Projections for South Atlantic
Gag Grouper SEDAR 71 Stock Assessment

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This document responds to a request from the SAFMC (Sep 27, 2021 email) for projections following the SEDAR 71 South Atlantic Gag Grouper stock assessment. The request described five projection scenarios:

1. OFL (F_{msy}), recruitment conditioned on the spawner-recruit model, and management starting in 2023

2. ABC with a Prebuild = 50% in 10 years, low recruitment scenario (mean recruitment from 2010 to 2019), and management starting in 2023

3. ABC with a Prebuild = 50% in 10 years, recruitment conditioned on the spawner-recruit model, and management starting in 2023

4. ABC with a Prebuild = 70% in 10 years, recruitment conditioned on the spawner-recruit model, and management starting in 2023

5. ABC with a Prebuild = 70% in 10 years, low recruitment scenario (mean recruitment from 2010 to 2019), and management starting in 2023

All projections were conducted with the standard methodology reported in the SEDAR 71 assessment report. All MSY-related benchmarks are unchanged and come from the SEDAR 71 stock assessment report, which are based on a freely estimated Beverton-Holt stock-recruit curve (steepness = 0.898 and R_0 = 526,309 fish). The SEDAR 71 stock assessment estimated that overfishing in 2017 – 20179 was more than twice the F_{msy} value (F/F_{msy} = 2.15) and the Gag Grouper stock was at 15% of its SSB_{msy} level in 2019. Landings during each of the interim years (2020-2022) were assumed to be the average landings during the last three years of the assessment (2017-2019). Management was assumed to start in 2023 and projections were run 10 years after that point (until 2032). For low recruitment scenarios, recruitment during the projection years is the average of that from the last 10 years (2010-2019) of the assessment. Results for the F_{msy} projection (number 1 above) are shown in Table 1 and Figure 1-2. There is a 14.2% probability of recovery in 10 years under F_{msy}. Results for rebuilding in 10 years with a 50% probability under low recruitment (number 2 above) are shown in Table 2 and Fig. 3-4. The fishing rate leading to recovery under this scenario is F = 0.047. Results for rebuilding in 10 years with a 50% probability with recruitment conditioned on the stock-recruitment curve (number 3 above) are shown in Table 3 and Fig. 5-6. The fishing rate leading to recovery under this scenario is F = 0.255. Results for rebuilding in 10 years with a 70% probability with recruitment conditioned on the stock-recruitment curve (number 4 above) are shown in Table 4 and Fig. 7-8. The fishing rate leading to recovery under this scenario is F = 0.165. Results for rebuilding in 10 years with a 70% probability under low recruitment (number 5 above) are shown in Table 5 and Fig. 9-10. The fishing rate leading to recovery under this scenario is F = 0.0017.

Table 1. Projection results with fishing mortality rate fixed at F = F$_{msy}$, management starting in 2023, and recruitment conditioned on the stock recruitment curve. R = number of age-1 recruits (in 1000s), F = fishing mortality rate (per year), S = spawning stock (mt), L = landings, and D = dead discards expressed in numbers (n, in 1000s) and in gutted weight (gutted, in 1000 lb). The extension 'base' indicates expected values (deterministic) from the base run. The extension 'med' indicates median values from the stochastic projections.

Year	R.base (1000)	R.med (1000)	F.base	F.med	S.base (mt)	S.med (mt)	L.base (1000)	L.med (1000)	L.base (1000 lb gutted)	L.med (1000 lb gutted)	D.base (1000)	D.med (1000)	D.base (1000 lb gutted)	D.med (1000 lb gutted)	pr.recover
2020	301.18	263.851	1.01	0.98	225.39	223.37	49.313	49.187	539.102	538.888	25.234	22.211	103.89	91.978	0
2021	296.442	254.319	0.95	0.96	211.9	208.41	55.544	54.916	539.102	538.888	24.425	22.735	103.915	97.437	0
2022	287.234	240.482	0.75	0.79	241.1	228.51	55.62	55.697	539.102	538.808	19.07	18.449	82.344	80.336	0
2023	306.491	243.895	0.36	0.35	333.45	304.45	35.621	31.301	367.235	321.842	9.862	8.133	42.474	35.465	0
2024	354.216	275.332	0.36	0.35	472.81	437.19	44.843	40.114	494.338	441.192	11.156	8.99	47.624	39.022	0.003
2025	402.431	314.71	0.36	0.35	602.76	564.43	52.622	47.347	605.227	547.542	12.702	10.283	54.154	44.264	0.007
2026	432.824	342.051	0.36	0.35	715.94	677.47	60.151	54.174	706.366	641.138	13.94	11.3	59.91	49.077	0.016
2027	452.481	359.91	0.36	0.35	822.33	778.93	68.072	61.337	808.266	735.304	14.785	12.032	64.044	52.799	0.027
2028	467.096	375.328	0.36	0.35	930.93	877.11	75.932	68.284	912.033	828.544	15.379	12.598	66.962	55.324	0.046
2029	479.248	387.993	0.36	0.35	1039.41	972.99	83.028	75.175	1011.133	923.094	15.84	13.022	69.172	57.387	0.069
2030	489.309	400.295	0.36	0.35	1138.99	1059.48	88.942	80.622	1098.379	1003.829	16.216	13.378	70.944	59.021	0.092
2031	497.138	412.176	0.36	0.35	1224.3	1134.51	93.683	85.062	1171.12	1072.22	16.516	13.718	72.362	60.479	0.118
2032	502.992	420.363	0.36	0.35	1294.88	1197.59	97.454	88.599	1230.363	1126.44	16.746	14.122	73.46	62.346	0.142

