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Scientific, Technical and Economic Committee for Fisheries (STECF) - Data gaps and Biomass Escapement Strategy for Adriatic anchovy and sardine (STECF-18-01)

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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 explores the effect of different decisions and management options, with regard to the implementation of a biomass escapement strategy for the Adriatic anchovy and sardine stocks.

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EWG-18-01 report:

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SCIENTIFIC, TECHNICAL AND ECONOMIC COMMITTEE FOR FISHERIES (STECF) - Data gaps and Biomass Escapement Strategy for Adriatic anchovy and sardine (STECF-18-01)

Request to the STECF

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

STECF response

STECF comments

EWG 18-01 was asked to develop and assess a biomass escapement harvest control rule (HCR) for anchovy and sardine in the Adriatic Sea (GSA 17-18) that would ensure a low probability of SSB to fall below B_{lim}. STECF reviewed the report of EWG 18-01 and notes that the EWG adequately addressed the ToRs. STECF acknowledges the extensive work undertaken by the working group.

STECF notes that information for the Adriatic eco-surveys on sampling design, sampling errors and abundance estimates uncertainty, was not available to the EWG. Consequently, only limited quantitative analysis could be carried out during the working group to assess the potential use of the current acoustic survey as a basis for a biomass escapement strategy HCR and to propose alternative settings. STECF notes that the conclusions on that term of reference (ToR 1.2) are thus mainly based on expert knowledge. STECF agrees with those conclusions but notes however that it would have been useful to quantify the impact of alternative survey settings (number of surveys, seasons) on the catch advice based on a biomass escapement strategy, and that such analysis could be further developed once the information needed is made available.

To address ToR 1.3, EWG 18-01 opted for a stepwise approach by first selecting from a grid of potential HCR parameters (biomass escapement, Besc; fishing mortality cap, Fcap), those which were delivering the objectives of low risk of falling below Blim ($P[SSB< B_{lim}] < 0.05$ across all operational models and secondly running management scenarios and robustness test using those selected parameters. STECF agrees with this stepwise approach which allows focusing the analysis on the "area of interest" and limit as much as possible the number of simulations to be conducted and interpreted.

STECF notes that the stock dynamics modelled in the simulations are somewhat optimistic due to the use of stock-recruitment models based on average recruitment, segmented regressions and geometric means. These models don't capture the linear relationship between SSB and recruitment observed in the data, which shows a decreasing trend in recruitment in the recent years. To mitigate this effect the EWG chose the most conservative combinations of B_{esc} and F_{cap} parameters as candidates to parametrize the HCR.

With relation to the analysis of long term effects, carried out without considering stock assessment uncertainty, STECF notes that large biomass escapement levels lead to more frequent closures of the fishery or provide very small catches. Conversely, small biomass escapement levels need to be complemented with low fishing mortality caps to avoid large inter-annual fluctuations in catches and exploitation levels.

STECF notes however that assessment uncertainty leads to a strong degradation of the performance of the harvest control rules for both stocks, with an increasing risk of SSB falling below B_{lim}. In the case of anchovy this risk becomes about 20% to 30%, while for sardine 5% to 10%.

To evaluate short term effects, the EWG tested the requested set of catch options during the intermediate period of 2017-2020. Using real reported catches for 2017, assuming status quo catches in 2018 and catch reductions of 5-10-20% per year in 2019 and 2020. STECF notes that the proposed levels of catch reductions led to the collapse of the stock of anchovy. STECF notes that these results are associated with the very poor status of the anchovy stock in the Adriatic (STECF EWG 17-09), and considers that additional measures are needed in the short-term to reduce catches and increase biomass above Blim.

For ToR 2 (economic analyses), STECF notes that, because of the limited time available, EWG 18-01 used an approach based on short-term projections. This approach was used for the AER short-term projections (STECF 2017b) through BEMEF (extension of the EIAA models). EWG 18-01 explored alternative functions to compute variable costs to the inverse of the Cobb-Douglas function (in order to link the estimated catches and biomass resulting from the HCR with corresponding fishing activity) as well as an alternative approach based on the existence of a correlation between fuel consumption per kilo of landings and the ratio between total catches and fishing mortality. The low number of observations for Croatian purse-seiners (only 4 years) did not allow the EWG to conclude with the parameters' estimation for that fleet.

STECF suggests that further work should be done on the socio-economic sustainability of the fishery, exploring e.g. the use of the minimum break-even revenue to set the minimum catches required from the HCRs and/or the maximum level of risk required to make these fisheries profitable. STECF also suggests that such analysis would also need to take into account the effects of a change in the level of catches on the canning industry and tuna farms, since a significant part of the catches are allocated to these industries.

Finally, STECF recalls the comments made by PLEN 17-01 (in ToR 4.2) that, "a common database with stock assessment results and DCF data will be a relevant development on bio-economic modelling, given the time require to collate all the data coming from different sources. Development of calibration methods based on an integrated database gathering main data needed for bio-economic parametrisation would improve the ability to perform impact assessments in a short interval". The development of such calibration methods would improve the ability of experts to perform impact assessments more quickly, such that they could be done effectively within a short EWG.

STECF conclusions

STECF endorses the general conclusions and recommendations from the EWG:

- STECF considers that the current acoustic survey settings could potentially be used to set fishing opportunities based on a biomass escapement strategy. Furthermore, providing the survey index to the assessment EWG, in the same year the survey is carried out, would allow a more precise application of the escapement strategy by removing the need to project the intermediate year. Having several surveys would also provide better estimates of recruitment for each stock (in the beginning of the year for anchovy and second half of the year for sardine), and better indications of spawning stock biomass, (in the summer for anchovy and winter for sardine).

- Under the condition of perfect knowledge of the stock dynamics (no error in the stock assessment results), the selected combinations of values of biomass escapement and fishing mortality caps generally fulfil the condition of a low probability of SSB to fall below B_{lim}. However, the inclusion of stock assessment uncertainty leads to a very strong increase in the risk. STECF thus consider that the framework developed during the EWG and the results of the simulations can serve as a basis for further discussion. However, the implementation of an HCR would need to be more conservative than the results presented here in order to account for assessment uncertainty.

- In the long term, large biomass escapements lead to more closure of the fishery or provide very small catches, while small biomass escapements need to be complemented with low fishing mortality caps to avoid large fluctuations in catches and exploitation levels.

- The short-term simulations led to stock collapse for anchovy for any level of catch reductions. This result is the consequence of the current very poor status of the anchovy and STECF considers that for that stock, additional measures are needed in the short-term to reduce catches and increase biomass above B_{lim}.

- The analysis carried out by EWG 18-01 showed that there is a high percentage of monospecies catches in the fishing operations analysed for the fisheries for anchovy and sardine in the Adriatic Sea (GSA 17-18), suggesting that potential choke species effects should be limited.

- Economic analysis of the different scenarios and HCRs was attempted but the short time series of available economic data for some fleets did not allow a full analysis of management options. STECF suggests exploring alternative options of e.g. aggregating national fleets segments into broader regional groups, which may allow performing further bio-economic impacts assessments of the management measures in the short- and medium-term.

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REPORT TO THE STECF

EXPERT WORKING GROUP ON
Data gaps and Biomass Escapement Strategy for Adriatic anchovy and sardine
(EWG-18-01)

Ispra, Italy, 26 February - 2 March 2018

1 INTRODUCTION

1.1 Background

STECF PLEN 17-03, having evaluated possible reference points for Adriatic small pelagic stocks and having examined alternative management strategies, identified a Biomass escapement strategy as a viable approach that could allow higher catches while maintaining similar risks with a traditional F_{MSY}-based strategy (STECF 2017a).

An escapement strategy had been already considered by STECF 15-04 (STECF 2015).

According to STECF PLEN 17-03, the MSY $B_{escapement}$ strategy is used by ICES for stocks of short-lived species that either (a) die after spawning, such as capelin, or (b) have very high natural mortality implying that future SSB is largely independent of survival after spawning, such as North Sea sprat or anchovy. Sardine and anchovy in GSA 17-18 have a large M and fall into category (b) of the ICES classification.

A constant F strategy (F_{MSY}) removes a defined fraction of the stock as long as the stock is above a given threshold. This works well when the stock maintains a small range of biomass and natural mortality is low, so that the fish not caught in one year survive and are available again a year later. When the stock is more variable, then the required limit biomass (B_{lim}) does not correspond to a fixed fraction of fishing mortality. In that situation, a more suitable strategy for highly variable stocks is to utilize a higher fraction when the stock is high and a smaller fraction when the stock is low, but always maintain a high probability that the biomass of mature fish (spawning biomass) in the subsequent year is sufficient to avoid stock collapse. This approach is described as a biomass escapement strategy. The strategy requires a projected probability of SSB < B_{lim}. This can be combined with but does not necessarily require an upper limit on F (F_{cap}).

Catch = Catch (< 5% risk of SSB <= B_{lim})

and optional (F < F_{cap})

This management procedure normally requires simulations to evaluate risk, and the risks may be acceptable even if F_{cap} is set higher than F_{MSY}. However, adopting such a procedure, irrespective of the value of F_{cap}, may also imply closure of the fishery if the spawning stock biomass is close to B_{lim}.

MSY $B_{escapement}$ is defined by ICES as a deterministic biomass limit below which a stock is considered to have reduced reproductive capacity. $B_{escapement}$ is often set to B_{lim} and the object of the plan is to have a high probability to keep SSB > B_{lim}. For some other stocks, a fixed MSY $B_{escapement}$ value is applied in the advice, complemented with an upper limit of F (i.e. F_{cap}). This ensures that a greater margin is applied when the stock is large; however, F_{cap} is not directly analogous to F_{pa} or F_{lim}. The reference points F_{pa} and F_{lim} are not considered relevant for these stocks of short-lived species where the advice is based on biomass escapement strategies.

F_{cap} is defined to limit exploitation rates when biomass is high. A large stock is usually estimated with greater uncertainty, i.e. when the catch is taken, the uncertainty in the amount of biomass that will escape fishing is greater. By capping the F, the escapement biomass is effectively increased in proportion to stock size, maintaining a high probability of achieving the minimum amount of biomass left to spawn. The yearly TAC is thus based on a 5% probability of SSB falling below B_{lim} following fishing, and an overall limit to exploitation rate if the stock is high. B_{lim} is set based on the observed dynamics of the stock. Overall, it is expected that catches in good years can be higher under the biomass escapement strategy. Thus, sardine and anchovy in GSA 17-18 should be considered for being managed using a MSY $B_{escapement}$ strategy *sensu* ICES (2017).

Requirements for a $B_{escapement}$ strategy for Sardine and Anchovy in GSA 17-18:

In order to move to management of the fisheries on these two stocks using the $B_{escapement}$ strategy there is a number of steps needed:

- Identify which information can be obtained from surveys (August and September) and fisheries (quarterly) to give the necessary management data quickly.

- Using the available data flow, evaluate the parameters of the harvest rules that can be implemented to maximize catch while maintain SSB > B_{lim} with a high probability.

- Put in place the timetable for data collection, data analysis, provision of catch advice, and decision process to define TAC.

- Implement the required data collection, analysis, decision process.

- Move to management using this approach.

The approach requires that survey data be evaluated quickly, following, for example, the data flow for anchovy in Bay of Biscay which is managed in this manner. It is not expected that the approach will increase the total workload, as surveys and data analysis are needed for both F_{MSY} and $B_{escapement}$ management. However, this alternative approach does require experts to deliver results more quickly, but no quicker than the regime already in place for Bay of Biscay anchovy. It is understood by STECF that current regulations require delivery of data only 6 months after data collection, which would not allow the escapement strategy to be followed effectively; however, managers may wish to deliver data earlier in order to obtain the benefits of the fishery managed in this way.

Once the data availability has been agreed, it will then be possible to parameterise the models to test different strategies for managers to consider. Then, if a satisfactory approach is found, management can be moved to this regime. It is anticipated that the development of this process may take a few (2+) years to complete the necessary planning and evaluation.

1.2 Overview of the fishery and the fleets

1.2.1 Stock distribution

It is well known that small pelagic species, such as anchovy and sardine, are migratory. Therefore, these species conduct their migrations during the year within the entire stock distribution area (i.e. GSAs 17-18). These migrations are driven by the feeding and spawning needs/behaviours of anchovy and sardine and they are largely influenced by environmental changes, as it has been described for sardine in the northern part of the Adriatic Sea (Tičina et al. 2000). Usually, the final outputs of acoustic surveys are maps showing spatial distributions of the stocks within the studied area during the period of the survey, as required by the MEDIAS handbook (MEDIAS Handbook 2017) (i.e. Figure 1.2.1 and Figure 1.2.2 – GSA17 East, Figure 1.2.3 and Figure 1.2.4 – GSA17 and GSA18 West). These spatial distributions of stocks as obtained from acoustic surveys, may exhibit large interannual changes in response to environmental properties and/or levels of stock abundance.

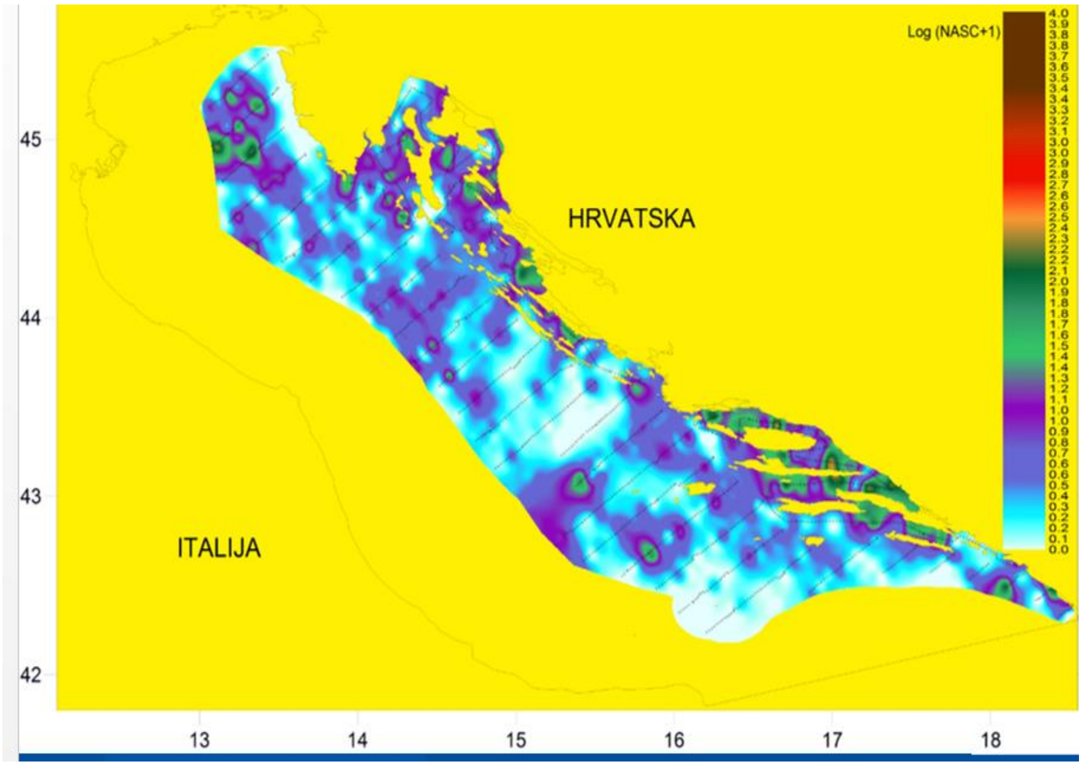


Figure 1.2.1 Spatial distribution of anchovy in September 2016 from MEDIAS echo-survey in GSA 17 East (TL > 6cm)

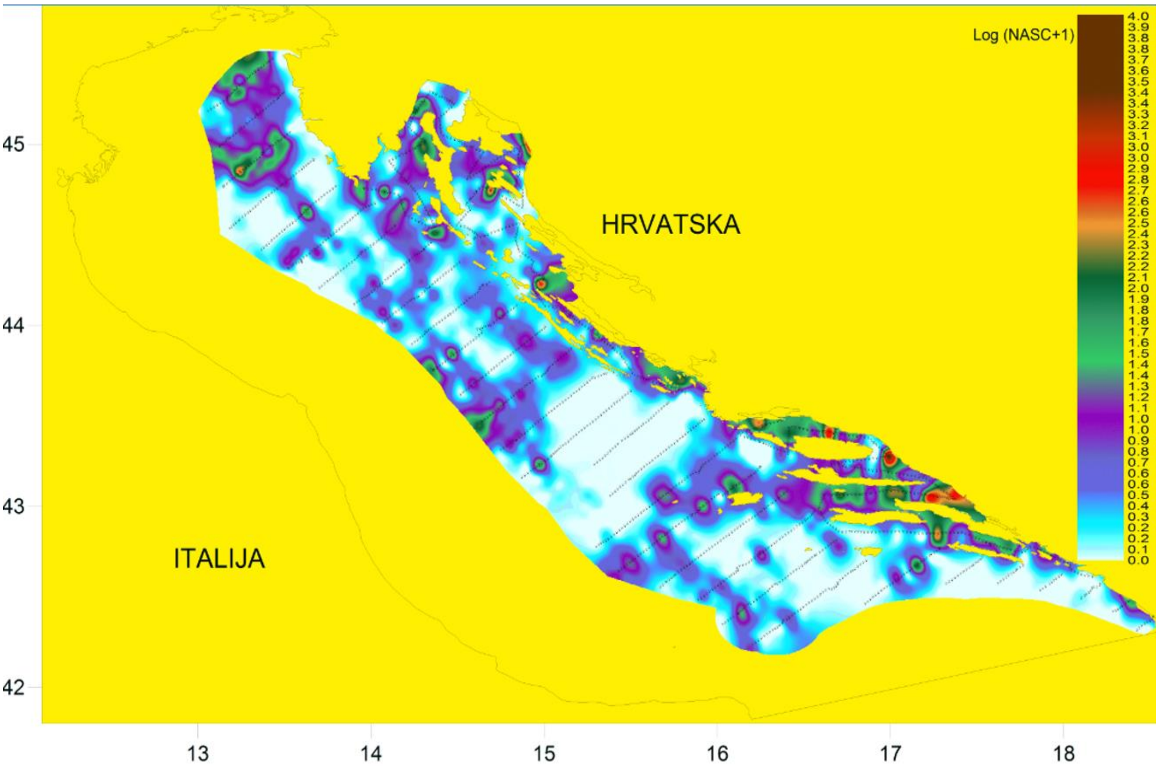


Figure 1.2.2 Spatial distribution of sardine in September 2016 from MEDIAS echo-survey in GSA 17 East (TL > 6cm)

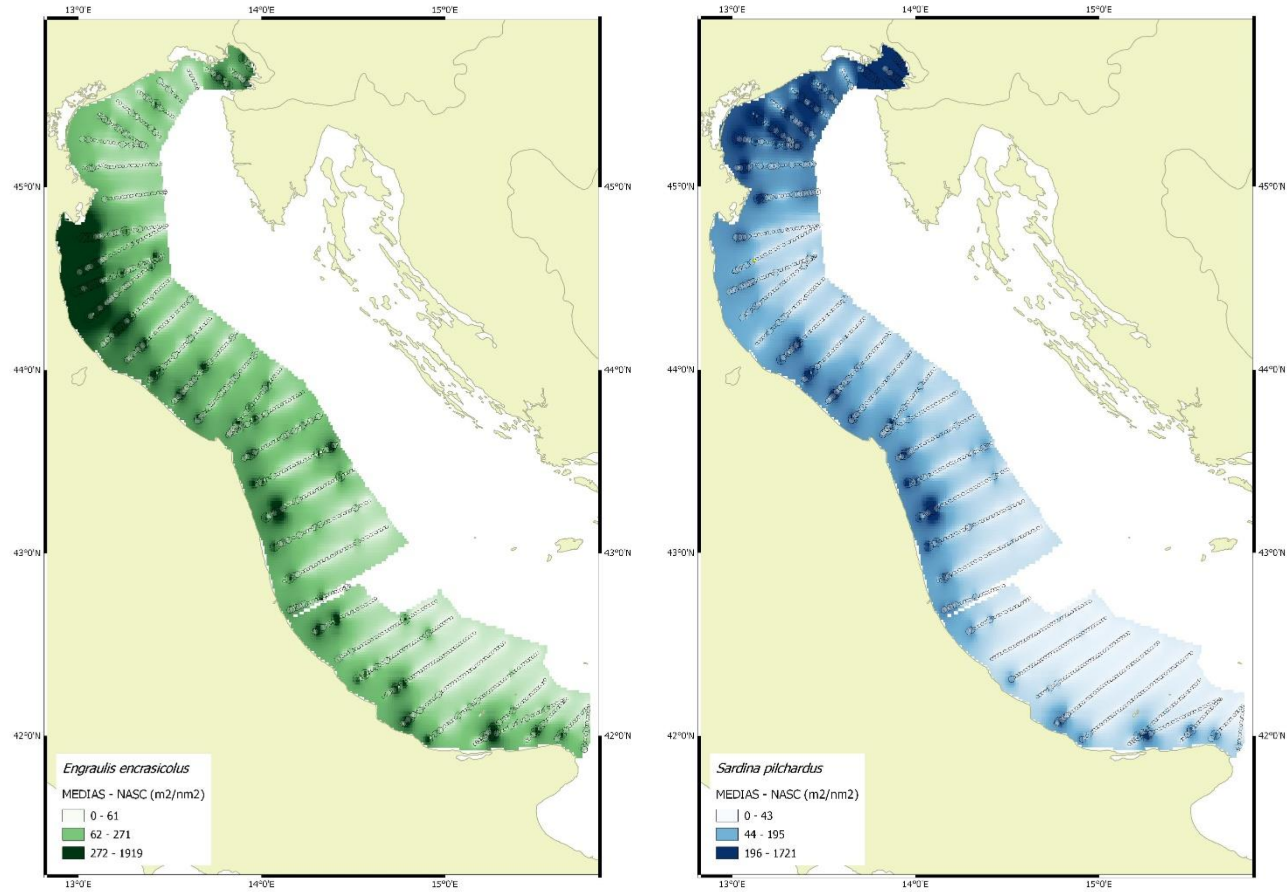


Figure 1.2.3 Spatial distribution of anchovy and sardine in 2016 from MEDIAS echo-survey in GSA 17 West

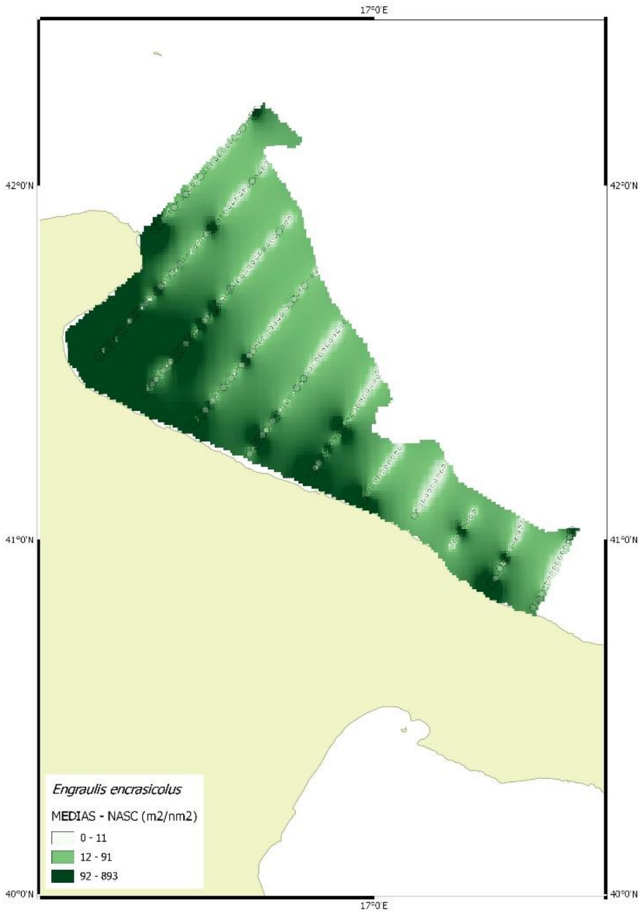


Figure 1.2.4 Spatial distribution of anchovy and sardine in 2016 from MEDIAS echo-survey in GSA 18 West

1.2.2 Overview of fleets' performance

Three EU Member States are involved in small pelagic fisheries in the Adriatic: Croatia, Italy and Slovenia; although the Slovenian contribution to total catches is negligible. Small pelagics are the main fisheries resources of the Adriatic Sea, accounting for a large share of the total catches. In the eastern part of GSA 17, Croatian vessels have been targeting mostly sardines, while in the western part of GSAs 17 and 18, the Italian fleet has focused on anchovies.

