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EU request to ICES on the assessment of a long-term management strategy for southern horse mackerel (*Trachurus trachurus*) in ICES Division 9.a

Advice summary

ICES advises that the harvest control rule (HCR) of the proposed long-term management strategy for southern horse mackerel in ICES Division 9.a is considered precautionary. Calculations show that when the HCR is applied, the stock is maintained at levels that can lead to catches around MSY.

ICES advises that none of the elements of the HCR are in contradiction with ensuring that the stock is fished and maintained, also in the future, at levels that can lead to MSY.

Request

*ICES is requested to assess whether the proposed plan[1] is seen as precautionary. ICES is furthermore asked, in analysing the elements of the plan, to assess whether the plan is constructed in such a way as to ensure that the stock is fished and maintained, also in the future, at levels which can produce **MSY**.*

*Should the proposed plan include elements that are in contradiction with ensuring that the stock is fished and maintained, also in the future, at levels which can produce **MSY**, ICES is requested to comment specifically on such elements, and their consequences for ensuring **MSY**.*

Elaboration on the advice

ICES evaluated the HCR in the proposed long-term management strategy (LTMS)[1], which is defined by a management F at F_{MSY} being applied when SSB is above MSY $B_{trigger}$ at the beginning of the TAC year, a linear reduction of F down to $F_{bycatch}$ = 0.01 when SSB is in the range MSY $B_{trigger}$ to B_{lim}, and an F at $F_{bycatch}$ when SSB is below B_{lim}. In addition, the HCR includes an interannual catch constraint of ±15% to be applied when SSB is above B_{lim}.

The probability of SSB being below B_{lim} is less than 5% in the simulation, and the HCR is considered precautionary under the ICES precautionary criterion (ICES, 2013). The current healthy state of the stock results in a very low probability of SSB being below MSY $B_{trigger}$ in the short term. This is also the case in the long term. The proposed HCR also ensures that the stock is able to produce long-term equilibrium catches around MSY.

The proposed HCR is also considered precautionary under changing parameters of stock productivity and selectivity, showing that the proposal is robust to some of the major assumptions made in the simulations.

Suggestions

ICES provides suggestions and comments to clarify Article 5 of the LTMS.

ICES interprets the gradual increase of fishing mortality towards F_{MSY} in 2025, stated in Article 5 Paragraph i), as being obtained from a linear increase in F, from F in 2016 to F_{MSY} in 2025.

ICES considers that the TAC constraints stated in Article 5 Paragraph iv) should only be applied for SSB larger than B_{lim}; however, this is not stated explicitly in the TAC-setting procedure in Article 5 Paragraph v) but merely implied through the order of the paragraphs.

The formula in Article 5 Paragraph ii) for calculating F does not follow the graphical representation of the HCR. The equation in Paragraph ii) should rather be $F = F_{bycatch} + (F_{MSY} - F_{bycatch}) / (B_{trigger} - B_{lim}) \times (SSB - B_{lim})$. ICES evaluation of the HCR is based on this rectified equation.

The *y*-axis of the graph says “Fishing effort”. This should be “Fishing mortality”.

[1] See Annex 1.

Basis of the advice

Background

The development of the LTMS for southern horse mackerel began in October 2014 through an interactive process between scientists and stakeholders. The process involved the definition of management objectives, a Harvest Control Rule and several TAC-setting options, an F_{MSY} target year, and catch stability levels proposed by the stakeholders of the Pelagic Advisory Council (PelAC) and the South Western Waters Advisory Council (SWWAC). Following the latest stock benchmark in 2017 (ICES, 2017a) and the adoption of biological reference points (BRPs; ICES, 2016a, b), a full-feedback MSE approach was used to assess the performance of the several options, including the proposed LTMS. In October 2017, the PelAC asked the European Commission to submit this LTMS proposal to ICES for evaluation.

