ECOREGION **Widely distributed and migratory stocks**
SUBJECT **NEAFC request to ICES to evaluate the harvest control rule element of the long-term management plan for blue whiting**

Advice summary

ICES has evaluated the reference points and concluded that B_{lim} and B_{pa} should remain unchanged. New values of $F_{pa} = 0.32$ and $F_{lim} = 0.48$ have been provided that are consistent with these biomass reference points. The corresponding MSY reference points are $F_{MSY} = 0.30$ and MSY $B_{trigger} = 2.25$ million t.

The current management plan is considered precautionary. A number of alternative F targets in the range of 0.1–0.35 were evaluated for the current harvest control rule (HCR) form and found to be precautionary up to an F target of 0.32 (corresponding to F_{pa}), with only a minimal increase in mean TAC for F targets above 0.3.

Inclusion of catch stabilization mechanisms have been tested in the current HCR and are considered precautionary as they do not increase the probability of SSB< B_{lim} above 0.05. Over the entire time period examined there are no significant differences in catch either with or without the stabilizers. The 50–50 rule may lead to considerably reduced interannual variation (IAV), but can generate high Fs during periods of stock decline and lower catches during periods of stock increase.

Initial evaluations indicate that a number of options for the newly proposed HCR form (with increasing F at high biomass) have been found to be precautionary. However, these preliminary evaluations are not considered sufficiently robust. Based on the results presented, ICES suggests that a small subset of such rules should be selected and tested further with greater rigour before they are judged suitable for precautionary management.

Testing of banking and borrowing scenarios showed very little impact of either extreme banking or borrowing. Allowing a maximum of 10% to be banked or borrowed any year is considered precautionary when used with the existing HCR.

Request

1. *"In accordance with point 7 of the Agreed Record of Fisheries Consultations between Iceland, the European Union, the Faroe Islands and Norway on the management of blue whiting in the North-East Atlantic, signed on 11 October 2011, it was agreed to conduct a review of the long-term management plan.*
2. *In order to facilitate discussions between Coastal States on possible modifications to the long-term management plan for blue whiting, ICES is requested by NEAFC, by 1 June 2013, to re-evaluate the reference points B_{lim}, B_{pa} and F_{msy} for the stock and to conduct an evaluation of the harvest control rule under the existing management plan.*
3. *ICES is further requested to evaluate the harvest control rule with the following stability mechanisms when the SSB is above B_{lim}:*

    a. *Setting a TAC in the TAC year based on the average of the projected TACs at target F over three years starting with the TAC year.*
    b. *Setting the TAC to be the average of the current TAC and the TAC that would result from the application of the harvest control rule for the TAC year.*

4. *ICES is also requested to evaluate the following approach shown in Fig 1."*

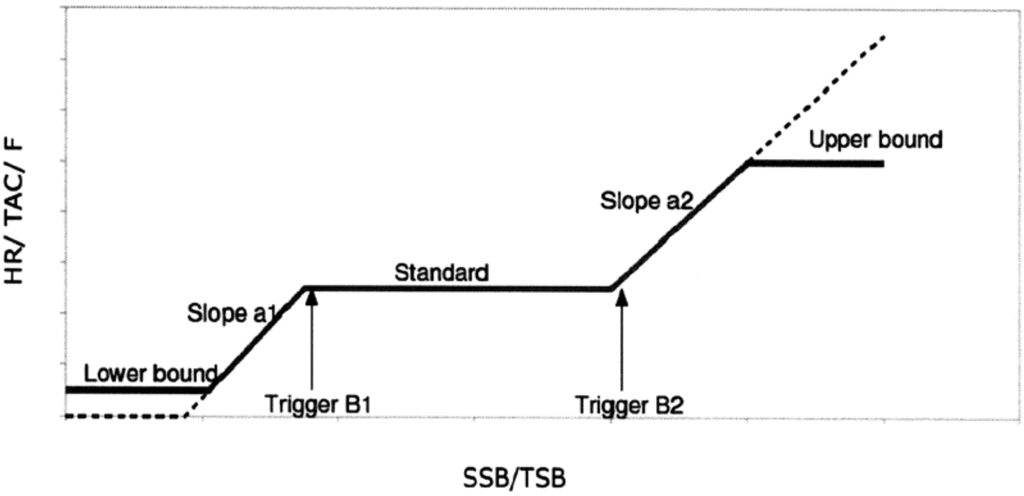

Figure 1. General outline of the new harvest rule examined, with different parameters indicated.

The harvest rule fixes a TAC, harvest rate or fishing mortality, the level of which depend on the estimated biomass, as follows:

- *A lower bound below Trigger B1;*
- *A linear sliding scale with slope a1 below Trigger B1;*
- *A standard level applied between Trigger B1 and Trigger B2;*
- *A linear sliding scale with slope a2 above Trigger B2; and*
- *An upper bound at higher stock sizes.*

ICES is asked to evaluate appropriate values for each of the parameters identified above in relation to stability, and maximum sustainable yield on a long-term basis.

5. With regard to the above requests, ICES is further requested to undertake an evaluation with respect to application of inter-annual quota flexibility of +/- 10% for the blue whiting stock."

In the text below, 'current HCR form' refers to harvest control rules that exclude Trigger B2, Slope a2, and the upper bound (i.e. includes everything to the left of Trigger B2 in Figure 1 of the request). 'Proposed HCR form' refers to HCRs that include all the elements contained in Figure 1.

Elaboration on the advice

Re-evaluation of reference points

ICES has evaluated the reference points and concluded that B_{lim} and B_{pa} should remain unchanged. F_{pa} and F_{lim} were undefined. Equilibrium stochastic simulations have been used to give a new value for $F_{lim} = 0.48$. On the basis of this and the uncertainty in the assessment, a corresponding value for $F_{pa} = 0.32$ was derived. Currently MSY advice is based on a management strategy evaluation which used $F_{0.1}$ as a proxy for F_{MSY} and an MSY $B_{trigger} = B_{pa}$. The new simulations provide estimates of $F_{MSY} = 0.30$. There are no scientific reasons to reduce MSY $B_{trigger}$ below B_{pa}, and no estimates of MSY $B_{trigger}$ are above B_{pa}. Under these circumstances it is proposed that B_{pa} be retained as MSY $B_{trigger}$ for the MSY framework.

Evaluation of options for HCRs

The current management plan has been evaluated and is considered precautionary. Evaluations indicate that the probabilities of SSB< B_{lim} are low.

A number of alternative F targets in the range of 0.1–0.35 for the current HCR form (Figure 1 of the request, leaving out Trigger B2 and everything above that) have been evaluated and found to be precautionary up to an F target of 0.32.

