SEDAR68-OA Scamp/Yellowmouth Grouper: SPR, Rebuilding Time Frame, and Additional Forecast Scenarios

Prepared by NMFS Southeast Fisheries Science Center

Issued: 31 March 2023

Introduction

In an email dated 2 February 2023, from Dr. Chip Collier to Dr. Larry Massey, the SAFMC requested additional information about South Atlantic scamp/yellowmouth grouper (hereafter, scamp) on behalf of the Council and the SSC. Specifically, the request was for the following:

- A base run with the MSY proxy at 30% static spr is needed. In the Comprehensive Amendment Addressing Sustainable Fishery Act Definitions and Other Provisions, the SAFMC established a proxy for snapper grouper species at 30% static spr (Amendment 11 1998). Goliath and Nassau Grouper were an exception at 40%. The MSY run will be needed as the Council considers changes to the MSY proxy.
- Guidance on developing a rebuilding scenario for overfished stocks to determine Tmin would be useful for the SSC discussions in April. Two recruitment levels were provided (recent average and long-term average) to the SSC but both have issues. The long-term average is not reasonable for determining Tmin because this level of recruitment has not been observed since 2010 based on the results of the stock assessment. This would give an overly optimistic recruitment scenario for rebuilding. The recent average should also not be used because there is no way to rebuild the population to MSY levels and a regime shift analysis did not indicate a change. What has been used in other areas to determine Tmin for stocks that are overfished and recent average recruitment is below long-term average recruitment?

In addition, in their review of the SEDAR68-OA, the SSC report of January 20, 2023 stated (SSC 2023):

- The rebuilding schedule should be based on long-term recruitment patterns following conclusions from the Catch Level Projections workgroup report. However, near-term ABC should be determined using recent recruitment estimates.
- The SSC requests the following analysis: Determine constant F that will allow the stock to rebuild within 10-year time frame assuming long-term average recruitment.

This report attempts to fulfill those requests, as well as provide forecasts that could be used for setting near-term ABCs.

Methods

Removals

The SEDAR68-RW CIE reviewers of this stock assessment recommended that landings and dead discards be pooled and modeled with a single selectivity curve. Following this advice, the stock assessment and projections provided estimates in terms of total removals (landings and dead discards combined).

Spawning Potential Ratio (SPR)

The assessment recommended that SPR=40% be used as a proxy for MSY-related quantities, based on scientific literature and grouper life history (SEDAR 2022). The SSC agreed with this recommendation (SSC 2023). $F_{X\%}$ is defined as the F that provides X% of the spawning potential relative to an unfished population, i.e., SPR = X%. Here we compare the assessment results using the recommended value of SPR=40% and the requested value of SPR=30%.

Note that the terms "percentages" and "ratios" are often used interchangeably (e.g., a ratio of 1.0 is equivalent to 100%) when speaking or writing about SPR.

Rebuilding Time Frame

The National Standard 1 Guidelines for rebuilding state:

> T_{min} means the amount of time the stock or stock complex is expect to take to rebuild to its MSY biomass level in the absence of any fishing mortality. In this context, the term "expected" means to have at least a 50 percent probability of attaining the B_{msy}, where such probabilities can be calculated. The starting year for the T_{min} calculation should be the first year that the rebuilding plan is expected to be implemented.
>
> If Tmin for the stock or stock complex is 10 years or less, then Tmax is 10 years. If Tmin for the stock or stock complex exceeds 10 years, then one of the following methods can be used to determine Tmax:
> (i) Tmin plus the length of time associated with one generation time for that stock or stock complex. "Generation time" is the average length of time between when an individual is born and the birth of its offspring,
> (ii) The amount of time the stock or stock complex is expected to take to rebuild to Bmsy if fished at 75 percent of MFMT, or
> (iii) Tmin multiplied by two.

It is expected that the SAFMC will be notified about scamp being overfished in the spring of 2023. After consultation with SERO, it seems the rebuilding plan should be implemented by spring of 2025 and we therefore assumed that any new management would take effect in that year. For the interim years, 2022-2024, landings were assumed to remain at their recent average (SEDAR 2022).

Using F = 0, we computed T_{min} under two different assumptions about recruitment, noting that the stock cannot rebuild under the assumption of recruitment staying at recent low values indefinitely. The first assumption was that recruitment returns to its long-term average in 2023. The second was that recruitment returns to the long-term average more gradually based on recruitment patterns from the assessment period. This latter hypothesis was modeled using a sine function fit to the assessment recruitment values and then extrapolating into the future until reaching long-term average recruitment (Figure 1). The approach is not intended to propose that recruitment is indefinitely cyclic, which could not be done with any confidence given that the recruitment values display only a single cycle. Rather, the sine curve is a convenient method to project an autocorrelated pattern of recruitment that increases at a rate consistent with recruitment gradients from the past. A fundamental assumption in its use is that the duration of below-average recruitment is the same as the duration of above-average recruitment. For stochastic projections, each MCBE iteration had its own sine curve fit (Figure 1) to model the average rate of increasing recruitment, to which lognormal annual deviations were applied.

The SSC control rule identified a probability of rebuilding ($P_{rebuild}$) equal to 0.7. We report results based on that probability, as well as 0.5.

Forecast scenarios that could be used to define T_{min} are the following:

- Scenario 1. F = 0 starting in 2025, with long-term average recruitment starting in 2023.
- Scenario 2. F = 0 starting in 2025, with increasing recruitment (sine) starting in 2023 until reaching long-term equilibrium.

Note that Scenario 1 was also included in the assessment report (SEDAR 2022), but differs slightly here in that F = 0 would be implemented in 2025 rather than 2024.

Additional forecast scenarios

Six additional forecast scenarios were run, either for potential use in setting ABCs or to fulfill the request in the SSC report (SSC 2023) utilizing $F_{rebuild}$. The $F_{rebuild}$ scenarios required a rebuilding time frame, which was assumed to be T_{max} = 10 years (as indicated by Scenarios 1 and 2), with a start year of 2025 and rebuild year of 2034. Each $F_{rebuild}$ configuration was run twice for two different probabilities of rebuilding, $P_{rebuild}$ = 0.5 and Prebuild = 0.7.

- Scenario 3. F = $F_{rebuild}$, with Prebuild = 0.5 and long-term average recruitment starting in 2023.
- Scenario 4. F = $F_{rebuild}$, with Prebuild = 0.7 and long-term average recruitment starting in 2023.
- Scenario 5. F = $F_{rebuild}$, with Prebuild = 0.5 and increasing recruitment (sine) starting in 2023 until reaching the long-term equilibrium.
- Scenario 6. F = $F_{rebuild}$, with Prebuild = 0.7 and increasing recruitment (sine) starting in 2023 until reaching the long-term equilibrium.
- Scenario 7. F = 75%F40, with recent average (low) recruitment.
- Scenario 8. F = $F_{current}$, with recent average (low) recruitment.

Scenarios 3 and 4 are provided because of the SSC request. Scenarios 5 and 6 are provided for their potential to produce ABCs, if the sine function hypothesis is adopted. Scenarios 7 and 8 are provided for their potential to produce ABCs, given the SSC's statement that near-term ABC should be determined using recent recruitment estimates. Note that Scenario 8 was also included in the assessment report (SEDAR 2022), but differs slightly here in that the new management would be implemented in 2025 rather than 2024. In all forecast scenarios, removals (landings plus dead discards) were held constant at their recent (2019-2021) average until 2025, when the scenario-specific F was implemented.

