Projection scenarios of Black Sea Bass off the Southeastern United States requested by the South Atlantic Fisheries Management Council

SEDAR 76 Assessment Addendum 4

Southeast Fisheries Science Center

National Marine Fisheries Service

Report issued: October 2024

Contents

List of Tables

List of Figures

1 Introduction

A memo was sent to Southeast fishery science center on April 17th, 2024 requesting the following additional projections:

"The Council is considering several changes to the management of Black Sea Bass which may require additional projection runs. We are asking the information be provided to for SSC review in July . The SSC will consider scheduling the July webinar meeting (when the requested information would be presented) during their April 16-19, 2024 meeting. We will follow up with the deadline for the materials when the July meeting has been scheduled.

- Changing size limits.
  - Develop new OFL and ABC projections with changes in minimum size limits of L50, of 11, 12, and 13 inches (both sectors being equal). The regulations would be implemented in 2025.
  - Maximum size limit where 50% or 100% of population is predicted to be male.
- Develop scenarios where the discard F is reallocated to landings F. See SEDAR73 Red Snapper Forecasts: New Methodology and Additional July Scenarios 16, 2021. In particular, scenarios 6, 8, 14 and 16 with recruitment based on long-term mean or short-term (2014 to 2019) recruitment and potentially change level of discards due to wave 1 and 2 being closed to match shallow water grouper closure."

Another memo was sent to the Southeast fishery science center on July 8, 2024 requesting additional scenarios following the June Council meeting. "For October SSC meeting: Provide additional Black Sea Bass projections:

- Using the current project methods, incorporate a phase-in of ABC reductions over 3 years for Black Sea Bass. Assume landings of 68,000 lbs in 2026, 61,000 lbs in 2027, and 54,000 lbs in 2028. Compare the probability of rebuilding by 2030 (approximately one generation based on SEDAR 76) and 2034 (10-year) with current projections.
- Applying the current commercial: recreational allocation (43/57) to total fishery yield and then subtract discards for each sector to provide sector ABCs.
  - Apply to both the 30% and 40% SPR scenarios.
  - Assume status quo selectivity for both sectors."

A memo was sent on September 26, 2024 to the Southeast fishery science center based on discussions at the September council meeting. The council requests:

- "Black Sea Bass projections (Frebuild) requested following the June meeting now need to be based on Fmsy. A rebuilding plan will be addressed later. We had initially requested this by due October 4 but due to the change to Fmsy catch levels, we would request the information no later than October 10."

Based on the sex transition ogive used in the stock assessment, the size that corresponds to 50% males is around 11". At the oldest age used in the assessment (11 years old) the percent of the population male is 99.8%. Therefore, after discussion with council staff specific scenarios that test the maximum size limit were deemed unnecessary as they were already being tested with the 11" size limit and no projections were conducted for the April request item 1 bullet 2. Additionally, the red snapper scenarios do not apply to the black sea bass projections as there were no discussion of reduction in discard mortality for black sea bass, which is the focus of the scenarios mentioned in the request. Following discussions with council staff and the SSC, the scenarios desired was determined to be a shallow water grouper closure during wave 1 and wave 2. The assumptions related to the scenario were discussed with the SSC during the August meeting and presented later (§2.1.4).

The Fishery Management Plan (FMP) for black sea bass has the proxy for F_{MSY} explicitly defined as $F_{30\%}$ of unfished levels. The SSC decided that the appropriate SPR proxy for MSY in SEDAR 76 should be $F_{40\%}$ (Table 1). Since the FMP is in a different metric than what is reported in the SEDAR 76, the Southeast regional office has not listed black sea bass as overfished to the council. The regional office is unlikely to classify black sea bass as overfished until the FMP has been changed to more flexible definition of proxy for F_{MSY} and associated management reference points. It is uncertain when changes to the FMP will be completed.

2 Projection Methods

Projection analysis from a catch at age model requires three main things:

1. abundance at age in the starting year,
2. selectivity at age, and
3. the apical fishing mortality rate in each year for the landings and discard components.

To conduct projections with a change in the minimum size limit of the fishery the selectivity applied to the population needs to be redefined. There are three components that must be defined for projections with discards due to a change in the minimum size limit:

1. selectivity at age for the landings
2. selectivity at age for the discards
3. relative weighting of the selectivity between the landings and the discards.

These three components were defined in different ways depending on the minimum size limit from estimated selectivities from the SEDAR 76 stock assessment model. Following discussions with the SSC in August 2024, the weighting of the selectivity between the landings and the discards was assumed to be the average from the last three years of the stock assessment (2019-2021). To conduct projections where the landings and discards are separated, the rate of fishing mortality for each component must be assumed or solved for. Numerous hypotheses about the apical discard fishing mortality can be made; for example, discard fishing mortality can be assumed to be at the rate in the most recent years, at an F similar to years with the same minimum size limit, or follow a linear trend in F in the recent years of discard mortality. For all scenarios presented, the apical fishing mortality for the discards is assumed to be the geometric mean of the apical fishing mortality rate in the terminal three years of the stock assessment (2019-2021). These assumptions were based on the premise that fishing pressure from the recreational discards would remain at similar levels as recent fishing mortality. The apical fishing mortality rate for the landings for scenarios with a minimum size limit was solved for such that it resulted in a 70% probability of rebuilding within 10 years (i.e., by 2034) assuming the long-term average recruitment scenario. Scenarios are presented with a long-term average recruitment and a recent mean recruitment (2014-2019) with different time periods for the OFL and ABC scenarios.

2.1 April 2024 requests

2.1.1 Minimum Size limit of 11"

To model projections with an 11" size limit we took selectivity curves from the recent stock assessment (SEDAR76 2023). An eleven inch size limit was implemented for the commercial pot and commercial handline fishery from 2013-2021. The landed selectivity for this size limit was obtained by averaging these two fisheries using the relative proportion of the geometric mean of the fishing mortality over the time block for each gear type. In other words, the geometric mean of F for 2013-2021 was calculated for each fleet and used to calculate the weighted average of the two selectivities. The stock assessment modeled the discards with a single combined selectivity for the commercial fleet from 2013 to 2021, which was used as the discard selectivity for the projection period. The weightings of landings to discards selectivities was based on the relative proportion of these two mortality sources for all fleets from the last three years of the stock assessment. This was based on the assumption that the relative impact of mortality from discards and landings would remain at current levels despite a change in the minimum size limit. Projections assuming long-term average recruitment was used to determine the F of landings that would result in a 70% probability of rebuilding to $SSB_{F40\%}$. This F was used with the recent mean recruitment to determine the ABC for this scenario. Management was assumed to be implemented in 2025 for these projections.

2.1.2 Minimum Size limit of 12"

Methods for projections assuming a 12" minimum size limit were similar to the 11" minimum size limit scenario, but used different quantities from the assessment to base the assumptions on. The landings selectivity was the average of the headboat and general recreational fleets from 2007-2012, where the average was weighted by the geometric mean of F from these two fleets during this time period. The discard selectivity for the projections was the recreational and headboat discard fleet selectivity from 2007-2012 because the two fleets had mirrored selectivity in the stock assessment. This scenario calculated the weighting of the landings to the discards selectivity at the proportions determined in the stock assessment from 2019-2021. OFL and ABC limits for this scenario were determined in the same manner as the 11" size limit (i.e., longterm average and recent mean recruitment). Management was assumed to be implemented in 2025 for these projections.

2.1.3 Minimum Size limit of 13"

Projection scenarios for a 13" minimum size limit were similar to the 12" minimum size limit scenarios but for the most recent selectivity time block from the assessment (2013-2021). The discard selectivity for this scenario was taken from the mirrored MRIP and headboat discard selectivity from 2013-2021. The landings selectivity was determined by combining the landed selectivities for the headboat and general recreational from 2013-2021 using an average that is weighted by the geometric mean of the relative F of the two fleets across the time block. The weighting of the selectivity of landings to the discards was calculated based on the stock assessment from the terminal three years. Management was assumed to be implemented in 2025 for these projections.

2.1.4 Wave 1 and 2 closure

The council was interested in a scenario that implemented a recreational shallow water snapper/grouper closure for black sea bass. Following discussions with the SSC during the August meeting, it was decided that the implementation of such a closure would result in an increase in discarding during this closure since not all forms of harvest would be prohibited by this closure. Therefore, landings that would have occurred during this season were assumed to be discarded and were included in the discard mortality rate. To calculate this, the proportion of landings occurring in wave 1 and 2 for the headboat and landings greater than 3 miles from the coast for the general recreational (MRIP) was calculated and average for the last three years of the stock assessment (2019-2021). This was 19.2% of the catch for the headboat during wave 1 and 2 and 13.4% for the general recreational greater than 3 miles. These proportions were multiplied by the current fishing mortality and the average discard mortality rate for the respective fleets and added to the current discard mortality rate. This resulted in a very modest increase in the discard mortality rate compared to the original projection. The wave 1 and 2 recreational closure was assumed to be implemented in 2025 for these projections. The fishing mortality for the landings that resulted in a 70% probability of rebuilding by 2034 was determined assuming the longterm average recruitment and applied to projections assuming recent mean recruitment.

2.2 July 2024 requests

2.2.1 Phase-In scenario

To lessen the impact of the large reduction in landings proposed by the rebuilding projection scenario, the council requested a scenario where they gradually decreased the landings starting in 2026. To implement this the projection assumed that fishing mortality between 2022 and 2025 was at current levels for both the landings and discards. Then in 2026 through 2028 the fishing mortality was solved to fit the desired quota exactly to provide the landings fishing mortality. The landings were 68 klb in 2026, 61 klb in 2027, and 54 klb in 2028. Fishing mortality for the discards from 2026 through the end of the projections (2034) was assumed to be at current fishing mortality rates. The fishing mortality from 2029 until the end of projections for the landings components was set at $0.13{*}F_{40\%}$ as determined by the original rebuilding scenario (Table 2). Recruitment was assumed to base on the longterm average recruitment.

2.3 September 2024 requests

Following discussions with council staff, it was determined that the scenarios requested by the most recent memo were PStar projections. The PStar determined by the SSC during the review of the stock assessment was 30%. The council staff requested that $P^*_{30\%}$scenarios be conducted for both $F_{40\%}$ and $F_{30\%}$ (Tables 1 and 14).

2.3.1 $\mathbf{P^*_{30\%}}$ $\mathbf{F_{40\%}}$

Two assumptions regarding discard mortality rates were crossed with two sets of assumptions of recruitment levels for a total of four PStar scenarios for $F_{40\%}$. The first assumption regarding discard mortality was that the rate would remain at current levels, and the second assumed that discard mortality would be reduced proportional to fishing mortality on landings. The two recruitment assumptions were the longterm average or recent mean recruitment (2014-2019). Management based on the $F_{40\%}$ PStar was assumed to be implemented in 2026 for these projections; thus fishing mortality from 2022 to 2025 was assumed to be at current rates.

2.3.2 $\mathbf{P^*_{30\%}}$ $\mathbf{F_{30\%}}$

Projections for a Pstar for $F_{30\%}$ were conducted in a similar manner as the projections for the PStar $F_{40\%}$. However, the multiplier of fishing mortality that results in a $P^*_{30\%}$was different between these two scenarios due to differences in the distributions of the two reference points. Four projection scenarios were conducted, which crossed the two recruitment and two discard mortality assumptions. Management was assumed to be initiated in 2026, while recruitment changes occurred in 2023.

2.4 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 to account for the fixed mean recruitment in the terminal two years of the stock assessment. However, if the longterm average recruitment was assumed in the projections this did not begin until 2023.

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.

3 Results

The selectivity functions for the MCBE replicates for the different minimum size limits and relative weighting of landings to discards are presented in Figures 1 to 3. The fishing mortality multiplier that obtained a 70% probability of rebuilding or was calculated from the distribution of $F_{40\%}$ or $F_{30\%}$ are presented in Table 2. The scenario with the 11" minimum size limit was not able to obtain a 70% probability with no fishing mortality attributed to landings and only obtained a 66.7% probability of rebuilding by 2034.

Rebuilding scenarios

Results for the OFL and ABC rebuilding scenario are presented in Figures 4 to 9 and Tables 3 and 4 as a reference for other projection scenarios.

11" minimum size limit

Results of the 2 projection scenarios with a minimum size limit of 11" are presented in Figures 10 to 15 and Tables 5 and 6.

12" minimum size limit

Results of the 2 projection scenarios with a minimum size limit of 12" are presented in Figures 16 to 21 and Tables 7 and 8.

13" minimum size limit

Results of the 2 projection scenarios with a minimum size limit of 13" are presented in Figures 22 to 27 and Tables 9 and 10.

Closed wave 1 and 2

Results of the 2 projection scenarios with a recreational closure for black sea bass in wave 1 and 2 are presented in Figures 28 to 33 and Tables 11 and 12.

Landings Phase-In

Results of the projection scenario with landing phase-in are presented in Figures 34 to 36 and Table 13.

$\mathbf{P^*_{30\%}}$ $\mathbf{F_{40\%}}$

Results of the 4 projection scenarios with $P^*_{30\%}$ $F_{40\%}$ are presented in Figures 37 to 48 and Tables 15 to 18.

$\mathbf{P^*_{30\%}}$ $\mathbf{F_{30\%}}$

Results of the 4 projection scenarios with $P^*_{30\%}$ $F_{30\%}$ are presented in Figures 49 to 60 and Tables 19 to 22.

3.1 Allocation Calculations from status quo selectivity

The allocation between the recreational and commercial fisheries are predetermined in the projections based on the weighted selectivity curve from the geometric mean of the terminal three years of the assessment. For projections where the landings and discards are separated the allocation is determined by the averaging within selectivity curves and the relative fishing mortality attributed to landings and discards. The general assumption for projections made in this analysis has been that discards will remain at recent fishing mortality as determined by the stock assessment. The recreational component of the discard selectivity accounts for 99.92% of the mortality. In the terminal years of the assessment the discard mortality accounts for 28.88% of the fishing mortality. Due the discards selecting the smaller fish before they are available to the large landed fish the proportion in terms of numbers is about 69% of total dead individuals but only 45% in terms of weight. Therefore, the weighting in the selectivity does not directly translate into the same proportion of landings due to differences in the age caught by different fleets or methods (e.g. landings vs. discards).

In the rebuilding scenario, due to the large reduction in the landings, the fishing mortality attributed to the discards in 2025 for the ABC scenario accounts for 97.7% in terms of numbers and 94.2% in terms of weight (Table 4). If the total yield (sum of landings and dead discards) from the ABC scenario in 2025 in weight of 751 klb is divided between sectors based on a 43% / 57% split, the recreational allocation would be 428.07 klb. However, the discards in the projection, which are almost completely attributable to the recreational sector, are predicted to be 708 klb and exceed the sector allocation. The same would be true if the allocation were calculated based on thousands of fish (1718), where the recreational allocation would be 979.26 but the discards would be 1678. Thus, based on the allocation and rebuilding projection scenario the recreational sector would exceed the allocation through discards alone.

A similar outcome occurs for the scenario with $P^*_{30\%}$ $F_{40\%}$ and discard mortality at current levels with recent mean recruitment (Table 16). The total mortalities in 2026 are 909 klb or 1882 thousand fish. The allocation to the recreational fishery would be 518.13 klb or 1072.74 thousands of fish (depending on which unit was used to determine the allocation). However, the discards in 2026 are projected to be 716 klb or 1700 thousand fish. Therefore, both the Pstar and rebuilding projections predict that the recreational fishing exceeds the allocation in terms of discards alone.

4 Discussion

The scenarios with a closed season was based on the assumption that there would still be recreational fishing in wave 1 and 2 but that they would not be able to harvest black sea bass. If there was a closure to all bottom reef fishing during wave 1 and 2, then the assumptions made for this scenario would not apply. A complete closure of fishing to all bottom reef species would be more likely to result in the desired effect of changing discards into landings. However, the proposed closures as described would be more likely to result in higher discards for black sea bass because of the mixed species nature of the fishery.

The phase-in landings projection scenarios results in a 70% probability of rebuilding by 2034. However, the projections assume that there is no management uncertainty and the landings targets are hit exactly. This rebuilding scenario would be overly optimistic in the rebuilding probability if there this a bias in the management uncertainty where the targets are exceeded through the projection time frame.

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.
- 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 change as a result of the change in minimum size limit.
- 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.

5 References

SEDAR76, 2023. South Atlantic Black Sea Bass Stock Assessment Report. SEDAR, North Charleston, SC.

6 Tables

Table 1. Estimated status indicators, benchmarks, and related quantities for $F_{40\%}$ 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. Spawning stock biomass (SSB) is measured as weight of mature fish in thousands of pounds.* L_{current} *and* D_{current} *are the average landings and discards from 2019–2021, respectively. Estimates of yield do not include discards;* $D_{\mathrm{F40\%}}$ *represents discard mortalities expected when fishing at* $F_{40\%}$*.*

Quantity	Units	Estimate	Median	SE
$F_{40\%}$	y^{-1}	1.18	1.28	1.36
$B_{\mathrm{F40\%}}$	1000 lb	17688.58	22071.29	18851.44
$\mathrm{SSB}_{\mathrm{F40\%}}$	1000 lb	8736.42	10219.24	1951.55
MSST	1000 lb	5460.26	5807.19	1152.61
$L_{\mathrm{F40\%}}$	1000 lb	674.53	492.38	367.25
$L_{75\%\mathrm{F40\%}}$	1000 lb	808.39	633.13	356.01
L_{current}	1000 lb	544.23	536.40	65.80
$D_{\mathrm{F40\%}}$	1000 dead fish	4530.85	6599.32	7825.67
$D_{\mathrm{F40\%}}$ klb	1000 lb	1901.63	2655.96	2374.23
$D_{75\%\mathrm{F40\%}}$	1000 dead fish	3678.27	2285.27	2220.61
$D_{75\%\mathrm{F40\%}}$ klb	1000 lb	1592.67	2285.27	2220.61
D_{current}	1000 dead fish	935.34	1242.30	530.60
D_{current} klb	1000 lb	437.42	575.19	234.03
$F_{2019-2021}/F_{40\%}$	—	0.79	0.61	1.14
$\mathrm{SSB}_{2021}/\mathrm{MSST}$	—	0.57	0.72	0.41
$\mathrm{SSB}_{2021}/\mathrm{SSB}_{\mathrm{F40\%}}$	—	0.36	0.42	0.27

Table 2. Value of F used for various projection scenarios. For scenarios except those using a $P^*_{30\%}$, the value of F was determined by resulting in a 70% probability of rebuilding by 2034. An † indicates that the projection scenario does not rebuild and the number in parenthesis is the percent of projections that rebuild by 2034.

Scenario	F
$F_{\text{Rebuild70\%}}$	0.13 $*F_{40\%}$
11" Minimum Size Limit	0 * $F_{40\%}$ † (66.7)
12" Minimum Size Limit	0.1 * $F_{40\%}$
13" Minimum Size Limit	0.16 * $F_{40\%}$
Closed wave 1 and 2	0.11 * $F_{40\%}$
$P^*_{30\%}$ $F_{40\%}$	0.5696 * $F_{40\%}$
$P^*_{30\%}$ $F_{30\%}$	0.5974 * $F_{30\%}$

Table 3. Projection results with fishing mortality rate at $F_{\text{Landed}} = F_{\text{Rebuild70\%}}$ and $F_{\text{Discard}} = F_{\text{current}}$ 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* $\text{SSB} \geq \text{SSB}_{\text{F40\%}}$. *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	3169	222	212	271	265	994	1286	359	455	0.002
2023	71	115	0.936	0.801	3644	4868	179	171	212	206	1489	1970	516	661	0.083
2024	71	114	0.936	0.801	5370	7277	168	160	179	174	2481	3295	892	1161	0.292
2025	71	116	0.383	0.474	6753	9066	39	49	39	48	3174	4259	1299	1707	0.449
2026	71	114	0.383	0.474	7721	10252	66	80	68	80	3331	4473	1430	1879	0.535
2027	71	115	0.383	0.474	8403	11017	100	118	109	125	3354	4501	1454	1906	0.593
2028	71	114	0.383	0.474	8901	11563	140	163	165	186	3356	4505	1456	1917	0.629
2029	71	115	0.383	0.474	9249	11867	170	194	211	233	3356	4497	1457	1906	0.655
2030	71	114	0.383	0.474	9487	12128	188	212	244	266	3356	4501	1457	1914	0.672
2031	71	115	0.383	0.474	9647	12253	199	223	266	288	3356	4491	1457	1906	0.681
2032	71	116	0.383	0.474	9754	12335	206	231	280	302	3356	4482	1457	1904	0.692
2033	71	115	0.383	0.474	9824	12470	211	236	290	311	3356	4473	1457	1907	0.696
2034	71	115	0.383	0.474	9869	12482	214	237	296	316	3356	4477	1457	1900	0.700

Table 4. Projection results with fishing mortality rate at $F_{\text{Landed}} = F_{\text{Rebuild70\%}}$ and $F_{\text{Discard}} = F_{\text{current}}$ 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* $\text{SSB} \geq \text{SSB}_{\text{F40\%}}$. *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	3166	222	212	271	265	924	1191	355	452	0.002
2023	25	43	0.936	0.801	2620	3467	178	169	211	206	1109	1462	458	583	0.004
2024	25	43	0.936	0.801	2734	3747	159	150	176	171	1151	1601	492	663	0.008
2025	25	43	0.383	0.474	2876	3979	32	40	35	44	1164	1679	503	704	0.012
2026	25	43	0.383	0.474	3062	4208	46	54	54	62	1167	1712	506	726	0.013

Table 5. Projection results with an 11" minimum size limit for commercial and recreational fisheries and fishing mortality rate at $F_{\text{Landed}} = 0$ *and* $F_{\text{Discard}} = F_{\text{current}}$ *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* $\text{SSB} \geq \text{SSB}_{\text{F40\%}}$*. 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	3169	222	212	271	265	994	1286	359	455	0.002
2023	71	115	0.936	0.801	3644	4868	179	171	212	206	1489	1970	516	661	0.083
2024	71	114	0.936	0.801	5370	7277	168	160	179	174	2481	3295	892	1161	0.292
2025	71	116	0.380	0.402	6664	8915	0	0	0	0	5099	7025	1720	2324	0.440
2026	71	114	0.380	0.402	7311	9637	0	0	0	0	4866	6637	1638	2182	0.495
2027	71	115	0.380	0.402	7874	10280	0	0	0	0	4788	6514	1596	2123	0.542
2028	71	114	0.380	0.402	8350	10841	0	0	0	0	4777	6458	1588	2097	0.579
2029	71	115	0.380	0.402	8731	11192	0	0	0	0	4776	6487	1587	2098	0.607
2030	71	114	0.380	0.402	9031	11537	0	0	0	0	4776	6468	1587	2095	0.627
2031	71	115	0.380	0.402	9263	11749	0	0	0	0	4776	6467	1587	2087	0.641
2032	71	116	0.380	0.402	9441	11918	0	0	0	0	4776	6431	1587	2073	0.653
2033	71	115	0.380	0.402	9576	12091	0	0	0	0	4776	6421	1587	2082	0.659
2034	71	115	0.380	0.402	9672	12199	0	0	0	0	4776	6465	1587	2089	0.667

Table 6. Projection results with an 11" minimum size limit for commercial and recreational fisheries and fishing mortality rate at $F_{\text{Landed}} = 0$ *and* $F_{\text{Discard}} = F_{\text{current}}$ *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* $\text{SSB} \geq \text{SSB}_{\text{F40\%}}$*. 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	3166	222	212	271	265	924	1191	355	452	0.002
2023	25	43	0.936	0.801	2620	3467	178	169	211	206	1109	1462	458	583	0.004
2024	25	43	0.936	0.801	2734	3747	159	150	176	171	1151	1601	492	663	0.008
2025	25	43	0.380	0.402	2860	3936	0	0	0	0	1798	2698	619	908	0.011
2026	25	43	0.380	0.402	2976	4047	0	0	0	0	1696	2544	573	836	0.011

Table 7. Projection results with a 12" minimum size limit for commercial and recreational fisheries and fishing mortality rate at $F_{\text{Landed}} = F_{\text{Rebuild70\%}}$ *and* $F_{\text{Discard}} = F_{\text{current}}$ *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* SSB $\geq$ $\text{SSB}_{\text{F40\%}}$. *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	3169	222	212	271	265	994	1286	359	455	0.002
2023	71	115	0.936	0.801	3644	4868	179	171	212	206	1489	1970	516	661	0.083
2024	71	114	0.936	0.801	5370	7277	168	160	179	174	2481	3295	892	1161	0.292
2025	71	116	0.380	0.414	6745	9076	43	48	41	46	3174	4108	1323	1682	0.449
2026	71	114	0.380	0.414	7681	10255	69	77	68	75	3360	4367	1477	1893	0.536
2027	71	115	0.380	0.414	8319	11001	108	119	113	122	3400	4424	1518	1943	0.592
2028	71	114	0.380	0.414	8770	11550	135	150	150	163	3406	4421	1525	1956	0.626
2029	71	115	0.380	0.414	9096	11829	153	168	178	192	3406	4413	1526	1952	0.652
2030	71	114	0.380	0.414	9331	12097	164	180	198	212	3407	4424	1526	1952	0.669
2031	71	115	0.380	0.414	9498	12247	171	188	212	227	3407	4417	1526	1950	0.680
2032	71	116	0.380	0.414	9616	12353	176	193	222	237	3407	4404	1526	1946	0.689
2033	71	115	0.380	0.414	9699	12470	179	195	229	244	3407	4404	1526	1948	0.695
2034	71	115	0.380	0.414	9754	12523	182	198	234	248	3407	4405	1526	1945	0.701

Table 8. Projection results with a 12" minimum size limit for commercial and recreational fisheries and fishing mortality rate at $F_{\text{Landed}} = F_{\text{Rebuild70\%}}$ *and* $F_{\text{Discard}} = F_{\text{current}}$ *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* SSB $\geq$ $\text{SSB}_{\text{F40\%}}$. *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	3166	222	212	271	265	924	1191	355	452	0.002
2023	25	43	0.936	0.801	2620	3467	178	169	211	206	1109	1462	458	583	0.004
2024	25	43	0.936	0.801	2734	3747	159	150	176	171	1151	1601	492	663	0.008
2025	25	43	0.380	0.414	2868	3980	36	40	38	42	1179	1636	526	711	0.012
2026	25	43	0.380	0.414	3032	4205	46	50	51	55	1183	1676	530	736	0.014

Table 9. Projection results with a 13" minimum size limit for commercial and recreational fisheries and fishing mortality rate 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* 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	3169	222	212	271	265	994	1286	359	455	0.002
2023	71	115	0.936	0.801	3644	4868	179	171	212	206	1489	1970	516	661	0.083
2024	71	114	0.936	0.801	5370	7277	168	160	179	174	2481	3295	892	1161	0.292
2025	71	116	0.381	0.491	6755	9068	29	35	33	40	3173	4261	1300	1708	0.449
2026	71	114	0.381	0.491	7728	10267	51	57	59	65	3333	4477	1431	1882	0.536
2027	71	115	0.381	0.491	8417	11043	84	92	99	107	3356	4504	1456	1910	0.594
2028	71	114	0.381	0.491	8918	11594	129	140	161	172	3358	4508	1459	1920	0.631
2029	71	115	0.381	0.491	9265	11894	162	175	213	225	3358	4503	1459	1911	0.656
2030	71	114	0.381	0.491	9496	12150	182	195	249	260	3358	4504	1459	1919	0.672
2031	71	115	0.381	0.491	9649	12264	194	206	272	284	3358	4496	1459	1911	0.682
2032	71	116	0.381	0.491	9749	12349	202	213	288	297	3358	4486	1459	1908	0.691
2033	71	115	0.381	0.491	9814	12472	206	218	298	307	3358	4478	1459	1912	0.694
2034	71	115	0.381	0.491	9854	12475	209	222	304	313	3358	4482	1459	1904	0.700

Table 10. Projection results with a 13" minimum size limit for commercial and recreational fisheries and fishing mortality rate 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* 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	3166	222	212	271	265	924	1191	355	452	0.002
2023	25	43	0.936	0.801	2620	3467	178	169	211	206	1109	1462	458	583	0.004
2024	25	43	0.936	0.801	2734	3747	159	150	176	171	1151	1601	492	663	0.008
2025	25	43	0.381	0.491	2877	3980	27	31	32	38	1164	1680	503	705	0.012
2026	25	43	0.381	0.491	3065	4215	42	46	52	56	1168	1713	507	727	0.013

Table 11. Projection results for a scenario simulating a shallow water grouper closure in wave 1 and 2 with fishing mortality rate at $F_{\text{Landed}} = F_{\text{Rebuild70\%}}$ *and* $F_{\text{Discard}} = F_{\text{current}}$ *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* $\text{SSB} \geq \text{SSB}_{\text{F40\%}}$. *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	3169	222	212	271	265	994	1286	359	455	0.002
2023	71	115	0.936	0.801	3644	4868	179	171	212	206	1489	1970	516	661	0.083
2024	71	114	0.936	0.801	5370	7277	168	160	179	174	2481	3295	892	1161	0.292
2025	71	116	0.387	0.462	6751	9059	33	42	33	41	3208	4318	1313	1731	0.448
2026	71	114	0.387	0.462	7711	10227	56	68	58	69	3364	4524	1442	1899	0.534
2027	71	115	0.387	0.462	8393	10993	85	100	94	107	3386	4552	1466	1925	0.590
2028	71	114	0.387	0.462	8895	11542	120	139	142	159	3388	4554	1469	1933	0.628
2029	71	115	0.387	0.462	9255	11856	146	166	182	201	3388	4545	1469	1925	0.653
2030	71	114	0.387	0.462	9505	12131	162	183	212	230	3388	4548	1469	1933	0.670
2031	71	115	0.387	0.462	9678	12272	173	193	232	250	3388	4541	1469	1925	0.681
2032	71	116	0.387	0.462	9796	12356	179	200	245	263	3388	4533	1469	1922	0.691
2033	71	115	0.387	0.462	9875	12491	183	204	255	272	3388	4524	1469	1925	0.696
2034	71	115	0.387	0.462	9927	12532	186	206	261	277	3388	4524	1469	1917	0.701

Table 12. Projection results for a scenario simulating a shallow water grouper closure in wave 1 and 2 with fishing mortality rate at $F_{\text{Landed}} = F_{\text{Rebuild70\%}}$ *and* $F_{\text{Discard}} = F_{\text{current}}$ *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* $\text{SSB} \geq \text{SSB}_{\text{F40\%}}$. *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	3166	222	212	271	265	924	1191	355	452	0.002
2023	25	43	0.936	0.801	2620	3467	178	169	211	206	1109	1462	458	583	0.004
2024	25	43	0.936	0.801	2734	3747	159	150	176	171	1151	1601	492	663	0.008
2025	25	43	0.387	0.462	2876	3976	28	34	30	37	1177	1702	509	714	0.012
2026	25	43	0.387	0.462	3062	4203	39	46	46	53	1178	1732	511	733	0.013

Table 13. Projection results with landings defined for 2026 through 2028 and fishing mortality for 2029 and later set at $F_{\mathrm{Landed}} = F_{\mathrm{Rebuild70\%}}$ and $F_{\mathrm{Discard}} = F_{\mathrm{current}}$ as defined in the original OFL scenario 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	3169	222	212	271	265	994	1286	359	455	0.002
2023	71	115	0.936	0.801	3644	4868	179	171	212	206	1489	1970	516	661	0.083
2024	71	114	0.936	0.801	5370	7277	168	160	179	174	2481	3295	892	1161	0.292
2025	71	116	0.936	0.801	6700	9024	213	200	203	192	3162	4247	1291	1699	0.446
2026	71	114	0.384	0.407	7584	10153	70	71	68	68	3324	4467	1424	1874	0.528
2027	71	115	0.382	0.405	8311	10975	57	59	61	61	3355	4503	1454	1908	0.588
2028	71	114	0.381	0.404	8890	11618	46	48	54	54	3360	4510	1459	1921	0.629
2029	71	115	0.383	0.474	9309	12017	175	203	218	247	3358	4500	1458	1908	0.658
2030	71	114	0.383	0.474	9530	12203	192	219	249	276	3357	4501	1457	1915	0.672
2031	71	115	0.383	0.474	9677	12298	202	227	270	295	3356	4491	1457	1906	0.682
2032	71	116	0.383	0.474	9775	12366	208	234	283	306	3356	4482	1457	1904	0.691
2033	71	115	0.383	0.474	9838	12484	212	237	292	314	3356	4473	1457	1907	0.695
2034	71	115	0.383	0.474	9878	12487	214	238	297	317	3356	4477	1457	1900	0.700

Table 14. Estimated status indicators, benchmarks, and related quantities for $F_{30\%}$ 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. Spawning stock biomass (SSB) is measured as weight of mature fish in thousands of pounds.* $L_{current}$ *and* $D_{current}$ *are the average landings and discards from 2019–2021, respectively. Estimates of yield do not include discards;* $D_{F30\%}$ *represents discard mortalities expected when fishing at* $F_{30\%}$*.*

Quantity	Units	Estimate	Median	SE
$F_{30\%}$	y^{-1}	2.11	2.38	1.71
$B_{F30\%}$	1000 lb	15362.20	19631.47	19323.52
$SSB_{F30\%}$	1000 lb	6552.58	7730.90	2327.61
MSST	1000 lb	4095.36	4556.86	933.88
$F_{30\%}$	1000 lb	363.87	243.58	316.19
$L_{75\%F30\%}$	1000 lb	516.47	369.24	355.25
$L_{current}$	1000 lb	544.23	536.40	65.80
$D_{F30\%}$	1000 dead fish	6519.88	9280.22	9131.64
$D_{F30\%}$ klb	1000 lb	2503.50	3343.97	2464.99
$D_{75\%F30\%}$	1000 dead fish	5502.56	3033.90	2345.73
$D_{75\%F30\%}$ klb	1000 lb	2218.17	3033.90	2345.73
$D_{current}$	1000 dead fish	935.34	1242.30	530.60
$D_{current}$ klb	1000 lb	437.42	575.19	234.03
$F_{2019-2021}/F_{30\%}$	—	0.44	0.33	0.70
SSB_{2021}/MSST	—	0.76	0.95	0.46
$SSB_{2021}/SSB_{F30\%}$	—	0.47	0.54	0.17