The inclusion of catch stabilization clauses in the current HCR form have been tested and are considered precautionary. The whole time period was examined and showed no significant differences in catch with or without the stabilizers. Neither of the stability mechanisms significantly increase the probability of SSB< B_{lim}. Both 50–50 rules (See below) can greatly reduce the IAV but result in delayed management reactions in response to changes in the level of recruitment. This can generate rather high Fs during periods of stock decline and result in lower catches during periods of stock increase. The transition from high to low recruitment in the 3-year rule (see below) may have higher probabilities of SSB< B_{lim} in reality than is concluded from the current simulations. The tests carried out assume that the normal and high recruitment regimes are known and that short-term forecasts are adjusted correctly. This knowledge would not be available in the real world, i.e. the current tests imply better knowledge of the recruitment process than is currently available.

A number of new HCRs that follow the proposed form (Figure 1 of the request), with increasing F/HR/TAC (targets based on Fishing mortality/Harvest Rate (TAC/SSB)/or TAC directly) at high biomass, have been evaluated and some have been found to be precautionary. However, the evaluation that was possible to be conducted during the time available is not considered sufficiently robust. A number of important additional areas have been identified to give more realistic exploration:

- The simulated assessment uncertainty may not reflect the measurement uncertainty that has actually been experienced in recent years (e.g. the revision of the assessment in 2011 (exclusion of the 2010 survey point) which lead to a significant change in the perception of the stock). Underestimating this error may give overly optimistic performance results. The more complex HCRs need to be more comprehensively tested for robustness to greater uncertainty.
- It is unclear if the major reduction in fishing opportunities that occurs when recruitment regimes change from high to normal state would be implemented with the same compliance as normal changes in TAC under the new HCRs. Current tests assume compliance will be good with only minor random errors.
- The tests carried out assume that the normal and high recruitment regimes are known and the short-term forecasts are adjusted correctly. This knowledge would not be available in the real world i.e. the current tests imply better knowledge of the recruitment process than is currently available. This is particularly important when testing HCRs with several biomass related triggers.
- Simulations have been based on stock and recruitment models without uncertainty in the mean level of recruitment. So the robustness of the biomass trigger points has not been fully evaluated.

Suggestions

ICES considers that testing the full range of HCRs and the complexities currently under consideration would require a large amount of time and resources which are currently not available. This particularly relates to testing HCRs that include higher Fs at high biomass. ICES suggests that managers should use the results presented here and in the expert working group report (ICES, 2012a) to identify a small subset of such rules to be tested with greater rigour against precautionary and MSY criteria.

Two extreme cases of banking and borrowing were evaluated (either continually banking or borrowing the full allowable amount). These were found to have a limited impact on the performance of the current HCR. However, it is very uncertain how this process would be implemented in reality.

Basis of the advice

<u>Background</u>

A management plan was agreed by Norway, the EU, the Faroe Islands, and Iceland in 2008 (ICES, 2012b). The plan uses:

i) a target fishing mortality (F = 0.18) if SSB is above SSB_{MP} (= B_{pa}),
ii) a linear reduction to F = 0.05 if SSB is between B_{pa} and B_{lim}, and
iii) F = 0.05 if SSB is below B_{lim}.

In order to facilitate discussions between Coastal States on possible modifications to the long-term management plan for blue whiting in the Northeast Atlantic, ICES was requested by NEAFC to conduct an evaluation of the harvest control rule elements under the existing long-term management plan – as outlined in the full request description above.

<u>Results and conclusions</u>

Reference points

Long-term equilibrium stochastic simulations (Figure 9.3.3.1.1) were carried out to determine reference points for the stock. The yield- and SSB-per-recruit with recent averages for weights, maturities, natural mortalities, and selection-at-age (three-year averages, as per the ICES short-term forecast) and using the normal recruitment scenario are shown in

Figure 9.3.3.1.2. $F_{0.1}$ from this analysis is 0.22 which compares with 0.18 from an evaluation at the time of the previous management plan evaluation, which was eventually adopted as the HCR F target.

F_{lim} and F_{pa} are evaluated from the same analysis. At F = 0.48 there is a 50% probability of SSB< B_{lim}. Hence F = 0.48 is proposed as a value for F_{lim}. Following standard ICES procedures and taking the precision of the SAM assessment for this stock into account leads to an associated F_{pa} value of 0.32. F = 0.32 also corresponds to a roughly 5% probability of SSB< B_{lim}. The precautionary biomass reference points remain unchanged.

F_{MSY} is obtained from the long-term stochastic yield curve which peaks at F = 0.35 (Figure 9.3.3.1.1), though there is only a small difference in equilibrium yield between Fs of 0.30 and 0.40. Fishing at the peak F = 0.35 leads to a greater than 5% probability of SSB< B_{lim}, hence F_{MSY} must be reduced so that it is precautionary and the recommended value is therefore F_{MSY} = 0.30.

Current management plan

The current HCR was re-evaluated in three different recruitment scenarios: ‘NHN’ (normal recruitment, followed by a 9-year period of high recruitment, followed by normal recruitment again), ‘normal’ (excluding a period of high recruitment), and ‘low’ (excluding high recruitment and peaks in recruitment). The low scenario can be considered a worst case scenario, while the NHN scenario is used primarily to see how HCRs behave under conditions of changing productivity and stock size.

Figure 9.3.3.1.2 shows the mean recruitment for each scenario and the annual probability of SSB< B_{lim}. Under all scenarios of recruitment the probability of SSB< B_{lim} is very low (< 1%). Figures 9.3.3.1.3 and 9.3.3.1.4 show more details of the performance of the current HCR with normal recruitment.

Following the new proposal of reference points for the stock, runs considering alternative F target values (with the same $B_{trigger}$) were conducted. Figure 9.3.3.1.5 shows the mean performance over time of a subset of these runs with normal recruitment. Figure 9.3.3.1.6 shows the relationship between F target and mean TAC and TAC IAV as well as SSB and the probability of SSB being below B_{lim} and $B_{trigger}$ over the last ten years simulated. Mean performance over the last ten years is also presented in Table 9.3.3.1.1. For F targets above 0.25 there is little additional gain in TAC in the long term, but IAV in TAC increases with increasing F target. This is partly due to SSB stabilizing in the region of $B_{trigger}$ for F targets >0.25, which results in the F used to calculate TAC often being less than the F target value. Hence changes in TAC arise due to both changes in F from the HCR and changes in stock biomass. F targets above 0.32 are not considered to be precautionary.

Stability mechanisms

Three potential stability mechanisms applied to the current HCR were evaluated in the NHN recruitment scenario.

1. The ‘3-year rule’ where the TAC is set as the average of the projected TAC for three years (part 3a in the request).
2. The ‘50–50 rule’ where the TAC is set as the average of the previous TAC and the HCR TAC for the next year (part 3b in the request).
3. The ‘HCR50–50 rule’ where the TAC is set as the average of the previous HCR TAC and the current HCR TAC for the next year (part 3b in the request).

