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EU, Norway, and the Faroe Islands request concerning long-term management strategy for mackerel in the Northeast Atlantic

Advice summary

ICES advises on revised fishing mortality reference points for Northeast Atlantic (NEA) mackerel (point 1 in the request): F_{MSY} should be revised to 0.21, F_{lim} revised to 0.48, and F_{pa} revised to 0.35.

ICES has updated the tables that were presented in its response to the EU, Norway, and the Faroe Islands request to ICES to evaluate a multi-annual management strategy for mackerel in the Northeast Atlantic (ICES, 2015). The options that are precautionary and maximize the median long-term yield are identified in the updated tables (Tables 2–10 in the Annex). F targets around 0.22–0.24 combined with $B_{trigger}$ values of around 3.4–4.2 million t result in the highest median long-term yields, when no TAC constraint applies. When the TAC constraint applies, a larger number of (F_{target}, $B_{trigger}$) combinations result in the highest median long-term yields. Generally, these combinations have F targets around 0.22–0.26 and $B_{trigger}$ values around 2.8 to 4.2 million t, with higher F targets being associated with higher $B_{trigger}$ values. Increasing the F_{target} or the $B_{trigger}$ values results in increased interannual variability in yield.

For any given (F_{target}, $B_{trigger}$) combination, the effect of incorporating a TAC constraint, as specified in point 4 of the request, is minor. The difference in median long-term yield with or without constraint never exceeds 5%. For most (F_{target}, $B_{trigger}$) combinations, the probability of SSB falling below B_{lim} and the interannual yield variability are somewhat lower with TAC constraint than without it.

Results from preliminary modelling of density-dependent weights suggest that higher target Fs would likely be possible while remaining precautionary. However, better scientific understanding of the link between stock size and growth and the development of an appropriate modelling approach would be needed before these types of changes in growth can be incorporated in the evaluation of the harvest control rule.

Request

Request to ICES concerning long-term management strategy for mackerel in the Northeast Atlantic

In order to revise the long-term management strategy, an evaluation of some alternative harvest control rules is needed. The Parties therefore ask ICES to evaluate the following harvest control rules:

1. *Evaluate new fishing mortality reference points for the Northeast Atlantic mackerel stock based on ICES 2017.*
2. *ICES is requested to update all the Tables given in its response to the EU, Norway and Faroe Islands request to ICES to evaluate a multi-annual management strategy for mackerel in the North East Atlantic (published 13 February 2015), using:*
   - *A range of Btrigger from two to five million tonnes with an appropriate range of target Fs*
   - *A harvest control rule with a fishing mortality equal to the target F when SSB is at or above Btrigger.*
   - *In the case that the SSB is forecast to be less than Btrigger at spawning time in the year for which the TAC is to be set, the TAC shall be fixed consistently with a fishing mortality that is given by:*
     *F = Ftarget*SSB/Btrigger*
3. *When updating the Tables referred to above, ICES should omit the constraint on F that had been evaluated in 2015.*
4. *All alternatives should be evaluated with and without a constraint on the inter-annual variation of TAC. When the rules would lead to a TAC, which deviates by more than 20% below or 25% above the TAC of the preceding year, the Parties shall fix a TAC that is respectively no more than 20% less or 25% more than the TAC of the preceding year. The TAC constraint shall not apply if the SSB at spawning time in the year for which the TAC is to be set is less or equal to Btrigger.*

Evaluation and performance criteria

Each alternative shall be assessed in relation to how it performs in the short term (2018-2022), medium term (2023-2032) and long term (2033-2052) in relation to:

- *Average SSB*
- *Average yield*
- *Indicator for year to year variability in SSB and yield*
- *Risk of SSB falling below Blim*
- *Average mean weight for age groups 3-8 years in relation to long-term average mean weight*

Evaluation of the management strategies shall be simulated with:

- *both fixed weight-at-age and with density dependent weight-at-age.*
- *assessment uncertainty representing the present assessment model and input data. ICES is invited to use the values established by WKMSYREF4 (ICES 2016) as default if it is not possible to estimate present assessment uncertainty for NEA mackerel.*

References:

ICES, 2015. Response to EU, Norway and Faroe Islands request to ICES to evaluate a multiannual management strategy for mackerel in the North East Atlantic (published 13 February 2015)

ICES. 2016. Report of the Workshop to consider FMSY ranges for stocks in ICES categories I and 2 in Western Waters (WKMSYREF4), 13-16 October 2015, Brest, France. ICES CM 2015/ACOM:58. 187 pp.

ICES. 2017. Report of the Benchmark Workshop on Widely Distributed Stocks (WKWIDE), 30 January-3 February 2017, Copenhagen, Denmark. ICES CM 2017/ACOM:36. 196 pp.

Elaboration on the advice

ICES advice on fishing mortality reference points and evaluation of harvest control rules (HCRs) takes into account the recent development in population dynamics parameters for mackerel. In line with this, the analyses forming the basis of the advice were done with constant (without trend) weights-at-age as observed in the last five years. The main findings of these analyses are presented below in relation to fishing mortality reference points and the long-term management strategy evaluation. Density-dependent weight implications are discussed separately at the end of this section.

Evaluation of the fishing mortality reference points

The fishing mortality reference points were evaluated using long-term stochastic simulations, in accordance with the ICES guidelines. This resulted in the following values: F_{lim} = 0.48, F_{pa} = 0.35, and F_{MSY} = 0.21.

The reference points reflect ICES current perception of the population dynamics of the stock. As this may change in future, the fishing mortality reference points may also change.

Long-term management strategy

All of the tables concerning the long-term period that were provided in ICES response on 13 February 2015 to the EU, Norway and Faroe Islands request to ICES to evaluate a multi-annual management strategy for mackerel in the Northeast Atlantic (ICES, 2015) have been updated in the current advice response, without and with a constraint in interannual TAC variation as indicated in point 4 of the request. The target fishing mortality values evaluated are in the range of 0.10 to 0.35. These were used in combination with $B_{trigger}$ values in the range of 2–5 million tonnes, including MSY $B_{trigger}$ = 2.57 million t. Two lower $B_{trigger}$ values, 0.6 million t and B_{lim} = 1.94 million t, were also included in the evaluation.

Precautionary (F_{target}, $B_{trigger}$) combinations were identified (Tables 2 and 3). There is a set of "borderline" combinations, corresponding to the 5% risk (i.e. probability of SSB falling below B_{lim}), in which larger values of F_{target} are associated with larger values of $B_{trigger}$ (for the same 5% risk) and vice versa. The precautionary F targets associated with the lowest and highest $B_{trigger}$ values and with MSY $B_{trigger}$ are shown in Table 1.

Table 1 Maximum precautionary F_{target} (≤ 5% risk) under the lowest, highest, and MSY $B_{trigger}$ values.

	$B_{trigger}$ = 0.6 million t	$B_{trigger}$ = 5 million t	$B_{trigger}$ = MSY $B_{trigger}$ = 2.57 million t
No TAC change constraint	0.19	0.28	0.21
TAC change constraint	0.18	0.29	0.21

For most (F_{target}, $B_{trigger}$) combinations, the probability of SSB falling below B_{lim} is somewhat lower with than without TAC constraint (Tables 2 and 3). However, for harvest control rules with low target Fs and $B_{trigger}$, the TAC constraint results in higher risk. The effects of the TAC constraint are not necessarily easy to anticipate. The fact that it only applies when SSB is forecast to be above $B_{trigger}$ may be part of the reason why it results in some reduction of risk.

A potential consequence of the TAC constraint as it is formulated in the request (i.e. a constraint on interannual change in TAC when the SSB is forecast to be above $B_{trigger}$ at spawning time of the advisory year, but no constraint when SSB is forecast to be less than or equal to $B_{trigger}$), is that the catch could get trapped at a low level if the stock is forecast to be below $B_{trigger}$ in one year. When the stock is forecast to drop below $B_{trigger}$, the catch could potentially experience a big decrease because the TAC constraint would no longer apply. Once the stock recovered above $B_{trigger}$, the 25% constraint on TAC increase could lead to a loss in potential catch because of the constraint on TAC increase being applied to a low starting point. Discontinuities in advice rules are in general not desirable and it could be useful to consider ways of achieving a smoother transition around $B_{trigger}$.

Within the set of precautionary (F_{target}, $B_{trigger}$) combinations, ICES has identified those combinations that would maximize the long-term yield (Tables 4 and 5).

F targets around 0.22–0.24 combined with $B_{trigger}$ values of around 3.4–4.2 million t result in the highest median long-term yields, when no TAC constraint applies (Table 4). For a given F target value, increasing $B_{trigger}$ can lead to increased median long-term yield (e.g. with F_{target} = 0.21, the yield increases when $B_{trigger}$ increases from 2.4 to 4 million t); this increase in yield with increasing $B_{trigger}$ also comes with an increase in interannual yield variability (Table 6).

