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Scientific, Technical and Economic Committee for Fisheries (STECF) - Methods for developing the fishing effort regime for demersal fisheries in western Mediterranean Sea – Part III (STECF-19-01)

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EWG-19-01 report:

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TABLE OF CONTENTS

Abstract

Commission Decision of 25 February 2016 setting up a Scientific, Technical and Economic Committee for Fisheries, C(2016) 1084, OJ C 74, 26.2.2016, p. 4–10. The Commission may consult the group on any matter relating to marine and fisheries biology, fishing gear technology, fisheries economics, fisheries governance, ecosystem effects of fisheries, aquaculture or similar disciplines.

This report is the third expert working group (EWG) report dealing with methods for developing the fishing effort regime for demersal fisheries in western Mediterranean Sea, after EWG 18-09 and 18-13. The group was requested to select the most appropriate model(s) to carry out a mixed-fisheries advice for the western Mediterranean demersal fisheries, and to analyse the ability of the model(s) to be compatible with the latest single-stock scientific advice provided for western Mediterranean demersal stocks Finally, the group was requested to discuss and suggest possible mixed-fisheries scenarios and type of results for future developments.

The EWG reviewed 8 different models, of different complexity levels and covering different GSAs and EMUs. For EMU2 (East side of Western Med, which mainly includes fisheries from one single Member State), 3 models were presented, which are fully parameterised and operational. The situation is more challenging in EMU1 (West side of Western Med, which covers fisheries from two Member States), where five models were presented but none of them is directly operational at the scale of the EMU. Progresses were reached during the EWG, but further intersessional work, involving scientists from the two Member States, is necessary before reaching the desired level of completion for the evaluation of management scenarios.

During the EWG, all models presented were updated to the most recent information available. Where possible, short-term forecasts were run, assuming a reduction in fishing effort in 2019 equivalent to the reduction necessary to achieve the target F (Fmsy, proxy F01). For all models, the aggregated results of the short term forecast were largely similar between the single-stock and the mixed-fisheries models. Then most models were able to run the basic MAP scenario of a gradual reduction of fishing effort between 2020 and 2024. Several alternative runs and model capabilities were discussed.

Finally, the EWG discussed a number of remaining issues and gaps that are important in relation to the scientific support to the MAP, and agreed on some future work.

SCIENTIFIC, TECHNICAL AND ECONOMIC COMMITTEE FOR FISHERIES (STECF) - Methods for developing fishing effort regime for demersal fisheries in Western Mediterranean – Part III (STECF-19-01)

Background provided by the Commission

TERMS OF REFERENCE

As a follow-up of the STECF Expert Working Group 18-13 (October 2018, Copenhagen), the group is requested to:

TOR 1. Select the most appropriate model(s) to carry out a mixed-fisheries advice for the western Mediterranean demersal fisheries. It should be taken into account the analyses done in the STECF Report 18-13 , the coverage in terms of stocks and fleets segments at the scale of the multi-annual plan and the availability of data requirements.

TOR 2. Analyse the ability of the model(s) to be compatible with the latest scientific advice provided for western Mediterranean demersal stocks in the STECF Report 18-12 . The group should also make any appropriate comments and recommendations to the stock assessments' group in order to ensure adequacy of the single-stock advice and the mixed-fisheries model(s).

TOR 3. Discuss and suggest possible mixed-fisheries scenarios and type of results displayed to be tested at the STECF EWG 19-14 concerning the multi-annual plan.

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 observations

EWG 19-01 was held in Barcelona, Spain, from 18 to 22 March 2019. The EWG was a follow-up of the EWG 18-09 held in June 2018 and the EWG 18-13 held in October 2018.
As the EWG 19-01 took place the week before the STECF plenary, the EWG report was not finalised. The STECF commented on a draft version of the report and the presentation and discussion held at the STECF plenary. The EWG had the following TORs:
TOR 1. Select the most appropriate model(s) to carry out a mixed-fisheries advice for the western Mediterranean demersal fisheries. It should be taken into account the analyses done in the STECF Report 18-13, the coverage in terms of stocks and fleets segments at the scale of the multi-annual plan and the availability of data requirements.
TOR 2. Analyse the ability of the model(s) to be compatible with the latest scientific advice provided for western Mediterranean demersal stocks in the STECF Report 18-12. The group should also make any appropriate comments and recommendations to the stock assessments' group in order to ensure adequacy of the single-stock advice and the mixed-fisheries model(s).
TOR 3. Discuss and suggest possible mixed-fisheries scenarios and type of results displayed to be tested at the STECF EWG 19-14 concerning the multi-annual plan.

STECF comments

STECF notes that the EWG 19-01 is part of the roadmap defined by the STECF (PLEN 18-03) in 2018 and the TORs or this EWG responds to this roadmap. They have been fully covered by the EWG.
STECF notes that, as required by the TORs, several models were tested in the EWG 19-01. These models can be categorized in terms of the model scale and complexity (fleet-based models with a simple annual setting, models adding more complex features and models with finer time-spatial

scale) and the Effort Management Unit (EMU) in which they are to be applied (EMU 1 including GSAs 1, 2, 5, 6 and 7 and EMU 2 including GSAs 8 to 11). STECF notes that both EMUs had a model of each scale presented, although not all at the same readiness level to perform the simulations required. However, it should be further noted that none of the models cover GSA 1 (Alboran Sea) and GSA 5 (Balearic Islands).
STECF notes that almost all the models are compatible with the stock assessments provided by the EWG 18-12, in the sense that they are able to replicate the short-term forecast for hake performed in the EWG 18-12. STECF further notes that these short-term projections require some working assumptions to be made, although STECF agrees with the EWG that the compatibility is sufficient to perform further mid-term projections.

STECF notes that for EMU2, the BEMTOOL model is almost ready for performing simulations of different scenarios. However, in the EWG 19-01 report the results presented did not include confidence intervals.
STECF also notes that results from BEMTOOL could be additionally supported by the outputs obtained from the SMART model. This last model can simulate effort reallocation following a reduction in effort within the historical fishing areas, and therefore, evaluate fishing mortality reductions after fleets have spatially reallocated their fishing effort. STECF notes that although the results of this model are still preliminary, they showed signs of hyperstability, that is, that effort can be reallocated to maintain similar levels of fishing mortality and economic performance.
For EMU 1 STECF notes that the work is more preliminary. However, STECF also notes that three candidate models were identified by the EWG (FLBEIA, FLASHER and IAM) although the development of the application of these three models to cover the entire EMU 1 is still preliminary and therefore the simulations provided in the EWG 19-01 have to be considered with caution.
STECF notes that the MEFISTO and ISIS-FISH models are not likely to be retained for further simulations in the frame of the demersal fisheries Western Mediterranean MAP due to the existing trade off among their complexity and the value added from more "simple" settings.
STECF notes that there is a problem on how to differentiate in the simulations the two types of activities foreseen in the plan, i.e. the mixed demersal metier and the deep-sea shrimp metier. These two métiers are not well identified in the current datasets available.
STECF notes that some of the simulations included fishing effort regimes characteristics identified in EWG 18-13 and EWG 18-09 such as hyperstability and technology creep.
STECF notes that while the effort baseline is clearly defined in the MAP (2015-2017 fishing days), the value of this baseline in terms of actual number of days are not provided yet. STECF further notes that these absolute values might differ depending on how the trip data (e.g. logbooks) are being computed and aggregated by different people or for different purposes in different databases.
Finally, STECF notes that EWG 19-01 also discussed on how to present the results. The EWG discussed two main approaches: the first approach is a web-based results-display app, where the user can select the indicator(s) to be displayed and the scenarios to be compared. The second approach is a multi-criteria approach in where each dimension (biological, economic and social) is weighted and a utility metric calculated based on these weights and the utility functional form itself. However, the value of this single metric is dependent on how the weights are selected and on the form of the utility function (additive, multiplicative, Rawls, max-min,…).

STECF conclusions

STECF concludes that EWG 19-01 proved the capacity of the models tested to produce a bio-economic assessment of different scenarios in the frame of the demersal fisheries West Med MAP. STECF also concludes that models differ in the readiness level to produce results and that those models to be used in the EMU 2 are at a more advanced readiness level than those to be used in EMU 1.
STECF concludes that given that the MAP only applies to trawlers, there is a potential risk of effort being transferred from trawlers to those gears not covered by the plan (i.e. gillnetters). This can cause that fishing mortality remains high under regulated effort reduction. Furthermore, due to the different overall selectivity a change in the productivity of the stocks could occur in this case, which will require new calculations of reference points such as FMSY. STECF also concludes that

even if this effort shifting does not occur, gears not covered by the plan will be clearly advantaged. These gears are likely to obtain higher catches benefited from the higher future stock abundance. These higher landings of the gear not covered by the plan could affect the market prices and outweigh, at least partially, the likely higher prices that trawlers would receive from their lower supply to the market.

STECF concludes that setting the correct baseline effort in terms of actual number of fishing days is critical for the simulations. In that sense it is important that the fleet's productivity estimations or calibrations (i.e. catchability) refer to the baseline values agreed by the Member States. Building on the suggestion from EWG 19-01, STECF suggests holding a scoping meeting before the next EWG planned in October. Such a scoping meeting involving Member States and scientists would be beneficial to discuss the data issues in relation to the baseline and to agree on a set of scenarios for the bio-economic simulations.

Regarding the problem of the identification of demersal mix and deep-sea shrimp métiers, STECF concludes that the metier identification will require an alignment between the recommendation given by the DCF Métier Workshop (2018) and the definitions applied by Member States in their monitoring of fishing effort. In this workshop it was recommended to use catch composition in value (instead of volume) as the metric to be used if the distinction between metiers is to be based on target assemblage reflecting fishers intentions. .

STECF encourages that, when possible, final results should include uncertainty of estimates, considering the uncertainty of both the stock assessment and of the projections.

Regarding the display of the results, STECF concludes that the multi-criteria approach proposed can be a step ahead, given that scenarios could be compared using a single dimensionless metric (utility). However, the value of this single metric is dependent on how the weights are selected and on the form of the utility function. These are likely to differ according to the different priorities from different actors (Commission, Member States, NGOs, fishing firms, etc.).

References

DCF Métier Workshop: Sub-group of the RCGs - North Sea and Eastern Arctic and North Atlantic. DTU Aqua, Lyngby, Denmark. January 2018.

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REPORT TO THE STECF

EXPERT WORKING GROUP ON methods for developing the fishing effort regime for demersal fisheries in western Mediterranean Sea – Part III (EWG-19-01)

Barcelona, Spain, 18-22 March 2019

This report does not necessarily reflect the view of the STECF and the European Commission and in no way anticipates the Commission's future policy in this area

1 INTRODUCTION

1.1 List of acronyms

DTS	Demersal Trawls and Seines
EMU	Effort Management Unit
EWG	Expert Working Group
MAP	Multi-Annual Management Plan
MCDA	Multi-Criteria Decision Analysis
PGP	Vessels using polyvalent passive gears only

1.1 Background

This Expert Working Group is the third EWG dealing with methods for developing the fishing effort regime for demersal fisheries in western Mediterranean Sea

1.2 Terms of Reference for EWG-19-01

As a follow-up of the STECF Expert Working Group 18-13 (October 2018, Copenhagen), the group is requested to:

TOR 1. Select the most appropriate model(s) to carry out a mixed-fisheries advice for the western Mediterranean demersal fisheries. It should be taken into account the analyses done in the STECF Report 18-13 , the coverage in terms of stocks and fleets segments at the scale of the multi-annual plan and the availability of data requirements.

TOR 2. Analyse the ability of the model(s) to be compatible with the latest scientific advice provided for western Mediterranean demersal stocks in the STECF Report 18-12. The group should also make any appropriate comments and recommendations to the stock assessments' group in order to ensure adequacy of the single-stock advice and the mixed-fisheries model(s).

TOR 3. Discuss and suggest possible mixed-fisheries scenarios and type of results displayed to be tested at the STECF EWG 19-14 concerning the multi-annual plan.

1.3 Main findings

ToR1 reviewed 8 different models, of different complexity levels and covering different GSAs and EMUs. For EMU2 (East side of Western Med, which mainly includes fisheries from one single Member State), 3 models were presented, which are fully parameterised and operational. By operating at different levels of complexity and scale, they appear complementary, allowing them to test different scenarios.

The situation is more challenging in EMU1 (West side of Western Med, which covers fisheries from two Member States), where five models were presented but none of them is directly operational at the scale of the EMU. Progresses were reached during the EWG, but further intersessional work, involving scientists from the two Member States, is necessary before reaching the desired level of completion for the evaluation of management scenarios.

During the EWG, all models presented were updated to be compatible with the latest stock assessment data coming from STECF EWG 18-12. Where possible, short-term forecasts were run, assuming a reduction in fishing effort in 2019 equivalent to the reduction necessary to achieve the target F (Fmsy, proxy F01). For all models, the aggregated results of the short term forecast were largely similar between the single-stock and the mixed-fisheries models.

Then most models were able to run the basic MAP scenario of a gradual reduction of fishing effort between 2020 and 2024. Several alternative runs and model capabilities were discussed and are reported in the various models' section. Future scenarios and outcomes would be best agreed in discussions with MARE and Member States / stakeholders before the next meeting.

Finally, the EWG discussed a number of remaining issues and gaps that are important in relation to the scientific support to the MAP, and agreed on some future work.

2 MAIN ELEMENTS OF THE WEST MED MAP TO BE SUPPORTED BY SCIENTIFIC ADVICE

2.1 MAP elements

DG Mare focal person presented the main elements of the West Med MAP.

The Commission adopted the MAP proposal on March 8th, 2018 and the European Parliament and Council reached an agreement on February 4th, 2019. The Official Journal of the EU will publish the regulation establishing the plan in early May 2019, and the plan will enter into force afterwards.

Scope

The scope is the Western Med, i.e. GSAs 1, 2, 5, 6, 7, 8, 9, 10 and 11, divided into two spatial units EMU (Effort Management Units).

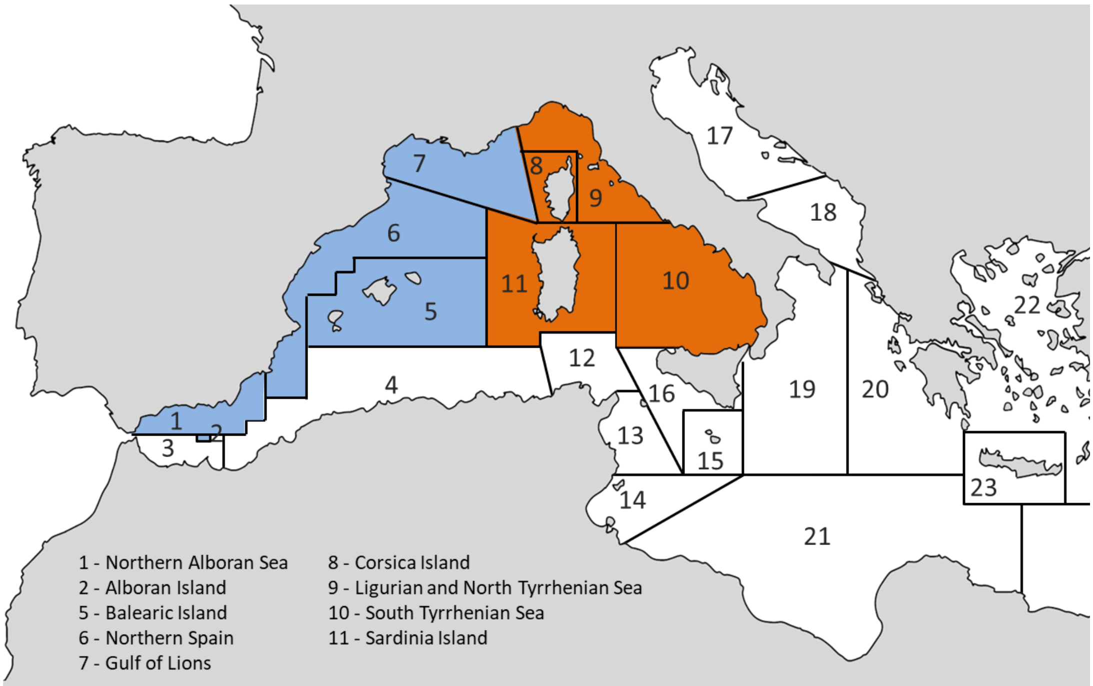

Figure 1. MAP region. Blue= EMU1. Red: EMU2

The Western MAP includes 6 species as category 1 stocks. In this report, these are referred to either as their common or latin name, or sometimes using the FAO 3-letter code. The correspondence between the three denomination is given below:

Common name	Latin name	FAO 3-letter code
Hake	*Merluccius merluccius*	HKE
Red mullet	*Mullus barbatus*	MUT
deep-water rose shrimp	*Parapenaeus longirostris*	DPS
Norway lobster	*Nephrops norvegicus*	NEP
giant red shrimp	*Aristaeomorpha foliacea*	ARS

blue and red shrimp	*Aristeus antennatus*	ARA

The main target of the plan is Maximum Sustainable Yield MSY. The plan states that "*The target fishing mortality, in line with the ranges of FMSY defined in Article 2, shall be achieved on a progressive, incremental basis by 2020 where possible, and by 1 January 2025 at the latest, for the stocks concerned, and shall be maintained thereafter within the ranges of FMSY*."

Effort limitations

The main instrument for reaching Fmsy is the effort regime. Annual effort quotas will be set by the Council, starting on 1.01.2020. The main characteristics of the regime are as follows:

- Effort regime applicable to all trawl vessels targeting demersal stocks in WMed.
- Two effort groups: mixed demersal fisheries; deep-shrimp fisheries.
- Four sub-groups of vessels: < 12m; 12-18m; 18-24m; and >24m.
- Effort quotas in terms of fishing days.
- Fishing day is limited to 15 hours (from port to port).
- Baseline: average fishing days between 1.1.2015 and 31.12.2017

Effort quotas will be managed within 16 categories across three criteria: fishing type ("regime"), fishing area ("effort management unit EMU") and vessel group.

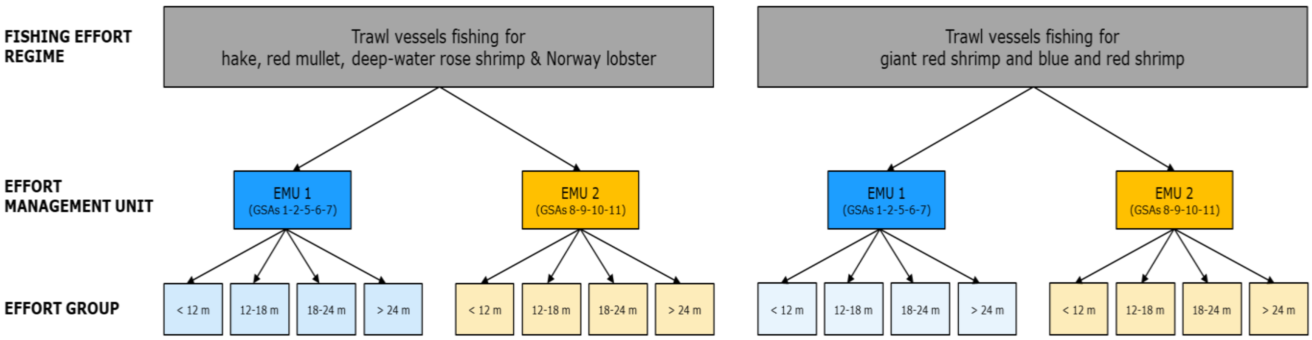

Figure 2. Fishing effort categories

A) Trawls fishing for red mullet, hake, deep-water rose shrimp and Norway lobster in the continental shelf and upper slope

Gear type	Geographical area	Stock *groups*	Overall length of vessels	Fishing effort group code
Trawls (TBB, OTB, PTB, TBN, TBS, TB, OTM, PTM, TMS, TM, OTT, OT, PT, TX, OTP, TSP)	GFCM sub-areas 1-2-5-6-7	Red mullet in GSAs 1, 5, 6 and 7; Hake in GSAs 1-5-6-7; Deep-water rose shrimp in GSAs 1, 5 and 6; and Norway lobster in GSAs 5 and 6.	< 12 m	EFF1/MED1_TR1
			≥ 12 m and < 18 m	EFF1/MED1_TR2
			≥ 18 m and < 24 m	EFF1/MED1_TR3
			≥ 24 m	EFF1/MED1_TR4
	GFCM sub-areas 8-9-10-11	Red mullet in GSAs 9, 10 ***and 11***; Hake in GSAs 9-10-11; Deep-water rose shrimp in GSAs 9-10-11; and Norway lobster in GSAs 9 and 10.	< 12 m	EFF1/MED2_TR1
			≥ 12 m and < 18 m	EFF1/MED2_TR2
			≥ 18 m and < 24 m	EFF1/MED2_TR3
			≥ 24 m	EFF1/MED1_TR4

Table 1. Fishing effort group codes

Throughout this report, the effort regime for trawls fishing for hake, red mullet, deep-water rose shrimp and Norway lobster is referred to as **"Mixed demersal métier"** and the effort regime for trawls fishing for giant red shrimp (ARS) and blue and red shrimp (ARA) is referred to as **"deep-water shrimp metier"**.

During the five-year transitional period, fishing effort reductions shall be as follows:

- YEAR 1 (2020): 10% reduction compared to the 2015-2017 baseline
- YEAR 2- 5 (2021 – 2024): up to 30% reduction. The effort reduction may be supplemented with other technical measures in order to achieve MSY by 2025.

Closures

An Annual closure is foreseen: trawl vessels are prohibited within 6nm from the coast except in areas deeper than 100m during 3 months each year. Member States may though ask for a derogation and establish other closure areas provided that a reduction of at least 20% of catches of juveniles hake in each GSA is achieved.

Other closures areas shall be established two years after the entry into force (by 2021) for the protection of juveniles, individuals under MCRS and spawning grounds.

Recreational fisheries

Where the scientific advice indicates that recreational fisheries is having impact on the fishing mortality, the Council may set non-discriminatory limits for recreational fisheries.

- Technical measures (under regionalisation) may be adopted.

- Where possible, Member States shall take necessary and proportionate measures for the monitoring and collection of data.

Timeline

After entry into force end of May 2019, the first 3 months-closure will take place between June and December 2019. The Commission will make its proposal on effort levels by end of October 2019, and the effort regime will enter into force on January 1st, 2020.

2.2 Overview of the MAP coverage

2.2.1 Percentage of MAP stocks caught by the regulated trawler fleets

Table 2. Percentages of landings of MAP species caught by the regulated trawler fleets (average values for 2015-2016). Percentages are calculated over the total landing per vessel length within one unit of management.

VL	ARA	ARS	DPS	HKE	MUT	NEP	GSA	EMU
VL0612	-	-	1	2	29	0	1	1
VL1218	3	0	5	5	7	1		
VL1824	4	0	2	3	2	1		
VL2440	3	0	1	1	0	0		
VL0612	-	-	-	-	-	-	5	
VL1218	0	0	0	2	1	0		
VL1824	3	0	0	1	1	1		
VL2440	1	0	0	1	0	0		
VL0612	1	-	10	16	37	4	6	
VL1218	2	1	4	25	36	6		
VL1824	9	1	6	26	17	7		
VL2440	15	0	3	27	12	5		
VL0612	-	-	-	-	-	-	7	
VL1218	0	-	0	0	0	0		
VL1824	1	0	0	12	2	0		
VL2440	2	0	1	25	1	1		
VL	ARA	ARS	DPS	HKE	MUT	NEP	GSA	EMU
VL0612	-	-	-	1	-	7	8	2
VL1218	-	-	0	0	-	1		
VL1824	-	-	0	0	-	0		
VL2440	-	-	0	0	-	1		
VL0612	-	-	6	9	34	0	9	
VL1218	2	1	14	10	21	4		
VL1824	2	1	19	20	24	2		
VL2440	1	0	7	7	9	2		
VL0612	-	0	19	11	17	-	10	
VL1218	1	3	14	5	9	0		
VL1824	2	5	8	7	5	0		
VL2440	-	-	-	-	-	-		
VL0612	-	-	-	-	-	-	11	
VL1218	1	1	1	5	8	0		
VL1824	0	0	0	1	2	0		
VL2440	12	20	5	29	5	3		

Landings values by FAO Geographic Sub Area (GSA), to create dependency tables and graphs, were obtained from the Annual Economic Report (AER) as in STECF 18-13. During STECF 18-13 dependencies were calculated also considering species and gears not considered in the MAP. In this report dependencies reported in Table 2 are instead calculated only for species and gears (Fig. 2.2.1 and 2.2.2) considered by the MAP. Table 3 was taken from STECF 18-12 to show the percentages of landings per stock by gear.

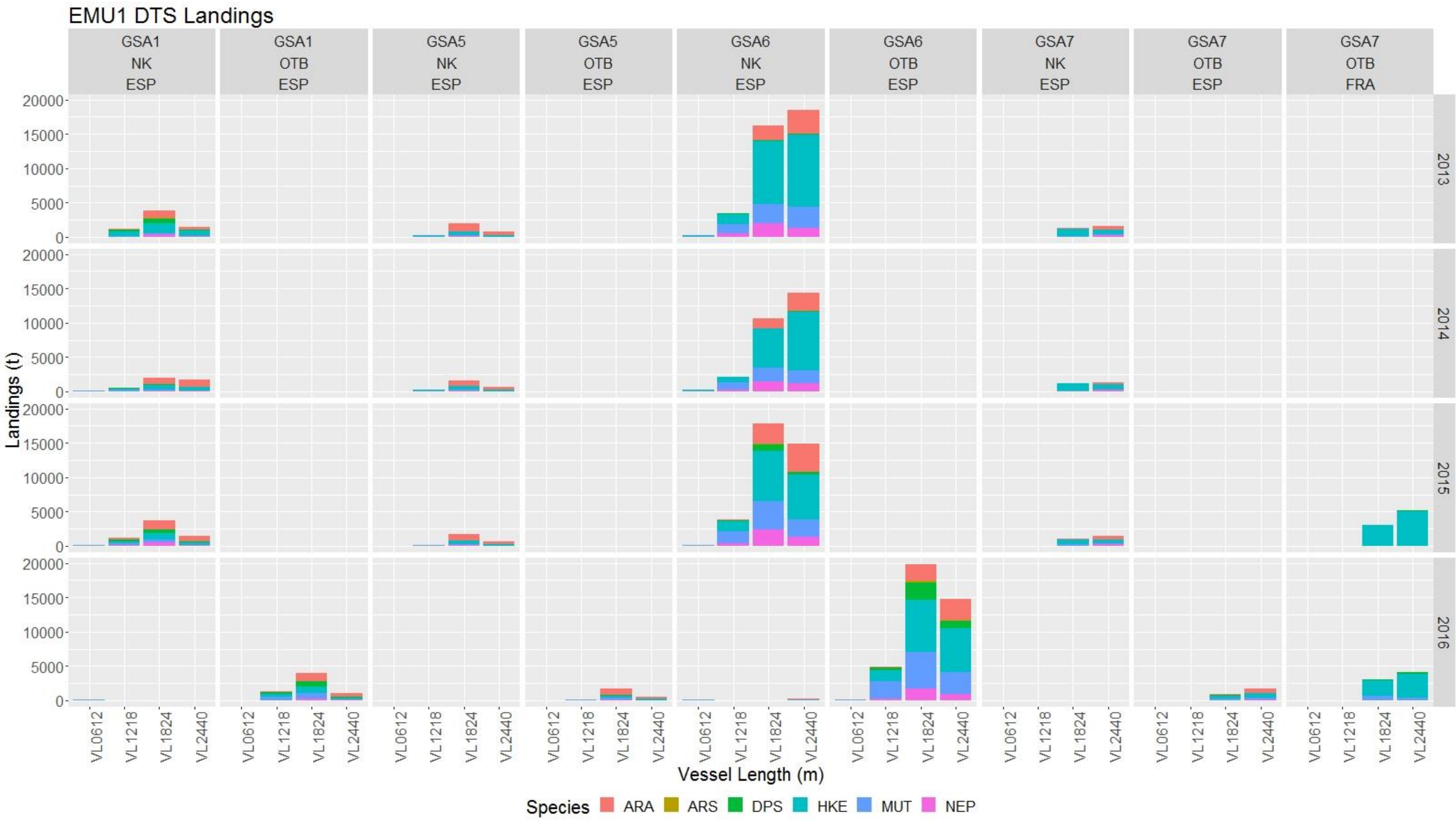

Figure 3 Total landings per GSA, gear, country and year within EMU 1

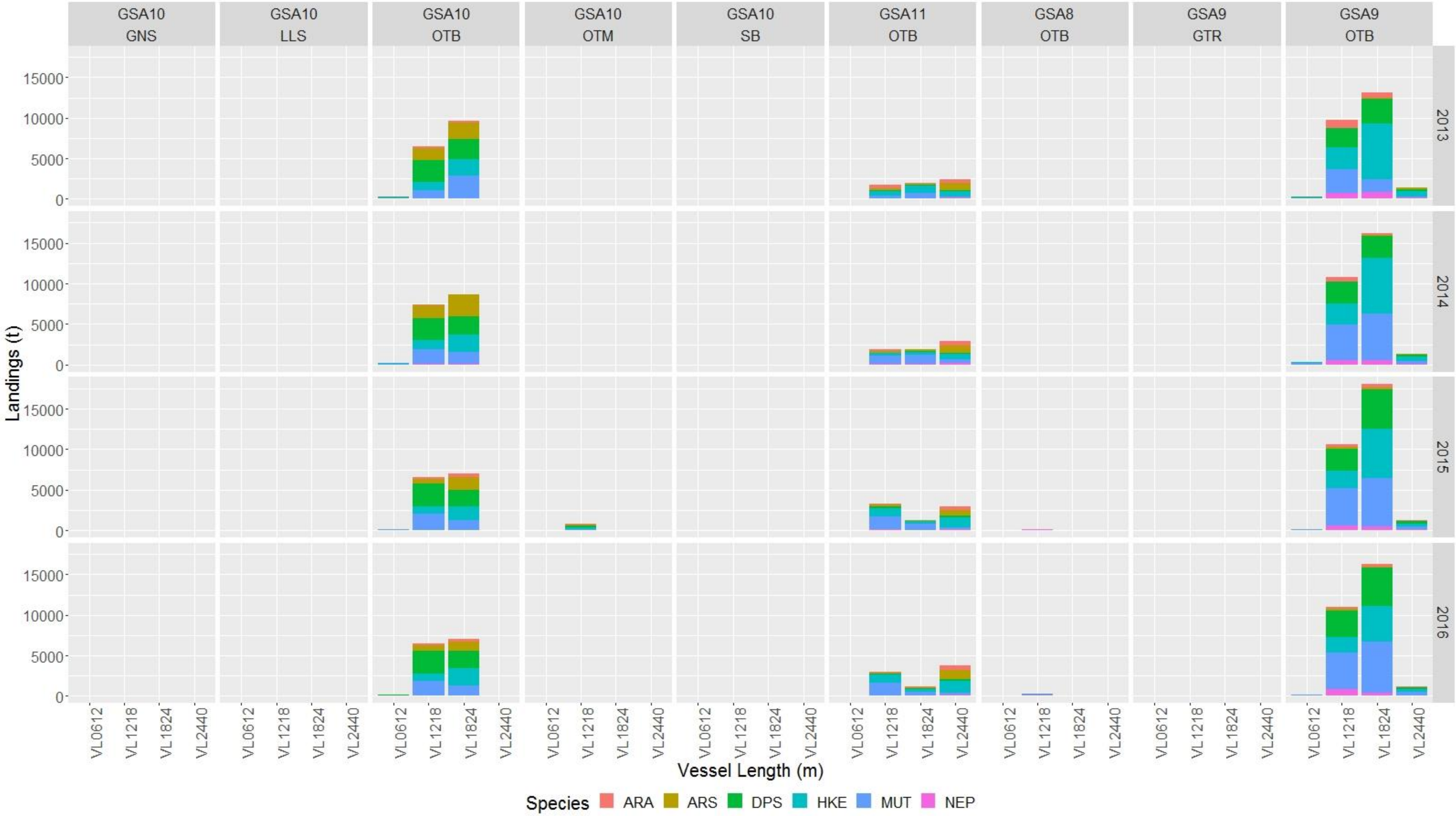

Figure 4. Total landings per GSA, gear and year within EMU 2

2.2.2 Percentage of MAP fleets catches from the MAP species

NB the EWG 19-01 found some minor issues in the way the dependencies and percentages were calculated in previous reports of EWG 18-12 and 18-13. This shall be solved before the next meeting.

