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Scientific, Technical and Economic Committee for Fisheries (STECF) - Evaluation of maximum catch limits and closure areas in the Western Mediterranean (STECF-22-01)

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Abstract

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

This report is the eighth of a suite of STECF EWG reports dedicated to the evaluation of the implementation of the Western Mediterranean Sea Multi-Annual management Plan (hereafter, MAP), following EWG reports 18-09, 18-13, 19-01, 19-14, 20-13, 21-01 and 21-13.

The group was requested to implement mixed fisheries bio-economic models to run a number of scenarios up to 2025 with varying parameters and up to 2030 with fixed parameters, to evaluate existing closure areas implemented since 2020 and 2022, maximum catch limits (MCLs) implemented since 2022 and draft a mixed fisheries advice.

For all mixed fisheries models applied during the EWG, the data from the DCF official data calls and from the western Mediterranean stock assessments, were the same as the ones used during STECF EWG 21-13, as there were no updates since 2021.

The non-spatially explicit mixed fisheries models, IAM (for EMU 1) and BEMTOOL (for EMU 2), focused on the scenarios evaluating MCLs on ARA, ARS and HKE. Reference MCLs for ARA and ARS where obtained from the Regulation EU 2022/110 and from STECF EWG 21-11, while for HKE were obtained solely from EWG 21-11.

IAM was updated to differentiate between a coastal and a deep-water trawling within the Spanish fleet segments, as France does not have a deep-water fishery at present. As the model timescale has a yearly resolution, it was not possible to estimate the effect of a monthly MCL. The scenarios considered had a MCL for HKE, one for ARA, and one for both HKE and ARA. These scenarios were run for a decreasing MCL through time (forward scenario: aims at reaching catch at Fmsy by 2025) and an increasing MCL through time (inverse scenario: starting value is catch at Fmsy) accounting for the distribution of stocks by GSA, for a total of 10 scenarios alternative to the baseline. None of the scenarios allowed reaching Fmsy for all six species targeted by the MAP, except when applying a MCL on both ARA and HKE, simultaneously. The results for the HKE stock should be taken with caution as the MCL was applied only to trawlers in these scenarios, but this species can generally be targeted also by longliners and gillnetters. The economic consequences of scenarios accounting for a MCL on HKE, or both ARA and HKE, lead to a massive drop of GVA for the Spanish and French trawling fleets, while economic advantages are observed for longliners and gillnetters.

BEMTOOL was updated and refined to consider the different types of fishing activity exerted by each fleet segment at metier level. The model timescale is set at a monthly resolution, so it was possible to run scenarios accounting for a monthly MCL (monthly flexibility was not considered). Only scenarios accounting for a MCL either for ARA or ARS where run, but never in combination (ARA+ARS), nor considering a MCL on HKE, for a total of eight scenarios: forward scenario, inverse scenario, monthly forward scenario, monthly inverse scenario, once with an MCL on ARA and once with an MCL on ARS. Implementing a MCL on the deep-water fisheries suggested an improvement for all stocks except for HKE. ARA and ARS would improve thanks to the control of the MCL, while MUT, DPS and NEP would stay within the upper and lower limits of Fmsy, despite the reallocation of fishing effort from deep to coastal fisheries. The implementation of a reverse MCL did not show a recovery of the stocks. Moreover, a MCL split by month seems to have a lower impact on the catches of ARA and ARS in the short term. The GVA shows an increase for the passive gears fleets (i.e., gillnetters and longliners) and a strong decrease for all trawling fleets in the first two years, with a stable trend over the following years.

The spatially explicit mixed fisheries model ISIS-Fish also ran scenarios accounting for MCLs, but only for HKE in GSA 7, implementing a forward, an inverse and a monthly MCL for a total of four scenarios. The forward scenario led to fishing mortalities below Fmsy in 2025 because the value defined for MCL did not account for biomass rebuilding. On the other hand, the fishing mortality

achieved using the HCR in the inverse scenario, never fell below Fmsy, because of the unrestricted catches of netters and long-liners. In terms of revenues, both MCL paths led to strong decreases for trawlers.

The spatially explicit mixed fisheries models, ISIS-Fish (GSA 7) and SMART (EMU 2), focused on the evaluation of closure areas: existing closure areas, existing closure areas which were seasonal to become permanent, existing closure areas extended to all fishing gears, additional closure areas (only EMU 2), expansion of closure areas by 50% (only EMU 2) and expansion of closure areas by 100% (only EMU 2).

ISIS-Fish was applied only for HKE in GSA 7 being the first time this model was used within this working group. The extension of closure areas to all fishing gears (passive gears on top of trawlers) in GSA 7 did not show any improvement, while shifting from a seasonal to a permanent closure showed a decrease in F and an increase in SSB. A decrease of catches of juvenile hake of 20% was observed both with seasonal and permanent closures. Catches of adults increased due to recovery of the stock and considering the low level of initial catches. It should be noted that revenues increased for passive gears but decreased for trawlers.

SMART was updated, increasing the spatial resolution of the spatial grid of the model, to be in line with outputs of the ad-hoc contracts preceding the EWG and with ISIS-Fish. None of the scenarios considered for EMU 2 evaluating spatial closures allowed to reach Fmsy by 2025, except for MUT in 10 and NEP in 9 which remains underutilized. SSB shows, nevertheless, an increase across years. None of the scenarios allowed to reduce catches by 20% for all species. All scenarios are associated with a sharp decrease in revenues; spatial closures not widened or seasonal would involve lower decrease of the profits than widened and permanent closures. Loss of profits is more evident for VL12-18 and VL18-24, although the loss is evident for all fleet segments.

During EWG 22-01 no explicit comparison between the implementation of an effort regime and a MCL regime was run. The group advices to do so accounting for the limitations encountered in the implementation of MCLs during EWG 22-01. It should be noted that the reduction of GVA is estimated in the short term (up to 2025), but further tests should be done to estimate the trend of GVAs in the mid- and long-term. It is highlighted that given the large number of other species exploited beyond the key ones included in the management plan and in the simulation models, the actual socio-economic impact of the plan remains uncertain. Also, the economic results are presented considering a constant number of vessels, and would differ if the number of vessels is reduced. Additionally, it is difficult to evaluate the socio-economic impact of the MAP on the fleets as at present no socio-economic reference points are used to compare the results against those.

SCIENTIFIC, TECHNICAL AND ECONOMIC COMMITTEE FOR FISHERIES (STECF) – Evaluation of maximum catch limits and closure areas in the Western Mediterranean (STECF-22-01).

Request to the STECF

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

Background provided by the Commission

EWG 22-01 was requested to address the following Terms of References:

ToR 1. STECF is requested to continue the development of management models including different levels of maximum catch limits for deep-water shrimps and for hake in both West Med management units.

ToR 2. STECF is also requested to develop mixed-fisheries spatio-temporal scenarios for all demersal fishing gear (e.g. bottom trawls, gillnets, longlines) in EMU1 and EMU2 with simulations from 2020 to 2030. The STECF evaluation should be looking at differences in captures reduction between the 2019 situation (prior to closure adoptions) by species and by age-class and the following scenarios:

a) Status quo scenario: closures adopted since the implementation start of the West Med MAP by the 3 Member States;

b) Same delineation of closures areas as in 2020, 2021 and 2022 and all closure areas become permanent from 2023 onwards;

c) Same delineation of closures areas as in 2020, 2021 and 2022 and all closure areas are for all fishing gear (e.g. trawlers, longliners, netters);

d) 10% of permanent closure areas in each GSA, taking into account the different types of habitats such as for instance waters shallower than 200m depth and waters deeper than 200m;

e) 20% of permanent closure areas in each GSA with half of it in waters shallower than 200m depth and half of it in waters deeper than 200m;

f) 30% of permanent closure areas in each GSA with half of it in waters shallower than 200m depth and half of it in waters deeper than 200m.

To provide an order of magnitude of the closures efficiency, it should be aimed at reducing about 20% of captures of juveniles and spawners of each target species in each GSA. For each GSA, the EWG is requested to propose recommendations for designing alternative closures based on criteria such as but not limited to bathymetry, depth, type of substrate, stock seasonality, establishment of a buffer area, minimal size of the closure area, etc.

TORs were further detailed in agreement with DG MARE to give additional directions to the working group experts':

As discussed during the meeting on 27 January 2022, the legal concept adopted in December 2021 by Member States to manage by output the deep-water shrimps in the western Mediterranean is "maximum catch limit". Contrary to the legal concept of total allowable catch (TAC), a maximum catch limit does not involve a legal right for the future years and does not create a fixed relative stability (i.e. a distribution of the fishing opportunities between the concerned Member States). Concretely, it means that there is no legal obligation for a continuity of catch levels between 2022, 2023, 2024, onwards. However, to simplify the modelling work, the

STECF experts are invited to work with TACs and use a reduction at percentage level through time (e.g. 10% reduction of the previous year catches: (TAC[year+1]=0.9*TAC[year])) as an alternative to following the transition path calculated by STECF EWG 21-11 for each stock. The model output should be analysed in order to determine whether such reductions allow to reach MSY by 2025 at the latest.

Details on TACs scenarios implementation:

- TACs should be implemented both on hake (HKE) for the coastal metiers and on deep-water shrimps (ARA and ARS) for the deep-water metiers. If possible, there would thus be 3 scenarios with TACs: a) hake only, b) deep-water shrimps only, c) simultaneously hake & deep-water shrimps. Those scenarios would be completed in September 2022 by the effort reductions and additional management measures as done in EWG 21-13.
- All models should be simulating 2 fleets corresponding to the two metiers (deep-water and coastal fisheries). This definition of metiers is unstable as fishing boats can move from one metier to the other easily from one day to the next, but changes due to external parameters cannot be accounted for in the models therefore the metiers will be treated as two separate fleets.
- Models that can implement a monthly time step (e.g. BEMTOOL and SMART) will test a first scenario where the TACs are implemented annually and fishers are assumed to follow a "run to fish" behaviour and a second scenario where TACs are implemented monthly. When TACs are implemented monthly, if possible, the value implemented each month should change depending on the seasonality of the fisheries. To obtain information on the seasonality the experts can rely on experts' opinions over the different areas and use DCF landings data by quarter, when data by quarter are available. The reference year should be 2015-2017.
- All models should account for monthly flexibility but not annual inter-flexibility. When the TAC is not consumed within one month, it can be used the next month (except for December).
- An optional scenario will be accounting for an "inverse TAC" system. Quotas will not be decreasing through time, but the first year of implementation will be the hardest with an increase of the quota through time as the stock recovers. The values could be taken from the transition path to Fmsy by 2025 calculated by STECF EWG 21-11.
- For 2022, the maximum catch limit values for deep-water shrimps can be found in the Fishing Opportunities Regulation for the Med and Black Sea: Council Regulation (EU) 2022/110 of 27 January 2022 fixing for 2022 the fishing opportunities for certain fish stocks and groups of fish stocks applicable in the Mediterranean and Black Seas (OJ L 21, 31.1.2022, p. 165–186)
- For 2022, there is no maximum catch values for hake in the EU regulation so modelling would start for hake with catch limits in 2023.

Details on Spatial scenarios implementation:

- Concerning point b) of TORs: if closures are already permanent within a GSA this point will not be tested.
- Concerning points d), e) and f) the closure of 10%, 20% and 30% of each GSA should be tested subtracting already existing closure areas from this percentage. Additionally, the areas >1000m and the <50m or within 3 nautical miles from the coast, should be excluded from what is considered the "total area of a GSA".
- Ad-hoc contracts ran prior to EWG 22-01 will produce shapefiles with the distribution of hotspots of juveniles and spawners of hake and potentially of the five main target species of the MAP. The location of the closure areas should take into account the distribution of hotspots to test the efficiency of the closure areas.
- As reported in the TORs: "To provide an order of magnitude of the closures efficiency, it should aim at reducing about 20% of captures of each target species in each GSA."

The reduction of ~20% should be calculated in comparison to captures in 2015-2017, as per TORs.

STECF comments

The Expert Working Group 22-01 met online from 28th February to 4th March 2022. The meeting was attended by 20 experts, including three STECF members and two JRC experts.

STECF notes that this EWG is one of several EWGs dedicated to providing advice to the Commission on the Western Mediterranean Multiannual Plan (Regulation (EU) 2019/1022, referred to as WestMed MAP) since 2018. These EWGs have improved knowledge and evaluated various management issues through mixed fisheries modelling.

Models

STECF notes that four different fleet-based mixed-fisheries models were used: two models in Effort Management Unit (EMU) 1, i.e. GSAs 1-2-5-6-7 (though one was applied to GSA7 only), two models in EMU 2 (GSAs 8-9-10-11). Three of these models (IAM in EMU 1, BEMTOOL and SMART in EMU 2) have been used and developed since STECF EWG 19-01. The fourth model, ISIS-fish (Mahevas and Pelletier, 2004; Pelletier et al., 2009), was tested during EWG 22-01 for the first time, in an attempt to implement a spatially explicit model for EMU1. ISIS-fish is a deterministic simulation model designed to explore the dynamics of mixed fisheries. It combines spatially explicit fish and fleet dynamics at a monthly time step. Fishing mortality results from the interaction between the spatial distribution of population abundance and the spatial distribution of fishing effort for the different métiers. It can evaluate closures effect accounting for effort reallocation and catch limitations.

STECF notes that this model was initially presented in EWG 19-01 but its case study application to the Western Med was not sufficiently mature at that time and could not be used. STECF acknowledges thus that progresses in parameterisation and implementation have been achieved since then and that the model could be tested again this year. STECF notes, however, that the ISIS-fish model was only used to analyse the European hake fishery in GSA7.

Parameterisation of scenarios and main results by EMU and type of scenarios

Testing proposals for maximum catch limits (MCLs) in EMU1

The scenarios run by EWG 22-01 in EMU1 considered MCLs for European hake (GSAs 1-5-6-7) and for blue and red shrimp (GSA1 and GSAs 6-7) applying MCLs for hake only, shrimps only, and for both species at the same time. These scenarios were run either with a decreasing MCL through time (forward scenario, aimed at reaching Fmsy by 2025, where MCL is progressively decreased from 2022 to 2025) or with an increasing MCL through time (inverse scenario: where MCL is set at Fmsy in 2022, and then gradually increased between 2023 and 2025), for a total of 10 scenarios compared to the baseline (Table 2.3.1.1.1 of the EWG 22-01 report).

The IAM model (Merzéréaud et al., 2011) was parameterised to differentiate between Spanish coastal and deep-waters trawl fisheries, while no deep-water fisheries were considered for France. STECF notes that since the model timescale has an annual time step, EWG 22-01 did not evaluate the effect of monthly MCLs.

STECF notes that the two scenarios that simulated the implementation of MCL simultaneously on European hake in GSAs 1-5-6-7 and blue and red shrimp in GSA 1 and GSAs 6-7 (forward and inverse scenarios, scenarios i and j) forecast a general increase of the biomass of the exploited stocks; however, only the forward scenario foresees exploitation levels in line with the objectives of the WestMed plan, or below (Section 2.3.1.2 of the EWG 22-01 report).

The implementation of a MCL only on European hake (scenario a) forecasts an increase in the biomass of hake in GSAs 1-5-6-7, red mullet in GSA1, GSA6 and GSA7, and Norway lobster in GSA6. This scenario allows the stocks of red mullet in GSA1 and GSA6 to reach Fmsy. However, this is associated to an increase of F and a decrease of blue and red shrimp biomass in both GSA1 and GSAs 6-7 (ARA1 and AR67), due to the reallocation of fishing effort to deeper waters.

STECF notes that, in general, all scenarios forecast bio-economic impacts for the French and Spanish trawlers in the short term with a decrease in their Gross Value Added (GVA). In the scenarios where MCL is applied on European hake only, all the trawl fleet segments are economically impacted. In contrast, in the scenarios where MCL is applied only on blue and red shrimp, only the fleet segments involved in deep-water trawling are impacted, (i.e. Spanish trawlers above 12 meters). Conversely, economic advantages are projected for vessels using longlines and gillnets (Sections 2.3.1.2 and 2.3.1.3 of the EWG 22-01 report).

STECF notes that none of the scenarios result in achieving Fmsy for all stocks, except when applying MCLs simultaneously on both blue and red shrimp and hake. However, STECF notes that the results for hake should be treated with caution as the MCL was applied in the simulations to trawlers only, not accounting for the longline and gillnet fisheries which also exploit this stock.

STECF notes that the spatially explicit mixed fisheries model, ISIS-Fish, was also used to run scenarios accounting for MCL for hake in GSA 7. Forward, inverse and monthly MCL scenarios were used for a total of four scenarios alternative to the baseline (Table 2.3.2.1.1 of the EWG 22-01 report).

Testing proposals for closed areas in EMU1 (GSA7 only here)

The ISIS-Fish model was also applied to evaluate the effects of area closures on European hake in GSA 7. The scenarios run by EWG 22-01 are summarized in the Table 3.4.1.1.1 of the EWG 22-01 report.

Testing proposals for maximum catch limits in EMU2

STECF notes that the BEMTOOL model (Rossetto et al., 2015; Russo et al., 2017) was used to run scenarios simulating the implementation of MCL on blue and red shrimp and giant red shrimp, separately. No scenario accounting for a simultaneous implementation of MCLs on the two shrimps was tested. In addition, the simulation of the implementation of MCL on European hake in EMU2 was not tested by EWG 22-01 (Section 2.3.3.1 of the EWG 22-01 report).

The BEMTOOL model was updated to consider the different types of fishing activity exerted by each fleet segment at a métier level. The model timescale was set at a monthly time step, so it was possible to run scenarios accounting for monthly MCLs.

STECF notes that implementing a MCL on the deep-water fisheries showed an improvement for all the stocks considered, with the only exception of hake. Blue and red shrimp and giant red shrimp showed an improved stock status, while red mullet, deep-water rose shrimp and Norway lobster remained within the upper and lower limits of Fmsy, despite the reallocation of fishing effort from deep-waters to coastal fisheries.

The implementation of an inverse MCL approach did not show a recovery of the stocks. In general, the GVA shows an increase for small-scale fisheries (i.e., gillnet and longlines), and a strong decrease for all the trawling fleets.

Testing proposals for closed areas in EMU2

The SMART model (Russo et al., 2014; D'Andrea et al., 2020) was updated increasing the spatial resolution of the spatial grid of the model in line with ISIS-Fish and with the outputs of the ad-hoc contracts preceding the EWG. This allowed improving the quality of the information on the spatial distribution of both the spawning and nursery areas.

STECF notes that EWG 22-01 advises that protection of stocks should not be evaluated considering percentages of areas of protection, but through the evaluation of the response of stocks to spatial management measures.

STECF notes that none of the scenarios considered for EMU 2 (Table 3.3.2.4.1 of EWG 22-01 report) evaluating spatial closures will achieve Fmsy by 2025, with the exception of red mullet in GSA10 and GSA9, and Norway lobster in GSA9. The SSB of most of the stocks showed does increase across year-on-year.

None of the scenarios reduce catches by 20% for all species. All scenarios are associated with a sharp decrease in profits in the short-term. The loss of profits is larger in the fleet segments VL12-18 and VL18-24.

General comments

STECF acknowledges that all the ToRs have been addressed by EWG 22-01. However, STECF notes h that not all the scenarios originally listed in the ToRs could be addressed by EWG 22-01.

Regarding ToR 1, STECF notes that not all the MCL scenarios could be run by EWG 22-01. In particular, no monthly MCL was tested in EMU1, while no scenario on European hake MCL was evaluated in EMU2. STECF notes that in the absence of specifications on how MCLs would be implemented and shared across countries and fleets, EWG 22-01 simulated MCLs as TACs as stated in the EWG ToRs. STECF notes that the scenarios run by EWG 22-01 did not take into account the adaptation of the MCL to the status of the stock (e.g. Fmsy, SSB) that is expected to change during the application of management measures. This aspect needs to be further explored to accommodate the adaptive setting of MCLs on a yearly basis in future projections.

Regarding ToR2, EWG 22-01 did not run scenarios accounting for 10, 20, and 30% permanent closures in each GSA. STECF notes that EWG 22-01 considered it not feasible to implement those scenarios as the EWG was not in the position to decide which areas should be closed. As an alternative to those scenarios, the increase by 50 and 100% of the surface of the existing closed areas was simulated (in EMU2 only).

In addition, STECF acknowledges that no biomass reference points are available for the key stocks in order to fully test scenarios based on Harvest Control Rules (HCR).

STECF notes that none of the scenarios tested by EWG 22-01 lead to achieving Fmsy for all the targeted stocks in EMU1, except when applying a MCL system in parallel with the effort regime reduction on both blue and red shrimp and European hake simultaneously.

STECF notes that implementing a MCL system on the deep-water fisheries targeting blue and red shrimp and giant red shrimp in EMU2 improved the exploitation status of all stocks, with the exception of European hake.

STECF notes that applying a permanent area closure in GSA7 would decrease the catches of juvenile hake by 20%, although Fmsy would not be reached by 2025.

STECF notes that in EMU2, none of the area closure scenarios tested by EWG 22-01 lead to reductions in the catches of all target species by 20% or achieve Fmsy for all species.

STECF notes that all scenarios show a sharp decrease in profits.

STECF notes that given the large number of other species that are exploited with the target species of the WestMed MAP, the actual socio-economic impact of the simulations remains uncertain. STECF notes that the models provide estimated trends in some economic indicators for a number of scenarios. However, STECF cannot assess to which extent these impacts threaten the economic sustainability of the fleets as no socio-economic reference points are available to qualify the results. Additionally, the socio-economic evaluations assume a constant number of vessels, and results would be different if the number of vessels is reduced through, for example, a decommissioning scheme, or effort increased as inactive vessels become active when stocks recover.

STECF acknowledges the efforts made to accommodate new types of management measures during the EWG. STECF recognises that the various models have different abilities to simulate different types of management measures and acknowledges that the model implementation of these new measures raised many conceptual and methodological questions for the modellers. This is particularly true regarding the modelling of MCL management and new area closures. STECF agrees with the EWG that some of these questions may require further elaboration.

Nevertheless, STECF acknowledges that the models implemented by EWG 22-01 are state-of-the-art and can be used for the evaluation of management strategies. They allow for a comparison of various management strategies in terms of both their likelihood to achieve the objectives of the MAP and their relative impact on the economic outcomes for the fleets. STECF agrees that the annual update of these models incorporating the most recent stock and fleet data allows monitoring the ongoing performance of the MAP.

STECF notes though that models used so far do not account for ecosystems effects of protecting sensitive habitats; therefore the current simulations may underestimate the risk posed to the stocks by displacement effects from persistent hotspots areas to the surrounding areas.

STECF notes that it would be worthwhile to carry out further investigation of potentially conflicting effects of cumulating several management measures, which may either add up or counteract each other, and may even have adverse effects on the stocks depending on effort redistribution.

STECF conclusions

STECF concludes that EWG 22-01, as the latest of a series of dedicated EWGs, has made further progress in assessing the consequences of management measures in the Western Mediterranean.

STECF concludes that EWG 22-01 ran scenarios of different management measures applying on different fleets in different areas various management measures. STECF acknowledges that there has been improvement in the modelling approach and in the range of results compared to previous EWGs reports, although sometimes strong assumptions or limited data still had to be used for the modelling. In particular, STECF concludes that uncertainty remains for the full evaluation of economic impacts of the management measures since not all species caught by the fleets are included in the model. STECF concludes thus that the results need to be interpreted with caution.

STECF acknowledges that the scenarios requested to EWG 22-01 are complex and comprehensive. STECF notes that not all scenarios could be run under the existing models' configuration and resolution, in spite of important modelling effort being mobilised. STECF concludes that available data, knowledge and manpower limit the level of precision and scale that mixed-fisheries models can achieve, and thus advises that management measures should not operate at a scale finer than the data and knowledge available to enforce, monitor and evaluate their effectiveness with some degree of confidence.

STECF concludes that most scenarios simulated indicate that Fmsy will not be achieved for all stocks by 2025. The implementation of additional measures like closed areas or MCLs would, however, improve in many cases the stock status compared to the current effort regime alone.

STECF concludes that all scenarios tested with mixed fisheries models predict, as in previous years, some worsening of the economic performance of the fleets during the first years of implementation. Although for some fleets the losses may be recovered later, the results emphasise the difficult trade-offs for between real short-term costs for individual fishers and expected collective long-term gains in the future.

References

D'Andrea, L., Parisi, A., Fiorentino, F., Garofalo, G., Gristina, M., Russo, T., Cataudella, S., 2020. smartR: a R package for spatial modelling of fisheries and simulation of effort management. Methods in Ecology and Evolution 00:1-10. 10.1111/2041-210X.13394

Mahévas, S., Pelletier, D., 2004. ISIS-Fish, a generic and spatially explicit simulation tool for evaluating the impact of management measures on fisheries dynamics. Ecological Modelling, 171: 65-84.

Merzéréaud, M., Macher, C., Bertignac, M., Frésard, M., Le Grand, C., Guyader, O., Fifas, S., 2011. Description of the impact assessment bio-economic model for fisheries management (IAM). Amure Electronic Publications, Working Papers Series D-29-2011, 19 p.

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

Rossetto, M., Bitetto, I., Spedicato, M. T., Lembo, G., Gambino, M., Accadia, P., et al. (2015). Multi-criteria decision-making for fisheries management: a case study of Mediterranean demersal fisheries. Marine Policy 53, 83–93. doi: 10.1016/j.marpol.2014.11.006

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

Russo, T., Bitetto, I., Carbonara, P., Carlucci, R., D'Andrea, L., Facchini, M.T., Lembo, G., Maiorano, P., Sion, L., Spedicato, M.T., Tursi, A. and Cataudella, S., 2017. A Holistic Approach to Fishery Management: Evidence and Insights from a Central Mediterranean Case Study (Western Ionian Sea). Front. Mar. Sci. 4:193. doi: 10.3389/fmars.2017.00193

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REPORT TO THE STECF

EXPERT WORKING GROUP ON EVALUATION OF MAXIMUM CATCH LIMITS AND CLOSURE AREAS IN THE WESTERN MEDITERRANEAN (EWG-22-01)

Virtual meeting, 28 of February – 4 of March 2022

1 INTRODUCTION

This report is the eighth of a suite of STECF EWG reports dedicated to the fishing effort regime in the Western Mediterranean Sea.

The first EWG in June 2018 (STECF 18-09) addressed a number of issues related to managing fisheries with fishing effort regimes. Building on a review of previous experiences worldwide, the report highlighted the main and well known concern that catchability estimates (relationship between fishing effort and fishing mortality) are imprecise and vary systematically since fishers will tend to increase their efficiency in order to maintain their historical catch and revenue levels in spite of effort reduction[1]. This was corroborated by quantitative analyses of differences in catch efficiency between fishing trips using trip-based data from Italy and Spain, differences that are only little explained by features such as vessel size or fishing area. Also, a study was presented monitoring continuous increase in gear size (width, opening, twin trawl etc) in the Mediterranean, highlighting a potential for further increase in fishing efficiency that may counteract the expected effect of effort reduction. Finally, a comparison of the completeness and consistency of the various datasets on catch and effort by fleet segments available at the JRC was performed, highlighting a number of gaps.

The second EWG in October 2018 (STECF 18-14) built further on these results. The relationship between fishing effort and fishing mortality, aggregated at the level of fleet segment and year, was analysed for a number of the MAP stocks using the available time series of stock assessment. This relationship was shown to be never linear, and in most cases it cannot even be detected in the time series. This means that a reduction of fishing effort will not translate by a similar reduction of fishing mortality at least in the first years of implementation. Secondly, the trips analyses were extended to new data from France, showing similar results as for Italy and Spain. Finally, a first review of existing bioeconomic mixed fisheries models in the Western Med was conducted. Considering that many models were potentially available but that none of them was directly operational for the purpose of the MAP, a 2 years road map was agreed to improve the availability and use of such models.

Accordingly, the third EWG in March 2019 (STECF 19-01) focused uniquely on updating and improving mixed-fisheries models. Several models of various complexity were presented and tested for the two regions (EMU1 & and EMU2). Good progresses were achieved but the most important issue left was the need to develop a single combined model for EMU1 including data from both Spain and France together, instead of the existing models by GSA. In addition, the EWG listed numerous other issues and future questions regarding data and models' dimensions (e.g. stock definition, inclusion of other species than the MAP species etc).

The fourth EWG in October 2019 (STECF 19-14) was the continuation of this work, progressing further on these issues in order to have models and datasets fully operational for providing mixed-fisheries advice on the MAP. In particular, a first version of a combined IAM model for EMU1 was presented, including both Spanish and French fleets but including only hake data. Two models were run in parallel for EMU 2 (BEMTOOL and SMART), providing different insights on future development. During the EWG 19-14, specific focus was also given to how to simulate closed areas in the bioeconomic models to evaluate their potential impact in the medium-term.

The fifth EWG in October 2020 (STECF 20-13) was largely an update of STECF 19-14 regarding models and scenarios (see ToRs). The models were updated with the most recent assessment data (from STECF EWG 20-09) and FDI effort data (from STECF 20-10) and extended to cover some of the gaps previously identified (mainly for EMU 1), and a number of scenarios were run. Additional issues were though considered. In 2020, the West Med MAP has been implemented since January 1st, through Regulation (EU) 2019/1022, with fishing opportunities in terms of maximum allowable fishing effort in fishing days fixed for 2020 in Council Regulation (EU)

[1] http://www.fao.org/gfcm/fishforum2018/presentations/en/, Theme 1 session 2

2019/2236. The EWG compared the reference levels used for fishing effort quotas and discussed the implications of the sometimes large discrepancies observed between scientific and policy data.

The sixth EWG in March 2021 (STECF EWG 21-01) explored the datasets on the trawl fleets exploiting demersal stocks to estimate the conversion factors between fleet segments to ensure that effort swaps will not lead to an undesirable increase in fishing mortality. The EWG highlighted the need to have data at fishing trip (VMS data) level when estimating conversion factors. The impact of recreational fishery on the stocks covered by the Western Mediterranean Multi-Annual Plan was found to be negligible. The EWG also assessed the proposals for additional closure areas for 2021 received from Spain, but had no time nor data to propose alternative closure areas for EMU 1 and 2.

The seventh EWG held the last week of September 2021 was partially an update of STECF 20-13 and partially an update of STCEF 21-01. The models were updated with the most recent assessment data (from STECF EWG 21-11) and FDI effort data (from STECF 21-12) and extended (compared to last year) to run scenarios accounting for alternative selectivity and introduction of TACs. The EWG updated the F-E relationships and estimated conversion factors at metier and stock level. In 2021, the second year of the West Med MAP has been implemented since January 1st, through Regulation (EU) 2021/90, setting fishing opportunities in terms of maximum allowable fishing effort in fishing days for 2021. This year as well the EWG compared the reference levels used for fishing effort quotas and found large discrepancies between scientific and policy data, the implications were discussed during the EWG.

This eighth EWG held the first week of Mach 2022 was a technical exercise to improve the mixed-fisheries modelling frameworks to in preparation of future EWGs. The EWG focused on the evaluation of two specific management measures considered in the western Mediterranean management plan: maximum catch limits (MCLs) and closure areas. In order to evaluate these measures in isolation from others considered in the western Mediterranean management plan, effort reductions applied in 2022 following Regulation (EU) 2022/110 were not considered during EWG 22-01. MCLs on ARA and ARS (following Regulation (EU) 2022/110) and on HKE and existing closure areas were evaluated. EWG 22-01 evaluated the the possibility of defining additional closure areas with the available data and highlighted numerous limitations in the process.

1.1 Terms of Reference for EWG-22-01

In adopting the western Mediterranean multi-annual management plan (West Med MAP), Member States agreed to implement several management measures, such as fishing effort reduction, closure areas and maximum catch limits, to secure the achievement of MSY by 1 January 2025 for all demersal stocks in the western Mediterranean. The work of the STECF expert working group will continue building on the previous evaluations by STECF expert working groups to look into (i) the implementation of maximum catch limits for deep-water shrimps and hake as well as (ii) the delineation of additional closure areas.

Regarding maximum catch limits, Article 7.3.b of the West Med MAP states that “The fishing effort decrease may be supplemented with any relevant technical or other conservation measures adopted in accordance with Union law, in order to achieve the FMSY by 1 January 2025.” The setting of a maximum catch limit framework for the most overfished stocks (hake and deep-water shrimps) is thus considered. STECF EWG 21-11 has identified transition values for maximum catch limits to achieve MSY by 2025 for all stocks and STECF EWG 21-13 has started developing models to include maximum catch limits in the evaluation of West Med management scenarios. Different levels of maximum catch limits for demersal species, in particular deep-water shrimps and European hake, in the management unit of the western Mediterranean should be analysed by STECF experts to prepare for the evaluation of management scenarios combining maximum catch limit and effort reductions.

Regarding closure areas, Article 11.1, alternatively Article 11.2, aims at protecting juveniles of European hake. All three concerned Member States adopted Article 11.3 and agreed to establish additional closure areas by 17 July 2021 and on the basis of best available scientific advice, where there is evidence of a high concentration of juvenile fish, below the minimum conservation reference size, and of spawning grounds of demersal stocks, in particular for the target stocks of the West Med MAP. In addition, France and Spain adopted in December 2020 targets of capture reductions of demersal stocks and committed to reduce between 15% and 25% the capture of juveniles and spawners in each GSA.

STECF PLEN 19-03, PLEN 20-01 and STECF EWG 21-01 have reviewed the proposals of closures (placement and period) submitted in 2020 and 2021 by the 3 Member States and determine their efficiency to protect juveniles of hake (as planned in Article 11.2) and juveniles and spawners of all six target demersal species included in the West Med MAP (as planned in Article 11.3).

However, in view of Article 11.4, the closure areas should be reviewed for Member States to update the closure areas based on STECF advice.

Request to the STECF:

1) STECF is requested to continue the development of management models including different levels of maximum catch limits for deep-water shrimps and for hake in both West Med management units.

2) STECF is also requested to develop mixed-fisheries spatio-temporal scenarios for all demersal fishing gear (e.g. bottom trawls, gillnets, longlines) in EMU1 and EMU2 with simulations from 2020 to 2030. The STECF evaluation should be looking at differences in captures reduction between the 2019 situation (prior to closure adoptions) by species and by age-class and the following scenarios:

a) Status quo scenario: closures adopted since the implementation start of the West Med MAP by the 3 Member States

b) Same delineation of closures areas as in 2020, 2021 and 2022 and all closure areas become permanent from 2023 onwards

c) Same delineation of closures areas as in 2020, 2021 and 2022 and all closure areas are for all fishing gear (e.g. trawlers, longliners, netters)

d) 10% of permanent closure areas in each GSA, taking into account the different types of habitats such as for instance waters shallower than 200m depth and waters deeper than 200m*

e) 20% of permanent closure areas in each GSA with half of it in waters shallower than 200m depth and half of it in waters deeper than 200m*

f) 30% of permanent closure areas in each GSA with half of it in waters shallower than 200m depth and half of it in waters deeper than 200m*

*see document attached of priority areas identified for delineation of additional closure areas

To provide an order of magnitude of the closures efficiency, it should be aimed at reducing about 20% of captures of juveniles and spawners of each target species in each GSA. For each GSA, the EWG is requested to propose recommendations for designing alternative closures based on criteria such as but not limited to bathymetry, depth, type of substrate, stock seasonality, establishment of a buffer area, minimal size of the closure area etc.

TORs were further detailed in agreement with DGMARE to give additional directions to the working group experts':

As discussed during the meeting on 27 January 2022, the legal concept adopted in December 2021 by Member States to manage by output the deep-water shrimps in the western Mediterranean is "maximum catch limit". Contrary to the legal concept of total allowable catch (TAC), a maximum catch limit does not involve a legal right for the future years and does not create a fixed relative stability (i.e. a distribution of the fishing opportunities between the concerned Member States). Concretely, it means that there is no legal obligation for a continuity of catch levels between 2022, 2023, 2024, onwards. However, to simplify the modelling work, the STECF experts are invited to work with TACs and use a reduction at percentage level through time (e.g. 10% reduction of the previous year catches: (TAC[year+1]=0.9*TAC[year])) as an alternative to following the transition path calculated by STECF EWG 21-11 for each stock. The model output should be analysed in order to determine whether such reductions allow to reach MSY by 2025 at the latest.

Details on TACs scenarios implementation:

- TACs should be implemented both on hake (HKE) for the coastal metiers and on deep-water shrimps (ARA and ARS) for the deep-water metiers. If possible, there would thus be 3 scenarios with TACs: a) hake only, b) deep-water shrimps only, c) simultaneously hake & deep-water shrimps. Those scenarios would be completed in September 2022 by the effort reductions and additional management measures as done in EWG 21-13.
- All models should be simulating 2 fleets corresponding to the two metiers (deep-water and coastal fisheries). This definition of metiers is unstable as fishing boats can move from one metier to the other easily from one day to the next, but changes due to external parameters cannot be accounted for in the models therefore the metiers will be treated as two separate fleets.
- Models that can implement a monthly time step (e.g. BEMTOOL and SMART) will test a first scenario where the TACs is implemented annually and fishers are assumed to follow a "run to fish" behaviour and a second scenario where TACs are implemented monthly. When TACs are implemented monthly, if possible, the value implemented each month should change depending on the seasonality of the fisheries. **To obtain information on the seasonality the experts can rely on experts' opinions over the different areas and using DCF landings data by quarter, when data by quarter are available. The reference year should be 2015-2017.**
- All models should account for monthly flexibility but not annual inter-flexibility. When the TAC is not consumed within one month, it can be used the next month (except for December).
- An optional scenario will be accounting for an "inverse TAC" system. Quotas will not be decreasing through time, but the first year of implementation will be the hardest with an increase of the quota through time as the stock recovers. The values could be taken from the transition path to Fmsy by 2025 calculated by STECF EWG 21-11.
- For 2022, the maximum catch limit values for deep-water shrimps can be found in the Fishing Opportunities Regulation for the Med and Black Sea: Council Regulation (EU) 2022/110 of 27 January 2022 fixing for 2022 the fishing opportunities for certain fish stocks and groups of fish stocks applicable in the Mediterranean and Black Seas (OJ L 21, 31.1.2022, p. 165–186)
- For 2022, there is no maximum catch values for hake in the EU regulation so modelling would start for hake with catch limits in 2023.

Details on Spatial scenarios implementation:

- Concerning point b) of TORs: if closures are already permanent within a GSA this point will not be tested.
- Concerning points d), e) and f) the closure of 10%, 20% and 30% of each GSA should be tested subtracting already existing closure areas from this percentage. Additionally, the areas >1000m and the <50m or within 3 nautical miles from the coast, should be excluded from what is considered the "total area of a GSA".
- Ad-hoc contracts ran prior to EWG 22-01 will produce shapefiles with the distribution of hotspots of juveniles and spawners of hake and potentially of the five main target species of the MAP. The location of the closure areas should take into account the distribution of hotspots to test the efficiency of the closure areas.

- As reported in the TORs: "To provide an order of magnitude of the closures efficiency, it should aim at reducing about 20% of captures of each target species in each GSA."

The reduction of ~20% should be calculated in comparison to captures in 2015-2017, as per TORs.

1.2 Main findings

KEY FINDINGS FOR EMU1 (GSAs 1 2 5 6 7)

In EMU 1, several stocks are strongly overexploited (STECF 21-11), including European hake (HKE) in GSAs 1-5-6-7, red mullet (MUT) in GSA 1 and in GSA 6, and Blue and red shrimp (ARA) in GSA 1 and in GSAs 6-7.

The scenarios investigated with the IAM model simulated an implementation of maximum catch limits (MCL) on European hake and/or on Blue and red shrimp. Two scenarios (scenarios i and j) simulate the implementation of MCL simultaneously on European hake in GSAs 1-5-6-7 and on both stocks of Blue and red shrimp in GSA 1 and GSAs 6-7, with for scenario i an implementation of MCL using a transition period where MCL is progressively decreased from 2022 to 2025; and the inverse (where MCL is progressively increased) for scenario j. The inverse MCL scenario are those that simulate a more restrictive MCL in 2022 and then a gradual increase in the MCL between 2023 and 2025. Although all scenarios predict globally an increase in the biomasses of the exploited stocks, only scenario i foresees exploitation levels in lines with the objectives of the plan, or below.

Globally, all scenarios imply fishing effort reduction up to 2021 and foresee some bio-economic impact for French and Spanish trawlers in the short term with a decrease in their Gross Value Added. In the scenarios where MCL is applied on European hake (scenarios a, b, i and j), all trawler fleet segments are economically impacted. However in the scenarios where MCL is applied only on Blue and red shrimp (scenarios c to h), only the fleet segments using deep water trawling are impacted, i.e. the Spanish trawlers above 12 meters.

The implementation of a MCL only on European hake (scenarios a and b) predicts an increase in hake biomass (Fig. 1.2.2), but also in Red mullet (for the three stocks MUT1, MUT6 and MUT7) and Norway lobster (NEP67) biomasses. The effort reductions associated with these scenarios allow the stocks of red mullet in GSA1 and GSA6 to reach Fmsy. However, those scenarios are associated with a decrease in Blue and red shrimp biomasses (ARA1 and AR67) and an increase in their fishing mortalities, due to the reallocation of fishing effort to deep water trawling.

When considering inverse MCL scenarios, the increases in biomass are less significant than with the MCL scenarios, however the negative economic impacts on the trawl fleets are less significant in the medium and long term.

It should be noted, that in the scenarios tested in this report, the MCL is only applied to trawlers, therefore total landings of European hake are higher than the MCL values, which explains why European hake fishing mortality (Fbar) is higher than Fmsy in 2025 with scenarios a and b.

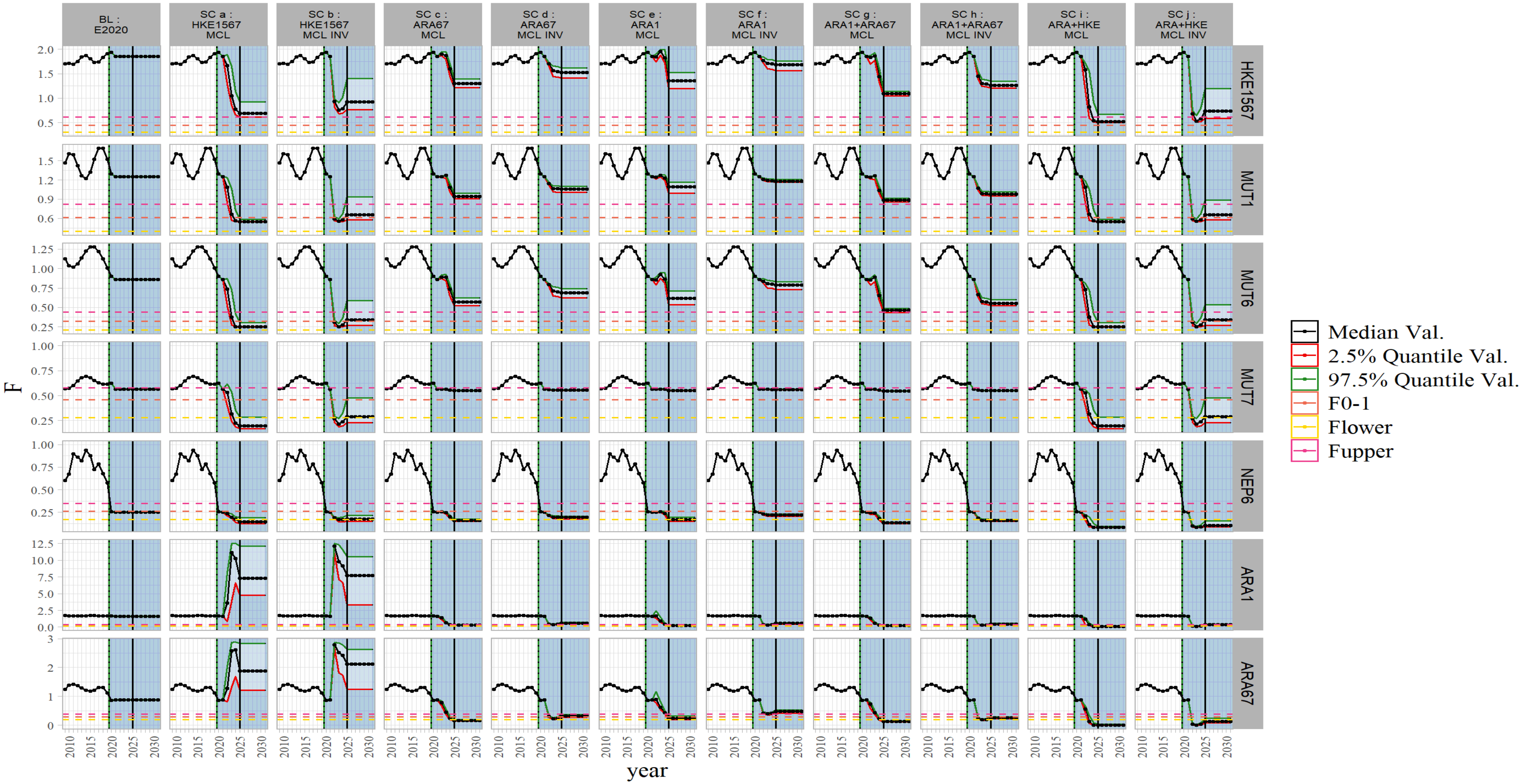


Figure 1.2.1. EMU 1 (IAM model). Predicted Fishing mortalities by modelled stock (in row) under alternative scenarios (in column). The stocks are as follow (from top to bottom): Hake GSAs1-5-6-7 (HKE1567), red mullet GSA1 (MUT1), red mullet GSA6 (MUT6), red mullet GSA7 (MUT7), Norway lobster GSA6 (NEP6), blue and red shrimp GSA1 (ARA1) and blue and red shrimp GSAs6-7 (ARA67). Historical values of Fbar are given in the white areas and simulated values in the blue area. Estimated F 0-1, Flower and Fupper from EWG 21-11 stock assessments are represented. Simulations run until 2031 and vertical black lines indicate the year 2025.

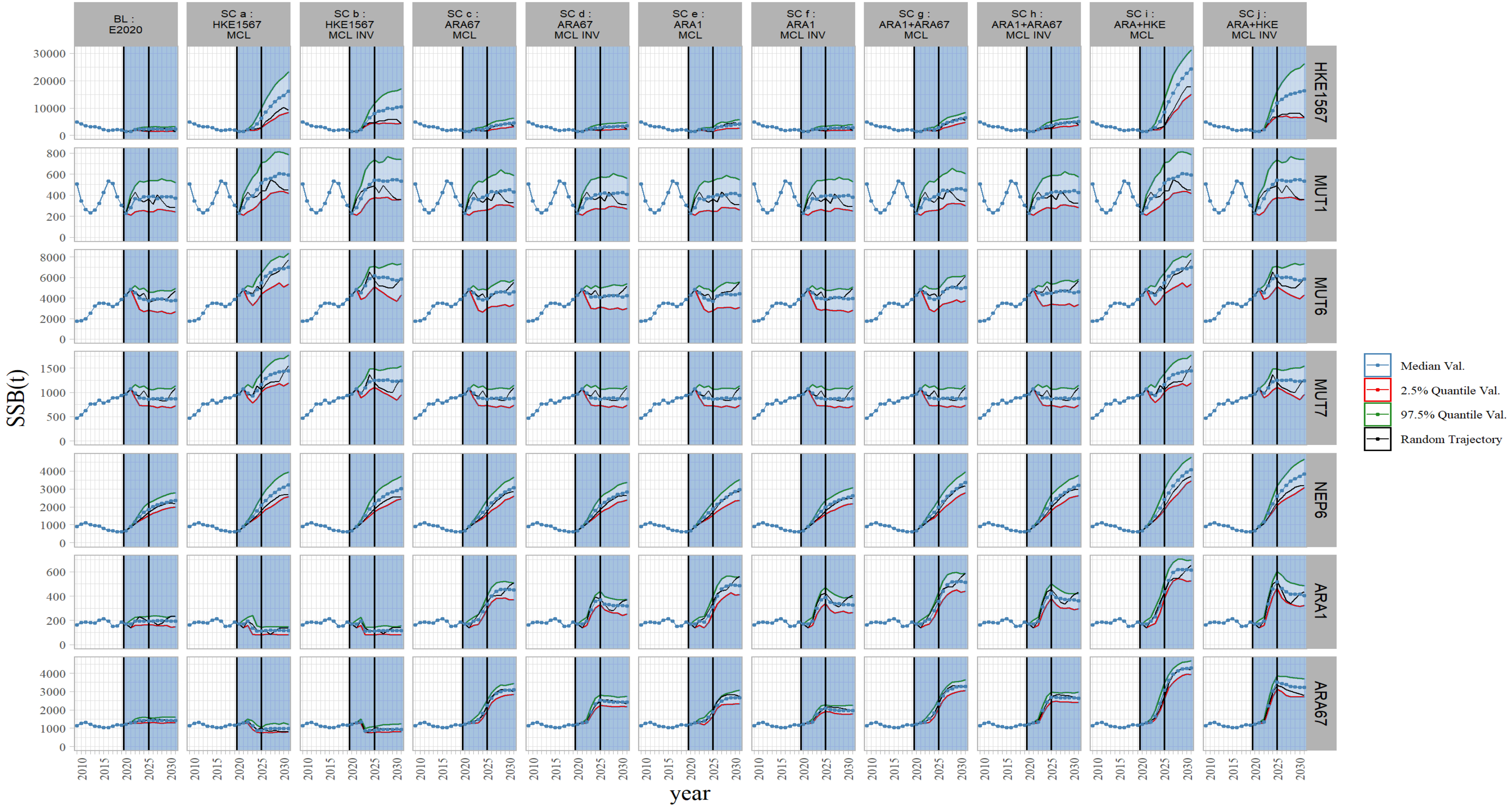


Figure 1.2.2. EMU 1 (IAM model). Predicted Spawning Stock Biomasses by modelled stock (in row) under alternative scenarios (in column). The stocks are as follow (from top to bottom): Hake GSAs1-5-6-7 (HKE1567), red mullet GSA1 (MUT1), red mullet GSA6 (MUT6), red mullet GSA7 (MUT7), Norway lobster GSA6 (NEP6), blue and red shrimp GSA1 (ARA1) and blue and red shrimp GSAs6-7 (ARA67). Historical values of SSBs are given in the white areas and simulated values in the blue area. Simulations run until 2031 and vertical black lines indicate the year 2025.

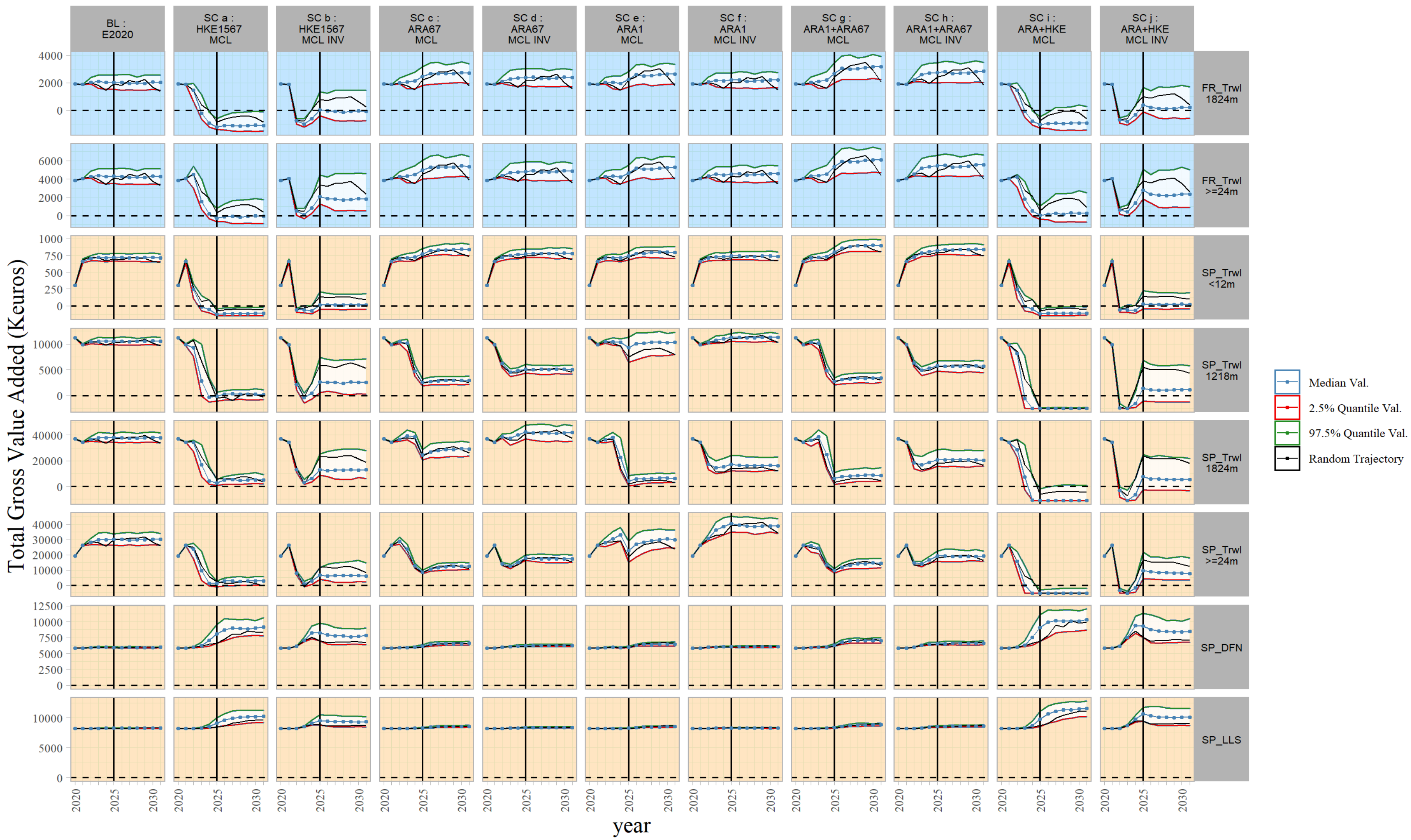


Figure 1.2.3. EMU 1 (IAM model). Evolution of the total Gross Value Added (GVA, i.e. proxy for the profit, in K euros) by fleet segment for each alternative scenario from 2020 to 2031. Vertical black lines indicate the year 2025. Scenarios are in column and fleet segment in row. The fleet segments are as follow (from top to bottom): French demersal trawlers 18-24m, French demersal trawlers >24m, other French vessels <12m and other French vessels >12m, Spanish trawlers < 12m, Spanish trawlers 12-18m, Spanish trawlers 18-24m, Spanish trawlers >24m, Spanish netters and Spanish vessels using hooks.

ISIS-Fish results provided further details about scenarios impacts on European hake in GSA7 including closure scenarios. Existing closures, scenario a, allowed a reduction of the fishing mortality compared to the reference period (2015-2017) of about 3%. Scenario b, when seasonal closures become permanent, provided an additional protection and a decrease in F of 7% compared to 2015-2017 particularly for older age classes. On the contrary, scenario c, when closures were applied to all gears, had little effect on fishing mortality compared to scenario a (Fig. 1.2.4). The impact on SSB of scenarios a and c in comparison to the reference period was negligible, while scenario b provided an increase of 7% (Fig. 1.2.5). In terms of gross revenues on hake, closures benefited Spanish longliners which revenues increase compared to 2015-2017, but trawlers revenues were reduced by 5 to 8% compared to 2015-2017 (Fig. 1.2.6).

These results were conditioned to the assumptions made in simulating fish and effort distribution and effort report (see section 3.3.1). They could be improved with the analysis of past behaviour of the fleets in response to 2020-2021 closures and new results regarding hake hotspots and stock-recruitment relationship. It is expected that in view of the current assumptions, the effect of closures was underestimated in terms of benefits for the stock and negative impact for the fleets.

Maximum catch limits were simulated for hake in GSA7. MCL in GSA7 was set equal the MCL defined for EMU1 multiplied by the historical (average 2018-2020) proportion of catch in GSA7 compared to EMU1. It was then apportioned to the trawler fleets according to historical share (2018-2020). The annual MCL 2022-2025 was either set based on a transition path from current fishing mortality to catch at Fmsy (using a priori set MCL values from STECF EWG 21-11) (SCd and f) or as catch at Fmsy from 2022 on (accounting for biomass evolution, HCR-like scenario) (SCe and g). An annual MCL allowing a race for quota (SCd and e) and a monthly distributed MCL (SCf and g) were compared. **Because of the very different nature of the ISIS-Fish model compared to the assessment model, fishing mortality cannot be compared.** An equivalent of Fmsy in ISIS was computed as 0.27 and used as a reference for HCR and evaluation of objectives.

Biomass of hake at the end of the simulations (2030) accounting for a MCL were in the same order of magnitude in all scenarios (6 to 7 times the average 2015-2017), but trajectories differed a lot particularly when comparing the transition scenario to the immediate Fmsy scenario. In fact, the transition scenario led to fishing mortalities below Fmsy in 2025 because the value defined for MCL did not account for biomass rebuilding. On the other hand, the fishing mortality achieved using the HCR, never fell below Fmsy, because of the unrestricted catches of netters and longliners.

In terms of revenues, both MCL paths led to strong decreases for trawlers. In case of the transition path the decrease is progressive and reached -71%, -80% and -90% respectively for French trawlers of 18-40m, 24-40m and Spanish trawlers in 2025. The inverse scenario led to a very sharp decrease in 2022, although slightly smaller than the transition (-67%,-77%,-89%). However revenues increased again from 2023 onwards to higher levels and outperformed the reference period for French fleets. Spanish trawlers on the other hand only reached 30% to 60% of their historical hake revenues by the end of the simulation (2030). The imbalance between fleets is likely to attribute to the catch allocation between fleets that reflects catch share in 2018-2020 while effort is constrained to 2015-2017 values. Finally, the previous results only concerned gross revenues on hake. The true consequences may be either lesser, if fleets have the ability to avoid hake and report on other species, or worst, if they had to completely stop fishing.

On the contrary, the re-allocation of effort from trawlers highly benefits netters and longliners fleets, whose revenues were multiplied respectively by 3 and 12. This latter result should be considered with caution, due to the rudimentary modelling of the Spanish longliner fleet.

Monthly distributed MCL reduced global F more than the annual MCL, but increased pressure on recruitment. The explanation lies in the assumption of the model regarding the gradual arrival of recruits in the fishery in the course of the year with a first peak in June. Revenues are higher for all fleets with these scenarios compared to their annual equivalent.

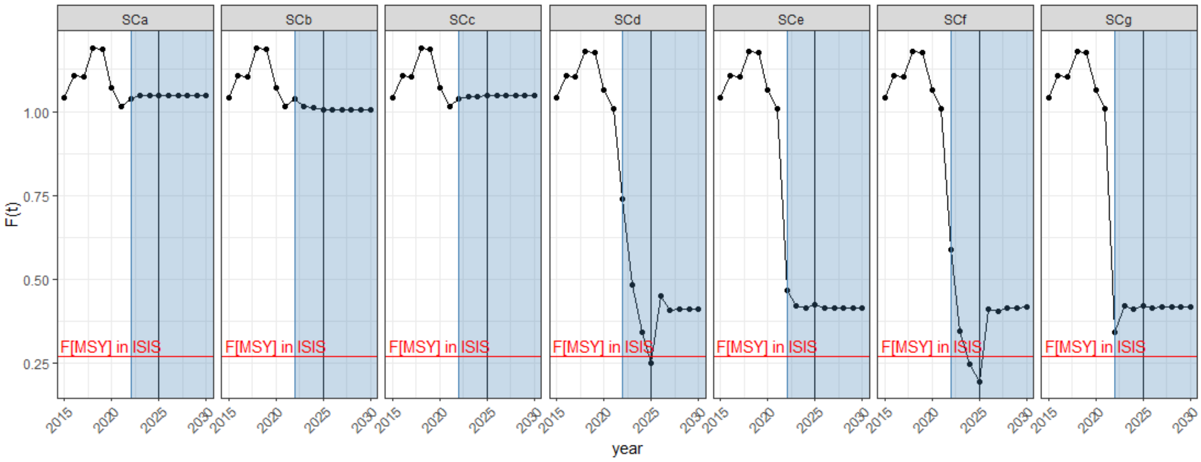


Figure 1.2.4 GSA7 (ISIS-Fish model). Predicted Fishing mortalities of hake under alternative scenarios (in column). Hindcasted values of Fbar are given in the white area and simulated values in the blue area. A fishing mortality of 0.27 was assessed as the equivalent of F0.1 for the ISIS-Fish model. Simulations run until 2030 and vertical black lines indicate the year 2022.

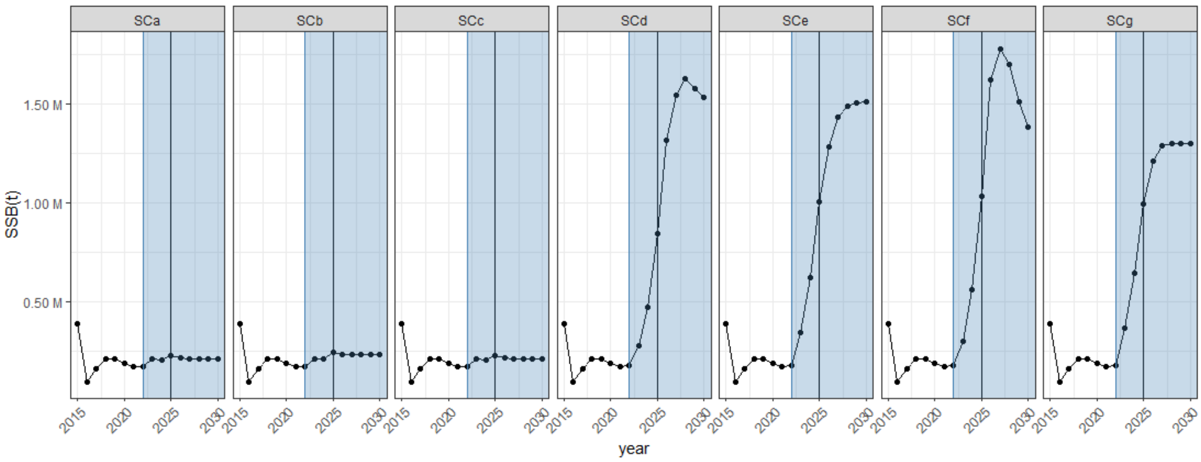


Figure 1.2.5 GSA7 (ISIS-Fish model). Predicted Spawning Stock Biomasses of Hake under alternative scenarios (in column). Hindcasted values of SSBs are given in the white area and simulated values in the blue area. Simulations are run until 2030 and vertical black lines indicate the year 2022.

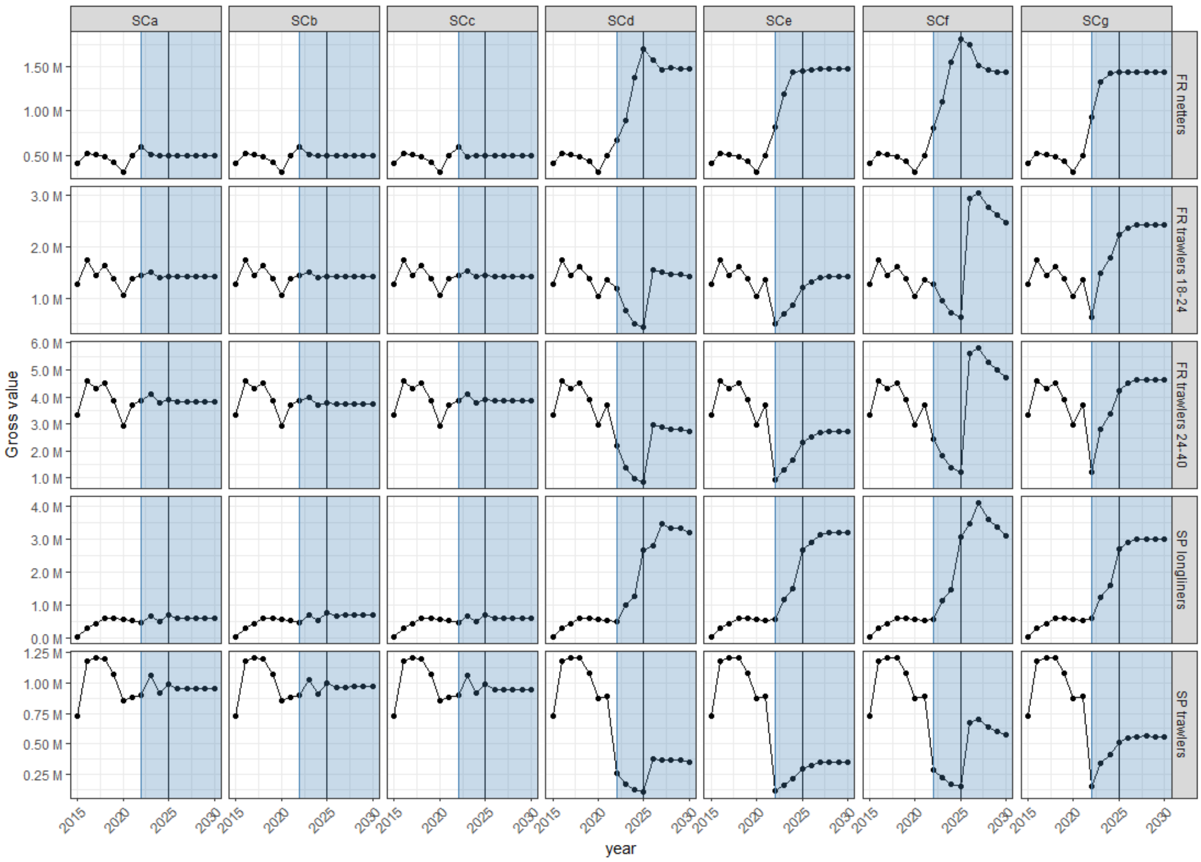


Figure 1.2.6 Evolution of the Gross Value (in K euros) associated to hake landings by fleet segment for each alternative scenario from 2015 to 2030. Vertical black lines indicate the year 2022. Scenarios are in column and fleet segment in row. The fleet segments are as follow (from top to bottom): French netters, French demersal trawlers 18-24m, French demersal trawlers >24m, Spanish long-liners, Spanish demersal trawlers.

KEY FINDINGS FOR EMU2 (GSAs 8 9 10 11)

The most overexploited stocks in EMU 2 are Blue and red shrimp (ARA) and European hake (HKE), for which a constant catch may lead to a further decrease of biomass, especially for ARA. The setting of a maximum catch limit foreseen in the EU Regulation 2022/110 would allow to approach Fmsy for ARA, but not for HKE that is mainly caught by different metiers, while deep-water rose shrimp (DPS) in GSAs 9-10-11 would reach Fmsy upper with all scenarios. ARS, that is the third species most overexploited after ARA and HKE, would see significantly reduced its fishing mortality below the Fmsy lower with all scenarios, except D (MCL_ARS_REV_monthly) and F (MCL_ARA_REV) scenarios. ARS, ARA and NEP stocks would benefit of all the scenarios, due to the re-allocation of the effort from the deep-water metier (OTB_DWS and OTB_DES) to the demersal (OTB_DES). This reallocation produces an increase in the fishing pressure on the other stocks, contributing to partly reduce the underutilization of red mullet in GSA10, red mullet in GSA 9 and Norway lobster in GSA 9.
Scenarios B and D, implementing a reverse MCL on ARS9-10-11 at annual and at monthly level respectively, represent the scenarios showing a performance slightly below status quo (SQ) in terms of revenues and profitability. This is due to the fact that the model predicts a decrease in the revenues of the more valuable stocks, partly compensated by the increase in the revenues of the other stocks, assuming the same fishing effort and fleet capacity of 2021 (and, thus, variable and fixed costs). B and D

scenarios would produce an improvement in SSB values of ARS and ARA only slightly smaller than scenarios E and G, setting the MCL on ARA. Moreover, a MCL split by month impacts less on the catches of ARA and ARS in the short term, while by about 3-4 years the scenarios reach the same catch level.

It is important to notice that the scenarios here presented do not yet consider the adaptation of the MCL to the status of the stock (e.g. Fmsy, SSB) that is expected to change during the application of management measures. This aspect needs to be further explored and refined to possibly accommodate the adaptive setting of MCL year by year in the projections.

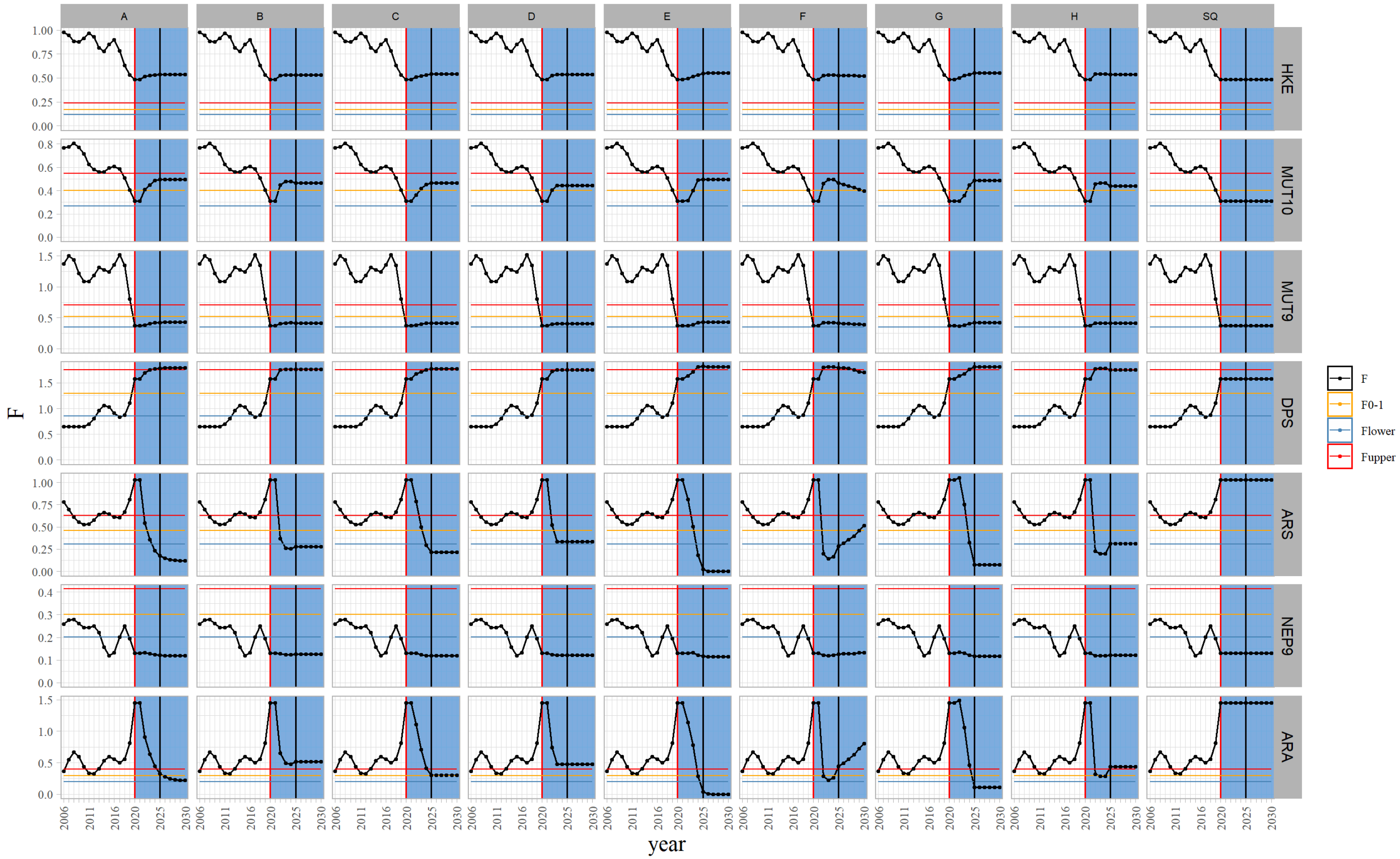


Figure 1.2.7. EMU 2 (BEMTOOL model). Predicted Fishing mortalities by modelled stock (in row) under the MAP scenario of effort reduction (in column). The stocks are as follow (from top to bottom): Hake GSAs8-9-10-11 (HKE), red mullet GSA10(MUT10), red mullet GSA9 (MUT9),deep-water rose shrimp GDSs9-10-11 (DPS), Giant red shrimp GSAs9-10-11(ARS), Norway lobster GSA9 (NEP9) and blue and red shrimp GSAs9-10-11 (ARA). Historical values of Fbar are given in the

white areas and simulated values in the blue area. Estimated F 0-1, Flower and Fupper from EWG 20-09 stock assessments are represented, in orange, blue and red horizontal lines, respectively.

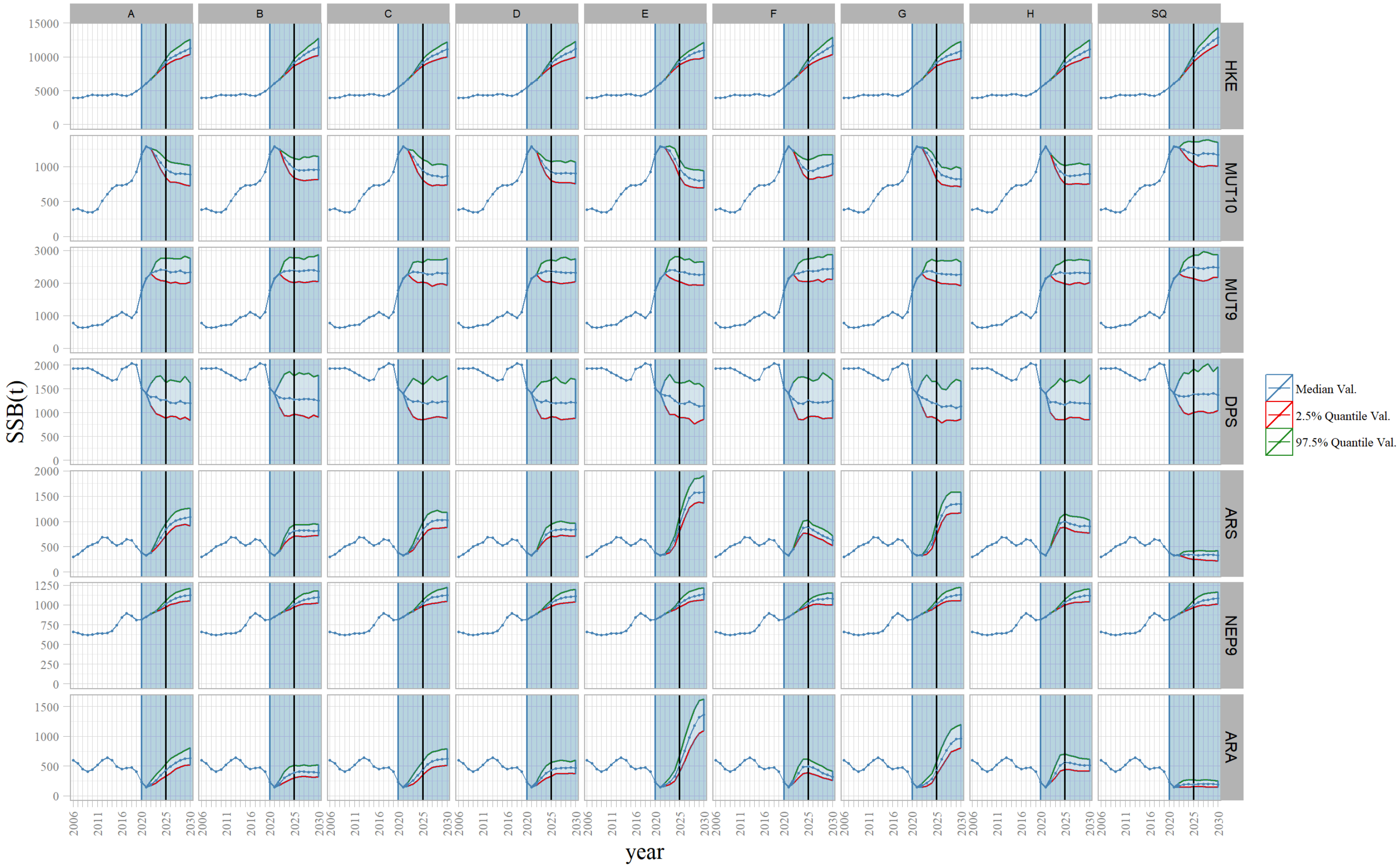


Figure 1.2.8 EMU 2 (BEMTOOL model). Predicted Spawning Stock Biomasses (in row) under the MAP scenario of effort reduction (in column). The stocks are as follow (from top to bottom): Hake GSAs8-9-10-11 (HKE), red mullet GSA10 (MUT10), red mullet GSA9 (MUT9), deep-water rose shrimp GSAs9-10-11 (DPS), Giant red shrimp GSAs9-10-11 (ARS), Norway lobster GSA9 (NEP9) and blue and red shrimp GSAs9-10-11 (ARA). Historical values of SSB are given in the white areas and simulated values in the blue area. Historical values of SSBs are given in the white areas and simulated values in the blue area. Simulations run until 2030 and vertical black lines indicate the year 2025.

