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Scientific, Technical and Economic Committee for Fisheries (STECF) - Economic impact of mixed fisheries options (STECF-18-05)

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Abstract

Commission Decision of 25 February 2016 setting up a Scientific, Technical and Economic Committee for Fisheries, C(2016) 1084, OJ C 74, 26.2.2016, p. 4–10. The Commission may consult the group on any matter relating to marine and fisheries biology, fishing gear technology, fisheries economics, fisheries governance, ecosystem effects of fisheries, aquaculture or similar disciplines. This report deals with options to assess the socio-economic impacts of the TAC and quota proposal in the longer-term context. STECF reviewed the EWG report during its plenary meeting on 2-6 July in Brussels, Belgium.

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STECF advice:

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EWG-18-05 report:

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TABLE OF CONTENTS

SCIENTIFIC, TECHNICAL AND ECONOMIC COMMITTEE FOR FISHERIES (STECF) - Economic impact of mixed fisheries options (STECF-18-05)

Request to the STECF

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

STECF observations

The Expert Working Group, STECF EWG 18-05, on the Economic impact of mixed fisheries options was convened in Copenhagen, Denmark, at the ICES headquarter, 21-25 May 2018. It ran in parallel to the ICES Working group on mixed fisheries.

STECF observes that the EWG was able to address all ToRs. This was the first meeting to analyse economic impacts of the mixed fisheries advice and TAC options by applying integrated bio-economic models. It is, therefore, to be seen as a test case to illustrate what kinds of results can be expected.

Two areas were selected to run the bio-economic models: North Sea and Atlantic Iberian Waters. For these two areas a number of updated integrated bio-economic models were available in the EWG:

- SIMFISH, FISHRENT, FLBEIA and DISPLACE for North Sea
- FLBEIA for Atlantic Iberian Waters

STECF notes that the bio-economic models include generally a well-developed biological and economic module incorporating an annual feedback mechanism. This means that the biological module of the models project the dynamic of the stocks and the results regarding available catch options feed into the economic and management module. The fishing fleet(s) in the model then utilise the fishing opportunities and this feeds back into the biological module for the assessment of stocks in the following year. Therefore, these models are able to analyse medium-term developments based on different scenarios and a set of assumptions about the development of certain factors (e.g. fuel costs, selling prices) over the next few years. The time frame for the test case is 5 years (2019-2023).

STECF notes that the aim of this parallel meeting of the EWG with ICES WGMIXFISH was to test the possibilities of producing economic assessment of the ICES MIXFISH advice (TOR 1 of the EWG). The main link between the two working groups is the dataset the WGMIXFISH produces for the two selected case studies that the EWG covered (North Sea (NS) and Atlantic Iberian Waters (AIW)).

STECF observes that the EWG assessed whether data produced by WGMIXFISH could be directly used in the bio-economic models without further data transformation. This was tested for the North Sea with the SIMFISH model. STECF notes that this direct use was not straightforward to do as the fleet segmentation used in WGMIXFISH is an aggregation of the standard AER fleet segments intended to reduce the number of modelling units in the model. Therefore, additional work is required to produce consistent model economic parameters at that higher level of aggregation.

STECF notes that for short-term assessments (TOR 3) the EWG applied options (next years TAC proposal) compared to the medium term (TOR 2) where scenarios were used (medium term 2019 to 2023). Options and scenarios were tested applying two simulation models – FISHRENT in the North Sea and FLBEIA in the Atlantic Iberian Waters.; a limited exercise was also done by applying the two other models DISPLACE and FLBEIA in the North Sea (North Sea only).

STECF notes that results do not represent a full Impact Assessment of options or scenarios; but only a subset of which scenarios might be analysed in a full impact assessment. In addition, the EWG was not using the most recent data, but the ICES WGMIXFISH 2017 dataset. This was done as the WGMIXFISH data for 2018 was not yet available at the beginning of the meeting.

WGMIXFISH needs approximately 4 days for the compilation of the data and, therefore, the EWG used the 2017 data for this test case.

STECF observes that the EWG applied two options to analyse the short-term effects of TAC options for 2019: Option 1: Fmsy; Option 2: MSY Fupper for the stocks that were estimated as being potential choke species under Option 1 run.

STECF observes that three scenarios are applied for the medium-term period 2019-2023: Fmsy in 2019, Fmsy in 2020 and Fupper. The Fupper scenario uses Fupper for all identified choke species in 2019 until end of period. These scenarios were chosen by the EWG to illustrate the range of possible scenarios and illustrate trade-offs when assessing impacts at different time steps. If a regular assessment is requested, then DG Mare and STECF would need to discuss which scenarios should be applied.

STECF observes that one result for the North Sea is that applying Fupper as a target for potential choke stocks (to reduce the risk of early closures of the fishery) generally lead in the short term to higher economic indicators (e.g. Gross Value Added) as when applying Fmsy. However, when considering the cumulated impacts in the medium term using Net Present Value of Gross Value Added/Net Profit, the Fmsy option can provide more overall economic benefits over the whole 5-year period than the Fupper scenario. The reason for this is that Fupper leads to lower stock levels than Fmsy in the medium term.

STECF observes that the EWG answered TOR 4 by elaborating on which data are available to assess the dependency of a local economy on the fish processing industry. A dependency assessment would enable partial analysis of the impact of changes in landings on downstream parts of the value chain. The EWG considered the TAC dependency tool developed by JRC (see STECF 17-05) and a 'social community indicator' by assessing registered vessels in ports.

STECF conclusions

STECF concludes that it was possible to run the bio-economic models during the EWG, resulting in projections of medium term bio-economic implications of the selected management options.

STECF concludes that the added value of applying integrated bio-economic models is to identify possible developments of choke stocks, quota uptake rates and economic indicators of the fleet (among others) over longer time periods, for various management scenarios and TAC options. Because of the longer time horizon of the models, short term versus medium-term trade-offs can be identified and assessed by calculating the Net Present Value of revenues, GVA or profits from different modelled scenarios or options.

STECF concludes that merging AER and ICES WGMIXFISH datasets requires common protocols to define meaningful levels of fleet aggregation and corresponding estimates of transversal and economic model parameters. The work initiated by Jardim et al. (2013)) in this regards needs to be further considered.

STECF concludes that a multi-model approach is useful to capture the details of the studied systems. It is also useful to understand the impact of model assumptions on the outcomes of scenarios, in order to identify management options that are robust to model error.

Currently, this kind of evaluation cannot be performed for all the fleets and stocks within EU waters, because updated and operational bioeconomic models are not readily available for all EU regions (gaps are West of Scotland, Irish Sea, Ionian and Aegean Seas and the Black Sea). For some other regions only one model is available (e.g. Celtic Sea).

STECF concludes that there are clear benefits of a joint effort of the STECF EWG with the ICES WGMIXFISH in terms of data availability and quality. There is, however, a necessity to merge the different databases.

STECF acknowledges that the projections from the bio-economic models may not be necessarily consistent with the projections provided in the Annual Economic Report using BEMEF model. The AER projections are derived from analysing different fleets or fleet segments under different sets of assumptions. Fully integrated bioeconomic models account for the technical interactions among the fleets. STECF concludes that both models may serve different purposes and may not be directly comparable.

STECF concludes that an evaluation of impacts on society beyond the fishing fleets alone (i.e., markets; communities etc, such as dependency of fish processing industry on certain fleets and stocks for example) is less straightforward and existing protocols are less well established. Appropriate methods and data would need to be further agreed on, especially with reagrds to the social aspects.

STECF proposes the following steps to provide regular economic and social advice regarding mixed fisheries options:

1) **Data accessibility:** Clarification is required on how required data sets can be made accessible. For EWG 18-05 the data of ICES and STECF were available. However, some preparatory work is necessary to have all the data available before the meeting. In addition, in order to merge the datasets quality protocols need to be developed.
2) **Model updates:** The bio-economic models need to be regularly updated by including the most recent data.
3) **Scoping meeting**: A scoping meeting with the European Commission would define the areas, stocks, and fleet segments to be included in advice. Management options and scenarios would need to be discussed and agreed with the Commission.
4) **EWG Meeting**: Further discussion will be necessary about the timing of the EWG. Meeting after the WGMIXFISH would allow experts to apply the most recent data. As the WGMIXFISH needs a lot of time to compile the data a parallel meeting as performed this year does not allow for full integration..

STECF concludes that STECF and DG Mare should discuss further about the approach for the MIXFISH advice in 2019. This discussion should include e.g. possible formats for presentation of results, options to be tested, stocks and fisheries to be analysed.

References

Jardim E., Urtizberea A., Motova A., Osio C., Ulrich C., Millar C., et al. 2013. Bioeconomic modelling applied to fisheries with R/FLR/FLBEIA, JRC scientific and policy report, EUR 25823 EN, p. 120 pp, DOI:10.2788/84780

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

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REPORT TO THE STECF

Copenhagen, Denmark, 21-25 May 2018

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 TERMS OF REFERENCE FOR EWG-18-05

Background

STECF was asked to elaborate the possibilities to assess the socio-economic impacts of the TAC and quota proposal in the longer-term context of e.g. the MSY policy and full implementation of the LO. In addition, STECF was asked to elaborate a methodology for incorporating multispecies interactions (e.g. predator-prey interactions) and choke species impact in the context of multi-species management plans (e.g. North Sea) and the implementation of the LO.

The methodology should be able to provide results at the level of regions dependent on fisheries.

In a first EWG (STECF 16-20) STECF described a possible approach for the assessments of TAC options and TAC proposals. The STECF bureau further elaborated with DG Mare on the possibilities for an EWG in 2018 and proposed this joint EWG with the ICES Working Group on mixed fisheries in May 2018.

Specific objectives

1. Update and parameterization of the available bio-economic models for the North Sea and South-Western Waters with the 2017 biological and 2016 economic data with a view to model multispecies interactions and choke species impacts in the LO. (DG MARE to define for which stocks).

2. Economic assessment up to 2023 within a multi-species and multi-fleet context from the 2017 ICES MIXFISH advice as add on to the ICES WGMIXFISH results. This economic assessment should include choke species effects of the implementation of the LO. Results should also include trade-offs regarding a group of economic variables e.g. turnover, net profit, operating costs (e.g. fuel costs), GVA and social such as employment or average salaries for crew – depending on the specific model.

3. Analysis of a limited number of single species, considered as pilot cases, TAC options (F ranges from the ICES advice sheet) in the context of the MSY objective, beyond 2020 and in the context of L0. Estimates of long-term economic gains compared to short term losses of moving to MSY should be analysed. Provide expert knowledge on the possibilities to assess fleet dependency on certain species/stocks, the impacts of changes in TACs on regions dependent on fisheries (such as Galicia, Brittany, etc.) and the fish processing sector (e.g. the collection of data on raw material and the linkages to to the EU fishing fleet segments).

4. Discuss possible formats, limitations, necessary infrastructure, resources, data, etc. for providing this advice every year. This shall include the development of a protocol/guidelines how to complete the exercise (timing, data needs, data sources, etc.) and/or recommendations to continue developing relevant methodologies or data collection in the future.

2 INTRODUCTION

Economic objectives in fisheries management were explicitly introduced in the Art. 2.1 of the reformed CFP ("*The CFP shall ensure that fishing and aquaculture activities are environmentally sustainable in the long-term and are managed in a way that is consistent with the objectives of achieving economic, social and employment benefits, and of contributing to the availability of food supplies*"). Agreements between the European Parliament and Council stated that Maximum Sustainable Yield (MSY) should be reached in 2015 for all the stocks and at the latest in 2020 with a timetable depending on socio-economic considerations (Regulation (EU) No 1380/2013). However, scientific advices provided by the ICES only accounts for biological dimension while the ecological and socio-economic dimensions are discussed during the negotiation step based on each Member States' or Parties 'expertise.

There is thus an increasing need to provide a more integrated scientific advice including the economic dimensions that are at stakes in the decision process.

STECF (2017) reviewed the methods for assessing economic impacts of Total Allowable Catch (TAC) options and concluded on the need to use integrated bio-economic models to provide multi-criteria advice addressing the trade-offs of alternative TAC options and future scenarios.

Bio-economic models include the biological dynamics of the stocks of interest and a greater consideration of the economics, meaning that there is an integration and feedback between biological and economic components. Consequently, these models can perform short-as well as long-term projections making them appropriate for providing the required TAC and quota advice along with longer-term assessments of the economic consequences of moving towards MSY. This is especially relevant in mixed and multispecies fisheries because, single stock advice does not necessarily reconcile fish portfolio and fishing possibilities (Ulrich et al., 2011). When dealing with multispecies fisheries, economics provides a useful approach to merge all the different catch profiles and fishing possibilities, because they can be measured using a single currency: money. However, this single currency does not imply that it can be interpreted using a single dimension. This interpretation can be covered using a country perspective (i.e. gross value added), a social perspective (i.e. wages) or from the capital owner perspective (i.e. net profit).

Assessing the socio-economic impacts of TAC options requires being aware that:

From a biological point of view, a TAC option will have the same impact on the stock whatever the variable adjusted to match the TAC[1] (fishing effort keeping the same capacity, or number of vessels keeping the same activity of the vessel).

From a socio-economic perspective, the way the TAC is fished is of high importance. Adjusting the capacity (i.e. number of vessels in the fishery) (assumptions 1a and 1b in Table 1), or the fishing effort, assuming the same number of vessels in the fishery (assumptions 2a and 2b in Table 1) will thus have different socio-economic impacts.

Table 1. Qualitative impact expected from two alternative assumptions to adjust the effort to TAC

Variable	Assumption 1a	Assumption 1b	Assumption 2a	Assumption 2b
Adjustment variable assumed to match the TAC	Number of vessels (exit from the fishery)	Number of vessels (change the fishery)	Fishing effort per vessel	Fishing effort per vessel and reallocation of effort

[1] Given that we assume a proportional adjustment of the variable for all the fleet and métier thus keeping the same global selectivity.

Biological impacts				
Target stocks				
Impact in other stocks				
Socio-economic impacts				
Number of vessels in the fishery	Decreases		Stable	
Employment in the fishery	Decreases		Stable	
Mean fishing effort by vessel	stable	?	Decreases with potential benefits to the labour conditions	Decreases with potential benefits to the labour conditions
Non variable costs	Decreases	Stable	stable	Stable
Variable costs par vessel	stable	?	Decreases	
Profit per vessel in the fishery	Increases if initial over-capacity situation	Increases if initial over-capacity situation	Decreases in the transition period, then increases	
Wage per crew in the fishery	Increases if initial over-capacity situation	Increases if initial over-capacity situation	Decreases in the transition period then increases	

Table 1 highlights in simplified way the potential socio-economic trade-offs existing in alternative options of adjustment to a TAC.

Considering assumption 1, the adjustment of the number of vessels in the fishery, the exit from the fishery of some vessels is expected to decrease the fixed costs in the fishery and the employment with potential territorial impacts but the remaining vessels and crew are expecting to improve their profit and wages, respectively, if there is an initial situation of overcapacity. These results will depend on if the vessels are not effectively removed or transferred to another fishery. (assumption 1b in Table 1).

Considering assumption 2, the adjustment of the fishing time (or fishing effort) keeping the same number of vessels in the fishery (same fixed costs), the fleets and employment in the fishery are expected to remain the same but the profit and wages are expected to decrease in the transition period according to the potential increase of the yields and thus the gross revenue and the decrease in variable costs expected. These results will depend on if the fishing effort is transferred to other fishing area or not (assumption 2b in Table1).

Socio-economic impacts of a TAC option thus depend on:

- Capacity adjustment operated at member states level and vessels' entry/exit dynamics;
- Fishing firm's future expectations on how the fishery will evolve;
- Allocation of TAC between fleets/vessels;
- Fisher's behaviour in terms of effort reallocation towards other métier and/or spatial-temporal allocation, which is expected to modify the technical interaction between species and thus the choke effects under landing obligation;
- An economic equilibrium condition, that determines the relationship between capacity (assumption 1) and effort intensity (assumption 2).

These issues need to be addressed when setting the scenarios and analysing the results. For example, considering constant capacity and allocation of TAC between fleet without effort reallocation possibilities is expected to produce an assessment of the worst economic impacts expected from a TAC option or scenario. However, it is unlikely that this situation will happen in reality. In terms of the capacity evolution, three possible alternatives can be considered in a bio-economic modelling context:

- Adaptive expectations: firms form their expectations about what will happen in the future based on what has happened in the past. This is the approach considered, in the models used for TOR 2 and TOR 3;
- Rational expectations: firms form their expectations about what will happen in the future based on what is going to happen the future. This is the approach considered, in the model presented in Annex 7;
- No capacity adjustments: A very short-terms assumption in where fishing firms do not have time to adapt their capacity.

The three alternatives have advantages and disadvantages: adaptative expectations do not consider the capacity adaptation within MSY recovery policy but are able to give simple rules which people could follow while making predictions; rational expectations assume that individual expectations are essentially the same as the predictions of the relevant economic theory (probably expecting too much from firm's individual knowledge and processing power); no capacity adjustment is un-realistic although useful to explain short-term results.

Economic analysis in general and the use of applied bio-economic models in particular, can provide alternative advice considering three different dimensions:

Structure of the fleet: In economics fishing firms are the decision-making unit. As in any other economic sector, they use production factors (i.e., capital, labour and energy) to produce output. However, they also need a natural and renewable resource to produce: fish. When fleets are segmented in order to create operationally computable units, fleet characteristics such as overall length, gear used, fishing intensity and catch composition have been considered, however other factors such as the combinations of energy, capital and labour should also be considered. This implies that from the economic side, the decision-making unit could require a different operationally computable unit when economics and social aspects are considered.

Time: The use of a renewable production factor such as fish implies that time is to be considered. In fisheries economics, it can be interpreted in terms of short-term versus long-term decisions, that can be measured using indicators such as profit. When the proper governing structures and incentives are in place, managers can decide on invest (not fish) or disinvest (fishing) on this natural capital and the optimal result will critically depend on how time is valued.

Space: Fish and fleets move. Natural process summed to anthropogenic effects (climate change, seabed erosion, …) create changes in the fish spatial distribution. These changes have effects on spatial fish availability but also on fish management process, given that the management unit, the stocks, are spatially defined. Fleets also change to adapt their spatial fishing intensity to the changes in fishing distribution. Furthermore, they can change their spatial behaviour to get adapted to management decisions (i.e. avoiding choke species under landing obligation or avoiding forbidden species).

In this work, evidences on the value added of using applied bio-economic models on top of the ICES mixed fisheries TAC advice is described, the limitations of the process addressed, and the protocol and data accessibility requirements expressed. It is done using two regional sea areas currently analysed in the ICES WGMIXFISH group: North Sea and Atlantic Iberian waters.

2. TOR 1: AVAILABLE DATA, METHODS, DEFINITIONS AND CONDITIONING

Within the report two sea areas were considered, the North Sea fisheries and the Atlantic Iberian waters. Both share the characteristic of being mixed and multi-species fisheries, in where technical interactions among fleets are likely to arise and where landing obligation is likely to create choke effects. Therefore, those case studies can be considered as a reference of the complexity of management implementation within the TAC regulated EU fisheries. The complexity of the management implementation was simulated using bio-economic models.

Bio-economic models have been used in the context of multiannual management plans impact assessments, in both sea areas. SIMFISH and FISHRENT have been used in the evaluation of the multiannual plan for the North Sea demersal stocks (STECF-15-04). FLBEIA has been used in the evaluation of the multiannual management plans in South Western Waters and North Western Waters (STECF-15-08). All these models, together with DISPLACE, have been peer-reviewed, e.g. through their use in STECF advisory processes, scientific publications and applications in EU projects thereby, increasing confidence in their future use (Table 2). Bio-economic models allow the inclusion of a wide range of fisheries structures, i.e. they can support métier level fleet data at a regional level, which allows for assessments for the inclusion of technical interactions. Additionally, uncertainty is considered in many of these models.

Table 2. Model and data sources for the case studies.

	North Sea (Danish fisheries)	**North Sea (Demersal mixed fisheries)**	**Atlantic Iberian waters (Demersal fleets)**
Model (reference)	DISPLACE (Bastardie et al. 2014)	FishRent (Simons et al., 2014)	FlBEIA (Garcia et al, 2017)
Economic data of the fleet (period)	National Fisheries Statistics	AER 2017 (2013-2015)	AER 2017 (2013-2015)
Transversal data - effort, capacity- (period)	Now: National Fisheries Statistics and EU vessel register – In future: could build upon 2017 WGMIXFISH and WGSFD for spatial data.	STECF FDI database (2013-2015)	2017 WGMIXFISH (2014-2016)
Price data (period)	National Fisheries Statistics (landed value/landings per fishing harbour)	AER 2017(2013-2015)	IEO (2013-2015)
Biological data	ICES stock assessments	IBTS (2013-2015)	ICES stock assessments

Models differ in what they can provide. For example, SIMFISH simulates fisher’s behaviour based on optimal effort allocation, FishRent also represents the spatial-temporal interplay of fleets and fish stocks, in a simulation (what if?) but also, in an optimization context (what’s best?). FLBEIA simulates, without considering spatial explicit dimension, within a management strategy evaluation framework. DISPLACE works at the finest temporal scale (fishing hour) of all models used in this report and at individual vessel level.

A review of the main features and existing applications of these models is available at the *Bioeconomic model database* of the STECF (https://stecf.jrc.ec.europa.eu/dd/bioeco/graphs).

2.1 Options and scenarios

Within the report an **option** is understood as a TAC option for the next year. For example, in the year 2017, a TAC option can be considered the single-stock catch advice F_{MSY} provided by ICES for the year 2018 for the individual stocks under study. To provide a comparison of the work that can be formed using bio-economic models, two options were tested:

- Single-stock catch advice provided by ICES;
- Stock advice corresponding to Fupper as defined by ICES WKMSYREF4 (ICES, 2016).

These TAC options were tested assuming implementation of the landing obligation with the exemptions (*de minimis*) already in place.

Within the report a **scenario** is understood as the fishing mortality advice provided for each stock individually for the simulation period. For example, a scenario will be to assume that within the simulation period (2017-2023), F_{MSY} will be advised for all the individual stocks under study[2].

Three alternative scenarios were defined (Table 3)[3]. Scenarios were tested assuming implementation of the landing obligation with the exemptions (*de minimis*) already in place.

Initial settings and assumptions for intermediate years were chosen to be as consistent as possible with the TAC options of the ICES 2017 WGMIXFISH group (Table 3).

Table 3. Definition of the scenarios used in the report

Scenarios	Definition	Links to WGMIXFISH scenarios
FMSY	Setting the F advised for year 2019 equal to F_{MSY} and keep this objective for the rest of the projection period	**MIN 2019**
FMSY20	Achieving MSY for all the stocks for which a F_{MSY} estimation exist in the year 2020	**MIN 2020**
FMSYup	Using Fupper value of the F_{MSY} range as defined by ICES for each stock during the whole projection period in such a way that: Fs, 2019 = Fs, 2018 - [(Fs, 2018 - Fs, upper)/2] if the stock is a choke stock for any of the fleets or Fs, 2019 = Fs, 2018 - [(Fs, 2018 - Fs, MSY)/2], if not.	**"range" scenarios**

[2] Note that the difference between scenario and option is just a working assumption for this work and, in any case, the intention is to provide a general definition of the two terms.

