SEDAR73 Red Snapper Forecasts: New Methodology and Additional Scenarios

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Introduction

In an email memorandum dated 8 July 2021, from Dr. Chip Collier to Dr. Larry Massey, the SAFMC requested additional information about South Atlantic red snapper on behalf of the Council and the SSC. This report fulfills portions of that request. Specifically, this report addresses the following:

1. Additional information on alternative forecast methods to account for reduced discard mortality that may result from increased use of descender devices.

2. Sixteen additional forecast scenarios not provided in the SEDAR73 assessment report (SEDAR 2021). Details of these scenarios are documented below.

Methods

General

Except for modifications described here, the projection methods are identical to those used in the SEDAR73 stock assessment of red snapper (SEDAR 2021). In these revised analyses, fishing mortality rates take effect in 2022, instead of 2023 as in the assessment report. Landings in 2020–2021 are fixed at the arithmetic average from 2017–2019. All projections were run through 2044. The $F_{REBUILD}$ scenarios achieve stock recovery ($SSB>SSB_{MSY}$) with probability of at least 50% in 2044. In this assessment and in this report, the SPR level of 30% is used as a proxy for MSY reference points. Specifically, the target for rebuilding, $SSB_{MSY}=SSB_{F30\%}$ is based on the long-term average recruitment level as indicated in the SEDAR73 stock assessment.

The projection scenarios considered here are defined by the following characteristics:

- Mean recruitment is defined by either the full assessment period ("long-term") or terminal 10 years (2010–2019, "recent"). In either case, the mean is the geometric mean (median-unbiased), to which deterministic projections apply the multiplicative bias correction, and stochastic projections apply lognormal deviations defined by the σ_R estimated by the assessment.
- Fishing mortality takes one of two definitions, F30 or $F_{REBUILD}$. The actual fishing rate that F30 or $F_{REBUILD}$ depicts depends on other configuration details of the scenario.
- Discard mortality takes one of two levels, based on the usage of descender devices. These levels are defined by either Block 3 or Block 4 of the assessment report [Table 1 here;

Table 6 of the assessment report (SEDAR 2021)], for which Block 3 assumed 25% usage of descender devices and Block 4 assumed 75% usage. For projections, these blocks are applied in one of the following ways.

- Apply Block 3 levels. This approach utilizes the benchmarks computed for the assessment period [Table 27 of the assessment report (SEDAR 2021)].
- Apply Block 4 levels. This approach was used for projections in the SEDAR73 assessment report, and benchmarks computed for the assessment period were recomputed for consistency with the reduced, Block 4 levels [Table 29 in the assessment report (SEDAR 2021)].
- Apply a combination of Blocks 3 and 4 ("mixed approach"). The details of this approach depend on whether the fishing rate is defined by F30 or $F_{REBUILD}$.
    - In the case of F30, the combination approach applies the Block 3 F30 benchmark (assessment period) as the projected fishing rate, but decrements that rate applied to discards based on the Block 4 reductions starting in 2021. The projected F applied to landings is either held at F30 or else is increased, depending on the scenario. In scenarios with increased F toward landings, that reallocation is assumed to start in 2022.
    - In the case of $F_{REBUILD,}$ the combination approach requires two steps, in which the first step applies Block 3 discard mortality rates to compute $F_{REBUILD}$ and the second step applies Block 4 discard mortality. In the second step, the projection F ($F_{REBUILD}$) applied to discards is reduced starting in 2021, and the projection F applied to landings is either held constant at $F_{REBUILD}$ or else is increased starting in 2022, depending on the scenario. This "two-step" approach is documented in more detail below.

Note that some combinations of characteristics could result in overfishing. For example, if recruitment assumed the recent average, it was possible for $F_{REBUILD}$ to exceed F30. This was possible because the recent average recruitment is higher than the long-term average on which benchmarks were based. To avoid this possibility, $F_{REBUILD}$ was capped at the limit reference point of F30.

Mixed Approach to Discard Mortality

In all cases of the mixed approach to discard mortality (combined Blocks 3 and 4), benchmarks were those associated with Block 3, i.e., the benchmarks from the assessment period [Table 27 of the assessment report (SEDAR 2021)], based on average recruitment from the whole time series. Technical details of the mixed approach depended on whether the fishing rate was defined by F30 or $F_{REBUILD}$.

For the mixed approach with F30, the projection F (F_{PROJ}) is based on F30, but that fishing rate is decreased by a multiplier (M_D<1) for computing discards. Here, the F applied to discards is $F_D=M_DF_{PROJ}$. Computation of M_D is based on the relative decrease in discard mortality proportion when shifting from Block 3 to Block 4 (more details below). Similarly, the F applied to landings (F_L) is adjusted by a multiplier (M_L; $F_L=M_LF_{PROJ}$). In scenarios with no reallocation of F toward landings, M_L=1. In scenarios with reallocation toward landings, a two-step approach is required. First, the projection is run with F_{PROJ}=F30 (i.e., $M_D=M_L$=1) to compute the probability of $SSB_{2044}\geq SSB_{F30}$. Second, the projection is re-run with M_D decremented as described above, and M_L increased iteratively until achieving the same probability of $SSB_{2044}\geq SSB_{F30}$ as in step one.

For the mixed approach with $F_{REBUILD}$, a similar two-step approach is applied. Here, in the first step, $F_{REBUILD}$ is computed as the F that provides a 50% chance of stock recovery in the year 2044 ($SSB_{2044}\geq SSB_{F30}$). Then, in step two, $F_{PROJ}= F_{REBUILD}$ and the F applied to discards is decremented by M_D, such that $F_D=M_DF_{PROJ}$. In scenarios with no reallocation of F toward landings, M_L=1. In scenarios with reallocation toward landings, M_L is increased iteratively until achieving the desired 50% chance of rebuilding in 2044.

The value of M_D varies across iterations of the Monte Carlo Bootstrap Ensemble (MCBE). For each iteration (i), the reduction in discard mortality rate was computed as the F-weighted average discard mortality proportion from Block 4 ($D_{4,i}$) divided by the F-weighted average from Block 3 ($D_{3,i}$):

$$M_{D,i} = D_{4,i}/D_{3,i}$$

To compute $D_{3,i}$ and $D_{4,i}$, the fleet-specific discard mortality proportions from the commercial ($D.CH_{3,i}$ and $D.CH_{4,i}$), headboat ($D.HB_{3,i}$ and $D.HB_{4,i}$), and general recreational ($D.GR_{3,i}$ and $D.GR_{4,i}$) fleets (Table 1), were averaged after being weighted by their fleet-specific discard Fs. These F values ($F_{D.CH}$, $F_{D.HB,}$ and $F_{D.GR}$) were computed as geometric means from the terminal three assessment years. Thus, the F-weighted average discard mortality rates for each MCBE iteration and for each discard block were computed as,

$$D_{3,i} = \left(F_{D.CH}D.CH_{3,i} + F_{D.HB}D.HB_{3,i} + F_{D.GR}D.GR_{3,i}\right)/(F_{D.CH} + F_{D.HB} + F_{D.GR})$$

$$D_{4,i} = \left(F_{D.CH}D.CH_{4,i} + F_{D.HB}D.HB_{4,i} + F_{D.GR}D.GR_{4,i}\right)/(F_{D.CH} + F_{D.HB} + F_{D.GR})$$

Using the base run as an example, point estimates of discard mortality rates from Block 3 and Block 4 are shown in Table 1, and the terminal mean fishing rates are $F_{D.CH}$=0.005, $F_{D.HB}$=0.007, and $F_{D.GR}$=0.406, with $F_{D.CH} + F_{D.HB} + F_{D.GR} = 0.418$. Given these values,

$$D_{3,base} = (0.005 \times 0.36 + 0.007 \times 0.25 + 0.406 \times 0.26)/(0.418) = 0.261$$

$$D_{4,base} = (0.005 \times 0.32 + 0.007 \times 0.22 + 0.406 \times 0.23)/(0.418) = 0.231$$

Thus, in the base case, the proportional reduction in discard mortality rate would be $M_{D,base} = \frac{0.231}{0.261} = 0.885$. Across MCBE iterations, M_D ranged from 0.504 to 0.999, with a mean of 0.857, median of 0.872, and standard deviation of 0.096. Using this method, the resultant reduction in discard mortality rate is approximate, because M_D is computed from weighted proportions but applied as a reduction in the instantaneous discard mortality rate.

Projection Scenarios

The various scenarios of this report are defined in Table 2 and are listed below. "Mixed" refers to the use of Block 3 benchmarks and Block 4 discard mortality.

- Scenario 1: Long-term mean recruitment, Block 3, F30
- Scenario 2: Long-term mean recruitment, Block 3, $F_{REBUILD}$
- Scenario 3: Long-term mean recruitment, Block 4, F30
- Scenario 4: Long-term mean recruitment, Block 4, $F_{REBUILD}$
- Scenario 5: Long-term mean recruitment, Mixed, F30, No reallocation of F toward landings
- Scenario 6: Long-term mean recruitment, Mixed, F30, Reallocation of F toward landings to provide same probability of rebuilding as in Scenario 1
- Scenario 7: Long-term mean recruitment, Mixed, $F_{REBUILD}$ from Scenario 2, No reallocation of F toward landings
- Scenario 8: Long-term mean recruitment, Mixed, $F_{REBUILD}$ from Scenario 2, Reallocation of F toward landings to provide 50% chance of rebuilding
- Scenario 9: Last 10-yr mean recruitment, Block 3, F30
- Scenario 10: Last 10-yr mean recruitment, Block 3, $F_{REBUILD}$
- Scenario 11: Last 10-yr mean recruitment, Block 4, F30
- Scenario 12: Last 10-yr mean recruitment, Block 4, $F_{REBUILD}$
- Scenario 13: Last 10-yr mean recruitment, Mixed, F30, No reallocation of F toward landings
- Scenario 14: Last 10-yr mean recruitment, Mixed, F30, Reallocation of F toward landings to provide same probability of rebuilding as in Scenario 9
- Scenario 15: Last 10-yr mean recruitment, Mixed, $F_{REBUILD}$ from Scenario 10, No reallocation of F toward landings
- Scenario 16: Last 10-yr mean recruitment, Mixed, $F_{REBUILD}$ from Scenario 10, Reallocation of F toward landings to provide 50% chance of rebuilding

Results

Results of scenarios using long-term mean recruitment (Scenarios 1–8) are shown in Tables 3–10 and Figures 1–8. Results of scenarios using recent mean recruitment (Scenarios 9–16) are shown

in Tables 11–18 and Figures 9–16. In all cases with recent mean recruitment, the stock could recover when fishing at F30. This occurred because the recent mean recruitment was higher than the long-term average on which benchmarks were based. Thus, in these cases, $F_{REBUILD}$ was capped at its analogous F30, such that Scenario 10 was identical to Scenario 9, Scenario 12 was identical to Scenario 11, Scenario 15 was identical to Scenario 13, and Scenario 16 was identical to Scenario 14.

Discussion

The forecasts of this report are accompanied by the typical list of caveats when forecasting fishery population dynamics (see SEDAR 2021). A key uncertainty here and when forecasting any fish stock lies in the level of future recruitment. If future recruitment remains higher than the long-term average, the South Atlantic stock of red snapper could recover before 2030. Currently there is no science or data analysis to support which future recruitment scenario is more likely for red snapper. Each scenario comes with a set of risks that could be realized if future recruitment does not occur as modeled. Further research and analysis might improve our ability to forecast red snapper recruitment, but for now it remains an influential source of uncertainty.

In the terminal three years of the assessment (2017–2019), estimates of total discard mortality (number fish) from the base assessment model were 409,472, 816,571, and 507,334, respectively, with an arithmetic mean near 578,000 fish. Over these three years, the proportion of these annual dead discards that were due to the general recreational fleet ranged from 96% to 98%. Relative to the current estimate of dead discards exceeding half a million fish, all of the forecast scenarios in this report require substantial reductions in discard mortality (Tables 3–18). For example, Scenario 1 allows for approximately 141,000 dead discards (base case), which is about 24% of the current average. Increased use of descender devices provided reductions in discard mortality (e.g., Scenarios 5-8 compared to Scenarios 1–4), however this reduction is nowhere near the scale of reduction required to meet the discard mortality levels in these rebuilding forecasts. To do so, additional management techniques will be required to reduce the number of red snapper being discarded. The SEDAR73 assessment, along with these projections, point toward one primary management implication: the need for a moderate to large overall reduction in red snapper discards, especially by the general recreational fleet.

Literature

SEDAR. 2021. SEDAR 73 South Atlantic Red Snapper Stock Assessment Report. SEDAR, North Charleston SC. 194 pp. available online at: http://sedarweb.org/sedar-73.

Table 1. Discard mortality for commercial handlines (cH), headboat (HB), and general recreational (GR). For cH, Block 1 ends in 2006, and Block 2 is 2007–2016. For HB and GR, Block 1 ends in 2010, and Block 2 is 2011–2017. For all fleets, Blcok 3 is 2017–2020, and Block 4 is post-2020. Shown in parentheses are the ranges used in uncertainty analyses. Note, this table is Table 6 of the SEDAR73 assessment report (SEDAR 2021), reproduced here for ease of reference.

Fleet	Block 1	Block 2	Block 3	Block 4
cH	$0.48(0.38-0.58)$	$0.38(0.28-0.48)$	$0.36(0.26-0.46)$	$0.32(0.22-0.42)$
HB	$0.37(0.27-0.45)$	$0.26(0.18-0.34)$	$0.25(0.17-0.33)$	$0.22(0.14-0.30)$
GR	$0.37(0.27-0.45)$	$0.28(0.20-0.36)$	$0.26(0.18-0.34)$	$0.23(0.15-0.31)$

Table 2. Characteristics of projection scenarios in this report. Discard mortality utilizes estimates from Block 3 or Block 4, or otherwise a mix of those estimates (Table 1). In scenarios using Block 3 only or Mixed approaches to discard mortality, the reference points (benchmarks) are from Block 3, the same benchmarks used in the assessment to gauge stock and fishery status from the assessment time period. In scenarios with only Block 4 discard mortality, the benchmarks were recomputed as described in the SEDAR73 assessment report (SEDAR73 2021).

Scenario	Recruitment	Discard mortality	F definition	Reallocate to L
1	Long-term mean	Block 3	F30	NA
2	Long-term mean	Block 3	Frebuild	NA
3	Long-term mean	Block 4	F30	NA
4	Long-term mean	Block 4	Frebuild	NA
5	Long-term mean	Mixed	F30	No
6	Long-term mean	Mixed	F30	Yes
7	Long-term mean	Mixed	Frebuild	No
8	Long-term mean	Mixed	Frebuild	Yes
9	Last 10-yr mean	Block 3	F30	NA
10	Last 10-yr mean	Block 3	Frebuild	NA
11	Last 10-yr mean	Block 4	F30	NA
12	Last 10-yr mean	Block 4	Frebuild	NA
13	Last 10-yr mean	Mixed	F30	No
14	Last 10-yr mean	Mixed	F30	Yes
15	Last 10-yr mean	Mixed	Frebuild	No
16	Last 10-yr mean	Mixed	Frebuild	Yes

Table 3. Scenario 1 projection results with F=F30 starting in 2022 and long-term average recruitment. Benchmarks and discard mortality are based on Block 3. R = number of age-1 recruits (in 1000s), F = fishing mortality rate (per year), S = spawning stock (1e8 eggs), L = landings expressed in numbers (n, in 1000s) or whole weight (w, in 1000 lb), D = dead discards expressed in numbers (n, in 1000s) or whole weight (w, in 1000 lb), and pr.reb = proportion of stochastic projection replicates with SSB $\geq$ SSB_{F30}. The extension "b" indicates expected values (deterministic) from the base run; the extension "m" indicates median values from the stochastic projections.

year	R.b	R.m	F.b	F.m	S.b	S.m	L.b(n)	L.m(n)	L.b(w)	L.m(w)	D.b(n)	D.m(n)	D.b(w)	D.m(w)	pr.reb
2020	437	380	0.39	0.34	306993	324501	40	39	416	409	408	378	1980	1874	0.052
2021	437	380	0.35	0.31	338742	362750	38	37	416	409	303	278	1671	1581	0.102
2022	437	381	0.21	0.21	374249	400208	22	25	266	297	153	156	874	932	0.153
2023	437	380	0.21	0.21	411269	433572	23	25	287	318	145	143	813	837	0.194
2024	437	381	0.21	0.21	443883	461733	23	25	302	331	142	138	773	770	0.227
2025	437	381	0.21	0.21	472381	485420	23	25	316	343	141	135	756	740	0.258
2026	437	377	0.21	0.21	496643	504784	24	25	329	352	141	135	751	727	0.281
2027	437	382	0.21	0.21	517862	520009	24	25	340	359	141	135	750	724	0.299
2028	437	381	0.21	0.21	535363	531677	24	25	349	366	141	135	751	724	0.315
2029	437	380	0.21	0.21	550214	541827	24	25	357	371	141	135	753	725	0.327
2030	437	378	0.21	0.21	562764	549243	25	25	364	375	141	135	754	727	0.336
2031	437	378	0.21	0.21	573277	555505	25	25	370	379	141	135	755	729	0.343
2032	437	380	0.21	0.21	582420	561037	25	25	375	382	141	135	756	729	0.352
2033	437	380	0.21	0.21	590058	565785	25	26	379	385	141	135	756	731	0.359
2034	437	381	0.21	0.21	596479	569695	25	26	383	388	141	135	757	731	0.365
2035	437	380	0.21	0.21	602101	573675	25	26	386	390	141	135	757	732	0.373
2036	437	379	0.21	0.21	606882	576363	26	26	389	391	141	135	757	732	0.379
2037	437	380	0.21	0.21	610837	578759	26	26	391	393	141	136	758	734	0.388
2038	437	381	0.21	0.21	614247	580997	26	26	393	394	141	136	758	735	0.395
2039	437	379	0.21	0.21	617142	582883	26	26	394	396	141	135	758	737	0.403
2040	437	381	0.21	0.21	619652	584419	26	26	396	397	141	135	758	736	0.409
2041	437	385	0.21	0.21	621821	585520	26	26	397	398	141	136	758	734	0.417
2042	437	381	0.21	0.21	623691	586753	26	26	398	399	141	135	758	736	0.424
2043	437	382	0.21	0.21	625305	588433	26	26	399	400	141	135	759	734	0.428
2044	437	380	0.21	0.21	626696	588621	26	26	400	400	141	135	759	735	0.435

Table 4. Scenario 2 projection results with F= $F_{REBUILD}$ starting in 2022 and long-term average recruitment. Benchmarks and discard mortality are based on Block 3. R = number of age-1 recruits (in 1000s), F = fishing mortality rate (per year), S = spawning stock (1e8 eggs), L = landings expressed in numbers (n, in 1000s) or whole weight (w, in 1000 lb), D = dead discards expressed in numbers (n, in 1000s) or whole weight (w, in 1000 lb), and pr.reb = proportion of stochastic projection replicates with SSB $\geq$ SSB_{F30}. The extension "b" indicates expected values (deterministic) from the base run; the extension "m" indicates median values from the stochastic projections.

