9.2.3.1 EU, Norway, and the Faroe Islands request to ICES to evaluate a multi-annual management strategy for mackerel (*Scomber scombrus*) in the Northeast Atlantic

Advice Summary

ICES advises on revised reference points for Northeast Atlantic (NEA) mackerel (point 1 in the request): B_{lim} should remain unchanged at 1.84 million t, F_{MSY} should be revised to 0.22, MSY $B_{trigger}$ and B_{pa} revised to 3.0 million t, F_{lim} revised to 0.36, and F_{pa} revised to 0.25.

ICES also advises that the proposed management plan is considered precautionary (points 2 and 3 in the request) if F_{target} is equal to or less than 0.22, assuming a $B_{trigger}$ of 2.2 million t. This would also ensure high long-term yield. Other options with higher target Fs and a higher trigger biomass are considered precautionary and would maximize short-term yields, ensure high long-term yields, but would also increase the interannual variations of the TACs and result in a smaller stock.

ICES advises that the inclusion of a 10% interannual quota flexibility (point 4 in the request) would have insignificant effects on precautionary considerations.

ICES advises that the implementation of a TAC variation limit of 20% is precautionary, but that its effectiveness is greatly reduced if a 10% deviation constraint on F_{bar} is applied simultaneously (point 5 in the request).

Request

COASTAL STATES REQUEST TO ICES ON THE LONG TERM MANAGEMENT PLAN FOR MACKEREL

In order for the Parties to develop a revised management plan for mackerel on which to base the appropriate fishing levels in the years 2015 to 2018, ICES is requested to:

1. Evaluate new biological reference points for the North East Atlantic mackerel stock based on the revised (WKPELA 2014) mackerel assessment method.
2. Evaluate the alternative fishing mortalities corresponding to Fmsy, 0.20, 0.25, 0.30 and 0.35 for appropriate age groups as defined by ICES.
3. Each alternative should be assessed in relation to how it performs with respect to stock development in the short, medium and the long term and the level of uncertainty in the stock assessment, inter annual TAC variability, long term yield, as well as in relation to the precautionary approach.
4. Each alternative shall be evaluated with an annual quota flexibility of 10%.
5. Each alternative shall also be assessed with a stability clause where the TAC shall not deviate by more than 20% from the TAC of the preceding year, but the F shall not deviate by more than 10% from the target F.

Elaboration on Advice

The Northeast Atlantic (NEA) mackerel stock is currently characterized by low weight-at-age, late maturity, and early spawning compared to the historical mean. There is no scientific basis to indicate whether this situation should be considered permanent or transient (either returning to the previous state or continuing change in the same direction). ICES provides MSY and management plan advice, taking into account selectivity, recruitment, growth, and natural mortality under recent ecosystem conditions (ICES, 2014a – Section 1.2). Consequently, the following advice is based on the recent stock dynamics. Other scenarios are documented in ICES (2015). Because the long-term dynamics of the stocks are not clear, ICES advises that the management strategy selected should be re-evaluated in about four years and revised if necessary.

Evaluation of the biological reference points

ICES evaluated the reference points and concluded that B_{lim}, which is based on the full historical time-series (ICES, 2014b), should remain unchanged. ICES advises that B_{pa} should be set at 3.0 million t, based on the standard ICES procedure (ICES, 2003) and the recent perception of the uncertainty associated with the assessment (ICES, 2015 – Section 5.2). It is acknowledged that this value is uncertain, but it is considered the best value currently available. Stochastic simulations (Figure 9.2.3.1.1; ICES, 2015) were also used to update the following values:

- F_{lim} associated with B_{lim}, estimated at 0.36.
- F_{pa} associated with B_{pa}, estimated at 0.25.
- F_{MSY} estimated at 0.22.

In order to determine a value for MSY $B_{trigger}$, stochastic simulations were run showing that the expected range of SSB when fishing at F_{MSY} extended below B_{pa}. This indicated that there were potential values for MSY $B_{trigger}$ below B_{pa}. Following the ICES procedure which sets a minimum for MSY $B_{trigger}$ at B_{pa}, MSY $B_{trigger}$ was set equal to B_{pa}. It should be noted that in the context of the management plan evaluations, biomass trigger values do not require to be constrained by B_{pa} for the plan to be precautionary.