[3] WGMIXFISH scenarios adopted for advice are summarized for the record in Appendix 3.

Four DISPLACE different scenarios were run to assess the effect of choke species under the landing obligation with a particular focus on the Danish Fleets: Scenario 1, baseline with landing obligation and stop when quota choked by one stock; Scenario 2, baseline plus F_{MSY} levels decreased by 10%; Scenario 3, baseline situation plus F_{MSY} levels increased by 10%; Scenario 4, baseline plus fishers being smarter at avoiding potentially choke species in space when one of the quota is running low. No specific plots to the present STECF meeting were produced because of the short notice. Instead, screenshots of the DISPLACE software Graphical User Interface showing single simulations are provided in Annex 3.

Considering landing obligation within the simulation period implies that "max" scenarios tested in ICES MIXFISH are not relevant. TACs are assumed to constraint the system as in, for example, the "min" scenario tested in the ICES MIXFISH, unless none of the fleets are choked by any stock (the constraint comes from a fishing capacity limit). The main difference between the "min" scenario and the ones tested in this report, is that the species limiting the effort by fleet ("min") can vary in the simulation period. Therefore, the EWG decided to work in the context of F_{MSY} ranges to explore the possible impact of adding flexibility (both as a scenario and as an option) when setting fishing possibilities.

Therefore, there is a direct relationship between the "min" scenario in the ICES WGMIXFISH and simulating the landing obligation. This is due to that total effort is obtained based on the limits of each individual stock management objective (i.e., F_{MSY}). Therefore, each fleet has different fishing effort limit by stock:

a/ If the minimum value is used, only the more restrictive fishing possibilities of the fleet are met, leaving unmet the fishing possibilities of the remaining stocks that are part of their catch profile. This is the case of the landing obligation, with the only difference that the "*de minimis*" exemptions are considered.

b/ If the maximum value is used, all the fishing possibilities are exhausted but those with more restrictive fishing possibilities have to be discarded. This scenario is, therefore not compatible with the landing obligation.

Landing obligation is modelled as case a/. Effort is constrained by the more limiting stock. Effort is lower and therefore landings are lower (given no changes in biomass). This is the so-called choke effect. If simulation is extended in time, there is a cascading effect coming from the higher relative abundances of those stocks which fishing possibilities have been unmet. These higher abundances imply that with the same effort, catches are increased (although not necessarily in the same proportion). The implementation of this choke effect in a simulation context has to be understood from two main elements: the first one is the production function, which is the function guiding the productivity of the fishing gear; the second one is the adaptability of the fleets to reduce this choke effect. Assuming constant selectivity parameters, this adaptability is embodied in the métier definition and/or in the spatial scale. If the effort share is fixed (among métiers or space), the choke effect is at métier level. If the effort share can vary through the projection, the choke effect is at fleet level.

2.2. Indicators used

The EWG 18-05 agreed on limiting the number of indicators presented to those effectively necessarily to highlight the (economic) trade-offs between different options and scenarios, including the differentiated impacts according to fleet segments, the distribution of impacts between owner and crew and the trade-offs between short-term versus mid-term approaches[4]. The indicators selected by the EWG 18-05 were:

[4] Other indicators could also be adopted, especially those highlighting the trade-offs between biological and socio-economic dimensions and the differentiated impacts at fishery level versus vessel level.

- Quota uptake by fleet for the projection period, defined as the catch divided by the quota that each fleet has for each stock. It can be interpreted as the met or unmet fishing possibilities that each fishing fleet has or as the stock constraining the effort in that period, due to the landing obligation.
- Gross Value Added (GVA) as defined in the 2017 Annual Economic Report on the EU Fishing Fleet (AER). It stands for the contribution to the Gross Domestic Product (GDP), and is paying the labour remuneration, the capital remuneration, and the depreciation of the productive capital. It is calculated subtracting all variable costs (except crew costs) and fixed costs from the gross value of the landings. This indicator reflects the contribution of each fleet segment to the economy.
- Crew costs (CC) divided by full time equivalents (FTE). The part of the value added that goes to remunerate labour, that when divided by FTE can be considered as a proxy of the average wage.
- Net Profit (NP): as defined in the AER. It is an economic long-term indicator that is calculated subtracting crew costs, depreciation costs and the opportunity cost of capital to the GVA. To compute opportunity costs of capital, the same procedure as the AER was followed, that is, real interest rate (r) was defined as:

$$r = [(1 + i)/ (1 + \pi)] - 1.$$

Where *i* represents the (nominal) interest rate and *п* for the inflation.

Additionally, the net present value of the 3 economic indicators were presented. Net present value is the current value of a future sum of money or stream of cash flows given a specified rate of return. It was calculated as:

$$NPV(Indicator) = \left(\frac{\sum_{t=2019}^{T=2023} Indicator_t}{(1+\partial)^t}\right)/t$$

Where t is a time index (i.e. t= 1, 2, …) and ∂ is the discount factor that operates as follows: $\partial = 0$, implies that equal value is given to all revenues (present and future) and $\partial > 0$ implies that future revenues are discounted. In the case studies analysed, $\partial = 0.035$ as documented in the World Bank (2016) impact assessments procedures, was used.

2.2. Databases

2.2.1 Annual Economic Report

The STECF's Annual Economic Report (AER) provides a comprehensive overview of the economic performance of the EU fishing fleets. The AER data covers transversal (capacity, landings and effort) and economic data (income, costs, employment, capital value and investment). Economic data in the AER are reported aggregated at fleet segment level; data by vessel cannot be reported because of confidentiality issues, and so the AER reports the evolution of similar groups of vessels. Fleet segment refers to a group of vessels with the same main fishing gear, vessel length group, country, supra-region, year and geo-indicator. According to the data collection framework (DCF), cf. Council regulation (European Commission (EC) No 199/2008 of 25th February 2008, economic data should be geographically disaggregated by country and supra-region. On a voluntary basis, EU Member States can further disaggregate the data by using geo-indicators. This helps to differentiate local fleets operating in outermost regions and distant water fleets.

The AER includes a detailed structural overview and an assessment of the annual economic performance of each EU Member State's fishing fleet, together with regional analyses by sea basin, EU overview with economic performance indicators and projections (up to the current year, since only year – 2 data are reported). The reliability of the data collected under the DCF remains responsibility of the Member States.

The data for STECF AER are requested according to the sector segmentation of Table 5B and according to the supra regions as defined in Table 5C of Commission Implementing decision (EU) 2016/1251 of 12 July 2016. These segments differ from biological métiers determined in Table 2 of Commission Implementing decision. Biological métiers are more disaggregated than segments in economic data call, so it would be necessary to find a way to combine métiers in sense to link with economic data set (see Section 2.4 in this report).

The report uses real values updated to the last year of the data available (the values in the 2017 AER are expressed in 2015 EUR – STECF, 2017a). All data, in nominal values (as they have been submitted by Member States) are made public once the report and the data are endorsed by the STECF plenary.

2.2.2 Fisheries dependent information (FDI)

The 'effort' data base contains detailed information on fishing effort, catches (landings and discards) by species, by pseudo métier and (for landings and effort only) by ICES statistical rectangle and has proved useful in capturing the evolution of catches and effort over the years and the impact of individual fisheries on many fish stocks, not only those subject to recovery and management plans.

Recently, the data was used in the work allocating TAC adjustments between fleets falling subject to article 15 of the CFP, the so-called Landings Obligation (STECF, 2017b). Under interim arrangements lasting from 2015 to 2018 fleets and stocks were progressively bought under the landing obligation and a one-off adjustment to stock TACs made to compensate for the possible required landing against quota of fish dis-allowed for human consumption. After verification by JRC and the STECF, processed aggregated data are made available via an interactive online data dissemination platform developed by the JRC.

However, although increasingly utilised by end uses outside of reporting on the species management regimes, the origins of the data set entailed certain limitations, e.g. vessel length categories were not consistent with those used for the AER data set restricting the ability to make use of the joint databases for bio-economic modelling. With new area-based multi-annual plans (MAPs) leading to the phased repeal of existing species management regimes, it was recognised there was an opportunity to rationalise the data base, make the changes necessary for compatibility with the AER data set and move to the collection of an EU wide data set of fishing capacity, effort, landings, and discards including data from the Mediterranean and distant fleets. In 2017, the new 'Fisheries Dependent Information' (FDI) data call was launched. This data call has been used as a trial exercise to test whether the aspirations for the new data set could be realised and refine the call and database where necessary.

2.2.3 TAC dependency tool

The JRC, based on economic data collected through the DCF, designed the TAC dependency tool to convert fleet segment data into fisheries specific data. This tool should allow to assess the socio-economic dependencies of different fisheries/fleet segments on stocks subject to quotas and assessment of economic impacts of changes in applied TACs.

The JRC has developed a TAC Dependency Indicator (TDI), both as a report and software tool, for stocks regulated by a Total Allowable Catch (TAC) as listed in the Council Regulations fixing fishing opportunities for certain fish stocks and groups of fish stocks applicable in Union waters and, for Union fishing vessels, in certain non-Union waters, in line with Regulation No 1380/2013 on the CFP.

TDI calculates dependency ratios on TAC units and they are calculated by fleet segment and gear-type, but the socio-economic indicators remain at the level of main fishing technique (fleet segment), which is the only way to establish a direct link to the economic variables on costs without the need to adopt a model-based disaggregation approach.

The report and online tool present a static situation with no attempt of forecasting. To appreciate impacts from quota changes and forecast dependencies consequent to a change of the TACs, a more complex modelling exercise would need to be undertaken using bio-economic models.

Nonetheless, consistency in dependency ratios over the time series may be indicative of a consolidated and stable relation between stocks and fleets. Under such circumstances, it is possible to foresee what will be the level of dependency in the short term and draw more robust conclusions in respect of the current year TACs proposal.

Management units are defined in the TAC and quota regulations as a combination of species (or species groups) and Fisheries Management Zones (FMZ). Fisheries Management Zones (FMZ) are geographical areas delineated with a regulatory perspective in mind. They incorporate a series of specifications such as the exclusion of external territorial waters. In some cases, these specifications result in different boundaries with respect to fishing areas defined by FAO and ICES, and therefore, areas identifying stocks according to a biological perspective. Hence, TAC units do not necessarily coincide with biological stocks, for which stock assessments are generally produced.

Moreover, many TACs and TAC units are linked to special conditions, notably related to inter-species quota flexibility, catch composition rules, obligations to release (discard) certain species with high survivability, etc. Special conditions are also in a number of cases connected to fishing in non-EU waters (in particular Norwegian waters).

TDI is intended to serve as a first step in the TAC proposal and impact assessment processes by identifying fleet segments that could potentially be impacted by the setting of TACs and quotas. Further scrutiny into these fleet segment and the possible socio-economic impacts would require the use of more sophisticated tools, such as bio-economic modelling.

The performance indicators provided in the AER relate to fleet segments and hence, not directly to fish stocks or TAC units. An indirect link between economic data (such as costs and income) and the TAC units could ideally be established through the so called 'transversal or fishing activity data', which include data on landings by species, gear-type and FAO fishing sub-region. Yet, the relatively high level of spatial aggregation of these data submitted by MS under the DCF fleet economic data call does not allow for a straightforward relation in many cases.

The analysis follows the regulatory perspective and maps stocks according to the TAC units as indicated in the Council Regulations fixing fishing opportunities for certain fish stocks and groups of fish stocks in line with Regulation No 1380/2013 on the CFP and taking into account catch data as reported by Member States in the EU Catch Reporting system (FIDES).

Thus, the TDI focuses on providing an estimate of the economic relevance that each stock subjected to a TAC has on EU fishing fleets from a regulatory perspective.

The TDI is calculated as the proportion between the value of landings associated to a given regulated stock and the total value of landings of a fleet segment. Employment and GVA associated to each TAC unit are also estimated proportionally.

The TDI stems from an earlier work produced by the JRC in collaboration with the Swedish Agency for Marine and Water Management (SwAM). The purpose of the Swedish case study was to develop a policy support tool to assess the economic dependency on regulated stocks for fishing coastal communities in Sweden. Access to logbook data for the fleet allowed disaggregating economic analyses at the level of vessels and hence, fishing ports and fishing communities. Hence, the dependency indicator was calculated for single ports (home and landing ports) for the national fleet. The tool allowed identifying coastal communities more likely to be affected in socio-economic terms from the setting of TACs and quotas. By availing detailed transversal data from logbooks, it is possible zoom-in the level of geographical analysis from countries to regions, provinces and single fishing coastal communities.

Given the non-availability of more detailed and disaggregated landings data (such as logbook data) in this current study, data limitations impede a precise conform to the regulation and vice-versa. As such, the TDI and the results presented in the online tool should be consulted and considered with some degree of caution.

2.2.4 ICES WGMIXFISH data

The ICES WGMIXFISH merges different data sets from different countries and different data sources together. After a long and time-consuming work, they produce a dataset in where by fleet segment and métier, effort and catches are merged. Furthermore, the database includes discards estimates (either imported or raised) for all stocks and métiers. An additional characteristic of this database is that it is passes through quality checks.

The chair of the EWG asked for the necessary permissions to have access to this database at the end of day 1 of the meeting. Access was granted by ICES at the end of day 2. The database contained the processed data for the year 2017, previously explained, for the North Sea and the Atlantic Iberian waters.

2.2.5 Other data sources

2.2.5.1. ICES WGs

Different stock assessment groups data were used to obtain stock numbers data including selectivity per gear and species.

2.2.5.2 ICES WGSFD

ICES WGSFD (Spatial Fisheries Data) is now routinely mapping the fishing activities at sea on a fine grid scale that can also inform the spatial fishing footprint. This database was used in the simulations performed using the DISPLACE model.

2.3 Comparing the databases

A comparison was made between, the existing parameterization of SIMFISH model (North Sea flatfish fishery) and the potential coverage that could be obtained using WGFISHMIX database.

2.3.1 Selecting the fleets and bycatch stocks is complex

The most important stocks of the North Sea flatfish fishery are the North Sea sole (ICES sub-area 4 and plaice (ICES sub-area 4, and Divisions 3a and 2a) stocks. To scope the fishery, we first considered those two stocks. Using the AER data (2013-2015), we identified 15 fleet segments which contributed to at least 2% of the total value of the stocks landings (Figure 1). Those accounted for 80 and 90 % of the landings value of plaice and sole.

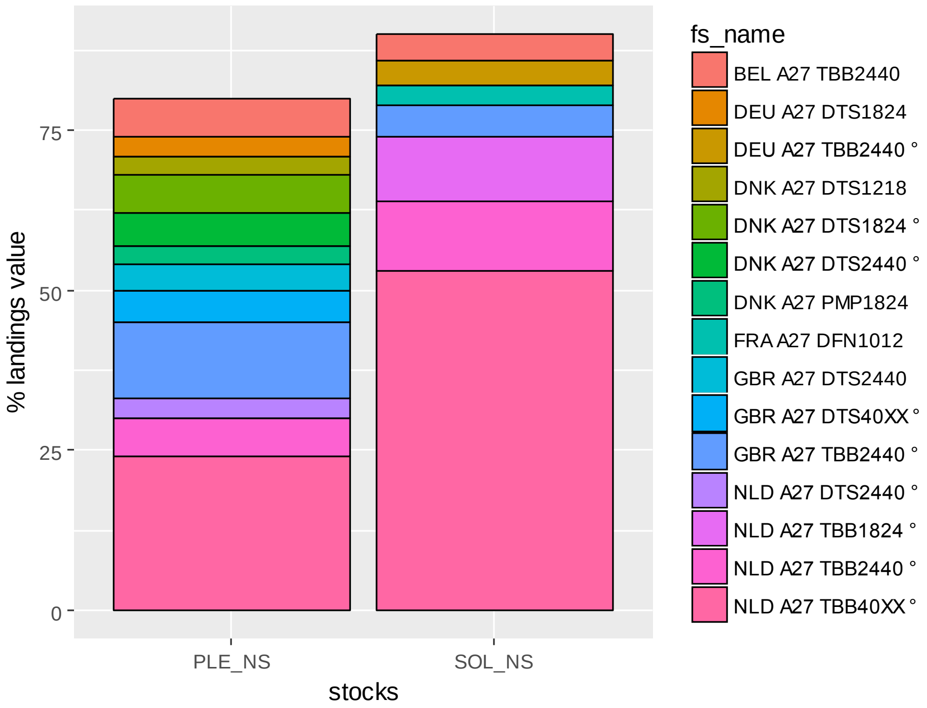

Figure 1 Segments contributing to landings of North Sea sole and plaice according to the AER.

While the 15 fleet segments have an impact on the stocks, not all them depend on the two stocks. The dependency varies greatly between fleets from less than 3% to 80% of the value of landings of the fleets. For the economic analysis, we can select only the fleets with a high dependency (here we arbitrarily chose 15%)[5]. The 10 remaining fleet segments cover 68 and 86% of the value of landings of the plaice and sole stocks.

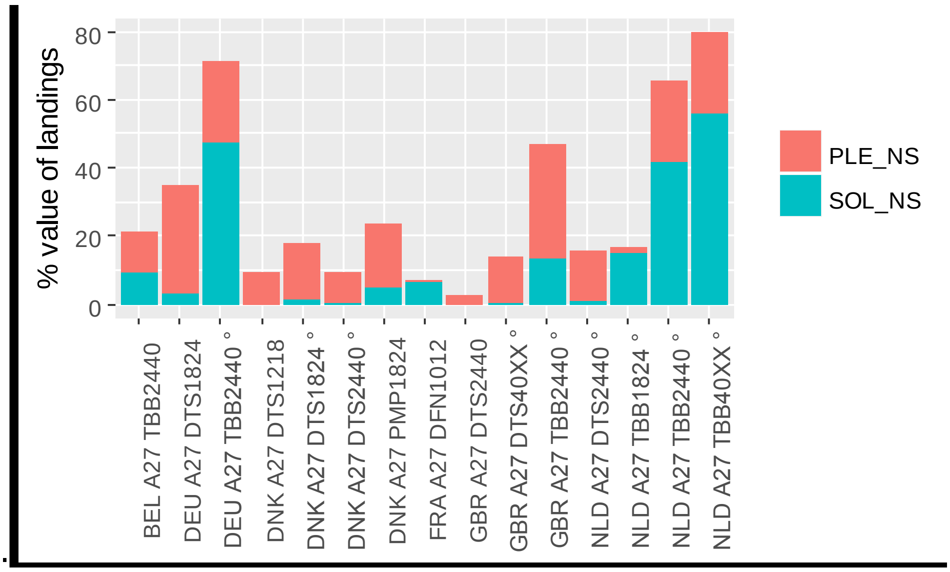

Figure 2 Dependency to North Sea sole and plaice according to the AER.

To make a meaningful analysis for those 10 fleets, it is important to cover a large part of their activity. To capture at least 50% of the revenue for each those 10 fleets, 14 stocks are needed.

[5] In case of a choke species it may be important to keep also fleets with low dependency.

The beam trawl segments (TBB: BEL_2440, DEU_2440, GBR_2440, NLD_1824, NLD_2440, NLD_40XX) typically mainly depend on 2 or 3 species. The Belgium segment depends on several stocks of sole that the fish not only in the North Sea but also the Channel and the Bay of Biscay. Demersal trawlers (DTS) target more species.

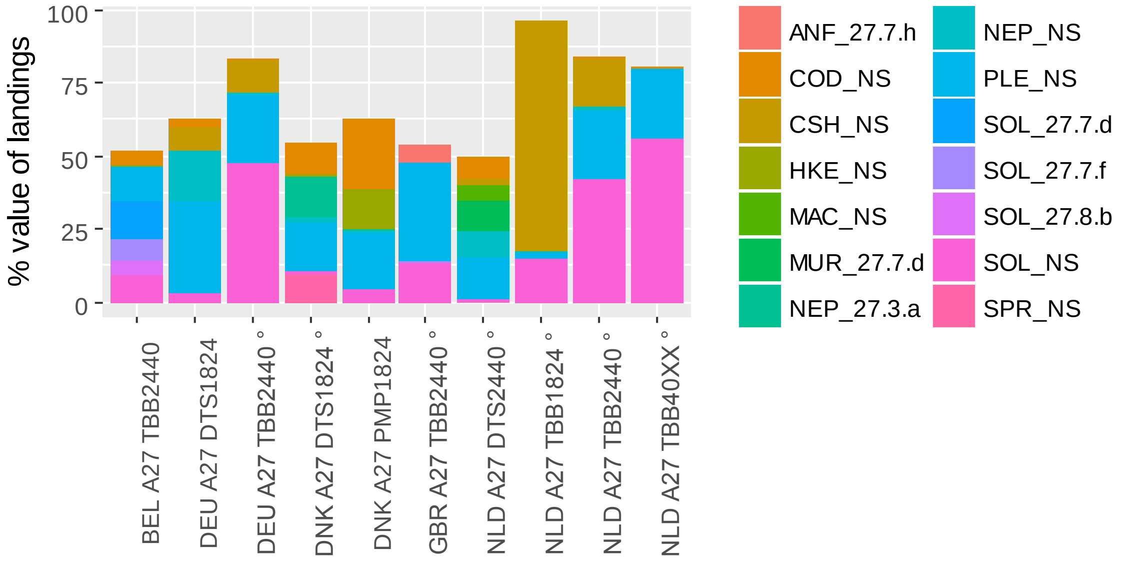

Figure 3 Stocks required to capture at least 50% of the revenue

Gears used by those fleets are shown in Table 4, the beam trawl fleets use almost exclusively TBB while demersal trawl fleets operate with mainly otter trawls (OTB) or twin trawls (OTT). The gears of the Danish polyvalent active gears (DNK A27 PMP1824) are not known.

Table 4 percentage of the value of landings per gear.

	GNS	NK	OTB	OTT	PTB	TBB	MIXFISH names
BEL A27 TBB2440			1			**99**	BE_Beam>=24 **BT1.4; BT2.4; BT2.7D; OTH**
DEU A27 DTS1824			**83**		2	15	GE_Otter<24 TR1.4; TR2.4; OTH
DEU A27 TBB2440 °	8		1			**92**	GE_Beam>=24 BT2.4; OTH
DNK A27 DTS1824			**100**				DK_Otter<24 TR1.3AN, TR1.4; TR2.3AN, TR2.4; OTH
DNK A27 PMP1824		**100**					??
GBR A27 TBB2440 °			2	-		**98**	EN_Beam BT1.4; BT2.4; BT2.7D; OTH
NLD A27 DTS1824 °		-	**35**	**53**		12	NL_Otter TR1.3AN; TR1.4; TR2.4; TR2.7D; OTH
NLD A27 TBB1824 °	0	-	1	1		**98**	NL_Beam<24 **BT2.4; OTH**
NLD A27 TBB2440 °	-	-	3	1		**96**	NL_Beam24-40 **BT2.4**
NLD A27 TBB40XX °		0	0			**100**	NL_Beam>=40 BT1.3AN BT1.4;

							BT2.4

2.3.2 Both AER fleets and MIXFISH métiers are needed for evaluation

To allocate effort and landings to different fishing activities and evaluate the adaptation possibilities of the fleet segments, the gear type as defined in AER data is not sufficient. Indeed, beam trawls can be used with different mesh sized nets depending on the target species (<30mm for shrimp, around 80mm for sole and above 90 mm for plaice). For this reason, we need the effort and landings data at the métier level (gear and mesh size).