Table 3 Percentage of landings of each stock across metiers. The columns summed to 100% for each line.

Stock	Bottom trawl nets	Gillnets	Trammel nets	Other
HKE 1_5_6_7	90%	6%	2%	2%
HKE 9_10_11	60%	23%	8%	9%
MUT 1	77%	0%	23%	0%
MUT 6	92%	0%	8%	0%
MUT 7	99%	1%	0%	0%
MUT 9	96.6%	0.8%	2.6%	0%
MUT 10	91%	8%	1%	0%
NEP 5	100%	0%	0%	0%
NEP 6	100%	0%	0%	0%
DPS 9_10_11	100%	0%	0%	0%
ARA 1	100%	0%	0%	0%
ARA 6	100%	0%	0%	0%
ARS 9_10_11	100%	0%	0%	0%

2.3 Requirements to the bioeconomic mixed-fisheries models in relation to the ToRs

A comprehensive review of the available models and their current state of development had been performed in EWG 18-13 (West Med Part II) ToR 5. The main conclusion from this review was that many models exist already in the Western Med area, but that none of them was directly operational for providing timely annual advice at the scale of the plan, i.e. across several stocks, GSAs and fleets.

Making the models operational was thus the main aim of the EWG 19-01. In advance of the meeting, modellers were asked to investigate the feasibility of their models to address the gaps listed in EWG 18-13 and in particular

- The coverage of several GSAs (models by the two EMU sub-areas of the plan)
- The inclusion of at least all the stocks of the 6 MAP species within the two sub-areas (and possibly more stocks if already included in the existing models)

- The ability to be updated with the most recent data (e.g. stock and transversal data up to 2017)
- The ability to match the most recent single-stock short-term advice (e.g. advice for 2019, for the stocks assessed in 2018 on 2017 data).

The EWG started with a presentation of each of the available models, and the progresses reached since EWG 18-13 in relation to the ToRs and above-mentioned gaps issues. Most models were those already described in EWG 18-13 report, but new approaches (such as FLR Flasher) were also presented. Then the EWG agreed on the requirements for the rest of the week.

The report is thus structured as follows:

Sections 3 to 10 are presentations of the various models:

- Model characteristics and use following the typology and scoring criteria developed by Nielsen et al., 2018 https://onlinelibrary.wiley.com/doi/full/10.1111/faf.12232 (summarised in Table 4 below)
- Case study application for the West Med MAP
- Short-Term forecast (projection 2018-2019) to assess the compatibility of the mixed-fisheries model with the single-stock forecast from EWG 18-12
- Deterministic Medium-Term baseline projection over the transitional period 2020-2024, simulating the basic provision of the plan, i.e. 10% reduction in fishing days in 2020 compared to the average 2015-2017 and 30% additional reduction between 2021 and 2024, corresponding to a 7.5% reduction per year uniformly applied to all fleet segments
- A discussion on which alternative scenarios are possible to run with this model

A Total of 8 models were presented and discussed during the EWG, of different setup, spatial coverage and complexity.

Fleet- and –year based models, "simple setup"	Fleet-based models with more complex features	Models with finer time- and spatial scale
FLBEIA (EMU1) *Section 3*	BEMTOOL (EMU2) *Section 6*	SMART (EMU2) *Section 9*
FLasher (EMU1) *Section 4*	IAM (EMU1) *Section 7*	ISIS-FISH (EMU1) *Section 10*
NIMED (EMU2) *Section 5*	MEFISTO (EMU1) *Section 8*	

Table 4. Models' characteristics and use following the typology and scoring criteria developed by Nielsen et al., 2018. More comprehensive model descriptions are found in STECF 18-13 and/or in Nielsen et al., 2018 (self-evaluation by modellers)

CRITERIA	SCORING	NIMED	FLBEIA	Flasher	IAM	BEMTOOL	MEFISTO	ISIS-FISH	SMART
Model capabilities									
Panel 1—model design	1= Short-term advice, 2= Medium-term MSE 3= Long-term strategic	1	1, 2 & 3	1 2 3	1, 2 & 3	1, 2, 3	1-2-3	1,2,3	1,2
Panel 2—management advice	1 =TACs 2= Effort 3= ITE 4= ITQ	2	1, 2	1 2	1, 2 & 4	1, 2	2	1,2,3,4	2,3,4
Panel 3—model structural characteristics in terms of advice on	1= data collection 2= Single Stock 3= Multispecies 4= Mixed fishery 5= Bioeconomic 6= Ecosystem	3 5	1, 2, 3, 4, 5	1 2 3 4 5	2, 3, 4 & 5	1, 2, 3, 4, 5	2-3-4-5	2,3,4,5	1,3,4,5
Panel 4—model use index in terms of included modules and their linkages for biology (stocks), economic and ecosystems	1= Single/multispecies only 2= single stock/economic 3= Multispecies/economic 4= Multispecies/ecosystem/economic	3	1, 2, 3	1 2 3	3	2, 3	3	3	3
Model characteristics									
Panel 1—fishing fleet characteristics	1= Full Fishery 2= Single Métier 3= Multiple Metiers 4 = Agent-Based (IBM)	1	1, 2, 3	1 2	1, 2, 3 & 4	1, 2, 3	3	1,2,3	2,3,4
Panel 2—spatial resolution	1= Ecosystem 2= Region 3= Stock Area 4= Stock sub-area 5= VMS track	3	3, 4	3 4	2 & 3	2, 3, 4	3	2,3, 4	2,3,4,5
Panel 3— biological characteristics	1= Biomass 2= Size-structured 3= Age-structured	3	1, 3	1 3	3	2, 3	3	1,2,3	1,2,3

Panel 4—time step	1= Year 2= Multiple Years 3= Season	1	1, 3	1 2 3	1	1, 3	1-2-3	1,2,3	1,3
Panel 5— time dynamic	1= Static 2= Equilibrium 3= Dynamic	3	3	3	3	3	3	1,3	3
Panel 6— Process	1= Simulation 2= Optimisation 3= Both	1	1	3	3	1	1	3	3
Panel 7 — fishing sector components	1= Catch sector 2=Fishery system including processing and distribution 3= Communities 4= Multi-sector of a local or regional economy	1	1	1	1	1	1-2-3	2	1,2
Panel 8 — estimation of model parameters	1= qualitative indicators 2= deterministic 3= stochastic	2	2, 3	2 3	2 & 3	2, 3	2-3	1,2,3	2,3
Panel 9 — revenues	1= market prices 2= consideration of the value chain 3= inclusion of non-market values;	1	1	1	1	1	1	1	1
Panel 10 — type of embedded interactions;	1= linear 2= nonlinear 3= both	3	3	3	3	3	2	3	3
Panel 11 — nature of embedded economic behavioural model	1= tactical 2= strategic 3= no behavioural module	3	1, 2	1	2	1	2	2,3	2
Panel 12 — included functions	1= recruitment 2= catchability 3= fish prices 4= harvest costs	3 4	1, 2, 3, 4,	1 2 3 4	1, 2, 3 & 4	1, 3, 4	1-2-3-4	1,2,3,4	1,2,3,4
Model trade-offs									
Panel 1—expertise required to conduct model runs	1= developer 2= specialized expertise or training 3= general expertise	1	2, 3	2	1	2, 3	3	2	1,2
Panel 2 — model applications	1= specialized 2= simple 3= flexible	3	1,2,3	3	3	1, 2, 3	1-3	3	2,3
Panel 3 — model accessibility to end	1= software required 2= open access 3= Manual/Website 4= User-friendly	1	1,2,3,4	2 4	2	2, 3. 4	2-4	2,3,4	2,4

users									
Panel 4 — relationship between model complexity and data needs	1= simple with low data needs 2= simple with high data needs 3= complex with high data needs	1	1,2,3	1	3	3	3	3	3
Summary of model use									
Panel 1 — model implementation	1= none 2= low 3= medium 4= high	2	3	2	3	3, 4	3	4	3,4
Panel 2—academic use	1= models that only have technical reports 2= models that have been published in the peer-reviewed literature 3= models that have been widely cited	1	2,3	1	2	2, 3	2	3	2
Panel 3—level of advice for models	1= National 2= EU (STECF) 3= Nation + EU (STECF) 4= EU (STECF) + ICES/GFCM 5= Nation + EU + ICES/GFCM	3	5	5	5	2, 3, 5	3	5	1,2,3,4,5

3 FLBEIA IN EMU1

3.1 Overview of the model's generic characteristics and use

3.1.1 Main features

FLBEIA is a generic tool to conduct Bio-Economic Impact Assessment of fisheries management strategies in a management strategy evaluation framework (Garcia et al., 2017). FLBEIA can be categorized as a 'Models of Intermediate Complexity for Ecosystem assessments' (MICE, (Plagányi et al., 2014)) which is focused on the fishing activity in a muti-stock and multi-fleet context.

FLBEIA has been built using R- FLR packages (Kell et al., 2007) and beneficiate automatically from the new developments in those packages. As any MSE algorithms it is formed by two main blocks, the Operating Model (OM) and the Management Procedure (MP) (Figure 5). The OM has three components that interact among themselves, the stocks, the fleets and the covariates. In turn the MP is divided in other three components, the observed data, the perceived stocks and the management advice.

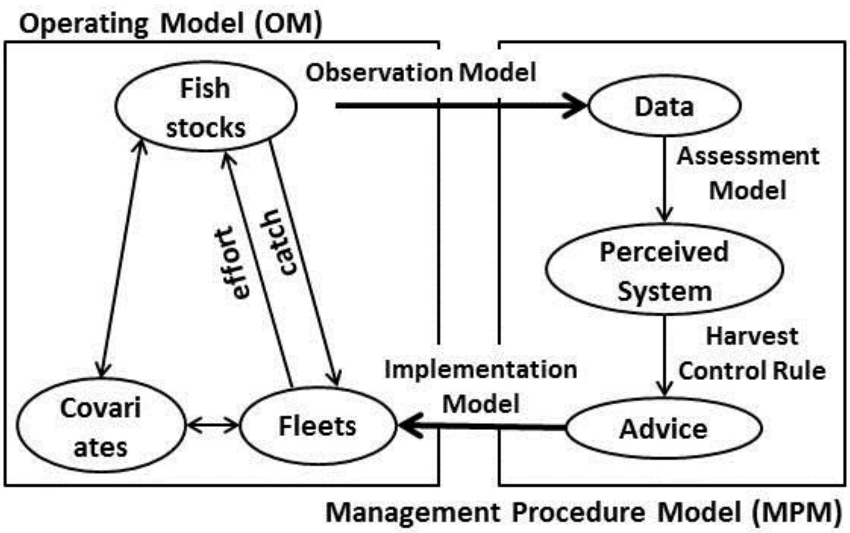

Figure 5. Conceptual diagram of FLBEIA (taken from Garcia et al. (2017))

The stocks can be age or biomass structured. Trophic interactions have never been modelled in FLBEIA but it could be done. There is also a development version where Gadget (Begley and Howell, 2004) can be used as operating model. The activity of the fleet is divided in metiers and four processes are modelled. The short-term dynamics (total effort and its distribution along metiers), long term dynamics (entry-exit of new vessels in the fishery), price formation and catch production. The covariates can be used to store any variable not included in the stocks and fleet components.

The link between the OM and the MP is done through the observation model that generate de observed data. Two types of data can be generated, the stocks and the abundance indices. Any observable variable can be subject to observation error and the error is divided in two components, the aging error component and a multiplicative error. As the errors are introduced as input data they can be conditioned using any distribution, bootstrap or other analysis. The perceived population is generated using an assessment model. There is the possibility of using the 'short-cut' approach or any assessment model available in R/FLR. What is needed is a wrapper that generates the input and output of the model in the right shape. Wrappers are already available for SPiCT, XSA, sca in Fla4a and FLSAM. The management advice is generated using a harvest control rule. Two types are available, model-free HCRs and model-based ones. The model-free HCRs use the abundance indices generated by the observation model and do not require to apply any assessment model. In turn, the model-based HCRs use the output of the short-cut approach of an assessment model to generate the advice.

The adaptative management advice based on catch can be accompanied by technical measures like changes in selectivity, implicitly simulated spatiotemporal closures or effort restrictions for example.

The stochasticity is introduced using montecarlo approximation and the iterations run in parallel. The results can be analysed and presented using the Shiny application available in the FLBEIAShiny package (https://github.com/flr/FLBEIAshiny).

The model is constructed in a modular way. The fishery system is discomposed in processes (recruitment, catch production, population growth…) and several models are provided to simulate each of them. Alternatively, new models can be coded and call from the function with no extra coding.

The model documentation is extensive. There is a research paper describing the model (Garcia et al., 2017). A manual which describes in detail all the models available is provided within the R library. And there is a set of dedicated tutorials in the FLR web-site http://www.flr-project.org/. The source code can be downloaded from github (https://github.com/flr/FLBEIA) and the compiled package from the FLR website (http://www.flr-project.org/). There is a support mailing list flbeia@azti.es.

3.1.2 References

Garcia, D. 2018. A multi-stock harvest control rule to support a consistent management along stocks in the framework of fishing mortality ranges. ICES annual sciencitic conference, Hamburg.

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Garcia, D., Urtizberea, A., Diez, G., Gil, J., and Marchal, P. 2013. Bio-economic management strategy evaluation of deepwater stocks using the FLBEIA model. Aquatic Living Resources, 26: 365-379.

Kell, L. T., Mosqueira, I., Grosjean, P., Fromentin, J.-M., Garcia, D., Hillary, R., Jardim, E., et al. 2007. FLR: an open-source framework for the evaluation and development of management strategies10.1093/icesjms/fsm012. ICES J. Mar. Sci., 64: 640-646.

Nielsen, J. R., Thunberg, E., Holland, D. S., Schmidt, J. O., Fulton, E. A., Bastardie, F., Punt, A. E., et al. 2018. Integrated ecological–economic fisheries models—Evaluation, review and challenges for implementation. Fish and Fisheries, 19: 1-29.

Prellezo, R., Carmona, I., and García, D. 2016. The bad, the good and the very good of the landing obligation implementation in the Bay of Biscay: A case study of Basque trawlers. Fisheries Research, 181: 172-185.

Prellezo, R., Carmona, I., García, D., Arregi, L., Ruiz, J., and Onandia, I. 2017. Bioeconomic assessment of a change in fishing gear selectivity: the case of a single-species fleet affected by the landing obligation. Scientia Marina, 81: 10.

Sánchez, S., Ibaibarriaga, L., Uriarte, A., Prellezo, R., Andrés, M., Abaunza, P., Jardim, E., et al. 2018. Challenges of management strategy evaluation for small pelagic fish: the Bay of Biscay anchovy case study. Mar Ecol Prog Ser.

3.2 Application of the model to the West Med MAP

The model was applied to the available data for the West Med. Six stocks were included "HKE_1-5-6-7," "MUT_1", "MUT_6", "MUT_7", "NEP_5", "NEP_6". The fleets included only one fleet that accounted for all the catch of the stocks.

All the stocks were simulated using the exponential survival equation with a geometric mean recruitment.

Regarding fleet dynamics two scenarios were simulated. A scenario were the effort in the whole projection was equal to historical effort and an alternative scenario where the effort was reduced according to the MAP.

The model was projected until 2025 in a deterministic simulation.

The model results were analyzed using a Shiny App that can be directly used in the outputs of FLBEIA. This app can also be used with other model outputs if they have the right shape (R data frames with certain columns).

3.3 Comparison of model's short-term forecast with the single-stock advice predictions

No comparisons were made

3.4 Baseline Run 2020-2024

The spawning stock biomass of the two scenarios simulated with FLBEIA are shown in Figure 6. For all the stocks the spawning stock biomass obtained in the MAP scenario increased sharply, while in the constant effort scenario the biomass stayed constant in the case of hake or decreased in the case of the other stocks.

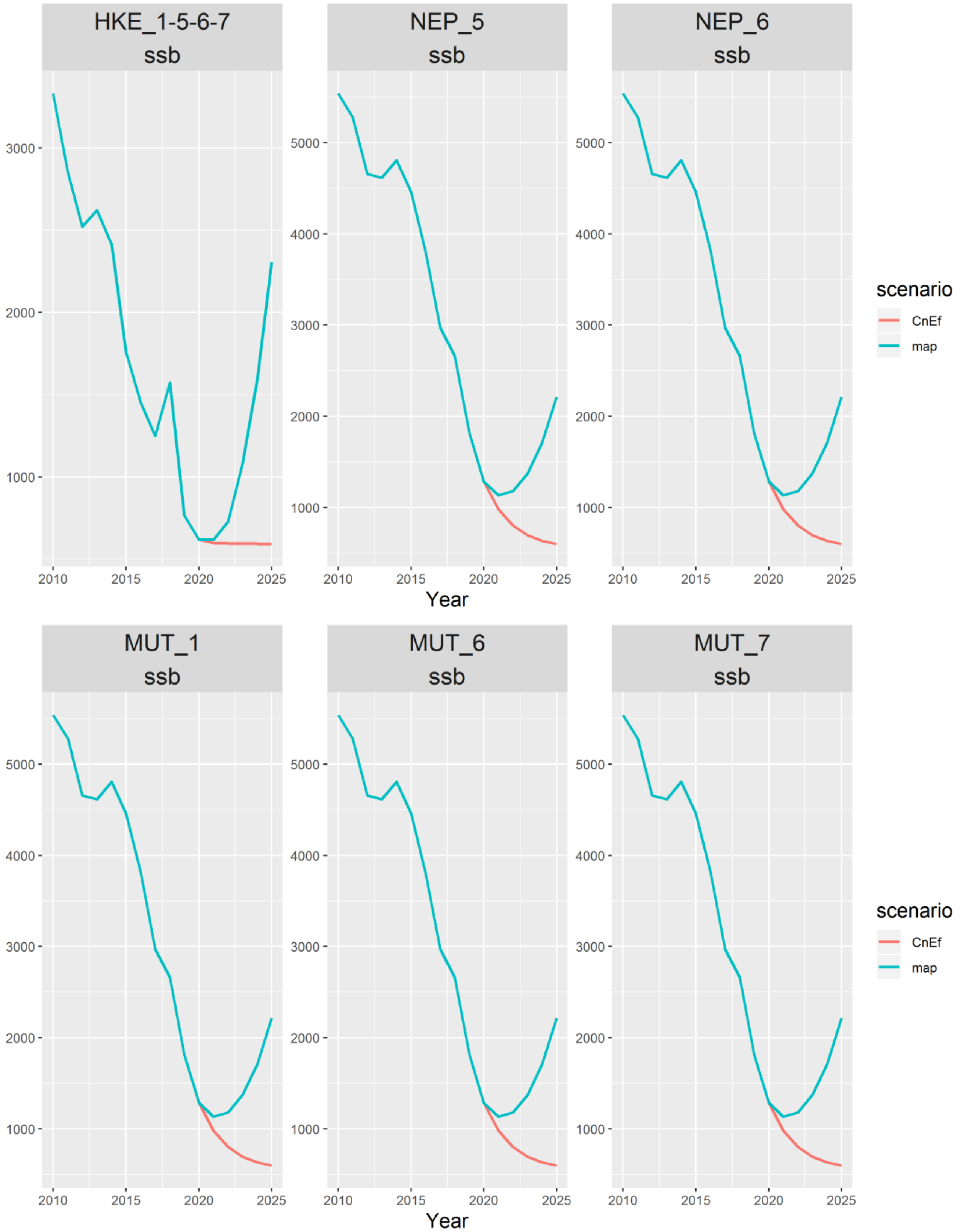

Figure 6. FLBEIA. Spawning stock biomass of the "HKE_1-5-6-7", "MUT_1", "MUT_6", "MUT_7", "NEP_5" and "NEP_6" stocks obtained with FLBEIA in constant effort and MAP scenarios.

3.5 Summary on the model: achievements, gaps still to be addressed, work plan from now to STECF 19-14 (October 2019)

The model was implemented with the available data. The implementation took one morning. To conduct a bio-economic impact assessment it would be necessary to disaggregate the exploitation of the fishing activity by fleet and metier. If the data were in the right shape, the implementation could be done in a short time using the functions available in FLBEIA to facilitate the conditioning of complex model implementations.

4 FLASHER IN EMU1

4.1 Overview of the model's generic characteristics and use

4.1.1 References

Only working report of STECF and IOTC

4.2 Application of the model to the West Med MAP

4.2.1 State of completion and additional development work specially undertaken before and during EWG 19-01

FLasher is able to simulate the EMU 1 Western Med Demersal mixed metier using the stock objects of previous assessments and the AER data for 4 stocks (HKE_1567, MUT_1, MUT_6, MUT_7). The reduction of the stock numbers was a proof of concept as it is easily extended to encompass all the required stocks. The main difficulty is the discrepancy between the stock assessments and the effort data: The catches in 2017 are known, but the effort is not. With FLasher this should be straight forward as it is possible to set the harvest control rule in terms of effort, fishing mortality, catch, and economic metrics. The HCR for this working group was parameterised as follows:

2017 – the same catches for all stocks as reported by the stock assessments (which should lead to a effort estimate)

2018-2019 – catches at the same effort level as in 2017

2020:2024 – reduction in effort levels compared to 2017

2025 – fishing at Fmsy level

FLasher exhibited an unusual result for the effort estimate in 2017 which needs further investigation. Thus the current results are not accurate and should not be used.

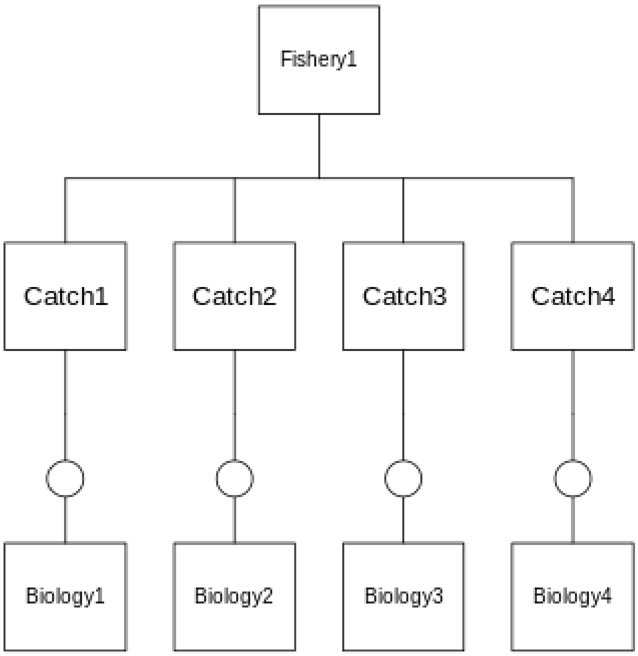

Figure 1 - Diagram of the relationship of the fisheries and stocks. As the catches are estimated and accounted for separately, the simulation keeps them separately. They are connected to one single fisheries, which means that the catch effort is the same for the 4 catches/stocks.

4.2.2 Space and time scale

The model updates yearly and has no spatial resolution.

4.2.3 Stocks (which stocks, which assessment data etc)

STECF assessment of Hake (GSA 1,5,6,7; stock object: GSAs_1-5-6-7_HKE), Red mullet (GSA 1,6,7 (separately); stock objects: Red Mullet GSA1, ESP_6_MUT, ESP_6_MUT), Nephrops (GSA 5,6 (separately); stock objects: ESP_5_NEP, ESP_6_NEP).

4.2.4 Fleets

EMU 1 level aggregated, AER data

4.3 **Comparison of model's short-term forecast with the single-stock advice predictions**

The forecast of catches with single stock advice works as long as the catches are set individually and not as a single aggregated fishery. A current bug causes the effort estimation to fail in the year 2017. I am currently working closely with the developers to alleviate the issue

4.4 **Baseline Run 2020-2024**

The baseline run was completed for 4 stocks (see above). It can be extended without much difficulty to incorporate all the stocks and catches. It cannot model the switch between the deep and shallow fisheries as the highest resolution is fisheries and not metier. As the fisheries are not directly linked, ie. they will have their own effort quota, it is possible to model them in separately. No economic data has been used (apart from effort) in the baseline run, but it can be included for the next meeting. The implemented HCR follows the MP agreed by the Commision. With the exception of the implementation of Fmsy in 2025 as agreed to by the STECF meeting.

4.5 **Alternative Runs**

4.5.1 Modellers' list of possible runs that can be implemented with the model and considered of direct relevance for the purpose of the West Med MAP

Exhaustive scenario testing is possible using FLasher. Possible options are selectivity shifts, natural mortality changing, recruitment changes, different stock recruitment relationships. Depending on the performance statistics and the goal of the forward projections, different selection of scenarios would be more sensible. Care needs to be taken as strong reductions in effort will lead to simulations that provide results outside the current data

4.5.2 Runs performed and analysed during EWG 19-01

Presentation and results

4.6 **Summary on the model: achievements, gaps still to be addressed, work plan from now to STECF 19-14 (October 2019)**

- Implement changes relevant to MAP in Flasher – end June
- Fixing effort estimations – mid June
- Fully implement all the Fisheries and metiers – mid July
- Full runs both metiers – end of July
- Scenarios runs– end August
- update model runs with new SA – mid september
- organising results to present to EWG - mid september
- Make code available (via Gitlab/hub) – end of end of August

5 NIMED IN EMU 2

5.1 Overview of the model's generic characteristics and use

5.1.1 Main features

Cf Table 4 above and STECF EWG 18-09 and 18-13 reports.

NIMED is a multi-species and multi-fleet bio-economic model developed within the Horizon 2020 research project "Science, Technology, and Society Initiative to minimize Unwanted Catches in European Fisheries (MINOUW)". The model was used in the project MINOUW to simulate management scenarios based on changes in selectivity and fishing effort for the demersal fisheries in GSA 9. During the EWG 18-09, additional scenarios on the reduction of fishing effort in GSA 9 demersal fisheries were simulated. Fleets included in the model were demersal trawlers divided in three length classes – 12-18m, 18-24m and 24-40m - and passive polyvalent vessels divided in two length classes, lower and greater than 12m. The model simulated the dynamics of five stocks: European hake, Norway lobster, surmullet, red mullet and deep-water rose shrimp.

5.1.2 References

Scientific, Technical and Economic Committee for Fisheries (STECF) – Fishing effort regime for demersal fisheries in the western Mediterranean Sea – Part II (STECF-18- 13). Publications Office of the European Union, Luxembourg, 2018, ISBN 978-92-79-79396-7, doi:10.2760/509604, JRC114702.

5.2 Application of the model to the West Med MAP

5.2.1 State of completion and additional development work specially undertaken before and during EWG 19-01

During the EWG 19-01, the model dimensions were extended to be adapted to the requirements of the Multi-Annual Management Plan for the western Mediterranean fisheries. Data for the Management Unit 2 (EMU2) was collected and economic parameters were estimated for the fleet segments involved in these fisheries. Furthermore, the stocks included in the model for simulations were changed according to the data available from the last stock-assessment. Two management scenarios were simulated: Status Quo scenario (no change in fishing effort) and Scenario 1 (10% reduction in fishing effort in 2020 and 7.5% reductions each year from 2021 to 2024).

5.2.2 Space and time scale

The model was used to simulate the effects of the management measures on all the stocks with known dynamics (available stock-assessment results) included in the western Mediterranean MAP and related to the Italian GSAs. The geographical area covered by the model consists in the EMU2 (GSAs 9, 10 and 11).

Regarding the time scale, the model works with an annual simulation step and projections can be run for an indefinite number of years. However, as the model used short-term forecasts for projecting stock population and catches, outcomes reliability decreases over time.

5.2.3 Stocks (which stocks, which assessment data etc)

The stocks included in the model are reported in Table 5. These are the stocks considered for the western Mediterranean MAP. Regarding the EMU2, the *Aristeus antennatus* is not considered. For the other species, stock-assessment outcomes are available at the geographical level reported in the column GSAs, except for Norway lobster. European hake, deep-water rose shrimp and giant red shrimp were analysed as single stocks in the EMU2, while two stocks are considered for both red mullet (separated stocks for GSAs 9 and 10) and Norway lobster (separated stocks for GSAs 9 and 11). However, stock-assessment results for Norway lobster were not available. Therefore, a total of 5 stocks was included in the model.

Table 5 – NIMED. Stocks included for the western Mediterranean MAP for the EMU 2

Common name	Scientific name	FAO code	GSAs	Model
European hake	Merluccius merluccius	HKE	(9-10-11)	Y
Red mullet	Mullus barbatus	MUT	9 - 10	Y - Y
Deep-water rose shrimp	Parapenaeus longirostris	DPS	(9-10-11)	Y
Norway lobster	Nephrops norvegicus	NEP	9 – 11	N - N
Giant red shrimp	Aristaeomorpha foliacea	ARS	(9-10-11)	Y
Blue and red shrimp	Aristeus antennatus	ARA	none	N

5.2.4 Fleets

The selection of the fleet segments to be included in the model for simulations was based on a combination of two criteria: 1) the relevance of the fleet segment in terms of contribution to the total landings of each of the stocks included in the model; 2) the relevance of the stocks included in the model on the revenues of the fleet segments.

Based on the first criterium, 13 fleet segments catching more than 2% of total landings for each stock were selected. Based on the second criterium, the fleet segment DTS VL0612 in GSA 9 was added to the list because the stocks selected impacted by more than 10% on its revenues. The combination of the two criteria determined the selection of the 14 fleet segments reported in Table 6.

In 2017, the selected fleet segments contributed to the 95% of the total landings of European hake in the area (GSAs 9, 10 and 11) and 99% of the total landings of red mullet in GSA 9. The landings of the other stocks included in the model are completely covered by the selected fleet segments. Even if the coverage of the total landings by stock is almost complete, the coverage of the total revenues by fleet segment is very limited. The 5 selected stocks represent a percentage of the total revenues varying from 4% for the PGP VL0612 in GSA 9 to 52% for the DTS VL2440 in GSA 11. Clearly, a low percentage of revenues covevered by the selected stocks produces also a low reliability of the simulated economic outcomes.

