ad-hoc contract for the preparation of STECF EWG 22-01 concerning closure areas to protect juveniles and spawners of all demersal stocks in western Mediterranean Sea

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1 1 ToR

1. Collate and analyse fisheries dependent data to identify the spatio-temporal distribution of juveniles and spawners of all demersal stocks (to the extent possible following the order presented in the Background), in EU waters of the Western Mediterranean Sea (GSAs 1-2-5-6-7-8-9-10-11).
2. After the above collating and identifying of hake spawning aggregations, the contractor shall draft a short report (20-page max) including detailed maps and GIS layers 2 to feed into the work of EWG 22-01 to develop an advice on the efficiency of the existing closure areas and the development of additional closure areas to protect juveniles and spawners of demersal stocks in the region.

raw VMS data (reference years: Complete available time series up to 2020, including vessel id and date of the VMS emission), VMS data will be linked to logbook data. It will allow computing CPUE (kg of landings per fishing time) at fine spatial scale. Fishing operation should be identified from VMS data by member states in order to take into account national specificities in fishing patterns. If fishing operation are not available, fishing operation will be identified based on common speed threshold.

logbook data (reference years: The same time series requested for VMS data up to 2020): logbook data should contain identifiers (vessel number and date) to be able to link logbook and VMS data to compute CPUE. Métier (levels 4, 5 and 6) should be specified to identify the different fleets and fishing behaviours within the data. When available, landings should be reported separating mature/juvenile fish. If not available landings should be reported by commercial category and an estimate of the fraction of juvenile/mature fish by commercial category provided independently. If the proportion of juvenile/mature fish by commercial category is not available an average proportion will be applied by commercial category based on available data. Fine scale georeference CPUE including information of mature/juvenile fish will be used to infer the latent biomass of respectively juvenile/mature fish.

3 3 Context

3.1 3.1 Background provided by the Commission

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 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.

In order to implement closure areas to protect juveniles and spawners of these demersal stocks, knowledge on their spatial distribution is needed. Information on their spatial distribution is usually available through MEDITS surveys but is then limited in time. Spatial monitoring of commercial data (based on logbooks crossed with Vessel Monitoring Systems) can provide an additional extensive data source to inform fish spatial distribution. These data have however hardly been used because considered biased by fishermen behaviour.

(Alglave et al. 2022) developed a spatial hierarchical framework integrating both scientific and commercial data sources while accounting for preferential sampling (PS) of commercial data in order to map fish spatio-temporal distribution. The model was adapted to inform on spatio-temporal distribution of either: - Hake Juveniles and adults - Hake biomass - Red mullet biomass - blue and red shrimps based on data availability.

4 4 Data

4.1 4.1 Logbook data

Raw logbook data were provided anonimized.

4.1.1 4.1.1 Merluccius merluccius (HKE)

Information on commercial landings were provided for 2015-2020 for France, 2017-2020 for Italy and 2018-2020 for Spain. Only France and Spain provided information by Commercial Categories. All landings could be allocated to different commercial categories for Spanish landings but a small fraction of the French landings were not allocated to commercial category.

Fig.4.1 and Fig.4.2 present the total French and Spanish landings and their share between commercial categories. Fig.4.3 presents total Italian landings.

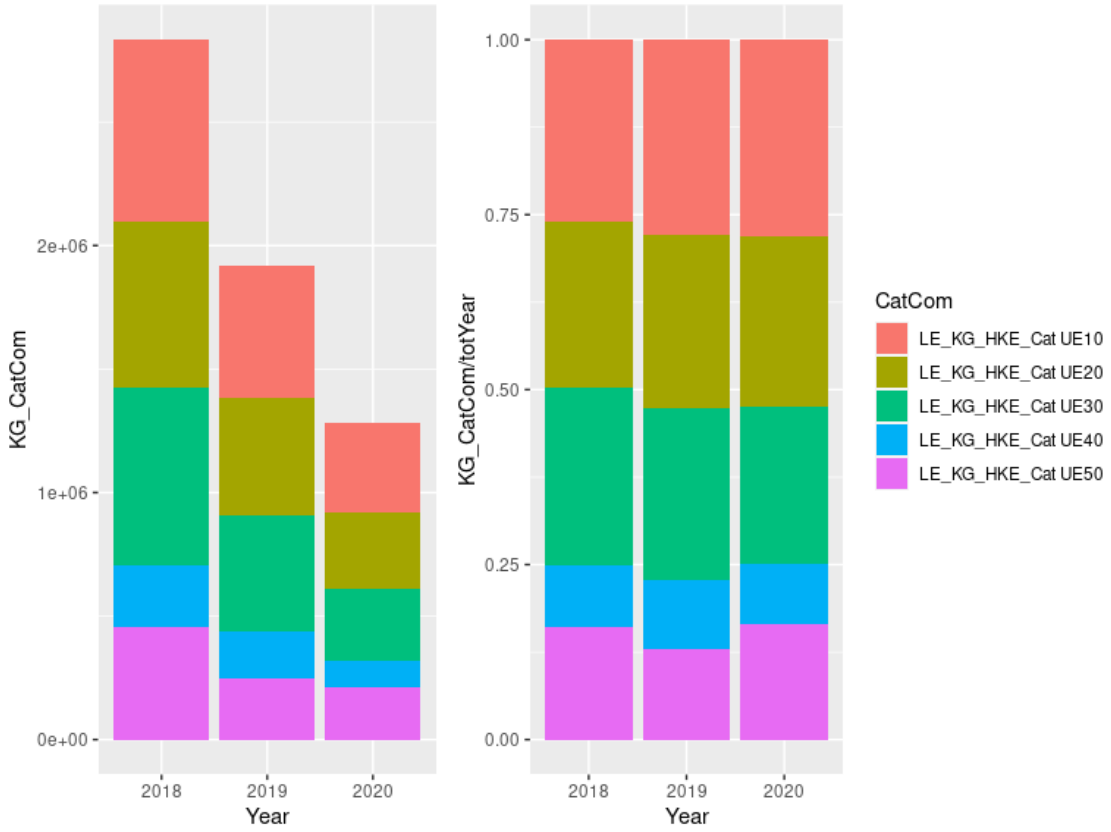


Figure 4.1: Spanish landings by commercial categories (left pannel: in kg, right pannel: in proportion of the total landings)

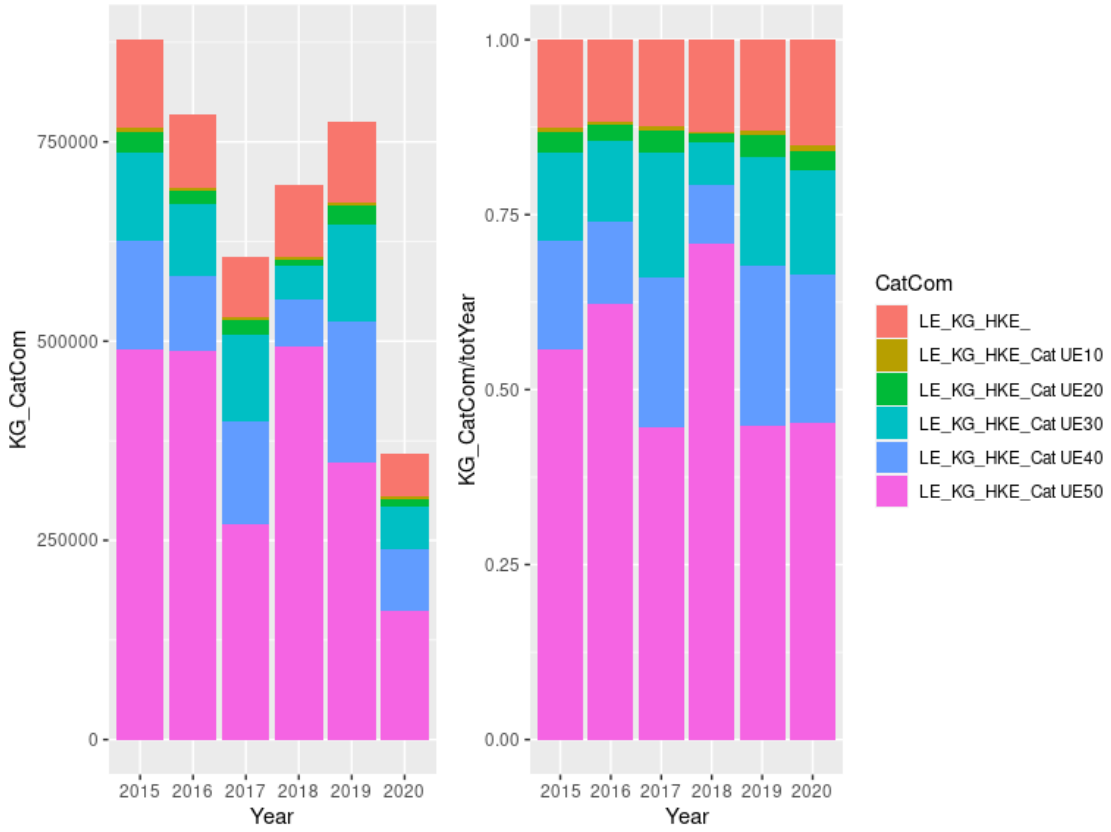


Figure 4.2: French landings by commercial categories (left pannel: in kg, right pannel: in proportion of the total landings)

