9.4.2 NEAFC request to ICES to evaluate a long-term management strategy for the fisheries on the blue whiting (*Micromesistius poutassou*) stock

Advice summary

ICES advises that the harvest control rule (HCR) proposed for the Long-Term Management Strategy (LTMS) for blue whiting, as described in the request, is precautionary given the ICES estimates of B_{lim} (1.5 million t), B_{pa} (2.25 million t), and F_{MSY} (0.32).

The HCR was found to be precautionary both with and without the 20% TAC change limits above B_{pa}. However, the 20% TAC change limits can lead to the TAC being lowered significantly if the stock is estimated to be below B_{pa}, while also limiting how quickly the TAC can increase once the stock is estimated to have recovered above B_{pa}.

The evaluation found that including a 10% interannual quota flexibility ('banking and borrowing') in the LTMS had an insignificant effect on the performance of the HCR.

Request

This advice is in response to a request from NEAFC to evaluate a long-term management strategy (LTMS) for blue whiting in the Northeast Atlantic as specified in the request from NEAFC, see Figure 9.4.2.1.

The request:

1. The Parties agree to implement a long-term management strategy for the fisheries on the Blue Whiting stock, which is consistent with the precautionary approach and the MSY approach, aiming at ensuring harvest rates within safe biological limits.
2. For the purpose of this long-term management strategy, in the following text, "TAC" means the sum of the Coastal State quotas and the NEAFC allowable catches.
3. As a priority, the long-term strategy shall ensure with high probability that the size of the stock is maintained above Blim.
4. In the case that the spawning biomass is forecast to be above or equal to Btrigger (=Bpa) on 1 January of the year for which the TAC is to be set, the TAC shall be fixed to a fishing mortality of Fmsy.
5. Where the rules in paragraph 4 would lead to a TAC, which deviates by more than 20% from the TAC of the preceding year, the Parties shall fix a TAC that is no more than 20% greater or 20% less than the TAC of the preceding year.
6. In the case that the spawning biomass (SSB) is forecast to be less than the precautionary biomass (Btrigger) on 1 January of the year for which the TAC is to be set, the TAC shall be fixed that is consistent with a fishing mortality given by:
Target F = 0.05 + [(SSB – Blim)(Fmsy – 0.05) / (Btrigger – Blim)]*
7. In the case that the spawning biomass is forecast to be less than Blim on 1 January of the year for which the TAC is to be set, the TAC will be fixed corresponding to a fishing mortality F=0.05.
8. Each Party may transfer to the following year unutilised quantities of up to 10% of the quota allocated to it. The quantity transferred shall be in addition to the quota allocated to the Party concerned in the following year.
9. Each Party may authorise fishing by its vessels of up to 10% beyond the quota allocated. All quantities fished beyond the allocated quota for one year shall be deducted from the Party's quota allocated for the following year.
10. The inter-annual quota flexibility scheme in paragraphs 8 and 9 should be suspended in the year following the TAC year, if the stock is forecast to be under Btrigger at the end of the TAC year.
11. The Parties, on the basis of ICES advice, shall review this long-term management strategy at intervals not exceeding five years.

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Elaboration on the advice

Long-term management strategy

ICES evaluated the proposed HCR as described in the request with the current reference points for the stock (B_{lim} = 1.5 million t, B_{pa} = 2.25 million t, and F_{MSY} = 0.32). The proposed HCR was found to be precautionary. The evaluation used current blue whiting biology and fishery characteristics (weight-at-age and selectivity in 2010–2014), and future recruitment was determined based on the whole estimated recruitment time-series (1981–2013, including auto-correlation). The application of 20% TAC change limits above B_{pa}, as proposed in the LTMS, could limit the potential yield for the fishery. This is because once the stock has been estimated to be below B_{pa} a large reduction in TAC can occur, whereas the TAC cannot increase by more than 20% once the stock is estimated to be above B_{pa}.

