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Methodologies for Mediterranean stock assessments and the estimation of reference points (STECF-24-02)

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CONTENTS

Abstract

Commission Decision of 25 February 2016 setting up a Scientific, Technical and Economic Committee for Fisheries, C(2016) 1084, OJ C 74, 26.2.2016, p. 4–10. The Commission may consult the group on any matter relating to marine and fisheries biology, fishing gear technology, fisheries economics, fisheries governance, ecosystem effects of fisheries, aquaculture or similar disciplines. This report addresses two main issues. On the one hand, in preparation of the full implementation of the Western Mediterranean EU Multiannual Plan (Regulation (EU) 2019/1022) in January 2025, a methodology to deliver F_{MSY} or F_{MSY} proxy targets and their corresponding ranges for the key stocks within the West Med EU MAP is proposed. This work is built upon framework to define the conservation reference points established by STECF EWG 22-03. Overall, the EWG made proposals of F_{MSY} proxy target and ranges for 12 stocks depending on the shape of the equilibrium production curves. The procedure shall be applied by the STECF stock assessment EWG 24-10 in September to provide final F_{MSY} ranges for these stocks. On the other hand, the report contains an evaluation of the R tools developed in the QualiTrain project (FRAMEWORK CONTRACT - EASME/EMFF/2020/OP/021, Specific Contract No. 3), regarding their usefulness in assisting Member States to identify and eventually reduce data issues and to make suggestions for improvements.

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SCIENTIFIC, TECHNICAL AND ECONOMIC COMMITTEE FOR FISHERIES (STECF) - METHODOLOGIES FOR MEDITERRANEAN STOCK ASSESSMENTS AND THE ESTIMATION OF REFERENCE POINTS (STECF-24-02)

Request to the STECF

STECF is requested to evaluate the findings of the STECF Expert Working Group meeting and make any appropriate comments and recommendations.

STECF observations

EWG 24-02 was held 8-12 April 2024 in hybrid form with some participants attending physically at the Joint Research Centre (Ispra, Italy) and others attending remotely. The meeting was attended by 22 experts in total, including 4 STECF members and 6 JRC experts.

ToR 1 Reference Points West Mediterranean EU MAP

STECF notes that the EWG delivered the ToR as requested.

STECF observes that during the EWG the methodology to compute Fmsy targets, or proxies, and related ranges was discussed and applied along the lines described by the West Med MAP for stocks which had a well-defined production curve, which the EWG classified as type 1 stocks. For stocks without a well-defined production curve, the EWG suggested a path forward to estimate Fmsy proxy targets and ranges. On the one hand, for stocks reaching a peak in the production curve but with an almost flat limb curve beyond it, F0.1 was taken as the Fmsy proxy and Fmax was taken as the upper bound of the F range (Fupper). On the other hand, for the stocks showing a continuously increasing production curve, the methods used previously were applied (F0.1 as a proxy for Fmsy and F ranges based on the empirical formulas from EWG 15-09).

STECF observes that in relation to Blim, the EWG used the figures calculated by EWG 23-09 according to the methodology developed by EWG 22-03. The EWG computed preliminary Fmsy proxies and Fmsy ranges for most stocks requested, and analysed the probability of SSB to be above Blim when such stocks are exploited at the relevant fishing mortality reference points. For the stocks of deep-water rose shrimp in GSA 1 and deep-water rose shrimp in GSAs 5, 6 & 7, the stock-recruitment relationship was not considered appropriate, and reference points were not estimated.

STECF notes that due to the challenge of estimating reference points for stocks that are heavily exploited and for which only a part of the stock dynamics is observed in the stock assessment, only preliminary Fmsy proxies and Fmsy ranges can be computed. In these cases, the stocks' productivity is poorly estimated, but they drive the estimation of stock recruitment relationships and reference points. This challenge is visible in the fraction of virgin biomass each of these reference points ended up with. For example, Blim is about 10% of virgin biomass for most stocks, and in one case as low as 1%, which is not appropriate. This situation reflects the complicated process of estimating biomass reference points that lay outside the stocks' historical range of values, including virgin biomass, Bmsy and Blim.

Additionally, having Blim reference points at such low level of biomass impacts the evaluation of the probability of exploitation levels bringing the stock below Blim, which can end up giving a false sense of low risk when exploiting these stocks at high exploitation levels as set by Fupper. Since Fupper is supposed to be capped by the probability of driving the stock below Blim, this situation ends up impacting its estimation since the Blim cap effect is seldomly triggered.

Furthermore, EWG 24-02 noted that applying F ranges calculations to situations for which they were not designed for, poses additional challenges and runs the risk that such ranges are inappropriate. For example, when the Fmsy proxy reference point is not at the top of a well-defined production curve (as for F0.1). In such a case, the exploitation level that generates 95% of the catch produced at the proxy's exploitation level, will lay far away on the right side of the production curve, potentially generating a Fupper at a very high level of exploitation, occasionally leading the stock to levels of biomass outside safe boundaries. For this reason, even though those potential Fupper values were reported in the tables by stocks together with other alternative values, they were not included in the final proposal of F ranges.

Nevertheless, STECF recognizes the need to estimate reference points to support the implementation of the West Med MAP and therefore looked at the short term needs of the MAP. STECF interprets article 6 of the MAP as follows: once one stock is below Bpa, the use of Fupper is not permitted for any stock, and Fmsy, or proxies, should be used to set effort reduction objectives. Due to the current overexploited situation of the hake stocks in the region, it is unlikely the MAP will need to use F ranges. For this reason, STECF suggests the Fmsy proxies identified by EWG 24-02 for each stock to be updated during EWG 24-10, and used in the MAP as preliminary estimates, setting the stocks on course to reduce overexploitation. STECF expects biomasses of the affected stocks to increase with the reductions of fishing mortality prescribed according to the MAP. Such trajectory will provide information about the stock dynamics outside the current ranges of biomass, allowing a better understanding of the stocks' productivity and, consequently, the estimation of reference points.

ToR 2 evaluation of 'QualiTrain' tools

STECF notes that he EWG delivered the ToR as requested.

STECF observes that the RDBqc and RoME packages were found to be useful in assisting Member States with identifying and reducing data issues. The tools are expected to contribute to a significant reduction in data errors and improve the overall quality of data submissions. STECF considers that the documentation provided for both tools is sufficient for users with a basic knowledge of R. However, continuous updates and improvements to the documentation are necessary to keep it relevant and user-friendly.

STECF conclusions

STECF concludes that the EWG 24-10 should estimate the reference points needed for the MAP implementation: Fmax for type 1 stocks and F0.1 for all the others. Furthermore, STECF concludes that if the 2024 hake stocks assessments performed by the EWG 24-10 show any of these stocks to be above Bpa, in which case F ranges may be needed, the F ranges estimated by the EWG 24-02 could be used preliminarily.

However, STECF concludes that the current framework to set Blim, Fmsy and Fmsy ranges, and the current reference points should be revised in a maximum of 3 years. STECF further concludes that if the use of F ranges is required, as per previous paragraph, the revision will have to be brought forward.

STECF concludes that the EWG analysed the Qualitrain tools described by ToR 2 as being appropriate and provided relevant feedback.

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[1] - Information on STECF members' affiliations is displayed for information only. In any case, Members of the STECF shall act independently. In the context of the STECF work, the committee members do not represent the institutions/bodies they are affiliated to in their daily jobs. STECF members also declare at each meeting of the STECF and of its Expert Working Groups any specific interest which might be considered prejudicial to their independence in relation to specific items on the agenda. These declarations are displayed on the public meeting's website if experts explicitly authorized the JRC to do so in accordance with EU legislation on the protection of personnel data. For more information: http://stecf.jrc.ec.europa.eu/adm-declarations

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REPORT TO THE STECF

EXPERT WORKING GROUP ON Methodologies for Mediterranean stock assessments and the estimation of reference points (EWG-24-02)

Hybrid meeting, 8-12 April 2024

1 INTRODUCTION

1.1 Terms of Reference for EWG-24-02

DG Mare focal person: Chato OSIO (MARE D1) and Venetia KOSTOPOULOU (MARE C3)

JRC Focal point: Christoph Konrad and Danai Mantopoulou

TOR 1 Reference Points West Mediterranean EU MAP

Background

As of 1 January 2025, the transitional phase of the West Med EU MAP[1] will end and the plans enters in the full implementation phase. As per Articles 21 of the MAP, Article 4 and Article 6(1) shall apply from 1 January 2025.

Article 4 details how the F_{MSY} ranges operate and the flexibilities given in the context of mixed-fisheries while accounting for the safeguards outlined in Article 6.

Tor1 A

STECF has worked on F_{MSY} ranges since STECF EWG 15-06 (STECF, 2015). To evaluate MSY ranges for stocks STECF has used the values of F associated with $F=F_{0.1}$. These are the FMSY values from the most updated assessments carried out on Mediterranean stocks assessment. Those values were then used in the formulas provided by STECF EWG 15-06 (STECF, 2015) to derive F_{MSY} range (F_{low} and F_{upp}). The empirical relationships used to estimate F_{MSY} range are the following:

F_{low} = 0.00296635 + 0.66021447 x F0.1

F_{upp} = 0.007801555 + 1.349401721 x F0.1

where $F_{0.1}$ is a proxy of F_{MSY}.

STECF concluded that none of these methods added information on the precautionary nature of the F_{MSY} ranges the values of F_{upp} and F_{low}. In the case of stock based on F0.1 the F_{MSY} was considered to be precautionary, and because F_{low} is a lower exploitation rate this is will also be precautionary. As the EWG's were unable to parameterise stock recruit models, it has not been possible to evaluate Fupp, until further evaluations can be completed should not be used for exploitation, and should be replaced with F_{MSY}.

The West Med MAP definition of F_{MSY} range in Article 2(4) is:

'range of FMSY' means a range of values provided for in the best available scientific advice, in particular by STECF, or a similar independent scientific body recognized at Union or international level, where all levels of fishing mortality within that range result in maximum sustainable yield (MSY) in the long term with a given fishing pattern and under current average environmental conditions, without significantly affecting the reproduction process for the stocks in question. It is derived to deliver no more than a 5 % reduction in long-term yield compared to the MSY. It is capped so that the probability of the stock falling below the limit reference point (BLIM) is no more than 5 %;

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[1] Regulation (EU) 2019/1022 of the European Parliament and of the Council of 20 June 2019 establishing a multiannual plan for the fisheries exploiting demersal stocks in the western Mediterranean Sea and amending Regulation (EU) No 508/2014

Consider the entry into force of the legal provision for the F_{MSY} ranges:

1. STECF should assess if the prior work performed by STECF EWGs for deriving F_{MSY} ranges from precautionary $F_{0.1}$ complies with the F_{MSY} range definition outlined above (Article 2(4)).

2. On this basis, and considering the availability of longer time series in respect to 2015, the STECF is requested to develop a methodology that would deliver:

a. F_{MSY} or F_{MSY} proxy targets for the key target stocks

b. F_{MSY} ranges for the key stocks defined in Article 1(2), that are compliant with the definition of Article 2(4).

3. STECF is requested to provide F_{MSY} ranges for the stocks of the MAP in view of providing updates in EWG 24-10.

The MAP has specific provisions for the most vulnerable stocks, as defined in Article 2(3), this being up to now the hake stocks in EMU 1 & 2. STECF is requested to give priority to the calculation of F_{MSY} or F_{MSY} proxies and F_{MSY} ranges for these stocks.

TOR 2 evaluation of 'QualiTrain' tools

The Quality checking of Mediterranean & Black Sea data and training for Member State experts' QualiTrain' project (FRAMEWORK CONTRACT - EASME/EMFF/2020/OP/021, Specific Contract No. 3) was launched to implement technical work on quality checks and to prepare, coordinate and organise technical training and information sessions for national experts on consolidated R tools for data quality. QualiTrain has integrated the work on data quality checking functions developed in the STECF-EWG 22-03[2], STREAM[3] and RDBFIS[4] projects and MEDITS Coordination Group initiatives into two free, extensively documented R tools, one for performing quality checks on commercial data (RDBqc) and one for MEDITS survey data (RoME).

The QualiTrain tools are specifically designed to assist Member States prior to the data submission of official EU data call for the Mediterranean and Black Seas and are expected to contribute to a reduction in the number of data errors and/or data inconsistencies. The long-term goal is to improve the quality of Med & BS data.

In addition, it is expected that the use of the QualiTrain tools will lead to a reduction in the time spent on quality checks during the STECF EWGs on stock assessment.

The EWG is hereby requested to: (i) provide an assessment of the usefulness of the QualiTrain tools in assisting Member States to identify and eventually reduce data issues and (ii) make suggestions on how the QualiTrain tools could be further improved.

Specifically, the following requirements should be addressed:

RDBqc package: https://github.com/COISPA/RDBqc

1) to assess whether the functions implemented in the RDBqc package cover the main sources of potential problems in the provision of aggregated data by the Member States (e.g. misreporting of total landings and/or discards in weight, availability and consistency of length/age composition provided, availability and consistency of biological parameters, cross-checks among data calls, etc…) and to evaluate if the tools can actually reduce the number of data issues before the data submission of commercial aggregated data;

[2] STECF EWG 22-03: Quality checking of Med & BS data and reference points, 02 - 06 May 2022, online.

[3] Microsoft Word - D0.3_STREAM_Final_Report (europa.eu)

[4] Med&MS RDBFIS – an Integrated Fisheries Information System for the Mediterranean and Black Sea (medbsrdb.eu) and rdbfis.eu

2) to evaluate if the documentation and material provided by the QualiTrain consortium is sufficient to run the quality checks with a basic knowledge of R and to interpret the outcomes of the checks;

3) to propose any further development and/or quality or coverage checks to be carried out to improve the tools.

RoME package: https://github.com/COISPA/RoME

1) to assess whether the checks implemented can be considered sufficient to ensure the quality of the data provided (e.g. data format, range of valid data, haul positions, reliable swept area estimates, etc…) and to evaluate if the tools can actually reduce the number of data issues before the data submission of survey data;

2) to evaluate if the documentation and material provided by the QualiTrain consortium is sufficient to run the quality checks with a basic knowledge of R and to interpret the outcomes of the checks;

3) to suggest any further development and/or quality or coverage checks to be implemented.

The EWG can evaluate the functionality of the RDBqc and RoME packages using the data provided to the EWG, as well as the dummy datasets already embedded in the packages.

The GitHub repositories contain vignettes and extended documentation describing in detail how to perform the functions and quality checks. The EWG is requested to analyse the following data calls formats:

- MED & BS: https://dcf.ec.europa.eu/data-calls/medbs_en
- FDI (only for landings and discards in weight cross-checks): https://dcf.ec.europa.eu/data-calls/fdi_en
- AER (only for landings in weight and landing value cross-checks): https://dcf.ec.europa.eu/data-calls/aer_en

Deliverable 1.1- 'Report on tests carried out and final version of RDBqc R package', produced by the QualiTrain consortium, will be included as a background document. In this Deliverable, there is a description of the existing tools, new ones, as well as further enhancements. The consolidated package was tested on a subset of stocks assessed during past STECF EWGs[5], covering different data issues and country/GSA combinations. All the results obtained on the selected stocks were systematically compared with the results documented in the respective STECF EWGs' reports and in the Data Transmission Monitoring Tool (DTMT).

1.2 Organisation of the meeting

The meeting was held from 8th to 12th April 2024 in hybrid form with some participants attending physically at the Joint Research Centre (Ispra) and others attending remotely. The meeting was attended by 22 experts in total, including 4 STECF members and 6 JRC experts.

The meeting started with a thorough examination of the ToRs. Then, the experts were allocated into two subgroups, each addressing a different ToR. Specifically, 18 experts worked on the calculation of reference points for the West Mediterranean EU MAP (ToR 1) and 4 experts tested and evaluated the 'QualiTrain' tools (ToR 2).

[5] STECF EWG 22-03 (Quality checking of Med & BS data and reference points), EWG 22-09 (Working Group on Stock Assessments in the Western Mediterranean), and EWG 22-16 (Working Group on Stock Assessments in the Adriatic, Ionian, and Aegean Sea).

Regarding ToR 1, the stocks were allocated to participants based on their expertise. Prior to the meeting, the JRC team developed a suite of R scripts that was used by experts during the meeting. Along the week, the results of each step for each of the stocks were shared and discussed with the rest of the subgroup. The final discussions regarding the methodology for delivering F_{MSY} or F_{MSY} proxy targets and corresponding F ranges took place on Friday at the end of the meeting. Due to the computational burden, the final step involving forward simulations could only be completed for a small number of iterations (< 100 iterations). The JRC team finalised this task and conducted the forward simulations with 1000 iterations in the JRC computing facilities the week after the meeting. Although the work is considered fit for purpose in general, for some stocks some issues remained a bit inconclusive and further work is recommended to test the robustness of the results produced by the EWG, in particular to expand the sensitivity test to some alternative SRRs.

Regarding ToR 2, the first day of the meeting Isabella Bitetto (COISPA) presented the work carried out in the 'QualiTrain' project (FRAMEWORK CONTRACT - EASME/EMFF/2020/OP/021, Specific Contract No. 3). During the week, the subgroup tested and evaluated the RDBqc and RoME packages using the dummy datasets that were already embedded in the packages, as well as additional real datasets provided to the EWG. The work from the subgroup was presented and discussed in plenary on Friday morning.

1.3 Organisation of the report

The report is organised as follows:

Section 2 provides a full description of the work conducted regarding ToR 1. First, the current basis for reference points in the west Mediterranean is described. Then, the procedure proposed by the EWG to define reference points is presented. The results obtained for each of the stocks are summarised in subsection 2.3, whereas the full sets of results for each of the stocks are available as electronic annexes. The proposed procedure and some pending issues are discussed in subsection 2.4. Finally, the conclusions of ToR 1 are listed in subsection 2.5.

Section 3 describes the work conducted regarding ToR 2. The testing and evaluation of RDBqc and RoME packages is summarised in subections 3.1 and 3.2 respectively. The final conclusions, including the evaluation of the packages and some suggestions from the EWG, are provided in subsection 3.4.

The lists of participants, annexes and background documents are given at the end of the report.

2 TOR 1 DEFINITION OF F_{MSY} OR F_{MSY} PROXIES AND CORRESPONDING F RANGES

2.1 Reference points in the Western Mediterranean Sea EU MAP

2.1.1 Definition of reference points in the Western Mediterranean Sea EU MAP

In Article 2 of the Western Mediterranean Sea EU Multiannual Plan (Regulation (EU) 2019/1022), the following target and conservation reference points are defined:

- 'range of F_{MSY}' means a range of values provided for in the best available scientific advice, in particular by STECF, or a similar independent scientific body recognised at Union or international level, where all levels of fishing mortality within that range result in maximum sustainable yield (MSY) in the long term with a given fishing pattern and under current average environmental conditions, without significantly affecting the reproduction process for the stocks in question. It is derived to deliver no more than a 5 % reduction in long-term yield compared to the MSY. It is capped so that the probability of the stock falling below the limit reference point (B_{lim}) is no more than 5 %;

- 'F_{MSY} point value' means the value of the estimated fishing mortality that, with a given fishing pattern and under current average environmental conditions, gives the long-term maximum yield;
- 'MSY F_{lower}' means the lowest value within the range of F_{MSY};
- 'MSY F_{upper}' means the highest value within the range of F_{MSY};
- 'lower range of F_{MSY}' means a range that contains values from MSY F_{lower} to F_{MSY} point value;
- 'upper range of F_{MSY}' means a range that contains values from F_{MSY} point value to MSY F_{upper};
- 'B_{lim}' means the limit reference point, expressed as spawning stock biomass and provided for in the best available scientific advice, in particular by STECF, or a similar independent scientific body recognized at Union or international level, below which there may be reduced reproductive capacity;
- 'B_{pa}' means the precautionary reference point, expressed as spawning stock biomass and provided for in the best available scientific advice, in particular by STECF, or a similar independent scientific body recognised at Union or international level, which ensures that the spawning stock biomass has less than 5 % probability of being below B_{lim}.

2.1.2 Current basis for reference points

The STECF advice for the demersal stocks in the West Med EU MAP is based on the stock assessments and the reference points provided by the stock assessment group (see the latest report by STECF EWG 23-09). For stocks with full analytical assessments, the list of reference points consists of: F_{MSY}, B_{MSY}, B_{lim}, B_{pa}, target range F_{lower} and target range F_{upper}. The technical basis for each of them is provided below.

- F_{MSY} is set at $F_{0.1}$ (the fishing mortality at which the slope of the yield-per-recruit curve is 10% of that at the origin). Currently, in the absence of full MSY evaluations, this is considered as a suitable proxy for F_{MSY} (STECF EWG 23-09).
- As a consequence of the F_{MSY} definition, B_{MSY} is set as $B_{F0.1}$ (spawning biomass at $F_{0.1}$).
- Target range F_{lower} and target range F_{upper} values are based on the following quantitative linear models:

  $$F_{lower} = 0.00296635 + 0.66021447 \times F_{0.1}$$

  $$F_{upper} = 0.007801555 + 1.349401721 \times F_{0.1}$$

  where $F_{0.1}$ is a proxy of F_{MSY}.

  These empirical relationships were established from a meta-analysis conducted on the F_{MSY} ranges estimates for demersal stocks in the Baltic Sea and the North Sea (see Annex V of STECF EWG 15-09 for details) and they were applied to estimate F_{lower} and F_{upper} for the first time by STECF EWG 15-06. STECF EWG 23-09 concluded that none of the empirical relationships added information on the precautionary nature of the ranges. The F_{MSY} proxy based on $F_{0.1}$ is considered to be precautionary, and because F_{lower} is lower such exploitation rate will also be precautionary. As the EWGs were unable to parameterise stock recruit models, it has not yet been possible to evaluate if F_{upper} was precautionary. Therefore, STECF concluded that until further evaluations can be completed, F_{MSY} should be considered as F_{upper}.

- The methodology to set conservation reference points (B_{lim} and B_{pa}) was developed by STECF EWG 22-03. Considering international practice, biological principles and the characteristics of the fairly short S-R time series, the two guiding principles for estimating B_{lim} are as follows:
    - Plausible B_{lim} estimates are assumed to be within the range 0.1% - 20% of SSB_0 (equivalent to 0.01−0.20 SPR_0) if determined by way of fitting a segmented regression.
    - If no clear break point can be identified within this range, B_{lim} can be derived analytically as $B_{lim} = 0.25B_{F0.1}$, where $B_{F0.1}$ is the equilibrium SSB corresponding to $F_{0.1}$. In the absence of reliable stock recruitment function, the $B_{F0.1}$ can be based on geometric mean of the available recruitment estimates.

  It follows that a direct estimate of B_{lim} shall only be derived empirically in cases where there is sufficient contrast in the S-R data to estimate a well-defined break-point that falls within plausible biological limits. Alternatively, it is suggested that B_{lim} be specified as a ratio of B_{MSY} or its proxy, which is taken as $B_{F0.1}$. The decision tree for deriving B_{lim} is shown in Figure 2.1.2.1.
- B_{pa} is set to 2*B_{lim}, equivalent to a sigma of 0.4 on the estimate of terminal year SSB (STECF EWG 22-03) (from the definition of Bpa based on Blim*exp(1.645 * sigma) in ICES 2021). The relatively high factor was chosen to reflect the considerable uncertainty in the Western Mediterranean stock assessments and the fact that B_{lim} is in all cases sensitive to some of the assumptions regarding stock productivity and in many cases outside the range of biomass observed. In contrast, ICES has used a factor of 1.4 based on a sigma of 0.2.

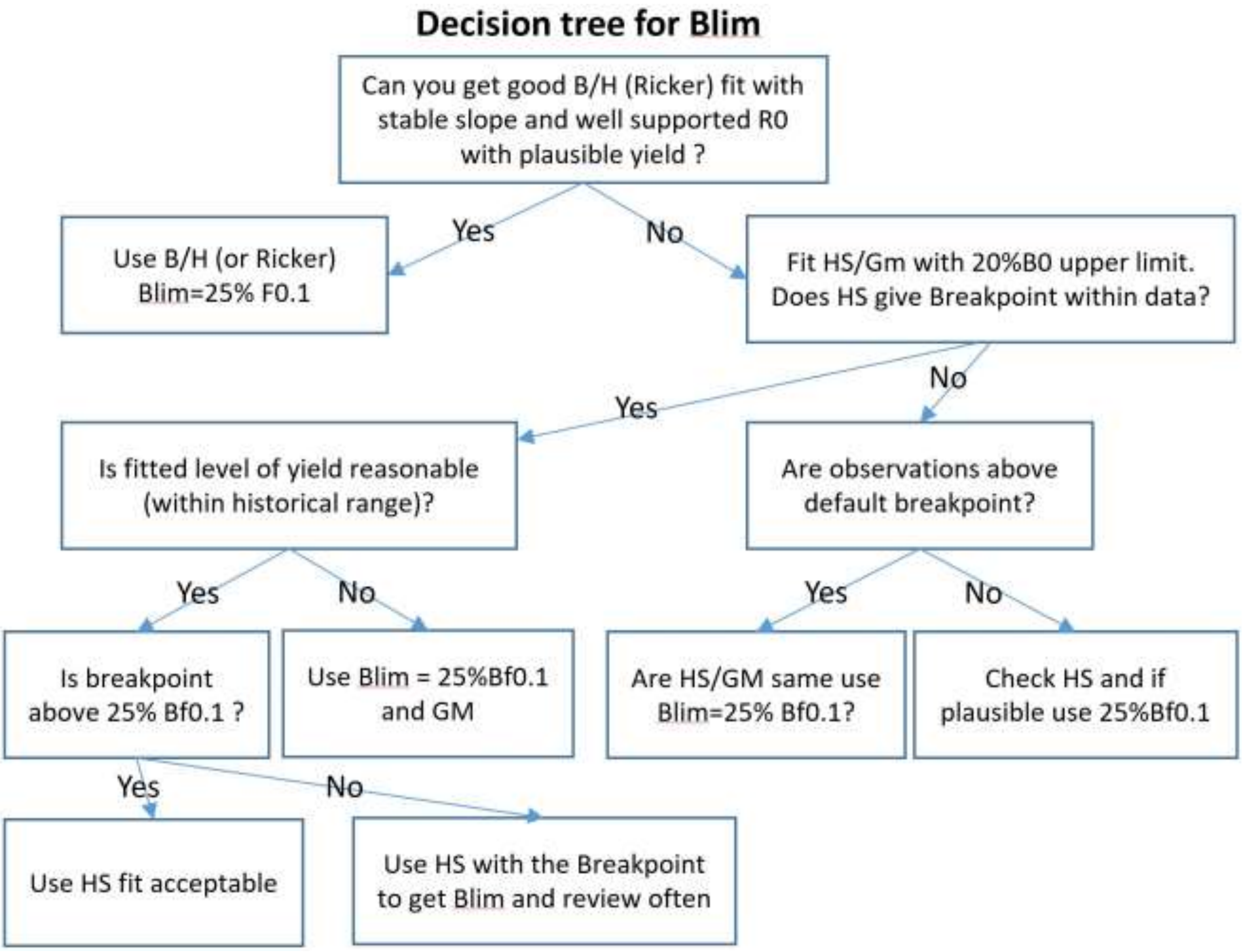


Figure 2.1.2.1. Decision tree for defining B_{lim} (taken from STECF EWG 22-03).

A summary of the current reference points ($F_{0.1}$, $B_{0.1}$ and B_{lim}) as reported in STECF EWG 23-09 in comparison with B_0 and with current F and Biomass ($F_{current}$ and $B_{current}$) and the relative position among them is reported in Table 2.1.2.1. There are only four stocks for which B_{lim} is estimated from the break point of a Hockey-stick fit, while for eight other stocks B_{lim} was set at 25%$B_{F0.1}$.

Table 2.1.2.1. Reference points ($F_{0.1}$, $B_{0.1}$ and B_{lim}) as reported in STECF EWG 23-09 in comparison with B0 and with current F and Biomass ($F_{current}$ and $B_{current}$), and with indication of the relative position among them.

Stock	Area	F 0.1	Fcurrent	F/ F0.1	B0.1	Bcurrent	B/ B0.1	B0	B0.1/B0	Blim	BasisBlim	Blim/ B0.1	Blim/B0
Hake	1_5_6_7	0.41	1.32	3.22	63,696	2,050	3.2%	226,475	28.1%	3,872	Estimated	6.1%	1.7%
Hake	8_9_10_11	0.17	0.5	2.94	49,500	2,050	4.1%	113,444	43.6%	5,132	Estimated	10.4%	4.5%
Norway lobster	6	0.16	0.787	4.78	1,890	157	8.3%	5,390	35.1%	472	forced	25.0%	8.8%
Red Mullet	6	0.31	1.63	5.19	3,600	668	18.6%	7,241	49.7%	770	forced	21.4%	10.6%
Blue and red shrimp	6_7	0.26	0.99	3.81	1,520	115	7.6%	3,810	39.9%	261	Estimated	17.2%	6.9%
Norway lobster	9	0.13	0.144	1.13	1,022	682	66.8%	2,448	41.7%	255	forced	25.0%	10.4%
Red Mullet	1	0.61	1.44	2.36	399	203	50.9%	1,236	32.3%	170	Estimated	42.6%	13.7%
Red Mullet	7	0.46	0.42	0.92	775	883	114%	1,591	48.7%	134	forced	17.2%	8.4%
Blue and red shrimp	5	0.34	1.25	3.68	302	115	38.1%	913	33.1%	75	forced	25.0%	8.3%
Giant red shrimp	8-9-10-11	0.43	0.7	1.63	772	551	71.4%	1,825	42.3%	193	forced	25.0%	10.6%
Deep-water rose shrimp	8-9-10-11	1.26	1.63	1.29	855	1,249	146%	2,900	29.5%	214	forced	25.0%	7.4%
Red Mullet	9	0.50	0.41	0.82	1,846	1,998	108%	4,444	41.5%	462	forced	25.0%	10.4%

2.2 General approach to define and evaluate F_{MSY} ranges

2.2.1 Methodology

The general approach followed by the STECF EWG 24-02 to define F_{MSY} ranges was built upon the framework to define the conservation reference points established by STECF EWG 22-03. Therefore, to be consistent with the current B_{lim} values, the EWG considered the Hockey-stick with the breakpoint at B_{lim} (HSBlim) as the default stock-recruitment relationship (SRR) best representing the current dynamics of the stocks. Then, the EWG calculated several F_{MSY} proxy targets and the respective ranges leading to a maximum drop of 5% over the yield at F_{MSY} proxy taking as basis both the Yield and Spawning Biomass per recruit analysis (SPR) and the associated Production curves. The risks of falling below B_{lim} for these ranges were assessed through forward simulation. The minimum fishing mortality value inducing risks of 5% or higher was used to define $F_{p.05}$ for fixing the maximum limits to exploitation.

Given the large uncertainties surrounding the actual SRR governing the productivity of the stocks, the EWG revisited the SRRs based on the results of the latest STECF assessments (STECF EWG 22-09 and STECF EWG 23-09) and identified potential alternative SRRs for each of the stocks. The F_{MSY} proxy targets and the respective ranges corresponding to the production curves of these alternative SRRs were also calculated, including evaluation of their respective $F_{p.05}$. The analysis aimed to check if the F ranges computed associated to the production curves from HSBlim and from the alternative SRRs were risk-averse to all these alternative plausible SRRs which accounted for different recruitment productivity of the stocks (i.e. F ranges should not induce risks of dropping below B_{lim} higher than 5% for any of the plausible SRR dynamics of the stock considered).

Furthermore, several options were considered and prioritised to propose proxies of F_{MSY} ranges for the cases where the production curves associated with the default HSBlim SRRs were ill-defined (either continuously growing or almost flat after the production peak).

The final discussion on the F target and corresponding ranges was held on a stock-by-stock basis according to the guidelines outlined below accounting for the shape of the production curve associated to the default HSBlim and identified alternative plausible SRRs.

Therefore, to address ToR 1, the EWG agreed to follow the following steps:

- Step 1: Obtain latest stock assessment results.
- Step 2: Review potential SRRs and definition of B_{lim}.
- Step 3: Calculate F_{MSY} or F_{MSY} proxy targets and respective F target ranges for every selected SRRs.
- Step 4: Calculate $F_{p.05}$ (fishing mortality that results in >95% annual probability that SSB remains at or above B_{lim} in long-term equilibrium) for every selected SRRs.
- Step 5: Evaluate F_{MSY} or F_{MSY} proxy targets and F target ranges in terms of the risks of falling below B_{lim} and other metrics such as catches and SSB.
- Step 6: Discuss and provide advise on F target ranges.

Each of the steps in described in detail below.

2.2.1.1 Step 1: Obtain latest stock assessment results

The first step was the obtention of the latest stock assessment outputs for Western Mediterranean demersal stocks with analytical assessments (Table 2.2.1.1). For 9 stocks the outputs were obtained from STECF EWG 23-09. For 5 stocks, STECF EWG 23-09 could not carry out the assessments due to the lack of MEDITS in EMU2 (i.e. Italian waters), and the stock assessment outputs from STECF EWG 22-09 were used. In all the cases, the stock assessments were conducted with the a4a model (Jardim et al., 2015) and the resulting FLStock objects were sourced.

Table 2.2.1.1. List of stocks considered for the reference point analysis.

Species	**Common name**	**Stock code**	**Years**	**Source**
Merluccius merluccius	Hake	HKE_1_5_6_7	2007-2022	STECF EWG 23-09

Parapenaeus longirostris	Deep-water rose shrimp	DPS_5_6_7	2008-2022	STECF EWG 23-09
Parapenaeus longirostris	Deep-water rose shrimp	DPS_1	2002-2022	STECF EWG 23-09
Mullus barbatus	Red Mullet	MUT_1	2002-2022	STECF EWG 23-09
Mullus barbatus	Red Mullet	MUT_6	2002-2022	STECF EWG 23-09
Mullus barbatus	Red Mullet	MUT_7	2002-2022	STECF EWG 23-09
Nephrops norvegicus	Norway lobster	NEP_6	2009-2022	STECF EWG 23-09
Merluccius merluccius	Hake	HKE_8_9_10_11	2005-2021	STECF EWG 22-09
Parapenaeus longirostris	Deep-water rose shrimp	DPS_8_9_10_11	2009-2021	STECF EWG 22-09
Mullus barbatus	Red Mullet	MUT_9	2003-2021	STECF EWG 22-09
Nephrops norvegicus	Norway lobster	NEP_9	1994-2021	STECF EWG 23-09 (updated assessment)
Aristeus antennatus	Blue and red shrimp	ARA_5	2002-2022	STECF EWG 23-09
Aristeus antennatus	Blue and red shrimp	ARA_6_7	2004-2022	STECF EWG 23-09
Aristaeomorpha foliacea	Giant red shrimp	ARS_9_10_11	2005-2021	STECF EWG 22-09

2.2.1.2 Step 2: potential SRRs and B_{lim}

For each of the stocks, a series of stock-recruitment relationships (SRRs) was fitted using a set of FLR (Fisheries Library in R) libraries (Kell et al. 2007). More specifically, following the framework proposed by STECF EWG 22-03, the models were fitted with the package FLSRTMB (Winker and Mosqueira, https://github.com/flr/FLSRTMB). To check the model robustness, these fits were compared to those obtained by the FLCore package. The explored SRRs included the following models: Beverton-Holt (BH), Ricker, Hockey-stick (HS), Hockey-stick with the breakpoint set at B_{lim} (HSBlim), Hockey-stick with the breakpoint set at B_{loss} (HSBloss) and geometric-mean (GM).

The models were compared in terms of Akaike Information Criteria (AIC) and Bayesian Information Criteria (BIC). In addition, consistency of R_0 with past estimates of recruitment and of expected yield at $B_{F0.1}$ from the related production curve with historical catches known for the fishery were evaluated.

To be consistent with the current definition of B_{lim} and with the framework to define conservation reference points, the EWG decided to consider the Hockey-stick model with the breakpoint at B_{lim}

as the default SR model. However, for some stocks the EWG identified potential alternative SRRs that provided better statistical fits or that were considered as plausible as the default SR model. These alternative plausible SRR models were used as alternative operating models to define F_{MSY} or F_{MSY} proxy targets and corresponding ranges and to assess the risks of dropping below the current B_{lim} in the long term. Alternative plausible SRR models corresponding to a less productive recruitment dynamics than the default HSBlim were considered especially relevant in the proposed framework, as they provided a more cautious scenario of stock productivity to be considered when assessing risks of falling below B_{lim} for the different F_{MSY} proxies and ranges.

Overall, the EWG considered that:

- For the stocks where the current B_{lim} was defined from the break point resulting from the unconditional fitting of a Hockey-stick model to the data and lying within or at the edges of biomass observations, it was often found that there was no obvious alternative SRR model resulting in a better statistical fit or resulting in a less productive recruitment dynamics. Then, the default SRR (HSBlim) was retained as the best SRR informing on the stock dynamics of the stock and no alternative SRR were considered.
- For the cases where there was a SRR resulting in a statistically better fit to the S-R pairs than the one obtained for the HSBlim (being also consistent with historical observations from the fishery), then this SRR was taken as an alternative to the HSBlim for robustness in the definition of F_{MSY} proxy and F ranges for the stock and in the assessment of the risks of dropping the stock below B_{lim}. When possible, an alternative plausible SRR model corresponding to a less productive recruitment dynamic than the HSBlim was selected.
- Finally, for the cases where B_{lim} was defined, as resulting from the application of the STECF 22-03 decision tree at 25% $B_{F0.1}$ at a range of biomass well below the historical estimates from the assessment, alternative SRR models were selected having a smaller slope towards the origin as plausible less productive SRR (risk averse) models. These alternative models were included for assuring robustness to a less productive dynamics of the stock throughout the rest of the analysis for the definition of F_{MSY} proxy and F ranges, as well as for the assessment of the risks of those F ranges of dropping the stock below B_{lim}.

The EWG discussed extensively the SRRs. The reduced range of biomasses and the length of the time series made difficult the selection of plausible SRRs. The decision on which alternative SRR should be best considered was taken on a stock-by-stock basis. However, given the high uncertainty of the SRRs, whenever possible the EWG supported the consideration of alternative SRRs other than the default HSBlim for comparative purposes and in support of the most risk-averse procedure.

2.2.1.3 Step 3: F target and respective ranges

For each of the selected SRR, F_{MSY} and the following F_{MSY} proxies were calculated:

- From Y/R analysis: $F_{0.1}$ (the current default one), F30%SPR, F35%SPR or F40%SPR (Clark 1991 and 1993) and F_{max}.
- From equilibrium production curve analysis: F_{MSY}, F35%B0 and F40%B0 (Horbowy and Luzeńczyk 2012; Thorson etal. 2012).

For each of the F_{MSY} or F_{MSY} proxies, the corresponding ranges were calculated (Hilborn, 2010; Rindorf et al., 2017). In line with the West Med EU MAP (see subsection 2.1.1), these were defined as the ranges of F's leading to a yield not lower than 95 of the yield of the target F. In addition, the current ranges around $F_{0.1}$ based on the empirical equations were also calculated. This led to the set of alternatives given in Table 2.2.1.2.

Table 2.2.1.2. List of options explored for F target and respective ranges.

Scenarios	F_{target}	**Target ranges**
F_{cur}	$F_{0.1}$	Empirical linear equations
$F_{0.1}$	$F_{0.1}$	Leading to 95% of target yield
F35%SPR	F35%SPR	Leading to 95% of target yield
F40%SPR	F40%SPR	Leading to 95% of target yield
F35%B0	F35%B0	Leading to 95% of target yield
F40%B0	F40%B0	Leading to 95% of target yield
F_{MSY}	F_{MSY} (from production curve)	Leading to 95% of target yield

The EWG identified three type of equilibrium production curves corresponding with the default HSBlim SRR:

- Type 1: the production curve has a well-defined maximum and the corresponding target ranges can be calculated.
- Type 2: the production curve has a well-defined maximum, but then yield decreases slowly and the range upper limit cannot be defined.
- Type 3: the production curve increases continuously and does not have a well-defined maximum.

These different production curves are due to the different SRRs, including the different slopes at the origin related to the relative position of B_{lim} over the B_0 or $B_{F0.1}$, and to the selectivity and biology of the stocks.

The EWG discussed extensively the three types of curves and implications in defining F_{MSY} or F_{MSY} proxies and corresponding target ranges. The main considerations are summarised below:

- In general, for type 1 stocks that have a well-defined dome shape production, F_{MSY} (F_{max} sensu) is well defined and estimable together with its corresponding F ranges.
- For type 1 stocks the ranges around F_{MSY} proxies are wider than for F_{MSY}. This is exacerbated for type 2 stocks where the upper limit of the F_{MSY} proxies can be very high due to the rather flat shape after the production peak. Therefore, even though the use of an F_{MSY} proxy aims at being a cautionary approach to define F_{MSY}, when the F_{MSY} is ill defined the corresponding F_{MSY} proxy ranges will result in a riskier approach than the true F_{MSY} range estimates.
- Type 2 stocks with rather flat production curves, and type 3 stocks with growing production curves, correspond to Hockey-stick SRR characterized by high slope and particular features of the stock biology or fishery selectivity. In those cases, F_{upper} values for the different F_{MSY} proxies were either very high or undefined. For these cases, the EWG discussed the following alternative options:
    - Set F_{upper} as $F_{p.05}$

- Use the empirical relationships between the MSY ranges (F_{lower} and F_{upper}) and F_{MSY} formerly defined in STECF 15-09 (STECF 2015), provided they comply with risks below B_{lim} smaller than 0.05 in the long-term.
- Use a symmetrical distance from F_{MSY} proxy to its F_{upper} as the one obtained between F_{lower} and F_{MSY} proxy. Though this approach was not followed because it resulted in the narrowest ranges of allowable fishing mortalities.
- Set F_{upper} as F_{max} when this is defined for the HSBlim as generally F_{max} is considered to be above F_{MSY}. Actually, in age-structured assessment models, the fishing mortality that results in the maximum yield per recruit (F_{max}) is close to F_{MSY} if the yield per recruit versus F curve has a well-defined peak. However, if that peak is less well defined, then F_{max} may be substantially larger than F_{MSY} (Tsikliras, A. C., & Froese, R. 2019). Furthermore, although F_{max} has often been used as a proxy for F_{MSY} (Gabriel and Mace, 1999; Lassen et al., 2014), it is quite well documented that under low productivity conditions F_{max} will be higher than F_{MSY} (Morgan et al. 2014; Cervino et al. 2013). Therefore, considering that quite often $F_{max}>F_{MSY}$ then it was proposed to set F_{upper} at F_{max}.
- Use the F ranges obtained from the alternative less productive SRR relationship selected for the stock.

It was decided to let the undefined F_{upper} as NA and consider any of the above alternatives when producing the advice (see discussion), to allow for a final discussion among them.

2.2.1.4 Step 4: $F_{p.05}$

This step involved the calculation of $F_{p.05}$ (fishing mortality that results in >95% annual probability that SSB remains at or above B_{lim} in long-term equilibrium) for every selected SRRs.

Steps 4 and 5 were based on forward projections of each of the stocks for different SRRs. In both cases the projections included the following sources of uncertainty:

- Variability in the starting population was included from the a4a output, using the variance-covariance matrix.
- The variability in the starting population was propagated to the SRR. For every iteration, a new SRR relationship was fitted and remained constant throughout the projection. Such a fitting was conditional to the type of SRR being tested in the simulation (BH, HS, Ricker, etc.). Interannual variability in recruitment was generated as stochastic draws around the SRR model accounting also for autocorrelation.
- Population biological parameters were fixed at the average of the last three years. The election of 3 years was made to be consistent with the period selected for the short-term forecast procedure.
- Fishery selectivity was fixed at the average of the last three years.
- Uncertainty in F accounting for assessment error, advice error and implementation error was included as auto-correlated AR(1) process in log scale around the desired F target. The default values were Fsigma=0.2, while a value for the autocorrelation was assumed to be 0.25. For step 5 alternative values of Fsigma=0 and 0.1 were also tested.

The populations were projected forward for 50 years. Performance statistics were calculated in the long term over the last 10 years. During the meeting a reduced number of iterations were run (20 or 100). After the meeting JRC runs 1000 iterations. Results presented in the report are based on 1000 iterations.

A range of F's by 0.1 steps were swept to calculate the risk of following below B_{lim} in the long term, and the F corresponding to $F_{p.05}$ was calculated by interpolation. Following ICES (2013), two types of risks were considered: Risk type 1 was calculated as the average probability that SSB is below B_{lim} over the last 10 years of the 50 years projection period and Risk type 3 was calculated as the maximum yearly probability that SSB is below B_{lim} over the last 10 years of the 50 years projection period. By definition, Risk type 3 is larger or equal than Risk type 1 (Annex 2 of ICES, 2013). However, Risk type 3 is expected to be equal to Risk type 1 under stationary conditions, i.e. provided the effect of the initial stock numbers has disappeared and a very large number of iterations are made.

2.2.1.5 Step 5: Forward projections

For each of the F_{MSY} or F_{MSY} proxies and the corresponding ranges given in Table 2.2.1.2, the stocks were projected forward including the same uncertainties as in Step 4. Beyond type 1 and type 3 risks described above, average SSB, average catch and average F in the last 10 years of the projections were also calculated.

2.2.1.6 Step 6: Final discussion

The final discussion on the F_{MSY} or F_{MSY} proxies and the corresponding ranges was held on a stock-by-stock basis, and included the following options:

- For stocks type 1, setting Ftarget and F ranges at F_{MSY} and their respective ranges.
- For type 2 stocks:
  - Option 1, setting Ftarget at $F_{0.1}$ and its F_{lower} range as calculated for the HSBlim, and placing F_{upper} at F_{max}, if available,
  - Option 2, staying at the former $F_{0.1}$ and the empirical F ranges as defined in STECF 15-09 (STECF 2015)
  - Option 3 using the F_{MSY} ranges obtained from the production curve corresponding to an alternative less productive SRR relationship selected for the stock.
- For type 3 stocks: staying at the former F ranges defined in STECF 15-09 provided they comply with being below $F_{p.05}$ (option 2). Alternatively, F_{MSY} ranges obtained from the production curve corresponding to the alternative less productive SRR relationship (option 3) could also be explored.

According to the definition of F ranges, F_{lower} and F_{upper} should be capped so that the probability of the stock falling below the limit reference point (B_{lim}) is no more than 5%. In other words, regardless of the above selected option, the F ranges should be below $F_{p.05}$. To be precautionary, given that risk type 3 is larger than risk type 1, the $F_{p.05}$ corresponding to risk type 3 assessment was the one selected to check that the F ranges do not imply a risk higher than 0.05 of falling below Blim. Furthermore, to account for the wide uncertainties surrounding the actual SRR governing the productivity of the stocks, the F ranges should be risk averse for all the alternative plausible SRRs. This means that the F ranges should comply with being below $F_{p.05}$ from all the plausible SRRs considered in the analysis. Thus, the smaller $F_{p.05}$ from risk type 3 among the alternative SRR relationships was proposed as a limit for the F ranges.

The following table of decisions was adopted (modified from ICES 2014):

Table 2.2.1.3.Table of decisions adopted (modified from ICES 2014) where 95%Yield ($F_{p.05}$) means the F's leading to the 95% of the yield corresponding to $F_{p.05}$.

Scenario	F_{lower}	F_{MSY} or F_{MSY} proxy	F_{upper}
$F_{upper} < F_{p.05}$	F_{Lower}	F_{MSY}	F_{upper}
$F_{MSY} < F_{p.05} < F_{upper}$	F_{lower}	F_{MSY}	$F_{p.05}$
$F_{p.05} < F_{MSY}$	F_{lower} =95%Yield($F_{p.05}$)	$F_{p.05}$	$F_{p.05}$
$F_{p.05} < F_{lower}$	F_{Lower} =95%Yield($F_{p.05}$)	$F_{p.05}$	$F_{p.05}$
$F_{p.05}$ cannot be defined	F_{lower}	F_{MSY}	F_{MSY}

2.2.2 Scripts

For the above-mentioned process, JRC prepared the following R scripts:

1. Script to read the FLStock objects and produce some exploratory plots.
2. Script to fit SR models using FLSRTMB and FLCore.
3. Script to calculate equilibrium F_{MSY} or F_{MSY} proxies and the corresponding ranges.
4. Script to propagate the stock assessment uncertainty throughout the SR models.
5. Script to calculate $F_{p.05}$
6. Script to conduct long-term projections for the F_{MSY} or F_{MSY} proxies and the corresponding ranges.
7. Script to plot the results of the projections.

These scripts were taken as the starting point and were adapted for each of the stocks. The final scripts for each of the stocks are stored in a common drive and are available upon request.

2.3 Results

In this section we summarise the results obtained for each stock according to the steps described in section 2.3.

2.3.1 Summary results for European hake in GSAs 1, 5, 6 & 7

- **The stock objects** were those produced in EWG 2023-09 with data up to 2022.
- **Biology**: Ages 0-5+. Decreasing M with age from 1.63 at age 0 to 0.22 at age 5+. Maturity increasing with age, being 15% at age 1, 82% at age 2, 98% at age 3 and reaching full maturity at age 4.
- **Stock status**: The stock is significantly overfished (F_{2022}=1.32 is well above $F_{0.1}$=0.41) and current biomass is estimated to be below B_{lim}.
- **Current F target and ranges**: F_{MSY} is based on $F_{0.1}$=0.41. The corresponding SSB is $B_{F0.1}$=63,696t . The F ranges for F0.1 based on the empirical linear models are 0.27 – 0.56.

- **Current SRR assumption and Blim definition**: The Hockey-stick model resulted in a breakpoint around the highest observed SSBs and close to the breakpoint estimated previously, on which B_{lim} is based (Figure 2.3.1.1). This value of B_{lim} (3872 tonnes) is around 6% of $B_{F0.1}$ and around 2% of B_0. Bpa is set as 2*Blim and takes the value 7743 t.
- **Alternative SRR and potential alternative Blim definitions**: Statistical comparison of the different SR models indicated that the Hockey-stick with breakpoint at B_{lim} was the most suitable in terms of AIC and BIC (Table 2.3.1.1, Figure 2.3.1.1). Ricker and Beverton-Holt models were discarded as plausible alternatives because the time series doesn't contain enough information to estimate with confidence the parameters that define the upper limit of curves. Therefore, no plausible alternative models were considered. However, just for comparative purposes the Ricker and the BH models were run for determination of Fmsy ranges that would be generated based on the production curves associated with these models (see discussion section of the report).
- **Production curves:** The equilibrium plot for the chosen model (HSBlim) is reported in Figure 2.3.1.2. The production curve is dome shaped showing a neat peak corresponding to F_{MSY} value (F_{max}). This implies that F_{MSY} and the F ranges associated to it can be estimated.
- **F_{MSY} or F_{MSY} proxies and corresponding ranges**: The values for the different F_{MSY} or F_{MSY} proxies and corresponding ranges are given in Table 2.3.1.2 and Figure 2.3.1.3. The values for the BH and Ricker corresponding to F_{MSY}, F_{lower} and F_{upper} were 0.48; 0.34; 0.66 and 0.993; 0.835; 1.14 respectively, letting the estimates for HSBlim placed intermediate between these two ranges.
- **Assessment of Risks and of Fp.05 by SRR models**. The risks of falling below the previously adopted B_{lim} were calculated through a forward projection. $F_{p.05}$ was estimated at 1.308 for risk type 1 and 1.139 for Risk type 3 (Table 2.3.1.3). All the results were shown for an assessment plus implementation error of intended fishing mortality of 0.2 (Fphi=0.2).
- **Discussion on F_{MSY} target and ranges**: This is a type 1 stock corresponding to dome shape productions curve allowing estimation of F_{MSY} and its ranges. Furthermore, the Hockey-stick model is well fitted statistically with a break point within the observed S-R pairs values. Therefore, the EWG considered that F_{MSY} and their ranges could be adopted for management, provided they comply with being below $F_{p.05}$. In this case all the F_{MSY} or F_{MSY} proxies considered, and the corresponding ranges were lower than $F_{p.05}$. Therefore, they all implied probabilities of being below B_{lim} less than 0.05 (Figure 2.3.1.4). Both the current F_{MSY} based on $F_{0.1}$ and the proposed F_{MSY} target as well as their associated ranges are compliant with not exceeding risks above 0.05 as stated in the West Med EU MAP.

  Figure 2.3.1.5 shows the relative implications of adopting alternative F_{MSY} proxies and F ranges versus the current values for the HSBlim default SRR assumption. F_{MSY} is around 44% larger than $F_{0.1}$, but the upper range of F_{MSY} is lower than the upper range that would correspond to $F_{0.1}$. All the lower and upper ranges considered except for the ones corresponding to Fspr40% and F40%, lead to long-term SSBs lower than those corresponding to the current F_{lower} and F_{upper} values.
- **Conclusions**: Current $F_{0.1}$ target and its F ranges according to the linear models are acceptable in relation to $F_{p.05}$. However, the F_{MSY} and its ranges deduced from the production curve are also compliant with being lower than $F_{p.05}$ and are consistent with the definition of the West Med EU MAP therefore the EWG proposes adopting F_{MSY} as the Ftarget and its ranges for the management of hake in GSAs 1, 5, 6 & 7.

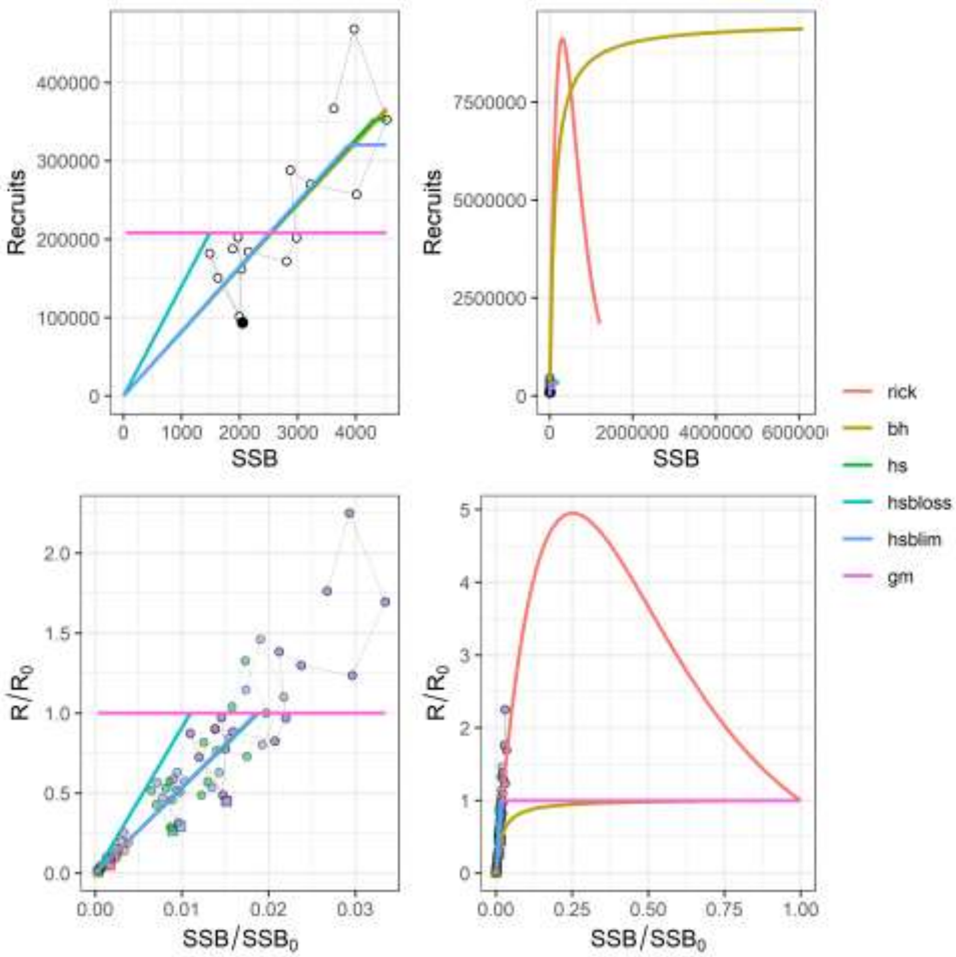


Figure 2.3.1.1. Stock recruitment relationships for hake in GSAs 1, 5, 6 & 7, both in absolute (top row) and in relative terms to R0 and B0 (bottom row) for two scales in the X axis (left and right panels).

Table 2.3.1.1. Statistical comparison of the fitting of different SRR models for hake in GSAs 1, 5, 6 & 7.

MODEL	AIC	BIC
Ricker	10.68	13
Beverton-Holt	10.69	13.01
Hockey-stick	10.66	12.97
Hockey-stick at Bloss	21.96	23.5
Hockey-stick at Blim	8.67	10.21
Geometric mean	21.96	23.5

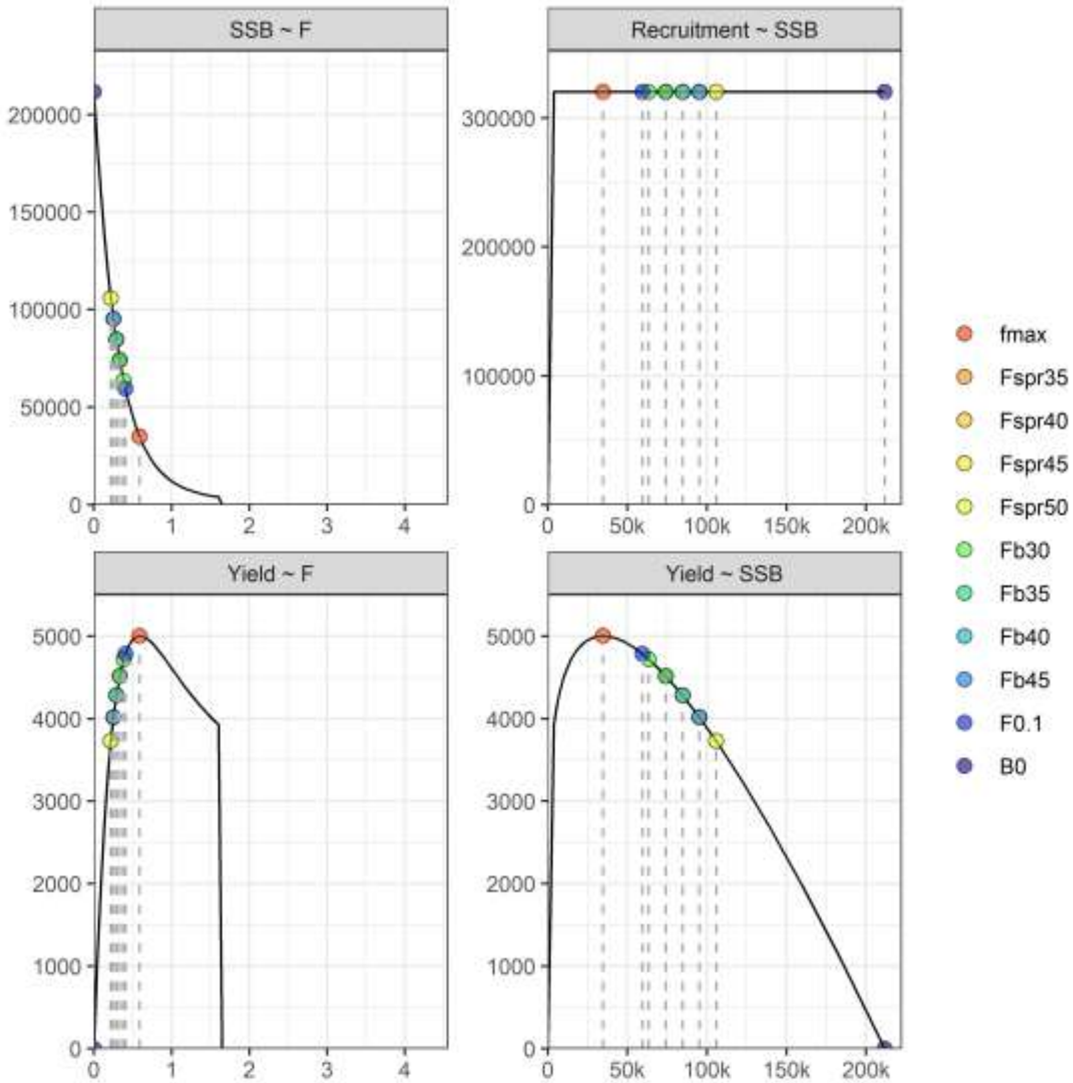


Figure 2.3.1.2. Biomass and Production curves as a function of F resulting from the HSBlim stock recruitment relationship for hake in GSA 1, 5, 6 & 7.