year	R.b	R.m	F.b	F.m	S.b	S.m	L.b(n)	L.m(n)	L.b(w)	L.m(w)	D.b(n)	D.m(n)	D.b(w)	D.m(w)	pr.reb
2020	437	380	0.39	0.34	306993	324501	40	39	416	409	408	378	1980	1874	0.052
2021	437	380	0.35	0.31	338742	362750	38	37	416	409	303	278	1671	1581	0.102
2022	437	381	0.2	0.2	374773	400826	22	24	261	291	150	153	858	915	0.154
2023	437	380	0.2	0.2	412734	435225	22	24	282	313	143	141	801	824	0.197
2024	437	381	0.2	0.2	446371	464289	22	24	298	327	140	136	763	760	0.232
2025	437	381	0.2	0.2	475915	488924	23	24	312	339	139	133	747	731	0.266
2026	437	377	0.2	0.2	501212	509399	23	24	325	348	139	133	742	719	0.293
2027	437	382	0.2	0.2	523441	525511	24	25	337	356	139	133	742	717	0.316
2028	437	381	0.2	0.2	541895	538067	24	25	347	363	139	133	743	716	0.335
2029	437	380	0.2	0.2	557640	549137	24	25	355	369	139	133	745	718	0.35
2030	437	378	0.2	0.2	571011	557469	25	25	362	373	139	133	746	719	0.365
2031	437	378	0.2	0.2	582267	564212	25	25	368	377	139	133	747	721	0.377
2032	437	380	0.2	0.2	592085	570344	25	25	374	381	139	133	748	722	0.389
2033	437	380	0.2	0.2	600322	575400	25	25	378	384	139	133	748	724	0.398
2034	437	381	0.2	0.2	607274	579864	25	25	382	386	139	133	749	724	0.41
2035	437	380	0.2	0.2	613368	584258	25	26	385	389	139	133	749	724	0.42
2036	437	379	0.2	0.2	618565	587259	25	26	388	390	139	134	750	725	0.431
2037	437	380	0.2	0.2	622882	589963	26	26	390	392	140	134	750	727	0.438
2038	437	381	0.2	0.2	626610	592629	26	26	392	394	140	134	750	728	0.449
2039	437	379	0.2	0.2	629781	594756	26	26	394	396	140	133	750	729	0.461
2040	437	381	0.2	0.2	632533	596423	26	26	396	397	140	133	751	728	0.468
2041	437	385	0.2	0.2	634912	597728	26	26	397	398	140	134	751	727	0.476
2042	437	381	0.2	0.2	636966	599091	26	26	398	399	140	134	751	728	0.484
2043	437	382	0.2	0.2	638739	600958	26	26	399	400	140	133	751	727	0.496
2044	437	380	0.2	0.2	640270	601435	26	26	400	400	140	134	751	728	0.503

Table 5. Scenario 3 projection results with F=F30 starting in 2022 and long-term average recruitment. Benchmarks and discard mortality are based on Block 4. R = number of age-1 recruits (in 1000s), F = fishing mortality rate (per year), S = spawning stock (1e8 eggs), L = landings expressed in numbers (n, in 1000s) or whole weight (w, in 1000 lb), D = dead discards expressed in numbers (n, in 1000s) or whole weight (w, in 1000 lb), and pr.reb = proportion of stochastic projection replicates with SSB $\geq$ SSB_{F30}. The extension "b" indicates expected values (deterministic) from the base run; the extension "m" indicates median values from the stochastic projections.

year	R.b	R.m	F.b	F.m	S.b	S.m	L.b(n)	L.m(n)	L.b(w)	L.m(w)	D.b(n)	D.m(n)	D.b(w)	D.m(w)	pr.reb
2020	437	380	0.39	0.34	306993	324501	40	39	416	409	408	378	1980	1874	0.052
2021	437	380	0.35	0.31	342360	367864	38	37	420	413	272	240	1499	1369	0.107
2022	437	381	0.22	0.23	381156	408572	25	29	295	341	151	153	868	917	0.166
2023	437	380	0.22	0.23	419337	443294	25	29	319	363	143	140	805	823	0.21
2024	437	381	0.22	0.23	452549	471021	25	28	336	378	139	134	761	753	0.245
2025	437	381	0.22	0.23	481211	495016	26	28	352	390	138	131	741	720	0.278
2026	437	377	0.22	0.23	505342	513966	26	28	365	400	137	130	734	705	0.301
2027	437	382	0.22	0.23	526244	528758	26	28	377	409	137	129	733	701	0.32
2028	437	381	0.22	0.23	543277	540162	27	28	386	415	137	129	733	699	0.335
2029	437	380	0.22	0.23	557585	549314	27	28	395	421	137	130	735	701	0.346
2030	437	378	0.22	0.23	569540	556258	27	29	402	425	137	130	736	702	0.355
2031	437	378	0.22	0.23	579445	561595	27	29	408	429	137	130	736	704	0.362
2032	437	380	0.22	0.23	588003	566958	28	29	413	432	137	130	737	706	0.37
2033	437	380	0.22	0.23	595080	570276	28	29	417	435	137	130	737	707	0.374
2034	437	381	0.22	0.23	600978	573689	28	29	421	438	137	130	738	707	0.38
2035	437	380	0.22	0.23	606122	577088	28	29	424	440	137	130	738	707	0.386
2036	437	379	0.22	0.23	610469	579839	28	29	426	441	137	130	739	707	0.392
2037	437	380	0.22	0.23	614032	581782	28	29	429	443	137	130	739	709	0.4
2038	437	381	0.22	0.23	617088	583909	28	29	430	445	137	131	739	710	0.407
2039	437	379	0.22	0.23	619664	585201	28	29	432	446	137	130	739	712	0.413
2040	437	381	0.22	0.23	621892	586109	28	29	433	447	137	130	739	711	0.418
2041	437	385	0.22	0.23	623810	587230	28	29	435	448	138	130	739	710	0.425
2042	437	381	0.22	0.23	625459	588360	28	30	436	448	138	130	740	710	0.432
2043	437	382	0.22	0.23	626877	589534	29	30	436	450	138	130	740	709	0.436
2044	437	380	0.22	0.23	628097	589834	29	30	437	450	138	130	740	709	0.442

Table 6. Scenario 4 projection results with F= $F_{REBUILD}$ starting in 2022 and long-term average recruitment. Benchmarks and discard mortality are based on Block 4. R = number of age-1 recruits (in 1000s), F = fishing mortality rate (per year), S = spawning stock (1e8 eggs), L = landings expressed in numbers (n, in 1000s) or whole weight (w, in 1000 lb), D = dead discards expressed in numbers (n, in 1000s) or whole weight (w, in 1000 lb), and pr.reb = proportion of stochastic projection replicates with SSB $\geq SSB_{F30}$. The extension "b" indicates expected values (deterministic) from the base run; the extension "m" indicates median values from the stochastic projections.

year	R.b	R.m	F.b	F.m	S.b	S.m	L.b(n)	L.m(n)	L.b(w)	L.m(w)	D.b(n)	D.m(n)	D.b(w)	D.m(w)	pr.reb
2020	437	380	0.39	0.34	306993	324501	40	39	416	409	408	378	1980	1874	0.052
2021	437	380	0.35	0.31	342360	367864	38	37	420	413	272	240	1499	1369	0.107
2022	437	381	0.22	0.22	381642	409105	25	28	290	335	148	150	853	902	0.167
2023	437	380	0.22	0.22	420695	444619	25	28	314	358	141	137	794	811	0.213
2024	437	381	0.22	0.22	454851	473467	25	28	332	373	137	132	752	743	0.251
2025	437	381	0.22	0.22	484473	498384	25	28	348	386	136	129	733	712	0.286
2026	437	377	0.22	0.22	509550	518168	26	28	362	397	136	128	726	698	0.312
2027	437	382	0.22	0.22	531369	533915	26	28	373	405	136	128	726	694	0.334
2028	437	381	0.22	0.22	549262	546114	27	28	384	412	136	128	726	692	0.354
2029	437	380	0.22	0.22	564372	556015	27	28	392	418	136	128	728	694	0.369
2030	437	378	0.22	0.22	577061	563607	27	28	400	423	136	128	729	695	0.382
2031	437	378	0.22	0.22	587630	569398	27	29	406	427	136	128	729	697	0.394
2032	437	380	0.22	0.22	596785	575433	28	29	411	430	136	129	730	699	0.404
2033	437	380	0.22	0.22	604391	579203	28	29	416	434	136	128	731	701	0.412
2034	437	381	0.22	0.22	610756	582941	28	29	420	437	136	128	731	700	0.419
2035	437	380	0.22	0.22	616314	586861	28	29	423	439	136	129	731	700	0.43
2036	437	379	0.22	0.22	621024	589855	28	29	426	440	136	129	732	701	0.44
2037	437	380	0.22	0.22	624902	591970	28	29	428	442	136	129	732	702	0.447
2038	437	381	0.22	0.22	628233	594277	28	29	430	444	136	129	732	703	0.455
2039	437	379	0.22	0.22	631049	595847	28	29	432	446	136	129	732	706	0.465
2040	437	381	0.22	0.22	633484	596890	28	29	433	447	136	129	732	705	0.472
2041	437	385	0.22	0.22	635583	598339	28	29	434	448	136	129	733	704	0.478
2042	437	381	0.22	0.22	637389	599469	28	29	436	448	136	129	733	704	0.487
2043	437	382	0.22	0.22	638943	600620	28	30	436	450	136	128	733	703	0.496
2044	437	380	0.22	0.22	640281	601199	28	30	437	450	136	129	733	703	0.502

Table 7. Scenario 5 projection results with F= F30 starting in 2022 and long-term average recruitment. Benchmarks are based on Block 3 and discard mortality on Block 4 with no reallocation of F toward landings. R = number of age-1 recruits (in 1000s), F = fishing mortality rate (per year), S = spawning stock (1e8 eggs), L = landings expressed in numbers (n, in 1000s) or whole weight (w, in 1000 lb), D = dead discards expressed in numbers (n, in 1000s) or whole weight (w, in 1000 lb), and pr.reb = proportion of stochastic projection replicates with SSB $\geq$ SSB_{F30}. The extension "b" indicates expected values (deterministic) from the base run; the extension "m" indicates median values from the stochastic projections.

year	R.b	R.m	F.b	F.m	S.b	S.m	L.b(n)	L.m(n)	L.b(w)	L.m(w)	D.b(n)	D.m(n)	D.b(w)	D.m(w)	pr.reb
2020	437	380	0.39	0.34	306993	324501	40	39	416	409	408	378	1980	1874	0.052
2021	437	380	0.35	0.31	342360	367864	38	37	420	413	272	240	1499	1369	0.107
2022	437	381	0.21	0.21	383368	411610	23	26	272	306	139	138	802	828	0.172
2023	437	380	0.21	0.21	425543	451782	24	26	297	332	133	127	753	754	0.228
2024	437	381	0.21	0.21	463111	485158	24	26	316	349	130	123	718	698	0.278
2025	437	381	0.21	0.21	496234	514040	24	26	333	364	129	120	703	672	0.326
2026	437	377	0.21	0.21	524777	537790	25	27	348	376	129	120	699	660	0.367
2027	437	382	0.21	0.21	549973	558120	25	27	362	387	129	120	699	658	0.407
2028	437	381	0.21	0.21	571053	574740	26	27	373	396	129	120	700	656	0.442
2029	437	380	0.21	0.21	589145	588635	26	27	383	403	129	120	701	659	0.475
2030	437	378	0.21	0.21	604572	600270	26	27	391	409	129	120	703	660	0.505
2031	437	378	0.21	0.21	617621	609684	27	28	399	415	129	120	703	663	0.532
2032	437	380	0.21	0.21	629021	616987	27	28	405	420	129	120	704	663	0.555
2033	437	380	0.21	0.21	638622	623669	27	28	410	424	129	120	705	664	0.579
2034	437	381	0.21	0.21	646751	628410	27	28	415	428	129	120	705	665	0.602
2035	437	380	0.21	0.21	653879	633676	27	28	419	431	129	120	706	666	0.619
2036	437	379	0.21	0.21	659968	637613	28	28	422	434	129	120	706	666	0.636
2037	437	380	0.21	0.21	665049	641425	28	28	425	437	129	120	706	667	0.649
2038	437	381	0.21	0.21	669434	644985	28	29	427	439	130	121	707	669	0.664
2039	437	379	0.21	0.21	673167	647829	28	29	430	441	130	121	707	671	0.678
2040	437	381	0.21	0.21	676404	650366	28	29	431	442	130	120	707	670	0.69
2041	437	385	0.21	0.21	679200	653062	28	29	433	443	130	121	707	669	0.702
2042	437	381	0.21	0.21	681614	654532	28	29	434	445	130	120	707	670	0.71
2043	437	382	0.21	0.21	683697	656977	28	29	435	446	130	121	708	669	0.721
2044	437	380	0.21	0.21	685495	657844	28	29	436	447	130	121	708	670	0.729

Table 8. Scenario 6 projection results with F= F30 starting in 2022 and long-term average recruitment. Benchmarks are based on Block 3 and discard mortality on Block 4 with reallocation of F toward landings. R = number of age-1 recruits (in 1000s), F = fishing mortality rate (per year), S = spawning stock (1e8 eggs), L = landings expressed in numbers (n, in 1000s) or whole weight (w, in 1000 lb), D = dead discards expressed in numbers (n, in 1000s) or whole weight (w, in 1000 lb), and pr.reb = proportion of stochastic projection replicates with SSB $\geq$ SSB_{F30}. The extension "b" indicates expected values (deterministic) from the base run; the extension "m" indicates median values from the stochastic projections.

year	R.b	R.m	F.b	F.m	S.b	S.m	L.b(n)	L.m(n)	L.b(w)	L.m(w)	D.b(n)	D.m(n)	D.b(w)	D.m(w)	pr.reb
2020	437	380	0.39	0.34	306993	324501	40	39	416	409	408	378	1980	1874	0.052
2021	437	380	0.35	0.31	342360	367864	38	37	420	413	272	240	1499	1369	0.107
2022	437	381	0.21	0.21	380267	408280	31	35	371	417	139	138	799	825	0.165
2023	437	380	0.21	0.21	417240	442832	32	35	400	447	132	127	745	745	0.209
2024	437	381	0.21	0.21	449221	470228	32	35	421	465	129	122	709	688	0.244
2025	437	381	0.21	0.21	476657	493456	33	35	440	480	128	119	693	661	0.273
2026	437	377	0.21	0.21	499627	511275	33	35	456	492	128	119	688	649	0.296
2027	437	382	0.21	0.21	519448	526468	33	35	470	502	128	119	687	646	0.313
2028	437	381	0.21	0.21	535520	537747	34	35	482	510	128	119	688	644	0.328
2029	437	380	0.21	0.21	548978	546957	34	35	492	516	128	119	690	647	0.338
2030	437	378	0.21	0.21	560176	554799	34	36	500	522	128	119	690	648	0.347
2031	437	378	0.21	0.21	569411	560922	35	36	507	526	128	119	691	651	0.356
2032	437	380	0.21	0.21	577353	565331	35	36	513	530	128	119	692	650	0.363
2033	437	380	0.21	0.21	583880	568159	35	36	518	534	128	119	692	651	0.37
2034	437	381	0.21	0.21	589286	571265	35	36	522	537	128	119	692	652	0.379
2035	437	380	0.21	0.21	593971	573690	35	36	526	540	128	119	693	652	0.384
2036	437	379	0.21	0.21	597900	576173	35	36	529	542	128	119	693	653	0.391
2037	437	380	0.21	0.21	601098	578473	36	36	531	545	128	119	693	654	0.398
2038	437	381	0.21	0.21	603820	580283	36	37	533	547	128	120	693	655	0.405
2039	437	379	0.21	0.21	606097	582040	36	37	535	549	128	119	693	657	0.411
2040	437	381	0.21	0.21	608048	583802	36	37	537	549	128	119	693	656	0.418
2041	437	385	0.21	0.21	609712	584691	36	37	538	550	128	119	694	655	0.42
2042	437	381	0.21	0.21	611129	586161	36	37	539	551	128	119	694	655	0.428
2043	437	382	0.21	0.21	612336	587458	36	37	540	552	128	120	694	655	0.431
2044	437	380	0.21	0.21	613364	587547	36	37	541	554	128	120	694	656	0.435

Table 9. Scenario 7 projection results with F= $F_{REBUILD}$ starting in 2022 and long-term average recruitment. Benchmarks are based on Block 3 and discard mortality on Block 4 with no reallocation of F toward landings. R = number of age-1 recruits (in 1000s), F = fishing mortality rate (per year), S = spawning stock (1e8 eggs), L = landings expressed in numbers (n, in 1000s) or whole weight (w, in 1000 lb), D = dead discards expressed in numbers (n, in 1000s) or whole weight (w, in 1000 lb), and pr.reb = proportion of stochastic projection replicates with SSB $\geq$ SSB_{F30}. The extension "b" indicates expected values (deterministic) from the base run; the extension "m" indicates median values from the stochastic projections.

year	R.b	R.m	F.b	F.m	S.b	S.m	L.b(n)	L.m(n)	L.b(w)	L.m(w)	D.b(n)	D.m(n)	D.b(w)	D.m(w)	pr.reb
2020	437	380	0.39	0.34	306993	324501	40	39	416	409	408	378	1980	1874	0.052
2021	437	380	0.35	0.31	342360	367864	38	37	420	413	272	240	1499	1369	0.107
2022	437	381	0.2	0.2	383867	412147	23	25	267	300	137	135	787	813	0.173
2023	437	380	0.2	0.2	426954	453263	23	26	292	326	131	125	741	742	0.231
2024	437	381	0.2	0.2	465527	487617	24	26	311	344	128	121	708	688	0.284
2025	437	381	0.2	0.2	499689	517662	24	26	329	359	127	119	694	663	0.334
2026	437	377	0.2	0.2	529267	542184	25	26	344	372	127	118	690	652	0.378
2027	437	382	0.2	0.2	555476	563755	25	26	358	382	127	118	690	650	0.422
2028	437	381	0.2	0.2	577517	581122	26	27	370	392	127	118	692	648	0.462
2029	437	380	0.2	0.2	596512	595721	26	27	380	399	127	118	693	651	0.497
2030	437	378	0.2	0.2	612771	608365	26	27	389	406	127	118	695	653	0.531
2031	437	378	0.2	0.2	626575	618268	27	27	396	412	128	118	695	656	0.561
2032	437	380	0.2	0.2	638662	626241	27	28	403	417	128	118	696	655	0.586
2033	437	380	0.2	0.2	648874	633531	27	28	408	422	128	118	697	657	0.614
2034	437	381	0.2	0.2	657547	638802	27	28	413	426	128	119	697	658	0.639
2035	437	380	0.2	0.2	665159	644153	27	28	417	429	128	119	698	658	0.658
2036	437	379	0.2	0.2	671676	648495	27	28	421	432	128	119	698	659	0.677
2037	437	380	0.2	0.2	677130	652505	28	28	424	435	128	119	699	660	0.69
2038	437	381	0.2	0.2	681843	656778	28	28	426	438	128	119	699	662	0.706
2039	437	379	0.2	0.2	685863	659688	28	28	429	440	128	119	699	663	0.72
2040	437	381	0.2	0.2	689351	662656	28	28	430	441	128	119	699	662	0.73
2041	437	385	0.2	0.2	692367	665335	28	29	432	442	128	119	700	662	0.745
2042	437	381	0.2	0.2	694972	666924	28	29	434	444	128	119	700	662	0.754
2043	437	382	0.2	0.2	697222	669497	28	29	435	445	128	119	700	662	0.763
2044	437	380	0.2	0.2	699165	670689	28	29	436	447	128	119	700	663	0.77

