ECOREGION **Iceland and East Greenland**
SUBJECT **Faroe Islands, Greenland, and Iceland request to ICES on evaluation of a proposed harvest control rule for deep pelagic redfish in the Irminger Sea and adjacent waters**

Advice summary

ICES has reanalysed the survey time-series, which is the main source of information for the assessment. This changed the perception of stock status and productivity: The stock appears to be at a historical low. ICES has also evaluated the proposed harvest control rules, and none of them are expected to lead to an increase in stock size by 2025. Therefore, ICES considers none of these options as being in accordance with the precautionary approach. It is suggested that managers discuss other options with ICES that might be more suitable, including a starting phase to reverse the decline of the stock.

Request

"The request: The coastal states aim to implement a management plan on redfish in the Irminger Sea and adjacent waters in 2015 in accordance with the MSY approach and ICES is requested to evaluate and elaborate on the suggestions for potential HCRs under such management plan as given in the attached document.

Justification: The coastal states (Faroe Islands, Greenland and Iceland) aim to implement a permanent management plan in 2015 when the present management measures of reaching 20.000 tonnes in 2014 is running out.

Objective: The management plan should be in accordance with international agreements on sustainable harvest and the coastal states request ICES to comment on the proposed rules."

Elaboration on ICES advice

This stock is data limited, with no analytical assessment available to assess the stock status. The targeted fishery started in 1989. A fishery-independent time-series has been available since 1999, with one biomass estimated every two years. The survey series has been re-evaluated; specifically, the first two survey values were revised and an error in the most recent survey estimate (2013) corrected (ICES, 2014). This revision had a large impact on the perception of the productivity of the stock; it strongly influenced the perception of the size at the virgin stock (B_0) and growth rate (r) stages and thus changed the status of the stock in relation to MSY reference points. According to an exploratory assessment, the stock is at a historical low, and recent catches (in the order of 30 000 to 60 000 t annually since 2007) have led to a continued decline in biomass. Point estimates of carrying capacity (K) and growth rate (r) from the Schaeffer model, when including all revised survey data points, are 1 420 000 t and 0.066, respectively.

ICES considers that, for a long-lived, slow-growing, and late-maturing stock any management action will take longer than five years before changes in the biomass can be detected. Therefore, ten years seems to be a more sensible time span to assess the impact of a harvest control rule (HCR). The life history characteristics of this stock also make it vulnerable to overfishing, and once overfished, recovery might take decades. ICES therefore recommends a rather conservative management approach. At present, the stock is much smaller than virgin stock size, and there are indications that it is further declining and probably in immediate need of recovery. ICES also acknowledges that there are compliance issues in the fishery on this stock. Historically there has been a large fraction of unaccounted fishing effort on both pelagic *Sebastes mentella* stocks in international waters (Lemoine *et al.*, 2006). In this situation, ICES would consider only those harvest control rule options as precautionary in the intermediate period that lead to an increase in biomass from B_{loss} by 2025 with high probability ($B_{2025} > B_{2014}$, with $p > 0.95$).

ICES was requested to test a large number of options for HCR candidates. The range of options with the advantages and disadvantages of individual choices are outlined below; they vary by harvest ratios (0.05–0.07 U), biomass trigger (0.5 U_{max}–0.85 U_{loss}), and application of a TAC-stabilizing element in the harvest control rule. ICES considers that none of these rules meet the precautionary criterion above; the most conservative option leads to an increase of biomass in 2025 with a probability of 0.72. The results of the evaluations presented here are based only on the specific management options requested. Currently ICES has not had sufficient time to explore further possibilities. It is suggested that managers discuss other options with ICES that might be more suitable, including a starting phase to reverse the decline of the stock.

Basis of the advice

Exploratory stock assessment

This stock is data limited and no analytical assessment is carried out on deep pelagic beaked redfish in the Irminger Sea and adjacent waters because of data uncertainties and a lack of reliable age data. The results from the international redfish surveys since 1999 form the basis for ICES advice for the stock and the status is assessed from biomass trends derived from the survey indices. The survey results were revised in early 2014 and thus a consistent data series is available from 1999.

Combining the available biomass index with the time-series of catches allows a simple Schaeffer model to be applied, assuming that both sources come from a single stock unit. The time-series for catches from this stock starts in the early 1990s and the low catches in the initial period suggest that the fisheries started around that time. From this observation it can be inferred that at the start of the fishery, the biomass of the stock was at carrying capacity ($B_0 = K$). This simple model also assumes that the catchability of the survey index is equal to 1. This exploratory stock assessment has not been benchmarked and was developed only to provide input to the harvest control rule evaluations.

