9.3.3.4 **Special request, Advice July 2013**

ECOREGION **Widely distributed and migratory stocks**
SUBJECT **EC request to ICES to evaluate possible modifications of the long-term management arrangement for the Western horse mackerel stock**

Advice summary

ICES considers that the current harvest control rule (HCR) in the Western horse mackerel management plan is not consistent with the precautionary approach (PA) because the plan is not robust to the two or more years of very low recruitment, which has been the observed for this stock since 2004.

However, ICES is able to advise on alternative options for amending the current HCR based on appropriate stock and recruitment modelling. The state of the stock, the stock productivity, and the effect of the fishery on the stock have a significant impact on the value of these parameters, and these aspects need to be analysed in greater detail to fully illustrate how the HCR might be made consistent with the PA.

Until these issues are addressed, ICES is neither able to advise on a suitable replacement plan nor a revision of the 2013 TAC.

Request

The EC has requested ICES advice on the following issue:

"In 2007, a management plan based on the triennial egg survey was proposed by the Pelagic RAC. The management plan was evaluated by ICES in 2007 and was found to be precautionary only in the short term because some relevant scenarios were not evaluated. ICES reviewed the plan again in 2012 and could not unequivocally conclude that the original or modified HCR is consistent with the precautionary approach in the long term. ICES further advised in 2012 that the plan should be subjected to a complete review. ICES did not advice on the basis of the management plan due to the fact it has not been established that it is precautionary in the long term.
Request

1. *ICES is requested to fully evaluate the plan, and ascertain whether it is precautionary in the long term as well as in the short term.*
2. *Should the plan be found not to be precautionary in the long term, ICES is requested to identify reinforcements in the harvesting rules that would resolve the plan's shortcomings in that respect.*
3. *ICES is furthermore requested to identify what TAC should apply in 2013 in accordance with a revised harvesting rule under point 2 above. "*

Elaboration on ICES advice

ICES evaluated the HCR in the management plan for western horse mackerel (ICES, 2013a). The simulations on which the original HCR was based were carried out in 2007, and since then the standards for these simulations have been amended and improved. Applying the most recent ICES standard (ICES, 2013b) to these simulations highlights shortcomings in the HCR and the basis for the calculations. As a consequence of these shortcomings ICES considers that the HCR in its original form is not consistent with the PA. In the primary findings the stock and recruitment modelling was considered inadequately conditioned (by contemporary standards and in the light of more years of data since 2007), and the HCR not robust to two or more years of very low recruitment. Since 2004 the frequency of low recruitment has increased, resulting in a potentially wider range of SSB to be taken into account in the management plan. ICES further evaluated measures to address these shortcomings (ICES, 2013a). These evaluations, with appropriate model (stock and recruitment) conditioning, show that the risks could be managed through the introduction of a protection rule in the HCR. This protection rule could take the form of an egg count threshold, below which the TAC arising from the HCR would be modified by a scalar parameter between zero and one. Results show that improved risk management comes at the cost of increased yield variability and reductions in average yield.

In order to parameterize the HCR appropriately (and evaluate risks in the short and long term) the simulations need to be updated to the most recent perception of the stock, the stock productivity, and the effect of the future fishery on the stock. The combination of all of these aspects (from the 2011 assessment) has changed considerably from the values on which the original simulations were based. In general terms the 2011 assessment implies that the stock is less productive (at least recently) and that the reduced productivity is being harvested earlier by the fishery. Taken together this would imply lower sustainable harvest rates compared to the perception in 2006. The consequences of this change in perception is a stock that has a risk of about 10% of being unable to sustain itself above 1.24 Mt (the current proxy reference point for B_{lim}), even with no fishing. These aspects (appropriateness of reference points and robustness of the selectivity in the assessment) need to be examined in more detail before parameterization of an alternative HCR can be carried out.

Suggestions

Future work could focus on:

- Benchmarking the stock assessment and the reference points;
- Simulations similar to the ones reported here, but with revised assessment and reference points;
- Stakeholder involvement in refining the trade-off between various possibilities.