Table 6. – Coverage of total landings and total revenues in the NIMED model

GSA	Tech	LFT	HKE	MUT 9	MUT 10	DPS	NEP 9	NEP 11	ARS	Revenues
9	DTS	VL0612	0%	1%		0%	0%		0%	23%
9	DTS	VL1218	5%	45%		23%	44%		2%	29%
9	DTS	VL1824	19%	48%		35%	54%		3%	32%
9	DTS	VL2440	1%	3%		2%	2%		0%	35%
9	PGP	VL0612	3%	3%		0%	0%		0%	4%
9	PGP	VL1218	3%	1%		0%	0%		0%	13%
10	DTS	VL1218	4%		51%	21%			21%	44%
10	DTS	VL1824	6%		36%	15%			32%	47%
10	PGP	VL0006	3%		5%	0%			0%	9%
10	PGP	VL0612	29%		7%	0%			0%	17%
10	PGP	VL1218	3%		1%	0%			0%	5%
11	DTS	VL1218	7%			1%		25%	4%	14%
11	DTS	VL1824	5%			1%		35%	9%	19%
11	DTS	VL2440	5%			2%		40%	28%	52%
COVERAGE			**95%**	**99%**	**100%**	**100%**	**100%**	**100%**	**100%**	

5.3 Comparison of model's short-term forecast with the single-stock advice predictions

The comparison of the NIMED model's short-term forecast with the single-stock advice predictions was carried out in terms of total catches in the period 2017-2020. In the model, the assumptions regarding the age classes used for the calculation of F as well as the methods for estimating the weight at age and the recruits were set accordingly to those used in the stock-assessment. The values of catch for each of the 4 years by stock and the differences in percentage are reported in Table 7. The differences are very small for all stocks, except for red mullet in GSA 10. For that stock, as it was not clear which variation in F was applied during the stock-assessment for simulating the short-term projections, a comparison was carried out considering both an increase in F by 120% (v1), from 0.25 to 0.54, and an increase by 84% (v2).

Table 7 – Comparison of NIMED and stock-assessment predictions of catch.

HKE	**2017**	**2018**	**2019**	**2020**		**ARS**	**2017**	**2018**	**2019**	**2020**
Nimed	1778	1703	510	764		Nimed	399	283	172	216
a4a	1782	1696	494	762		a4a	399	283	171	215
%	100%	100%	103%	100%		%	100%	100%	101%	100%
DPS	**2017**	**2018**	**2019**	**2020**		**MUT 9**	**2017**	**2018**	**2019**	**2020**
Nimed	1508	847	640	861		Nimed	1773	1683	808	1093
a4a	1508	858	644	865		a4a	1773	1675	812	1081
%	100%	99%	99%	100%		%	100%	100%	99%	101%
MUT 10 v1	**2017**	**2018**	**2019**	**2020**		**MUT 10 v2**	**2017**	**2018**	**2019**	**2020**
Nimed	606	659	1259	984		Nimed	606	659	1095	912
a4a	596	646	1056	881		a4a	596	646	1056	881
%	102%	102%	119%	112%		%	102%	102%	104%	104%

5.4 Baseline Run 2020-2024

The MAP proposal includes the following for the five-year transitional period:

- Average fishing days 2015-2017
- 10 % reduction in 2020
- 7.5% reduction per year between 2021 and 2024

The model was used to simulate two scenarios related to the points listed above: Status Quo (SQ), where no change in fishing effort compared to the average 2015-2017 is applied, and Scenario 1 (S1), where the additional two points in the MAP proposal are simulated (10% reduction in fishing effort in 2020 and 7.5% reductions each year from 2021 to 2024).

5.5 Alternative Runs

No alternative scenario to SQ and S1 were simulated through NIMED during the EWG 19-01.

5.5.1 Modellers' list of possible runs that can be implemented with the model and considered of direct relevance for the purpose of the West Med MAP

The NIMED model can be used to simulate management scenarios based on changes in selectivity and fishing effort. Scenarios on alternative paths to achieve the same reductions in fishing effort or stronger reductions in fishing effort can be simulated.

5.5.2 Runs performed and analysed during EWG 19-01

During EWG 19-01, two management scenarios were simulated: Status Quo (SQ: no change in fishing effort) and Scenario 1 (S1: 10% reduction in fishing effort in 2020 and 7.5% reductions each year from 2021 to 2024). The main outcomes of the simulations are reported in Tables and Figure below. The tables show the values for the baseline (average 2015-2017) and the two scenarios in 2024, and the variations of the two scenarios compared to the baseline.

Table 8 shows that the reductions in fishing effort (days at sea), amounting to a total of 40% in 2024 compared to the baseline, which are assumed to be applied equally to all fleet segments.

Table 9 shows the potential impact of the two scenarios on the total landings in value. Under SQ, limited variations between -3% and +1% in revenues are expected in 2024. Under S1, landings value for the whole demersal fleet is expected to decline by 14%. Around this value, variations by fleet segment depend on the specific composition of landings.

The ratios between current revenues and break-even revenues (CR/BER), which measure the ability of the fleets to produce enough income to cover fixed and variable costs, are reported in Table 6. Values in red (the indicator is lower than 1) indicate that revenues are not enough to cover the costs. This condition, registered on the baseline for DTS VL2440 in GSAs 9 and 11, PGP VL1218 in GSA 9 and DTS VL1824 in GSA 11, is expected to be held also in 2024 under both scenarios. The CR/BER shows a negative economic performance under both scenarios. The indicator calculated for the whole fleet indicates reductions by 3% and 4% under the SQ and S1 respectively. Almost all fleet segments are expected to register a decrease in the indicator under SQ, while some cases of relevant increases are expected under S1. These are related to the DTS VL2440 in GSAs 9 and 11.

The average salary per employee for the whole demersal fleet is also expected to register limited reductions by 3% and 4% under SQ and S1 respectively. Improvements in this indicator are expected for the larger trawlers, DTS VL2440, in GSAs 9 and 11, while the worse performance is expected for PGP VL1218 in GSA 10.

The net profits are expected to register a reduction by 10% under SQ and 14% under S1. As reported in Figure 7, the strongest reduction under S1 is expected for the trawlers operating in GSA 11 (-39%), followed by the polyvalent vessels in GSAs 9 and 10 (-13% and -24% respectively). On the contrary, trawlers in GSAs 9 and 10 are expected to increase their profits by 3% and 9% respectively. Under SQ, profits are expected to decline for all groups of vessels except for trawlers in GSA 10, where the model projects an increase by 7%.

Table 8 – NIMED. Days at sea by fleet segment

Fleet Segment	Baseline	SQ 2024	S1 2024	SQ 2024 %	S1 2024 %
9_DTSVL0612	1687	1687	1012	0%	-40%
9_DTSVL1218	22586	22586	13552	0%	-40%
9_DTSVL1824	23777	23777	14266	0%	-40%
9_DTSVL2440	1676	1676	1005	0%	-40%
9_PGPVL0612	101559	101559	60935	0%	-40%
9_PGPVL1218	6172	6172	3703	0%	-40%
10_DTSVL1218	23097	23097	13858	0%	-40%
10_DTSVL1824	11621	11621	6973	0%	-40%
10_PGPVL0006	68499	68499	41099	0%	-40%

10_PGPVL0612	170350	170350	102210	0%	-40%
10_PGPVL1218	11613	11613	6968	0%	-40%
11_DTSVL1218	9428	9428	5657	0%	-40%
11_DTSVL1824	3711	3711	2227	0%	-40%
11_DTSVL2440	3455	3455	2073	0%	-40%

Table 9 – NIMED. Total landings in value by fleet segment.

Fleet Segment	Baseline	SQ 2024	S1 2024	SQ 2024 %	S1 2024 %
9_DTSVL0612	845249	824192	736136	-2%	-13%
9_DTSVL1218	22129859	21715070	18709681	-2%	-15%
9_DTSVL1824	30862934	30475893	26624284	-1%	-14%
9_DTSVL2440	1978964	1955244	1772175	-1%	-10%
9_PGPVL0612	22415454	21534293	19872740	-4%	-11%
9_PGPVL1218	3960861	3821755	3585587	-4%	-9%
10_DTSVL1218	11959964	12083684	10348542	1%	-13%
10_DTSVL1824	14843281	14930341	12886965	1%	-13%
10_PGPVL0006	9770039	9448724	8584205	-3%	-12%
10_PGPVL0612	32737828	31626751	29578061	-3%	-10%
10_PGPVL1218	9872119	9538126	7175582	-3%	-27%
11_DTSVL1218	8551014	8410305	7086796	-2%	-17%
11_DTSVL1824	5318423	5284878	4203834	-1%	-21%
11_DTSVL2440	6386650	6416775	5638002	0%	-12%

Table 10 – NIMED. Current Revenues on Break Even Revenues by fleet segment

Fleet Segment	Baseline	SQ 2024	S1 2024	SQ 2024 %	S1 2024 %
9_DTSVL0612	2.18	2.10	1.97	-4%	-10%
9_DTSVL1218	2.61	2.54	2.44	-3%	-6%
9_DTSVL1824	1.06	1.03	1.14	-3%	8%
9_DTSVL2440	0.42	0.41	0.52	-3%	23%
9_PGPVL0612	1.42	1.34	1.36	-6%	-4%
9_PGPVL1218	0.85	0.81	0.89	-6%	4%
10_DTSVL1218	1.62	1.65	1.62	2%	0%
10_DTSVL1824	1.05	1.07	1.09	1%	4%
10_PGPVL0006	2.80	2.69	2.51	-4%	-10%
10_PGPVL0612	1.55	1.48	1.46	-4%	-5%
10_PGPVL1218	1.91	1.82	1.39	-5%	-27%
11_DTSVL1218	2.79	2.72	2.47	-3%	-11%
11_DTSVL1824	0.95	0.94	0.78	-1%	-17%
11_DTSVL2440	0.57	0.58	0.67	2%	17%

Table 11 –NIMED. Average salary by fleet segment

Fleet Segment	Baseline	SQ 2024	S1 2024	SQ 2024 %	S1 2024 %
9_DTSVL0612	10154	9851	9388	-3%	-8%
9_DTSVL1218	19135	18638	17990	-3%	-6%
9_DTSVL1824	17958	17556	19188	-2%	7%

9_DTSVL2440	12639	12335	15077	-2%	19%
9_PGPVL0612	6167	5860	5937	-5%	-4%
9_PGPVL1218	9749	9258	10123	-5%	4%
10_DTSVL1218	5827	5918	5834	2%	0%
10_DTSVL1824	11129	11234	11451	1%	3%
10_PGPVL0006	4779	4606	4336	-4%	-9%
10_PGPVL0612	5283	5075	5031	-4%	-5%
10_PGPVL1218	8897	8530	6716	-4%	-25%
11_DTSVL1218	11534	11281	10435	-2%	-10%
11_DTSVL1824	12592	12478	11000	-1%	-13%
11_DTSVL2440	14599	14719	15966	1%	9%

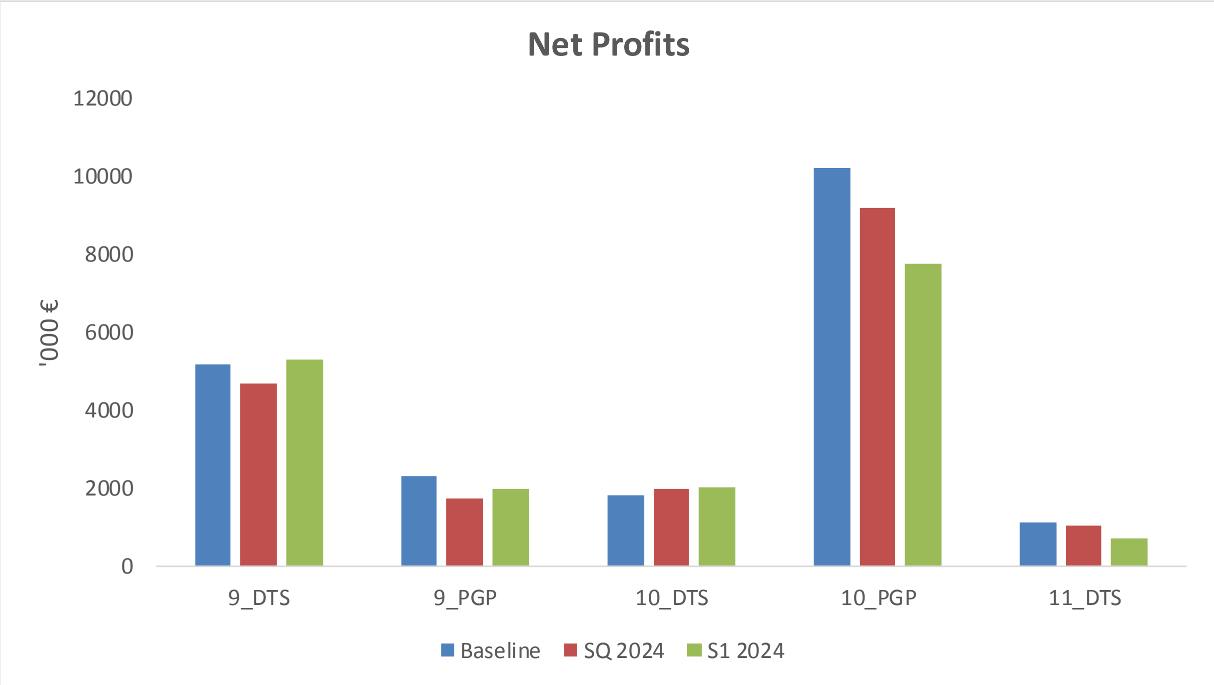

Figure 7 – NIMED. Net profits by fleet segments groups (GSA and fishing technique) under different scenarios.

5.6 Summary on the model: achievements, gaps still to be addressed, work plan from now to STECF 19-14 (October 2019)

The model was used to estimate the expected economic outcomes of two scenarios, Status Quo and the scenario including the fishing effort reductions of the MAP proposal, for the most relevant fleet segments operating in the demersal fisheries in EMU2. However, the standard version of NIMED needs catch at age by stock and fishing gear (at least for the most relevant ones) as inputs. During the EWG 19-01, data provided from the stock assessments did not achieve this level of detail. Catch at age was provided by stock without the quotas from each fishing gear.

The gap was overcome using an "equivalent effort" measure. However, this solution shows some limitations because it does not consider the different selectivity of the fleet segments. As the same data format on the stock assessment outcomes is expected for the STECF EWG 19-14, an adaptation of the model will be carried out. Furthermore, the outputs of the NIMED model will be compared with the outputs of other models proposed during the EWG 19-01, like BEMTOOL, for a validation of the results.

6 BEMTOOL IN EMU2

6.1 Overview of the model's generic characteristics and use

6.1.1 Main features

BEMTOOL is a multi-species multi-gear bio-economic simulation model for mixed fisheries, which resumes and integrates the different bio-economic models and biological modelling tools developed for Mediterranean fisheries[1]. It consists of six operational modules characterized by components communicating by means of relationships and equations: Biological (age/length structured dynamic model, Lembo et al., 2009), Impact, Economic, Behavioural, Policy and Multi Criteria Decision Analysis (MCDA) (Rossetto et.al, 2014; Russo et.al, 2017). BEMTOOL follows a multi-fleet approach simulating the effects of management options on stocks and fisheries on a fine time scale (month). The model accounts for length/age-specific selection effects, discards, economic and social performances, effects of compliance with landing obligation and reference points. The model can consider a large number of fleet groups. The implementation of a decision module (Multi-Criteria Decision Analysis and Multi-attribute utility theory) allows stakeholders to weight model-based indicators and rank different management strategies. The model can simulate management scenarios based on changes in fishing pattern, fishing effort, fishing mortality and TAC. A wide set of biological, pressure and economic indicators is the default output. The uncertainty (process error) implemented in the model following Monte Carlo paradigm allows a risk evaluation in terms of biological sustainability of the different management strategies accounting for the economic performances.

In BEMTOOLv.3 (Spedicato et.al, 2017) the uncertainty component has been expanded, allowing an approach comparable to MSE. The process error is implemented on recruitment, individual growth and natural mortality, while the model error on maturity ogive and selectivity functions. Uncertainty can be applied according to three different probability distributions: normal, lognormal and uniform. BEMTOOLv.3 platform allows also the implementation of a scenario based on a TAC set according to an MSE approach (GFCM, 2018). Every year the model checks that the SSB level and the fishing mortality are within safe biological limits, so the TAC is set accordingly. Further information on the model applications can be found in STECF (2018).

6.1.2 References

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[1] Tender DGMARE 2009/05/Lot1. MAREA Framework Contract. Accadia P., Bitetto I., Facchini M.T., Gambino M., Kavadas S., Lembo G., Maynou F., Melià P., Maravelias C., Rossetto M., Sartor P., Sbrana M., Spedicato M.T., BEMTOOL Deliverable D10: BEMTOOL FINAL REPORT. February 2013. 46 pp.

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STECF, 2018 – Fishing effort regime for demersal fisheries in the western Mediterranean Sea – Part II (STECF-18-13). Publications Office of the European Union, Luxembourg, 2018, ISBN 978-92-79-79396-7, doi:10.2760/509604, JRC114702

6.2 **Application of the model to the West Med MAP**

6.2.1 State of completion and additional development work specially undertaken before and during EWG 19-01

Before and during the EWG 19-01, DCF data (landings, discards, fishing effort, biological and economic parameters) and results from the assessments carried out in the EWG 18-12 were analysed, to allow the parameterization of the mixed fishery bio-economic simulation model BEMTOOL. This was first parameterized in the hindcasting mode for 4 species (European hake, red mullet, deep-water rose shrimp and giant red shrimp) of the Multiannual Management Plan (MAP) in the eastern part of the western Mediterranean (GSAs 9-10-11), to compare the assessed fishing mortality, spawning stock biomass and the observed catches with the simulated ones. Runs of the model in the short-terms were done for comparison to the short-term forecasts of EWG 18-12. Results were in agreement. Three scenarios referred to the baseline run 2020-2024 have been implemented. Four additional scenarios that included also the simulation of hyperstability (STECF 18-03) were also run for the transition MAP period 2020-2024. These tests were only deterministic to get a first feedback on the model settings and scenarios' design and feasibility. Stochastic runs were left to the next phase. Estimates of stock-recruitment relationships were initiated using the Eqsim approach, to test their possible use in the next STECF EWG 19-14.

6.2.2 Space and time scale

The space scale the eastern side of the western Mediterranean. This area is belonging to the FAO fishing area 37.1; sub-division 1.1 and 1.3; it includes three geographical subareas (GSA) according to the GFCM convention[2]: GSA9 – Ligurian Sea and North Tyrrhenian Sea; GSA10 – Southern and Central Tyrrhenian Sea and GSA11, composed by Western (GSA11.1) and Eastern (GSA11.2) Sardinia.

The time scale of the available DCF data goes from 2006 to 2017. The time scale of the model encompass the same time range for the hindcasting. For 2018 and 2019 an invariant situation compared to 2017 is assumed. The forecasts are covering the period from 2020 to 2024, corresponding to the transitional phase of the Multiannual Management Plan. The time unit of the model is the month.

6.2.3 Stocks (which stocks, which assessment data etc)

The stocks taken into consideration in BEMTOOL simulations are:

- European hake in GSAs 9, 10 and 11;
- Red mullet in GSA9;
- Red mullet in GSA10;
- Deep-water rose shrimp in GSAs 9, 10 and 11;

[2] Res. GFCM/33/2009/2 on the establishment of geographical subareas in the GFCM area of application

- Giant red shrimp in GSAs 9, 10 and 11

These are the ones for which stock assessment results from EWG 18-12 are available and can be used to parameterize BEMTOOL model.

Norway lobster is a stock considered in the MAP for GSA9 and GSA11, but it has not been included in the present exercise, as an analytical assessment was not available.

The relevant results of the assessment for the model parameterization, i.e. the current fishing mortality (F_{curr}) and the reference point (**$F_{0.1}$**) are reported in the Table 12.

This table also reports the upper and lower range of F_{MSY}, according to the formulas used in EWG 18-02:

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

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

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

and the needed reduction to reach $F_{0.1}$.

Considering the ratio between the current fishing mortality and the reference point ($F_{curr}/F_{0.1}$ and $F_{curr}/F_{0.1upper}$) European hake is the stock more at risk (ratio=3.9; 2.75), while giant red shrimp (ratio=1.96; 1.45) is the stock less impacted, after red mullet in the GSA 10, which is a stock actually less impacted, because sustainably exploited (ratio=0.46; 0.34).

Table 12 Results of the assessments from EWG 18-02 relevant for BEMTOOL parameterization. The computation of the reduction by stock to reach $F_{0.1}$ is also reported.

Stock	F_{curr}	$F_{0.1}$	$F_{curr}/F_{0.1}$	$F_{0.1lower}$	$F_{0.1upper}$	F_{curr}/F_{upper}	% red to $F_{0.1}$
Hake9-10-11	0.55	0.14	3.93	0.10	0.20	2.75	75
RedMullet10	0.25	0.54	0.46	0.36	0.74	0.34	0
RedMullet9	1.57	0.54	2.91	0.36	0.74	2.12	66
Deep-water rose shrimp9-10-11	1.68	0.74	2.27	0.49	1.01	1.66	56
GiantRedShrimp9-10-11	1.12	0.57	1.96	0.38	0.77	1.45	49

6.2.4 Fleets

In the simulation and forecast scenarios the following fleet segments have been considered:

GSA9_DTS_1824	GSA10_DTS_VL1218	GSA11_DTS_VL1218
GSA9_DTS_VL1218	GSA10_DTS_VL1824	GSA11_DTS_VL1824
GSA9_DTS_VL2440	GSA10_PGP_VL0006	GSA11_DTS_VL2440
GSA9_PGP_VL0012	GSA10_PGP_VL0612	GSA11_PGP_VL0012
GSA9_PGP_VL1218		GSA11_PGP_VL1218

The dependency of landings and revenues on the pool of the assessed/target species in the MAP proposal is differentiated according to the fleet segment and it is generally more marked for the fleets targeting European hake and crustaceans (Table 13) If the geographical areas are considered, dependency in GSA9 and GSA10 is more marked compared to GSA11, where a higher dependency is observed only for the bigger trawlers (OTB_VL2440).

Table 13 - Percentage of landings and revenues of the pool of the target species of the MAP in respect to the total landing (demersal and bento-pelagic species) and total revenues by GSA and fleet segment (source: authors from the data of the Annual Economic Report 2018, data refer to 2016).

	% target species landings/total landings			% target species revenues /total revenues		
	GSA9	GSA10	GSA11	GSA9	GSA10	GSA11
OTB_VL0612	*18.57*	*44.61*	-	*13.49*	*48.84*	-
OTB_VL1218	*41.06*	*37.09*	*10.98*	*44.26*	*44.67*	*14.77*
OTB_VL1824	*36.37*	*37.51*	*5.86*	*35.09*	*40.47*	*7.88*
OTB_VL2440	*49.71*	-	*33.74*	*49.99*	-	*41.76*
GNS_VL0006	*10.35*	*16.73*	-	*12.56*	*15.35*	-
GNS_VL0612	*16.78*	*30.92*	*0.16*	*23.28*	*28.53*	*0.12*
GNS_VL1218	*23.99*	*44.27*	*6.14*	*24.26*	*39.79*	*5.68*
GTR_VL0006	*0.75*	*7.08*	*4.12*	*0.86*	*8.59*	*2.78*
GTR_VL0612	*8.94*	*14.81*	*2.26*	*7.23*	*18.86*	*1.42*
GTR_VL1218	*2.19*	-	*17.68*	*1.38*	-	*10.62*
LLS_VL0006	-	*3.66*	-	-	*2.35*	-
LLS_VL0612	*1.07*	*25.10*	-	*2.58*	*38.92*	-
LLS_VL1218	*17.71*	*41.05*	*0.66*	*30.54*	*57.82*	*0.44*
Total	***31.02***	***28.52***	***11.59***	***31.02***	***31.63***	***13.15***

6.3 Comparison of model's short-term forecast with the single-stock advice predictions

Table 14 reports the results of the comparison between the short terms forecasts in EWG 18-02 with the results from BEMTOOL in this working group. The level of change of catches between 2017 and 2019 agrees between the short-term forecasts and BEMTOOL for the five stocks assessed also the status of SSB showed the same direction in the two approaches.

Table 14 – Comparison of the short terms forecasts of EWG 18-02 with the results from BEMTOOL (EWG 19-01).

			Catch 2017		**Catch 2019**		**% Catch change**		**SSB status**	
Stock	F red.	F0.1	EWG 18-02	BEMTOOL	EWG 18-02	BEMTOOL	EWG 18-02	BEMTOOL	EWG 18-02	BEMTOOL
Hake	-75%	0.14	1782	1825	494	488	-72%	-73%	Decreas.	Decreas.
Red mullet9	-66%	0.54	1601	1743	812	959	-49%	-45%	Increas.	Increas.
Red mullet10	84%	0.54	596	353	1056	763	-	116%	Increas.	Increas.
Deep-water rose shrimp9-10-11	-56%	0.74	1507	1487	644	659	-57%	-56%	Decreas.	Decreas.

Giant red shrimp	-49%	0.57	399	575	171	257	-57%	-55%	Decreas.	Decreas.

6.4 Baseline Run 2020-2024

Three scenarios have been implemented to test the possibility of matching the MAP requirements. For sake of available time the running were deterministic to get a first feedback on:

1) the completeness and coherence of inputs and of the BEMTOOL parameterization;
2) the different scenarios settings to restrict the focus on a more suitable set in a next phase.

Given the computation time, stochastic run can be performed in the second step.

Scenarios related to the baseline run 2020-2024 were the following:

S0: StatusQuo, with the days at sea in 2019 equal to the average of 2015-2017;

S1: Baseline, with days at sea in 2019 equal to the average of 2015-2017, reduction of trawlers' activity (days at sea) equally distributed among the fleet segments: 10% in 2020; 30% by 2024

S2: Baseline differentiated by DTS Fleet Segments.

For **S2** the basis was given by the different impacts that the fleet segments have in terms of fishing mortality on the pool of the target species of the MAP (on the basis of the overall impact on the MAP species, excluding *N. norvegicus;* see Figure 8)

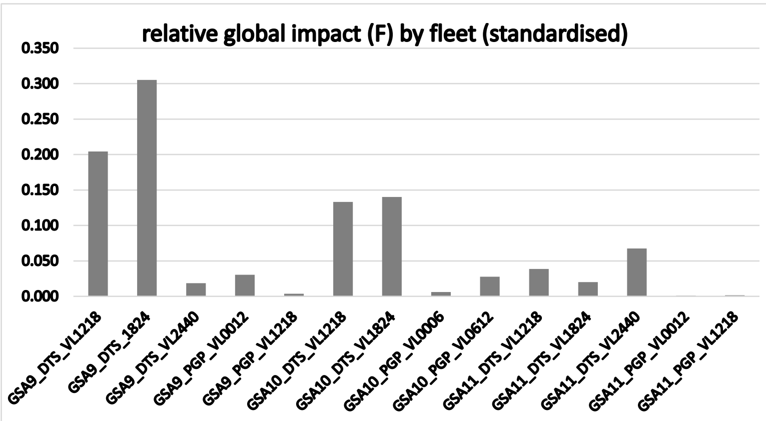


Figure 8 – BEMTOOL. Relative impact of the different fleet segments on the fishing mortality pooled for the different species of the MAP (excluding *N. norvegicus*).

6.5 Alternative Runs

Four scenarios have been implemented:

S3: Baseline differentiated by DTS Fleet Segments focusing the reductions in the months of European hake and giant red shrimp recruitment;

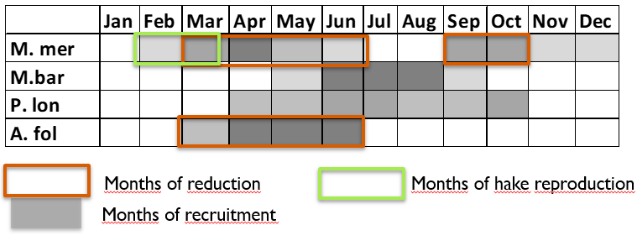
S4: As S2 + Fishing Ban of PGP in winter months;

S5: As S2, assuming hyperstability of F;

S6: As S2 + closure of areas within 100 m.

For **S3** the basis was given by the knowledge of the recruitment peaks of European hake and giant red shrimp in the region (Figure 9).

Figure 9. BEMTOOL. Scheme of the calendar in which the reductions at month level were applied in S3.



Regarding scenario **S4** the basis was given by the fact that the production of PGP is representing 40% of European hake production; the ban was placed in February-March, which are considered the main spawning months of European hake.

In scenario **S5**, the basis was given by the assumption of hyperstability in the relationship between fishing mortality and fishing effort taking, as an example, for all the stocks and DTS fleet segments, the following coefficients: a=1 and b=0.5 in a relationship of the form: $F=a*E^b$ (STECF EWG 18-03, 2018).

In BEMTOOL the coefficient *b* has been applied to the factor $f_{act,f}$ of the following equation, which internally the model recalculates the fishing mortality:

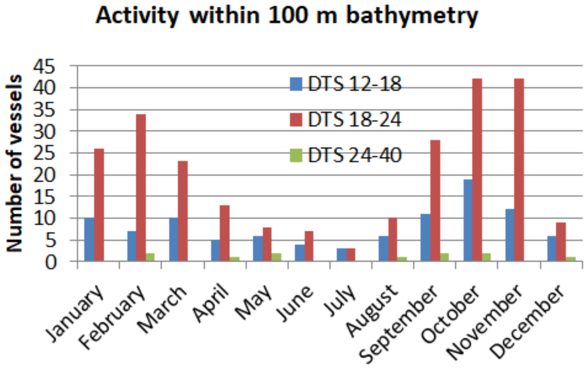
$$F_f(a) = (Z_{\text{inp}} - \text{mean}(M)) * \text{Sel}_f(a) * f_{\text{act},f} * p_f;$$

where $f_{act,f}$ in the forecast is the ratio between the product of the number of fishing days, the number of vessels and the average GT (or Kw) of the fleet segment *f* for each month of forecast to the product of the number of fishing days, the number of vessels and the average GT (or Kw) of the fleet segment *f* in the last year of the simulation, which is considered as reference for the application of change in fishing effort. $Sel_{f(a)}$ is the fleet selectivity at a given length/age; p_f is the monthly ratio between the fleet segment catch to the total catch in the simulation (in the forecast it is fixed as an average of the last (*n*) years).

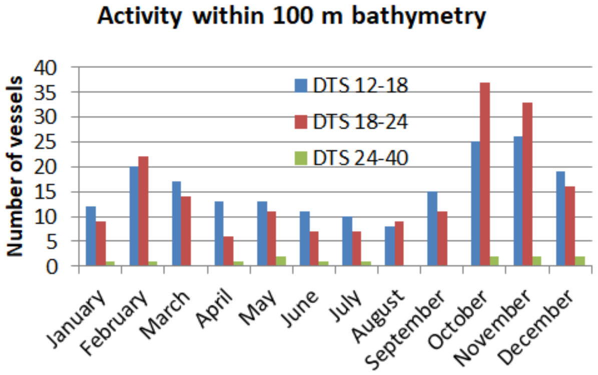
Regarding the scenario **S6** the basis was given by the knowledge on the distribution of the juveniles of key species and the fleet activity by month in the depth range 50-100 m (VMS data, Figure 10):

- for DTS GSA 9 in June and July (to still protect recruitment of red mullet in GSA 9)
- for DTS GSA 10 from April to June (to partially protect recruitment of deep-water rose shrimp, considering that in GSA10 red mullet is exploited sustainably).

In addition, the activity within 50-100 m depth of the different fleet segments in the GSA9 and GSA10 was taken into account to tune the selectivity of the involved fleets.



GSA 9
DTS 1218: 27 %
DTS 1824: 69 %
DTS 2440: 0%



GSA 10
DTS 1218: 49 %
DTS 1824: 47 %
DTS 2440: 0%

Figure 10 – BEMTOOL. Basis for changing the exploitation pattern in scenario S6. Activity within 100m depth of the different fleets according to the month, as observed in the last two years.

