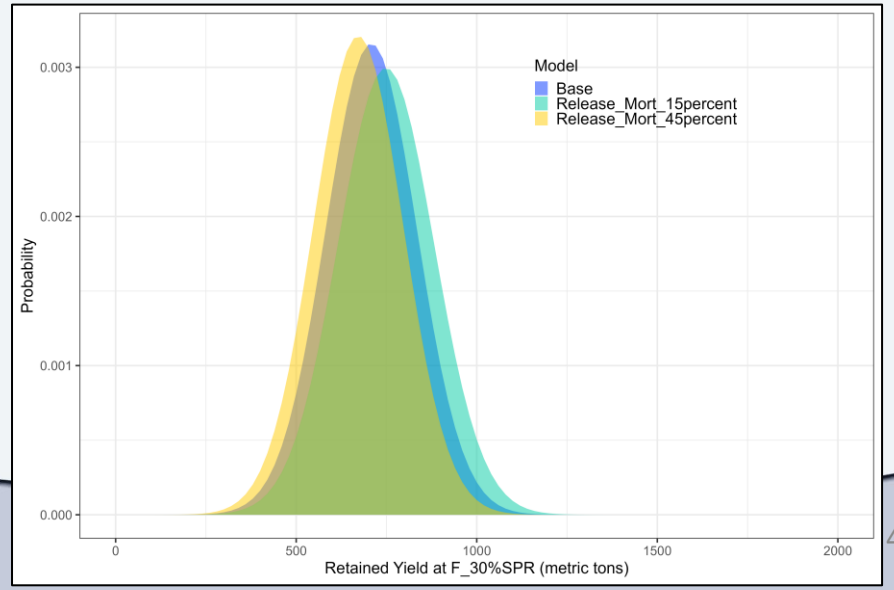




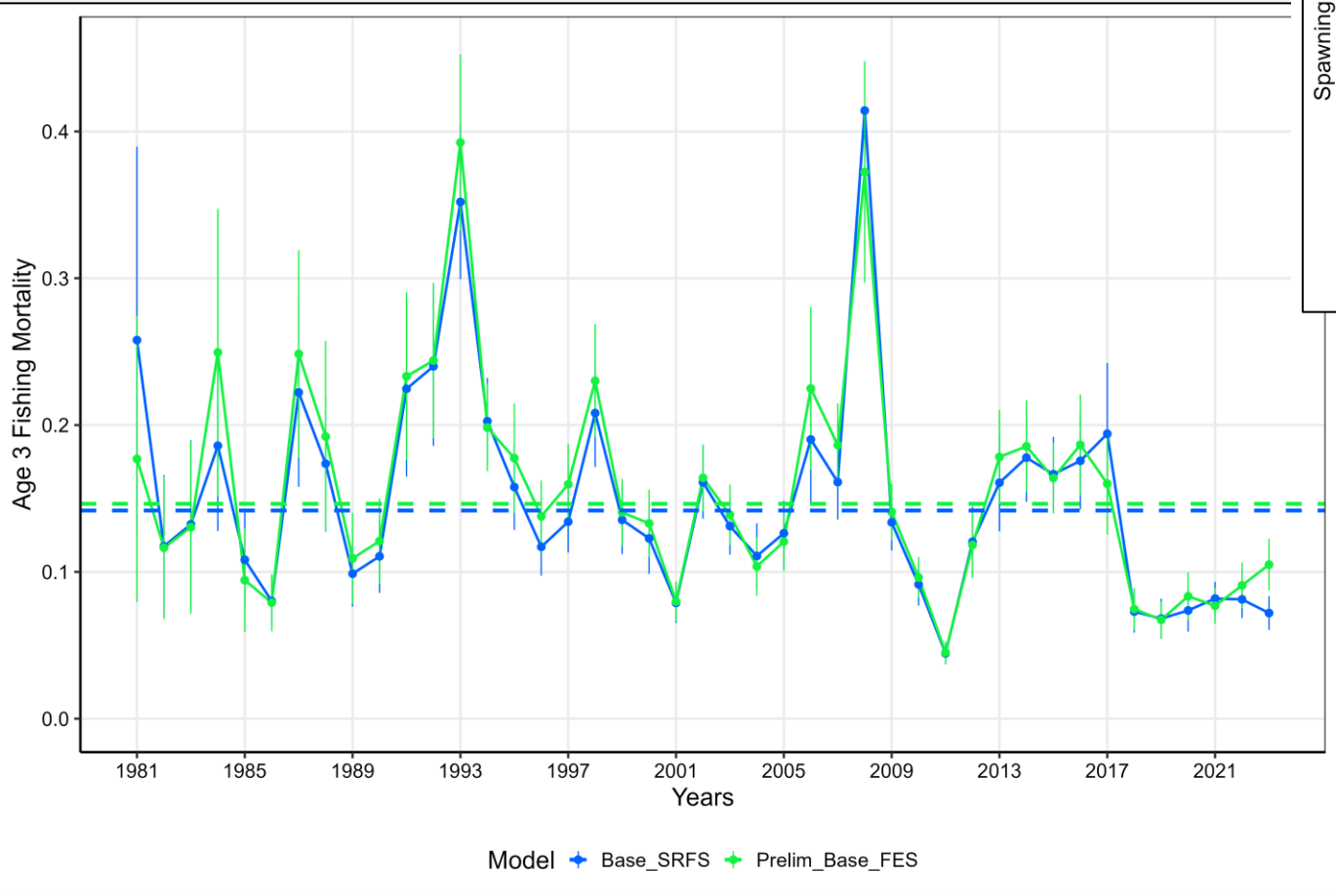
Release Mortality = 15% and 45%

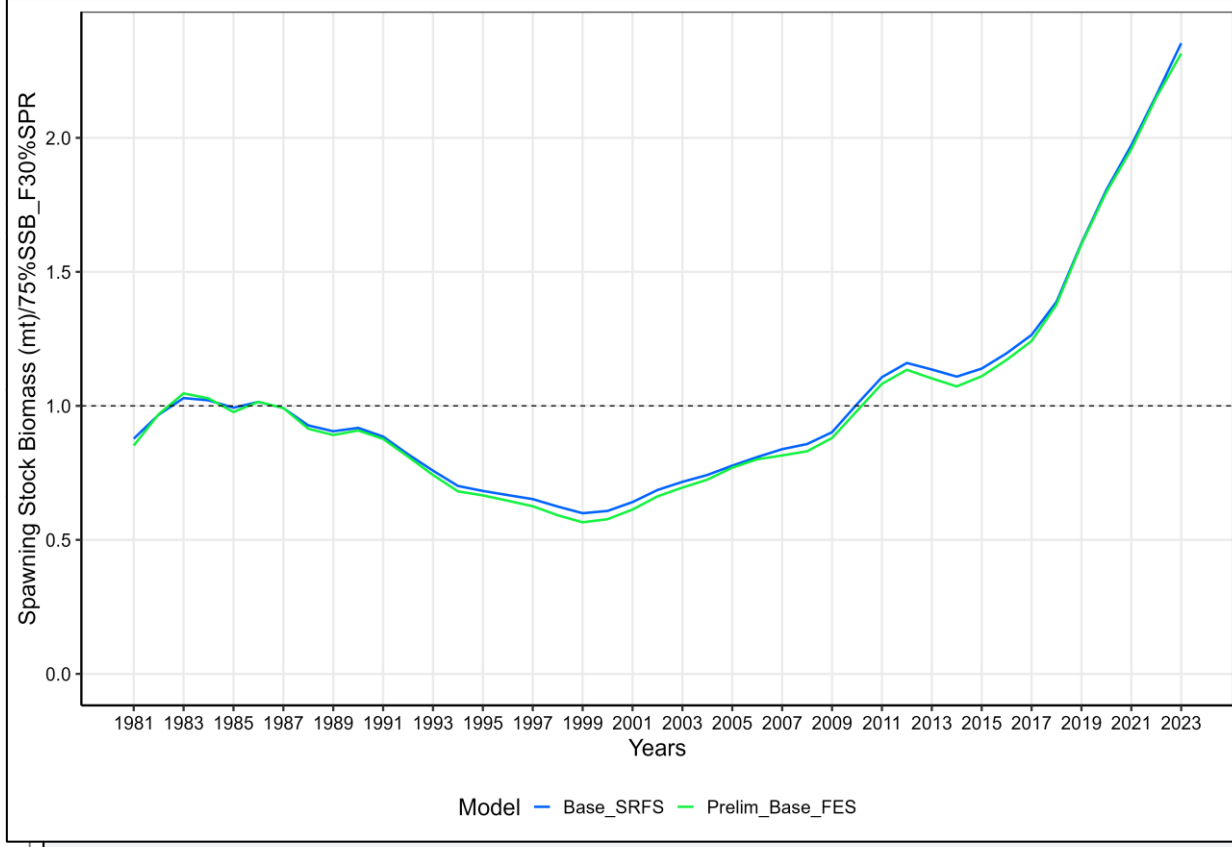


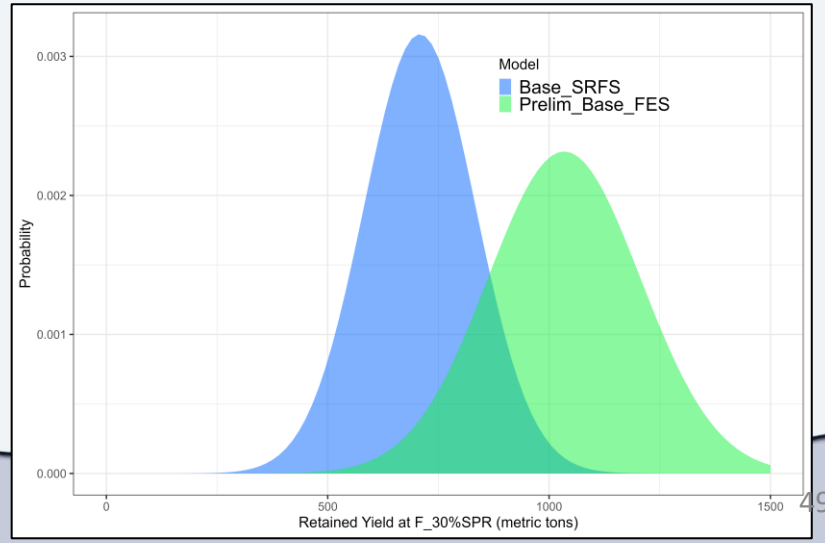




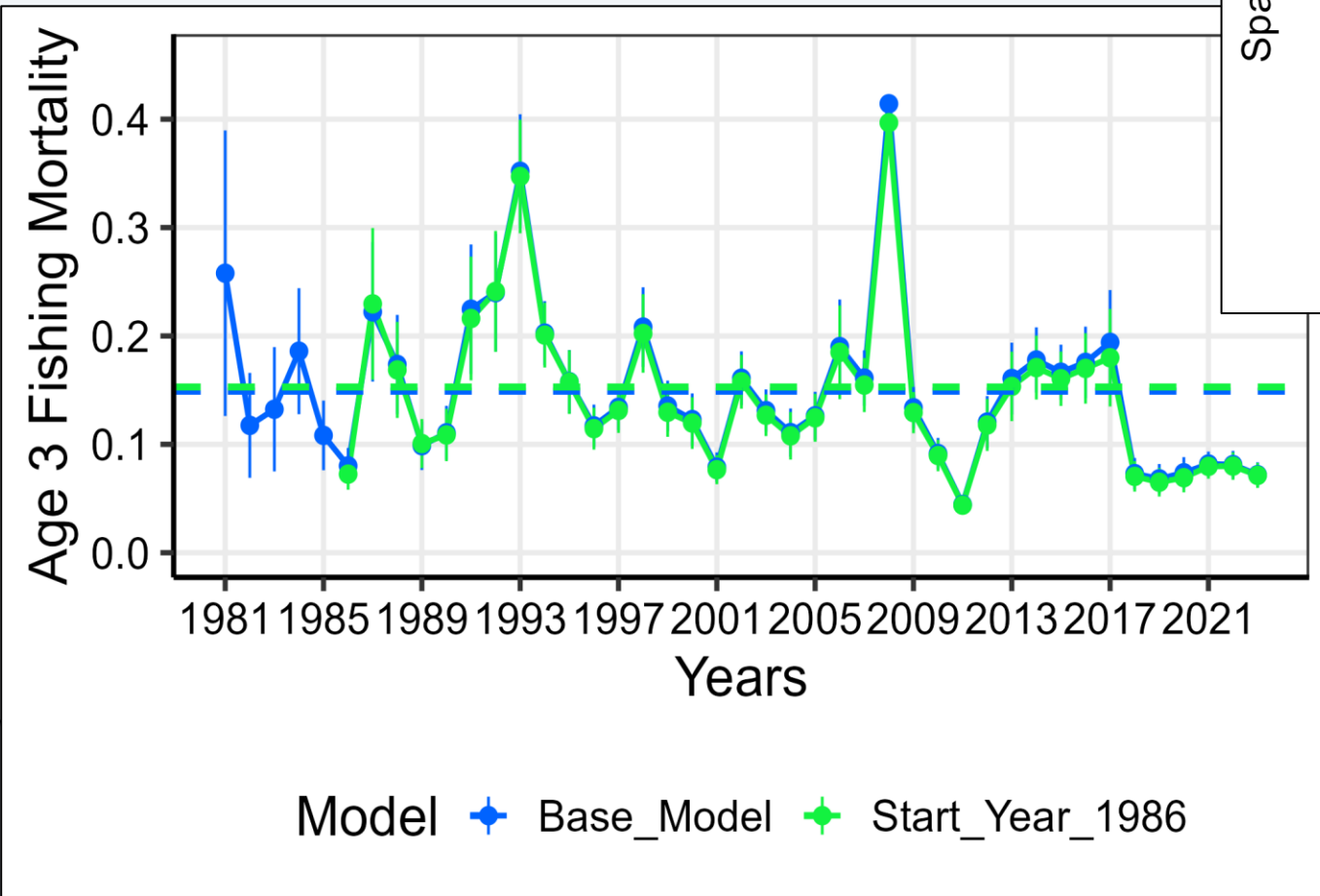
MRIP-FES Private Mode Landings & Releases

