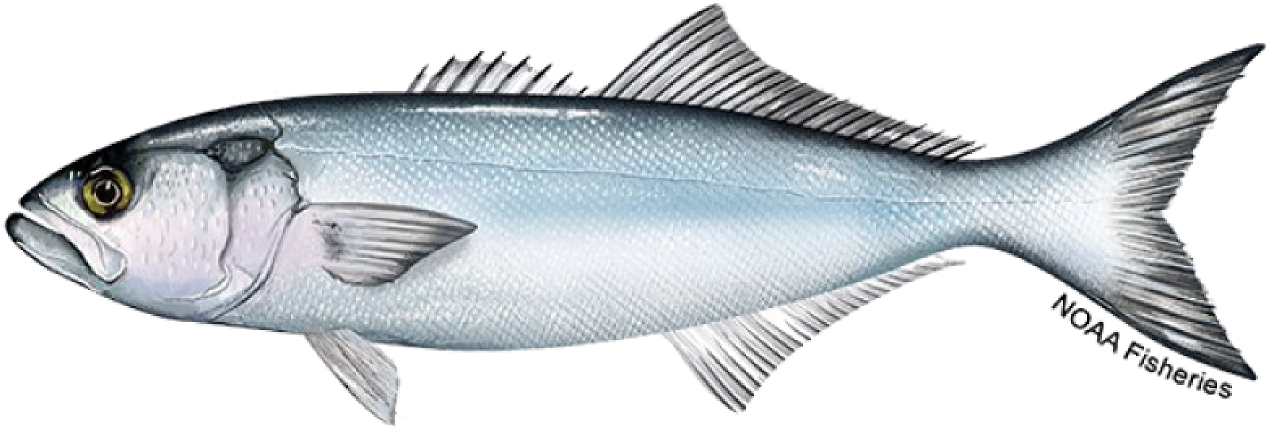
NOAA FISHERIES

NEFSC

Bluefish Research Track Final Model, Status, and Projections



Model Building Summary

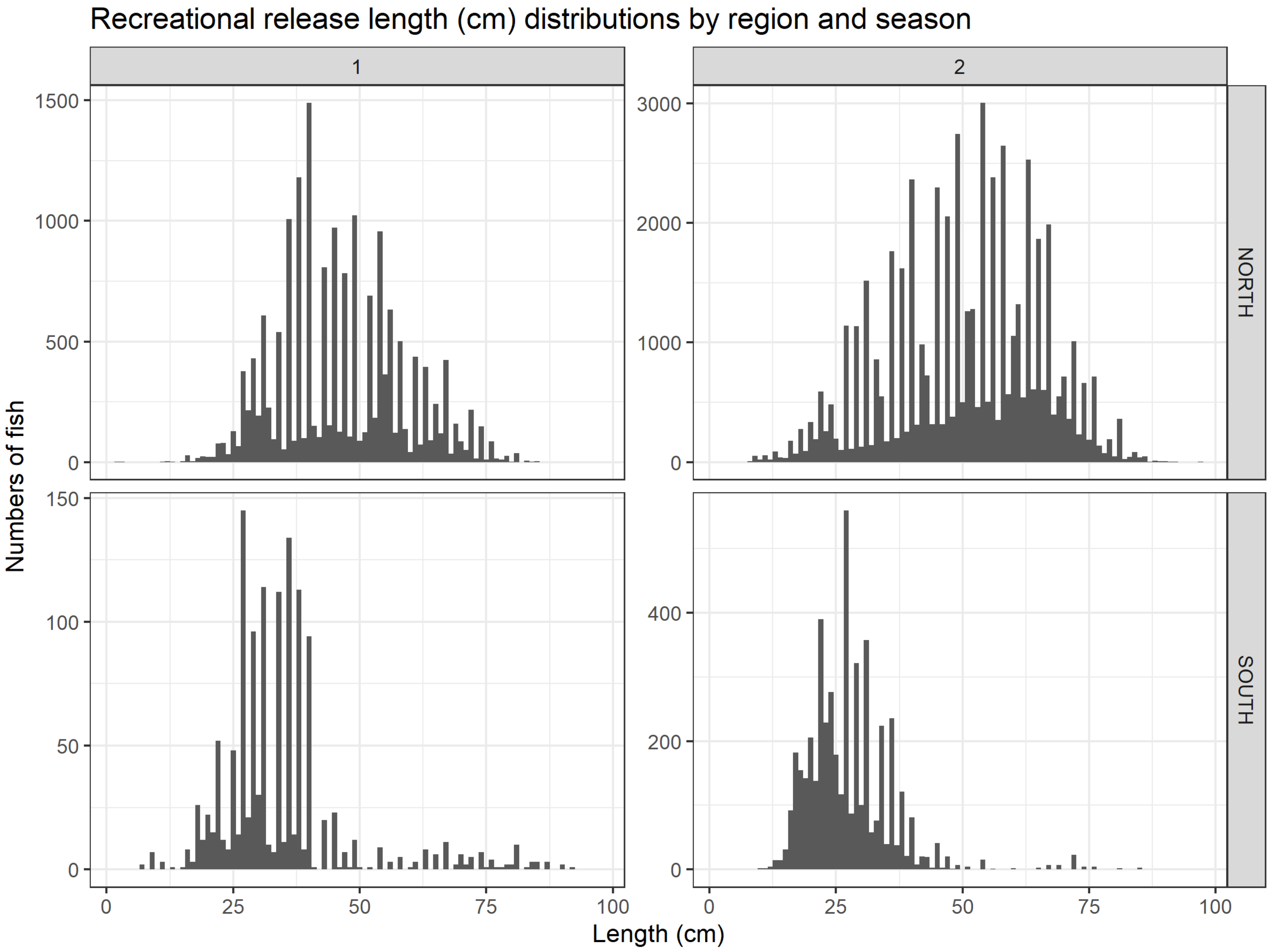
- Model building procedure was primarily carried out in ASAP
- First step was to update the SAW60 model through 2021: Continuity run
- A base model was constructed by adding new data and indices to the continuity run
- A model bridge was then built through step wise changes in data (changes in calculation, addition of new data, removal of data), model specifications, and weights
- The final ASAP model was shifted into a new model framework, WHAM
  - General state-space age-structured assessment model that is able to incorporate environmental effects on population processes
  - Models that included random effects on the NAA were explored and model selection was used to select the final model

Model Building: Notable Changes

- New L-W parameters were calculated using updated biological information
- Recreational discard mortality rate was re-evaluated, changing from 15% to 9.4%
- Commercial discards were incorporated (although insignificant ~0.2% of total catch)
- MRIP index was derived using a Guild approach
- New Indices: SEAMAP Age 1 and ChesMMAP
- Recreational discard lengths were stratified by season and region (North/South)
  - New VAS from SC, ~3000 lengths from 1985-2021
- Natural mortality was changed to age-specific based on Lorenzen empirical WAA
  - Changed from 0.2 to M-at-age (constant across years): Age 0: 0.850, Age 1: 0.575, Age 2: 0.453, Age 3: 0.373, Age 4: 0.324, Age 5: 0.294, Age 6+: 0.268
- Multinomial ALKs
- Added selectivity blocks into both fleets

Model Building: Recreational Discard Lengths

- Added a regional level of stratification to the distribution of discard lengths
- Southern length information mostly from ALS, SC VAS
- Previously, by using northern length distribution for southern fish we were likely over-estimating discard weight
- Overall effect of reducing discard weight
- GARFO/Center will use same rec discard estimate going forward



Woods Hole Assessment Model (WHAM)