The recruitment used for the projection was the same as for the short-term forecasts

6.5.1 Modellers' list of possible runs that can be implemented with the model and considered of direct relevance for the purpose of the West Med MAP

Other possible runs that can be implemented using BEMTOOL and considered relevant for the MAP are:

- Exploring the effects of changes in the exploitation pattern of European hake associated to the closure of nurseries and/or changes in gear selectivity (e.g. mesh size) to rescale the ratio of the current F to the reference point;

- Still severe reductions should be implemented (a situation close to a moratoria), because for European hake the reduction of the fishing activity in the transition phase of the MAP will be not enough to bring the stock to the $F_{MSY;}$

- Management measures on the whole fleet exploiting the relevant stocks of the MAP; indeed, in the application of BEMTOOL explored during the STECF EWG 19-01, also fleet segments using gears different from trawlers were included, because were found to impact on European hake stock;

- Scenarios of reaching F_{MSY} upper of European hake and giant red shrimp, simulate combinations of the abovementioned scenarios.

6.5.2 Runs performed and analysed during EWG 19-01

Regarding the reduction of fishing mortality, the higher value for the more vulnerable stock (European hake) is obtained in the scenario S4, while the lowest percentage of reduction in the scenario with hyperstability S5 (Table 15). For the less vulnerable stock (except red mullet in GSA10 which is currently exploited sustainably) the higher change was achieved in the S1 scenario (Figure 11). The stock of red mullet in GSA10 would be negatively impacted by all scenarios.

For the stock of *A. foliacea* the reduction of fishing activity applied in the transition phase of the MAP would contribute to get close to the reference point. For European hake, instead, even the higher reduction of activity (not assuming hyperstability) would not reach the reference point. The exploitation of this stock would though be quite far from this target (F at 2024 around 0.4 compared to $F_{0.1}$ upper of about 0.2). This would mean the needing of introducing changes in the exploitation pattern to mitigate a possible severe reduction of fishing activity to reach F_{MSY} in the phase following the transition.

Table 15 – BEMTOOL. Changes (in percentage) of the fishing mortality F of the 5 stocks in the 6 tested scenario compared to the status quo S0. This is referred to 2024.

Stock	S0 – Status Quo F	S1 – Baseline	S2 – Baseline Diff	S3 – Baseline Diff_FS_period	S4 - Baseline_ FB_PGP	S5 - Baseline_ Hyp	S6 – Baseline Closure100
A. fol	1.11	**-40%**	-24%	-23%	**-40%**	-23%	**-40%**
M. bar10	0.20	**-35%**	-31%	-15%	**-35%**	-20%	**-35%**
M. bar9	1.38	-32%	-36%	**-37%**	-32%	-18%	-35%
M. mer	0.55	-24%	-18%	-19%	**-27%**	-14%	-24%
P. lon	1.60	-40%	-41%	-36%	-40%	-23%	**-42%**

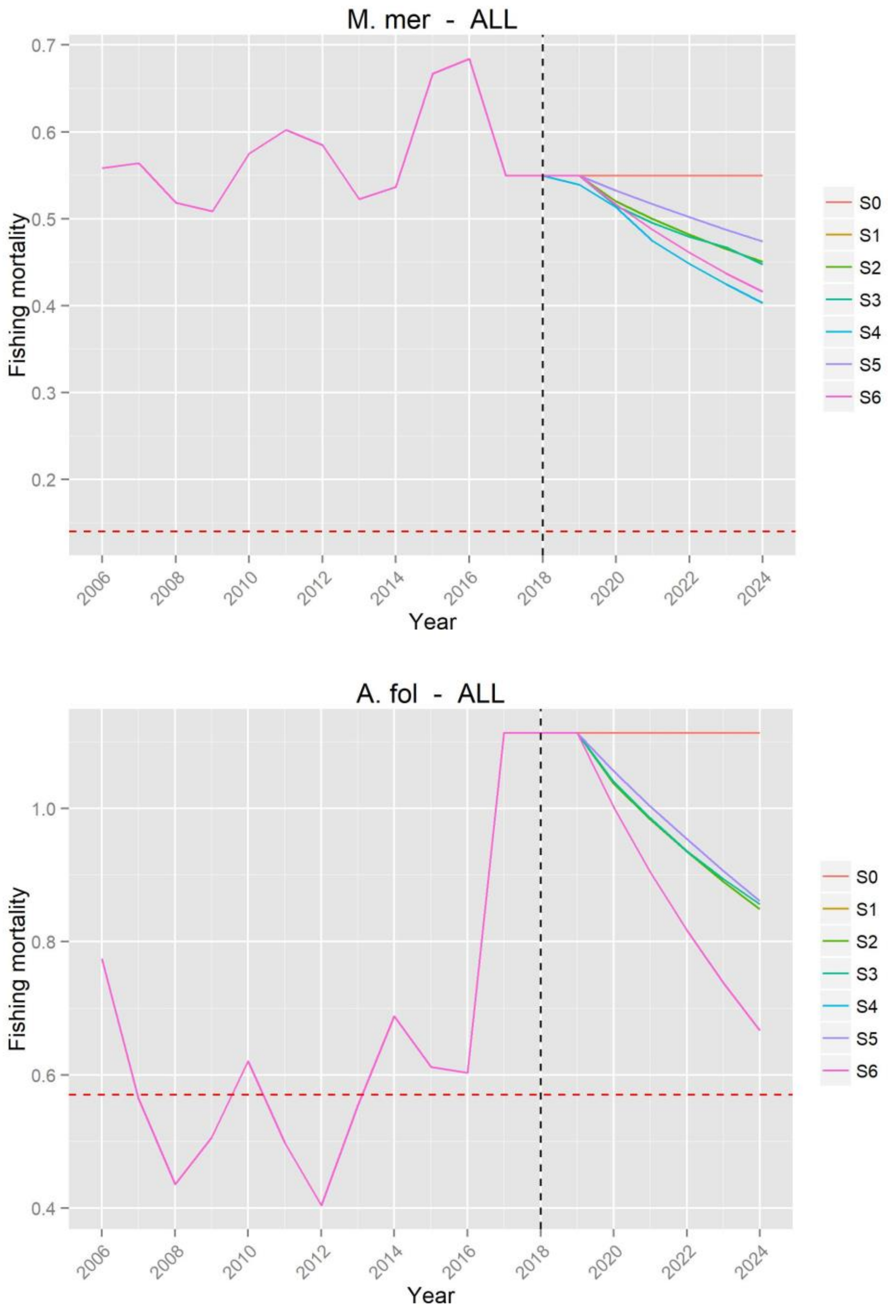
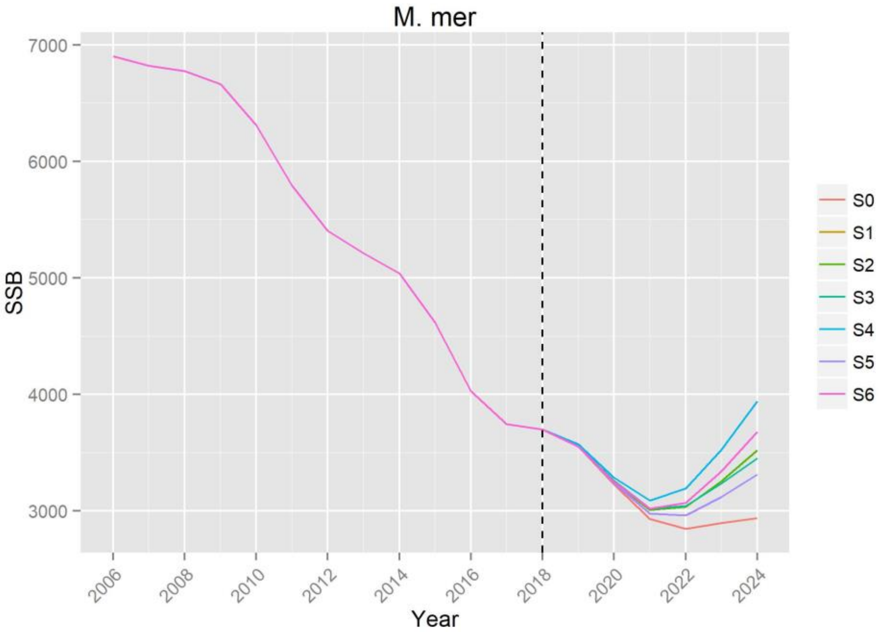


Figure 11. BEMTOOL. Trajectories of the Fishing mortality for the 2 stocks in the hindcasting phase (until 2018) and in the forecast phase (after 2018). The horizontal dotted line represents the reference point $F_{0.1}$.

Regarding SSB all scenarios gave better results than S0. For European hake the better results would be achieved in the scenario S4, when also the PGP fisheries are reduced. For A. foliacea te better ressults would be achieved n S1, S4 and S6 that for this stock would be equivalent (Table 16 and Figure 12).

Table 16. BEMTOOL. Changes (in percentage) of the SSB of the 5 stocks in the 6 tested scenarios compared to the status quo S0. This is referred to 2024 (the SSB in S0 is reported in tons).

Stock	S0 – Status Quo SSB	S1 – Baseline	S2 – Baseline Diff	S3 – Baseline Diff_FS_period	S4 - Baseline_ FB_PGP	S5 - Baseline_ Hyp	S6 – Baseline Closure100
A. fol	111	**89%**	45%	39%	**89%**	41%	**89%**
M. bar10	2024	14%	12%	13%	**14%**	7%	14%
M. bar9	1551	38%	46%	**55%**	39%	19%	44%
M. mer	3011	25%	20%	17%	**35%**	13%	25%
P. lon	1145	28%	30%	32%	28%	14%	**35%**



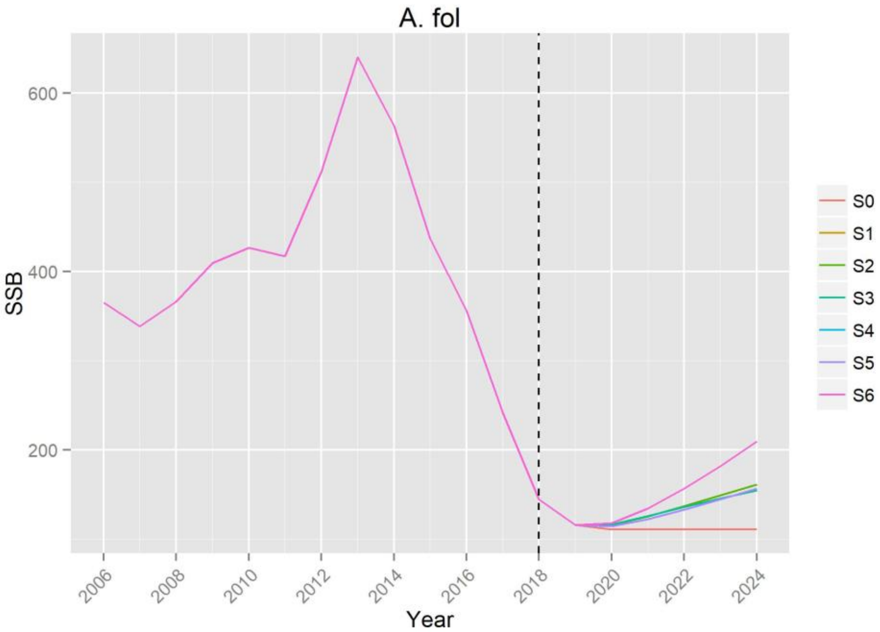
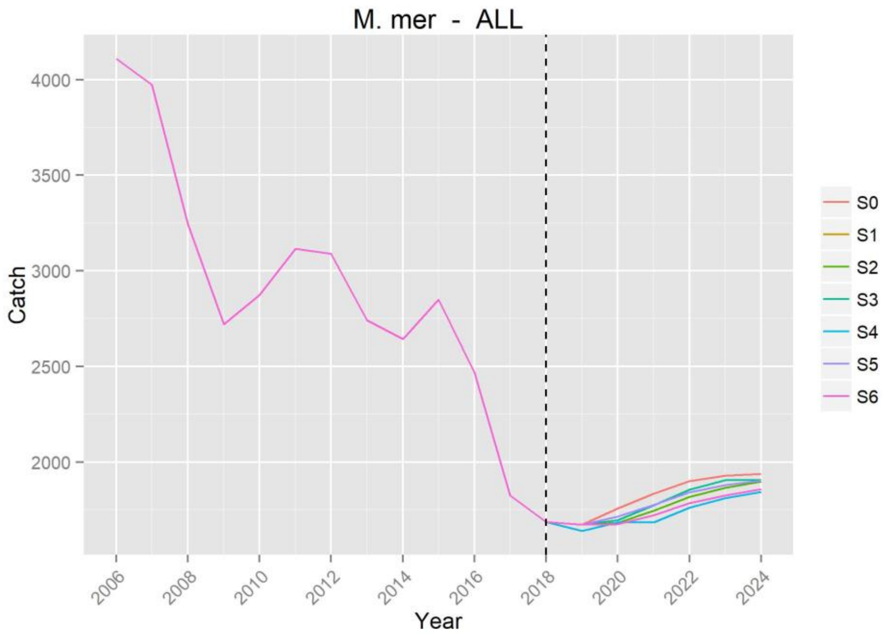


Figure 12. BEMTOOL. Trajectories of the SSB for the 2 stocks in the hindcasting phase (until 2018) and in the forecast phase (after 2018).

The reduction of the activity would imply a reduction of the catches for the DTS fleets and a stability or improvement for the PGP fleets. (Table 17). The two months of ban for the PGP in the scenario S4 would not affect negatively the catches. The scenario with hyperstability would have the lower influence on the catches reduction, but this was due to a lower reduction of fishing mortality. The lower reduction of European hake catches for DTS would result in S3. The trajectories of the predicted catches for the 6 scenarios appear more similar for European hake than for giant red shrimp (Figure 13).

Table 17. BEMTOOL. - Changes (in percentage) of the catches of the 5 stocks by fleet groups (DTS and PGP) in the 6 tested scenarios compared to the status quo S0. This is referred to 2024 (the catches in S0 are reported in tons).

DTS Fleets							
Stock	S0 - StatusQuo	S1 - Baseline	S2 - Baseline Diff	S3 - BaselineDiff_FS_period	S4 - Baseline_FB_PGP	S5 - Baseline_Hyp	S6 - BaselineClosure 100
A. fol	400	-13%	-6%	**-4%**	-13%	-6%	-13%
M. bar10	356	-34%	**-29%**	**-29%**	-33%	*-18%*	-34%
M. bar9	1629	**-19%**	-23%	-27%	-18%	*-9%*	-21%
M. mer	1222	-24%	-17%	**-14%**	-20%	*-12%*	-24%
P. lon	1246	**-16%**	-17%	-18%	-16%	*-8%*	-18%
PGP Fleets							
Stock	S0 - StatusQuo	S1 - Baseline	S2 - Baseline Diff	S3 - BaselineDiff_FS_period	S4 - Baseline_FB_PGP	S5 - Baseline_Hyp	S6 - BaselineClosure 100
M. bar10	42	15%	13%	14%	1%	8%	15%
M. bar9	232	52%	63%	77%	43%	25%	61%
M. mer	722	29%	22%	18%	21%	15%	29%



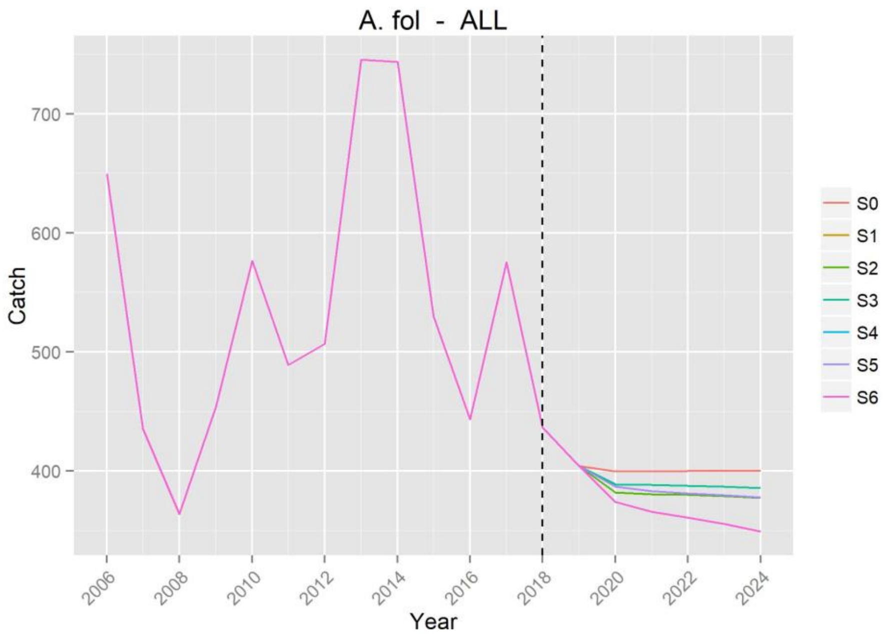


Figure 13 – BEMTOOL. Trajectories of the catches (in tons) for the 2 stocks in the hindcasting phase (until 2018) and in the forecast phase (after 2018).

A more clear picture of the comparison among the different scenarios is obtained by the MCDA analysis in BEMTOOL (see chapter 11.10), that show a similar utility among the different scenarios compared to the status quo that has the lower utility. Considering the ensemble of stocks, fleets and the different indicators of the biological, economic and social domain the scenarios with a slight better performance are S1, S4 and S6.

6.6 Summary on the model: achievements, gaps still to be addressed, work plan from now to STECF 19-14 (October 2019)

The availability of the socio-economic data at GSA-fleet segment level is crucial to parameterize the model. This data have to be available to the next STECF 19-14 to allow to run updated projections of the fleet socio-economic performances.

After the next EWG on stock assessment, the stock-recruitment relationships preliminarily estimated for this EWG 19-01 can be updated and applied in the projections of BEMTOOL, thus runs can be also done with different assumptions on the recruitment;

During this EWG 19-01 only the deterministic runs have been carried out for time constrains. The workplan for the next STECF 19-14 is to include uncertainty in the simulations (through process and model errors) to take it into account in the evaluation of the different strategies.

In case in the next EWG on stock assessment the biomass reference points will be defined (i.e. Bpa, Blim), the probability to have an SSB below the reference point could be derived in the STECF 19-14, alternatively an empirical limit, as the lower level of the SSB observed in the time series could be considered to make a risk evaluation.

The comparison of the scenarios using the MCDA analysis to synthetise the results, taking into account the biological, economic and social components, is also planned in the STECF 19-14. This tool represents also a basis for developing a participatory approach with stakeholders, making them aware of the consequences of different management strategies.

The application of BEMTOOL to EMU1 was also considered feasible, given the availability of the relevant input well in advance (at least 3 weeks before), this also because the model with uncertainty requires time for running and thus the basic model should be available in advance.

7 IAM IN EMU1

7.1 Overview of the model's generic characteristics and use

7.1.1 Overview

See Table 4, description in Nielsen et al, and STECF reports 18-09 and 18-13.

7.1.2 References

STECF (Scientific, Technical and Economic Committee for Fisheries) (2015). **Multiannual management plans SWW and NWW (STECF - 15 - 08)**. CSTEP/STECF, Ref. EUR XXXX EN, JR C XXXX,, 80p.

Merzéréaud Mathieu, Biais Gerard, Lissardy Muriel, Bertignac Michel, Biseau Alain (2013). **Evaluation of proposed harvest control rules for Bay of Biscay sole**. CIEM, Ref. ICES CM 2013/ACOM:75, 18p.

STECF (Scientific, Technical and Economic Committee for Fisheries) (2011) **Impact Assessment of Bay of Biscay sole (STECF-11-01)**. European Commission, Ref. Publications Office of the European Union, Luxembourg, EUR 24814 EN - 2011, 41p.

Merzéréaud Mathieu, Macher Claire, Bertignac Michel, Fresard Marjolaine, Le Grand Christelle, Guyader Olivier, Daures Fabienne, Fifas Spyros (2011). **Description of the Impact Assessment bio-economic Model for fisheries management (IAM)**.

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Macher Claire, Bertignac Michel, Guyader Olivier, Frangoudes Katia, Fresard Marjolaine, Le Grand Christelle, Merzéréaud Mathieu, Thebaud Olivier (2018). **The role of technical protocols and partnership engagement in developing a decision support framework for fisheries management** . Journal Of Environmental Management , 223, 503-516 . https://doi.org/10.1016/j.jenvman.2018.06.063

Guillen Jordi, Macher Claire, Merzéréaud Mathieu, Bertignac Michel, Fifas Spyros, Guyader Olivier (2013). **Estimating MSY and MEY in multi-species and multi-fleet fisheries, consequences and limits: an application to the Bay of Biscay mixed fishery** . Marine Policy , 40, 64-74 . Publisher's official version : https://doi.org/10.1016/j.marpol.2012.12.029 , Open Access version : https://archimer.ifremer.fr/doc/00129/24000/

7.2 Application of the model to the West Med MAP

Two applications of the IAM model have been implemented; one specifically designed for the GSA 7, and another encompassing GSAs 1,5,6,7. Both models focus on Hake population dynamics, consider explicitly 5 fleet categories: French trawlers (<18m, 18-24m and >24m), French non-trawlers (<12m and >12m), while spanish vessels are all pooled together. For GSA 7, it is assumed that spanish vessels are only trawlers. For GSA 1,5,6,7, trawlers are responsible for 94% of the catch – based on the catch data available to the working group. The models are initially set-up with 2017 values issued from the parameters of the stock assessment models, i.e. the CGPM/GFCM stock assessment carried out for the GSA 7 (XSA model, Certain et al. 2018), and the STECF stock assessment for the GSA 1,5,6,7 (a4a model, version made available to the working group). In this specific application, the models are used to produce short-term and medium-term forecasts (up to 2031), tracking hake biomasses and catch.

For the short-term forecasts, we use a scenario based on the recommendation of the management plan, i.e. a reduction of the 2019 fishing mortality (1.81) of 10% on the first year (in 2020), then a succession of 7.5% per year (still based on the 2019 fishing mortality) until 2024, and finally a drastic reduction in 2025 to reach the fishing mortality expected under sustainable harvesting (Fmsy = 0.23). According to the management plan, fishing reduction should solely apply to trawlers.

In a preliminary exercise, we compare the short-term forecast directly issued from the stock assessment model (XSA – GSA7) to the short-term forecast obtained by the IAM-GSA7 model, in order to ensure that the Hake dynamics simulated by both models is consistent. For that exercise, the reduction in fishing effort is applied uniformly to all fishing fleets, for the sake of simplicity.

Then, we apply the fishing reduction scenario to the IAM short-term forecasts to propose a preliminary assessment of the potential effects of the management plan on catches and spawning stock biomasses. Here, we use both IAM – GSA7 and IAM – GSA1,5,6,7 models, and we apply fishing mortality reduction only to the trawlers.

Finally, as a control, we run the short-term forecast according to a "status quo" scenario, in which fishing mortality is kept constant through time.

7.2.1 State of completion and additional development work specially undertaken before and during EWG 19-01

The current set-up for the IAM model is rather simple, and its capacity to explore the consequences of the management plan could be increased in many ways, such as the addition of further stocks (red mullets and shrimps), the further specification of fleets (e.g. explicitly separating spanish trawlers, gillnetters, longliners, etc..), or the use of economic information for all fleets to build economic indicators.

7.2.2 Space and time scale

Our model set-up allows comparing a relatively localized (GSA 7) with a broad (GSA 1,5,6,7) spatial scale. Our short-term forecast extends up to 2031, but we will only extract quantitative results up to 2024 – further trends will only be interpreted qualitatively.

7.2.3 Stocks (which stocks, which assessment data etc)

The current implementation of the IAM model focuses only on Hake (*Merluccius merluccius*) as stock dynamics.

7.2.4 Fleets

Input data on a disaggregated typology of french fleets for IAM on GSA7 was already available before the group (cf STECF 18-09), but here a simpler typology was used, that could answer particularly the questions asked, testing at the same time the ability of the model to easily be updated with the most recent data. This current implementation of the IAM model explicitly consider the French trawler size categories of the management plan, i.e. <12m, 12-18m, 18-24m, and >24m. However, no trawler in France has a size <12m so there are only 3 categories. Conversely, due to a lack of information on the fleet composition, especially in GSA 1,5,6, all the spanish fleet together were pooled together. In GSA 7, we assumed that it was composed of spanish trawlers only, while when considering GSA1,5,6,7 together, we assumed that trawlers represented 94% of the catch, applying this sharing rate to Spanish vessels fishing mortality.

7.3 **Comparison of model's short-term forecast with the single-stock advice predictions**

The outputs of the short-term forecasts produced by XSA-GAS7 and IAM-GSA7 are very similar, in terms of fishing mortality, spawning stock biomass and landings.

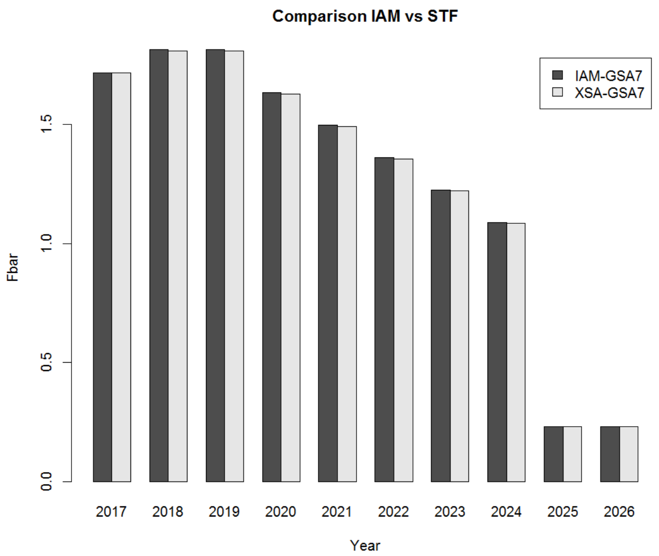

Figure 14. IAM. – Comparison between IAM and XSA short-term forecast: fishing mortality

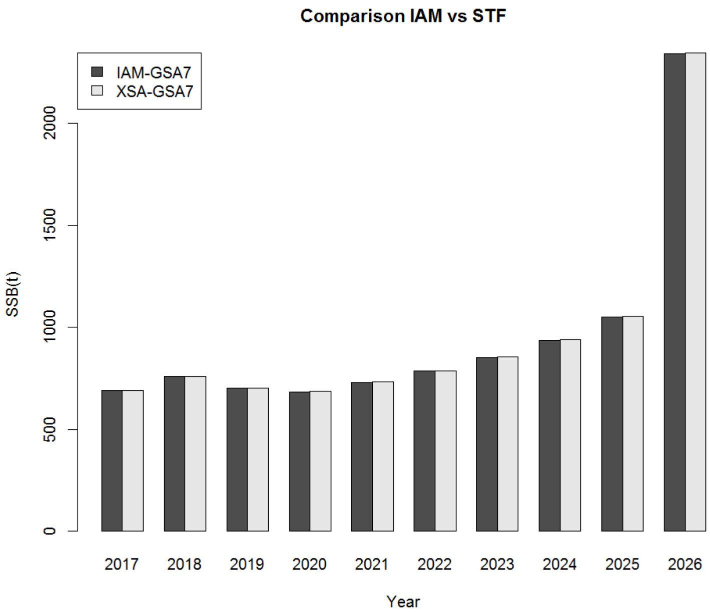

Figure 15. IAM – Comparison between IAM and XSA short-term forecast: spawning stock biomass

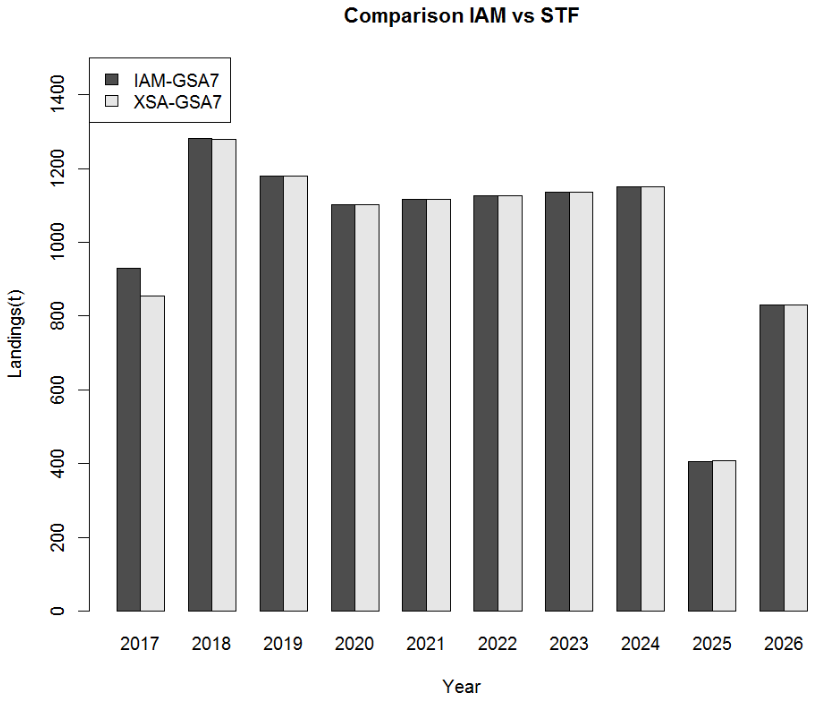

Figure 16. IAM.– Comparison between IAM and XSA short-term forecast : Hake landings

7.3.1 Short-Term Forecast IAM-GSA7

The results of the run for GSA-7 only are displayed below (mean effort per vessel/fleet, in nb of trips, ssb HKE, and total HKE landings per fleet) :

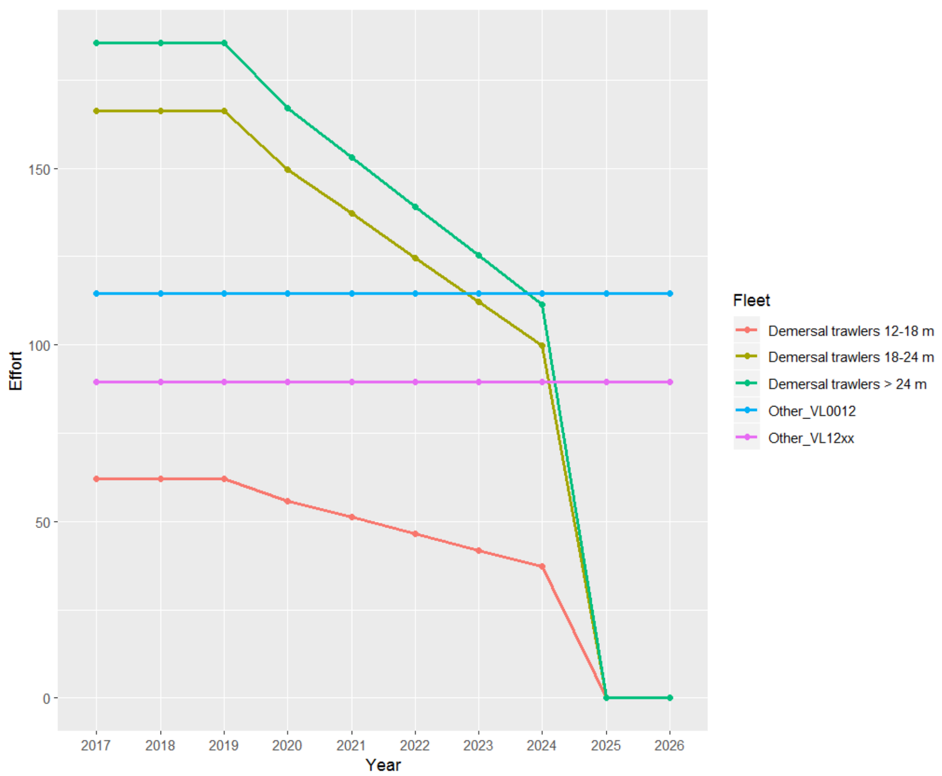

Figure 17. IAM – Short-Term Forecast IAM-GSA7: Mean effort per vessel per fleet (nb trips)