When the TAC constraint applies, a larger number of (F_{target}, $B_{trigger}$) combinations result in the highest median long-term yields (Table 5). Generally, these combinations have F targets around 0.22–0.26 and $B_{trigger}$ values around 2.8 to 4.2 million t, with higher F targets being associated with higher $B_{trigger}$ values.

For any given (F_{target}, $B_{trigger}$) combination, the difference in median long-term yield between HCRs without and with TAC constraint is minor; the difference is always ≤ 5% in the long term (Tables 4 and 5).

Increasing the F_{target} or the $B_{trigger}$ in the HCR leads to increased interannual variability in yield (Tables 6 and 7). For most (F_{target}, $B_{trigger}$) combinations, some reduction in interannual yield variability will result when the TAC constraint is included. However, as was the case for risk, the opposite occurs for harvest control rules with low target Fs and $B_{trigger}$.

Figures 2 and 3 illustrate that, for any given (F_{target}, $B_{trigger}$) combination, a wide range of yield and interannual yield variability values may occur in the future. This means that future values could be quite different from the medians reported in Tables 4–7. The range of possible future values widens as the F target increases. For interannual yield variability (Figure 3) the range widens considerably with increases in either the F target or the $B_{trigger}$; in such cases, interannual yield variability values that are much higher than the medians reported in the tables cannot be ruled out.

Short- and medium-term evaluation

As the stock is currently at a high biomass level, the P(SSB < B_{lim}) is higher in the long-term than in the medium or short-terms; determining whether a management strategy can be considered precautionary (i.e. if P(SSB < B_{lim}) ≤ 5% in all years) thus depends only on the long-term risk.

Table 8 presents additional results for the short term (2018–2022), medium term (2023–2032), and long term (2033–2052) for an illustrative selection of (F_{target}, $B_{trigger}$) combinations. However, short-term results should be interpreted with some caution as the results from the management strategy evaluation are considered to be both more valid and more useful when evaluating the medium and long terms than for short-term evaluations. The model forming the basis of the evaluation for the HCR uses historically observed stock–recruitment relationships. While this approach is appropriate for long-term considerations, it is not suitable for assessing the short-term consequences of the proposed HCR. The management strategy evaluation may provide different results in the short term when compared to the annual short-term forecast based on the assessment model used for the mackerel stock, because the recruitment estimates at age 0 from the management strategy evaluation and the annual assessment differ on a year-to-year basis. This difference is, however, less at ages 3 and 4, the ages at which mackerel starts to contribute significantly to the fisheries.

Density-dependent weight-at-age

Recent scientific publications (Jansen and Burns, 2015; Olafsdottir *et al*., 2016) have evaluated changes in growth observed in mackerel. However, better scientific understanding of the link between stock size and growth and the development of an appropriate modelling approach would be needed before these changes in growth can be incorporated in the evaluation of the harvest control rule.

The simulations conducted by ICES with density-dependent weights are for illustrative purposes. They are useful in indicating the likely direction of impacts of density dependence in growth on the performance of an HCR. In the density-dependent models, higher values of F result in higher weights-at-age of mackerel in the medium and long terms, because of lower stock sizes. According to the simulations conducted, it would be possible to have higher target Fs while remaining precautionary. The results suggest that there is likely to be some loss in yield if the management strategy is based on recent low weights but the actual weights are density dependent. However, losses in yield in the medium and long term did appear to be relatively minor. If, on the contrary, the management strategy was based on an assumption of density dependence but the mackerel weights stay at the recent low values, then the probability of the stock going below B_{lim} would be greater than 5% (according to the simulations conducted) and the management strategy would not be precautionary.

Basis of the advice

Background

A new stock assessment method was adopted for mackerel at the benchmark assessment in 2017 (ICES, 2017a). The benchmark also evaluated and updated the biomass reference points for the stock. B_{lim} was revised to 1.94 million t, and B_{pa} and MSY $B_{trigger}$ were both revised to 2.57 million t.

In June 2017 Norway, the EU and the Faroe Islands sent a request to ICES for an evaluation of the fishing mortality reference points for the stock, as well as a range of harvest control rules that could form the basis for a long-term management strategy for the stock. This request was dealt with by WKMACMSE (ICES Workshop on management strategy evaluation for the mackerel in subareas 1–7 and 14, and in divisions 8.a–e and 9.a; ICES, 2017b), which met in August 28-29, 2017, and also worked by correspondence.

The updated biomass reference points from the 2017 benchmark were used in the work conducted by WKMACMSE.

Results and conclusions

ICES performed stochastic simulations for a wide range of settings to test whether the different harvest control rules would be in accordance with the precautionary approach and produce high long-term yield. The results of the simulations should be used for comparison between scenarios and not as forecasts of absolute quantities.

Evaluation of fishing mortality reference points

The fishing mortality reference points were evaluated using long-term stochastic simulations, in accordance with the ICES guidelines. The reference points were derived in accordance with recent ecosystem conditions (weights and maturity as in the most recent five years, 2011–2015). Given the absence of information on the stock–recruitment form and the fact that there has been no impaired recruitment observed historically (i.e. since the beginning of the stock assessment, in 1980), the reference points and management strategy evaluation are based on a hockey-stick (i.e. segmented regression) stock–recruitment form, with annual deviations around it.

This led to the following values:

• F_{lim} = 0.48, calculated as the value that results in P(SSB < B_{lim}) = 50% in long-term equilibrium, assuming the breakpoint of the hockey-stick is at B_{lim}, and without including any $B_{trigger}$ (i.e. constant F exploitation) or any assessment error.

• F_{pa} = 0.35, derived from F_{lim} taking assessment error into account, i.e. $F_{pa} = F_{lim} \times \exp(-1.645 \times \sigma)$, where σ is estimated from the assessment uncertainty in F in the terminal year. The standard factor σ = 0.20 has been applied as it is considered to provide a more realistic characterization of uncertainty than the smaller estimate of σ from the stock assessment; this is in accordance with the ICES guidelines.

• F_{MSY} = 0.21. The value of F that maximised the median long-term yield, assuming a hockey-stick stock–recruitment form (without fixing the breakpoint), without including any $B_{trigger}$ (i.e. constant F exploitation), but including assessment error, was F = 0.23. However, this F resulted in long-term P(SSB < B_{lim}) > 5%. Therefore, in accordance with ICES guidelines, F_{MSY} was set at the value of F that resulted in long-term P(SSB < B_{lim}) = 5% when that F was applied in combination with $B_{trigger}$ = MSY $B_{trigger}$ = 2.57 million t; this led to F_{MSY} = .21. This is illustrated in Figure 1.

Long-term management strategy

A range of harvest control rules were evaluated, as requested, using long-term stochastic simulations. All evaluations were done without and with a constraint in interannual TAC variation, as specified in point 4 of the request. Tables 2–5 present the results for long-term P(SSB < B_{lim}) and median long-term yield. As the stock is currently at a high biomass level, the P(SSB<B_{lim}) is higher in the long-term than in the medium or short terms; determining whether a management strategy can be considered precautionary (i.e. if P(SSB < B_{lim}) ≤ 5% in all years) thus depends only on the long-term risk. The options that were found to maximize the long-term yield and considered precautionary are identified in these tables. It is clear from the tables that high long-term yields can be achieved for a variety of (F_{target}, $B_{trigger}$) combinations.

Tables 6 and 7 provide information on the interannual variability that may be expected in catches under the different options. The tables show that increasing the F_{target} or the $B_{trigger}$ in the HCR leads to increased interannual variability in yield.

For most (F_{target}, $B_{trigger}$) combinations, including the TAC constraint leads to some reduction in interannual yield variability as well as in risk (P(SSB < B_{lim})). The exception seems to be the rules with rather low target Fs and $B_{trigger}$, where the opposite occurs.

Future values of yield and interannual yield variability can differ sustantially from the values reported in Tables 4–7, as illustrated by the distributions shown in Figures 2 and 3.

It should be understood that (high F_{target}, high $B_{trigger}$) combinations result in actual Fs that can, on average over time, be substantially lower than the target F. This is because the F used to set the catch according to the HCR is reduced below the F_{target} whenever the SSB is forecast to be below $B_{trigger}$. This is illustrated in Tables 9 and 10: even though F targets up to 0.28 (Table 9) or 0.29 (Table 10) are precautionary with a sufficiently high $B_{trigger}$ (5 million t), all (F_{target}, $B_{trigger}$) combinations that have risk at or just under the 5% borderline value result in realised Fs in the range of 0.19–0.22 (Table 9) or 0.18–0.21 (Table 10). Rules with higher target F do, however, result in higher interannual changes in both F and yield (see Figure 3 for interannual yield variability).