According to the 2017 Annual Economic Report on the EU Fishing Fleet (STECF 2017b), in 2015 the fleets were composed of 368 vessels, of which 250 were purse seiners and 118 mid-water trawlers, with a combined gross tonnage (GT) of 27720 tonnes (5% less than in 2014). The main gear used by the Croatian and Slovenian fleets was the purse seine, while most of the Italian fleet used the "volante" mid-water pair-trawl (towed by two vessels). Italian fleets operated most of the time in the northern and central area of the Adriatic, while the Croatian purse seine fleet operated mainly in the central Adriatic.

Landings of small pelagics in GSAs 17 and 18 amounted to 121047 tonnes in 2015, of which about 90% were sardine and anchovy, with a value of first sell of €94.6 million. There were 2339 fishers employed (~1900 FTE), a small decrease from 2014 (2543 employees and ~2000 FTEs).

Prices for sardines and anchovies exhibit a high variability between countries. In Croatia the average prices in 2015 were 0.38 €/kg for sardines and 0.85 €/kg for anchovies, while in Italy they were 0.78 €/kg and 1.68 €/kg, respectively. These price differences are partly explained by the markets in each Member State. In Croatia, small pelagics are used by the processing, salting and marinating industries, as well as for fish feed in tuna farms. In Italy fish are mainly sold fresh for local consumption and, in minor quantities, exported to Spain for processing.

The revenues generated by the Adriatic pelagic fleet in 2015 were estimated at €97.7 million, an increase of 10% with regards to 2014. Gross profit was estimated at €27.5 million.

The dependencies of the Croatian and Italian fleets on sardine and anchovy are presented in Table 1.2.1, by fleet segment and GSA.

Table 1.2.1 Percentage of sardine (PIL), anchovy (ANE) and other species (OTH) in the landings of Croatian purse seiners (HR-PS), Italian mid-water trawlers (IT-TM) and Italian purse seiners (ITA-PS) in GSAs 17-18 in 2015.

Country, gear and area	Vessel length	2015 landings (kg)	Species	Percentage per fleet segment
HR-PS in GSA 17	VL0612	141720	PIL	45%
HR-PS in GSA 17	VL0612	51758	ANE	16%
HR-PS in GSA 17	VL0612	124688	OTHER	39%
HR-PS in GSA 17	VL1218	3925877	PIL	76%
HR-PS in GSA 17	VL1218	1062475	ANE	21%
HR-PS in GSA 17	VL1218	192947	OTHER	4%
HR-PS in GSA 17	VL1824	14441877	PIL	75%
HR-PS in GSA 17	VL1824	4225364	ANE	22%
HR-PS in GSA 17	VL1824	651786	OTHER	3%
HR-PS in GSA 17	VL2440	32533317	PIL	80%
HR-PS in GSA 17	VL2440	7252490	ANE	18%
HR-PS in GSA 17	VL2440	1003432	OTHER	2%
IT-TM in GSA 17		21772258	PIL	53%
IT-TM in GSA 17		17282724	ANE	42%
IT-TM in GSA 17		1696282	OTHER	4%
IT-TM in GSA 18		2462331	PIL	32%
IT-TM in GSA 18		4371094	ANE	57%
IT-TM in GSA 18		864268	OTHER	11%
IT-PS in GSA 17		850957	PIL	16%
IT-PS in GSA 17		3899240	ANE	75%
IT-PS in GSA 17		481507	OTHER	9%
IT-PS in GSA 18		164642	PIL	10%
IT-PS in GSA 18		1312492	ANE	78%
IT-PS in GSA 18		199682	OTHER	12%

In terms of capacity by Member State, according to the 2015 data presented in Table 1.2.2, the Croatian purse seine fleet has 201 vessels with total gross tonnage of 16498 GT. The Italian mid-water trawl and purse seine fleets account for 162 vessels with a gross tonnage of 12069 GT. The Slovenian fleet has only 2 vessels of 24 GT in total.

Table 1.2.2 Number of vessels involved in the Adriatic small pelagic fisheries and their cumulative gross tonnage (GT), horse power (kW) and employees by fleet segment in 2015.

Fleet segment	N of vessels	GT	kW	Days at sea	Employed
HRV 17 PS0612	40	259	3535	3737	88
HRV 17 PS1218	38	795	6615	5053	189
HRV 17 PS1824	52	4148	17966	8033	395
HRV 17 PS2440	71	11295	39901	12072	659
SVN 17 PS1218	2	24	214	225	10
ITA 17 PS1218	12	120	1448	1289	78
ITA 17 PS2440	17	1635	6407	2108	180
ITA 17 TM1218	37	1108	7010	4726	121
ITA 17 TM1824	38	3558	16652	5201	213
ITA 17 TM2440	26	2787	12475	4082	156
ITA 18 PS2440	7	799	3368	850	115
ITA 18 TM2440	25	2062	10680	2586	120
Total	365	28591	126269	49961	2324

1.3 Terms of Reference

For anchovy and sardine in the Adriatic Sea (GSA 17-18), develop a biomass escapement harvest control rule (HCR) that will ensure a low probability of SSB to fall below B_{lim} (5% probability). The HCR should be tested in a Management Strategy Evaluation (MSE) and the HCR needs to be robust to different assumptions on recruitment, assessment model, to misspecification of age 0 maturity, M and age. The EWG will also need to define whether an F_{cap} is needed to set a ceiling on the high biomass removals.

The EWG is requested to undertake MSE simulations commencing in January 2021. For the intervening period, catches should be modelled in accordance with point 1 below.

Conditioning / background for simulation testing:

1. Model an intermediate period 2017-2018-2019-2020 in line with the work performed for STECF 18-02 (Request for Services 1744-STECF Ad hoc contract on Adriatic Small Pelagic Stocks – STECF 2018):

    - Using real reported catches from 2017, assuming status quo catches in 2018 and according to different levels of catch reductions for sardine [of 5-10-20%

per year] and anchovy [of 5-10-20% per year] starting in January 2019 and ending in December 2020.

2. Condition operating models (OM) for sardine and anchovy in the Adriatic Sea (GSA 17-18) with the results of Request for services - 1743 - STECF Ad hoc contract on Adriatic Small Pelagic stocks (STECF 2018), taking into account the current stock assessment and adding stock-recruitment models that consider multi-annual cycles of recruitment, which can consider both biomass or non-biomass related drivers for recruitment in the past. Additionally, model recruitment:

    - In line with S/R in model conditioning.
    - Segmented-regression.
    - Persistent low.
    - Other deemed appropriate.

3. Use an age structured population model based on a single area and a calendar year basis (January to December)

TOR 1:

In the MSE follow the specifications below:

1. Implementation Model

    - Annual catch limits to be set for the period January – December.

2. Observation Model

The MSE testing should address the following questions:

a) Is the current eco-survey set up (covering Italy, Albania and Montenegro in May-June, Croatia in Sept-Oct, with data delivery in March of Y+1) viable for implementing a robust Biomass escapement strategy for both stocks of anchovy and sardine?
b) Would data delivery of current echo-survey setting in November/December of the same year allow a better escapement strategy?
c) Test if two surveys are needed and/or if better performance of the HCR would be achieved.
d) What would be the best timing for deployment of 2 echo-surveys and timing for data provision?

3. Management Decision

Develop a biomass escapement HCR that will ensure a low probability of SSB to fall below B_{lim} (5% probability) for anchovy and sardine. The HCR should start operating in January 2021.

For the HCR, define:

1. an optimal level of the Bescapement.
2. the need of an Fcap.

TOR 2:

Economic Performance

If economic data are available and of adequate quality, evaluate the maximum economic performance of the HCR.

TOR 3:

Performance Statistics

Evaluate performance of alternate scenarios (at least 250 iterations) on 10-20 year time scale using standard MSE diagnostic tools, focusing in particular on the following in relation to Harvest Rate:

- Probability of SSB falling below B_{lim}.
- Risk vs catch level.
- Catch variability.
- Average catch.
- Level of SSB.

1.4 Addressing the ToRs

The ToRs were addressed using a mix of quantitative analysis based on MSEs and expert knowledge.

In particular ToR 1.2 (section 3) was mostly based on expert discussions, supported by partial quantitative analysis. The EWG notes that information about sampling design, sampling errors, or abundance estimates uncertainty were not available, which severely limited the analysis carried out during the EWG.

To address ToR 1.3 (sections 2 and 4) the following analysis was carried out:

1. Conditioning operating models
   a. Add uncertainty to stock assessment based on the official SAM fit using a a4a model fit.
   b. Set up stock-recruitment models to be tested.
2. Run a grid of HCR parameters to test which parametrizations deliver the required objective of $P[SSB<B_{lim}] < 0.05$ for each OM in the long term.
3. Run management scenarios using candidate HCR parameters and intermediate year scenarios.

The economic analysis (section 0) was built following the attempts carried out in STECF 16-21 (STECF 2016).

The full set of indicators is available for download in the EWG webpage (https://stecf.jrc.ec.europa.eu/ewg1801). The code and data used in the analysis is available upon request.

2 MSE

2.1 Operating models

The OMs set for the present study are summarized in

Table **2.1.1** and Table 2.1.2. For these stocks, natural mortality, maturity and recruitment were considered to be the most important processes in relation to potential impacts in the results. OMs A for each species were taken as the base cases since these were the most similar with the official stock assessments. The EWG decided to keep OMs A-D, which deal with recruitment options, as alternative representations of stock dynamics, and the other OMs as robustness tests.

Table 2.1.1 Operating models for anchovy

OM	R	M	maturity	Blim
A	segreg	gislason	mat age 0 = 0	20155
B	geomean low	gislason	mat age 0 = 0	20155
C	segreg cyclic	gislason	mat age 0 = 0	20155
D	geomean low cyclic	gislason	mat age 0 = 0	20155
E	segreg	gislason	mat age 0 = 0.5	32177
F	segreg	constant (0.65)	mat age 0 = 0	15972
G	segreg	constant (0.65)	mat age 0 = 0.5	17826

Table 2.1.2 Operating models for sardine

OM	R	M	maturity	Blim
A	segreg	gislason	mat age 0 = 0	112922
B	geomean low	gislason	mat age 0 = 0	112922
C	segreg cyclic	gislason	mat age 0 = 0	112922
D	geomean low cyclic	gislason	mat age 0 = 0	112922
E	segreg	constant (0.55)	mat age 0 = 0	104448

2.2 Conditioning

The OMs were conditioned using a4a model fits, which replicated as close as possible the official assessment carried out with SAM (STECF 2017c). For OMs with changed M a new fit was required, which was kept as similar as possible to the base cases' models for later comparisons. Stock recruitment models were based on Plenary fits (STECF 2017a), adjusted where needed to shifts in SSB levels due to alternative settings of M and maturity.

Figure 2.2.1 shows the official stock assessment fit for anchovy and the OMs obtained. There are no major changes in catch. For F, the a4a model is smoother than SAM; nevertheless, the confidence intervals cover the SAM assessment. OM E considers individuals of age 0 to be 50% mature and, as such, show a higher level of SSB, while OM, F which uses a constant lower M, presents a lower level of recruitment. OM G is a mixture of OMs E and F.

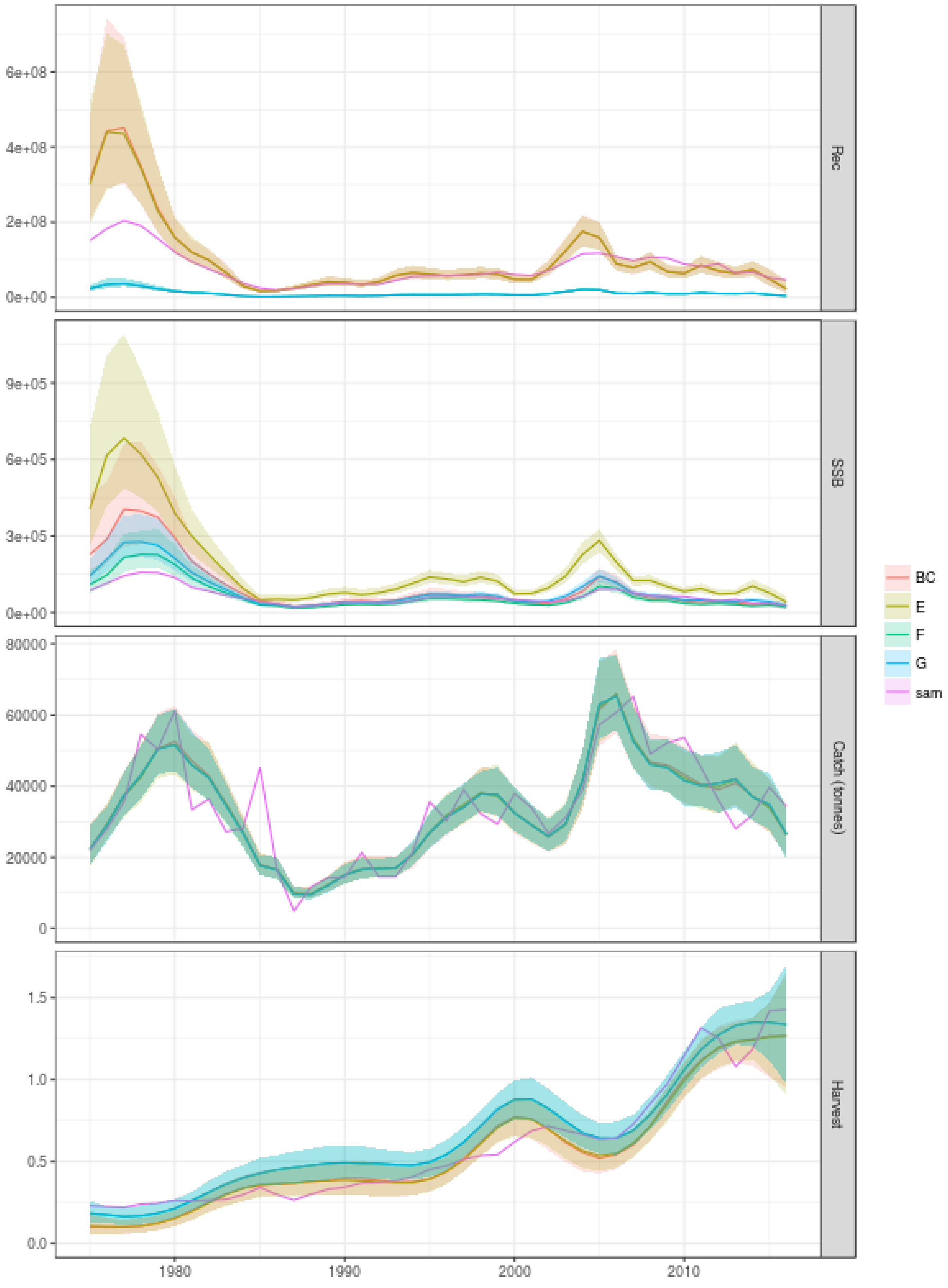


Figure 2.2.1 Anchovy operating models. BC=Base case, sam=official assessment, E= alternative maturity, F= constant M, G= mix of OMs E and F.

Figure 2.2.2 shows the F surface at age and year of the base case (OM A) and SAM's estimate. The main differences exist in the beginning of the time series, which is not expected to influence the final results of the analysis, and the older ages in recent periods, which has a reduced impact in the stock dynamics, since most of the catches are concentrated in ages 0 and 1.

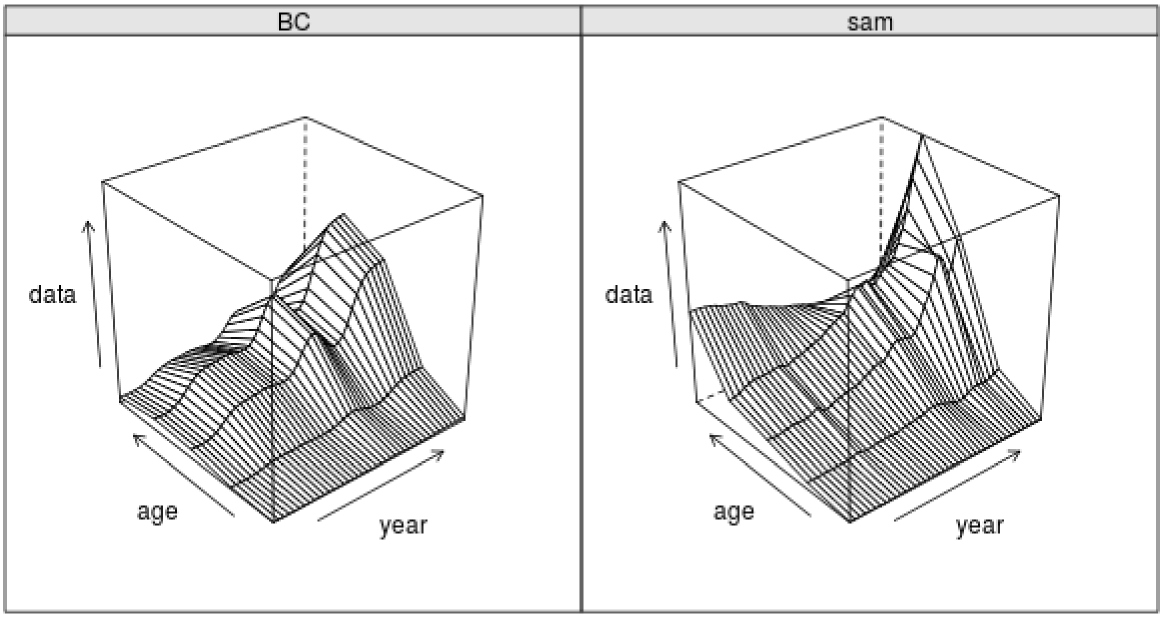


Figure 2.2.2 Anchovy fishing mortality at age by year. Comparison between the official assessment (sam) and the a4a replication (BC)

Figure 2.2.3 shows the models and levels of recruitment used in the forecast for each OM. The models fitted were segmented regressions and geometric means (for low recruitment options). OMs C and D were added a cyclic term (see annex 2), which introduces time auto-correlation, although without affecting the average level of recruitment.