Table 15. Projection results with fishing mortality rate at $F_{\text{Landings}} = P^*_{30\%} * F_{40\%}$ *and* $F_{\text{Discard}} = F_{\text{current}}$ *starting in 2026 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* $\text{SSB} \geq \text{SSB}_{\text{F40\%}}$*. 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	3169	222	212	271	265	994	1286	359	455	0.002
2023	71	115	0.936	0.801	3644	4868	179	171	212	206	1489	1970	516	661	0.083
2024	71	114	0.936	0.801	5370	7277	168	160	179	174	2481	3295	892	1161	0.292
2025	71	116	0.936	0.801	6700	9024	213	200	203	192	3162	4247	1291	1699	0.446
2026	71	114	0.671	0.852	7535	10060	234	290	223	273	3314	4446	1416	1859	0.521
2027	71	115	0.671	0.852	8093	10629	340	406	343	397	3335	4468	1438	1880	0.568
2028	71	114	0.671	0.852	8413	10977	445	518	483	544	3336	4470	1440	1890	0.592
2029	71	115	0.671	0.852	8559	11075	496	565	561	616	3336	4465	1440	1883	0.605
2030	71	114	0.671	0.852	8620	11155	515	584	593	647	3336	4470	1440	1889	0.610
2031	71	115	0.671	0.852	8644	11148	522	593	607	663	3336	4458	1440	1880	0.610
2032	71	116	0.671	0.852	8654	11144	524	596	612	670	3336	4447	1440	1879	0.611
2033	71	115	0.671	0.852	8658	11205	525	598	614	676	3336	4442	1440	1881	0.611
2034	71	115	0.671	0.852	8659	11192	526	596	615	675	3336	4443	1440	1875	0.614

Table 16. Projection results with fishing mortality rate at $F_{\text{Landings}} = P^*_{30\%} * F_{40\%}$ *and* $F_{\text{Discard}} = F_{\text{current}}$ *starting in 2026 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* $\text{SSB} \geq \text{SSB}_{\text{F40\%}}$*. 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	3166	222	212	271	265	924	1191	355	452	0.002
2023	25	43	0.936	0.801	2620	3467	178	169	211	206	1109	1462	458	583	0.004
2024	25	43	0.936	0.801	2734	3747	159	150	176	171	1151	1601	492	663	0.008
2025	25	43	0.936	0.801	2827	3935	172	159	182	171	1157	1671	498	699	0.012
2026	25	43	0.671	0.852	2904	4051	149	182	162	193	1160	1700	500	716	0.011

Table 17. Projection results with fishing mortality rate at $F = P^*_{30\%} * F_{40\%}$ *for both landings and discards starting in 2026 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* SSB $\geq$ $\mathrm{SSB_{F40\%}}$*. 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	3169	222	212	271	265	994	1286	359	455	0.002
2023	71	115	0.936	0.801	3644	4868	179	171	212	206	1489	1970	516	661	0.083
2024	71	114	0.936	0.801	5370	7277	168	160	179	174	2481	3295	892	1161	0.292
2025	71	116	0.936	0.801	6700	9024	213	200	203	192	3162	4247	1291	1699	0.446
2026	71	114	0.671	0.734	7647	10063	239	291	227	272	2446	4278	1050	1796	0.513
2027	71	115	0.671	0.734	8538	10704	365	392	365	381	2543	4373	1117	1858	0.556
2028	71	114	0.671	0.734	9088	11221	504	456	541	460	2568	4376	1136	1869	0.618
2029	71	115	0.671	0.734	9376	11703	588	490	661	513	2572	4402	1140	1878	0.676
2030	71	114	0.671	0.734	9512	12119	631	533	727	579	2573	4362	1140	1872	0.721
2031	71	115	0.671	0.734	9571	12353	649	566	759	635	2573	4361	1140	1869	0.750
2032	71	116	0.671	0.734	9596	12514	656	590	772	666	2573	4345	1140	1864	0.768
2033	71	115	0.671	0.734	9606	12622	659	603	777	685	2573	4349	1140	1859	0.778
2034	71	115	0.671	0.734	9609	12737	660	610	779	697	2573	4381	1140	1862	0.791

Table 18. Projection results with fishing mortality rate at $F = P^*_{30\%} * F_{40\%}$ *for both landings and discards starting in 2026 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* SSB $\geq$ $\mathrm{SSB_{F40\%}}$*. 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	3166	222	212	271	265	924	1191	355	452	0.002
2023	25	43	0.936	0.801	2620	3467	178	169	211	206	1109	1462	458	583	0.004
2024	25	43	0.936	0.801	2734	3747	159	150	176	171	1151	1601	492	663	0.008
2025	25	43	0.936	0.801	2827	3935	172	159	182	171	1157	1671	498	699	0.012
2026	25	43	0.671	0.734	2943	4064	151	181	163	193	856	1622	371	685	0.006

Table 19. Projection results with fishing mortality rate at $F_{\text{Landings}} = P^*_{30\%} * F_{30\%}$ *and* $F_{\text{Discard}} = F_{\text{current}}$ *starting in 2026 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* $\text{SSB} \geq \text{SSB}_{\text{F40\%}}$*. 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	3169	222	212	271	265	994	1286	359	455	0.002
2023	71	115	0.936	0.801	3644	4868	179	171	212	206	1489	1970	516	661	0.083
2024	71	114	0.936	0.801	5370	7277	168	160	179	174	2481	3295	892	1161	0.292
2025	71	116	0.936	0.801	6700	9024	213	200	203	192	3162	4247	1291	1699	0.446
2026	71	114	1.260	1.434	7479	9974	409	520	381	475	3301	4430	1407	1849	0.515
2027	71	115	1.260	1.434	7898	10373	543	662	524	616	3315	4444	1423	1861	0.550
2028	71	114	1.260	1.434	8088	10574	655	777	671	762	3315	4444	1423	1867	0.566
2029	71	115	1.260	1.434	8141	10614	687	805	719	804	3315	4439	1423	1858	0.569
2030	71	114	1.260	1.434	8153	10648	693	811	730	819	3315	4440	1423	1864	0.571
2031	71	115	1.260	1.434	8155	10617	694	820	733	827	3315	4432	1423	1860	0.569
2032	71	116	1.260	1.434	8156	10584	695	816	733	827	3315	4424	1423	1858	0.568
2033	71	115	1.260	1.434	8156	10632	695	817	734	828	3315	4416	1423	1860	0.569
2034	71	115	1.260	1.434	8156	10628	695	815	734	830	3315	4417	1423	1855	0.569

Table 20. Projection results with fishing mortality rate at $F_{\text{Landings}} = P^*_{30\%} * F_{30\%}$ *and* $F_{\text{Discard}} = F_{\text{current}}$ *starting in 2026 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* $\text{SSB} \geq \text{SSB}_{\text{F40\%}}$*. 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	3166	222	212	271	265	924	1191	355	452	0.002
2023	25	43	0.936	0.801	2620	3467	178	169	211	206	1109	1462	458	583	0.004
2024	25	43	0.936	0.801	2734	3747	159	150	176	171	1151	1601	492	663	0.008
2025	25	43	0.936	0.801	2827	3935	172	159	182	171	1157	1671	498	699	0.012
2026	25	43	1.260	1.434	2863	3988	252	314	268	325	1155	1693	496	710	0.010

Table 21. Projection results with fishing mortality rate at $F = P^*_{30\%} * F_{30\%}$ *for both landings and discards starting in 2026 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	3169	222	212	271	265	994	1286	359	455	0.002
2023	71	115	0.936	0.801	3644	4868	179	171	212	206	1489	1970	516	661	0.083
2024	71	114	0.936	0.801	5370	7277	168	160	179	174	2481	3295	892	1161	0.292
2025	71	116	0.936	0.801	6700	9024	213	200	203	192	3162	4247	1291	1699	0.446
2026	71	114	1.260	1.440	7345	9492	400	484	375	447	4293	7435	1820	3071	0.462
2027	71	115	1.260	1.440	7414	9071	495	439	483	410	4153	6844	1744	2725	0.368
2028	71	114	1.260	1.440	7409	9258	559	426	577	412	4116	6729	1716	2634	0.361
2029	71	115	1.260	1.440	7367	9498	552	435	578	430	4110	6747	1711	2621	0.381
2030	71	114	1.260	1.440	7343	9688	539	459	563	451	4109	6719	1710	2627	0.400
2031	71	115	1.260	1.440	7335	9803	534	470	556	454	4109	6702	1710	2633	0.406
2032	71	116	1.260	1.440	7333	9855	533	477	554	456	4109	6674	1710	2614	0.416
2033	71	115	1.260	1.440	7332	9872	533	479	554	457	4109	6666	1710	2612	0.422
2034	71	115	1.260	1.440	7332	9963	533	479	554	456	4109	6694	1710	2617	0.429

Table 22. Projection results with fishing mortality rate at $F = P^*_{30\%} * F_{30\%}$ *for both landings and discards starting in 2026 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	3166	222	212	271	265	924	1191	355	452	0.002
2023	25	43	0.936	0.801	2620	3467	178	169	211	206	1109	1462	458	583	0.004
2024	25	43	0.936	0.801	2734	3747	159	150	176	171	1151	1601	492	663	0.008
2025	25	43	0.936	0.801	2827	3935	172	159	182	171	1157	1671	498	699	0.012
2026	25	43	1.260	1.440	2816	3833	248	297	265	312	1502	2783	642	1156	0.003

7 Figures

Figure 1. Selectivity curves from the MCBE models for landings, discards, and weighted total for a minimum size limit of 11". The black lines represent individual MCBE models, the green dotted line is the selectivity curve for the base model and the red dashed line is the weighted selectivity from the assessment used to calculate the $F_{40\%}$ reference point.

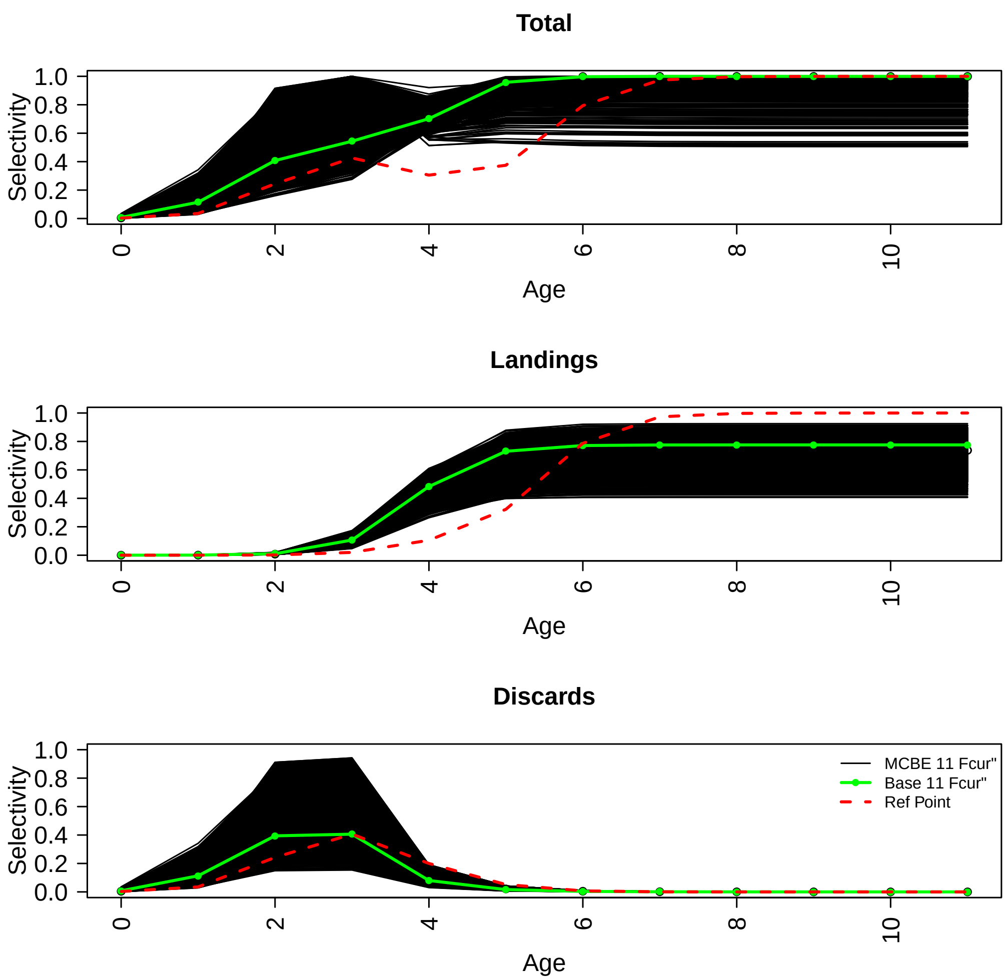


Figure 2. Selectivity curves from the MCBE models for landings, discards, and weighted total for a minimum size limit of 12". The black lines represent individual MCBE models, the green dotted line is the selectivity curve for the base model and the red dashed line is the weighted selectivity from the assessment used to calculate the $F_{40\%}$ reference point.

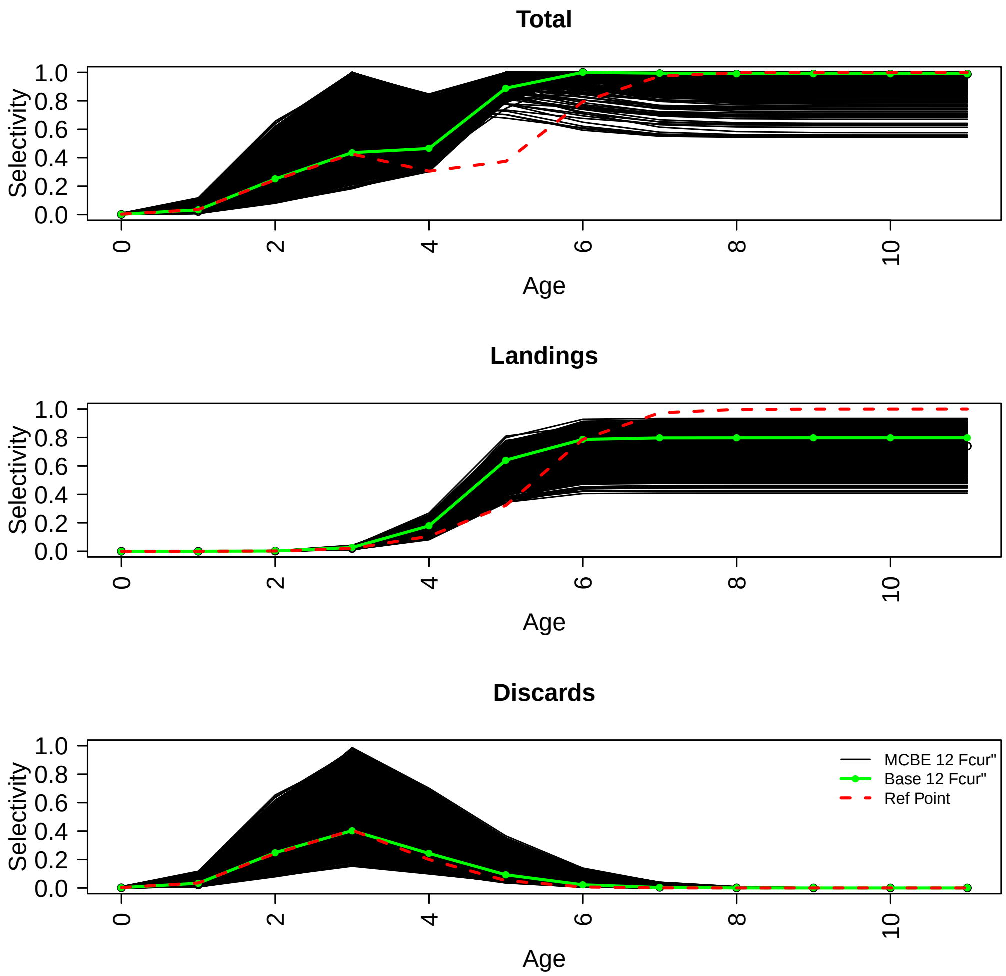


Figure 3. Selectivity curves from the MCBE models for landings, discards, and weighted total for a minimum size limit of 13". The black lines represent individual MCBE models, the green dotted line is the selectivity curve for the base model and the red dashed line is the weighted selectivity from the assessment used to calculate the $F_{40\%}$ reference point.

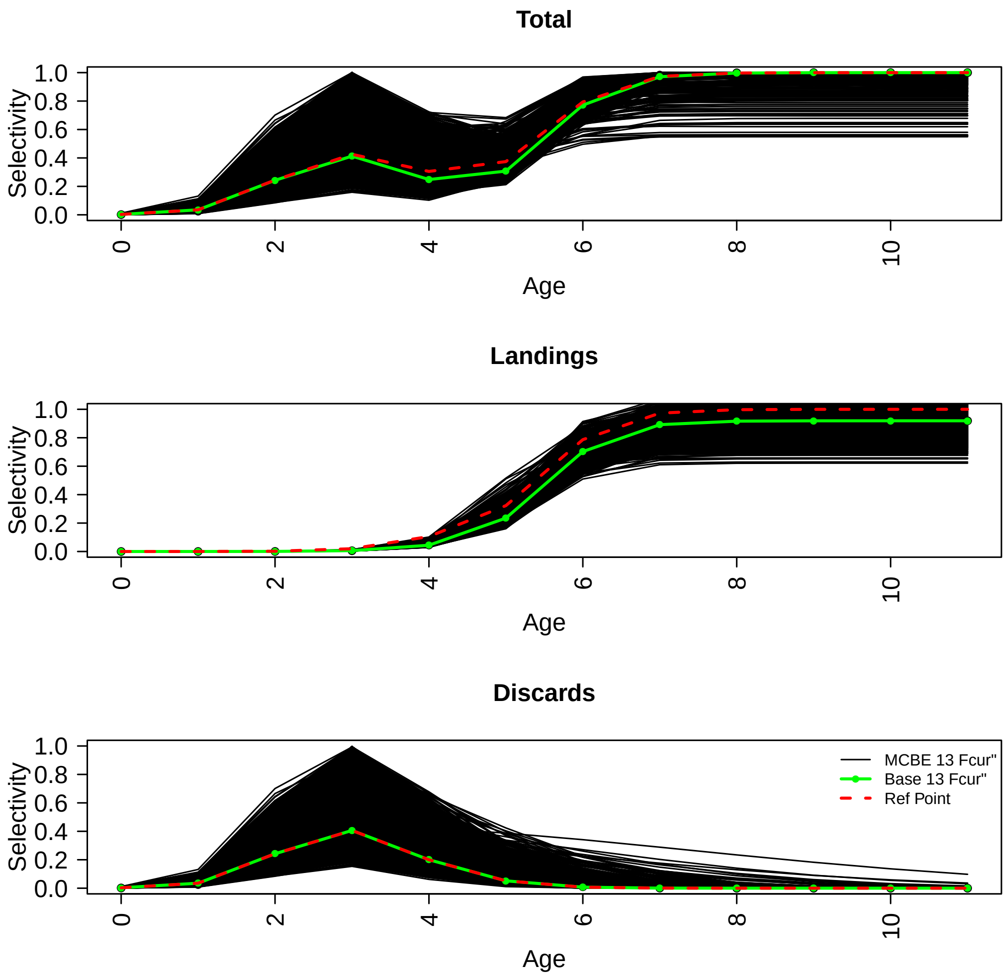


Figure 4. Projected time series for the OFL scenario with fishing mortality rate at $F_{\text{Landed}} = F_{\text{Rebuild70\%}}$ *and* $F_{\text{Discard}} = F_{\text{current}}$ *starting in 2025 and longterm average recruitment starting in 2023. Expected values (base run) represented by solid lines with 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.*

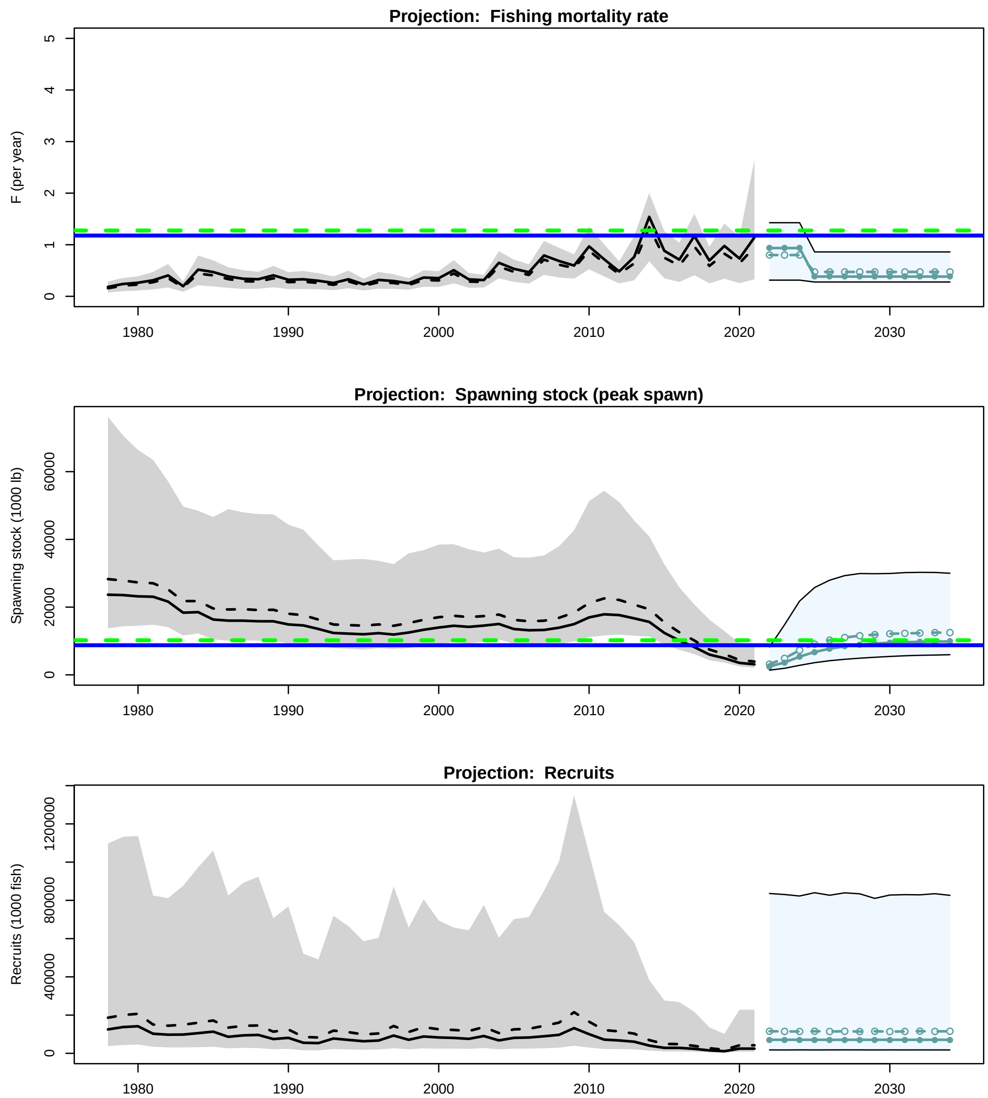


Figure 5. Projected fishing mortality (top left panel), spawning stock biomass (top right panel), landings (middle panels) in weight (left) and numbers (right) and discards (bottom panels) in weight (left) and numbers (right) for the projected time series for the OFL scenario with fishing mortality rates at $F_{\text{Landed}} = F_{\text{Rebuild70\%}}$ *and* $F_{\text{Discard}} = F_{\text{current}}$ *starting in 2025 and longterm average recruitment starting in 2023. 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.*

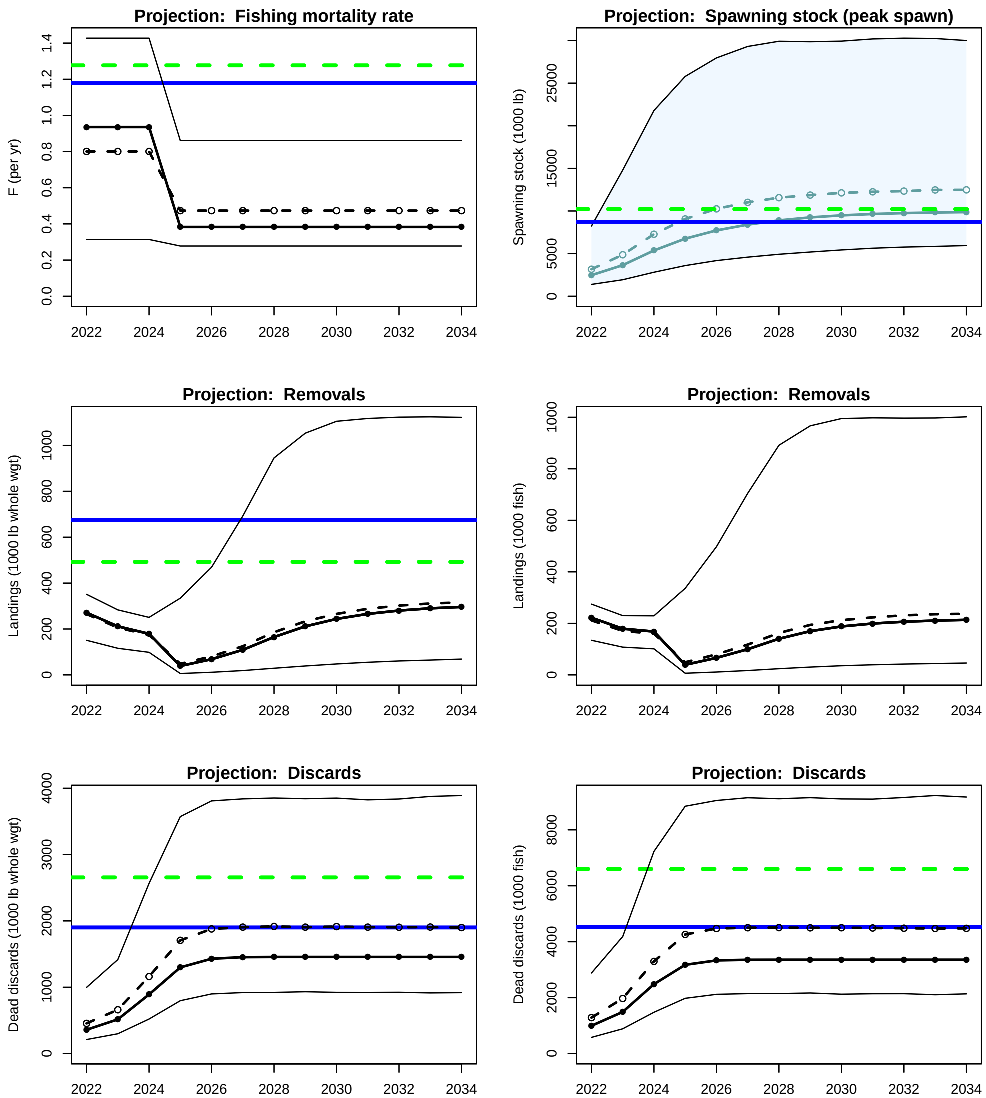


Figure 6. Top Panel: Projected probability of rebuilding under OFL scenario and longterm average recruitment. The curve represents the proportion of projection replicates for which SSB has reached the replicate-specific $\mathrm{SSB}_{\mathrm{F}40\%}$, *with reference lines at 0.5 and 0.7. Bottom panel: 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.*

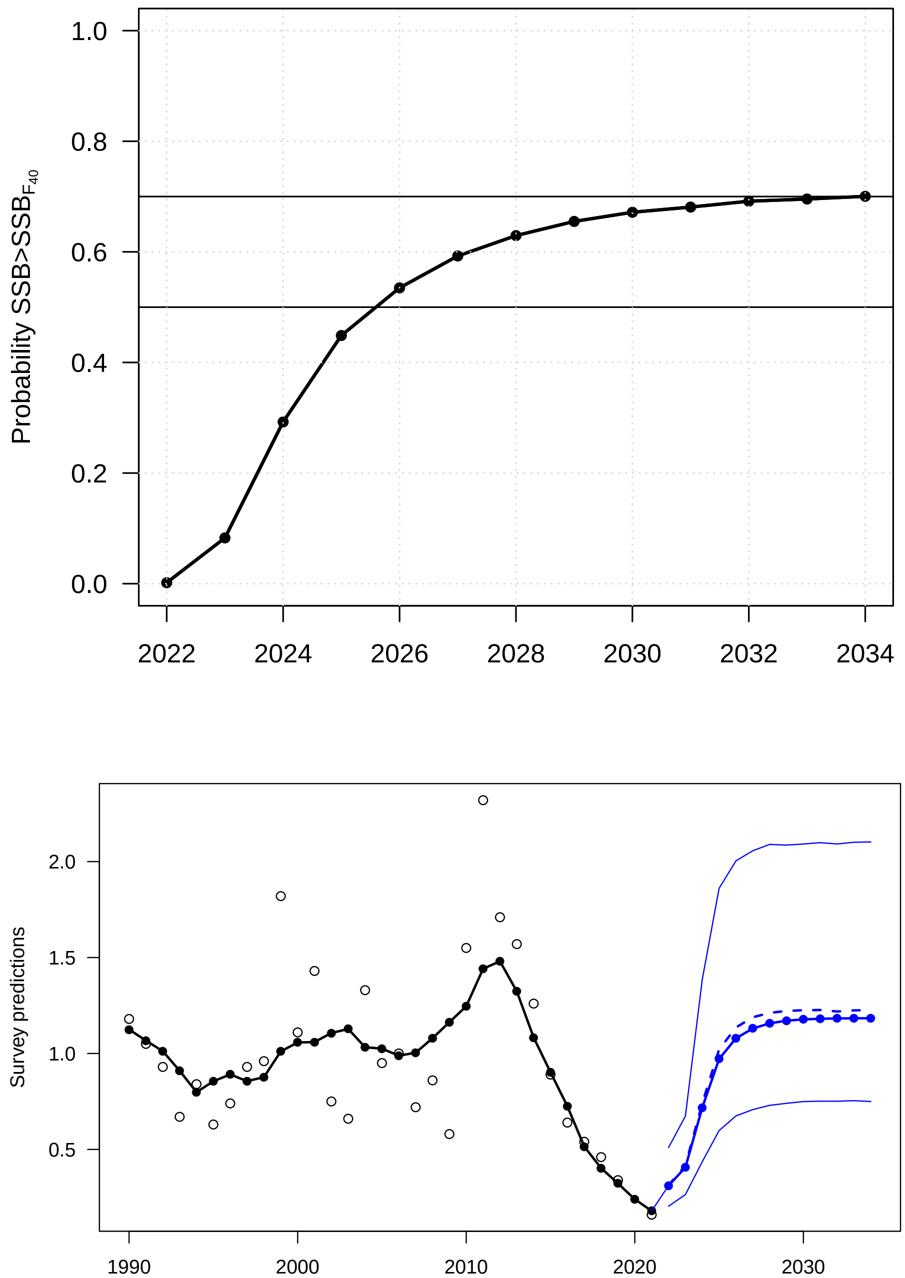


Figure 7. Projected time series for the ABC scenario with fishing mortality rate at $F_{\text{Landed}} = F_{\text{Rebuild70\%}}$ and $F_{\text{Discard}} = F_{\text{current}}$ starting in 2025 and recent mean recruitment starting in 2023. Expected values (base run) represented by solid lines with solid 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.