The international biennial acoustic and trawl survey for redfish is the primary source of biomass information for this stock. The survey started in 1999 as a pilot survey, and until recently the validity of the first two survey index values (1999 and 2001) has been uncertain. Previous stock assessments have excluded the 2005 and 2007 index value because of a change in the survey strata definition. Generally, the surveyed depth range between the shallow and the deep stratum is 500 m with the exception of these two years when the depth range was limited to 350 m. Survey data was reanalysed prior to the management plan evaluation, making it possible to include the 2005 and 2007 index values. In addition, the first two survey estimates (for 1999 and 2001) have been revised, and an error in the 2013 survey estimate has been corrected. The results of the updated assessment (Figure 2.2.3.2.1) served as basis for the evaluation of different management plan options.

Evaluation of the harvest control rule

The evaluation spans 18 different HCR candidates: three different HCR shapes were applied (Figure 2.2.3.2.2), with different trigger points and harvest rates, and with or without a TAC stabilizer. The stabilizer meant that the proposed TAC_{i+1} was equal to the mean of the advised TAC in the current year (TAC_i) and the TAC calculated from the application of the HCR without stabilizer (TAC_r), such that

$$TAC_{i+1} = (TAC_i + TAC_r)/2.$$

This rule is applied every second year because the TAC is fixed for two years. This is because new survey information is collected only every second year.

A third approach suggested in the request was to follow method 3.2.0 (the “2 vs. 3 rule”) of the ICES approach for data-limited stocks (DLS; ICES, 2012), or a variant thereof. ICES decided that this would not be a preferred option. Ideally this method would utilize an annual survey, which is not available for this stock. In addition, this method is largely untested for expected performance and its ability to satisfy precautionary and MSY objectives. Another criticism of trend-based HCRs (such as the “2 vs. 3 rule”) is that while they may arrest an increase in exploitation on the stock, they are likely to maintain stocks near to their current condition, which may be suboptimal. It was argued that target-based strategies (in terms of F_{MSY} proxies or index targets) could be preferable.

The results of the Schaeffer model are used as the basis for forecasting biomass trajectories and catches. The candidate HCRs are listed in Table 2.2.3.2.1. In the harvest control rule the trigger points refer to survey index biomass estimates (U) and target harvest rates are expressed as fractions of U.

Because survey data is only available every second year, TACs are set biennially by the HCR in the management plan. Currently there is no agreed TAC. NEAFC has set a TAC for 2014 for contracting parties at 20 000 tonnes. The non-Russian share of that TAC is about 80%. Russia has set an autonomous quota for both pelagic *S. mentella* stocks in the Irminger Sea (shallow and deep) at 27 000 tonnes for 2014. 87% of this quota is expected to be taken from the deep pelagic stock. Combining this information, catches in each of 2014 and 2015 are assumed to be (0.8 × 20 000 tonnes + 0.87 × 27 000 tonnes ≈) 39 490 tonnes.

Uncertainty in parameters is estimated using parametric bootstrapping. Parameter means come from the stock assessment point estimates. The required variance matrix is derived from the inverse of the Hessian matrix estimated in the stock assessment. The stock biomass in 2014 can be estimated for each bootstrap iteration; these estimates are used as starting values.

It should be noted that the evaluation of the HCR candidates is done assuming full compliance with the TACs. It is also assumed that the observation uncertainty present in the survey has been constant over time, and will remain constant in the future.

Results

The TACs in the harvest control rule of the management plan are set biennially as a fraction of the most recent survey index. The mean harvest ratio as a fraction of the survey index in the period 1999–2013 is approximately 0.11, with the most recent estimate being 0.16. Hence, targets below these values are expected to lead to a reduction in fishing mortality assuming full compliance.

The main differences in the outcomes stem from the target harvest rate (Table 2.2.3.2.2). Lower target rates resulted in larger median increases in biomass, and higher probabilities of increases in stock size. On the other hand, higher target harvest rates are likely to result in higher median catches in the period 2015–2025. More specifically, the difference in median catches between a target harvest rate of 0.05 and 0.07 is about 20–25% for this period.

The HCR candidates with the stabilizer clearly had lower TAC variation than the HCR candidate without stabilizer, as may be expected. The HCR candidates with the stabilizer also had lower median SSBs, caused by the fact that harvest rates in the former strategies were higher than in the strategies without stabilizer. Median catches in the period 2015–2025 were similar, but the HCR candidates with low target harvest rates and no stabilizer cause considerable reductions in catches at the beginning of the plan.