Results and conclusions

The trajectories of the key parameters (recruitment, SSB, yield, and fishing mortality) of the MSE simulations are shown in Figure 1. The stock has recently been exploited below F_{MSY} and the SSB at the beginning of the simulation period is at a historical high. The short-term (2017–2027) median SSB is at 424 669 t which, after a small decrease in the initial period stabilizes and reaches a long-term (2070–2080) median of 352 148 t. This healthy state of the stock at the beginning of the simulated period results in short-term median catches of 51 468 t, while the long-term average catch is estimated at 40 877 t.

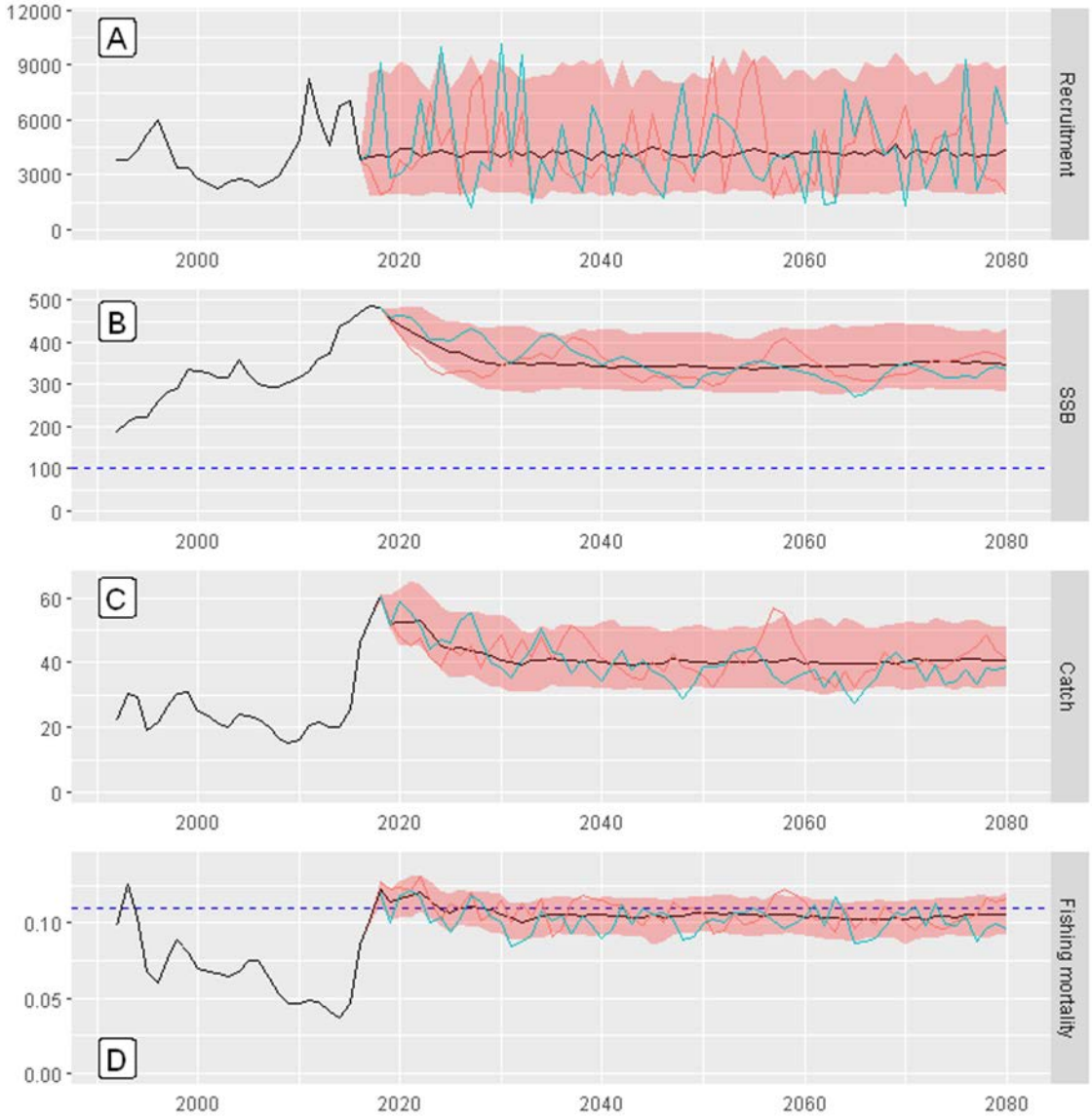

Figure 1 Panel A – Recruitment (millions). Panel B – SSB (thousand tonnes) with B_{lim} (blue line). Panel C – Yield (thousand tonnes). Panel D – Fishing mortality (year^{-1}) with F_{MSY} = 0.11 (blue line). The black line indicates the median value of the 200 simulations from 2017 to 2080 and the shaded area the 5th and 95th percentiles. The green and red lines show the results from two simulated populations selected randomly.

