SEDAR 76 Update Projections of Black Sea Bass off the Southeastern United States

SEDAR Update Projections

Southeast Fisheries Science Center

National Marine Fisheries Service

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1 Introduction

The SEDAR 76 Update stock assessment of black sea bass in the southeastern United States Atlantic Ocean was presented to the South Atlantic Fisheries Management Council's (SAFMC) Scientific and Statistical Committee (SSC) in April 2025. The SSC reviewed the updated stock assessment model and determined it to be best scientific information available (BSIA). During the review of the stock assessment there were many discussions regarding the starting conditions and interim year fishing mortality parameterization. Additional projections were requested and discussed during the SSC meeting that were provided for review. However, after further discussion the SSC determined that the conditions requested were not sufficient and that a different $P^{\star}$ would need to be used. The SSC requested that projections be conducted starting in 2024 (i.e., after the terminal year of the stock assessment) with an $F = P^{\star}_{20\%}F_{\text{MSY}}$. There was extensive discussion about whether the high fishing mortality in the terminal year of the stock assessment should be included in the interim years of projections. Unfortunately, the SSC did not have sufficient time during the meeting to agree upon whether the interim F should be the geometric mean for 2021-2023 or 2020-2022. Therefore, we conducted projection scenarios for both of these assumptions for potential OFL and ABC scenarios.

2 Projections—Probabilistic Analysis

Projections were run to predict stock status in years after the assessment with a terminal year of 2023. Short term projections for catch advice were run for 5 years in accordance with SSC precedent.

The structure of the projection model was the same as that of the assessment model, and parameter estimates were those from the assessment. Any time-varying quantities, such as selectivity, were fixed to the most recent values of the assessment period. A single selectivity curve was applied to calculate landings, and one applied to calculate dead discards, each computed by averaging selectivities across fleets using geometric mean Fs from the last three years of the assessment period.

Expected values of SSB (time of peak spawning), F, recruits, landings, and discards were represented by deterministic projections using parameter estimates from the base run. Uncertainty in future time series was quantified through stochastic projections that extended the Monte-Carlo Bootstrap Ensemble (MCBE) fits of the stock assessment model.

2.1 Initialization of projections

Initial age structure at the start of 2024 was computed by applying the 2023 age-dependent mortality (Z_a) to the 2023 abundance at age (N_a), where both Z_a and N_a in 2023 were estimated by the assessment.

Fishing rates that define the management for the projection scenario were assumed to start in 2027. Because the assessment period ended in 2023, the projections required an assumed static fishing mortality interim period (2024–2026). For this period, two options for the interim F were conducted: the geometric mean F from the terminal three years of the assessment (2021-2023) and the geometric mean F from 2020-2022 (3 year average excluding the terminal year).

2.2 Uncertainty of projections

To characterize uncertainty in future stock dynamics, stochasticity was included in replicate projections, each an extension of a single MCBE assessment model fit. Thus, projections carried forward uncertainties in natural mortality, indices, landings, discards, and discard mortality, as well as in estimated quantities such as mean recruitment, selectivity curves, and initial (start of 2024) abundance at age.

Initial and subsequent recruitment values were generated with stochasticity using a Monte Carlo procedure, in which the estimated Beverton–Holt model of each MCBE fit is used to compute mean annual recruitment values ($\bar{R}_y$). Variability is added to the mean values by choosing multiplicative deviations at random from a lognormal distribution,

$$R_y = \bar{R}_y \exp(\epsilon_y). \tag{1}$$

For recruitment in 2024 to 2028 ϵ_y is defined as $\epsilon_y = \gamma_y + \nu$, where γ_y is drawn from a normal distribution with mean 0 and standard deviation σ_R , where σ_R is the standard deviation from the relevant MCBE fit, and ν is the average recruitment deviate from the assessment for 2014-2021. This methodology was chosen to account for the recent negative trend in deviates in the stock recruitment relationship and is consistent with the SAFMC SSC's report of April, 2022 titled "SSC Catch Level Projections Workgroup". For recruitment in 2029 and later, ϵ_y is drawn from a normal distribution with mean 0 and standard deviation σ_R, which assumes that recruitment will return to levels consistent with the stock recruitment relationship. This assumption is highly uncertain and it may be equally as likely that recruitment continues to stay below the stock recruitment relationship or decline even further.

The procedure generated 20,000 replicate projections of MCBE model fits drawn at random (with replacement) from the MCBE runs. In cases where the same MCBE run was drawn, projections would still differ as a result of stochasticity in projected recruitment streams. Central tendencies were represented by the deterministic projection of the base run, as well as by medians of the stochastic projections. Precision of projections was represented graphically by the 5^{th} and 95^{th} percentiles of the replicate projections.

2.3 Projection Scenarios

Four projection scenarios are presented in this report.

- Scenario 1: $F = F_{\text{MSY}}$ with interim $F_{2021-2023}$
- Scenario 2: $F = P^{\star}_{20\%} F_{\text{MSY}}$ with interim $F_{2021-2023}$
- Scenario 3: $F = F_{\text{MSY}}$ with interim $F_{2020-2022}$
- Scenario 4: $F = P^{\star}_{20\%} F_{\text{MSY}}$with interim $F_{2020-2022}$

3 Projection Results

Reference points from SEDAR 76 Update are presented in Table 1 for reference.

The two F_{MSY} scenario represents the harvest that would be expect if fishing at the MFMT and could be used as an OFL. Projection results assuming the interim year F includes the terminal year of the assessment and subsequently F_{MSY} are presented in Figures 1 to 3 and Table 2. The projection scenario assuming the interim F as the geometric mean F from 2020-2022 followed by fishing at F_{MSY} is presented in Figures 7 to 9 and Table 4.

The two $P^{\star}_{20\%}F_{\text{MSY}}$ scenarios represent the expectation of maximizing fishing while accounting for biological uncertainty. These scenarios assume that there is a reduction in fishing mortality in both landings and discards in equal proportions which is reflect in the reduction in discards and landings starting in 2027. The $P^{\star}_{20\%}F_{\text{MSY}}$ scenario with the interim years F at the geomtric mean from 2021-2023 is presented in Figures 4 to 6 and Table 3. This projection scenario assumes that discards decrease by 94.2% compared to those in 2023. The $P^{\star}_{20\%}F_{\text{MSY}}$ scenario with the interim years F at the geomtric mean from 2020-2022 is presented in Figures 10 to 12 and Table 5. This projection scenarios puts the discards at a 93.1% reduction relative to the discards in 2023.

4 Discussion

4.1 Comments on the Projections

As usual, projections should be interpreted in light of the model assumptions and key aspects of the data. Some major considerations are the following:

- In general, projections of fish stocks are highly uncertain, particularly in the long term (e.g., beyond 5 years).
- Although projections included many major sources of uncertainty, they did not include structural (model) uncertainty. That is, projection results are conditional on one set of functional forms used to describe population dynamics, selectivity, recruitment, etc.
- Landings and discarding rates were assumed to continue at their estimated current proportions of total fishing mortality, using the estimated current selectivity patterns. New management regulations that alter those proportions or selectivities will affect projection results.
- The projections assumed no change in the selectivity applied to discards. As population increases generally begins with the smallest size classes, management action may be needed to meet that assumption.
- The projections assumed that the estimated spawner-recruit relationship applies in the future and that recent past deviations represent short-term future uncertainty in recruitment (5 years). If future recruitment is characterized by runs of large or small year classes, possibly due to environmental or ecological conditions, stock projections may be affected.
- Projections apply the Baranov catch equation to relate F and landings using a one-year time step, as in the assessment. The catch equation implicitly assumes that mortality occurs throughout the year. This assumption is violated when seasonal closures are in effect, introducing additional and unquantified uncertainty into the projection results.