There is a trade-off in the height of the trigger point and the target harvest rate: higher trigger points allow for higher target harvest rates, resulting in the same probabilities of biomass increase. However, the variability in the catches is also higher for candidates with higher trigger points. The reason for this is that higher trigger points will result in more time being spent on the "slope" of the HCR.

The evaluation demonstrates that the differences between the different HCR shapes (linear with one or two breakpoints, or sigmoid) are minor in all parameters estimated. The choice of the biomass trigger level, harvest ratio, and the application of a TAC stabilizing rule had a much greater effect. The outcome of two candidate HCRs (candidate numbers B1F and B1T in Table 2.2.3.2.2) are shown in Figures 2.2.3.2.3 and 2.2.3.2.4.

Sources

ICES. 2012. ICES Implementation of Advice for Data-limited Stocks in 2012 in its 2012 Advice. ICES CM 2012/ACOM:68. 42 pp.

ICES. 2013. Report of the North Western Working Group (NWWG), 25 April–02 May 2013, ICES Headquarters, Copenhagen. ICES CM 2013/ACOM:07. 1538 pp.

ICES. 2014. Workshop on Redfish Management Plan Evaluation (WKREDMP), 20–25 January 2014, ICES Headquarters. ICES CM 2014/ACOM:52.

Lemoine, G., Indregard, M., Cesena, C., Thoorens, F. X., Greidanus, H., and Dörner, H. 2006. Evaluation of Vessel Detection System Use for Monitoring of Fisheries Activities. ICES CM 2006/N:02.

Table 2.2.3.2.1 Overview of the selected HCR candidates that were evaluated.

HCR candidate	HCR shape	Upper $U_{trigger}$	Lower $U_{trigger}$	Target harvest ratio
1	Linear, 2 breakpts	0.5 U_{max} (= 530 kt)	0.2 U_{max} (= 210 kt)	0.05 U / 0.01 U
2	Linear, 1 breakpt	0.85 U_{loss} (= 340 kt)	none	0.05 U
3	Linear, 1 breakpt	0.85 U_{loss} (= 340 kt)	none	0.07 U
4	Linear, 1 breakpt	0.85 U_{loss} (= 340 kt)	none	0.09 U
5	Linear, 1 breakpt	0.5 U_{max} (= 530 kt)	none	0.05 U
6	Linear, 1 breakpt	0.5 U_{max} (= 530 kt)	none	0.07 U
7	Linear, 1 breakpt	0.5 U_{max} (= 530 kt)	none	0.09 U
8	Sigmoid (σ = 2)	0.85U_{loss} (= 340 kt)	none	0.05 U
9	Sigmoid (σ = 2)	0.5 U_{max} (= 530 kt)	none	0.09 U

Table 2.2.3.2.2 Results from the forecasts for selected HCR candidates, using all available survey data (assessment scenario B). Performance indicators include median SSB, median catches, TAC variation (every second year as the TAC is set biennially), and probabilities of increased biomass in 2020 and 2025 compared to 2014. None of the HCR candidates have a higher than 0.95 probability of SSB increase in 2025 and therefore none could be considered precautionary. SSB, catch, and biennial variation results are median from 2015–2025.

