NEAFC request to evaluate a harvest control component of a long-term management plan for haddock at Rockall

Advice summary

ICES has evaluated the harvest control rules (HCRs) proposed for haddock in Division 6.b (Rockall) and advises that they are considered precautionary in the short, medium, and long term under the assumption of intermediate levels of productivity.

The HCRs are considered precautionary in the long term under most robustness test scenarios. The HCRs with TAC constraint rule (a) in the request are precautionary in the long term under all scenarios, except those with very low recruitment. If recruitment is very low (as observed between 2007 and 2012) for a long time period, without sporadic recruitment peaks, none of the HCRs are precautionary in the long term. TAC constraint rule (a) generally leads to lower probability of SSB < B_{lim} than constraint rule (b), both in the short and long term.

Request

NEAFC requests ICES to evaluate the following proposal for the harvest control component of a long-term management plan for Rockall haddock (HAD.27.6.b) and in particular to consider whether the plan is consistent with the precautionary approach and will provide for the sustainable harvesting of the stock. If the plan fails to be precautionary ICES will also be asked to suggest possible options to bring the plan aligned with the precautionary approach.

NEAFC proposal for harvest control component of a long-term management plan for haddock at Rockall:

In the following, the TACs refer to total catches, not just landings.

1. Every effort shall be made to maintain a level of Spawning Stock Biomass (SSB) greater than B_{pa} and a minimum level of SSB greater than B_{lim}. $SSBF_{tar}$ denotes the SSB at the end of the year in which the TAC is applied, assuming F_{tar}= F_{MSY} during that year. No iterative process is involved anywhere in the calculations in paragraphs 2–5.

2. For [20XX] and subsequent years the Parties agreed to set a TAC to be consistent with a fishing mortality rate of no more than F_{MSY} (as estimated by ICES) for appropriate age-groups, when the SSB in the end of the year in which the TAC is applied ($SSBF_{tar}$) is estimated above B_{pa}.

3. The Parties agree that the TAC that results from the application of the fishing mortality referred to in paragraph 2 will be adjusted according to either of the following rules:

*a. TACy = TACf + 0.2 * (TACy-1 – TACf)*

where TACy is the TAC that is to be set by the management plan, TACy-1 is the TAC that was fixed the previous year and TACf is the TAC resulting from the provisions in paragraphs 1 and 2.

Or

b. Where the rules in paragraph 2 would lead to a TAC, which deviates by more than 20% below or 25% above the TAC of the preceding year (TACy-1), the Parties shall fix a TAC that is respectively no more than 20% less or 25% more than the TAC of the preceding year.

4. Where SSBFtar is estimated to be below B_{pa} but above B_{lim}, the TAC shall not exceed a level, which will result in a fishing mortality rate equal to

$F_{MSY} - [(F_{MSY} - F_{low}) \times (B_{pa} - SSBF_{tar}) / (B_{pa} - B_{lim})]$, where F_{low} = 0.1 or 0.05 or 0.

This consideration overrides paragraph 3.

5. Where $SSBF_{tar}$ is estimated to be below B_{lim} the TAC shall be set at a level corresponding to a total fishing mortality rate of no more than Flow = 0.1 or 0.05 or 0.

This consideration overrides paragraph 3.

6. The Parties shall review and if deemed necessary, revise this long-term management plan at the latest in [20XX] on the basis of, inter alia, the ICES benchmark report. If the Parties receive new and relevant information, an earlier review of the management plan will be considered.

Intended use of the request output

The long-term management strategy evaluations will inform the management of haddock at the Rockall area.

Elaboration on the advice

Six management options were tested with a management strategy evaluation (MSE). The three HCR options provided by the requesting parties differ in the reduction of F if SSB is below B_{PA} (B_{PA} = MSY $B_{trigger}$; see Figure 1). These HCRs are combined with two alternative TAC constraint rules (a, b) that are applied if SSB is above B_{PA}, resulting in a total of six HCR options to be tested in the MSE. Rule (a) refers to TAC constraint rule $TAC_y = TAC_f + 0.2 \times (TAC_{y-1} - TAC_f)$. Rule (b) refers to a TAC constraint of no more than 20% less or 25% more than the TAC of the preceding year.

