EU request to ICES on the assessment of a new rebuilding plan for western horse mackerel (*Trachurus trachurus*) in ICES Subarea 8 and divisions 2.a, 4.a, 5.b, 6.a, 7.a–c, and 7.e–k

Advice summary

ICES advises that the evaluated rebuilding plan as proposed by PELAC shows potential to reach the specified target (three consecutive years > B_{pa}) within the time frame specified in the plan (< ten years) and is considered to be precautionary in the long term. The time frame to rebuild the stock is estimated to be two years longer following the rebuilding plan (by 2028) compared to zero catch (by 2026) given current starting conditions.

Once rebuilding is achieved, ICES advises that alternative harvest control rules (HCRs) should be examined for long-term management of the fishery to satisfy maximum sustainable yield (MSY) objectives.

Request

On 19 October 2020, ICES received the following request from the European Commission, accompanied by a PELAC evaluation report (Pastoors *et al.* 2020):

ICES is requested to evaluate the proposal for a rebuilding plan for Western Horse Mackerel as prepared by the Pelagic Advisory Council in July 2020:
- *In particular, ICES is requested to assess whether this plan is seen as precautionary on the short term as well as on the long term.*
- *ICES is furthermore requested to assess whether the plan is consistent with the objectives to ensure stock recovery and bringing the biomass above sustainable levels within the indicated timeframes, and whether it is consistent with the maximum sustainable yield objectives of the CFP.*
- *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.*

The proposed rebuilding plan is detailed in Annex 1: PELAC proposal for a rebuilding plan for Western horse mackerel.

Elaboration on the advice

ICES has not yet defined fixed criteria for evaluating rebuilding plans, this plan has been evaluated against the targets and time frames set out in the plan (Annex 1). The western horse mackerel stock is currently estimated to be close to B_{lim}, so for any harvest rule there will always be some risk in the short term of SSB being below B_{lim}. The proposed rebuilding plan has a rebuilding time frame of a maximum of ten years. The stock is considered to be rebuilt when SSB is estimated to have been above B_{pa} with a 50% probability for three consecutive years.

The application of the proposed double breakpoint rule with a target fishing mortality of F = 0.074 (F_{MSY}) shows a high probability of rebuilding of the stock in the short term. Based on the 2020 assessment, the first year that the rebuilding probability is estimated to be more than 50% is 2028. The probability of SSB being below B_{lim} is estimated to be less than 5% by 2025.

The rebuilding plan HCR is based on a target fishing mortality of F_{MSY} and is considered to be precautionary in the long term.

The timing of rebuilding of the stock has been shown to be sensitive to the recent higher recruitment. If that higher recruitment does not materialize or is fished sooner than expected, the rebuilding of the stock will be delayed. Recovery is still expected (2031–2035) but may exceed the ten-year time frame. This evaluation was conditioned on the 2020 assessment; if future assessments downscale the stock size estimates significantly, this will also delay the time required to reach the targets outlined in the plan.

Suggestions

Should the reference points for this stock be revised before rebuilding has been achieved, it will be necessary to re-evaluate the performance of the HCR.

The 20% TAC constraint defined in the rebuilding plan allowed for quicker rebuilding times but contributed to long-term fishing mortality being below the target F. The rebuilding plan showed that large reductions in TAC could occur when the SSB was below $B_{trigger}$ and TAC constraints did not apply. Once the stock subsequently climbed above $B_{trigger}$, the 20% TAC change limits applied to a low starting TAC led to fishing mortalities below the target F. Therefore, once rebuilding has been achieved, ICES recommends examining alternative HCRs for long-term management of the fishery to satisfy MSY objectives.

Articles 3.1 and 5.2 of the proposed rebuilding plan states: "…*all attempts will be made to realise that target within five years*." It could be more clearly specified whether five or ten years is the preferred rebuilding time frame.

Article 3.2 could more clearly specify what probability of exceeding B_{pa} is expected before rebuilding is considered to have been achieved.