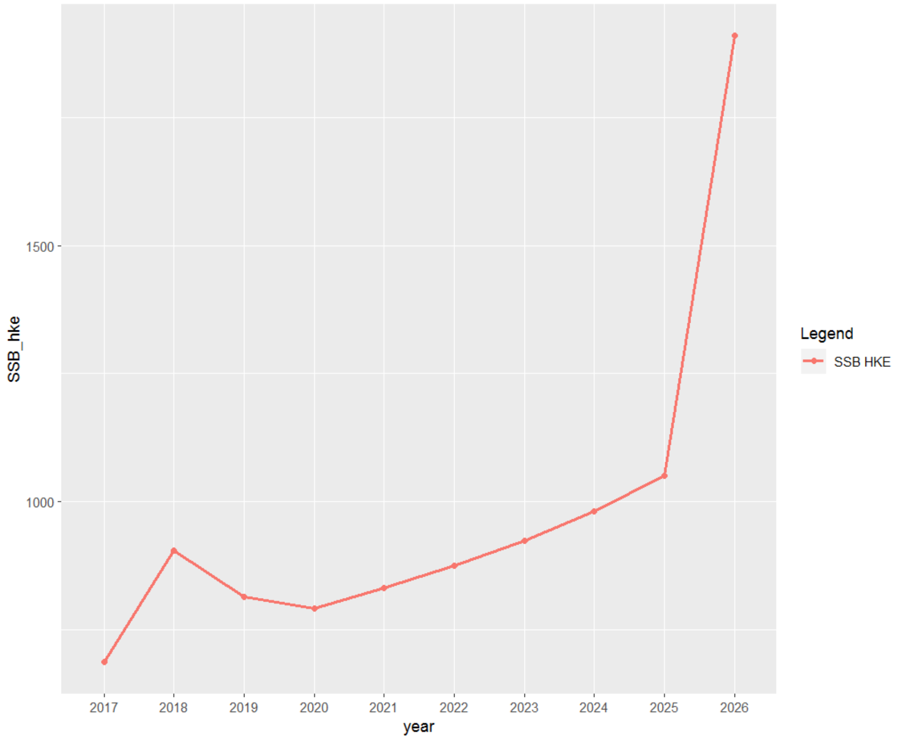

Figure 18. IAM– Short-Term Forecast IAM-GSA7 : Hake Spawning Stock Biomass (tons)

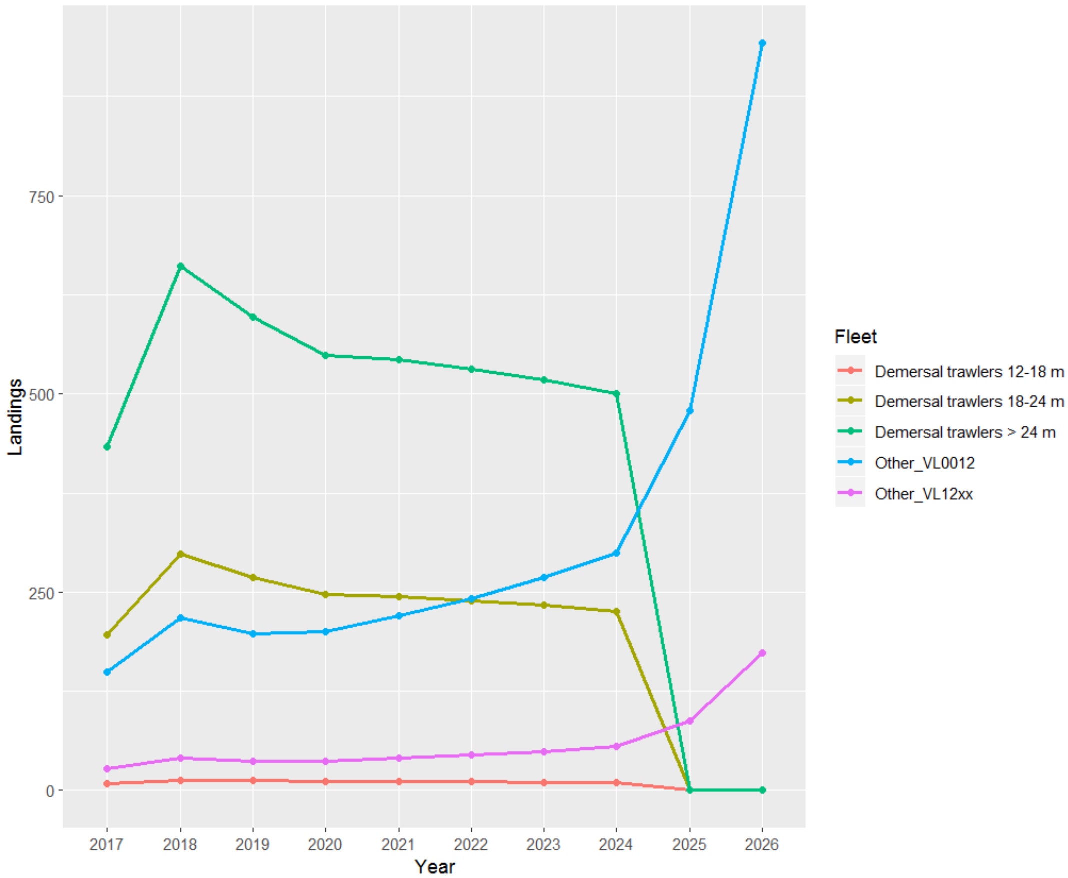

Figure 19. IAM – Short-Term Forecast IAM-GSA7 : Total Hake Landings per fleet (tons)

When running the model in GSA 7 only, the fishing mortality reduction envisioned by the plan result in a drastic reduction in trawlers effort, while other fishing vessels effort remains unchanged. SSB recovers slowly in the first year of the plan (2020-2024), while the fishing mortality reduction remains progressive, and then recovers quickly once fishing mortality approached Fmsy in 2025. However, it should be noted that in this set-up, we could not reach Fmsy (0.23) by solely applying the fishing mortality reduction to trawler, as the other fleets (which are french gillnetters for the most part) continue to fish as usual. As a result, the landings of these other fleets increased significantly, together with the Spawning stock biomass.

7.3.2 Short-Term Forecast IAM-GSA1,5,6,7

Only the results of the run for GSA-1,5,6,7 are displayed below:

Figure 20. IAM – Short-Term Forecast IAM-GSA1567 : Mean effort per vessel per fleet (nb trips)

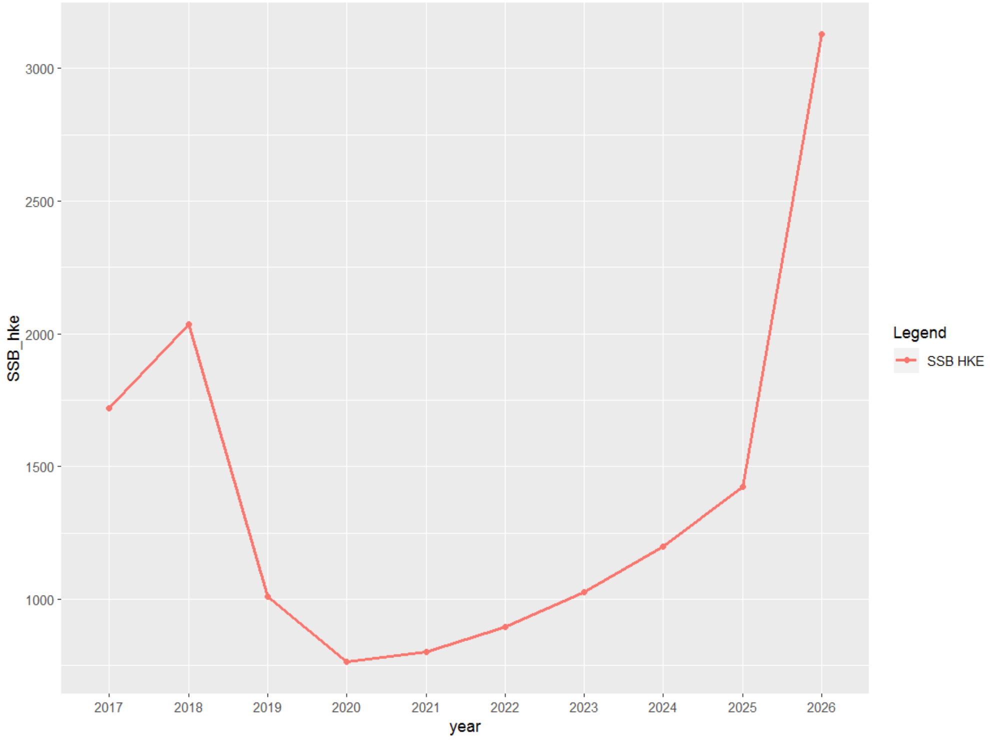

Figure 21. IAM – Short-Term Forecast IAM-GSA1567 : Hake Spawning Stock Biomass (tons)

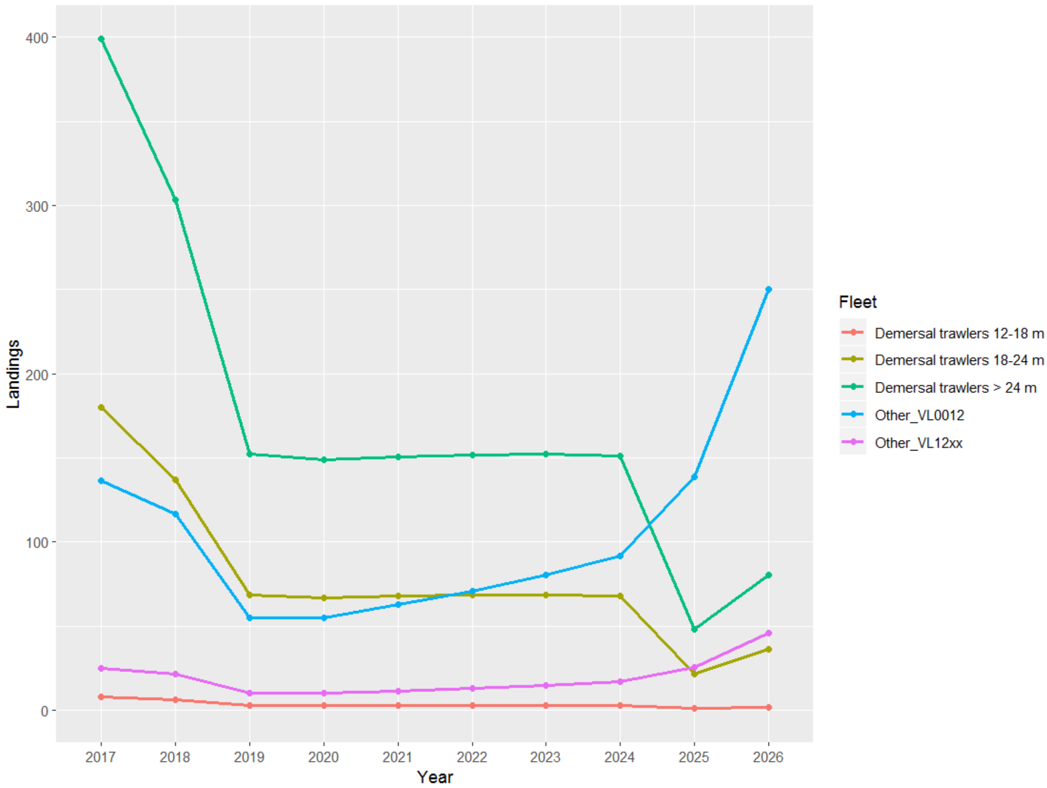

Figure 22. IAM – Short-Term Forecast IAM-GSA1567 : Total Hake Landings per fleet (tons)

The results displayed by the IAM – GSA 1,5,6,7 model show a very similar trend than with the IAM - GSA 7 run, with the difference that some levels of trawling effort can be maintained in 2025 when reaching Fmsy. Other fishing vessels belonging to the <12m category (mostly gillnetters) are still the one benefitting mostly from the management plan.

7.4 **Results of the Status Quo Scenario, IAM-GSA1,5,6,7**

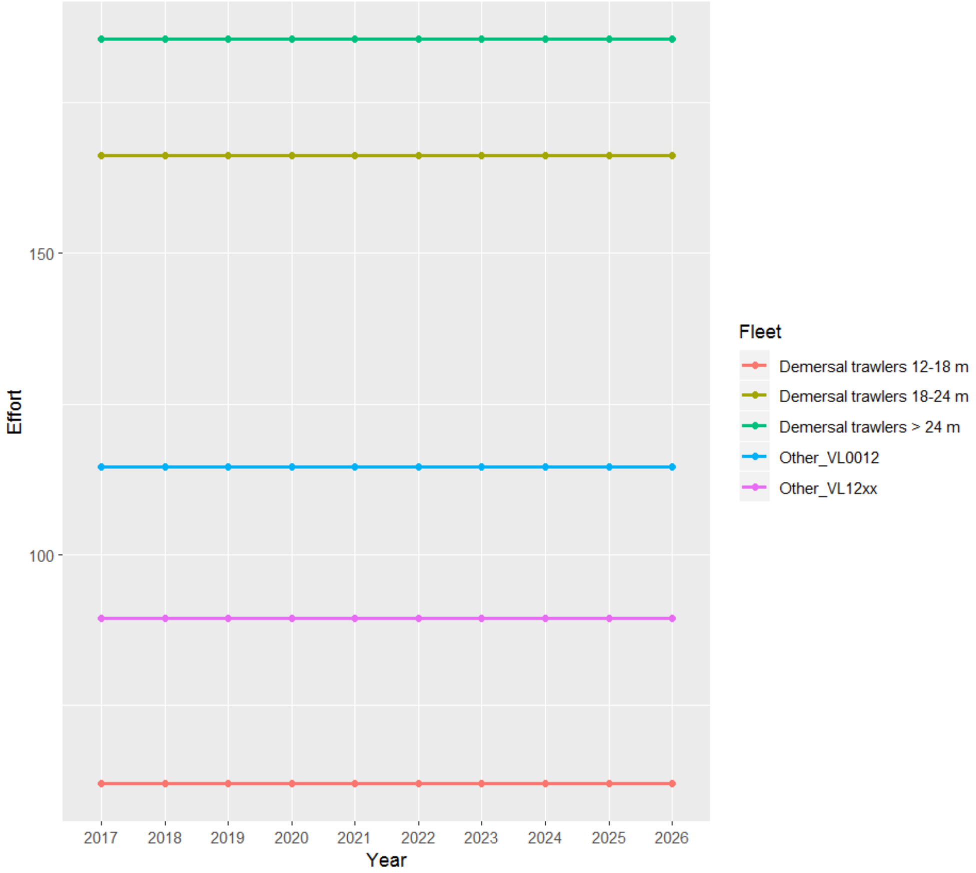

Figure 23. IAM – Short-Term Forecast IAM-GSA1567-SQ : Mean effort per vessel per fleet (nb trips)

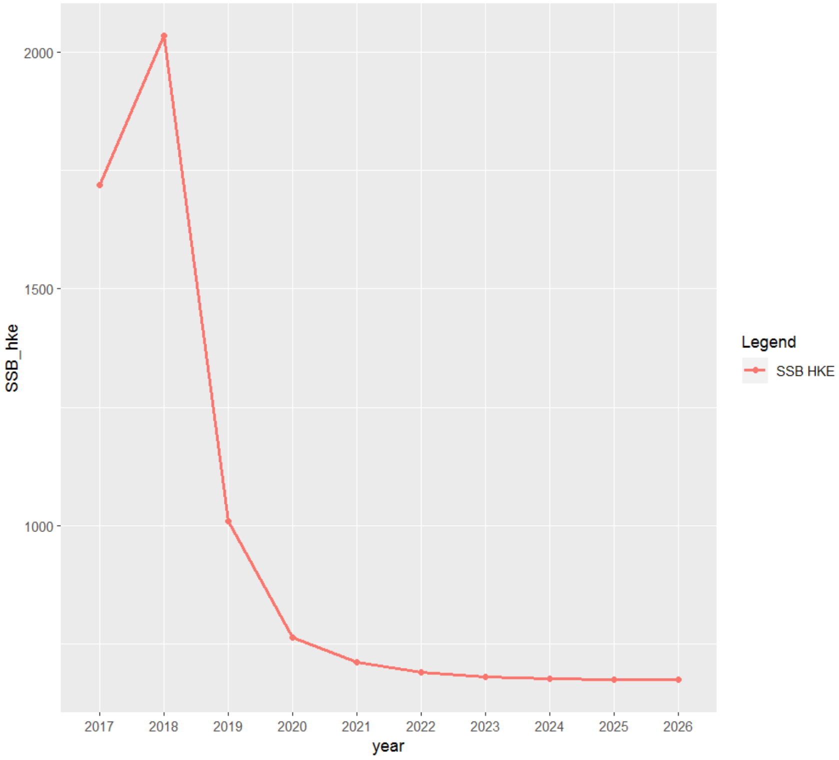

Figure 24. IAM – Short-Term Forecast IAM-GSA1567-SQ : Hake Spawning Stock Biomass (tons)

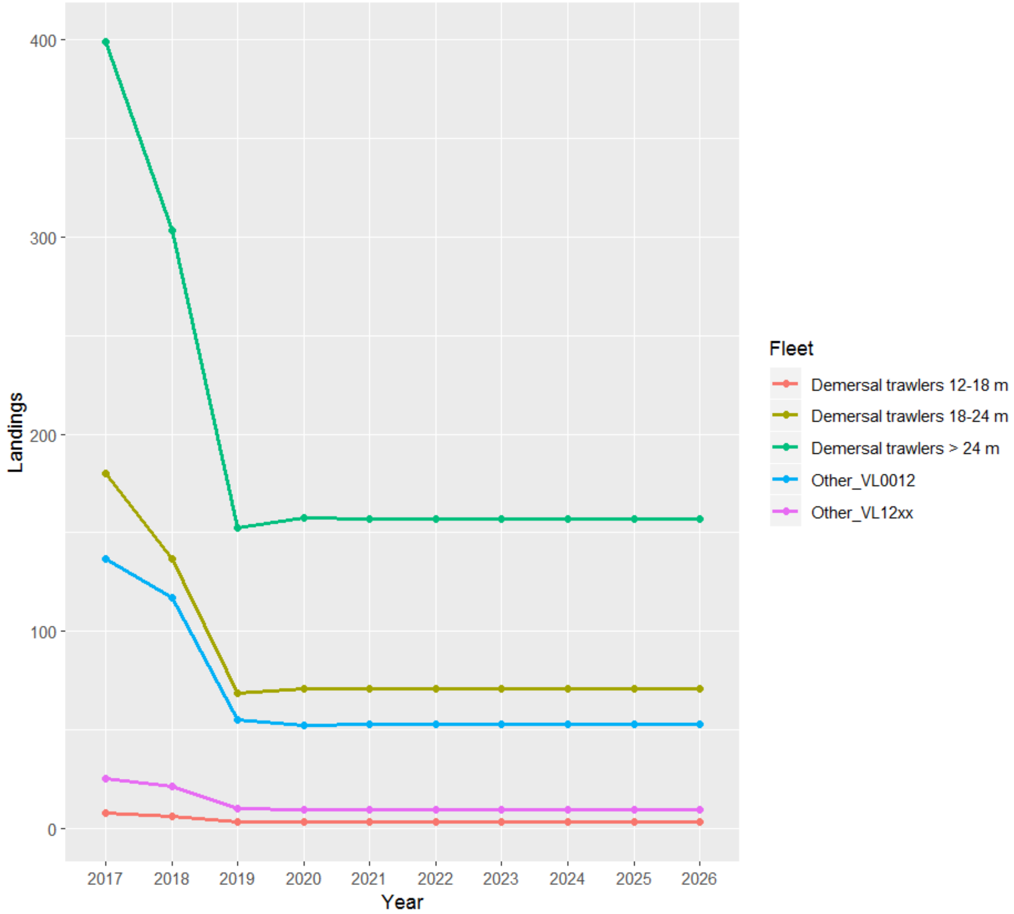

Figure 25. IAM – Short-Term Forecast IAM-GSA1567-SQ : Total Hake Landings per fleet (tons)

The forecasts of the status quo scenario points towards a collapse of the fisheries, with both SSB and landings pushed towards very low values if fishing effort is maintained at its current level.

7.5 Quantitative results for 2024

In both IAM-GSA7 and IAM-GSA1,5,6,7, the drastic effort reduction required to reach Fmsy in 2025 does not seem fully realistic from a management point of view. Hence, for this preliminary exercise, we will concentrate on providing quantitative estimates of the consequence of the management plan for the French stocks and fleet, as forecasted by the model in 2024, that is, after 5 years of consecutive effort reductions.

Model	Statistic	2019	2024	% change
IAM – GSA7	F	1,82	1,24	-31,67
	SSB (t)	814,82	981,77	20,49
	LDGS (t)	1262,42	1218,93	-3,44
IAM – GSA1,5,6,7	F	1,26	0,80	-35,88
	SSB (t)	1008,84	1199,91	18,94
	LDGS (t)	1472,36	1338,51	-9,09

Regarding the stock status, our forecasts envision an increase in the spawning stock biomass of around 20%, while total landings (ldgs) would only have decreased by either 3,5% (in GSA 7) or 9% (when grouping GSA 1,5,6,7). In both cases, hake fishing mortality should be reduced by ~30-35%.

The forecasted consequences of the management plan for the French fleet are summarized in the table below:

Model	Fleet segment	Effort 2019 (N days at sea / vessel)	Effort 2024 (N days at sea / vessel)	% Effort Change	Landings 2019	Landings 2024	Landings Change
IAM – GSA7	FR Trawl 12-18	62,00	37,20	-40,00	11,94	10,03	-16,04
	FR Trawl 18-24	166,25	99,75	-40,00	268,71	225,61	-16,04
	FR Trawl >24	185,58	111,35	-40,00	596,20	500,56	-16,04
	FR Other <12	114,67	114,67	0,00	197,00	299,06	51,81
	FR Other >12	89,50	89,50	0,00	36,31	55,12	51,81
IAM – GSA1,5, 6,7	FR Trawl 12-18	62,00	37,20	-40,00	3,05	3,03	-0,89
	FR Trawl 18-24	166,25	99,75	-40,00	68,72	68,11	-0,89
	FR Trawl >24	185,58	111,35	-40,00	152,48	151,12	-0,89
	FR Other <12	114,67	114,67	0,00	54,96	91,71	66,85
	FR Other >12	89,50	89,50	0,00	10,13	16,90	66,85

The forecasts of our models suggests that a global reduction of trawling effort of 40% operated between 2019 and 2024 should result in a moderate, but still substantial decrease of trawler landings (from -1% to -15%, depending on the spatial scale considered), while landings of other fishing vessels (gillnetters for the most part) would increase significantly (from +50% to +67%, again depending on scale).

7.6 Summary: achievements, gaps still to be addressed, work plan from now to STECF 19-14

Our modelling exercise, while preliminary, highlights unbalanced consequence of the current management plan between the trawlers and the other fishing vessels. Therefore, any further modification or revision of the current management plan may need to address this issue. Indeed, such discrepancy of consequences between fleet segments may undermine the fishermen compliance to the management plan.

The current implementation of the IAM model is rather preliminary and could be extended in many ways (more detailed economic informations, explicit consideration of spanish fleet segments, inclusion of more fish stocks). To explore in which way the model should be extended, it would be necessary to organize a joint French/Spanish workshop on this issue.

8 MEFISTO IN EMU1

8.1 Overview of the model's generic characteristics and use

8.1.1 Main features

See Table 4 above, previous descriptions in STEF EWG 18-09, 18-13 and references below

8.1.2 References

Lleonart, J., F. Maynou, L. Recasens and R. Franquesa. 2003. A bioeconomic model for Mediterranean Fisheries, the hake off Catalonia (Western Mediterranean) as a case study. *Scientia Marina* 67 (suppl. 1): 337-351. *In: Fisheries stock assessments and predictions: Integrating relevant knowledge*, Ø. Ulltang, G. Blom
[eds.] http://dx.doi.org/10.3989/scimar.2003.67s1337

Merino, G., A. Quetglas, F. Maynou, A. Garau, H. Arrizabalaga, H. Murua, J. Santiago, M. Barange, R. Prellezo, D. García, J. Lleonart, G. Tserpes, N. Carvalho, M. Austen, J.A. Fernandes, P. Oliver, A.M. Grau. 2015. Improving the performance of a Mediterranean demersal fishery toward economic objectives beyond MSY. *Fisheries Research* 161: 131–14.

8.2 Application of the model to the West Med MAP

8.2.1 State of completion and additional development work specially undertaken before and during EWG 19-01

The MEFISTO v.4.0 model was parameterized with biological and economic data for the demersal fisheries in EMU1 (west Western Mediterranean or GSAs 1, 5, 6, 7). The biological data was obtained from EWG 18-12, which included analytical stock assessments[3]. Economic data was derived from DCF 2018 data facilitated by the JRC through the repository (2018-07_STECF 18-07 - EU Fleet Economic and Transversal data_fs level_final.xlsx and 2018-07_STECF 18-07 - EU Fleet Landings FAO Gear levels_final.xlsx).

8.2.2 Space and time scale

The model was applied over the period 2017 to 2024, considering the following:

- 2017 year for which assessment data was available
- 2020 first year of the implementation of the MAP
- 2021-2024 second phase of the implementation

The model application was run at annual scale, although the MEFISTO model can work at time steps smaller than one year (quarter, month, week).

MEFISTO does not allow for analysis of spatial scale.

8.2.3 Stocks (which stocks, which assessment data etc)

The biological data was obtained from EWG 18-12, which included analytical stock assessments, for 8 species or stock combinations, as shown in the following table:

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[3] Note that MEFISTO can work with stocks assessed with age-structured models only, and not with index derived or biomass pool stock assessments.

	GSA1	GSA5	GSA6	GSA7
HKE		X		
MUT	X	no advice	X	X
NEP	-	X	X	-
DPS		index advice		
ARA	X	index advice	X	-

For hake (HKE) a stock assessment combining the four GSAs was available. For red mullet (MUT), separate stock assessments were available, except for GSA5. For Norway lobster (NEP) assessment results were available for the two GSAs for which it is a relevant stock (GSA5 and GSA6). For the deep-water rose shrimp (DPS) only index advice was produced in EWG 18-12. The blue and red shrimp (ARA) is an important fishery species in the three Spanish GSA, but only index advice was available for GSA5.

8.2.4 Fleets

The five species concerned by the Multi-Annual Plan are exploited by three fishing techniques in EMU1: DFN, DTS and HOK. DFN comprises passive set net fishing gear (GTR and GNS). DTS includes only OTB in the three Spanish GSAs, but includes OTB, OTT and OTM in GSA7 (France). HOK comprises set longlines (LLS). Fishing techniques DFN and HOK are employed by small scale fishing vessels, usually in VL classes VL0006 and VL0612, while DTS comprise VL1218 and larger. The model runs carried out during the meeting were based on an exhaustive list of 30 fleet segments:

	GSA1	GSA5	GSA6	GSA7 France	GSA7 Spain
DFN	2: VL0612 VL1218		2: VL0612 VL1218	3: VL0006 VL0612 VL1218	
DTS	4: VL0612 VL1218 VL1824 VL2440	3: VL1218 VL1824 VL2440	4: VL0612 VL1218 VL1824 VL2440	2: VL1824 VL2440	3: VL1218 VL1824 VL2440
HOK			2: VL0612 VL1218	2: VL0006 VL0612	3: VL0612 VL1218 VL1824

The landings of the 8 stocks comprising the biological basis of the MEFISTO model application represent between 5 and 20% of the landings of the main three demersal fleets (DFN, DTS, HOK), as shown in the following table (from data in 2018-07_STECF 18-07 - EU Fleet Landings FAO Gear levels_final.xlsx):

	GSA1	GSA5	GSA6	GSA7
HKE	157,164	60,539	1,622,841	973,068
MUT	153,395		1,190,048	130,471
NEP		20,455	310,971	
DPS				
ARA	187,092		579,997	82,552
Total landings	3,507,429	1,558,359	18,226,110	9,881,378
assessed	497,650	80,994	3,703,857	1,186,091
prop.	14%	5%	20%	12%

This means that, depending on the GSA, between 80 and 95% of the landings are not represented by a population dynamics model in the MEFISTO application, but considered as a pool of secondary species. In MEFISTO the landings resulting from the secondary species are related to the population dynamics of the main species by means of a linear or non-linear regression model; in our case a simple linear regression was used. However, note that due to the short span of the landings data series in 2018-07_STECF 18-07 - EU Fleet Landings FAO Gear levels_final.xlsx (2013-2016 only), the relationship between main and secondary species could only be estimated with very low accuracy.

The value of the main economic parameters calculated for the model application from are given in the following table:

GSA	fishing technique	Number of vessels	Average annual fuel consumption by vessel (l/yr)	Average annual total costs by vessel (€/yr)	Average Capital by vessel (€)
1	DFN	262	1900	14489	20346
1	DTS	64	193000	48333	69644
5	DTS	40	193000	60272	85411
6	DFN	761	1900	14489	20346
6	DTS	220	193000	48333	69644
6	HOK	197	1600	23833	38109
7	DFN	369	8700	18255	66970
7	DTS	36	383800	96548	253702
7	HOK	89	3760	21452	33598

8.3 Comparison of model’s short-term forecast with the single-stock advice predictions

The following table summarizes changes in the relevant indicators, Catch and SSB, over the short term period as shown in the short term forecast of EWG 18-12 or from MEFISTO. Four scenarios were compared: immediate reduction of fishing mortality to achieve F01 as proxy for Fmsy, a bracket of F(lower) and F(upper) around F01, and continuing with the status quo current fishing mortality. Note the following:

- the R object containing the results of the a4a stock assessment for HKE 1-5-6-7 did not match the results shown in table 6.1.5.1 of EWG 18-12. In particular, Fbar(0-2) is given as 1.14 in the report, but can be estimated 1.129

- Table 6.1.5.1 reports catches of 2017 as derived from the SOP correction, while the R object does not seem to incorporate that.

HKE 1·5·6·7				CATCH2017		MODEL DIFF (MEFISTO / EWG 18·12)	CATCH2019		MODEL DIFF (MEFISTO / EWG 18·12)	% CHANGE IN CATCH		SSB TREND (2019-2020)	
RATIONALE	Ffactor	Fbar	Fred	EWG 18·12	MEFISTO 4.0		EWG 18·12	MEFISTO 4.0		EWG 18·12	MEFISTO 4.0	EWG 18·12	MEFISTO 4.0
F01	0.2	0.23	80%	3171	2890	91%	819	899	110%	-74%	-69%	226%	149%
SQ	1	1.14	0%	3171	2890	91%	2661	2993	112%	-16%	4%	28.32%	102%
FUPP	0.281	0.32	72%	3171	2890	91%	1083	1207	111%	-66%	-58%	195.19%	105%
FLOW	0.137	0.16	86%	3171	2890	91%	574	639	111%	-82%	-78%	254.45%	148%

The MEFISTO estimate of catches for 2017 was 9% lower than the value reported in EWG 18-12, but the estimate for 2019 was 10 to 12% higher. The trend in SSB between 2020 and 2019 was similar and in the same direction (increasing) but the magnitudes of change were quite different.