The NHN recruitment scenario was used specifically to see how these stability mechanisms work under scenarios of changing recruitment regime. Figure 9.3.3.1.7 shows the mean performance of the current HCR compared to the performance of the current HCR with stability mechanisms applied. Table 9.3.3.1.2 shows the mean performance statistics over three distinct recruitment and stock status periods and over the whole time period. Resulting values are merely indicative of relative performance and should not be interpreted as absolute values.

The ‘3-year rule’ reacts quickest to changes in the level of recruitment, leading to higher TACs during the period of high recruitment and an increasing stock. The TAC IAV also has a peak over this period, and on average over the whole time period this stability mechanism actually increases the IAV. The ‘50–50 rule’ has the lowest IAV, but is also the slowest to react to changes in the level of recruitment. This leads to lower TACs when stock size is increasing and higher TACs when stock size is decreasing. This in turn leads to large fluctuations in the level of F exerted on the stock. By altering this rule to use the average of the TAC given by the HCR in the previous year (rather than the agreed TAC), ‘HCR50–50 rule’ this effect is dampened. All the stability rules tested are precautionary with a target F = 0.18, but it is unsure if this would still hold for F target values higher than 0.18 (at an F target of 0.18 the 50–50 rule still has a maximum annual probability of SSB< B_{lim} of 0.033).

Proposed HCR

The proposed HCR contains a large number of parameters and options for decision basis (total [TSB] vs spawning stock biomass [SSB]) and advice mechanisms (HR vs TAC vs F).

TSB vs SSB

A test was run to examine the performance when TSB is used rather than SSB. The general impression is that the performance is largely the same in terms of probability of SSB< B_{lim} and average catch. Using TSB allows for slightly quicker reactions to changes in stock size at the cost of incorporating more poorly estimated age classes (1 and 2). All options presented below use SSB as the decision basis.

Harvest rate rule option

The mean catch always increases with decreasing Trigger B2, i.e. the lower the biomass when the rate exploitation increases again, the higher the average catch. Trigger B2 should be above what can be expected under the normal recruitment scenario, which has a 95% probability when it is in the region of 4000 kt. Accordingly, Trigger B2 was fixed at 4000 kt when exploring HR options. Although the probability of SSB< B_{lim} is still mostly tolerable within the range examined, a more drastic response to an assumed regime shift is probably not advisable, since the actual conditions in such a case may deviate from what is assumed here.

Selections of low, medium, and high standard targets for the HR, TACs, and Fs rules were made and then examined further by scanning over a range of Slope a2 and Upper bound HR options (assuming a Trigger B2 of 4000 kt). The mean performance statistics for these exploratory runs are shown in Tables 9.3.3.1.3–5.

To explore the proposed HCR further, runs were done for the current HCR with added Trigger B2 and Slope a2 parameters. Examples are plotted in Figure 9.3.3.1.8 for an option with low Trigger B2 and high Slope a2 (early and large changes to exploitation rate at high biomass) and an option with high Trigger B2 and low Slope a2 (later and more gradual changes to exploitation rate at high biomass). Results of more options for Trigger B2 and Slope a2 are presented in Table 9.3.3.1.6.

For all options examined, average TAC, IAV, mean F, and probability of SSB<B_{lim} were all higher than for the current HCR with target F = 0.18. The current HCR allows SSB to become higher during and following periods of high recruitment. Similar benefits in average TAC could be obtained by increasing the target standard F without including the option to increase exploitation rate at high biomass; the additional yield at high biomass by fishing harder is very small, but the yield is taken sooner and with greater IAV. Selecting appropriate values for Trigger B2 and Slope a2 will require trading off the level of standard F and the rate of increasing exploitation. The higher the standard F, the less frequent F should change to the top exploitation regime (i.e. Trigger B2 should be set higher) and there should be more gradual increases in exploitation to be prudent (lower Slope a2). With a lower standard F, more frequent changes to the top exploitation rate (i.e. lower Trigger B2) and rapid increases in exploitation rate at high biomass (higher Slope a2) may still be precautionary.

Banking and borrowing

Two extreme banking and borrowing scenarios were examined, one in which the maximum allowable amount is banked every year (BBminus), and another where the maximum allowable amount is borrowed every year (BBplus). These scenarios were applied to the current HCR and compared to a scenario with no banking or borrowing. The results show very minor differences in long-term performance, with all cases being precautionary.

Methods

For the evaluation of the HCRs a stochastic simulation model was used. Parameterization of the model was based on the latest information of the stock from WGWIDE 2012 (ICES, 2012a). The model was run from 2012 to 2042 or 2052, depending on the recruitment scenario applied, for 1000 stochastic iterations (replicate runs). Stochasticity was implemented in weight-at-age in the stock, catch, initial stock numbers, recruitment, and implementation and observation parts of the model. Natural mortality, maturation, and fisheries selectivity were deterministic.

Recruitment was simulated to reproduce patterns and levels observed in the past. Blue whiting has historically had recruitments at a baseline level with occasional strong year classes at about 6 to 7-year intervals. In the period 1995–2004, recruitments were far better, and this is regarded as a different regime. Accordingly, three different recruitment regimes were used, with parameters derived from the historical data:

1. Normal recruitment: corresponding to all year classes except 1995–2004, including occasional spikes (every 6–7 years).
2. Normal–high–normal (NHN) recruitment: a period of normal recruitment, then high recruitment for 9 years, then normal recruitment again.
3. Low recruitment: as for normal recruitment, without the occasional spikes.

The 'true' stock numbers were modified by an observation model to provide stock numbers for the decision process. This observation model mimics the uncertainty expected from the SAM assessment for this stock. In the decision process, recruitment predictions in the short-term forecast were according to the deterministic stock–recruitment function, with parameters representing the regime at the beginning of the projection period, which here is the year before the TAC year (i.e. the current recruitment regime was known when setting TACs based on the HCR). It was noted that some elements of the rules that were tested relied heavily on the assumptions in the modelling that biomass reference points were accurately defined relative to modelled recruitment and that the current recruitment regime was known when carrying out short-term forecasts. Simulations are required that include more realistic uncertainty in mean recruitment and where the transition between recruitment regimes is not known but must be detected.

Sources

ICES. 2012a. Report of the Working Group on Widely Distributed Stocks (WGWIDE), 21–27 August 2012, Lowestoft, UK. ICES CM 2012/ACOM:15. 931 pp.

ICES. 2012b. Section 9.4.4. Blue whiting in Subareas I–IX, XII, and XIV (Combined stock). *In* ICES Advice 2012, Book 9: 100–113.