Basis of the advice

Building upon previous work, ICES carried out a review of some elements of the HCR at a workshop in June 2013 (ICES, 2013a). This workshop addressed the following concerns raised in relation to the conditioning of the simulation and the construction of the HCR:

a) appropriate modelling of recruitment;
b) the scenario of successive years of poor recruitment; and
c) the implementation of an explicit protection rule.

The original simulations modelled recruitment as a single fit to a hockey-stick function and did not incorporate autocorrelation in recruitment. An analysis of the time-series (excluding the very large 1982 year class) showed significant autocorrelation at a 1-year time lag. In order to conform to current standards it was necessary to include this autocorrelation so that the probability of low biomass could be correctly investigated. The autocorrelation was parameterized and applied in new simulation runs. The implementation of autocorrelation had little effect on the yield and yield variability statistics. The frequency and magnitude of interannual TAC changes were also little altered. There was, however, a significant increase in risk to the reference SSB level, with a doubling of the risk in the initial period (first ten years). A scenario of successive poor recruitment was not explicitly tested in the original simulations, although successive low recruitment could have been drawn from the recruitment function, albeit with low probability. In order to investigate the effect of sustained periods of low recruitment and the response of the harvest rule, scenarios were tested which imposed the minimum observed recruitment from the historical time-series for periods of one, two, and three consecutive years (ICES, 2013a). The conclusion was that the HCR is not sufficiently flexible to cope with more than one successive year with the minimum estimated recruitment to date. In addition, the risk increases significantly with two or three successive years of minimum recruitment (see Table 9.3.3.4.1).

Table 9.3.3.4.1 Illustration of the effect of including increasing risk (autocorrelation) for poor recruitment. In the column AC (Auto-Correlation) Y means including and N excluding autocorrelation. In the column "10Yr Per" 1 stands for the ten-year period 2011–2020, and 2 for 2021–2030. Risk1 is the average risk within the ten-year period and Risk 2 is the risk of falling below SSB_{1982} at least once in the ten-year period. It can be seen that the risk approximately doubles when autocorrelation is taken into account.

			Yield		**Risk of SSB< SSB1982**	
AC	TACref	10yr Per	Mean (kt)	CV (%)	Risk1 (%)	Risk2 (%)
Y	140	1	162	12.1	10.1	20.7
N	140	1	162	11.8	4.9	11.0
Y	140	2	139	12.5	15.2	27.2
N	140	2	141	11.6	4.4	9.7

The inertia in the original HCR and the increased stress-testing requirement result in risk values (SSB< SSB_{1982}) above 5% for the parameters in the HCR as defined in the plan. A protection rule was examined which takes the form of an egg count threshold limit (normally called a trigger point) below which a factor (between 0 and 1) is applied. This modification decreases the yield, based on the ratio of the observed egg count to the threshold (ICES, 2013a). The results showed that the risk could be managed through the use of different values of the threshold limit whereby higher thresholds would lower the risk, but at the cost of increased yield variability and lesser reductions in average yield.

Simulations were also conducted with further modification to the HCR: an additional multiplier for the TAC. The multiplier is based on an egg limit and a divisor. For example, if the egg limit is 500 with a divisor of 500 and the egg count is 400, then the multiplier applied to the TAC is 400/500 = 0.8. With the same settings but using a divisor of 1000 would result in a multiplier of 400/1000 = 0.4, i.e. more stringent action. So, the limit sets the point at which action is taken and the divisor sets the strength of the action. Table 9.3.3.4.2 lists various combinations of egg limit and egg divisor and Table 9.3.3.4.3 shows the results of the simulations.

Table 9.3.3.4.2 Egg limits and divisors for the protection rules investigated.

HCR	Egg limit	Egg divisor
1	NA	NA
2	500	500
3	500	1000
4	750	750
5	1000	1000
6	1000	2000
7	1500	1500
8	1500	3000
9	2000	2000
10	2000	4000

Table 9.3.3.4.3 Results of simulations with the various protection rules from Table 9.3.3.4.2. The simulation results are shown for the HCR and the two risk options in the future first (1–10), second (11–20), and third (31–40) ten-year periods.

