ICES ADHOC REPORT 2013

ICES ADVISORY COMMITTEE

ICES CM 2013/ACOM:75

Evaluation of proposed harvest control rules for Bay of Biscay sole

September 2013

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Contents

1 Introduction

The evaluations reported here were carried out following an EU request to ICES on an evaluation of proposed harvest control rules for sole in the Bay of Biscay. The authors worked together in September 2013 to answer this request. Their affiliations are listed in the Annex.

1.1 Basis for the advice: Analysis

1.1.1 Request

ICES received the following request from the European Commission:

For a harvest control rule based on a fixed TAC and safeguard mechanisms as described below, ICES is requested to:

- *advise on whether these management provisions are consistent with ICES precau tionary approach in the long-term, and*
- *to give the year at which FMSY is reached with high probability for each of the TAC values in point 2 below.*

Point 1: Fixed TAC

1) *Rules for setting the TAC for the stock of sole in the Bay of Biscay are defined with the objective to reach FMSY (i.e., F = 0.26) by 2020;*

2) *The TAC is set at a constant value until the fishing mortality is equal to FMSY. TAC levels in a range of 3500 to 4500 tonnes (by 100 tons steps) are tested;*

3) *When fishing mortality is equal to FMSY, the TAC is set to maintain fishing mortality at FMSY (0.26);*

4) *When the rule of paragraph 3 applies, the TAC set for a given year shall not correspond to a variation of less than or more than 10% compared to the TAC of the preceding year;*

5) *Notwithstanding paragraph 2, if fishing mortality increases during the two years preceding the advice on the status of the stock, the TAC is reduced by 10% compared to the previous year. The TAC level set in this way becomes the reference TAC fixed for the application of the rule in paragraph 2;*

6) *If the spawning stock biomass is estimated to be less than the biomass limit (Blim = 13,000 tons), the TAC is set at a level corresponding to FMSY.*

Point 2: In the absence of validated analytical assessment

1) If the analytical assessment of the stock of sole in the Bay of Biscay is not available or is not validated by ICES and / or STECF, the setting of the TAC is based on the trend in abundance indices;

2) Based on the index of abundance derived from the scientific campaign ORHAGO, the TAC is increased by 15% if the average stock abundance of the two preceding years is at least more than 20% compared to the average abundance of the previous three years. The TAC is otherwise reduced by 15% if the index indicates a decline in abundance of 20% or more on the same basis.

1.2 Interpretation of the request

Point 1: Fixed TAC

ICES notes that even though the plan gives Blim=13 000 t, this value is actually for Bpa and not Blim. In principal, ICES considers a plan as precautionary when the probability of having SSB below Blim is less than 5%. Here, despite the absence of defined Blim, ICES considers that the very high probabilities of having SSB above Bpa fulfil this requirement and considers the proposed plan as precautionary.

The proposed harvest rules were simulated as described thereafter:

- Rule 1: a catch series (3 500 tons to 4 500 tons with 100 tons steps) and F_{MSY} (0.26) were set as targets.
- Rule 2: the catch adjustment is effective in the second year (2014) on a target (TAC) as long rule 3 does not apply (fishing mortality above F_{MSY}).
- Rule 3: if catch adjustment leads to a fishing mortality below F_{MSY} during year n, then the target become F_{MSY} from year n+1 onwards to the end of the simulation (2032).

Other following rules are conditions that modify rules 1 to 3.

- Rule 4: the catch changes (when rule 3 applies) are limited to a percentage X of the preceding catch target.
- Rule 5: if at a beginning of a year n, F(n-1)>F(n-2)>F(n-3), then the catch target in rule 2 is decreased by X %
- Rule 6: if SSB is below a value Y, then the target becomes a reference fishing mortality

Point 2: In the absence of validated analytical assessment

When no analytical assessment is available, ICES has defined stock categories and advice basis for each of them (ICES, 2012). If such a situation should occur, ICES will refer to this framework to provide an advice. If abundance indices are available (ORHAGO survey or reliable fishery-dependant indices), the ICES framework gives guidelines for a TAC advice. Consequently, ICES advice should comply with the item 1 of point 2 but it will not be in accordance to item 2. The WG is unable to simulate such future event and consequently to provide any assessment of the implementation of this later rule.

1.3 Data and methods

The simulations of the implementation of the proposed harvest control rules for the Bay of Biscay sole fishery management were carried out using the Impact Assessment bio-economic Model for fisheries management (IAM). This software can provide stochastic projections for several species, several fleets and several metiers by combining biological and economic dynamics of a fishery (Merzéréaud *et al*, 2011). It has been used for the Impact Assessment of the Bay of Biscay sole management plan (Simmonds *et al.*, 2011) to assess the economic effects of this plan by integrating 3 species, 12 fleets and 6 métiers. However, it can also be used in a simpler way to simulate fishery dynamics considering only the biological factors for one stock and one fleet as for the present advice. Constraints on catches or on fishing mortalities can be fixed and outputs (biomasses, yields and fishing mortalities) are derived from the usual stock dynamic equations.