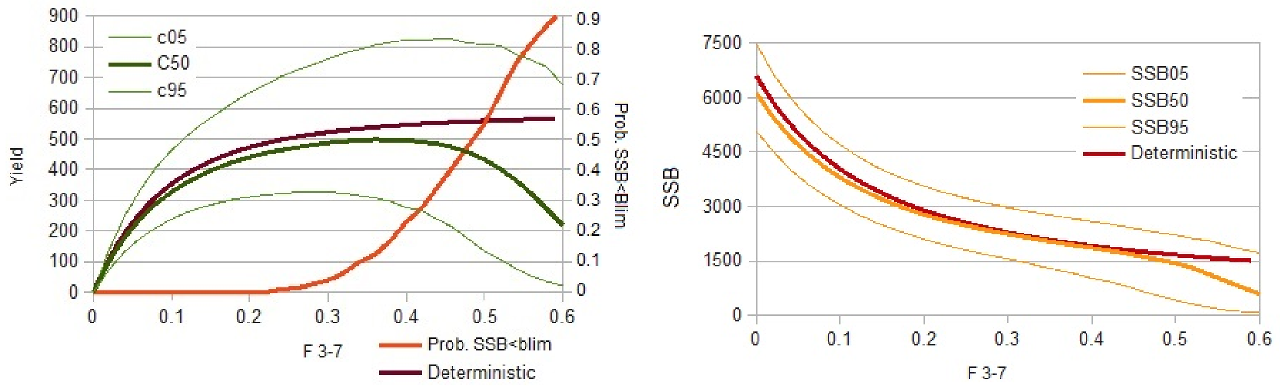

Figure 9.3.3.1.1 Stochastic and deterministic equilibrium yield and SSB under the normal recruitment scenario.

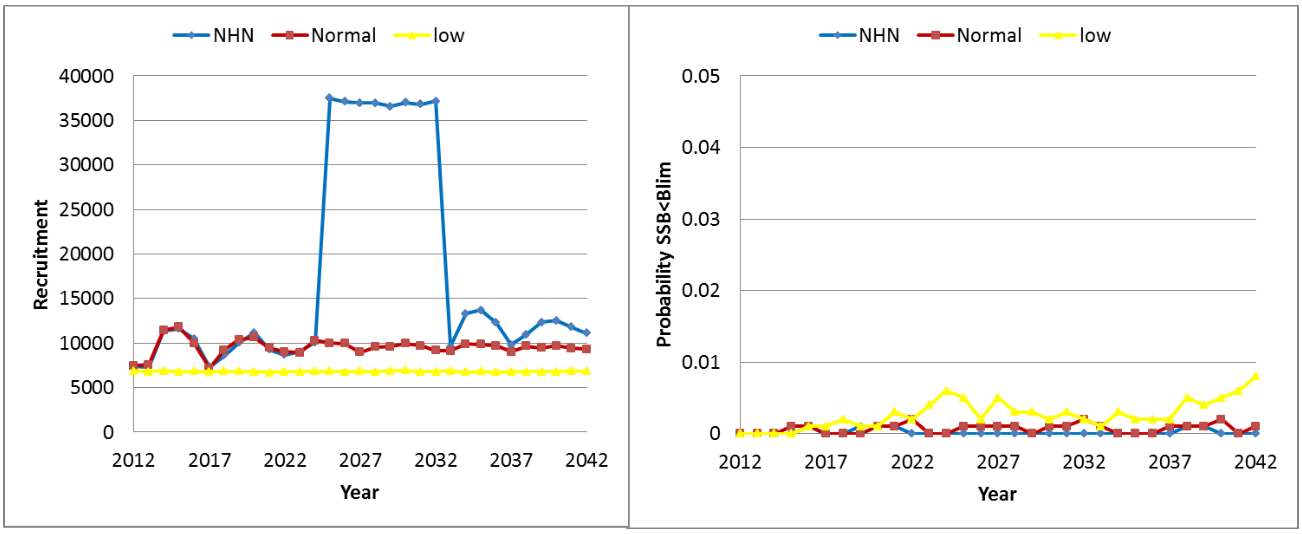

Figure 9.3.3.1.2 Mean annual recruitment (left) and maximum annual probability of SSB< B_{lim} (right) for the current management plan harvest control rule in three recruitment scenarios: NHN (blue, high recruitment period included), normal (red, excluding high recruitment period), and low (yellow, excluding high period with no occasional peaks).