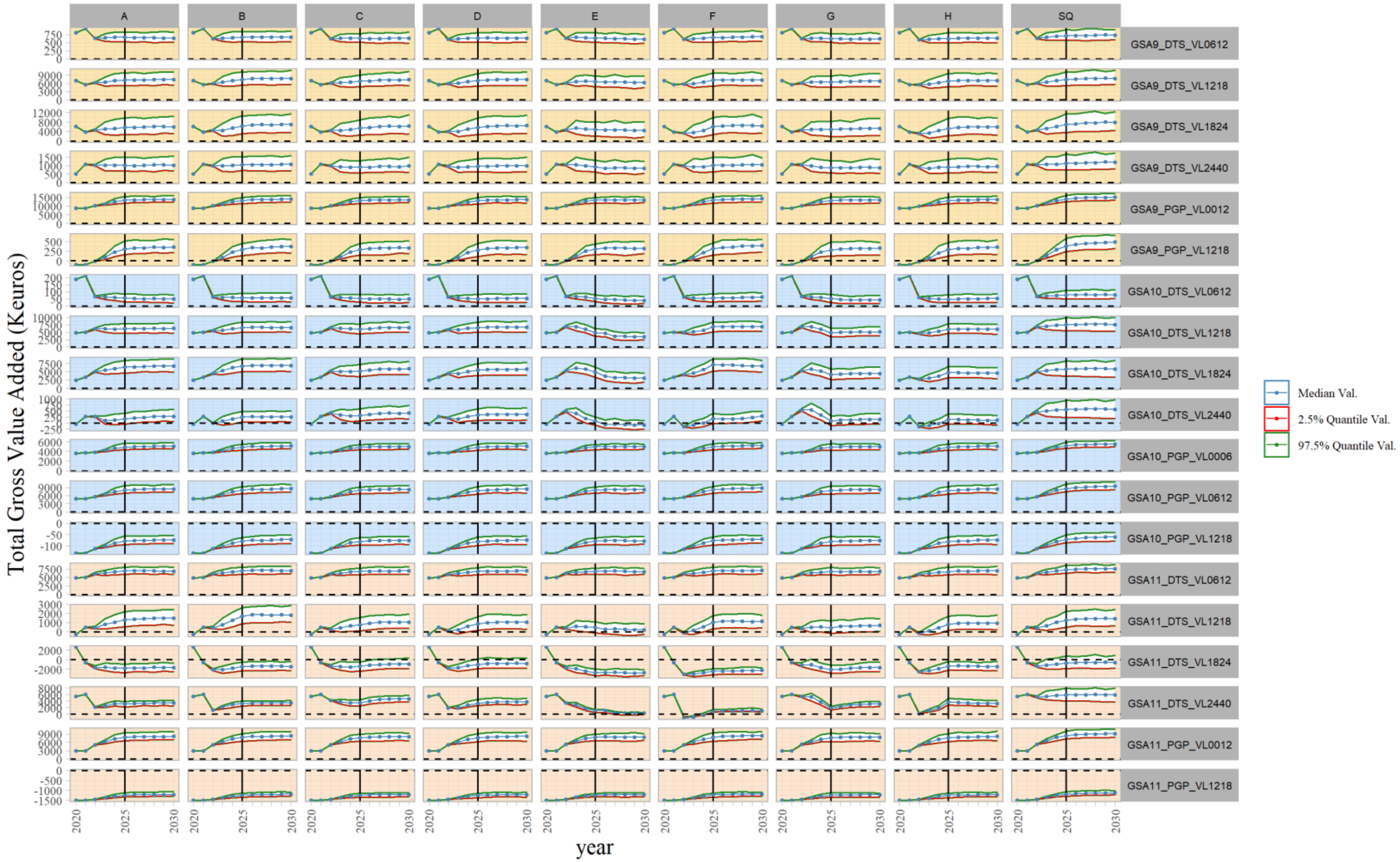


Figure 1.2.6. Evolution of the total Gross Value Added (GVA, i.e. proxy for the profit, in K euros) by fleet segment for each alternative scenario from 2020 to 2031. Vertical black lines indicate the year 2025. Scenarios are in column and fleet segment in row.

The results of the SMART model indicate that most of the spatial scenarios could significantly improve the conditions of some stocks both in terms of SSB and F. In particular, Base + extended New Closures scenarios are very promising for HKE, ARA, ARS but for the other stocks (DPS, NEP and MUT) the benefits are less evident.

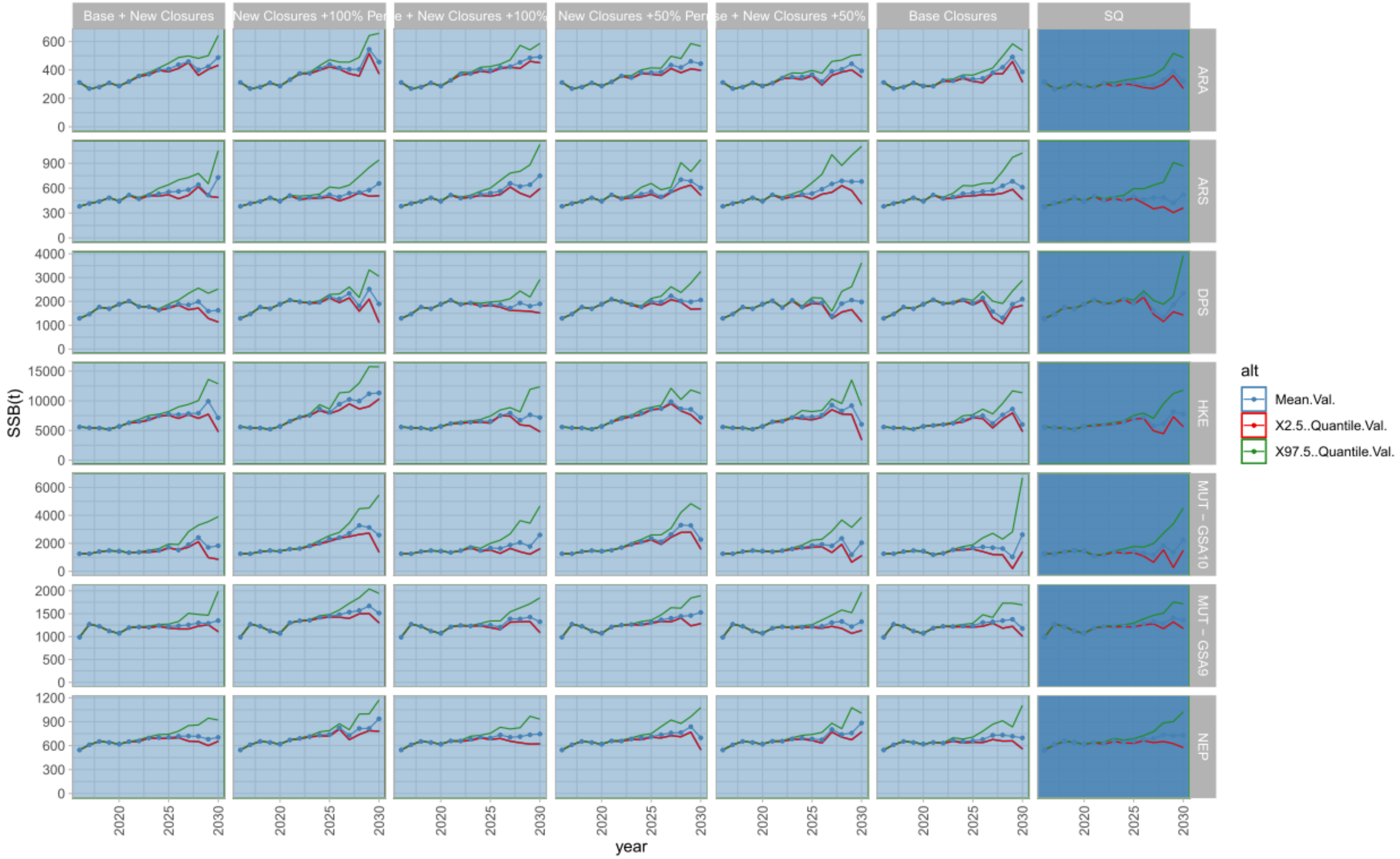


Figure 1.2.7. Evolution of the Spawning Stock Biomass (SSB) by stock for each alternative scenario from 2020 to 2030. Scenarios are in column and fleet segment in row.

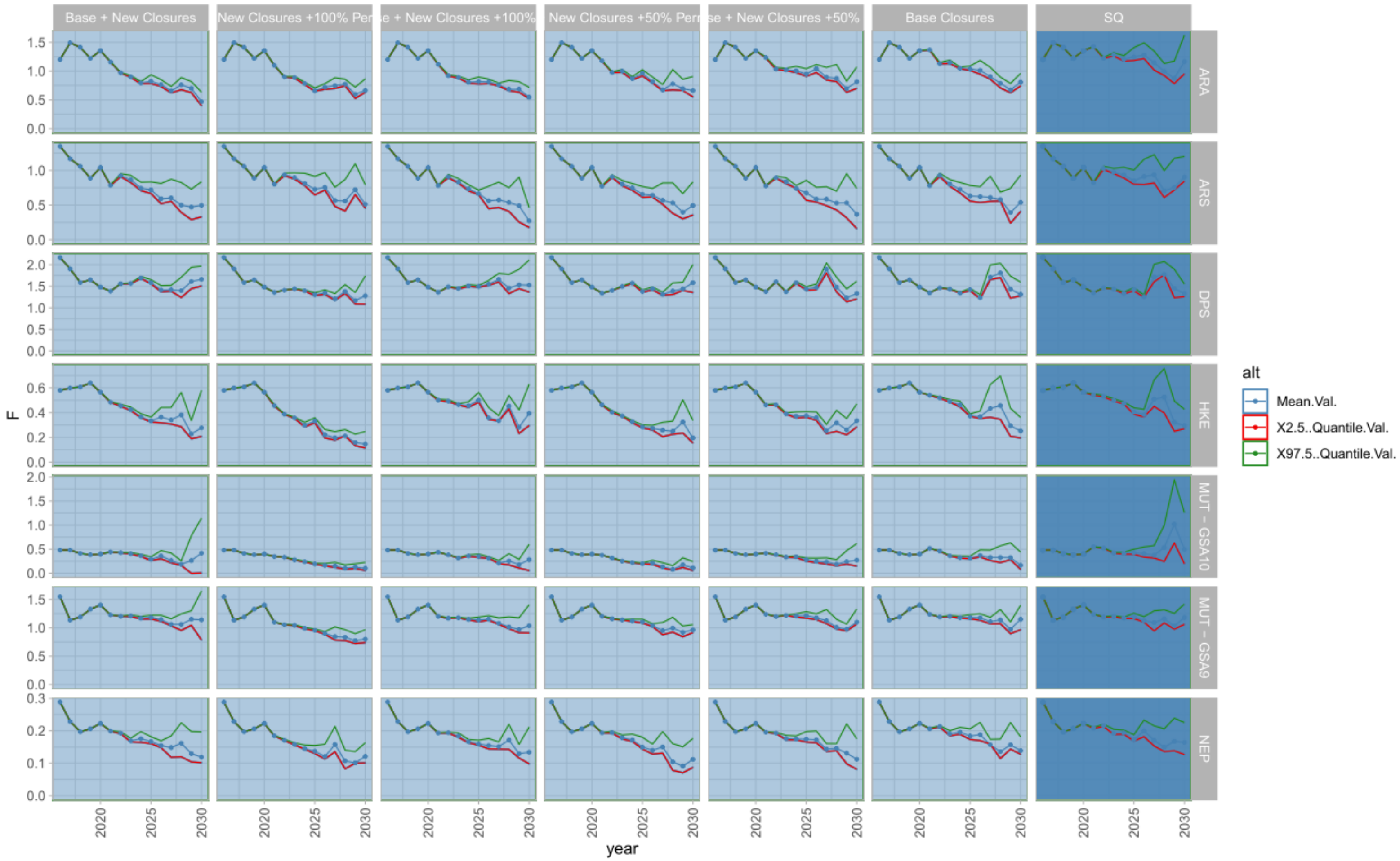


Figure 1.2.7. Evolution of the fishing mortality (F) by stock for each alternative scenario from 2020 to 2030. Scenarios are in column and stocks in rows.

METHODS AND DATA SOURCES

Four different fleet-based mixed-fisheries models were used for the two EMUs (Two models in EMU1 (although one is applied only to GSA 7 for now), two models in EMU 2). All four models present some levels of similarities, but also some differences. The selection of three of the models (BEMTOOL, IAM, SMART) was initially performed during STECF EWG 19-01 among existing options in each area, and the subsequent developments were progressed during STECF 19-14, STECF 20-13, EWG 21-13 and for this EWG 22-01. A fourth model (ISIS-fish) was added during this EWG 22-01 in order to have a spatial model also for EMU 1.

In EMU 1, no global model covering all Spanish and French fleets in all GSAs 1,2,5,6,7 did exist prior to EWG 19-01. Therefore, some work was necessary to select the most appropriate modelling platform and extend it to cover the required stocks and fleets. Progresses were achieved during STECF 19-14, where French and Spanish effort and hake catch data for 10 fleet segments were brought together in the IAM model (Merzereaud et al., 2011). This model was extended to all assessed MAP stocks during STECF 20-13 and updated to simulate increased selectivity and account for a TAC regime during this EWG 21-13. IAM also accounts for stochasticity in its process now.

The second model applied to EMU1, ISIS-fish is a deterministic simulation model designed to explore the dynamics of mixed fisheries (Mahevas and Pelletier, 2004; Pelletier et al., 2009). It combines spatially explicit fish and fleet dynamics at a monthly time step. Fishing mortality results from the interaction between the spatial distribution of population abundance and the spatial distribution of fishing effort for the different métiers. It can evaluate closures effect accounting for effort reallocation and catch limitations. It currently describes the hake fishery in GSA7.

EMU 2 extends along the coast of a single Member State, and several models already existed prior to STECF 19-01 covering all Italian activities in GSAs 9, 10 and 11. Two models (BEMTOOL and SMART) were updated and adapted during EWGs 19-01, 19-14, 20-13, 21-13 and 22-01 for the purpose of the MAP evaluation. They differ widely in their scale and purposes. The first model, BEMTOOL is a multi-species multi-gear bio-economic simulation model for mixed fisheries simulating the effects of management options on stocks and fisheries on a fine time scale (month). For the closure areas aimed at reducing the catches of juveniles, the proportion of effort reduced in the closed spatial subunits was used to calibrate the changes in the exploitation patterns, based on an increase of the size at first capture. BEMTOOL includes 19 fleet segments and 7 stocks.

The second model applied to EMU 2, SMART (Russo et al., 2014) is an individual-based model where each fishing vessel is considered as an independent agent that operates to maximize gains (as difference between revenues and costs), which can thus explore the potential effects of different spatial and/or temporal closures taking into account the potential reallocation of fishing vessels towards other fishing grounds.

IMPORTANT ISSUES IN RELATION TO THE ADVICE

As discussed in STECF EWG 19-01 and 21-13 the fishing effort regime described in the Multi-Annual management Plan in the Western Mediterranean for the fisheries exploiting demersal stocks, is applied to all vessels fishing with trawls in the areas (GSA 1-2-5-6-7-8-9-10-11), targeting two main stock groups (the continental shelf and upper slope group and the deep waters group) and vessel length categories included in the regulation. Thus, each fishing trip should be allocated in a category formed by a combination of area/stock/length category. Although the first and last variables are easily determined (area being the GSA where the boat operates, and vessel length being part of the vessel characteristic), the allocation to a stock group is not as direct. This is related to the multispecific nature of the trawl Mediterranean fishery, also characterized by high versatility, as vessels can target both stock groups within the same fishing day, working at different depth strata. In order to account for this issue all four mixed-fisheries bio-economic models (except ISIS-Fish for now as it is applied only to GSA 7 were no deep-water fisheries is carried out) were updated so to consider for Spanish and Italian fleet segments a coastal and a deep-water fisheries and account for effort reallocation due to Maximum Catch Limits (MCLs) implementation and follow the fishing days limitations defined by the Western Mediterranean MAP. Nevertheless, there are not fixed rules for allocating each fishing trip to one of the two stock groups, specifically there not fixed rules across countries and the definition of "coastal metier" applied to all GSAs is considered to be too coarse as fishing strategies in the coastal areas can vary quite widely, depending on the GSA and the country considered. There this issue is still pending.

Following Regulation 2022/110 the MCLs for Spain and Italy were considered within the modelling frameworks as the reference catch value for the deep-water fisheries in EMU 1 and EMU 2 in 2022. The MCL for France, instead could not be accounted for due to the lack of data suggesting the presence of such a fishery in GSA 7 and 8, and to the lack of stock assessment for ARA and ARS in GSA 7 and 8. Therefore, it was not possible to account for the effect of a potential increase in the pressure on ARA and ARS stocks if a deep-water fishery started in GSA 7 and 8 by a French fleet. A number of revisions on how MCLs were implemented during EWG 22-01 are reported in section 4.2.1. The main point that experts highlighted is to consider Fmsy as the target for 2025 instead of a value of catch at Fmsy. This procedure would allow to evaluate the consequences of implementing a MCL, as biomass response is updated. In order to have a meaningful update of the biomass though, specific harvest control rules (HCR) to be accounted for should be defined. It should than be stressed that all stocks evaluated in the western Mediterranean at present lack official biomass reference points such as Bpa or Blim.

During the procedure followed to define hotspots that could potentially help define additional closure areas, a number of limitations due to the availability of spatial data were highlighted in section 4.2.1. One of the main points raised was the lack of survey data for more than one quarter per GSA limiting the potential to test the effect of seasonal closures against permanent closures independently from fishers' behavior. As highlighted in section 3.2.2 the complete lack of information on the distribution and behaviour of fleet segments under 15m is quite limiting when defining spatial management measures as it could underestimate the importance of management of coastal areas compared to high seas ones. These caveats should be considered when interpreting results obtained from spatially explicit mixed-fisheries models. Due to time limitations it was not possible for either of the spatially-explicit models to explore the effects of implementing both MCLs and closure areas which aim at limiting fishing mortality on the same species. EWG 22-01 highlights that managing a resource by controlling multiple aspects at the same time can become counterproductive, therefore these kind of scenarios should be explored in future EWGs and considered with caution, specifically considering that the Western Mediterranean MAP plans to implement effort reductions, closure areas and MCLs at the same time on the same fisheries.

Bioeconomic models rely on modelling the population dynamics of fish stocks and the economic dynamics of fleets. In the case of multi-species fisheries, such as the western Mediterranean demersal fisheries, the number of fish stocks for which there are parameters to populate a population dynamics models are typically few. For instance, in EMU1 demersal fisheries land around 60 species in significant quantities, but only 6 are concerned by the Multi-Annual Management Plan (see STECF 18-13 and STECF 20-13). These 6 species are, obviously, the main species in terms of landings and economic importance at EMU level, and stock assessments are regularly produced for those. However, they may represent 20% or less (depending on the GSA) of the total demersal fisheries production (see STECF 20-13). However, the population dynamics of the majority of these other demersal stocks ("secondary species" or commercial bycatch) is not well-known and the effect of the effort reduction proposed in the MAP on these secondary species cannot be assessed with any accuracy. Similarly, for EMU 2 data of FDI of 2020 confirm that the target species of the MAP represent 45% in volume and 56% in value, compared to the total landing. Accounting for other important species of the trawl fisheries in EMU2 for both landing volume and value would bring the evaluation of the total landings around 59% in volume and 72% in value. Though, at present, analytical stock assessments are not available for these additional species. As a consequence, the evaluation of the true economic effect of the effort reduction remains uncertain.

2 MAXIMUM CATCH LIMITS

Under the Western Mediterranean Multiannual Plan (Regulation (EU) 2019/1022), fishing effort reduction could be supplemented (Article 7(3)(b)) with specific technical or conservation measures, where scientific advice shows that remedial measures are needed, in order to achieve the required F_{MSY} levels for demersal stocks. The additional measures can be a combination of changes in fishery selectivity, temporal and/or permanent closures or maximum catch limits (MCLs), among others.

MCLs have already been set for sardine and anchovy in the Adriatic Sea since 2019, where a maximum level of catches for both species is given limited to Croatia, Italy and Slovenia, but without an allocation between the three MSs until 2021, temporal or by fleet (Council Regulation 2019/2236). MCLs have also been established in 2022 for blue and red shrimp and giant red shrimp, with quota allocated between Italy and Spain (France does not have a fisheries targeting blue and red shrimps and giant red shrimp) (Regulation (EU) 2022/110). Examples of local MCLs implemented in Mediterranean fisheries include boat seines targeting transparent gobies in Italy and Spain (Commission Implementing Regulation (EU) 2018/1634 and Commission Implementing Regulation (EU) No 2020/1243 & No 2020/1242, respectively), as well as sandeel in Catalonia (NE Spain, Commission Implementing Regulation (EU) 2021/1713). Perhaps the best documented example of successful MCL implementation in Mediterranean fisheries is the co-management plan of the sandeel boat seine fishery in Catalonia, Spain where a monthly MCL is divided by quotas allocated per vessel and day (Lleonart et al., 2014). Both this fishery and the crystal goby fisheries are carried out by a limited number of small vessels using specific fishing gear and with limited effort, so the main output control measure (MCL) is complemented by a number of input measures.

Annually-agreed Total Allowable Catches (TACs) for EU North East Atlantic stocks have been in place since the beginning of the CFP. TACs are shared among the different MSs according to 'relative stability', a system by which MS are allocated a fixed proportion of a stock' TAC, that was assigned to each MS participating in the fishery at the time of joining the EU (Borges, 2018). On the other hand, MCLs as currently in force in Mediterranean fisheries are fixed exclusively for one year and without prejudice to any other measures adopted in the future and any possible allocation scheme between Member States (Council Regulation 2019/2236). Regardless of the different EU legal definitions and requirements, both TACs and MCLs constitute output control fisheries management measures, designed to limit fishing mortality of a particular stock when its predetermined catch amount is exhausted. In addition, both TACs and MCLs carry the requirement of the Landing Obligation (Art. 15 of Regulation (EU) 2013/1380).

Lizaso et al. (2020) and Bellido et al. (2020) offer a general discussion of the advantages and disadvantages of input fisheries control measures, and was adapted as follows. Output limits are flexible and may adapt fishing mortalities to stock status but they may be ineffective due to several reasons, among them a rush to fish, insufficient enforcement or to discarding. If fishers have exhausted their quota of a given stock but continue fishing for other stocks, they will discard or land illegally catches of the species for which the quota is exhausted. The Landing Obligation intends to stop this practice but introduces additional problems, namely early closure of a fishery due to the exhaustion of one of its quotas (choke effect), in addition to new enforcement challenges. According to STECF 21-13 however, in an input effort management system fishers tend to invest in technical improvements to increase their efficiency in catching fish (higher catch per unit of effort (CPUE)) as the overall catch is not limited. Calculations by EUROSTAT show an increase in efficiency in fishing fleets in the past even in areas without effort management system in place (EUROSTAT, 2019). The consequences of an increase in efficiency would be that the effort must be reduced regularly to adjust for the technical improvements. In addition, the definition and measurement of a reasonable unit measure of fishing effort is also a challenge.

It is important to notice that neither the management of fishing effort or of catch are likely to be effective unless they are correctly implemented and applied to all fishers (or at least the overwhelming majority) engaged in a fishery (adapted from Pope, 2002). In general, output or input controls will only be effective if its overall baselines and ceilings are in line and consistent with the reality of the fishery they are meant to limit (for example, the landings of sardine and anchovy in the Spanish Mediterranean purse seine fisheries are much lower than the TACs in force because of the low biomass levels of these stocks). Specifically, technological creep and increase fishing efficiency in an effort scheme needs to be taken into account, while discarding and illegal landings need to be controlled in a catch system.

2.1 Background

2.1.1 LPUE data by quarter in EMU 1

The Landings per Unit of Effort (LPUE) for species European hake (HKE) and blue and red shrimp (ARA) were computed from FDI data for France (FRA) (Tables A and G) and MBS data (DCF 2021, tables catch and effort). As explained in the section "Data issues" the data for ESP had numerous inconsistencies for the years 2015-2017.

2.1.1.1 EMU1 European hake (passive gears)

HKE is exploited by three main types of passive (static) fishing gears in EMU1 by Spain (ESP) and FRA fleets. Passive gears are operated by small to medium sized vessels (VL0006 to VL1218) operating set longlines (LLS), gillnets (GNS) and to a lesser extent trammel nets (GTR). The quarterly evolution of HKE LPUE in GSA1 shows the main contributor to LPUE is VL1218 using GNS, while LLS activity was very low for the years 2019-2020. In this last two years the LPUE of HKE in GSA1 comes practically entirely from set nets, except in the last quarter of 2020 when the contribution of LLS in VL0612 appears to become significant again. Vessels in the smallest length class VL0006 have very low production of HKE (fig. 2.1.1.1.1).

In GSA5 only the vessel class VL0612 is active on HKE, with most of the LPUE attributed to GNS except in certain years (2016 and first half of 2017; 2019) when the contribution of LLS is dominant (fig. 2.1.1.1.1).

In GSA6 the main vessel length-gear combination responsible for HKE LPUE is VL1218 operating LLS, also for some years (2015, 2019) vessels in the medium-size class VL1218 are important. The LPUE produced by vessels in classes VL0612 and VL1218 operating GNS is low (20-30% of total LPUE) but consistent across all years and quarters. As in GSA1, vessels in the smallest length class VL0006 have sporadic, very low production of HKE (fig. 2.1.1.1.1).

Two member states operate passive gears in GSA7: ESP and FRA, but only FRA has consistent, high production of HKE. The ESP units operating in GSA7 use practically always LLS, with some quarters of inactivity in 2015, 2016 and 2017 and are in most cases attributed to the VL1218 vessel length class. In FRA instead most of the HKE LPUE is due consistently to units operating GNS in the length class VL1218, with some contribution of the smaller VL0612 class. Note however than in the last quarter of 2020 practically the entire HKE production is attributed to the VL0612 vessel length class operating different types of set nets (GNS, GTR, GTN) or even LLS, which had very low incidence on previous quarters (fig. 2.1.1.1.1).

Overall no significant changes in the proportions of HKE LPUE allocated to the different vessel length classes and métier combinations can be appreciated for the period 2015-2020.

2.1.1.2 EMU1 European hake (active gears)

HKE is produced by otter bottom trawls (OTB) operated by ESP in GSA1, 5, 6 and 7. In GSA7 the FRA trawlers operate increasingly twin and midwater trawls (OTT and OTM).

In GSA1, 50% or more of the HKE LPUE is consistently (across all quarters) produced by large trawlers operating OTB in the vessel length class VL2440, attributed to the main three demersal *métiers*: DEF, MDD and DWS, with predominance of DEF. A variety of mid-size to small vessels have some contribution to LPUE consistently each quarter of the period 2015-2020 in small proportions each, mostly attributed to the DEF *métier*. The smallest vessel length class represented in the data set (VL0612) had some contribution to LPUE only in the first two years (fig. 2.1.1.2.1).

In GSA5 the contribution of the largest vessel class VL2440 to HKE LPUE has increased from less than 20% in 2015 to practically 50% in recent years. Again, HKE LPUE is attributed to the main three demersal *métiers* but the contribution of DEF is more important. As in GSA1, units in VL1218 and VL1824 also have consistent contributions to HKE LPUE along the entire period, distributed among the three demersal *métiers* (fig. 2.1.1.2.1).

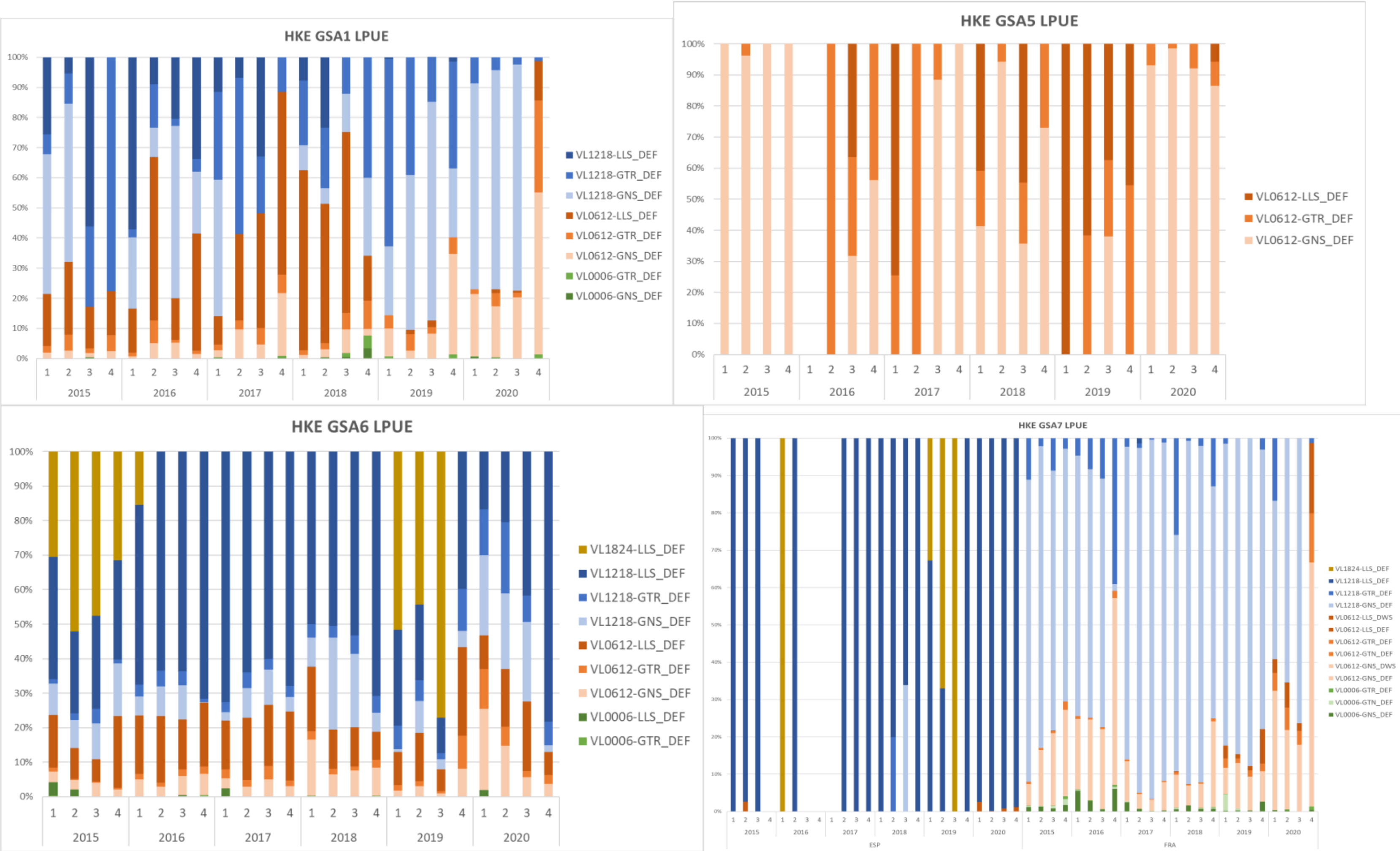


Figure 2.1.1.1.1 LPUEs of European hake caught by passive gears in EMU 1 calculated in relation to fishing days, by GSA and fleet segment.

In GSA6, 50% or more of the HKE LPUE is consistently produced by large trawlers operating OTB in the vessel length class VL2440, with the largest share attributed to the DEF *métier* (cf. with GSA1 and GSA5 where the contributions of MDD and DWS where relatively important). Similar to GSA1, vessel length classes VL1218 and VL1824 produce consistent proportions of HKE LPUE along the entire period 2015-2020, attributed to the three demersal métiers, with predominance of DEF. The contribution of small vessels VL0612 is testimonial (fig. 2.1.1.2.1).

In GSA 7, HKE LPUE for ESP is split practically equally between the largest vessel class VL2440 and the medium sized VL1824 and the LPUE is generally attributed to the DEF *métier*. Note however sporadic contribution to HKE LPUE by units in VL1218 by ESP in some quarters of the period and in the entire year 2020. In FRA between 60 and 70% of the HKE LPUE is contributed by the largest vessel class VL2440 operating OTB, OTM, or OTT generally in the DEF métier. Consistent contribution the VL1824 class in the DEF métier is also observed (fig. 2.1.1.2.1).

Overall no significant changes in the proportions of HKE LPUE allocated to the different vessel length classes and métier combinations can be appreciated for the period 2015-2020.

2.1.1.3 EMU1 Blue and red shrimp (active gears)

The Blue and red shrimp (ARA) is produced exclusively by ESP otter bottom trawl in EMU1 in GSAs 1, 5 and 6. For the purposes of this analysis the relatively small production of ARA in GSA2 is included in GSA1 and the production of ARA by ESP in GSA7 is combined within GSA6.

In GSA1 the three vessel length classes VL1218, VL1824 and VL2440 produce similar contributions to ARA LPUE. Most of the production is attributed to *métier* DWS, but a certain, non-negligible amount is attributed to MDD (fig. 2.1.1.3.1).

In GSA5 the contribution of the smaller VL1218 vessel length class to ARA LPUE is very low across the entire study period. The contribution of the MDD métier is relatively more important here than in GSA1 and the chart shows that small proportions of ARA LPUE are attributed even to the DEF *métier* for vessel length class VL2440 (fig. 2.1.1.3.1).

In GSA6, similar to GSA1, the three vessel length classes VL1218, VL1824 and VL2440 produce comparable contributions to ARA LPUE. In some quarters of the years 2015-2016 small contributions to LPUE by the smaller vessel length class VL0612 are also shown. In GSA6 ARA LPUE is consistently attributed to *métiers* DWS and MDD.

Overall no significant changes in the proportions of ARA LPUE allocated to the different vessel length classes and métier combinations can be appreciated for the period 2015-2020.

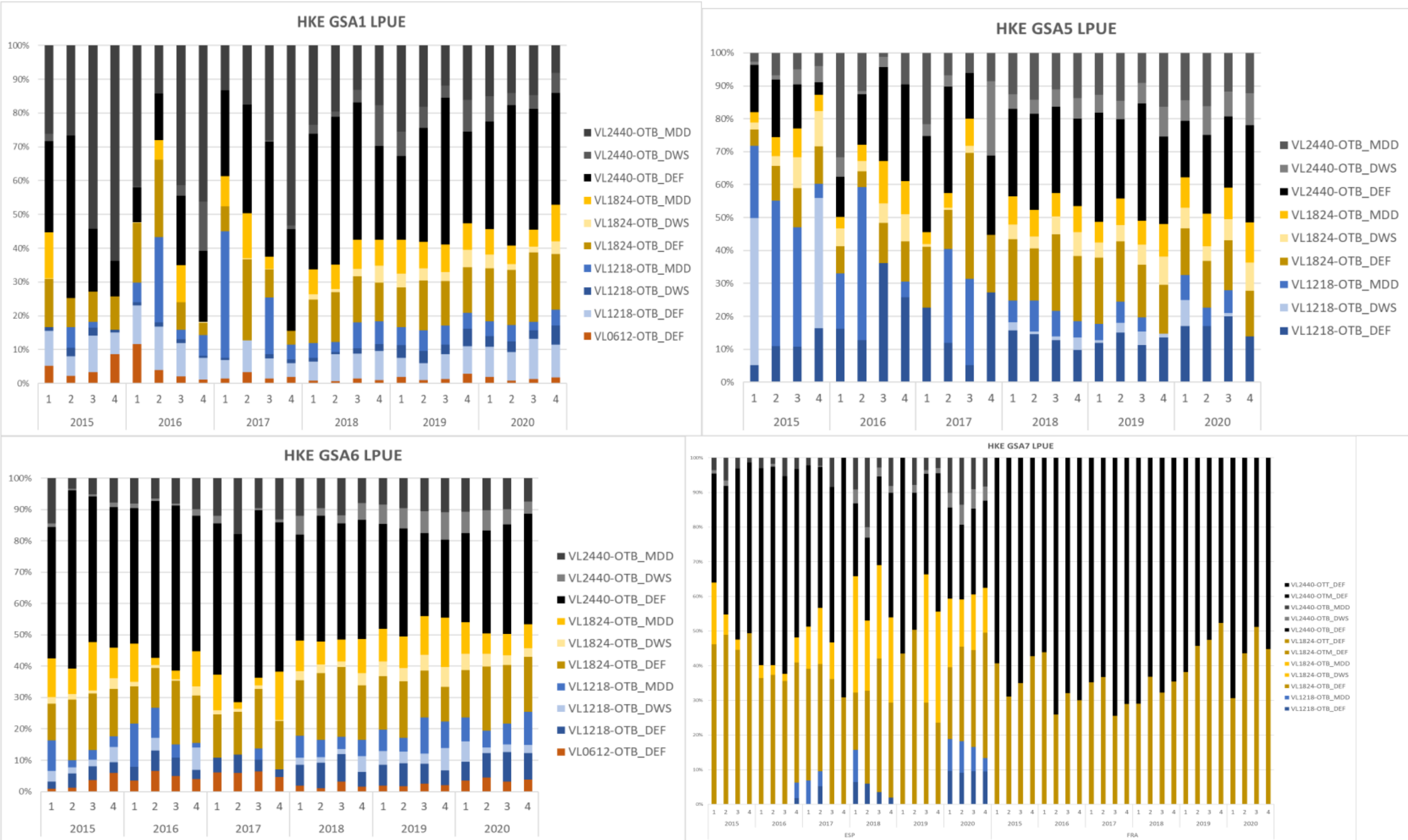
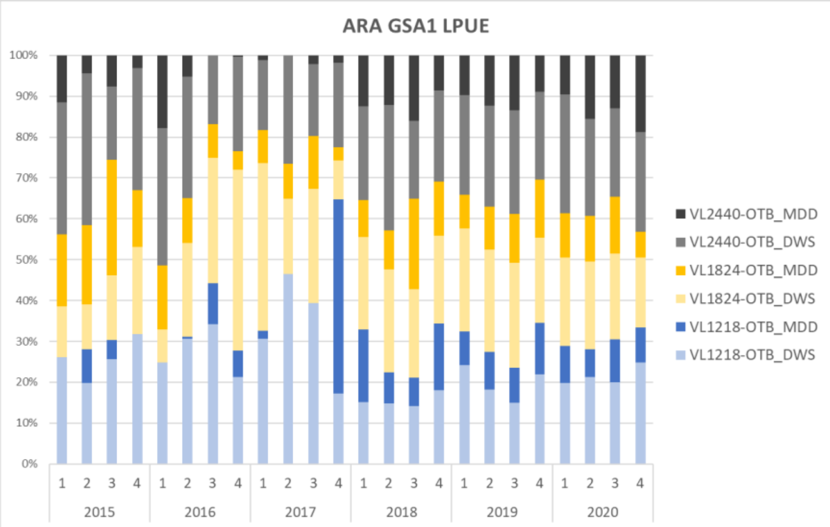
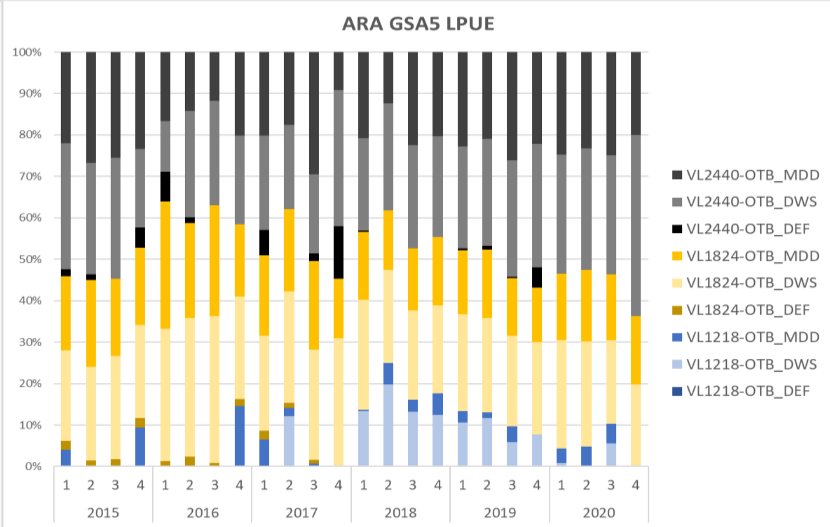


Figure 2.1.1.2.1 LPUEs of European hake caught by passive gears in EMU 1 calculated in relation to fishing days, by GSA and fleet segment.


ARA GSA1 LPUE
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4
2015 2016 2017 2018 2019 2020
VL2440-OTB_MDD
VL2440-OTB_DWS
VL1824-OTB_MDD
VL1824-OTB_DWS
VL1218-OTB_MDD
VL1218-OTB_DWS


ARA GSA5 LPUE
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4
2015 2016 2017 2018 2019 2020
VL2440-OTB_MDD
VL2440-OTB_DWS
VL2440-OTB_DEF
VL1824-OTB_MDD
VL1824-OTB_DWS
VL1824-OTB_DEF
VL1218-OTB_MDD
VL1218-OTB_DWS
VL1218-OTB_DEF

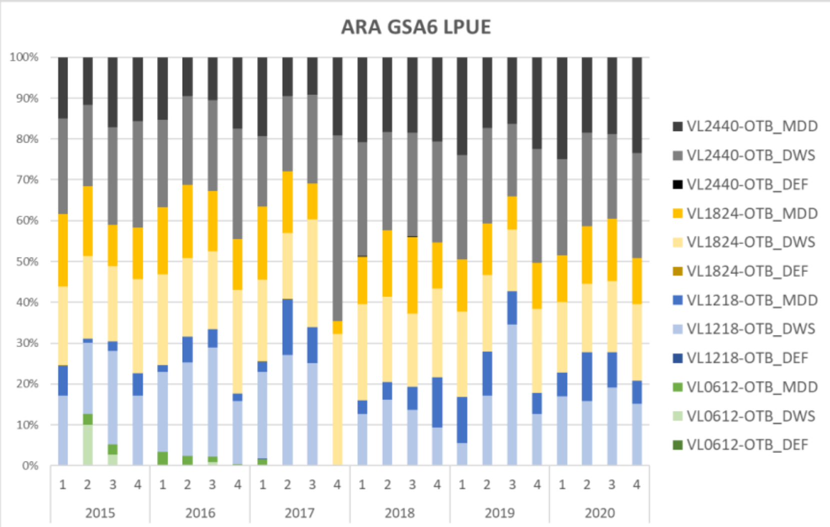

ARA GSA6 LPUE
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4
2015 2016 2017 2018 2019 2020
VL2440-OTB_MDD
VL2440-OTB_DWS
VL2440-OTB_DEF
VL1824-OTB_MDD
VL1824-OTB_DWS
VL1824-OTB_DEF
VL1218-OTB_MDD
VL1218-OTB_DWS
VL1218-OTB_DEF
VL0612-OTB_MDD
VL0612-OTB_DWS
VL0612-OTB_DEF

Figure 2.1.1.3.1 LPUEs of Blue and red shrimp caught by trawling gears in EMU 1 calculated in relation to fishing days, by GSA and fleet segment.

2.1.2 Data issues in EMU 1

The DCF Fisheries Dependent Information (FDI) data made available to EWG 22-01 for GSAs 1, 2, 5, 6, 7 submitted by ESP had numerous inconsistencies in Tables A (landings) and G (effort) for the years 2015-2017. These inconsistencies were revelead by internal checks of the quarterly data series for the primary indicators of interest to EWG 22-01: total landings for Table A, and total fishing days and total sea days for Table G. Cross checks with the data bases in the Mediterranean and Black Sea (MBS, DCF 2021) and in the Annual Economic Report electronic appendix were also made. The data issues identified for the two target stocks (hake: HKE; blue and red shrimp: ARA) and the demersal fleets were as follows:

2.1.2.1 FDI Table A (Landings)

The landings for the years 2015-2017 of HKE and ARA in FDI Table A are consistenly lower (40 to 50% lower, depending on the year and quarter) than the landings reported in the MBS data set (fig.2.1.2.1.1). Figures 2.1.2.1.1-.2 compare the value landings of HKE and ARA in the different GSAs of EMU1 exploited by the ESP fleets. The MBS landings data (in grey) are systematically higher than the FDI data for the years 2015-2017 but coincide exactly in the years 2018-2020.

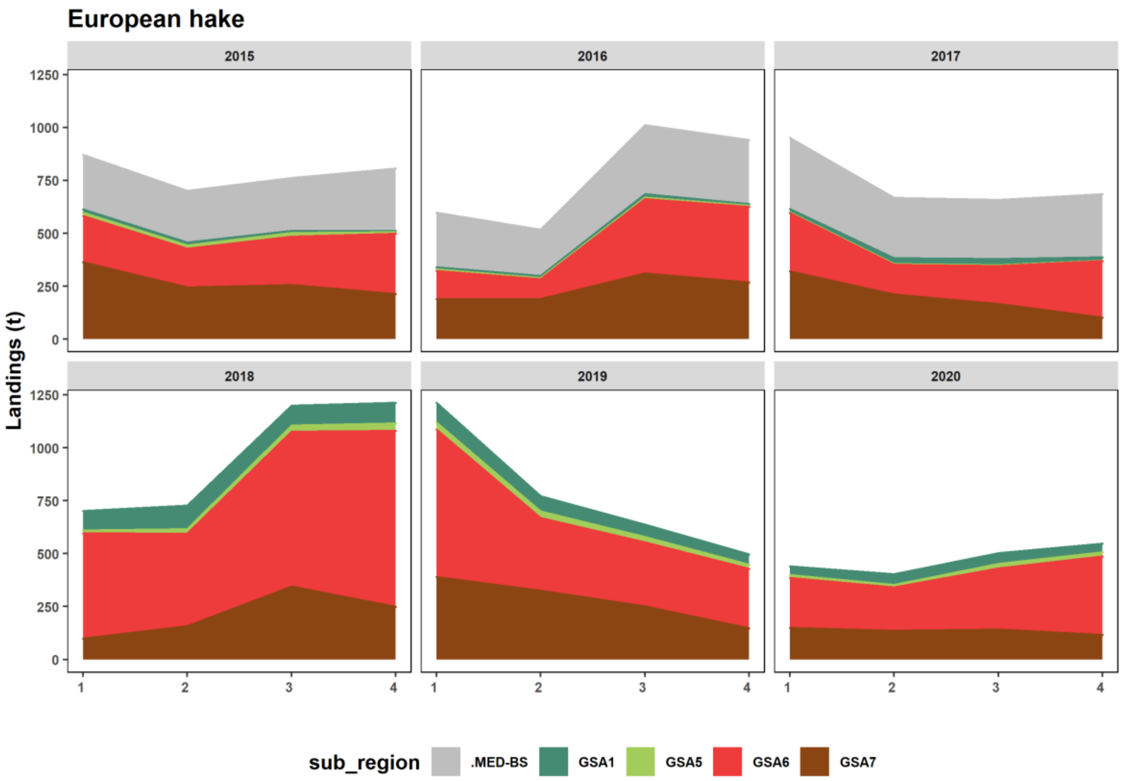


Figure 2.1.2.1.1 Landings per quarter of European hake (HKE) in the GSAs exploited by ESP in EMU1 according to the FDI_A data (color) and from the MED_BS data (DCF 2021) (grey).

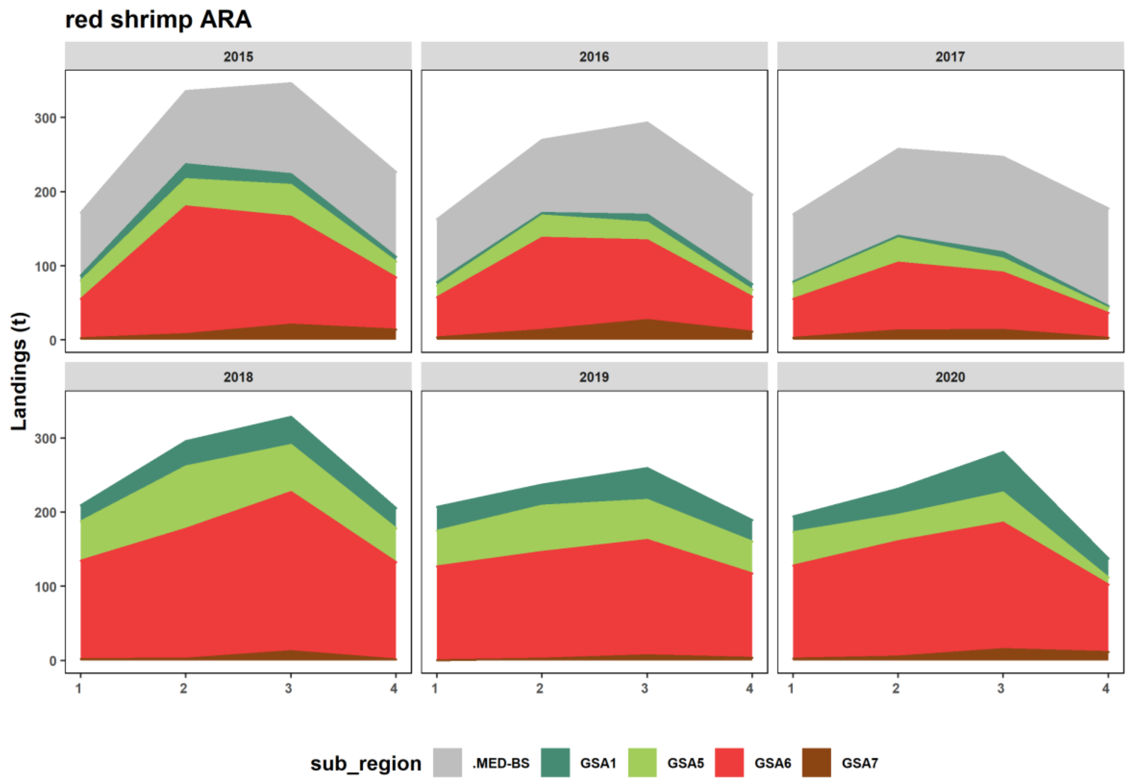


Figure 2.1.2.1.2 Landings per quarter of blue and red shrimp (ARA) in the GSAs exploited by ESP in EMU1 according to the FDI_A data (color) and from the MED_BS data (DCF 2021) (grey).

2.1.2.2 FDI Table G (Effort)

Immediately prior to EWG 21-13 a new data set was made available to the group from the ESP administration to correct from previous inconsistencies. The group from EWG 22-01 notes that this new dataset is still showing inconsistencies in the indicator **total fishing days**. Figures 2.1.2.2.1-.2 show this indicator in the *original* FDI Table G data set and in the *revised* FDI Table G. Both data sets are inconsistent for the years 2015-2017, specifically OTB which is the most important gear contributing to the total catches of Western Mediterranean MAP target species in EMU1. The total fishing days are largely underreported for all vessel length classes of OTB of ESP in EMU1 for years 2014-2017 (Fig. 2.1.2.2.1). Total fishing days in other sources, such as the electronic annex to the Annual Economic Review or the MED_BS data set, show a progressive decrease in fishing effort for all vessel length classes, from high values in 2014 to low values in 2020. This downward trend is correctly reported in the revised FDI Table G data for OTB vessel classes VL1218 and VL1824 (Fig. 2.1.2.2.2) but not for VL2440 or VL40XX. Moreover, the data series for the latter ends in 2017 (Fig. 2.1.2.2.2). Furthermore, for OTB the revised data series adds two vessel length classes (VL0010 and VL1012) with incomplete time coverage. In addition, in the revised Table G data set further inconsistencies were introduced in other fishing gear. For instance, compare LLS, GNS and PS in the figures 2.1.2.2.1-.2). The data series for PS, which was correct in the original FDI Table G, shows now in the revised table very large values of effort for the years 2014-2017, incosistent with 2018-2020 for all length classes (Fig. 2.1.2.2.2). Similarly GNS and LLS show abrupt jumps for certain vessel length classes in the revised data series (Fig. 2.1.2.2.2). Although not relevant for this EWG, the values of fishing days reported for DRB are more than one order of magnitude higher in the revised FDI Table G compared with the original. Note also the very large amount of effort reported for "NK" fishing gear in the revised table (Fig. 2.1.2.2.2).

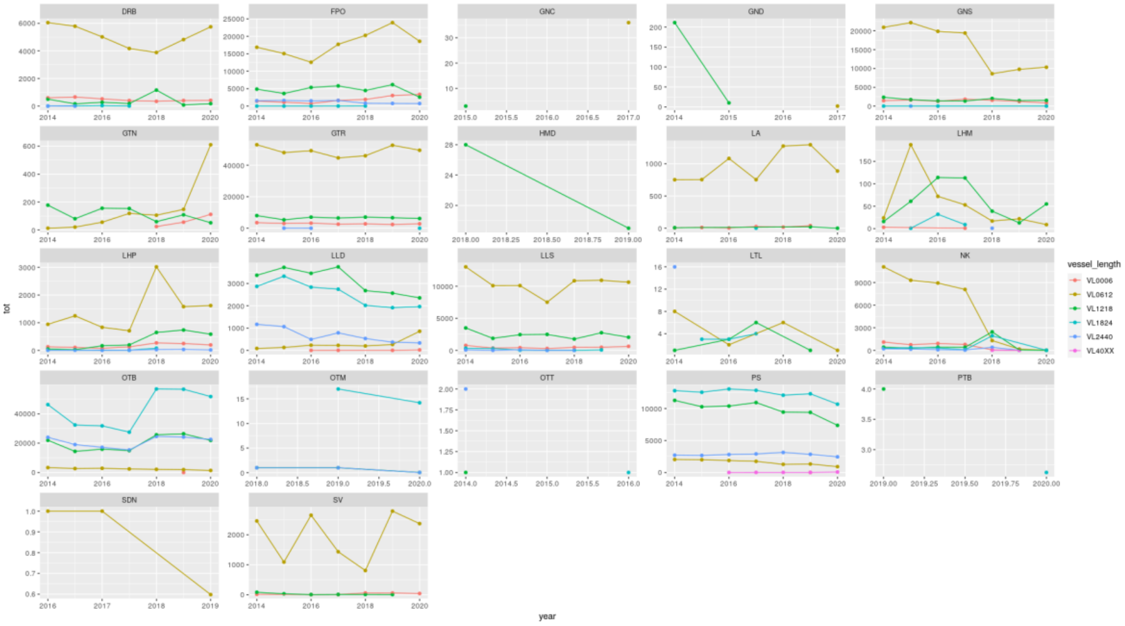


Figure 2.1.2.2.1. Total fishing days per vessel length and fishing gear for ESP fleets in EMU1 in the <u>original</u> (submitted to the official 2021 FDI datacall) FDI Table G data set.

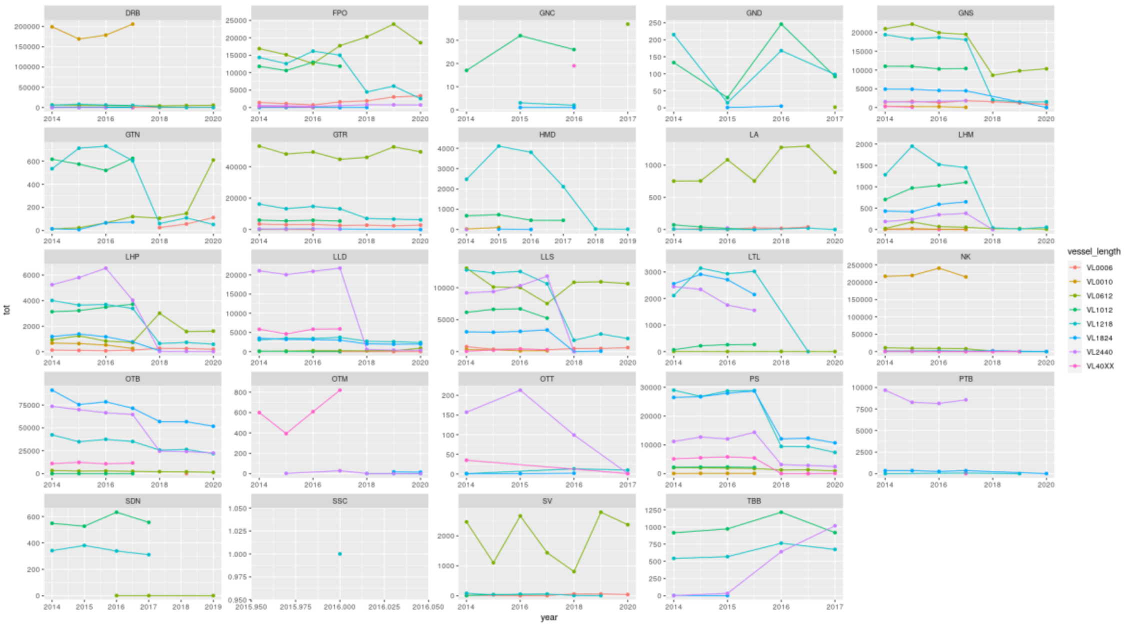


Figure 2.1.2.2.2. Total fishing days per vessel length and fishing gear for ESP fleets in EMU1 in the <u>revised</u> (submitted prior to EWG 21-13) FDI Table G data set.

Figure 2.1.2.2.3 shows in more detail the discrepancy between the original FDI Table G effort and the MBS Table effort in total fishing days for the main three demersal fishing gears

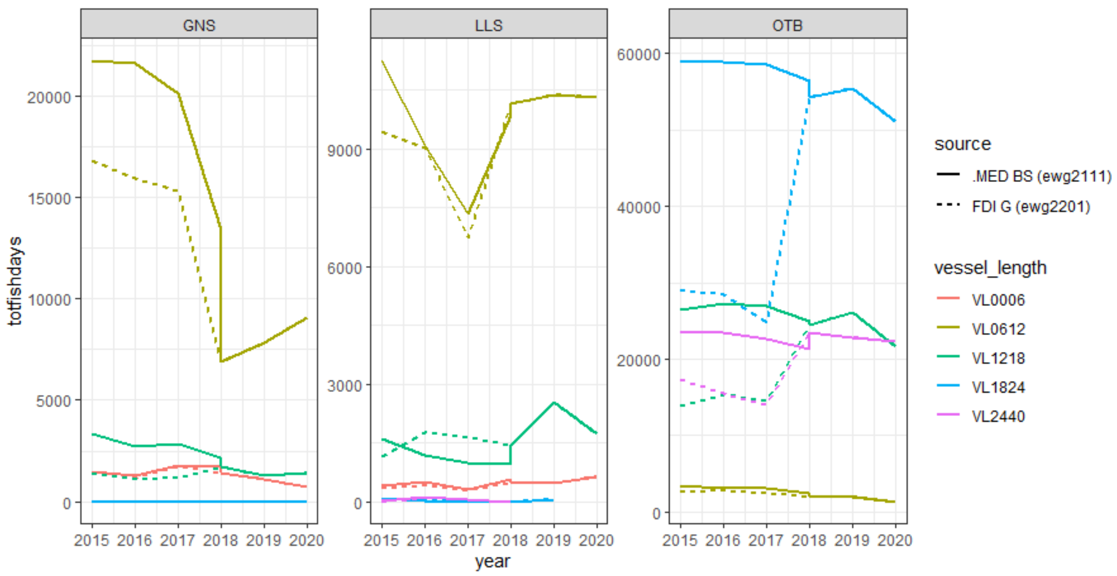


Figure 2.1.2.2.3. Fishing effort (total fishing days) in GSAs 1, 2, 5, 6 and 7 exploited by ESP by vessel class for the three main fishing gears. Continuous line: effort table from MBS (DCF 2021); broken line: Table G from FDI (original table).

The **total fishing days** indicator in FDI Table G was compared with the electronic data from the Annual Economic Report (STECF 21-08) and partial agreement for certain years and combinations gear / vessel length was found. Instead, the indicator **total sea days** in FDI Table G (revised) and in the electronic appendix to STECF 21-08 coincided almost exactly. For this reason, it was decided to use **total sea days** as proxy for fishing effort by ESP in EMU1 for the present EWG. Furthermore, as fishing days and sea days are equivalent 1 to 1 in ESP, due to the historical limitation of fishing trips to 12 or 15 h per day, the use of the correctly reported **total sea days** in the present EWG is justified.

2.1.3 LPUE data by quarter in EMU 2

Landings per Unit Effort (LPUE) for European hake (HKE), blue and red shrimp (ARA) and giant red shrimp (ARS) were computed from FDI data (Tables A and G) for FRA (GSA 8) and ITA (GSAs 9, 10 and 11).

2.1.3.1 EMU2 European hake (passive gears)

As per Figure 2.1.3.1.1 in GSAs 8, 9 10 and 11 (FRA and ITA), HKE is targeted by three different passive gears: gillnets (GNS), trammel nets (GTR) and longlines (LLS), generally belonging to length classes from VL0006 to VL1218.
Overall, no significant changes in the proportions of HKE LPUE allocated to the different vessel length classes and métier combinations can be appreciated for the period 2015-2020, but some differences are present among the GSAs.
GSA 8 is the only one in which small vessels (VL0006 and VL0612) are dominant in terms of contribution to HKE LPUE. Set nets are the most present, while longlines strongly contribute only in the last part of the timeseries.
Vessels belonging to length class VL1218 are the most represented in GSA9, especially by set nets. The main fleet segment responsible for HKE LPUE is VL1218 operating GNS. The LPUE produced by vessels in length classes VL0006 and VL0612 is low (less than 10-20% of total LPUE), but consistent across all years.

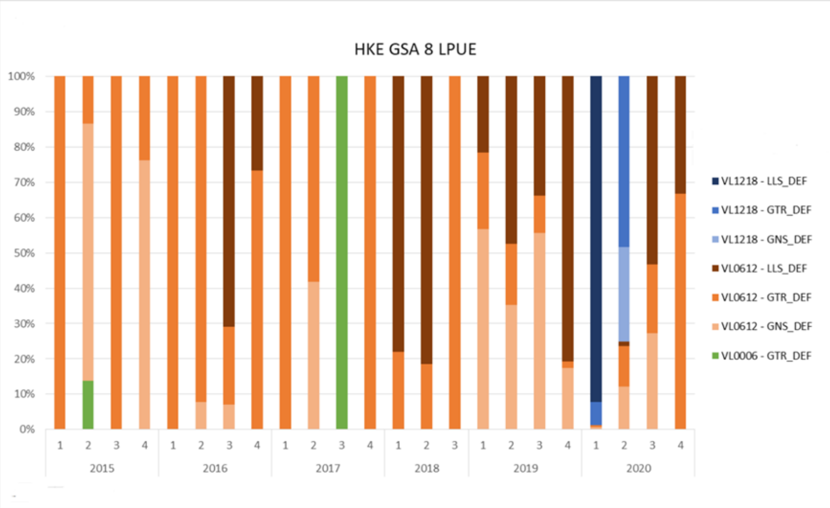
In GSA 10 there is an important contribution of vessels operating LLS, belonging to length classes from VL0612 to VL1824. Also small-medium vessels (VL0612 and VL1218) operating GNS are well represented, giving more than 30% of total HKE LPUE.
Similarly to GSA 9, vessels in length class VL1218 are the most represented in GSA 11, operating both set nets and longlines. Only in the last two quarters of 2020, vessels in class VL1824 operating LLS appear to consistently increase their contribution to LPUE.

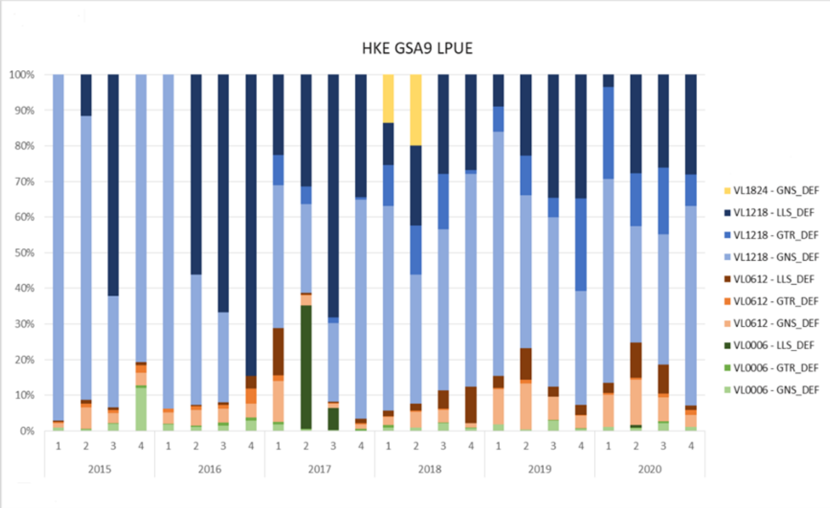
2.1.3.2 EMU2 European hake (active gears)

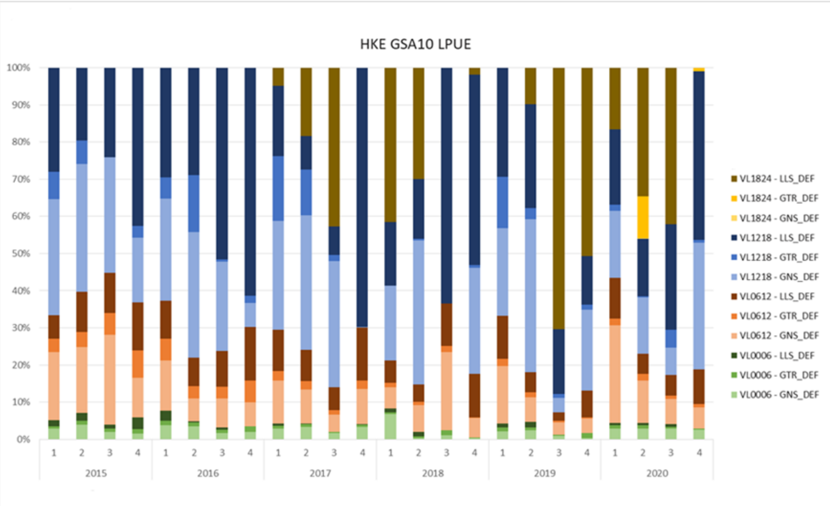
As per Figure 2.1.3.2.1 HKE is exploited by bottom otter trawls (OTB) with three different *métiers*: vessels targeting demersal species (DEF), the ones targeting deep water species (DWS) and those targeting a mixed demersal species and deep water species (MDD).
In GSA 8 only trawls targeting demersal species are operating, especially vessels in length classes VL2440 and VL1218.
In GSA 9, the two largest length classes (VL1824 and VL2440) are equally represented, contributing around 30-35% of total LPUE each. In both cases, production is splitted between vessels targeting demersal species (DEF) and the mixed ones (MDD). Vessels targeting deep water species have very low production of HKE.
Vessels in length class VL1824, DEF and MDD, are the most important in GSA 10 in terms of contribution to LPUE, until 2018. In the last two years, largest vessels (more than 24 m) started increasing their contribution to LPUE (35-50% of total LPUE, with maximum in the second quarter of 2020). Again, the most present *métiers* are DEF and MDD.
The contribution of vessels VL2440 is quite consistent and dominant in GSA 11. The LPUE produced by vessels in length class VL1824 increases since 2017.

2.1.3.3 EMU2 Blue and red shrimp and giant red shrimp (active gears)

As per Figure 2.1.3.3.1-2 the blue and red shrimp (ARA) and the giant red shrimp (ARS) in EMU2 are produced by bottom otter trawl attributed generally to DWS and minimally to MDD *métiers*. For this species, LPUEs have been calculated only for GSAs 9, 10 and 11, as there are no landings reported in GSA 8.
In GSA 9 the most contributing fleet segment, both for ARA and ARS, is OTB-DWS VL1824 (around 40% of total LPUE for each species), followed by OTB-DWS VL1218 (20-25% of LPUE). Small proportions of LPUE are also attributed to MDD *métiers* of same length classes and MDD *métier* of larger vessels (VL2440).
In GSA 10 fleet segment OTB-DWS VL1824 is the most contributing to ARA and ARS LPUE until 2018, while in the last two years more than 40% of LPUE are attributed to vessels in length class VL2440. A lower but non-negligible amount of LPUE is attributed to vessels in length class VL1218.
In GSA 11 most of the contribution to ARA and ARS LPUEs is attributed to length classes VL2440. Production given by vessels in length class VL1218 is consistent during the time series, while medium size vessels (VL1824) start increasing their contribution since 2017.
All the three GSAs attribute a low amount of ARA and ARS LPUEs to small vessels (VL0612) in the last part of the time series, since 2018. This seems to be a misreporting issue, as small vessels are usually not equipped to perform deep water fishing activities (see data issues section).


HKE GSA 8 LPUE
VL1218 - LLS_DEF
VL1218 - GTR_DEF
VL1218 - GNS_DEF
VL0612 - LLS_DEF
VL0612 - GTR_DEF
VL0612 - GNS_DEF
VL0006 - GTR_DEF
2015
2016
2017
2018
2019
2020


HKE GSA9 LPUE
VL1824 - GNS_DEF
VL1218 - LLS_DEF
VL1218 - GTR_DEF
VL1218 - GNS_DEF
VL0612 - LLS_DEF
VL0612 - GTR_DEF
VL0612 - GNS_DEF
VL0006 - LLS_DEF
VL0006 - GTR_DEF
VL0006 - GNS_DEF
2015
2016
2017
2018
2019
2020


HKE GSA10 LPUE
VL1824 - LLS_DEF
VL1824 - GTR_DEF
VL1824 - GNS_DEF
VL1218 - LLS_DEF
VL1218 - GTR_DEF
VL1218 - GNS_DEF
VL0612 - LLS_DEF
VL0612 - GTR_DEF
VL0612 - GNS_DEF
VL0006 - LLS_DEF
VL0006 - GTR_DEF
VL0006 - GNS_DEF
2015
2016
2017
2018
2019
2020

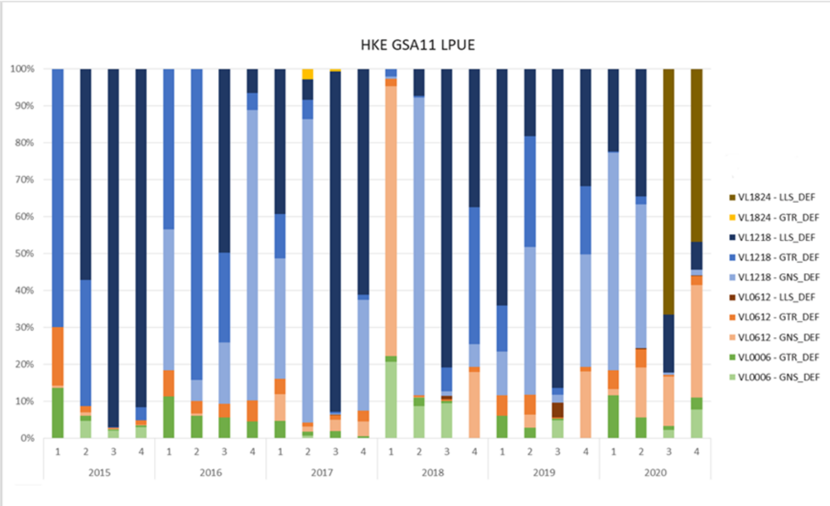

HKE GSA11 LPUE
VL1824 - LLS_DEF
VL1824 - GTR_DEF
VL1218 - LLS_DEF
VL1218 - GTR_DEF
VL1218 - GNS_DEF
VL0612 - LLS_DEF
VL0612 - GTR_DEF
VL0612 - GNS_DEF
VL0006 - GTR_DEF
VL0006 - GNS_DEF
2015
2016
2017
2018
2019
2020

Figure 2.1.3.1.1 LPUEs of European hake caught by passive gears in EMU 2 calculated in relation to fishing days, by GSA and fleet segment.

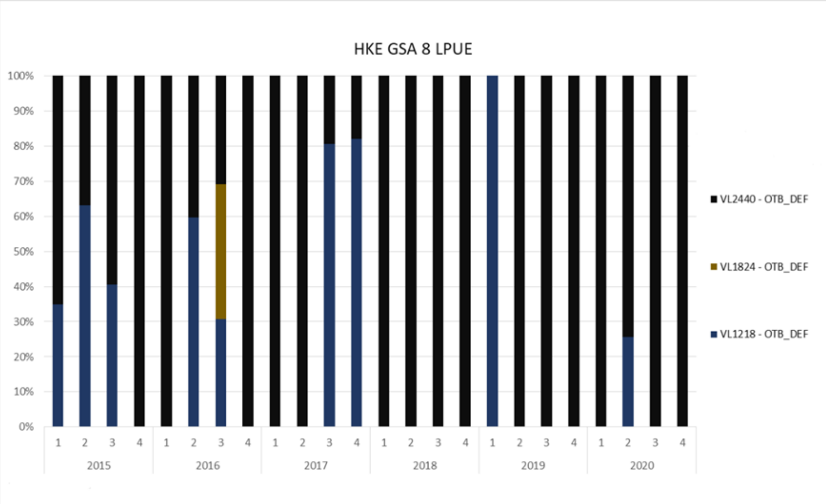
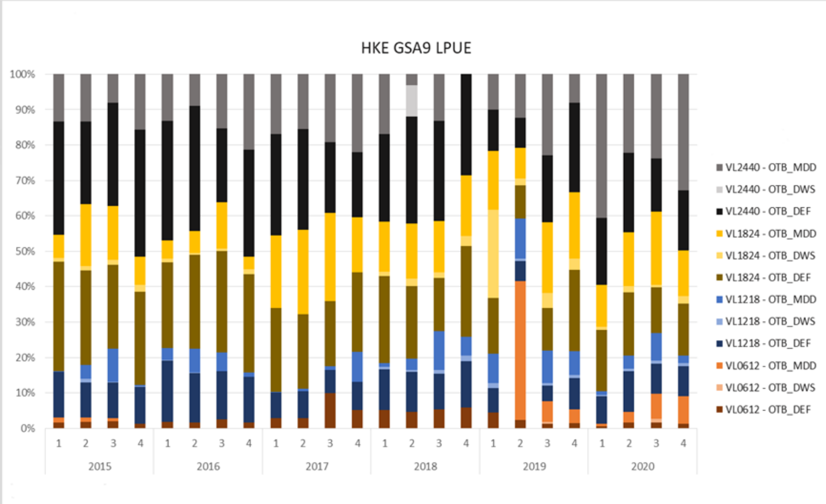
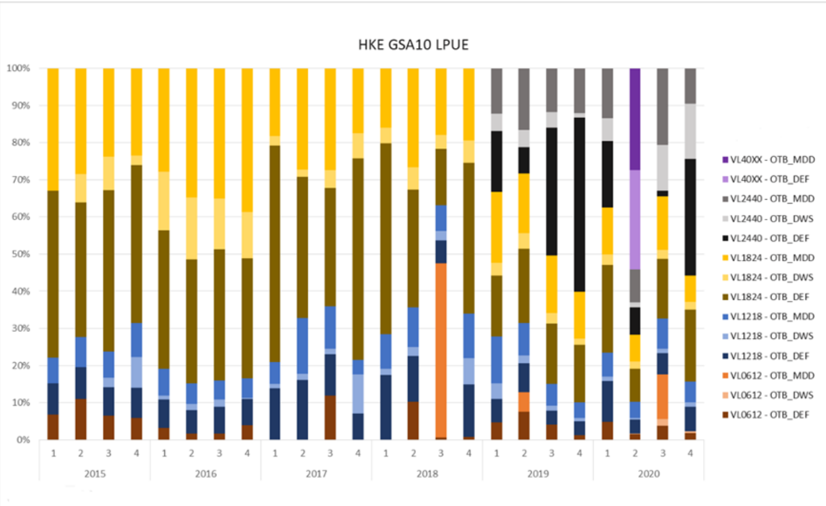
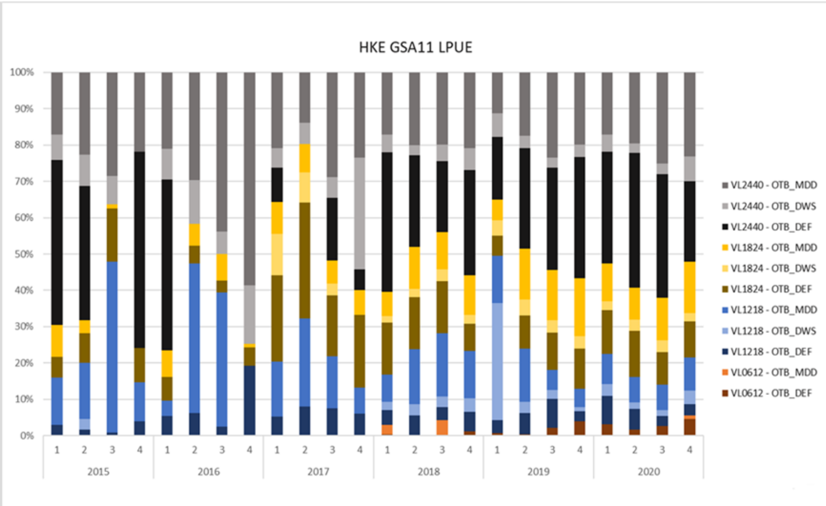

HKE GSA 8 LPUE
VL2440 - OTB_DEF
VL1824 - OTB_DEF
VL1218 - OTB_DEF
2015
2016
2017
2018
2019
2020

HKE GSA9 LPUE
VL2440 - OTB_MDD
VL2440 - OTB_DWS
VL2440 - OTB_DEF
VL1824 - OTB_MDD
VL1824 - OTB_DWS
VL1824 - OTB_DEF
VL1218 - OTB_MDD
VL1218 - OTB_DWS
VL1218 - OTB_DEF
VL0612 - OTB_MDD
VL0612 - OTB_DWS
VL0612 - OTB_DEF
2015
2016
2017
2018
2019
2020

HKE GSA10 LPUE
VL40XX - OTB_MDD
VL40XX - OTB_DEF
VL2440 - OTB_MDD
VL2440 - OTB_DWS
VL2440 - OTB_DEF
VL1824 - OTB_MDD
VL1824 - OTB_DWS
VL1824 - OTB_DEF
VL1218 - OTB_MDD
VL1218 - OTB_DWS
VL1218 - OTB_DEF
VL0612 - OTB_MDD
VL0612 - OTB_DWS
VL0612 - OTB_DEF
2015
2016
2017
2018
2019
2020

HKE GSA11 LPUE
VL2440 - OTB_MDD
VL2440 - OTB_DWS
VL2440 - OTB_DEF
VL1824 - OTB_MDD
VL1824 - OTB_DWS
VL1824 - OTB_DEF
VL1218 - OTB_MDD
VL1218 - OTB_DWS
VL1218 - OTB_DEF
VL0612 - OTB_MDD
VL0612 - OTB_DEF
2015
2016
2017
2018
2019
2020

Figure 2.1.3.2.1 LPUEs of European hake caught by active gears in EMU 2 calculated in relation to fishing days, by GSA and fleet segment.