Adding costs and revenue to the MIXFISH data may be tempting but disregarding the vessel dimension of the fleet segments also takes away the chance to adapt. Fleet segments of specialists (one gear one area) risk to be impacted harder than fleet segments with generalist vessels that can reallocate their efforts to other areas, other stocks.

The MIXFISH data is not available at the fleet level, but an attempt was made to try and reconcile the database of WGMIXFISH with the fleet segmentation of the AER.

2.3.3 Data merging between AER and MIXFISH impossible without fleets

Combining the landings from MIXFISH with AER data, several problems arise:

- Not all the stocks identified above were available in ICES MIXFISH. Of the 14 stocks, only four are also found in the MIXFISH database: COD-NS, NEP-NS6, PLE-NS, SOL-NS. None of the oth er stocks were currently available;
- The fleet dimension was missing in the ICES MIXFISH data. Instead of being a group of vessel s, the fleets are approximated as a group of métiers for vessels of the same size. If an AER fle et segment fish with more than one type of gears (level 4) then the AER landings could be hig her than the MIXFISH landings for the "fleet". Conversely if several fleet segments fish with th e same gear then the MIXFISH landings of the fleet could be lower. It is then impossible to kn ow how to allocate the fishing activities in the métier (level 6) to the AER fleet segments.

Even for fleets relatively simple in their activity such as the beam trawl fleets of the Netherlands which have more than 95% of their landings in one gear, the discrepancies are substantial (Figure 4). For example, up to 50% of the AER landings of plaice are missing for the 24-40m beam trawl fleet in the MIXFISH NL_Beam24-40 "fleet" because a substantial part of the landings is allocated to the "MIS_MIS" métier, while the sole landings are 25% lower in the AER data compared to the MIXFISH because the fleet segment "NLD A27 DTS1824" also uses TBB gears for about 12% of their activity, catching sole.

[6] These are several stocks in the MIXFISH database.

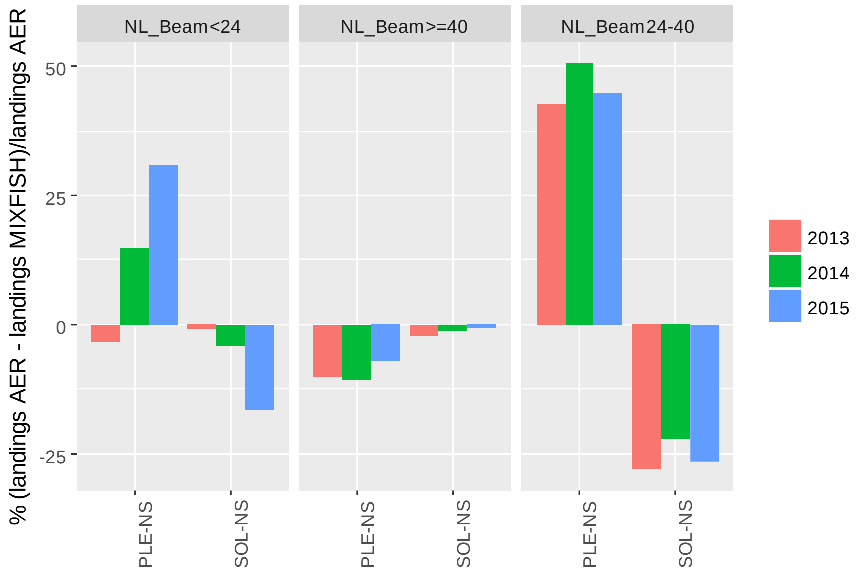

Figure 4 AER and ICES MIXFISH landings comparison.

To provide a proper merging among the two data sets, true fleet segments are needed in the ICES MIXFISH. Alternatively, an operational FDI database could allow the reconciliation of the data.

Therefore, the first step of the modelling exercise should be defining the extend of the case study and the available data. Here we took the example of the North Sea flatfish fishery, largely dominated by plaice and sole, mainly caught by the Dutch beam trawl fleets. However, many more fleets contribute to the mortality of the two stocks. To capture the full activity of those fleets and assess their capability to report their efforts to other zones or stocks if their quota was up, more than 10 stocks from the North Sea and other areas should be added. To properly assess the technical interactions and separate the stocks caught together with the stocks of interest from the stocks corresponding to an alternative activity, a finer level of fishing activity is needed than what is currently available in the AER database (gear level 4). The ICES WGMIXFISH has their own data call that covers fishing activities at a more adequate level (métier level 6) but missing the fleet dimension, the possibilities to report fishing effort to other métiers cannot be analysed.

2.4 Merging the datasets

As explained in Section 2.3 AER fleet segments (gear level 4) and WGMIXFISH métiers (métier level 6) do not coincide. Costs data are available at a fleet segment level in the AER, therefore some kind of relationship between the métier level 6 and gear level 4 is required to match both datasets.

Matching consist on combining the two databases using one or more variables. These two datasets (WGMIXFISH and AER) share common variables, such as effort, number of vessels or landings that, in the two cases analysed, are not necessarily consistent. The EWG considered that landings are reasonable approach to match these two databases given that they share the same measuring units. Therefore, the EWG considers that including the fleet segment dimension in the ICES WGMIXFISH will be a clear step forward to match these two datasets and that landings is probably the best variable to do so.

However, matching is not the only process required for the inclusion of a combined data in a bio-economic model. A scaling process is required. Scaling implies that to include the AER data in the bio-economic model, AER data which is given using absolute values at segment level, have to be scaled down to a level in where they can be incorporated in the model. After that, they have to be scaled up again at the level of the WGMIXFISH dataset. The scale down process depends on the variable itself, for example variable costs can be scaled down using fishing effort, fixed costs using number of vessels and crew costs using landings. It will depend on the type of variable but also on the specific bio-economic model considered. EWG 18-05 considered that these scaling processes are not complicated. However, when merging and scaling, some incongruences and errors can occur. Therefore, the EWG agreed that some quality check protocols have to be developed, to assess if the final result of this "cooking" are adequate or not.

Once the two datasets are merged revenues can be converted into costs and therefore, accounting indicators of the fleet segments can be computed, including those used in this report and previously explained in Section 2.1.

Additionally, other issues such as landing revenues have to be considered. From the AER ex-vessel prices can be obtained at fleet segment level. This is an average value of the prices received by each métier. Using these average values implies that the price differentials among métiers are not captured, unless some other (national institutes) data are used.

The EWG considered that the work done in Jardin et al. (2013) is a good starting point on this process of merging-scaling the two datasets. In this work accounting costs for the North Sea demersal fishery has been computed based on modelling accounting variables by unit as a function of the fleet's components. These components are shared between the two datasets and use the ICES WHMIXFISH North Sea information to scale the variables and estimate absolute economic indicators.

2.5 Updating the conditioning during the meeting

On addition to the comparison work presented in the section above, two models were updated or conditioned during the meeting using the ICES WGMIXFISH dataset (FLBEIA and DISPLACE).

In combination with the ICES WGMIXFISH group, FLBEIA was conditioned using all fleet and métiers included in ICES database for the North Sea and also using the AER data. One ICES WGFISHMIX TAC option was tested (TAC MIN), although no economic indicators were calculated. From the results obtained it was shown how existing bio-economic models can handle the complexity of the North Sea's fleet-métiers stock combinations (see Annex 6), which is an important outcome for the future application of these types of models.

DISPLACE was updated during the meeting to increase the stock numbers considered and using the single stock ICES analytical assessments. Using this updated model, several scenarios were run (TOR 3).

Due to time constraints, the remaining two models were not updated during the meeting. FLBEIA for AIW because it was already including the same fleet structure as the ICES WGMIXFISH and FishRent, because it was decided to use it as it was at the beginning of the meeting, to provide reliable results for the options and scenarios selected by the group (TORs 2 and 3).

2.6 Decision unit

It is worth to mention how the bio-economic models used in this report are operating at métier level. This is probably the best approach to capture the effort adaptation possibilities that fleets have to management actions, such as the change of fishing possibilities or landing obligation. However, it should be noted that the decision unit in an economic sector is more related to the fishing firm. Considering individual vessels, or individual fleet segments, implies that their decisions are independent among them, which is not necessarily true.

3. TOR 2. Assessing the TAC options

It should be noted that TOR 2 and TOR 3 do not differ substantially from the point of view of how bio-economic models have to be conditioned and used for projections. Therefore, once the basic conditioning and initial setting are decided, options or scenarios can be simulated, and results interpreted accordingly.

In TOR 2, using two bio-economic models FishRent (North Sea mixed demersal fisheries) and FLBEIA (Atlantic Iberian waters demersal fisheries) and using similar initial settings (see TOR 1), different TAC options were compared. Given the limited time that the EWG had available for the modelling exercise, the group decided to limit to two the number of options tested[7].

This section of the report is divided in reporting results of two studies. Firstly, an analysis of the North Sea mixed demersal fisheries is provided using the FishRent model. Secondly, FLBEIA is used to analyse the Atlantic Iberian waters demersal fisheries case. For both cases, the analysis is based on comparing two TAC options for the year after. For the case of the North Sea applying the single stock based advised TAC for 2018 is compared to the use either of F_{MSY} or the upper value of the F_{MSY} ranges in the year 2019. For the AIW, the same comparison is made for the years 2017 and 2018. The selection of these models was based on the availability of the conditioning prior to the meeting.

3.1 North Sea mixed demersal fisheries

3.1.1 Introduction

The case study focuses on the mixed demersal fisheries in the North Sea where complex biological and technical interactions occur. For these fisheries the important target species such as cod, haddock, saithe and hake are considered. Potential consequences of current and changing (e.g. F_{MSY} upper) management principles including the landing obligation on fleet and fish stock dynamics are addressed in this case study.

The model was run for a period of 8 years (2016–2023). Economic data of the years 2013–2015 and biological data up to 2017 were used. The model accounted for five fleet segments covering vessels from Denmark (den_bottom trawls_o10m), England (gbr_bottom trawls_o10m), Ireland (irl_bottom trawls_o10m), France (fra_bottom trawls_o10m) and Germany (ger_bottom trawls_o10m) that fished mainly cod, haddock, hake and saithe in the North Sea saithe either as the main target species or an important bycatch species (Figure 5).

[7] Some other scenarios and scenarios were run during the meeting, including a “smart” use of the FMSY ranges. These are not presented here, given that comparability between the two case studies is not so straightforward, but these alternative scenarios running, can be seen as the potentiality and flexibility of the bio-economic models to simulate different options an scenarios.

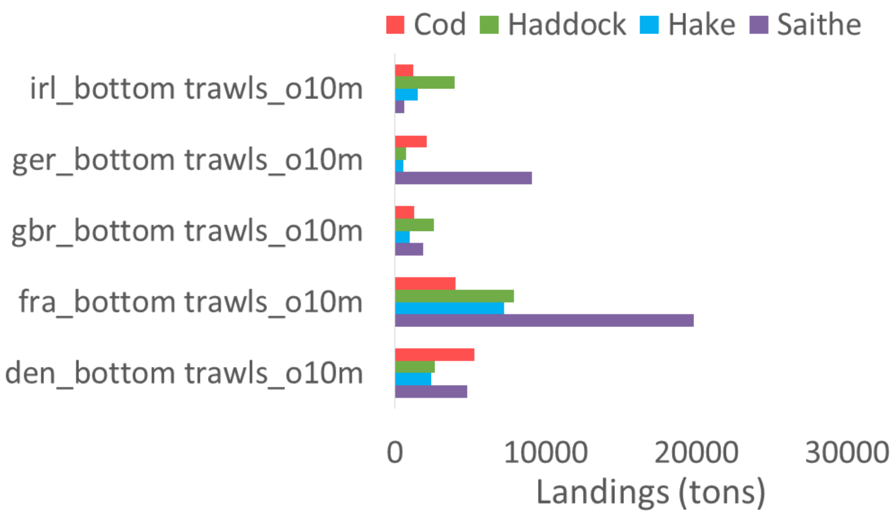

Figure 5 Average landings (tons) for modelled fleet segments and stocks from 2013-2015.

3.1.2 Results obtained from the comparison of two TAC options

The model runs were used to provide the economic performance of the ICES WGMIXFISH options. In this case, results can be seen as a short-term projection. The EWG 18-05 decided to allow for capital adjustments (adaptive expectations) in this short term, which can be seen as a strong assumption, but simplifies the comparison with the mid-term simulations. That is, effort and capital supported the TAC's option implementation. Two options were compared to the single stock catch advices for 2018:

Option 1: Using the F_{MSY} values for each stock for which this value is available.

Option 2: Using the Fupper range for all the stocks limiting the effort (choke stocks identified under Option 1) in 2019.

3.2.3.1 Choke identification

Table 5 makes a comparison of the choke stocks identified in 2018 with those identified under the two TAC options.

Table 5. Identified choke stock for the NS for the two fishing mortality options simulated

	2018	2019	
Fleet Segment		**FMSY**	**F upper**
den_bt_o10m	Hake	Hake	Haddock
fra_bt_o10m	Cod	Cod	Cod
gbr_bt_o10m	Hake	Hake	Cod
ger_bt_o10m	Hake	Hake	Cod
irl_bt_o10m	Saithe	Cod & Hake	Cod

Result show how choke stocks can vary depending on which option is taken. Remarkably, the use of F_{MSY} range upper value for hake makes this stock not a choke stock in 2019.

3.2.3.2 Quota uptake

All fleets considered in this case study have a choke effect due to the landing obligation. This implies that not all the available fishing possibilities are met (Figure 6).

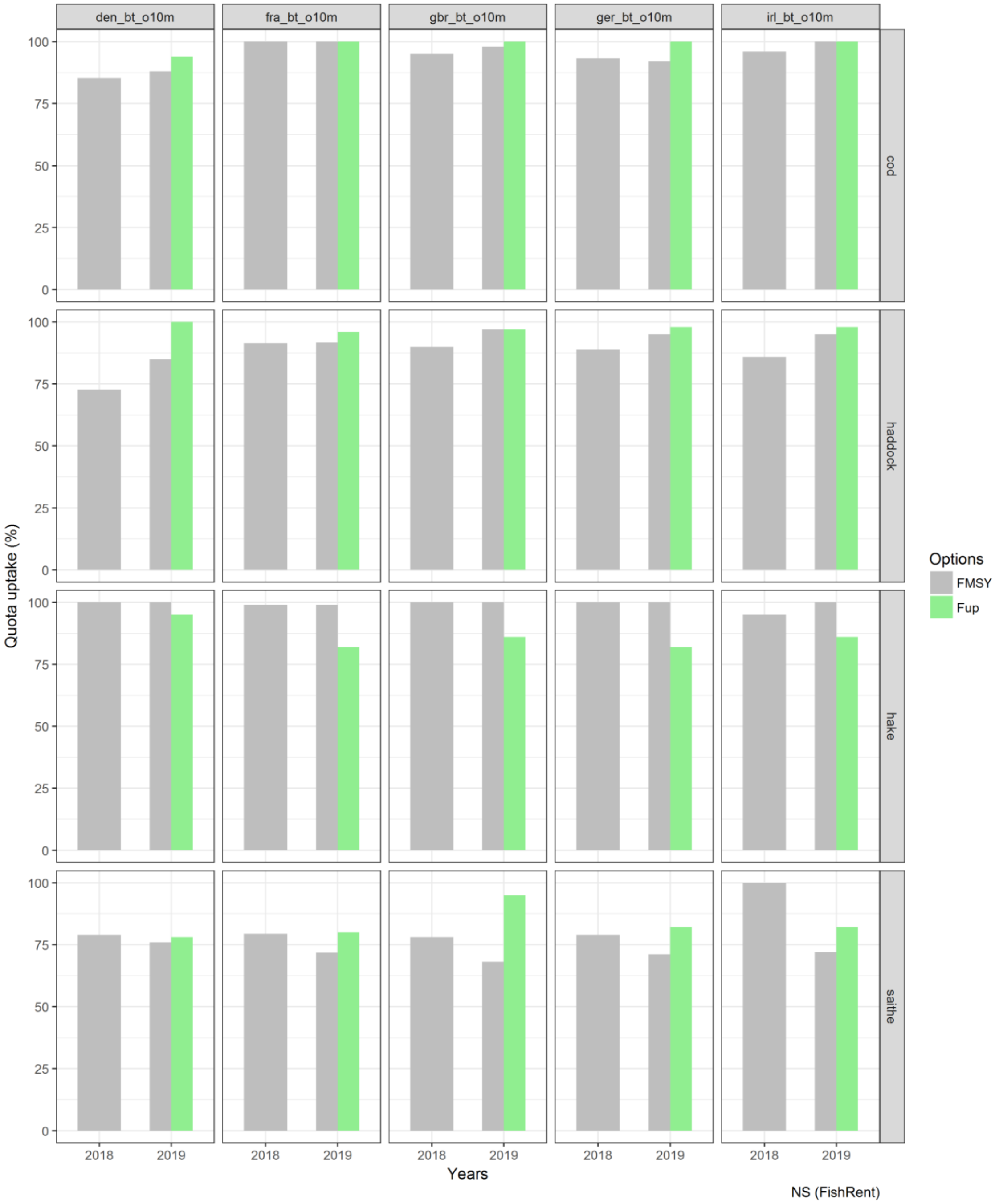

Figure 6 Quota uptake by stock and fleet segment. North Sea.

Figure 6 shows the complexity of the case analysed. Not all the fleet segments increase their quota uptake by using the F upper range. This is a situation in where only the subsequent year is compared. However, it should be noted that this does not imply that catches of fleet segment with lower quota uptakes are lower. The final effect can be summarized using the economic indicators of the fleet.

3.2.3.3 Fleet performance: Identifying trade-offs among fleets and economic dimensions

Considering the economic component in the model, it was possible to estimate the associated costs and benefits of using *FMSY* or *Fup options*, compared to the single stock TAC advice for 2018 (Figure 7).

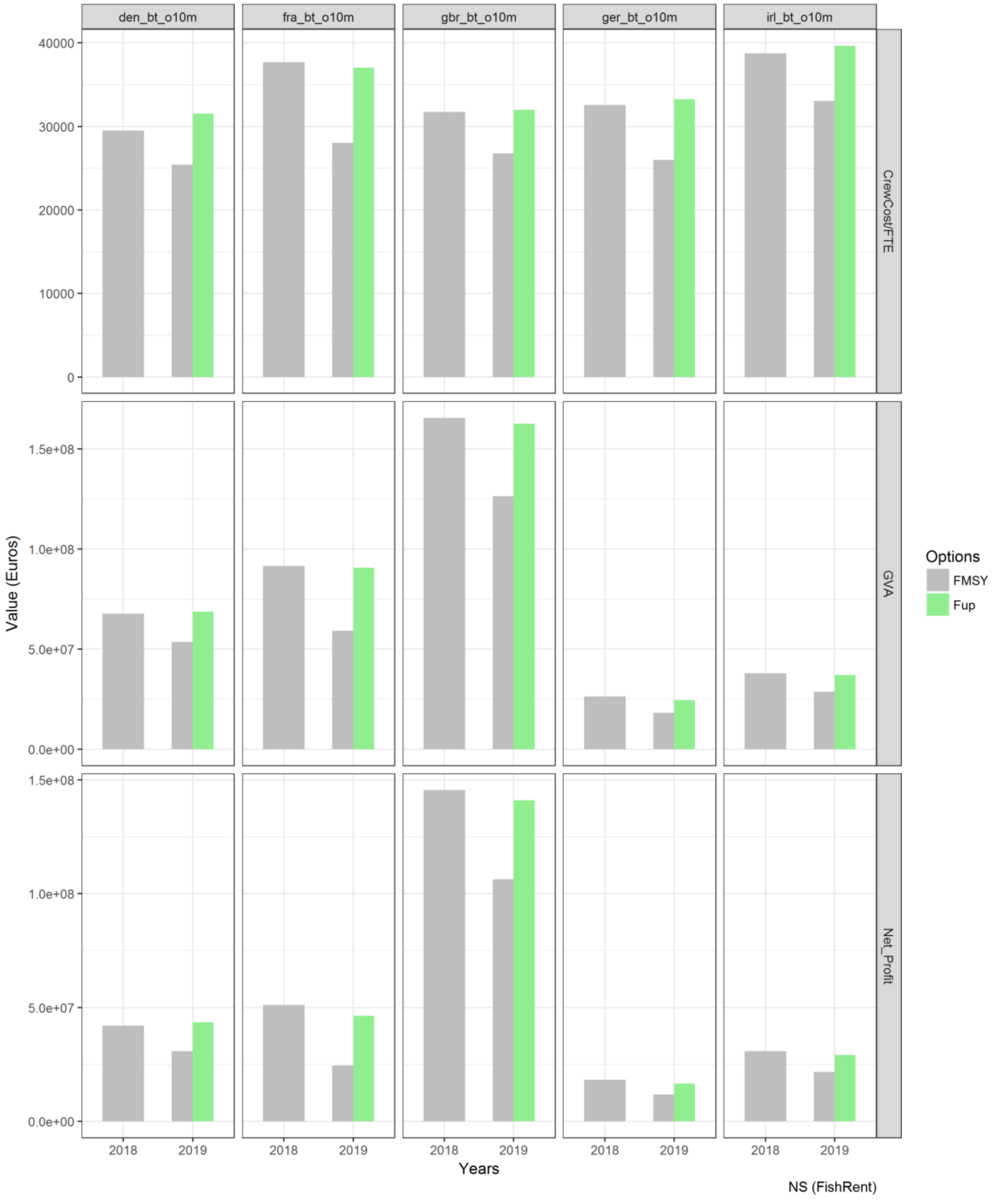

Figure 7 Economic indicators for the NS fleet segments and the two options for 2019 in comparison with 2018.

In the model, the catch of the stocks in each year depends on the dynamics of the fleet segments. For the *Fup* option, catches increased for most fleet segments when quotas of choke stocks were higher than in the *FMSY* option. Furthermore, comparing the two options, there is a change in the choke stocks, given that in the *Fup* option cod becomes the most common choke stock. From the comparison of the two options for 2018, for all the analysed fleets and the three economic indicators, results were higher using *Fup* option than using *FMSY* option. Nevertheless, this does not imply that the value of the indicators will be higher in 2019 than in 2018 for all fleet segments. For example, for the segment gbr_bt_o10m, net profit will be lower in 2019 than in 2018, independently of the option selected for 2019.

