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Increase options in the Jack Mackerel Risk Table

Chile



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Abstract

The fast recovery of the jack mackerel stock and the application of a catch stabilator has produced an important increase in the difference between the catch quota and the catch at MSY. The quota stabilator was introduced when the stock was overexploited, but now the stock is in a very good condition. Every year the SC informs the Commission the catch options in a risk catch table that is based on different fixed fishing mortality projections. So far, the highest stabilator included in the table is +20% of previous quota. Given the good stock status was important to explore the impact of increasing the stabilator upper limit. As an exercise, projections with stabilator of +50%, +75% and +100% were conducted using the same program, codes and R scripts used during the SC11. The +100% stabilator produced a 2024 catch that was 44% of the catch with FMSY, and a high probability (0.88) that SSB will be greater than SSBMSY in the year 2033. Therefore, the additional projections showed that there is room to increase the upper limit of the stabilator under a precautionary approach.

1. Background

Ten years ago, in year 2014, the SC2 estimated that the CJM stock was in an overexploited status, with a spawning stock biomass (SSB) below SSBMSY, and in a 10-year-period of low recruitments (Figure 1). Therefore, the commission in year 2025 recommended a recovery HCR (Table 1).

Four years later, in year 2019, the SC7 estimated that the CJM stock was recovered, SSB was reached SSBMSY after a 4-year period of high recruitments (Figure 2). Then the commission in the year 2020 introduced in the HCR the catch quota stabilator, that limited the quota change to a range of $\pm 15\%$ of the previous catch quota.

The SC10 estimated that the CJM stock was in good conditions in year 2022, SSB was greater than SSBMSY and F was lower than FMSY (Figure 3). The commission in the year 2023 increased the upper limit of the catch stabilator from 15% to 20%.

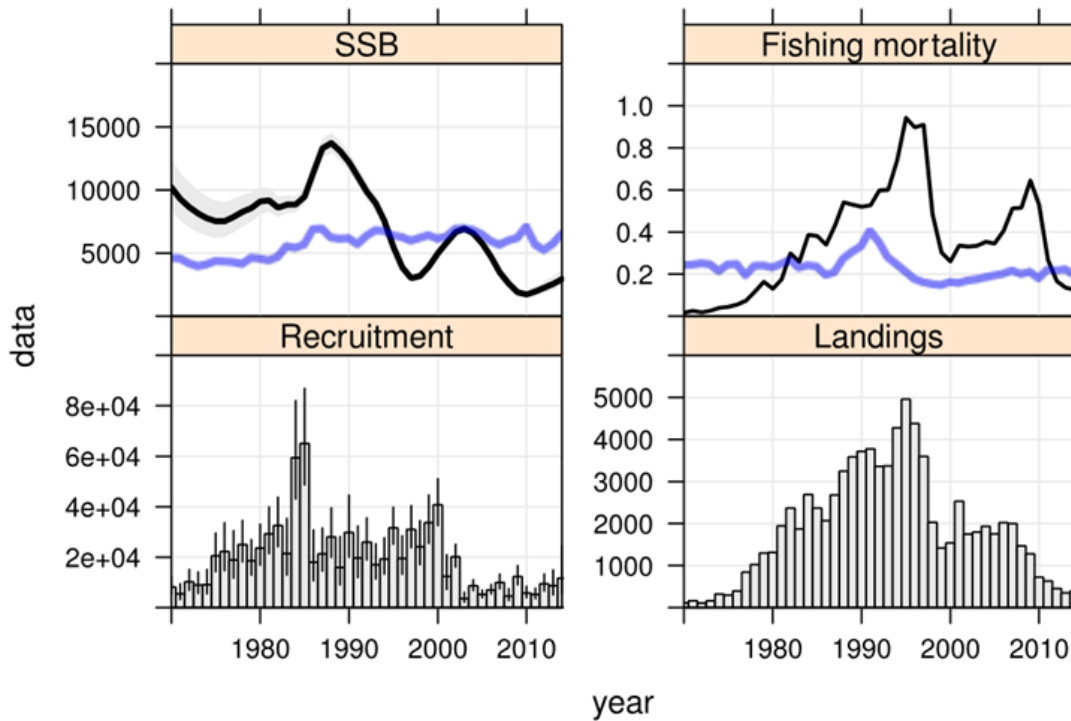


Figure 1. SC2 estimates up to year 2014 of biomass (kt; top left), recruitment at age 1 (millions; lower left), total fishing mortality (top right), and total catch (kt; bottom right). The blue lines are the SSBMSY and FMSY.