Figure 1. Probability of rebuilding with fishing mortality rate fixed at F = F_{msy}, management starting in 2023, and recruitment conditioned on the stock recruitment curve. Solid horizontal lines reflect the 50% and 70% rebuilding probabilities.
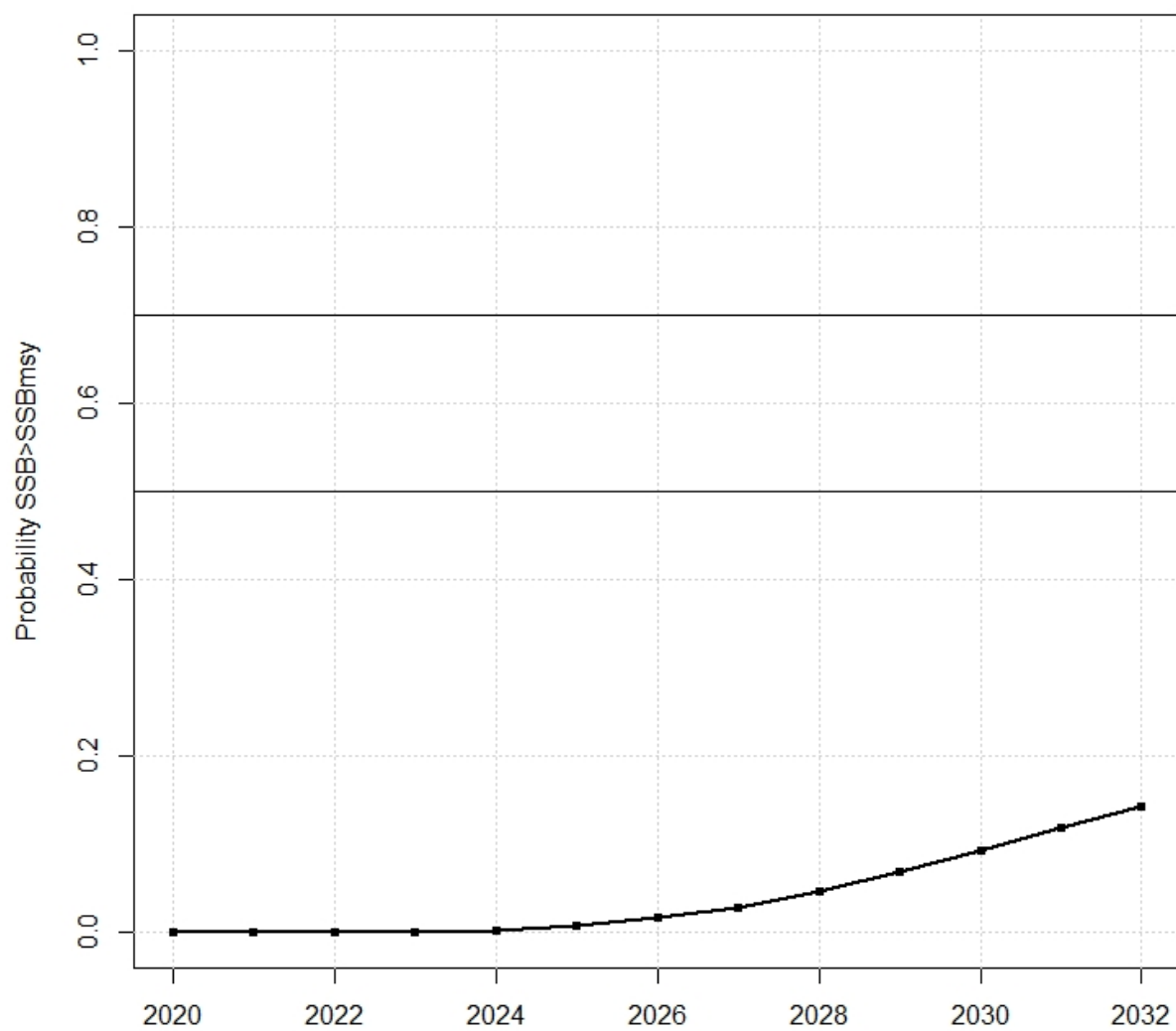
Figure 2. Ten-year projection results with fishing mortality rate at F = F_{msy} starting in 2023 and recruitment conditioned on the stock-recruitment curve. The interim years (2020-2022) use a mean of the 2017-2019 landings. In the top four panels, expected values (base run) represented by solid lines 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 MSY-related quantities from the base run; dashed horizontal lines represent corresponding median values from the replicate projections. Spawning stock (SSB) is at time of peak spawning.
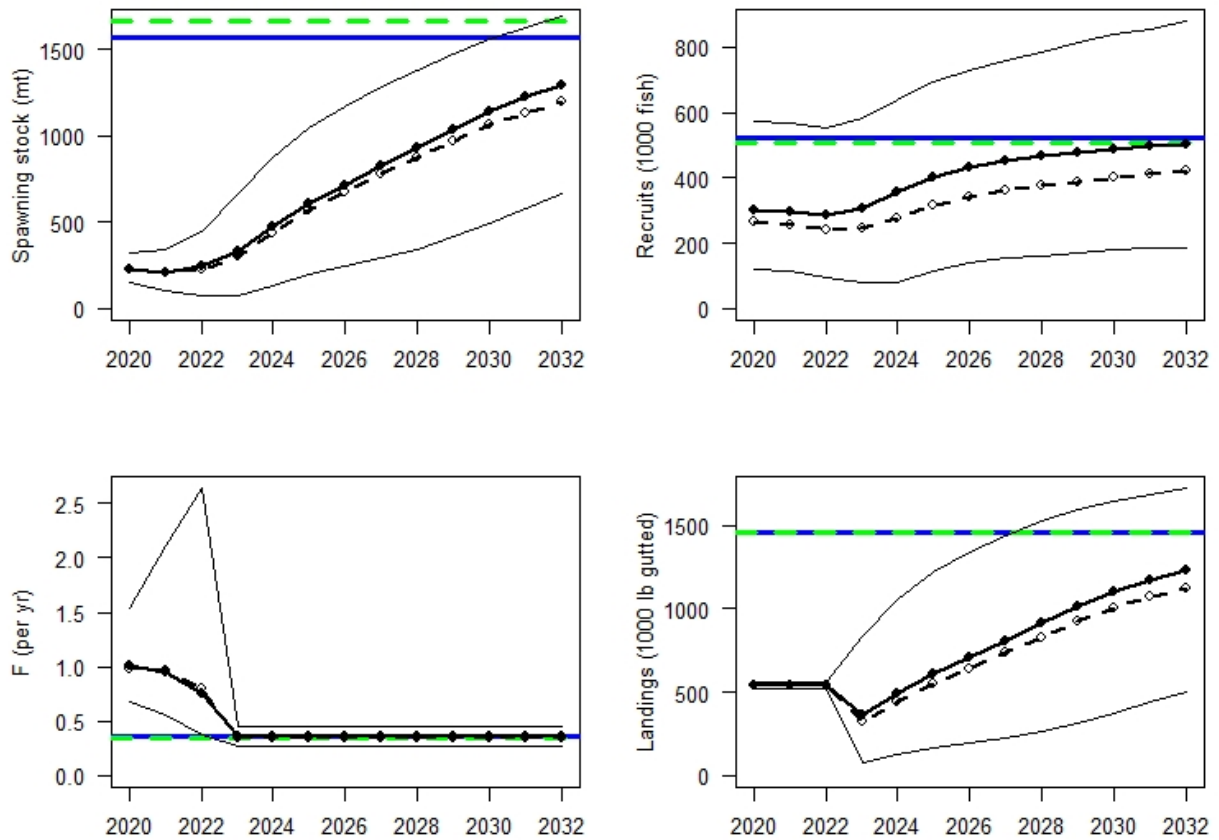
Table 2. Projection results with Prebuild = 50% in 10 years, low recruitment (mean recruitment from 2010-2019), and management starting in 2023. R = number of age-1 recruits (in 1000s), F = fishing mortality rate (per year), S = spawning stock (mt), L = landings, and D = dead discards expressed in numbers (n, in 1000s) and in gutted weight (gutted, in 1000 lb). The extension 'base' indicates expected values (deterministic) from the base run. The extension 'med' indicates median values from the stochastic projections.