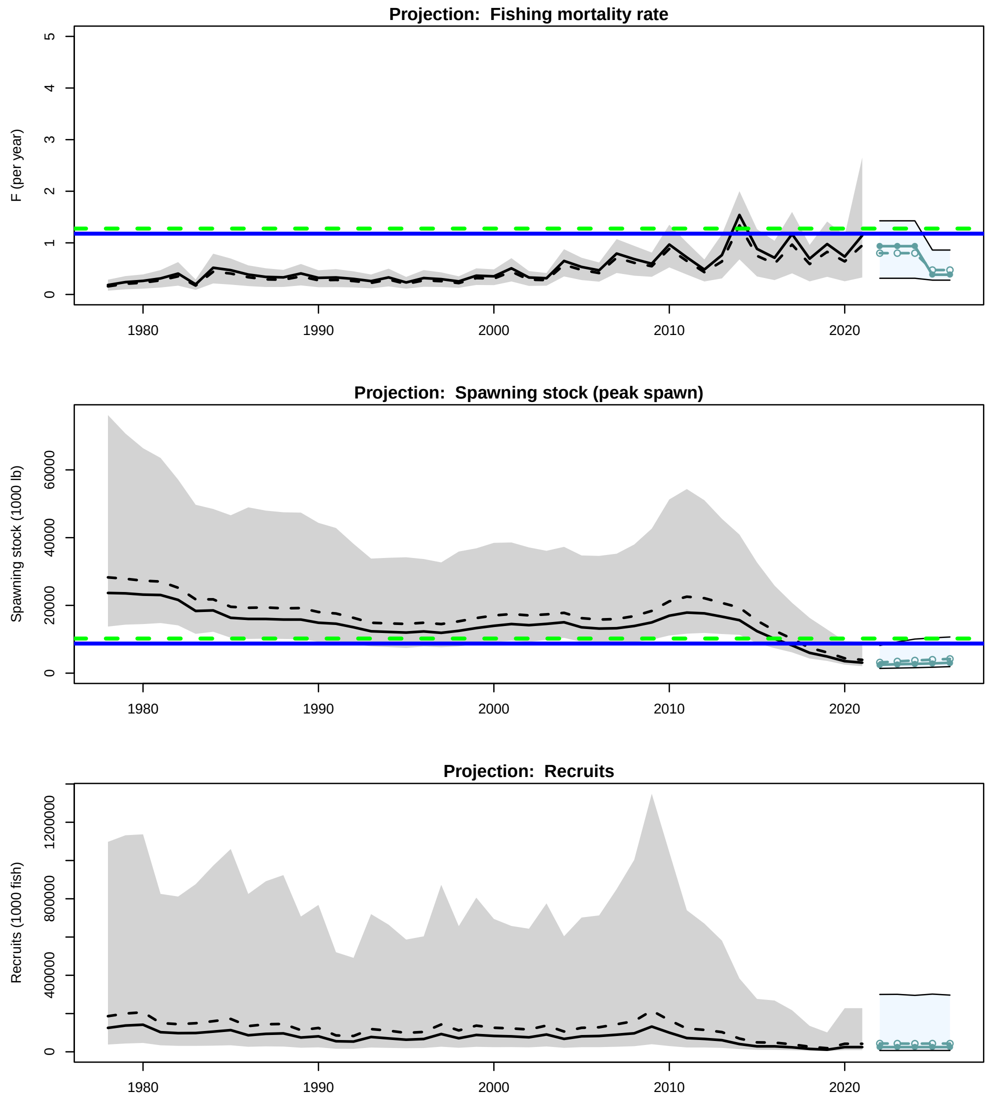


Figure 8. Projected fishing mortality (top left panel), spawning stock biomass (top right panel), landings (middle panels) in weight (left) and numbers (right) and discards (bottom panels) in weight (left) and numbers (right) for the projected time series for the ABC scenario with fishing mortality rates at $F_{\text{Landed}} = F_{\text{Rebuild70\%}}$ *and* $F_{\text{Discard}} = F_{\text{current}}$ *starting in 2025 and recent mean recruitment starting in 2023. 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.*

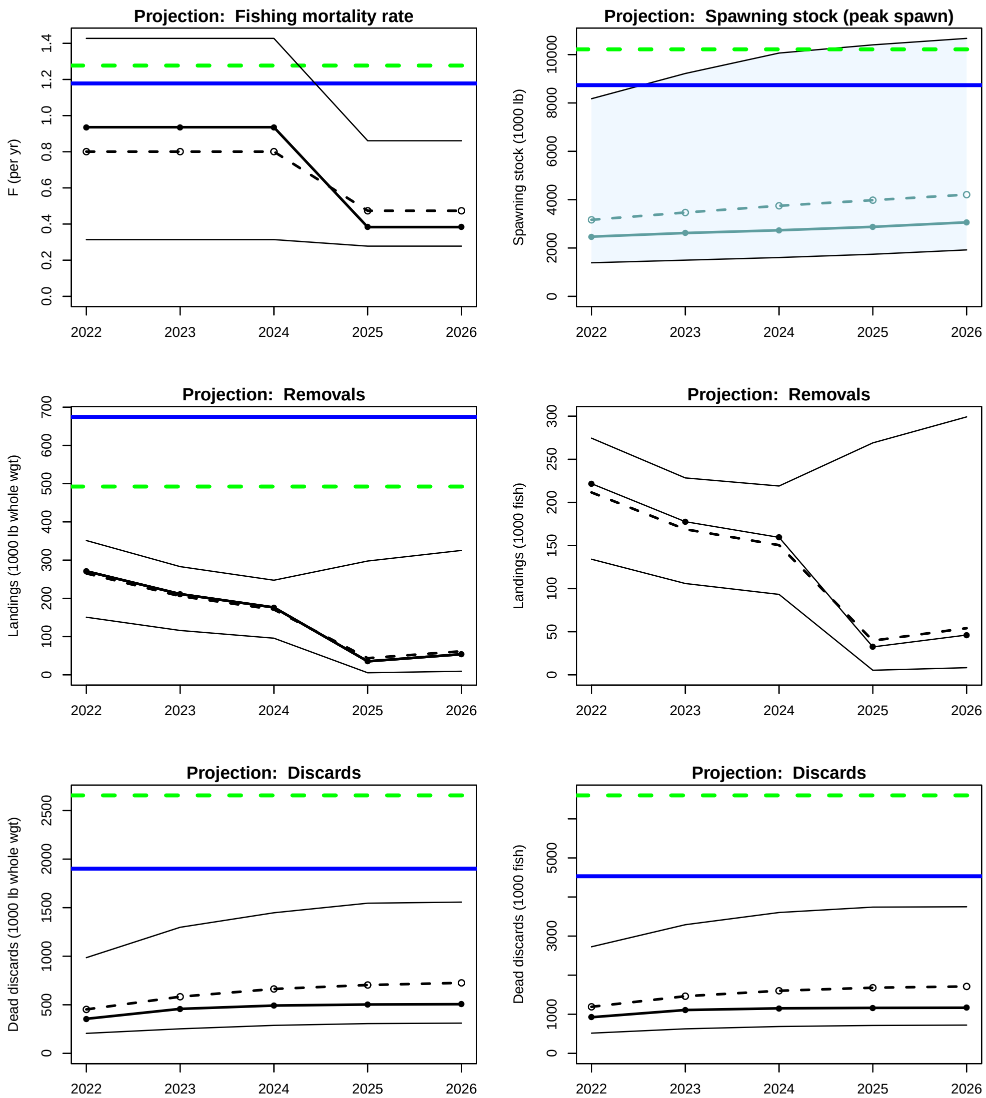


Figure 9. Top Panel: Projected probability of rebuilding under ABC scenario and recent mean recruitment. The curve represents the proportion of projection replicates for which SSB has reached the replicate-specific $\mathrm{SSB}_{\mathrm{F40\%}}$, *with reference lines at 0.5 and 0.7. Bottom panel: Projected SERFS 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.*

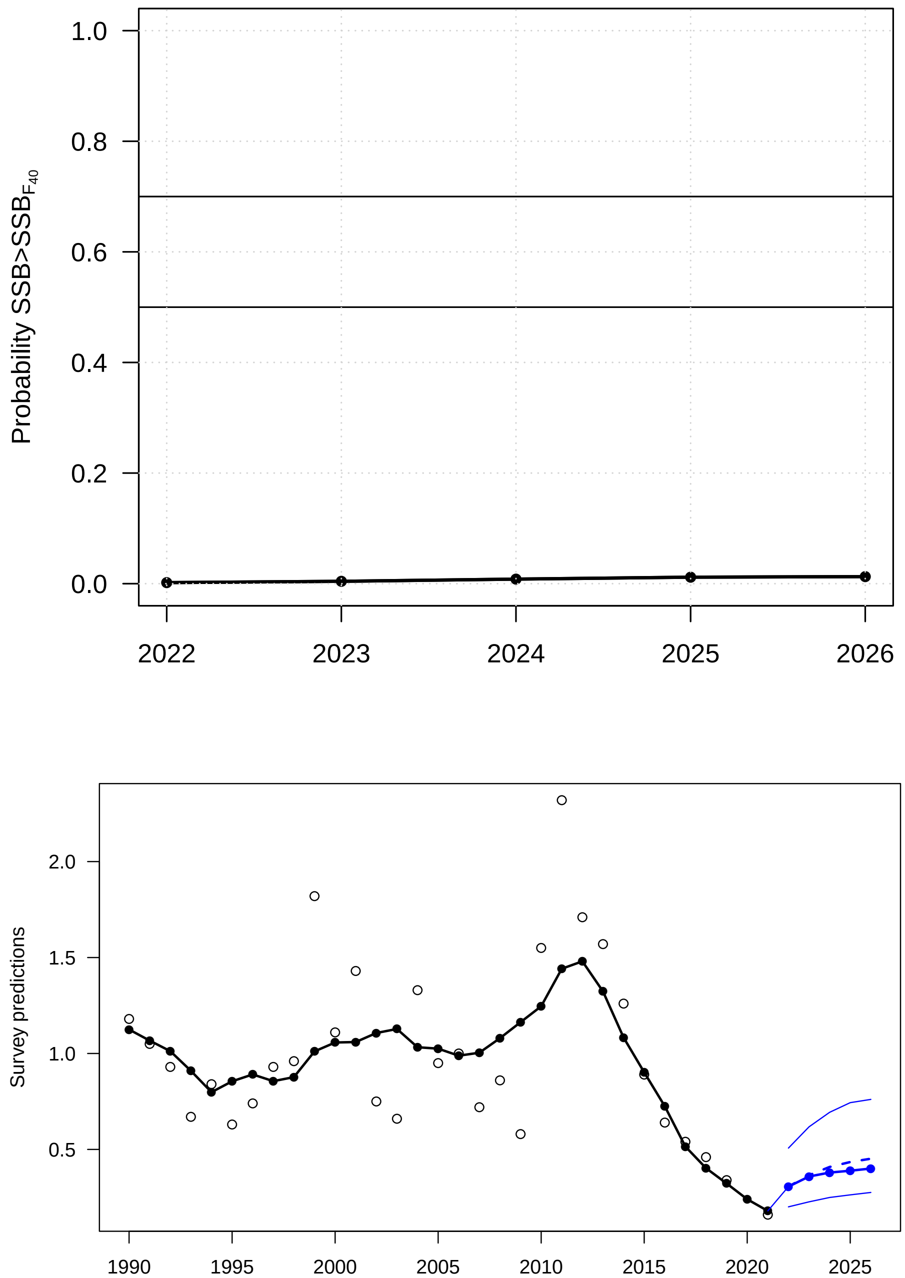


Figure 10. Projected time series for the 11" minimum size limit scenario where the selectivity weighting was based on the all fleets in the terminal year of the stock assessment. Expected values (base run) represented by solid lines with solid circles, medians represented by dashed lines with open circles, 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.

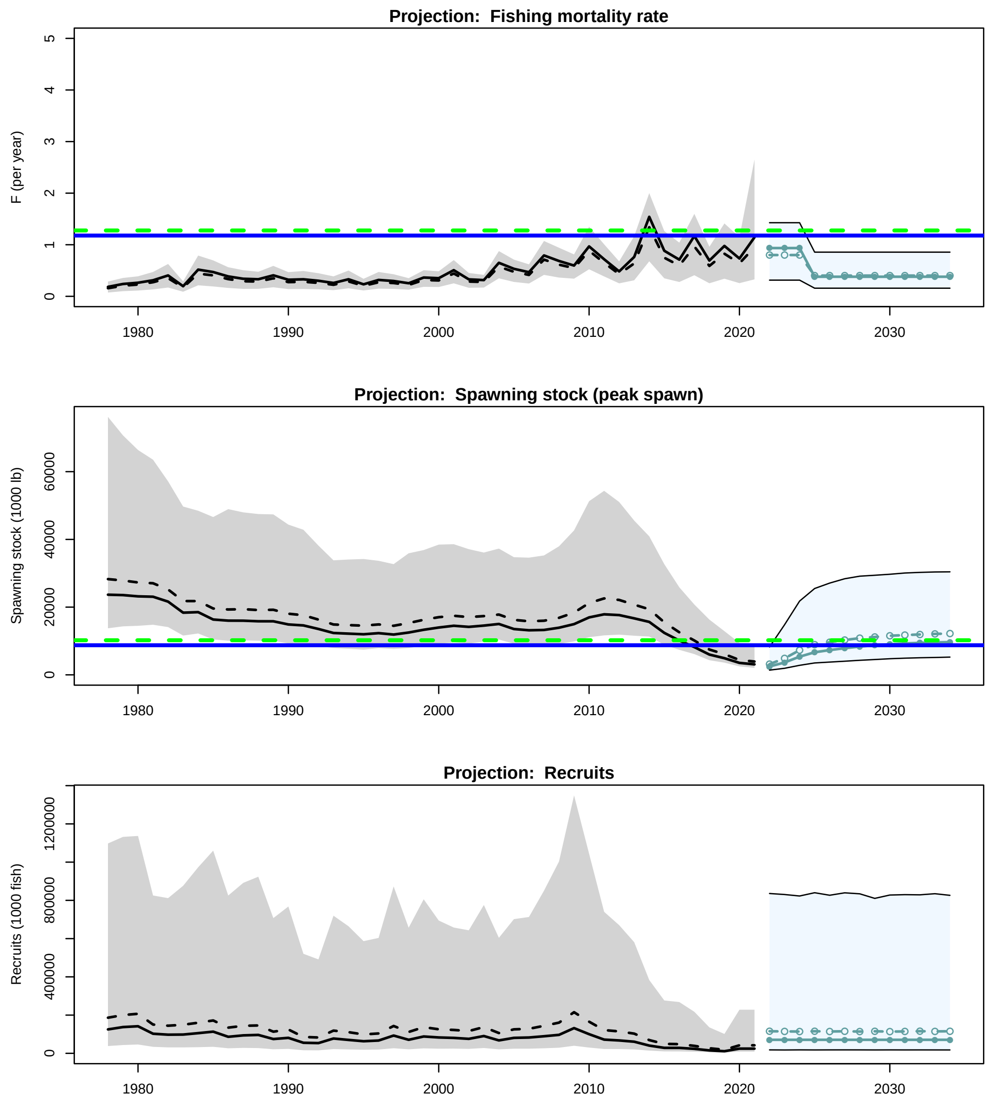


Figure 11. Projected fishing mortality (top left panel), spawning stock biomass (top right panel), landings (middle panel) in weight (left) and numbers (right) and discards (bottom panel) in weight (left) and numbers (right) for the projected time series for the scenario with minimum size limit of 11" and a weighting of landings to discard selectivity from all fleets in the terminal year of the stock assessment. 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.

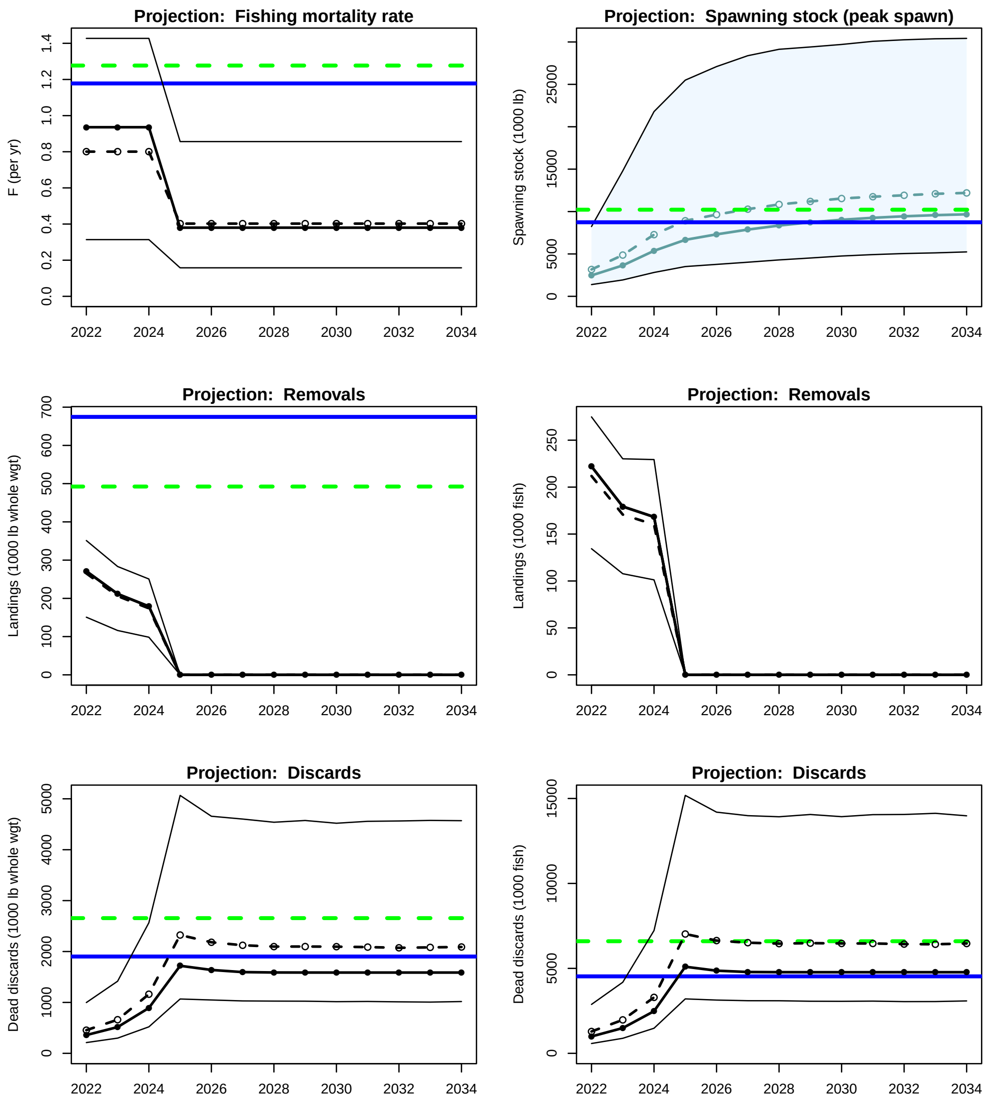


Figure 12. Top Panel: Projected probability of rebuilding under scenario fishing mortality rates that gives a 70% probability of rebuilding in 10 years, discards at current fishing levels, and a minimum size limit of 11". The curve represents the proportion of projection replicates for which SSB has reached the replicate-specific $SSB_{F40\%}$*, with reference lines at 0.5 and 0.7. Bottom panel: Projected SERFS 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.*

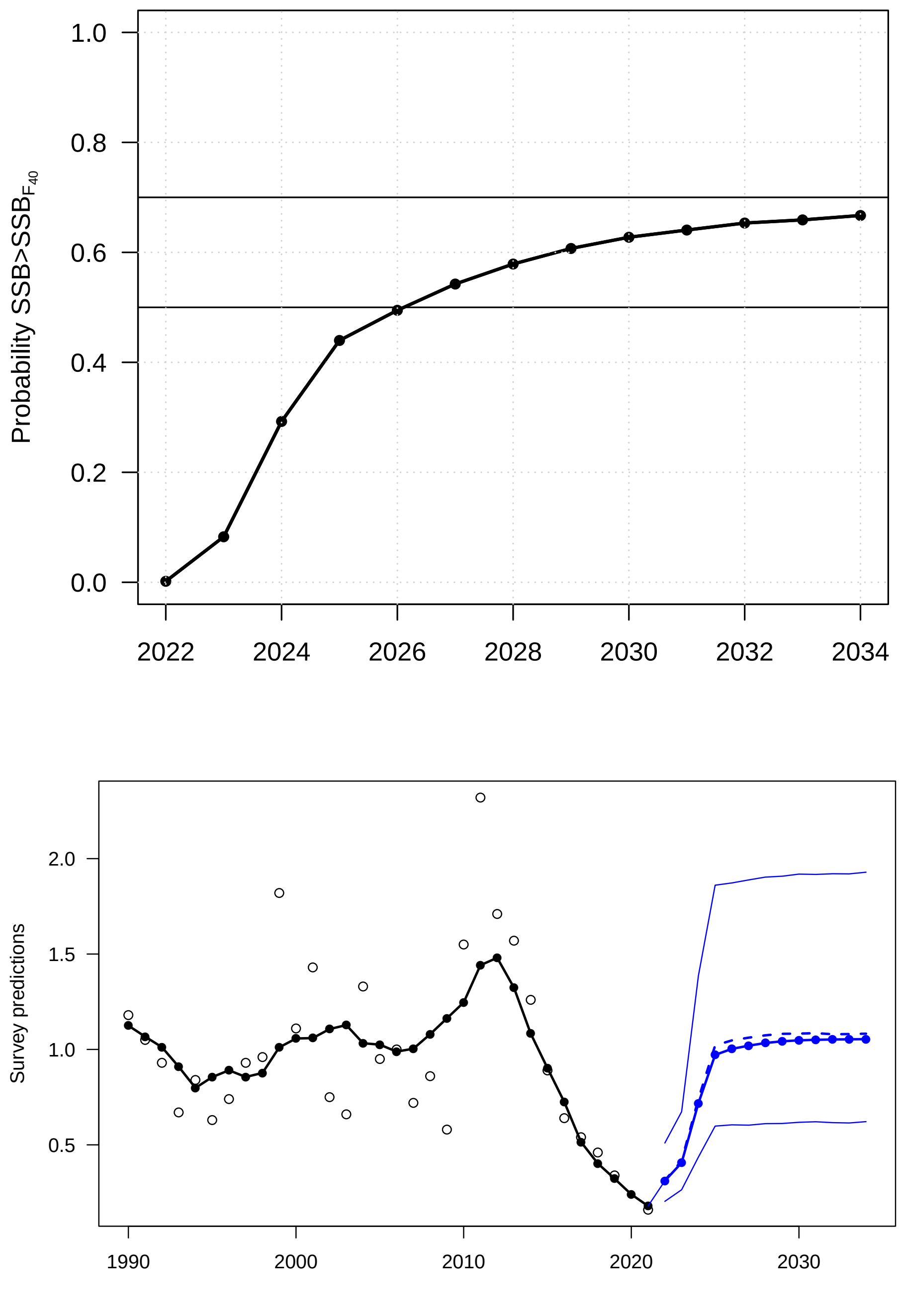


Figure 13. Projected time series for the 11" minimum size limit scenario where the selectivity weighting was based on the all fleets in the terminal year of the stock assessment. Expected values (base run) represented by solid lines with solid circles, medians represented by dashed lines with open circles, 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.

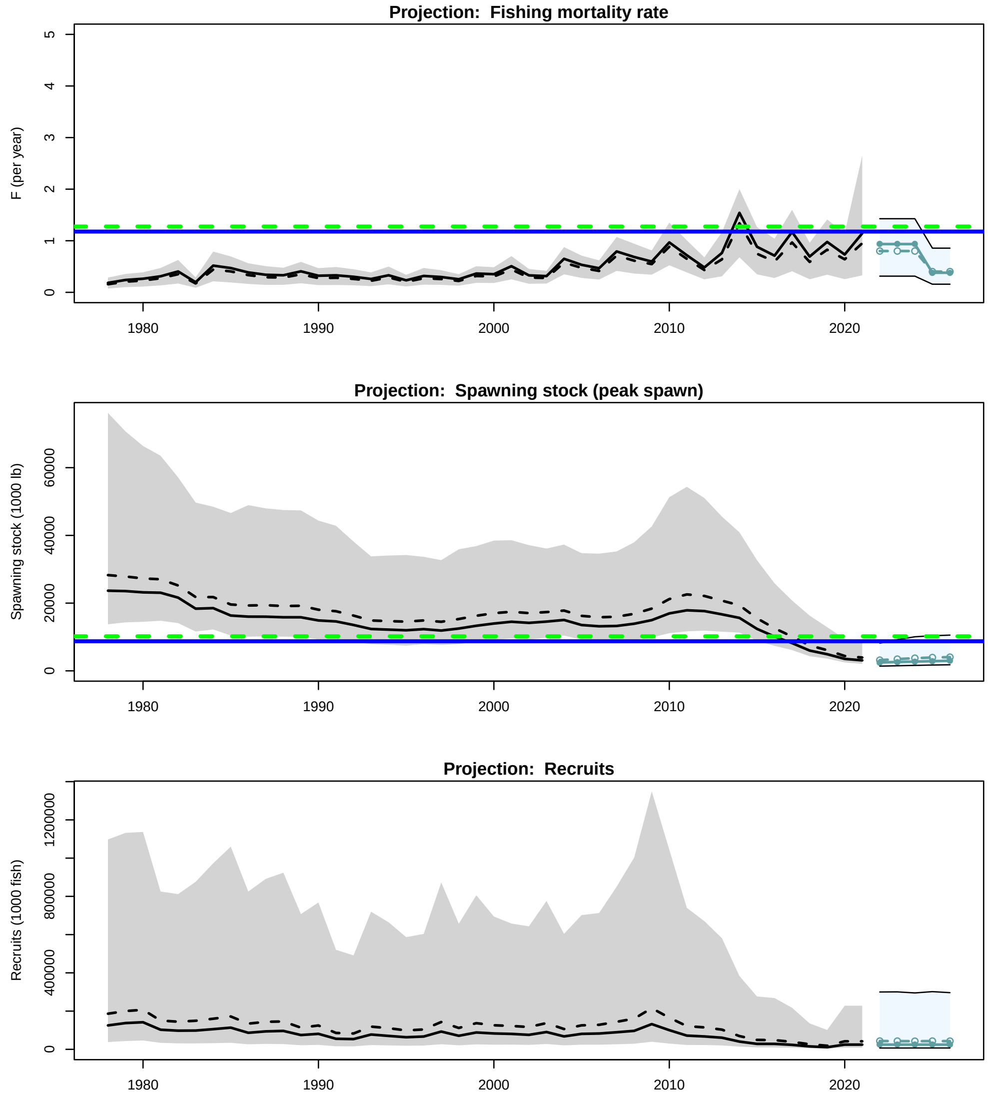


Figure 14. Projected fishing mortality (top left panel), spawning stock biomass (top right panel), landings (middle panel) in weight (left) and numbers (right) and discards (bottom panel) in weight (left) and numbers (right) for the projected time series for the scenario with minimum size limit of 11" and a weighting of landings to discard selectivity from all fleets in the terminal year of the stock assessment. 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.

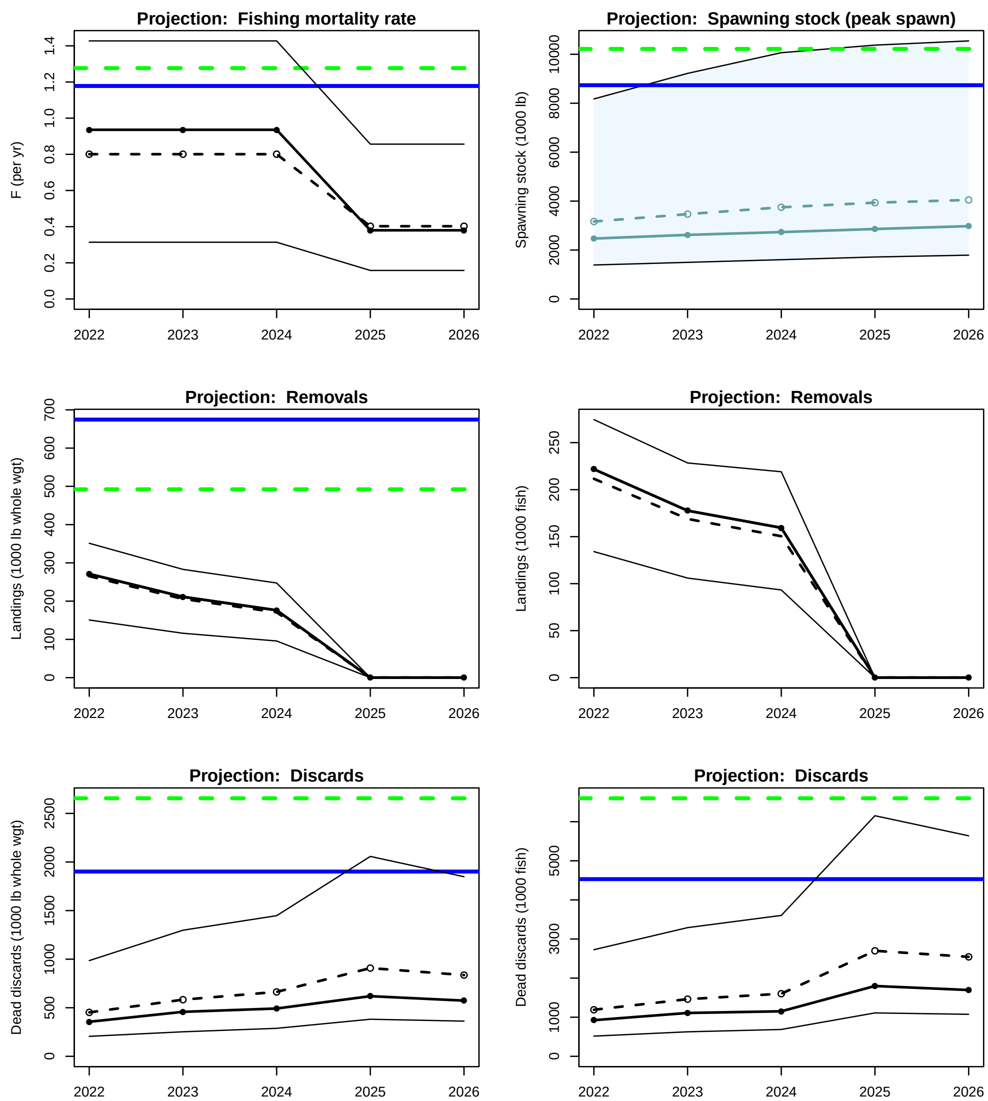
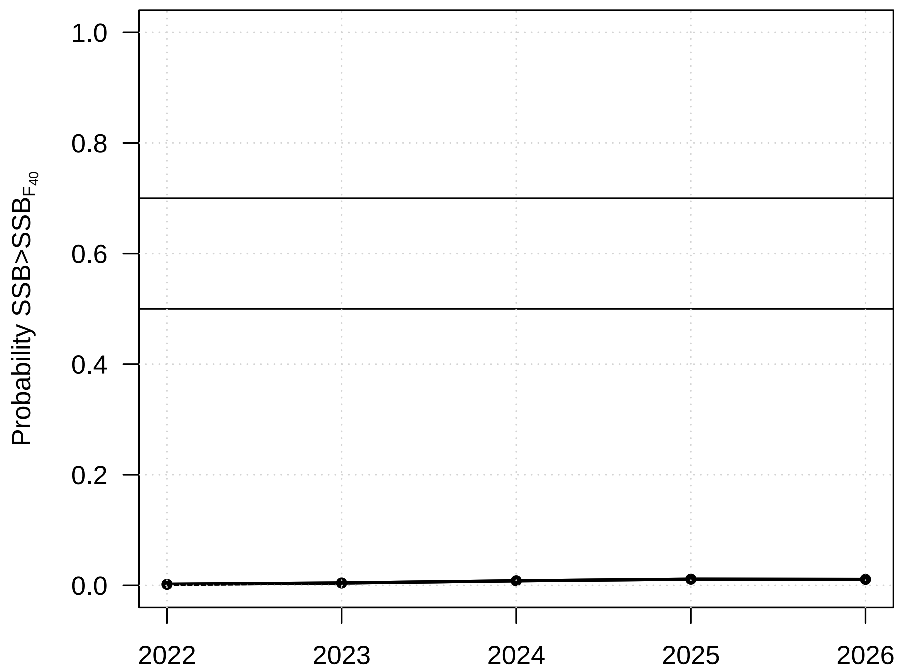


Figure 15. Top Panel: Projected probability of rebuilding under scenario fishing mortality rates that gives a 70% probability of rebuilding in 10 years, discards at current fishing levels, and a minimum size limit of 11". The curve represents the proportion of projection replicates for which SSB has reached the replicate-specific $\mathrm{SSB}_{\mathrm{F40\%}}$*, with reference lines at 0.5 and 0.7. Bottom panel: Projected SERFS 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.*



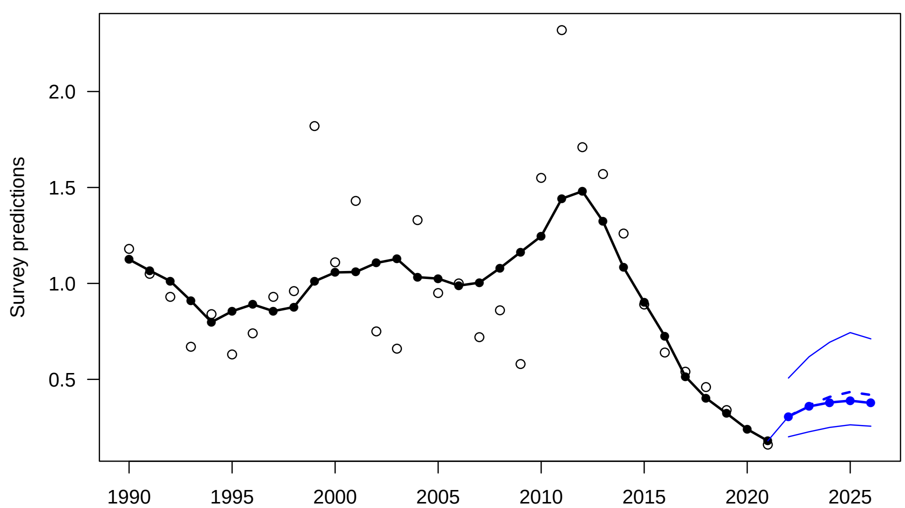


Figure 16. Projected time series for the 12" minimum size limit scenario where the selectivity weighting was based on the all fleets in the terminal year of the stock assessment. Expected values (base run) represented by solid lines with solid circles, medians represented by dashed lines with open circles, 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.

