5.3.3.2 **Special request, Advice August 2013**

ECOREGION **Celtic Sea and West of Scotland**
SUBJECT **Request from NEAFC to evaluate the proposals for the harvest control components of the management plan for Rockall haddock fisheries**

Advice summary

ICES advises that the proposed harvest control rule (HCR) for Rockall haddock fisheries, using the existing reference points, is not in accordance with the precautionary approach under the conditions of low recruitment that have prevailed since 2004. The proposed HCR implies that the stock will be below B_{lim} with a high probability under those recruitment conditions. The modification of the HCR introducing a parameter for low recruitment situations (the α parameter, to be used in paragraph 4 of the HCR definition) appears to have little impact on the performance of the HCR.

ICES advises that when SSB is greater than B_{pa} a maximum F value of 0.2 would be required for the HCR to be consistent with the precautionary approach even under a low recruitment regime. In the HCR that was found to be precautionary, the SSB value used in paragraph 4 is calculated directly applying F = 0.2 during the TAC year, without performing any iterative steps.

Request

The objective of the management plan is to be consistent with the precautionary approach, provide for the sustainable harvesting of the stock and maximize the yield.

In the following, the TACs refer to total catches, not just landings. Measure shall be put in place to ensure that total catch does not exceed the established TAC including measures to record and minimise discards. After the introduction of these measures, the method of setting a human consumption TAC currently used by ICES shall not be applied.

1.Every effort shall be made to maintain a level of Spawning Stock Biomass (SSB) greater than Bpa and a minimum level of SSB greater than Blim.

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 either Fmsy for appropriate age- groups, when the SSB at the end of the year in which the TAC is applied is estimated above Bpa.

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

TACy = TACf + 0.2 x (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.

4. Where the SSB referred to in paragraph 2 is estimated to be below Bpa but above Blim, the TAC shall not exceed a level, which will result in a fishing mortality rate equal to

Fmsy - [Fmsy x (Bpa - SSB) / (Bpa - Blim)].

This consideration overrides paragraph 3.

5.Where the SSB referred to in paragraph 2 is estimated to be below Blim, there should be no directed fishery for haddock (F = 0.0) and by-catch and discards of haddock should be minimised. This consideration overrides paragraph 3.

6. No later than the end of the fifth year after the implementation of the Plan, the Parties shall review the Plan taking account inter alia advice from ICES concerning the performance of the Plan."

As part of the evaluation, ICES is asked to determine the best proxy for Fmsy and to advise on the most appropriate values for Blim and Btrigger.

ICES is further requested to evaluate the above harvest control rule with paragraph 4 replaced by the following:

"Where the SSB referred to in paragraph 2 is estimated to be below Bpa but above Blim, the TAC shall not exceed a level, which will result in a fishing mortality rate equal to

Fmsy - [Fmsy x (Bpa - SSB) / (Bpa – α x Blim)]

where α takes a value greater than 1 when the stock is in a period of low recruitment.
This consideration overrides paragraph 3."

ICES is requested to:

Advise on an appropriate methodology to define periods of low recruitment
Advise on the calculation of appropriate values of α
Indicate whether or not the inclusion of α makes the plan more consistent with the precautionary approach or has any significant implications for the delivery of its objectives

Elaboration of the advice

ICES has provided advice on the Rockall haddock HCR on two previous occasions (ICES, 2011 and ICES, 2012a).

In conducting the analyses for the present request, ICES considered that there was insufficient data to provide improved estimates of biomass and fishing mortality reference points for the Rockall haddock stock at this time. Precautionary approach (PA) reference points have been unchanged since 1998 (ICES, 1999), with B_{lim} set at 6000 t (lowest observed SSB) and B_{pa} set at 9000 t (1.5 × B_{lim}, to account for assessment uncertainty). MSY reference points were evaluated in 2010 (ICES, 2010) and again in 2012 (ICES, 2012b). MSY $B_{trigger}$ is, for the time being, set equal to B_{pa}. The number of stock and recruit observations for this stock is fairly limited. Therefore, even though F_{MSY} values associated with different forms of the stock–recruit relationship can be formally calculated, there is high uncertainty associated with the resulting F_{MSY} estimates. Recent analyses (ICES, 2012b) suggest that yield-per-recruit for this stock, under the current exploitation pattern, is either maximized for an F of about 0.2 (with high uncertainty), or does not have a clearly defined maximum. The F_{MSY} proxy (0.3) for Rockall (and also for West of Scotland) haddock was chosen by analogy with the North Sea haddock stock; this is considered as a provisional proxy until further data or analyses are available for the Rockall haddock stock.