3.2 Atlantic Iberian waters demersal fleets

3.2.1 Introduction

This case study was only considering the Atlantic front and the Cantabrian Sea (ICES Divisions 8c and 9a). Fleets in these areas operate on a narrow continental shelf where they exploit a variety of fishing resources by using different type of gears (trawl, gillnet, long lines…), forming a common demersal mixed-fisheries fleet. Although recent changes in fishing strategies and gears design have led some traditional demersal fleets to also exploit pelagic species, the combined management of demersal and pelagic stocks is not simple. On the one hand, most of the landings of pelagic stocks are made by fleets (purse seine, hand lines…) without any effect on demersal stocks. On the other hand, many pelagic species are widely distributed, and the participation of the Spanish and Portuguese Iberian fleets in the total catches are small. On the shake of this report and according to the last data available the fishery, this is formed by approximately 2500 vessels grouped into five fleets segments. For Spain two fleet segments were considered, demersal trawlers (DTS_SP) and non-trawlers (NTR_SP) which include gillnetters and long-liners. From Portugal two segments were taken, demersal trawlers (DTS_PT) and polyvalent artisanal fleet (PGP_PT). This complexity reduces the number of explicit stocks that can be considered, although the total coverage is high and around the 35% of the total catches. Eight stocks are explicitly included although they are modelled differently:

Hake (*Merluccius merluccius*), Megrim (*Lepidorhombus whiffiagonis*), Four Spot megrim (*Lepidorhombus boscii*), White Anglerfish (*Lophius piscatorius*), are demersal stocks which distribution coincides with the area analyzed. All of them are assessed by ICES and have analytical assessments. In terms of the simulation, these stocks have been projected using an age structured exponential survival model together with a stock-recruitment model to simulate the new individuals that incorporate to the fishery. For all the stocks a deterministic segmented regression model has been used and uncertainty has been introduced multiplying a lognormal error to the stock recruitment point estimate. This error has a median equal to one and coefficient of variation obtained in the historical stock recruitment model fit.

Within the simulation all the demersal fleets (Portuguese and Spanish) were considered, however, only economic results for two Spanish fleet segments are given. The reason is that for the Portuguese fleets, although conditioned using the AER data, no expertise on their activity was available in the EWG. Additionally, although the métier structure presented in Table 6 was maintained within the simulation, results are reported as Trawlers and Non-trawlers segments.

Table 6. Fleet segments and métiers for AIW

Fleet segment	Métier	Description

Non-Trawlers	GNS_DEF_>=100_0_0	Set gillnet targeting demesal fish with mesh size >= 100
	GNS_DEF_60-79_0_0	Set gillnet targeting demesal fish with mesh size range 60-79
	GNS_DEF_80-99_0_0	Set gillnet targeting demesal fish with mesh size range 80-99
	GTR_DEF	Trammel net targeting demesal fish with mesh size range 60-79
	LHM_DEF_0_0_0	Hand line targeting demersal fish
	LHM_SPF_0_0_0	Hand line targeting other fish
	LLS_DEF_0_0_0	Longline targeting demersal fish
Trawlers	OTB_DEF_>=55_0_0	Bottom otter trawl targeting hake, anglerfish and megrim using "Baka" nets.
	OTB_MPD_>=55_0_0	Bottom otter trawl targeting mixed pelagic and demersal fish using "Baka" nets.
	PTB_MPD_>=55_0_0	Bottom pair trawl targeting mixed pelagic and demersal fish.

Additional information on how the model was set and data used is presented in Annex 4.

3.2.3 Results obtained from the comparison of two TAC options

The model runs were used to provide the economic performance of the ICES WGMIXFISH options. In this case, results can be seen as a short-term projection. The EWG 18-05 decided to allow for capital adjustments (adaptive expectations) in this short term, which can be seen as a strong assumption, but simplifies the comparison with the mid-term simulations. That is, effort and capital supported the TAC’s option implementation. Two options are compared with the simulated results of the final 2017 TAC for all stocks:

Option 1: Using the single stock advice provided by ICES for these stocks in 2018.

Option 2: Using the Fupper range for all the stocks limiting the effort (choke stocks identified using Option 1) in 2018.

3.2.3.1 Choke identification

Table 7. Identified choke stocks for AIW for the two options for the year 2018

	2017	**2018**	
Fleet Segment		**FMSY**	**Fup18**
Spanish Trawlers	Hake	Hake	Hake
Spanish non-trawlers	Hake	Hake	-

According to results obtained from the simulation, for trawlers whatever the option taken the species identified as choke did not change. This implies that even the F upper range of F_{MSY} implies (*Fup18*) higher fishing possibilities, the choke stock identified by the model does not vary. However, in the Fup18 scenario, and for non-trawlers in some years capacity is the limiting the effort (no choke stocks). In this case it should be noted, that not all the stocks have been explicitly included, and that it could be the case that stocks including in “others” could act as choke stocks (pelagic stocks managed using TACs).

3.2.3.2 Quota uptake

Trawlers are being limited by a choke effect due to landing obligation. This implies that not all the available fishing possibilities are met (Figure 8).

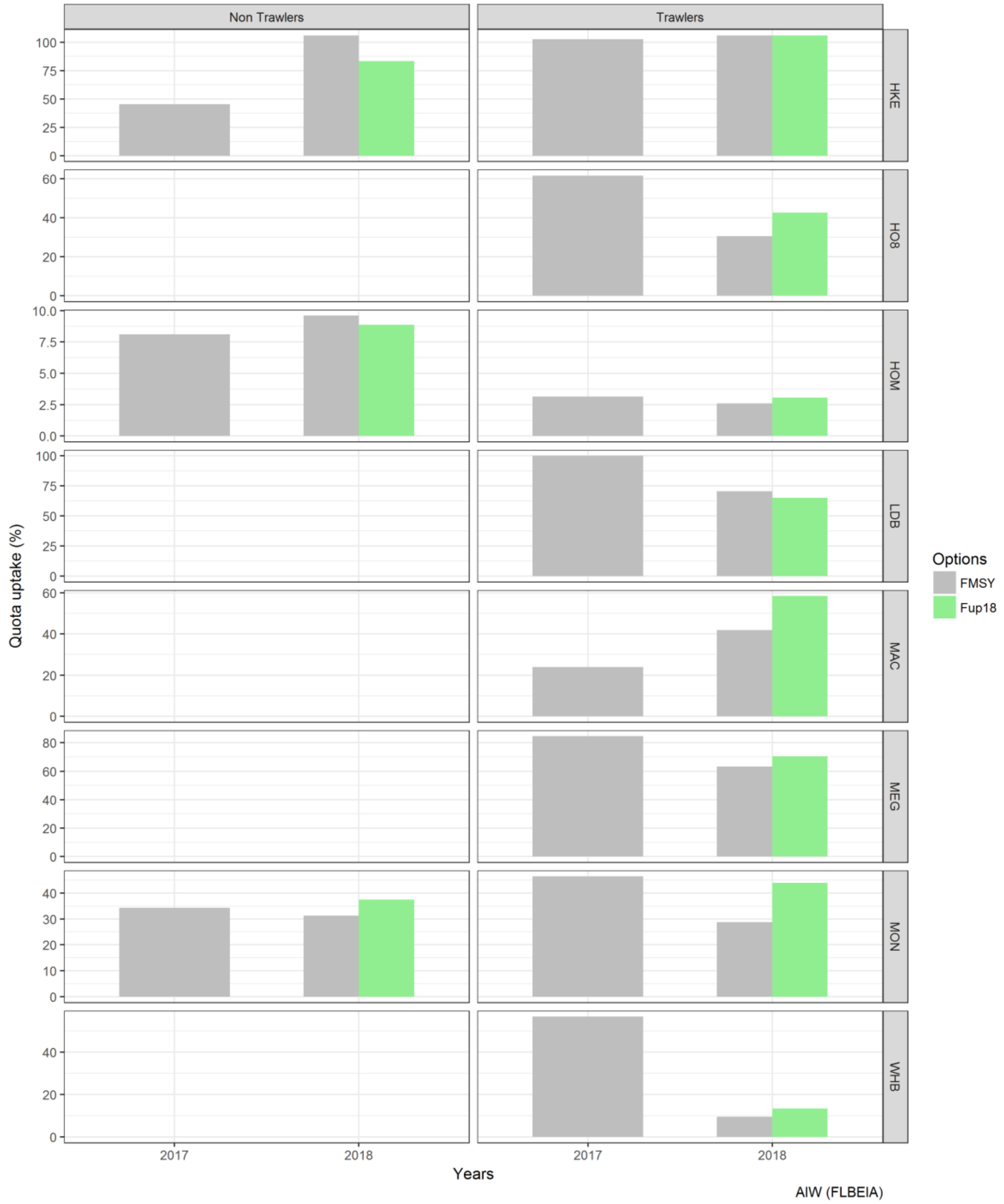

Figure 8 Quota uptake by stock and fleet segment.

A comparison between the two options implies that using Fupper for hake, is not only increasing the fishing possibilities of this stock but also increasing the catches of the other species captured by this fleet. The reason is that effort constraints are relaxed. For example, for Mackerel (MAC) quota uptake by trawlers is higher using *Fup18* option than using *FMSY*. However, some trade-offs among the fleets were observed: Non-trawlers quota uptake for Horse Mackerel (HOM) and Hake (HKE) was reduced using the Fupper range for hake. This effect comes from the limits in their capacity previously identified (Table 7 and Figure 8). Again, results are better summarized using the accounting indicators of the fleets.

3.2.3.3 Fleet performance: Trade-offs among fleets and economic dimensions

It is complicate to determine which are the final consequences of using one option or the other. The use of accounting indicators for the fleets, provided a more general overview of the results. Figure 9 is presenting the likely trade-offs among the different fleet segments reported (trawlers and non-trawlers) from the labour remuneration (CREW/FTE), contribution to the economy (GVA) and capital remuneration (Net Profit). Figure 9 can also be interpreted as the likely trade-offs among the different dimensions studied.

Even if some different directions on the quota uptake were identified, the three accounting indicators used showed the same direction in the change (although obtaining different absolute values) for the different fleet segments: GVA, crew remuneration and net profit would have been increased for 2018 if *Fup18* option was used.

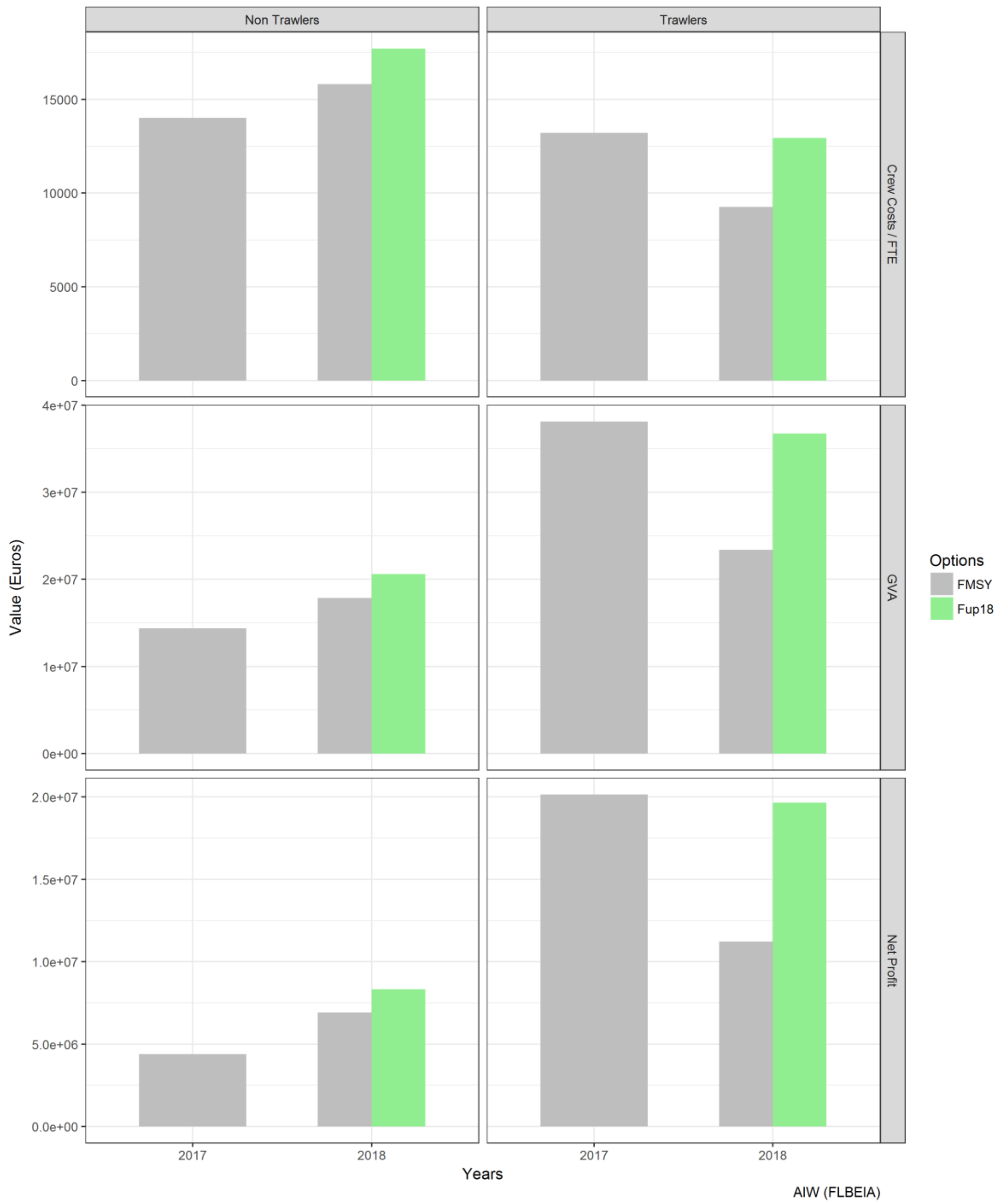

Figure 9 Economic indicators for the two fleet segments and the two options for 2018.

3.3 Conclusions

It is not the intention of this work to provide an impact assessment of these two fisheries and of the two TAC options tested. In neither case studies all the available information of catches was used, and some assumptions on them were made. However, the examples presented here can show that any TAC option could create different management implementation levels that could affect differently the dimension studied and/or the fleet studied and that they can be captured in a short-term projection of a bio-economic model. Different quota uptakes by stock and fleet require effort adjustments (in intensity and/or allocation by métier) that at the end, will affect the economic performance of the fleets. Even in a short-term projection the mechanisms are complex, and this complexity is exacerbated by the number of fleets and stocks considered. Economic indicators are able to show a summary of the results from the fleet's perspective, while form the biological side, sustainability is always considered in the management objective applied (FMSY or Fup).

4. TOR 3 ASSESSING THE MID-TERM-EFFECTS COMPARED TO SHORT TERM LOSSES OF MOVING TO MSY

In this TOR several scenarios are tested and analysed considering the existing trade-offs between short term and long-term objectives, but also considering the options analysed in the ICES WGMIXFISH group. Additionally, a methodology is provided to link the results from applying bio-economic models to assess the dependency of the regions and industry, using the existing and available public data.

Three scenarios are tested for the two case studies analysed (North Sea and Atlantic Iberian waters demersal fleets). Three of them were compared in the sections below:

- Scenario 1 (FMSY). It consists on setting the fishing mortality (F) advised for year 2019 equal to F_{MSY} for each individual stock and keep this objective for the rest of the projection period. It can be linked to the ICESWGMIXFISH with the "Min" scenario.
- Scenario 2 (FMSY20). Achieving MSY for all the stocks for which a F_{MSY} estimation exist in the year 2020.
- Scenario 3 (Fup). Using the Fupper value of the F_{MSY} ranges as defined by ICES for each choke stock in 2018, during the whole projection period in such a way that:

  Fs, 2019 = Fs, 2018 - [(Fs, 2018 - Fs, upper)/2] if the stock is a choke stock for any of the fleets (segments), or

  Fs, 2019 = Fs, 2018 - [(Fs, 2018 - Fs, MSY)/2], if not.

This scenario 3 can be linked to the ICESWGMIXFISH with the "range" scenario (see TOR 1)

In this TOR, we use the same models and parametrization as in TOR 2. Therefore, the introduction to the case study is the same. In addition to the results obtained using the bio-economic models presented in TOR 2, those obtained from applying the model DISPLACE are also presented. This last bio-economic model is suitable for a mid-term analysis as the one presented in this TOR.

4.1 North Sea mixed demersal fisheries

4.1.1 Choke stock identification for the period 2018-2023

The bio-economic model used to assess the North Sea demersal fisheries case study (FishRent) can identify which stock(s) is acting as choke in all the projection period. In contrast to TOR 2, choke stock(s) can differ depending on the year analysed (Table 8).

Table 8. Identified choke stock for NS for the three scenarios analysed. NS.

Fleet Segment	Scenario	2019	2020	2021	2022	2023
den_bt_o10m	FMSY19	Hake	Hake	Hake	Hake	Hake
	FMSY20	Hake	Hake	Hake	Hake	Hake
	FMSYUP	haddock	haddock	haddock	haddock	haddock
fra_bt_o10m	FMSY19	Cod	Cod	Cod	Cod	Cod
	FMSY20	Cod	Cod	Cod	Cod	Cod

	FMSYUP	Cod	Cod	Cod	Cod	Cod
gbr_bt_o10m	FMSY19	Hake	Hake	Hake	Hake	Hake
	FMSY20	Hake	Hake	Hake	Hake	Hake
	FMSYUP	Cod	Cod	Cod	Haddock & Cod	Haddock & Cod
ger_bt_o10m	FMSY19	Hake	Hake	Hake	Hake	Hake
	FMSY20	Hake	Hake	Hake	Hake	Hake
	FMSYUP	Cod	Cod	Cod	Cod	Cod
irl_bt_o10m	FMSY19	Cod & Hake	Cod & Hake	Hake	Hake	Hake
	FMSY20	Hake	Hake	Hake	Hake	Hake
	FMSYUP	Cod	Cod	Cod	Cod	Cod

From Table 8 it can be shown how changing the F_{MSY} objective from 2019 to 2020 does not change the identified choke stock. However, using the Fupper ranges for the choke stocks identified in 2018, creates changes in the stock that is causing the choke effect, for 4 of the 5 fleets analysed.

4.1.2 Quota uptake projection for the period 2018-2023

Figure 10 is presenting the quota uptake by species and fleet segment. The main result obtained is in the *FMSYUP* scenario fishing quota possibilities of cod are met, while hake is no longer identified as choke species. Additionally, there are no many differences between the *FMSY20* and *FMSY* scenarios, but a smaller general quota uptake for FMSY19 than in FMSY20 scenario. The main conclusion is that for the fleets analysed the FMSYUP scenario is able to reduce choke effects. However, this higher use of fishing possibilities also implies higher variable costs and lower biomasses of the stocks. The likely consequences of using these higher fishing possibilities can be addressed from the economic perspective of the fleets.

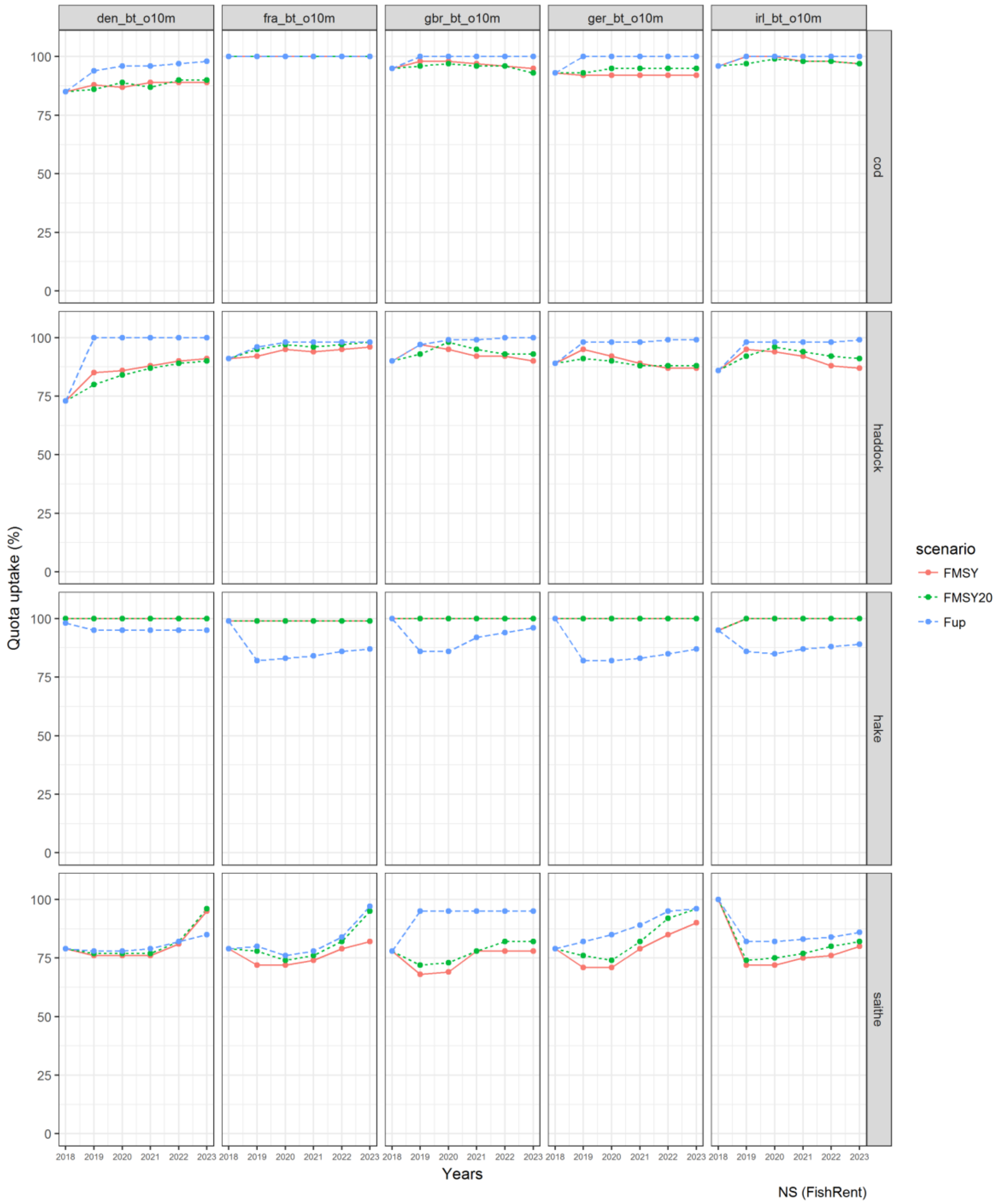

Figure 10. Quota uptake by stock and fleet segment for the North Sea case study in the period 2019-2023.