Basis of the advice

Background

The development and adoption of a management plan for the provision of catch advice has been a long-term goal of the Pelagic Advisory Council (PELAC) since a plan was first proposed in 2008, and in 2020 a PELAC technical focus group was established to identify and evaluate a number of potential harvest strategies. Given the continued estimates of low stock size and recognizing that the risk to B_{lim} in the short term will remain above the precautionary 5% threshold, the focus group evaluated candidate harvest rules on the basis of proposing a rebuilding plan. The PELAC submitted the evaluation for consideration to the European Commission, who requested that ICES review the evaluation (ICES, 2021a).

Methods

The evaluation was carried out using an adaption of ICES standard software package EqSim. This framework is used for the estimation of MSY reference points with the code updated to include alternative harvest rules with optional stability mechanisms, incorporate uncertainty in initial conditions, and generate additional outputs for model validation and HCR performance. The framework captures future uncertainty in the assessment and short-term forecast via an assessment emulator which is configured to generate future assessment errors consistent with those from the historical period (a 'shortcut' approach; ICES, 2021b).

Evaluations were performed for three different HCRs:

- a constant F rule: a fixed F_{target} independent of the SSB;
- a single breakpoint rule: a fixed F_{target} when SSB is above $B_{trigger}$ with a linear decline in F to zero at the origin (similar to ICES advice rule but still allowing for fishing when recovery above B_{lim} is not possible within one year);
- a double breakpoint rule: a fixed F_{target} when SSB is above $B_{trigger}$ with a linear decline to 20% of F_{target} at B_{lim}. Below B_{lim} the target fishing mortality remains at 20% of F_{target}.

For all evaluations, $B_{trigger}$ was set at the corresponding MSY $B_{trigger}$ (= B_{pa}) value. Six F_{target} values were simulated: 0, 0.05, 0.074 (F_{MSY}), 0.1, 0.125, and 0.15. Three variants were examined to explore a range of TAC stabilization measures:

- no stability mechanism;
- a minimum TAC of 50 kt;
- a +/- 20% limitation on the interannual variation (IAV) in TAC, applied only when SSB is above $B_{trigger}$.

The proposed management strategy is a double breakpoint rule with a 20% limitation on the IAV in TAC when above $B_{trigger}$ and with a target fishing mortality of 0.074; it is shown in Figure 1. This rule has a steeper reduction in F with declining SSB between $B_{trigger}$ and B_{lim} than the single breakpoint rule.

The simulations were initially conditioned on the 2019 Stock Synthesis 3 (SS3) assessment and were updated when the 2020 SS3 assessment became available. The operating model conditioned on the 2020 SS3 assessment was considered the base case operating model. A range of additional runs were conducted to investigate the sensitivity of results with regard to assumptions on recent levels of recruitment, the parameterization of assessment/advice error, an alternative operating model based on the SAM assessment of the stock, and reference point values.