- WHAM is a flexible model framework that can be configured as a traditional statistical catch-at-age model, which allows for bridge building transitions from models like ASAP
- The RT2022 working group chose WHAM because of its flexible framework, specifically allowing for the estimation of random effects on recruitment and NAA
- State-space models tend to have lower retrospective bias in model results, and more realistic estimates of uncertainty
- Also shifted into WHAM to explore environmental covariate links on the catchability of different surveys indices
- The focus of the model exploration in WHAM was to investigate NAA RE with the final bluefish model from ASAP, and not continue building a model bridge

Final Bluefish Model: BF28W

- The Final model was explored with random effects on recruitment and numbers-at-age
- Each model explored different options for treating the yearly transitions in survival

1. Deterministic survival (Traditional SCAA model, recruitment in each year is estimated as independent fixed effect parameters).
2. Recruitment deviations (random about mean) are random effects
   a. Random effects are independent, uncorrelated: model _m2 going forward
   b. Autoregressive (AR1) by year (autocorrelated): model _m3 going forward
3. Full state-space model where survival of all ages are random effects
   a. Random effects are independent, uncorrelated: model _m4 going forward
   b. Autoregressive (AR1) deviations by year: model _m5 going forward
   c. Autoregressive (AR1) deviations by age: model _m6 going forward
   d. Autoregressive deviations by age and year (2D AR1): model _m7 going forward

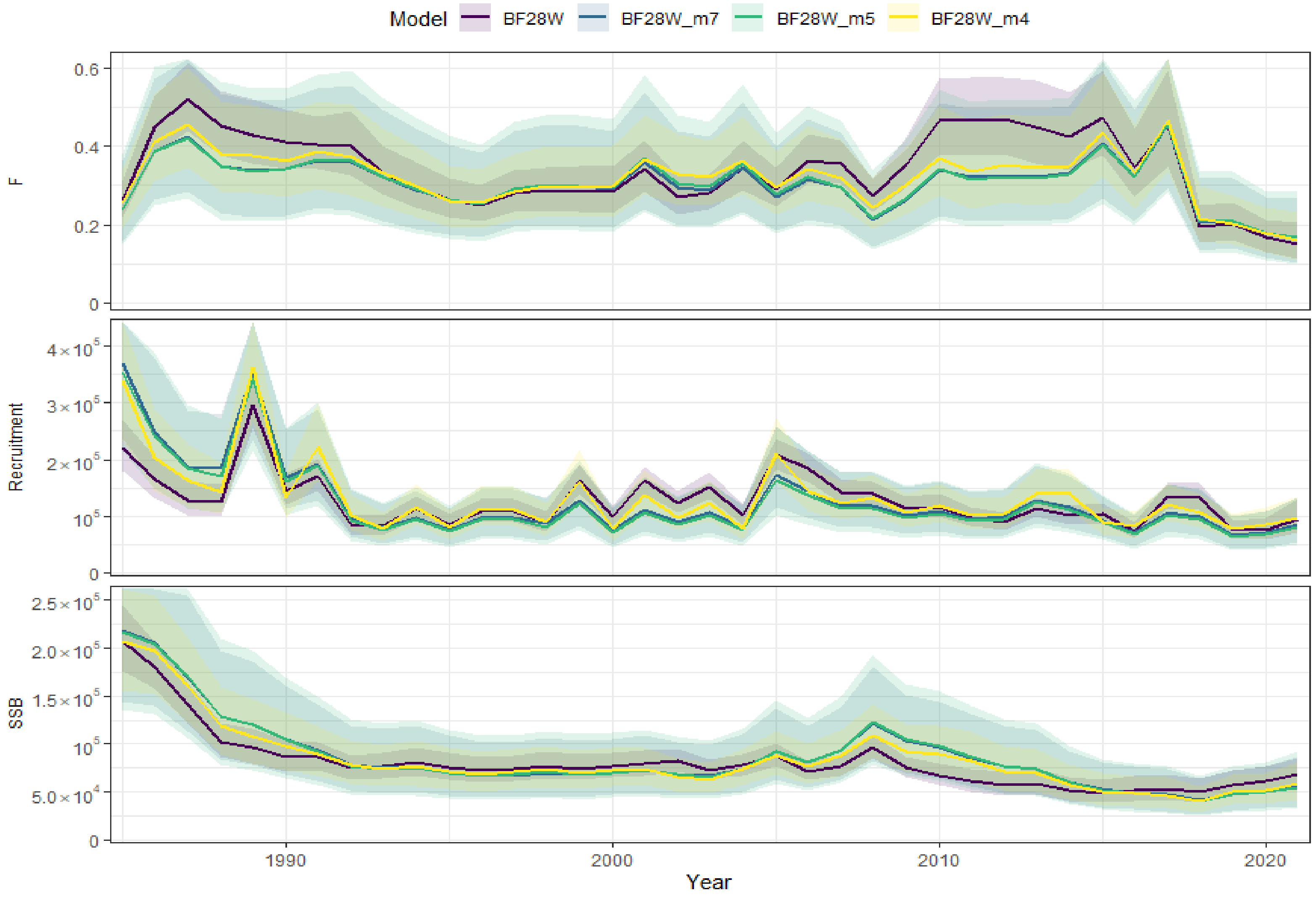
BF28W m1-m7: Results table

Model	Description	dAIC	AIC	2021 SSB (MT)	2021 R (mil)	2021 F	R ρ	SSB ρ	F ρ	Con-verged?	Positive definite Hessian?
BF28W	Base model: traditional statistical catch-at-age	~	~	68,631	96.4	0.152	-0.063	0.248	-0.197	TRUE	TRUE
m7	All NAA transitions are random effects correlated by year and age	0	3229	55,344	86.5	0.166	0.010	0.130	-0.096	TRUE	TRUE
m5	All NAA transitions are random effects correlated by year	3	3232	55,070	82.3	0.167	0.019	0.126	-0.097	TRUE	TRUE
m4	All NAA transitions are random effects independent, identically distributed	46.2	3275	58,114	98.6	0.160	-0.008	0.172	-0.144	TRUE	TRUE
m6	All NAA transitions are random effects correlated by age	46.9	3276	58,786	99.9	0.159	-0.004	0.177	-0.148	TRUE	TRUE
m2	Recruitment transitions are random effects independent, identically distributed	111	3340	73,843	104.1	0.144	-0.022	0.236	-0.195	TRUE	TRUE
m3	Recruitment transitions are random effects correlated by year	111	3340	72,329	101.3	0.146	-0.020	0.245	-0.198	TRUE	TRUE

- All state space models converged and had a positive definite hessian matrix
- Based on AIC selection, all of the top models were full state-space models, where survival of all ages were random effects
- The model with the lowest AIC was BF28W_m7, which included correlation in the random effects by year and age (2DAR1)

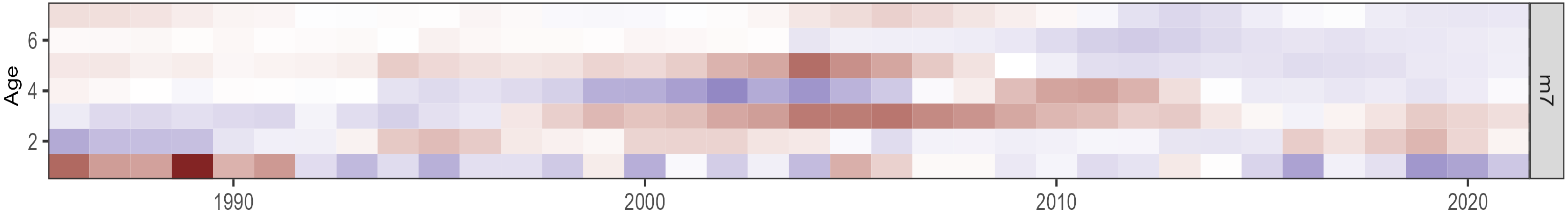
BF28W top models: Results

- Results from the top 3 state-space models (BF28W_m7, BF28W_m5, and BF28W_m4) and the base statistical catch-at-age model (BF28W) show good agreement among the model results
- Final model chosen as full state-space model with NAA devs on all ages and 2DAR1 correlation (**BF28W_m7**)