Long-term management plan

ICES evaluated the target fishing mortality values in the range of 0.15 to 0.35, which is a wider range than specified in the request (F_{MSY}: 0.20, 0.25, 0.30, and 0.35). These were used in combination with $B_{trigger}$ values in the range of 2.0–3.2 million tonnes, including the 2.2 million t of the current management plan. All scenarios were tested with the combined 20% limit on interannual variation of the TAC and a limit of 10% deviation from the target F (Figure 9.2.3.1.2 and Tables 9.2.3.1.1–3). The effect of the interannual quota flexibility rule was evaluated separately.

With current mackerel biology characteristics (low individual weight-at-age, late maturity, and early spawning) and with the current $B_{trigger}$ of 2.2 million tonnes, only the F_{target} values of up to 0.22 (F_{MSY}) were found to be precautionary and showed little difference in yield (4% in the short term and no difference in the long term compared to an F_{target} of 0.20) and mean SSB (2% in the short term and 8% in the long term compared to an F_{target} of 0.20) (Figure 9.2.3.1.2 and Table 9.2.3.1.1).

ICES identified the combinations of F and $B_{trigger}$ that would maximize the long-term yield and be precautionary (i.e. a less than 5% probability of SSB falling below B_{lim}; Table 9.2.3.1.2). Combinations of $B_{trigger}$ values at 2.0–3.2 million tonnes and F_{target} at 0.20–0.25 are precautionary and ensure maximum long-term yields. Increasing F_{target} jointly with $B_{trigger}$ generally leads to similar long-term yields and a small gain (6%) in the short-term yields, but results in a highly increased TAC variability (27% to 40%) and a smaller stock size (Table 9.2.3.1.3).

Additional scenarios were tested with the 20% limit on interannual TAC variation and without the F constraint, and this reduces the probability of SSB< B_{lim} in the long term in precautionary scenarios. This clause stabilizes the TAC, but induces a loss in yields in the medium term. Implementing the limit of 10% deviation from the target F overrides the effect of the TAC constraint and increases the probability of SSB < B_{lim} and the interannual variability of TAC (Figure 9.2.3.1.3).

A wide range of quota flexibility combinations were tested and most were found to be precautionary. The scheme can lead to a slightly increased probability of SSB< B_{lim} when used to constantly bank 10% of the TAC for 40 years and for the whole fleet, i.e. the worst-case scenario.

Suggestions

For this management situation a TAC deviation constraint at 20% and an F target deviation constraint of ±10% can operate in conflict. The uncertainty in the mackerel assessment results in variable estimates of F which, if used directly, give considerable variability in the catch advice. This variability is dampened by the 20% TAC constraint. The subsequent 10% F deviation constraint often overrides this and forces the TAC to follow the estimated F more closely, re-introducing much of the estimation variability back into the TAC. If managers are looking for a management regime where the perceived F in the advice is close to the overall target F, the 10% F constraint will deliver this result. In contrast, if the objective is to obtain more stable high long-term yields with slightly lower probability of SSB< B_{lim} the 20% TAC constrain alone will perform better. If the desire is to constrain the F deviation and to moderate TAC variability, a less restrictive F deviation constraint of e.g. 20% could be a better compromise.

Basis of the advice

Background

The current management plan for the NEA mackerel was agreed between Norway, Faroe Islands, and the EU in October 2008, and used to provide the ICES advice from 2009 onwards. This management plan was evaluated by ICES in 2007 (ICES, 2008) and found to be precautionary.

A new assessment method was adopted at the mackerel benchmark assessment in 2014 (ICES, 2014b), which led to a substantial revision of the perception of the NEA mackerel stock and of the MSY reference points. The F_{MSY} was updated by ICES in 2014 to F = 0.25. ICES concluded at the time that the management plan could still be used as the basis for advice as it was still considered precautionary, but that its implementation may no longer result in a maximization of the yield in the long term; ICES thus recommenced an evaluation of this plan (ICES, 2014a).

The Coastal States for the management of the NEA mackerel presented in September 2014 a request to ICES for an evaluation of the biological reference points and of the management strategy fishing mortality target. This request was dealt with by WKMACLTMP (ICES Workshop on the NEA Mackerel Long-Term Management Plan) which met twice (in June and in November 2014) and also worked by correspondence.

Results and conclusions

ICES performed stochastic simulations for a wide range of settings to test whether the proposed long-term management strategy (LTMS) is in accordance with the precautionary approach and whether it could produce high long-term yield. Simulation results are presented for the short term (2014–2018), the medium term (2019–2028), and the long term (2029–2050). The results of the simulations should be used for comparison between scenarios and not as forecasts of absolute quantities.