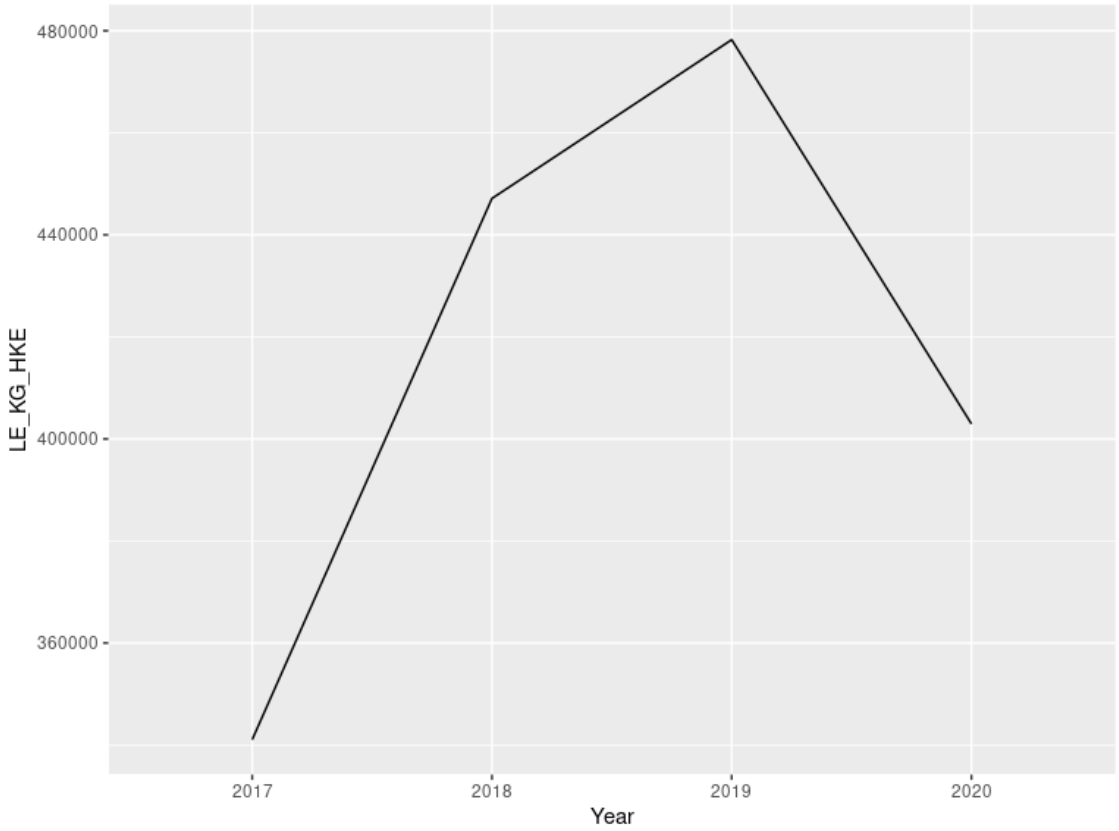


Figure 4.3: Italian landings in kg

Previous work (Billet et al. 2021), derived proportion of juvenile and adult by commercial category based on commercial sampling and a size of 29 cm to differentiate juveniles and adults (http://www.fao.org/gfcm/data/safs). (Billet et al. 2021) then computed the proportion of juveniles and adults in weight per commercial category for the demersal trawl fleet operating in GSA 7. These proportions were the only available data to compute juvenile/adult fraction for

landings data. They were used to divide landings in juveniles and adults of French and Spanish landings. Tab.4.1 presents the proportion of juveniles per commercial categories used to derive juveniles and adults landings from total French and Spanish landings per commercial categories.

Table 4.1: Observed juveniles percentages (in weight) per commercial category and year for demersal trawlers in GSA 7

Species	Commercial.Category	Y2015	Y2016	Y2017	Y2018	Y2019	Y2020
Merluccius merluccius	UE10	0.0	0.0	0.0	0.0	0.0	0.0
Merluccius merluccius	UE20	5.2	0.0	0.0	1.1	0.0	1.5
Merluccius merluccius	UE30	13.0	13.8	7.6	15.8	5.1	4.7
Merluccius merluccius	UE40	17.6	20.0	16.7	29.6	7.7	26.2
Merluccius merluccius	UE50	89.9	89.6	92.6	88.5	77.7	90.6

4.1.2 4.1.2 Aristeus antennatus (ARA) and Aristaeomorpha foliacea (ARS)

For these two shrimps, no landing by commercial was available. The total landings were used as a proxy of the total shrimp biomass. Data from Italy were used.

Fig.4.4 presents the total Italian landings for these two different shrimps.

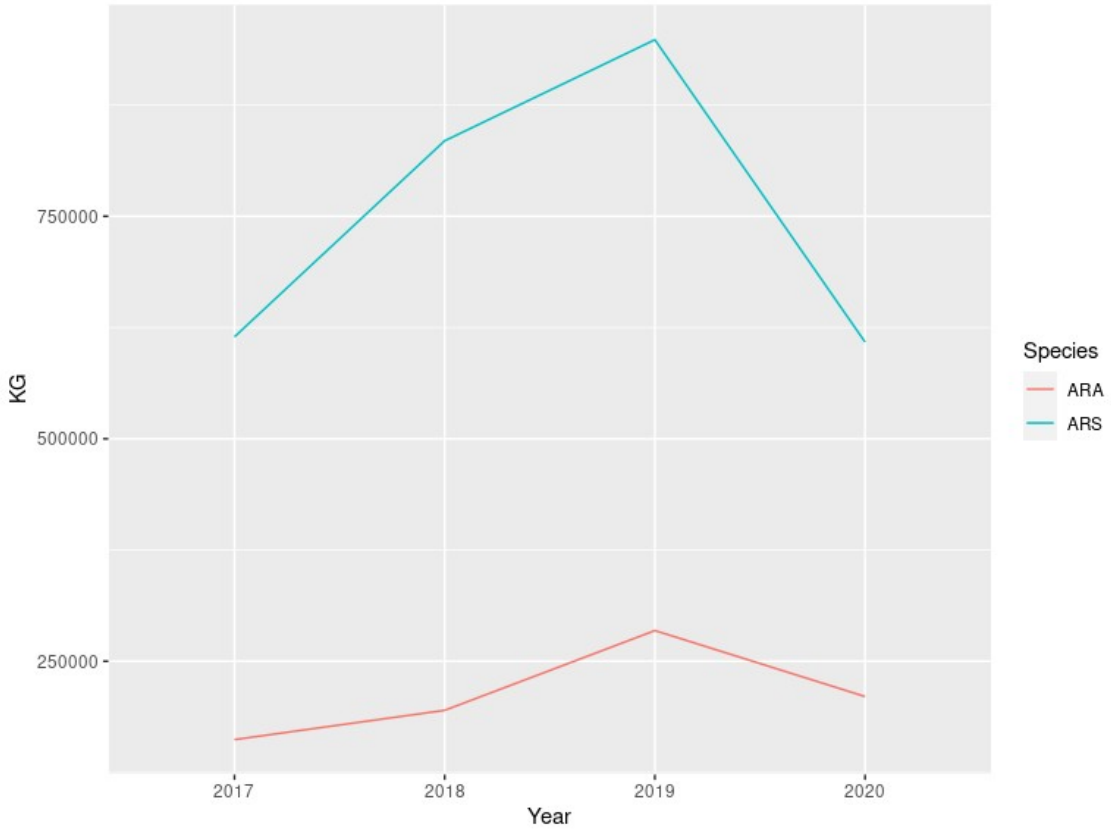


Figure 4.4: Italian landings in kg

4.1.3 4.1.3 Mullus barbatus (MUT)

(Billet et al. 2021) shown that no juvenile was caught by demersal trawlers. Even if landings were provided by commercial categories for France, total landings were used as a proxy of the total biomass.