Figures 4 and 5 show the simulated future distribution of SSB, catch (i.e. yield), and Fbar, as well as the P(SSB < B_{lim}), for the years 2018–2052, for several combinations of (F_{target}, $B_{trigger}$), without or with the constraint on interannual TAC change. The panels corresponding to the realised SSB, catch, and Fbar show percentiles of the simulated distribution as well as one particular realisation, i.e. one possible trajectory, selected randomly among the 1000 trajectories generated in the simulation. The range of variation covered by the 1000 iterations in the simulation, which results from the combination of the uncertainty in the assessment/forecast and the natural variability of the mackerel stock, is very large, as depicted by the shaded transparent areas in the figures. As a consequence, the stock may follow a trajectory very different from the one represented by the median, as illustrated by the randomly selected trajectory of a single iteration.

Results and advice concerning the short-term period are presented in the “Elaboration on the advice” section, earlier in this document, as are considerations pertaining to density-dependent weights.

Methods

A stochastic simulation model was used for the estimation of the reference points and for the evaluation of the management strategy scenarios. This tool, designed to offer a realistic representation of the dynamics of the mackerel stock and of its exploitation, integrates historical assessment, short-term forecast, and long-term simulation within the same framework (a separable model). First the historical assessment model was run, using the mackerel data since 1980, as in the standard ICES assessment with the SAM model, except that tagging data were not included in the separable model due to time constraints. Recruitment was modelled using a hockey-stick stock–recruitment function with annual deviations autocorrelated in time. The separable model provided historical estimates of biological parameters and selection pattern of the fisheries (considering two periods for selection, with a change in 1996), stock size, and fishing mortality. The inverse Hessian matrix was then used as proposal distribution in MCMC simulations, where the number of simulations were 5 million and the parameters from every 5000th run saved to a file. The saved 1000 sets of parameters were then used in 1000 stochastic runs; in each run the assessment model outputs fed directly into the future population dynamics model, observation model, and the harvest control rule. Uncertainty or errors in data, assessment, and short-term forecast are included in the simulation.

Although the framework does not mimic exactly the historical dynamic estimates from the assessment framework used by ICES for the annual asessment of mackerel (SAM), the historical estimates were overall similar for the two methods (particularly over the last two decades) and the approach is considered appropriate for the purpose of long-term simulation. Results for the short-term time period should be treated with some caution. The management strategy evaluation may provide different results in the short term compared to the annual short-term forecast based on the assessment model used for the mackerel stock, because the recruitment estimates at age 0 from the management strategy evaluation and the annual assessment differ on a year-to-year basis. This difference is, however, less at ages 3 and 4, the ages at which mackerel starts to contribute significantly to the fisheries.

In the simulations, assumptions about future weights and maturity of mackerel were based on the average of the last five years (2011–2015), with additional auto-correlated random variations. Illustrative runs assuming density-dependent weights were also carried out.

The framework was run using actual catch data until 2015 and using survey indices until 2016 (i.e. with the data available during the stock benchmark in early 2017). A catch of 1.06 million t was assumed for 2016 and harvest control rules were applied to provide catches for 2017 and subsequent years. Simulations were run until year 2085. Results were summarized for the periods indicated in the request, i.e. short term (ST; 2018–2022), medium term (MT; 2023–2032), and long term (LT; 2033–2052). The main performance diagnostics were related to the precautionary approach (the requirement that the probability of SSB < B_{lim} should not exceed 5%), long-term yields, and interannual yield variability.

Sources and references

Jansen, T., and Burns, F. 2015. Density dependent growth changes through juvenile and early adultlife of North East Atlantic Mackerel (*Scomber scombrus*). Fisheries Research, 169: 37–44.

Olafsdottir, A. H., Slotte, A., Jacobsen, J. A., Oskarsson, G. J., Utne, K. R., and Nøttestad, L. 2016. Changes in weight-at-length and size-at-age of mature Northeast Atlantic mackerel (*Scomber scombrus*) from 1984 to 2013: effects of mackerel stock size and herring (*Clupea harengus*) stock size. ICES Journal of Marine Science, 73: 1255–1265.

ICES. 2015. EU, Norway, and the Faroe Islands request to ICES to evaluate a multi-annual management strategy for mackerel (*Scomber scombrus*) in the Northeast Atlantic. *In* Report of the ICES Advisory Committee, 2015. ICES Advice 2015, Book 9, Section 9.2.3.1. 11 pp.

ICES. 2017a. Report of the Benchmark Workshop on Widely Distributed Stocks (WKWIDE), 30 January–3 February 2017, Copenhagen, Denmark. ICES CM 2017/ACOM:36. 196 pp.

ICES. 2017b. Report of the Workshop on management strategy evaluation for the mackerel in subareas 1–7 and 14, and in divisions 8.a–e and 9.a (Northeast Atlantic) (WKMACMSE), 28–29 August 2017, Copenhagen, Denmark. ICES CM 2017/ACOM:48. 210 pp.

Annex

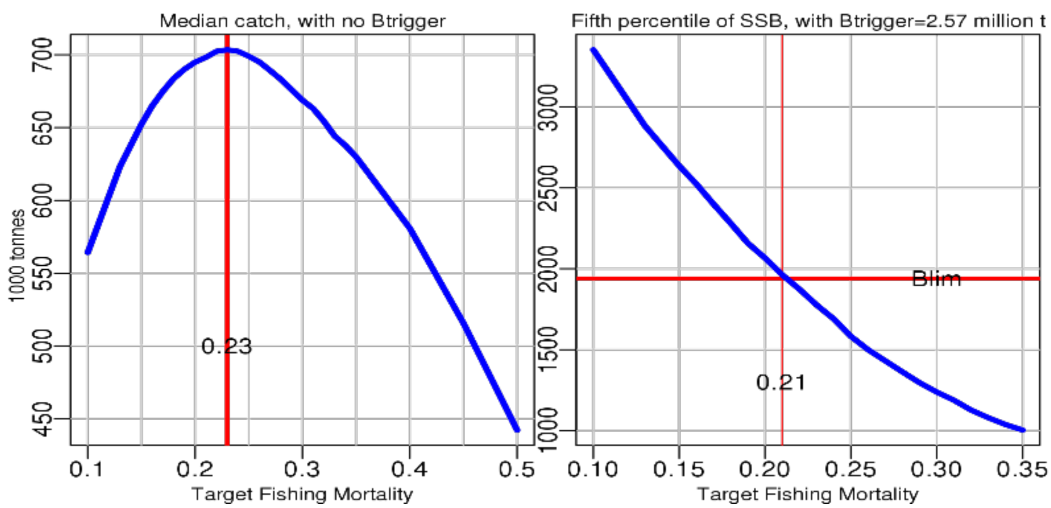

Figure 1 Left panel: Median long-term yield, as a function of target F, with no $B_{trigger}$. The maximum of the yield curve is at F = 0.23. Right panel: Fifth percentile of the long-term distribution of SSB, as a function of target F, with $B_{trigger}$ = MSY $B_{trigger}$ = 2.57 million t. The horizontal line corresponds to B_{lim}. The vertical line corresponds to the F (0.21) that results in P(SSB < B_{lim}) = 5%.