Table 1. Recovery HCR set in year 2014

The Commission recommends the default HCR have the following set of conditions to allow for future fishing opportunities:

Stock status	TAC calculation method
$SSB_t \leq 80\%$ of B_{MSY} (or proxy)	1) Compute yield (C_{trial}) at estimated F_{2013} or F_{MSY} (whichever is smaller) <i>If $C_{trial} < C_{replacement}$</i> Set catch at or below C_{trial} <i>(the stock will increase)</i> <i>Else if $C_{trial} > C_{replacement}$</i> Set catch at or below $C_{replacement}$ <i>(the stock remains stable)</i>
	2) Compute yield (C_{trial}) at estimated F_{MSY} (or proxy) <i>If $C_{trial} < C_{replacement}$</i> Set catch at or below C_{trial} <i>(the stock will increase)</i> <i>Else if $C_{trial} > C_{replacement}$</i> Use method 1)
$SSB_t > B_{MSY}$ (or proxy)	3) Set catch at or below value based on F_{MSY}

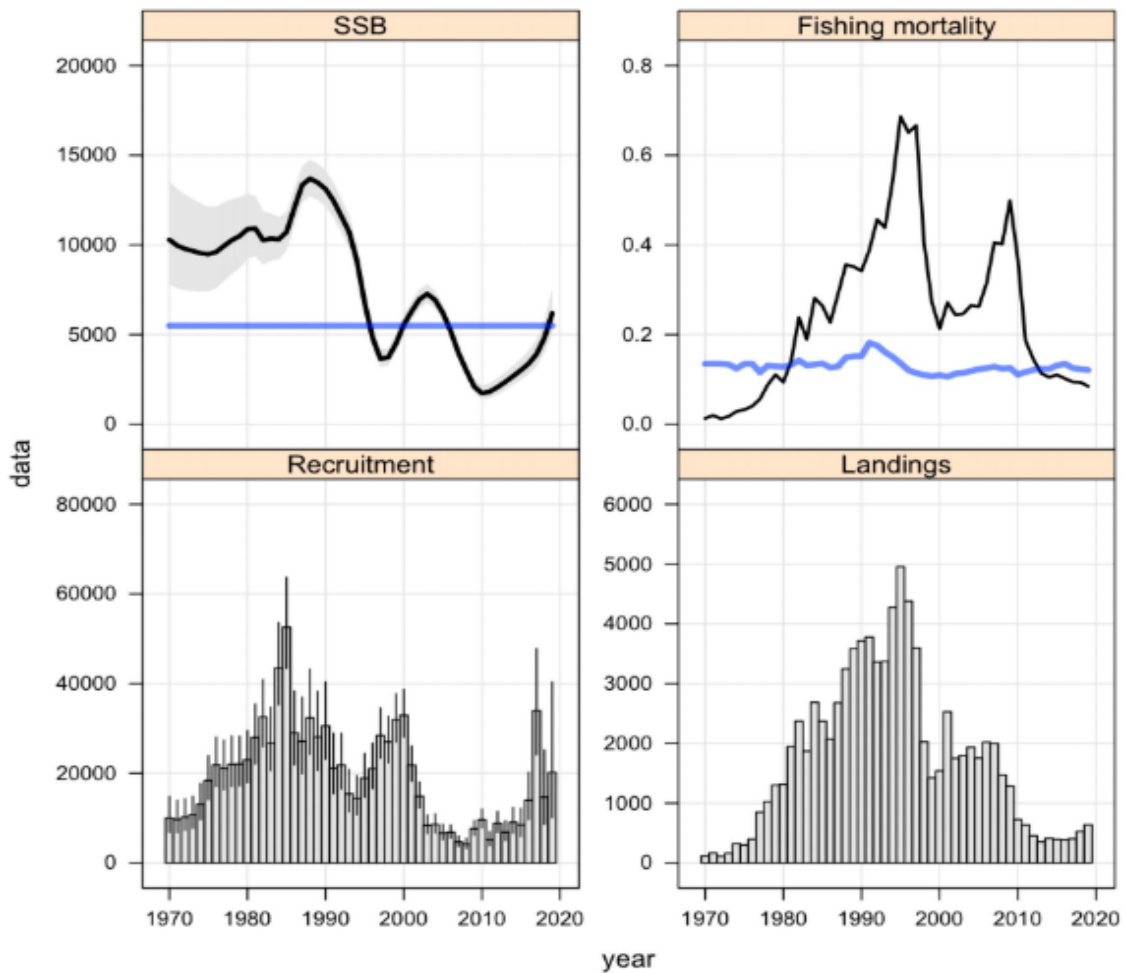


Figure 2. SC7 estimates up to year 2019 of biomass (kt; top left), recruitment at age 1 (millions; lower left), total fishing mortality (top right), and total catch (kt; bottom right). The blue lines represent the provisional SSB_{MSY} and the dynamic estimates of FMSY.