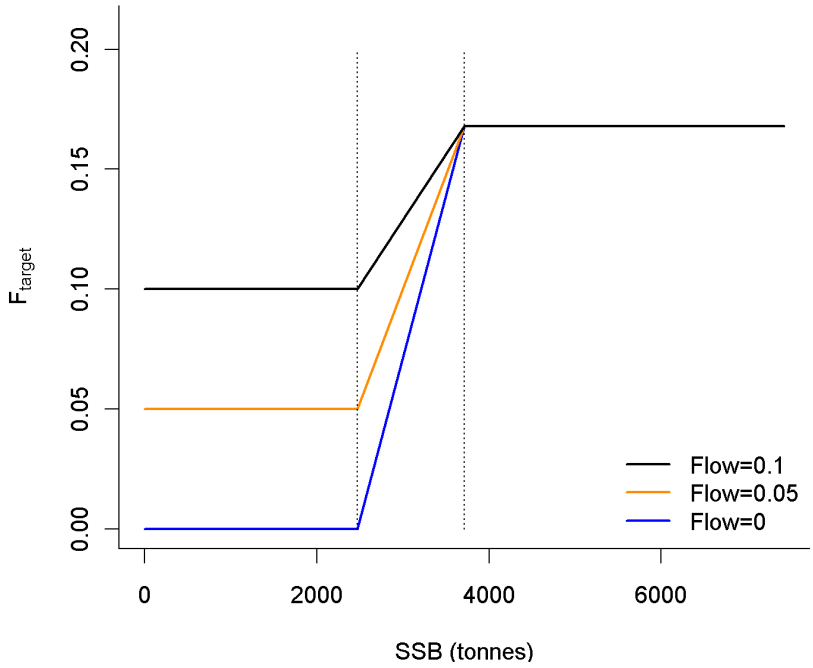

Figure 1 Graphic illustration of the requested harvest control rules depending on F_{low}. B_{lim} and B_{pa} (B_{PA} = MSY $B_{trigger}$) are shown as vertical dotted lines.

For the purposes of this advice, short term refers to the first five years, medium term to years 6–10, and long term to years 11–20 of the projection period. The MSE approach was to model the assessment and forecast in the management procedure (MP), as implemented by ICES, to mimic the assessment and advice process as closely as possible.

The operating model (OM) used as the baseline OM (OM0) was the accepted benchmark assessment, using recruitment based on historical data, weights-at-age sampled from the recent ten years, knife-edge maturity at age 3, natural mortality

M = 0.2 for all ages and years in OM and MP, and without implementation error in the projection period. Robustness tests were carried out using eight alternative operating models (Table 1).

Table 1 Alternative operating models (OM) for robustness tests.

Alternative OM	Difference to baseline OM0 projection
OM1	Low recruitment level
OM2	Misspecification of M (OM: M = 0.3; MP: M = 0.2)
OM3	Misspecification of maturity (OM: knife-edge age 2; MP: knife-edge age 3)
OM4	Misspecification of M (OM: M = 0.1; MP: M = 0.2)
OM5	Weights-at-age sampled from the recent 20 years
OM6	Weights-at-age sampled from the recent 20 years Misspecification of M (OM: M = 0.3; MP: M = 0.2) Low recruitment level
OM7	Implementation error
OM8	Very low recruitment level

Basis of the advice

Background

The haddock stock at Rockall (Division 6.b) is a stock separate from that on the continental shelf of the British Isles. Rockall haddock have a lower growth rate and reach a lower maximum size than other haddock populations in the Atlantic. This stock shows the characteristics of typical haddock stocks in having no apparent stock–recruitment relationship. For example, recruitment between 2007 and 2012 was extremely low despite a moderately large SSB, while low SSB in 2012 and 2013 produced moderate recruitment.