5 Tables

Table 1. Estimated status indicators, benchmarks, and related quantities from the base run of the BAM, conditional on estimated current selectivities averaged across fleets. Also presented are median values and measures of precision (standard errors, SE) from the Monte Carlo/Bootstrap ensemble analysis. Rate estimates (F) are in units of y^{-1}; status indicators are dimensionless; biomass estimates are in units of thousands of pounds, as indicated; and recruits are in millions of age-0 fish. Spawning stock biomass (SSB) is measured as mature weight (1000 lbs). L_{current} and D_{current} are the average landings and discards from 2021–2023, respectively. Estimates of yield include landings and discards in weight; D_{MSY} represents discard mortalities expected when fishing at F_{MSY}; T_{MSY} represents total harvest (landings and discards) expected when fishing at F_{MSY}.

Quantity	Units	Estimate	Median	SE
F_{MSY}	y^{-1}	0.32	0.33	0.15
$75\%F_{\mathrm{MSY}}$	y^{-1}	0.24	0.25	0.11
B_{MSY}	1000 lb	23946.38	31774.95	47522.56
$\mathrm{SSB}_{\mathrm{MSY}}$	1000 lb	14182.85	14546.38	37762.97
MSST	1000 lb	8864.28	7574.79	28417.79
L_{MSY}	1000 lb	1956.49	2148.97	3685.48
L_{MSY}	1000 dead fish	1154.26	1008.55	2130.65
$L_{75\%\mathrm{MSY}}$	1000 lb	1308.81	1047.19	2875.41
L_{current}	1000 lb	508.00	509.39	67.39
D_{MSY}	1000 lb	685.83	1093.68	966.57
D_{MSY}	1000 dead fish	1485.11	2426.36	2078.38
T_{MSY}	1000 lb	2642.32	3249.55	4547.01
T_{MSY}	1000 dead fish	2639.36	3420.59	3896.09
$D_{75\%\mathrm{MSY}}$	1000 dead fish	594.71	2127.04	1819.98
D_{current}	1000 dead fish	947.46	1255.76	540.76
R_{MSY}	millions fish	8.67	16.61	14.38
$F_{2021-2023}/F_{\mathrm{MSY}}$	—	4.08	3.11	2.45
$\mathrm{SSB}_{2023}/\mathrm{MSST}$	—	0.16	0.27	0.22
$\mathrm{SSB}_{2023}/\mathrm{SSB}_{\mathrm{MSY}}$	—	0.10	0.15	0.09

Table 2. Projection results with fishing mortality rate fixed at geometric mean F from 2020-2022 for projection years 2024-2026 and $F = F_{\mathrm{MSY}}$ *starting in 2027 and a recent average recruitment deviate until 2028. R = number of age-0 recruits (in millions), F = fishing mortality rate (per year), S = spawning stock (1000* lb*), L = landings and D = discards expressed in numbers (n, in 1000s) or whole weight (w, in 1000* lb*), pr.reb = proportion of stochastic projection replicates with* $\mathrm{SSB} \geq \mathrm{SSB}_{\mathrm{MSY}}$*. The extension* b *indicates expected values (deterministic) from the base run; the extension* med *indicates median values from the stochastic projections.*

Year	R.b	R.med	F.b	F.med	S.b	S.med	L.b(n)	L.med(n)	L.b(w)	L.med(w)	D.b(n)	D.med(n)	D.b(w)	D.med(w)	pr.reb
2024	6	14	1.287	1.047	1114	1531	166	182	132	151	610	796	260	341	0
2025	5	11	1.287	1.047	959	1307	171	174	144	149	512	668	226	290	0
2026	4	9	1.287	1.047	763	1062	155	150	134	132	384	534	175	236	0
2027	4	7	0.316	0.334	659	928	42	52	38	46	82	159	38	71	0
2028	3	7	0.316	0.334	674	914	53	62	52	59	76	149	36	70	0

Table 3. Projection results with fishing mortality rate fixed at geometric mean F from 2021-2023 for projection years 2024-2026 and $F = P^{\star}_{20\%}F_{\mathrm{MSY}}$ starting in 2027 and a recent average recruitment deviate until 2028. R = number of age-0 recruits (in millions), F = fishing mortality rate (per year), S = spawning stock (1000 lb*), L = landings and D = discards expressed in numbers (n, in 1000s) or whole weight (w, in 1000* lb*), pr.reb = proportion of stochastic projection replicates with* $\mathrm{SSB} \geq \mathrm{SSB_{MSY}}$. *The extension* b *indicates expected values (deterministic) from the base run; the extension* med *indicates median values from the stochastic projections.*

Year	R.b	R.med	F.b	F.med	S.b	S.med	L.b(n)	L.med(n)	L.b(w)	L.med(w)	D.b(n)	D.med(n)	D.b(w)	D.med(w)	pr.reb
2024	6	14	1.287	1.047	1114	1531	166	182	132	151	610	796	260	341	0
2025	5	11	1.287	1.047	959	1307	171	174	144	149	512	668	226	290	0
2026	4	9	1.287	1.047	763	1062	155	150	134	132	384	534	175	236	0
2027	4	7	0.193	0.204	668	942	27	33	24	30	51	99	23	45	0
2028	3	7	0.193	0.204	710	970	36	43	35	41	48	95	23	45	0

Table 4. Projection results with fishing mortality rate fixed at geometric mean F from 2020-2022 for projection years 2024-2026 and $F = F_{\mathrm{MSY}}$ *starting in 2027 and a Beverton-Holt recruitment with a recent average deviate until 2028. R = number of age-0 recruits (in millions), F = fishing mortality rate (per year), S = spawning stock (1000* lb*), L = landings and D = discards expressed in numbers (n, in 1000s) or whole weight (w, in 1000* lb*), pr.reb = proportion of stochastic projection replicates with* $\mathrm{SSB} \geq \mathrm{SSB_{MSY}}$*. The extension* b *indicates expected values (deterministic) from the base run; the extension* med *indicates median values from the stochastic projections.*

Year	R.b	R.med	F.b	F.med	S.b	S.med	L.b(n)	L.med(n)	L.b(w)	L.med(w)	D.b(n)	D.med(n)	D.b(w)	D.med(w)	pr.reb
2024	6	14	0.690	0.576	1170	1600	103	117	83	98	352	488	152	211	0
2025	5	11	0.690	0.576	1146	1528	139	142	122	127	320	443	148	201	0
2026	5	11	0.690	0.576	1010	1348	153	146	142	137	251	368	122	173	0
2027	5	9	0.316	0.334	902	1208	75	88	74	85	96	186	47	87	0
2028	4	8	0.316	0.334	878	1153	79	89	83	90	89	172	43	81	0

Table 5. Projection results with fishing mortality rate fixed at geometric mean F from 2020-2022 for projection years 2024-2026 and $F = P^{\star}_{20\%}F_{\mathrm{MSY}}$ *starting in 2027 and a Beverton-Holt recrutiment with a recent average deviate until 2028.* R *= number of age-0 recruits (in millions),* F *= fishing mortality rate (per year),* S *= spawning stock (1000* lb*),* L *= landings and* D *= discards expressed in numbers (n, in 1000s) or whole weight (w, in 1000* lb*), pr.reb = proportion of stochastic projection replicates with* $\mathrm{SSB} \geq \mathrm{SSB_{MSY}}$*. The extension* b *indicates expected values (deterministic) from the base run; the extension* med *indicates median values from the stochastic projections.*

Year	R.b	R.med	F.b	F.med	S.b	S.med	L.b(n)	L.med(n)	L.b(w)	L.med(w)	D.b(n)	D.med(n)	D.b(w)	D.med(w)	pr.reb
2024	6	14	0.690	0.576	1170	1600	103	117	83	98	352	488	152	211	0
2025	5	11	0.690	0.576	1146	1528	139	142	122	127	320	443	148	201	0
2026	5	11	0.690	0.576	1010	1348	153	146	142	137	251	368	122	173	0
2027	5	9	0.193	0.204	916	1229	48	56	48	54	60	116	29	55	0
2028	4	9	0.193	0.204	931	1228	54	62	58	64	57	110	27	53	0

6 Figures

Figure 1. Projected time series with fishing mortality rates at geometric mean F from 2021-2023 for projection years 2024-2026 and $F = F_{\text{MSY}}$ starting in 2027. Expected values (base run) represented by solid lines with solid circles, medians represented by dashed lines with open circles, and uncertainty represented by thin lines corresponding to 5th and 95th percentiles of replicate projections. Solid horizontal lines mark F_{MSY}-related benchmarks from the base model; dashed horizontal lines represent corresponding medians from the MCBE. Spawning stock (SSB) is at time of peak spawning.