Table 2.3.1.2. F, yield and SSB for each of the F_{MSY} proxies and F ranges considered for hake in GSAs 1, 5, 6 & 7 from the default SRR (HSBlim).

	Ftarget			Flower			Fupper		
	F	Yield	SSB	F	Yield	SSB	F	Yield	SSB
msy_ranges	0.589	5003	34706	0.393	4753	61508	0.889	4753	15621
f0.1_ranges	0.405	4786	59447	0.338	4546	72705	1.05	4546	10791
spr.30_ranges	0.383	4720	63501	0.325	4484	75726	1.09	4484	9709
Fspr35_ranges	0.331	4515	74245	0.29	4290	84330	1.25	4290	7067
Fspr40_ranges	0.288	4282	84670	0.257	4068	93304	0.257	4068	93304
Fb35_ranges	0.331	4515	74245	0.29	4290	84330	1.25	4290	7067
Fb40_ranges	0.288	4282	84669	0.257	4068	93303	0.257	4068	93303

Table 2.3.1.3 $F_{p.05}$ values in relation to the risk of dropping SSB below current B_{lim} for hake in GSAs 1, 5, 6 & 7.

$F_{p.05}$	HSBlim
Risk 3	1.139
Risk 1	1.308

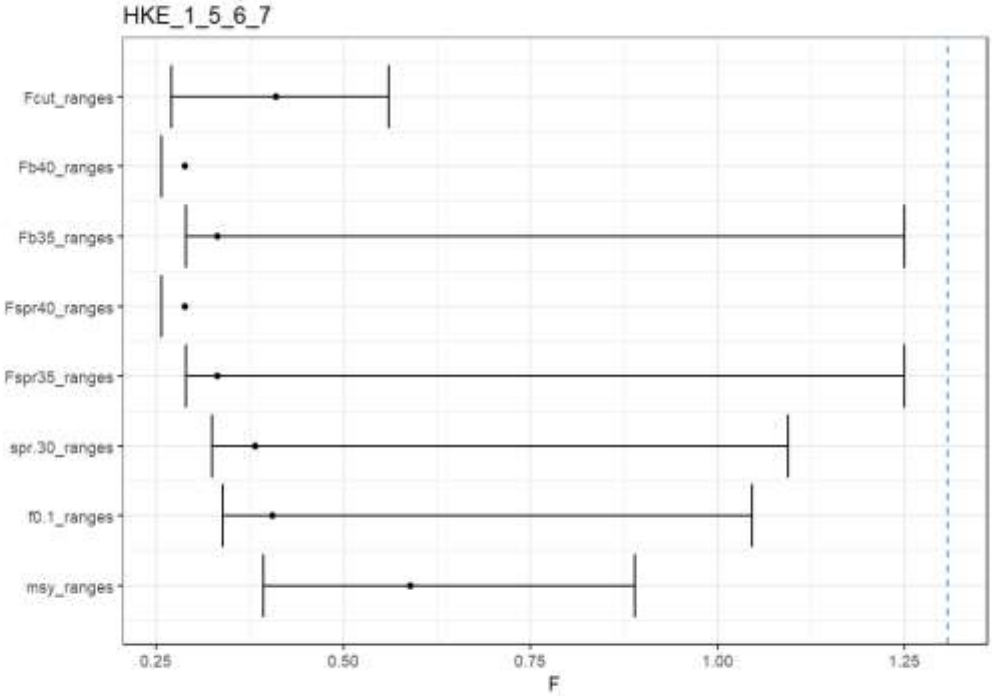


Figure 2.3.1.3 F_{MSY} proxies and corresponding ranges for the default SRR model (HSBlim) for hake in GSAs 1, 5, 6 & 7. The dashed vertical line represents Fp0.05 value (type 1 risks). Fcut_ranges refer to the current F_{MSY} proxy ($F_{0.1}$) and the ranges based on the empirical relationships.

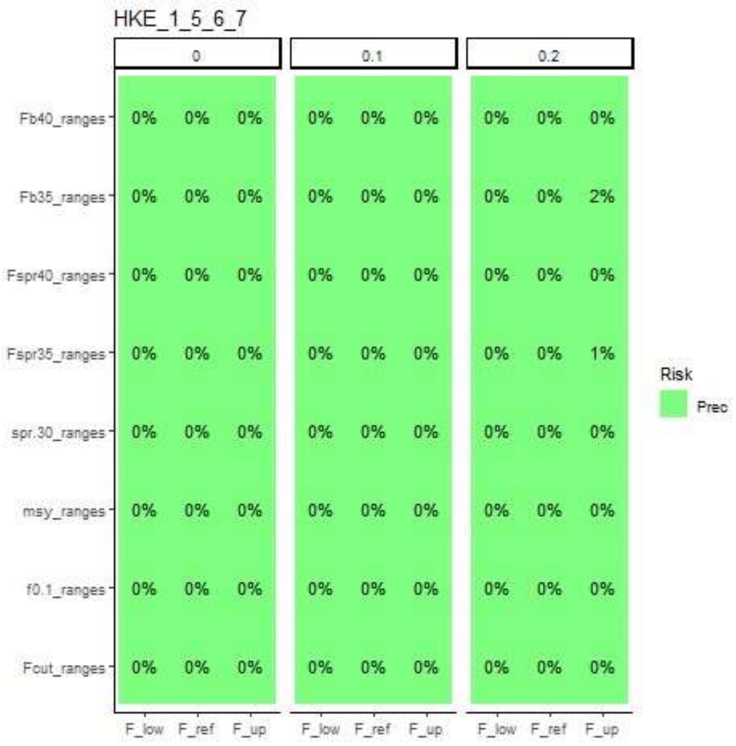


Figure 2.3.1.4. Probability of SSB being below B_{lim} (risk type 1) for alternative F_{MSY} proxies and corresponding F ranges for the default SRR (HSBlim) for hake in GSAs 1, 5, 6 & 7. The vertical panels correspond to Fsigma equal to 0, 0.1 and 0.2.

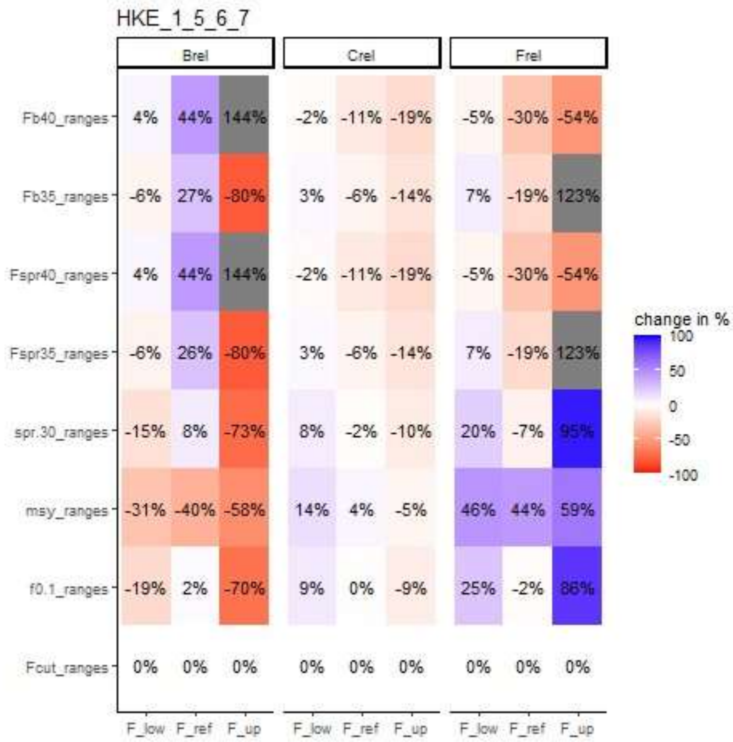


Figure 2.3.1.5 Changes in terms biomass, catches and fishing mortalities induced by adopting alternative F_{MSY} proxies and corresponding F ranges relative to the current F target and F ranges

(from $F_{0.1}$ and the linear models respectively), for the default SRR (HSBlim) for hake in GSAs 1, 5, 6 & 7.

2.3.2 Summary results for Deep-water rose shrimp in GSA 1

- **The stock objects** were those produced in EWG 2023-09 with data up to 2022.
- **Biology**: Ages 0-3+. Decreasing M with age from 2.05 at age 0 to 0.4 at age 3+. Maturity increasing with age, being 2% at age 0 and reaching full maturity at age 1.
- **Stock status**: Biomass is increasing, and the stock is being fished slightly below F_{MSY} (F_{2022}=0.97 < $F_{0.1}$=1.01).
- **Current F target and ranges**: F_{MSY} is based on $F_{0.1}$=1.01. The F ranges for $F_{0.1}$ based on the empirical linear models are 0.67 – 1.37.
- **Current SRR assumption and Blim definition**: Biomass reference points were not estimated by EWG 23-09 due to the increasing trend in biomass and recruitment which created instability in the assessment.
- **Discussion**: The EWG reviewed the available information for this stock. Assuming constant maturity and natural mortality by ages over the time series and limited variation in weight at age, selectivity at age shows the highest fishing mortality at age 2 (Figure 2.3.2.1). The stock assessment results indicate strong increases in recruitment and SSB (Figure 2.3.2.2, Figure 2.3.2.3), with the corresponding fishing mortality rates remaining almost constant in recent years and below the reference F target ($F_{0.1}$).
  STECF EWG 23-09 suggested that the trend in R and SSB may be environmental rather than stock driven, and that productivity continues to increase. Biological reference points have not been calculated for these stocks as assessments need to be carried out over several years to assess their stability before reference points are set.
- **Conclusion**: The EWG 24 02 agreed with the conclusions from STECF EWG 23-09 and did not carry out further analyses for this stock, hence no F ranges were estimated.

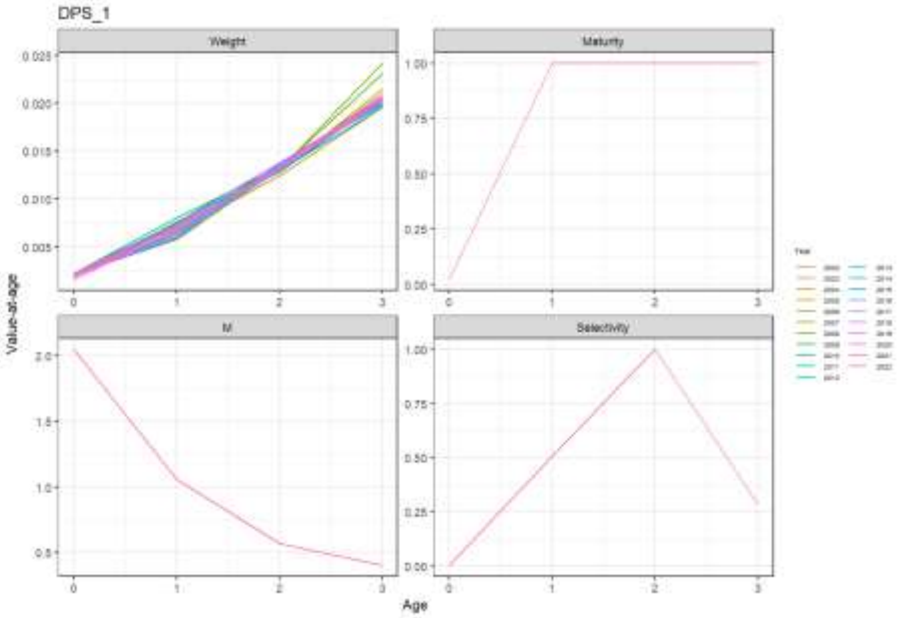


Figure 2.3.2.1. Mean weight, maturity, natural mortality and selectivity by age for deep-water rose shrimp in GSA 1.

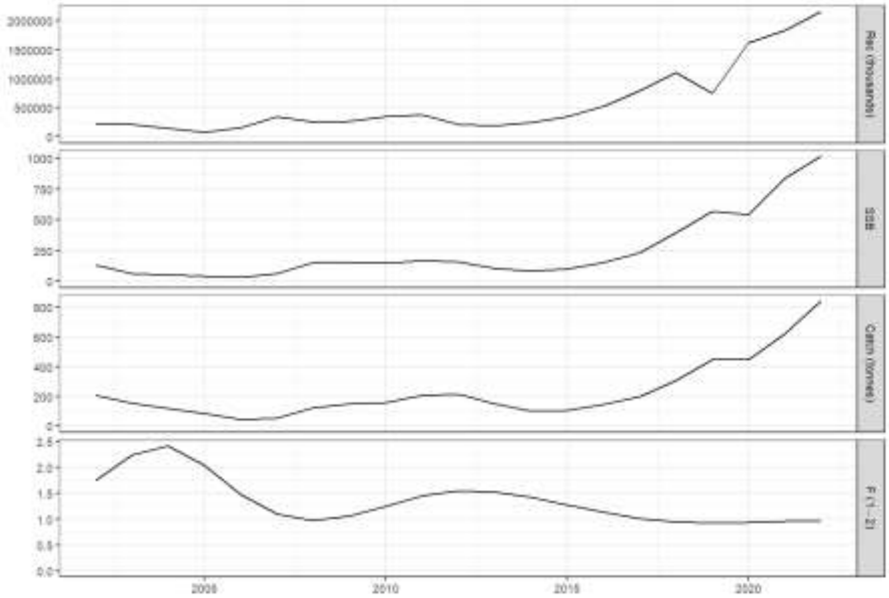


Figure 2.3.2.2. Time series of recruitment, SSB, catch and F for deep-water rose shrimp in GSA 1.

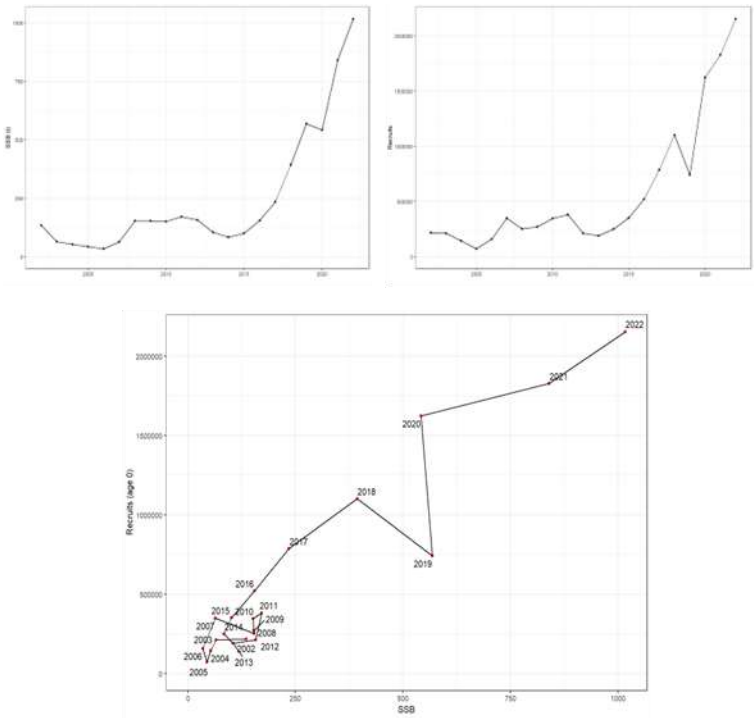


Figure 2.3.2.3. Trend in recruitment (age0) and SSB (top row) and S-R pairs (bottom row) for deep-water rose shrimp in GSA 1.

2.3.3 Summary results for Deep-water rose shrimp in GSAs 5, 6 & 7

- **The stock objects** were those produced in EWG 2023-09 with data up to 2022.
- **Biology**: Ages 0-3+. Decreasing M with age from 2.1 at age 0 to 0.77 at age 3+. Maturity increasing with age, being 0% at age 0, 50% at age 1, 80% at age 2 and reaching full maturity at age 3+.
- **Stock status**: Biomass is increasing, and the stock is being fished below F_{MSY} (F_{2022}=0.81 < $F_{0.1}$=1.46).
- **Current F target and ranges**: F_{MSY} is based on $F_{0.1}$=1.46. The F ranges for $F_{0.1}$ based on the empirical linear models are 0.96 – 1.96.
- **Current SRR assumption and Blim definition**: Biomass reference points were not estimated by EWG 23-09 due to the increasing trend in biomass and recruitment which created instability in the assessment.
- **Discussion**: The EWG reviewed the available information for this stock. Assuming constant maturity and natural mortality at age and limited variation in weight at age, selectivity at age shows the highest fishing mortality at age 2 (Figure 2.3.3.1). The stock assessment results indicate strong increases in recruitment and SSB, especially in the last years of the time series (Figure 2.3.3.2, Figure 2.3.3.3), with the corresponding fishing mortality rates oscillating along the time series and decreasing in the most recent years remaining below the reference F target ($F_{0.1}$).
  STECF EWG 23-09 suggested that the trend in recruitment and SSB for this stock may be environmental rather than stock driven, and that productivity seems to continue increasing. Therefore, reference points were not calculated for this stock as it was considered that this assessment needs to be carried out over several more years to assess its stability before reference points could be set.

Considering the instability of the dynamics of this stock (constant growing productivity) and due to the short length of the time series of the stock, the EWG agreed with the conclusions from STECF EWG 23-09 and decided that is too early and premature to provide an assessment advice of this stock in terms of fitting with the SR models, setting of B_{lim} and calculation of F_{MSY} ranges. The high increase in catches during the last years of the time series caused a high instability in the stock results and prevents to provide an appropriate assessment. This stock needs more data along the time series to be assessed and therefore should be reanalysed in the following years.

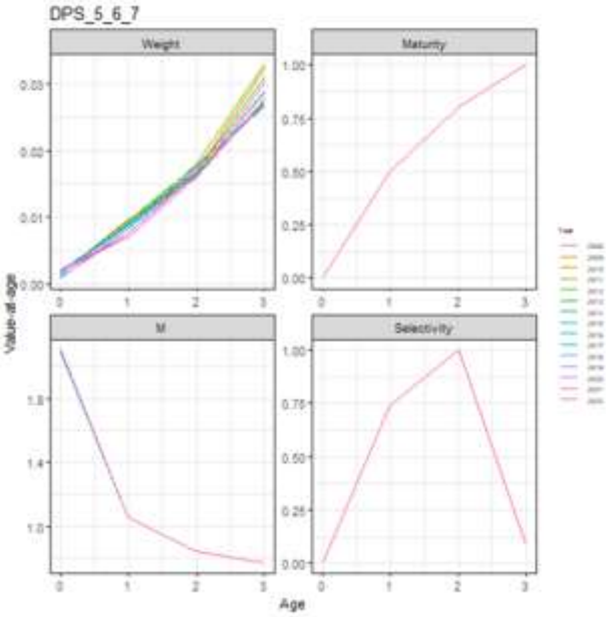


Figure 2.3.3.1. Mean weight, maturity, natural mortality and selectivity by age for deep-water rose shrimp in GSAs 5, 6 & 7.

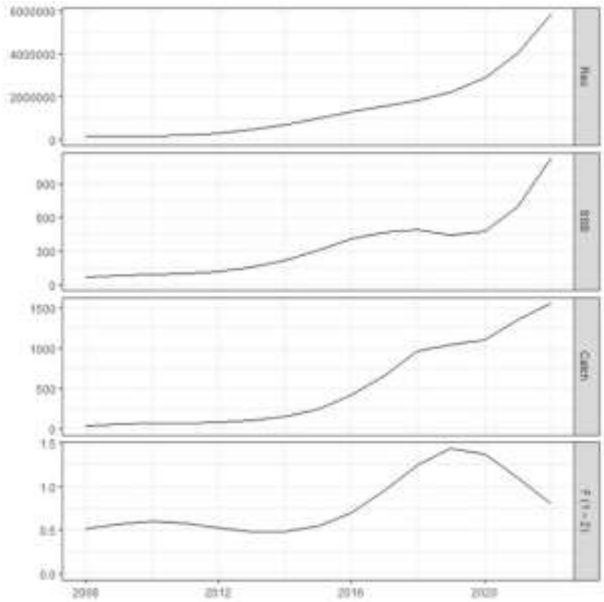


Figure 2.3.3.2. Time series of recruitment, SSB, catch and F for deep-water rose shrimp in GSAs 5, 6 & 7.

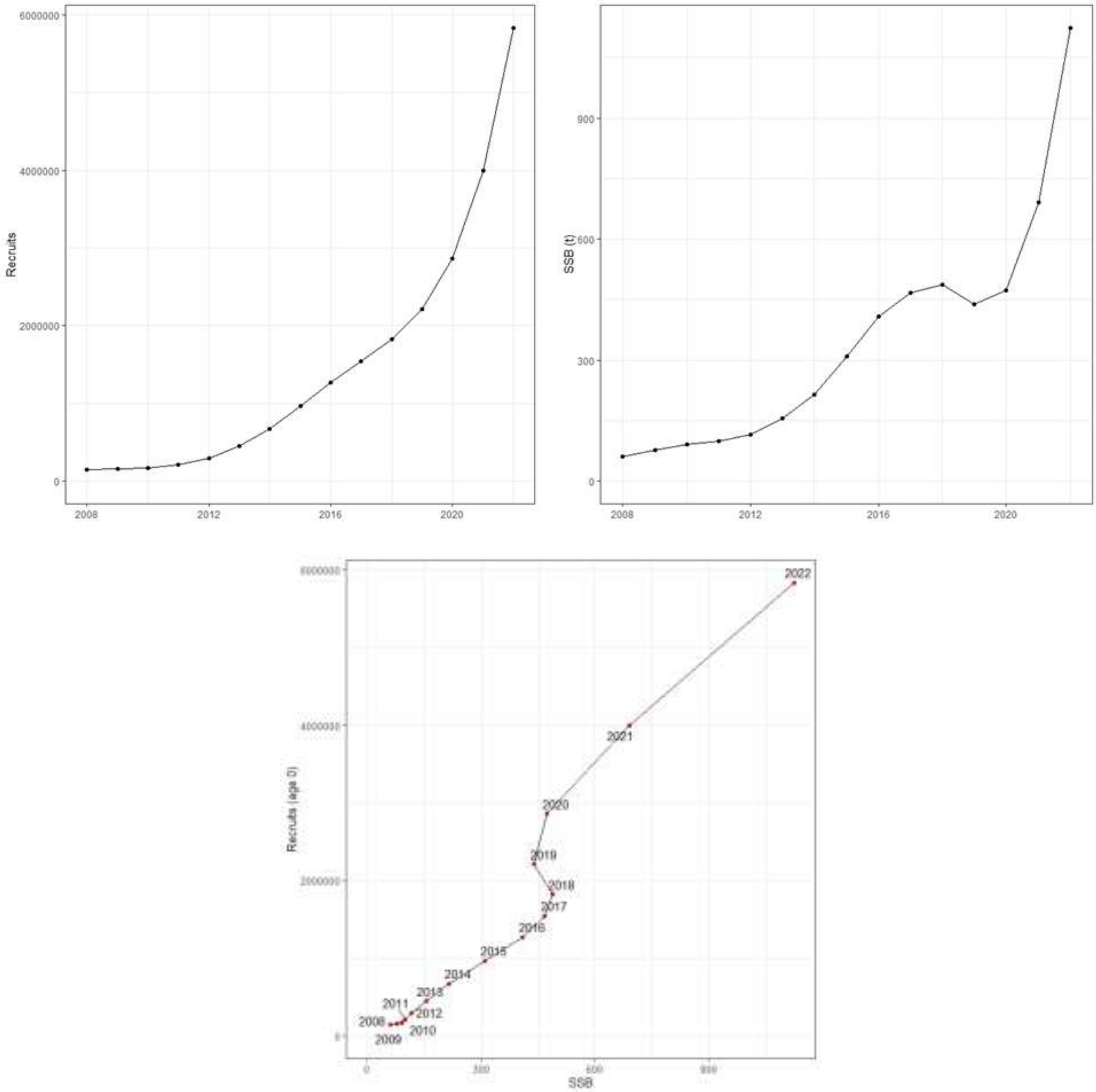


Figure 2.3.3.3. Trend in recruitment (age0) and SSB (top row) and S-R pairs (bottom row) for deep-water rose shrimp in GSAs 5, 6 & 7.

2.3.4 Summary results for Red mullet in GSA 1

- **The stock objects** were those produced in EWG 2023-09 with data up to 2022.
- **Biology**: Ages 1-4+. High natural mortalities at all ages (M=> 0.4) with respective values from age 1 to 4 at 0.8, 0.57, 0.48, 0.43. Full maturity at age 1.
- **Current F target and ranges**: F_{MSY} is based on $F_{0.1}$=0.61. The corresponding SSB is $B_{F0.1}$=399 t. The F ranges for F0.1 based on the empirical linear models are 0.4 – 0.82.
- **Stock status**: The stock is suffering overfishing (current F=1.44) relative to an $F_{0.1}$ of 0.61, with current biomass between B_{pa} and B_{lim}.
- **Current SRR assumption and B_{lim} definition**: B_{lim} was estimated by EWG 22-03 (STECF 2022) from the breakpoint resulting from the Hockey-stick SRR model. This results in a B_{lim} of about 170 t which is about 43%$B_{F0.1}$ (Figure 2.3.4.1) and about 14% B_0. B_{lim} is placed

within the ranges of biomass observation within the mid upper range. It implies a steepness of 1, because it is placed below 20%B_0.

- **Alternative SRR and potential alternative Blim definitions**: Statistical comparison of the fitting of different SRR models show that HS either fitted unconditionally in 2023 or the HSBlim (at the B_{lim} from 22-03) were the best two models (Table 2.3.4.1). Past EWG 2023-09 considered that the differences in the two HS were negligible, and the original B_{lim} set in 22-03 could be kept fixed, without revision. Therefore, it is considered that HSBlim was the best model describing the dynamic of the population. This B_{lim} is placed in the middle of historical biomass assessments. No other SRR models were explored. The BH or Ricker models could have been considered, but given that their slopes at the origin are almost identical to the HSBlim its likely that no major difference would have been found (see discussion below) (Figure 2.3.4.1). No alternative B_{lim} definition was considered as the location of the current B_{lim} around 14% B_0 seems plausible and lays within the past biomass observations.
- **Production curves:** A comparison of the production curves resulting from the different SRR models is shown in Figure 2.3.4.2. Although the production curve resulting from the default HSBlim reaches a peak at F_{MSY} value (F_{max}= 1.54) it becomes almost flat (only decreasing slightly) at higher F values, making impossible the estimation of F_{upper}. Notice that the production curves corresponding to the BH or Ricker SRR models are well-defined dome shape curves. The peak corresponding to the F_{MSY} for the BH is around 0.58, a value like the $F_{0.1}$ of the HSBlim (0.61). The Ricker curve is bit shifted to the right and has peak at an F_{MSY} = 0.88.
- **F_{MSY} or F_{MSY} proxies and corresponding ranges**: The values for the different F_{MSY} proxies and the corresponding ranges are shown in Table 2.3.4.2 and Figure 2.3.4.3 .
- **Assessment of Risks and of $F_{p.05}$ by SRR models**. The risks of falling below the previously adopted B_{lim} (by STECF) were calculated through a forward projection (see methods) for the HSBlim model (Table 2.3.4.3**)**. The $F_{p.05}$ estimates for the HSBlim was 0.83 for the type 3 risk and of 1.1 for the type 1 risk. All the results were shown for an assessment plus implementation error of intended fishing mortality of 0.2 (Fsigma=0.2).
- **Discussion on F_{MSY} target and ranges**: This a type 2 stock corresponding to productions curve showing an F_{ma}x but beyond which the curve is almost flat so that F_{upper} is undefined (NA). Furthermore, these are stocks for which a Hockey-stick was fitted with a break point either at around the lowest observed S-R pairs values (including Bloss) or within the cloud of S-R observed pairs (in this case, around the middle of observations). For all these cases, three alternatives have been considered: a) let a priori current Ftarget ($F_{0.1}$) and empirical Franges b) the same but setting F_{upper} as F_{max} provided they are compliant with the risks to B_{lim} c) adopt F_{MSY} and ranges from an alternative SRRs provided they are compliant with the risks to B_{lim}. Figure 2.3.4.5 shows the relative implications of adopting alternative Fmsy.proxy and F ranges versus the current F ranges, in terms biomass, catches and fishing mortalities for the HSBlim default SRR assumption. However, before adopting straightforward the current F target and F ranges, there are several points requiring discussion about the sustainability of $F_{0.1}$ and of those ranges:
    - The $F_{p.05}$ derived from HSBlim and BH (Type 3 risk estimates) are placed around 0.83, well above the current Ftarget ($F_{0.1}$ = 0.63), but well below the estimated F_{max} (=1.54). The F_{upper} value of the current F ranges (= 0.82) is placed just below the $F_{p.05}$ for Risk Type 3 of the current HSBlim. Therefore, the current Ftarget and F ranges (based on the linear models) are compliant not exceeding $F_{p.05}$, implying risks <= 0.05 for the SSB of falling below Blim.
    - In the absence of a proper definition of F_{upper} relative to $F_{0.1}$, from the former observations, the potential use of F_{max} (1.54) as an alternative F_{upper} is discarded as it is well above F_{max}. Furthermore, the F_{max} leads to a biomass around B_{lim}.

- There have not been calculated any F_{MSY} ranges from any potential alternative SRR, but the Ricker F_{MSY} (0.87) was above $F_{p.05}$, while the BH F_{MSY} (0.58) was about current $F_{0.1}$ target (0.61). The latter observation gives support to adopting current F_{MSY} target at $F_{0.1}$ and its ranges based on the empirical linear models as suitable and sustainable for this stock.
- Suggestion: Future full exploration of the BH model and their ranges and risks to B_{lim} would be worth exploring for comparison and for full consideration of the third option (c) proposed for the stocks in group 2.

- **Conclusions**: Current F target at $F_{0.1}$ and F ranges, based on the empirical linear models, are acceptable in terms of risks (Franges < $F_{p.05}$, and could be passed for management purposes.

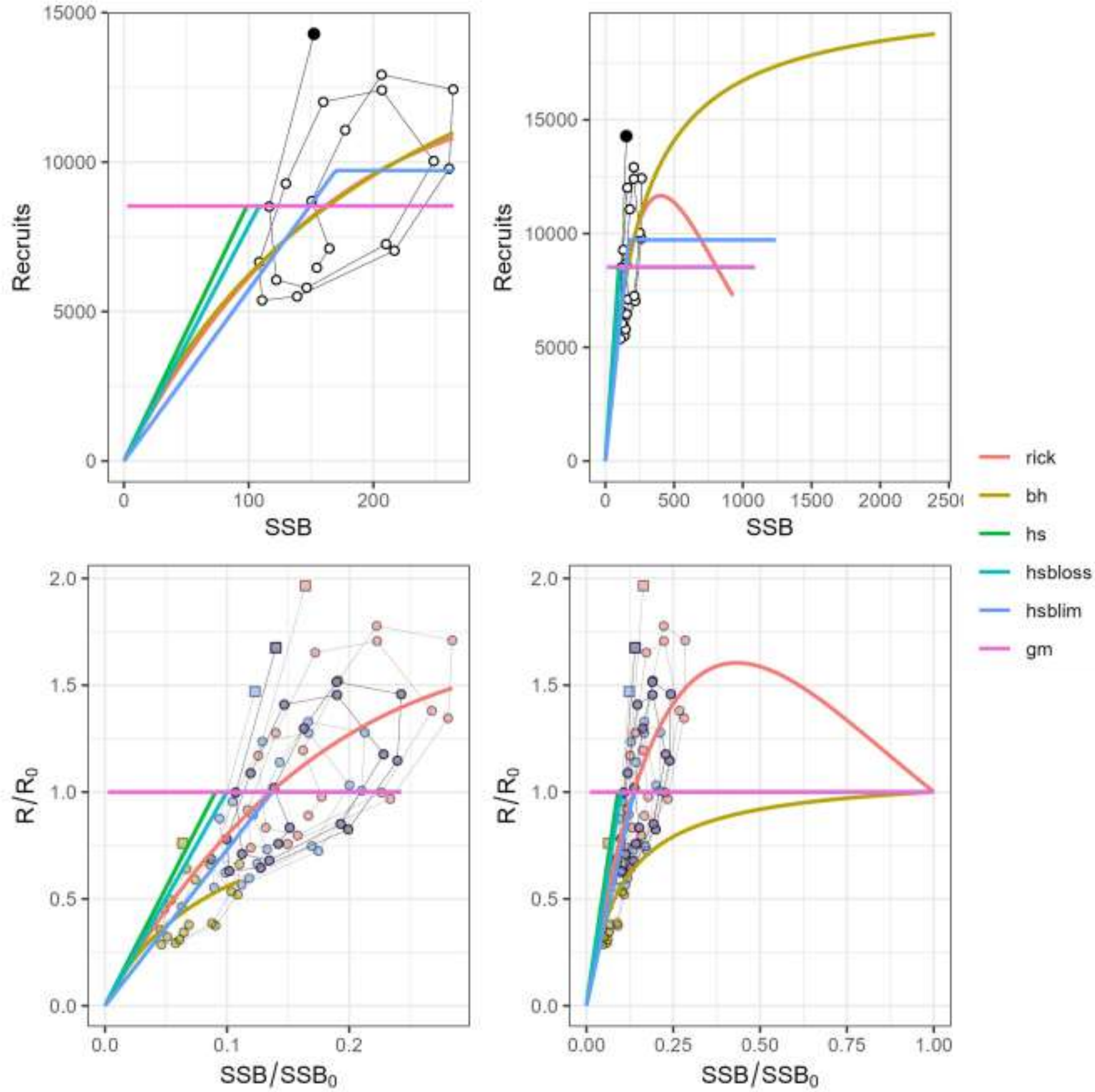


Figure 2.3.4.1 Fitting of alternative stock recruitment relationships for Red Mullet in GSA 1, both in absolute and in relative terms to R0 and B0 for two scales in the X axis.

Table 2.3.4.1 Statistical comparison of the fitting of different SRR models for Red Mullet in GSA 1.

MODEL	AIC	BIC

Ricker	8.896	11.884
Beverton-Holt	8.989	11.976
Hockey-stick	15.425	18.412
Hockey-stick at Bloss	13.310	15.301
Hockey-stick at Blim	6.671	8.662
Geometric mean	13.310	15.301

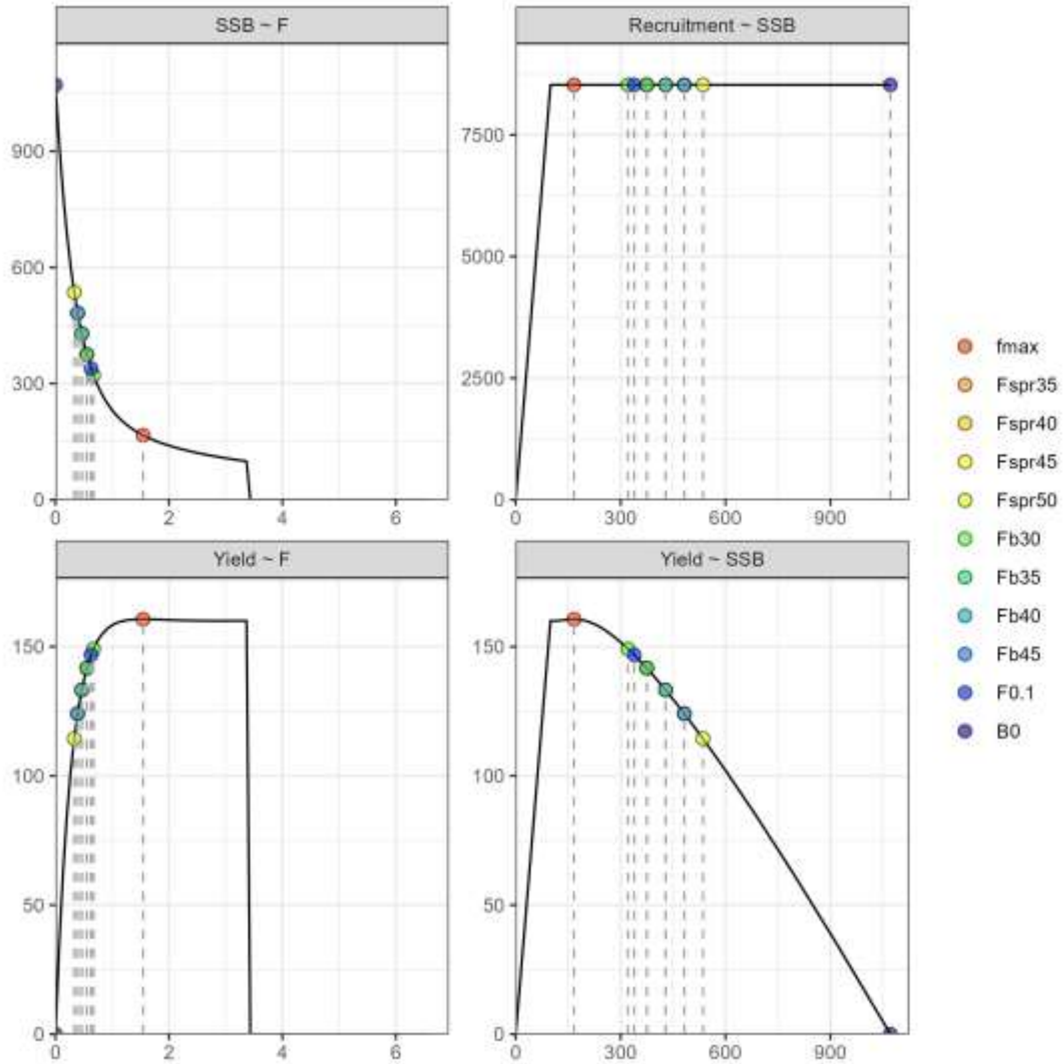


Figure 2.3.4.2 Biomass and Production curves as a function of F resulting from the default HSBlim stock recruitment relationship for Red Mullet in GSA 1.

Table 2.3.4.2 F, yield and SSB for each of the F_{MSY} proxies and F ranges considered for red mullet in GSA 1 from the default SRR (HSBlim).

	Ftarget			Flower			Fupper		
	F	Yield	SSB	F	Yield	SSB	F	Yield	SSB
msy_ranges	1.54	161	167	0.75	153	293	NaN	NaN	NaN
f0.1_ranges	0.628	147	339	0.526	139	389	NaN	NaN	NaN
spr.30_ranges	0.67	149	321	0.553	142	375	NaN	NaN	NaN
Fspr35_ranges	0.552	142	375	0.475	135	420	NaN	NaN	NaN

Fspr40_ranges	0.462	133	429	0.408	127	468	NaN	NaN	NaN
Fb35_ranges	0.553	142	375	0.475	135	420	NaN	NaN	NaN
Fb40_ranges	0.462	133	429	0.408	127	468	NaN	NaN	NaN

Table 2.3.4.3 $F_{p.05}$ values in relation to the risk of dropping SSB below current Blim adopted for Red Mullet in GSA 1, as obtained for the different SRR models.

$F_{p.05}$	HSBlim
Risk 3	0.821
Risk 1	1.052

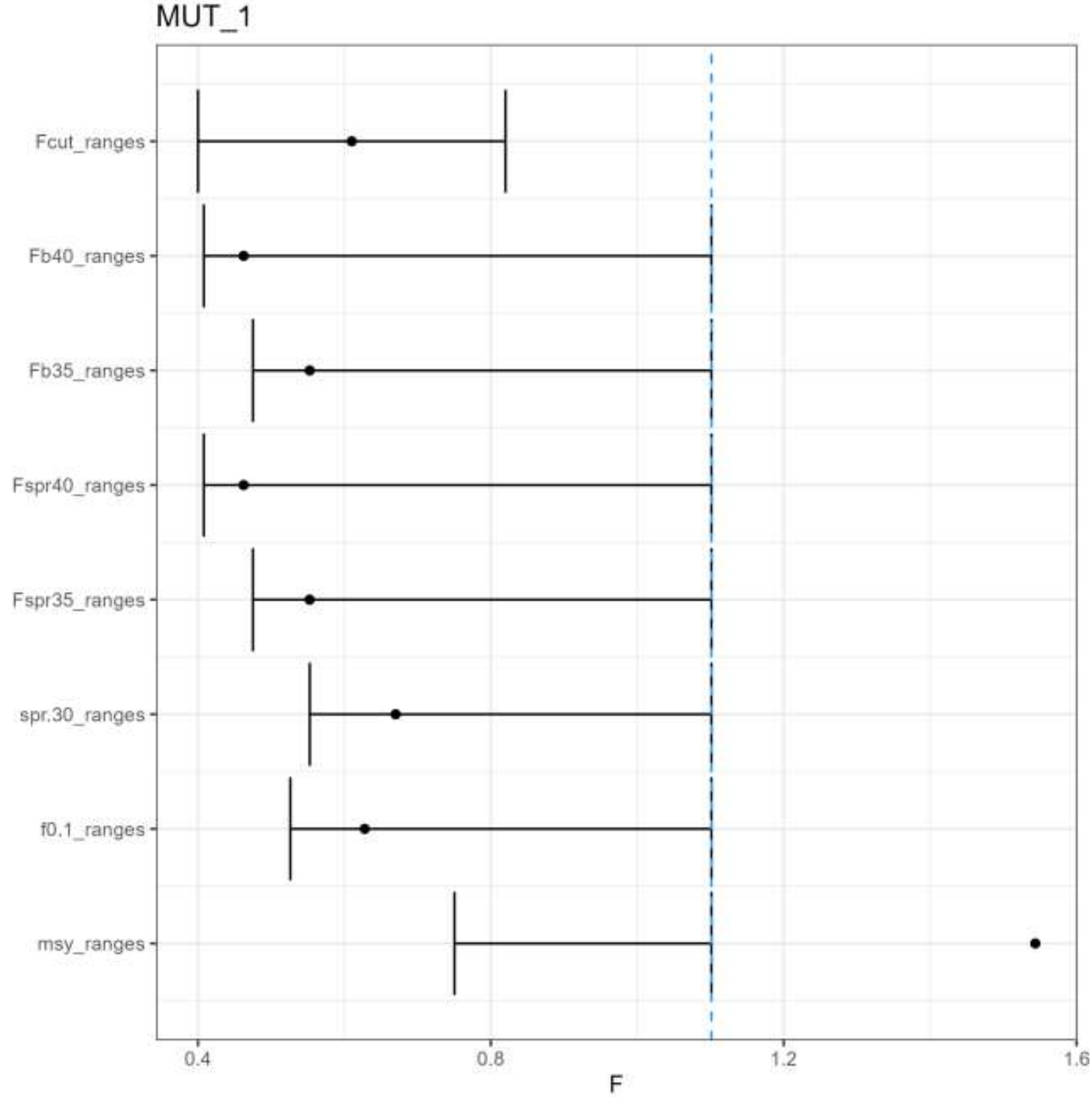


Figure 2.3.4.3 F_{MSY} proxies and their corresponding ranges for the default SRR model (HSBlim) for Red Mullet in GSA 1.

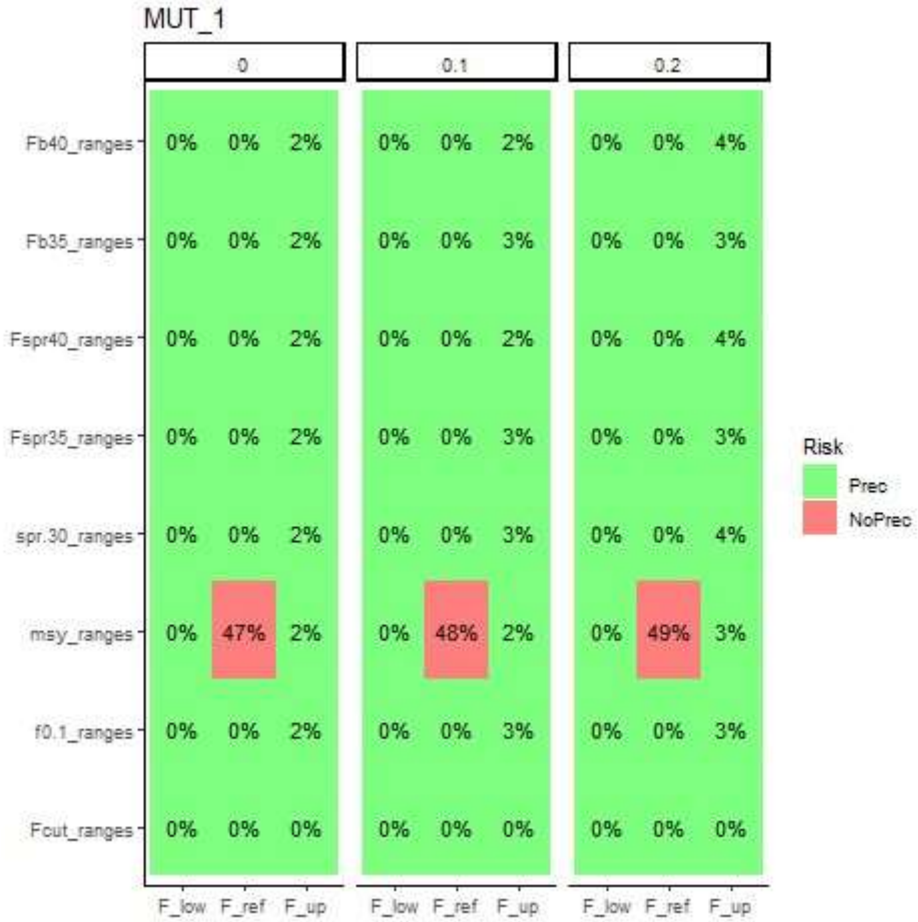


Figure 2.3.4.4 Probability of SSB being below B_{lim} (risk type 1) for alternative F_{MSY} proxies and corresponding F ranges for the default SRR (HSBlim) for red mullet in GSA 1 for Fsigma=0, 0.1 and 0.2.

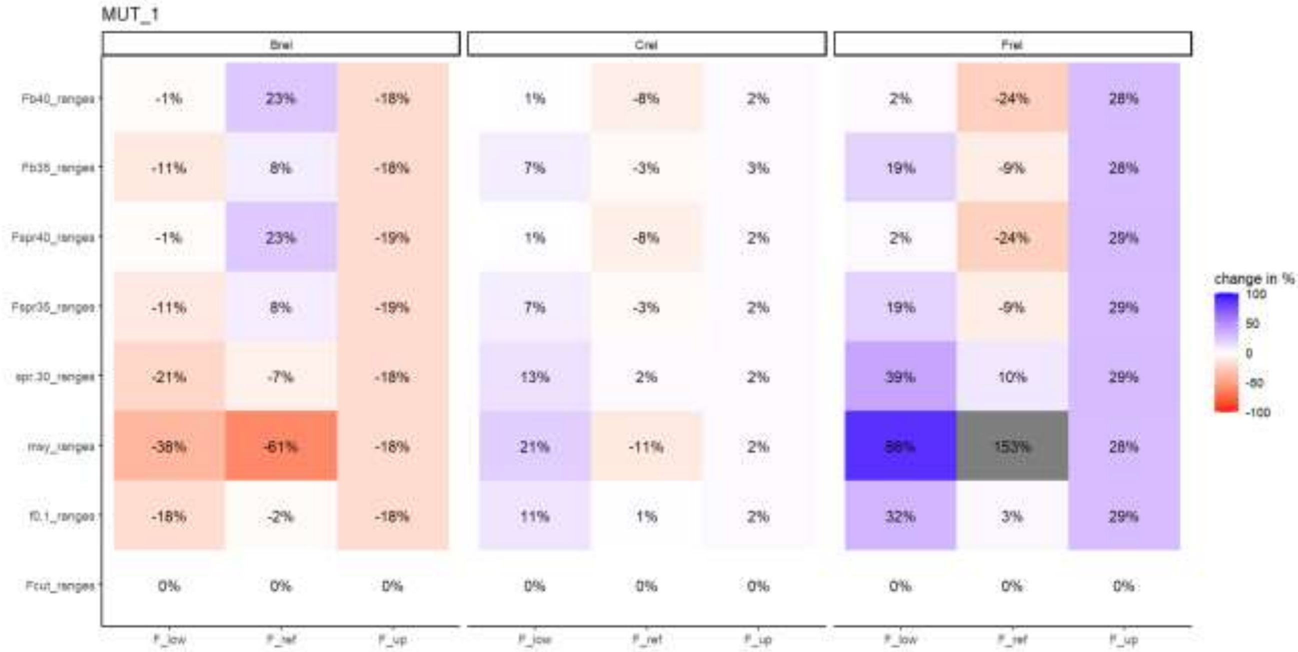


Figure 2.3.4.5 Changes in terms biomass, catches and fishing mortalities induced by adopting alternative F_{MSY} proxies and corresponding F ranges relative to the current F target and F ranges (from $F_{0.1}$ and the linear models respectively), for the default SRR (HSBlim) and for BH for red mullet in GSA 1 (Fsigma=0.2).

2.3.5 Summary results for Red mullet in GSA 6

- **The stock objects** were those produced in EWG 2023-09 with data up to 2022.
- **Biology**: Ages 0-4+. High natural mortalities at all ages (M=> 0.4) (with respective values from age 0 to 4 at 1.74, 0.8, 0.57, 0.48, 0.43. Full maturity at age 1.
- **Stock status**: The stock is suffering severe overfishing (F_{2022}=1.1) relative to an $F_{0.1}$ of 0.31, with current biomass between B_{pa} and B_{lim}.
- **Current F target and ranges**: F_{MSY} is based on $F_{0.1}$=0.314. The corresponding SSB is $B_{F0.1}$=3600t. The F ranges for $F_{0.1}$ based on the empirical linear models are 0.210 – 0.432.
- **Current SRR assumption and B_{lim} definition**: Under no clear SRR the Geometric Mean (GM) is used to force a HS SRR with a plateau at the GM and with a break point at 25%$B_{F0.1}$ (Figure 2.3.5.1). This implies B_{lim} (770 t) is about 10.6% B_0 but it is placed above B_{loss} equalling the second lower biomass. It implies a steepness of 1, an extremely high value.
- **Alternative SRR and potential alternative B_{lim} definitions**: The location of B_{lim} within the past observations is not problematic. Looking at the AIC profile, an alternative could be placed at B_{loss}, though it would lead to a more productive SRR. Statistical comparison of the fitting of different SRR models show that Beverton-Holt could be a better SRR in terms of AIC and BIC than the rest of models (Table 2.3.5.1), with an R_0 estimate about 10% above the maximum past observed Recruitments (Figure 2.3.5.1). It was considered that the BH SRR might be a good alternative to represent the SR dynamics, showing a faster reduction of recruitment versus spawning biomass than the HSBlim (Figure 2.3.5.1). The curvature of the SRR to the left of the centre of gravity of the observations is the one which matters the most for the definition of the F_{upper} range relative to F_{MSY} and risks to B_{lim} as Fishing mortality increases. Therefore, BH was selected as an alternative SRR to test for robustness of the production curve and F_{MSY} ranges properties to a less productive SRR.

- **Production curves:** A comparison of the production curves resulting from the two selected SRR are shown in (Figure 2.3.5.2). Although the production curve resulting from the default HSBlim reaches to an F_{MSY} value (F_{max}), the curve becomes almost flat (only decreasing slightly) at higher F values, making impossible to estimate F_{upper}. The production curve corresponding to the BH SRR is a well-defined dome shape curve, with a neat peak corresponding to an F_{MSY}, and asymmetrical descending shape as F increases.
- **F_{MSY} or F_{MSY} proxies and corresponding ranges**: The values for the different F_{MSY} proxies and corresponding ranges are shown in Table 2.3.5.2 and Figure 2.3.5..
- **Assessment of Risks and of $F_{p.05}$ by SRR models**. The risks of falling below the previously adopted B_{lim} (by STECF) were calculated through a forward projection (see methods) for the different SRR models (Table 2.3.5.3). The $F_{p.05}$ estimates are rather consistent for the two SRR models, being slightly larger for the BH than for the HSBlim. In addition, $F_{p.05}$ corresponding to Risk 3 type of estimates are smaller than those corresponding to Type 1 risks. All the results were shown for an assessment plus implementation error of intended fishing mortality of 0.2 (Fsigma=0.2).
- **Discussion on F_{MSY} target and ranges**: This is a type 2 stock corresponding to productions curve showing an F_{max} but beyond which the curve is almost flat so that F_{upper} is undefined (NA). Furthermore, these are stocks for which a Hockey-stick was fitted with a break point either at around the lowest observed S-R pairs values (including B_{loss}) (as in this case) or within the cloud of S-R observed pairs. Three alternatives have been considered: a) let a priori current Ftarget ($F_{0.1}$) and empirical Franges b) the same but setting F_{upper} as F_{max} provided they are compliant with the risks to B_{lim} c) adopt F_{MSY} and ranges from an alternative SRRs provided they are compliant with the risks to B_{lim}.

  In this case all the F_{MSY} or F_{MSY} proxies considered and the corresponding ranges (when existing) were lower than $F_{p.05}$ estimated for the HSBlim or the BH models. Therefore, they all implied probabilities of being below B_{lim} less than 0.05 (Figure 2.3.5.3). Figure 2.3.5.4 shows the relative implications of adopting alternative F_{MSY} proxy and F ranges versus the current F ranges, in terms biomass, catches and fishing mortalities for the HSBlim and BH models.

  From all the above it is important to note that:

  - The Beverton and Holt (which showed the best AIC) would imply a steepness of 0.83, smaller than the assumed one (=1) for the HSBlim. Therefore, the actual productivity of the stock is very uncertain and might be lower than currently assumed.
  - The $F_{p.05}$ derived from HSBlim and BH (Type 3 risk estimates) are placed around 1.13, well above the current Ftarget ($F_{0.1}$ = 0.31) and well above F_{max} (=0.71). The F_{upper} value of the current F ranges (= 0.432) is also placed well below the $F_{p.05}$ for Risk Type 3 of the current HSBlim. Therefore, the current Ftarget and Franges (based on the linear models) are compliant not exceeding $F_{p.05}$, implying risks <= 0.05 for the SSB of falling below B_{lim}.
  - In the absence of a proper definition of F_{upper} relative to $F_{0.1}$, from the former observations it can also be deduced that F_{max} could be used as F_{upper} for this stock as it also smaller than $F_{p.05}$. Furthermore, F_{max} is about the same as the F_{upper} obtained for the F_{MSY} ranges corresponding to BH. So, it might also coincide with the actual F_{MSY} range for the alternative plausible SRR (the BH).
  - The F_{MSY} target and corresponding ranges obtained for the alternative plausible SRR (BH) are also smaller than $F_{p.05}$ and could be used as an alternative risk averse F_{MSY} ranges.
  - All the three alternative proposals for definition of Ftarget and Franges are robust to the current uncertainties on the plausible models of SRR governing the dynamics of this stock. The current Franges based on the linear models would result in the lowest of the allowed F ranges (0.21-0.43). Setting F_{upper} at F_{max} will expand further this

range up to 0.71 and by moving to the alternative SRR model (BH) it will allow the highest Ftarget (at 0.45, just above 35%SPR from HSBlim) and with Franges F_{lower} and F_{upper} of 0.27 and 0.73.

- **Conclusions**: Current F target ($F_{0.1}$) and F ranges (from the empirical linear relationships) are acceptable in relation to $F_{p.05}$, but its range could be widened if setting F_{upper} at F_{max} (0.71) or by adopting the Ftarget and ranges corresponding to the alternative SRR (of BH) for this Red Mullet in GSA 6, being always compliant with $F_{p.05}$.

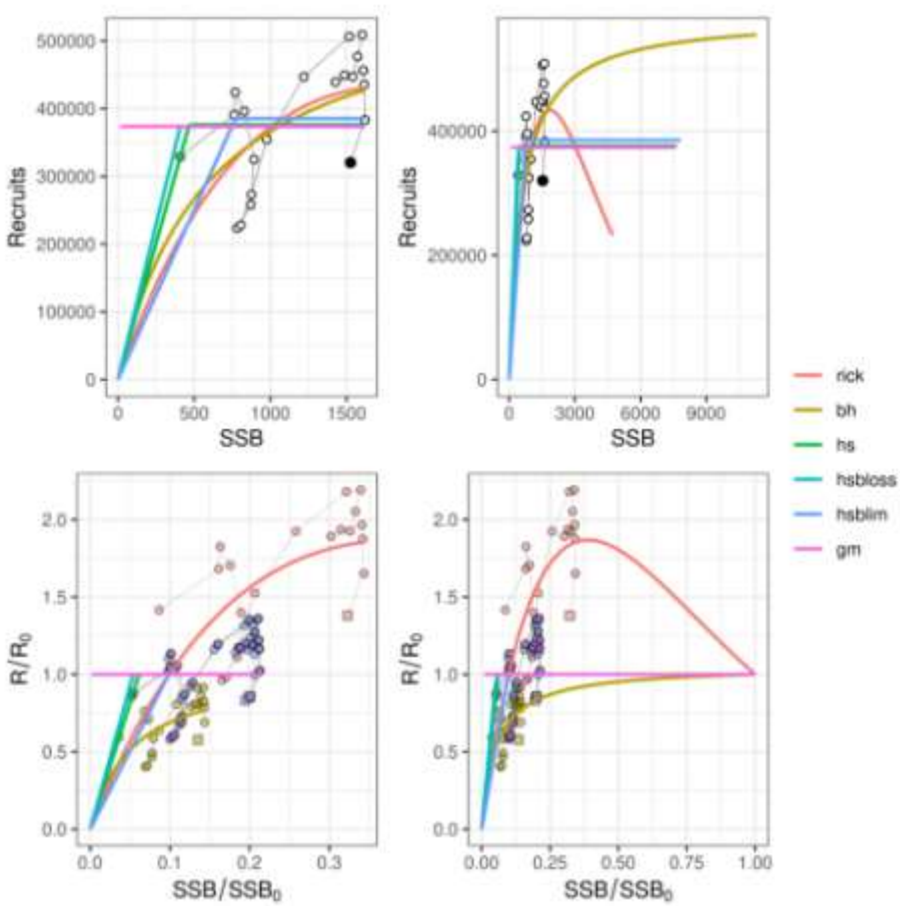


Figure 2.3.5.1. Stock recruitment relationships for red mullet in GSA 6, both in absolute (top row) and in relative terms to R0 and B0 (bottom row) for two scales in the X axis (left and right panels).

Table 2.3.5.1 Statistical comparison of the fitting of different SRR models for red mullet in GSA 6.