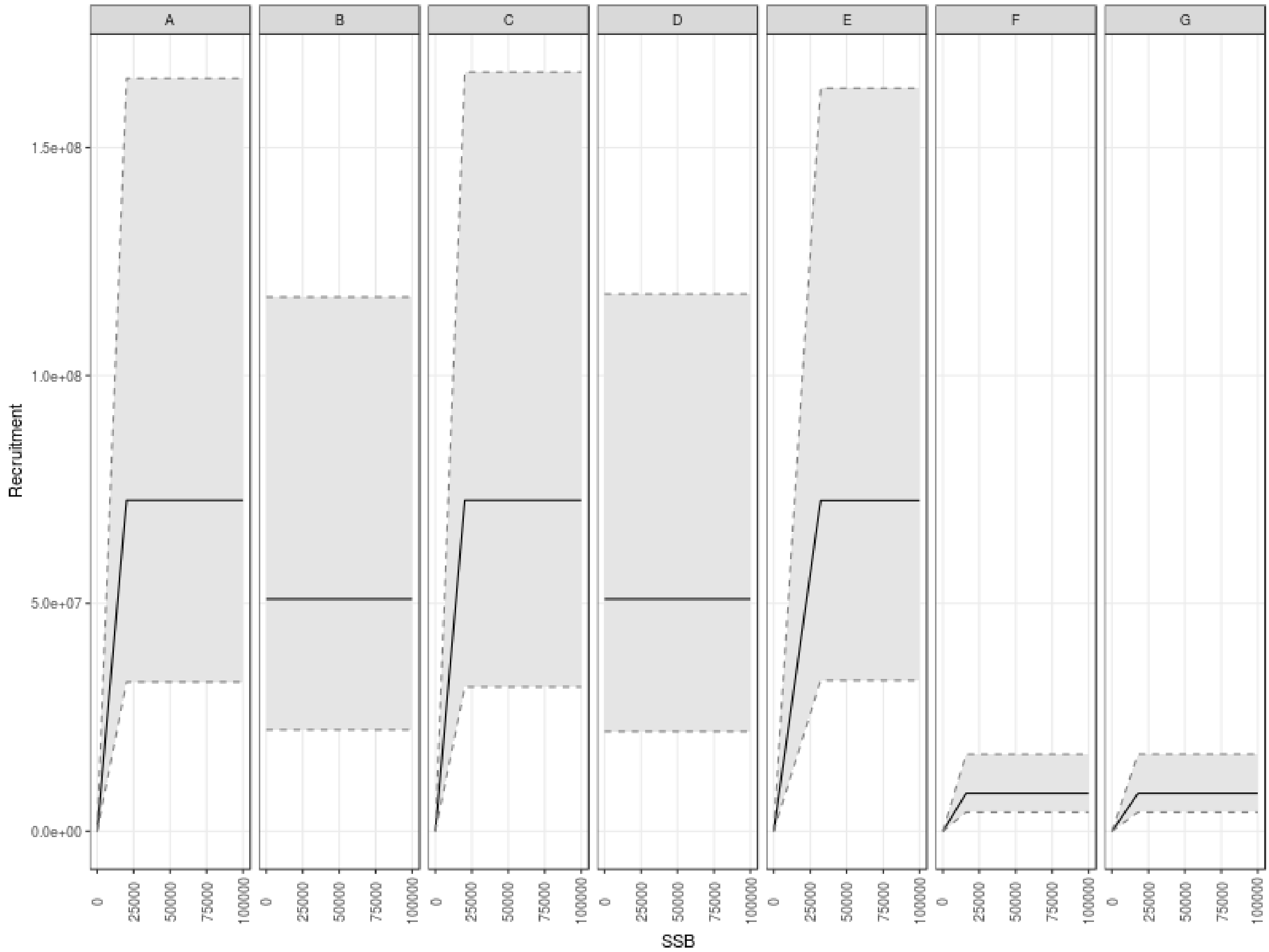


Figure 2.2.3 Anchovy stock-recruitment relationships. Black line is the median model estimate, dashed lines and grey region shows the 90% confidence interval.

For sardine, a similar pattern was obtained although less pronounced than for anchovy (Figure 2.2.4). There are no major changes in catches. F estimates by the a4a model are slightly smoother than SAM. OM E, which uses a constant lower M, exhibits a lower level of recruitment.

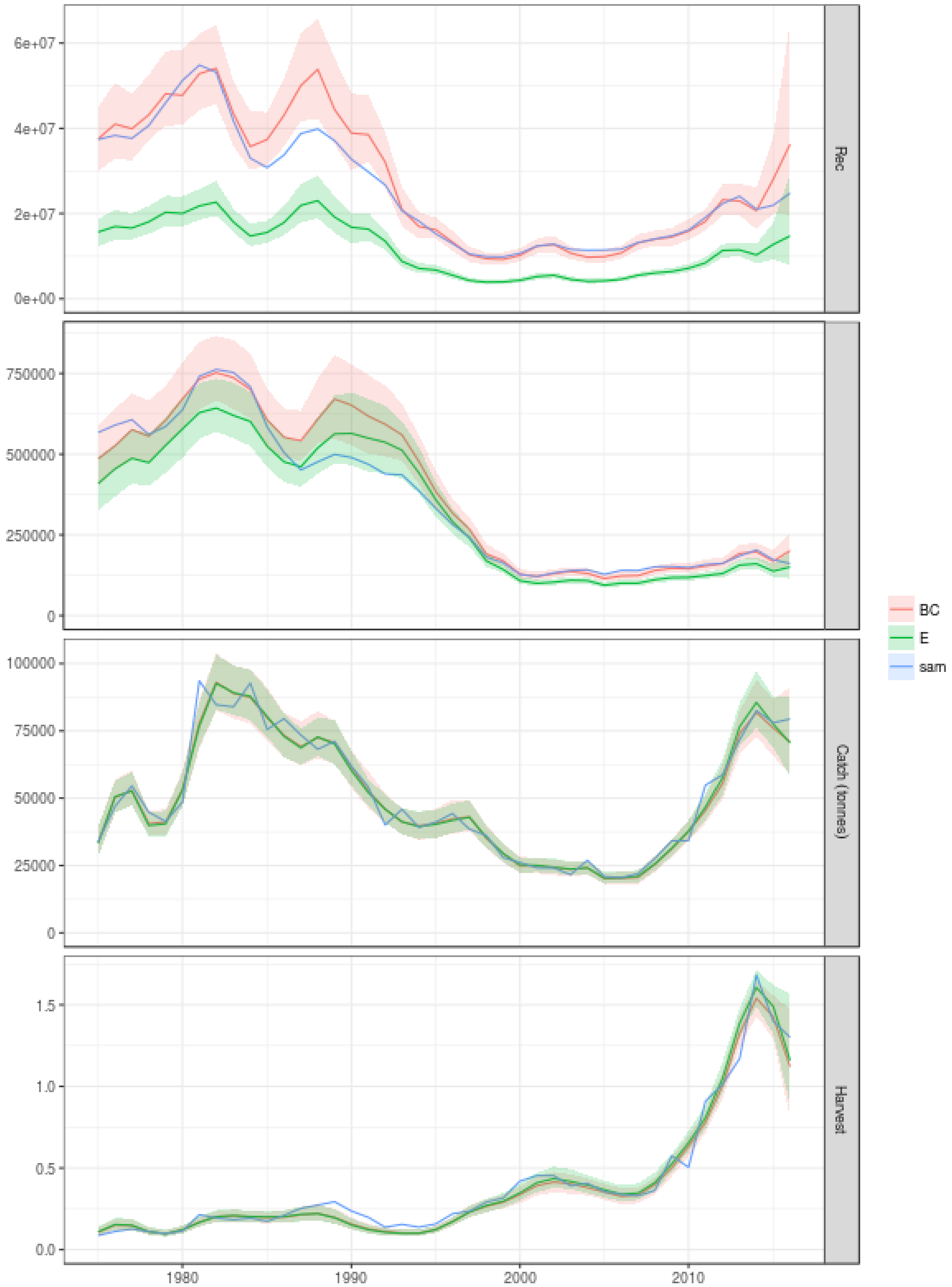


Figure 2.2.4 Sardine operating models. BC=Base case, sam=official assessment, E=constant M.

Figure 2.2.5 shows the F surface at age and year of the base case (OM A) and SAM's estimate. Both estimates are very similar, with the a4a estimate being slightly smoother than SAM's.

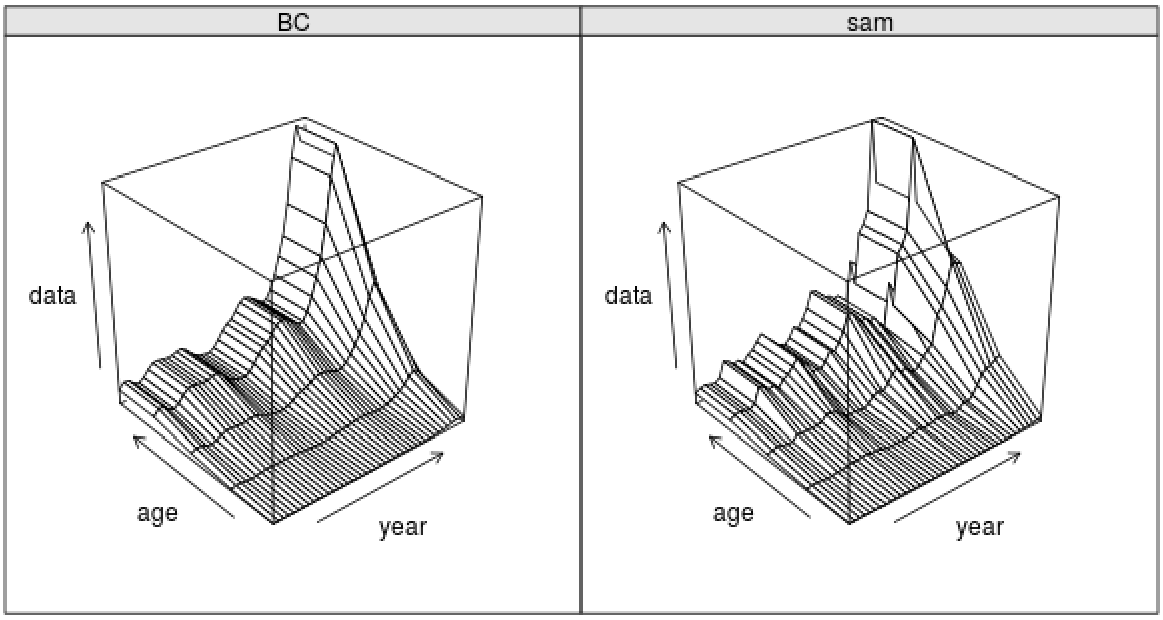


Figure 2.2.5 Sardine fishing mortality at age by year. Comparison between the official assessment (sam) and the a4a replication (BC)

Figure 2.2.6 shows the models and levels of recruitment used in the forecast for each OM. The models fitted were segmented regressions and geometric means (for low recruitment options). OMs C and D included a cyclic term (see annex 2), which introduced time auto-correlation although without affecting the average level of recruitment.

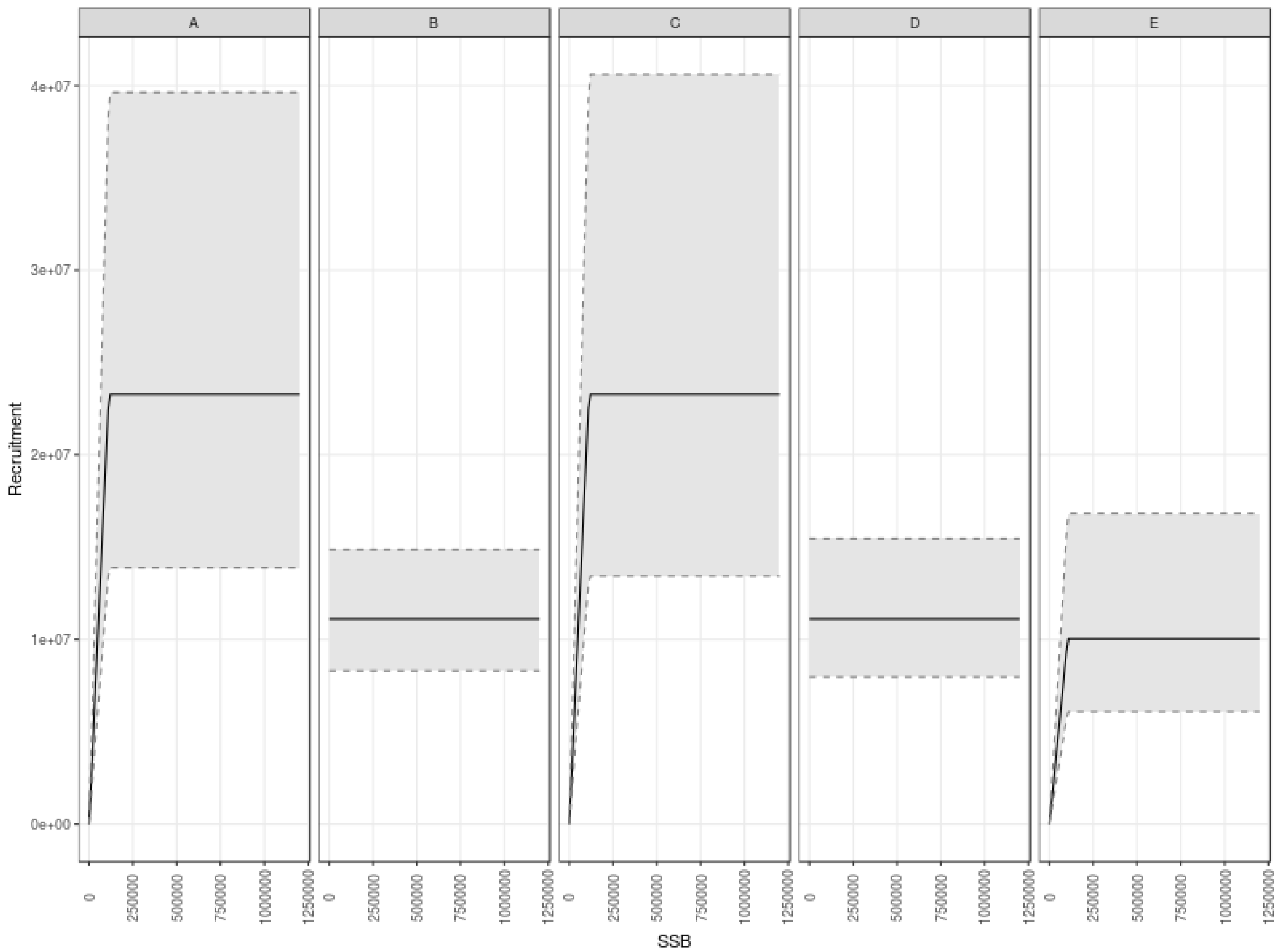


Figure 2.2.6 Sardine stock-recruitment relationships. Black line is the median model estimate, dashed lines and grey region shows the 90% confidence interval.

2.3 Escapement HCR

The escapement HCR tested in this study sets fishing opportunities in total allowable catches (TAC) for year $y+1$ which are estimated to leave at sea a level of biomass similar or higher than a predefined "escapement biomass" (B_{esc}), while simultaneously keeping fishing mortality equal or lower than a specified cap (F_{cap}).

This can be described mathematically as following:

$$TAC_{y+1} = \hat{C}_{y+1} \mid \widehat{SSB}_{y+1} = B_{esc}, \hat{F}_{y+1} \leq F_{cap}$$

Where TAC is the total allowable catch, C is catch weight, SSB is spawning stock biomass at the moment of spawning, F is fishing mortality, B_{esc} is the biomass to be left at sea (hence escapement), F_{cap} is the maximum fishing mortality allowed, y indexes years, $\widehat{}$ identifies estimates and $|$ represents "conditional". For the sake of simplicity variables that are fixed along the period of forecasting (e.g. maturity) were not included in the notation.

To find $\hat{C}_{y+1}$ one needs to project the stock into $y+1$, which requires estimates of the population structure at age ($N_{a,y+1}$), selection pattern ($F_{a,y+1}$) and recruitment (R_{y+1}). Nevertheless, since stock assessment provides estimates until year $y-1$, it's also necessary to forecast the intermediate year, y, requiring at least two more parameters, $\hat{C}_y$ or $\hat{F}_y$ and $\hat{R}_y$. The input data to apply the HCR is N_a, which is taken directly from assessment, estimates for year $y-1$, F_a and R, which are computed as the average of the last 3 years in the assessment, $y-1$, $y-2$ and $y-3$, and kept constant over y and $y+1$.

Note that:

$$if\ \widehat{SSB}_{y+1} < B_{esc} : TAC_{y+1} = 0$$

and

$$if\ \hat{F}_{y+1} > F_{cap} : TAC_{y+1} = g(F_{cap})$$

where g is the Baranov equation.

2.4 Management scenarios

Table 2.4.1 and

Table **2.4.2** describe the management scenarios examined in this study. The scenarios were set to reply to the ToRs (1-3) and run robustness tests (4-6 in anchovy, 4-5 in sardine). An attempt to include a robustness test for the alternative of having age 0 individuals with 50% maturity for sardine was carried out. However, a new set of reference points would be needed to evaluate this option properly, which the EWG could not compute due to time constraints.

Table 2.4.1 Scenarios for anchovy. OM: operating models, letters refer to Table 2.1.1; OEM: observation error model, "srv=y-1" refers to survey data being available in year y-1, "srv=y" refers to survey data being available in the assessment year y, "srv q, Ca historical" refers to error being introduced in survey catchability and catch at age based in historical estimates; SA: stock assessment, "perfect" refers to perfect information being used in the HCR without taking into account stock assessment uncertainty, "a4a sep s()" refers to a a4a separable stock assessment model; HCR: harvest control rule as described in previous section; IMP: implementation model, only for options with a transition period as described in the ToRs; IEM: Implementation error model, considered perfect implementation for all scenarios; ToR: term of reference the scenario was used for.

Scenarios			OM	OEM	MP			IEM	ToR
					SA	HCR	IMP		
Management	1	Parameters	A-H	perfect srv=y-1	perfect	B_{esc} (F_{cap}=0.5-2, B_{esc}=20-90)*		perfect	1.3
	2	Intermediate path	A,B,C	perfect srv=y-1	perfect	B_{esc}	transition period**	perfect	conditioning
	3	Survey timing	A	perfect srv=y	perfect	B_{esc}		perfect	1.2.b
Robustness	4	M	A,F,G	perfect srv=y-1	perfect	B_{esc}		perfect	conditioning
	5	Maturity	A,E,G	perfect srv=y-1	perfect	B_{esc}		perfect	conditioning
	6	stock assessment	A	srv q, Ca historical	a4a sep s()	B_{esc}		perfect	1.3
	7	Alternative S/R	I	perfect srv=y-1	perfect	B_{esc}		perfect	1.3

* these vectors were adjusted between OMs with mat0=0 and mat0=0.5

** 2016 and 2017 catches provided by MARE from FIDES and assessment inputs. Adjustments were done by the EWG to the 2017 Italian landings to account for the discrepancy between FIDES reports and assessment data. Total landings in 2017 estimated to 33300t.

Table 2.4.2 Scenarios for sardine. OM: operating models, letters refer to Table 2.1.2; OEM: observation error model, "srv=y-1" refers to survey data being available in year y-1, "srv=y" refers to survey data being available in the assessment year y, "srv q, Ca historical" refers to error being introduced in survey catchability and catch at age based in historical estimates; SA: stock assessment, "perfect" refers to perfect information being used in the HCR without taking into account stock assessment uncertainty, "a4a sep s()" refers to a a4a separable stock assessment model; HCR: harvest control rule as described in previous section; IMP: implementation model, only for options with a transition period as described in the ToRs; IEM: Implementation error model, considered perfect implementation for all scenarios; ToR: term of reference the scenario was used for.

Scenarios			OM	OEM	MP			IEM	ToR
					SA	HCR	IMP		
Management	1	Parameters	A-E	perfect srv=y-1	perfect	B_{esc} (F_{cap}=0.4-2, B_{esc}=100-500)		perfect	1.3
	2	Intermediate path	A,B,C	perfect srv=y-1	perfect	B_{esc}	transition period*	perfect	conditioning
	3	Survey timing	A	perfect srv=y	perfect	B_{esc}		perfect	1.2.b
Robustness	4	M	A,E	perfect srv=y-1	perfect	B_{esc}		perfect	conditioning
	5	stock assessment	A	srv q, Ca historical	a4a sep s()	B_{esc}		perfect	1.3
	6	Maturity	A, A+mat=0.5	perfect srv=y-1	perfect	B_{esc}		perfect	1.3

* 2016 and 2017 catches provided by MARE from FIDES and assessment inputs. Adjustments were done by the EWG to the 2017 Italian landings to account for the discrepancy between FIDES reports and assessment data. Total landings in 2017 estimated to 71149t.

3 ToR 1.2: Data provision and survey timing

The EWG notes that there are a number of issues that can benefit from better coordination of these surveys, namely synchronized timings, similar gears, age reading calibration, coordination of sampling protocols, sampling design, methods to estimate sampling error and estimation uncertainty. For more detailed information, refer to STECF (2017d), FAO AdriaMed (2017), ICES (2017b) and GFCM (2017).

3.1 Is the current eco-survey set up (covering Italy, Albania and Montenegro in May-June, Croatia in Sept-Oct, with data delivery in March of Y+1) viable for implementing a robust Biomass escapement strategy for both stocks of anchovy and sardine?

The current acoustic survey settings, constituting of direct observations of stock biomass and abundance of recruits, can be used to set fishing opportunities based on a biomass escapement strategy.

However, due to the gap between the end of the survey and data provision[1], the application of the HCR will require the projection of population abundance for 2 years (Figure 3.1.1).

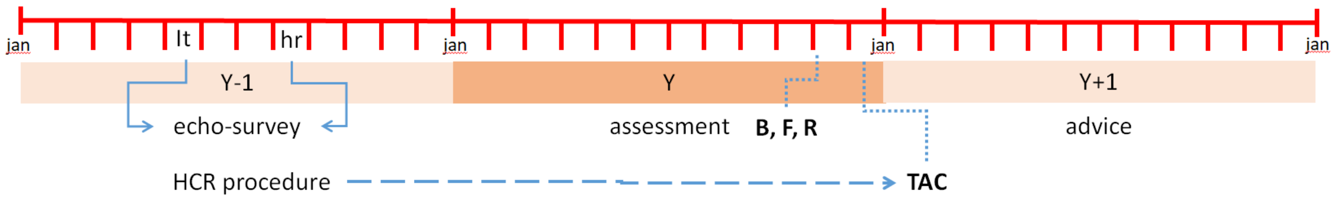


Figure 3.1.1 Current timeline of data collection, assessment and advisory process in GSA 17-18 for sardine and anchovy. Note the ToR refers to year y+1, which in the figure maps to year y.