ICES reviewed analyses of the proposed harvest control rule (HCR) of a management plan for Rockall haddock fisheries in two approaches with slightly different treatment of uncertainty and error. Both analyses suggest that the proposed HCR based on the current F_{MSY} proxy (0.3) has a low long-term risk of the SSB being below B_{lim}, using simulated recruitment based on the assessment time-series since 1991 ("medium recruitment" scenario). However, analyses conducted with simulated recruitment based on the values observed from 2004 onward ("low recruitment" scenario) resulted in a greater than 5% probability of the SSB being below B_{lim}. Therefore, the HCR cannot be considered to be in accordance with the precautionary approach under the "low recruitment" scenario. Because haddock stocks are, in general, characterized as having periods of relatively poor recruitment interspaced with unpredictable periodic high recruitment events, it is important to consider periods of low recruitment as a realistic scenario in the HCR evaluation.

Evaluation of a new proposed element of the harvest control rule in the form of an α parameter to determine the slope of F when SSB< B_{pa} in cases of low recruitment, suggested that the use of this additional parameter did not change the results of risk calculations significantly and, as such, did not appear to have much impact on the HCR's performance. Therefore, appropriate methodology to define periods of low recruitment for the application of a modified HCR was not examined in detail.

Additional analyses of the HCR (unmodified, i.e. with α = 1), using a maximum F of 0.2 instead of 0.3, indicated a less than 5% probability of SSB being below B_{lim} in the long term, even under the scenario where the generally low recruitment observed since 2004 persists in the future. In the short term (next few years), however, a higher than 5% probability of SSB being below B_{lim} is expected, because of the very low recruitment observed every year since 2007. Given the current poor stock situation, an HCR under which the probability of SSB being below B_{lim} is expected to be reduced to less than 5% within a few years, and to remain at this low value in the long term, has been considered to be precautionary.

As indicated in the advice issued by ICES in 2012 (ICES, 2012a), the definition of the HCR is open to interpretation when the SSB calculated in paragraph 2 of the management plan is less than B_{pa}. In that case, two different interpretations of the SSB value to be used in paragraph 4 are possible: 1) the SSB value calculated in paragraph 2, or 2) the SSB value that results from applying during the TAC year the F actually obtained in paragraph 4. The latter involves an iteration process because the value of SSB at the end of the TAC year is part of the formula to calculate F. These two interpretations correspond to different definitions of the HCR and, hence, generate different Fs at stock biomasses below B_{pa}, with the first interpretation leading to lower Fs. The HCR that has been found to be precautionary in the analyses corresponds to the first interpretation, so if this HCR is implemented in practice, it should be applied using the first interpretation. This means that paragraphs 4 and 5 should be directly based on the SSB at the end of the TAC year obtained from applying F = 0.2 during the TAC year, without using any iteration process.

ICES considers F = 0.3 as a provisional F_{MSY} proxy for the Rockall haddock stock and given that the stock is currently at very low abundance, the main objective in the short term is to ensure that SSB recovers above B_{lim} and B_{pa}. As such, the HCR was not examined as to whether it is consistent with maximizing yield (when adequately implemented) at this time. Rather, the analyses focused on finding an HCR that could be considered precautionary even under low recruitment. The HCR that was found to be precautionary is more stringent than the standard ICES HCR for the MSY approach, as the maximum F (0.2) is lower than the provisional F_{MSY} proxy and F declines to 0 at B_{lim}. It is, however, noted that the SSB used in the HCR definition differs between the standard ICES HCR for the MSY approach (SSB at the start of the TAC year) and the HCR proposed by NEAFC and evaluated here (SSB at the end of the TAC year). The low recruitment regime is considered relevant for the HCR evaluation because it reflects the situation observed for almost a decade (since 2004). Whether this situation prevails in the future is uncertain, but if it does the findings here for the NEAFC-proposed HCR indicate that the standard ICES HCR for the MSY approach with the existing reference points would be unlikely to be precautionary.

ICES notes that the proposed HCR is an improvement compared to the current management approach, because the TAC would account for total catches (landings and discards) from all sources, including the international fishery.