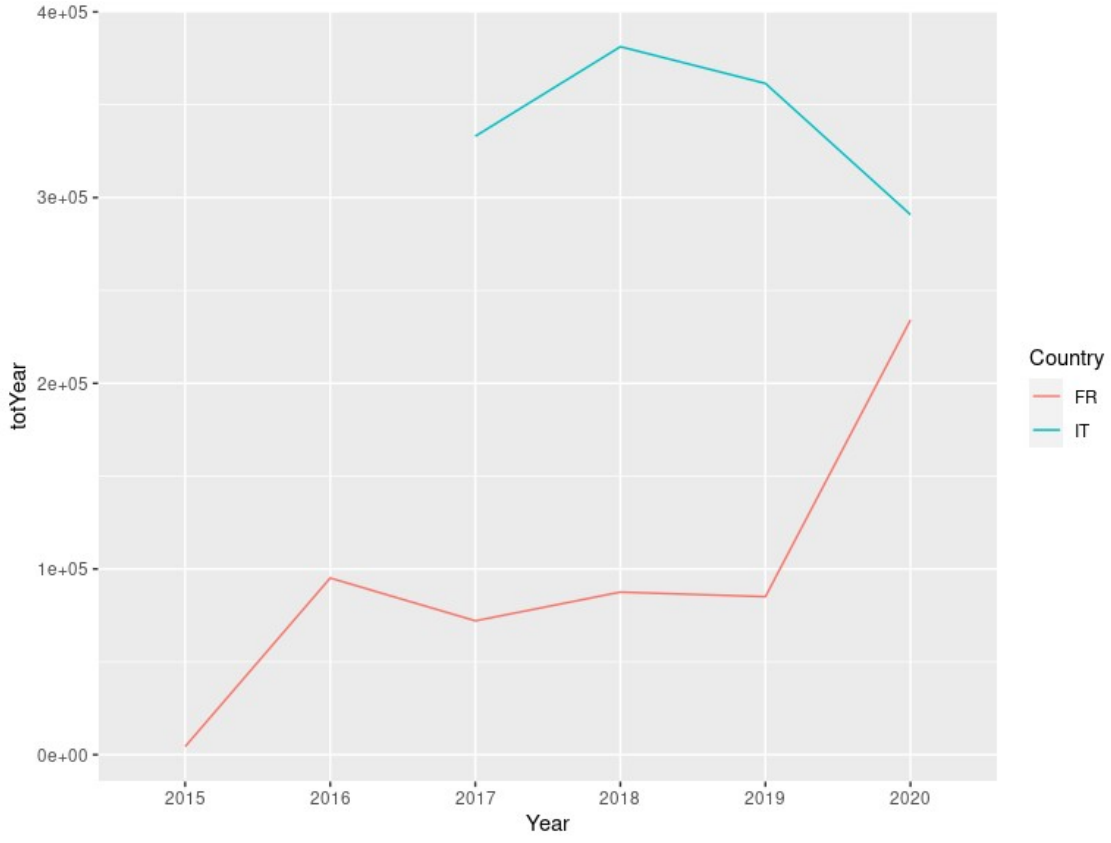


Figure 4.5: red mullet landings in kg

Fig.4.5 presents the total Italian and French red mullet landings. It should be noted that some mismatch in the French landings were observed with lower landings in the data used than in the data reported in other reports and used for assessment. However, as in the final model, only LPUE are used and not total landings, the impact might be mitigated. Some improvement in the input data might be necessary in the future.

4.2 4.2 VMS data

VMS data were provided with the same anonimization code and on the same historical series for the 3 countries. Each country defined the pings identified as "fishing" according to their own algorithm.

Using VMSTools package (Hintzen et al. 2012), logbooks and VMS data were merged to get a better spatialisation of effort and landing data. Landings and effort were used to compute Landings Per Unit of Effort (LPUE).

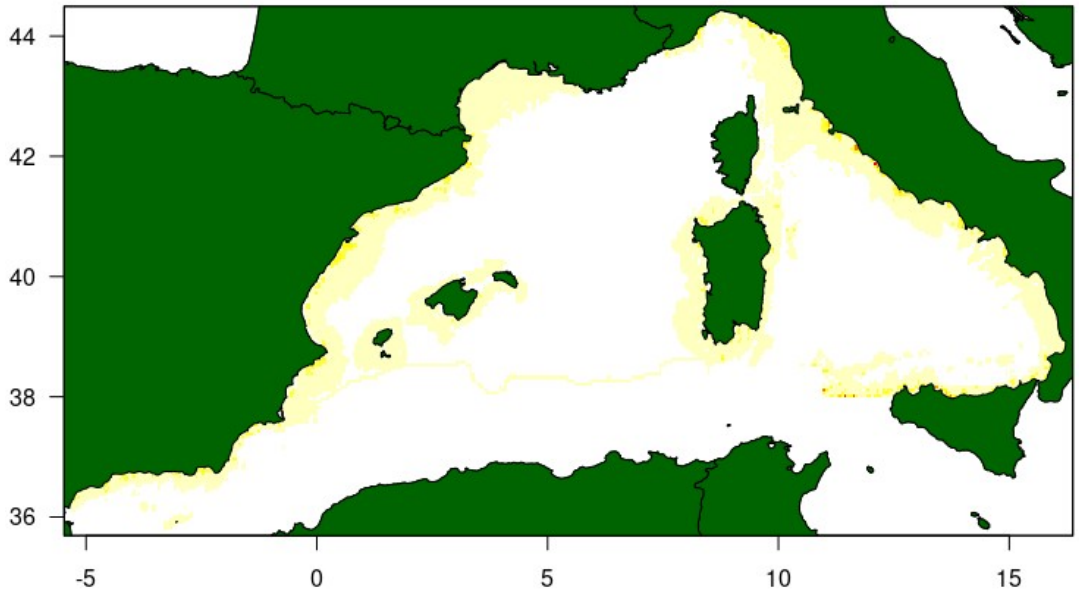


Figure 4.6: Sum of effort for France, Italy and Spain over the years 2019 and 2020

5 5 Method

Based on the methodology described in (Alglave et al. 2022), Species Distribution Models (SDM) were developed for Merluccius merluccius, Aristeus antennatus and Aristaeomorpha foliacea and Mullus barbatus. LPUEs for the different species are computed based on "spatialised" landings and effort data (commercial data and survey data). Both scientific and commercial observations (LPUE (in weights / unit effort)) are considered as proportional to the underlying biomass through a zero-inflated observation process. The model allows to interpolate biomass predictions on the entire area of study based on punctual observations of biomass. No covariates were 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 (i.e. areas with relatively higher biomass - Alglave et al., in prep). Here we make the strong hypothesis that discarding behavior does not change the biomass perception due to spatial specific discarding events. As described in (Alglave et al. 2022), when commercial data far exceed scientific data, the later bring little information to spatial predictions in the areas sampled by commercial data and integrating scientific data in inference will not modify the maps.

Then, when building the SDM the MEDITS data were not used to feed the model except in the case where both French and Italian data had to be combined (map of total biomass for Mullus barbatus and Merluccius merluccius). In these cases, there is no overlap between the French and the Italian fleets, and then MEDITS data allow to standardize country specific catchabilities by assuming a constant catchability for the MEDITS survey.