Banking and borrowing

The banking and borrowing (10%) scenarios tested indicated a negligible effect on the probability of the stock being below B_{lim} and on the long-term average catch.

Suggestions

Trade-off between F target and advice variability

F targets lower than F_{MSY} lead to less interannual variability in TAC. The SSB from recent assessments has been shown to be uncertain. This large uncertainty in estimated SSB means that management will be more stable if a lower F is applied, allowing the stock size to grow further above B_{pa}. The lower the target F, the further the SSB will be from B_{pa} on average, with less chance of large reductions in TAC based on an incorrect perception of the stock being below B_{pa} or B_{lim}.

TAC change limits

The evaluation of the 20% TAC change limits above B_{pa} showed that large reductions in TAC (>50%) could occur when the SSB fell below B_{pa} and TAC constraints no longer applied. Once the stock recovered above B_{pa} the 20% TAC change limits led to a loss in potential catch because of the restrictive 20% increase in TAC being applied to a low starting point. Managers may therefore wish to reconsider the TAC change limits from the HCR or to explore alternative stabilizing mechanisms.

ICES notes that the 20% TAC change constraints are not balanced. If the TAC is decreased by 20% one year, and increased by 20% the next year, it will return to a value lower than the initial starting point. Ideally, for balanced changes the TAC decrease limit should be the inverse of the TAC increase limit, i.e. 1/(TAC increase limit). This could be relevant to the management of blue whiting fisheries, given the uncertainty in the assessment. The 20% change limits may well be reached in alternating years as the perception of the stock goes up and down: if the stock is perceived to be very low in one year a 20% TAC decrease may be advised; if the stock is perceived to be high again in the next year and a 20% increase is advised, the TAC would then still be 4% lower than its original value.

Basis of the advice

Background

The previous management strategy for blue whiting was discontinued in 2015 and the ICES MSY approach was used to give catch advice for 2016 (ICES, 2015a). ICES was requested by NEAFC to conduct an evaluation of a new long-term management strategy as outlined in the full request description above.

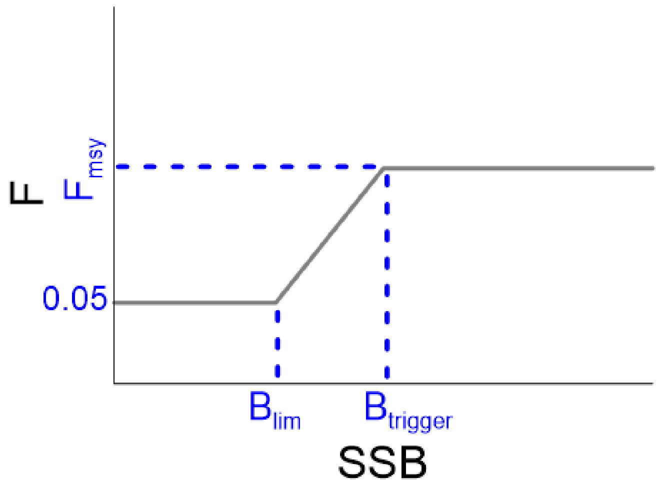

Figure 9.4.2.1 Diagram of the requested long-term management strategy to be evaluated for blue whiting. $B_{trigger} = B_{pa}$.

Biological reference points

At the WKBWMSE workshop (ICES, 2016a) the reference points were re-evaluated and it was concluded that B_{lim} and B_{pa} should remain unchanged (1.5 million t and 2.25 million t, respectively). F_{MSY} (0.32) was re-evaluated using standard ICES software and following the ICES guidelines for biological reference points. There is considerable uncertainty in the setting of appropriate F_{MSY} values for this stock, and ultimately precautionary considerations limit the maximum F (less than 5% probability of SSB < B_{lim} in the long term).