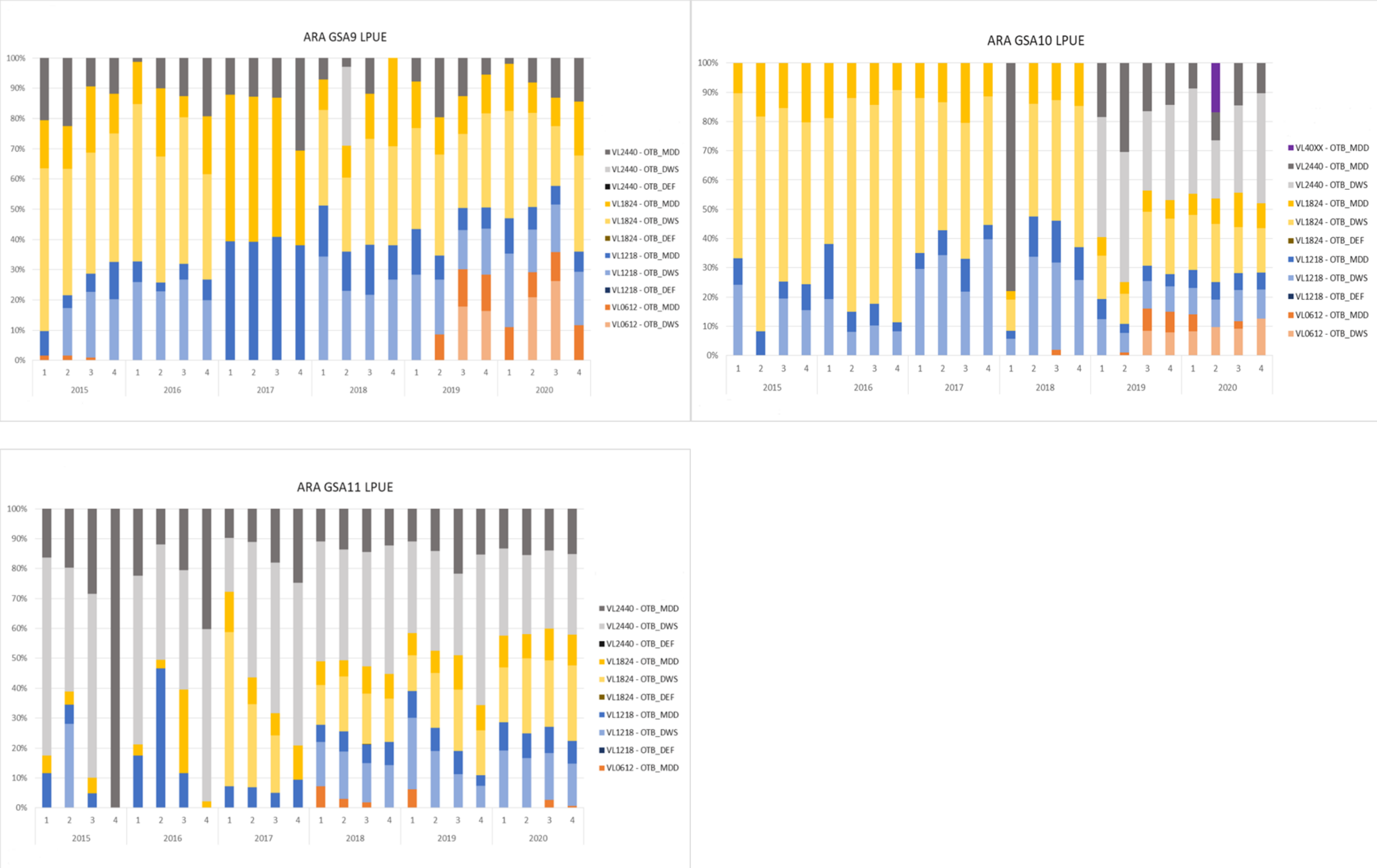


Figure 2.1.3.3.1 LPUEs of Blue and red shrimp caught by active gears in EMU 2 calculated in relation to fishing days, by GSA and fleet segment.

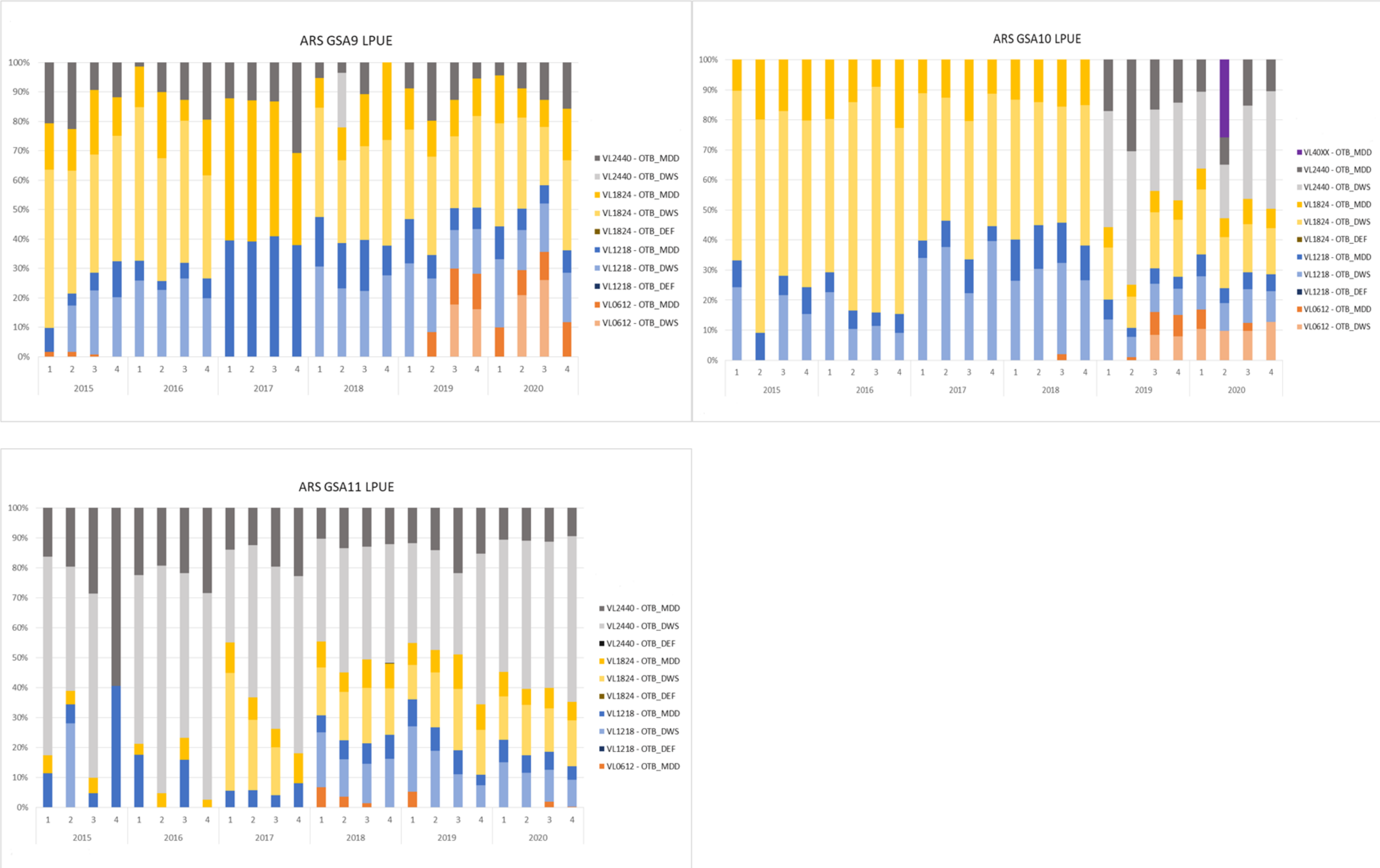


Figure 2.1.3.3.2 LPUEs of Giant red shrimp caught by active gears in EMU 2 calculated in relation to fishing days, by GSA and fleet segment.

2.1.4 Data issues in EMU 2

The DCF Fisheries Dependent Information (FDI) data made available to EWG 22-01 for GSAs 8, 9, 10 and 11 submitted by FRA and ITA did not show any particular inconsistency.

The only issue identified checking Tables A (landings) and G (effort) for years 2015-2020, is a probable misreporting in terms of landings for vessels fishing ARA and ARS. Specifically, a small amount of landings for the two species is attributed to small vessels (VL0612) in the last part of the time series, from 2018 to 2020 (GSAs 9, 10 and 11) and also at the beginning of the time series (first three quarters of 2015) in GSA 9 (fig. 2.1.4.1-2).

Figure 2.1.4.1 Landings of ARA in EMU 2 by GSA and fleet segment.

Figure 2.1.4.2 Landings of ARs in EMU 2 by GSA and fleet segment.

This issue is not evident in GSA 11 graphs, as the landings values are very low, but they still contribute to the computation of LPUEs (see table below).

ARA GSA11 Landings					
Year	quarter	VL0612	VL1218	VL1824	VL2440
2015	1		4.184	0.334	6.785
2015	2		7.059	0.233	17.084
2015	3		1.978	0.597	14.521
2015	4				4.779
2016	1		3.767	0.702	12.328
2016	2		5.24	1.486	23.383
2016	3		1.567	11.454	18.597
2016	4			0.065	10.812
2017	1		3.372	8.248	9.935
2017	2		6.04	12.552	17.535
2017	3		3.059	6.387	26.309
2017	4		2	2.123	12.464
2018	1	0.124	3.96	6.671	38.452
2018	2	0.034	10.676	18.623	76.28
2018	3	0.014	9.625	21.454	50.935
2018	4		3.65	8.184	36.031
2019	1	0.032	8.082	9.741	35.682

2019	2		10.149	22.677	59.173
2019	3		7.331	15.51	27.822
2019	4		2.811	5.709	42.408
2020	1		3.255	8.755	20.462
2020	2		4.295	14.228	27.864
2020	3	0.004	4.315	14.892	22.162
2020	4	0.007	1.725	4.159	12.955

ARS GSA11 Landings					
Year	quarter	VL0612	VL1218	VL1824	VL2440
2015	1		7.033	0.562	11.406
2015	2		11.866	0.391	28.716
2015	3		3.326	1.004	24.409
2015	4		1.035		8.034
2016	1		6.997	1.303	22.896
2016	2			2.76	43.972
2016	3		2.91	3.995	29.834
2016	4			0.121	12.765
2017	1		6.262	15.318	35.524
2017	2		11.226	23.31	43.446
2017	3		5.681	11.862	63.724
2017	4		3.713	3.942	25.167
2018	1	0.073	2.693	4.748	20.846
2018	2	0.028	6.255	12.676	57.388
2018	3	0.007	6.426	14.673	30.999
2018	4		2.61	5.871	23.132
2019	1	0.018	5.211	6.353	25.885
2019	2		6.946	15.519	40.495
2019	3		5.016	10.612	19.04
2019	4		1.925	3.907	29.022
2020	1		2.201	5.877	22.655
2020	2		2.829	9.051	39.727
2020	3	0.003	2.961	9.765	34.122
2020	4	0.005	1.17	2.774	22.447

2.1.5 References

Bellido, JM., Sumaila, UR., Sánchez-Lizaso, JL., Palomares, LM., Pauly, D. 2020. Input versus output controls as instruments for fisheries management with a focus on Mediterranean fisheries. Marine Policy, 118: 4p. https://doi.org/10.1016/j.marpol.2019.103786

Borges. L. 2018. Setting of total allowable catches in the 2013 EU common fisheries policy reform: possible impacts. Marine Policy, 91: 97-103.

Lizaso, JLS, Sola, I, Guijarro-García, E, Bellido, JM, Franquesa, R. 2020. A new management framework for western Mediterranean demersal fisheries. Marine Policy, 112: 4 pp. https://doi.org/10.1016/j.marpol.2019.103772

Lleonart J., Demestre M., Martín P., Rodón J., Sainz-Trápaga S., Sánchez P., Segarra I., Tudela S. 2014. The co-management of the sand eel fishery of Catalonia (NW Mediterranean): the story of a process. In: Lleonart J., Maynou F. (eds), The Ecosystem Approach to Fisheries in the Mediterranean and Black Seas. Sci. Mar. 78S1: 87-93. doi: http://dx.doi.org/10.3989/scimar.04027.25A

Pope, J. Chapter 4 - Input and output controls: the practice of fishing effort and catch management in responsible fisheries. FAO, Rome (Italy) 75-94. https://www.fao.org/3/y3427e/y3427e04.pdf

2.2 Progress of operational mixed fisheries models

2.2.1 IAM in EMU 1

2.2.1.1 Recall on the main issues and conclusions from EWG 21-13

The implementation of the IAM model for GSAs 1-5-6-7 carried out during the STECF meeting is still in development. During EWG 21-13, a major element missing was the differentiation of fishing effort between Spanish demersal trawling and deep water trawling. It was pointed out that a parameterisation of the IAM model at fleet-metier level would address this issue, and that it was essential if maximum catch limit (MCL) scenarios were investigated.

Further developments suggested were the integration of additional socio-economic indicators such as employment, gross profit and gross profit margin, provided that the relationship between Full-Time Equivalents (FTE) and fishing effort were discussed before the meeting, and that if additional indicators were requested, they should be provided before the meeting, and sufficiently in advance to adapt the model. It was also pointed out that scenarios involving changes in the number of vessels, rather than just changes in fishing effort, could be explored if included in the TORs.

2.2.1.2 Implementation progresses in EWG 22-01

IAM (Impact Assessment Model), a bioeconomic mixed fishery simulation model, was implemented in EMU1, following the experiences gained in EWG 19-14, EWG 20-13 and EWG 21-13.

The data sources used for the French and Spanish update were the FDI data, the Annual Economic Report (AER) data, the landings and discards data from the Med and Black sea data call (MBSDC), and the outputs of the EWG 21-11 group on the Mediterranean Stock Assessment.

2.2.1.3 Stocks

The stocks that were explicitly modelled in the IAM-Med model from the previous STECF EWG 21-13 were used in the EWG 22-01.

This includes:

- European hake (*Merluccius merluccius*) in GSAs 1-5-6-7,
- Red mullet (*Mullus barbatus*) in GSA 1,
- Red mullet (*Mullus barbatus*) in GSA 6,
- Red mullet (*Mullus barbatus*) in GSA 7,
- Norway Lobster (*Nephrops norvegicus*) in GSA 6,
- Blue and red shrimp (*Aristeus antennatus*) in GSA 1,
- Blue and red shrimp (*Aristeus antennatus*) in GSAs 6-7.

Stochastic recruitment has been explicitly considered for those stocks, as in EWG 21-13. To build a random succession of recruitments for stocks to be applied on the 2021-2031 projection period, 11 years are randomly drawned with replacement from the available historical period (2009-2020). Each draw will determine for each projection year the annual recruitment combinations to be applied for each stock. **100 such trajectories** are simulated and used to build confidence intervals. Simulations run from 2020 to 2031.

Furthermore, landings of the following species from the management plan are simulated in the IAM model, however the dynamics of these species are not explicitly represented, due to lack of analytical or accepted stock assessments. They are referenced hereafter as “static species”, and associated catches are simulated as a linear function of the simulated fishing effort, assuming a constant value of Landings Per Unit of Effort (LPUE). LPUE data are based on the 2020 values.

- Red mullet (*Mullus barbatus*) in GSA 5,
- Deep-water rose shrimp (*Parapenaeus longirostris*) in GSA 1, 5, 6 and 7,
- Blue and red shrimp (*Aristeus antennatus*) in GSA 5,
- Norway lobster (*Nephrops norvegicus*) in GSA 1, 5 and 7.

The other « static species » considered in the model and that are not included in the management plan are: stripped red mullet (MUR), anchovy (ANE), sardine (PIL), Atlantic mackerel (MAC), monkfish (MNZ), common octopus (OCC), octopuses (OCT), Atlantic bluefin tuna (BFT), and « ZZZ » (which stands for all other species caught per fleet).

Table 2.2.1.3.1 Summary of the stocks in the Western Mediterranean management plan and how they are integrated in the IAM model.

Stocks in management plan	**Dynamic or static in IAM**	**Comment**
blue and red shrimp (*Aristeus antennatus*) in GFCM subareas 1, 5, 6 and 7	Dynamic: stocks ARA1 (GSA 1) and ARA67 (GSAs 6-7) Static: stock ARA5 (GSA 5)	No population dynamics available from the stock assessments for ARA 5
deep-water rose shrimp (*Parapenaeus longirostris*) in GFCM subareas 1, 5 and 6	Static: stocks DPS1 (GSA1), DPS5 (GSA 5), DPS6 (GSA 6) and DPS7 (GSA 7)	No population dynamics available from the stock assessments for DPS 1, 5, 6 and 7
European hake (*Merluccius merluccius*) in GFCM subareas 1-5-6-7	Dynamic: stock HKE1567 (GSAs 1-5-6-7)	
Norway lobster (*Nephrops norvegicus*) in GFCM subareas 5 and 6	Dynamic: stocks NEP6 (GSA6) Static: stock NEP5 (GSA 5)	No population dynamics available from the stock assessments for NEP5
red mullet (*Mullus barbatus*) in GFCM subareas 1, 5, 6 and 7	Dynamic: stocks MUT 1 (GSA 1), MUT 6 (GSA 6), and MUT 7 (GSA 7) Static: stock MUT 5 (GSA 5)	Stock assessment are not available for *Mullus barbatus* in GSA 5.

2.2.1.4 Fleet segments

The fleet typology used is based on the fleet segmentation of the Data Collection Framework (DCF). A fleet segment is the combination of a particular fishing technique category and a vessel length category. Spanish and French fleet segments are based on what was used in EWG 19-14, EWG 20-13 and EWG 21-13 implementations. The parameters of EWG 21-13 model were used in this implementation.

The French fleets represented are French demersal trawlers 18-24m, French demersal trawlers >24m, other French vessels <12m and other French vessels >12m. The "other" vessels are essentially gillnetters, but encompass all forms of French small-scale fisheries in the Gulf of Lions (pots and traps, lamparo, longliners, etc.).

Regarding the Spanish fleets, six Spanish fleet segments were considered: Spanish trawlers < 12m, Spanish trawlers 12-18m, Spanish trawlers 18-24m, Spanish trawlers >24m, Spanish netters and Spanish vessels using hooks.

Compared to what was done in EWG 21-13, the IAM model has been adapted to **differentiate between coastal and deep-sea trawling**. This concerns the three Spanish fleet segments: Spanish trawlers 12-18m, Spanish trawlers 18-24m, and Spanish trawlers >24m where a distinction between fishing effort toward deep-sea trawling and coastal trawling has been made. The entry "Target-assemblage" in the FDI database has been used to parametrize the IAM model (see Table 2.2.1.4.1 for more details).

Table 2.2.1.4.1 Modelled fleets in the IAM application in EMU1 and correspondence with FDI and AER fleets. "!= " means different. DFN stands for Drift and/or fixed netters, DTS for Demersal trawlers and/or demersal seiners, HOK for Vessels using hooks, and DWS for deep water species.

IAM Fleet segment names	Names in the report figures	Fleet segments in AER	Fishing techniques in FDI	"Metier" explicitly modelled
French demersal trawlers 18-24m	FR_Trwl 1824m	fs_name => FRA MBS DTS1824 NGI* cluster_name=> **MBS DTS VL1824**	fishing tech = DTS vessel_length = VL1824	No distinction as no effort and catches for DWS in FDI database
French demersal trawlers 24-40m	FR_Trwl >=24m	fs_name => FRA MBS DTS2440 NGI* cluster_name=> **MBS DTS VL2440**	fishing tech = DTS vessel_length = VL2440	No distinction as no effort and catches for DWS in FDI database
Other French vessels <12m	FR_Oth <12m	*Not relevant*	fishing tech != DTS vessel_length = VL0006 and VL0612	
Other French vessels >12m	FR_Oth >=12m	*Not relevant*	fishing tech != DTS vessel_length = VL1218, VL1824, and VL2440	

<table>
<tr><td>Spanish trawlers < 12m</td><td>SP_Trwl < 12m</td><td>fs_name => ESP MBS DTS0612 NGI</td><td>country_code =ESP
fishing tech = DTS vessel_length = VL0006, and VL0612
sub_region= GSA1, GSA5 , GSA6 and GSA7</td><td>No distinction as no effort and catches for DWS in FDI database</td></tr>
<tr><td rowspan="2">Spanish trawlers 12-18m</td><td rowspan="2">SP_Trwl 1218m</td><td rowspan="2">fs_name => ESP MBS DTS1218 NGI</td><td>fishing tech = DTS vessel_length = VL1218
target_assemblage = DWS</td><td>DWS</td></tr>
<tr><td>fishing tech = DTS vessel_length = VL1218
target_assemblage != DWS</td><td>other</td></tr>
<tr><td rowspan="2">Spanish trawlers 18-24m</td><td rowspan="2">SP_Trwl 1824m</td><td rowspan="2">fs_name => ESP MBS DTS1824 NGI</td><td>fishing tech = DTS vessel_length = VL1824
target_assemblage = DWS</td><td>DWS</td></tr>
<tr><td>fishing tech = DTS vessel_length = VL1824
target_assemblage != DWS</td><td>other</td></tr>
<tr><td rowspan="2">Spanish trawlers >24m</td><td rowspan="2">SP_Trwl >=24m</td><td rowspan="2">fs_name => ESP MBS DTS2440 NGI</td><td>fishing tech = DTS vessel_length = VL2440
target_assemblage = DWS</td><td>DWS</td></tr>
<tr><td>fishing tech = DTS vessel_length = VL2440
target_assemblage != DWS</td><td>other</td></tr>
<tr><td>Spanish netters</td><td>SP_DFN</td><td>fs_name => ESP MBS DFN0612 NGI and ESP MBS DFN1218 NGI</td><td>fishing tech = DFN vessel_length = VL0006, VL0612, VL1218, VL1824, and VL2440</td><td></td></tr>
</table>

Spanish vessels using hooks	SP_LLS	fs_name => ESP MBS HOK0612 NGI*, ESP MBS HOK1218 NGI*, ESP MBS HOK1218 LLD*, and ESP MBS HOK1824 LLD* cluster_name=> **MBSHOKVL0612NGI, MBSHOKVL1218NGI, MBSHOKVL1218NGILLD, MBSHOKVL1824NGILLD**	fishing tech = HOK vessel_length = VL0006, VL0612, VL1218, VL1824, and VL2440	

On the basis of this segmentation, the FDI data (table A) were used to represent the proportions of gears employed by each IAM fleet segment (Fig. 2.2.1.4.1). The fishing gear classification is the FAO classification, that can be consulted here: https://www.fao.org/cwp-on-fishery-statistics/handbook/capture-fisheries-statistics/fishing-gear-classification/en/.

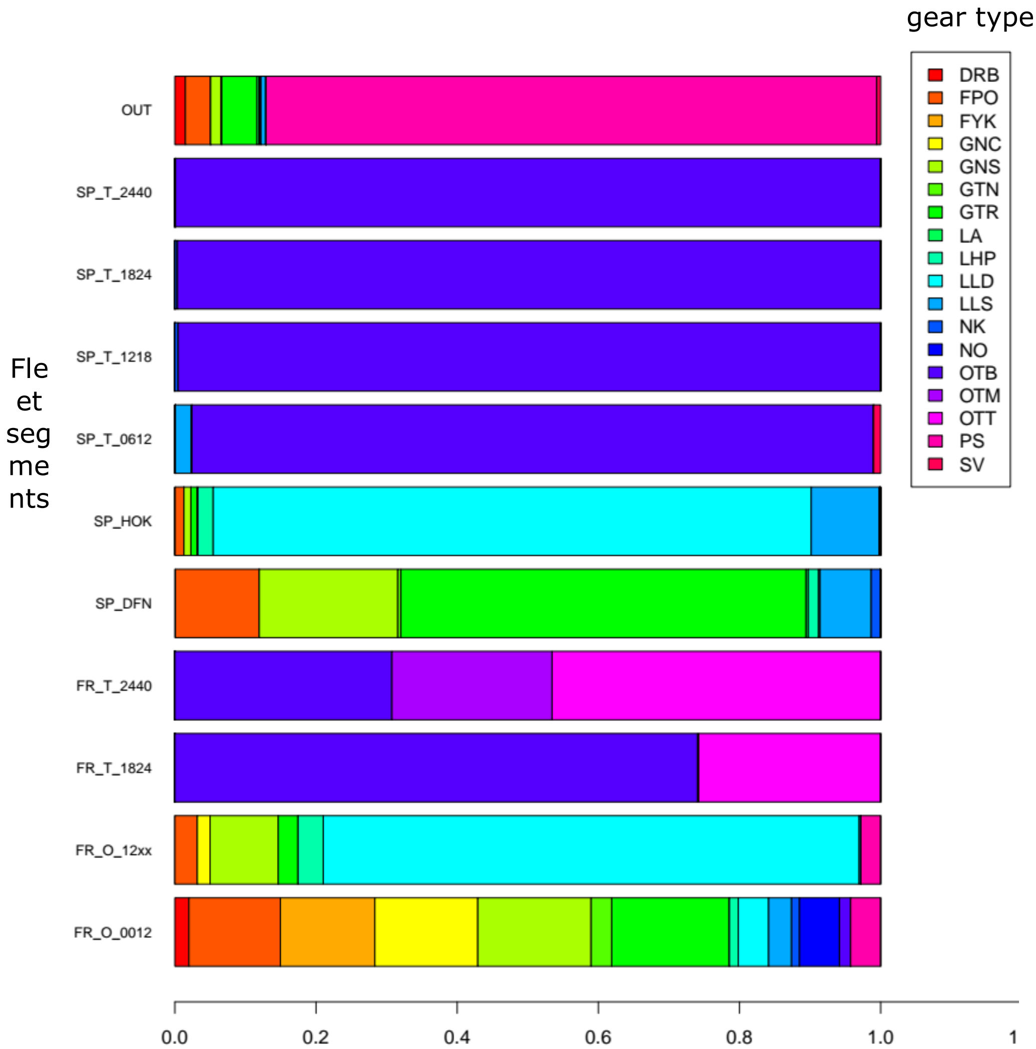


Figure 2.2.1.4.1. Proportion of gear usage (computed in terms of % of landings issued from each gear) among current IAM fleet segments (in row). The "OUT" segment cumulates all fleet segments left out. T is short for DTS and stands for demersal trawlers and/or demersal seiners, DFN for drift and/or fixed netters, and HOK for vessels using hooks. The vessel length class 12xx means all vessels superior to 12 meters. For the gear types, DRB stands for boat dredge, FPO for pots and traps, FYK for fyke nets, GNC for Encircling gillnets, GNS for Set gillnet, GTN for Combined gillnets-trammel nets, GTR for Trammel net, LA for Lampara nets, LHP for Hand and Pole lines, LLD for Drifting longlines, LLS for Set longlines, OTB for Bottom otter trawl, OTM for Midwater otter trawl, OTT for Multi-rig otter trawl, PS for Purse seine, SV for Beach and boat seine, and NK and NO for unknown gear. Roughly, red to orange colors corresponds to dredges and traps (DRB – FPO – FYK), yellow to green corresponds to various gillnets (GNC – GNS - GTN – GTR), green to lightblue corresponds to longlines (LA -LHP – LLD – LLS), darkblue corresponds to unknown gears (NK – NO), purple corresponds to trawls (OTB – OTM – OTT), and purple to red corresponds to seines (PS – SV).

Upon examination, Figure 2.2.1.4.1 reveals some heterogeneities in gear usage in the current non-trawlers fleet segments in IAM. This is especially true for the French small-scale fishery <12m (FR_O_0012) which is constituted of a number of traps and dredge gears (FAO codes DRB – FPO – FYK) and longlines (LA – LHP – LLD – LLS). This is not surprising as this IAM fleet segment FR_O_0012 currently encompasses many different fleets. As a reminder, the segmentation for the Spanish non-trawler fleets focuses on fishing technique while segmentation for the French non-trawler fleets only focuses on vessel size. Figure 2.2.1.4.2 displays the proportion of landings in weight and value of the species of the plan for each IAM fleet segments.

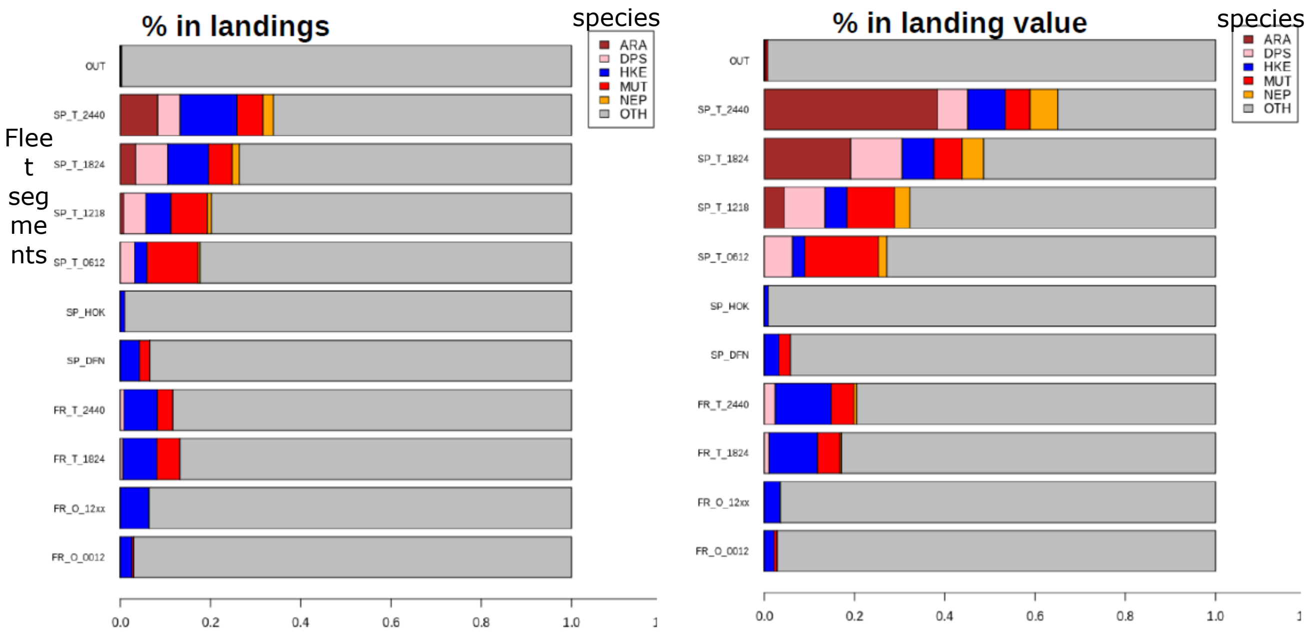


Figure 2.2.1.4.2. Proportion of species of the plan landed by current IAM fleet segments (in row), according to their landings in weight (left panel) and in value (right panel). The "OUT" segment cumulates all fleet segments left out. T is short for DTS and stands for demersal trawlers and/or demersal seiners, DFN for drift and/or fixed netters, and HOK for vessels using hooks. Coloured space represents species targeted by the westmed management plan (ARA: Aristeus antennatus, DPS: Parapeneus longirostris, HKE: Merluccis merluccius, MUT: Mullus barbatus, NEP: Nephrops norvegicus), and grey areas (OTH) represents all other species cumulated.

2.2.1.5 Economic indicators

Economic indicators are produced for the French and Spanish fleets. As in EWG 21-13, AER data were used to parameterize the model. The economic indicators produced are revenue per fleet and gross value added (GVA) per fleet. It should be noted that these indicators are not produced for the two fleets "other French vessels <12m" and "other French vessels >12m", which correspond to a very heterogeneous mix of vessels with a great deal of heterogeneity in their cost structure, so it was not appropriate to produce economic indicators for them. A suggested adaptation of the fleet segmentation in IAM to be carried out for the next group is available in section 4.1.1.2.

Revenue corresponds to landings multiply by market prices, such as in equation (1):

$$GVL_{f,t} = \sum_{s}\sum_{c} L_{s,c,f,t}\, p_{s,c,f} + \sum_{ss} LPUE_{ss,f}\, p_{ss,f}\, E_{f,t} \qquad (1)$$

With $GVL_{f,t}$ the gross value of landings (or revenue) of fleet *f* at time *t*, $L_{s,c,f,t}$ the landings (in weight) of modelled stock *s* for commercial category *c* by fleet *f* at time *t*, $p_{s,c,f}$ the market price of stock *s* for commercial category *c* for fleet *f*, $LPUE_{ss,f}$ the landing per unit of effort of static species *ss* for fleet *f* (i.e. not explicitly modelled species, static species include all species caught by the fleet *f*), $p_{ss,f}$ the average market price of species *ss* for fleet *f*, and $E_{f,t}$ the fishing effort of fleet *f* at year *t*.

Landings per commercial category are estimated from landings per age-classes and using the commercial categories/ages matrices described in the EWG 20-13 report.

Calculation of the gross value added (GVA) by fleet is described in equation (2):

$$GVA_{f,t} = GVL_{f,t} - (fuelc_f + ovc_f)E_{f,t} - rep_f - Fixc_f \qquad (2)$$

Where $fuelc_f$ is the fuel cost per unit of effort of fleet *f*, ovc_f the other variable costs per unit of effort (including landing costs, oil, bait, gear, food and ice costs), $E_{f,t}$ the fishing effort of fleet *f* at time *t*, rep_f the reparations and maintenance costs and $Fixc_f$ the other annual fixed costs of fleet *f* (including costs related to equipment, insurance and management costs).

Fishing effort is expressed in fishing days.

2.2.2 ISIS-Fish in EMU 1 (GSA 7)

2.2.2.1 ISIS-Fish implementation for European hake in GSA 7

It is the first time ISIS-Fish is used to evaluate management scenarios for the West-Med MAP. The model was until now used in an academic context and further developments are required to complete its transition towards an operational use.

ISIS-Fish was parametrized for European hake in GSA7 during the research projects (Galion http://www.amop.fr/le-projet-galion/ and Pechalo (Wendling et al. 2019, Leforestier et al.2020). It is spatially (0.5 x 0.5 degree resolution) and monthly resolved.

Twenty fleets are considered parameterized according to declarative data. The 17 French trawler fleets were segmented according to home harbor, vessel length and strategy. Their effort is finely distributed over métiers (gear and area of practice) and across seasons. Métiers are defined as a gear (OTB, OTT, OTM) and an area of practice that is fleet dependent. A rougher modeling of the French gillnetter fleet and of the Spanish trawlers and longliners fleets is used, assuming only one métier and approximating spatial distribution of effort.

Population dynamics of hake are based on the same assumptions as the assessment model from EWG 21-11 regarding age classes and natural mortality. It is further spatially distributed over two habitats, Plateau (shelf) and Accores (slope), according to Medits data, which results in a higher proportion of small individuals on the Plateau. The dynamics is seasonal, with weight continuously growing and recruitment progressively entering the fishery in course of the year. The model is currently restricted to GSA7 and assumes no connectivity of hake between GSAs. Prices vary between month but do not depend yet on fish size.

The model is fitted to catch at age over the period 2015-2017 (available from declarative data) but as a complex mechanistic model, it does not reproduce catches perfectly (fig.2.2.2.1.1) and the results should be considered relative to a base case rather than in absolute values (Le Forestier et al. 2020, fig. 2.2.2.1.1).

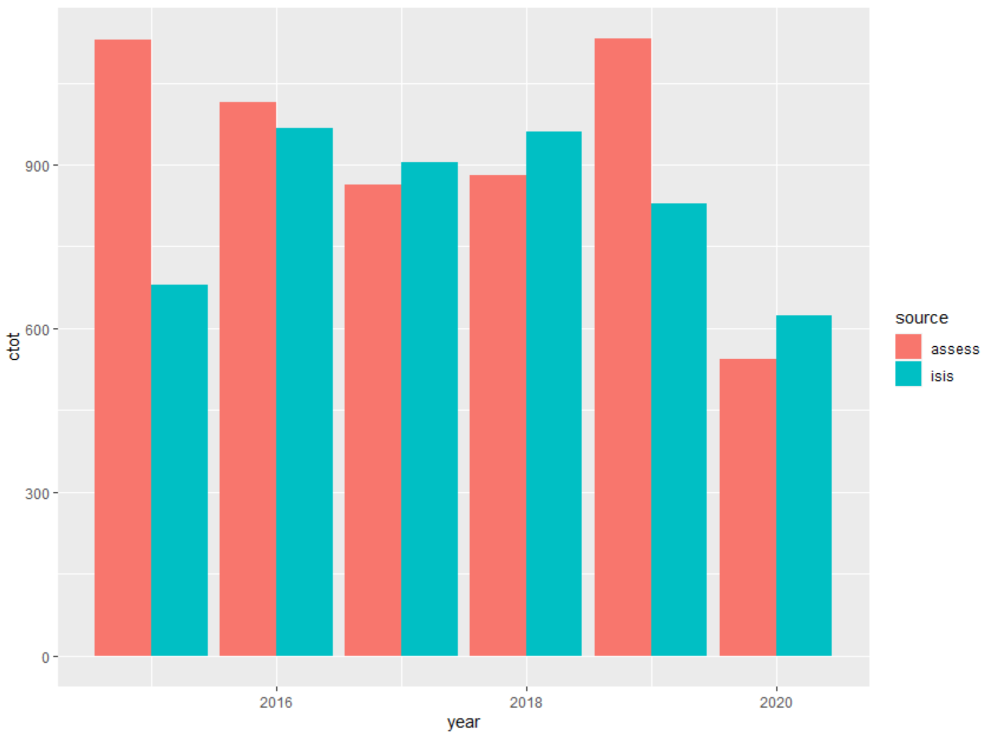


Figure 2.2.2.1.1 Total catch in ISIS-Fish (isis) for HKE in GSA7 compared with values from the assessment working group (STECF EWG 21-11) (assess) for calibration years 2015-2017 and hindcasted years (2018-2020).

Simulations are run for 2015-2030 with recruitment forced at observed values (adapted from the assessment) for 2015-2020 and using the average 2018-2020 after. Effort per month and its distribution among fleet and métiers is forced to observed values for 2015-2017 and then equals the average 2015-2017.

Maximum catch limits were simulated for European hake in GSA7. It was therefore necessary to scale down the MCL value defined for EMU1 to catch in GSA7. The MCL for EMU1 was multiplied by the historical (average 2018-2020) proportion of catch in GSA7 compared to EMU1. The GSA7 MCL was then further apportioned to the trawler fleets according to their historical share (2018-2020) of the catch in GSA7.

Because of the very different nature of the ISIS-Fish model compared to the assessment model, fishing mortalities cannot be compared. An equivalent of Fmsy in ISIS was computed as 0.27 and used as a reference for HCR and evaluation of objectives. We assumed the same ratio applied between F0.1 and the average F reported by the STECF EWG 21-11 over the 2015-2017 period and between ISIS-Fish equivalent F0.1 and average value between 2015-2017 (F0.1/F2015-2017 = 0.25).

Within the simulation, during the year, fleets concerned by MCL behave according to their historical effort pattern until the MCL is reached. Thereafter, under the assumption of a strict implementation of the landing obligation, they stop fishing assuming no report on other species is possible. In case of monthly MCL, monthly flexibility was not yet implemented.

When the HCR is enforced, the MCL is computed in January of the management year assuming abundance, age structure, previous year F and upcoming recruitment perfectly known. Mean weights at age used in the MCL computation are average weight in the catch of the previous year.

2.2.3 BEMTOOL in EMU 2

2.2.3.1 State of completion during EWG 22-01

BEMTOOL bio-economic simulation model was implemented for EMU2, following the experiences gained in EWG 19-01, 19-14, 20-13 and 21-13. DCF data (FDI and MED&BS Data Call on landings, discards, fishing effort, biological and economic parameters) and results from the assessments carried out during the EWG 21-11 were analysed, to allow the parameterization of BEMTOOL during EWG 22-01. The model included the seven stocks (section 2.2.3.2) covered by the Multiannual Management Plan (MAP) in EMU2 (GSAs 9-10-11).

During EWG 22-01 the model used in EWG 21-13 was further refined, to take into account the different types of fishing activity exerted by each fleet segment at metier level. The allocation of the different fleet segments to the metiers were accomplished using the routine developed in the SECFISH project (details in chapter 2.2.3.3). Assessed fishing mortality, spawning stock biomass and the observed catches were compared with the simulated ones, as done in previous EWGs. Stock-recruitment relationships of the seven stocks were estimated using Eqsim during EWG 21-13. Results for deep-water rose shrimps and blue and red shrimp were not satisfactory so the stocks were projected using the recruitment used in the short term forecasts. The same assumptions on recruitment used previously, were maintained.

2.2.3.1 Space and time scale

EMU2 belongs to the FAO fishing area 37.1; sub-division 1.1 and 1.3; it includes three geographical subareas (GSA) according to the GFCM convention[2]: GSA9 – Ligurian Sea and North Tyrrhenian Sea; GSA10 – Southern and Central Tyrrhenian Sea and GSA11, composed by Western (GSA11.1) and Eastern (GSA11.2) Sardinia. As the model is not spatially explicit, the spatial scale covers the whole area. The time scale of the available DCF data goes from 2006 to 2020. The time scale of the model encompasses the same time range for the hindcasting. For 2020 FDI effort data was used in the model and for 2021 it was assumed that in the EU Reg 2021/90. For 2022 the same effort of 2021 was assumed, while the maximum catch limits in EU Reg 2022/110 were considered for ARS and ARA. The forecasts are covering the period from 2022 to 2025, however the projections were performed to 2030 to check the biological and economic results in the medium term. The time scale of BEMTOOL has a monthly resolution. The reference years on which the reductions of effort in fishing days are computed are 2015-2017. Average reference fishing days are thus calculated for this time frame.

2.2.3.2 Stocks

The stocks taken into consideration in BEMTOOL simulations are those for which analytic stock assessment results from EWG 21-11 were available:

- European hake in GSAs 9, 10 and 11 (HKE);
- Red mullet in GSA9 (MUT9);
- Red mullet in GSA10 (MUT10);
- Deep-water rose shrimp in GSAs 9, 10 and 11 (DPS);
- Giant red shrimp in GSAs 9, 10 and 11 (ARS);
- Norway lobster in GSA9 (NEP9);
- Blue and red shrimp GSA9, 10 and 11 (ARA).

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

Table 2.2.3.3.1 reports the parameters of the stock-recruitment relationships for the seven stocks.

Table 2.2.3.3.1 Parameters of the stock recruitment relationships

Stock	Break Point	a
European hake GSAs 9-10-11	3000	112
Red mullet GSA9	500	575
Red mullet GSA10	300	503
Deep water rose shrimp GSAs 9-10-11*		
Giant red shrimp GSAs 9-10-11	350	710
Norway lobster GSA9	400	119
Blue and red shrimp GSAs 9-10-11*		

*for this stock the recruitment of STF carried out in EWG 21-11 for projections was used.

The relevant results of the assessment for the model parameterization, i.e. the current fishing mortality (F_{curr}) and the reference point ($F_{0.1}$) are reported in Table 2.2.3.3.2

The table also reports the upper and lower range of F_{MSY}, according to the formulas used in EWG 21-11:

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

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

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

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

Considering the ratio between the current fishing mortality and the reference point ($F_{curr}/F_{0.1}$), the stocks more at risk are blue and red shrimp (ARA; ratio=5.8) and European hake (HKE; ratio=2.9). Red mullet in GSA10 (MUT10), red mullet in GSA9 (MUT9) and Nephrops in GSA 9 (NEP9) are considered underexploited, while deep-water rose shrimp is slightly overexploited (ratio 1.2) and giant red shrimp (ARS) is overexploited with a ratio of 2.1.

Table 2.2.3.3.2 Results of the assessments from EWG 21-11 relevant for BEMTOOL parameterization. The computation of the reduction by stock to reach F0.1 is also reported.

Stock	Fcurrent	F0.1	Change in F
Hake 8-9-10-11	0.5	0.17	-67%
Red mullet 9	0.37	0.52	37%
Red mullet 10	0.31	0.4	27%
Pink shrimp 9-10-11	1.58	1.29	-19%
Giant red shrimp 9-10-11	0.98	0.46	-35%
Nephrops 9	0.15	0.3	100%
Blue and red shrimp 9-10-11	1.68	0.29	-82%

The results of the stock assessment for the 7 considered stocks were replicated in BEMTOOL, considering the effort by metier for each fleet segment. The comparison of F, SSB and Catch showed a good level of agreement between BEMTOOL and the stock assessment results (Figure 2.2.3.3.1 and 2.2.3.3.2).

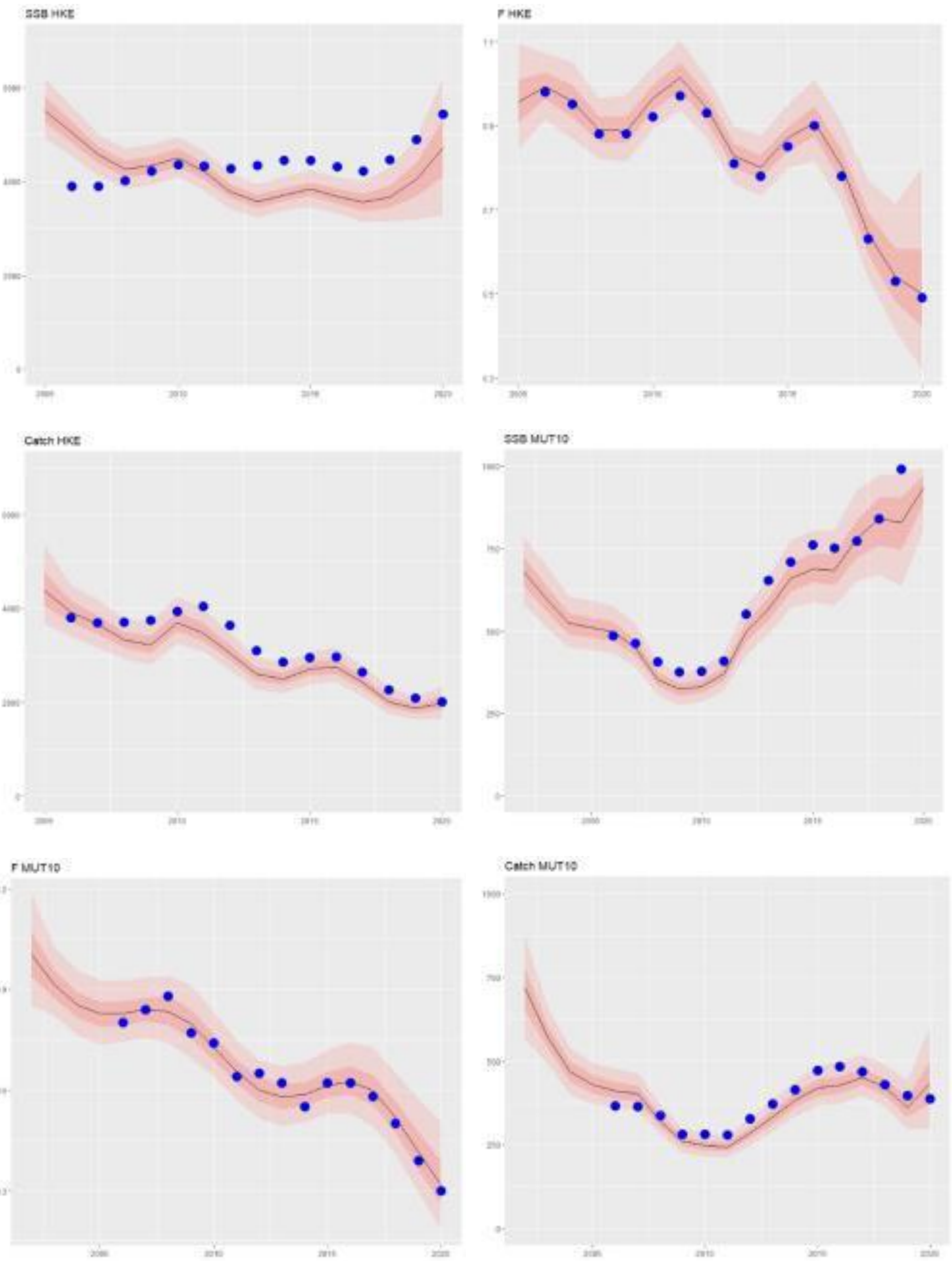
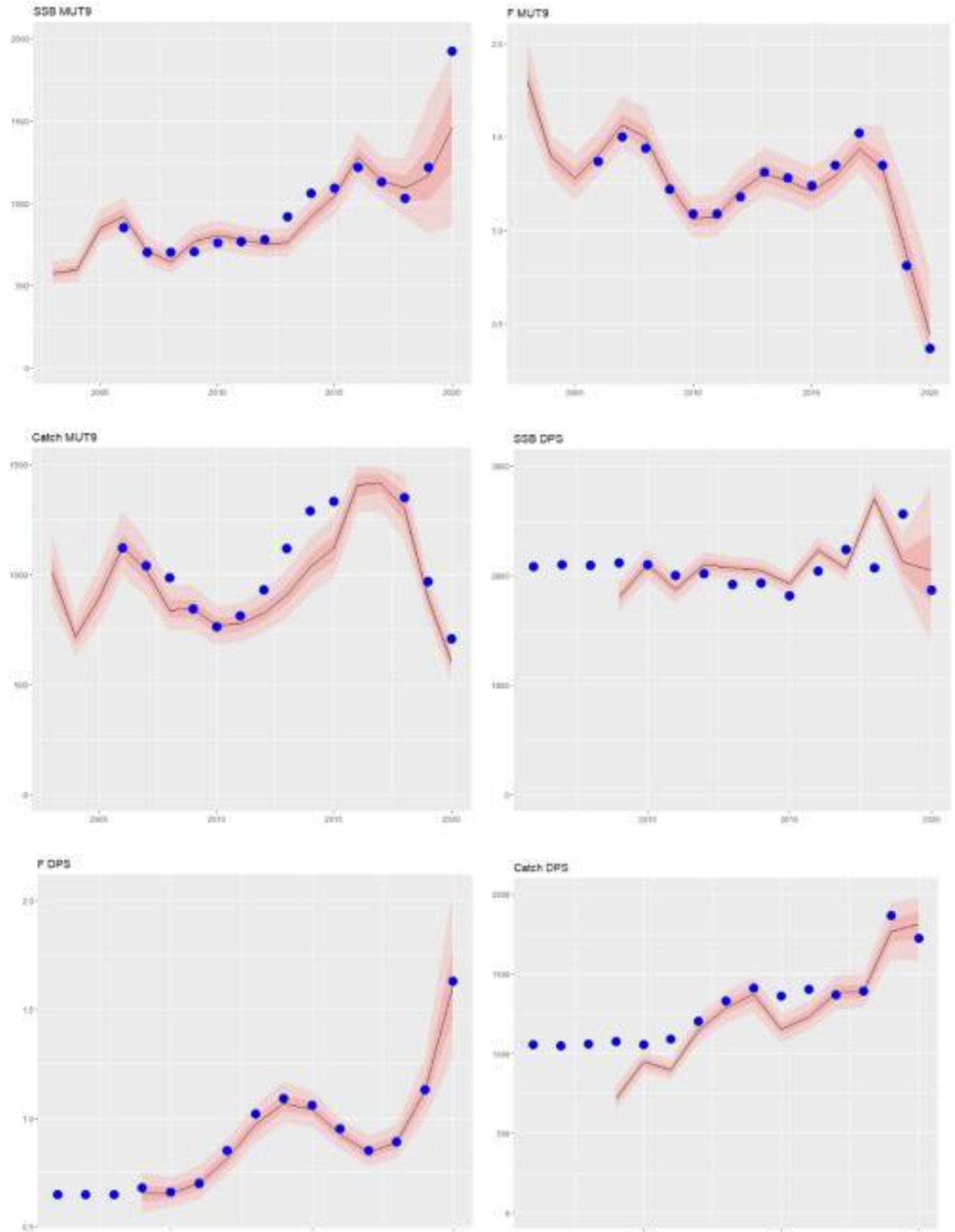
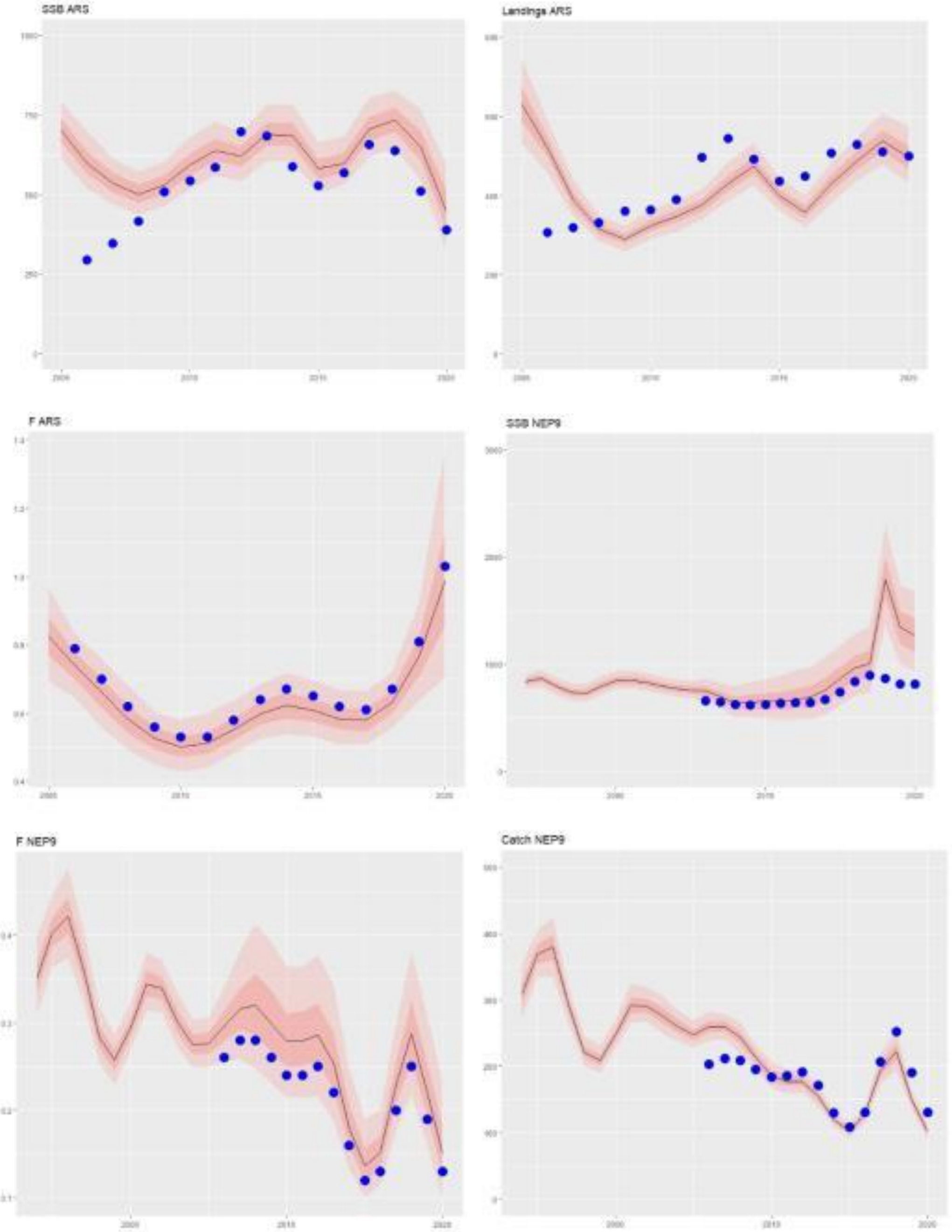


Figure 2.2.3.3.1 Comparison between stock assessment results with 95% confidence interval (pink) and BEMTOOL estimates (blue dots) on F, SSB and Catch for HKE 8-9-10-11 and MUT10.


SSB MUT9
F MUT9
Catch MUT9
SSB DPS
F DPS
Catch DPS


SSB ARS
Landings ARS
F ARS
SSB NEP9
F NEP9
Catch NEP9

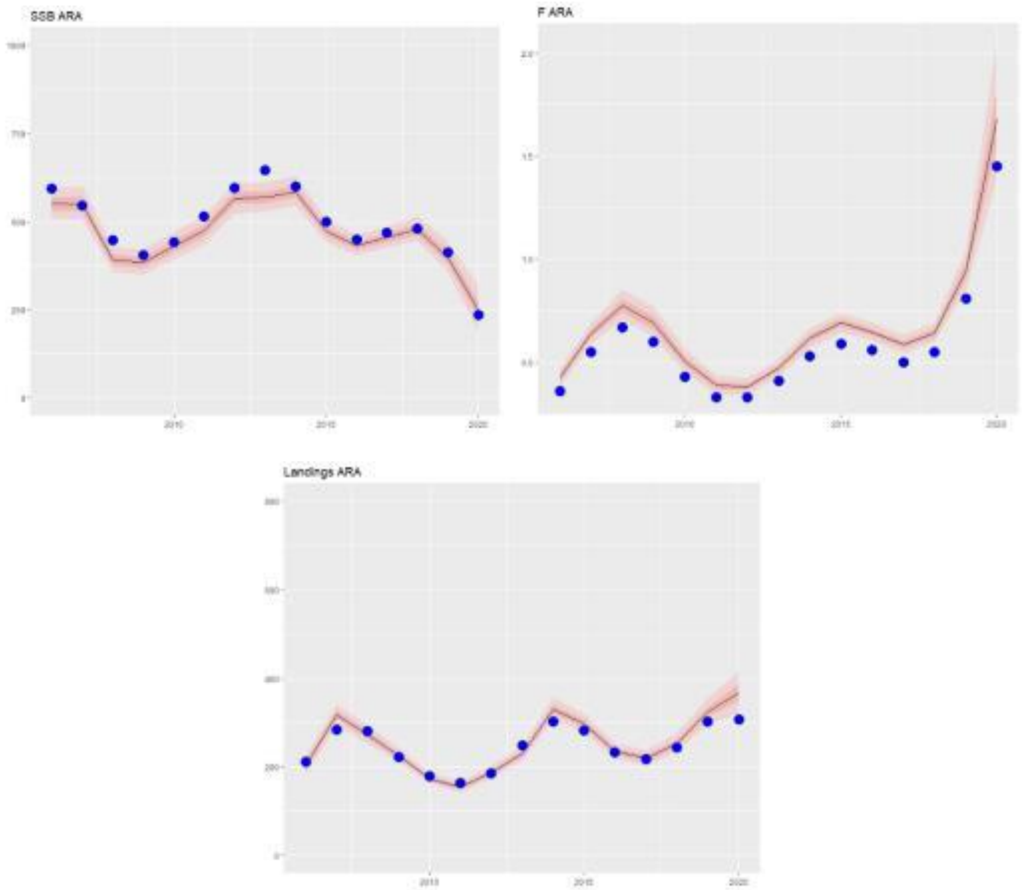


Figure 2.2.3.3.2 Comparison between stock assessment results with 95% confidence interval (pink) and BEMTOOL estimates (blue dots) on F, SSB and Catch for MUT9, DPS 9-10-11, ARS9-10-11, NEP9 and ARA 9-10-11.

2.2.3.3 Fleets

In the simulation and forecast scenarios 19 fleet segments corresponding to 36 metiers (see Table 2.2.3.4.1) were analysed. Trawlers have been disaggregated by fishing activity at metier level (OTB_DEF, OTB_DWS and OTB_MDD) as shown in Table 2.2.3.4.1. Transversal data from the Annual Economic Report (STECF 21-08) were used for the period 2008 to 2013 while from 2014 onward FDI data were used. STECF 18-07 EU Fleet Economic and Transversal data from 2008 to 2013 were used because those years are not present at metier level in the STECF 21-08 EU Fleet Economic and Transversal data. All data include both active and passive demersal gears operated by fleet segments that rely on, and influence, some or all the stocks included in the MAP. Six fleets are allocated to GSA9 and to GSA11 and seven fleets to GSA10, overall 12 fleets are trawlers and 7 fleets use passive gears.

The fuel costs, the other variable costs and the labour costs have been disaggregated at metier level following the methodology to disaggregate economic variables by activity developed in the SECFISH project (MARE/2016/22- SI2.768889, https://datacollection.jrc.ec.europa.eu/docs/regional-grants). This methodology allows to take into account the difference in the variable costs associated to the activity of each metier as well as the difference in the labour costs as depending on the revenues and, thus, indirectly by the metier. The SECFISH methodology is divided into two steps: the first based on the individual vessel costs, effort and revenues data, to derive the relationships between costs and transversal variables; the second step is represented by the disaggregation of the costs times series through the relationships (step 1) and the transversal variables. For this application, the relationships related to the Italian fleet within SECFISH project were used to derive the costs at metier level.

Fixed costs, maintenance costs and capital costs have been associated to the vessels and, thus, to the fleet segment (see Table 2.2.3.4.1)

Table 2.2.3.4.1 Combinations fleet segments-metier included in the BEMTOOL simulations and forecast scenarios by GSA, gear type, including demersal trawlers (DTS) and polyvalent passive gears (PGP), and vessel length (VL).

	GSA 9	GSA 10	GSA 11
DTS	GSA9_DTS_VL0612 DEF	GSA10_DTS_VL0612 DEF	GSA11_DTS_VL0612 DEF
	GSA9_DTS_VL1218 DEF	GSA10_DTS_VL1218 DEF	GSA11_DTS_VL1218 DEF
	GSA9_DTS_VL1218 DWS	GSA10_DTS_VL1218 DWS	GSA11_DTS_VL1218 DWS
	GSA9_DTS_VL1218 MDD	GSA10_DTS_VL1218 MDD	GSA11_DTS_VL1218 MDD
	GSA9_DTS_VL1824 DEF	GSA10_DTS_VL1824 DEF	GSA11_DTS_VL1824 DEF
	GSA9_DTS_VL1824 DWS	GSA10_DTS_VL1824 DWS	GSA11_DTS_VL1824 DWS
	GSA9_DTS_VL1824 MDD	GSA10_DTS_VL1824 MDD	GSA11_DTS_VL1824 MDD
	GSA9_DTS_VL2440 DEF	GSA10_DTS_VL2440 DEF	GSA11_DTS_VL2440 DEF
	GSA9_DTS_VL2440 MDD	GSA10_DTS_VL2440 DWS	GSA11_DTS_VL2440 DWS
		GSA10_DTS_VL2440 MDD	GSA11_DTS_VL2440 MDD
PGP	GSA9_PGP_VL0012	GSA10_PGP_VL0006	GSA11_PGP_VL0012
	GSA9_PGP_VL1218	GSA10_PGP_VL0612	GSA11_PGP_VL1218
		GSA10_PGP_VL1218	

2.2.4 References

Scientific, Technical and Economic Committee for Fisheries (STECF) – Stock Assessments: demersal stocks in the western Mediterranean Sea (STECF-21-11). Publications Office of the European Union, Luxembourg, 2021, EUR 28359 EN, ISBN 978-92-76-46116-6, doi:10.2760/046729, JRC127744

Scientific, Technical and Economic Committee for Fisheries (STECF) – Evaluation of the fishing effort regime in the Western Mediterranean – part VI (STECF-21-13). Publications Office of the European Union, Luxembourg, (2021).

Scientific, Technical and Economic Committee for Fisheries (STECF) – Evaluation of fishing effort regime in the Western Mediterranean – part V (STEC-20-13).

Scientific, Technical and Economic Committee for Fisheries (STECF) – 60th Plenary Meeting Report (PLEN-19-01). Publications Office of the European Union, Luxembourg, (2019).

Scientific, Technical and Economic Committee for Fisheries (STECF) – Evaluation of fishing effort regime in the Western Mediterranean – part IV (STECF-19-14). Publications Office of the European Union, Luxembourg, (2019).

2.3 Management scenarios and results

2.3.1 IAM in EMU 1

2.3.1.1 Management scenarios considered

The scenarios that were tested are based on the implementation of Maximum Catch Limits (MCL) on three stocks: European hake in GSAs 1-5-6-7 (HKE1567), Blue and red shrimps in GSA 1 (ARA1) and blue and red shrimps in GSA 6 (ARA6). According to the scenario, MCLs are implemented for one, two or the three stocks. The scenarios are summarized in table 2.3.1.1.1.

The scenarios starts in 2021 where the reduction of effort from the 2021 regulation is taken into account. As per TORs, the effort reductions for trawlers and longliners written in the 2022 regulation were not implemented in the simulations.

As in EWG 21-13, catchability values were set to the 2020 values. Fishing effort in 2020 are assumed identical to the one described in the EU Regulation 2021/90 for EMU1.

It is important to note that for all scenarios, the MCL implementation, and therefore the associated changes in fishing effort concern only the trawl fleets (i.e. French demersal trawlers 18-24m, French demersal trawlers >24m, Spanish trawlers <12m, Spanish trawlers 12-18m, Spanish trawlers 18-24m and Spanish trawlers >24m). The values of Fmsy catch and F transition catch from the stock assessment group EWG 21-11 for HKE1567, ARA1 and ARA67 were used to set the MCL values in the MCL scenarios (described in table 2.3.1.1.1). For the MCL scenarios: the value of Ftransition catch for HKE1567 and values from the regulation for ARA were used for the MCL in 2022, and the value of Fmsy catch was used for 2025. A linear decrease was calculated for 2023 and 2024. Regarding the reverse MCL scenario, the same values were used in reverse (i.e., value of 2022 MCL was used for 2025, etc.).

Fishing capacity and fishing effort of the other modelled fleets are constant (and based on 2020 values). To note also that fishing capacity, i.e. numbers of vessels per fleet remain constant through the simulation (based on the number of vessels in 2020).

Table 2.3.1.1.1 Management scenarios and corresponding variables affected in the IAM model

Scenario	Fishing effort per vessel for trawl fleets (in fishing days)	Maximum Catch Limit (MCL)
Baseline	-17.5% in 2021 (=E2015-2017[3]*0.825) (and constant afterwards)	NO
Scenario a	-17.5% in 2021 (=E2015-2017*0.825) •fishing effort adjusted to reach HKE1567 MCL of 2022 •fishing effort adjusted to reach	**MCL on HAKE for trawlers** 2022 : 2435 tonnes *(corresponds to Ftransition catch value from the stock assessment group EWG 21-11)* 2023 : 1828 tonnes 2024 : 1372 tonnes

3 **E2015-2017 corresponds to the average value of FDI fishing effort by fleet between 2015 and 2017.**

	HKE1567 MCL of 2023 •fishing effort adjusted to reach HKE1567 MCL of 2024 •fishing effort adjusted to reach HKE1567 MCL of 2025 and same as in 2025 afterwards (2026-2031)	2025: 1220 tonnes *(corresponds to Fmsy catch value from the stock assessment group EWG 21-11)*
Scenario b	-17.5% in 2021 (=E2015-2017*0.825) •fishing effort adjusted to reach HKE1567 MCL of 2022 •fishing effort adjusted to reach HKE1567 MCL of 2023 •fishing effort adjusted to reach HKE1567 MCL of 2024 •fishing effort adjusted to reach HKE1567 MCL of 2025 and same as in 2025 afterwards (2026-2031)	**Reverse MCL on HAKE for trawlers** 2022: 1220 tonnes 2023 : 1372 tonnes 2024 : 1828 tonnes 2025 : 2435 tonnes
Scenario c	-17.5% in 2021 (=E2015-2017*0.825) •fishing effort adjusted to reach ARA67 MCL of 2022 •fishing effort adjusted to reach ARA67 MCL of 2023 •fishing effort adjusted to reach ARA67 MCL of 2024 •fishing effort adjusted to reach ARA67 MCL of 2025 and same as in 2025 afterwards (2026-2031)	**MCL on ARA67 for trawlers** 2022 : 566.63 tonnes for Spanish trawlers (i.e. regulation values) 2023 : 417 tonnes 2024 : 307 tonnes 2025 : 267 tonnes

Scenario d	-17.5% in 2021 (=E2015-2017*0.825) •fishing effort adjusted to reach ARA67 MCL of 2022 •fishing effort adjusted to reach ARA67 MCL of 2023 •fishing effort adjusted to reach ARA67 MCL of 2024 •fishing effort adjusted to reach ARA67 MCL of 2025 and same as in 2025 afterwards (2026-2031)	**Reverse MCL on ARA67 for trawlers** 2022 : 267 tonnes 2023 : 307 tonnes 2024 : 417 tonnes 2025 : 566.63 tonnes
Scenario e	-17.5% in 2021 (=E2015-2017*0.825) •fishing effort adjusted to reach ARA1 MCL of 2022 •fishing effort adjusted to reach ARA1 MCL of 2023 •fishing effort adjusted to reach ARA1 MCL of 2024 •fishing effort adjusted to reach ARA1 MCL of 2025 and same as in 2025 afterwards (2026-2031)	**MCL on ARA1 for trawlers** 2022 : 123.90 tonnes for Spanish trawlers (i.e. regulation values) 2023 : 78 tonnes 2024 : 50 tonnes 2025 : 33.05 tonnes
Scenario f	-17.5% in 2021 (=E2015-2017*0.825) •fishing effort adjusted to reach ARA1 MCL of 2022 •fishing effort adjusted to reach ARA1 MCL of 2023 •fishing effort adjusted to reach ARA1 MCL of 2024 •fishing effort adjusted to reach ARA1 MCL of 2025 and same as in 2025 afterwards (2026-2031)	**Reverse MCL on ARA1 for trawlers** 2022 : 33.05 tonnes 2023 : 50 tonnes 2024 : 78 tonnes 2025: 123.90 tonnes
Scenario g	-17.5% in 2021 (=E2015-2017*0.825) •fishing effort adjusted to reach ARA1 and ARA67 MCL of 2022 •fishing effort adjusted to reach ARA1 and ARA67 MCL of 2023	**MCL on ARA1 and ARA67 for trawlers** *With distinction between quota for ARA1 and quota for ARA67* 2022 : 123.90 tonnes for ARA1 and

	•fishing effort adjusted to reach ARA1 and ARA67 MCL of 2024 •fishing effort adjusted to reach ARA1 and ARA67 MCL of 2025 and same as in 2025 afterwards (2026-2031)	566.63 tonnes for ARA67 for Spanish trawlers (i.e. regulation values) 2023 : 78 tonnes for ARA1 and 417 tonnes ARA67 2024 : 50 tonnes for ARA1 and 307 tonnes for ARA67 2025 : 33.05 tonnes for ARA1 and 267 tonnes for ARA67
Scenario h	-17.5% in 2021 (=E2015-2017*0.825) •fishing effort adjusted to reach ARA1 and ARA67 MCL of 2022 •fishing effort adjusted to reach ARA1 and ARA67 MCL of 2023 •fishing effort adjusted to reach ARA1 and ARA67 MCL of 2024 •fishing effort adjusted to reach ARA1 and ARA67 MCL of 2025 and same as in 2025 afterwards (2026-2031)	**Reverse MCL on ARA1 and ARA67 for trawlers** *With distinction between quota for ARA1 and quota for ARA67* 2022 : 33.05 tonnes for ARA1 and 267 tonnes for ARA67 2023 : 50 tonnes for ARA1 and 307 tonnes for ARA67 2024 : 78 tonnes for ARA1 and 417 tonnes ARA67 2025 : 123.9 tonnes for ARA1 and 566,63 tonnes for ARA67
Scenario i	-17.5% in 2021 (=E2015-2017*0.825) •fishing effort adjusted to reach HKE1567, ARA1 and ARA67 MCL of 2022 •fishing effort adjusted to reach HKE1567, ARA1 and ARA67 MCL of 2023 •fishing effort adjusted to reach HKE1567, ARA1 and ARA67 MCL of 2024 (and constant afterwards) •fishing effort adjusted to reach HKE1567, ARA1 and ARA67 MCL of 2025 and same as in 2025 afterwards (2026-2031)	**MCL on HKE1567 and on ARA1, and AR67 for trawlers** 2022 : 123.90 tonnes for ARA1, 566.63 tonnes for ARA67 (i.e. regulation values) and 2435 tonnes for HKE1567 2023 : 78 tonnes for ARA1, 417 tonnes ARA67, and 1828 tonnes for HKE1567 2024 : 50 tonnes for ARA1, 307 tonnes for ARA67, and 1372 tonnes for HKE1567 2025 : 33.05 tonnes for ARA1, 267 tonnes for ARA67, and 1220 tonnes for HKE1567
Scenario j	-17.5% in 2021 (=E2015-2017*0.825) •fishing effort adjusted to reach HKE1567, ARA1 and ARA67 MCL of 2022	**Reverse MCL on HKE1567 and on ARA1, and AR67 for trawlers** 2022 : 33.05 tonnes for ARA1, 267 tonnes for ARA67, and 1220 tonnes for HKE1567

•fishing effort adjusted to reach HKE1567, ARA1 and ARA67 MCL of 2023 •fishing effort adjusted to reach HKE1567, ARA1 and ARA67 MCL of 2024 (and constant afterwards) •fishing effort adjusted to reach HKE1567, ARA1 and ARA67 MCL of 2025 and same as in 2025 afterwards (2026-2031)	2023 : 50 tonnes for ARA1, 307 tonnes for ARA67, and 1372 tonnes for HKE1567 2024 : 78 tonnes for ARA1, 417 tonnes ARA67, and 1828 tonnes for HKE1567 2025 : 123.90 tonnes for ARA1, 566.63 tonnes for ARA67, and 2435 tonnes for HKE1567

For each stock, its MCL value was divided by fleet segment. Therefore, each fleet segment had a quota by year by stock. The allocation of the MCL by fleet was proportional to their 2018-2020 landings of the stock in weight (based on FDI data).

The proportions are detailed in tables 2.3.1.1.2 to 2.3.1.1.4.

Table 2.3.1.1.1 Maximum Catch Limit weighting by fleet segment for trawlers according to their FDI 2018-2022 landings in weight by species by GSA.

Fleet segments	**HKE1567**	**ARA1**	**ARA67**
French demersal trawlers 18-24m	0.075	0	0
French demersal trawlers >24m	0.148	0	0
Spanish trawlers < 12m	0.002	0	0
Spanish trawlers 12-18m	0.088	0.149	0.016
Spanish trawlers 18-24m	0.417	0.536	0.391
Spanish trawlers >24m	0.270	0.315	0.592

The MCL level for ARA in 2022 from the regulation were adjusted to remove the landings of ARA in GSA 5 (i.e., 20.81 % of the total ARA landings in EMU1, according to 2018-2022 FDI data). Then the remaining quota was dispatched between ARA1 and ARA67 according to the proportion of FDI 2018-2020 landings of Blue and red shrimps in GSA 1 and in GSAs 6 and 7 (i.e., 17.94% for ARA1 and 82.06% for ARA67).

For 2022 to 2025, fishing efforts by fleet were adjusted each year to catch the fleet quota, and then for 2026 to 2031, the fishing effort per fleet was assumed constant and equal to their effort of 2025.

For the three Spanish trawler fleets over 12 meters (i.e., the ones with the two metier: deep-sea and coastal trawling that were explicitly modelled), a report of the effort of the metier catching the species the most towards the other metier was assumed. And if this was not enough to reach the quota, the fishing effort of the other metier was also reduced.

For the scenario with MCL implementation on both European hake and Blue and red shrimps, a reconciliation of the marginal scenarios (i.e. per stock) already implemented was carried out.

2.3.1.2 Results

The 10 alternative scenarios described in section 2.3.1.1 were investigated using the IAM model. Simulations of the IAM model starts in 2020 and run up to 2031 (the year 2025 is represented by a vertical black line in each figure).

Results of IAM simulations regarding **fishing effort**, **landings by trawlers**, **total landings** of Hake in GSAs 1-5-6-7, red mullet in GSA1, GSA6 and GSA7, Norway lobster in GSA6 and blue and red shrimp in GSA 1 and in GSAs 6-7 by fleet segments, and **Gross Value of Landings (GVL)** by fleet segment are, respectively, displayed in Figures 2.3.1.2.1 to 2.3.1.2.4.

For each stock, Figures 2.3.1.2.5 to 2.3.1.2.11 compare the evolutions of their Fbar, SSB and total landings according to the different scenarios. Finally, table 2.3.1.2.1 compares biological and economic performances of each scenario in terms of the ratio of Fbar in 2025 to Fmsy per stock and GVA in 2025 to GVA in 2020 per fleet segment.

The fishing mortalities, SSBs and Gross Value of Landings are displayed in section 1.2.

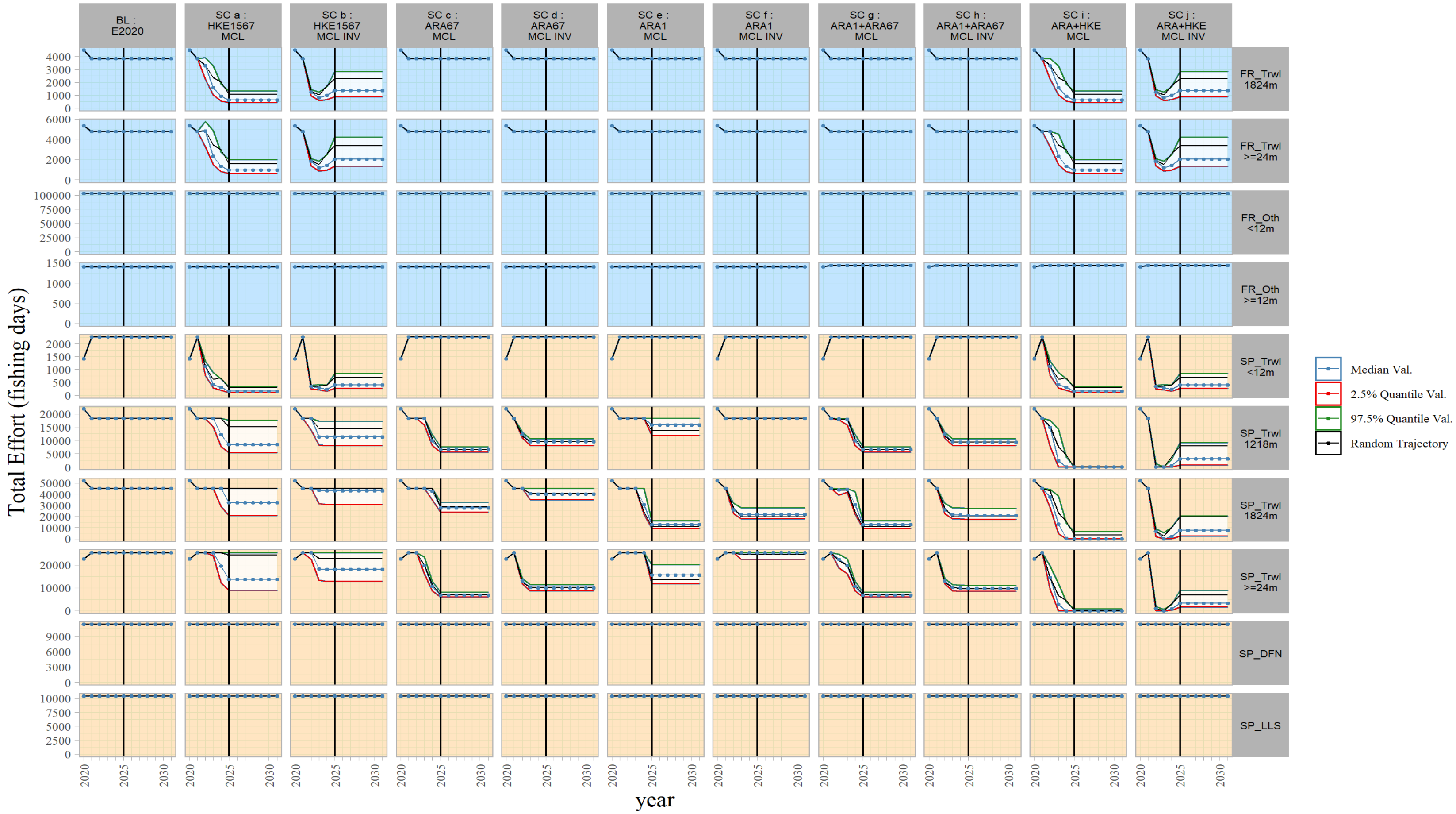


Figure 2.3.1.2.1. Evolution of the annual fishing effort (in fishing days) by fleet segment for each alternative scenario from 2020 to 2031. Vertical black lines indicate the year 2025. Scenarios are by columns and fleet segments by row. The fleet segments are as follow (from top to bottom): French demersal trawlers 18-24m, French demersal trawlers >24m, other French vessels <12m and other French vessels >12m, Spanish trawlers < 12m, Spanish trawlers 12-18m, Spanish trawlers 18-24m, Spanish trawlers >24m, Spanish netters and Spanish vessels using hooks.