Variability in starting numbers is incorporated via 1000 stock replicates derived from uncertainty estimates from the stock assessment. During the simulation period, uncertainty in weight-at-age is based on the variability observed in historical weight-at-age data and fishery selection from the stock assessment estimates. Maturity-at-age and natural morality for the simulation period are considered to be time invariant, as in the assessment. Future recruitment is modelled using the EqSim approach (ICES, 2015), incorporating a segmented regression model with the breakpoint constrained at B_{lim}.
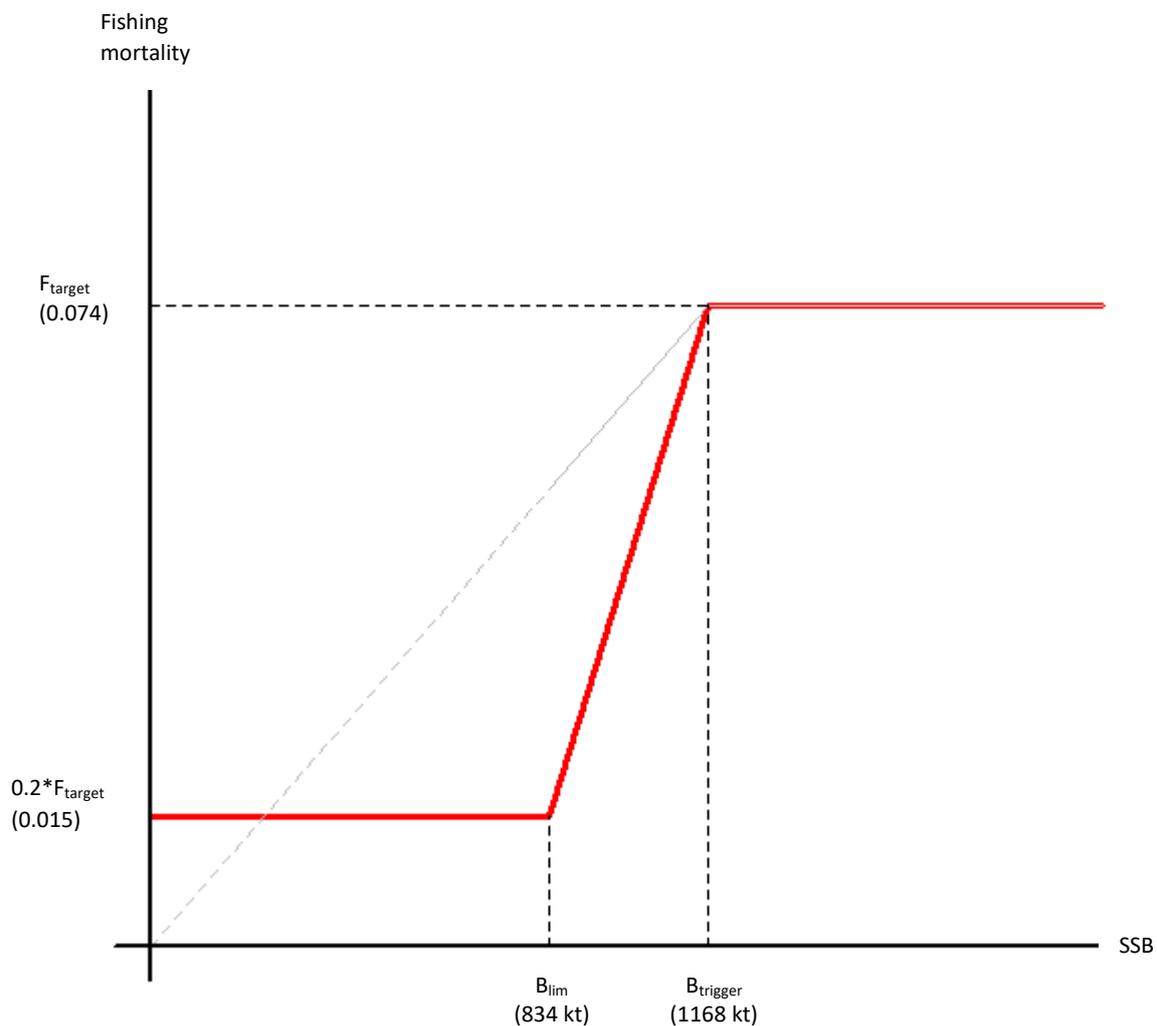

Figure 1   Schematic of the proposed double breakpoint HCR for western horse mackerel. When SSB is above the $B_{trigger}$ value, the fishing mortality to be applied is set as F_{target}, constrained by a 20% limit on the IAV in TAC. When SSB is below B_{lim}, a target fishing mortality of 20% of F_{target} is set. When SSB is below $B_{trigger}$ but above B_{lim}, the F applied is reduced linearly. The light grey line shows the single breakpoint rule with a linear reduction in target F (from $F_{MSY} = 0.074$) to the origin.

Because this is considered a rebuilding plan, annual values of performance metrics were considered rather than results summarized by periods. These performance indicators were:

- SSB;
- realized fishing mortality;
- yield;
- simulated recruitment;
- probability that SSB < B_{lim};
- progress towards stock rebuilding, defined as the proportion of iterations that have remained above B_{pa} for three consecutive years.