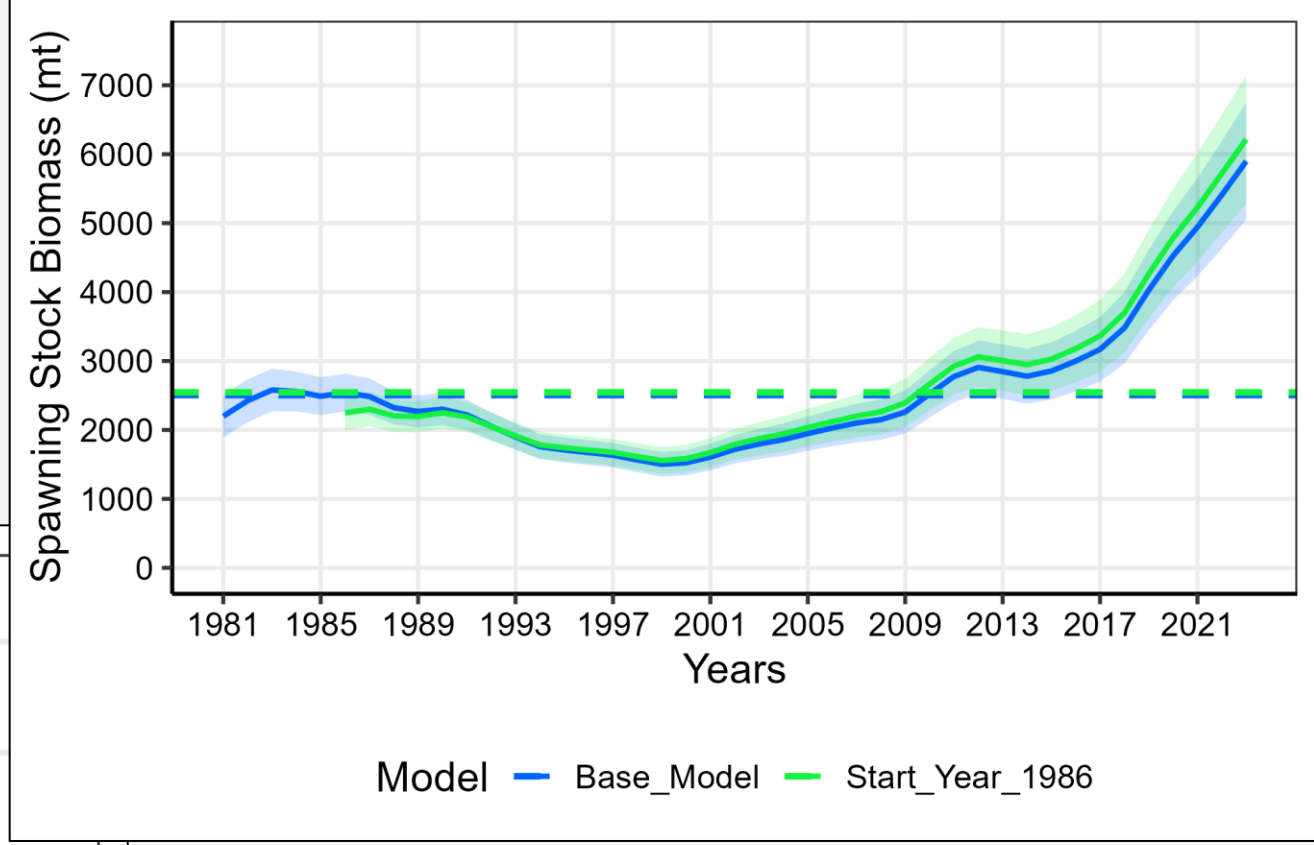


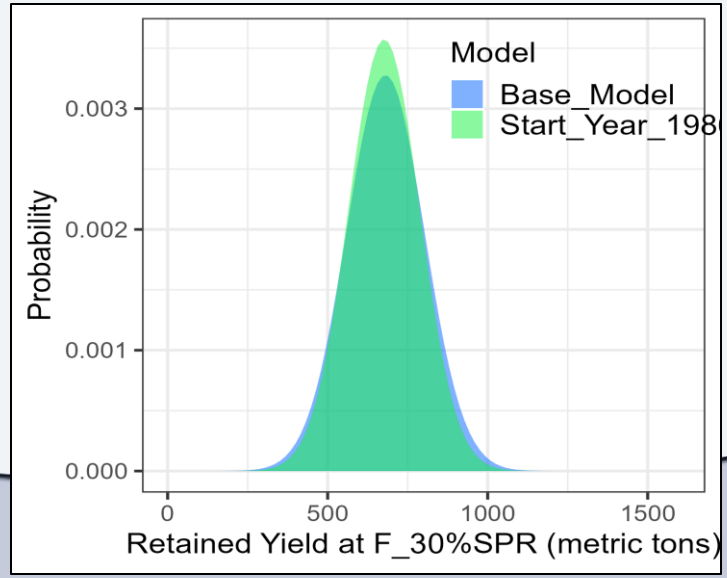




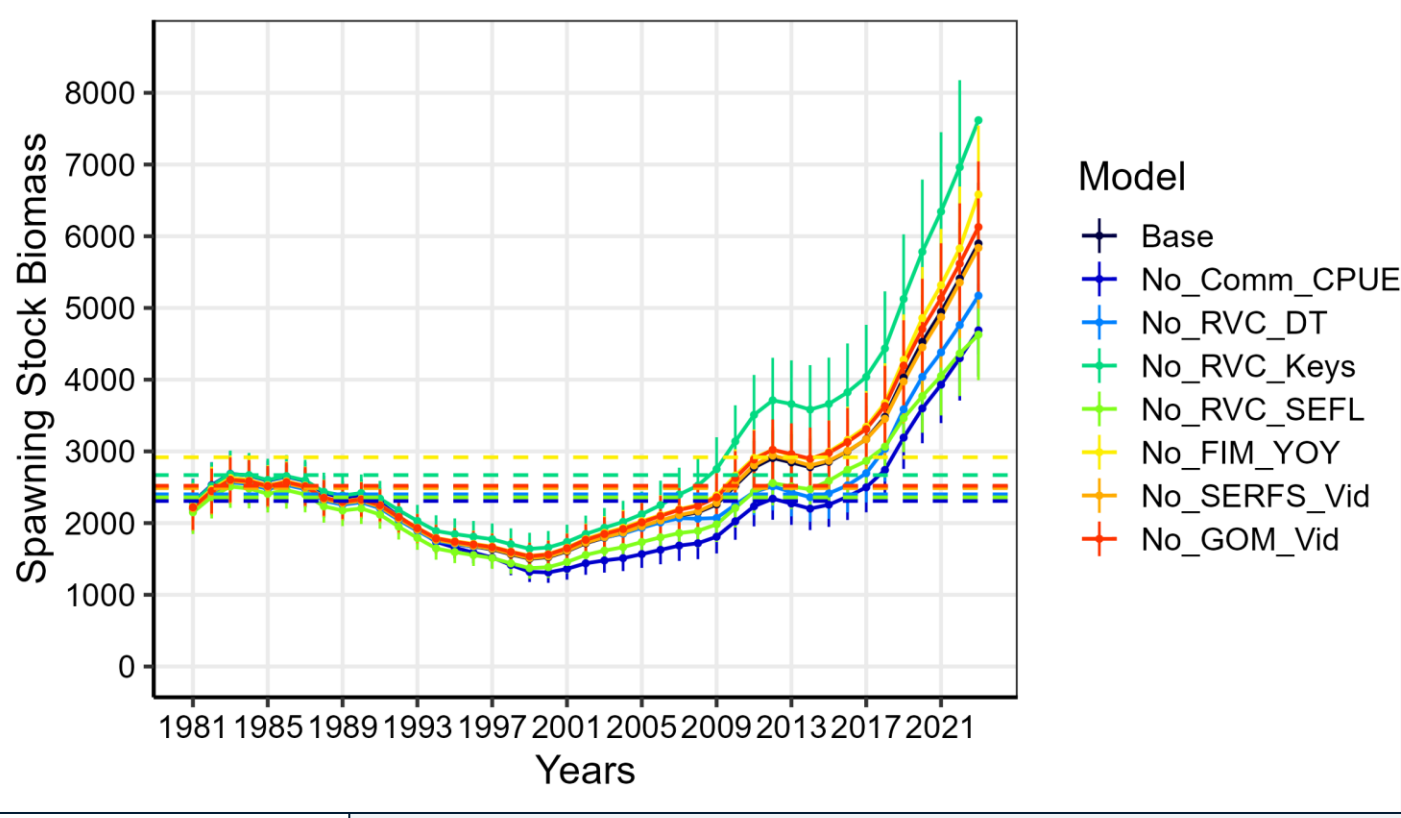
Start Year = 1986

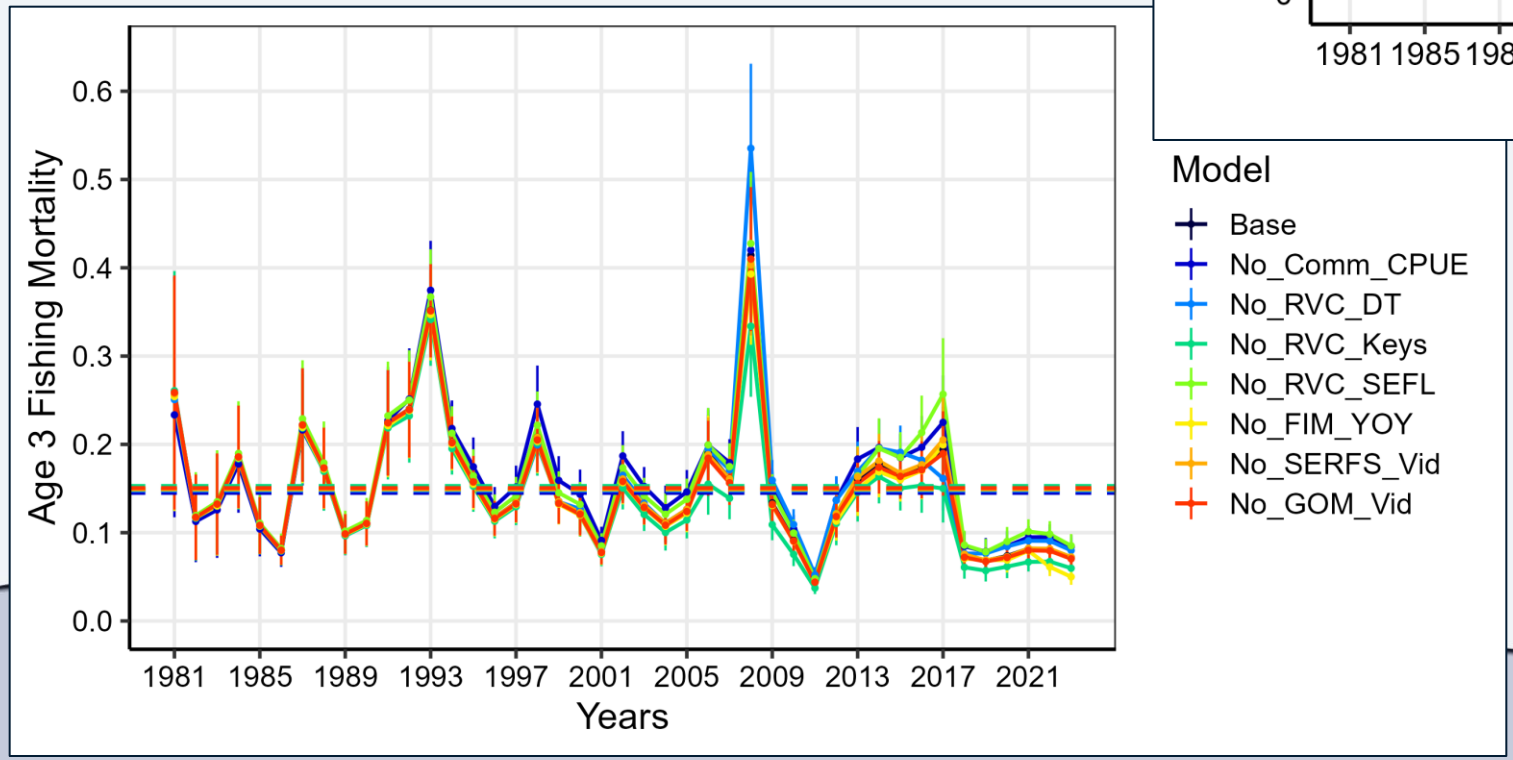




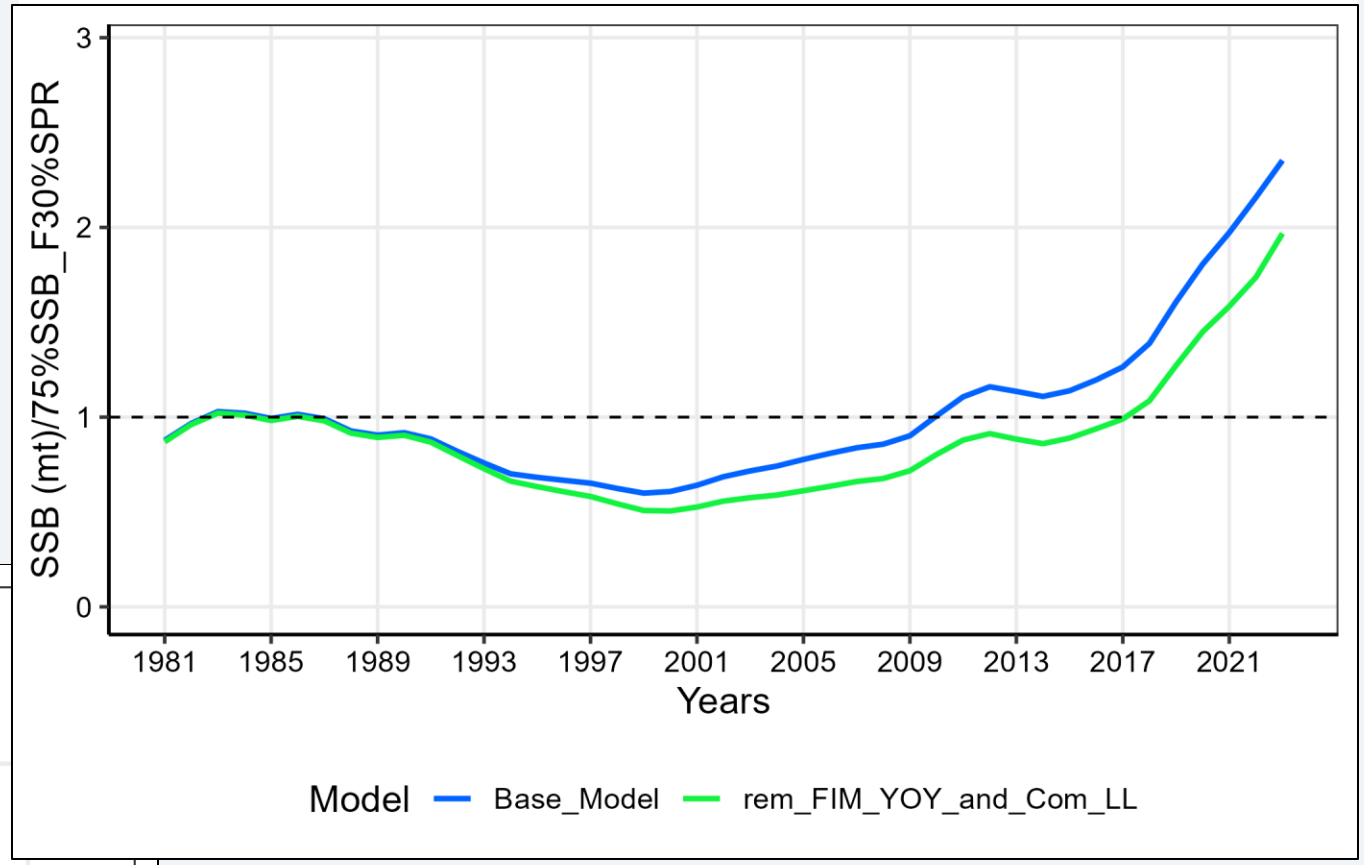


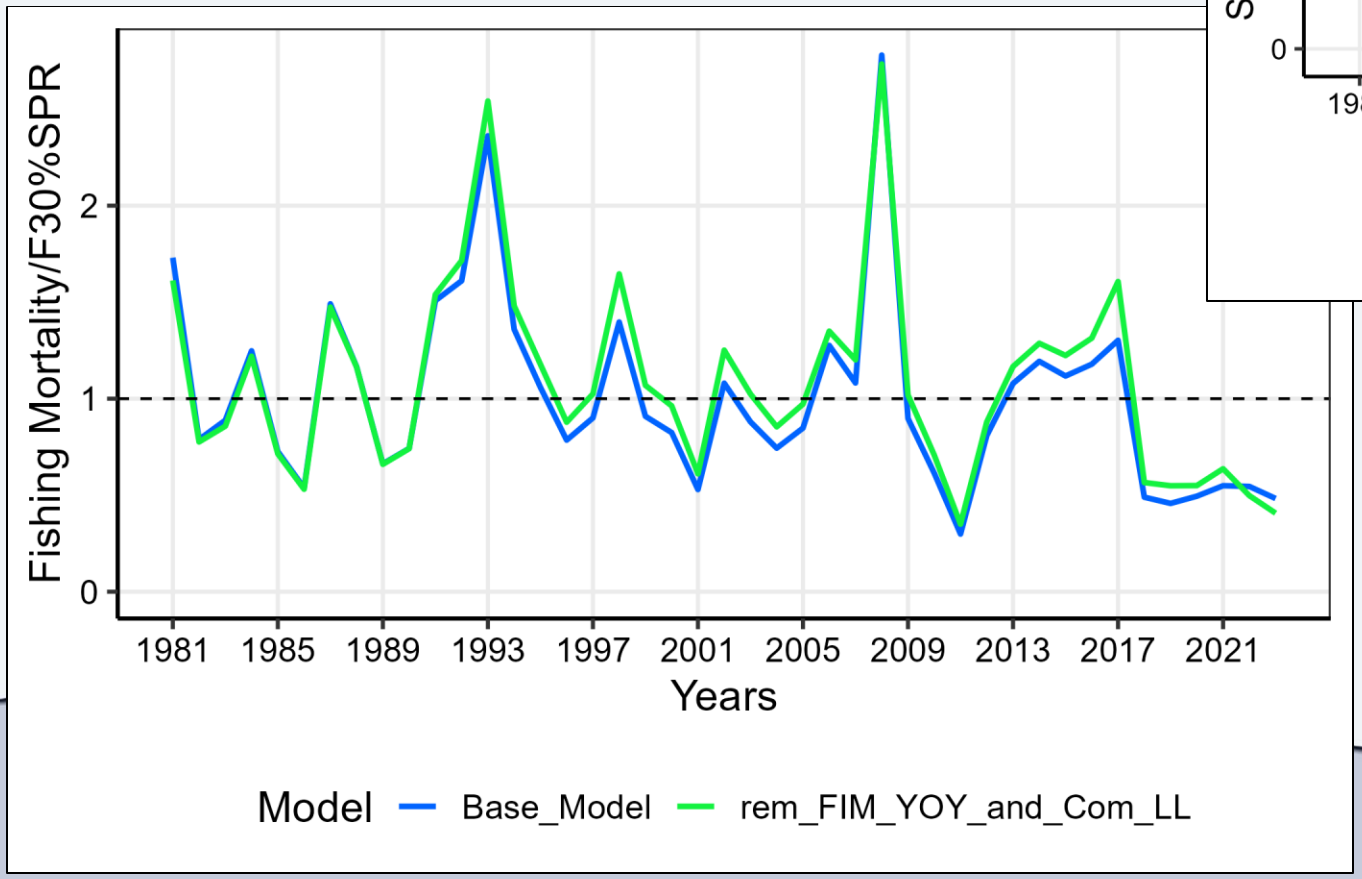
Jack-knife Analysis (leave one index out)

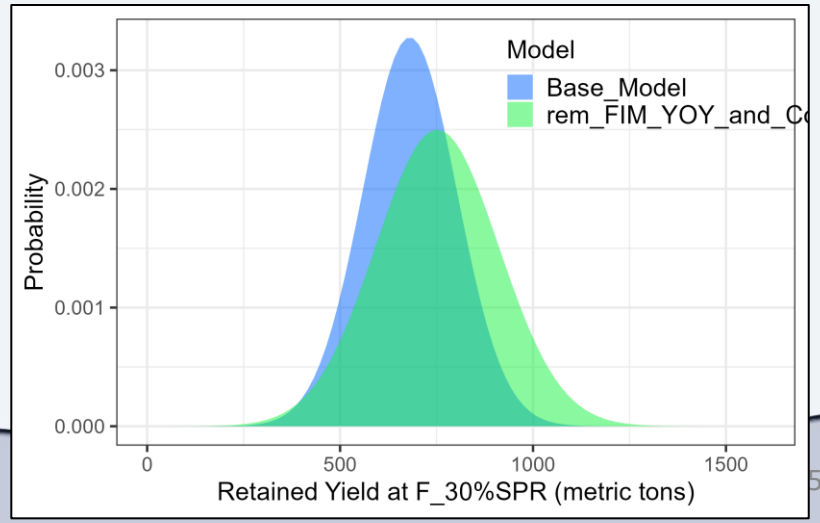




Remove FIM YOY & COM LL Indices







Projections (LAST section!)

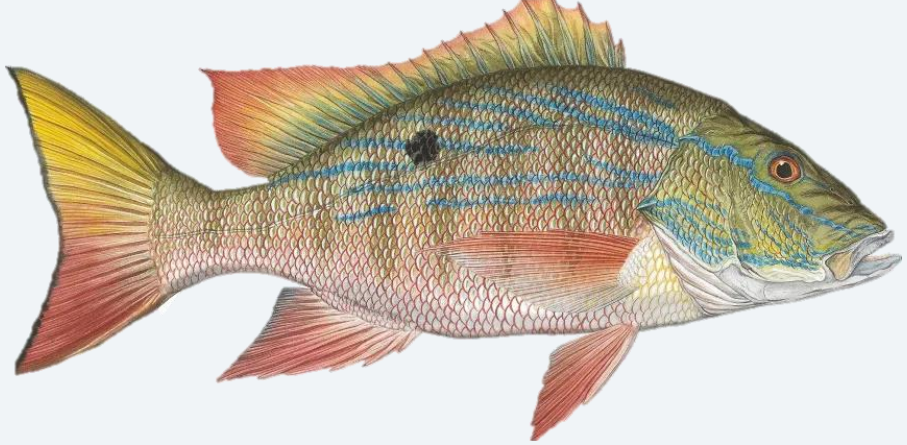
Projection Methods

- Goal: To project SSB and yield (or fishing mortality rates) under a range of harvest scenarios
- Method (developed by SEFSC staff):
  - An iterative process to set fleet-specific Fs each year to ensure that a given constant fishing mortality rate (or constant catch) scenario is achieved
- Settings:
  - Held constant for all years: Fishing mortality rate (or catch), Fleet allocations, Growth, stock-recruit parameters, fleet selectivity and retention.