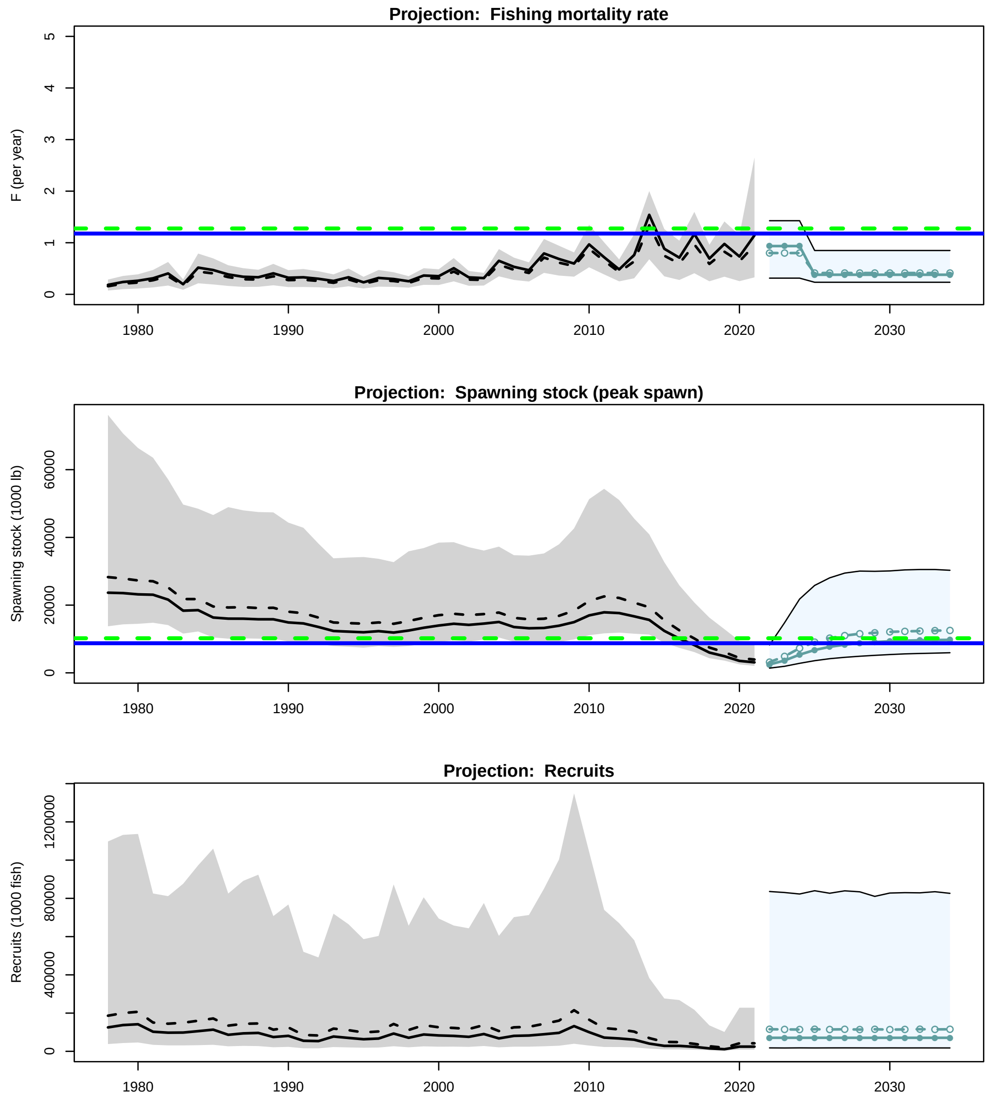


Figure 17. Projected fishing mortality (top left panel), spawning stock biomass (top right panel), landings (middle panel) in weight (left) and numbers (right) and discards (bottom panel) in weight (left) and numbers (right) for the projected time series for the scenario with minimum size limit of 12" and a weighting of landings to discard selectivity from all fleets in the terminal year of the stock assessment. 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.

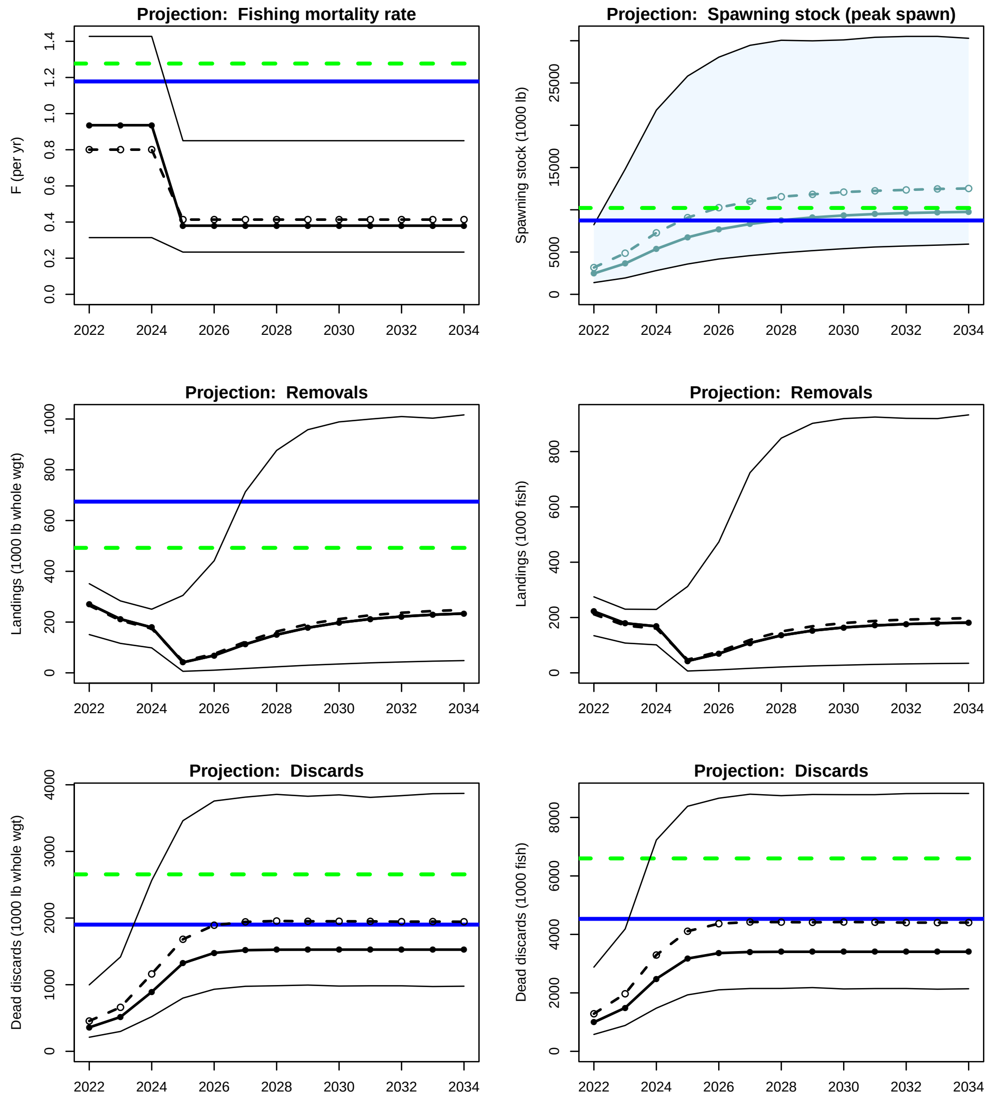


Figure 18. Top Panel: Projected probability of rebuilding under scenario fishing mortality rates that gives a 70% probability of rebuilding in 10 years, discards at current fishing levels, and a minimum size limit of 12". The curve represents the proportion of projection replicates for which SSB has reached the replicate-specific $SSB_{F40\%}$*, with reference lines at 0.5 and 0.7. Bottom panel: Projected SERFS 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.*

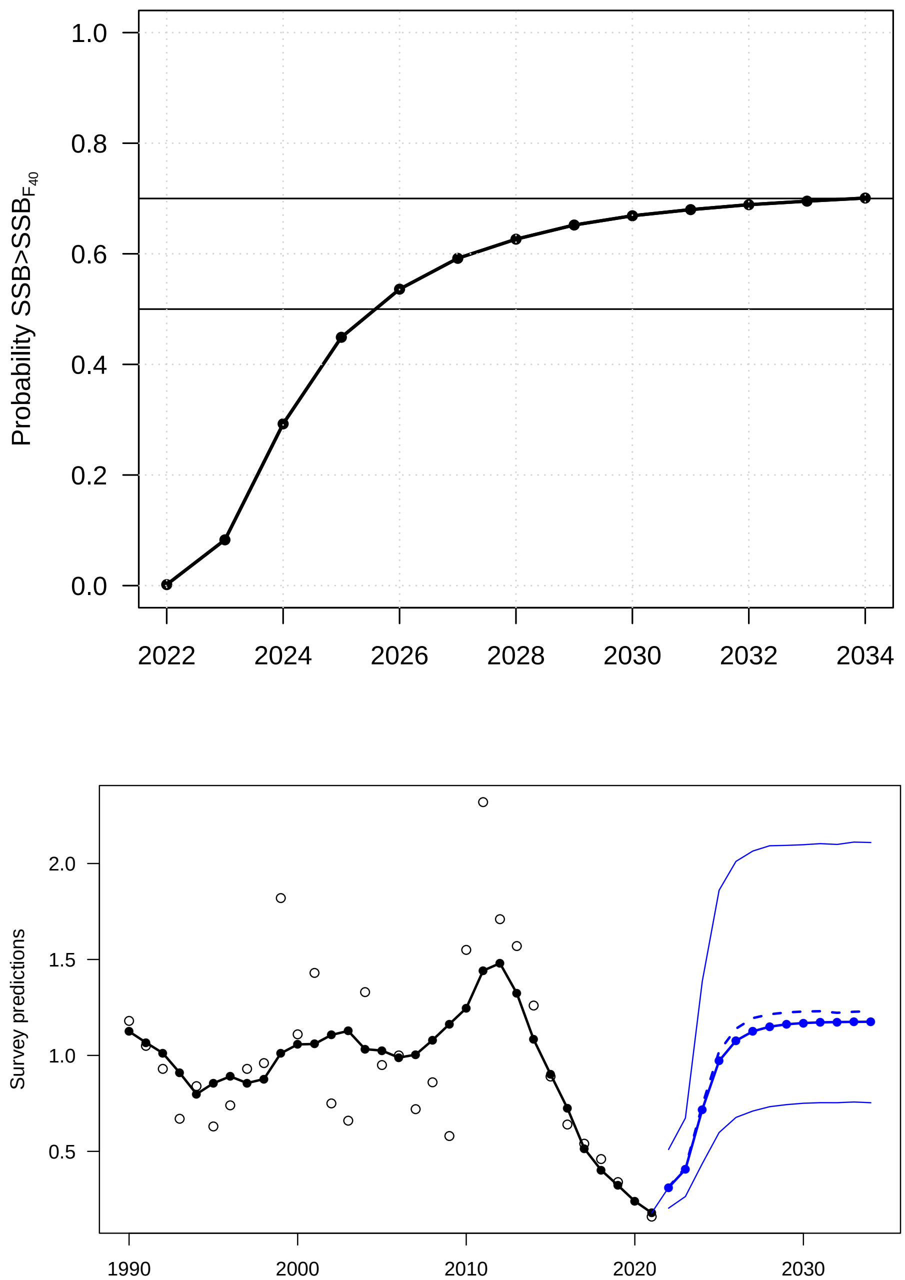


Figure 19. Projected time series for the 12" minimum size limit scenario where the selectivity weighting was based on the all fleets in the terminal year of the stock assessment. Expected values (base run) represented by solid lines with solid circles, medians represented by dashed lines with open circles, 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.

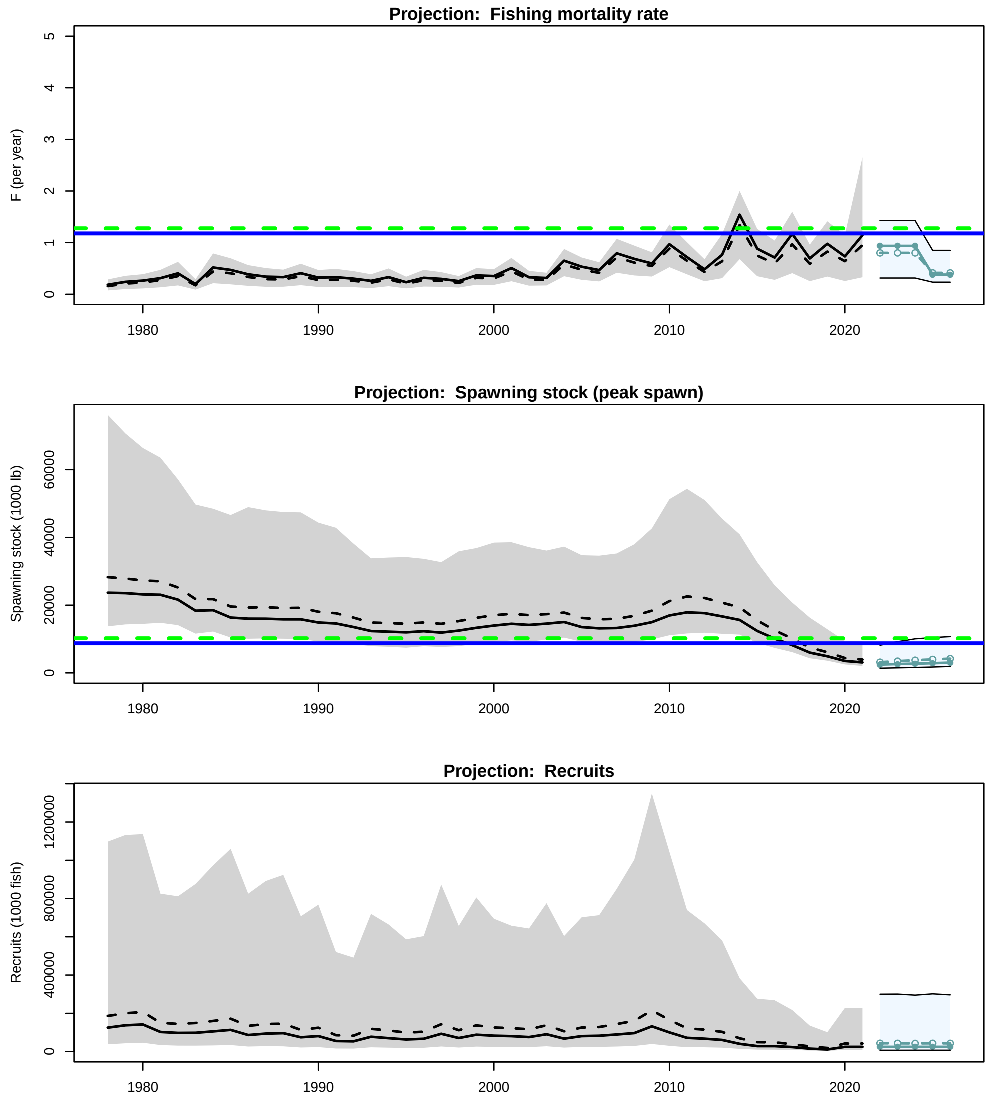


Figure 20. Projected fishing mortality (top left panel), spawning stock biomass (top right panel), landings (middle panel) in weight (left) and numbers (right) and discards (bottom panel) in weight (left) and numbers (right) for the projected time series for the scenario with minimum size limit of 12" and a weighting of landings to discard selectivity from all fleets in the terminal year of the stock assessment. 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.

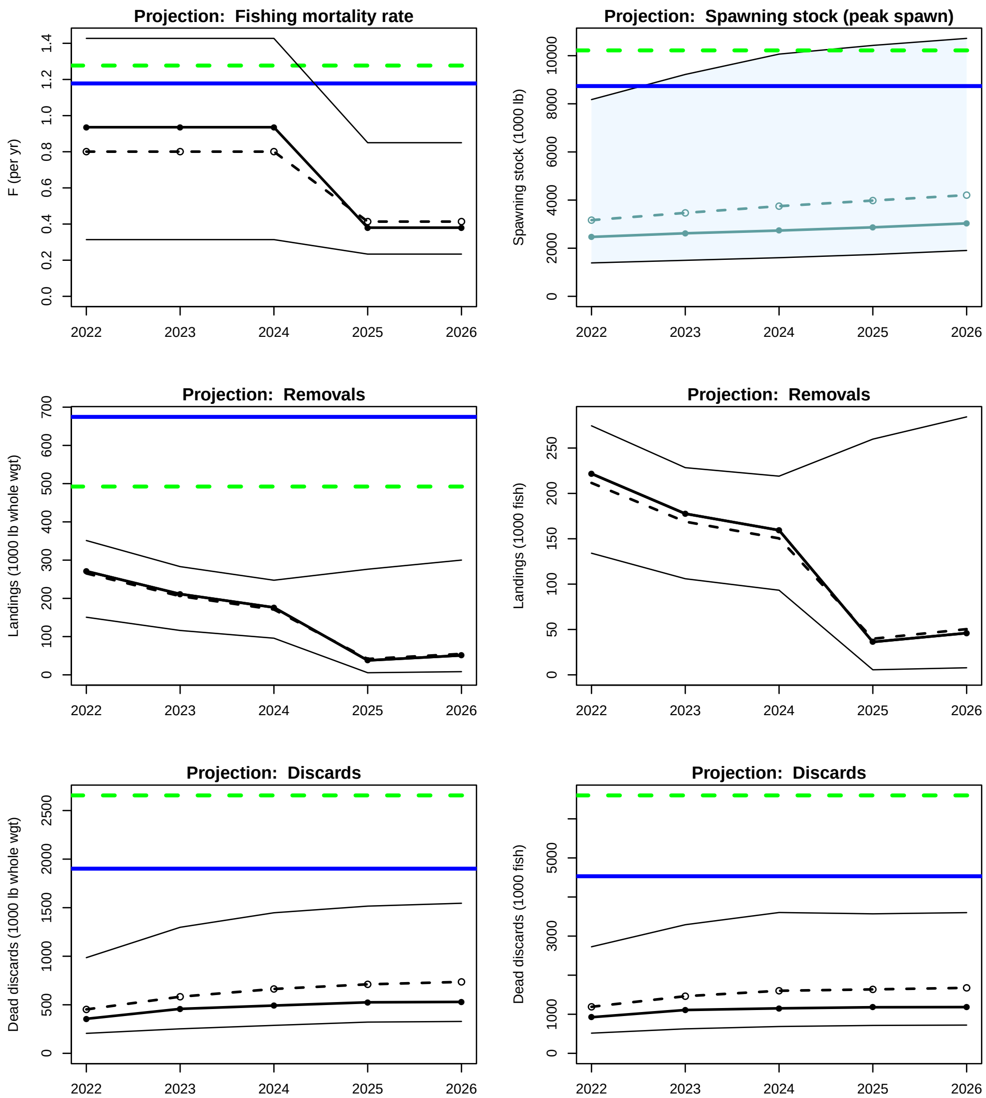
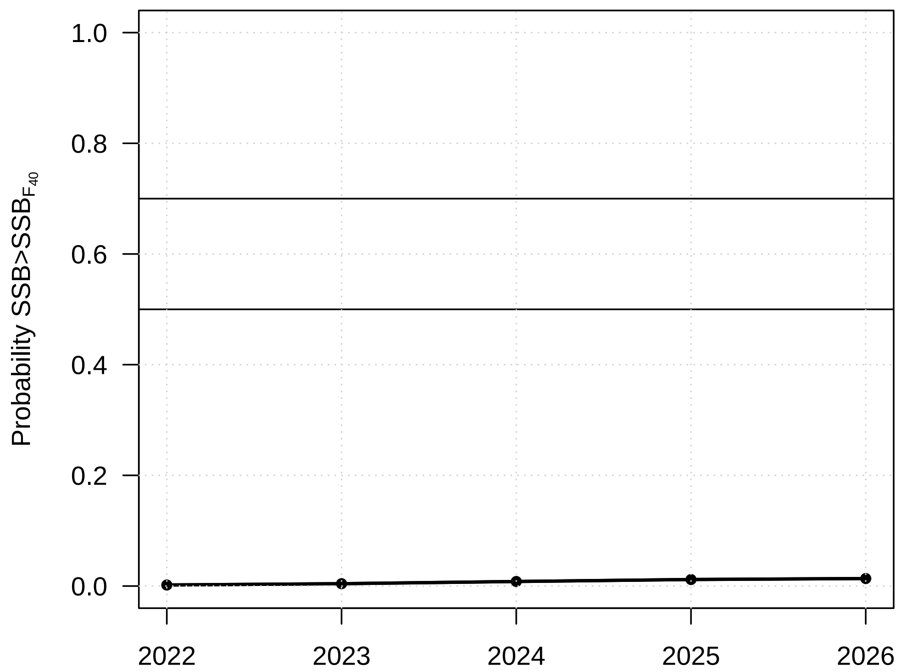


Figure 21. Top Panel: Projected probability of rebuilding under scenario fishing mortality rates that gives a 70% probability of rebuilding in 10 years, discards at current fishing levels, and a minimum size limit of 12". The curve represents the proportion of projection replicates for which SSB has reached the replicate-specific $SSB_{F40\%}$*, with reference lines at 0.5 and 0.7. Bottom panel: Projected SERFS 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.*



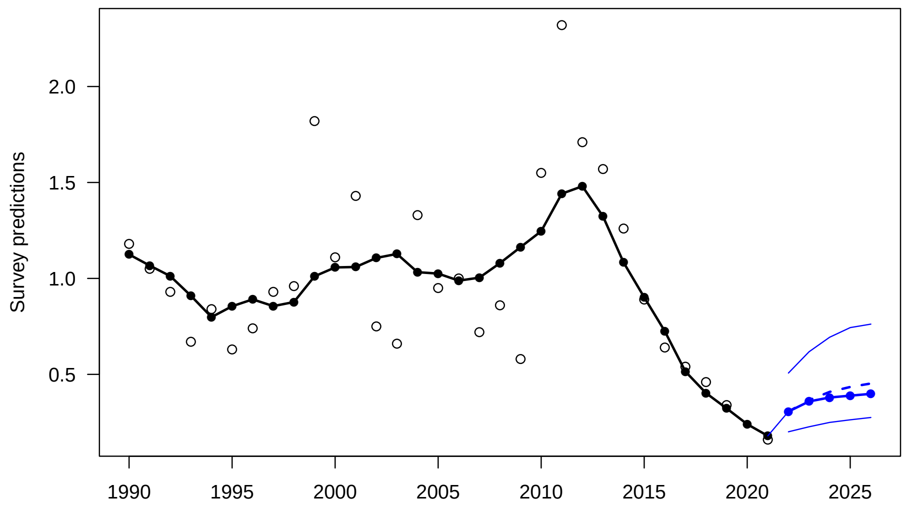


Figure 22. Projected time series for the 13" minimum size limit scenario where the selectivity weighting was based on the all fleets in the terminal year of the stock assessment. Expected values (base run) represented by solid lines with solid circles, medians represented by dashed lines with open circles, 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.

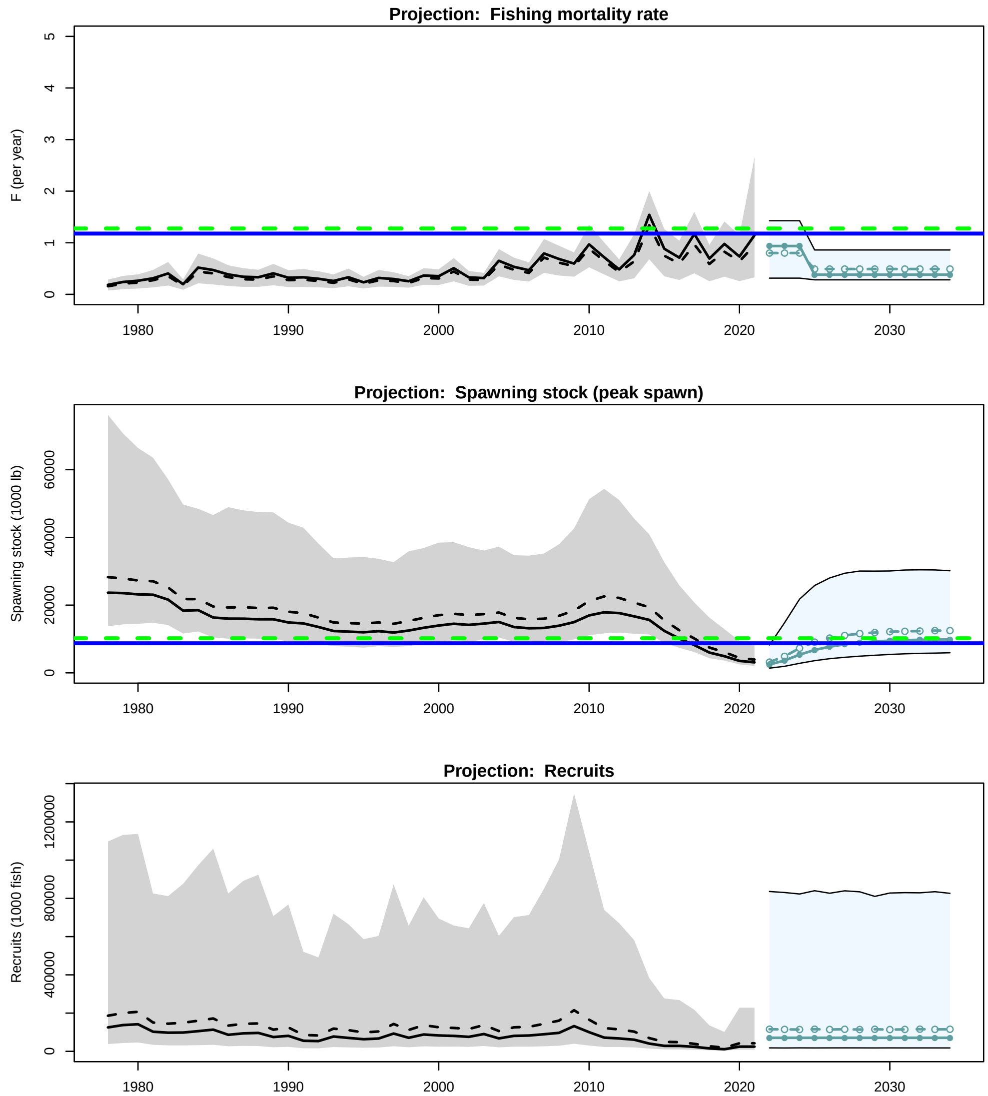


Figure 23. Projected fishing mortality (top left panel), spawning stock biomass (top right panel), landings (middle panel) in weight (left) and numbers (right) and discards (bottom panel) in weight (left) and numbers (right) for the projected time series for the scenario with minimum size limit of 13" and a weighting of landings to discard selectivity from all fleets in the terminal year of the stock assessment. 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.

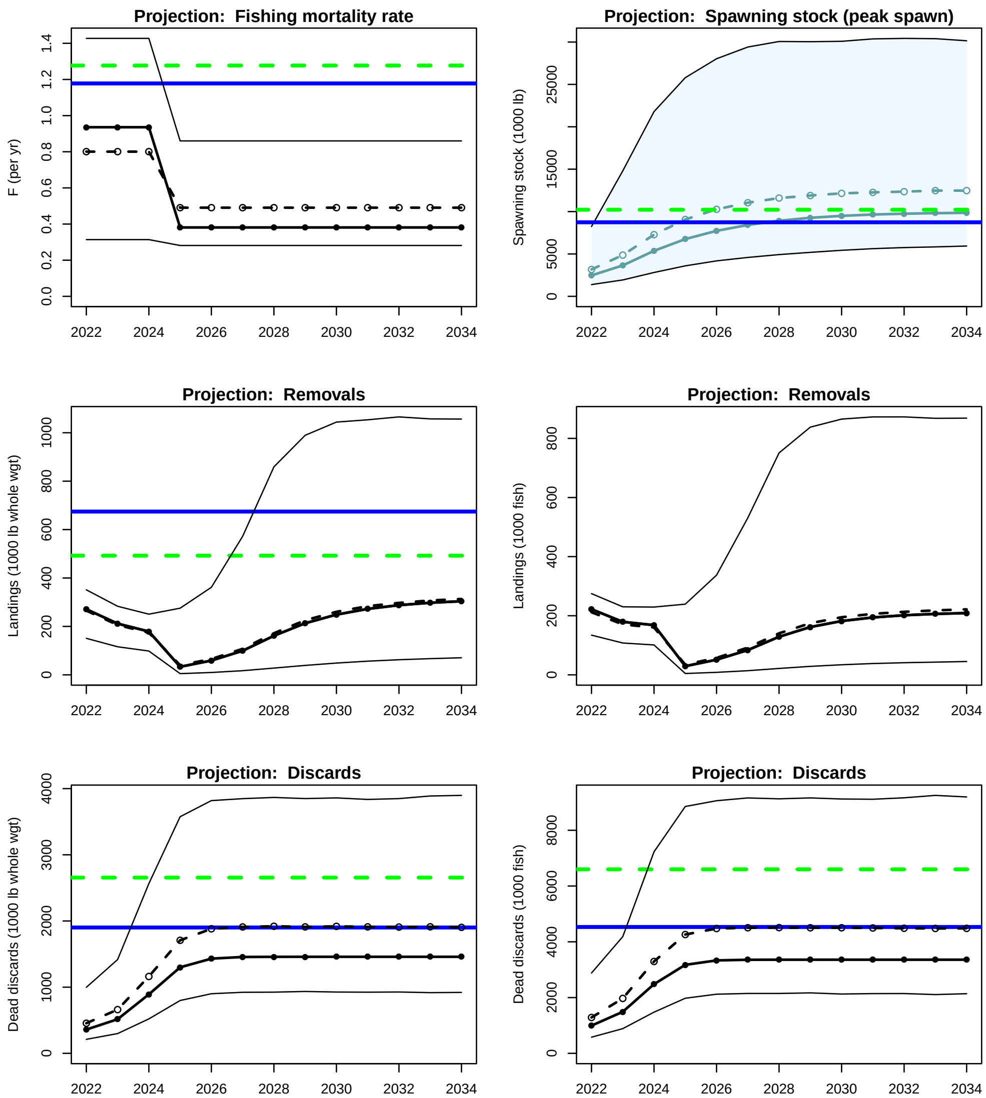
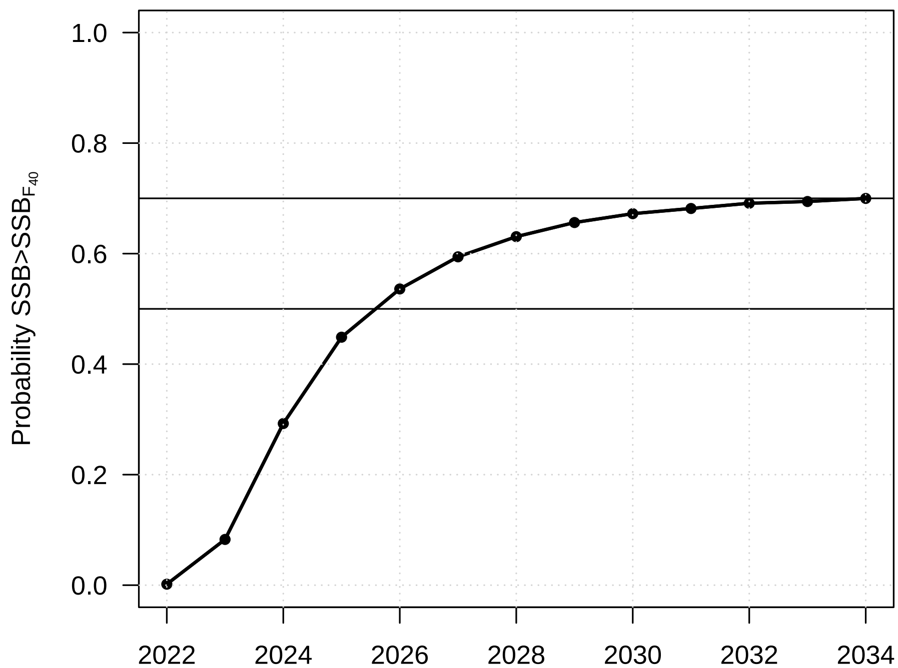


Figure 24. Top Panel: Projected probability of rebuilding under scenario fishing mortality rates that gives a 70% probability of rebuilding in 10 years, discards at current fishing levels, and a minimum size limit of 13". The curve represents the proportion of projection replicates for which SSB has reached the replicate-specific $\mathrm{SSB_{F40\%}}$*, 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.*



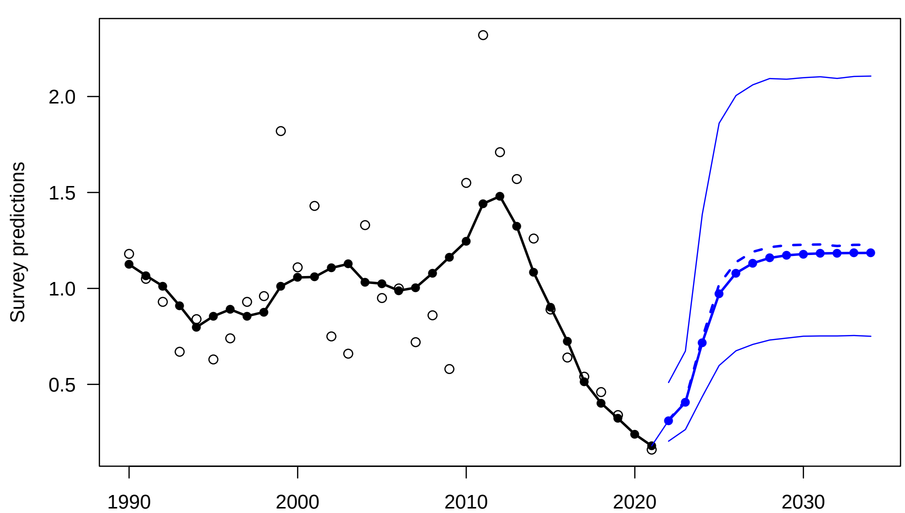


Figure 25. Projected time series for the 13" minimum size limit scenario where the selectivity weighting was based on the all fleets in the terminal year of the stock assessment. Expected values (base run) represented by solid lines with solid circles, medians represented by dashed lines with open circles, 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.