Evaluation of biological reference points

The value for B_{lim} of 1.84 million t, established by ICES (2014b) was considered to be still appropriate. The value for B_{pa} of 2.36 million t, established by ICES (2014b) was, however, considered to be inappropriate. The calculation of the previous value was based on an estimate of the uncertainty in SSB in the terminal year of the assessment of a CV = 0.15. After careful consideration of the uncertainty in the mackerel assessment, ICES (2015) concluded that the value CV = 0.15, representing the uncertainty estimated by the assessment model SAM, was an underestimate of overall uncertainty in SSB, as other sources of uncertainty (related for instance to the process error implemented in SAM) were not included in this estimate. ICES (2015) estimated that a CV of 0.30 would be a more realistic estimate of uncertainy in SSB. It is acknowledged that this value is uncertain, but it is considered to be the best value currently available and this value has therefore been used to calculate B_{pa} from B_{lim}. ICES advises that B_{pa} should be set at 3.0 million t, based on the standard ICES procedure (ICES, 2003). F_{pa} was calculated on the basis of B_{pa}. During the benchmark assessment in 2014, F_{MSY} for mackerel was estimated at F = 0.25 using a 10-year average mean weight-at-age. Updated long-term equilibrium simulations based on the current state of the mackerel biology (a 3-year reference period of biological data and a revised assessment with updated values of SSB and recruitment) indicated that the long-term yields are now maximized for F = 0.22 (Figure 9.2.3.1.1). The shorter reference period of three years was chosen because it reflects the current situation, including the lower weights-at-age and later maturation and earlier spawning. A corresponding biomass trigger value (defined as the 5% percentile of the SSB for $F_{bar} = F_{MSY}$) was estimated at 2.35 million tonnes. However, ICES considers that MSY $B_{trigger}$ should not be lower than B_{pa}; therefore, MSY $B_{trigger}$ was set at B_{pa}.

The fishing mortalities that would correspond to SSB = B_{lim} and SSB = B_{pa} were estimated as F_{lim} = 0.36 (previously 0.39) and F_{pa} = 0.25 (previously 0.26), respectively (Figure 9.2.3.1.1).

The table below summarizes the revised reference points:

Updated ICES reference points for NEA mackerel

Type		Value	Technical basis
MSY approach	MSY $B_{trigger}$	3.0 million tonnes	B_{pa}
	F_{MSY}	0.22	Stochastic simulations (WKMACLTMP 2015)
Precautionary approach	B_{lim}	1.84 million tonnes	B_{loss} in 2002 (WKPELA 2014 assessment)
	B_{pa}	3.0 million tonnes	B_{lim} × exp(1.654 × σ), σ = 0.3 (WKMACLTMP 2015)
	F_{lim}	0.36	F that on average leads to B_{lim} (WKMACLTMP 2015)
	F_{pa}	0.25	F that on average leads to B_{pa} (WKMACLTMP 2015)

Evaluation of the management strategy

a. Proposed target Fs for the management strategy

The results of simulation runs for the evaluation of the target fishing mortality specified in the request (F_{MSY}: 0.20, 0.25, 0.30, and 0.35; $B_{trigger}$ = 2.2 million t) are shown in Figure 9.2.3.1.2 and Table 9.2.3.1.1.

Using an $F_{target} \leq 0.22$ (F_{MSY}) is considered precautionary, and the other F_{target} values (0.25, 0.30, and 0.35) are not precautionary in the medium and long term (probability of SSB< B_{lim} larger than 5%). The yields decrease in the short term for the lower F_{target} values but quickly stabilize at their long-term level (Figure 9.2.3.1.2). For higher target Fs, yields remain higher in the medium term and take more time to stabilize at a long-term level. Short- and medium-term yields are maximized for the highest F_{target} values, but long-term yields are higher for F_{target} values between 0.20 and 0.22. The decline in SSB is faster for higher F_{target} values, and the probability of SSB falling below B_{lim} exceeds 5%. The mean SSBs in the short, medium, and long term are inversely related to the value of F_{target}. The interannual variation in the TAC increases with the value of F_{target}, and for the scenarios tested, ranges between 27% and 42% (Table 9.2.3.1.1).