  - Recruitment in 2024: Can be specified or determined by using the stock-recruitment parameters as estimated by the base model.

Projection Methods (cont.)

- Growth, stock-recruit parameters, fleet allocations, selectivity & retention
  - Set as the average of the last 3-year estimates from the base model
- Recruitment (Age 1) in Jan 2024
  - For long term projections: predicted by using the estimated stock-recruitment parameters & SSB in 2023
  - For short-term projections: equal to the geometric mean of 2019-2023 Age 1 Recruitment

Projection Scenarios

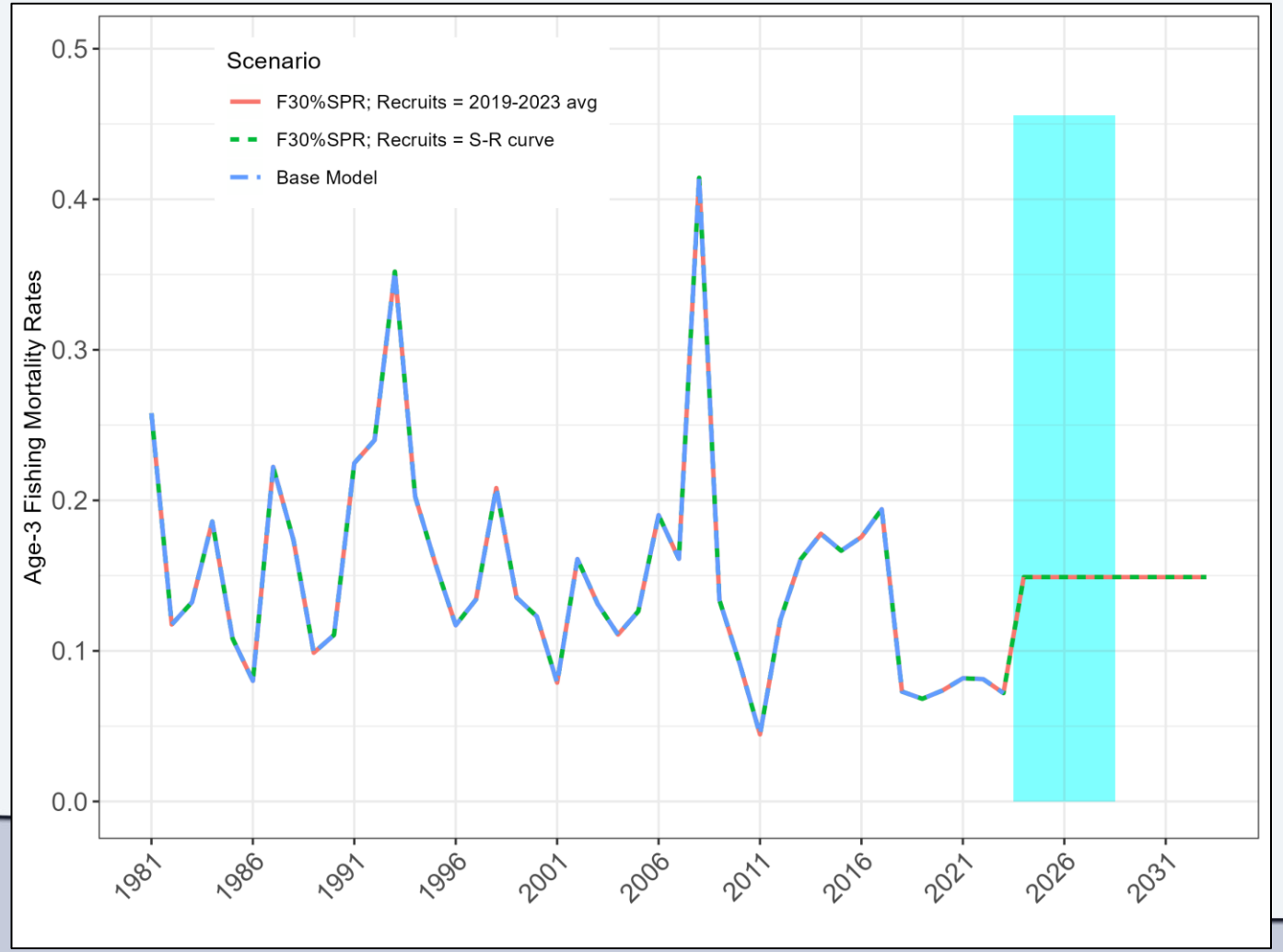


- Constant F scenarios In TORs (TOR 10):
  - $F_{30\%SPR}$
  - 75% of $F_{30\%SPR}$
  - $F_{40\%SPR}$ (Current definition of F_{OY}) but equal to 75% of $F_{30\%SPR}$
  - Fcurrent (geometric mean of 2021-2023 estimates)
- Expected SSC Recommendations:
  - F based on P* method
  - Constant catch scenarios?