The SSB trajectory in the simulated period reveals that the size of the stock is maintained above B_{lim} with high probability. The probability of (SSB < B_{lim}) is estimated at 0%, both in the short and the long term. SSB is not estimated to be below MSY $B_{trigger}$ in the simulated period. With such a low P (SSB < B_{lim}), the number of iterations (200) used in the simulations is considered adequate to conclude that the HCR is precautionary, even though ICES default recommendation is a minimum of 1000 iterations.

Figure 2 shows the long-term average catch distribution. The long-term median catch was slightly lower than the median maximum sustainable yield when fishing at F_{MSY} = 0.11. The main reason for the difference was that the assessment model in the MSE consistently overestimated F, which resulted in a catch advice below the maximum sustainable yield level (ICES, 2018).

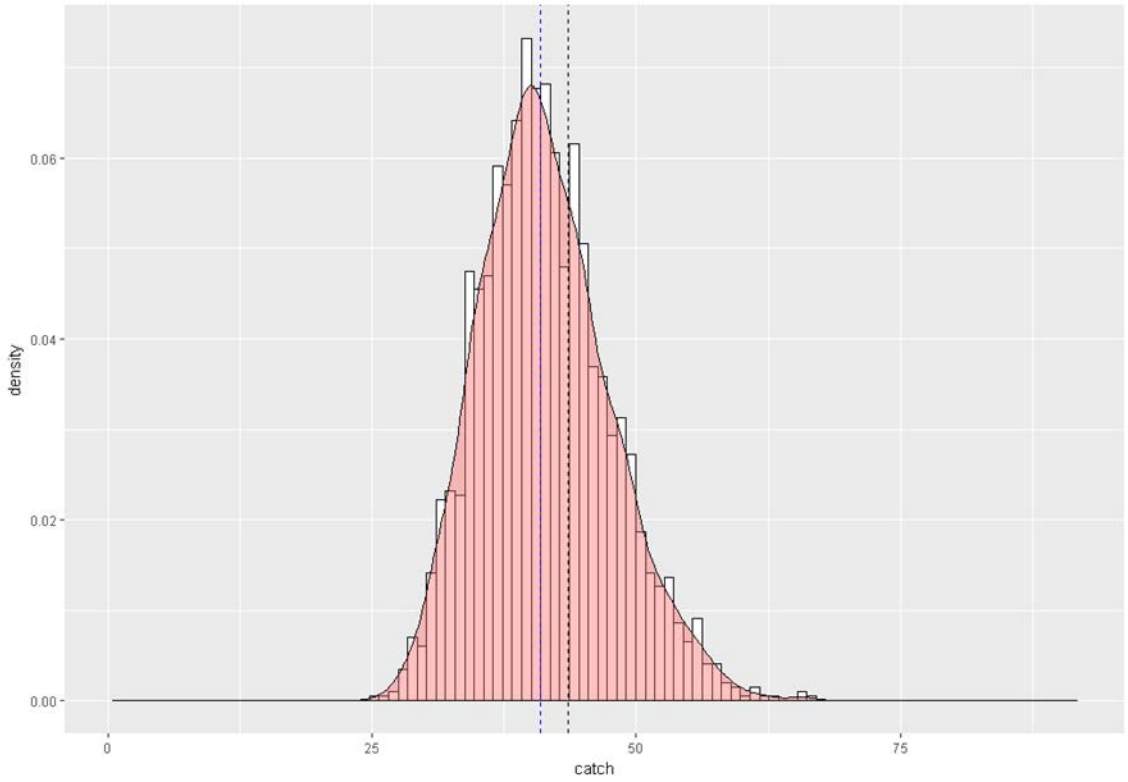

Figure 2 The long-term average catch distribution (2070–2080), with the median of the distribution (40 877 t, blue line) and the median MSY (43 516 t, black line) as estimated by ICES (ICES, 2018).