Results and conclusions

ICES performed stochastic simulations, using two different simulation tools (SimpSIM and HCS), for a range of settings to test whether the proposed LTMS is in accordance with the precautionary approach and whether it could produce high long-term yield. A range of F target values was also examined, but no alternative biomass trigger points were tested. Simulation results are presented as time-series, with results summarized over the short term (first 5 years) and the long-term equilibrium (last 50 years of the 100-year simulation). The long-term equilibrium results are not influenced by the starting points of the simulations and should be used for comparison between scenarios and not as forecasts of absolute quantities.

Evaluation of the management strategy

a. *Proposed target F=0.32 for the management strategy, with 20% TAC change limits above B_{pa}*

The proposed LTMS ensures that the size of the stock is maintained above B_{lim} with high probability (Figures 9.4.2.2 and 9.4.2.3). Long-term average catch fluctuates around 750 kt although there is a large variation in catch over time, caused mainly by the fluctuating size of year classes entering the fishery. The 20% TAC limits are often applied, reducing interannual variability in yield compared to an HCR with no TAC change limits. Once the stock falls below B_{pa} and TAC change limits no longer apply, the HCR leads to large reductions in TAC. When the stock subsequently recovers above B_{pa}, the 20% TAC change limits only allow for the TAC to increase slowly over the following 5–15 years (Figures 9.4.2.2 and 9.4.2.3). This implies extended periods where the applied F is below the target F and low catches are taken.