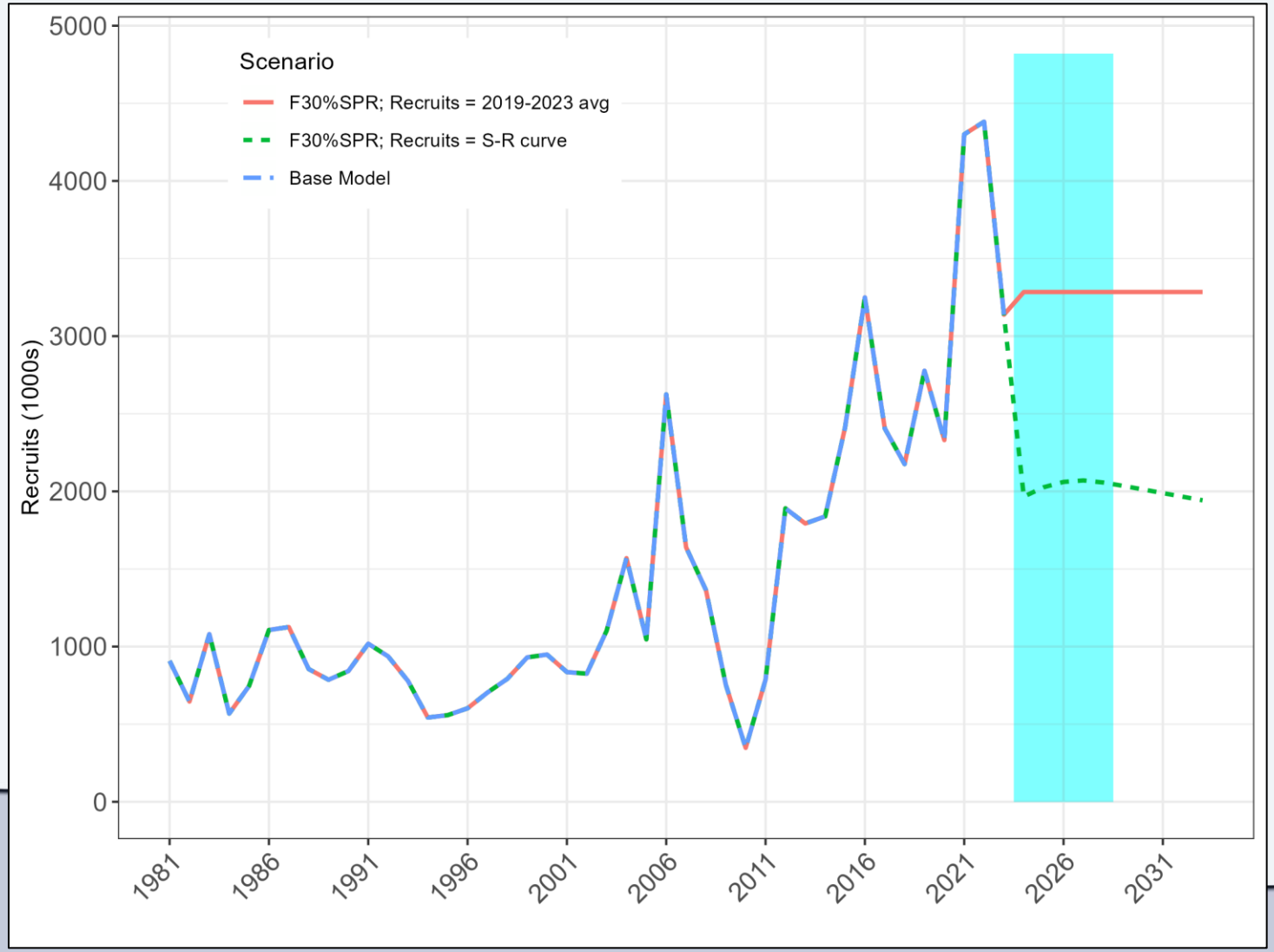
Projection Scenario – $F_{30\%SPR}$ (short- and long-term)

	Long-Term Projections					Short-Term Projections				
Year	**Age 1 Recruits**	**F**	**SSB**	**Retained Yield**	**Retained Num**	**Age 1 Recruits**	**F**	**SSB**	**Retained Yield**	**Retained Num**
2024	1.966	0.149	6,488	3,278,980	627,789	3,284	0.149	6,488	3,280,143	628,742
2025	2.026	0.149	6,864	3,372,143	623,832	3,284	0.149	6,867	3,384,760	630,618
2026	2.061	0.149	6,974	3,249,912	564,280	3,284	0.149	7,029	3,363,706	605,530
2027	2.070	0.149	6,821	3,023,751	495,817	3,284	0.149	7,089	3,313,030	583,152
2028	2.057	0.149	6,584	2,814,305	446,663	3,284	0.149	7,118	3,270,355	568,844
2029	2.035	0.149	6,342	2,650,664	415,719	3,284	0.149	7,130	3,239,178	560,244
2030	2.012	0.149	6,109	2,523,697	395,653	3,284	0.149	7,130	3,216,409	554,984
2031	1.989	0.149	5,889	2,421,114	381,362	3,284	0.149	7,123	3,199,290	551,639
2032	1.965	0.149	5,682	2,335,047	370,254	3,284	0.149	7,112	3,186,071	549,426
2033	1.942	0.149	5,490	2,261,068	361,084	3,284	0.149	7,098	3,175,662	547,907

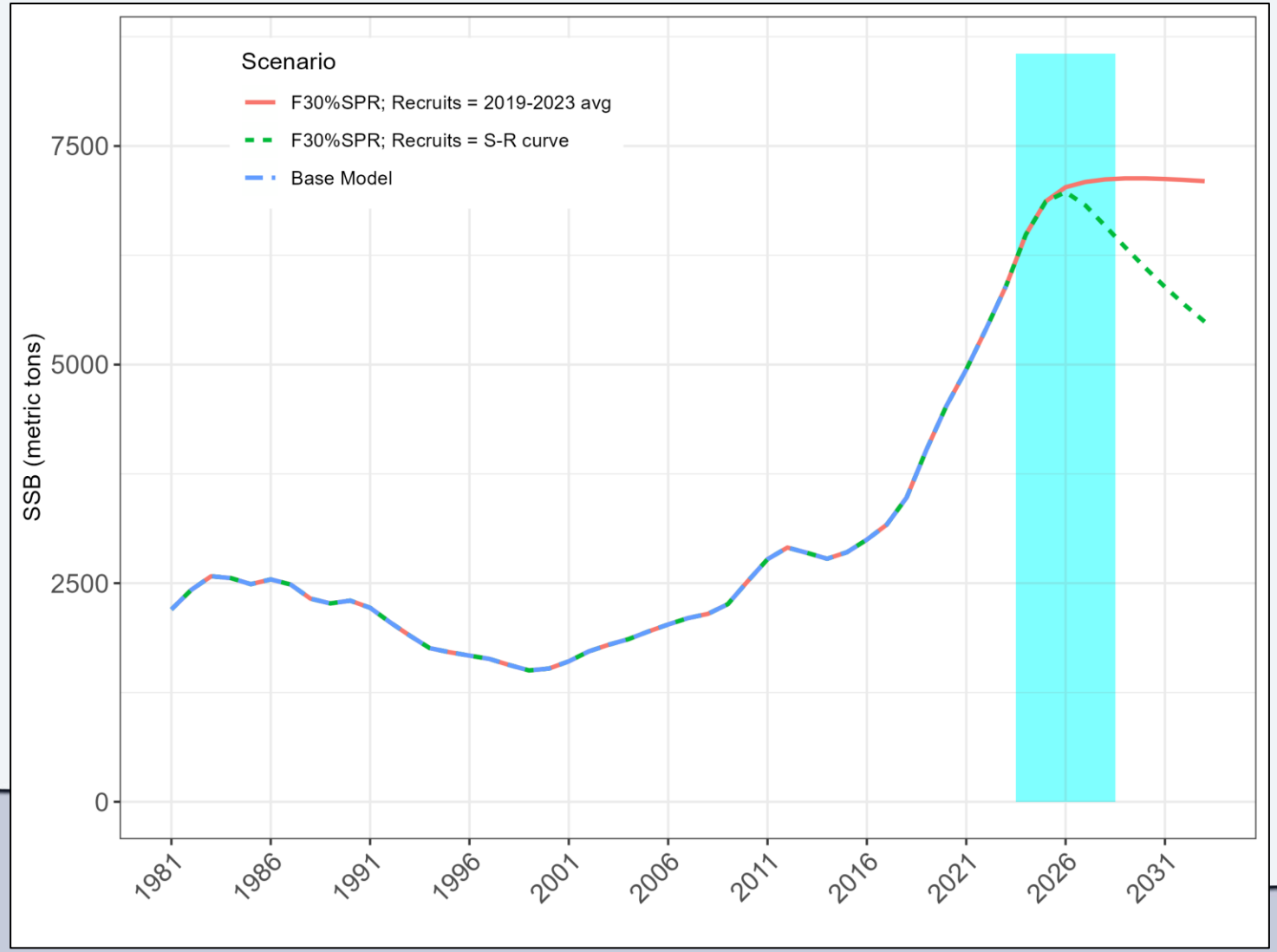
$F_{30\%SPR}$ Projection Scenario – Fishing Mortality



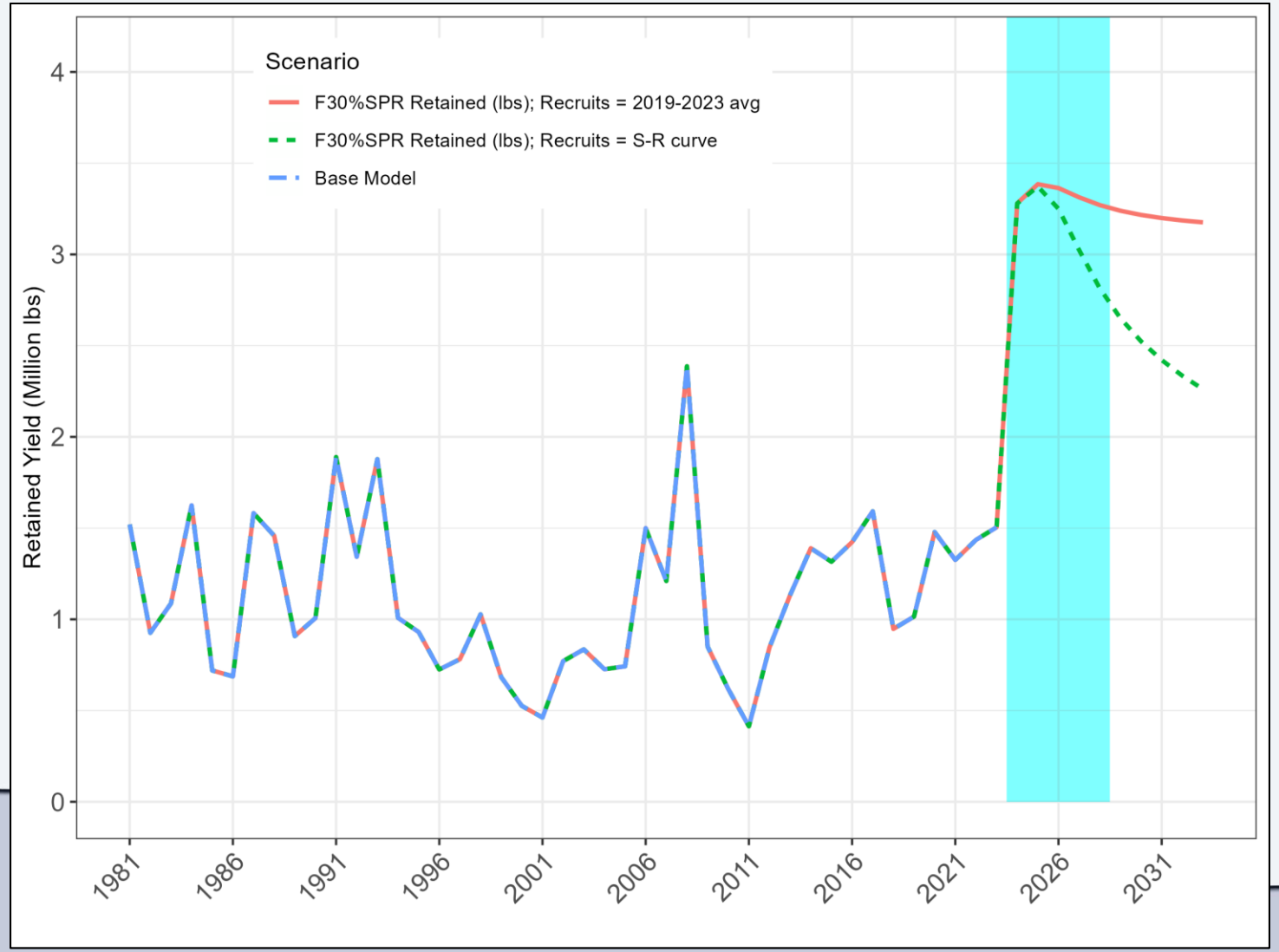
$F_{30\%SPR}$ Projection Scenario - Recruits