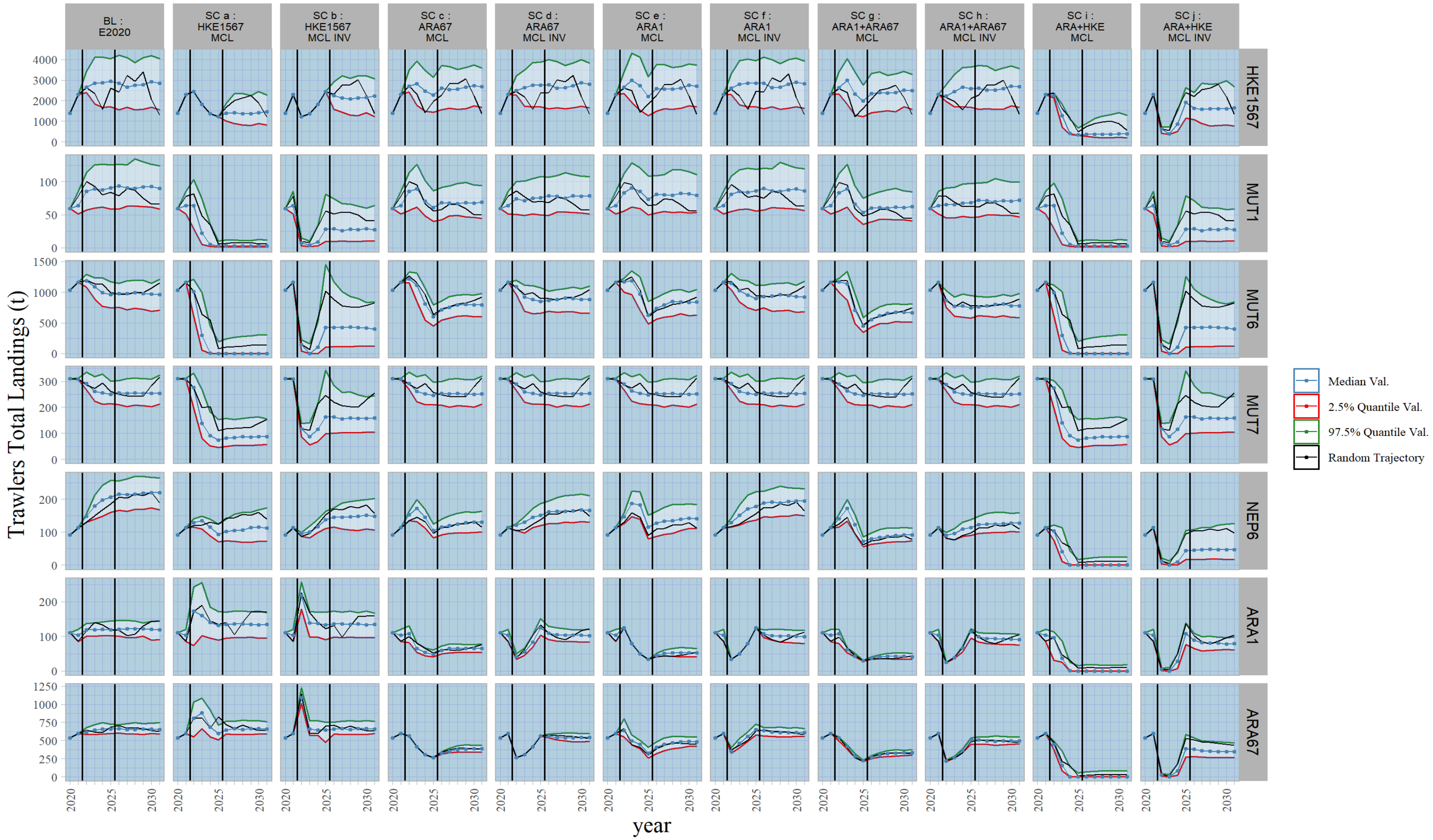


Figure 2.3.1.2.2. Evolution of the annual landings (in tonnes) of the modelled stocks by the trawl fleets (i.e. the ones for which MCL are implemented) for each alternative management scenario. Vertical black lines indicate the year 2025. Scenarios are in column and stocks in row. The stocks are as follow (from top to bottom): Hake GSAs1-5-6-7 (HKE1567), red mullet GSA1 (MUT1), red mullet GSA6 (MUT6), red mullet GSA7 (MUT7), Norway lobster GSA6 (NEP6), blue and red shrimp GSA1 (ARA1) and blue and red shrimp GSAs6-7 (ARA67).

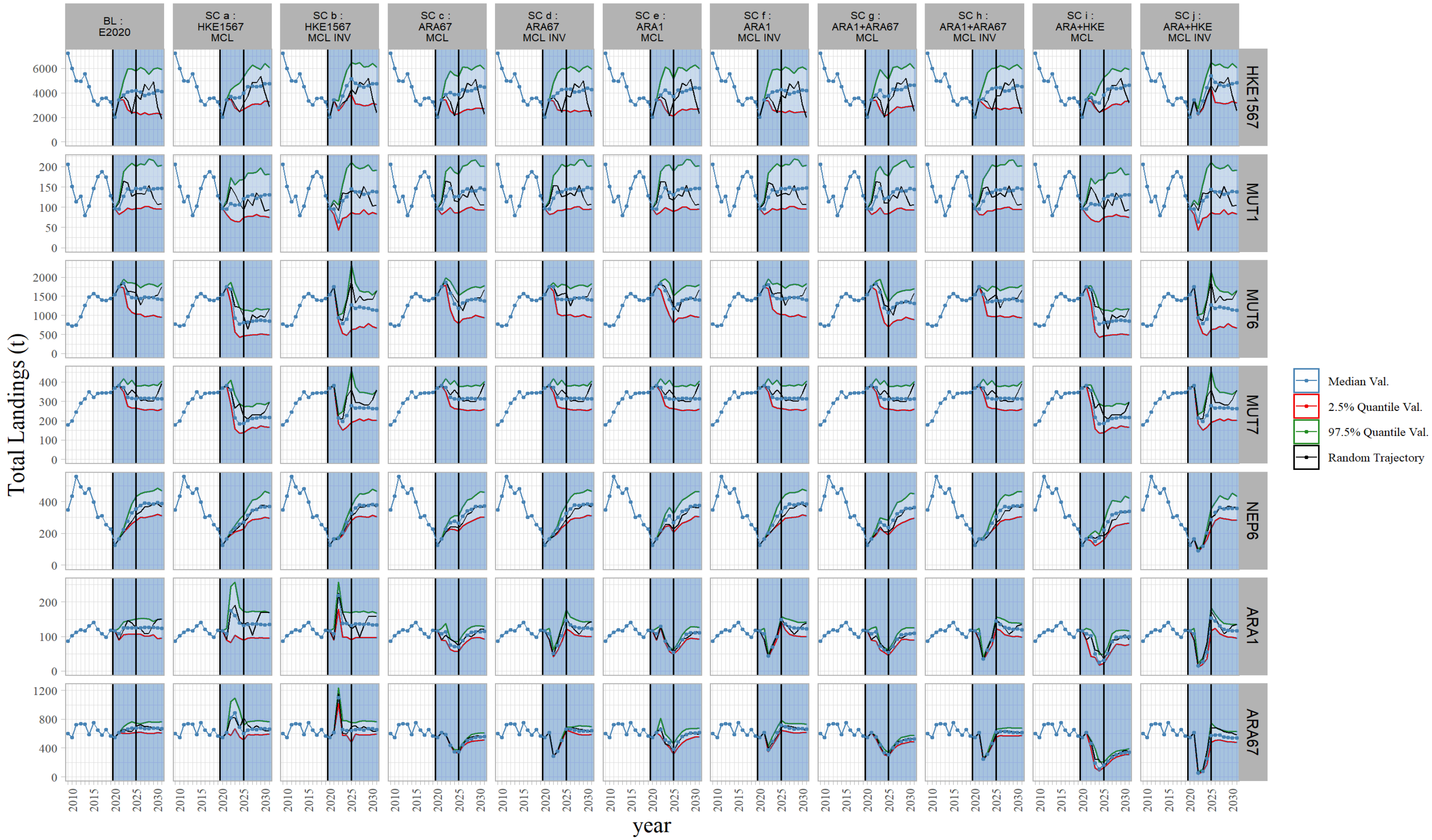


Figure 2.3.1.2.3. Evolution of the total annual landings (in tonnes) of the modelled stocks for each alternative management scenario. Vertical black lines indicate the year 2025. Scenarios are in column and stocks in row. The stocks are as follow (from top to bottom): Hake GSAs1-5-6-7 (HKE1567), red mullet GSA1 (MUT1), red mullet GSA6 (MUT6), red mullet GSA7 (MUT7), Norway lobster GSA6 (NEP6), blue and red shrimp GSA1 (ARA1) and blue and red shrimp GSAs6-7 (ARA67). Historical values of landings are given in the white areas and simulated values in the blue area.

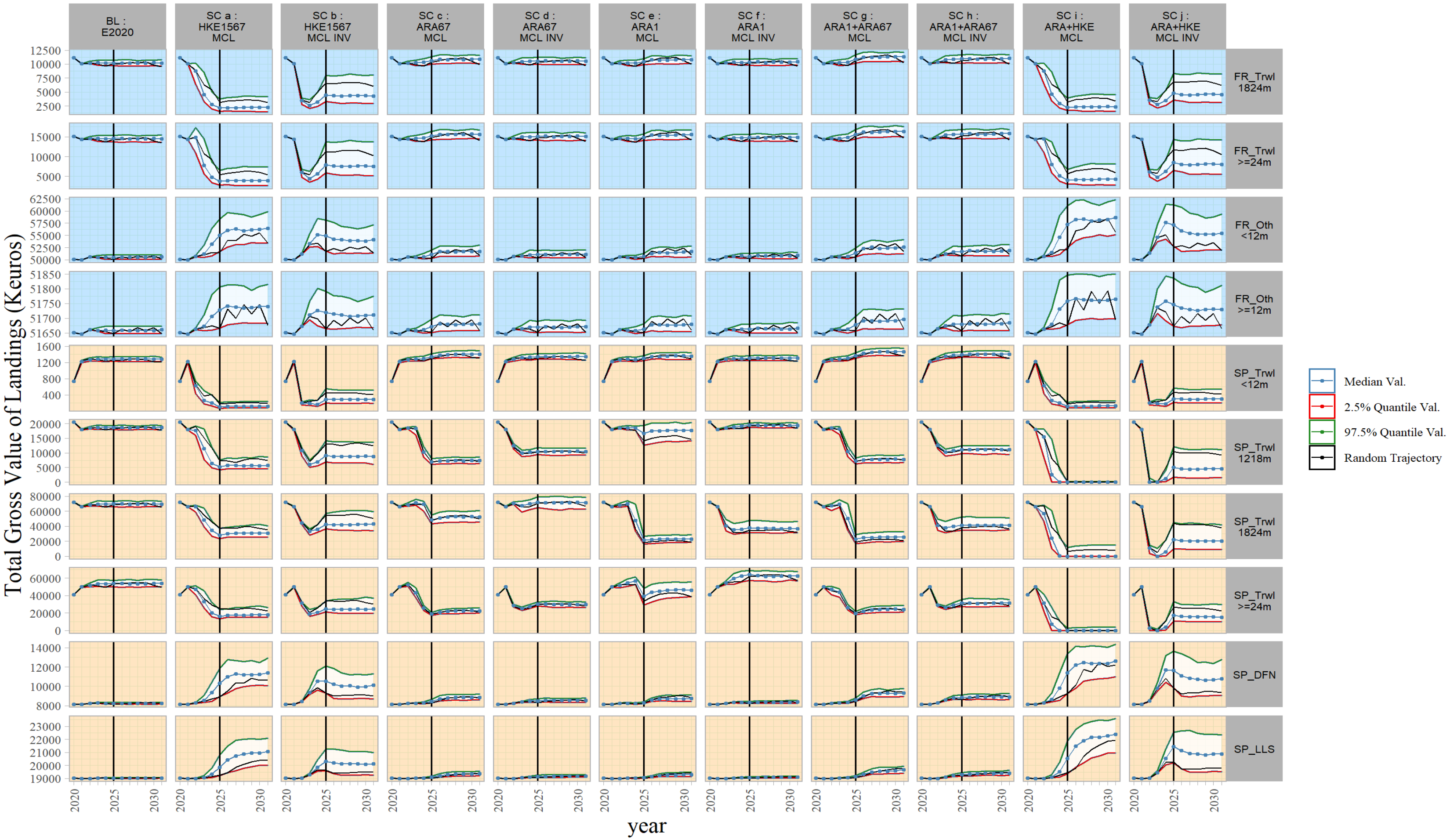


Figure 2.3.1.2.4. Evolution of the total Gross Value of Landings (GVL, i.e. revenues, in K euros) by fleet segment for each alternative scenario from 2020 to 2031. Vertical black lines indicate the year 2025. Scenarios are in column and fleet segment in row. The fleet segments are as follow (from top to bottom): French demersal trawlers 18-24m, French demersal trawlers >24m, other French vessels <12m and other French vessels >12m, Spanish trawlers < 12m, Spanish trawlers 12-18m, Spanish trawlers 18-24m, Spanish trawlers >24m, Spanish netters and Spanish vessels using hooks.

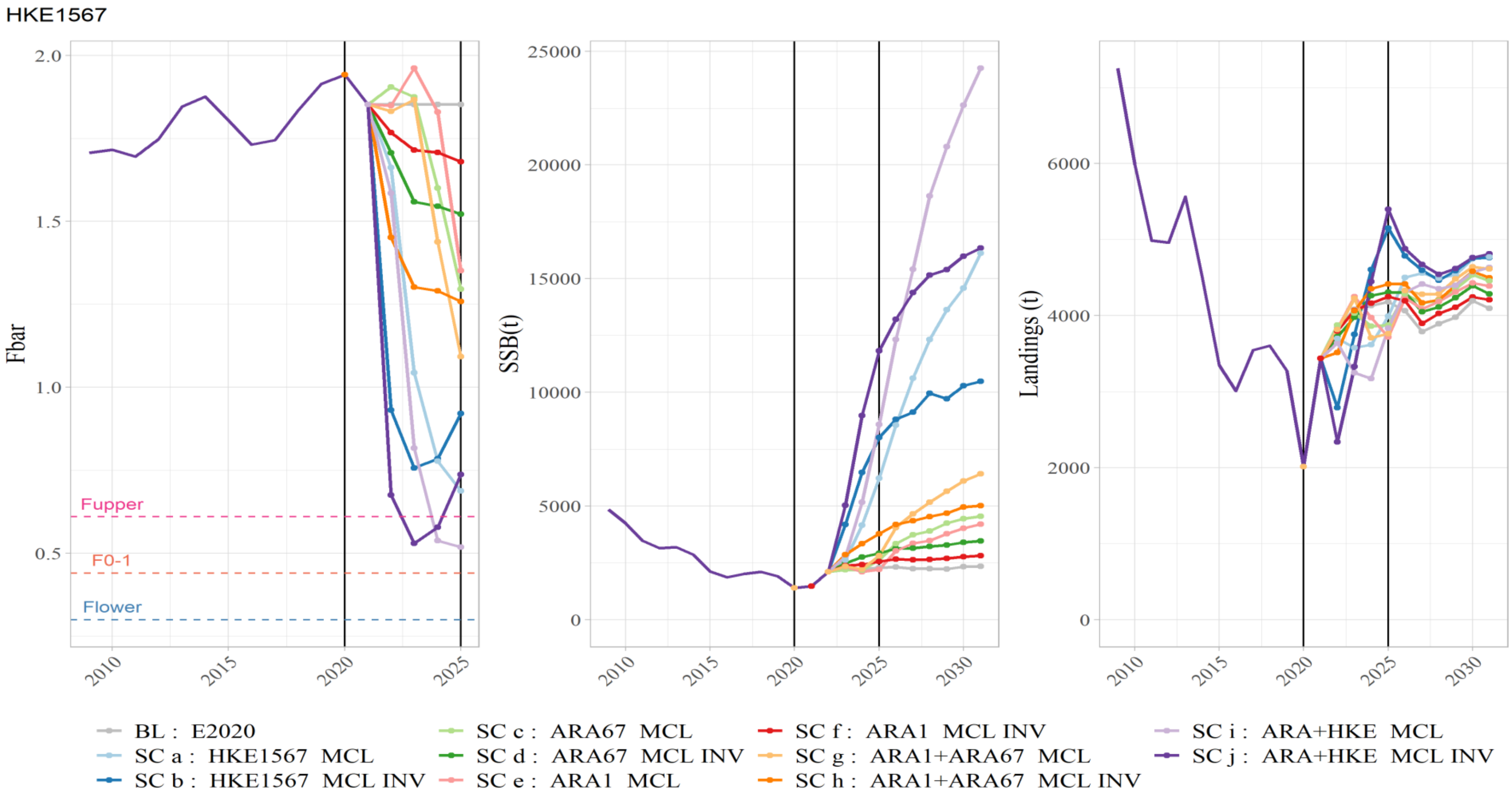


Figure 2.3.1.2.5. EMU 1. Predicted median values for Hake in GSAs 1-5-6-7 (HKE1567) Fishing mortality (left), SSB (middle) and total landings (right) under the alternative scenarios (in colors).

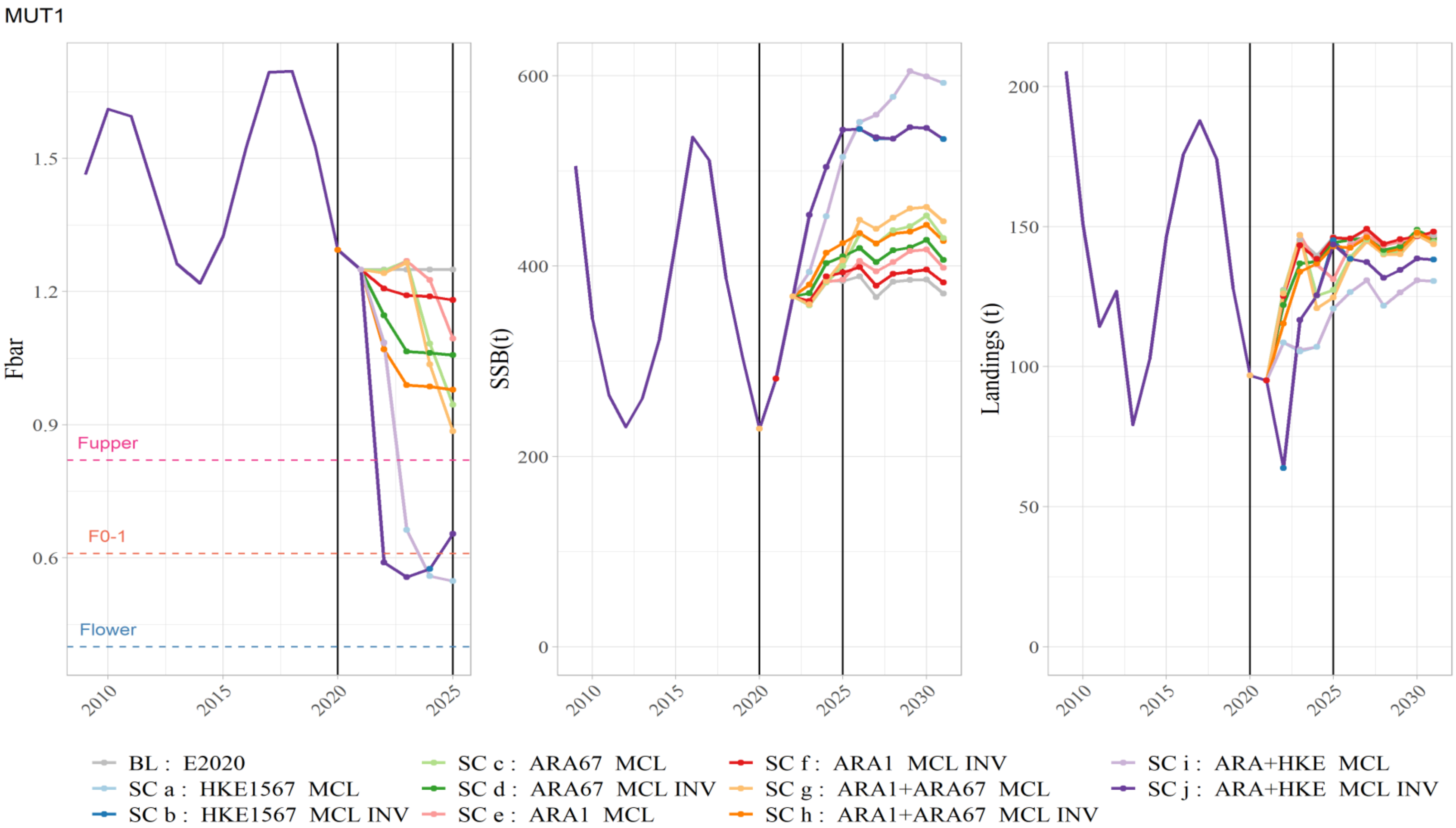


Figure 2.3.1.2.6. EMU 1. Predicted median values for red mullet in GSA 1 (MUT1) Fishing mortality (left), SSB (middle) and total landings (right) under the alternative scenarios (in colors).

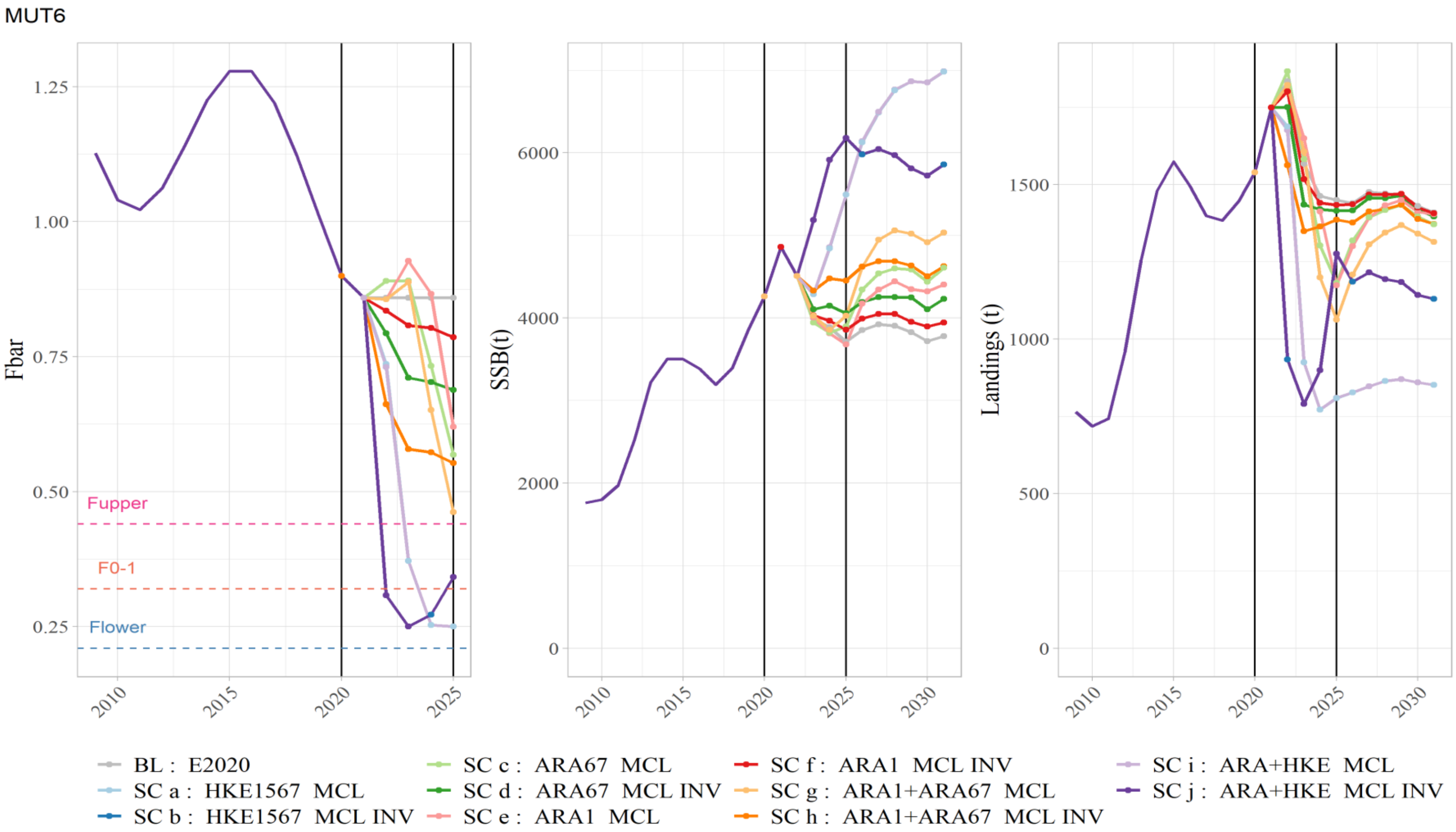


Figure 2.3.1.2.7. EMU 1. Predicted median values for red mullet in GSA 6 (MUT6) Fishing mortality (left), SSB (middle) and total landings (right) under the alternative scenarios (in colors).

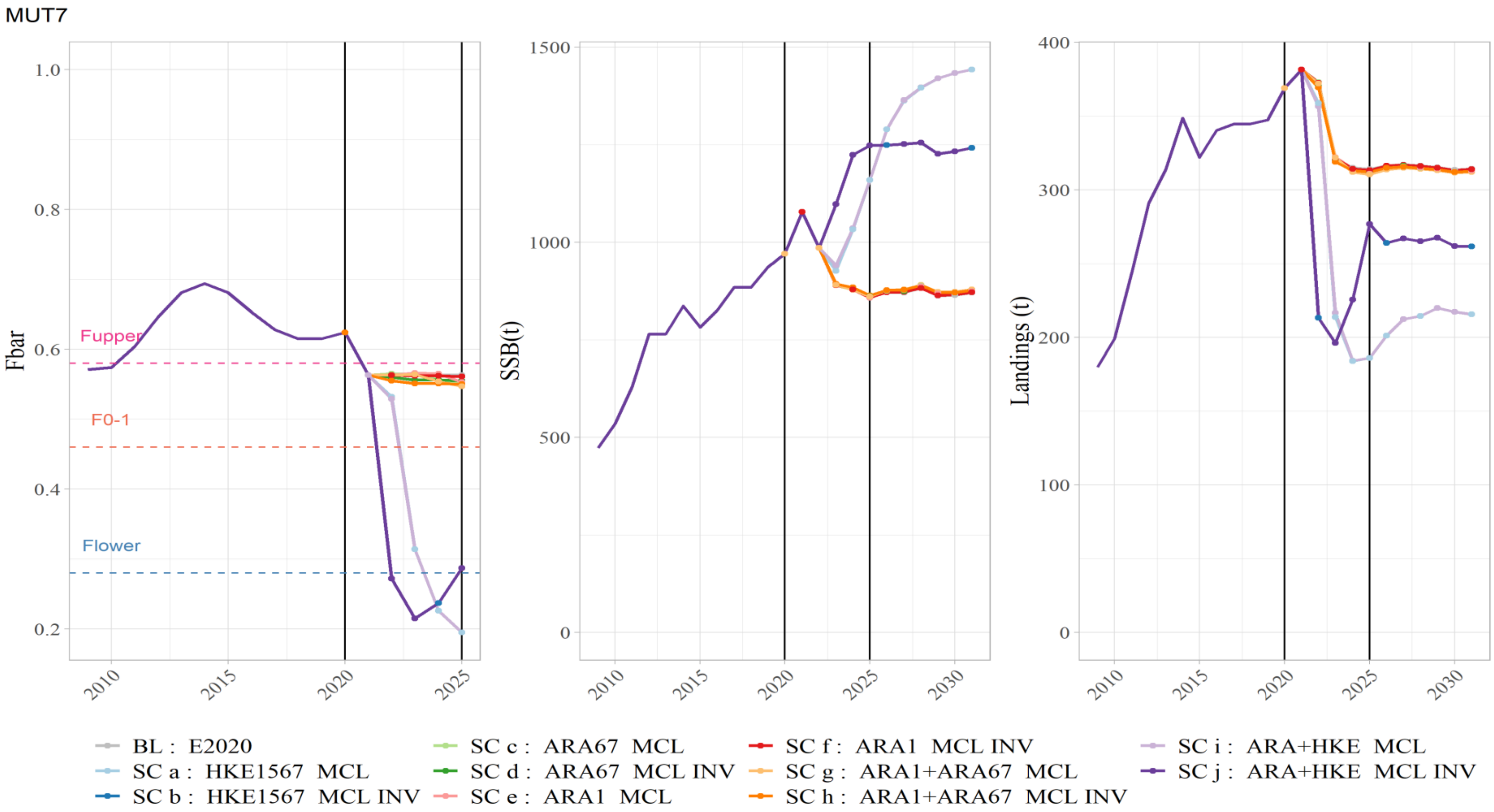


Figure 2.3.1.2.8 EMU 1. Predicted median values for red mullet in GSA 7 (MUT7) Fishing mortality (left), SSB (middle) and total landings (right) under the alternative scenarios (in colors)

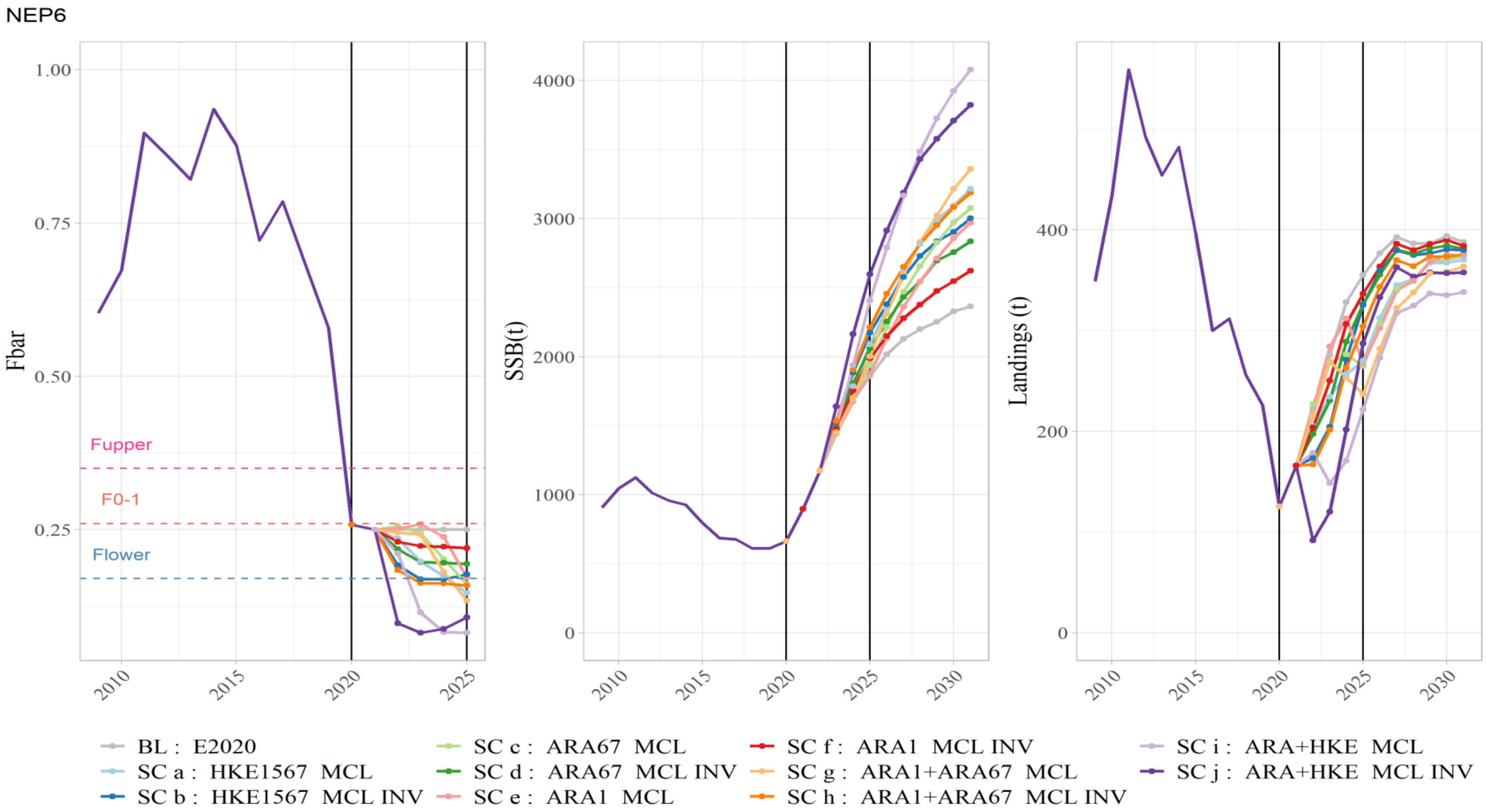


Figure 2.3.1.2.9 EMU 1. Predicted median values for Norway lobster in GSA 6 (NEP6) Fishing mortality (left), SSB (middle) and total landings (right) under the alternative scenarios (in colors)

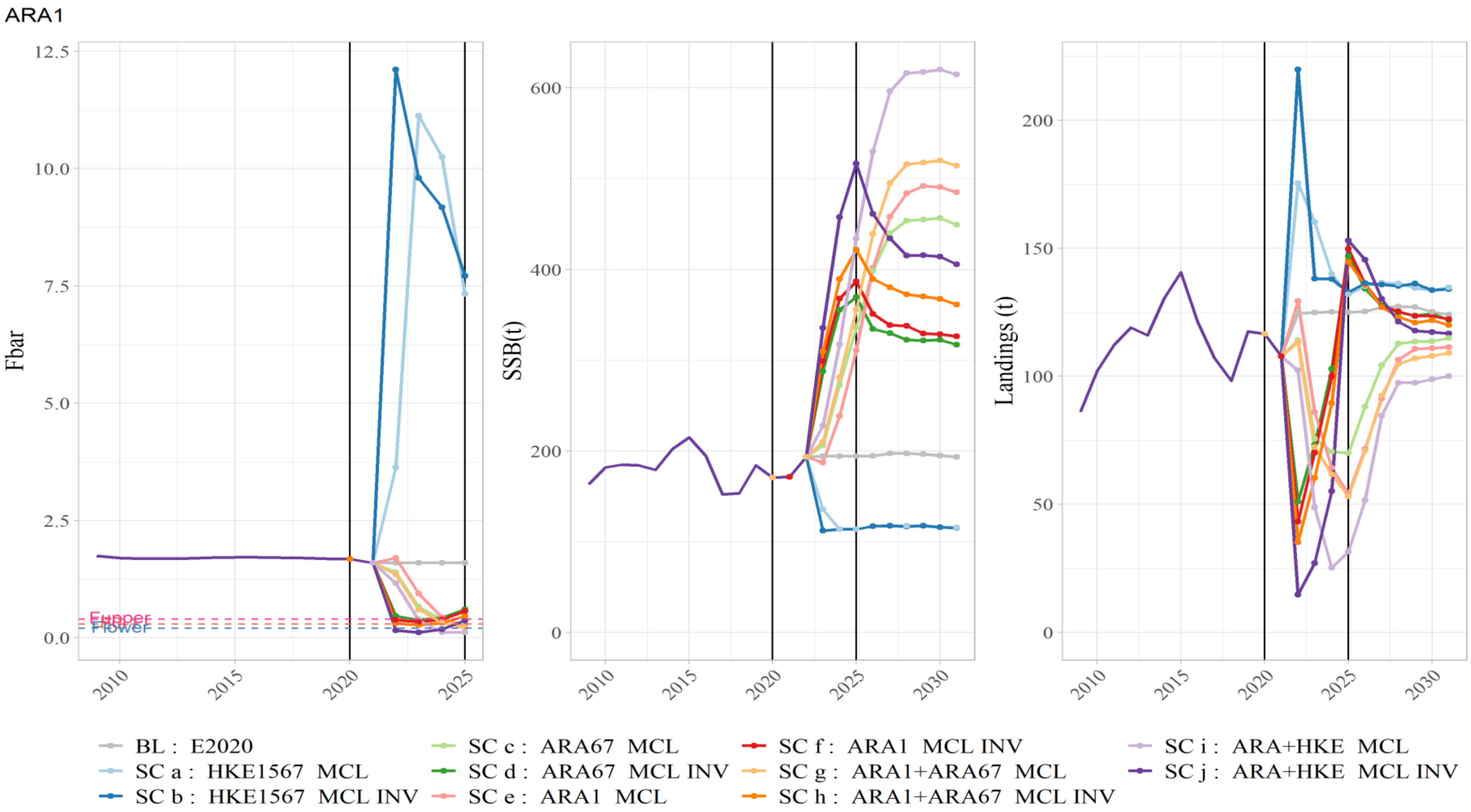


Figure 2.3.1.2.10 EMU 1 Predicted median values for blue and red shrimp in GSA 1 (ARA1) Fishing mortality (left), SSB (middle) and total landings (right) under the alternative scenarios (in colors)

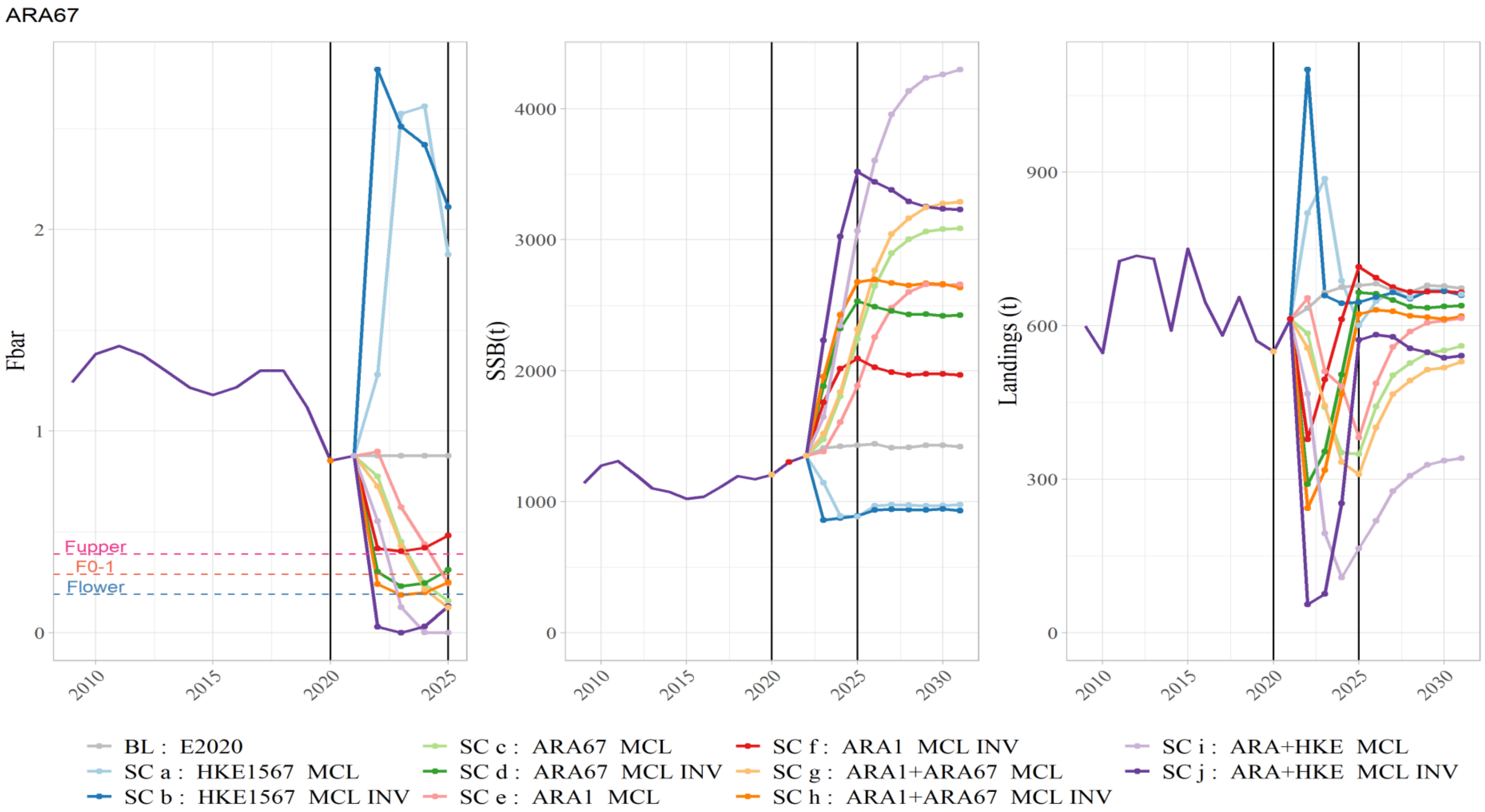


Figure 2.3.1.2.11 EMU 1. Predicted median values for blue and red shrimp in GSAs 6-7 (ARA67) Fishing mortality (left), SSB (middle) and total landings (right) under the alternative scenarios (in colors)

Table 2.3.1.2.1. EMU1. Ratio Fbar 2025/Fmsy and ratio SSB 2025/SSB 2021 per stock by scenario. The median values are used.

		Baseline (E=E2021)	Sce.a HKE1567 MCL	Sce.b HKE1567 MCL INV	Sce.c ARA67 MCL	Sce.d ARA67 MCL INV	Sce.e ARA1MCL	Sce.f ARA1MCL INV	Sce.g ARA1 + ARA67 MCL	Sce.h ARA1+ ARA67 MCL INV	Sce.i ARA + HKE MCL	Sce.j ARA + HKE MCL INV
Fbar in 2025/ Fmsy	HKE 1567	4.21	1.56	2.09	2.95	3.46	3.07	3.82	2.48	2.86	1.18	1.68
	MUT1	2.06	0.90	1.08	1.56	1.74	1.80	1.94	1.46	1.61	0.90	1.08
	MUT6	2.71	0.79	1.08	1.79	2.17	1.96	2.48	1.46	1.74	0.79	1.08
	MUT7	1.23	0.43	0.63	1.21	1.22	1.21	1.23	1.20	1.21	0.43	0.63
	NEP6	0.96	0.57	0.68	0.62	0.75	0.66	0.85	0.52	0.61	0.32	0.41
	ARA1	5.50	25.28	26.60	1.02	2.08	0.85	1.95	0.73	1.60	0.40	1.28
	ARA67	3.07	6.56	7.38	0.55	1.09	0.85	1.69	0.43	0.87	0.00	0.46
SSB in 2025/ SSB in 2021	HKE 1567	1.561	4.242	5.462	1.794	1.985	1.508	1.746	1.918	2.57	5.851	8.058
	MUT1	1.364	1.826	1.929	1.421	1.456	1.37	1.396	1.441	1.505	1.827	1.929
	MUT6	0.764	1.131	1.272	0.802	0.835	0.757	0.794	0.829	0.916	1.131	1.272
	MUT7	0.796	1.075	1.157	0.798	0.799	0.795	0.796	0.798	0.801	1.076	1.157
	NEP6	2.073	2.329	2.422	2.162	2.296	2.094	2.217	2.23	2.464	2.682	2.896
	ARA1	1.134	0.663	0.663	1.962	2.157	1.815	2.258	2.076	2.463	2.536	3.017
	ARA67	1.098	0.68	0.683	1.72	1.942	1.445	1.606	1.775	2.055	2.355	2.702

Table 2.3.1.2.2. EMU1. Ratio GVA 2025/GVA 2021 and ratio Fishing effort 2025/Fishing effort 2021 per fleet segment by scenario. The median values are used.

		Baseline (E=E2021)	Sce.a HKE1567 MCL	Sce.b HKE1567 MCL INV	Sce.c ARA67 MCL	Sce.d ARA67 MCL INV	Sce.e ARA1MCL	Sce.f ARA1MCL INV	Sce.g ARA1 + ARA67 MCL	Sce.h ARA1+ ARA67 MCL INV	Sce.i ARA + HKE MCL	Sce.j ARA + HKE MCL INV
GVA in 2025/ GVA in 2021	Fr. trawlers 18-24m	1.084	-0.644	0.021	1.31	1.259	1.196	1.164	1.428	1.465	-0.557	0.213
	Fr. trawlers >24m	1.065	-0.071	0.511	1.23	1.194	1.148	1.124	1.317	1.35	0.009	0.684
	Sp. trawlers < 12m	1.089	-0.189	0.022	1.174	1.174	1.129	1.123	1.217	1.251	-0.181	0.042
	Sp. trawlers 12-18m	1.066	-0.013	0.268	0.255	0.521	0.948	1.151	0.273	0.583	-0.25	0.148
	Sp. trawlers 18-24m	1.099	0.084	0.38	0.711	1.225	0.126	0.494	0.175	0.599	-0.319	0.219
	Spanish trawlers >24m	1.154	0.049	0.25	0.335	0.691	0.869	1.542	0.367	0.741	-0.193	0.367
	Spanish netters	1.021	1.379	1.412	1.056	1.065	1.032	1.038	1.08	1.122	1.562	1.599
	Sp. vessels using hooks	1.006	1.106	1.16	1.012	1.018	1.007	1.01	1.017	1.037	1.186	1.295
Fishing Effort in 2025/ Fishing effort in 2021	Fr. trawlers 18-24m	1	0.166	0.355	1	1	1	1	1	1	0.166	0.355
	Fr. trawlers >24m	1	0.201	0.428	1	1	1	1	1	1	0.201	0.428
	Sp. trawlers < 12m	1	0.07	0.18	1	1	1	1	1	1	0.07	0.18
	Sp. trawlers 12-18m	1	0.465	0.62	0.353	0.519	0.864	1	0.353	0.517	0	0.164
	Sp. trawlers 18-24m	1	0.715	0.949	0.616	0.89	0.278	0.479	0.278	0.466	0	0.17
	Spanish trawlers >24m	1	0.535	0.71	0.27	0.391	0.609	1	0.27	0.378	0	0.125
	Spanish netters	1	1	1	1	1	1	1	1	1	1	1
	Sp. vessels using hooks	1	1	1	1	1	1	1	1	1	1	1

2.3.1.3 Discussion

The main objective of the management plan is to reach fishing mortality values in between Fmsy ranges for each of the stock mentioned in the management plan by 2025. IAM simulations outputs suggest that, beside a scenario of MCL for trawlers on both Hake and Blue and red shrimps, none of the proposed scenario would achieve this goal. The reverse MCL scenario on both Hake and Blue and red shrimp does not allow reaching this objective for HKE1567. Similarly, this is the case for MCL on Hake only. This is because the values of MCL are the one estimated by the stock assessment EWG 21-11 group, and these values are applied only for trawlers, while they are estimated accounting for all gears. In order to reach Fmsy in 2025, catches from other fleet segments (such as longliners and gillnetters) should be taken into account in the Hake MCL estimation for trawlers.

This would not have happened with scenarios where the fishing effort of the trawl fleet segments were adjusted to reach Hake Fmsy, rather than having an exogenous MCL value to reach.

Still, the scenarios of MCL on Hake (a, b, i and j) lead to a strong reduction of Fbar for all stocks reviewed, placing most of them at or below Fmsy; except for ARA1 and ARA67 for which the Fbar is increasing. This increase in ARA1 and AR67 fishing mortalities is explained by the assumption in the model that the fishing effort from the coastal trawling is reported toward the deep-water trawl metier. This leads to an increase in the fishing pressures on deep-water species, including ARA. However, the economic consequences of these scenarios are severe for all the trawl fleets. Indeed, the implementation of MCL on Hake in IAM lead to a massive GVA (Gross Value Added) drop for the Spanish and French trawler fleet segments. However, these scenarios are advantageous to Spanish gillnetters and vessels using hooks (especially longliners). Indeed they are not regulated in those scenario - i.e. their fishing effort remain constant at 82.5% of their 2015-2017 effort level -, and they are the primary benefactor from the increased SSB of Hake.

The scenarios of applying a MCL and a reverse MCL on ARA1 and/or ARA67 (scenarios c to h) negatively affect the economic performance (i.e. gross value added) only of Spanish trawlers over 12 meters, while these scenarios benefit French trawlers and Spanish trawlers under 12 metres. Indeed, as these fleets do not catch ARA, their fishing effort is not reduced due to the application of an MCL on ARA, and they benefit from the increase in biomass of Hake, Red mullet and Norway lobster. In MCL on ARA scenarios, European hake, red mullet and Norway lobster stocks are indeed experiencing slight SSB increases compared to the baseline scenario, due to a slight reduction in their fishing pressures as shown in the Fbar figures. These fishing mortality reductions are explained by the reduction in deep-water trawl effort. In the IAM model parametrization, based on FDI data, the deep-trawl metier indeed catches – to a small extent – European Hake, Red mullet and Norway lobster stocks. From an ecological point of view, the MCL scenarios on ARA stocks achieve the plan's objectives for ARA, while the reverse MCL scenarios do not completely.

When comparing the MCL and reverse MCL scenarios, it is important to keep in mind that, in the IAM simulations, the fishing effort of the different fleet segments is assumed constant from 2026 to 2031 and equal to their fishing effort in 2025. Therefore, the efforts of the trawler fleets are higher for the period 2026-2031 in the reverse MCL scenarios than in the MCL scenarios.

As said in EWG 20-13 and EWG 21-13, it is important to note that landings per unit of effort of other species (than the ones that are explicitly modelled) are assumed constant in time. Consequently, potential positive impacts of effort reduction on those other stock biomasses are not simulated and total landings might thus be underestimated. As the proportion of the landings of those other species are very high for most fleet segments, the negative economic impacts of the effort reduction management scenarios displayed might be overestimated in our simulations. This is true especially in the long run, as positive effect of effort reduction in stock biomasses are not instantaneous.

2.3.2 ISIS-fish in EMU 1 (GSA 7)

2.3.2.1 Management scenarios considered

Management scenarios are based on TOR 1 of EWG22-01 and inputs provided by the experts in course of the working group as for the definition of MCL values and allocation between fleets and months. The five scenarios are listed in Table 2.3.2.1.1. The annual MCL 2022-2025 was either set based on a transition path from current fishing mortality to catch at Fmsy (using a priori set MCL values) between 2022 and 2025 (SCd and f) or as catch at Fmsy from 2022 on (accounting for biomass evolution, HCR-like scenario) (SCe and g). From 2026, MCL is based on Fmsy. An annual MCL allowing a race for quota (SCd and e) and a monthly distributed MCL (SCf and g) were compared. MCLs only apply to trawlers. MCL is split by fleet (3 fleets): Spanish trawlers, French trawlers <24m, French trawlers >24m

Table 2.3.2.1.1 Scenarios implemented in ISIS-fish for HKE in GSA 7.

	Scenario	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	… 2030
		0	1	2	3	4	5	6	7	8	9	10	15
		Calibration			Hindcast					Projection			
Effort	a	2015	2016	2017	Mean 2015-2017					Mean 2015-2017			
Effort reduction trawlers (rel.2015-17)							-10%	-17.5%	-17.5%	-17.5%			
Closures							Existing ones			Existing ones			
Recruitment		2015	2016	2017	2018	2019	2020	Mean 2018-2020		Mean 2018-2020			
MCL	d Annual = a + MCL								2435	1828	1372	1220	HCR FMSY
MCL	e = a + MCL Inverse								1220	HCR FMSY			
MCL	f = a + Monthly MCL								2435	1828	1372	1220	HCR FMSY
MCL	g = a + Monthly MCL inverse								1220	HCR FMSY			

2.3.2.2 Results

Results are discussed in terms of decrease in fishing mortality (F) and pressure over the different stages, biomass and fleet revenues and change in effort pattern due to limitation in catch.

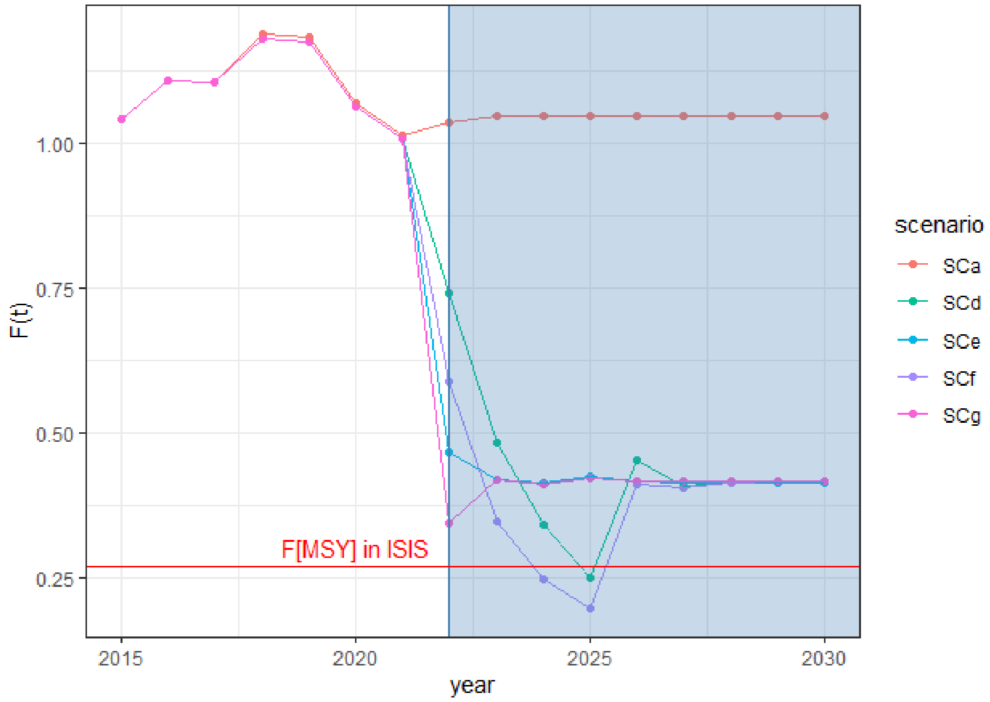


Figure 1.3.2.2.1: Predicted fishing mortality of hake (GSA7) by in the reference scenario (SCa) and the four MCL scenarios (d- annual transition, e- annual inverse, f- monthly transition, g- monthly inverse).

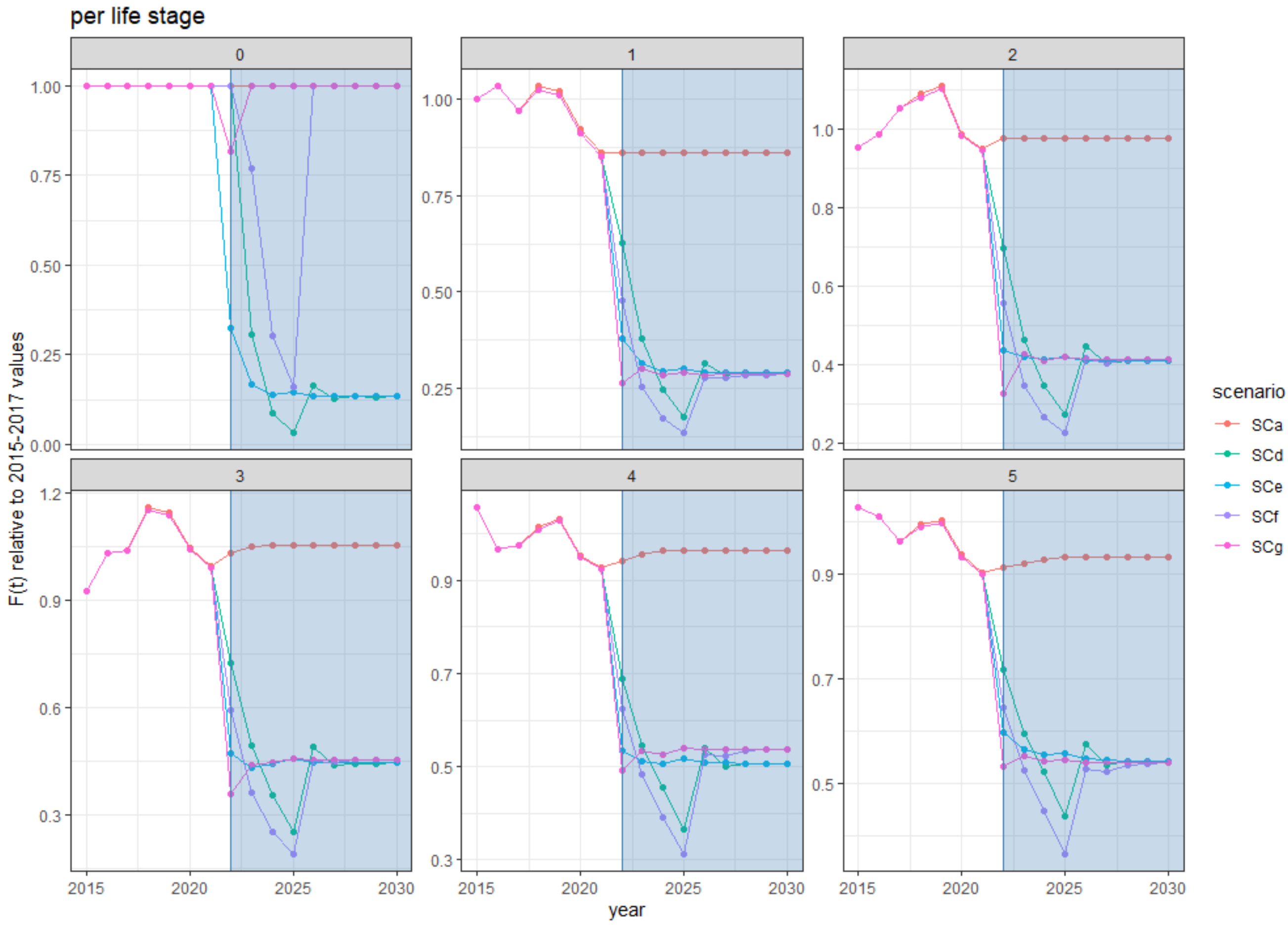


Figure 2.3.2.2.2: Fishing mortality at age (panels 0 to 5) of Hake GSA7 relative to average values 2015-2017 as predicted by the ISIS-Fish model for the reference scenario (SCa) and the four MCL scenarios (d- annual transition, e- annual inverse, f- monthly transition, g- monthly inverse).

Despite a significant reduction in fishing mortality, Fmsy is not sustainably reached in 2030 because of the unconstrained catch of the netters and longliners (F2030 = 1.5 x Fmsy) (fig. 2.3.2.2.1). In scenarios with the transition path, F dropped progressively from 2022 and fell below Fmsy in 2025 (SCd) or 2024 (SCf -monthly). This is due to the rapid rebuilding of the biomass, which made the pre-defined MCL values too constraining. However, when the HCR took over in 2026, the fishing mortality increased again to stabilise at 0.38. In the inverse scenario, the MCL value set based on the assessment for 2022 allowed reducing fishing mortality to 0.68 and 0.54 respectively in the annual and monthly scenario (2.7 and 2 times Fmsy). F then stabilised at 0.38 under the HCR control, just like in the transition path.

Pressure was particularly released on younger age classes (-60% to 80%) with the annual MCL (fig. 2.3.2.2.2). On the contrary, the pressure on age-0 fishes is identical as in the reference scenario when the MCL is monthly spread. The processes at play are i) that the recruitment was modelled as constant and ii) that the recruitment arrives progressively in the fishery in course of the year. i) caused the pressure on age-0 fish to stay high because the MCL increased but not the recruitment and ii) made the annual MCL act as a protection for juveniles because the fishery stopped before the peak of recruits entered the fishery.

Apart from the above-mentioned differences, the pattern of fishing mortality reduction is similar in annual and monthly implementation of the MCL, but the reduction is stronger in the monthly scenario for the older age classes.

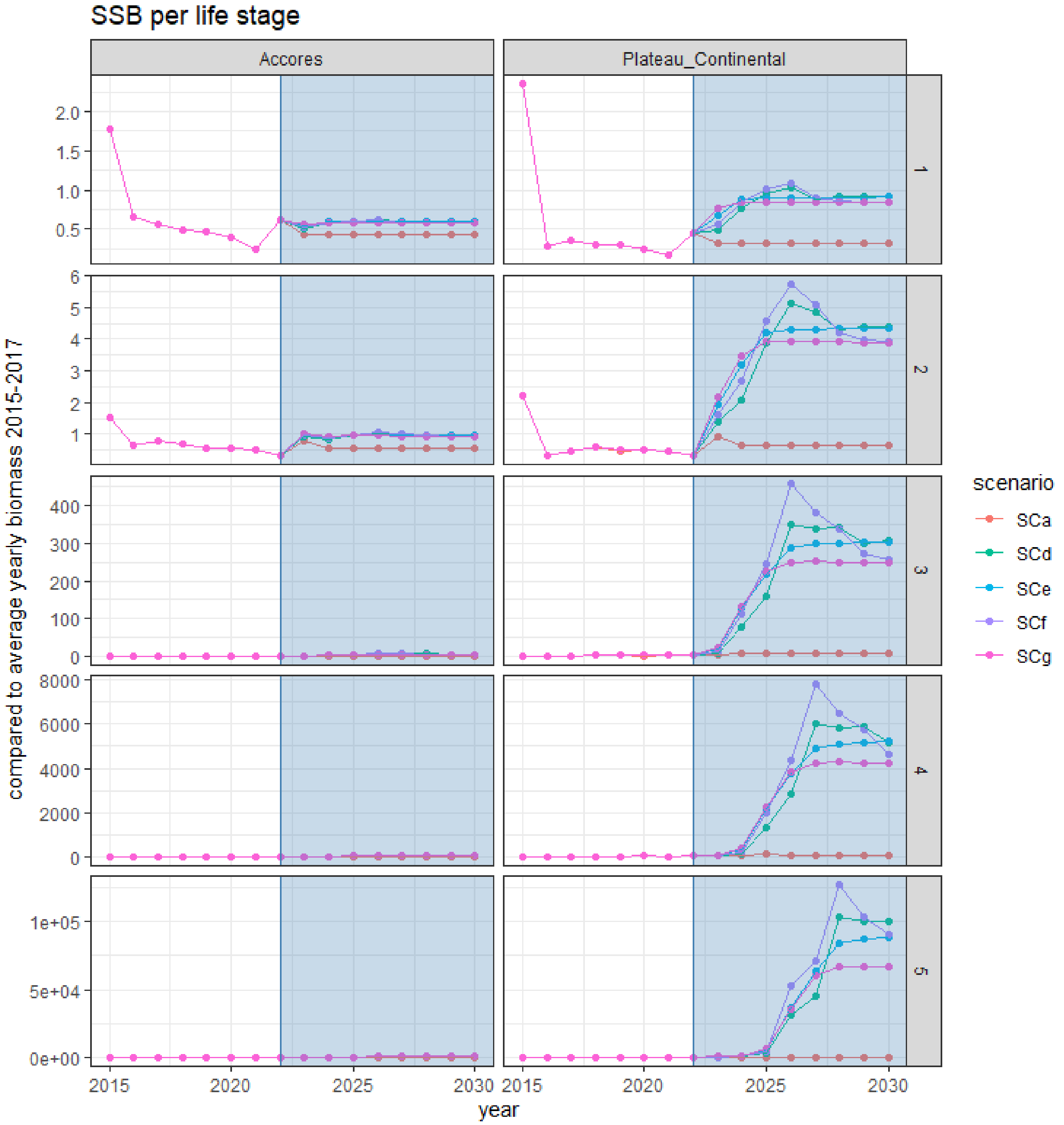


Figure 3.3.2.2.3 Biomass at age of hake in the two habitats (GSA7) predicted by the model relative to average values 2015-2017 for the reference scenario (SCa) and the four MCL scenarios (d- annual transition, e- annual inverse, f- monthly transition, g- monthly inverse).

Biomass rebuilding is fast and particularly spectacular on the Plateau (shelf) (fig. 2.3.2.2.3). Because of the constant recruitment, it is expected that the effect is amplified for older age classes and limited on younger fishes.

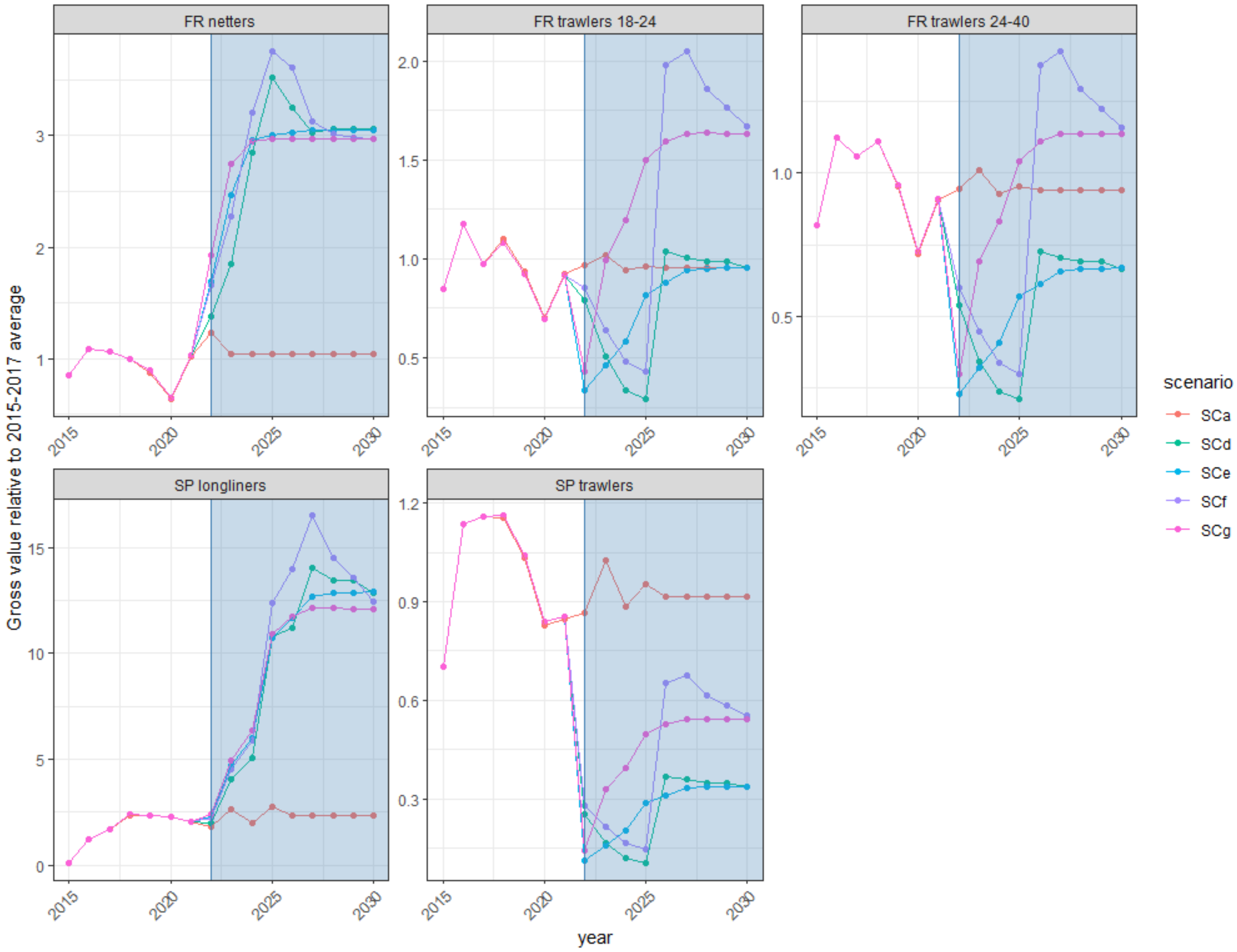


Figure 4.3.2.2.4 Gross revenues associated to hake (GSA7) per fleet as predicted by the model relative to average values 2015-2017 for the reference scenario (SCa) and the four MCL scenarios (d- annual transition, e- annual inverse, f- monthly transition, g- monthly inverse).

The model predicted an important decrease of trawler revenues in the first years of MCL implementation (fig. 2.3.2.2.4). The decrease was as strong as -90% for Spanish trawlers. For French trawlers the decrease was more moderate (-50% to -70%). Netters and longliners benefitted for the release of pressure and their revenues increased. A positive effect of the monthly spread MCL was observed which allowed significantly higher revenues, and even outperformed the reference scenario and historical averages (except for Spanish trawlers).

In terms of effort, the annual MCL imposed very early closures of the fisheries. Generally, trawlers fish until March under the HCR and in the Inverse scenario. However Spanish trawlers were constrained to stop fishing in January in 2024 and 2025 of the transition scenario when the MCL was set too low.

When the MCL is spread over months, effort is around 4 times lower than the average 2015-2017 with variations depending on the fleet and the month of the year.

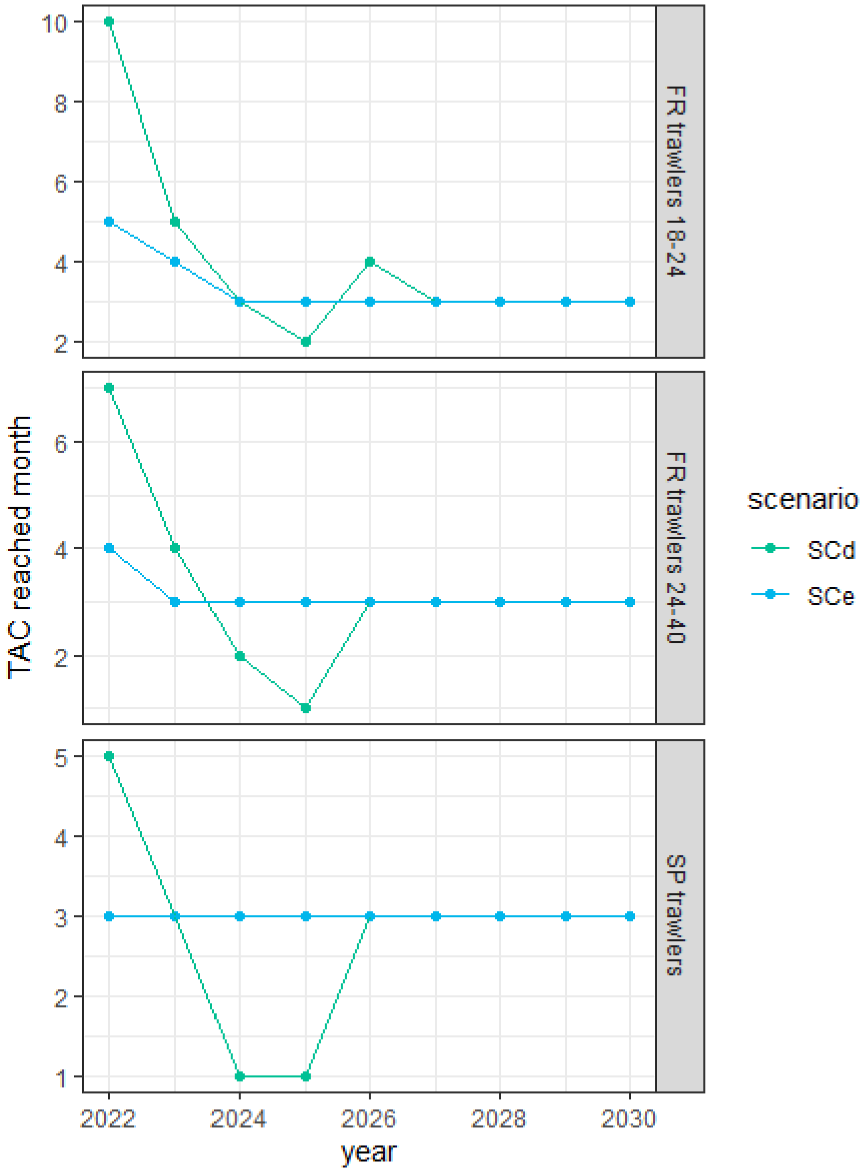


Figure 5.3.2.2.5 Month of choke per fleet predicted by the ISIS-Fish model for hake MCL in GSA7 for scenarios of annual MCL (d- annual transition, e- annual inverse).

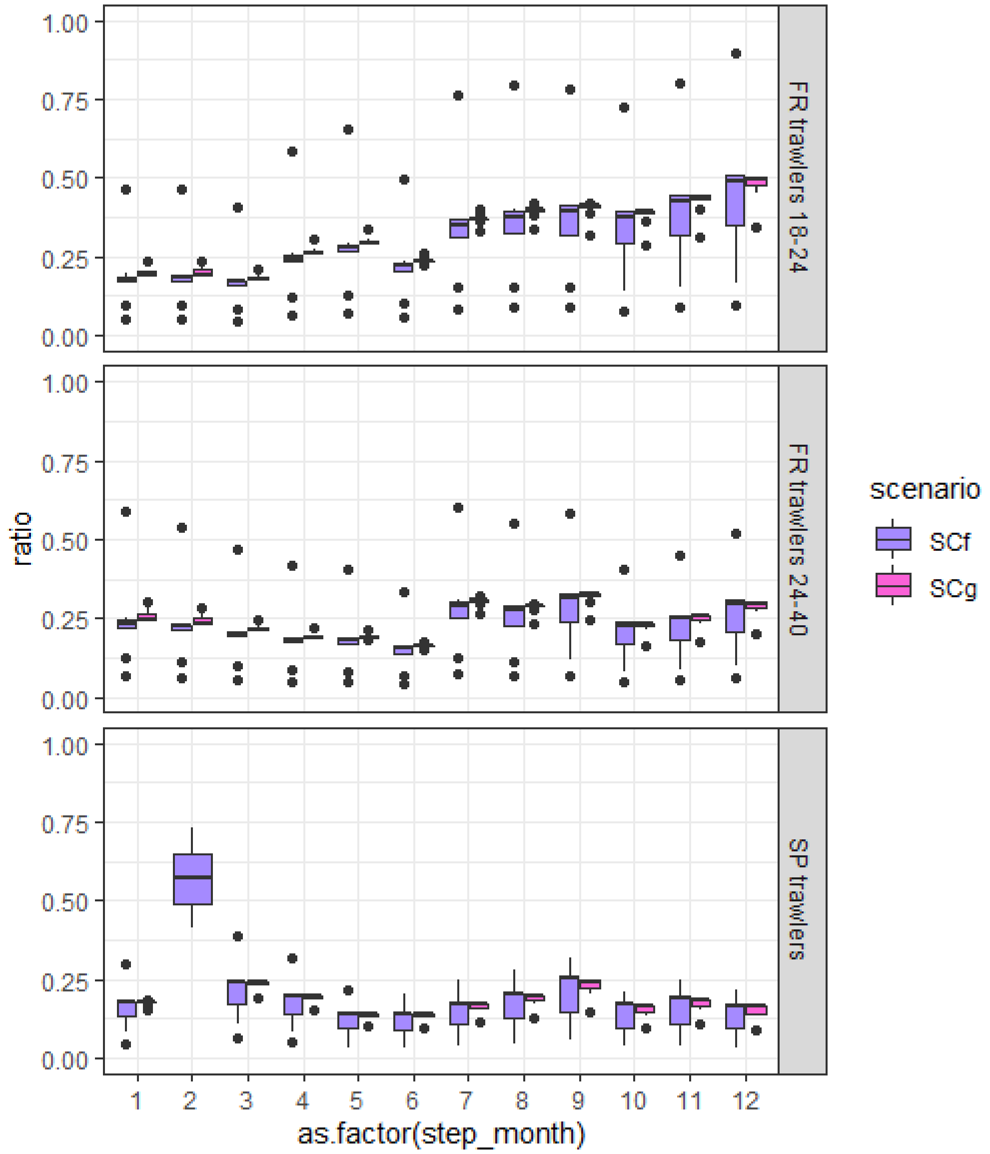


Figure 6.3.2.2.6 Effort per month as a ratio of the effort in the same month between 2015 and 2017, per fleet as predicted by the ISIS-Fish model for hake MCL in GSA7 for scenarios of monthly MCL (f- transition, g-inverse).

2.3.3 BEMTOOL in EMU 2

2.3.3.1 Baseline Run 2022-2025

Eight scenarios among the ones listed in the ToRs were implemented:

A) Annual MCL (maximum catch limit) on ARS from the year 2022, set as the maximum catch limit in EU Reg 2022/110, to the year 2025, set as the catch associated to Fmsy by EWG 21-11;

B) Annual MCL on ARS inverse: as scenario A, inverting the MCL values from 2022, to 2025;

C) Monthly MCL on ARS from 2022, from the year 2022, set as the maximum catch limit in EU Reg 2022/110, to the year 2025, set as the catch associated to Fmsy by EWG 21-11;
D) Monthly MCL on ARS inverse: as scenario C, inverting the MCL values from 2022, to 2025;
E) Annual MCL (maximum catch limit) on ARA from the year 2022, set as the maximum catch limit in EU Reg 2022/110, to the year 2025, set as the catch associated to Fmsy by EWG 21-11;
F) Annual MCL on ARA inverse: as scenario A, inverting the MCL values from 2022, to 2025;
G) Monthly MCL on ARA from 2022, from the year 2022, set as the maximum catch limit in EU Reg 2022/110, to the year 2025, set as the catch associated to Fmsy by EWG 21-11;
H) Monthly MCL on ARA inverse: as scenario C, inverting the MCL values from 2022, to 2025.

A status quo (SQ) scenario was carried out assuming no change in management measures from 2021.

The maximum catch limit by year was estimated for each species in order to have a gradual reduction from the maximum catch limit in the EU Reg 2022/110 and the catch associated to Fmsy as estimated by EWG 21-11. The maximum catch limits of ARS and ARA were split among the fleet segments and quarters according to their proportion in the landing in the FDI data in the reference period 2015-2017. The catch limit for the stocks by year and by quarter are reported in Table 2.3.3.1.