Table 10. Scenario 8 projection results with F= $F_{REBUILD}$ starting in 2022 and long-term average recruitment. Benchmarks are based on Block 3 and discard mortality on Block 4 with reallocation of F toward landings. R = number of age-1 recruits (in 1000s), F = fishing mortality rate (per year), S = spawning stock (1e8 eggs), L = landings expressed in numbers (n, in 1000s) or whole weight (w, in 1000 lb), D = dead discards expressed in numbers (n, in 1000s) or whole weight (w, in 1000 lb), and pr.reb = proportion of stochastic projection replicates with SSB $\geq$ SSB_{F30}. The extension "b" indicates expected values (deterministic) from the base run; the extension "m" indicates median values from the stochastic projections.

year	R.b	R.m	F.b	F.m	S.b	S.m	L.b(n)	L.m(n)	L.b(w)	L.m(w)	D.b(n)	D.m(n)	D.b(w)	D.m(w)	pr.reb
2020	437	380	0.39	0.34	306993	324501	40	39	416	409	408	378	1980	1874	0.052
2021	437	380	0.35	0.31	342360	367864	38	37	420	413	272	240	1499	1369	0.107
2022	437	381	0.2	0.2	380989	409049	30	34	359	403	136	135	784	810	0.167
2023	437	380	0.2	0.2	419228	444933	31	34	388	433	130	124	734	734	0.212
2024	437	381	0.2	0.2	452573	473703	31	34	410	453	127	120	700	679	0.251
2025	437	381	0.2	0.2	481393	498269	32	34	429	468	127	118	685	653	0.285
2026	437	377	0.2	0.2	505717	517454	32	34	446	481	126	117	680	642	0.313
2027	437	382	0.2	0.2	526842	533939	33	34	460	491	126	117	680	639	0.335
2028	437	381	0.2	0.2	544126	546174	33	35	473	500	126	117	681	637	0.353
2029	437	380	0.2	0.2	558704	556521	34	35	483	507	127	117	683	640	0.369
2030	437	378	0.2	0.2	570918	565230	34	35	492	513	127	117	683	642	0.386
2031	437	378	0.2	0.2	581063	572410	34	35	500	518	127	117	684	644	0.4
2032	437	380	0.2	0.2	589820	577490	34	35	506	523	127	117	685	644	0.411
2033	437	380	0.2	0.2	597064	580794	34	35	511	527	127	117	685	645	0.418
2034	437	381	0.2	0.2	603097	584433	35	35	516	531	127	118	685	646	0.429
2035	437	380	0.2	0.2	608336	587458	35	36	519	533	127	118	686	646	0.44
2036	437	379	0.2	0.2	612747	590527	35	36	523	536	127	118	686	647	0.45
2037	437	380	0.2	0.2	616361	592519	35	36	525	539	127	118	686	647	0.459
2038	437	381	0.2	0.2	619445	595086	35	36	528	541	127	118	686	649	0.468
2039	437	379	0.2	0.2	622034	596967	35	36	530	543	127	118	687	651	0.474
2040	437	381	0.2	0.2	624255	599216	35	36	531	543	127	118	687	650	0.481
2041	437	385	0.2	0.2	626153	600234	35	36	533	544	127	118	687	649	0.489
2042	437	381	0.2	0.2	627772	602004	35	36	534	546	127	118	687	649	0.496
2043	437	382	0.2	0.2	629153	603265	35	36	535	547	127	118	687	649	0.502
2044	437	380	0.2	0.2	630331	603700	35	36	536	549	127	118	687	649	0.504

Table 11. Scenario 9 projection results with F=F30 starting in 2022 and recent average recruitment. Benchmarks and discard mortality are based on Block 3. R = number of age-1 recruits (in 1000s), F = fishing mortality rate (per year), S = spawning stock (1e8 eggs), L = landings expressed in numbers (n, in 1000s) or whole weight (w, in 1000 lb), D = dead discards expressed in numbers (n, in 1000s) or whole weight (w, in 1000 lb), and pr.reb = proportion of stochastic projection replicates with SSB $\geq$ SSB_{F30}. The extension "b" indicates expected values (deterministic) from the base run; the extension "m" indicates median values from the stochastic projections.

year	R.b	R.m	F.b	F.m	S.b	S.m	L.b(n)	L.m(n)	L.b(w)	L.m(w)	D.b(n)	D.m(n)	D.b(w)	D.m(w)	pr.reb
2020	718	628	0.39	0.34	307585	325212	40	39	416	409	443	407	2019	1910	0.053
2021	718	629	0.35	0.31	343365	367787	39	38	416	409	370	334	1813	1702	0.111
2022	718	629	0.21	0.21	391577	417670	25	27	277	309	214	215	1073	1124	0.185
2023	718	629	0.21	0.21	448929	471102	27	29	315	348	221	217	1120	1131	0.268
2024	718	629	0.21	0.21	506685	523075	29	31	351	381	226	219	1159	1144	0.355
2025	718	630	0.21	0.21	562985	572372	31	33	387	413	229	220	1187	1159	0.452
2026	718	623	0.21	0.21	616074	618089	33	34	420	442	231	220	1206	1170	0.551
2027	718	630	0.21	0.21	665981	660147	34	35	450	468	231	221	1217	1176	0.645
2028	718	629	0.21	0.21	711427	697062	35	36	476	491	232	222	1223	1182	0.728
2029	718	630	0.21	0.21	752683	730745	37	37	500	512	232	223	1227	1187	0.796
2030	718	624	0.21	0.21	789801	760895	37	38	522	530	232	222	1230	1190	0.856
2031	718	625	0.21	0.21	822738	788941	38	39	541	547	232	222	1233	1193	0.901
2032	718	628	0.21	0.21	852016	812188	39	39	557	563	232	223	1235	1196	0.933
2033	718	627	0.21	0.21	877703	833529	39	40	572	575	232	223	1237	1199	0.955
2034	718	631	0.21	0.21	900120	850354	40	40	584	588	232	223	1238	1203	0.971
2035	718	629	0.21	0.21	919768	867450	40	41	595	597	232	224	1240	1206	0.981
2036	718	626	0.21	0.21	936868	881982	41	41	605	606	232	224	1241	1209	0.988
2037	718	630	0.21	0.21	951626	893285	41	41	613	613	232	224	1242	1212	0.992
2038	718	629	0.21	0.21	964437	903603	41	42	620	621	233	224	1243	1212	0.995
2039	718	629	0.21	0.21	975493	912935	42	42	627	627	233	224	1244	1214	0.997
2040	718	630	0.21	0.21	985050	922621	42	42	632	631	233	224	1244	1214	0.998
2041	718	634	0.21	0.21	993300	929405	42	42	637	635	233	224	1245	1213	0.998
2042	718	627	0.21	0.21	1000416	934866	42	42	641	639	233	224	1246	1213	0.999
2043	718	631	0.21	0.21	1006553	940902	42	43	644	643	233	224	1246	1214	0.999
2044	718	627	0.21	0.21	1011847	945990	42	43	647	646	233	224	1246	1213	0.999

Table 12. Scenario 10 projection results with F= $F_{REBUILD}$ starting in 2022 and recent average recruitment. Benchmarks and discard mortality are based on Block 3. R = number of age-1 recruits (in 1000s), F = fishing mortality rate (per year), S = spawning stock (1e8 eggs), L = landings expressed in numbers (n, in 1000s) or whole weight (w, in 1000 lb), D = dead discards expressed in numbers (n, in 1000s) or whole weight (w, in 1000 lb), and pr.reb = proportion of stochastic projection replicates with SSB $\geq$ SSB_{F30}. The extension "b" indicates expected values (deterministic) from the base run; the extension "m" indicates median values from the stochastic projections.

SEE TABLE 11. FOR SCENARIO 10, $F_{REBUILD}$ EXCEEDED F30 AND WOULD THUS BE CAPPED AT F30, THE RATE APPLIED IN SCENARIO 9.

Table 13. Scenario 11 projection results with F=F30 starting in 2022 and recent average recruitment. Benchmarks and discard mortality are based on Block 4. R = number of age-1 recruits (in 1000s), F = fishing mortality rate (per year), S = spawning stock (1e8 eggs), L = landings expressed in numbers (n, in 1000s) or whole weight (w, in 1000 lb), D = dead discards expressed in numbers (n, in 1000s) or whole weight (w, in 1000 lb), and pr.reb = proportion of stochastic projection replicates with SSB $\geq$ SSB_{F30}. The extension "b" indicates expected values (deterministic) from the base run; the extension "m" indicates median values from the stochastic projections.

year	R.b	R.m	F.b	F.m	S.b	S.m	L.b(n)	L.m(n)	L.b(w)	L.m(w)	D.b(n)	D.m(n)	D.b(w)	D.m(w)	pr.reb
2020	718	628	0.39	0.34	307585	325212	40	39	416	409	443	407	2019	1910	0.053
2021	718	629	0.35	0.31	343365	367787	39	38	416	409	370	334	1813	1702	0.111
2022	718	629	0.21	0.21	391577	417670	25	27	277	309	214	215	1073	1124	0.185
2023	718	629	0.21	0.21	448929	471102	27	29	315	348	221	217	1120	1131	0.268
2024	718	629	0.21	0.21	506685	523075	29	31	351	381	226	219	1159	1144	0.355
2025	718	630	0.21	0.21	562985	572372	31	33	387	413	229	220	1187	1159	0.452
2026	718	623	0.21	0.21	616074	618089	33	34	420	442	231	220	1206	1170	0.551
2027	718	630	0.21	0.21	665981	660147	34	35	450	468	231	221	1217	1176	0.645
2028	718	629	0.21	0.21	711427	697062	35	36	476	491	232	222	1223	1182	0.728
2029	718	630	0.21	0.21	752683	730745	37	37	500	512	232	223	1227	1187	0.796
2030	718	624	0.21	0.21	789801	760895	37	38	522	530	232	222	1230	1190	0.856
2031	718	625	0.21	0.21	822738	788941	38	39	541	547	232	222	1233	1193	0.901
2032	718	628	0.21	0.21	852016	812188	39	39	557	563	232	223	1235	1196	0.933
2033	718	627	0.21	0.21	877703	833529	39	40	572	575	232	223	1237	1199	0.955
2034	718	631	0.21	0.21	900120	850354	40	40	584	588	232	223	1238	1203	0.971
2035	718	629	0.21	0.21	919768	867450	40	41	595	597	232	224	1240	1206	0.981
2036	718	626	0.21	0.21	936868	881982	41	41	605	606	232	224	1241	1209	0.988
2037	718	630	0.21	0.21	951626	893285	41	41	613	613	232	224	1242	1212	0.992
2038	718	629	0.21	0.21	964437	903603	41	42	620	621	233	224	1243	1212	0.995
2039	718	629	0.21	0.21	975493	912935	42	42	627	627	233	224	1244	1214	0.997
2040	718	630	0.21	0.21	985050	922621	42	42	632	631	233	224	1244	1214	0.998
2041	718	634	0.21	0.21	993300	929405	42	42	637	635	233	224	1245	1213	0.998
2042	718	627	0.21	0.21	1000416	934866	42	42	641	639	233	224	1246	1213	0.999
2043	718	631	0.21	0.21	1006553	940902	42	43	644	643	233	224	1246	1214	0.999
2044	718	627	0.21	0.21	1011847	945990	42	43	647	646	233	224	1246	1213	0.999

Table 14. Scenario 12 projection results with F= $F_{REBUILD}$ starting in 2022 and recent average recruitment. Benchmarks and discard mortality are based on Block 4. R = number of age-1 recruits (in 1000s), F = fishing mortality rate (per year), S = spawning stock (1e8 eggs), L = landings expressed in numbers (n, in 1000s) or whole weight (w, in 1000 lb), D = dead discards expressed in numbers (n, in 1000s) or whole weight (w, in 1000 lb), and pr.reb = proportion of stochastic projection replicates with SSB $\geq$ SSB_{F30}. The extension "b" indicates expected values (deterministic) from the base run; the extension "m" indicates median values from the stochastic projections.

SEE TABLE 13. FOR SCENARIO 12, $F_{REBUILD}$ EXCEEDED F30 AND WOULD THUS BE CAPPED AT F30, THE RATE APPLIED IN SCENARIO 11.

Table 15. Scenario 13 projection results with F= F30 starting in 2022 and recent average recruitment. Benchmarks are based on Block 3 and discard mortality on Block 4 with no reallocation of F toward landings. R = number of age-1 recruits (in 1000s), F = fishing mortality rate (per year), S = spawning stock (1e8 eggs), L = landings expressed in numbers (n, in 1000s) or whole weight (w, in 1000 lb), D = dead discards expressed in numbers (n, in 1000s) or whole weight (w, in 1000 lb), and pr.reb = proportion of stochastic projection replicates with SSB $\geq$ SSB_{F30}. The extension "b" indicates expected values (deterministic) from the base run; the extension "m" indicates median values from the stochastic projections.

year	R.b	R.m	F.b	F.m	S.b	S.m	L.b(n)	L.m(n)	L.b(w)	L.m(w)	D.b(n)	D.m(n)	D.b(w)	D.m(w)	pr.reb
2020	718	628	0.39	0.34	307585	325212	40	39	416	409	443	407	2019	1910	0.053
2021	718	629	0.35	0.31	347034	372325	39	38	420	413	332	288	1626	1473	0.117
2022	718	629	0.21	0.21	401322	430186	25	28	284	319	195	189	983	996	0.206
2023	718	629	0.21	0.21	465178	491225	28	31	327	363	202	191	1036	1016	0.307
2024	718	629	0.21	0.21	529917	551037	31	33	368	403	207	194	1076	1034	0.415
2025	718	630	0.21	0.21	593360	608291	33	35	408	441	210	196	1104	1050	0.526
2026	718	623	0.21	0.21	653509	662653	35	36	446	475	211	196	1122	1062	0.637
2027	718	630	0.21	0.21	710246	712268	36	38	480	506	212	197	1133	1067	0.733
2028	718	629	0.21	0.21	762093	757711	38	39	511	533	212	197	1138	1072	0.81
2029	718	630	0.21	0.21	809274	799286	39	40	538	559	212	197	1143	1076	0.871
2030	718	624	0.21	0.21	851779	835646	40	41	562	581	212	198	1146	1080	0.915
2031	718	625	0.21	0.21	889553	868429	41	42	584	602	212	198	1148	1083	0.946
2032	718	628	0.21	0.21	923163	896936	42	43	603	619	213	198	1151	1086	0.968
2033	718	627	0.21	0.21	952682	921751	42	44	620	635	213	198	1153	1092	0.98
2034	718	631	0.21	0.21	978473	944097	43	44	634	649	213	199	1154	1093	0.988
2035	718	629	0.21	0.21	1001094	963960	44	45	647	662	213	199	1156	1096	0.993
2036	718	626	0.21	0.21	1020799	981064	44	45	658	673	213	199	1157	1097	0.996
2037	718	630	0.21	0.21	1037826	995602	44	45	668	683	213	199	1158	1099	0.998
2038	718	629	0.21	0.21	1052612	1008953	45	46	676	692	213	199	1159	1103	0.999
2039	718	629	0.21	0.21	1065380	1019871	45	46	683	698	213	199	1160	1103	0.999
2040	718	630	0.21	0.21	1076422	1030010	45	46	689	704	213	198	1161	1102	1
2041	718	634	0.21	0.21	1085957	1038653	45	47	695	710	213	199	1161	1105	1
2042	718	627	0.21	0.21	1094186	1046759	46	47	699	715	213	199	1162	1102	1
2043	718	631	0.21	0.21	1101288	1053572	46	47	703	719	213	199	1162	1103	1
2044	718	627	0.21	0.21	1107417	1059173	46	47	707	722	213	199	1163	1104	1

Table 16. Scenario 14 projection results with F= F30 starting in 2022 and recent average recruitment. Benchmarks are based on Block 3 and discard mortality on Block 4 with reallocation of F toward landings. R = number of age-1 recruits (in 1000s), F = fishing mortality rate (per year), S = spawning stock (1e8 eggs), L = landings expressed in numbers (n, in 1000s) or whole weight (w, in 1000 lb), D = dead discards expressed in numbers (n, in 1000s) or whole weight (w, in 1000 lb), and pr.reb = proportion of stochastic projection replicates with SSB $\geq$ SSB_{F30}. The extension "b" indicates expected values (deterministic) from the base run; the extension "m" indicates median values from the stochastic projections.

year	R.b	R.m	F.b	F.m	S.b	S.m	L.b(n)	L.m(n)	L.b(w)	L.m(w)	D.b(n)	D.m(n)	D.b(w)	D.m(w)	pr.reb
2020	718	628	0.39	0.34	307585	325212	40	39	416	409	443	407	2019	1910	0.053
2021	718	629	0.35	0.31	347034	372325	39	38	420	413	332	288	1626	1473	0.117
2022	718	629	0.21	0.21	399101	427696	32	35	356	400	195	189	981	994	0.201
2023	718	629	0.21	0.21	459085	484471	35	38	407	452	201	191	1030	1010	0.293
2024	718	629	0.21	0.21	519400	539678	38	41	456	498	206	194	1067	1024	0.391
2025	718	630	0.21	0.21	578012	591785	41	43	502	542	209	195	1094	1039	0.494
2026	718	623	0.21	0.21	633080	641587	43	45	546	581	210	195	1111	1051	0.598
2027	718	630	0.21	0.21	684583	685289	45	47	585	616	211	195	1120	1055	0.688
2028	718	629	0.21	0.21	731206	725769	46	48	620	647	211	196	1126	1059	0.768
2029	718	630	0.21	0.21	773256	761720	48	49	651	674	211	196	1130	1063	0.832
2030	718	624	0.21	0.21	810800	794397	49	50	678	699	211	196	1133	1066	0.878
2031	718	625	0.21	0.21	843858	823226	50	51	702	721	211	197	1135	1069	0.917
2032	718	628	0.21	0.21	873010	846969	51	52	722	741	211	197	1137	1072	0.943
2033	718	627	0.21	0.21	898377	868201	52	53	741	757	211	197	1138	1078	0.964
2034	718	631	0.21	0.21	920333	886782	52	53	756	773	211	198	1140	1078	0.974
2035	718	629	0.21	0.21	939417	903830	53	54	770	786	212	197	1141	1081	0.983
2036	718	626	0.21	0.21	955888	916764	53	54	781	798	212	198	1142	1082	0.989
2037	718	630	0.21	0.21	969984	929308	53	55	791	808	212	198	1143	1084	0.992
2038	718	629	0.21	0.21	982115	939095	54	55	800	817	212	198	1144	1087	0.994
2039	718	629	0.21	0.21	992492	949281	54	55	807	824	212	198	1144	1087	0.996
2040	718	630	0.21	0.21	1001384	956512	54	56	814	830	212	197	1145	1085	0.997
2041	718	634	0.21	0.21	1008991	964064	55	56	819	836	212	198	1146	1089	0.998
2042	718	627	0.21	0.21	1015495	969475	55	56	824	842	212	198	1146	1086	0.998
2043	718	631	0.21	0.21	1021056	976039	55	56	827	845	212	198	1146	1086	0.999
2044	718	627	0.21	0.21	1025810	978469	55	56	831	848	212	198	1147	1088	0.999

Table 17. Scenario 15 projection results with F= $F_{REBUILD}$ starting in 2022 and recent average recruitment. Benchmarks are based on Block 3 and discard mortality on Block 4 with no reallocation of F toward landings. R = number of age-1 recruits (in 1000s), F = fishing mortality rate (per year), S = spawning stock (1e8 eggs), L = landings expressed in numbers (n, in 1000s) or whole weight (w, in 1000 lb), D = dead discards expressed in numbers (n, in 1000s) or whole weight (w, in 1000 lb), and pr.reb = proportion of stochastic projection replicates with SSB $\geq$ SSB_{F30}. The extension "b" indicates expected values (deterministic) from the base run; the extension "m" indicates median values from the stochastic projections.