Table 1 summarizes the results of the LTMS performance metrics for yield, fishing mortality, and SSB in the short (2017–2027) and the long term (2070–2080). For precautionary considerations, the probabilities P (SSB < B_{lim}) and P (SSB < MSY $B_{trigger}$) were defined as the maximum probability in any year over the entire simulation period (2017–2080).

Table 1 LTMS performance statistics for yield, fishing mortality, and SSB.

	Short term 2017–2027	Long term 2070–2080
Yield		
Median catch	51 468 t	40 877 t
5th percentile catch	38 423 t	31 979 t
95th percentile catch	60 954 t	52 425 t
Fishing mortality		
Median F	0.113	0.104
5th percentile F	0.099	0.090
95th percentile F	0.127	0.117
SSB		
Median SSB	424 669 t	352 148 t
5th percentile SSB	337 165 t	286 844 t
95th percentile SSB	485 520 t	436 682 t
P (SSB < MSY $B_{trigger}$)	0%	0%*
P (SSB < B_{lim})	0%	0%*

* Maximum probability (type Risk3; ICES, 2013) over the entire simulation period (2017–2080).

The HCR was also robust (P (SSB < B_{lim}) ≤ 5%) in a sensitivity analysis with reduced recruitment and modified selectivity parameters.

Methods

A Management Strategy Evaluation (MSE) of the HCR was conducted, with the operating model conditioned to the latest stock assessment and following the stock benchmark in early 2017 (ICES, 2017a). The operating model treats biological and fishery parameters as constant over time. The most recent information on horse mackerel biology (weight-at-age, proportion mature, natural mortality, spawning time), together with the exploitation pattern of higher selectivity for young ages and lower selectivity to older ages that characterizes the fishery in the period 2012–2016, formed the basis for parameterization of the underlying population dynamics. Future recruitment was determined based on a hockey-stick relationship with variability introduced from a lognormal distribution with autocorrelation, modelled as a 1st order AR model with $\phi_1 = 0.8$. The adopted value for ϕ_1 was based on the upper limit of the observed autocorrelation in recruitment.

The management procedure component included a stock assessment and an advice based on short-term forecasts in each assessment loop of the MSE. The statistical catch-at-age stock assessment model was implemented in the FLa4a stock assessment framework (Jardim *et al.*, 2017) instead of the current AMISH assessment model. Although the operating model based on the statistical catch-at-age in FLa4a did not match exactly the historical dynamics of the stock from the AMISH model (Figure 3), it was considered satisfactory for the implementation of the full-feedback MSE simulations, given comparable fits to catch-at-age, index-at-age, and retrospective pattern. Survey indices were used as input to each assessment cycle and generated from the observed catchability-at-age with log-normally distributed errors to simulate observation error.