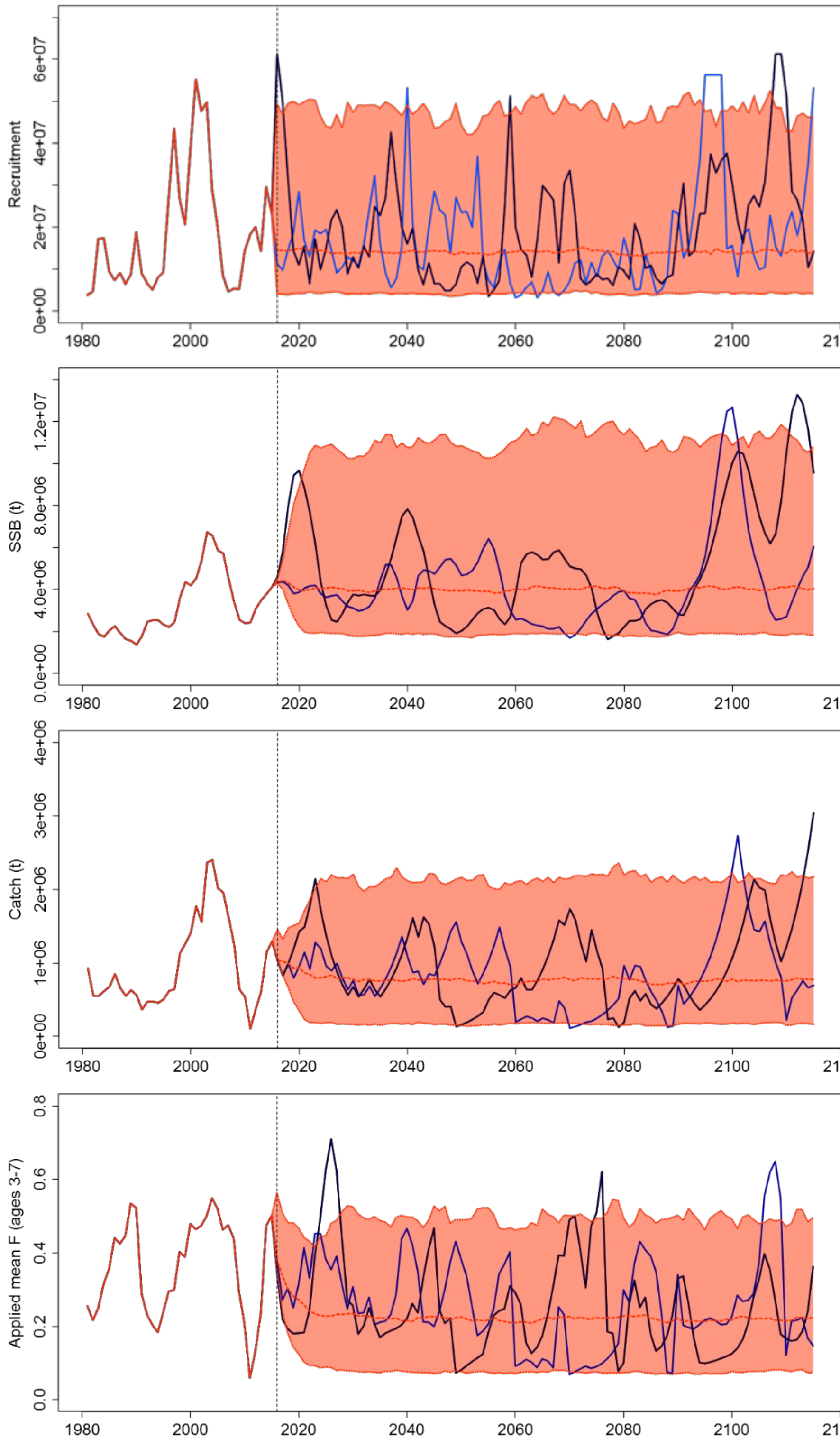

Figure 9.4.2.2 Recruitment (top panel), SSB (second panel), catch (third panel), and applied mean F (bottom panel) from the SimpSIM simulation of the proposed HCR (no banking and borrowing). Median values (dashed red lines), the 90% range (between the 5th and 95th percentiles, shaded area), and two iterations (blue and black lines) are plotted.