MODEL	AIC	BIC
Ricker	1.1	4.23
Beverton-Holt	-0.84	2.29
Hockey-stick	6.39	9.52
Hockey-stick at Bloss	4.57	6.66
Hockey-stick at Blim	7.95	10.04
Geometric mean	4.57	6.66

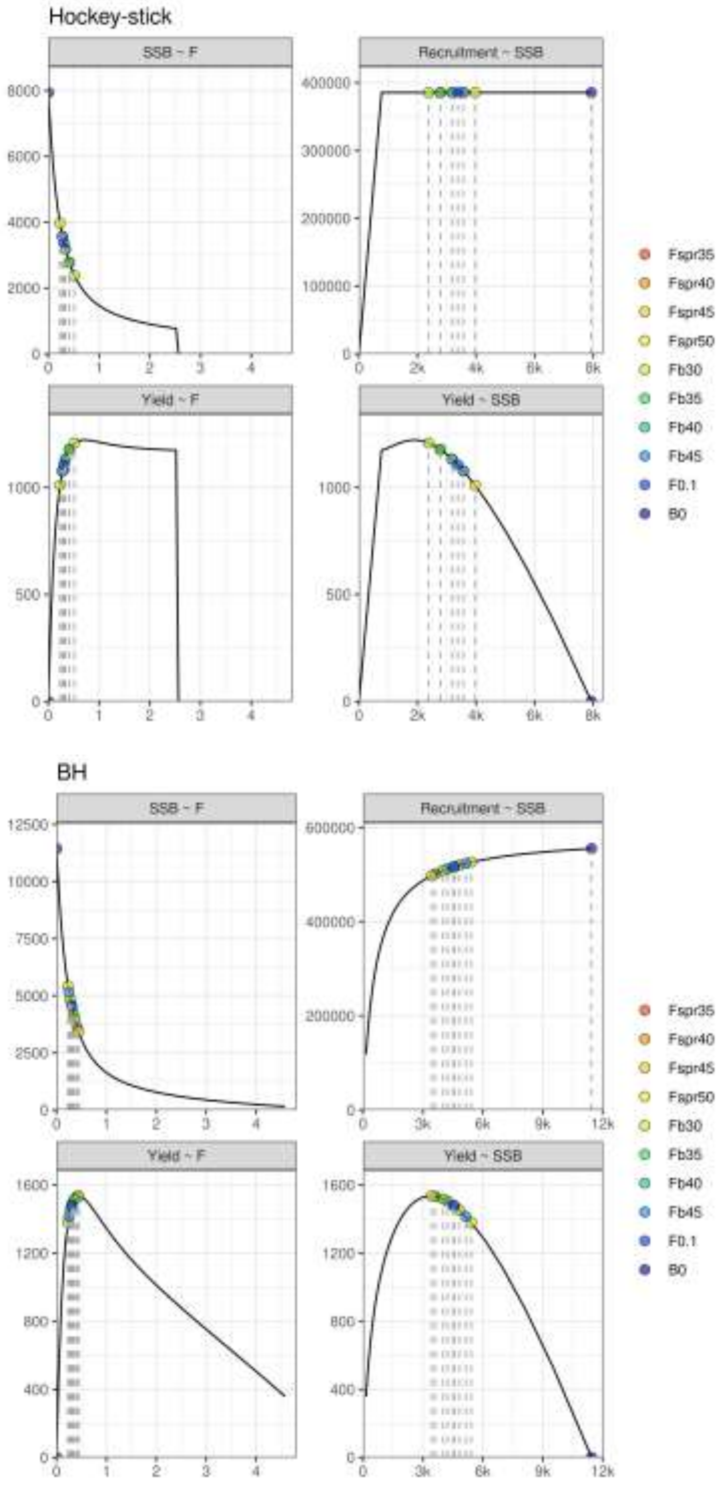


Figure 2.3.5.2 Biomass and production curves as a function of F resulting from the alternative plausible stock recruitment relationships under consideration for red mullet in GSA 6.

Table 2.3.5.2 F, yield and SSB for each of the F_{MSY} proxies and F ranges considered for red mullet in GSA 6 from HSBlim and BH models.

		Ftarget	Ftarget	Ftarget	Flower	Flower	Flower	Fupper	Fupper	Fupper
SRR	Case	F	Yield	SSB	F	Yield	SSB	F	Yield	SSB
HSBlim	msy_ranges	0.707	1192	1846	0.378	1133	2875	NaN	NaN	NaN
HSBlim	f0.1_ranges	0.304	1079	3298	0.256	1025	3646	NaN	NaN	NaN
HSBlim	spr.30_ranges	0.514	1179	2325	0.356	1120	2988	NaN	NaN	NaN
HSBlim	Fspr35_ranges	0.412	1149	2710	0.318	1092	3206	NaN	NaN	NaN
HSBlim	Fspr40_ranges	0.332	1103	3122	0.275	1049	3501	NaN	NaN	NaN
HSBlim	Fb35_ranges	0.413	1149	2709	0.319	1092	3205	NaN	NaN	NaN
HSBlim	Fb40_ranges	0.333	1103	3120	0.275	1049	3499	NaN	NaN	NaN
BH	msy_ranges	0.449	1536	3380	0.282	1459	4764	0.728	1459	2210
BH	f0.1_ranges	0.304	1481	4528	0.245	1407	5212	0.851	1407	1907
BH	spr.30_ranges	0.514	1529	3016	0.277	1453	4824	0.743	1453	2168
BH	Fspr35_ranges	0.412	1533	3615	0.28	1456	4788	0.734	1456	2193
BH	Fspr40_ranges	0.332	1503	4255	0.259	1429	5039	0.801	1429	2021
BH	Fb35_ranges	0.361	1519	4004	0.269	1443	4916	0.767	1443	2104
BH	Fb40_ranges	0.299	1477	4577	0.242	1403	5245	0.861	1403	1886

Table 2.3.5.3 $F_{p.05}$ values in relation to the risk of dropping SSB below current B_{lim} adopted for Red Mullet in GSA 6, as obtained for the different SRR models.

$F_{p.05}$	HSBlim	BH
Risk 3	1.108	1.165
Risk 1	1.525	1.537

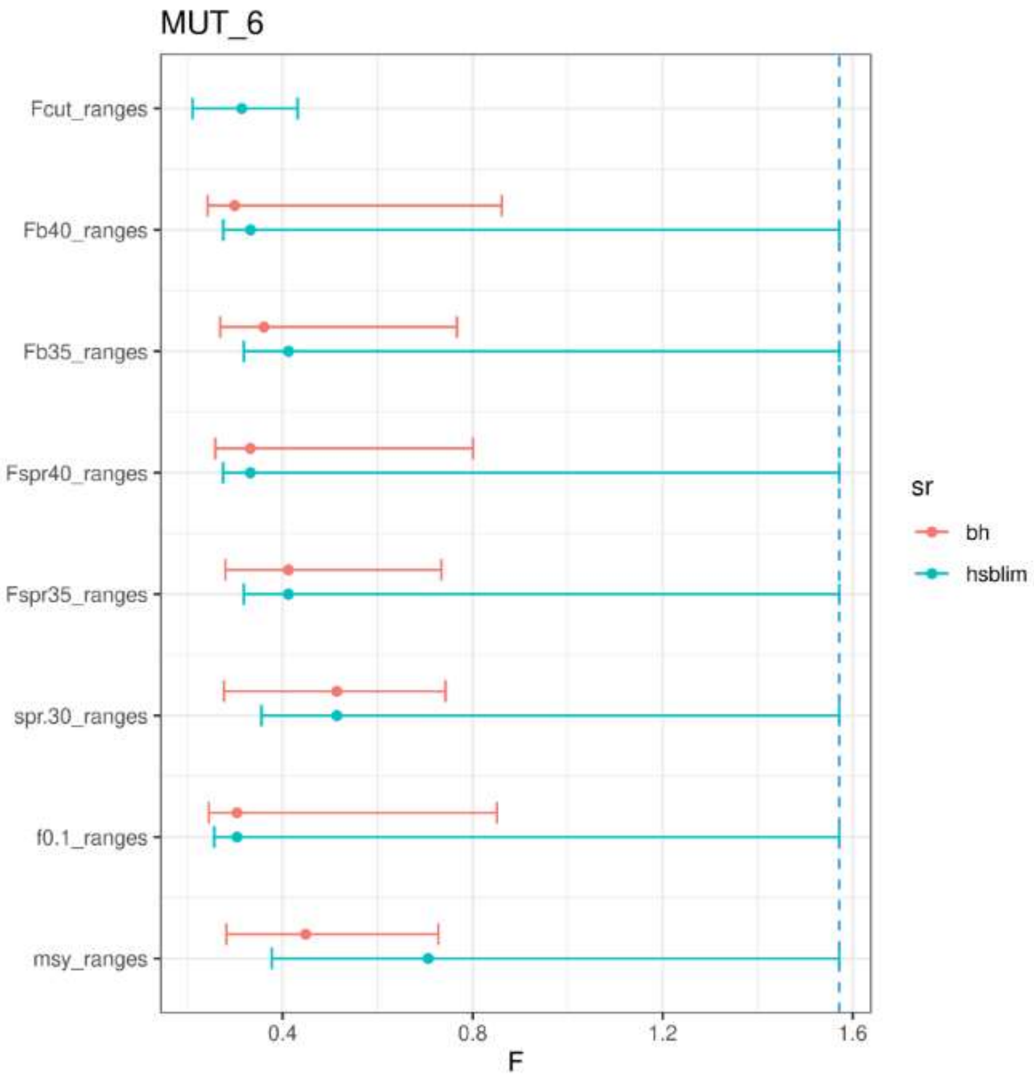


Figure 2.3.5. F_{MSY} proxies and corresponding ranges for the default SRR model (HSBlim) and for BH for red mullet in GSA 6. The dashed vertical line represents $F_{p.05}$ value (type 1 risks) for HSBlim.

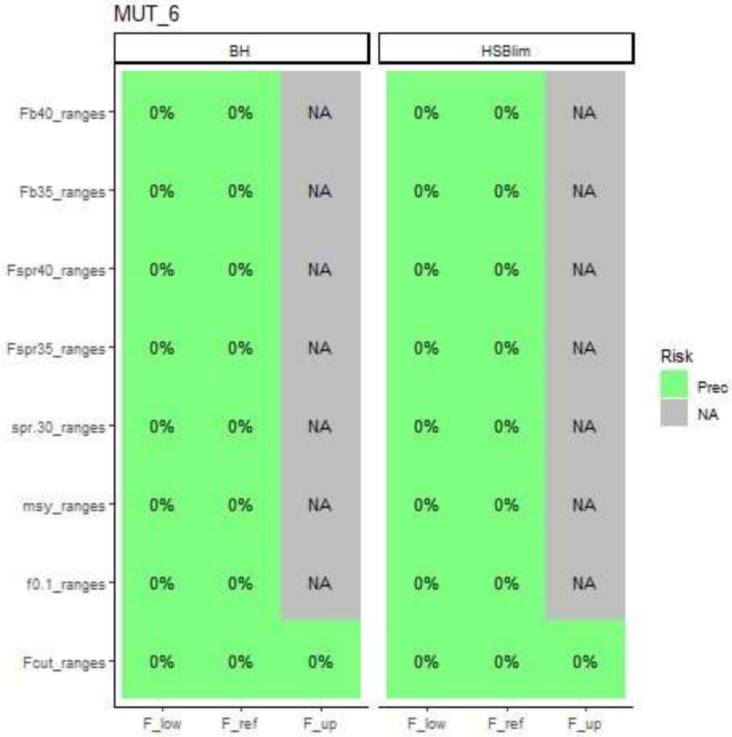


Figure 2.3.5.3 Probability of SSB being below B_{lim} (risk type 1) for alternative F_{MSY} proxies and corresponding F ranges for the default SRR (HSBlim) and for BH for red mullet in GSA 6 for Fsigma=0.2.

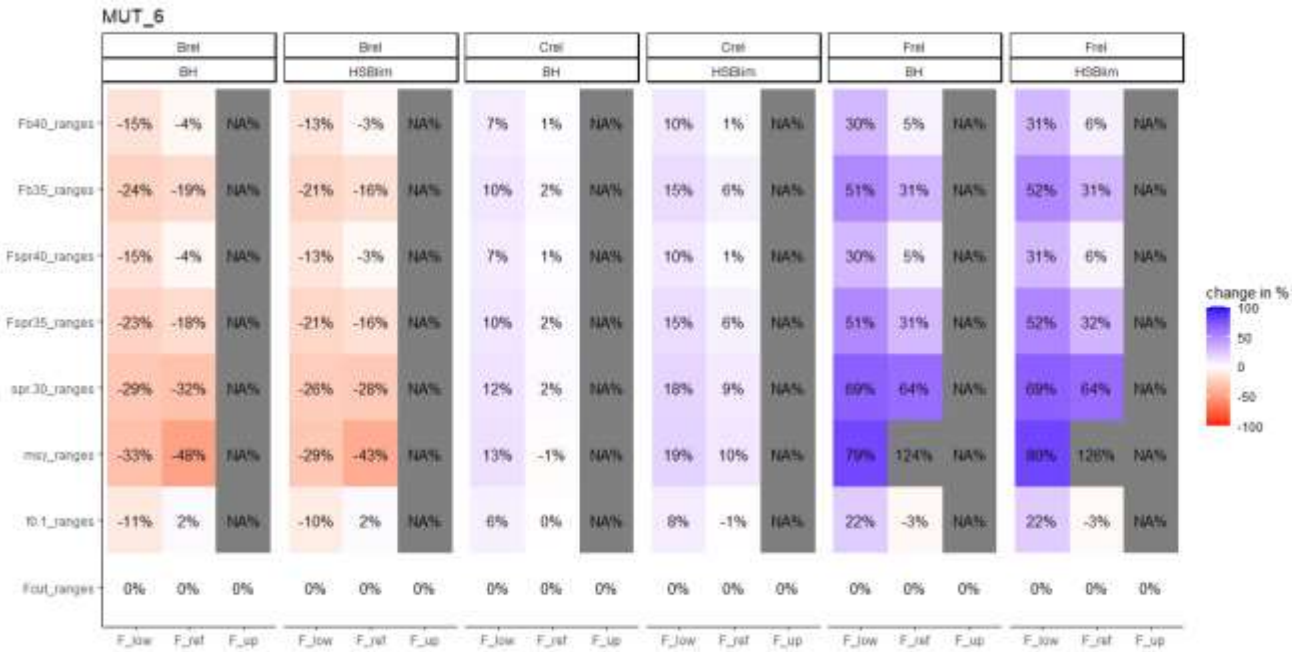


Figure 2.3.5.4. Changes in terms biomass, catches and fishing mortalities induced by adopting alternative F_{MSY} proxies and corresponding F ranges relative to the current F target and F ranges

(from $F_{0.1}$ and the linear models respectively), for the default SRR (HSBlim) and for BH for red mullet in GSA 6 (Fsigma=0.2).

2.3.6 *Summary results for Red Mullet in GSA 7*

- **The stock objects** were those produced in EWG 2023-09 with data up to 2022.
- **Biology**: Ages 0-4+. High natural mortalities at all ages (M>= 0.4) decreasing from 0.95 at age 0 to 0.45 at age 4+. Full maturity at age 1.
- **Stock status**: The stock is being exploited at below $F_{0.1}$ (F_{2022}=0.417 < $F_{0.1}$=0.46). Current biomass is above B_{pa} and B_{lim}.
- **Current F target and ranges**: F_{MSY} is based on $F_{0.1}$=0.46. The corresponding SSB is $B_{F0.1}$=775 t. The F ranges for $F_{0.1}$ based on the empirical linear models are 0.30 – 0.62.
- **Current SRR assumption and B_{lim} definition**: The Geometric Mean (GM) was used to force a HS SRR with a plateau at the GM and with a forced break point. However, the reported Blim (134 t) does not match with the expected 25%$B_{F0.1}$, but it is at 17.2% of $B_{F0.1}$ (Figure 3.3.5.1). This implies a B_{lim} placed to the left of the cloud of observations just around B_{loss}. It implies a steepness of 1, because B_{lim} if lower than 20%B_0 (around 8.4%B_0). B_{pa} is set as 2*B_{lim} and takes the value 267 t. A free fitting of the Hockey-stick model resulted in a breakpoint within the range of observed SSBs (around 344 t) well above the current B_{lim} (Figure 2.3.6.1).
- **Alternative SRR and potential alternative B_{lim} definitions**: Statistical comparison of the fitting of different SRR models indicates that Ricker and Beverton-Holt are the best fitting SRR models, followed at some distance by HS (free fitting) in terms of AIC and BIC while HSBlim and HSBloss or GM are the poorest models by a great difference (**Table 2.3.6.1**). The curvature of the SRR to the left of the center of gravity of the observations is the one which matters the most for the definition of the F_{upper} range relative to F_{MSY} and risks to B_{lim} as fishing mortality increases. Due to the same curvature of the BH and Ricker towards the origin and to the fact that BH has the best AIC and BIC, BH and HS free were selected as two alternative SRRs to test for robustness of the production curves and F_{MSY} ranges properties to less productive SRRs (in addition to HSBlim). The break point of the HS free fitting almost double current Blim and gives a warning on the current definition of Blim (though it would imply placing the B_{lim} above 25% $B_{F0.1}$.
- **Production curves:** A comparison of the production curves resulting from the three selected SRR are shown in Figure 2.3.6.2. Although the production curve resulting from the default HSBlim reaches to an F_{MSY} value (F_{max}), the curve becomes almost flat (only decreasing slightly) at higher F values, making impossible to estimate F_{upper}. The production curve corresponding to the alternative HS doesn't reach F_{MSY} (as it crashes earlier), whereas BH has a well-defined dome shape curve, with a neat peak corresponding to an F_{MSY}, and asymmetrical descending shape as F increases.
- **F_{MSY} or F_{MSY} proxies and corresponding ranges**: The values for the different F_{MSY} proxies and corresponding ranges are shown in Table 2.3.6.2 and Figure 2.3.6.3.
- **Assessment of Risks and of $F_{p.05}$ by SRR models**. The risks of falling below the previously adopted B_{lim} (by STECF) were calculated through a forward projection (see methods) for the different SRR models (Table 2.3.6.3). The $F_{p.05}$ estimates are rather consistent for the two SRR models for Risk 3, being slightly larger for the HSBlim than for the HS for risk type 1. In addition, $F_{p.05}$ corresponding to Risk 3 type of estimates are smaller than those corresponding to Type 1 risks. All the results were shown for an assessment plus implementation error of intended fishing mortality of 0.2 (Fsigma=0.2).

- **Discussion on F_{MSY} target and ranges**: This is a type 2 stock corresponding to productions curve showing an F_{max} but beyond which the curve is almost flat, so that F_{upper} is undefined (NA). Furthermore, these are stocks for which a Hockey-stick was fitted with a break point either at around the lowest observed S-R pairs values (including B_{loss}) or within the cloud of S-R observed pairs. Three alternatives have been considered: a) let a priori current Ftarget ($F_{0.1}$) and empirical Franges b) the same but setting F_{upper} as F_{max} provided they are compliant with the risks to B_{lim} c) adopt F_{MSY} and ranges from an alternative SRRs provided they are compliant with the risks to B_{lim}.

  In this case all the F_{MSY} proxies considered except F_{MSY} were lower than $F_{p.05}$ estimated for the HSBlim. Therefore, they all implied probabilities of being below B_{lim} less than 0.05 (Figure 2.3.6.4). The F_{upper} could not be calculated for none of the F_{MSY} proxies for the HSBlim and the HS. Figure 2.3.6.5 shows the relative implications of adopting alternative FMSY proxies and F ranges versus the current F ranges, in terms biomass, catches and fishing mortalities for the HSBlim and HS models.

  From all the above it is important to note that:

  - The actual productivity of the stock is very uncertain and might be lower than currently assumed. The SRR models which best fit the data have all smaller slopes to the origin than the HSBlim. The break point of the HS free fitting almost double current Blim and gives a warning on the current definition of Blim (though it would imply placing the B_{lim} above 25% $B_{F0.1}$.
  - The $F_{p.05}$ derived from HSBlim and HS (Type 3 risk estimates) are placed around 1, well above the current Ftarget ($F_{0.1}$ = 0.46). The F_{upper} value of the current F ranges (0.62) is also placed well below the $F_{p.05}$ for Risk type 3 of the current HSBlim. Therefore, the current Ftarget and Franges (based on the linear models) are compliant not exceeding $F_{p.05}$, implying risks <= 0.05 for the SSB of falling below B_{lim}.
  - For this type 2 stocks, in the absence of an F_{upper} relative to $F_{0.1}$, it has been proposed that F_{max} could be used as F_{upper} , but for this stock F_{max} (1.15) while being below $F_{p.05}$ type 1 estimate, it is bigger than $F_{p.05}$ type 3 estimate from HSBlim and HS. Given the high uncertainties affecting the actual productivity of the stock and the actual definition of B_{lim}, here as for other stocks, compliance with $F_{p.05}$ risk 3 is given priority for precautionary reasons. Therefore, F_{upper} should not be higher than 1.01.
  - The F_{MSY} target and corresponding ranges obtained for the alternative plausible SRR (BH and Ricker) are also smaller than $F_{p.05}$ and could be used as an alternative risk averse F_{MSY} ranges. Actually, the Ricker F_{MSY} ranges are very close to the former $F_{0.1}$ target and its ranges proposed for this stock, while the BH Franges are placed at smaller F values. While the formerly $F_{0.1}$ and F_{upper} are 0.466 and 0.62, for the Ricker modelling F_{MSY} proxy and F_{upper} are 0.5 and 0.64 respectively.
  - Therefore, among the three alternative proposals for definition of Ftarget and Franges only that of staying at former Franges (Option 2) and that of selecting F_{MSY} and ranges from an alternative less productive SRRs (Option 3) are robust to the current uncertainties on the plausible models of SRR governing the dynamics of this stock. Option 1 cannot be applied as F_{upper} taken as F_{max} would exceed $F_{p.05}$ for type 3 risk estimates As the Franges based on the linear models are very similar to the F_{MSY} ranges of the alternative less productive SRR model (Ricker), we suggest staying at the original STECF ranges based on the empirical linear models, which proves to be robust to the uncertainties on the productivity of the population, being consistent with F_{MSY} ranges for a plausible (better fitting) less productive SRR (Ricker) and gives at the same time a safe margin between F_{upper} and $F_{p.05}$ as estimated for HSBlim and HS.
  - Suggestion: Verification of $F_{p.05}$ for the best fitted models (BH and Ricker) would be of interest.

- **Conclusions**: EWG suggests keeping at the Current F target ($F_{0.1}$) and F ranges (from the empirical linear relationships) because they are acceptable in relation to $F_{p.05}$, being consistent with F_{MSY} ranges for a plausible (best fitting) less productive SRR (Ricker) and gives at the same time a safe margin between F_{upper} and $F_{p.05}$ as estimated for HSBlim and HS.

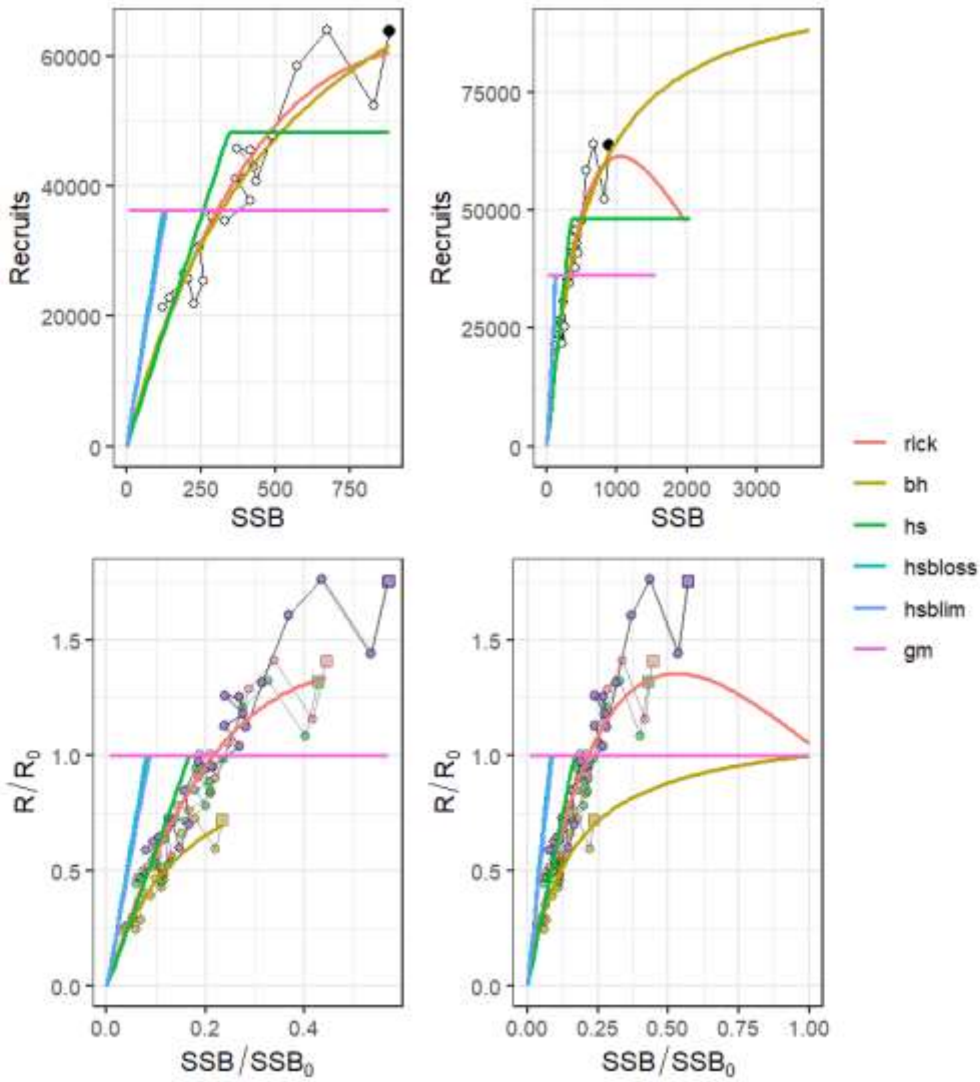


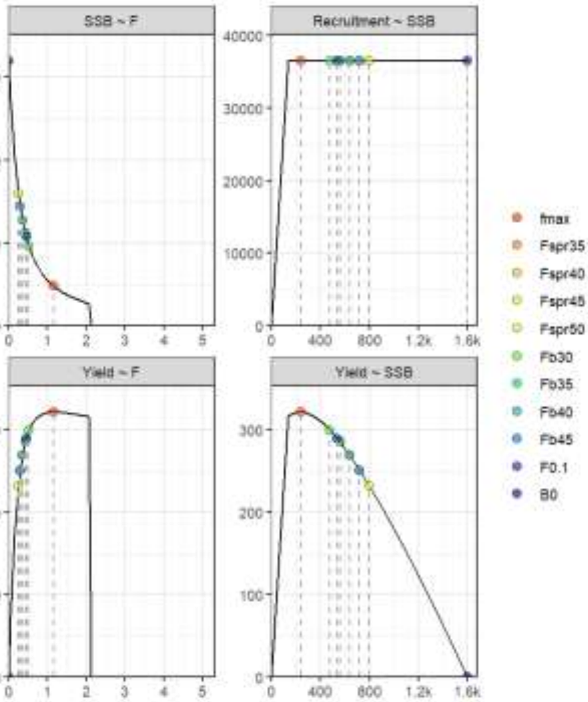
Figure 2.3.6.1. Stock recruitment relationships for red mullet in GSA 7, both in absolute (top row) and in relative terms to R0 and B0 (bottom row) for two scales in the X axis (left and right panels).

Table 2.3.6.1 Statistical comparison of the fitting of different SRR models for red mullet in GSA 7.

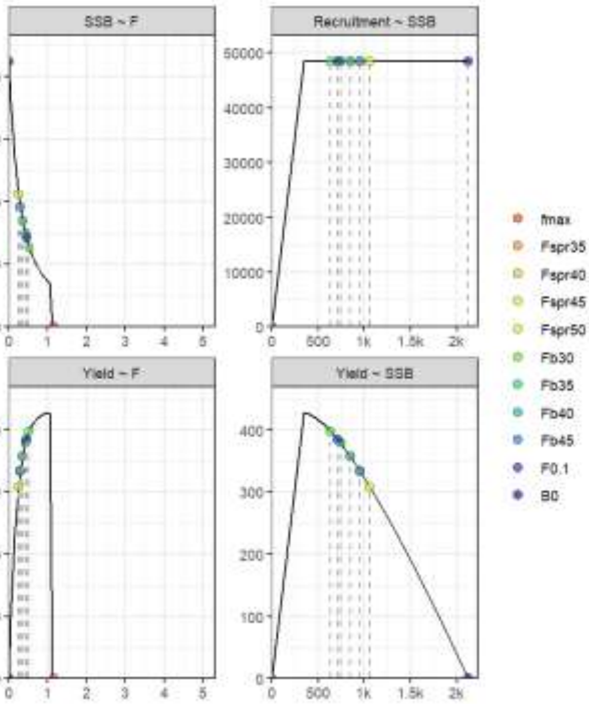
MODEL	AIC	BIC
Ricker	-22.23	-19.10
Beverton-Holt	-24.57	-21.44
Hockey-stick	-2.84	0.30
Hockey-stick at Bloss	19.36	21.45
Hockey-stick at Blim	18.69	20.78

Geometric mean	19.36	21.45

a)



b)



c)

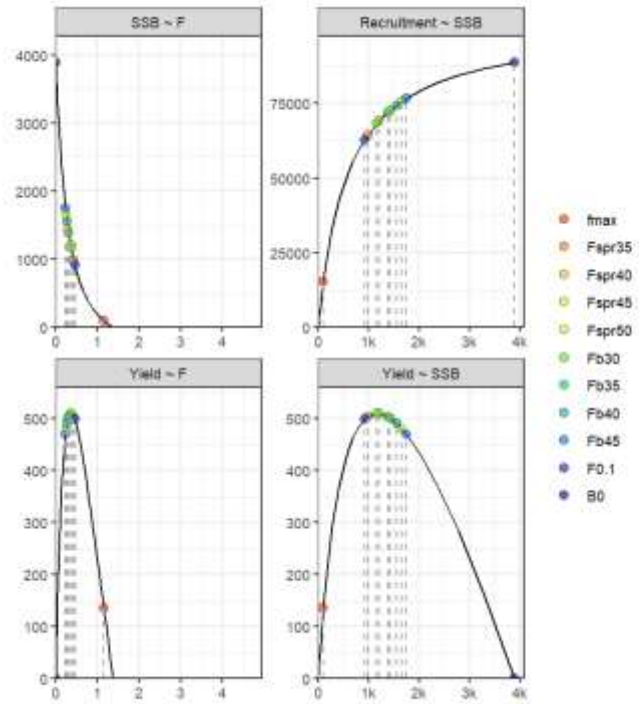


Figure 2.3.6.2 Biomass and production curves as a function of F resulting from the alternative plausible stock recruitment relationships under consideration for red mullet in GSA 7. From top to bottom HSBlim, HS (free fitting) and BH.

Table 2.3.6.2 F, yield and SSB for each of the F_{MSY} proxies and F ranges considered for red mullet in GSA 7 from HSBlim and BH models.

		Ftarget	Ftarget	Ftarget	Flower	Flower	Flower	Fupper	Fupper	Fupper
SRR	Case	F	Yield	SSB	F	Yield	SSB	F	Yield	SSB
HSBlim	msy_ranges	1.15	321.00	242	0.584	305	439	NaN	NaN	NaN
HSBlim	f0.1_ranges	0.46	289	536	0.384	275	610	NaN	NaN	NaN
HSBlim	spr.30_ranges	0.53	299	479	0.427	284	563	NaN	NaN	NaN
HSBlim	Fspr35_ranges	0.43	285	559	0.367	271	629	NaN	NaN	NaN
HSBlim	Fspr40_ranges	0.36	269	639	0.314	255	700	NaN	NaN	NaN
HSBlim	Fb35_ranges	0.43	285	559	0.367	271	629	NaN	NaN	NaN
HSBlim	Fb40_ranges	0.359	269	639	0.314	255	700	NaN	NaN	NaN
HS	f0.1_ranges	0.456	385	712	0.384	365	810	NaN	NaN	NaN
HS	spr.30_ranges	0.525	398	637	0.427	378	748	NaN	NaN	NaN
HS	Fspr35_ranges	0.432	379	743	0.367	360	837	NaN	NaN	NaN
HS	Fspr40_ranges	0.359	357	849	0.314	339	930	NaN	NaN	NaN
HS	Fb35_ranges	0.432	379	743	0.367	360	836	NaN	NaN	NaN
HS	Fb40_ranges	0.359	357	849	0.314	339	930	NaN	NaN	NaN
BH	msy_ranges	0.37	510	1176	0.259	485	1626	0.507	485	804
BH	f0.1_ranges	0.456	499	924	0.241	474	1720	0.537	474	743
BH	spr.30_ranges	0.525	478	766	0.214	454	1871	0.586	454	652
BH	Fspr35_ranges	0.432	504	989	0.249	479	1678	0.523	479	770

BH	Fspr40_ranges	0.359	510	1212	0.259	484	1628	0.508	484	803
BH	Fb35_ranges	0.309	503	1400	0.248	478	1683	0.525	478	766
BH	Fb40_ranges	0.274	491	1556	0.23	467	1779	0.556	467	707
Ricker	msy_ranges	0.501	486	817	0.376	461	1043	0.637	461	609
Ricker	f0.1_ranges	0.456	483	893	0.37	459	1057	0.645	459	598
Ricker	spr.30_ranges	0.525	485	776	0.374	461	1047	0.639	461	606
Ricker	Fspr35_ranges	0.432	478	938	0.361	454	1075	0.656	454	583
Ricker	Fspr40_ranges	0.359	454	1078	0.318	431	1165	0.71	431	511
Ricker	Fb35_ranges	0.564	480	715	0.364	456	1068	0.652	456	588
Ricker	Fb40_ranges	0.501	486	816	0.376	461	1043	0.637	461	609

Table 2.3.6.3 $F_{p.05}$ values in relation to the risk of dropping SSB below current B_{lim} adopted for Red Mullet in GSA 7, as obtained for the default HSBlim and for the HS SRR models.

$F_{p.05}$	HSBlim	HS
Risk 3	1.006	1.011
Risk 1	1.349	1.112

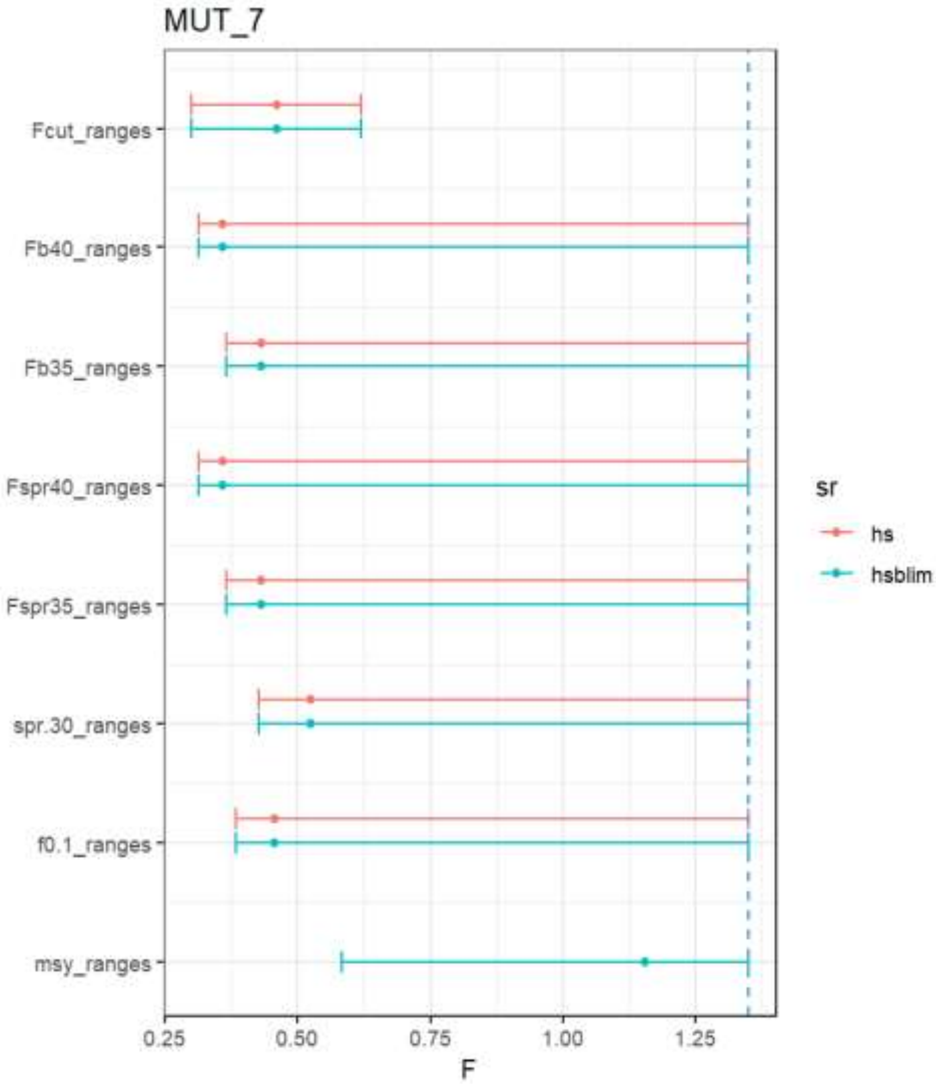


Figure 2.3.6.3 F_{MSY} proxies and corresponding ranges for the default SRR model (HSBlim) and for HS for red mullet in GSA 7. The dashed vertical line represents $F_{p.05}$ value (type 1 risks) for HSBlim.

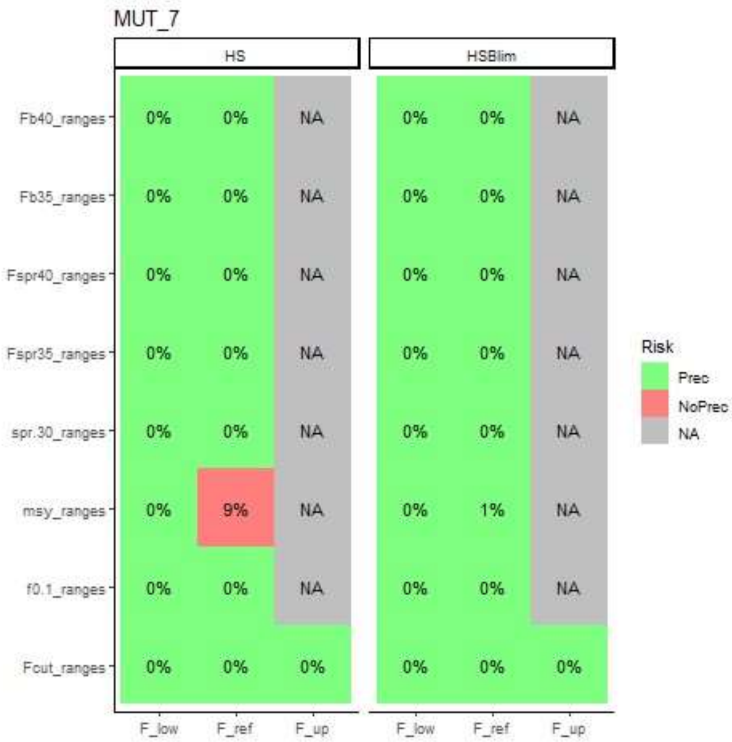


Figure 2.3.6.4 Probability of SSB being below B_{lim} (risk type 1) for alternative F_{MSY} proxies and corresponding F ranges for the default SRR (HSBlim) and for HS for red mullet in GSA 7 for Fsigma=0.2.

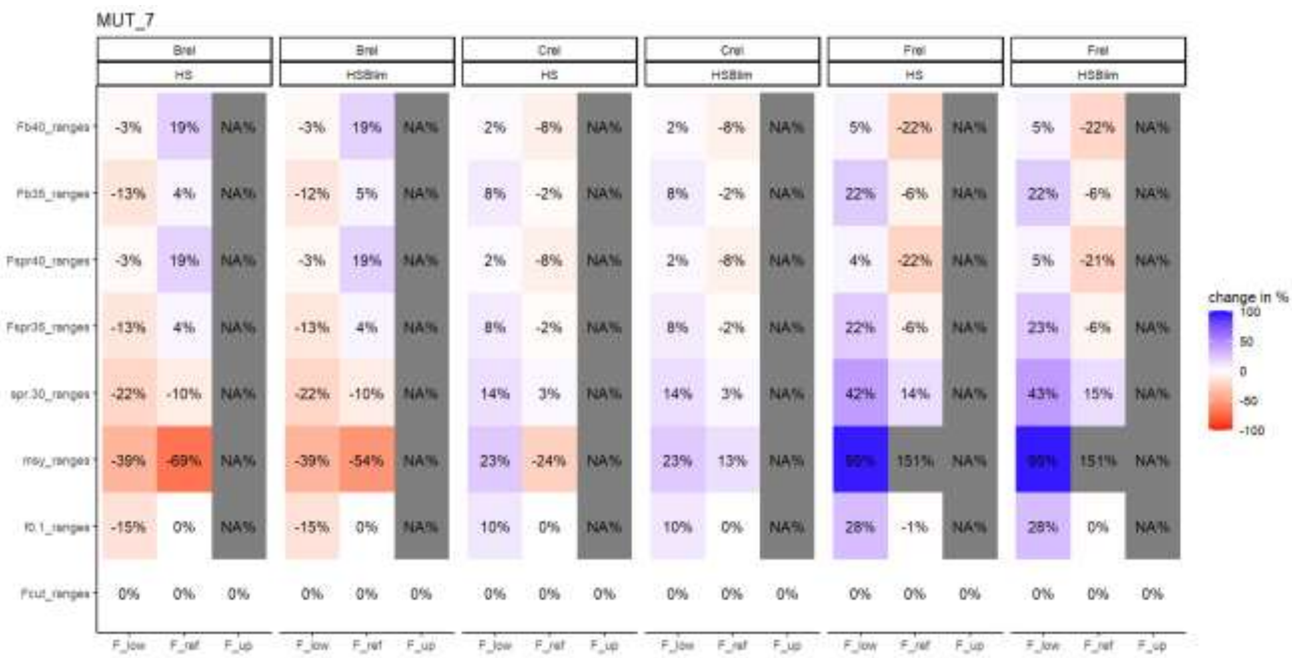


Figure 2.3.6.5. Changes in terms biomass, catches and fishing mortalities induced by adopting alternative F_{MSY} proxies and corresponding F ranges relative to the current F target and F ranges

(from $F_{0.1}$ and the linear models respectively), for the default SRR (HSBlim) and for BH for red mullet in GSA 7 (Fsigma=0.2).

2.3.7 Summary results for Norway lobster in GSA 6

- **The stock objects** were those produced in EWG 2023-09 with data up to 2022.
- **Biology**: Ages 2-9+. Decreasing M with age from 0.47 at age 2 to 0.18 at age 9+. Maturity increasing with age, being 20% at age 2, 60% at age 4, 89% at age 6 and reaching full maturity at age 9+.
- **Stock status**: The stock is significantly overfished (F_{2022}=0.79 is well above $F_{0.1}$=0.17) and current biomass is estimated to be below B_{lim}.
- **Current F target and ranges**: F_{MSY} is based on $F_{0.1}$=0.17. The corresponding SSB is $B_{F0.1}$=1620t. The F ranges for $F_{0.1}$ based on the empirical linear models are 0.11 – 0.23.
- **Current SRR assumption and B_{lim} definition**: Current B_{lim} (472 t) is based on the 25% $B_{F0.1}$ at geometric mean recruitment. B_{pa} is set as 2*B_{lim} and takes the value 944 t.
- **Alternative SRR and potential alternative B_{lim} definitions**: Statistical comparison of the different SR models indicated that the Hockey-stick with breakpoint at B_{lim} resulted in the best fitting in terms of AIC and BIC (Table 2.3.7.1). Ricker and Beverton-Holt models were discarded due to the high levels of R_0 and B_0. Therefore, no alternative models were considered.
- **Production curves:** The equilibrium plot for the chosen model (HS_{Blim}) is reported in Figure 2.3.7.2. The production curve is dome shaped showing a neat peak corresponding to F_{MSY} value (F_{max}). This implies that F_{MSY} and the F ranges associated to it can be estimated.
- **F_{MSY} or F_{MSY} proxies and corresponding ranges**: The values for the different F_{MSY} or F_{MSY} proxies and corresponding ranges are given in Table 2.3.7.2and Figure 2.3.7.3.
- **Assessment of Risks and of $F_{p.05}$ by SRR models**. The risks of falling below the previously adopted B_{lim} were calculated through a forward projection. $F_{p.05}$ was estimated at 0.508 for risk type 1 and 0.426 for Risk type 3 (Table 2.3.7.3). All the results were shown for an assessment plus implementation error of intended fishing mortality of 0.2 (F_{sigma}=0.2).
- **Discussion on F_{MSY} target and ranges**: This is a type 1 stock corresponding to dome shape productions curve allowing estimation of F_{MSY} and its ranges. Therefore, the EWG considered that F_{MSY} and their ranges could be adopted for management, provided they comply with being below $F_{p.05}$. In this case both the current F_{MSY} based on $F_{0.1}$ and the proposed F_{MSY} target as well as their associated ranges are compliant with not exceeding risks above 0.05 as stated in the West Med EU MAP (Figure 2.3.7.4). For some of the F_{MSY} proxies (e.g. $F_{40\%SPR}$) the upper value could not be calculated, whereas for some others (e.g. $F_{0.1}$) the upper limit implied probabilities of SSB being below B_{lim} larger than 0.05 indicating that the upper limit should be capped at $F_{p.05}$. In particular, the F_{upper} corresponding to F_{MSY} (0.47) is above $F_{p0.5}$ Type 3 error (0.43), therefore for assuring full compliance with the precautionary principle the F_{upper} will be capped to 0.43.

  Figure 2.3.7.5 shows the relative implications of adopting alternative F_{MSY} proxies and F ranges versus the current values for the HSBlim default SRR assumption. F_{MSY} is around 44% larger than $F_{0.1}$, but the upper range of F_{MSY} is lower than the upper range that would correspond to $F_{0.1}$. All the lower and upper ranges considered except for the ones corresponding to $F_{spr40\%}$ and $F_{40\%}$, lead to long-term SSBs lower than those corresponding to the current F_{lower} and F_{upper} values.

- **Conclusions**: Current $F_{0.1}$ target and its F ranges according to the linear models are acceptable in relation to $F_{p.05}$. The F_{MSY} and its lower range deduced from the production curve are also compliant with being lower than $F_{p.05}$ (type 1 estimate), however to be fully precautionary and consistent with the definition of the West Med EU MAP the F_{upper} is to be restricted to the $F_{p.05}$ = 0.43 (type 3 estimates). Therefore, the EWG proposes adopting F_{MSY} (0.28) as the Ftarget and the values of 0.18 and 0.43 as F_{lower} and F_{upper} ranges respectively for the management of Norway lobster in GSA 6.

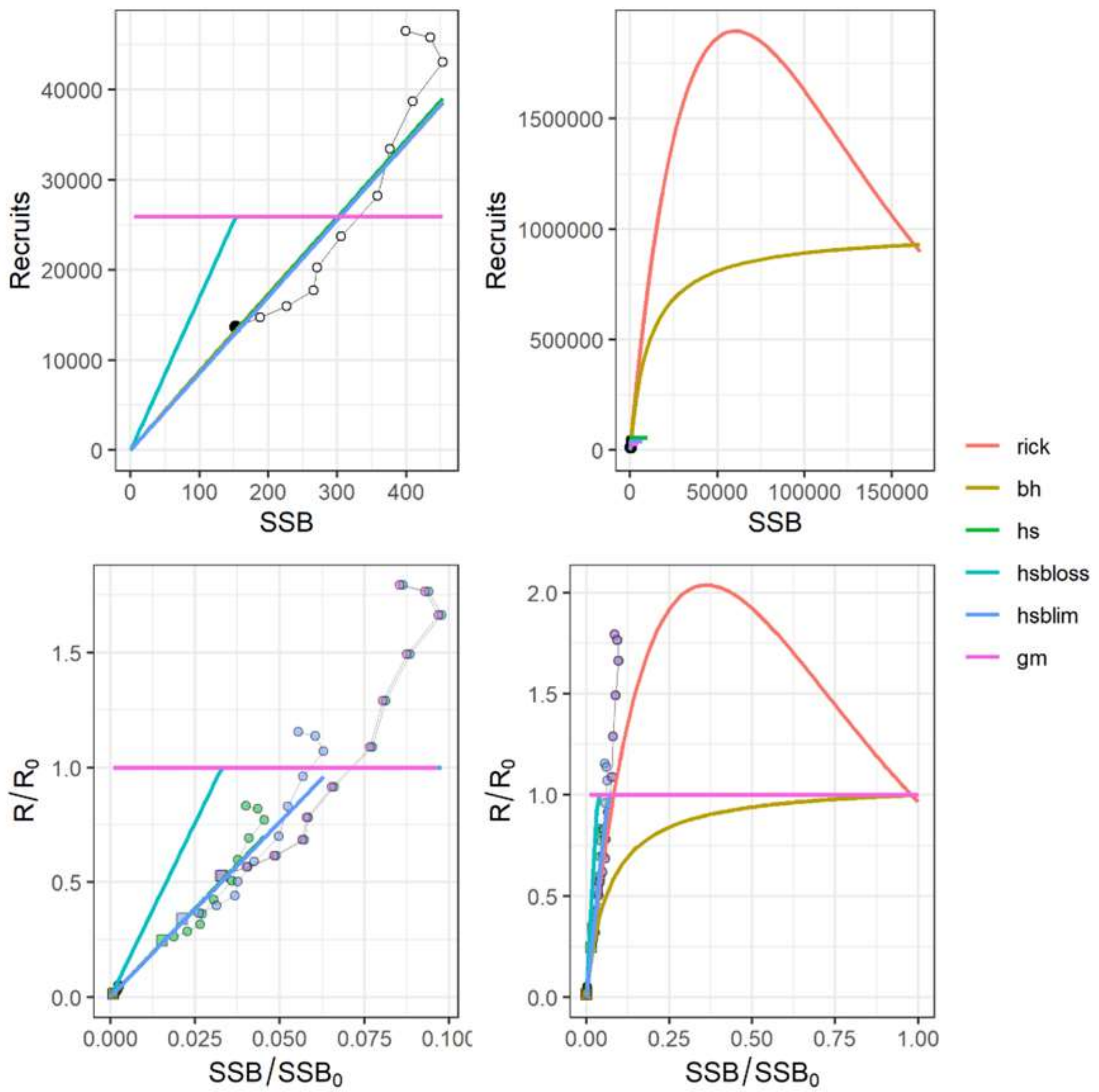


Figure 2.3.7.1. Stock recruitment relationships for Norway lobster in GSA 6, both in absolute (top row) and in relative terms to R0 and B0 (bottom row) for two scales in the X axis (left and right panels).

Table 2.3.7.1. Statistical comparison of the fitting of different SRR models for Norway lobster in GSA 6.

MODEL	AIC	BIC
Ricker	-3.73	-2.27
Beverton-Holt	-2.05	-0.60
Hockey-stick	-2.78	-1.33
Hockey-stick at Bloss	18.39	19.35
Hockey-stick at Blim	-6.08	-5.11
Geometric mean	18.39	19.35

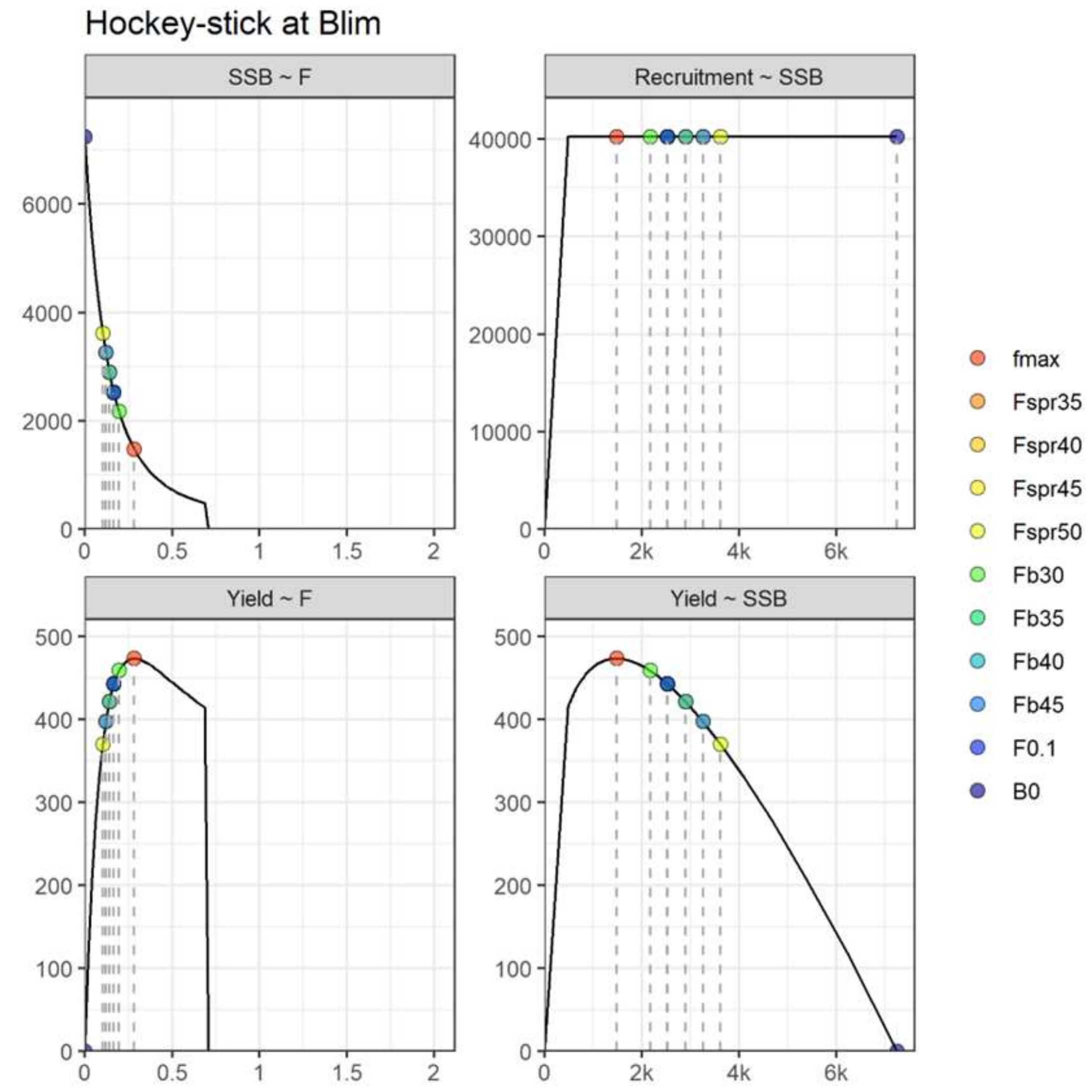


Figure 2.3.7.2. Biomass and Production curves as a function of F resulting from the HSBlim stock recruitment relationship for Norway lobster in GSA 6.

Table 2.3.7.2. F, yield and SSB for each of the F_{MSY} proxies and F ranges considered for Norway lobster in GSA 6 from the default SRR (HSBlim).

	Ftarget			F_{lower}			F_{upper}		
	F	Yield	SSB	F	Yield	SSB	F	Yield	SSB
msy_ranges	0.281	474	1483	0.176	450	2390	0.47	450	789
f0.1_ranges	0.165	443	2523	0.139	421	2910	0.642	421	526
spr.30_ranges	0.195	459	2173	0.155	436	2658	0.549	436	644
Fspr35_ranges	0.164	443	2535	0.138	421	2920	0.646	421	522
Fspr40_ranges	0.140	422	2897	0.121	401	3215	0.121	401	3215
Fb35_ranges	0.164	443	2535	0.138	421	2920	0.646	421	522
Fb40_ranges	0.140	422	2897	0.121	401	3215	0.121	401	3215

Table 2.3.7.3 $F_{p.05}$ values in relation to the risk of dropping SSB below current B_{lim} for Norway lobster in GSA 6.

$F_{p.05}$	HSBlim
Risk 3	0.426
Risk 1	0.508

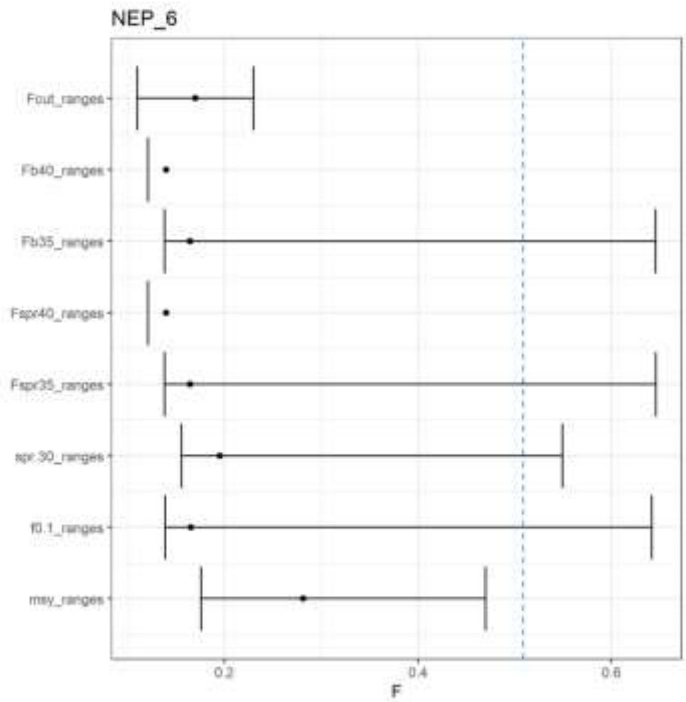


Figure 2.3.7.3 F_{MSY} proxies and corresponding ranges for the default SRR model (HSBlim) for Norway lobster in GSA 6. The dashed vertical line represents $F_{p.05}$ value (type 1 risks).

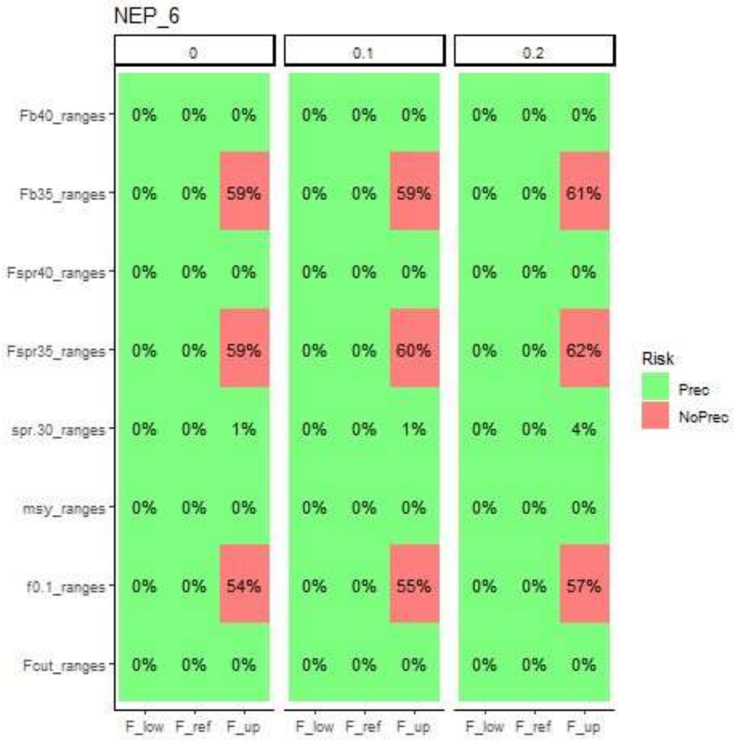


Figure 2.3.7.4. Probability of SSB being below B_{lim} (risk type 1) for alternative F_{MSY} proxies and corresponding F ranges for the default SRR (HSBlim) for Norway lobster in GSA 6. The vertical panels correspond to Fsigma equal to 0, 0.1 and 0.2.