HCR	Yield 1–10	Risk1 1–10	Risk2 1–10	Yield 11–20	Risk1 11–20	Risk2 11–20	Yield 31–40	Risk1 31–40	Risk2 31–40
1	170	42%	70%	171	32%	58%	168	23%	39%
2	167	42%	69%	161	24%	54%	167	11%	28%
3	165	42%	71%	135	21%	52%	164	9%	24%
4	154	41%	68%	142	19%	48%	163	9%	23%
5	138	40%	66%	123	15%	43%	154	6%	16%
6	101	36%	59%	74	10%	30%	135	2%	6%
7	96	29%	49%	96	10%	30%	132	2%	7%
8	45	19%	32%	57	4%	12%	92	0%	1%
9	70	25%	41%	79	6%	20%	107	1%	3%
10	33	16%	28%	39	3%	10%	62	0%	0%

Effect of the changes in the perception of the stock, the stock productivity, and the effect of the future fishery on the stock

The analyses suggest that in its original form the HCR would not meet the minimum criteria to satisfy a precautionary approach. This is primarily because in the original tests, recruitment was not modelled adequately. The original HCR is not robust to scenarios of successive poor recruitment and requires strengthening in the form of a protection rule. In the evaluation so far the original model conditioning has been addressed through the inclusion of autocorrelation in recruitment. These elements were then tested with the introduction of a protection rule in the HCR. The Management Plan workshop report (ICES, 2013a) presents examples of parameters for these amendments to the HCR. However, the perception of risk associated with the HCR depends also on the productivity of the stock and the effect of the future fishery on the stock. These aspects have not yet been fully explored. The perception of both of these aspects (from the 2011 assessment) has changed considerably from the view on which the original simulations were based. The selection in the fishery was lower on young fish in 2006, but in 2011 the selection is estimated by the assessment to be very high on young fish (1.5 to 2 times that on older fish) and decreasing on older fish (Fig 9.3.3.4.1). Also, a comparison of the stock and recruitment pairs shows that the current perception of productivity is more variable than it was in 2006 (Figure 9.3.3.4.1).

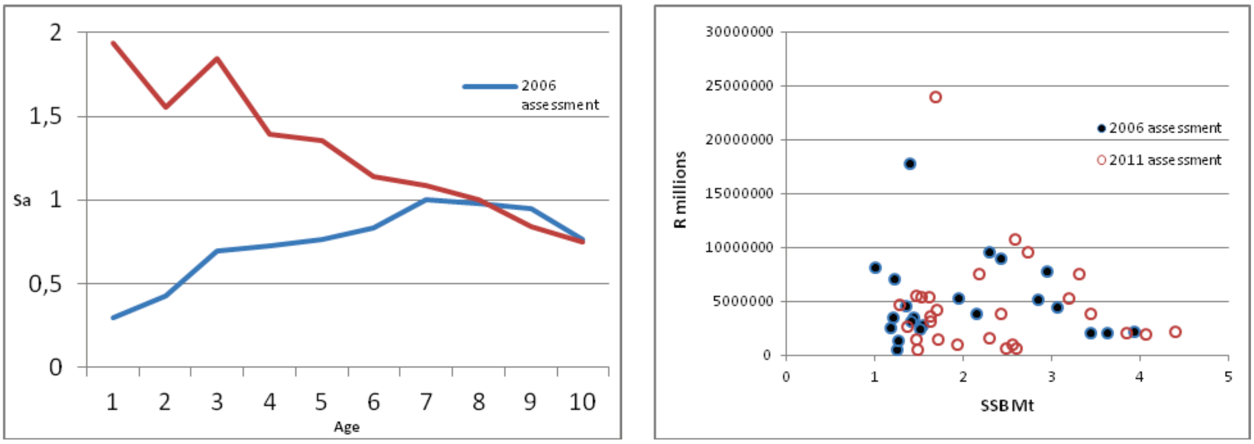

Figure 9.3.3.4.1 Comparison of the results of the assessments carried out in 2006 and 2011, in terms of exploitation pattern "sa" (i.e. relative fishing mortality) by age in the left panel, and in terms of recruitment against SSB in the right panel. Please note that the exceptional 1982 year class is not included.

