Projection scenarios for ABC and OFL of Black Sea Bass off the Southeastern United States assuming recent F in 2022

SEDAR 76 Assessment Addendum 3

Southeast Fisheries Science Center

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1 Introduction

Projections of black sea bass abundance for SEDAR 76 have evolved over time as a result of input from the SSC. Preliminary projections were first presented to the SSC in April 2023. Following that meeting, the South Atlantic Fisheries Management Council requested modifications to the preliminary projections with changes in assumptions and specific scenarios. Revised projections for SEDAR 76 were presented at the October 2023 SSC meeting; during which, the SSC expressed concerns over the high fishing mortality rate (F $>$ 3) that occurred as a result of fitting to the 2022 catch estimates. These high fishing mortality rates were a result of the maintained high levels of catch and discards from the recreational fishery in 2022, the low estimated biomass in the assessment, and the assumption of the low recent average (2014–2019) recruitment in 2020 and 2021. The SSC recommended conducting additional projections that set the fishing mortality rate in 2022 to the average F from 2019-2021. This report will present the methodology and assumptions used to project the population forward through time and the results.

2 Projection Methods

Projections were run to predict stock status in years after the assessment (2022–2034) using $F_{40\%}$ as the reference point. Additionally, these projections use a P^* of 30% based on discussions by the SSC during the October 2023 meeting. Following SSC protocol, 70% of projections must exceed the rebuilding target of $\text{SSB}_{\text{F}40\%}$ for the stock to be considered rebuilt. Based on previous projections that were parameterized with zero fishing mortality (both discard and landings) and long-term average recruitment, the stock was determined to be able to rebuild in less than 10 years. In addition, the generation time was computed given the life-history characteristics of black sea bass and was found to be 6 years. Therefore, the rebuilding time frame for the species was set at 10 years.

The structure of the projection model was the same as that of the assessment model, and parameter estimates were from the assessment. Any time-varying quantities, such as selectivity curves, were fixed to the most recent values of the assessment period. As in the assessment, projected removals include landings and dead discards.

Expected values of SSB (time of peak spawning), F, recruits, removals, and the SERFS index were represented by deterministic projections using parameter estimates from the base run. These projections applied mean recruit with bias correction, and were thus consistent with estimated benchmarks in the sense that long-term fishing at $F_{40\%}$ would yield $L_{\text{F}40\%}$ from a stock size at $\text{SSB}_{\text{F}40\%}$. Uncertainty in future time series was quantified through stochastic projections that extended the ensemble (MCBE) fits of the stock assessment model.

2.1 Initialization of projections

Initial age structure at the start of 2022 was computed by applying the 2021 age-dependent mortality (Z_a) to the 2021 abundance at age N_a, where both Z_a and N_a in 2021 were estimated by the assessment. Variability was added to the recent mean recruitment for 2020 and 2021 based on the recent standard deviation (2014-2019) from each MCBE iteration and carried forward to initialize the 2022 abundance at age using the estimated mortality.

Fishing rates corresponding to likely management action were assumed to start in 2025. Because the assessment period ended in 2021, the projections required an interim period (2022–2024). Fishing mortality rates for the interim years 2022–2024 were set at the F that matched the current level of landings (arithmetic mean of 2019-2021) for the respective MCBE iteration. Recruitment in 2022 was assumed to be generated from a distribution with the mean equal to either the long-term average or recent average depending on the scenario.

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 2022) abundance at age.

Initial and subsequent recruitment values were generated with stochasticity using a Monte-Carlo procedure, in which the estimated recruitment parameters (i.e. R_0, σ_R) of each MCBE fit was used to compute mean annual recruitment values ($\bar{R}_y = R_0$). Variability is added to the mean values by choosing multiplicative deviations at random from a lognormal distribution, $R_y = \bar{R}_y \exp(\epsilon_y)$. Here ϵ_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. Random recruitment was generated for all years from 2020 to the end of the projection period.

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 projections 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.