This software allows to take account for uncertainties of prediction parameters. These uncertainties were set all along the simulation period, including the first year (20 years from 2013 to 2032), or only at the starting point of the simulation when they are derived later on from other parameters uncertainties (stock numbers at age). For each parameter, a set of values was generated by a Monte Carlo iterative process based on the statistical characteristics of the parameters (means, variances and distributions) with the exception of recruitment, see thereafter. Each iteration uses one of these values for each parameter to get a set of outputs for which the classic dispersion and uncertainty indicators (variance, quantiles, probabilities…) have been calculated. 1 000 iterations have been carried out for each scenario over 20 years and thus 20 000 values are used for each parameter. In case of lack of convergence of the optimizing process that simulates the harvest control rules (described in section 1.2), the iteration has been excluded (less than 5 output values on 20 000 on average). The same set of parameters values were used for all the investigated scenarios.

The simulations were started in 2013 using the same parameters than the 2013 WGHMM (ICES, 2013) for the short term predictions (Table 1): recruitment in 2013 is the geometric mean over 1993-2010, numbers at age 3 and above are XSA outputs, natural mortality is assumed to be 0.1 at all ages, maturity ogive as estimated by ICES WG since 2001, input Fs are 2010-2011 mean at age 2 and 2010-2012 means at age 3 to 8, catch and stock weights are 2010-2012 means.

Table 1 : Simulation input data

Fbar age range (Total) : 3-6
Input Fs are 2010-2011 means at age 2
Input Fs are 2010-2012 means at age 3 to 8
unscaled F
Catch and stock wts are 2010-2012 means
Recruits are 1993-2010 GM
Input units are thousands and kg

2013

Age	N	M	Mat	Stock Wt	F Landings	Landing WT
2	22673	0.1	0.32	0.198	0.099	0.186
3	18585	0.1	0.83	0.232	0.354	0.218
4	10993	0.1	0.97	0.277	0.591	0.261
5	4588	0.1	1	0.348	0.368	0.329
6	6000	0.1	1	0.426	0.293	0.405
7	1900	0.1	1	0.483	0.171	0.458
8	4810	0.1	1	0.689	0.171	0.653

CV

Age	N	M	Mat	Stock Wt	F Landings	Landing WT
2	0.22	0.1	0.1	0.04	0.25	0.04
3	0.19	0.1	0.1	0.05	0.16	0.05
4	0.12	0.1	0	0.04	0.07	0.04
5	0.15	0.1	0	0.05	0.27	0.05
6	0.12	0.1	0	0.08	0.34	0.08
7	0.09	0.1	0	0.10	0.22	0.10
8	0.08	0.1	0	0.16	0.22	0.16

For all the parameters except the recruitment and numbers at age 3 and above (endogenous parameter), these values were used to generate random values in subsequent years, considering that parameters are random variables of which the means are the 2013 values. Normal distributions were assumed, with in some cases a minimum and/or a maximum value(s) (0-1 for maturity, 0 for mean weights). Their CV are calculated on the same range of years than parameter as estimated as a mean:

recruitment CV on 1993-2010 (for initial input value), fishing mortalities CV on 2010-2011 at age 2 and on 2010-2012 at age 3 to 8 and stock weight CV on 2010-2012. Because the stock weights at age are derived from the catch weight for this stock (old fresh-gutted coefficient kept for stock weights to calculate SSB with the same basis than the Bpa), catch weights at age are derived from stock weights at age using the ratios of the 2010-2012 means.

Number at age CV at age 3 and above are XSA outputs.

Maturities at age CV are assumed to be 0.1 from age 2 to 3 and to be null at age 4 and above. Natural mortality CV are assumed to be 0.1 at all ages.

The recruitments in 2014 and subsequent years were generated using a stock and recruitment model based on a segmented regression ("Smooth Hockey Stick"). The model was fitted to the series of yearly recruitment and SSB values obtained from the XSA assessment (period 1993-2010) by minimising a log-likelihood function. Parameters of this relationship are estimated with ADmodel builder using the R function plotMSY developed by Cefas and uncertainties around the estimates are characterised using an MCMC approach. 20 000 values of parameters of the S/R relationship were thus generated. Figure 1 gives an indication of the uncertainty inherent in the estimation of the stock and recruitment curves. The left hand curve shows the confidence intervals from 20 000 re-samples (printed at the bottom of the legend) from the MCMC chain (the solid red lines is the median). The right hand figures present curves plotted from 100 re-samples for illustration. The blue line indicates the deterministic estimate (maximum likelihood), separate from the MCMC chain.