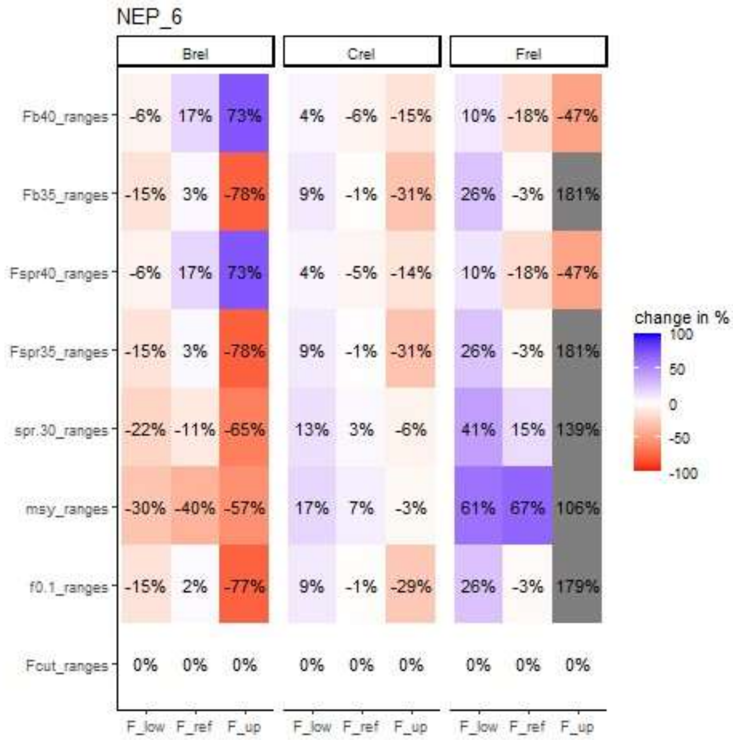


Figure 2.3.7.5 Changes in terms biomass, catches and fishing mortalities induced by adopting alternative F_{MSY} proxies and corresponding F ranges relative to the current F target and F ranges (from $F_{0.1}$ and the linear models respectively), for the default SRR (HSBlim) for Norway lobster in GSA 6.

2.3.8 Summary results for European hake in GSAs 8, 9, 10 & 11

- **The stock objects** were those produced in EWG 2022-09 with data up to 2021.
- **Biology**: Ages 0-7+. Decreasing M with age from 1.85 at age 0 to 0.22 at age 7+. Gradual maturity reaching 80% at age 2 and full maturity at age 3.
- **Stock status**: The stock is suffering severe overfishing (current F_{2021}=0.5) relative to an $F_{0.1}$ of 0.17, with current biomass below B_{lim}.
- **Current F target and ranges**: F_{MSY} is based on $F_{0.1}$=0.17. The corresponding SSB is $B_{F0.1}$=49500t. The F ranges for $F_{0.1}$ based on the empirical linear models are 0.11 – 0.23.
- **Current SRR assumption and B_{lim} definition**: A Hockey-stick model is fitted resulting in a break point at 10.4% of $B_{F0.1}$ (Figure 2.3.8.1). This implies B_{lim} (5132 t) is about 4,5% B_0. Such break point is placed around the highest past observed biomasses. It implies a steepness of 1, as a result of being below 20%B_0.
- **Alternative SRR and potential alternative Blim definitions**: Statistical comparison of the fitting of different SRR models shows that the Hockey-stick stock recruitment model could be the most suitable in terms of AIC and BIC, by comparison with rest of models (Figure 2.3.8.1**,** Table 2.3.8.1). Even though at the EWG different stock recruitment models were applied (see annex) none one supposed a better alternative fitting than the default HS with the breakpoint fixed at B_{lim}.
- **Production curves:** The equilibrium plot for the chosen model (HSBlim) is reported in Figure 2.3.8.2. The Production curve is well dome shaped showing a neat peak corresponding to F_{MSY} value (F_{max}). This implies that the F_{MSY} value is estimable as well as the F ranges associated to it.
- **F_{MSY} or F_{MSY} proxies and corresponding ranges**: F_{MSY} or F_{MSY} proxies and corresponding ranges are shown in Table 2.3.8.2 and Figure 2.3.8.3.
- **Assessment of Risks and of $F_{p.05}$ by SRR models**. The risks of falling below the previously adopted B_{lim} were calculated through a forward projection (see methods) for the different SRR models (**Table 2.3.8.3**). The $F_{p.05}$ is about 0.64 for Type 1 risks, and of 0.57 for Type 3 risk. All the results were shown for an assessment plus implementation error of intended fishing mortality of Fsigma=0.2.
- **Discussion on F_{MSY} target and ranges**: This a type 1 stock corresponding to dome shape productions curve allowing estimation of F_{MSY} and its ranges. Furthermore, these are stocks for which a Hockey-stick is well fitted statistically (lowest AIC) with a break point within the observed S-R pairs values or up the upper range of them. Given the credibility of the HS fitting defining and the well-defined dome shape production curve it is suggested that F_{MSY} and their ranges are adopted for management, provided they comply with being below $F_{p.05}$.

  In this case all the F_{MSY} or F_{MSY} proxies considered and the corresponding ranges were lower than $F_{p.05}$. Therefore, they all implied probabilities of being below B_{lim} less than 0.05 (Figure 2.3.8.4). In particular:

  - The $F_{p.05}$ derived from (Type 3 risk estimates) are placed around 0.57 well above the current Ftarget ($F_{0.1}$ = 0.17) and well above the current F_{upper}. Therefore, the current Ftarget and Franges (based on the linear models) are compliant not exceeding $F_{p.05}$, implying risks <= 0.05 for the SSB of falling below B_{lim}.

- The F_{MSY} target and corresponding ranges obtained for the HSBlim SRR are also smaller than $F_{p.05}$ and could be used as well for management purposes with a better alignment to the definition of the F_{MSY} ranges as stated in the West Med EU MAP.

Figure 2.3.8.5 shows the relative implications of adopting alternative F_{MSY} proxies and F ranges versus the current F ranges, in terms biomass, catches and fishing mortalities for the HSBlim default SRR assumption.

- **Conclusions**: Current $F_{0.1}$ target and its F ranges according to the linear models are acceptable in relation to $F_{p.05}$. However, the F_{MSY} and corresponding ranges deduced from the production curve are also compliant with being lower than $F_{p.05}$ and are consistent with the definition of the West Med EU MAP. Therefore, therefore the EWG proposes adopting Fmsy as the Ftarget and its ranges for the management of hake in GSAs 8, 9, 10 & 11.

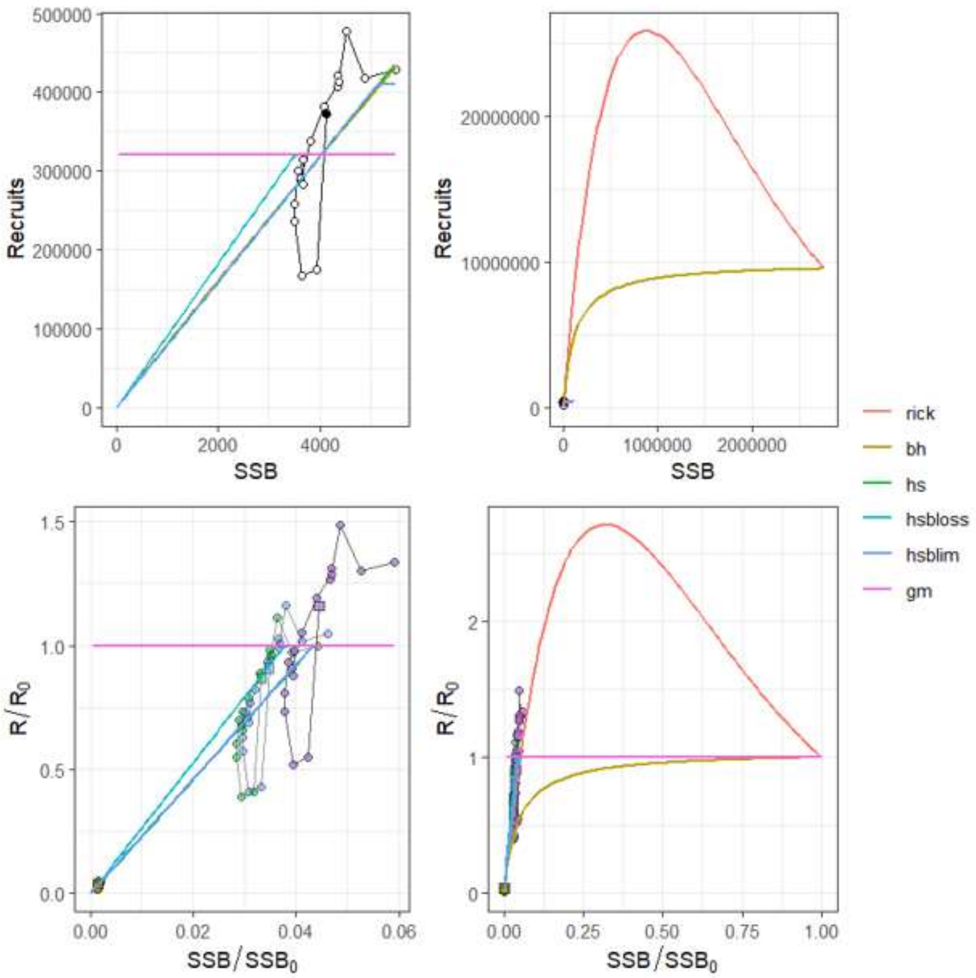


Figure 2.3.8.1. Stock recruitment relationships for hake in GSAs 8, 9, 10 & 11, both in absolute (top row) and in relative terms to R0 and B0 (bottom row) for two scales in the X axis (left and right panels).

Table 2.3.8.1. Statistical comparison of the fitting of different SRR models for hake in GSAs 8, 9, 10 & 11.

Model	AIC	BIC
Hockey-stick Blim	2.614	4.281
Hockey-stick	4.714	7.213
Ricker	4.748	7.248
Beverton-Holt	4.929	7.429
Hockey-stick Bloss	11.16352	12.82995
Geomean	11.16352	12.82995

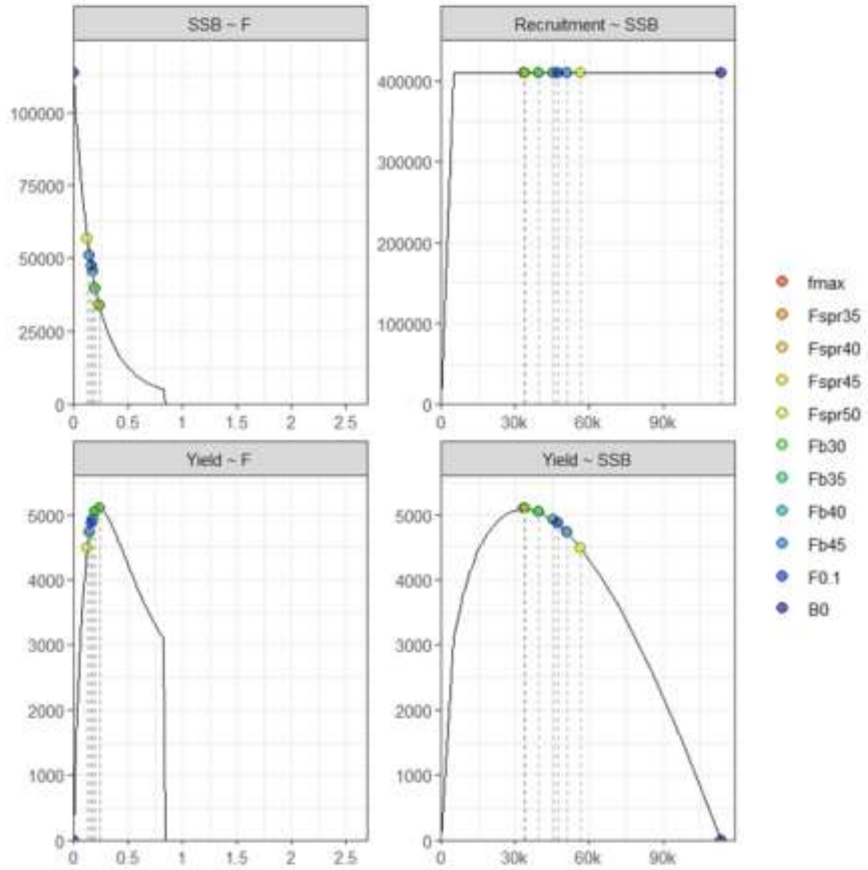


Figure 2.3.8.2 Biomass and Production curves as a function of F resulting from the HSBlim stock recruitment relationship for hake in GSAs 8, 9, 10 & 11.

Table 2.3.8.2. F, yield and SSB for each of the F_{MSY} proxies and F ranges considered for hake in GSAs 1, 5, 6 & 7 from the default SRR (HSBlim).

	Ftarget			Flower			Fupper		
	F	Yield	SSB	F	Yield	SSB	F	Yield	SSB
msy_ranges	0.241	5091	33737	0.162	4836	48179	0.354	4836	21381
f0.1_ranges	0.166	4864	47298	0.139	4621	53838	0.408	4621	17494
spr.30_ranges	0.239	5091	34033	0.162	4836	48183	0.354	4836	21378
Fspr35_ranges	0.204	5043	39705	0.157	4791	49491	0.366	4791	20437
Fspr40_ranges	0.175	4921	45379	0.144	4675	52551	0.395	4675	18337

Fb35_ranges	0.204	5044	39704	0.157	4791	49491	0.366	4791	20438
Fb40_ranges	0.175	4921	45377	0.144	4675	52550	0.395	4675	18337

Table 2.3.8.3 $F_{p.05}$ values in relation to the risk of dropping SSB below current Blim adopted for hake in GSAs 8, 9, 10 & 11, as obtained for the different SRR models.

$F_{p.05}$	HSBlim
Risk 3	0.571
Risk 1	0.644

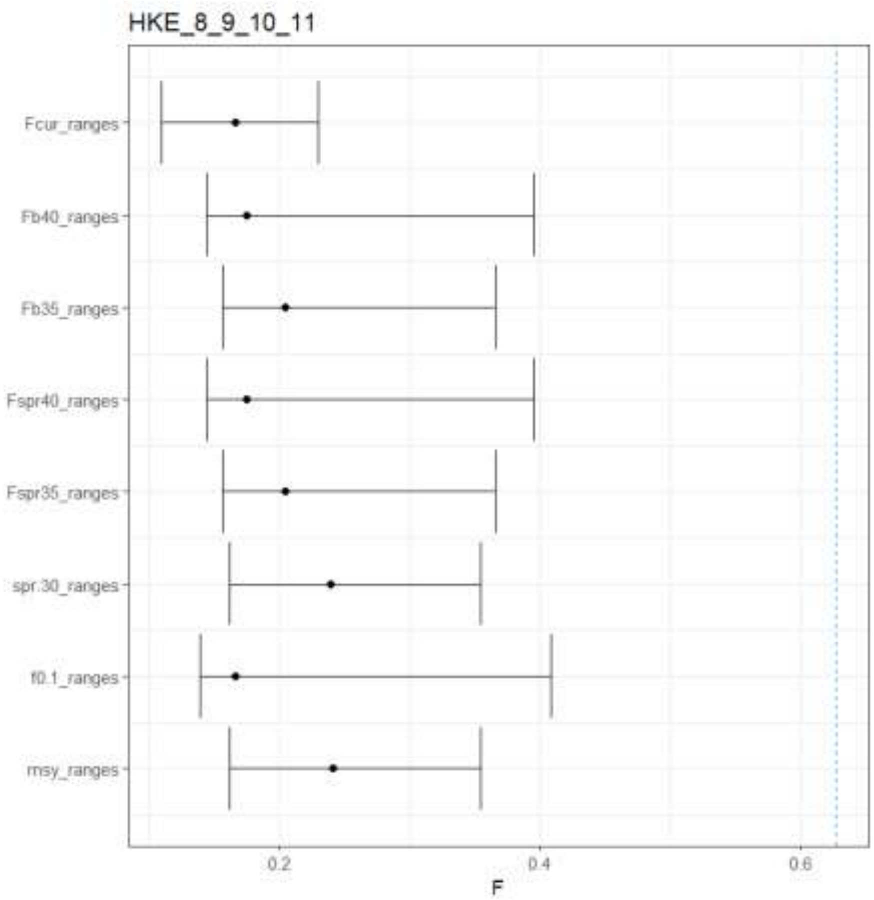


Figure 2.3.8.3 F_{MSY} proxies and corresponding ranges for the default SRR model (HSBlim) for hake in GSAs 8, 9, 10 & 11. The dashed vertical line represents $F_{p.05}$ value (type 1 risks).

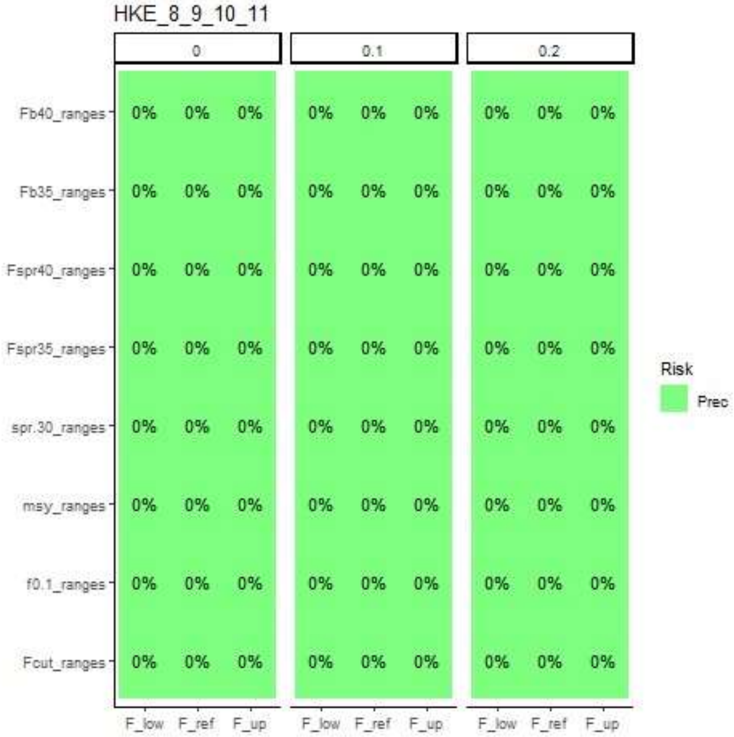


Figure 2.3.8.4. Probability of SSB being below B_{lim} (risk type 1) for alternative F_{MSY} proxies and corresponding F ranges for the default SRR (HSBlim) for Norway lobster in GSA 6. The vertical panels correspond to Fsigma equal to 0, 0.1 and 0.2.

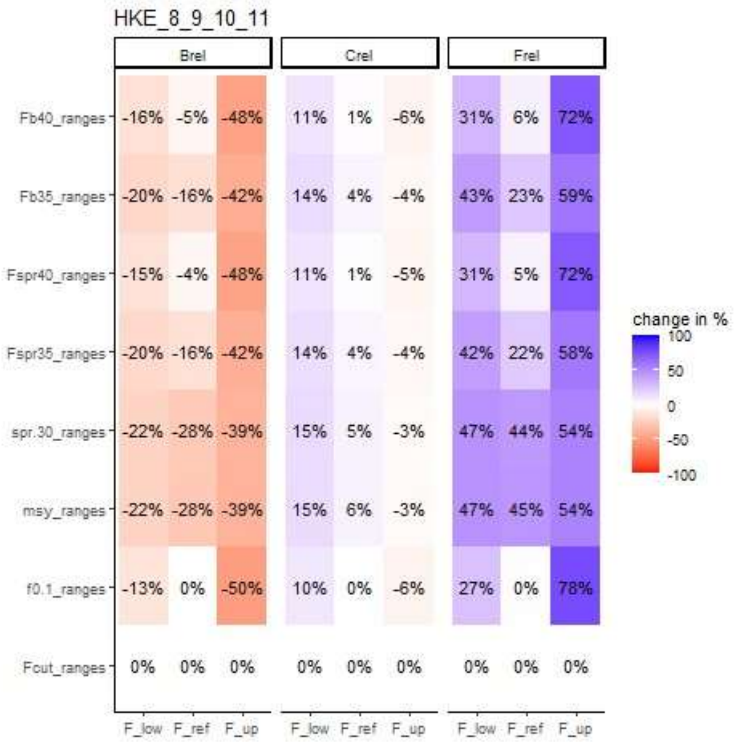


Figure 2.3.8.5 Changes in terms biomass, catches and fishing mortalities induced by adopting alternative F_{MSY} proxies and corresponding F ranges relative to the current F target and F ranges

(from $F_{0.1}$ and the linear models respectively), for the default SRR (HSBlim) for hake in GSAs 8, 9, 10 & 11.

2.3.9 Summary results for Deep-water rose shrimp in GSAs 8, 9, 10 & 11

- **The stock objects** were those produced in STECF EWG 22-09. The lack of MEDITS survey in 2022 in GSAs 9, 10 and 11 prevented to carry out an assessment in STECF EWG 23-09, and the advice was based on a two-year short-term forecast.
- **Biology**: Age groups from 0 to 3+. High natural mortalities at all ages (M≥ 0.9). Full maturity at age 2 and maturity-at-age1=0.7.
- **Stock status**: The stock is overfished (F_{2022}=1.63 is above F_{MSY}=1.26). SSB in 2022 is estimated to be below B_{MSY}, and above B_{pa} and B_{lim}.
- **Current F target and ranges**: F_{MSY} is based on $F_{0.1}$=1.26. The corresponding SSB is $B_{F0.1}$=855 t. The F ranges for $F_{0.1}$ based on the empirical linear models are 0.83 – 1.71.
- **Current SRR assumption and Blim definition**: Under no clear SRR, B_{lim} is based on 25% $B_{F0.1}$ and GM recruitment (STECF EWG 22-09). This implies B_{lim} (214 t) is about 7.4% B_0 and well below B_{loss}, being actually placed far to the left of the historical observations of biomass.
- **Alternative SRR**: Statistical comparison of the different SRR models shows that the default HSBlim and the less productive HSBloss have equal fitting to the data. While the Beverton-Holt could be a better SRR in terms of AIC and BIC than the rest of models (Table 2.3.9.1). However, due to the fact that BH R0 is defined well above all observed recruitments from the assessment (at about 50% the maximum past observed R) (Figure 2.3.9.1), it was considered that the BH SRR might not represent the SRR dynamics adequately. Instead, the Ricker SRR was selected as an alternative to test the robustness of the production curve. The Ricker SSR shows an increasing rate of recruitment with SSB to the left of the observed cloud of SR pairs very similar to the BH SRR (steepness of 0.58 and 0.65 for BH and Ricker respectively). That curvature of the SRR to the left of observations is the one which matters the most for the definition of the F_{upper} range relative to F_{MSY}. Ricker model will be rather similar HSBloss regarding the ascending limb to the left of observations. HSBloss would imply break point (B_{lim}) at 86% B($F_{0.1}$) and at 25% of B_0, far less productive SRR than the current HSBlim.
- **Production curves:** Three SRRs were selected: HS with the breakpoint at Blim (HSBlim), HS with the breakpoint at Bloss (HSBloss) and Ricker. A comparison of the production curves resulting from the selected SRRs is shown in Figure 2.3.9.2. Although the production curve resulting from the default HSBlim is a continuously increasing curve, the production curve from HSBloss crashes just beyond $F_{0.1}$ (1.26) from the SPR analysis. Finally, the production curve corresponding to the Ricker SRR is a well-defined dome shape curve, with a neat peak.
- **F_{MSY} or F_{MSY} proxies and corresponding ranges**: F_{MSY} or F_{MSY} proxies and corresponding ranges are shown in Table 2.3.9.2 and Figure 2.3.9.3.
- **Assessment of Risks and of $F_{p.05}$ by SRR models**. The risks of falling below B_{lim} were calculated through a forward projection (see methods) for the different SRR models based on 1000 iterations (Table 2.3.9.3). The $F_{p.05}$ values are higher for the HSBlim (above 2) than for the HSBloss or the Ricker SRRs, being rather similar for these two models, type 3 risks estimated at 1.5 and 1.6 respectively, and at 1.7 and 2 for type 1 estimates. Therefore, to be precautionary to all the plausible ranges of SRRs considered for this stock the Franges should be below $F_{p.05}$ values of the HSBloss/Ricker SRR curves. All the results were shown for an assessment plus implementation error of intended fishing mortality of 0.2 (F_{sigma}=0.2).
- **Discussion on F_{MSY} target and ranges**: This a type 3 stock corresponding to a continuously increasing production curve for the default HSBlim. In these cases, EWG 24 02 has considered to let a priori the current F target ($F_{0.1}$) and F ranges (from the linear

models). **Figure 2.3.9.4** and **Figure 2.3.9.5** show the relative implications of adopting alternative F_{MSY} proxy and Franges versus the current Franges, in terms risks to Blim (first figure) and biomass, catches and fishing mortalities (second figure) for the HSBlim default SRR assumption. However, before adopting straightforward the current F target and ranges, there are several contradictory results requiring discussion about the sustainability of $F_{0.1}$ and of those ranges:

- The two extreme alternative SRRs relationships imply extremely divergent steepness: with values or 1 and 0.65 for the HSBlim and Ricker respectively. The fitting to the Beverton and Holt (which showed the best AIC) would have implied a steepness even lower (0.58). Therefore the actual productivity of the stock is very uncertain and might be far lower than currently assumed.
- The F_{upper} value of the current Franges (= 1.76) is not above the $F_{p.05}$ for Risk Type 3 of the current HSBlim SRR assumption (= 2.28), therefore current F target and ranges are acceptable regarding the $F_{p.05}$ of the default HSBlim, however its F_{upper} is above the type 3 $F_{p.05}$ values from the HSBloss and of the Ricker models. This imply that under these two plausible less productive stock SRR models, the current F_{upper} would not be sustainable and would require being reduced to the smallest of these $F_{p.05}$ values (i.e., to 1.5). Therefore, for this type 3 stock the default proposal could be the current F targets but reducing F_{upper} to 1.5.
- In order to be sure that the F target and F ranges are fully robust to the current uncertainties on the actual SRR an alternative proposal could that of setting the F_{MSY} target and ranges at the ones obtained for the Ricker model which has an F target of 0.91 and F_{upper} of 1.14.
- Suggestion: Further analysis based on HSBloss could be considered before the assessment EWG for a full evaluation of other potential alternatives.

- **Conclusions**: EWG proposed to modify the current F target and F ranges relative to F(0.1) by reducing the F_{upper} to 1.5 (the lowest $F_{p.05}$ among the two alternative plausible less productive SRR), resulting in F(0.1) target at 1.26 and F ranges 0.83-1.5. In order to be fully risk averse to such SRR uncertainty EWG put forward for consideration adopting F_{MSY} target and ranges obtained for the Ricker model (F target at 0.91 and F ranges of 0.68 – 1.14), which allows for safer margins versus $F_{p.05}$ values coming from the different SRRs.

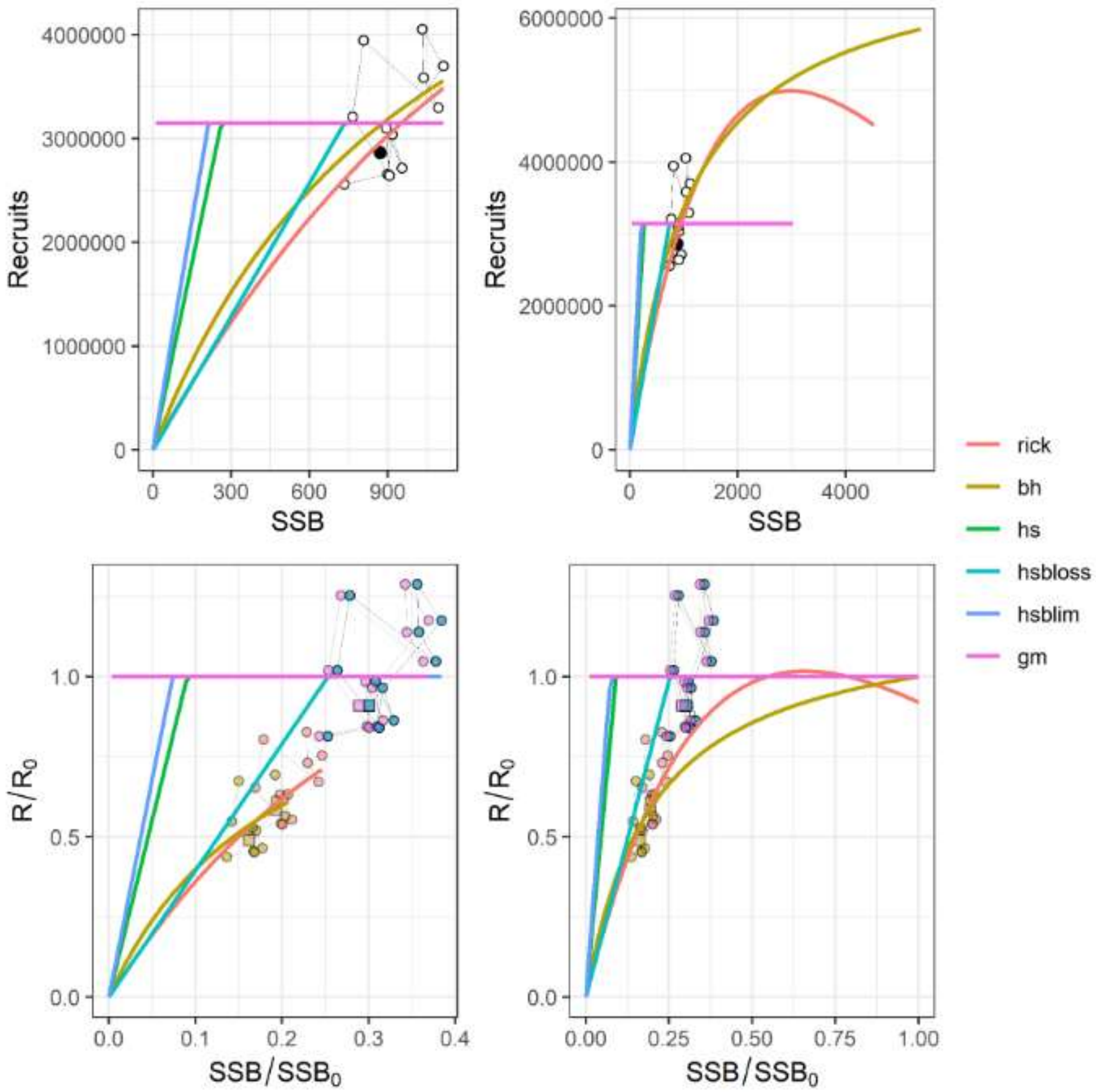


Figure 2.3.9.1. Stock recruitment relationships for Deep-water rose shrimp in GSAs 8, 9, 10 & 11, both in absolute (top row) and in relative terms to R0 and B0 (bottom row) for two scales in the X axis (left and right panels).

Table 2.3.9.1. Statistical comparison of the fitting of different SRR models for Deep-water rose shrimp in GSAs 8, 9, 10 & 11.

model	AIC	BIC
Ricker	-8.565	-6.870
Beverton-Holt	-8.674	-6.979
Hockey-stick	-6.170	-4.476
Hockey-stick at Bloss	-8.362	-7.232

Hockey-stick at Blim	-8.362	-7.232
Geometric mean	-8.362	-7.232

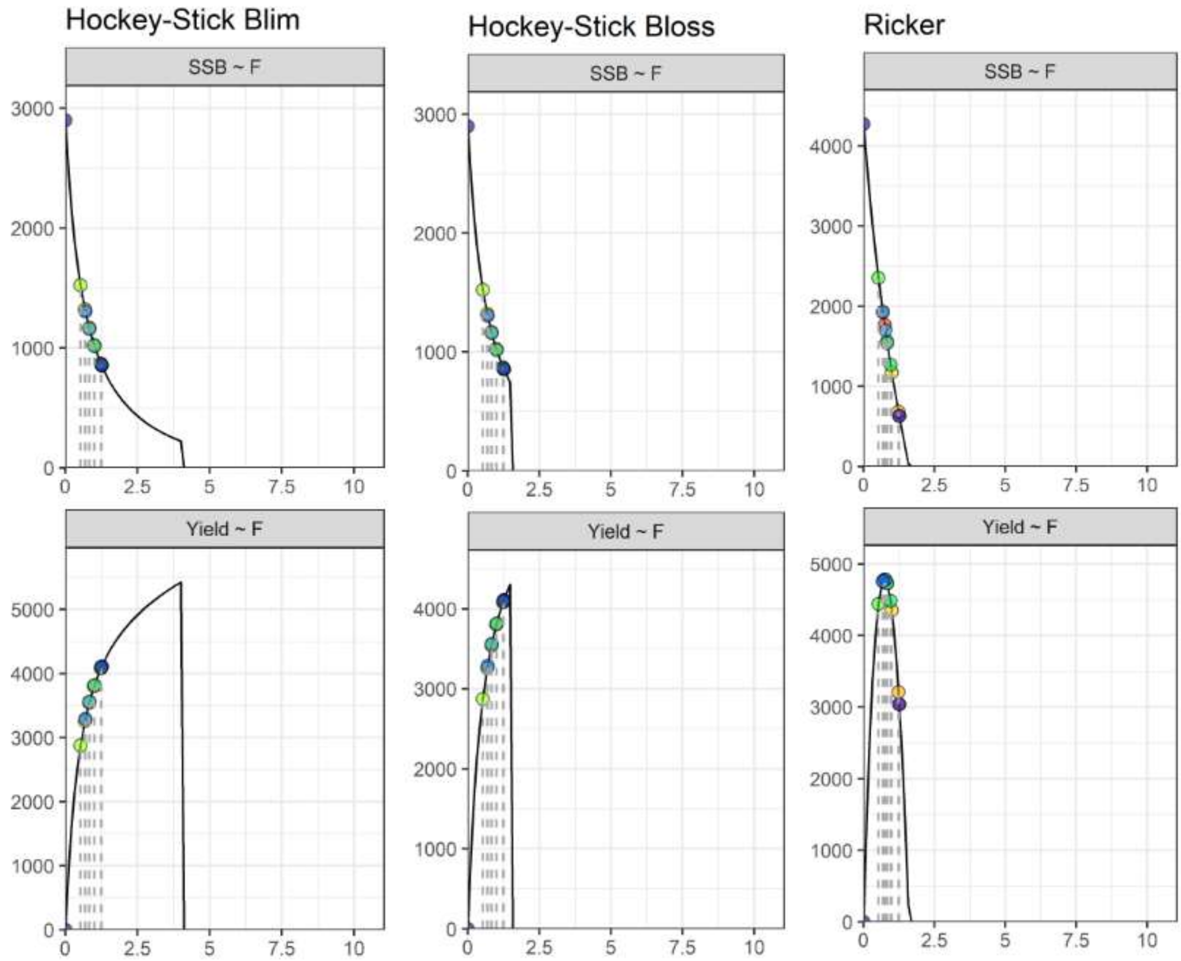


Figure 2.3.9.2. Biomass and Production curves as a function of F resulting from the alternative stock recruitment relationships for Deep-water rose shrimp in GSAs 8, 9, 10 & 11.

Table 2.3.9.2. F, yield and SSB for each of the F_{MSY} proxies and F ranges considered for Deep-water rose shrimp in GSAs 8, 9, 10 & 11 from the default SRR (HSBlim), HBloss and for Ricker.

		Ftarget			Flower			Fupper		
		F	Yield	SSB	F	Yield	SSB	F	Yield	SSB
HSBlim	f0.1_ranges	1.26	4110	855	1.08	3905	969	NaN	NaN	NaN
HSBlim	spr.30_ranges	1.23	4083	870	1.06	3879	983	NaN	NaN	NaN
HSBlim	Fspr35_ranges	0.998	3804	1024	0.87	3613	1129	NaN	NaN	NaN
HSBlim	Fspr40_ranges	0.83	3545	1166	0.733	3367	1263	0.733	3367	1263
HSBlim	Fb35_ranges	1.01	3815	1018	0.878	3626	1122	NaN	NaN	NaN
HSBlim	Fb40_ranges	0.844	3570	1153	0.744	3387	1252	0.744	3387	1252
HSBloss	f0.1_ranges	1.26	4110	855	1.08	3905	969	NaN	NaN	NaN

HSBloss	spr.30_ranges	1.23	4083	870	1.06	3879	983	NaN	NaN	NaN
HSBloss	Fspr35_ranges	0.998	3804	1024	0.87	3613	1129	NaN	NaN	NaN
HSBloss	Fspr40_ranges	0.83	3545	1166	0.733	3367	1263	NaN	NaN	NaN
HSBloss	Fb35_ranges	1.01	3815	1018	0.878	3626	1122	NaN	NaN	NaN
HSBloss	Fb40_ranges	0.844	3570	1153	0.744	3387	1252	NaN	NaN	NaN
Ricker	msy_ranges	0.908	4274	1277	0.685	4060	1637	1.14	4060	948
Ricker	f0.1_ranges	1.26	3775	785	0.514	3586	1949	1.32	3586	706
Ricker	spr.30_ranges	1.23	3846	819	0.533	3654	1912	1.3	3654	733
Ricker	Fspr35_ranges	0.998	4240	1142	0.669	4028	1665	1.15	4028	925
Ricker	Fspr40_ranges	0.83	4249	1398	0.673	4036	1659	1.15	4036	930
Ricker	Fb35_ranges	1.01	4232	1127	0.665	4019	1673	1.16	4019	919
Ricker	Fb40_ranges	0.921	4273	1256	0.685	4060	1638	1.14	4060	947

Table 2.3.9.3. $F_{p.05}$ values in relation to the risk of dropping SSB below current Blim adopted for Deep-water rose shrimp in GSAs 8, 9, 10 & 11, as obtained for the different SRR models.

$F_{p.05}$	HSBlim	HSBloss	Ricker
Risk 3	2.282	1.505	1.605
Risk 1	2.979	1.705	1.958

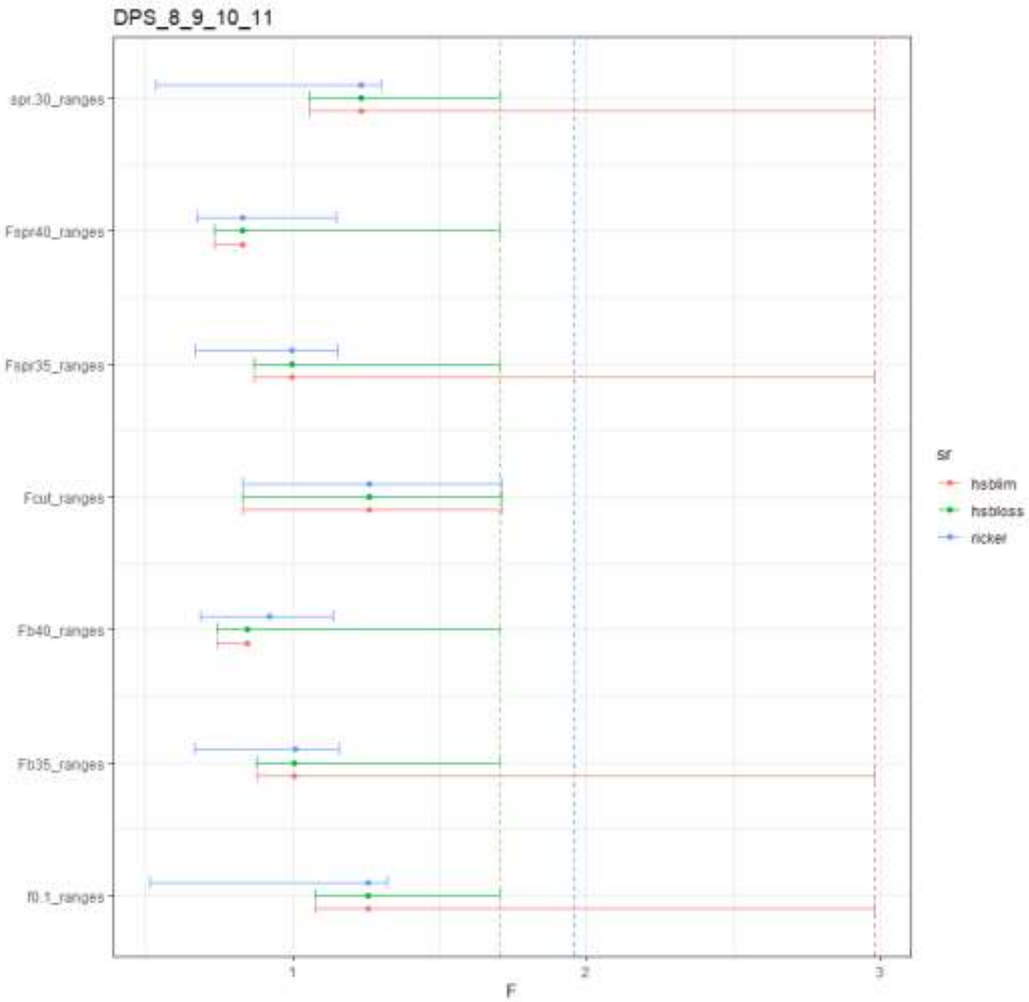


Figure 2.3.9.3 F_{MSY} proxy ranges for the different SRR models for Deep-water rose shrimp in GSAs 8, 9, 10 & 11. The three dashed vertical lines refer to the $F_{p.05}$ values (type 1 risks) corresponding to the HSBlim, HSBloss and Ricker SRRs.

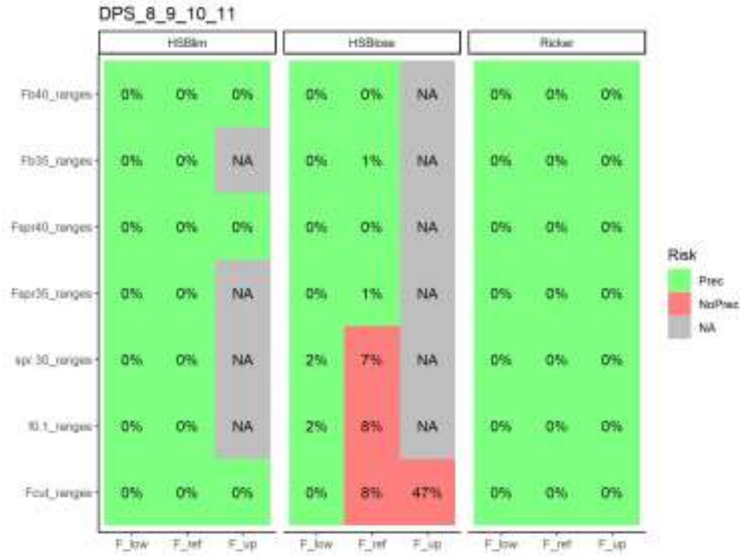


Figure 2.3.9.4. Probability of SSB being below B_{lim} (risk type 1) for alternative F_{MSY} proxies and corresponding F ranges for the default SRR (HSBlim) and HSBloss for Deep-water rose shrimp in GSAs 8, 9, 10 & 11 (F_{sigma}=0.2).

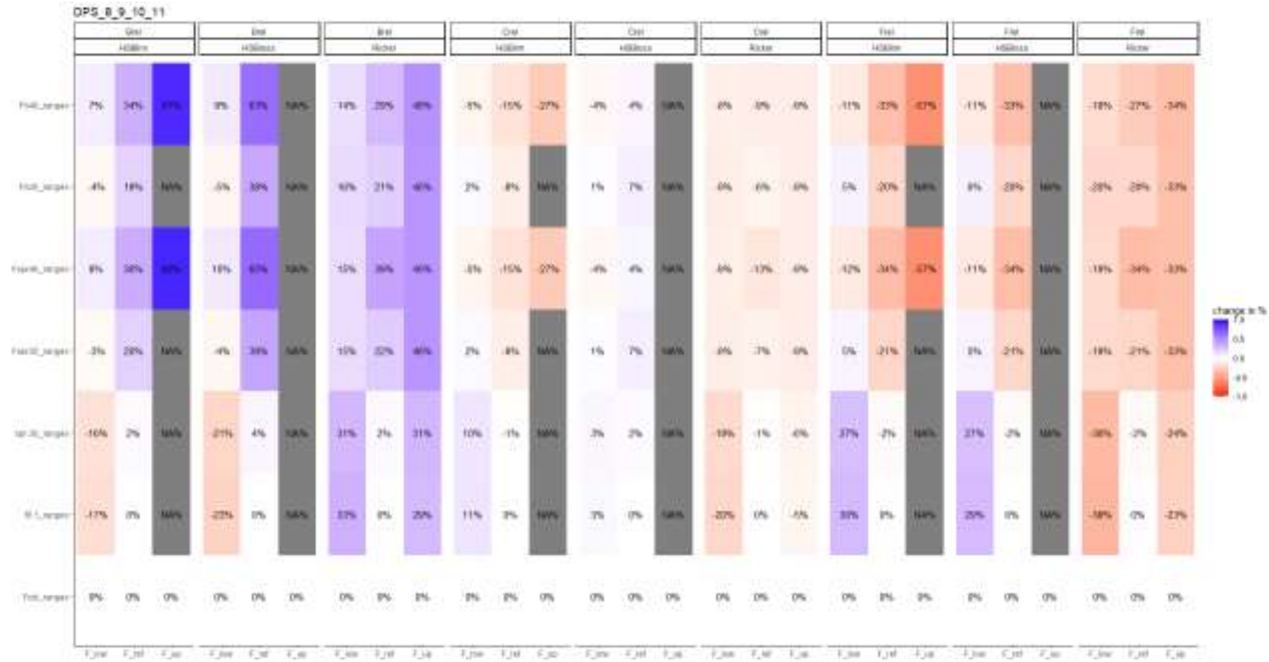


Figure 2.3.9.5 Changes induced by adopting alternative F_{MSY} proxy and F ranges relative to the current F target and F ranges (from F(0.1) and the linear models respectively), in terms biomass, catches and fishing mortalities for the HSBlim default SRR assumption for Deep-water rose shrimp in GSAs 8, 9, 10 & 11.

2.3.10 Summary results for Red mullet in GSA 9

- **The stock objects** were those produced in EWG 2022-09 with data up to 2021, because of the lack of the MEDITS survey in EMU2 in 2022.

- **Biology**: Ages 0-4+. High natural mortality (M>=0.59) but decreasing with ages (from age 0 to 4+, M decreases from 1.52 to 0.59). Full maturity is reached at age 1.
- **Stock status**: Current level of fishing mortality (about 0.4) is below the reference point $F_{0.1}$, used as a proxy of F_{MSY}. Current biomass is above B_{lim} and B_{pa} but below $B_{F0.1}$.
- **Current F target and ranges**: F_{MSY} is based on $F_{0.1}$=0.50. The corresponding SSB is $B_{F0.1}$=1846 t. The F ranges for $F_{0.1}$ based on the empirical linear models are 0.33 – 0.68.
- **Current SRR assumption and Blim definition**: Under no clear SRR the Geometric Mean (GM) recruitment is used to force a HS with a plateau at the GM and with a break point at 25%$B_{F0.1}$ (Figure 2.3.10.1). This implies B_{lim} (462 t) is about 10.4% of B_0 and it is placed to left of all previous biomass observations (below B_{loss}). It implies a steepness of 1, because B_{lim} is below 20%B_0.
- **Alternative SRR and potential alternative Blim definitions**: Statistical comparisons of the fitting of different SRR models shows that Ricker followed by BH fits best to the data in terms of AIC and BIC (Table 2.3.10.1), with an Rmax or R0 estimate consistent with the maximum past observed recruitments (Figure 2.3.10.1) while HSBlim follow the GM but with a break point at B_{lim} to the left of the observations (well below Bloss). It cannot be discarded Blim to be above current definition of Blim at 25%B0.1, for instance by using Bloss, which has the same statistical fitting. Blim will increase by 28% and will result in a value of 592 t at 30% B0.1 and 13% of B0. For comparative purposes BH and Ricker SRRs were also used to generate Fmsy ranges (and BH for $F_{p.05}$ definition too).
- **Production curves:** A comparison of the production curves resulting from the alternative SRRs is shown in Figure 2.3.10.2. The production curve resulting from the default HSBlim is a continuously growing curve, not reaching any peak and preventing thus the definition of F_{MSY} or of F_{upper} for any of the alternative F_{MSY} proxies. The production curves associated to the BH and Ricker are dome shape (not shown).
- **F_{MSY} or F_{MSY} proxies and corresponding ranges**: The values for the different F_{MSY} or F_{MSY} proxies and corresponding ranges corresponding to the different SRRs are shown Table 2.3.10.2 and Figure 2.3.10.3. New estimates of $F_{0.1}$ and F40%SPR are almost identical.
- **Assessment of Risks and of $F_{p.05}$ by SRR models**. The risks of falling below B_{lim} were calculated through a forward projection (see methods) for the HSBlim and BH models (Table 2.3.10.3). The $F_{p.05}$ estimates for the HSBlim were 1.92 for risk type 1 and 1.38 for risk type 3. The respective $F_{p.05}$ values were slightly higher for the BH SRR (based on 100 simulations only) All the results were shown for an assessment plus implementation error of intended fishing mortality of 0.2 (Fsigma=0.2).
- **Discussion on Fmsy target and ranges**:

  This a type 3 stock corresponding to a continuously increasing production curve for the default HSBlim. In these cases, EWG 24 02 has considered to keep a priori the current Ftarget ($F_{0.1}$) and Franges (from the empirical models). In this case, the current F_{MSY} based on $F_{0.1}$ and the proposed F_{MSY} target as well as their associated ranges are compliant with not exceeding risks above 0.05, as stated in the West Med EU MAP (Figure 2.3.10.3).

  Figure 2.3.10.5 shows the relative implications of adopting alternative FMSY proxies and F ranges versus the current F ranges, in terms biomass, catches and fishing mortalities for the HSBlim default SRR assumption. Both the new estimates of $F_{0.1}$ and the F40%SPR are the ones resulting in the smallest changes versus current F ranges. However, before adopting straightforward the current F target and ranges, some discussion about the sustainability of F0.1 and associated ranges follow:

  - The current Ftarget and Franges (based on the linear models) are compliant with not exceeding $F_{p.05}$, implying risks <= 0.05 for the SSB of falling below Blim.

- Evaluation of risks for other alternative candidate SRR models which might have resulted in a more risk-averse modelling than the HSBlim (like BH or Ricker) were not made by the group due to lack of time. Although preliminary assessment of the $F_{p.05}$ for BH SRR based on a 100 iterations resulted in values slightly higher than for HSBlim.
- Suggestion: EWG 2024-09 could revisit these other alternative SRR models (like BH and Ricker) to make sure that the Fp.05 of these alternative models does not drop below Fupper of the linear models, but the difference between the Fupper of the current ranges and the $F_{p.05}$ of the HSBlim is large enough as to presume they could be also safe versus other slightly more restrictive $F_{p.05}$.
- The Fmsy ranges resulting from the BH SRR is less risk averse, ranging between 0.53 and 1.51 for the Flower and upper, respectively (Table 2.3.10.3), hence exceeding the Fupper the $F_{p.05}$ for the HSBlim. More risk prone ranges (but equal Fupper) was obtained for Ricker model. Therefore, no evident alternative to the current F ranges were found for this stock.

- **Conclusions**: *To be sure that the Ftarget and F ranges are robust to the current uncertainties on the SRR models, the only proposal which can be put forwards is to stay at the previously stablished Fmsy proxy ranges from the $F_{0.1}$ and definition of F ranges from the empirical linear model*.

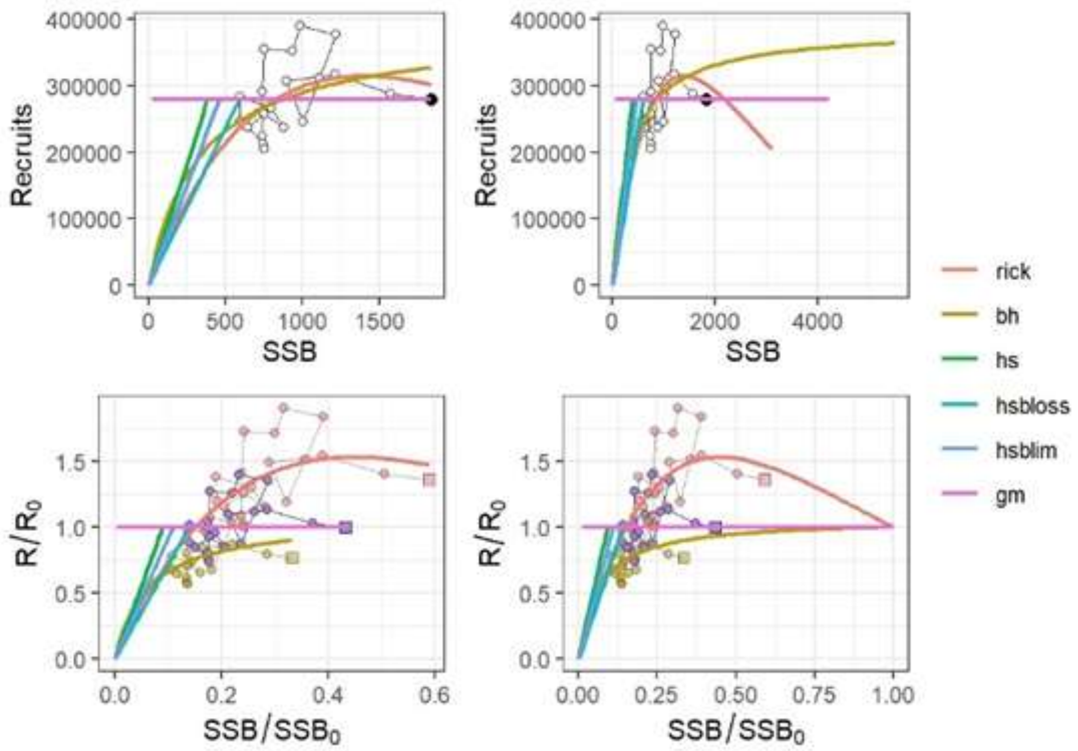


Figure 2.3.10.1 Stock recruitment relationships for red mullet in GSA 9, both in absolute (top row) and in relative terms to R0 and B0 (bottom row) for two scales in the X axis (left and right panels).

Table 2.3.10.1 Statistical comparison of the fitting of different SRR models for Red mullet in GSA 9

MODEL	AIC	BIC
Ricker	-10.277	-7.289
Beverton-Holt	-8.909	-5.922
Hockey-stick	-5.163	-2.176
Hockey-stick at Bloss	-7.278	-5.287
Hockey-stick at Blim	-7.278	-5.287
Geometric mean	-7.278	-5.287

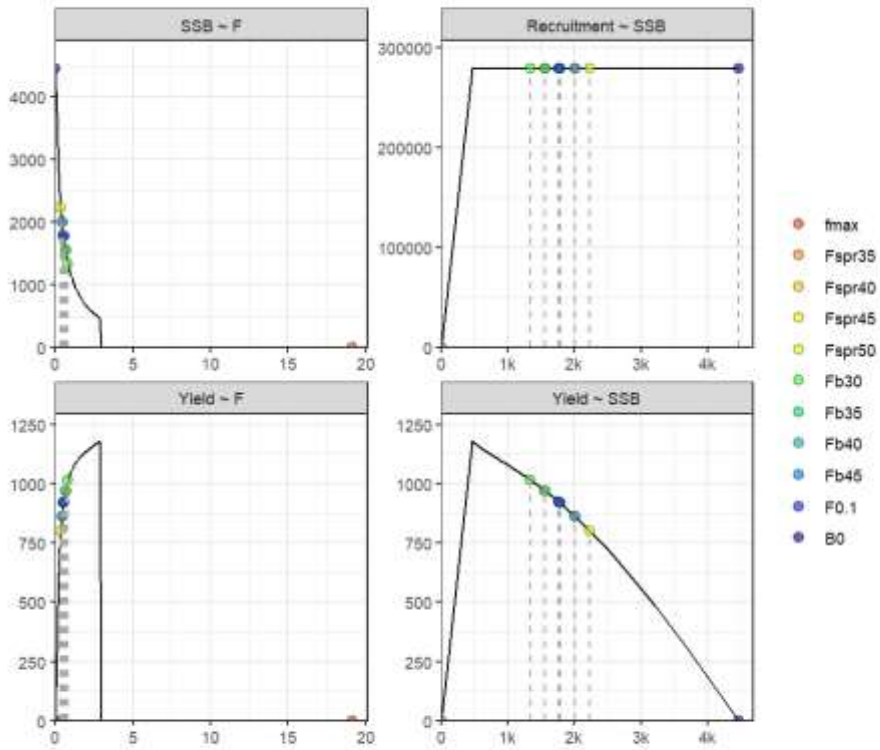


Figure 2.3.10.2 Biomass and Production curves as a function of F resulting from the alternative plausible stock recruitment relationships under consideration for red mullet in GSA 9.

Table 2.3.10.2. F, yield and SSB for each of the F_{MSY} proxies and F ranges considered for red mullet in GSA 9 from the default SRR (HSBlim) and alternative BH and Ricker SRRs.

		Ftarget	Flower	Fupper	Ftarget	Flower	Fupper	Ftarget	Flower	Fupper
SRR	Case	F	Yield	SSB	F	Yield	SSB	F	Yield	SSB
HSBlim	f0.1_ranges	0.541	922	1770	0.458	876	1954	0.458	876	1954
HSBlim	spr.30_ranges	0.825	1017	1338	0.646	966	1581	NaN	NaN	NaN
HSBlim	Fspr35_ranges	0.659	970	1560	0.54	922	1772	0.54	922	1772
HSBlim	Fspr40_ranges	0.534	919	1783	0.453	873	1966	0.453	873	1966
HSBlim	Fb35_ranges	0.659	971	1559	0.54	922	1771	0.54	922	1771
HSBlim	Fb40_ranges	0.535	919	1782	0.453	873	1966	0.453	873	1966
BH	msy_ranges	0.897	1153	1409	0.529	1096	2145	1.51	1096	841
BH	f0.1_ranges	0.541	1100	2111	0.433	1045	2453	1.8	1045	677
BH	spr.30_ranges	0.825	1152	1515	0.525	1094	2154	1.51	1094	835
BH	Fspr35_ranges	0.659	1133	1822	0.487	1077	2270	1.62	1077	770
BH	Fspr40_ranges	0.534	1098	2129	0.429	1043	2466	1.82	1043	670
BH	Fb35_ranges	0.569	1110	2035	0.448	1055	2400	1.75	1055	702
BH	Fb40_ranges	0.45	1056	2392	0.379	1005	2662	2.01	1005	584
Ricker	msy_ranges	1.12	1185	1186	0.783	1126	1552	1.51	1126	863
Ricker	f0.1_ranges	0.541	986	1892	0.485	937	1984	1.94	937	565
Ricker	spr.30_ranges	0.825	1141	1501	0.689	1084	1675	1.63	1084	771
Ricker	Fspr35_ranges	0.659	1067	1716	0.576	1014	1836	1.79	1014	660

Ricker	Fspr40_ranges	0.534	981	1902	0.479	932	1994	1.95	932	560
Ricker	Fb35_ranges	1.2	1182	1112	0.776	1123	1561	1.52	1123	856
Ricker	Fb40_ranges	1.03	1182	1272	0.774	1123	1564	1.52	1123	854

Table 2.3.10.3 $F_{p.05}$ values in relation to the risk of dropping SSB below current B_{lim} for red mullet in GSA 9. Note that BH results are based on 100 iterations.