SEE TABLE 15. FOR SCENARIO 15, $F_{REBUILD}$ EXCEEDED F30 AND WOULD THUS BE CAPPED AT F30, THE RATE APPLIED IN SCENARIO 13.

Table 18. Scenario 16 projection results with F= $F_{REBUILD}$ starting in 2022 and recent average recruitment. Benchmarks are based on Block 3 and discard mortality on Block 4 with reallocation of F toward landings. R = number of age-1 recruits (in 1000s), F = fishing mortality rate (per year), S = spawning stock (1e8 eggs), L = landings expressed in numbers (n, in 1000s) or whole weight (w, in 1000 lb), D = dead discards expressed in numbers (n, in 1000s) or whole weight (w, in 1000 lb), and pr.reb = proportion of stochastic projection replicates with SSB $\geq$ SSB_{F30}. The extension "b" indicates expected values (deterministic) from the base run; the extension "m" indicates median values from the stochastic projections.

SEE TABLE 16. FOR SCENARIO 16, $F_{REBUILD}$ EXCEEDED F30 AND WOULD THUS BE CAPPED AT F30, THE RATE APPLIED IN SCENARIO 14.

Figure 1A. Scenario 1 projection results with F=F30 starting in 2022 and long-term average recruitment. Benchmarks and discard mortality are based on Block 3.

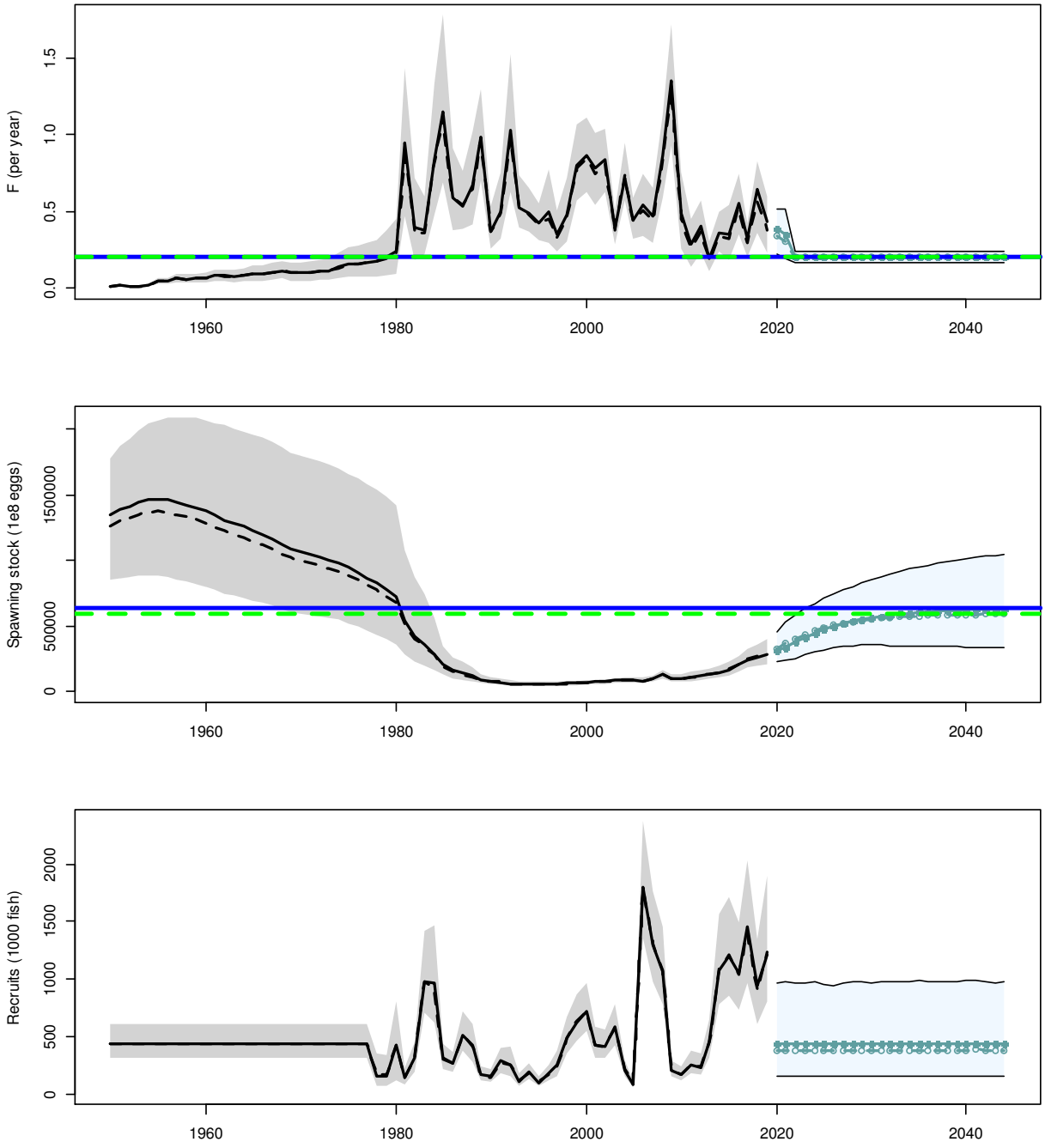

Figure 1B. Scenario 1 probability density and cumulative probability of stock recovery ($SSB>SSB_{F30}$).

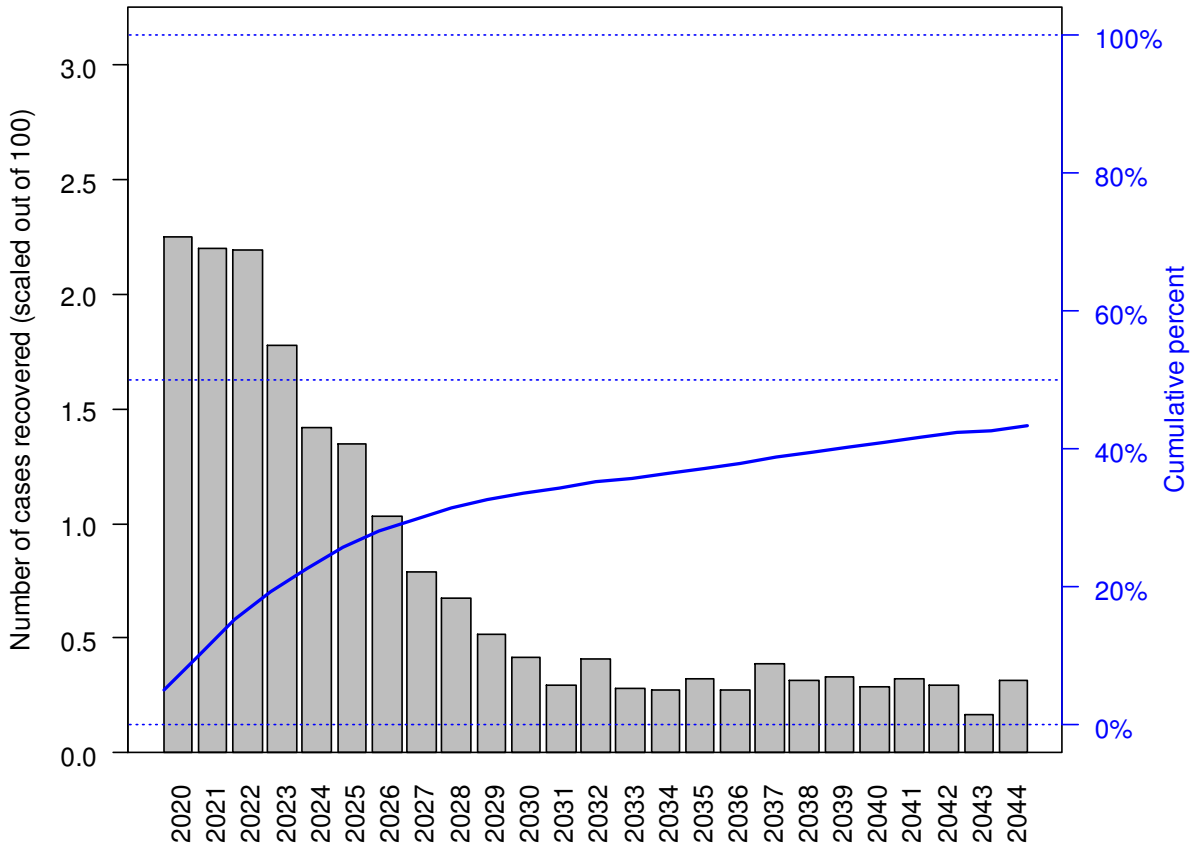

Figure 2A. Scenario 2 projection results with F=F$_{REBUILD}$ starting in 2022 and long-term average recruitment. Benchmarks and discard mortality are based on Block 3.

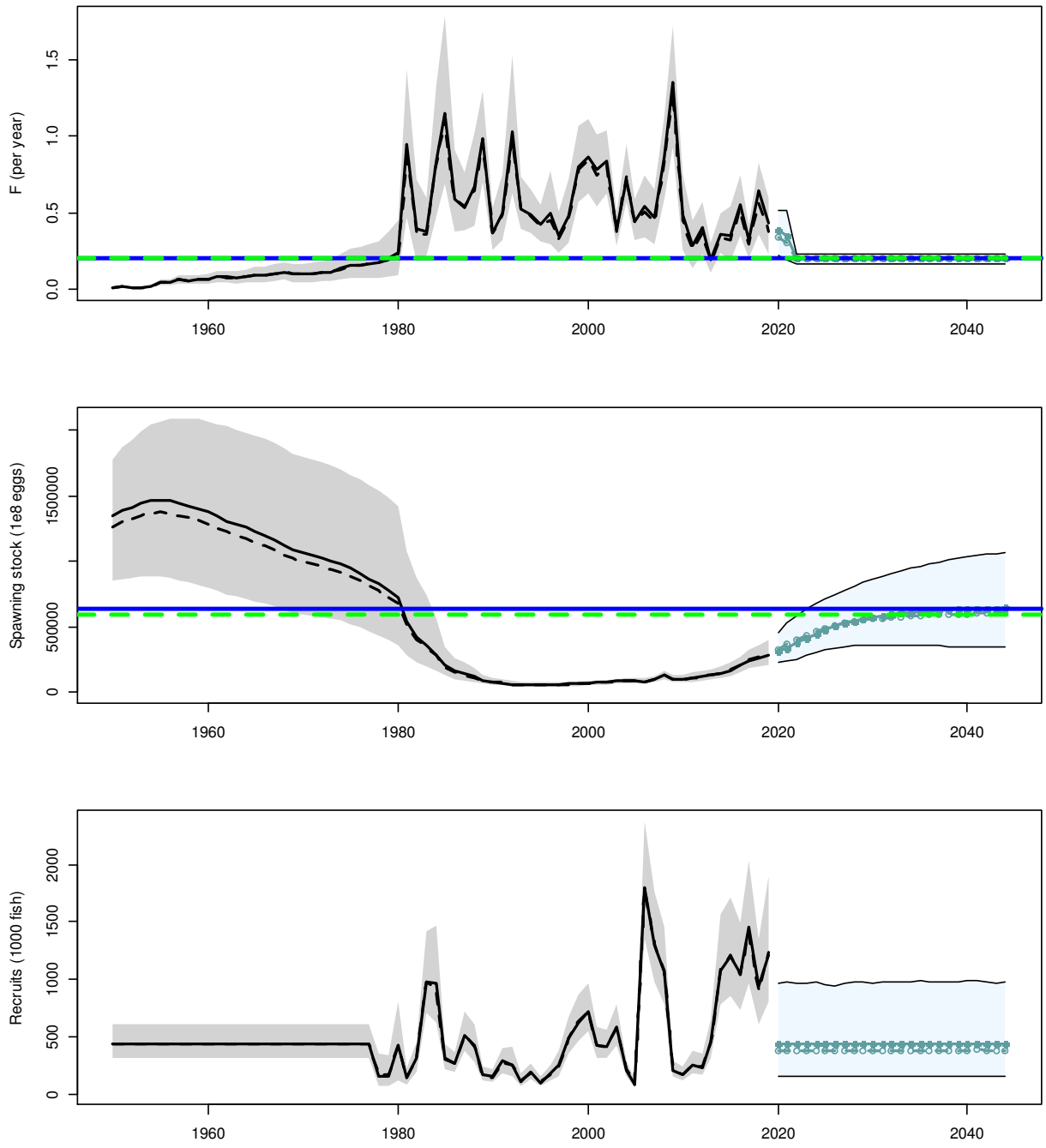

Figure 2B. Scenario 2 probability density and cumulative probability of stock recovery ($SSB>SSB_{F30}$).

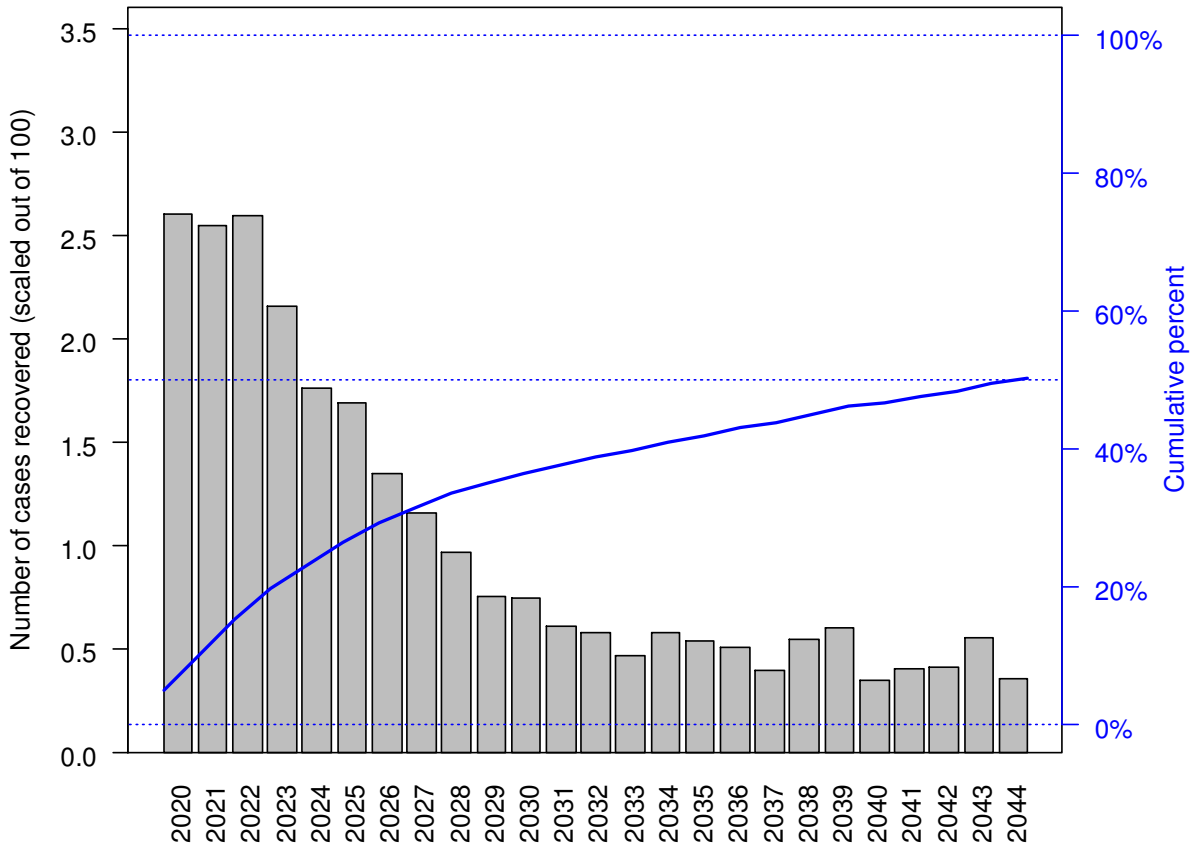

Figure 3A. Scenario 3 projection results with F=F30 starting in 2022 and long-term average recruitment. Benchmarks and discard mortality are based on Block 4.

