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Black Sea Bass Projections

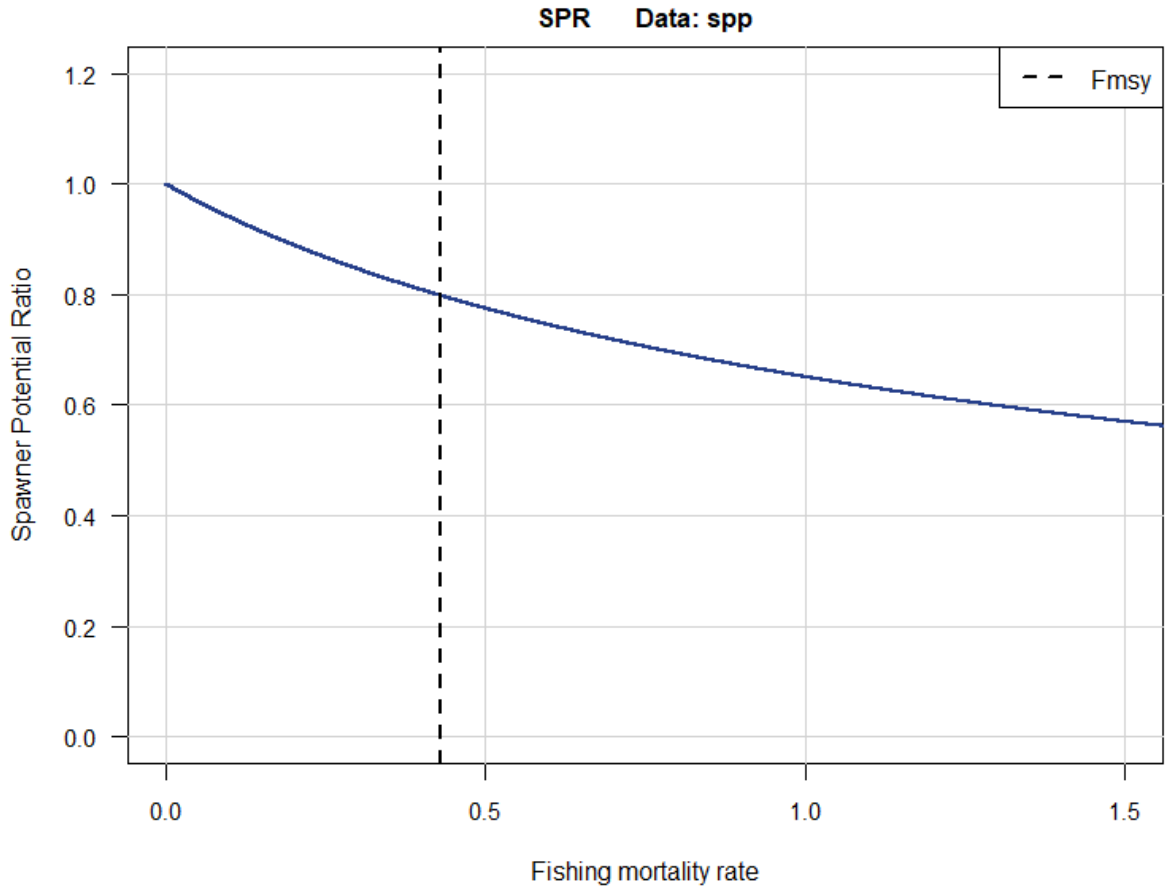
October SSC 2023

Projections Recommendations from SSC

- Fixed F for the interim years, with F being the average of the last three years of the time series.
- Projection using F0.1 instead of Fmax (F_{MLY})
- Allow F from discard fleet to remain constant or increase
- Use both recent average and long-term average recruitment in projections.
- Consider all available information regarding actual landings and discards for 2022
- Exploration of “sine-wave” increase in recruitment scenarios similar to Scamp assessment projections.
  - Likely not possible because of lack of uptick in recruitment
- ABC projection using recent (2014-2019) average recruitment and 75%*F0.1
- 10 year rebuilding projection using long-term average recruitment and $F_{0.1}$

Recommendations from SSC

- Investigate alternative calculations for SPR
  - Use of female fecundity may not be an appropriate metric for a hermaphroditic species
- "MSY" presented in assessment is not truly a MSY because it does not incorporate density dependence due to the mean SRR
  - It is a maximum landed yield and does not take into account discards
  - Conduct projections using $F_{0.1}$ as alternative reference point



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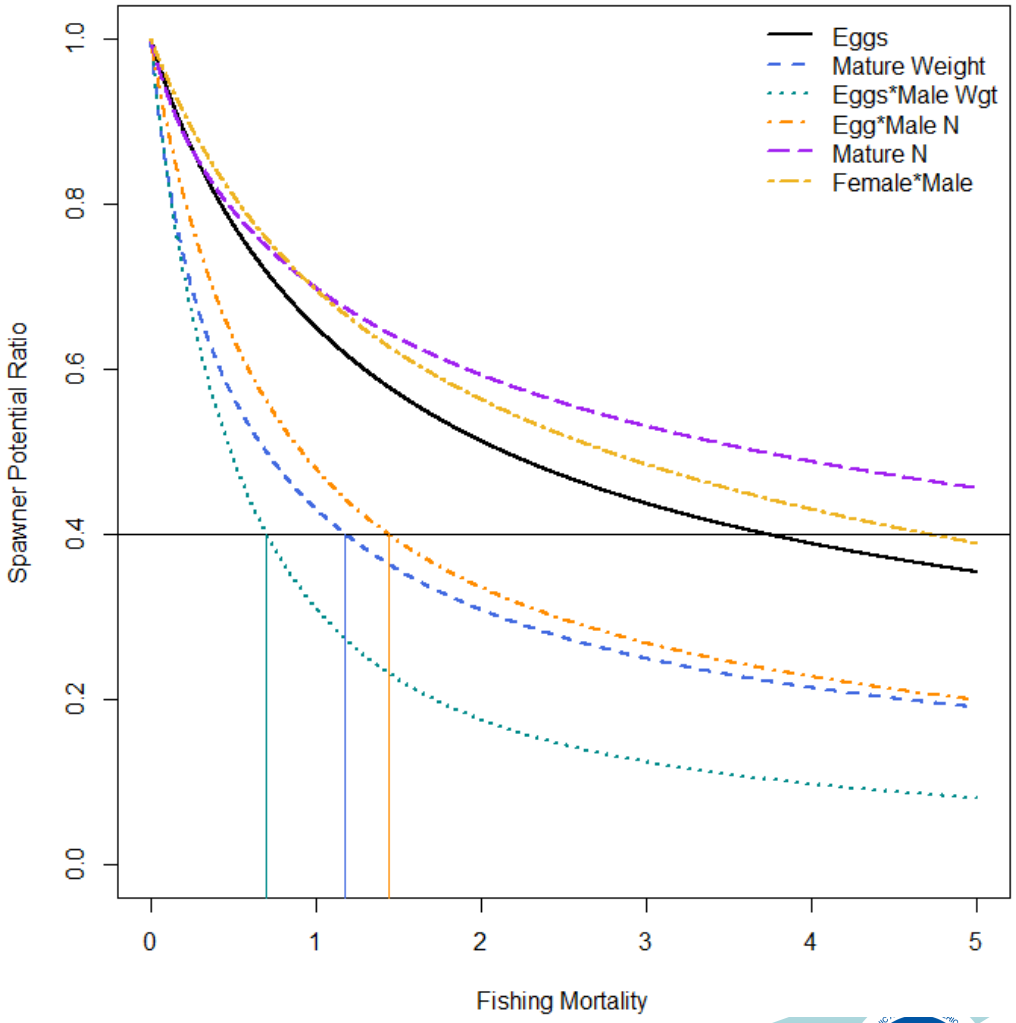
Options for calculating SPR

- Previous assessment is based on female egg production
- Sum of mature male and female weight used in other species
  - Could allow for removal of males if selectivity targets largest fish and protogynous species
- The product of male and female abundance could be used if sperm limitation occurs
  - As males decrease then SPR would also decrease accordingly
  - Needs further research



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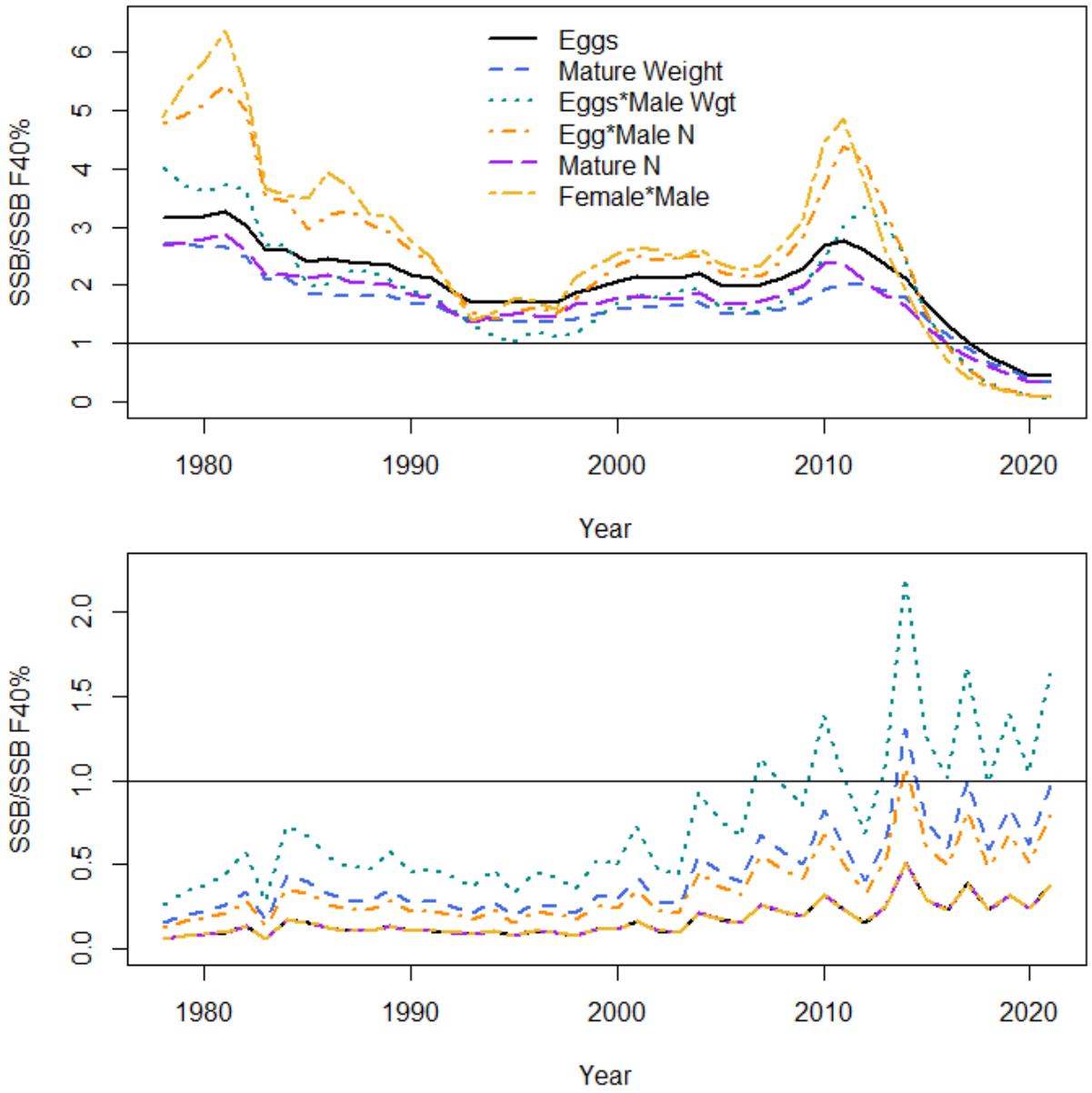
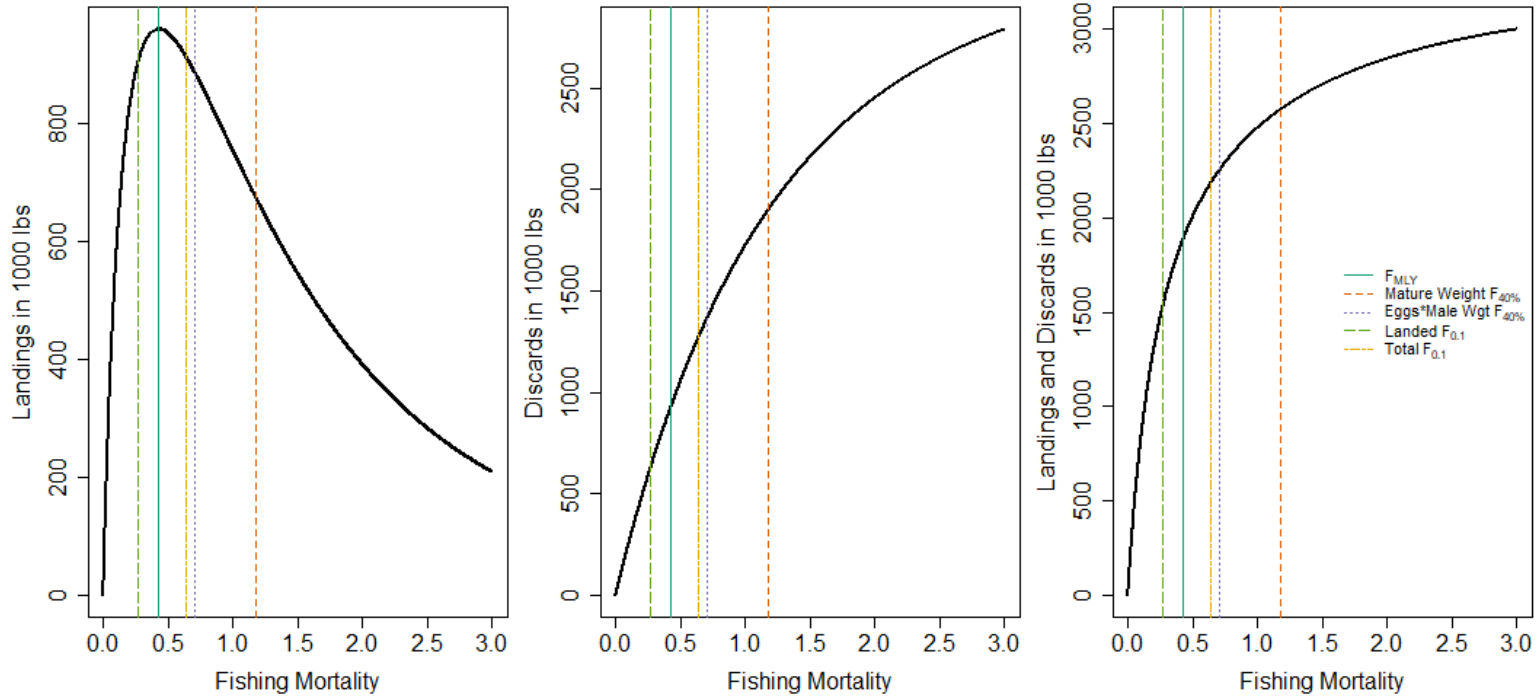
Decision from working group

- There is no evidence for or against sperm limitation
  - I.e., currently unknown
- Concern that importance of males would be overemphasized by using alternative metrics (untested)
- Chose weight of mature fish based on precedent of other SEDARs
- Chose 40% SPR based on literature and scamp precedent



Options for Reference point calculations

- "F_{MSY}" – F that maximizes the landed yield (F_{MLY})
- Landed $F_{0.1}$ – YPR F calculated from landings
- Total $F_{0.1}$ – YPR F calculated from landings and discards
- Mature Weight $F_{40\%}$ - SPR calculated from mature weight SSB



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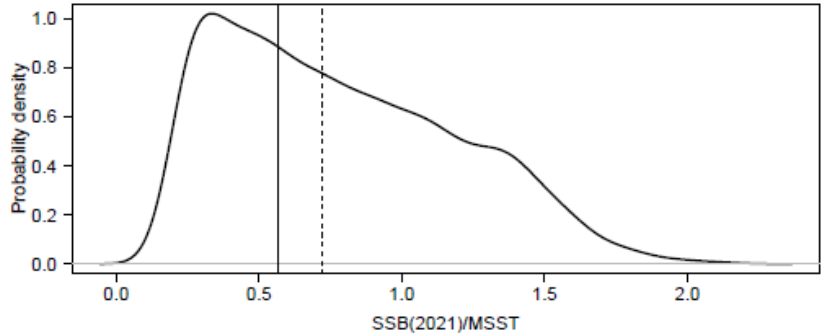
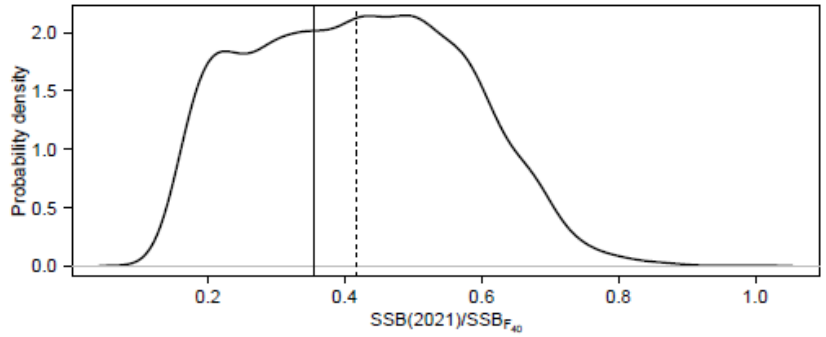
Decisions from working group

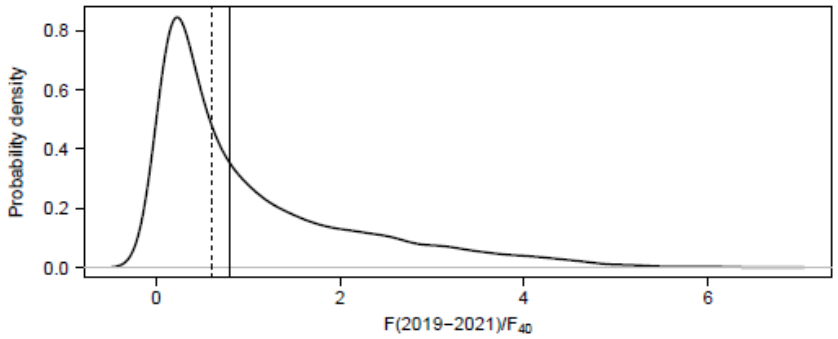
- Working group decided that reference points should be based on both landings and discards
  - Removes "F_{MSY}" and Yield $F_{0.1}$
- Working group decided that SPR metrics are more closely related to replenishment rate of stocks than YPR metrics
- The working group chose to use the SPR mature weight F40 based on the scientific literature and precedent set by other recent SEDARs

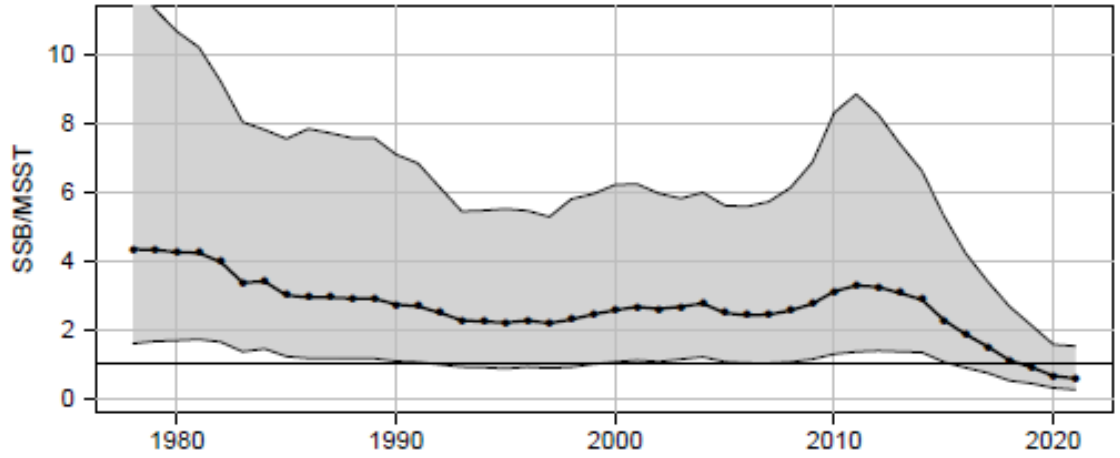
Revised reference points

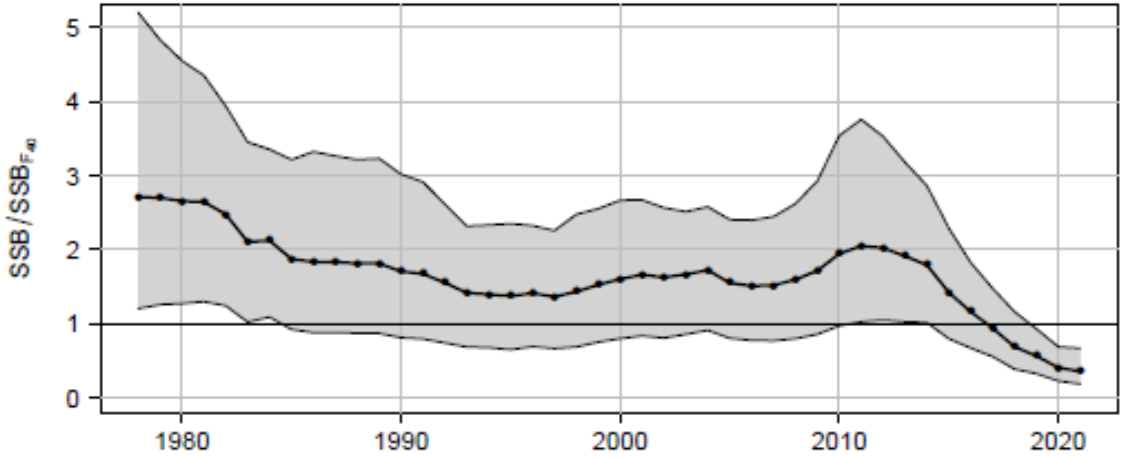
- Overfished
  - 69.6%
- Not undergoing overfishing
  - 62.9%

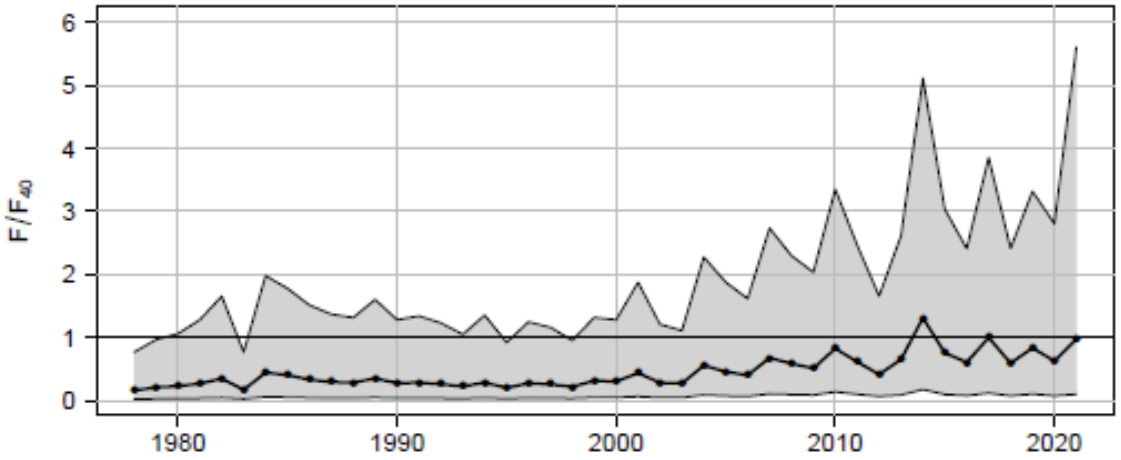




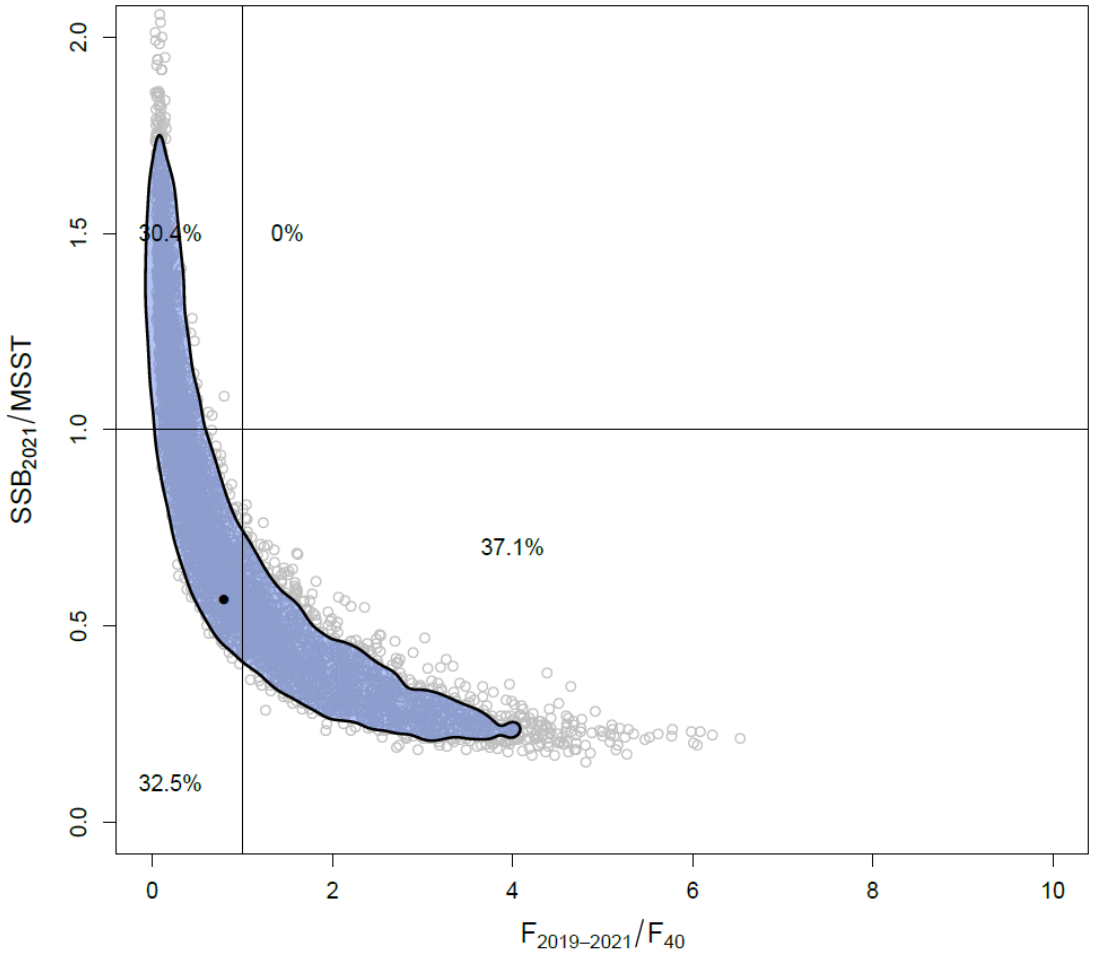


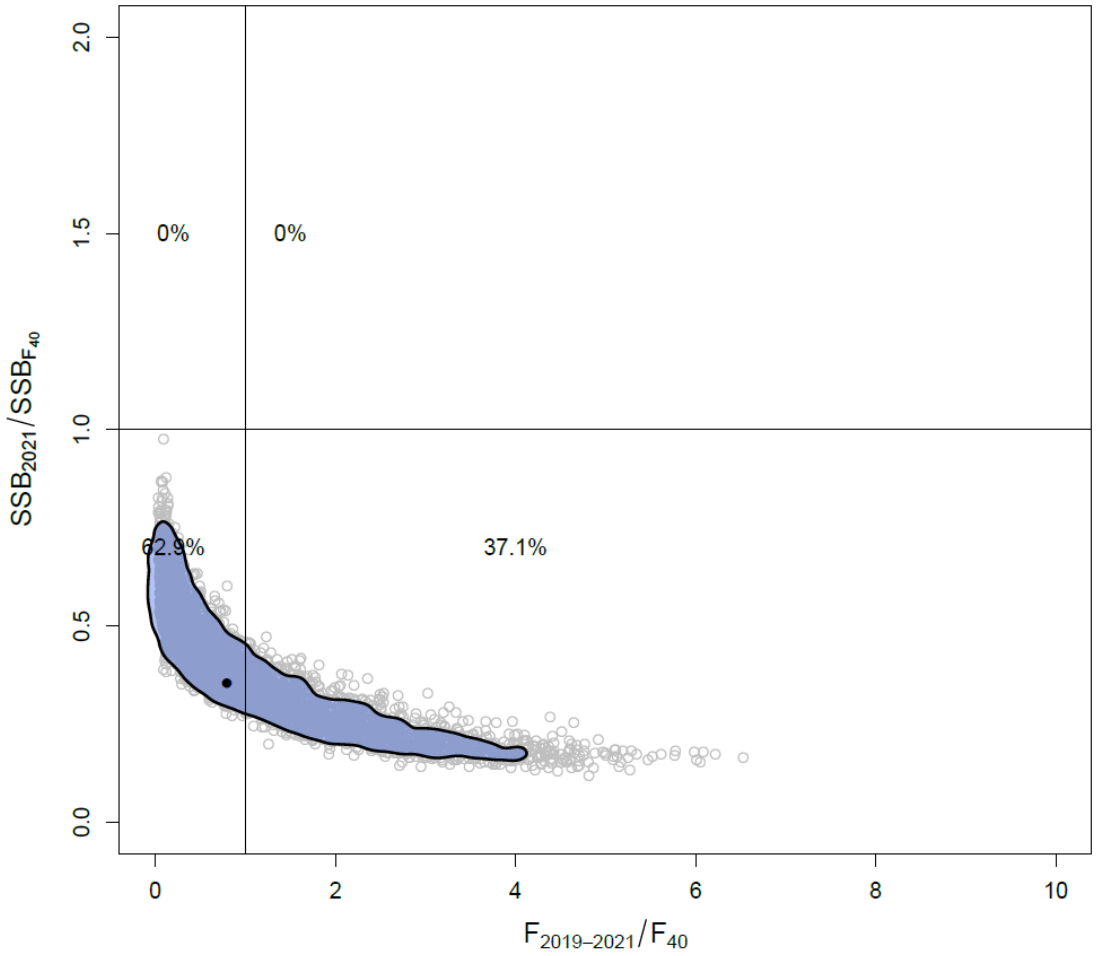






Revised Stock Status





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Stock status using F40%

Table 1. Estimated status indicators, benchmarks, and related quantities for $F_{40\%}$ from the base run of the BAM, conditional on estimated current selectivities averaged across fleets. Also presented are median values and measures of precision (standard errors, SE) from the Monte Carlo/Bootstrap ensemble analysis. Rate estimates (F) are in units of y^{-1}; status indicators are dimensionless; biomass estimates are in units of thousands of pounds, as indicated. Spawning stock biomass (SSB) is measured as weight of mature fish in thousands of pounds. L_{current} and D_{current} are the average landings and discards from 2019–2021, respectively. Estimates of yield do not include discards; $D_{\text{F40\%}}$ represents discard mortalities expected when fishing at $F_{40\%}$.