$F_{p.05}$	HSBlim	BH*
Risk 3	1.377	1.5
Risk 1	1.915	2

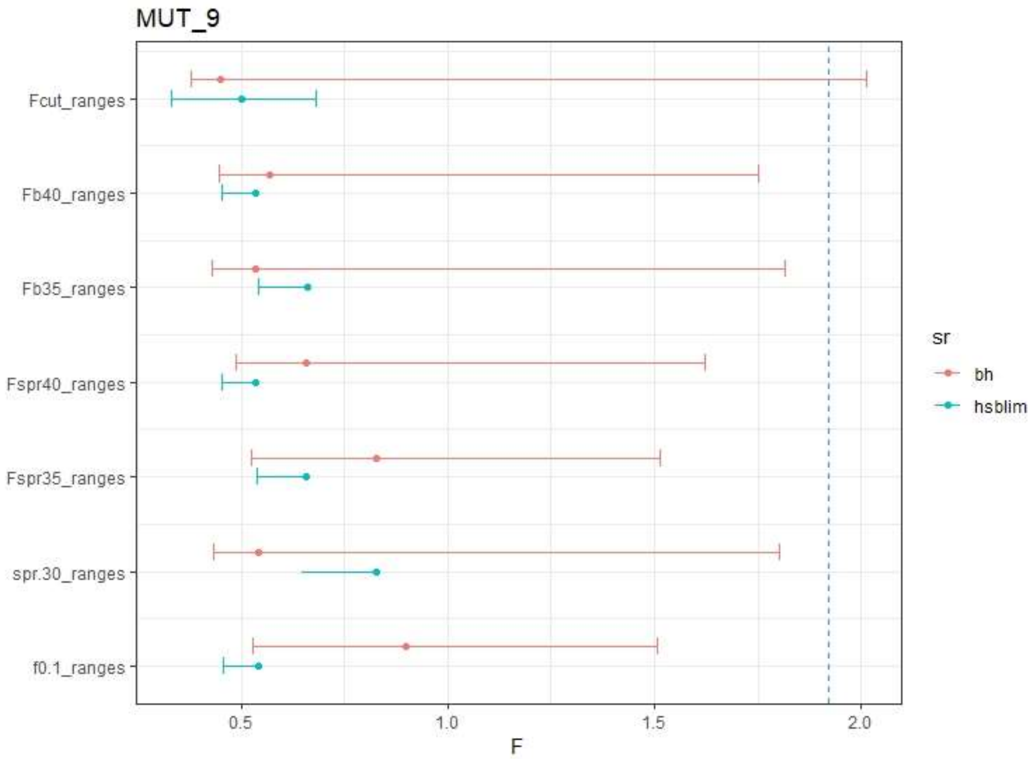


Figure 2.3.10.3 Fmsy.proxy ranges for the different SRR models for red mullet in GSA 9. The dashed vertical lines refer to the $F_{p.05}$ value (type 1 risks) for HSBlim.

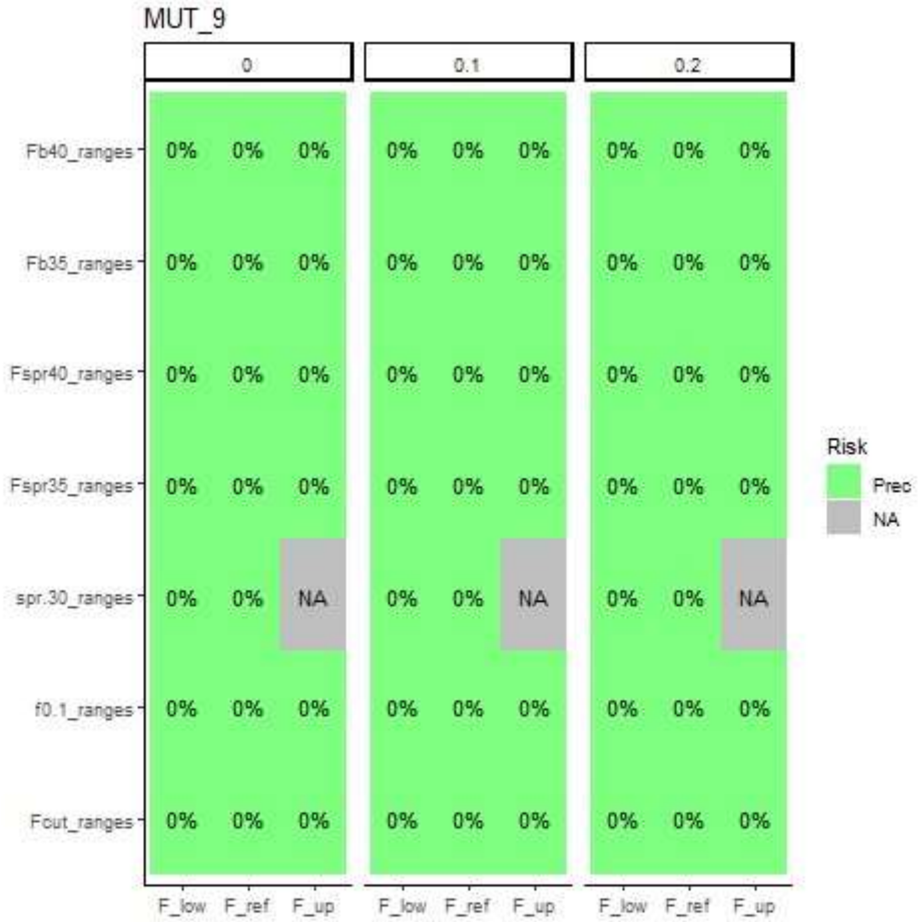


Figure 2.3.10.4. Probability of SSB falling below B_{lim} (risk type 1) for alternative F_{MSY} proxies and the corresponding F ranges for the default SRR (HSBlim) for red mullet in GSA 9. (Fcut_ranges refers to the current F ranges produced by the empirical models). The vertical panels correspond to Fsigma equal to 0, 0.1 and 0.2.

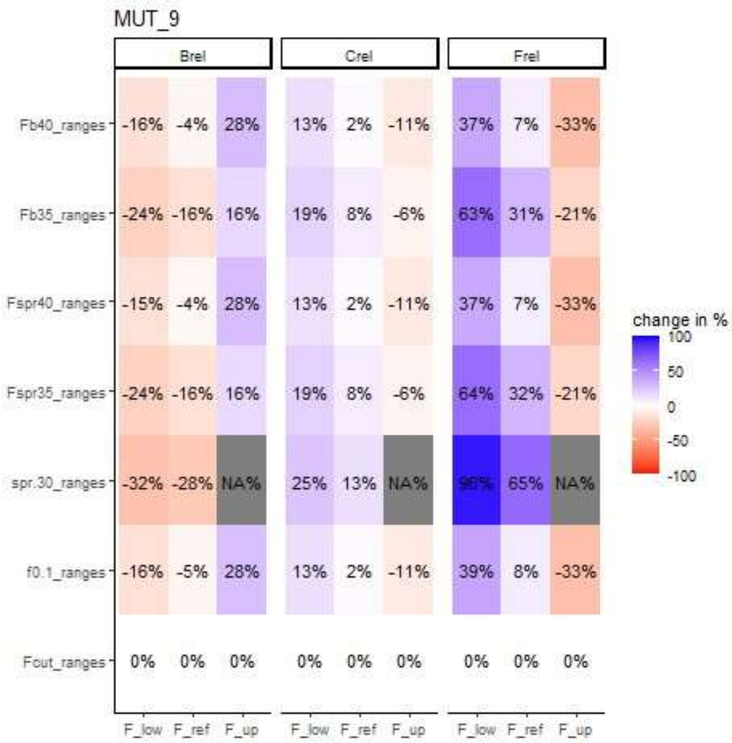


Figure 2.3.10.5 Changes in terms biomass, catches and fishing mortalities induced by adopting alternative F_{MSY} proxies and corresponding F ranges relative to the current F target and F ranges (from $F_{0.1}$ and the linear models respectively, named as Fcut_ranges), using the default SRR (HSBlim) for red mullet in GSA 9.

2.3.11 Summary results for Norway lobster in GSA 9

- **The stock objects** were those produced in EWG 2023-09 with data up to 2022.
- **Biology**: Ages 1-9+. Decreasing natural mortalities with ages (from age 1 to 9+ decreasing from 0.75 to 0.23). Slow maturation reaching full maturity at age 4.
- **Stock status**: After several years of overfishing, recent reductions of F has led it around current F=0.14 just above $F_{0.1}$ of 0.127, with current biomass above B_{pa}.
- **Current F target and ranges**: F_{MSY} is based on $F_{0.1}$=0.127. The corresponding SSB is $B_{F0.1}$=1021 t. The F ranges for $F_{0.1}$ based on the empirical linear models are 0.087 – 0.18.
- **Current SRR assumption and Blim definition**: Under no clear SRR the Geometric Mean (GM) is used to force a HS SRR with a plateau at the GM and with a break point at 25%$B_{F0.1}$ (Figure 2.3.11.1). This implies Blim (255 t) is about 10.4% B_0 and it is placed below Bloss (which is around 300 t). It implies a steepness of 1, an extremely high value.
- **Alternative SRR and potential alternative Blim definitions**: Statistical comparison of the fitting of different SRR models shows that Beverton-Holt could be a better SRR in terms of AIC and BIC than the rest of models (Table 2.3.11.1), with an R0 estimate consistent with the maximum past observed Recruitment . It was therefore considered that the BH SRR might be a good alternative to represent the SR dynamics, showing a faster reduction of Recruitment versus spawning biomass than the HSBlim (Figure 2.3.11.1). That curvature of the SRR to the left of the center of gravity of the observations is the one which matters the most for the definition of the Fupper range relative to F_{MSY} and risks to B_{lim} as fishing mortality increases. The fitted BH imply steepness of 0.78. If Blim would set at 50% of R0

for the Beverton and Holt SRR model then B_{lim} would be set at 271 t (very similar to current Blim), but if B_{lim} would be set at 25%$B_{F0.1}$ of the BH SRR then it would be set at 353 t.

- **Production curves:** A comparison of the production curves resulting from the two selected SRR are shown in (Figure 2.3.11.2). Although the production curve resulting from the default HSBlim reaches to an F_{MSY} value (F_{max}) it becomes almost flat at higher F values (only decreasing slightly), just allowing to estimate the F_{upper} for the F_{MSY} of the HSBlim, but not for the other FMSY proxy values (as for the $F_{0.1}$ for which there is no defined F_{upper}). Finally, the production curve corresponding to the BH SRR is a well-defined dome shape curve, with a neat peak corresponding to an F_{MSY}, and asymmetrical descending shape as F increases, therefore the corresponding ranges are narrower than in the HSBlim model.
- **F_{MSY} or F_{MSY} proxies and corresponding ranges**: The values for the different Fmsy.proxy ranges are shown in Table 2.3.11.2 and Figure 2.3.11.3.

Assessment of Risks and of $F_{p.05}$ by SRR models. The risks of falling below the previously adopted Blim (by STECF) were calculated through a forward projection (see methods) for the different SRR models (Table 2.3.11.3). The $F_{p.05}$ estimates are rather consistent for the two SRR models, being slightly smaller for the BH than for the HSBlim for the Type 1 error, being the contrary for the Type 3 errors. In addition, $F_{p.05}$ corresponding to Risk 3 type of estimates are smaller than those corresponding to Type 1 risks. Therefore, in order to be precautionary to all the plausible ranges of SRRs considered for this stock the F ranges should be below $F_{p.05}$ values of the HSBlim SRR curve for risk type 3 (=0.3). As a result, all the upper limits that were feasible to be estimated for reference points with Hockey-stick Blim model (as for the F35% or F_{MSY}), were higher than $F_{p.05}$, which means that they couldn't be used as the upper limits for the F ranges related to these reference points. All the results were shown for an assessment plus implementation error of intended fishing mortality of 0.2 (Fphi=0.2).

- **Discussion on F_{MSY} target and ranges**: This a type 2 stock corresponding to productions curves showing an F_{max} but beyond which the curve is almost flat, so that F_{upper} is usually undefined (NA). Furthermore, these are stocks for which a Hockey-stick was fitted with a break point either at around the lowest observed S-R pairs values (including Bloss) or within the cloud of S-R observed pairs. In these cases, three alternatives have been considered: a) keep current Ftarget ($F_{0.1}$) and empirical Franges b) the same but setting F_{upper} as F_{max} provided they are compliant with the risks to B_{lim} c) adopt F_{MSY} and ranges from an alternative SRRs provided they are compliant with the risks to B_{lim}.

  In this case the current F_{MSY} based on $F_{0.1}$ and the proposed F_{MSY} target as well as their associated ranges are compliant with not exceeding risks above 0.05 as stated in the West Med EU MAP (Figure 2.3.11.4). Figure 2.3.11.5 shows the relative implications of adopting alternative F_{MSY} proxies and F ranges versus the current F ranges, in terms biomass, catches and fishing mortalities for the default HSBlim and for the BH SRR assumption. However, before adopting straightforward the current F target and F ranges, there are several points requiring discussion about the sustainability of F0.1 and of those ranges:

  - The Beverton-Holt (which showed the best AIC) would imply a steepness of 0.78, smaller than the assumed one (=1) for the HSBlim. Therefore, the actual productivity of the stock is uncertain and can be lower than currently assumed.
  - The $F_{p.05}$ derived from HSBlim and BH (Type 3 risk estimates) are placed around 0.3, well above the current Ftarget ($F_{0.1}$ = 0.13) and above F_{max}=0.26. The F_{upper} value of the current F ranges (= 0.18) is also placed well below the $F_{p.05}$ for risk type 3 of the current HSBlim. Therefore, the current Ftarget and Franges (based on the empirical models) are compliant with not exceeding $F_{p.05}$, implying risks <= 0.05 for the SSB of falling below B_{lim}.
  - In the absence of a proper definition of F_{upper} relative to $F_{0.1}$, F_{max} could be used as F_{upper} for this stock as it also smaller than $F_{p.05}$. Furthermore, F_{max} is about the same as the F_{upper} obtained for the F_{MSY} ranges corresponding to BH. So, it might also coincide with the actual F_{MSY} range for the alternative plausible SRR (BH).

- The F_{upper} obtained for the F_{MSY} ranges estimated from the HSBlim is not smaller than $F_{p.05}$ (0.3) and hence such F_{MSY} upper range cannot be used for management purposes.
- The F_{MSY} target and F_{MSY} ranges obtained for the alternative plausible SRR (the BH) are smaller than $F_{p.05}$ and could be used for management purposes because they are based in a risk averse SRR relationship (lower steepness than currently assumed HSBlim), while shows the best fitting to the data.
- The three alternative proposals for definition of Ftarget and Franges are robust to the current uncertainties on the plausible models of SRR governing the dynamics of this stock. The current Franges based on the linear models would result in narrowest of the allowed F ranges (0.09-0.18), being placed at smaller F values than the other potential ranges. Setting F_{upper} at F_{max} will expand further this range up to 0.26. Finally, moving to the alternative SRR model (BH) it will allow an Frange of 0.10-0.23 with an Ftarget=F_{MSY}(BH) of 0.16, which supposes a rather similar range as the former one but with a slightly smaller F_{upper}.

- **Conclusions**: Current F target and F ranges risk are acceptable in relation to $F_{p.05}$, but its range could be widened up to around 0.26 if setting F_{upper} at Fmax or by adopting the Ftarget and ranges corresponding to the alternative SRR (BH) for this Norway lobster in GSA 9. EWG 24-02 proposes to adopt Option 1 for Norway Lobster in GSA 9, i.e., adopting as F target and Flower ranges those estimated relative to $F_{0.1}$, but setting Fupper at Fmax, resulting in F(0.1) target at 0.13 and F ranges 0.11-0.26.

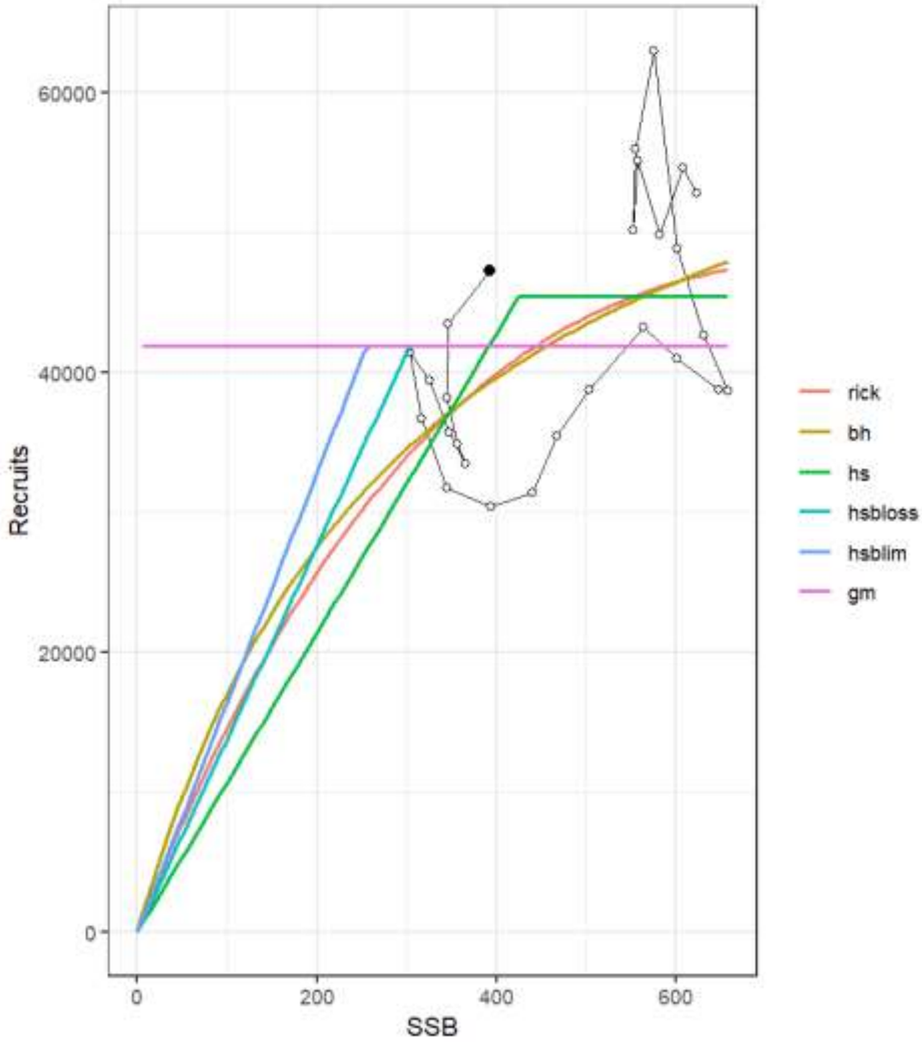


Figure 2.3.11.1 Stock recruitment relationships for Norway lobster in GSA 9, both in absolute (top row) and in relative terms to R0 and B0 (bottom row) for two scales in the X axis (left and right panels).

Table 2.3.11.1 Statistical comparison of the fitting of different SRR models for Norway lobster in GSA 9

Model	AIC	BIC
Beverton-Holt	-79.52513	-76.93345
Ricker	-79.35163	-76.75996
Hockey-stick	-74.32406	-71.73239
Geomean	-71.62621	-70.33037
Hockey-stick Blim	-71.62621	-70.33037
Hockey-stick Bloss	-71.62621	-70.33037

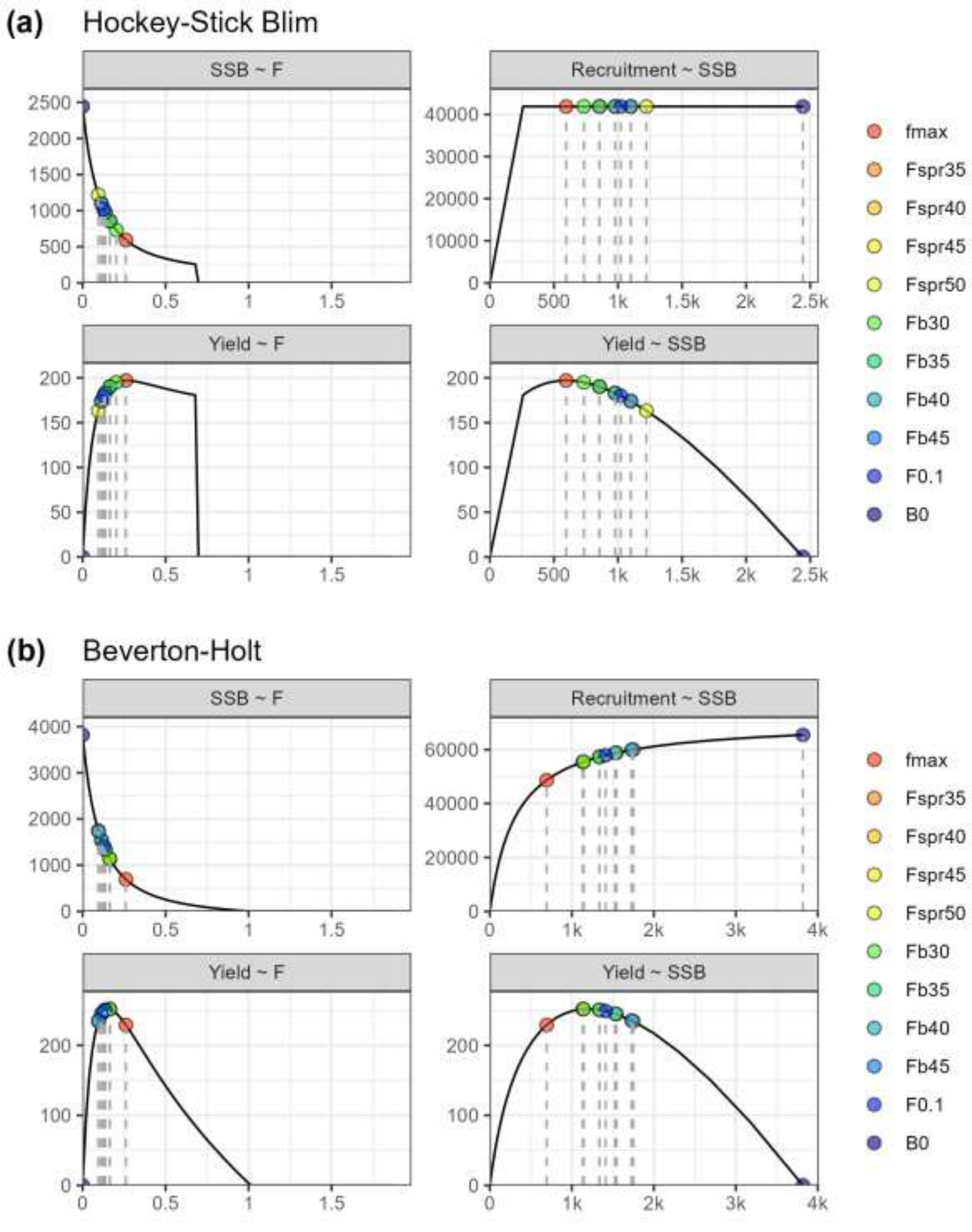


Figure 2.3.11.2 Biomass and Production curves as a function of F resulting from the alternative plausible stock recruitment relationships under consideration for Norway lobster in GSA 9.

Table 2.3.11.2. F, yield and SSB for each of the F_{MSY} proxies and F ranges considered for Norway lobster in GSA 9 from the selected SRRs.

		Ftarget	Flower	Fupper	Ftarget	Flower	Fupper	Ftarget	Flower	Fupper
SRR	Case	F	Yield	SSB	F	Yield	SSB	F	Yield	SSB
HSBlim	msy_ranges	0.261	197	595	0.151	187	911	0.516	187	328
HSBlim	f0.1_ranges	0.127	180	1022	0.107	171	1136	NA	171	1136
HSBlim	spr.30_ranges	0.202	195	733	0.143	185	944	0.561	185	305
HSBlim	Fspr35_ranges	0.165	190	856	0.129	181	1012	0.68	181	258
HSBlim	Fspr40_ranges	0.136	183	977	0.113	174	1101	NaN	NaN	NaN
HSBlim	Fb35_ranges	0.165	190	855	0.129	181	1012	0.68	181	259
HSBlim	Fb40_ranges	0.136	183	977	0.113	174	1101	NaN	NaN	NaN
BH	msy_ranges	0.155	252	1199	0.102	239	1657	0.228	239	812
BH	f0.1_ranges	0.127	249	1412	0.0978	237	1710	0.237	237	775
BH	spr.30_ranges	0.202	246	924	0.0935	234	1760	0.247	234	741
BH	Fspr35_ranges	0.165	252	1132	0.102	239	1663	0.229	239	807
BH	Fspr40_ranges	0.136	251	1338	0.1	238	1680	0.232	238	795
BH	Fb35_ranges	0.136	251	1336	0.1	238	1680	0.232	238	795
BH	Fb40_ranges	0.115	245	1527	0.0926	233	1772	0.249	233	733

Table 2.3.11.3 $F_{p.05}$ values in relation to the risk of dropping SSB below current B_{lim} for Norway lobster in GSA 9 under the selected SRRs.

$F_{p.05}$	HSBlim	BH
Risk 3	0.403	0.322
Risk 1	0.479	0.403

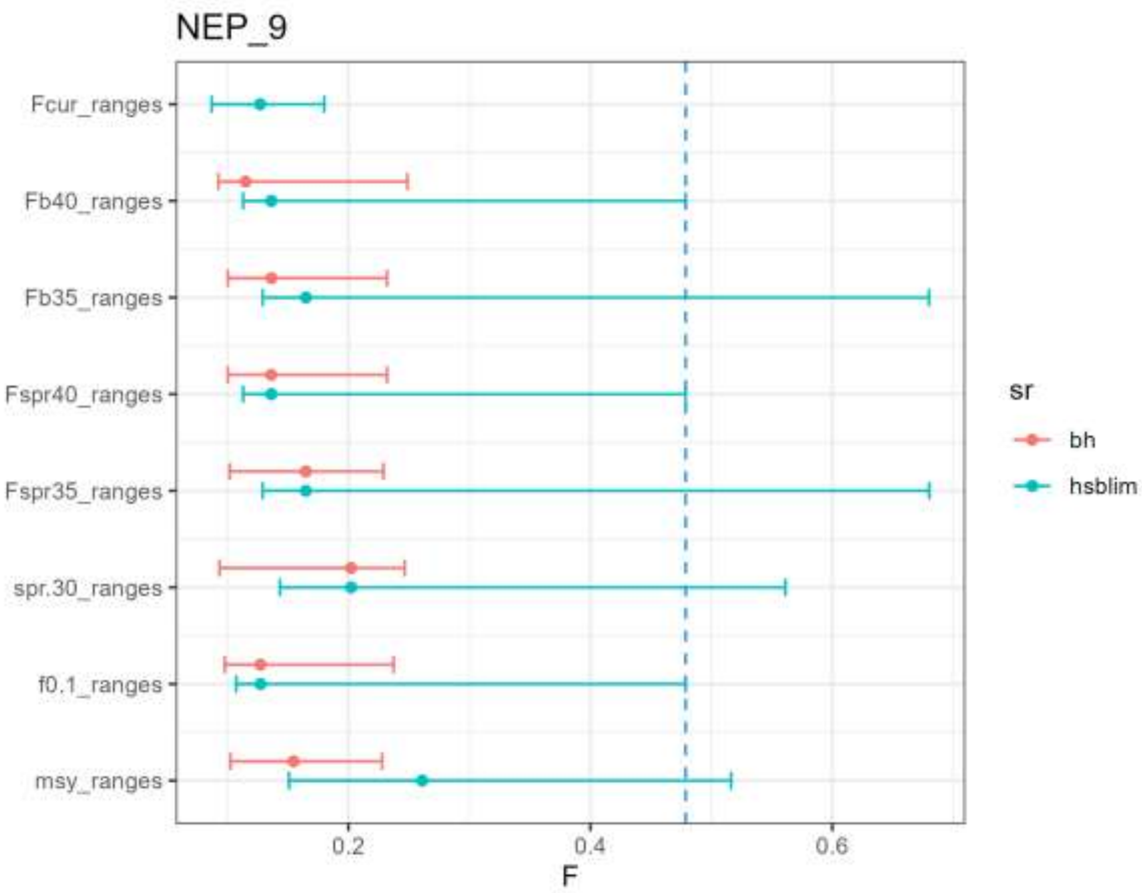


Figure 2.3.11.3 F_{MSY}.proxy ranges for the different SRR models for Norway lobster in GSA 9. The dashed vertical lines refer to the $F_{p.05}$ value (type 1 risks) corresponding to HSBlim.

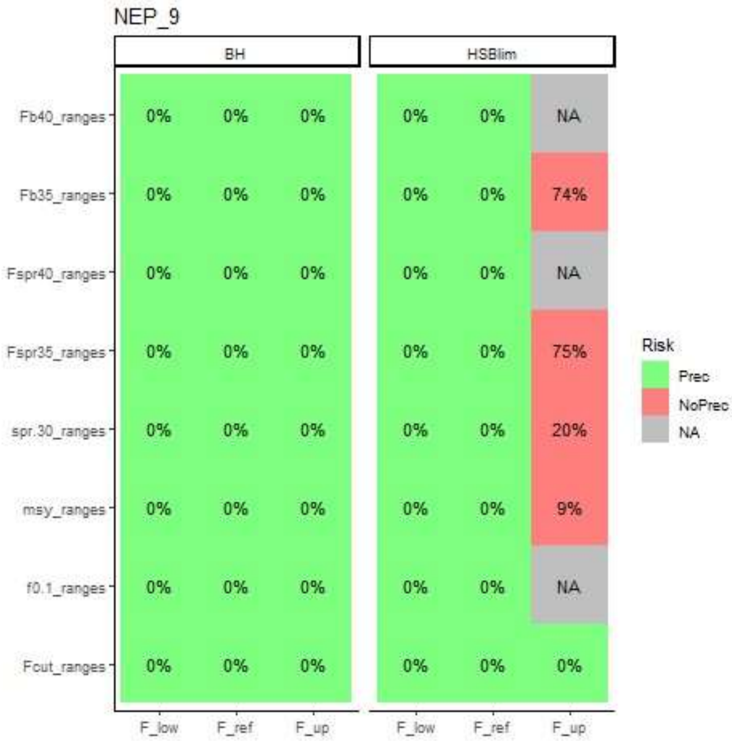


Figure 2.3.11.4. Probability of SSB being below B_{lim} (risk type 1) for alternative F_{MSY} proxies and corresponding F ranges for the default SRR (HSBlim) for Norway lobster in GSA 9for Fsigma equal to 0.2.

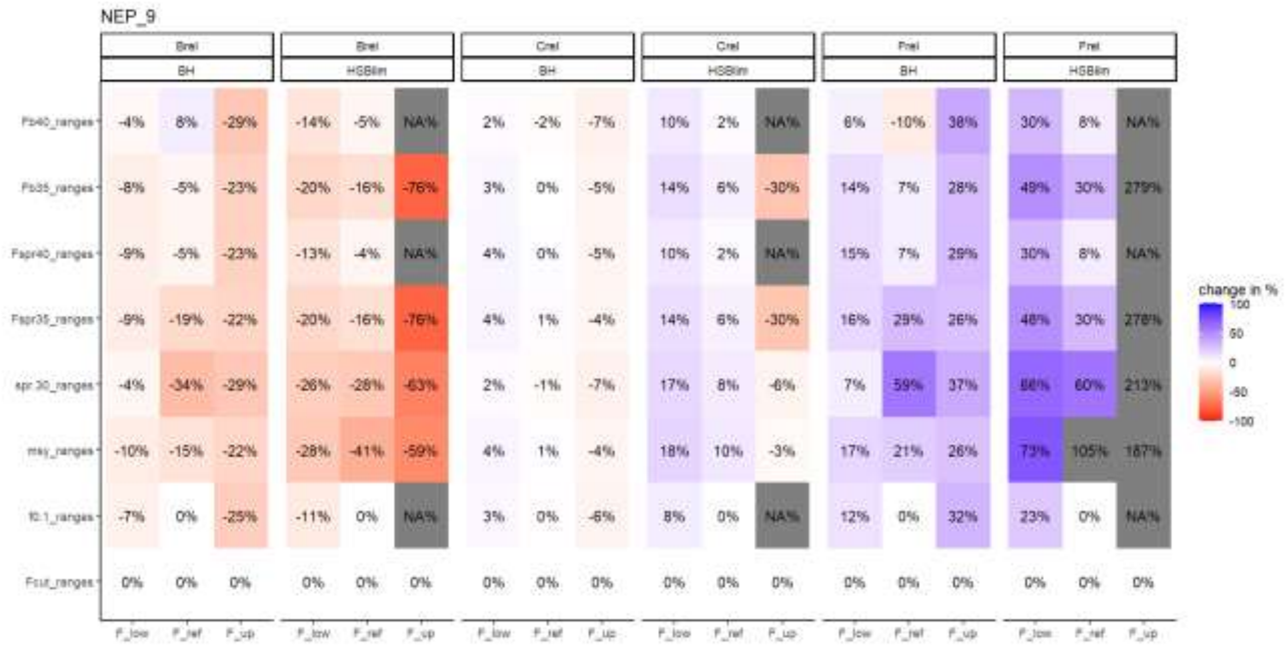


Figure 2.3.11.5. Changes in terms biomass, catches and fishing mortalities induced by adopting alternative F_{MSY} proxies and corresponding F ranges relative to the current F target and F ranges (from $F_{0.1}$ and the linear models respectively), for the default SRR (HSBlim) for Norway lobster in GSA 9.

2.3.12 *Summary results for Blue and red shrimp in GSA 5*

- **The stock objects** were those produced in EWG 2023-09 with data up to 2022.
- **Biology**: Ages 1-5+. High Natural mortality (M>=0.4), but decreasing with ages (from age 1 to 5 decreasing from 2.4 to 0.43). Early maturity at age 0 around 0.5 but slow maturation afterwards reaching full maturity at age 3.
- **Current F target and ranges**: F_{MSY} is based on $F_{0.1}$=0.34. The corresponding SSB is $B_{F0.1}$=309 t . The F ranges for F0.1 based on the empirical linear models are 0.23 – 0.46.
- **Stock status**: current level of fishing mortality (1.25) is 3.7 times the reference point $F_{0.1}$ which is used as a proxy of F_{MSY}. Current biomass is between B_{pa} and B_{lim}.
- **Current SRR assumption and Blim definition**: Under no clear SRR the Geometric Mean (GM) recruitment is used to force a HS SRR with a plateau at the GM and with a break point at 25%$B_{F0.1}$ (Figure 2.3.12.1). This implies B_{lim} (75 t) is about 8,3% B_0 and it is placed around the middle of the biomass observed in the past. It implies a steepness of 1, because it is placed below 20%B0.
- **Alternative SRR and potential alternative Blim definitions**: Statistical comparison of the fitting of different SRR models indicates that BH could be a better SRRs in terms of AIC than the HSBlim default model (**Table 2.3.12.1**), with an R0 estimate consistent with the maximum past observed Recruitments. There were other models which might better fit the

data as for instance HSBloss, therefore it is admitted that there is no complete coverage of the alternative potential SRRs for this stock. For the sensitivity exercise, the BH SRR was selected as an alternative SR model. This shows a slower reduction of recruitment with the spawning biomass than the HSBlim, being thus a more risk prone SRR model (Figure 2.3.12.1). In summary, we have selected two SRRs one being rather risk-averse (HSBlim) and the other rather risk-prone (BH). The fitted BH implies steepness of 0.71. If B_{lim} would be set at 50% of R0 for the BH SRR model then B_{lim} would be set at 72 t (very similar to current B_{lim}), and if B_{lim} would be set at 25%$B_{F0.1}$ of the BH SRR then it would be set at 81 t, again very similar to the current one. The Ricker model has a more similar slope towards the origin as the HSBlim and might have been an alternative SRR worth exploring, however it has poorer AIC and BIC indicators. It seems in any case that there is no large uncertainty about the B_{lim} selection.

- **Production curves:** A comparison of the production curves resulting from the different SRR models is shown in Figure 2.3.12.2. The production curve resulting from the default HSBlim is continuously growing curves, not reaching any peak and preventing thus the definition of F_{MSY} or of the F_{upper} for any alternative F_{MSY} proxies. The production curve corresponding to the BH SRR has a well defined F_{MSY} value (F_{max}=1.03) but at higher F values it becomes rather flat making the estimates of F_{upper} for the F_{MSY} or for $F_{0.1}$ to be reached just at extremely high values. Finally, the production curve from the Ricker model is a well-defined dome shape curve peaking around 1.2.
- **F_{MSY} or F_{MSY} proxies and corresponding ranges**: The values for the different Fmsy.proxy ranges are shown in Table 2.3.12.2 and Figure 2.3.12.3.
- **Assessment of Risks and of $F_{p.05}$ by SRR models**. The risks of falling below the previously adopted B_{lim} were calculated through a forward projection (see methods) for the HSBlim and BH models (Table 2.3.12.3). The $F_{p.05}$ estimates are rather consistent for the two SRR models, being slightly smaller for the BH (0.81 and 1.1) than for the HSBlim (0.86 and 1.18 for risk type 3 and 1 respectively). As the F_{MSY} target from the BH model was higher than $F_{p.05}$ it couldn't be used to propose any F ranges. All the results were shown for an assessment plus implementation error of intended fishing mortality of 0.2 (Fsigma=0.2).
- **Discussion on Fmsy target and ranges**:

  This a type 3 stock corresponding to a continuously increasing production curve for the default HSBlim. In these cases, EWG 24 02 has considered to keep a priori the current Ftarget ($F_{0.1}$) and Franges (from the empirical models). Figure 2.3.12.4 shows the risk type 1 in the long-term and Figure 2.3.12.5 shows the relative implications of adopting alternative Fmsy.proxy and F ranges versus the current F ranges, in terms biomass, catches and fishing mortalities for the HSBlim default SRR assumption. However, before adopting straightforward the current F target and ranges, there are several results requiring discussion about the sustainability of $F_{0.1}$ and associated ranges:

  - The $F_{p.05}$ derived from HSBlim and from BH (Type 3 risk estimates) are placed around 0.9 and 0.8, well above the current Ftarget ($F_{0.1}$ = 0.34) and above as well of the current F_{upper} value (0.46). Therefore, the current Ftarget and Franges (based on the empircal models) are compliant with not exceeding $F_{p.05}$, implying risks <= 0.05 for the SSB of falling below B_{lim}.
  - Re-estimation of $F_{0.1}$ values under HSBlim were consistent with the previous esimates.
  - F_{MSY} value (1.03) and the corresponding F_{upper} (3.77) from the BH SRR model cannot be used as guidance for management as they are placed above $F_{p.05}$, for the two SRR models tested for this stock. The fact that the F_{MSY} and ranges are higher than those derived from the HSBlim is partly due to the fact that in this particular case study this a riskier SRR in comparison with the HSBlim. There was no obvious SRR

alternative candidate model which would have resulted in a more risk-averse modelling than the HSBlim.

  - Future analysis of the Ricker model and their ranges and risks to Blim might be convenient for exploration, as it will be risk averse in comparison with BH, though it is unclear whether it will be actually risk averse in comparison with HSBlim.

- Conclusions: In order to be sure that the Ftarget and F ranges are robust to the current uncertainties on the SRR models the only proposal which can be put forward is that of staying at the previously stablished F_{MSY} proxy and ranges from the $F_{0.1}$ and definition of F ranges from the linear model.

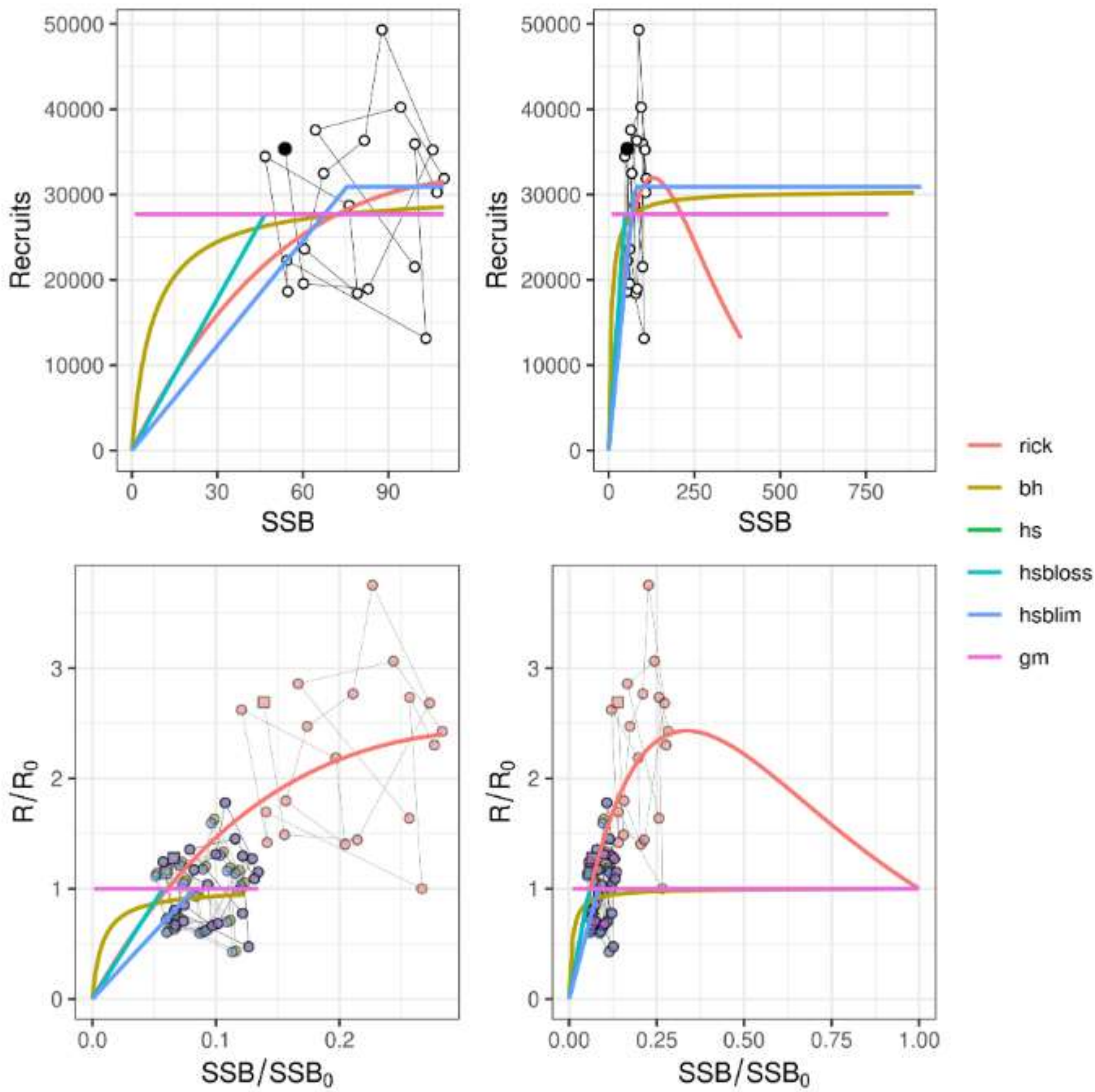


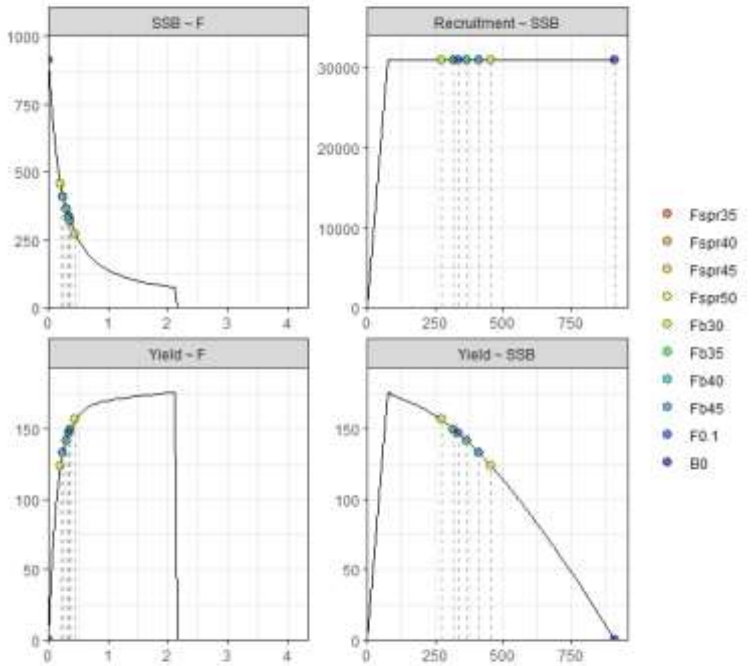
Figure 2.3.12.1 Stock recruitment relationships for blue and red shrimp in GSA 5, both in absolute (top row) and in relative terms to R0 and B0 (bottom row) for two scales in the X axis (left and right panels).

Table 2.3.12.1 Statistical comparison of the fitting of different SRR models for blue and red shrimp in GSA 5.

Model	AIC	BIC
Ricker	20.1	23.09
Beverton-Holt	18.7	21.69
Hockey-stick	18.79	21.78
Hockey-stick at Bloss	16.68	18.67

Hockey-stick at Blim	19.5	21.49
Geometric mean	16.68	18.67

a)



b)

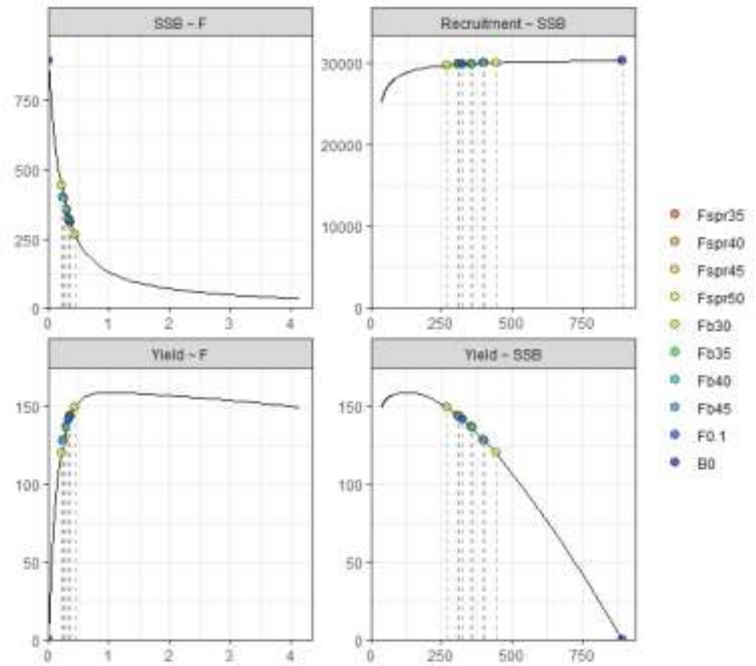


Figure 2.3.12.2 Biomass and Production curves as a function of F resulting for the a) HSBlim and b) BH SRR for Blue and red shrimp in GSA 5.

Table 2.3.12.2 F, yield and SSB for each of the F_{MSY} proxies and F ranges considered for blue and red shrimp in GSA 5 from HSBlim and BH models.

		Ftarget	Flower	Fupper	Ftarget	Flower	Fupper	Ftarget	Flower	Fupper
SRR	Case	F	Yield	SSB	F	Yield	SSB	F	Yield	SSB
HSBlim	f0.1_ranges	0.338	147	336	0.285	140	377	0.285	140	377
HSBlim	spr.30_ranges	0.445	157	274	0.354	149	325	0.354	149	325
HSBlim	Fspr35_ranges	0.363	150	319	0.302	142	363	0.302	142	363
HSBlim	Fspr40_ranges	0.299	142	365	0.257	135	402	0.257	135	402
HSBlim	Fb35_ranges	0.363	150	319	0.302	142	363	0.302	142	363
HSBlim	Fb40_ranges	0.299	142	365	0.258	135	402	0.258	135	402
BH	msy_ranges	1.03	159	127	0.46	151	256	3.77	151	38.7
BH	f0.1_ranges	0.338	142	324	0.283	135	366	6.45	135	18.3
BH	spr.30_ranges	0.445	150	263	0.347	143	317	5.38	143	24.7
BH	Fspr35_ranges	0.363	144	307	0.299	137	353	6.17	137	19.8
BH	Fspr40_ranges	0.299	137	352	0.256	130	391	6.92	130	15.9
BH	Fb35_ranges	0.355	144	312	0.294	136	357	6.25	136	19.3
BH	Fb40_ranges	0.294	136	357	0.252	130	394	6.98	130	15.6

Table 2.3.12.3 $F_{p.05}$ values in relation to the risk of dropping SSB below current Blim adopted for Blue and red shrimp in GSA 5, as obtained for the different SRR models.

$F_{p.05}$	HSBlim	BH
Risk 3	0.857	0.806
Risk 1	1.177	1.102

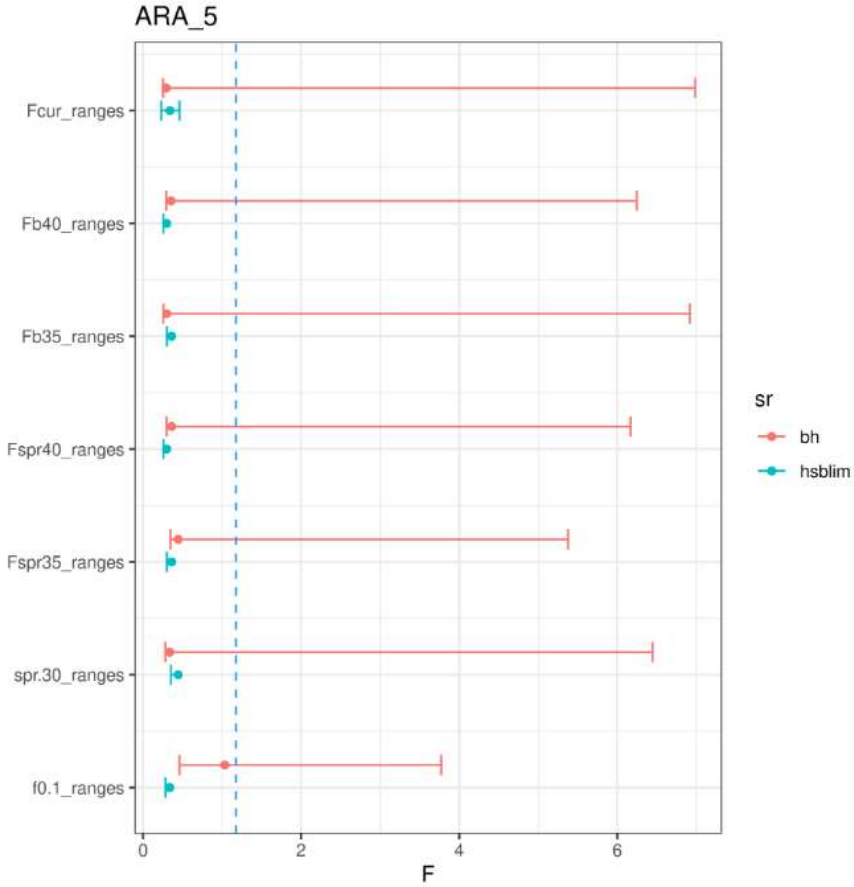


Figure 2.3.12.3 Fmsy.proxy and corresponding ranges for the different SRR models for blue and red shrimp in GSA 5. The dashed vertical line refers to the $F_{p.05}$ values (type 1 risks) corresponding to the HSBlim.

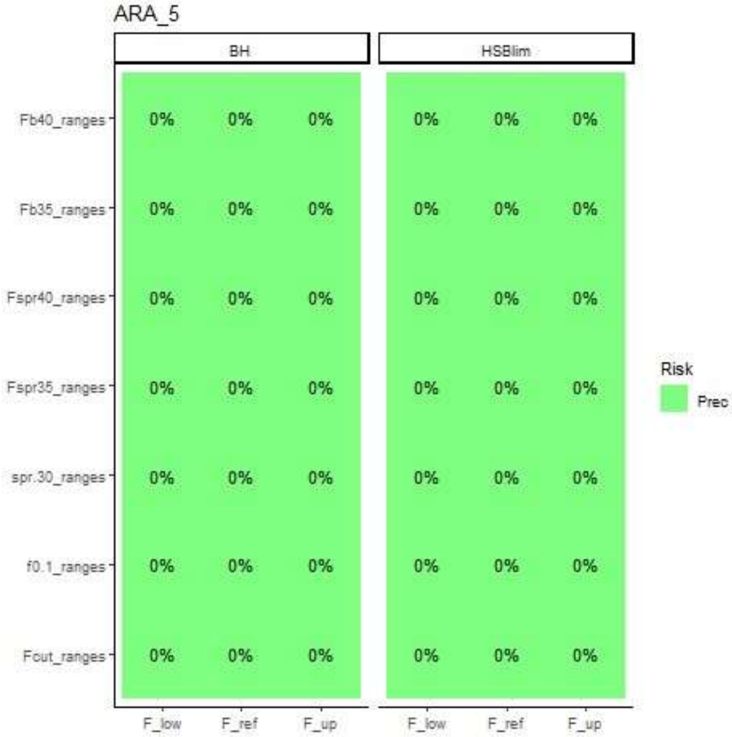


Figure 2.3.12.4. Probability of SSB being below B_{lim} (risk type 1) for alternative F_{MSY} proxies and corresponding F ranges for the default SRR (HSBlim) and for BH for blue and red shrimp in GSA 5 for Fsigma=0.2. (Fcut_ranges refers to the current F ranges produced by the empirical models)

Figure 2.3.12.5. Changes in terms biomass, catches and fishing mortalities induced by adopting alternative F_{MSY} proxies and corresponding F ranges relative to the current F target and F ranges

(from $F_{0.1}$ and the linear models respectively), for the default SRR (HSBlim) and for BH for blue and red shrimp in GSA 5 (Fsigma=0.2).

2.3.13 Summary results for Blue and red shrimp in GSAs 6 & 7

- **The stock objects** were those produced in EWG 2023-09 with data up to 2022.
- **Biology**: Ages 1-5+. High natural mortalities at all ages (M=> 0.4) decreasing from 0.85 at age 1 to 0.43 at age 5+. Maturity equal to 77% at age 1, 99% at age 2 and reaching full maturity at age 3.
- **Stock status**: The stock is severely overfished (F_{2022}=0.99) relative to an $F_{0.1}$ of 0.26, with current biomass between B_{pa} and B_{lim}.
- **Current F target and ranges**: F_{MSY} is based on $F_{0.1}$=0.26. The corresponding SSB is $B_{F0.1}$=1520 t. The F ranges for $F_{0.1}$ based on the empirical linear models are 0.17 – 0.36.
- **Current SRR assumption and B_{lim} definition**: The Hockey-stick model resulted in a breakpoint within the range of observed SSBs (at the lower range of biomasses) and very close to the breakpoint estimated previously, on which B_{lim} is based (Figure 2.3.13.1).
- **Alternative SRR and potential alternative B_{lim} definitions**: Statistical comparison of the fitting of different SRR models show that Beverton-Holt is the second best SRR model in terms of AIC and BIC (Table 2.3.13.1). It was considered that the BH SRR might be a good alternative to represent the SR dynamics, showing a faster reduction of recruitment versus spawning biomass than the HSBlim (Figure 2.3.13.1). The curvature of the SRR to the left of the center of gravity of the observations is the one which matters the most for the definition of the F_{upper} range relative to F_{MSY} and risks to B_{lim} as fishing mortality increases. Therefore, BH was selected as an alternative SRR to test for robustness of the production curve and F_{MSY} ranges properties to a less productive SRR.
- **Production curves:** A comparison of the production curves resulting from the two selected SRR are shown in Figure 2.3.13.2. Although the production curve resulting from the default HSBlim reaches to an F_{MSY} value (F_{max}), the curve becomes almost flat (only decreasing slightly) at higher F values, making impossible to estimate F_{upper}. The production curve corresponding to the BH SRR is a well-defined dome shape curve, with a neat peak corresponding to an F_{MSY}, and asymmetrical descending shape as F increases.
- **F_{MSY} or F_{MSY} proxies and corresponding ranges**: The values for the different F_{MSY} proxies and corresponding ranges are shown in Table 2.3.13.2 and Figure 2.3.13.3.
- **Assessment of Risks and of $F_{p.05}$ by SRR models**. The risks of falling below the previously adopted B_{lim} (by STECF) were calculated through a forward projection (see methods) for the different SRR models (Table 2.3.5.3). The $F_{p.05}$ estimates are very similar for the two SRR models, being slightly larger for the HSBlim than for the BH. In addition, $F_{p.05}$ corresponding to Risk 3 type of estimates are smaller than those corresponding to Type 1 risks. Therefore, in order to be precautionary to all the plausible ranges of SRRs considered for this stock the F ranges should be below $F_{p.05}$ values of the BH SRR curve for type 3 errors. All the results were shown for an assessment plus implementation error of intended fishing mortality of 0.2 (Fsigma=0.2).
- **Discussion on F_{MSY} target and ranges**: This is a type 2 stock corresponding to a production curve showing an F_{max} but beyond which the curve is almost flat so that F_{upper} is undefined (NA). Furthermore, these are stocks for which a Hockey-stick was fitted with a break point either at around the lowest observed S-R pairs values or within the cloud of S-R observed pairs. Three alternatives have been considered: a) let a priori current Ftarget (F0.1) and empirical Franges b) the same but setting F_{upper} as F_{max} provided they are compliant with the risks to B_{lim} c) adopt F_{MSY} and the corresponding ranges from an alternative SRR provided they are compliant with the risks to B_{lim}.

In this case all the F_{MSY} or F_{MSY} proxies considered were lower than $F_{p.05}$ estimated for the HSBlim or the BH models. Therefore, they all implied probabilities of being below B_{lim} less than 0.05 (Figure 2.3.13.4). However, F_{upper} could not be calculated for any of the proxies. Figure 2.3.13.5 shows the relative implications of adopting alternative F_{MSY} proxies and F ranges versus the current F ranges, in terms biomass, catches and fishing mortalities for the HSBlim and BH models.

From all the above it is important to note that:

- The $F_{p.05}$ derived from HSBlim and BH (Type 3 risk estimates) are placed around 1.1, well above the current Ftarget ($F_{0.1}$ = 0.26) and well above F_{max} (=0.77). The F_{upper} value of the current F ranges (= 0.36) is also placed well below the $F_{p.05}$ for Risk Type 3 of the current HSBlim. Therefore, the current Ftarget and Franges (based on the linear models) are compliant not exceeding $F_{p.05}$, implying risks <= 0.05 for the SSB of falling below B_{lim}.
- In the absence of a proper definition of F_{upper} relative to $F_{0.1}$, from the former observations it can also be deduced that F_{max} could be used as F_{upper} for this stock as it also smaller than $F_{p.05}$. Furthermore, F_{max} is about the same as the F_{upper} obtained for the F_{MSY} ranges corresponding to BH. So, it might also coincide with the actual F_{MSY} range for the alternative plausible SRR (the BH).
- The F_{MSY} target and corresponding ranges obtained for the alternative plausible SRR (BH) are also smaller than $F_{p.05}$ and could be used as an alternative risk averse Fmsy ranges.
- All the three alternative proposals for definition of Ftarget and Franges are robust to the current uncertainties on the plausible models of SRR governing the dynamics of this stock. The current Franges based on the linear models would result in the lowest of the allowed F ranges (0.17-0.36). Setting F_{upper} at F_{max} will expand further this range up to 0.77 and by moving to the alternative SRR model (BH) it will allow the highest Ftarget (at 0.45) and with Franges F_{lower} and F_{upper} of 0.27 and 0.77.