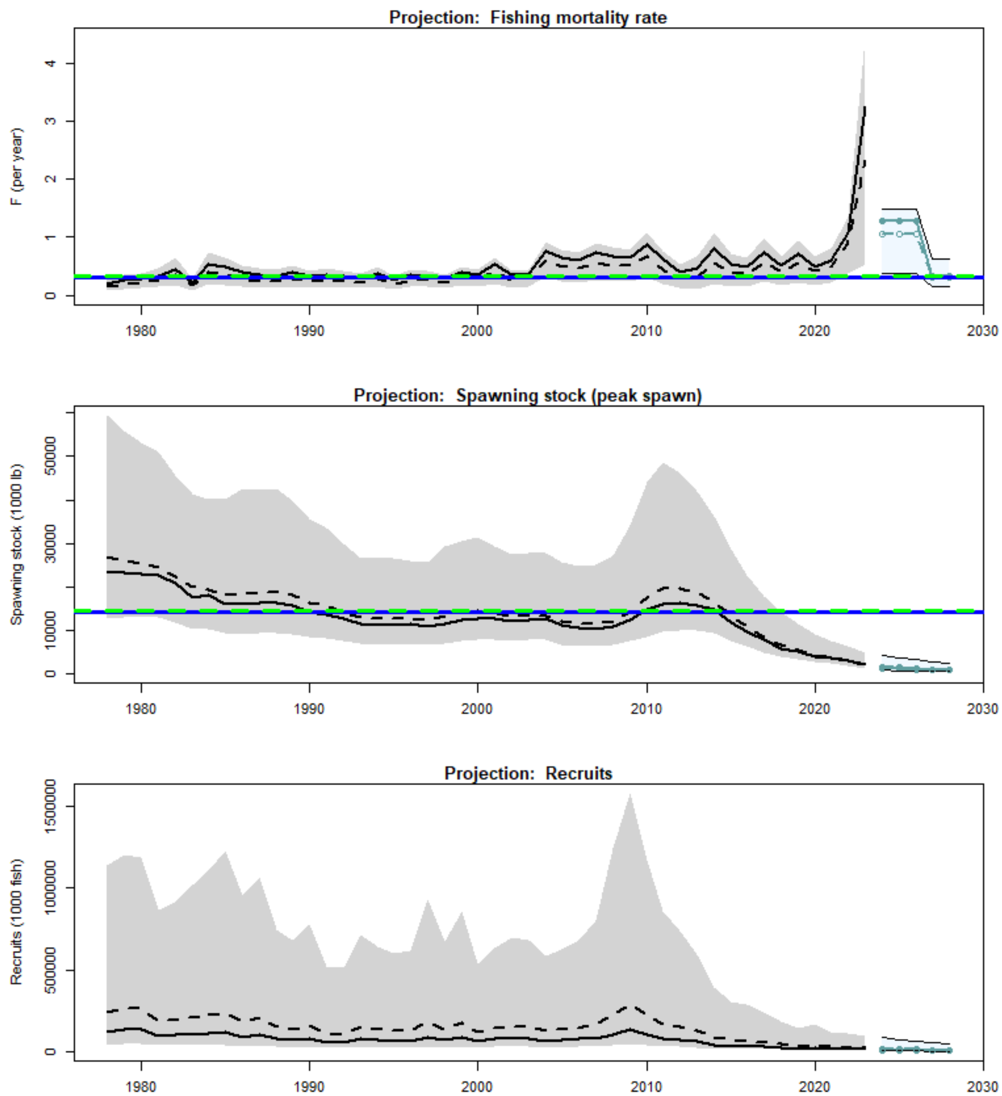


Figure 2. Projected fishing mortality (top left panel), spawning stock biomass (top right panel), landings (middle panels) in weight (left) and numbers (right) and discards (bottom panels) in weight (left) and numbers (right) for the projected time series with fishing mortality rates at geometric mean F from 2021-2023 for projection years 2024-2026 and at $F = F_{\mathrm{MSY}}$ starting in 2027. Expected values (base run) represented by solid lines with solid circles, medians represented by dashed lines with open circles, and uncertainty represented by thin lines corresponding to 5th and 95th percentiles of replicate projections.