Year	R.base (1000)	R.med (1000)	F.base	F.med	S.base (mt)	S.med (mt)	L.base (1000)	L.med (1000)	L.base (1000 lb gutted)	L.med (1000 lb gutted)	D.base (1000)	D.med (1000)	D.base (1000 lb gutted)	D.med (1000 lb gutted)	pr.recover
2020	301.18	177.076	1.01	0.98	225.39	217.32	49.313	48.964	539.102	538.654	25.234	17.497	103.89	76.025	0
2021	196.725	176.865	0.95	1	206.15	191.78	55.36	53.761	539.102	538.654	19.296	16.478	87.093	71.992	0
2022	196.725	179.031	0.77	0.97	224.9	189.31	54.674	53.503	539.102	538.596	13.677	16.029	60.582	69.123	0
2023	196.725	177.528	0.05	0.05	317.84	242.53	4.289	3.307	46.551	35.128	0.852	0.78	3.752	3.406	0
2024	196.725	177.723	0.05	0.05	514.95	391.85	5.772	4.705	69.274	54.367	0.871	0.816	3.873	3.627	0.003
2025	196.725	178.12	0.05	0.05	714.7	570.15	7.031	6.075	91.145	75.557	0.875	0.825	3.913	3.706	0.007
2026	196.725	177.671	0.05	0.05	905.52	760.19	8.057	7.269	110.951	96.348	0.877	0.826	3.927	3.731	0.025
2027	196.725	176.055	0.05	0.05	1085.2	949.49	8.887	8.264	128.523	115.712	0.877	0.826	3.933	3.733	0.073
2028	196.725	177.19	0.05	0.05	1247.76	1124.19	9.541	9.069	143.655	132.463	0.877	0.821	3.935	3.717	0.152
2029	196.725	178.047	0.05	0.05	1390.74	1281.02	10.052	9.686	156.47	147.11	0.877	0.826	3.936	3.747	0.249
2030	196.725	177.022	0.05	0.05	1514.33	1420.09	10.454	10.161	167.253	159.504	0.877	0.823	3.937	3.736	0.344
2031	196.725	176.344	0.05	0.05	1619.76	1539.47	10.772	10.55	176.292	169.888	0.877	0.823	3.937	3.741	0.426
2032	196.725	176.534	0.05	0.05	1708.8	1641.24	11.025	10.852	183.84	178.829	0.877	0.826	3.937	3.732	0.495