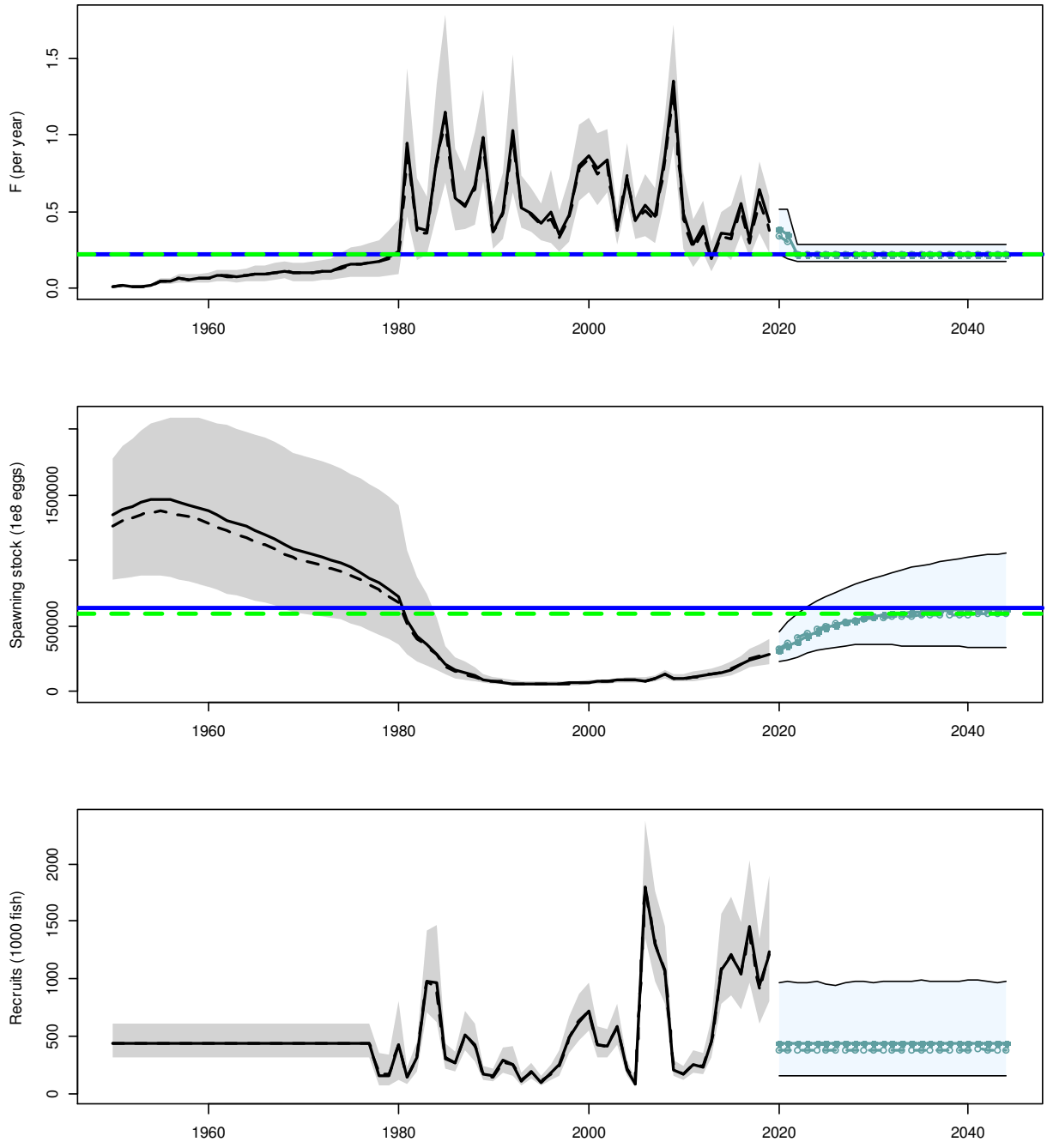

Figure 3B. Scenario 3 probability density and cumulative probability of stock recovery ($SSB>SSB_{F30}$).

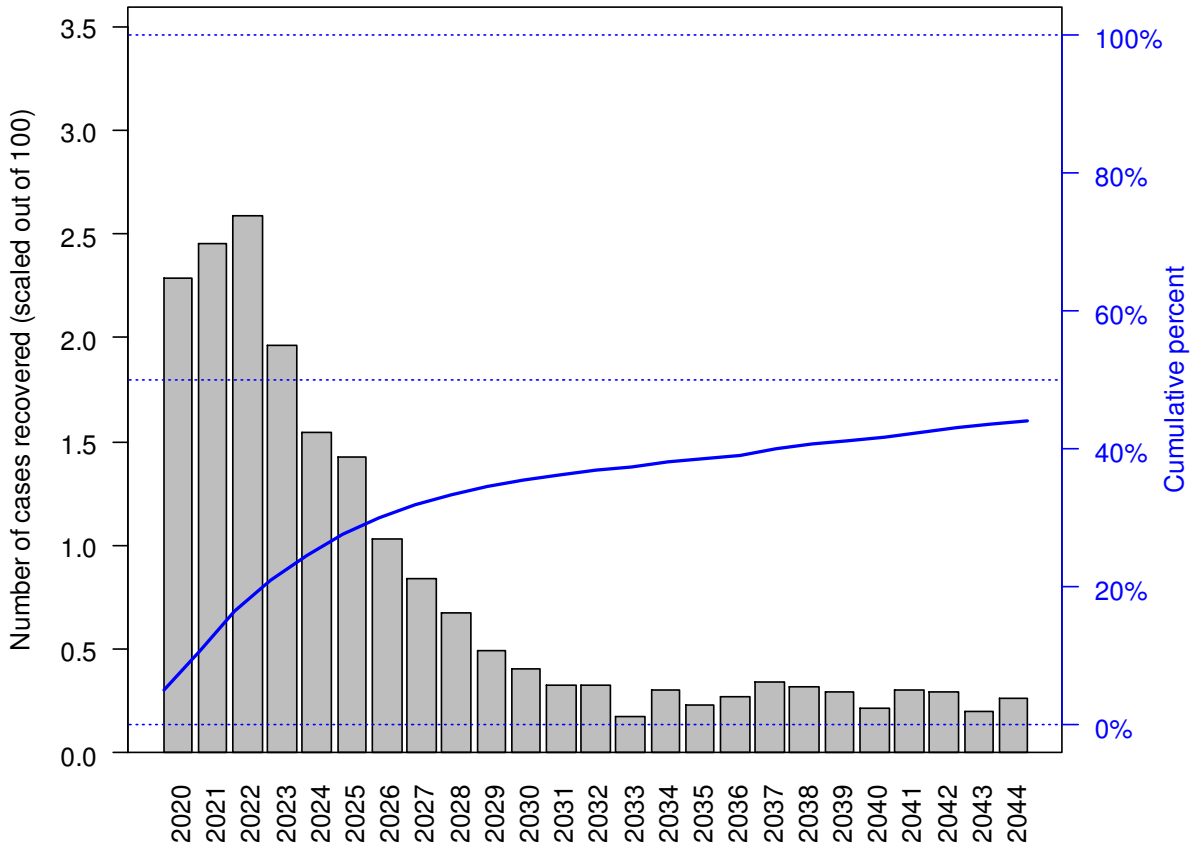

Figure 4A. Scenario 4 projection results with F=F$_{REBUILD}$ starting in 2022 and long-term average recruitment. Benchmarks and discard mortality are based on Block 4.

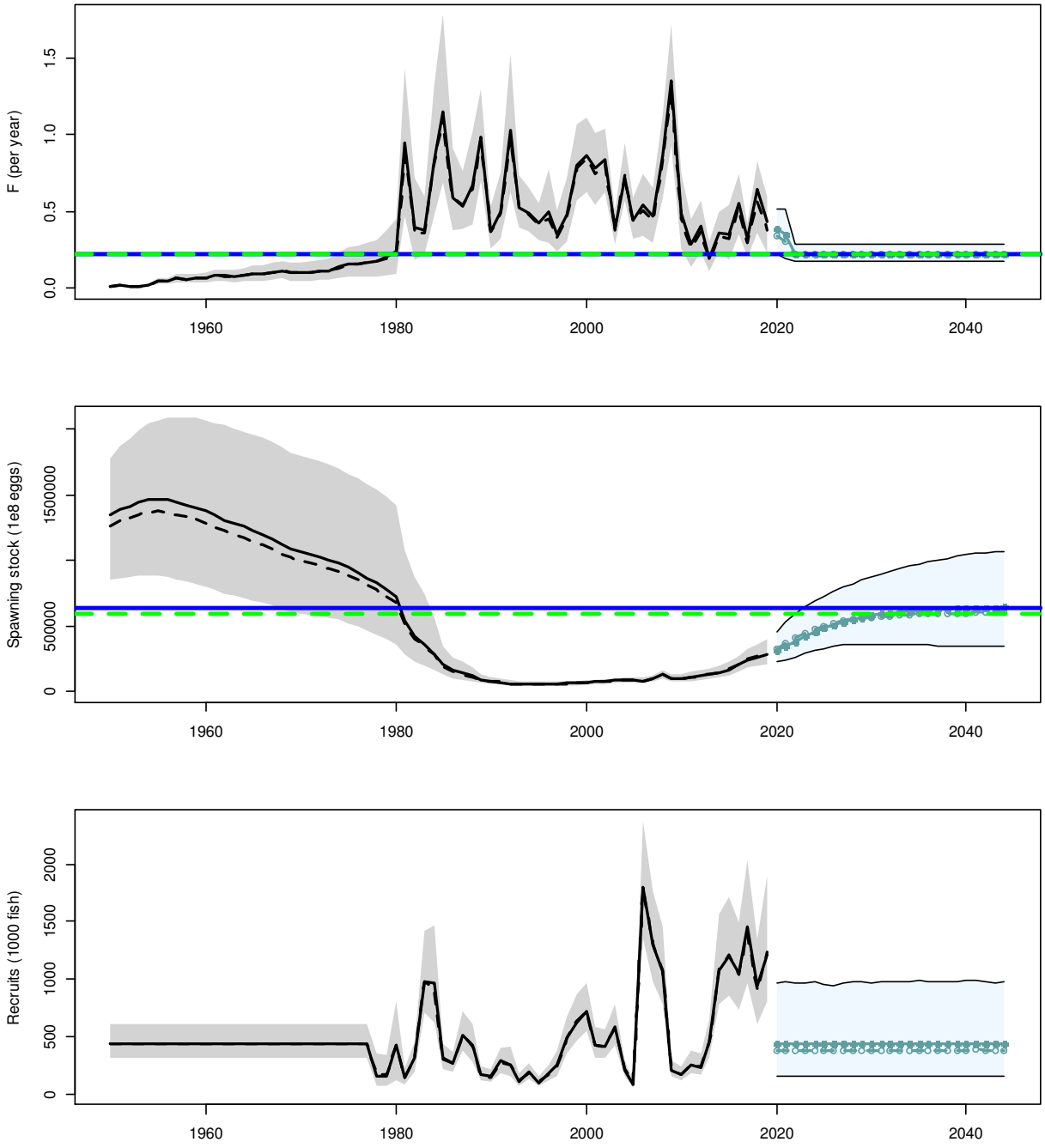

Figure 4B. Scenario 4 probability density and cumulative probability of stock recovery ($SSB>SSB_{F30}$).

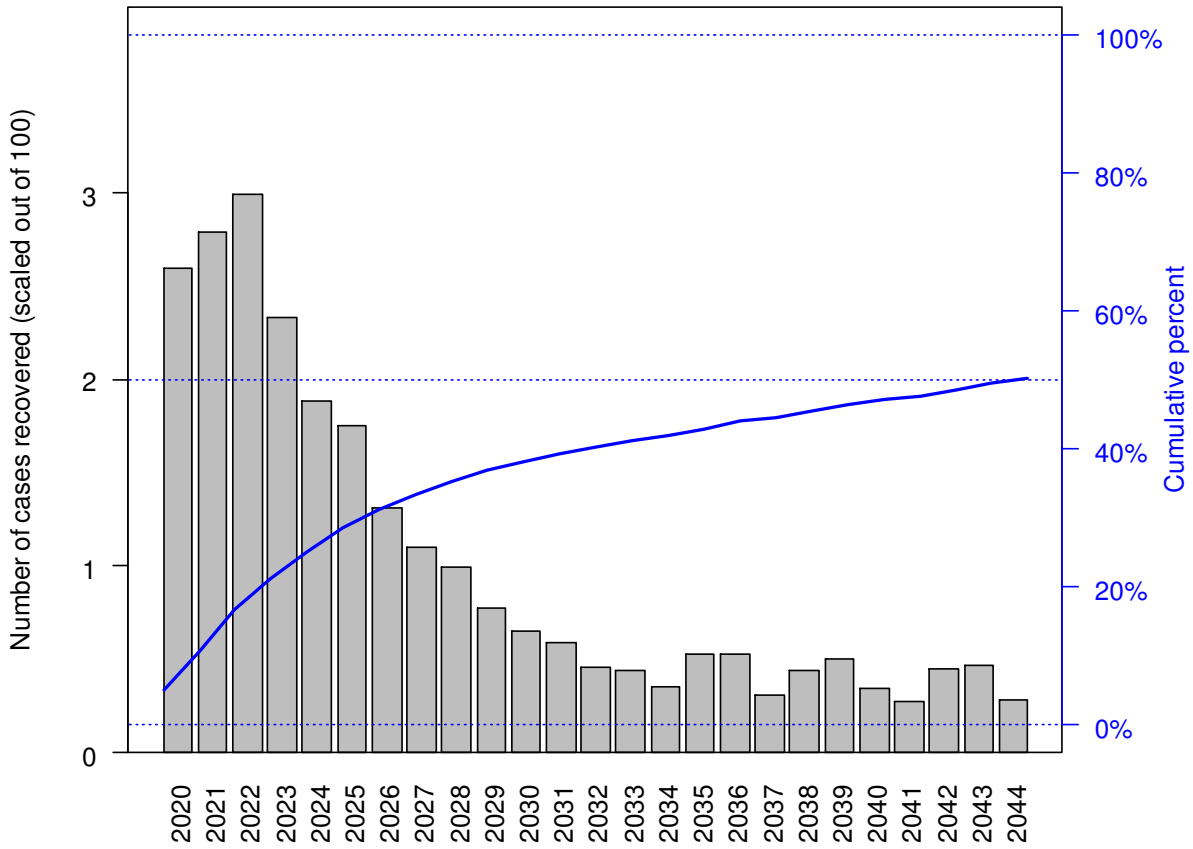

Figure 5A. Scenario 5 projection results with F=F30 starting in 2022 and long-term average recruitment. Benchmarks are based on Block 3, and discard mortality on Block 4 with no reallocation of F toward landings.

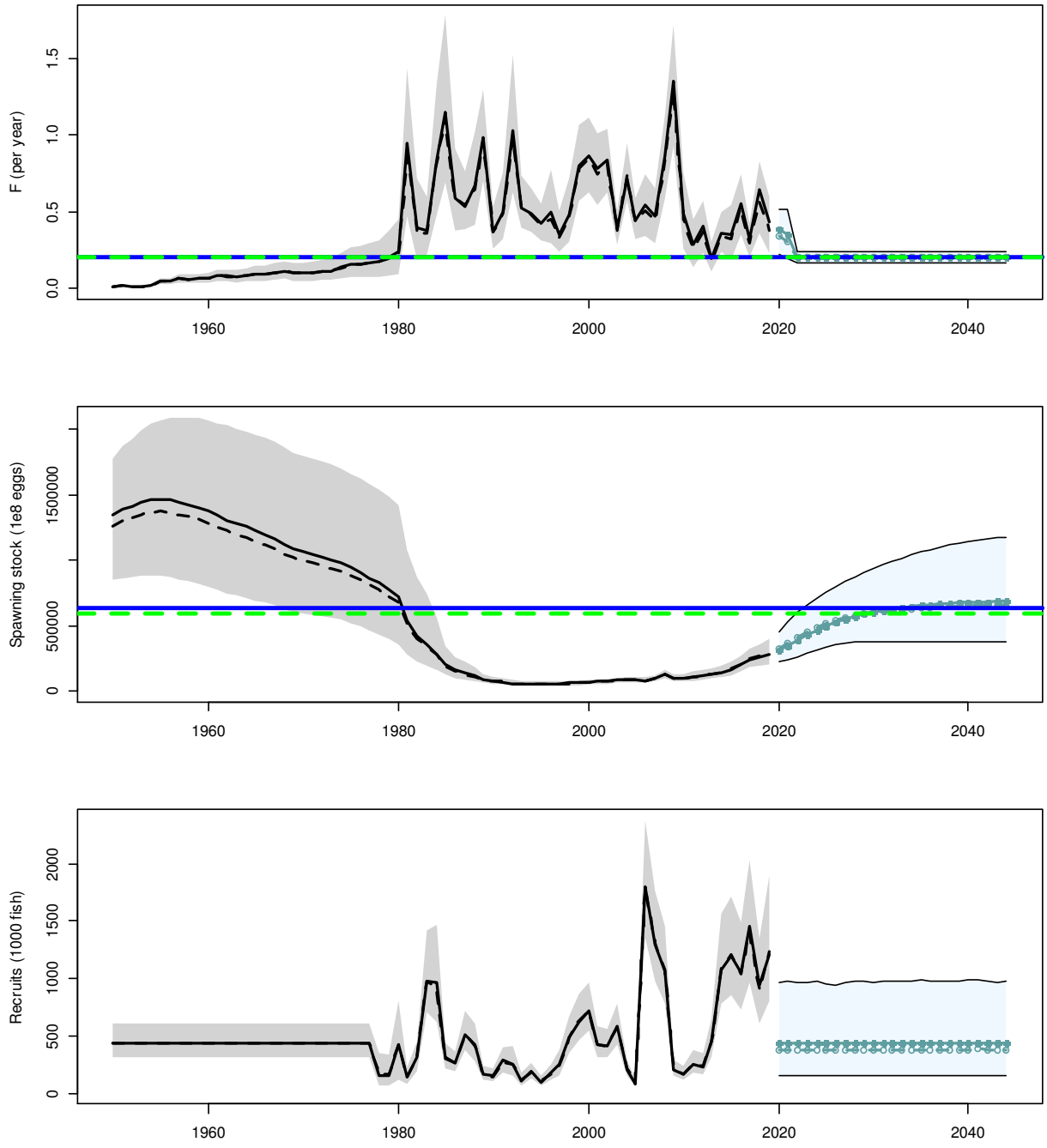

Figure 5B. Scenario 5 probability density and cumulative probability of stock recovery ($SSB>SSB_{F30}$).