3.2 Would data delivery of current echo-survey setting in November/December of the same year allow a better escapement strategy?

EWG 18-01 is of the opinion that setting the data delivery of current echo-surveys in November/December would allow a more precise application of the escapement strategy, by removing the need to project the intermediate year.

Referring to the HCR procedure (Figure 3.2.1), the EWG notes that having the full assessment information of year y, even if preliminary, available for the assessment EWG of the same year, removes the intermediate year projection. This case would reduce the projection from 2 to 1 year, which would improve the precision of TAC's estimate.

[1] Currently survey data becomes available for assessment purposes in the end of March, in agreement with DGMARE's data call deadlines and MEDIAS' Steering Committee decisions (Palma, 2017), confirmed by the RCG Med&BS (DCF-Regional Coordination Group meeting 2017, Larnaca).

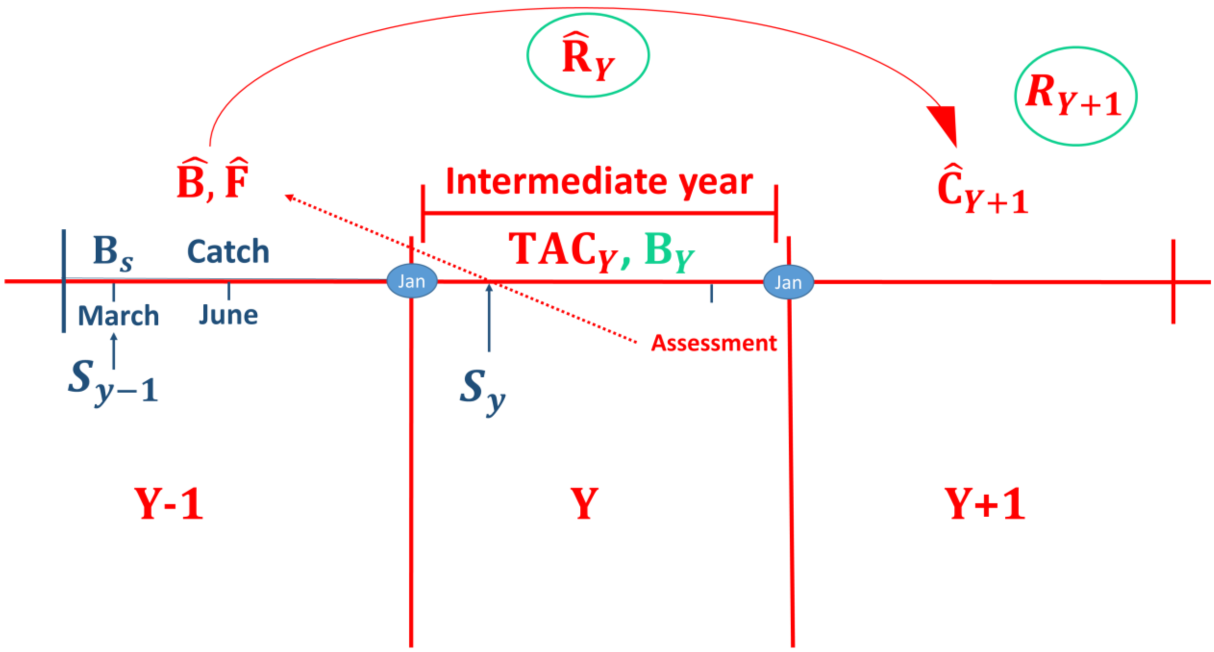


Figure 3.2.1 Procedure for the evaluation of the current harvest control rule (HCR, January to December advice). TAC = total allowable catch, C = catch weight, B = stock biomass, F=fishing mortality, R = recruitment, S=survey, Y= indexes years, ^ = estimates.

As an example, EWG 18-01 performed a simulation of anchovy for GSAs 17-18 with and without the survey data gap (i.e. with or without an intermediate year in the modelling process). B_{esc} was set to 30000t, F_{cap} to 0.65 and everything else was set equal to the base case (OM A). Figure 3.2.2 shows the comparison between the two options. Although no stock assessment feedback was used in these simulations, the scenarios resemble an option of setting the TAC using data until y-1 (data gap 1) or y (data gap 0). There is a clear improvement of the fishing mortality confidence intervals when the survey data gap is shorter (data gap 0). In the long term (equilibrium), no other benefits seem to exist. In the short term, catches would be more aligned with recruitment, due to faster reaction to its changes, which the 2-year management gap between assessment and catches (data gap 1) does not allow. If the stock is not close to equilibrium, or stable, having a shorter period for reacting to changes in recruitment may be an important advantage to manage these stocks and fisheries.

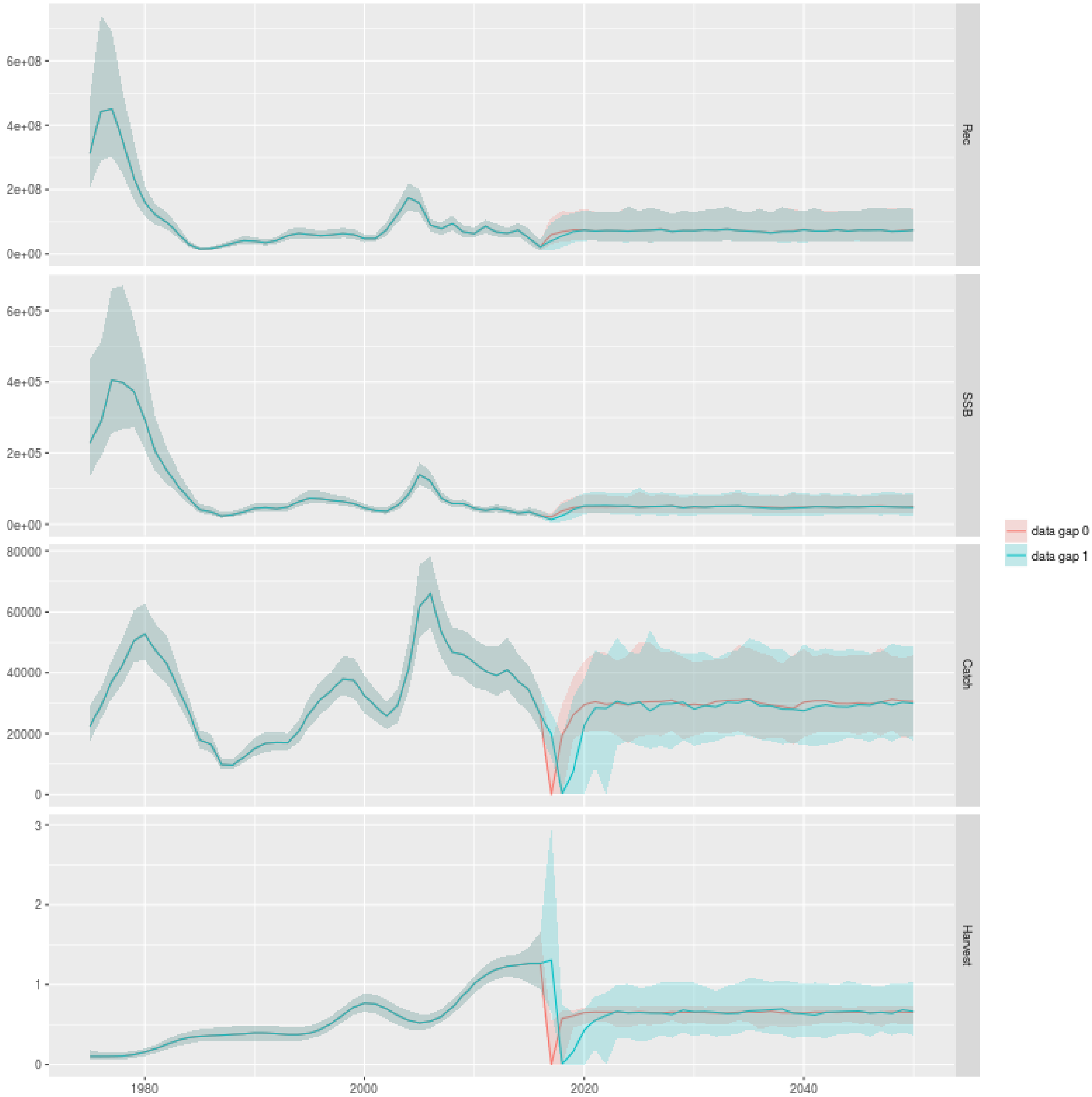


Figure 3.2.2 Comparison between the base case and the option of a shortened data gap, so that data from the year y is used in the assessment and then immediately used by the HCR.

The current operational agreements within the MEDIAS steering committee and the DCF regional coordination groups (RCG Med and BS) requires survey estimates for stock assessment purposes to be provided 6 months after the end of the survey. EWG 18-01 notes that to shorten the period for provision of survey estimates, a revision of the MEDIAS agreement and adjustments to the DCF national programs will be required.

The EWG notes that even if the full set of echo-surveys data would not be possible to be delivered in year y, it might be possible to derive recruitment indices from preliminary survey information, and thus improve recruitment strength estimates. Alternatively, or complementarily, the use of environmental data collected during the acoustic surveys could also be used to estimate recruitment trends (Tommasi et al. 2017). Both cases have the potential to improve recruitment forecasts and consequently estimate fishing opportunities more precisely. Further studies are required to test the possibility of including these indicators in the HCR.

3.3 Test if two surveys are needed and/or if better performance of the HCR would be achieved.

EWG 18-01 notes that anchovy and sardine have two different periods of spawning (summer for anchovy and winter for sardine) and recruitment (beginning of the year for anchovy, second half of the year for sardine). As such, EWG 18-01 considers that having two separate surveys in appropriate periods would be preferable in order to describe the dynamics of each stock. The objectives of these surveys will need to be precisely defined in order to provide the appropriate data.

3.4 What would be the best timing for deployment of 2 echo-surveys and timing for data provision?

The benefits from potential changes in the timing of the surveys depend on the goals. If the surveys should provide reliable recruitment estimates they should be performed at recruitment time (for anchovy beginning of the year, for sardine in the second half of the year).

In terms of timing for data provision, the EWG 18-01 suggests the timeline for data provision to be reduced as much as possible, in order to enable the assessment of the stocks in the same year of the survey. However, EWG 18-01 notes that such shift will require the revision of the MEDIAS agreement and adjustments to the DCF national programs.

On the other hand, discontinuing surveys’ time series must be considered carefully and take into account the information loss it may create (Regulation 2017/1004).

4 ToR 1.3: Management options

4.1 Tuning the HCR

Figure 4.1.1 shows isolines of 5% biological risk for anchovy, aggregated for the period 2035-2044, as a function of B_{esc} and F_{cap}. The isolines reflect three different boundaries computed as the maximum, minimum and mean biological risk across OMs A-D, each one respectively referring to the less conservative (blue line), the most conservative (red line) and the average (green line) scenario.

Considering that the present stock forecasts are quite optimistic, the parameters between the mean and the most conservative options were selected (black dots). These parameters were kept for further analysis.

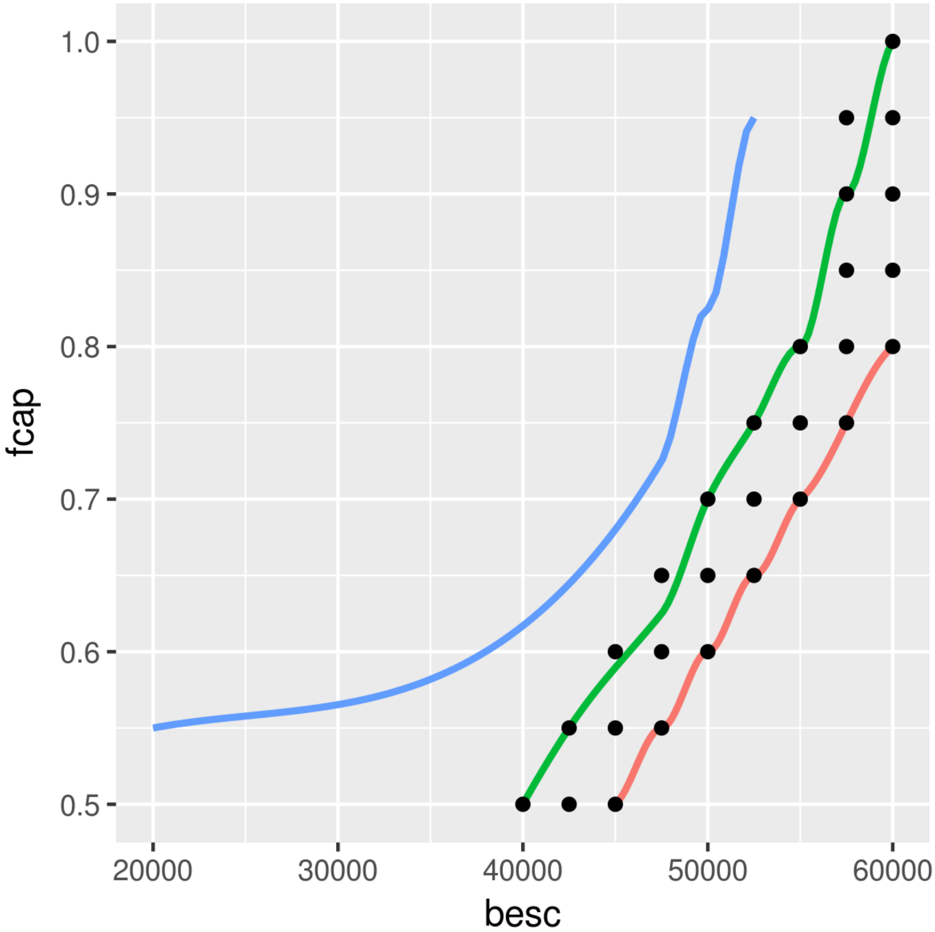


Figure 4.1.1 Tuning the HCR for anchovy. Dots represent the pairs of parameters chosen by the EWG as candidates for further analysis. Lines represent isolines of biological risk close to 5%, with three scenarios: the less conservative (blue line), the most conservative (red line) and the average (green line).

With regards to sardine, the two groups of OMs, median and low recruitment showed a large impact on the perception of risk. To account for the difference, both groups were kept separated and two sets of isolines were depicted (Figure 4.1.2). The parameters selected are those that overlap the two sets, limited by a maximum F_{cap} of 1.5, plus some ad-hoc choices made by the EWG.

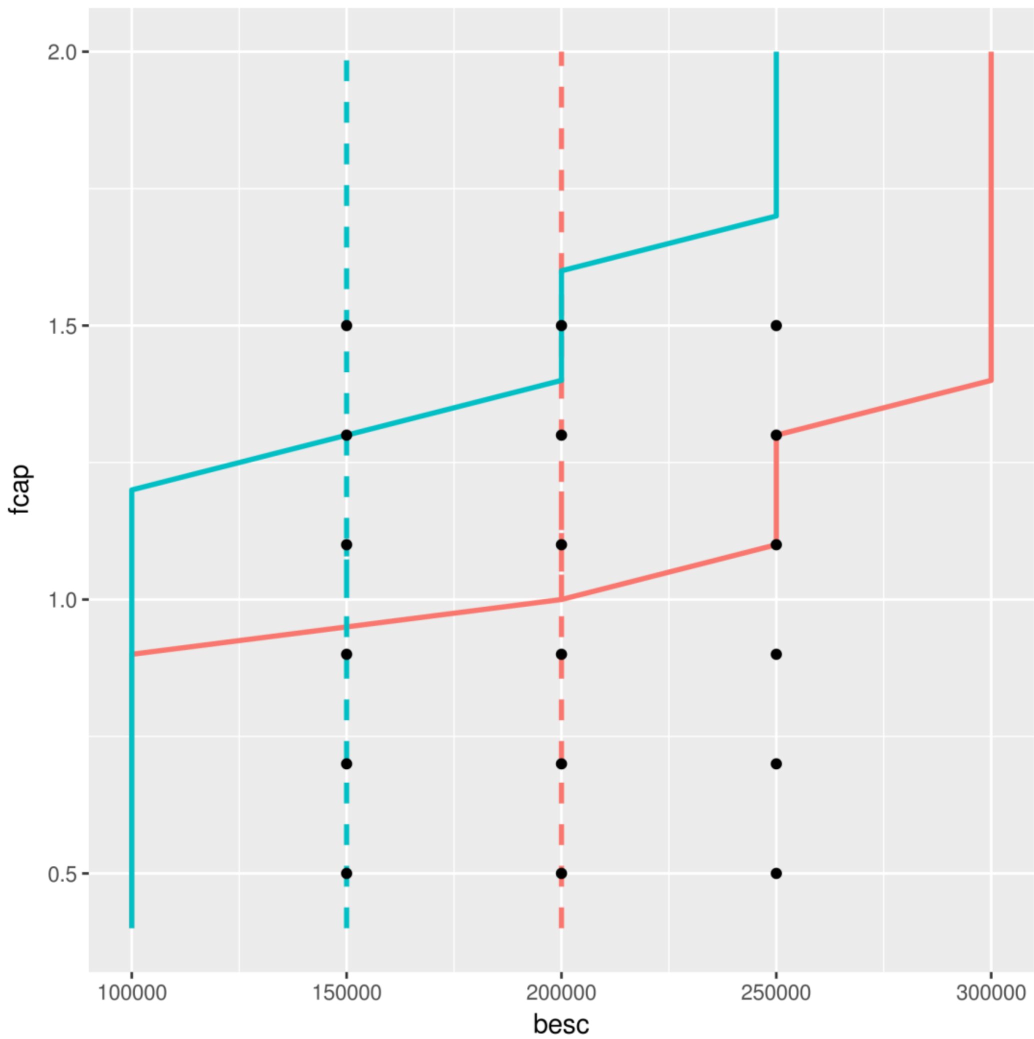


Figure 4.1.2 Tuning the HCR for sardine. Continuous and dashed lines correspond to the high (OM A and C) and low recruitment scenarios (OM B and D), respectively. Dots represent the pairs of parameters chosen by the EWG as candidates for further analysis.

4.2 Long term effects

The figures included in this section show results computed across OMs (A-D for anchovy; A, C for sardine). As such, the results were presented in terms of ranges (min-max) and not with confidence intervals, for which the data was considered insufficient.

4.2.1 Anchovy

Figure 4.2.1 shows the probability of SSB being below B_{lim} at different combinations of the selected B_{esc}-F_{cap} pairs. As expected, the median values are below or very close to 5%; nevertheless, there is a pattern of increasing risk with increasing F_{cap}.

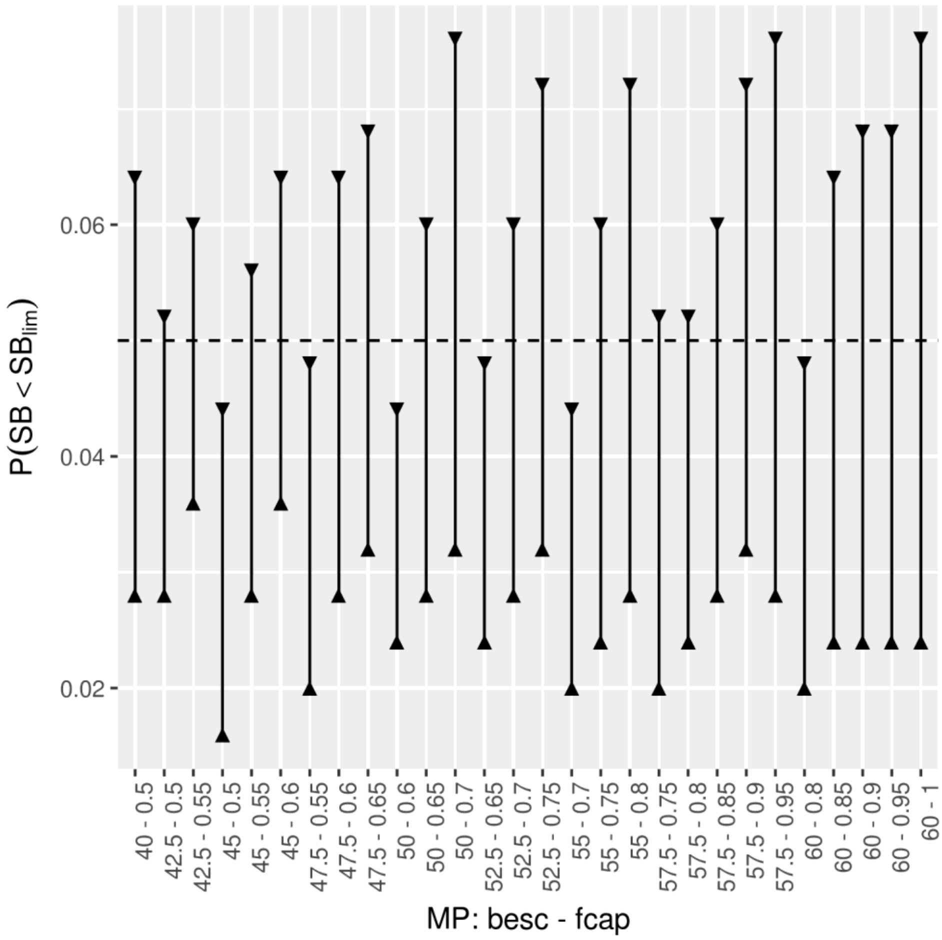


Figure 4.2.1 The probability of SSB falling below B_{lim} for the selected combinations of B_{esc}-F_{cap} for anchovy. Solid lines represent ranges across OMs A-D.