HCR	HCR	$U_{trigger}$	F_{target}	SSB	Catch	Biennial TAC var.	$P(B_{2020} > B_{2014})$	$P(B_{2025} > B_{2014})$
no stabilizer								
B1F	Linear, 2 breakpts	0.5 U_{max} / 0.2 U_{max}	0.05	299 000	7 000	0.51	0.38	0.72
B2F	Linear, 1 breakpt	0.85 U_{loss}	0.05	267 000	14 300	0.26	0.19	0.3
B3F	Linear, 1 breakpt	0.85 U_{loss}	0.07	249 000	18 900	0.27	0.09	0.12
B4F	Linear, 1 breakpt	0.85 U_{loss}	0.09	231 000	22 900	0.27	0.03	0.02
B5F	Linear, 1 breakpt	0.5 U_{max}	0.05	290 000	8 800	0.39	0.31	0.6
B6F	Linear, 1 breakpt	0.5 U_{max}	0.07	278 000	11 600	0.38	0.2	0.39
B7F	Linear, 1 breakpt	0.5 U_{max}	0.09	267 000	13 800	0.37	0.1	0.18
B8F	Sigmoid	0.85 U_{loss}	0.05	265 000	14 500	0.45	0.07	0.13
B9F	Sigmoid	0.5 U_{max}	0.09	267 000	14 300	0.24	0.18	0.29
stabilizer								
B1T	Linear, 2 breakpts	0.5 U_{max} / 0.2 U_{max}	0.05	259 000	12 700	0.33	0.13	0.33
B2T	Linear, 1 breakpt	0.85 U_{loss}	0.05	240 000	18 700	0.22	0.09	0.17
B3T	Linear, 1 breakpt	0.85 U_{loss}	0.07	228 000	23 000	0.19	0.06	0.08
B4T	Linear, 1 breakpt	0.85 U_{loss}	0.09	215 000	26 600	0.18	0.04	0.02
B5T	Linear, 1 breakpt	0.5 U_{max}	0.05	254 000	14 200	0.28	0.12	0.28
B6T	Linear, 1 breakpt	0.5 U_{max}	0.07	247 000	16 500	0.26	0.08	0.18
B7T	Linear, 1 breakpt	0.5 U_{max}	0.09	240 000	18 800	0.24	0.05	0.08
B8T	Sigmoid	0.85 U_{loss}	0.05	238 000	19 400	0.27	0.04	0.05
B9T	Sigmoid	0.5 U_{max}	0.09	240 000	18 800	0.21	0.09	0.17

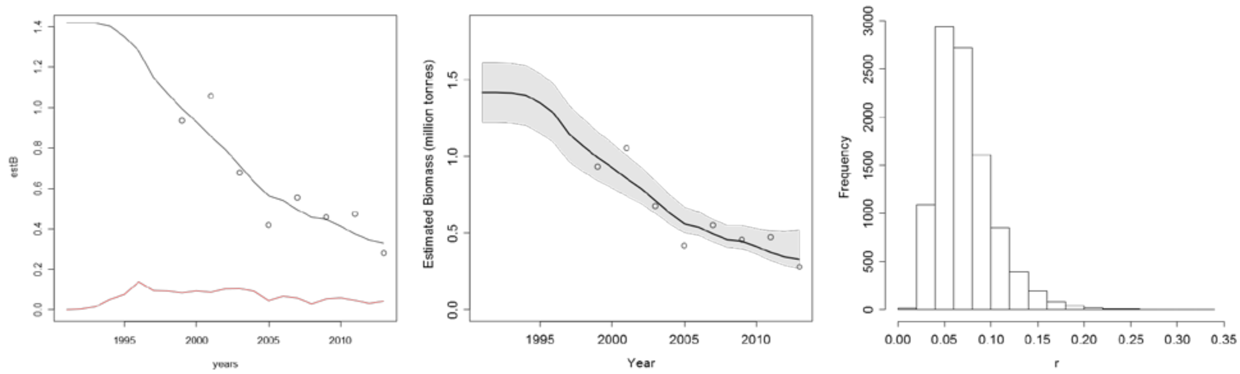

Figure 2.2.3.2.1 Time-series of index biomass, total catch, and the deterministic Schaeffer assessment model fit (left panel); the assessment model fit with stochastic uncertainty bounds (centre panel); and the distribution of values of the intrinsic growth parameter (*r*) from the stochastic model fits (right panel). Open dots indicate survey indices. The solid line indicates the estimated trend in biomass. The shaded area indicates the 95% confidence interval of model estimates.