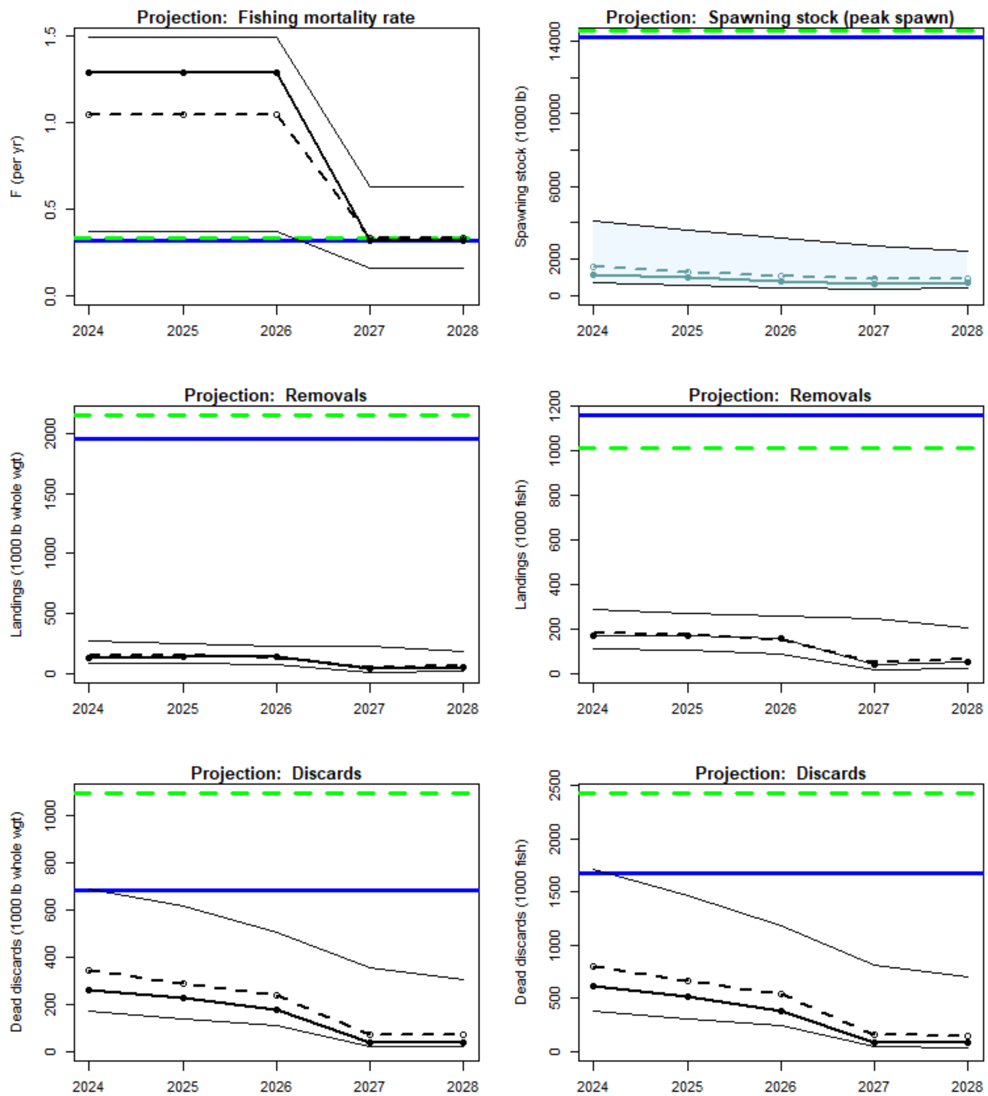


Figure 3. Top Panel: Projected probability of rebuilding with fishing mortality at geometric mean F from 2021-2023 for projection years 2024-2026 and $F = F_{\mathrm{MSY}}$ starting in 2027. The curve represents the proportion of projection replicates for which SSB has reached the replicate-specific $\mathrm{SSB}_{\mathrm{MSY}}$, with reference lines at 0.5 and 0.7. Bottom panel: Projected SERFS index where the expected values (base run) are represented by solid lines with solid circles, medians represented by dashed lines with open circles, and uncertainty represented by thin lines corresponding to 5th and 95th percentiles of replicate projections.

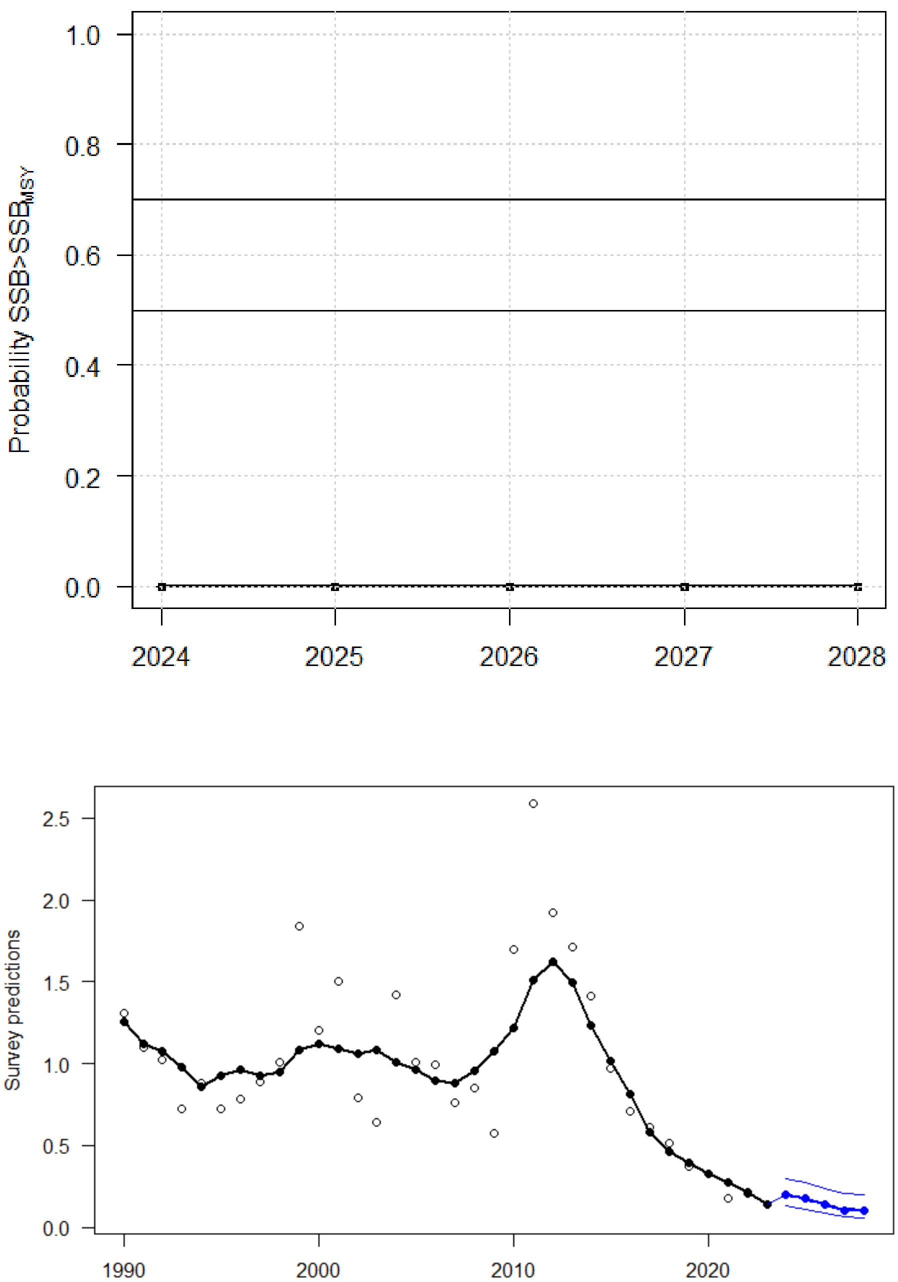


Figure 4. Projected time series with fishing mortality rates at geometric mean F from 2021-2023 for projection years 2024-2026 and at fixed F that provides $P^{\star}_{20\%}$ for F_{MSY} starting in 2027. Expected values (base run) represented by solid lines with solid circles, medians represented by dashed lines with open circles, and uncertainty represented by thin lines corresponding to 5th and 95th percentiles of replicate projections. Solid horizontal lines mark F_{MSY}-related benchmarks from the base model; dashed horizontal lines represent corresponding medians from the MCBE. Spawning stock (SSB) is at time of peak spawning.