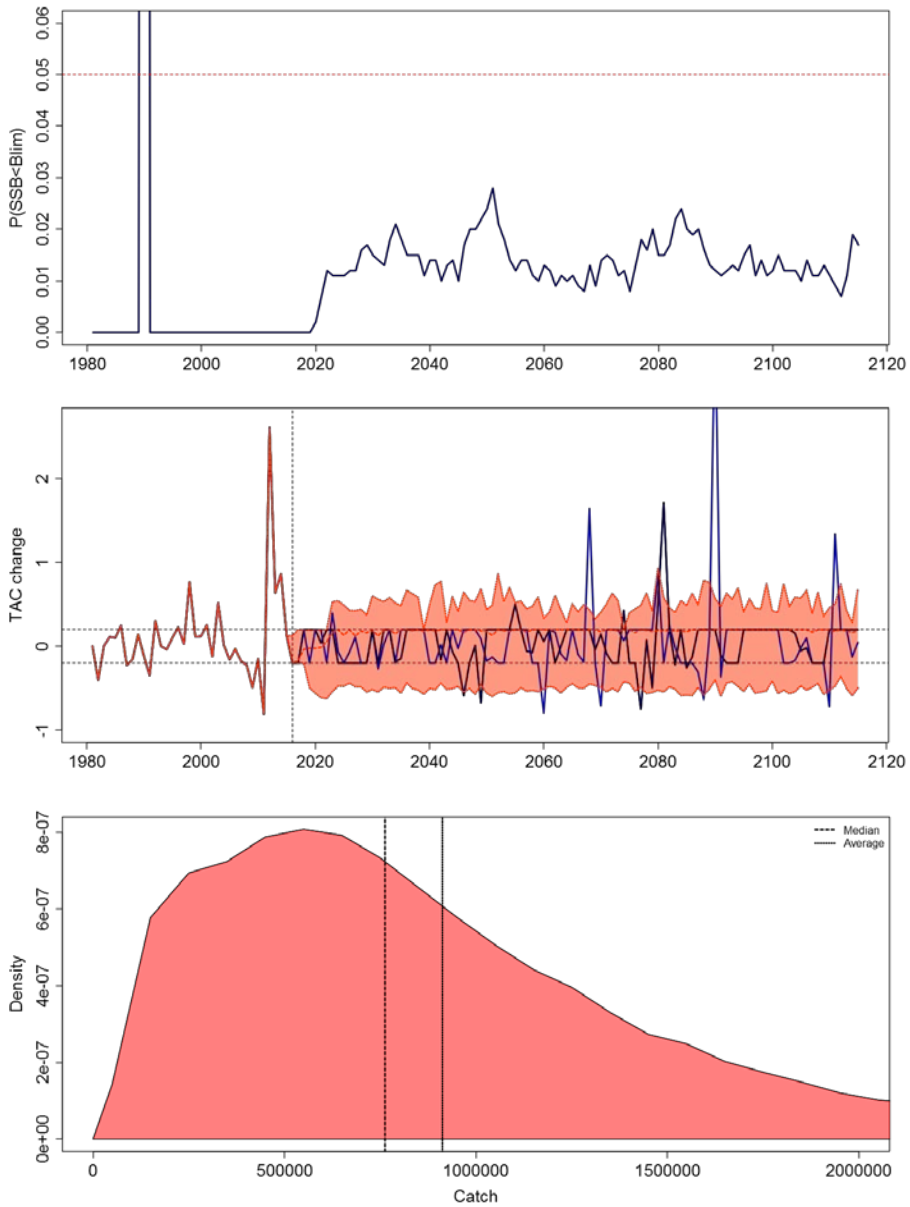

Figure 9.4.2.3 The annual probability of SSB < B_{lim} (top panel; dashed line indicates 5% probability), interannual TAC change (middle panel; median values (dashed red lines), the 90% range (between the 5th and 95th percentiles, shaded area), and two iterations (blue and black lines) are plotted), and the density distribution of long-term catch (bottom panel; vertical lines indicate median and average values).

b. Interannual quota flexibility

Always applying 10% banking or 10% borrowing annually has minimal impact on the probability of the stock going below B_{lim}. While it is recognised that there are other ways of applying the banking and borrowing in practice, the impact of this on the probability of going below B_{lim} would be limited because the scheme is suspended when the stock is forecast to go below B_{pa} at the end of the TAC year (Rule 10 in the LTMS). Previous advice issued by ICES has shown that banking and borrowing of 10% generally does not have a significant impact on the stock size (ICES, 2013a, 2013b).

Evaluation of other options

a. Trade-off between F target and advice variability

The interannual variability in catch would decrease with a lower F target in the HCR (Figure 9.4.2.4). This is because the higher the target F, the lower the SSB in the long term. The lower the SSB, the more likely it is to be perceived as being below the trigger points of the HCR (B_{pa}, B_{lim}) because of assessment uncertainty. As a result, the F applied from the HCR is often lower than the target F. In the long term this means that the average realised F is lower than the target F. With a target F = 0.32, the average realised F in the long term is within the range of 0.07–0.50 (median 0.22).