First deterministic runs were done to get a first feedback on:

1) the completeness and coherence of inputs and of the BEMTOOL parameterization;
2) the different scenarios settings.

Then, given the computation time, stochastic runs were performed in a second step and are here reported.

For all scenarios the basis was given by the number of fishing days by fleet as the average in the period 2015-2017.

Table 2.3.3.1 MCL of ARS and ARA by year and by quarter (weights in tons).

Year	Quarters	1	2	3	4	Tot
2022	ARA	44	71	96	39	250
2023	ARA	26	42	56	23	148
2024	ARA	15	25	33	14	87
2025	ARA	8	13	17	7	45
2022	ARS	71	106	127	61	365
2023	ARS	59	88	106	50	303
2024	ARS	49	73	88	42	252
2025	ARS	47	70	84	40	241

Scenarios A to D were carried out with the hypothesis of maximum catch limit on ARS (generally targeted together with ARA), while scenarios E to H were implementing MCL on ARA (the most overexploited species). Scenarios B, D, F and H assumed inverse levels for catch limit, increasing the value toward 2025. The MCL associated to Fmsy was set according to the results of the short-term forecast (STF) carried out in STECF EWG 21-11. The model works at monthly level, checking every month and for each trawl fleet if the catch limit is reached or not. In the hypothesis of annual catch limit (scenarios A, B, E and F), when the catch limit is reached, the fleet stops to fish ARS and ARA, targeted by OTB DWS and OTB MDD metier, and allocates the remaining effort to OTB DES, increasing the pressure on the stocks targeted by this metier. This is to simulate that, when a catch limit on ARA and/or ARS is reached, the fleet moves on other fishing grounds, inhabited by other stocks.

In scenarios C, D, G and H the same scenarios are implemented but the catch limit is set on a monthly level, according to the distribution of the landing among the months. These scenarios were implemented to avoid the "run to fish" behaviour.

The effort in the projections is assumed to be distributed among the months as in the last year of simulation; the monthly ratio between each fleet segment catch to the total catch (p coefficient, used to split the total F among the fleet segments in the BEMTOOL F formulation) in the forecast is the same of the last year of simulation.

The following equation, internally applied by the model to recalculate the fishing mortality, was used to reshape the F by fleet, acting on the activity, as modified by the fleet when the MCL is reached:

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

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

2.2.4 Runs performed and analysed during EWG 22-01: discussion

The scenarios were implemented on the basis of historical information on the stocks status (SSB, F, catch) mimicked in BEMTOOL model that was observed in agreement with the outcomes of the STECF EWG 21-11.

The performance of the scenarios was evaluated on the basis of spawning stock biomass, catch, F, revenues, gross value added and current revenues to break-even revenues (CR/BER). The latter is an economic indicator that shows how close the current revenue of a fleet is to the revenue required for the economic break even. Ratios > 1 indicate that enough income is generated to cover operational costs (variable and non-variable costs) and therefore break-even. If the ratio is less than 1, insufficient income is generated to cover operational costs and therefore the fleet is in a loss. The formulations of CR/BER and gross value added follow:

Gross value added:

$$\boldsymbol{GVA = R_{f,t} - VC_{f,t} - FC_{f,t} - MC_{f,t}},$$

where $R_{f,t}$ are the total revenues for fleet f at time t, VC the variable costs, FC the fixed costs and MC the maintenance costs;

CR/BER (Annual Economic Report on the EU Fishing Fleet, 2013): ratio between current revenues (CR) and BER: $BER_{f,t} = \frac{OFC_{f,t}+DC_{f,t}+OC_{f,t}}{1-\frac{LC_{f,t}+VC_{f,t}+MC_{f,t}}{R_{f,t}}}$, where $OFC_{f,t}$ are other fixed costs for the fleet segment f at time t; $DC_{f,t}$ are the depreciation costs; $OC_{f,t}$ the opportunity costs; $LC_{f,t}$ are the labour costs; $VC_{f,t}$ are the variable costs ; $MC_{f,t}$ are the maintenance costs; $R_{f,t}$ the total revenues.

Figure 2.3.4.1 reports the reached F for each scenario and stock. The scenarios E and G, setting a MCL for ARA (annual and monthly respectively), are the ones reducing more the fishing mortality on ARS9-10-11 and ARA9-10-11. Both scenarios excessively decrease the F on ARS9-10-11 and ARA9-10-11 from 2026 and going below Fmsy for both stocks. This is due to the fact that in the scenarios the annual MCL are set at the beginning of the projections, according to STF carried out in 2021 and according to a gradual MCL decrease towards Fmsy level. Indeed, the hypothesis of a gradually decreasing MCL, especially in scenario A, representing the "run to fish" hypothesis, could not completely accommodate the dynamic of the stock, that is expected to recover when the MCL is implemented. A smaller MCL in the second year of implementation, would be reached before, respect to the previous year and so on. In scenario G, where the MCL is set monthly and the fishing effort split among the months according to the fishery seasonality, the F remains more stable even after 2025, although below the reference point.
Scenarios F and H represent an alternative possibility to set the MCL, as a gradual increasing MCL, that theoretically would allow for a new, possibly higher, MCL in the next year to be derived according to the new Fmsy. Both scenarios allow to importantly reduce the F approaching the reference point of ARA9-10-11, although scenario H allows to maintain a more stable level of F after. Both scenarios highlight that for ARS9-10-11 the F reaches values well below Fmsy, with risk of underutilization(Figure 2.3.4.1). Moreover, when a MCL on ARA and/or ARS is reached, the fleet is expected to move on other fishing grounds, inhabited by other stocks, possibly changing the pressure on them. The change in pressure is modelled as a reallocation of the metier from OTB_DWS and OTB_MDD to OTB_DES.
It is worth noting that the MCL scenarios would need to be further refined, to possibly accommodate the implementation of MCL on more than one species at a time.

For HKE9-10-11 no scenario will be effective to reach Fmsy, because the MCL on red shrimps produces the expected effect to increase the fishing mortality exerted by the fleet on the fishing grounds inhabited by this stock, when applying the metier OTB_DES. A similar pattern is showed by the F of MUT9 and MUT10, although the F remains in the Fmsy ranges. In particular for this two stocks the risk of underutilization would be reduced respect to Status quo scenario(SQ), under these alternative scenarios. Regarding DPS9-10-11, in almost all the scenarios, the fishing mortality will remain in line or slightly above the Fupper. For NEP9 all scenarios show the F remaining well below the Fmsy ranges, with a risk of underutilization of this resource, currently fished below Flower(Figure 2.3.4.1).

In Figure 2.3.4.2 are shown the SSB for the seven stocks under the 8 alternative scenarios and the SQ. In the scenario SQ the SSB is expected to remain approximately stable for ARS and ARA9-10-11. For DPS9-10-11 and MUT10 there will be a certain decrease, but in the short term. An increase is foreseen instead for HKE9-10-11, NEP9 and MUT9 (Figure 2.3.4.2), given that the most recent perception of the biomass trend in the stock assessment results is an increasing pattern compared to the last years. Catches would remain quite stable for some stocks, slightly decreasing for MUT10 and DPS9-10-11 and increasing for HKE9-10-11, NEP9 (Figure 2.3.4.3). Total revenues, gross value added and CR/BER for the overall fleet are predicted to slightly increase respect to the lowest values of the time series reached in 2020-2021 (Figure 2.3.4.4-6).

For ARA9-10-11, ARS9-10-11 and NEP9 all MCL scenarios return a catch value that is below or in line with the SQ, while for the other stocks the catches are higher than the SQ for all the scenarios. The total revenues across all fleets will decrease with respect to the situation under the SQ, remaining slightly above the recent values. A similar pattern is observed for R/BER and gross value added (Figures 2.3.4-6.4).

All the alternative scenarios explored, implementing a MCL on ARA and ARS, mainly target by OTB_DWS and OTB_MDD metier, show an improvement in the SSB of ARA9-10-11, ARS9-10-11 and NEP9, targeted by those metier, respect to the SQ. For the other stocks, targeted also by OTB_DES, all the scenarios return an SSB value lower than the status quo, due to the re-allocation of the effort on OTB_DES, when the MCL is reached.

The SSB of ARS9-10-11 and ARA9-10-11 increased faster under scenario E, implementing the MCL for ARA in the hypothesis of annual catch and "run to fish", followed by scenario G, setting the MCL on ARA by month. A and C scenarios follow scenarios E and G, implementing the annual and the monthly MCL on ARS (Figure 2.3.4.2). For NEP9 all the scenarios implementing MCL on ARA9-10-11 return higher of SSB, followed by the scenarios implementing MCL on ARS. For the other stocks, scenarios E, F, G and H generally return lower SSB values, because the MCL on ARA9-10-11 is lower than the MCL on ARS and, thus easier to hit. For this reason those scenarios correspond to a higher pressure on these stocks and a lower biomass level.

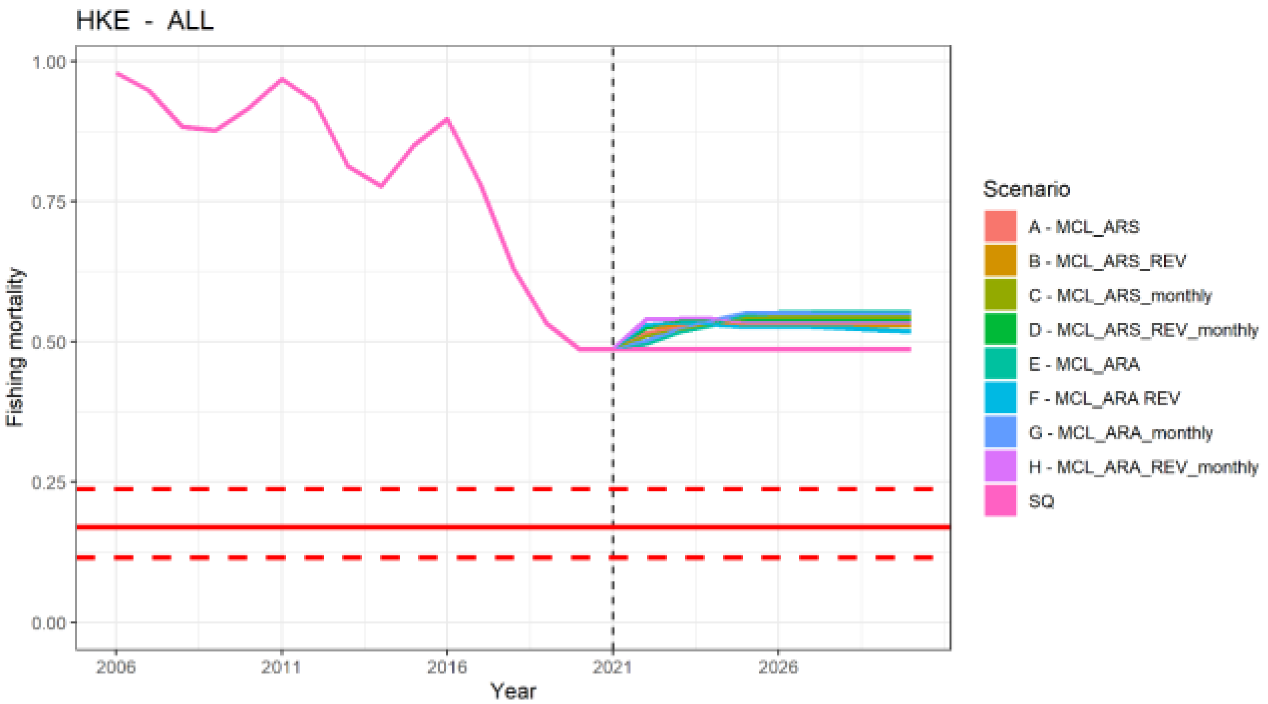
Scenarios A, B, C and D allow to importantly approach the Fmsy range of ARA and ARS, and in some cases to go below, respect to the current fishing level. For the other stocks, except NEP9 already exploited below Fmsy, the alternative scenarios do not allow to reach the Fmsy range. It is important to notice that Fmsy value is expected to change in time, due to the application of management measures, but, for simplicity, it was assumed to be fixed along the years.

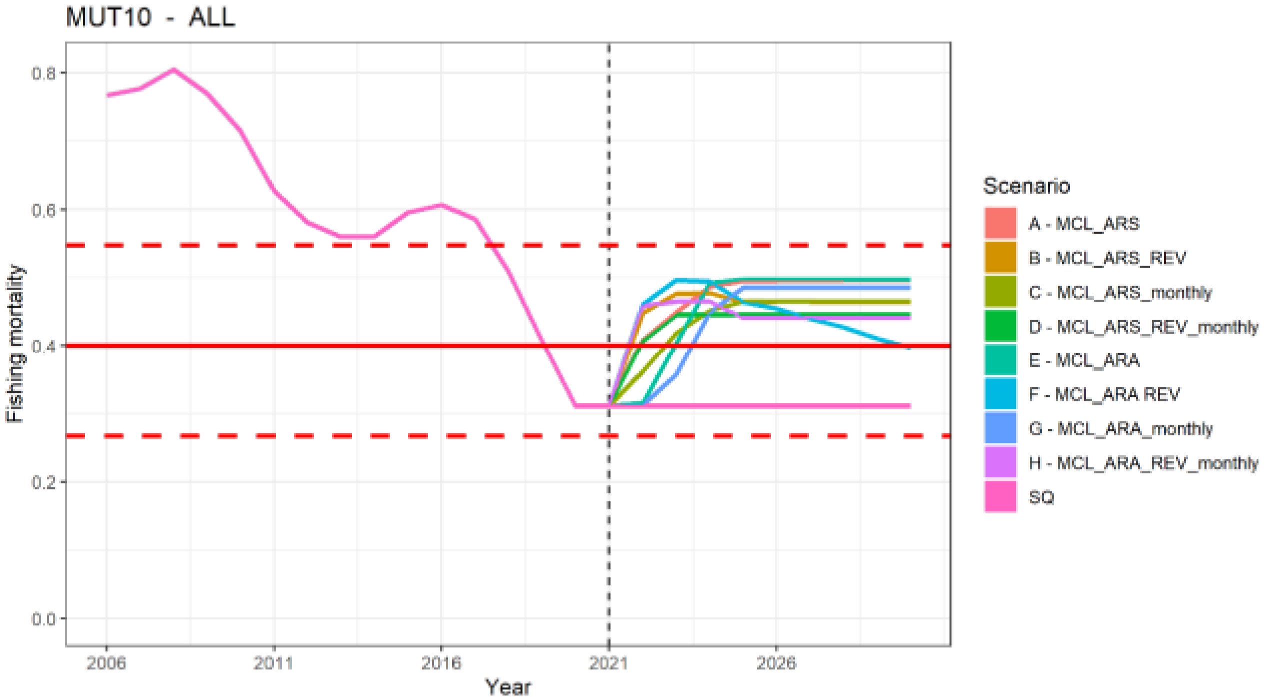
Scenarios B and D, implementing a reverse MCL on ARS9-10-11 at annual and at monthly level respectively, represent the scenarios showing a performance slightly below SQ in terms of revenues and profitability. This is due to the fact that the model predicts a decrease in the revenues of the more valuable stocks, partly compensated by the increase in the revenues of the other stocks, assuming the same fishing effort and fleet capacity of 2021 (and, thus, variable and fixed costs) (Figures 2.3.4.4-6). B and D scenarios would produce an improvement in SSB values of ARS and ARA stocks around 135%, only slightly smaller than scenarios E and G, setting the MCL on ARA (Table 2.3.4.2). Scenario D, based on monthly MCL is very similar to scenario B, but in the short term impacts less on the reduction of the catches.

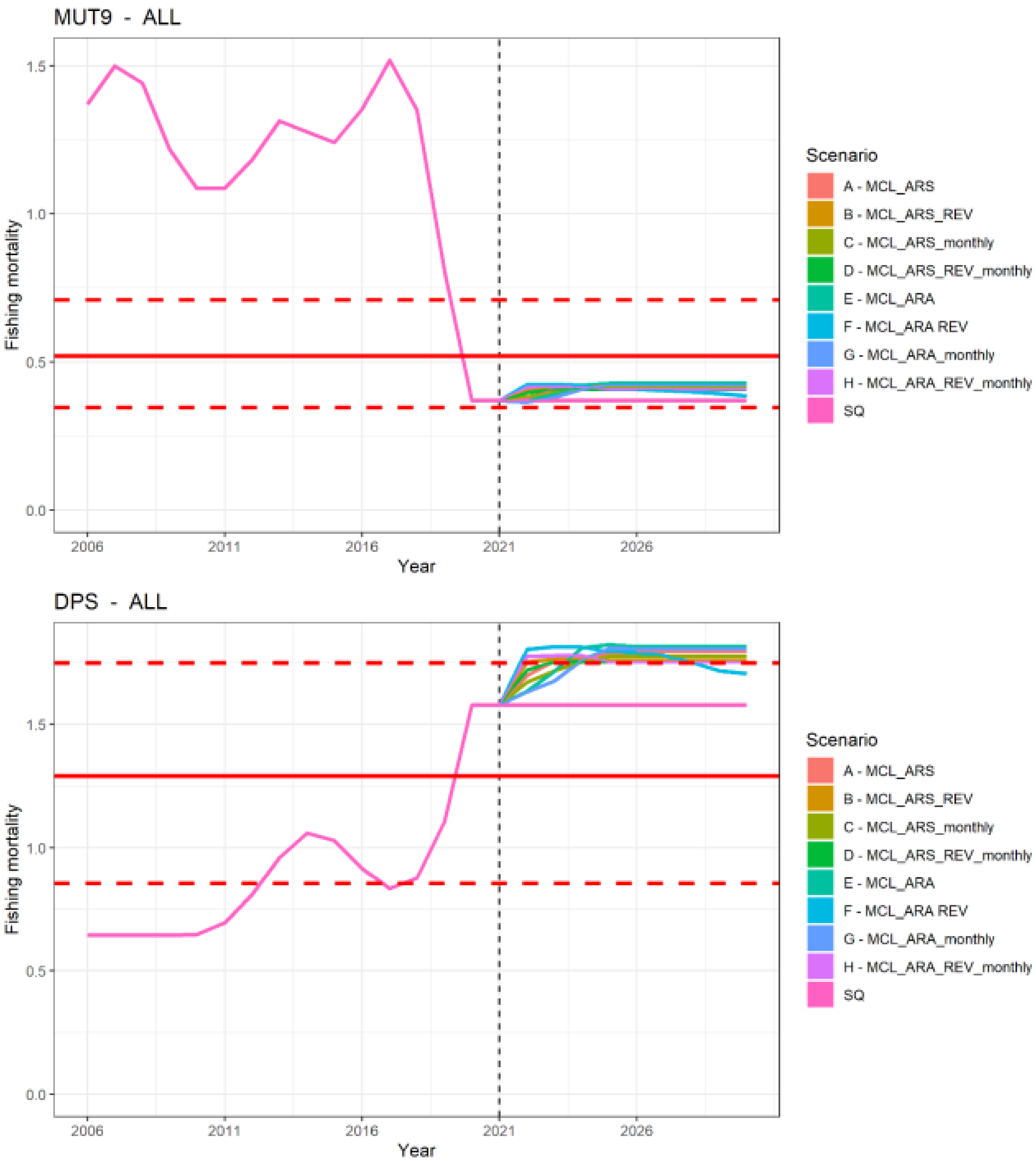
Following EWG 19-01 and 19-14, it is important to highlight that the results from EWG 21-13 for all scenarios are based on the assumption that a reduction in F is a direct consequence of an effort reduction. Inclusion of hyperstability in BEMTOOL was explored by EWG 19-01 and EWG 20-13, where the relationship between fishing effort and fishing mortality was assumed non-linear.

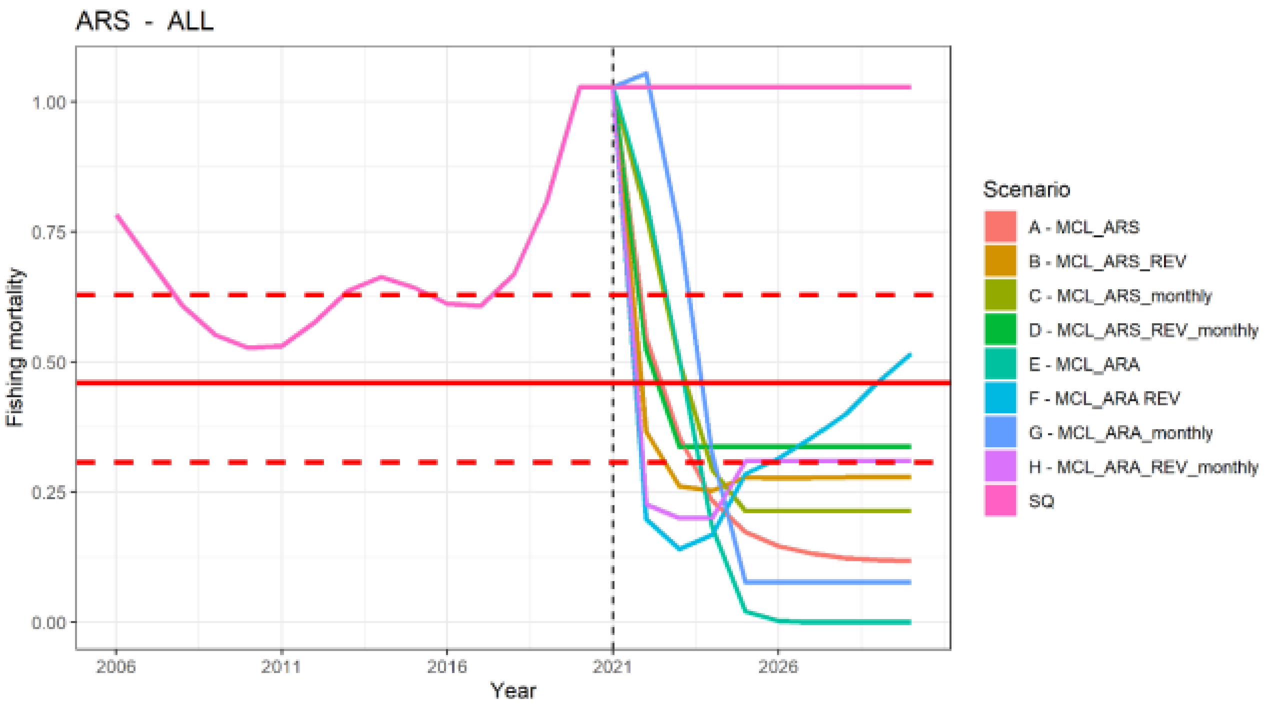
In the next figures, for F, Catch and SSB, the historical part (until 2020) is represented by the stock assessment results replicated by BEMTOOL.

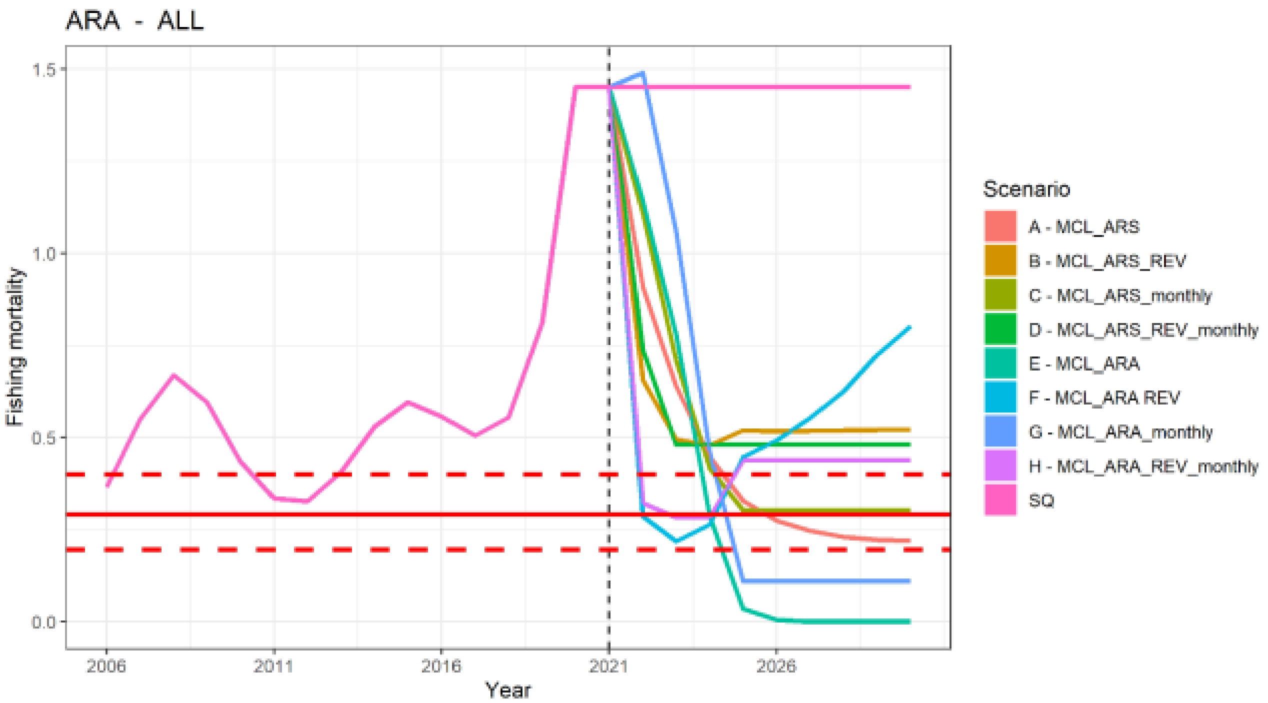
Fishing Mortality






MUT9 - ALL
Fishing mortality
Year
2006
2011
2016
2021
2026
0.0
0.5
1.0
1.5
Scenario
A - MCL_ARS
B - MCL_ARS_REV
C - MCL_ARS_monthly
D - MCL_ARS_REV_monthly
E - MCL_ARA
F - MCL_ARA REV
G - MCL_ARA_monthly
H - MCL_ARA_REV_monthly
SQ
DPS - ALL
Fishing mortality
Year
2006
2011
2016
2021
2026
0.0
0.5
1.0
1.5
Scenario
A - MCL_ARS
B - MCL_ARS_REV
C - MCL_ARS_monthly
D - MCL_ARS_REV_monthly
E - MCL_ARA
F - MCL_ARA REV
G - MCL_ARA_monthly
H - MCL_ARA_REV_monthly
SQ


ARS - ALL
Fishing mortality
1.00
0.75
0.50
0.25
0.00
2006
2011
2016
2021
2026
Year
Scenario
A - MCL_ARS
B - MCL_ARS_REV
C - MCL_ARS_monthly
D - MCL_ARS_REV_monthly
E - MCL_ARA
F - MCL_ARA REV
G - MCL_ARA_monthly
H - MCL_ARA_REV_monthly
SQ


ARA - ALL
Fishing mortality
1.5
1.0
0.5
0.0
2006
2011
2016
2021
2026
Year
Scenario
A - MCL_ARS
B - MCL_ARS_REV
C - MCL_ARS_monthly
D - MCL_ARS_REV_monthly
E - MCL_ARA
F - MCL_ARA REV
G - MCL_ARA_monthly
H - MCL_ARA_REV_monthly
SQ

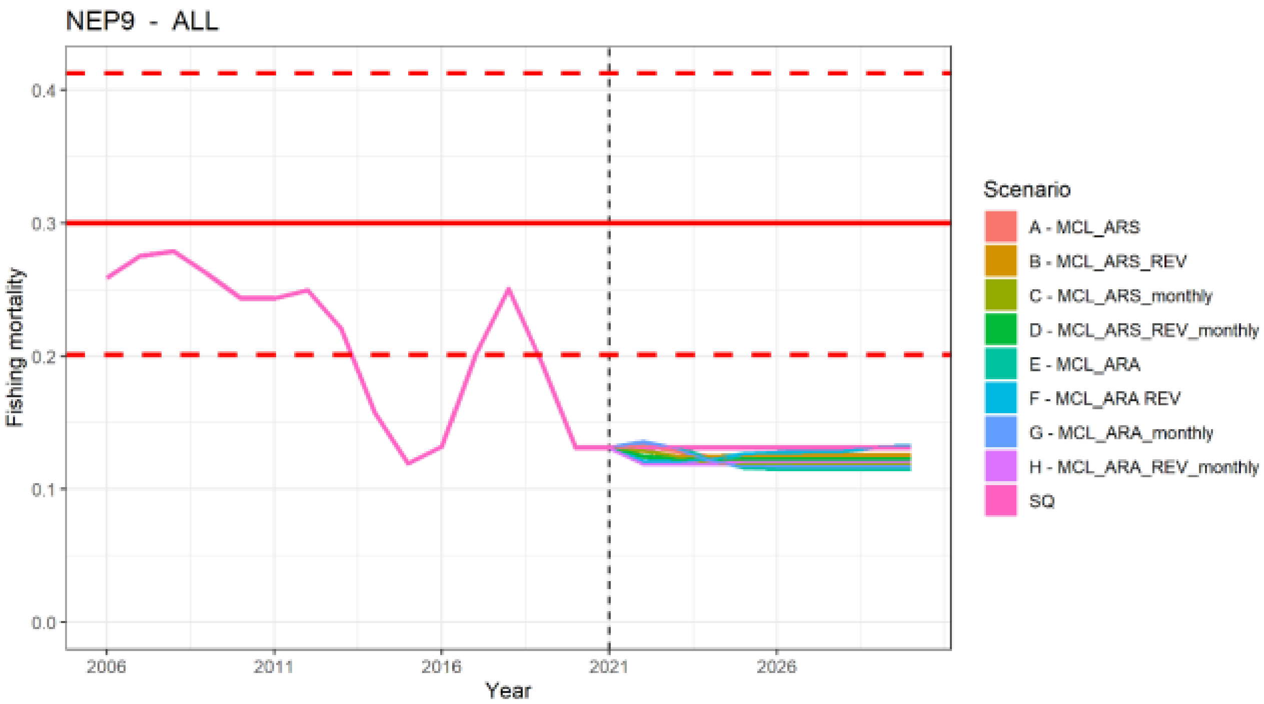
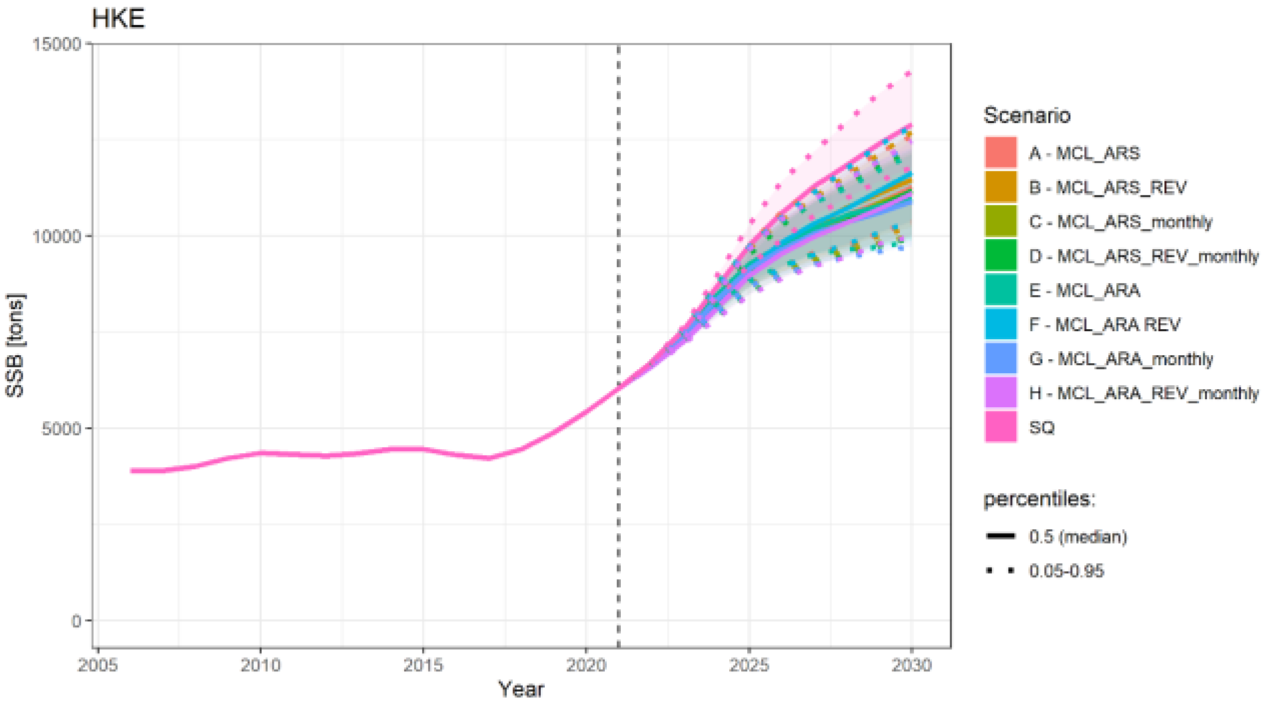
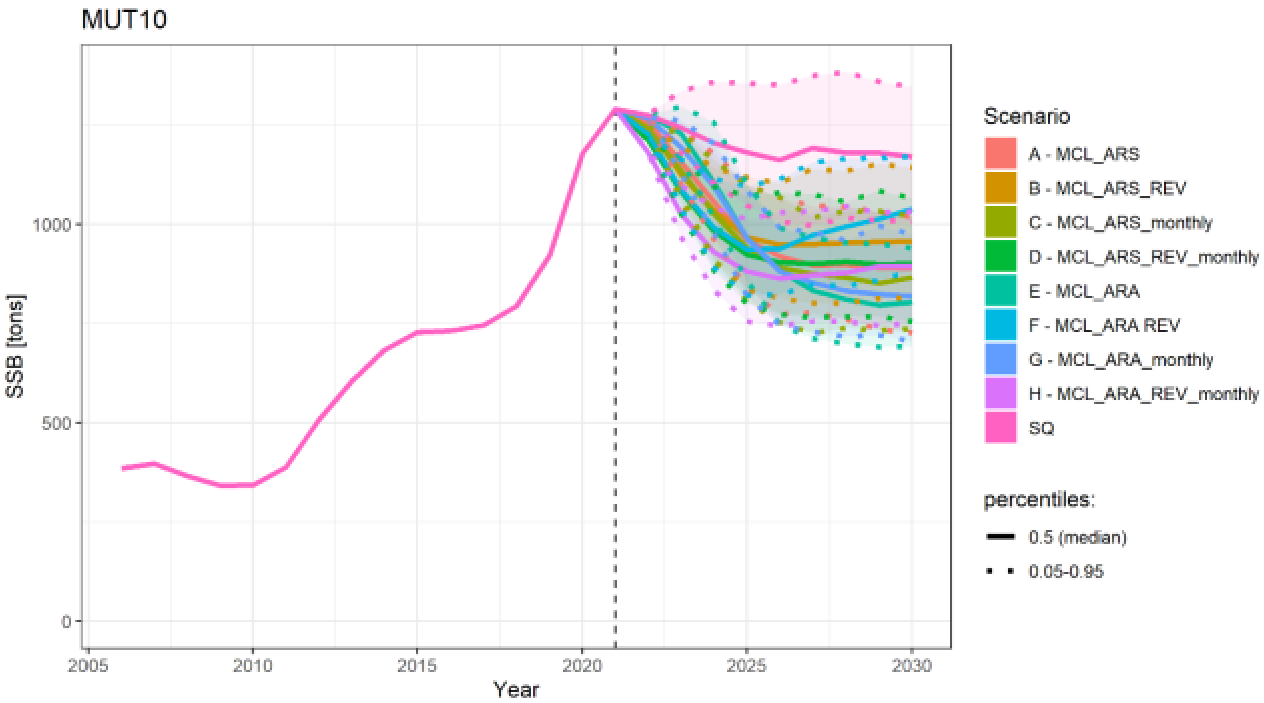


Figure 2.3.4.1 – BEMTOOL. Trajectories of the fishing mortality (F) for the seven stocks in the hindcasting phase (until 2021) and in the forecast phase (after 2021) under the alternative scenarios. The black vertical dashed lines corresponds to 2021. Red horizontal solid line correspond to the F_{MSY}=F0.1, and red horizontal dashed lines correspond to Fupper and Flower.

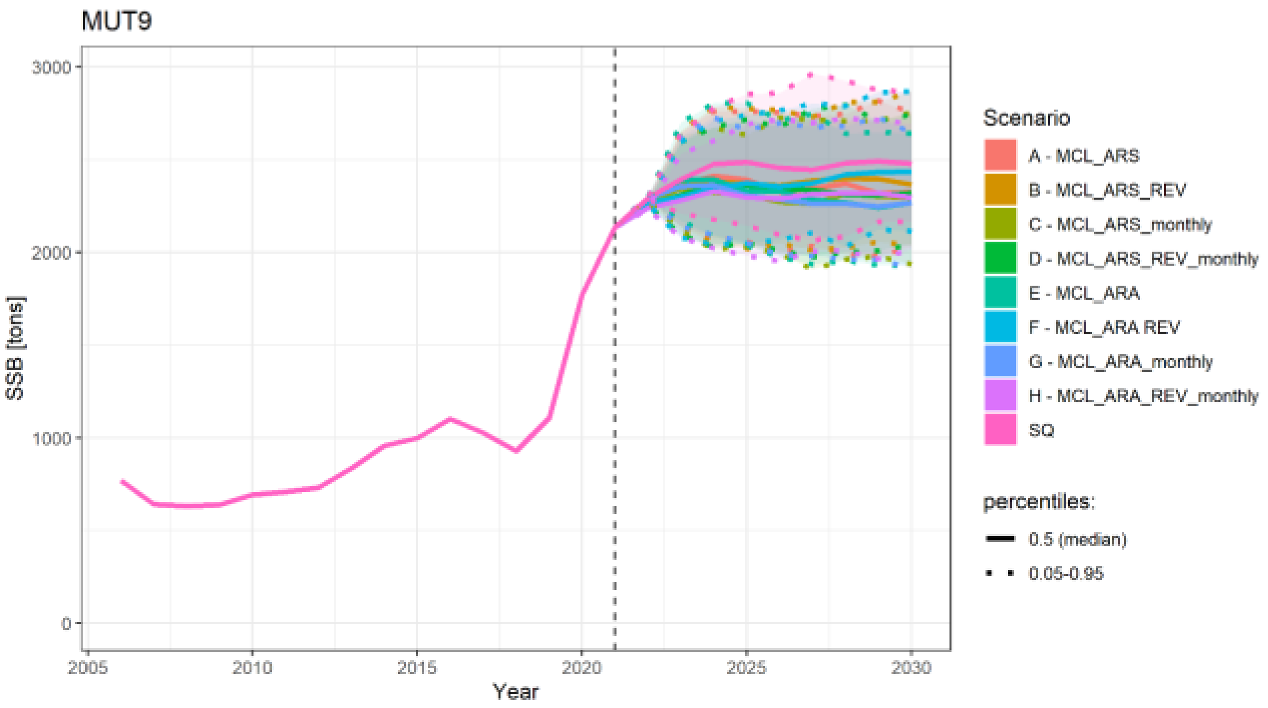
SSB

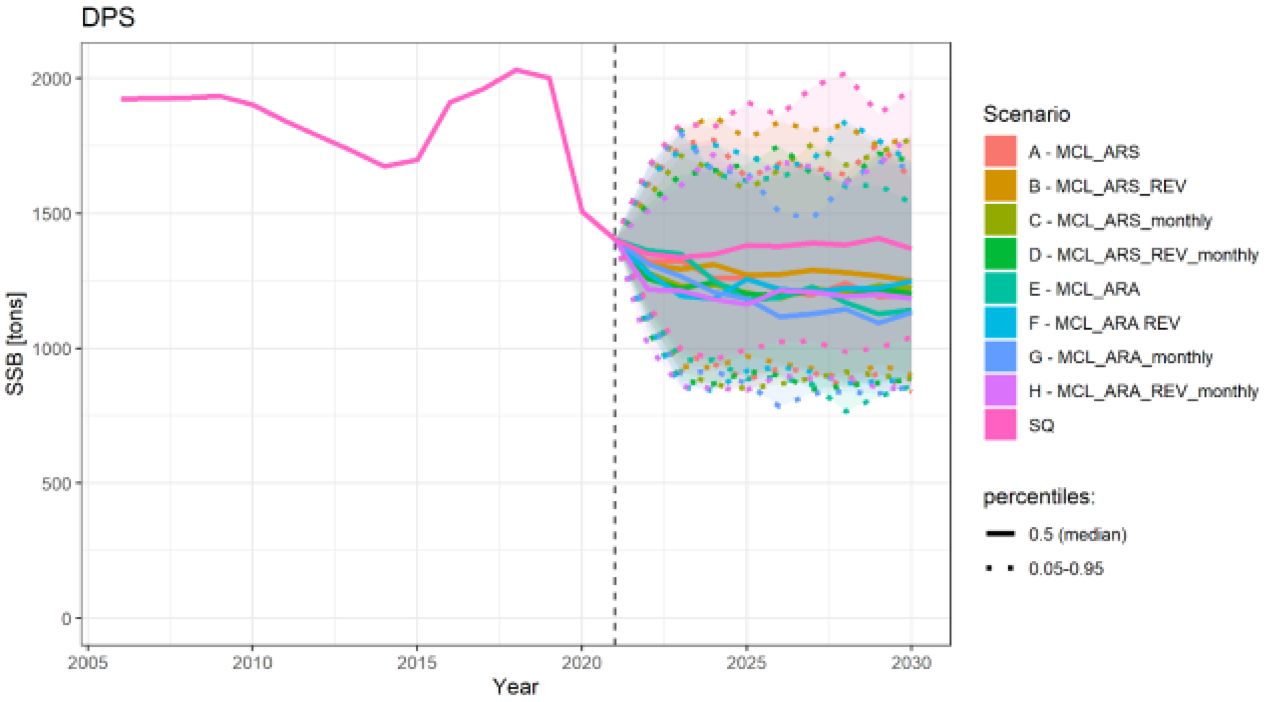


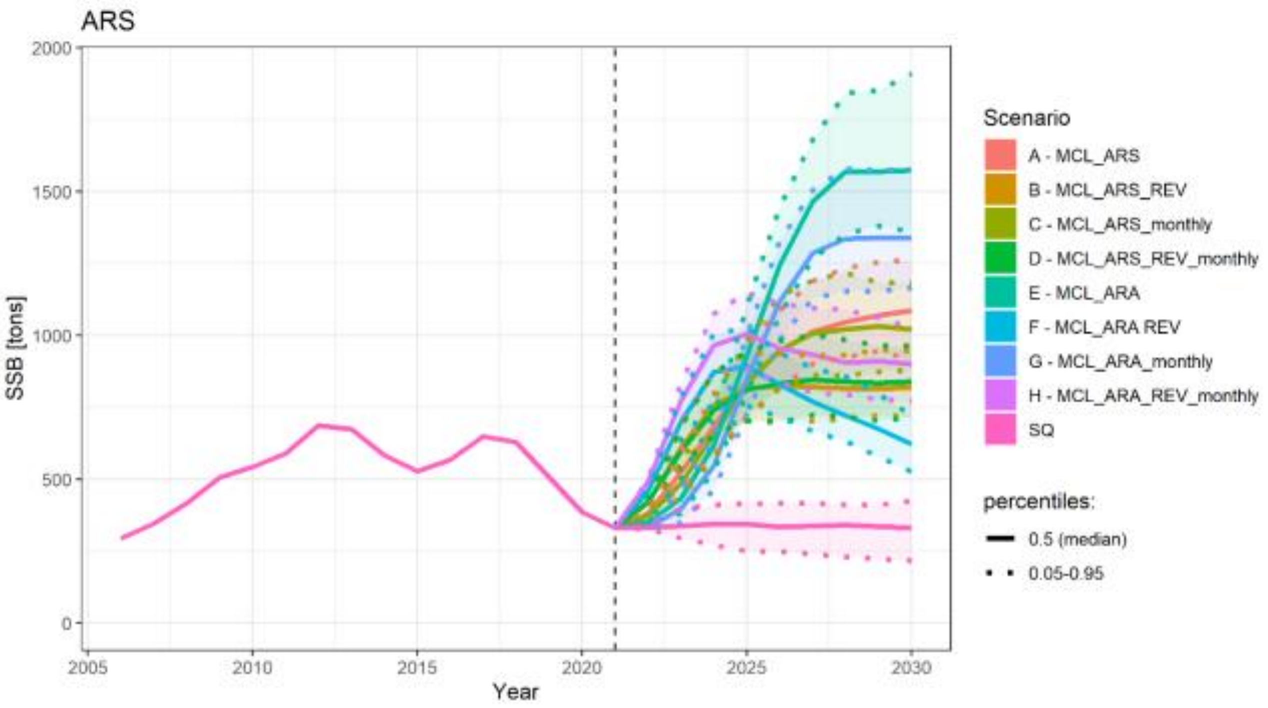
HKE
15000
10000
5000
0
SSB [tons]
2005
2010
2015
2020
2025
2030
Year
Scenario
A - MCL_ARS
B - MCL_ARS_REV
C - MCL_ARS_monthly
D - MCL_ARS_REV_monthly
E - MCL_ARA
F - MCL_ARA REV
G - MCL_ARA_monthly
H - MCL_ARA_REV_monthly
SQ
percentiles:
0.5 (median)
0.05-0.95

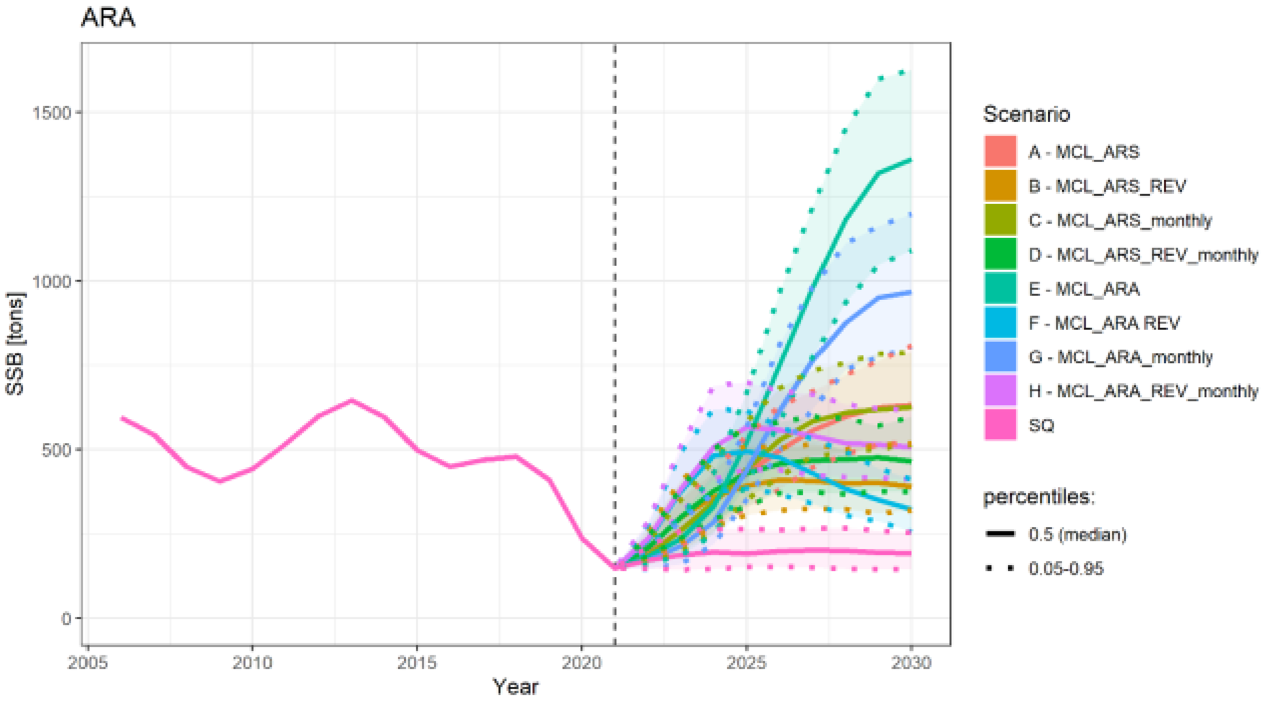


MUT10
1000
500
0
SSB [tons]
2005
2010
2015
2020
2025
2030
Year
Scenario
A - MCL_ARS
B - MCL_ARS_REV
C - MCL_ARS_monthly
D - MCL_ARS_REV_monthly
E - MCL_ARA
F - MCL_ARA REV
G - MCL_ARA_monthly
H - MCL_ARA_REV_monthly
SQ
percentiles:
0.5 (median)
0.05-0.95


MUT9
SSB [tons]
3000
2000
1000
0
2005
2010
2015
2020
2025
2030
Year
Scenario
A - MCL_ARS
B - MCL_ARS_REV
C - MCL_ARS_monthly
D - MCL_ARS_REV_monthly
E - MCL_ARA
F - MCL_ARA REV
G - MCL_ARA_monthly
H - MCL_ARA_REV_monthly
SQ
percentiles:
0.5 (median)
0.05-0.95


DPS
SSB [tons]
2000
1500
1000
500
0
2005
2010
2015
2020
2025
2030
Year
Scenario
A - MCL_ARS
B - MCL_ARS_REV
C - MCL_ARS_monthly
D - MCL_ARS_REV_monthly
E - MCL_ARA
F - MCL_ARA REV
G - MCL_ARA_monthly
H - MCL_ARA_REV_monthly
SQ
percentiles:
0.5 (median)
0.05-0.95


ARS
2000
1500
1000
500
0
SSB [tons]
2005
2010
2015
2020
2025
2030
Year
Scenario
A - MCL_ARS
B - MCL_ARS_REV
C - MCL_ARS_monthly
D - MCL_ARS_REV_monthly
E - MCL_ARA
F - MCL_ARA REV
G - MCL_ARA_monthly
H - MCL_ARA_REV_monthly
SQ
percentiles:
0.5 (median)
0.05-0.95


ARA
1500
1000
500
0
SSB [tons]
2005
2010
2015
2020
2025
2030
Year
Scenario
A - MCL_ARS
B - MCL_ARS_REV
C - MCL_ARS_monthly
D - MCL_ARS_REV_monthly
E - MCL_ARA
F - MCL_ARA REV
G - MCL_ARA_monthly
H - MCL_ARA_REV_monthly
SQ
percentiles:
0.5 (median)
0.05-0.95

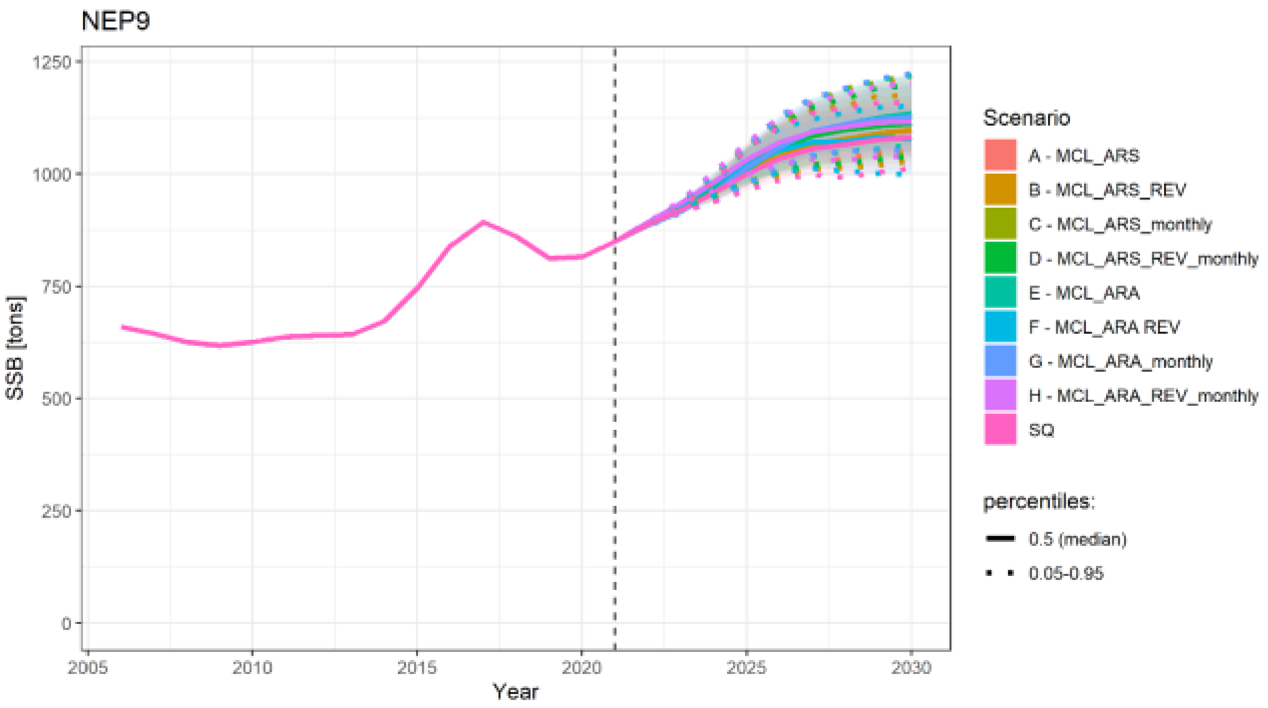
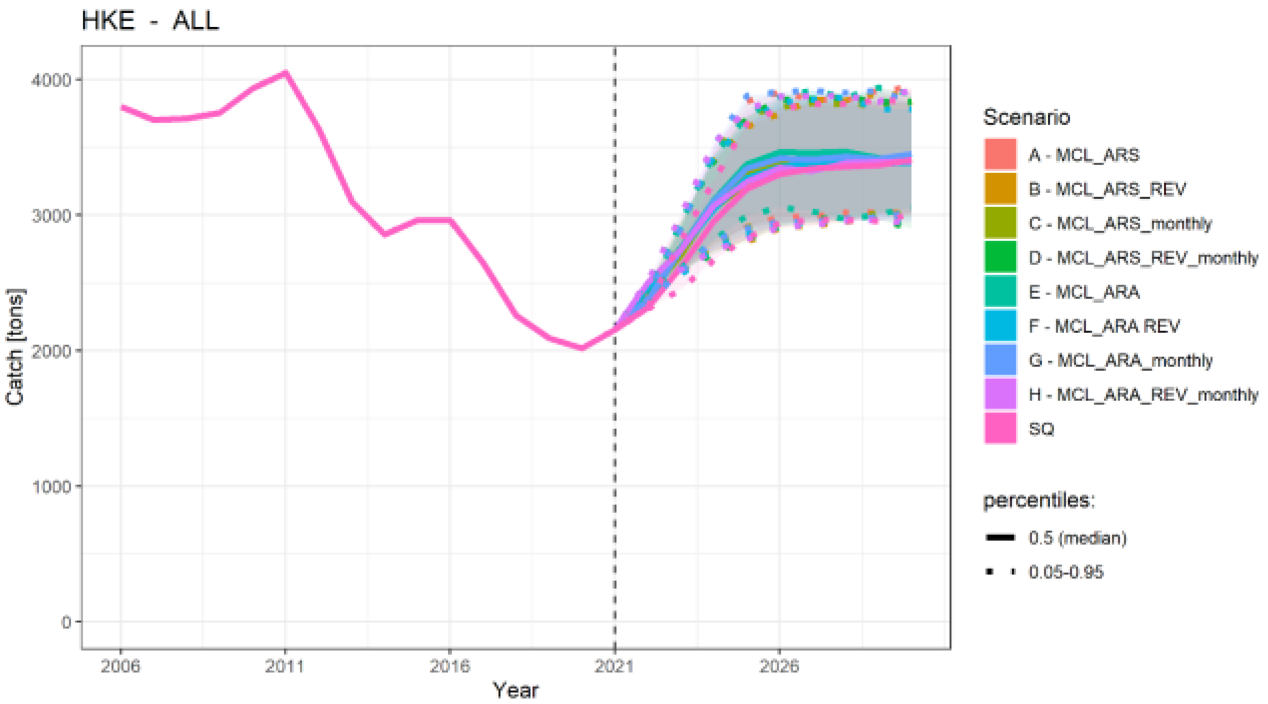
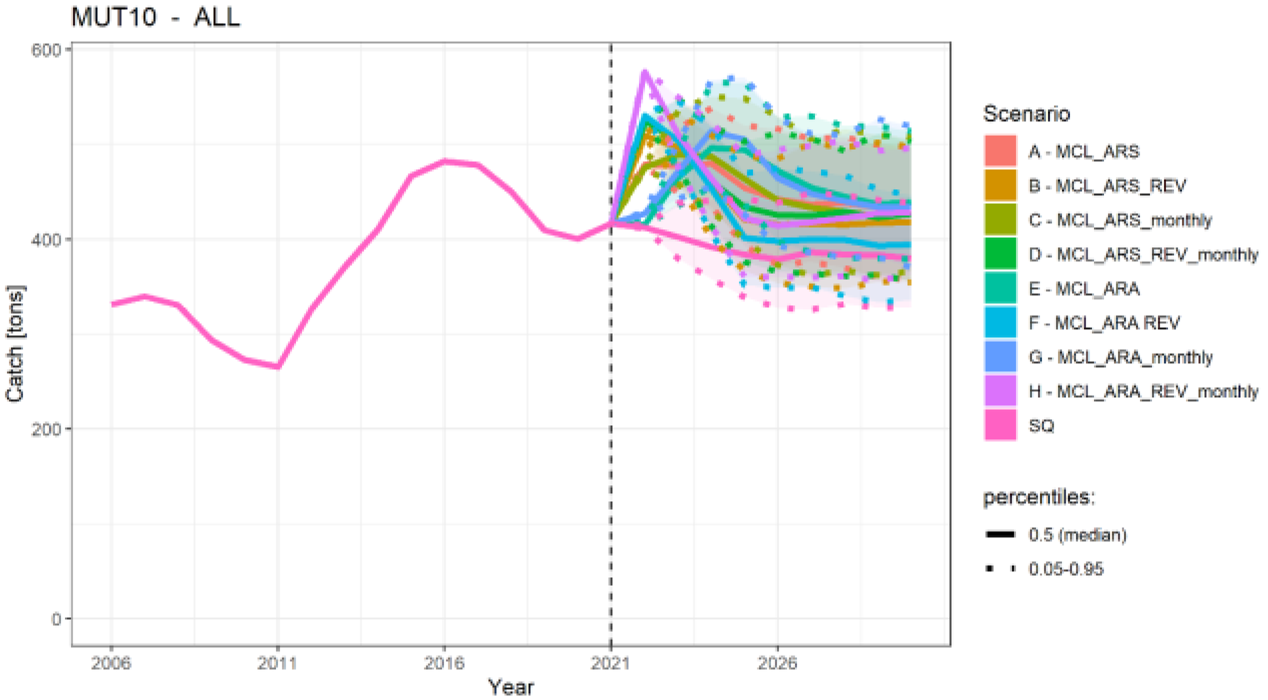
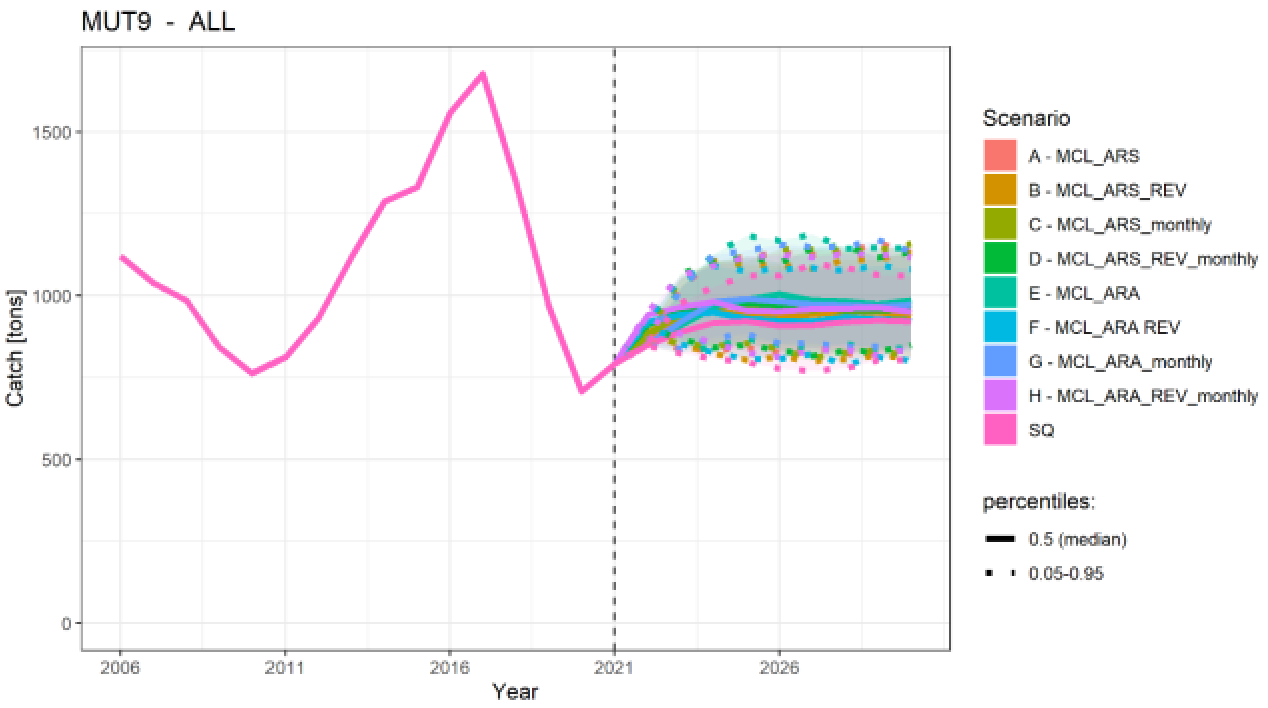


Figure 2.3.4.2 – BEMTOOL. Trajectories of the SSB (in tons) for the seven stocks in the hindcasting phase (until 2021) and in the forecast phase (after 2021) under the alternative scenarios. Solid lines correspond to medians, while shaded area correspond to interquantile range between 5th and 95th quantiles, indicated by the dashed lines. The black dashed lines corresponds to 2021.

Catches:

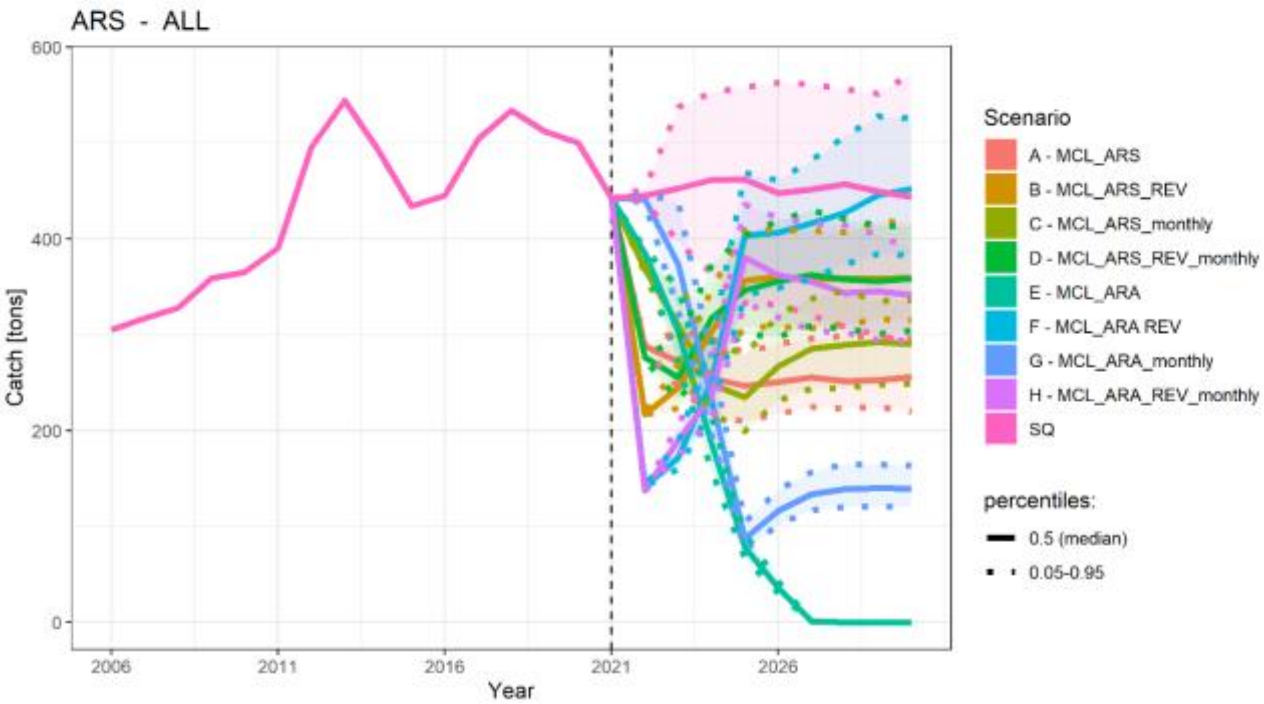

HKE - ALL
Catch [tons]
4000
3000
2000
1000
0
2006
2011
2016
2021
2026
Year
Scenario
A - MCL_ARS
B - MCL_ARS_REV
C - MCL_ARS_monthly
D - MCL_ARS_REV_monthly
E - MCL_ARA
F - MCL_ARA REV
G - MCL_ARA_monthly
H - MCL_ARA_REV_monthly
SQ
percentiles:
0.5 (median)
0.05-0.95

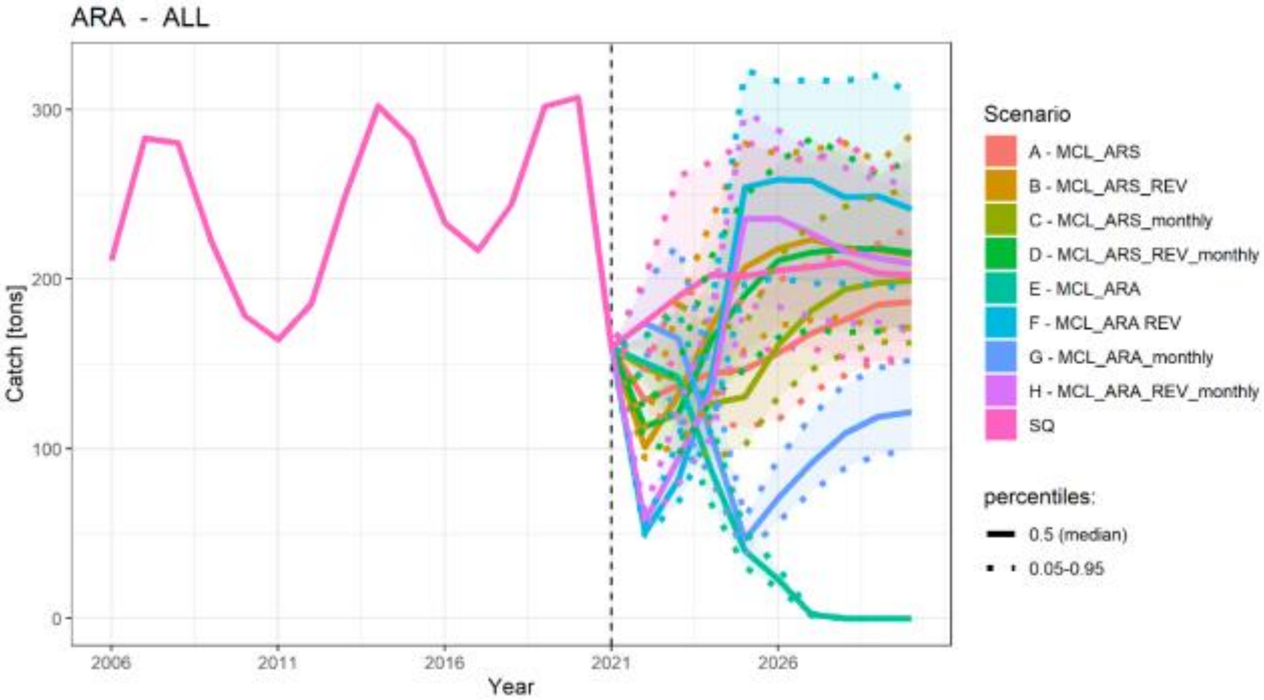

MUT10 - ALL
Catch [tons]
600
400
200
0
2006
2011
2016
2021
2026
Year
Scenario
A - MCL_ARS
B - MCL_ARS_REV
C - MCL_ARS_monthly
D - MCL_ARS_REV_monthly
E - MCL_ARA
F - MCL_ARA REV
G - MCL_ARA_monthly
H - MCL_ARA_REV_monthly
SQ
percentiles:
0.5 (median)
0.05-0.95



MUT9 - ALL
Catch [tons]
1500
1000
500
0
2006
2011
2016
2021
2026
Year
Scenario
A - MCL_ARS
B - MCL_ARS_REV
C - MCL_ARS_monthly
D - MCL_ARS_REV_monthly
E - MCL_ARA
F - MCL_ARA REV
G - MCL_ARA_monthly
H - MCL_ARA_REV_monthly
SQ
percentiles:
0.5 (median)
0.05-0.95

DPS - ALL
Catch [tons]
2000
1000
0
2006
2011
2016
2021
2026
Year
Scenario
A - MCL_ARS
B - MCL_ARS_REV
C - MCL_ARS_monthly
D - MCL_ARS_REV_monthly
E - MCL_ARA
F - MCL_ARA REV
G - MCL_ARA_monthly
H - MCL_ARA_REV_monthly
SQ
percentiles:
0.5 (median)
0.05-0.95


ARS - ALL
Catch [tons]
Year
Scenario
A - MCL_ARS
B - MCL_ARS_REV
C - MCL_ARS_monthly
D - MCL_ARS_REV_monthly
E - MCL_ARA
F - MCL_ARA REV
G - MCL_ARA_monthly
H - MCL_ARA_REV_monthly
SQ
percentiles:
0.5 (median)
0.05-0.95


ARA - ALL
Catch [tons]
Year
Scenario
A - MCL_ARS
B - MCL_ARS_REV
C - MCL_ARS_monthly
D - MCL_ARS_REV_monthly
E - MCL_ARA
F - MCL_ARA REV
G - MCL_ARA_monthly
H - MCL_ARA_REV_monthly
SQ
percentiles:
0.5 (median)
0.05-0.95

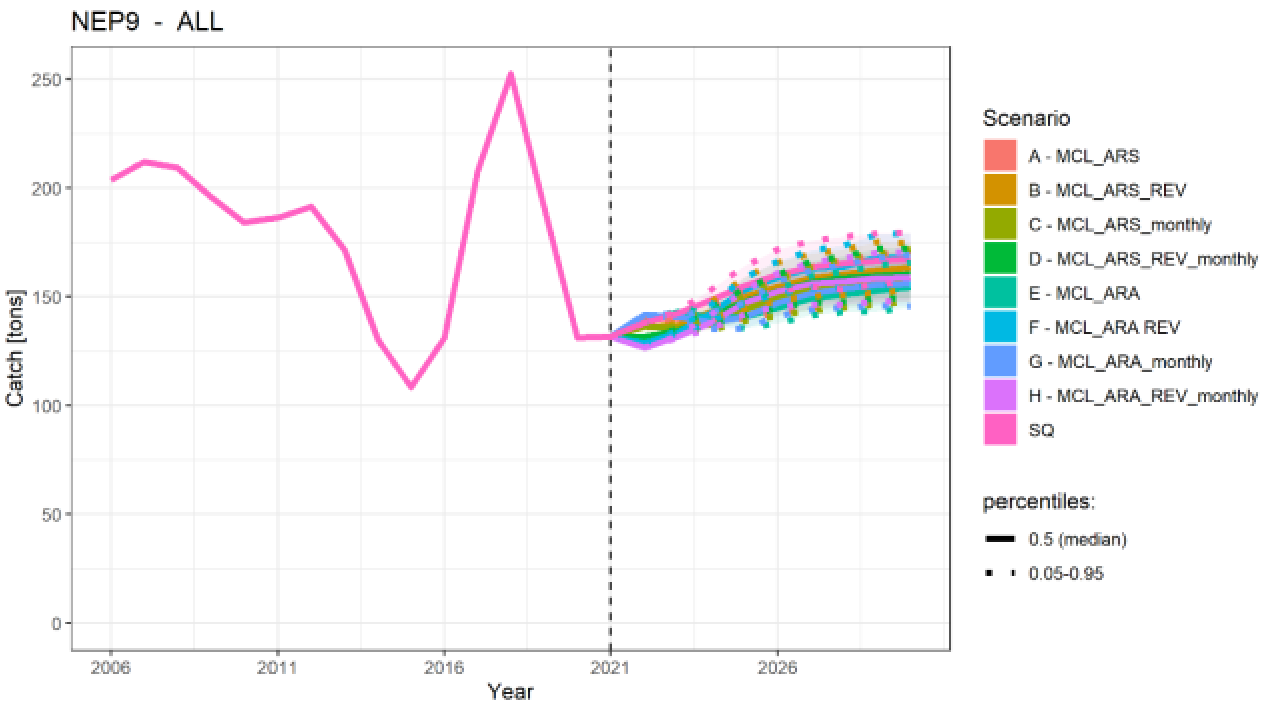


Figure 2.3.4.3 – BEMTOOL. Trajectories of catches (tons) for the seven stocks in the hindcasting phase (until 2021) and in the forecast phase (after 2021) under the alternative scenarios. Solid lines correspond to medians, while shaded area correspond to interquantile range between 5th and 95th quantiles, indicated by the dashed lines. The black dashed lines corresponds to 2021.

Total revenues (target stocks+ other species)

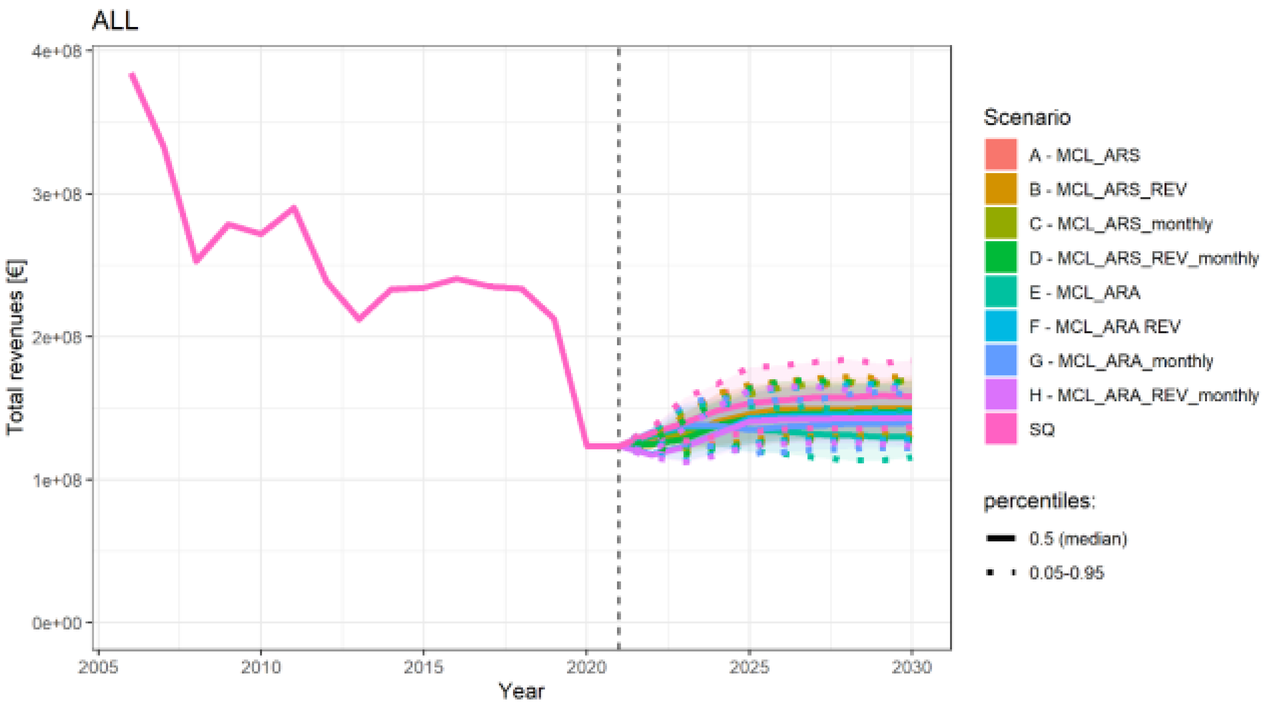


Figure 2.3.4.4 – BEMTOOL. Trajectories of revenues (thousand Euro) for all fleets combined in the hindcasting phase (until 2021) and in the forecast phase (after 2021) under the alternative scenarios. Solid lines correspond to medians, while shaded area correspond to interquantile range between 5th and 95th quantiles, indicated by the dashed lines. The black dashed lines corresponds to 2021.

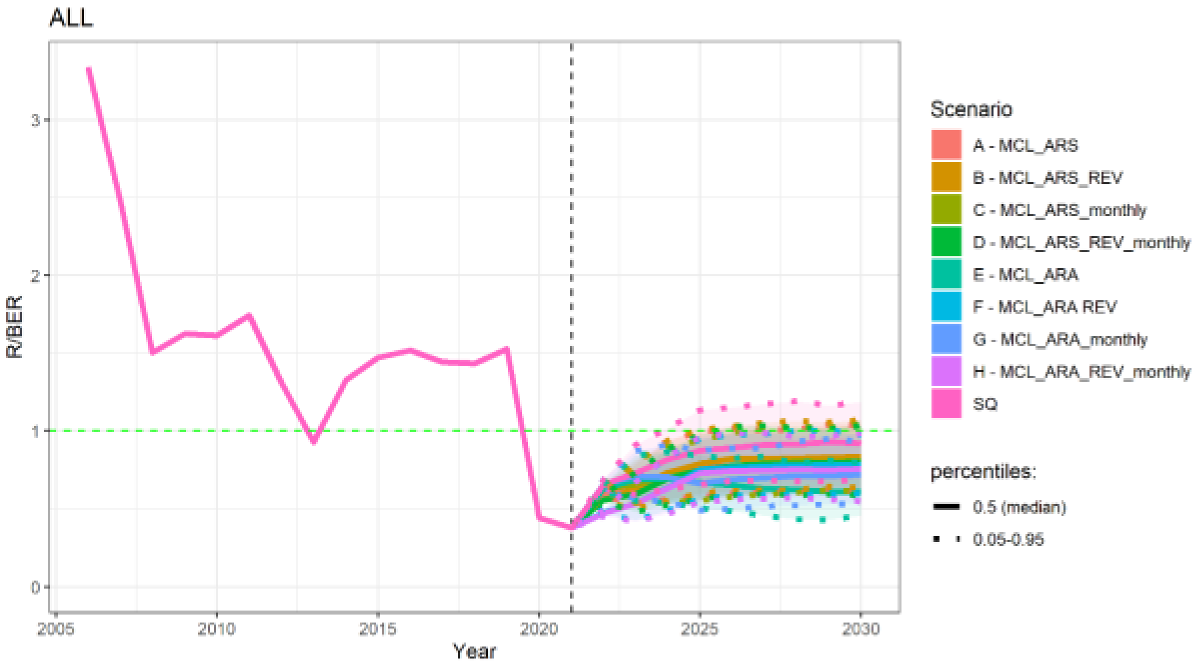


Figure 2.3.4.5 – BEMTOOL. Trajectories of current revenues/Break-Even Revenues (R/BER) ratio for all fleets combined in the hindcasting phase (until 2021) and in the forecast phase (after 2021) under the alternative scenarios. Solid lines correspond to medians, while shaded area correspond to interquantile range between 5th and 95th quantiles, indicated by dashed lines. The black dashed lines corresponds to 2021. The green horizontal dashed line indicates R/BER=1, the threshold of profitability of the fishery.