Quantity	Units	Estimate	Median	SE
$F_{40\%}$	y^{-1}	1.18	1.28	1.36
$B_{\text{F40\%}}$	1000 lb	17688.58	22071.29	18851.44
$\text{SSB}_{\text{F40\%}}$	1000 lb	8736.42	10219.24	1951.55
MSST	1000 lb	5460.26	5807.19	1152.61
$L_{\text{F40\%}}$	1000 lb	674.53	492.38	367.25
$L_{\text{75\%F40\%}}$	1000 lb	808.39	633.13	356.01
L_{current}	1000 lb	544.23	536.40	65.80
$D_{\text{F40\%}}$	1000 dead fish	4530.85	6599.32	7825.67
$D_{\text{F40\%}}$ klb	1000 lb	1901.63	2655.96	2374.23
$D_{\text{75\%F40\%}}$	1000 dead fish	3678.27	2285.27	2220.61
$D_{\text{75\%F40\%}}$ klb	1000 lb	1592.67	2285.27	2220.61
D_{current}	1000 dead fish	935.34	1242.30	530.60
D_{current} klb	1000 lb	437.42	575.19	234.03
$F_{2019-2021}/F_{40\%}$	—	0.79	0.61	1.14
$\text{SSB}_{2021}/\text{MSST}$	—	0.57	0.72	0.41
$\text{SSB}_{2021}/\text{SSB}_{\text{F40\%}}$	—	0.36	0.45	0.27

Stock status using F30% for comparison

Table 2. Estimated status indicators, benchmarks, and related quantities for $F_{30\%}$ from the base run of the BAM, conditional on estimated current selectivities averaged across fleets. Also presented are median values and measures of precision (standard errors, SE) from the Monte Carlo/Bootstrap ensemble analysis. Rate estimates (F) are in units of y^{-1}; status indicators are dimensionless; biomass estimates are in units of thousands of pounds, as indicated. Spawning stock biomass (SSB) is measured as weight of mature fish in thousands of pounds. $L_{current}$ and $D_{current}$ are the average landings and discards from 2019–2021, respectively. Estimates of yield do not include discards; $D_{F30\%}$ represents discard mortalities expected when fishing at $F_{30\%}$.

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

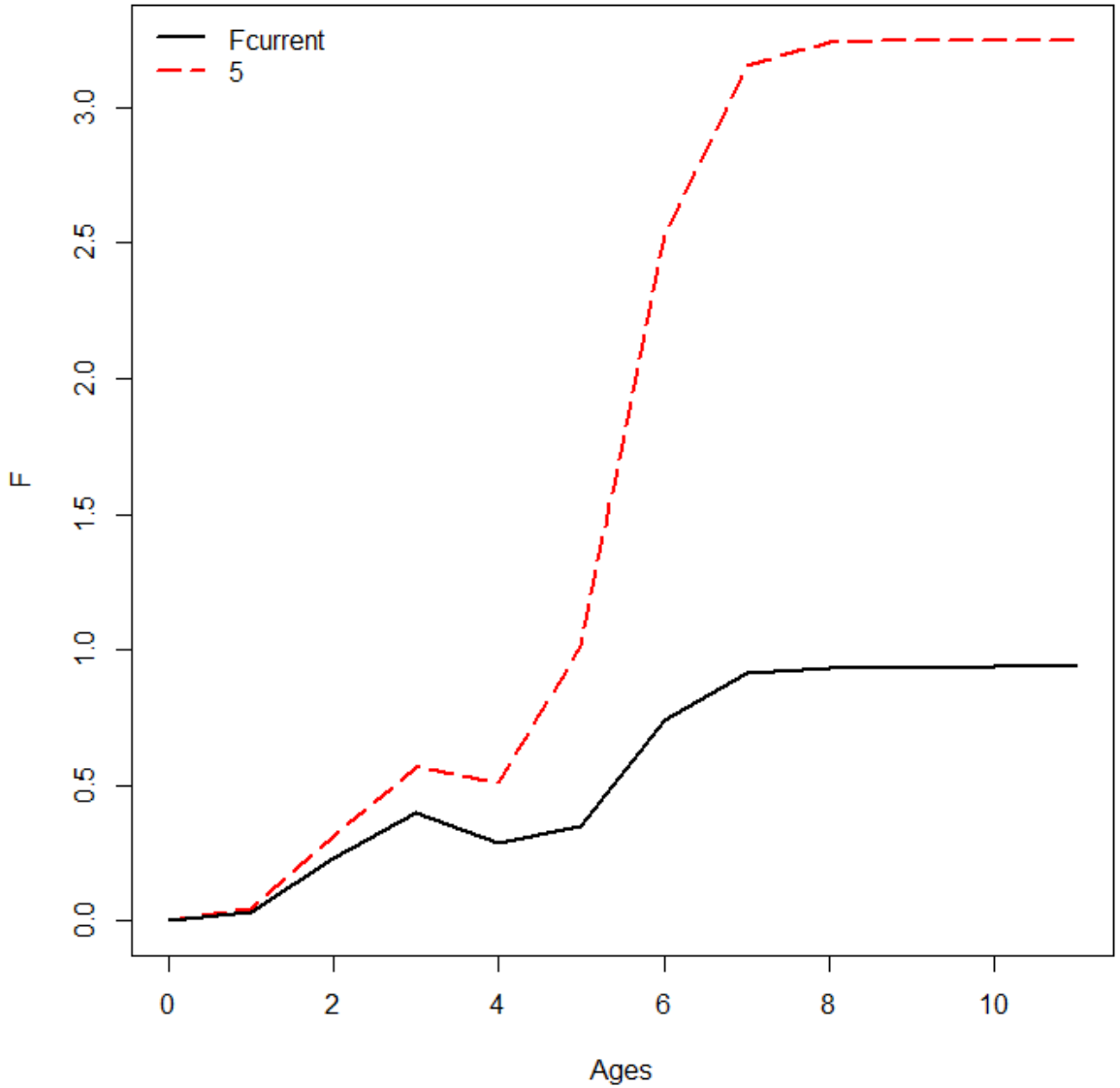
P-Star Options

- Two tentative levels for P-Star were discussed
  - Using previous rules: 35%
  - Using new rules : 30%

- Given the stock is overfished based on the updated reference points the stock would be in a rebuilding plan
  - Probability of rebuilding would be 1-P-Star (i.e., 65% or 70%)

Fitting to Landings and Discards

- Multiple ways to fit to landings and/or discards
  - Fit landings or discards with weighted selectivity
  - Fit both landings and discards
  - Fit to each fishery separately
- Decision:
  - Use F estimated for each fishery using assessment selectivity
  - Set the maximum rate by fishery to 5



Which last 3 years should be used for $F_{current}$?

- Options:
  1. Use average $F_{2019\text{-}2021}$ from assessment for $F_{2023\text{-}2024}$
  2. Recalculate $F_{current}$ from 2020-2022
     - May require reweighting selectivities across gears
     - Reweighted selectivity would result in a change to $F_{0.1}$, F_{MAX} , and other reference points
- Decision
  - Use $F_{current}$ from assessment for 2023-2024
  - Use F_{2022} to calculate abundance in 2023 from which to do projections
  - Do a sensitivity recalculating $F_{current}$ using 2022 (not shown)

Projection Recruitment Options

- R0 – Recruitment based on long-term average and associated SD
- Rec mu – Recruitment based on recent (2014-2019) average and SD
- AR – Log recruitment deviates fit to Autoregressive (AR1) process and projections follow a random walk starting at recent average in 2021
  - Allows for low recent recruitment in the short-term and a gradual transition towards long-term recruitment levels
  - Alternative to sine wave used for scamp

Projection Discard Options

- D_{prop} – Discards decrease proportional to F in landings
- $D_{current}$ – Discards calculated based on $F_{current}$ and selectivity

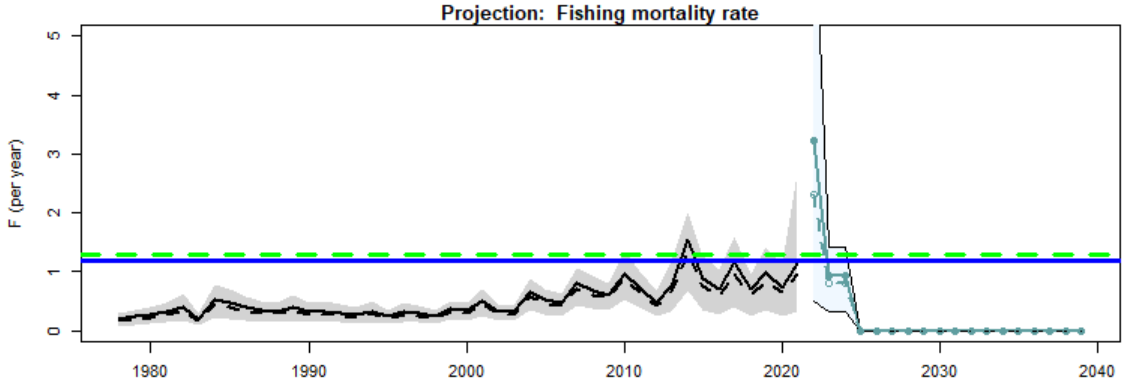
Projection F scenarios

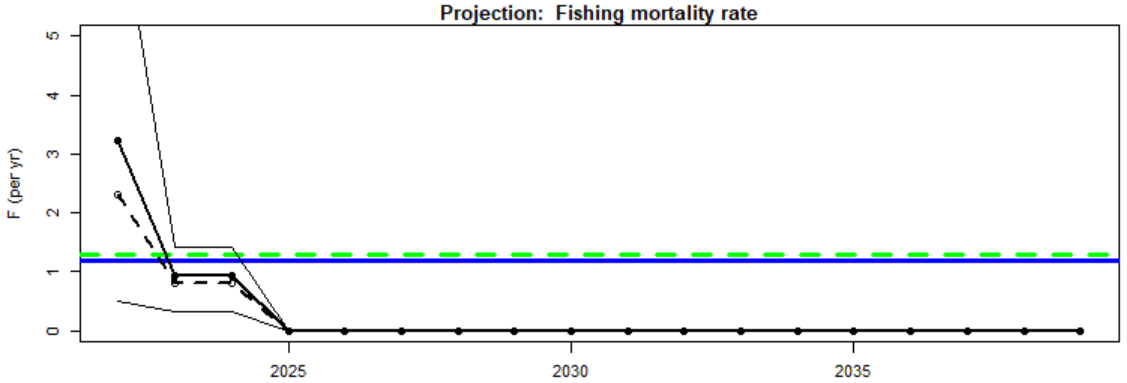
- F=0 – No fishing mortality (may only apply to landings)
- $F_{R65\%}$ – $F_{Landings}$ that gives a 65% rebuilding in 10 years with $D_{current}$
- $F_{R70\%}$ – $F_{Landings}$ that gives a 70% rebuilding in 10 years with $D_{current}$

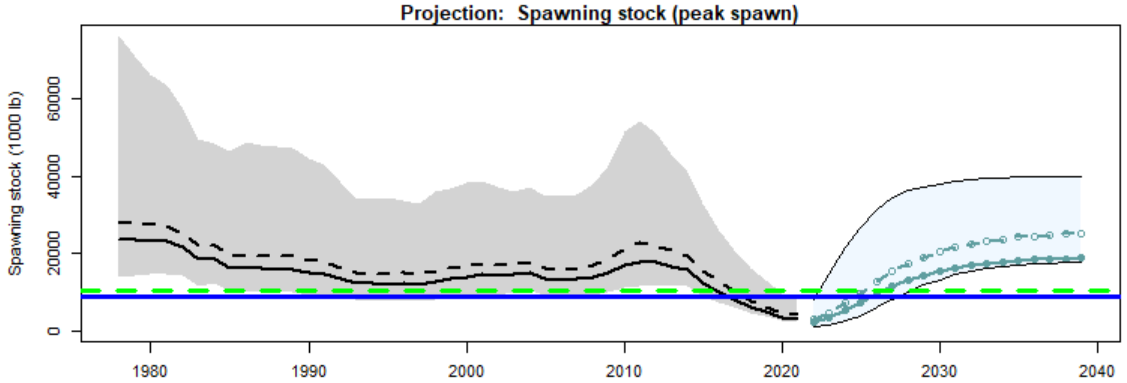
Projection Scenarios

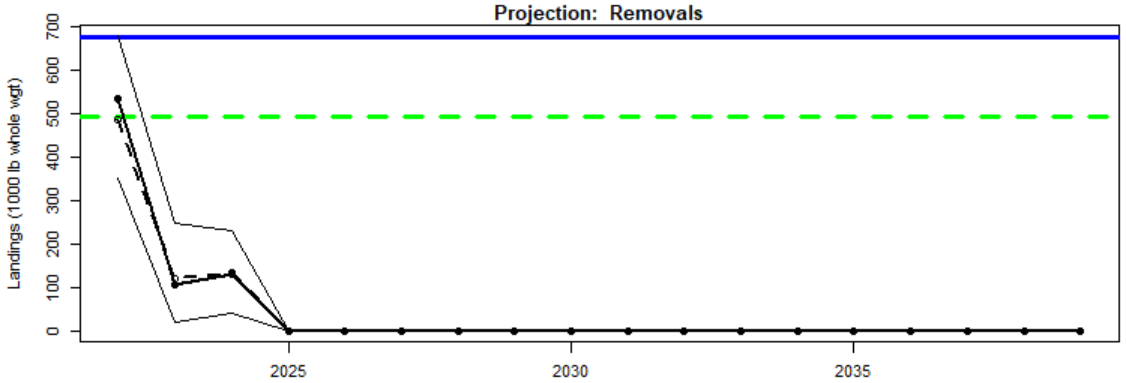
- R0 D_{prop} F=0 — Long-term recruitment rebuilding scenario
- Rec-mu D_{prop} F=0 — Recent recruitment rebuilding scenario
- AR D_{prop} F=0 — Autocorrelated recruitment rebuilding scenario
- R0 $D_{current}$ F=0 — Long-term recruit recent discards no landings
- Rec-mu $D_{current}$ F=0 — Recent recruitment recent discards no landings
- AR $D_{current}$ F=0 — Autocorrelated recruit recent discards no landings
- R0 $D_{current}$ $F_{R65\%}$ — 65% rebuilding long-term recruits recent discards
- R0 $D_{current}$ $F_{R70\%}$ — 70% rebuilding long-term recruits recent discards

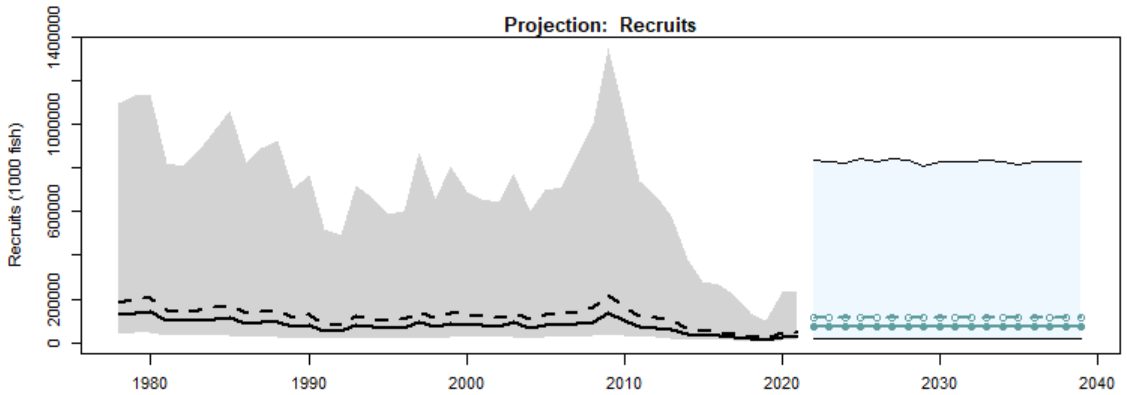
RO D_{prop} F=0

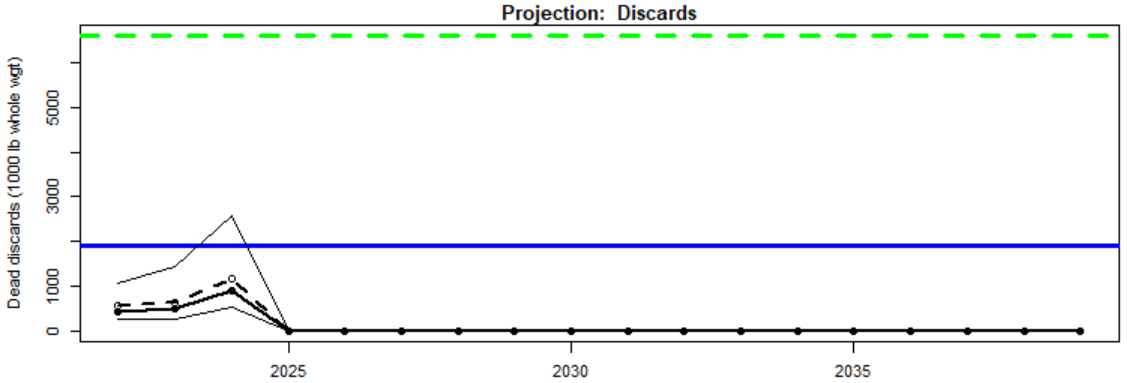

Projection: Fishing mortality rate
F (per year)
0
1
2
3
4
5
1980
1990
2000
2010
2020
2030
2040


Projection: Fishing mortality rate
F (per yr)
0
1
2
3
4
5
2025
2030
2035

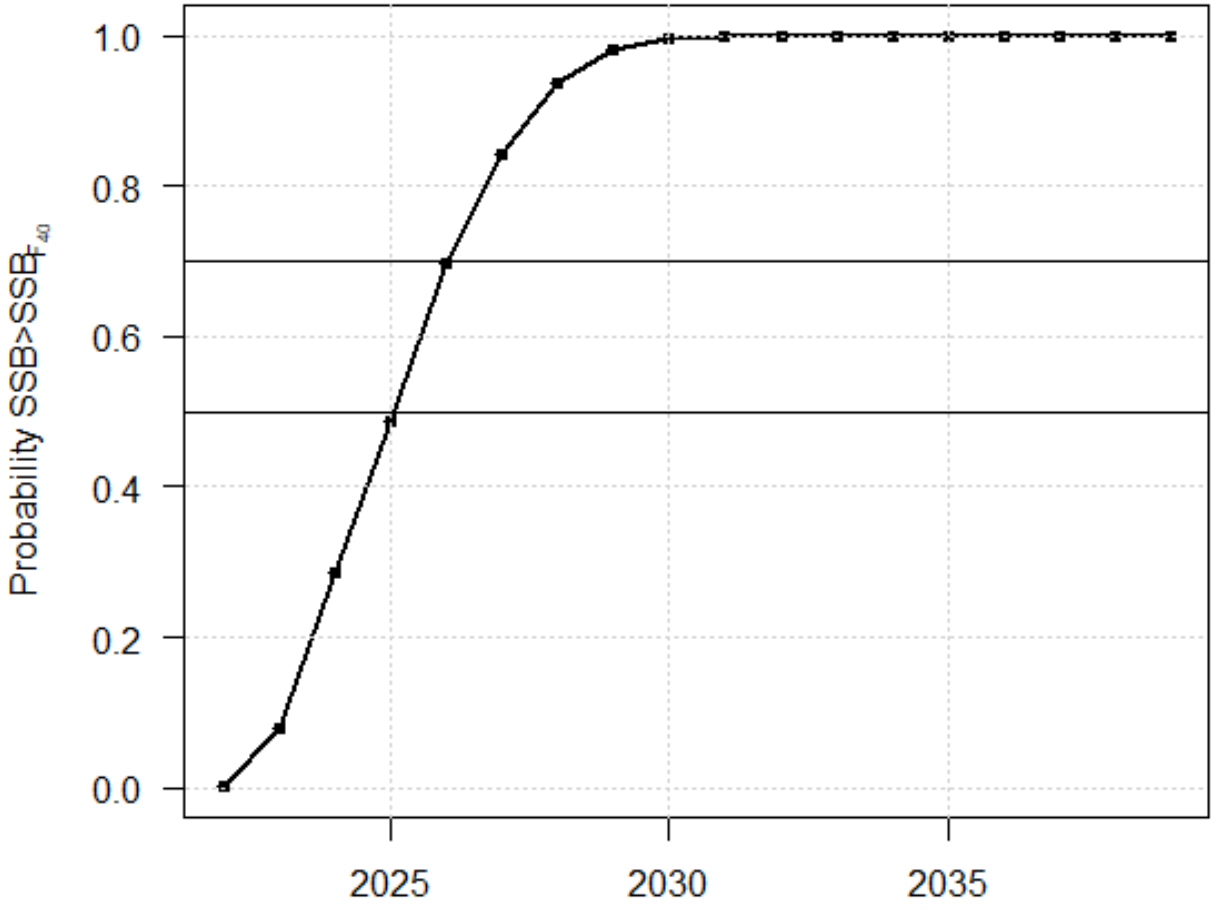

Projection: Spawning stock (peak spawn)
Spawning stock (1000 lb)
0
20000
40000
60000
1980
1990
2000
2010
2020
2030
2040

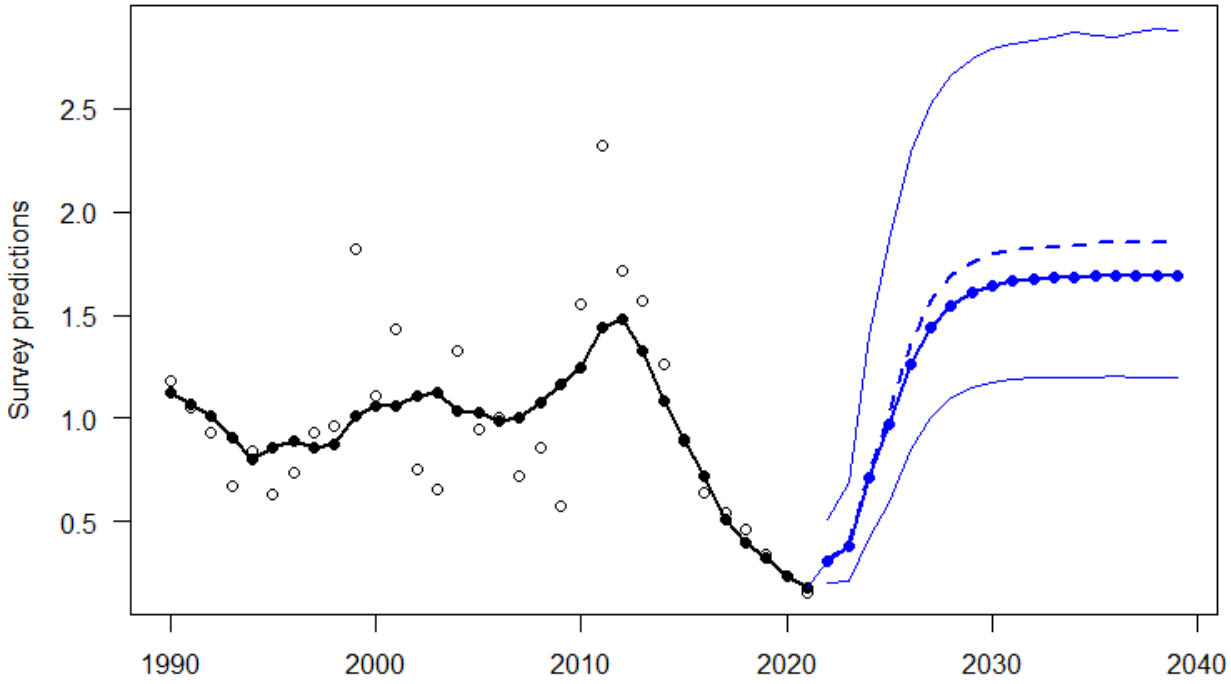

Projection: Removals
Landings (1000 lb whole wgt)
0
100
200
300
400
500
600
700
2025
2030
2035