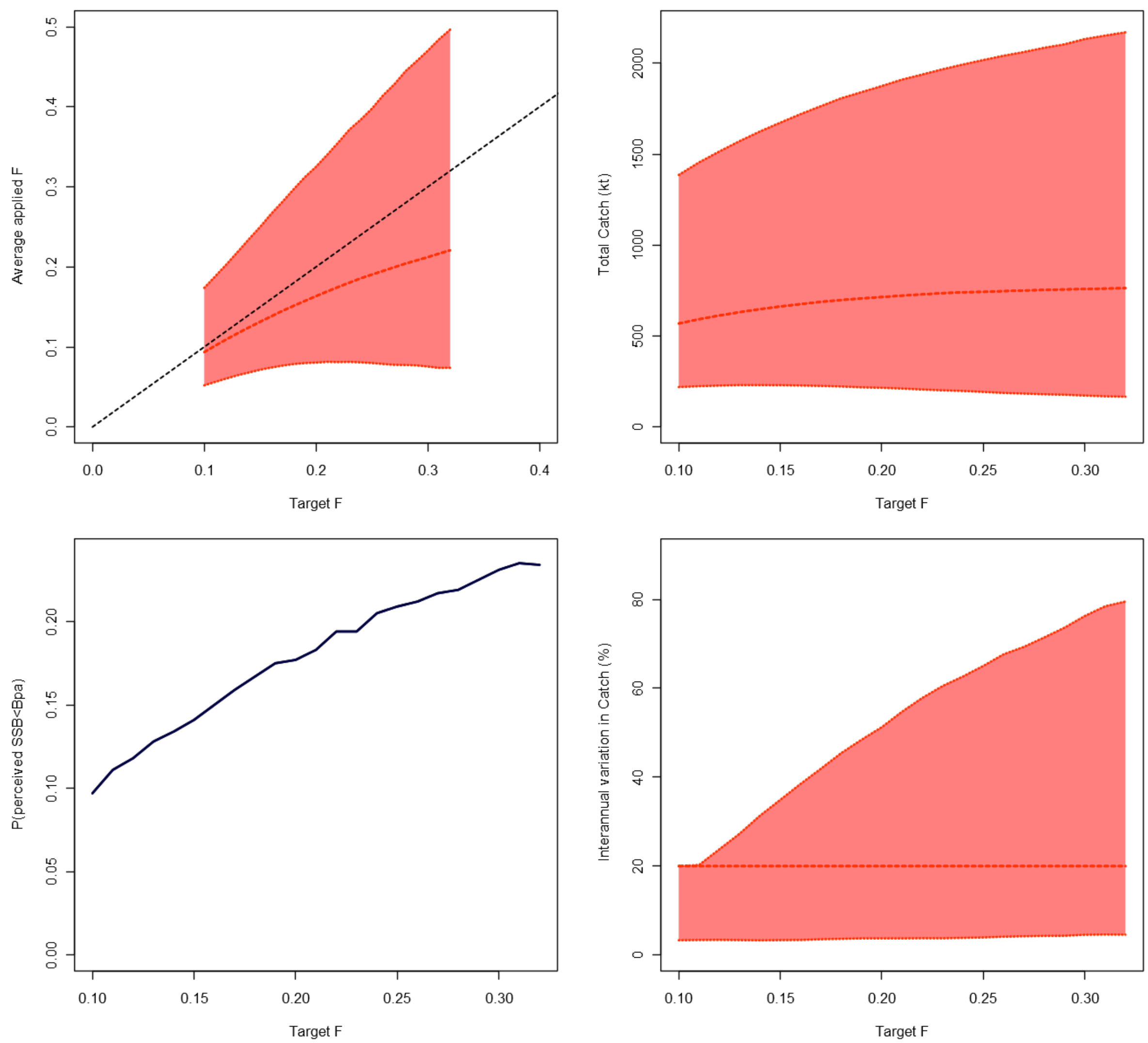

Figure 9.4.2.4 Comparison of target F (0.1–0.32) in the proposed HCR versus applied (realised) fishing mortality (top left), catch (top right), probability of perceived SSB< B_{pa} (bottom left), and interannual variation in catch (bottom right). Median values (red lines) and the 90% range (between the 5th and 95th percentiles, shaded area) are plotted. Results are shown for the long-term equilibrium situation (last 50 years of the simulations).

b. *Additional TAC change limit scenarios*

The large uncertainty in annual assessments for this stock could lead to the stock being perceived to be below B_{pa} even if it is larger. As a result, TAC reductions of greater than 20% may be applied. The three following alternative TAC change limit scenarios were explored.

When applying the 20% TAC change limits above B_{lim}, there can still be very sharp reductions in TAC once the stock is below B_{lim}, and the problem of gradual increase of the TAC thereafter (limited to 20% once the stock is above B_{lim}) remains. Overall the probability of dropping below B_{lim} is higher than when the TAC change limits only apply above B_{pa}, although it remains less than 5% in the long term and long-term interannual variation in TAC is reduced.