The range of variation covered by the 1000 iterations, resulting from the combination of the uncertainty in the assessment and the natural variability of the mackerel stock, is very large (as depicted by the shaded transparent areas in Figure 9.2.3.1.2). This implies that the stock may follow a trajectory very different from the one represented by the median, as illustrated by the grey line representing the trajectory of the single iteration.

b. Alternative $B_{trigger}$ and F_{target} combinations

In addition to the scenarios tested to answer the request, simulations were run for a larger range of target Fs and for a series of different $B_{trigger}$ values, in order to look for alternative scenarios not explicitly covered by the request. The options that were found to maximize the long-term yield and considered precautionary are presented in Tables 9.2.3.1.2–3.

The maximum long-term yields (around 690 thousand t) can be achieved for a variety of management options, corresponding to F_{target} values in the range of 0.20 to 0.25, and fot the whole range of $B_{trigger}$ values tested. Higher target Fs require higher B triggers in order to be precautionary (Tables 9.2.3.1.2–3). Management options with higher fishing mortalities (0.24 and 0.25) also allow maximizing the short- and medium-term yields, but the difference between scenarios is 6% or less. Options with higher fishing mortality result in a larger TAC variability, and in a lower biomass. Using a high $B_{trigger}$, even when associated to a lower F_{target}, results in a larger TAC variability.

Stability mechanisms

The request specifies that "e*ach alternative shall also be assessed with a stability clause where the TAC shall not deviate by more than 20% from the TAC of the preceding year, but the F shall not deviate by more than 10% from the target F"*. In order to assess the effect of these two constraints, simulations ($B_{trigger}$ = 2.2 mt, F_{target} at 0.20–0.25) were run with one or both constraints turned off.

The TAC variation limit, when implemented alone, reduced the TAC interannual variability effectively from 35%–45% to 20%–25% (Figure 9.2.3.1.3). The probability of SSB < B_{lim} in the long term is also reduced. Catches are similar in the short and long term, but lower in the medium term. Implementing a TAC variation limit of 20% often results in advice on a fishing mortality that differs by more than 10% from the fishing mortality corresponding to the harvest control rule. Therefore, when the F deviation limit is in place, it almost always overrules the TAC constraint, and greatly reduces its effect. This comes with no reduction in the probability of SSB< B_{lim}, but with a positive effect on the medium-term yields.

Interannual quota flexibility

A range of scenarios which are extreme interpretations of the banking and borrowing scheme were examined over 40 years in which it was assumed that all parties in the mackerel fishery used their quota flexibility in the same way, and that the amount transferred was always the maximum allowance of 10%. Scenarios consisted of: constantly banking, constantly borrowing, banking in the first year and borrowing thereafter (for 39 years), alternating banking and borrowing, and using the quota transfer to reduce TAC variation (e.g. banking when the TAC, including the transfer from previous years, increases).

The results showed that the influence of the interannual quota transfer in terms of increased probability of SSB< B_{lim} is insignificant, except for the one case when all participants in the fishery bank continuously use the maximum allowance. In this specific case, the probability of SSB< B_{lim} increases by an additional 2.3%. TAC variability is also reduced especially when the interannual quota transfer is used for that purpose, but also for the scenario with constant banking. In summary, the impact of the addition of interannual quota flexibility largely depends on the use of this scheme in practice. The results presented here are conditional on all fishing nations supplying ICES with a summary of banked and borrowed quotas of the previous year along with the catch statistics of that year prior to the assessment, and thus allow for the inclusion of this data in the advice for the next year.

Methods

Simulation tool

A stochastic simulation model was used for the estimation of the reference points and for the evaluation of the management strategy scenarios. This tool was designed to offer a realistic representation of the dynamics of the NEA mackerel stock and of its exploitation, and to mimic as closely as possible the stock assessment and management procedures to be evaluated. The simulation tool was parameterized to give a correct representation of the natural sources of variability in the stock (e.g. recruitment and growth variability) and of the uncertainty in the system. This was done by incorporating stochasticity in the starting conditions, in the future biology of the stock (recruitment, weights, maturity, proportion of mortality before spawning time) and of the fishery characteristics (selection pattern), and in the observation and stock assessment parts of the model. Parameterization of the simulation was based on the most recent NEA mackerel assessment (ICES, 2014c).

Simulations were run in parallel for 1000 iterations (replicates of the stock), each having their own equally likely starting conditions and individual biological and exploitation parameters.

Recruitment was generated using stock–recruitment functions with a log-normal error distribution. The historical stock–recruit pairs (covering the years 1990–2012) did not give clear support for any particular stock–recruitment model formulation. Therefore, the approach developed for the previous management plan evaluation (Simmonds *et al.*, 2011) was adopted here. The method consisted in estimating a probability for a selection of model formulations (Beverton and Holt, Ricker, and segmented regression), to assign randomly one model formulation to each of the 1000 iterations according to these probabilities, and to estimate the shape, auto-correlation, and variance parameters individually for each iteration.