4.1.3 Fleet economic performance

Using the Fupper ranges for the stocks producing the choke effect, produces for all the fleets and all the indicators analysed, improved economic results (Figure 11). However, when comparing the base case (*FMSY19*) with postponing it to the year 2020 (*FMSY20*), the main time trade-offs arise. *FMSY* as soon as possible imply short-term losses (years 2018 and 2019) that are (or not) recovered after the year 2020.

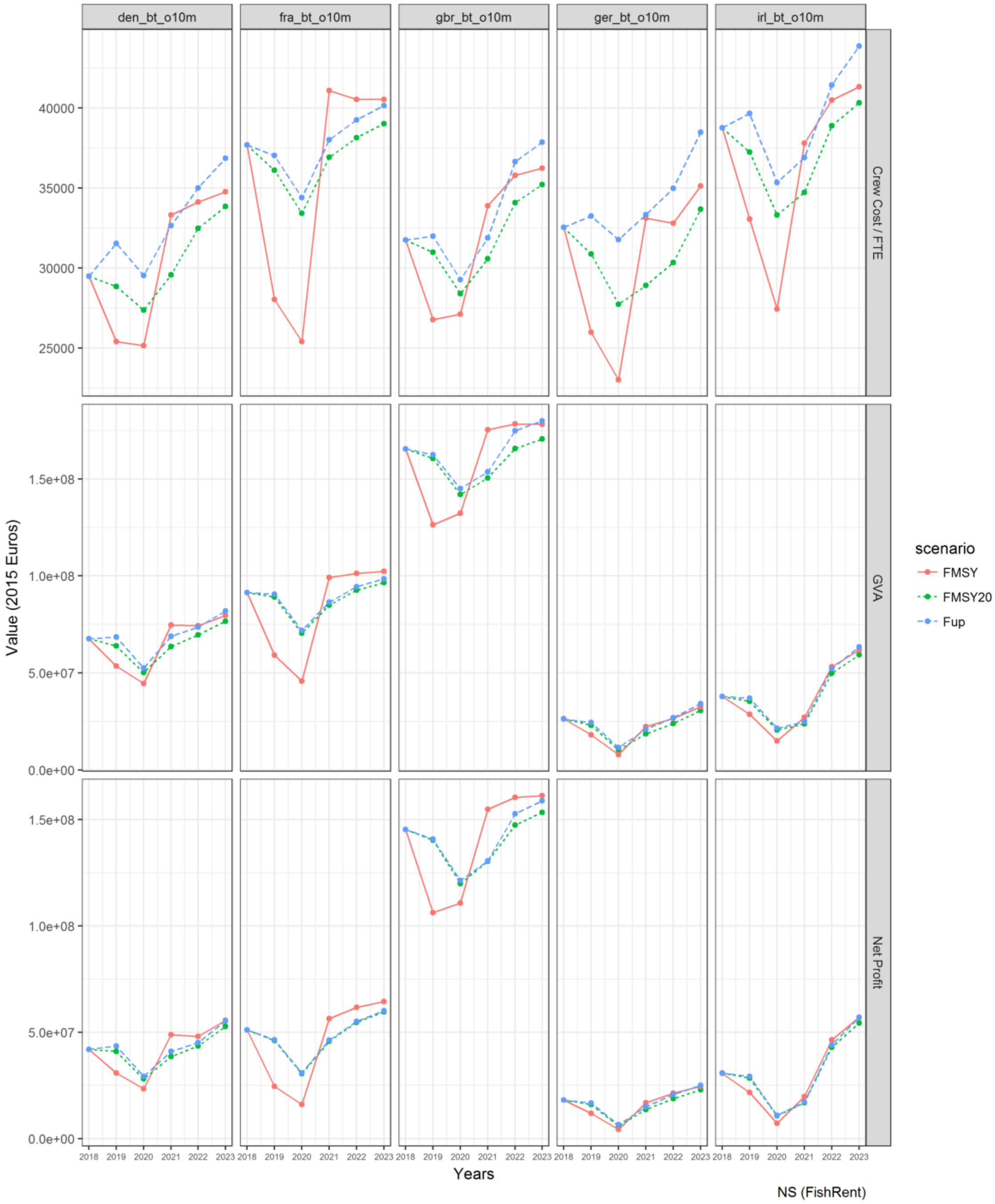

Figure 11. Economic indicators by fleet segment for the North Sea case study in the period 2019-2023.

Graphically, it can be seen how the area of the comparative losses (2018 and 2019) and the area of comparative gains (after 2020) differ for all the indicators. One possible way of looking at which one is higher, can be obtained using the net present value (NPV) of the flow of indicators as presented in TOR 1. The next section explains the results from computing this NPV.

4.1.4 Time trade-offs.

When a shift from a gain (loss) to a loss is projected for a fleet segment one of the possibilities to assess the overall period is to calculate the average sum of the flow of each indicator from today's perspective (present value) (Table 9).

Table 9. Net present value of the three indicators selected for the three scenarios: NS

Fleet Segment	Scenario	GVA	CREW/FTE	Net Profit
den_bt_o10m	FMSY19	68,762,857	31,794	43,255,981
	FMSY20	68,473,815	31,746	42,937,203
	FMSYUP	72,206,061	34,060	44,713,041
fra_bt_o10m	FMSY19	86,917,978	37,215	47,566,613
	FMSY20	91,958,047	38,751	50,278,344
	FMSYUP	93,335,359	39,652	50,621,567
gbr_bt_o10m	FMSY19	166,898,351	33,437	146,382,880
	FMSY20	167,206,378	33,413	146,635,461
	FMSYUP	171,719,770	34,831	148,775,269
ger_bt_o10m	FMSY19	23,312,846	31,899	16,847,848
	FMSY20	23,268,257	32,257	16,651,001
	FMSYUP	25,179,370	35,732	17,775,250
irl_bt_o10m	FMSY19	38,735,320	38,251	31,499,697
	FMSY20	39,449,403	39,100	31,857,446
	FMSYUP	41,096,379	41,281	32,702,365

The first noticeable result from Table 9 is that using F ranges to limit choke situations is positive from the economic perspective and for all the fleets analysed. GVAs are between 3% and 8% higher in *FMSYUP* scenario than in *FMSY19* scenario. Increments in crew remuneration can be up to a 12% for German fleets and net profit increments are in a range between 2 and 6 per cent.

Postponing the F_{MSY} achievement to 2020, is not necessarily positive for all the fleets analysed. For example, for the Danish and German fleet segments, the NPV of the three scenarios and the three indicators, does not differ, while for the French segment results are 6% higher from the GVA and net profit perspective, respectively.

4.2 The Atlantic Iberian waters demersal fleets

4.2.1 Choke stock identification for the period 2018-2023

The bio-economic model used to assess the Atlantic Iberian waters demersal fleets case study (FLBEIA) can identify which stock is acting as choke in all the projection period. In this case no changes are observed on which stock acts as choke. (always hake, -Table 10-).

Table 10. Identified choke stock for AIW for the three scenarios analysed

Options	Fleet Segment	2018	2019	2020	2021	2022	2023
FMSY in 2019	Spanish Trawlers	Hake	Hake	Hake	Hake	Hake	Hake
	Spanish non-trawlers	Hake	None	Hake	Hake	Hake	Hake
FMSY in 2020	Spanish Trawlers	Hake	Hake	Hake	Hake	Hake	Hake
	Spanish non-trawlers	Hake	Hake	Hake	Hake	Hake	Hake
Fupper for chokes	Spanish Trawlers	Hake	Hake	Hake	Hake	Hake	Hake
	Spanish non-trawlers	Hake	None	Hake	None	None	None

4.2.2 Quota uptake projection for the period 2018-2023

The main result that can be obtained from Figure 12 is how for Spanish trawlers the *Fup* scenario is always producing higher quota uptakes for their main stocks harvested[8]. This is not necessarily true for non-trawlers in were not all their fishing possibilities of hake are met, although for anglerfishes they are increased. Again, even if the fishing quota possibilities are the main effect that is obtained from the application of these type of models, results are clearer if economic indicators of the fleets are considered.

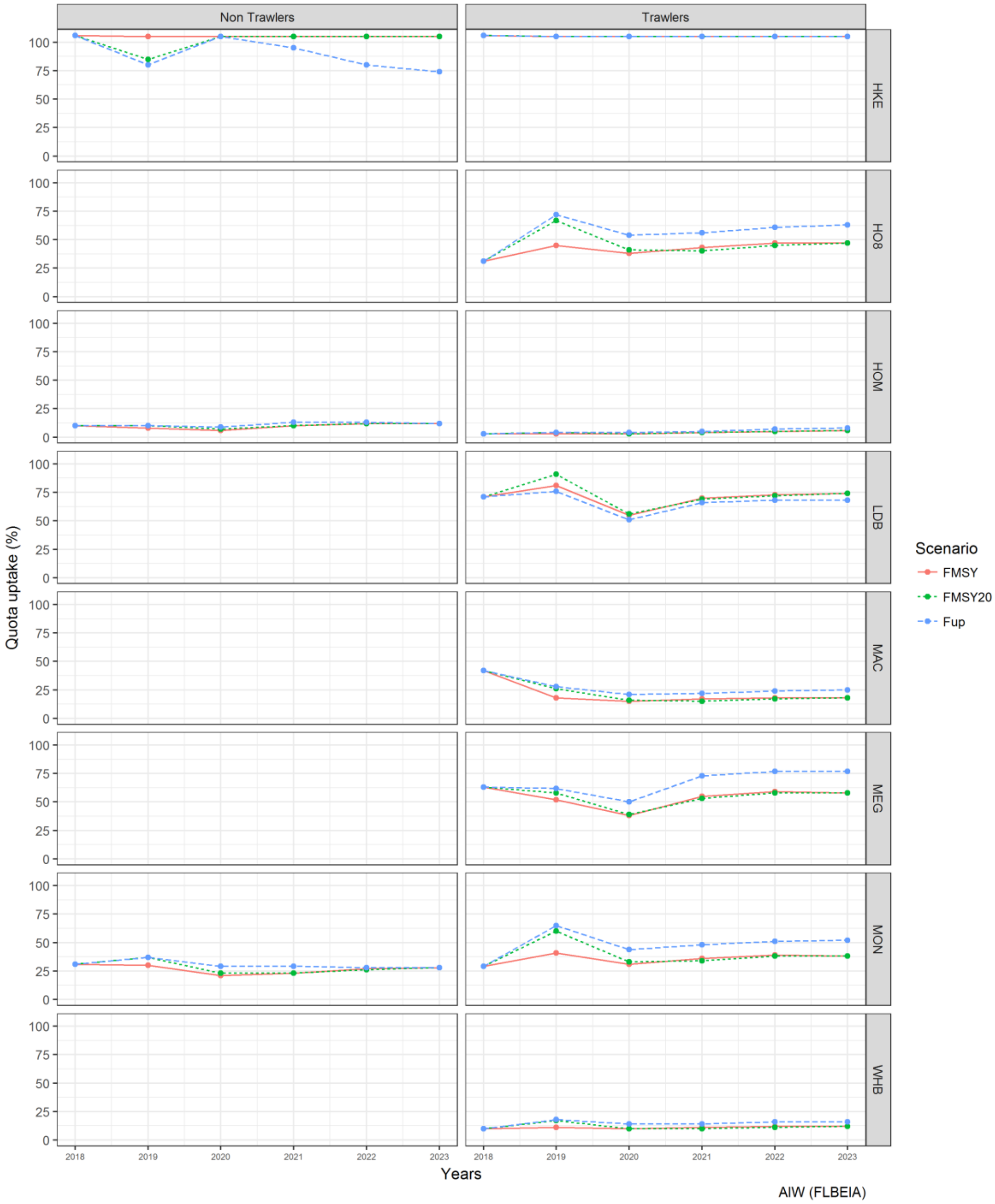

Figure 12. Quota uptake by stock and fleet segment for the Atlantic Iberian waters case study in the period 2019-2023.

[8] In year 2019 FMSY is the scenario producing the higher quota uptake.

4.2.3 Fleet performance

In Figure 13 the three economic indicators are analysed for each scenario. As in the North Sea case study F upper is creating higher GVA and crew remuneration by FTE, although lower net profit. However, when comparing the base case (achieving F_{MSY} in 2019) with postponing it to the year 2020, the main time trade-offs arise. FMSY as soon as possible imply short term (years 2018 and 2019) lower results in comparison with the FMSY20 scenario that are recovered after the year 2020.

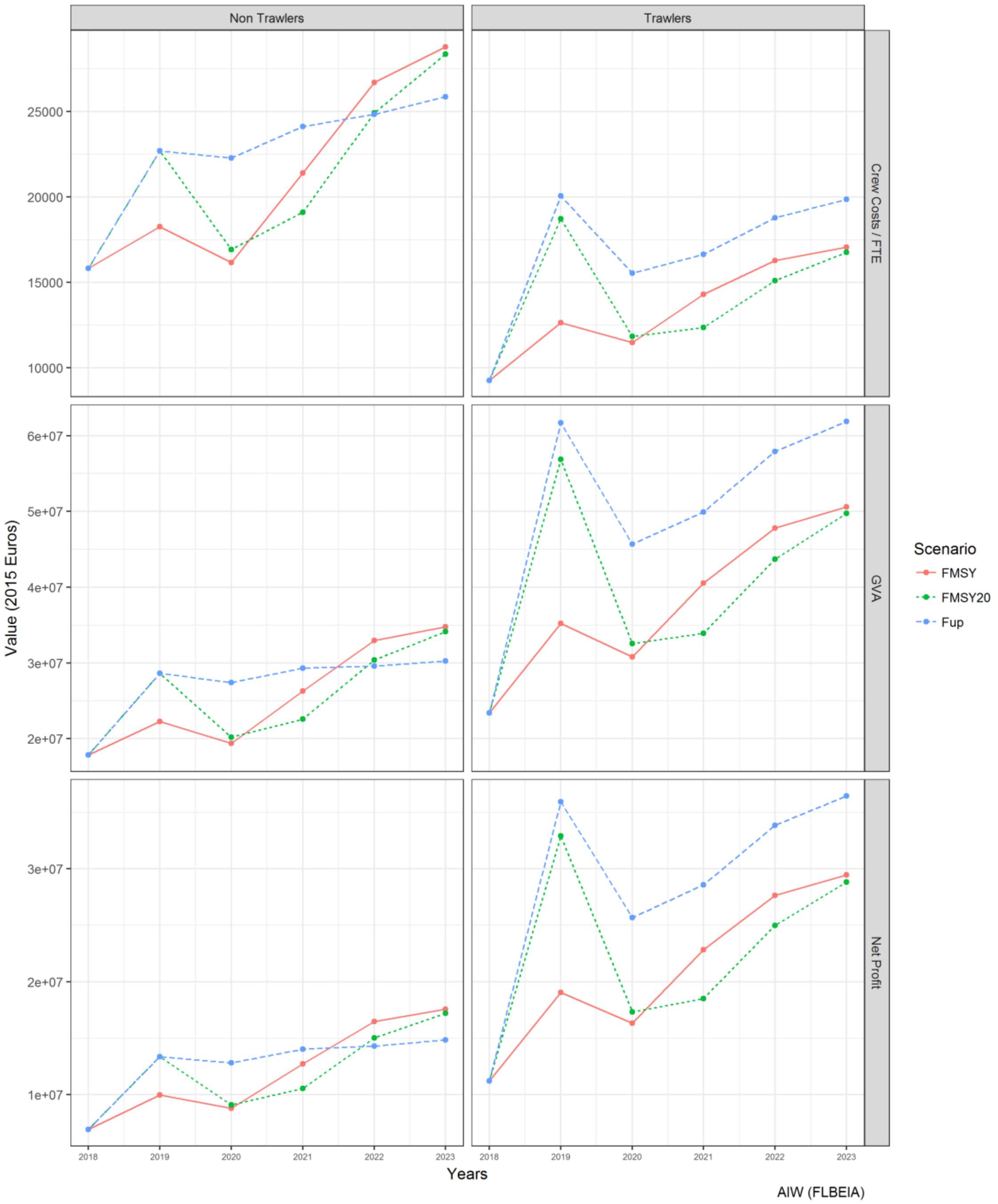

Figure 13. Economic indicators by fleet segment for the Atlantic Iberian waters case study in the period 2019-2023.

Graphically, it can be seen how the area of the losses (2018 and 2019) and the area of gains (after 2020) differ for all the indicators. One possible way of looking at which one is higher can be obtained using the present value of the flow of indicators as presented in TOR 1. The next section deals with this issue.

4.2.4 Time trade-offs.

When a shift from a gain (loss) to a loss is projected for a fleet segment one of the possibilities to assess the overall period is to calculate the average sum of the flow of each indicator from today's perspective (net present value) (Table 11).

Table 11. Net present value of the three indicators selected for the three scenarios: AIW.

Fleet Segment	Scenario	GVA	CREW/FTE	Net Profit
Spanish Trawlers	FMSY19	38,401,175	13,457	21,584,409
	FMSY20	40,923,317	14,111	23,129,090
	FMSYUP	52,215,407	17,128	30,229,017
Spanish non-trawlers	FMSY19	25,389,807	20,822	12,245,275
	FMSY20	25,529,802	21,020	12,239,336
	FMSYUP	27,372,777	22,546	13,063,831

From the results obtained it can be seen how using the F ranges is better for the trawlers and non-trawlers fleet segments analysed. The overall increase in, for example, the GVA indicator is up to 35% higher using F ranges (Fup scenario) than in the *FMSY* base case scenario for trawlers (8 % for non-trawlers). The comparison of the base case to postponing the FMSY achievement to year 2020 is not as significative: Trawlers are increasing their GVA in approximately a 4%, while for non-trawlers no significant changes are observed.

4.3 North Sea (DISPLACE)

The application of DISPLACE to the North Sea considered adjustment of spatiotemporal distribution of effort to maximize the profit of the whole fishery under TAC constraints**.** This model is used to model the catches of the North Sea fleets focusing on the Danish fishing vessels that is active in the Baltic Sea and the North Sea in 2015. For the finest level, the simulations use hourly time steps and a 6 by 6 km geodesic spatial grid (providing 35,309 possible fishing locations). In all, 693 vessels were simulated representing 46% of the 1,505 Danish vessels for which logbooks were available in 2015. Each simulated vessel could only fish in the set of EUNIS habitats and areas where it had previously been fishing. The simulated fishing vessels were allowed to use several different gear types within the same trip. After each trip, the simulated vessels return to port and earn money from selling their landings in the harbour. Fish prices are given per stock and marketable category (small, medium, large) and the gross added value is computed from income generated by selling the landings and the actual operating costs of the trip. For the coarser level (currently, other nations than Denmark) the catches are computed from the TACs and the relative stability keys and apply on the distribution areas of the harvested stocks.

4.3.1 Baseline assuming landing obligation

This scenario assumes that fishing vessels will stop fishing when the quota TAC is constraining their effort.

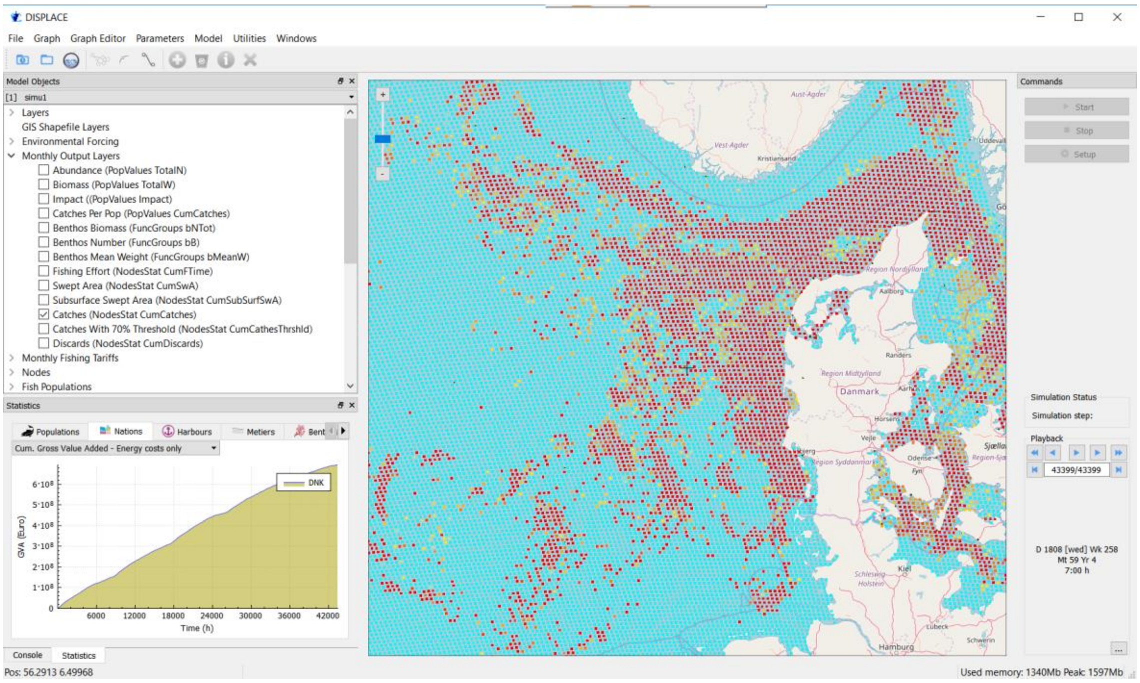

Figure 1 – A snapshot of the DISPLACE user interface for the North Sea waters around Denmark illustrating the outcome for the baseline scenario)

Results show the origin of catches for the Danish fleets and the resulting Gross Value Added along the 5 years simulation from the 2015 situation. Catches from other countries are accounted for in the model, but not mapped neither accounted in the economic indicators.

Preliminary outcomes show that fishers trying to avoid the choke species will have their profit negatively affected by increasing their cost for fishing which will not offset the gain from fishing opportunities they got from "being choked" later in the year. However, results show that GVA can go negative for some of the fleet-segments even in the baseline situation, likely because "Other incomes" (e.g. subsidies) are not accounted for while these segments may lie at the edge of profitability.

4.3.1 Baseline assuming landing obligation and FMSY increased by a 10%.

This scenario tries to simulate a situation in were all stocks are managed the Fupper of the MSY ranges.