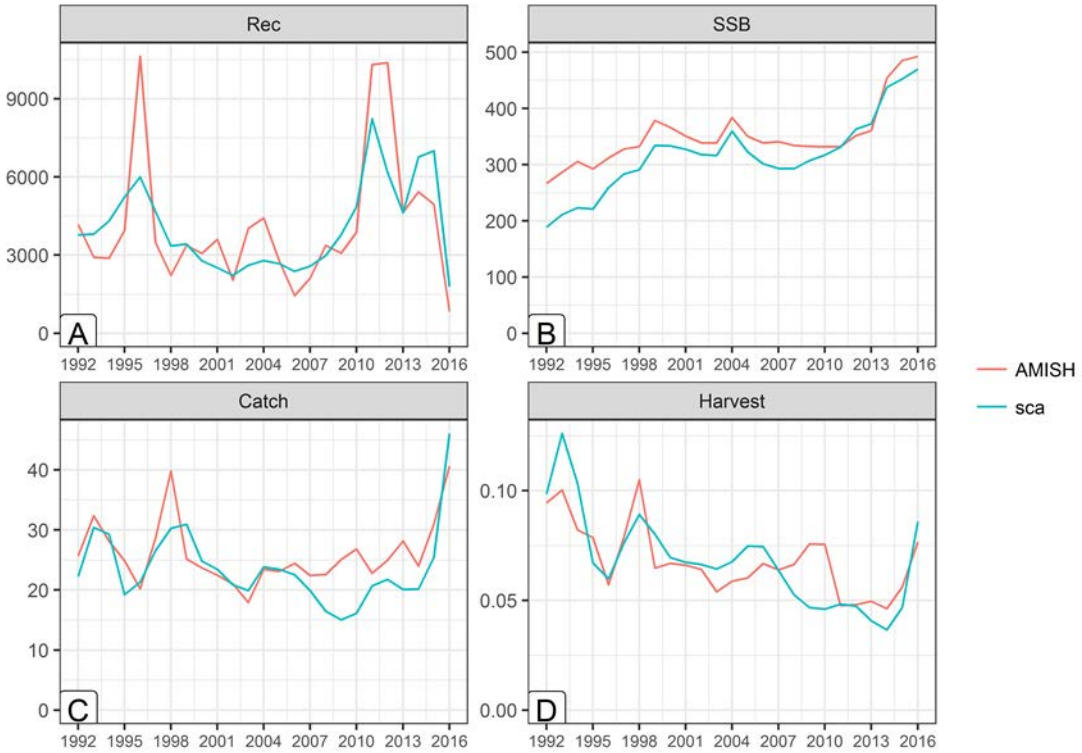

Figure 3 Comparison of the outputs of key parameters between the AMISH model (red) currently used in the assessment and the statistical catch-at-age model (blue) used to perform the full-feedback MSE. Panel A – recruitment (millions). Panel B – spawning–stock biomass (thousand tonnes). Panel C – yield (thousand tonnes). Panel D – fishing mortality ($year^{-1}$).

The simulation carried out to analyse the performance of the proposed HCR is based on 200 iterations, each projected from 2017 to 2080. The main performance diagnostics relate to the HCR risk criterion (that the probability of SSB < B_{lim} should not exceed 5%) and estimates of long-term yield. Results on SSB, yield, interannual yield variability, and fishing mortality ('true' and 'perceived') were analysed for the short and long terms. Further details on the methodology and results are available in ICES (2018).

A sensitivity run, using 40% of the observed recruitment, was made to test the robustness of the HCR in a system with lower productivity. Tests were also conducted, with changing parameters of selectivity and period used to calculate inputs to the forecasts, to investigate whether the proposal is robust to some of the major assumptions made in the MSE.

Sources and references

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Annex 1 Proposed long-term management strategy for southern horse mackerel

Background

A long-term management strategy (LTMS) was developed for this stock by initiative of the Pelagic Advisory Council (PELAC) in a collaborative work between scientists from IPMA and IEO and stakeholders from Portugal and Spain, with collaboration/knowledge of the South Western Waters Advisory Council (SWWAC).

Objectives

The Parties agree to propose a LTMS for the fisheries on the southern horse mackerel stock, which is consistent with the precautionary approach and the MSY objective (article 2.2) of the Common Fisheries Policy[2].

Criteria and definitions

Article 1 - Subject matter
This management strategy pertains to the southern horse mackerel stock.

Article 2 - Geographical definitions of stocks
ICES Division 9.a (The Iberian coast from the Strait of Gibraltar to Cape Finisterre in Galician waters).

Article 3 - Definitions
For the purpose of this management strategy, in addition to the definitions laid down in Article 4 of Regulation (EC) No 1380/2013, the following definitions shall apply:

i) "Fby-catch" refers to the level of fishing mortality which shall be applied when the Spawning Stock Biomass (SSB) is equal to or below B_{lim} to account for horse mackerel by-catches.