Figure 3. Probability of rebuilding with 50% probability in 10 years with management starting in 2023 and low recruitment (mean recruitment from 2010-1019). Solid horizontal line reflects the 50% probability.
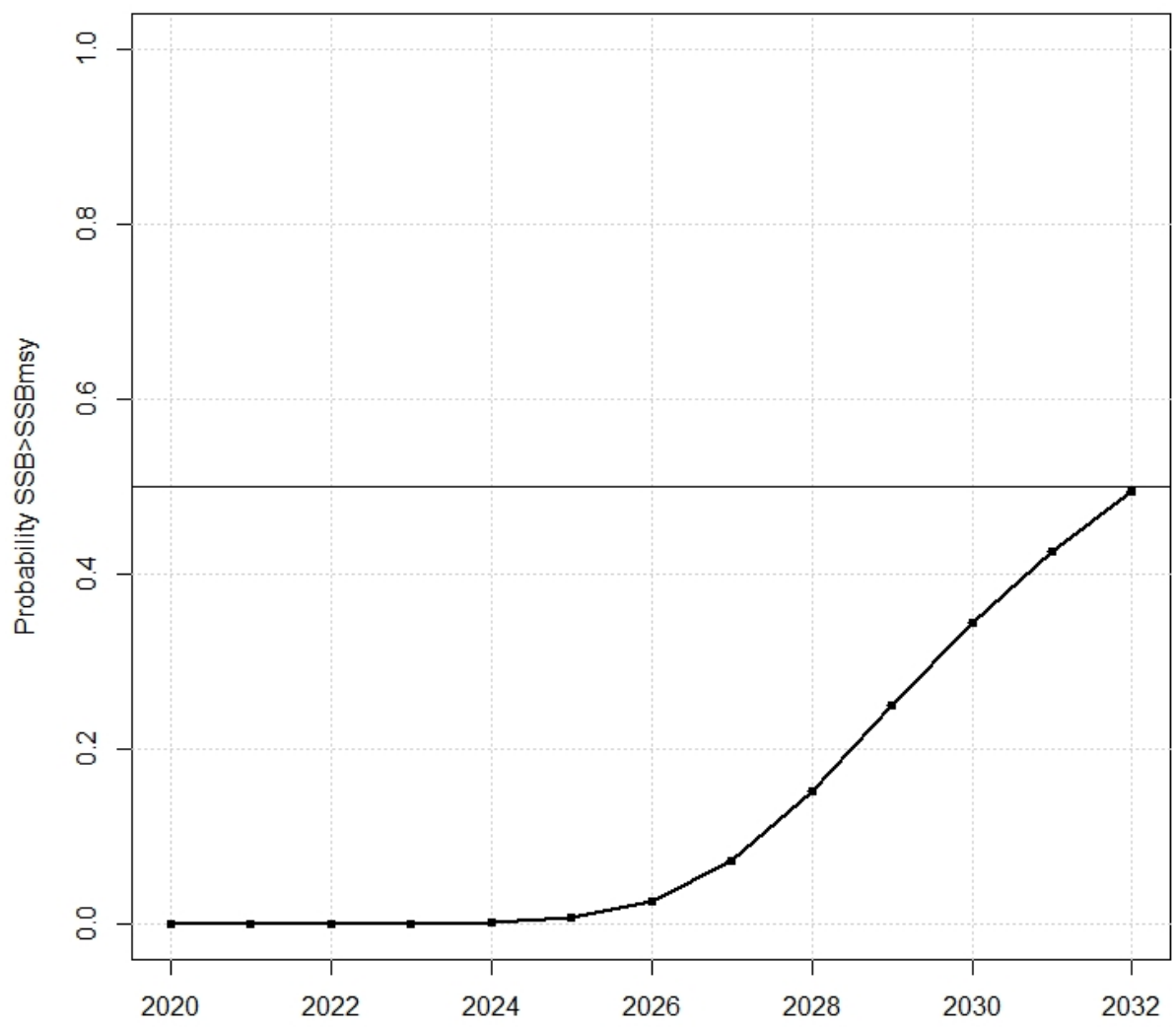
Figure 4. Ten-year projection results with Prebuild = 50%, management starting in 2023 and low recruitment (mean recruitment from 2010-2019). The interim years (2020-2022) use a mean of the 2017-2019 landings. In the top four panels, expected values (base run) represented by solid lines with solid circles, 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 MSY-related quantities from the base run; dashed horizontal lines represent corresponding median values from the replicate projections. Spawning stock (SSB) is at time of peak spawning.
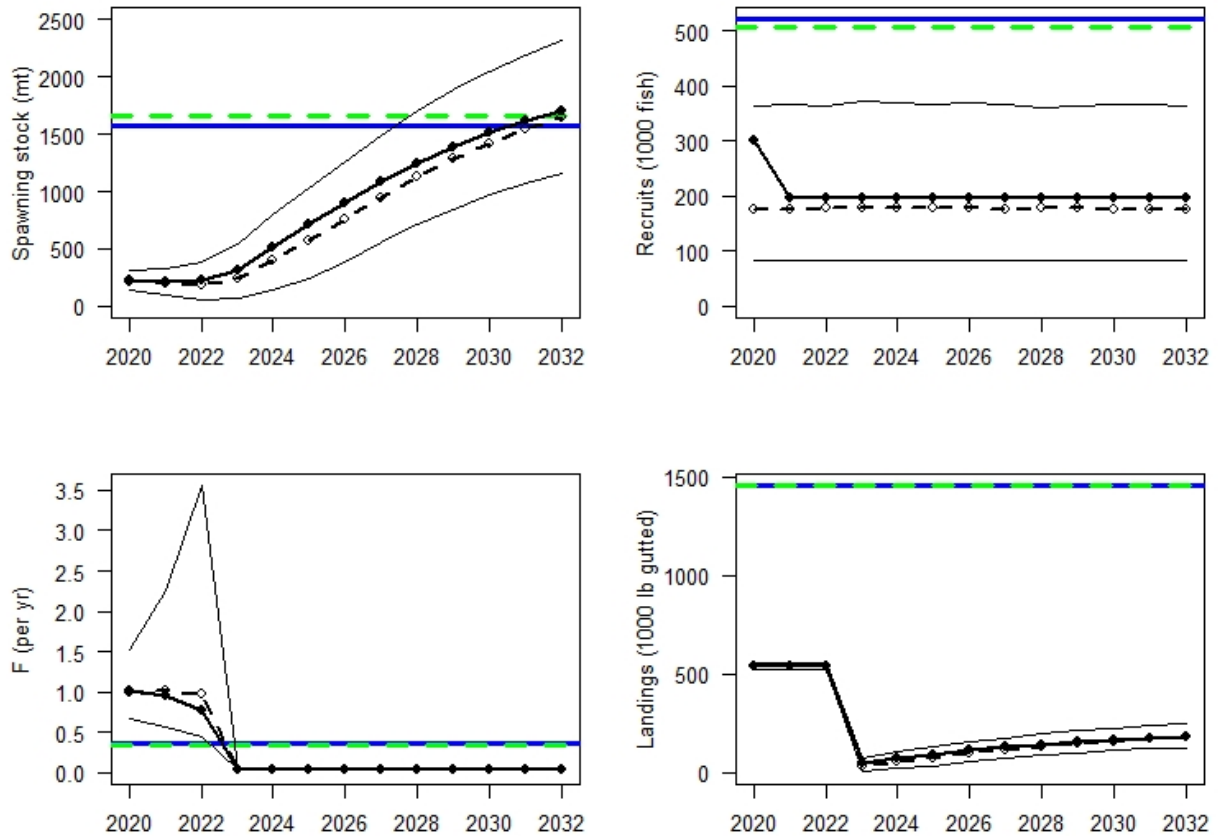
Table 3. Projection results with Prebuild = 50% in 10 years, recruitment conditioned on the stock-recruitment curve, and management starting in 2023. R = number of age-1 recruits (in 1000s), F = fishing mortality rate (per year), S = spawning stock (mt), L = landings, and D = dead discards expressed in numbers (n, in 1000s) and in gutted weight (gutted, in 1000 lb). The extension 'base' indicates expected values (deterministic) from the base run. The extension 'med' indicates median values from the stochastic projections.

Year	R.base (1000)	R.med (1000)	F.base	F.med	S.base (mt)	S.med (mt)	L.base (1000)	L.med (1000)	L.base (1000 lb gutted)	L.med (1000 lb gutted)	D.base (1000)	D.med (1000)	D.base (1000 lb gutted)	D.med (1000 lb gutted)	pr.recover
2020	301.18	263.851	1.01	0.98	225.39	223.37	49.313	49.187	539.102	538.888	25.234	22.211	103.89	91.978	0
2021	296.442	254.319	0.95	0.96	211.9	208.41	55.544	54.916	539.102	538.888	24.425	22.735	103.915	97.437	0
2022	287.234	240.482	0.75	0.79	241.1	228.51	55.62	55.697	539.102	538.808	19.07	18.449	82.344	80.336	0
2023	306.491	243.895	0.26	0.26	340.44	310.16	25.58	23.763	264.663	245.469	6.932	5.949	29.895	26.02	0.001
2024	357.195	277.007	0.26	0.26	511.12	467.71	33.688	31.487	376.03	349.29	7.911	6.615	33.85	28.71	0.009
2025	412.502	319.725	0.26	0.26	685.76	630.93	40.972	38.428	481.847	450.948	9.131	7.588	38.978	32.883	0.037
2026	447.715	349.708	0.26	0.26	849.07	789.64	48.067	44.969	582.49	545.64	10.134	8.406	43.635	36.631	0.095
2027	470.315	369.359	0.26	0.26	1006.96	938.44	55.493	51.7	684.508	640.846	10.822	9.01	47.023	39.434	0.171
2028	486.484	386.404	0.26	0.26	1169.06	1082.98	62.962	58.465	789.231	736.03	11.299	9.456	49.396	41.698	0.242
2029	499.283	400.136	0.26	0.26	1334.26	1237.41	69.921	65.03	892.019	832.729	11.654	9.817	51.136	43.529	0.313
2030	509.595	412.494	0.26	0.26	1491.58	1385.75	75.925	70.351	986.101	921.526	11.933	10.162	52.482	44.952	0.38
2031	517.573	424.685	0.26	0.26	1632.07	1517.68	80.864	74.864	1067.554	997.422	12.151	10.431	53.534	46.104	0.445
2032	523.558	432.617	0.26	0.26	1752.67	1629.54	84.844	78.542	1135.838	1060.141	12.318	10.709	54.343	47.533	0.501