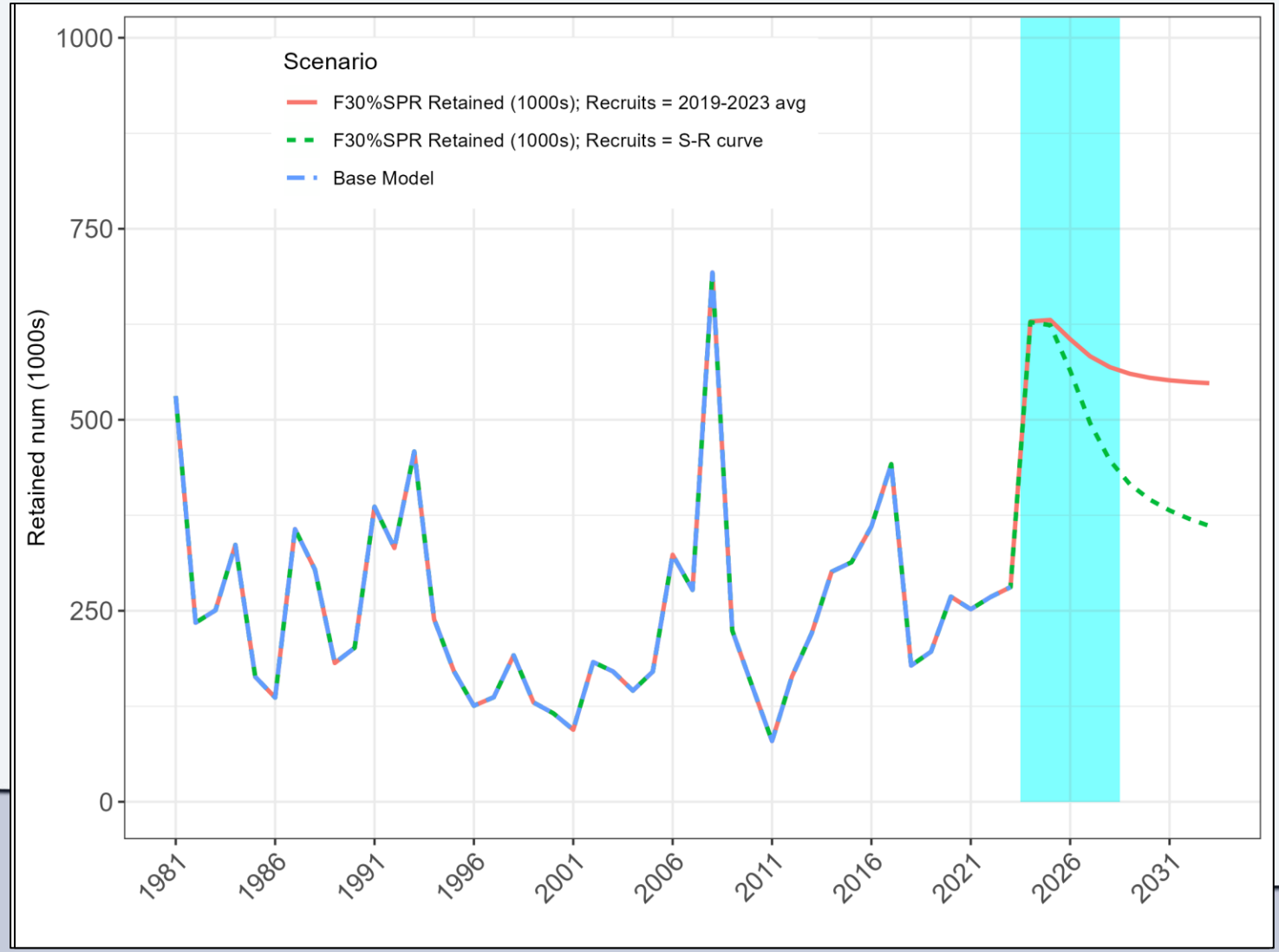
$F_{30\%SPR}$ Projection Scenario - SSB



$F_{30\%SPR}$ Projection Scenario – Retained Yield (lbs)



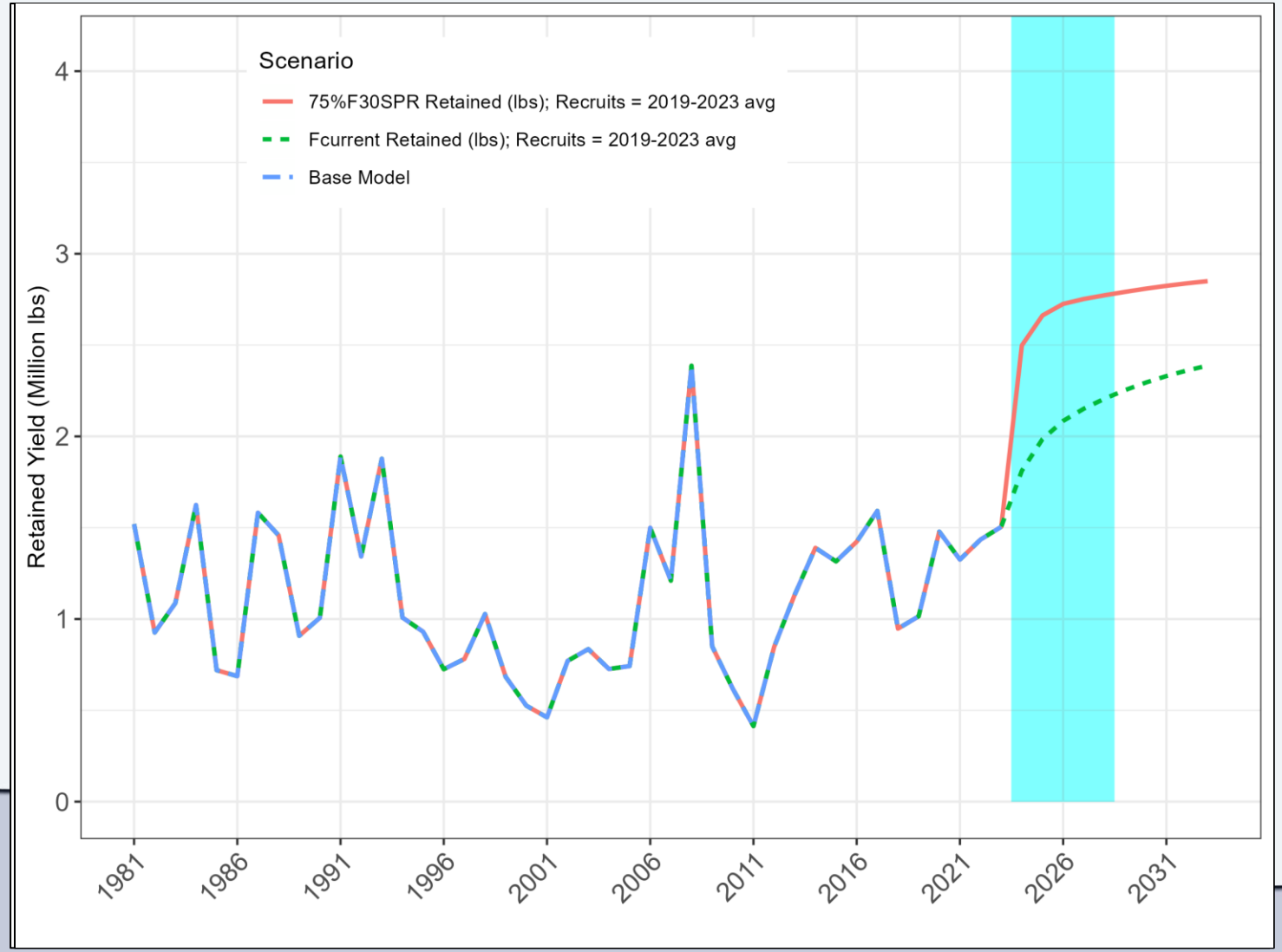
$F_{30\%SPR}$ Projection Scenario – Retained Yield (num)



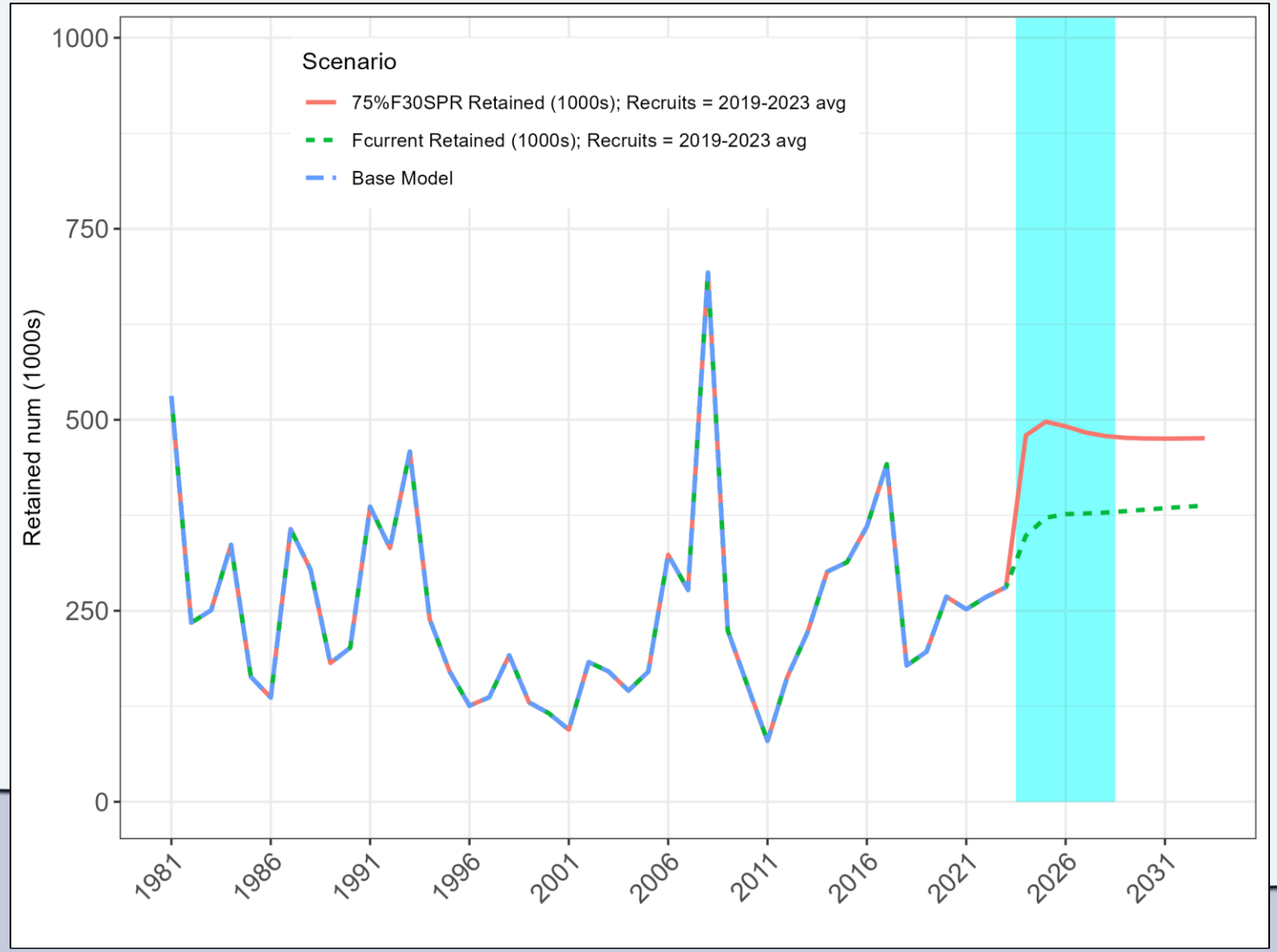
Projection Scenarios – Fcurrent & 75% $F_{30\%SPR}$

	Short-Term Projections - 75% $F_{30\%SPR}$					Short-Term Projections - $F_{current}$				
Year	**Age 1 Recruits**	**F**	**SSB**	**Retained Yield**	**Retained Num**	**Age 1 Recruits**	**F**	**SSB**	**Retained Yield**	**Retained Num**
2024	3.284	0.112	6,565	2,498,073	479,551	3.284	0.080	6,631	1,811,994	348,293
2025	3.284	0.112	7,160	2,662,320	497,423	3.284	0.080	7,419	1,985,255	371,812
2026	3.284	0.112	7,547	2,725,359	491,431	3.284	0.080	8,022	2,084,741	376,453
2027	3.284	0.112	7,822	2,752,377	483,445	3.284	0.080	8,512	2,151,561	377,279
2028	3.284	0.112	8,047	2,772,615	478,662	3.284	0.080	8,942	2,206,166	378,545
2029	3.284	0.112	8,233	2,791,436	476,385	3.284	0.080	9,319	2,253,469	380,361
2030	3.284	0.112	8,386	2,808,849	475,505	3.284	0.080	9,646	2,294,626	382,360
2031	3.284	0.112	8,513	2,824,461	475,332	3.284	0.080	9,930	2,330,278	384,303
2032	3.284	0.112	8,618	2,838,173	475,501	3.284	0.080	10,177	2,361,052	386,090
2033	3.284	0.112	8,705	2,850,076	475,824	3.284	0.080	10,389	2,387,571	387,685

Other Projection Scenarios – Retained Yield (lbs)

