

### 5.3.3.1 EC request on evaluation of a management plan for Haddock in zones VIa and EC waters of Vb

#### Request

ICES is requested to evaluate the consequences of applying the following harvest rule for the management of haddock in zones VIa and EC waters of Vb:

1. For 2010 and subsequent years the TAC will be set consistent with a fishing mortality rate of no more than 0.3 for appropriate age-groups, when the SSB in the end of the year in which the TAC is applied is estimated to be above 30,000 tonnes ( $B_{pa}$ ).
2. Where the rule in paragraph 1 would lead to a TAC which deviates by more than 15 % from the TAC of the preceding year, the TAC will be set that is no more than 15 % greater or 15 % less than the TAC of the preceding year.
3. Where the SSB referred to in paragraph 1 is estimated to be below  $B_{pa}$  but above 22,000 tonnes ( $B_{lim}$ ) the TAC shall not exceed a level which will result in a fishing mortality rate equal to  $0.3 - 0.2 * (B_{pa} - SSB) / (B_{pa} - B_{lim})$ . This consideration overrides paragraph 2.
4. Where the SSB referred to in paragraph 2 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 0.1. This consideration overrides paragraph 2.
5. In the event that STECF advises that changes are required to the precautionary reference points  $B_{pa}$  (30,000t) or  $B_{lim}$  (22,000t) paragraphs 1-4 shall be reviewed.

The evaluation should address:

- the consequences of implementing the above rule instead of implementing ICES' current advice for this stock according to the precautionary approach;
- the extent to which the application of this rule would deliver management in conformity with the precautionary approach;
- the extent to which the application of this rule would deliver maximum sustainable yield from the stock;
- where possible, stochastic future time-streams of TACs and fishing effort necessary to catch those TACs should be made available to STECF for economic analysis. ICES is invited to liaise with STECF on this issue.

ICES is also invited to propose alternative rules or modified rules on its own initiative or in consultation with RACs and to evaluate these. Such alternative rules should lead to either or both higher or more stable catches and lower biological risks.

Following ICES consultations with the NWWRAC (NWWRAC Focus Group, 3<sup>rd</sup> July 2009, Aberdeen) it was concluded that the terms of the EC request to ICES formed an appropriate basis for consideration for the management of haddock in zones VIa and EC waters of Vb but the analysis should consider fishing mortality options for the target F from 0.2 to 0.4, limits in TAC changes from  $\pm 15\%$  to  $\pm 25\%$  and a simulation period of 20 years into the future.

#### ICES Response

**ICES advises that a harvest rule with a target fishing mortality of 0.3 and a TAC constraint of  $\pm 15\%$  is consistent with the precautionary approach (high probability of SSB being above  $B_{lim}$  by 2015 and beyond). In addition, simulations suggest that this harvest rule has the best chance, among those tested, of producing a combination of low risk to biomass and high cumulative yield, thus it conforms with the goal of achieving long-term maximum sustainable yield from the stock.**

The harvest rule was tested for several combinations of target fishing mortality (0.2, 0.3, 0.4) and interannual variation in TAC ( $\pm 15\%$ ,  $\pm 20\%$ ,  $\pm 25\%$ ). The range of analyzed fishing mortality options included values encompassing proxies for  $F_{msy}$  ( $F_{0.1}$ - $F_{max}$ ). The main results of the evaluation are presented in the Table below and in Figures 5.3.3.1.1 and 5.3.3.1.2.

Summaries of risk (number of years in each iteration in which biomass was lower than  $B_{pa}$  and  $B_{lim}$ , averaged over iterations and probability of SSB in 2015 being above  $B_{lim}$ ) and cumulative yield (summed true landings, averaged over iterations) for each of the target F and TAC limits combination.

Target F	TAC constraint	Num years B < $B_{pa}$	Num years B < $B_{lim}$	P( $B_{2015} > B_{lim}$ )	Cumulative yield ('000 t)	Cumulative yield (relative)
0.2	15%	3.76	0.80	> 95%	704	0.89
0.3	15%	3.70	0.94	> 95%	789	1.00
0.4	15%	6.24	2.34	> 80%	667	0.85
0.2	20%	3.60	1.04	> 95%	664	0.84
0.3	20%	4.40	1.10	> 95%	804	1.02
0.4	20%	4.70	1.18	> 95%	785	0.99
0.2	25%	3.46	0.86	> 95%	711	0.90
0.3	25%	4.00	1.08	> 90%	807	1.02
0.4	25%	6.26	2.20	> 80%	776	0.98

Over all tested combinations of target F and TAC constraint, spawning biomass was below  $B_{pa}$  in fewer than seven of the 22 years in the simulations (on average). The bulk of these years occurred during the first years of the simulations as the stock recovered from its current low state. Biomass was below  $B_{lim}$  in fewer than three years in the simulations (on average), and these years nearly always occurred during the initial few years of recovery. Cumulative yield is also likely to increase for all analyzed combinations.