Figure 2.3.4.6 – BEMTOOL. Trajectories of gross value added for all fleets combined in the hindcasting phase (until 2021) and in the forecast phase (after 2021) under the alternative scenarios. Solid lines correspond to

medians, while shaded area correspond to interquantile range between 5th and 95th quantiles, indicated by dashed lines. The black dashed lines corresponds to 2021.

Changes of the main indicators (F, SSB, Catches, Revenues and GVA) by fleet segment and scenarios are reported in the tables from 2.3.4.1 to 2.3.4.5. The scenarios more negatively impacting the revenues of all the trawlers fleet are scenarios E and G. The fleets of PGP are slightly negatively influenced by all scenarios.

Table 2.3.4.1. Changes (in percentage) of F of the seven stocks in the tested scenarios compared to the status quo scenario (SQ). This is referred to 2025. A = MCL_ARS, B = MCL_ARS_REV, C = MCL_ARS_monthly, D = MCL_ARS_REV_monthly, E = MCL_ARA, F = MCL_ARA REV, G = MCL_ARA_monthly, H = MCL_ARA_REV_monthly.

Stock	SQ	A	B	C	D	E	F	G	H
ARA	1.45	-77%	-64%	-79%	-67%	-98%	-69%	-92%	-70%
ARS	1.03	-83%	-73%	-79%	-67%	-98%	-72%	-93%	-70%
DPS	1.58	13%	11%	13%	11%	16%	14%	15%	11%
HKE	0.49	10%	9%	12%	11%	13%	9%	13%	10%
MUT10	0.31	59%	49%	50%	43%	60%	49%	56%	42%
MUT9	0.37	15%	12%	12%	11%	16%	11%	14%	11%
NEP9	0.13	-8%	-4%	-9%	-7%	-11%	-4%	-11%	-8%

Table 2.3.4.2. Changes (in percentage) of the spawning stock biomass (SSB) of the seven stocks in the tested scenarios compared to the scenario SQ. This is referred to 2025 (SSB in baseline are reported in tons). A = MCL_ARS, B = MCL_ARS_REV, C = MCL_ARS_monthly, D = MCL_ARS_REV_monthly, E = MCL_ARA, F = MCL_ARA REV, G = MCL_ARA_monthly, H = MCL_ARA_REV_monthly.

Stock	SQ	A	B	C	D	E	F	G	H
ARA	192	123.6%	104.4%	130.4%	123.4%	171.9%	157.6%	128.5%	194.9%
ARS	344	144.0%	136.9%	142.0%	135.8%	170.2%	159.0%	146.5%	191.9%
DPS	1383	-8.6%	-7.9%	-12.6%	-13.0%	-14.5%	-9.1%	-14.3%	-15.8%
HKE	9759	-6.0%	-6.4%	-6.2%	-7.4%	-5.0%	-6.3%	-6.3%	-8.1%
MUT10	1182	-18.7%	-18.1%	-20.4%	-21.9%	-18.2%	-20.7%	-18.3%	-25.4%
MUT9	2487	-3.9%	-4.7%	-7.2%	-5.0%	-6.3%	-4.6%	-7.3%	-7.6%
NEP9	999	1.0%	0.8%	1.8%	2.4%	1.1%	2.2%	1.4%	3.2%

Table 2.3.4.3. Changes (in percentage) of the catches of the seven stocks by fleet groups (DTS and PGP) in the tested scenarios compared to the status quo scenario (SQ). This is referred to 2025 (the catches in baseline are reported in tons). A = MCL_ARS, B = MCL_ARS_REV, C = MCL_ARS_monthly, D = MCL_ARS_REV_monthly, E = MCL_ARA, F = MCL_ARA REV, G = MCL_ARA_monthly, H = MCL_ARA_REV_monthly.

DTS	**SQ**	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**
ARA	202	-27%	2%	-35%	-5%	-80%	26%	-77%	17%
ARS	462	-47%	-23%	-49%	-25%	-83%	-13%	-81%	-18%
DPS	1534	8%	5%	7%	5%	7%	6%	9%	1%
HKE	1707	10%	8%	13%	10%	16%	9%	15%	9%
MUT10	384	18%	10%	21%	13%	29%	5%	32%	10%
MUT9	902	6%	2%	6%	6%	8%	1%	8%	4%
NEP9	155	-6%	-3%	-7%	-5%	-9%	-1%	-9%	-5%
PGP	**SQ**	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**
HKE	1485	-5%	-6%	-6%	-7%	-5%	-4%	-7%	-7%
MUT10	38	-6%	-5%	-11%	-8%	-7%	-7%	-8%	-9%
MUT9	20	-6%	-5%	-10%	-8%	-7%	-7%	-9%	-9%

Table 2.3.4.4. Changes (in percentage) of the revenues of the seven stocks by fleet groups (DTS and PGP) in the tested scenarios compared to the status quo scenario (SQ). This is referred to 2025. A = MCL_ARS, B = MCL_ARS_REV, C = MCL_ARS_monthly, D = MCL_ARS_REV_monthly, E = MCL_ARA, F = MCL_ARA REV, G = MCL_ARA_monthly, H = MCL_ARA_REV_monthly.

DTS Fleet	**SQ**	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**
GSA10_DTS_VL0612	117624	-10%	-9%	-11%	-12%	-11%	-10%	-11%	-14%
GSA10_DTS_VL1218	7058458	-27%	-19%	-26%	-17%	-47%	-12%	-45%	-20%
GSA10_DTS_VL1824	7444992	-11%	0%	-26%	-16%	-37%	8%	-47%	-20%
GSA10_DTS_VL2440	1118373	-40%	-30%	-38%	-29%	-63%	-29%	-64%	-33%
GSA11_DTS_VL0612	66929	-6%	-6%	-7%	-7%	-7%	-5%	-8%	-8%
GSA11_DTS_VL1218	1436075	1%	23%	-26%	-18%	-46%	-13%	-45%	-19%
GSA11_DTS_VL1824	9916639	8%	4%	12%	10%	6%	-3%	11%	4%
GSA11_DTS_VL2440	7832931	-44%	-38%	-29%	-26%	-63%	-62%	-51%	-23%
GSA9_DTS_VL0612	322119	-5%	-5%	-8%	-7%	-8%	-5%	-9%	-9%
GSA9_DTS_VL1218	7716320	-5%	-2%	-10%	-6%	-14%	-2%	-14%	-7%
GSA9_DTS_VL1824	11108936	-10%	-4%	-12%	-9%	-17%	-4%	-18%	-11%
GSA9_DTS_VL2440	796608	-3%	-2%	-17%	-12%	-10%	-2%	-20%	-16%
PGP Fleet	**SQ**	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**
GSA10_PGP_VL0006	968015	-4.4%	-4.6%	-4.9%	-5.8%	-4.2%	-3.4%	-6.0%	-5.6%
GSA10_PGP_VL0612	6211727	-4.1%	-4.5%	-4.7%	-5.7%	-4.1%	-3.3%	-5.7%	-5.5%
GSA10_PGP_VL1218	1005841	-4.2%	-4.5%	-4.8%	-5.7%	-4.0%	-3.4%	-5.6%	-5.5%
GSA11_PGP_VL0012	1643682	-4.4%	-4.3%	-4.9%	-5.7%	-4.4%	-3.3%	-5.7%	-5.4%
GSA11_PGP_VL1218	8409	-4.1%	-4.7%	-4.7%	-5.7%	-4.0%	-3.5%	-5.7%	-5.3%
GSA9_PGP_VL0012	1846259	-4.2%	-4.9%	-5.1%	-5.8%	-4.2%	-3.7%	-5.8%	-5.5%

GSA9_PGP_VL1218	932337	-4.2%	-5.0%	-5.0%	-5.8%	-4.2%	-3.7%	-5.7%	-5.4%

Table 2.3.4.5. Changes (in percentage) of the by fleet groups (DTS and PGP) in the tested scenarios compared to the status quo scenario (SQ). This is referred to 2025. A = MCL_ARS, B = MCL_ARS_REV, C = MCL_ARS_monthly, D = MCL_ARS_REV_monthly, E = MCL_ARA, F = MCL_ARA REV, G = MCL_ARA_monthly, H = MCL_ARA_REV_monthly.

DTS Fleet	SQ	A	B	C	D	E	F	G	H
GSA10_DTS_VL0612	76171	-28%	-26%	-32%	-34%	-31%	-28%	-32%	-38%
GSA10_DTS_VL1218	7562413	-19%	-13%	-19%	-14%	-36%	-9%	-36%	-20%
GSA10_DTS_VL1824	5836212	9%	16%	-10%	-6%	-17%	22%	-29%	-19%
GSA10_DTS_VL2440	574455	-71%	-56%	-43%	-42%	-86%	-66%	-84%	-73%
GSA11_DTS_VL0012	7394956	-6%	-6%	-7%	-8%	-8%	-5%	-8%	-8%
GSA11_DTS_VL1218	1270802	2%	32%	-39%	-32%	-64%	-16%	-65%	-34%
GSA11_DTS_VL1824	-676062	159%	116%	100%	45%	293%	249%	201%	99%
GSA11_DTS_VL2440	5891756	-47%	-44%	-41%	-44%	-82%	-87%	-68%	-37%
GSA9_DTS_1824	721037	-8%	-8%	-12%	-11%	-12%	-8%	-13%	-13%
GSA9_DTS_VL0612	7440135	-3%	-1%	-9%	-5%	-12%	-2%	-13%	-9%
GSA9_DTS_VL1218	7042966	-19%	-11%	-22%	-18%	-31%	-12%	-33%	-24%
GSA9_DTS_VL2440	1139343	-10%	-9%	-20%	-17%	-18%	-10%	-23%	-22%
PGP Fleet	**SQ**	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**
GSA10_PGP_VL0006	5175794	-5%	-5%	-6%	-7%	-5%	-4%	-7%	-7%
GSA10_PGP_VL0612	8675086	-7%	-7%	-7%	-9%	-6%	-5%	-9%	-9%
GSA10_PGP_VL1218	-70763	11%	12%	12%	15%	10%	9%	14%	14%
GSA11_PGP_VL0012	8411287	-8%	-7%	-8%	-10%	-7%	-6%	-10%	-9%
GSA11_PGP_VL1218	-1189158	4%	4%	4%	5%	4%	3%	5%	5%
GSA9_PGP_VL0012	14129720	-5%	-6%	-7%	-7%	-5%	-5%	-8%	-7%
GSA9_PGP_VL1218	383037	-19%	-23%	-22%	-26%	-19%	-17%	-26%	-24%

A dependency analysis by GSA, to understand the contribution of the target species to the total landings and revenues was conducted in the EWG 1901. Data of FDI of 2020 confirm that the target species of the MAP represent in EMU2 45% in volume and 56% in value, compared to the total landing. Generally these species are on the top of the list. Other important species of the trawl fisheries in EMU2 for both landing volume and value are: *Octopus vulgaris, Eledone cirrhosa, Mullus surmuletus and Penaeus keraturus*. Considering these species, the pool of the main ones would be around 59% in volume and 72% in value.

3 CLOSURE AREAS

3.1 Background

The western Mediterranean is one of the most developed sub-regions in terms of fisheries in the Mediterranean. It accounts for around 22% of landings, 33% of revenues and 21% of the officially reported Mediterranean fishing fleet (FAO, 2020).

The Regulation (EU) 2019/1022 of the European Parliament and of the Council of 20 June 2019, establishing a Multiannual Plan for the fisheries exploiting demersal stocks in the western Mediterranean Sea, is aimed at the conservation and sustainable exploitation of demersal stocks in the western Mediterranean Sea, mainly based on regulation of fishing effort.

This Regulation applies to the following stocks: blue and red shrimp (*Aristeus antennatus*), deep-water rose shrimp (*Parapenaeus longirostris*), giant red shrimp (*Aristaeomorpha foliacea*), European hake (*Merluccius merluccius*), Norway lobster (*Nephrops norvegicus*), and red mullet (*Mullus barbatus*), that represent the most important species in the western Mediterranean demersal fisheries.

Together with the reduction of fishing activity in terms of fishing days to reverse the current overfishing state for most of the demersal resources, some technical measures are adopted to contribute to achieve the MAP objective to move the stocks to MSY within 2025.

In particular, in the Article 11(1), the Plan **provides that trawling shall be prohibited within six nautical miles from the coast except in areas deeper than 100 m depth during three months each year**. Those three months of closure shall be determined by each Member State and shall apply during the most relevant period, determined on the basis of the best available scientific advice.

The Article 11(2) provides that Member States may derogate from Article 11(1) establishing other closure areas, on the basis of the best available scientific advice. Those closures shall account for a reduction of at least 20% of catches of juveniles of European hake.

3.1.1 Implementation of closure areas in EMU 1

In order to accomplish objectives established by WMMAP in Article 11[1], MS have adopted spatial closures as a tool to manage demersal fishing resources. In most GSAs in EMU1, Article 11.2 has been adopted and so Article 11.1 derogated. At the moment only Spain has submitted closure areas responding to Article 11.3.

In France two zones in GSA 7 were closed for bottom trawling for 8 and 6 months, whereas in GSA 8 as Article 11.1 was adopted the 6 miles/100 m isobath has been closed for 3 months (*Arrêté du 20 décembre 2019, NOR: AGRM1936906A*)[2]. These management measures were evaluated by STECF in PLEN 19-03 [3]. Besides closures adopted in response to WMMAP there are also other three permanent closures in GSA7 between approximately 100 and 300 m depth where any fishing activity is forbidden (see Table 3.1.1.1).

A distinct strategy has been implemented for Spain where areas implemented are smaller and distributed throughout the fishing grounds. In all GSAs (1,2,5 and 6) Article 11.2 was adopted by designing several temporal and permanent areas published in *Orden APA/423/2020 of 18 May, BOE no. 142* [4]. A total of 18 areas were published covering more than 2700 km^2 (see Table 3.1.1.1). After the first implementation of Article 11.2, Spain adopted WMMAP Article 11.3 and therefore new closure areas were designed and published in *Orden APA/1397/2021, de 10 de diciembre*, *BOE nº 298* [5]. For GSA 1 and 5 a total of 7 temporal areas were implemented covering 127 and 1892 km^2 (Table 3.1.1.1) respectively, whereas in GSA6 a strategy of establishing a network of small areas along the coast was adopted (16 areas covering 539 km^2). Besides closure areas implemented after the WMMAP publication, there are two other protected areas where trawling activities are prohibited: Cabrera national park in Mallorca waters (GSA5) and Columbretes marine reserve in Valencian coast (GSA6, Table 3.1.1.1).

Table 3.1.1.1 Summary of implemented closure areas in the Western Mediterranean adopting the WMMAP legislation in EMU1 GSAs. Areas affecting trawlers activity established before the WMMAP were also taken into account.
***Depending on the area fishing activity can be prohibited for all gears. It should also be considered that in some areas the extension of a closure can also include bathimetries under 50 m depth.**

	WMMAP	Time closing	Fleets	Nº areas	Managed area
GSA1	Article 11.2	Temporal (3 to 4 months)	Trawlers Longliners Gillneters	4	41 km^2
	Article 11.3	Temporal	Trawlers	2	127 km^2
GSA2	Article 11.2	Permanent	Trawlers	1	<100m depth
GSA5	Article 11.2	Temporal	Trawlers Longliners Gillneters	2	416 km^2
	Article 11.3	Temporal	Trawlers	5	1892 km^2
	Previous to WMMAP	Permanent	All	1	909 km^2
GSA6	Article 11.2	Temporal	Trawlers	3	1653 km^2
			Trawlers Longliners Gillneters	1	443 km^2
		Permanent	Trawlers	1	40 km^2
			Trawlers Longliners Gillneters	6	158 km^2
	Article 11.3	Permanent	Trawlers	2	273 km^2
			Trawlers Longliners Gillneters	14	266 km^2
	Previous to WMMAP	Permanent	All	1	55 km^2
GSA7	11.2	Temporal	Trawlers	2	5004 km^2
	Previous to WMMAP	Permanent	All	3	130 km^2

3.1.1.1 References

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

[2] Arrêté du 20 décembre 2019 portant modification de l'arrêté du 28 février 2013 portant adoption d'un plan de gestion pour la pêche professionnelle au chalut en mer Méditerranée par les navires battant pavillon français. NOR : AGRM1936906A

[3] Scientific, Technical and Economic Committee for Fisheries (STECF) – 62nd Plenary Meeting Report (PLEN-19-03). Publications Office of the European Union, Luxembourg, 2019, ISBN 978-92-76-14169-3, doi:10.2760/1597, JRC118961

[4] Orden APA/423/2020, de 18 de mayo, por la que se establece un plan de gestión para la conservación de los recursos pesqueros demersales en el mar Mediterráneo.

[5] Orden APA/1397/2021, de 10 de diciembre, por la que se modifica el Anexo III de la Orden APA/423/2020, de 18 de mayo, por la que se establece un plan de gestión para la conservación de los recursos pesqueros demersales en el mar Mediterráneo.

3.1.2 Implementation of closure areas in EMU 2

On the basis of available scientific knowledge, in GSAs 9, 10 and 11, the Italian government asked to apply Paragraph 2 of Art. 11, e.g. the closure of specific areas, in order to pursue the objective of reducing at least 20% of catches of juveniles of European hake. In fact, there are important nursery areas of hake, distributed from 100 to 300 m depth, in the three GSAs, characterized by high spatio-temporal stability. In particular, 10 Fishery Restricted Areas (FRAs) to protect EFH for recruitment of hake were implemented in the Ligurian and the Tyrrhenian Seas covered by Reg. EU 1022/2019 in GSA 9, 10 and 11 in order to reduce the catch of undersized hake. The location of these FRAs take into account the results reported in the previous document prepared by the Italian Administration, and examined by the 62nd Plenary Meeting of STECF (STECF, 2020a).

These FRAs, in which the use of any towed gear, such as "divergent trawls", "rapid trawls", "divergent twin nets", "pelagic trawls with pairs", "divergent pelagic trawls" and "dredges pulled by vessels", is prohibited, have been identified in the Annex 1 of the **Decree of the General Director of Fisheries (MiPAAF) Prot. No 9045689 of 6 August 2020.** The geographical location of the FRAs is reported below.

https://www.politicheagricole.it/flex/cm/pages/ServeBLOB.php/L/IT/IDPagina/15871

3.1.2.1 Fishery Restricted Areas in GSA 9 to protect Hake Juveniles, according to the Italian Decree of 6 August 2020.

Argentario (50 Km^2, from 160 to 220 m depth)

Latitude	Longitude
42.3333 N	10.8333 E
42.3833 N	10.8333 E
42.3333 N	10.7333 E
42.3833 N	10.7333 E

North Tuscany (107 km^2)

Latitude	Longitude
43.8167 N	9.8 E

43.8333 N	9.85 E
43.7 N	9.9667 E
43.6667 N	9.8833 E

Capraia (145 km^2)

Latitude	Longitude
43.22597 N	10.01694 E
43.25438 N	10.12259 E
43.15000 N	10.18333 E
43.12331 N	10.07653 E
43.22597 N	10.01694 E

3.1.2.2 Fishery Restricted Areas in GSA 10 to protect Hake Juveniles, according to the Italian Decree of 6 August 2020.

Gulf of Gaeta (125 km^2, from 100 to 200 m depth)

Latitude	Longitude
41.1322 N	13.4511 E
41.0864 N	13.6325 E
41.0225 N	13.6083 E
41 0686 N	13.4269 E

Gulf of Patti: 150 km^2, the sea area delimited by the line connecting Cape Milazzo and Cape Calavà (from coastline to 500 m depth)

Gulf of Castellammare: 250 km^2, the sea area delimited by the line connecting Cape Rama and Torre dell'Uzzo (from coastline to 200 m depth).

Sorrentine Peninsula Area (196 km^2)

Latitude	Longitude
40.35701 N	14.59957 E
40.34901 N	14.75355 E
40.21391 N	14.74194 E
40.22181 N	14.59058 E

40.35701 N	14.59957 E

Area facing Amantea: between the coastline and the line connecting the following coordinates: 188 km^2

Latitude	**Longitude**
38.92968 N	16.02349 E
38.92293 N	16.14812 E
38.77169 N	16.13715 E
38.77321 N	16.01086 E
38.92968 N	16.02349 E

3.1.2.3 Fishery Restricted Areas in GSA 11 to protect Hake Juveniles, according to the Italian Decree of 6 August 2020.

Asinara (269 km^2)

Latitude	**Longitude**
41.2773 N	8.7727 E
41.2773 N	8.9873 E
41.1427 N	8.9873 E
41.1427 N	8.7727 E
41.2773 N	8.7727 E

Buggerru (619 km^2)

Latitude	**Longitude**
39.50 N	8.04 E
39.50 N	8.28 E
39.23 N	8.28 E

39.23 N	8.04 E
39.50 N	8.04 E

3.1.2.4 Additional areas restricted to bottom trawling in EMU 2 implemented before the Italian Decree of 6 August 2020.

In addition to the Fishing Areas Limited by the Italian Decree of 6 August 2020, in GSAs 9, 10 and 11 we find other areas that are protected and where trawling is prohibited.

In Tuscany the seven main islands and some smaller islets, many of which are simple shoals or outcropping rocks, are largely protected by the Tuscan Archipelago National Park.

The marine areas where fishing is regulated, in addition to the coastal area where trawl activity is prohibited, can be identified in specific sectors around the islands of Gorgona, Capraia, Pianosa, Giannutri and Montecristo; and in the Marine Protected Area of Secche della Meloria, in front of Livorno.

Tuscan Archipelago National Park

The Tuscan Archipelago National Park, definitively established on 22 July 1996 with a Decree of the President of the Republic, consists of a protected land area of about 18,000 hectares and a marine area of 60,000 hectares. It includes seven islands: Elba, Giglio, Capraia, Montecristo, Pianosa, Gorgona and Giannutri. In the Tuscan Archipelago National Park the rules are established by L. 394/91, dal D.P.R. 22 luglio 1996 and by D.M. Ambiente 19 dicembre 1997.

In the marine and terrestrial areas included in the park, two different types of protection have been established:

a) Protection and Promotion Areas - extend 3 nautical miles from the coastline. Underwater fishing and trawling are prohibited. These areas are referred to here as type 2 zones to facilitate understanding of park zoning.
b) Areas of significant naturalistic value with limited or no degree of anthropization (type 1 areas): they extend for 1000m or one nautical mile from the coast line. In these areas, in addition to the restrictions defined for zone 2, the following are prohibited: visitor access, both professional and sport fishing exercised with any gear, diving, navigation and anchoring and any type of environmental alteration.

The islands included in the Archipelago park do not enjoy the same constraints. The two major islands, Elba and Giglio have only land parks; in four islands: Capraia, Gorgona, Giannutri, Montecristo, there are both marine and terrestrial protected areas with type 1 and 2 zones. In Pianosa, unlike the other islands, only zone type 1 up to 1 nautical mile from the coast.

In summary, the perimeter of the Marine Protected Areas follows this scheme:

Gorgona Island. Prison island - terrestrial and marine park: zone 1 (1000m from the coast); zone 2 (3 nautical miles from the coast).

Capraia Island. - terrestrial and marine park: zone 1 (1000m from the coast); zone 2 (3 nautical miles from the coast).

Pianosa Island. Prison island until 31/12/1997 - - terrestrial and marine park: zone 1 (D.M.) (1 nautical mile from the coast) (Fig.xxx).

Montecristo Island. It is a nature reserve since 1971). - terrestrial and marine park: zone 1 (1 nautical mile from the coast); zone 2 (3 nautical miles from the coast).

Giannutri Island. - terrestrial and marine park: zone 1 (1 nautical mile from the coast); zone 2 (3 nautical miles from the coast).

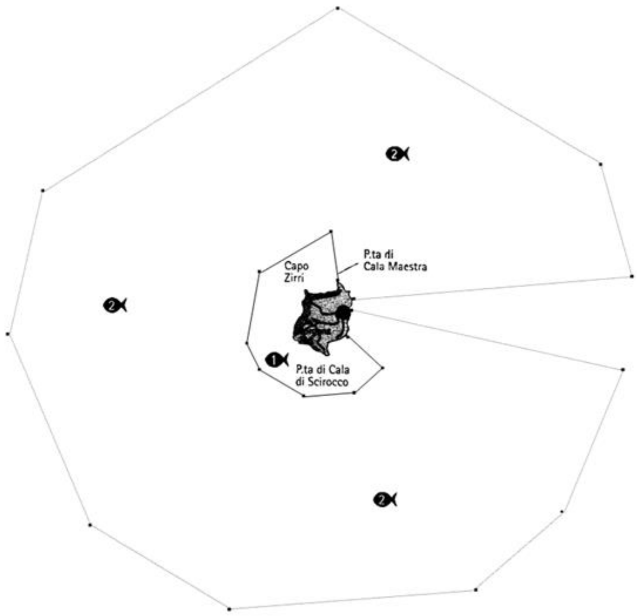


Figure 3.1.2.4.1 Gorgona Island. The solid line indicates the boundaries of zone 1, with dashed the boundaries of zone 2.

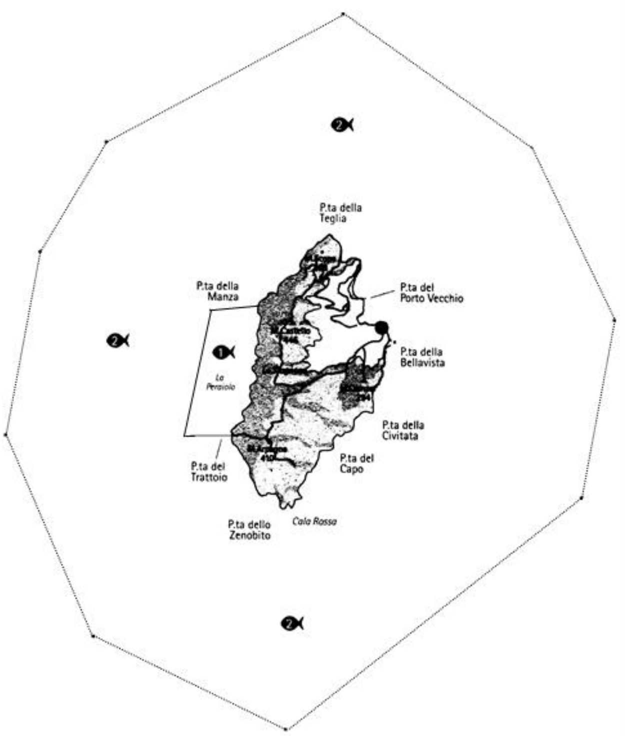


Figure 3.1.2.4.2 Capraia Island. The solid line indicates the boundaries of zone 1, with dashed the boundaries of zone 2.

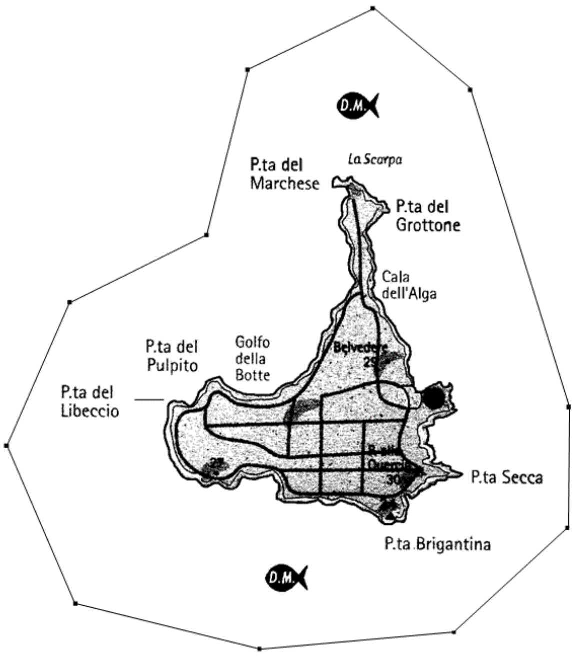


Figure 3.1.2.4.3 Pianosa Island. The solid line indicates the boundaries of zone 1, with dashed the boundaries of zone 2.

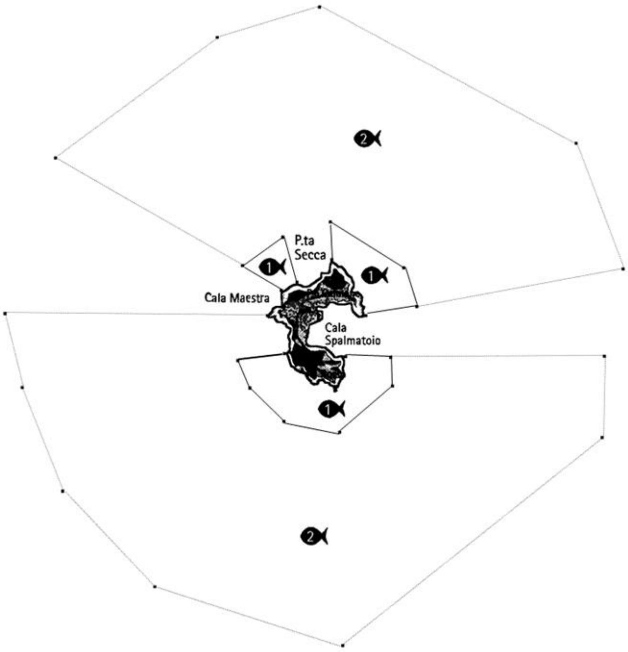


Figure 3.1.2.4.4 Giannutri Island. The solid line indicates the boundaries of zone 1, with dashed the boundaries of zone 2.

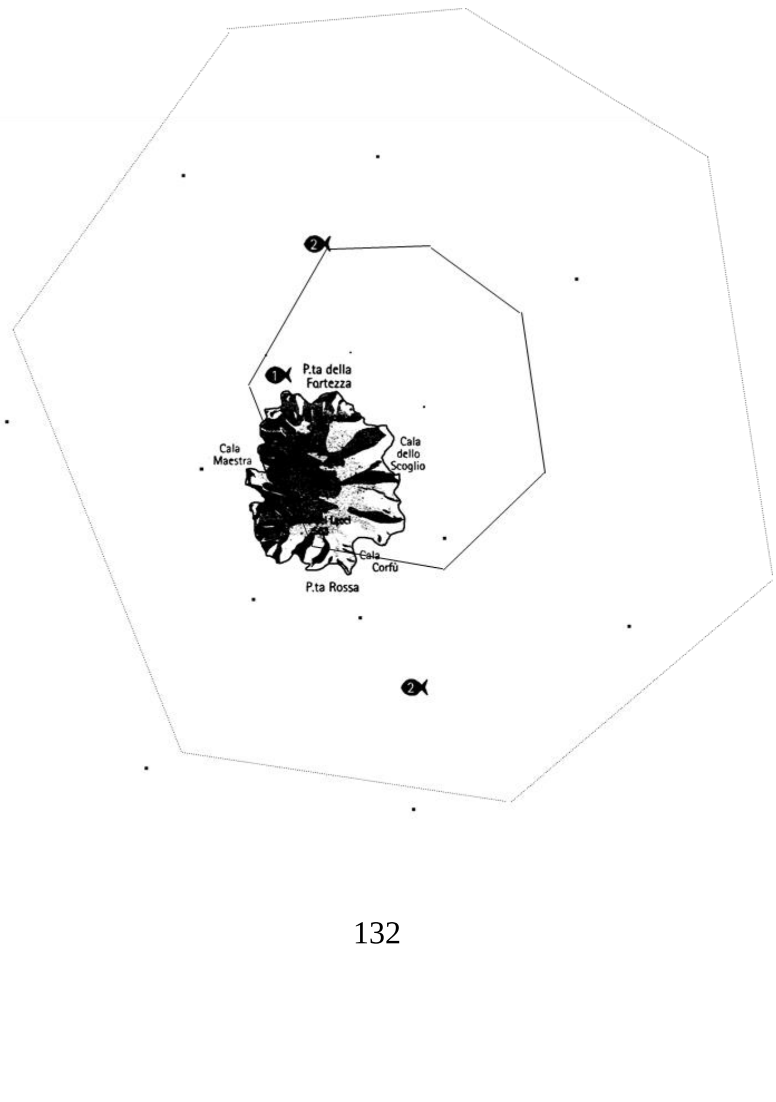


Figure 3.1.2.4.5 Montecristo Island. The solid line indicates the boundaries of zone 1, with dashed the boundaries of zone 2.

The regasification terminal "FSRU Toscana

The regasification terminal "FSRU Toscana" is one of the main infrastructures of national interest for the import of LNG (Liquefied Natural Gas.
The terminal is moored about 22 kilometers off the coast between Livorno and Pisa whith 6 anchors that moored the terminal to the seabed (120 meters depth).
All fishing activity in the area that extend 4 nautical miles from the terminal are prohibited.

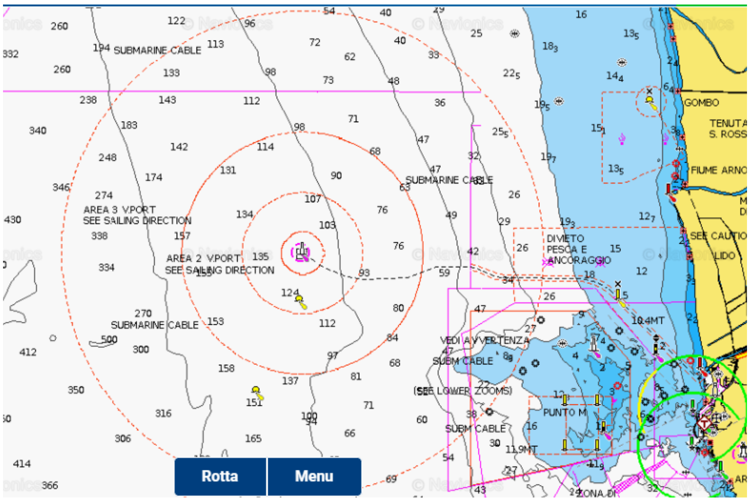


Figure 3.1.2.4.6 The regasification terminal "FSRU Toscana.

Portofino marine protected area

The marine protected area of Portofino established with the Decree of 6 giugno 1998, fully replaced by the Decree of 9 November 2004 and most recently by the Decree of 26 April 1999 (Official Gazette no. 131 of 7 June 1999).

The Regulation for the implementation and organization of the marine protected area of the Cinque Terre, currently in force, was approved by Decreto 1 luglio 2008 (GU General Series n.181 of 4 August 2008). Art. 21. Discipline of professional fishing activity: Trawl and driftnet are not permitted.

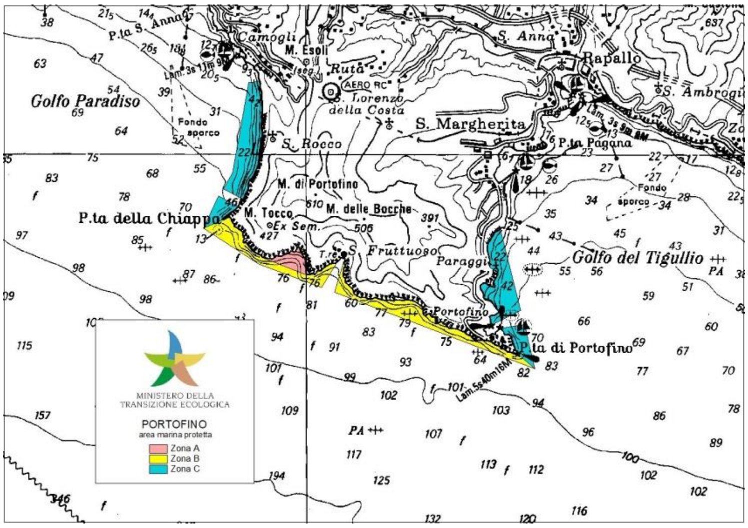


Figure 3.1.2.4.7 Portofino marine protected area

Cinque Terre marine protected area

The marine protected area of the Cinque Terre was established with the Decree of 12 December 1997, fully replaced by the Decree of 9 November 2004 and most recently by the Decree of 20 July 2011 (Official Gazette no. 266 of 15 November 2011).
The Regulation for the implementation and organization of the marine protected area of the Cinque Terre, currently in force, was approved by Decreto 24 febbraio 2015 (GU General Series n.62 of 16 March 2015). Art. 25. Discipline of professional fishing activity: **Trawl, drift and purse seine, aquaculture and active restocking are not permitted.**

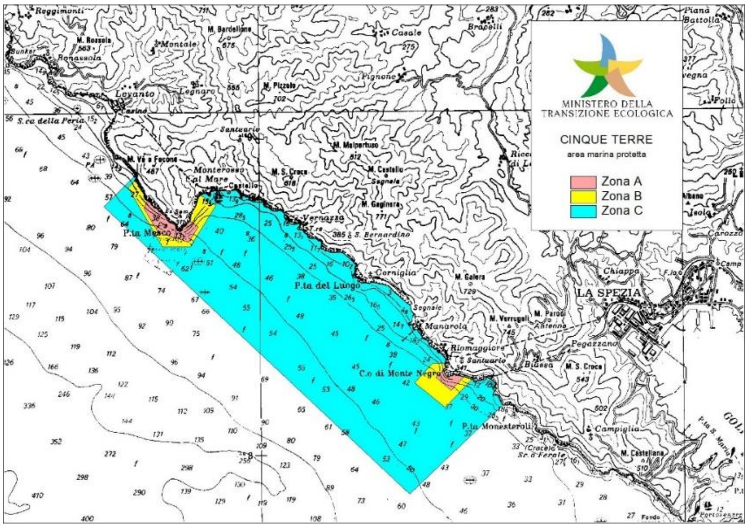


Figure 3.1.2.4.8 Cinque Terre marine protected area

Marine protected area Secche di Tor Paterno

The marine protected area of Secche di Tor Paterno was established in 2000. Regulation for the implementation and organization of the marine protected area of Secche di Tor Paterno, currently in force, was approved by Decreto 16 settembre 2014 (GU n. 234 of 8 october 2014). Art. 19. Discipline of professional fishing activity: **Trawl, drift and purse seine, aquaculture and active restocking are not permitted.**

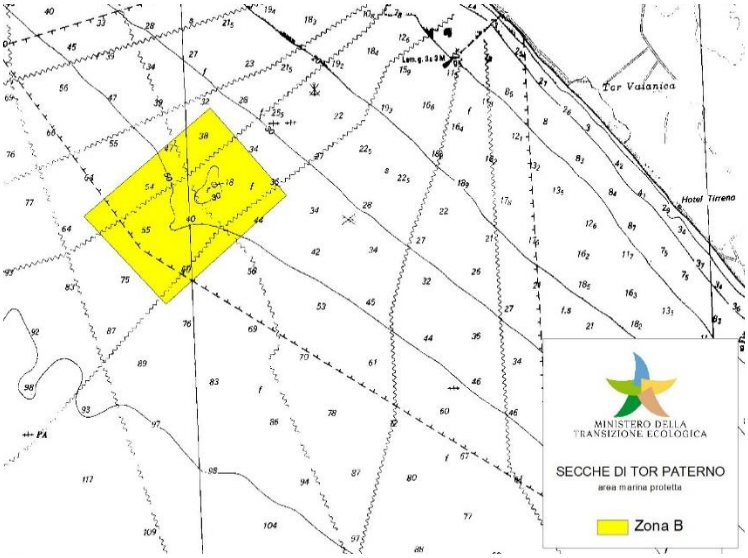


Figure 3.1.2.4.9 Marine protected area Secche di Tor Paterno

Marine protected area of Isole di Ventotene and Santo Stefano

The marine protected area of Isole di Ventotene e Santo Stefano was established in 1997. Regulation for the implementation and organization of the marine protected area of Isole di Ventotene e Santo Stefano, currently in force, was approved by [Decreto 18 aprile 2014]() (GU n. 112 of 16-5-2014 - Suppl. Ordinario n. 40). **Art. 23.** Discipline of professional fishing activity: **Trawl, drift and purse seine.**

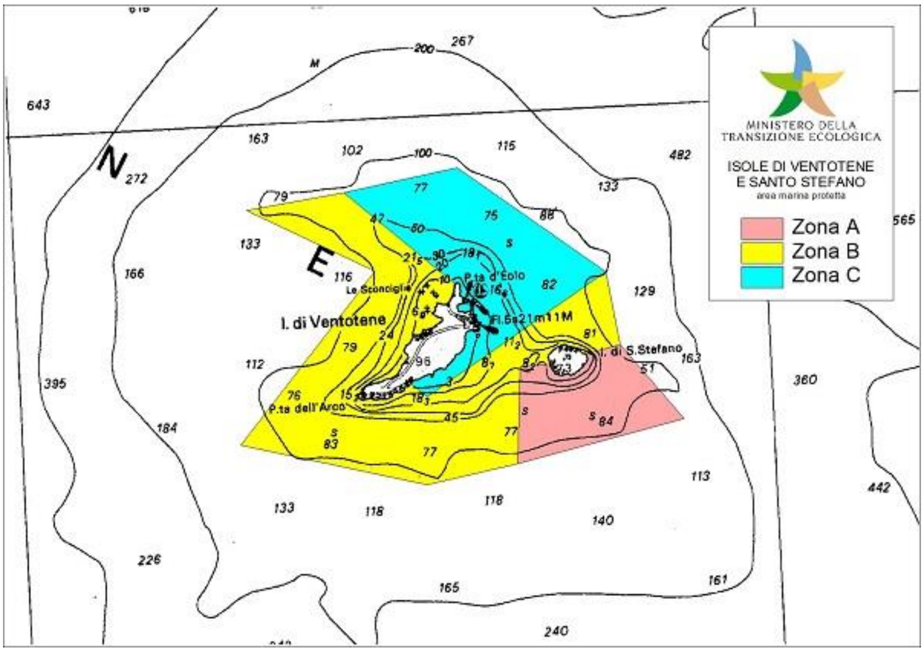


Figure 3.1.2.4.10 Marine protected area of Isole di Ventotene and Santo Stefano

Marine protected area Regno di Nettuno

The marine protected area of Regno di Nettuno was established in 2000. Regulation for the implementation and organization of the marine protected area of Regno di Nettuno, currently in force, established with Decreto 30 luglio 2009 (GU n. 198 of August 2009). Art. 23. Discipline of professional fishing activity: **Trawling is not permitted.**

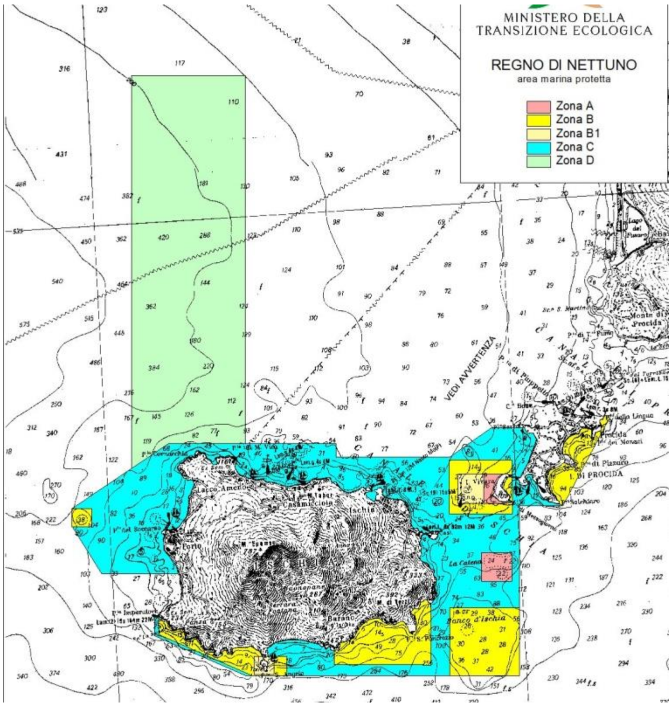


Figure 3.1.2.4.11 Marine protected area Regno di Nettuno

Marine protected area of Punta Campanella

The marine protected area of Punta Campanella was established in December 1997. Regulation for the implementation and organization of the marine protected area of Punta Campanella, currently in force, Decreto 30 luglio 2010 (GU n. 195 del 21 agosto 2010).Art. 18 Discipline of professional fishing activity: **Trawl, Purse Seine are not permitted.**

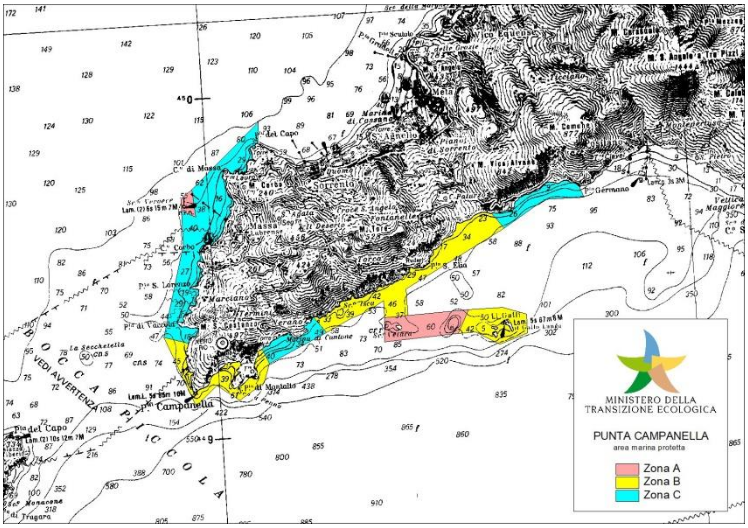


Figure 3.1.2.4.12 Marine protected area of Punta Campanella

Marine protected area of Santa Maria di Castellabate

The marine protected area of **Santa Maria di Castellabate** was established in October 2009. Almost all of the area is located within the 50 m depth bathymetry.

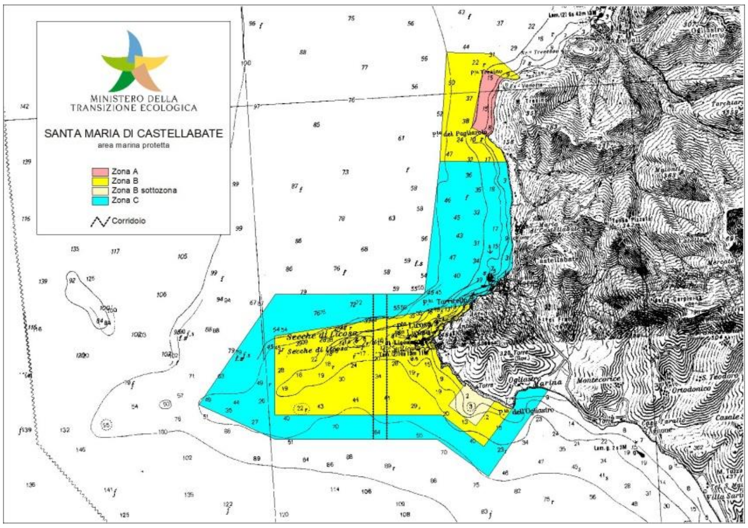


Figure 3.1.2.4.13 The marine protected area of Santa Maria di Castellabate.

Marine protected area of Costa degli Infreschi e della Masseta

the marine protected area of Costa degli Infreschi e della Masseta was established in October 2009. Regulation for the implementation and organization of the marine protected area of Punta Campanella, currently in force, established with Decreto 9 aprile 2015 (GU n. 98 of 29 April 2015). Art. 24 Discipline of professional fishing activity stated that **Trawls and Purse Seines are not permitted.**

Marine protected area of Capo Milazzo

The marine protected area of Capo Milazzo was established in May 2018. Regulation for the implementation and organization of the marine protected area of Capo Milazzo is not yet established.

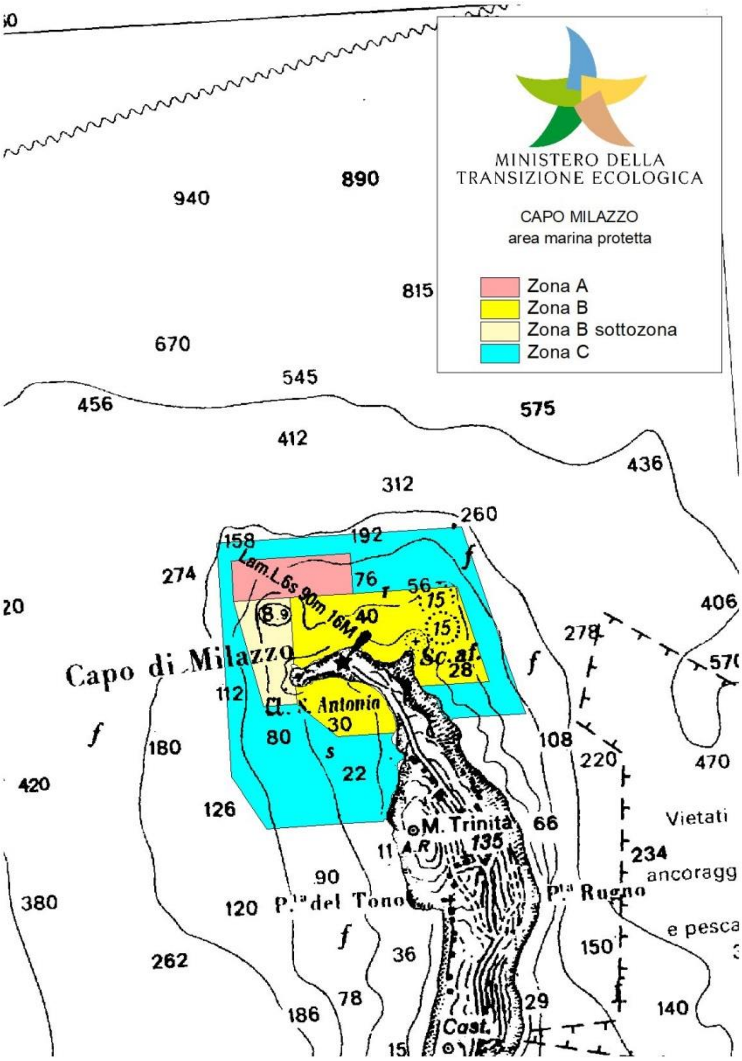


Figure 3.1.2.4.14 The marine protected area of Capo Milazzo.

Marine protected area of Capo Gallo-Isola delle Femmine

the marine protected area of Capo Gallo-Isola delle Femmine was established in July 2002, [Decreto 24 luglio 2002] (GU n. 285 of 5 December 2002). Art. 4 stated that fishing activity **are not permitted.**

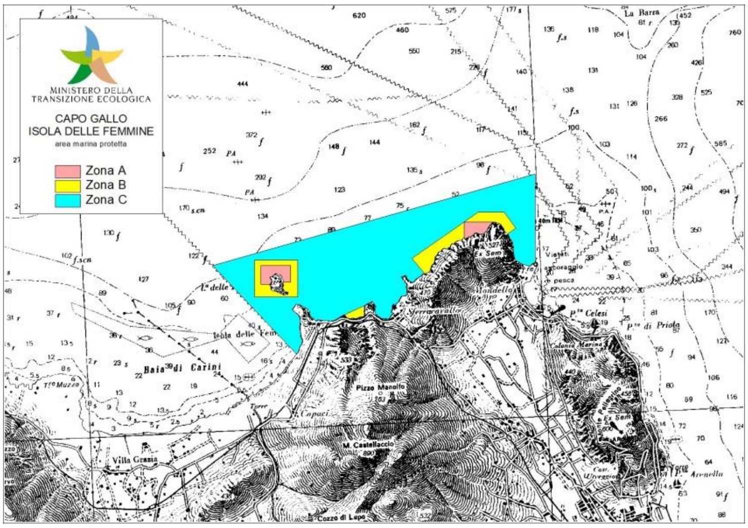
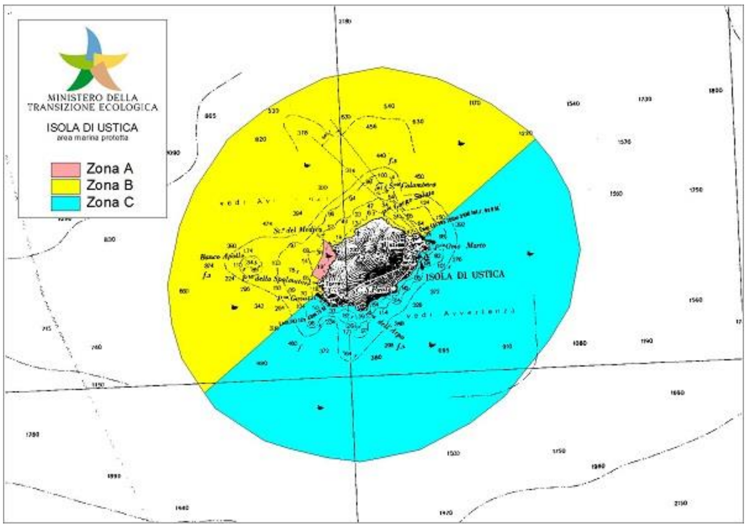


Figure 3.1.2.4.15 Marine protected area of Capo Gallo-Isola delle Femmine

Marine protected area of Isola di Ustica

The marine protected area of Isola di Ustica was established with [Decreto 12 novembre 1986]() (GU n. 71 of 26 March 1987). Art. 4 stated that professional fishing activity **are not permitted.**



Marine protected area of Capo Carbonara

The marine protected area of Capo Carbonara was established in February 2012. Regulation for the implementation and organization of the marine protected area of Isole di Capo Carbonara, currently in force, was approved by [Decreto 12 maggio 2017]() (GU n. 124 of 30 May 2017). **Art. 24.** Discipline of professional fishing activity stated that Trawl, driftnet and purse seine are not permitted .

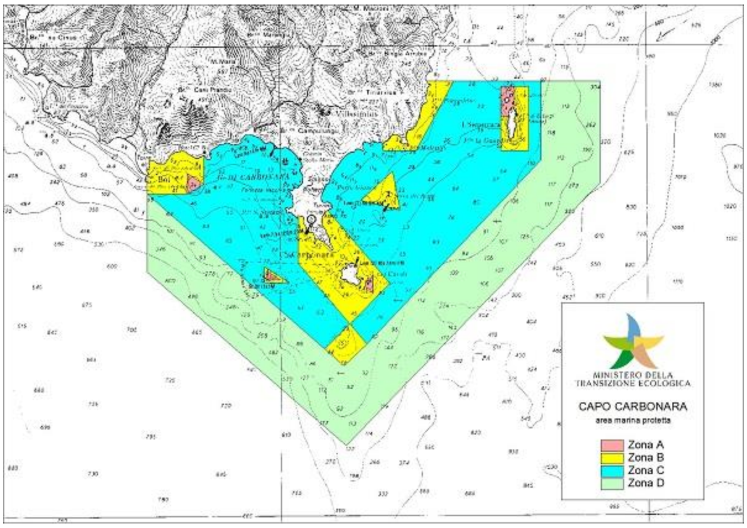


Figure 3.1.2.4.16 Marine protected area of Capo Carbonara

Marine protected area of Tavolara-Punta Coda Cavallo

The marine protected area of Tavolara-Punta Coda Cavallo was established in December 1997. Regulation for the implementation and organization of the marine protected area of Tavolara-Punta Coda Cavallo, currently in force, was approved by [Decreto 3 dicembre 2014] (GU n. 6 del 9 gennaio 2015). **Art. 25.** Discipline of professional fishing activity stated that Trawl, driftnet and purse seine are not permitted .

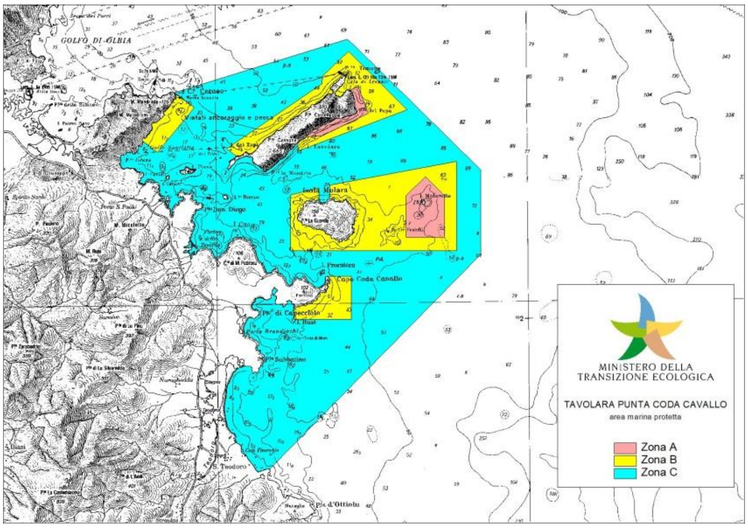


Figure 3.1.2.4.17 Marine protected area of Tavolara-Punta Coda Cavallo

Marine protected area of Penisola del Sinis-Isola Mal di Ventre

The marine protected area of Penisola del Sinis-Isola Mal di Ventre was established in December 1997. Almost all of the area is located within the 50 m depth bathymetry.

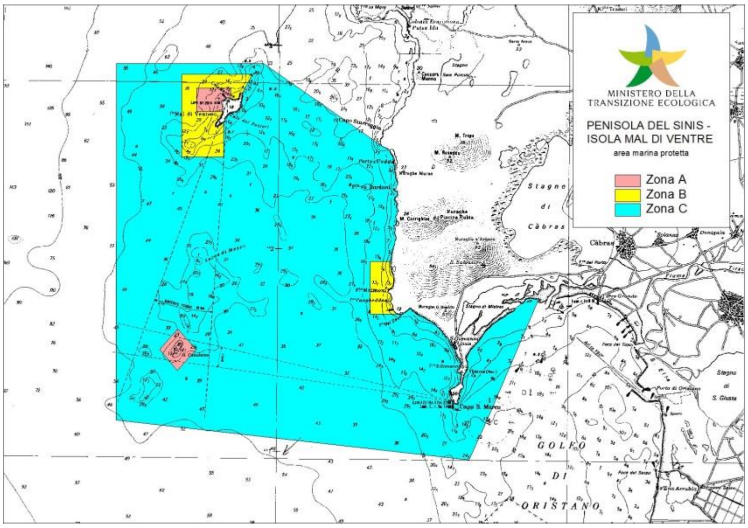


Figure 3.1.2.4.18 Marine protected area of Penisola del Sinis-Isola Mal di Ventre

Marine protected area of Capo Caccia - Isola Piana

The marine protected area of Capo Caccia - Isola Piana was established in September 2002. Almost all of the area is located within the 50 m depth bathymetry.

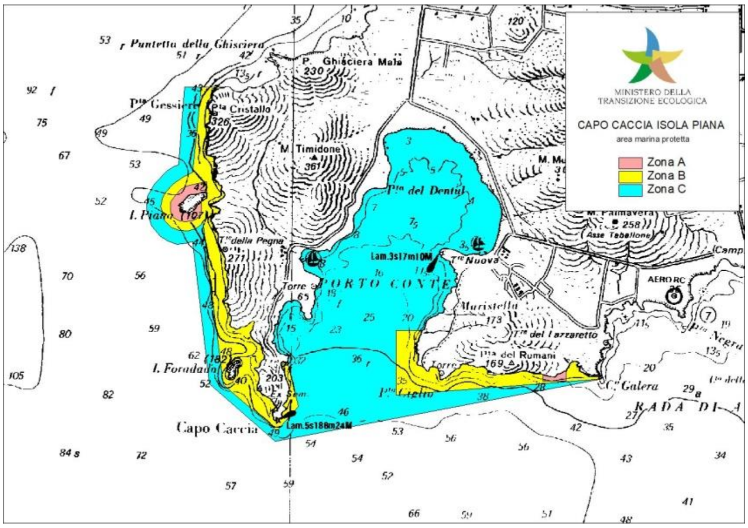


Figure 3.1.2.4.19 Marine protected area of Capo Caccia - Isola Piana

Marine protected area of Isola dell'Asinara

The marine protected area of Capo Caccia - Isola Piana was established in August 2002. Almost all of the area is located within the 50 m depth bathymetry.

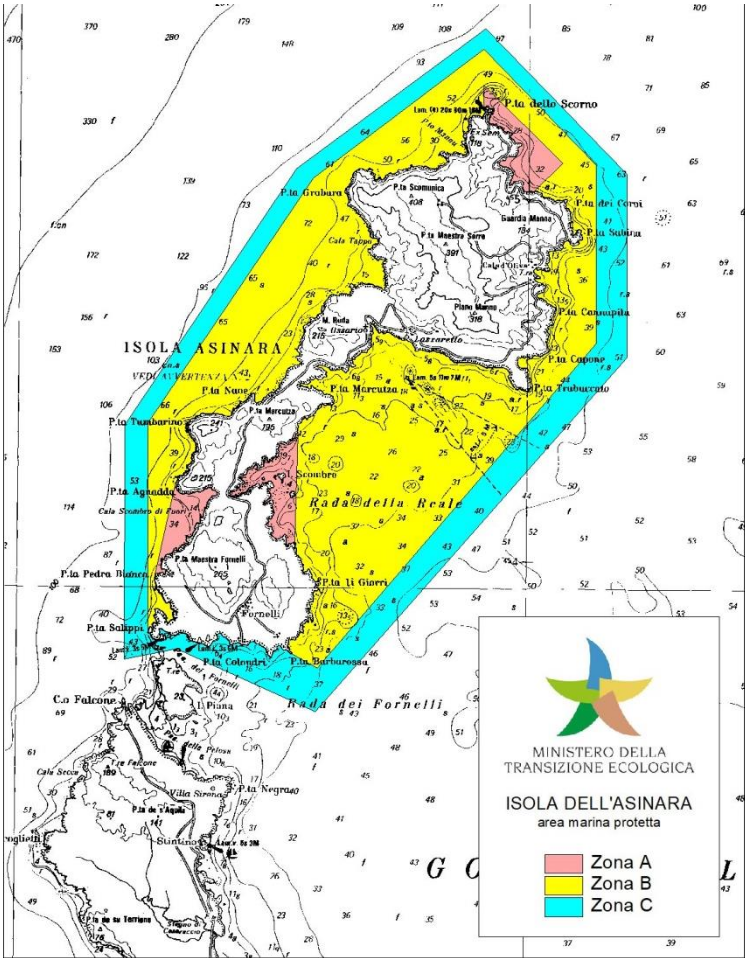


Figure 3.1.2.4.20 Marine protected area of Isola dell'Asinara

Marine protected area of Capo Testa Punta Falcone

the marine protected area of Capo Testa Punta Falcone was established with [Decreto 17 maggio 2018](). **Art. 5.** Stated that professional fishing activity is not permitted .

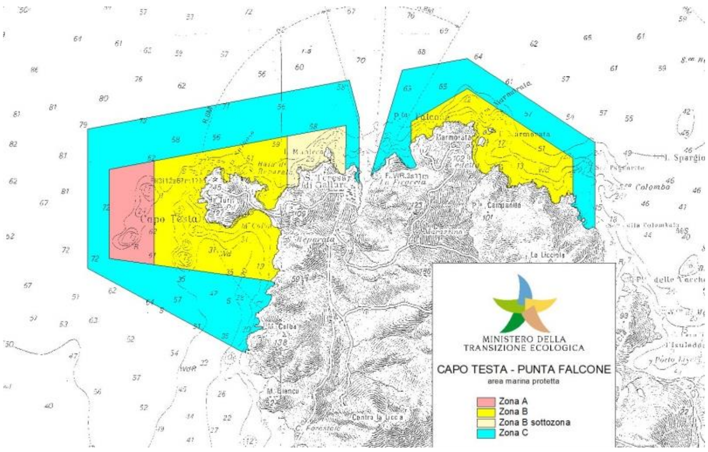


Figure 3.1.2.4.14 Marine protected area of Capo Testa Punta Falcone

Table 3.1.2.4.1 List of MPAs and extension in hectares in EMU 2. Percentages refer to the percentage of each management area (A, B, C) over the total area of the MPA (Casola et al., 2014).

Marine Protected Area	Area A	%	Area B	%	Area B1	%	Area C	%	Area D	%	Total area of MPA
Capo Caccia - Isola Piana	38	1	539	20	-	-	2.089	79	-	-	2.667
Capo Carbonara	99	1	1.699	12	-	-	6.572	46	5.916	41	14.285
Capo Gallo - Isola delle Femmine	72	3	250	12	-	-	1.833	85	-	-	2.155
Cinque Terre	79	2	186	4	-	-	4.565	94	-	-	4.830
Costa degli Infreschi e della Masseta	37	2	504	22	-	-	1.703	76	-	-	2.244
Isola dell'Asinara	639	6	6.960	64	-	-	3.247	30	-	-	10.846
Isola di Bergeggi	4	2	46	21	-	-	168	77	-	-	21 8
Isola di Ustica	55	<1	7.946	51	-	-	7.621	49	-	-	15.623
Isole di Ventotene e Santo Stefano	395	14	1.579	57	-	-	814	29	-	-	2.788
Parco naz. Arcipelago Toscano	838	2	53.295	98	-	-	-	-	-	-	54.133
Penisola del Sinis - Isola di Mal di Ventre	435	2	971	4	-	-	22.853	94	-	-	24.260
Portofino	19	5	198	51	-	-	172	44	-	-	389
Punta Campanella	167	11	654	44	-	-	685	45	-	-	1.505
Regno di Nettuno	157	1	2.182	19	135	1	4.467	40	4.528	40	11.469
Santa Maria di Castellabate	156	2	2.943	41	153	2	3.908	55	-	-	7.160
Secche della Meloria	431	5	1.080	12	-	-	7.410	83	-	-	8.921
Secche di Tor Paterno	-	-	1.380	100	-	-	-	-	-	-	1.380
Tavolara - Punta Coda Cavallo	537	4	3.043	20	-	-	11.578	76	-	-	15.158

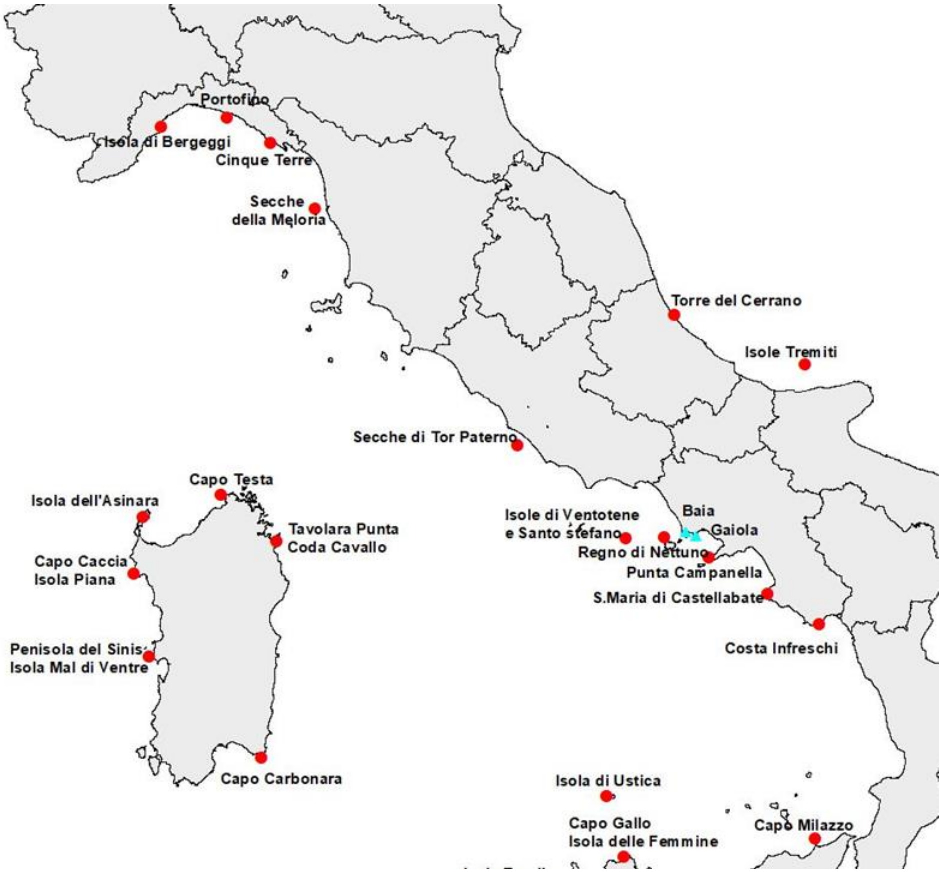


Figure 3.1.2.4.15 Marine protected areas in EMU 2.

In addition to the aforementioned areas, there are other underwater areas subject to regulation and where fishing is prohibited, for example presence of submarine cables, military polygons; in addition, the presence of wrecks that limit the operation of fishing vessels on the high seas should also be considered. Detailed information on the exact location and extension can only be found at the local Port Authorities or are part of the experience of master of fishing vessels operating in those specific areas. All these areas should be taken into account when planning to limit fishing effort through spatial management.

3.1.2.5 References

Enrico Casola, Michele Lariccia, Michele Scardi - 2014. Aree Marine protette e pesca professionale. UNIMAR: 204pp

3.1.3 Evaluation of closure areas in previous working groups

The first evaluations of the implemented closure areas were done by MS scientific agencies and presented in PLEN 19-03 (Spain and France) and PLEN 20-01 (Italy and Spanish resubmission). All proposals were related to article 11.1 and, if derogated, to article 11.2. All countries adopted 11.2 in all GSAs except France for GSA8, were article 11.1 was applied. Therefore, in most cases hake juvenile catches reduction in response to closure areas had to be evaluated. French methodologies only considered commercial data: VMS and landings data for the estimation of juvenile catches reduction. Spanish methods only considered nurseries distribution models from MEDITS survey data and Italian’s considered both, fisheries dependent and independent information. Other differences between methodologies were detected in the use of a non-standardized TL threshold defining hake juvenile, in the consideration of effort redistribution and in including or not the effort reduction implemented to the fleet in the analysis.

Considering the widely different justifications and supporting information provided by MS, STECF suggested how this analysis could be performed in a more standardized criteria: *"The assessment of the best location and timing for closures should compare and overlay a) where the fisheries are taking place and the likely catch composition and b) where juveniles are most likely to be distributed, in order to assess the expected impact of the fisheries on the juvenile stock component. Juvenile hake habitats can be modelled using fishery-independent trawl surveys and applying persistency analyses of the juvenile hake distribution to document hotspots in time and space."* (see PLEN 19-03 report) [2]. Moreover, after evaluating Italian and Spanish proposals in STECF PLEN 20-01 [3] also suggested that the analysis of the reduction in hake catches should be predicted from the commercial effort accounting for fishery gear selectivity. It was also pointed out that effort redistribution derived from the closures has to be considered in order to avoid assuming a net reduction of catches in closed areas corresponding to the past catches made inside the areas proposed.

In paragraph 3 of WMMAP Article 11 [1] states that: *"By 17 July 2021 and on the basis of the best available scientific advice, the Member States concerned shall establish other closure areas where there is evidence of a high concentration of juvenile fish, below the minimum conservation reference size, and of spawning grounds of demersal stocks, in particular for the stocks concerned"*. On top of that, during EWG 21-01 [4], STECF observed that the objective of additional closures has changed as stipulated the joint statement by France and Spain in December 2020 (European Council, statement 5415/1/21 Rev1): *"The additional closures should result in a reduction of between 15% and 25% in the by catch of juveniles and spawners of each stock covered by the WMMAP"* (the term "by catch" used in the literal sentence from the joint statement, was interpreted as catch in the analysis carried out by STECF). Therefore, the overlap between new proposed areas should now be checked against information regarding juveniles and spawners distribution of the 6 species covered by WMMAP.

EWG 21-01 was expected to evaluate countries new areas proposals. Only Spain provided documentation with new areas evaluations. Most of the evaluations met the standardized methodology developed by STECF: closure areas were compared with fishery-independent data on MAP species distribution (spawners and adults), closures were also overlapped with fishing effort, landings data were also used and fishing effort redistribution was also considered [4]. However, none of the areas evaluated reached the objectives required for any fraction of the stocks.

In EWG 21-01, methodologies to redistribute fishing effort were also discussed together with the need of including information on sensitive and essential fish habitats in closure areas definitions. EWG was also required to delineate proposals of new closure areas and to parametrize of spatial explicit models but had no time nor data to address these points [7].

STECF (EWG 21-01 and PLEN 21-02) were asked to delineate new closure areas if the ones submitted by MS do not accomplish with the objectives established. In this point STECF stressed that designing new closure areas is not a straightforward process as many factors are at play and insist on the need of considering juveniles and spawning aggregations distributions is a key requirement for new delineations. As a conclusion, in PLEN 21-02 (p.33) [5], STECF suggests a roadmap for identifying and testing the effects of closure areas: *"a) define recruits and spawners (a number of assumptions can be made to identify thresholds for these two categories); b) estimate the distribution of recruits and spawners densities using several modelling approaches depending on species and area; c) identify hotspots (i.e., areas with higher density) of recruits and spawners (e.g., by means of survey data and sampling onboard); d) verify the spatial and temporal persistency/stability of such hotspots; e) evaluate the importance of each area in a multispecies context by analysing the spatial overlap among the persistent hotspots (areas including nurseries and spawning aggregations for multiple species should be ranked as highly* *priority areas); f) define a number of closure areas scenarios prioritizing areas with overlapping hotspots and gradually increasing their spatial extensions; g) verify the effect of such scenarios (closure areas) in reducing juveniles and spawners in catches along with effort redistribution (e.g., ideally through a dynamic modelling). Following this roadmap, it could be possible to optimize spatial management objectives for demersal fisheries by identifying the precise location and extension of closure areas achieving a given reduction of juveniles and spawners in catches."*

3.1.4 References

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

[2] Scientific, Technical and Economic Committee for Fisheries (STECF) – 62nd Plenary Meeting Report (PLEN-19-03). Publications Office of the European Union, Luxembourg, 2019, ISBN 978-92-76-14169-3, doi:10.2760/1597, JRC118961

[3] Scientific, Technical and Economic Committee for Fisheries (STECF) – 63 rd Plenary Report – Written Procedure (PLEN-20-01). Publications Office of the European Union, Luxembourg, 2020, ISBN 978-92-76-18117-0, doi:10.2760/465398, JRC120479

[4] Scientific, Technical and Economic Committee for Fisheries (STECF) – West Med assessments: conversion factors, closures, effort data and recreational fisheries (STECF-21-01). Publications Office of the European Union, Luxembourg, 2021, EUR 28359 EN, ISBN 978-92- 76-36193-0, doi:10.2760/36048, JRC124913.

[5] Scientific, Technical and Economic Committee for Fisheries (STECF) – 67 th Plenary Report (PLEN-21-02). EUR 28359 EN, Publications Office of the European Union, Luxembourg, 2021, ISBN 978-92-76-40592-4 (online), doi:10.2760/559965 (online), JRC126123.

3.2 Development of hotspots' seascape

EWG 22-01 was tasked to provide evidence of a high concentration (named hereafter "hotspots") of juvenile fish and of spawning grounds of demersal stocks, in particular for the target stocks of the West Med MAP (EC Reg 2019/1022, Article 1). The identification of high concentration areas for the harvested resources in the Western Mediterranean requires the analysis of spatial data on abundance and density distribution, which can be obtained by sampling the populations in space and time as a basis for applying statistical models to infer the distribution in non-sampled areas. In a second step, the persistence of these high concentration areas is analysed by overlapping annual density distribution throughout the years.

3.2.1 Survey data: MEDISEH shapefiles

Shapefiles of nursery areas and spawning aggregations of hake, red mullet, Norway lobster, deep-water rose shrimp, giant red shrimp, and spawning aggregations of blue and red shrimp were calculated in the framework of the MEDISEH Project (DG MARE Specific Contract No 2 SI2.600741; Giannoulaki et al., 2013). These shapefiles were obtained on the basis of the MEDITS bottom trawl survey data for the period 1994–2010. This survey is carried out in EU Mediterranean waters in spring - summer (May-August) (WP, 2019) to gather data on benthic and demersal fish and shellfish in a wide depth range, from 10 to 800 m depth (MEDITS-handbook, 2017). In the Western Mediterranean, given the timing of the MEDITS survey (third quarter), it is likely that the resulted habitat mapping cannot be considered as fully representative of the actual distribution of nurseries and spawning areas (Colloca et al., 2013).

Recruits were considered as those specimens that have settled on the bottom, becoming available to the fishing gear in well-defined habitats at the end of their larval-pelagic stage and which remain in these habitats before dispersing or migrating. Due to the lack of specific studies on the dispersal behaviour of juveniles, it was assumed that the first separable modal component of the age group 0 was composed of specimens recently settled on the bottom sharing similar habitat preferences. The Bhattacharya's method was used to separate the first modal component of the 0-age group from the annual standardized trawl survey length frequency distributions (LFDs). The 0-age group threshold limit was defined using growth data available in the Mediterranean and routinely collected within the EU DCF. In some circumstances, when the splitting of modal components in the LFDs was difficult (e.g. low number of recruits), recruits were computed using a fixed threshold length derived from validated local studies (Colloca et al., 2013; Colloca et al., 2015).

Spawners of hake, Norway lobster, deep-water rose shrimp, giant red shrimp, and blue and red shrimp were considered the adult females fraction of the populations using the length-at-maturity calculated from MEDITS or landing data (DCF) as threshold length. For red mullet, which has its spawning peak during the MEDITS survey period, models were based either on mature female specimens or on the adults' fraction. In GSAs 1, 5 and 6 mature females of giant red shrimp were used instead of length-at-first maturity (Colloca et al., 2013; Colloca et al., 2015).