Figure 5. Probability of rebuilding with 50% probability in 10 years with management starting in 2023 and recruitment conditioned on the stock recruitment curve. Solid horizontal line reflects the 50% probability.
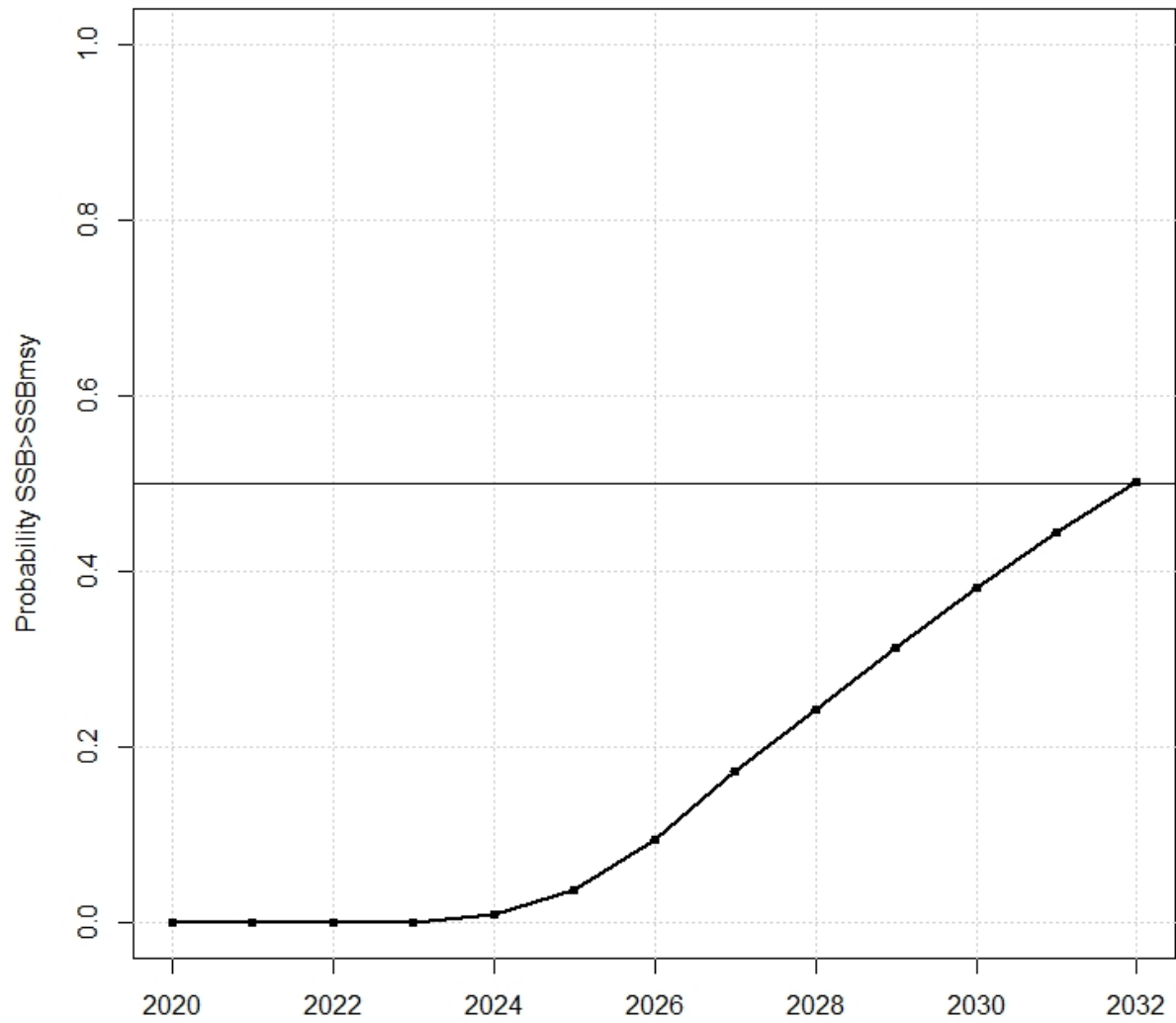
Figure 6. Ten-year projection results with Prebuild = 50%, management starting in 2023 and recruitment conditioned on the stock recruit curve. The interim years (2020-2022) use a mean of the 2017-2019 landings. In the top four panels, expected values (base run) represented by solid lines with solid circles, 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 MSY-related quantities from the base run; dashed horizontal lines represent corresponding median values from the replicate projections. Spawning stock (SSB) is at time of peak spawning.
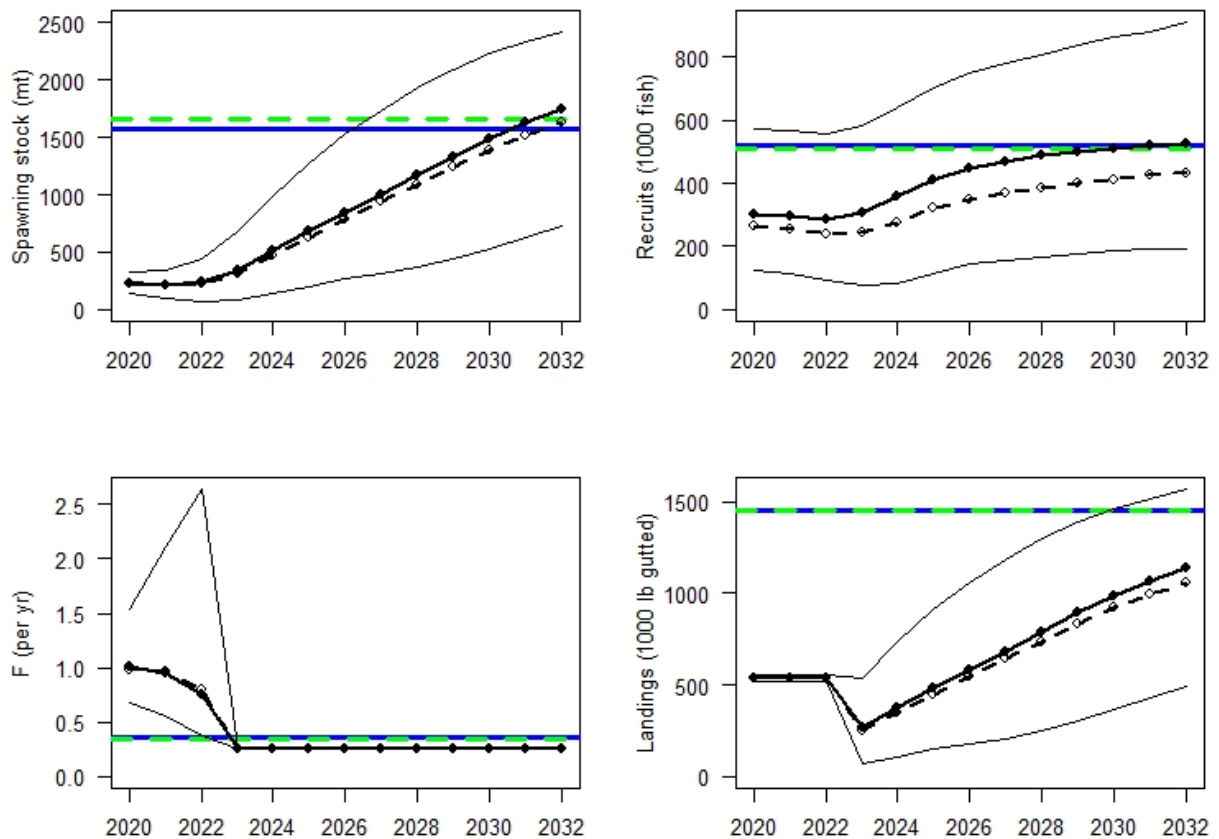
Table 4. Projection results with Prebuild = 70% in 10 years, recruitment conditioned on the stock-recruitment curve, and management starting in 2023. R = number of age-1 recruits (in 1000s), F = fishing mortality rate (per year), S = spawning stock (mt), L = landings, and D = dead discards expressed in numbers (n, in 1000s) and in gutted weight (gutted, in 1000 lb). The extension 'base' indicates expected values (deterministic) from the base run. The extension 'med' indicates median values from the stochastic projections.