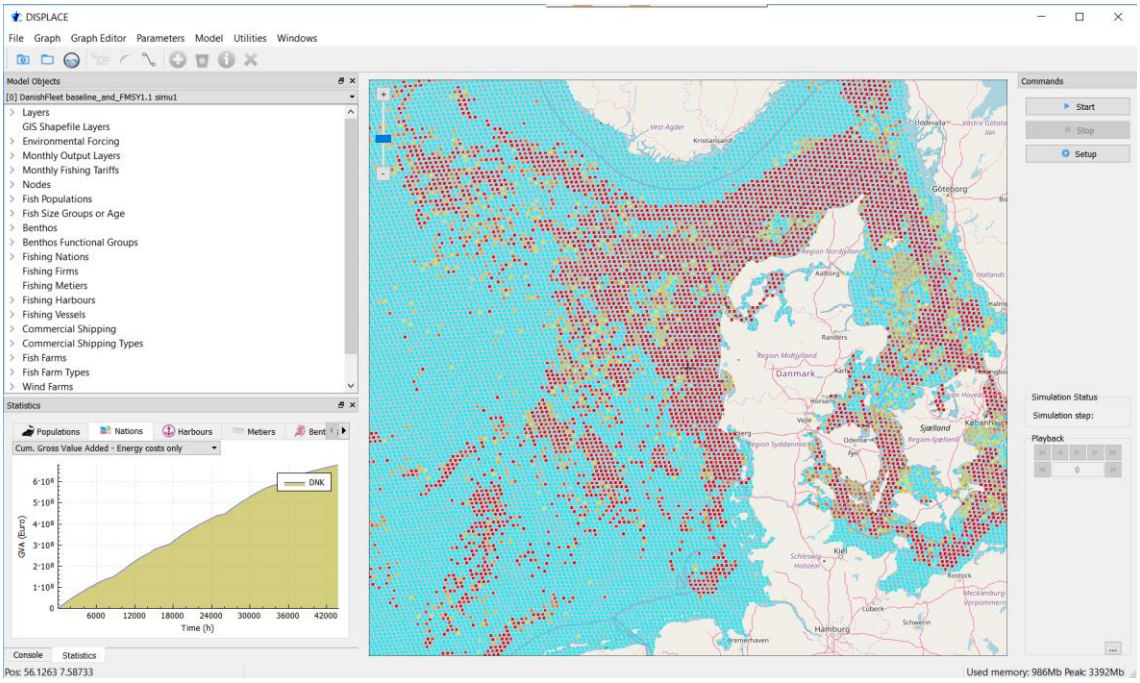

Figure 2 – A snapshot of the DISPLACE user interface for the North Sea waters around Denmark illustrating the outcome for the baseline scenario using a 10% increase in FMSY values.

Results show how the use of Fupper instead F_{MSY} changes the value of the indicators (slightly increasing the Gross Value Added) but also will affect the spatial allocation of the fishing effort.

4.4 Possibilities of Assessing the Dependency of a Local Economy on the Fish Processing Industry

The standard device of economists to examine the dependency of economies, however delineated, on a given industry or sector is input-output analysis. The economy in which the industry (in the case of this study the industry would be defined as a fleet) operates may be national or local. Data for local economies is available at the NUTS II level. Input-output analysis would be very effective in determining the current dependency of the economy on a given fleet. It could offer an assessment of the dependency via multipliers on output (landings) value, income, and employment. This may be done upstream from the target fleet and also downstream to assess the dependency of an economy via both demand (Leontief multipliers) and supply (Ghosh multipliers). The direct and indirect effects are shown through Type I multipliers and the induced effect may be deduced through the Type II multipliers.

It may also be possible to assess the impact of relatively small changes (perhaps up to ±20%) but because of the linearity of the underlying equations in the model estimates of the impact of large changes could prove insufficiently reliable for policymaking. While the Leontief and Ghosh multipliers may be added, avoiding double counting the direct dependency, to determine the current dependency, they cannot be summed to estimate the overall impact of changes.

The most serious difficulty is not, however, technical. It is that input-output analysis is time-consuming and, in terms of the limited amounts of funding available for economic analysis in general, relatively expensive. The analysis is based on a consolidated transactions matrix which includes the cost and earnings data for the fleet under consideration and that at the level of the base economy. If the base economy is the Member State, then the consolidated transactions matrix need only be amended for each fleet's data to be input. If the economy is more local, then it can only be used for each fleet to be considered that is based within the locality.

This problem could to some extent be ameliorated by focusing only on fleets identified as likely to suffer a significant impact from proposed reductions in TACs. It would also be necessary to work up the proposed changes in TACs to a summation of an impact on a given fleet, having first, for example, estimated the share of a TAC or quota taken by the fleet. How much analysis is to be considered is therefore a policy decision, but this methodology though not extensively used in fisheries, is proven in a local context in the European Union, having been carried out, for example, on the local fleet in Ros a Bhíl in the Republic of Ireland at the behest of the Irish Sea Fisheries Board[9]. The purpose of input-output analysis is, in essence, to determine the multipliers which indicate the additional output, income and employment generated within a defined economy by the existence of, in this case, a fleet.

In the past, the European Commission has commissioned studies to determine local dependency on fishing. It should be noted once more, that this is different from dependence on particular stocks. The last of these examined the dependence of localities at levels as low as NUTS IV and V (though in some Member States only data for travel-to-work areas were available) for EU12 and EU15 Member States. It follows that the necessary dependency estimates do not exist and would need to be calculated. Once the spread sheets were developed they could be updated and used for analysis in subsequent years.

Roy, Arnason and Schrank (2009) developed a methodology for identifying economic base industries and measuring their importance and illustrated it by applying it to the Newfoundland fishing industry. A base industry is defined as an industry, which has a greater importance to an economy than its contribution to Gross Domestic Product (GDP) would imply (Tiebout 1956). Thus, an economic base industry is one whose contribution to the economy of a region is disproportionately important in the sense that other industries (or segments) depend upon the base but not vice versa, at least to the same extent. The value of the methodology developed by Roy et al (2009) lies in the ability of the researcher to apply rigorous statistical and econometric testing to the results in a way that is not possible with Input-Output Analysis. Also, the model is not confined to linearity and therefore would appear to offer the possibility of considering the likely impact on a community even where it is proposed to reduce a TAC to zero.

Like input-output analysis the Roy methodology could be time-consuming but if targeted it would offer the chance to consider impacts on significant fisheries. It would perhaps be useful to prepare a set of results for the major fishing communities, or where it is recognised that an important stock is falling well short of the MSY objective, which could be applied as necessary in the EWG.

The methodology would appear to offer opportunities to understand the importance of fleets, fishing sectors and fish processing in local communities and might justify a study to examine a sample of key ports; as Guilvinec (where tourism runs alongside the fishing industry), Peterhead (which has a high volume of landings and a large on-shore processing sector) and Vigo (which also has a large fish processing and canning industry alongside two major car factories).

Another source of information from which elements of dependence may be gleaned is shown in Hadjimichael et al (2013), which demonstrates the use of a resilience framework in a socio-ecological system (a complex, integrated system in which humans are part of nature) in the context of two inshore fisheries.

In all the above there remains the problem of mapping the fish stocks, or more precisely the TACs, onto the fishing fleets. This problem is present in the bioeconomic modelling in this report and any examination of the dependency of localities on fleets needs to be constructed consistently with the bioeconomic models used here.

The study of Morzaria-Luna et al. (2014) proposes to assess the impact of changes in the fisheries by creating a synthetic indicator. This indicator measures: (1) **sensitivity** of the fleet of the port (region) to changes, (2) the **exposure** of the coastal community to changes in the fishing sector, and (3) each **adaptive capacity** of the coastal community.

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[9] Output, Income and Employment Multipliers for the Fishing and Fish Processing Industries of Rossaveal and its Hinterland, Report for the Irish Sea Fisheries Board by Erinshore Economics Ltd, An Bord Iascaigh Mhara, Dún Laoghaire, April 2013.

4.4 Conclusions from TOR 3

Short-term perspective versus mid-term perspective provides a useful outlook of the consequences of any management option (TAC option) or scenario. In here, different trade-offs have assessed, including time, fleet segments and space, considering the identification of the choke effects (implementation of the landing obligation), the quota uptake levels (likely unmet fishing possibilities), redistribution of the gains and losses among fleet segments and redistribution of gain and losses among different dimensions of the economic perspective (labour and capital remuneration).

Results have been presented as an add-on to the ICES WGMIXFISH and do not constitute any impact assessment of any management scenario, given that not all the available information at the time of the study was used. On the contrary, the intention was to show how trade-offs can be illustrated from an economic point of view. A further analysis of the results obtained would be necessary, including biomass evolution, catches, discards…, to fully understand the evolution of the indicators presented.

However, some conclusions can be obtained from the results. Firstly, that the use of Fupper ranges to avoid choke stocks, provides higher economic performance for all fleet segments. This is true from the short-term perspective, the mid-term perspective and from combining the short and mid-term using the net present value (for the period studied). However, the same cannot be said from the comparison of the reaching MSY as soon as possible or postponing it to the year 2020. In this case, benefits are not significant for all the fleet segments analysed in both case studies.

It is also important to see the value added of using these bio-economic models from the modelling side. In both models (FLBEIA and FishRent), the link between biology and economy is implemented via the Cobb–Douglas production function. For this function a bi-non-linear relationship is assumed between two inputs, fishing effort and total stock biomass, and the produced catch. This production function can take into account the possibility of crowding. In turn, crowding makes extra trips less efficient, resulting in a flattened fishing mortality rate. Crowding is a direct interference between vessels that reduces their efficiency, e.g. when a trawler and its gear are blocking the way of another trawler. This type of models considers the costs of fishing, and therefore the catches of the modelled fleet segments can be below the quota. The non-linear relationship between stock and catch might also be appropriate, as mobile species such as the modelled stocks can concentrate in restricted areas due to food availability or spawning events. However, it also shows the complexity of conditioning these models. The values used as exponents for effort and biomass must be determined carefully, given that depending on the values used for those exponents, the produced management advice may differ.

Additionally, after reviewing the literature, the EWG proposed the following methodology to assess the impact of fisheries regulation on the fleet, coastal community and industry:

- **Define** the species (e.g. choke species, most commercial relevant species), fleet segment and spatial area of interest. For areas, it can be catch areas or specific coastal communities.
- Use **bio-economic models** to measure the changes in the fleet behaviour with changes in stock via TAC regulations. Focuses of these models are the fleet and their behaviour in the maritime environment.
- **TAC dependency tool** links the impact of the changes in TAC to the fishery sector and evaluates which part of the fleet is impacted. This tool has been developed by Carvalho et al., (2017);
- Measured by vessels registered in the port, this **social community indicator** links the marine environment with the terrestrial one (for method see Natale et al. 2013).
- Create a synthetic indicator reflecting the impact on the wider community as described by Morzaria-Luna et al. (2014).

For the latter, the following data could be combined with help of a factor analysis reflecting the three indices with indicator 1 used as base indicator and indicator 2 and 3 as weights to reflect the capacity of the community to adapt to changes as well as environmental barriers hindering adaptations to sectorial changes in the fisheries.

Indicator 1. Sensitivity of the fisheries dependence indicator, for example measured by:

- number of target species handled in the port, characteristics of the fishery (diversity in gear, vessel sizes etc.) – specialization of fishery indicator;
- number of vessels registered in the area – size/scale indicator;
- number of fishermen out of 100 of population – employment dependency indicator in fisheries sector;
- fraction of employment/GVA in fisheries-related industries in the area - employment dependency of the industry/supply chain indicator.

Indicator 2. Adaptive capacity of the community, for example measured by:

- Regional/local disposable income;
- Education structure;
- Unemployment rate;
- Age structure of population;
- Population growth;
- Female head of household (%);
- Home ownership as fraction of population;
- Number of family-members dependent on head of household income;
- Industrial diversification (e.g. HHI of regional industrial sectors);

Indicator 3. Exposure vs carrying capacity of the region, for example measured by:

- population density;
- road density/ infrastructure fractionalization index;
- use of area/intensity of recreational fisheries/tourism;
- Number of recent extreme weather events (data available?) [e.g. maps on coastal flood risks].

Most of the variables proposed to create these three individual indicators, are already available for European regions, either via regional statistics of Eurostat, Open Street Maps (OSM), or others.

Decisions in terms of the next steps are required, whether a static or dynamic approach is to be followed. In a static approach, the three created indicators bundled as a simple representation of a weighted direct impact could be translated into macro-economic impact by using regional multiplier (as shown by Moore et al. 2016 or described above). However, as actors tend to change behaviour, a system-dynamic approach would be more advisable. In such an approach these three indicators would serve as parameters to condition the changes in the socio-economic representation in the model.

5 TOR 4

5.1 Infrastructure and resources

The increase in model complexity means that these models can only be operated by experts. Additionally, these types of models can often be computationally intensive, increasing the run time. The inclusion of a more complex fleet structure and biological components means that the models may be time-consuming to condition. In general, models conditioning is not regularly updated unless an ad-hock task or project is to be done with them.

The framework of ICES WGMIXFISH provides a stable update of part of the data required to condition these models, and the AER and FDI are also regularly updated. Therefore, the main problem comes from merging the existing datasets (see sections below). Currently, there is not a common infrastructure to do so, and updated and conditioning models relays on the national institutes, which normally, requires an ad-hock task (project or request for service) to do so.

5.2 Phases required

Following EWG 16-20 and SOCIOEC project, the EWG decided that the main phases should be at least:

A Scoping meeting to, select a number of tactical options to be evaluated, decide on the models to be used and select indicators to be retained and presented.

A working and reporting phase where models are parameterized and simulations of decided options are run, assessed and reported.

The overall objective of these two phases is to have a clear mandate on what is expected from the group, in such a way that results can be obtained and discussed within the working and reporting phase.

5.3 Data

One of the most time-consuming part of the model update is to extract and format the data and estimate the necessary parameters, including conditioning their uncertainty. Bio-economic models require, biological, economic and the so-called transversal variables (catch and effort) data. Biological data include (age structured) assessment outputs and biological parameters (such as natural mortality, maturity and weight at age). Economic data include costs and earnings at the DCF fleet segment level. Transversal variables should match both the biological and economic levels of disaggregation. Currently there is a mismatch across the different data sources.

5.3.1 Link to ICES WGMIXFISH

From 2012 ICES WGMIXFISH has requested data according to aggregations based on the definitions of the EU Data Collection Framework (DCF). The data call allowed merging across DCF métiers and as such national data entries were sometimes not by métier in strict sense. Merging of métiers to reduce to a manageable number going forwards in the forecasts further leads to the formation of combined or ‘supra-métiers’.

ICES WGMIXFISH has been developing a process to automatize the various steps of merging different datasets from different countries and different data sources together have also increased the amount of checks and graphical visualization of the data. However, is still a time demanding task to understand and correct a number of data mismatches which had not been detected in previous years.

The EWG considers that the work done within the ICES WGMIXFISH is a major step forward to condition bioeconomic models, although discrepancies on fleet's segmentation can be found. These discrepancies can be derived that the fleet segmentation required to provide an economic assessment can be different from the segmentation required to provide a short-term advice. However, this problem can be solved in future years.

The possibility to have access to the database create in ICES WGMIXFISH is important and in fact can determine the final procedure to be followed. If the work of providing economic advice, on a short-term basis or on a mid-term basis is decided to be done on top of the ICES WGMIXFISH advice, access to the database created by the ICES group is required. Additionally, access to the single stock advice is required. The former implies that or either it is necessary to wait until the single stock advice is approved and published by the relevant ICES procedures, or the work has to be done under ICES working group auspices. Access to the ICES WGMIXFISH database is also a limitation, firstly for the same reason as for the access single stock advice, but secondly because it is a product of the ICES WGMIXFISH group itself. It simply implies that is preferable to have this database ready before any economic condition is started.

5.3.2 Link to STECF AER

In the fleet economic data call (data for STECF AER) Member States should provide aggregated scientific data collected under DCF regulation. Member States are, therefore, hereby invited to submit economic and fishing activity data (landings, effort and capacity data). Fleet segment level data and national totals are requested for all parameters. In most recent data call (launched 30. January 2018) data was requested for the years 2008 – 2016, with the exception of capacity data, which was requested for period 2008 – 2017. Also, some other data (value of landings, No. of vessel by region, fishing days, days at sea, weight and value of landings per species) were requested for 2017, but on the voluntary basis.

Data submitted by Member States in response to an official data call may sometimes contain errors and gaps. Therefore, an operational deadline of two calendar weeks after the first AER meeting (usually organized in April) has been established. After that, the JRC databases shall be considered final and no further uploads are permitted. This, in practice, means that the data are final and ready to use. Those data are also checked and validated. In the first step through validation tulles provided from JRC team of expert (DV tool, Tableau…) and finally on the first AER meeting by the team of independent experts. That is for the beginning of May the data is available, and no changes can be made to them. However, AER is officially published after the STECF summer plenary, which means that the economic data for the further analyses are available relatively late during the year. Additionally, it should be noted that the AER data refers to the situation of the fleet with a two years delay (see EWG 16-20), that is in the year 2018 data for 2016 will be published.

EWG therefore considers that, with the STECF and the EU Commission approvals, economic data can be available two weeks after the first AER meeting and they can be made available to the group. This does not necessarily implies breaking up the STECF procedures, given that, the STECF reviews the AER report itself, that is, the conclusions obtained from the use of AER data. However, if within the AER meeting fleet economic performance projections are made, these cannot necessarily coincide with the results obtained from the approach of a group on top of the ICES MIXFISH advice.

5.3.3 Link to FDI

The FDI data call normally takes place in the middle of the year (around June-July), and the meeting takes place around September and the report and data be reviewed and endorsed by STECF's winter plenary (around November). This implies that the availability of the data is probably too late in the year. The existing plan for a new FDI should help reconcile the different data sets (see EWG 16-20).

5.3.4 Link to fleet TAC dependency indicator

The EWG considers that this database can be used in two different parts of the overall process:

Use it in the scoping meeting to select the fleets that are required to be analysed. The approach of selecting the case studies should ideally be based on what is required or necessary and not on what is available from datasets point of view.

Use it in the dependency indicators that can be developed (see TOR 3) to assess the consequences of TAC changes on regional and industry dependency.

The EWG notes that we had only a temporal access to this database.

5.4 Quality checks and replicability

It was one of the intentions of this report to show that models, data and expertise is already available to, at least, start providing an economic advice of TAC options or management scenarios. It has been also the intention that this assessment is able to first, capture the implementation problems of any management option, and second evaluate the trade-offs created among different fleets and/or among different dimensions (economic indicators) including the biological and economic ones. This can be done, either, from the short-term perspective and from the mid-term perspective.

It has been also the intention to show that the process of providing economic advice of TAC options or management scenarios, requires the use of different data sets that have to be matched. This implies that protocols are also required to provide quality checks, replicability of the process and to facilitate the review of the work. This is a challenging task, given that, currently, different models are used for each specific fishing-areas, and furthermore, for different fisheries within the same fishing area. To create a protocol in where minimum requirements are defined for all models will be a big step forward.

5.5 Presentation of the results

In a work as the one presented in TORs 2 and 3, many indicators were calculated, including biological (i.e. biomass and removals by stock), transversal (i.e. capacity, fishing effort, catches…), management implementation (i.e. quota uptake by fleet or fleet segments…) and economic indicators of the fleets (i.e. revenue, profit…). Given the integrated nature of the bio-economic models, all of them are necessary to explain the results. That is, is difficult to interpret one indicator, without considering the others. Additionally, uncertainty has to be considered when analysing the results. In TORs 2 and 3 medians of the values were used in the graphs, however, in a scientific assessment of any work like the one presented here, uncertainty (and its conditioning) has to be considered.

For FLBEIA in AIW uncertainty has been introduced multiplying a lognormal error to the stock recruitment point estimate. This error has a median equal to one and coefficient of variation obtained in the historical stock recruitment model fit. (see Annex 4)

For FishRent the percentage deviation from base case values (FMSY 2020), both of profits and spawning stock biomass of cod by varying parameter values, was evaluated (see Annex 5).

Different ways of presenting the results can be proposed. Using a *shiny* app or any other internet based interactive tool, is useful in the sense that the user can select which indicator wants to analyse individually, the period and even the way in which is presented. However, the drawback is that results are only linked but not presented in the report. Using annexes is another way of presenting results, with the positive side that they are included in the report, but with drawback of being fixed and that it is not possible to show all the indicators that are produced. Finally, using a qualitative traffic lights system is also possible.

5.6 Limitations

There are some limitations inherent to a work like this. Fundamentally they come from the assumptions taken, which include how market prices evolve or how GVA is distributed among capital and labour. FLBEIA AIW and FIshRent NS have not considered any changes in ex-vessel prices for species in the simulation process, which is unlikely to happen. Both models assume an average crew number by vessel which does not change during the projection period. This assumption has important effects on how wages are calculated.

In the literature there are many possible solutions to deal with these issues. One possible one, is to consider that prices and wages are endogenously determined in the model. To do so, the GVA projections obtaining from the different scenarios or TAC options of the bio-economic models have to be considered and using households fish consumptions (obtained from national statistic) and economic theory, infer the evolution of these prices and wages, in such a way that they (when aggregated) match with the, for example, the AER data (see Annex 7).

Following this argument, it is important to mention how the model projection do not rely on any equilibrium (e.g. competitive). This implies that projections of economic indicators are not necessarily compatible with the economic theory, which implies that the correlation between, for example, projected and observed profits can be weak.

Additional limitations come from how uncertainty is considered. For example, in FLBEIA uncertainty has only be included in the stock recruitment relationship. However, it is not clear if this is the dimension of the model which has a higher effect in the result. There could be other relationships or parameters that affect more deeply on them. To select which are the main key dimensions, a global sensitivity analysis is one of the procedures that could be considered. However, it should be noted that this is a high computing-time consuming procedure and that, therefore, cannot be done during a meeting.

6. CONCLUSIONS

The objective of this work was to demonstrate the value added of using fully integrated bio-economic models to produce an advice on TAC options and future scenarios from concrete case studies. It emphasized the added value of using these models in mixed fisheries context and pointed out the improvements to make the process fully operational.

EWG 18-05 reviewed several datasets including, Annual Economic Report (AER), Fisheries Dependent Information (FDI), TAC Dependency Tool (TDT) and ICES WGMIXFISH dataset, from how they can be combined to parametrize the bio-economic models, point of view. It was concluded that the necessary data exists although in different disaggregation and coverage levels.

EWG 18-05 reviewed the likely problems of conditioning bio-economic models. The first step of the modelling exercise should be defining the extend of the case study and the available data including fleets to be studied, stocks to be considered and TAC options and management scenarios. It also reviewed the current conditioning of one case study (North Sea flatfish fishery) using a model (SIMFISH) conditioned before the meeting with the coverage of the ICES WGMIXFISH dataset. From this comparison it was concluded that to capture the full activity of those fleets and assess their capability to report their efforts to other zones or stocks if their quota was up, more than 10 stocks from the North Sea and other areas should be added. To properly assess the technical interactions and separate the stocks caught together with the stocks of interest from the stocks corresponding to an alternative activity, a finer level of fishing activity was needed than what was currently available in the AER database (gear level 4).

EWG 18-05 analysed how the AER and the ICES WGMIXFISH dataset should be merged. It was concluded that a common minimum protocol is required to guarantee fair standards of quality, replicability and review. Furthermore, this protocol can be seen as a first major step towards deriving fully quality assured and quality audited economic assessment of TAC options or scenarios. This protocol can be seen as a further extension and formalisation of the work started by Jardim et al. (2013).