2.2.1 Projection Scenarios

Projection scenarios were configured differently from previous SEDAR projections where the ratio of fishing mortality from discards and landings were assumed to stay at levels estimated from the assessment. In these projections, the fishing mortality attributed to discards was separated from the fishing mortality due to landings by using the weighted selectivity from the stock assessment and providing different fishing mortalities to the landings and discards. For scenarios presented here, the fishing mortality assumed for the discards was determined by the average F from 2019-2021 multiplied by the weighted discard selectivity. The fishing mortality for the landings was determined by solving for a value with a 70% probability that the stock would rebuild above $\mathrm{SSB}_{\mathrm{F40\%}}$. This fishing mortality was used for both the Over Fishing Limit (OFL) and Allowable Biological Catch (ABC) scenarios. The OFL scenario assumed long-term recruitment, recent discard fishing mortality levels, and a landings fishing mortality that resulted in a 70% probability of exceeding $\mathrm{SSB}_{\mathrm{F40\%}}$. The ABC calculations assumed the same fishing and discard mortality rates as the OFL scenario with recent mean recruitment.

2.3 Assessment model incorporating 2022 Landings

To ensure that the high rates of fishing mortality observed in the projections previously presented to the SSC that fit to the 2022 landings and discards were not a result of the projection coding, the 2022 removal estimates were incorporated into the Beaufort Assessment Model (BAM). For this exploratory model the terminal year of the assessment was set at 2022 and recruitment in this year was set at the average recruitment of 2014–2019, i.e., the same as the previous 2 years. The estimates of fishing mortality, spawning stock biomass and recruits from this model was compared against the base SEDAR 76 model that ended in 2021 and the estimated Fs from the stochastic projections in 2022 (Figure 5).

3 Results

3.1 Projections

Projections for the OFL scenario was able to rebuild with 70% based on the assumption of a return to the long-term average recruitment levels (Figures 1 and 2 and Table 1). However, the ABC scenario was never able to rebuild due the assumption of the low recent mean recruitment (Figures 3 and 4 and Table 2). The fishing mortality applied to the landings component of the projections was determined to be 13% of $F_{40\%}$. The mortality attributed to discards formed the major component of total fishing mortality on black sea bass for these projection scenarios.

3.2 Assessment model incorporating 2022 Landings

Estimates of fishing mortality, spawning stock biomass and recruits for 1987 through 2021 were nearly identical to estimates from the original assessment model (Figure 5). Estimates of fishing mortality from this model for 2022 were similar to the estimates from the projections that fit to the 2022 landings.

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 selectivity patterns. New management regulations that alter selectivities such as changes to minimum size limits would likely affect projection results.
- The projections assumed no change in the selectivity applied to discards. As stock increase generally begins with the smallest size classes, management action may be needed to meet that assumption.
- Projections assume that the discard mortality rate remains at levels that are similar to recent years. This implicitly assumes that fishing effort (particularly recreational) remains at recent levels and does not change as a result of management actions. Additionally, the efficiency of the fleets are assumed to not increase.
- Projections assume that mortality from discarding is only for fish below the size limit. This assumption is likely to be violated if seasonal closures are implemented during which both large and small fish will be discarded and will increase discard mortality on the population.
- Reported discards and landings in 2022 are higher than those predicted by the projections using the assumed recent Fs. This will likely bias the fishing mortality estimates in 2022 and population size in 2023.

- 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.

- Changing the proportion of discards to landings in the projections will ultimately result in a change in reference point due to changes in the weighted selectivity. However, changes to the reference points were not calculated and benchmarks in figures were those estimated for the last 3 years of the assessment.

- Projection results were highly dependent on assumptions regarding future recruitment. The recent average recruitment scenarios implicitly assume a regime shift in the productivity of the stock, but there is currently not sufficient evidence to support such a conclusion. However, whether recruitment can return to long-term average levels quickly is unknown.

- Projections of the survey index are for the combined trap and video index. These should not be compared to either the trap or video index individually. Projections of the survey index assume that the variance used to combine the trap and video indices using the Conn method will remain the same in the future.