Results and Discussion

Spawning Potential Ratio (SPR)

Following the typical pattern, SPR declines with F (Figure 2). Given the rate of decline, $F_{30\%}$ = 0.52 is nearly twice that of $F_{40\%}$ = 0.28 (Table 1). The higher rate of fishing mortality results in higher equilibrium total removals (landings plus dead discards) and lower equilibrium values of biomass and spawning biomass, which relates to the reason why $F_{30\%}$ is considered a risky proxy for F_{MSY} for all but the most resilient stocks. Throughout the assessment period, the apical fishing never exceeded $F_{30\%}$, although the stock would still be considered overfished based on the MSST associated with SSB_{F30} (Figure 3).

Rebuilding Time Frame

The stock is projected to rebuild within 10 years if recruitment returns to its long-term average in 2023 (Figure 4) or if recruitment increases until reaching the long-term average according to the hypothesized timeline (Figure 5). Rebuilding was a little slower in the latter case. For both scenarios, the value of T_{min} depended on whether $P_{rebuild}$ is 0.5 or 0.7. However, in any case, T_{min} < 10 yr, which means that T_{max} = 10 yr, and the stock would need to be rebuilt by 2034. Thus, the $F_{rebuild}$ scenarios use 2034 as the year to measure rebuilding success.

Of course, the above rebuilding analyses (Scenarios 1 and 2) are predicated on the assumption that recruitment will return to the long-term average, either in a single jump (Scenario 1) or along the path predicted by a sine function (Scenario 2). If one were forced to choose between the two scenarios, Scenario 2 would seem the better choice, as it at least predicts a more gradual return to the long-term average, similar to gradients observed in the past. However, there was only a single increasing trend and a single decreasing trend during the assessment period, which provides little information on which to base predictions of the future. The return to long-term average may be very different from either of these forecast scenarios, or may not occur at all if there has been a regime shift. The evidence does not support declaring that a regime has occurred (SEDAR 2022), but that is different from declaring that one has definitely not occurred. In short, neither assumption (Scenario 1 or 2) is well supported by scientific evidence.

The scientifically honest answer is that we do not know how future recruitment will behave. We do not know if recruitment will return to the long-term average or, if it does, we do not know when that will be or what the trajectory will look like. Thus, science has little to say about T_{max}.

Additional forecast scenarios

Scenario 3 could rebuild in 2034 given $F_{rebuild}$ = 0.248 (Table 2, Figure 6). Scenario 4 could rebuild given $F_{rebuild}$ = 0.169 (Table 3, Figure 7). Scenario 5 could rebuild given $F_{rebuild}$ = 0.237 (Table 4, Figure 8). Scenario 6 could rebuild given $F_{rebuild}$ = 0.154 (Table 5, Figure 9).

Forecasts using recent average (low) recruitment may be appropriate for setting ABCs. Scenario 7 applied F = 75%$F_{40\%}$ (Table 6, Figure 10), and Scenario 8 applied F = $F_{current}$ (Table 7, Figure 11), both with recent average recruitment.

References

SEDAR. 2022. SEDAR 68 South Atlantic Scamp Stock Assessment Report. SEDAR, North Charleston SC. 162 pp. Available online at: https://sedarweb.org/assessments/sedar-68/

SSC. 2023. SAFMC Science and Statistical Committee Meeting Report, 20 January 2023.

Table 1. Estimates of MSY proxies using SPR=40% and SPR=30% from the SEDAR68OA base run of scamp/yellowmouth grouper. The quantity TR (total removals) is an MSY level that includes landings and dead discards combined.

Quantity	Units	SPR=40%	SPR=30%
F proxy	y^{-1}	0.28	0.52
B_{Fproxy}	metric tons	1503.87	1230.16
SSB_{Fproxy}	metric tons	1068.80	801.49
MSST	metric tons	801.60	601.12
TR_{Fproxy}	1000 lb whole	372.28	416.20
$F_{2019-2021}$/Fproxy	unitless	0.91	0.49
SSB_{2021}/MSST	unitless	0.36	0.48
SSB_{2021}/SSB_{Fproxy}	unitless	0.27	0.36

Table 2. Scenario 3: $F = F_{rebuild}$, with $P_{rebuild} = 0.5$ and long-term average recruitment starting in 2023. Values shown include recruitment (R), fishing rate (F), spawning biomass (S), total removals of landings and dead discards (TR) in both numbers and weight, and probability of rebuilding (pr.rebuild). Extension ".base" refers to deterministic projections extending from the base assessment model, and ".med" refers to median values from the stochastic MCBE projections.

year	R.base (1000)	R.med (1000)	F.base	F.med	S.base (mt)	S.med (mt)	TR.base (1000)	TR.med (1000)	TR.base (1000 lb)	TR.med (1000 lb)	pr.rebuild
2022	76	83	0.32	0.30	289	311	17	17	115	115	0.000
2023	291	240	0.33	0.31	291	318	18	18	115	115	0.000
2024	291	241	0.34	0.31	331	362	19	19	115	115	0.000
2025	291	242	0.25	0.25	436	458	15	16	88	97	0.010
2026	291	240	0.25	0.25	576	584	20	21	109	117	0.049
2027	291	238	0.25	0.25	712	711	30	29	157	158	0.124
2028	291	239	0.25	0.25	824	818	39	37	210	205	0.213
2029	291	240	0.25	0.25	909	901	46	44	252	244	0.296
2030	291	241	0.25	0.25	972	960	50	48	284	275	0.365
2031	291	241	0.25	0.25	1018	1006	53	51	306	296	0.417
2032	291	242	0.25	0.25	1050	1040	55	53	322	312	0.459
2033	291	238	0.25	0.25	1074	1062	56	54	334	323	0.486
2034	291	240	0.25	0.25	1090	1077	57	55	342	331	0.503
2035	291	240	0.25	0.25	1101	1089	57	55	348	338	0.518
2036	291	240	0.25	0.25	1109	1096	58	56	352	342	0.527

Table 3. Scenario 4: F = $F_{rebuild}$, with Prebuild = 0.7 and long-term average recruitment starting in 2023. Values shown include recruitment (R), fishing rate (F), spawning biomass (S), total removals of landings and dead discards (TR) in both numbers and weight, and probability of rebuilding (pr.rebuild). Extension ".base" refers to deterministic projections extending from the base assessment model, and ".med" refers to median values from the stochastic MCBE projections.