Discussions between the European Union (EU) and the Russian Federation (RF) on possible joint management measures for the Rockall haddock fishery began almost 20 years ago following changes in the EU Exclusive Economic Zone (in 1999) which led to a renewal of the RF haddock fishery at Rockall. Meetings involving scientists and fisheries managers from both the EU and the RF were held on an almost annual basis for a period of around ten years from 2001 onwards to determine what is known about the fisheries, and how such information should be used to develop a productive and sustainable management system. A proposal for a joint EU–RF management plan (MP) for Rockall haddock was first presented to NEAFC in 2010. A series of special requests to ICES followed, requesting that the first MP, and subsequent modified versions of the MP, be evaluated (ICES, 2011, 2012a, 2012b, 2013a). The previous analysis (ICES, 2013a) suggested that a maximum value of F = 0.2 would be required for the HCR to be consistent with the precautionary approach, even under the low recruitment regime that was being experienced at the time (ICES, 2013b).

Results and conclusions

The stock has recently been exploited below F_{MSY} (0.168) with biomass well above MSY $B_{trigger}$ (3712 t). Short-, medium-, and long-term evaluations indicate that all six HCR options are precautionary in the baseline OM (OM0: Risk 3 and Risk 1 lower than 5%). Risk 3 refers to the maximum annual probability of SSB < B_{lim} (2474 t) within each of the evaluated time periods. Risk 1 refers to the mean annual probability of SSB < B_{lim} over the evaluated time periods (ICES, 2013c). Median long-term catches vary by less than 1% between HCRs (Table 2). In the projection period, SSB initially increases following the relatively high recruitment in 2017 and stabilizes around a median between 26 750 and 27 038 tonnes in the long term, well above B_{lim} (Table 2). Results for the full projection period are shown in Figure 2 for HCR 1a; all HCRs in the baseline OM are compared in Figure 3.