Results and conclusions

HCR performance

The results of the simulation for the proposed double breakpoint rule with a target fishing mortality of 0.074 are shown in figures 2 and 3.
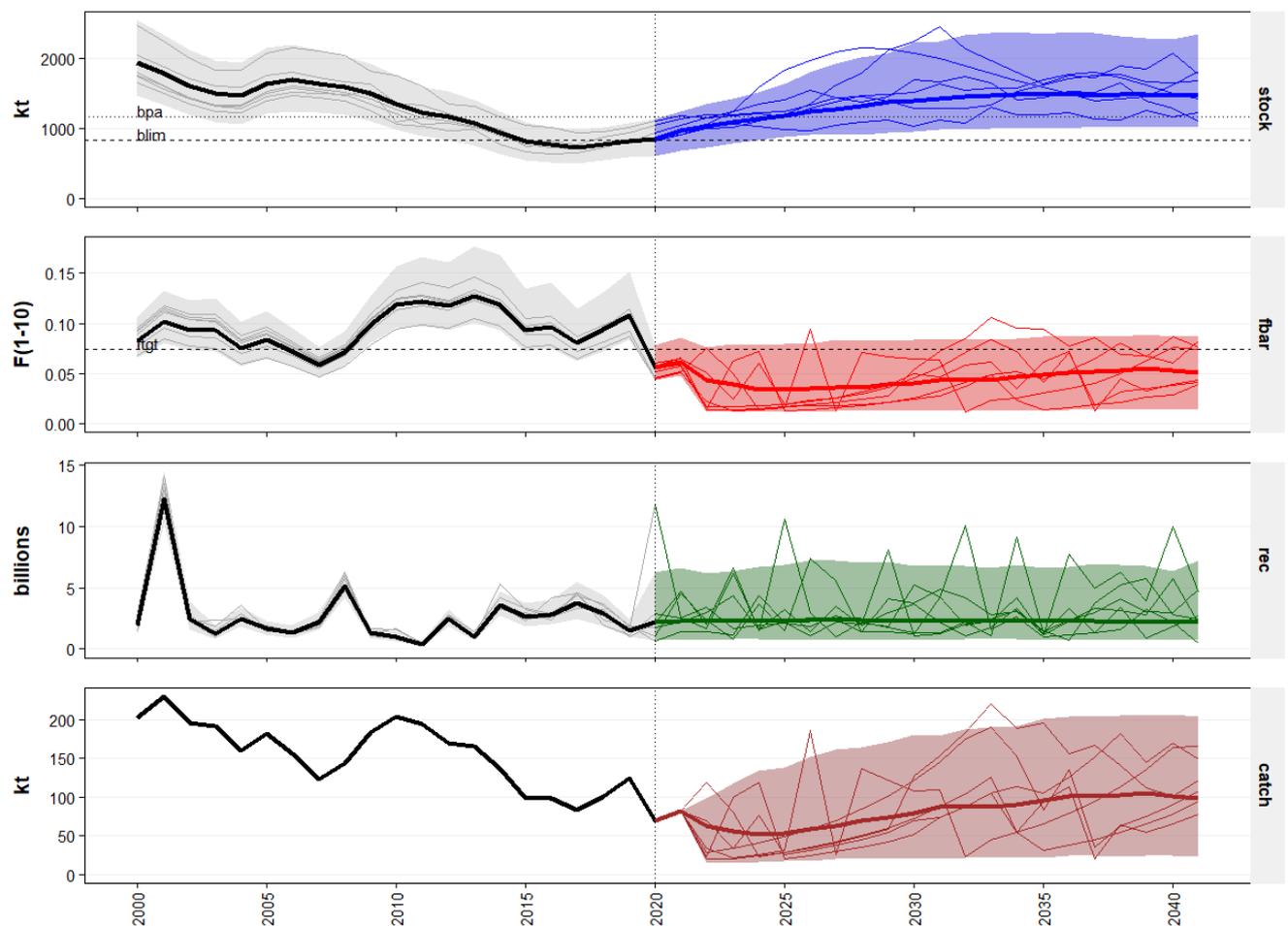

Figure 2   Historical stock development (grey) and simulation output (coloured) for the double breakpoint rule with F_{target} = 0.074 and a 20% TAC change limitation when above $B_{trigger}$. The top plot represents SSB (in kilotonnes), the second fishing mortality, the third recruitment (age 0; in billions), and the bottom yield (in kilotonnes). For each plot, the shaded area represents the 5th and 95th percentiles, while the thick line is the median value from the assessment and projection periods The remaining lines depict five individual iterations.