The harvest rule was tested under assumptions about stock biology, unaccounted removals and assessment performance, (as outlined below). If these assumptions do not pertain in the future, the rule should be revisited.

## Background

The evaluation of the harvest rule was conducted using simulations of the projected population from 2009 to 2030 (20 years into the future, as requested, plus 2 years to allow for quota-setting forecasts). A Management Strategy Evaluation (MSE) approach was used to generate true and assessed catches and population sizes as follows:

- (i) Reported landings (in weight and numbers-at-age) were generally determined by the quota for each year (set by the management module run in the previous year). If not enough fish were available for the quota to be taken, reported landings were adjusted downwards *pro rata (in proportion)*. Otherwise, reported landings were assumed equal to the quota. Reported catch and discards were generated from reported landings by applying fixed proportions-at-age (average of proportions of catch and discards over 2006–2008);
- (ii) True catch (in yield and number of fish-at-age) was generated by applying a fixed multiplier (average of the ratio of estimated to observed catches over 2006–2008) to reported catch generated in (i). True landings and discards were generated from true catch by applying fixed proportions-at-age (average of proportions landed and discarded over 2006–2008);
- (iii) The assessed population was generated deriving stock size and fishing mortality by applying random noise to true stock size and fishing mortality. Assessed catch, landings and discards were derived from the assessed population estimates by first applying the catch equation, and then applying the proportion discarded. The approach assumes that the assessment method (TSA) gives a good approximation of the true population.

In the first year of the simulations, the 2009 quota (3520 t) was used to generate reported landings. The reported landings were considered the intended landings and the true fishing mortality was used as the intended fishing mortality. Future recruitments were predicted from a “hockey-stick” S-R model with a breakpoint at  $B_{lim}$  (fitted to the period 1978–2008), with residuals generated from an autoregressive moving average ARMA(1,0) model. Natural mortality (0.2), weights-at-age and proportion mature-at-age (averaged over 2006–2008) were assumed to be time-invariant and without error.

The analysis was conducted by the Marine Scotland Science Laboratory, Aberdeen, using R (R Development Core Team, 2005) and FLR libraries (FLR Team, 2006).

## Discussion

The analytical approach used assumes fixed future relationships (fixed proportions) between observed and estimated removals, and between landings and discards. Discard practices were also assumed constant into the future. These assumptions may have had a large influence on the results as some simulations generated show biomasses larger than any observed. The multiplier used to generate true catches was based on the average during 2006–2008 but prior to 2006 higher values were observed. It was also assumed that the quota would be taken annually, which has not been common in the fishery. To have more confidence in the robustness of the harvest rule, subsequent analyses would have to be performed explicitly accounting for these aspects.