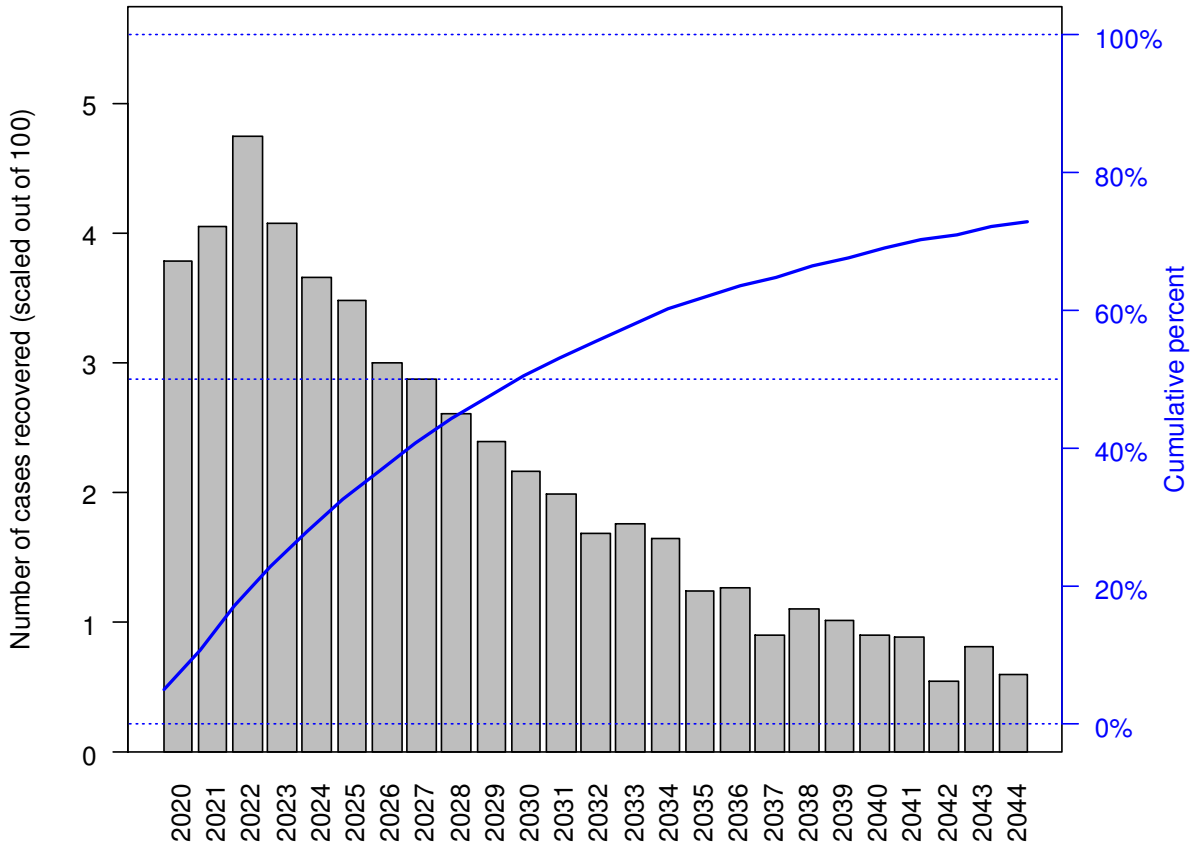

Figure 6A. Scenario 6 projection results with F=F30 starting in 2022 and long-term average recruitment. Benchmarks are based on Block 3, and discard mortality on Block 4 with reallocation of F toward landings.

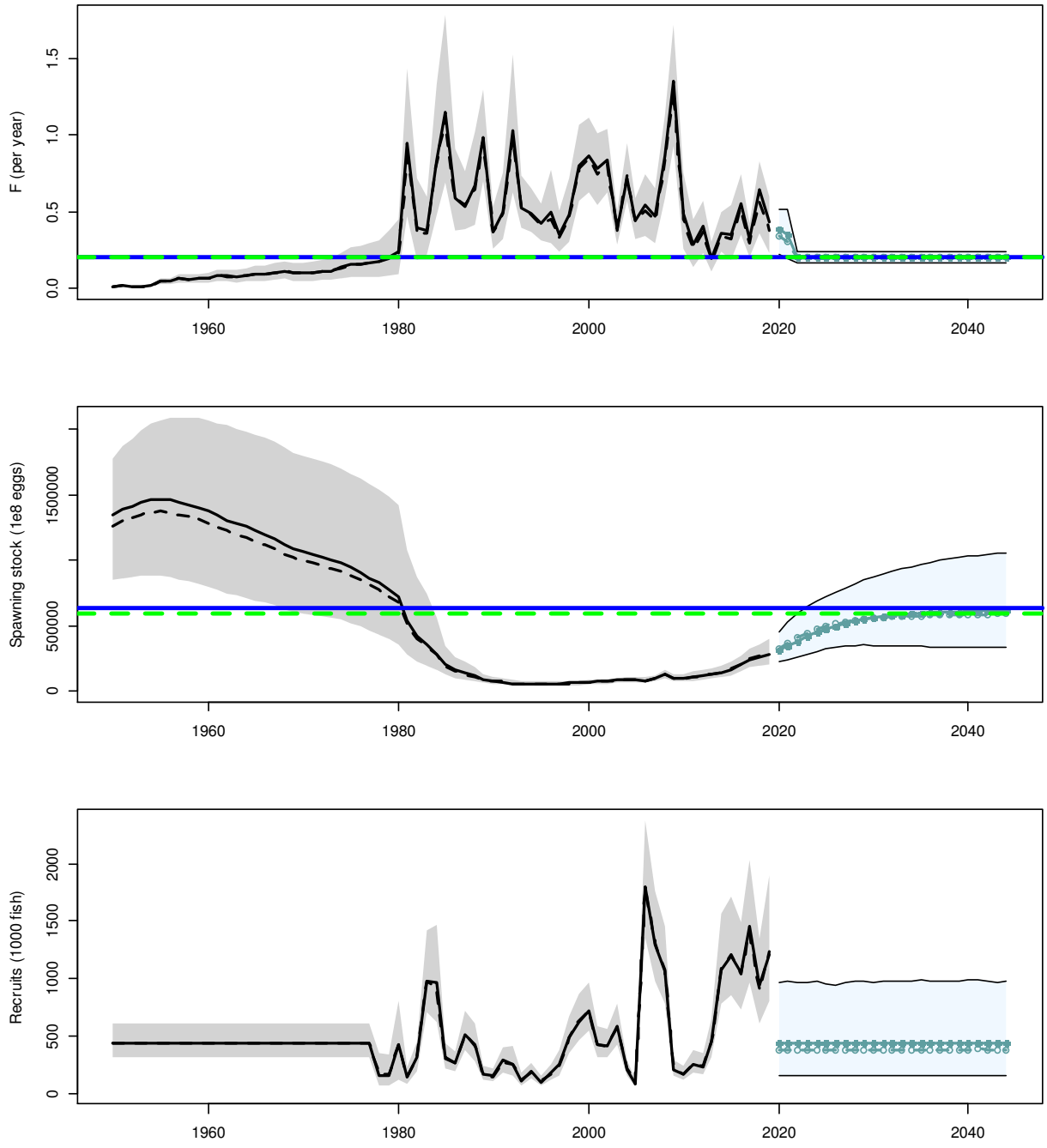

Figure 6B. Scenario 6 probability density and cumulative probability of stock recovery ($SSB>SSB_{F30}$).

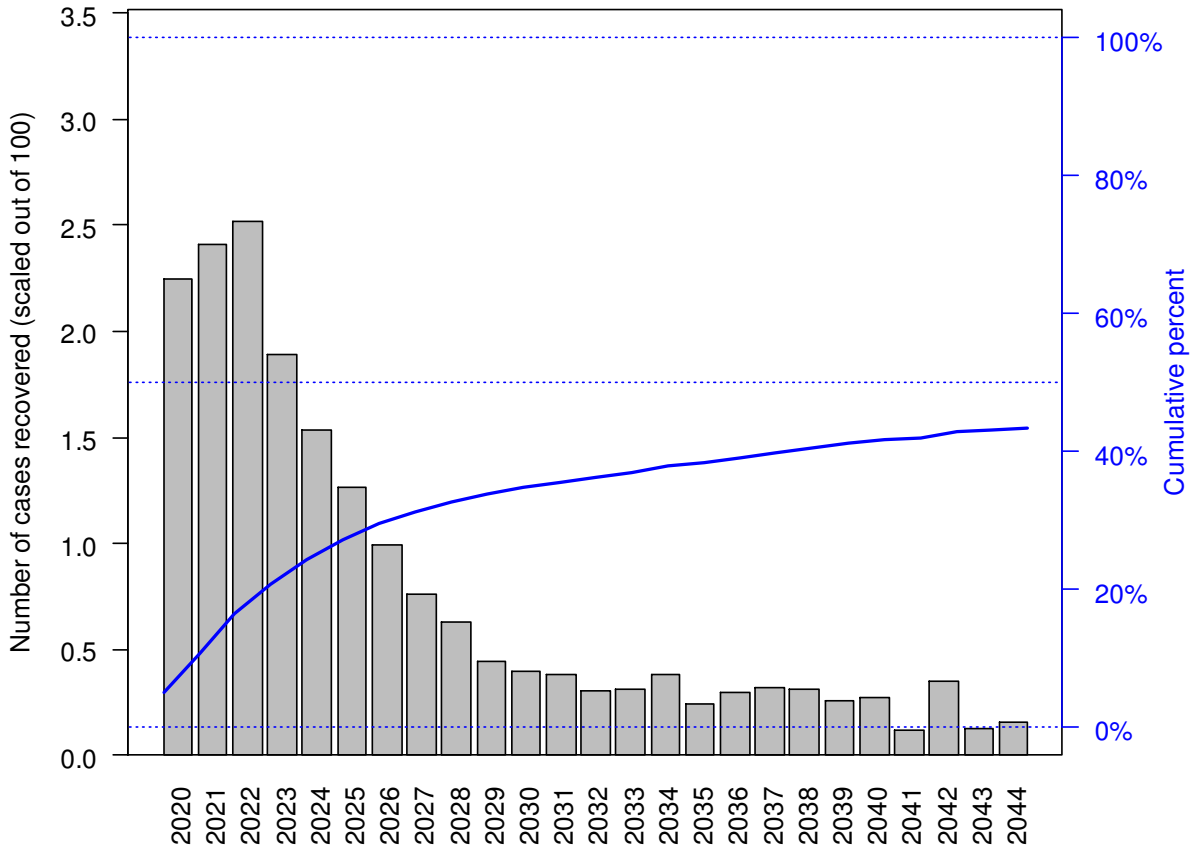

Figure 7A. Scenario 7 projection results with F=F$_{REBUILD}$ starting in 2022 and long-term average recruitment. Benchmarks are based on Block 3, and discard mortality on Block 4 with no reallocation of F toward landings.

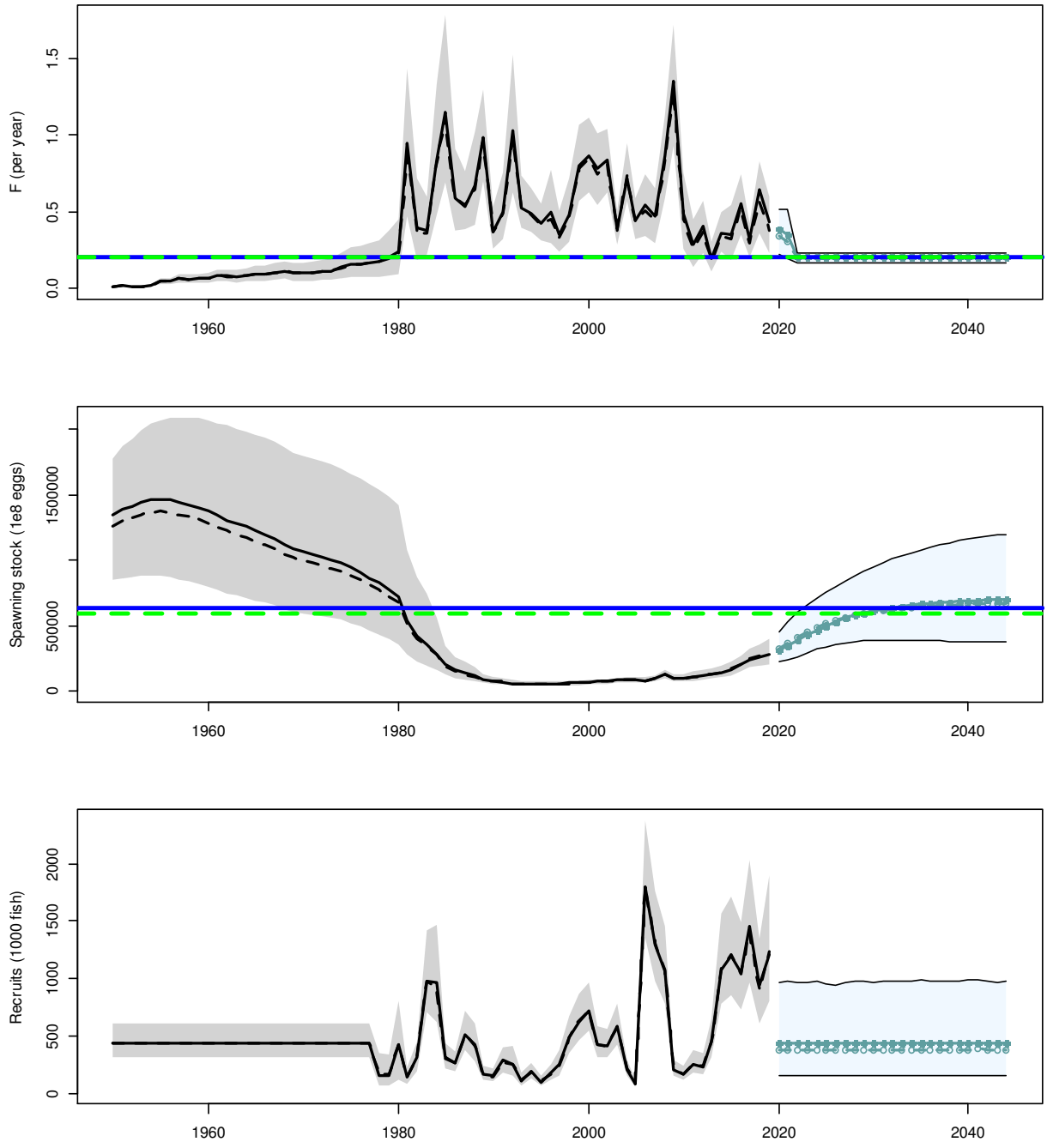

Figure 7B. Scenario 7 probability density and cumulative probability of stock recovery ($SSB>SSB_{F30}$).

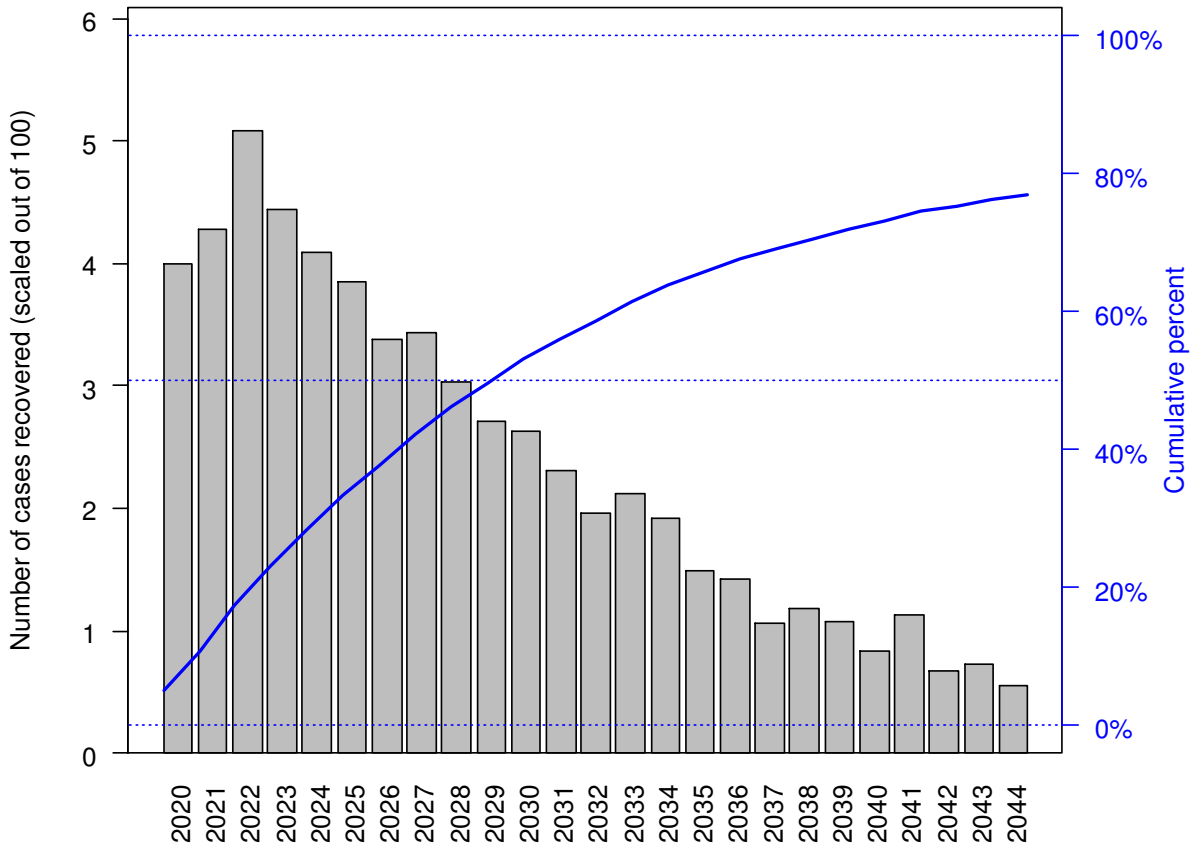

Figure 8A. Scenario 8 projection results with F=F$_{REBUILD}$ starting in 2022 and long-term average recruitment. Benchmarks are based on Block 3, and discard mortality on Block 4 with reallocation of F toward landings.