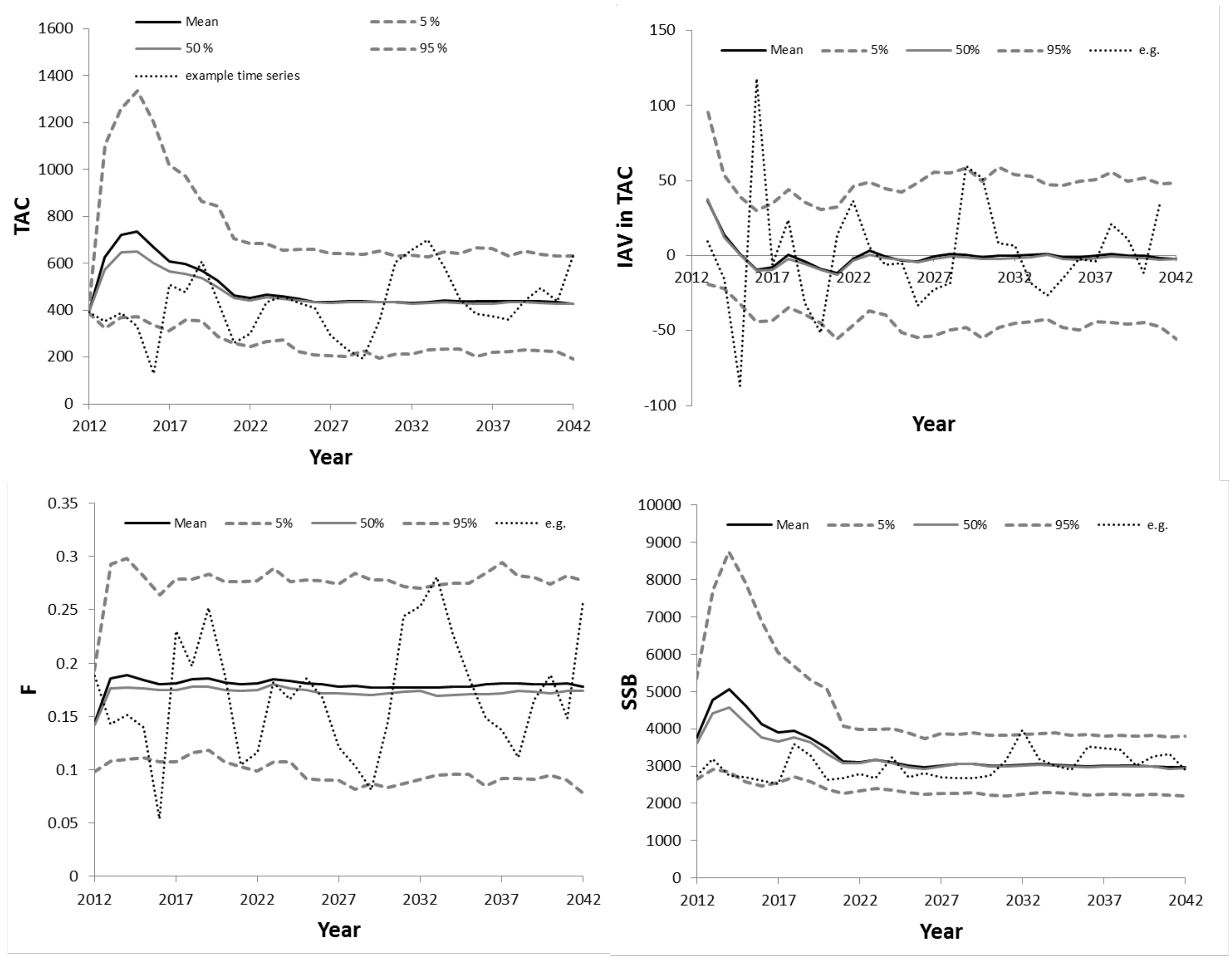

Figure 9.3.3.1.3 Performance of the current management plan harvest control rule in the normal recruitment scenario (2012–2042). Means, medians, and confidence bounds of TAC, TAC IAV (interannual variation), mean F, and SSB are plotted.

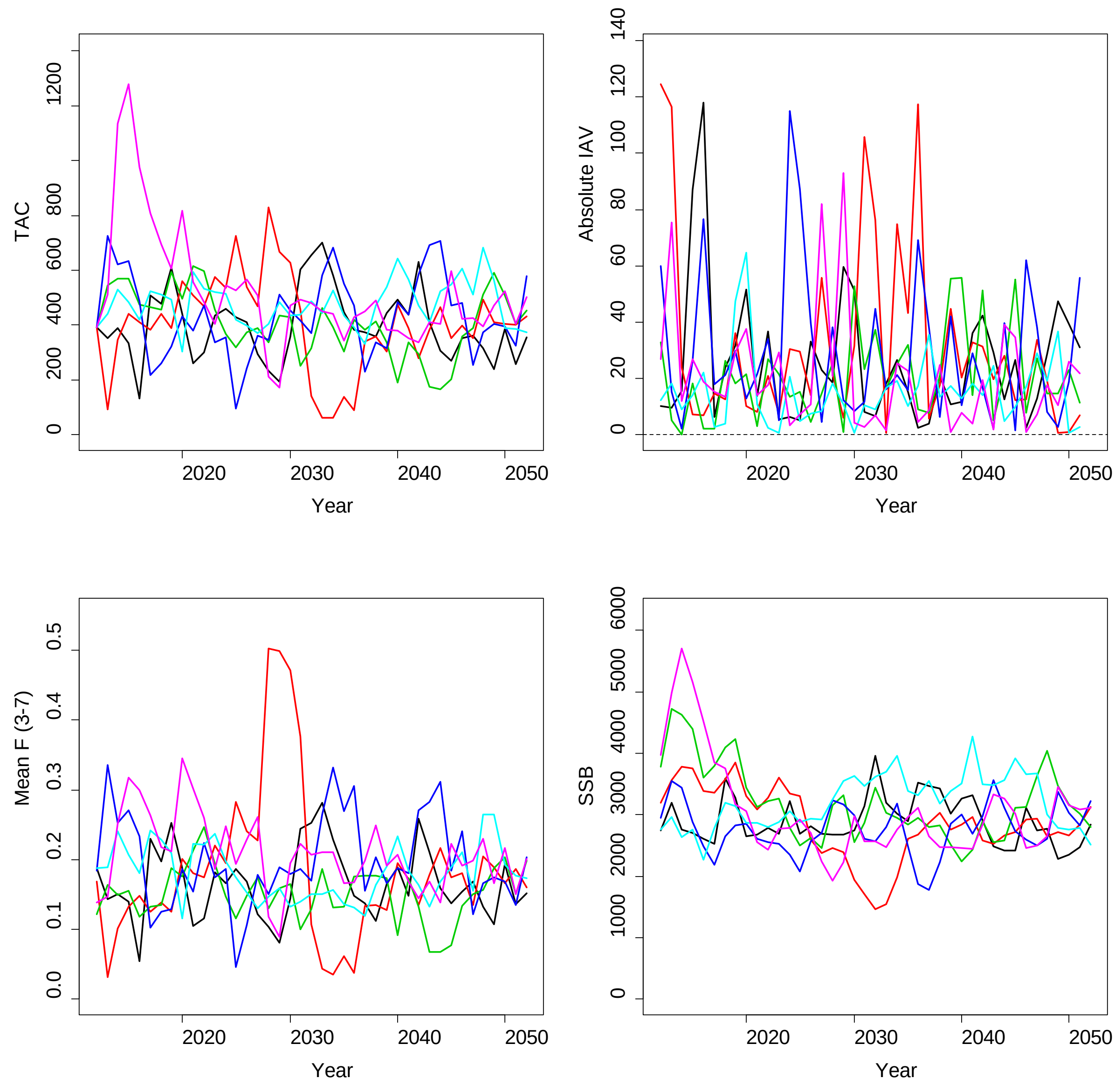

Figure 9.3.3.1.4 Five random trajectories (individual runs) of the current management plan harvest control rule in the normal recruitment scenario (2012–2052): TAC, TAC IAV (interannual variation), mean F, and SSB.