When always applying the 20% TAC change limits, the probability of reducing the stock below B_{lim} increases substantially, with some simulations crashing the stock from lack of responsiveness in the HCR. Starting from a catch of more than 1 million tonnes, the 20% change limits do not allow the catch to reduce quickly enough after a period of sustained low recruitment (as has been observed to occur in the past). This option is not considered to be precautionary.

If TAC change limits are never applied the HCR is still found to be precautionary. However, this leads to a much higher interannual variation in advised TAC.

Sensitivity to assumptions and methodology

All HCRs were tested using two different recruitment scenarios. One based on the whole time-series (base case), including every year from 1981 to 2013. Another one was based on a shorter time-series where years of extremely high and extremely low recruitment were eliminated (sensitivity check, using the years 1981–1994 and 2010–2013). In the SimpSIM simulations, the lower recruitment scenario leads to lower average catch. The probability of SSB being less than B_{lim} remains below 5% in both scenarios. The probability is actually lower in the low recruitment scenario because of less autocorrelation in recruitment, leaving fewer extended periods of low recruitment that can interact with overestimation of the stock to drive it down to a low SSB.

Comparisons of the results from the SimpSIM and HCS tools were made for a range of target F values and alternative scenarios of the application of TAC change constraints (see WKBWMSE report; ICES, 2016a). In general the SimpSIM evaluations have a broader range of observed SSB over time because of the autocorrelation included in the recruitment. Extended periods of low recruitment will lead to the stock reaching lower levels than may be observed when these are broken up with occasional spikes in recruitment (as are generated in HCS). The main performance consideration, i.e. $P(SSB< B_{lim})$, is in both cases less than 5% in the long run for target F = 0.32 with 20% TAC change limits above B_{pa}.

Summary of results

Selected summary statistics of the key runs done in this evaluation are provided for the long-term equilibrium (Table 9.4.2.1) and the short term (2016–2020; Table 9.4.2.2). Note: in the short term, HCS and SimpSIM are not comparable. SimpSIM uses fixed initial numbers, HCS uses stochastic initial numbers with a large CV.

Table 9.4.2.1 Summary of long-term equilibrium performance statistics for different versions of the HCR in the SimpSIM and HCS simulations. No 'banking and borrowing' was applied in the SimpSIM simulations.

	SimpSIM					HCS		
	Proposed HCR	No change limits	20% above B_{lim}	20% always	Proposed HCR	Proposed HCR	Banking	Borrowing
Recruitment	Base case recruitment (whole time-series), autocorrelation				Excluding recruitment extremes	Base case recruitment (whole time-series), no autocorrelation		
Avg. catch	911	978	890	707	608	645	642	645
Median catch	763	786	754	597	552	635	633	635
10th perc. of catch	240	288	204	0	222	84	83	84
Median SSB	4020	3732	4256	3106	3055	6135	6144	6145
10th perc. of SSB	2141	2169	2131	0	2086	2980	2987	3008
P(SSB< B_{lim})	2.4	1.5	3.3	37.3	1.0	0.4	0.3	0.3
P(SSB< B_{pa})	14.8	13.9	14.0	43.4	18.6	10.5	10.5	10.5
IAV*	28.4	54.2	21.2	36.2	31.3	27.1	27.1	27.0
P(>50% reduction in catch)	5.2	12.4	3.2	24.7	6.7	N/A	N/A	N/A
SD of catch as proportion of mean	0.71	0.75	0.73	0.94	0.57	N/A	N/A	N/A

* Calculated differently between SimpSIM (change vs. previous year) and HCS (change vs. mean of previous and current years).
N/A = Not available

Table 9.4.2.2 Summary of short-term (2016–2020) performance statistics for different versions of the HCR in the SimpSIM and HCS simulations. No 'banking and borrowing' was applied in the SimpSIM simulations.