In combination with ICES WGMIXFISH, EWG 18-05 conditioned the FLBEIA bio-economic model for the North Sea starting from the scratch. In this wok the raw data available to the ICES WG and the AER data were combined in such a way that the could be used as inputs to a bio-economic model (FLBEIA). One scenario was presented (TAC min) although no economic indicators were calculated. The EWG did not review the protocol of merging the two datasets, however, it was concluded that the bio-economic model used is compatible with a complex case study such as the one studied in the North Sea in the ICES WG and that it can be conditioned using the available data.

Two case studies were analysed as case tests: North Sea mixed demersal fisheries and Atlantic Iberian waters demersal fleets. The two models/case studies were conditioned prior to the meeting itself. In TOR 2 two TAC options were considered and the likely choke stocks identified. Additionally, the stock quota uptake and several indicators of the fleets were analysed (gross value added, crew costs and net profit). These last indicators were displayed in such a way that trade-offs among fleets and the trade-offs among indicators (economic dimensions) were shown. It was concluded that the two models were able to explain that under landing obligation, a given implementation of a TAC option implies that not all the fishing possibilities are met and that this has several and different consequences on each individual fleet. It was also concluded that this type of short-term analysis requires to assume that the flexibility is to be handled by fishing effort. To obtain the right balance between capacity and intensity an equilibrium condition is necessary, and this normally requires projecting future scenarios. None of the two options are perfect (no capital adjustments or equilibrium conditions). As shown in EWG 16-20, equilibrium model exists although they are not currently able to handle the complexity of the full fleet segmentation of, for example, the ICES WGMIXFISH dataset. On the other hand, if no capital adjustments are considered, fishing effort will have to support all the TAC's options implementation. Obtaining the adequate relationship between fishing intensity and capacity still requires further study.

The two applications showed the value added of using these models from the choke identification point of view of each TAC option. They also showed how quota uptake differ among the TAC options simulated and how these differences can vary according to the fleet segment and the economic indicator considered.

In TOR 3, the same case studies as in TOR 2 were analysed from the time and space perspectives. The main conclusion in here was that short-term versus mid-term trade-offs are likely to arise from the application of any management scenario, and that the indicators selected can capture these economic trade-offs. Furthermore, a single indicator such as the present value of economic indicators can give an indication of this short term versus mid-term trade-offs. The mid-term projections have the advantage of, once technical interactions are addressed, their likely effects on stocks' abundances are captured. It has a cascading effect, that can alter the performance of the fleets through the projection period.

To answer TOR 3, EWG 18-05 run several scenarios for a regional North Sea DISPLACE application. It was concluded that this model can be built upon the outcomes of ICES WGMIXFISH for informing the vessel-based parameters with specific catch rates (from landings/effort per activity per vessel size or fleet-segment) and discard ratios.

TOR 3 was also asking for a methodology to assess effects on TAC changes on the regional dependency and the industry. The indicators recommended by EWG 18-05 were based on past work by STECF/JRC as well as data collection of different sources. The EWG concluded that constant updates and improvement of the data to capture the actual changes in the fisheries is crucial in order to assess the impact of changes in the fisheries to the communities and supply chain/industry. Moreover, data compatibility needs to be considered when defining the focus of the impact study. The approach presented by the EWG relied on the assumption that the linkage between maritime and terrestrial system has to be made in an appropriate way. However, this would require more research to tackle methodological issues related to the fact that a fleet is active in different management areas or can be capable to offset regulation on one species with changes in fishing behaviour. The EWG also concluded that some more discussions are required, especially to emphasis the social aspects of this approach.

EWG 18-05 also proposed a protocol to address a work like this. In this protocol the main aspects were a clear definition of the system to be studied, a two-step meeting process and a guide on how to merge the existing datasets. It was concluded that quality, replicability and easy review are characteristic highly desired in the output of this process, although some work is still necessary to achieve them. The models used in the EWG, while highly developed, still have limitations on producing economic indicators compatible with economic theory.

EWG 18-05 concluded that once conditioned, running a bio-economic model and exploring results within a 5 days group is not a limiting factor.

EWG 18-05 concluded that for the existing (and conditioned) bio-economic models, the short-term vs mid-term trade-offs, the differences among fleets, and the different dimensions of a fishery can be assessed.

EWG 18-05 concluded that bio-economic models can capture technical interactions among the fleets. This is a major step in assessing the economic consequences of TAC options or management scenarios, specially under the application of the landing obligation, in where limits on effort that fleets can exert can be anticipated, choke stocks identified and met or unmet fishing possibilities, calculated.

EWG18-05 concluded that the existing multi-model approach is appropriate to capture the specificities of the studied systems. However, this multi model approach requires to understand the differences in the results coming from a management option from those coming from the model characteristics, themselves.

EWG 18-05 expressed its willingness to provide advice on TAC options and/or scenarios using bio-economic models. However, this advice cannot be done for all the fleets and stocks for which this management regimen applies within the EU.

The work done under ICES WGMIXFISH group, in the form of providing advice on mixed fisheries options has the "hidden" output of a dataset of fleet-métier segments for which catches by stocks and effort are provided. To work close to the ICES WG results would have clear benefits in terms of data availability and quality of them. The ICES WG has its own quality protocol to ensure that the single stock advice that would result from the application of a model is exactly the one given in the stock advisory groups, which implies that "fleet behaviour" is not affecting the results prior to the year for which advise is given. Therefore, using the same bio-economic model as in the ICES WG would have advantages in terms of the quality of the process. However, EWG 18-05 concluded that it has also drawbacks coming from the necessity of merging databases and a mismatch with the AER results, this last derived from analysing different fleets or fleet segments and specially because fully integrated models account for the technical interactions among the fleets.

EWG 18-05 concluded that some clarification is required in terms of the last data that can be available to any potential group or contractor dealing, routinely, with this work. ICES WGFISHMIX dataset is an output of the ICES working group itself and is produced by the end of May. Single stock advice requires the approval of ICES to be publicly released (June-July). Additionally, AER is reviewed in the summer plenary of the STECF. TAC dependency tool is not an open access dataset and FDI is reviewed in the winter plenary of the STECF. Therefore, the EWG considers that data accessibility clarifications are required, which undoubtedly will depend on the framework in which this work is done (ICES, STECF or by contract).

EWG 18-05 considered that an integrated database in where fleet segments, stock dynamic's parameters, landings, catches, discards and fishing effort and accounting data of fleet segments are available will be ideal situation to make bio-model conditioning a simpler task than what currently is. This is an ongoing request from STECF EWG 16-20. The EWG identified the lack of this database therefore, the conditioning process will ideally require a protocol to follow in the matching and scaling exercises explained in TOR 1. In this protocol apart from the process itself, quality and replicability aspect should be considered.

EWG 18-05 would like to thank the Commission for funding this work, which apart from the intention of producing the results asked in the TORs, offered an important discussion forum for those researchers working in bio-economic modelling in fisheries.

7 References

Bastardie, F., J. R. Nielsen, and T. Miethe. 2014. DISPLACE: a dynamic, individual-based model for spatial fishing planning and effort displacement – integrating underlying fish population models. Canadian Journal of Fisheries and Aquatic Sciences 71:366–386.

European Commission (2008) European Commission Decision (EC) No 949/2008 of 6 November 2008 adopting a multiannual Community programme pursuant to Council Regulation (EC) No 199/2008 establishing a Community framework for the collection, management and use of data in the fisheries sector and support for scientific advice regarding the Common Fisheries Policy. OJ L 346: 37–88.

Sanderson, E.W., Jaiteh, M., Levy M.A, Redford K. H., Wannebo, A. V. and Woolmer G. The human footprint and the last of the wild bioscience oct 2002 vol. 52 (10) 891- 904.

Siordia, C. and A. Fox (2013). "Public use microdata area fragmentation: research and policy implications of polygon discontinuity." Spatial Demography 1(1): 41-55.

STECF (2017a) Scientific, Technical and Economic Committee for Fisheries (STECF) – The 2017 Annual Economic Report on the EU Fishing Fleet (STECF 17-12); Publications Office of the European Union, Luxembourg; ISBN 978-92-79-73426-7-1; doi:10.2760/36154.

STECF (2017b) Scientific, Technical and Economic Committee for Fisheries (STECF) – Data and information requested by the Commission to support the preparation of proposals for fishing opportunities in 2018(STECF-17-13). Publications Office of the European Union, Luxembourg, 2017, ISBN 978-92-79-67485-3, doi:10.2760/628725.

Carvalho, N., Guillen, J., Gibin, M., Contini, F., Natale, F., The TAC Dependency Tool: EU fishing fleet's economic dependency on stocks subjected to TAC and quotas. Online tool v2, including Species_GSA units for the Mediterranean & Black Sea fleet, EUR 28703 EN, Publications Office of the European Union, Luxembourg, 2017, ISBN 978-92-79-71214-2, doi:10.2760/663051, JRC106989.

Garcia, D., Sánchez, S., Prellezo, R., Urtizberea, A., and Andrés, M. 2017. FLBEIA: A simulation model to conduct Bio-Economic evaluation of fisheries management strategies. SoftwareX, 6: 141-147.

Goulding, I., Hallam, D., Harrison-Mayfield, L., Mackenzie-Hill, V., da Silva, H., Regional Socio-economic Studies on Employment and the Level of Dependency on Fishing, Megapesca Lda, Alfeizerão, Portugal, undated, believed to be 1999, http://edz.bib.uni-mannheim.de/daten/edz-kr/gmf/00/Lot23final_report_en.pdf, viewed 23rd May 2018.

Hadjimichael, M., Delaney, A., Kaiser, M.J., and Edwards-Jones, G., How Resilient Are Europe's Inshore Fishing Communities to Change? Differences Between the North and the South, Ambio. 2013 Dec; 42(8): 1037–1046. Published online 2013 Nov 9. doi: 10.1007/s13280-013-0458-7, viewed 23rd May 2018.

ICES. 2016. Report of the Workshop to consider FMSY ranges for stocks in ICES categories 1 and 2 in Western Waters (WKMSYREF4), 13–16 October 2015, Brest France. ICES CM 2015/ACOM:58. 187 pp.

Jardim E., Urtizberea A., Motova A., Osio C., Ulrich C., Millar C., et al. Bioeconomic modelling applied to fisheries with R/FLR/FLBEIA, JRC scientific and policy report, EUR 25823 EN (2013), p. 120 pp, 10.2788/84780.

Regulation (EU) No 1380/2013 of the European Parliament and of the Council of 11 December 2013 on the Common Fisheries Policy, amending Council Regulations (EC) No 1954/2003 and (EC) No 1224/2009 and repealing Council Regulations (EC) No 2371/2002 and (EC) No 639/2004 and Council Decision 2004/585/EC.

Roy, N., Arnason, R., Schrank, W.E., The Identification of Economic Base Industries, with an Application to the Newfoundland Fishing Industry, Land Economics, 85, 4, 675-691, 2009.

Salz, P., Frost, H., Model for economic interpretation of the ACFM advice (EIAA), LEI, Den Haag, 1992, http://busieco.samnet.sdu.dk/ime/eafe2000/Papers/Frostmf.pdf, viewed 25/1/17.

Scientific, Technical and Economic Committee for Fisheries (STECF) – Evaluation of management plans: Evaluation of the multi-annual plan for the North Sea demersal stocks (STECF-15-04). 2015. Publications Office of the European Union, Luxembourg, EUR 27232 EN, JRC 95959, 152 pp.

Scientific, Technical and Economic Committee for Fisheries (STECF) – Multiannual management plans SWW and NWW (STECF-15-08). 2015. Publications Office of the European Union, Luxembourg, EUR 27406 EN, JRC 96964, 82 pp.

Simons, S. L., Bartelings, H., Hamon, K. G., Kempf, A. J., Döring, R., & Temming, A. (2014). Integrating stochastic age-structured population dynamics into complex fisheries economic models for management evaluations: the North Sea saithe fishery as a case study. ICES Journal of Marine Science, 71(7), 1638-1652.

Tiebout C.M (1956) Exports and Regional Economic Growth, Journal of Political Economy, 64 (2): 160-64.

Ulrich, C., S. A. Reeves, et al. (2011). "Reconciling single-species TACs in the North Sea demersal fisheries using the Fcube mixed-fisheries advice framework." ICES Journal of Marine Science 68: 1535-1547.

World Bank (2006), 'Where is the Wealth of Nations?' Washington, DC: World Bank.

8 Annexes

Annex 1. Variables included in the AER.

Table A.1: Variables requested under the DCF data call for economic data on the EU fishing fleet

Variable groups	Variables
Employment	Engaged crew FTE national FTE harmonised
Income	Value of landings Income rights Direct subsidies Other income
Expenditure	Wages and salaries of crew Value of unpaid labour Energy costs Repair and maintenance costs Variable costs Non-variable costs Rights costs Annual depreciation
Capital value	Depreciated replacement value Depreciated historical value Fishing rights value Investments Financial position
Capacity	Number of vessels Number of vessels by region Vessel tonnage Vessel engine power Mean age Mean LOA
Effort	Days at sea Fishing days Number of trips Kw per fishing days GT per fishing days Energy consumption Hours at sea GT per hours at sea Kw per hours at sea Maximum number of days at sea
Landings	Value of landings Live weight of landings
Fishing enterprises	Fishing enterprises with 1 owned vessel Fishing enterprises with 2-5 owned vessel Fishing enterprises with >5 owned vessel
Catches	Weight or recreational catches

Annex 2. North Sea case study using DISPLACE

DISPLACE is used to model the catches of the North Sea fleets with the current version having a special focus on the Danish fishing vessels that is active in the Baltic Sea and the North Sea in 2015. For the finest level, the simulations use hourly time steps and a 6 by 6 km geodesic spatial grid (providing 35,309 possible fishing locations). In all, 693 vessels were simulated representing 46% of the 1,505 Danish vessels for which logbooks were available in 2015. For 380 of the simulated vessels no VMS data were available. The remaining 812 vessels were all below 8m and were not simulated.

The model included 39 fish populations in total. Analytical ICES assessments exist for 11 of these species. For these 11 species the population dynamics were explicitly modelled. The population model used is size-based and split each stock into 14 body size groups arranged in 5 cm classes. Fishing fleet dynamics are modelled by aggregating the results from individual fishing vessels, where each vessel is allowed to participate in one (or several) type of fishing activities defined by specific fishing métiers (17 fishing métiers at EU DCF (EU Data Collection Framework) level 6) with a unique gear selectivity for each stock. DISPLACE was used to model the Danish fishing vessels that were active in the Baltic Sea and the North Sea in 2015. The simulations used hourly time steps and a 6 by 6 km geodesic spatial grid (providing 35,309 possible fishing locations). In all, 693 vessels were simulated representing 46% of the 1,505 Danish vessels for which logbooks were available in 2015. For 380 of the simulated vessels no VMS data were available. The remaining 812 vessels were all below 8m and were not simulated. Each simulated vessel could only fish in the set of EUNIS habitats and areas where it had previously been fishing. The simulated fishing vessels were allowed to use several different gear types within the same trip. After each trip, the simulated vessels return to port and earn money from selling their landings in the harbor. Fish prices are given per stock and marketable category (small, medium, large) and the gross added value is computed from income generated by selling the landings and the actual operating costs of the trip.

DISPLACE can address fleet/skipper behavior facing the experienced catches and the fisheries management in force. Fish below the Minimum Landings size specific to each stock are discarded. When a discard ban is active (as it was in this application), discards are counted in the TACs (the total quota of a particular species allotted to Denmark), but does not generate income. Each vessel stops fishing if she is being “choked” by an exhausted quota. Each vessel can also develop tactics to avoid the fishing grounds where there will most likely being choked soon by a quota running low. All harbors visited by the Danish fleet are accounted for (302 ports including foreign ports) and are the locations for landing the catches (landings only i.e. the marketable fish). Fish prices are given per stock and commercial category (small, medium, large). At the time of writing, the variables describing the economics of the fisheries (e.g. fixed costs, opportunity costs, etc.) were derived from default parameter values. The management system simulated is an annual TAC system that follows the EU Common Fisheries Policy according to which all stocks should be fished at FMSY levels (Fishing mortality generating the Maximum Sustainable Yield (MSY)). Each annual TAC is split into individual vessel quotas using the same distribution key across years.

The “Danish Fleet” application with the input dataset used here is available online on request. Danish fishing vessels can fish both in the North Sea and in the Baltic Sea, and both areas must therefore be covered and simulated simultaneously in the model, making the spatial extent of the model very large (-4W to 18E, 51N to 62N). Due to runtime constraints, we had to limit the number of replicate predictions for each scenario to a small number. It was however concluded that this model can be built upon the outcomes of ICES WGMIXFISH for informing the vessel-based parameters with specific catch rates (from landings/effort per activity per vessel size or fleet-segment) and discard ratio for all counties fishing in a given area such as the North Sea.

Table A.2: Restrained needs for developing a fisheries-centered DISPLACE regional application obtained from different sources.

Type of data	DISPLACE parameters	Data Source
Fisheries	Species specific catch rates per	WGMIXFISH:

	vessel or fleet-segments	• Landings, discards by gear by stocks from ICES Intercatch database • Effort per métier per vessel size from MIXFISH ICES data call
	Selectivity per gear per species and gear footprint	ICES WGs
	Finely resolved spatial distribution of the fisheries per fleet segment	ICES WGSFD
	Fisheries economic indicators including costs for fishing and harbor fish stock prices per marketable category	STECF Annual Economic Report and National Statistics
	Number of vessels per fishing harbor per fleet-segment	EU register and national statistics
Biology-related data	Finely resolved fish stock spatial distribution	Spatial statistics
	Biological stock parameters including size spectra trophic parameters	ICES Stock assessment WGs, fishbase.org and size spectra modelling
	Stock numbers	ICES Stock assessment WGs

Table A.3: Type of reactions to choke species implemented into the DISPLACE mixed fisheries modelling with several TACs in force and under a Landing Obligation context.

TACs with landing obligation (i.e. all catches counted)	**With ”Stop going fishing on first choke”**	**Without ”Stop going fishing on first choke”**	**With FMSY range**	**With spatial avoidance**
Overall Quotas	All vessels stay on quayside as soon as one stock quota is exhausted	All vessels continue fishing but silently discard the stock with the exhausted quota	Next year TAC is calculated based on the FMSYdown for the non-choking species, with FMSYup for the choking species. A species is considered choking if >x% of the vessels were choked during last year	As soon as the quotas are getting less than x% remaining, each vessel judge her risk of bycatching a potential choke species and then select alternative fishing grounds
Grouped Quotas	All vessels stay on quayside as soon as the a group quota is exhausted	All vessels continue fishing, but silently discard the stock with the exhausted grouped quota, until all the	idem	idem

		quotas are exhausted		
Individual Quotas	A vessel stay on quayside as soon as the a stock or grouped quota she is targeting is exhausted	All vessels continue fishing, but silently discard the stock with the exhausted grouped quota, until all the quotas specific to this vessel are exhausted	idem	idem

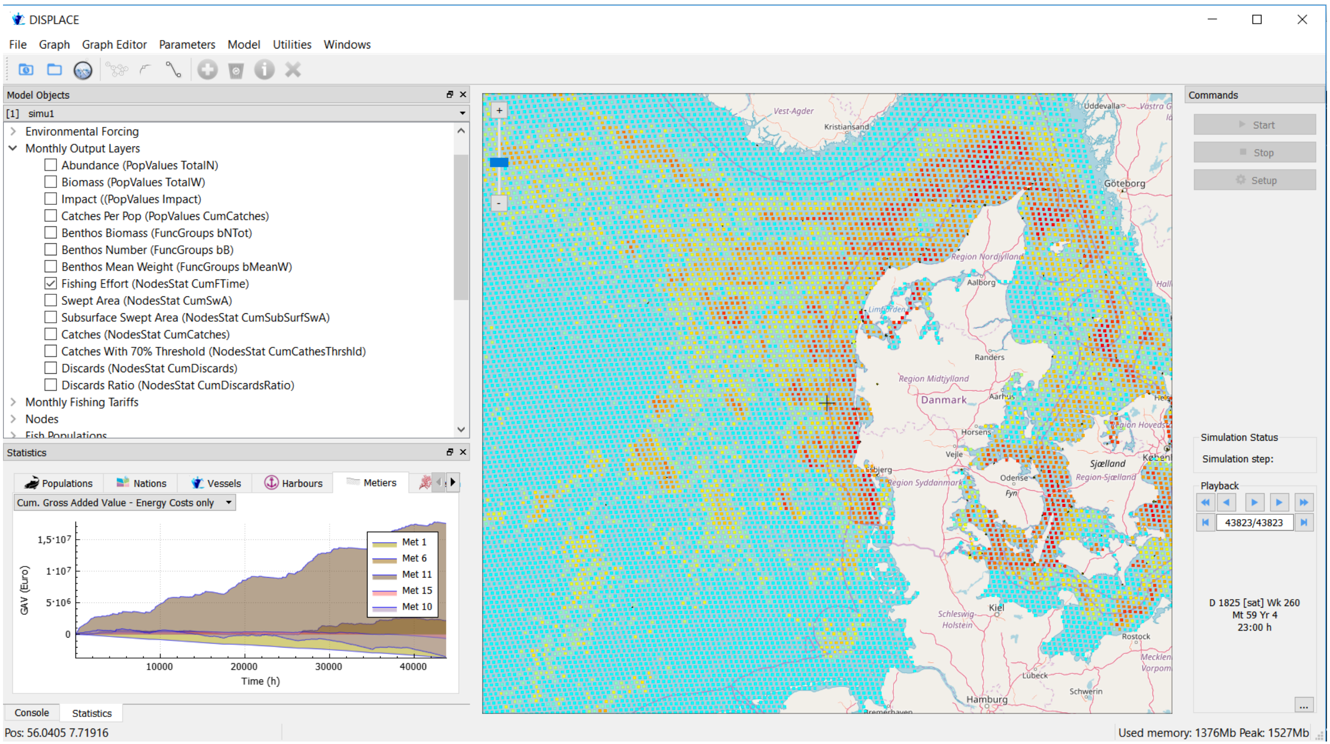

Figure A.1 – DISPLACE projected EU MSFD and AER bioeconomic indicators can be aggregated at various levels (Vessels, to Metiers, to Harbours, to Nations) and simultaneously mapped in a unified framework. This particular screen-shoot of the user interface is showing some métiers at the edge of profitability over the 5 years projection period

Annex 3. Options analysed in the ICES WGMIXFISH

- **max**: The underlying assumption is that fishing stops for a fleet when all quota species are fully utilized for that fleet with quotas set corresponding to single stock exploitation boundary for each species.
- **min**: The underlying assumption is that fishing stops for a fleet when the catch for the first quota species for that fleet meets the corresponding single stock exploitation boundary.
- "**Species**" where effort would decrease in 2017 and 2018 compared to 2016 following the constraining species TACs.
- **TACs.sq_E**: The effort for each fleet is set equal to the effort in the most recently recorded year for which landings and discard data were available.
- "**Value**": this is a simple scenario incorporating elements of the economic importance of each stock for each fleet. The effort by fleet is equal to the average of the efforts required to catch the quota of each of the stocks, weighted by the historical catch value of that stock. This option causes overfishing of some stocks and underutilisation of others.
- "**range**" scenario is presented, as described in Ulrich et al. (2017). This scenario searches for the minimum sum of differences between potential catches by stock under the "min" and the "max" scenarios within the FMSY ranges.