The probability of closing the fishery, or having catches smaller than 1t, is shown in Figure 4.2.2. This statistic is within the range of 0.1 to 0.7 and shows a pattern of increasing risk with higher B_{esc} and F_{cap}.

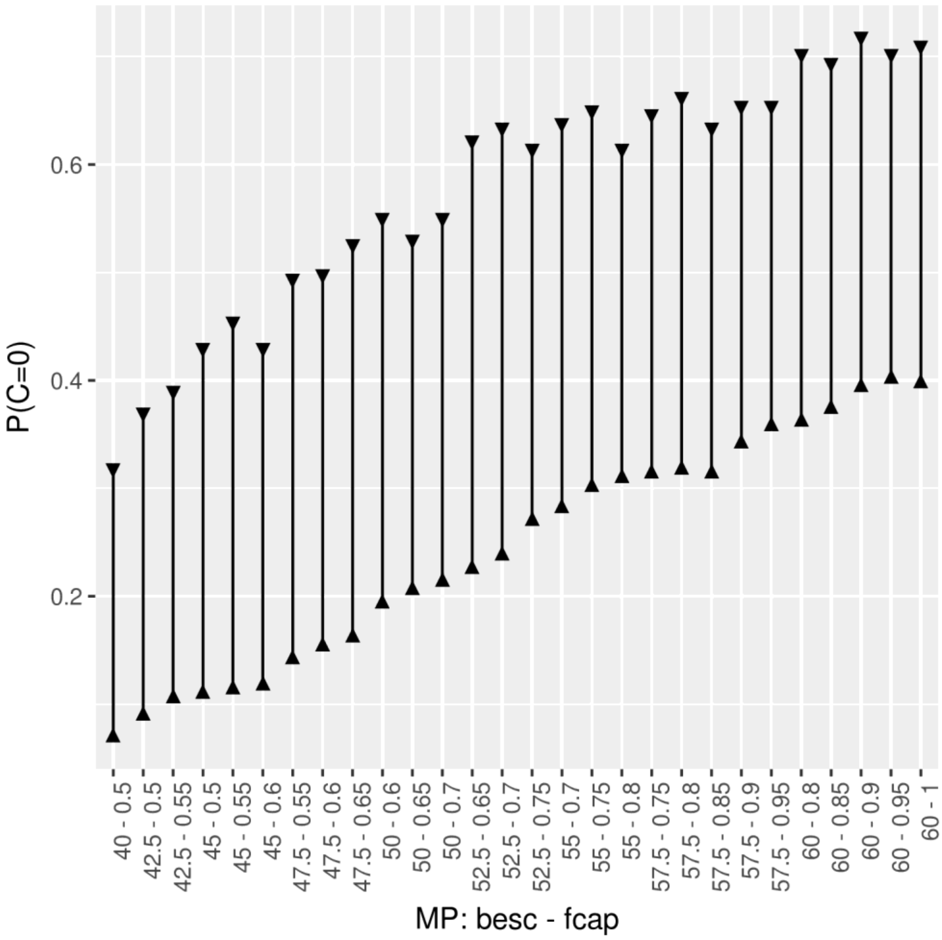


Figure 4.2.2 The probability of closing the fishery for the selected combinations of B_{esc}-F_{cap} for anchovy. Solid lines represent ranges across OMs A-D.

Figure 4.2.3 presents the annual median catch for the different scenarios. In this case, a decrease in catches is observed with higher B_{esc}. Uncertainty about the catches increases with increasing B_{esc} and F_{cap}.

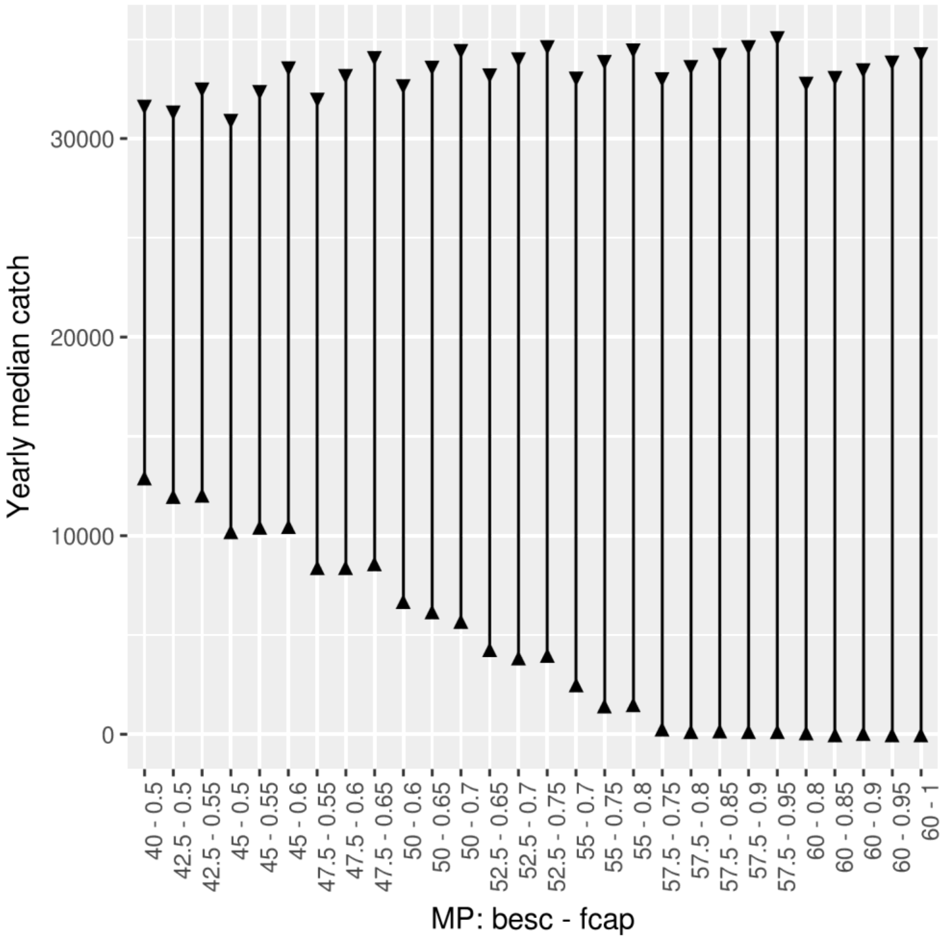


Figure 4.2.3 The yearly median catch for the selected combinations of B_{esc}-F_{cap} for anchovy. Solid lines represent ranges across OMs A-D.

The change of SSB compared to the initial level of SSB increases with larger B_{esc}, while larger F_{cap} has the opposite effect (Figure 4.2.4).

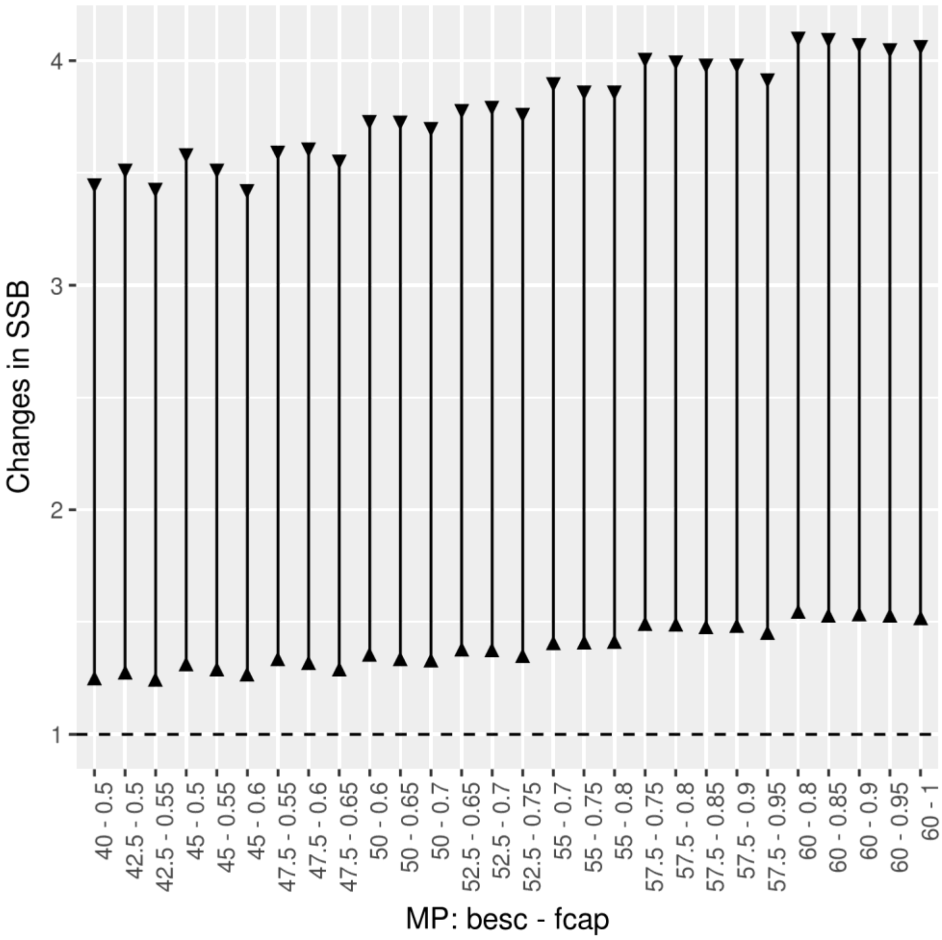


Figure 4.2.4 The change in SSB compared to its initial level for the selected combinations of B_{esc}-F_{cap} for anchovy. Solid lines represent ranges across OMs A-D.

Figure 4.2.5 shows the trade-offs between biological risk and catches. The results show a large range of values for each statistic, which reflects the large uncertainty associated with anchovy's forecasts. Larger F_{cap} introduces larger uncertainties in catches, without changing average catches. The combination of large B_{esc} and F_{cap} increases the biological risk above 5%.

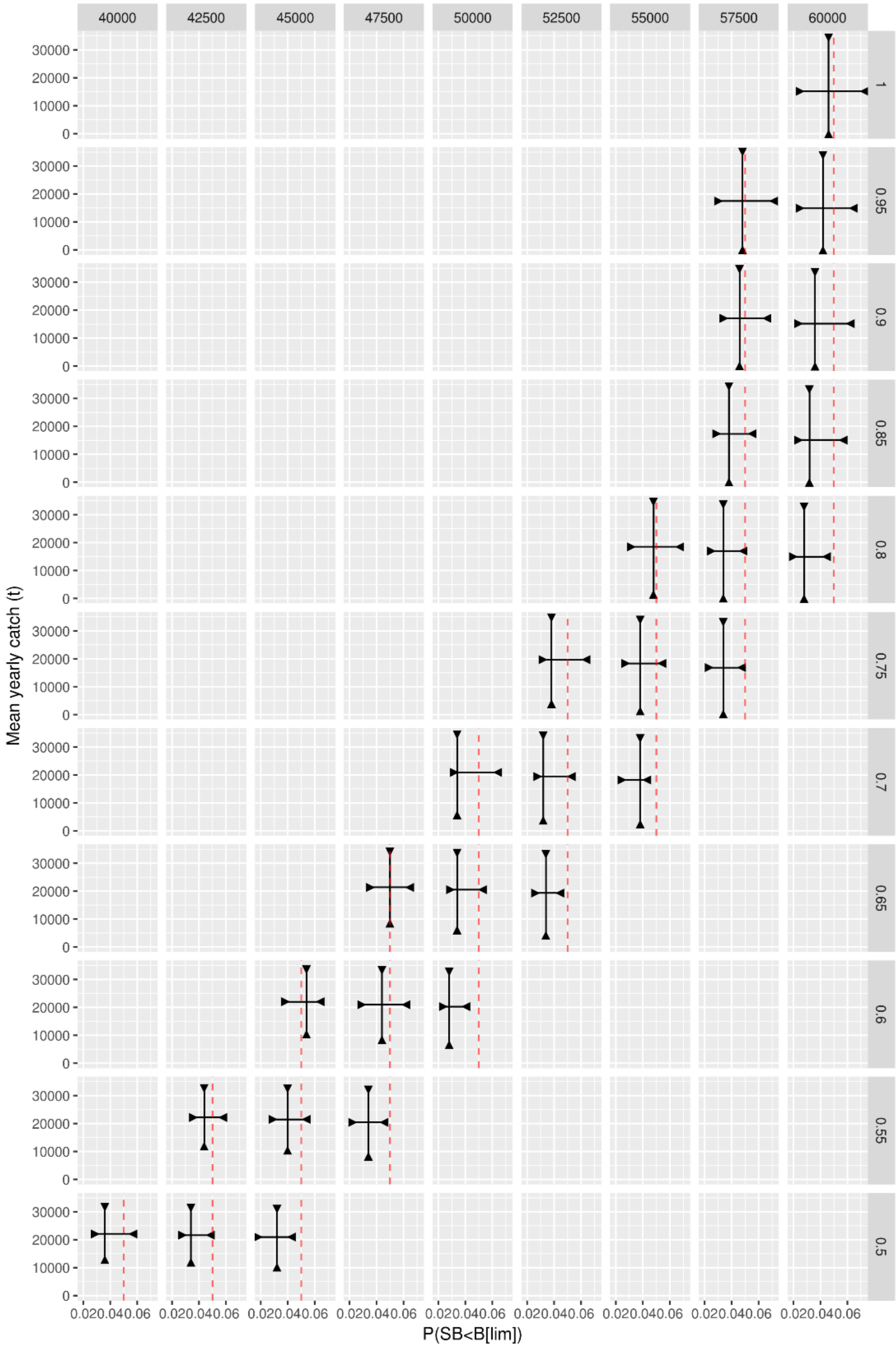


Figure 4.2.5 Mean yearly catch against the probability of stock falling below B_{lim} for the selected combinations of B_{esc}-F_{cap} for anchovy. Solid lines represent ranges across OMs A-D. B_{esc} options are presented in columns and F_{cap} in rows.

4.2.2 Sardine

The probability that SSB will drop below B_{lim} in relation to F_{cap} and B_{esc} (Figure 4.2.6) shows fluctuations driven dominantly by F_{cap}. F_{cap} values of 0.5 - 0.9 present biological risks below 5%, while F_{cap} larger than 0.9 show higher biological risks, with the exception of B_{esc} values of 250000 t that presented biological risks below the 5% threshold for any combination of F_{cap}.

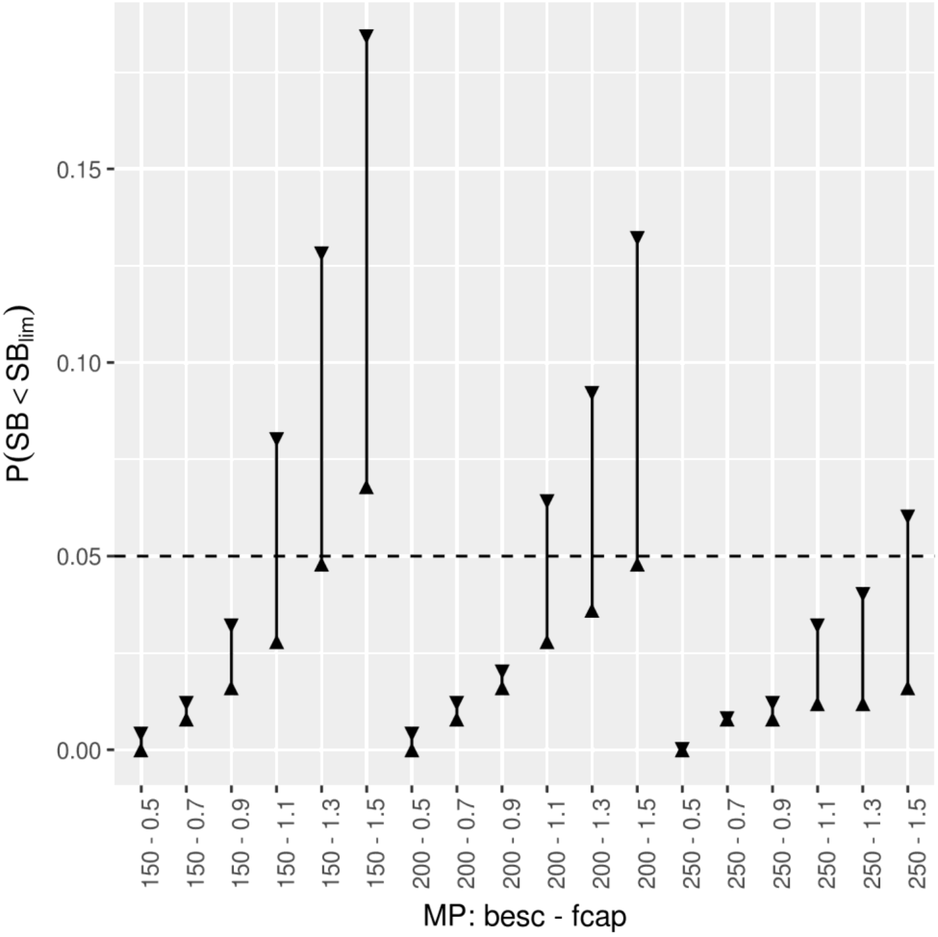


Figure 4.2.6 The probability of SSB falling below B_{lim} for the selected combinations of B_{esc}-F_{cap} for sardine. Solid lines represent ranges across OMs A and C.

With relation to the probability of closing the fishery (catches smaller than 1t), Figure 4.2.7 shows a clear increasing trend from 0 to 0.3, driven by increasing B_{esc} and F_{cap}. For a B_{esc} of 150000 t all probabilities were below 5%. For values of B_{esc} of 200000 t, the probability was in the range of 5-13%. The highest probability for closing the fishery was observed for B_{esc} of 250000 t with any tested F_{cap}, at 25-30%.

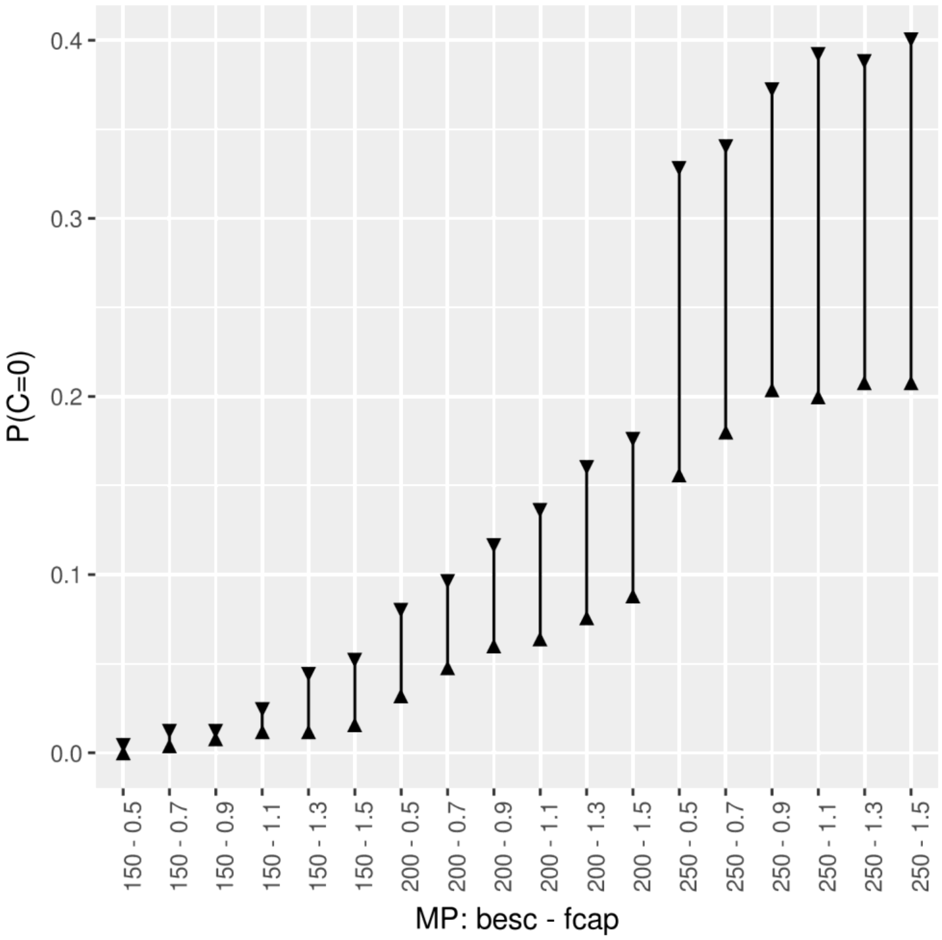


Figure 4.2.7 The probability of closing the fishery for the selected combinations of B_{esc}-F_{cap} for sardine. Solid lines represent ranges across OMs A and C.

Yearly median catch showed clear increasing trend with F_{cap} within each B_{esc} scenario (Figure 4.2.8). At the same time, increasing B_{esc} resulted in wider ranges of catches. The highest value was obtained with a B_{esc} of 150000 t and F_{cap} of 1.5, reaching about 80000 t per year. Pairs of F_{cap} of 0.5, 0.7, and 0.9 in combination with B_{esc} of 150000 t and 200000 t resulted in similar values. The lowest value, around 50000 t, was obtained with B_{esc} of 250000 t and F_{cap} of 0.5.