5 Tables

Table 1. Projection results with fishing mortality rate fixed at $F_{\mathrm{Landed}} = F_{\mathrm{Rebuild70\%}}$ *and* $F_{\mathrm{Discard}} = F_{\mathrm{current}}$ *starting in 2025 and longterm recruitment starting in 2023. 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* $\mathrm{SSB} \geq \mathrm{SSB}_{\mathrm{F40\%}}$. *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
2022	71	116	0.936	0.801	2469	3155	222	212	271	265	994	1293	359	459	0.002
2023	71	115	0.936	0.801	3644	4881	179	171	212	206	1489	1971	516	663	0.084
2024	71	114	0.936	0.801	5370	7280	168	160	179	174	2481	3309	892	1168	0.293
2025	71	116	0.383	0.474	6753	9078	39	49	39	48	3174	4266	1299	1709	0.450
2026	71	114	0.383	0.474	7721	10244	66	79	68	80	3331	4471	1430	1880	0.536
2027	71	115	0.383	0.474	8403	11009	100	118	109	125	3354	4500	1454	1906	0.592
2028	71	114	0.383	0.474	8901	11555	140	162	165	185	3356	4505	1456	1917	0.629
2029	71	115	0.383	0.474	9249	11862	170	193	211	233	3356	4497	1457	1906	0.655
2030	71	114	0.383	0.474	9487	12125	188	212	244	266	3356	4501	1457	1914	0.672
2031	71	115	0.383	0.474	9647	12244	199	224	266	289	3356	4491	1457	1906	0.681
2032	71	116	0.383	0.474	9754	12341	206	231	280	302	3356	4482	1457	1904	0.691
2033	71	115	0.383	0.474	9824	12469	211	235	290	311	3356	4473	1457	1907	0.695
2034	71	115	0.383	0.474	9869	12479	214	237	296	316	3356	4477	1457	1900	0.700

Table 2. Projection results with fishing mortality rate fixed at $F_{\mathrm{Landed}} = F_{\mathrm{Rebuild70\%}}$ *and* $F_{\mathrm{Discard}} = F_{\mathrm{current}}$ *starting in 2025 and recent average recruitment starting in 2023. 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* $\mathrm{SSB} \geq \mathrm{SSB}_{\mathrm{F40\%}}$. *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
2022	25	44	0.936	0.801	2469	3155	222	212	271	265	924	1192	355	454	0.002
2023	25	43	0.936	0.801	2620	3449	178	169	211	206	1109	1454	458	582	0.005
2024	25	43	0.936	0.801	2734	3740	159	151	176	171	1151	1602	492	659	0.009
2025	25	43	0.383	0.474	2876	3979	32	40	35	43	1164	1678	503	708	0.012
2026	25	43	0.383	0.474	3062	4216	46	54	54	62	1167	1713	506	726	0.013

Table 3. SERFS combined video and trap index using the Conn method predicted values for the OFL scenario that assumed long-term recruitment deviates starting in 2023.

Year	Base	Median	5% Quantile	95% Quantile
2022	0.311	0.314	0.205	0.513
2023	0.406	0.418	0.265	0.678
2024	0.718	0.740	0.436	1.401
2025	0.972	1.023	0.597	1.858
2026	1.079	1.136	0.675	2.004
2027	1.130	1.189	0.708	2.060
2028	1.157	1.212	0.730	2.090
2029	1.171	1.222	0.740	2.086
2030	1.178	1.225	0.750	2.092
2031	1.181	1.227	0.751	2.098
2032	1.183	1.219	0.751	2.092
2033	1.183	1.225	0.754	2.101
2034	1.184	1.226	0.750	2.102

Table 4. SERFS combined video and trap index using the Conn method predicted values for the ABC scenario that assumed recent average recruitment deviates starting in 2023.

Year	Base	Median	5% Quantile	95% Quantile
2022	0.306	0.308	0.200	0.508
2023	0.359	0.366	0.225	0.617
2024	0.379	0.407	0.249	0.699
2025	0.389	0.434	0.264	0.743
2026	0.400	0.452	0.276	0.759

6 Figures

Figure 1. Projected time series under the Over Fishing Limit (OFL) that gives a 70% probability of rebuilding in 10 years, discards at current fishing levels, and long-term average recruitment. 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 $F_{40\%}$-related benchmarks from the base model; dashed horizontal lines represent corresponding medians from the MCBE. Spawning stock (SSB) is at time of peak spawning.