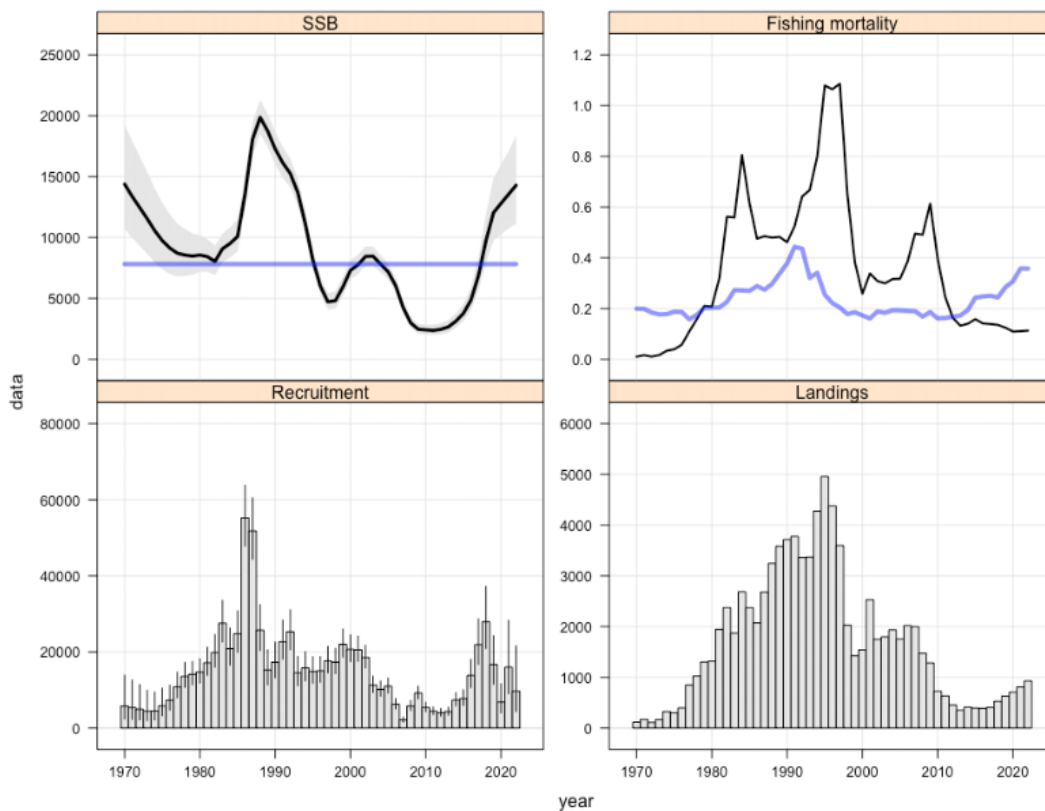


Figure 3. SC10 estimates up to year 2022 of biomass (kt; top left), recruitment at age 1 (millions; lower left), total fishing mortality (top right), and total catch (kt; bottom right). The blue lines represent the average SSBMSY over the most recent ten years (upper left) and the dynamic estimates of FMSY (upper left).

The SC11 confirmed that the CJM stock was in a very good condition in year 2023, SSB was much greater than BMSY and F was much lower than FMSY (Figure 4). The commission in the year 2024 applied the 15% of stabilator.

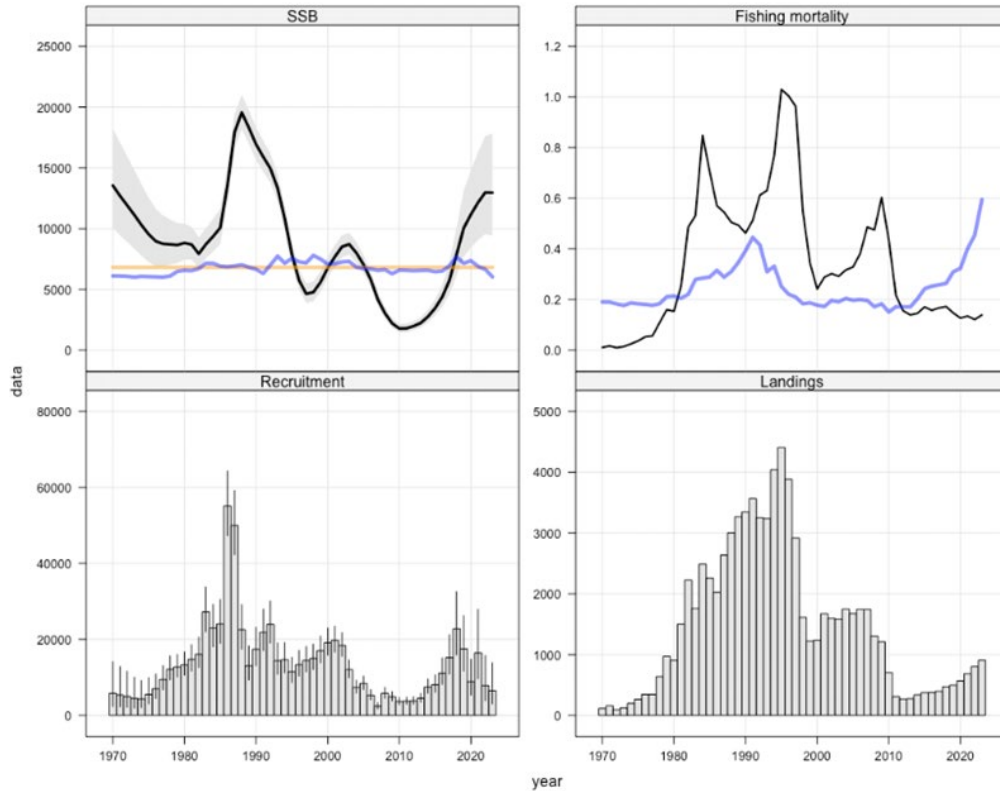


Figure 4. SC11 estimates up to year 2023 of biomass (kt; top left), recruitment at age 1 (millions; lower left), total fishing mortality (top right), and total catch (kt; bottom right). The blue lines represent the dynamic estimates of SSBMSY (upper left) and of FMSY (upper right). The orange line represents the average SSBMSY over the most recent ten years

The fast recovery of the stock and the application of the catch quota stabilator has produced an important increase in the difference between the catch quota and the catch at MSY. Because the quota stabilator was introduced in the HCR when the jack mackerel stock was overexploited, and nowadays the stock is a very good condition (SSB well above SSBMSY, and F well below FMSY), it seems reasonable to explore the impact of increasing the F options traditionally presented in the catch risk table. The risk table shows short and medium projections of the stock under different fixed fishing mortalities.