The model provides an estimate of the underlying biomass at each cell of the discretization grid at a monthly time step. Biomass are expressed in units of LPUE (kg/hr) except for the model where MEDITS data were used to intercalibrate (biomass of Mullus barbatus and Merluccius merluccius) where biomass are in the unit of the survey (kg/km2).

5.1 5.1 Maps for Juvenile and Adult fraction

For Merluccius merluccius and for France and Spain, it was possible to divide landings in Juvenile and Adult fraction using the commercial categories and commercial sampling. Models were then built based on Juveniles and Adults fraction in the areas covered by French and Spanish fleets.

5.2 5.2 Maps of total biomass

When it was not possible to share the landings on juvenile and adult fraction, landings were considered representative of the total biomass.

5.3 5.3 Plotting the maps

To plot the overall pattern distribution of the species, we averaged biomass distribution over the whole period (average pattern) and by quarter (quarterly patterns). To extract the areas with higher biomass, we plotted the 90% quantile as a threshold for hotspot identification (red points in the following figures). The model theoretically allows to estimate biomass on the whole domain even if no observation were made. However, outside the range of the fleets predictions were not considered to be reliable, only the predictions inside the spatial extent of the fleet are plotted. And maps were produced reducing geographical contours to the areas were effort was observed at least once on the full time series.

6 6 Results

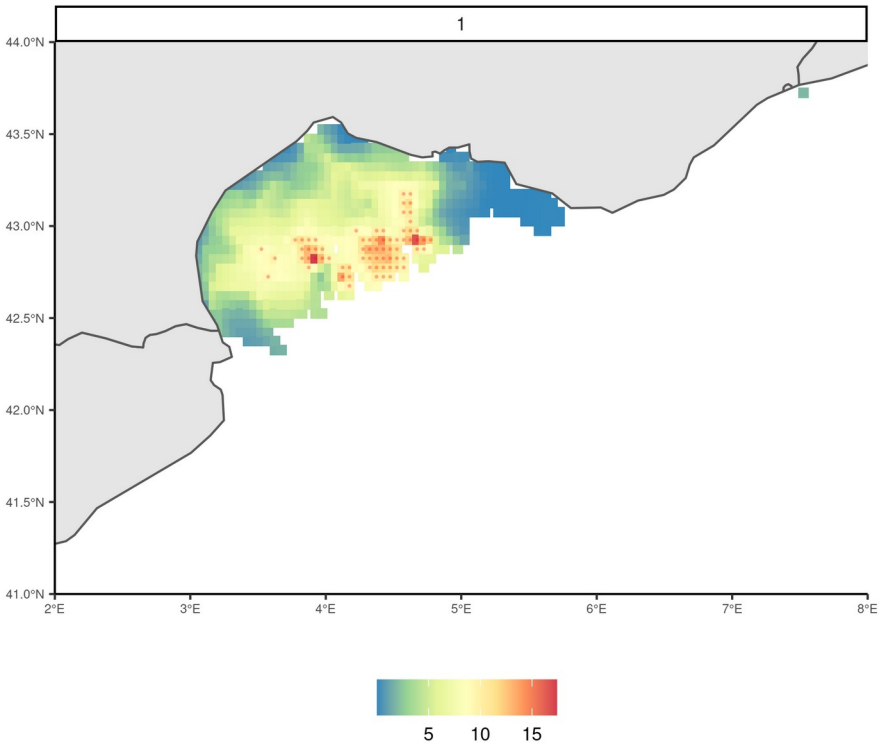
6.1 6.1 Merluccius merluccius

6.1.1 6.1.1 Juvenile/Adult distribution based on French landings

French landings from demersal trawls were divided into juveniles (JUV in subtitle) and adult (SSB in subtitle) landings based on the method described above. Estimated biomass distribution is presented in the following figures. Each time the yearly pattern and quarterly patterns are presented. Squares that are in the quantile 90% are overlaid with red points.

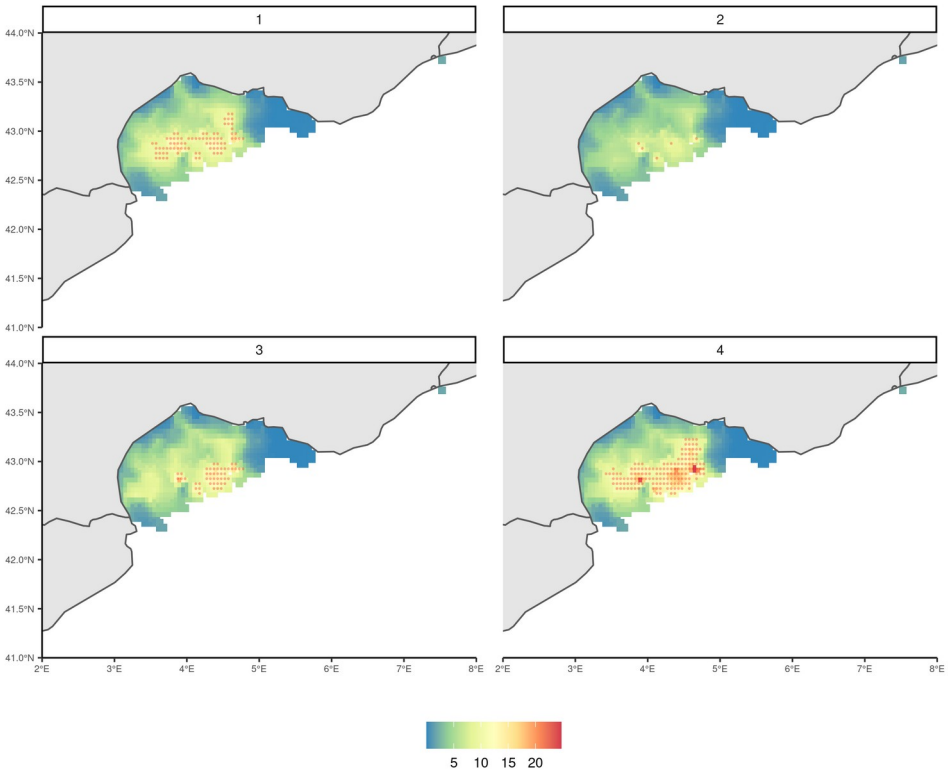
Mean distribution (quantiles)