Year	R.base (1000)	R.med (1000)	F.base	F.med	S.base (mt)	S.med (mt)	L.base (1000)	L.med (1000)	L.base (1000 lb gutted)	L.med (1000 lb gutted)	D.base (1000)	D.med (1000)	D.base (1000 lb gutted)	D.med (1000 lb gutted)	pr.recover
2020	301.18	263.776	1.01	0.98	225.39	224.39	49.313	49.156	539.102	538.9	25.234	21.922	103.89	91.036	0
2021	296.442	256.188	0.95	0.96	211.9	209.63	55.544	54.863	539.102	538.9	24.425	22.628	103.915	96.657	0
2022	287.234	242.554	0.75	0.79	241.1	229.66	55.62	55.611	539.102	538.855	19.07	18.417	82.344	80.024	0
2023	306.491	247.035	0.16	0.16	346.3	318.03	16.925	15.765	175.632	163.358	4.505	3.885	19.45	16.991	0.001
2024	359.64	277.292	0.16	0.16	545.55	501.69	23.158	21.688	261.171	244.306	5.179	4.308	22.202	18.787	0.014
2025	420.701	328.196	0.16	0.16	765.23	707.54	29.077	27.192	348.352	326.123	6.042	5.003	25.826	21.681	0.069
2026	459.641	360.882	0.16	0.16	984.01	913.66	34.954	32.588	435.081	406.069	6.763	5.638	29.176	24.554	0.168
2027	484.396	386.694	0.16	0.16	1203.36	1115.8	41.129	38.369	524.625	490.171	7.258	6.087	31.627	26.777	0.273
2028	501.62	407.898	0.16	0.16	1432.4	1332.63	47.415	44.367	617.778	578.332	7.596	6.438	33.333	28.5	0.373
2029	514.749	419.62	0.16	0.16	1670.67	1559.54	53.422	50.002	711.419	667.376	7.841	6.728	34.557	29.86	0.465
2030	525.047	435.112	0.16	0.16	1904.94	1779.41	58.772	55.083	800.088	752.284	8.027	6.93	35.475	30.851	0.551
2031	532.929	449.995	0.16	0.16	2122.35	1993.02	63.304	59.391	879.758	829.754	8.17	7.169	36.177	31.953	0.631
2032	538.838	458.191	0.16	0.16	2316.29	2180.5	67.043	62.972	948.911	897.005	8.278	7.324	36.71	32.745	0.704