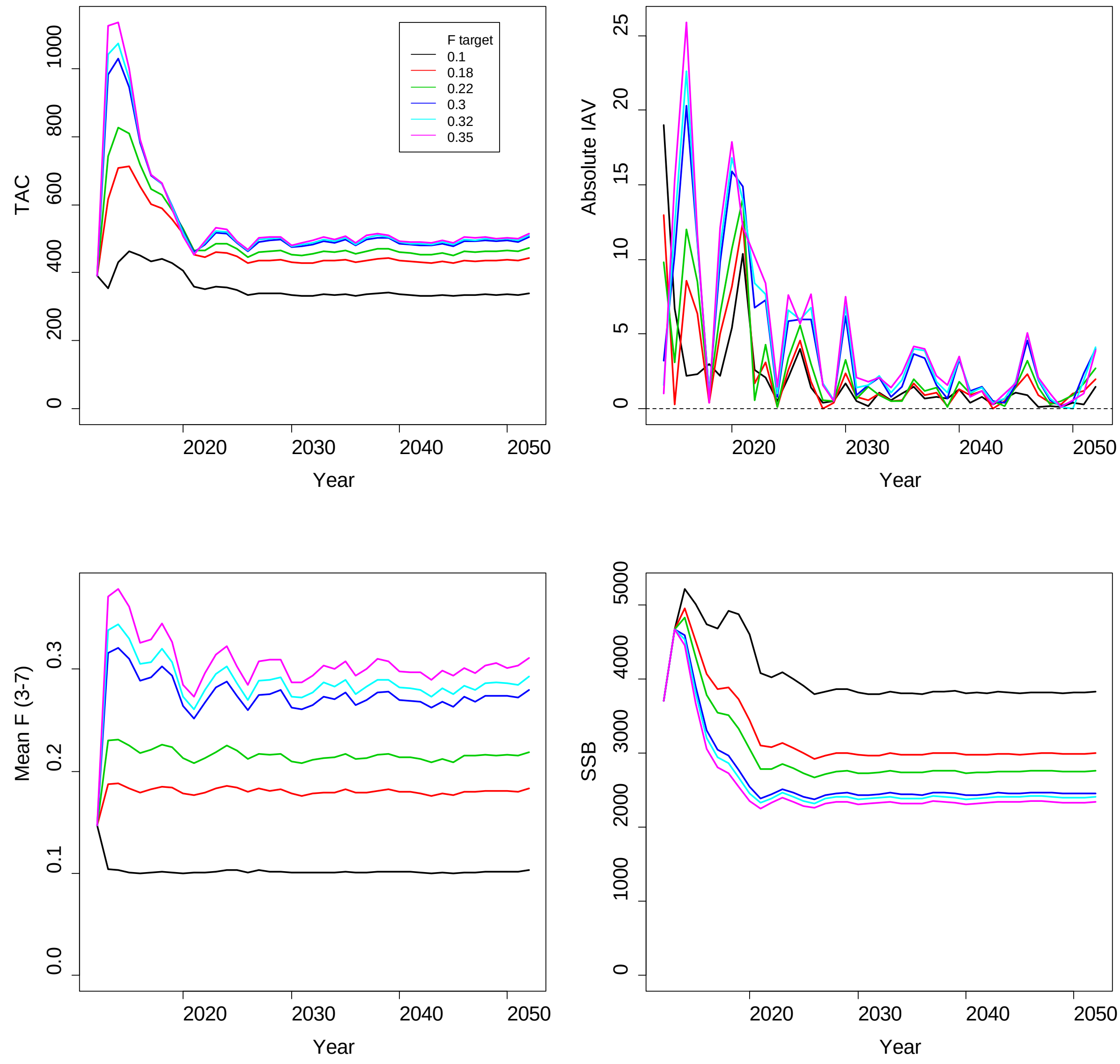

Figure 9.3.3.1.5 Mean performance for the current management plan HCR using alternative target F values in the normal recruitment scenario.

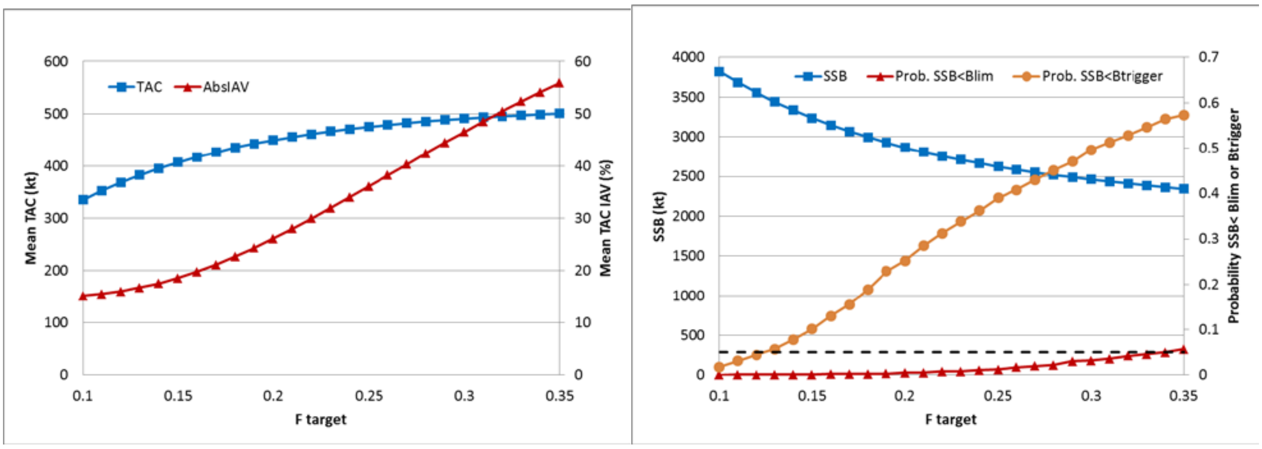

Figure 9.3.3.1.6 Left: Mean TAC and mean interannual variation in TAC. Right: SSB (blue) and the maximum annual probability of SSB being below B_{lim} (1500 kt) and $B_{trigger}$ (2250 kt) for the current management plan HCR, using alternative target F values. Values are for the last ten years (2043–2052) in the normal recruitment scenario. The dashed line (---) indicates 5% probability of SSB being below B_{lim} or $B_{trigger}$.