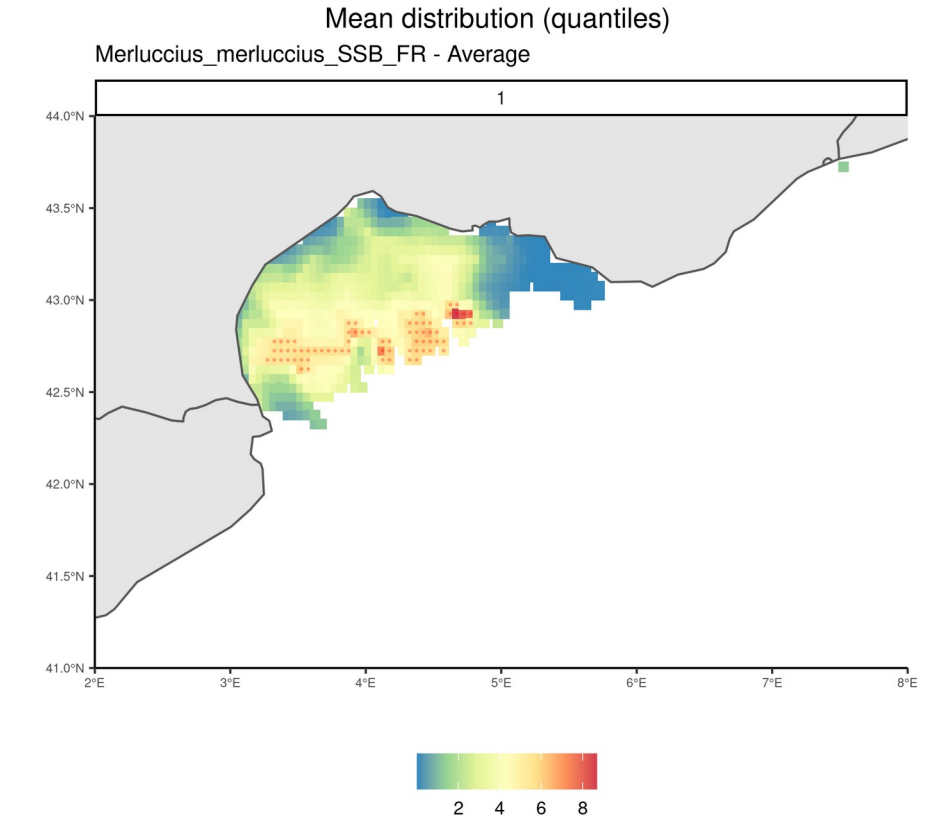
Merluccius_merluccius_JUV_FR - Average

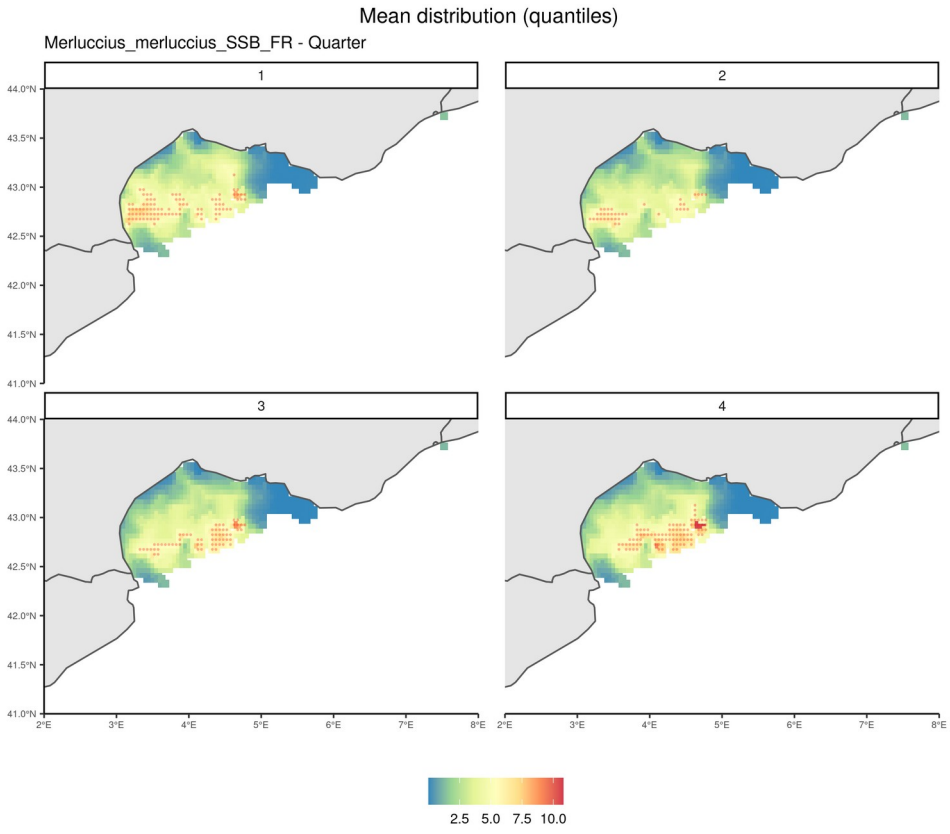


Mean distribution (quantiles)

Merluccius_merluccius_JUV_FR - Quarter





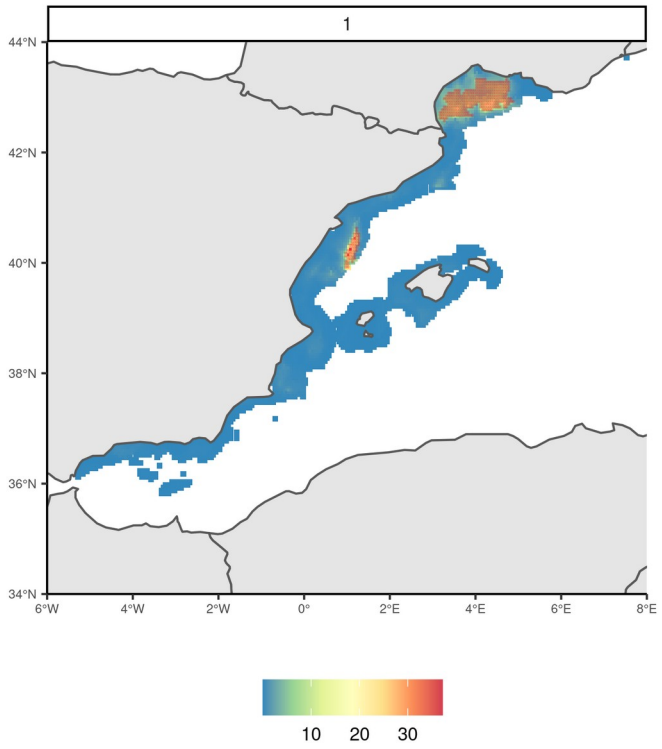


6.1.2 6.1.2 Juvenile/Adult distribution based on French and Spanish landings

French and Spanish landings from demersal trawls were divided into juveniles (JUV in subtitle) and adult (SSB in subtitle) landings based on the method described above. Estimated biomass distribution is presented in the following figures. Each time the yearly pattern and quarterly patterns are presented. Squares that are in the quantile 90% are overlaid with red points.

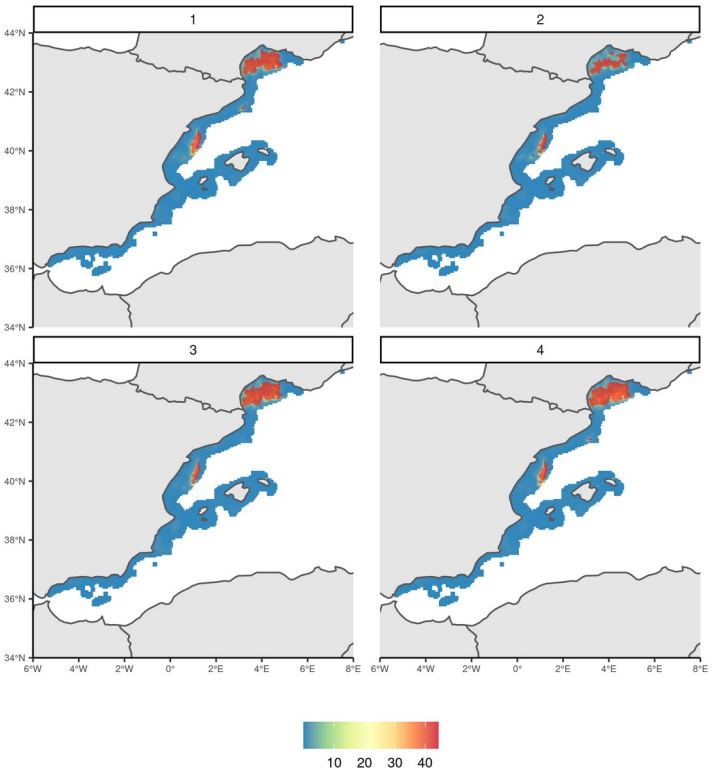
Mean distribution (quantiles)

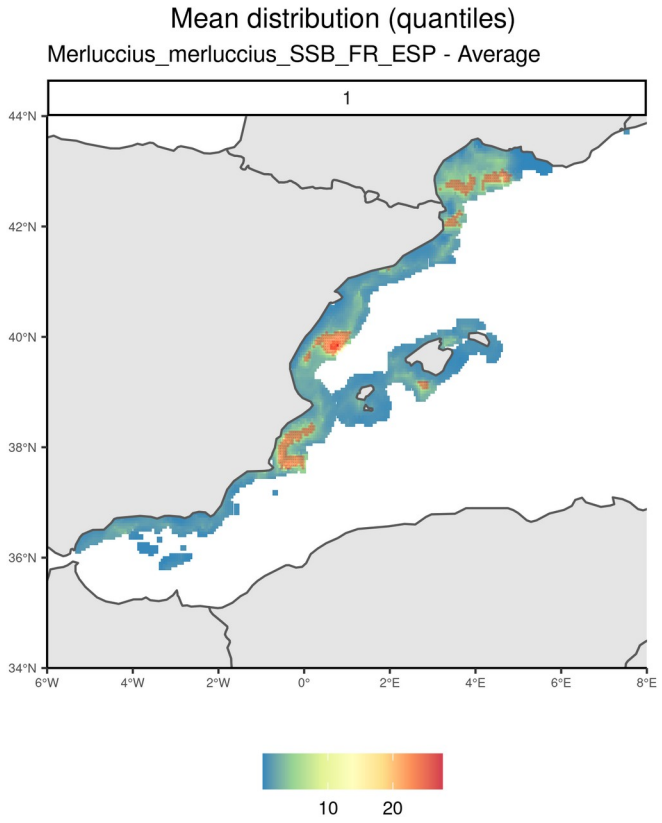
Merluccius_merluccius_JUV_FR_ESP - Average