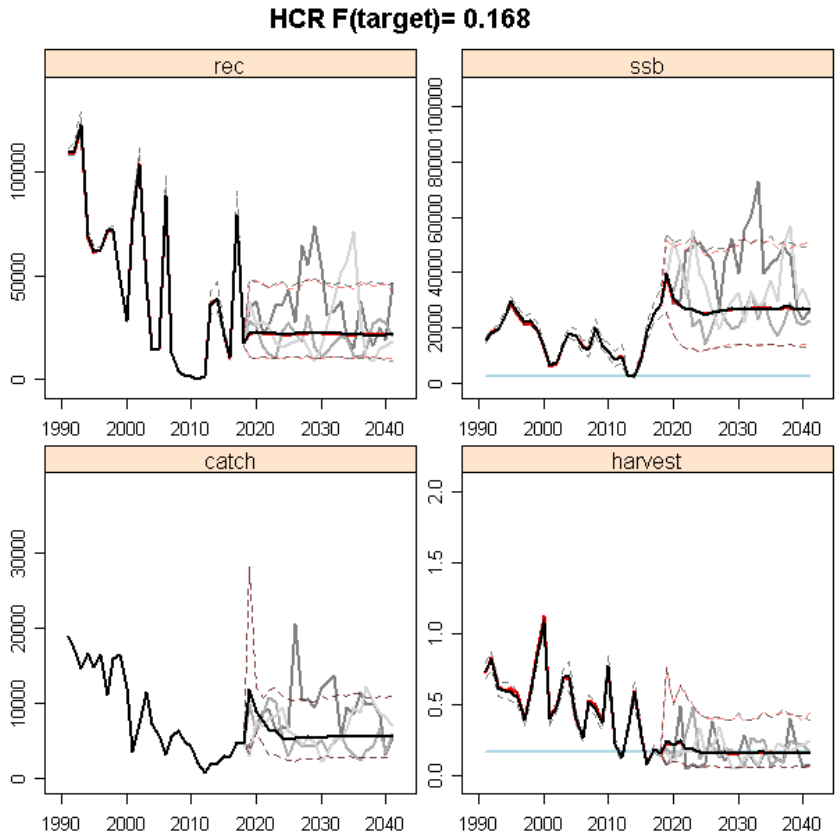

Figure 2 Results of the Rockall haddock baseline OM (OM0), HCR 1a (F_{low} = 0, TAC constraint rule a). Recruitment is in thousands, SSB and catch are in tonnes, the harvest rate is expressed as fishing mortality F_{bar} (age 2–5), OM is in red (grey: single iterations of OM), and MP in black. Medians (solid lines – MP: red, OM: black) are plotted with the 95th and 5th percentile of 1000 iterations (dashed lines – MP: red, OM: black). F_{MSY} and B_{lim} are in blue.

Table 2 Results of the Rockall haddock baseline OM (OM0) in the long term. Median values for SSB, catch, IAV (interannual catch variability), realized F_{bar} (ages 2–5), as well as Risk 3 (the maximum annual probability of SSB < B_{lim} in years 11–20 of the projection) and Risk 1. HCR 1: F_{low} = 0, 2: F_{low} = 0.05, 3: F_{low} = 0.1 with TAC constraint options a or b.

HCR	F_{low}	SSB (t)	Catch (t)	IAV (%)	Risk3 (%)	Risk1 (%)	Realized F_{bar} (2–5)
1a	0	26750	5631	24	0	0	0.161
1b	0	26876	5635	20	0.3	0.06	0.1625
2a	0.05	26750	5631	24	0	0	0.161
2b	0.05	27038	5615	20	0.3	0.06	0.162
3a	0.1	26750	5631	24	0	0	0.161
3b	0.1	26898	5631	20	0.3	0.06	0.1625

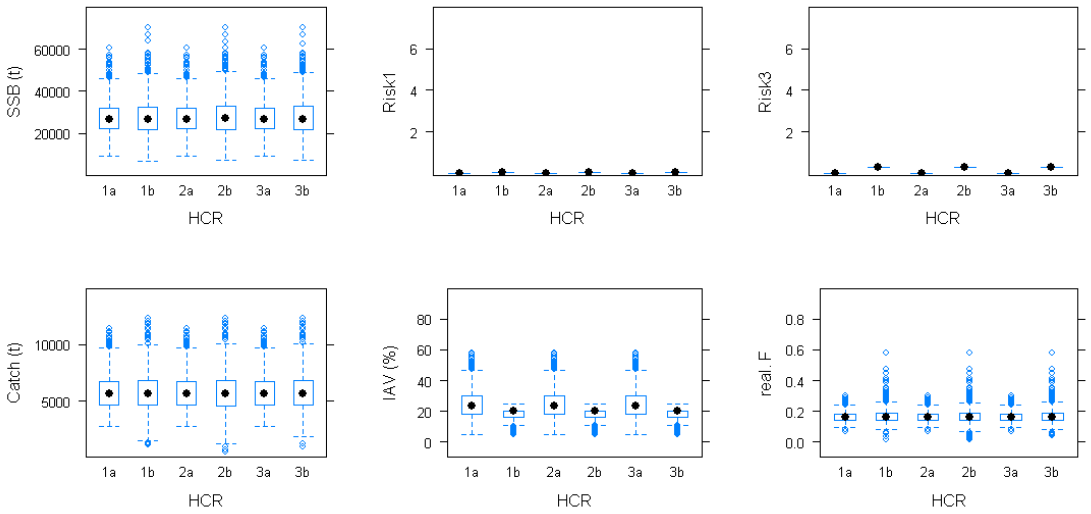

Figure 3 Results of the Rockall haddock baseline OM (OM0), in the long term (year 11–20). Black dots indicate median values of SSB for Risk 1, Risk 3, Catch, IAV (interannual catch variability), and realized F_{bar} (ages 2–5). HCR 1: $F_{low} = 0$; HCR 2: $F_{low} = 0.05$; HCR 3: $F_{low} = 0.1$ with AC constraint options a or b.

Robustness tests

All HCRs are precautionary in the short, medium, and long term under the alternative OMs OM3, OM4, and OM7.