Projection: Recruits
Recruits (1000 fish)
0
200000
600000
1000000
1400000
1980
1990
2000
2010
2020
2030
2040

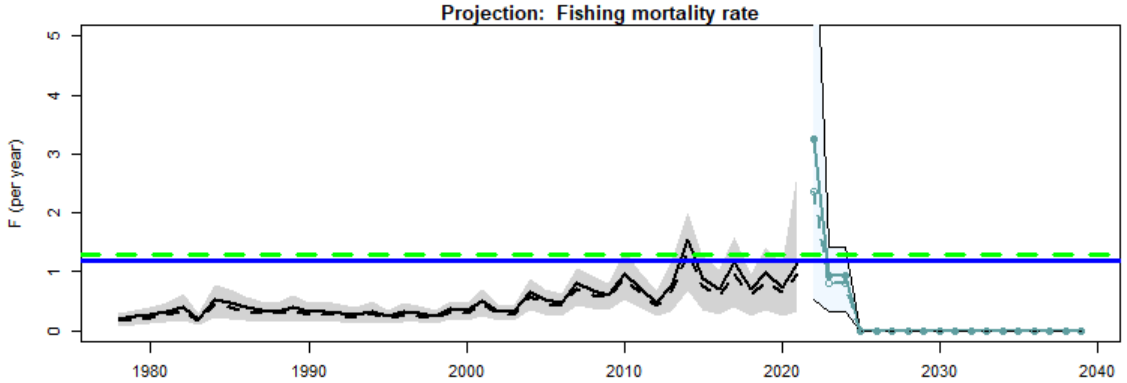

Projection: Discards
Dead discards (1000 lb whole wgt)
0
1000
3000
5000
2025
2030
2035

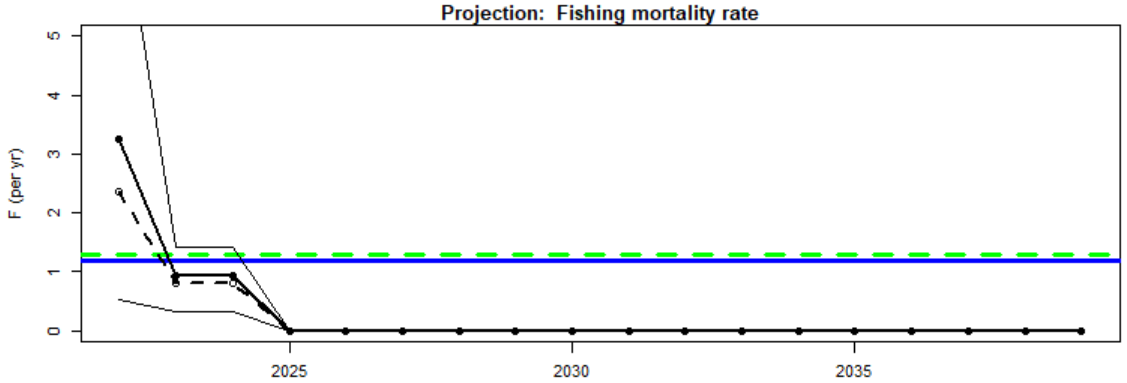
R0 D_{prop} F=0

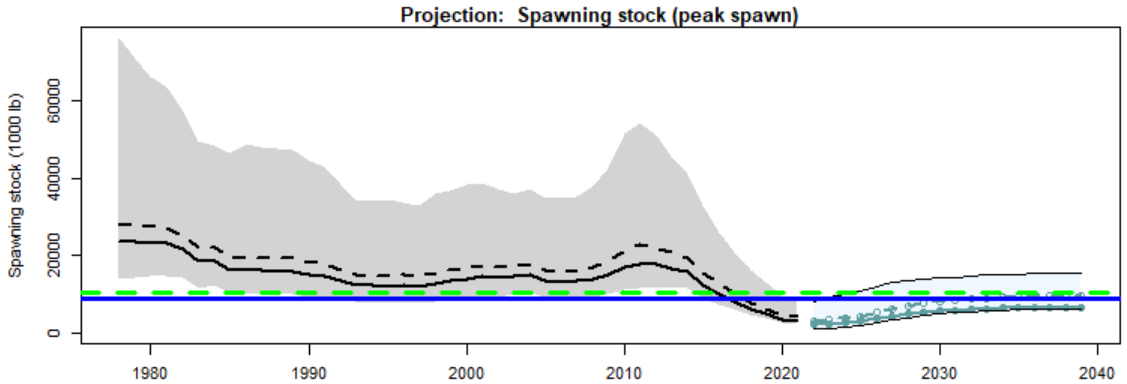

Probability SSB>SSB40
1.0
0.8
0.6
0.4
0.2
0.0
2025
2030
2035

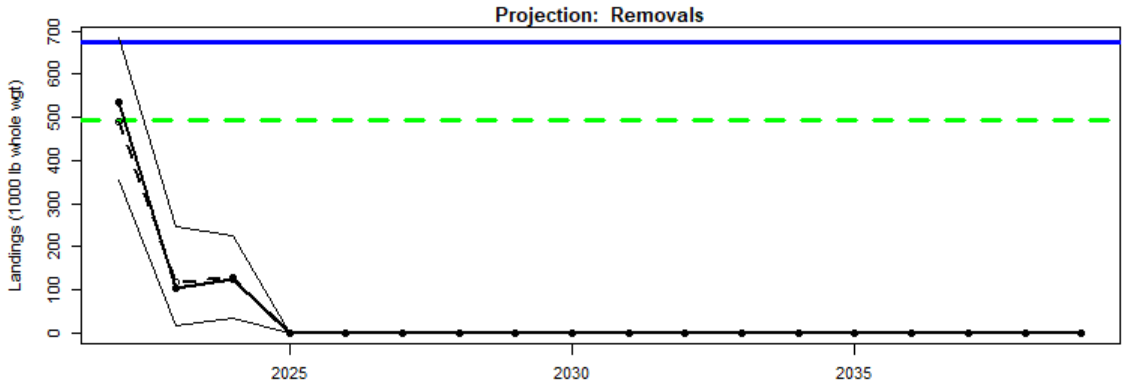

Survey predictions
2.5
2.0
1.5
1.0
0.5
1990
2000
2010
2020
2030
2040

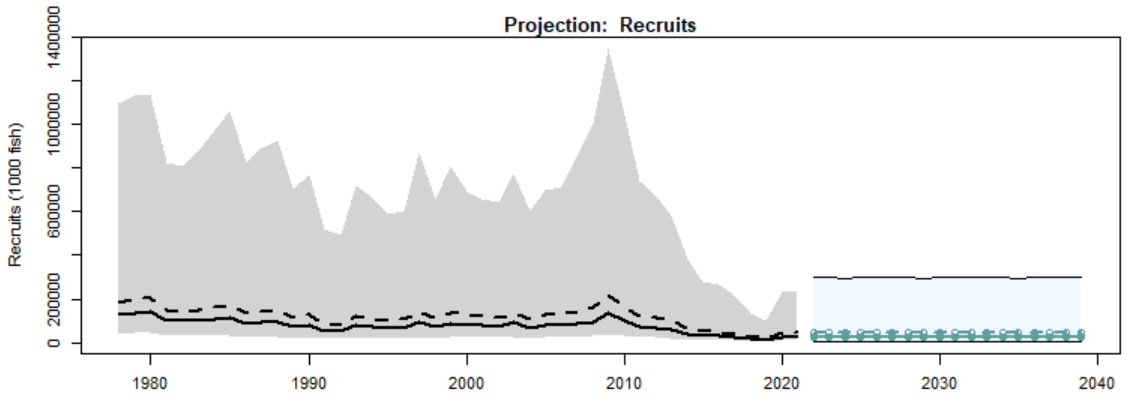
Rec-mu D_{prop} F=0

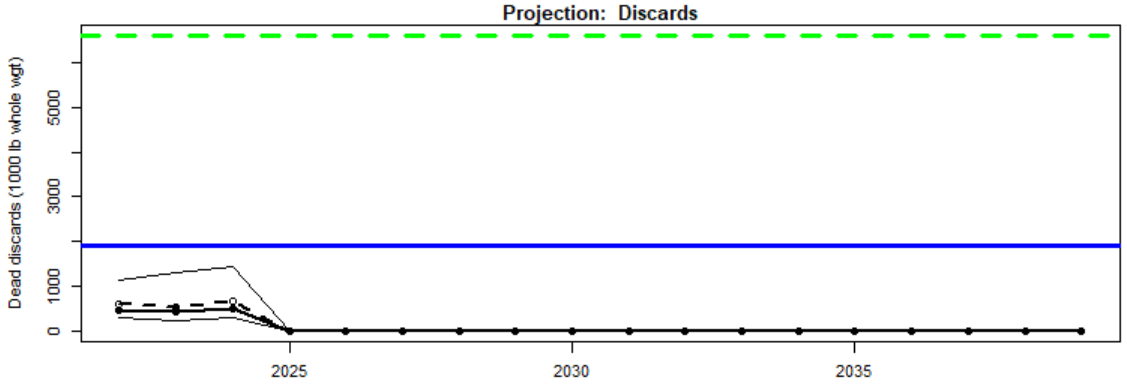




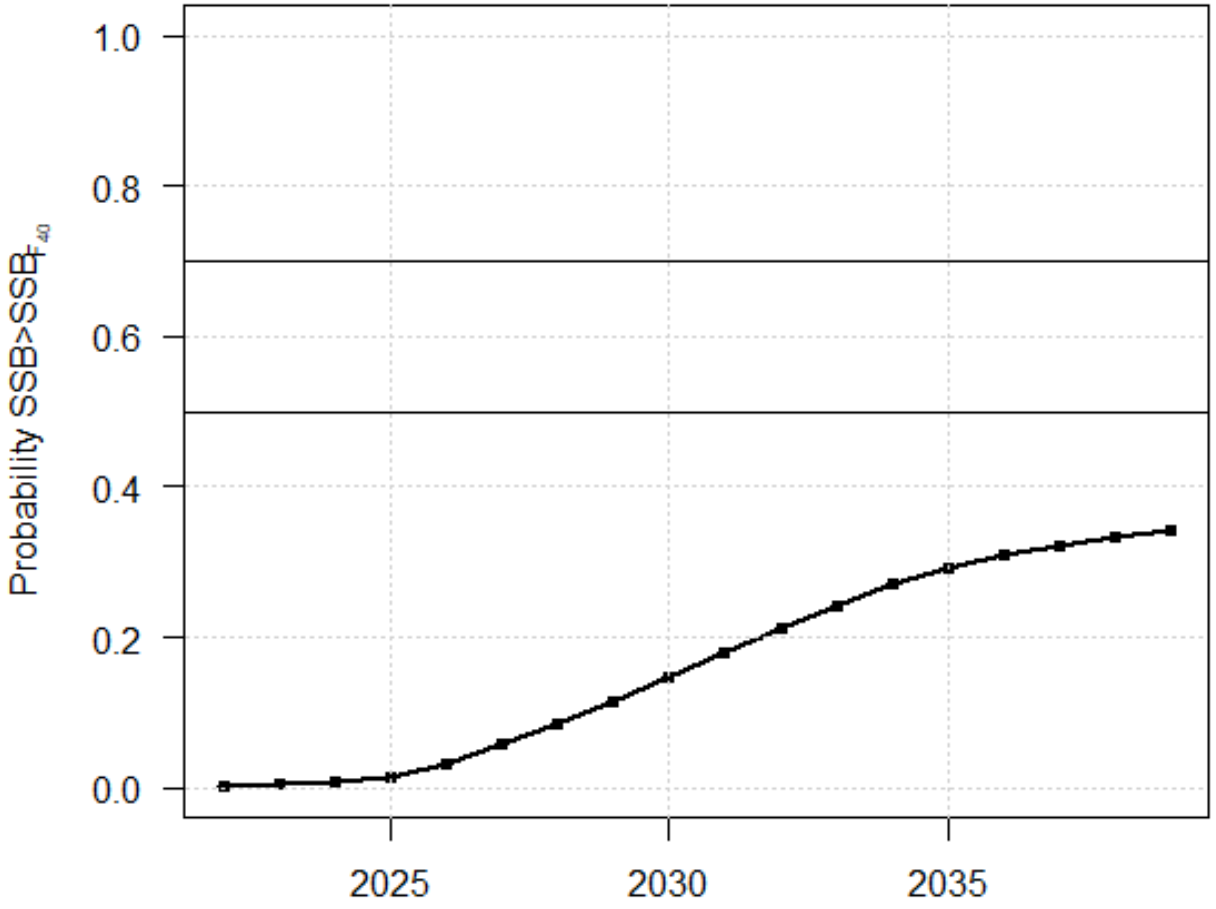


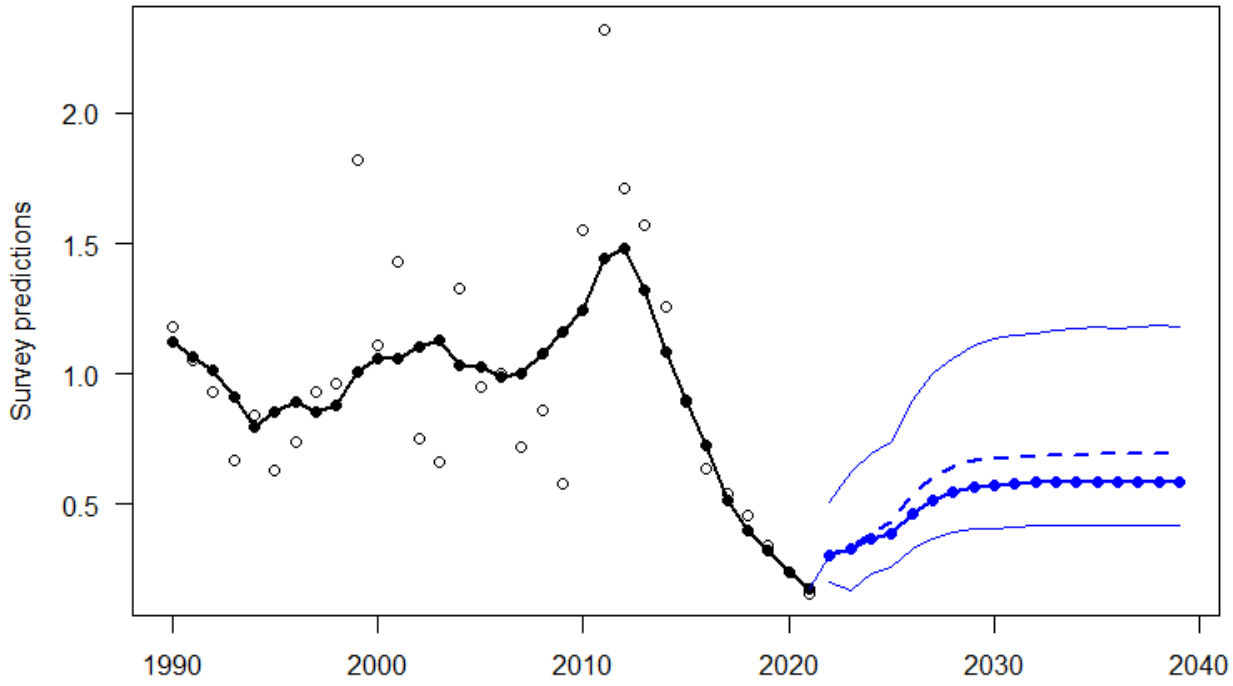




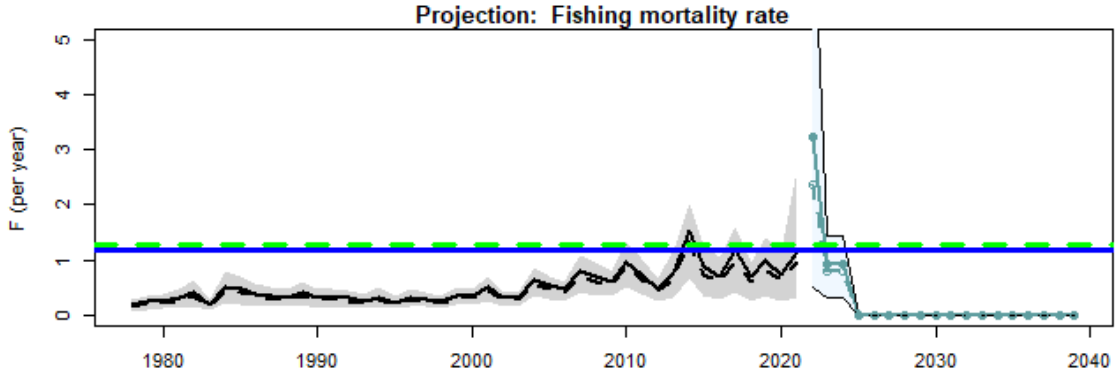


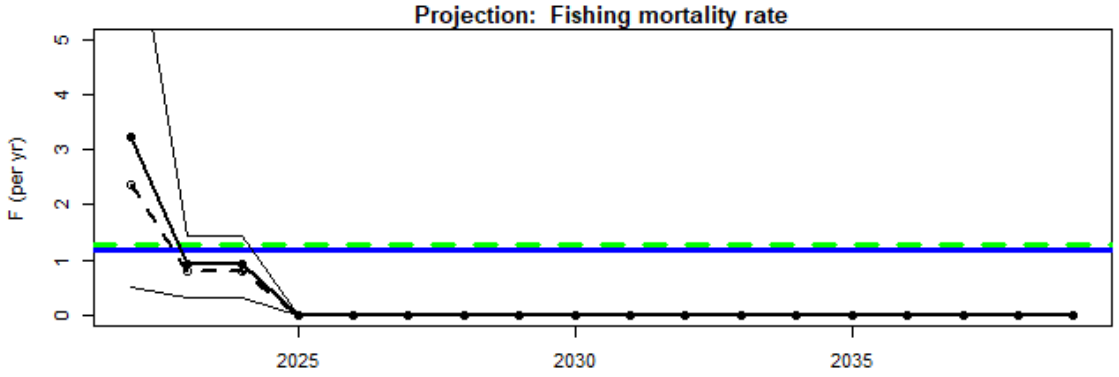
Rec-mu D_{prop} F=0





AR D_{prop} F=0


Projection: Fishing mortality rate
F (per year)
0
1
2
3
4
5
1980
1990
2000
2010
2020
2030
2040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F (per yr)
0
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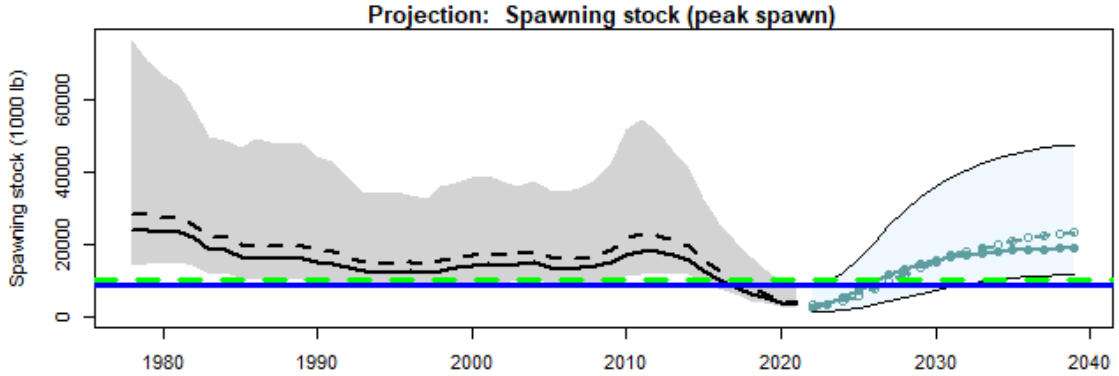
2
3
4
5
2025
2030
2035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40000
60000
1980
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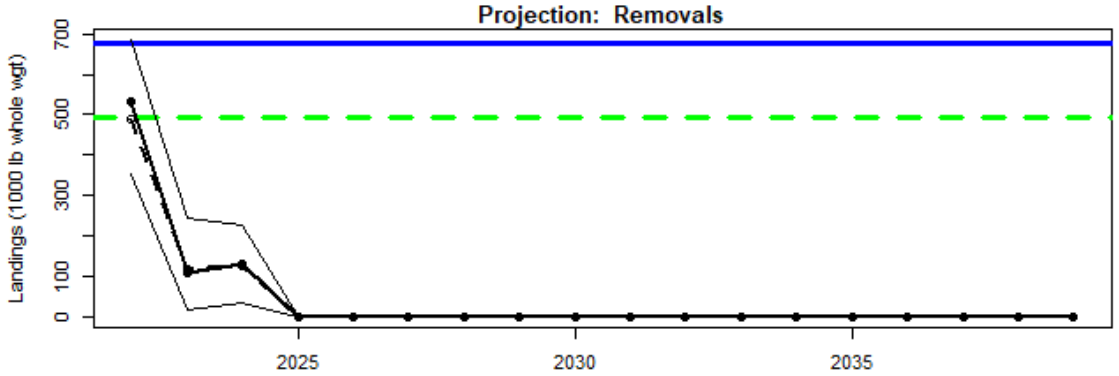
2010
2020
2030
2040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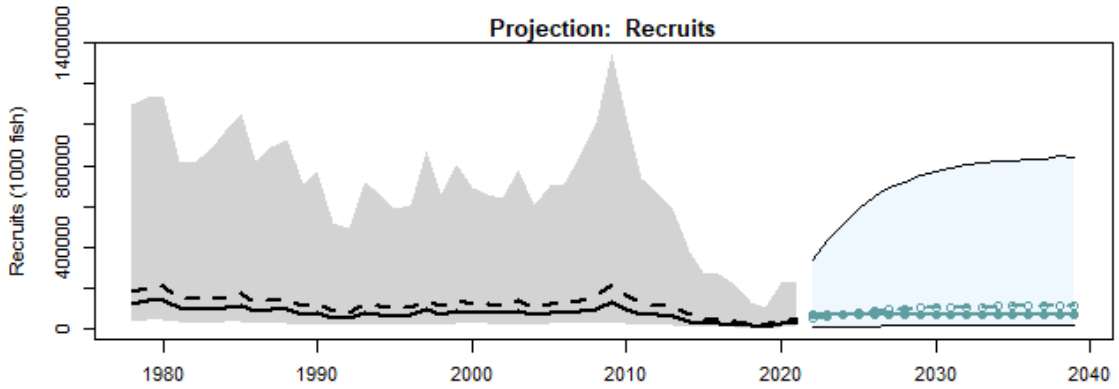
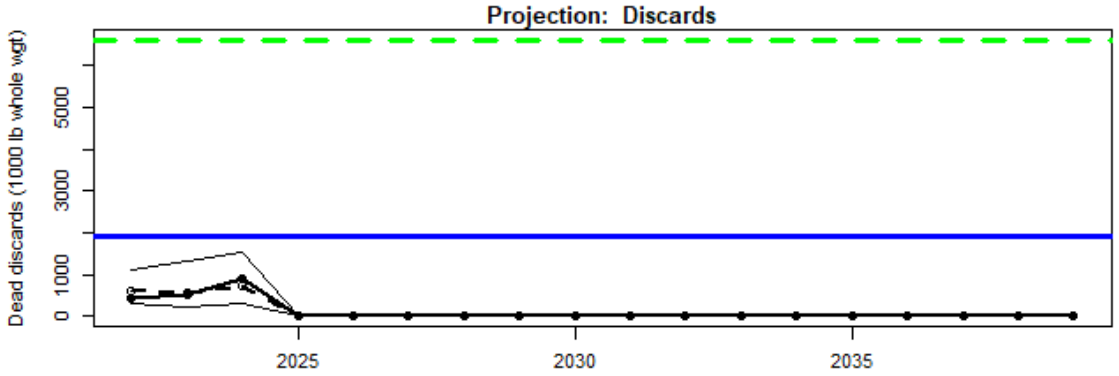
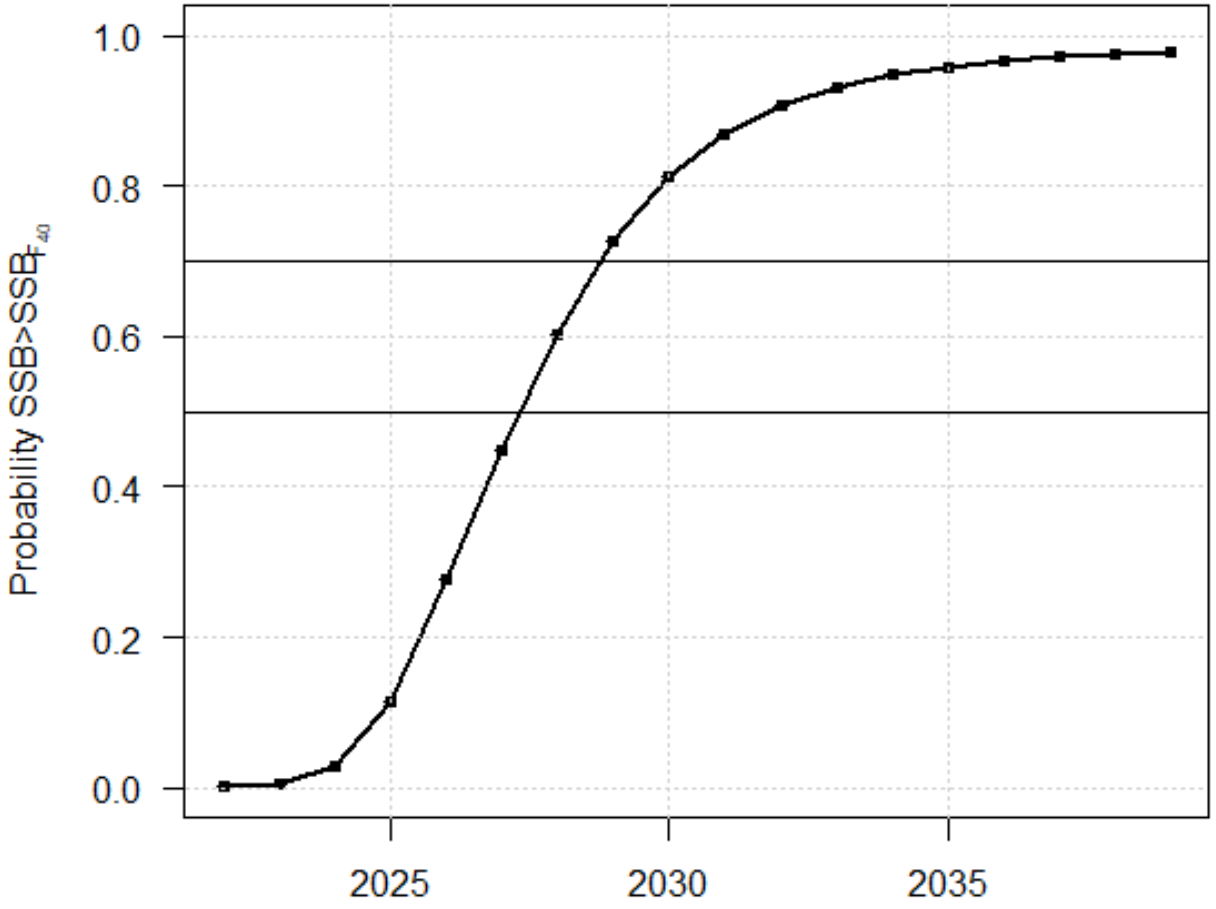
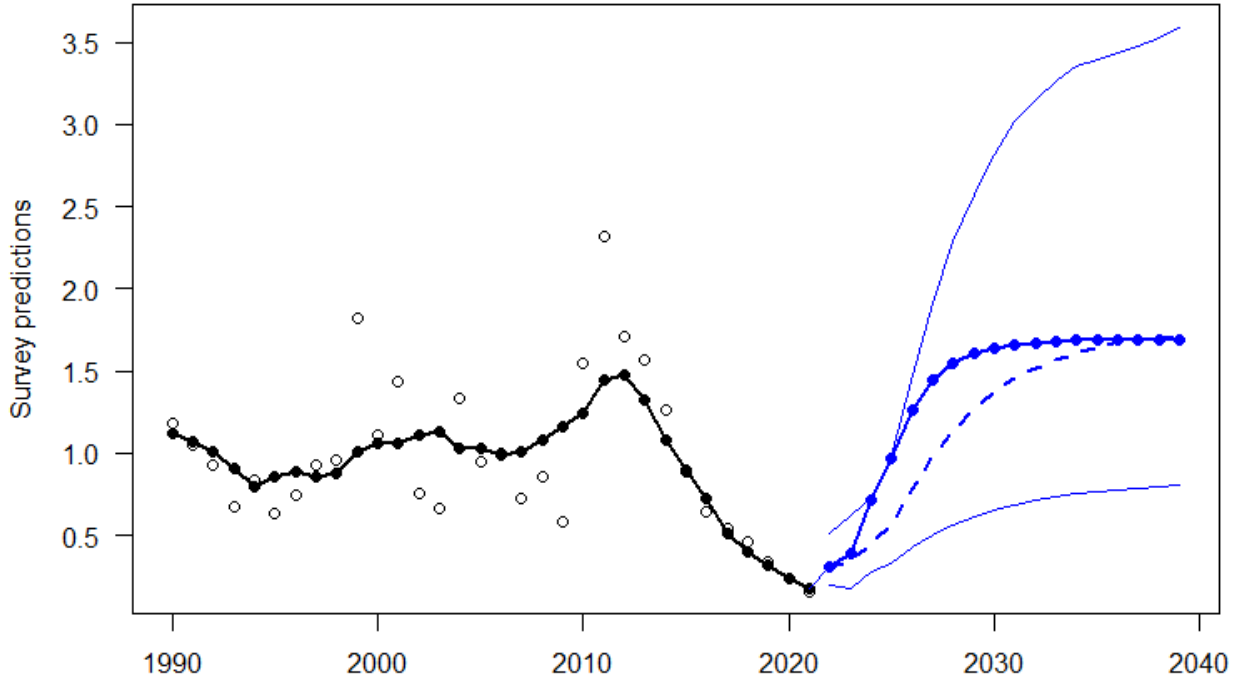
Landings (1000 lb whole wgt)
0
100
300
500
700
2025
2030
2035