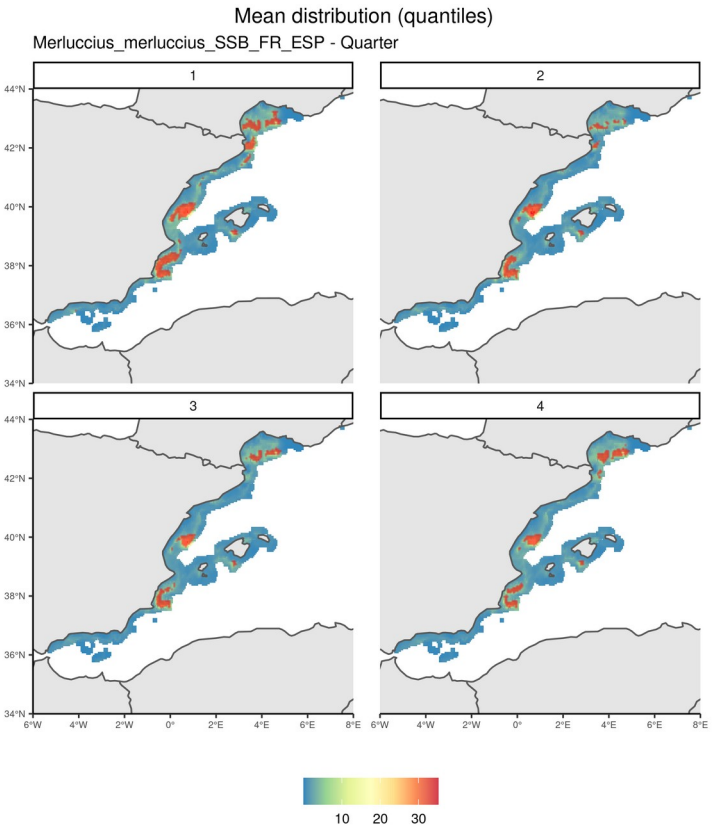


Mean distribution (quantiles)

Merluccius_merluccius_JUV_FR_ESP - Quarter





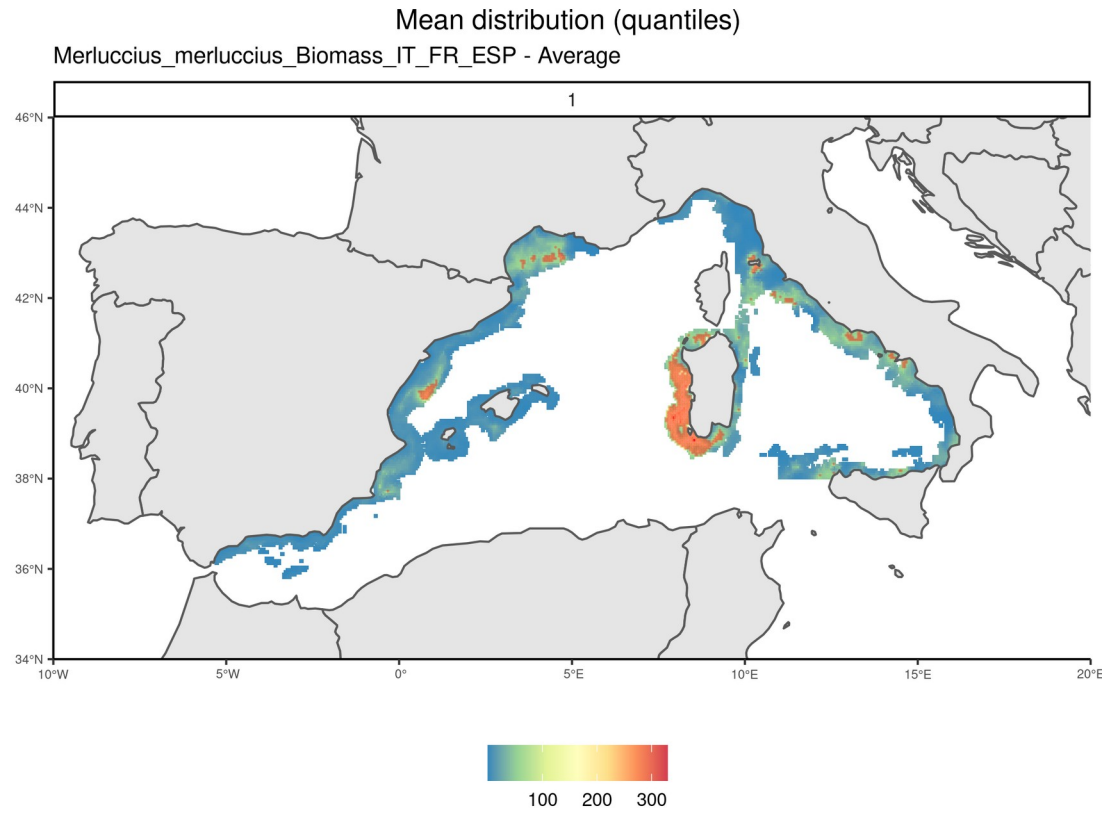


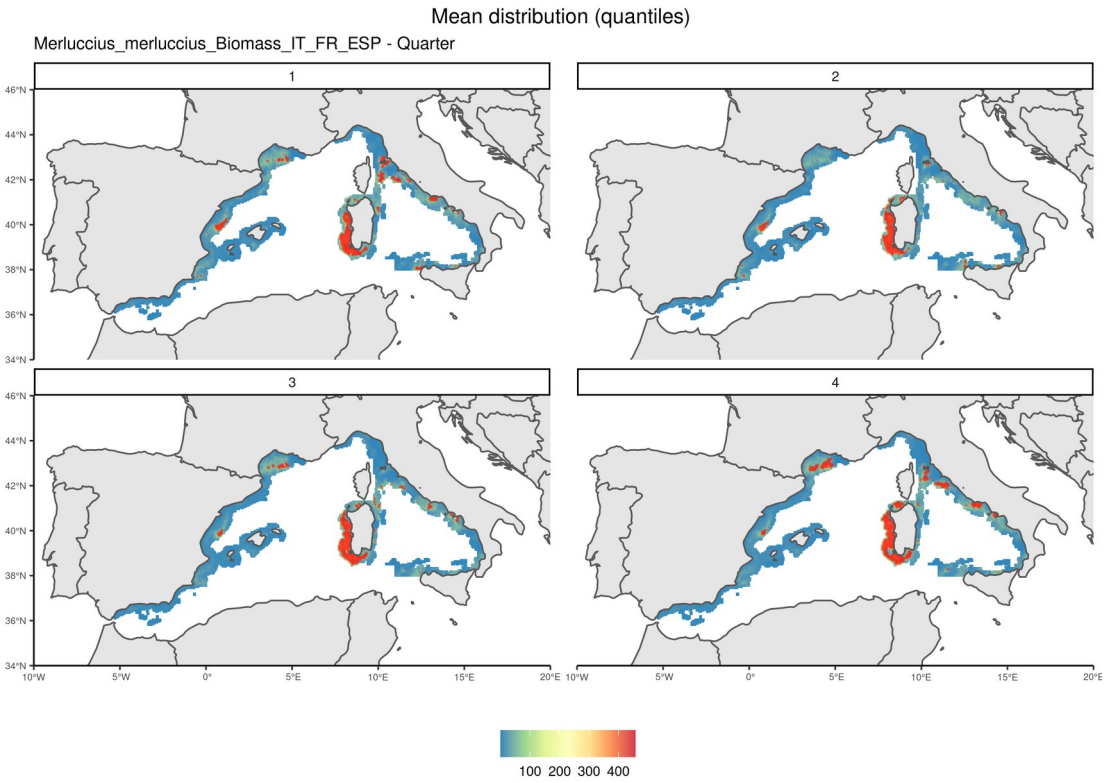
6.1.3 6.1.3 Biomass distribution based on French Italian and Spanish landings

Italian, French and Spanish landings from demersal trawls were merged to estimate 'total biomass.' MEDITS data were used to standardize country/gear catchability.