HCRs with constraint rule (a) are also precautionary in the short, medium, and long term under OM1, OM2, and OM5. In contrast, under alternative OM1 (low recruitment), HCRs with constraint rule (b) are not precautionary in the short term. Under alternative OM2 (M = 0.3) and OM5 (lower catch weights), HCRs with constraint rule (b) are not precautionary in the short and medium term.

Under OM6, combining low recruitment level with low weights-at-age and misspecification of natural mortality (M = 0.3), all HCRs are not precautionary in the short and medium term. In the long term, only HCRs with constraint rule (a) are precautionary. In all time periods, HCRs using TAC constraint rule (a) show lower risks of SSB falling below B_{lim} than rule (b) (Tables 3 and 4).

Under OM8 (very low recruitment, Figure 4) all HCRs are not precautionary, with risks of SSB falling below B_{lim} being above 5% in the medium and long term. In the short term only HCRs using constraint rule (a) are precautionary. With rule (a), HCRs show lower risks in the short, medium, and long term. In the long term, HCRs with $F_{low} = 0$ showed lower risk than other HCRs (Figure 5).

For all alternative OMs, long-term median catches and SSB are compared among HCR options in Tables 5 and 6.

Table 3 Short-term risk (year 1–5) for Rockall haddock. Risk 3 (maximum annual probability SSB < B_{lim}) in %. Shaded cells indicate risk probabilities higher than 5% of SSB falling below B_{lim}. HCR 1: F_{low} = 0; HCR 2: F_{low} = 0.05; HCR 3: F_{low} = 0.1 with TAC constraint option a or b.

HCR	OM0	OM1	OM2	OM3	OM4	OM5	OM6	OM7	OM8
1a	0.1	0.7	1.1	0	0	1.9	5.5	0	4.2
1b	0.8	5.3	5.6	0.1	0.2	7.8	26.8	0.8	21.9
2a	0.1	0.7	1.1	0	0	1.9	5.5	0	4.2
2b	0.9	5.3	5.6	0.1	0.2	8.2	27.1	0.8	23
3a	0.1	0.7	1.1	0	0	1.9	5.5	0	4.3
3b	0.9	5.4	5.6	0.1	0.2	8.3	27.7	0.8	23.7

Table 4 Long-term risk (year 11–20) for Rockall haddock. Risk 3 (maximum annual probability SSB < B_{lim}) in %. Shaded cells indicate risk probabilities higher than 5% of SSB falling below B_{lim}. HCR 1: F_{low} = 0; HCR 2: F_{low} = 0.05; HCR 3: F_{low} = 0.1 with TAC constraint option a or b.

HCR	OM0	OM1	OM2	OM3	OM4	OM5	OM6	OM7	OM8
1a	0	0.1	0.2	0	0	0.2	2.2	0	8.3
1b	0.3	1.4	1.8	0.1	0.1	0.7	6.5	0.2	8.2
2a	0	0.1	0.2	0	0	0.2	2.2	0	10.7
2b	0.3	1.4	1.9	0.1	0.1	0.7	6.6	0.2	11.6
3a	0	0.1	0.2	0	0	0.2	2.2	0	13
3b	0.3	1.6	2	0.1	0.1	0.7	7.4	0.3	17.7

Table 5 Long-term median SSB (t) for Rockall haddock. The largest median biomass for each operating model is shaded. HCR 1: F_{low} = 0; HCR 2: F_{low} = 0.05; HCR 3: F_{low} = 0.1 with TAC constraint option a or b.

HCR	OM0	OM1	OM2	OM3	OM4	OM5	OM6	OM7	OM8
1a	26750	13372	13882	32498	60052	19312	7007	26700	4270
1b	26876	13474	14048	32837	61475	20271	7833	26872	5249
2a	26750	13372	13882	32498	60052	19312	6997	26700	4062
2b	27038	13801	14252	32927	61642	20900	8223	27199	4538
3a	26750	13372	13882	32498	60052	19312	6997	26700	3971
3b	26898	13422	13965	32835	61642	20469	7633	26984	4094

Table 6 Long-term median catch (t) for Rockall haddock. The largest median catch for each operating model is shaded. HCR 1: F_{low} = 0; HCR 2: F_{low} = 0.05; HCR 3: F_{low} = 0.1 with TAC constraint option a or b.