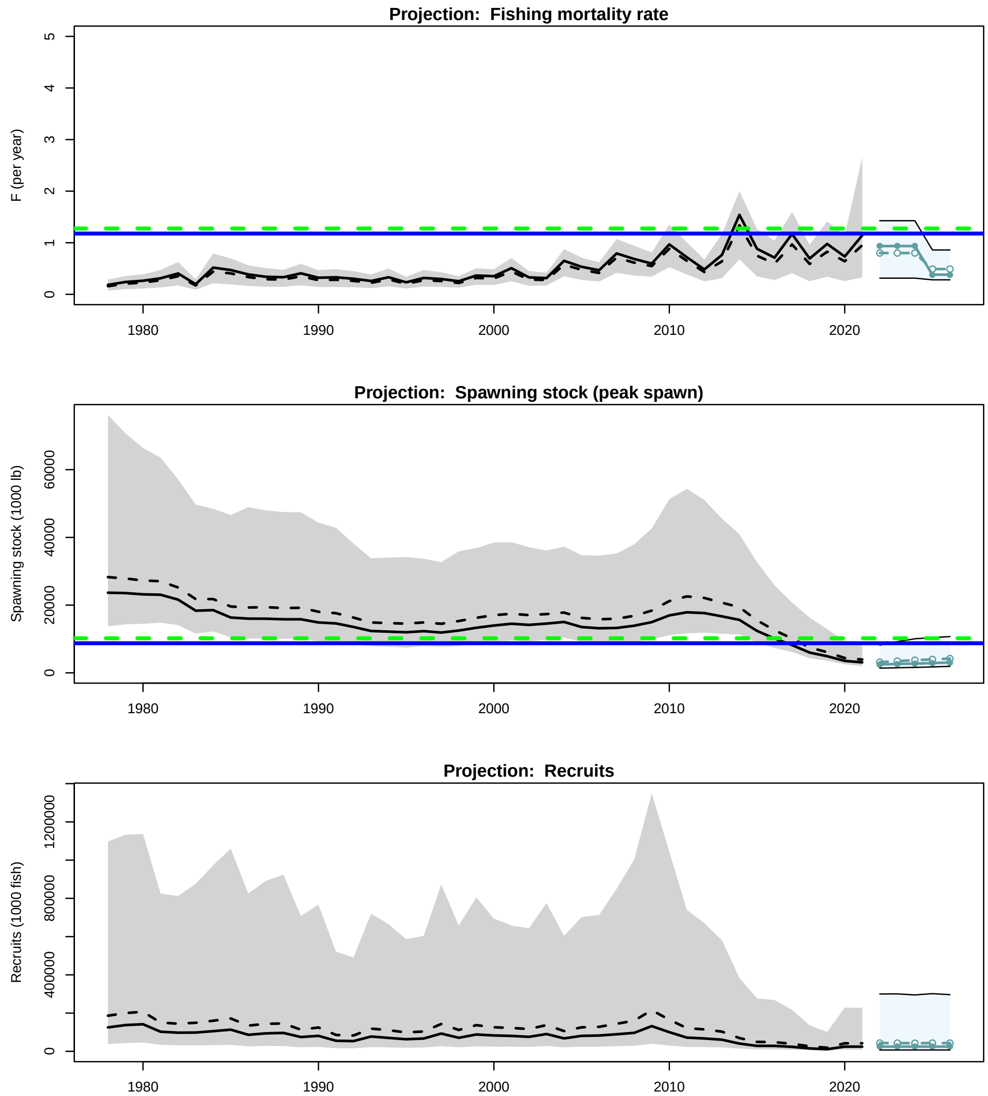


Figure 26. Projected fishing mortality (top left panel), spawning stock biomass (top right panel), landings (middle panel) in weight (left) and numbers (right) and discards (bottom panel) in weight (left) and numbers (right) for the projected time series for the scenario with minimum size limit of 13" and a weighting of landings to discard selectivity from all fleets in the terminal year of the stock assessment. 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.

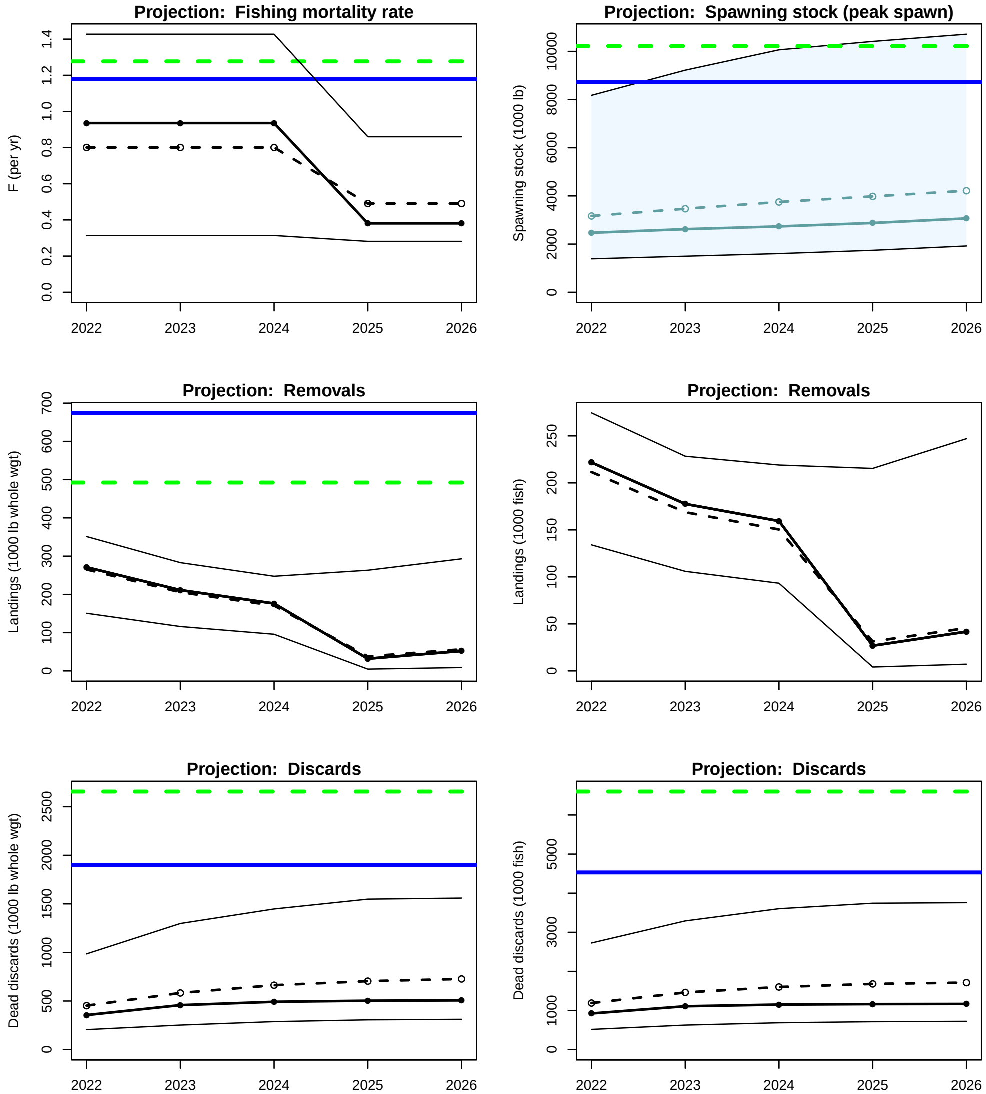
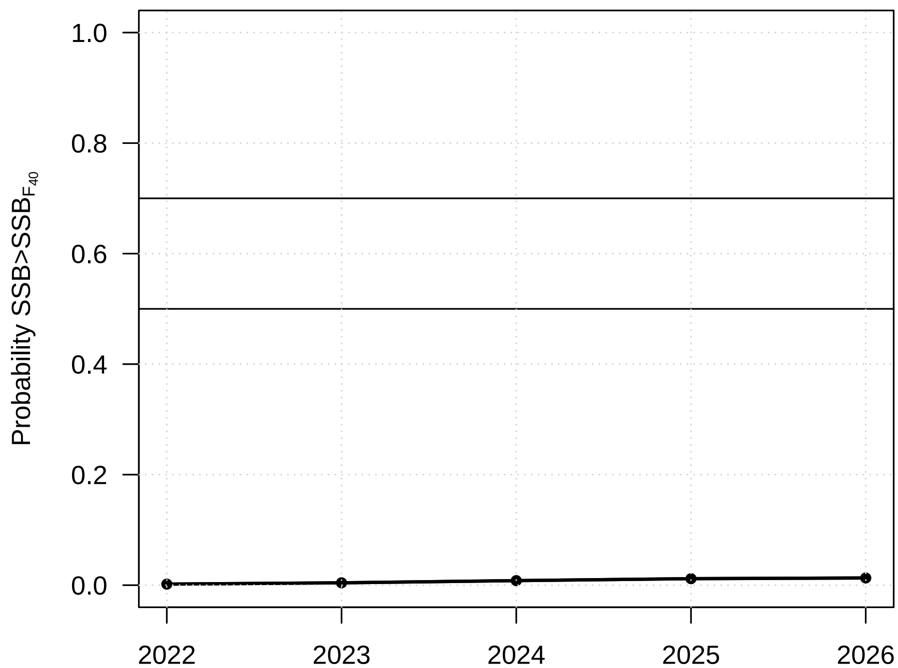


Figure 27. Top Panel: Projected probability of rebuilding under scenario fishing mortality rates that gives a 70% probability of rebuilding in 10 years, discards at current fishing levels, and a minimum size limit of 13". The curve represents the proportion of projection replicates for which SSB has reached the replicate-specific $\mathrm{SSB}_{\mathrm{F40\%}}$*, with reference lines at 0.5 and 0.7. Bottom panel: Projected SERFS 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.*



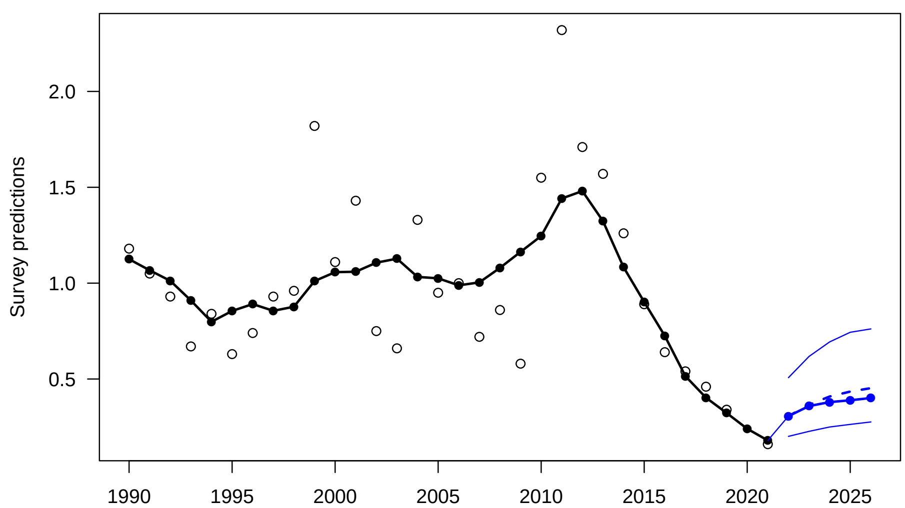


Figure 28. Projected time series for the scenario projecting a shallow water grouper closure in wave 1 and 2 with fishing mortality rates at $F_{\text{Landed}} = F_{\text{Rebuild70\%}}$ *and* $F_{\text{Discard}} = F_{\text{current}}$ *starting in 2025 and longterm average recruitment starting in 2023. 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.*

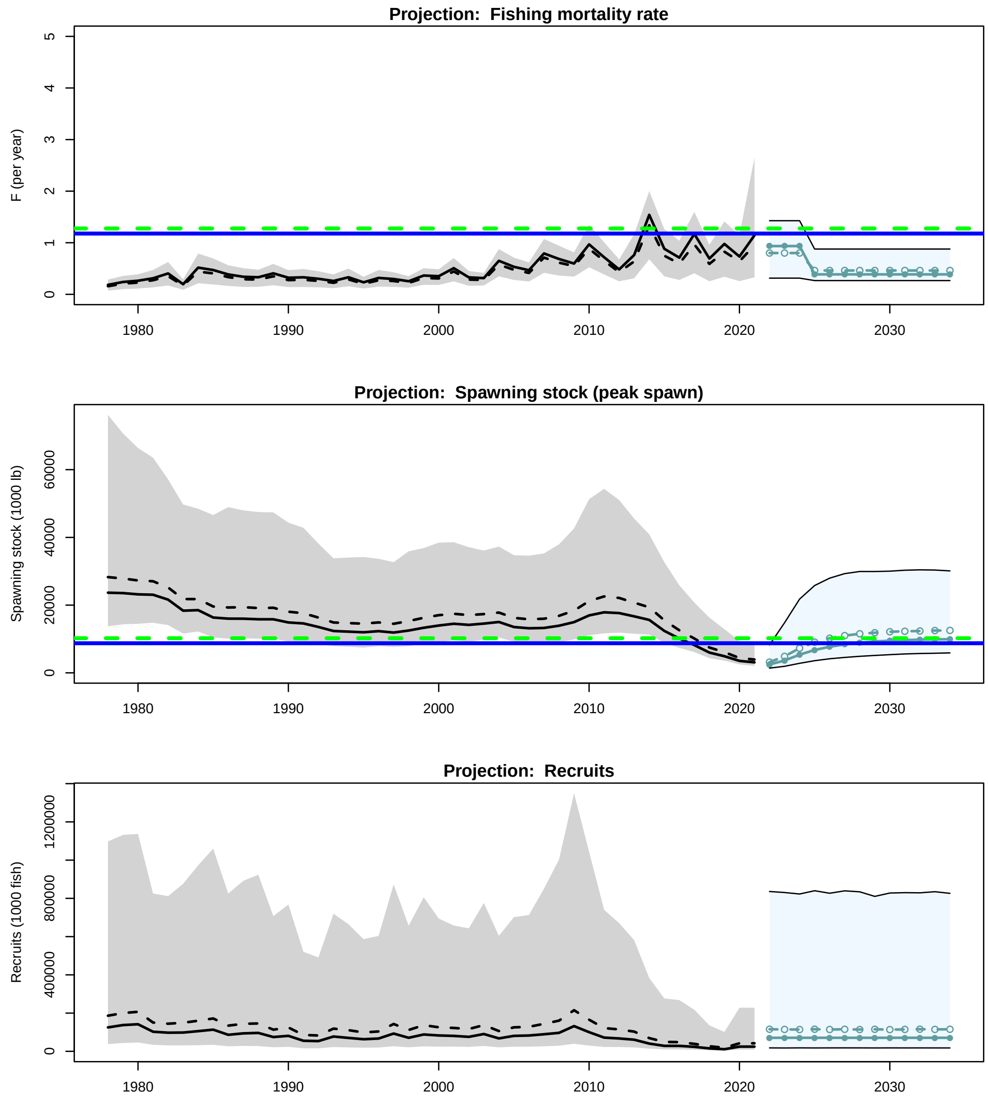


Figure 29. Projected fishing mortality (top left panel), spawning stock biomass (top right panel), landings (middle panels) in weight (left) and numbers (right) and discards (bottom panels) in weight (left) and numbers (right) for the projected time series for a shallow water grouper closure in wave 1 and 2 with fishing mortality rates at $F_{\mathrm{Landed}} = F_{\mathrm{Rebuild70\%}}$ *and* $F_{\mathrm{Discard}} = F_{\mathrm{current}}$ *starting in 2025 and longterm average recruitment starting in 2023. 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.*

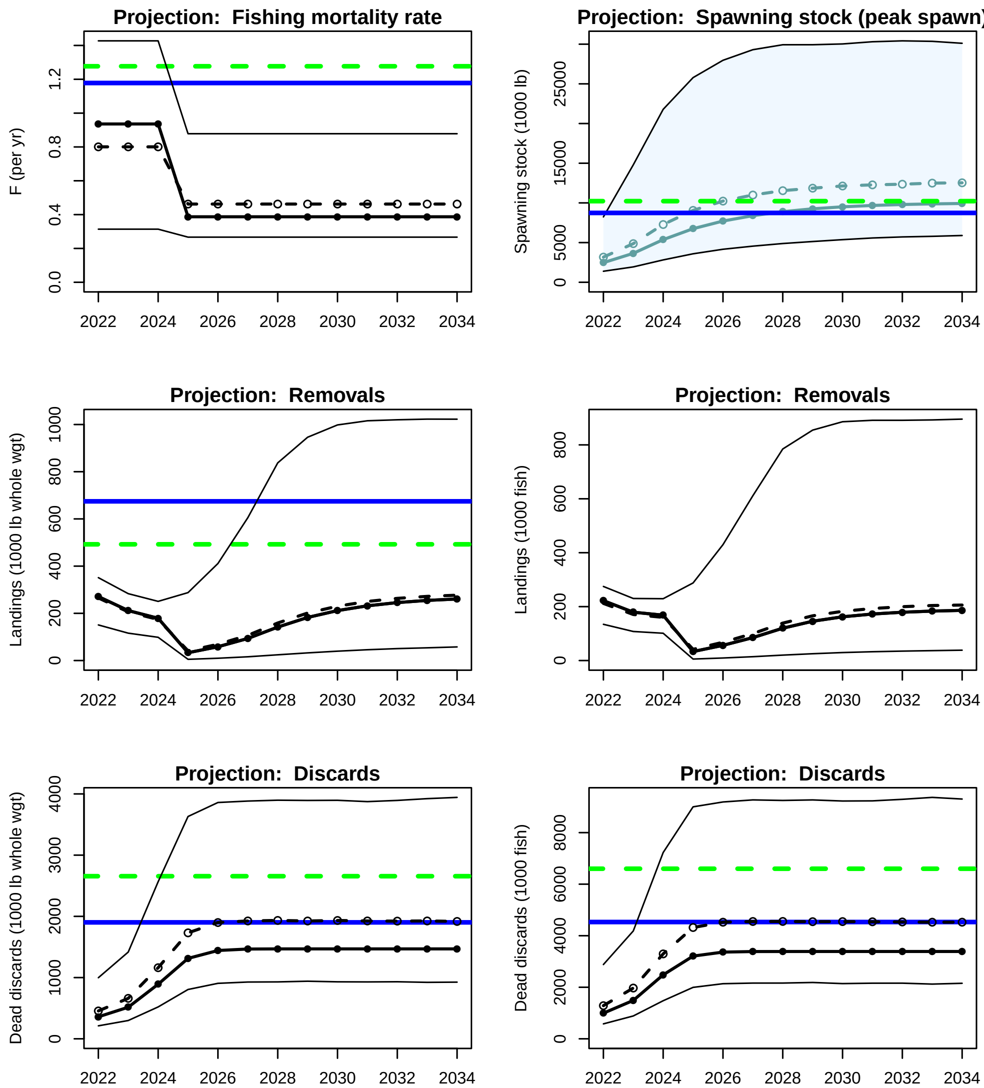


Figure 30. Top Panel: Projected probability of rebuilding under scenario with a wave 1 and 2 shallow water grouper closure and longterm average recruitment. The curve represents the proportion of projection replicates for which SSB has reached the replicate-specific $\mathrm{SSB}_{\mathrm{F40\%}}$*, with reference lines at 0.5 and 0.7. Bottom panel: Projected SERFS 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.*

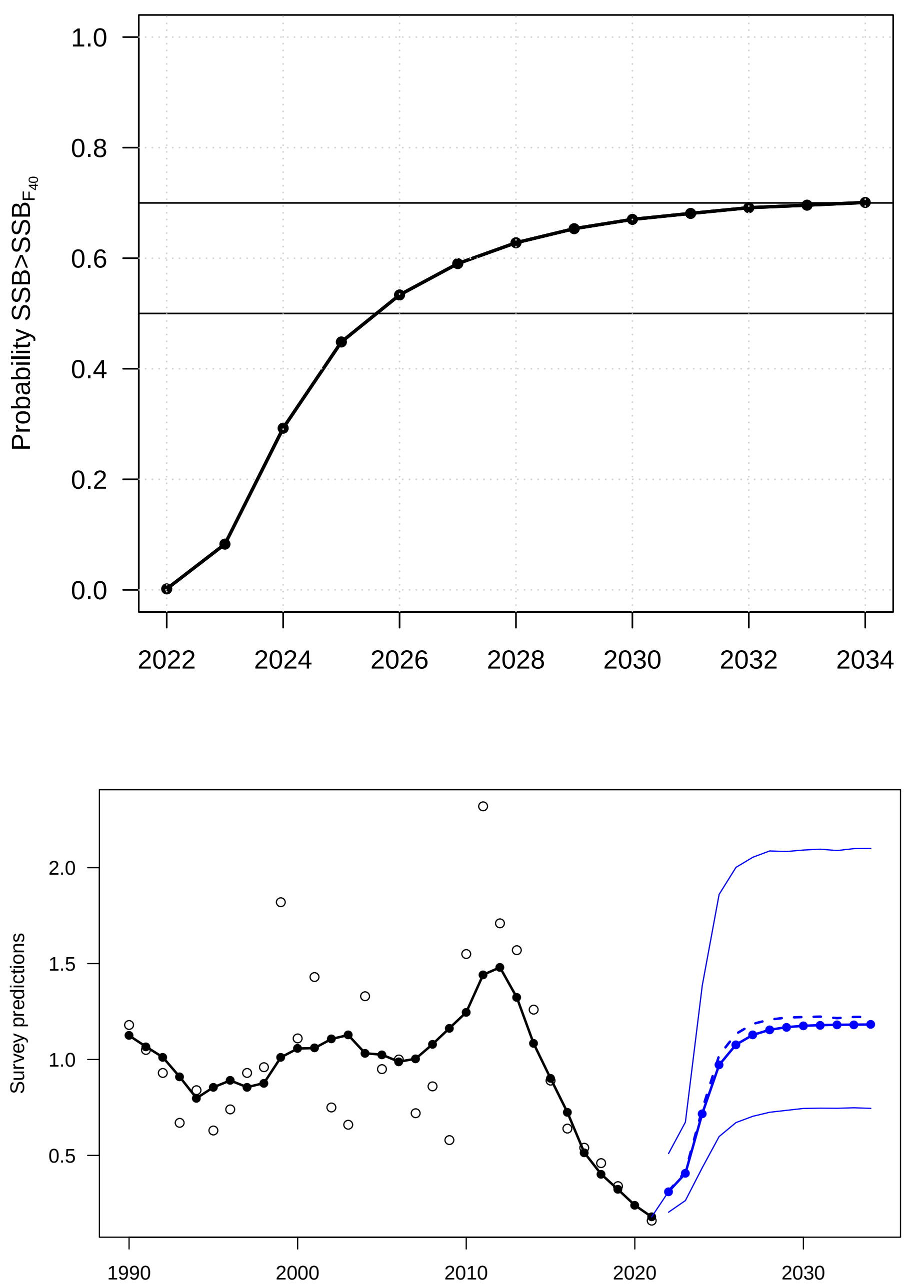


Figure 31. Projected time series for the scenario projecting a shallow water grouper closure in wave 1 and 2 with fishing mortality rates at $F_{\text{Landed}} = F_{\text{Rebuild70\%}}$ and $F_{\text{Discard}} = F_{\text{current}}$ starting in 2025 and recent mean recruitment starting in 2023. Expected 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.

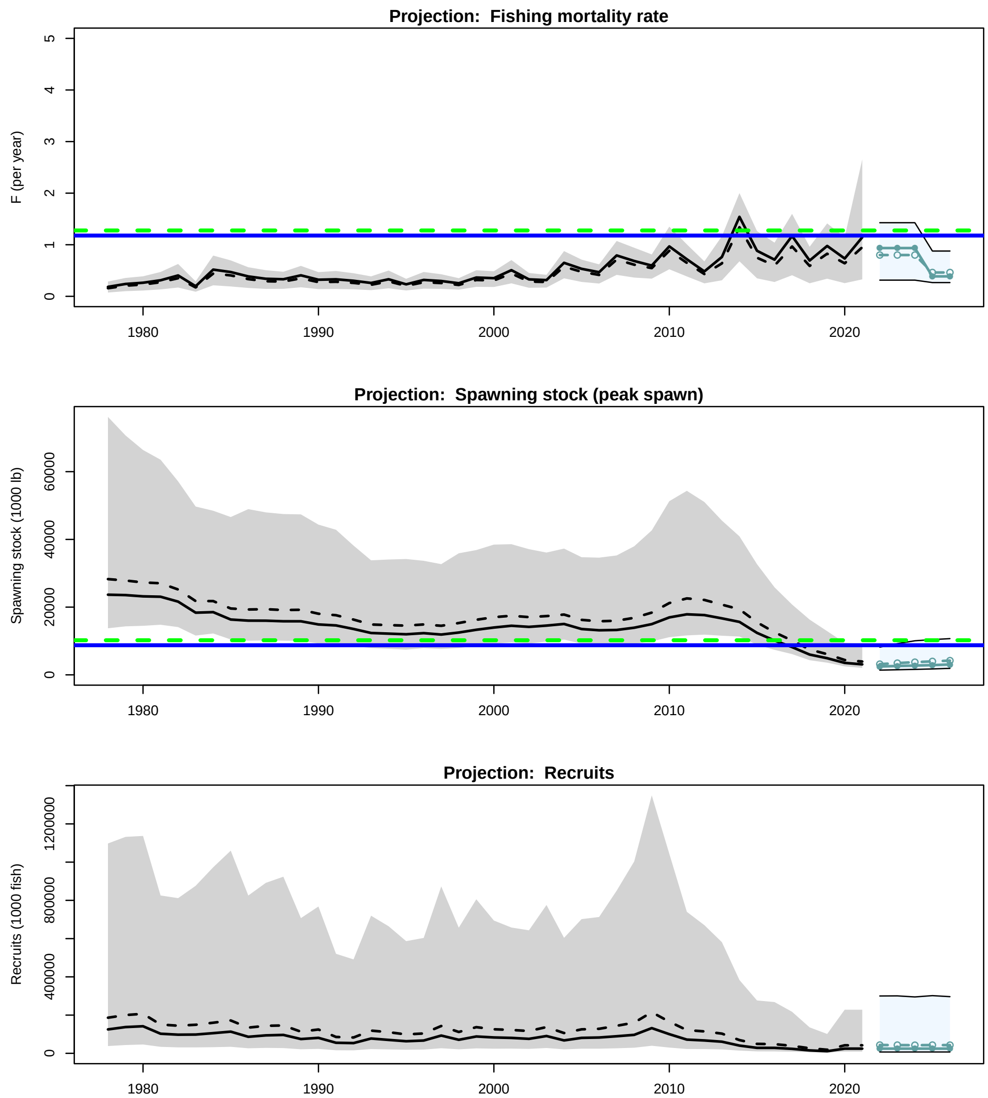


Figure 32. Projected fishing mortality (top left panel), spawning stock biomass (top right panel), landings (middle panels) in weight (left) and numbers (right) and discards (bottom panels) in weight (left) and numbers (right) for the projected time series for a shallow water grouper closure in wave 1 and 2 with fishing mortality rates at $F_{\text{Landed}} = F_{\text{Rebuild70\%}}$ *and* $F_{\text{Discard}} = F_{\text{current}}$ *starting in 2025 and recent mean recruitment starting in 2023. 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.*

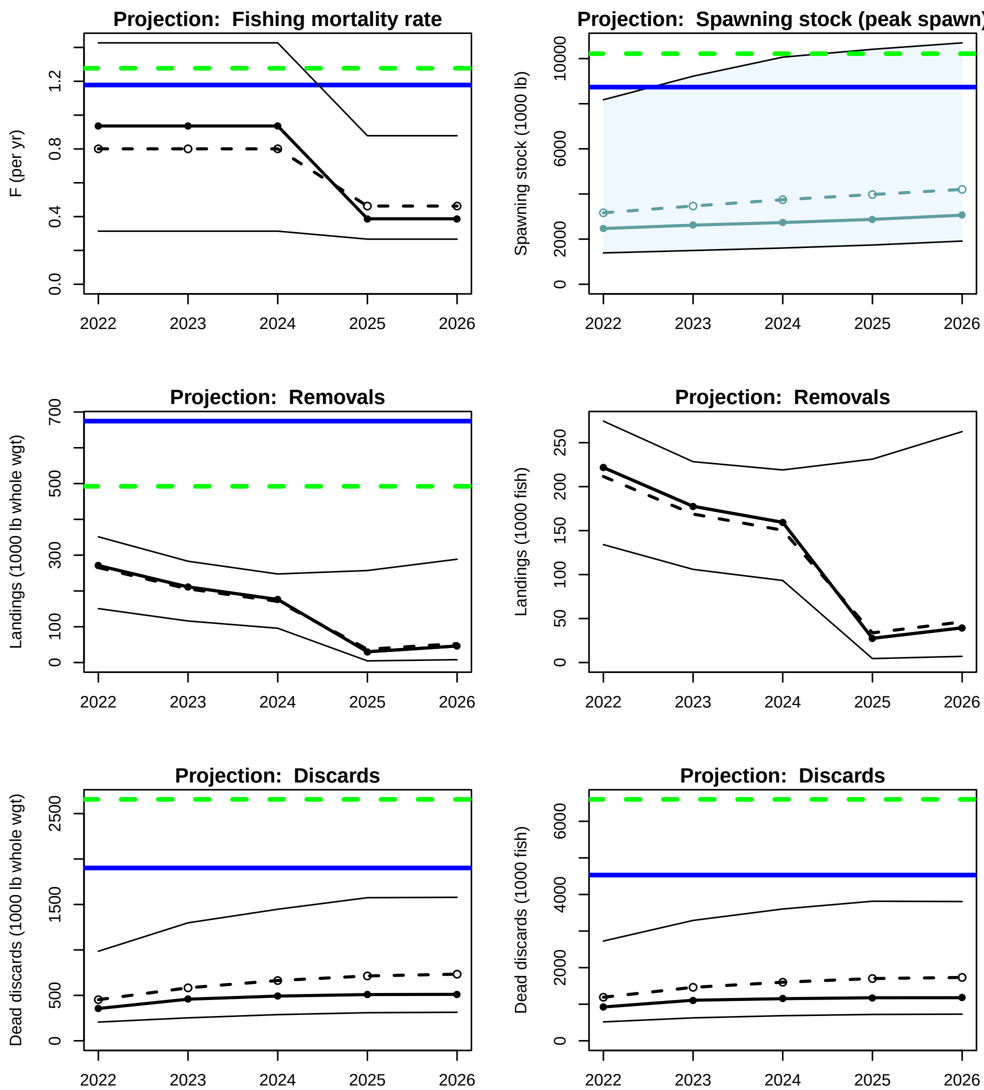


Figure 33. Top Panel: Projected probability of rebuilding under scenario with a wave 1 and 2 shallow water grouper closure and recent mean recruitment. The curve represents the proportion of projection replicates for which SSB has reached the replicate-specific $\mathrm{SSB_{F40\%}}$*, with reference 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.*

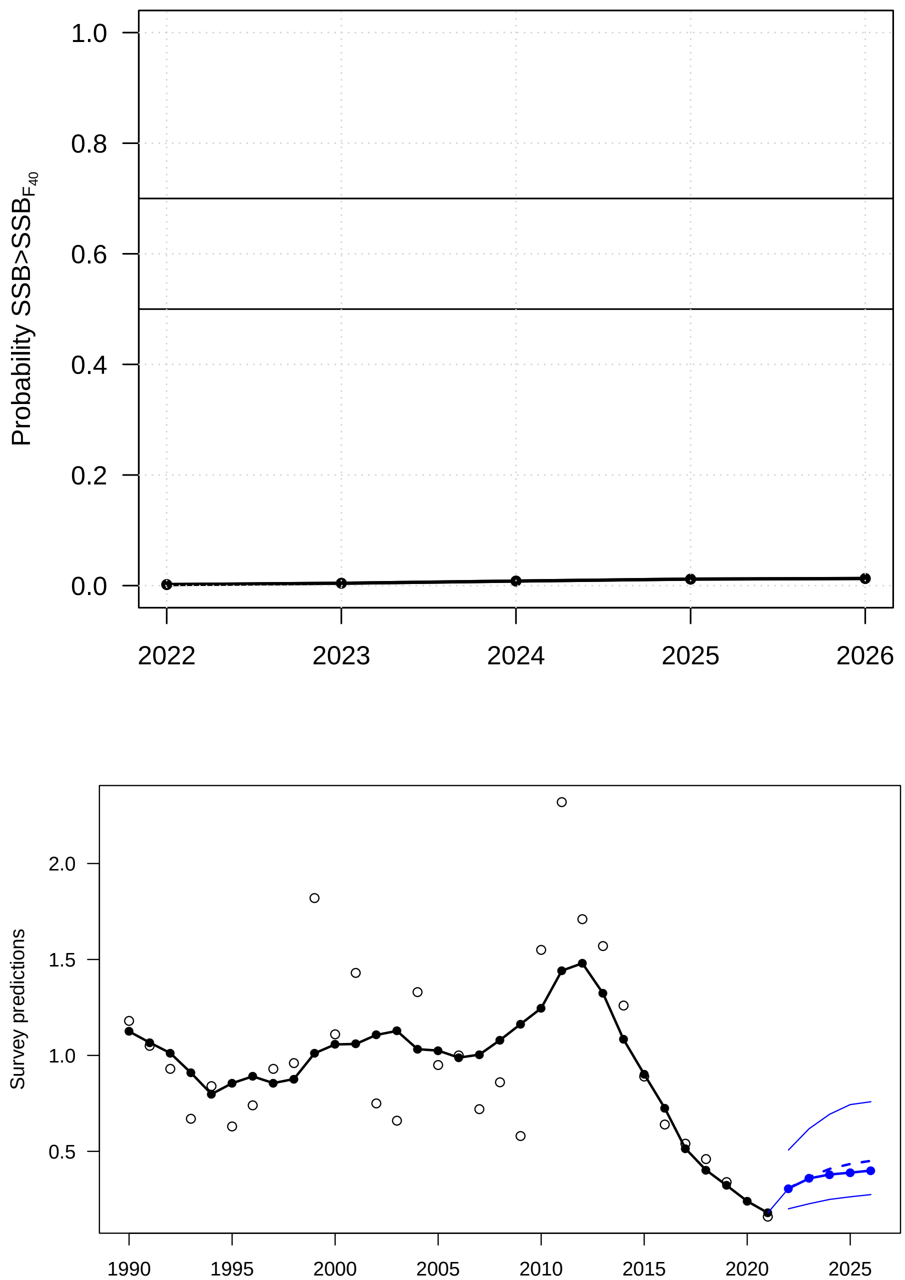


Figure 34. Projected time series for the phase-in landings from 2026 to 2028 and then fishing mortality rate at $F_{\text{Landed}} = F_{\text{Rebuild70\%}}$ *from the OFL scenario and* $F_{\text{Discard}} = F_{\text{current}}$ *and longterm average recruitment starting in 2023. Expected values (base 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.*

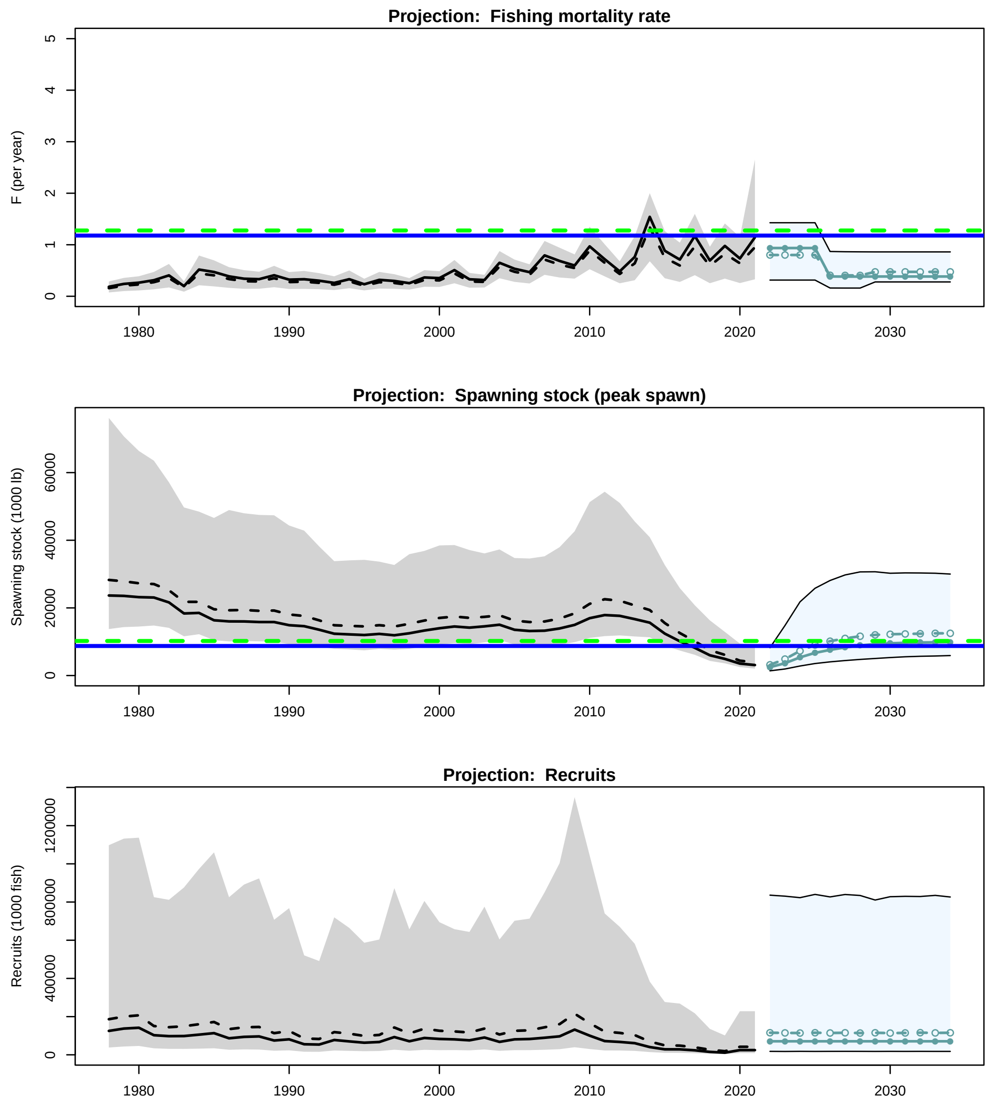


Figure 35. Projected fishing mortality (top left panel), spawning stock biomass (top right panel), landings (middle panels) in weight (left) and numbers (right) and discards (bottom panels) in weight (left) and numbers (right) for phase-in landings from 2026 to 2028 and then fishing mortality rate at $F_{\mathrm{Landed}} = F_{\mathrm{Rebuild70\%}}$ from the OFL scenario and $F_{\mathrm{Discard}} = F_{\mathrm{current}}$ starting in 2025 and longterm average recruitment starting in 2023. 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.