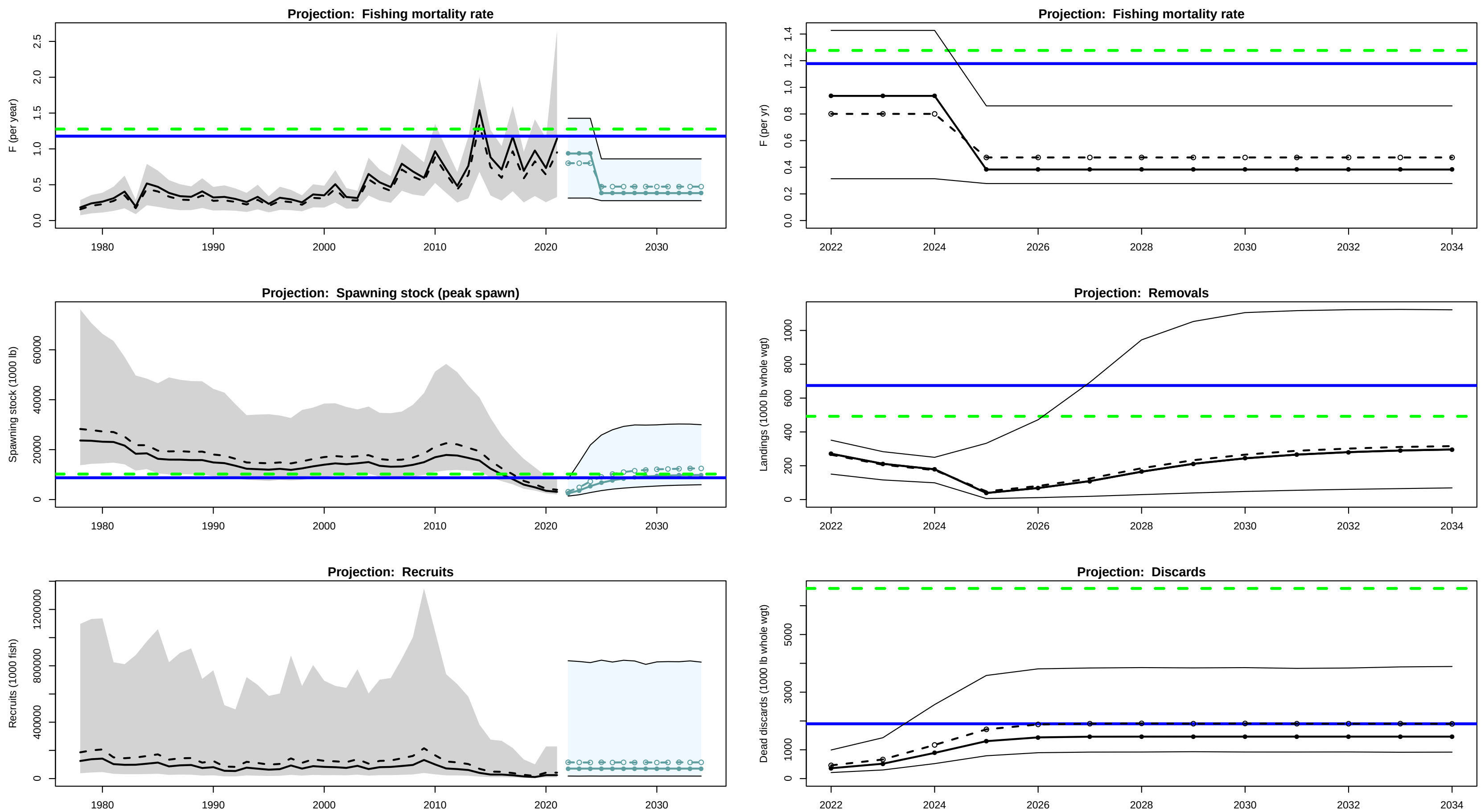


Figure 2. Top Panel: Projected probability of rebuilding for the Over Fishing Limit (OFL) scenario with fishing mortality rate that gives a 70% probability of rebuilding in 10 years, discards at current fishing levels, and long-term average recruitment. The curve represents the proportion of projection replicates for which SSB has reached the replicate-specific $\mathrm{SSB}_{\mathrm{F40\%}}$*, with reference lines at 0.5 and 0.7. Bottom panel: Projected SERFS combined video and trap index using the Conn method 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.*