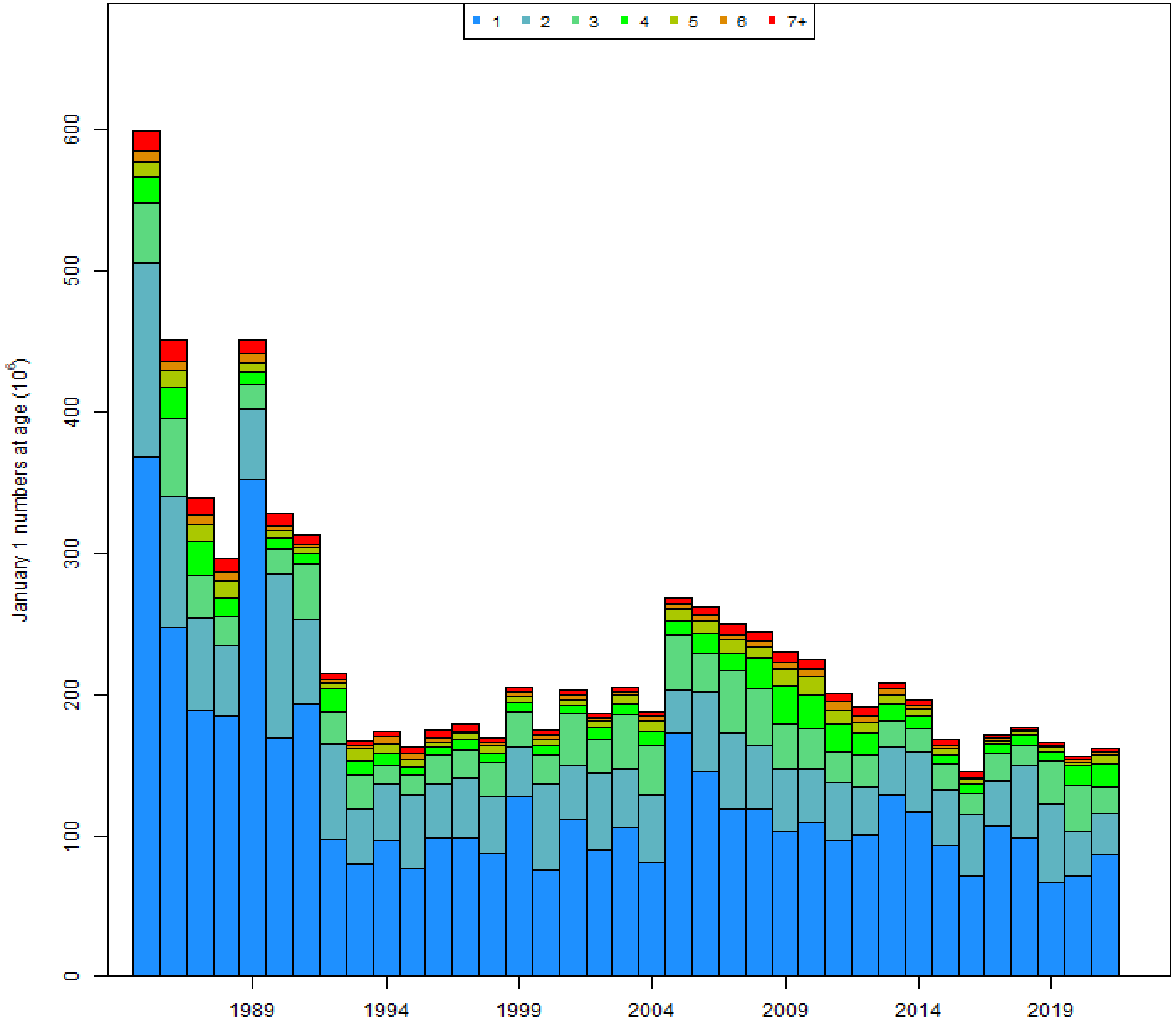
BF28W_m7 Results: NAA deviations

	Estimate	Std. Error	95% CI lower	95% CI upper
NAA σ (age 1)	0.305	0.049	0.223	0.419
NAA σ (age 2-7+)	0.149	0.021	0.112	0.197
NAA residual AR1 ρ age	-0.310	0.130	-0.292	-0.019
NAA residual AR1 ρ year	0.800	0.063	0.362	0.617



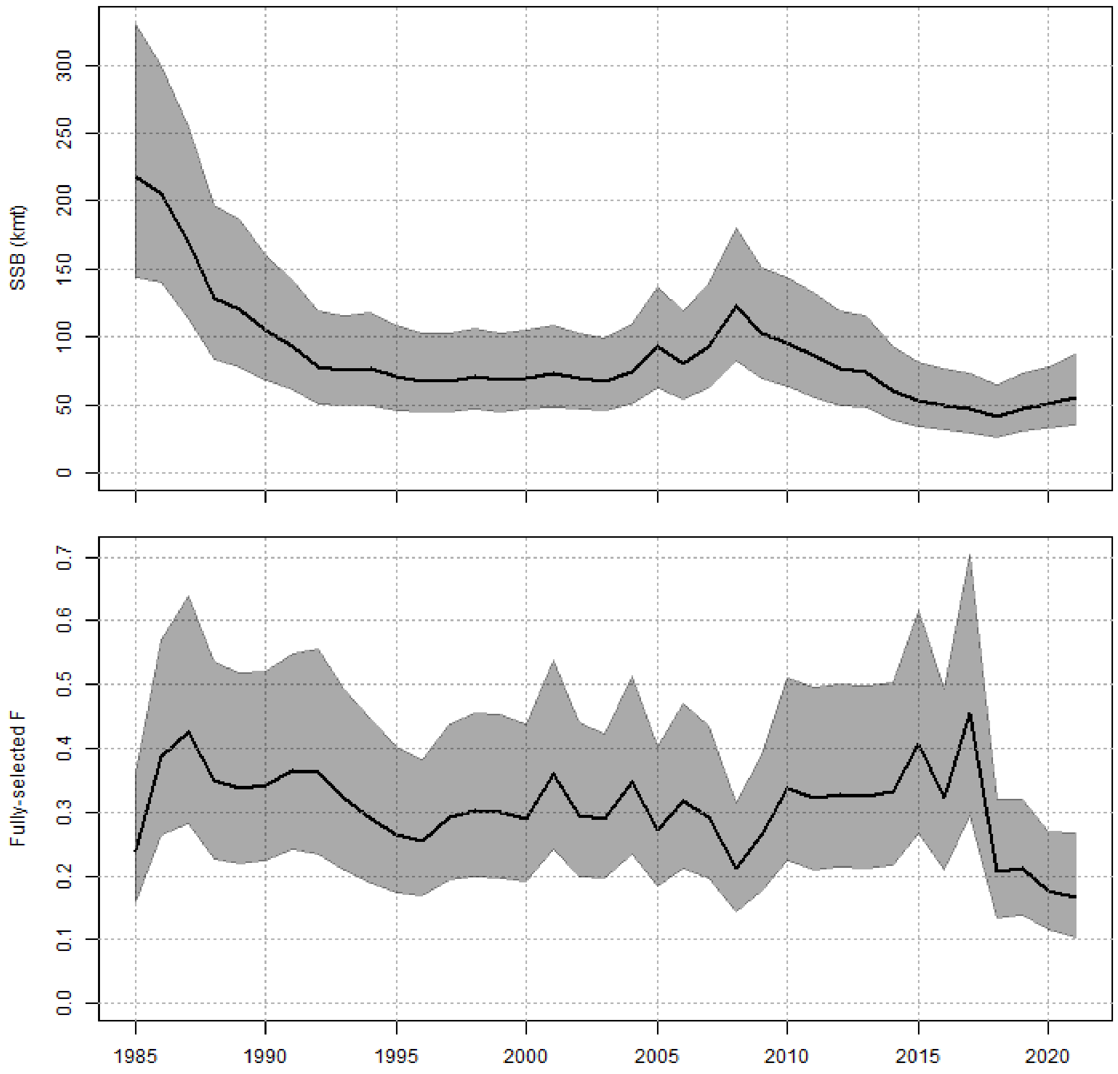
- Correlation by age is low, and shows series of positive, negative and positive values from age-3 to age-5 in the middle of the time-series
- negative correlation between these ages is likely a result of the changing availability over time of this size class to the fisheries