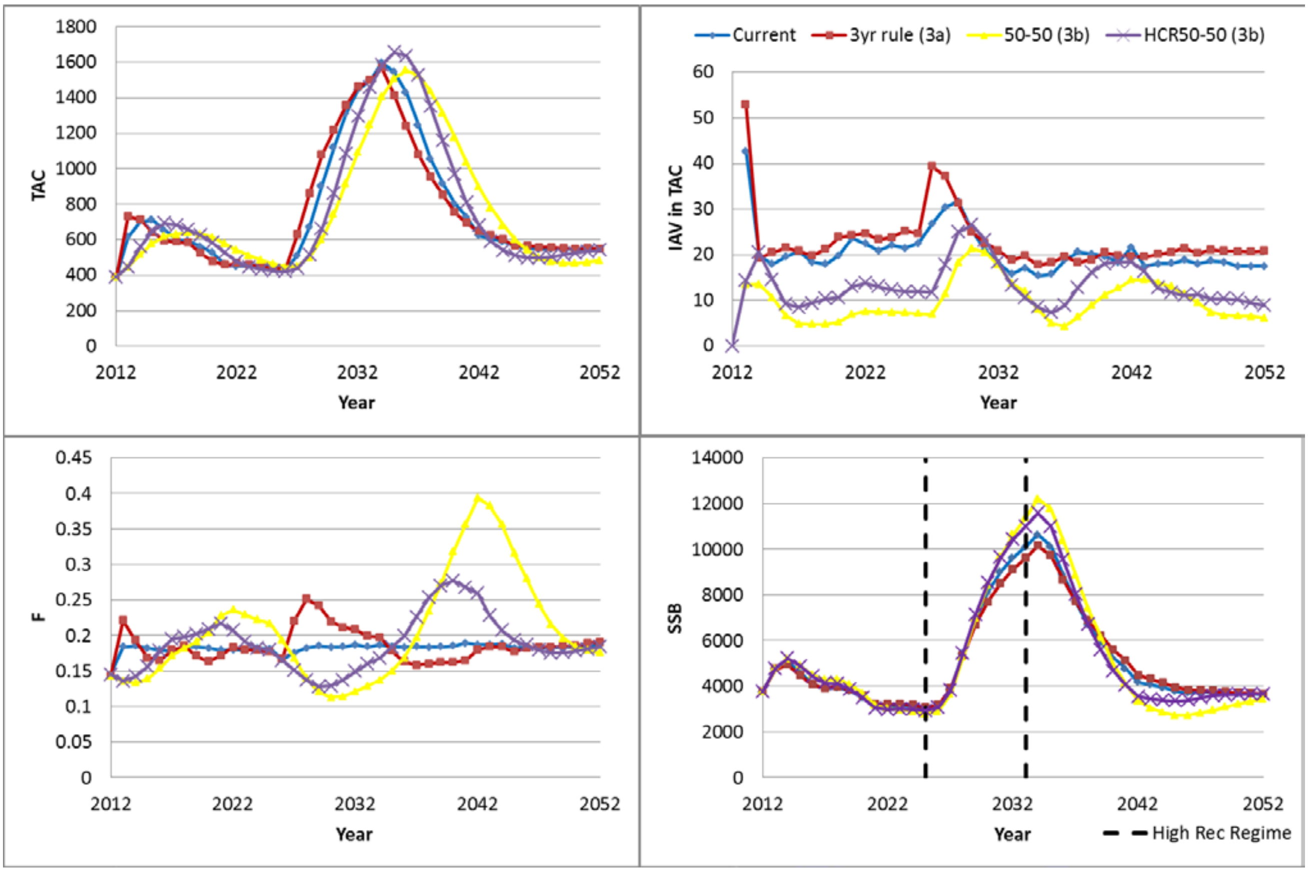

Figure 9.3.3.1.7 Mean performance of the current management plan HCR with and without alternative TAC stability mechanisms in the NHN recruitment scenario. The vertical dashed lines in the SSB plot indicate the period with high recruitment.

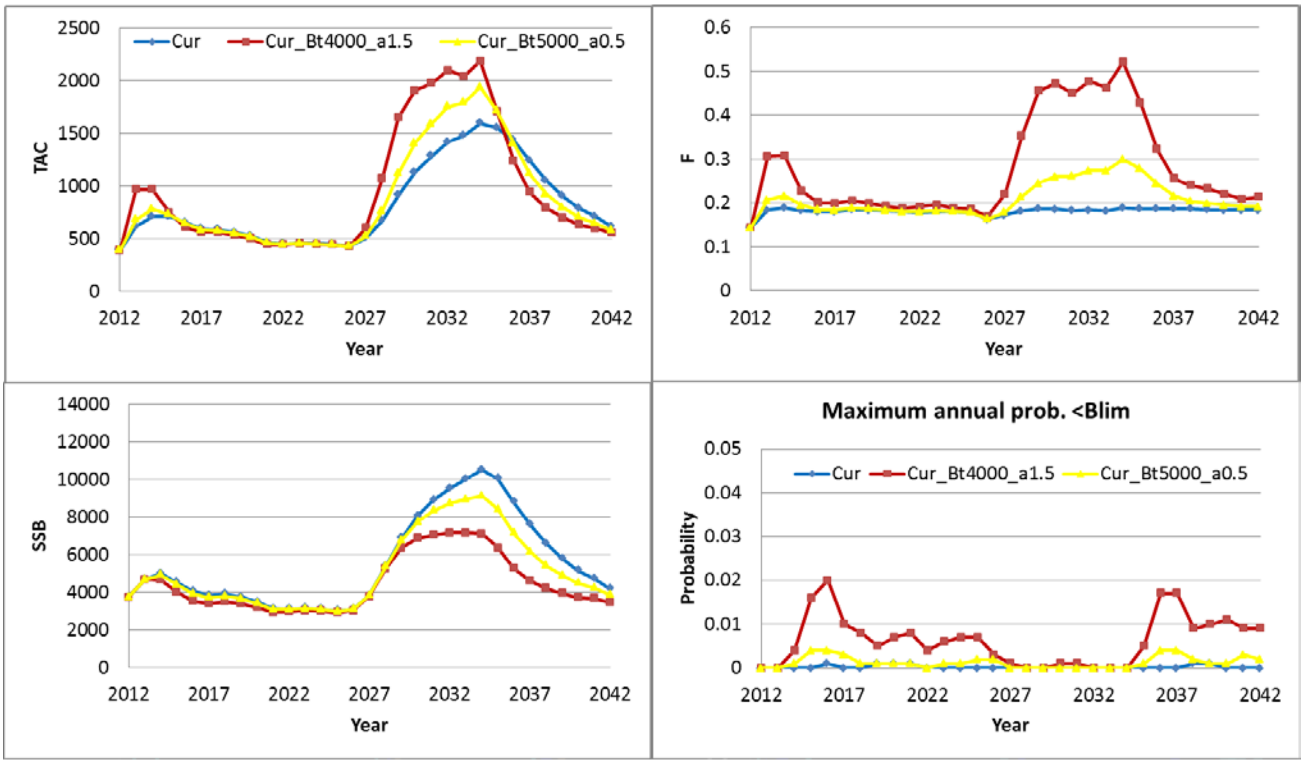

Figure 9.3.3.1.8 Performance of example runs adding alternative Trigger B2 and Slope a2 values to the current HCR in the NHN recruitment scenario.

Table 9.3.3.1.1 Mean performance in the last ten years (2043–2052) for the current management plan HCR using alternative target F values in the normal recruitment scenario. The TAC and SSB values are in thousand tonnes.

	F target	TAC	Mean F	SSB	TAC IAV %	Max. annual prob. SSB< B_{lim}	Max. annual prob. SSB< $B_{trigger}$
Low F	**0.10**	335	0.10	3820	15	0.00	0.02
	0.15	406	0.15	3237	19	0.00	0.10
Current target	**0.18**	435	0.18	2994	23	0.00	0.19
	0.20	449	0.20	2864	26	0.01	0.25
New $F_{0.1}$	**0.22**	461	0.21	2756	30	0.01	0.31
	0.25	475	0.24	2624	36	0.01	0.39
Proposed F_{MSY}	**0.30**	491	0.27	2461	47	0.03	0.50
Proposed F_{PA}	**0.32**	495	0.28	2408	50	0.04	0.53
High F	**0.35**	500	0.30	2340	56	0.06	0.57

Table 9.3.3.1.2 Mean performance of the current management plan HCR with and without alternative TAC stability mechanisms in the NHN recruitment scenario. Results are presented for 2014–2024 (normal recruitment, stable stock), 2025–2032 (high recruitment, increasing stock), 2033–2052 (normal recruitment, decreasing stock), and for the whole time period. The TAC and SSB values are in thousand tonnes.