Figure 7. Probability of rebuilding with 70% probability in 10 years with management starting in 2023 and recruitment conditioned on the stock recruitment curve. Solid horizontal line reflects the 70% probability.
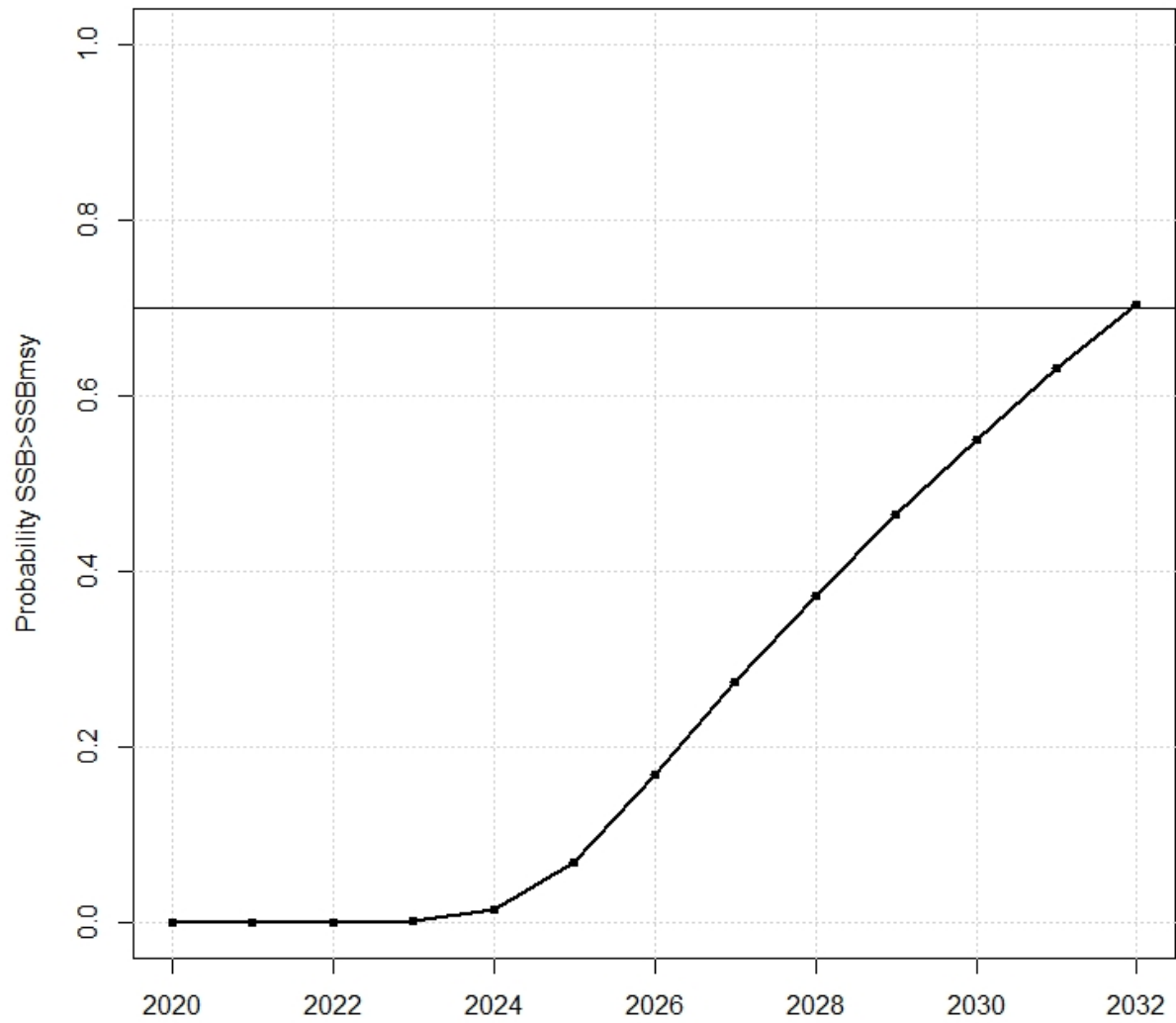
Figure 8. Ten-year projection results with Prebuild = 70%, management starting in 2023 and recruitment conditioned on the stock recruit curve. The interim years (2020-2022) use a mean of the 2017-2019 landings. In the top four panels, expected values (base run) represented by solid lines with solid circles, 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 MSY-related quantities from the base run; dashed horizontal lines represent corresponding median values from the replicate projections. Spawning stock (SSB) is at time of peak spawning.
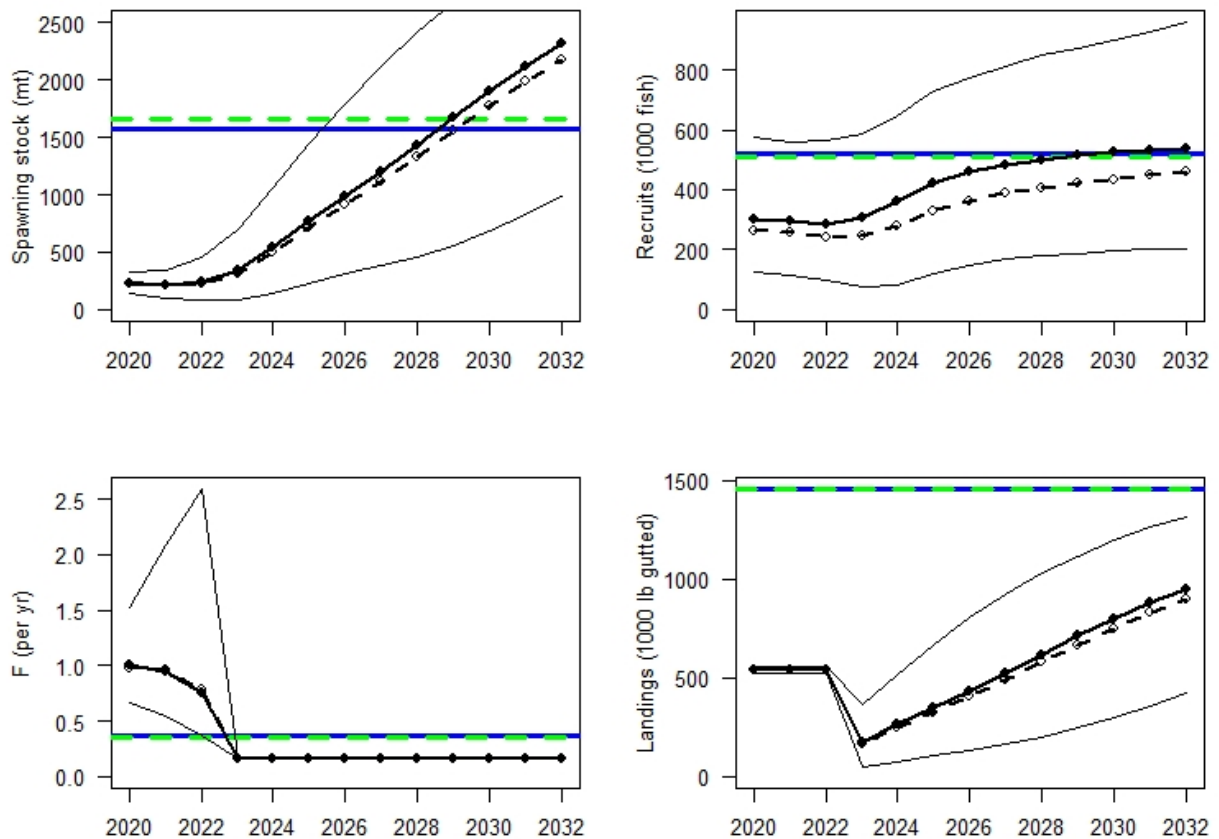
Table 5. Projection results with Prebuild = 70% in 10 years, low recruitment (mean recruitment from (2010-2019), and management starting in 2023. R = number of age-1 recruits (in 1000s), F = fishing mortality rate (per year), S = spawning stock (mt), L = landings, and D = dead discards expressed in numbers (n, in 1000s) and in gutted weight (gutted, in 1000 lb). The extension 'base' indicates expected values (deterministic) from the base run. The extension 'med' indicates median values from the stochastic projections.