year	R.base (1000)	R.med (1000)	F.base	F.med	S.base (mt)	S.med (mt)	TR.base (1000)	TR.med (1000)	TR.base (1000 lb)	TR.med (1000 lb)	pr.rebuild
2022	76	83	0.32	0.30	289	311	17	17	115	115	0.000
2023	291	240	0.33	0.31	291	318	18	18	115	115	0.000
2024	291	241	0.34	0.31	331	362	19	19	115	115	0.000
2025	291	242	0.17	0.17	440	463	10	11	62	68	0.010
2026	291	240	0.17	0.17	592	601	14	15	80	86	0.054
2027	291	238	0.17	0.17	741	743	22	21	117	118	0.145
2028	291	239	0.17	0.17	872	868	29	28	159	156	0.262
2029	291	240	0.17	0.17	978	972	35	33	196	191	0.378
2030	291	241	0.17	0.17	1063	1053	39	37	224	219	0.474
2031	291	241	0.17	0.17	1129	1119	42	40	247	240	0.552
2032	291	242	0.17	0.17	1180	1172	44	42	265	257	0.615
2033	291	238	0.17	0.17	1219	1210	45	43	278	271	0.665
2034	291	240	0.17	0.17	1249	1238	46	44	289	281	0.700
2035	291	240	0.17	0.17	1272	1260	47	45	297	290	0.725
2036	291	240	0.17	0.17	1289	1276	47	46	303	296	0.745

Table 4. Scenario 5: F = $F_{rebuild}$, with Prebuild = 0.5 and increasing recruitment (sine) starting in 2023 until reaching the long-term equilibrium. Values shown include recruitment (R), fishing rate (F), spawning biomass (S), total removals of landings and dead discards (TR) in both numbers and weight, and probability of rebuilding (pr.rebuild). Extension ".base" refers to deterministic projections extending from the base assessment model, and ".med" refers to median values from the stochastic MCBE projections.

year	R.base (1000)	R.med (1000)	F.base	F.med	S.base (mt)	S.med (mt)	TR.base (1000)	TR.med (1000)	TR.base (1000 lb)	TR.med (1000 lb)	pr.rebuild
2022	76	83	0.32	0.30	289	311	17	17	115	115	0.000
2023	148	158	0.33	0.31	284	313	18	18	115	115	0.000
2024	175	187	0.34	0.31	294	338	19	19	115	115	0.000
2025	204	218	0.24	0.24	335	399	14	15	82	91	0.003
2026	234	236	0.24	0.24	409	495	16	18	91	104	0.016
2027	266	238	0.24	0.24	499	606	20	23	111	130	0.057
2028	291	239	0.24	0.24	598	720	25	30	139	164	0.124
2029	291	240	0.24	0.24	701	820	30	36	169	201	0.211
2030	291	241	0.24	0.24	801	900	36	42	201	236	0.298
2031	291	241	0.24	0.24	888	965	41	46	234	264	0.371
2032	291	242	0.24	0.24	958	1016	46	49	265	287	0.429
2033	291	238	0.24	0.24	1012	1051	50	51	290	304	0.473
2034	291	240	0.24	0.24	1051	1076	52	52	309	316	0.502
2035	291	240	0.24	0.24	1080	1094	54	53	323	326	0.525
2036	291	240	0.24	0.24	1101	1107	55	54	333	332	0.541

Table 5. Scenario 6: $F = F_{rebuild}$, with Prebuild = 0.7 and increasing recruitment (sine) starting in 2023 until reaching the long-term equilibrium. Values shown include recruitment (R), fishing rate (F), spawning biomass (S), total removals of landings and dead discards (TR) in both numbers and weight, and probability of rebuilding (pr.rebuild). Extension ".base" refers to deterministic projections extending from the base assessment model, and ".med" refers to median values from the stochastic MCBE projections.

year	R.base (1000)	R.med (1000)	F.base	F.med	S.base (mt)	S.med (mt)	TR.base (1000)	TR.med (1000)	TR.base (1000 lb)	TR.med (1000 lb)	pr.rebuild
2022	76	83	0.32	0.30	289	311	17	17	115	115	0.000
2023	148	158	0.33	0.31	284	313	18	18	115	115	0.000
2024	175	187	0.34	0.31	294	338	19	19	115	115	0.000
2025	204	218	0.15	0.15	340	404	9	10	55	61	0.003
2026	234	236	0.15	0.15	425	513	11	13	64	74	0.018
2027	266	238	0.15	0.15	526	638	14	17	81	94	0.068
2028	291	239	0.15	0.15	638	767	18	21	103	121	0.158
2029	291	240	0.15	0.15	756	886	22	26	127	151	0.278
2030	291	241	0.15	0.15	871	988	27	31	153	180	0.396
2031	291	241	0.15	0.15	976	1073	31	34	180	205	0.498
2032	291	242	0.15	0.15	1066	1144	35	37	206	227	0.583
2033	291	238	0.15	0.15	1138	1199	38	39	229	243	0.651
2034	291	240	0.15	0.15	1196	1241	40	41	247	257	0.701
2035	291	240	0.15	0.15	1242	1273	42	42	261	268	0.737
2036	291	240	0.15	0.15	1278	1298	43	43	273	276	0.763

Table 6. Scenario 7: F = 75%$F_{40\%}$, with recent average (low) recruitment. Values shown include recruitment (R), fishing rate (F), spawning biomass (S), total removals of landings and dead discards (TR) in both numbers and weight, and probability of rebuilding (pr.rebuild). Extension ".base" refers to deterministic projections extending from the base assessment model, and ".med" refers to median values from the stochastic MCBE projections.

year	R.base (1000)	R.med (1000)	F.base	F.med	S.base (mt)	S.med (mt)	TR.base (1000)	TR.med (1000)	TR.base (1000 lb)	TR.med (1000 lb)	pr.rebuild
2022	76	83	0.32	0.30	289	311	17	17	115	115	0.00
2023	76	65	0.33	0.31	281	307	18	18	115	115	0.00
2024	76	65	0.34	0.31	273	305	19	19	115	115	0.00
2025	76	66	0.21	0.22	273	304	12	14	71	83	0.00
2026	76	65	0.21	0.22	284	308	12	14	76	88	0.00
2027	76	64	0.21	0.22	293	311	13	14	79	89	0.00
2028	76	65	0.21	0.22	300	313	13	14	82	90	0.00
2029	76	65	0.21	0.22	305	314	14	14	84	90	0.00
2030	76	66	0.21	0.22	309	316	14	14	86	91	0.00
2031	76	65	0.21	0.22	312	317	14	14	87	91	0.00
2032	76	65	0.21	0.22	314	318	14	14	88	91	0.00
2033	76	65	0.21	0.22	315	320	14	14	88	91	0.00
2034	76	65	0.21	0.22	317	320	14	14	89	92	0.00
2035	76	65	0.21	0.22	317	320	14	14	89	92	0.00
2036	76	65	0.21	0.22	318	320	14	14	90	92	0.00

Table 7. Scenario 8: F = $F_{current}$, with recent average (low) recruitment. Values shown include recruitment (R), fishing rate (F), spawning biomass (S), total removals of landings and dead discards (TR) in both numbers and weight, and probability of rebuilding (pr.rebuild). Extension ".base" refers to deterministic projections extending from the base assessment model, and ".med" refers to median values from the stochastic MCBE projections.