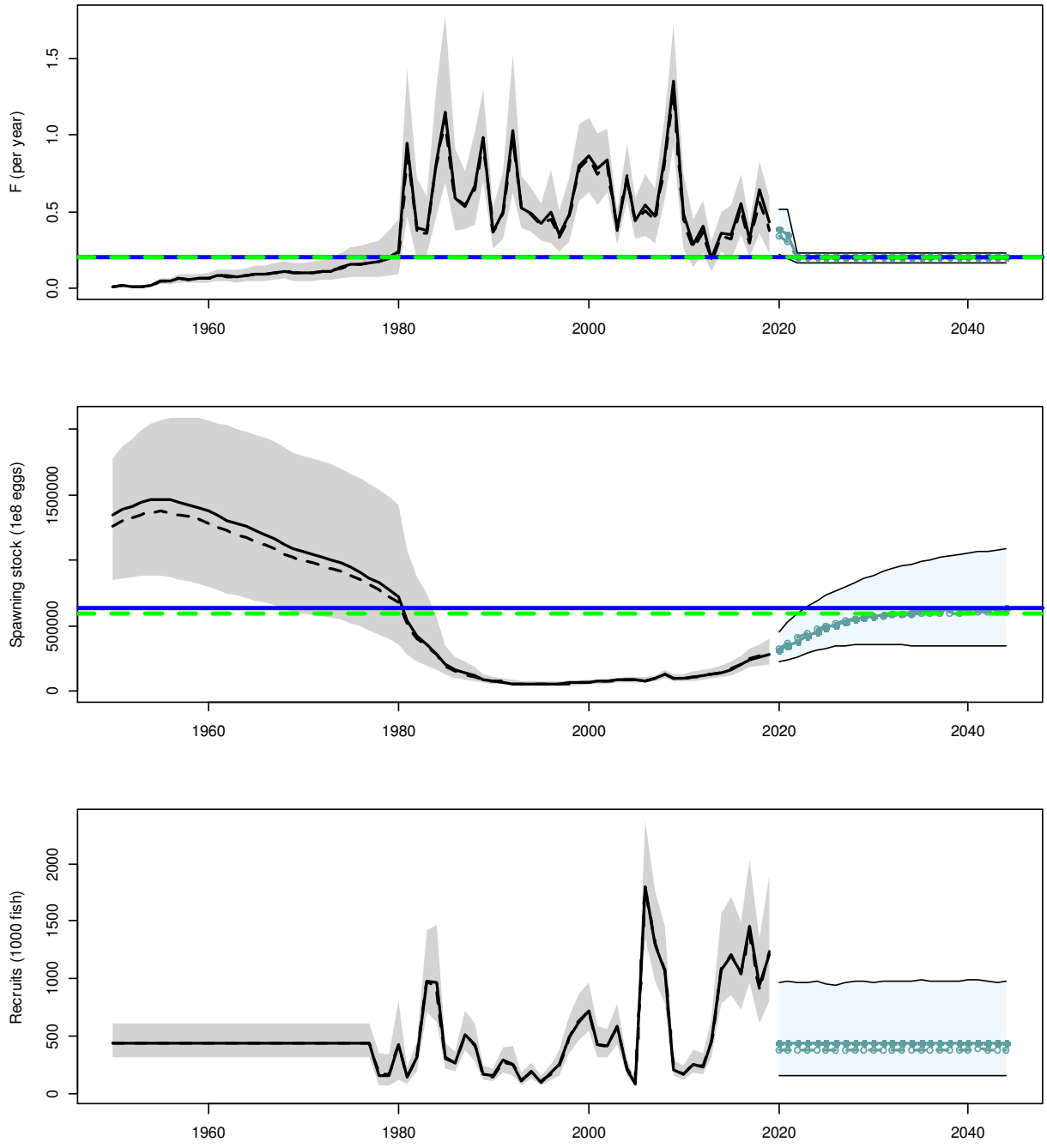

Figure 8B. Scenario 8 probability density and cumulative probability of stock recovery ($SSB>SSB_{F30}$).

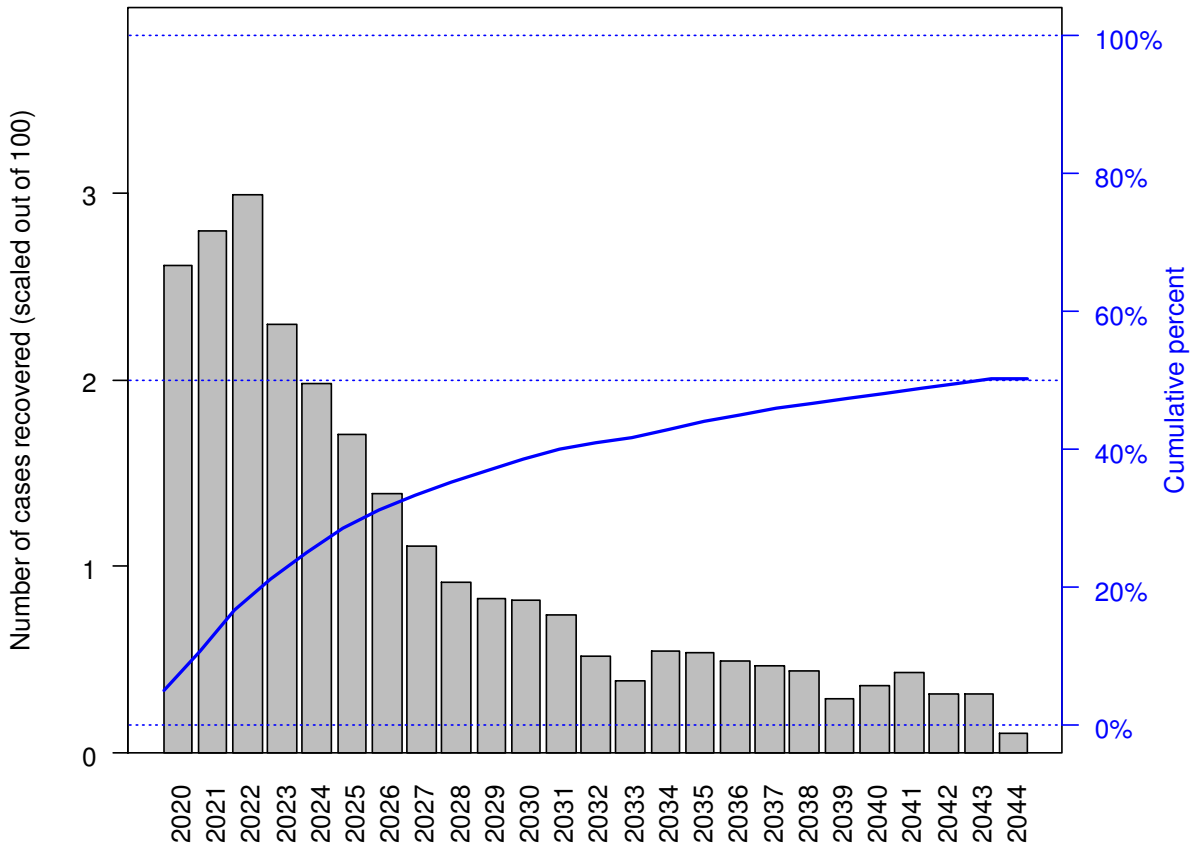

Figure 9A. Scenario 9 projection results with F=F30 starting in 2022 and recent average recruitment. Benchmarks and discard mortality are based on Block 3.

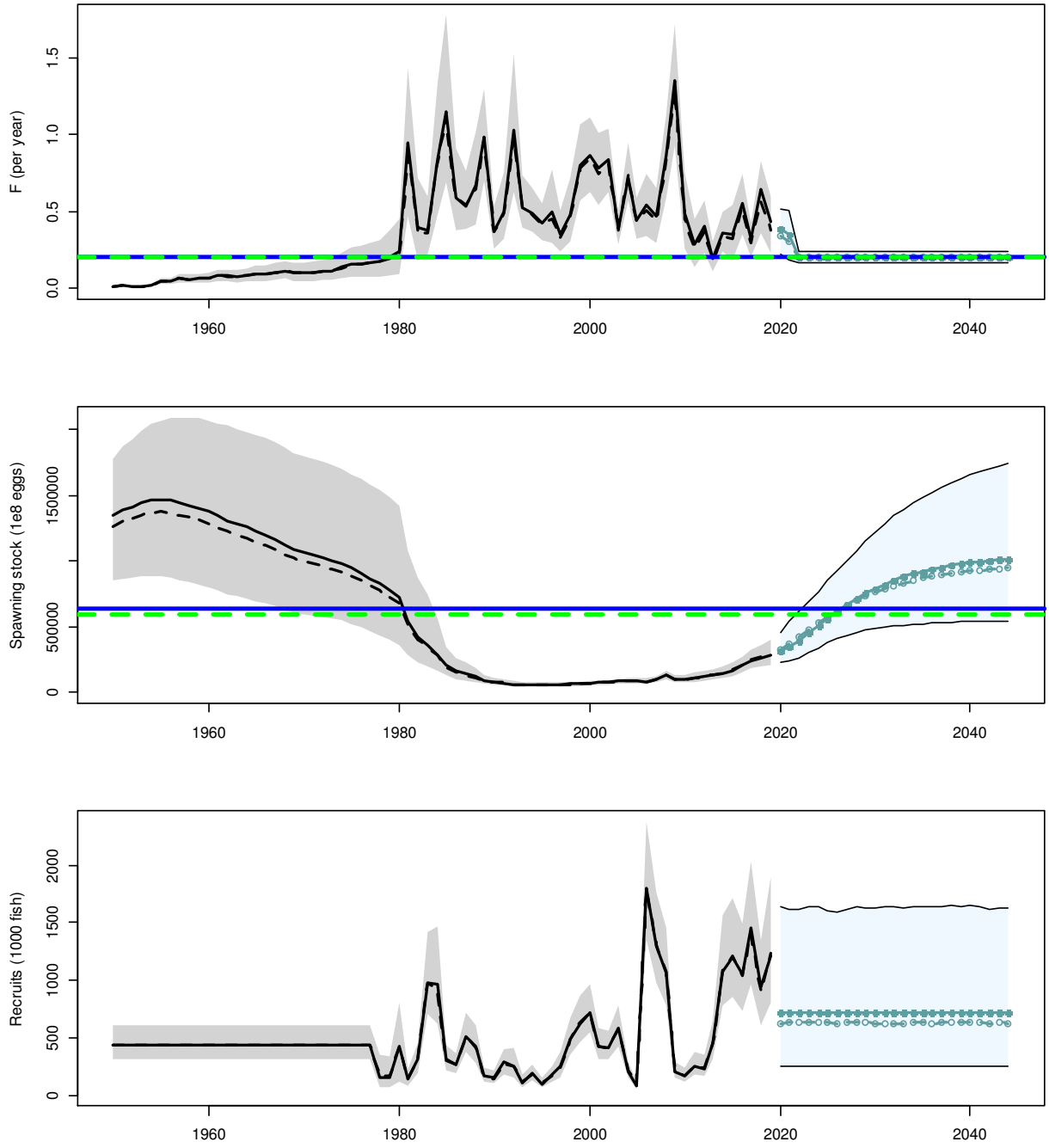

Figure 9B. Scenario 9 probability density and cumulative probability of stock recovery ($SSB>SSB_{F30}$).

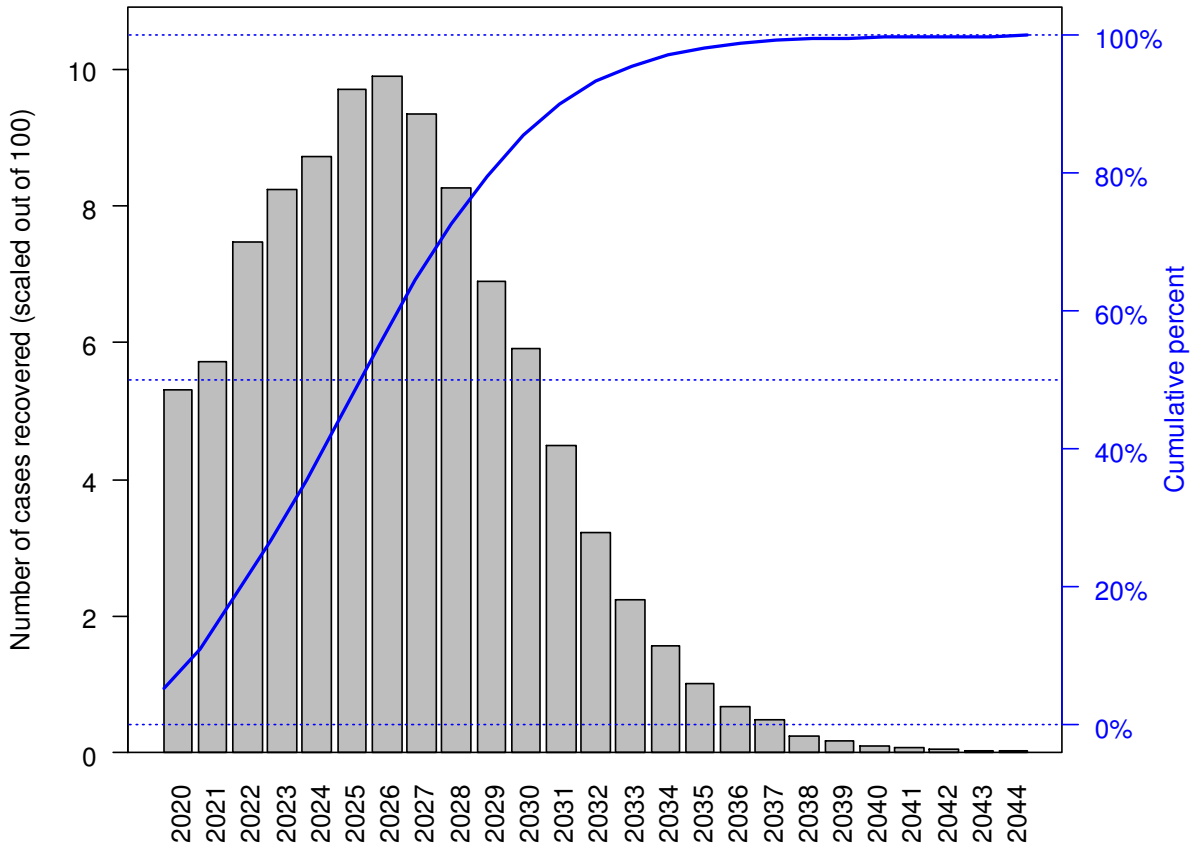

Figure 10A. Scenario 10 projection results with $F=F_{REBUILD}$ starting in 2022 and recent average recruitment. Benchmarks and discard mortality are based on Block 3.

SEE FIGURE 9A. FOR SCENARIO 10, $F_{REBUILD}$ EXCEEDED F30 AND WOULD THUS BE CAPPED AT F30, THE RATE APPLIED IN SCENARIO 9.

Figure 10B. Scenario 10 probability density and cumulative probability of stock recovery ($SSB>SSB_{F30}$).

SEE FIGURE 9B. FOR SCENARIO 10, $F_{REBUILD}$ EXCEEDED F30 AND WOULD THUS BE CAPPED AT F30, THE RATE APPLIED IN SCENARIO 9.

Figure 11A. Scenario 11 projection results with F=F30 starting in 2022 and recent average recruitment. Benchmarks and discard mortality are based on Block 4.

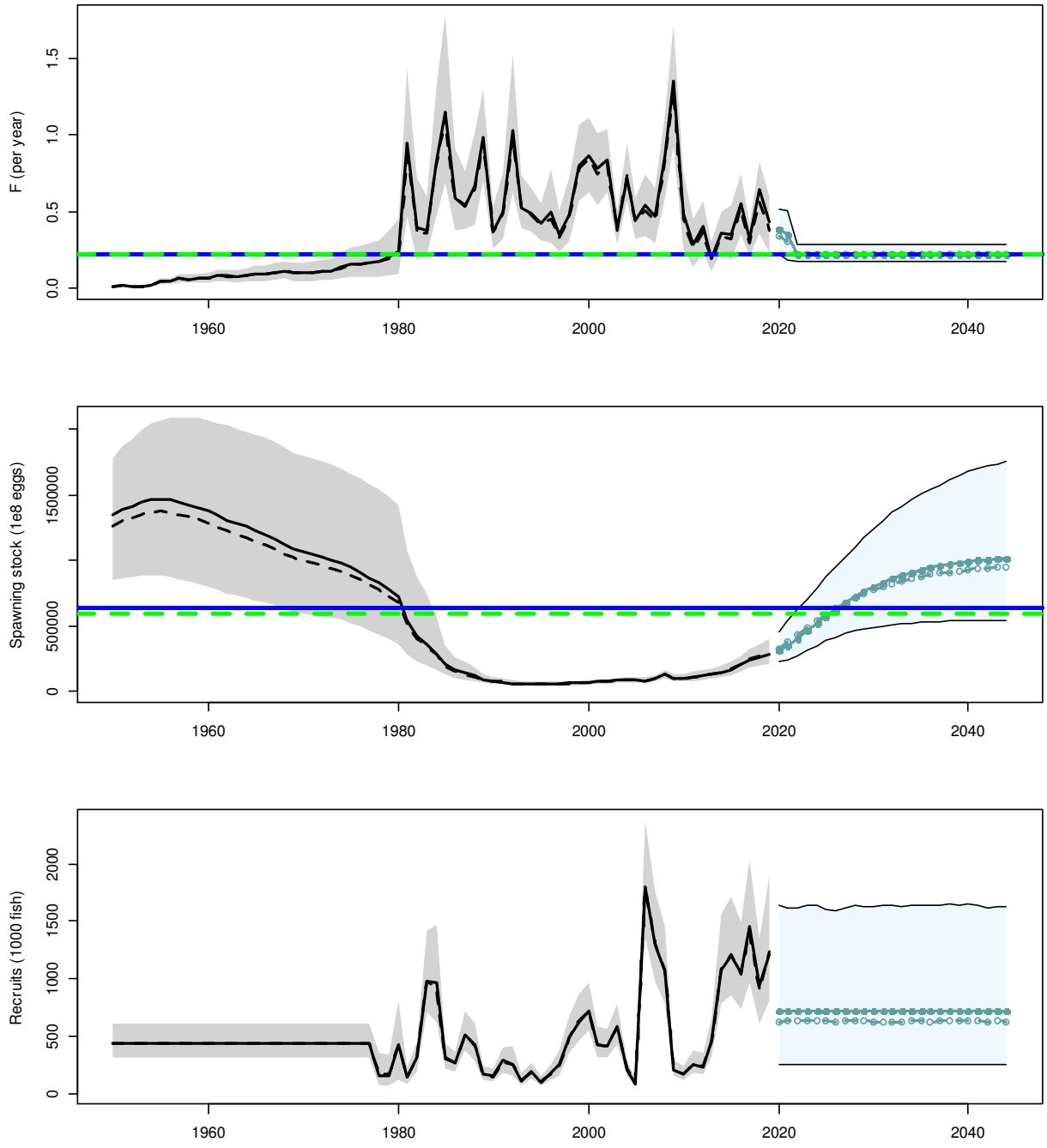

Figure 11B. Scenario 11 probability density and cumulative probability of stock recovery ($SSB>SSB_{F30}$).