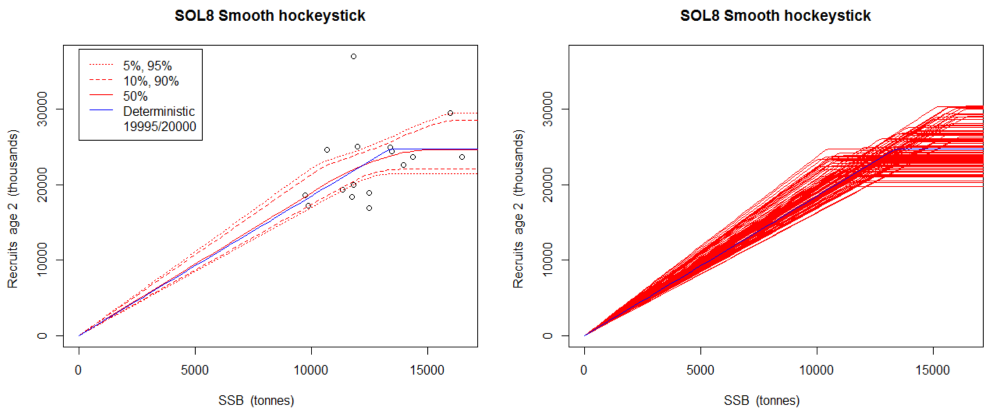

Figure 1 Plot of the S/R relationships obtained from the MCMC chain. Circles on the left hand side graph represents SSB and R estimates (1993-2010) from the stock assessment.

For each iteration, the recruitments at age 2 are generated using the S/R relationship with parameters drawn from the MCMC chain. In 2014, the SSB in 2012 as estimated by the last ICES assessment (14 663 t) is used and thereafter, the recruitments in year n which are generated by the estimated SSB in year n-2.

The recruitment distributions are the same all along the year range of the simulation but the mean recruitment is lower in 2013 (GM as assumed by the 2013 WGHMM) than in following years when this mean is at the plateau of the segmented regression (Figure 2).

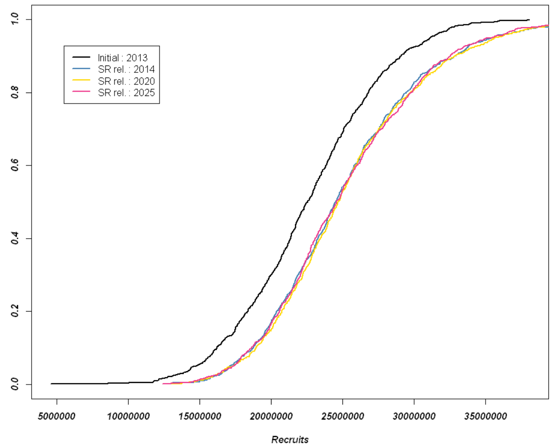

Figure 2 Cumulative probability distribution of the recruitments in 2013, 2014, 2020 and 2025.

The software includes an optimizing process that allows adjusting the catches or the fishing mortalities to given targets, according to the harvest control rules to simulate. This adjustment is performed from 2014 onwards.

Further to the population uncertainties, two additional sources of uncertainty were added. For the Fixed TAC rule a CV of 5% was applied to the fixed TAC to mimic variability in mean weight which would result in variability in number removed. For the F rule, a CV of 20% was applied on the intended F (i.e., F=0.26) to get the actual applied F. This was done to mimic uncertainty in the assessment, uncertainty in mean weights and a small increase resulting from the short term forecast.

1.4 Results

The simulations were carried out using the 20 000 values of parameters of hockey stick S/R relationship generated by the MCMC.

Figures 3 shows the trends in total catches when applying the plan with TAC values between 3 500 and 4 500 t and the resulting trends in F and SSB.