8.4 Baseline Run 2020-2024

Average fishing days 2015-2017. The average fishing days by fleet segment over 2015-2017 is given in the following table considered in the baseline run are the following:

fleetname	Number of Fishing Days (2015-2017)
DTS0612_1	150
DTS1218_1	190
DTS1824_1	200
DTS2440_1	200
DFN0612_1	150
DFN1218_1	170
DTS1218_5	190
DTS1824_5	200
DTS2440_5	200
DTS0612_6	150
DTS1218_6	190
DTS1824_6	200
DTS2440_6	200
DFN0612_6	150
DFN1218_6	190
HOK0612_6	150
HOK1218_6	190
DTS1824_7FR	200
DTS2440_7FR	200

DFN0006_7FR	100
DFN0612_7FR	150
DFN1218_7FR	170
HOK0006_7FR	100
HOK0612_7FR	150
DTS1218_7ES	190
DTS1824_7ES	200
DTS2440_7ES	200
HOK0612_7ES	150
HOK1218_7ES	170
HOK1824_7ES	170

10 % reduction in 2020. A linear 10% reduction in the number of days per fleet segment was applied, resulting in the following effort values:

fleetname	Number of Fishing Days (2020)
DTS0612_1	135
DTS1218_1	171
DTS1824_1	180
DTS2440_1	180
DFN0612_1	135
DFN1218_1	153
DTS1218_5	171
DTS1824_5	180
DTS2440_5	180
DTS0612_6	135
DTS1218_6	171
DTS1824_6	180
DTS2440_6	180
DFN0612_6	135
DFN1218_6	171
HOK0612_6	135
HOK1218_6	171
DTS1824_7FR	180
DTS2440_7FR	180
DFN0006_7FR	90
DFN0612_7FR	135
DFN1218_7FR	153
HOK0006_7FR	90
HOK0612_7FR	135
DTS1218_7ES	171
DTS1824_7ES	180
DTS2440_7ES	180
HOK0612_7ES	135
HOK1218_7ES	153
HOK1824_7ES	153

7.5% reduction per year between 2021 and 2024. The following linear reduction of 7.5% each year between 2021 and 2024 was applied:

fleetname	2021	2022	2023	2024
DTS0612_1	125	116	107	99
DTS1218_1	158	146	135	125
DTS1824_1	167	154	142	132
DTS2440_1	167	154	142	132
DFN0612_1	125	116	107	99
DFN1218_1	142	131	121	112
DTS1218_5	158	146	135	125
DTS1824_5	167	154	142	132
DTS2440_5	167	154	142	132
DTS0612_6	125	116	107	99
DTS1218_6	158	146	135	125
DTS1824_6	167	154	142	132
DTS2440_6	167	154	142	132
DFN0612_6	125	116	107	99
DFN1218_6	158	146	135	125
HOK0612_6	125	116	107	99
HOK1218_6	158	146	135	125
DTS1824_7FR	167	154	142	132
DTS2440_7FR	167	154	142	132
DFN0006_7FR	83	77	71	66
DFN0612_7FR	125	116	107	99
DFN1218_7FR	142	131	121	112
HOK0006_7FR	83	77	71	66
HOK0612_7FR	125	116	107	99
DTS1218_7ES	158	146	135	125
DTS1824_7ES	167	154	142	132
DTS2440_7ES	167	154	142	132
HOK0612_7ES	125	116	107	99
HOK1218_7ES	142	131	121	112
HOK1824_7ES	142	131	121	112

8.5 **Alternative Runs**

8.5.1 Modellers' list of possible runs that can be implemented with the model and considered of direct relevance for the purpose of the West Med MAP

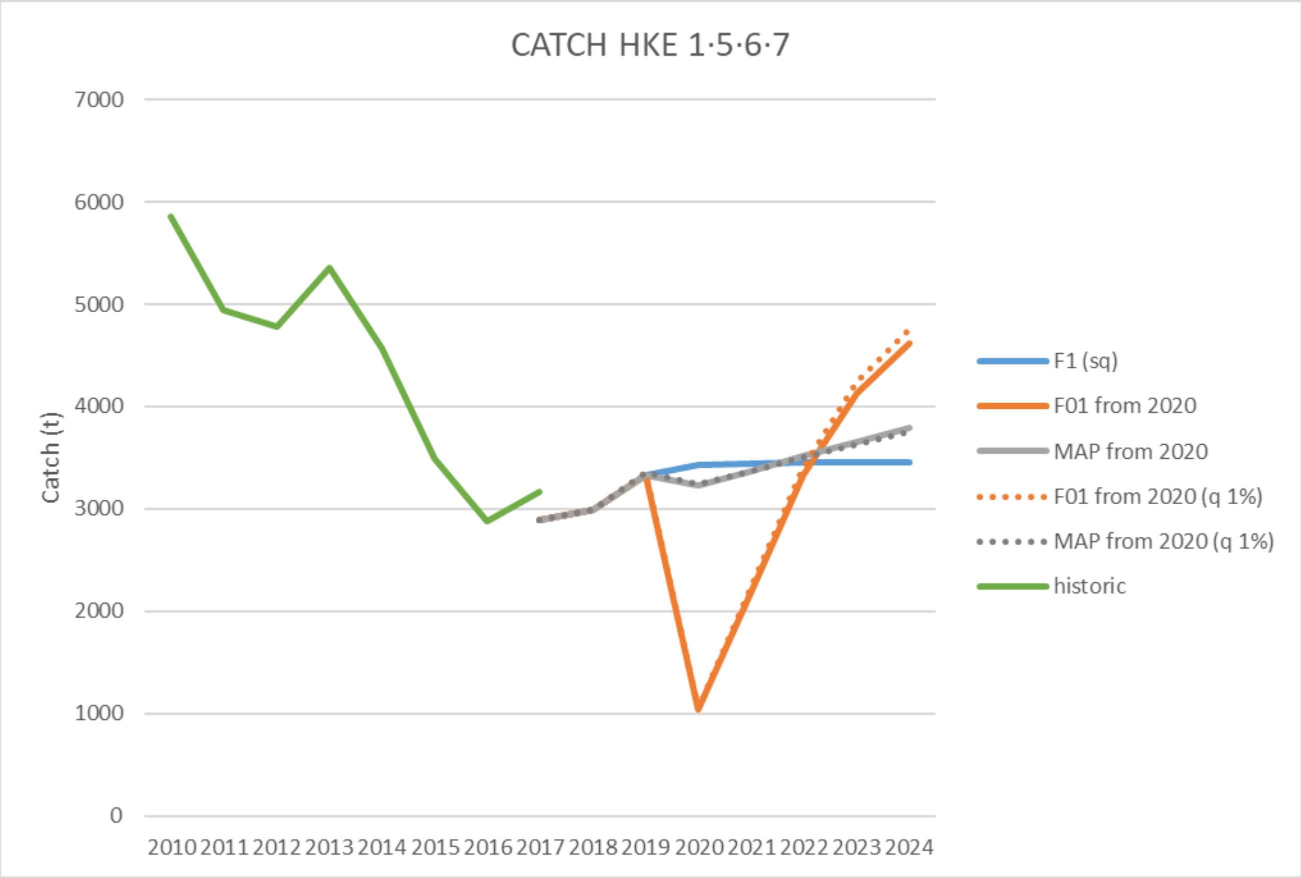
The MEFISTO model application was parameterized for 8 stocks and 30 fleet segments. However, the simulation of this large problem proved impractical during EWG 19-01 and only the subset with HKE as main species and all fleet segments was run and is presented in the next section.

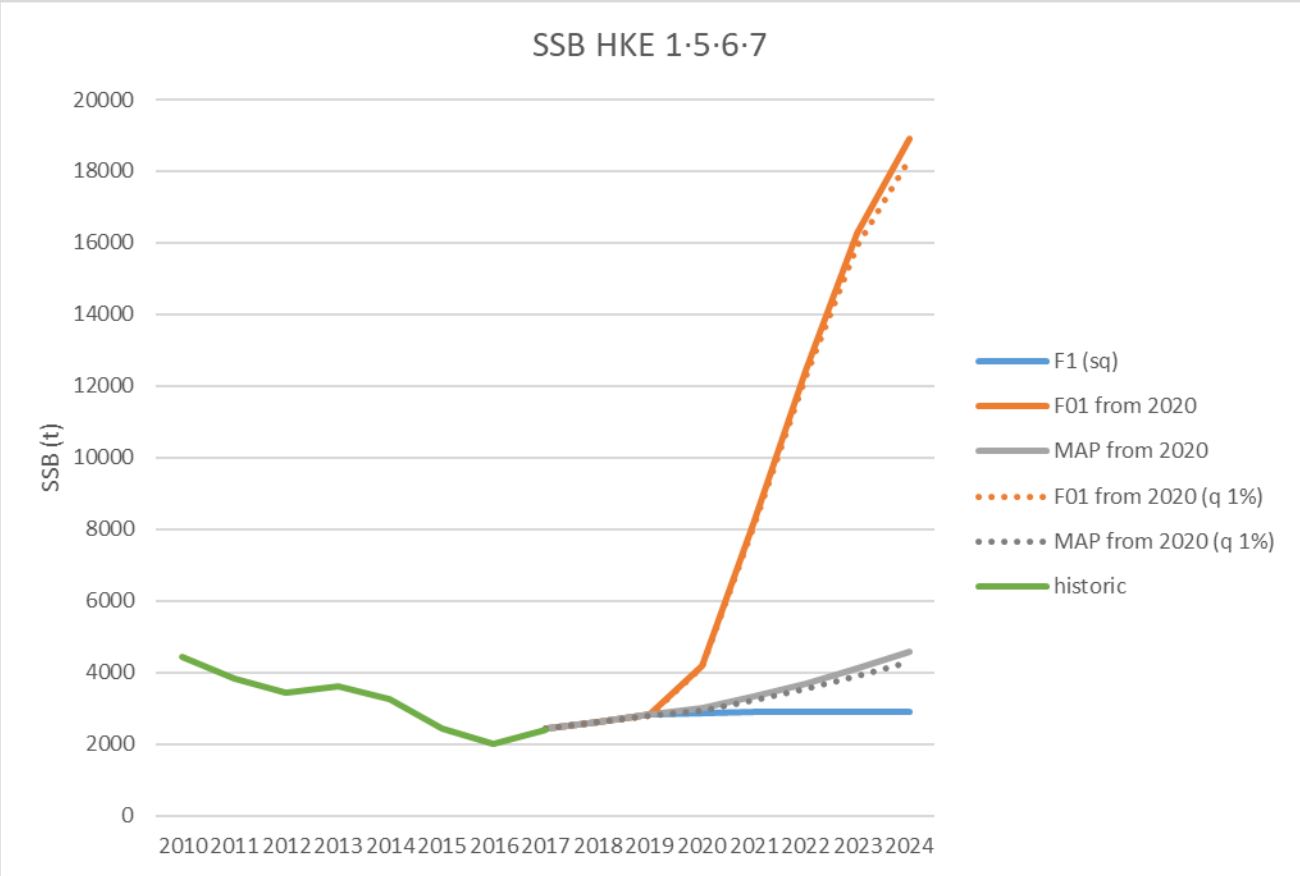
In addition to the effort reduction specified in the MAP, the policy of implementing F01 in 2020 was also simulated. In the two scenarios, a model with constant catchability and a model with catchability increasing at 1% per annum were also run.

8.5.2 Runs performed and analysed during EWG 19-01

Presentation and results

The figures below represent the trajectory of two indicators, catch and spawning stock biomass of HKE in GSAs 1·5·6·7, comparing the results of the application of an F01 regime in 2020, the progressive reduction of effort established in the MAP, against the status quo. The scenarios considering a 1% in catchability did not result in important differences.





8.6 Summary on the model: achievements, gaps still to be addressed, work plan from now to STECF 19-14 (October 2019)

<u>Achievements:</u>

A full bioeconomic model application of MEFISTO was parameterized from stock assessment data and economic data facilitated by the JRC. Although the biological and economic data used are far from perfect, the exercise shows that MEFISTO can be used to answer the bioeconomic consequences of the change in effort regime proposed in the MAP, at least regarding the non-spatial management measures foreseen in the plan. However, due to the short data series in the economic data set and the fact that the assessed stocks typically represent 20% or less of the production of the demersal fishing gear in the area the precision of the results is relatively low. The following gaps can be identified:

Shortcomings of MEFISTO as a model application to assess the proposed effort regime and to provide advice on mixed fisheries in general

* The definition of economic variables in MEFISTO does not match perfectly with the definitions in the DCF;

* Complex problems such as the one attempted (8 stocks and 30 fleet segments) are difficult and time-consuming to parameterize with DCF official data;

* Complex problems such as the one attempted (8 stocks and 30 fleet segments) will take a few hours to run in stochastic mode.

Limitations in the application of the integrated bioeconomic model MEFISTO to official European Commission data

* Not all concerned stocks had analytical assessment results;

* Inconsistencies between assessment results in the published report EWF 18·13 and the "RData objects" provided by the JRC;

* Economic data incomplete or inconsistent for certain fleet segments, particularly in VL0006 and VL0612;

* MEFISTO requires a model to relate the total production of each fleet segment with the target species. This model cannot be computed with accuracy from the short data series available in the DCF.

For the next EWG 19-14, the utilization of FLBEIA or BEMTOOL, or the extension of IAM, in EMU1 will be explored as an alternative to MEFISTO.

9 SMART IN EMU2

9.1 Overview of the model's generic characteristics and use

9.1.1 Main features

See previous descriptions in STECF 18-13, in Table 4 and in references below

The rationale of the SMART model, as well as the workflow of the smartR package, can be summarized in the following logical steps:

1. Use landings and catch data, combined with VMS data, to estimate the spatial/temporal productivity of each cell, in terms of aggregated LPUE by species;
2. Use catch data to estimate the Length-Frequency Distribution (LFD) and the Age-Frequency Distribution (AFD), by species, for each cell/time;
3. Use VMS data to assess the fishing effort by vessel/cell/time;
4. Combine LPUE, LFD/AFD and VMS data to model the landings by vessel/species/length class/time;
5. Estimate the cost by vessel/time associated to a given effort pattern and the related revenues, which are a function of the landings by vessel/species/length class/time (step 4);
6. Combine costs and revenues by vessel, at the yearly scale, to obtain the incomes, which are the proxy of the vessel performance. Incomes could be aggregated at the fleet level to estimate the overall performance;
7. Use estimated landings by species/age, together with survey data, to run MICE model for the selected case of study in order to obtain a biological evaluation of the fisheries.

Each of these steps corresponds to a different module of the package.

9.1.2 References

Russo T, Parisi A, Garofalo G, Gristina M, Cataudella S, et al. (2014) SMART: A Spatially Explicit Bio-Economic Model for Assessing and Managing Demersal Fisheries, with an Application to Italian Trawlers in the Strait of Sicily. PLoS ONE 9(1): e86222. doi:10.1371/journal.pone.0086222.

Russo T, Morello EB, Parisi A, Scarcella G, Angelini S, Labanchi L, Martinelli M, D'Andrea L, Santojanni A, Arneri E, Cataudella S (2018). A model combining landings and VMS data to estimate landings by fishing ground and harbor. Fisheries Research 199, 218-230.

D'Andrea L, Parisi A, Fiorentino F, Garofalo G, Gristina M, Russo T, Cataudella S. (submitted). smartR: an R package for spatial modelling of fisheries and simulation of effort management. Journal of Statistical Software.

9.2 Application of the SMART model to the West Med MAP

9.2.1 State of completion and additional development work specially undertaken before and during EWG 19-01

An almost complete application of SMART to the case study of West Med was prepared before the EWG. In particular, the spatial productivity (monthly LPUE as grams of catch per meter of LOA and hour of fishing) was estimated using landings and VMS data, according to the procedure of Russo et al., 2018. In the same time, the economic parameters needed to model the relationships between: 1) fishing effort and its related costs (crew salaries, fixed costs, etc.); 2) spatial fishing footprint and its related costs (i.e. fuel consumption); 3) yield and production costs (i.e.

commercialization); 4) yield and revenues (using the prices at market of the different species by size class) were collected and integrated into the model.

During the EWG, the data about biological sampling of catches were integrated in order to split, at the monthly scale and for each cell of the grid, the total catch by species in its component in terms of age classes.

9.2.2 Space and time scale

For this application of SMART to the case study of West Med, the GFCM standard grid (composed by 30 x 30 nm cells) for the GSAs 9, 10 and 11 was selected (Figure 26). The cells covering the area deeper than 800m depth were excluded to reduce complexity and computational time required for the simulations. From a temporal point of view, the set up of the model was limited to the years 2015-2016.

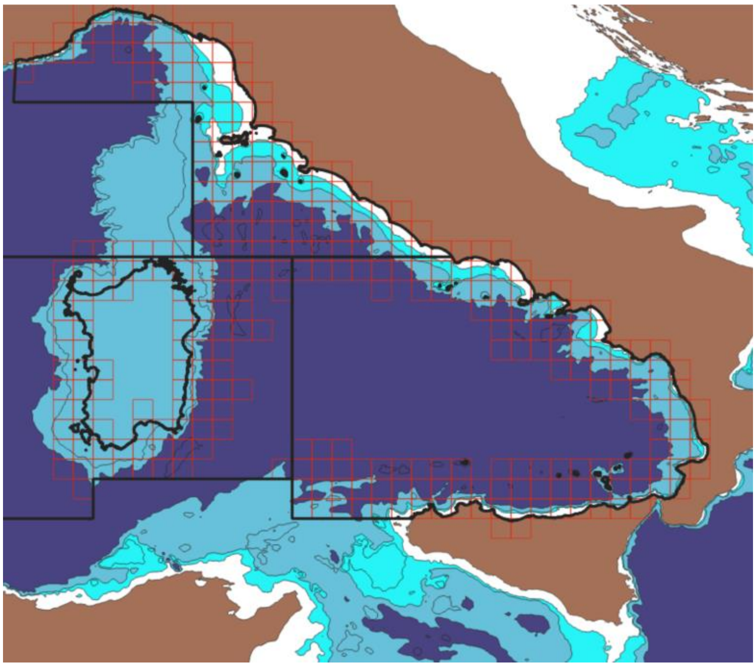


Figure 26 – 30 x 30 nm square grid (defined by the GFCM) used for the implementation of SMART on the case study of the three Italian GSAs in the Tyrrhenian Sea.

Thus, 24 months' temporal series of LPUE (Figure 27) and AFD (proportion of age classes/length by species –Figure 28) were estimated for the cells of the grid, together with accessory economic models. These represent the basis for the simulation of different effort scenarios, including the status quo. In fact, within SMART, the key aspect is represented by the optimization, at the scale of each vessel, of the fishing effort pattern at the monthly temporal scale. This is done through the iterative exploration of alternative vessel-specific effort patterns and evaluation of the corresponding catch converted in revenues and compared with the total costs to estimate the gains.

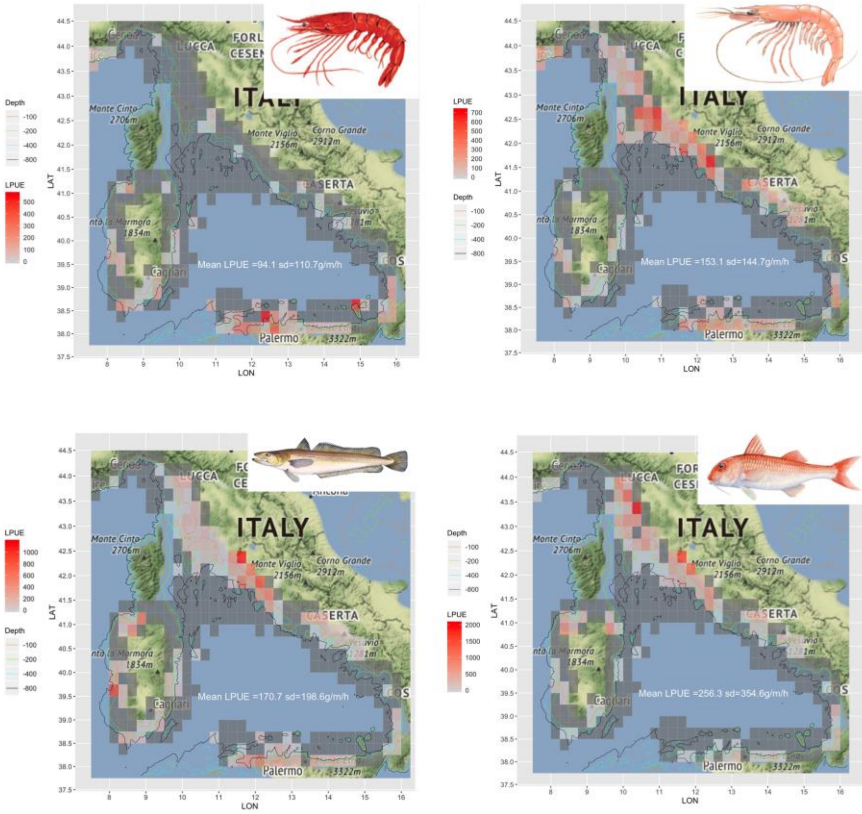


Figure 27 – Representation of the mean LPUE (in red scale) as grams of catch per meter of LOA and hour of fishing, for the 24 months' temporal series (years 2015-2016).

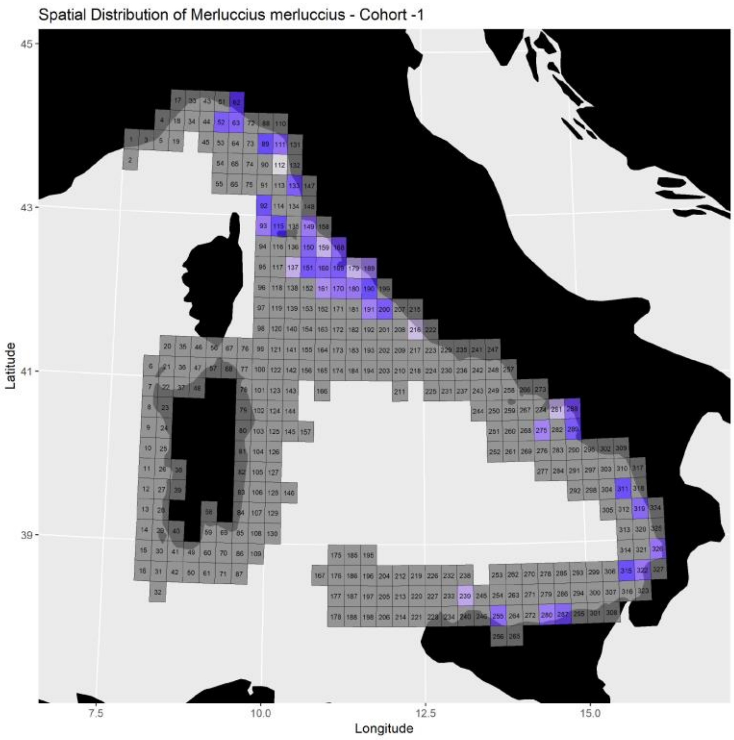


Figure 28 – Distribution (frequence into catch) of the Age 0 (cohort 1) for the HKE. This kind of result represents the LFD (proportion of age classes/length by species) estimated for each cell and time in order to allow distributing total catch by age/length class

9.2.3 Stocks

Four species of the MAP were considered for this implementation of SMART. Namely: the Giant red shrimp (*Aristeomorpha foliacea* - ARS), the Deep-water rose shrimp (*Parapenaeus longirostris* – DPS), the Hake (*Merluccius merluccius* – HKE), and the Red mullet (*Mullus barbatus* – MUT).

Beyond the fishing activity of trawlers on the stocks of this species in the GSA9, 10 and 11, the following trophic interactions were considered: 1) the cannibalism between the different age classes of the hake and 2) the predation of the hake on deep-water rose shrimp (Figure 29).

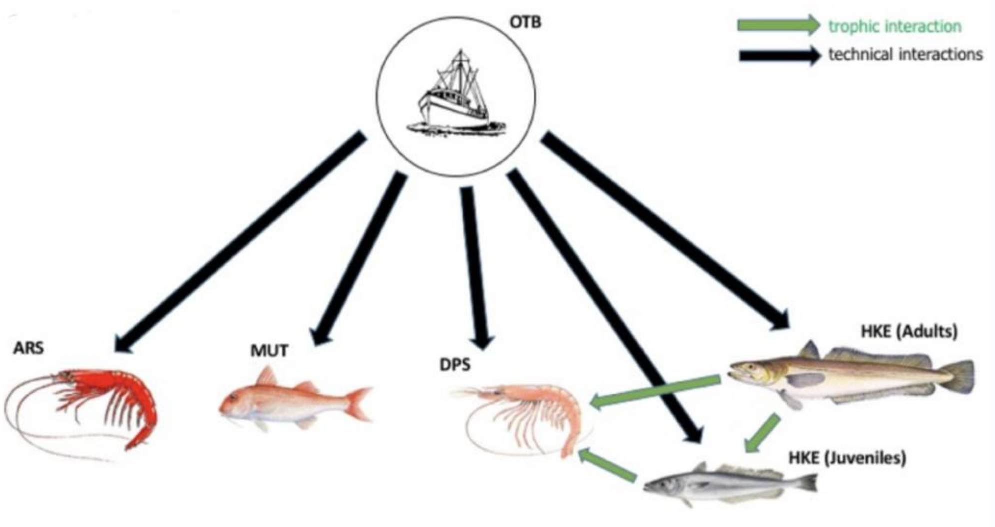


Figure 29 – Representation of the trophic and technical interactions modelled with the MICE approach integrated into SMART.

9.2.3.1 MEDITS data

Abundance and biomass indices by age class coming from the MEDITS trawl surveys for the years 2015 and 2016 have been utilised for tuning the SMART model. Based on the Data Collection Framework data (DCF), abundance and biomass indices for GSAs 9, 10 and 11 combined were calculated. For red mullet, the indices are reported for GSAs 9 and 10 as the last stock assessment was performed separately in the two GSAs. In Table 18 the number of hauls was reported per depth stratum in each GSA.

Table 18 Number of hauls per year and depth stratum in GSAs 9-10-11, period 2015-2016.

GSA	9	9	10	10	11	11
STRATUM	2015	2016	2015	2016	2015	2016
10-50	14	14	7	7	18	18
50-100	19	18	8	8	19	19
100-200	30	31	14	14	24	24
200-500	35	36	18	18	21	21
500-800	22	21	23	23	17	17
Total	120	120	70	70	99	99

Data were assigned to strata based upon the shooting position and average depth (between shooting and hauling depth). Catches by haul were standardized to 60 minutes hauling duration. Hauls noted as valid were used only, including stations with no catches of hake, red mullet, giant red shrimp or pink shrimp (zero catches are included).

The abundance and biomass indices by GSA were calculated through stratified means. This implies weighting of the average values of the individual standardized catches and the variation of each stratum by the respective stratum areas in each GSA:

$Yst = \Sigma (Yi*Ai) / A$

$V(Yst) = \Sigma (Ai^2 * si^2 / ni) / A^2$

Where:

A=total survey area

Ai=area of the i-th stratum

si=standard deviation of the i-th stratum

ni=number of valid hauls of the i-th stratum

n=number of hauls in the GSA

Yi=mean of the i-th stratum

Yst=stratified mean abundance

V(Yst)=variance of the stratified mean

The variation of the stratified mean is then expressed as the 95 % confidence interval: Confidence interval = Yst ± t(student distribution) * V(Yst) / n

GSA	Species	Year	Index	Age 0	Age 1	Age 2	Age 3	Age 4*	Age 5	Age 6+
9-10-11	HKE	2015	N/km2	762.6	476.5	63.7	19.6	1.6	0.8	0.5
9-10-11	HKE	2016	N/km2	789.8	152.1	31.9	5.4	1.6	0.6	0.6
9-10-11	HKE	2015	Kg/km2	6.9	21.4	8.8	5.8	0.8	0.6	0.8
9-10-11	HKE	2016	Kg/km2	7.9	6.7	4.3	1.6	0.8	0.5	1.0
9	MUT	2015	N/km2	2627.5	648.5	58.6	2.8	0.5		
9	MUT	2016	N/km2	491.4	531.9	65.8	1.2	1.3		
9	MUT	2015	Kg/km2	26.4	21.5	4.0	0.3	0.1		
9	MUT	2016	Kg/km2	9.6	18.1	4.8	0.1	0.2		
10	MUT	2015	N/km2	1.5	88.0	249.2	49.6	16.1		
10	MUT	2016	N/km2	1368.4	557.2	136.8	33.6	6.0		
10	MUT	2015	N/km2	0.0	1.6	9.2	3.4	1.7		
10	MUT	2016	Kg/km2	11.4	10.4	5.1	2.2	0.7		
9-10-11	ARS	2015	N/km2	45	27.3	20.6	3.5	0.6		
9-10-11	ARS	2016	N/km2	30.9	42.8	18	5.2	0.9		
9-10-11	ARS	2015	Kg/km2	0.54	0.74	0.80	0.02	0.05		
9-10-11	ARS	2016	Kg/km2	0.40	1.20	0.61	0.27	0.06		
9-10-11	DPS	2015	N/km2	63.9	711.1	100	2.8	0.2		
9-10-11	DPS	2016	N/km2	34.9	595.9	84.3	2.3	0.1		
9-10-11	DPS	2015	N/km2	0.128	3.556	1.500	0.056	0.004		
9-10-11	DPS	2016	Kg/km2	0.070	2.980	1.265	0.058	0.003		

*Age 4+ for MUT, ARS and DPS

Table 19 the abundance and biomass indices by age

9.2.3.2 *Demographic structure of the commercial data*

The data collection Framework provides for demographic structures of the commercial catches at level 5 of Table 2 of the Commission Implementing Decision (EU) 2016/1251. The data collection is carried out for a defined number of samples for each GSA, subdivided in observations at the landing points and embarks of scientists on board of professional vessels. The observations on board allow collecting detailed information by haul on the quantities and demographic structure of the commercial and discarded fractions. The importance of this typology of sampling is related, in addition to the collection of discard, to the fact that the data are georeferenced.

The length frequency distributions of the catches in each haul have been transformed in age classes by sex applying the growth parameters estimated in the three GSAs.

9.2.4 *Fleets*

The fleet included in the analyses is composed by the Italian trawlers with LOA equal or larger than 15m, that is the portion of the fleet equipped with VMS. The native VMS pings were pre-processed using the VMSbase platform (Russo et al., 2014) and coupled, at the level of single vessels and at a monthly scale, with logbook, landings and economic data (fuel consumption, etc.)

9.3 **Comparison of model's short-term forecast with the single-stock advice predictions**

Figure 30 summarizes the output of the prediction in terms of catch by species. Given that the values from EWG18-12 are referred to all the gears and length classes, we integrated into the plot the corresponding DCF values of catch for the trawlers in the LOA range 15-40m. The catches returned by SMART at the year 2017 are close to the DCF ones, in particular for HKE and MUT.