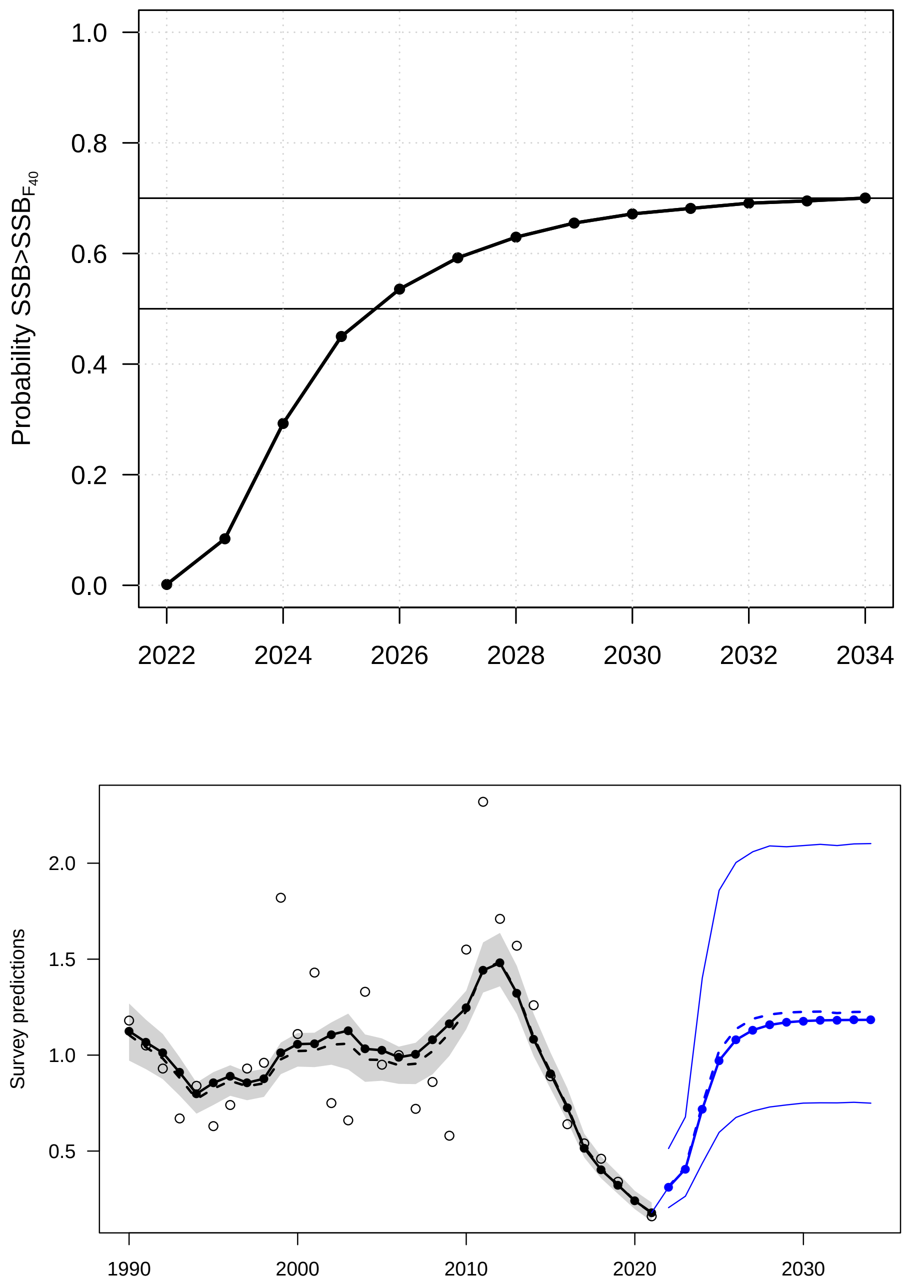


Figure 3. Projected time series under Allowable Biological Catch (ABC) scenario with fishing mortality rate set at that determined by the OFL scenario, discards at current fishing levels, and recent mean recruitment. Expected values (base run) represented by solid lines with solid circles, medians represented 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 $F_{40\%}$-related benchmarks from the base model; dashed horizontal lines represent corresponding medians from the MCBE. Spawning stock (SSB) is at time of peak spawning.