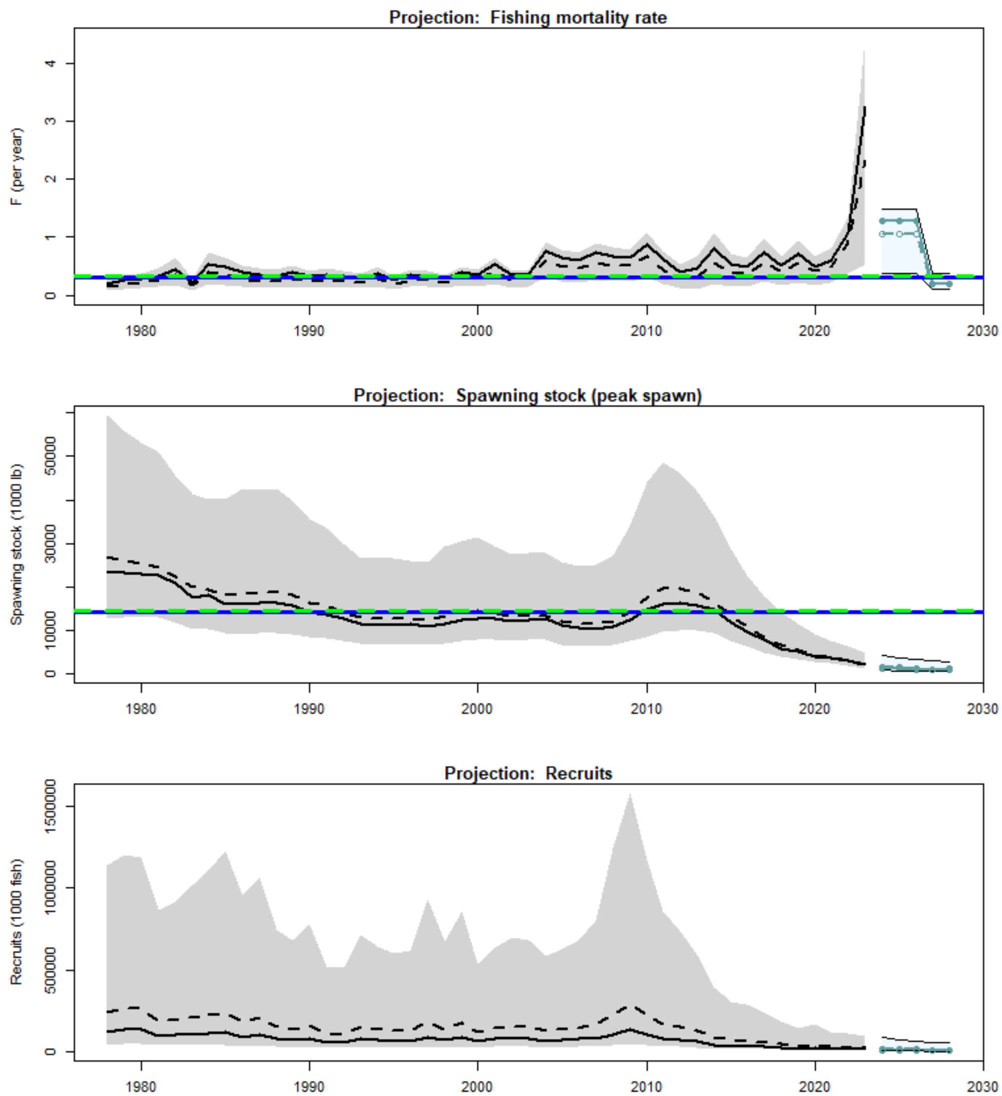


Figure 5. Projected fishing mortality (top left panel), spawning stock biomass (top right panel), landings (middle panels) in weight (left) and numbers (right) and discards (bottom panels) in weight (left) and numbers (right) for the projected time series with fishing mortality rates at geometric mean F from 2021-2023 for projection years 2024-2026 and at at fixed F that provides $P^{\star}_{20\%}$ for F_{MSY} starting in 2027. Expected values (base run) represented by solid lines with solid circles, medians represented by dashed lines with open circles, and uncertainty represented by thin lines corresponding to 5th and 95th percentiles of replicate projections.

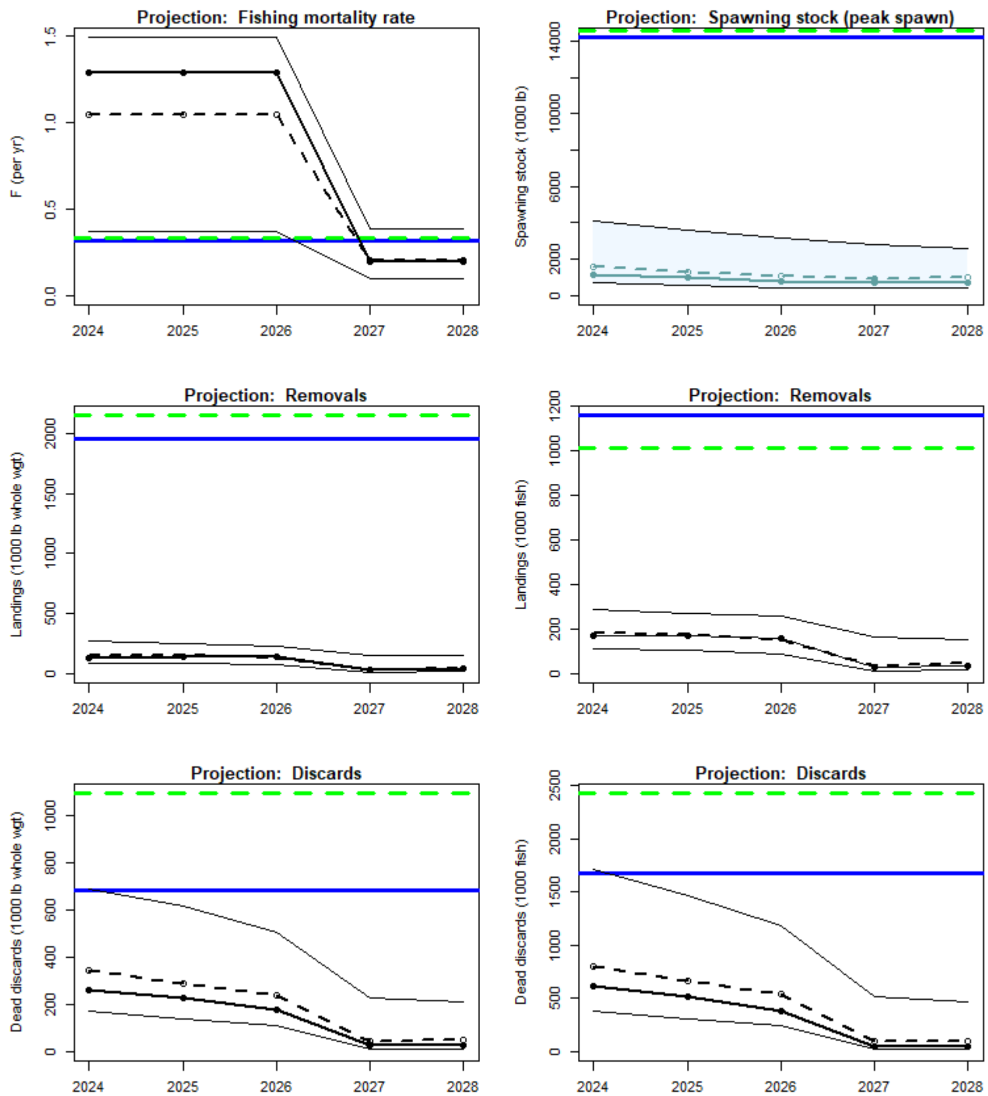


Figure 6. Top Panel: Projected probability of rebuilding with fishing mortality at geometric mean F from 2021-2023 for projection years 2024-2026 and at fixed F that provides $P^{\star}_{20\%}$ *for* F_{MSY} *starting in 2027. The curve represents the proportion of projection replicates for which SSB has reached the replicate-specific* $\mathrm{SSB}_{\mathrm{MSY}}$*, with reference lines at 0.5 and 0.7. Bottom panel: Projected SERFS index where the expected values (base run) are represented by solid lines with solid circles, medians represented by dashed lines with open circles, and uncertainty represented by thin lines corresponding to 5th and 95th percentiles of replicate projections.*