year	R.base (1000)	R.med (1000)	F.base	F.med	S.base (mt)	S.med (mt)	TR.base (1000)	TR.med (1000)	TR.base (1000 lb)	TR.med (1000 lb)	pr.rebuild
2022	76	83	0.32	0.30	289	311	17	17	115	115	0.000
2023	76	65	0.33	0.31	281	307	18	18	115	115	0.000
2024	76	65	0.34	0.31	273	305	19	19	115	115	0.000
2025	76	66	0.25	0.24	271	304	14	14	85	88	0.000
2026	76	65	0.25	0.24	277	307	14	15	87	91	0.000
2027	76	64	0.25	0.24	281	309	15	15	89	92	0.000
2028	76	65	0.25	0.24	284	310	15	15	91	93	0.000
2029	76	65	0.25	0.24	287	310	15	15	92	93	0.000
2030	76	66	0.25	0.24	288	309	15	15	93	93	0.000
2031	76	65	0.25	0.24	290	309	15	15	94	93	0.000
2032	76	65	0.25	0.24	291	309	15	15	94	93	0.000
2033	76	65	0.25	0.24	291	309	15	15	94	93	0.000
2034	76	65	0.25	0.24	292	309	15	15	95	93	0.000
2035	76	65	0.25	0.24	292	308	15	15	95	93	0.000
2036	76	65	0.25	0.24	292	308	15	15	95	93	0.000

Figure 1. Fit of a sine curve to recruitment estimates (blue) from the base model and the extrapolation of that curve into the future until reaching the long-term average (green). Gray intervals show the 5th to 95th percentiles of similar fits from MCBE iterations.

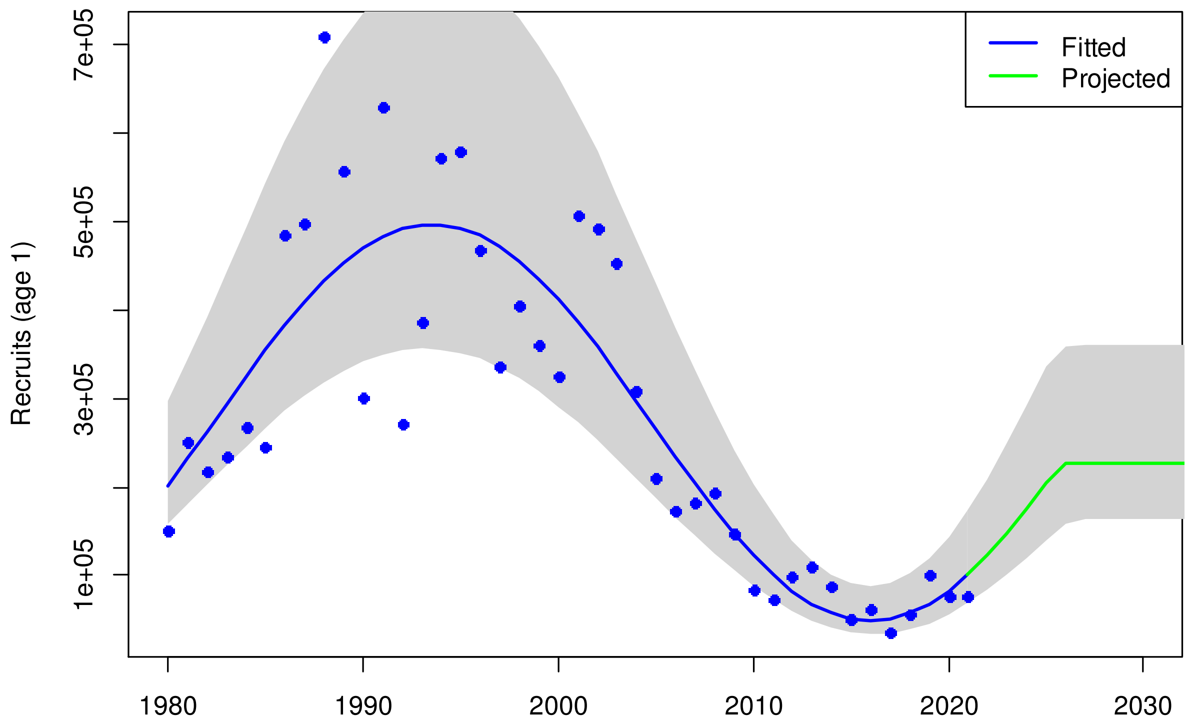

Figure 2. Spawning potential ratio (SPR) as a function of fishing mortality rate, with $F_{40\%}$ and $F_{30\%}$ overlaid.

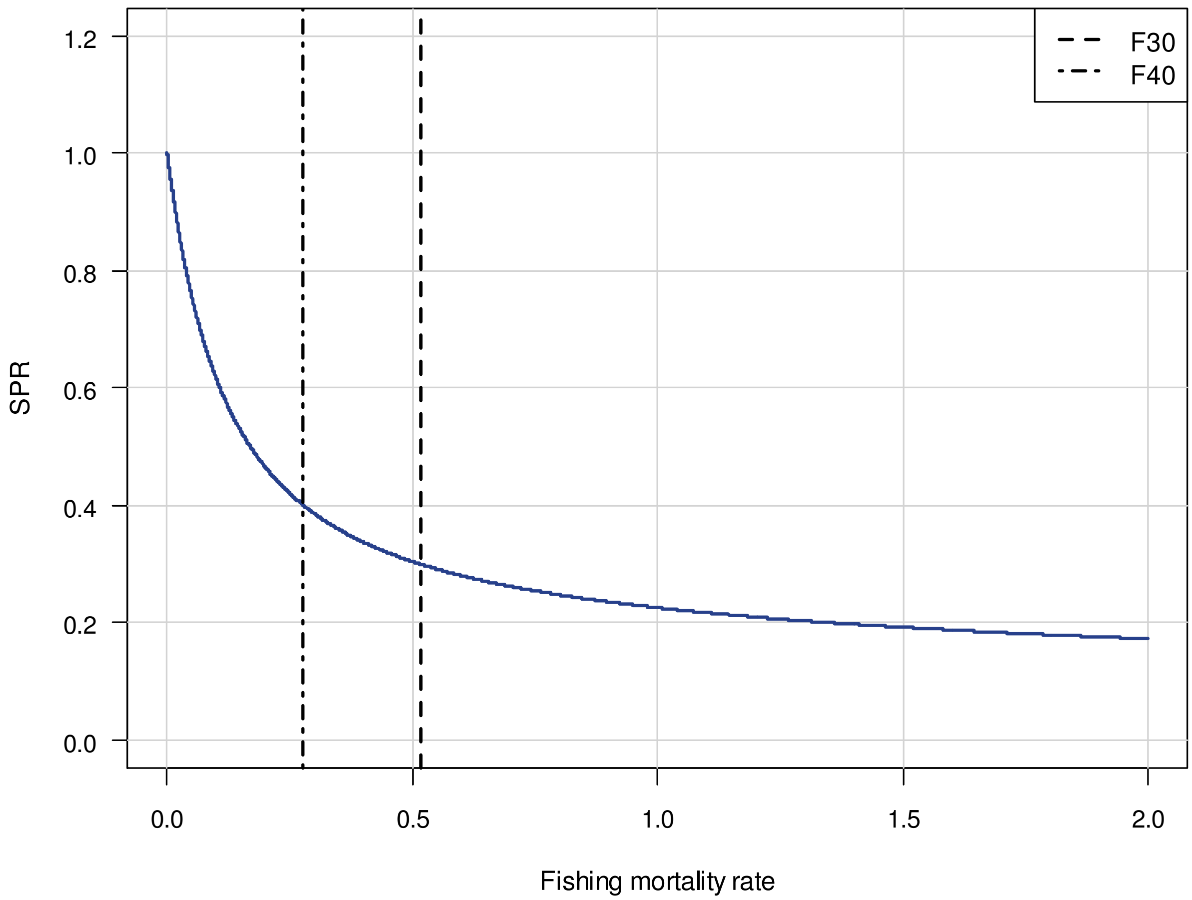

Figure 3. Time series estimated by the SEDAR68OA base run of scamp/yellowmouth grouper. Top panel: fishing mortality rate (F). Bottom panel: spawning biomass (SSB, mt). Horizontal lines on each panel show the SPR proxies related to SPR=30% and SPR=40%.