Density indices (n. km^{-2}) by year both for recruits and spawners, MEDITS station, GSA and species were calculated following the method used by Fiorentino et al. (2003). To locate and classify nurseries and spawning aggregations, annual density spatial hot-spots were identified through the Getis' G statistic (Getis and Ord, 1992) with a radius of 2.5 – 5.0 km and a 0.95 level of significance. This approach was applied separately in each GSA and for each year of the time series to spatially locate clusters of recruits and spawners displaying a significantly higher density. Finally, the Index of Persistence was calculated to measure the relative persistence of annual nurseries and spawning aggregations in each GSA (see Colloca et al., 2015). Here we identified hotspots selecting the spatial persistence higher than 20%.

Figures 3.2.1.1-3 show the spatial distribution of juveniles and spawners of giant red shrimp, European hake, Norway lobster, red mullet, blue and red shrimp, and deep-water rose shrimp from MEDISEH shapefiles.

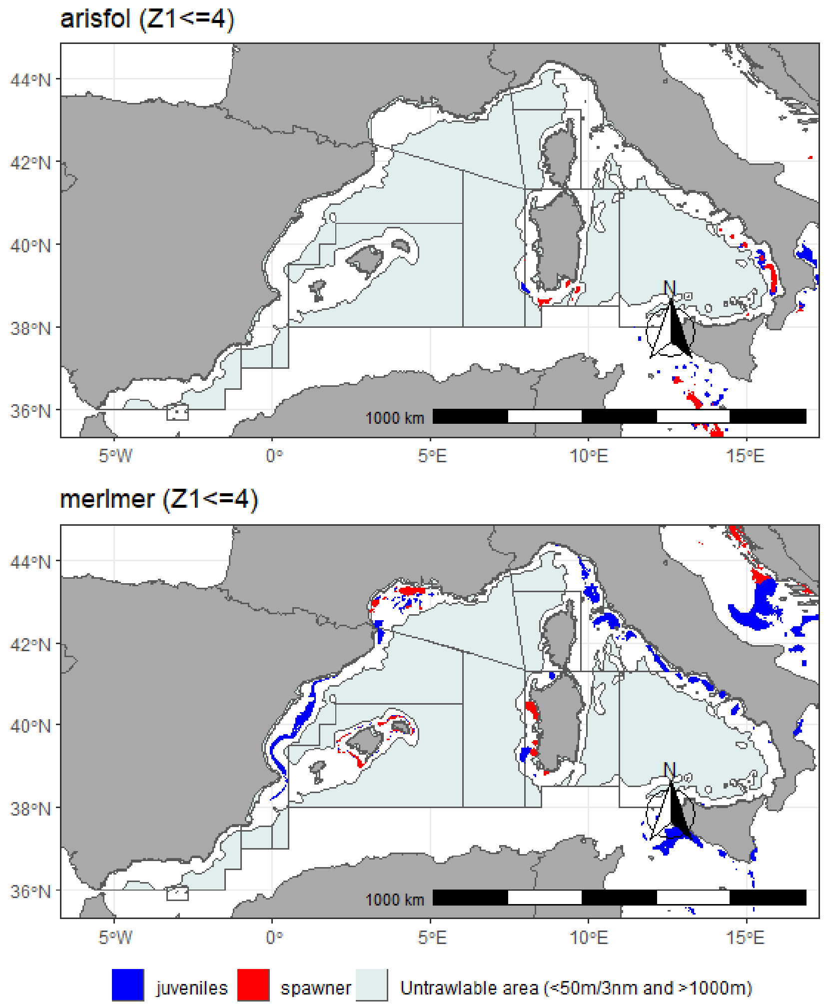


Figure 3.2.1.1. Spatial distribution of juveniles and spawners' hotspots of giant red shrimp (ARS) and European hake (HKE) from MEDISEH shapefiles. Z1 refers to the temporal persistence class >20%.

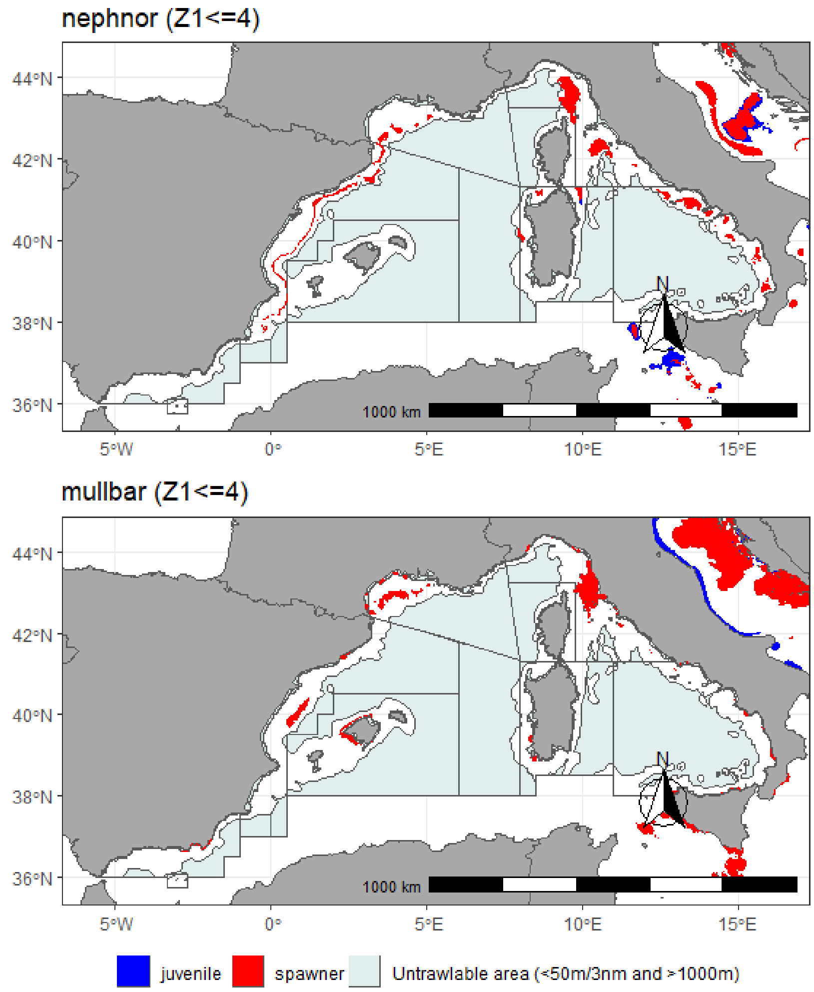


Figure 3.2.1.2 Spatial distribution of juveniles and spawners' hotspots of Norway lobster (NEP) and red mullet (MUT) from MEDISEH shapefiles. Z1 refers to the temporal persistence class >20%.

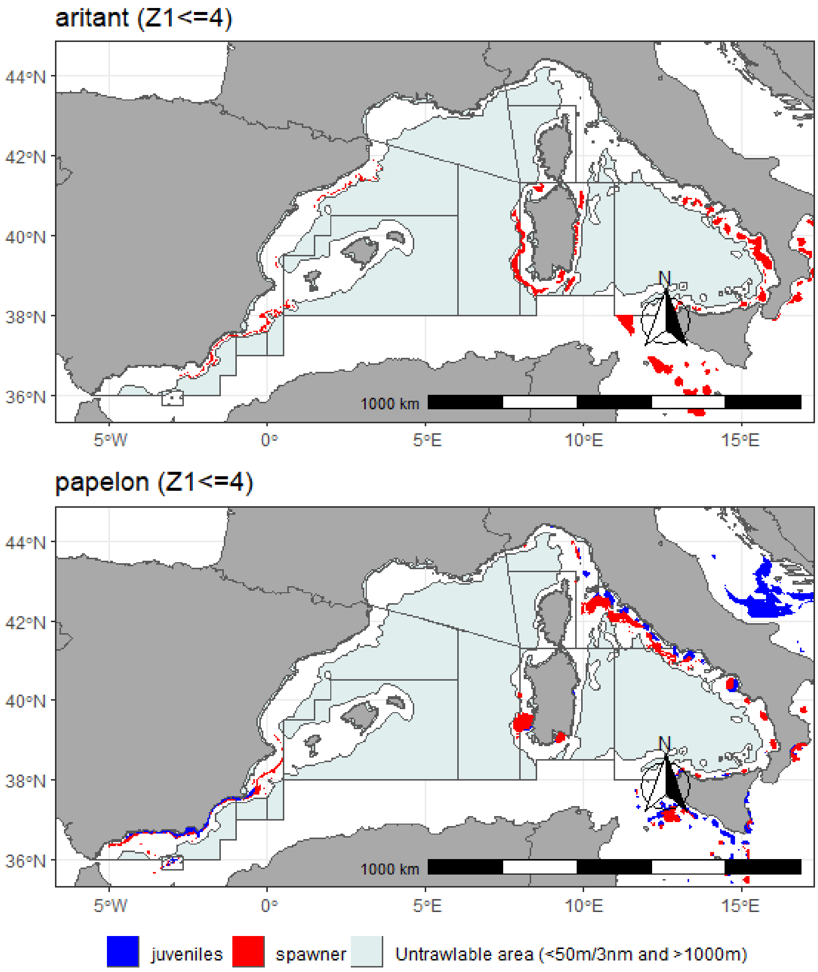


Figure 3.2.1.3 Spatial distribution of juveniles and spawners' hotspots of blue and red shrimp (ARA) and deep-water rose shrimp (DPS) from MEDISEH shapefiles. Z1 refers to the temporal persistence class >20%.

3.2.2 Commercial data coupled to survey data

Ahead of the EWG 22-01, preliminary works on mapping species distribution and possible persistence of hotspot areas over the years were done using scientific surveys and commercial data (*ad hoc* contracts n. 2191 and n. 2192, respectively). Both data sources have different advantages that could complement to identify suitable areas. Scientific surveys following standardised procedures aim to provide large-scale consistent estimates of density across the area of interest, but often they lack the fine-scale spatial and temporal information necessary to delineate hot-spots. In contrast commercial data rarely has consistent estimates of abundance across broad regions, but provides much higher spatial and temporal resolution locally. For the commercial data log-book information was linked to position data (VMS/AIS). The two data sets are therefore highly complementary in there information and the EWG aimed to use both to provide additional option for hot-spot based closures .

The EWG was provided with two ad hoc contract reports (see Annexes I and II) mapping the species density or fishing effort areas:

- In Annex I demersal trawls logbooks are merged with the VMS data of the French, Spanish and Italian fleets in both EMU1 and EMU2 during the period (2015-2020 for the French trawlers, 2017-2020 for the Italian trawlers and 2018-2020 for the Spanish trawlers in a VAST model that accounts for regional differences in fleet catchability using the available survey information from MEDITS data). The outcome of the approach provides spatially interpolated maps of average LPUEs or average density (kg/km2) of European hake, Red mullet, and two deep-water shrimp species (*Aristeus antennatus* and *Aristaeomorpha foliacea*) per GSA for both EMU1 and EMU2. Applied annually, the approach also provides a coefficient of variation per grid cell of 0.05 x 0.05 degrees over the studied area.
- In Annex II the STECF Fisheries Dependent Information (FDI) database collecting EU member states landings and effort statistics per DCF fleet-segments for the passive gears (longline, gillnet, driftnet) targeting hake, are coupled to spatial AIS data (Automatic Identification System) in the Italian EMU2 areas, and during the period 2018-2020. The approach provides a dispatch of landing data over geographical position as a basis to identify persistent, high LPUEs areas for passive gears targeting European hake.

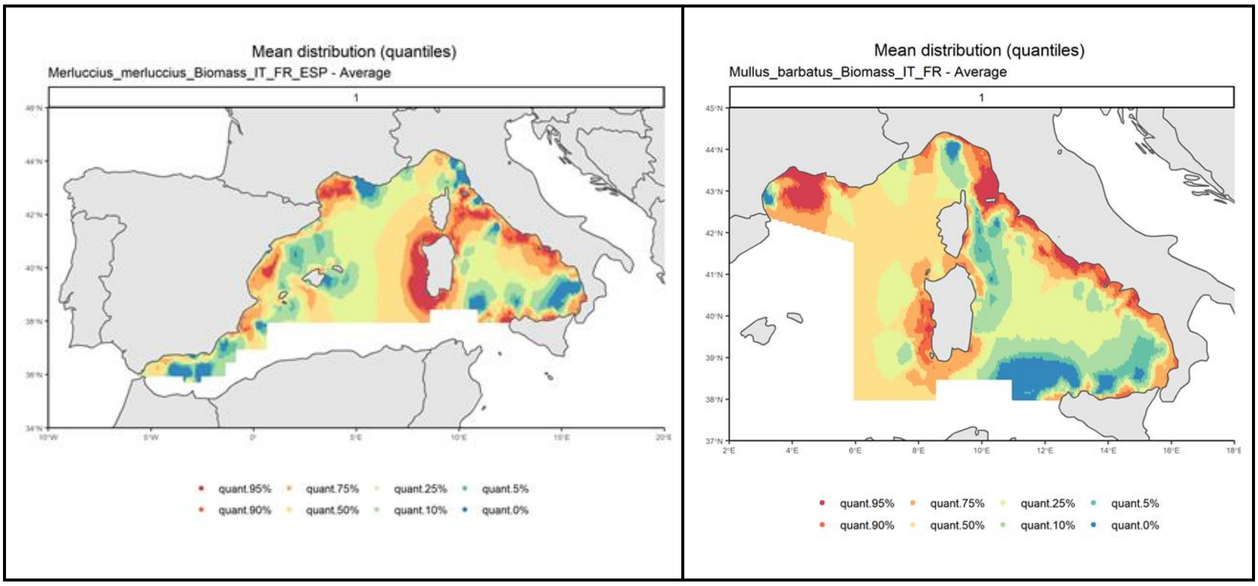


Figure 3.2.2.1 Mapping the 2015-2020 average hake (left) and red mullet (right) density, here classified by quantile, obtained by applying the statistical modeling approach described in Alglave et al. (2022) in EMU1 and EMU2. Hake based on Spanish, Italian and French commercial data, and the MEDITS survey, red mullet based on Italian and French data, and MEDITS survey. Mapped on 0.05 x 0.05 grid cells.

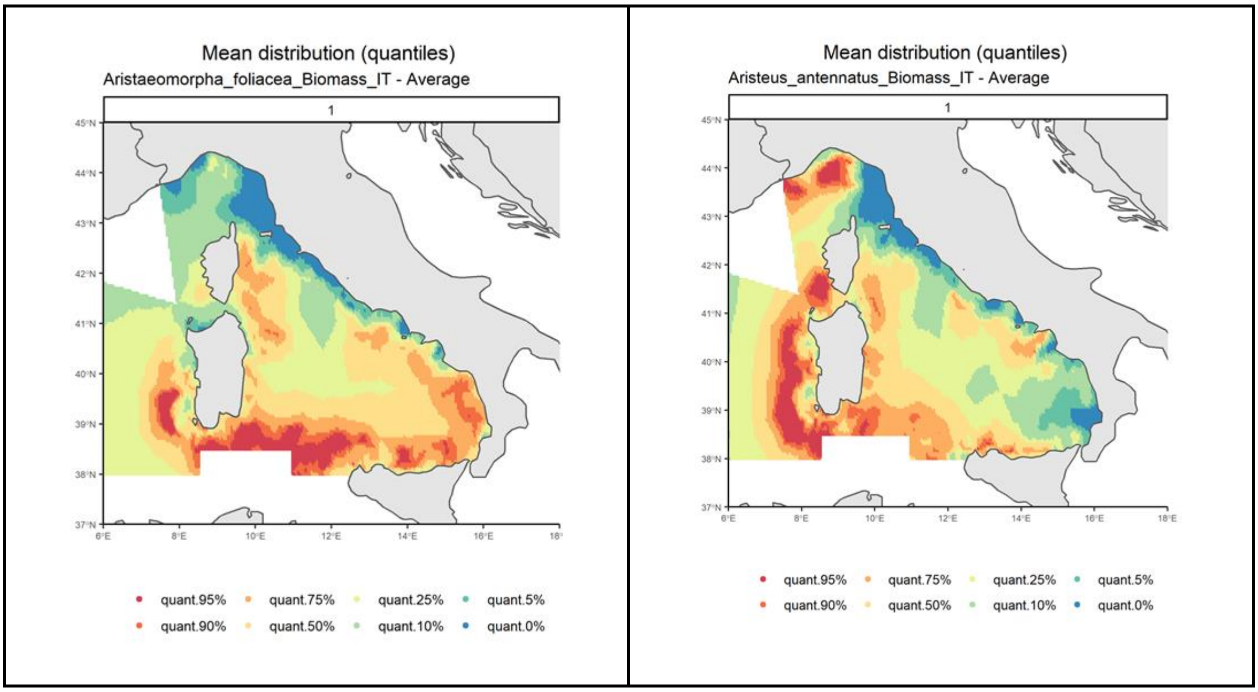


Figure 3.2.2.2 Mapping the 2015-2020 average Aristeus antennatus and Aristaeomorpha foliacea density, here classified by quantile, obtained by applying the statistical modeling approach described in Alglave et al. (2022) in EMU2 and based on Italian data only. Mapped on 0.05 x 0.05 grid cells.

To be conservative and limit the uncertainty, the EWG decided to filter out the maps only to keep the area where there was some fishing effort collected in the data to get rid of the statistical model extrapolation outside the historical range of area visited by the fleet during the period investigated. No additional covariates were indeed included in the model as VMS-logbook data do not provide reliable estimates for the species-habitat relationship and only allow to identify spatial and spatio-temporal correlation structures (Alglave et al. 2022, Annex I). Therefore, no hotspots could be identified in no trawled areas following our conservative approach.

The EWG decided on criteria to identify the persistent areas of high concentration of juveniles and spawners based on the average density and the coefficient of variation. to identify persistent areas by selecting grid cells defined with high commercial LPUEs and CV approximately above 0.5 and below 1, areas of low variance associated with extrapolation to low data density were excluded (Table 3.2.2.1).

Table 3.2.2.1. Ad hoc CV ranges per species chosen to delineate areas of high fish concentration on the species-specific density maps provided by Alglave et al. (2022)

Species	CV range
Hake SSB	0.5-1.3
Hake recruit	0.4-1.0
Hake Biomass	0.25-1.4

Red shrimp	0.2-1.3
Blue shrimp	0.4-1.0
Mullet	0.5-2.4

The EWG notes that the definition of what constitutes a hotspot area could be interpreted differently. It is questionable if a hotspot of high LPUEs for a given year is also a persistent area of high abundance over the years. Protecting low LPUEs but persistent areas might also be beneficial for stock development when protecting a large supporting area (essential fish habitat), provided the areas are commensurately larger to have the same protective effect as hotspots, less detrimental to the fishery as well as more beneficial to other conservation objectives. The models we have at hand might underestimate the positive effects of protecting coastal habitats instead of the concentration of fish and avoiding affecting where the fishing effort distributed the most could also prevent effort displacement and unwished side effects that could lead the fishery to explore much more extensive areas of low LPUEs but persistent areas in an attempt to compensate for the losses.

The EWG notes that using commercial LPUEs could be a biased approach because it could pool vessels with different fishing power, where the largest vessel expected to develop higher catch rates (STECF EWG 18-09). However, the experts observe that the difference in catching power is most likely due to difference in area visited between large and small vessels, as a result of different mobility range, as shown from the GLM analysis in STECF EWG 18-09. Therefore, higher LPUEs on the more distant fishing grounds from the coastline would likely not be due to different catchability power between large and small vessels but to an inherent difference in stock distribution.

The EWG decided not to use the set net/longline data as a direct source for the hotspot identification due to the fact that experts considered the fleet targeting hake spawners mainly characterized by small vessels (VL0006 and VL0612) not-equipped with AIS or adopting polyvalent gears that brought bias when not matching with official registers or FDI spatial data. This piece of information however has been used as a post-hoc confirmation of the hotspots identified, only where AIS data and FDI landings matched. However, the mismatch with the FDI was considered high (i.e., FDI record with no corresponding AIS, AIS records with no corresponding FDI declaration of landings), resulting in a few AIS-based fishing grounds.

3.2.3 Define closure areas based on persistent hotspots

EWG 22-01 identified the new closure areas by prioritizing the overlapping surfaces of the above identified hot spots (i.e., MEDISEH data, AIS data, VMS data, logbooks, FDI spatial data) for recruits and spawners of all species. Specifically, MEDISEH data were used for all the species concerned in the West Med MAP, VMS/logbook data four (HKE, MUT, ARA, ARS) species, while AIS and FDI data were used for post-hoc confirmation of hake hotspots only. The seasonal closures were identified only when the spatial information used for their selection was based on quarterly data, also accounting for the spawning period of HKE and on the distribution of HKE spawners. The permanent closures were identified based also on survey data, which are collected only during quarter 3.

Figures 3.2.3.1-3 below show the proposed areas for closure together with the existing closure areas per GSA of the West Med.

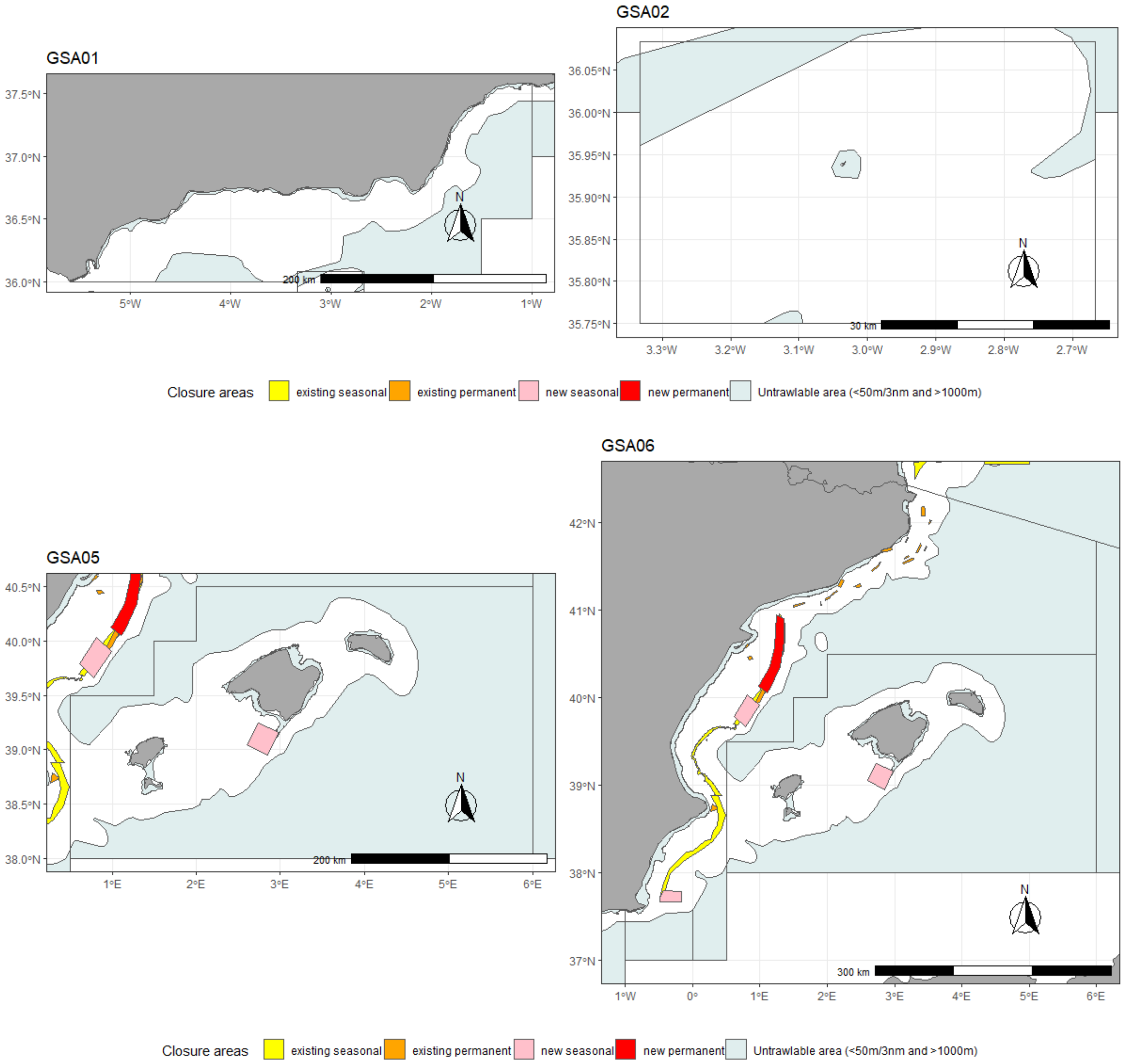


Figure 3.2.3.1. Existing and proposed areas by the EWG for closure in GSAs 1, 2, 5 and 6 of the western Mediterranean.

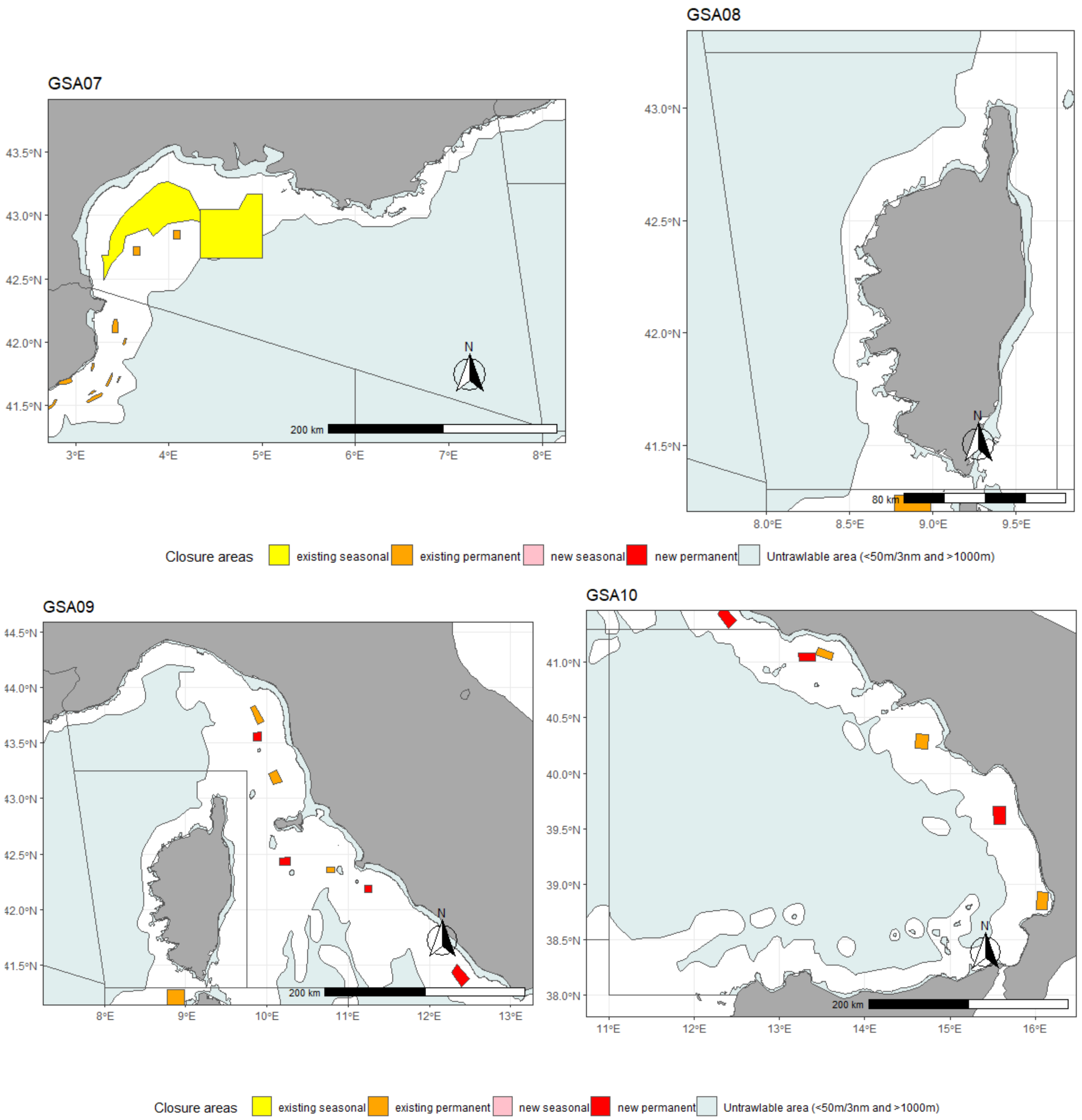


Figure 3.2.3.2 Existing and proposed areas by the EWG for closure in GSAs 7, 8, 9 and 10 of the western Mediterranean.

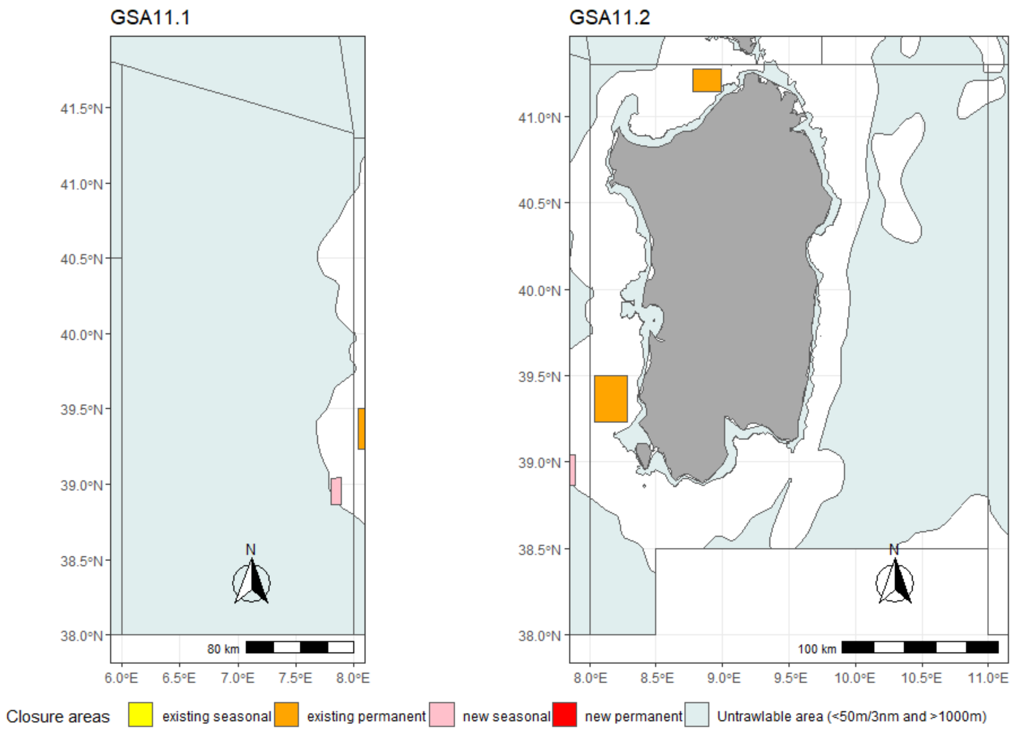


Figure 3.2.3.3 Existing and proposed areas by the EWG for closure in GSAs 11.1 and 11.2 of the western Mediterranean.

The EWG provides the percent ratio of the existing closures (Base closures, Fig. 3.2.3.4) and proposed surface area for closure (New closures, Fig. 3.2.3.4) over the trawlable area (>50m depth or >3nm and <1000m depth) per GSA to get the first insight on possible impact on the fleets. It is worth noting that larger percentages are obtained in case the surface area of closure is compared to the trawled areas historically, given not all trawlable areas, which are defined on bathymetric limits, are trawled in practice. Hence, in Fig. 3.2.3.4 the trawled area was derived by the grounds exerted by the VMS-equipped demersal trawls (see Annex I). Finally, computed percentages also account for the fact that not all areas are closed all year around.

Figure 3.2.3.4 shows that the impact of both existing and additional closures strongly differs among GSAs in terms of percent of the overall GSA area closed to fishing. In particular, GSA 7 is currently and will still be the most impacted one, by the area-based management, with about 40% of the trawled area already affected by the existing area closures. The Italian GSAs are the ones which are currently less affected by the closure in terms of surface percentage, and will not be much more affected by the proposed addition (always below the 5% of the GSA surface area). GSA 6 shows an area closure of about 10% of the total surface area. These impacted surface areas are almost halved in GSA6 and GSA7 when accounting for the part of the closure that is seasonal only (Figure 3.2.3.4, right).

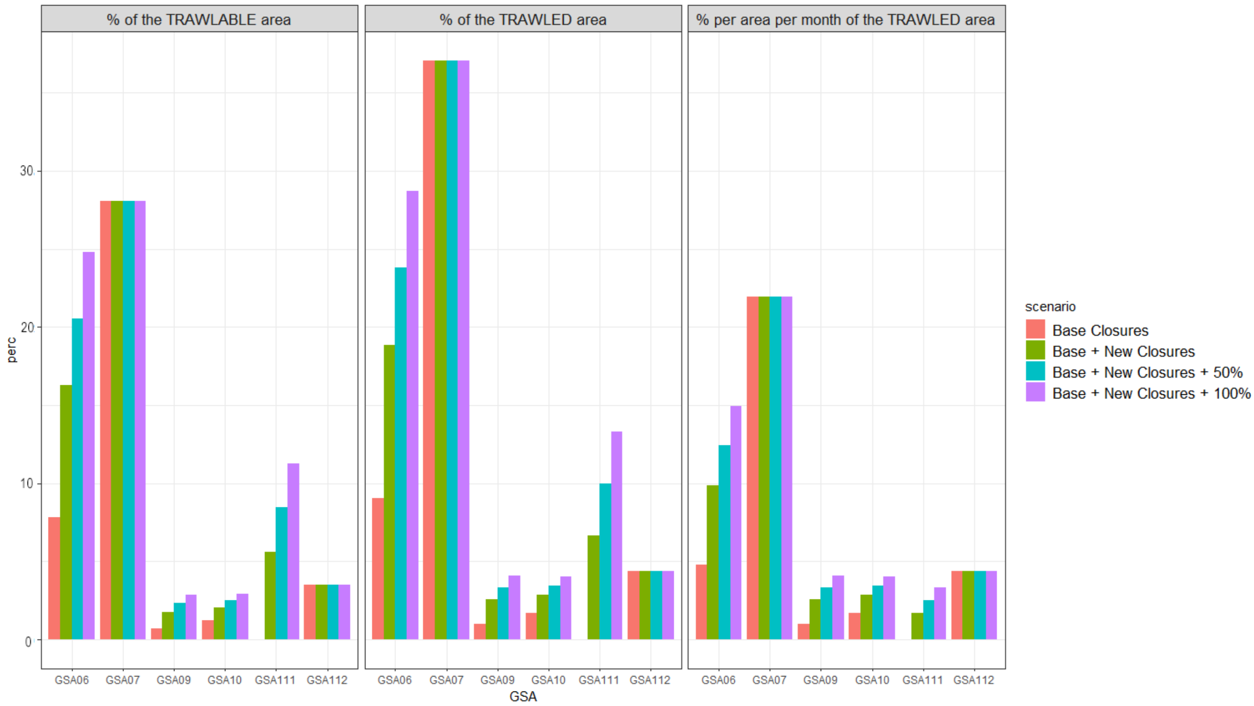


Figure 3.2.3.4 left- Percentage of the trawlable area (>50m/3nm and <1000m) covered by the closure; middle- Percentage of the trawled area covered by existing (Base Closures) and suggested new closures; right- Percentage of trawled area covered by the closure per area per month. 50% and 100% scenarios correspond to an expansion of the surface areas around the closure by 50 and 100%, which are not applied to GSA 7 and GSA 11.2. Besides, no new closures are proposed for GSA7 and GSA 11.2.

3.2.4 References

Alglave et al. 2022. Combining scientific survey and commercial catch data to map fish distribution. ICES Journal of Marine Science, 0, 1-17

Colloca F., M. T. Spedicato, E. Massutí, Garofalo G., G. Tserpes, P. Sartor, A. Mannini, , A. Ligas, G. Mastrantonio, B. Reale, C. Musumeci, I. Rossetti, M. Sartini, M. Sbrana, F. Grati, G. Scarcella, M. Iglesias, M. P. Tugores, F. Ordines, L. Gil de Sola, G. Lembo, I. Bitteto, M.T. Facchinii, A. Martiradonna, W. Zupa, R. Carlucci, M.C. Follesa, P. Carbonara, A. Mastradonio, Fiorentino F., Gristina M., Knittweis L., Mifsud R., Pace M.L., C. Piccinetti, C. Manfredi, G. Fabi, P. Polidori, L. Bolognini, R. De Marco, F. Domenichetti, R. Gramolini, V. Valavanis, E. Lefkaditou, K. Kapiris, A. Anastasopoulou and N.Nikolioudakis, (2013) Mapping of nursery and spawning grounds of demersal fish. Mediterranean Sensitive Habitats (MEDISEH) Final Report, DG MARE Specific Contract SI2.600741, Heraklion (Greece).

Colloca F, Garofalo G, Bitetto I, Facchini MT, Grati F, Martiradonna A, et al. (2015) The Seascape of Demersal Fish Nursery Areas in the North Mediterranean Sea, a First Step Towards the Implementation of Spatial Planning for Trawl Fisheries. PLoS ONE 10(3): e0119590. doi:10.1371/journal.pone.0119590

Fiorentino F, Garofalo G, De Santi A, Bono, Giusto GB, et al. Spatio-temporal distribution of recruits (0 group) of Merluccius merluccius and Phycis blennoides (Pisces, Gadiformes) in the Strait of Sicily (Central Mediterranean). Hydrobiologia. 2003; 503: 223–236.

Getis A, Ord JK. The analysis of spatial association by use of distance statistics. Geogr Anal. 1992; 24: 189–206.

Giannoulaki M., A. Belluscio, F. Colloca, S. Fraschetti, M. Scardi, C. Smith, P. Panayotidis, V. Valavanis M.T. Spedicato (2013). Mediterranean Sensitive Habitats, DG MARE Specific Contract SI2.600741, Final Report, 557 p.

MEDITS-Handbook. Version n. 9, 2017, MEDITS Working Group: 106 pp.

WP, 2019. Italian Work Plan for data collection in the fisheries and aquaculture sectors, 2020-2021, Version 1.0 – October 2019, Rome, 30 October 2019.

3.3 Progress of operational mixed fisheries models

3.3.1 ISIS-Fish in EMU 1 (GSA 7)

3.3.1.1 ISIS-Fish assumptions related to spatial features

ISIS-Fish allows explicitly accounting for the spatial and seasonal distribution of fish and fishers in the evaluation of impact of closures. Impact on biomass is highly dependent on assumptions made regarding fish movements. In this case, we considered two habitats for hake, Accores (slope) and Plateau (shelf) that differ both in terms of level of biomass and age composition of European hake population according to MEDITS survey data. Within each habitat, hake is assumed uniformly distributed and highly mobile. This results in the biomass are uniformly redistributed within the habitat at the beginning of each time step. If a closure partially protects an habitat, local improvement in fish biomass directly benefits to the full habitat at the next time step.

ISIS-Fish simulates effort reallocation outside the closed area under user-defined assumptions. Here reallocation is computed at fleet and métier level, and we assumed a reallocation of effort over the métier area still opened to fishing, which may locally increase pressure outside the area closed.

3.3.2 SMART in EMU 2

3.3.2.1 Background

Following the work done within the previous STECF-EWG - Evaluation of fishing effort regime in the Western Mediterranean, and in particular during EWG 19-01, the implementation of the SMART bioeconomic model for EMU2 was updated. During EWG 22-01, the spatial resolution was increased to be aligned with the spatial analyses performed in ad-hoc contracts about the spatial distribution of spawning and nursery areas. In addition, the input data for fishing effort were updated to consider the year 2020 and, in this way, to account for the effect of the COVID-19 pandemic. On another hand, both the economic parameters (fuel prices, price at the market of resources by species/ size class) and the data for the stocks were retrieved from EWG 19-01.

The rationale of the SMART model, as well as the workflow of the smartR package (D'Andrea et al., 2020), can be summarized in the following logical steps:

1. Use landings and catch data, combined with VMS data, to estimate the spatial/temporal productivity of each cell, in terms of aggregated LPUE by species;

2. Use catch data to estimate the Length-Frequency Distribution (LFD) and the Age- Frequency Distribution (AFD), by species, for each cell/time;

3. Use VMS data to assess the fishing effort by vessel/cell/time;

4. Combine LPUE, LFD/AFD and VMS data to model the landings by vessel/species/length class/time;

5. Estimate the cost by vessel/time associated to a given effort pattern and the related revenues, which are a function of the landings by vessel/species/length class/time (step 4);

6. Combine costs and revenues by vessel, at the yearly scale, to obtain the incomes, which are the proxy of the vessel performance. Incomes could be aggregated at the fleet level to estimate the overall performance;

7. Use estimated landings by species/age, together with survey data, to run MICE model for the selected case of study in order to obtain a biological evaluation of the fisheries.

Each of these steps corresponds to a different module of the package. Within SMART, the key aspect is represented by the optimization, at the scale of each vessel, of the fishing effort pattern at the monthly temporal scale. This is done through the iterative exploration of alternative vessel-specific effort patterns and evaluation of the corresponding catch converted in revenues and compared with the total costs to estimate the gains.

A detailed description of the method is available in Russo et al., 2019.

3.3.2.2 Application of the SMART model to the West Med MAP

The spatial productivity (monthly LPUE as grams of catch per meter of LOA and hour of fishing) was estimated using landings and VMS data, according to the procedure of Russo et al., 2018 and Russo et al., 2019. In the same time, the economic parameters needed to model the relationships between: 1) fishing effort and its related costs (crew salaries, fixed costs, etc.); 2) spatial fishing footprint and its related costs (i.e. fuel consumption); 3) yield and production costs (i.e. commercialization); 4) yield and revenues (using the prices at market of the different species by size class) were collected and integrated into the model. Values of prices at the market by species and length class, together with the price of fuel, were partially retrieved by Russo et al. (2014b) and integrated using the public databases provided by the "Istituto di servizi per il mercato agricolo alimentare" (ISMEA http://www.ismea.it/flex/FixedPages/IT/WizardPescaMercati.php/L/IT) and by the Ministry of Economic Development (https://dgsaie.mise.gov.it/prezzi_carburanti_mensili.php).

The model developed for the previous EWG has been updated in order to better represent the array of species exploited by trawlers in the EMU2. Namely, monthly LPUE were computed for the species in Table 3.3.2.2.1.

Table 3.3.2.2.1 Species considered within the model.

Species	Code
Aristeus antennatus	**ARA**
Aristaeomorpha foliacea	**ARS**
Sepia officinalis	**CTC**
Parapenaeus longirostris	**DPS**
Eledone cirrhosa	**EOI**
Eledone moschata	**EDT**
Merluccius merluccius	**HKE**
Mullus surmuletus	**MUR**
Mullus barbatus	**MUT**
Nephrops norvegicus	**NEP**
Octopus vulgaris	**OCC**
Illex coindetii	**SQM**

After the estimation of the monthly LPUE by species, and the "historical" behaviour of each vessel (proportion of its effort for each cell of the spatial grid), SMART allows to predict the vessel-specific adaptation to different management scenarios, including the establishment of spatial closures, using a Bayesian approach. In practice, while the effort in closed areas (cells of the grid) is forbidden, a new effort patter is identified through the optimization of the total monthly profits. Monthly profits are, in turn, determined by the combination of effort and LPUE (by species), which gives the revenues, minus the cell-specific costs, which are mainly represented by fuel consumption. This optimization procedure is applied several times (100 runs), in order to avoid local maxima. At the end of this procedure, the new effort pattern of the different vessels are aggregated to obtain the new exploitation pattern (monthly landings by species).

The mice model applied to predict the effect of this new exploitation pattern is represented in Fig. 3.3.2.2.1. It is important to notice that, while all the 12 species listed above were considered in the optimization phase, only the six stocks in the MAP were considered.

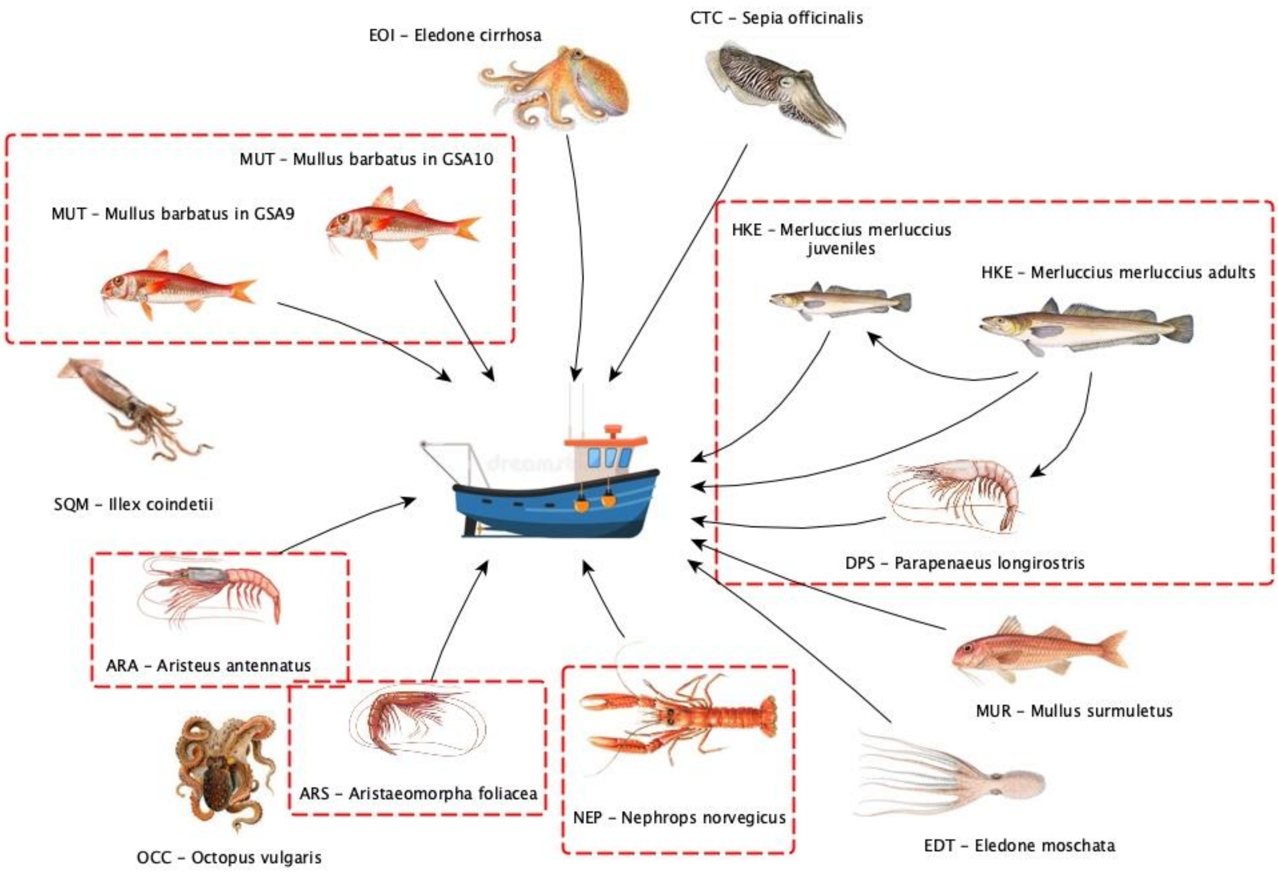


Figure 3.3.2.2.1 Representation of the trawl fishery model for EMU2. All species represented were considered in terms of contribution to the landings (and so the strategy adopted by fishers in selecting the fishing grounds), but the effects of the different scenarios were explored only for the ones within red-dashed boxes.

3.3.2.3 Space and time scale

For this application of SMART to the case study of Western Mediterranean Effort Management Unit 2, the resolution of the square grid for the GSAs 9, 10 and 11 was increased from the 30 x 30 nm of the EWG 19-01 to cells of 2 x 3 nm (Figure 3.3.2.3.1). The cells covering the area deeper than 800m depth were excluded to reduce complexity and computational time required for the simulations.

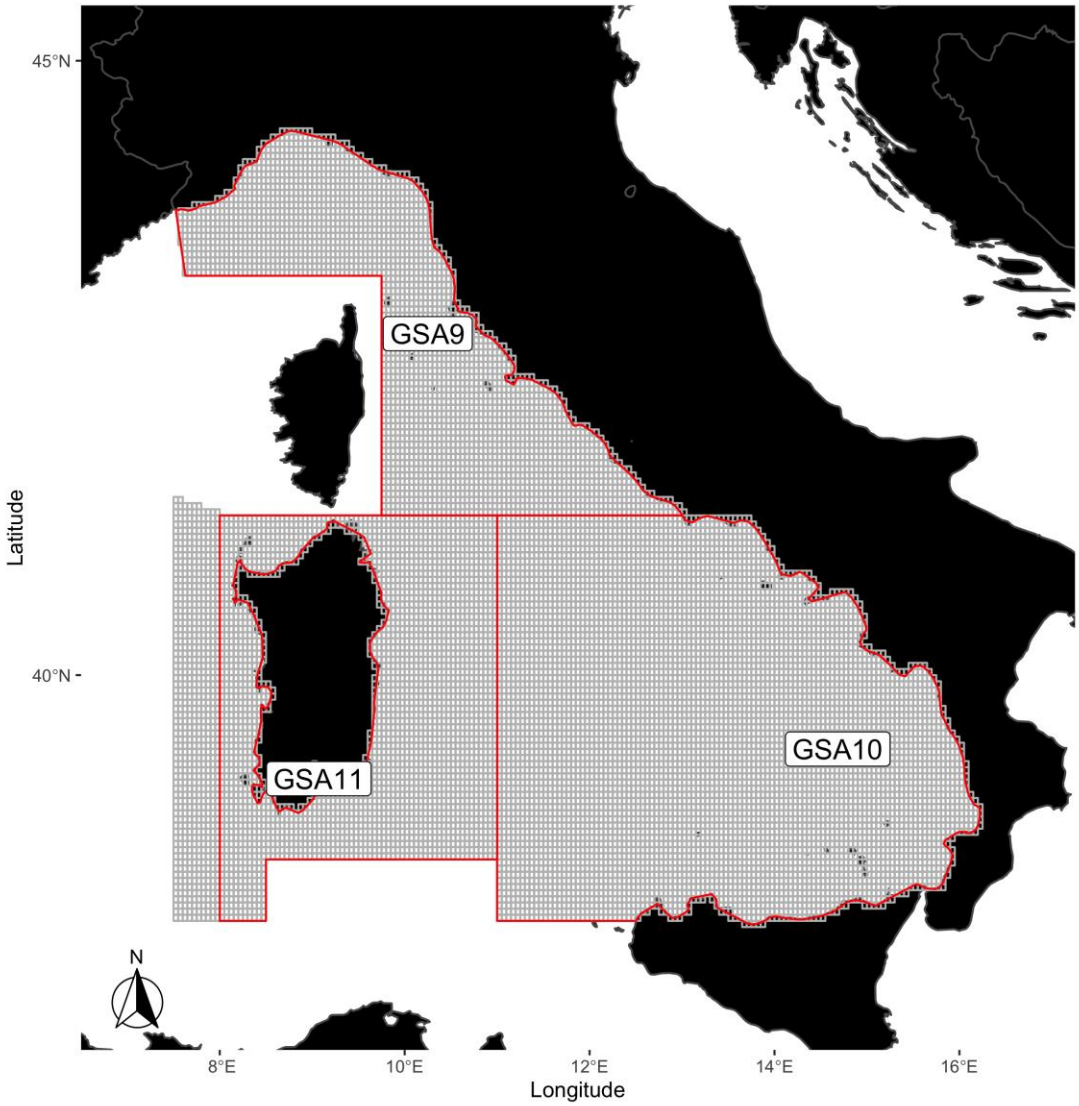


Figure 3.3.2.3.1 Map of the EMU2 representing the grid and the three GSAs considered.

Compared to the previous EWG, also the temporal ranges were extended. The considered time series starts in 2012 and ends in 2020. Accordingly, 108 months' temporal series of LPUE and AFD (proportion of age classes/length by species) were estimated for the cells of the grid. These represent the basis for the simulation of different effort scenarios, including the *Status quo*.

3.3.2.4 Simulated Scenarios

The SMART model is devised to estimate the potential effect of whatever management actions on the effort (including reduction of fishing capacity, effort, or spatial closures) instead of directly setting a desired value of F for the target stocks and evaluate the related effects of this new exploitation pattern. Thus, the SMART model was used to assess the potential effect of the scenarios listed in Table 3.3.2.4.1.

Table 3.3.2.4.1 Scenarios ran to test closure areas in EMU 2.

Scenario	Characteristics	Time
Status quo		
Base Closures	Already existing closure areas	Full year
Base + New Closures	Already existing closure areas + New closures defined following the Ad-hoc contracts ran prior to EWG 22-01 according to the distribution of hotspots of juveniles and spawners of hake and potentially of the five main target species of the MAP	Full year
Base + New Closures +50% Q1	Already existing closure areas + New closures (see definition above) increased by 50% in terms of area	Full year (Base) + First quarter of the year (New Closures)
Base + New Closures +100% Q1	Already existing closure areas + New closures (see definition above) increased by 100% in terms of area	Full year (Base) + First quarter of the year (New Closures)
Base + New Closures +50% Permanent	Already existing closure areas + New closures (see definition above) increased by 50% in terms of area	Full year
Base + New Closures +100% Permanent	Already existing closure areas + New closures (see definition above) increased by 100% in terms of area	Full year

For each scenario, 100 simulation runs were carried out and, for each scenario, the potential effects for the stocks in the MAP were assessed in terms of SSB value and Fishing mortality (F). In the same time, the economic effects for the fleet were estimated in terms of total yearly landings by species, total yearly revenues, costs, and profits. It is worth noticing that, for these economic indicators, the estimated effects were related only to the entry-into-force of the scenarios.

3.3.3 References

Russo, T., Morello, E. B., Parisi, A., Scarcella, G., Angelini, S., Labanchi, L., et al. (2018). A model combining landings and VMS data to estimate landings by fishing ground and harbor. Fish. Res. 199, 218–230. doi: 10.1016/j.fishres.2017. 11.002

Russo T et al (2019). Simulating the Effects of Alternative Management Measures of Trawl Fisheries in the Central Mediterranean Sea: Application of a Multi-Species Bio-economic Modeling Approach. Front. Mar. Sci. 6:542. doi: 10.3389/fmars.2019.00542

D'Andrea et al (2020). smartR: An r package for spatial modelling of fisheries and scenario simulation of management strategies. Methods Ecol Evol. 2020;00:1–10

3.4 Management scenarios and results

3.4.1 ISIS-fish in EMU 1 (GSA 7)

3.4.1.1 Management scenarios considered

Management scenarios are based on those listed in ToR2 a-b-c of EWG22-01 (Table 3.4.1.1.1).

Table 3.4.1.1.1 Scenarios ran for HKE in GSA 7.

	Scenario	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	… 2030
		0	1	2	3	4	5	6	7	8	9	10	15
		Calibration			Hindcast					Projection			
Effort	a	2015	2016	2017	Mean 2015-2017					Mean 2015-2017			
Effort red. trawlers (rel.2015-17)							-10%	-7.5% (-17.5%)	(-17.5%)				
Closures							Existing ones						
Recruitment		2015	2016	2017	2018	2019	2020	Mean 2018-2020		Mean 2018-2020			
Closures	b = a + >2022 closures all year						Existing ones			Permanent			
Closures	c = a + >2022 closures all gear						Existing ones			All gear			

All three scenarios provide a decrease of catch of the younger age classes (0-2). Catches of these age classes are lower than the 2015-2017 by respectively 22%, 27,% and 7%. On the other hand the catch of older age classes increase. This is due to the rapid rebuilding of the population and the re-apparition of these older age classes almost absent in 2015-2017. Scenario b (permanent closures) gave significantly higher catch of age 4 and 5 than the two others scenarios. The fishing mortalities at age (Fig.3.4.1.1.1) testimony of the release of fishing pressure on every stages particularly in scenario b.

The effect on fleets was contrasted between trawlers whose revenues stabilised at values lower than the average 2015-2017 (-5% to -9%) and the other fleets who benefited from the release pressure and improved their revenues, particularly Spanish longliners who doubled their historical revenues (Fig. 3.4.1.1.2). These results are of course dependent on the assumptions made on fish distribution and reallocation of effort. It must be stressed that the gross revenues presented here only account for hake landings. It is expected that the current shortcomings in the modelling of closures lead to an underestimation of the positive effect of closures on hake population and possibly of the losses for the fleets.

Interestingly although the closures cover both hake habitats the benefit on biomass mainly showed for the plateau contingent (Fig. 3.4.1.1.3)

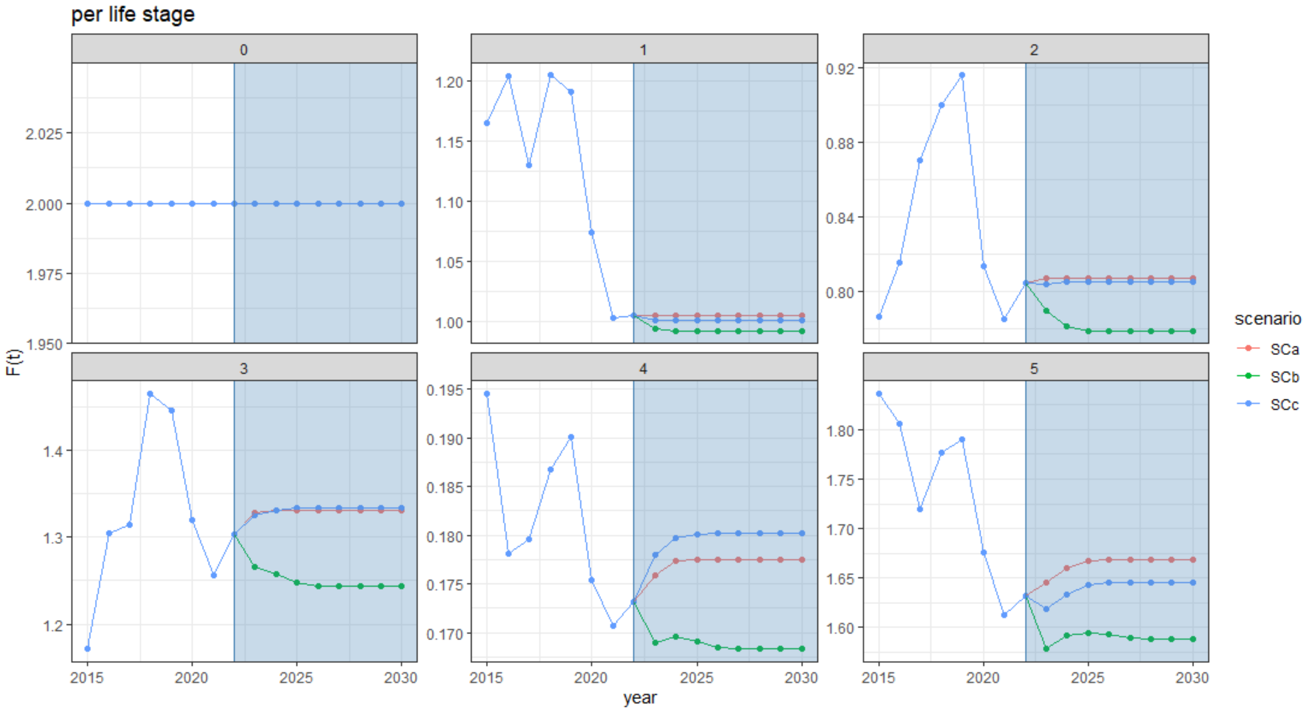


Figure 3.4.1.1.1 Predicted fishing mortality under the three scenarios of closures.

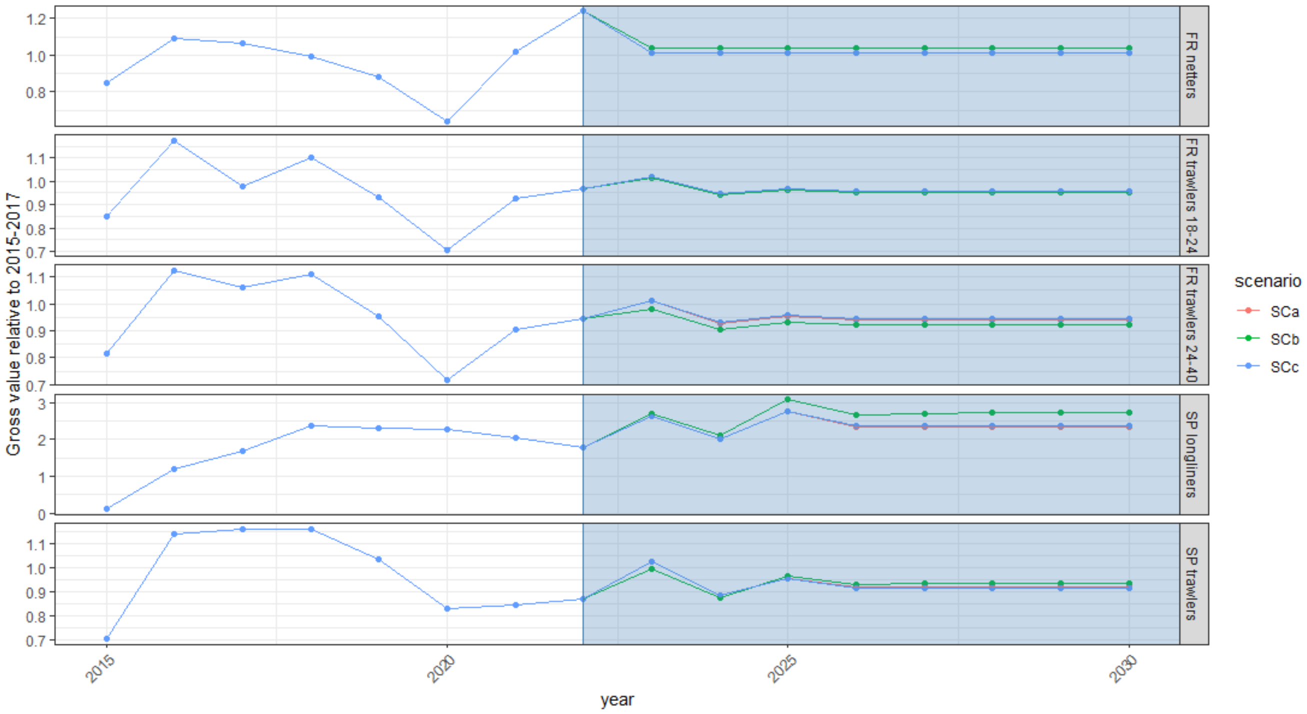


Figure 3.4.1.1.2 Predicted gross revenues on hake (GSA7) per fleet relative to the average 2015-2017 under the three scenarios of closures.

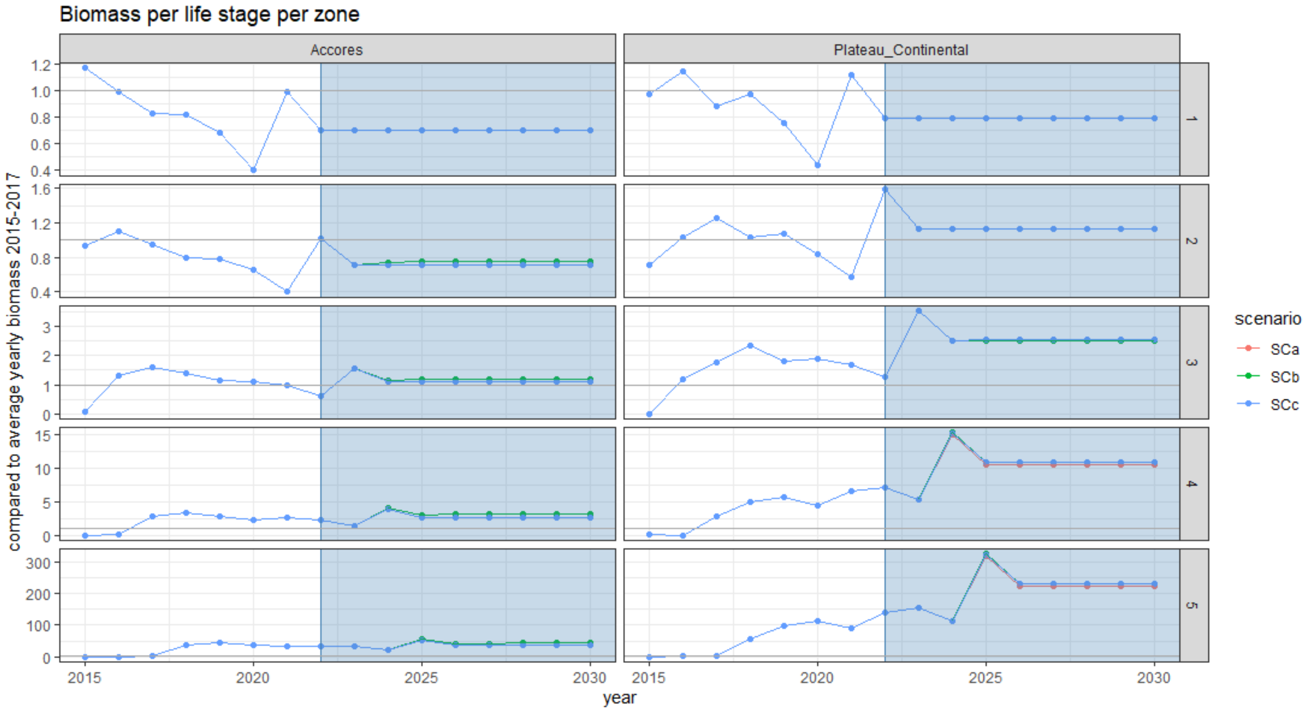


Figure 3.4.1.1.3 Biomass of Hake (GSA7) predicted per age class (lines) and zones (columns) under the three closure scenarios. Values are relative to the average 2015-2017. The grey line represent the historical value (reference period), the average 2015—2017.

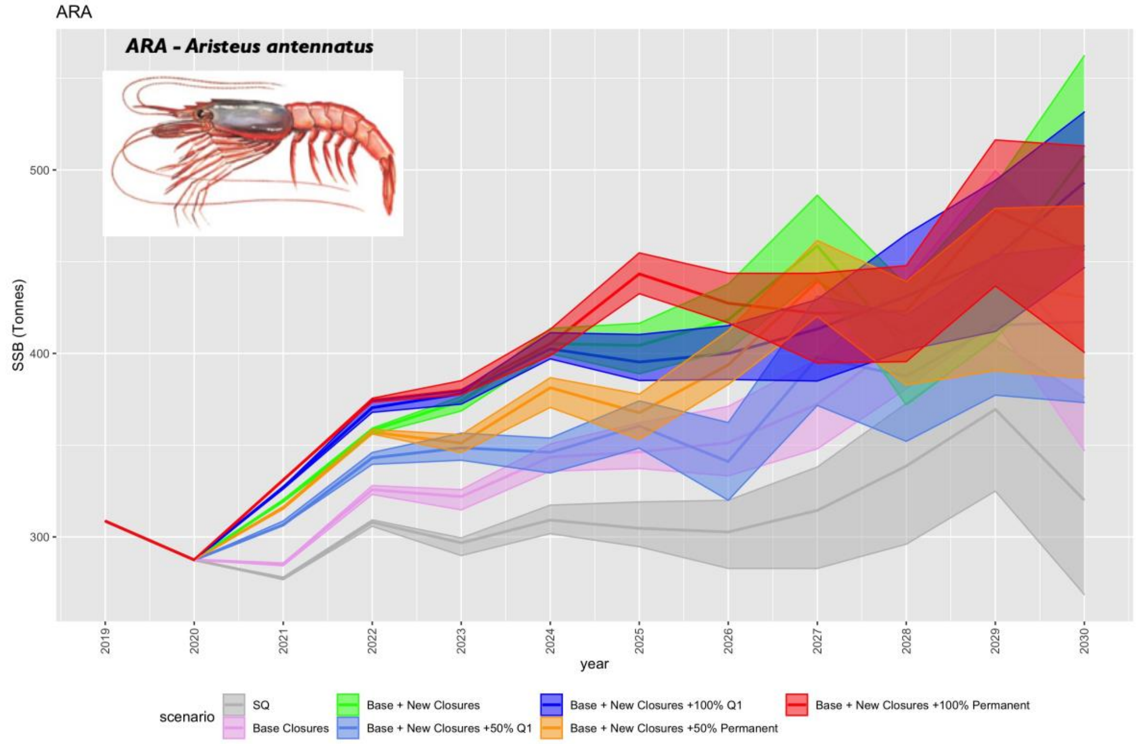
3.4.2 SMART in EMU 2

3.4.2.1 Effects on the stocks: Spawning Stock Biomass (SSB) and Fishing mortality (F)

The effects of the new fishing effort pattern (as predicted by SMART after the estimation of the effort displacement) on the exploited stocks are summarized in Figures 3.4.2.1.1-7. In the case of ARA (fig. 3.4.2.1.1), it seems that most of the scenarios are expected to determine a recovery of SSB, and in particular the most “aggressive” in terms of spatial extent of area closed to trawl fishing (i.e. Base + New Closures +100% Permanent, Base + New Closures +50% Q1). However, none of these scenarios lead to a sustainable value of F. The situation is quite similar in the case of ARS (Figs. 3.4.2.1.2), but with an important difference: in this case several scenarios seem capable of allowing the achievement of Fmsy in a period of about 8 years.

In the case of DPS (fig. 3.4.2.1.3), no marked effect associated with the different scenarios explored is recognizable. This could be due to the fact that all spatial scenarios were designed to protect other stocks (e.g. HKE, ARA, ARS) and, therefore, the redistribution of fishing effort could penalize the DPS that would become relatively more exploited. In the case of HKE (fig. 3.4.2.1.4), the results indicate that all scenarios could bring great benefits to the stock in terms of SSB, which could more than double in about 10 years, but only the most aggressive scenario (Base + New Closures +100% Permanent) would achieve the value of Fmsy.