BF28W_m7 Abundance



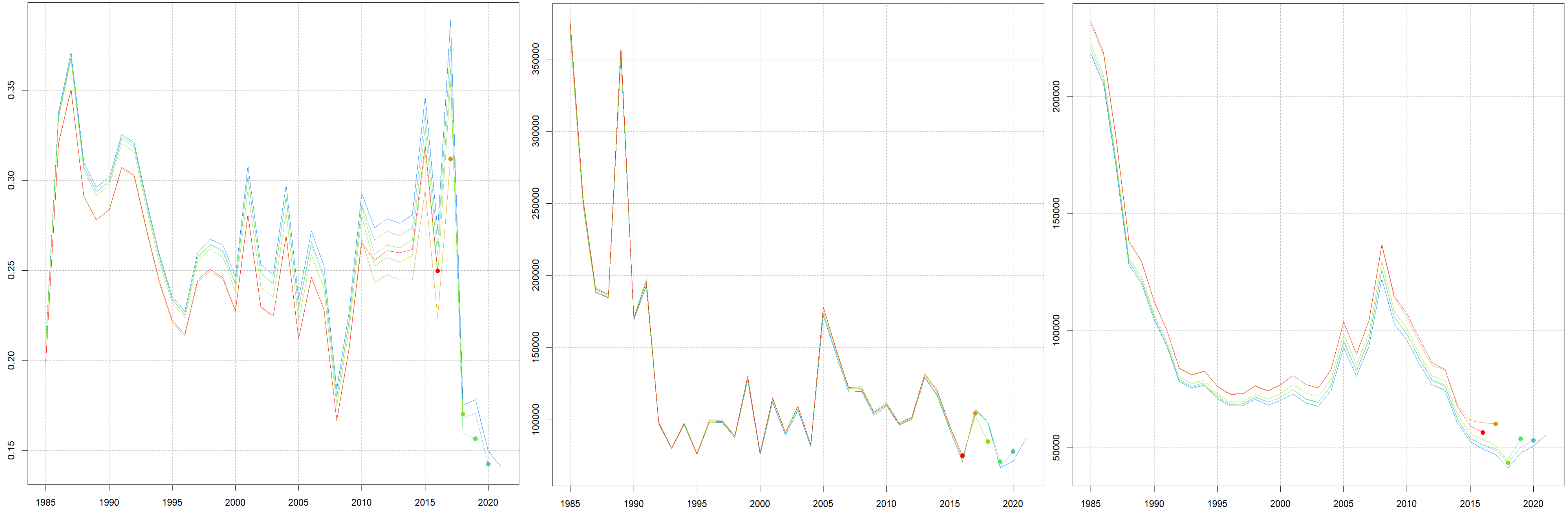
- Abundance estimates max of 599 million fish in 1985, declining to 162 million in 1995, increasing to a peak of 269 million in 2005, declined to a low of 144 million in 2016, and a terminal year estimate of 162 million fish
- Estimates of recruitment have remained steady since 1992, fluctuating around a time-series average of 128 million fish.
- Recruitment has remained below average for the past 12 years, and was estimated at 87 million fish in 2021

BF28W_m7 SSB and F



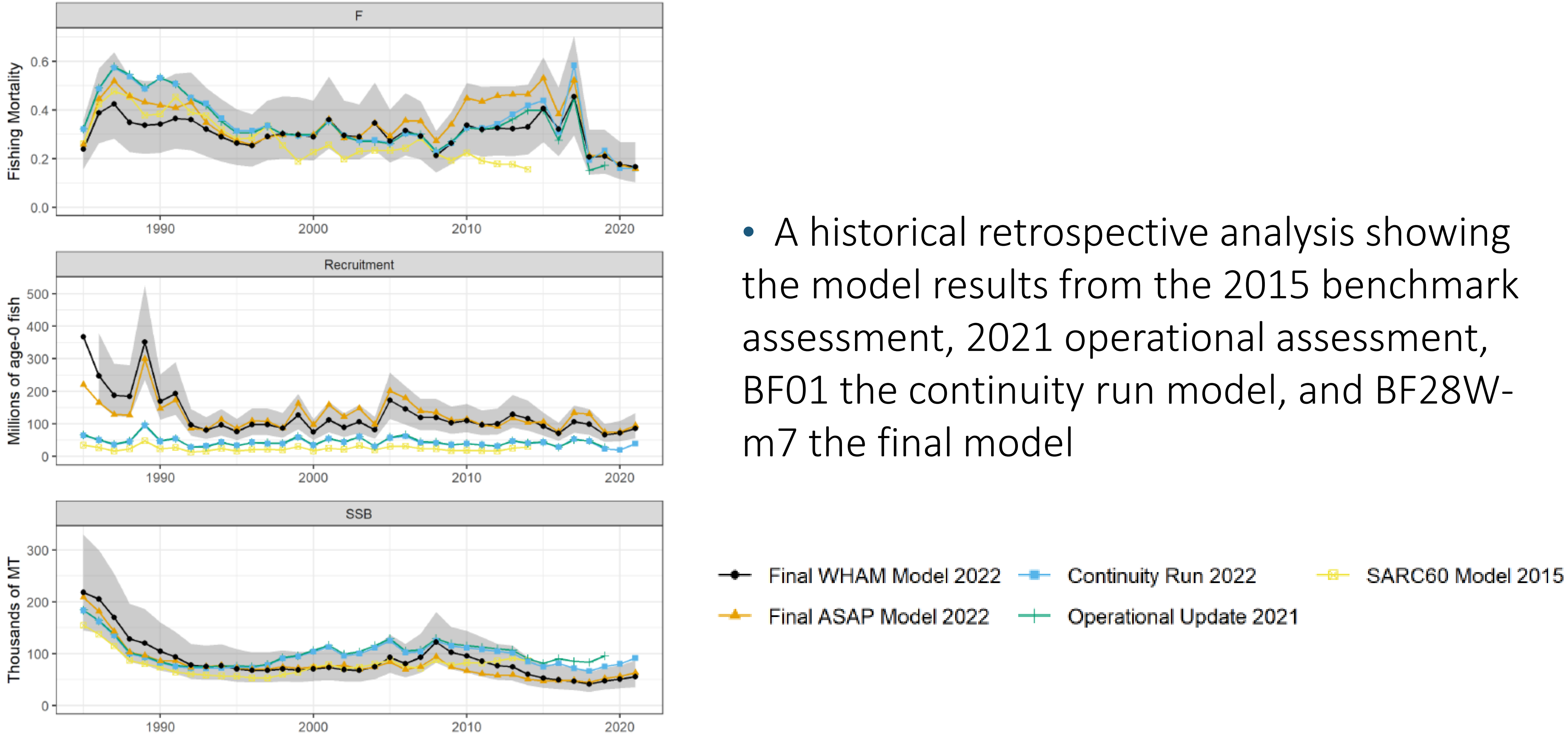
- Spawning stock biomass started from a high of 218,291 MT in 1985, declined over the time-series to a low of 41,377 MT in 2018, and increased to a value of 55,343 MT in 2021
- The majority of the spawning stock biomass is ages 4, 5, and 6+ for the entire time-series
- Fully selected fishing mortality in 2021 was 0.166, compared to an average F from 1985 to 2021 of 0.309.
- Estimates of F have varied over the time series with a peak in 2018 of 0.456, and the lowest value of 0.166 in 2021

BF28W_m7 Retrospective



- Retrospective patterns for BF28W_m7 are improved over the base SCAA model and were considered minor for fishing mortality (-0.096 vs -0.197), recruitment (0.01 vs 0.06), and SSB (0.130 vs 0.248).