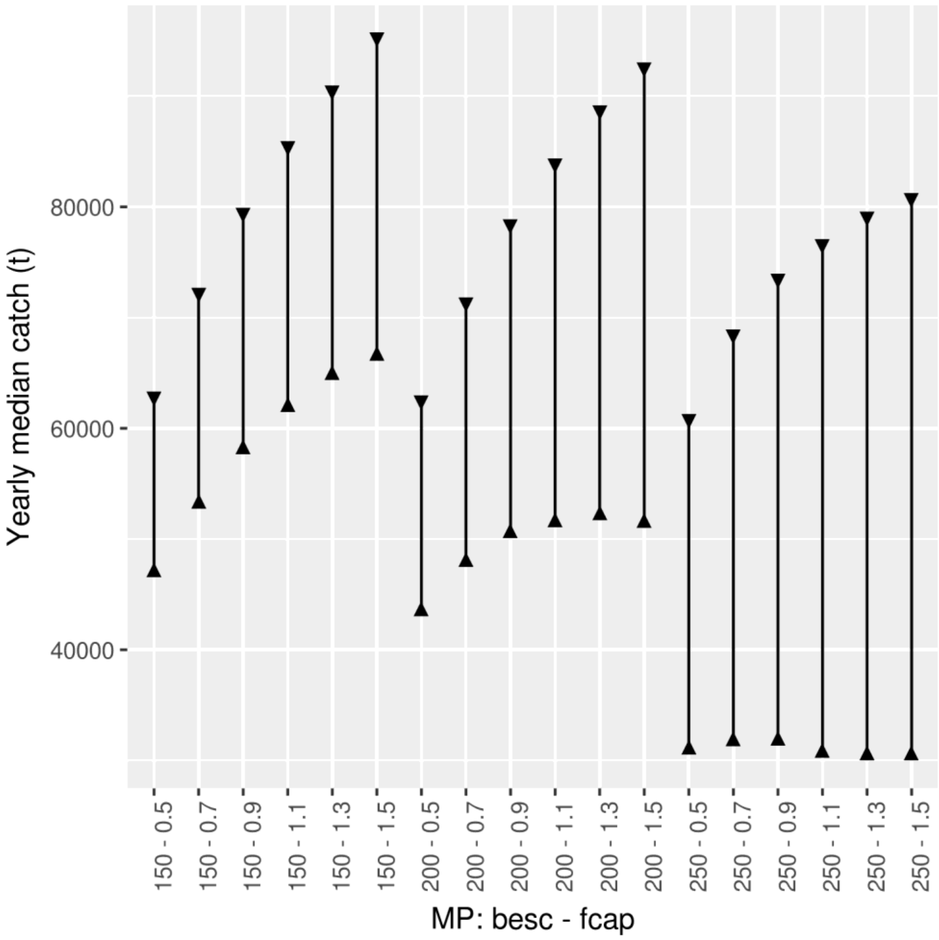


Figure 4.2.8 The yearly median catch for the selected combinations of B_{esc}-F_{cap} for sardine. Solid lines represent ranges across OMs A and C.

All scenarios result in values of SSB over the SSB in 2016 around 1 (Figure 4.2.9). This result is due to fishing mortalities being kept at high levels compared to the stock history, which generates SSBs lower or similar to the recent estimates. Future assessments will show if the result holds or it will be revised due to retrospective effects. Nevertheless, there is a clear pattern of lower biomass as F_{cap} increases and higher biomasses as B_{esc} increases.

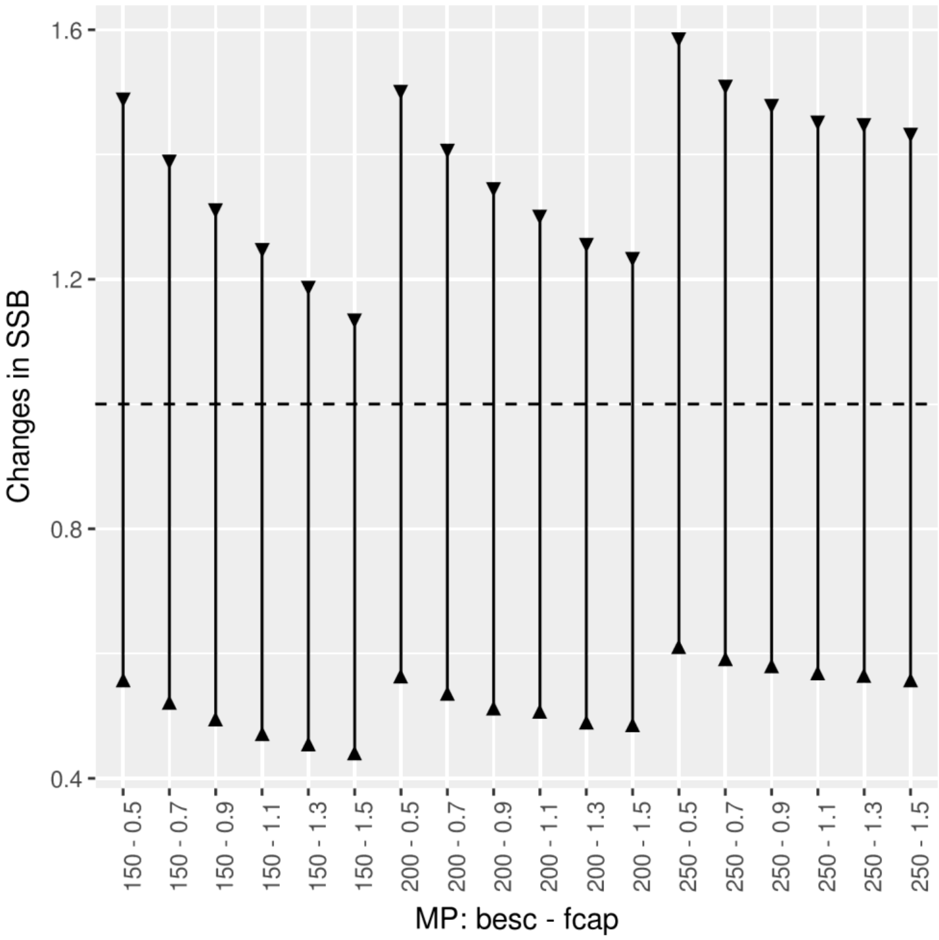


Figure 4.2.9 The change in SSB compared to its initial level for the selected combinations of B_{esc}-F_{cap} for sardine. Solid lines represent ranges across OMs A and C.

Figure 4.2.10 shows the trade-off between biological risk and catches. The results show a common feature of fisheries management, higher catches are correlated with larger risks, and vice-versa. As with anchovy, catches show a larger uncertainty than biological risk, in particular for values of F_{cap} above 0.9, showing also a high probability of driving biological risk above the 5% threshold.

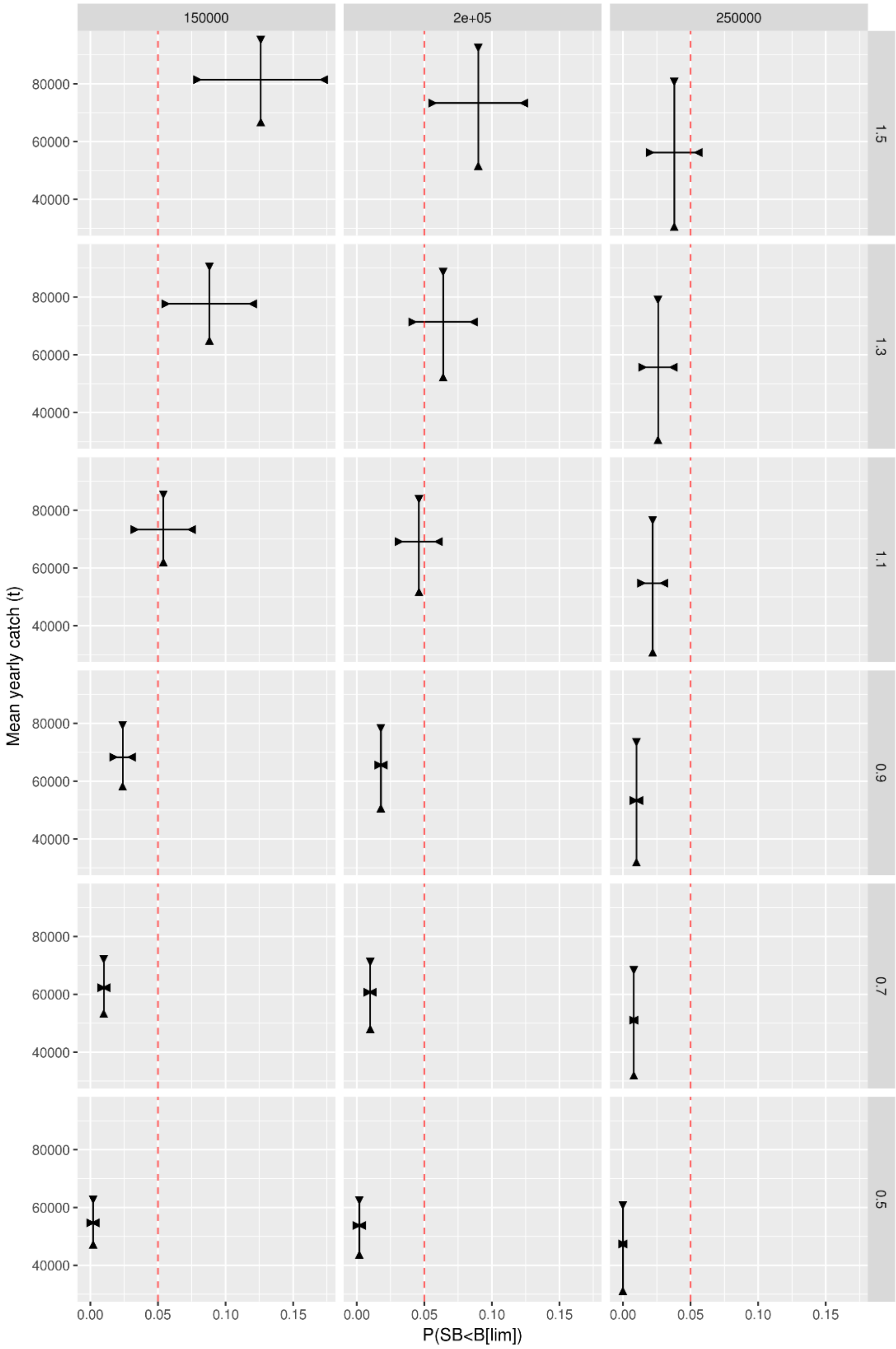


Figure 4.2.10 Mean yearly catch against the probability of stock falling below B_{lim} for the selected combinations of B_{esc}-F_{cap} for sardine. Solid lines represent ranges across OMs A and C. B_{esc} options are presented in columns and F_{cap} in rows.

4.3 Short term effects

The EWG notes that the analysis of short term effects requires a more dedicated EWG, like a stock assessment EWG, where (i) recent information about the stock and the fishery may be available, and consequently (ii) the parametrization of the short term forecasts can be more precise.

Short term effects were simulated by forcing the intermediate period to follow the pre-specified paths described in the ToRs, as such delaying the application of the HCR until 2021. Since the analysis was focused on short term effects, the EWG evaluated 2 periods in this analysis: the 2017-2020 period, when the intermediate period options were applied, and the 2021-2025 period when the effects of those options could be assessed.

The catches used to condition the intermediate period options were derived from the preliminary declarations of Italy and Croatia to FIDES and the input data for stock assessment, both provided by DG MARE. Due to the discrepancy found in the Italian landings between FIDES reports and assessment data (for anchovy in 2016 FIDES=15164 t while stock assessment = 22430 t, for sardine in 2016 FIDES=12002 t while stock assessment = 24092 t) the EWG adjusted the total landings in 2017, which were estimated to be 33300 t for anchovy and 71149 t for sardine.

In the case of anchovy, the 2017 catches, which are maintained in 2018, crashed the stock since SSB is at a very low level and recruitment is also at a historical low (Figure 4.3.1). The full analysis was not possible to be carried out without having more precise information about catches and recent information on recruitment. Additionally, for more precise results the official assessment should be used, or the a4a model fine-tuned to match the final year results.

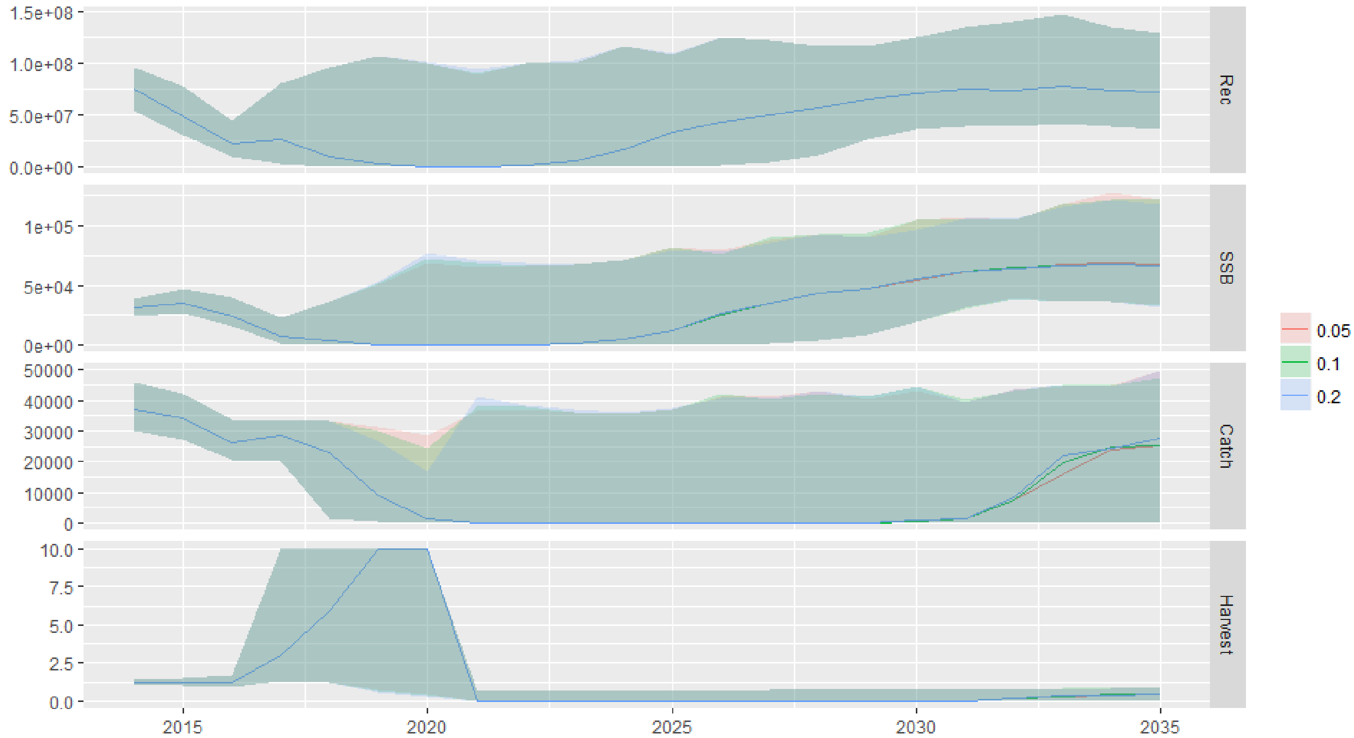


Figure 4.3.1 Example of stock development during the intermediate period and beyond for anchovy (OM A). B_{esc} = 50000 t and F_{cap} = 0.6. Median values (solid lines) and 90% confidence intervals (shaded areas) are presented for Recruitment (Rec), SSB, catch, and fishing mortality (Harvest) and the three catch reduction options defined in the ToR: 5% (0.05) 10% (0.1) and 20% (0.2).

Figure 4.3.2 shows the projection results of sardine's base case (OM A) with a Besc of 150000 t and a Fcap of 0.9, for the period 2016-2025 and for each catch reduction option (5, 10 or 20%). It is evident that a higher reduction in catches during the intermediate period results in higher catches during the first two years of the implementation of the HCR.

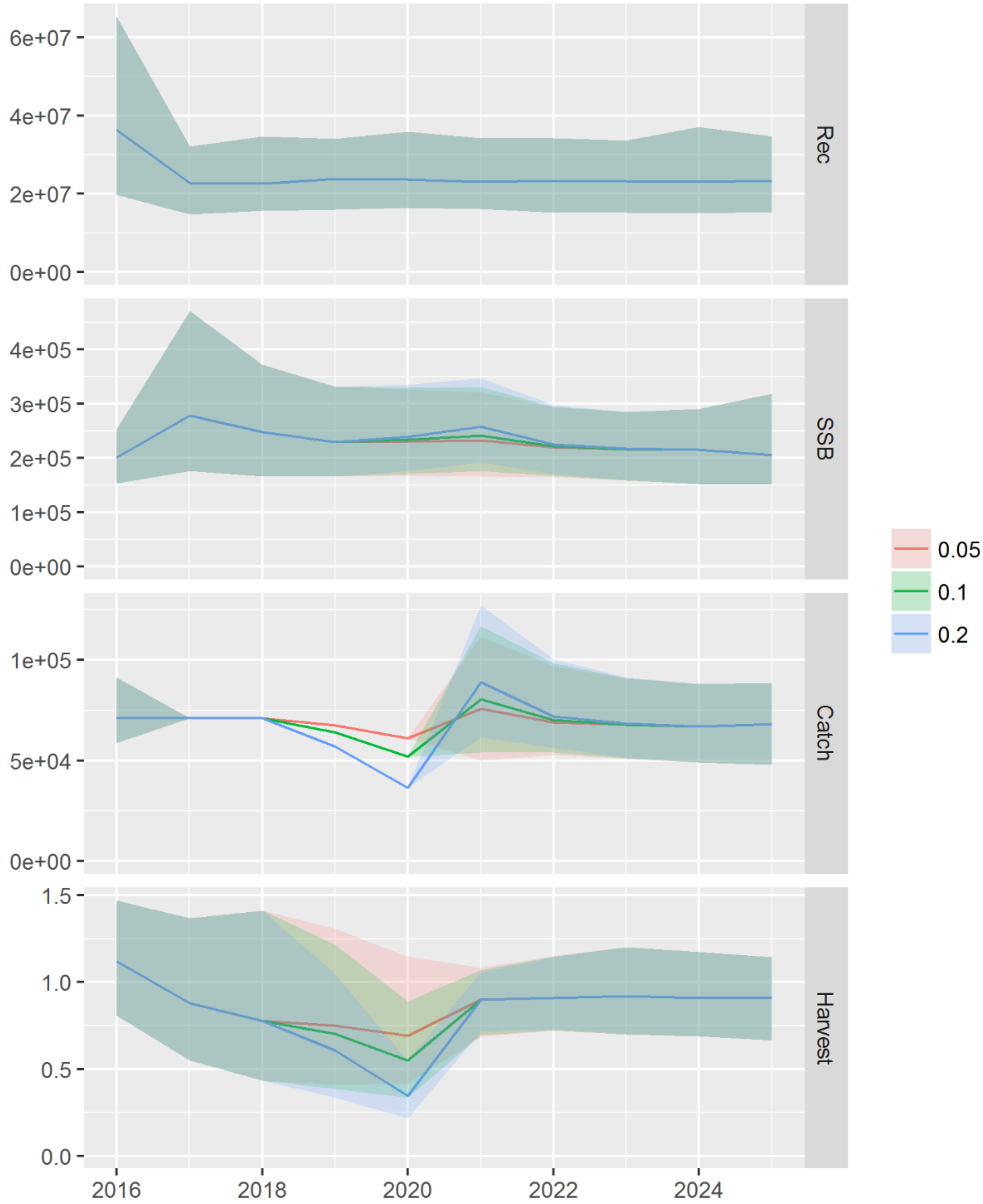


Figure 4.3.2 Stock dynamics during the intermediate period for sardine (OM A). B_{esc} = 150000 t and F_{cap} = 0.9. Median values (solid lines) and 90% confidence intervals (shaded areas) are presented for Recruitment (Rec), SSB, catch, and fishing mortality (Harvest) and the three catch reduction options defined in the ToR: 5% (0.05) 10% (0.1) and 20% (0.2).

Table 4.3.1 summarizes the short term effect results for sardine. As expected, smaller reductions in catch result in higher catches and smaller increases in SSB during the intermediate period. Note that indicator 5 (I5) refers to 2016's survivors, which in Figure 4.3.2 are plotted in 2017, since the biomass refers to the 1st of January.

Table 4.3.1 Short term effects for each OM and intermediate period option for sardine, between 2017 and 2020. I3: median values of inter-annual variability in catches; I4: yearly median catch; I5: changes in SSB compared to 2016's survivors SSB (SSB in the 1st January 2017).

Period	B_{esc}*	F_{cap}*	% catch reduction	OM	Var (C) (I3)	C (I4)	SSB/SSB[2016] (I5)
2017-2020	All values	All values	20	A	-0.13939	58910.54	0.880472
2017-2020	All values	All values	10	A	-0.07189	64549.02	0.876340
2017-2020	All values	All values	5	A	-0.03627	67721.78	0.873855
2017-2020	All values	All values	20	B	-0.13939	58910.54	0.589164
2017-2020	All values	All values	10	B	-0.07198	64549.02	0.585205
2017-2020	All values	All values	5	B	-0.04269	67721.78	0.583321
2017-2020	All values	All values	20	C	-0.13939	58910.54	0.863519
2017-2020	All values	All values	10	C	-0.07189	64549.02	0.858531
2017-2020	All values	All values	5	C	-0.03627	67721.78	0.856396
2017-2020	All values	All values	20	D	-0.13939	58910.54	0.579951
2017-2020	All values	All values	10	D	-0.07189	64549.02	0.576541
2017-2020	All values	All values	5	D	-0.04126	67721.78	0.574440

* 'All values': the same result was obtained for all B_{esc}-F_{cap} pairs.