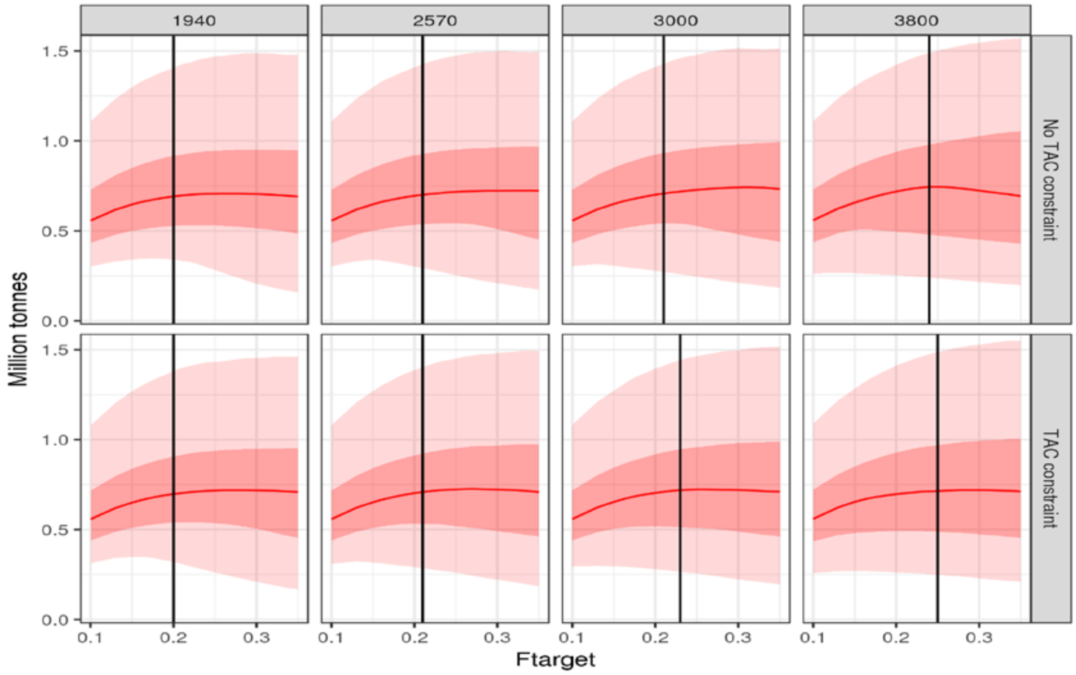

Figure 2 Long-term yield versus F_{target} for rules without (top panels) and with (bottom panels) TAC constraint. From left to right, the panels correspond to $B_{trigger}$ = 1.94, 2.57, 3.0, and 3.8 million t. The figures show the 5th, 25th, 50th, 75th, and 95th percentiles of the long-term distribution. The vertical black line in each panel indicates the highest F target that results in a precautionary rule (i.e. P(SSB < B_{lim}) ≤ 5% in Tables 2 and 3) with the $B_{trigger}$ value in that panel.

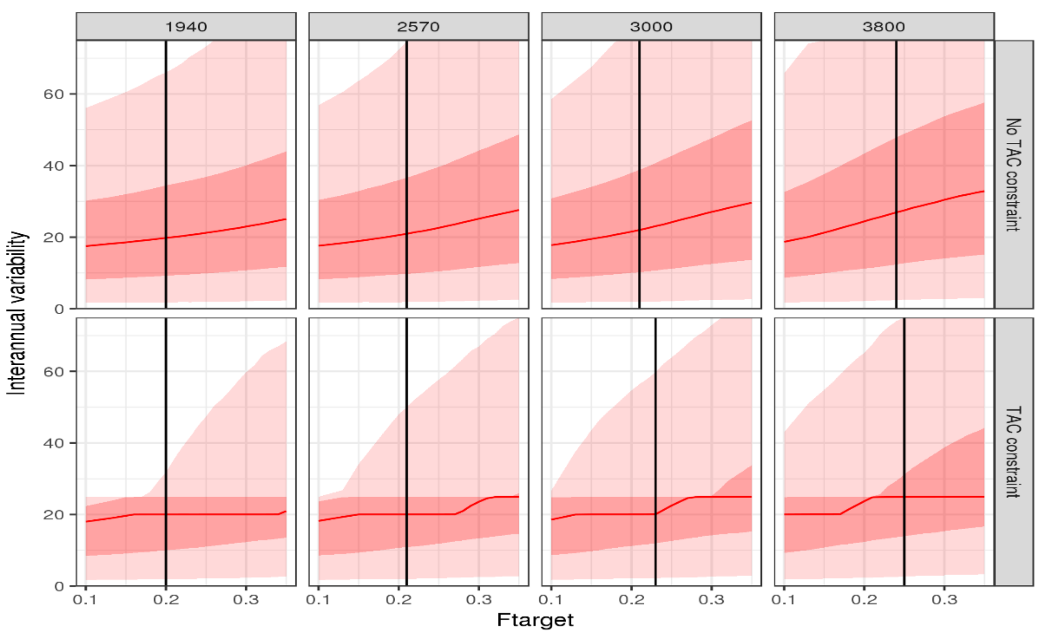

Figure 3 Long-term interannual variability (IAV, defined as the percentage change between two consecutive years) in yield versus F_{target} for rules without (top panels) and with (bottom panels) TAC constraint. From left to right, the panels correspond to $B_{trigger}$ = 1.94, 2.57, 3.0, and 3.8 million t. The figures show the 5th, 25th, 50th, 75th, and 95th percentiles of the long-term distribution. The vertical black line in each panel indicates the highest F target that results in a precautionary rule (i.e. P(SSB < B_{lim}) ≤ 5% in Tables 2 and 3) with the $B_{trigger}$ value in that panel.

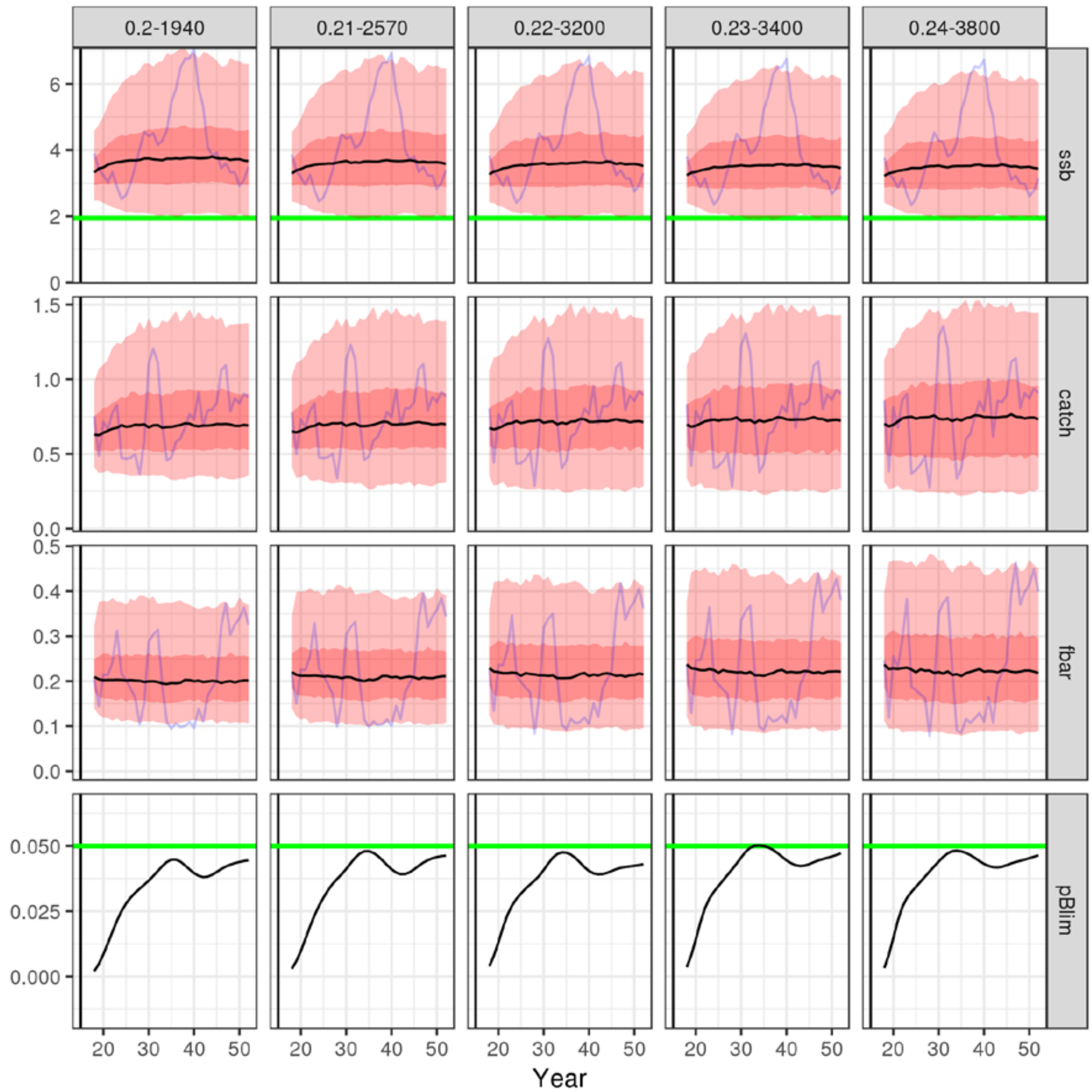

Figure 4 Simulation results for 2018–2052, for rules without constraint in interannual TAC change. Each column corresponds to the (F_{target}, $B_{trigger}$) combination indicated in the column's heading. The top three rows correspond to the realised SSB (horizontal green line is B_{lim}), catch, and Fbar(ages 4–8), and show the 5th, 25th, 50th, 75th, and 95th percentiles of their distribution, and one specific realisation (selected randomly). The bottom row shows the P(SSB < B_{lim}), with the horizontal green line at 0.05 (i.e. 5%).