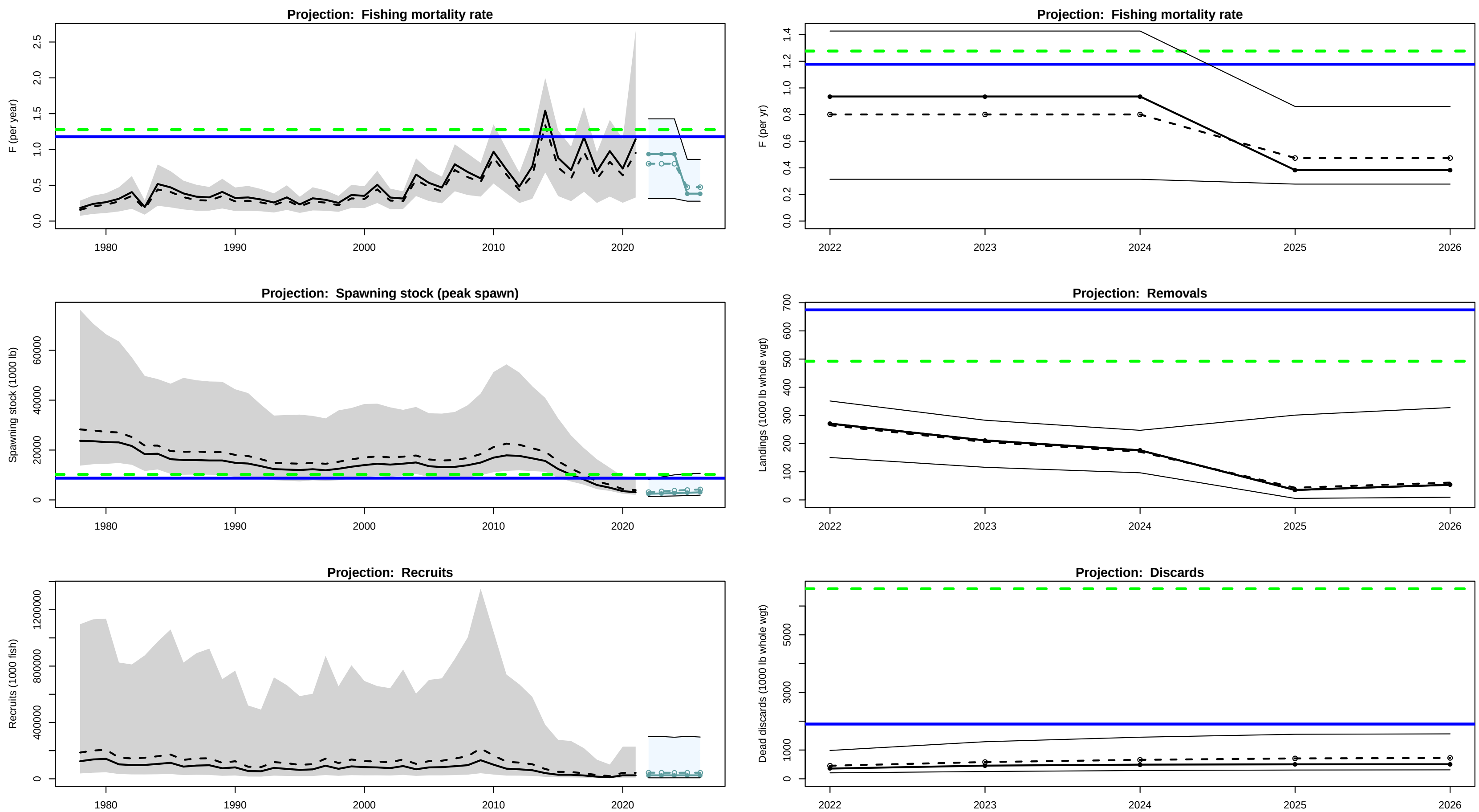
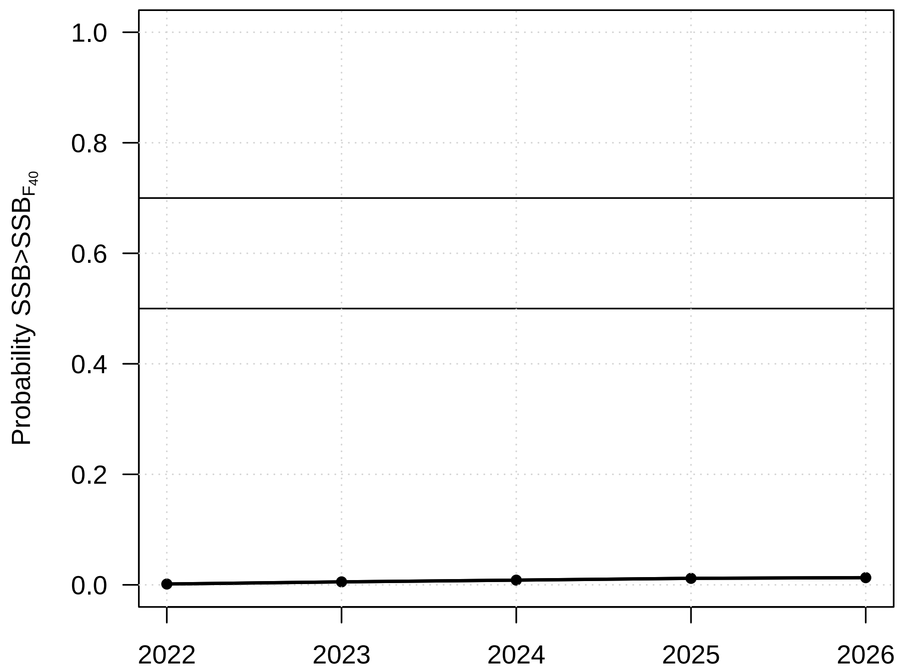