2. Aim

To expand the fishing mortality options in the jack mackerel risk table.



3. Method

3.1 Validation of the codes to replicate the risk table estimated during the SC11.

The projection codes available in the “github” of the JMWG were reviewed and run to replicate the projection risk table reported in Annex 7 of the SC11 report in Table A10.37 (Table 1).

Table 1. Risk table in Annex 7 of the SC11 report.

Table A10.37. Summary results for the short, medium, and long-term predictions for Model *h1_1.07.1s* (single-stock hypothesis, low steepness, short time series). Note that “B” in all cases represents thousands of tonnes of spawning stock biomass, “P” represents probability as a percentage and B_{MSY} is taken to be the average B_{MSY} estimated over the last ten years.

F	B ₂₀₂₅	P(B ₂₀₂₅ >B _{MSY})	B ₂₀₂₉	P(B ₂₀₂₉ >B _{MSY})	B ₂₀₃₃	P(B ₂₀₃₃ >B _{MSY})	Catch 2024 (kt)	Catch 2025 (kt)
0	17758	100	17851	100	16774	100	0	0
0.75 x F ₂₀₂₃	15938	100	12768	100	11369	97	974	1100
1 x F ₂₀₂₃	15402	100	11692	99	10401	95	1282	1406
1.25 x F ₂₀₂₃	14895	100	10804	98	9629	93	1581	1685
F _{MSY}	10167	100	5790	58	5166	44	4934	3823
F _{TAC2023}	15752	100	12377	100	11013	96	1080	1207
1.15 x F _{TAC2023}	15470	100	11821	99	10515	95	1242	1367
1.2 x F _{TAC2023}	15377	100	11646	99	10361	95	1296	1419

3.2 Adaptation of the codes to incorporate alternative F multipliers.

a. F multipliers (F_{mult}) of F₂₀₂₃.

The F multipliers are located inside the ADMB code of the JJM program, therefore, the code was modified and then compiled. The new F multipliers incorporated were 1.5 and 2.0, so the F were denominated as 1.5x F₂₀₂₃ and 2.0x F₂₀₂₃. The R script “run_projections_tac.R” available in the “github” of the JMWG was modified to estimate the risk table and the plots.

b. F multipliers of F that produce the TAC₂₀₂₃.

The R script “run_projections_tac.R” available in the “github” were modified to execute the JJM program with different catch quotas; , to estimate the risk table, and the plots. Alternative 2024 catches were calculated as 1.5, 1.75, and 2.0 times FTAC₂₀₂₃, and labeled as 1.5xFTAC₂₀₂₃, 1.75xFTAC₂₀₂₃, and 2.0xFTAC₂₀₂₃.



4. Results

4.1 Validation of the codes.

The modified and compiled codes were able to replicate the Table A10.37 in the Annex 7 of the SC11 report (Table 2).

Table 2. Risk table in Annex 7 of the SC11 report replicated with adapted codes.

F	B2025	P(B2025>BMSY)	B2029	P(B2029>BMSY)	B2033	P(B2033>BMSY)	Catch (kt)	
							2024	2025
0	17758	100	17851	100	16774	100	0	0
0.75x F2023	15938	100	12768	100	11369	97	974	1100
1x F2023	15402	100	11692	99	10401	95	1282	1406
1.25x F2023	14895	100	10804	98	9629	93	1581	1685
FMSY	10167	100	5790	58	5166	44	4934	3823
FTAC2023	15752	100	12377	100	11013	96	1080	1207
1.15x FTAC2023	15470	100	11821	99	10515	95	1242	1367
1.2x FTAC2023	15377	100	11646	99	10361	95	1296	1419

4.2 Risk table with additional F multipliers.

The additional F multipliers were included as complementary rows in the risk table (Table 3) and the catch projections in figure 1.