A catch constraint applies in the years up to 2021 of the projection, given that estimates of total catch or TAC are available for these years. The first management year for the simulation is therefore 2022, during which the target fishing mortality is relatively low given the proximity of the stock to B_{lim}. This leads to median yields of the order of 50 kt in the short term.

The realized F remains below the F_{MSY} target in the long term (2031–2040) due to a combination of the TAC constraint when the stock is larger than $B_{trigger}$ and the steep reduction in F when the stock is between $B_{trigger}$ and B_{lim}.
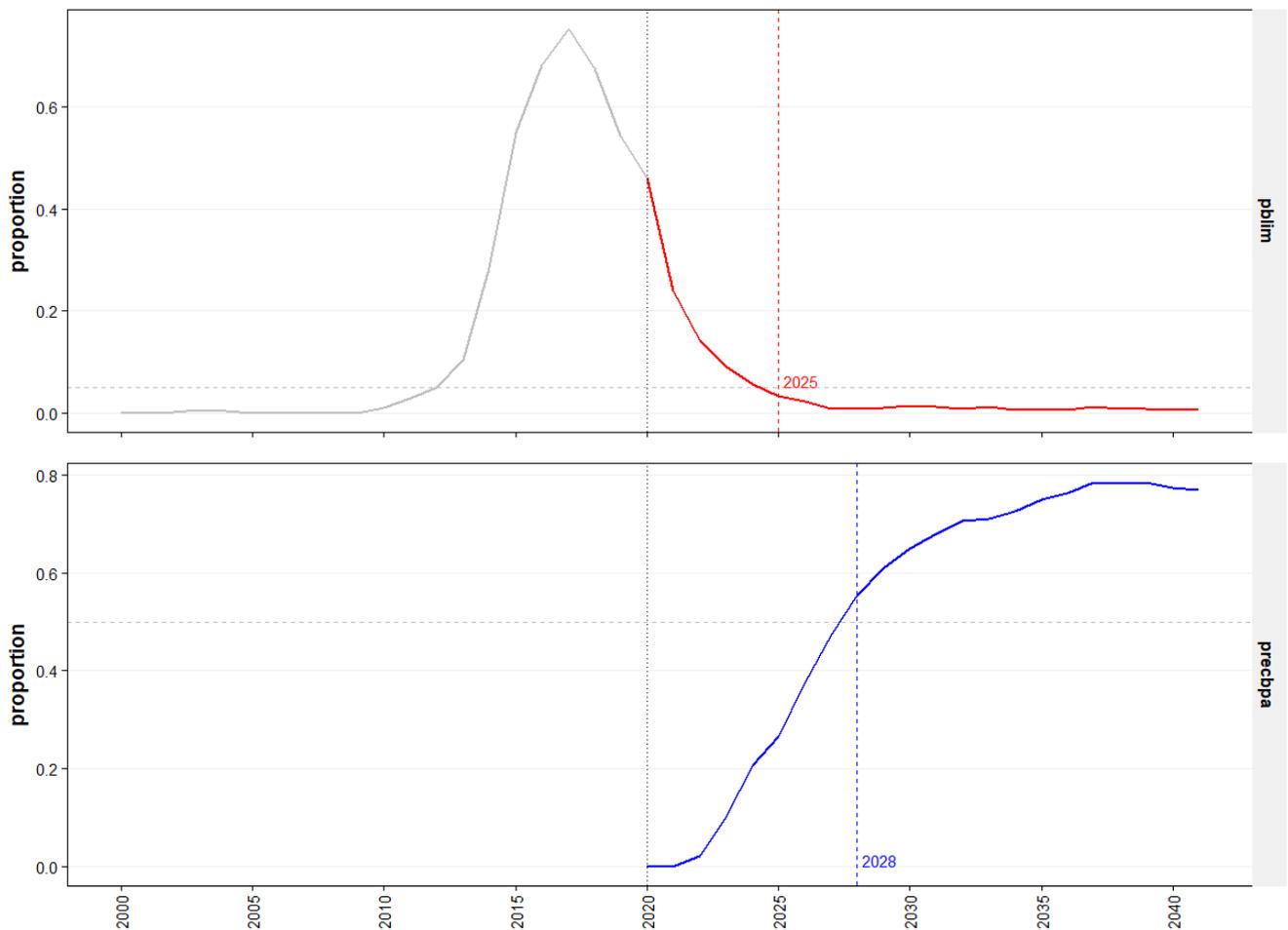