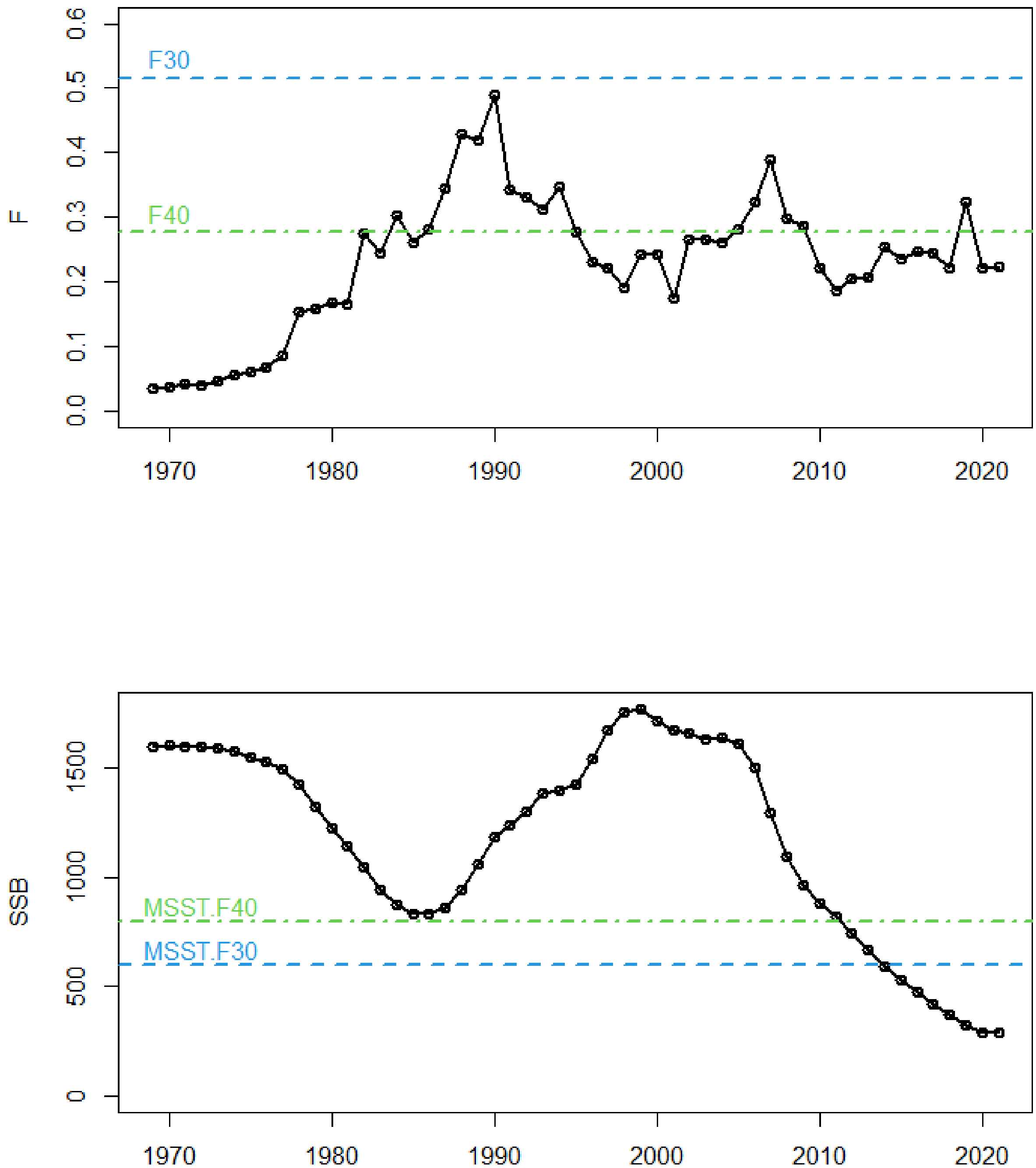

Figure 4. Probability of rebuilding using Scenario 1, with recruitment at the long-term average.

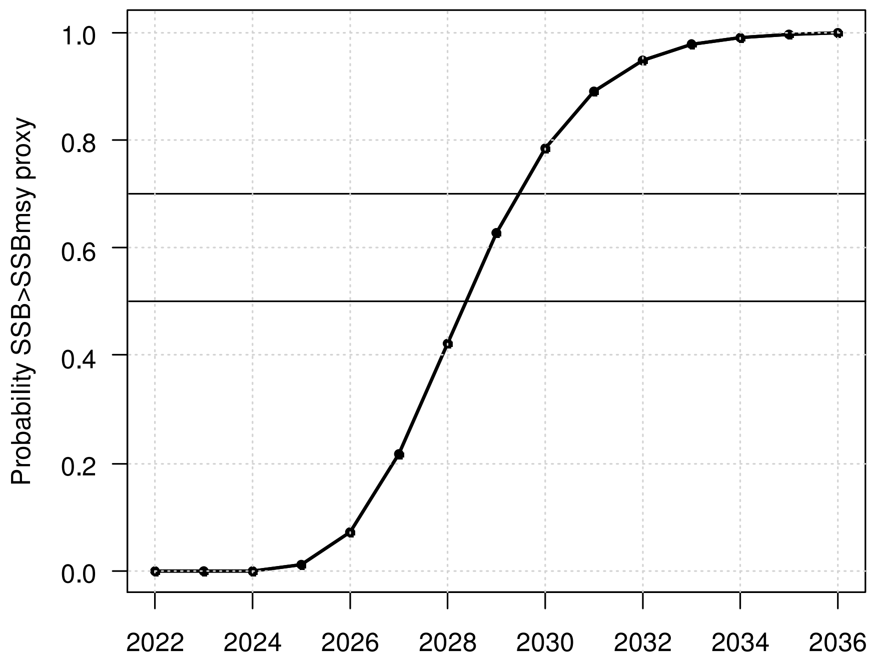

Figure 5. Probability of rebuilding using Scenario 2, with recruitment increasing until reaching the long-term average.