- **Conclusions**: Current F target ($F_{0.1}$) and F ranges (from the empirical linear relationships) are acceptable in relation to $F_{p.05}$, but its range could be widened if setting F_{upper} at F_{max} (0.77) or by adopting the Ftarget and ranges corresponding to the alternative SRR (of BH) for this blue and red shrimp in GSAs 6 & 7, being always compliant with $F_{p.05}$. . EWG 24-02 proposes to adopt Option 1 for Blue and red shrimp in GSAs 6 & 7, i.e., adopting as F target and Flower ranges those estimated relative to F(0.1), but setting Fupper at Fmax, resulting in F(0.1) target at 0.26 and F ranges 0.22-0.77.

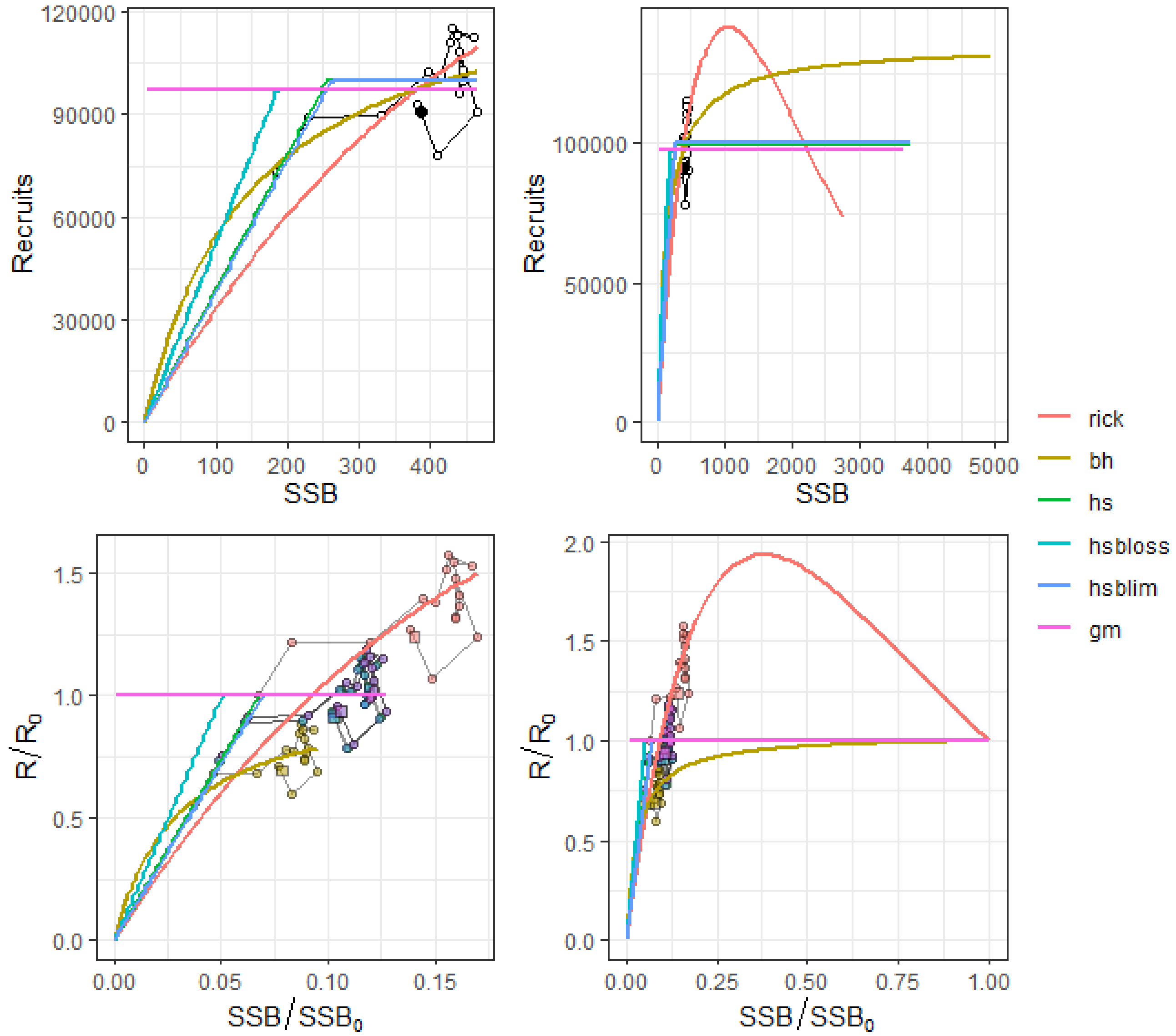


Figure 2.3.13.1. Stock recruitment relationships for blue and red shrimp in GSAs 6 & 7, both in absolute (top row) and in relative terms to R0 and B0 (bottom row) for two scales in the X axis (left and right panels).

Table 2.3.13.1 Statistical comparison of the fitting of different SRR models for blue and red shrimp in GSAs 6 & 7.

MODEL	AIC	BIC
Ricker	-16.642	-13.971
Beverton-Holt	-28.864	-26.193
Hockey-stick	-26.978	-24.307
Hockey-stick at Bloss	-20.834	-19.053
Hockey-stick at Blim	-28.942	-27.161
Geometric mean	-20.834	-19.053

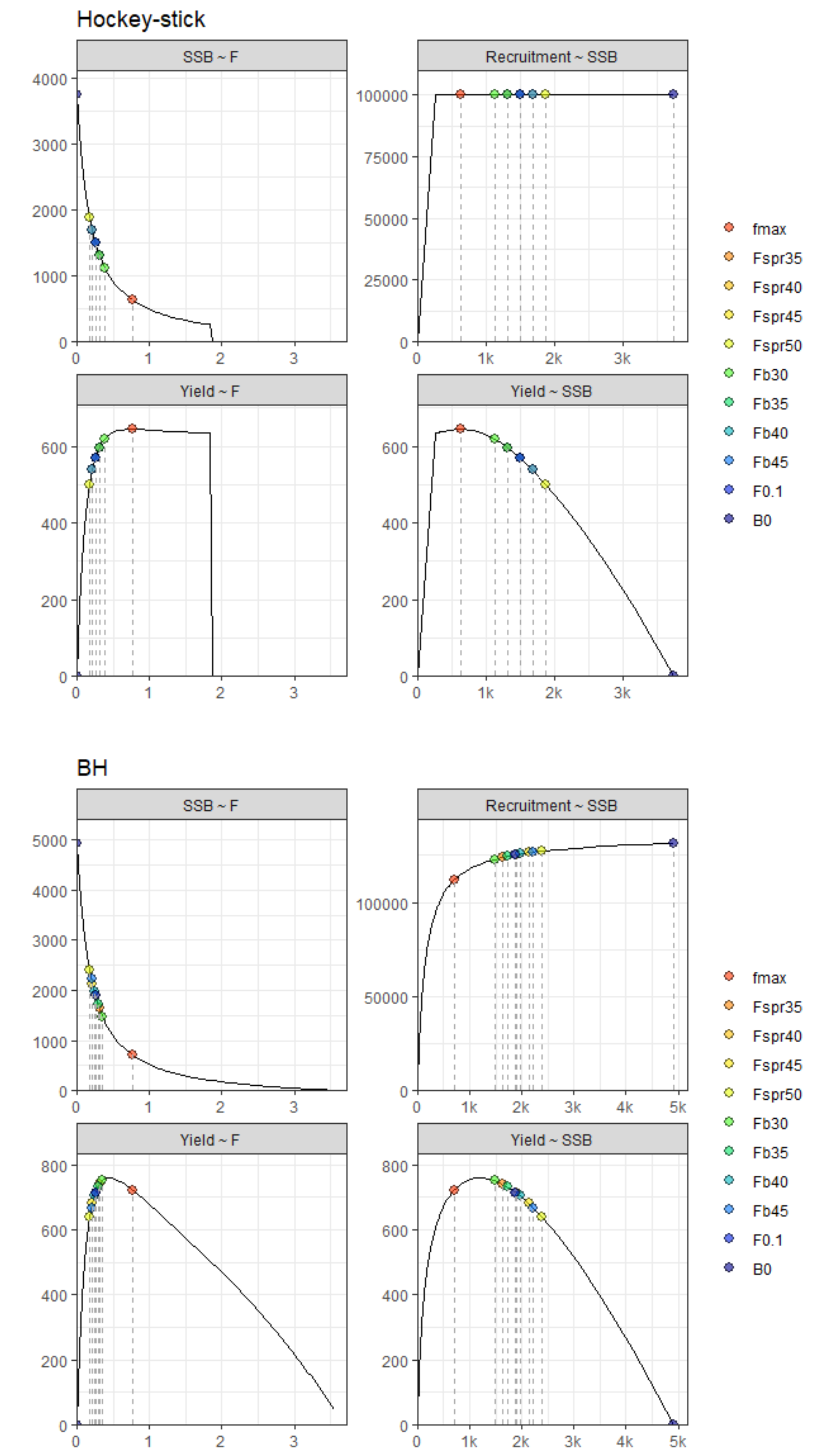


Figure 2.3.13.2 Biomass and production curves as a function of F resulting from the alternative plausible stock recruitment relationships under consideration for blue and red shrimp in GSAs 6 & 7.

Table 2.3.13.2 F, yield and SSB for each of the F_{MSY} proxies and F ranges considered for blue and red shrimp in GSAs 6 & 7 from HSBlim and BH models.

		Ftarget	Ftarget	Ftarget	Flower	Flower	Flower	Fupper	Fupper	Fupper
SRR	Case	F	Yield	SSB	F	Yield	SSB	F	Yield	SSB
HSBlim	msy_ranges	0.765	645	637	0.362	612	1190	NaN	NaN	NaN
HSBlim	f0.1_ranges	0.259	570	1504	0.218	541	1672	NaN	NaN	NaN
HSBlim	spr.30_ranges	0.389	619	1126	0.294	588	1380	NaN	NaN	NaN
HSBlim	Fspr35_ranges	0.306	594	1343	0.251	565	1533	NaN	NaN	NaN
HSBlim	Fspr40_ranges	0.257	569	1510	0.217	540	1677	NaN	NaN	NaN
HSBlim	Fb35_ranges	0.306	594	1342	0.251	565	1533	NaN	NaN	NaN
HSBlim	Fb40_ranges	0.257	569	1511	0.218	541	1675	NaN	NaN	NaN
BH	msy_ranges	0.452	759	1205	0.271	721	1824	0.77	721	708
BH	f0.1_ranges	0.259	714	1886	0.213	678	2148	0.994	678	525
BH	spr.30_ranges	0.389	756	1374	0.265	718	1851	0.787	718	691
BH	Fspr35_ranges	0.306	737	1667	0.239	701	1988	0.877	701	610
BH	Fspr40_ranges	0.257	713	1894	0.212	678	2154	0.998	678	522
BH	Fb35_ranges	0.293	732	1723	0.232	695	2032	0.908	695	586
BH	Fb40_ranges	0.243	704	1968	0.203	669	2212	1.04	669	494

Table 2.3.13.3 $F_{p.05}$ values in relation to the risk of dropping SSB below current Blim adopted for blue and red shrimp in GSAs 6 & 7, as obtained for the different SRR models.

$F_{p.05}$	HSBlim	BH
Risk 3	1.072	1.071
Risk 1	1.370	1.315

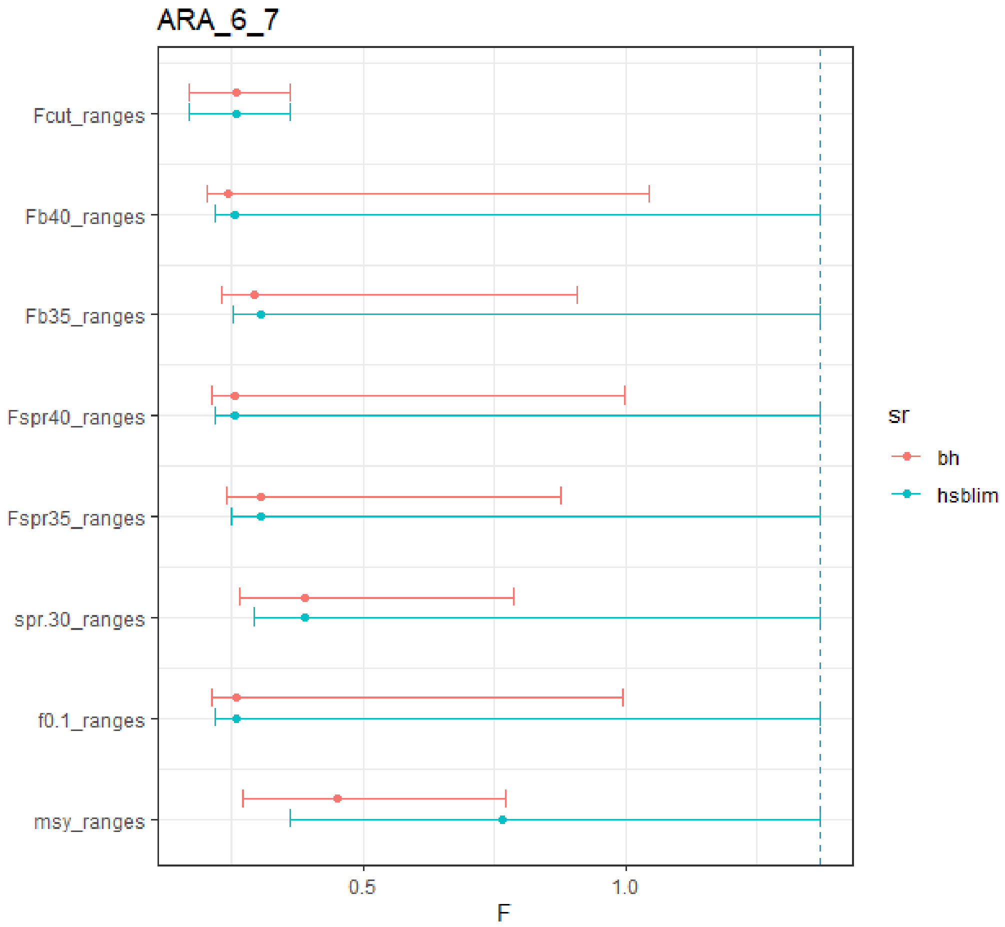


Figure 2.3.13.3 F_{MSY} proxies and corresponding ranges for the default SRR model (HSBlim) and for BH for blue and red shrimp in GSAs 6 & 7. The dashed vertical line represents $F_{p.05}$ value (type 1 risks) for HSBlim.

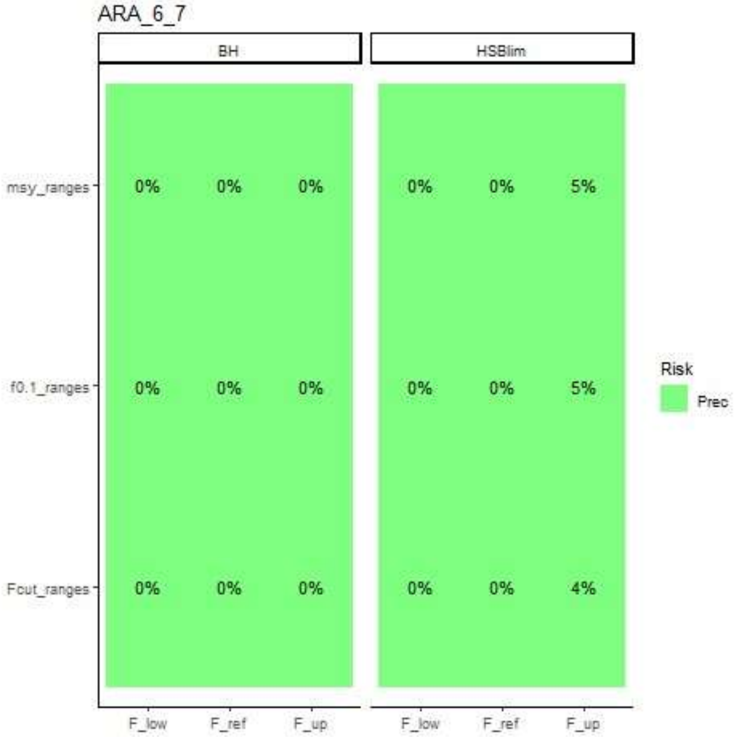


Figure 2.3.13.4 Probability of SSB being below B_{lim} (risk type 1) for alternative F_{MSY} proxies and corresponding F ranges for the default SRR (HSBlim) and for BH for blue and red shrimp in GSAs 6 & 7 for Fsigma=0.2.

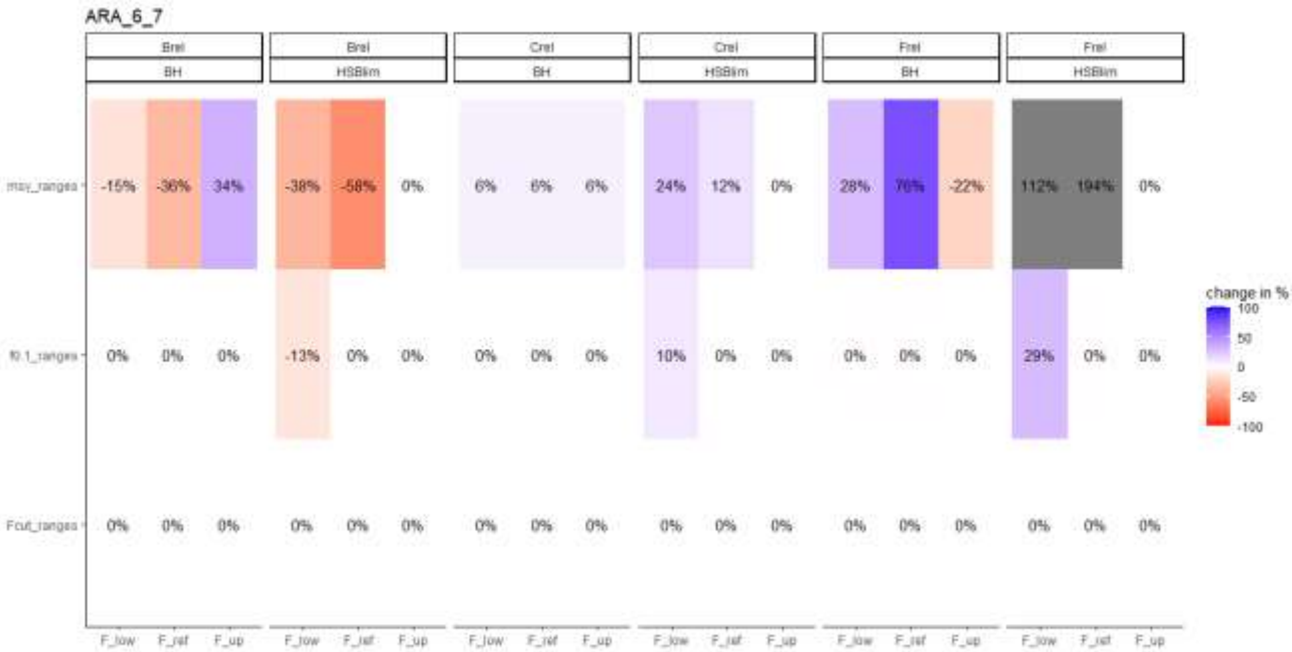


Figure 2.3.13.5. Changes in terms biomass, catches and fishing mortalities induced by adopting alternative F_{MSY} proxies and corresponding F ranges relative to the current F target and F ranges

(from $F_{0.1}$ and the linear models respectively), for the default SRR (HSBlim) and for BH for blue and red shrimp in GSAs 6 & 7 (Fsigma=0.2).

2.3.14 Summary results for Giant red shrimp in GSAs 9, 10 & 11

- **The stock objects** were those produced in EWG 2023-09 with data 2005-2021 because of the lack of MEDITS survey in EMU2 in 2022.
- **Biology**: Ages 0-4+. High Natural mortality (M>=0.4), but decreasing with ages (from age 1 to 4+ decreasing from 1.9 to 0.48). Maturity at age 1 is equal to 0.4, full maturity is reached at age 2.
- **Current F target and ranges**: F_{MSY} is based on $F_{0.1}$=0.43. The corresponding SSB is $B_{F0.1}$=772 t. The F ranges for $F_{0.1}$ based on the empirical linear models are 0.28 – 0.58.
- **Stock status**: Current level of fishing mortality (0.76) is well above the reference point $F_{0.1}$ (0.43) which is used as a proxy of F_{MSY}. Current biomass is above B_{pa}.
- **Current SRR assumption and Blim definition**: Under no clear SRR the Geometric Mean (GM) recruitment is used to force a HS SRR with a plateau at the GM and with a break point at 25%BF0.1 (Figure 2.3.14.1). This implies Blim (193 t) is about 10,6% B0 and it is placed to the left of the biomass observed in the past. It implies a steepness of 1 because B_{lim} is below 20%B0
- **Alternative SRR and potential alternative Blim definitions**: Statistical comparison of the fitting of different SRR models shows that HSBloss and HSBlim provide the same fit to the data in terms of AIC and BIC, being the best among all models (Table 2.3.14.1), with an R0 estimate consistent with the maximum past observed Recruitments, at the geometric mean in both cases (Figure 2.3.14.1). There were other models which might well fit the data, but the differences were minimal between models. Therefore, it is admitted that there is no complete coverage of the alternative potential SRRs for this stock. For the sensitivity exercise, the HSBloss was selected as an alternative SR model, having a lower slope at the origin that the HSBlim, placed very much to the left of observations (Figure 2.3.14.1).
- **Production curves:** A comparison of the production curves resulting from the different SRR models is shown in Figure 2.3.14.2. The Production curve resulting from the default HSBlim is a continuously growing curve, not reaching any peak and preventing thus the definition of F_{MSY} or of the F_{upper} for any of the alternative F_{MSY} proxies. The production curve corresponding to the HSBloss SRR is also a continuously growing curve, not allowing determination of any F_{MSY} either. The BH and Ricker models would have result in dome shaped production curves, with F_{MSY} around 1,5 and 0.9 respectively.
- **F_{MSY} or F_{MSY} proxies and corresponding ranges**: The values for the different F_{MSY} proxies and corresponding ranges are shown in Table 2.3.14.2 and Figure 2.3.14.3.
- **Assessment of Risks and of $F_{p.05}$ by SRR models**. The risks of falling below the B_{lim} were calculated through a forward projection (see methods) for the different SRR models (Table 2.3.14.3). The $F_{p.05}$ estimates differ very much between models, being very high for the HSBlim (around 2.2 for type 1 of risk estimates) but being reduced to about 0.8 for the HSBloss model (and up to 0.58 for the type 3 risk estimation procedure). All the results were shown for an assessment plus implementation error of intended fishing mortality of 0.2 (Fsigma=0.2).
- **Discussion on Fmsy target and ranges**:

  This a type 3 stock corresponding to a continuously increasing production curve for the default HSBlim. In these cases EWG 24 02 has considered to let a priori the current Ftarget ($F_{0.1}$) and Franges (from the linear models). The long-term probabilities of being below B_{lim} for the different F_{MSY} proxies and the corresponding ranges (if existing) are shown in Figure 2.3.14.4, whereas the relative implications of adopting alternative FMSY proxies and the corresponding F ranges for the HSBlim default SRR assumption are shown in Figure 2.3.14.5. Some discussion on the former results follows:

- The lowest $F_{p.05}$, as derived from the HSBloss (Type 3 risk estimates) is placed around 0.58, above the current Ftarget ($F_{0.1}$ = 0.43) but is equal to the current F_{upper} value. Therefore, the current Ftarget and Franges (based on the empirical linear models) are compliant with not exceeding $F_{p.05}$, implying risks <= 0.05 for the SSB of falling below B_{lim}.

- Re-estimation of F(0.1) values under HSBlim were consistent with the previous estimates, as expected.

- F_{MSY} values have not been estimable nor for the HSBlim neither for the HSBloss. There might be other SRR alternative candidate models which might have resulted in a more risk-averse modelling than the HSBloss (as perhaps the Ricker even if showing a bit poorer AIC and BIC values) but due to the lack of time it was not analysed by the group. EWG 2024-09 coould revisit these or other alternative SRR models to make sure that their $F_{p.05}$ for the current B_{lim} does not drop down the F_{upper} of the linear models and to check if their Franges could be advisable or not.

- **Conclusions**: In order to be sure that the Ftarget and F ranges are robust to the current uncertainties on the SRR models the only proposal which can be put forwards is that of staying at the previously stablished F_{MSY} proxy and the corresponding ranges based on $F_{0.1}$ and the empirical linear model.

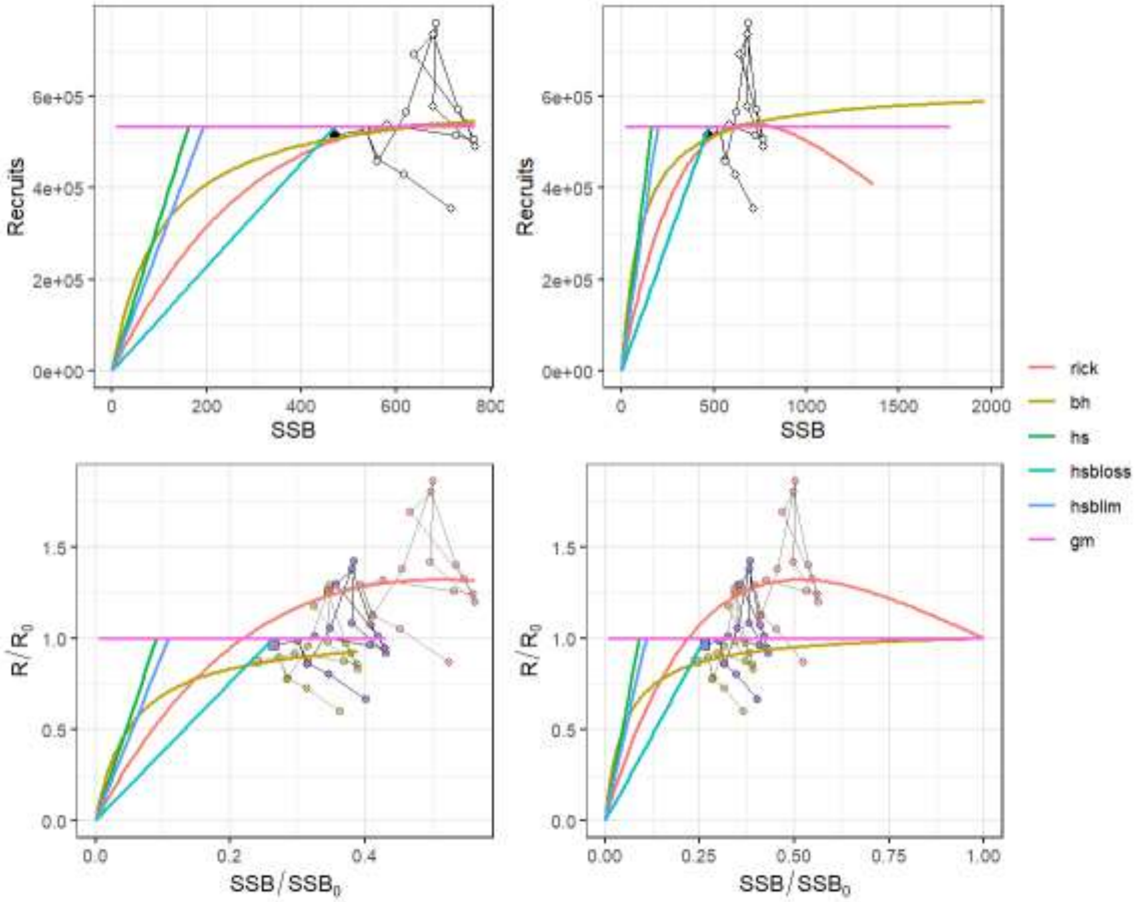
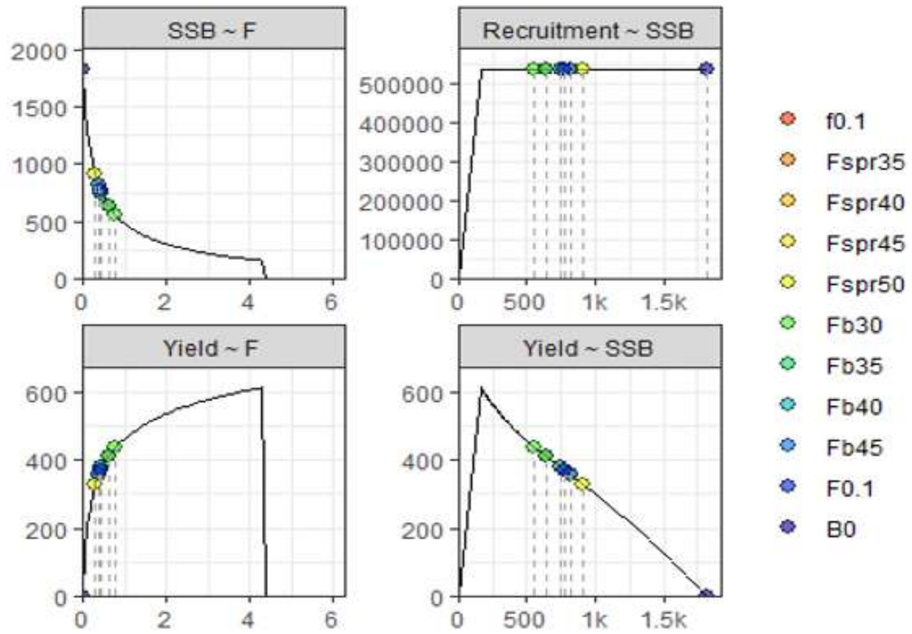


Figure 2.3.14.1 Stock recruitment relationships for Giant red shrimp in GSAs 9, 10 & 11, both in absolute (top row) and in relative terms to R0 and B0 (bottom row) for two scales in the X axis (left and right panels).

Table 2.3.14.1 Statistical comparison of the fitting of different SRR models for Giant red shrimp in GSAs 9, 10 & 11

Model	AIC	BIC
Ricker	-3.375	-0.875
Beverton-Holt	-3.111	-0.611
Hockey-stick	-2.920	-0.421
Hockey-stick at Bloss	-5.059	-3.393
Hockey-stick at Blim	-5.059	-3.393
Geometric mean	-5.059	-3.393

HS Blim


SSB ~ F
Recruitment ~ SSB
Yield ~ F
Yield ~ SSB
f0.1
Fspr35
Fspr40
Fspr45
Fspr50
Fb30
Fb35
Fb40
Fb45
F0.1
B0

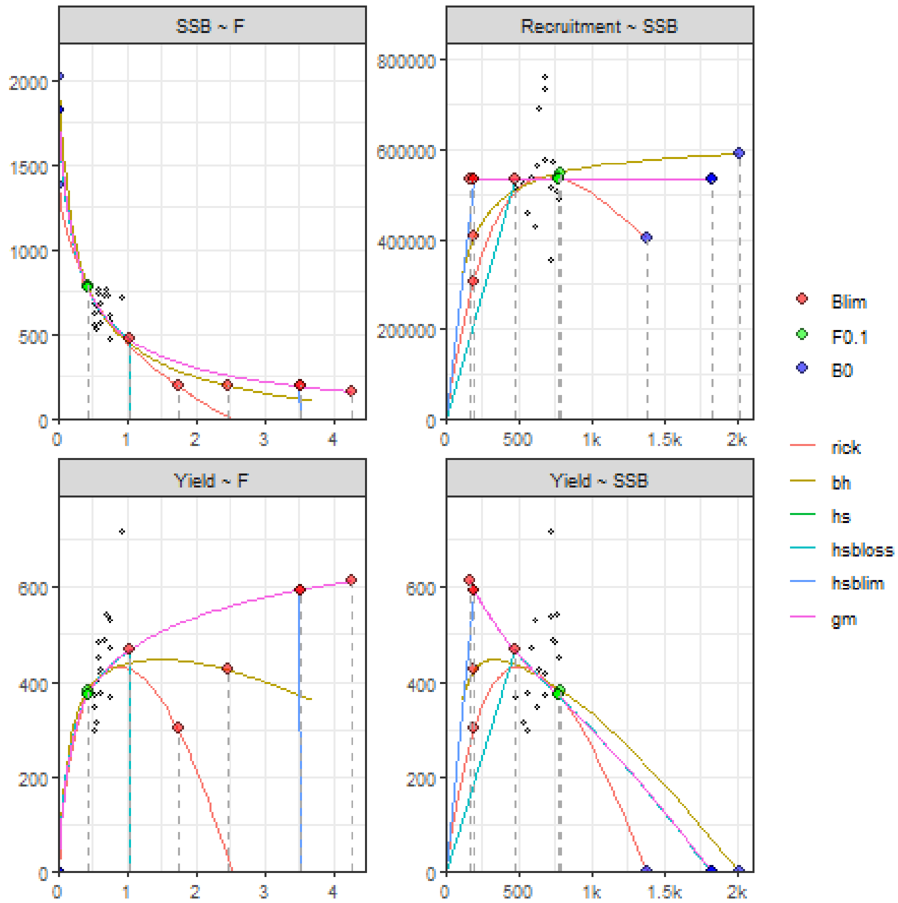

SSB ~ F
Recruitment ~ SSB
Yield ~ F
Yield ~ SSB
Blim
F0.1
B0
rick
bh
hs
hsbloss
hsblim
gm

Figure 2.3.14.2 Biomass and Production curves as a function of F resulting from the alternative plausible stock recruitment relationships under consideration for Giant red shrimp in GSAs 9, 10 & 11. Upper graph for HSBlim. Bottom graph for all tested SRRs.

Table 2.3.14.2 F, yield and SSB for each of the F_{MSY} proxies and F ranges considered for blue and red shrimp in GSAs 6 & 7 from HSBlim and HSBloss.

		Ftarget	Ftarget	Ftarget	Flower	Flower	Flower	Fupper	Fupper	Fupper
SRR	Case	F	Yield	SSB	F	Yield	SSB	F	Yield	SSB
HSBlim	f0.1_ranges	0.426	372	772	0.364	353	833	0.364	353	833
HSBlim	spr.30_ranges	0.808	441	548	0.654	419	616	NaN	NaN	NaN
HSBlim	Fspr35_ranges	0.609	411	641	0.504	391	709	0.504	391	709
HSBlim	Fspr40_ranges	0.452	379	749	0.384	360	812	0.384	360	812
HSBlim	Fb35_ranges	0.612	412	639	0.506	391	707	0.506	391	707
HSBlim	Fb40_ranges	0.451	378	750	0.383	359	813	0.383	359	813
HSBloss	f0.1_ranges	0.426	372	772	0.364	353	833	NaN	NaN	NaN
HSBloss	spr.30_ranges	0.808	441	548	0.654	419	616	NaN	NaN	NaN
HSBloss	Fspr35_ranges	0.609	411	641	0.504	391	709	NaN	NaN	NaN
HSBloss	Fspr40_ranges	0.452	379	749	0.384	360	812	NaN	NaN	NaN
HSBloss	Fb35_ranges	0.612	412	639	0.506	391	707	NaN	NaN	NaN
HSBloss	Fb40_ranges	0.451	378	750	0.383	359	813	NaN	NaN	NaN

Table 2.3.14.3 $F_{p.05}$ values in relation to the risk of dropping SSB below current Blim adopted for Giant red shrimp in GSAs 9, 10 & 11, as obtained for the different SRR models.

$F_{p.05}$	HSBlim	HSBloss
Risk 3	1.568	0.575
Risk 1	2.225	0.8

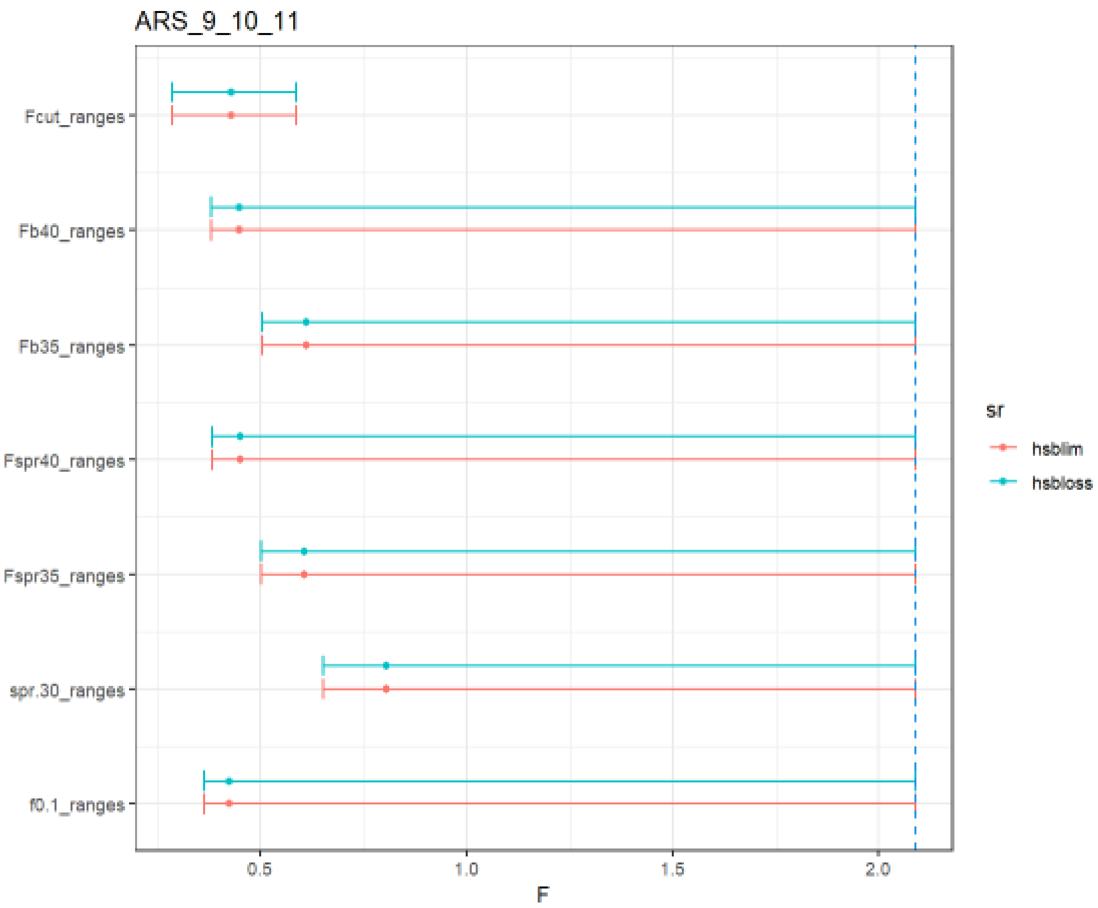


Figure 2.3.14.3 Fmsy.proxy ranges for the different SRR models for Giant red shrimp in GSAs 9, 10 & 11. The dashed vertical line refers to the $F_{p.05}$ values (type 1 risks) corresponding to the HSBim.

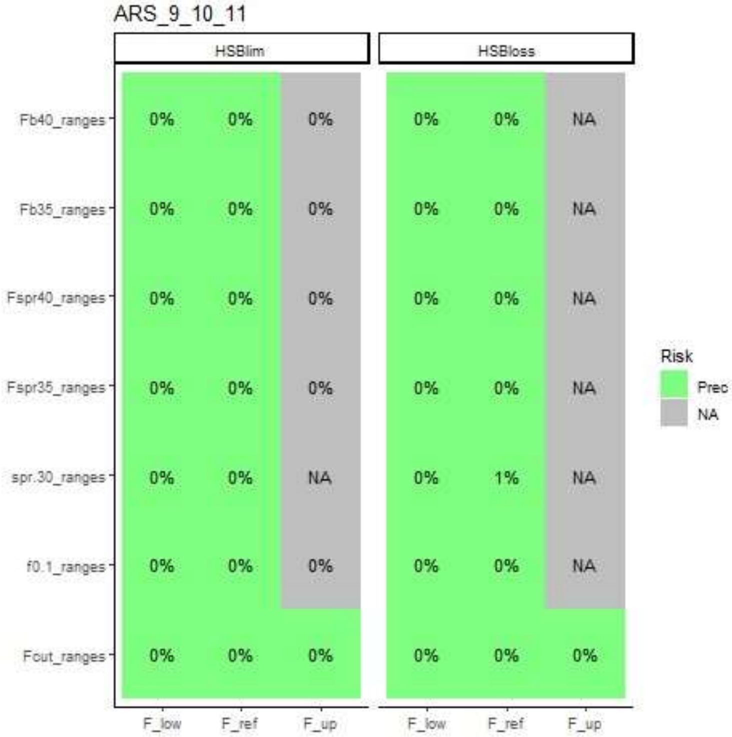


Figure 2.3.14.4 Probability of SSB being below B_{lim} (risk type 1) for alternative F_{MSY} proxies and corresponding F ranges for the default SRR (HSBlim) and for HSBloss for Giant red shrimp in GSAs 9, 10 & 11 for Fsigma=0.2.

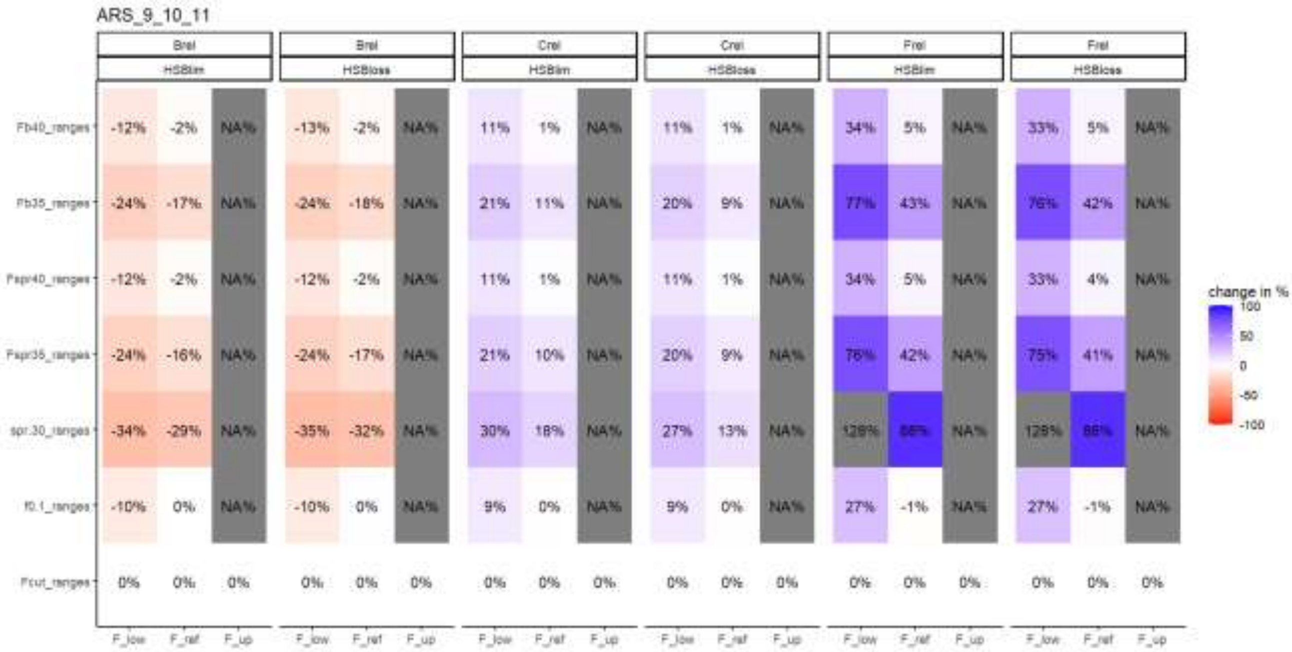


Figure 2.3.14.5. Changes in terms biomass, catches and fishing mortalities induced by adopting alternative F_{MSY} proxies and corresponding F ranges relative to the current F target and F ranges

(from $F_{0.1}$ and the linear models respectively, named as Fcut-ranges), for the default SRR (HSBlim) and for HSBloss for Giant red shrimp in GSAs 9, 10 & 11 (Fsigma=0.2).

2.4 Discussion

2.4.1 Current F ranges based on empirical formulas

The current F ranges are based on two empirical formulas that set F_{lower} and F_{upper} relative to F_{MSY}. These equations were derived from a meta-analysis conducted on the F_{MSY} ranges estimates for demersal stocks in the Baltic Sea and the North Sea (STECF EWG 15-09).

The EWG notes that these formulas were derived based on F_{MSY} not on $F_{0.1}$, as they have been applied by the STECF in the Western Mediterranean Sea. From the analyses carried out in this EWG, there were four stocks for which F_{MSY} and their ranges could be calculated (HKE 1_5_6_7, HKE 8_9_10_11, NEP_6 and NEP_9). These values were compared in relation to the current empirical formulas (Figure 2.4.1.1). While the formula to infer F_{lower} from F_{MSY} estimates can still be considered a valid approximation, the four stocks were above the empirical formula between F_{upper} and F_{MSY}, indicating larger observed F_{upper} values than those suggested by the empirical formula.

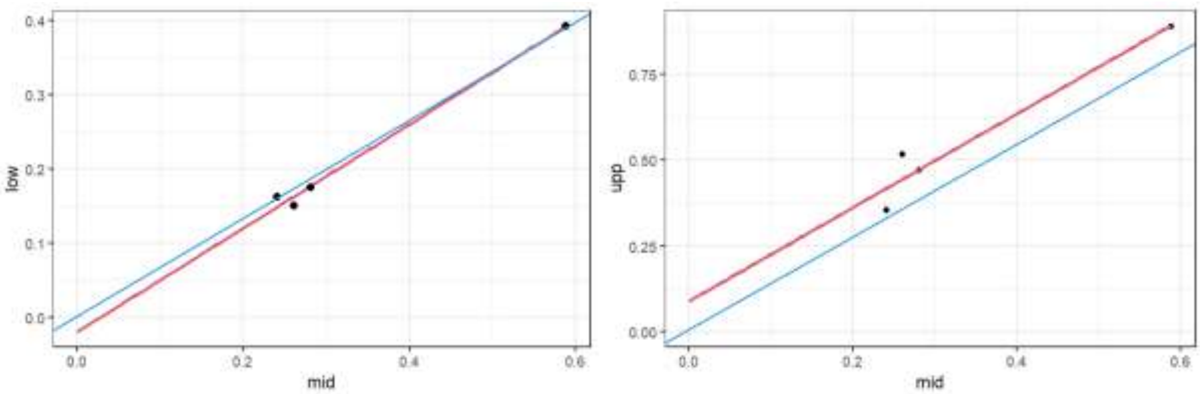


Figure 2.4.1.1 Relationship between F_{lower} and F_{MSY} (left panel) and F_{upper} and F_{MSY} (right panel). The black bullets are the actual observations for the four stocks with available F_{MSY} range estimates among the stocks studied in this EWG (HKE 1_5_6_7, HKE 8_9_10_11, NEP_6 and NEP_9). The blue line represents the empirical formulas from STECF EWG 15-09, whereas the red line is the model fitted to the four stocks.

The F ranges from the empirical formulas were applied for the first time by STECF EWG 15-06 prior to the legislation was put in place, so they were not intended to comply with the F_{MSY} range definition outlined in Article 2(4) of the Western Mediterranean EU MAP. According to this definition, the range of F_{MSY} is the range of F's that delivers no more than a 5 % reduction in long-term yield compared to the MSY and it is capped so that the probability of the stock falling below the limit reference point (B_{lim}) is no more than 5 %.

To assess if the current F ranges fulfill the definition in the West Med EU MAP, the EWG analysed the results of the long-term projections carried out for each stock (see section 3.3) and evaluated the probability of the stock falling below the limit reference point (B_{lim}) and the yield of the current F ranges in relation to the current F_{MSY} proxy ($F_{0.1}$).

For all stocks of the West Med EU MAP, the current Ftarget of $F_{0.1}$ and their F ranges (based on the empirical linear models) did not exceed $F_{p.05}$ values estimated from the default HSBlim SRR (type

1 risk), implying risks <= 0.05 for the SSB of falling below B_{lim} in the long term (Table 2.4.1.1). Therefore, it can be concluded that the current F ranges obtained from the empirical linear models are precautionary in the long-term. It is important to note that these are long-term risks. Very different evaluations of risks are found over short-term forecasts from the assessment EWG, as they are very much conditioned on the most recent stock status.

Regarding the yield, F_{lower} and F_{upper} resulted into yields around 85% and 105% of the yield corresponding to $F_{0.1}$ (Table 2.4.1.1, Figure 2.4.1.2). Hence, the F ranges from the empirical formulas do not result necessarily in 95% of the catches at $F_{0.1}$ neither in 95% of the catches at the true F_{MSY}. The fact that F_{upper} from the empirical formula leads to yields higher than $F_{0.1}$ is due to the selection of the HSBlim SRR and the corresponding shape of the production curves (in many cases not pronounced dome shape curves, but rather flat beyond F_{MSY} or asymptotically growing curves). In addition, these results confirm the precautionary nature of $F_{0.1}$ and of the application of the empirical formulas based on $F_{0.1}$.

In summary, the current F ranges based on the empirical linear approach do not comply with the F_{MSY} range definition outlined in Article 2(4)) (Regulation (EU) 2019/1022), but they are considered precautionary (risk-averse) in the long-term.

Table 2.4.1.1. Yield and probability of being below B_{lim} for current $F_{0.1}$ and corresponding ranges based on the empirical formulas (HSBlim and Fsigma=0.2).

Stock	Yield at F_{lower}	Yield at $F_{0.1}$	Yield at F_{upper}	Risk at F_{lower}	Risk at $F_{0.1}$	Risk at F_{upper}
HKE_1_5_6_7	4202	4838	5028	0	0	0
MUT_1	145	167	178	0	0	0
MUT_6	987	1129	1202	0	0	0
MUT_7	253	295	315	0	0	0
NEP_6	388	449	472	0	0	0
HKE_8_9_10_11	4316	5015	5290	0	0	0
DPS_8_9_10_11	*3735*	*4400*	*4859*	*0*	*0*	*0*
MUT_9	762	889	965	0	0	0
NEP_9	158	179	192	0	0	0
ARA_5	130	149	159	0	0	0
ARA_6_7	516	596	658	0	0	0
ARS_9_10_11	323	372	407	0	0	0

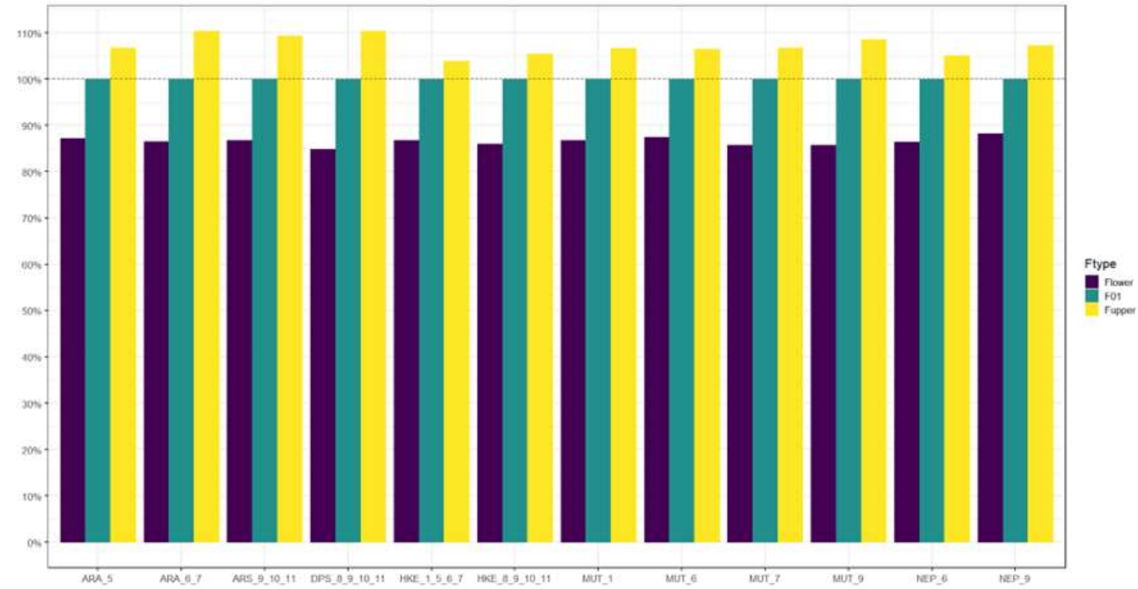


Figure 2.4.1.2 Relative yield of current F ranges based on the empirical linear models with respect to the yield corresponding to $F_{0.1}$.

2.4.2 F_{MSY} or F_{MSY} proxies and corresponding ranges depending on the production curve

The procedure followed to determine F_{MSY} or F_{MSY} proxies and the corresponding ranges depended on the shape of the production curve.

Type 1 production curves

Setting F_{MSY} and F ranges according to the standard definition in the West Med EU MAP (Regulation (EU) 2019/1022) could only be achieved for Type 1 stocks which have well-defined dome shape production curves. These were the two hake stocks (HKE_1_5_6_7 and HKE 8_9_10_11) and the Norway Lobster in GSA 6 (NEP_6).

Adopting the F_{MSY} ranges as the ranges for the West Med EU MAP implies moving from the precautionary F target at $F_{0.1}$ adopted previously by STECF to the F_{MSY} target for the production curves defined under the assumption of the HSBlim SRR governing the population dynamics. This is in practice equal to moving to F_{max} from the SPR (as they are both equal for F values above F_{lim}). Such change from $F_{0.1}$ to F_{MSY} supposes an increase in the F target of 44% and 42% and in the F_{upper} of 59% and 54 % for HKE_1_5_6_7 and HKE 8_9_10_11 respectively, in comparison with the $F_{0.1}$ and its empirical ranges defined before. The increases in Norway Lobster were of 71% in the F target and of 104% in F_{upper}. For both hake stocks, the F_{upper} is well below the $F_{p.05}$ (type 3) and the biomass expected at those harvest levels double the B_{pa} values. In the case of Norway Lobster in GSA 6, F_{upper} (0.47) is just below $F_{p.05}$ (type 1 risk value of 0.51), and above $F_{p.05}$ (type 3 risk value of 0.43) and leads to a biomass (789) placed between B_{pa} (944) and B_{lim} (472). In order to be fully compliant with the precautionary principle and following the decision table of step 6 in section 2.2.1.6 above, it is suggested to reduce F_{upper} to $F_{p.05}$ (type 3 estimates), i.e., to 0.43. Therefore, for this stock the adoption of the F_{MSY} target and ranges was not automatically adopted but required applying the $F_{p.05}$ filtering. Despite such reduction, F_{upper} for NEP_6 would still be 85% above its previous empirical F_{upper}.

Moving to F_{MSY} (F_{max}) and their ranges implies certainly higher exploitation levels for these three stocks, but still complying with the definition in the west Med EU MAP of risks of falling below B_{lim} of 0.05 in the long-term. Within the context of seeking implementation of the F ranges for management, moving to F_{MSY} ranges implies in fact lower F_{upper} values than using the F_{upper} of $F_{0.1}$, therefore it can be considered partly as a risk-averse strategy (see Table 2.4.2.1 for an example). If such a decision was not undertaken in the past was probably linked to the common overall precautionary approach of adopting F0.1 for all the stocks and to uncertainties around the actual SRRs, given the short ranges of biomass observed over the available historical series.

In these three cases B_{lim} was defined by the break point resulting from the HS fitting, which was the best among alternative SRRs. Therefore, the decision on the SRR was quite well statistically supported. The alternative Ricker or BH were discarded already in STECF EWG 22-03 and subsequent assessment expert groups, mainly because the catches and recruitment levels expected al lower fishing mortality were out of range from the historical data from the fishery. A sensitivity analysis on the F_{MSY} ranges that would result from these alternative unlikely SRR models was run for Hake in 1, 5, 6 & 7 (see table below). The differences by an order of magnitude in the expected biomass or catches are evident. However, it is interesting to note that the F_{MSY} ranges resulting from the HSBlim SRR model were between those resulting from the BH model and the Ricker model. All those ranges do not exceed the $F_{p.05}$ limit estimated from simulations based on the HSBlim. Therefore, the new F_{MSY} range proposal will lay between the two other SRR models (BH and Ricker), something partly expected as far as they all had very similar slopes towards the origin.

Table 2.4.2.1 $F_{0.1}$ former values (upper pannel) with associated F ranges from the empirical linear models, and new estimates of these $F_{0.1}$ ranges (second pannel) and of F_{MSY} (third pannel) for the HSBlim, along with the F_{MSY} ranges would have been obtained for F_{MSY} under BH (fourth pannel – Alternative 1) or with Ricker SRRs (bottom pannel – Alternative 2) for the Hake in GSA 1,5, 6 & 7. The $F_{p.05}$ corresponding to estimates type 3 or 1 for the HSBlim are 1.139 and 1.308 respectively.

	Reference points value EWG 23-09				
	Parameter	F0.1	Flower	Fupper	Fpa
	F value	0.41	0.27	0.56	NA (1.27)
	Biom.	63,696			7,743
	Yield				
SRR basis		Reference point for $F_{0.1}$ from HSBLim EWG 24 02			
HSBlim	HSBlim	F(0.1)	Flower	Fupper	Fmax
HSBlim	F value	0.41	0.34	1.05	0.589
HSBlim	Biom.	59400	72700	10800	34700
HSBlim	Yield	4790	4550	4550	5000
EWG PROPOSAL		Reference point for FMSY from HSBLim EWG 24 02			
SRR basis	F basis	Fmsy	Flower	Fupper	
HSBlim	Fmsy	0.59	0.39	0.89	
HSBlim	Biom.	34706	61508	15621	
HSBlim	Yield	5003	4753	4753	
Alternative 1		Reference point for FMSY from BH SRR review EWG 24 02			
SRR basis	F basis	Fmsy	Flower	Fupper	
BH	Fmsy	0.48	0.34	0.66	
BH	Biom.	1,288,766	2,041,708	734,035	
BH	Yield	135189	128430	128430	
Alternative 2		Reference point for FMSY from Ricker SRR review EWG 24 02			

SRR basis	F basis	Fmsy	Flower	Fupper	
Ricker	Fmsy	0.993	0.835	1.14	
Ricker	Biom.	343,686	459,616	247,020	
Ricker	Yield	130,254	123,741	123,741	

There was a fourth stock (Norway lobster in GSA 9, NEP_9) where F_{MSY} and the corresponding ranges could actually be estimated, but as result of the very skewed production curve, those estimates produced very large F_{upper} value, well above $F_{p.05}$, and were considered unreliable. The stock was therefore included in the group 2 type of stock.

Type 2 production curves

There were five stocks (the aforementioned Norway lobster in GSA 9 plus Red Mullet in GSA 1, Red Mullet in GSA 6, Red Mullet in GSA 7 and Blue and red shrimp in GSAs 6 & 7) which showed very asymmetric production curve, so that after reaching the maximum become almost flat or with just very minor decreasing of production as F increases (group 2 stocks). For these stocks the F_{upper} values of most of the F_{MSY} proxies could not be defined. F_{upper} could be set by default at $F_{p.05}$ estimated for the HSBlim SRR, a value several times above former Ftarget at $F_{0.1}$ for ARA_6_7, MUT_1, MUT_6, MUT_7 and to a lesser extent for NEP_9 too.