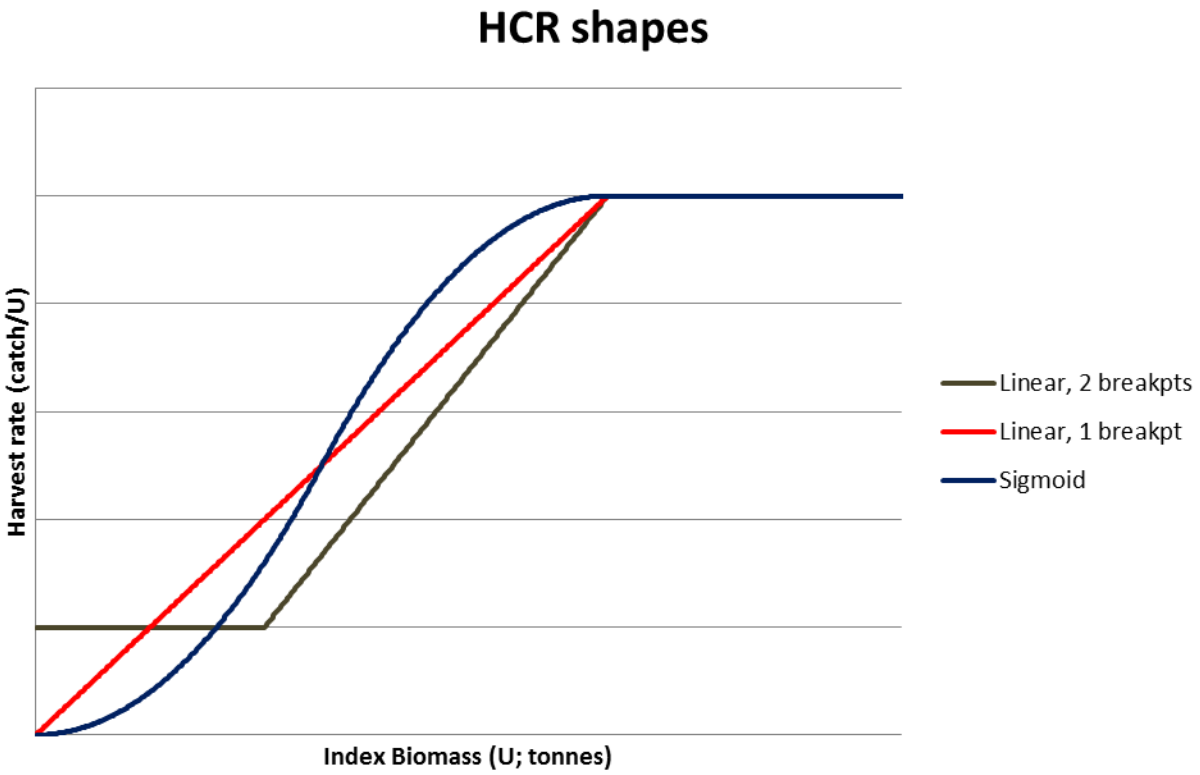

Figure 2.2.3.2.2 An illustration of the alternative HCR shapes considered in the evaluation. The two- and one-breakpoint shapes correspond to those described in the request, while the sigmoid curve was proposed as an alternative at WKREDMP (ICES, 2014). The values of the biomass trigger point(s) and target F vary.