Figure 3   Annual probability of SSB < B_{lim} (top panel; 5% level indicated by horizontal dashed line) and proportion of replicates recovered to be above B_{pa} (a recovered replicate is one which, having fallen below B_{pa}, subsequently recovers and remains above B_{pa} for three consecutive years) for the double breakpoint rule with F_{target} = 0.074 and a 20% TAC change limitation when above $B_{trigger}$. The vertical red line depicts the year when < 5% of the replicates are below B_{lim} and the vertical blue line depicts the year when ≥ 50% of replicates have recovered to B_{pa}.

The simulation results indicate that the proposed plan offers the potential for rebuilding of the stock by 2028, with rebuilding considered to be achieved when the stock size has exceeded B_{pa} with a 50% probability for three consecutive years. Risk to B_{lim} falls below 5% by 2025.

Robustness tests

Because rebuilding will be particularly sensitive to the recruitment estimates in the period 2014–2018 and these estimates have higher uncertainty in the assessment model, a robustness test was carried out to assess the impact of a lower recruitment in that period. The sensitivity to recent (stronger) recruitment was explored via three alternative scenarios that reduced recruitment for 2014–2018. Under these scenarios, there was a delay in the onset of the period of stock growth. The rebuilding plan target could still be met with the proposed HCR, but the time period of rebuilding may extend past the ten-year rebuilding plan time frame. In the poor recruitment scenarios, the rebuilding year was delayed by approximately two–three years when compared with a zero fishing scenario.

Sources and references

ICES. 2015. Report of the Joint ICES-MYFISH Workshop to consider the basis for FMSY ranges for all stocks (WKMSYREF3), 17–21 November 2014, Charlottenlund, Denmark. ICES CM 2014/ACOM:64. 156 pp.

ICES. 2021. Workshop for the review of the assessment of a new rebuilding plan for Western Horse Mackerel (WKWHMRP). ICES Scientific Reports. 3:37. 232 pp. http://doi.org/10.17895/ices.pub.8023

ICES. 2021b. The third Workshop on Guidelines for Management Strategy Evaluations (WKGMSE3). ICES Scientific Reports, 2:116. 112 pp. http://doi.org/10.17895/ices.pub.7627.

Pastoors, M. A., Campbell, A., Trijoulet, V., Skagen, D., Gras, M., Lambert, G. I., Sparrevohn, C. R., and Mackinson, S. 2020. Report on Western Horse Mackerel Technical Focus Group On Harvest Control Rule Evaluations 2020. Report for Pelagic Advisory Council.

Annex 1

PELAC proposal for a rebuilding plan for Western horse mackerel

28 July 2020

Background

1. The development of a robust and scientifically evaluated management plan for Western horse mackerel (WHOM) has been a long-term objective of the Pelagic Advisory Council (PELAC). We achieved this very early on in our existence in 2007, but unfortunately the agreed management plan was no longer considered precautionary by ICES in 2013. Efforts to achieve this objective again have been ongoing since 2015, but have encountered a number of challenges.

2. In 2015, the Marine Institute (MI), together with Cefas, sought to update the agreed management plan of 2007, which was no longer considered precautionary. There was a change in perception of the stock related to perceived changes in the egg survey, which changed the perception of the assessment as well. The MI and Cefas conducted two evaluations, and found that even with no fishing, the risk of falling below B_{lim} was more than 5%. While the SSB appeared to increase, the uncertainties were still so high that it increased slowly. The uncertainty in the assessment was therefore too large to conduct a meaningful Management Strategy Evaluation (Campbell et al. 2015)

3. In 2017, the inclusion of new data sources during a benchmark meeting resulted in a new assessment approach (ICES 2017). From that assessment, new reference points were estimated.