Projection: Recruits
Recruits (1000 fish)
0
400000
800000
1400000
1980
1990
2000
2010
2020
2030
2040


Projection: Discards
Dead discards (1000 lb whole wgt)
0
1000
3000
5000
2025
2030
2035

AR D_{prop} F=0





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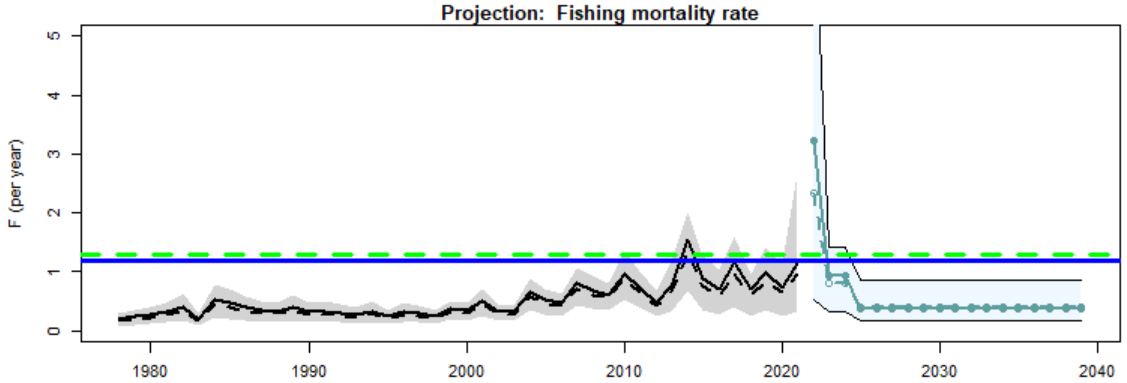
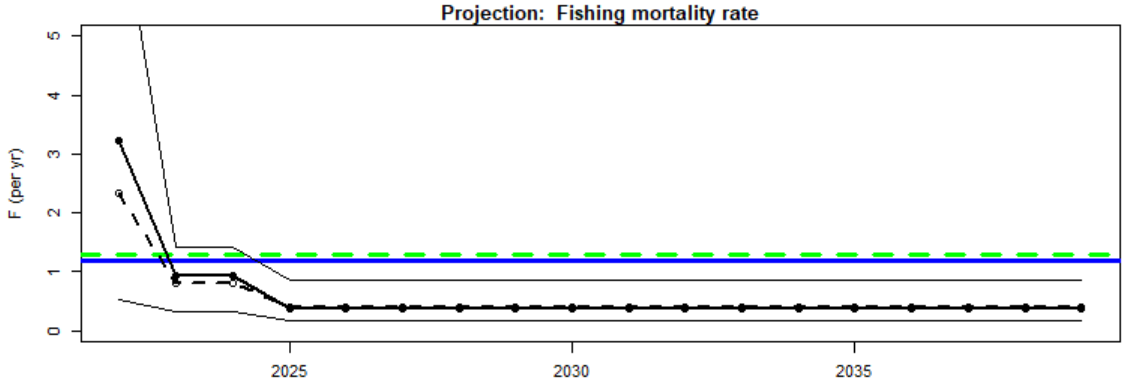
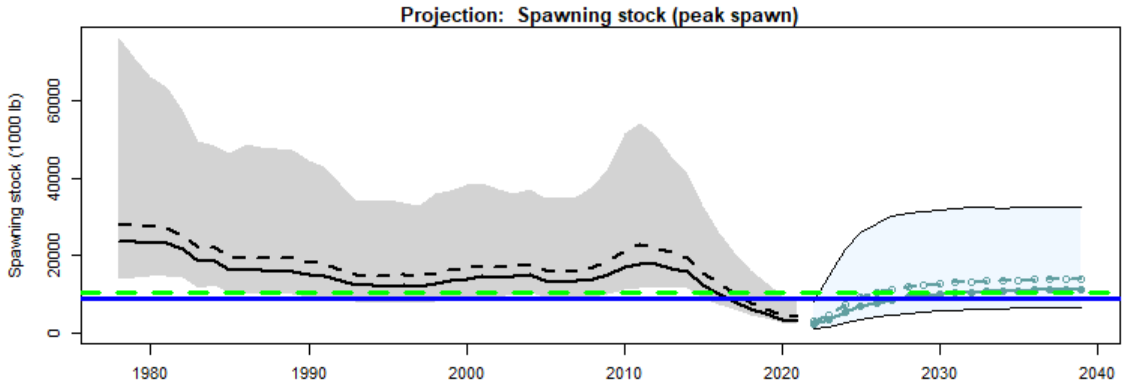
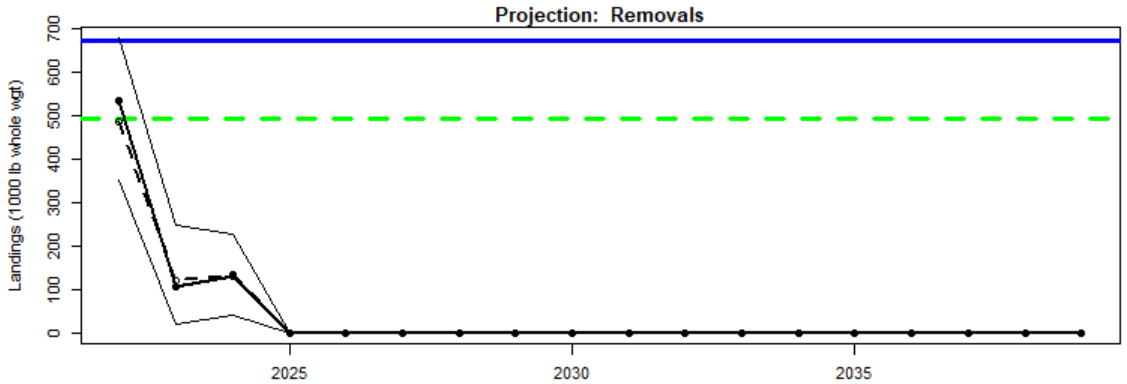
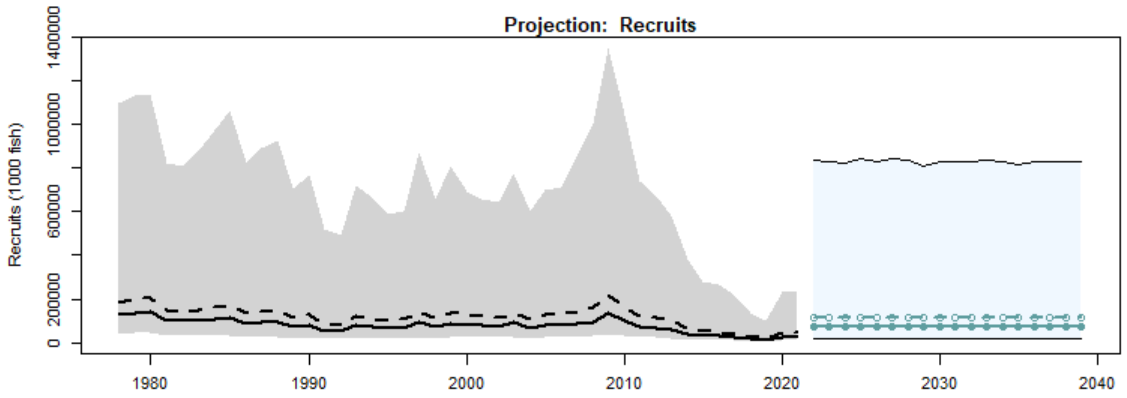
R0 $D_{current}$ F=0