Table 3. Risk table with additional F multipliers. Additional F multipliers are highlighted in green color.

F	B2025	P(B2025>BMSY)	B2029	P(B2029>BMSY)	B2033	P(B2033>BMSY)	Catch (kt)	
							2024	2025
0	17758	100	17851	100	16774	100	0	0
0.75 x F2023	15938	100	12768	100	11369	97	974	1100
1 x F2023	15402	100	11692	99	10401	95	1282	1406
1.25 x F2023	14895	100	10804	98	9629	93	1581	1685
1.5 x F2023	14417	100	10062	97	8992	90	1873	1941
2.0 x F2023	13537	100	8891	93	7988	85	2434	2392
FMSY	10167	100	5790	58	5166	44	4934	3823
FTAC2023	15752	100	12377	100	11013	96	1080	1207
1.15 x FTAC2023	15470	100	11821	99	10515	95	1242	1367
1.2 x FTAC2023	15377	100	11646	99	10361	95	1296	1419
1.5 x FTAC2023	14831	100	10699	98	9538	93	1620	1720
1.75x FTAC2023	14389	100	10021	97	8957	90	1890	1956
2.0 x FTAC2023	13960	100	9425	95	8447	88	2160	2179

The 2024 catch projected with FMSY was 4934 kt, and quickly fell in the projections, quite similar to the maximum historical catch (Figure 1). The highest 2024 catch projected with the new F multipliers was 2434 kt (49% of C_{FMSY}), which was projected with $2.0 \times F_{2023}$, while the lowest catch was 1620 kt (33% of C_{FMSY}), projected with $1.5 \times FTAC_{2023}$ (Table 1). The 2024 catch projected with the highest stabilator, $2.0 \times FTAC_{2023}$, was 2160 kt (44% of C_{FMSY}). In all new F multipliers, the 2024 catches were about the 2025 catches, especially with $2.0 \times FTAC_{2023}$ (+200% stabilator).

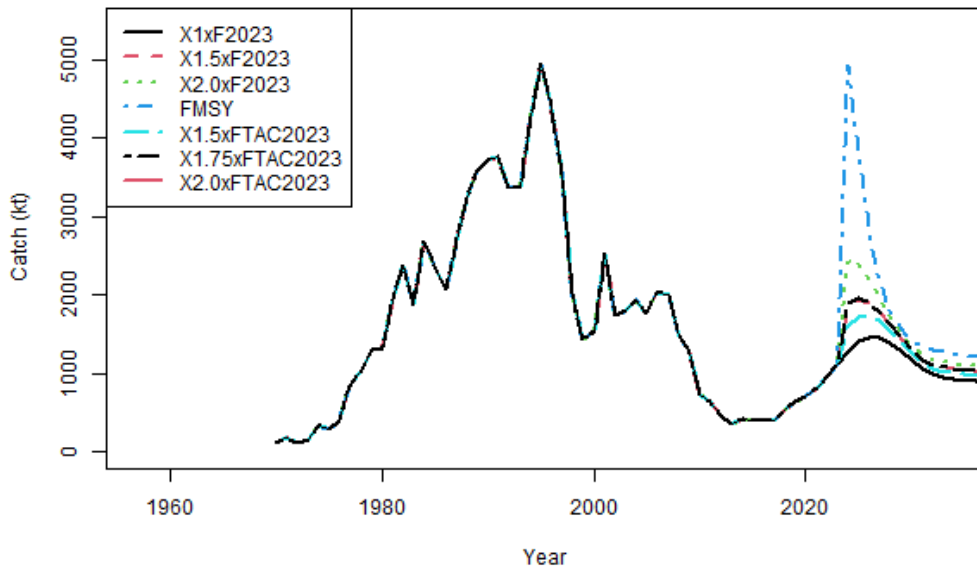


Figure 1. Historical catches and future catch projected with different constant fishing mortalities.