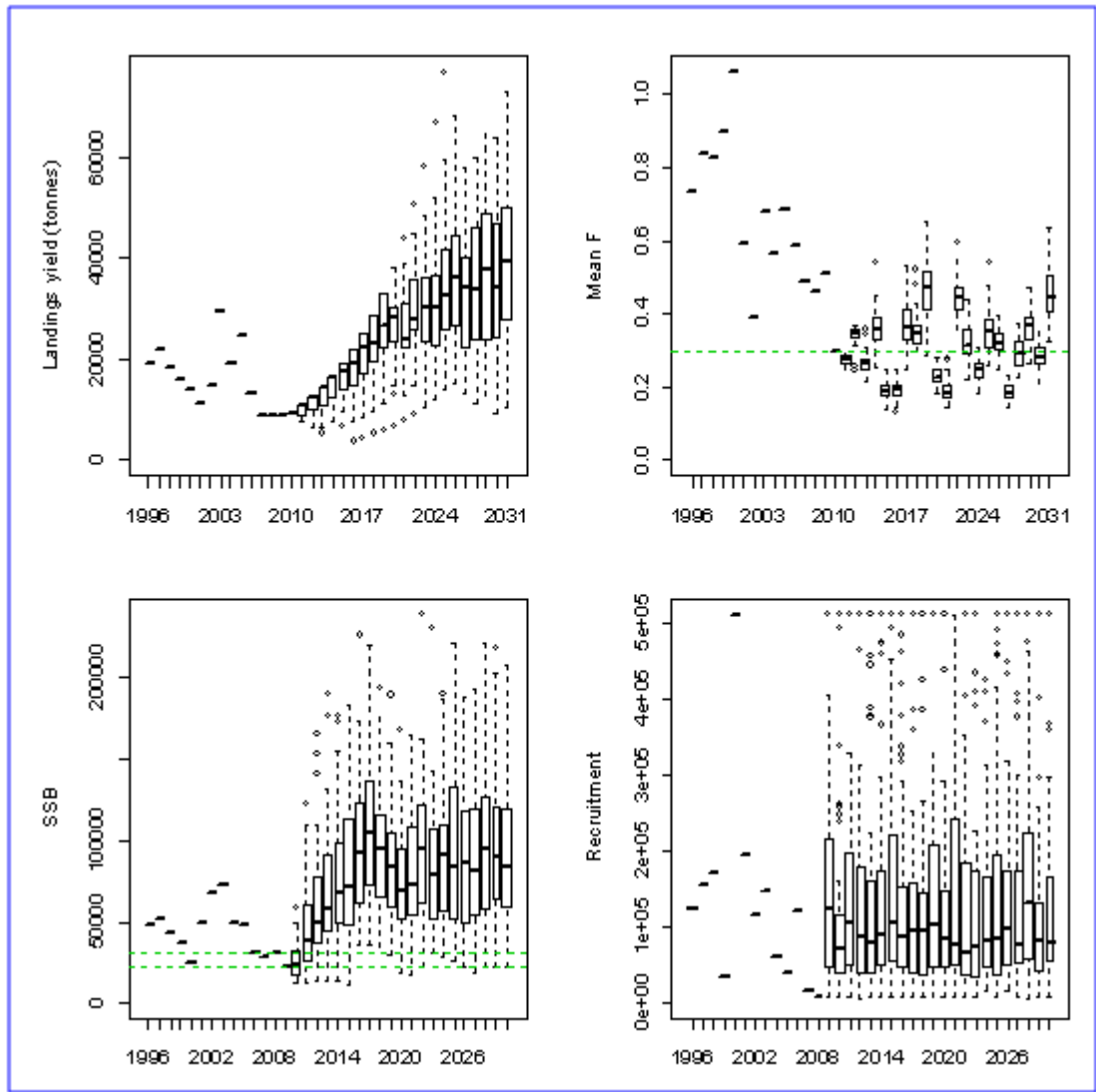
Future recruitments were simulated to reflect recent below-average recruitment. This approach gives robustness to the conclusion that the stock is likely to be sustainable if managed according to the advised harvest rule.

$F_{msy}$  was not estimated but the simulation results show that cumulative yield is highest (under all TAC constraints) at a target  $F$  of 0.3, thus supporting the perception that  $F_{msy}$  for haddock is around 0.3 given the current exploitation pattern. As such, fishing at  $F=0.3$  would be expected to "...deliver maximum sustainable yield from the stock".  $F=0.3$  is also within the range of values of  $F_{0.1}$  and  $F_{max}$  estimated for this stock (ICES, 2009), and these fishing reference points are generally considered proxies for  $F_{msy}$ .