Observed discard percentages of certain trawl fleets from the European Union have been as high as 52% to 87% by numbers, although much lower in recent years. The discarding percentage is highly dependent on the abundance of incoming recruitment because small fish are more likely to be discarded than large fish. The proposed HCR specifies that TACs refer to total catch, not just landings. ICES considers that controlling total catch is the only way to control fishing mortality. Closer monitoring of actual catches (instead of just landings) is therefore required. The long-term management plan needs to specify how this will be accomplished. ICES advises, in line with previous advice (ICES, 2011, 2012a), that it would be beneficial to develop and introduce fisheries practices and measures aimed at preventing catches of juvenile haddock.

Suggestions

The maximum value of F to be used in the HCR (at present advised to be 0.2 for consistency with the precautionary approach) could be reconsidered in a future review of the management plan approximately five years from now. A larger value of maximum F may be possible if recruitment improves with respect to what has been observed since 2004. The explorations during that review could, for example, consider a maximum F of 0.3, possibly in combination with a trigger biomass (from which F is reduced) larger than B_{pa}. This would allow a wider range of Fs within the HCR, depending on stock biomass. Consideration of yield maximization should be part of the evaluation at that time.

The formulation of the HCR should be clear, particularly in relation to the SSB value to be used in paragraphs 4 and 5. To avoid ambiguities, the HCR should be rewritten and the details of the calculations documented. It is suggested that the HCR that has been found to be consistent with the precautionary approach should be rewritten as follows:

"*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}.*

In paragraphs 2–5, $SSB_{0.2}$ denotes the SSB at the end of the year in which the TAC is applied, assuming F = 0.2 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 0.2 for appropriate age groups, when $SSB_{0.2}$ is estimated to be above B_{pa}.

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

$$TAC_y = TAC_f + 0.2 \times (TAC_{y-1} - TAC_f)$$

where TAC_y is the TAC that is to be set by the management plan, TAC_{y-1} is the TAC that was fixed the previous year, and TAC_f is the TAC resulting from the provisions in paragraphs 1 and 2.

4. Where $SSB_{0.2}$ 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

$$0.2 - [0.2 \times (B_{pa} - SSB_{0.2}) / (B_{pa} - B_{lim})].$$

This consideration overrides paragraph 3.

5. Where $SSB_{0.2}$ is estimated to be below B_{lim}, there should be no directed fishery for haddock (F = 0.0) and bycatch and discards of haddock should be minimized. This consideration overrides paragraph 3.

6. No later than the end of the fifth year after the implementation of the Plan the Parties shall review the Plan, taking into account inter alia *advice from ICES concerning the performance of the Plan.*"

Basis of ICES advice

Background

The haddock stock at Rockall 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 for the last six years has been extremely low despite a moderately large SSB.

Discussions between the European Union (EU) and the Russian Federation (RF) on possible joint management measures for the Rockall haddock fishery have taken place for over ten years. Changes in the configuration of the EU Exclusive Economic Zone in 1999 led to a renewal of the RF Rockall haddock fishery, highlighting that joint management would be desirable although potentially difficult to implement. Meetings involving scientists and fisheries managers from both the EU and the RF have been held on an almost annual basis since 2001 to determine what is known about the fisheries, and how such information should be used to develop a productive and sustainable management system.

Building on the history of Rockall fisheries and the supporting scientific work presented by Newton *et al*. (2008) and Filina *et al*. (2009), the EU–RF Working Group on Rockall haddock met several times during 2008–2010 and produced a state-of-the-art review of available data and scientific analyses pertaining to Rockall haddock. EU–RF (2011) documents the first three of these meetings. At the fourth meeting in Edinburgh in September 2010, a proposal was drafted for a joint EU–RF management plan for Rockall haddock. Following further refinements, a final version was presented to NEAFC near the end of 2010. Subsequently, NEACF forwarded the management plan proposal to ICES for evaluation in 2011. Analyses were conducted by ICES in 2011, but these were considered preliminary and incomplete, and ICES was unable to assess if the HCRs in the plan were consistent with the precautionary approach (ICES, 2011). This resulted in NEAFC making a new request in 2012 for evaluation of the HCR, with some modifications over the HCR presented in 2011. The modified 2011 HCR was found to be not consistent with the precautionary approach under the conditions of low recruitment that had existed since 2004 (ICES, 2012a, 2012c). NEAFC requested advice on a modified HCR for Rockall haddock again in 2013. The modification to the 2012 HCR included a decrease in F when SSB < B_{pa} to F = 0 (as opposed to F = 0.1 in the 2012 request) when SSB ≤ B_{lim}. Another potential modification to the HCR included the use of an additional parameter in the calculation of the reduction in fishing mortality under paragraph 4, for cases of low recruitment.