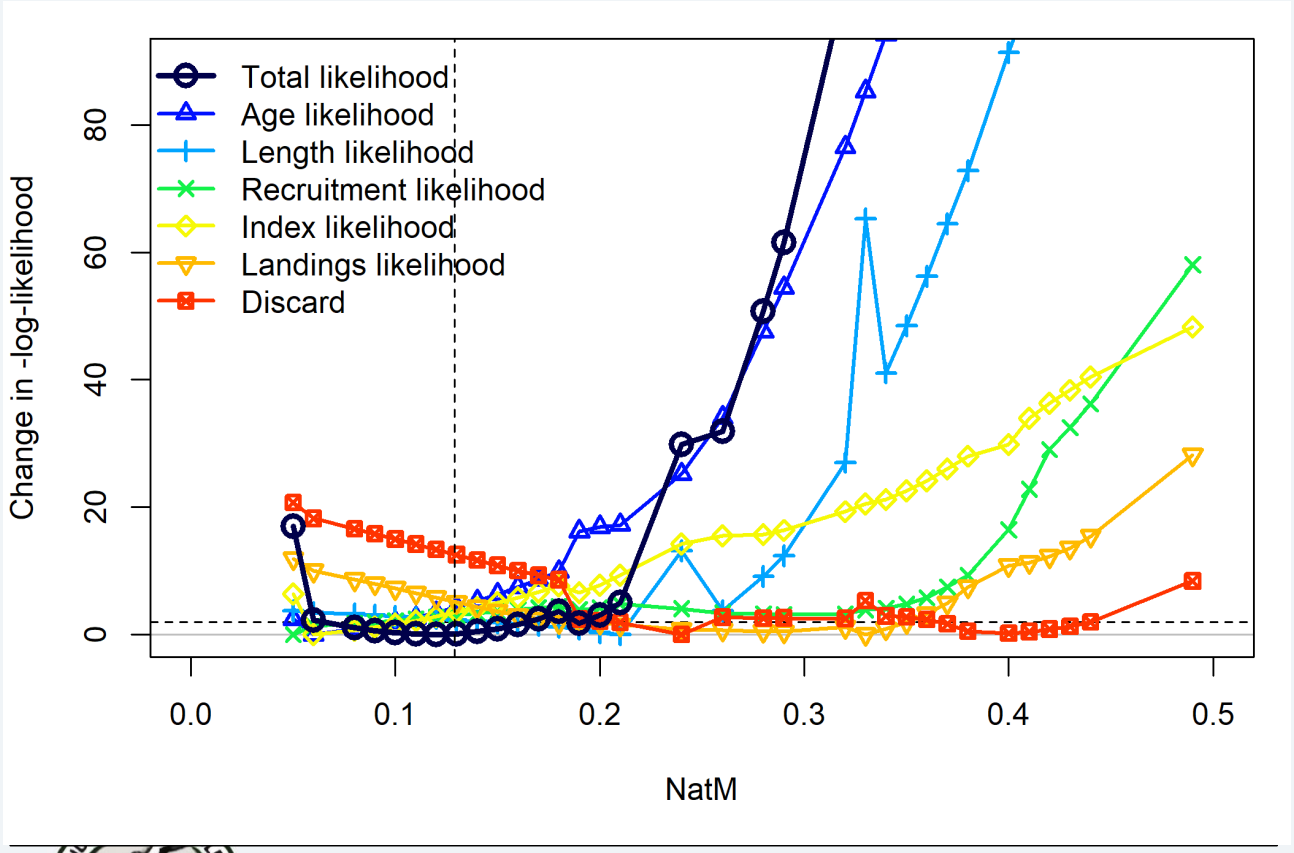


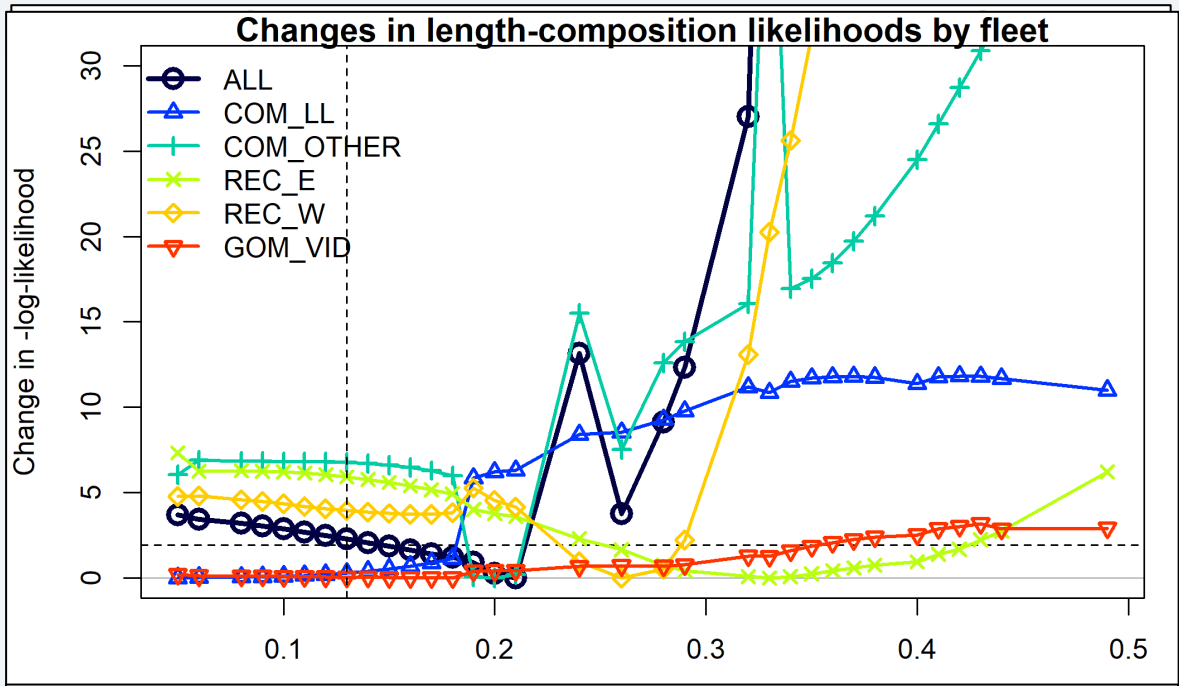
Other Projection Scenarios – Retained Yield (num)