Alternative F ranges were left open to examination across the different stocks, based on either:

- Option 1: using the Ftarget at $F_{0.1}$ and its F_{lower} as calculated for the HSBlim, and placing F_{upper} at F_{max}, if available.
- Option 2: staying at the former empirical linear models for F ranges, as defined in STECF 15-09 (STECF 2015).
- Option 3: using the F_{MSY} ranges obtained from a production curve corresponding to an alternative less productive SRR relationship selected for the stock.

Any option to be applicable should result in F ranges below $F_{p.05}$ of the plausible SRR models for the stock. In these cases, the default SRR was a Hockey-stick with a fixed break point at B_{lim} which was set either around the lowest observed S-R pairs values or within the cloud of S-R observed pairs. Alternative SRRs were based on BH.

Examination of these options across the case studies shows that:

- Option 1, i.e., using the Ftarget at $F_{0.1}$ with its F_{lower} and setting F_{upper} at F_{max} (the F_{MSY} from HSBlim) seemed suitable for three of the five cases. For ARA_6_7, NEP_9 and MUT_6 F_{max} resulted in a biomass just around B_{pa}, being lower than $F_{p.05}$. In contrast, for MUT_1 and MUT 7 F_{max} resulted in a biomass around B_{lim} and B_{pa} respectively with F_{max}>$F_{p.05}$ (type 3 risk). The lesser ranges for safe exploitation associated to MUT_1 is probably related to the fact that it is a less productive stock (with B_{lim} located around 43% $B_{0.1}$), but not in the case MUT_7, which places it around 17% $B_{0.1}$. It is likely that F_{max} can used as a safe F_{upper} limit for exploitation below $F_{p.05}$, for the cases where B_{lim} is placed around 25% or a lower fraction of $B_{F0.1}$. But the rule cannot be applied without carefully verifying that F_{upper} based on F_{max} results below $F_{p.05}$. In support of F_{max} being used as a reference for F_{upper} is also that for three of these stocks (ARA_6_7, NEP_9, MUT_6, all with $B_{lim}/BF_{(0.1)}$ =<0.1) F_{max} was around the F_{upper} limit of the F_{MSY} ranges obtained for the alternative less productive SRR relationships.

- Option 2, i.e., staying at the former F ranges defined in STECF 15-09 (STECF 2015), would be a generally applicable rule for the five stocks because in all cases F_{upper} values were either equal or smaller than $F_{p.05}$ type 3 derived from the HSBlim and from the alternative less productive SRRs (when estimated, as for NEP_9, MUT_6; MUT_7). In the case of MUT_1, MUT_9 and NEP_9 the empirical F_{upper} were just around $F_{p.05}$.
- Option 3, i.e. using the F_{MSY} ranges obtained from production curves corresponding to the alternative less productive SRR relationship selected for the stock, seemed suitable. These alternative F_{MSY} ranges obtained for the less productive SRR have always resulted in a range of values below $F_{p.05}$ whenever were calculated (ARA_6_7, NEP_9, MUT_6 and MUT_7), although for MUT_1 this was not verified. Furthermore, for these three stocks and for MUT_1, F_{MSY} from BH was always placed either around $F_{0.1}$ or between this value and F_{max}. The alternative F_{MSY} ranges based on the alternative less productive SRRs were well defined and complied with being below $F_{p.05}$ of the available $F_{p.05}$ estimates and allowed occasionally F targets a bit higher than those based on $F_{0.1}$, while complied with the standard definition of F_{MSY} ranges of the West Med EU MAP for those alternative production curves. The F_{upper} from BH was usually around F_{max}. A corollary of these observations is that it is unlikely that F_{MSY}(HS)(=F_{max}) could be adopted as Ftarget for these group 2 stocks, because such value was often around the F_{upper} values arising from the alternative SRRs assumptions (BH), instead it would support its consideration as Fupper as made in option 1.

All the three alternative proposals for definition of Ftarget and F ranges are generally robust to the current uncertainties on the plausible models of SRR governing the dynamic of this stock. The current F ranges based on the linear models (Option 2) would usually result in the lowest and narrowest of the allowed F ranges. Setting F_{upper} at F_{max} can expand further this range, but verification of being below $F_{p.05}$ for the plausible SRRs is required. Finally, moving to the F ranges defined for a selected alternative of a plausible less productive SRR model (Option 3) will allow generally rather similar F ranges as the former one, but based on F targets occasionally slightly higher. Among these three options, option 3 will be the only one complying with the definition of F ranges in the West Med EU MAP for the selected alternative SRR. Although pivoting on such alternative SRR may partly question the current definition of B_{lim} and its basis.

Type 3 production curves

For the stocks with a continuously growing production curve (group 3), no F_{MSY} or F_{upper} can be defined on the basis of the default HSBlim. There are four stocks: Red Mullet in GSA 9, Blue and red shrimp in GSA 5, Deep-water rose shrimp in GSA 8-9-10-11 and Giant red shrimp in GSA 8-9-10-11. These stocks are featured by having a B_{lim} fixed at 25%$B_{0.1}$, being actually placed in three of these stocks well below the cloud of observed S-R pairs (DPS_8_9_10_11; ARS_9_10_11 and MUT_9) and in one case within the cloud of observations (ARA_5). For the cases where B_{lim} lays well to the left it will generally imply that the stock would be very resilient and robust to hard harvest rates, what explains the nature of a continuously growing production curve for the HSBlim, leading to an undefined F_{max}.

For all these stocks the EWG had a priori decided not to change the Ftarget, therefore it was left at $F_{0.1}$ and the F ranges adopted were just those previously derived from the empirical relationships defined in STECF 15-09 (STECF 2015). For the four cases such F ranges were compliant with being lower than $F_{p.05}$ (estimated from the HSBlim), although in one case (for the DPS in 8-9-10-11) compliance of the F_{upper} to be below $F_{p.05}$ type 3 obtained from the alternative (less productive) HSBloss SRR required reduction of such F_{upper} value.

For these stocks, a rule like the Option 3 devised for the group 2 could have also been tried, i.e., that of using the F_{MSY} ranges obtained from production curves corresponding to some alternative less productive SRR relationship selected for the stock. Three stocks of this group had the B_{lim} well to the left, and for them alternative SRRs like HS with the breakpoint at B_{loss} or within the cloud of observations or like BH or Ricker should help defining risk averse F targets and ranges and would allow estimating the $F_{p.05}$ for such alternative SRR (expected to be lower than the $F_{p.05}$ of the HSBlim). For instance, for Giant red shrimp in GSAs 9, 10 & 11, the lower $F_{p.05}$ corresponding to the more risk averse HSBloss (with a break point at 61% $B_{F0.1}$ and at 26% of B_0) indicated that the $F_{0.1}$ ranges were also precautionary versus such alternative $F_{p.05}$. This confirmed the robustness of the $F_{0.1}$ ranges to the major uncertainties affecting the productivity of the stock. In the case of DPS in 8-9-10-11, the F_{MSY} values and ranges derived from the less productive Ricker SRR define ranges complying with all the $F_{p.05}$ values defined (either for the HSBlim as for the Ricker models) and could be passed for management being robust to the main uncertainty affecting the SRR. Such alternative range has the benefit of allowing a safer margin versus the $F_{p.05}$ and of matching the actual definition of the F ranges in the West Med EU MAP for the selected plausible less productive SRR. For ARA 5 and MUT 9, the F_{MSY} ranges available from the alternative SRRs had F_{upper} too high (above $F_{p.05}$ from the HSBlim) as to be proposed, something related to the alternative SRR which were not less productive in the case of ARA 5 and doubtful in the other case. Therefore, application of this Option 3 cannot be applied in a blind manner without verification of passing the $F_{p.05}$ filtering.

2.4.3 Proposed methodology for defining F_{MSY} or F_{MSY} proxies and corresponding ranges

The procedure followed and the potential options to define F_{MSY} or F_{MSY} proxies and the corresponding ranges are summarised in Figure 2.4.3.1. Whenever possible (type 1 production curves) EWG 24-02 proposed to set F_{MSY} and the corresponding ranges based on the standard method (option 0) for the default HSBlim SRR. Alternatively, the EWG proposed Option 1 and Option 2 gradually reverting to the $F_{0.1}$ and empirical F ranges proposed earlier by STECF, according to the feasibility of applying or not other options depending upon the shape of the production curve associated to the default HSBlim SRR. For type 2 production curves, option 1 was preferred over option 2 because its basis was presumed to be closer to the actual definition of F ranges than the empirical formulas.

Option 3 which has been shown to be applicable at least to group 2 and 3 stocks, and which might be probably applicable to group 1 stocks too, was left open for consideration as the criteria to select the alternative plausible SRRs were not pre-agreed by the group and it was based on a rather stock-by-stock basis (Table 2.4.4.1). Alternative SRR were set up more for sensitivity analyses rather than as a systematic coverage of all plausible less-productivity SRR. Actually, no option 3 alternative has been the basis of the proposals put forward for STECF consideration from this EWG. However, there are cases where the F_{MSY} and ranges obtained with option 3 for some stocks might be preferred over those proposed by the group, particularly when the F_{upper} approaches $F_{p.05}$ values. For instance, in deep-water rose shrimp 8-9-10-11 (group 3 stock) the original F_{upper} based on empirical results was too high in comparison with the $F_{p.05}$ type 3 estimate of an alternative HSBloss, and it was decided to suggest capping the empirical F_{upper} to such $F_{p.05}$ value. But the F_{MSY} ranges produced for the Ricker curve (a less productive SRR) gives a slightly smaller Ftarget and ranges, hence allowing for a safer margin below $F_{p.05}$. For this case further analysis based on the BH model could have been done as it showed the best statistical fitting, but they were discarded because of the very high R0 in comparison with past observations, and because Ricker model was considered a priori a sufficient similar model representative of a less productive SRR. The issue now is that if the F_{MSY} and ranges steaming from the Ricker SRR were to be passed to managers then it might be argued that the analysis should have included as well the other plausible (best fitting) SRR (the BH) for completeness. Another example appears with Red Mullet in GSA 6 (group 2 stock), where the F_{MSY} ranges from the BH could be also advised. This alternative would barely change the F_{upper}, but it would revise upward the F target (though still keeping it well below F_{max}). For this stock BH SRR had the best statistical fitting in terms of AIC and BIC, and hence it was a good alternative candidate of a SRR model. A very similar example is also shown for red mullet in 7, where the F ranges based on the linear models were very similar to the F_{MSY} ranges of an alternative less productive SRR model (Ricker). Here again, this alternative would barely change the F_{upper}, but it would revise slightly upward the F target (keeping it well below F_{max}).

Certainly, the examples above define conditions over which Option 3 can be considered a valid option for provision of F_{MSY} ranges: The Option 3 is based on a better statistical fitting of a SRR than the default HSBlim and it is based on a less productivity SRR, and complies with being below $F_{p.05}$ of the default and the alternative SRRs. In this circumstances Option 3 produces F_{MSY} ranges which are risk-averse to the uncertainties about the actual productivity of the stock, and which comply with the definition of the F_{MSY} ranges in article 2(4) of Regulation (EU) 2019/1022 for a cautionary plausible less productivity SRR than the default SRR. Therefore, final adoption of this Option 3 for providing F_{MSY} ranges to mangers is let open for discussion at STECF level. There is one stock (DPS 8_9_10_11) for which such alternative could be better than the default Option 2 passed for consideration, because it implies a safer margin versus the $F_{p.05}$.

Taking into account the need for consistency between the underlying assumptions on the calculation of the reference points and of the F_{MSY} ranges, the consideration of alternative SRRs for the definition of F ranges (by Option 3) may also imply the revision of B_{lim} in future in case such alternative SRR is consolidated with the addition of new S-R observations as the best fitting SRR.

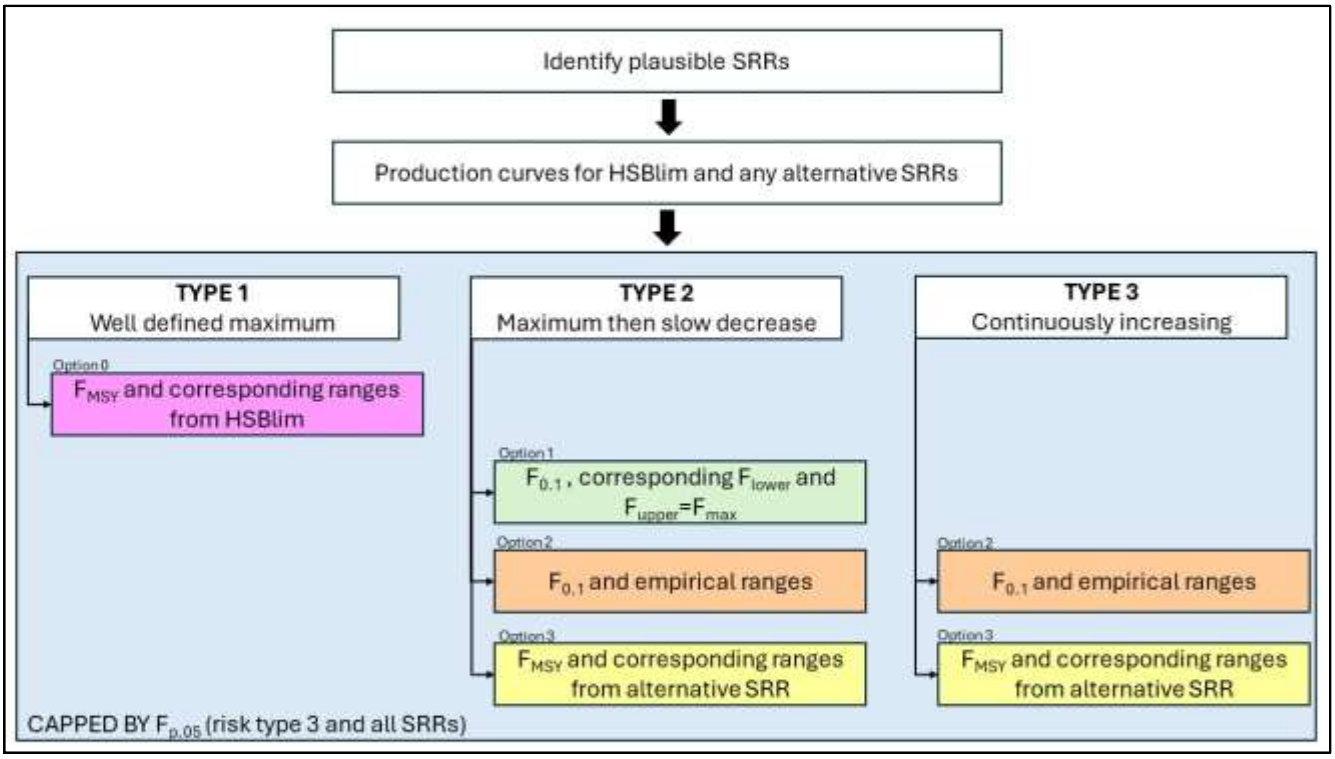


Figure 2.4.3.1 General procedure on the options to define F_{MSY} or F_{MSY} proxies and their respective ranges by EWG 24-02.

In the proposed framework of this EWG, compliance to the precautionary principle according to the West Med EU MAP (Regulation (EU) 2019/1022) was guaranteed by assuring all proposed F ranges were smaller than the $F_{p.05}$ obtained from the HSBlim and from any other alternative SRRs, including the less productive plausible SRRs (blue box in Figure 2.4.3.1). An alternative approach to ensure that the F_{MSY} proxies and their corresponding ranges comply with the precautionary principle while accounting for the uncertainty of the SRR could have been based on carrying out the forward simulations averaging alternative plausible SRRs according to their respective AIC (as it is made in ICES with Eqsim - ICES 2021b; Buckland et al. 1997; see also Simmonds et al. 2011). This approach was not attempted during the EWG, but could be considered in the future.

2.4.4 General considerations on the proposed procedure

The EWG made the following general considerations:

a) Selection of alternative SRRs

Standardization of criteria to select SRRs for analysis has to pivot on statistical basis, on visual examination of the fitting from the origin to the cloud of observed biomass, as well as on general criteria as the ones of the STECF decision tree to set B_{lim} (consistency with past recruitments or catches). If there are better fitted SRR models with smaller slopes between the origin and observations, these are less productive SRRs which deserve consideration as alternative SRR models for assessing risks to B_{lim} and potentially to assess alternative F ranges.

Among the 12 stocks covered four showed the best fitting for the HSBlim SRR (the three stocks in group 1, the two hake stocks and NEP_6, plus MUT_1 from group 2), placing the break point either at the middle or around the mid-upper ranges of past S-R pairs of observations (Table 2.4.4.1). For them there was no clear plausible alternative less productive SRR model. Thus, the work for these four stocks can be considered representative of the current productivity of the stock and sufficiently reliable. For the remaining eight stocks, B_{lim} was placed either at the middle (ARA_5) or mid-left o well below (to the left) of past observations (all the other stocks). For all of them at least one plausible alternative SRR was identified (usually based on BH). For seven of them this was a better fitting of a less productive SRR model, while in the other one (ARA_5) a less productive fitting (Ricker) was not included due to the lack of time and hence further work it is recommended prior or during the assessment working group on this stock (based Ricker) (Table 2.4.4.2Table 2.4.4.1). Among the remaining 7 stocks (in groups 2 or 3), the determination of the plausible less productive SRRs was quite well stablished, and covered by the analysis, and therefore results are considered reliable. For verification, optional completion of another alternative less productive SRR (BH) is suggested for MUT_1, MUT_7, MUT_9 and ARS 8_9_10_11 (Table 2.4.4.2).

In addition, pre-specifying how much risk averse an alternative SRR can be when this is not well defined by the available S-R observations, is also a decision that should be pre-agreed in advance. For instance, for the group 1 stocks, which showed the best statistical fitting for the HSBlim it was unclear what alternative SRR would be worth exploring as the slope to the origin was quite clearly defined by the S-R observations. Looking for an alternative HS forcing the B_{lim} to be as high as 20%B_0 could be an option to setting a highest R0 consistent with general default option in literature, but it would imply strong revision of B_{lim}, Ftarget and of the stock status assessment.

For stocks in groups 2 and 3, in particular those six stocks having the B_{lim} placed well below previous biomass observation (to the left of observations) as a result of the pre-agreed decision of placing them at 25%$B_{0.1}$, the alternative less productive SRRs place B_{lim} quite often around 30-33% $B_{0.1}$ if based on B_{loss} or on HS (NEP_9; MUT_9; MUT_7) or at a higher fractions (ARS 9_10_11 at 61% or DPS_8_9_10_11 at 86%) and in all cases they did not exceed 27%B_0. These fractions of $B_{0.1}$ might be considered too high, but it might be worth considering if in those cases where the productivity is so badly informed by the data, a default alternative SRR should cover either HS at B_{loss} (whenever it does not exceed 20%B_0), or a HS placing B_{lim} at 20%B_0 otherwise. In this way a standard default less productive SRR could be pre-agreed for all stocks.

Table 2.4.4.1. Summary of the current B_{lim} value with its basis ($BasisB_{lim}$) and position relative to past biomass observations (B_{lim} location); Default SRR and indication of what alternative SRR were used for determination of F_{MSY} proxy ranges (Alternative SRR?) (in bold when they correspond to the best statistical fitting), followed by indication of whether they include some Less Productive SRR (LessProd?; Yes/No)) and of what SRR were used for projections to evaluate $F_{p.05}$ (SRRs for projections).

Stock type	Stock Sp.	Area	B_{lim}	$BasisB_{lim}$	B_{lim} location	Default SRR	Alterna-tive SRR?	Include Less Prod?	SRRs for Projections
1	Hake	1_5_6_7	3,872	Estimated	Within UP	**HSBlim**	No	No	HSBlim
1	Hake	8_9_10_11	5,132	Estimated	Within UP	**HSBlim**	No	No	HSBlim
1	Norway lobster	6	472	forced	Within UP	**HSBlim**	No	No	HSBlim
2	Red Mullet	6	770	forced	Within Low	HSBlim	**BH**	Yes	HSBlim/BH
2	Blue and red shrimp	6_7	261	Estimated	Within Low	HSBlim	**BH**	Yes	HSBlim/BH
2	Norway lobster	9	255	forced	Left	HSBlim	**BH**	Yes	HSBlim/BH
2	Red Mullet	1	170	Estimated	Within Mid	**HSBlim**	No	No	HSBlim
2	Red Mullet	7	134	forced	Left	HSBlim	**HSfree/ BH**	Yes	HSfree/BH
3	Blue and red shrimp	5	75	forced	Within Mid	HSBlim	BH	No	HSBlim/BH
3	Giant red shrimp	8-9-10-11	193	forced	Left	HSBlim	**HSBloss**	Yes	HSBlim/HSBloss
3	Deep-water rose shrimp	8-9-10-11	214	forced	Left	HSBlim	**HBLoss / Ricker**	Yes	HSBlim/HBLoss / Ricker
3	Red Mullet	9	462	forced	Left	HSBlim	**BH / Ricker**	Doubtful	HSBlim/BH

Table 2.4.4.2 Summary comments by stocks of the further simulation work suggested to be covered.

GROUP	Stock Sp.	Area	Further work?	Comments
1	Hake	1_5_6_7	Optional	Full Management Strategy Evaluation
1	Hake	8_9_10_11	Optional	Full Management Strategy Evaluation
1	Norway lobster	6	No	$F_{p.05}$ only based on HSBlim.
2	Red Mullet	6	No	$F_{p.05}$ based on both HSBlim and on BH.
2	Blue and red shrimp	6_7	No	$F_{p.05}$ based on both HSBlim and on BH.
2	Norway lobster	9	No	$F_{p.05}$ based on both HSBlim and on BH.
2	Red Mullet	1	Optional	No evident better plausible less productive SRR. $F_{p.05}$ only based on HSBlim. Might be convenient to verify with alternative BH
2	Red Mullet	7	Optional	$F_{p.05}$ based on both HSBlim and on HS free. As BH & Ricker are the best fitting models and the less productive ones, $F_{p.05}$ could be evaluated for them as well (or at least for BH)
3	Blue and red shrimp	5	Yes	$F_{p.05}$ based on both HSBlim and on BH. As visually Ricker seems to be a plausible less productive SRR Evaluation of F_{MSY} ranges and $F_{p.05}$ for Ricker is recommended
3	Giant red shrimp	8-9-10-11	Optional	$F_{p.05}$ based on both HSBlim and on HBloss. Verification of the $F_{p.05}$ of Ricker and BH is advisable
3	Deep-water rose shrimp	8-9-10-11	No	$F_{p.05}$ based on these models: HSBlim, HSBloss & Ricker, with the latter ones being the best fitting models and the less productive ones.
3	Red Mullet	9	Optional	$F_{p.05}$ only based on HSBlim and BH (based on 100 iterations). Might be convenient to verify 1000 iterations with BH and with alternative Ricker

b) Uncertainty sources and risk evaluation

The uncertainty sources considered in the forward projections consisted in uncertainty in the stock status, uncertainty in the recruitment process and uncertainty in the intended fishing mortality. The former two were based on the results from the latest stock assessments, whereas the later (representing assessment and implementation error) was simulated by a Fsigma (at 0, 0.1 and 0.2) and Frho (at 0.25). The impact on the results of the different Fsigma values was found to be negligible. However, the exact evaluation of what levels of Fsigma and Frho would be most appropriate for the fisheries in the West Med EU MAP deserves further work. If larger values than the ones applied here are found to affect the performance of the intended Fishing mortality for managing these fisheries, then a re-evaluation of the performance indicators for every Ftarget and ranges should be performed.

Furthermore, for vulnerable stocks like the two hake stocks (HKE_1_5_6_7 and HKE_8_9_10_11) the EWG considered that it could be useful to carry out a full Management Strategy Evaluation of the harvest strategies based on their respective F_{MSY} target and ranges (Table 2.4.4.1). In addition to the sources of uncertainty already included in the forward projections, the MSE should include model averaging of pre-agreed plausible alternative SRR, and the full evaluation of stock status though inclusion within the simulations of the observation inputs from the monitoring system and the assessments of the stock according to those inputs.

In general, risks type 3 for the SSB of falling below B_{lim} in the long-term projections has been the preferred over risk type 1, as a way to be robust to the many uncertainties surrounding the analysis. This is consistent with the criterion used as the basis for defining a multi-annual plan as precautionary in ICES (ICES 2019), and here it was considered to be risk averse in the formulation of F ranges for the implementation of the West Med EU MAP.

As mentioned before, the EWG tried to assure robustness to alternative plausible SRRs, including plausible less productive ones than the default SRR, whenever defined and selected for the stocks, by making mandatory that the F_{MSY} range passed for consideration comply with being smaller than the smallest $F_{p.05}$ defined from the different plausible SRR models.

Finally, the initial forward projections carried out during the meeting (20 or 100 iterations) were considered insufficient to provide reliable estimates of risks. Therefore, additional simulations were conducted after the meeting. The results presented in the report are based on 1000 iterations. This number of iterations is considered generally large enough to obtain robust estimates while being computationally affordable, but it was not based on any analysis.

c) Reliability of the current B_{lim} estimates and associated uncertainty

The method proposed to derive F ranges adopted as reference the SRRs and B_{lim} already defined by STECF for these West Med stocks (STECF EWG 22-03, STECF EWG 23-09) (Table 2.1.2.1). However, for most of the stocks, alternative SRRs were identified. These SRRs (specially the less productive ones) may imply different B_{lim} for the dynamics of the population, which have not been defined in the current work. For instance, for the six stocks having the B_{lim} placed well below previous biomass observation (to the left of observations), as result of the predefined B_{lim} at 25%$B_{0.1}$, B_{lim} is on average about 10% B0 (Table 2.1.2.1). If the default value of 20%B0 threshold of several International RFMO would be taken as a reference for these stocks, Risks for the same F ranges will be increased, and assessment of the status of the stock might be substantially affected. The uncertainty around the true B_{lim} has not been assessed by this EWG. Such an omission asks for a deliberate precautionary approach when defining the F_{MSY} ranges in an operative manner such that the risk not only for the current Blim, but also for other plausible higher B_{lim} values which might actually govern the population dynamics, are also taken into consideration. The only way to approach such an uncertainty in a qualitative manner is to assure not only that the F_{MSY} ranges are below any putative plausible $F_{p.05}$, but also by favouring those F_{MSY} ranges resulting in safe margins below $F_{p.05}$. In the way the F_{MSY} ranges have been proposed for most of the group 2 and group 3 stocks, quite safe margin to the lowest estimated $F_{p.05}$ is included. The only ones who are touching the limits of the $F_{p.05}$ are MUT_1 and DPS 8_9_10_11. For the former one optional further work is proposed to verify the behaviour under another poor productive SRR like the BH (Table 2.4.4.1). For the DPS 8_9_10_11 the analysis was rather complete And the alternative based on Option 3 might be better than the default Option 2 passed for consideration, because it implies a safer margin versus the Fp.05.

The uncertainty surrounding the B_{lim} as derived from the plausible alternative SRRs, might be taken into account if they were defined independently for every model, and the forward projections would evaluate the relative performance of the F_{MSY} ranges over the respective B_{lim} by SRR. In this way reported risks would be relative to respective B_{lim} values by SRR. Under this approach B_{lim} would not be an objective external BRP explicit in the management plan but a hidden parameter in the simulations. This exercise was briefly considered but discarded for the purposes of the EWG as we pivot upon the pre-agreed B_{lim} decision of the former STECF EWGs.

d) Additional considerations

- It is important to note that the evaluation of risks carried out by this EWG are based on a long-term application of constant fishing mortality F to harvest the stocks. Much higher risks are found over short-term forecasts carried out by the assessment EWGs, as they are very much conditioned on the most recent stock status.
- ICES has an advice rule that reduces the target F_{MSY} when SSB is below MSY $B_{trigger}$. While the assessment EWG has used this rule in the past in the provision of advice (by setting B_{pa} as $B_{trigger}$), this advice rule is not explicit in the West Med EU MAP and is not inherent in the STECF procedure. Therefore, the EWG 24-02 simulated management only based on direct implementation of the Ftarget and F ranges, without inclusion of any other advisory rule of the kind mentioned above. Stocks in very poor condition below the B_{lim} (break point of the HSBlim) may require reduced harvest strategies to speed up their recovery. Developing Recovery strategies within rebuilding management plans are tools which may deserve consideration in the context of the WestMed EU MAP stocks.
- The EWG considered other F_{MSY} proxies than $F_{0.1}$ (e.g. F40%SPR, F40%B0) and did all the corresponding calculations. Given that it was not possible to extract general conclusions across all the stocks, the results are presented but are not discussed in detail in the report.
- The reference points are calculated every year, but there are no clear criteria yet on how often they should be re-assessed or how big the change should be to trigger a revision. A criterion might be to reassess them every 3-5 years in benchmark processes. As a matter of rutinary checking and to avoid spurious changes by the addition of a single new S_R observation, allowance of yearly changes could be restricted, for instance, only to cases where the addition of new S-R pairs let the former parameters of the default SRR outside the 95% confidence interval of the current estimates. Devising the criteria for allowance of yearly changes in the B_{lim} or Ftargets deserve further consideration.
- Given the paucity of information on the recruitment / stock dynamics and the history of applying proxy reference points for precautionary reasons in the Med fisheries generally, setting management targets in relation to maximum yield in the West Med MAP as requested is a difficult task, furthermore, considering the variety of production curve shapes encountered. Technically, for stocks for which a maximum yield cannot be established, management is not possible in accordance with the plan. Previously, a proxy target $F_{0.1}$ has been implemented precautionarily as a single target value. Full implementation of the management plan based F ranges with proxy reference point proves to be problematic as it requires mirroring such precautionary proxies on the yield curve as a percentage of maximum yield. The more precautionary a reference point is when applied on the left of maximum yield the more risky is also to the right of maximum yield when applied as a range in accordance with the MAP regulation. The respective level of risk and precaution implied in the range are not symmetrical. The limit for the F ranges, based on $P(SSB < B_{lim}) < 5\%$, calculated irrespective of the consideration of whether the actual limit (B_{lim}) is a suitable one, is intended to guard against a lack of sustainability. Other options in terms of safer threshold of probability values, or in terms of the likelihood of keeping biomass around the target biomass reference point (B_{MSY}) would be options worth for consideration, but would not be consistent with the current management plan.

- For the cases of undefined F_{upper}, and where F_{max} of the F_{MSY} of the alternative SRR led to values above $F_{p.05}$, the default rule has been that of staying at the former $F_{0.1}$ and F ranges stablished from the empirical linear models, provided they were actually below $F_{p.05}$ (as for instance for ARA_5). Other alternative approaches not followed by this EWG such as setting F_{upper} at $F_{p.05}$, setting F_{upper} at some intermediate point between $F_{0.1}$ and $F_{p.05}$ or setting symmetrical F ranges around the target Fproxy were not explored in detail and may be considered in the future.
- Management has already acted significantly on these stocks in recent years through different independent management measures (effort regulations, area closures and catch limits) which makes the current selectivity estimates less certain than the assessment uncertainty indicates and potentially biased for those assessments where separable assumptions on catches are made. This adds uncertainty to all output metrics from the simulations, including the risk of SSB < B_{lim} given levels of F, and may affect as well in future to the assessment of the implied effort required to achieve that level of F.
- Additional issues on stock-by-stock basis are detailed on the stock annexes with the main outcomes by stock and may be worth considering particularly for the Experts attending the assessment working group.
- As requested EWG 24-02 has proposed a method for setting F ranges for the stocks included in the WestMed MAP, which includes several options depending on the shape of the production curve. The adoption of the final procedure will be carried out at the STECF plenary in July. The final procedure will be applied by the STECF assessment working group in September, providing final F_{MSY} ranges for these stocks.
- In contrast to other EU fisheries which occur in eutrophic seas, the MED fisheries occur in an oligotrophic environment and the basin is characterized by mostly narrow shelves meaning the demersal fisheries are concentrated along the coasts forming a more or less one dimensional environment spatially with strong environmental gradients leading to strong regional environmental contrasts. This greatly affects the distribution and free movement of both fish and fishers as well as secondary characteristics such as population dynamics and fleet structure and economics. In addition, few of the species under the MAP can or are routinely aged because they are either shellfish or lack the clear annual markings used to age fish in temperate environments with greater seasonal contrast. The combination of these factors means that our understanding of the populations, their dynamics and the fishers exploiting them is limited. Nevertheless, our understanding on current population dynamics has increased considerably in recent years, but most of the stock assessments in the MAP are limited to relatively short timeseries indicating limited contrast in population size which provide few clues as to the stock recruitment dynamics thus complicating medium- to long-term predictions. Furthermore, management mostly based by effort regulation in mixed fisheries can be more challenging than based on single species TAC on little mixed fisheries.

While the West MED MAP has the overall objective of exploiting all stocks covered by the MAP at maximum sustainable fishing mortalities it does recognize the technical interactions caused by the mixed fishery nature of many of the fleets. Therefore, the MAP contains provisions in the form of F ranges that explicitly allow some stocks to be exploited at F values greater than F_{MSY} in order to avoid large reductions in yield (effort) which would be indicated for less susceptible stocks. EWG 24-02 was requested to provide a range of F by stock that maintain catches at 95% of maximum long-term yield while keeping the risk of the stock dropping below B_{lim} at less than 5% in a given year. Therefore, the analysis was carried out on single stock basis, simply ignoring the interactions or difficulties that the implementation of the fishing targest or ranges may have in the context of these mixed fisheries. It is understood, that such mixed fisheries considerations will be made during future EWGs under the effort regime.

2.5 Conclusions TOR 1

Answers to the EWG24 02 subTORs in TOR 1 follow:

A) STECF should assess if the prior work performed by STECF EWGs for deriving F_{MSY} ranges from precautionary $F_{0.1}$ complies with the F_{MSY} range definition outlined above (Article 2(4))

Answer: For all stocks of the West Med EU MAP, the current Ftarget of $F_{0.1}$ and their F ranges (based on the empirical linear models) did not exceed $F_{p.05}$ values estimated from the default HSBlim SRR (type 1 risk). Therefore, it can be concluded that the current F ranges obtained from the empirical linear models are precautionary in the long-term. However in terms of compliance with the F_{MSY} range definition outlined in Article 2 (4), these F_{MSY} proxy ranges did not deliver no more than a 5 % reduction in long-term yield neither compared to the MSY (as shown for the Hake stocks and for NEP_6), nor with the catch at $F_{0.1}$ (as shown for the rest of stocks). Generally empirical estimate of F_{upper} were smaller than current estimates of F_{upper} (relative to the $F_{0.1}$ or to F_{MSY} target). Therefore, the prior work performed by STECF EWGs for deriving F_{MSY} ranges from precautionary $F_{0.1}$ does not comply with the F_{MSY} range definition outlined in Article 2 (4).

B) On this basis, and considering the availability of longer time series in respect to 2015, the STECF is requested to develop a methodology that would deliver:

- F_{MSY} or F_{MSY} proxy targets for the key target stocks
- F_{MSY} ranges for the key stocks defined in Article 1(2), that are compliant with the definition of Article 2(4).

Answer: The EWG applied the following method to define F_{MSY} ranges for the WestMed MP stocks

a. The EWG 24 02 decided to accept by default the B_{lim} and the Hockey-stick (HSBlim) Stock Recruitment relationships (SRR) stablished in the past (STECF 2022-03; STECF 23-09) for the stocks in the WestMed EU MAP

b. Several F_{MSY} proxy targets and respective ranges were defined for every stock taking as basis both the Yield and Spawning Biomass per recruit analysis (SPR) and the associated Production curves (from the default HSBlim) as the ranges comprising up to a maximum drop of 5% over the yield at F_{MSY} proxy.

c. When several competing alternative plausible SRR were found to be present, particularly when supposing a less productive plausible SRR modelling of the S-R pairs observations in terms of AIC and BIC, these alternative plausible SRR were also included for an analysis of sensitivity to define alternative F_{MSY} and ranges and to assess for the risk of the original F_{MSY} proxy targets and ranges (as defined for HSBlim) of leading below the default B_{lim}.

d. The risk of falling below B_{lim} for these ranges was assessed through forward simulation; the Fishing mortality value inducing a risk of 5% or higher was used to define $F_{p.05}$ for fixing the maximum limits to exploitation under the default HSBlim, and, when selected, for alternative SRRs.

e. The general idea of these sensitivity analysis was to check if the F_{MSY} proxy ranges were risk-averse to the alternative plausible SRRs. This was made by comparing those F_{MSY} proxy ranges with the $F_{p.05}$ values derived from the selected plausible alternative SRRs. In order to be risk averse: The preference was that the F ranges passed to managers should not induce risks to dropping below B_{lim} higher than 5% for any of the plausible SRR dynamics of the stock considered in the analysis.

After analysis of the Production curves of the stocks it was decided to:

f. For stocks with a well-defined dome shape Production Curve (group 1) the F ranges were estimated according to the standard definition in the West Med EU MAP (Regulation (EU) 2019/1022) (as the ranges comprising 95% of the expected catches at MSY.

g. For stocks showing a very asymmetric production curve, so that after reaching the maximum becomes almost flat or with just very minor decreasing of production as F increases (group 2 stocks), as the F_{MSY} proxy ranges cannot be defined (because F_{upper} is not found), the EWG analysed the following options:

   i. Option 1: using the Ftarget at $F_{0.1}$ and its F_{lower} range as calculated for the HSBlim, and placing F upper at F_{max}, if available,

   ii. Option 2: staying at the former F ranges defined in STECF 15-09 (STECF 2015),

   iii. Option 3: using the F_{MSY} ranges obtained from a production curve corresponding to an alternative less productive SRR relationship selected for the stock.

   iv. Any option to be applicable should result in F ranges below $F_{p.05}$ of the plausible SRR models for the stock.

   v. The preference was for option 1 whenever feasible, followed by Option 2, while Option 3 was more for exploratory sensitivity analysis.

h. For the stocks which were showing a continuously growing production curve (group 3), as no F_{MSY} or F_{upper} can be defined on the basis of the default HSBlim, the EWG decided not to change the Ftarget, therefore it was left at $F_{0.1}$ and the F_{MSY} ranges adopted were just those previously derived from the empirical relationships defined in STECF 15-09 (STECF 2015). Potential for application of option 3 above was also put for consideration.

In summary, the procedure followed by EWG 24 02 to set F_{MSY} ranges (Figure 2.4.3.1) consisted in applying the standard method (option 0) whenever possible. Alternatively, Option 1 and Option 2 by order of preference and gradually reverting to the original F ranges proposed earlier by STECF, should be applied conditional to the shape of their production curves associated to the default HSBLim SRR. Compliance to the precautionary principle according to the Regulation of the Management Plan was guaranteed by assuring all proposed F ranges were smaller than the $F_{p.05}$ obtained from HSBlim and from any other alternative SRR, including less productive plausible SRRs.

The third Option 3 was left open for future consideration as the criteria to select the alternative plausible SRRs were not pre-agreed by the group, and it was based on a rather *ad hoc* stock by stock basis. However, it should be noticed that this option 3 whenever based on a better statistical fitting of a SRR than the default HSBlim and on a less productive SRR, and when complying with being below $F_{p.05}$ for the default and the alternative SRRs, it will produce F_{MSY} ranges which are risk-averse to the uncertainties about the actual productivity of the stock, and which comply with the definition of the F_{MSY} ranges in article 2(4) of Regulation (EU) 2019/1022, for a cautionary plausible less productivity SRR than the default SRR. Therefore, final adoption of this Option 3 for providing F_{MSY} ranges to managers could be acceptable and it is let open for discussion at STECF level. The major drawback about this option is that it may need revisiting the definition of B_{lim} for consistency with the underlying SRRs.

As requested EWG 24-02 has proposed a method for setting F ranges for the stocks included in the WestMed MAP, which includes several options depending on the shape of the production curve. The adoption of the final procedure will be carried out at the STECF plenary in July. The final procedure will be applied by the STECF assessment working group in September, providing final F_{MSY} ranges for these stocks.

C) STECF is requested to provide F_{MSY} ranges for the stocks of the MAP in view of providing updates in EWG 24-10.

For deep-water rose shrimp in GSA 1 and in 5_6_7, showing continuously growing recruitments, it was considered that no SRR can be defined, and no further analysis was carried out.

For the remaining 12 stocks with stocks assessment and acceptable SRR fitting, the methods outlined above were applied.

There were three stocks with a dome shaped production curve for which F ranges were set according to the standard definition in the WestMed MAP (Regulation (EU) 2019/1022) (**Table 2.**) the two hake stocks and NEP_6. This implies moving from the former target at $F_{0.1}$ to F_{max} from SPR. In all these three cases B_{lim} was defined by the break point resulting from the HS fitting, and the fitting of that HS model was the best among alternative SRRs. Therefore, the decision on the SRR was quite well statistically supported. Such change from $F_{0.1}$ to F_{MSY} supposed increases in the F target of 44% and 42% and in the F_{upper} of 59% and 54 % for the hake stocks in 1-7 and in 8-11 respectively, in comparison with the $F_{0.1}$ and its empirical ranges defined before. The increases in Norway Lobster were of 71% in the F target and of 104% in F_{upper}. For the Norway Lobster, the F_{upper} (0.47) is just above the $F_{p.05}$ (type 3 risk value of 0.43) and leads to a biomass (789) placed between B_{pa} (944) and B_{lim} (472). In order to be fully compliant with the precautionary it is suggested to reduce F_{upper} to $F_{p.05}$ (type 3 estimates), i.e., to 0.43.

Table 2.5.1 EWG 24-02 F_{MSY} range proposals for stocks in group 1: Original F reference points from EWG 23-09 (left part of the table) and EWG 24-02 proposal (right part of the table) from F_{MSY} ranges, with indication F, biomass and catches and the $F_{p.05}$ values obtained from HSBlim SRR (last column).

			Reference points value EWG 23-09				**Basis B_{lim}**	**EWG PROPOSAL**		**HSBLim EWG 24 02**			**HSBlim**
Stock	**Area**	**Parameter**	**$F_{0.1}$**	**F_{lower}**	**F_{upper}**	**F_{pa}**	**Blim**	**SRR basis**	**F basis**	**F_{MSY}**	**F_{lower}**	**F_{upper}**	**$F_{p.05}$**
Hake	1_5_6_7	Fishing F	0.41	0.27	0.56	NA (1.27)	NA	HSBlim	Fmsy	0.59	0.39	0.89	1.139
		Biomass	63,696			7,743	3,872	HSBlim	Biomass	34706	61508	15621	1.308
		Yield						HSBlim	Yield	5003	4753	4753	
Hake	8_9_10_ 11	Fishing F	0.17	0.11	0.23	0.584	NA	HSBlim	Fmsy	0.24	0.16	0.35	0.57
		Biomass	49,500			10,264	5,132	HSBlim	Biomass	33737	48179	21381	0.644
		Yield						HSBlim	Yield	5091	4836	4836	
Norway lobster	6	Fishing F	0.16	0.11	0.23	0.324	NA	HSBlim	Fmsy	0.28	0.18	0.43	0.43
		Biomass	1,890			944	472	HSBlim	Biomass	1483	2390		0.51
		Yield					944	HSBlim	Yield	474	450		

There were five stocks which showed very asymmetric production curve (group 2): Red Mullet in GSA 1, Red Mullet in GSA 6, Red Mullet in GSA 7, Norway lobster in GSA 9, Blue and red shrimp in GSA 6_7. These are stocks with Hockey-stick forced to be fitted to a break point (B_{lim}) set either around the lowest observed S-R pairs values (including B_{loss}) or within the cloud of S-R observed pairs. The preferred Option 1 was applicable over three of those stocks MUT_7; ARA 6_7 and NEP_9, but not for MUT_1 and MUT 7 because for them F_{max} resulted in a biomass around B_{lim} and B_{pa} respectively with F_{max}>$F_{p.05}$ (type 3 errors) (Table 2). Therefore Option 1 rule cannot be applied without carefully verifying that F_{max} is below $F_{p.05}$.For these two stocks Option 2, i.e., staying at the former F ranges defined in STECF 15-09 (STECF 2015), was applied. Actually, for all these stocks Option 2 was generally applicable because in all cases F_{upper} values were either equal or smaller than $F_{p.05}$ type 3 derived from the HSBlim and from the alternative less productive SRR

Table 2.5.2 EWG 24-02 F_{MSY} range proposals for stocks in group 2: Original F reference points from EWG 23-09 (left part of the table) and EWG 24-02 proposal (right part of the table) based on the current Evaluation of $F_{0.1}$ and its F_{lower} and on the evaluation of F_{upper} at F_{max} or based F_{upper} in the former empirical estimate and with the last two column indicating $F_{p.05}$ values obtained from HSBlim SRR and from an alternative SRR (if available).

			Reference points value EWG 23-09				**Basis**	**EWG PROPOSAL**		**HSBLim EWG 24 02**			**HSBlim**	**Alternative**
Stock	**Area**	**Parameter**	**F0.1**	**Flower**	**Fupper**	**Fpa**	**Blim**	**SRR basis**	**F basis**	**Fmsy**	**Flower**	**Fmax**	**Fp0.05**	BH
Red Mullet	**6**	F value	**0.31**	0.21	0.432	0.871	*	**HSBlim**	**F(0.1)**	**0.30**	**0.26**	**0.71**	1.13	1.10
		Biom.	**3,600**			**1,540**	**770**	HSBlim	Biom.	3298	3646	1,846	1.58	1.55
		Yield	**1,106**					HSBlim	Yield	1079	1025	1,192		
			F0.1	**Flower**	**Fupper**	**Fpa**		**HSBlim**	**F(0.1)**	**F(0.1)**	**Flower**	**Fmax**	**Fp0.05**	**BH**
Blue and red shrimp	**6_7**	F value	0.26	0.17	0.36	0.954		**HSBlim**	**F(0.1)**	**0.26**	**0.22**	**0.77**	1.07	1.07
		Biom.	**1,520**			**521**	**261**	HSBlim	Biom.	1504	1672	637	1.37	1.32
		Yield						HSBlim	Yield	570	541	645		
			F0.1	**Flower**	**Fupper**	**Fpa**	*	**HSBlim**	**F(0.1)**	**F(0.1)**	**Flower**	**Fmax**	**Fp0.05**	**BH**
Norway lobster	**9**	F value	**0.13**	0.087	0.18	0.31		**HSBlim**	**F(0.1)**	**0.13**	**0.11**	**0.26**	0.30	0.32

		Biom.	**1,022**			**511**	**255**	HSBlim	Biom.	1021.5	1135.7	595	0.48	0.40
		Yield						HSBlim	Yield	180.1	171.09	197		
			F0.1	**Flower**	**Fupper**	**Fpa**		**Empirical F ranges**		**F(0.1)**	**Flower**	**Fupper**	**Fp0.05**	**NA**
Red Mullet	**1**	F value	**0.61**	0.4	0.82			HSBlim	**F(0.1)**	**0.63**	**0.526**	**0.82**	0.83	
		Biom.	**399**			**338**	**170**	HSBlim	Biom.	**339**	389.47		1.10	
		Yield							Yield	146.82	139.48			
			F0.1	**Flower**	**Fupper**	**Fpa**	*	**Empirical F ranges**		**F(0.1)**	**Flower**	**Fupper**	**Fp0.05**	**Hsfree**
Red Mullet	**7**	F value	0.456	0.3	0.62	1.03		HSBlim	**F(0.1)**	**0.46**	**0.38**	**0.62**	1.01	1.01
		Biom.	**775**			**267**	**134**	HSBlim	Biom.	536	610		1.35	1.11
		Yield							Yield	289	275			

Four stocks showed a continuously growing production curve (group 3). These stocks are featured by having a B_{lim} fixed at 25%$B_{0.1}$, being actually placed in three of these stocks well below the cloud of observed S-R pairs (DPS 8, 9, 10 & 11; ARS 9, 10 & 11 and MUT 9) and in one case within the cloud of observations (ARA 5). For all these stocks the EWG had a priori decided not to change the Ftarget, therefore it was left at $F_{0.1}$ and the ranges adopted were just those previously derived from the empirical relationships defined in STECF 15-09 (STECF 2015). For the four cases such F_{MSY} ranges were compliant with being lower than $F_{p.05}$ (estimated from the HSBlim), although in once case (for the DPS in 8-9-10-11) compliance of the F_{upper} to be below $F_{p.05}$ type 3 obtained from the alternative (less productive) HSBloss SRR required reduction of such F_{upper} value (Table 2.).

Table 2.5.3 EWG 24-02 F_{MSY} range proposals for stocks in group 3: Original F reference points from EWG 23-09 (left part of the table) and the EWG 24-02 proposal (right part of the table) based on the same original proposal of the EWG 23-09 of $F_{0.1}$ and its F range and with the last two column indicating $F_{p.05}$ values obtained from HSBlim SRR and from an alternative SRR (if available).

			Reference points value EWG 23-09				**Basis**	**EWG PROPOSAL**		**HSBLim EWG 24 02**			HSBlim	Alternative
Stock	Area	Parameter	F0.1	Flower	Fupper	Fpa	**Blim**	SRR basis	F basis	Fmsy	Flower	Fupper	**Fp.05**	**BH Fp.05**
Blue and red shrimp ARA	5	F value	0.34	0.23	0.46			HSBlim	F(0.1)	0.34	0.23	0.46	0.90	0.81
		Biom.	302			151	75	HSBlim	Biom.	302			1.17	1.13
		Yield							Yield					
			F0.1	Flower	Fupper	Fpa		Empirical F ranges		F(0.1)	Flower	Fupper	Fp.05	HSBloss
Giant red shrimp	8-9-10-11	F value	0.43	0.28	0.58		*	HSBlim	F(0.1)	0.43	0.28	0.58	1.57	0.70
		Biom.	772			386	193	HSBlim	Biom.	772			2.23	0.84
		Yield							Yield					
			F0.1	Flower	Fupper	Fpa	*	Empirical F ranges		F(0.1)	Flower	Fupper	HSBloss	Ricker
Deep-water rose shrimp	8-9-10-11	F value	1.26	0.83	1.71	2.53		HSBlim	F(0.1)	1.26	0.83	1.51	1.51	1.61
		Biom.	855			427	214	HSBlim	Biom.	855			1.71	1.96
		Yield	4110						Yield	4110				
			F0.1	Flower	Fupper	Fpa	*	Empirical F ranges		F(0.1)	Flower	Fupper	HSBlim	BH (100 it)
Red Mullet	9	F value	0.50	0.33	0.68	1.34		HSBlim	F(0.1)	0.50	0.33	0.68	1.38	1.50
		Biom.	1,846			923	462	HSBlim	Biom.	1,846			1.92	2.00

		Yield							Yield					

Option 3, selecting the F_{MSY} ranges obtained from production curves corresponding to some alternative less productive SRR relationships, was shown to be applicable to four of the five stocks in group 2 (for MUT_1 it was not evaluated) and to two over the four stocks in group 3, while for the other two the F_{MSY} upper ranges from alternative SRRs were too high (above $F_{p.05}$ from the HSBlim) as to be proposed (for ARA_5 and MUT_9), something related to their alternative SRRs which were not less productive in the case of ARA_5 and doubtful in the other case. The rule (Option 3) of selecting the F_{MSY} ranges obtained from production curves corresponding to some alternative less productive SRR relationship could be applicable to groups 2 and 3, if desired, conditional to verification of passing the $F_{p.05}$ filtering.

Adoption of option 3, requires that the criteria for selecting alternative less productive SRRs are well pre-stablished since the beginning of the process. These criteria were not clearly stated since the beginning of the EWG 24 02 and therefore the selection procedure has been open to debate on a stock-by-stock basis. Summary of the F_{MSY} ranges resulting from the default and alternative SRRs analysed by stocks in this work are shown in Table 2.5.4. Alternative SRR were set up more for sensitivity analyses rather than as a systematic coverage of all plausible less-productivity SRR as will be required for a rigorous application of Option 3. Actually, no Option 3 alternative has been the basis of the proposals put forward for management consideration from this EWG. But there are cases where the F_{MSY} and ranges obtained in some stocks might be preferred over those proposed by the group, particularly when the F_{upper} approaches $F_{p.05}$ values, because they may allow safer margins below such $F_{p.05}$ and matching the actual definition of F_{MSY} ranges from the WestMedMP for the alternative SRRs.

While defining alternative SRRs and in particular for the cases where less productive SRR were defined, those SRR may imply different true B_{lim} values for the dynamics of the population, which have not been defined in the current work. The uncertainty around what the true B_{lim} can be has not been assessed by this EWG. Such an omission asks for a deliberate precautionary approach when defining the F_{MSY} ranges in an operative manner such that the risk not only for the current B_{lim}, but also for other plausible higher B_{lim} values which might be governing the population dynamics, are also somehow considered. The only way to approach such an uncertainty in a qualitative manner is to assure not only that the F_{MSY} ranges are below any putative plausible $F_{p.05}$, but that those resulting in safe margin below $F_{p.05}$ are preferred.

Overall EWG consider that the coverage made of the plausible SRRs is sufficient as to show the robustness of the F_{MSY} ranges evaluated for the different stocks. However, due to time limitations some additional work could be have been made to assure such robustness, which listed in the table above (Table 2.4.4.2), preferably before next EWG, putting special emphasis on the need to carry out a full Management Evaluation for the two Hake stocks which are of major priority for the WestMed MP given their vulnerable stock status, as defined in Article 2(3).

Table 2.5.4 EWG 24-02 F_{MSY} range proposals for stocks in group 2 (first 5 stocks) and in group 3 (last four stocks) (left part of the table) and the alternative Option 3 proposal for F_{MSY} and F ranges from the alternative SRRs (right hand last 6 columns) with the 7th and last columns referring to the $F_{p.05}$ values obtained from HSBlim SRR and from the alternative SRRs. For ARA 5 and MUT 9, the F_{MSY} ranges available from the alternative SRRs had F_{upper} too high (above $F_{p.05}$ from the HSBlim) as to be proposed.

		Proposal	HSBLim EWG 24 02			HSBlim	Alterna-tive	Option 3	Alternative SRR review EWG 24 02			**Altern. Fp.05**
Stock	**Area**	**F basis**	**Fmsy**	**Flower**	**Fmax**	**Fp.05**	BevHolt	Fmsy	Fmsy	Flower	Fupper	**BH**
Red Mullet	**6**	**F(0.1)**	0.30	0.26	0.71	1.13	BevHolt	Fmsy	0.45	0.28	0.73	1.10
		Biom.	3298	3646	1,846	1.58	BevHolt	Biom.	3,380	4,764	2,210	1.55
		Yield	1079	1025	1,192		BevHolt	Yield	1,536	1,459	1,459	
		F(0.1)	F(0.1)	Flower	**Fmax**	Fp.05	BevHolt	Fmsy	Fmsy	Flower	Fupper	BH
Blue and red shrimp ARA	**6_7**	**F(0.1)**	0.26	0.22	0.77	1.07	BevHolt	Fmsy	0.45	0.27	0.77	1.07
		Biom.	1504	1672	637	1.37	BevHolt	Biom.	1,205	1,824	708	1.32
		Yield	570	541	645		BevHolt	Yield	759	721	721	
		F(0.1)	F(0.1)	Flower	**Fmax**	Fp.05	BevHolt	Fmsy	Fmsy	Flower	Fupper	BH
Norway lobster	**9**	**F(0.1)**	0.13	0.11	0.26	0.30	BevHolt	Fmsy	0.13	0.10	0.24	0.32
		Biom.	1021.5	1135.7	595	0.48	BevHolt	Biom.	1,412	1,710	775	0.40
		Yield	180.1	171.09	197		BevHolt	Yield	249	237	237	
			F(0.1)	Flower	Fupper	Fp.05	BevHolt	Fmsy	Fmsy	Flower	Fupper	NA
Red Mullet	**1**	F(0.1)	**0.63**	0.526	0.82	0.83	BevHolt	Fmsy	0.58			

		Biom.	**339**	389.47		1.10	BevHolt	Biom.	639			
		Yield	146.82	139.48			BevHolt	Yield	255			
			F(0.1)	Flower	**Fupper**	HSBlim	Ricker	Fmsy	Ricker SRR review EWG 24 02			Hsfree
Red Mullet	**7**	F(0.1)	0.46	0.38	0.62	1.01	Ricker	Fmsy	0.50	0.38	0.64	1.01
		Biom.	536	610		1.35	Ricker	Biom.	817	1,043	609	1.11
		Yield	289	275			Ricker	Yield	486	461	461	
		F basis	**Fmsy**	Flower	Fupper	**Fp.05**						BH
Blue and red shrimp ARA	**5**	F(0.1)	**0.34**	0.23	0.46	0.90						0.81
		Biom.	**302**			1.17						1.13
		Yield										
			F(0.1)	Flower	Fupper	Fp.05	HSBloss	F(0.1)	F(0.1)	Flower	Fupper	HSBloss
Giant red shrimp	8-9-10-11	F(0.1)	**0.43**	0.28	0.58	1.57	HSBloss	F(0.1)	0.43	0.36	NaN	0.70
		Biom.	**772**			2.23	HSBloss	Biom.	772	833	NaN	0.84
		Yield					HSBloss	Yield	372	353	NaN	
			F(0.1)	Flower	Fupper	HSBloss	Ricker	Fmsy	Fmsy	Flower	Fupper	Ricker
Deep-water rose shrimp	8-9-10-11	F(0.1)	**1.26**	0.83	1.51	1.51	Ricker	Fmsy	0.91	0.69	1.14	1.61
		Biom.	**855**			1.71	Ricker	Biom.	1,277	1,637	948	1.96
		Yield	**4110**				Ricker	Yield	4,274	4,060	4,060	

			F(0.1)	Flower	Fupper	HSBlim						BH (100 it)
Red Mullet	9	F(0.1)	**0.50**	0.33	0.68	1.38						1.50
		Biom.	**1,846**			1.92						2.00
		Yield										

D) The MAP has **specific provisions for the most vulnerable stocks**, as defined in Article 2(3), this being up to now the hake stocks in EMU 1 & 2. STECF is requested to give priority to the calculation of F_{MSY} or F_{MSY} proxies and F_{MSY} ranges for these stocks.

The two hake stocks (HKE_1_5_6_7 and HKE_8_9_10_11) are currently assessed to be heavily exploited well beyond $F_{0.1}$, and to be below B_{lim}. Hence, they are considered to be in a vulnerable status. For these two stocks, the adoption of the F_{MSY} target and ranges derived from the production curves (steaming from the HSBlim) implies moving from the former target at $F_{0.1}$ to F_{max} from SPR. This supposes substantial increases in the F target and in the F_{upper}, in comparison with the $F_{0.1}$ and its empirical ranges defined before. However, the increase in F_{upper} is lower than the expected increase if F_{upper} was calculated with respect to $F_{0.1}$. When evaluating the risks of falling below B_{lim} for these stocks, no other alternative plausible SRR was determined by the group, as they were not considered to be more likely than the default HSBlim.

In order to increase the certainty about the sustainability of the implementation of the F_{MSY} target and ranges, it is suggested to carry out a full Management Strategy Evaluation of the harvest strategies based on their respective F_{MSY} target and ranges. In addition to the sources of uncertainty already included in the simulations carried out by the EWG 24-02, the MSE should include model averaging of pre-agreed plausible alternative SRR, and the full evaluation of stock status through inclusion within the simulations of the observation inputs from the monitoring system and the assessments of the stock according to those inputs. In this way, a true evaluation of the uncertainties in the assumed SRR and from the errors in the evaluation of stock status would be better taken into account.

3 TOR 2 EVALUATION OF 'QUALITRAIN' TOOLS

3.1 Introduction

EWG 24-02 evaluated the functionality of the RDBqc and RoME packages using the data provided to the EWG, as well as the dummy datasets that were already embedded in the packages. EWG 24-02 referred to https://github.com/COISPA/RDBqc for RDBqc package and https://github.com/COISPA/RoME for RoME package.