HCR	OM0	OM1	OM2	OM3	OM4	OM5	OM6	OM7	OM8
1a	5631	2904	3644	5682	9593	4119	1873	5551	840
1b	5635	2769	3487	5682	9817	3918	1674	5548	630
2a	5631	2904	3644	5682	9593	4119	1874	5551	849
2b	5615	2763	3464	5669	9817	3789	1697	5531	777
3a	5631	2904	3644	5682	9593	4119	1874	5551	846
3b	5631	2776	3497	5676	9817	3885	1780	5547	792

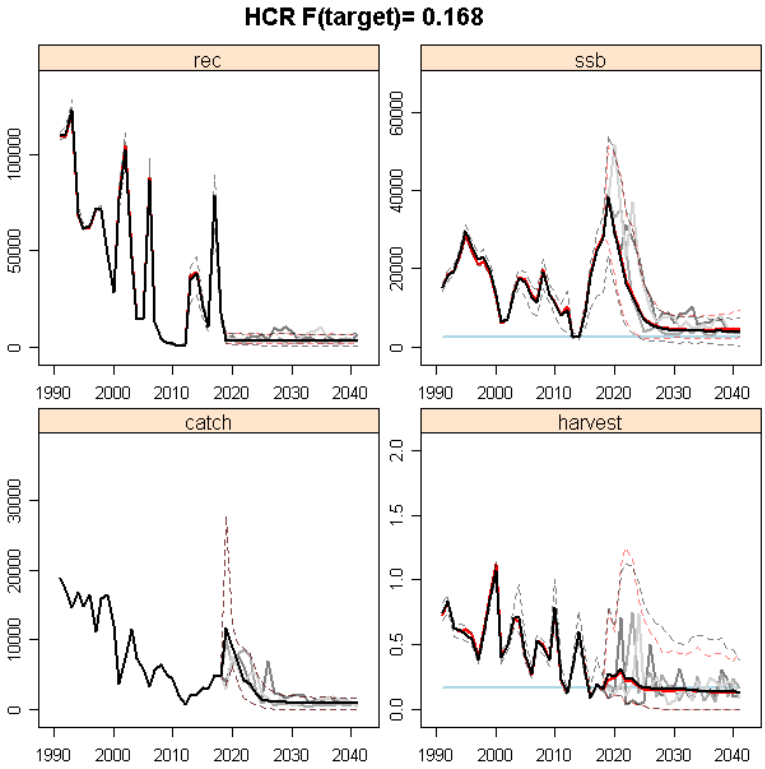

Figure 4 Results under OM8 (very low recruitment) for Rockall haddock, HCR 1a (F_{low} = 0, TAC constraint rule a). Recruitment is in thousands, SSB and catch are in tonnes, the harvest rate is expressed as fishing mortality F_{bar} (age 2–5), OM is in red (grey: single iterations of OM), and MP in black. Medians (solid lines – MP: red, OM: black) are plotted with the 95th and 5th percentile of 1000 iterations (dashed lines – MP: red, OM: black). F_{MSY} and B_{lim} are in blue.