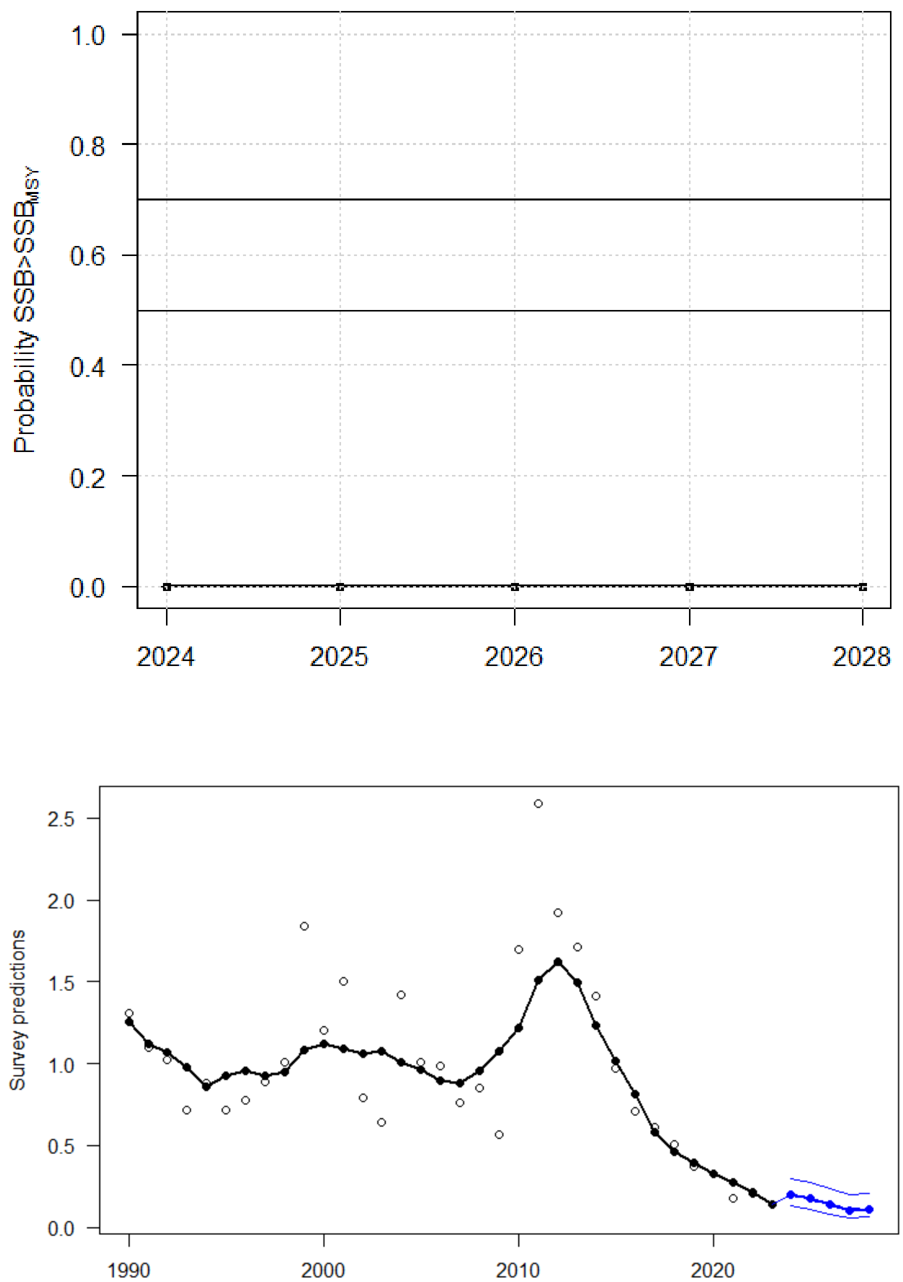


Figure 7. Projected time series with fishing mortality rates at geometric mean F from 2020-2022 for projection years 2024-2026 and $F = F_{\mathrm{MSY}}$ *starting in 2027. Expected values (base run) represented by solid lines with solid circles, medians represented by dashed lines with open circles, and uncertainty represented by thin lines corresponding to 5th and 95th percentiles of replicate projections. Solid horizontal lines mark* F_{MSY}*-related benchmarks from the base model; dashed horizontal lines represent corresponding medians from the MCBE. Spawning stock (SSB) is at time of peak spawning.*

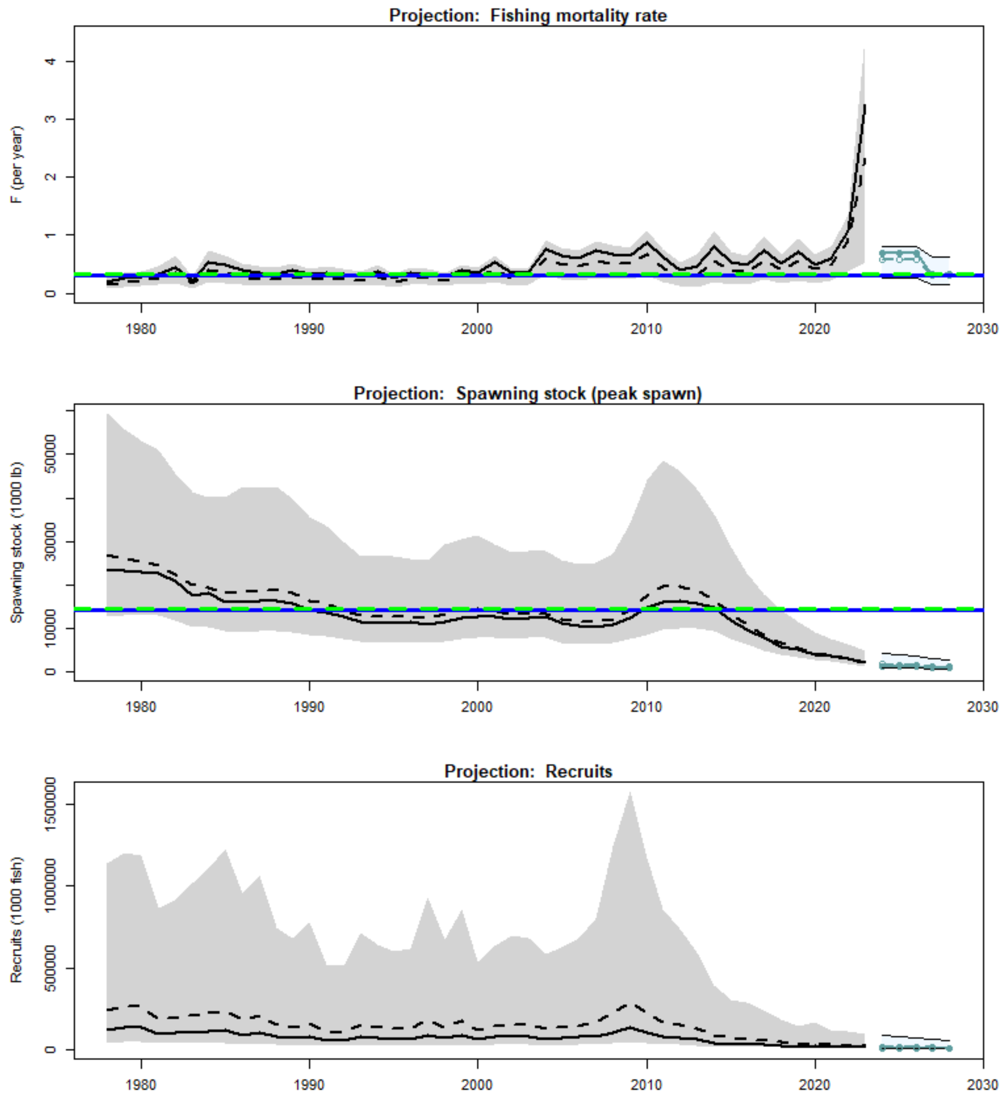
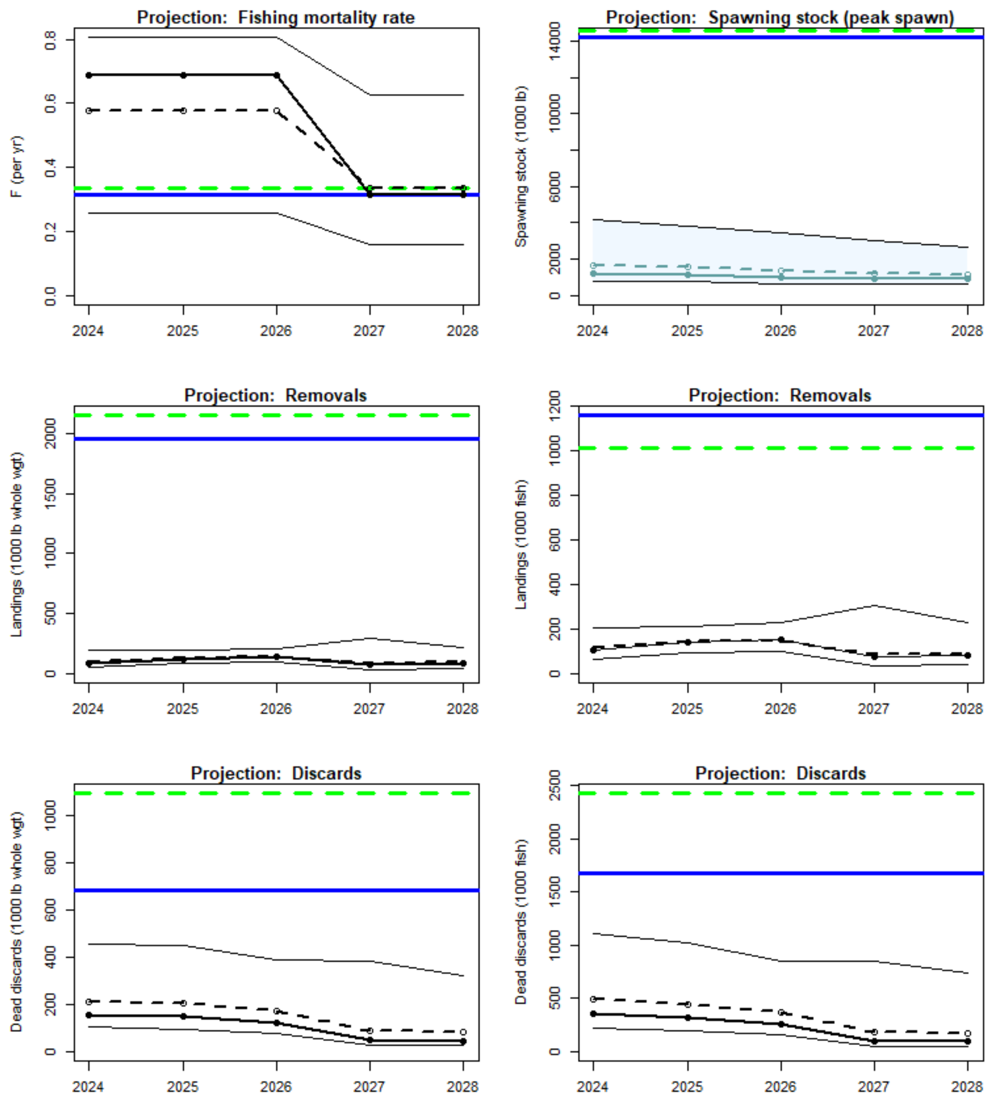