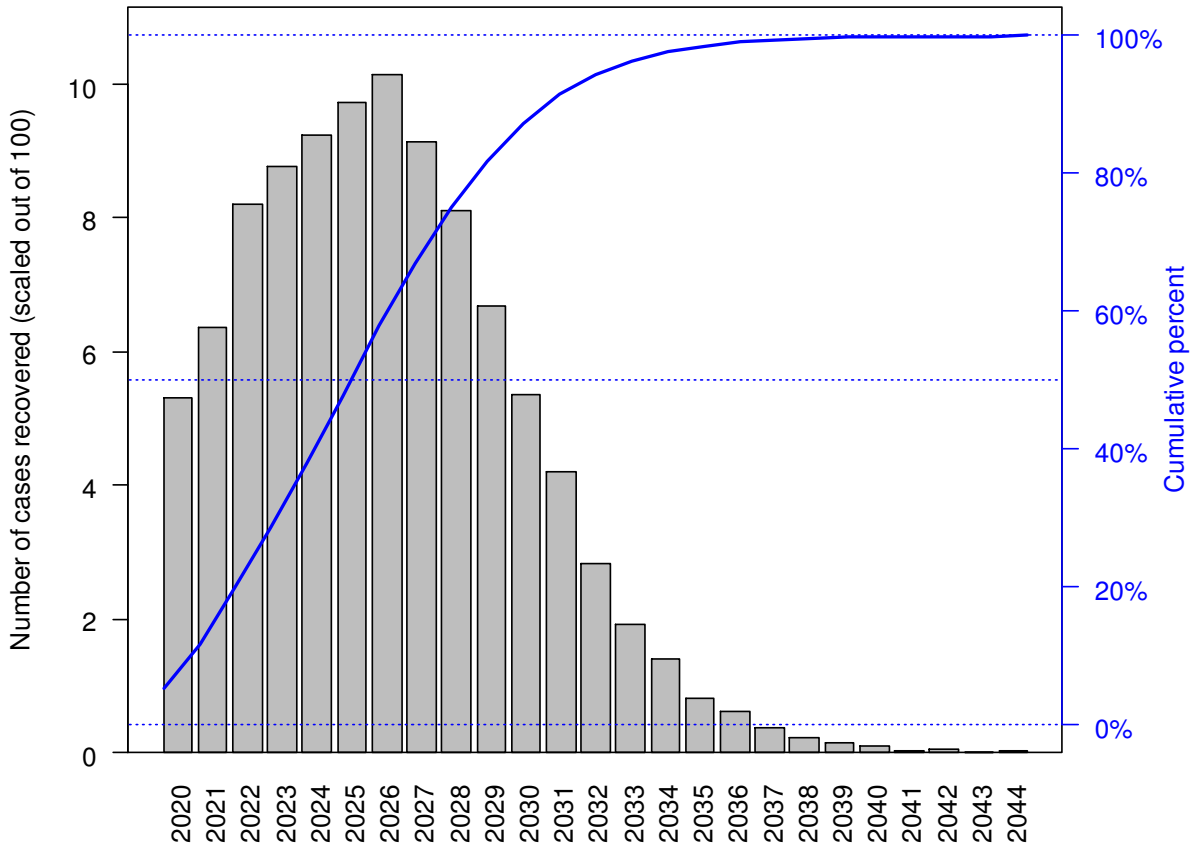

Figure 12A. Scenario 12 projection results with $F=F_{REBUILD}$ starting in 2022 and recent average recruitment. Benchmarks and discard mortality are based on Block 4.

SEE FIGURE 11A. FOR SCENARIO 12, $F_{REBUILD}$ EXCEEDED F30 AND WOULD THUS BE CAPPED AT F30, THE RATE APPLIED IN SCENARIO 11.

Figure 12B. Scenario 12 probability density and cumulative probability of stock recovery ($SSB>SSB_{F30}$).

SEE FIGURE 11B. FOR SCENARIO 12, $F_{REBUILD}$ EXCEEDED F30 AND WOULD THUS BE CAPPED AT F30, THE RATE APPLIED IN SCENARIO 11.

Figure 13A. Scenario 13 projection results with F=F30 starting in 2022 and recent average recruitment. Benchmarks are based on Block 3, and discard mortality on Block 4 with no reallocation of F toward landings.

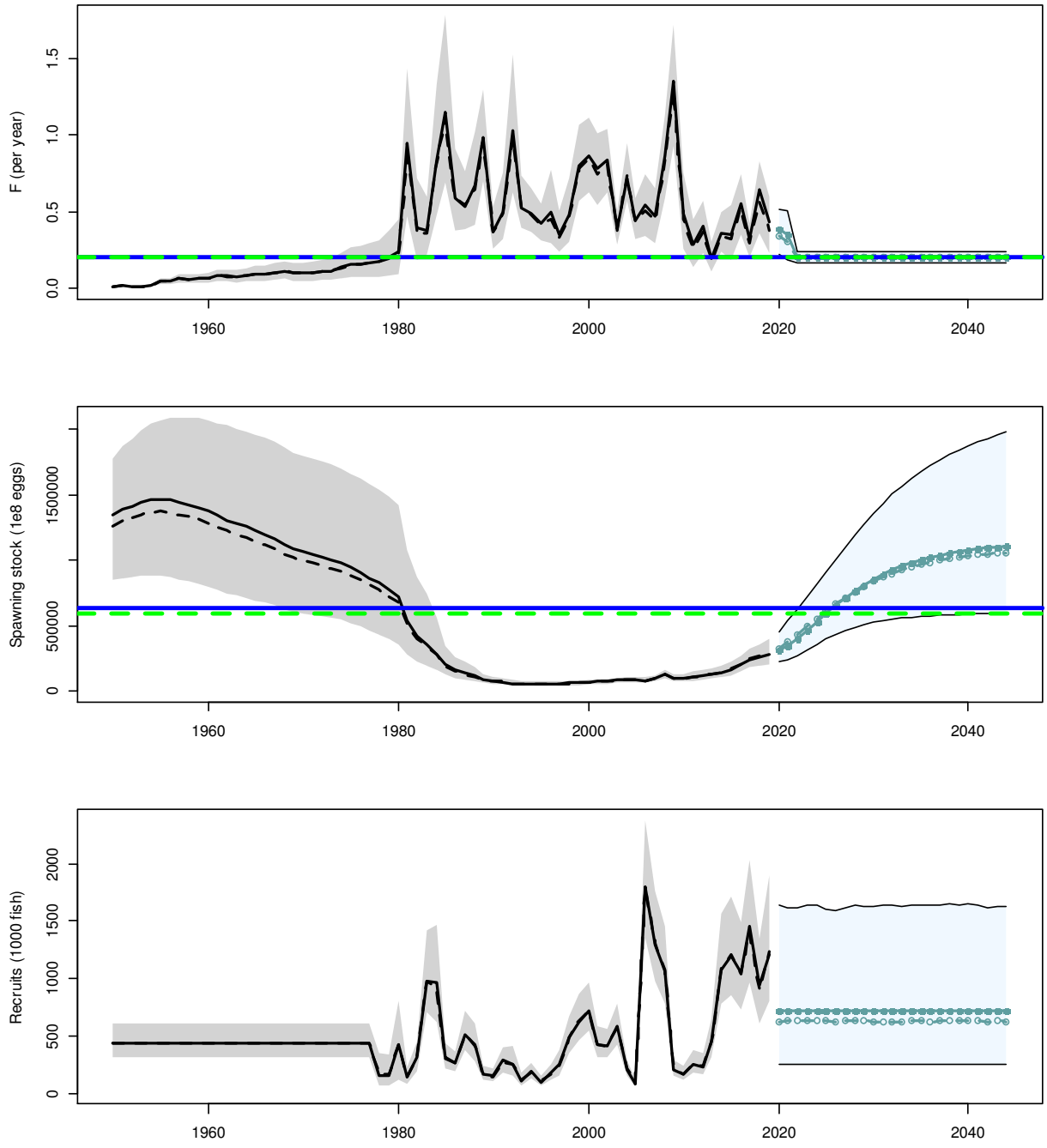

Figure 13B. Scenario 13 probability density and cumulative probability of stock recovery ($SSB>SSB_{F30}$).

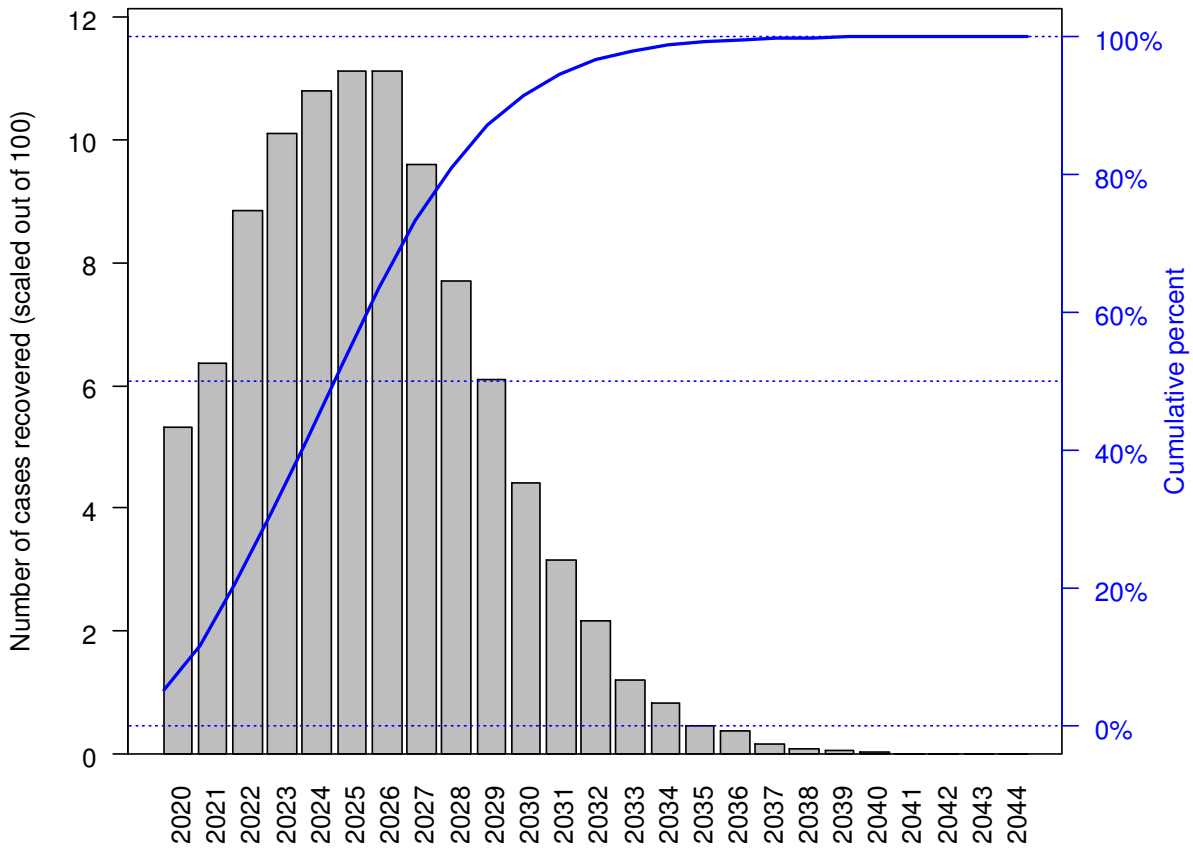

Figure 14A. Scenario 14 projection results with F=F30 starting in 2022 and recent average recruitment. Benchmarks are based on Block 3, and discard mortality on Block 4 with reallocation of F toward landings.

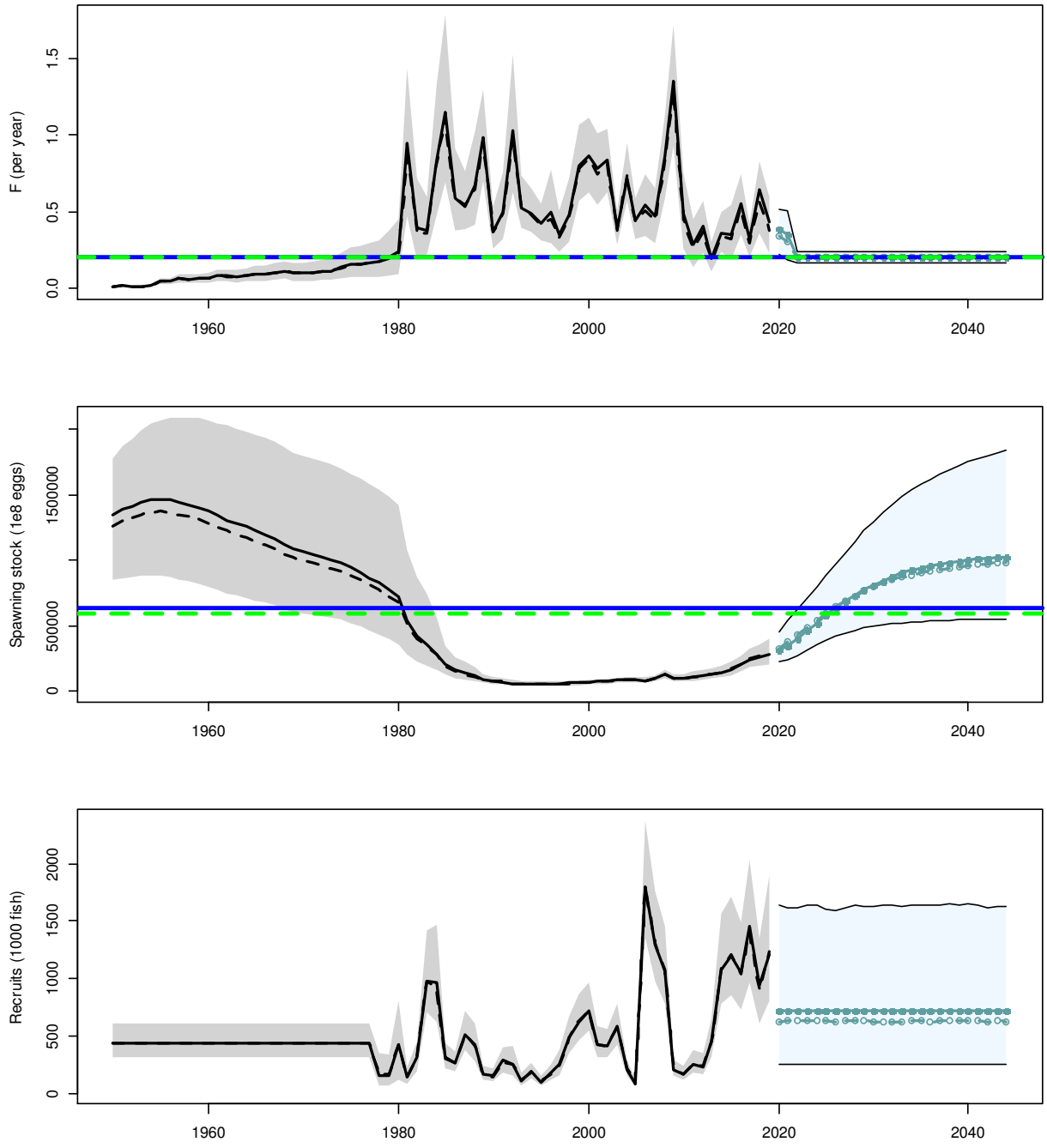

Figure 14B. Scenario 14 probability density and cumulative probability of stock recovery ($SSB>SSB_{F30}$).

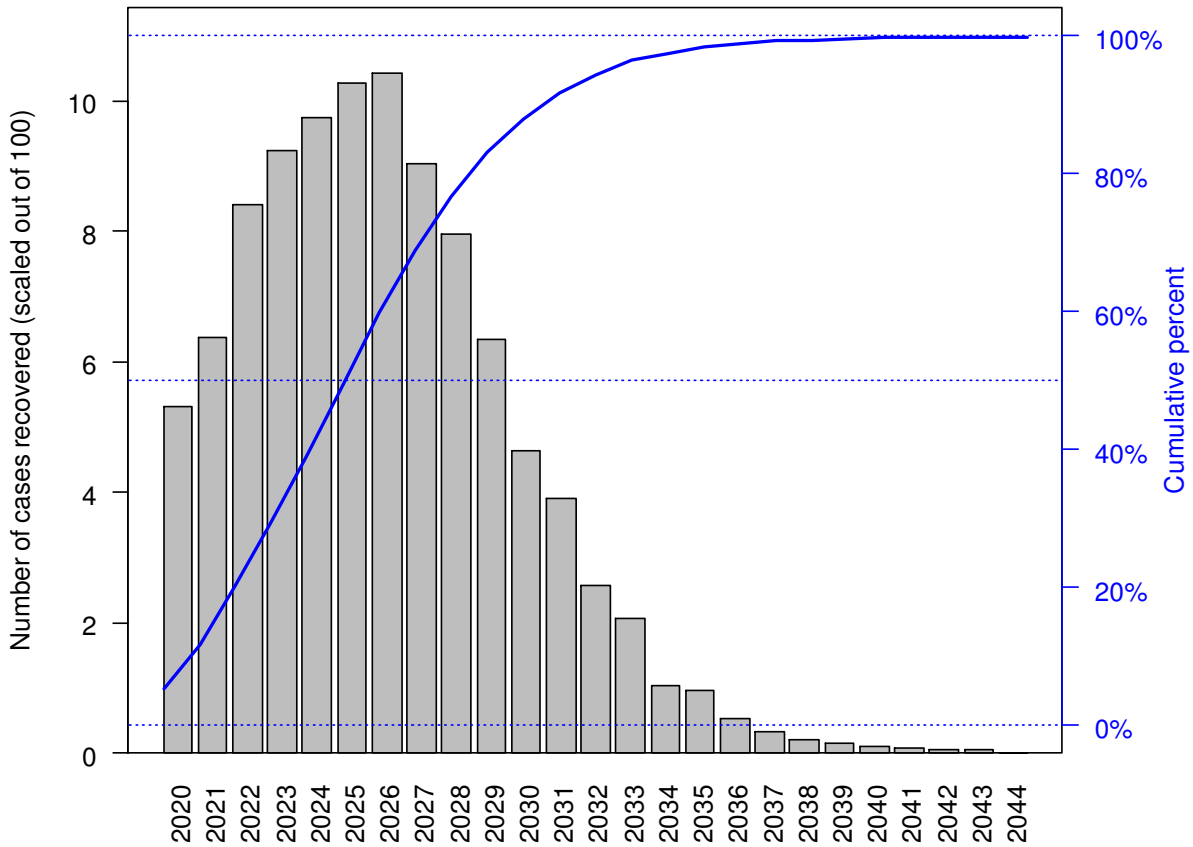

Figure 15A. Scenario 15 projection results with $F=F_{REBUILD}$ starting in 2022 and recent average recruitment. Benchmarks are based on Block 3, and discard mortality on Block 4 with no reallocation of F toward landings.

SEE FIGURE 13A. FOR SCENARIO 15, $F_{REBUILD}$ EXCEEDED F30 AND WOULD THUS BE CAPPED AT F30, THE RATE APPLIED IN SCENARIO 13.

Figure 15B. Scenario 15 probability density and cumulative probability of stock recovery ($SSB>SSB_{F30}$).

SEE FIGURE 13B. FOR SCENARIO 15, $F_{REBUILD}$ EXCEEDED F30 AND WOULD THUS BE CAPPED AT F30, THE RATE APPLIED IN SCENARIO 13.

Figure 16A. Scenario 16 projection results with $F=F_{REBUILD}$ starting in 2022 and recent average recruitment. Benchmarks are based on Block 3, and discard mortality on Block 4 with reallocation of F toward landings.

SEE FIGURE 14A. FOR SCENARIO 16, $F_{REBUILD}$ EXCEEDED F30 AND WOULD THUS BE CAPPED AT F30, THE RATE APPLIED IN SCENARIO 14.

Figure 16B. Scenario 16 probability density and cumulative probability of stock recovery ($SSB>SSB_{F30}$).

SEE FIGURE 14B. FOR SCENARIO 16, $F_{REBUILD}$ EXCEEDED F30 AND WOULD THUS BE CAPPED AT F30, THE RATE APPLIED IN SCENARIO 14.