Estimated biomass distribution is presented in the following figures. Each time the yearly pattern and quarterly patterns are presented.

Squares that are in the quantile 90% are overlaid with red points.





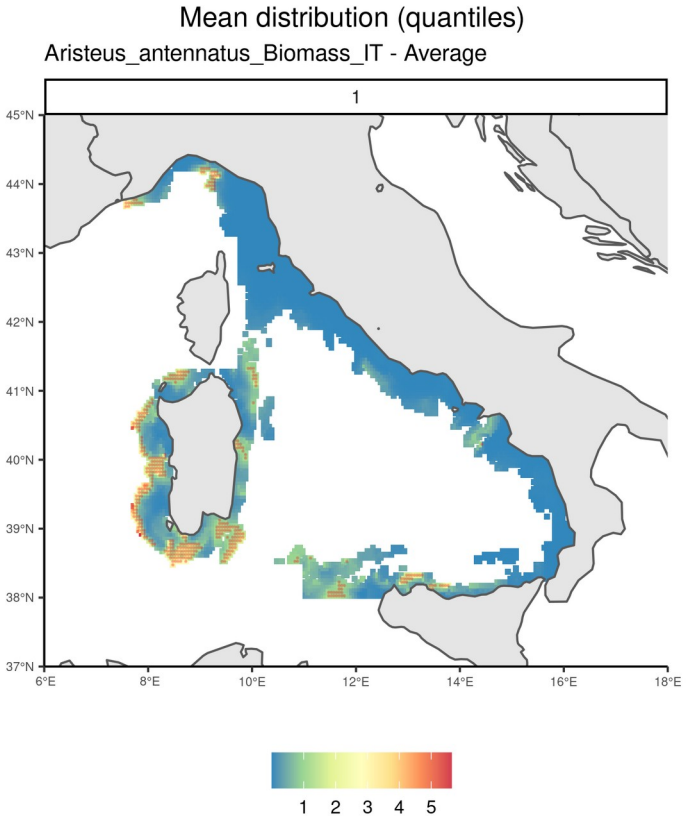
6.2 6.2 Aristeus antennatus

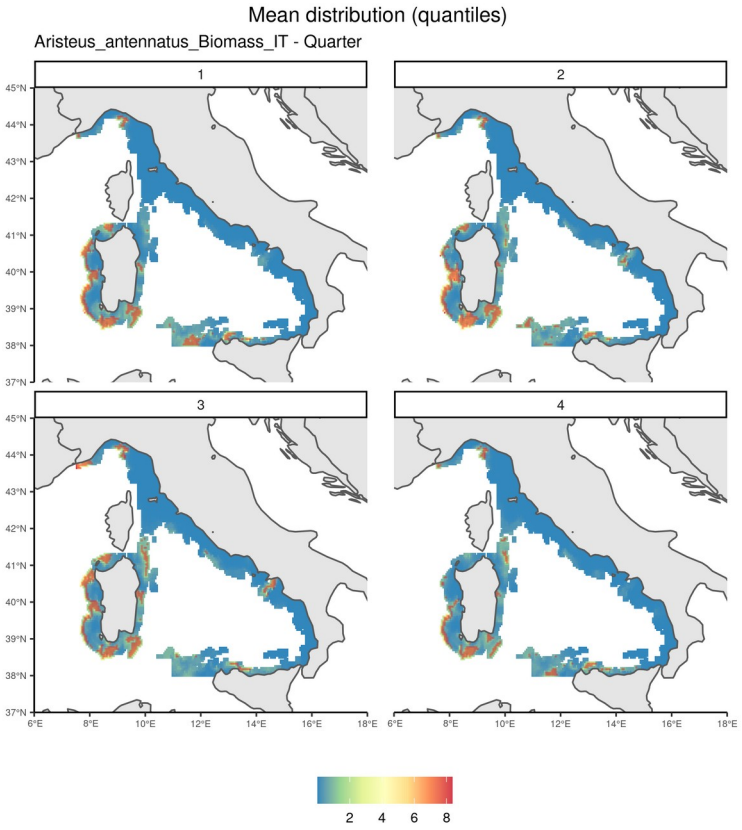
6.2.1 6.2.1 Biomass distribution based on Italian landings

Italian landings from demersal trawls were merged to estimate 'total biomass.'

Estimated biomass distribution is presented in the following figures. Each time the yearly pattern and quarterly patterns are presented.

Squares that are in the quantile 90% are overlaid with red points.





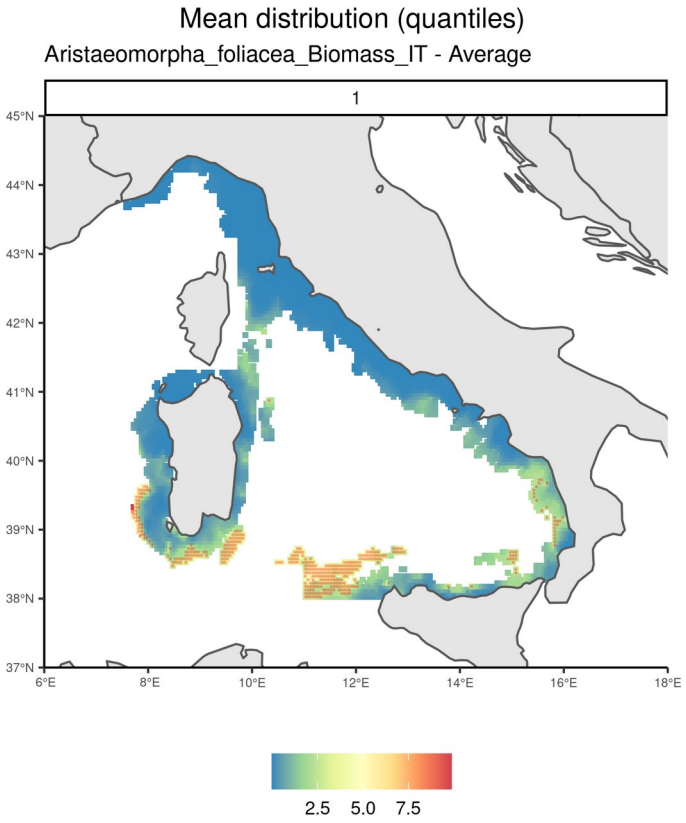
6.3 6.3 Aristaeomorpha foliacea

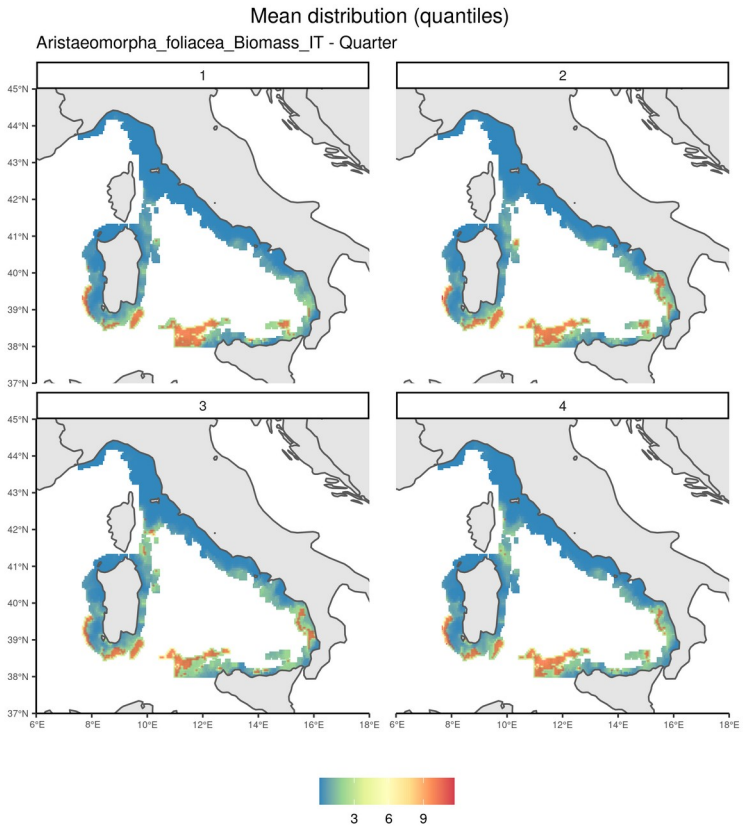
6.3.1 6.3.1 Biomass distribution based on Italian landings

Italian landings from demersal trawls were merged to estimate 'total biomass.'