Changes were observed in the mackerel biology in the last decade, characterized by trends towards low weights-at-age, earlier spawning, and later maturation (ICES, 2014b). In the simulations, assumptions on the future biology were based on the average of the last three years (2011–2013) with additional auto-correlated random variations parameterized on the full time-series.

The future age selectivity of the fishery was simulated using resampling of the historical period (2000–2013) by blocks of years.

The stock assessment process was mimicked to estimate the state of the stock in the simulations, providing a basis to give advice according to the management strategies investigated. Stock assessment error matrices were applied to the “true" abundance and fishing mortality-at-age and resulted in temporally auto-correlated errors on SSB and F_{bar}.

A series of test runs was conducted to validate the model and investigate the effect of the main assumptions.

Estimation of reference points

B_{pa} and B_{lim} were estimated using the standard procedure defined in ICES (2003). Long-term (70-year) simulations were performed applying a constant F_{bar} (ranging from 0 to 0.5) to reach stochastic equilibrium. Values at equilibrium (30 last simulation years) were used to estimate MSY reference points (ICES, 2015) as well as F_{lim} and F_{pa}, the two fishing mortalities that lead to B_{lim} and B_{pa}, respectively.

Evaluation of the management plan

The evaluation of the management plan was carried out based on projections over 40 years. Inspection of performance diagnostics were related to the precautionary approach (the probability of SSB< B_{lim} should not exceed 5%), the long-term yields and stock status, the TAC variability, and the mean weight in the catch.

In addition to the five management options specified in the request, simulations were run for a full range of F_{target} values varying from 0.15 to 0.30 and a range of $B_{trigger}$ (not explicitly requested) varying from 2.0 million t to 3.2 million t.

Extra information

Potential deviation of B_{pa} and management biomass trigger

ICES advises a revision of B_{pa}, setting it at 3.0 million tonnes; this implies that MSY $B_{trigger}$ should also be set at this value, following ICES rules. The evaluation of the management strategy resulted in lower biomass triggers, which is considered precautionary, partly in combination with lower F_{target} values. ICES notes that it is not required for management strategy biomass trigger values to be constrained by B_{pa} for the plan to be precautionary. Following the management strategy is likely to result in the stock status being periodically considered to be "at risk" or "overfished" with respect to the PA or MSY frameworks, while it would still be considered "appropriate" with respect to the implemented precautionary management strategy.

This situation could have some unintended adverse effects:

- under the EU landing obligation, only bycatches of stocks within safe biological limits (SSB $>B_{pa}$, $F< F_{pa}$) can be counted against the target species quota (EU Council Regulation No. 1380/2013), so in periods where the stock is considered below B_{pa} this would not be possible for mackerel bycatches, e.g. in the herring fishery;
- most third party eco-labelling schemes require that the stock "fluctuates around B_{MSY} or proxies of B_{MSY}" – in ICES definitions, this criterion is met if the stock is above MSY $B_{trigger}$ for a reasonable period. If B falls below MSY $B_{trigger}$, certification could therefore be suspended. The management strategy would not call for immediate action in such a situation (management $B_{trigger}$ < SSB < MSY $B_{trigger}$).

The probability of these situations occurring can be reduced by choosing the lower F_{target} strategies. The certification issue would be resolved by choosing $B_{trigger}$ values at or above MSY $B_{trigger}$.

Exploration of alternative implementations of the management strategy

ICES has investigated alternative approaches to develop advice for NEA mackerel which were not part of the requested evaluation of a LTMS. All these alternatives involved different treatments of the assessment data through a short-term forecast. From these evaluations, ICES has concluded that a short-term forecast provides a useful step in the provision of advice. However, the current methodology which was chosen in the benchmark (ICES, 2014b) appears to result in a rather variable selection being used to estimate the catch in the TAC year. Preliminary results indicate a potential gain in performance (increased long-term yield of up to 5%) if a more stable selection is used, such as a harvest rate or a fixed selection. ICES is prepared to examine the trade-offs of the alternative approaches with managers once these options have been explored further. ICES welcomes feedback from managers on the priority this work should have.