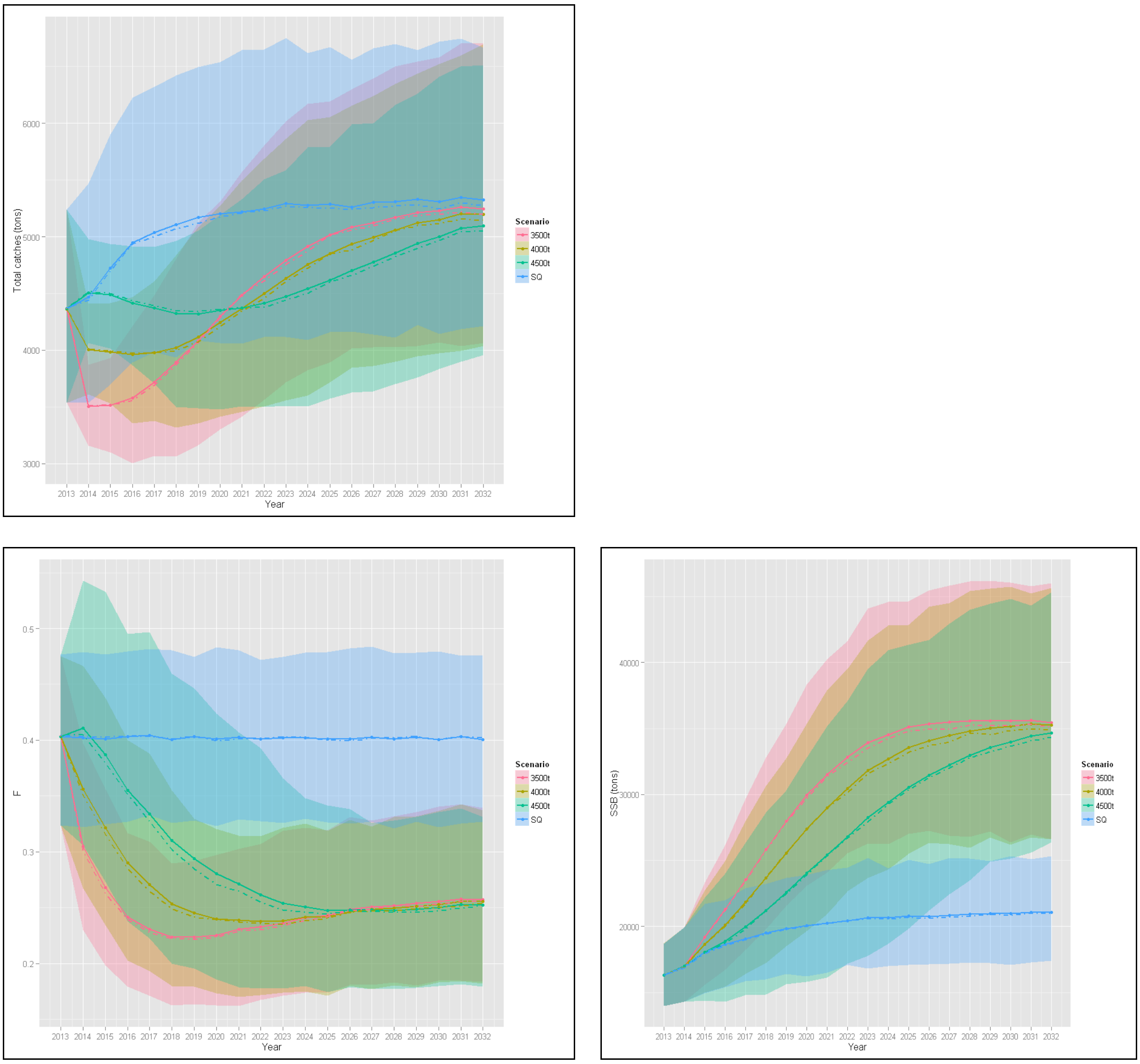

Figure 3 Trends in total catch, F and SSB for 3 values of TAC. The solid line is the mean, the dotted one, the median. 95% CI is also presented for each scenario.

It should be noted that the realized catches are constrained by the fixed values of the TAC during the transition period (when rule 2 applied). In some of the iterations for which F_{MSY} is reached or when F increased during two consecutive years, other rules may apply, leading to a mean catch different from the original fixed TAC values.

F is expected to be equal or below F_{MSY} with at least 50% probability in 2016 for a TAC value equal or lower than 3700 tonnes, in 2017 if TAC does not exceed 3900 tonnes, in 2018 for a TAC of 4100 tonnes, in 2019 for a TAC equal or lower than 4200 tonnes, and in 2020 for a constant TAC not in excess of 4300 tonnes (Table 2).

Table 2 The probability (in %) for F ≤ F_{MSY} for fixed TAC between 3 500 and 4 500 tonnes. Shaded values have >50% probability of F<F_{MSY}.

Fixed TAC	2013	2014	2015	2016	2017	2018	2019	2020	2021
3500	0	14.1	47.2	71.8	83.6	86.6	86.4	84.7	79.0
3600	0	9.0	36.6	63.1	78.0	82.6	84.0	81.3	78.2
3700	0	6.4	28.7	55.0	70.9	77.3	81.1	79.9	77.8
3800	0	4.2	22.1	46.2	61.1	71.4	76.7	78.3	76.8
3900	0	2.7	16.4	37.9	54.4	66.3	72.2	76.0	74.9
4000	0	2.0	12.1	30.8	46.4	59.9	67.2	71.8	72.7
4100	0	1.5	8.5	22.7	37.7	52.2	60.8	66.0	68.3
4200	0	1.0	5.7	17.0	30.6	44.4	53.9	60.8	64.2
4300	0	0.9	3.4	13.6	24.5	38.2	45.2	54.7	58.9
4400	0	0.6	2.2	9.2	17.9	29.6	39.0	47.7	53.0
4500	0	0.4	2.1	6.5	13.2	24.7	32.4	41.7	45.8

In all scenarios, SSB will remain above 13 000 tonnes with a high probability (greater than 99%) (Table 3).