Results and conclusions

Under the proposed HCR, the 2013 analyses (ICES, 2013a) indicate that there is a greater than 5% probability that the spawning-stock biomass will be below B_{lim}, both in the short and long terms, if future recruitment is characteristic of the range observed since 2004 (see Table 5.3.3.2.1 for the long-term probabilities). This result is for an HCR based on the provisional F_{MSY} proxy of 0.3.

The analyses using an α parameter for low recruitment situations (assumed as 'since 2004'), to be used in paragraph 4, as indicated in the NEAFC request, suggested that the use of the α parameter in the range of values tested did not have much impact on the performance of the HCR (Table 5.3.3.2.2). It should be noted that the differences in probabilities of SSB < B_{lim} have to be treated with caution because the number of iterations (100) used for most of the analyses was small.

Following these analyses, supplementary analyses using a maximum F = 0.2 in the HCR (when SSB > B_{pa}) were conducted (for the unmodified HCR, i.e. with α = 1). These were found to result in probabilities of SSB < B_{lim} that are greater than 5% in the first few years of the simulation, but smaller than 5% in the long term (see Table 5.3.3.2.1 for long-term probabilities and Figure 5.3.3.2.1 for a graphical display of development through time). Therefore, this HCR was considered to be consistent with the precautionary approach.

In determining the consistency of the HCR with the precautionary approach, consideration was given to the fact that current stock abundance is very low, following from the very low recruitments observed since 2007. Applying the HCR does not lead to a smaller than 5% probability of SSB < B_{lim} in the immediate future. However, it is unlikely that such a low probability could be achieved immediately, even under no fishing. This will be highly dependent on the incoming recruitment in 2013 and subsequent years. In these circumstances, an HCR under which the probability of SSB < B_{lim} is estimated to be < 5% after some initial years, while then remaining at < 5% in the long term, has been considered to be consistent with the precautionary approach.

Methods

Two different Management Strategy Evaluation (MSE) analyses were conducted to investigate the properties of the proposed HCR (ICES, 2013a). Both approaches were based on the most recent (2013) ICES assessment results of the Rockall haddock stock (ICES, 2013b), which uses an XSA model, with catch (landings and discards) numbers-at-age data and an abundance index provided by a Scottish survey conducted annually in Division VIb. In the ICES assessment, recruitment is at age 1, and the same age-at-recruitment was used in the MSE analyses. In forward simulations, both analyses used the mean of values observed in the most recent ten years for weights-at-age, exploitation patterns, and discarded proportion-at-age (for scenarios that considered discards). Two different recruitment scenarios were considered. One scenario ("medium recruitment") was based on random draws from the historical estimates of recruitment over the full time-series of the assessment (1991–2012), while the other scenario ("low recruitment") used random draws over the period 2004–2012, when recruitment has generally been low.

One of the analyses used the Fisheries Library in R (FLR; see Kell *et al.*, 2007; Needle, 2008). The HCR was applied to generate TACs for 2014 and future years. When paragraph 4 was invoked, the interpretation of the HCR used the SSB at the end of the TAC year corresponding to the F derived from the calculation in paragraph 4. This involved an iterative calculation of F because SSB at the end of the TAC year was part of the calculation. The assessment errors were limited to those associated with the recruitment assumptions. Each iteration was run for 32 years in the future, and the initial 10-year period was not included in the risk calculations. The calculations were initially performed with the maximum F corresponding to the provisional F_{MSY} proxy (F = 0.3) when SSB > B_{pa}.

The other analysis, carried out in Excel, shares many methodological features with the FLR one. In addition to incorporating variability in recruitment, assessment errors derived from retrospective analyses of past assessments were also included in the MSE loop. Unlike the FLR approach the iterative approach to calculate the F for the TAC year was not used. Simulations were run for the period 2013–2041 and the calculation of risk of falling below reference points was based on results from 2020–2040.