With no age-structured population index, there is no independent information in the assessment to rationalize increased numbers of young fish in the catches. Currently, these observations are described by the assessment model as increased selection on young fish, though an alternative possibility is that these data are the result of increased recruitment, with unchanged fishery selection. In general terms the view from the 2011 assessment implies that the stock is less productive (at least recently) and that the productivity is harvested earlier by the fishery, which in turn would imply sustainable harvest rates that are lower from the 2011 point of view than the perception in 2006.

Figure 9.3.3.4.2 illustrates the implication of the differences in conditioning based on the 2006 and 2011 assessments. For comparative purposes both simulations did not include the 1982 year class in the data and also did not include autocorrelation in recruitment (although autocorrelation was included in further analyses based on the 2011 assessment). Fig 9.3.3.4.2 shows that with the 2011 conditioning (panel B), the risk (probability of SSB $>SSB_{1982}$ after 50 years) is above 10% even with zero fishing and increases most rapidly for Fs above 0.05; MSY (around 130 kt) is achieved at an F of about 0.08. With the 2006 conditioning (panel A) the risks are low (< 10%) up to Fs in the region of 0.08. MSY based on the 2006 conditioning (around 200 kt) is achieved at an F around 0.13. It can also be seen that in both cases that maximum yield is achieved with risks in the region of 50%.

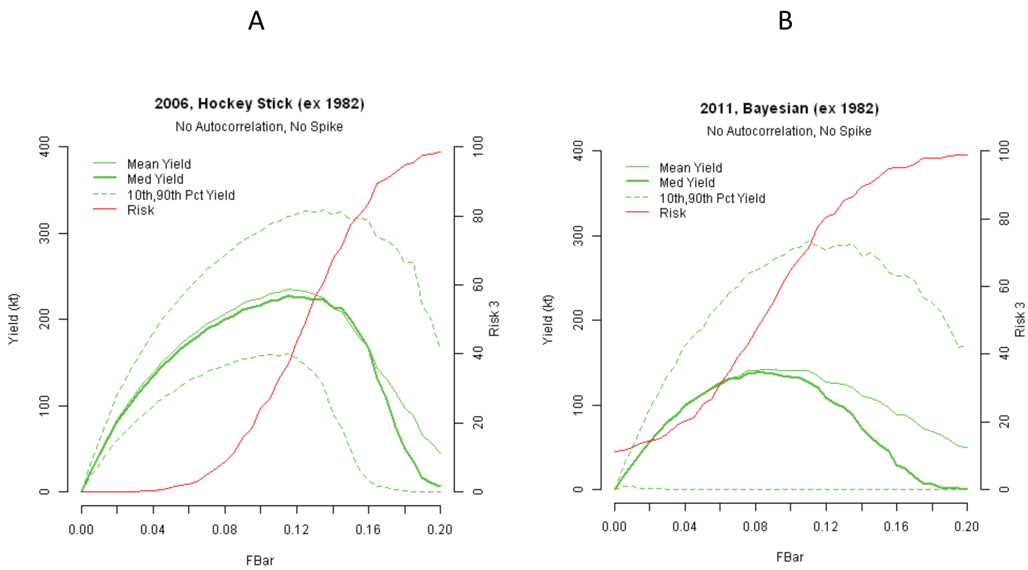

Figure 9.3.3.4.2 Long-term stochastic yield and risk plots for western horse mackerel. Plots of risk (called "Risk 3" on the secondary *y*-axis in the plots) and yield against F for simulations conditioned on the 2006 (panel A) and 2011 (panel B) assessments. The yield is shown as mean, median, and with 10[th] and 90[th] percentiles. The risk is calculated after 50 years run time, based on 1000 iterations for each step of F (0.01).