Table 3 The probability (in %) for SSB ≤ 13 000 t for fixed TAC between 3 500 and 4 500 tonnes.

Fixed TAC	2013	2014	2015	2016	2017	2018	2019	2020	2021
3500	0.1	0.2	0	0	0	0	0	0	0
3600	0.1	0.2	0	0	0	0	0	0	0
3700	0.1	0.2	0	0	0	0	0	0	0
3800	0.1	0.2	0	0	0	0	0	0	0
3900	0.1	0.2	0	0	0	0	0	0	0
4000	0.1	0.2	0.1	0	0	0	0	0	0
4100	0.1	0.2	0.1	0	0	0	0	0	0
4200	0.1	0.2	0.1	0	0	0	0	0	0
4300	0.1	0.2	0.2	0.1	0	0	0	0.1	0
4400	0.1	0.2	0.2	0.1	0	0.1	0	0	0
4500	0.1	0.2	0.2	0.1	0.1	0.2	0.1	0	0

Figure 4 shows that the rule 6 of the plan nearly never applied (in less than 1% iterations, and only on the first years of the simulation). This is not surprising given the current state of the stock and the S-R used.

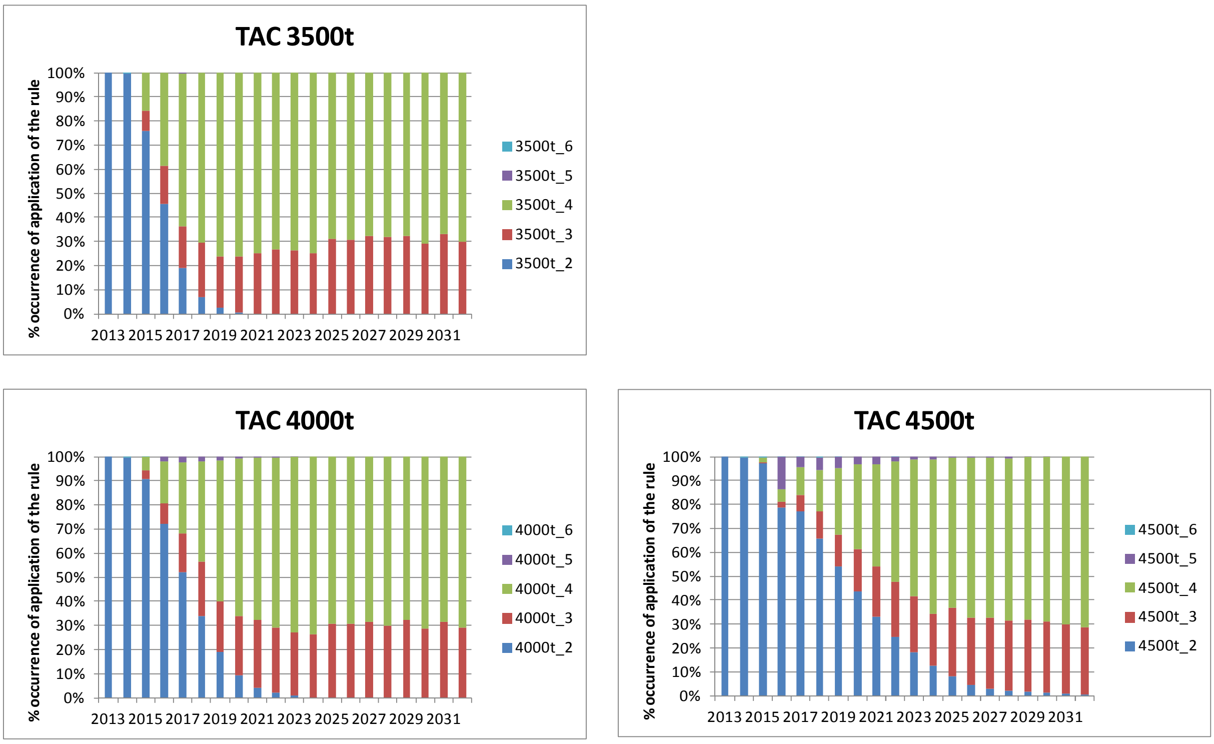

Figure 4 The proportion of iterations for which each rule applied for three TAC values (3500, 4000 and 4500 tonnes). The number following the TAC values are the rule number.