BF28W_m7 Historical Retrospective

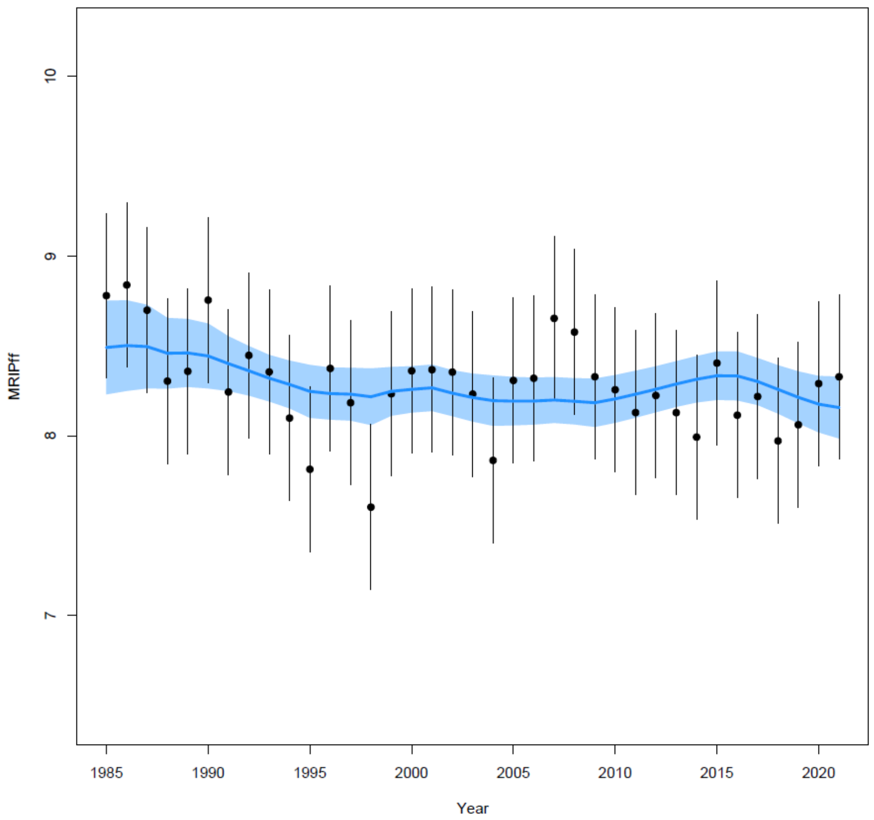


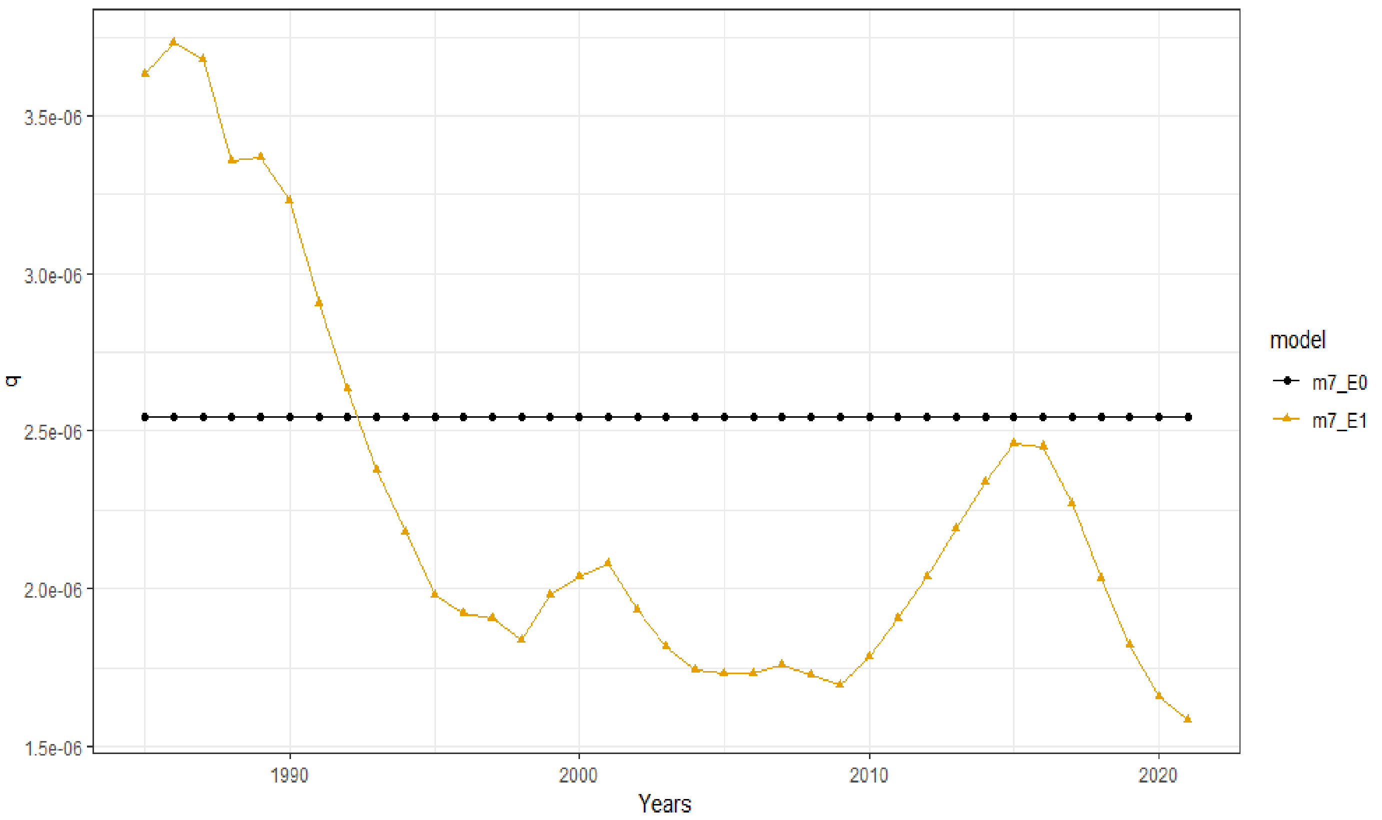
- A historical retrospective analysis showing the model results from the 2015 benchmark assessment, 2021 operational assessment, BF01 the continuity run model, and BF28W-m7 the final model

BF28W_m7ecov Companion Model

- One of the main reasons the bluefish assessment model was moved in WHAM was to explore environmental covariates on the catchability of different survey indices.
- The application of the forage fish index to the MRIP CPA catchability was successful when implemented as an autoregressive process over the time-series with WHAM estimating the standard error
- The inclusion of the forage fish index improved the fit of all models (m2-m7), and model selection via AIC chose the environmental version of BF28W_m7 as the best model (BF28W_m7ecov)