Sources

ICES. 2013a. Report of the Workshop to evaluate the EU management plan for Western horse mackerel (WKWHMAC), 18–19 June 2013, ICES Headquarters, Copenhagen. ICES CM 2013/ACOM:59.

ICES. 2013b. Report of the Workshop on Guidelines for Management Strategy Evaluations (WKGMSE), 21–23 January 2013, ICES Headquarters, Copenhagen, Denmark. ICES CM 2013/ACOM:39. 121 pp.

Appendix 9.3.3.4 Excerpt of harvest rules from the European Commission's Western horse mackerel management proposal

Article 5
Procedure for setting the TAC

1. In order to achieve the objective laid down in Article 4, each year the Council, acting in accordance with the procedure laid down in Article 20 of Council Regulation (EC) No. 2371/2002 and after consultation of the STECF, shall decide on the TAC for western horse mackerel for the following year.
2. The TAC shall be set in accordance with this Chapter.

Article 6
Calculation of the TAC

1. The TAC shall be calculated by deducting from the total removal calculated in accordance with Articles 7 and 8 a quantity of fish equivalent to the discards, including slipped fish, having occurred in the year preceding the year in which the latest scientific assessment has been made, as estimated by STECF.
2. Where the STECF is not able to estimate the level of discards including slipped fish for the year preceding the year in which the latest scientific assessment has been made, the deduction shall be equal to the highest relative amount of discards including slipped fish scientifically estimated as having occurred within the last 15 years, but not lower than 5%.
3. Where the TAC is calculated on the basis of the total removal calculated provisionally in accordance with Article 7(3), it shall be adapted during the year of its application to the final calculation of the removal.

Article 7
Calculation of the total removal for a year following an egg survey

1. Where the TAC is to be set for a year that follows a year in which an egg survey has been carried out, the total removal shall be calculated on the basis of the following elements:

   a) a constant factor equal to 1.07, reflecting a final increase of the total removal as simulated in underlying mathematical models that aims at maximising the annual yield without compromising the objective of keeping the risk to stock size decline at a very low level;
   b) the TAC set for the year in which the egg survey was carried out, hereinafter referred to as "reference TAC";
   c) a weighting factor set in accordance with the Annex, reflecting the trend in stock abundance on the basis of egg survey indices;
   d) a minimal total removal amount, including estimates of discards, of 75 000 tonnes.

2. The total removal referred to in paragraph 1 shall be calculated in accordance with the following formula:

   1.07 * (75 000 tonnes + (reference TAC * weighting factor) / 2)

3. Where only a provisional calculation of the latest egg survey index is available, the total removal shall be calculated in accordance with paragraphs 1 and 2 based on the provisional index and adapted during the year of application of the relevant TAC to the final result of the egg survey.

Article 8
Calculation of total removal for subsequent years

1. Where the TAC is to be set for a year that does not follow a year in which an egg survey has been carried out, the total removal shall be equal to the total removal calculated for the previous year.
2. However, if more than three years have expired since the last egg survey, calculated from the year for which the TAC is to be set, the total removal shall be reduced by 15%, unless STECF advises that such a reduction is not appropriate, in which case the total removal shall be equal to the previous one or calculated with a lower reduction, based on the advice of STECF.

Calculation of the weighting factor

The weighting factor is calculated as follows:

a) If the slope of the last three egg survey indices is equal to or smaller than – 1.5, the weighting factor is 0;
b) If the slope of the last three egg survey indices is bigger than –1.5 and smaller than 0, the weighting factor is equal to 1 + (2/3 * the slope);
c) If the slope of the last three egg survey indices is equal to or bigger than 0 and not bigger than 0.5, the weighting factor is equal to 1 + (0.8 * the slope);
d) If the slope of the last three egg survey indices is bigger than 0.5, the weighting factor is 1.4.

The slope is calculated from the three latest available egg survey indices. The egg survey index means the estimated number of horse mackerel eggs resulting from the triennial international egg survey for mackerel and horse mackerel in the Atlantic, divided by 10^{15}.