Figure 8. Projected fishing mortality (top left panel), spawning stock biomass (top right panel), landings (middle panels) in weight (left) and numbers (right) and discards (bottom panels) in weight (left) and numbers (right) for the projected time series with fishing mortality rates at geometric mean F from 2020-2022 for projection years 2024-2026 and at $F = F_{\mathrm{MSY}}$ starting in 2027. Expected values (base run) represented by solid lines with solid circles, medians represented by dashed lines with open circles, and uncertainty represented by thin lines corresponding to 5th and 95th percentiles of replicate projections.



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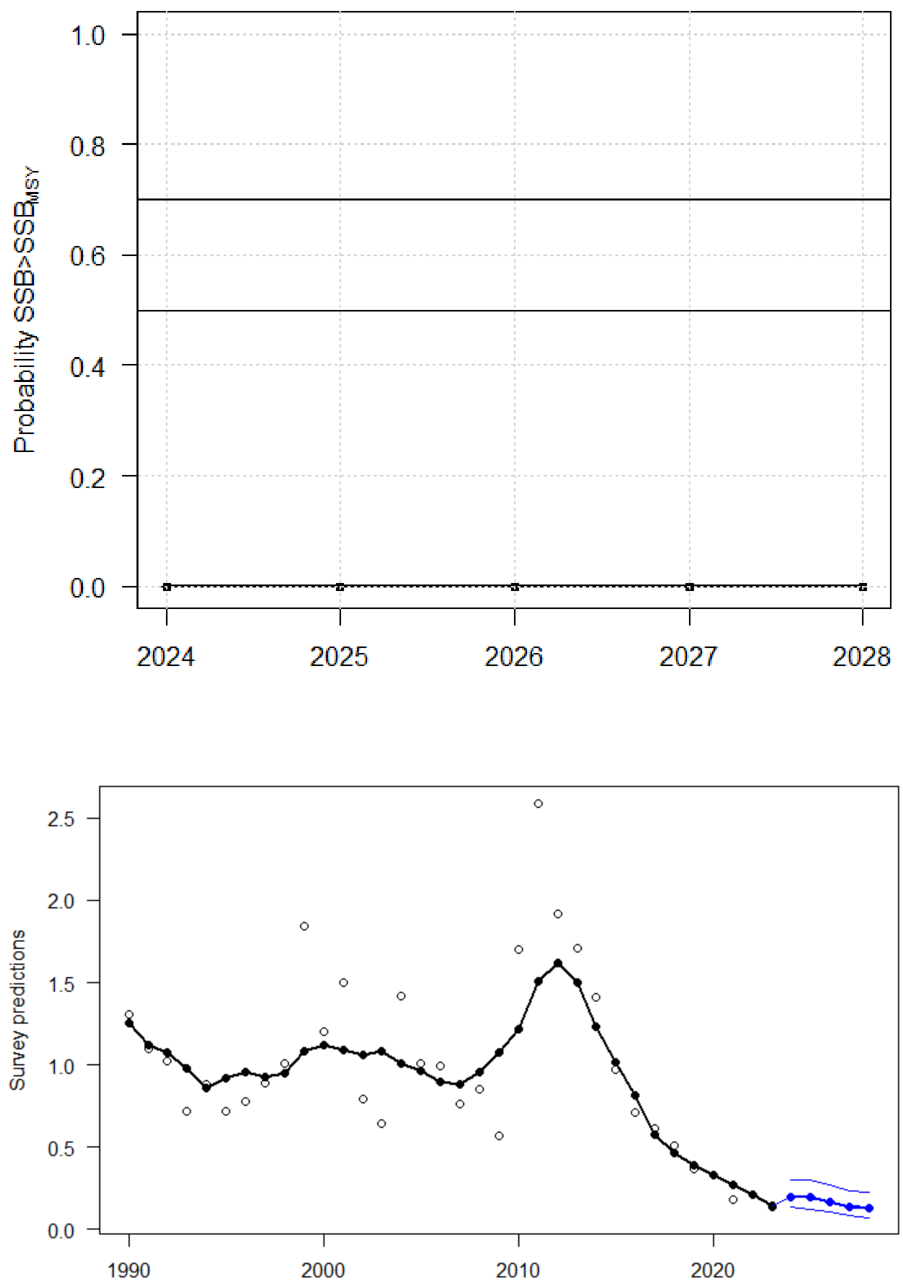

Figure 10. Projected time series with fishing mortality rates at geometric mean F from 2020-2022 for projection years 2024-2026 and at fixed F that provides $P^{\star}_{20\%}$ for F_{MSY} starting in 2027. Expected values (base run) represented by solid lines with solid circles, medians represented by dashed lines with open circles, and uncertainty represented by thin lines corresponding to 5th and 95th percentiles of replicate projections. Solid horizontal lines mark F_{MSY}-related benchmarks from the base model; dashed horizontal lines represent corresponding medians from the MCBE. Spawning stock (SSB) is at time of peak spawning.