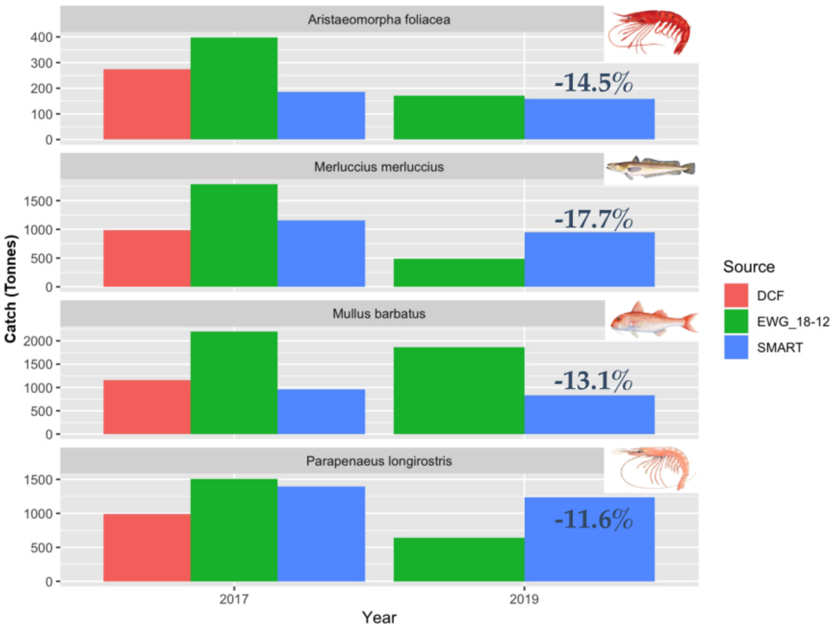


Figure 30 – Fitted and predicted (SMART) against official (DCF) and estimated (EWG_18-12) catch for the four MAP species considered by SMART

9.4 **Baseline Run 2020-2024**

The baseline run 2020-2024 and the corresponding progressive decreases of the effort (7.5% reduction per year between 2021 and 2024) was not simulated during this EWG, given that it requires more time and a longer temporal series to return robust estimates.

9.5 **Alternative Runs**

It could be interesting to test the decline of fishing effort together with some spatial closures, such as the main nurseries and spawning areas.

9.5.1 Modellers' list of possible runs that can be implemented with the model and considered of direct relevance for the purpose of the West Med MAP

The application of SMART to the case study of Italian, French and Spanish GSA was discussed. The main issue toward this hypothesis could be related to the long pre-processing of input data, which could be characterized by different structures and levels of aggregation. However, a tentative roadmap was defined as follows:

1. Development of the present SMART application with the integration of the temporal series used for training (to cover the period 2013-2017);
2. Possible extension to the French and Spanish GSAs;
3. Integration of the fleet segment 12-15 (using some modelling approach);
4. Integration of the other species in the MAP;
5. Simulation of 10% decrease in 2019 and successive decreases of the effort (7.5% reduction per year between 2021 and 2024);
6. Simulation of effort regime combined with spatial closures.

9.5.2 Runs performed and analysed during EWG 19-01

It is important to notice that the SMART model is devised to estimate the potential effect of whatever management actions on the effort (including reduction of fishing capacity, effort, or spatial closures) instead that to directly set a desired value of F for the target stocks. Thus, the SMART model was used to assess the potential effect of a 10% decrease of trawling effort, which is rather different from the F reduction in single-stock advice used as benchmark for the EWG. However, the 10% decrease of effort at year 2019 is likely to determine a reduction of catch between 11% (ARS) and 17% (HKE). This result could be commented with the observation that high value species (ARS) are still targeted whereas some accessory ones (HKE) are more preferentially avoided. However, the estimated catch is far from the EWG18-12 targets corresponding to a4a MSY. The corresponding impact in term of F is represented in Figure 31, together with the reference from a4a. It seems that the 10% decrease of effort could determine lower levels of F for the four species, although it is not sufficient to reach the F_{MSY}.

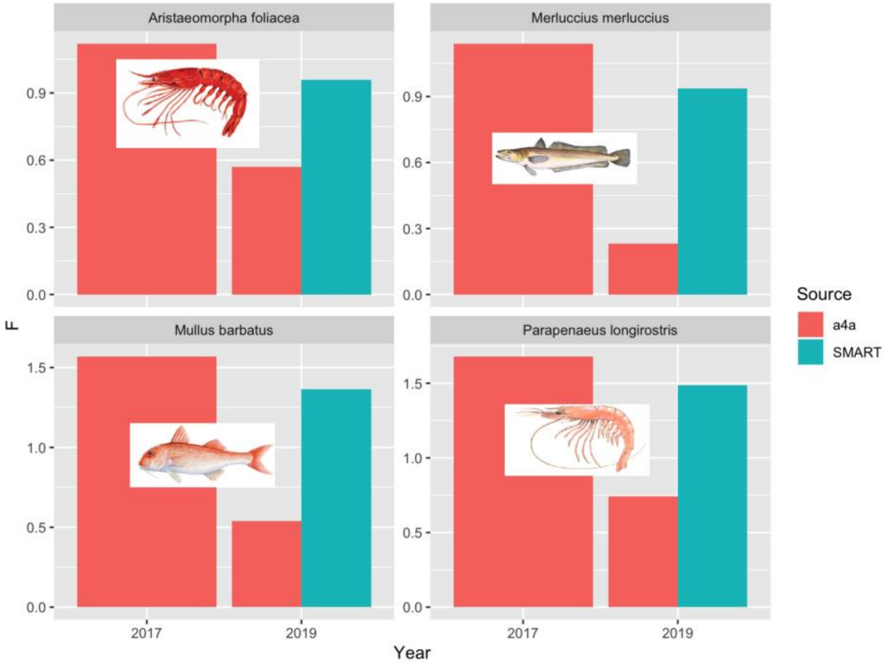


Figure 31 – Comparison between the EWG_18-12 estimates (from a4a) and the values of F predicted by SMART. Year 2019 corresponds to the 10% decrease of fishing effort.

The predicted pattern of fishing effort was obtained as consequence of the 10% reduction of the total yearly effort of each vessel (Figure 32). The model predicted some positive (increment of the effort) and negative (decrease of the effort) displacements. In particular: some fishing grounds far from the coast are likely to be abandoned (especially in the southern part of the GSA10) while some other areas (northern part of the Sardinia, north of the GSA10, etc.) attract more effort. However, the whole pattern is similar to the observed one.

From an economic point of view, SMART returned the aggregated data of Figure 33 .

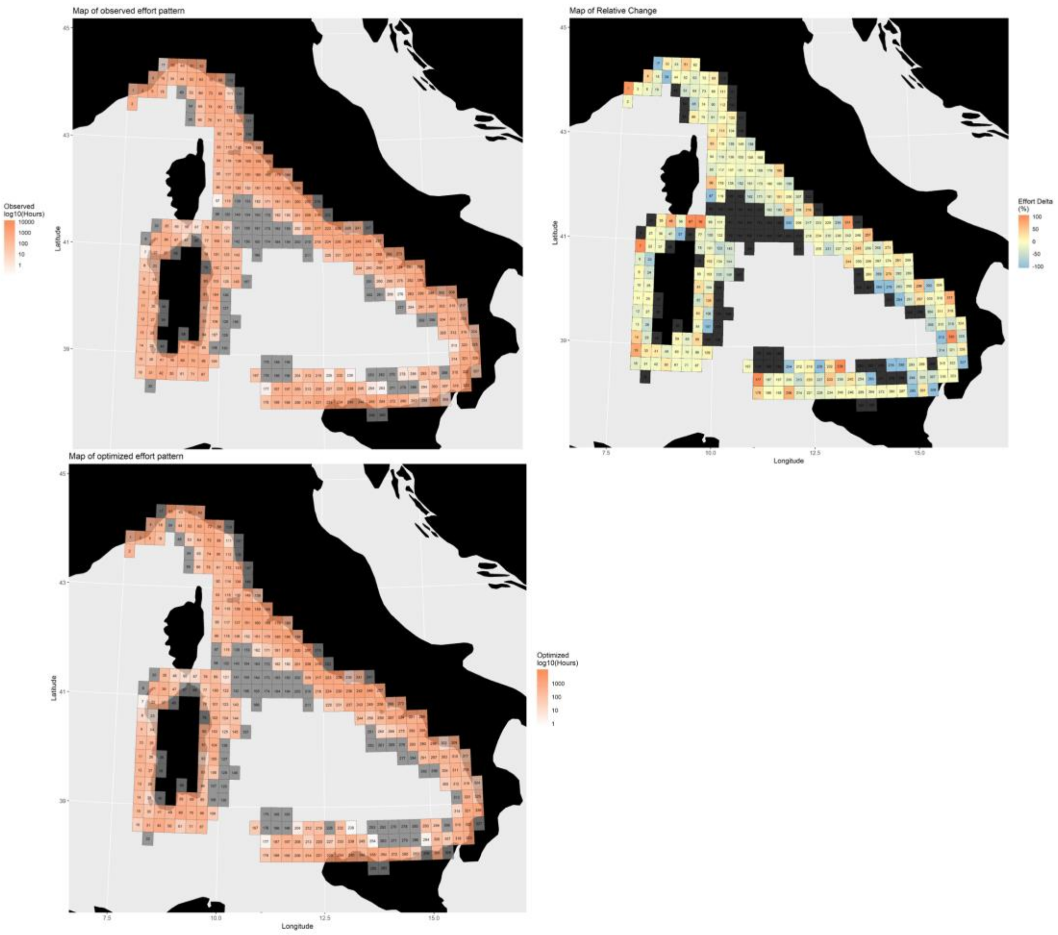


Figure 32 – SMART. Observed fishing effort (upper left panel) for the years 2015-2016; predicted fishing effort (bottom left panel) after the 10% reduction of the total effort; difference in percentage, for each cell, between observed and predicted patterns (right panel).

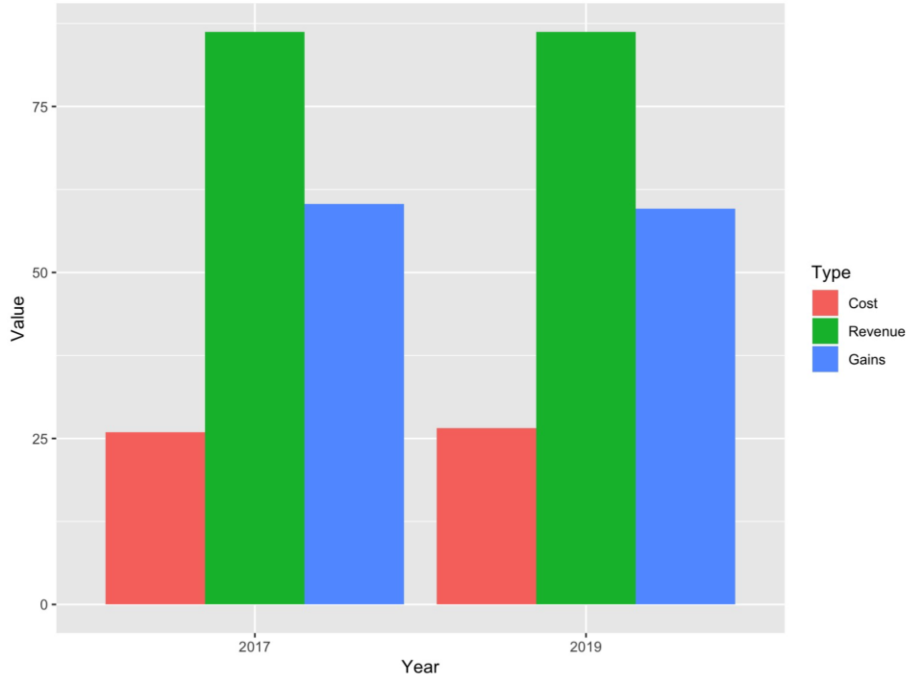


Figure 33 – Main economic parameters summarizing the performance of the trawling fleet before and after the 10% decrease of the effort.

9.6 Summary on the model: achievements, gaps still to be addressed, work plan from now to STECF 19-14 (October 2019)

This preliminary application of SMART to EMU2 is still in his infancy, but it is possible to summarize that:

- The estimates of the baseline are partially coherent with DCF data end EWG18-12, even considering that the modelled segments are related to trawlers equipped with VMS, and thus they represent only a subset of the whole Italian fleet operating in the area;
- The management measures in the MAP are likely to determine different consequences for the four demersal stocks considered. In particular, the displacement of the fishing effort from less productive areas to the main fishing grounds is expected to partially compensate the MAP measures. In this way, SMART predicted that the new F by species will be lower than before the establishment of the MAP but still higher of the target values.

The next step towards STECF 19-14 will be:

- The extension of the historical time series used to train the model;
- If possible, the extension of the model to other (French of Spanish) GSA;
- The integration of additional species;
- The exploration of additional management scenarios and the preparation of middle-term forecast of the effect on the Spawning Stock Biomass of the different stocks.

10 ISIS-FISH IN THE GULF OF LIONS (GSA 7, EMU1)

10.1 Overview of the model's generic characteristics and use

10.1.1 Main features

See Table 4 above, previous descriptions in Nielsen et al., 2018 and references below

10.1.2 References

Mahevas, S., & Pelletier, D. (2004). ISIS-Fish, a generic and spatially explicit simulation tool for evaluating the impact of management measures on fisheries dynamics. Ecological Modelling, 171(1–2), 65–84.

Pelletier, D., Mahevas, S., Drouineau, H., Vermard, Y., Thebaud, O., Guyader,O., & Poussind, B. (2009). Evaluation of the bioeconomic sustainability of multi-species multi-fleet fisheries under a wide range of policy options using ISIS-Fish. Ecological Modelling, 220(7), 1013–1033.

10.2 Application of the model to the West Med MAP

10.2.1 State of completion and additional development work specially undertaken before and during EWG 19-01

ISIS-FISH model is being used to model the trawlers fleets targeting hake in the Gulf of Lions (GSA 7). Its main objectives are to simulate and compare impacts of effort reduction and spatial and/or seasonal closures on Hake stock dynamics and age structure of catches. At present, this model is not yet operational and needs improved calibration to properly reproduce observed biomass dynamics. A framework including calibration and uncertainty analysis has been developed to assess model skills and to provide a robust diagnostic of management scenarios consequences.

10.2.2 Space and time scale

It is spatially structured and uses a 3'x3' regular grid covering the whole Gulf of Lion. It reproduces monthly dynamics and allows investigating intra-annual and inter-annual stock and fleet dynamics and the response to effort reductions and seasonal closures.

10.2.3 Stocks (which stocks, which assessment data etc)

Hake stock dynamics is detailed based on GFCM (Hake, GSA 7) stock evaluation parameters and MEDITS data. Other species catch value and their static distribution may be added in the future to investigate short-term income change in case of spatial closure scenarios.

10.2.4 Fleets

French and Spanish trawlers' fleets are described. French trawlers are further detailed depending on main landing harbour, vessel size (above or below 24m), gear used (OTM, OTT, OTB). Fishing ground and hake catch distribution are obtained from data aggregating daily VMS data and landing data.

This model was not used during the STECF EWG 19-01 meeting

10.3 Summary on the model: achievements, gaps still to be addressed, work plan from now to STECF 19-14 (October 2019)

More efforts are still needed to make this model operational. At present it should be considered as a research object and planned work aims at improving its realism in the next few months. If model calibration is achieved by October 2019, it will be possible to simulate effort reduction in 2019 corresponding to the F reduction in single-stock advice and investigate its effect on catches and biomass. Model outputs comparison with IAM short-term forecast may also be undertaken using a common aggregation level. Providing that these preliminary results are satisfactory, base-line scenario of effort reduction over 2020-2025 period may be forecasted. These however, will still only cover the hake population in GSA 7.

11 MAIN ISSUES AND GAPS

This section summarises the main issues that have been identified by the EWG regarding the implementation of an operational mixed-fisheries advice for the West Med MAP, and the next steps needed to progress.

11.1 Estimation of fishing effort (compatibility of the different databases)

11.1.1 What is the problem

The issue of the estimation of fishing effort was discussed extensively in the two previous reports (EWGs 18-09 and 18-13). The two main questions were i) what would be the most appropriate unit to measure effort and ii) which would be the primary source of information for monitoring this measure? The first question relates to the fact that fishing effort can be measured in many different ways (e.g. days, hours etc). The second question relates to the fact that EWGs 18-09 and 18-13 identified differences, sometimes substantial, for the same unit of effort extracted from different databases available at JRC.

11.1.2 Where are we in addressing this issue

STECF 18-09 and 18-13 reviewed the quality and availability of several fishing effort descriptors. A good measure shall be easy to measure (i.e. how to monitor the fulfilling of the measure compared to the agreed ceiling), easy to control (i.e. what happens once the ceiling has been reached), and reflect the true activity of the fleet. This last one is the most important, since it is expected that managing the effort measure at the agreed level should have a tangible effect on the stocks. Days at sea are easiest to measure, but can easily be biased if reduced numbers of days are compensated by longer trips. Therefore, monitoring also the number of hours at sea is of crucial importance, in order to track and if necessary correct against this potential substitution. The MAP contains already some elements against the increase of hours at sea above 15 hours per day.

11.1.3 What are the next steps

Regarding the first issue, hours at sea are now already recorded in the FDI database, and this should be maintained. Hours at sea are becoming increasingly to measure using VMS or AIS, and these data provide also very useful information for more in-depth analyses of how fishing effort is targeted towards the various species.

Regarding the second issue, the inconsistency between databases needs to be investigated further, checking the procedures involved to answer the different data calls in the different member states, and aligning them with each other where necessary.

There is also a need for dialogue between the scientific institutes and the national authorities to make sure that the procedures are also fully aligned between the scientific databases and the ways member states will calculate the effort baselines and the monitoring of fishing effort.

Similar adjustments took place in the Atlantic EU waters in the previous decade when effort regimes were put in place, and it is reasonable to believe that such alignements can be overcome without major hindrances.

11.2 Mixed-metiers vs. deep water metiers

11.2.1 What is the problem

In the Management Plan of western Mediterranean, the fisheries are distinguished by species and gear: the continental shelf and upper slope group is defined by catches of red mullet, deep water rose shrimp, hake and Norway lobster; while the deep waters group is defined by catches of blue and red shrimp and giant red shrimp. It should be clarified by the Management Plan if the metiers fishing for red shrimps (MDD and the DWS) utilised in the Data Collection Framework (DCF) will be both classified as deep fisheries (independently by the share of deep water species caught). In fact, this could risk overestimating the fishing effort on deep water fisheries, as during trips classified as mixed fisheries (MDD) often hauls on shallow areas are carried out, but, according to the Management Plan, will fall anyway on the deep fisheries effort group (Table 20).

Table 20. The table shows the allocation of the fishery in the management plan, depending on the allocation done in the data collection process.

Continental shelf and upper slope fishery	DEF	No deep water species
Deep waters fishery	MDD	Deep water species <40% or not the first species in the catch
Deep waters fishery	DWS	Deep water species >40% or the first species in the catch

11.2.2 Where are we now in addressing this issue

The Data Collection on Fisheries (DCF) provides for the collection of demographic and landing data of the catches obtained from different target assemblages (level 5) for the gear OTB (level 4) as reported in Appendix IV (Fishing activity by region) of the Commission Decision of 18 December 2009 adopting a multiannual Community programme for the collection, management and use of data in the fisheries sector for the period 2011-2013 (2010/93/EU). Other gears, classified as trawling and included in the Management Plan, are OTT (multi-rig otter trawl), PTB (bottom pair trawl), TBB (beam trawl), OTM (midwater otter trawl) and PTM (midwater pair trawl). For those gears, landings were registered in the DCF database for the western Mediterranean. However, they operate in shallower waters and do not exploit deep water species. The Management plan reports also other gears but currently they are not utilised in the western Mediterranean.

The Mediterranean Planning Group for Methodological Development (PGMed, Report of the 2nd Meeting in 2008) reported that the term "deep water species" for the Mediterranean area referred only to red shrimps, *Aristaeomorpha foliacea* and *Aristeus antennatus*, species not included in the definition of deep sea species given by the Council Regulation (EC) 2347/2002.

The Mediterranean Planning Group for Methodological Development (PGMed, Report of the 3rd Meeting in 2009) reported that for the Mediterranean the basic métier for which a threshold is required for allocating the target assemblages at level 5 is the bottom otter trawl (OTB), with three target assemblages (demersal species, deep water species, mixed demersal and deep water species). PGMed reported that different approaches are applied by the MS for allocating the target assemblages of a bottom otter trawl at a trip level: either a quantitative threshold (e.g. 40% contribution in the total catch in weight) or a qualitative one (presence/absence of species) was used. The Group suggested that, when deep water species occur in the catch, the catch should be sorted to demersal and deep water species and be ranked by value. In the case the deep water species are ranked first, the target assemblage should be assigned to deep water species (DWS); in the case the deep water species are ranked second, the target assemblage should be assigned to mixed demersal and deep water species (MDD). The PGMed was informed that a study for allocating metiers based on VMS and logbook data was granted by the Commission by the end of 2010. It was expected that the outcomes of the study should provide support to MS for setting common thresholds for allocating target assemblages but this did not happen as the study was finally not carried out.

ITALY

The distinction among the metiers level 5 for OTB is based on the presence/absence and relative importance in the landing of the two species of red shrimps (Blue and red shrimp, *Aristeus antennatus* and giant red shrimp, *Aristaeomorpha foliacea*). The first metier related to bottom trawling is defined DEF (demersal species) and it is attributed to the trips in which red shrimps are not present in the landing. The second metier, MDD (mixed demersal and deep water species) is attributed to the fishing trips in which the red shrimps (one or both species) are present in the landing but they represent less of the 40% of the total biomass landed in that trip. The third metier, DWS (deep water species) is characterised by the presence of red shrimps (one or both species) in the landing in a percentage higher than 40% of the total landing. Italy has adopted this scheme of attribution of level 5 of the metier starting from the National Program 2009-2010.

The sampling unit for the collection of the demographic and landing data is represented by the fishing trip that could be constituted by one or more fishing days. It could happen that, during the fishing trip to which the target assemblage MDD or DWS is attributed, some hauls are performed in deep waters to target red shrimps and other hauls in shallower waters where other species than red shrimps are caught.

The Italian fleet operating in the western Mediterranean does not utilise other types of bottom trawling than OTB with the only exception of OTM in GSA 10.

FRANCE

The French fleet operating in GSAs 7 (Gulf of Lyons) and 8 (waters around Corsica) does not fish for red shrimps. In GSA 7, the wide extension of the continental shelf makes the deep fishing grounds very far from the fishing ports. In this area, the red shrimps are exploited only by some Spanish vessels coming from GSA6. In GSA 8, the trawling fleet is composed by very few small vessels not equipped for fishing in deep waters. In this area, deep water resources are not exploited.

Since 2002, PTB has never been used by the French fleet operating in the western Mediterranean waters. Landing of TBB have been registered in GSA7 only in 2013. OTT is utilized by French vessels in GSA7 starting from 2014. OTM is commonly used in the GSA.

SPAIN

The attribution of the target assemblage (Level 5) is done for each single trip that in Spain corresponds to one fishing day (12 hours). The metier demersal species (DEF) is attributed to the fishing trips of OTB when red shrimps are not landed. Mixed demersal and deep water species (MDD) represents the trips in which the catch of red shrimps is accompanied by other demersal species. As in the case of the Italian fleet, some hauls are performed in deep waters to target red shrimps and other hauls in shallower waters where other red shrimps are not caught. The deep sea species target assemblage (DWS) is attributed to the trips in which red shrimps constitute the large predominance of the total landing. At the present there is no limit in effort allocation between metiers and it is extremely variable between boats but also for the same boat. There are differences between ports related with the extension of the continental shelf. Moreover, it is not rare that boats may do fishing sets at both metiers in the same day.

Since 2002, PTB, TBB, OTM and PTM have never been used by the Spanish fleet in the western Mediterranean.

11.2.3 What are the next steps

The Management Plan provides for a management of fishing effort in relation to the target species. It is very important that the classification of the fisheries is compatible with the one applied in the DCF. In the western Mediterranean the fishery is typically multispecific and the trips are characterized by hauls performed at different depths even during the same day. It will therefore be important to define a method to correctly attribute the catches and the related fishing effort to one of the two groups identified by the Management Plan.

It is a concern that at the moment Member States do not use the same process to allocate metier depending on the composition of the catch. There should be an agreement among the member states on which should be the standardized method to do so, so that the data collected can be comparable and effort allocation will not vary depending on the data collection but on the actual catch compositions.

11.3 **Multiple assessments and differences in stock definitions for hake**

11.3.1 What is the problem

The Hake stock is currently being assessed at several spatial scales. Most stock assessment models are focusing on the GSA scale (which is the scale at which GFCM is currently providing advice), while in STECF hake is assessed at the level of the combined GSAs. The GSA scale may not be the most convenient to propose management measures at the European level. Furthermore, biological information is still uncertain regarding the degree of connection of hake populations between GSAs (see among other discussions in STECF EWG 18-12, 18-13 and STOCKMED report)

11.3.2 Where are we with addressing this issue

Hake stock assessment in the western Mediterranean will undergo a benchmark in 2020, during which options for grouping GSAs for stock assessment purposes will be explored. We hope that the benchmark will result with proposal for grouping that makes sense from both a biological and a management perspective.

11.3.3 What are the next steps

Perform the benchmark.

11.4 **One broad vs. several detailed models in the EMU1**

11.4.1 What is the problem

EMU1 covers the GSAs bordering two Member States, Spain and France, and a number a while EMU2 covers mainly one. Different Member States means different access to data, and different developments according to the national and/or regional priorities. As a result, the existing models developed in Italy covers GSAs 9,10 and 11, while, at contrary, the models available in Spain and France do not cover the entire EMU1. IAM and ISIS-FISH, developed in France, cover only GSA 7. MEFISTO, developed by CSIC in Barcelona, covers mainly GSA6, although some applications have also been developed for GSA5 in the past. No models cover the GSAs 1 and 2.

11.4.2 Where are we with addressing this issue

During the EWG, some trails were made both with MEFISTO and with IAM to extend the current models' set up to additional GSAs. Also, simpler models like FLBEIA and Flasher were implemented for the first time during the EWG. FLBEIA showed that it was very easy to deal with several stocks once supplied in the appropriate FLStock format, and that similar ease of use is expected for fleet data once formatted as FLFleets objects (but this was not done during the EWG).

11.4.3 What are the next steps

During the EWG it was concluded that MEFISTO was not appropriate for running scenarios over several GSAs, being too complex to parameterise and slow to operate. Three options for future work were thus considered by the experts:

- Extending IAM to the GSAs along the Spanish coasts, with appropriate stocks and fleets data
- Further developing the FLBEIA application with appropriate fleets data
- Implementing a BEMTOOL application from scratch, to be consistent with EMU2.

After the EWG, the conclusion reached by the experts was that the preferred option would be the first one (extending IAM), on the basis that this is this model where most expertise is in the region. It was understood that further work should take place intersessionally, depending on funding options for supporting the work before the next EWG.

11.5 **Other species**

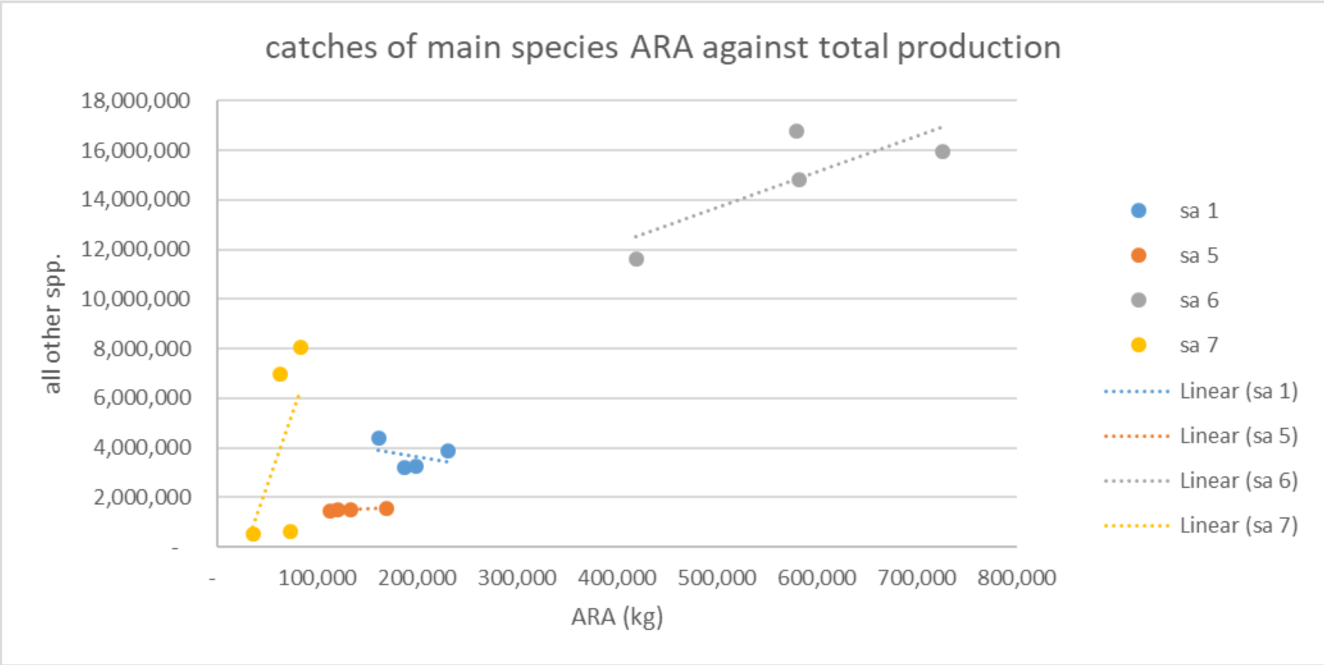
11.5.1 What is the problem

Bioeconomic models rely on modelling the population dynamics of fish stocks and the economic dynamics of fleets. In the case of multi-species fisheries, such as the western Mediterranean demersal fisheries, the number of fish stocks for which there are parameters to populate a population dynamics models are typically few. For instance, in EMU1 demersal fisheries produce of the order of 60 species in significant quantities, but only 5 are concerned by the Multi-Annual management Plan. These 5 species are, naturally, the main species in terms of landings and economic importance and stock assessments are regularly produced. However, they represent 20% or less (depending on the GSA) of the total demersal fisheries production. Hence the population dynamics of the majority of demersal stocks ("secondary species" or commercial bycatch) is not well-known and the effect of the effort reduction proposed in the MAP on these secondary species cannot be assessed with any accuracy.

11.5.2 Where are we in addressing this issue

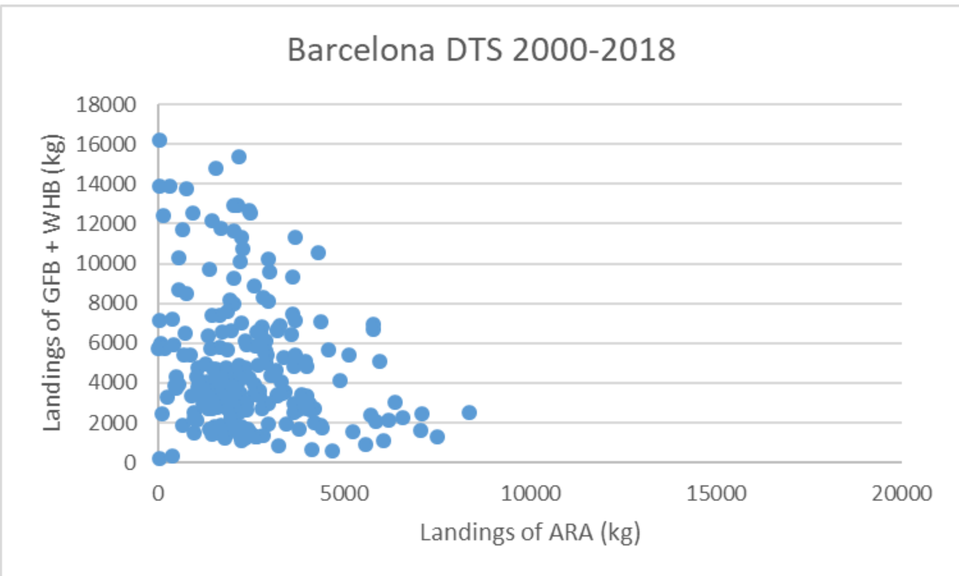
There are two common approaches to relate the production of secondary species to the production, and hence the population dynamics, of main species: constructing a mathematical relationship between main stocks and secondary species in terms of catches or using fishing effort as a proxy for the production of secondary species. Both approaches are simplistic and can be the source of large uncertainty in the bioeconomic results, especially when the models are fitted with short data series.