To further investigate short term effects, the probability of closing the fishery in the period 2021-2025 was also computed. Figure 4.3.3 shows the probability of closing the fishery during 2021-2025 for periods of time of 1 (P(close=1y)) to 5 years (P(close=5y)). For example, for F_{cap} of 0.5 and B_{esc} of 200000 t, OM B shows a very high probability of closing the fishery for periods of 4 or 5 years; consequently, the probability of closing the fishery for just 1 or 2 years is negligible.

In the low recruitment scenarios (OMs B and D), the probability of closing the fishery is high and can be extensive, up to 5 years, i.e. the full period after the intermediate period (Figure 4.3.3). On the other hand, for B_{esc} of 150000 t and a high recruitment scenario (OMs A and C), the probability of closing the fishery is negligible.

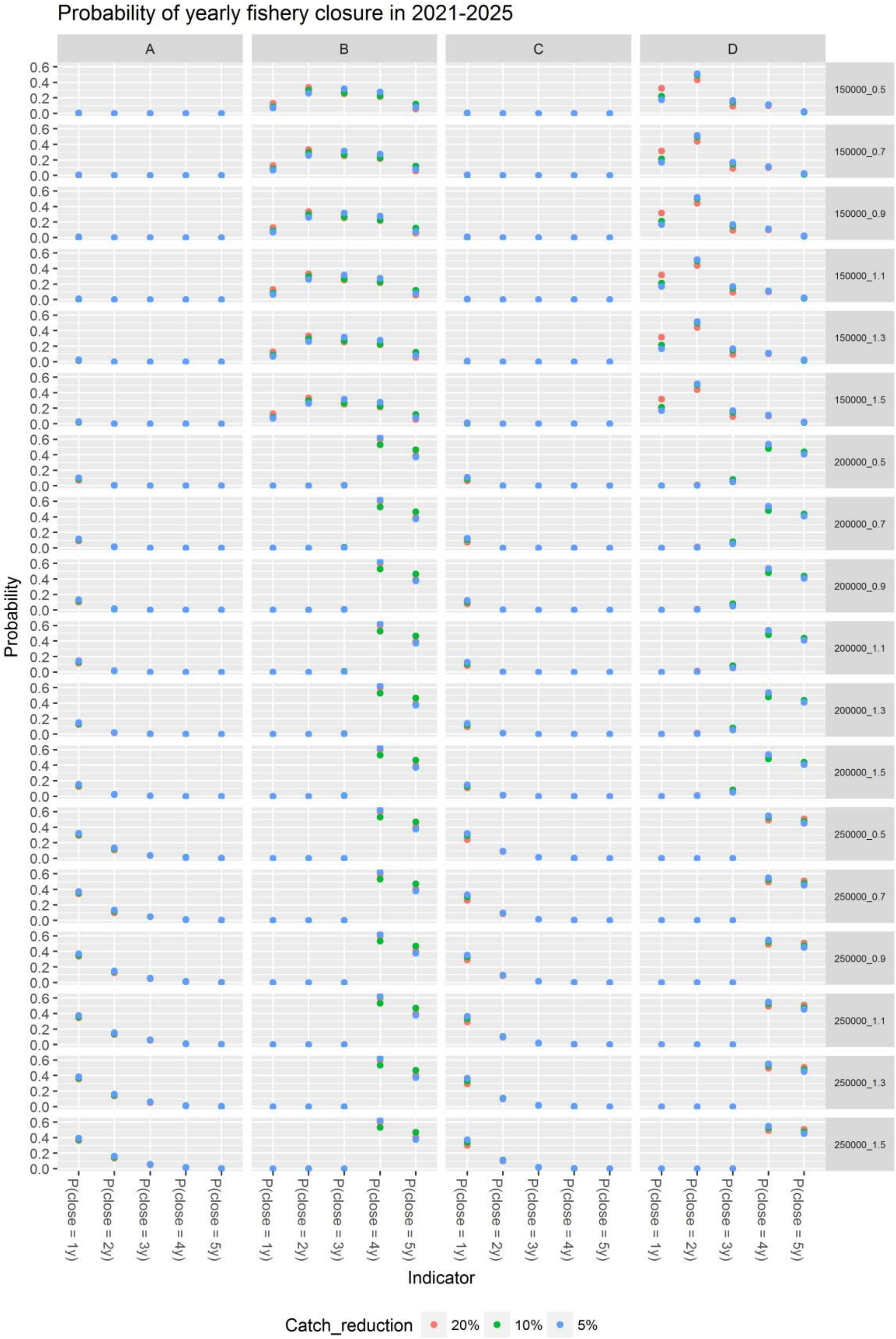


Figure 4.3.3 The probability of a fishery closure for 1-5 years in 2021-2025 for sardine, for each of the four OMs (A-D) and each of the B_{esc}-F_{cap} pairs selected. Different colours indicate the three different catch reduction scenarios.

4.4 Robustness to uncertainty in natural mortality, maturity at age 0 and stock assessment.

Testing the robustness of HCRs to uncertainty in relevant processes is extremely important to clarify potential 'weak points' of the MP. Hence, the EWG decided to test the MPs' robustness to different natural mortality and maturity options. In the current case, it was also important to test the impact of stock assessment uncertainty to the performance of the HCR, since due to time constraints it was not possible to include a full feedback loop in all tests.

In the case of anchovy (

Table 4.4.1), the perception of biological risk is severely affected by the stock assessment model, increasing by ~5 times. The risk of closure is also affected by the options of natural mortality, although only slightly. Sardine (Table 4.4.2) shows a similar pattern, although less pronounced.

Table 4.4.1 Biological risk (probability of SSB fall below B_{lim}) and fishing closure risk (probability of catches being less than 1t) in the long term (2035-2044) for each selected Management Procedure (MP) for anchovy. Robustness tests are stock assessment uncertainty (SA, OM A), natural mortality (M, OM F), maturity in age 0 (Mat, OM E) and a combination of the previous 2 (M&Mat, OM G). The base case is used as reference.

MP		Biological risk					Fishing closure risk				
F_{cap}	B_{esc}	Base case	SA	M	Mat	M&Mat	Base case	SA	M	Mat	M&Mat
0.50	40000	0.03	0.18	0.01	0.00	0.00	0.07	0.17	0.09	0.00	0.03

MP		Biological risk					Fishing closure risk				
F_{cap}	B_{esc}	Base case	SA	M	Mat	M&Mat	Base case	SA	M	Mat	M&Mat
0.50	42500	0.03	0.18	0.01			0.09	0.16	0.10		
0.50	45000	0.02	0.19	0.00	0.00	0.00	0.11	0.20	0.14	0.00	0.05
0.55	42500	0.04	0.20	0.01			0.11	0.21	0.13		
0.55	45000	0.03	0.22	0.00			0.12	0.22	0.14		
0.55	47500	0.03	0.21	0.00			0.14	0.22	0.17		
0.60	45000	0.04	0.23	0.01	0.00	0.00	0.12	0.24	0.16	0.00	0.07
0.60	47500	0.03	0.24	0.01			0.16	0.27	0.19		
0.60	50000	0.02	0.25	0.01	0.00	0.00	0.20	0.27	0.21	0.01	0.10
0.65	47500	0.04	0.26	0.02			0.16	0.29	0.20		
0.65	50000	0.03	0.24	0.02			0.21	0.29	0.23		
0.65	52500	0.03	0.24	0.01			0.23	0.32	0.25		
0.70	50000	0.04	0.25	0.02	0.00	0.01	0.22	0.31	0.23	0.01	0.12
0.70	52500	0.04	0.27	0.01			0.24	0.34	0.27		
0.70	55000	0.04	0.25	0.01	0.00	0.01	0.28	0.35	0.30	0.01	0.15
0.75	52500	0.04	0.26	0.01			0.27	0.35	0.27		
0.75	55000	0.04	0.23	0.01			0.30	0.35	0.32		
0.75	57500	0.04	0.24	0.01			0.32	0.38	0.32		
0.80	55000	0.06	0.28	0.02	0.00	0.01	0.31	0.38	0.30	0.01	0.17
0.80	57500	0.04	0.26	0.01			0.32	0.41	0.35		
0.80	60000	0.04	0.25	0.01	0.00	0.01	0.36	0.42	0.37	0.02	0.22
0.85	57500	0.04	0.28	0.01			0.32	0.40	0.36		
0.85	60000	0.04	0.27	0.01			0.38	0.40	0.38		
0.90	57500	0.05	0.33	0.01			0.34	0.44	0.36		
0.90	60000	0.05	0.28	0.01	0.01	0.02	0.40	0.42	0.38	0.02	0.24
0.95	57500	0.06	0.30	0.02			0.36	0.43	0.38		
0.95	60000	0.06	0.26	0.01			0.40	0.43	0.39		
1.00	60000	0.06	0.27	0.01	0.01	0.02	0.40	0.45	0.39	0.02	0.25

Table 4.4.2 Biological risk (probability of SSB fall below B_{lim}) and fishing closure risk (probability of catches being less than 1t) in the long term (2035-2044) for each selected Management

Procedure (MP) for sardine. Robustness tests are stock assessment uncertainty (SA, OM A), natural mortality (M, OM F), maturity in age 0 (Mat, OM E) and a combination of the previous 2 (M&Mat, OM G). The base case is used as reference.

MP		Biological risk				Fishing closure risk			
Fcap	Besc	Base case	SA	M	Mat	Base case	SA	M	Mat
0.50	150000	0.00	0.06	0.01	0.00	0.00	0.06	0.01	0.00
0.50	250000	0.00	0.07	0.00	0.00	0.16	0.32	0.26	0.03
0.50	200000	0.00	0.06	0.01	0.00	0.03	0.20	0.09	0.01
0.70	150000	0.01	0.06	0.02	0.00	0.01	0.12	0.02	0.00
0.70	250000	0.01	0.06	0.00	0.00	0.18	0.45	0.27	0.04
0.70	200000	0.01	0.08	0.01	0.00	0.05	0.30	0.10	0.01
0.90	150000	0.02	0.09	0.06	0.00	0.01	0.17	0.03	0.00
0.90	250000	0.01	0.08	0.01	0.00	0.20	0.49	0.26	0.05
0.90	200000	0.02	0.07	0.02	0.00	0.06	0.39	0.11	0.01
1.10	150000	0.03	0.11	0.10	0.00	0.01	0.23	0.04	0.00
1.10	250000	0.01	0.06	0.01	0.00	0.20	0.53	0.26	0.05
1.10	200000	0.03	0.07	0.04	0.00	0.06	0.41	0.11	0.01
1.30	150000	0.05	0.09	0.14	0.00	0.01	0.30	0.07	0.00
1.30	250000	0.01	0.06	0.01	0.00	0.21	0.53	0.27	0.06
1.30	200000	0.04	0.08	0.05	0.00	0.08	0.48	0.12	0.01
1.50	150000	0.07	0.09	0.18	0.00	0.02	0.30	0.10	0.00
1.50	250000	0.02	0.05	0.01	0.00	0.21	0.58	0.27	0.06
1.50	200000	0.05	0.07	0.06	0.00	0.09	0.50	0.12	0.01

5 ToR 2: Economic performance

As reported by STECF 17-05 on bio-economic methodology (STECF 2017d), the available approaches to assess economic and social impacts on fleets of TAC and quota allocations are: short-term projections models, integrated bio-economic models and economic general dynamic equilibrium models.

Given the limited time available, an approach based on short-term projections models was explored. This approach was used for the AER short-term projections (STECF 2017b) through the Bio-Economic Model of European Fleets (BEMEF), which is an extension of the Economic Interpretation of the ICES Advisory Committee for fisheries management (EIAA) model. The model simulates the future changes in the economic variables by fleet segment using the changes in TAC as the main driver. These variations in TACs impact prices and revenues, which are modelled by a price flexibility function per species, and, for fishing effort, by the inverse of a Cobb-Douglas production function. This function includes also the effects of changes in the size of biomass, expressed in terms of SSB. Changes in fishing effort are then converted into changes in variable costs.

As the different scenarios on the HCR for small pelagic in the Adriatic are defined in terms of changes in total catches through the setting of TAC for both sardine and anchovy, only the economic variables directly affected by variations in landings and fishing effort are supposed to change over time. Under a short-term approach, the size of the fleets is assumed to be constant over the simulation period and variables associated with the fleet size, like fixed costs, repair and maintenance costs and capital costs, are assumed to be constant over time. Therefore, the economic short-term effects of changes in TACs are measured only in terms of changes in revenues and variable costs.

5.1 Availability of economic data

The fleets involved in the Adriatic pelagic fisheries include three EU Member States, Croatia, Italy and Slovenia, plus Albania and Montenegro. However, most of the landings of anchovy and sardine come from Italian and Croatian fleets. As such, the economic analysis was based on these two Member States' fleets.

Economic data for the Italian and Croatian fleets are available from the 2017 Annual Economic Report on the EU Fishing Fleet (STECF 2017b). For the Italian fleets, data from 2008 to 2015 is available, although for the whole area covered by Italian fleets operations. To overcome this limitation and focus on the Adriatic, additional data was requested by the Italian Ministry and received during the EWG. The time series provided covered the period 2008-2016 (9 years). The data available for Croatian fleets covered the period 2012-2015 (4 years). Economic data include all variables collected under the DCF.

5.2 Drivers for simulations

The simulated HCRs produce three potential inputs for the evaluation of the economic performance of the fleets involved in these fisheries, under the different scenarios:

- total catches or quotas (TAC),
- fishing mortality for anchovy and sardine,
- SSB for anchovy and sardine.

All inputs were available for each year of the simulated period.

5.3 Methodology and results

Revenues were estimated for anchovy and sardine by splitting the total catches defined by TACs under the different scenarios among fleet segments and applying a price flexibility function (eq.1). The allocation of quotas to the different fleet segments was based on the relative shares registered in 2015. Quotas for both species are assumed to be fully achieved by each fleet segment (see section 5.4 on mixed fisheries). Total revenues by fleet segment are given by eq.2 assuming a constant percentage of revenues from species other than anchovy and sardine.

$$p_{s,f,t} = p_{s,f,t-1}\left(\frac{L_{s,.,t}}{L_{s,.,t-1}}\right)^{\varepsilon_s} \qquad \text{(eq.1)}$$

$$R_{f,t} = rr_f \sum R_{s,f,t} \qquad \text{(eq.2)}$$

The variable costs, which include the DCF variables energy costs and other variable costs, in the BEMEF model are estimated indirectly through the level fishing activity needed to catch the quota. This level of effort is estimated by the following function:

$$Activity\_coefficient\ t_{t+1} = \sum\left(Landings_t\ x\ Price_t\ x\ \theta\right)\left(\frac{TAC_{t+1}}{TAC_t}\right)^{X}\left(\frac{SSB_{t+1}}{SSB_t}\right)^{Y}, \qquad \text{(eq.3)}$$

where, as reported in STECF (2017b):

- θ represents a fleet segment effort driver for the TACs that influence fishing activity,
- χ represents an activity-landing flexibility rate (1/catch-effort coefficient),
- γ represents an activity-stock flexibility rate (stock-catch coefficient/catch-effort coefficient).

As the level of fishing effort or activity which allows to achieve the quota is expected to be positively correlated to the TAC and negatively correlated to the SSB, coefficients χ and γ are expected to be positive and negative, respectively.

Given the limitations associated to the use of the short-term projections approach reported by STECF-17-05, the EWG decided to adopt this or other similar functions for the economic evaluation of the HCR only if they show a good fitting on real data.

To this end, the Adriatic pelagic fleet was divided into three fleet segments based on the country and the main fishing gear used:

1. the Italian purse seiners operating in GSAs 17 and 18,
2. the Italian pelagic trawlers operating in GSAs 17 and 18,
3. the Croatian purse seiners operating in GSA 17.

Using the data available on days at sea for the first two fleet segments, covering the period 2008-2016, a regression on SSB and total catches was carried out with the results reported below (Figure 5.3.1, Figure 5.3.2, Figure 5.3.3 and Figure 5.3.4). Assuming a multiplicative function, regressions for the Italian fleet segments (Croatian data are not sufficient for a regression as it covers only 4 years) were performed considering both the relative variations from year t to year t+1, as in the eq.3, and the original (non-modified) values at time t of the variables.

. regress Ldd_ps Lane_ps Lssb_ane

Source	SS	df	MS			
				Number of obs	=	9
				F(2, 6)	=	5.23
Model	.259550226	2	.129775113	Prob > F	=	0.0484
Residual	.148846089	6	.024807682	R-squared	=	0.6355
				Adj R-squared	=	0.5140
Total	.408396316	8	.051049539	Root MSE	=	.1575

Ldd_ps	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
Lane_ps	.4535853	.1459938	3.11	0.021	.0963515	.8108192
Lssb_ane	-.2627191	.1824799	-1.44	0.200	-.7092314	.1837932
_cons	4.04702	2.701033	1.50	0.185	-2.56217	10.65621

Figure 5.3.1 ITA-PS: regression on original data

```
. regress Ldd_tm Lane_tm Lssb_ane

      Source |       SS           df       MS      Number of obs   =         9
-------------+----------------------------------   F(2, 6)         =      0.93
       Model |  .023710877         2  .011855438   Prob > F        =    0.4459
    Residual |  .076755319         6  .012792553   R-squared       =    0.2360
-------------+----------------------------------   Adj R-squared   =   -0.0187
       Total |  .100466196         8  .012558275   Root MSE        =     .1131

------------------------------------------------------------------------------
      Ldd_tm |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
     Lane_tm |   .2186214   .1605848     1.36   0.222    -.1743154    .6115582
    Lssb_ane |  -.0481891   .1339021    -0.36   0.731    -.3758356    .2794575
       _cons |   6.646312   2.715199     2.45   0.050     .0024607    13.29016
------------------------------------------------------------------------------
```

Figure 5.3.2 ITA-TM: regression on original data

```
. regress Ldd_ps2 Lane_ps2 Lssb_ane2

      Source |       SS           df       MS      Number of obs   =         8
-------------+----------------------------------   F(2, 5)         =      4.08
       Model |  .240671825         2  .120335913   Prob > F        =    0.0890
    Residual |  .147540802         5   .02950816   R-squared       =    0.6199
-------------+----------------------------------   Adj R-squared   =    0.4679
       Total |  .388212627         7  .055458947   Root MSE        =    .17178

------------------------------------------------------------------------------
     Ldd_ps2 |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
    Lane_ps2 |   .4377252     .17618     2.48   0.056    -.0151598    .8906103
   Lssb_ane2 |  -.2846823   .2247523    -1.27   0.261    -.8624265    .2930619
       _cons |  -.0485861   .1544672    -0.31   0.766    -.4456567    .3484844
------------------------------------------------------------------------------
```

Figure 5.3.3 ITA-PS: regression on relative variations

```
. regress Ldd_tm2 Lane_tm2 Lssb_ane2

      Source |       SS           df       MS      Number of obs   =         8
-------------+----------------------------------   F(2, 5)         =      1.50
       Model |  .033343016         2  .016671508   Prob > F        =    0.3095
    Residual |  .055701279         5  .011140256   R-squared       =    0.3745
-------------+----------------------------------   Adj R-squared   =    0.1242
       Total |  .089044295         7  .012720614   Root MSE        =    .10555

------------------------------------------------------------------------------
     Ldd_tm2 |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
    Lane_tm2 |   .2467269   .1512438     1.63   0.164    -.1420578    .6355115
   Lssb_ane2 |    .038903   .1400979     0.28   0.792    -.3212301     .399036
       _cons |   .1779905   .0749861     2.37   0.064    -.0147674    .3707485
------------------------------------------------------------------------------
```

Figure 5.3.4 ITA-TM: regression on relative variations

The results reported in Figure 5.3.1, Figure 5.3.2, Figure 5.3.3 and Figure 5.3.4 show that coefficients have the correct signs when estimated on original data, but only the coefficient of total catches of anchovy for the Italian purse seiners is significantly different from zero (Figure 5.3.1).

Given these results and the lack of sufficient data for the Croatian fleet, the EWG decided to explore other approaches. An alternative to the BEMEF function, which holds the relation between variable costs from one side and TAC and the SSB on the other side, consisted in exploring the existence of a correlation between fuel consumption per kilo of landings and the ratio between total catches and fishing mortality.

The approach is based on the disaggregation of variable costs into energy costs and other variable costs, and the energy costs into fuel consumption and fuel price. As energy costs are affected by changes in fuel price, the fuel consumption was considered more suitable for identifying a possible relation with the outputs of the biological model. The fuel consumption per kilo of landings is expected to depend on the size of the stock. An increase in the biomass is expected to reduce the time spent at sea to catch the same amount of fish, and so the fuel consumed during that time. This relation is expected to be more relevant for demersal species than pelagic ones.

The ratio between the total catch (or the TAC) and the associated F for the target species (anchovy for the Italian fleets and sardine for Croatian ones) for each fleet segment was selected as the indicator of biomass size. This indicator can be interpreted as a CPUE proxy, where fishing mortality is a measure of the total fishing effort of the whole fleet. The use of F instead of other measures of fishing effort has the advantage that it does not need any weighting procedure to sum the effort units of fleet segments with different productivities.

The relation between fuel consumption per kilo of landing and the ratio between catch and F was tested for the three fleet segments. Results are showed in Figure 5.3.5, Figure 5.3.6 and Figure 5.3.7.