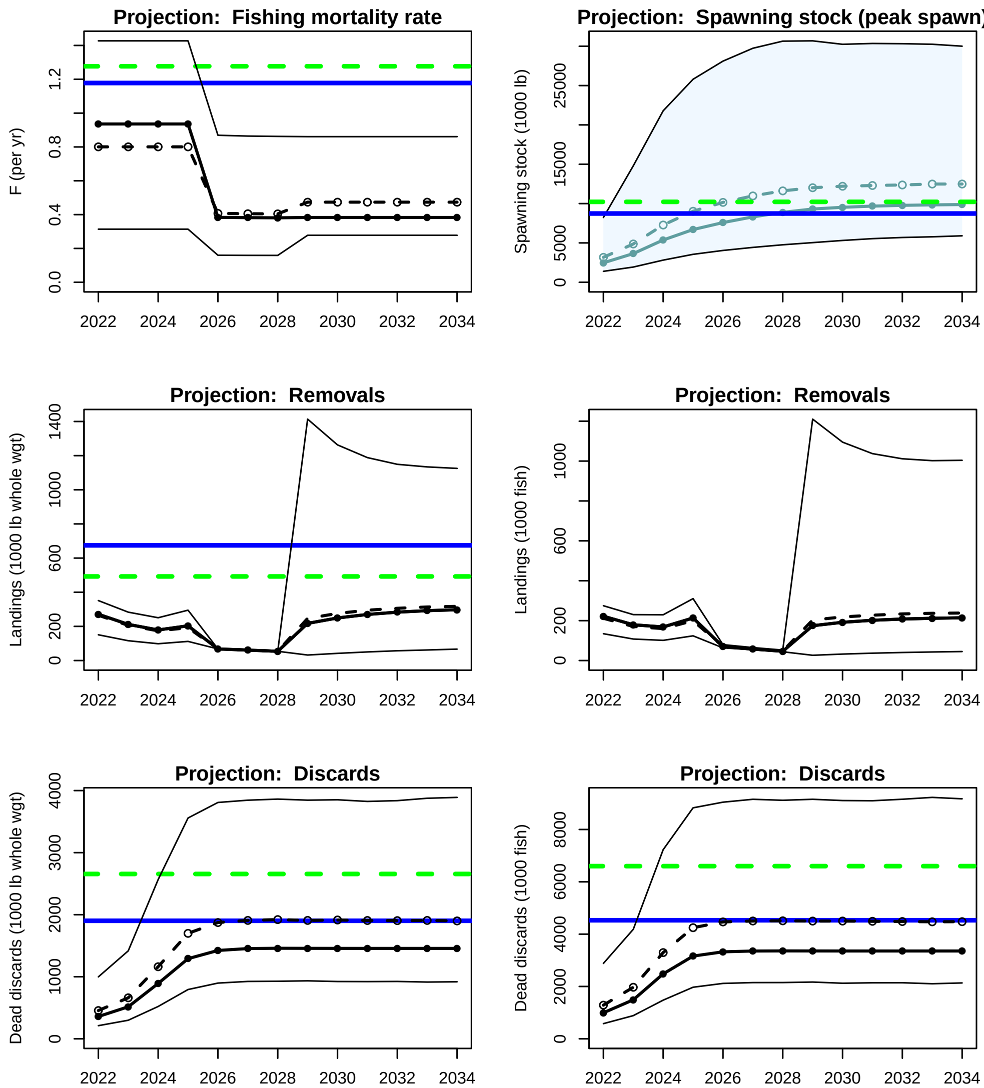


Figure 36. Top Panel: Projected probability of rebuilding under phase-in landings scenario and longterm average recruitment. The curve represents the proportion of projection replicates for which SSB has reached the replicate-specific $\mathrm{SSB}_{\mathrm{F40\%}}$*, with reference lines at 0.5 and 0.7. Bottom panel: Projected SERFS 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.*

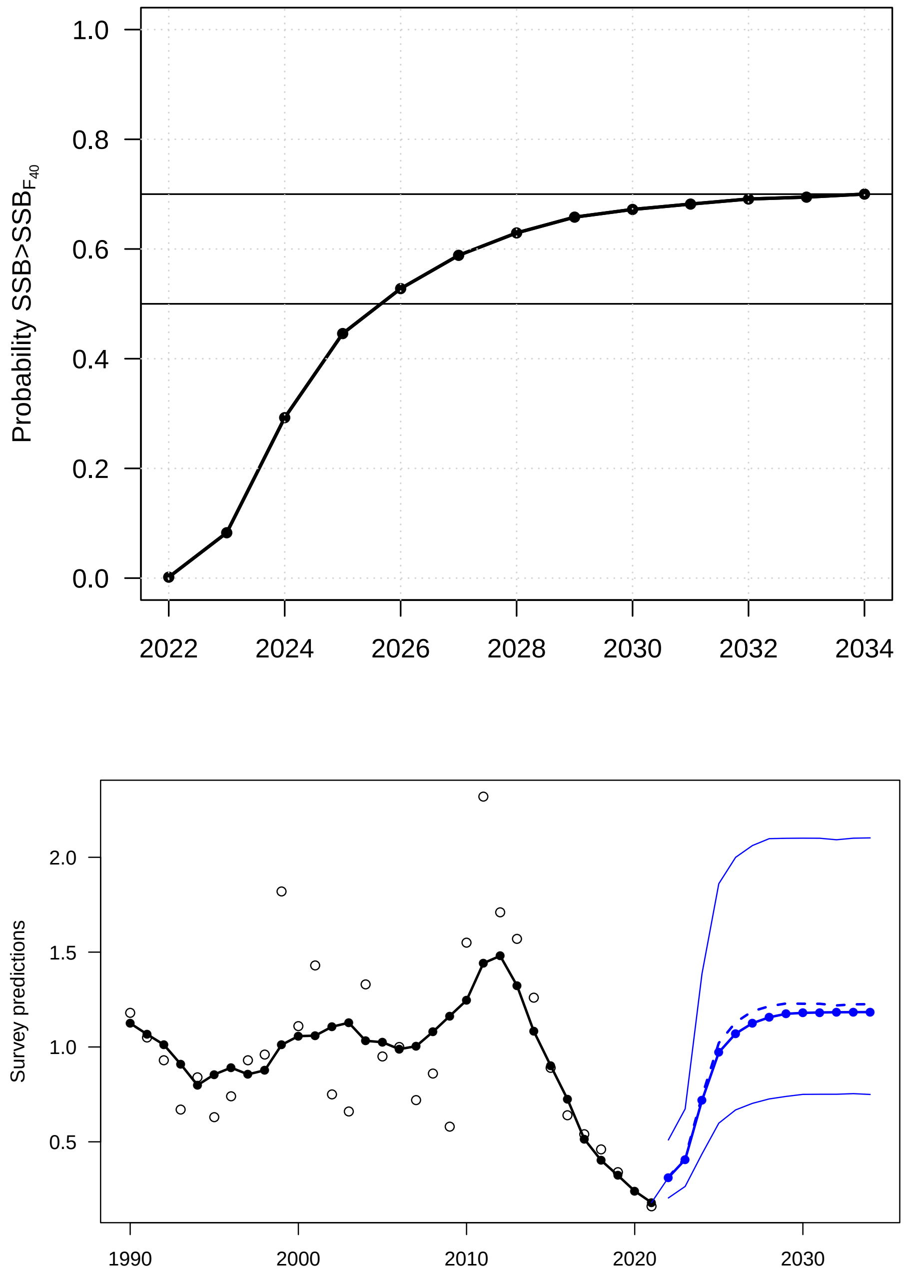


Figure 37. Projected time series for the scenario with fishing mortality rates at $F_{\text{Landed}} = P^*_{30\%}\ F_{40\%}$ *and* $F_{\text{Discard}} = F_{\text{current}}$ *starting in 2026 and longterm average recruitment starting in 2023. Expected values (base run) represented by solid lines with 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.*

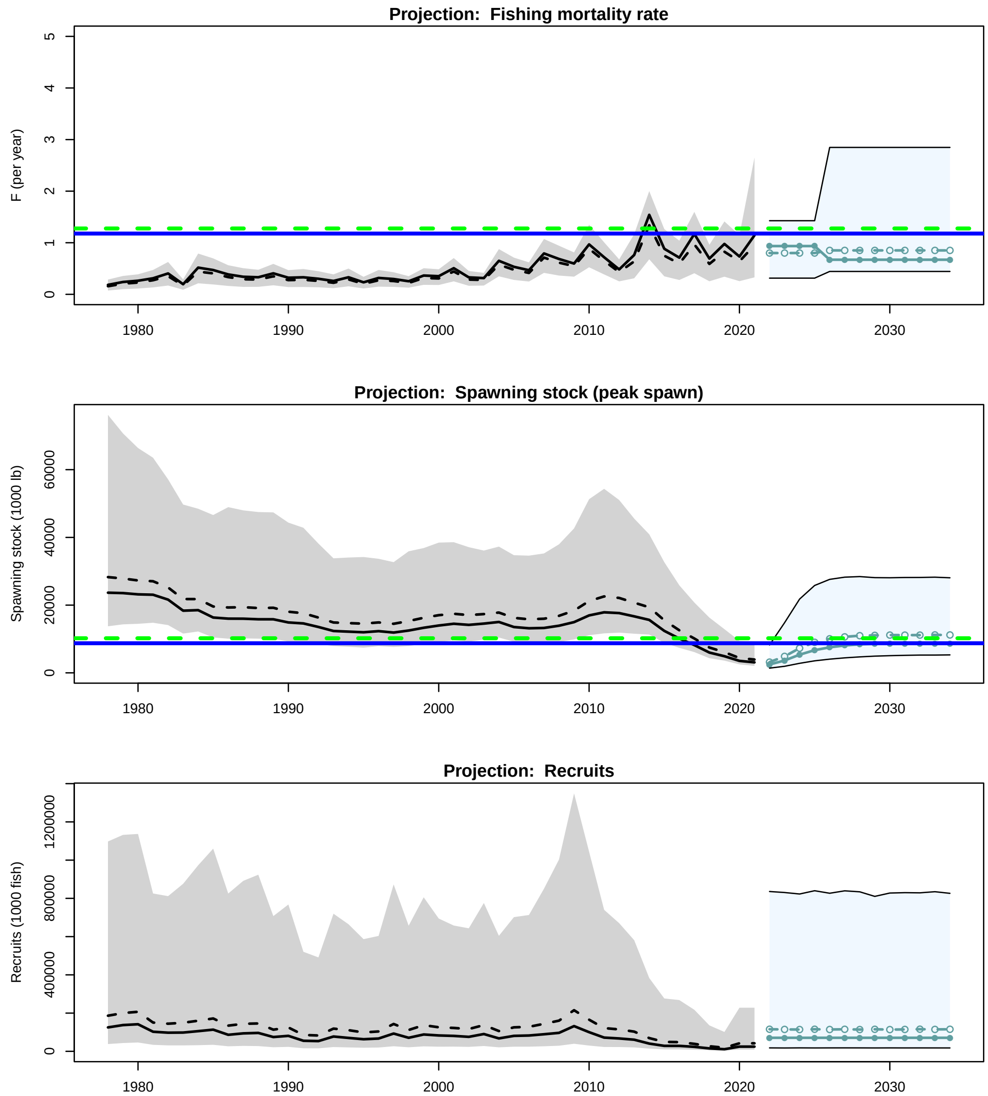


Figure 38. Projected fishing mortality (top left panel), spawning stock biomass (top right panel), landings (middle panels) in weight (left) and numbers (right) and discards (bottom panels) in weight (left) and numbers (right) for the projected time series for the scenario with fishing mortality rates at $F_{\text{Landed}} = P^*_{30\%}\ F_{40\%}$ *and* $F_{\text{Discard}} = F_{\text{current}}$ *starting in 2026 and longterm average recruitment starting in 2023. 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.*

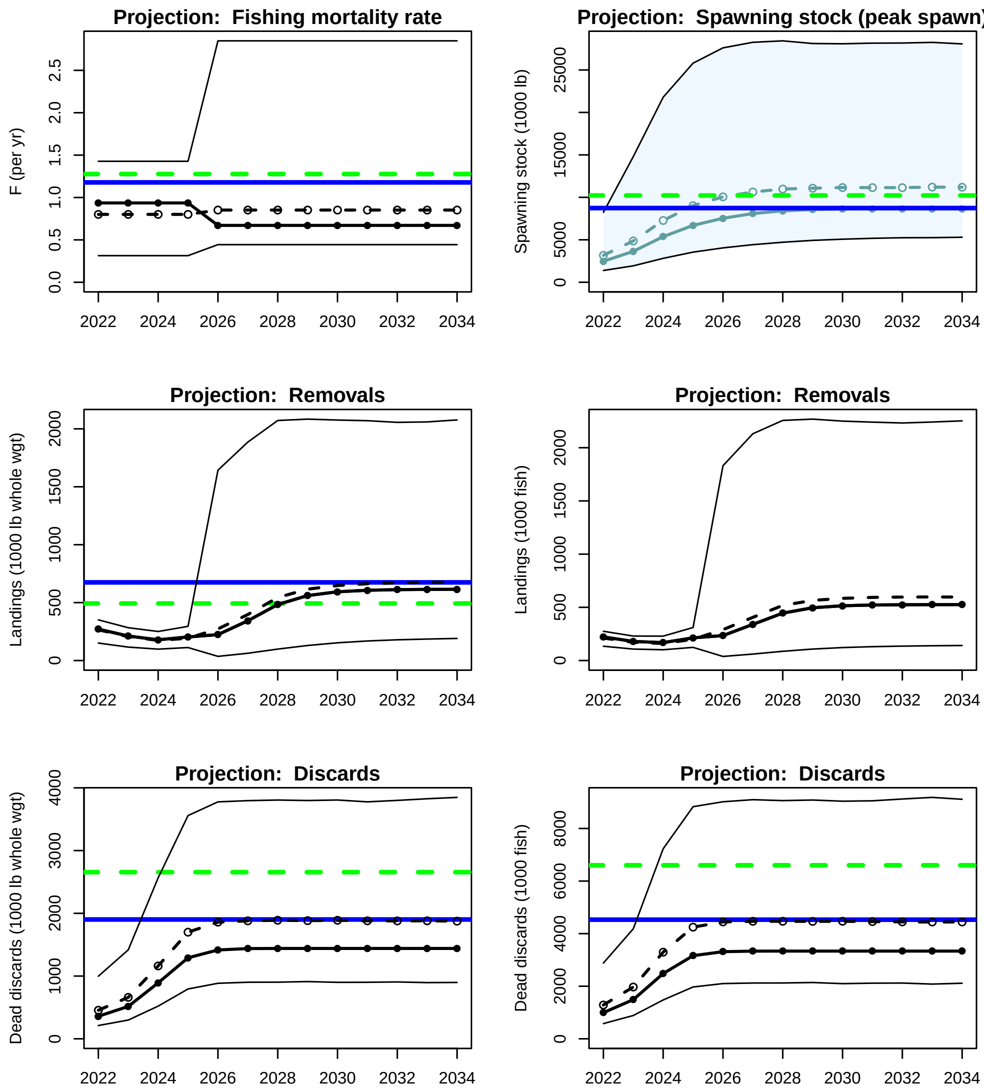


Figure 39. Top Panel: Projected probability of rebuilding under scenario with fishing mortality rates at $F_{\text{Landed}} = P^{*}_{30\%}\ F_{40\%}$ *and* $F_{\text{Discard}} = F_{\text{current}}$ *starting in 2026 and longterm average recruitment. The curve represents the proportion of projection replicates for which SSB has reached the replicate-specific* $\text{SSB}_{\text{F40\%}}$*, 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.*

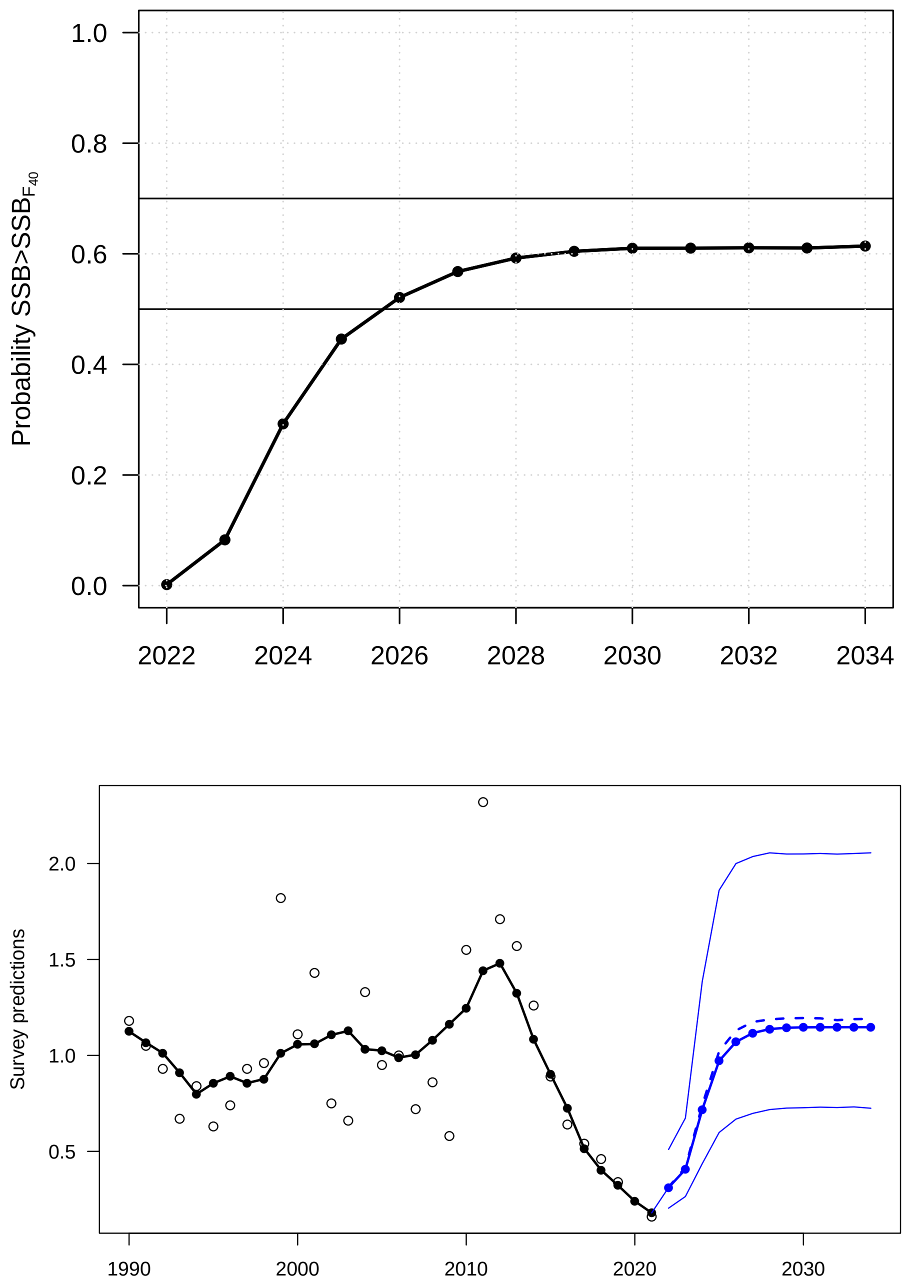


Figure 40. Projected time series for the scenario with fishing mortality rates at $F_{\text{Landed}} = P^*_{30\%}\ F_{40\%}$ and $F_{\text{Discard}} = F_{\text{current}}$ starting in 2026 and recent mean recruitment starting in 2023. Expected values (base run) represented by solid lines with solid circles, 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.

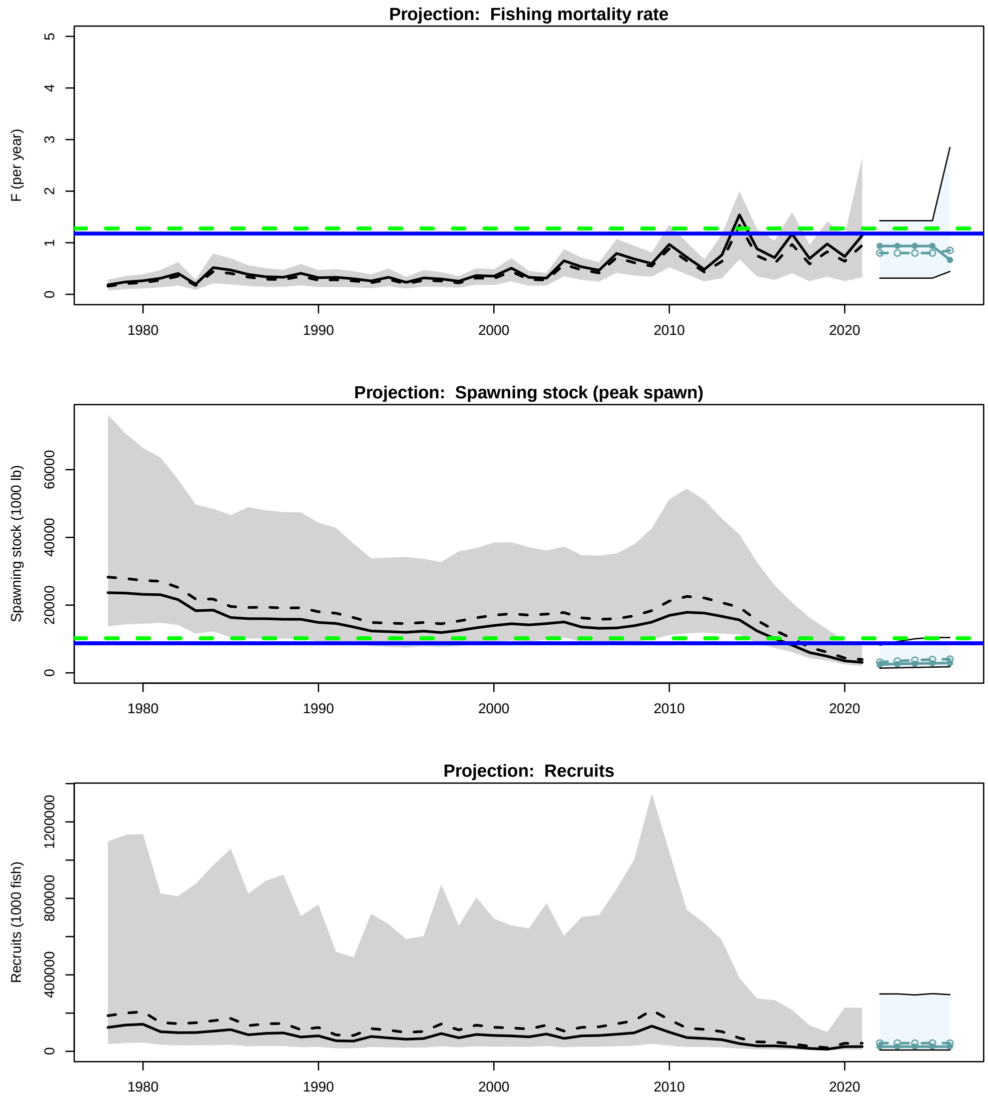


Figure 41. Projected fishing mortality (top left panel), spawning stock biomass (top right panel), landings (middle panels) in weight (left) and numbers (right) and discards (bottom panels) in weight (left) and numbers (right) for the projected time series for the scenario with fishing mortality rates at $F_{\text{Landed}} = P^*_{30\%}\ F_{40\%}$ and $F_{\text{Discard}} = F_{\text{current}}$ starting in 2026 and recent mean recruitment starting in 2023. 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.

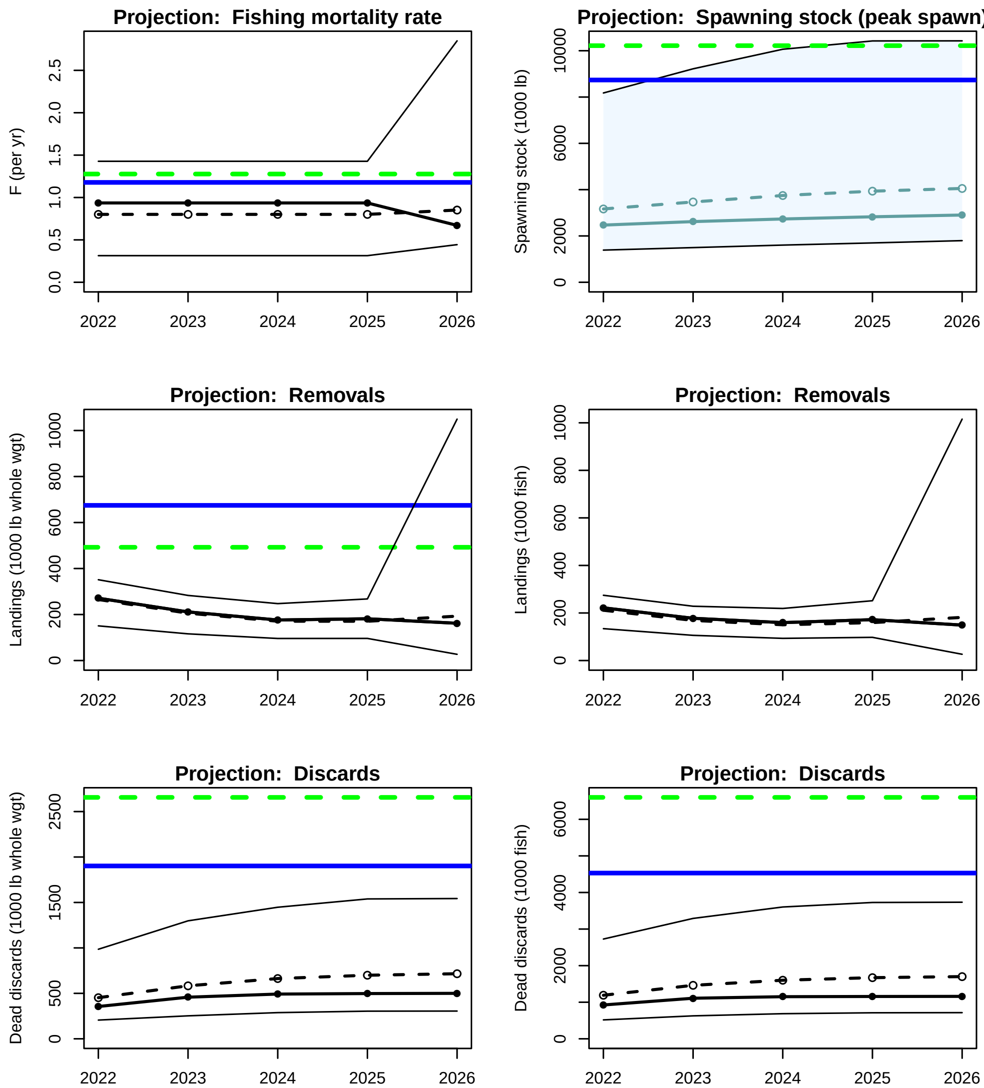


Figure 42. Top Panel: Projected probability of rebuilding under scenario with fishing mortality rates at $F_{\text{Landed}} = P^*_{30\%}\ F_{40\%}$ *and* $F_{\text{Discard}} = F_{\text{current}}$ *starting in 2026 and recent mean recruitment. The curve represents the proportion of projection replicates for which SSB has reached the replicate-specific* $\text{SSB}_{\text{F40\%}}$*, 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.*

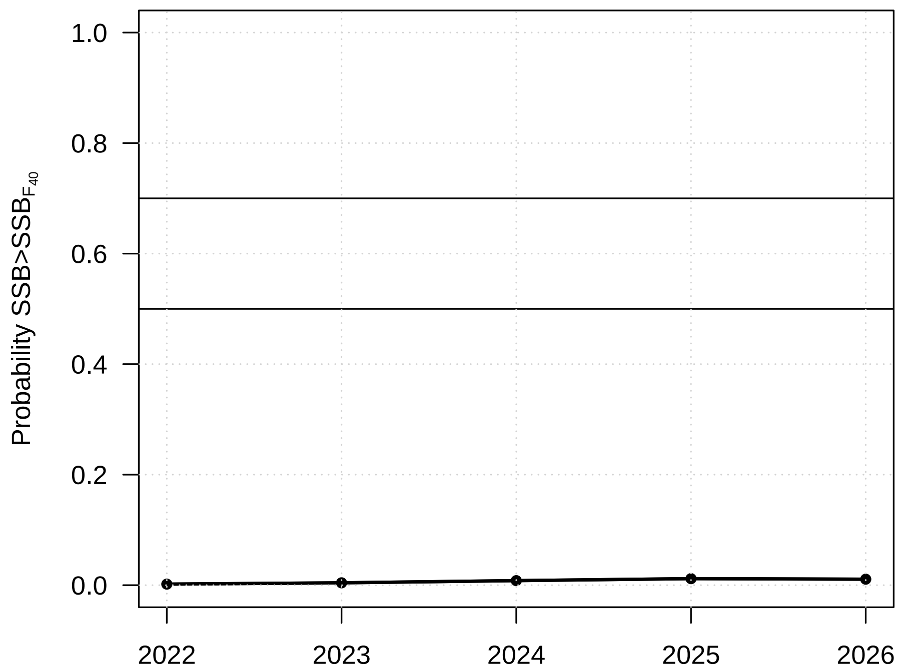


Figure 43. Projected time series for the scenario with fishing mortality rates at $F_{\text{Landed}} = P^*_{30\%}\ F_{40\%}$ *and* $F_{\text{Discard}} = P^*_{30\%}\ F_{40\%}$ *starting in 2026 and longterm average recruitment starting in 2023. Expected values (base run) represented by solid lines with 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.*