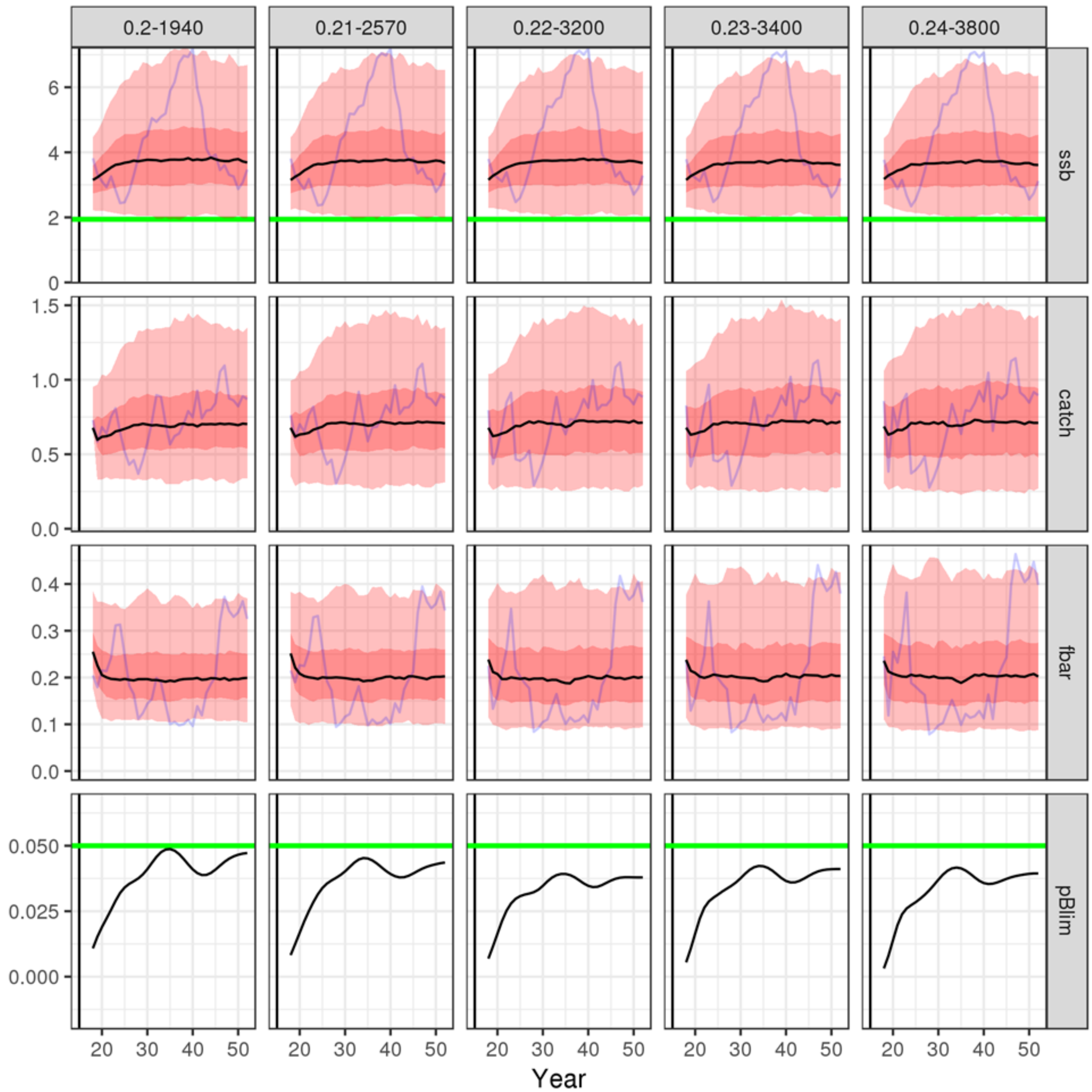

Figure 5 Simulation results for 2018–2052, for rules with constraint in interannual TAC change. Each column corresponds to the (F_{target}, $B_{trigger}$) combination indicated in the column's heading. The top three rows correspond to the realised SSB (horizontal green line is B_{lim}), catch, and Fbar(ages 4–8), and show the 5th, 25th, 50th, 75th, and 95th percentiles of their distribution, and one specific realisation (selected randomly). The bottom row shows the P(SSB < B_{lim}), with the horizontal green line at 0.05 (i.e. 5%).

Table 2 P(SSB < B_{lim}), expressed as a percentage, in the long term for HCRs without a constraint in interannual TAC change. Unshaded cells correspond to the precautionary (F_{target}, $B_{trigger}$) combinations. $B_{trigger}$ in the table is expressed in thousand tonnes.

Btrigger	0.1	0.13	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	0.31	0.32	0.33	0.34	0.35
600	0.2	0.7	1.3	1.9	2.7	3.5	4.2	5.1	6.4	7.7	9.3	10.8	12.6	14.9	16.7	18.9	21.3	24.1	27.1	29.4	32.1	34.7	37.2
1940	0.1	0.6	1.3	1.7	2.3	3.2	3.8	4.5	5.5	6.9	8.4	9.8	11.3	13.4	15.1	17	19.1	21.5	23.8	25.8	27.8	30.6	32.9
2000	0.1	0.6	1.2	1.7	2.3	3.1	3.8	4.5	5.4	6.8	8.2	9.7	11.3	13.1	14.8	16.9	18.9	21.2	23.4	25.6	27.5	30	32.5
2200	0.1	0.6	1.2	1.7	2.2	2.9	3.7	4.4	5.2	6.5	7.8	9.2	10.8	12.4	14.3	16.1	17.9	20.3	22.4	24.2	26.4	28.4	30.8
2400	0	0.5	1.1	1.6	2.1	2.7	3.4	4.2	5	6.1	7.4	8.7	10.2	11.8	13.5	15.2	16.9	19.2	21.1	22.9	25	27	28.8
2570	0	0.5	1.1	1.5	2	2.5	3.2	4	4.8	5.7	7	8.3	9.6	11.1	12.7	14.4	16.1	18.1	20.1	21.8	23.8	25.5	27.7
2600	0	0.5	1.1	1.4	2	2.5	3.2	3.9	4.8	5.7	6.8	8.2	9.5	10.9	12.5	14.2	15.9	17.8	19.9	21.6	23.5	25.2	27.4
2800	0	0.4	1	1.3	1.9	2.3	3	3.7	4.6	5.5	6.4	7.7	8.9	10.2	11.6	13.1	14.7	16.7	18.5	20.2	21.9	23.6	25.4
3000	0	0.4	0.8	1.2	1.6	2.2	2.7	3.4	4.2	5.2	5.8	7.1	8	9.5	10.8	12.1	13.5	15.3	17.2	18.9	20.3	21.9	23.7
3200	0	0.3	0.8	1.1	1.5	2	2.5	3	3.8	4.8	5.5	6.4	7.5	8.6	9.9	11.3	12.6	14.1	15.7	17.4	18.8	20.3	21.8
3400	0	0.3	0.7	1	1.4	1.7	2.3	2.8	3.4	4.3	5	5.9	6.8	7.9	9.2	10.3	11.6	12.9	14.4	15.9	17.3	18.8	20.3
3600	0	0.3	0.6	0.9	1.2	1.6	2.1	2.6	3.2	3.9	4.6	5.4	6.2	7.3	8.3	9.5	10.5	11.7	13.2	14.6	15.9	17.4	18.9
3800	0	0.3	0.5	0.8	1.1	1.4	1.9	2.3	2.9	3.6	4.1	4.8	5.7	6.6	7.6	8.5	9.6	10.7	12	13.3	14.7	15.9	17.3
4000	0	0.2	0.5	0.7	0.9	1.3	1.7	2.2	2.6	3.3	3.8	4.4	5.1	5.9	7	7.9	8.7	9.8	10.9	12.1	13.3	14.6	15.8
4200	0	0.2	0.4	0.6	0.8	1.1	1.5	2	2.3	2.9	3.5	4	4.7	5.3	6.2	7.3	8.1	8.8	9.8	10.9	12.1	13.3	14.4
4400	0	0.2	0.4	0.6	0.8	1	1.3	1.8	2.2	2.7	3.2	3.6	4.2	4.9	5.5	6.5	7.4	8.1	8.9	9.8	10.8	12.1	13.2
4600	0	0.1	0.4	0.5	0.7	0.9	1.1	1.5	2.1	2.3	2.9	3.4	3.8	4.4	5	5.7	6.6	7.6	8.3	9	9.9	10.8	11.9
4800	0	0.1	0.4	0.5	0.6	0.8	1	1.3	1.8	2.2	2.6	3.1	3.5	4	4.6	5.1	5.8	6.8	7.6	8.5	9.1	9.7	10.8
5000	0	0.1	0.3	0.4	0.6	0.7	0.9	1.1	1.5	1.9	2.3	2.7	3.2	3.6	4.1	4.6	5.2	5.9	6.8	7.6	8.4	9	9.8

Table 3 P(SSB < B_{lim}), expressed as a percentage, in the long term for HCRs with a constraint in interannual TAC change. Unshaded cells correspond to the precautionary (F_{target}, $B_{trigger}$) combinations. $B_{trigger}$ in the table is expressed in thousand tonnes.