Year	R.base (1000)	R.med (1000)	F.base	F.med	S.base (mt)	S.med (mt)	L.base (1000)	L.med (1000)	L.base (1000 lb gutted)	L.med (1000 lb gutted)	D.base (1000)	D.med (1000)	D.base (1000 lb gutted)	D.med (1000 lb gutted)	pr.recover
2020	301.18	177.174	1.01	0.98	225.39	217.75	49.313	48.986	539.102	538.756	25.234	17.447	103.89	76.131	0
2021	196.725	177.549	0.95	1	206.15	191.73	55.36	53.736	539.102	538.754	19.296	16.554	87.093	72.184	0
2022	196.725	177.218	0.77	0.97	224.9	189.17	54.674	53.442	539.102	538.644	13.677	15.917	60.582	69.128	0
2023	196.725	177.982	0	0	320.78	245.14	0.157	0.121	1.707	1.29	0.031	0.028	0.136	0.124	0
2024	196.725	177.752	0	0	534.16	406.14	0.216	0.176	2.608	2.048	0.032	0.03	0.141	0.132	0.003
2025	196.725	178.128	0	0	762.13	605.27	0.269	0.231	3.52	2.9	0.032	0.03	0.143	0.135	0.013
2026	196.725	177.395	0	0	990.59	827.74	0.314	0.283	4.384	3.789	0.032	0.03	0.143	0.136	0.049
2027	196.725	177.015	0	0	1214.91	1059.97	0.352	0.327	5.184	4.653	0.032	0.03	0.143	0.137	0.133
2028	196.725	176.889	0	0	1426.55	1284.09	0.383	0.363	5.901	5.435	0.032	0.03	0.143	0.136	0.26
2029	196.725	178.065	0	0	1620.78	1491.28	0.408	0.392	6.535	6.139	0.032	0.03	0.144	0.137	0.394
2030	196.725	177.006	0	0	1795.92	1679.85	0.428	0.416	7.092	6.755	0.032	0.03	0.144	0.137	0.516
2031	196.725	177.838	0	0	1951.74	1850.2	0.446	0.436	7.578	7.287	0.032	0.03	0.144	0.137	0.62
2032	196.725	178.425	0	0	2088.94	2000.02	0.46	0.453	8.002	7.762	0.032	0.03	0.144	0.137	0.701

Figure 9. Probability of rebuilding with 70% probability in 10 years with management starting in 2023 and low recruitment (mean recruitment from 2010-1019). Solid horizontal line reflects the 70% probability.
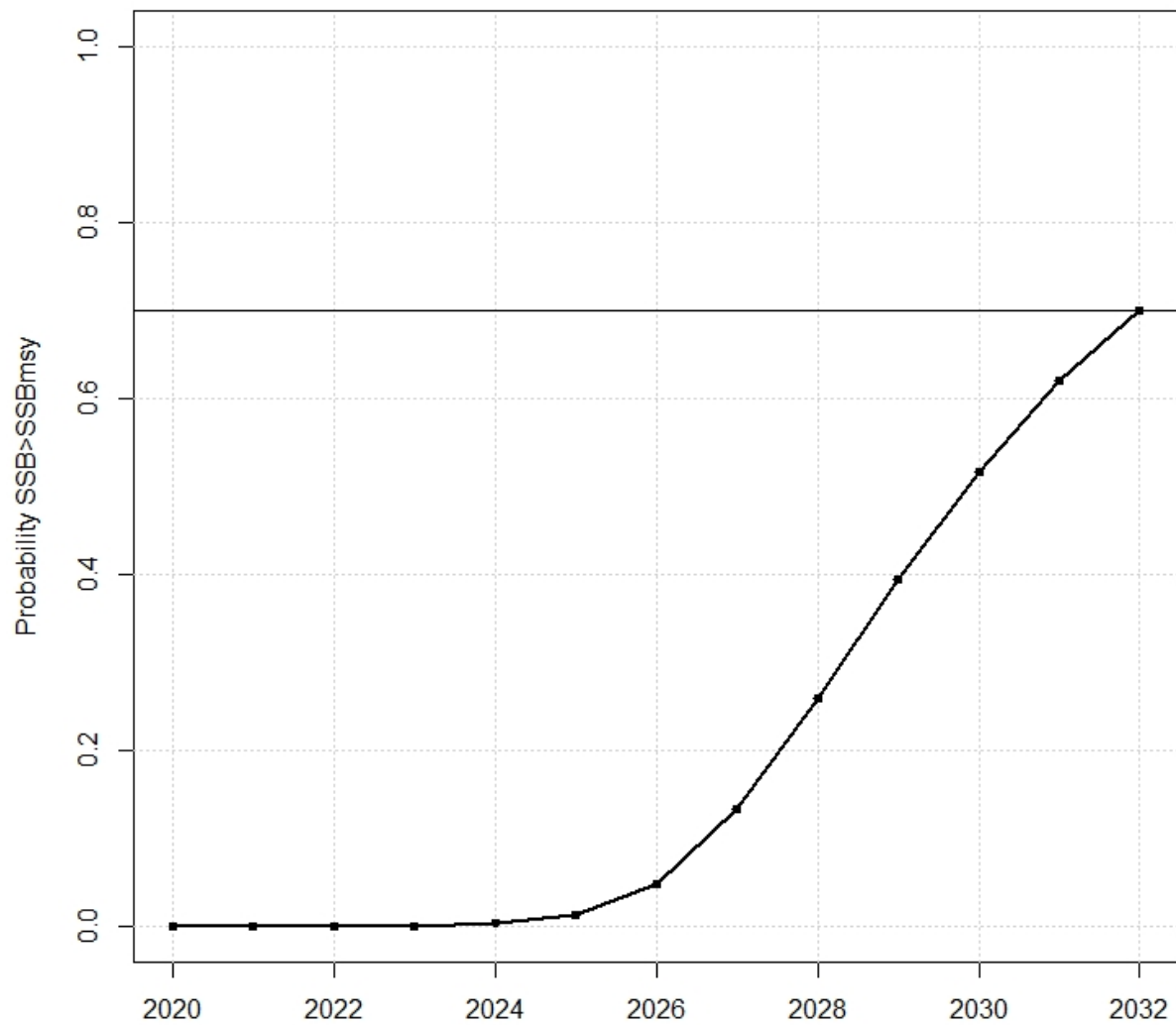
Figure 10. Ten-year projection results with Prebuild = 70%, management starting in 2023 and low recruitment (mean recruitment from 2010-2019). The interim years (2020-2022) use a mean of the 2017-2019 landings. In the top four panels, expected values (base run) represented by solid lines with solid circles, 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 MSY-related quantities from the base run; dashed horizontal lines represent corresponding median values from the replicate projections. Spawning stock (SSB) is at time of peak spawning.