The 10% interannual TAC variation limitation (rule 4) is invoked for around 70% of the iterations once F_{MSY} is reached whatever the TAC value is. This rule more often applied in the beginning of the simulated period for the lower TAC values (Figure 5).

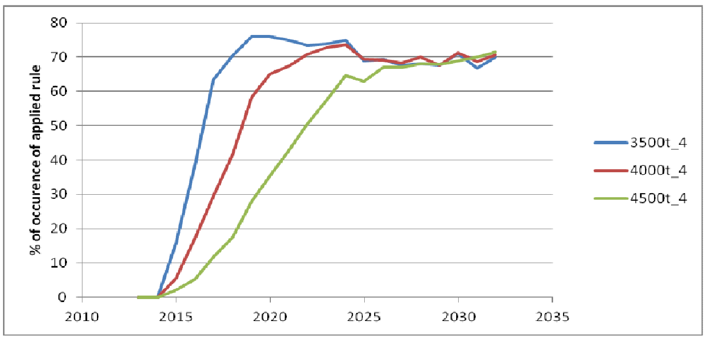

Figure 5 The proportion of iterations for which the 10% TAC variation limitation (rule 4) applied for three TAC values (3500, 4000 and 4500 tonnes).

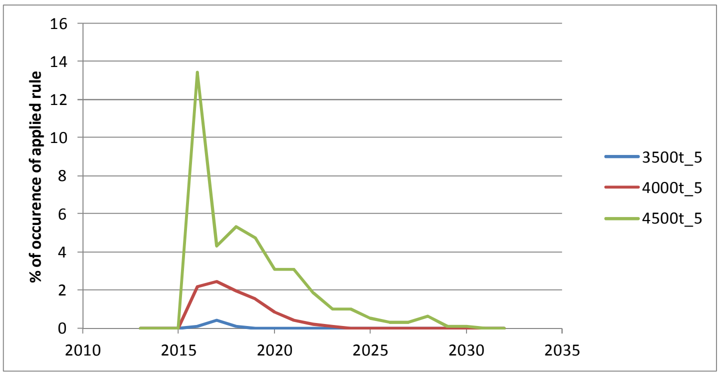

Figure 6 The proportion of iterations for which the rule 5 applied for three TAC values (3 500, 4 000 and 4 500 tonnes).

The rule 5 (10% decrease in TAC if F increases over two consecutive years) not often applied (maximum in 12% iterations for TAC=4500 tonnes in 2016). This rule applies more for higher simulated TACs (Figure 6), and in that case (Figure 7), leads to higher probabilities of reaching F_{MSY} during the transition period with a more pronounced effect for higher fixed TAC levels.