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Annex(es)

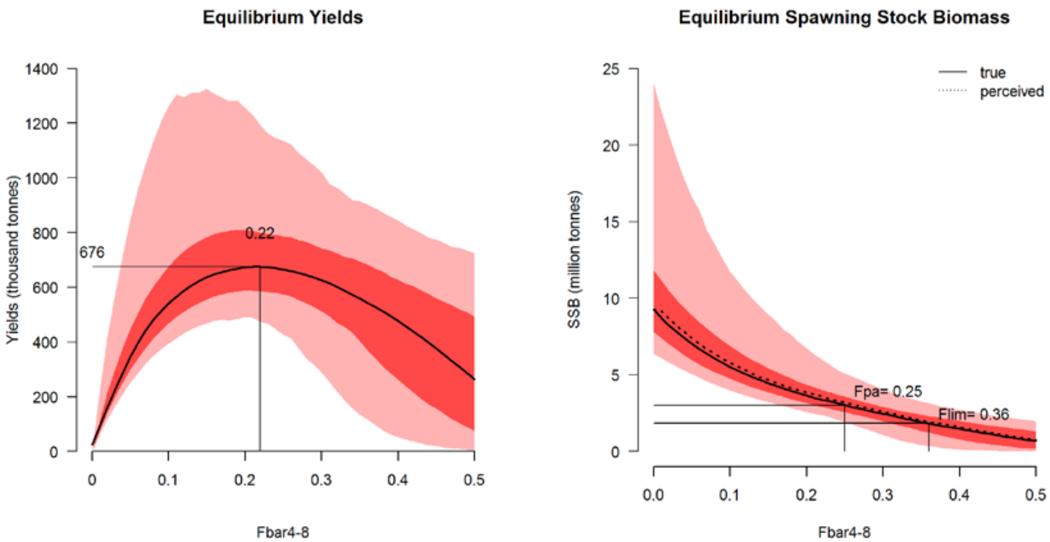

Figure 9.2.3.1.1 Equilibrium yields and SSB as a function of $F_{bar4–8}$ (black line: median over the 1000 replicates, dark and light red area: 50% and 90% of the distribution among the 1000 replicates).