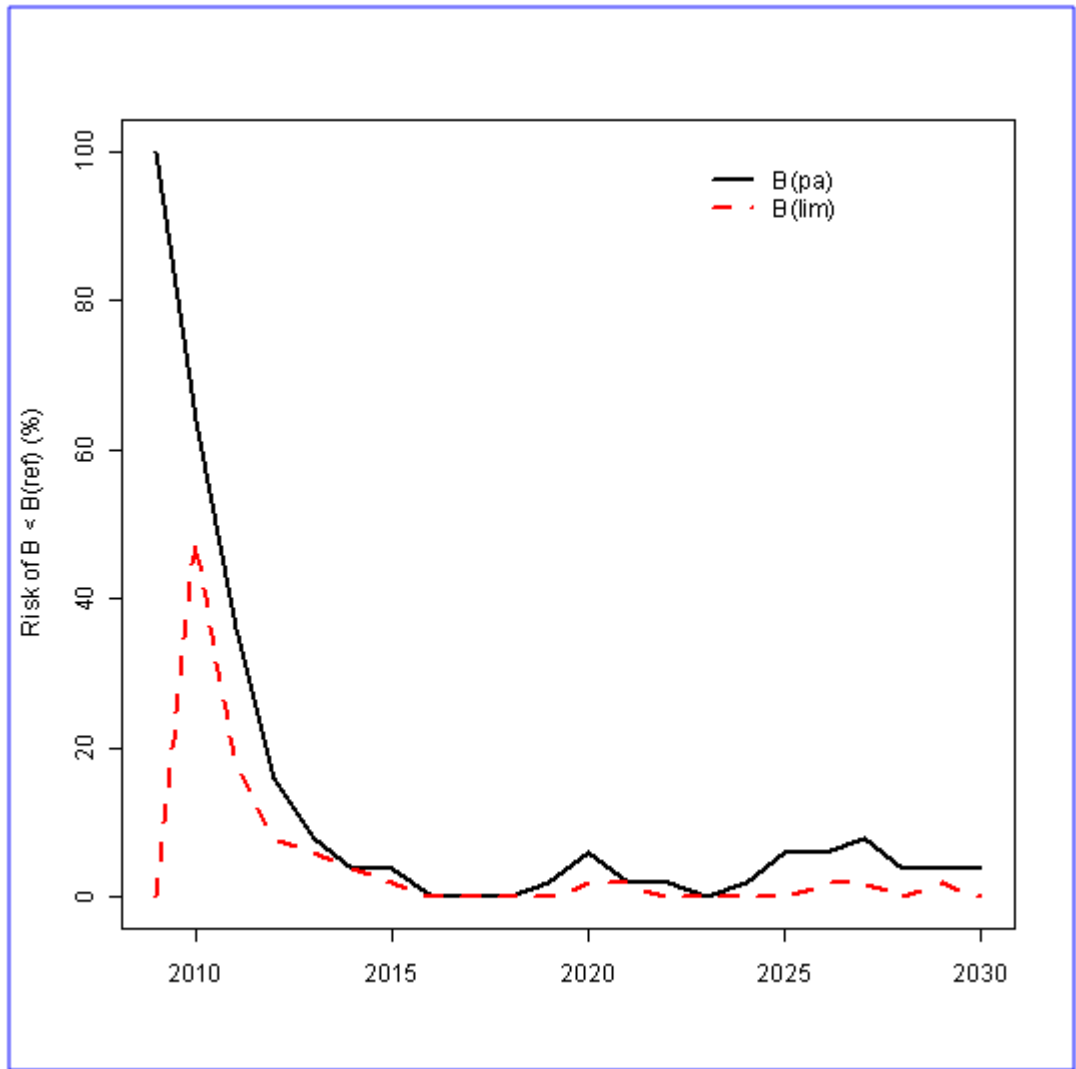
The EC requested an evaluation of "*the consequences of implementing the above rule instead of implementing ICES' current advice for this stock according to the precautionary approach*". The ICES advice for 2010 was that no fishing should take place in 2010 for haddock in VIa so as to rebuild the stock to close to  $B_{pa}$  in 2011. In the simulations testing the harvest rule, the starting conditions (e.g recruitment), assumptions and TAC restrictions were different from those used for the short-term prediction of SSB, which was the basis for ICES 2010 advice. The simulation results suggest that none of the tested combinations of  $F$  and TAC constraint would allow, with high probability, recovery of SSB to  $B_{pa}$  in 2011 (e.g., for  $F=0.3$  and a TAC constraint of 15%, the probability (risk) of SSB being below  $B_{pa}$  in 2011 was estimated to be 80%, Figure 5.3.1.1.2). However, it is noted that all the combinations of  $F$  and TAC limits resulted in relatively small changes to current landings compared to the current ICES advice of no fishing indicating that, if the assumptions in the analysis are met in practice, SSB has a high probability of rebuilding to  $B_{pa}$  by 2015.

## Source of information

- ICES. 2009. Report of the Working Group on the Celtic Seas Ecoregion (WGCSE), 13–19 May 2009, ICES Headquarters, Copenhagen. ICES CM 2009\ACOM:09.
- Needle, C. 2009. An evaluation of a proposed management plan for haddock in Division VIa: 2<sup>nd</sup> edition, 14<sup>th</sup> January 2010 (<http://groupnet.ices.dk/advice2009/adghad>).



**Figure 5.3.3.1.1** Landings (weight), mean  $F_{(2-6)}$ , spawning biomass (SSB) and recruitment for target  $F$  of 0.3 and TAC constraint of  $\pm 15\%$ . The short horizontal lines indicate the medians, the boxes the quartiles (25<sup>th</sup> and 75<sup>th</sup> percentiles), and the whiskers the 5<sup>th</sup> and 95<sup>th</sup> percentiles. Outliers are shown by open circles. The dashed line on the top-right plot shows the target  $F$ , while those on the bottom-left plot show  $B_{pa}$  (upper) and  $B_{lim}$  (lower). Historical estimates (pre-2009) are shown as short horizontal lines only.



**Figure 5.3.3.1.2** Probability (risk) of SSB being below  $B_{pa}$  and  $B_{lim}$  for target  $F$  of 0.3 and TAC constraint of  $\pm 15\%$ . The probability was computed from the proportion of iterations in each year for which predicted biomass was less than reference points.