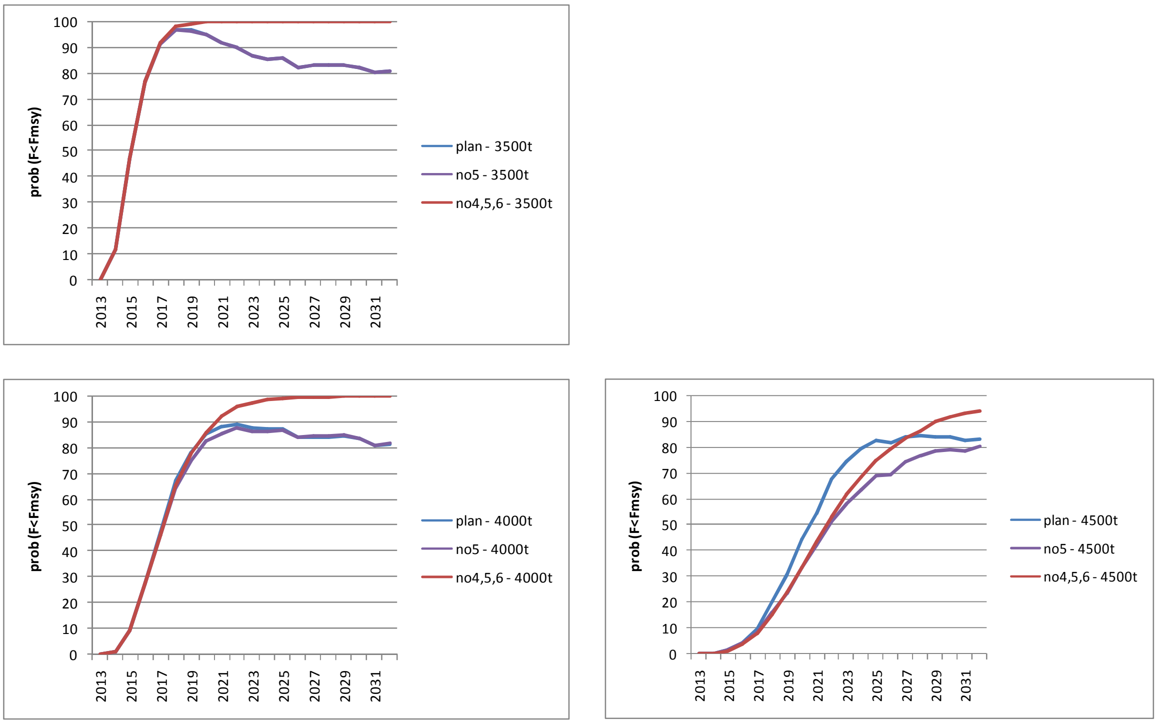

Figure 7 The probability of F<=F_{MSY} if rule 5 not applied for three values of TACs. Note that "no5 – 3500 tonnes" means that no rule 5 applied when simulated TAC is 3500 tonnes.

Alternative simulations with a 15% variation in rule 4 and 5 and without TAC variation regulation were carried out with uncertainties included only in the simulated population. The use of a 15% variation instead of a 10% one in rule 4 (and 5) affects only slightly the probabilities to be at or below F_{MSY} (Figure 8). The occurrences of fishing mortalities above F_{MSY} are obviously lower with 15% than with 10% and the probability to be at or below F_{MSY} is expected to be higher in the second part of the simulation period for all the simulated TAC values, while it is slightly lower in the beginning of the period for lower TAC values, similar for intermediate values and still higher for the higher TAC values.

Removing any TAC variation regulation (labeled 'no' on Figure 8) would obviously lead to a very high probability (>99%) of being at or below F_{MSY} in the long term. However, in the transition period, it only slightly changes the values of this probability and therefore hardly modifies the year for which this probability is equal or greater to 50%.

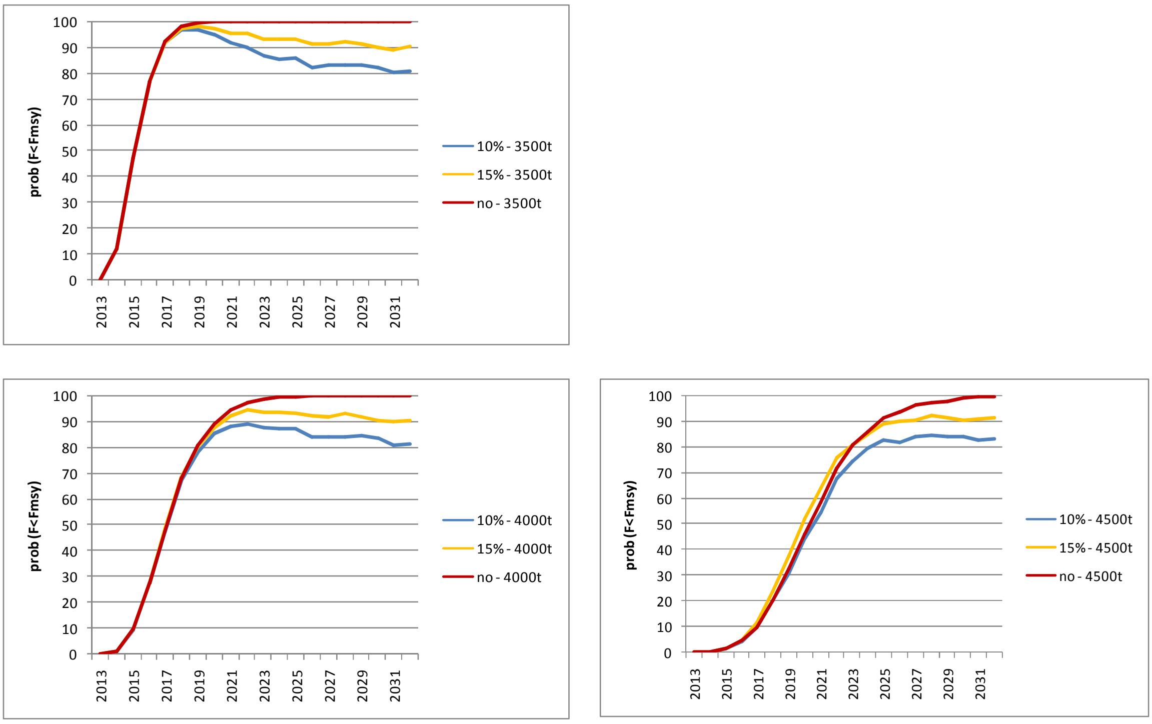

Figure 8 The probability of F<= F_{MSY} with a 10% (the plan), 15% and no TAC variation limitation for three TAC values. Note that the 15% scenario allows a 15% variation value for both rules 4 and 5.