	SimpSIM					HCS		
	Proposed HCR	No change limits	20% above B_{lim}	20% always	Proposed HCR	Propose d HCR	Banking	Borrowing
Recruitment	Base case recruitment (whole time-series), autocorrelation				Excluding recruitment extremes	Base case recruitment (whole time-series), no autocorrelation		
Avg. catch	1011	1037	1002	1032	935	399	399	400
Median catch	1033	971	1030	1033	964	526	526	527
10th perc. of catch	689	536	706	759	636	13	13	13
Median SSB	4344	4379	4335	4335	4209	5057	5008	5081
10th perc. of SSB	3155	3310	3170	3135	2943	2844	2296	2354
P(SSB< B_{lim})	0.2	0.0	0.1	0.3	0.0	4.3	4.3	4.3
P(SSB< B_{pa})	5.7	3.5	5.7	6.3	6.0			
IAV*	20.0	46.8	17.7	16.5	20.1	41.3	41.4	41.2
P(>50% reduction in catch)	2.9	12.5	2.1	0.0	3.8	N/A	N/A	N/A
SD of catch as proportion of mean	0.28	0.46	0.25	0.23	0.26	N/A	N/A	N/A

* Calculated differently between SimpSIM (change vs. previous year) and HCS (change vs. mean of previous and current years).
N/A = Not available

Methods

All simulations were conditioned on the most recent benchmark assessment of the stock (ICES, 2016b). The simulations were conducted using two different tools: HCS and SimpSIM.

HCS

HCS is a single-stock, single-fleet program for stochastic simulation of harvest control rules. It has evolved over a number of years and has been used for several ICES stocks (see ICES, 2013a, 2013b). The present version is HCS15_1 (Skagen, 2015), with some small amendments. Stochasticity was implemented in initial stock numbers, recruitment, and observation parts of the model. Natural mortality, maturation, weights-at-age, and fisheries selectivity were deterministic. The simulations were run for 100 years using 1000 iterations.

The 'true' stock numbers were modified by an observation model to provide stock numbers for the decision process. This observation model mimics the total uncertainty expected from the SAM assessment for this stock. In the decision process, a short-term forecast is conducted making a geometric mean assumption on recruitment in the intermediate year.

SimpSIM

For the purposes of this evaluation, the EQSIM simulation code (see ICES, 2015b) has been adapted to function also as a non-equilibrium simulator, SimpSIM. SimpSIM was developed with the intention of creating a harvest control rule simulation program similar in concept and philosophy, but programmed in the R language (R Core Team, 2015). R version 3.1.3 (2015-03-09) – "Smooth Sidewalk" – was used to run the simulations.

EQSIM was altered to start the long-term simulations from specific stock numbers-at-age, and with specific initial catches or F, and to output the time-series of stock numbers and fishing mortality-at-age rather than simply long-term equilibrium reference points. The forecasting procedure, handling of uncertainty and advice error, and the flexibility to include multiple recruitment models (including auto-correlation in recruitment) remains the same as EQSIM. Like HCS it is an age-disaggregated simulation model that imitates assessment/advice error. However, this error is applied directly to the 'true' SSB and/or F in the advice year rather than to the numbers-at-age in the final assessment year. As such no forecast procedure is mimicked (inputted SSB and F uncertainty is calculated for the advice year).

Comparison of simulation tools

For both models, two different recruitment scenarios were applied, segmented regression models with a breakpoint at B_{loss} with the recruitment plateaus determined by: (1) all years from 1981 to 2013, and (2) a shorter series which includes years from 1981 to 1994 and from 2010 to 2013. The key difference between the simulated recruitment from the two tools was that autocorrelation in recruitment was applied in the SimpSIM simulations, while the HCS generated spikes in recruitment without autocorrelation.

Selectivity of the fishery and the weight-at-age and maturity of the fish were taken from the last five years (2010–2014).

Advice error was determined by examining historical advice sheets back to 2006 and comparing the forecasted SSB and F used in advice to what the values are now estimated to be.

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