Figure 4. Top Panel: Projected probability of rebuilding for the Allowable Biological Catch (ABC) scenario with fishing mortality rate set at that determined by the OFL scenario, discards at current fishing levels, and recent mean recruitment. The curve represents the proportion of projection replicates for which SSB has reached the replicate-specific $SSB_{F40\%}$*, with reference lines at 0.5 and 0.7. Bottom panel: Projected SERFS combined video and trap index using the Conn method 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.*



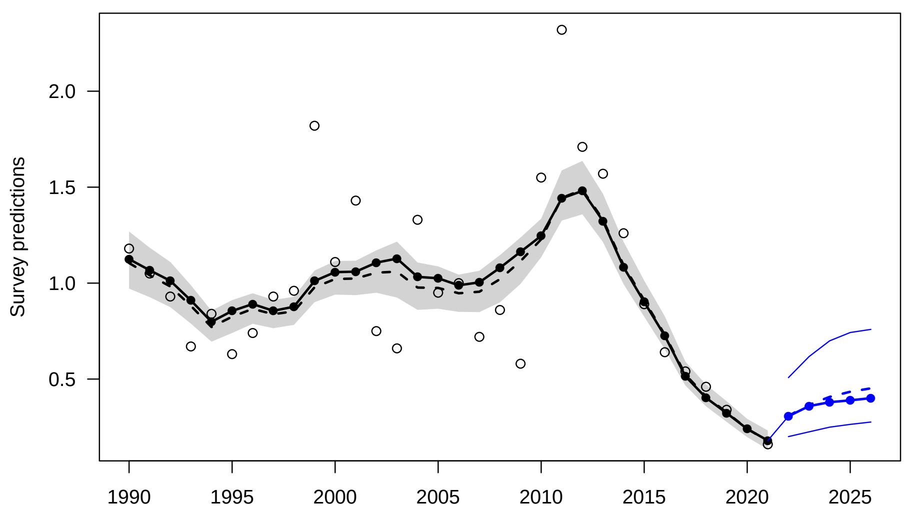


Figure 5. This figure shows the estimates of spawning stock biomass in 1000s lbs (top panel), fishing mortality (middle panel) and number of recruits (bottom panel) from the base SEDAR 76 assessment model (black solid line) and a BAM model that incorporated the 2022 landings (red dashed line). The green dot in the middle panel is the median estimated F from projections that were fit to the 2022 landings and the dotted lines are the 5th and 95th quantiles of stochastic projections.