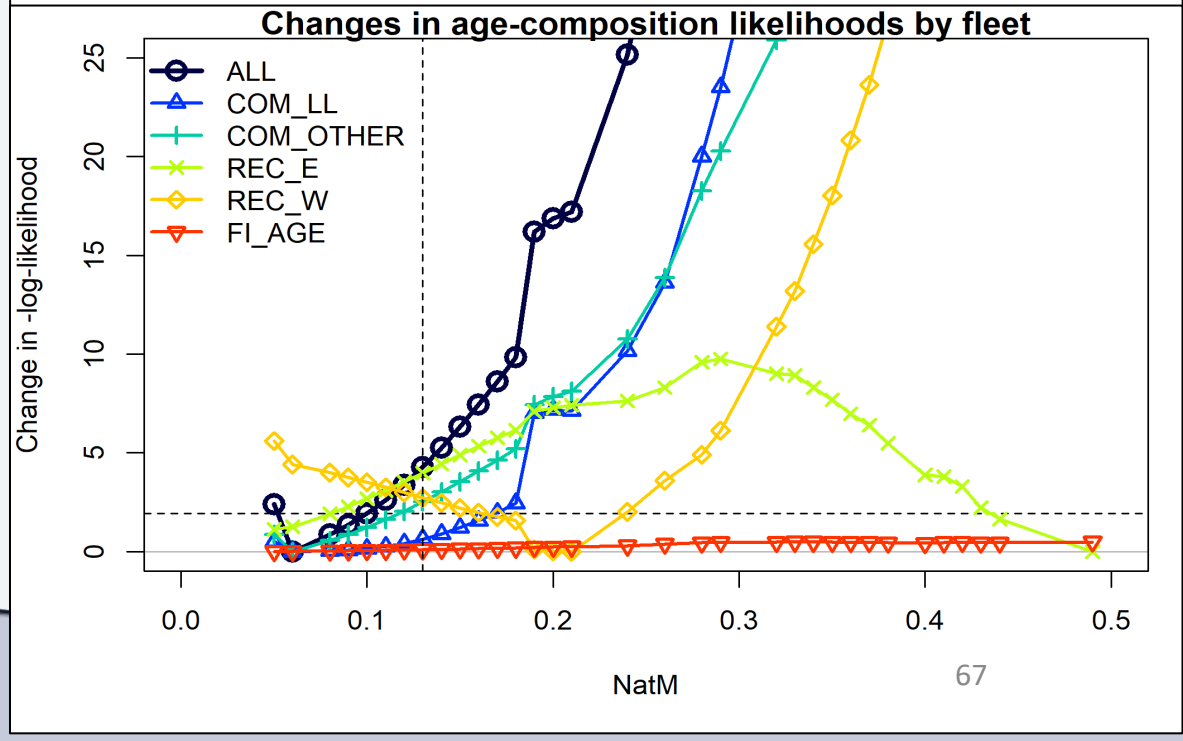


Feeley et al. 2018

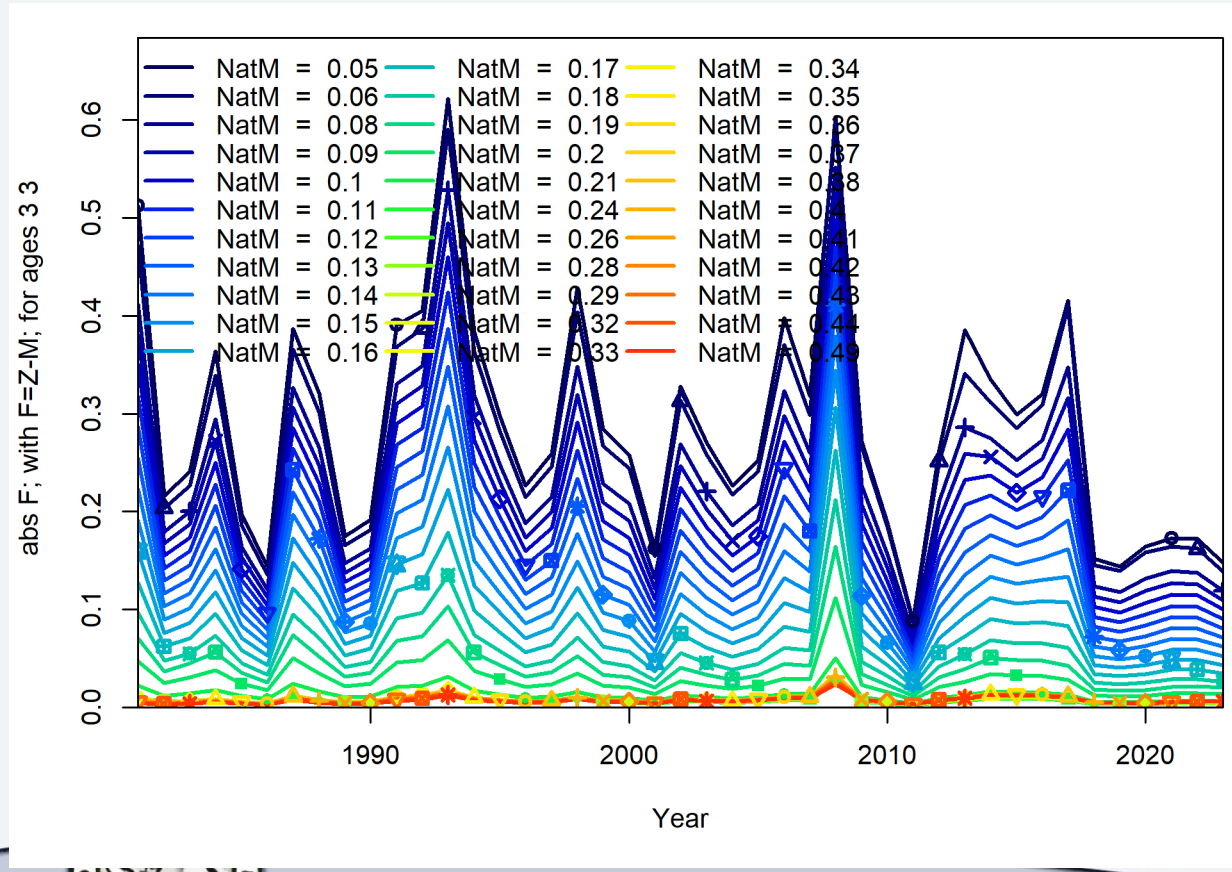
Profiling on Base M

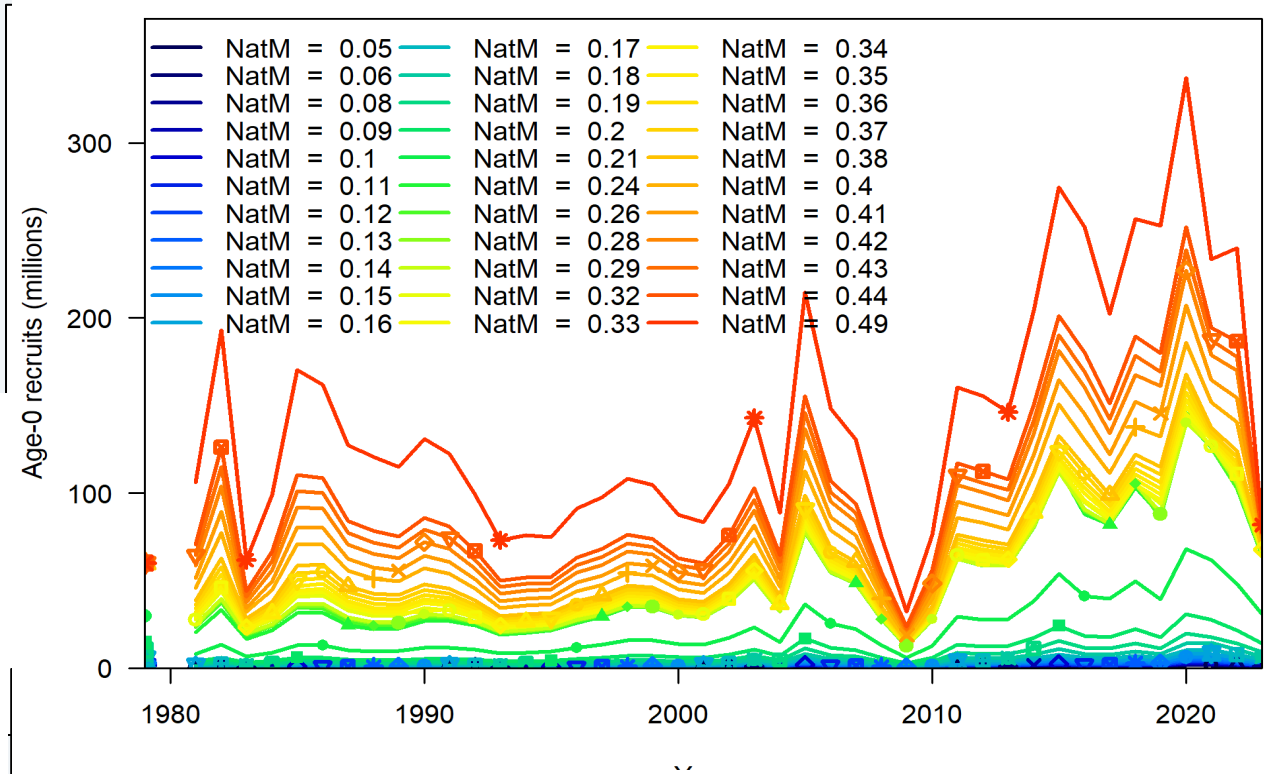


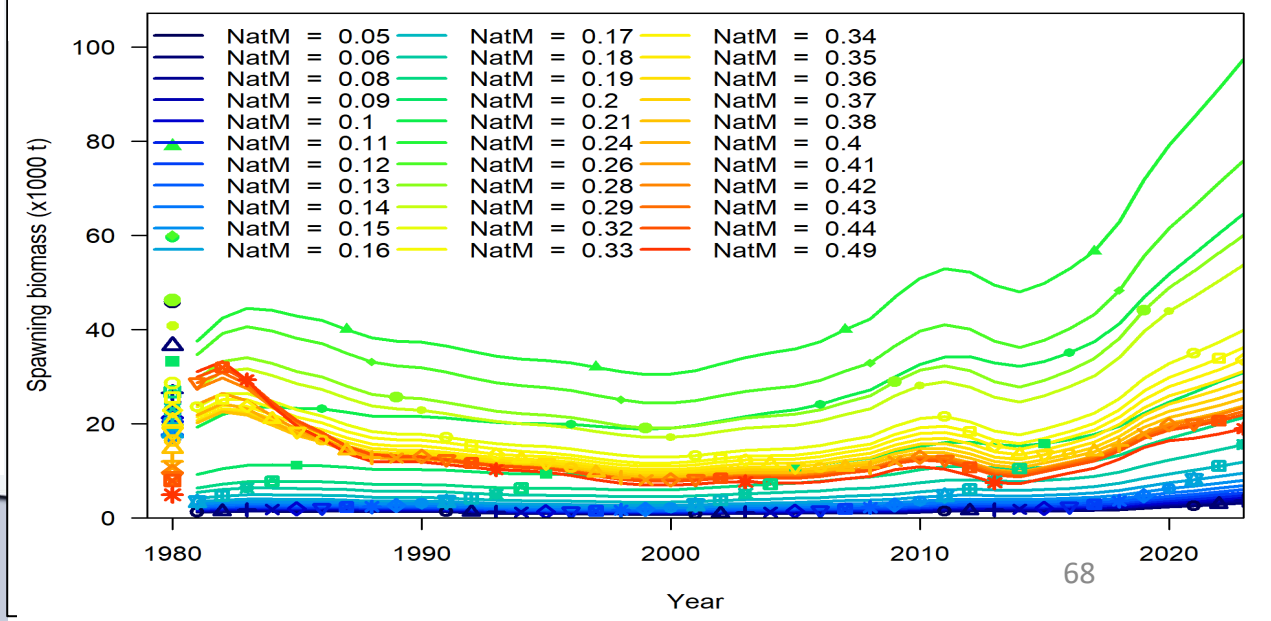




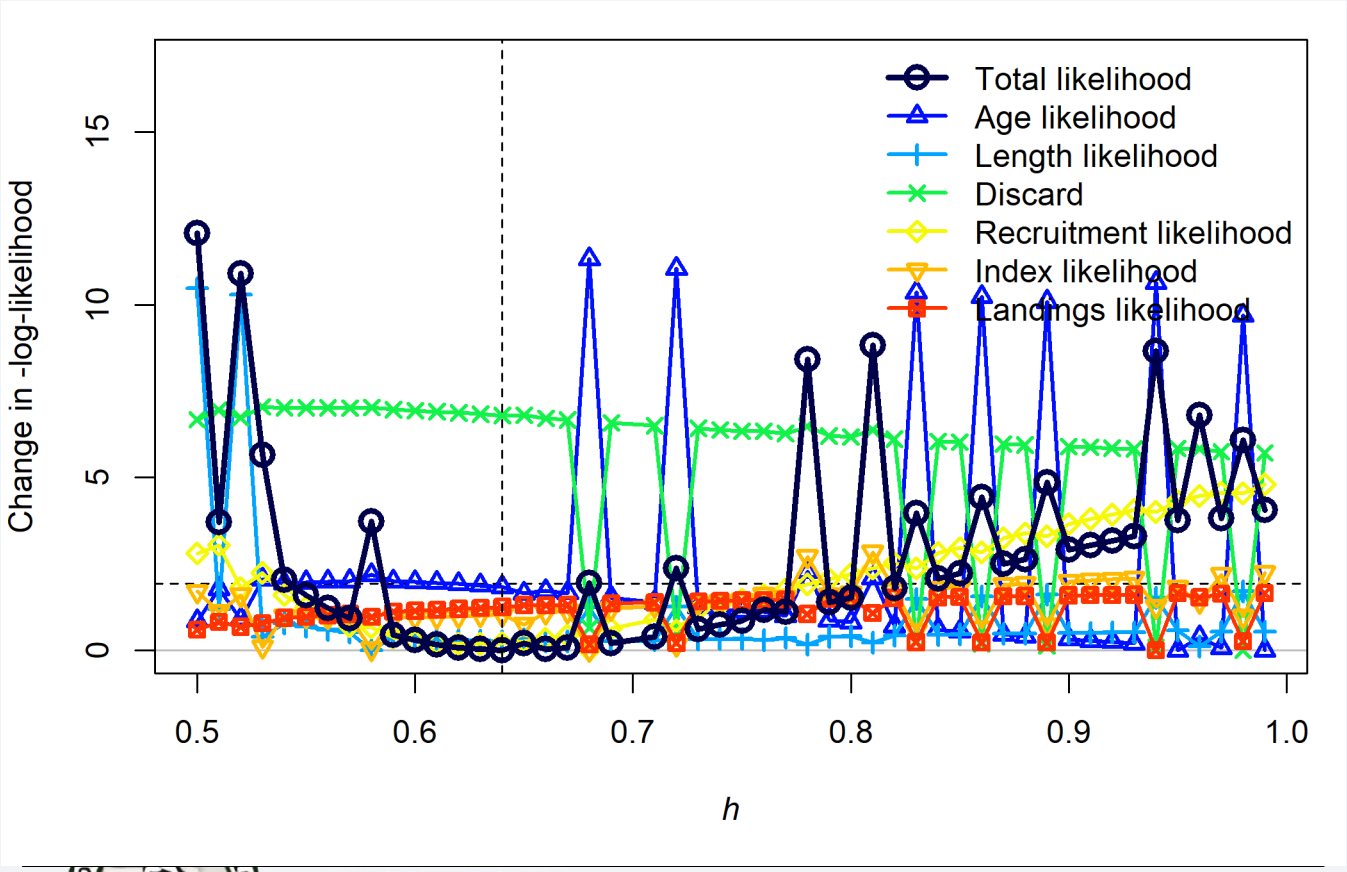
Profiling on Base M

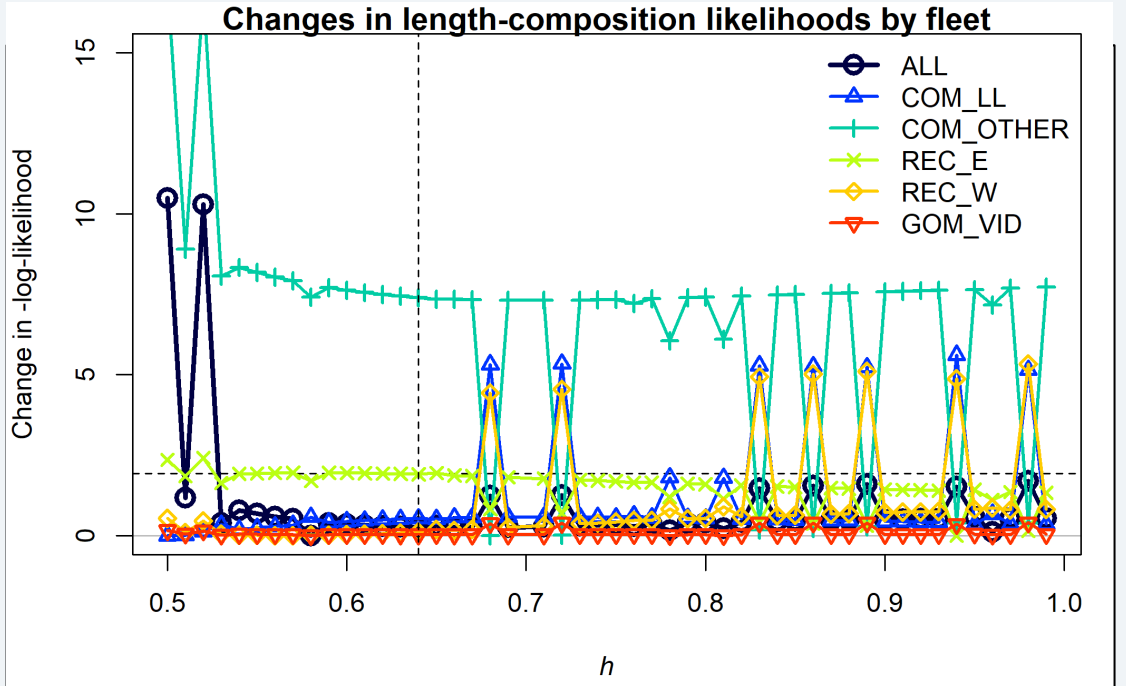