Btrigger	0.1	0.13	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	0.31	0.32	0.33	0.34	0.35
600	0.5	1	1.7	2.5	3.3	4.3	5.1	6.2	7.6	9.4	11.3	13.1	15.4	17.4	20.5	22.9	25.7	29.2	31.4	33.6	35.7	38	40.4
1940	0.4	0.7	1.4	2	2.5	3.1	4	4.9	5.8	6.8	8	9.2	10.9	12.4	14.3	16.2	18.1	20	21.9	23.7	25.5	27.4	29.3
2000	0.4	0.7	1.4	2	2.4	3	4	4.8	5.7	6.7	7.7	9	10.7	12.2	14.1	16	17.7	19.7	21.5	23.2	24.9	26.7	28.8
2200	0.3	0.7	1.2	1.7	2.3	2.7	3.7	4.4	5.4	6.2	7.2	8.5	9.8	11.4	13.2	15	16.2	18.1	19.8	21.4	23.2	24.6	26.6
2400	0.3	0.6	1	1.6	2.1	2.5	3.4	4.1	5	5.8	6.8	7.8	9.1	10.4	12	13.7	15	16.7	18.4	20.2	21.5	23	25
2570	0.3	0.6	1	1.4	1.9	2.4	3.1	3.7	4.6	5.3	6.2	7.3	8.3	9.6	11	12.8	14.2	15.7	17.2	18.9	20.5	21.9	23.6
2600	0.3	0.6	1	1.4	1.8	2.3	3	3.6	4.5	5.3	6.2	7.2	8.2	9.3	10.9	12.6	14.1	15.5	17	18.7	20.3	21.9	23.3
2800	0.2	0.6	0.9	1.3	1.7	2.1	2.8	3.3	4.1	4.9	5.6	6.4	7.4	8.8	10.2	11.3	12.9	14.3	15.9	17.3	18.7	20.5	22
3000	0.2	0.5	0.8	1.1	1.5	1.9	2.4	3	3.7	4.2	5	6	7	7.9	9.2	10.6	11.8	13	14.6	15.8	17.5	18.9	20.4
3200	0.1	0.3	0.8	1	1.3	1.7	2.1	2.8	3.3	4	4.6	5.5	6.4	7.2	8.6	9.8	10.9	12.2	13.2	14.8	16.2	17.5	18.8
3400	0	0.3	0.7	0.9	1.2	1.5	2	2.4	3	3.6	4.3	4.8	5.9	6.8	7.7	8.9	9.9	11.2	12.4	13.7	14.8	15.9	17.1
3600	0	0.3	0.6	0.8	1	1.4	1.8	2.2	2.8	3.3	3.7	4.5	5.4	6	7	8	8.8	10.1	11.4	12.6	13.6	14.8	15.8
3800	0	0.2	0.5	0.7	1	1.3	1.6	2	2.5	3	3.5	4.2	4.8	5.6	6.2	7.2	8.2	9.4	10.5	11.4	12.4	13.5	14.5
4000	0	0.2	0.4	0.6	0.8	1.2	1.5	1.9	2.3	2.7	3.2	3.7	4.4	5	5.9	6.5	7.4	8.5	9.4	10.2	11.4	12.4	13.3
4200	0	0.2	0.4	0.6	0.7	1	1.4	1.8	2.1	2.5	2.9	3.5	4	4.7	5.3	6	6.8	7.6	8.6	9.3	10.2	11.3	12.2
4400	0	0.2	0.4	0.5	0.7	0.9	1.2	1.6	1.9	2.3	2.8	3.2	3.6	4.3	4.9	5.6	6.4	7	7.6	8.5	9.4	10.2	11.2
4600	0	0.1	0.4	0.4	0.5	0.7	1	1.3	1.8	2.1	2.6	3	3.4	3.9	4.4	5.2	5.7	6.5	7.3	7.8	8.5	9.4	10.4
4800	0	0.1	0.3	0.4	0.5	0.7	0.9	1.1	1.6	1.9	2.4	2.8	3.2	3.6	4.1	4.5	5.2	6	6.5	7.2	7.8	8.6	9.4
5000	0	0.1	0.3	0.4	0.4	0.6	0.8	1	1.4	1.8	2.2	2.5	2.8	3.3	3.6	4	4.6	5.3	5.9	6.6	7.4	8.1	8.7

Table 4 Median yield (in thousand tonnes) in the long term for HCRs without a constraint in interannual TAC change. Cells shaded red correspond to the unprecautionary (F_{target}, $B_{trigger}$) combinations (P(SSB < B_{lim}) > 5% in Table 2). Cells shaded in other colours indicate the combinations that result in yield ≥ 95% of the maximum yield among the precautionary combinations; each colour corresponds to a 1% change in yield (i.e. yield ≥ 99%, 98%, 97%, 96%, and 95% of the maximum yield among the precautionary combinations). $B_{trigger}$ in the table is expressed in thousand tonnes.

Btrigger	0.1	0.13	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	0.31	0.32	0.33	0.34	0.35
600	557	618	647	658	668	677	684	691	696	699	702	703	703	703	702	701	699	696	693	688	684	679	674
1940	557	618	647	659	669	678	685	691	697	701	704	706	706	707	707	707	706	705	703	700	697	694	691
2000	557	618	647	659	669	678	685	692	697	701	704	706	707	708	708	707	706	706	704	702	699	696	694
2200	557	618	647	659	669	678	686	692	698	702	705	708	710	711	711	711	711	710	709	707	706	705	703
2400	557	618	647	660	670	679	687	693	699	703	708	711	713	715	716	717	717	715	716	716	715	714	714
2570	557	618	648	660	670	680	688	695	700	706	709	714	717	719	721	722	723	723	723	724	724	724	723
2600	557	618	648	661	671	680	688	695	701	706	710	715	718	720	721	723	724	724	725	725	725	726	724
2800	557	619	649	662	672	682	690	697	703	709	714	719	723	725	727	730	732	733	734	735	735	735	734
3000	557	619	649	663	674	684	693	701	707	714	719	724	728	732	735	738	740	741	742	741	740	737	732
3200	557	620	651	664	676	686	696	704	711	719	724	729	734	739	743	744	746	746	745	742	738	731	724
3400	558	621	653	666	678	689	699	708	716	724	730	736	741	745	747	747	747	744	739	734	727	721	713
3600	558	623	655	668	681	693	704	714	722	730	736	742	746	747	745	743	741	735	729	723	716	709	701
3800	559	624	657	671	685	698	709	719	728	735	740	744	744	743	740	735	730	724	718	712	706	700	693
4000	560	627	660	675	689	702	714	724	731	735	738	738	736	732	727	721	717	712	707	702	697	692	687
4200	561	629	663	679	693	706	717	725	730	731	730	728	723	720	714	710	706	702	697	694	690	685	681
4400	562	631	667	683	697	708	716	721	722	721	718	714	710	706	702	700	696	694	690	687	683	680	675
4600	564	634	670	685	698	706	711	711	710	707	705	702	699	695	693	690	688	687	683	680	677	675	672
4800	566	637	672	684	694	698	698	698	697	696	694	692	689	685	685	682	681	679	676	674	672	670	667
5000	568	639	670	679	684	685	686	685	685	685	684	683	680	678	677	676	674	673	671	668	667	665	664

Table 5 Median yield (in thousand tonnes) in the long term for HCRs with a constraint in interannual TAC change. Cells shaded red correspond to the unprecautionary (F_{target}, $B_{trigger}$) combinations (P(SSB < B_{lim}) > 5% in Table 3). Cells shaded in other colours indicate the combinations that result in yield ≥ 95% of the maximum yield among the precautionary combinations; each colour corresponds to a 1% change in yield (i.e. yield ≥ 99%, 98%, 97%, 96%, and 95% of the maximum yield among the precautionary combinations). $B_{trigger}$ in the table is expressed in thousand tonnes.