BF28W_m7ecov Companion Model

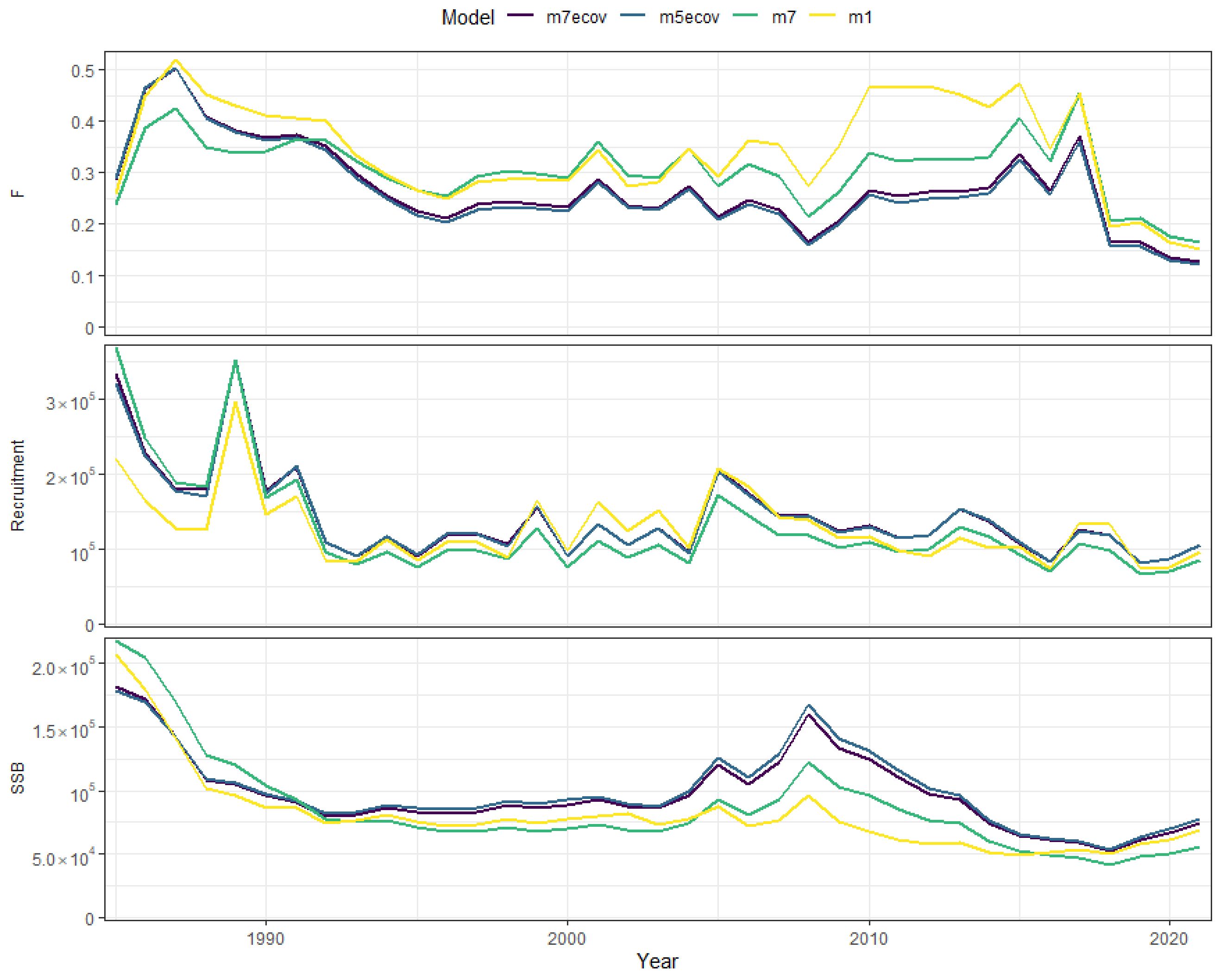




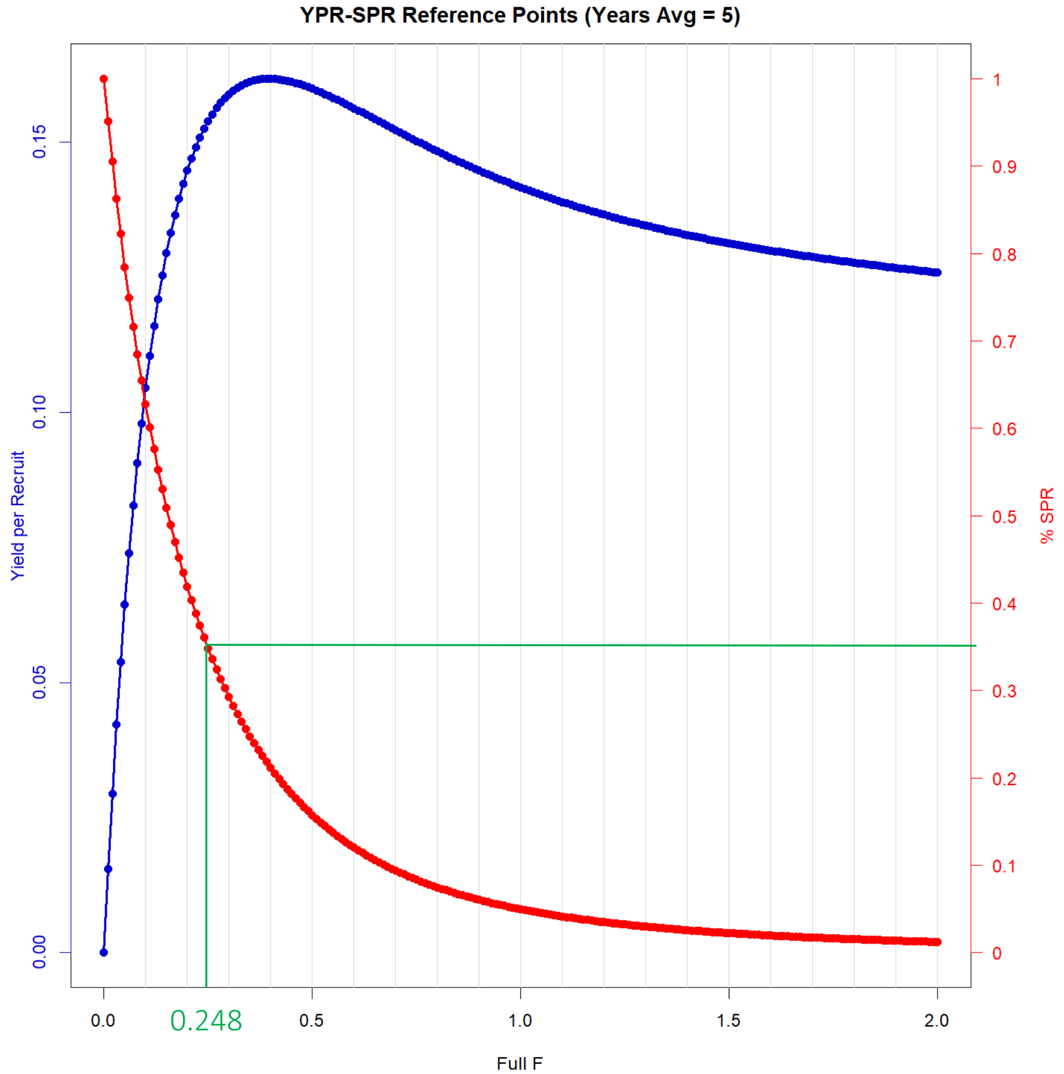
- Model fit to the forage fish index (Blue) shows a slight decline over-time, which results declining catchability (availability) over-time (Yellow) when fit as a covariate on MRIP CPUE

BF28W_m7ecov Companion Model

- Results from the top 2 ecov models, the final model, and the base SCAA model.
- There is good agreement in trend for all results, with the ecov models estimating a lower F and higher SSB for most of the time-series.