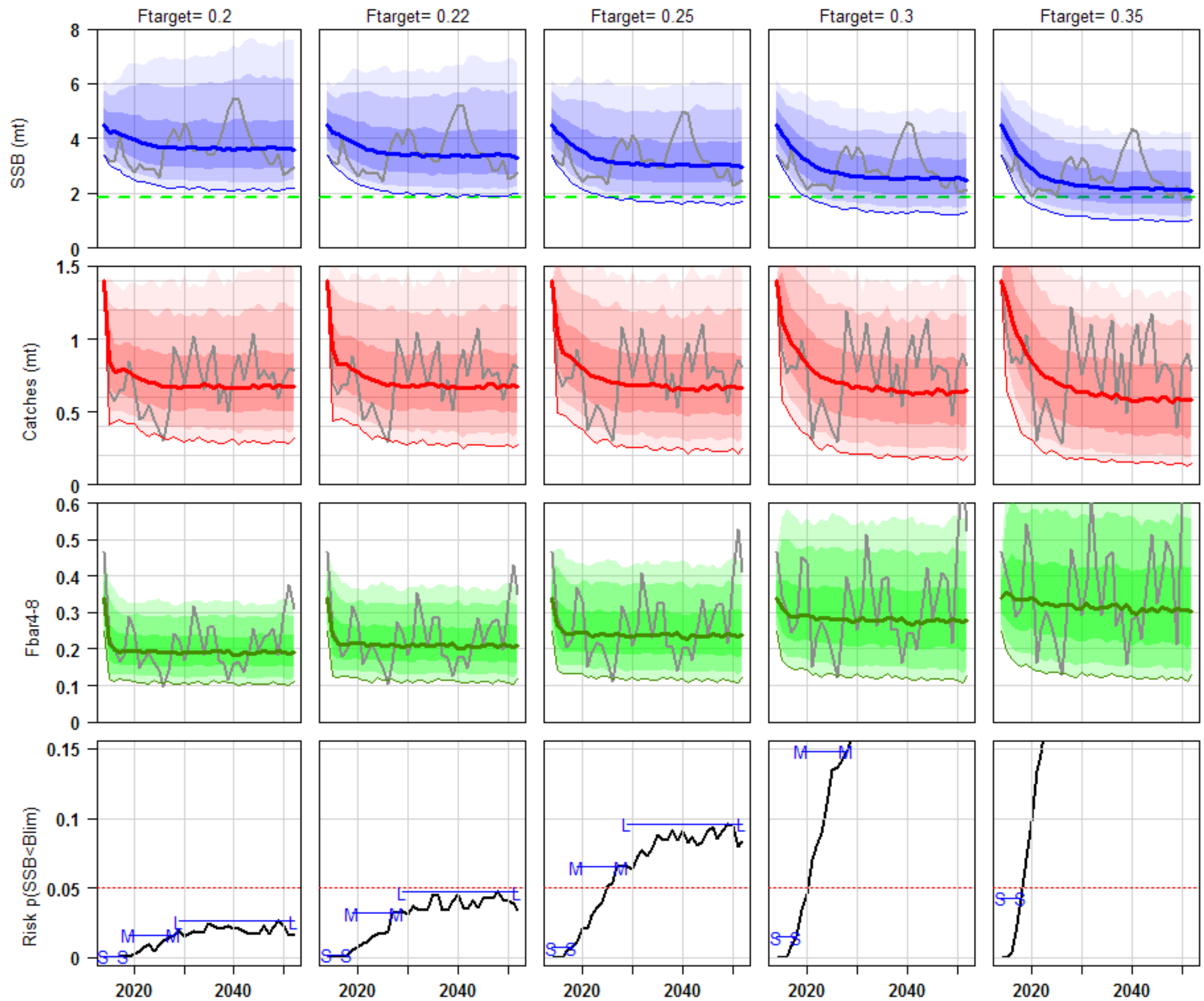

Figure 9.2.3.1.2 Management plan simulations: future trajectories for SSB, catches, fishing mortality, and the probability of SSB< B_{lim} for $B_{trigger}$ = 2.2 million tonnes, including a range of F_{target} values. For SSB, catches, and F_{bar}, the darker solid line represents the median and the shaded areas represent the 50%, 75%, and 90% (darker to lighter shade) of the distribution of the 1000 iterations. The grey line is an example of the trajectory for one iteration. The horizontal lines represent the probability value of SSB< B_{lim} in the short, medium, and long term.

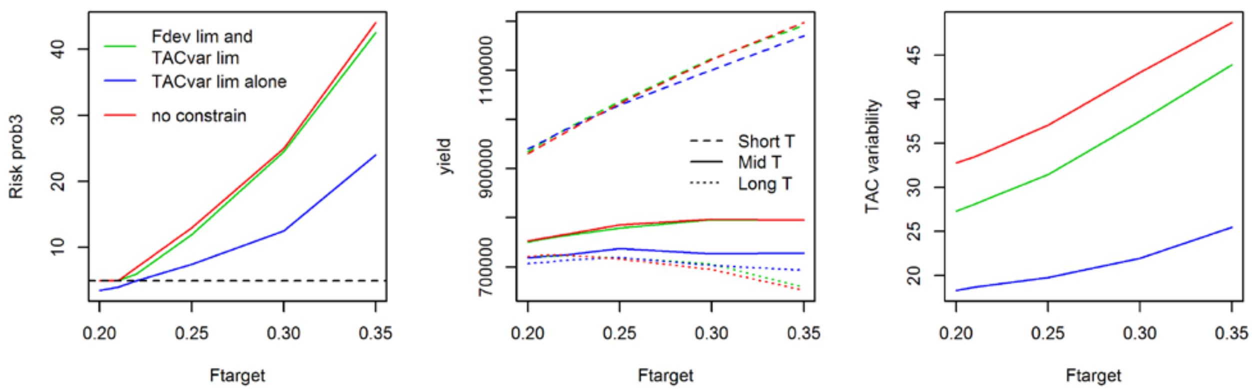

Figure 9.2.3.1.3 Comparison of simulation output (probability of SSB< B_{lim} in the long term, yields, and TAC interannual variability) with and without interannual TAC variation limit and F_{target} deviation limit for $B_{trigger}$ = 2.2 mt in combination with different F_{target} values.

Table 9.2.3.1.1 Performance of management options as specify in the request ($B_{trigger}$ = 2.2 mt, for F_{target} values of [F_{MSY}: 0.20, 0.25, 0.30, 0.35], with a 20% TAC variation constraint and a 10% maximum deviation from F_{target} but with no interannual quota flexibility). Values correspond to the median for the distribution among the 1000 iterations.