ARA - Aristeus antennatus in GSA 9, 10, and 11



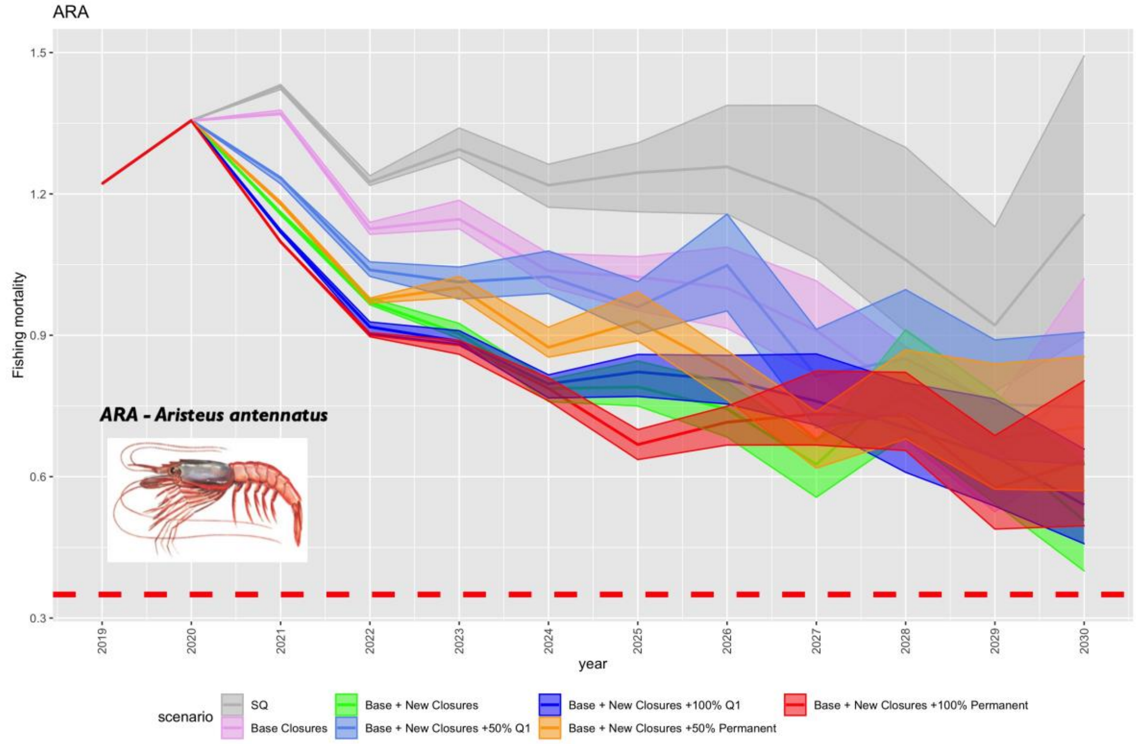
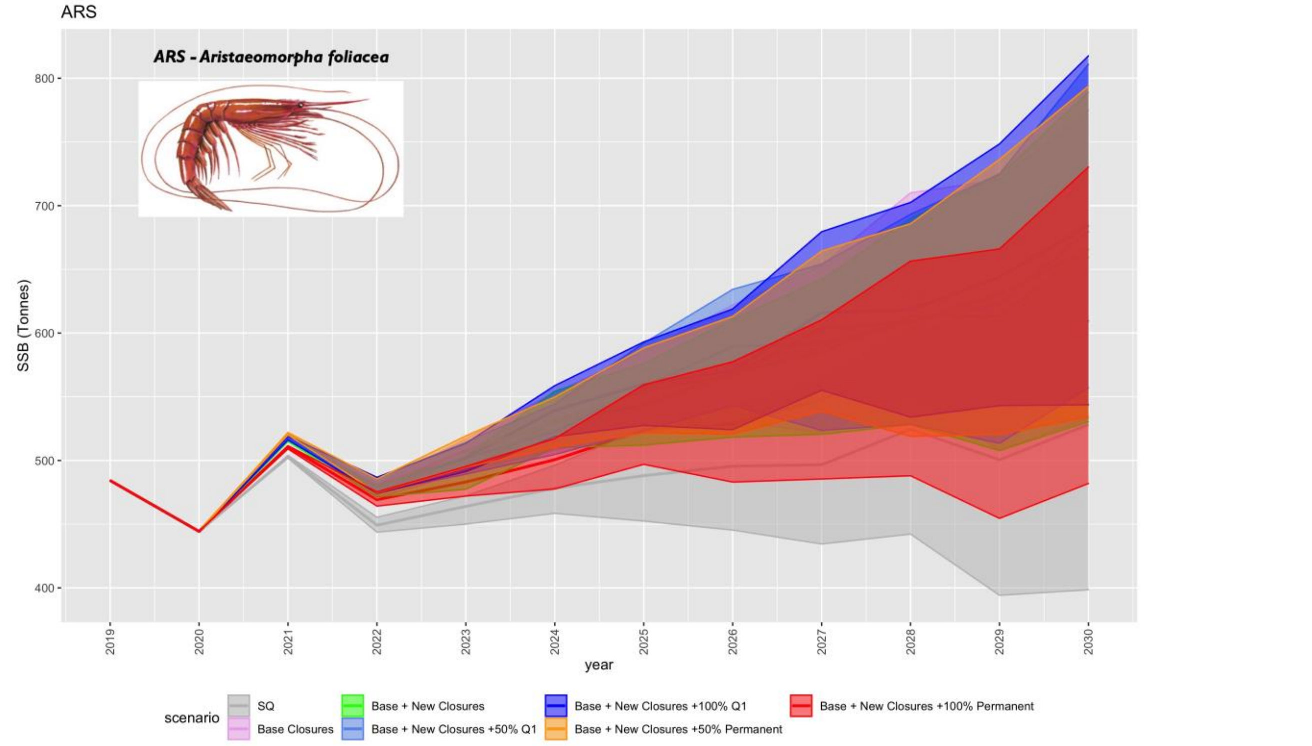


Figure 3.4.2.1.1 Predicted trends of SSB and F for each scenario. The semi-transparent area around each mean line is referred to the variability of predictions over 100 simulation runs. The red dashed line in the plot of Fishing mortality corresponds to F_{MSY}

ARS - Aristaeomorpha foliacea in GSA9, 10, and 11



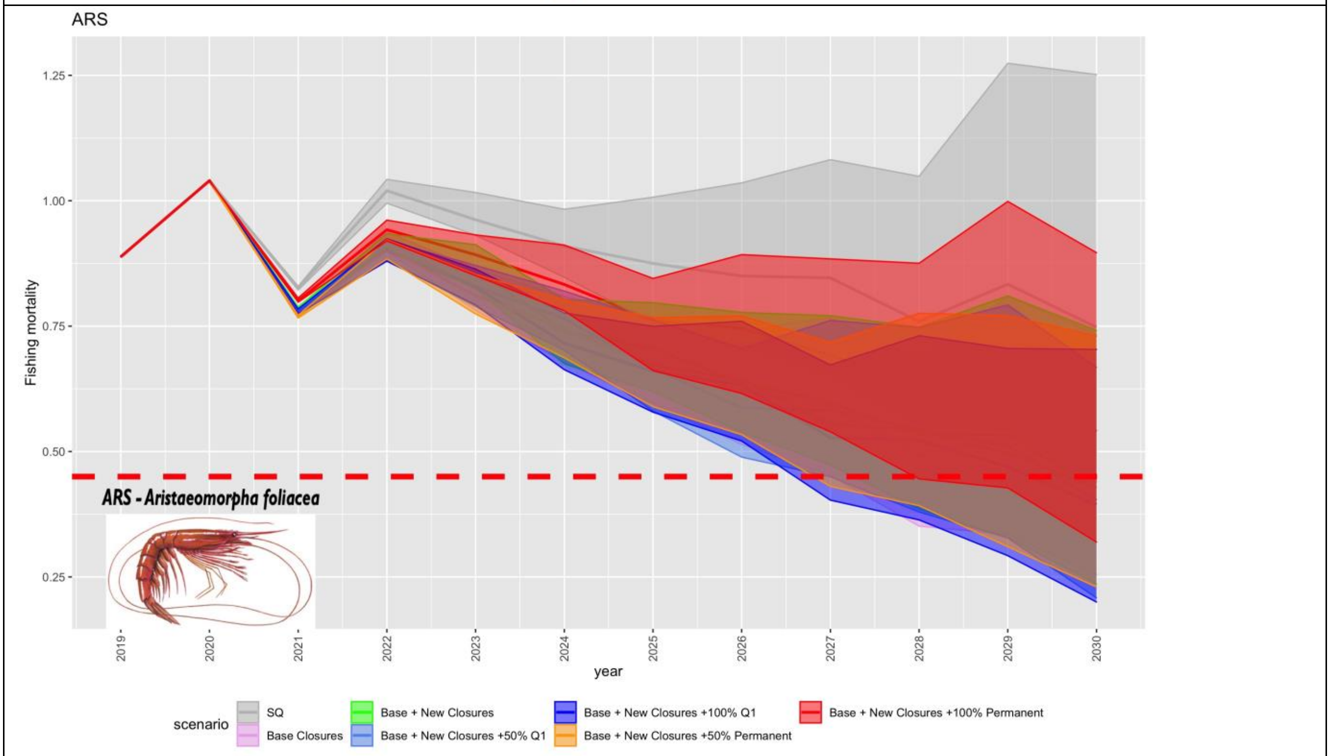
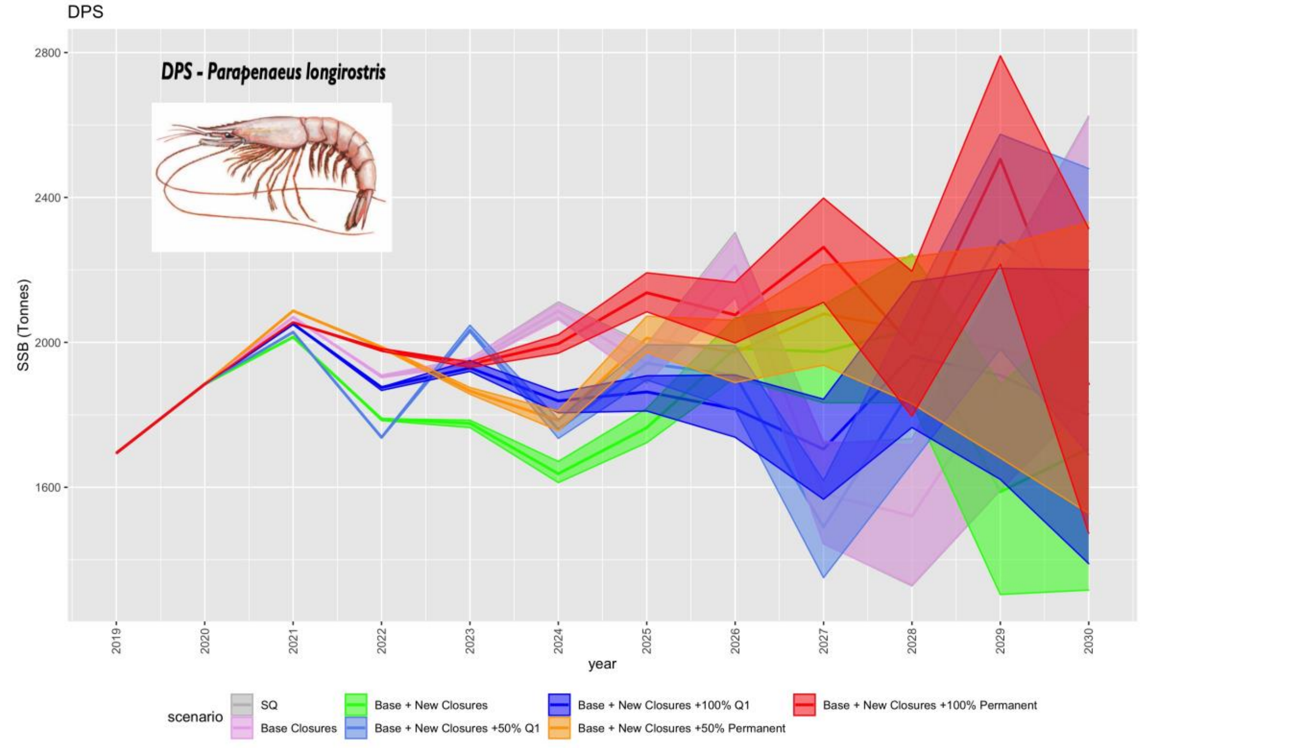


Figure 3.4.2.1.2 Predicted trends of SSB and F for each scenario. The semi-transparent area around each mean line is referred to the variability of predictions over 100 simulation runs. The red dashed line in the plot of Fishing mortality corresponds to F_{MSY}

DPS – Parapenaeus longirostris in GSA9, 10, and 11



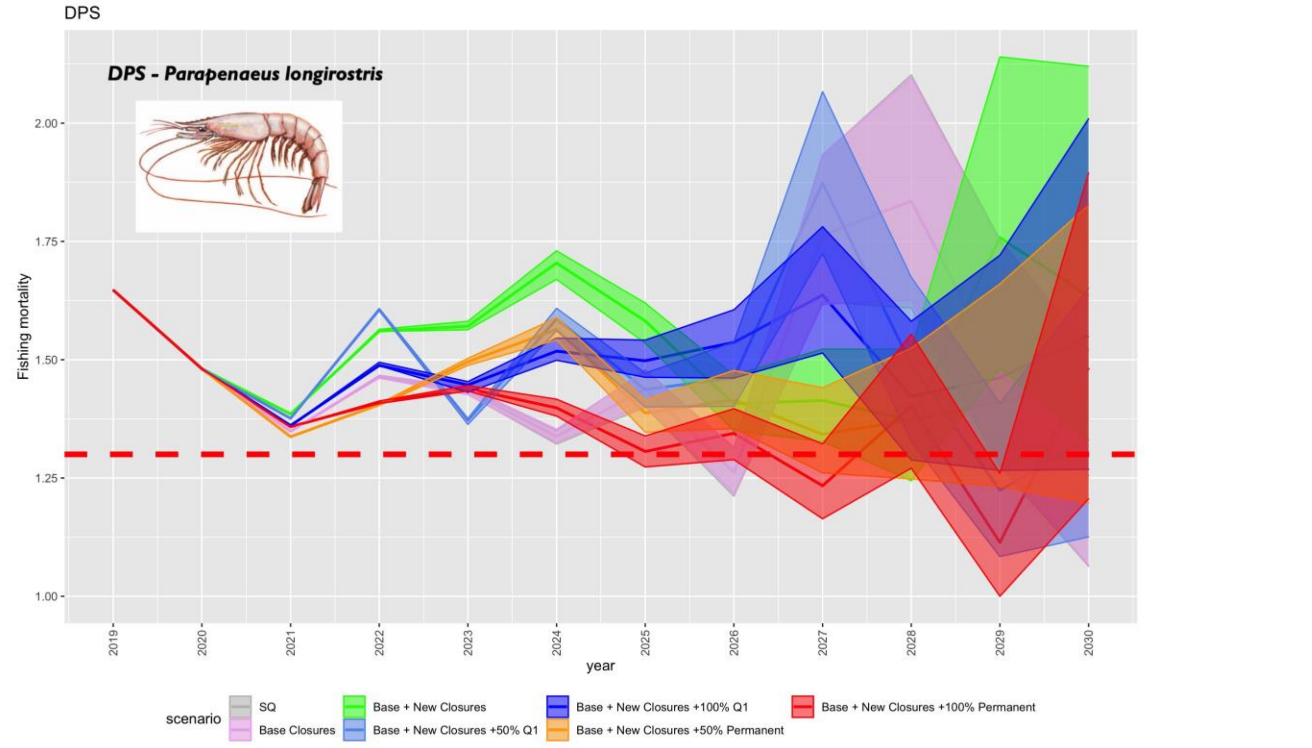
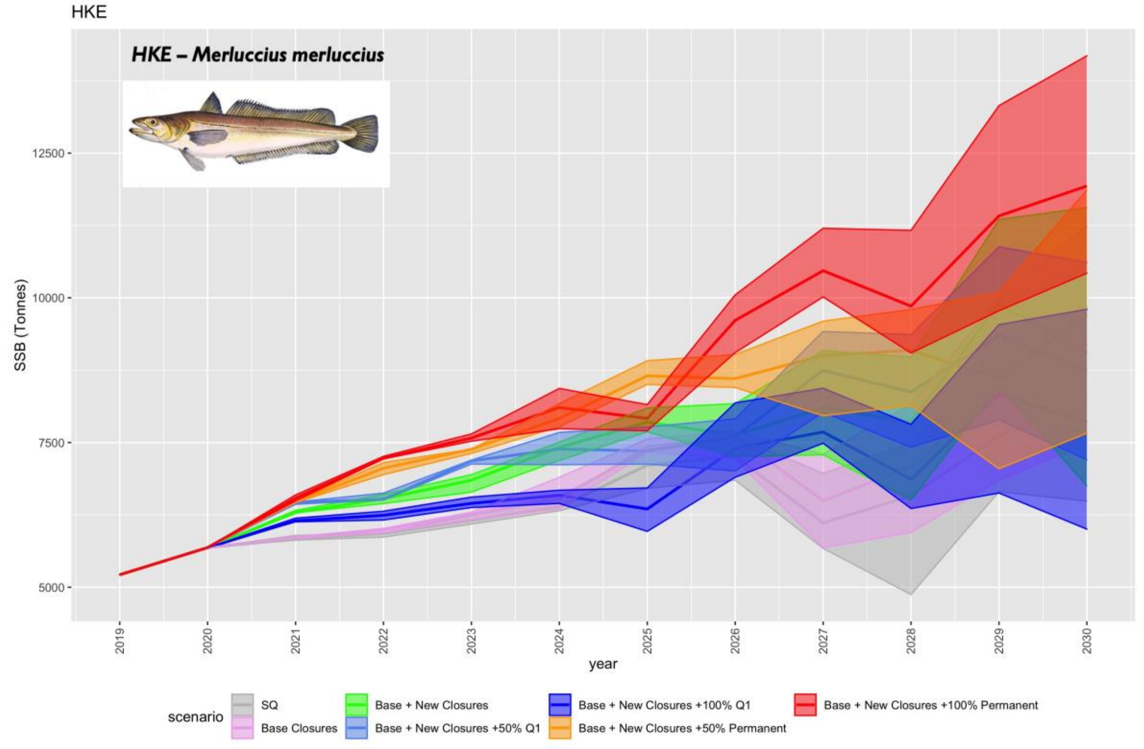


Figure 3.4.2.1.3 – Predicted trends of SSB and F for each scenario. The semi-transparent area around each mean line is referred to the variability of predictions over 100 simulation runs. The red dashed line in the plot of Fishing mortality corresponds to F_{MSY}

HKE – Merluccius merluccius in GSA9, 10, and 11



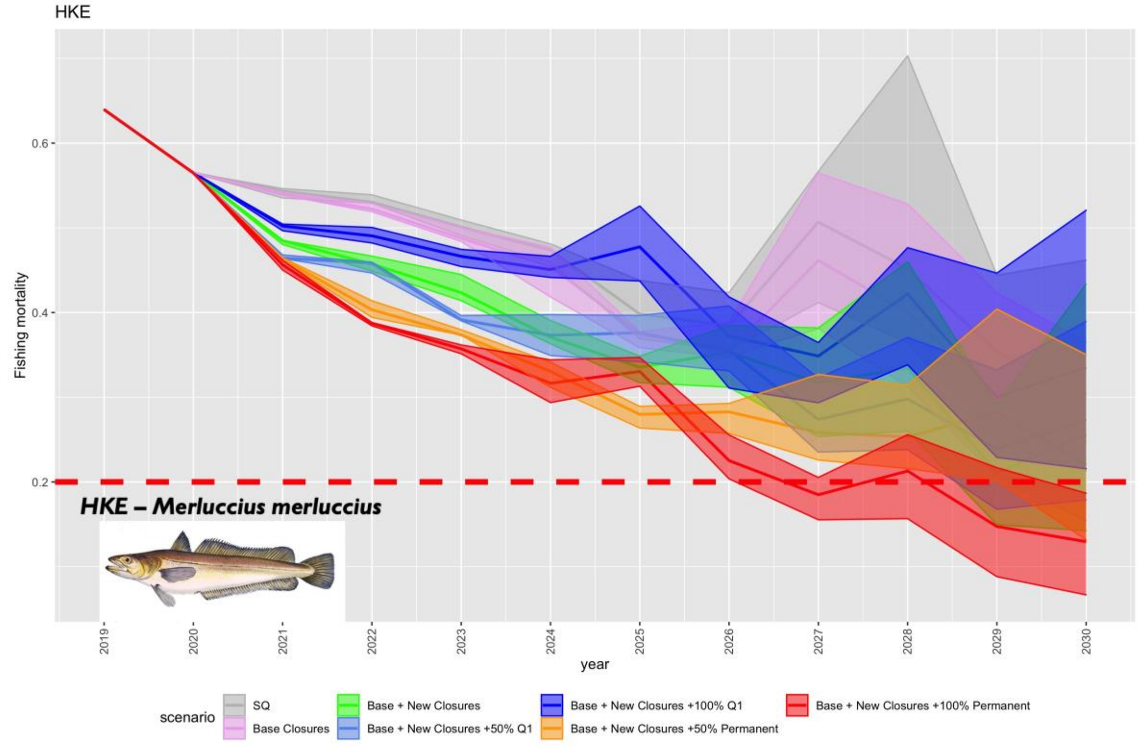
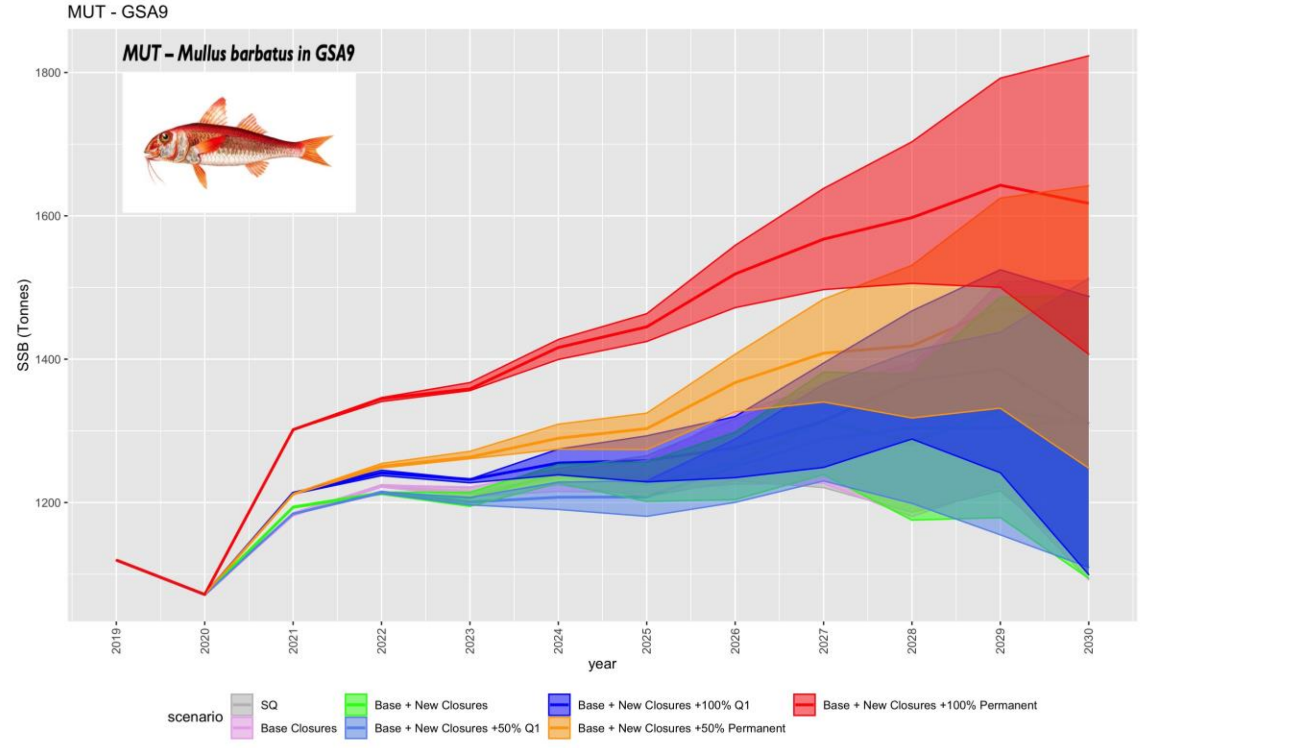


Figure 3.4.2.1.4 Predicted trends of SSB and F for each scenario. The semi-transparent area around each mean line is referred to the variability of predictions over 100 simulation runs. The red dashed line in the plot of Fishing mortality corresponds to F_{MSY}.

The differences between the explored scenarios are more evident in the case of MUT in GSA9. Here, permanent extended closures (Base + New Closures +50% Permanent and Base + New Closures +100% Permanent) do support an increase of the SSB, whereas the values of F remain far from F_{MSY}.

MUT – Mullus barbatus in GSA9



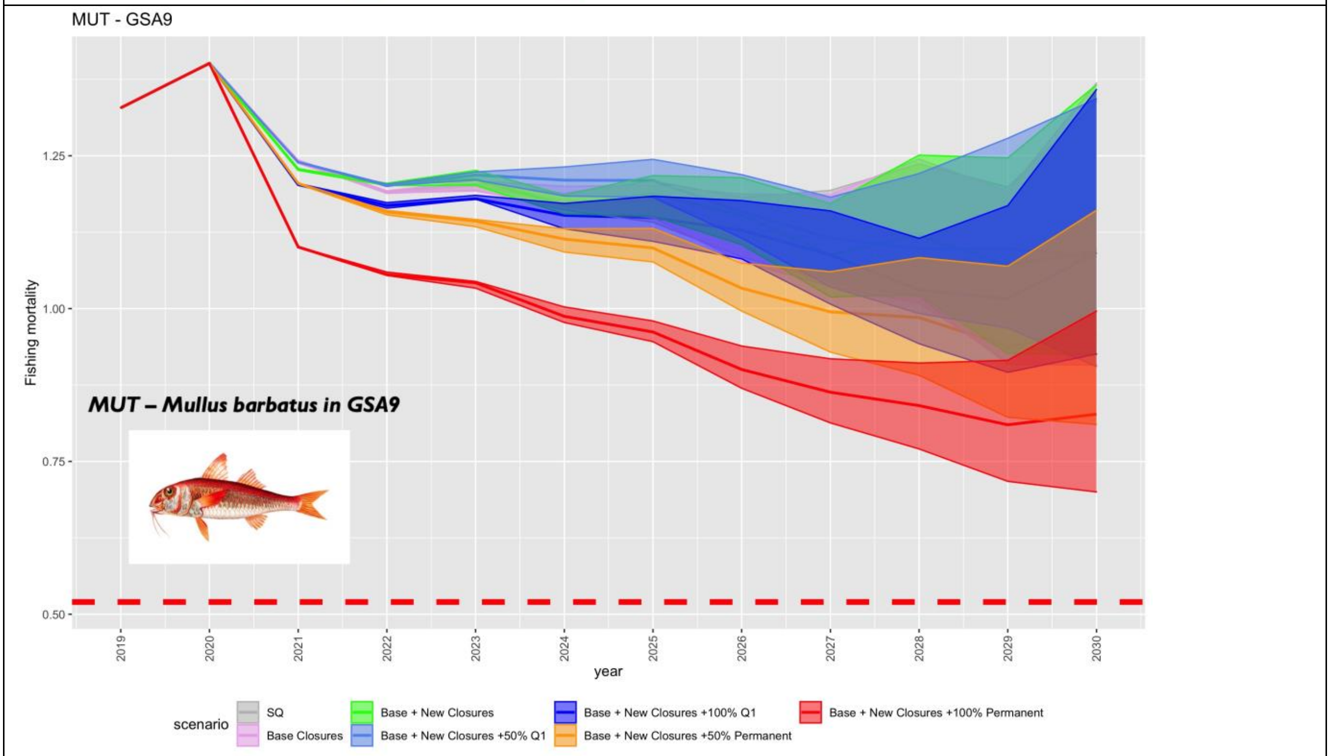
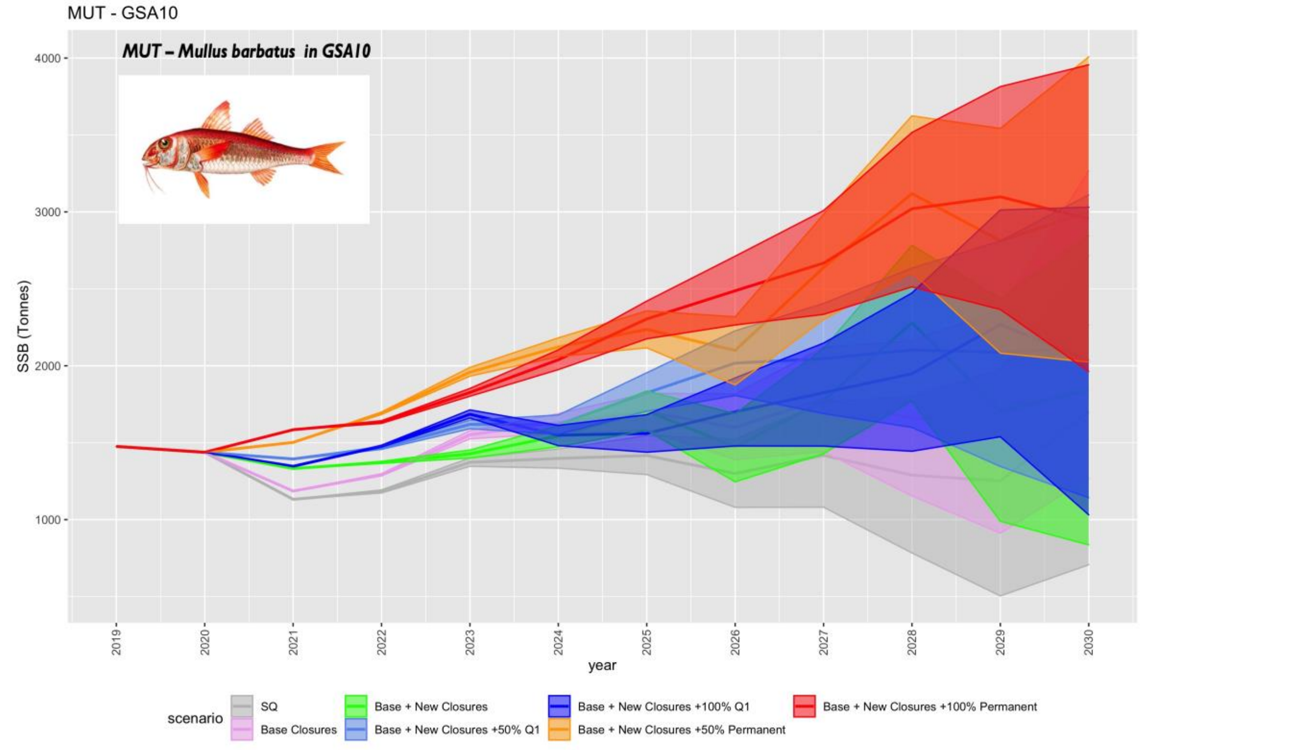


Figure 3.4.2.1.5 Predicted trends of SSB and F for each scenario. The semi-transparent area around each mean line is referred to the variability of predictions over 100 simulation runs. The red dashed line in the plot of Fishing mortality corresponds to F_{MSY}

MUT – Mullus barbatus in GSA10



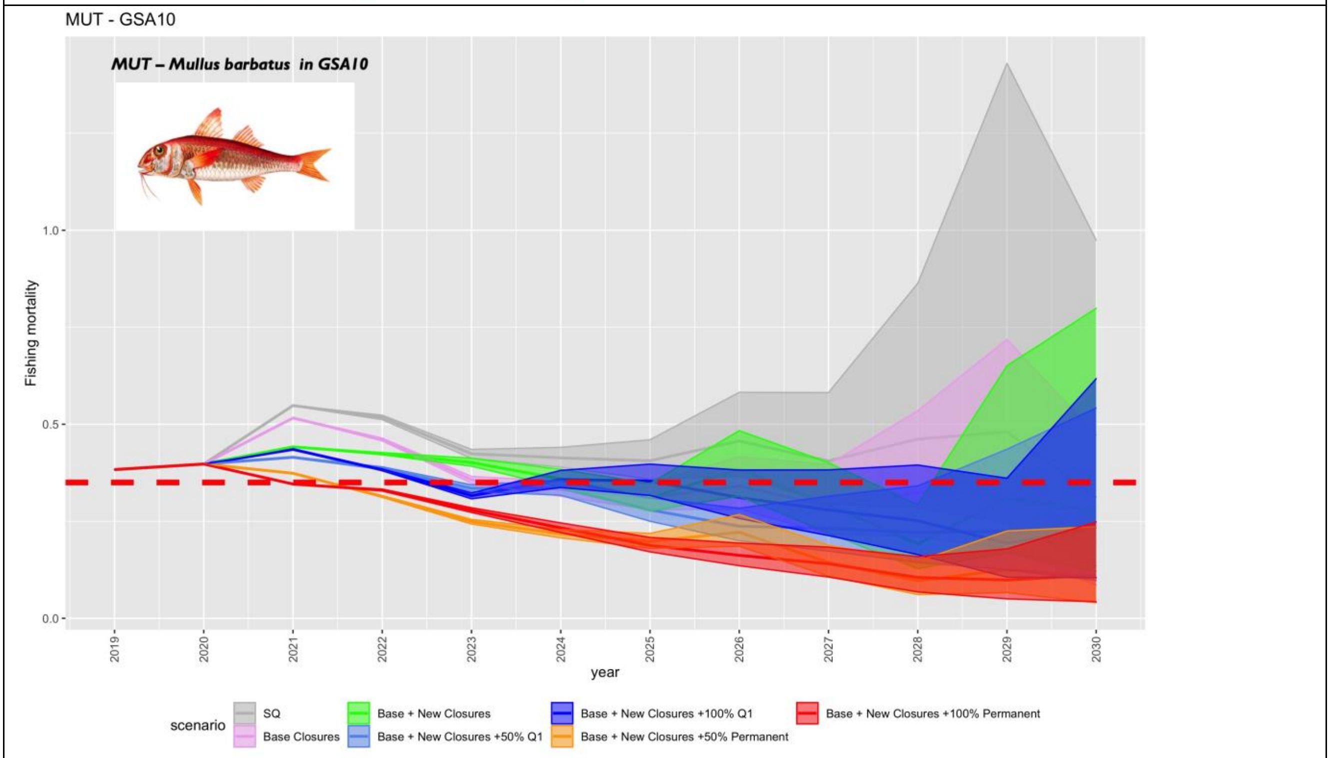
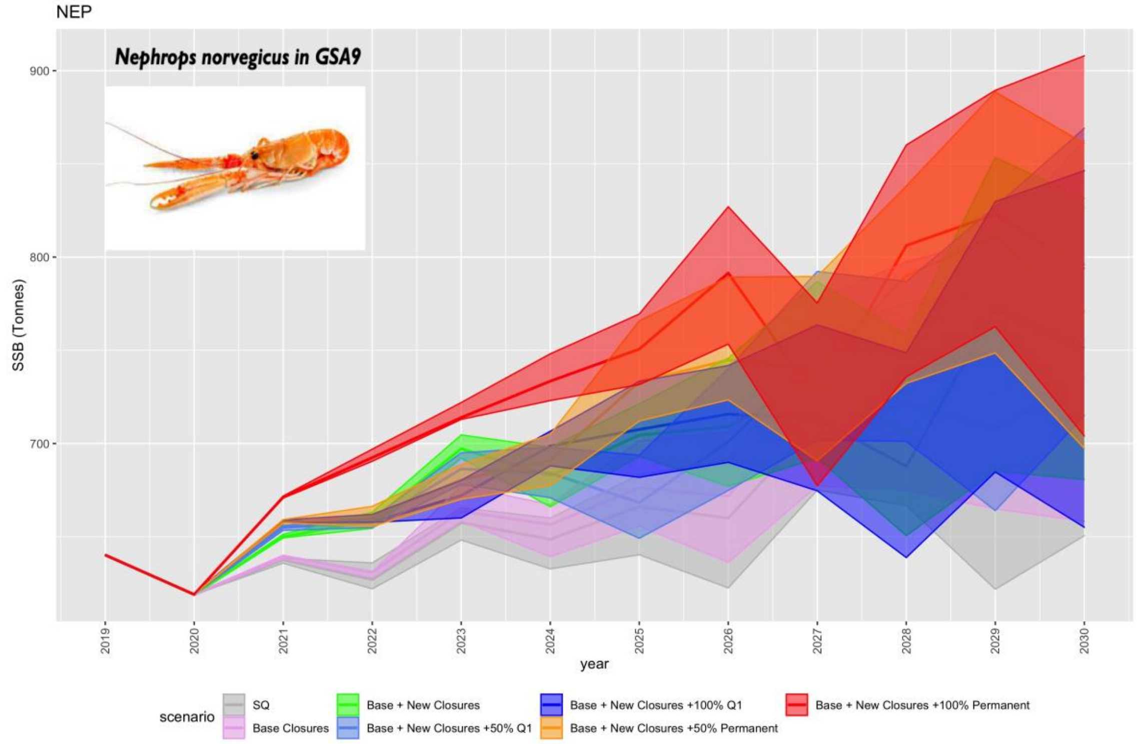


Figure 3.4.2.1.6 Predicted trends of SSB and F for each scenario. The semi-transparent area around each mean line is referred to the variability of predictions over 100 simulation runs. The red dashed line in the plot of Fishing mortality corresponds to F_{MSY}

The expected trends for MUT in GSA10 indicate a substantial stability of this stock, with a relative improvement associated to the scenarios based on the largest spatial closures.

NEP – *Nephrops norvegicus in GSA10*



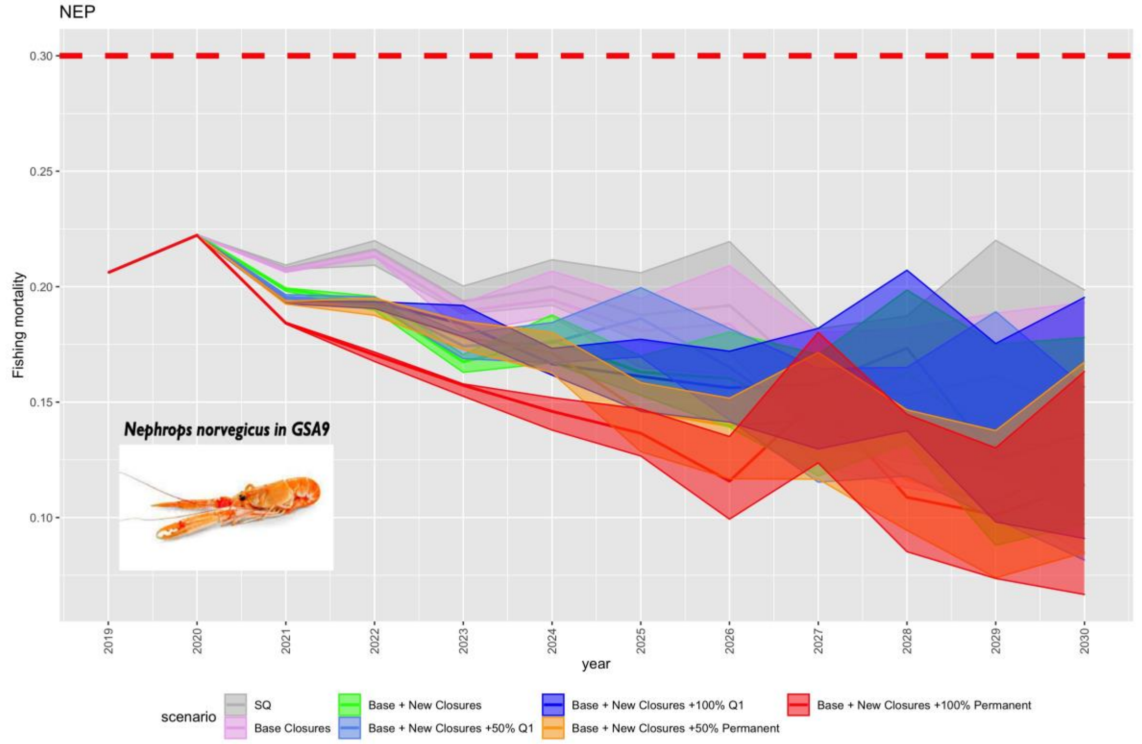


Figure 3.4.2.1.7 Predicted trends of SSB and F for each scenario. The semi-transparent area around each mean line is referred to the variability of predictions over 100 simulation runs. The red dashed line in the plot of Fishing mortality corresponds to F_{MSY}

Small but appreciable improvements in both SSB and F are also noted in the case of NEP.

3.4.2.2 Effects on Fleets

The analysis of the effects of the various scenarios on the activity of the fleets shows that, in all the cases, decreases of the landings are expected. These decreases are much more marked in the case of the space closures and for HKE, as expected as both the new areas and the already existing ones have been identified with the aim of reducing the capture of HKE juveniles. It is important to note that, in the case of Base + New Closures +100% Permanent, you get almost a 20% reduction.

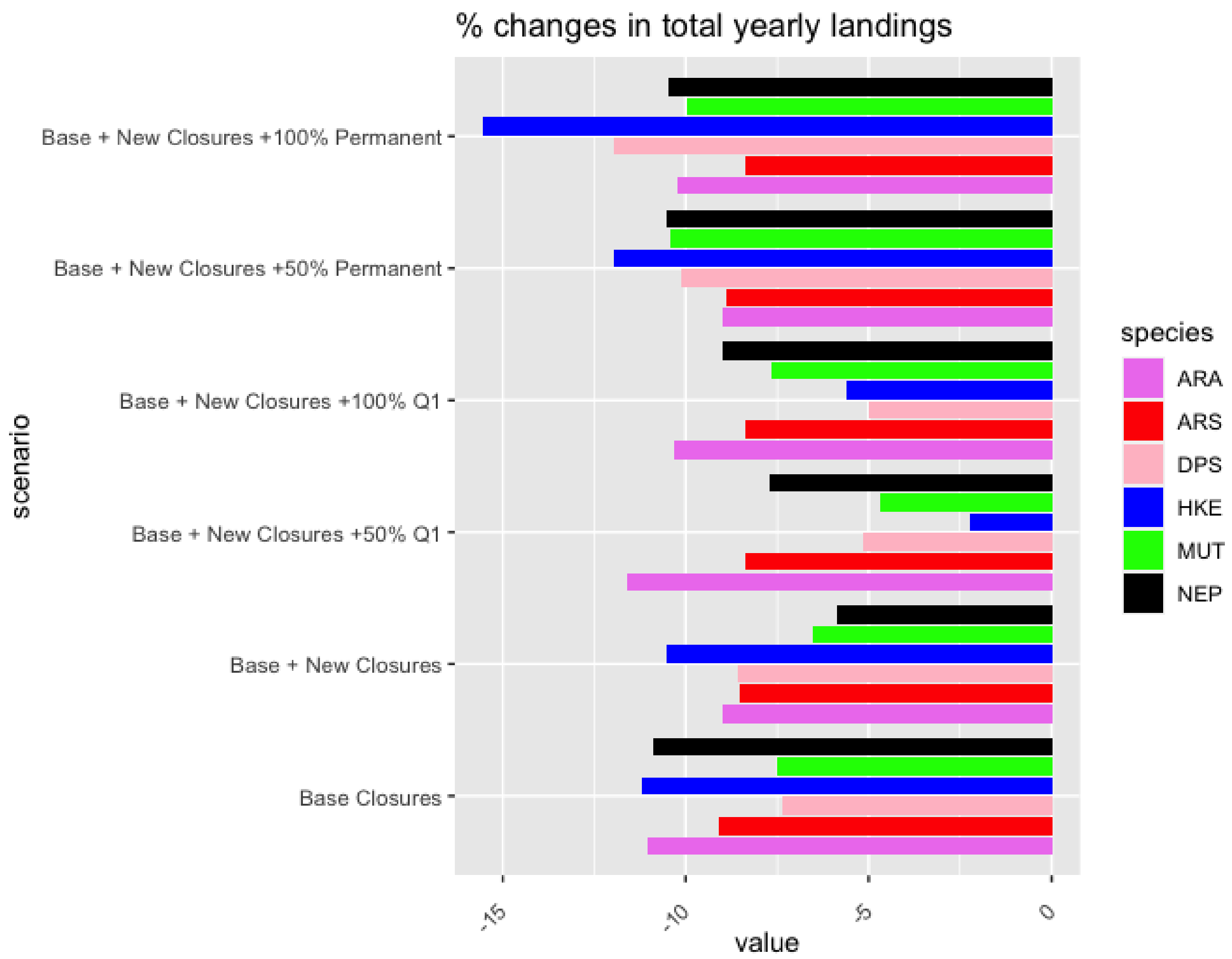


Figure 3.4.2.2.1 Predicted changes (% with respect to the status quo) in the total annual landings by species, according to the different scenarios.

However, the effect on the captured fleet from the economic indicators is very heterogeneous. This is clear at a high level of aggregation (Fig. 2.3.4.2.2), showing how all scenarios are associated with a sharp decrease in revenues but, in some cases, this reduction is offset by a concomitant reduction in costs while (Base + New Closures +50% Q1 and Base + New Closures +100% Q1), in the other cases, the negative effect of the reduction in revenues increased by the concomitant increase in costs.

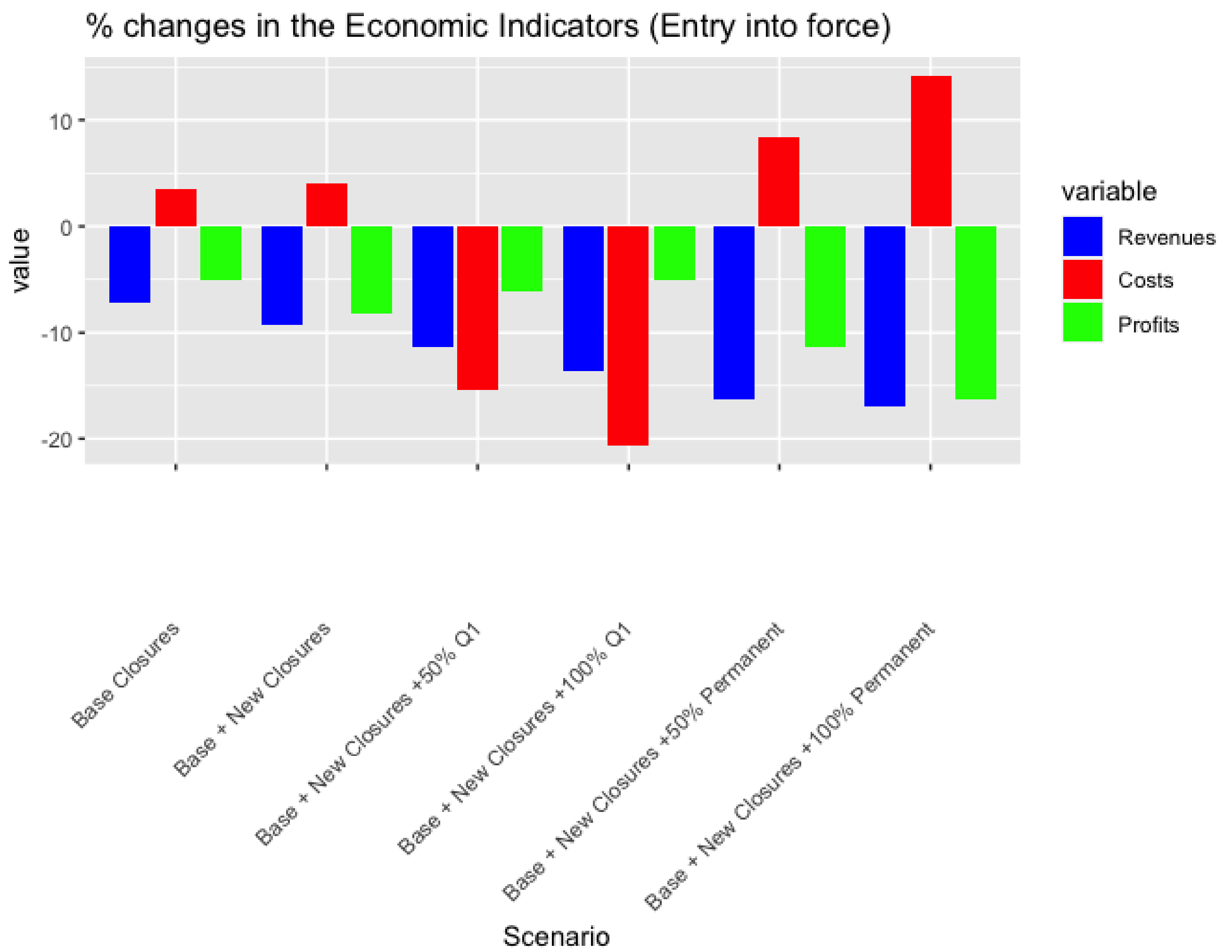


Figure 3.4.2.2.2 Predicted changes (% with respect to the status quo) in the total annual revenues, costs and profits, according to the different scenarios.

In this way, the spatial closures not widened or seasonal would involve lower decrease of the profits than widened and permanent closures that, at the entry-into-force, would have a very strong impact on the fleet in terms of reduction of the profits (up to 15% of profits lost). When these economic effects are inspected for each fleet segment (Fig. 2.3.4.2.3), the results indicate that the loss of profits is more evident for small vessels (VL12-18 and VL18-24) when large permanent closures are enstablished.

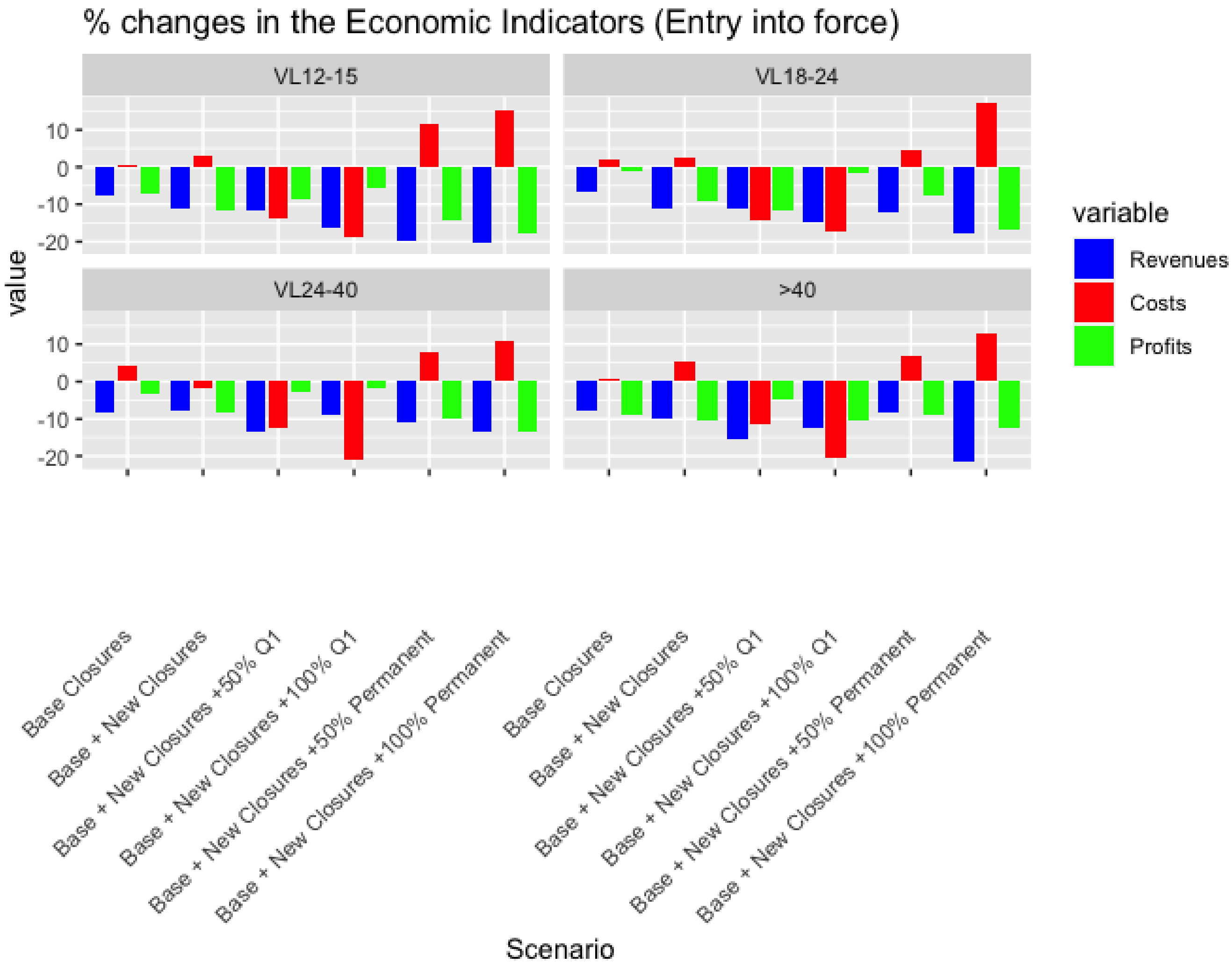


Figure 3.4.2.2.3 Predicted changes (% with respect to the status quo) in the total annual revenues, costs and profits, according to the different scenarios, for each fleet segment.

4 REMAINING ISSUES AND FUTURE DEVELOPMENTS

4.1 Future development of operational mixed fisheries models

4.1.1 IAM in EMU 1

4.1.1.1 Proposed changes in IAM for next group

In EMU1, the implementation of the IAM model for GSAs 1-5-6-7 carried out during the STECF meeting is still in development. Additional socio-economic indicators such as employment, gross profit and gross profit margin can be made available for the next meeting, provided that the relationship between Full-Time Equivalents (FTE) and fishing effort is discussed before the meeting, and that the calculation of salary/crew costs is discussed prior the next meeting. If additional indicators are requested, they should be provided before the meeting, and sufficiently in advance to adapt the model.

For the MCL implementation scenarios, it would be preferable for the fishing effort per fleet segment to be adjusted to reach Fmsy, rather than a MCL value given as input to the IAM model. This issue could be explored in future groups.

Scenarios involving changes in the number of vessels, rather than just changes in fishing effort, could be explored if included in the TORs.

An adjustment of the fleet segmentation would allow the economic impacts of the alternative scenarios to be simulated on other fleet segments than trawlers; see the next section for more details on a proposed adaptation of the fleet segmentation.

4.1.1.2 Fleet segmentation in IAM

The fishing fleets of the current IAM model is constituted of 10 categories, 4 for the French fleet and 6 for the Spanish fleet. For the French fleet, IAM distinguishes between trawlers 18-24m, trawlers 24-40m, and other vessels <12m and >12m. For the Spanish fleet, distinction is being made between trawlers of 4 size class (<12m, 12-18m, 18-24m and 2-40m), and two other fleets: netters and vessels using hooks. These distinctions are being made on the basis of the "fishing technique" and "vessel size" fields of the FDI and AER data tables, which are common to both tables and allows the correspondence between economic and landings information across fleet segments and serves as input for the IAM model.

During EWG 22-01 and using 2018-2020 data available within FDI data table A, for GSAs 1, 5, 6 and 7, we performed an analysis of the gear and landings distribution within the current IAM fleet categories. On the basis of Figure 2.2.1.4.1, it appears that a most consistent fleet definition for the Spanish and French non trawler fleets might be needed. The major caveat in the current definition is that the French "other" fleets are exclusively defined based on vessel size, regardless of other criterions, while the Spanish "other" fleets are only defined through the prism of the fishing technique, without consideration of vessel size. This leads to inconsistencies in the representation in the model of French and Spanish "other" fleets, especially for small-scale fishery. It also leads to the inclusion of French fleet segments that are irrelevant to the plan (such as PS, PGP, FPO), and to the exclusion of Spanish fleet segments that might be relevant (such as PMP).

Therefore, we propose to redefine for the next groups the categorisation for the "other" fleets, with 4 categories replicated for Spain and France: vessels using hooks above and below 12m, and netters above and below 12m. In this segmentation, vessels using hooks are assimilated to longliners and netters to gillnetters by discriminating between two of the dominant gears - since all vessels are operating a number of different gears through the year.

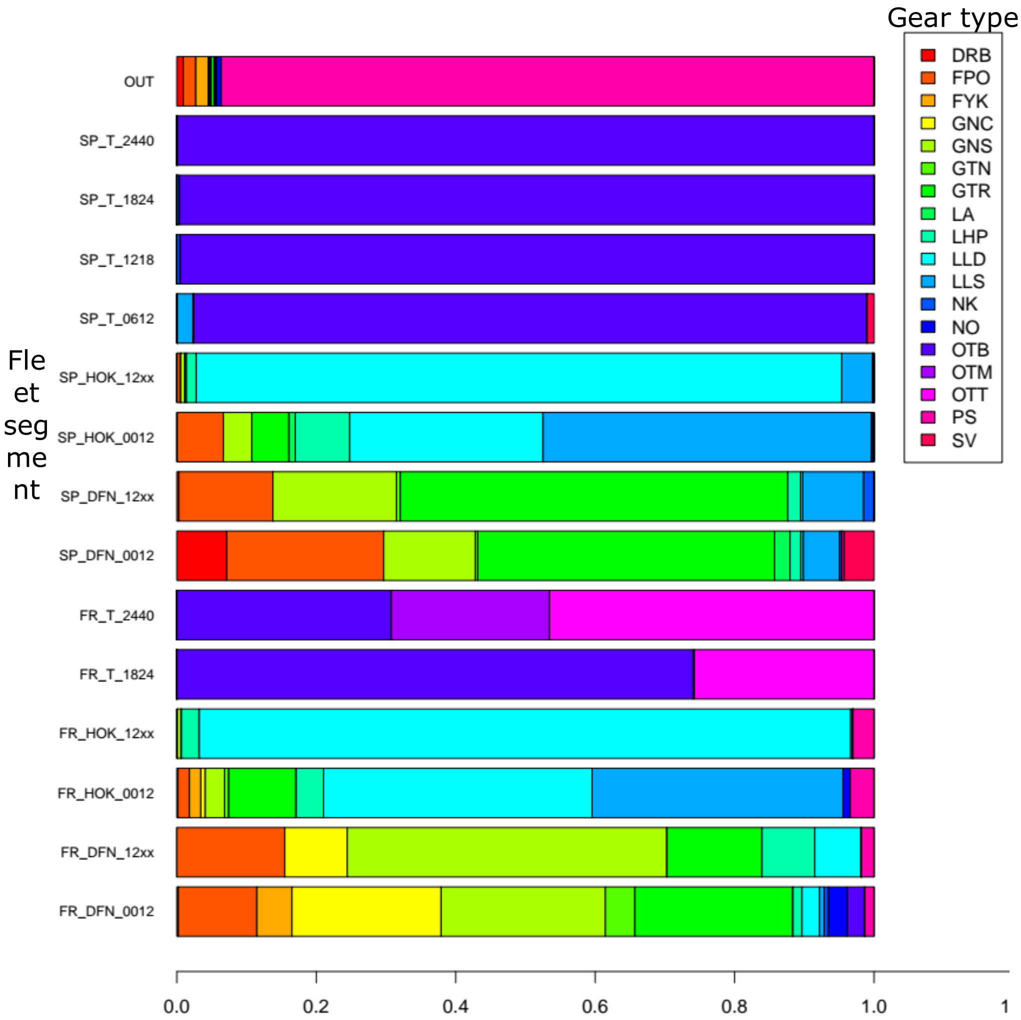


Figure 4.1.1.2.1. Proportion of gear usage (computed in terms of % of landings issued from each gear) among revised IAM fleet segments (in row). The "OUT" segment cumulates all fleet segments left out. T is short for DTS and stands for demersal trawlers and/or demersal seiners, DFN for drift and/or fixed netters, and HOK for vessels using hooks. The vessel length class 12xx means all vessels superior to 12 meters. For the gear types (colour legend), DRB stands for boat dredge, FPO for pots and traps, FYK for fyke nets, GNC for Encircling gillnets, GNS for Set gillnet, GTN for Combined gillnets-trammel nets, GTR for Trammel net, LA for Lampara nets, LHP for Hand and Pole lines, LLD for Drifting longlines, LLS for Set longlines, OTB for Bottom otter trawl, OTM for Midwater otter trawl, OTT for Multi-rig otter trawl, PS for Purse seine, SV for Beach and boat seine, and NK and NO for unknown gear. Roughly, red to orange colors corresponds to dredges and traps (DRB – FPO – FYK), yellow to green corresponds to various gillnets (GNC – GNS - GTN – GTR), green to lightblue corresponds to longlines (LA -LHP – LLD – LLS), darkblue corresponds to unknown gears (NK – NO), purple corresponds to trawls (OTB – OTM – OTT), and purple to red corresponds to seines (PS – SV).

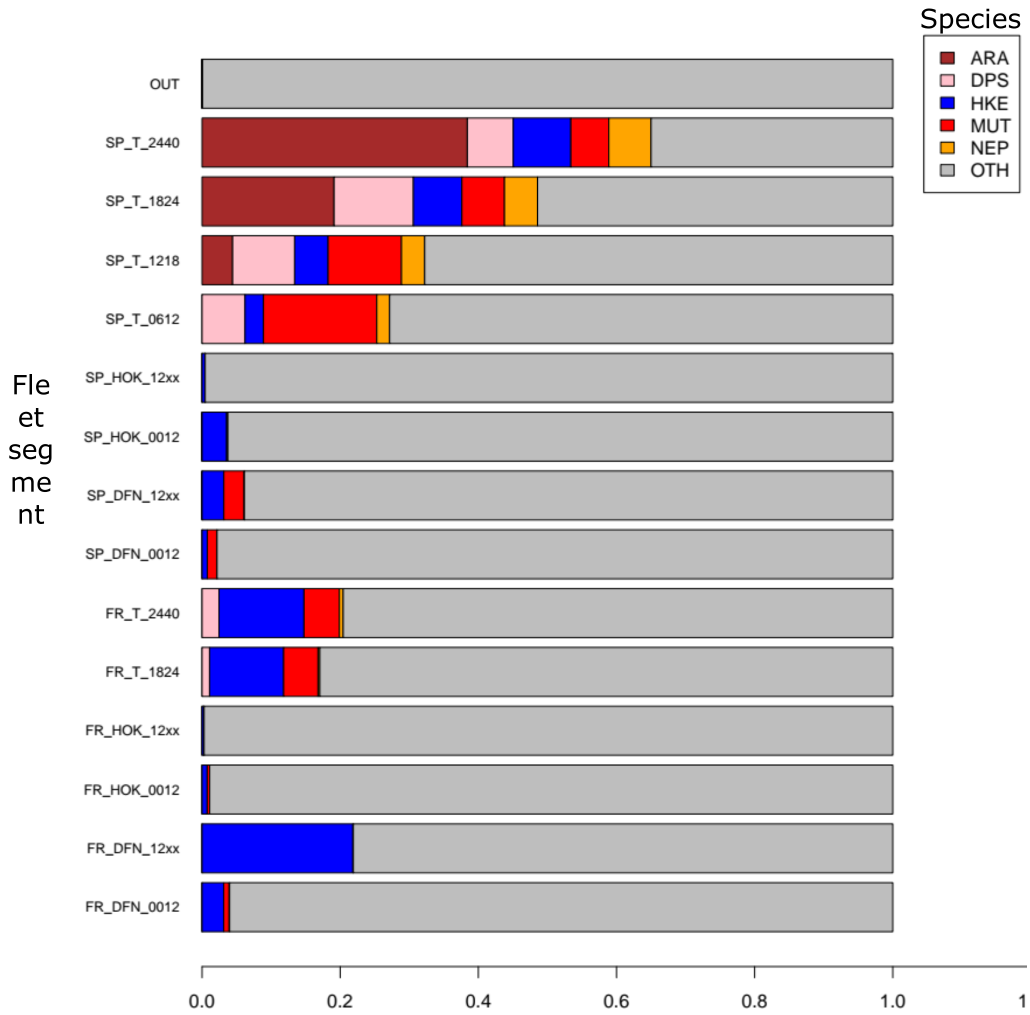


Figure 4.1.1.2.2. Proportion of species of the plan landed (in weight) by revised IAM fleet segments (in row). The "OUT" segment cumulates all fleet segments left out. T is short for DTS and stands for demersal trawlers and/or demersal seiners, DFN for drift and/or fixed netters, and HOK for vessels using hooks. The vessel length class 12xx means all vessels superior to 12 meters. Coloured space represents species targeted by the westmed management plan (ARA: Aristeus antennatus, DPS: Parapeneus longirostris, HKE: Merluccis merluccius, MUT: Mullus barbatus, NEP: Nephrops norvegicus), and grey areas (OTH) represents all other species cumulated.

The proposed revision of the IAM fleet segments reveals a much better harmonization between French and Spanish "other" fleets (Figure 4.1.1.2.1) while leaving out fleet segments that do not contribute to the mortality of nor economically depends on the species of the plan (Figure 4.1.1.2.2, "OUT" section). Also, upon observation, it appears that both French and Spanish longliners >12m (i.e. HOK in the figures) only present a very tiny fraction of the plan species in their landings. This corresponds to the present (2018-2020) situation, in which the hake stock has collapsed. However in the past (2000-2010), it is known that these longliners used to land significant proportions of large hake individuals. Therefore, we believe that these fleet segments should still be explicitly modelled within IAM, in order to be able to account for their potential impact on the hake stock, should it recover.

Figure 4.1.1.2.3 represents the mapping between detailed fleet categories and the current IAM fleet segments, and Figure 4.1.1.2.4 the mapping between detailed fleet segments and the proposed new IAM fleet segmentation. The detailed fleet segments have been reconstructed from the FDI data, by concatenating "country", "fishing technique", "vessel size", and "target assemblage" fields of the FDI table A. Note that for "target assemblage", we only distinguished between deep-water species ("DWS") and the rest (noted "OTH" for others).

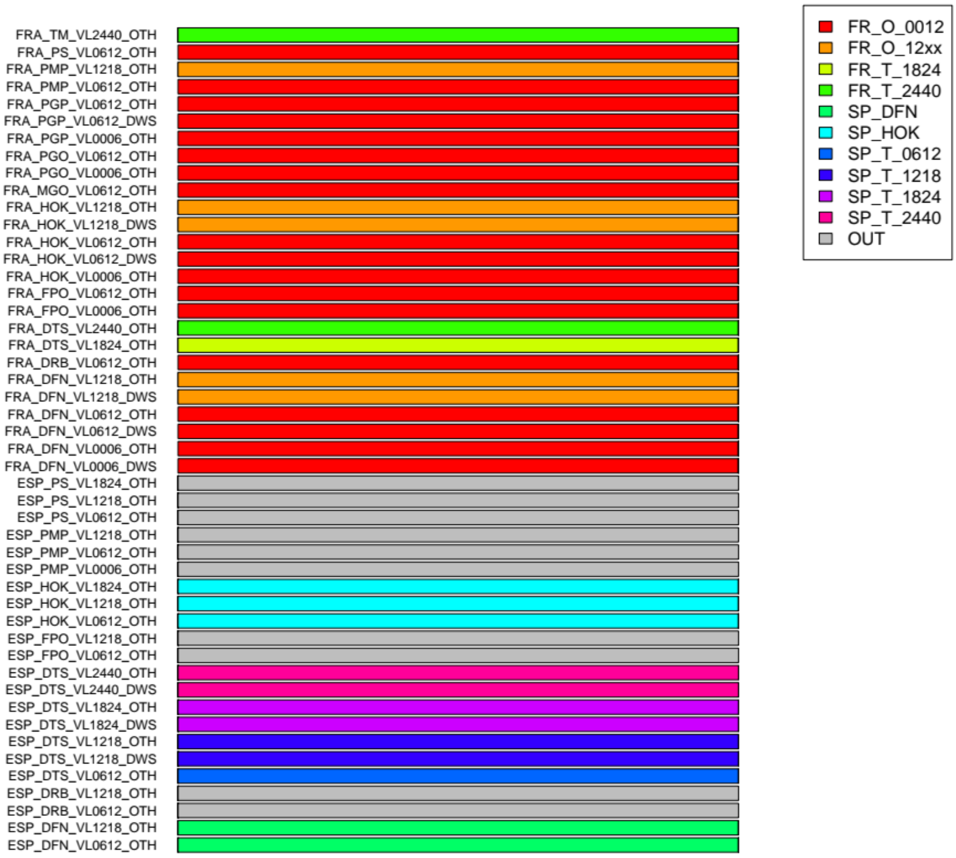


Figure 4.1.1.2.3. Match between detailed fleet segments (in row) and current IAM fleet categories (colours). Grey shows fleet segment currently not considered into IAM fleet categories.

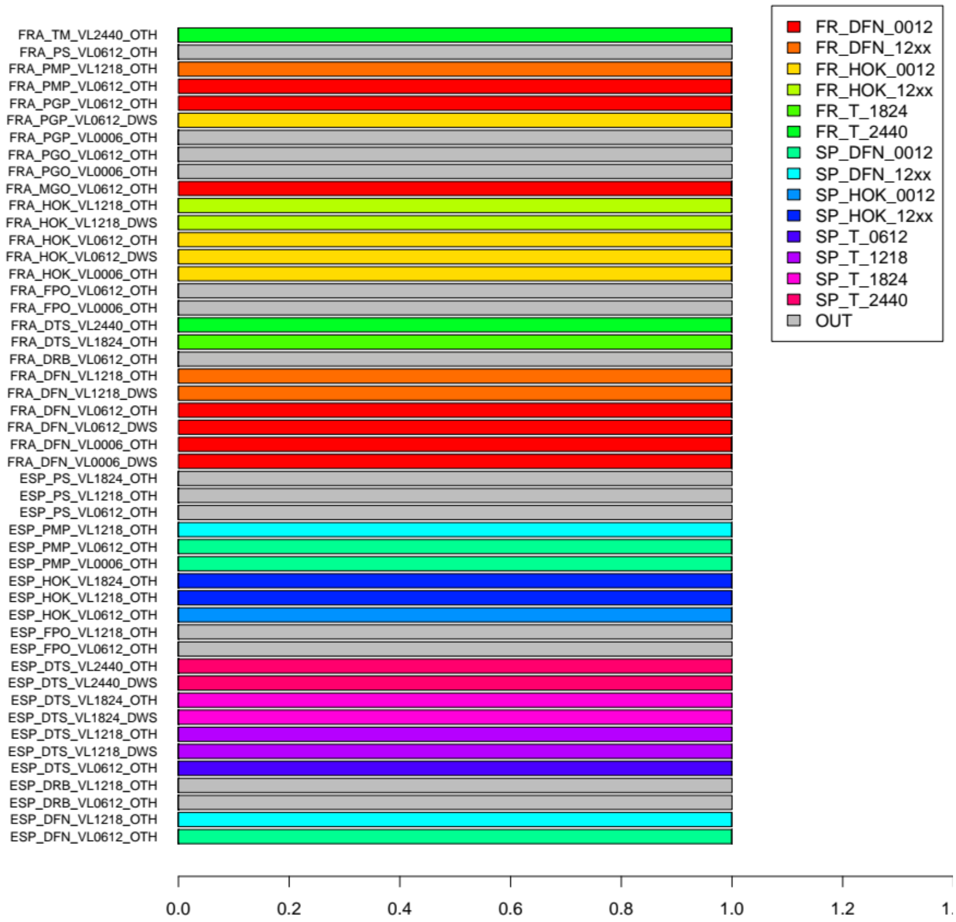


Figure 4.1.1.2.4. Match between detailed fleet categories (in row) and revised IAM fleet categories (colours). Grey shows fleet segment not considered into the revised IAM fleet categories.

To have a better idea of the dependence of the detailed fleet categories to the species of the management plan, Figure 4.1.1.2.5 shows the proportions of species of the plan landed by each detailed fleet category. Hence, it is clear that trawling and gillnetting fleet segments (e.g. fishing technique "DTS" and "DFN") present the most dependence to the species of the plan.

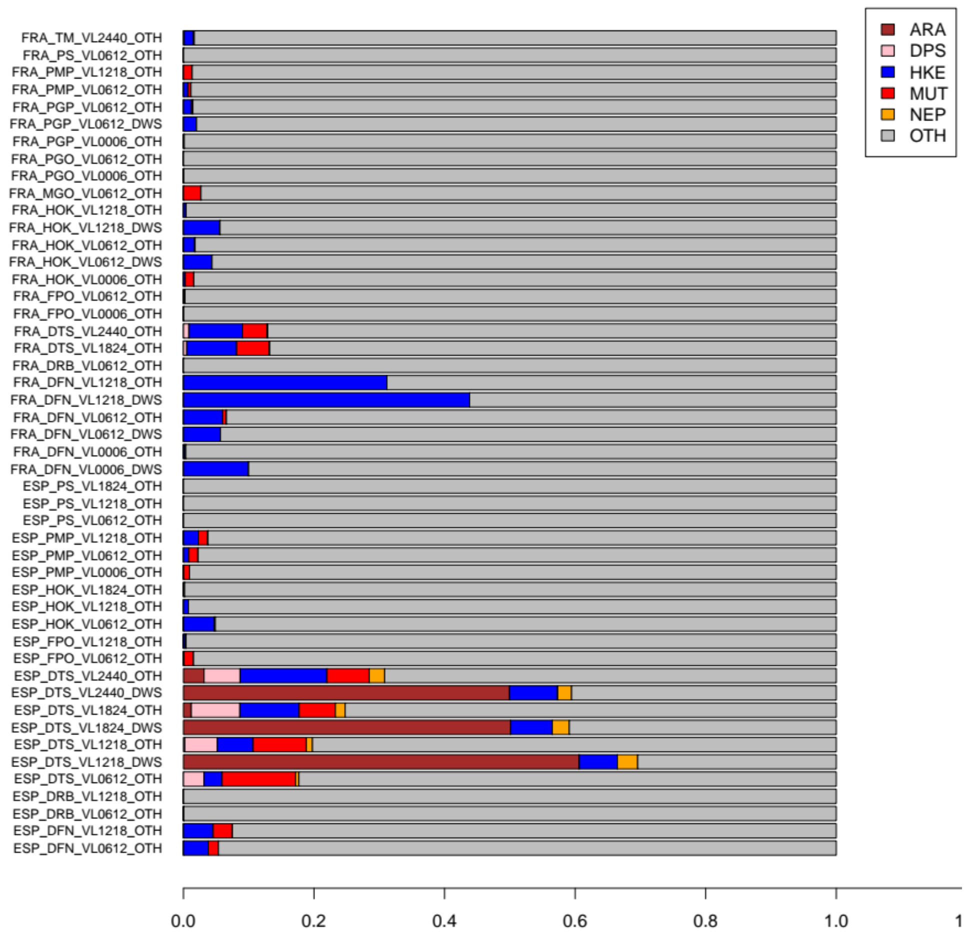


Figure 4.1.1.2.5 Proportions of species of the plan landed by each detailed fleet category, obtained by concatenating country, fishing technique, vessel size and target assemblage of the FDI data table. Coloured space represents species targeted by the Western Mediterranean MAP (ARA: Aristeus antennatus, DPS: Parapeneus longirostris, HKE: Merluccis merluccius, MUT: Mullus barbatus, NEP: Nephrops norvegicus), and grey areas represents all other species cumulated.

4.1.2 ISIS-Fish in EMU 1

The parameterisation and calibration of the ISIS-Fish model would benefit further efforts particularly to improve the representation of French netters and Spanish fleets, but also to use a more recent parameterisation of fleet activity in projection (currently 2015-2017).

As for the spatial closures, improvements are required regarding hake distribution. Using the results of the ad hoc contracts, the spatial distribution of hake will be updated and assumptions on fish movement revised. The current assumption of effort reallocation when a zone is closed is theoretical. Analysis of fishing effort distribution in the first years of closure implementation (2020-2021) should help propose more realistic assumptions.

As for the MCL, because fish were assumed to grow continuously along the year, the assumption regarding mean weight for the MCL computation has been evidenced as crucial and should be chosen carefully. The allocation of the MCL between fleets also proved important to refine given the important inequity evidenced.

If a stock-recruitment relationship for hake is to be defined, it would be worth using it in projection to evidence possible propagation of the benefit of spawners protection.

Uncertainty analysis is required at least on recruitment, but possibly on other key parameters and processes.

4.1.3 BEMTOOL in EMU 2

The implementation of BEMTOOL in EMU can include scenarios focused on the issue of the potential increase of the fishing power associated to the technological creep. In addition, a module present in BEMTOOL and related to the reaction of the sector to a management measure, can be applied, taking into account the lower limit for changes in fishing activity and the possibility of disinvestment. A missing element to be implemented is the possibility to adapt the MCL according to the annual change in the stock status. The implementation of MCL on more than one species will be also investigated.

4.1.4 SMART in EMU 2

Future application of SMART in EMU2 could explore the potential effects of TAC and inverse-TAC, as done in EWG 21-13. In fact, the present set up of SMART for EMU2 includes all the relevant parameters and variables, and all the metadata (e.g. spatial LPUE, landings, and bioeconomic indicators) were processed at a monthly base, providing the baseline to explore several additional scenarios. However, different aspects of the complex dynamics associated with TAC (including the potential changes in the price at market of some resources) are largely unexplored and hardly predictable, although their potential effects on fishers strategy could be very relevant. Finally, it could be important to assess the potential effects of different scenarios at a finer spatial scale, e.g. that of harbours. This could return insights about the economic sustainability of management measures for the different fleets distributed along the Italian coasts.

4.2 Issues important for the advice and the interpretation of results

The results of the present working group should be interpreted as those of a technical exercise which allowed the further development of the four bio-economic mixed-fisheries models (IAM, ISIS-Fish, BEMTOOL, SMART) used within the working group, and highlighted issues that should be accounted for in future EWGs giving scientific advice in relation to the Western Mediterranean MAP (EU 2019/2236). EWG 22-01 focused on two main topics, the evaluation of maximum catch limits (MCLs) and the evaluation of closure areas.

4.2.1 Maximum catch limits

MCLs on species caught by the trawling fishery were implemented for the first time in the western Mediterranean this year, 2022, by the European Regulation 2022/110. MCLs were specifically defined on blue and red shrimp (ARA) and on giant red shrimp (ARS) as reported in Table 4.2.1.1.. The MCLs for Spain and Italy were considered within the modelling frameworks as the reference catch value for the deep-water fisheries in EMU 1 and EMU 2 in 2022. The MCL for France, instead could not be accounted for due to the lack of data suggesting the presence of such a fishery in GSA 7 and 8, and to the lack of stock assessment for ARA and ARS in GSA 7 and 8. Therefore, it was not possible to account for the effect of a potential increase in the pressure on ARA and ARS stocks if a deep-water fishery started in GSA 7 and 8 by a French fleet. On the same line, it should be noted that the stock of ARA in GSA 5 does not have an analytical stock assessment, therefore the evolution of the fishery in this area after setting a MCL could not be explored by the mixed-fisheries models implemented in EMU 1.

Table 4.2.1.1 MCLs per country as defined by Regulation 2022/110.

Country	ARA	ARS
Spain	872	-
France	65	5
Italy	250	365

MCLs for European hake (HKE) are not defined by any Regulation at present, therefore the values used were obtained from the short-term forecast (STFs) obtained during the stock assessment EWG 21-11. By TORs it was requested to consider an MCL for HKE solely on trawlers, as this year a reduction of effort of 6% compared to the reference period 2015-2017 (EU 2022/110) was applied to longliners for the first time. The values obtained from EWG 21-11 though are relative to the fisheries of HKE exerted by both, passive and active gears, which create a conflict on how these values are used as a MCL was solely defined on trawlers within the mixed-fisheries models. This implementation was followed due to a shortage of time, but in future it would be necessary to have a MCL for passive gears and one for active gears, in case there should be an implementation of such a catch limit on HKE in the western Mediterranean. Additionally, it should be noted that the HKE fisheries is characterized by the presence of discards, which are embedded in the catch values projected by STFs during a stock assessment procedure. Within the mixed-fisheries models used in EWG 22-01 only BEMTOOL can account for discards at present, therefore MCL values given to EWGs following EWG 22-01 should account for this potential issue. During EWG 21-13 and EWG 22-01 target MCL values for transition years (2023-2024) and for 2025 were fed into the models as it was easier to run the models at the time. Experts suggested that in future it would be better to directly feed a value of Fmsy by 2025 and estimate the corresponding catch/landings value (depending on the model used). This procedure would allow to evaluate the consequences of implementing a MCL, as biomass response is updated. In order to have a meaningful update of the biomass though, specific harvest control rules (HCR) to be accounted for should be defined. It should than be stressed that all stocks evaluated in the western Mediterranean at present lack official biomass reference points such as Bpa or Blim.

4.2.2 *Closure areas*

During the procedure followed to define hotspots that could potentially help define additional closure areas, a number of limitations due to the availability of spatial data were highlighted.

As TORs requested to consider protection through a percentage of each GSA, the first step in order to define hotspots related to trawling activity was to define the areas where trawling is possible. To do so only the area between the 50m depth or 3 nautical miles and 1000m depth was considered, as outside this range trawling is already prohibited. Existing closure areas and untrawlable areas were deducted as well by the final area. It should be highlighted that it was not possible to account for most of the untrawlable areas, such as the ones reported at the end of section 3.1.2, due to lack of mapping of the submarine structures. EWG 22-01 advices that protection of stocks should not be evaluated considering percentages of areas of protection, but through the evaluation of the response of stocks to spatial management measures. Additionally, it should be considered that, following Regulation (EC) 1967/2006, derogations can be applied to specific areas, such areas should be accounted for when looking at total trawlable area.

As reported in section 3.2.2 the combination of both commercial and scientific data complements each other, increasing spatial and temporal coverage, but commercial data are biased by nature being led by the species distribution. Scientific data are fundamental to understand species distribution and dynamics, being based on standardized sampling. MEDITS is the only scientific survey that covers the whole area interested by the western Mediterranean MAP and is held during the second and third quarter (depending on the area), which limits the potential of describing the seasonality of species' dynamics. It should be noted that when testing the effect of seasonal closures against permanent closures, the only quarterly information available are actually led by the distribution and dynamics of commercial data, while there is a lack of information of the species dynamics independently from fishers' behaviour. This caveat should be considered when interpreting results obtained from spatially explicit mixed-fisheries models such as SMART (which does not include survey data) and ISIS-Fish (which includes survey data only for a single quarter). Additionally, the experts stressed that MEDITS data are not suitable to identify distribution hotspots for all species targeted by the MAP, such as, for example, HKE spawners and ARA and ARS juveniles. EWG 22-01 highlights that species' hotspots defined during the MEDISEH project should be updated with data up to 2020, as it was not possible to do it for this EWG due to lack of time. Both the ad hoc contracts and EWG 22-01 were limited in identifying HKE spawners hotspots, as large hake are mainly targeted by vessels having LOA<15m and using passive gears in both EMU 1 and in EMU 2, which are not tracked by remote monitoring systems (VMS or AIS). As highlighted in section 3.2.2 the complete lack of information on the distribution and behaviour of fleet segments under 15m is quite limiting when defining spatial management measures as it could underestimate the importance of management of coastal areas compared to high seas ones. As reported in section 3.1.3, EWG 22-01 followed the procedure suggested by STECF PLEN 21-02, highlighting that the main limiting factor in the evaluation of closure areas effectiveness is the lack of data (both scientific and commercial), while since the modelling frameworks available would allow to consider most of the limiting issues reported in previous working groups since 2020. Finally, the group would like to stress that at present it is not possible to evaluate spatial management in GSAs 1-2-5-6 as there is no spatially explicit mixed fisheries model implemented yet in that area of the western Mediterranean.

4.2.3 Economic indicators

STECF EWGs 18-09, 18-13, 19-01, 19-14, 20-13, 21-01, 21-13 and 22-01 aimed at evaluating the implementation of the western Mediterranean MAP from an ecological, social and economic perspective. Four mixed fisheries models looking at the development of both the state of stocks and the state of the fisheries are implemented. EWG 22-01 highlighted that while reference points to assess the state of the stocks are being updated and, when possible, improved, across the EWGs, reference points that would evaluate the socioeconomic performance are still lacking. The decrease in GVAs observed by the models cannot be compared against reference levels which would allow to define the socio-economic consequences of the implementation of the western Mediterranean management plan. Specifically the EWG was unable to evaluate which if any the management measures proposed would drive the fishery to unsustainable economic levels or not.

EWG 22-01 highlights that data regarding subsidies invested at national and international level to support temporal fishing bans and vessels decommissioning would be necessary to integrate data on revenues and better evaluate the economic impact of management measures on the fisheries.

4.2.4 References

Regulation (EC) No 1967/2006 of 21 December 2006 concerning management measures for the sustainable exploitation of fishery resources in the Mediterranean Sea, amending Regulation (EEC) No 2847/93 and repealing Regulation (EC) No 1626/94

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

Regulation (EU) 2022/110 of 27 of January 2022 fixing for 2022 the fishing opportunities for certain fish stocks and groups of fish stocks applicable in the Mediterranean and Black Seas

Scientific, Technical and Economic Committee for Fisheries (STECF) – 67th Plenary Report (PLEN-21-02). EUR 28359 EN, Publications Office of the European Union, Luxembourg, 2021, ISBN 978-92-76-40592-4 (online), doi:10.2760/559965 (online), JRC126123

Scientific, Technical and Economic Committee for Fisheries (STECF) – Stock Assessments: demersal stocks in the western Mediterranean Sea (STECF-21-11). Publications Office of the European Union, Luxembourg, 2021, EUR 28359 EN, ISBN 978-92-76-46116-6, doi:10.2760/046729, JRC127744

Scientific, Technical and Economic Committee for Fisheries (STECF) – Evaluation of the fishing effort regime in the Western Mediterranean – part VI (STECF-21-13). Publications Office of the European Union, Luxembourg, 2021, EUR 28359

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[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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6 LIST OF ANNEXES

Electronic annexes are published on the meeting's web site on:
https://stecf.jrc.ec.europa.eu/ewg2201
List of electronic annexes documents:
EWG-22-01 – Annex I – Ad-hoc contract Report STECF 2191
EWG-22-01 – Annex II – Ad-hoc contract Report STECF 2192

7 LIST OF BACKGROUND DOCUMENTS

Background documents are published on the meeting's web site on:
https://stecf.jrc.ec.europa.eu/ewg2201

List of background documents:

EWG-22-01 – Doc 1 - Declarations of invited and JRC experts (see also section 6 of this report – List of participants)

EWG-22-01 –Doc 2 – Council Regulation (EU) 2022/110 fixing for 2022 the fishing opportunities for certain fish stocks and groups of fish stocks applicable in the Mediterranean and Black Seas

KJ-AX-22-003-EN-N

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