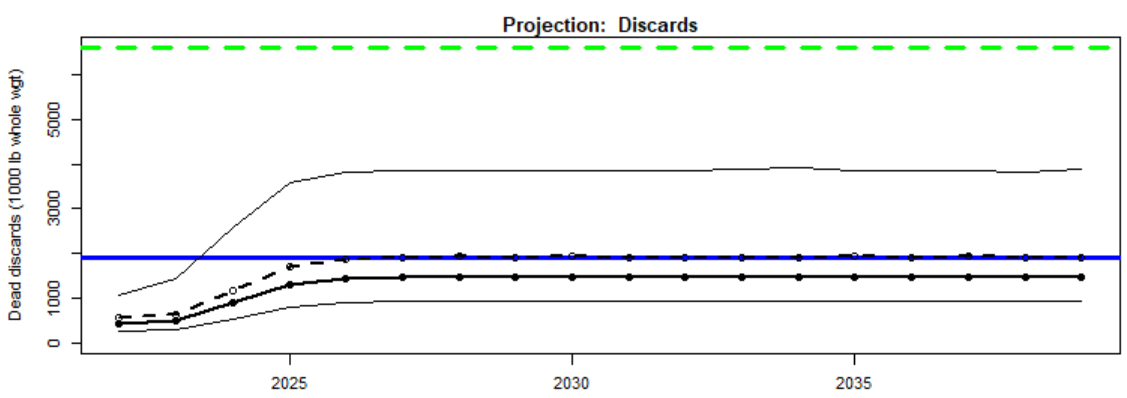




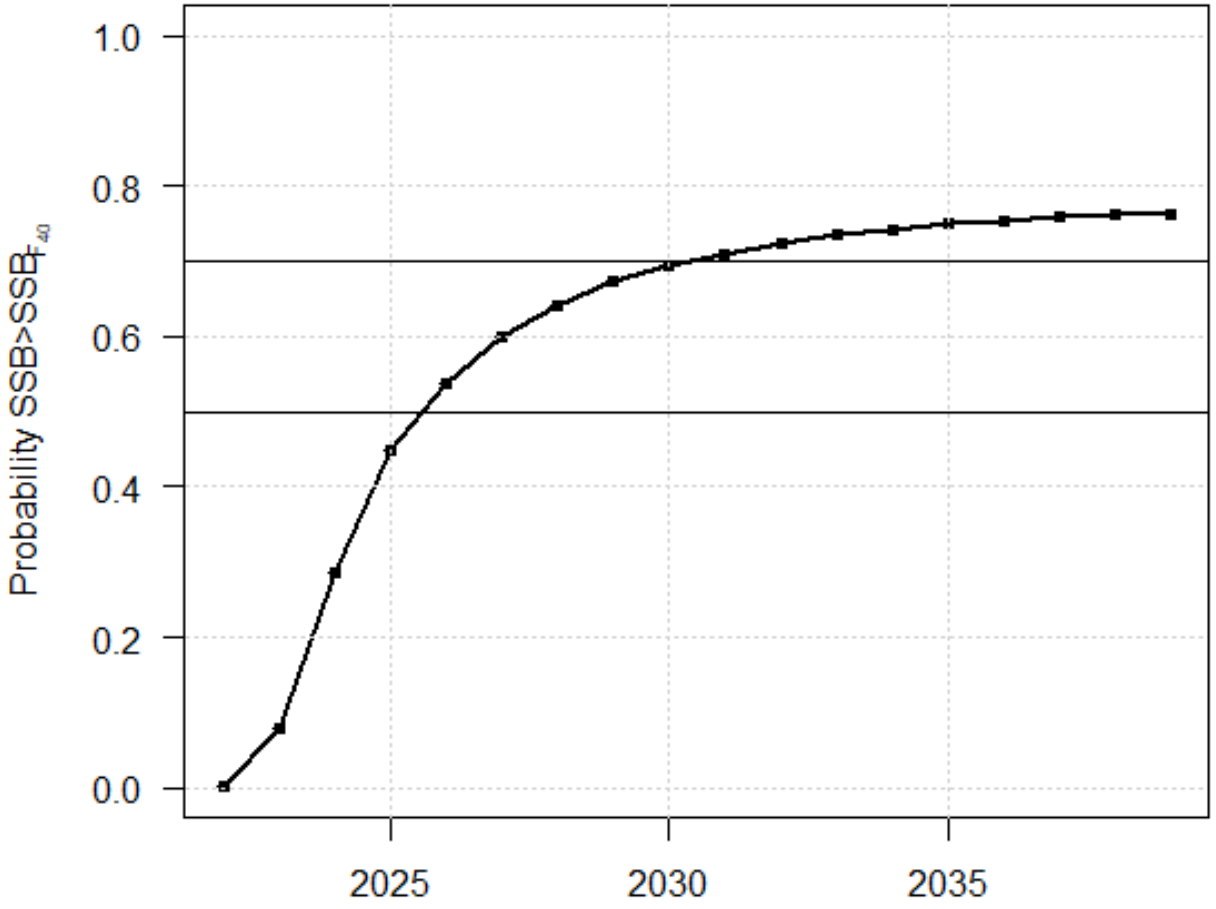


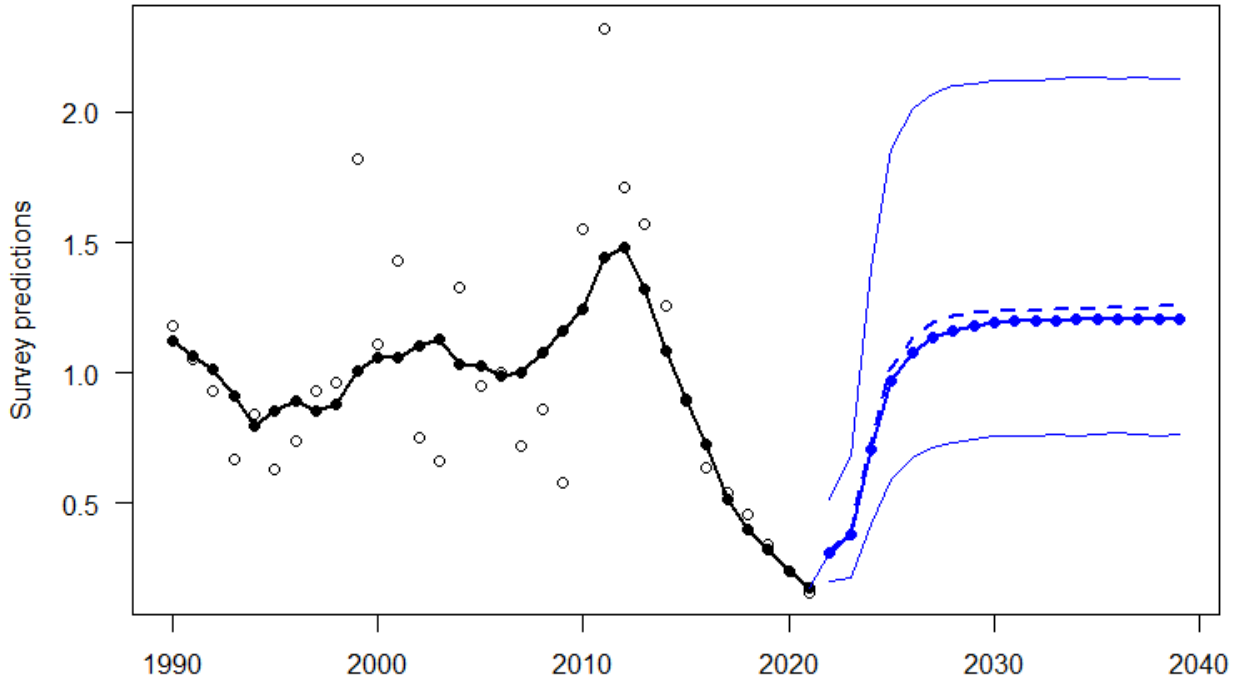




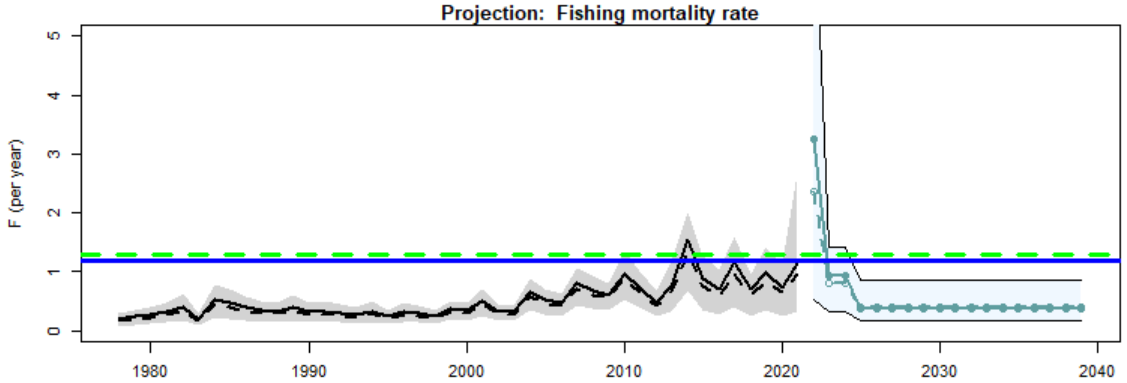


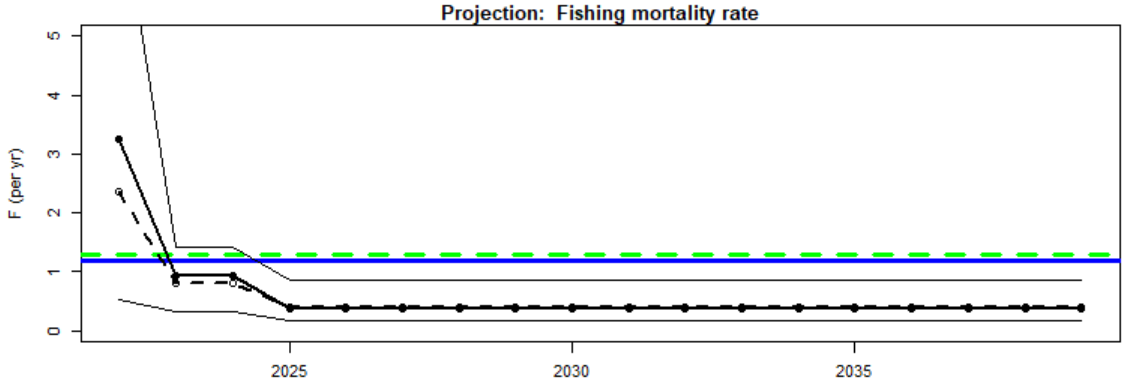
R0 $D_{current}$ F=0

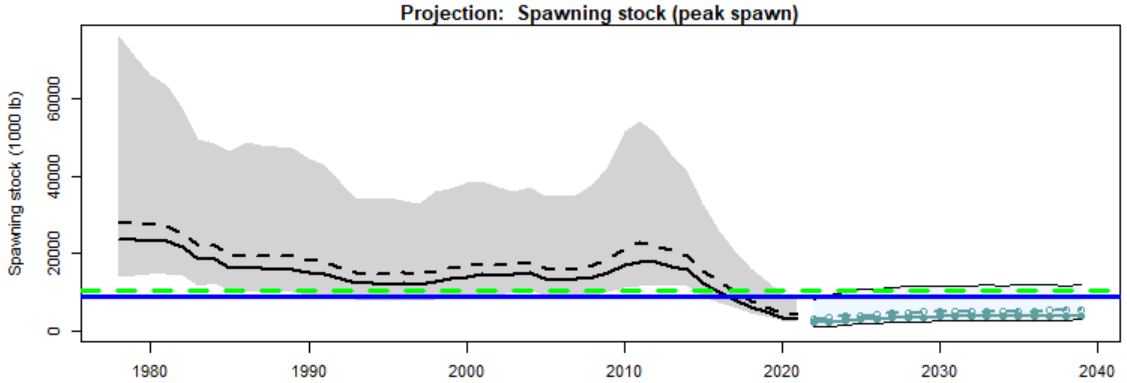


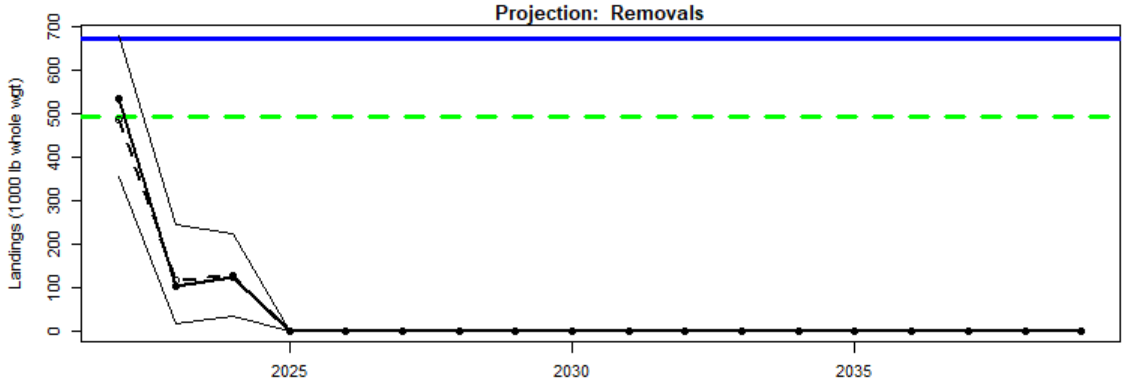


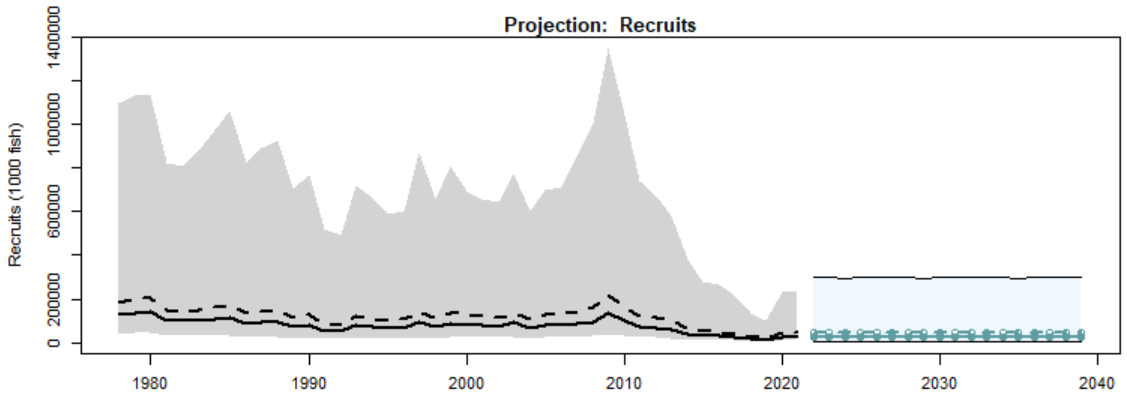
Rec-mu $D_{current}$ F=0

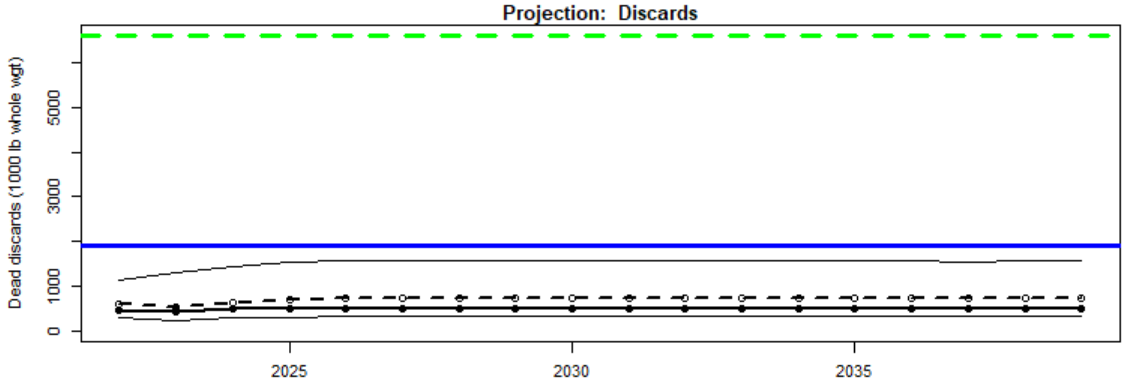




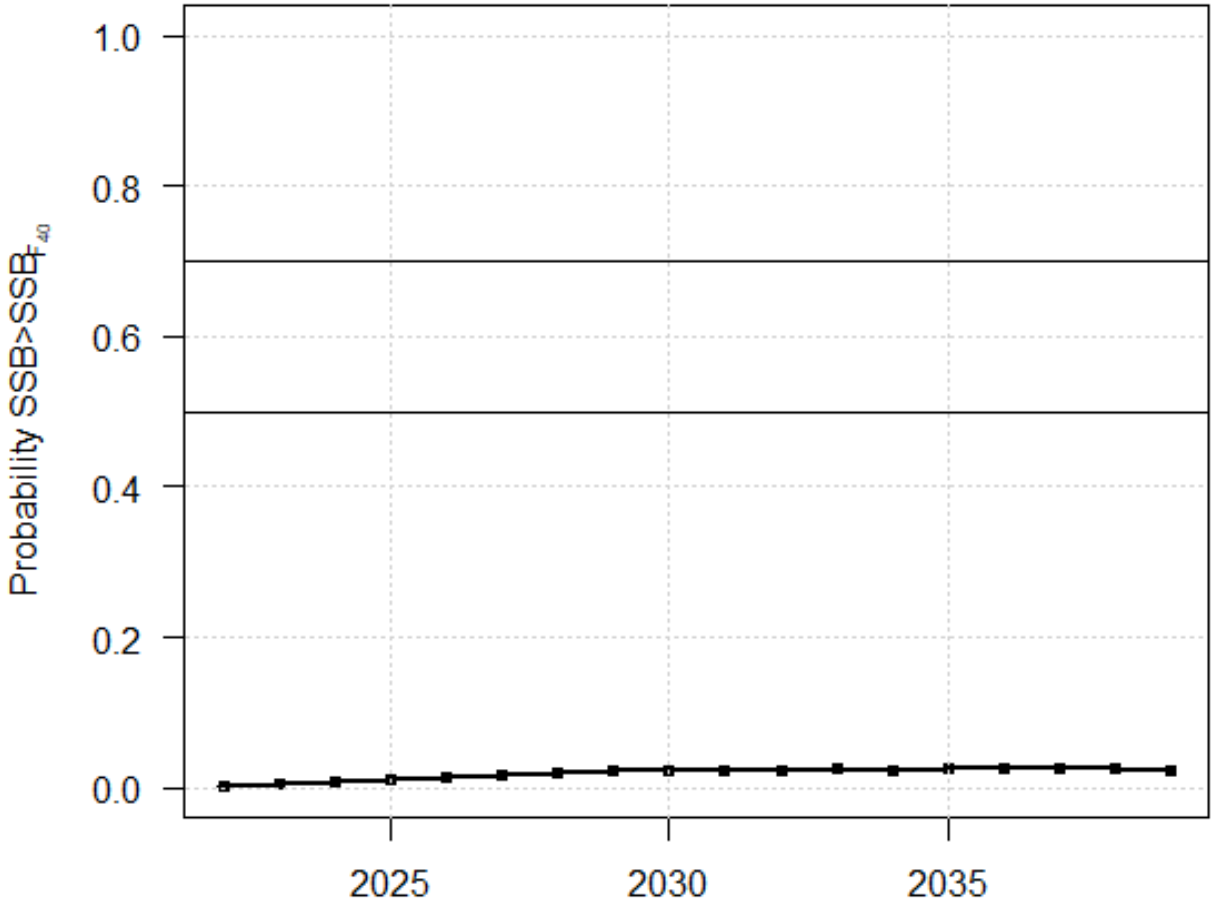


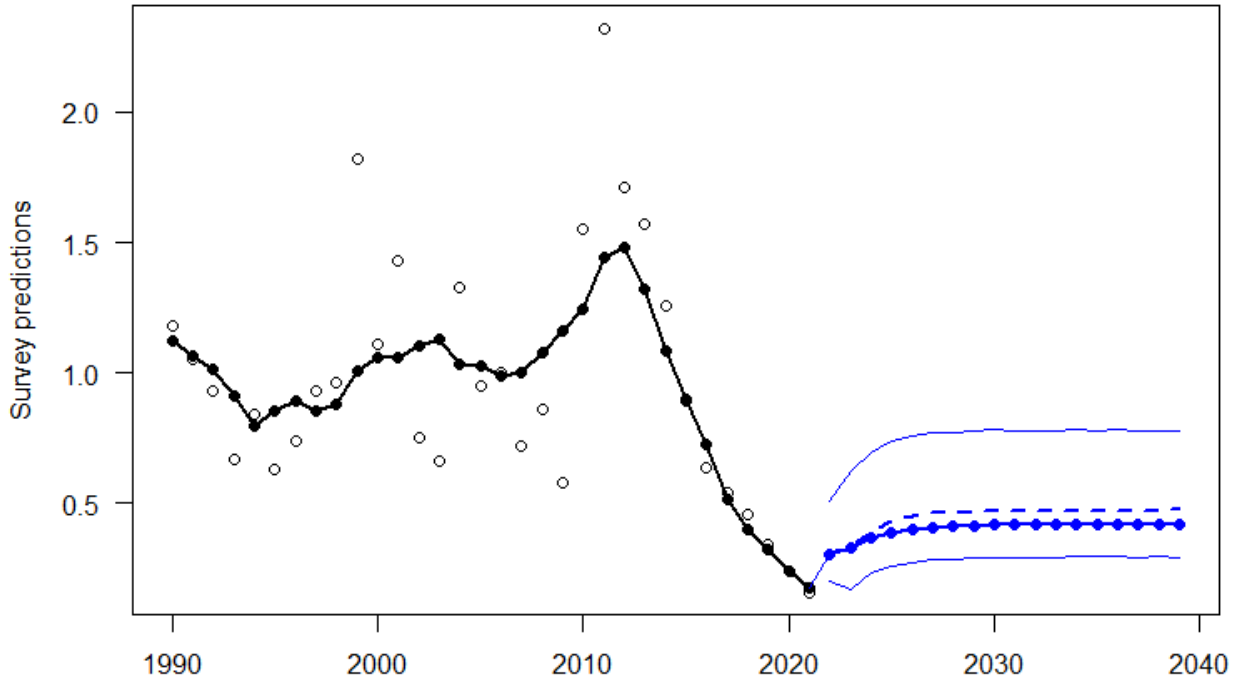




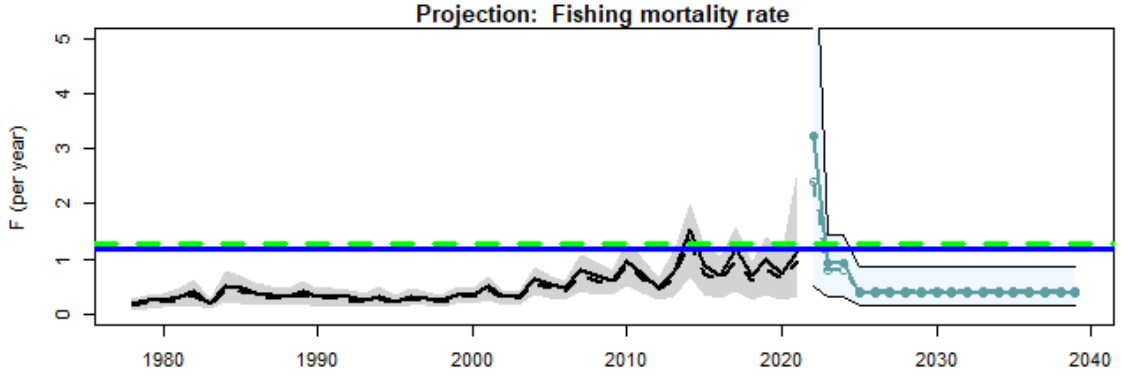


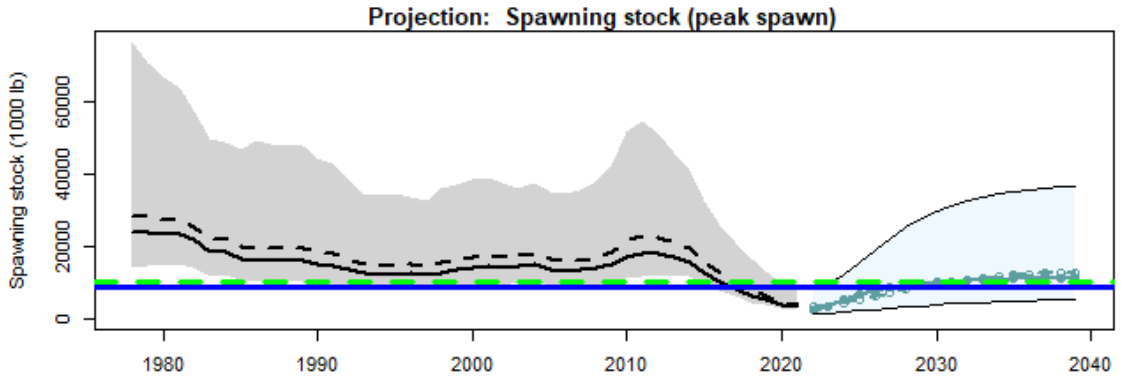
Rec-mu $D_{current}$ F=0

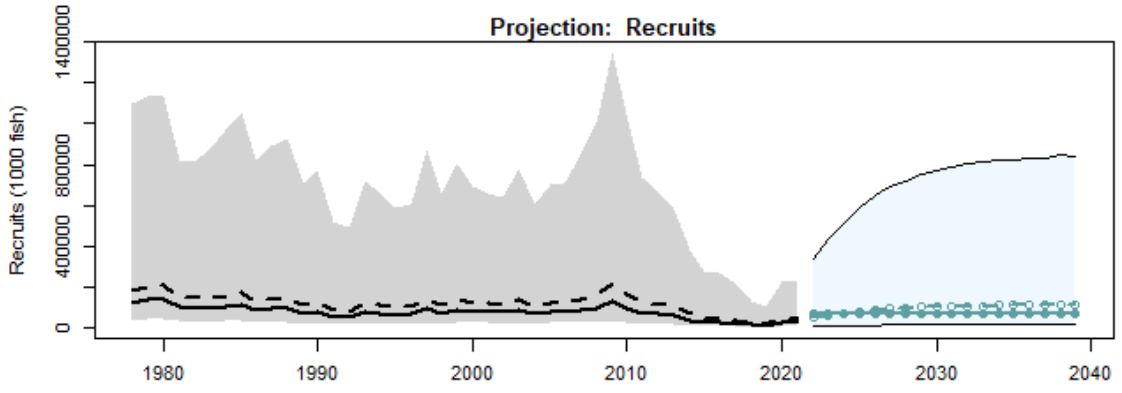


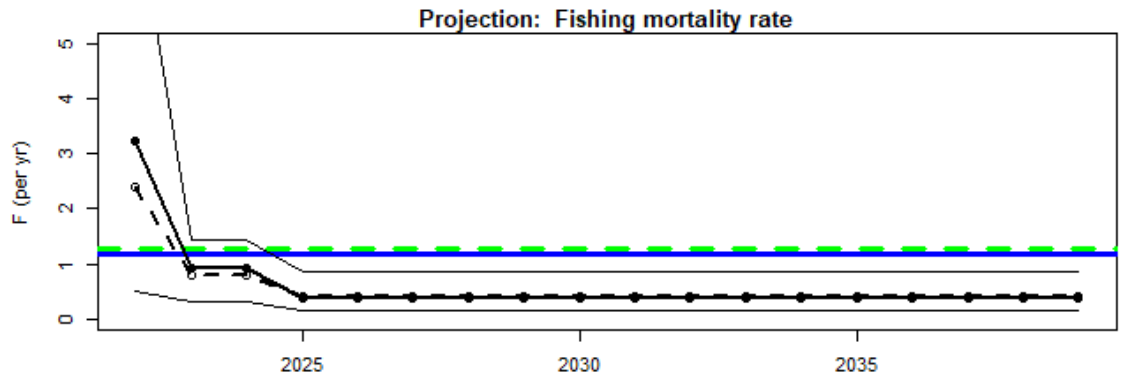


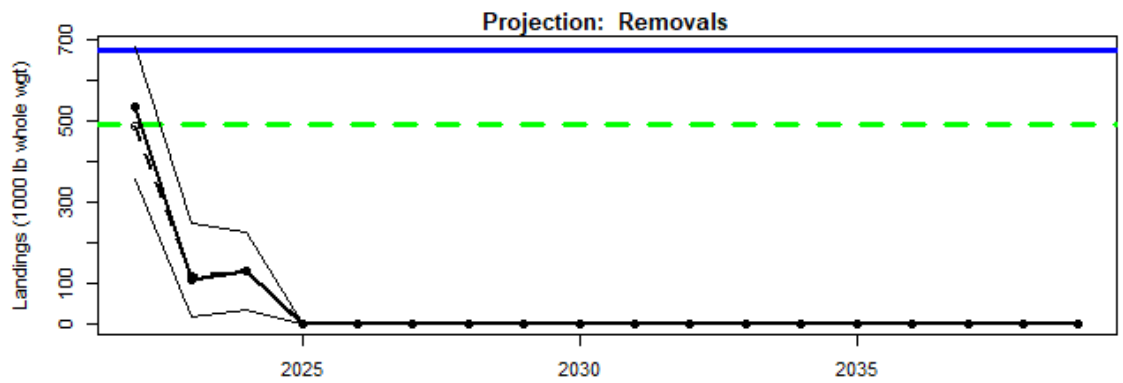
AR $D_{current}$ F=0

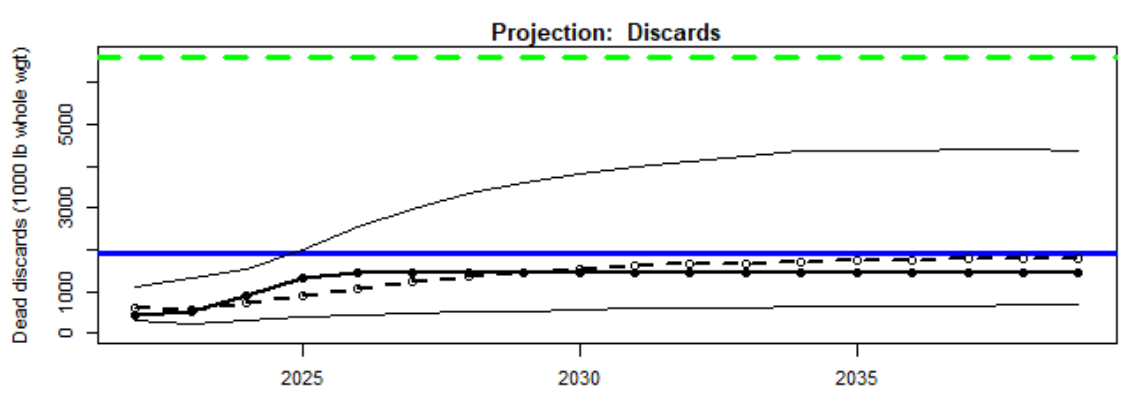




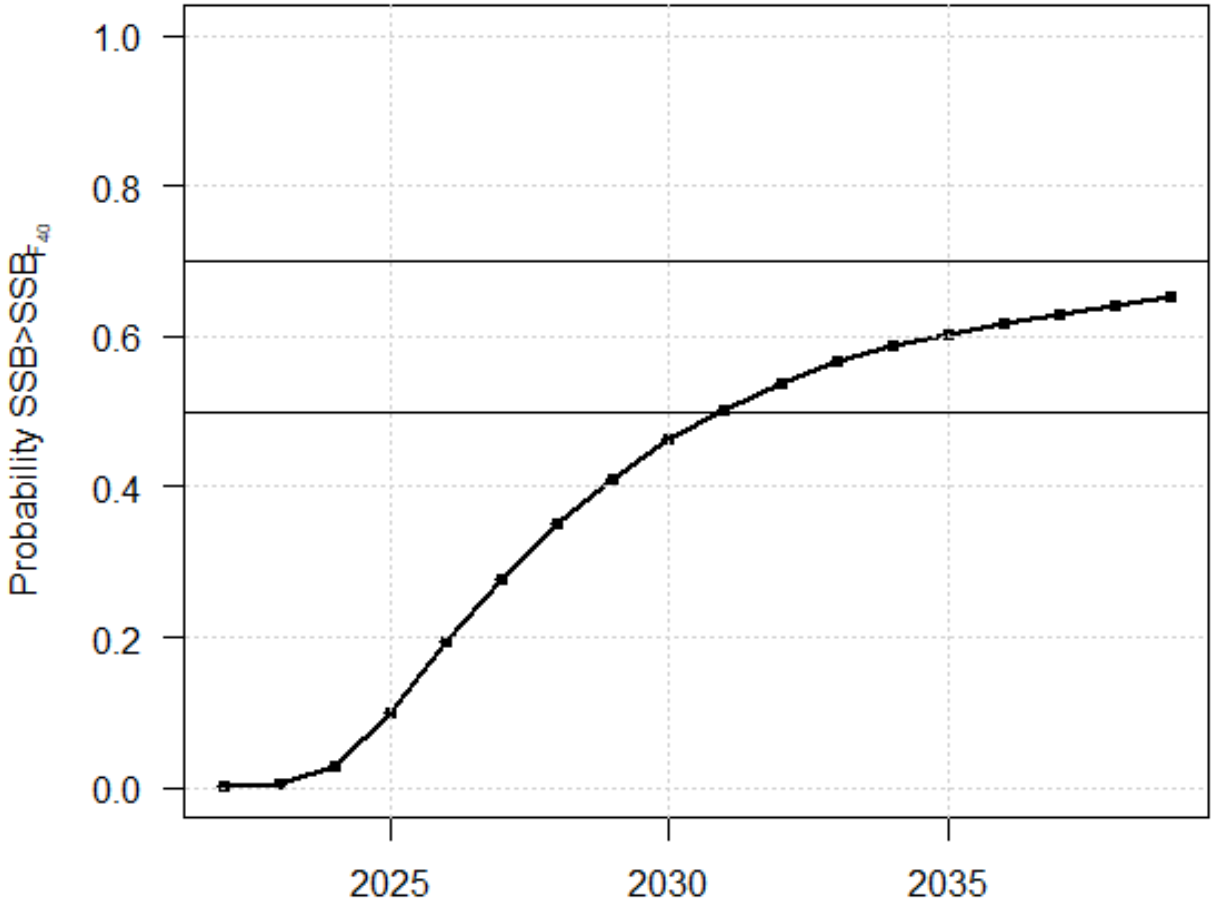


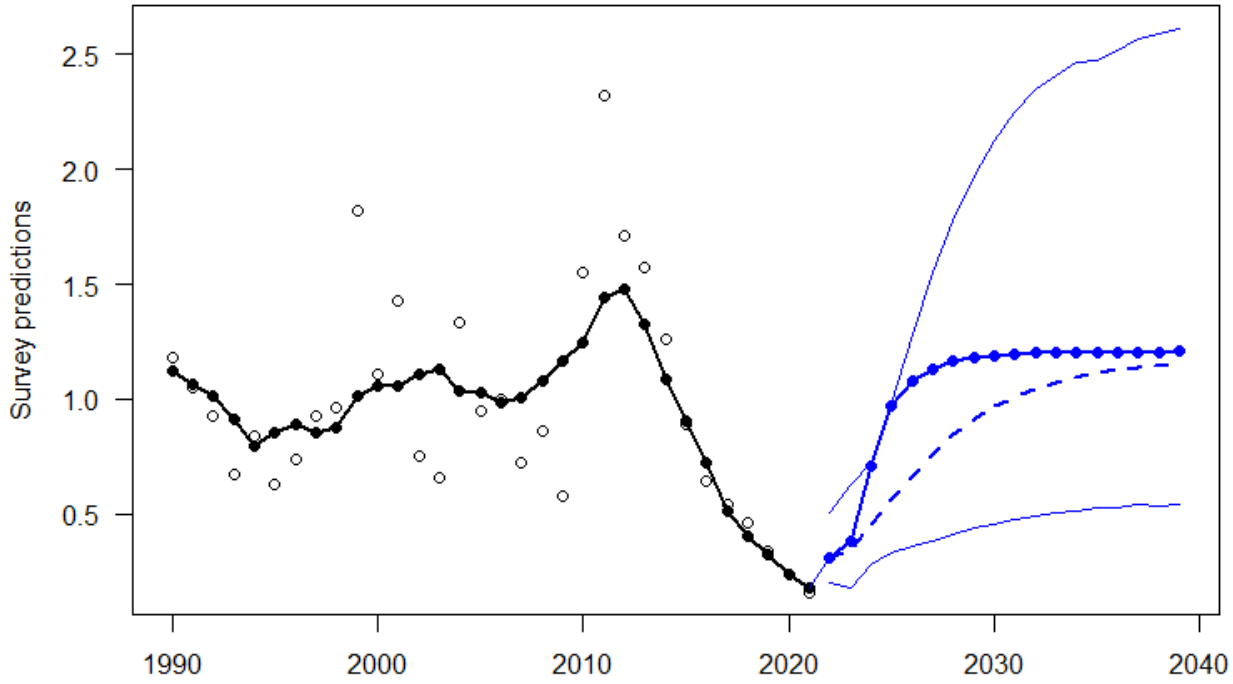




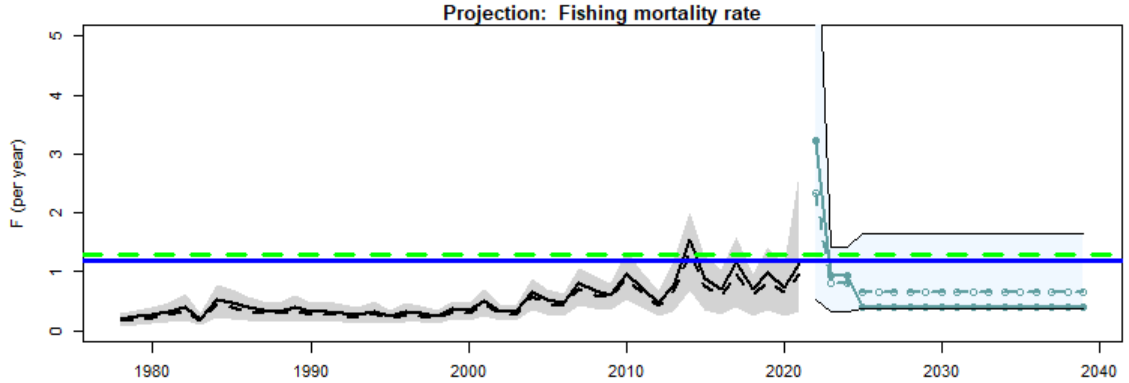


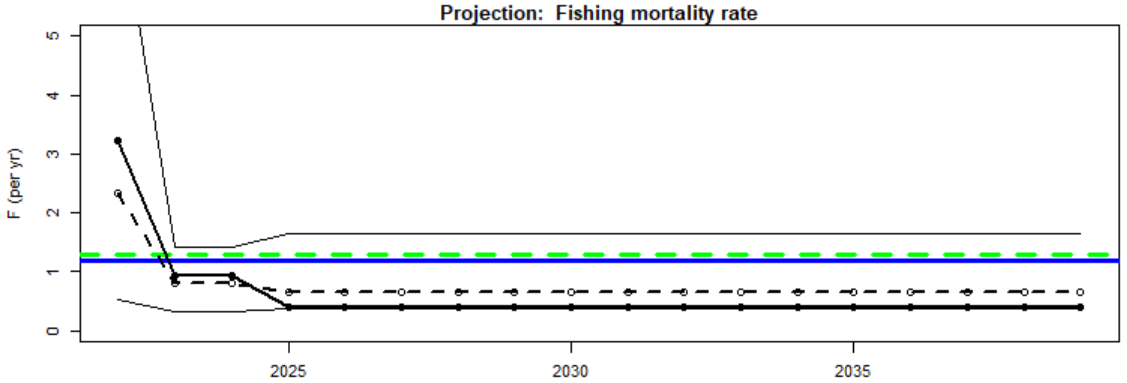
AR $D_{current}$ F=0

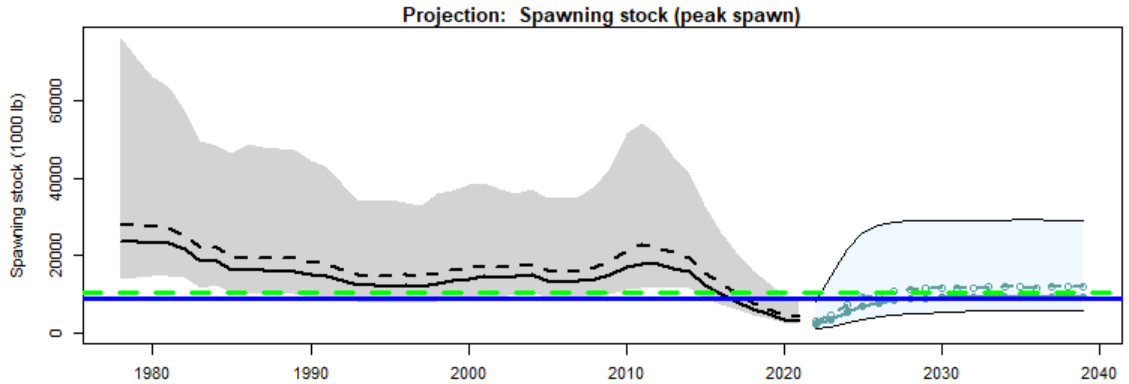


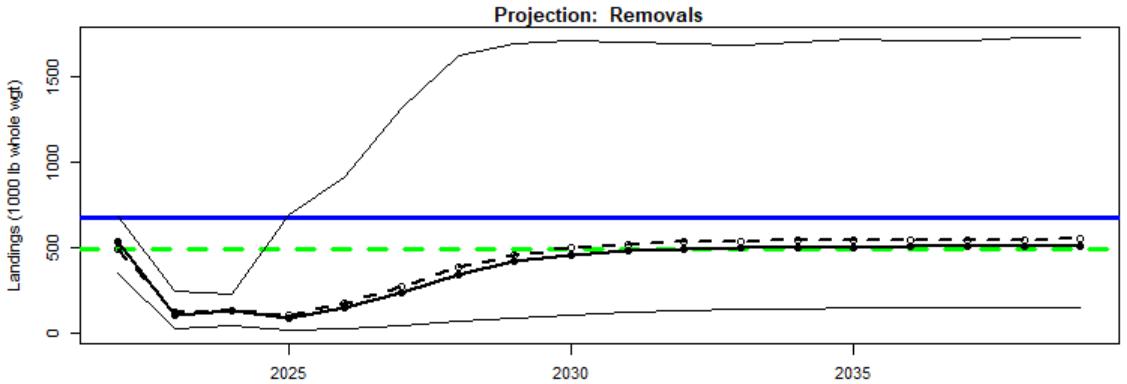


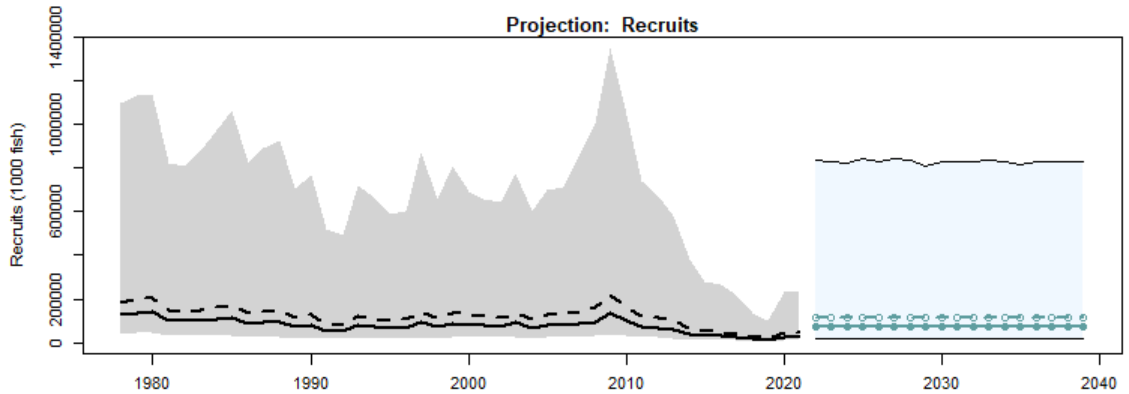
RO $D_{current}$ $F_{R65\%}$

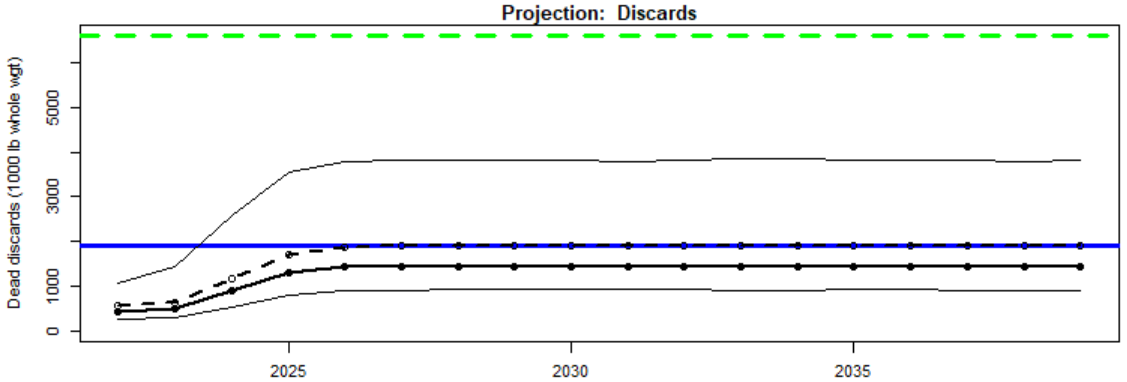




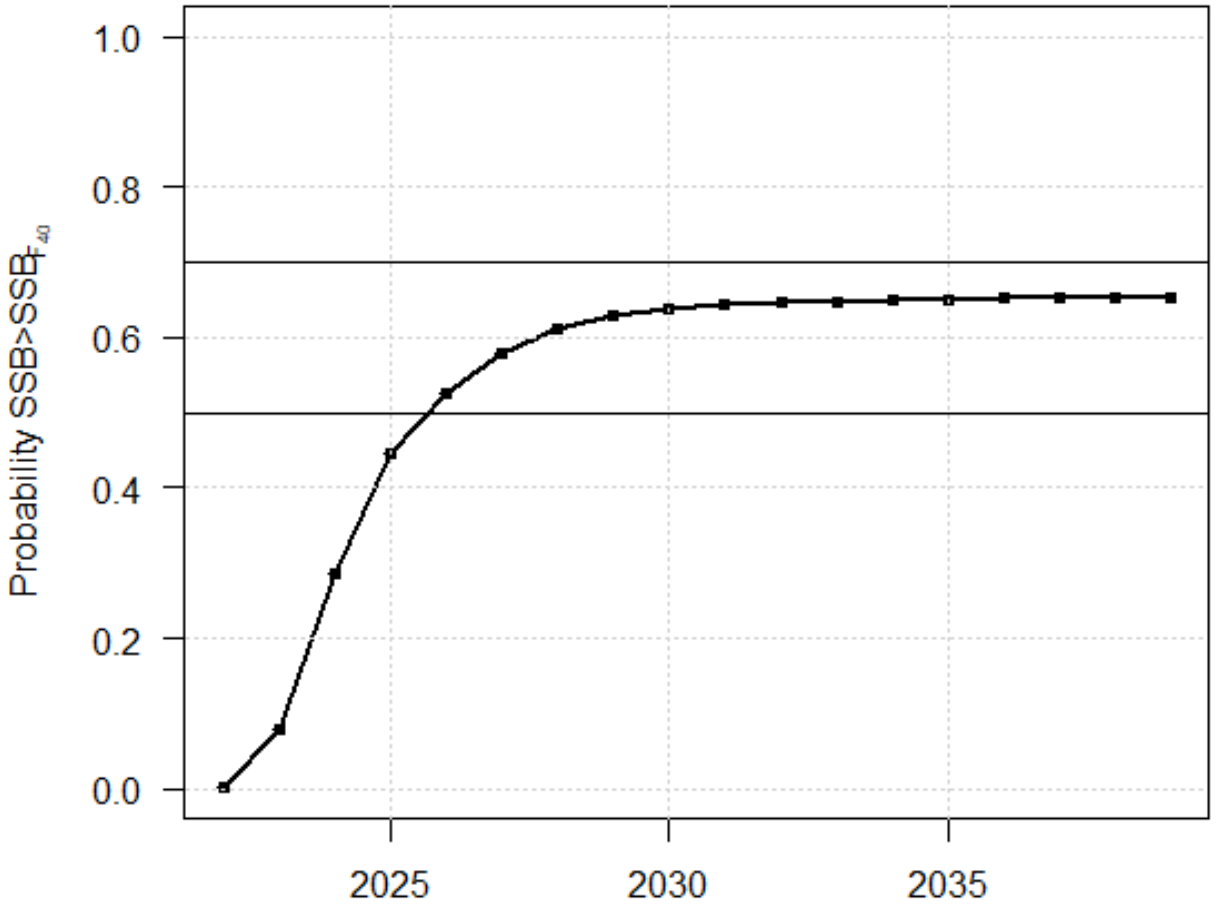


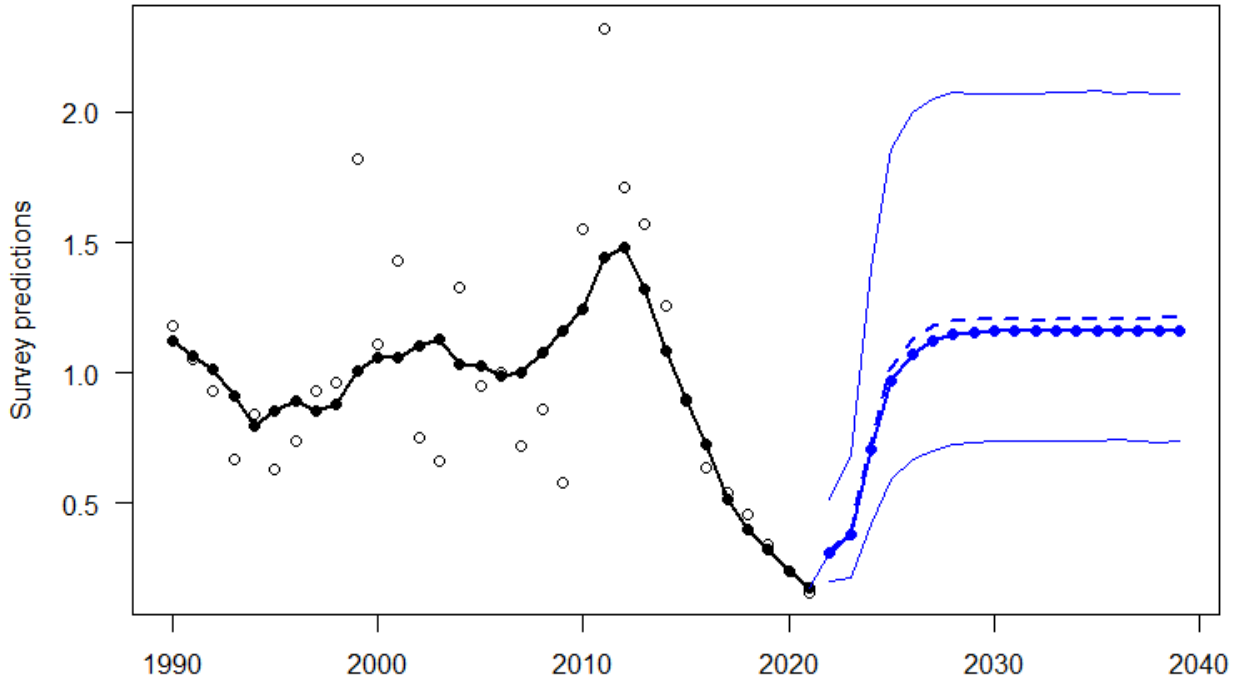




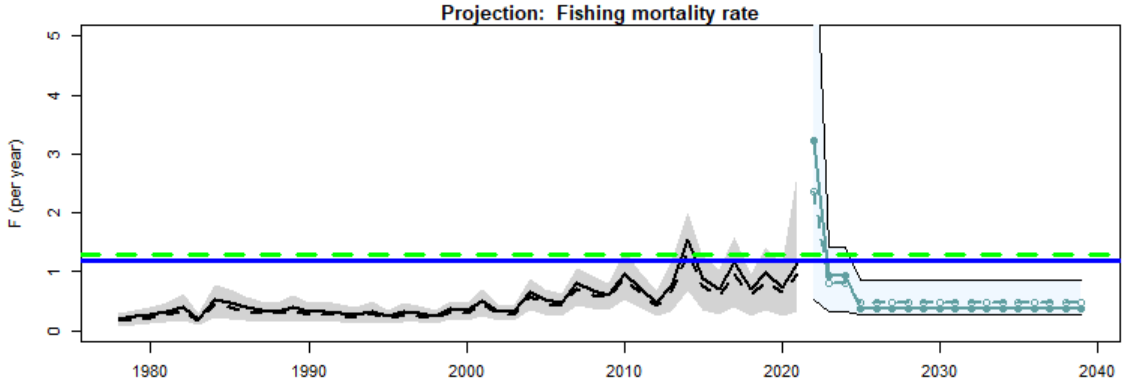


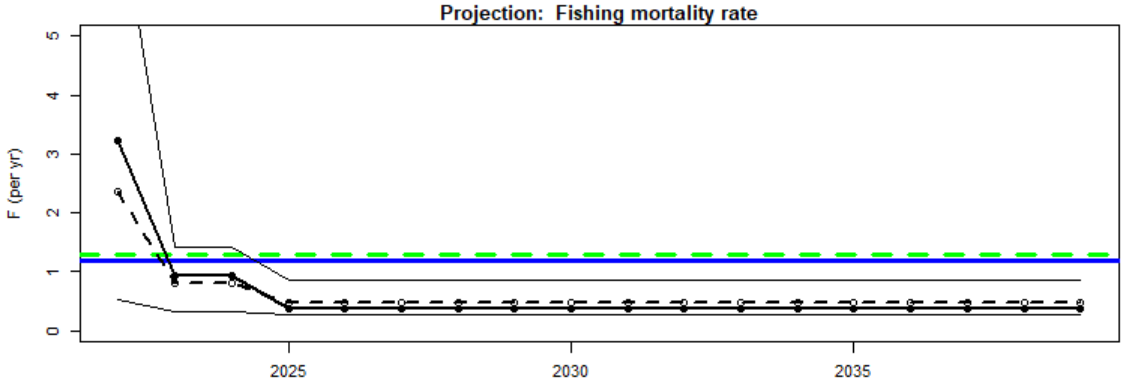
R0 $D_{current}$ $F_{R65\%}$

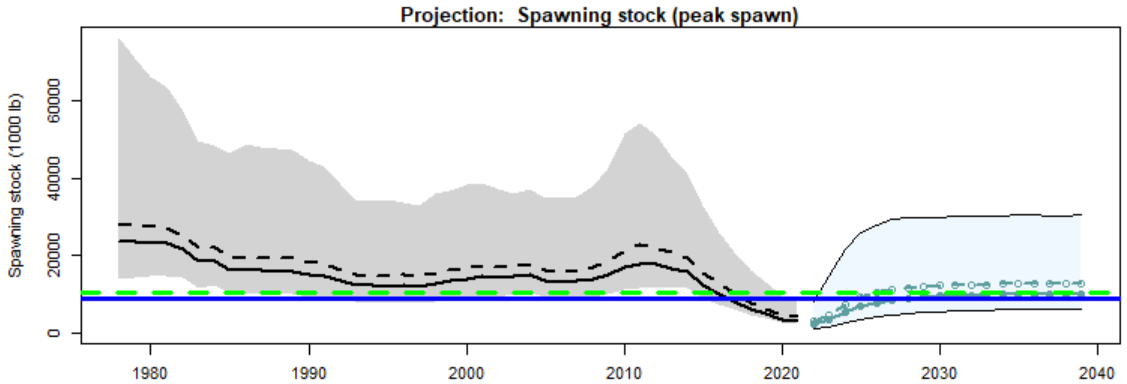


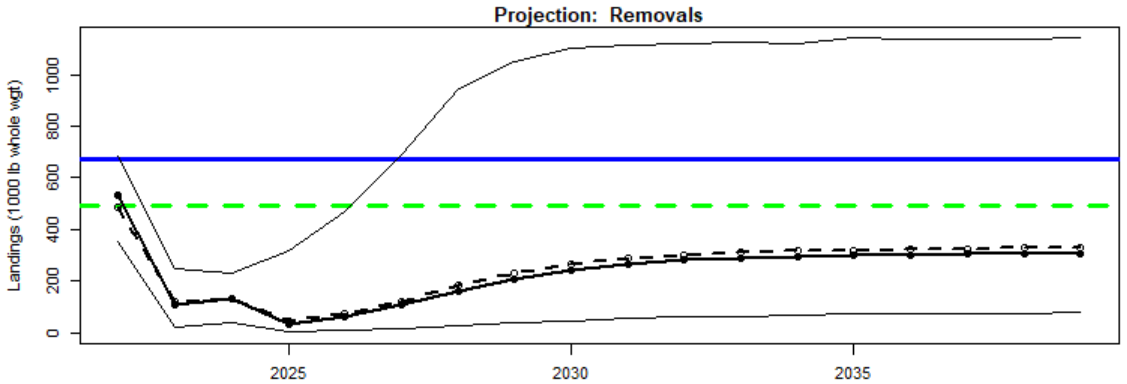


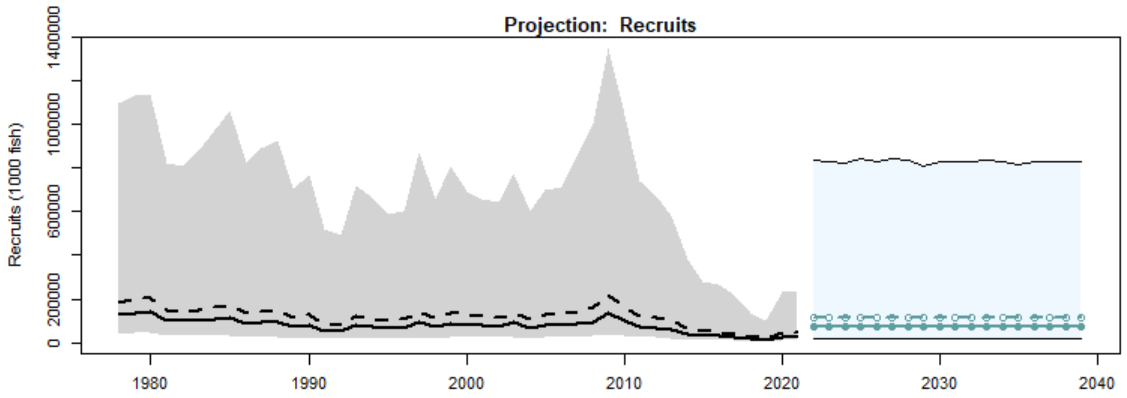
RO $D_{current}$ $F_{R70\%}$

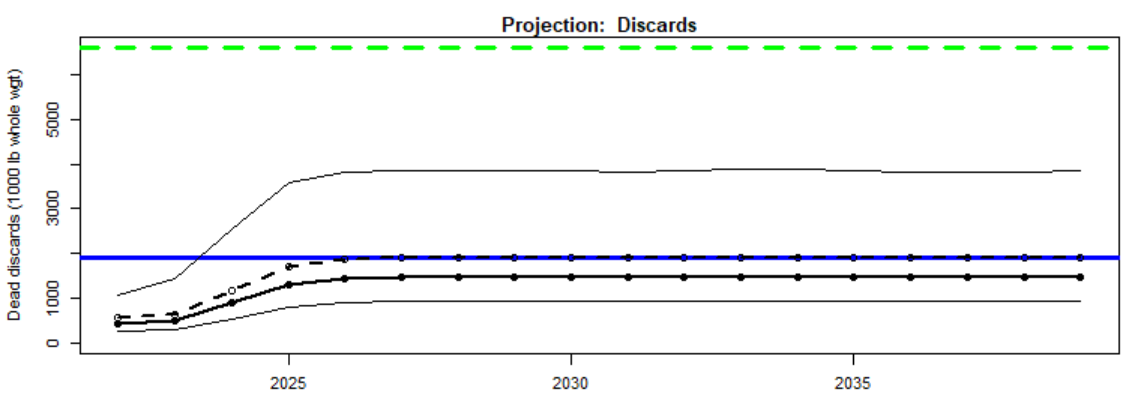