2014–2024	**"Normal" – stable stock**					
HCR	**TAC**	**F**	**SSB**	**TAC IAV %**	**Max. annual prob. SSB< B_{lim}**	**Max. annual prob. SSB< $B_{trigger}$**
Current	561	0.18	3758	20	0.002	0.148
3-year rule (3a)	542	0.18	3772	22	0.005	0.256
50–50 (3b)	577	0.19	3907	7	0.005	0.210
HCR50–50 (3b)	575	0.19	3826	12	0.006	0.209
2025–2032	**"High Recruitment Regime" – increasing stock**					
HCR	**TAC**	**F**	**SSB**	**TAC IAV %**	**Max. annual prob. SSB< B_{lim}**	**Max. annual prob. SSB< $B_{trigger}$**
Current	856	0.18	6137	25	0.000	0.162
3-year rule (3a)	935	0.21	5928	28	0.001	0.284
50–50 (3b)	653	0.15	6292	14	0.008	0.290
HCR50–50 (3b)	713	0.15	6372	18	0.003	0.217
2033–2052	**"Normal" – decreasing stock**					
HCR	**TAC**	**F**	**SSB**	**TAC IAV %**	**Max. annual prob. SSB< B_{lim}**	**Max. annual prob. SSB< $B_{trigger}$**
Current	852	0.18	5590	18	0.001	0.057
3-year rule (3a)	819	0.18	5635	20	0.003	0.108
50–50 (3b)	929	0.24	5538	10	0.033	0.358
HCR50–50 (3b)	904	0.21	5540	12	0.005	0.137
ALL	**Whole time period**					
HCR	**TAC**	**F**	**SSB**	**TAC IAV %**	**Max. annual prob. SSB< B_{lim}**	**Max. annual prob. SSB< $B_{trigger}$**
Current	758	0.18	5141	20	0.002	0.162
3-year rule (3a)	754	0.18	5125	22	0.005	0.284
50–50 (3b)	756	0.21	5185	10	0.033	0.358
HCR50–50 (3b)	755	0.19	5180	13	0.006	0.217

Table 9.3.3.1.3 HR rule (TAC/SSB) in the NHN recruitment scenario. Means over years 2023–2042, which includes a period of high recruitment followed by 10 years of normal recruitment. Trigger B2 = 4000 kt in all cases. The mean catches are in thousand tonnes.

	Std HR	**Slope a2**	**Upper bound HR**	**Mean catch: 5 – 50 – 95 percentiles**	**Prob. SSB< B_{lim}**
Low Std HR	0.1	1.5	0.20	890-1096-1310	1.0
		2.0	0.30	908-1126-1356	2.3
		3.0	0.40	926-1149-1377	3.3
Medium Std HR	0.12	1.5	0.20	923-1123-1331	1.4
		2.0	0.30	940-1153-1378	3.1
		3.0	0.40	955-1173-1396	4.1
High Std HR	0.16	1.0	0.20	962-1154-1360	4.9
		2.0	0.30	988-1188-1413	6.0
		3.0	0.40	999-1201-1426	6.8

Table 9.3.3.1.4 TAC rules in the normal recruitment scenario – examples of candidate rule parameters. Trigger B1 and B2, TAC, mean catch, and mean SSB values are in thousand tonnes.

	Trigger B1	Std TAC	Slope a1	Trigger B2	Slope a2	Upper bound TAC	Mean catch: 5 – 50 – 95 percentiles	Mean SSB: 5 – 50 – 95 percentiles	Prob. SSB< B_{lim}
Low Std TAC	2250	350	0.75	4000	4	2000	823-1005-1188	5008-5992-7022	0.6
Medium Std TAC	2250	450	0.75	4000	4	2000	873-1062-1240	4478-5445-6469	3.5
High Std TAC	2250	550	0.75	All options show a high probability of SSB< B_{lim}.					

Table 9.3.3.1.5 F rules in the normal recruitment scenario – examples of candidate rule parameters. Trigger B2, mean catch, and mean SSB values are in thousand tonnes.

	Trigger B2	Std F	Slope a2	Upper bound F	Mean catch: 5 – 50 – 95 percentiles	Mean SSB: 5 – 50 – 95 percentiles	Prob. SSB< B_{lim}
Low Std F	4000	0.19	2.0	0.30	898-1084-1272	4399-5302-6231	0.4
	4000	0.19	3.0	0.40	923-1123-1329	4029-4871-5723	0.8
Medium Std F	4000	0.24	2.0	0.30	922-1103-1292	4204-5109-6054	0.9
	4000	0.24	3.0	0.40	951-1144-1348	3805-4647-5504	1.5
High Std F	4000	0.32	2.0	0.30	940-1117-1303	4022-4944-5887	3.2
	4000	0.32	3.0	0.40	978-1166-1365	3551-4411-5264	5.7

Table 9.3.3.1.6 Mean performance (all years) of example runs adding alternative Trigger B2 and Slope a2 values to the current HCR in the NHN recruitment scenario. Trigger B2, SSB, and TAC values are in thousand tonnes.

	Trigger B2	Slope a2	Mean F	SSB	TAC	Abs. IAV in TAC	Prob. SSB< B_{lim}	Prob. SSB < Trigger B1
Current HCR	-	-	0.18	5582	819	22	0.001	0.194
Low Trigger B2	4000	0.5	0.23	5075	941	30	0.01	0.202
		1	0.27	4803	994	34	0.013	0.207
		1.5	0.30	4625	1026	38	0.02	0.215
		2	0.32	4495	1049	42	0.025	0.221
High Trigger B2	5000	0.5	0.21	5235	908	27	0.004	0.197
		1	0.24	5029	951	31	0.01	0.198
		1.5	0.26	4888	978	34	0.013	0.201
		2	0.27	4784	998	36	0.017	0.202

Table 9.3.3.1.7 Mean performance (all years) of the current HCR with and without banking and borrowing scenarios in the NHN recruitment scenario. The catch and SSB values are in thousand tonnes.

2012–2042	All years					
HCR	Catch	F	SSB	TAC IAV %	Max. annual prob. SSB< B_{lim}	Max. annual prob. SSB< $B_{trigger}$
Current	818	0.18	5541	21	0.001	0.194
BBminus	821	0.18	5570	19	0.002	0.139
BBplus	819	0.18	5543	19	0.001	0.163