Article 4 - Reference points

i) The minimum spawning biomass level and the precautionary spawning biomass level for the combined shall be as follows: B_{lim} = 103 000 tonnes, B_{pa} or MSY $B_{trigger}$ = 181 000 tonnes (ICES, 2017a,b).

ii) The maximum fishing mortality associated with Maximum Sustainable Yield (F_{MSY}) for the southern horse mackerel stock shall be as follows: F_{MSY}= 0.11 (ICES, 2017a,b).

Article 5 - TAC setting procedures

i) In the case that the spawning stock biomass is forecast to be above or equal to MSY $B_{trigger}$ (equivalent to Bpa) at mid-January of the year for which the TAC is to be set, the TAC shall be fixed to a catch estimated based on an gradual increase of fishing mortality towards Fmsy in 2025.*

ii) In the case that the spawning stock biomass of the stock is forecast to be less than MSY Btrigger and larger than Blim at mid-January of the year for which the TAC is to be set, the TAC shall be fixed that is consistent with a fishing mortality (F) given by the harvest control rule:

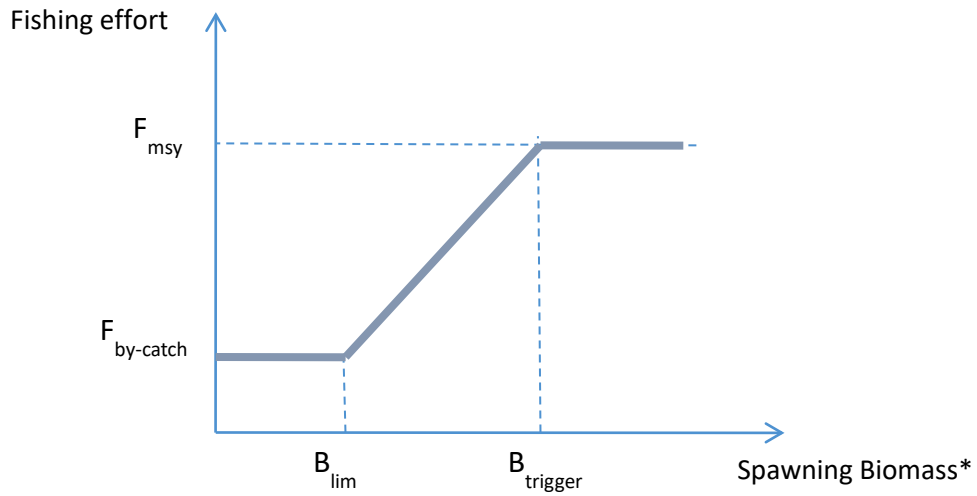
$$F = F_{by\text{-}catch} + [(F_{MSY} - F_{by\text{-}catch}) / (B_{trigger} - B_{lim}) / (SSB - B_{lim})]$$

iii) In accordance with the objectives of the plan detailed above, where the rules in paragraph i and ii would lead to a fishing mortality higher than F_{MSY}, this fishing mortality shall be set in line with article 2.2 of the CFP.

iv) Where the rules in paragraph i, ii and iii would lead to a TAC which deviates by more than 15%from the TAC of the preceding year a TAC shall be set that is no more than 15% greater or 15% less than the TAC of the preceding year.

v) In the case that the spawning biomass is forecast to be equal to or less than B_{lim} in mid-January of the year for which the TAC is to be set, the TAC will be fixed corresponding to a fishing mortality $F_{by\text{-}catch}$=0.01.

[2] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2013:354:0022:0061:EN:PDF.



**For this stock, the spawning stock biomass is determined at spawning time (assumed to be mid-January).*

Article 6 - Conditions of the monitoring fishery

Vessels participating in the fishery, if requested, shall take on-board scientific fisheries observers under the Data Collection Framework (DFC) to improve knowledge of the state of the stock. Those vessels upon request shall provide samples for the same scientific purpose.

Article 7 - End of the management strategy

The Parties, on the basis of ICES advice, shall review the biological reference points and this long-term management strategy at intervals not exceeding five years.