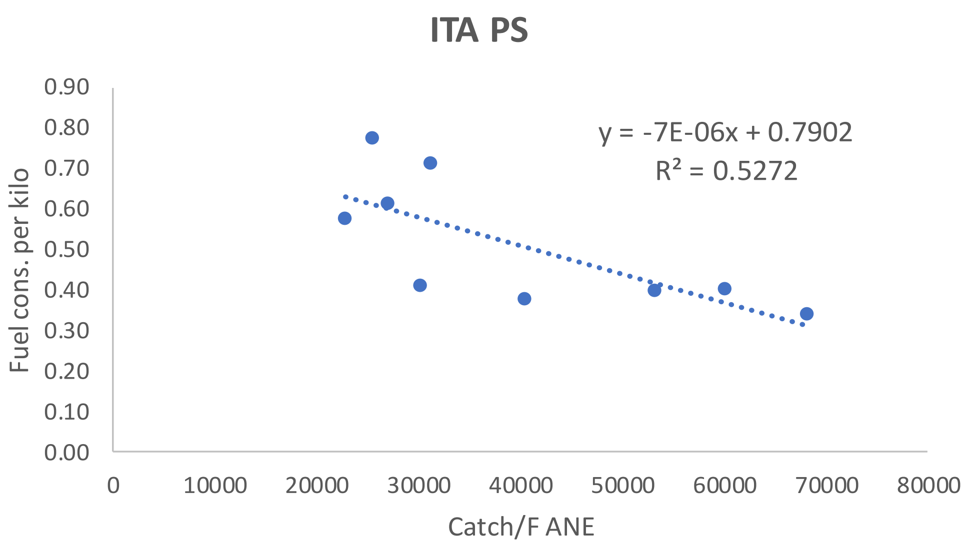


Figure 5.3.5 Fuel consumption per kilo for the Italian purse seiners vs. Catch/F for anchovy

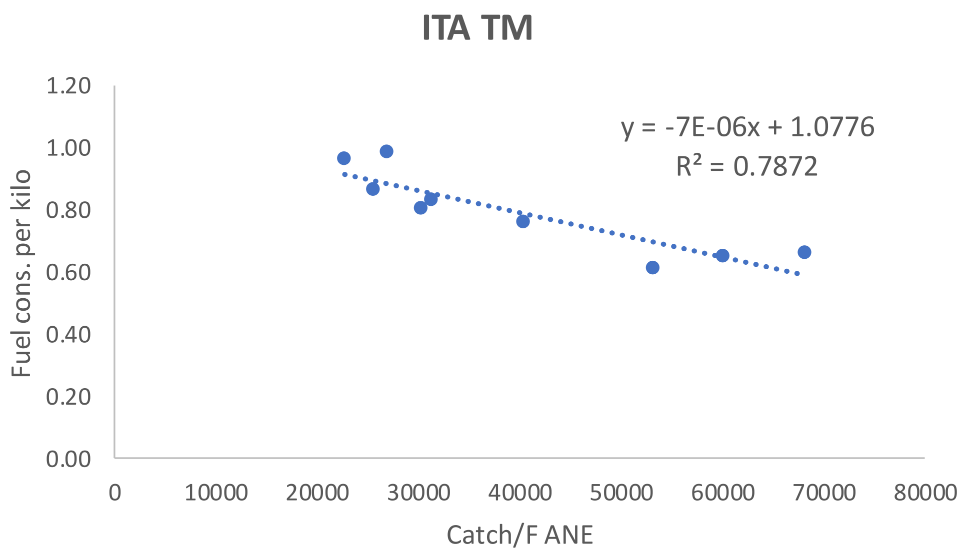


Figure 5.3.6 Fuel consumption per kilo for the Italian pelagic trawlers vs. Catch/F for anchovy

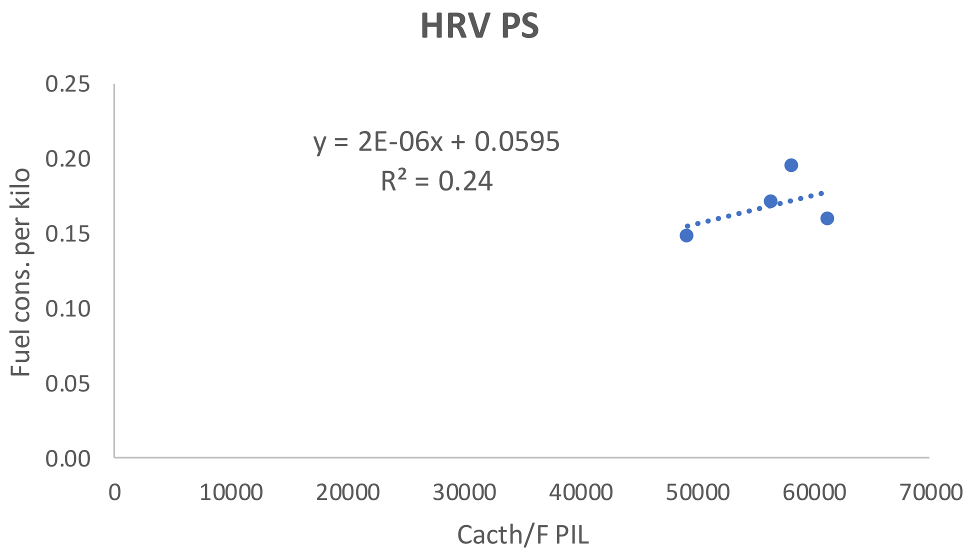


Figure 5.3.7 Fuel consumption per kilo for the Croatian purse seiners vs. Catch/F for sardine

The relations estimated on the Italian data show the expected sign for the parameters and a good fitting, with R^2 higher than 0.5 for purse seiners (Figure 5.3.5) and almost 0.8 for the pelagic trawlers (Figure 5.3.7). Unfortunately, the same equation for the Croatian purse seiners shows a positive parameter (not acceptable), with a very low R^2. The EWG considered the main problem with the Croatian data to be the low number of data points, which didn't allow the parameters' estimation.

The last approach explored during the meeting was a direct linear relationship between variable costs and the value of F for the main target species of the fleet segment. A proportionality between days at sea and fishing mortality and a proportionality between variable costs and days at sea are assumed under this approach. Even though this approach has the advantage of simplicity, its application has shown a problem of excessive variability in the days at sea. Indeed, as F for anchovy in 2017 is expected to increase by 212%, also the average days at sea for the Italian fleets should follow the same dynamic. The average days at sea would increase from 117 days in 2016 to 248 in 2017 for purse seiners and from 132 to 279 in the same period for pelagic trawlers. As these variations are clearly unrealistic, the EWG decided to reject this approach.

The EWG concluded that due to data limitations and time constraints it was not possible to carry out an economic analysis of management options.

5.4 Mixed fisheries

The EWG discussed the potential existence of choke species effects in the context of the economic performance of the fleet, since such effects tend to prevent the fleets from fulfilling their fishing opportunities, or create an incentive to discarding, resulting in both cases to loss of economic value.

To evaluate the extent to which the fleets involved in the fishery could be impacted by limitations in one of the species included in the MAP, the EWG requested both MS (Italy and Croatia) to provide data on catch structure by species disaggregated to haul level. National programs of on-board sampling have this type of information, as well as logbooks, although the latter are not so precise and reliable. Both Member States provided the information timely, which allowed the analysis to be carried out.

The results showed that a high percentage of clean catches were observed for both Member States, suggesting that choke species effects should not be limiting severely the majority of the fleet. Nevertheless, part of the fishery may be affected by choke species limitations, which may require further consideration.

5.4.1 Italian fleets

Data collected by observers on-board the relevant fleets was made available by the Italian authorities for the period 2014-2016. Catch ratios between anchovy and sardine were computed for each haul, area and metier.

The main gears targeting small pelagic are: (i) purse seine (PS, 'lampara'), that are spread out mostly south of the Ancona harbour and in a small area of the northernmost part of the Adriatic Sea around the Trieste harbour; and (ii) pelagic pair trawl (PTM, 'volante'), that are diffused in the rest of the Adriatic.

Figure 5.4.1 shows the ratios between anchovy and sardine computed by haul, area and gear considering three different years separately (2014, 2015 and 2016). Data from mid and south Adriatic purse seine (PS) are grouped together, since this fishery has a clear behaviour. The histogram shows that the purse seine fishery targets anchovy, while sardine is caught in very few cases. Pelagic pair trawlers (PTM) can catch both anchovy and sardine, even if anchovy is caught in higher percentage and with higher occurrence.

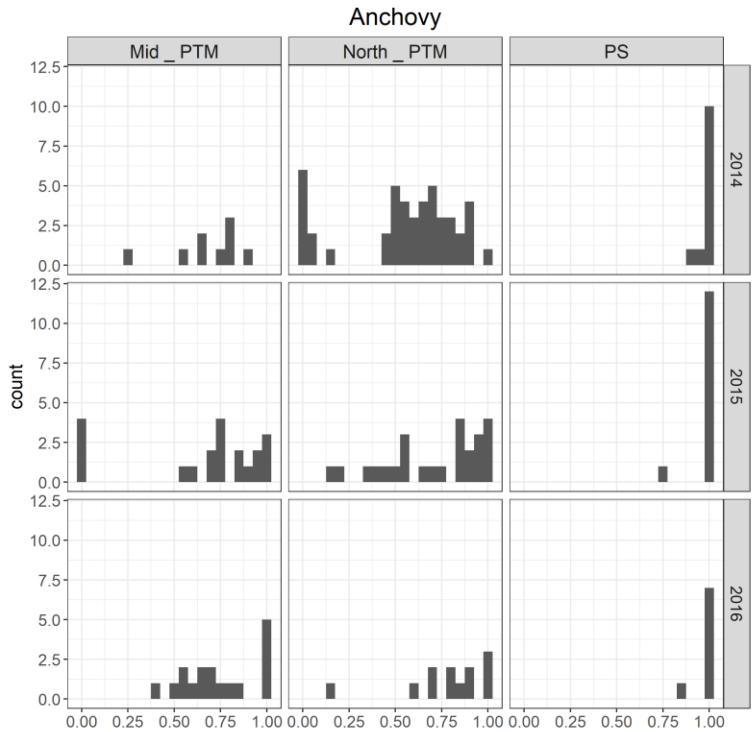
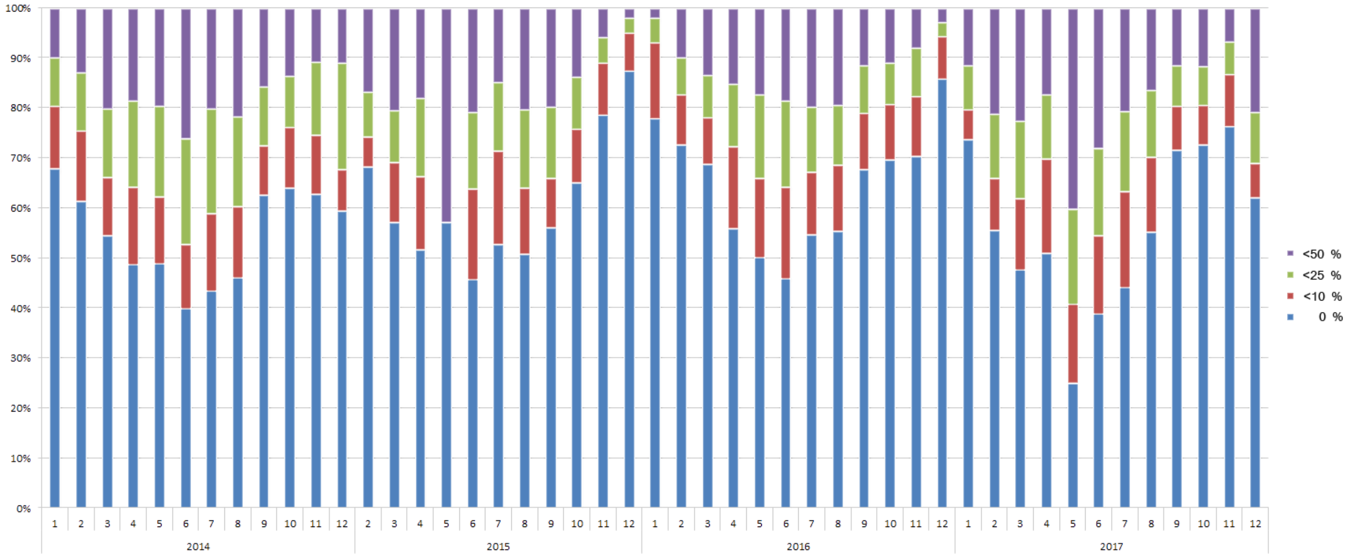


Figure 5.4.1 Anchovy over sardine catch ratio by haul, area and gear (Mid_PTM, North_PTM, PS) for the years 2014, 2015 and 2016 obtained by the Italian DCF on-board data.

Considering these results, it emerges that the small pelagic fishery can be a mixed fishery; however, fishermen operating the pelagic pair trawlers should be able to target one species rather than the other. Obviously this possibility depends on the technology on-board and the ability and experience of the fisher. On the other hand, the purse seine fishery is more selective and targets mostly anchovy.

5.4.2 Croatian fleets



Directorate of Fisheries, 2017 / preliminary data

Figure 5.4.2 Frequency of occurrence of mixed fishery (sardine and anchovy) for the Croatian PS fleet per catch by month in 2014-2017. Bars indicate the proportion of fishing days (catches) with different fractions of mixed catches between anchovy and sardine.

The Croatian Directorate of fisheries provided Figure 5.4.2 based on overall data from the logbooks coming from vessels using the purse seine "srdelara" in the period 2014 to 2017. The data was analysed on the level of individual catch and presented by month. Since this analysis was made on short notice, this data needs to be considered preliminary and a further exploration can be done in order to improve the quality of the results.

Figure 5.4.2 clearly shows seasonal fluctuations over the years, where during the winter period the majority of catches are single species (over 85% in 12/2015 and 12/2016), while the percentage of single species catches is lower in the spring period (40% in 6/2014, 45% in 6/2015 and 6/2016, and only 25% in 5/2017). This result indicates that this is a mixed fishery where occurrence of mixing of sardine and anchovy varies depending on season and most probably area. On the other hand, this trend reflects also fishers' preferences and market demands.

6 Final comments

6.1 ToR 1.2

- The current acoustic survey settings, constituting of direct observations of stock's biomass and abundance of recruits, can be used to set fishing opportunities based on a biomass escapement strategy.
- Setting the data delivery of current echo-surveys in November/December would allow a more precise application of the escapement strategy, by removing the need to project the intermediate year.
- Having two separate surveys in appropriate periods would be preferable in order to describe the dynamics of each stock; primarily to estimate recruitment for each stock, in the beginning of the year for anchovy and second half of the year for sardine, and secondarily to provide indications of spawning stock biomass, in the summer for anchovy and winter for sardine.
- The timing for data provision should be reduced as much as possible in order to enable the assessment of the stocks in the same year of the survey.
- If it cannot be possible to deliver the full set of echo-surveys data in the assessment year, it might be possible to derive recruitment indices from preliminary survey information, and thus improve recruitment strength estimates. Alternatively, or complementarily, the use of environmental data collected during the acoustic surveys could also be used to estimate recruitment trends. Both cases have the potential to improve recruitment forecasts and consequently estimate fishing opportunities more precisely.
- Changes in data provision will require MEDIAS protocols to be revised, as well as the DCF programmes of Italy, Croatia and Slovenia.

6.2 ToR 1.3

- Both stock dynamics estimated from the assessment and stock-recruitment models are optimistic; in particular, they do not capture the linear relationship between SSB and R which is observed in the data.
- A set of parameters were selected and tested as candidates to parameterize the HCR and the required set of indicators were computed for each one of them.
    - The long term effects showed the common trade off (negative relationship) between stock size and catch levels. In both cases, large B_{esc} tend to close the fishery or provide very small catches, while small B_{esc} need to be complemented with small F_{caps} to avoid large fishing mortalities, which tend to introduce a large variability in catches and exploitation levels.
    - The short term effects for each set of parameters and catch reduction options were computed. The EWG notes that analysis of short term effects requires a more dedicated EWG, like the stock assessment EWG, where (i) recent information about the stock and the fishery may be available, and consequently (ii) the parameterisation of short term forecasts can be more precise. In the case of

anchovy, catches assumed during the intermediate period crashed the stock and the analysis was not carried forward. For sardine, smaller reductions in catches generate larger catches and smaller increases in SSB during the intermediate period. Furthermore, in the low recruitment scenarios there is a non-negligible probability of closing the fishery in the period after the catch constraints.

- Robustness tests showed the results to be robust to changes in maturity and natural mortality but not to stock assessment uncertainty, which showed to deteriorate biological risk about 5 times more than the results estimated without a feedback option, to levels well above the 5% threshold.

6.3 ToR 2

- These fisheries have a component of mixed fisheries; nevertheless, our results showed that a high percentage of clean catches were observed in both Member States, suggesting that choke species effects should not be limiting considerably the majority of the fleet.
- Economic analysis of the different scenarios and HCRs was attempted but the short time series of data available for economic variables did not allow a full analysis of management options.

7 ACKNOWLEDGEMENTS

The EWG acknowledges the timely contribution of the Member States Italy and Croatia for providing data requested during the EWG meeting. Italy provided estimates of catch fractions of sardine and anchovy from on-board sampling programmes, and economic data for the fleets of the Adriatic Sea. Croatia provided estimates of catch fractions of sardine and anchovy from logbooks. The datasets were send on time and with the necessary format to allow the discussion of ToR 2.

8 REFERENCES

FAO AdriaMed 2017. Report of the Eighteenth Meeting of the AdriaMed Coordination Committee, GCP/REP/010/ITA/TD42. AdriaMed Technical Documents, 42: 49pp.

GFCM 2017. Working Group on Stock Assessment of Small Pelagic species (WGSASP). FAO HQ, Rome, Italy, 13-18 November 20, final report

ICES 2017. ICES fisheries management reference points for category 1 and 2 stocks. ICES Advice Technical Guidelines 12.4.3.1. DOI: 10.17895/ices.pub.3036

ICES 2017. Report of the Workshop on Age estimation of European anchovy (*Engraulis encrasicolus*). WKARA2 2016 Report 28 November - 2 December 2016, Pasaia, Spain. ICES CM 2016/SSGIEOM, 17: 223 pp.

MEDIAS Handbook 2017. (http://www.medias-project.eu/medias/website/handbooks-menu/handbooks/MEDIAS-Handbook-April-2017.pdf/)

Regulation (EU) 2017/1004 of the European parliament and of the Council of 17 May 2017 on the establishment of a Union framework for the collection, management and use of data in the fisheries sector and support for scientific advice regarding the common fisheries policy and repealing Council Regulation (EC) No 199/2008. Official Journal of the European Union L 157/1

Scientific, Technical and Economic Committee for Fisheries (STECF) 2015. Monitoring the performance of the Common Fisheries Policy (STECF-15-04). Publications Office of the European Union, Luxembourg, EUR 27152 EN, JRC 95185, 36 pp.

Scientific, Technical and Economic Committee for Fisheries (STECF) 2016. Multiannual plan for demersal fisheries in the Western Mediterranean (STECF-16-21); Publications Office of the European Union, Luxembourg; EUR 27758 EN; doi:10.2788/103428

Scientific, Technical and Economic Committee for Fisheries (STECF) 2017a. 56th Plenary Meeting Report (PLEN-17-03); Publications Office of the European Union, Luxembourg; ISBN 978- 92-79-77297-9, doi:10.2760/605712, JRC109344

Scientific, Technical and Economic Committee for Fisheries (STECF) 2017b. The 2017 Annual Economic Report on the EU Fishing Fleet (STECF-17-12). Publications Office of the European Union, Luxembourg, 2017, ISBN 978-92-79-73426-7, doi:10.2760/36154, PUBSY No. JRC107883

Scientific, Technical and Economic Committee for Fisheries (STECF) 2017c. Mediterranean Stock Assessments 2017 part I (STECF-17-15). Publications Office of the European Union, Luxembourg, 2017, ISBN 978-92-79-67487-7, doi:10.2760/897559, JRC109350

Scientific, Technical and Economic Committee for Fisheries (STECF) 2017d. Bio-Economic Methodology (EWG-17- 05); Publications Office of the European Union, Luxembourg; EUR 28359 EN; doi:10.2760/759034

Scientific, Technical and Economic Committee for Fisheries (STECF) 2018. Evaluation of alternative scenarios for Adriatic small pelagic MAP (STECF-18-02). Publications Office of the European Union, Luxembourg

Tičina V., Ivančić I. and Emrić V. 2000. Relation between the hidrographic properties of the northern Adriatic Sea water and sardine (*Sardina pilchardus*) population schools. *Period Biol.* 102, Supplement 1: 181-192

Tommasi D., Stock C.A., Pegion K., Vecchi G.A., Methot R.D., Alexander M.A. and Checkley Jr. D.M. 2017. Improved management of small pelagic fisheries through seasonal climate prediction. *Ecological Applications* 27(2): 378–388

9 CONTACT DETAILS OF EWG-18-01 PARTICIPANTS

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10 List of Annexes

Electronic annexes are published on the meeting's web site on: https://stecf.jrc.ec.europa.eu/ewg1801

List of electronic annexes documents:

EWG-18-01 – Annex 1 – Millar C.P. 2018. Operating models for Sardine in the Adriatic Sea: developing recruitment. Request for services - 1743 - STECF Ad hoc contract on 'Adriatic Small Pelagic stocks' models with a cyclical nature
EWG-18-01 – Annex 2 – Mosqueira I., 2018. Beverton-Holt stock-recruitment with cyclic residuals, Sardine GSA 17-18.
EWG-18-01 – Annex 3 – Ticina V. 2018. MEDIAS presentation.
EWG-18-01 – Annex 4 – Jardim E., Scott F., Mosqueira I. 2017. Assessment for All initiative(a4a): The a4a Management Strategies Evaluation algorithm

11 LIST OF BACKGROUND DOCUMENTS

Background documents are published on the meeting's web site on:
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List of background documents:

EWG-18-01 – Doc 1 - Declarations of invited and JRC experts (see also section 9 of this report – List of participants)

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