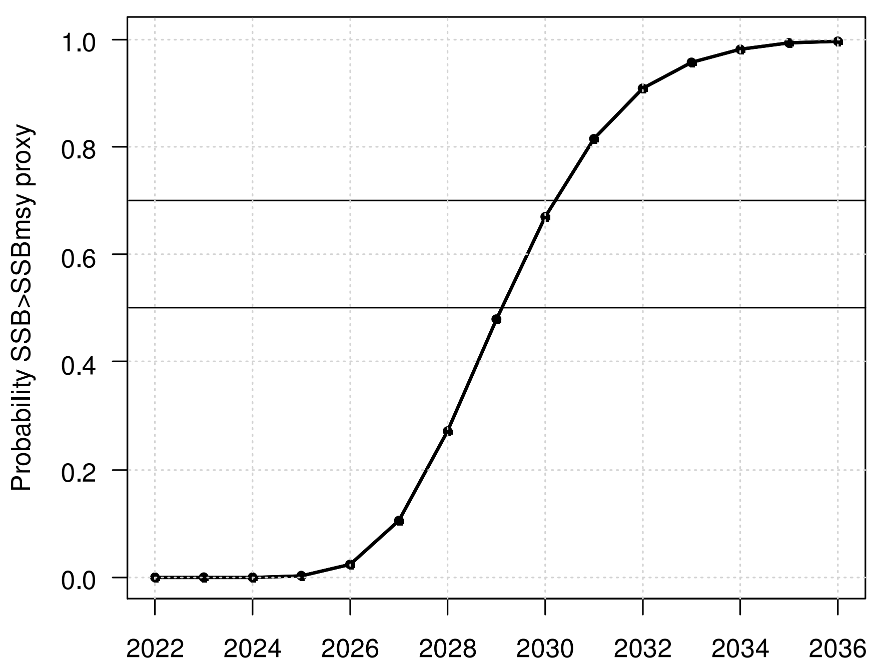

Figure 6. Scenario 3: $F = F_{rebuild}$, with Prebuild = 0.5 and long-term average recruitment starting in 2023.

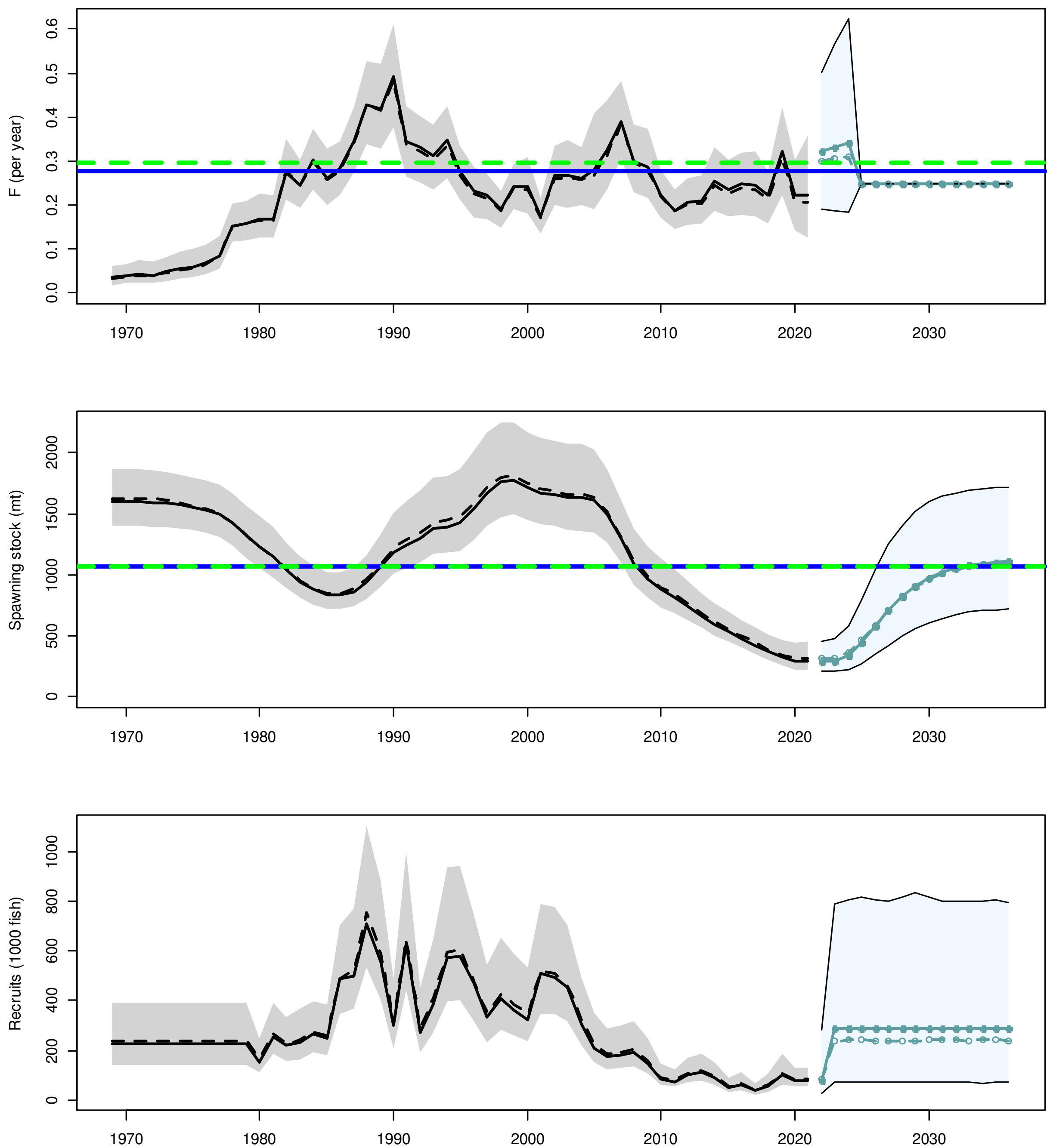

Figure 7. Scenario 4: F = $F_{rebuild}$, with Prebuild = 0.7 and long-term average recruitment starting in 2023.