Both approaches used 100 iterations in the simulation. The analyses involved in the two approaches allowed for examination of results with:

- the two assumptions on recruitment: either a low scenario, based on the recruitments from 2004 onwards, or a medium scenario based on the full assessment time-series;
- two formulations of paragraph 4 (with and without the α parameter) for the low recruitment situation;
- with or without implementation errors, allowing a total catch value in excess of the TAC (referred to as 'discards scenario' in ICES (2013a);
- the TAC constraint in the HCR (paragraph 3) being enforced or not, explored only in the FLR analyses;
- different values of the minimum F in the HCR (when SSB < B_{lim}), explored only in the FLR analyses;
- different values of the maximum F in the HCR (when SSB > B_{pa}), initially explored only in the EXCEL analyses.

Not all of these analyses were part of the request, but were explored during the WKROCKHAD2 workshop (ICES, 2013a).

Following results of analyses carried out in EXCEL which suggested that the HCR with a maximum F of 0.2 may be consistent with the precautionary approach, an analysis was conducted with FLR using the same maximum F and the same approach to calculate the SSB in paragraph 4 as the EXCEL analyses (i.e. no iterative process). For this FLR analysis, 1000 iterations were conducted to get a more accurate estimation of risk, as this was very close to 5%.

Sources

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ICES. 2010. Report of the Working Group on the Celtic Seas Ecoregion (WGCSE), 12–20 May 2010, Copenhagen, Denmark. ICES CM 2010/ACOM:12. 1435 pp.

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ICES. 2012b. Report of the Working Group for the Celtic Seas Ecoregion (WGCSE), 9–18 May 2012, Copenhagen, Denmark. ICES CM 2012/ACOM:12. 1747 pp.

ICES. 2012c. Report of the Workshop to evaluate the EU–Russian proposal for the harvest control component of the management plan for Rockall haddock, 29–31 May 2012, ICES HQ, Copenhagen, Denmark. ICES CM 2012/ACOM:63. 39 pp.

ICES. 2013a. Report of the Second Workshop to evaluate the EU–Russian proposal for the harvest control component of the management plan for Rockall haddock, 4–6 June 2013, ICES HQ, Copenhagen, Denmark. ICES CM 2013/ACOM:67.

ICES. 2013b. Report of the Working Group on the Celtic Seas Ecoregion (WGCSE), 8–17 May 2013, Copenhagen, Denmark. ICES CM 2013/ACOM:12

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Newton, A. W., Peach, K. J., Coull, K. A., Gault, M., and Needle, C. L. 2008. Rockall and the Scottish haddock fishery. Fisheries Research, 94(2): 133–140.

Table 5.3.3.2.1 Summary of long-term probability of SSB < B_{lim}, excluding the first 10 years in the simulation (unmodified HCR, i.e. $\alpha = 1$). The results are from the FLR (first value in each cell) and Excel (second value in each cell) analyses under two recruitment scenarios and two values of maximum F in the HCR (when SSB > B_{pa}). The number of iterations is indicated in parentheses.

Maximum F in the HCR*	Low (recent) recruitment	Medium (historical) recruitment
0.2	4.8% (1000) or 4.7% (100)	Not available
0.3	17.1% (100) or 7.1% (100)	0.2% (100) or 0.1 % (100)

*the interpretation of the SSB to be used in paragraph 4 of the HCR differed for the FLR (iterative calculation) and the EXCEL (non-iterative calculation) approaches for the analyses with maximum F = 0.3, whereas both approaches used the same interpretation (non-iterative calculation) for the analyses with maximum F = 0.2.

Table 5.3.3.2.2 Summary of long-term probability of SSB < B_{lim}, excluding the first 10 years in the simulation, with maximum F = 0.3 in the HCR and different values of α. The results in the first row are from the Excel analysis and correspond to the low recruitment scenario. The results in the second row are from the FLR analysis and correspond to the two recruitment scenarios (low and medium recruitment). The HCRs use values of $\alpha > 1$ when the three most recent recruitments are low, although the details of the implementation differ between the Excel and FLR analyses. All results in the table are based on 100 iterations.