4. In 2018, ICES issued an advice for a considerable increase in TAC, close to MSY $B_{trigger}$, due to re-scaling of the assessment (ICES 2018).

5. An external expert (Landmark Fisheries) carried out an analysis to look at possible HCRs for potential management plans for WHOM. In most of the scenarios, the stock was expected to increase (Cox *et al*. 2018). The outcomes were presented at WGWIDE in 2018. The conclusion was that while the approach was welcomed, it did not take into account the right types of uncertainty in the starting conditions, which then lead to an overly optimistic evaluation (ICES 2018).

6. In 2019, an inter-benchmark meeting led to a revision of the reference points, indicating the stock was just above B_{lim} (ICES 2019). A collaboration between scientists working on different rebuilding methods for herring stocks subject to a zero catch advice (Celtic Sea, Western Baltic spring spawning and 6a herring) was set up, to explore whether these techniques could be applied to WHOM (PELAC 2019). While formally the stock is not in the rebuilding phase, it could potentially happen at any moment because of revisions in the assessment. The overall stock biomass levels are considered low, the assessment is volatile and the uncertainties are great. Therefore, the PELAC considers the development of a rebuilding plan more appropriate than a management strategy.

Rebuilding Plan Western horse mackerel

ICES Subarea 8 and divisions 2.a, 4.a, 5.b, 6.a, 7.a–c, and 7.e–k in the Northeast Atlantic

Objective

The purpose of the Western horse mackerel rebuilding plan is to ensure stock recovery to safe biomass levels and a long-term stock exploitation that is consistent with the precautionary approach and with achieving the objective of maximum sustainable yield (MSY).

Criteria and definitions

Article 1 - Subject matter

This rebuilding plans pertains to the Western horse mackerel stock.

Article 2 - Geographical definitions of stock

ICES Subarea 8 and divisions 2.a, 4.a, 5.b, 6.a, 7.a–c, and 7.e–k in the Northeast Atlantic.
In certain times of the year, for the purposes of the scientific assessment, the divisions between the Western and North Sea horse mackerel stocks change. ICES division 4a and the Western part of division 3a are considered to be part of the North Sea stock in quarters one and two, but are part of the Western stock in quarters three and four (ICES 1989).

Article 3 Definitions

1. "Rebuilding plan timeframe": the timeframe for achieving the rebuilding plan target is a maximum of ten years, although all attempts will be made to realise that target within five years.

2. "Rebuilding plan target": when the spawning stock biomass is greater than B_{pa} for a minimum of three consecutive years.

Biological reference points used in this rebuilding plan are defined in the introduction to the 2018 ICES advice (ICES (2018). 1.2 Advice basis, ICES. ices.pub.4503).

Article 4 Reference points

1. The applicable biomass reference points for the Western horse mackerel stock shall be as follows: B_{lim} = 834 480 tonnes.

    MSY $B_{trigger}$ = B_{pa} = 1 168 272 tonnes.

It should be noted in case of this rebuilding plan the value of MSY $B_{trigger}$ is identical to B_{pa} and should be read as one wherever mentioned in the text. Should this relationship change in the future the plan is no longer valid.

2. The maximum fishing mortality associated with Maximum Sustainable Yield (F_{MSY}) for the Western horse mackerel stock shall be as follows: F_{MSY}= 0.074.

These values are based on the 2019 inter-benchmark report (ICES 2019).

Article 5 Rebuilding plan targets and measures

1. The rebuilding plan will be considered to be achieved when the spawning stock biomass is greater than B_{pa} for a minimum of three consecutive years.

2. The timeframe for achieving the rebuilding plan target is a maximum of ten years although all attempts will be made to realise that target within five years.