To test the tools the R software (R core Team, 2022) version 4.3.3 (2024-02-29 ucrt, 64-bit) was used inside the Rstudio IDE (Rstudio Team, 2020; version 2023.12.1 Build 402) (**Figure 3.1**).

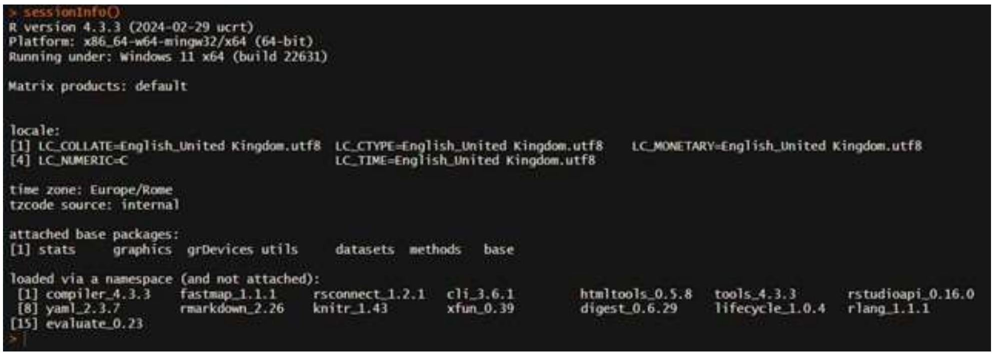


Figure 3.1 R session information.

3.2 Testing the RDBqc package

The subgroup was requested specifically:

1) to assess whether the functions implemented in the RDBqc package cover the main sources of potential problems in the provision of aggregated data by the Member States (e.g. misreporting of total landings and/or discards in weight, availability and consistency of length/age composition provided, availability and consistency of biological parameters, cross-checks among data calls, etc…) and to evaluate if the tools can actually reduce the number of data issues before the data submission of commercial aggregated data;

2) to evaluate if the documentation and material provided by the QualiTrain consortium is sufficient to run the quality checks with a basic knowledge of R and to interpret the outcomes of the checks;

3) to propose any further development and/or quality or coverage checks to be carried out to improve the tools.

For the RDBqc package the subgroup assessed if the functions implemented in the RDBqc package cover the main sources of potential problems in the provision of aggregated data by the Member States.

The subgroup referred to RDBqc_0.0.17.18 version which worked on 142 functions and 32 dummy datasets.

EWG 24-02 confirms that the RDBqc_0.0.17.18 package throughout the checking procedure prevent the main sources of potential problems that in the past were often highlighted by the DTMT.

For the RDBqc the subgroup evaluated if the documentation and material provided by the QualiTrain consortium is sufficient to run the quality checks with a basic knowledge of R and to interpret the outcomes of the checks

To test the documentation and material provided by the QualiTrain consortium EWG 24-02 referred to the provided github link.

EWG 24-02 specifically evaluated:

- the installation process
- documentation and help files
- quality checks procedures
- outputs of quality checks

3.2.1 Installation

During the installation process the EWG 24-02 noted that a README page is missing from the github link (RDBqc package) and the installation was not straightforward. The EWG 24-02 started by downloading the RDBqc package directly from the github. The EWG noted that the information on how to install the package is missing and is needed.

The EWG loaded the RDBqc.Rproj from the github. In the working directory (RDBqc-main/RDBqc) the README.Rmd markdown documentation was found but when one tried to knit to html-vignette or pdf-vignette it did not work.

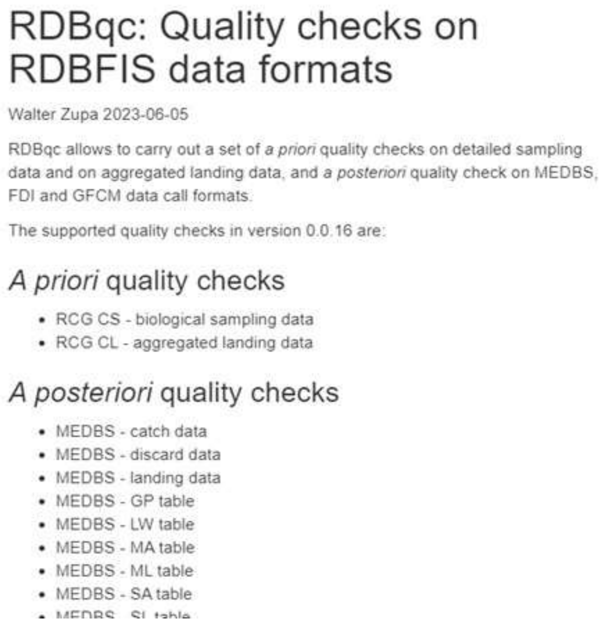
Further, to be able to see the README.Rmd markdown, one should also install in their computer the markdown library and other libraries listed in the Tutorial_Rmarkdown.docx. This document is not in the main directory, but in the sub-directory RMD reports, thus is not easy to find unless all directories and files are searched. EWG 24-02 noted that for people not familiar with R the installation procedure this process is not easy. A classical line of code for installation would be helpful.

Running the R Markdown document did not work ($README.Rmdlibrary(RDBqc)$ due to a specific function on line 18 $library(RDBqc)$.

However, if the markdown package is not installed the execution of chunk-1 is halted.

EWG 24-02 was able to preview the plain markdown document ($Readme.md$) even if the RDBqc library was not installed. However, EWG 24-02 noted that this procedure of getting information is not straightforward.

From the Readme.md (see below visualisation) no information on the procedure to install the package was obtained (Figure 3.2).



RDBqc: Quality checks on RDBFIS data formats

Walter Zupa 2023-06-05

RDBqc allows to carry out a set of *a priori* quality checks on detailed sampling data and on aggregated landing data, and *a posteriori* quality check on MEDBS, FDI and GFCM data call formats.

The supported quality checks in version 0.0.16 are:

A priori quality checks

- RCG CS - biological sampling data
- RCG CL - aggregated landing data

A posteriori quality checks

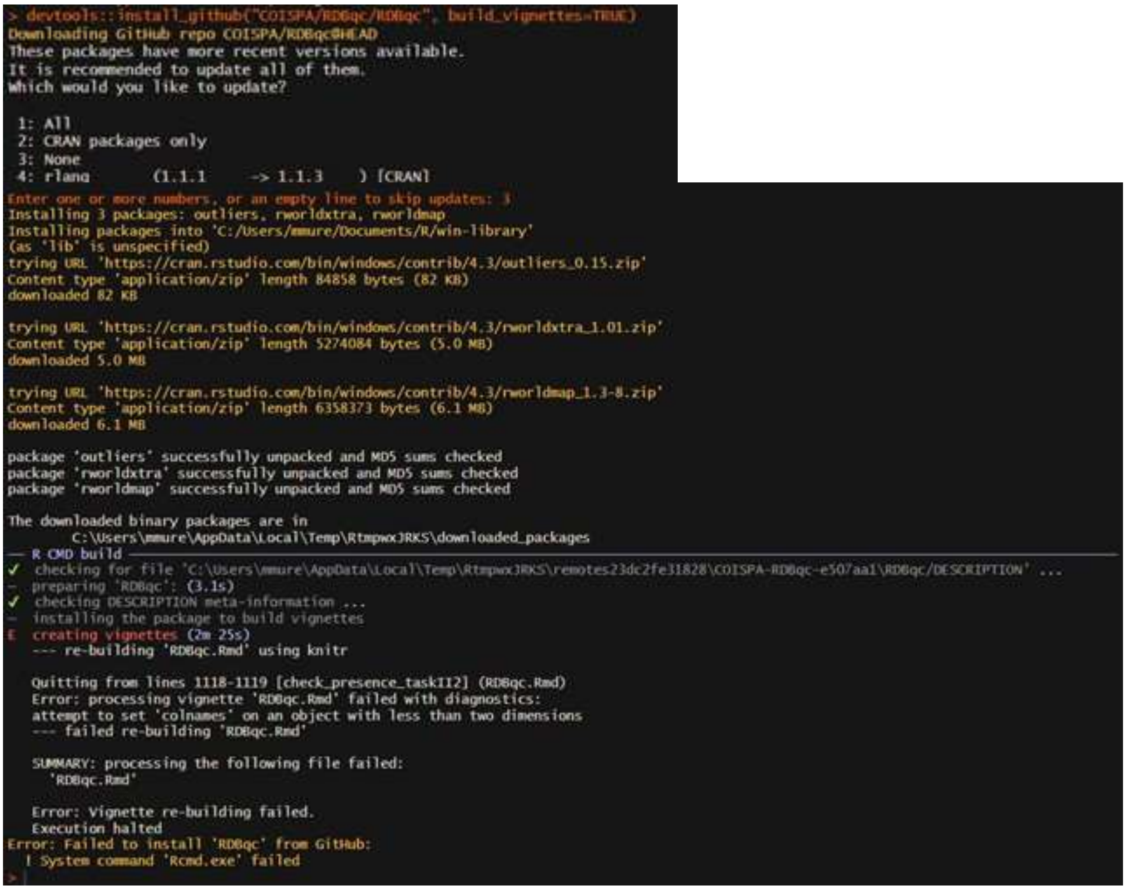
- MEDBS - catch data
- MEDBS - discard data
- MEDBS - landing data
- MEDBS - GP table
- MEDBS - LW table
- MEDBS - MA table
- MEDBS - ML table
- MEDBS - SA table
- MEDBS - SI table

Figure 3.2 Head of the plain *Readme.md*

The subgroup tried to install the RDBqc_0.0.17.18 that was found in the main page of the github for RDBqc by applying:

install.packages("../RDBqc-main/RDBqc_0.0.17.18.zip", repos = NULL, type = "win.binary")

However, an issue was encountered as shown below in the images (Figure 3.3).



```
> devtools::install_github("COISPA/RDBqc/RDBqc", build_vignettes=TRUE)
Downloading GitHub repo COISPA/RDBqc@HEAD
These packages have more recent versions available.
It is recommended to update all of them.
Which would you like to update?

 1: All
 2: CRAN packages only
 3: None
 4: rlang        (1.1.1      -> 1.1.3     ) [CRAN]
Enter one or more numbers, or an empty line to skip updates: 3
Installing 3 packages: outliers, rworldxtra, rworldmap
Installing packages into 'C:/Users/mmure/Documents/R/win-library'
(as 'lib' is unspecified)
trying URL 'https://cran.rstudio.com/bin/windows/contrib/4.3/outliers_0.15.zip'
Content type 'application/zip' length 84858 bytes (82 KB)
downloaded 82 KB

trying URL 'https://cran.rstudio.com/bin/windows/contrib/4.3/rworldxtra_1.01.zip'
Content type 'application/zip' length 5274084 bytes (5.0 MB)
downloaded 5.0 MB

trying URL 'https://cran.rstudio.com/bin/windows/contrib/4.3/rworldmap_1.3-8.zip'
Content type 'application/zip' length 6358373 bytes (6.1 MB)
downloaded 6.1 MB

package 'outliers' successfully unpacked and MD5 sums checked
package 'rworldxtra' successfully unpacked and MD5 sums checked
package 'rworldmap' successfully unpacked and MD5 sums checked

The downloaded binary packages are in
        C:\Users\mmure\AppData\Local\Temp\RtmpwxJRKS\downloaded_packages
── R CMD build ─────────────────────────────────────────────────────────────
✓  checking for file 'C:\Users\mmure\AppData\Local\Temp\RtmpwxJRKS\remotes23dc2fe31828\COISPA-RDBqc-e507aa1\RDBqc/DESCRIPTION' ...
-  preparing 'RDBqc': (3.1s)
✓  checking DESCRIPTION meta-information ...
-  installing the package to build vignettes
E  creating vignettes (2m 25s)
   --- re-building 'RDBqc.Rmd' using knitr

   Quitting from lines 1118-1119 [check_presence_taskII2] (RDBqc.Rmd)
   Error: processing vignette 'RDBqc.Rmd' failed with diagnostics:
   attempt to set 'colnames' on an object with less than two dimensions
   --- failed re-building 'RDBqc.Rmd'

   SUMMARY: processing the following file failed:
     'RDBqc.Rmd'

   Error: Vignette re-building failed.
   Execution halted
Error: Failed to install 'RDBqc' from GitHub:
  ! System command 'Rcmd.exe' failed
>
```

Figure 3.3 Installation issue with the RDBqc package.

Reason of this issue is that when processing $RDBqc.Rmd$ it failed. Apparently, there is a code problem **Figure 3.4**

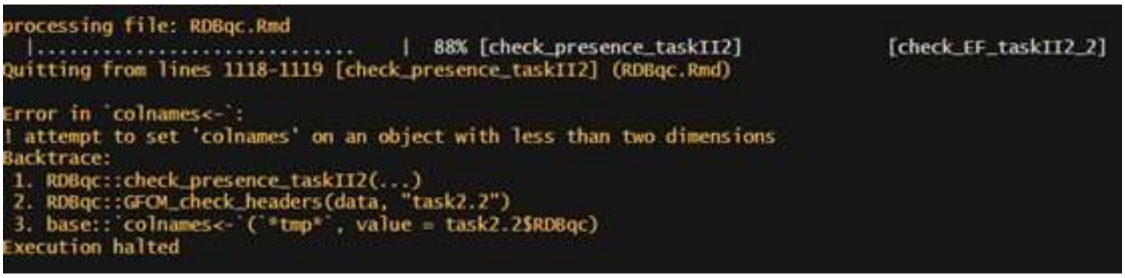


Figure 3.4 Error generated during the installation of RDBqc.

Because of that EWG 24-02 manually installed the package using the latest version available (…/RDBqc-main/RDBqc_0.0.17.18.zip) (Figure 3.5).

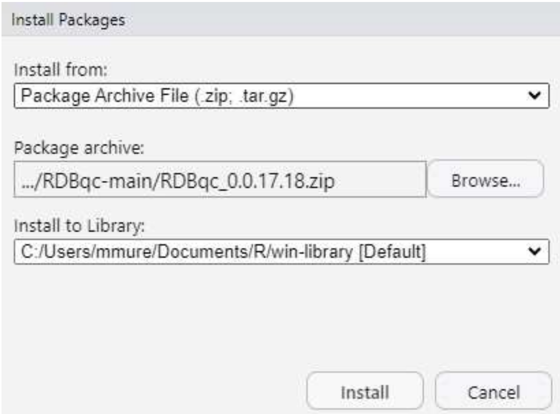


Figure 3.5 Manual installation of RDBqc package.

3.2.2 Documentation

In the main page of the package in the github, the README.Rmd output of for the latest version of the package RDBqc_0.0.17.1 is missing. The only README document that is found is the RDBqc_0.0.14.pdf document which includes only 118 functions.

EWG 24-02 noted that RDBqc_0.0.17.1 has more functions, all well documented.

```
library(RDBqc)
length(ls("package:RDBqc")) # how many functions
## [1] 142
```

As already stated above the vignette was not accessible.

```
vignette(package = "RDBqc")
## no vignettes found
```

Running both the README.Rmd and RDBqc.Rmd resulted in an error message and documents were not generated.

3.2.3 Explore functions

- The functions are quite intuitive for data format, since they start with the name of data set (RCG, MED&BS, FDI, GFCM).

3.2.4 Quality check procedures

The EWG was requested to analyse the following data calls formats:

- MED & BS: https://dcf.ec.europa.eu/data-calls/medbs_en
- FDI (only for landings and discards in weight cross-checks): https://dcf.ec.europa.eu/data-calls/fdi_en
- AER (only for landings in weight and landing value cross-checks): https://dcf.ec.europa.eu/data-calls/aer_en

EWG 24-02 evaluated the check procedures both referring to dummy and raw data.

3.2.4.1 Testing the dummy data sets

Dummy datasets contained in the package are reported in **Table 3.1**.

Table 3.1 Dummy datasets available in the RDBqc package.

Item	Title
ALK_tab_example	ALK table in MED&BS datacall format
Catch_tab_example	Catch table in MED&BS datacall format
Discard_tab_example	Discard table in MED&BS datacall format
GP_tab_example	GP table in MED&BS datacall format
GSAlist	GSAlist table
Landing_tab_example	Landing table in MED&BS datacall format
MA_tab_example	MA table in MED&BS datacall format
MEDBSSP	MEDBSSP table
ML_tab_example	ML table in MED&BS datacall format
SA_tab_example	SA table in MED&BS datacall format
SL_tab_example	SL table in MED&BS datacall format
SSPP	SSPP table
aer_catch (datAER)	AER catch table
catfau_check	catfau_check in GFCM datacall format
circabc	Ports coordinates according to codification CIRCABC
combination_taskII2	combination_taskII2 in GFCM datacall format
data_ex	RCG CS example
data_exampleCL	RCG CL example
fdi_a_catch	fdi_a_catch in FDI DGMAREMED&BS datacall format
fdi_g_effort	fdi_g_effort in FDI DGMAREMED&BS datacall format
fdi_h_spatial_land	fdi_h_spatial_land in FDI DGMAREMED&BS datacall format

Item	Title
fdi_h_spatial_landings	fdi_h_spatial_landings in FDI DGMAREMED&BS datacall format
fdi_i_spatial_effort	fdi_i_spatial_effort in FDI DGMAREMED&BS datacall format
fdi_j_capacity	fdi_j_capacity in FDI DGMAREMED&BS datacall format
minmaxLtaskVII2 (minmax_L_taskVII2)	minmaxLtaskVII2 in GFCM datacall format
minmaxLtaskVII31	minmaxLtaskVII31 in GFCM datacall format
sex_mat	sex_mat in GFCM datacall format
task_ii2	task_ii2 in GFCM DCRF datacall format
task_iii	task_iii in GFCM DCRF datacall format
task_vii2	task_vii2 in GFCM DCRF datacall format
task_vii31	task_vii31 in GFCM datacall format
task_vii32	task_vii32 in GFCM DCRF datacall format

Functions contained in the package are reported in Table 3.2.

Table 3.2 List of functions in the RDBqc package.

x1	x2	x3
aer_catch	circabc	MEDBS_ks
ALK_tab_example	combination_taskII2	MEDBS_land_mean_weight
Catch_tab_example	data_ex	MEDBS_Landing_coverage
catfau_check	data_exampleCL	MEDBS_length_ind
check_age_MEDBS_AR	Discard_tab_example	MEDBS_lengthclass_0
check_cs_header	fdi_a_catch	MEDBS_LFD
check_EF_FDI_A	FDI_AER_land_landvalue	MEDBS_LW_check
check_EF_FDI_G	FDI_check_coord	MEDBS_MA_check
check_EF_FDI_H	FDI_checks_spatial_HI	MEDBS_ML_check
check_EF_FDI_I	FDI_cov_tableA	MEDBS_plot_disc_vol
check_EF_FDI_J	FDI_cov_tableG	MEDBS_plot_discard_ts
check_EF_taskII2	FDI_cov_tableJ	MEDBS_plot_land_vol
check_EF_taskIII	FDI_coverage	MEDBS_plot_landing_ts
check_EF_taskVII2	FDI_cross_checks_AG	MEDBS_SA_check
check_EF_TaskVII31	FDI_cross_checks_AH	MEDBS_SL_check
check_EF_TaskVII32	FDI_cross_checks_IG	MEDBS_SOP
check_gfcm_header	FDI_cross_checks_JG	MEDBS_weight_0
check_l50_TaskVII.3.1	FDI_disc_coverage	MEDBS_weight_minus1
check_ldf_TaskVII.2	FDI_fishdays_cov	MEDBS_yr_missing_length
check_lengths_MEDBS_AR	fdi_g_effort	MEDBSSP
check_lmat_TaskVII.3.2	fdi_h_spatial_land	minmaxLtaskVII2

x1	x2	x3
check_lw_TaskVII.2	fdi_h_spatial_landings	minmaxLtaskVII31
check_lw_TaskVII.3.2	fdi_i_spatial_effort	ML_tab_example
check_maturity_MEDBS_AR	fdi_j_capacity	RCG_check_AL
check_minmaxl_TaskVII.2	FDI_landweight_cov	RCG_check_CL
check_minmaxl50_TaskVII.3.1	FDI_prices_cov	RCG_check_LFD
check_n_trips_MEDBS_AR	FDI_prices_not_null	RCG_check_LFD_comm_cat
check_presence_taskII2	FDI_vessel_lenth	RCG_check_loc
check_RD_FDI_A	FDI_vessel_numbers	RCG_check_lw
check_RD_FDI_G	GFCM_check_headers	RCG_check_mat
check_RD_FDI_H	GFCM_cov_II2	RCG_check_mat_ogive
check_RD_FDI_I	GFCM_cov_task_iii	RCG_summarize_ind_meas
check_RD_FDI_J	GP_tab_example	RCG_summarize_trips
check_RD_taskII2	GSAlist	SA_tab_example
check_RD_taskIII	Landing_tab_example	sex_mat
check_RD_taskVII2	MA_tab_example	SL_tab_example
check_RD_taskVII31	MEDBS_ALK	SSPP
check_RD_TaskVII32	MEDBS_Catch_coverage	task_ii2
check_species_catfau_TaskVII.3.2	MEDBS_check_disaggregated	task_iii
Check_Tot_Disc	MEDBS_check_duplicates	task_vii2
Check_Tot_Disc_gear	MEDBS_check_missing_years	task_vii31
Check_Tot_Disc_gear_Q	MEDBS_comp_disc_YQ	task_vii32
Check_Tot_Disc_metier	MEDBS_comp_disc_YQ_fishery	
Check_Tot_Land	MEDBS_comp_land_Q_VL	
Check_Tot_Land_gear	MEDBS_comp_land_Q_VL_fishery	
Check_Tot_Land_gear_Q	MEDBS_comp_land_YQ	
Check_Tot_Land_metier	MEDBS_comp_land_YQ_fishery	
Check_Tot_Land2	MEDBS_disc_mean_weight	
Check_Tot_Land3	MEDBS_discard_coverage	
check_weights_MEDBS_AR	MEDBS_GP_check	

EWG 24-02 noted that these functions widely cover the frequent issues that can occur in reporting data.

3.2.4.2 Test raw data

On COISPA GitHub repository https://github.com/COISPA/RDBqc, in the sub-folder "RMD reports", four specific R markdown report scripts are available to perform both a priori and a posteriori checks by means of an Automatic Reporting procedure.

A priori checks are for data validation and a posteriori checks are for data quality checks. Each of them is related to a specific data call as the prefix of the reported explain. They are:

- RCG_report_HTML.Rmd
- MEDBS_report_HTML.Rmd
- FDI_report_HTML.Rmd
- GFCM_report_HTML.Rmd

Considering the EWG_24-02 TORs, the subgroup checked the MEDBS and FDI automatic reporting scripts following the *Tutorial_Rmarkdown.docx* documentation found in COISPA's github.

- ***Test MEDBS_report_HTML***

Using raw data from EWG 22-03, EWG 24-02 checked the data for different species and countries to assess the robustness of the tool.

In more detail, the EWG 24-02 tested the tool functioning by using some stock examples in order to compare results with issues reported by EWG22-03 in the DTMT system (Data Transmission and Monitoring tool). In general, the R markdown detected the issues reported in the DTMT helping to reduce the possible misreporting in the DTMT. The package also detected differences in SOP (sum of product) correction, which were due to a more restrictive threshold (5% instead of 10%) used by the RDBqc.Rmd. Plots in RDBqc have been improved to show years with 0 landing weights and finally, the package reported missing years that are not reported in DTMT.

The Species and GSAs tested were the following:

SPs <- c("ANE"); MS <- "ESP" ; GSAs <- "GSA 1" ; end_year <- 2021

SPs <- c("OCC"); MS <- "FRA" ; GSAs <- "GSA 7" ; end_year <- 2021

SPs <- c("ARA"); MS <- "ITA" ; GSAs <- "GSA 16" ; end_year <- 2022

SPs <- c("ARS"); MS <- "ITA" ; GSAs <- "GSA 18" ; end_year <- 2022

The analysis generated automatic reports named MEDBS_report_HTML.html which the subgroup found very useful. Reports were renamed adding the suffix of species alfa code and GSA and stored (see the output directory). The comparison between DTMT and RDBqc outcomes are reported below.

ANE 1 – MEDBS_report_htm

Comparing DTMT reports with reports from the RDBqc package for anchovy in GSA1, in general the same issues were found (Table 3.3). In the case of missing data, some years were not reported in the DTMT and SOP cases, probably due to the RDBqc package's more restrictive threshold (5% instead of 10%). The package also shows the records in which length class numbers are 0 and length distribution missing years and this was found very useful.

Table 3.3 *Engraulis encrasicolus* (ANE) in GSA01. DTMT vs RDBqc checks.

Issue detected on the stock in EWG 22-03 (DTMT report)	**Outcomes from RDBqc functions**

23 cases in landings records in which SOP is needed are found.	More cases in RBDqc: the 5% threshold could be the reason *In RDBqc RMD a more restrictive threshold is used (5% instead of 10%).*
Check if discards in 2015 are for purse seine gear	Same results
Data missing for years 2007 and 2020 for discards.	The following years are missing in the discards data time series (ANE – ESP – GSA 1): 2002, 2003, 2004, 2007, 2020.
There are 14 cases in which length class number are zero and discards >0 for discards. Is it correct?	Same results
Check if tonnes for landings in year 2002 (around 3000t) are correct.	Same results
No issue	120 landing records in which length class numbers are 0 for ANE in GSA 1 over a total of 227 rows
No issue	No length distributions available for the following years: 2002

OCC 7 – MEDBS_report_htm

Comparing DTMT report with reports from the RDBqc package for *Octopus vulgaris* in GSA 7, some additional issues were found using the RDBqc package (Table 3.4).

Specifically, some issues in the DMTM are related to the quality of the data, such as anomalous landing values for some years. These issues are reflected in the RDBqc package. Other records, such as length class numbers with 0 or missing length distributions and discarded data for some years, were not reported in the DTMT.

Table 3.4 *Octopus vulgaris* (OCC) in GSA07. DTMT vs RDBqc checks.

Issue detected on the stock in EWG 22-03 (DTMT report)	**Outcomes from RDBqc functions**
Discards at age. Data only reported for 2020.	The following years are missing in the discards data time series (OCC - FRA - GSA 7): 2002, 2003, 2004, 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012, 2014, 2016, 2019

Landings mean weight. Values for some métiers and years (OTB_CEP in 2010 and 2012; OTB_CRU in 2012, OTB_DES in 2010, 2012, 2017 and 2018) seem very high.	Same results
Landing by gear. Landings for FPO drastically increase in 2019 and 2020 in comparison with the other years and seem very high.	Same results
No issue	The following years are missing in the Catch data time series (OCC - FRA - GSA 7): 2002, 2003, 2004, 2005, 2006, 2007, 2008, 2009
No issue	The following years are missing in the landings data time series (OCC - FRA - GSA 7): 2002, 2003, 2004, 2005, 2006, 2007, 2008, 2009
No issue	870 landing records in which length class numbers are 0 for OCC in GSA 7 over a total of 1450 rows
No issue	No length distributions available for the following years: 2010, 2011
No issue	113 discard records in which length class numbers are 0 for OCC in GSA 7 over a total of 122 rows
No issue	No length distributions available for the following years: 2014, 2016, 2018, 2019, 2020

ARA 16 – MEDBS_report_htm

Comparing DTMT report with reports from the RDBqc package for blue and red shrimps in GSA 16, generally the same errors were detected (Table 3.5).

Specifically, some issues in the DTMT are related to the quality of the data, such as anomalous landing values for some years. These issues are reflected in the RDBqc package. Other records, such as length class numbers with 0 or missing length distributions and discarded data for some years, were not reported in the DTMT.

Table 3.5 *Aristeus antennatus* (ARA) in GSA16. DTMT vs RDBqc checks.

Issue detected on the stock in EWG 22-03 (DTMT report)	**Outcomes from RDBqc functions**

2002, 2003, 2005, 2006, 2007, 2008, 2017 and 2018 are completely missing, also 2012 (OTB_MDD). 2004 (OTB_DEMF) should be checked	Same results
The same growth function was used for both sexes which do not grow the same in this species	Same results
L_{inf} values (year 2019 and combined sex) is not realistic having set VB units in cm	
Mean weight in Year 2014, metier OTB, quarter 4 should be checked for a low value as well as 2016, metier MDD, quarter 4	Same results
No issue	The following years are missing in the Catch data time series (ARA - ITA - GSA 16): 2002, 2003
No issue	The following years are missing in the landings data time series (ARA - ITA - GSA 16): 2002, 2003
No issue	178 landing records in which length class numbers are 0 for ARA in GSA 16 over a total of 221 rows
No issue	No length distributions available for the following years: 2005, 2006, 2007, 2008, 2017, 2018

ARS 18 – MEDBS_report_htm

Comparing DTMT report with reports from the RDBqc package for red shrimp in GSA 18, additional errors were detected (Table 3.6).

Table 3.6 *Aristaeomorpha foliacea* (ARS) in GSA18.

Issue detected on the stock in EWG 22-03 (DTMT report)	**Outcomes from RDBqc functions**
Landings reported under gear GTR in 2003	Is GNS in the markdown - The R markdown reduces misreporting issues

Landings data are missing from year 2019	The following years are missing in the landings data time series (ARS - ITA - GSA 18): 2002, 2013, 2019, 2020
No issue	The following years are missing in the Catch data time series (ARS - ITA - GSA 18): 2002, 2021
No issue	10 landing records in which length class numbers are 0 for ARS in GSA 18 over a total of 20 rows.
No issue	No length distributions available for the following years: 2003, 2004, 2005, 2006, 2007, 2008, 2013, 2019, 2020
No issue	The following years are missing in the discards data time series (ARS - ITA - GSA 18): 2002, 2003, 2004, 2005, 2006, 2007, 2008, 2010, 2012, 2013, 2014, 2015, 2016, 2017, 2018, 2019, 2020, 2021
No issue	No length distributions available for the following years: 2010

MEDBS_report_html document

EWG 24-02 noted that markdown documents created by the automatic reporting procedure have two minor formatting problems:

1. The figure caption of the "Plot of cumulative length distributions by fishery and year" reported in section 2.6.1 includes a command line for the ggplot grid that should not be there ("TableGrob ….") (Fig. 4.6).

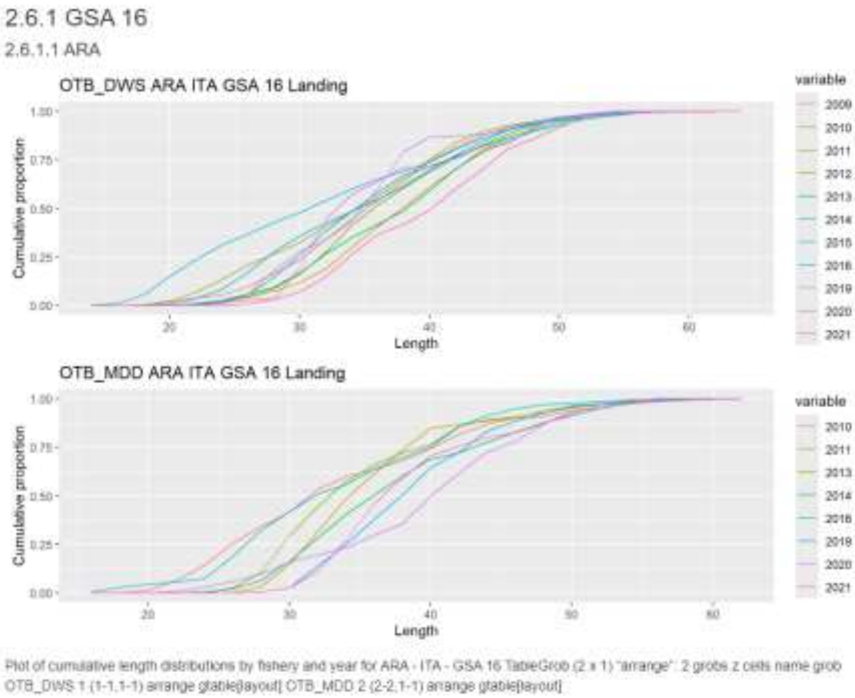


Figure 3.6 Figure caption error.

2. All figure captions are generally located above the figure and not below as it should usually be.

- ***Test FDI_report_HTML***

To test the FDI reporting markdown EWG 24-02 used a subset of 3 years (2020-2022).

During the knit procedure an error occurred due to a mismatch of raw data and tool's table structure. Specifically, the problem was due to different naming of country column ("country_code" vs "country") for all FDI tables and an additional name mismatch for the fdi_j_capacity table ("avgage" vs "avage").

After these adjustments, the markdown report was produced easily.

As indicated in the Tutorial_Rmarkdown report checks were performed for one country (MS) per time. Checking was done initially considering diverse species and GSAs separately (Figure 3.7).

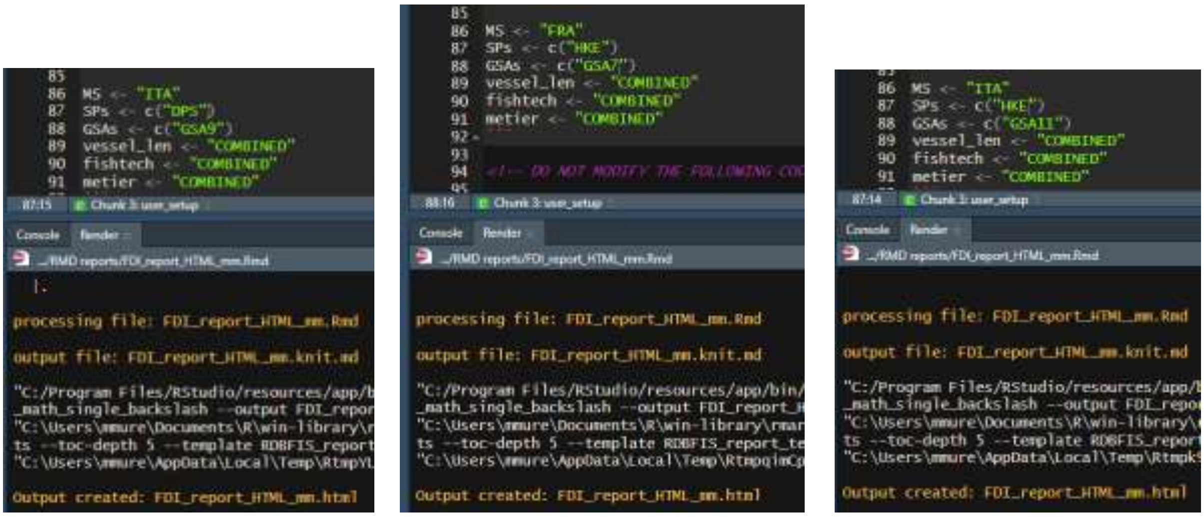


Figure 3.7 Testing the FDI reporting markdown filtering data with a single selection.

Additionally, some checks were done filtering data for multiple species ((“DPS” and “HKE) and one GSA (GSA 17 or GSA 9) (Figure 3.8) and one species (“HKE”) and two GSAs (GSA9 or GSA11) (Figure 3.9).

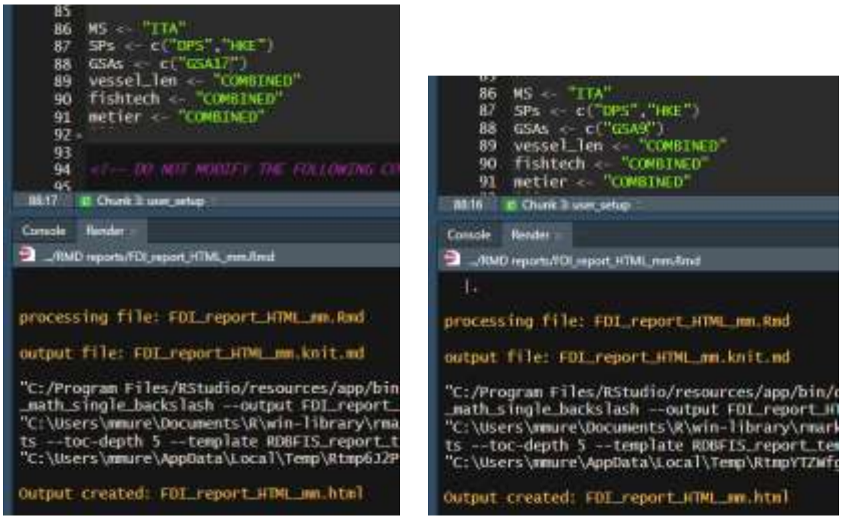


Figure 3.8 Testing the FDI reporting markdown filtering data with a multiple selection (two species, one GSA).

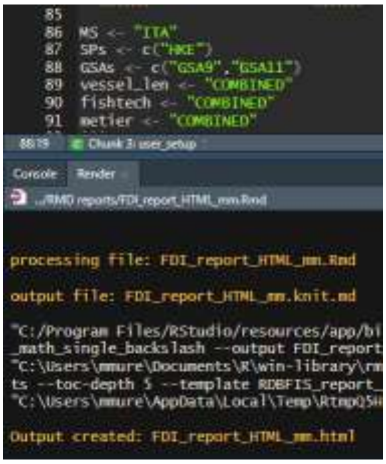
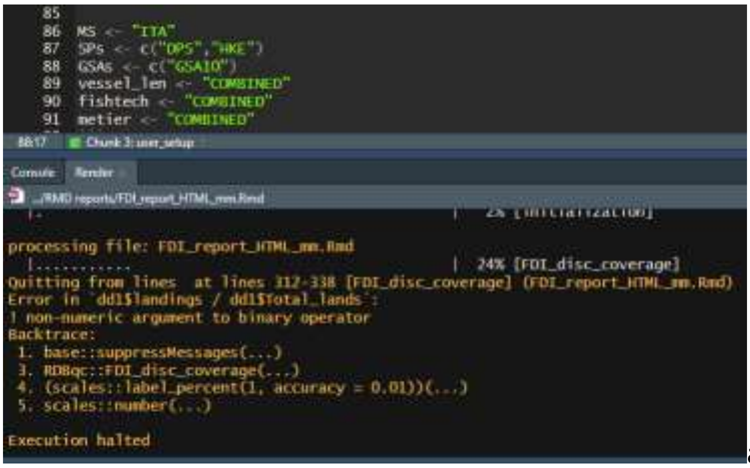


Figure 3.9 Testing the FDI reporting markdown filtering data with a multiple selection (one species, two GSA).

In some cases, an error occurred and the report was not generated (Figure 3.10).



a

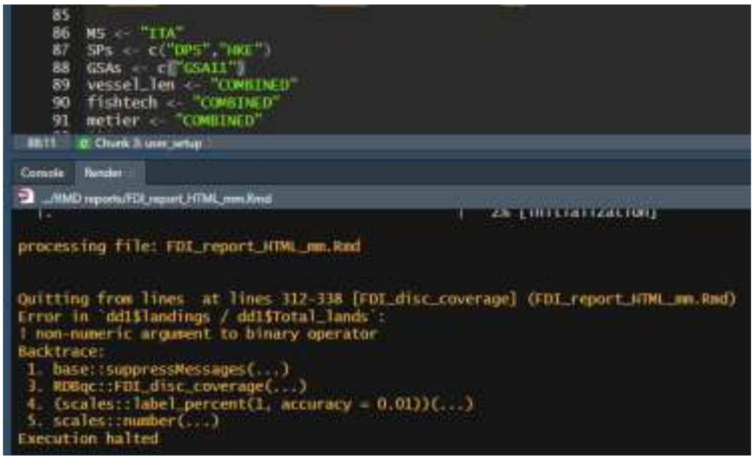


Figure 3.10 Testing the FDI reporting markdown filtering data with a multiple selection (two species, one GSA) that generated an issue.

This error was because apparently there is an issue on specific species and GSA (Figure 3.11).

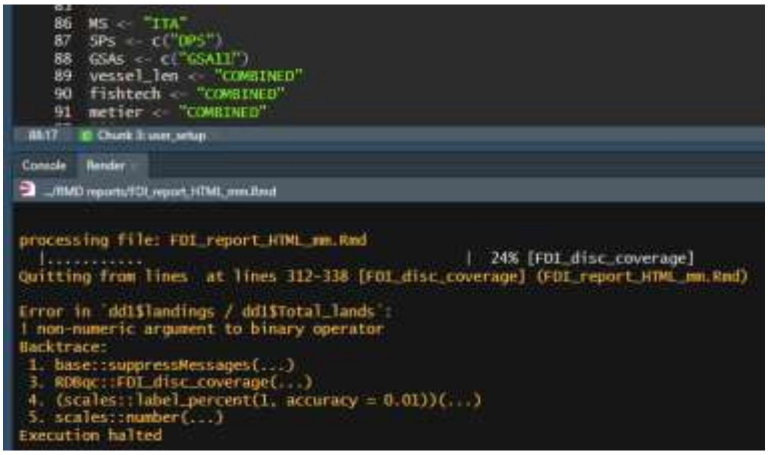


Figure 3.11 Error on testing the FDI reporting markdown procedure.

EWG 24-02 finally tested the reporting procedure using one country ("ESP" or "ITA"), two species ("DPS" and "HKE") and two GSAs ("GSA5" and "GSA6" or "GSA9" and "GSA11") by filtering the data which produced the markdown document correctly (Figure 3.12).

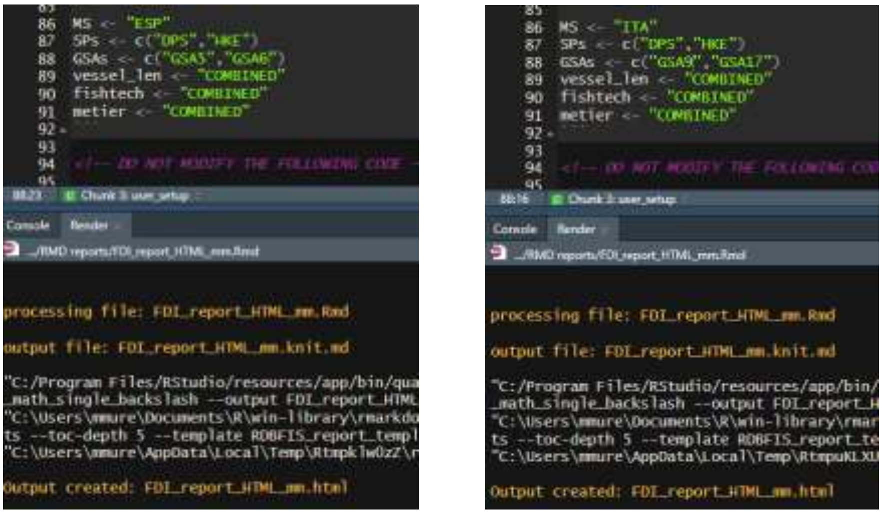


Figure 3.12 Testing the FDI reporting markdown filtering data with a multiple selection (two species, two GSAs).

EWG 24-02 concludes that FDI reports were exhaustive and covered all the main possible issues. Some minor formatting changes are needed (see below in the suggestion section) but overall, the report is readable. For example, in the FDI report the "Summary table of the mutual inconsistency of tables A and G by country, GSA and year", rows are separated by several blank spaces. It makes the table particularly long and removing extra space can improve readability. Finally, the FDI_disc_coverage function should be implemented to avoid the problems that sometime can occur (Figure 3.10).

3.2.5 Feedback

Overall, the main comments regarding the RDBqc package are the following:

- In https://github.com/COISPA/RDBqc there's no package description, but there is in https://github.com/COISPA/RDBqc/tree/main/RDBqc, so users need to go into RDBqc project to get information.

- Even when is expected that users are familiar with these data, EWG 24-02 believes is necessary to include a brief introduction to input data format and content (as for the MEDITS data, where a full explanation is given by the handbook).

- Dummy data could be more diverse, since most of the examples only contain 1 species, country or GSA (for example in the dummy data table GP_tab_example, GP are for DPS and MUT but always refers to 1 country).

- Vignette requires to include guidelines for installation.

- Markdown tutorial should be more visible.

- In the FDI report the Summary table of the mutual inconsistency of tables A and G by country, GSA and year rows are separated by several blank spaces. It makes the table particularly long and reformatting can improve readability.

- Sometimes the script crashed applying the command FDI_disc_coverage.

3.3 Testing the RoME package

The subgroup was requested to check specifically:

1) to assess whether the checks implemented can be considered sufficient to ensure the quality of the data provided (e.g. data format, range of valid data, haul positions, reliable swept area estimates, etc…) and to evaluate if the tools can actually reduce the number of data issues before the data submission of survey data;

2) to evaluate if the documentation and material provided by the QualiTrain consortium is sufficient to run the quality checks with a basic knowledge of R and to interpret the outcomes of the checks;

3) to suggest any further development and/or quality or coverage checks to be implemented.

RoME package integrates a list of common quality checks on survey data, which are a list of cross checks aimed to guarantee consistency among the data tables. There are two main functions for data checks: function RoME, that stops at the first detected error, allowing user to correct data; and function RoMEcc, which does not stop at error detection, checking all the data and returning a report on the errors found, as well as compiling a detailed log file.

The subgroup referred to RoME_0.1.33 version which worked on 22 datasets (Table 3.7) and 90 functions (Table 3.8).

EWG 24-02 confirms that the RoME_0.1.33 package throughout the checking procedure prevents the main sources of potential problems.

3.3.1 Installation

Following the information given in the github site (https://github.com/COISPA/RoME), the installation was carried out using the recommended code

```
remotes::install_git("https://github.com/COISPA/RoME/tree/master"
```

but it did not work (Figure 3.13).

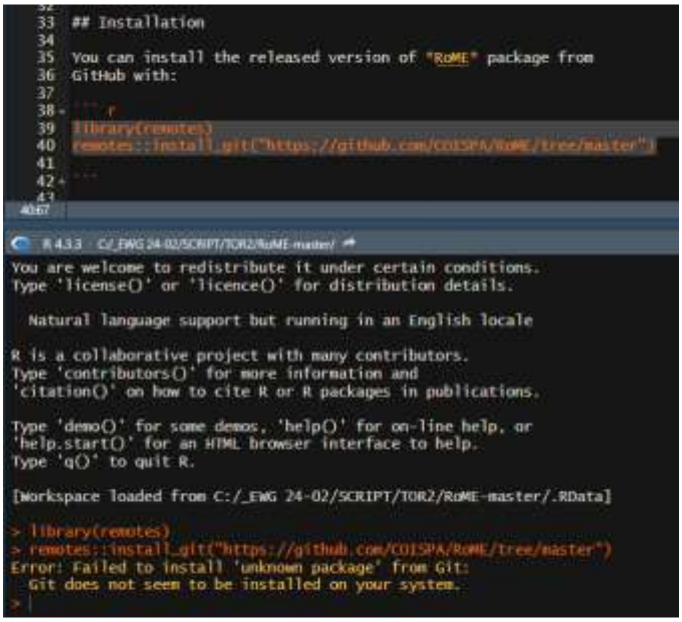


Figure 3.13 Installation error with the RoME package using the information provided in the github site.

Successful installation was achieved using the following code:

```
remotes::install_github("https://github.com/COISPA/RoME/tree/master")
```

3.3.2 Documentation

README.md document provides a basic introduction to the package using the dummy data, but there is no development regarding the output or function options.

The NEWS.md document provides a list of fixes applied to the package.

3.3.3 Explore functions

As mentioned before, there are two main functions in the package, RoME and RoMEcc. These two functions compile all the check functions presented in Table 3.8.

First exploration was done using dummy data (**Table 3.7**), specifically TA (data on haul), TB (catches by haul) and TC (length and aggregated biological parameters), as in the example provided in the README.md.

No performance issues were found with the functions, and no data quality issues were detected either, as the dummy data contains no errors.

Table 3.7 Datasets available in the RoME package.

Item	Title
DataTargetSpecies	Length and weight ranges
GSAs	List of GFCM Geographical subareas (GSAs)
LW	Table of the Length-Weight parameters
Maturity_parameters	Maturity parameters
MedSea	Shapefile of Mediterranean and Black Sea area

Item	Title
TA	TA
TB	TB
TC	TC
TE	TE
TL	TL
TM_list	TM list
assTL	TL association between categories and sub-categories
classes	Class of fields
list_g1_g2	List of G1 and G2 species
mat_stages	Table of maturity stages
stratification_scheme	stratification_scheme
templateTA	Template haul data table (TA).
templateTB	Template catch data table (TB).
templateTC	Template biological data table (TC).
templateTE	Template individual data table (TE).
templateTL	TL table template
time	allowed values for SHOOTING_TIME and HAULING_TIME

Functions contained in the package are reported in **Table 3.8**.

Table 3.8 Functions available in the RoME package.

x1	x2	x3
assTL	check_numeric_range	graphs_TA
check_0_fieldsTA	check_position	GSAs
check_area	check_position_in_Med	haul_at_sea
check_associations_category_TL	check_quadrant	headers.conversion
check_bridles_length	check_quasiidentical_records	list_g1_g2
check_class	check_raising	LW
check_consistencyTA_distance	check_rubincode	mat_stages
check_consistencyTA_duration	check_smallest_mature	Maturity_parameters
check_date_haul	check_spawning_period	MEDITS.to.dd
check_depth	check_species_TBTC	MedSea
check_dictionary	check_step_length_distr	printError
check_distance	check_stratum	printError_cc
check_dm	check_stratum_code	RoME
check_G1_G2	check_subsampling	RoMEBScc
check_haul_species_TCTB	check_TE_TC	RoMEcc
check_hauls_TATB	check_temperature	RSufi_files
check_hauls_TATL	check_type	scheme_individual_data
check_hauls_TBTA	check_unique_valid_haul	stratification_scheme
check_hauls_TLTA	check_weight	TA

check_identical_records	check_weight_tot_nb	TB
check_individual_weightTC	check_year	TC
check_individual_weightTE	checkHeader	TE
check_length	classes	templateTA
check_length_class_codeTC	create_catch	templateTB
check_mat_stages	create_haul	templateTC
check_nb_per_sexTC	create_length	templateTE
check_nb_TE	create_strata	templateTL
check_nbtotTB	DataTargetSpecies	time
check_nm_TB	dd.distance	TL
check_no_empty_fields	error.table	TM_list

3.3.4 Quality check exploration

After testing the functionality of the package with the dummy databases, we proceeded to test the functionality of the package with official databases.

RoME package is designed to work with MS survey data. In a first instance MS survey data was used to verify the package functionality, but as we wanted to be coherent with RDBqc quality procedures and the DTMT errors report, RoME package was tested using the JRC survey data for the same species and areas as the ones from the RDBqc quality check exploration section. The JRC RDB refers to the compiled survey data of each MS, which is commonly used for the STECF stock assessments working groups. In any case, the use of JRC survey data does not imply any problem, since regardless of the database to be used, it was necessary to reshape the data.

Based on the issues reported in the DTMT and the "Report on tests carried out and final version of RDBqc R package", the functionality of the package was tested in different species and GSAs (Table 3.9). For simplicity, the year 2021 was used as the reference year for the analysis.

Table 3.9 Species by GSA tested using the RoME package.

DTMT reference year	**GSA**	**FAO code**	**MEDITS code**	**Scientific name**
2021	01	ANE	ENGRENC	*Engraulis encrasicolus*
2021	07	OCC	OCTOVUL	*Octopus vulgaris*
2021	16	ARA	ARITANT	*Aristeus antennatus*
2021	18	ARS	ARISFOL	*Aristaeomorpha foliacea*

A summary of the results obtained with RoME and RoMEcc are presented in **Table 3.10**. Most of the data errors are detected by RoMEcc, but there is not a clear coherence between the results from RoME and RoMEcc. Worth mentioning is that the DTMT issues were reported using the JRC MEDITS R script[6], so it's expected to see discrepancy between the errors detected with RoME.

Table 3.10 Summary of check results using the RoME package.

Issue detected on the stock in EWG 22-03 (DTMT report) **related to MEDITS data**	Results with RoME function	Results with RoMEcc function
***Engraulis encrasicolus* (ANE) in GSA01**		
No issues	script interrupted by error	Issues detected related to haul details
***Octopus vulgaris* (OCC) in GSA07**		
Hauls time series. Number of total hauls performed in years 1997, 1998, 2003, 2008, 2010 and 2019 differs from those performed the other years.	Stoped at: Check dictionary for field: MEASURING_SYSTEM	Not detected in logfile, but can be seen in graphs (2020 is evident)
Checking wrong step lengths. Inconsistencies in five cases: Lengths of 14, 16 and 18 in 1999; length of 6 in 2000 and length of 17 in 2005.		Same results
Checking if total weight and number reported in TB are consistent with the ones in TC. Inconsistencies in 20 cases: Haul nº 62 and 85 in 1998; haul nº 29 and 82 in 1999; haul nº 46 and 60 in 2000; haul nº 59 and 72 in 2001; haul nº 26, 34 and 51 in 2002; haul nº 29, 31, 32, 44 and 96 in 2003; haul nº 24 and 35 in 2004, haul nº 77 in 2005 and haul nº 66 in 2013.		Not detected in logfile, but check on consistency of weight and number for TB is noted for some years
Hauls in TC but not in TA. Inconsistencies in two cases: Haul nº87 in 1997 and haul nº 27 in 2011.		Same results

[6] European Commission, Joint Research Centre, Mannini, A., *The JRC MEDITS R script – A tool to analyse MEDITS data during STECF EWGs*, Publications Office, 2020, https://data.europa.eu/doi/10.2760/5799

Comparing hauls in TB and TC where the species was caught. Inconsistencies in number of hauls in TB and TC in several years: from 1994 to 1999.		Same results
Hauls in TB but not in TA. Inconsistencies in two cases: Haul nº 87 in 1997 and Haul nº 27 in 2011.		Same results
***Aristeus antennatus* (ARA) in GSA16**		
No issues	Stoped at: Check consistency of length classes TC: errors occurred!	Issues detected related to haul details
***Aristaeomorpha foliacea* (ARS) in GSA18**		
No issues	Stoped at: Check consistency of length classes TC: errors occurred!	Issues detected related to haul details

3.3.4.1 *Engraulis encrasicolus* (ANE) in GSA01 for 2021

DTMT showed no problems related to MEDITS data, so EWG 24-02 expected to find none by performing the checking procedure with ROME or ROMEcc.

- RoME stopped not because of an error with the data, but because of an error during its execution. The error was the following:

```
[1] Check dictionary for field: MEASURING_SYSTEM in progress...
Error in if (any(as.character(Result[k, indexcol]) == Valuesf) == FALSE &  :
  missing value where TRUE/FALSE needed
```

- RoMEcc performed all the checks successfully. No error was detected related to dictionary for field. The summary document (.csv) indicates errors related to consistency of length classes TC, but no indication of this was shown in the logfile.

3.3.4.2 *Octopus vulgaris* (OCC) in GSA07 until 2021

The issues detected in the DTMT were from previous years, therefore, the quality check was carried out for the entire time series.

- RoME stopped due to a detection of error in the data, as expected. The error detected was the following:

```
[1] Check dictionary for field: MEASURING_SYSTEM: errors occurred! Please correct files and run again the script. For more details see Logfile.dat
```

- RoMEcc performed all the checks successfully. For the year 2021, the summary document (.csv) indicates errors related to consistency of length classes TC, but no indication of this was shown in the logfile. Regarding the errors detected in the JRC MEDITS R script, we found no equal comparison for the results of RoME when examining the inconsistencies between the total weight and number reported in TB compared to TC. The group acknowledges that these are different tools used for different goals, but considering the data in TA, TB, and TC are related, and there should be no differences for a same haul, we believe it would be a valuable addition to the crosschecks within the RoME package to implement a similar check for these inconsistencies.

3.3.4.3 *Aristeus antennatus* (ARA) in GSA16 for 2021

DTMT showed no problems related to MEDITS data, so EWG 24-02 expected to find none by performing the checking procedure with ROME or ROMEcc.

- RoME stopped due to a detection of error in the data, as expected. The error detected was the following:

```
[1] Check consistency of length classes TC: errors occurred! Please correct files and run again the script. For more details see Logfile.dat
```

- RoMEcc performed all the checks successfully. No error was detected related to consistency of length classes TC as in RoME. The summary document (.csv) indicates errors related to consistency of length classes TC, but no indication of this was shown in the logfile.

3.3.4.4 *Aristaeomorpha foliacea* (ARS) in GSA18 for 2021

DTMT showed no problems related to MEDITS data, so EWG 24-02 expected to find none by performing the checking procedure with ROME or ROMEcc.

- RoME stopped due to a detection of error in the data, as expected. The error detected was the following:

```
[1] Check consistency of length classes TC: errors occurred! Please correct files and run again the script. For more details see Logfile.dat
```

- RoMEcc performed all the checks successfully. No error was detected related to consistency of length classes TC as in RoME. The summary document (.csv) indicates errors related to consistency of length classes TC, but no indication of this was shown in the logfile.

3.3.5 Feedback

Overall, the main suggestions regarding the RoME package are the following:

- Update the information for package installation with the following code that works: remotes::install_github("https://github.com/COISPA/RoME/tree/master")
- Update the readme.md with a more detailed documentation, providing examples for the RoMEcc function, more detailed explanation of the outputs generated (graphs, logfiles, summary excel and backup file) and if possible, dummy data with common errors.
- Provide suggestions for upload/modify input data, to avoid errors associated with format.
- Consider the inclusion of a crosscheck that compares total weight and number from TB to the corresponding values of TC

- Clarify issues related to errors detection in generated documents (summary document vs logfile).

3.4 Conclusions ToR2

3.4.1 Final feedback

Overall, the QualiTrain packages (Rome and RDBqc) were found very useful to detect issues in the data sets and fix errors before data submissions to RDB by institutes and Member States.

The high number of functions developed in R language, very well and fully documented, were tested with dummy and raw data to look at tool performance in different conditions and find possible bugs.

The coding part was very long but easy to understand and, when unexpectedly script error happens, allows to figure out where the code is not behaving in the way expected.

EWG 24-02 find the RDBqc cross-checks procedures helpful in providing good quality data to be used in STECF EWGs, particularly in the assessment EWG. The reporting procedures of RDBqc are very useful and easy to run.

Regarding RoME, the number of checks implemented are sufficient to ensure the quality of data. For documentation and material is necessary to improve the guides available on the website, especially those meant for new users. Minor errors were detected for RoME, but the package still worked satisfactorily.

3.4.2 Final suggestions

To improve the QualiTrain tools EWG 24-02 suggests some possible improvements listed here below.

- Provide a "common mistakes" section in a tutorial
- Tutorial_Rmarkdown. This is the tutorial of RDBqc tool, not the tutorial of Rmarkdown. The name should be change accordingly (we suggest RDBqc_tutorial_Rmarkdown).
- Use a link in the main page of the package to make the Tutorial_Rmarkdown more visible.
- Include the description and the installation instruction for RDBqc in github.com.
- Package’s vignette should include guidelines for installation also.
- Include a brief introduction to input data format and content for RDBqc.
- Dummy data could be more diverse, since most of the examples only contain 1 species, country or GSA (for example in the dummy data table GP_tab_example, GP are for DPS and MUT but always refers to 1 country).
- In RDBqc the FDI automatic report, long tables should be avoided with blank space (see the Summary table of the mutual inconsistency of tables A and G by country).
- In RDBqc try to address reporting issues when FDI_disc_coverage function generates an error.
- Ensure that installation procedures indicated in the documentation works.
- Refine the formatting of markdown automatic report documents.
- Update tutorial information related to RoME package.

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List of background documents:

Deliverable 1.1- 'Report on tests carried out and final version of RDBqc R package', produced by the Qualitrain consortium.

EWG-24-02 – Doc 1 - Declarations of invited and JRC experts (see also section XX of this report – List of participants)

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