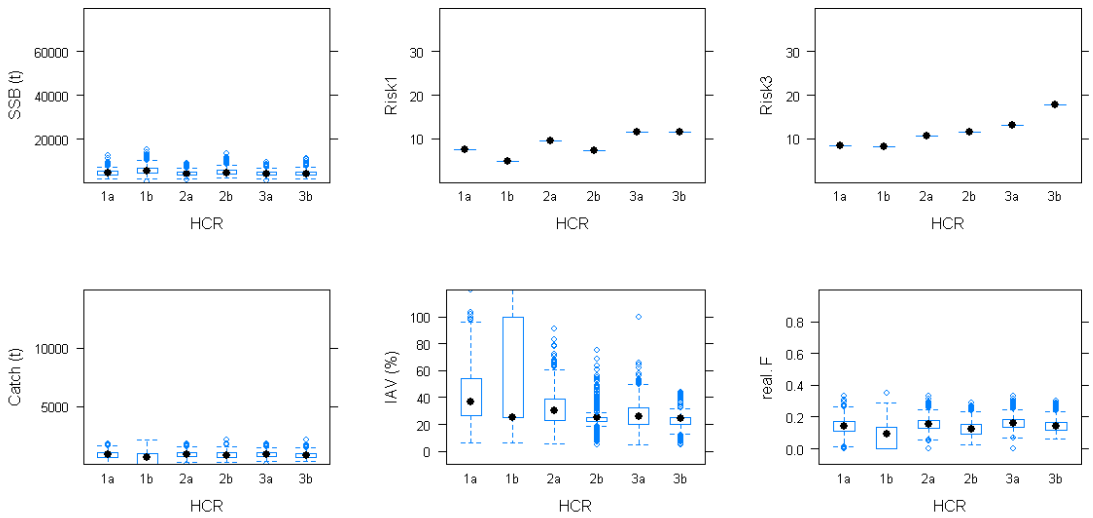

Figure 5 Results under OM8 (very low recruitment) for Rockall haddock in the long term (year 11–20). Black dots indicate median values of SSB for Risk 1, Risk 3, Catch, IAV (interannual catch variability), and realized F_{bar} (ages 2–5). HCR 1: $F_{low} = 0$; HCR 2: $F_{low} = 0.05$; HCR 3: $F_{low} = 0.1$ with AC constraint options a or b.

Methods

The management strategy evaluation (MSE) was conducted using the Fisheries Library for R (FLR; Kell *et al.,* 2007) framework and making use of a full feedback approach (i.e. not using a "short-cut" approach to generate assessment error), as described in ICES (2013c) and Punt *et al.* (2016). In this approach, the assessment model used in the simulations is exactly the same as the one used by ICES to conduct annual assessments (as described in the stock annex – ICES, 2019a), having exactly the same model settings and the same type of data. For this stock, the assessment model used is Extended Survivor Analysis (XSA) and the input data consist of catch (landings and discards) numbers-at-age plus an annual survey index, together with assumptions on natural mortality and maturity ogive. The MSE also incorporates the same assumptions used for conducting the short-term forecast through the intermediate year to the start of the TAC year where possible. The exception to this is the use of RCT3 and the 0-group survey index in the "true" forecast, while an 0-group index is not available from the OM in the MSE projection. Instead, the recruitment-at-age 1 was assumed to be the 25% percentile rank of the entire recruitment time-series since 1991.

A 25-year projection period was adopted as this was considered long enough that the effects of initial numbers had largely dissipated by the time the long-term phase had been reached (years 11–20) and median SSB had stabilized (WKNSMSE: ICES, 2019b). Current guidelines suggest 1000 replicates should be the default and that was considered adequate (ICES, 2016).

A key part of the MSE is the inclusion of uncertainty. This is introduced through the operating model (OM) by including parameter uncertainty (resampling of mean weights and fishery selectivity from most recent ten years in the assessment), process error (in recruitment), observation error (when generating survey data), and implementation error (as a robustness test). Implementation error was modelled as multiplicative lognormal error on the TAC.

Recruitment was modelled by a Beverton–Holt stock–recruitment relationship fitted to stock recruit pairs from the stock assessment, with bias-corrected lognormal stochasticity and autocorrelated deviations. A validation check was conducted and this showed that recruitment generated in the future is consistent with that estimated in the past.

The base case OM was conditioned on the current ICES assessment with a number of alternative OMs used as robustness tests.

The proposed strategies were also evaluated using an approach that randomly resampled from the historical recruitment estimates (as in the previous MSE evaluation in ICES, 2013a). Results support the conclusions of the analysis presented here. More information can be found in the WKROCKMSE report (ICES, 2019c).

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