Estimated biomass distribution is presented in the following figures. Each time the yearly pattern and quarterly patterns are presented.

Squares that are in the quantile 90% are overlaid with red points.





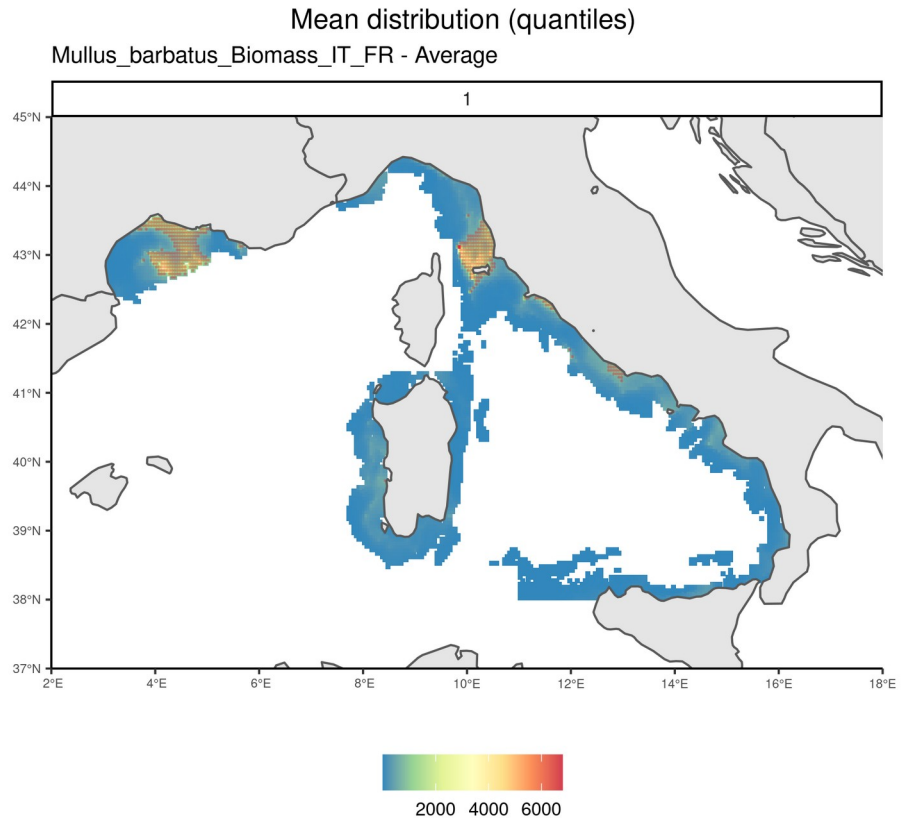
6.4 6.4 Mullus barbatus

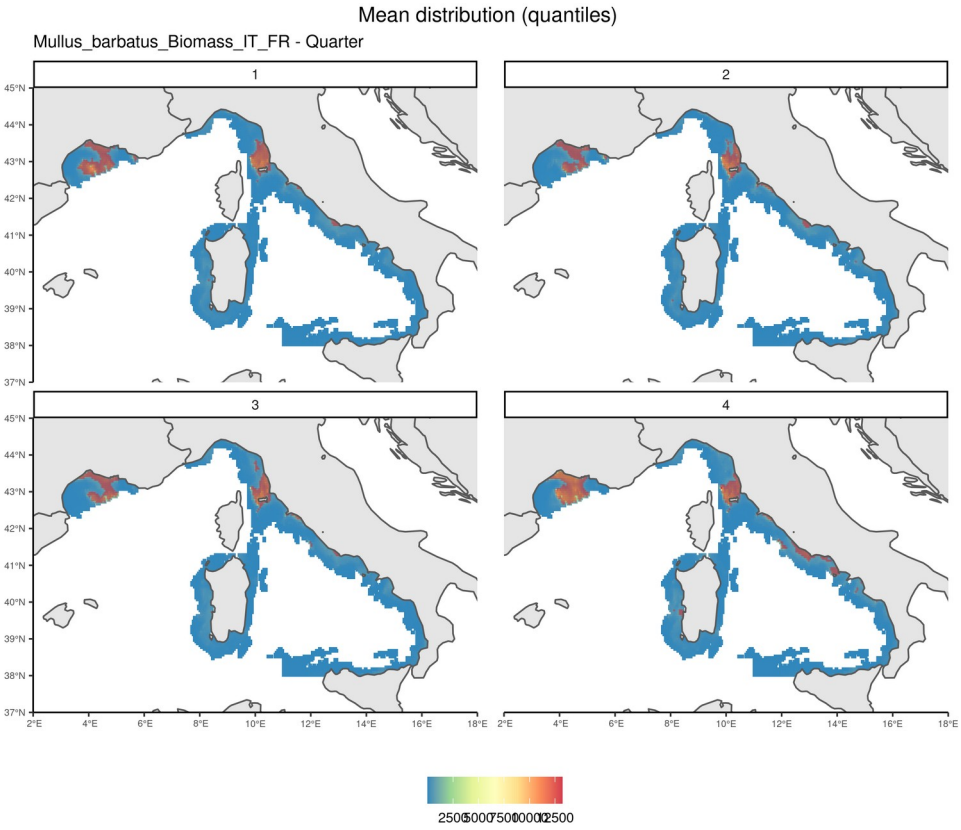
6.4.1 6.4.1 Biomass distribution based on French and Italian landings

Italian, French and Spanish landings from demersal trawls were merged to estimate 'total biomass.' MEDITS data were used to standardize country/gear catchability.

Estimated biomass distribution is presented in the following figures. Each time the yearly pattern and quarterly patterns are presented.

Squares that are in the quantile 90% are overlaid with red points.





7 7 Limitations

- The study is based primarily on the reallocation of landings to GPS positions estimated to be fishing. It is known that fishermen can, within a day, explore a large number of areas resulting in very different catch profiles. These aggregations of different profiles into a single declaration can bias models of species spatial distribution. The maps produced must therefore be critically reviewed by experts familiar with the distribution of these species in the area.
- The study was conducted using bottom trawlers. Bottom trawlers were used because the calculation of LPUEs from VMS/logbook processing is routinely done on these gears, which may be more problematic on passive gears such as nets. However, by filtering on a gear category, part of the space may not have been represented and the distribution of species may not be fully mapped.
- For the distribution between juvenile and adult hake, only the French commercial category structures were available and were applied to the Spanish landings. Data on the Spanish and Italian category structures by commercial category would undoubtedly improve the distribution by stage.

8 8 Outputs to the group

All maps presented in this report were provided to the group in .Rdata format with a document explaining the different objects and attached to the report.

9 References

Alglave, Baptiste, Etienne Rivot, Marie-Pierre Etienne, Mathieu Woillez, James T Thorson, and Youen Vermard. 2022. "Combining Scientific Survey and Commercial Catch Data to Map Fish Distribution." *Ices Journal of Marine Science*. https://doi.org/10.1093/icesjms/fsac032.

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Hintzen, Niels T., Francois Bastardie, Doug Beare, Gerjan J. Piet, Clara Ulrich, Nicolas Deporte, Josefine Egekvist, and Henrik Degel. 2012. "VMStools: Open-Source Software for the Processing, Analysis and Visualisation of Fisheries Logbook and VMS Data." *Fisheries Research* 115-116: 31–43. https://doi.org/10.1016/j.fishres.2011.11.007.