Strategy	**risk**		**Yield (Mill. tonn)**			**SSB**			**IAV tac (%)**
LTMP with Btrigger =2.2 mt	MT	LT	ST	MT	LT	ST	MT	LT	
Ftarget=0.20	1.6	2.6	0.934	0.728	0.692	4.3	3.8	3.67	27
Ftarget=0.22 (Fmsy)	3.2	4.7	0.978	0.739	0.692	4.23	3.59	3.41	29
Ftarget=0.25	6.5	9.6	1.037	0.751	0.688	4.13	3.32	3.09	31
Ftarget=0.3	14.8	19.6	1.125	0.762	0.666	3.99	2.93	2.66	37
Ftarget=0.35	27.5	38.1	1.196	0.757	0.635	3.86	2.61	2.27	42

ST: short term (2014–2018); MT: medium term (2019–2028); LT: long term (2029–2050).

Table 9.2.3.1.2 Probability of falling below B_{lim} and mean yield in the long term for the range of management options investigated in the simulations. In the top table, management options in green are precautionary, options in red are not. In the bottom table, the colouring is proportional to the yield (highest in red, lowest in green); non-precautionary options have been shaded.

probability of SSB falling below Blim in the long term

	Ftarget																
Btrigger	0.15	0.16	0.17	0.18	0.19	0.2	0.21	0.22	0.23	0.24	0.25	0.26	0.27	0.28	0.29	0.3	0.35
2.0 mt	0.7	0.8	1.2	1.6	2.2	3	3.9	5.3	6.8	8.4	10.8	13.3	16	19.2	21.1	24.1	42.2
2.2 mt	0.7	0.8	1.1	1.4	2.2	2.6	3.6	4.7	6.1	7.7	9.6	11.8	14	16.9	19.6	22.2	38.1
2.4 mt	0.5	0.8	1	1.4	1.9	2.5	3	4.3	5.5	7.1	8.4	10.5	12.5	14.8	17.5	19.6	33.8
2.6 mt	0.4	0.5	1	1.2	1.8	2.2	2.7	3.6	4.8	6.1	7.6	9.1	11.1	13.1	15.2	17.8	30.1
2.8 mt	0.3	0.5	0.8	1.1	1.4	2	2.4	3	4	5.3	6.5	8	9.2	11.7	13.7	15.4	27.2
3.0 mt	0.3	0.5	0.7	1.1	1.2	1.7	2.2	2.7	3.2	4.6	5.7	7.1	8.4	9.9	11.7	14.1	24.1
3.2 mt	0.2	0.5	0.7	0.8	1.1	1.4	1.8	2.3	2.8	3.5	5	6.1	7.2	8.5	10.2	11.8	21.4

mean yield in the long term

	Ftarget																
Btrigger	0.15	0.16	0.17	0.18	0.19	0.2	0.21	0.22	0.23	0.24	0.25	0.26	0.27	0.28	0.29	0.3	0.35
2.0 mt	651	663	674	682	687	692	693	692	691	691	689	684	679	674	668	666	627
2.2 mt	651	662	673	681	688	692	693	692	693	690	688	683	679	676	671	666	635
2.4 mt	651	662	673	681	687	692	692	692	693	691	686	683	680	676	672	668	639
2.6 mt	650	661	672	681	686	692	693	692	693	691	688	686	681	678	674	669	644
2.8 mt	649	661	672	679	685	690	692	692	694	693	689	688	684	679	675	671	650
3.0 mt	648	661	671	678	686	689	692	692	694	695	691	687	686	682	677	675	656
3.2 mt	646	659	670	677	684	689	691	694	693	693	693	691	689	683	680	677	659

Table 9.2.3.1.3 Performance of a selection of management options maximizing the long-term yields (with a 20% TAC variation constraint and 10% maximum deviation from F_{target}, but with no interannual quota transfer). Values correspond to the median for the distribution among the 1000 iterations.

Strategy		**risk**		**Yield (Mill. tonn)**			**SSB**			**IAV tac (%)**
Btrigger	Ftarget	MT	LT	ST	MT	LT	ST	MT	LT	
2	0.21	2.1	3.9	0.957	0.736	0.693	4.26	3.69	3.52	27
2.2	0.22	3.2	4.7	0.978	0.739	0.692	4.23	3.59	3.41	29
2.6	0.23	3.5	4.8	0.997	0.74	0.693	4.2	3.52	3.34	32
3	0.24	3.8	4.6	1.008	0.74	0.695	4.18	3.49	3.32	37
3.2	0.25	3.9	5	1.021	0.742	0.693	4.16	3.43	3.27	40

ST: short term (2014–2018); MT: medium term (2019–2028); LT: long term (2029–2050).