2 Discussion and conclusion

The proposed HCR for the Bay of Biscay sole were set with the aim to avoid large variations in TAC from 2014 onwards to reach F_{MSY} at the latest in 2020, with a limitation in TAC changes to 10 % and some safeguards rules/measures when F increases or when SSB is below B_{pa}.

The simulations show that F could be reduced at or below F_{MSY} at the latest in 2020 when aiming at a fixed TAC equal or lower than 4300 tonnes.

The main difference between the TAC options is the year in which the F will be at or below F_{MSY}, the lower is the fixed TAC, the higher is the probability to be at or below in F_{MSY} 2020.

It should be kept in mind that from 2004 to 2008 as well as in 2010 and in 2011, the recruitments are estimated by the last WGHMM to be below the mean values which are used in the simulations. The analysis carried out here is conditional on the assumption on the stock-recruitment relationship. If the recruitments estimated in future assessments continue to be lower than GM, this may impact the stock-recruitment relationship and the evaluation of the HCR will need to be updated. If a management plan is to be developed based on this HCR, some provision should be incorporated in the plan to allow for such a revision.

For all the TAC values tested, the risk of SSB falling below B_{pa} is negligible.

A TAC variation limitation (rule 4) does not seem to have a great impact during the transition period. Once the F_{MSY} objective is reached, it leads to more stable F and therefore to a higher probability of staying above F_{MSY}.

Rule 5 appears to be useful for the higher values of TAC in order to reach F_{MSY} quicker.

Given the current state of the stock, rule 6 hardly ever applies.

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Annex 2 Minutes of the advice drafting group for the Bay of Biscay sole

(RG/ADG BOBS) By Correspondence 8-11 October 2013

Participants:

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Muriel Lissardy (France)

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John Simmonds (United Kingdom)

Secretariat: Anne Cooper

General considerations

The review group met by correspondence on 8 and 9 October and maintained contact by telephone on the 10 October and met again by correspondence on 11 October to finalize the text.

The RG/ADG BOBS acknowledges the hard work done by the Ad Hoc group and thanks the participants for the quality of the report and the preparation of the draft advice sheet dealing with the main issues for the special request.

Specific issues

The group reviewed the report and identified a number of potential issues. Each is noted with the decision on action.

Issue	Action
The simulation of the recruitment did not fully represent the variability that is likely to be encountered. Autocorrelation in the recruitment had been observed, and it was particularly noted that this had led to a sequence of low values in 2004-2008.	This issue was already identified as an important issue by the Ad Hoc group; however, insufficient time was available to redo the analysis with autocorrelation added. A paragraph indicating this issue was added to the advice. In the future, autocorrelation in recruitment residuals should be included in the model.
Fitted stock recruitment relationships gave a model with high point of inflection and shallow slope. This might lead to slightly over optimistic recruitment and response to fixed TACs, but it would lead to pessimistic response to F exploitation due to shallower slope to the origin resulting in an increase in the likelihood of stock crash	No action required. Although this is not ideal, the balance of problems was considered acceptable. If more time was available, a stock recruit function with point of inflection at lowest observed point would allow sensitivity to this issue to be evaluated.
The population uncertainty is well parameterized; however, observation error was not included in the model. This has only a minor impact on the population trajectories under the fixed TAC part of the regime as very little is	It was agreed that in addition to the current population uncertainties, several modifications would be made and the model rerun: 1) For the Fixed TAC rule, a CV of 5% applied to the fixed TAC (to mimic variability in mean

estimated, and it is only uncertainty in mean weights and selection that influence the results. Variability in selection is included in the model. However, annual assessments are needed to evaluate if F is less than or equal to F_{MSY} to determine if the HCR should implement clause 3 and 4. Subsequent to this, uncertainty in F influences the setting of TAC.	weight that would result in variability in number removed; it will be applied to the TAC for convenience); and 2) For the F rule noise with a CV of 20% is added to the F target from the plan (to mimic uncertainty in the assessment, uncertainty in mean weights, and a small increase resulting from the short term forecast). These choices were made to allow the model to be rerun in the time available. For any future studies it would be preferable to include an observation model to mimic assessment error and to use for all decision process in the HCR. The chosen approach does not include uncertainty in F for evaluating if clause 3 should apply for the first time, so transition from fixed TAC to F rule is assumed to be taken with perfect knowledge. This may slightly underestimate the variability in transition under the HCR. As all scenarios result in only negligible occurrence of SSB>B_{pa} implying that the probability of SSB< candidate B_{lim} can be effectively ignored these short comings were considered acceptable.