3. The TAC setting mechanism during the rebuilding plan shall be as follows:

    a. When the stock (SSB) is estimated to be below B_{lim} in the assessment year, the TAC will be fixed with a fishing mortality equivalent to 20% of F_{MSY} = 0.015.

    b. When the stock (SSB) is estimated to be between B_{lim} and B_{pa} in the assessment year, the TAC will be fixed with a fishing mortality equivalent to:

    $$0.015 + (SSB-B_{lim})/(B_{pa}-B_{lim}) * (F_{MSY}-0.015).$$

    c. When the stock (SSB) is estimated to be above B_{pa} in the assessment year, the TAC shall be fixed with a fishing mortality equal to F_{MSY} (0.074), subject to the constraint that the change in TAC compared to the current (assessment) year does not exceed 20%.

Article 6 End of the rebuilding plan

The rebuilding plan may be superseded by a long-term strategy for the stock when, according to ICES, the spawning stock biomass is assessed to have been above B_{pa} for three consecutive years.

Should any other underlying assumption, or the definitions of the stocks in Article 2, of the rebuilding plan change based on new scientific knowledge this rebuilding plan will be deemed no longer to be applicable.

Article 7 Evaluation and implementation

This rebuilding plan will be submitted to the European Commission by the Pelagic AC with a request that the Commission forward it to ICES for scientific review of the management strategy evaluation of this rebuilding plan. The Pelagic AC requests that the rebuilding plan option, if deemed precautionary by ICES, be included in the short-term forecast options table for the following year and thereafter in the ICES advice.

References

Campbell, A., De Oliveira, J. A. A., Kelly, C., and Roel, B. 2015. Report on Western Horse mackerel Management Strategy Evaluations (MSE). Report for Pelagic Fishing Industry.

Cox, S. P., Benson, A. J., Doherty, B., and Johnson, S. 2018. Evaluation of potential rebuilding strategies for the Western Horse Mackerel (*Trachurus trachurus*) fishery.

ICES. 1989. Report of the Working Group on the assessment of pelagic stocks in Divisions VIIIc and IXa and horse mackerel. 10-19 May 1989, ICES Headquarters, Copenhagen. ICES CM 1989/Assess:19:143pp.

ICES, 2017. Report of the Benchmark workshop on widely distributed stocks (WKWIDE) 30 January–3 February 2017, Copenhagen, Denmark. ICES CM 2017/ACOM:36.

ICES 2018a. Horse mackerel *(Trachurus trachurus*) in Subarea 8 and divisions 2.a, 4.a, 5.b, 6.a, 7.a–c, and 7.e–k (the Northeast Atlantic). In Report of the ICES Advisory Committee, 2018. 28 September 2018: http://www.ices.dk/sites/pub/Publication%20Reports/Advice/2018/2018/hom.27.2a4a5b6a7a-ce-k8.pdf. 1.2 Advice basis, ICES. ices.pub.4503.

ICES. 2018b. Report of the Working Group on Widely Distributed Stocks (WGWIDE) 28 August – 3 September2018, Torshavn, Faroe Islands. ICES C.M. 2018 / ACOM:23

ICES. 2019a. Interbenchmark Protocol on Reference points for Western horse mackerel *(Trachurus trachurus*) in subarea 8 and divisions 2.a, 4.a, 5.b, 6.a, 7.a-c,e-k (the Northeast Atlantic) (IBPWHM).ICES Scientific Reports. 84 pp.

ICES. 2019b. Horse mackerel (*Trachurus trachurus*) in Subarea 8 and divisions 2.a, 4.a, 5.b, 6.a, 7.a–c,and 7.e–k (the Northeast Atlantic). In Report of the ICES Advisory Committee, 2019. 1 October 2019. http://ices.dk/sites/pub/Publication%20Reports/Advice/2019/2019/hom.27.2a4a5b6a7a-ce-k8.pdf

ICES. 2020. Workshop on guidelines and methods for the evaluation of rebuilding plans (WKREBUILD). 2:55. 79 pp. . Volume 2, Issue 55. 79 pp.

PELAC 2019 Minutes to the PELAC WHOM Focus Group 20 June 2019 Schiphol: https://www.pelagic-ac.org/media/afbeeldingen/Minutes%20WHOM%2020.06.2019_FINAL.pdf