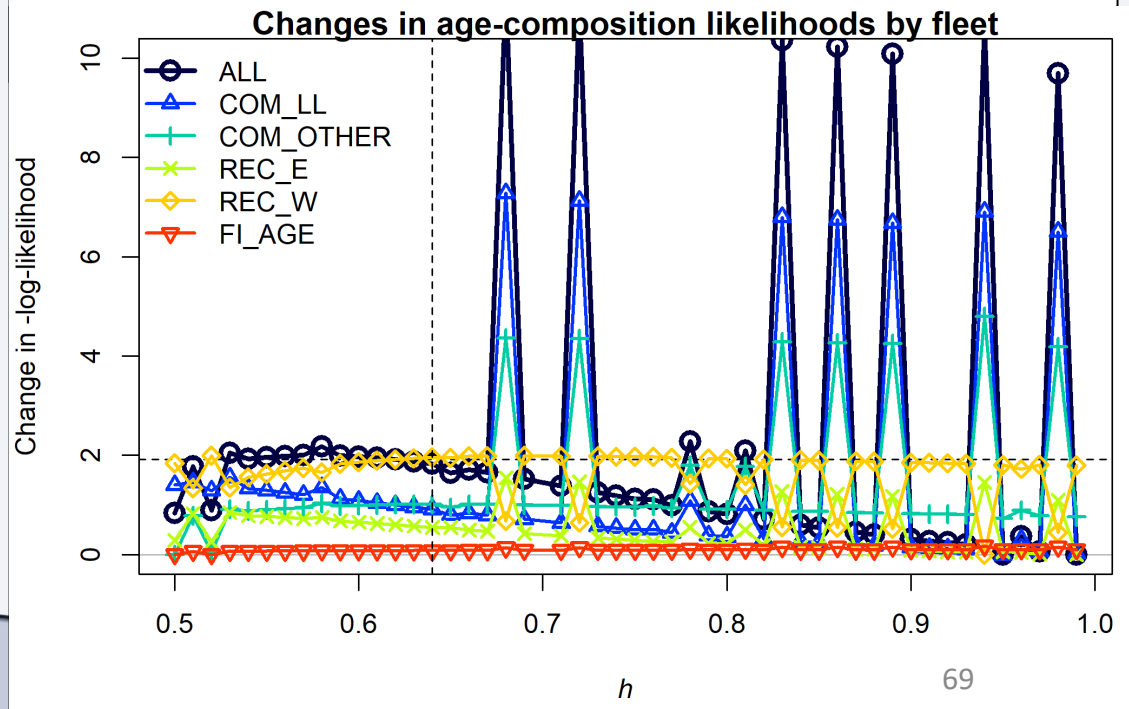




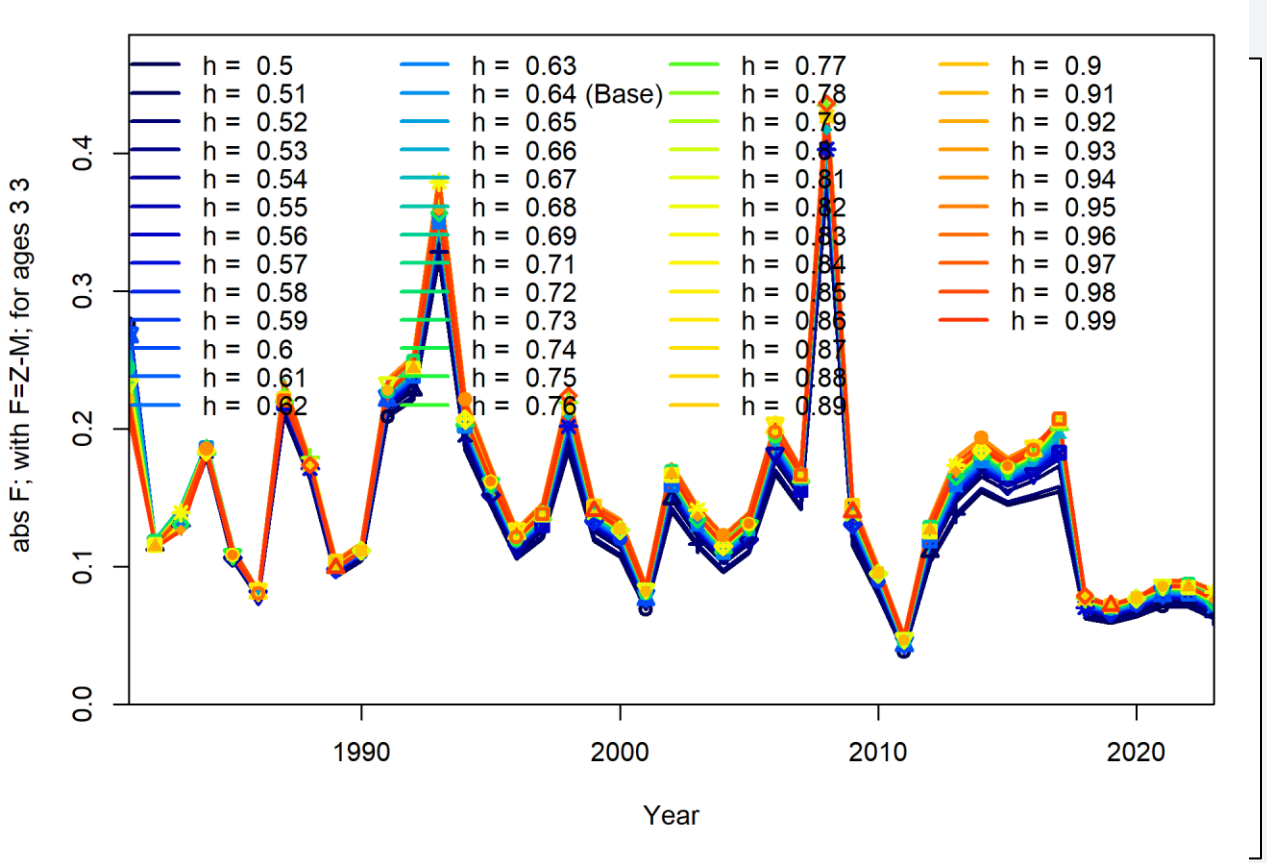
Profiling on Steepness

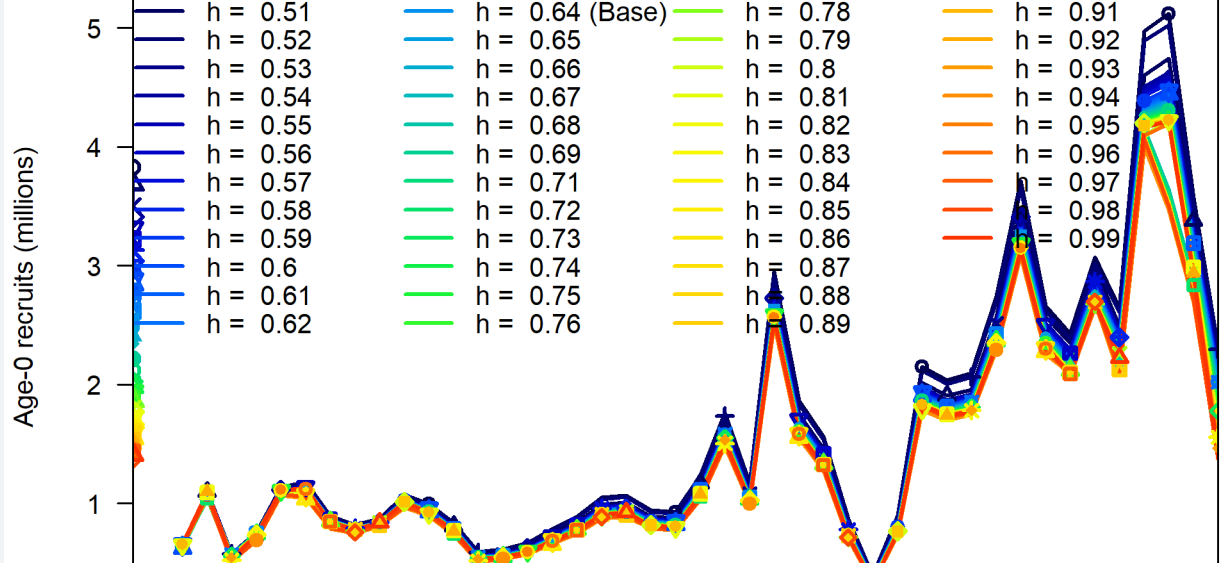


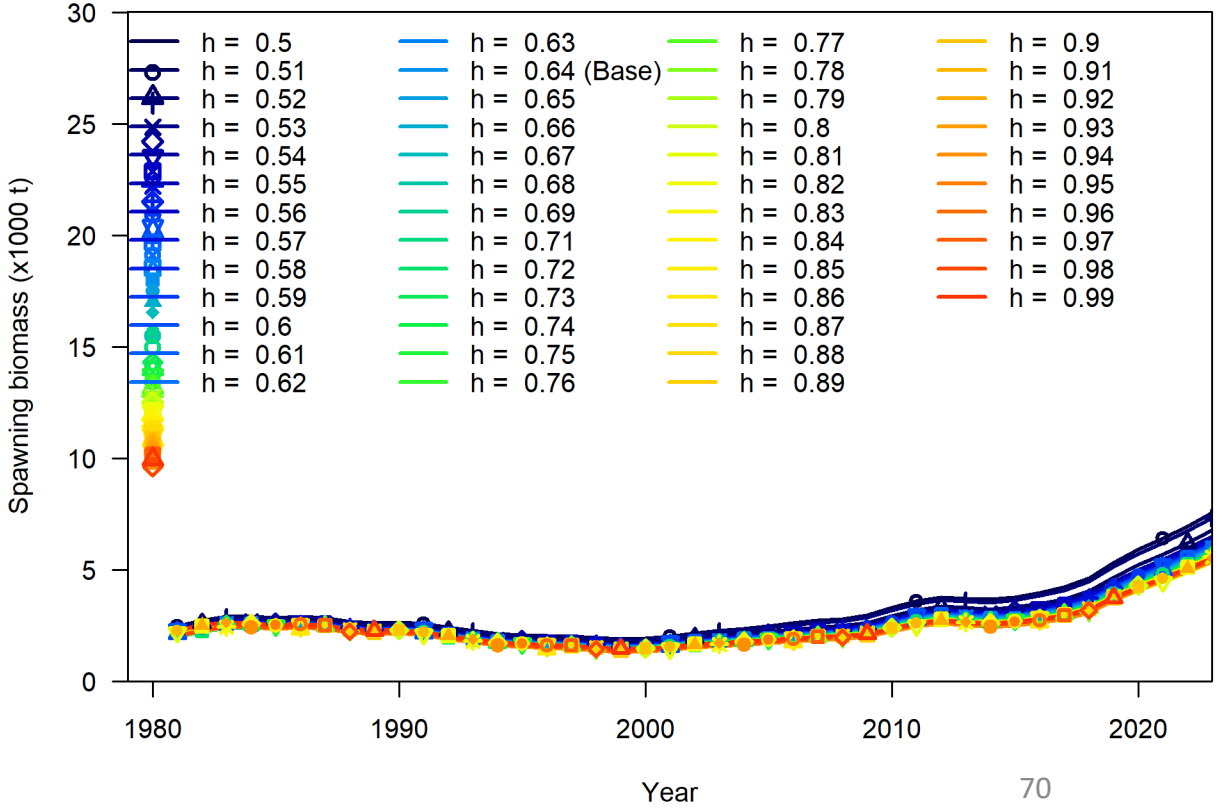




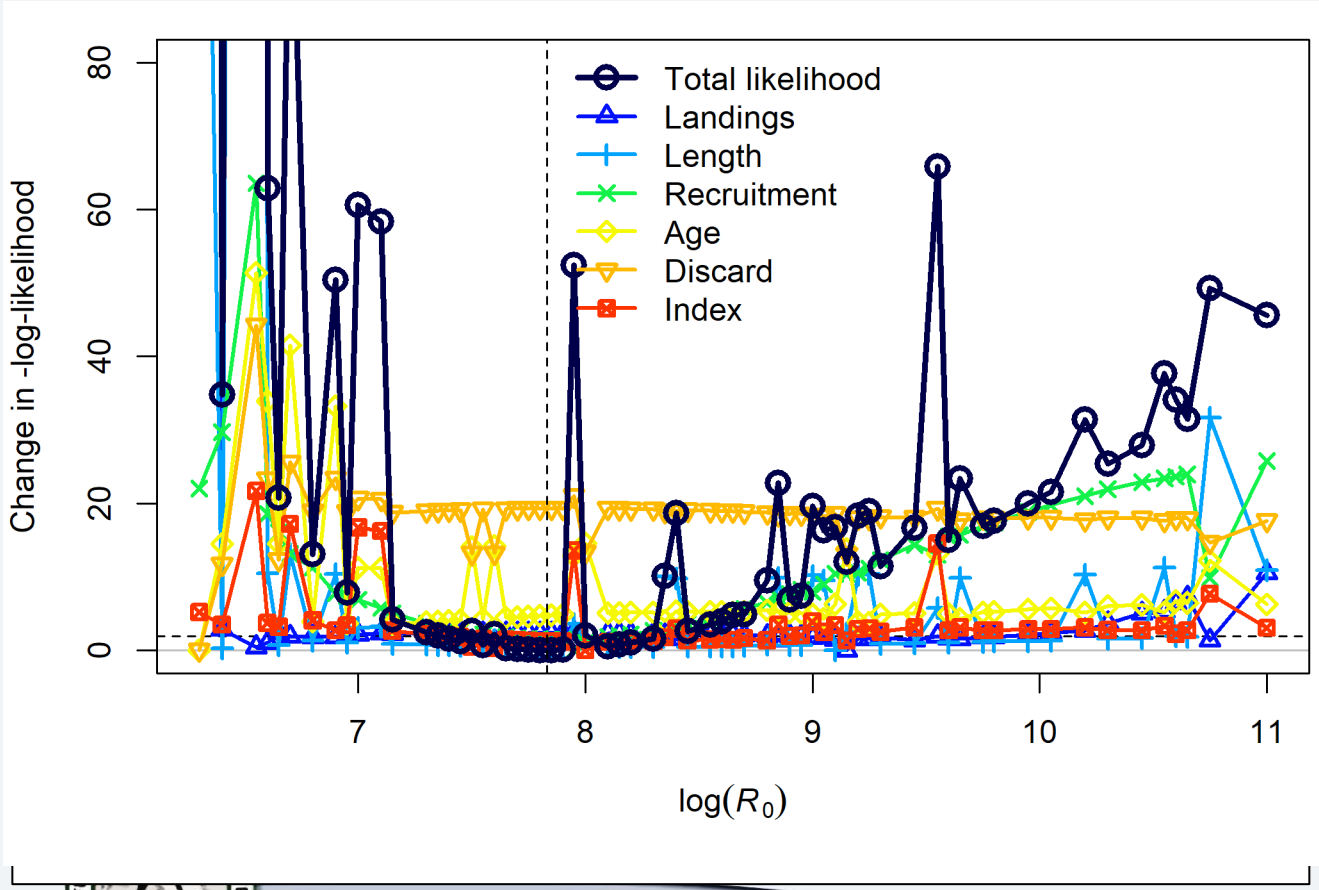
Profiling on Steepness

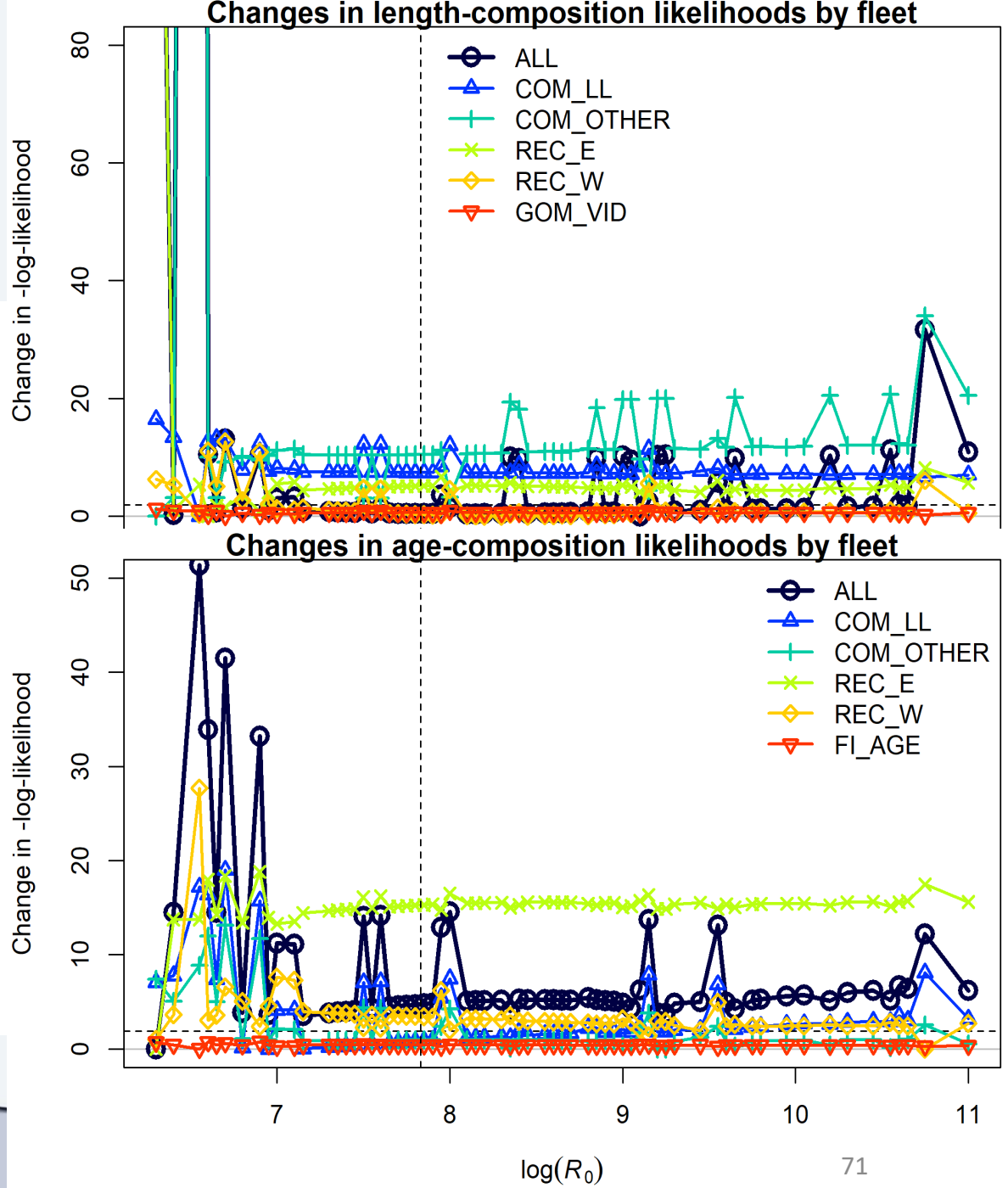






Profiling on R0





Profiling on R0