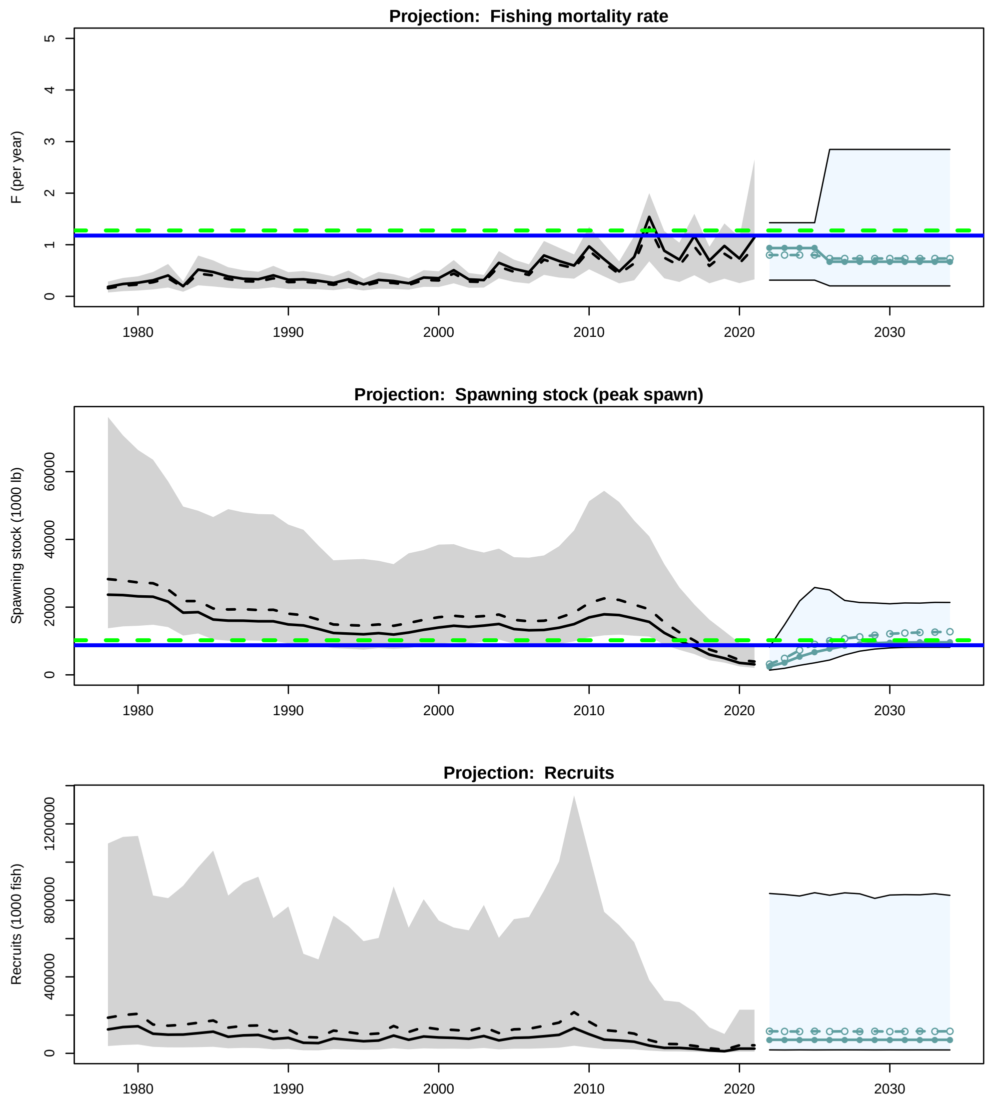


Figure 44. Projected fishing mortality (top left panel), spawning stock biomass (top right panel), landings (middle panels) in weight (left) and numbers (right) and discards (bottom panels) in weight (left) and numbers (right) for the projected time series for the scenario with fishing mortality rates at $F_{\mathrm{Landed}} = P^*_{30\%}\ F_{40\%}$ *and* $F_{\mathrm{Discard}} = P^*_{30\%}\ F_{40\%}$ *starting in 2026 and longterm average recruitment starting in 2023. 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.*

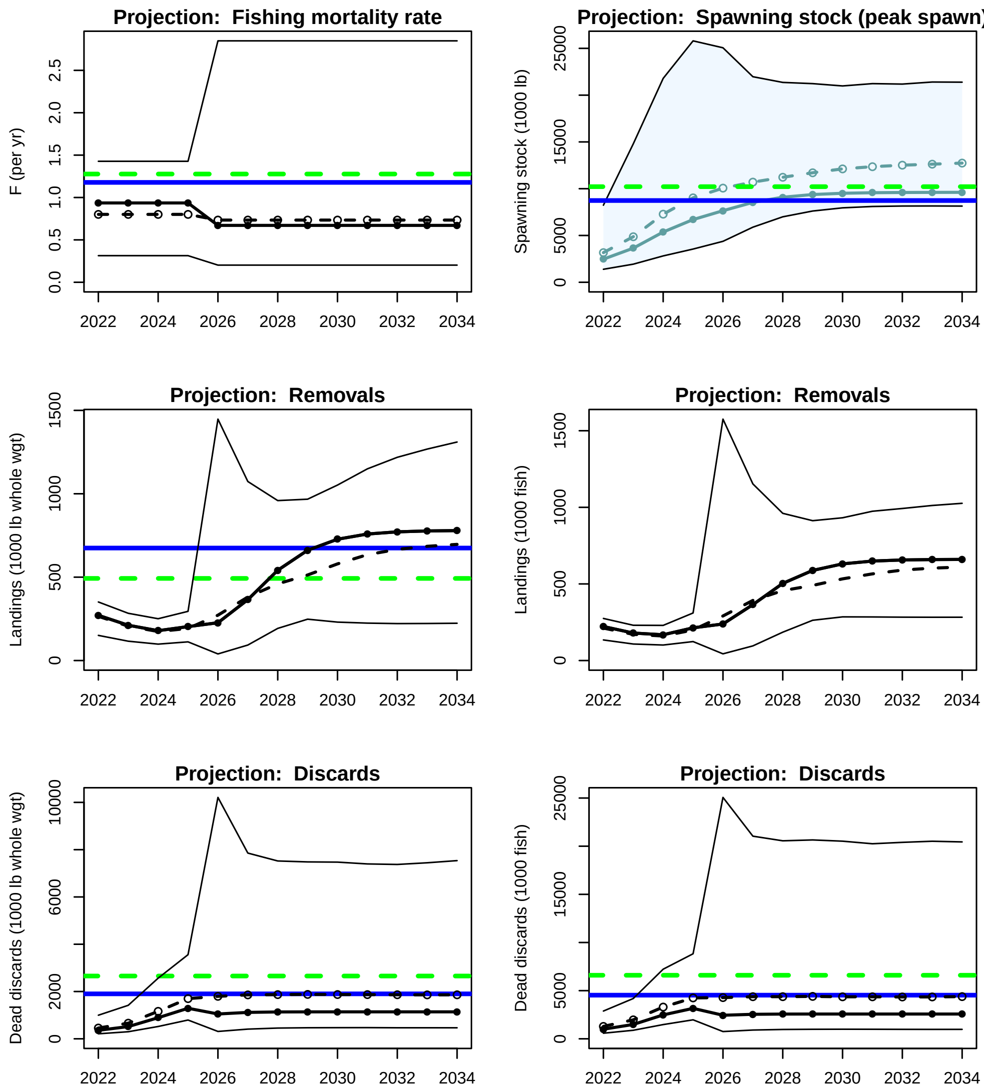
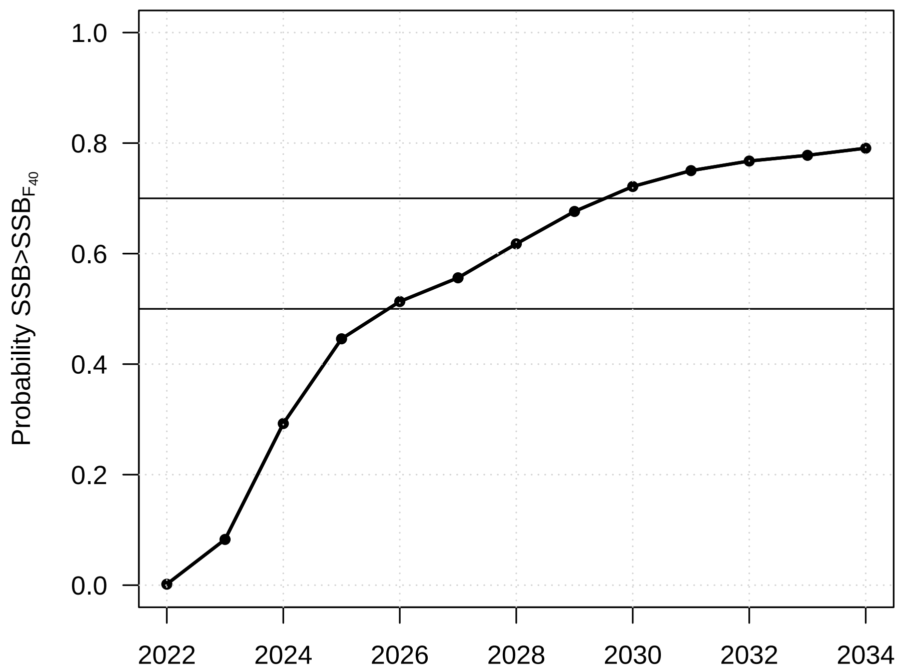


Figure 45. Top Panel: Projected probability of rebuilding under scenario with fishing mortality rates at $F_{\text{Landed}} = P^*_{30\%}\ F_{40\%}$ *and* $F_{\text{Discard}} = P^*_{30\%}\ F_{40\%}$ *starting in 2026 and longterm average recruitment. The curve represents the proportion of projection replicates for which SSB has reached the replicate-specific* $\text{SSB}_{\text{F40\%}}$*, 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.*



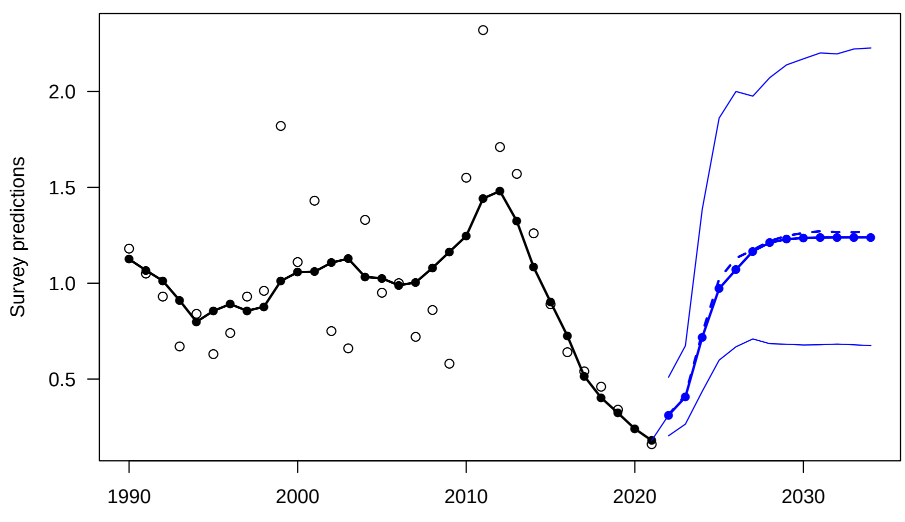


Figure 46. Projected time series for the scenario with fishing mortality rates at $F_{\mathrm{Landed}} = P^*_{30\%}\ F_{40\%}$ and $F_{\mathrm{Discard}} = P^*_{30\%}\ F_{40\%}$ starting in 2026 and recent mean recruitment starting in 2023. Expected values (base run) represented by solid lines with solid 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.

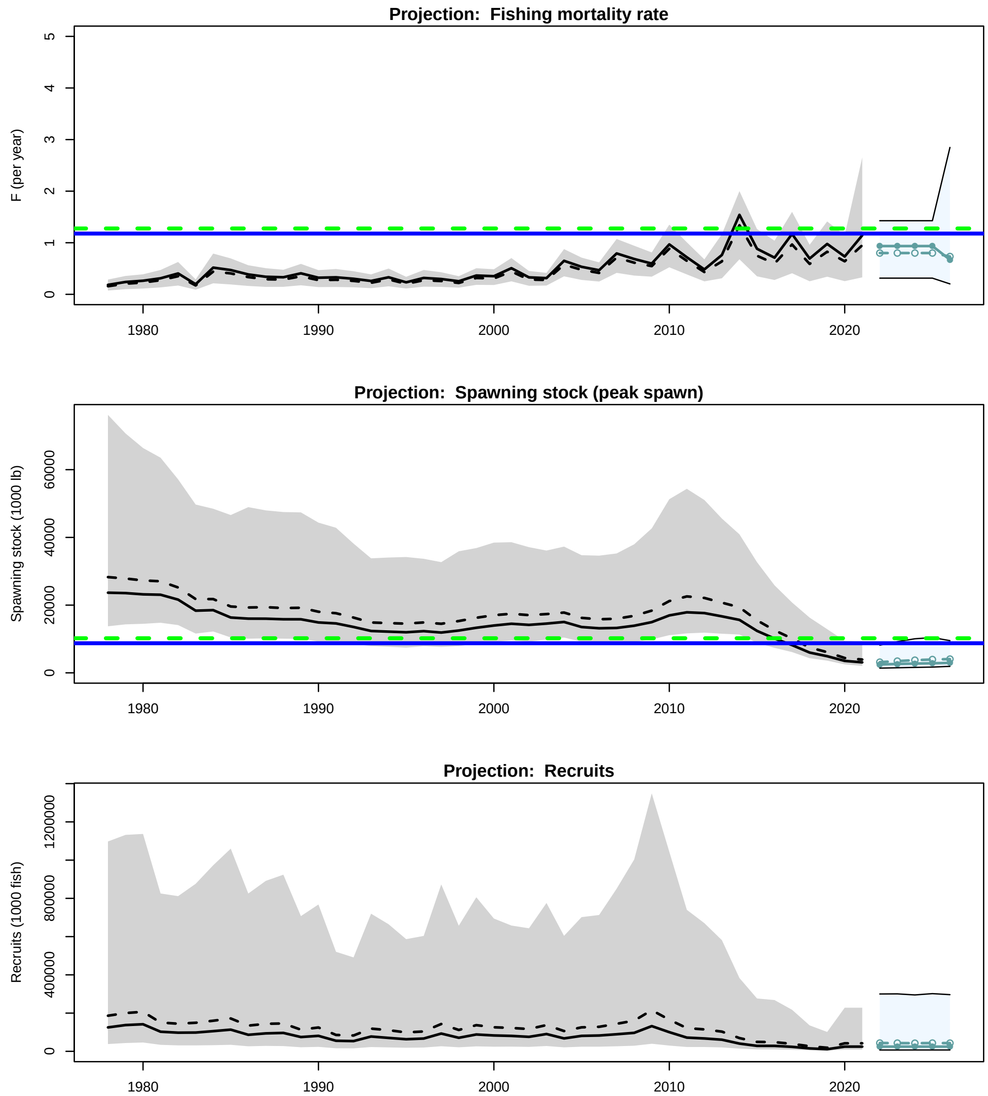


Figure 47. Projected fishing mortality (top left panel), spawning stock biomass (top right panel), landings (middle panels) in weight (left) and numbers (right) and discards (bottom panels) in weight (left) and numbers (right) for the projected time series for the scenario with fishing mortality rates at $F_{\text{Landed}} = P^*_{30\%}\ F_{40\%}$ and $F_{\text{Discard}} = P^*_{30\%}\ F_{40\%}$ starting in 2026 and recent mean recruitment starting in 2023. 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.

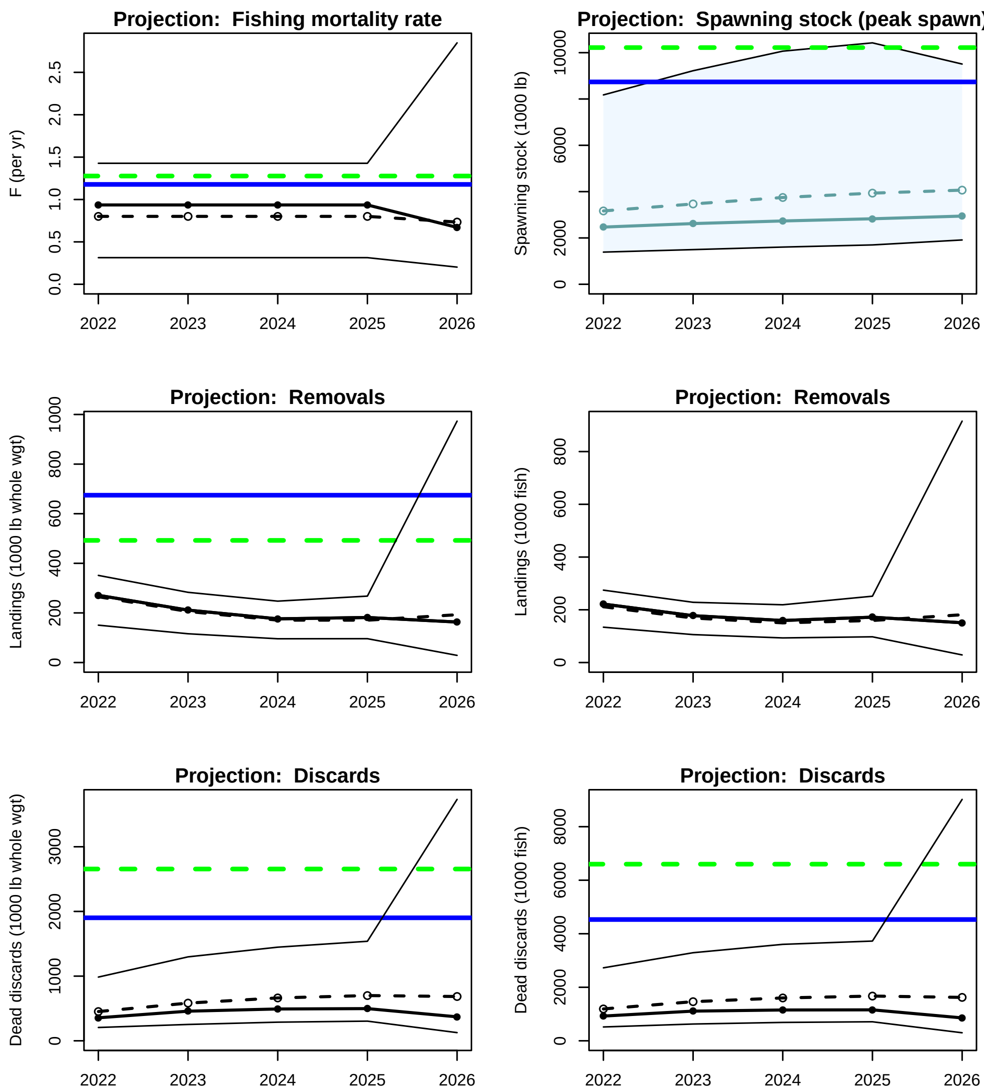


Figure 48. Top Panel: Projected probability of rebuilding under scenario with fishing mortality rates at $F_{\text{Landed}} = P^*_{30\%}\ F_{40\%}$ *and* $F_{\text{Discard}} = P^*_{30\%}\ F_{40\%}$ *starting in 2026 and recent mean recruitment. The curve represents the proportion of projection replicates for which SSB has reached the replicate-specific* $\text{SSB}_{\text{F40\%}}$*, 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.*

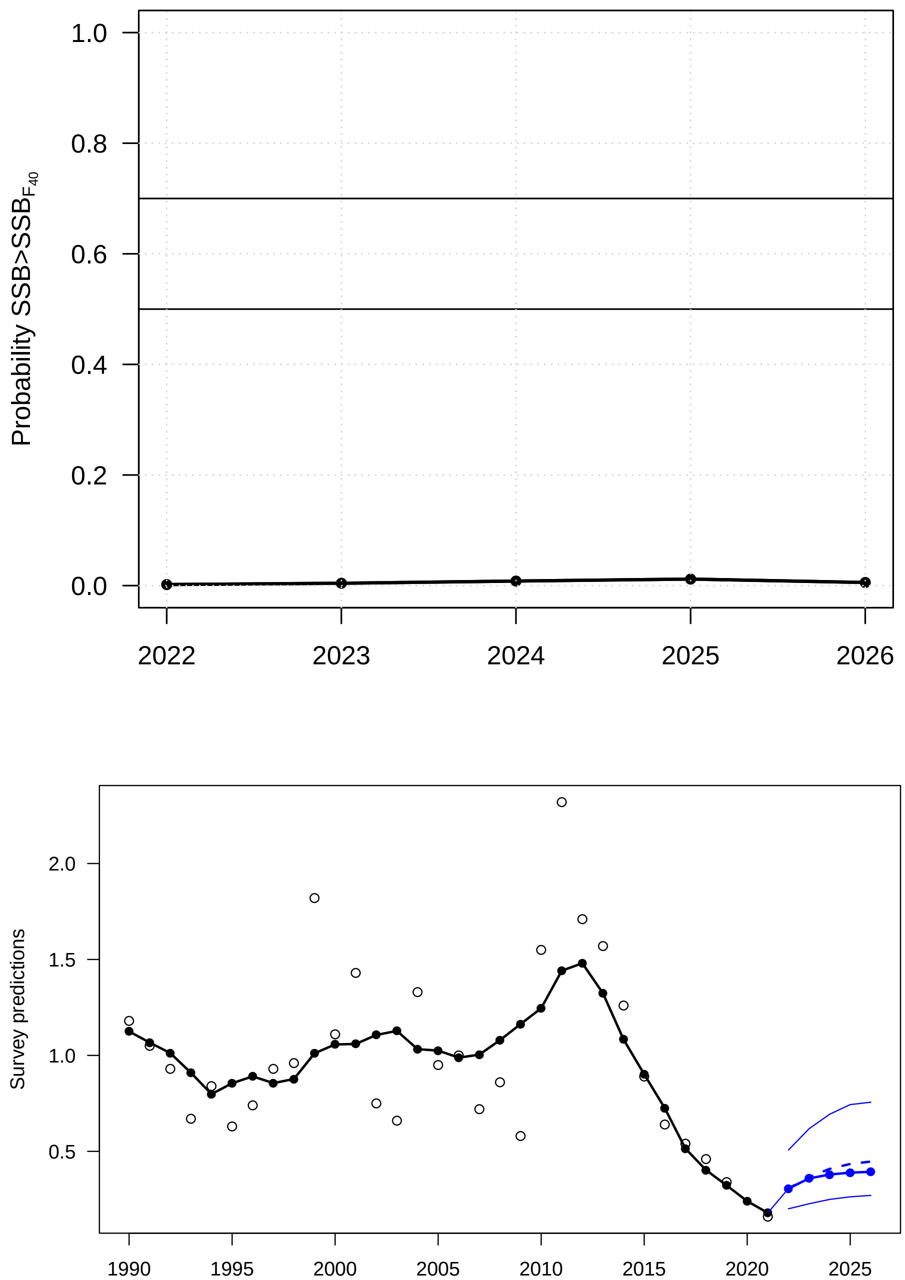


Figure 49. Projected time series for the scenario with fishing mortality rates at $F_{\text{Landed}} = P^*_{30\%}\ F_{30\%}$ and $F_{\text{Discard}} = F_{\text{current}}$ starting in 2026 and longterm average recruitment starting in 2023. Expected values (base run) represented by solid lines with solid 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.

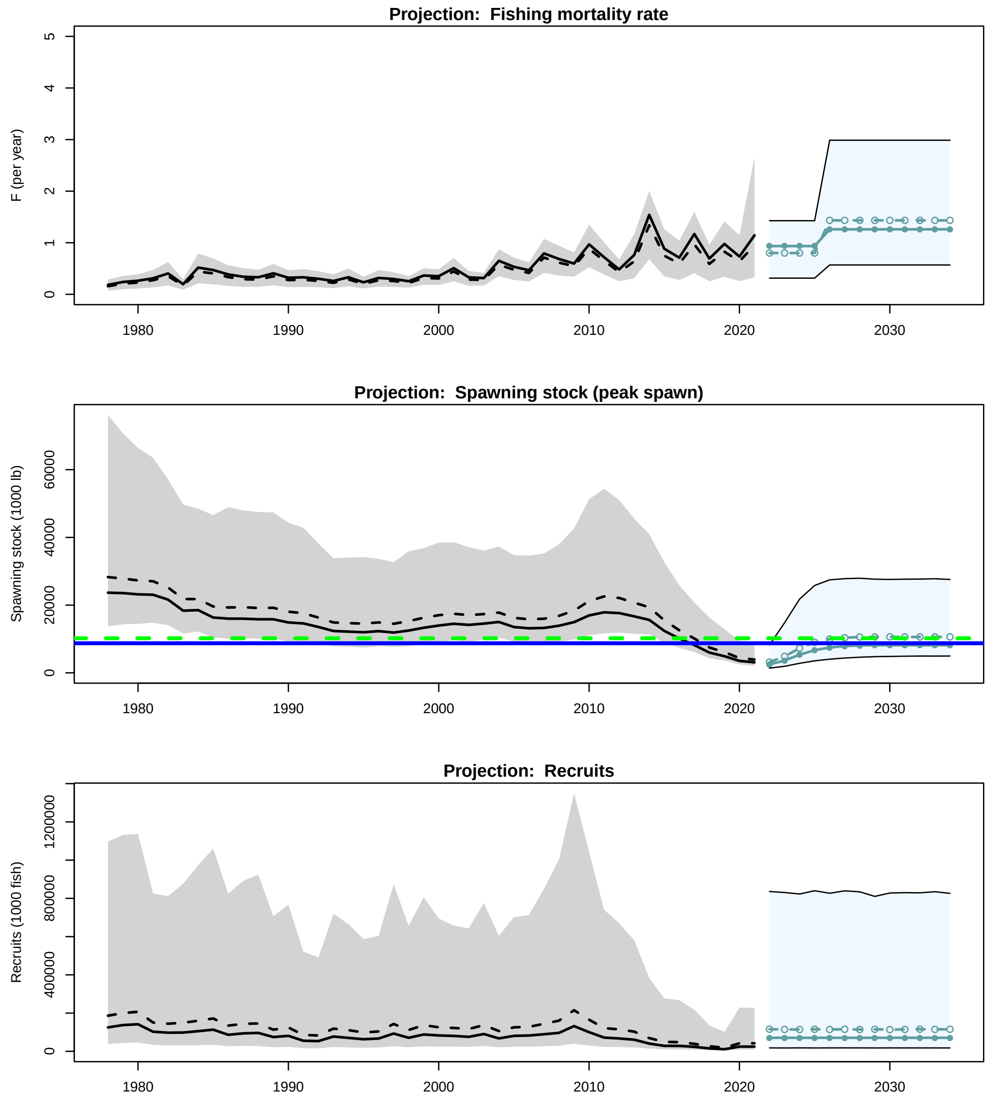


Figure 50. Projected fishing mortality (top left panel), spawning stock biomass (top right panel), landings (middle panels) in weight (left) and numbers (right) and discards (bottom panels) in weight (left) and numbers (right) for the projected time series for the scenario with fishing mortality rates at $F_{\text{Landed}} = P^*_{30\%}\ F_{30\%}$ *and* $F_{\text{Discard}} = F_{\text{current}}$ *starting in 2026 and longterm average recruitment starting in 2023. 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.*

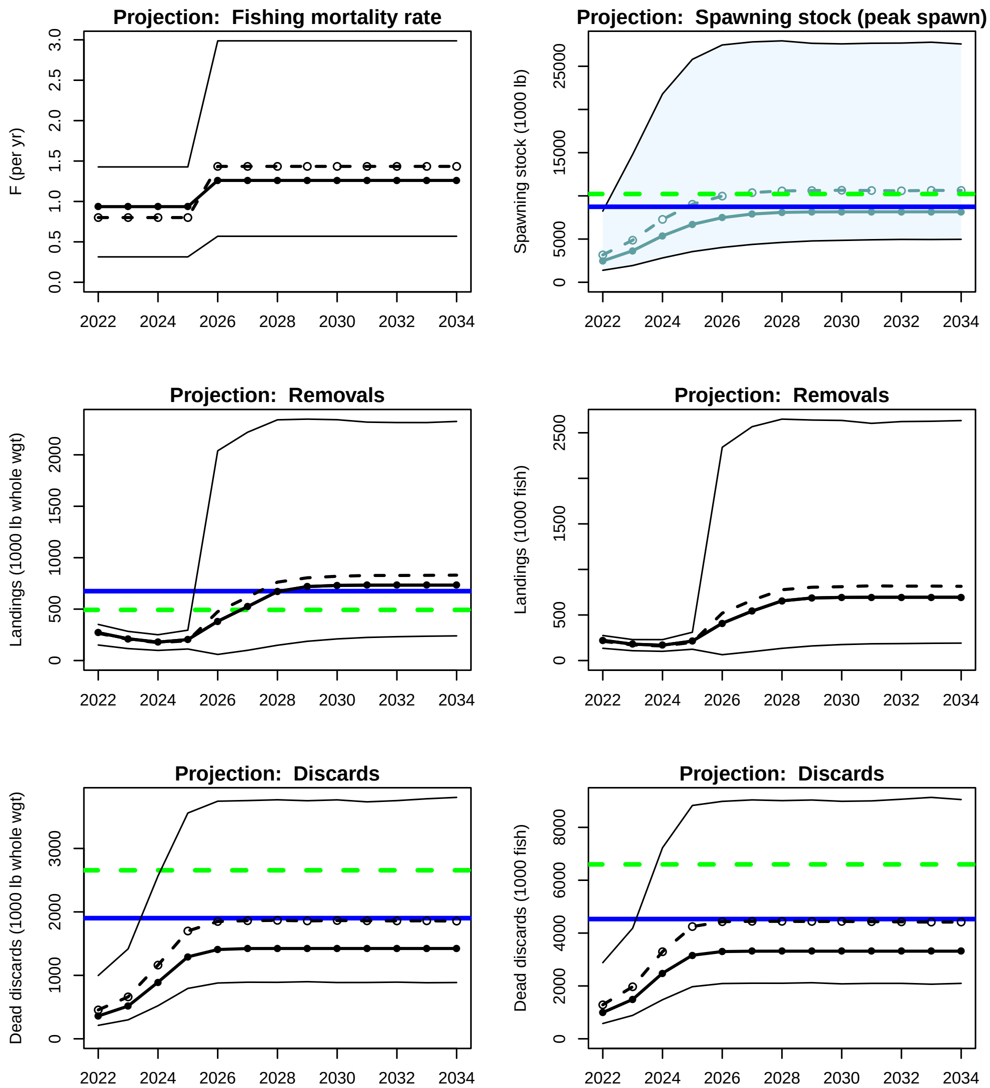


Figure 51. Top Panels: Projected probability of rebuilding to $\mathrm{SSB}_{\mathrm{F40\%}}$ *(left) and* $\mathrm{SSB}_{\mathrm{F30\%}}$ *(right) under scenario with fishing mortality rates at* $F_{\mathrm{Landed}} = P^{*}_{30\%}\ F_{30\%}$ *and* $F_{\mathrm{Discard}} = F_{\mathrm{current}}$ *starting in 2026 and longterm average recruitment. The curve represents the proportion of projection replicates for which SSB has reached the replicate-specific* $\mathrm{SSB}_{\mathrm{F40\%}}$ *or* $\mathrm{SSB}_{\mathrm{F30\%}}$*, 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.*

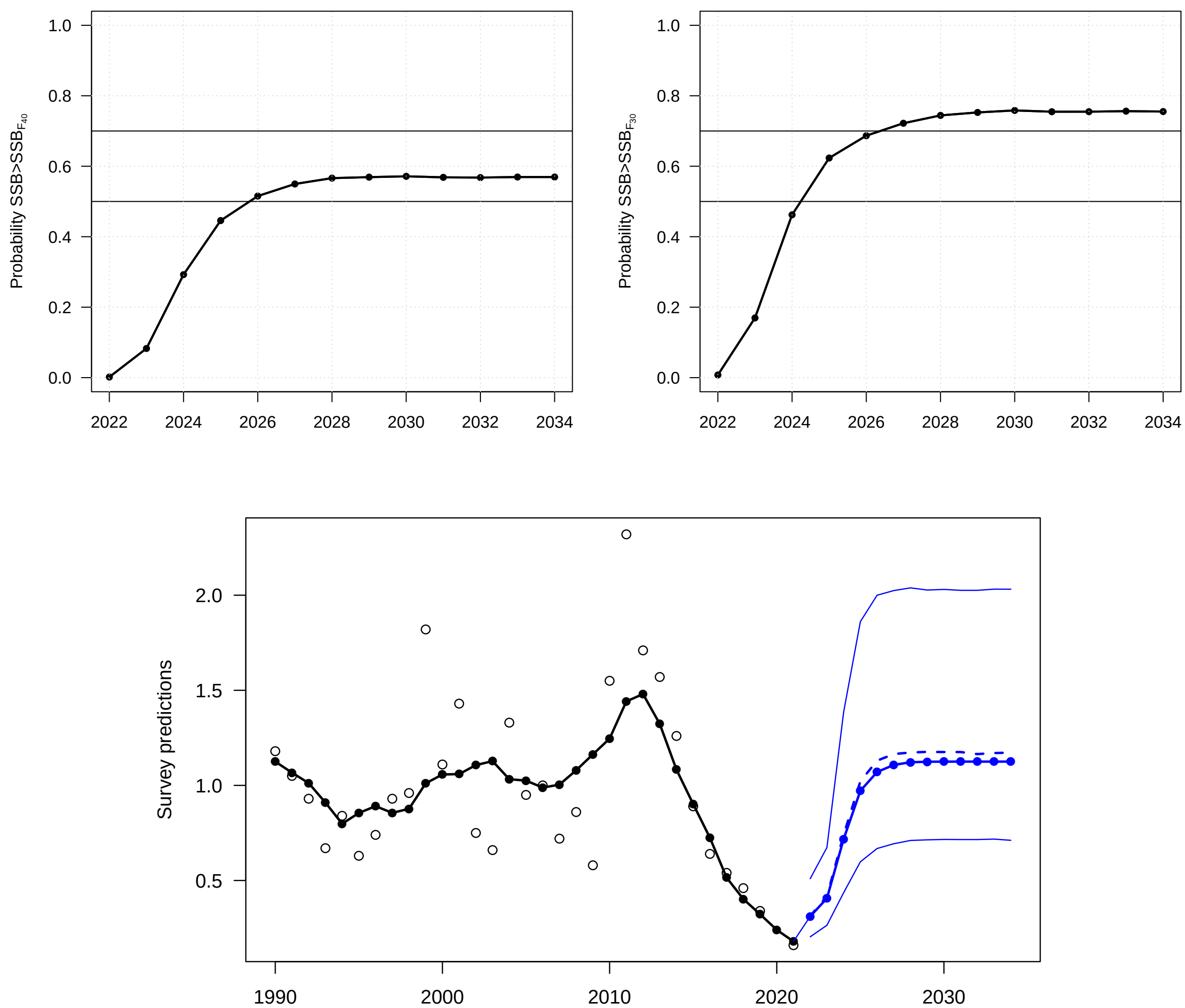


Figure 52. Projected time series for the scenario with fishing mortality rates at $F_{\text{Landed}} = P^*_{30\%}\ F_{30\%}$ and $F_{\text{Discard}} = F_{\text{current}}$ starting in 2026 and recent mean recruitment starting in 2023. Expected values (base run) represented by solid lines with solid circles, 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.