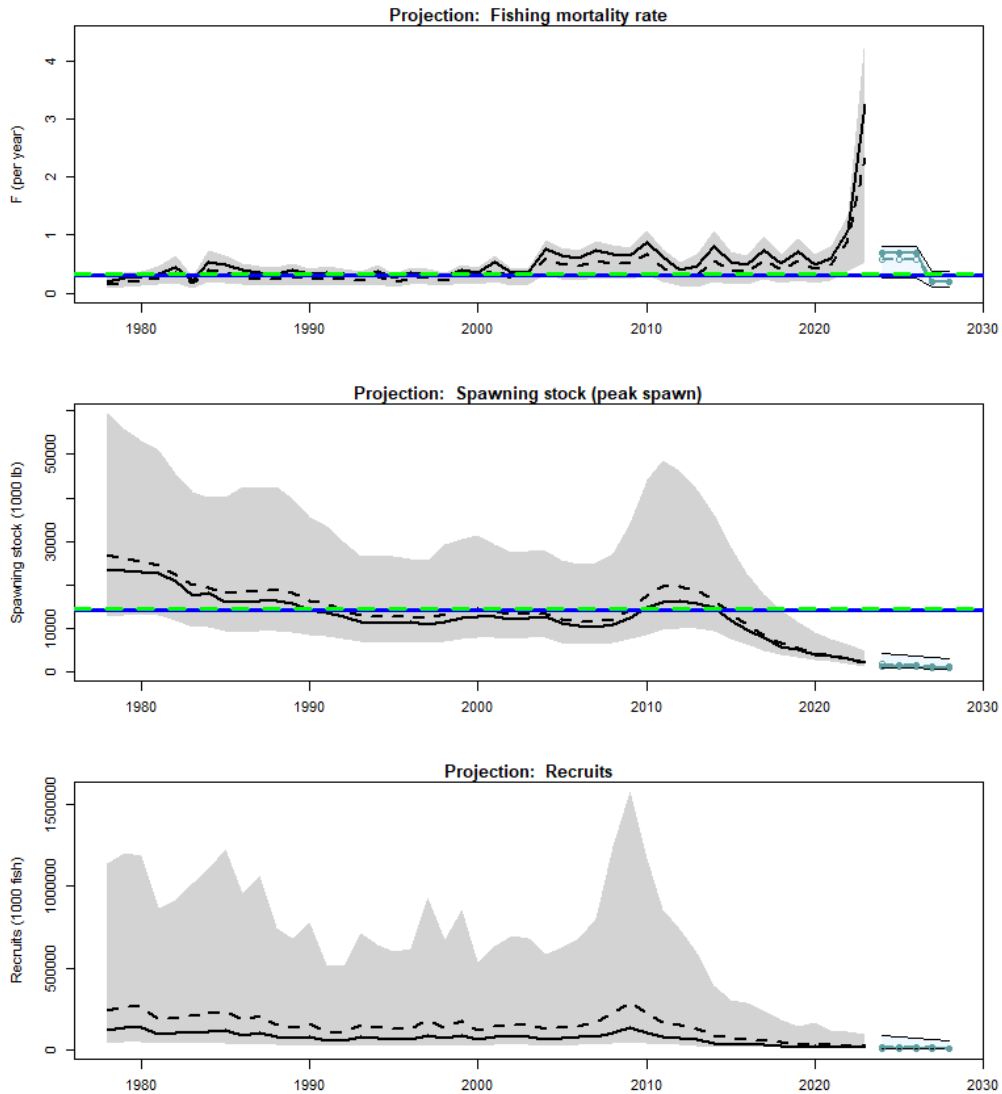

Figure 11. Projected fishing mortality (top left panel), spawning stock biomass (top right panel), landings (middle panels) in weight (left) and numbers (right) and discards (bottom panels) in weight (left) and numbers (right) for the projected time series with fishing mortality rates at geometric mean F from 2020-2022 for projection years 2024-2026 and at at fixed F that provides $P^{\star}_{20\%}$ *for* F_{MSY} *starting in 2027. Expected values (base run) represented by solid lines with solid circles, medians represented by dashed lines with open circles, and uncertainty represented by thin lines corresponding to 5th and 95th percentiles of replicate projections.*

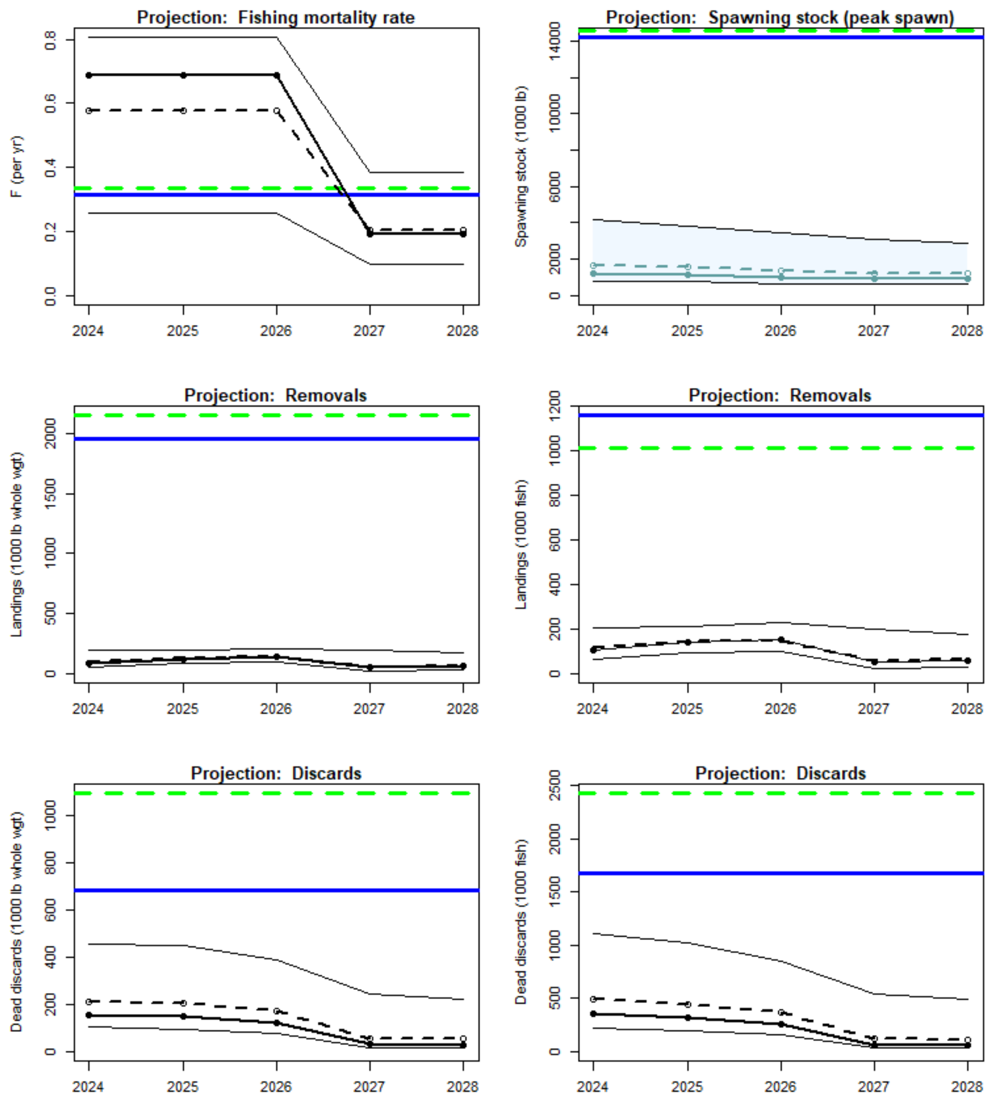

Figure 12. Top Panel: Projected probability of rebuilding with fishing mortality at geometric mean F from 2020-2022 for projection years 2024-2026 and at fixed F that provides $P^{\star}_{20\%}$ for F_{MSY} starting in 2027. The curve represents the proportion of projection replicates for which SSB has reached the replicate-specific SSB_{MSY}, with reference lines at 0.5 and 0.7. Bottom panel: Projected SERFS index where the expected values (base run) are represented by solid lines with solid circles, medians represented by dashed lines with open circles, and uncertainty represented by thin lines corresponding to 5th and 95th percentiles of replicate projections.