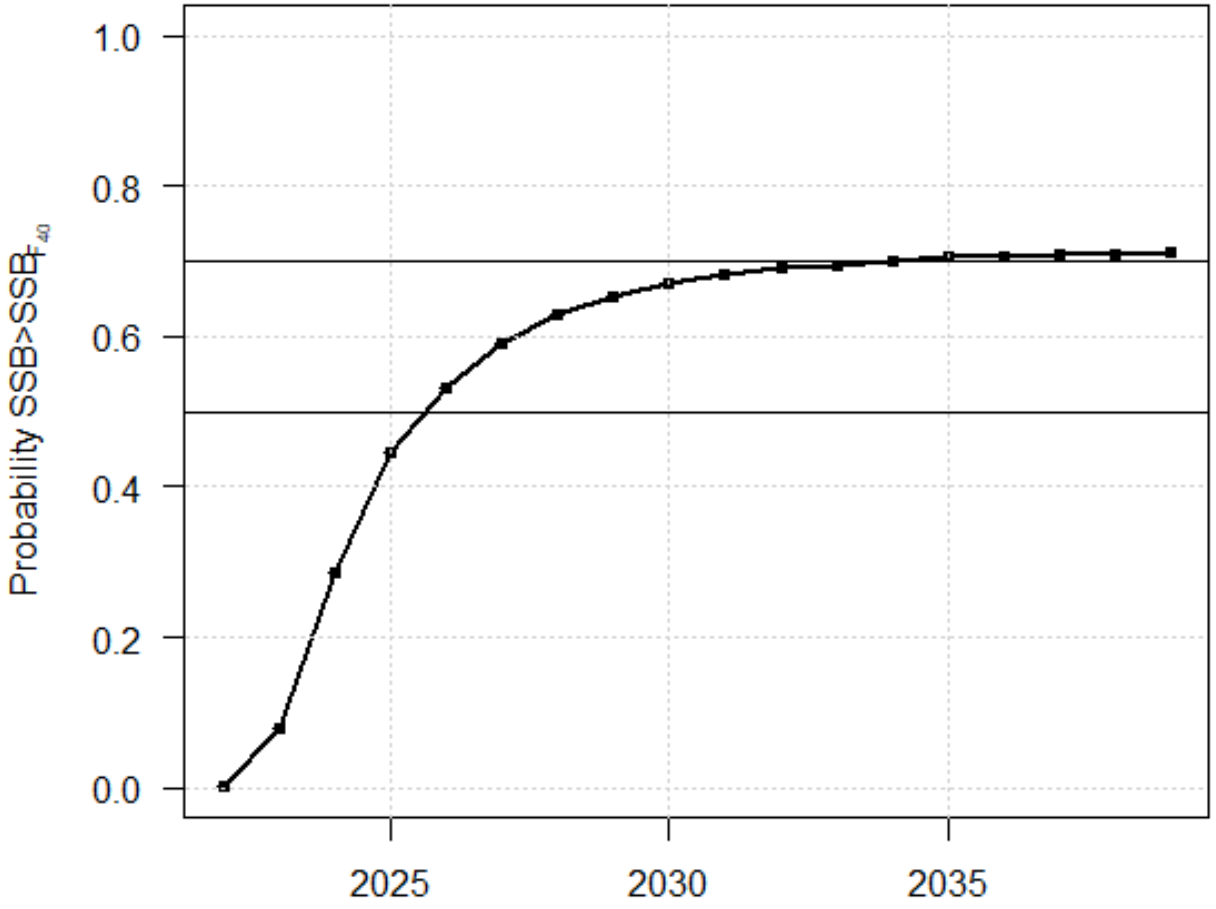


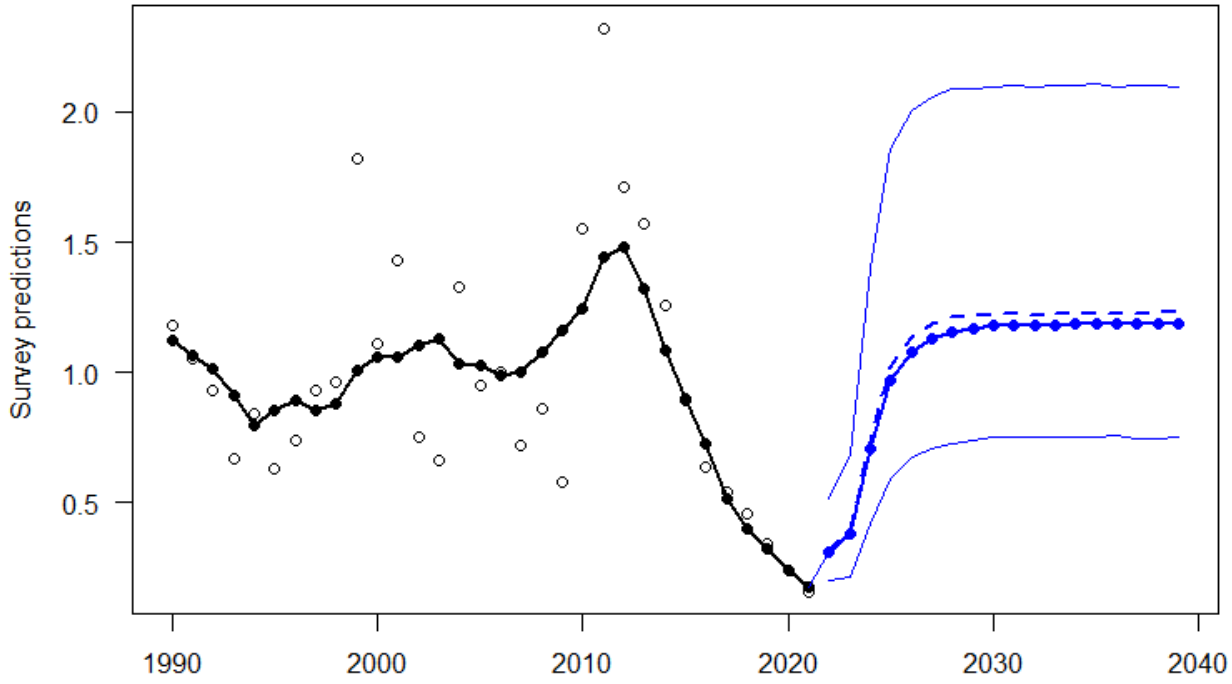






R0 $D_{current}$ $F_{R70\%}$





SPR Summary

- Calculating SPR using mature weight of males and females results in a status of overfished but not undergoing overfishing
- The status of both fishing mortality and stock status is less certain using this metric than the previous "F_{MSY}" and $F_{0.1}$
- Further research needed on sperm limitation in black sea bass

Projections Summary

- Under assumptions of long-term recruitment and autocorrelated recruitment deviates the stock can rebuild within 10 years
- Under assumptions of recent recruitment the stock can never rebuild to reference points based on long-term recruitment
- Current discarding levels prevent rebuilding to 70% within 10 years assuming autocorrelated recruitment
- Assuming long-term recruitment and $D_{current}$ the stock can rebuild with a 65% and 70% probability with $F_{R65\%}$ and $F_{R70\%}$

ABC and OFL Possible scenarios

- ABC
  - Probability Rebuild scenarios (e.g., R0 $D_{current}$ $F_{R65\%}$),
  - AR $D_{current}$ F=0 – AR scenario with $D_{current}$
  - Rec-mu D_{prop} F = P*$F_{40\%}$ – Recent recruitment, current discards, P* Fs, or
  - Rec-mu $D_{current}$ F = P*$F_{40\%}$ – Recent recruitment, current discards, P* Fs
- OFL
  - R0 $D_{current}$ $F_{40\%}$ - Long-term recruitment with reference F and current discards
  - R0 D_{prop} $F_{40\%}$ - Long-term recruitment with reference F
- Need final decision on P* 35 or 30

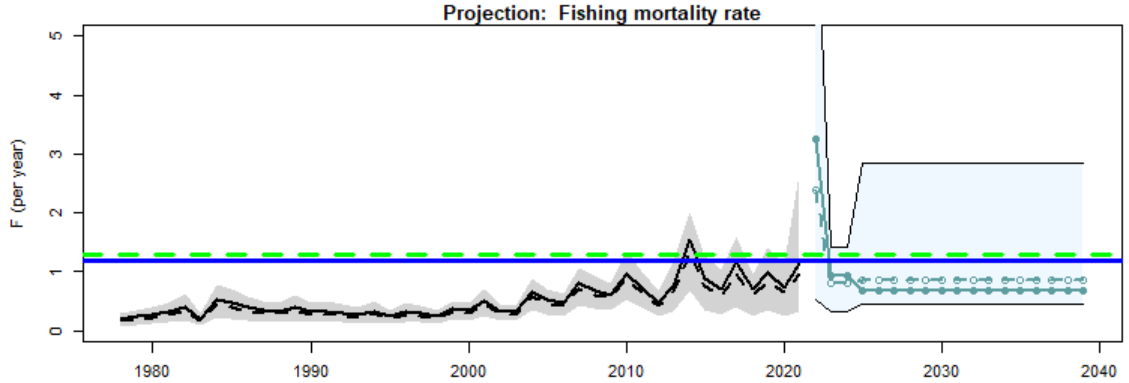
- Additional scenarios not presented available