Compare the following relationships between a main species (ARA) and the bycatch of DTS across the four GSAs in EMU 1. The official data available to establish these relationships was just a short data series (2013-2016) in the 2018-07_STECF 18-07 - EU Fleet Landings FAO Gear levels_final.xlsx.



11.5.3 What are the next steps

The correct parameterization of models of target species with bycatch, or secondary species, needs to be done with sufficiently long data series. Additionally, it is not necessary to limit the analysis to a single pool of accessory species per main species. A detailed species-by-species analysis of catch data series would suggest groups of secondary species that follow the same trend of the target species or groups of secondary species that follow a different trend. And naturally the relationship between main and secondary species does not need to be a linear model. The following figure shows the monthly landings of the Barcelona trawl fleets in the period 2000-2018, considering ARA as the target species and the two main species of commercial (GFB: *Phycis blennoides* or greater forkbeard, and WHB: *Micromesistius poutassou* or blue whiting) by catch as secondary species. There is an overall decreasing relationship between the target species and the secondary species, but the large variability suggests that many other factors (e.g. seasonality, year to year variation, market price of secondary species) should be considered.



11.6 **Other gears**

11.6.1 What is the problem

The MAP for the western Mediterranean is aimed at the management of the towed gears fisheries. However, we must take into account the fact that Mediterranean fishing is not only multi-specific but also multi-gear, in the sense that some species are exploited by different gears that can be used in different periods of the year, in different areas and targeted to catch different demographic portions of a certain stock. From the analysis of the landing data (DCF database as used in STECF EWG 18-12) of the period 2015-2017 in the two effort management units, it appears that the four target crustaceans species of the MAP (ARS, ARA, DPS and NEP) are exclusively exploited by the towed gears. On the other hand, gears used by the small scale fishery, essentially gillnet (GNS) and trammel net (GTR) for demersal species, also significantly contribute to the commercial landing of the two species of bony fish included in the MAP, HKE and MUT. In the management unit east western Mediterranean (EMU2), almost 40% of the total catch of hake comes from small-scale fisheries. In particular, there is a fishery in the GSA9 that uses GNS to catch adults of this species. The nets used are highly size-selective and catch exclusively specimens above the Minimum Reference Conservation Size. In the GSA10, the landings of hake are essentially due to the small scale fishing gears (70-80%) that land much more than the towed ones. In this area, GNS, GTR and bottom longline (LLS) are important. In the GSA8, according to the different years analysed, from 2 to 24% of the hake landing is due to the set nets, GNS and GTR. Information on GSA11 is not available in the DCF data; however from the national database the landing of hake from small scale fishery in this area resulted around 10% of the total.

As concerns red mullet in the east western Mediterranean management unit, the landings from the small scale fisheries (mostly GTR) is about 5-7% of the total. Also in this case, the specimens caught by GTR are adults of medium-large size, given the high selectivity of the gears used. The fishery targeting this species with GTR is particularly developed in the GSA10, but it is also presents in the GSA9 and GSA11. The landing of red mullet in GSA8 are not reported in the DCF database.

In the west western Mediterranean effort management unit, the hake and red mullet landings by small-scale fisheries represent about 7-10% of the total landings of the two species. Hake is captured mainly with GNS and, to a lesser extent, with GTR and LLS. Fishing with GNS is particularly important in GSA7, while LLS are more utilised by the Spanish fleets operating in GSA1 and GSA6. Red mullet is caught by the small scale fishery exclusively with GTR that represents an important fishery in GSA1 and GSA6.

From the analysis of the available landings and the relative demographic structures, it appears that in the case of the two species of bony fish, hake and red mullet, the importance of small scale fishery gears is not negligible, contributing to 5 to 40% of the total landing of each species. This fraction of the landings is of high importance from a management point of view if we consider that it is composed exclusively by adult individuals, given the high selectivity of the gears used. In the evaluation on the exploitation status of these two species, it is therefore important to include also the catches due to these gears. Their exclusion can in fact lead to inaccurate conclusions, especially for the estimation of spawning stock biomass. The fact that the MAP does not take into consideration the management of these gears as a major gap, as the effect that an increase in the catches by those gears cannot be taken into account.

Table 21 – Contribution of the different gears to the landing of hake in tons and in percentage of biomass landed (data from EWG 18-12, Med&BS data call).

		Landings (tons)						Landings (in percentage)					
species	HKE	Other gears	GNS	GTR	LLS	OTB-OTM-OTT-PTM	Total	Other gears	GNS	GTR	LLS	OTB-OTM-OTT-PTM	Total
2015	GSA 1	0	2	4	5	172	183	0	1	2	3	94	100
2015	GSA 2					1	1					100	100
2015	GSA 5					102	102					100	100
2015	GSA 6		39	21	72	1594	1726		2	1	4	92	100
2015	GSA 7	2	153	16	7	940	1118	0	14	1	1	84	100
2015	**GSA 1-2-5-6-7**	**2**	**194**	**41**	**85**	**2808**	**3130**	**0**	**6**	**1**	**3**	**90**	**100**
2016	GSA 1		2	2	3	169	176		1	1	2	96	100
2016	GSA 2					1	1					100	100
2016	GSA 5					67	67					100	100
2016	GSA 6		22	24	45	1719	1810		1	1	2	95	100
2016	GSA 7	2	124	2	4	899	1031	0	12	0	0	87	100
2016	**GSA 1-2-5-6-7**	**2**	**148**	**29**	**52**	**2854**	**3084**	**0**	**5**	**1**	**2**	**93**	**100**
2017	GSA 1	0	1	7	3	288	299	0	0	2	1	96	100
2017	GSA 2					2	2					100	100
2017	GSA 5					72	72					100	100
2017	GSA 6		24	38	49	1617	1728		1	2	3	94	100
2017	GSA 7	0	148	5	6	688	847	0	17	1	1	81	100
2017	**GSA 1-2-5-6-7**	**0**	**173**	**50**	**58**	**2667**	**2948**	**0**	**6**	**2**	**2**	**90**	**100**
2015	GSA 8		0	0		1	1		9	15		76	100
2015	GSA 9		158	35		855	1048		15	3		82	100
2015	GSA 10	2	363	190	202	287	1043	0	35	18	19	27	100
2015	GSA 11					220	220					100	100
2015	**GSA 8-9-10-11**	**2**	**522**	**225**	**202**	**1362**	**2312**	**0**	**23**	**10**	**9**	**59**	**100**
2016	GSA 8	0	0	0	0	0	0	1	9	12	1	77	100
2016	GSA 9		83	37		661	782		11	5		85	100
2016	GSA 10	28	275	208	227	314	1052	3	26	20	22	30	100
2016	GSA 11				0	265	265				0	100	100
2016	**GSA 8-9-10-11**	**28**	**359**	**245**	**227**	**1241**	**2100**	**1**	**17**	**12**	**11**	**59**	**100**
2017	GSA 8	0	0	0		14	15	0	0	2		98	100
2017	GSA 9	0	85	13		474	572	0	15	2		83	100
2017	GSA 10	13	266	113	129	133	653	2	41	17	20	20	100
2017	GSA 11					304	304					100	100
2017	**GSA 8-9-10-11**	**13**	**350**	**126**	**129**	**926**	**1545**	**1**	**23**	**8**	**8**	**60**	**100**

Table 22. – Contribution of the different gears to the landing of red mullet in tons and in percentage of biomass landed (data from EWG 18-12, Med&BS data call).

		Landings (tons)						Landings (in percentage)					
species	MUT	Other gears	GNS	GTR	LLS	OTB OTT OTM TBB	Total	Other gears	GNS	GTR	LLS	OTB OTT OTM TBB	Total
2015	GSA 1	1	0	9		126	136	1	0	7		93	100
2015	GSA 2	0				0	0	0				0	100
2015	GSA 5	0		1		1	2	0		28		72	100
2015	GSA 6	1	1	130	1	1387	1519	0	0	9	0	91	100
2015	GSA 7	0	1	0	0	313	314	0	0	0	0	100	100
2015	**GSA 1-2-5-6-7**	**2**	**2**	**140**	**1**	**1827**	**1971**	**0**	**0**	**7**	**0**	**93**	**100**
2016	GSA 1	1	0	78		181	260	0	0	30		69	100
2016	GSA 2	0				0	0	0				0	100
2016	GSA 5	0				10	10	0				100	100
2016	GSA 6	1		92	0	1581	1674	0	0	6	0	94	100
2016	GSA 7	0	32	16		388	436	0	7	4		89	100
2016	**GSA 1-2-5-6-7**	**2**	**32**	**186**	**0**	**2160**	**2381**	**0**	**1**	**8**	**0**	**91**	**100**
2017	GSA 1	0		64		211	275	0		23		77	100
2017	GSA 5	0				13	13	0				100	100
2017	GSA 6	1		110	1	1338	1449	0		8	0	92	100
2017	GSA 7	0	4			268	272	0	1			99	100
2016	**GSA 1-2-5-6-7**	**1**	**4**	**174**	**1**	**1830**	**2009**	**0**	**0**	**9**	**0**	**91**	**100**
2015	GSA 9	0	8	54		1121	1183	0	1	5		95	100
2015	GSA 10	10	13	37		362	421	2	3	9		86	100
2015	GSA 11	0				197	197	0				100	100
2015	**GSA 9-10-11**	**10**	**21**	**91**	**0**	**1680**	**1802**	**1**	**1**	**5**	**0**	**93**	**100**
2016	GSA 9	0	11	70		1140	1222	0	1	6		93	100
2016	GSA 10	0	2	31		319	353	0	1	9		91	100
2016	GSA 11	0				232	232	0				100	100
2016	**GSA 9-10-11**	**0**	**13**	**102**	**0**	**1692**	**1806**	**0**	**1**	**6**	**0**	**94**	**100**
2017	GSA 9	0	12	38		1410	1461	0	1	3		97	100
2017	GSA 10	0	1	29		209	240	0	1	12		87	100
2017	GSA 11	0				91	91	0				100	100
2017	**GSA 9-10-11**	**0**	**13**	**68**	**0**	**1710**	**1791**	**0**	**1**	**4**	**0**	**95**	**100**

11.6.2 Where are we with addressing this issue

The models presented during EWG 19-01 already include to some extent the non-trawlers fleets. Examples of this are given for e.g. BEMTOOL, NIMED, IAM or MEFISTO. The data needs for including these non-trawlers fleets in the model are the same as for the trawlers, and there is thus no specific challenges in including these other fleets.

11.6.3 What are the next steps

The final models to be used in the future shall all include the non-trawls fleets, either in disaggregated form or aggregated into a single "others" fleets. The main requirement is that all catches from the single-stock assessment must be allocated to some fleets, in order to have the full adequacy between the fleets' module and the stocks' module, and to account for all sources of fishing mortality.

This will also allow testing management scenarios for the non-regulated fleets, and to assess their role in the achievement of the MAP objectives.

11.7 **Various scales of models**

11.7.1 What is the problem

For EMU2, 3 models (BEMTOOL, NIMED ad SMART) were presented as parameterized and operational to test different scenarios aimed at developing the fishing effort regime. The three models are characterized by different level of complexity and different time and spatial scales.

11.7.2 Where are we with addressing this issue

NIMED has been used in chapter 5 in association with the short term.

BEMTOOL has been used in chapter 6 to predict the impact of MAP measures on a fine time scale (temporal closure) and taking into account implicitly spatial considerations (simulating spatial closure of areas within 100 m). The reductions in effort was differentiated by fleet segment, according to the impact on the stocks and also assuming hyperstability. Due to time constraints, the simulations did not include the uncertainty, but this will be included in the next steps.

A preliminary application of SMART presented in chapter 9 was carried out, parameterizing only the training phase.

11.7.3 What are the next steps

The next steps to address the problem in EMU2 are:

- Update BEMTOOL application to EMU2, using the outcomes of the next EWG on stock assessment in the area and exploring the scenarios that will be considered useful for the aims of the MAP, including uncertainty;
- SMART model, can be coupled to BEMTOOL to derive, in the short term, the actual fishing mortality most likely to occur from effort reduction considering that fishing vessels may change their fishing pattern and spatial effort allocation.

11.8 **Requirements for the stock assessment (consistency between stock object and assessment report)**

11.8.1 What is the problem

The working group analysed the output of the STECF 18-12 working group to be used for the purposes of the EWG 19-01. The assessment procedures were analysed to check the consistency between the information reported in the text and the data generated as output of the assessment provided as R stock object.

Outputs of the assessment have been used to set the target for both F and catches and to parametrise the models in order to evaluate the effort regime in the western Mediterranean Sea as requested in the ToRs.

The short term forecast (STF) estimates catch in year Y+1 based on the assessment with final year Y-1 to predict 2 years forward and define the catch options to target the F0.1 as a proxy of Fmsy. The EWG 19-01 checked the STF output from the assessments against the output from the mixed fisheries models used in the WG.

Moreover in the report STECF-18-12, both the stock specific summary sheets (section 5) and assessment results (section 6) by stock were checked. Inconsistencies were found in the report, since the text did not always correspond to the outputs. In addition, the information in the report was not always the same as in the stock objects.

Inconsistence were for both EMU1 and EMU2, and listed below and reported on the table below.

West Western Mediterranean Sea - EMU1 (GSAs 1,2,5,6,7)

Stock numbers at age and F at age are required as input for MEFISTO, that was applied to GSAs 1-5-6-7 to HKE. Furthermore, in some cases these values are not presented in the report.

HKE1-5-6-7

Small differences in F at age, that result in different Fbar (0-2) values and small difference in $F_{0.1}$ (see table below)

Small differences in the recruitment (geometric mean of the last 6 years): 115880 in the report and 116039 in the stock object.

Small differences in numbers at age

MUT1

F at age in the report higher than in the stock object.

Stock numbers at age not presented in the report.

R much higher in the stock object than in the report.

ARA1

F at age and catch at age not presented in the report.

ARA6

F at age and catch at age not presented in the report.

East Western Mediterranean Sea - EMU2 (GSAs 8,9,10,11)

EWG19-01 detected some contradictory information in the stock assessment of Hake and Giant red shrimp in the eastern management unit (GSA 9_10_11).

For hake, the F target had been calculated as an average of all age classes while in the report is clearly stated that Fbar 0-2 was used (Table below). Moreover by reproducing the STF with the provided stock object a slight discrepancy on terminal F in the assessment (2017) and catch were found.

When the Fbar was set to 0-2 as indicate in the report, the output of STF replication showed a slight different value for the target F and a different % of change between target F in 2019 and the estimated F for 2017.

For Giant red shrimp (ARS), the replication of the STF using the provided stock object (Fbar 0-4) gives the same numbers listed in the report. When the Fbar range was set to the values indicated in the report (Fbar 1-3) to replicate the STF a 10% change in the estimation of terminal and target F was found.

Table 23. Comparison of stock objects and STF assumptions and results listed in the report.
F status quo is the Fbar estimated as reported in the report; F 2017 is terminal F in the assessment. Change in F is the difference (as a fraction) between target F in 2019 and the estimated F for 2017. Change in catch is from catch 2017 to catch 2019. (in red are highlighted discrepancies on Fbar settings).

stock	source	Fbar range	F status quo	F 2017	F 2019	Change in F	catch 2017	catch 2019	Change in catch	Fbar/Fmsy
hke 9-10-11	EWG18-02 report	0-2	0.6	0.55	0.14	-75	1782	494	-72	4.29
hke 9-10-11	Check stock object	0-6	0.6	0.54	0.14	-74	1778	506	-72	4.22
hke 9-10-11	EWG19-01 new STF	0-2	0.71	0.62	0.17	-73	1778	506	-72	4.22
ars 9-10-11	EWG18-02 report	1-3	1.12	1.12	0.57	-50	399	171	-57	1.96
ars 9-10-11	Check stock object	0-4	1.12	1.12	0.57	-50	399	172	-57	1.98
ars 9-10-11	EWG19-01 new STF	1-3	1.37	1.37	0.69	-50	399	172	-57	1.98
hke 1-5-6-7	EWG18-02 report	0-2	1.14	1.14	0.23	-80	3172	819	-74	4.96
hke 1-5-6-7	Check stock object	0-2	1.13	1.13	0.22	-80	3166	466	-85	5.06
hke 1-5-6-7	EWG19-01 new STF	0-2	1.13	1.13	0.22	-80	3166	466	-85	5.06
ara 1	EWG18-02 report	0-2	0.73	0.73	0.42	-42	99	97	-2	1.74
ara 1	Check stock object	0-2	0.73	0.57	0.42	-27	115	88	-23	1.73
ara 1	EWG19-01 new STF	0-2	0.73	0.57	0.42	-27	115	88	-23	1.73
ara 6	EWG18-02 report	0-2	0.96	0.96	0.32	-67	527	223	-58	3.00
ara 6	Check stock object	0-2	1.04	0.96	0.32	-67	526	216	-59	3.3
ara 6	EWG19-01 new STF	0-2	1.04	0.96	0.32	-67	526	216	-59	3.3
mut 1	EWG18-02 report	0-2	1.47	1.47	0.26	-82	231	35	-85	5.65
mut 1	Check stock object	0-2	1.19	1.19	0.26	-78	278	122	-56	4.55
mut 1	EWG19-01 new STF	0-2	1.19	1.19	0.26	-78	278	122	-56	4.55

11.8.2 Where are we now with addressing this issue

Some models need some specific raw data to improve the analysis, and others need different format of data output to facilitate an easier parametrization of models. EWG 19-01 suggest some improvement to be taken in to account in the next coming stock assessment EWG.

1) Data and parameters used for the STF should be made available for reproducibility of the forecast
2) Assessors should upload the STF object and the code done to implement it to allow using it in the following working group
3) Input catch data used for the assessment should be reported as landings and discard separated matrices and disaggregated by gear (NIMED)
4) Abundance index of the tuning fleet should be available by length age class (SMART)
5) F should be also provided by metiers as an output of the stock assessment
6) MEFISTO is an age structured model, therefore only results from analytical assessments can be used as input to the biological sub-model
7) Ensure that the results in the report are presented at least as tables, not only as figures.

11.8.3 What are the next steps

Update the models with the new outputs of stock assessment and test the usefulness for the purposes of West Med MAP

11.9 **What happens in 2025?**

All simulations presented below shows that while effort reductions are expected to have a positive effect on the status of the West Med stocks, they will likely not be sufficient for reaching Fmsy in 2025. Additionally, the simulations presented here are deterministic, and do not include major sources of uncertainty –and, first of all, the uncertainty regarding the actual relationship between fishing effort and fishing mortality that has been discussed at length in STECF EWG 18-09 and 18-13.

As such, it is important to keep in mind that when reaching the end of the transition period in 2024, it might be necessary to call for larger adjustments of fishing effort in order to reach the objectives stated in the plan.

11.10 **Balancing different objectives**

The main challenge in fisheries management is that the different objectives point often out to different direction, with the long-term conservation objectives having short-term economic and social consequences.

In BEMTOOL, a conceptual framework was developed to support a multi-criteria evaluation of alternative management scenarios. By combining different multi-criteria techniques, the approach allows comparing alternative management scenarios on the basis of their ability to achieve a set of biological and socio economic goals. The analysis involved:

(1) the identification of appropriate biological and socio-economic indicators and their organization into a proper hierarchy;

(2) the definition of a set of mathematical functions to evaluate the satisfaction (utility) associated with each level of the different indicators (Figure 34); and

(3) the determination of a set of weights that represent the relative importance of each indicator to the overall utility.

The multi-criteria decision analysis (MCDA) in BEMTOOL is combining two multi-criteria techniques: multi-attribute utility theory (MAUT) and the analytic hierarchy process (AHP). MAUT relies on the idea that decision-makers attempt to maximize their utility with respect to a number of independent attributes, each one representing a management objective. The weighting set in MAUT were set by using the AHP, a method that facilitates the elicitation of individual preferences toward the different attributes and their conversion into a set of weights (Table 24).

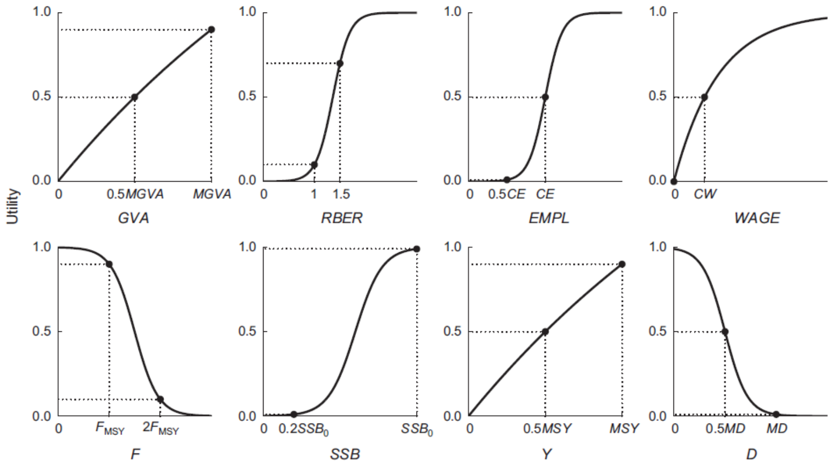


Figure 34 - Utility functions for the eight selected indicators

The indicators used are: MGVA: maximum GVA; CW: current wage; CE: current employment; F_{MSY}: fishing mortality at maximum sustainable yield; SSB0: spawning stock biomass in unexploited conditions (F=0); MSY: maximum sustainable yield; MD: maximum discard rate.

Table 24 -Final weights associated with the indicators obtained through an AHP within a panel of experts.

Indicator	Weight
GVA	0.01
RBER	0.04
EMPL	0.19
WAGE	0.06
F	0.26
SSB	0.26
Y	0.14
D	0.04

The output of the MCDA in BEMTOOL is a combination of three graphs (Figure 35) that synthetize the utility of each scenario, taking into account the set of indicators estimated by the model. A different weighing set, reflecting a different perception about the relative importance of the different indicators by a stakeholder panel could be implemented following, for example, a consultation and a survey with stakeholders.

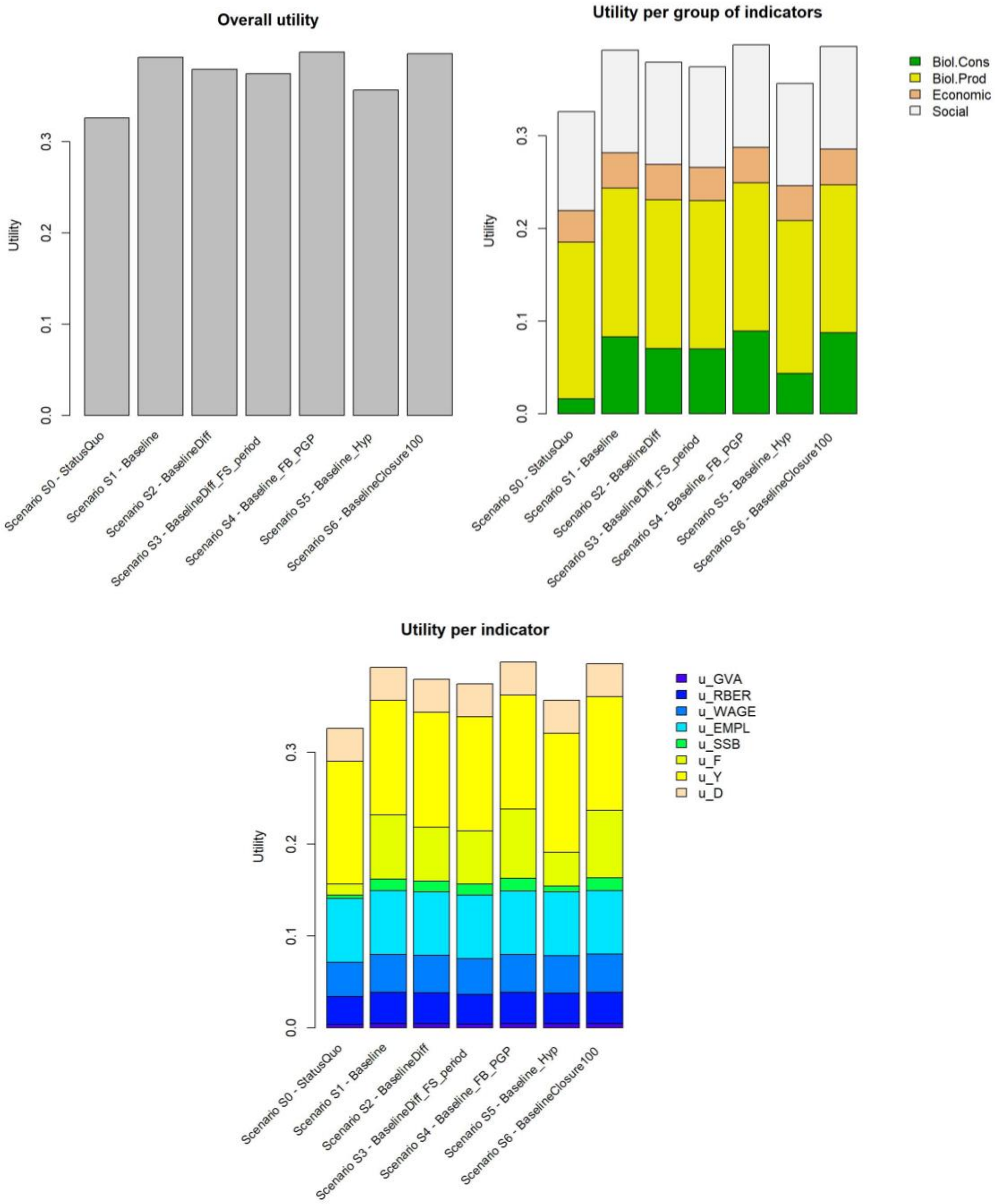


Figure 35 – Examples of the MCDA results obtained in BEMTOOL for the scenarios performed in EWG 19-01.

12 SUMMARY IN RELATION TO THE TORS

ToR 1: Selection of models

ToR1 reviewed 8 different models, of different complexity levels and covering different GSAs and EMUs. For EMU2, the 3 models (BEMTOOL, NIMED and SMARTFISH) are fully parameterised and operational, and by operating at different levels of complexity and scale, they appear complementary, allowing them to test different scenarios. For example, the expected short-, medium- and long term impacts of various options for effort reduction can be tested in BEMTOOL assuming a constant catchability and different types of relationships between fishing effort and fishing mortality (e.g. hyperstability), while SMART can mechanistically estimate what is the actual fishing mortality most likely to occur from effort reduction in the short-term, considering that fishing vessels may change their fishing pattern and spatial effort allocation.

The situation is more complex in EMU1, where five models were available but none of them is directly operational at the scale of the EMU.

No global model with a simple setup (fleet- and yearly based), was available prior to the EWG. Trials were started during the EWG to implement FLR models (FLBEIA, Flasher) from scratch. FLBEIA was easy to setup in terms of stocks, but the fleet data were not made available in an appropriate format and compatible with the catch (e.g. the sum of catches by fleet shall be the same as the total catches used in the stock assessment), so more work wold be required to get the fleet data in an appropriate and accurate dataset. FLasher could not be parameterised correctly during the EWG itself, and more work is needed to fix the coding issues encountered.

Two models with a more complex set up were presented, covering only a limited part of the EMU1: IAM in GSA 7 and MEFISTO in GSA 6. Trials to update and expand both models (in ToR2) demonstrated that IAM was rather flexible and operational, while MEFISTO was deemed more challenging to be extended to the entire EMU1. This model will not be investigated further in the context of the MAP. Finally, the fifth model, ISIS-FISH, was not ready to be used yet.

For progressing further on EMU1, more work is thus necessary to extent IAM model to the whole EMU1 and/or to complete the set-up of the FLBEIA model.

ToR 2: Stocks and forecasts

This TOR has been satisfactorily achieved by the EWG. All models presented have been updated to incorporate the latest stock assessment data coming from STECF EWG 18-12. A few models in EMU 1 were initially parameterised with the most recent GFCM assessments, which may involve a different stock definition, in particular for hake (single-GSA assessment vs. combined GSAs 1-2-5-6-7 assessment). These models were adapted accordingly and comparative runs with the two assessments were run.

For a number of models (NIMED, BEMTOOL, IAM, MEFISTO), short-term forecasts were run, assuming a reduction in fishing effort in 2019 equivalent to the reduction necessary to achieve the target F (Fmsy, proxy F01). For all models, the aggregated results of the short term forecast were largely similar between the single-stock and the mixed-fisheries models, though with larger discrepancies observed in MEFISTO.

ToR 3: Scenarios and displays

All models except ISIS-FISH and SMART were able to run the basic MAP scenario of a gradual reduction of fishing effort between 2020 and 2024. Several alternative runs and model capabilities were discussed and reported in the various models' section, with some examples given mainly for BEMTOOL. Actual scenarios and outcomes would be best agreed in discussions with MARE and Member States / stakeholders before the next meeting.

In addition, the EWG discussed a number of options for the easy display of complex results involving many stocks and many fleets. Two aspects are worth putting forward:

- FLBEIA has developed a generic R shiny application (FLBEIAShiny package, https://github.com/flr/FLBEIAshiny) for the standard display of mixed-fisheries bioeconomic projections. These do not require the models to be run with FLBEIA or even with FLR, as the R shiny involves only standard R data frames, with pre-defined column headers related to e.g. biomass and fishing mortality by stock and year or catches by fleet and year. This quick and easy display can thus advantageously be used with any model's outcomes
- BEMTOOL has a functionality for comparing the outcomes of scenarios across multiple objectives, allowing trade-offs to be highlighted in a simple and elegant way (see section 11.10). This option can be a very useful manner to convey complex information, and its use should also be discussed with managers and stakeholders

13 CONCLUSIONS AND NEXT STEPS

In conclusion, the EWG achieved its ToRs and progressed towards providing operational models for running bioeconomic mixed-fisheries scenarios in support of the MAP.

The EWG suggests that a scoping meeting with DG Mare and Member States / managers could be held before the next EWG planned at the end of September, to agree on the desired next steps and scenarios.

The main problem identified in the short term is the need to progress on the setup and parameterisation of one or more models covering all of EMU1, bring together data on both Spanish and French fleets. It remains to be decided with DG Mare and the experts involved how this progress can take place before the next EWG.

14 CONTACT DETAILS OF EWG-19-01 PARTICIPANTS

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

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15 LIST OF BACKGROUND DOCUMENTS

Background documents are published on the meeting's web site on:
https://stecf.jrc.ec.europa.eu/reports/management-plans

List of background documents:

EWG-18-09 – Fishing Effort regime of demersal fisheries of the western Mediterranean – Part I

EWG-18-13 – Fishing Effort regime of demersal fisheries of the western Mediterranean – Part II

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STECF

The Scientific, Technical and Economic Committee for Fisheries (STECF) has been established by the European Commission. The STECF is being consulted at regular intervals on matters pertaining to the conservation and management of living aquatic resources, including biological, economic, environmental, social and technical considerations.

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