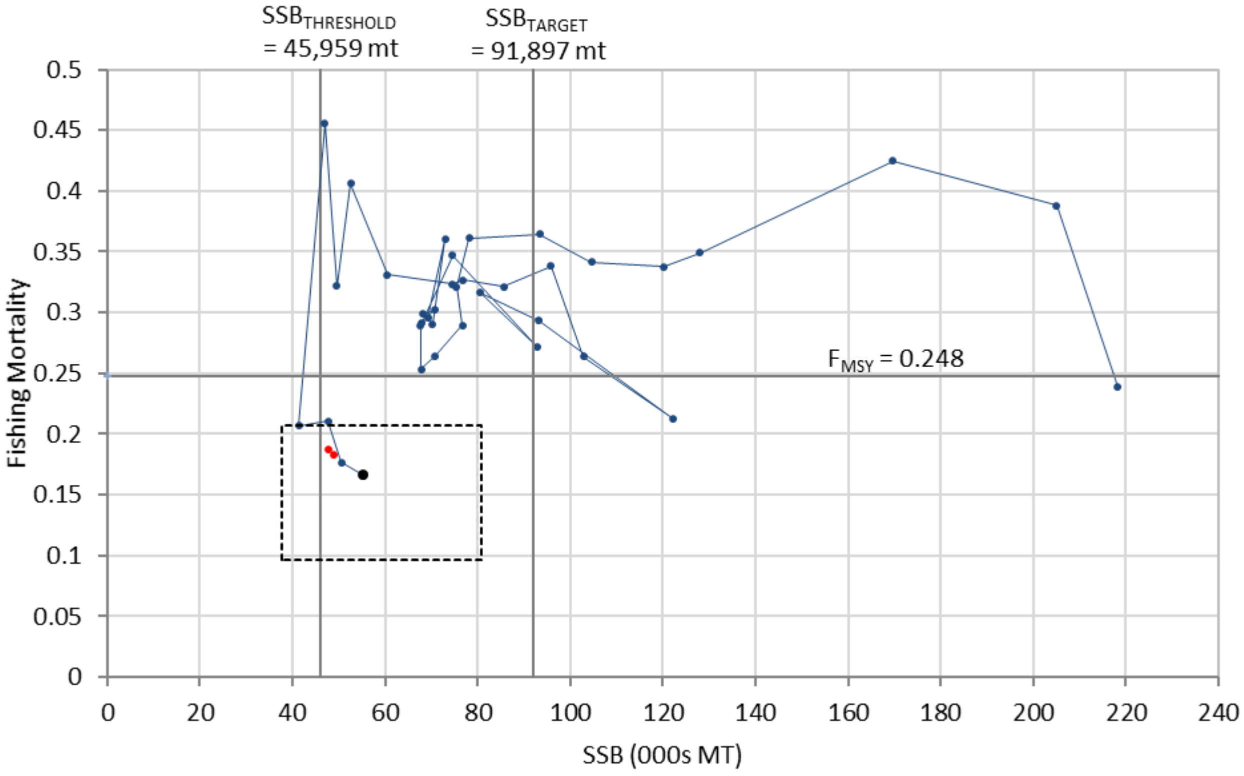


BF28W_m7 Reference Points



- Both F35% and SSB35% were calculated internally in WHAM using average recruitment over the time series (1985-2021), and 5 year averages for fishery selectivity, maturity and weights-at-age for SSB per recruit calculations
  - F35% = 0.248
- SSB35% was calculated using SPR at 35% (0.718) and the mean of the full time series of recruitment (127,924 MT)
  - SSB35% = 91,849 MT

BF28W_m7 Stock Status



Not overfished and overfishing is not occurring

- Reference points from the final model:

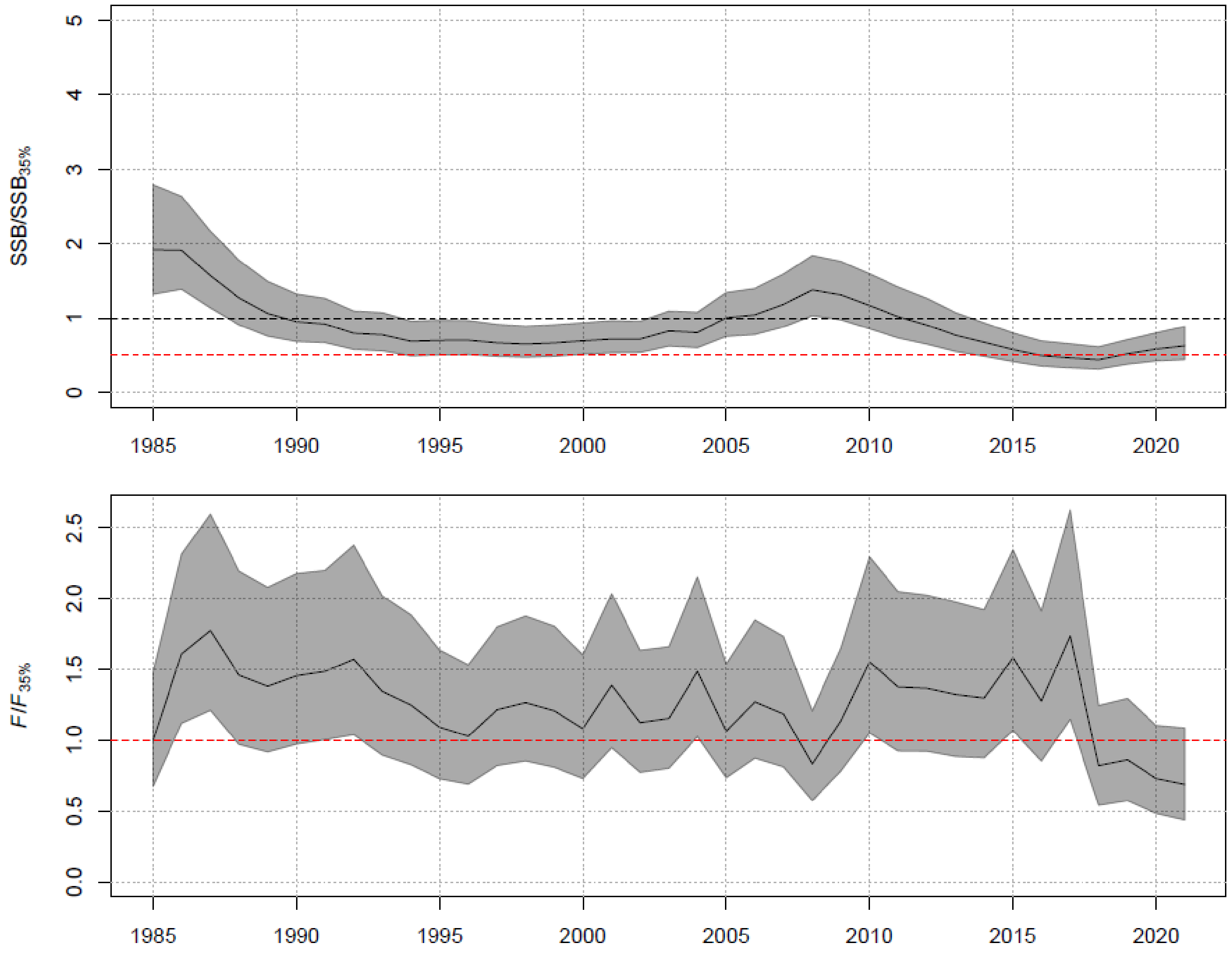
$F_{35\%}$ = 0.248 (0.209 – 0.299)