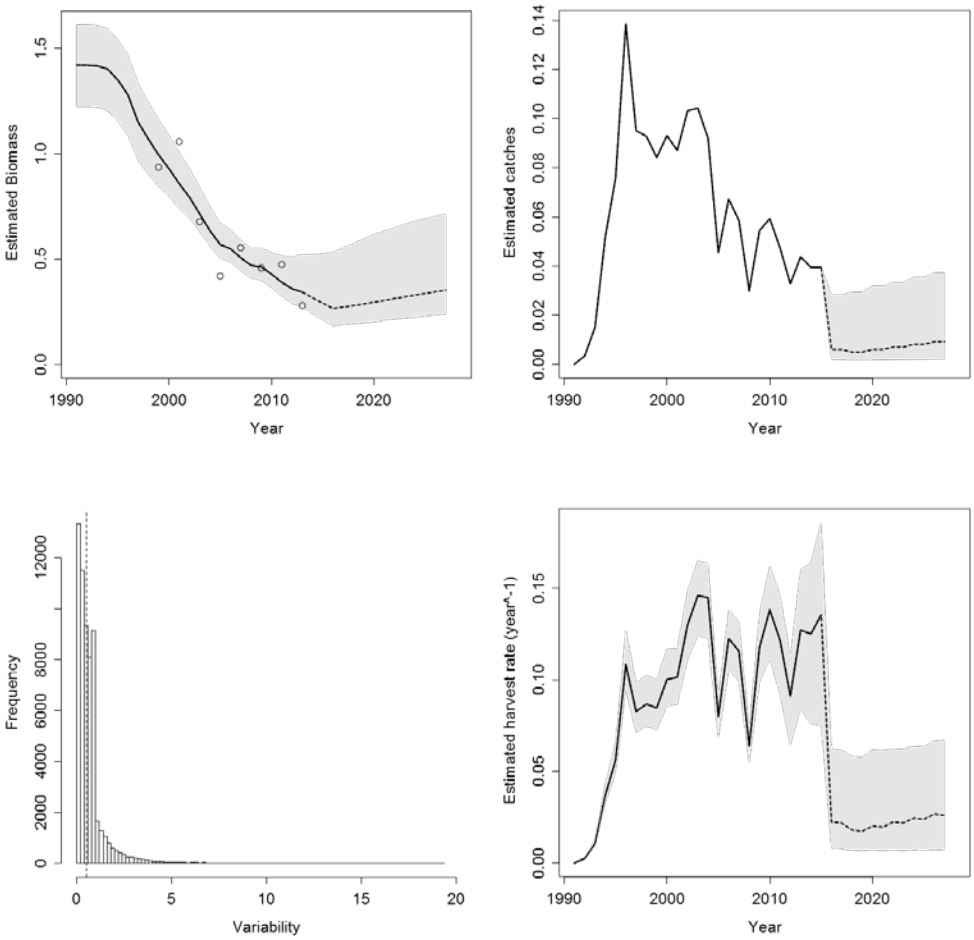

Figure 2.2.3.2.3 Example of a linear HCR candidate with two breakpoints (at 0.5 U_{max}, 0.2 U_{max}) and a target harvest rate of 0.05 in the absence of a stabilizer. Panels represent time-series of biomass, catches, and harvest rate and variability in TAC (expressed as the ratio of subsequent TACs). Shaded areas denote 95% of runs, lines denote medians of runs.

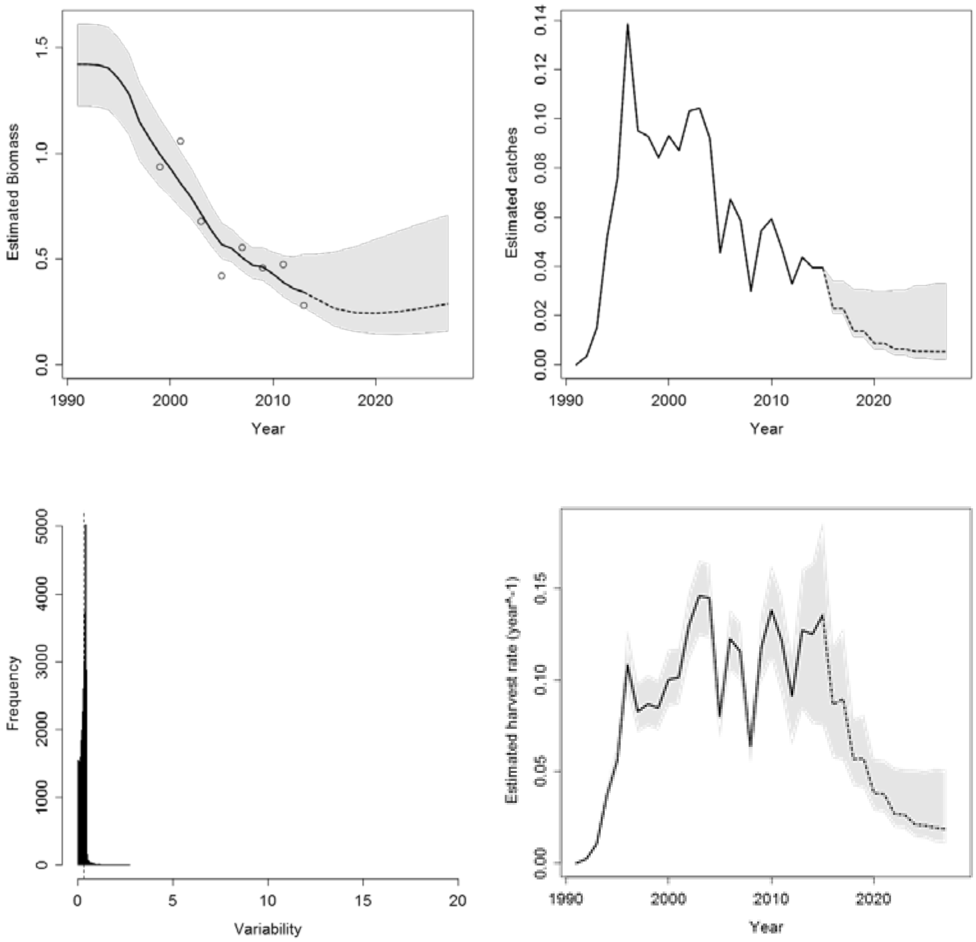

Figure 2.2.3.2.4 Example of a linear HCR candidate with two breakpoints (at 0.5 U_{max}, 0.2 U_{max}) and a target harvest rate of 0.05 in the presence of a stabilizer. Panels represent time-series of biomass, catches, and harvest rate and variability in TAC (expressed as the ratio of subsequent TACs). Shaded areas denote 95% of runs, lines denote medians of runs.