The 2024 SSB was the second highest spawning biomass in the history and similar to initial spawning biomass, and seems to be the end of the last biomass recovery period (Figure 2). The projected SSB decreasing rate increased with F multipliers, the highest decrease was projected with FMSY, which reduced the biomass to the MSY level in a few years, while all others F multipliers projected biomass well above the BMSY. Consequently, all the F multipliers had a probability (express in percentage) of 100% that $B > BMSY$ in 2025, and all, except FMSY, had very high probabilities ($\geq 88\%$) of $B > BMSY$ until 2033. The 44% probability of $B > BMSY$ projected with FMSY for year 2033 is because the mean of projected biomass should be close to the BMSY (Figure 3). The 88% probability of $B < BMSY$ projected with $2.0 \times FTAC_{2023}$ (+200% stabilator) for year 2033 is because the mean of the B projected was well above BMSY (Figure 4).

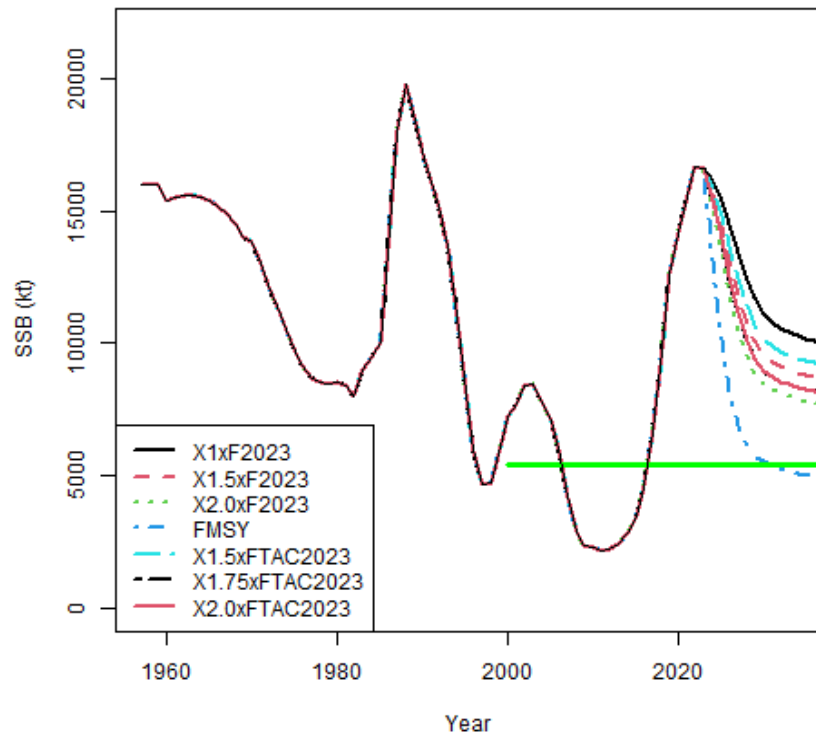


Figure 2. Historical spawning biomass and future spawning biomass projected with with different constant fishing mortalities. The green line represented the SSBMSY.

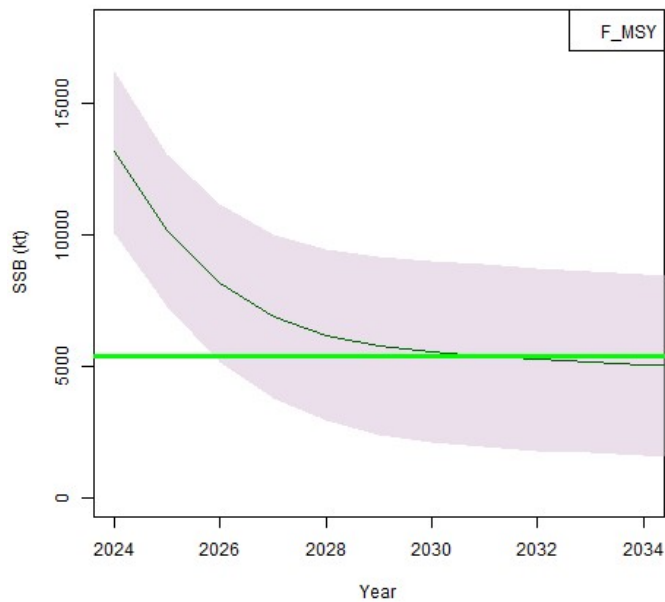


Figure 3. Future spawning biomass projected with FMSY. The purple area is the with 95%CI, and the green line is the SSBMSY.