Low (recent) recruitment, $\alpha = 1.3$: 6.2%	Low (recent) recruitment, $\alpha = 1.4$: 5.6%	Low (recent) recruitment, $\alpha = 1.5$: 4.9%
Low (recent) recruitment, variable α (1.1 or 1.25): 15.2%	Medium (historical) recruitment, variable α (1.1 or 1.25): 0.3%	

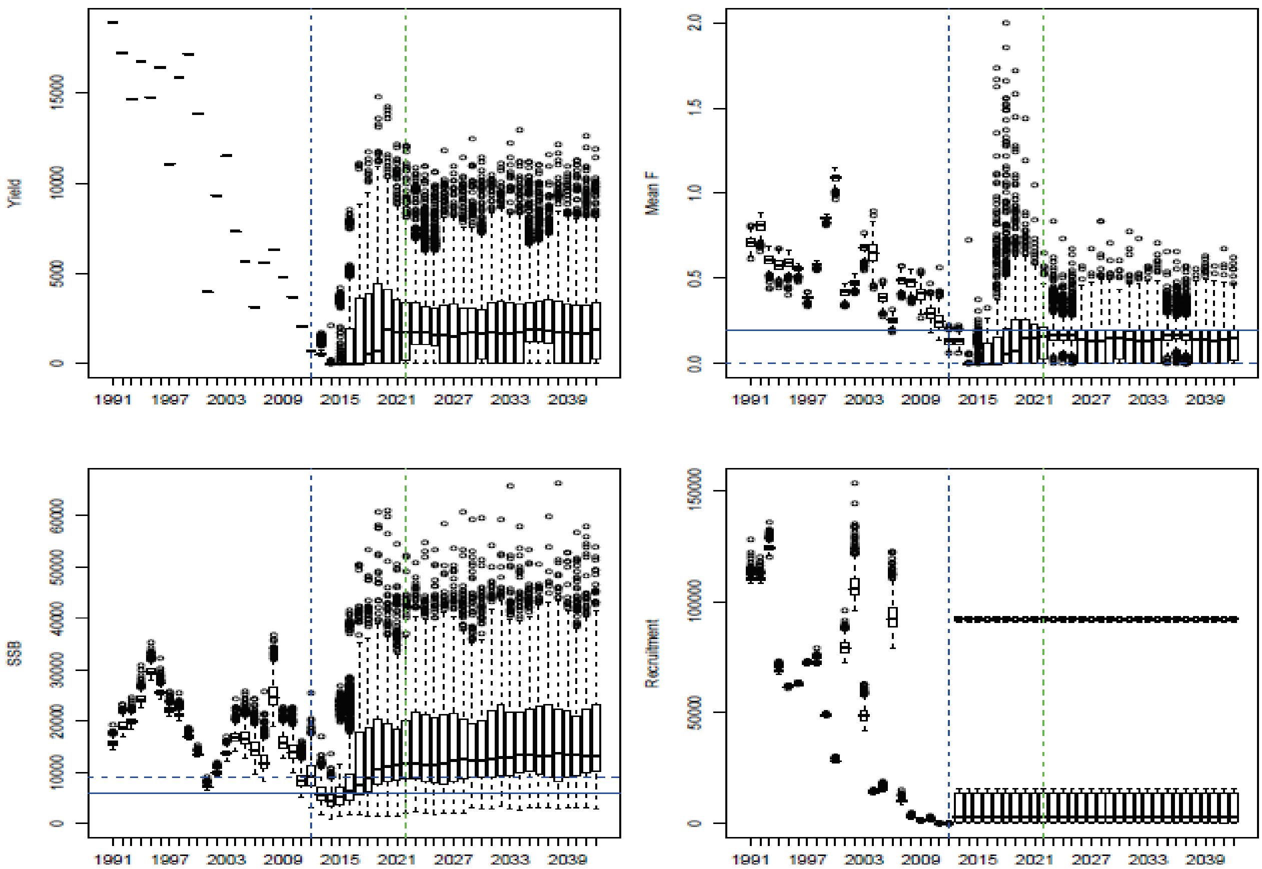

Figure 5.3.3.2.1 Summary plots for the HCR with maximum F = 0.2 (when SSB > B_{pa}). The graphs correspond to true population values from the 1000 simulation iterations for the run of the FLR MSE, assuming low recruitment (i.e. recruitment as observed since 2004). The panels show box-plots of yield (i.e. total catch; top left), F (top right), SSB (bottom left), and recruitment (bottom right). The short horizontal lines in the box-plots indicate the medians, the boxes the quartiles (25th and 75th percentiles), and the whiskers extend out to the most distant point which is at no more than 1.5 times the interquartile range distance from the end of the box. Outliers are shown by open circles. The horizontal lines in the top-right plot show F = 0.2 and F = 0, while those in the bottom-left plot show B_{pa} and B_{lim}. Vertical dashed blue lines show the last historical year, while the vertical green lines show the start of years that are included in risk analyses.