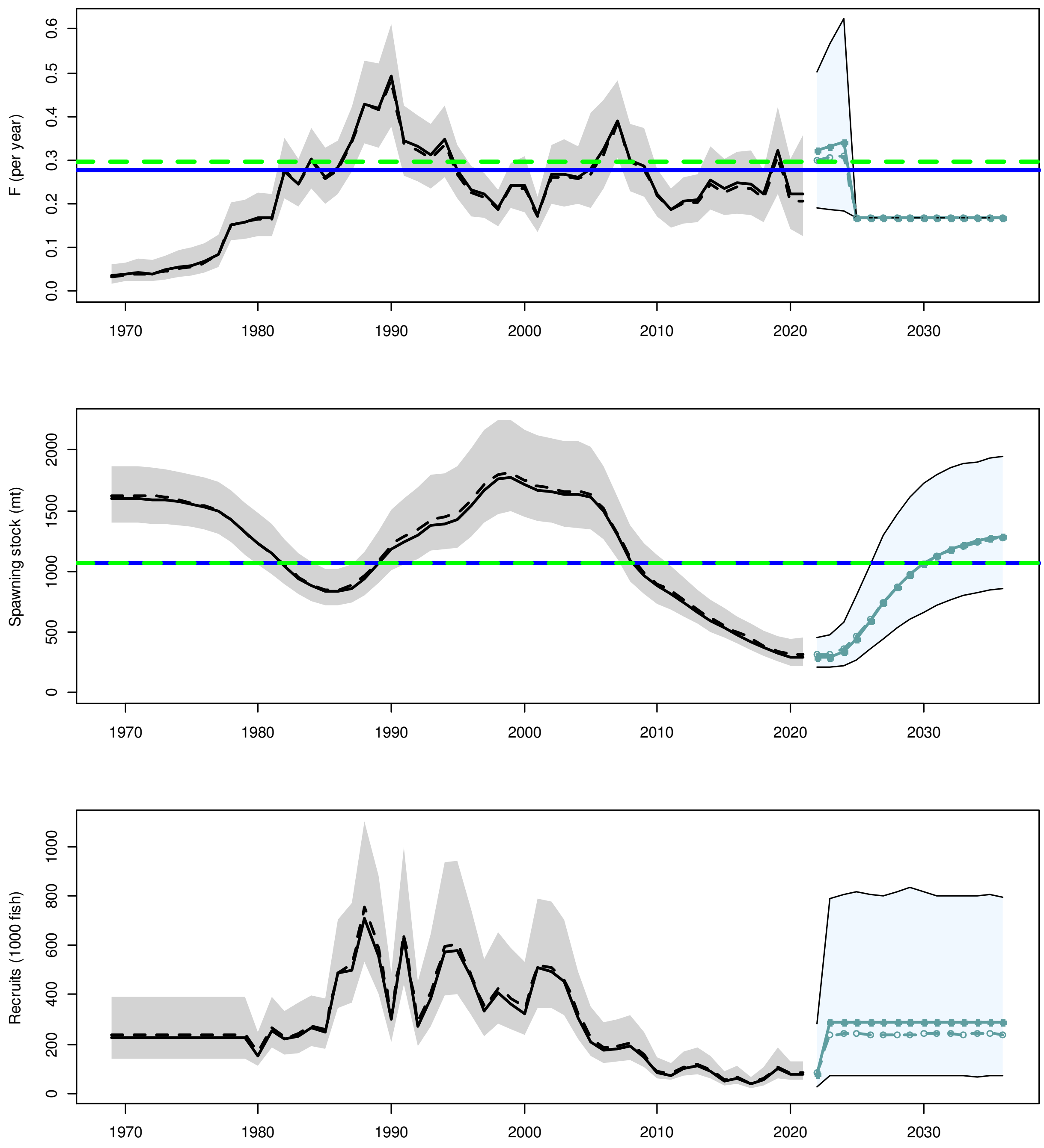

Figure 8. Scenario 5: F = $F_{rebuild}$, with Prebuild = 0.5 and increasing recruitment (sine) starting in 2023 until reaching the long-term equilibrium.

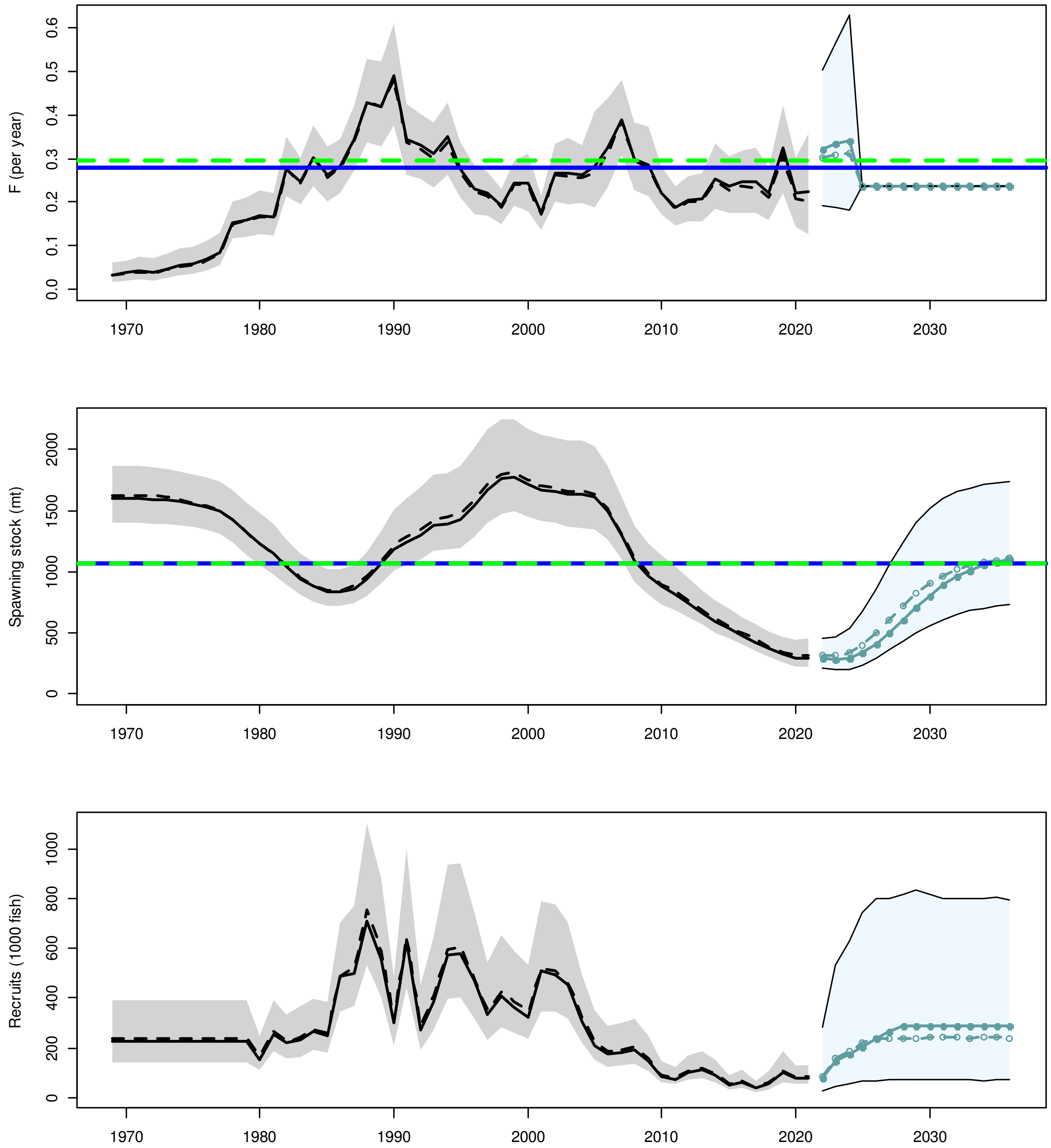

Figure 9. Scenario 6: F = $F_{rebuild}$, with Prebuild = 0.7 and increasing recruitment (sine) starting in 2023 until reaching the long-term equilibrium.