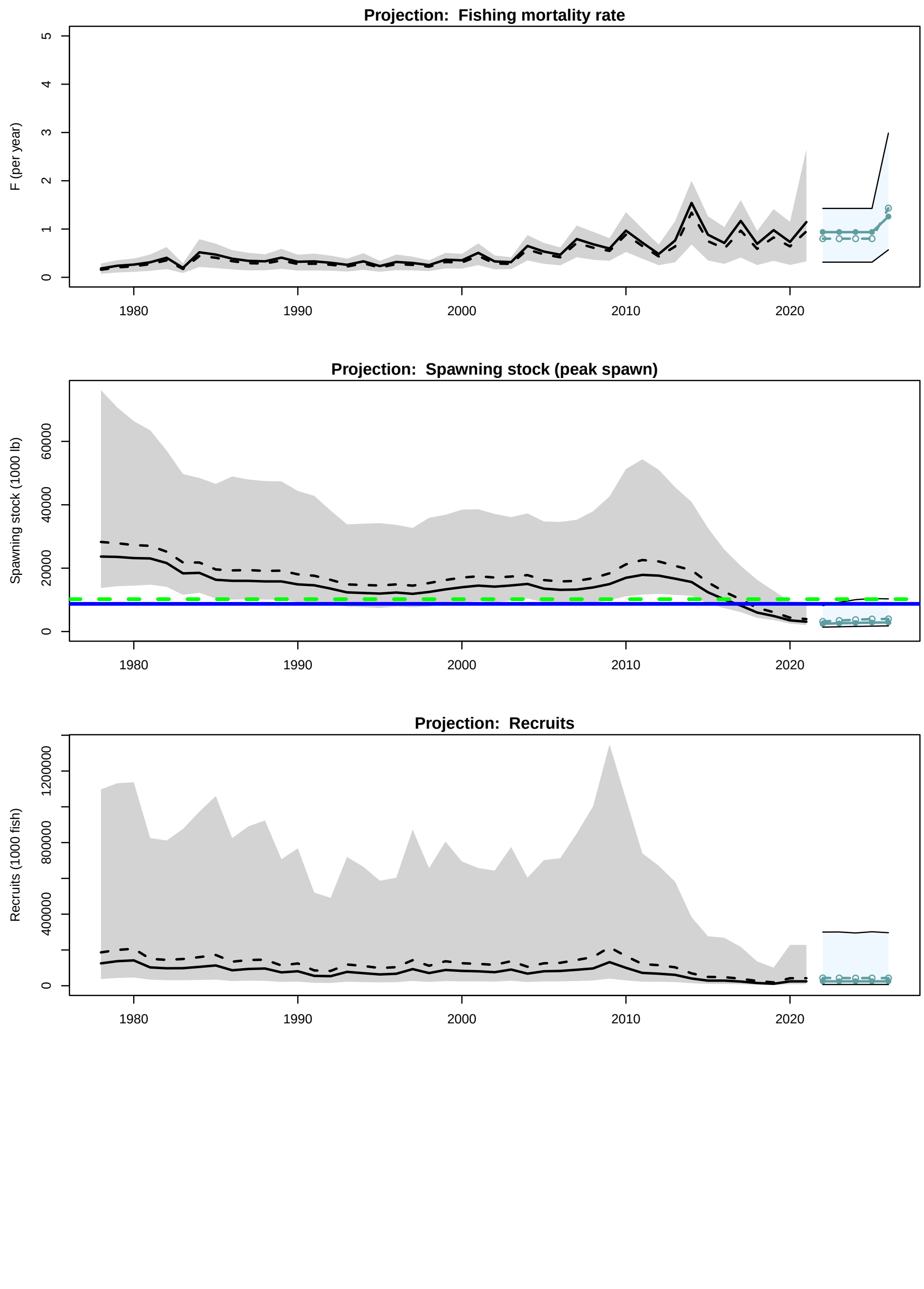


Figure 53. Projected fishing mortality (top left panel), spawning stock biomass (top right panel), landings (middle panels) in weight (left) and numbers (right) and discards (bottom panels) in weight (left) and numbers (right) for the projected time series for the scenario with fishing mortality rates at $F_{\text{Landed}} = P^*_{30\%}\ F_{30\%}$ and $F_{\text{Discard}} = F_{\text{current}}$ starting in 2026 and recent mean recruitment starting in 2023. 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.

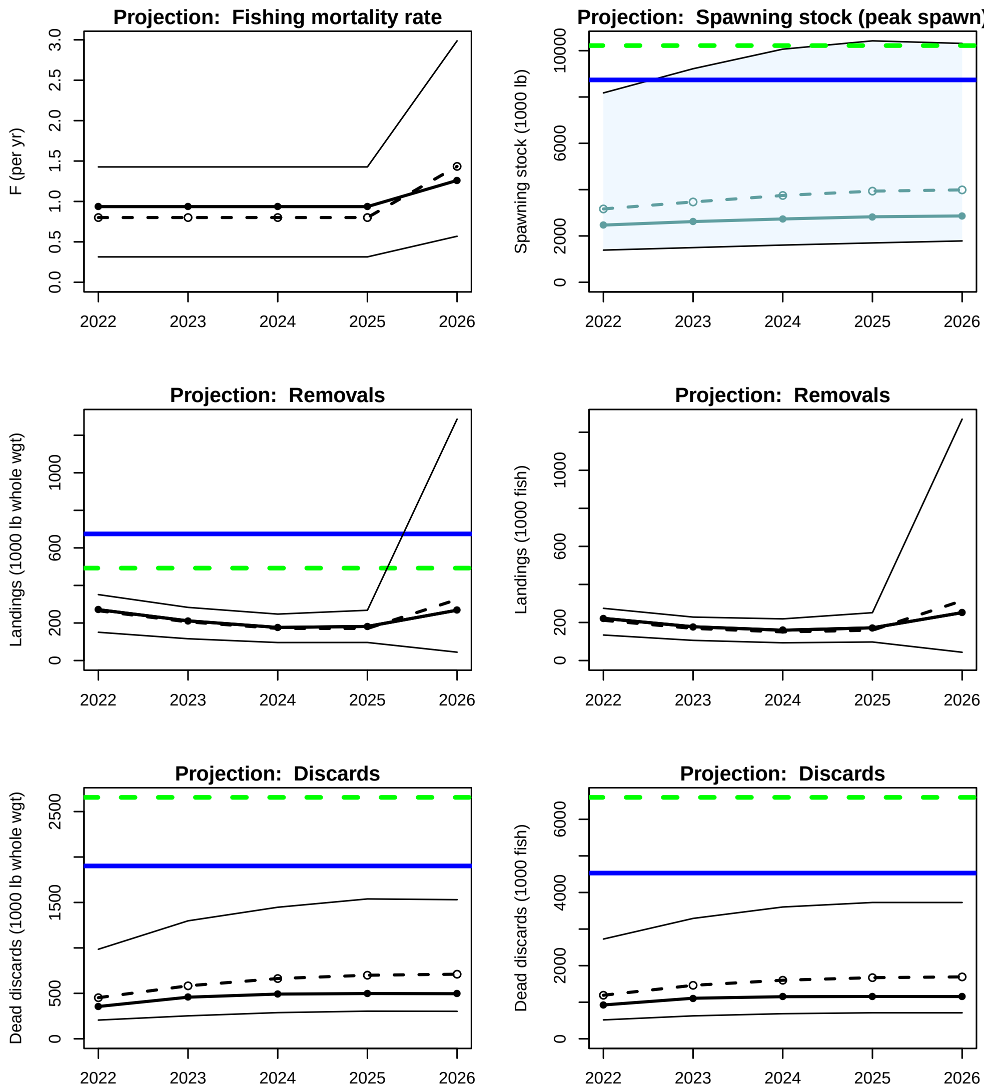


Figure 54. Top Panels: Projected probability of rebuilding to $\mathrm{SSB}_{\mathrm{F40\%}}$ *(left) and* $\mathrm{SSB}_{\mathrm{F30\%}}$ *(right) under scenario with fishing mortality rates at* $F_{\mathrm{Landed}} = P^{*}_{30\%}\ F_{30\%}$ *and* $F_{\mathrm{Discard}} = F_{\mathrm{current}}$ *starting in 2026 and recent mean recruitment. The curve represents the proportion of projection replicates for which SSB has reached the replicate-specific* $\mathrm{SSB}_{\mathrm{F40\%}}$ *or* $\mathrm{SSB}_{\mathrm{F30\%}}$*, 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.*

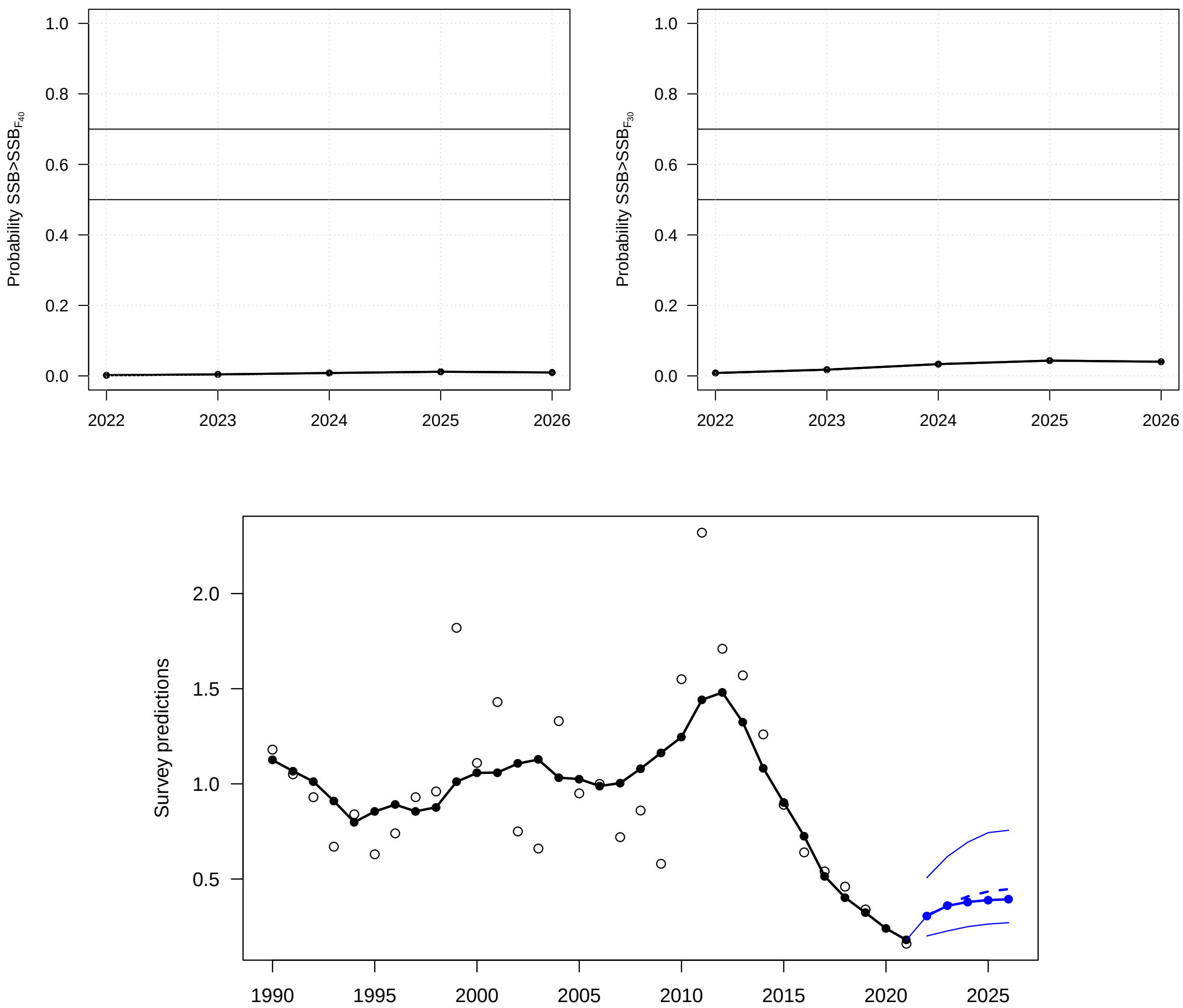


Figure 55. Projected time series for the scenario with fishing mortality rates at $F_{\text{Landed}} = P^*_{30\%}\ F_{30\%}$ *and* $F_{\text{Discard}} = P^*_{30\%}\ F_{30\%}$ *starting in 2026 and longterm average recruitment starting in 2023. Expected values (base run) represented by solid lines with 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.*

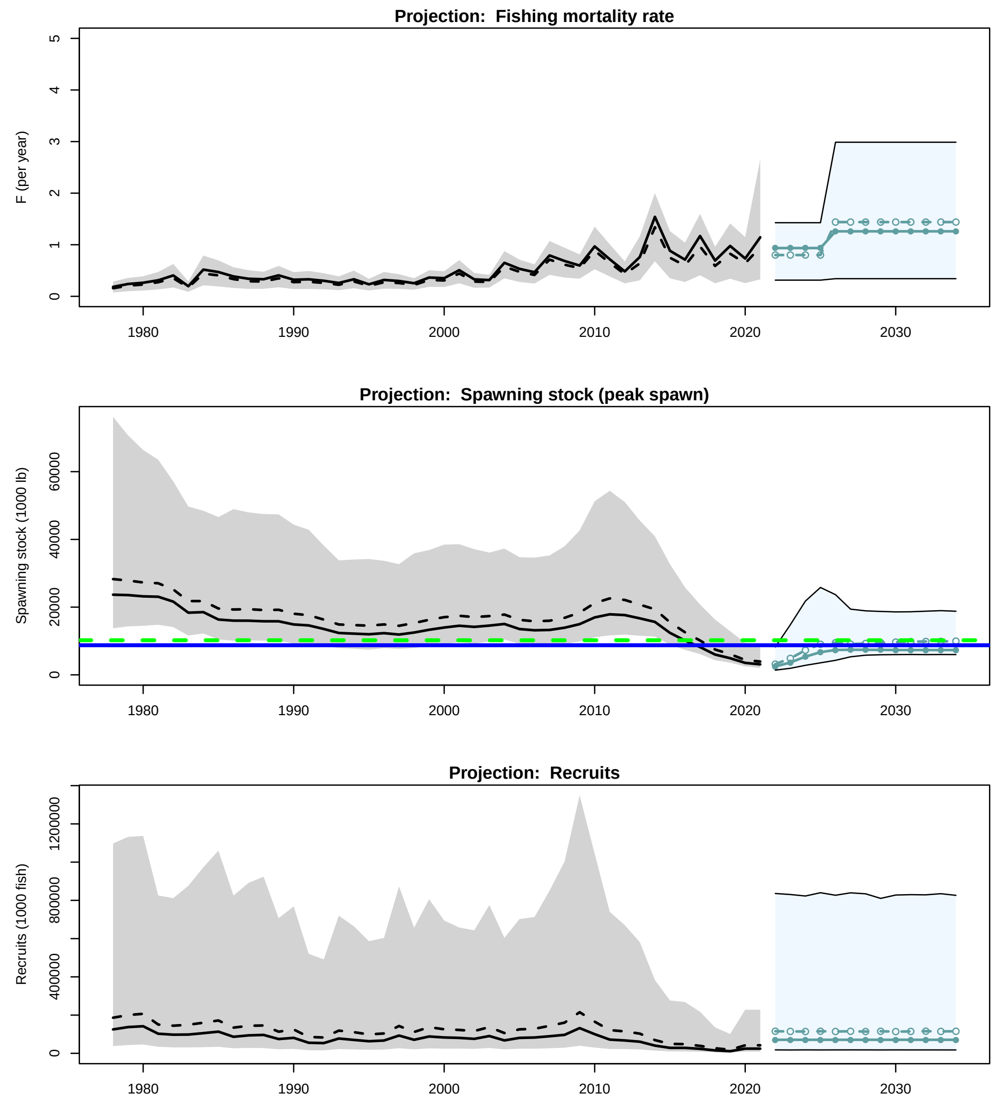


Figure 56. Projected fishing mortality (top left panel), spawning stock biomass (top right panel), landings (middle panels) in weight (left) and numbers (right) and discards (bottom panels) in weight (left) and numbers (right) for the projected time series for the scenario with fishing mortality rates at $F_{\text{Landed}} = P^*_{30\%}\ F_{30\%}$ and $F_{\text{Discard}} = P^*_{30\%}\ F_{30\%}$ starting in 2026 and longterm average recruitment starting in 2023. 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.

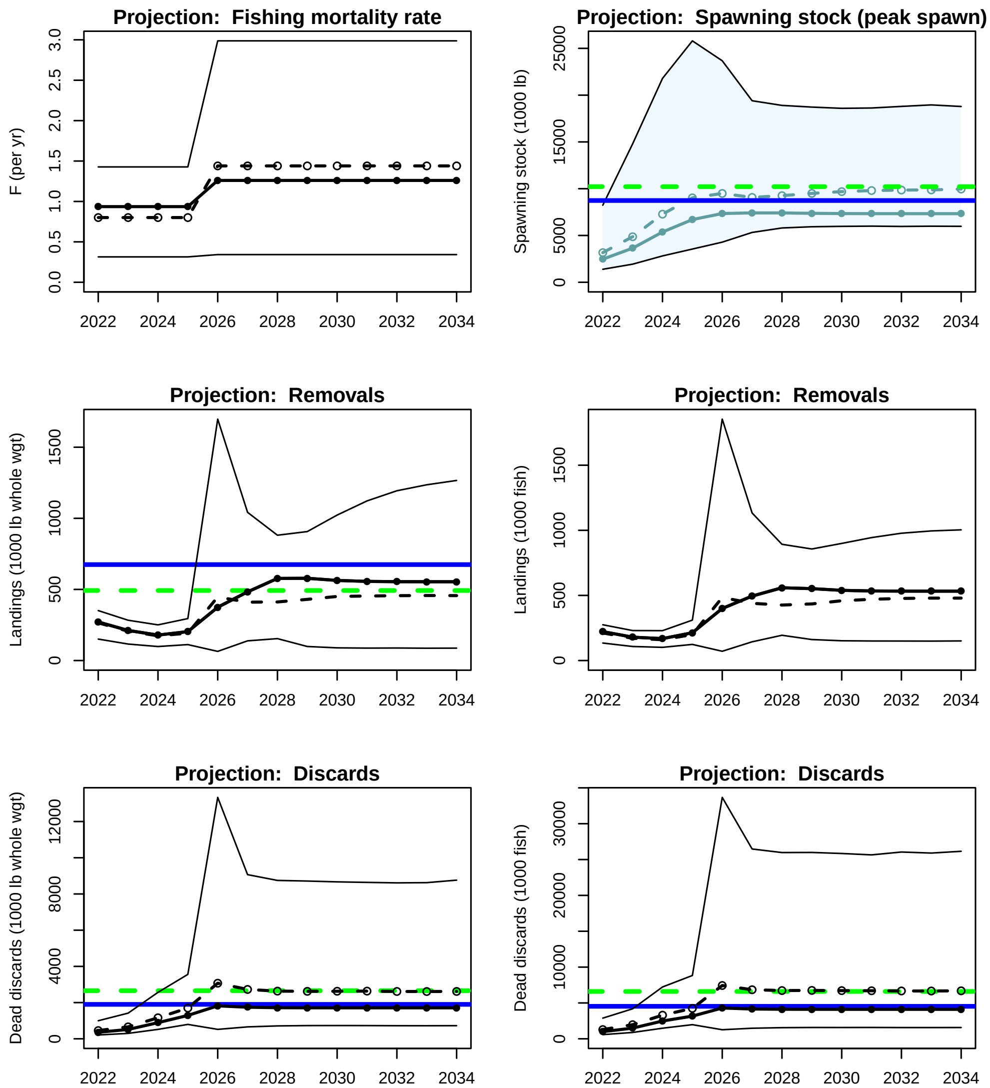


Figure 57. Top Panels: Projected probability of rebuilding to $\mathrm{SSB}_{\mathrm{F40\%}}$ *(left) and* $\mathrm{SSB}_{\mathrm{F30\%}}$ *(right) under scenario with fishing mortality rates at* $F_{\mathrm{Landed}} = P^{*}_{30\%}\ F_{30\%}$ *and* $F_{\mathrm{Discard}} = P^{*}_{30\%}\ F_{30\%}$ *starting in 2026 and longterm average recruitment. The curve represents the proportion of projection replicates for which SSB has reached the replicate-specific* $\mathrm{SSB}_{\mathrm{F40\%}}$ *or* $\mathrm{SSB}_{\mathrm{F30\%}}$*, 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.*

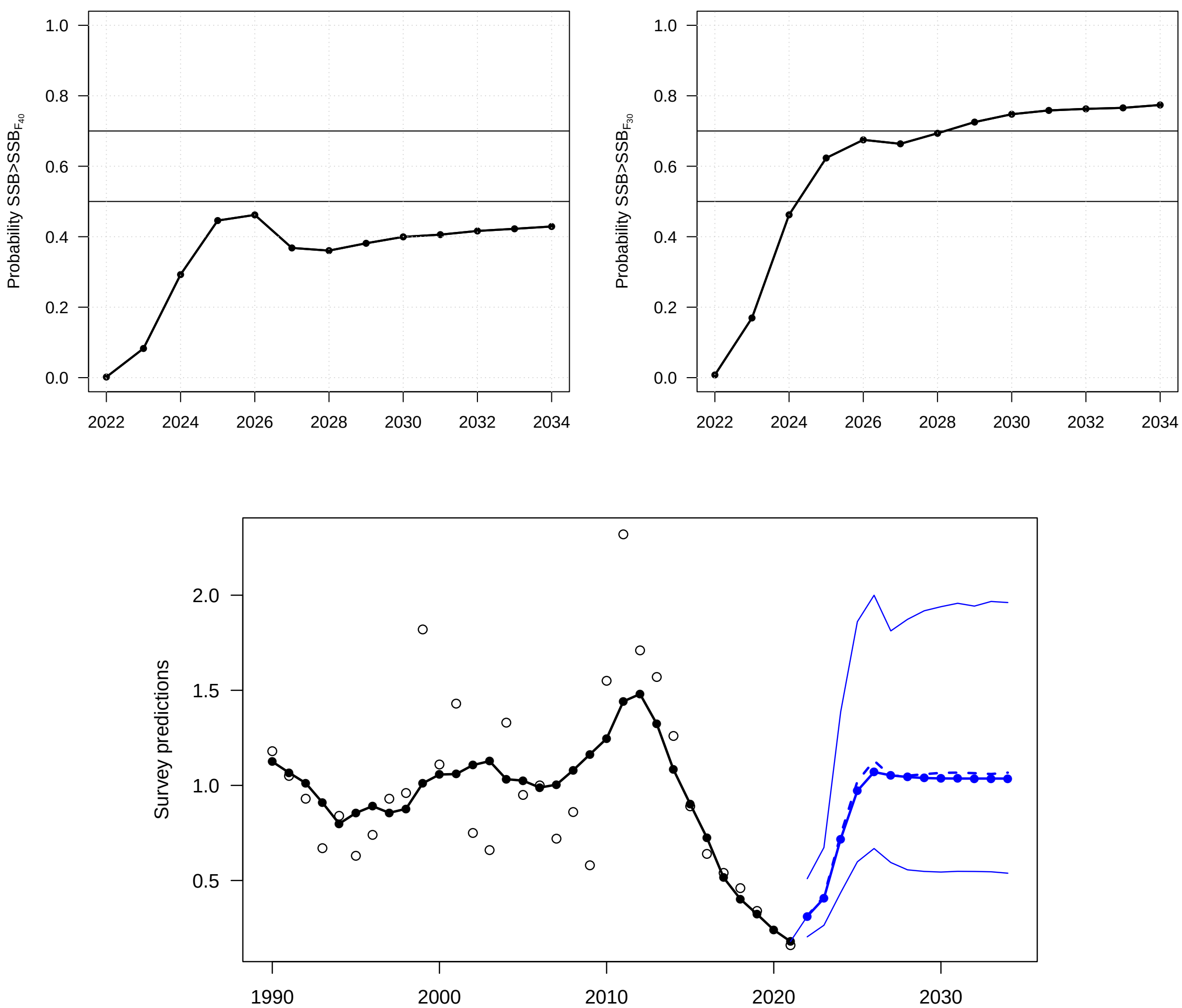


Figure 58. Projected time series for the scenario with fishing mortality rates at $F_{\text{Landed}} = P^*_{30\%}\ F_{30\%}$ and $F_{\text{Discard}} = P^*_{30\%}\ F_{30\%}$ starting in 2026 and recent mean recruitment starting in 2023. Expected values (base run) represented by solid lines with solid 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.

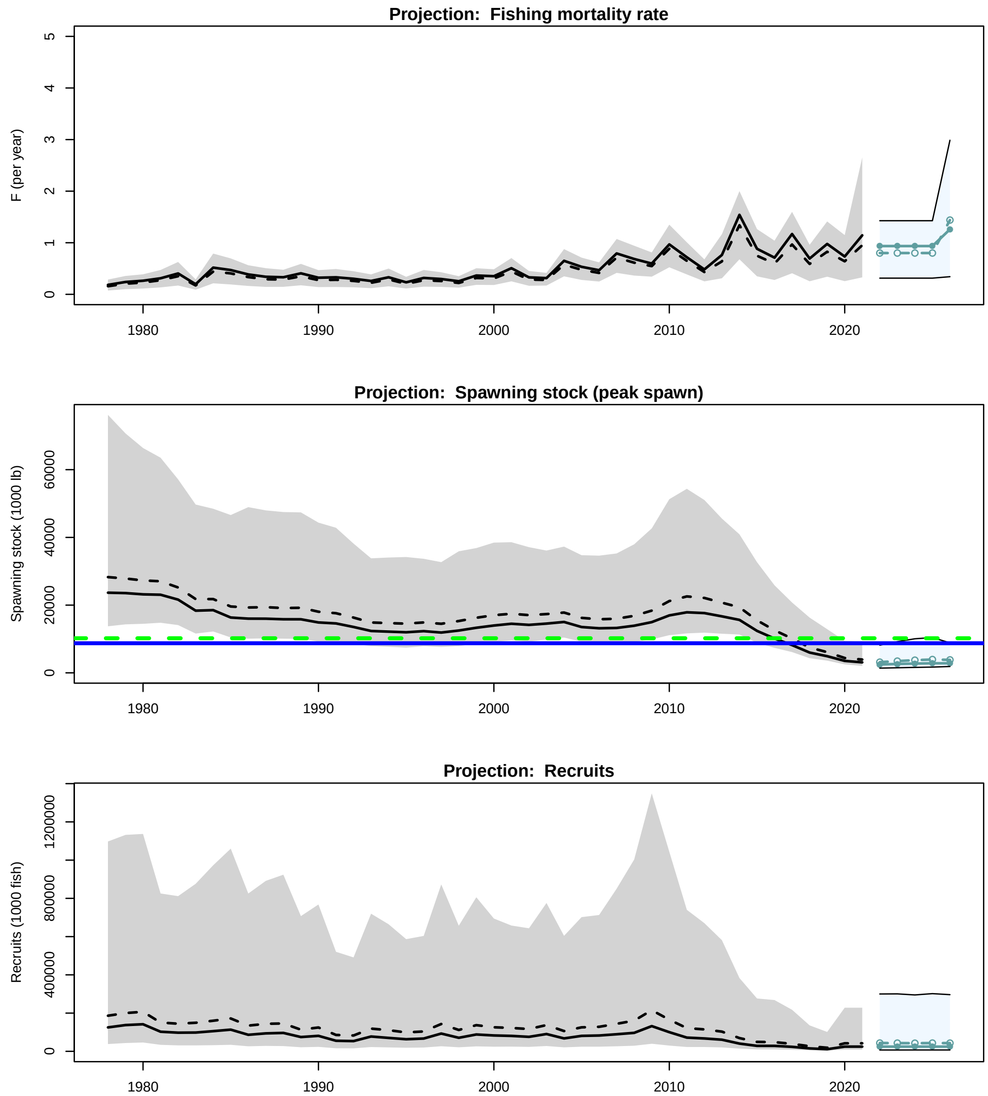


Figure 59. Projected fishing mortality (top left panel), spawning stock biomass (top right panel), landings (middle panels) in weight (left) and numbers (right) and discards (bottom panels) in weight (left) and numbers (right) for the projected time series for the scenario with fishing mortality rates at $F_{\text{Landed}} = P^{*}_{30\%}\ F_{30\%}$ *and* $F_{\text{Discard}} = P^{*}_{30\%}\ F_{30\%}$ *starting in 2026 and recent mean recruitment starting in 2023. 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.*

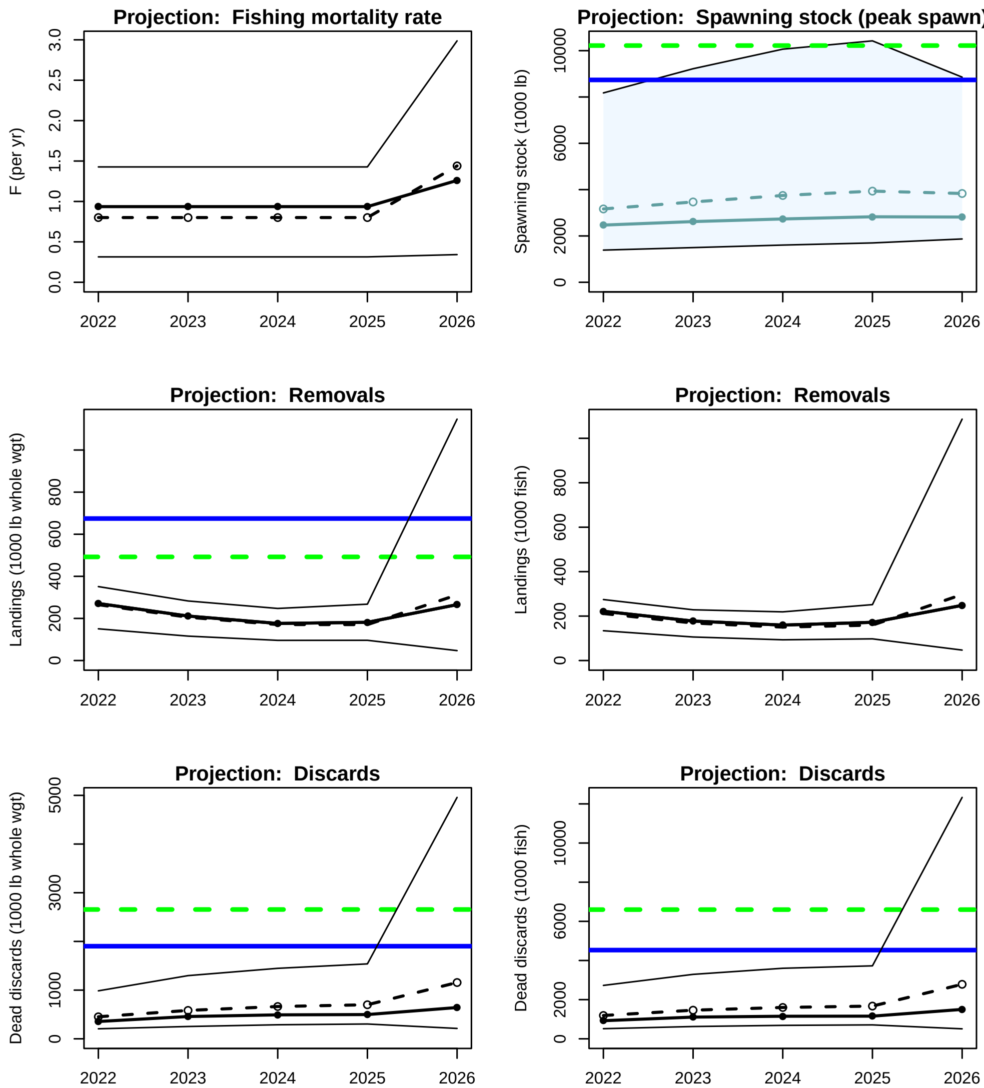


Figure 60. Top Panels: Projected probability of rebuilding to $\mathrm{SSB}_{\mathrm{F40\%}}$ *(left) and* $\mathrm{SSB}_{\mathrm{F30\%}}$ *(right) under scenario with fishing mortality rates at* $F_{\mathrm{Landed}} = P^{*}_{30\%}\ F_{30\%}$ *and* $F_{\mathrm{Discard}} = P^{*}_{30\%}\ F_{30\%}$ *starting in 2026 and recent mean recruitment. The curve represents the proportion of projection replicates for which SSB has reached the replicate-specific* $\mathrm{SSB}_{\mathrm{F40\%}}$ *or* $\mathrm{SSB}_{\mathrm{F30\%}}$*, 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.*