Btrigger	0.1	0.13	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	0.31	0.33	0.34	0.35
600	557	619	648	661	672	681	689	695	699	703	706	706	707	706	707	703	700	692	690	680	675	669
1940	558	620	650	663	674	683	692	698	703	708	712	715	717	718	718	719	718	718	717	713	711	709
2000	558	620	650	663	674	684	692	698	703	709	712	716	718	719	719	720	719	720	717	715	713	710
2200	558	621	651	664	675	685	693	700	705	710	715	719	721	721	722	722	723	722	721	719	716	711
2400	558	621	651	664	676	685	694	701	707	712	717	720	723	724	725	726	725	724	722	718	714	709
2570	558	621	652	665	676	687	695	703	709	714	718	722	723	725	726	725	724	723	721	716	713	708
2600	558	621	652	665	676	687	696	703	709	714	718	722	724	725	727	725	723	722	721	716	713	707
2800	559	622	653	667	678	688	697	704	710	715	720	722	724	725	724	723	723	722	720	713	711	710
3000	559	623	654	667	679	690	697	704	710	715	719	721	724	724	722	721	721	720	718	713	711	711
3200	559	623	655	668	679	688	697	704	711	715	718	720	721	722	720	719	719	719	718	714	712	711
3400	559	624	655	668	679	688	696	703	708	711	715	716	717	718	720	719	718	719	719	717	714	713
3600	560	624	654	667	678	687	695	701	705	709	712	713	716	717	719	718	718	719	719	716	716	714
3800	560	623	654	666	677	685	692	697	702	706	711	712	713	716	718	720	719	720	719	716	715	712
4000	560	623	653	664	674	682	689	695	701	706	710	711	712	715	715	716	717	718	718	716	713	710
4200	559	622	650	662	671	679	686	693	699	704	706	709	711	713	713	714	715	716	715	712	709	707
4400	559	620	647	658	667	676	683	689	695	699	704	707	709	710	711	710	710	710	710	707	707	705
4600	559	617	643	654	664	672	679	685	691	696	699	703	704	706	705	705	706	705	705	704	702	699
4800	558	613	640	650	661	668	676	682	688	692	696	699	700	700	701	701	700	701	701	698	695	693
5000	556	610	636	647	656	663	672	679	683	686	691	693	694	694	696	695	695	695	694	692	691	690

Table 6 Median interannual variability (IAV, defined as the percentage change between two consecutive years) in yield in the long term for HCRs without a constraint in interannual TAC change. Unshaded cells correspond to the precautionary (F_{target}, $B_{trigger}$) combinations (P(SSB < B_{lim}) ≤ 5% in Table 2). $B_{trigger}$ in the table is expressed in thousand tonnes.

Btrigger	0.1	0.13	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	0.31	0.32	0.33	0.34	0.35
600	17	18	18	18	18	18	19	19	19	19	19	20	20	20	20	20	21	21	21	21	21	22	22
1940	17	18	18	18	18	19	19	19	20	20	20	20	21	21	21	22	22	22	23	23	24	24	24
2000	17	18	18	18	19	19	19	19	20	20	20	20	21	21	21	22	22	23	23	23	24	24	25
2200	17	18	18	18	19	19	19	19	20	20	20	21	21	21	22	22	23	23	23	24	24	25	25
2400	17	18	18	19	19	19	19	20	20	20	21	21	22	22	22	23	23	24	24	25	25	26	26
2570	17	18	18	19	19	19	20	20	20	21	21	22	22	22	23	23	24	25	25	26	26	27	27
2600	17	18	18	19	19	19	20	20	20	21	21	22	22	23	23	24	24	25	25	26	26	27	27
2800	17	18	19	19	19	20	20	21	21	21	22	22	23	23	24	24	25	26	26	26	27	27	28
3000	17	18	19	19	20	20	21	21	21	22	22	23	24	24	25	25	26	26	27	27	28	28	29
3200	17	18	19	20	20	21	21	22	22	23	23	24	24	25	26	26	27	27	28	28	29	29	30
3400	18	19	20	20	21	21	22	22	23	23	24	25	25	26	26	27	28	28	29	29	30	30	31
3600	18	19	20	21	21	22	22	23	24	24	25	25	26	27	27	28	28	29	29	30	30	31	31
3800	18	19	21	21	22	23	23	24	24	25	26	26	27	27	28	29	29	30	30	31	31	32	32
4000	18	20	21	22	23	23	24	25	25	26	26	27	28	28	29	29	30	30	31	32	32	32	33
4200	19	21	22	23	23	24	25	25	26	26	27	28	28	29	30	30	31	31	32	32	32	33	33
4400	19	21	23	23	24	25	25	26	27	27	28	28	29	30	30	31	31	32	32	33	33	33	34
4600	20	22	23	24	25	25	26	27	27	28	28	29	30	30	31	31	32	32	33	33	33	34	34
4800	20	22	24	24	25	26	27	27	28	28	29	30	30	31	31	32	32	33	33	33	34	34	35
5000	21	23	24	25	26	27	27	28	28	29	30	30	31	31	32	32	33	33	33	34	34	35	35

Table 7 Median interannual variability (IAV, defined as the percentage change between two consecutive years) in yield in the long term for HCRs with a constraint in interannual TAC change. Unshaded cells correspond to the precautionary (F_{target}, $B_{trigger}$) combinations (P(SSB < B_{lim}) ≤ 5% in Table 3). $B_{trigger}$ in the table is expressed in thousand tonnes.

Btrigger	0.1	0.13	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	0.31	0.32	0.33	0.34	0.35
600	17	18	19	19	19	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
1940	18	18	19	19	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
2000	18	18	19	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
2200	18	19	19	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	21	22	23
2400	18	19	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	21	22	24	25	25
2570	18	19	20	20	20	20	20	20	20	20	20	20	20	20	20	20	21	23	23	25	25	25	25
2600	18	19	20	20	20	20	20	20	20	20	20	20	20	20	20	20	22	23	24	25	25	25	25
2800	18	19	20	20	20	20	20	20	20	20	20	20	20	20	22	23	24	25	25	25	25	25	25
3000	18	19	20	20	20	20	20	20	20	20	20	20	21	23	24	25	25	25	25	25	25	25	25
3200	18	20	20	20	20	20	20	20	20	20	21	22	23	24	25	25	25	25	25	25	25	25	25
3400	19	20	20	20	20	20	20	20	20	22	23	24	25	25	25	25	25	25	25	25	25	25	25
3600	19	20	20	20	20	20	20	21	22	23	25	25	25	25	25	25	25	25	25	25	25	25	25
3800	19	20	20	20	20	20	22	23	24	25	25	25	25	25	25	25	25	25	25	25	25	25	25
4000	20	20	20	20	21	22	23	24	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25
4200	20	20	20	21	22	24	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25
4400	20	20	21	22	24	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25
4600	20	20	23	24	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25
4800	20	21	24	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25
5000	20	22	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	26

Table 8 Performance of a selection of management options that are precautionary and result in high long-term yields. Values (except risk) correspond to the median of the distribution among the 1000 iterations. Risk is the P(SSB < B_{lim}), expressed as a percentage. Time periods are as follows: short term (ST) = years 2018–2022, medium term (MT) = years 2023–2032, and long term (LT) = years 2033–2052.

F_{target}	$B_{trigger}$ (thousand t)	TAC constraint	Risk (%)		Yield (thousand t)			SSB (thousand t)			IAV (%)
			MT	LT	ST	MT	LT	ST	MT	LT	LT
0.21	2570	No	4.6	4.8	659	699	700	3412	3610	3653	20
0.21	3000	No	4	4.2	660	704	707	3420	3633	3683	21
0.22	3200	No	4.6	4.8	678	716	719	3376	3560	3602	23
0.23	3600	No	4.5	4.6	700	734	736	3347	3531	3565	25
0.24	3800	No	4.7	4.8	705	744	744	3316	3483	3514	26
0.28	5000	No	4.6	4.6	650	675	676	3333	3454	3480	32
0.21	2400	Yes	4.7	5	677	697	707	3307	3668	3710	20
0.21	2570	Yes	4.4	4.6	677	698	709	3321	3689	3735	20
0.22	2800	Yes	4.6	4.9	678	704	715	3308	3630	3679	20
0.23	3000	Yes	4.9	5	678	709	719	3288	3579	3626	20
0.24	3400	Yes	4.8	4.8	677	710	716	3287	3571	3613	24
0.29	5000	Yes	4.5	4.6	660	695	695	3344	3531	3543	25

Table 9 Median of the real F in the long term for HCRs without a constraint in interannual TAC change. Unshaded cells correspond to the precautionary (F_{target}, $B_{trigger}$) combinations (P(SSB < B_{lim}) ≤ 5% in Table 2). $B_{trigger}$ in the table is expressed in thousand tonnes.