Annex 4. The Atlantic Iberian waters case study (FLBEIA)

The Atlantic Iberian waters (ICES Divisions 8c and 9a) include three areas with different oceanographic characteristics: Gulf of Cadiz with Mediterranean influence, Atlantic front with high upwelling process, and Cantabrian Sea (south area of Bay of Biscay) with transition between subtropical and sub-polar areas. Politically, the Atlantic Iberian waters are compounded by the Spanish and Portuguese national waters. The here presented case study of the Iberian waters is only considering the Atlantic front and the Cantabrian Sea.

These fleets operate on a narrow continental shelf where they exploit a variety of fishing resources by using different type of gears (trawl, gillnet, long lines…), forming a common demersal mixed-fisheries fleet. Although recent changes in fishing strategies and gears design have led some traditional demersal fleets to also exploit pelagic species, the combined management of demersal and pelagic stocks is not simple. On the one hand, most of the landings of pelagic stocks are made by fleets (purse seine, hand lines…) without any effect on demersal stocks. On the other hand, many pelagic species are widely distributed, and the participation of the Spanish and Portuguese Iberian fleets in the total catches are small.

On the shake of this report and according to the last data available the fishery, this is formed by approximately 2500 vessels grouped into five fleets segments. For Spain two fleet segments were considered, demersal trawlers (DTS_SP) and non-trawlers (NTR_SP) which include gillnetters and long-liners. From Portugal two segments were taken, demersal trawlers (DTS_PT) and polyvalent artisanal fleet (PGP_PT).

The multispecies characteristic of the fishery analyzed creates an important complexity in terms of the interaction between the advice and its implementation. Things like fleet behavior, discards behavior and the individual computation of the reference points generate a complex system. When simulating, not all the stocks can be considered explicitly because the quality of data available differs. This complexity reduces the number of explicit stocks that can be considered, although the total coverage is high and around the 35% of the total catches. Eight stocks are explicitly included although they are modelled differently:

Hake (*Merluccius merluccius*), Megrim (*Lepidorhombus whiffiagonis*), Four Spot megrim (*Lepidorhombus boscii*), White Anglerfish (*Lophius piscatorius*), are demersal stocks which distribution coincides with the area analyzed. All of them are assessed by ICES and have analytical assessments. In terms of the simulation, these stocks have been projected using an age structured exponential survival model together with a stock-recruitment model to simulate the new individuals that incorporate to the fishery. For all the stocks a deterministic segmented regression model has been used and uncertainty has been introduced multiplying a lognormal error to the stock recruitment point estimate. This error has a median equal to one and coefficient of variation obtained in the historical stock recruitment model fit.

Southern Horse Mackerel (*Trachurus trachurus*), is a pelagic species and its distribution coincides with the study area. It is assessed by ICES and has an analytical assessment. In terms of the projection of the population the same procedure as explained above has been used.

Western Horse Mackerel (*Trachurus trachurus*), is a pelagic stock which is distributed along the northeast continental shelf of Europe from the Bay of Biscay to Norway. In terms of its projection throughout the simulation their abundance has been maintained constant and equal to the 2014-2016 mean level.

Mackerel (*Scomber scombrus*), and B lue Whiting (*Micromesistius poutassou*) are widely distributed pelagic stocks. In terms of their projection throughout the simulation their abundance has been maintained constant and equal to the 2014-2016 mean level

The total catches of the Iberian Waters Demersal fleets of Mackerel and Blue Whiting represent a 3% of the total catches of these stocks and around 16% for Western Horse Mackerel. However, they could play an important role if we consider the Landing Obligation applied to them under the new CFP. This effect comes from the low quotas available to the fleets analyzed that could cause what is named as choke effects. That is, these species could constraint the total effort that these fleets could exert.

These eight stocks cover more than 35% of total catch and income for each of the fleets. However, to perform an economic analysis of the fleets all the income must be considered. For doing so, a dummy stock was introduced into the model (denoted as OTH) including all these other incomes. The catches and income coming from this dummy stock is métier dependent, that is, each métier will have different catches of this stock as well as a different average price.

Table A3. Stocks considered and first sale prices for Spanish métiers.

		Black Anglerfish	**Hake**	**Horse Mackerel**	**Megrims**	**Mackerel**	**Blue Whiting**	**Other Stocks**
Metiér	**Description**	ANK	HKE	HOM	LEZ&MEG	MAC	WHB	OTH
GNS_DEF_>=100_0_0	Set gillnet targeting demesal fish with mesh size >= 100	5.95	3.05	1.41	5.43	0.70	2.01	4.82
GNS_DEF_60-79_0_0	Set gillnet targeting demesal fish with mesh size range 60-79	5.81	3.45	1.18	6.92	0.87	1.45	3.56
GNS_DEF_80-99_0_0	Set gillnet targeting demesal fish with mesh size range 80-99	6.06	3.25	1.69	3.04	0.70	1.77	3.11
GTR_DEF	Trammel net targeting demesal fish with mesh size range 60-79	5.06	3.34	0.99	6.19	0.84	1.40	6.05
LHM_DEF_0_0_0	Hand line targeting demersal fish	6.73	4.22	1.57	7.69	0.74	2.09	7.62
LHM_SPF_0_0_0	Hand line targeting other fish	5.06	4.03	1.12	8.97	0.66	1.44	0.85
LLS_DEF_0_0_0	Longline targeting demersal fish	6.13	4.32	1.29	4.71	0.79	1.53	4.57
OTB_DEF_>=55_0_0	Bottom otter trawl targeting hake, anglerfish and megrim using "Baka" nets.	7.03	2.88	0.91	5.77	1.02	0.80	2.23
OTB_MPD_>=55_0_0	Bottom otter trawl targeting mixed pelagic and demersal fish using "Baka" nets.	6.55	2.89	1.08	6.09	0.89	0.74	1.66
PTB_MPD_>=55_0_0	Bottom pair trawl targeting mixed pelagic and demersal fish.	6.12	2.46	0.87	5.24	0.91	0.87	1.90

FLBEIA was used as a simulation Bio-economic Model coupled in the economic and biologic dimensions. it was developed in R using FLR libraries (Garcia et al. 2017). FLBEIA follows the Management Strategy Evaluation (MSE) approach.

The simulation algorithm was divided into two blocks. the Operating Model (OM) and the Management Procedure Model (MPM). In FLBEIA the OM is made up of the fish stocks, the fleets, the covariates and their interactions. The MPM describes the management process and is formed by the observation. assessment and management advice models. The stocks can be age structured or aggregated in biomass and there are no trophic interactions. Fleet activity is divided into métiers where métiers are defined as trips within a fleet that share the same characteristics in terms of gear used, fishing area and catch profiles.

The stocks can be age structured or aggregated in biomass. The interaction between fish population and catch is done in biomass and the relationship between catch and effort is based on a Cobb Douglas production mode at age level.

The stochasticity in the model is introduced using Monte Carlo simulation and can be introduced in any model parameter. In the simulations it has been introduced only in the biological side (in the stock recruitment relationship) and a Monte Carlo simulation has been performed with 200 iterations. The coupled characteristic of FLBEIA implies that this uncertainty is spread through all the remaining dimensions of the model (economic and social).

To couple the biological and economic side a catch by fleet was generated. It was done using a Cobb Douglas production with constant return to scale. Historical catchability (2014-2016) was calculated using historical biomass and effort data to parameterize this catch function.

In terms of the effort share, it was considered to be constant along métiers and equal to 2014-2016 years average.

Total effort was calculated in each step based on the quota share of the stocks caught by the fleet. The total effort that corresponds with the catch quota of each of the stocks was calculated. Given that, landing obligation is in place since the beginning of the simulation. the total effort is set equal to the lowest one in order to avoid over-quota discarding.

Capital dynamics were modelled through changes in fleet’s capacity. Capital varies according to a model that relates the investment and disinvestment in new vessels with the ratio between revenue and break-even revenue, that is the amount of revenue needed to cover both fixed and variable costs.

The annual investment for each fleet was determined by the possible maximum investment multiplied but the profit share that will go to the investment itself; however. investment in new vessels will only occur if the operational days of existing vessels are equal to the maximum days.

Annex 5. for North Sea mixed demersal fisheries (FishRent)

The case study focuses on the mixed demersal fisheries in the North Sea where complex biological and technical interactions occur. For these fisheries the important target species such as cod, haddock, saithe and hake are taken into account. Potential consequences of current and changing (e.g. FMSY up or FMSY range) management principles including the landing obligation on fleet and fish stock dynamics will be addressed in this case study.

The model was run for a period of 8 years (2016–2023). Economic data of the years 2013–2015 and biological data up to 2017 were used. The model accounted for five fleet segments covering vessels from Denmark (den_bottom trawls_o10m), England (gbr_bottom trawls_o10m), Ireland (irl_bottom trawls_o10m), France (fra_bottom trawls_o10m) and Germany (ger_bottom trawls_o10m) that fished mainly cod, haddock, hake and saithe in the North Sea saithe either as the main target species or an important bycatch species (Figure 1 in the main text).

According to the Data Collection Framework (DCF), fleet segments were classified by vessel length and predominant gear type. The calibration of the model was based on average biological and economic data for the period 2013–2015. In the model, recruitment and SSB were forced until 2017, using observed values for these years. In the following years a segmented regression was used to calculate recruitment. The greater North Sea region was included in the model and subdivided by the grid of ICES rectangles (30 × 30 nautical mile2) (Fig. A.2).

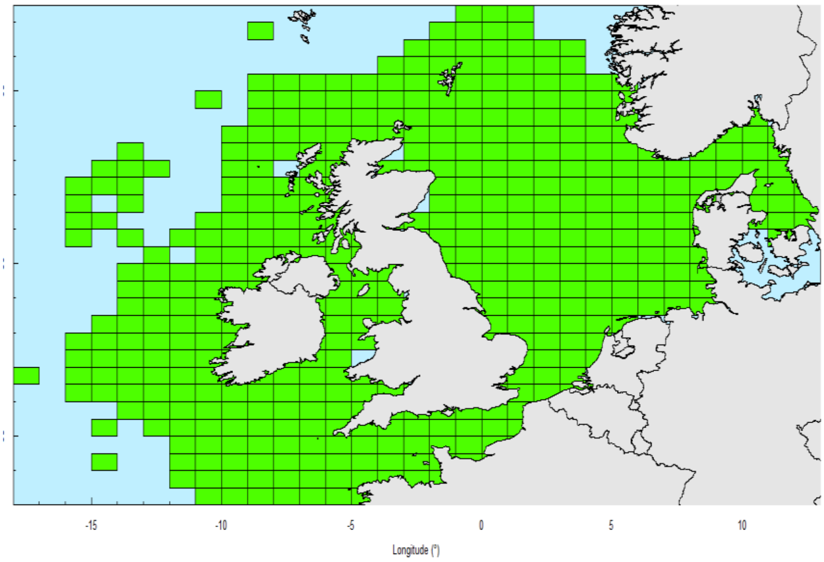

Figure A.2: Modelling area.

FishRent is a dynamic feedback model with quartal time-steps, including independent procedures for the stock development (e.g. growth, recruitment and mortality), the catch, the effort distribution, and the investment behaviour. The economic performance of individual fleet segments can be compared with each other over a long period of time (e.g. 50 years). It is a model of a fishery system that focuses on the economic drivers, among which the profit earned by the fleet segments is the main driver. Profit depends on the amount of landed fish, prices for the landed fish, the costs of fishing, and on the interest rate for capital invested in the fleet. Profit generated from other non-explicitly modelled species or areas are taken into account in the model as a fixed proportion of the revenue. It is presumed that effort in realistic settings responds to economic incentives. In particular, it is assumed that fleet segments seek to maximize their profits by setting an optimal level of fishing effort, which in turn affects the commercial fish stock. In the model, management constraint activities affect the stock and control the fishery. Simulations of changes in stock biology (e.g. changes in stock productivity), fisheries economics (e.g. changing fuel costs) and/or policy (e.g. alternative management strategies) can be conducted using the model.

Both scenarios, with either FMSY reached in 2019 or in 2020, increased SSB of most stocks. Simulation results suggest that a short-term reduction in TACs (FMSY19) will result in around 5% higher SSB values for all stocks than reaching FMSY in 2020.

The findings of this case study imply that both scenarios (FMSY20 and FMSY19) will negatively impact the stock size of saithe. For instance, the FMSY20 scenario caused a strong increase of the saithe TAC, resulting in higher catches of saithe. Subsequently, SSB was negatively impacted in mid- term. More importantly, especially for the French and German fleet targeting mainly saithe there was a shift in effort towards the spawning area of saithe. This change in fishing effort resulted in an increase in pressure on the saithe stock and led to a lower spawning stock of saithe in the mid-term. Such a shift of effort to areas with high probability of catching the target stock while avoiding cod bycatch is consistent with the shift that actually has been observed in the saithe fishery since 2009, when regulations were introduced that EU fleets targeting saithe will experience strong cuts in their allowed days-at-sea if their cod catch exceeds a certain level of their total catch. The finding that fishing at FMSY in 2020 will negatively impact the saithe stock is relevant in the ongoing debate about the success of MSY, because it shows that although reaching FMSY in 2020 may be beneficial for most stocks (cod, haddock, hake), it can cause a decline of other stocks (saithe). It is therefore important to take into account multispecies interactions in fisheries when evaluating the effects of the proposed options before it will be implemented.

The simulation results suggest that FMSY19 and FMSY20 will be costly in terms of a reduction in net profits for each fleet segment. Even when assuming that catch rates are perfectly known (assumption made by the model) profits of all fleet segments were reduced by up to 40% in the FMSY19 scenario in the short-term. This is an important result, because it shows that all included fleet segments of the North Sea mixed demersal fishery will potentially suffer from short-term losses in profits. However, as mid-term profits were higher than the initial net profits this finding supports the idea of compliance of fishers if FMSY is reached in either 2019 or 2020, because according to the simulation results, they need to accept drastic short-term reductions but will gain higher profits in the long term.

The simulated FMSY 2019 was favorable in the short-term, as it allowed a faster reaction to the stock development. However, this option may be more difficult to accept by fishers than the FMSY20 scenario due to its high economic short-term costs in terms (up to 40% lower net profits) and a potential reduction of fleet size.

The percentage deviation from base case values (FMSY 2020), both of profits and SSB of cod by varying parameter values, was evaluated. Even if the standard variation of recruitment was halved or doubled or the fuel cost halved or doubled, FMSY 2019 and FMSY20 were successful in increasing the cod stock and SBB of cod did not drop below Blim (high risk of a stock collapse) in any of the conducted iterations. These results indicate that not only was the model robust, but the tested scenarios of reaching FMSY in 2019 or 2020 were also robust. However, when the standard variation of recruitment was set to four times the base case values, it overwhelmed the density dependence portion of the model, and both FMSY2019 and FMSY2020 had little effect on stock development. Doubling of the fuel costs was actually beneficial for stock increases because this led to a significantly stronger reduction in effort and fleet size. The model was highly sensitive towards the effort and total stock biomass scaling factors (the exponents of fishing effort and total stock biomass in the Cobb–Douglas production function).

Table A. 4. Results of sensitivity analysis, shown as deviations (%) from base case values of profit and SSB of cod in short-term (2019) and mid-term (2023).

Parameter	Values	Scenario	Profit		SSB of cod	
			2019	2023	2019	2023
Recruitment	0.5x std.					
		FMSY19	-39	5	15	14
		FMSY20	-28	4	10	12
	2x std.					
		FMSY19	-22	5	22	19
		FMSY20	-14	5	29	15
Fuel costs (FuC)	0.5 * FuC					
		FMSY19	-28	6	5	6
		FMSY20	-17	5	3	2
	2 * FuC					
		FMSY19	-55	5	16	38
		FMSY20	-36	2	12	25
Effort scaling factor alpha	0.1					
	0.1	FMSY19	-160	-15	103	300
	0.1	FMSY20	-190	-12	150	200
	1					
	1	FMSY19	-29	-2	20	25
	1	FMSY20	-16	-5	10	15
Biomass scaling factor beta	0.1					
	0.1	FMSY19	-121	-5	100	23
	0.1	FMSY20	-114	-10	70	19
	1					
	1	FMSY19	-33	16	25	34
	1	FMSY20	-25	13	18	17

Annex 6. North Sea (FLBEIA)

FLBEIA was used to model demersal mixed fisheries of the North Sea (FLBEIA-NS). The model consists of 43 fleets and a total of 119 fleet/metièr segments. Currently, 11 stocks have been implemented, of which 8 use an age-based dynamics model (North Sea cod - COD-NS; North Sea plaice - PLE-NS, English Channel plaice - PLE-EC, North Sea sole - SOL-NS, English Channel sole - SOL-EC, saithe - POK, and whiting - WHG) and 3 use a biomass-based dynamics model (dab – DAB, brill – BLL, and anglerfish – ANF). Stock with biomass dynamics have been parameterized using the SPiCT model. Information on landings and discards were derived from Intercatch data, while a separate WGMIXFISH data call provided additional information on effort by fleet segment (including vessel length) and prices by fleet segment and species. AER data from 2015 was used to derive information on fixed and variable costs associated with each fleet segment, although further checking and revision of designations is still required. Merging AER data was done on a per unit effort basis (Euros / kW day).

A single forecast was run for 6 years (2017-2022), using the "minimum" scenario employed by ICES WGMIXFISH. This scenario limits fishing effort for a given fleet to the level that allows for the first stock TAC share to be fulfilled (i.e. the "choke species"). For the intermediate year of 2017, the TAC advice levels issued in 2016 were used, while other forecast years employed the ICES harvest control rule based on Fmsy, Blim and Btrigger reference points. For the data-limited biomass-based stocks, Blim was set to the lowest observed biomass levels, while Btrigger was set 1.4x higher than Blim.

The capabilities of a conditioning like that is displayed in Figure A.3 where landings to TAC share ratio by fleet, stock and year as calculated

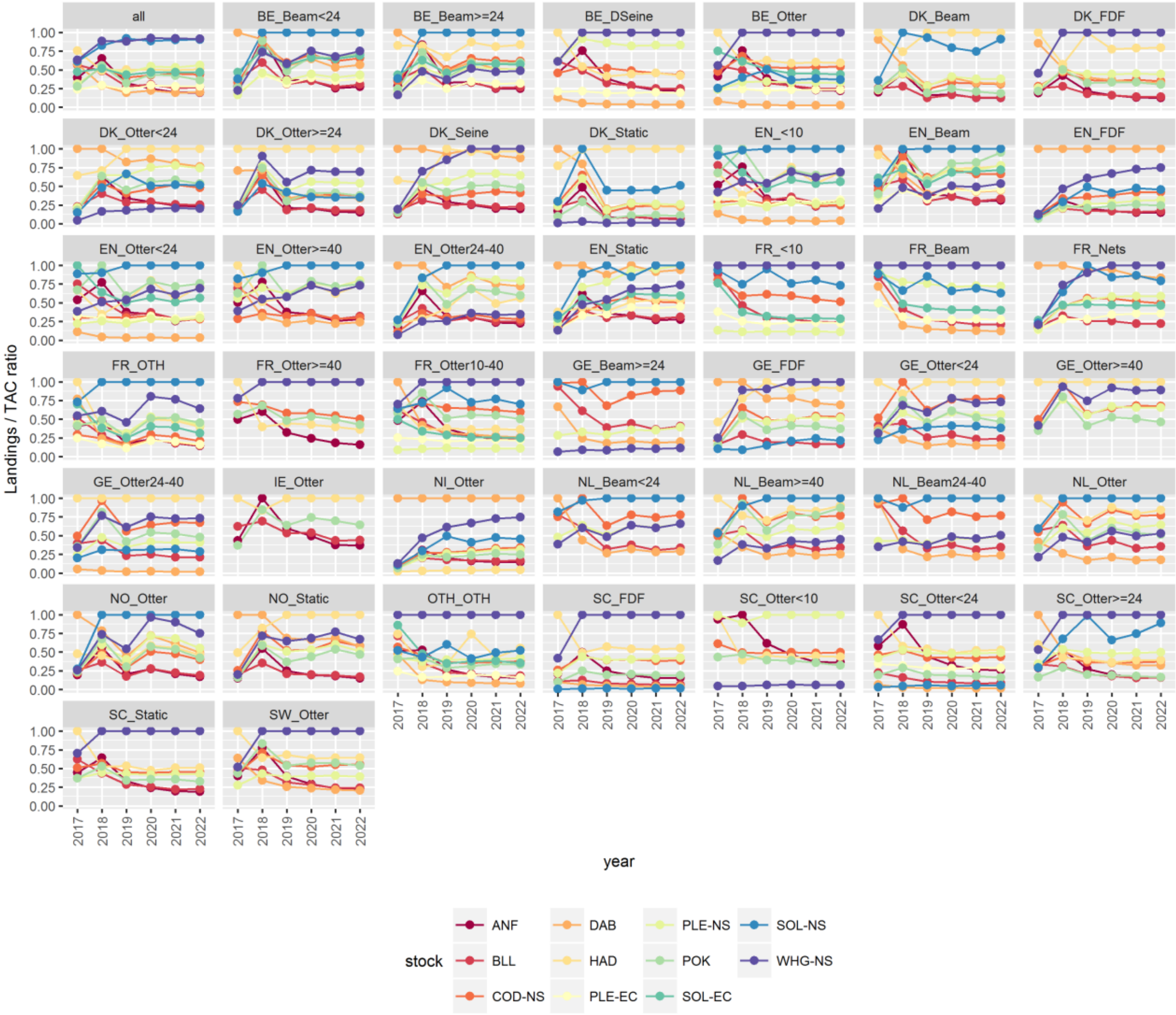

Figure A.3: Landings to TAC share ratio by fleet, stock and year as calculated by the FLBEIA-NS model. A ratio of 1.0 indicates TAC fulfilment and identifies the choke species for each fleet and year combination.

Annex 7. A methodology to address the endogenous calculation of prices and wages

Talk_EWG_18_05_Iberian_hake.pdf

9 CONTACT DETAILS OF EWG-18-05 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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10 List of Background Documents

Background documents are published on the meeting's web site on:
http://stecf.jrc.ec.europa.eu/web/stecf/ewg1805

List of background documents:

EWG-18-05 – Doc 1 - Declarations of invited and JRC experts (see also section nine of this report – List of participants)

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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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