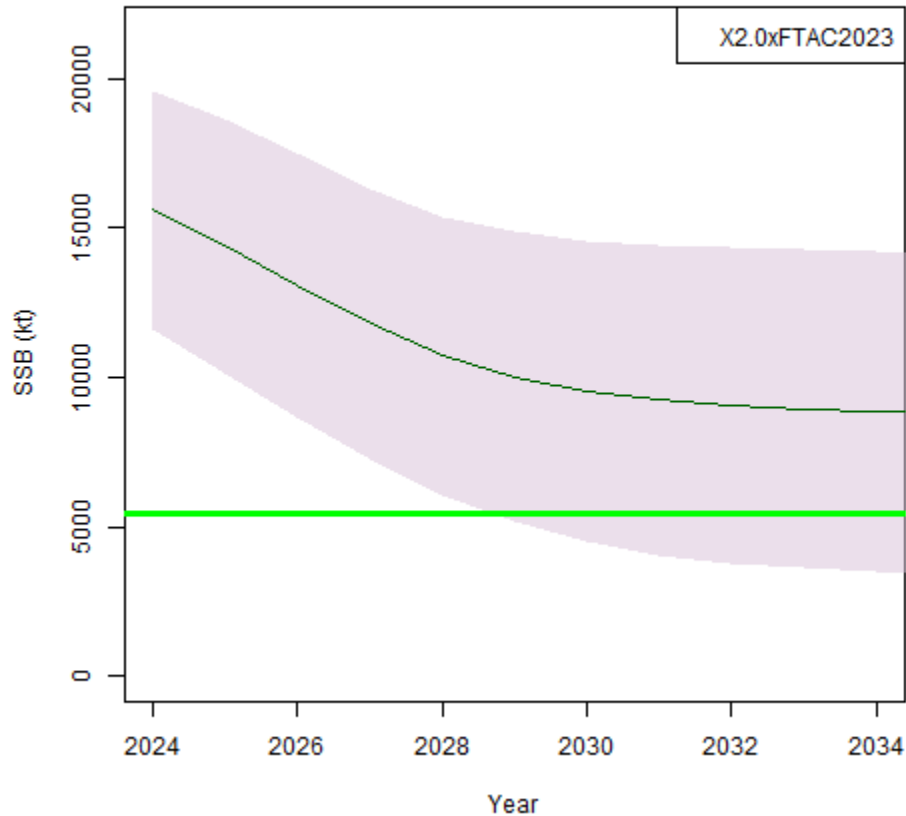


Figure 4. Future spawning biomass projected with a F that duplicates the 2023 catch quota. The purple area is the with 95%CI, and the green line is the SSBMSY.

5. Discussion

All new calculations were done using the same programs (ADMB codes, R scripts) that were used by the JMWG in SC11, and had the same model configurations described in the annex 7 of the SC11 report, therefore are fully comparable with risk table Table A10.37. in the annex 7. The projections were done under the low productivity scenario, as it was agreed in the benchmark 2022, this projects low recruitment level which is precautionary but the BMSY is low, 5 million tons, compare with 8 million used in the Kobe plot, and therefore all projections are optimistic in terms of probability of $B > BMSY$.



6. Conclusions.

- 1) The additional projections showed room to increase the upper limit of the stabilator under a precautionary approach.
- 2) The highest F multiplier, 2.0xFTAC2023, projected a 2024 catch that was 44% of the 2024 catch at FMSY, and projected a high probability that $B > BMSY$ for the year 2033.

7. Reference

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