Btrigger	0.1	0.13	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	0.31	0.32	0.33	0.34	0.35
600	0.1	0.13	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	0.31	0.32	0.33	0.34	0.34
1940	0.1	0.13	0.15	0.16	0.17	0.18	0.19	0.2	0.21	0.22	0.23	0.24	0.25	0.26	0.26	0.27	0.28	0.29	0.3	0.31	0.31	0.32	0.33
2000	0.1	0.13	0.15	0.16	0.17	0.18	0.19	0.2	0.21	0.22	0.23	0.24	0.25	0.26	0.26	0.27	0.28	0.29	0.3	0.31	0.31	0.32	0.33
2200	0.1	0.13	0.15	0.16	0.17	0.18	0.19	0.2	0.21	0.22	0.23	0.24	0.25	0.25	0.26	0.27	0.28	0.29	0.3	0.3	0.31	0.32	0.33
2400	0.1	0.13	0.15	0.16	0.17	0.18	0.19	0.2	0.21	0.22	0.23	0.24	0.24	0.25	0.26	0.27	0.28	0.29	0.29	0.3	0.31	0.32	0.32
2570	0.1	0.13	0.15	0.16	0.17	0.18	0.19	0.2	0.21	0.22	0.23	0.23	0.24	0.25	0.26	0.27	0.28	0.28	0.29	0.3	0.31	0.31	0.32
2600	0.1	0.13	0.15	0.16	0.17	0.18	0.19	0.2	0.21	0.22	0.23	0.23	0.24	0.25	0.26	0.27	0.28	0.28	0.29	0.3	0.31	0.31	0.32
2800	0.1	0.13	0.15	0.16	0.17	0.18	0.19	0.2	0.21	0.22	0.22	0.23	0.24	0.25	0.26	0.27	0.27	0.28	0.29	0.29	0.3	0.31	0.31
3000	0.1	0.13	0.15	0.16	0.17	0.18	0.19	0.2	0.21	0.21	0.22	0.23	0.24	0.25	0.26	0.26	0.27	0.28	0.28	0.29	0.3	0.3	0.31
3200	0.1	0.13	0.15	0.16	0.17	0.18	0.19	0.2	0.2	0.21	0.22	0.23	0.24	0.25	0.25	0.26	0.27	0.27	0.28	0.29	0.29	0.3	0.3
3400	0.1	0.13	0.15	0.16	0.17	0.18	0.19	0.19	0.2	0.21	0.22	0.23	0.23	0.24	0.25	0.26	0.26	0.27	0.27	0.28	0.28	0.29	0.3
3600	0.1	0.13	0.15	0.16	0.17	0.18	0.18	0.19	0.2	0.21	0.22	0.22	0.23	0.24	0.24	0.25	0.26	0.26	0.27	0.27	0.28	0.28	0.29
3800	0.1	0.13	0.15	0.16	0.17	0.17	0.18	0.19	0.2	0.21	0.21	0.22	0.23	0.23	0.24	0.25	0.25	0.26	0.26	0.27	0.27	0.28	0.28
4000	0.1	0.13	0.15	0.16	0.16	0.17	0.18	0.19	0.2	0.2	0.21	0.22	0.22	0.23	0.24	0.24	0.25	0.25	0.26	0.26	0.27	0.27	0.27
4200	0.1	0.13	0.15	0.15	0.16	0.17	0.18	0.19	0.19	0.2	0.21	0.21	0.22	0.22	0.23	0.24	0.24	0.25	0.25	0.26	0.26	0.26	0.27
4400	0.1	0.13	0.14	0.15	0.16	0.17	0.18	0.18	0.19	0.2	0.2	0.21	0.21	0.22	0.22	0.23	0.23	0.24	0.24	0.25	0.25	0.26	0.26
4600	0.1	0.13	0.14	0.15	0.16	0.17	0.17	0.18	0.19	0.19	0.2	0.2	0.21	0.21	0.22	0.22	0.23	0.23	0.24	0.24	0.25	0.25	0.25
4800	0.1	0.12	0.14	0.15	0.16	0.16	0.17	0.18	0.18	0.19	0.19	0.2	0.2	0.21	0.21	0.22	0.22	0.23	0.23	0.24	0.24	0.24	0.25
5000	0.1	0.12	0.14	0.15	0.15	0.16	0.17	0.17	0.18	0.18	0.19	0.19	0.2	0.2	0.21	0.21	0.22	0.22	0.23	0.23	0.23	0.24	0.24

Table 10 Median of the real F in the long term for HCRs with a constraint in interannual TAC change. Unshaded cells correspond to the precautionary (F_{target}, $B_{trigger}$) combinations (P(SSB < B_{lim}) ≤ 5% in Table 3). $B_{trigger}$ in the table is expressed in thousand tonnes.

Btrigger	**0.1**	**0.13**	**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**	**0.31**	**0.32**	**0.33**	**0.34**	**0.35**
600	0.1	0.13	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	0.31	0.31	0.32	0.33	0.34
1940	0.1	0.13	0.15	0.16	0.17	0.18	0.19	0.2	0.2	0.21	0.22	0.23	0.24	0.25	0.25	0.26	0.27	0.27	0.28	0.29	0.29	0.3	0.31
2000	0.1	0.13	0.15	0.16	0.17	0.18	0.19	0.2	0.2	0.21	0.22	0.23	0.24	0.25	0.25	0.26	0.27	0.27	0.28	0.29	0.29	0.3	0.3
2200	0.1	0.13	0.15	0.16	0.17	0.18	0.19	0.19	0.2	0.21	0.22	0.23	0.24	0.24	0.25	0.26	0.26	0.27	0.28	0.28	0.29	0.29	0.3
2400	0.1	0.13	0.15	0.16	0.17	0.17	0.18	0.19	0.2	0.21	0.22	0.22	0.23	0.24	0.25	0.25	0.26	0.26	0.27	0.28	0.28	0.29	0.29
2570	0.1	0.13	0.15	0.16	0.16	0.17	0.18	0.19	0.2	0.21	0.21	0.22	0.23	0.24	0.24	0.25	0.26	0.26	0.27	0.27	0.28	0.28	0.29
2600	0.1	0.13	0.15	0.16	0.16	0.17	0.18	0.19	0.2	0.21	0.21	0.22	0.23	0.23	0.24	0.25	0.25	0.26	0.27	0.27	0.28	0.28	0.29
2800	0.1	0.13	0.15	0.15	0.16	0.17	0.18	0.19	0.2	0.2	0.21	0.22	0.22	0.23	0.24	0.24	0.25	0.26	0.26	0.27	0.27	0.28	0.28
3000	0.1	0.13	0.14	0.15	0.16	0.17	0.18	0.19	0.19	0.2	0.21	0.21	0.22	0.23	0.23	0.24	0.25	0.25	0.26	0.26	0.27	0.27	0.28
3200	0.1	0.13	0.14	0.15	0.16	0.17	0.18	0.18	0.19	0.2	0.2	0.21	0.22	0.22	0.23	0.24	0.24	0.25	0.25	0.26	0.26	0.27	0.27
3400	0.1	0.13	0.14	0.15	0.16	0.17	0.17	0.18	0.19	0.19	0.2	0.21	0.21	0.22	0.23	0.23	0.24	0.24	0.25	0.25	0.26	0.26	0.27
3600	0.1	0.12	0.14	0.15	0.16	0.16	0.17	0.18	0.19	0.19	0.2	0.2	0.21	0.22	0.22	0.23	0.23	0.24	0.24	0.25	0.26	0.26	0.26
3800	0.1	0.12	0.14	0.15	0.15	0.16	0.17	0.18	0.18	0.19	0.2	0.2	0.21	0.21	0.22	0.22	0.23	0.24	0.24	0.25	0.25	0.26	0.26
4000	0.1	0.12	0.14	0.15	0.15	0.16	0.17	0.17	0.18	0.19	0.19	0.2	0.2	0.21	0.22	0.22	0.23	0.23	0.24	0.24	0.25	0.25	0.26
4200	0.1	0.12	0.14	0.14	0.15	0.16	0.16	0.17	0.18	0.18	0.19	0.2	0.2	0.21	0.21	0.22	0.22	0.23	0.23	0.24	0.24	0.25	0.25
4400	0.09	0.12	0.13	0.14	0.15	0.16	0.16	0.17	0.17	0.18	0.19	0.19	0.2	0.2	0.21	0.21	0.22	0.22	0.23	0.23	0.24	0.24	0.25
4600	0.09	0.12	0.13	0.14	0.15	0.15	0.16	0.17	0.17	0.18	0.18	0.19	0.19	0.2	0.21	0.21	0.22	0.22	0.23	0.23	0.23	0.24	0.24
4800	0.09	0.12	0.13	0.14	0.14	0.15	0.16	0.16	0.17	0.17	0.18	0.19	0.19	0.2	0.2	0.21	0.21	0.22	0.22	0.23	0.23	0.23	0.24
5000	0.09	0.11	0.13	0.14	0.14	0.15	0.15	0.16	0.17	0.17	0.18	0.18	0.19	0.19	0.2	0.2	0.21	0.21	0.22	0.22	0.23	0.23	0.23