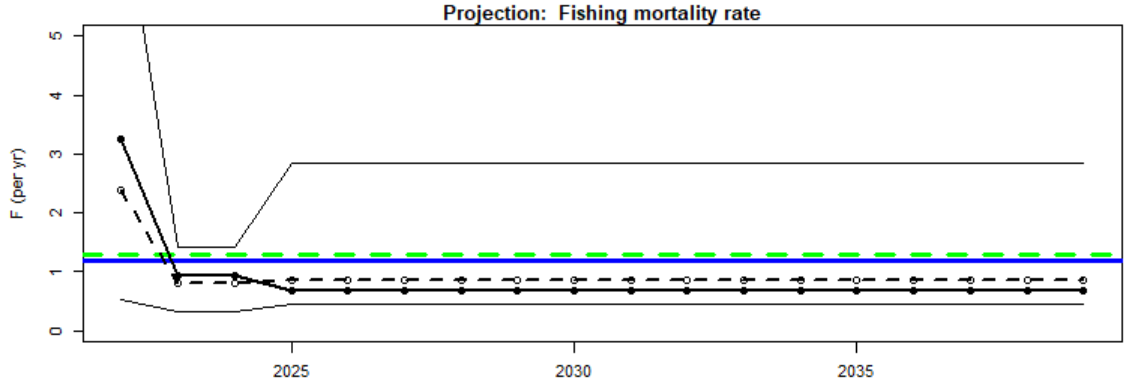
NOAA FISHERIES

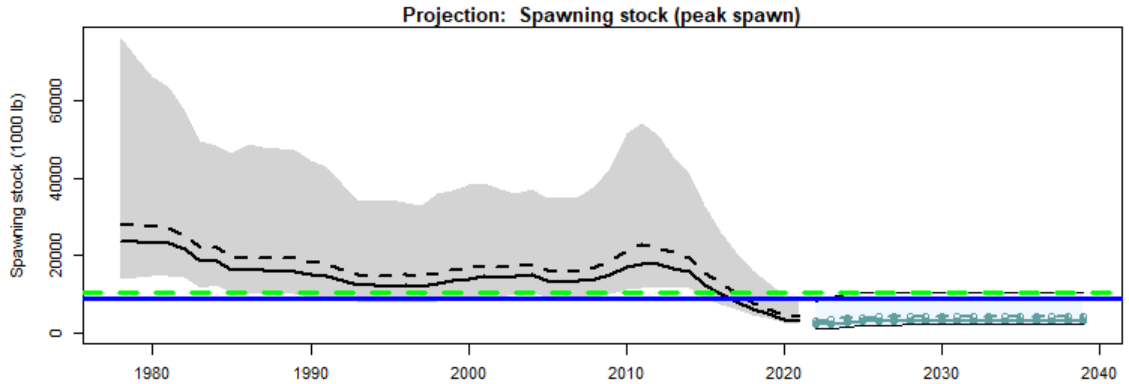
NOAA FISHERIES

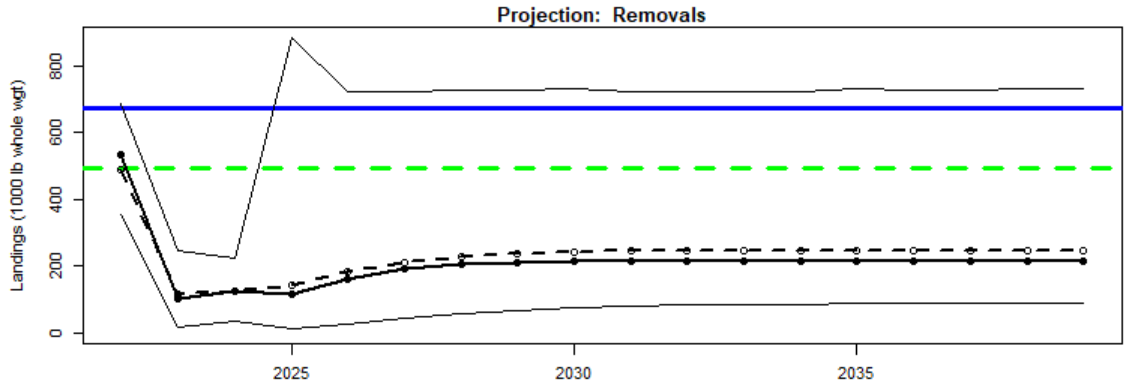
Additional Slides

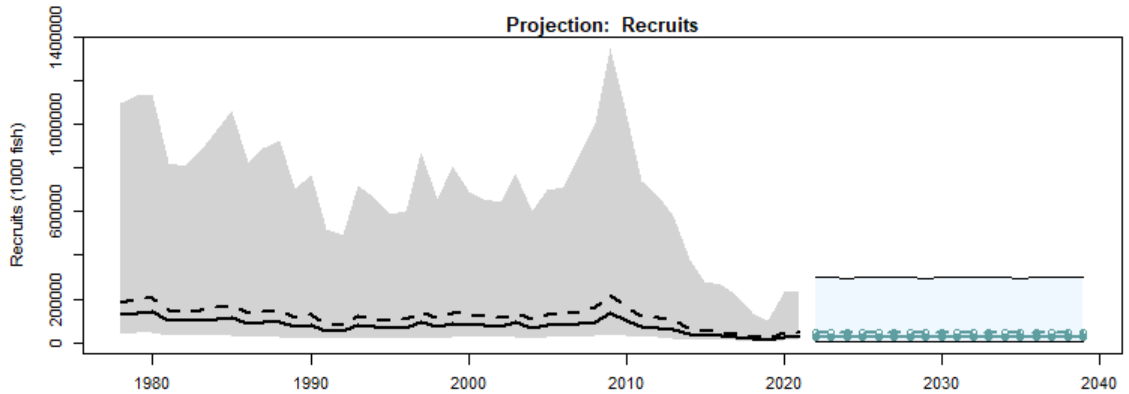
ABC – Rec-mu $D_{current}$ F = P*(30) F40

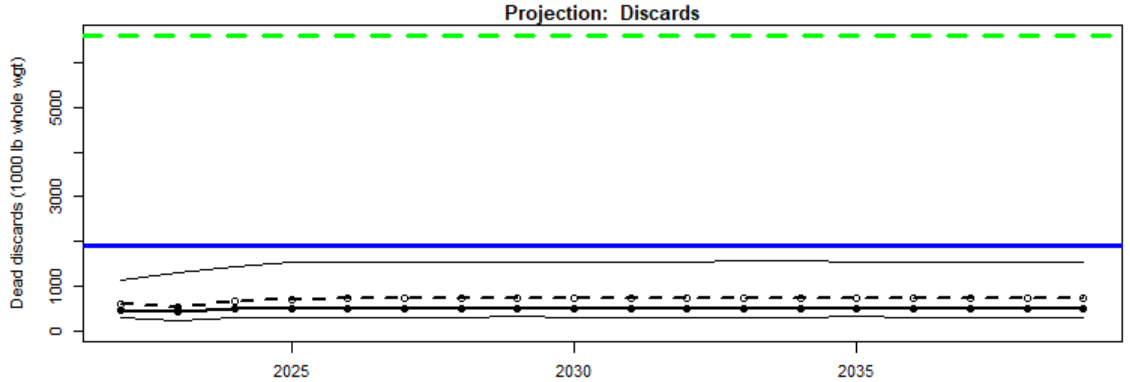




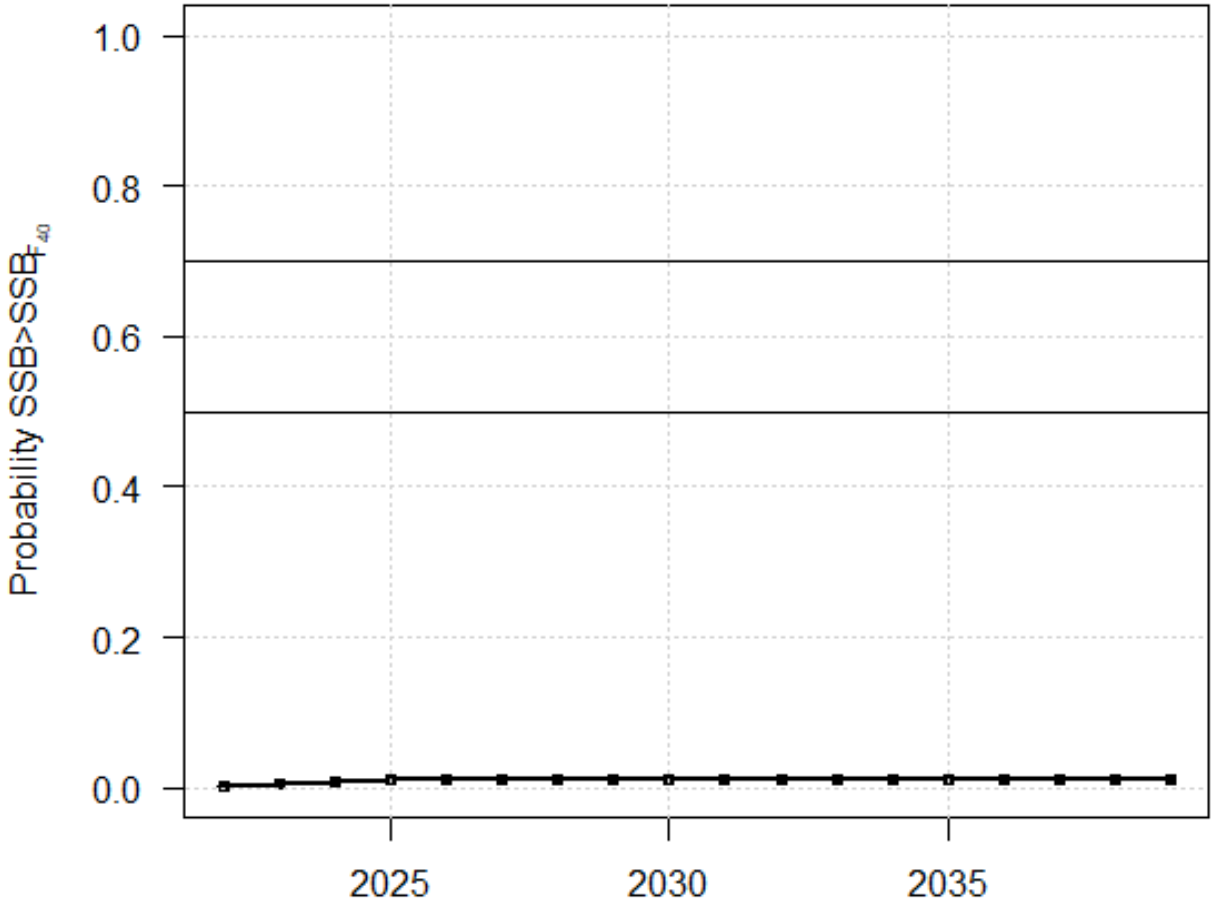


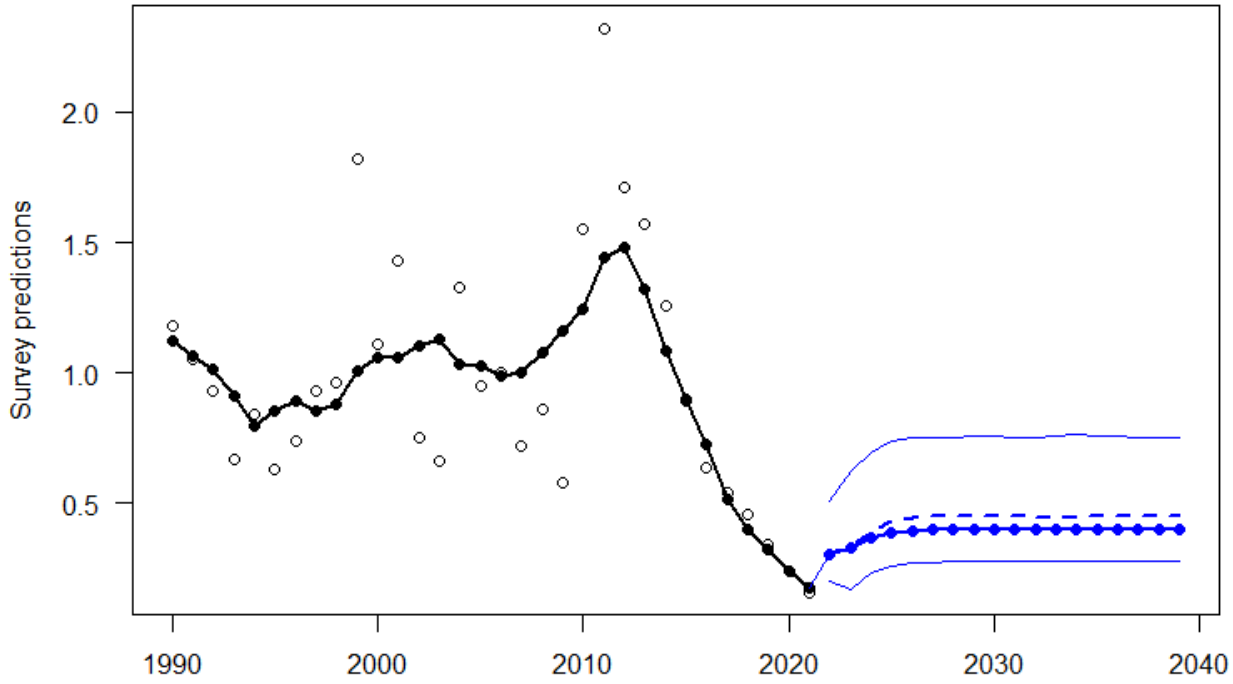






ABC – Rec-mu $D_{current}$ F = P*(30) F40



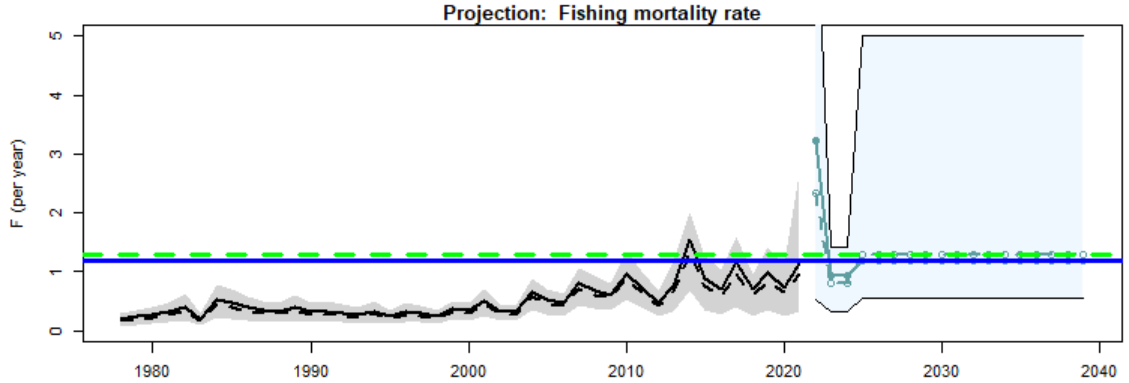


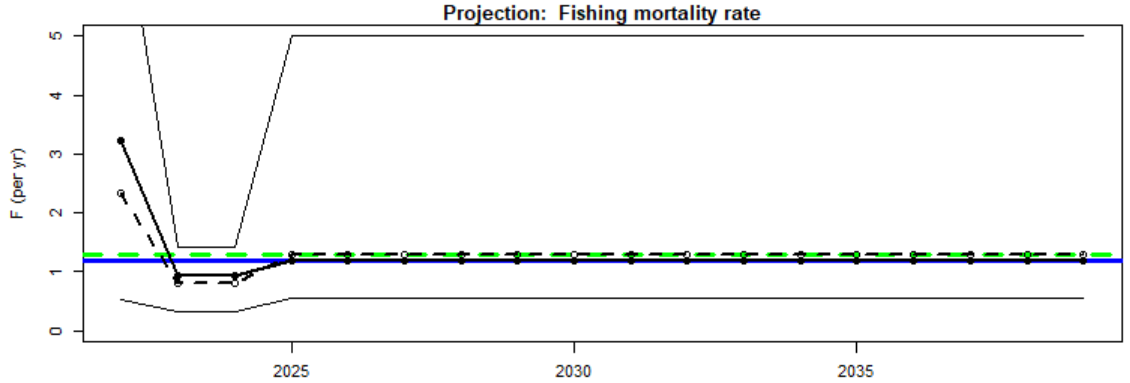
ABC – Rec-mu $D_{current}$ F = P*(30) F40

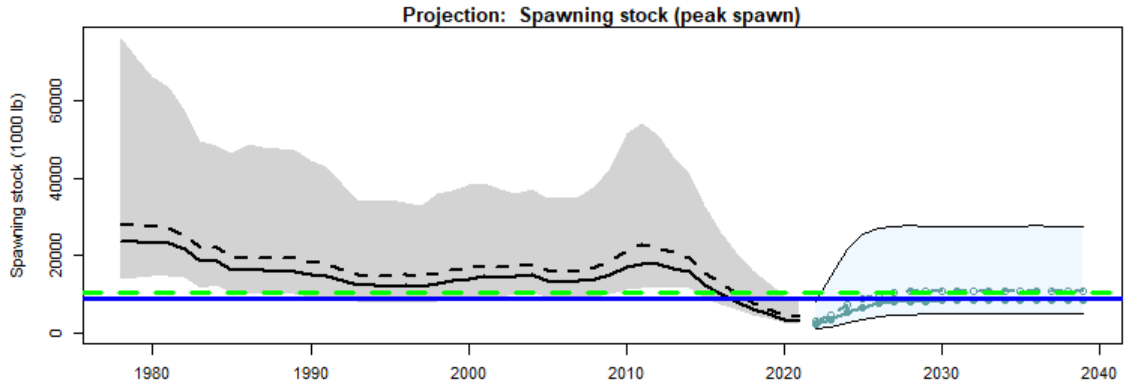
Table 11. Projection results with fishing mortality rate fixed at $F_{\text{Landed}} = F_{\text{PStar70\%}}$ *and* $F_{\text{Discard}} = F_{\text{current}}$ *starting in 2025 and recent average recruitment starting in 2023. R = number of age-0 recruits (in millions), F = fishing mortality rate (per year), S = spawning stock (1000* lb*), L = landings and D = discards expressed in numbers (n, in 1000s) or whole weight (w, in 1000* lb*), pr.reb = proportion of stochastic projection replicates with* $\text{SSB} \geq \text{SSB}_{\text{F40\%}}$*. The extension* b *indicates expected values (deterministic) from the base run; the extension* med *indicates median values from the stochastic projections.*

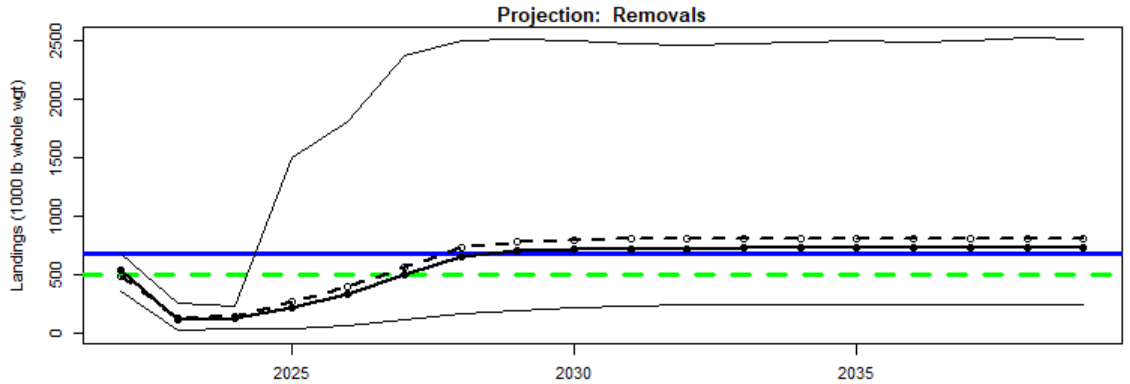
Year	R.b	R.med	F.b	F.med	S.b	S.med	L.b(n)	L.med(n)	L.b(w)	L.med(w)	D.b(n)	D.med(n)	D.b(w)	D.med(w)	pr.reb
2022	25	44	3.247	2.380	2276	2970	451	420	534	488	1215	1625	460	602	0.002
2023	25	43	0.936	0.801	2350	3187	101	108	104	115	1066	1371	432	532	0.005
2024	25	43	0.936	0.801	2609	3610	123	120	124	126	1139	1580	483	643	0.008
2025	25	43	0.671	0.852	2784	3863	115	139	117	141	1157	1667	498	698	0.010
2026	25	43	0.671	0.852	2907	4025	149	173	161	181	1160	1700	501	715	0.010
2027	25	43	0.671	0.852	2968	4095	169	197	190	212	1161	1701	501	720	0.009
2028	25	43	0.671	0.852	2994	4145	178	209	204	230	1161	1694	501	719	0.011
2029	25	43	0.671	0.852	3005	4169	181	215	210	238	1161	1691	501	716	0.011
2030	25	43	0.671	0.852	3010	4185	182	217	213	242	1161	1699	501	718	0.011
2031	25	43	0.671	0.852	3011	4173	183	219	213	245	1161	1687	501	717	0.011
2032	25	43	0.671	0.852	3012	4178	183	219	214	246	1161	1683	501	714	0.011
2033	25	43	0.671	0.852	3012	4184	183	219	214	246	1161	1682	501	714	0.010
2034	25	44	0.671	0.852	3012	4173	183	219	214	247	1161	1687	501	715	0.011
2035	25	43	0.671	0.852	3012	4178	183	218	214	247	1161	1691	501	718	0.011
2036	25	43	0.671	0.852	3012	4184	183	219	214	247	1161	1694	501	717	0.010
2037	25	43	0.671	0.852	3012	4188	183	218	214	247	1161	1692	501	719	0.011
2038	25	44	0.671	0.852	3012	4174	183	218	214	246	1161	1685	501	713	0.010
2039	25	43	0.671	0.852	3012	4178	183	219	214	247	1161	1692	501	714	0.009

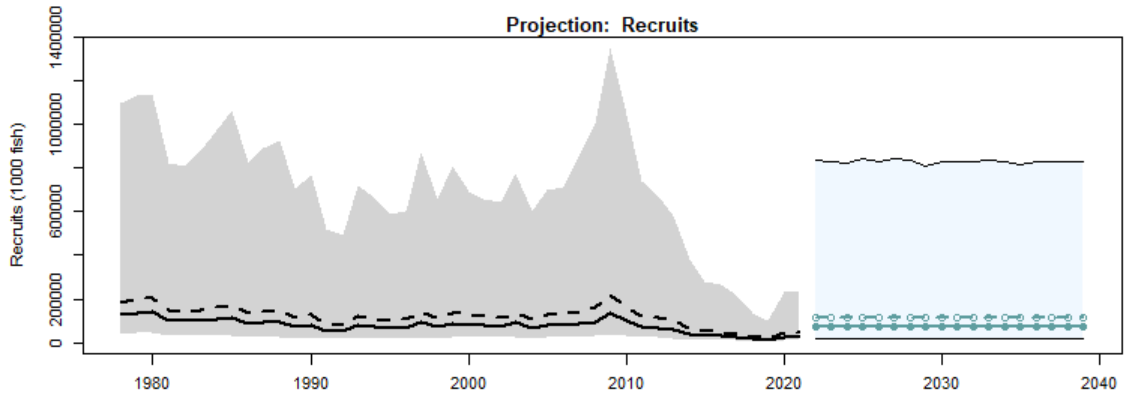
OFL – R0 $D_{current}$ F = F40

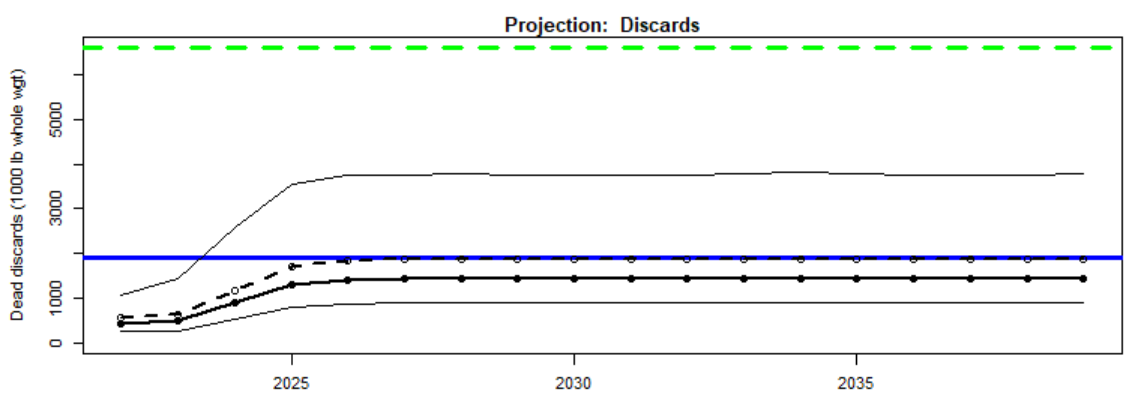




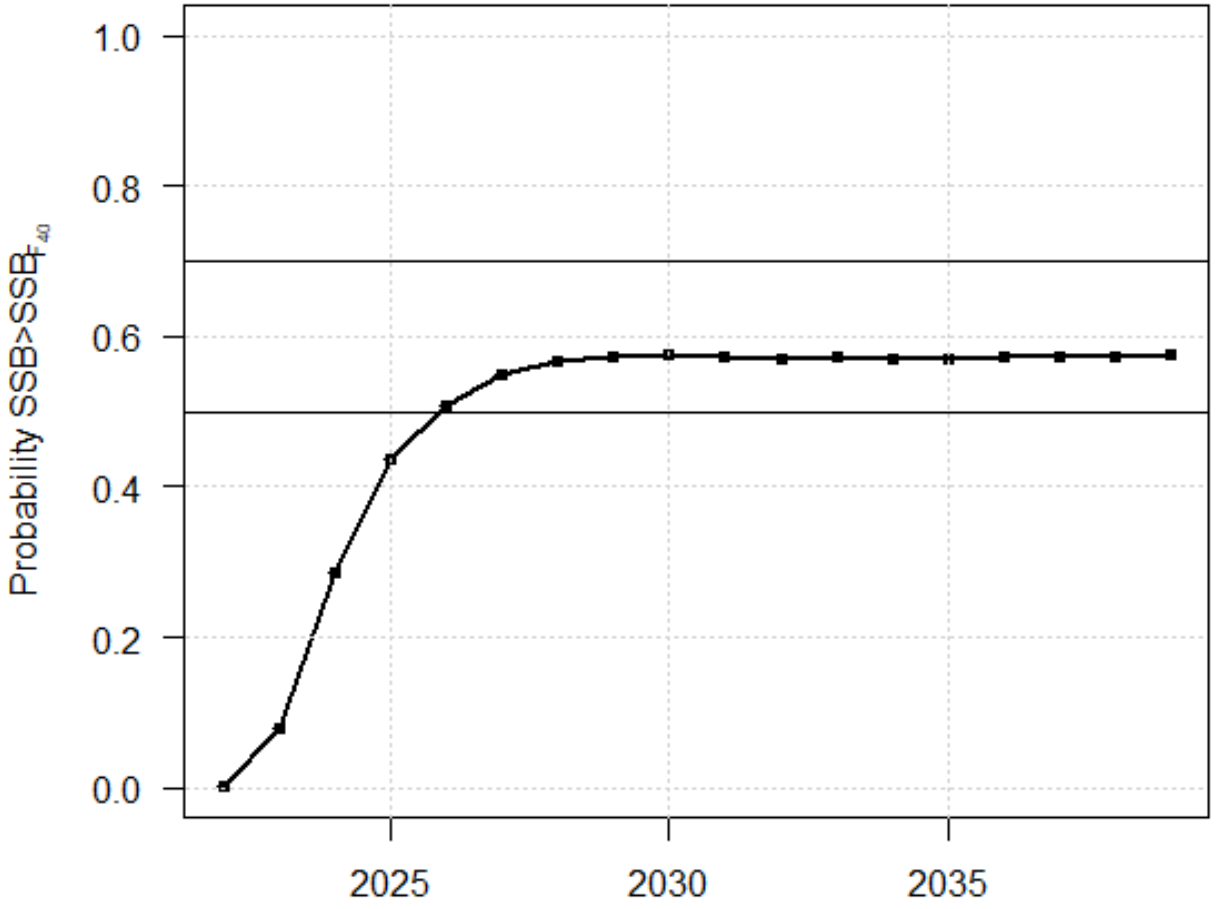


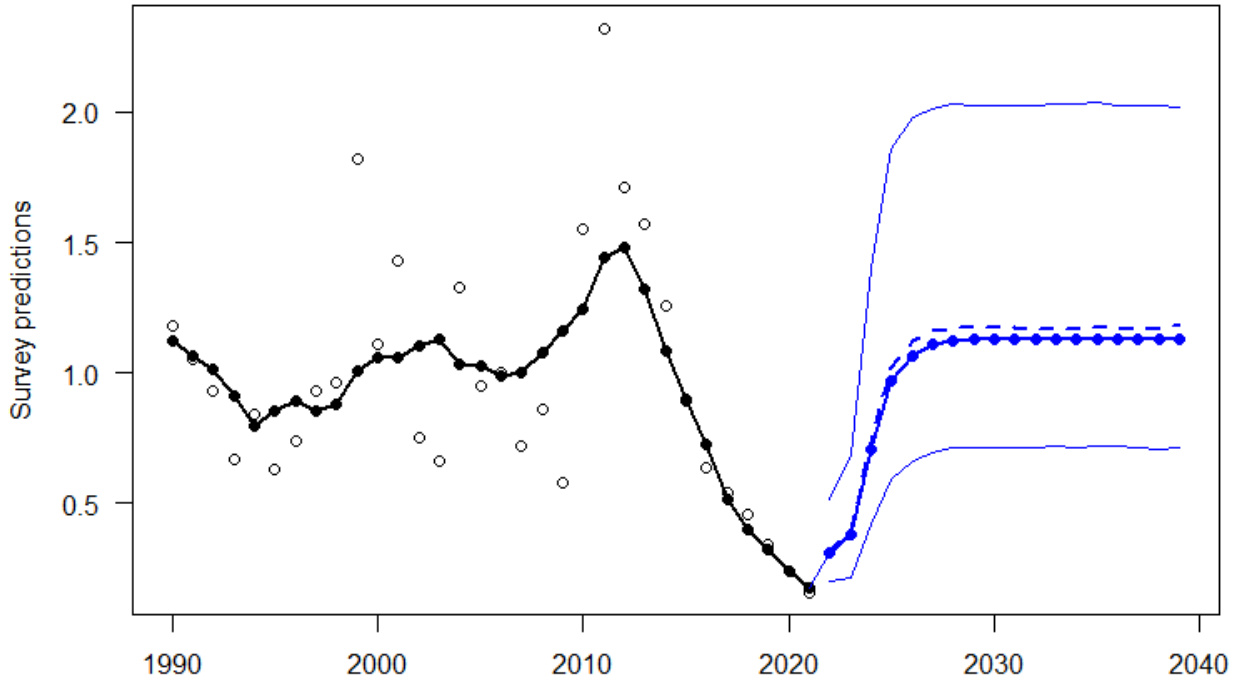






OFL – R0 $D_{current}$ F = F40





OFL – R0 $D_{current}$ F = F40

Table 12. Projection results with fishing mortality rate fixed at $F_{\text{Landed}} = F_{40\%}$ *and* $F_{\text{Discard}} = F_{\text{current}}$ *starting in 2025 and longterm recruitment starting in 2023. R = number of age-0 recruits (in millions), F = fishing mortality rate (per year), S = spawning stock (1000* lb*), L = landings and D = discards expressed in numbers (n, in 1000s) or whole weight (w, in 1000* lb*), pr.reb = proportion of stochastic projection replicates with* $\text{SSB} \geq \text{SSB}_{\text{F40\%}}$*. The extension* b *indicates expected values (deterministic) from the base run; the extension* med *indicates median values from the stochastic projections.*