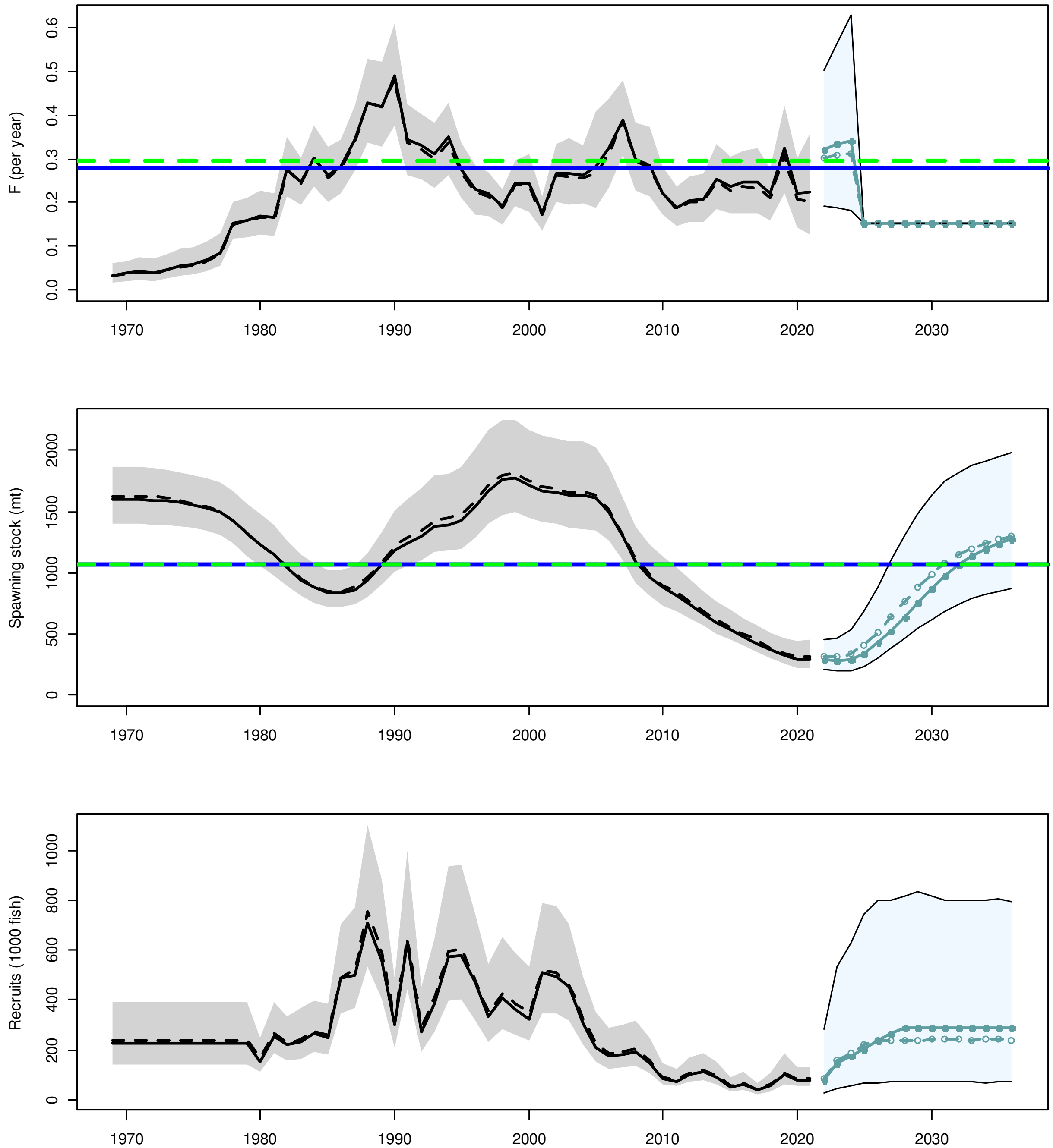

Figure 10. Scenario 7: F = 75%$F_{40\%}$, with recent average (low) recruitment.

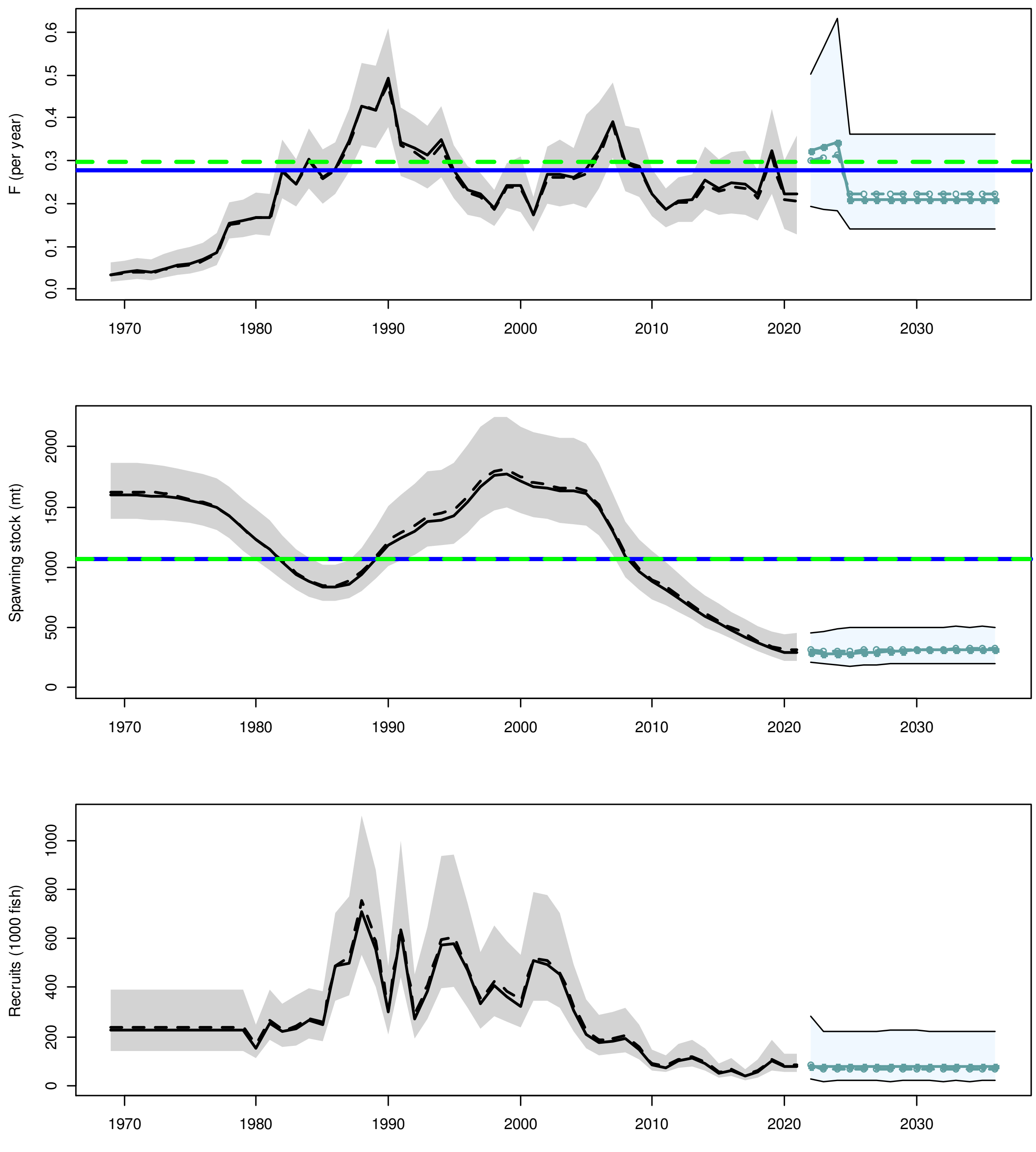

Figure 11. Scenario 8: F = $F_{current}$, with recent average (low) recruitment.