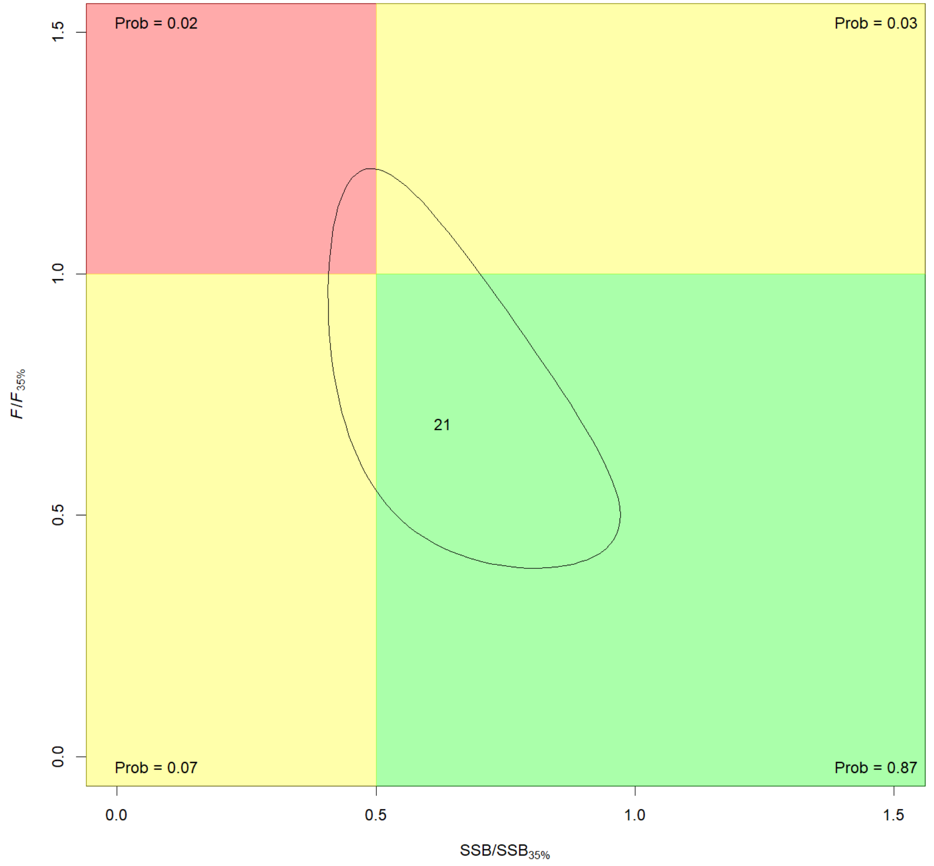
$SSB_{35\%}$ = 91,897 MT (66,219 – 127,534 MT)

$SSB_{THRESHOLD}$ = 45,949 MT (33,110 – 66,768 MT)

- Retrospective pattern minor for both F and SSB and adjustment not necessary

BF28W_m7 Stock Status





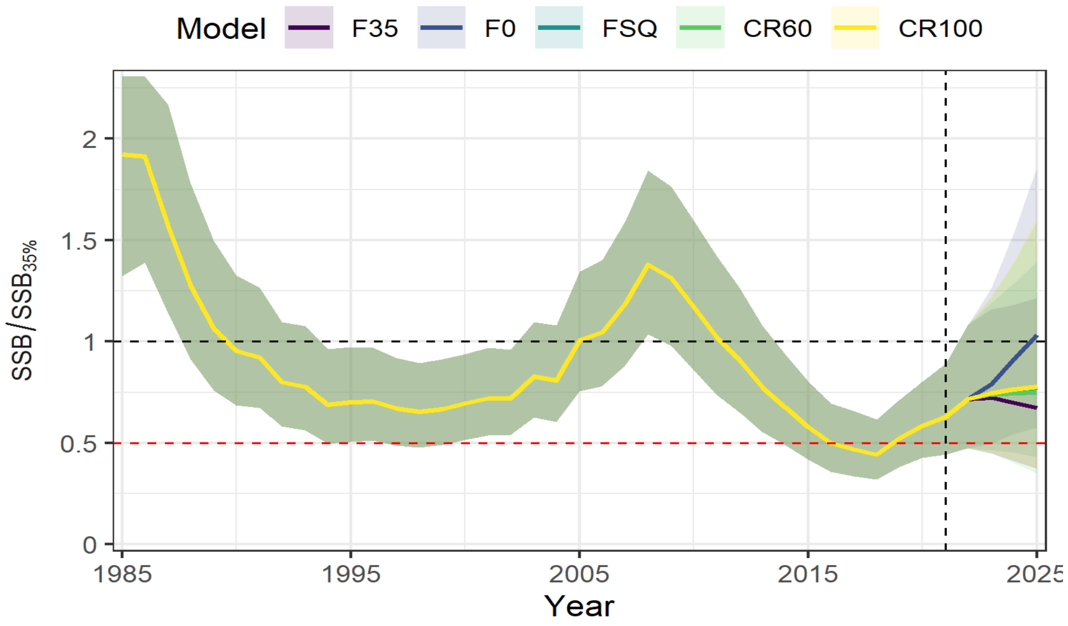
- 87% chance that the bluefish stock is currently not overfished and over-fishing is not occurring

BF28W_m7 Projections

- Short-term projections were conducted in WHAM, and incorporate model uncertainty, auto-regressive processes and uncertainty in recruitment and numbers-at-age
- Removals in 2022 were assumed to be equal to the 2022 ABC (11,460 MT), and projections were carried forward for years 2023-2025 with different F and harvest assumptions:
  - F = 0, $F_{status\ quo}$ = 0.166, $F_{35\%}$ = 0.248, and that harvest in each year is equal to the acceptable biological catch (ABC) in each year
  - The annual ABC values were derived using projected OFL catch and applying the Mid-Atlantic Fishery Management Council (MAFMC) risk policy (CV = 60% and 100%)
- The projections use 5-year averages for natural mortality, maturity, fishery selectivity and weights-at-age
- The full time-series of recruitment (1985-2021) was chosen to fully capture the range of possible recruitment

BF28W_m7 Projections: SSB

Projection scenario	2022	2023	2024	2025	P (2025) > Bthreshold
$F_{MSY} = 0.248$	65,805 (39,305-110,170)	66,340 (37,604-117,034)	64,083 (35,017-117,275)	61,784 (32,086-118,971)	0.84
$F_0 = 0$	65,805 (39,305-110170)	72,637 (41,394-127,462)	83,806 (46,270-151,792)	94,956 (49,788-181,098)	0.99
$F_{status\_quo} = 0.166$	65,805 (39,305-110170)	68,357 (38,820-120,367)	70,009 (38,411-127,601)	71,150 (37,110-136,412)	0.93
MAFMC risk policy (60% CV)	65,805 (39,305-110170)	67,891 (37,217-123,847)	68,583 (33,654-139,765)	68,804 (29,551-160,198)	0.85
MAFMC risk policy (100% CV)	65,805 (39,305-110170)	68,514 (37,767-124,295)	70,385 (35,116-141,078)	71,553 (31,586-162,089)	0.88



- SSB increased for all of the projection scenarios except for fishing at $F_{MSY} = 0.248$
- Probability of being above $B_{THRESHOLD}$ in 2025 ranged from 0.84 (F_{MSY}) to 0.99 (F0)

BF28W_m7 Projections: Catch

Projection scenario	2022	2023	2024	2025
$F_{MSY} = 0.248$	11,460	13,909 (8,098-23,889)	13,957 (7,784-25,022)	13,584 (7,157-25,784)
$F_0 = 0$	11,460	0	0	0
$F_{status\_quo} = 0.166$	11,460	9,569 (5,564-16,458)	10,127 (5,628-18,223)	10,292 (5,399-19,623)
MAFMC risk policy (60% CV)	11,460	10,581 (P* = 0.311)	11,118 (P* = 0.314)	11,202 (P* = 0.316)
MAFMC risk policy (100% CV)	11,460	9,225 (P* = 0.311)	10,027 (P* = 0.321)	10,357 (P* = 0.327)

- Projected OFL catch decreased from 13,909 MT in 2023 to 13,584 MT in 2025
- Projected ABC from council risk policy (CV = 100%) increased from 9,225 MT in 2023 to 10,357 MT in 2025
- Most recent ABCs for bluefish: 2018-2019 = **9,895 MT**, 2020-2021 = **7,385 MT**
  2022 = **11,460 MT**, 2023 = **13,890 MT**