Year	R.b	R.med	F.b	F.med	S.b	S.med	L.b(n)	L.med(n)	L.b(w)	L.med(w)	D.b(n)	D.med(n)	D.b(w)	D.med(w)	pr.reb
2022	71	116	3.235	2.330	2287	2988	452	421	534	489	1215	1621	432	562	0.002
2023	71	115	0.936	0.801	3403	4657	105	113	106	118	1458	1910	497	624	0.080
2024	71	114	0.936	0.801	5262	7185	135	133	130	132	2472	3290	885	1155	0.287
2025	71	116	1.178	1.286	6639	8924	242	299	219	268	3156	4234	1287	1688	0.436
2026	71	114	1.178	1.286	7441	9875	367	442	334	389	3300	4420	1406	1843	0.507
2027	71	115	1.178	1.286	7906	10375	510	605	492	562	3317	4442	1424	1859	0.550
2028	71	114	1.178	1.286	8122	10609	628	732	647	725	3318	4440	1426	1867	0.568
2029	71	115	1.178	1.286	8186	10665	665	766	702	779	3318	4437	1426	1858	0.572
2030	71	114	1.178	1.286	8202	10703	673	775	717	797	3318	4441	1426	1866	0.576
2031	71	115	1.178	1.286	8206	10679	675	782	720	806	3318	4431	1426	1858	0.572
2032	71	116	1.178	1.286	8207	10644	675	780	721	806	3318	4423	1426	1856	0.571
2033	71	115	1.178	1.286	8207	10703	675	781	721	808	3318	4416	1426	1858	0.572
2034	71	115	1.178	1.286	8207	10684	675	778	721	811	3318	4415	1426	1855	0.572
2035	71	115	1.178	1.286	8207	10715	675	779	721	805	3318	4435	1426	1866	0.572
2036	71	115	1.178	1.286	8207	10680	675	784	721	806	3318	4422	1426	1861	0.574
2037	71	115	1.178	1.286	8207	10699	675	780	721	809	3318	4442	1426	1867	0.573
2038	71	115	1.178	1.286	8207	10694	675	781	721	808	3318	4415	1426	1854	0.573
2039	71	114	1.178	1.286	8207	10727	675	781	721	807	3318	4438	1426	1859	0.576

RO D_{prop} F=0

Table 1. Projection results with fishing mortality rate fixed at $F = 0$ starting in 2025 and longterm recruitment starting in 2023. R = number of age-0 recruits (in millions), F = fishing mortality rate (per year), S = spawning stock (1000 lb), L = landings and D = discards expressed in numbers (n, in 1000s) or whole weight (w, in 1000 lb), pr.reb = proportion of stochastic projection replicates with $SSB \geq SSB_{F40\%}$. The extension b indicates expected values (deterministic) from the base run; the extension med indicates median values from the stochastic projections.

Year	R.b	R.med	F.b	F.med	S.b	S.med	L.b(n)	L.med(n)	L.b(w)	L.med(w)	D.b(n)	D.med(n)	D.b(w)	D.med(w)	pr.reb
2022	71	116	3.235	2.315	2287	2995	452	421	534	487	1215	1621	432	563	0.002
2023	71	115	0.936	0.801	3403	4659	105	113	106	119	1458	1910	497	624	0.080
2024	71	114	0.936	0.801	5262	7178	135	133	130	133	2472	3291	885	1154	0.286
2025	71	116	0.000	0.000	7079	9597	0	0	0	0	0	0	0	0	0.486
2026	71	114	0.000	0.000	9419	12675	0	0	0	0	0	0	0	0	0.697
2027	71	115	0.000	0.000	11418	15194	0	0	0	0	0	0	0	0	0.843
2028	71	114	0.000	0.000	13070	17311	0	0	0	0	0	0	0	0	0.937
2029	71	115	0.000	0.000	14408	19014	0	0	0	0	0	0	0	0	0.982
2030	71	114	0.000	0.000	15476	20394	0	0	0	0	0	0	0	0	0.996
2031	71	115	0.000	0.000	16319	21526	0	0	0	0	0	0	0	0	1.000
2032	71	116	0.000	0.000	16977	22361	0	0	0	0	0	0	0	0	1.000
2033	71	115	0.000	0.000	17487	23077	0	0	0	0	0	0	0	0	1.000
2034	71	115	0.000	0.000	17868	23704	0	0	0	0	0	0	0	0	1.000
2035	71	115	0.000	0.000	18148	24121	0	0	0	0	0	0	0	0	1.000
2036	71	115	0.000	0.000	18353	24434	0	0	0	0	0	0	0	0	1.000
2037	71	115	0.000	0.000	18503	24684	0	0	0	0	0	0	0	0	1.000
2038	71	115	0.000	0.000	18614	24892	0	0	0	0	0	0	0	0	1.000
2039	71	114	0.000	0.000	18694	25025	0	0	0	0	0	0	0	0	1.000

Rec-mu D_{prop} F=0

Table 2. Projection results with fishing mortality rate fixed at $F = 0$ starting in 2025 and recent average recruitment starting in 2023. R = number of age-0 recruits (in millions), F = fishing mortality rate (per year), S = spawning stock (1000 lb), L = landings and D = discards expressed in numbers (n, in 1000s) or whole weight (w, in 1000 lb), pr.reb = proportion of stochastic projection replicates with $SSB \geq SSB_{F40\%}$. The extension b *indicates expected values (deterministic) from the base run; the extension* med *indicates median values from the stochastic projections.*

Year	R.b	R.med	F.b	F.med	S.b	S.med	L.b(n)	L.med(n)	L.b(w)	L.med(w)	D.b(n)	D.med(n)	D.b(w)	D.med(w)	pr.reb
2022	25	44	3.247	2.356	2276	2978	451	420	534	489	1215	1627	460	604	0.002
2023	25	43	0.936	0.801	2471	3377	106	115	107	120	60	159	9	22	0.007
2024	25	43	0.936	0.801	3152	4414	160	158	154	160	63	166	10	25	0.017
2025	25	43	0.000	0.000	3756	5351	0	0	0	0	64	170	12	29	0.032
2026	25	43	0.000	0.000	4355	6226	0	0	0	0	65	173	13	33	0.054
2027	25	43	0.000	0.000	4842	6962	0	0	0	0	66	175	15	35	0.082
2028	25	43	0.000	0.000	5230	7529	0	0	0	0	67	176	15	38	0.109
2029	25	43	0.000	0.000	5537	7985	0	0	0	0	67	178	16	40	0.140
2030	25	43	0.000	0.000	5777	8349	0	0	0	0	67	177	17	41	0.172
2031	25	43	0.000	0.000	5963	8629	0	0	0	0	68	178	17	43	0.198
2032	25	43	0.000	0.000	6102	8843	0	0	0	0	68	179	18	43	0.225
2033	25	43	0.000	0.000	6205	8990	0	0	0	0	68	178	18	44	0.247
2034	25	44	0.000	0.000	6280	9115	0	0	0	0	68	179	18	45	0.267
2035	25	43	0.000	0.000	6335	9214	0	0	0	0	68	178	18	45	0.280
2036	25	43	0.000	0.000	6375	9291	0	0	0	0	68	179	18	45	0.293
2037	25	43	0.000	0.000	6404	9328	0	0	0	0	68	178	18	46	0.299
2038	25	44	0.000	0.000	6426	9368	0	0	0	0	68	179	18	46	0.308
2039	25	43	0.000	0.000	6441	9396	0	0	0	0	68	179	18	46	0.312

AR D_{prop} F=0

Table 5. Projection results with fishing mortality rate fixed at $F = F0$ starting in 2025 and autocorrelated recruitment deviates starting in 2023. R = number of age-0 recruits (in millions), F = fishing mortality rate (per year), S = spawning stock (1000 lb), L = landings and D = discards expressed in numbers (n, in 1000s) or whole weight (w, in 1000 lb), pr.reb = proportion of stochastic projection replicates with $SSB \geq SSB_{F40\%}$. The extension b indicates expected values (deterministic) from the base run; the extension med indicates median values from the stochastic projections.

Year	R.b	R.med	F.b	F.med	S.b	S.med	L.b(n)	L.med(n)	L.b(w)	L.med(w)	D.b(n)	D.med(n)	D.b(w)	D.med(w)	pr.reb
2022	71	55	3.235	2.381	2287	2972	452	420	534	487	1215	1625	432	598	0.002
2023	71	65	0.936	0.801	3403	3385	105	109	106	116	1458	1451	497	544	0.005
2024	71	75	0.936	0.801	5262	4240	135	122	130	127	2472	1885	885	723	0.029
2025	71	83	0.000	0.000	7079	5513	0	0	0	0	0	0	0	0	0.114
2026	71	90	0.000	0.000	9419	7589	0	0	0	0	0	0	0	0	0.278
2027	71	96	0.000	0.000	11418	9656	0	0	0	0	0	0	0	0	0.449
2028	71	99	0.000	0.000	13070	11667	0	0	0	0	0	0	0	0	0.603
2029	71	102	0.000	0.000	14408	13497	0	0	0	0	0	0	0	0	0.727
2030	71	105	0.000	0.000	15476	15152	0	0	0	0	0	0	0	0	0.814
2031	71	107	0.000	0.000	16319	16636	0	0	0	0	0	0	0	0	0.870
2032	71	108	0.000	0.000	16977	17905	0	0	0	0	0	0	0	0	0.907
2033	71	109	0.000	0.000	17487	19020	0	0	0	0	0	0	0	0	0.932
2034	71	111	0.000	0.000	17868	20011	0	0	0	0	0	0	0	0	0.949
2035	71	111	0.000	0.000	18148	20920	0	0	0	0	0	0	0	0	0.959
2036	71	112	0.000	0.000	18353	21605	0	0	0	0	0	0	0	0	0.966
2037	71	113	0.000	0.000	18503	22168	0	0	0	0	0	0	0	0	0.972
2038	71	114	0.000	0.000	18614	22633	0	0	0	0	0	0	0	0	0.975
2039	71	113	0.000	0.000	18694	22971	0	0	0	0	0	0	0	0	0.978

R0 $D_{current}$ F=0

Table 4. Projection results with fishing mortality rate fixed at $F_{\text{Landed}} = 0$ *and* $F_{\text{Discard}} = F_{\text{current}}$ *starting in 2025 and longterm recruitment starting in 2023. R = number of age-0 recruits (in millions), F = fishing mortality rate (per year), S = spawning stock (1000* lb*), L = landings and D = discards expressed in numbers (n, in 1000s) or whole weight (w, in 1000* lb*), pr.reb = proportion of stochastic projection replicates with* $\text{SSB} \geq \text{SSB}_{\text{F40\%}}$*. The extension* b *indicates expected values (deterministic) from the base run; the extension* med *indicates median values from the stochastic projections.*

Year	R.b	R.med	F.b	F.med	S.b	S.med	L.b(n)	L.med(n)	L.b(w)	L.med(w)	D.b(n)	D.med(n)	D.b(w)	D.med(w)	pr.reb
2022	71	115	3.235	2.352	2287	2986	452	422	534	489	1215	1626	432	566	0.002
2023	71	115	0.938	0.803	3534	4773	110	119	109	122	155	375	17	39	0.057
2024	71	114	0.938	0.803	5964	7837	174	171	161	166	170	404	23	51	0.321
2025	71	114	0.003	0.004	8322	10728	0	0	0	0	178	422	29	63	0.556
2026	71	115	0.003	0.004	10468	13302	0	0	0	0	184	435	34	73	0.727
2027	71	115	0.003	0.004	12253	15484	0	0	0	0	188	444	38	82	0.837
2028	71	114	0.003	0.004	13704	17340	0	0	0	0	190	448	41	89	0.901
2029	71	114	0.003	0.004	14866	18756	0	0	0	0	192	454	44	95	0.936
2030	71	114	0.003	0.004	15785	19932	0	0	0	0	193	453	46	100	0.954
2031	71	114	0.003	0.004	16504	20876	0	0	0	0	194	454	48	104	0.965
2032	71	114	0.003	0.004	17060	21559	0	0	0	0	195	456	49	106	0.972
2033	71	114	0.003	0.004	17485	22075	0	0	0	0	195	456	50	109	0.976
2034	71	114	0.003	0.004	17795	22503	0	0	0	0	195	457	51	111	0.979
2035	71	114	0.003	0.004	18022	22928	0	0	0	0	196	457	52	112	0.980
2036	71	114	0.003	0.004	18188	23226	0	0	0	0	196	458	52	114	0.981
2037	71	115	0.003	0.004	18309	23347	0	0	0	0	196	459	52	115	0.982
2038	71	115	0.003	0.004	18398	23528	0	0	0	0	196	463	53	115	0.982
2039	71	114	0.003	0.004	18463	23598	0	0	0	0	196	460	53	116	0.983

Rec-mu $D_{current}$ F=0

Table 5. Projection results with fishing mortality rate fixed at $F_{\text{Landed}} = 0$ *and* $F_{\text{Discard}} = F_{\text{current}}$ *starting in 2025 and recent average recruitment starting in 2023. R = number of age-0 recruits (in millions), F = fishing mortality rate (per year), S = spawning stock (1000* lb*), L = landings and D = discards expressed in numbers (n, in 1000s) or whole weight (w, in 1000* lb*), pr.reb = proportion of stochastic projection replicates with* $\text{SSB} \geq \text{SSB}_{\text{F40\%}}$*. The extension* b *indicates expected values (deterministic) from the base run; the extension* med *indicates median values from the stochastic projections.*

Year	R.b	R.med	F.b	F.med	S.b	S.med	L.b(n)	L.med(n)	L.b(w)	L.med(w)	D.b(n)	D.med(n)	D.b(w)	D.med(w)	pr.reb
2022	25	44	3.247	2.363	2276	2971	451	419	534	488	1215	1627	460	603	0.002
2023	25	43	0.938	0.803	2471	3371	106	114	107	120	60	159	9	21	0.007
2024	25	43	0.938	0.803	3152	4410	160	158	154	160	63	166	10	25	0.017
2025	25	43	0.003	0.004	3756	5349	0	0	0	0	64	170	12	29	0.032
2026	25	43	0.003	0.004	4355	6227	0	0	0	0	65	173	13	33	0.055
2027	25	43	0.003	0.004	4842	6961	0	0	0	0	66	176	15	35	0.081
2028	25	43	0.003	0.004	5230	7532	0	0	0	0	67	176	15	38	0.109
2029	25	43	0.003	0.004	5537	7988	0	0	0	0	67	178	16	40	0.140
2030	25	43	0.003	0.004	5777	8347	0	0	0	0	67	177	17	41	0.171
2031	25	43	0.003	0.004	5963	8627	0	0	0	0	68	178	17	43	0.197
2032	25	43	0.003	0.004	6102	8844	0	0	0	0	68	179	18	43	0.225
2033	25	43	0.003	0.004	6205	8988	0	0	0	0	68	178	18	44	0.247
2034	25	44	0.003	0.004	6280	9115	0	0	0	0	68	179	18	45	0.267
2035	25	43	0.003	0.004	6335	9215	0	0	0	0	68	178	18	45	0.279
2036	25	43	0.003	0.004	6375	9292	0	0	0	0	68	179	18	45	0.293
2037	25	43	0.003	0.004	6404	9330	0	0	0	0	68	178	18	46	0.299
2038	25	44	0.003	0.004	6426	9368	0	0	0	0	68	179	18	46	0.308
2039	25	43	0.003	0.004	6441	9397	0	0	0	0	68	179	18	46	0.312

AR $D_{current}$ F=0

Table 8. Projection results with fishing mortality rate fixed at $F_{\text{Landed}} = 0$ *and* $F_{\text{Discard}} = F_{\text{current}}$ *with autocorrelated recruitment starting in 2025 and autocorrelated deviates around the long-term average recruitment starting in 2023. R = number of age-0 recruits (in millions), F = fishing mortality rate (per year), S = spawning stock (1000* lb*), L = landings and D = discards expressed in numbers (n, in 1000s) or whole weight (w, in 1000* lb*), pr.reb = proportion of stochastic projection replicates with* $\text{SSB} \geq \text{SSB}_{\text{F40\%}}$*. The extension* b *indicates expected values (deterministic) from the base run; the extension* med *indicates median values from the stochastic projections.*

Year	R.b	R.med	F.b	F.med	S.b	S.med	L.b(n)	L.med(n)	L.b(w)	L.med(w)	D.b(n)	D.med(n)	D.b(w)	D.med(w)	pr.reb
2022	71	55	3.235	2.389	2287	2973	452	421	534	488	1215	1621	432	595	0.002
2023	71	65	0.936	0.801	3403	3386	105	109	106	116	1458	1453	497	544	0.005
2024	71	75	0.936	0.801	5262	4246	135	122	130	127	2472	1886	885	723	0.029
2025	71	83	0.380	0.403	6710	5216	0	0	0	0	3174	2308	1299	912	0.101
2026	71	90	0.380	0.403	7730	6234	0	0	0	0	3336	2687	1433	1079	0.194
2027	71	96	0.380	0.403	8485	7233	0	0	0	0	3360	3012	1459	1231	0.278
2028	71	99	0.380	0.403	9081	8092	0	0	0	0	3363	3269	1462	1352	0.350
2029	71	102	0.380	0.403	9557	8868	0	0	0	0	3363	3477	1462	1447	0.412
2030	71	105	0.380	0.403	9935	9546	0	0	0	0	3363	3666	1462	1531	0.463
2031	71	107	0.380	0.403	10230	10124	0	0	0	0	3363	3798	1462	1598	0.503
2032	71	108	0.380	0.403	10459	10690	0	0	0	0	3363	3891	1462	1637	0.537
2033	71	109	0.380	0.403	10634	11162	0	0	0	0	3363	3960	1462	1670	0.566
2034	71	111	0.380	0.403	10763	11510	0	0	0	0	3363	4039	1462	1701	0.587
2035	71	111	0.380	0.403	10857	11814	0	0	0	0	3363	4079	1462	1732	0.602
2036	71	112	0.380	0.403	10926	12055	0	0	0	0	3363	4139	1462	1755	0.617
2037	71	113	0.380	0.403	10976	12298	0	0	0	0	3363	4164	1462	1773	0.630
2038	71	114	0.380	0.403	11013	12488	0	0	0	0	3363	4175	1462	1776	0.643
2039	71	113	0.380	0.403	11041	12599	0	0	0	0	3363	4207	1462	1785	0.653

R0 $D_{current}$ $F_{R65\%}$

Table 7. Projection results with fishing mortality rate fixed at $F_{\text{Landed}} = F_{\text{Rebuild65\%}}$ *and* $F_{\text{Discard}} = F_{\text{current}}$ *starting in 2025 and longterm recruitment starting in 2023. R = number of age-0 recruits (in millions), F = fishing mortality rate (per year), S = spawning stock (1000* lb*), L = landings and D = discards expressed in numbers (n, in 1000s) or whole weight (w, in 1000* lb*), pr.reb = proportion of stochastic projection replicates with* $\text{SSB} \geq \text{SSB}_{\text{F40\%}}$*. The extension* b *indicates expected values (deterministic) from the base run; the extension* med *indicates median values from the stochastic projections.*

Year	R.b	R.med	F.b	F.med	S.b	S.med	L.b(n)	L.med(n)	L.b(w)	L.med(w)	D.b(n)	D.med(n)	D.b(w)	D.med(w)	pr.reb
2022	71	116	3.235	2.330	2287	2988	452	422	534	489	1215	1618	432	560	0.002
2023	71	115	0.936	0.801	3403	4656	105	112	106	119	1458	1912	497	624	0.080
2024	71	114	0.936	0.801	5262	7176	135	133	130	132	2472	3291	885	1155	0.286
2025	71	116	0.389	0.659	6685	9003	88	109	82	102	3168	4255	1295	1701	0.444
2026	71	114	0.389	0.659	7618	10118	149	179	146	171	3324	4459	1424	1870	0.525
2027	71	115	0.389	0.659	8238	10807	222	262	232	265	3345	4486	1447	1894	0.578
2028	71	114	0.389	0.659	8641	11260	302	350	341	381	3347	4489	1449	1904	0.610
2029	71	115	0.389	0.659	8873	11438	350	398	416	456	3347	4483	1449	1895	0.629
2030	71	114	0.389	0.659	8999	11579	374	423	457	497	3347	4488	1449	1902	0.639
2031	71	115	0.389	0.659	9066	11618	386	433	479	519	3347	4475	1449	1894	0.645
2032	71	116	0.389	0.659	9101	11626	391	440	491	530	3347	4464	1449	1893	0.646
2033	71	115	0.389	0.659	9120	11700	394	445	497	537	3347	4457	1449	1894	0.647
2034	71	115	0.389	0.659	9129	11704	396	444	500	539	3347	4462	1449	1888	0.650
2035	71	115	0.389	0.659	9133	11745	396	443	502	543	3347	4480	1449	1903	0.649
2036	71	115	0.389	0.659	9136	11685	397	445	503	543	3347	4464	1449	1897	0.652
2037	71	115	0.389	0.659	9137	11719	397	446	503	545	3347	4486	1449	1904	0.653
2038	71	115	0.389	0.659	9137	11723	397	445	503	546	3347	4462	1449	1889	0.652
2039	71	114	0.389	0.659	9138	11774	397	445	503	546	3347	4490	1449	1895	0.654

RO $D_{current}$ $F_{R70\%}$

Table 8. Projection results with fishing mortality rate fixed at $F_{\text{Landed}} = F_{\text{Rebuild70\%}}$ *and* $F_{\text{Discard}} = F_{\text{current}}$ *starting in 2025 and longterm recruitment starting in 2023. R = number of age-0 recruits (in millions), F = fishing mortality rate (per year), S = spawning stock (1000* lb*), L = landings and D = discards expressed in numbers (n, in 1000s) or whole weight (w, in 1000* lb*), pr.reb = proportion of stochastic projection replicates with* $\text{SSB} \geq \text{SSB}_{\text{F40\%}}$*. The extension* b *indicates expected values (deterministic) from the base run; the extension* med *indicates median values from the stochastic projections.*

Year	R.b	R.med	F.b	F.med	S.b	S.med	L.b(n)	L.med(n)	L.b(w)	L.med(w)	D.b(n)	D.med(n)	D.b(w)	D.med(w)	pr.reb
2022	71	116	3.235	2.355	2287	2986	452	422	534	488	1215	1617	432	561	0.002
2023	71	115	0.936	0.801	3403	4661	105	113	106	118	1458	1913	497	623	0.080
2024	71	114	0.936	0.801	5262	7180	135	133	130	133	2472	3288	885	1154	0.286
2025	71	116	0.383	0.474	6700	9022	36	45	34	42	3172	4258	1298	1706	0.446
2026	71	114	0.383	0.474	7683	10215	63	76	64	75	3331	4470	1429	1879	0.533
2027	71	115	0.383	0.474	8378	10990	98	116	106	121	3354	4500	1454	1906	0.590
2028	71	114	0.383	0.474	8883	11541	139	161	163	183	3356	4505	1456	1917	0.628
2029	71	115	0.383	0.474	9238	11852	169	193	210	231	3356	4497	1457	1906	0.654
2030	71	114	0.383	0.474	9480	12116	188	212	243	265	3356	4501	1457	1914	0.671
2031	71	115	0.383	0.474	9643	12240	199	223	265	288	3356	4491	1457	1906	0.681
2032	71	116	0.383	0.474	9751	12338	206	231	280	301	3356	4482	1457	1904	0.691
2033	71	115	0.383	0.474	9823	12467	211	235	290	311	3356	4473	1457	1907	0.695
2034	71	115	0.383	0.474	9868	12478	214	237	296	316	3356	4477	1457	1900	0.700
2035	71	115	0.383	0.474	9896	12548	215	239	300	320	3356	4495	1457	1915	0.705
2036	71	115	0.383	0.474	9914	12516	217	240	302	322	3356	4480	1457	1909	0.706
2037	71	115	0.383	0.474	9925	12569	217	241	304	323	3356	4503	1457	1916	0.710
2038	71	115	0.383	0.474	9932	12582	218	241	305	326	3356	4480	1457	1902	0.709
2039	71	114	0.383	0.474	9936	12607	218	240	305	327	3356	4504	1457	1909	0.712