VULNERABLE MARINE ECOSYSTEMS IN EU WATERS – SCENARIOS FOR THE SOCIOECONOMIC ANALYSIS

Deliverable for the STECF ad hoc contracts 2326 & 2327

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Background provided by the Commission

The **Deep-sea Access Regulation**[1] is governing access to deep-sea fishing and setting conditions for protecting "Vulnerable Marine Ecosystems" (VMEs) in EU and international waters. The Deep-sea Access Regulation aims to establish a sustainable exploitation of deep-sea stocks while reducing the environmental impact of these fisheries and preventing significant adverse impacts on VMEs, and to improve the information base for scientific assessment, through data collection.
On 15 September, the Commission has adopted the **Implementing Act (EU) 2022/1614** determining the existing deep-sea fishing areas and establishing a list of areas where vulnerable marine ecosystems are known to occur or are likely to occur[2].
The Implementing act is based on ICES advice (final advice in Jan. 2021 and coordinates in Feb. 2022)[3], which aims to balance the protection of VMEs with the continuation of fishing activities under Scenario 2 – option 1. A list of **87 areas** where VMEs occur or are likely to occur in EU waters has been established in the Implementing Act, based on the ICES advice. The Deep-sea Access Regulation provides that fishing with bottom gears shall be prohibited in all listed areas below a depth of 400 meters.
As per article 9(6) of the framework Regulation (EU) 2016/2336, the Commission "*shall review the list annually on the basis of advice received from the Scientific, Technical and Economic Committee for Fisheries and, where appropriate, amend the list by means of implementing acts. The Commission may remove an area from the list provided that it determines, on the basis of an impact assessment and after consulting the competent scientific advisory body, that there is sufficient evidence to indicate that VMEs are not present, or that appropriate conservation and management measures have been adopted which ensure that significant adverse impacts on VMEs in that area are prevented*."

Terms of References

(Contract 2326) This analysis will perform data operation (incl. coding) and build socioeconomic indicators (by fleet segments), based on STEP 1.1 – GIS analysis. This will assist STECF draft their opinion on the economic performance of the fleet in light of the changes in the list of VMEs areas, established in Regulation (EU) 2022/1614[4], as put forward by the ICES advice of 18 April 2023.

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[1] Regulation (EU) 2016/2336 of the European Parliament and of the Council of 14 December 2016 establishing specific conditions for fishing for deep-sea stocks in the north-east Atlantic and provisions for fishing in international waters of the north-east Atlantic and repealing Council Regulation (EC) No 2347/2002.
[2] Commission Implementing Regulation (EU) 2022/1614 of 15 September 2022 determining the existing deep-sea fishing areas and establishing a list of areas where vulnerable marine ecosystems are known to occur or are likely to occur
[3] ICES. 2021. EU Request to advise on the list of areas where VMEs are known to occur or are likely to occur and on the existing deep-sea fishing areas (ref. (EU)2016/2336.). ICES. 2022. EU request for a Technical Service to provide data output of the ICES 2021 advice on the deep-sea access regulation (ref. (EU)2016/2336) as coordinates for EU waters area only
[4] Commission Implementing Regulation (EU) 2022/1614 of 15 September 2022 determining the existing deep-sea fishing areas and establishing a list of areas where vulnerable marine ecosystems are known to occur or are likely to occur.

- TOR1.1 Based on the findings of the GIS analysis, it is requested to carry out an analysis of landings and landings value by species/stocks and fishing effort in the VMEs closed areas in 2022 at fleet segment level, based on the AER fleet segmentation. The analysis includes calculation of the percentage of the value of landings (by species/stocks and in total) in each VME closure and the reduction of effort, using a representative time series.
- TOR1.2 Building on these results and data, economic indicators (i.e. turnover, value added, gross and net profits) should be calculated by fleet segment comparing the 2022 closures to the ones foreseen in the new ICES advice of 18 April 2023, for the short and long term.

(Contract 2327) This analysis will perform data operation (incl. coding) and build socioeconomic indicators (by fleet segments), based on STEP 1.1 – GIS analysis. This will assist STECF draft their opinion on the economic performance of the fleet in light of the changes in the list of VMEs areas, established in Regulation (EU) 2022/1614, as put forward by the ICES advice of 18 April 2023.

- TOR2.1 Assess the short and long-term impact of the closures on employment by fleet segment.
- TOR2.2 Based on the findings of the GIS analysis, propose and analyse different scenarios on the possible effort reallocation with differentiation between fishing gears, (for example the minimum effort level/fishing area reallocation of effort required to break even). Expose limits and likelihoods of scenarios and the assumptions behind them.

Results should be made in an accessible way for the STECF Plenary, in excel tables (by fleet segment, year, VMEs areas) and in a report, with clear descriptions that can be assessed and replicable by the STECF.

The Commission will make sure that all coordinates of the existing closures (as per ICES advice 2021) as well as the coordinates of the new closures or re-openings (as per ICES advice 2023) are submitted to the contractors.

Summary

Recent decisions have been taken to prevent significant adverse impacts on Vulnerable Marine ecosystems (VMEs) and contribute to the objectives of the EU Common Fisheries Policy (CFP). To complement this, the present study aims at estimating socioeconomic indicators by fleet segment for VMEs, which will assist STECF in drafting their opinion on the economic performance of the fleet in light of the changes in the list of VMEs areas.

The study has merged several datasets to conduct an economic impact evaluation of the VMEs at the fleet-segmentation level defined by the STECF AER dataset. The study split the evaluation into two parts:

- An evaluation of the impacted EU fleet segments in terms of Gross Value Added (GVA), gross and net profits, and the crew engaged in the impacted segments. This also disaggregates the possible socioeconomic impact of each VME alongside the different scenarios in defining those VMEs.
- An evaluation of the possibility for compensation and economic implications by displacing the fishing effort toward surrounding areas or other fishing grounds.

The main findings show that overall, by analysing the finely spatially resolved data, or all scenarios combined, i.e. closures implemented in 2022 and the future closures, as proposed in ICES advice 2023 under scenario C and D, the overall socioeconomic impact would not exceed 10% of the GVA. The most affected segments would be the ESP_DTS_VL2440 and the ESP_DTS_1824 fleet segments with a possibility of offsetting the loss of spatial opportunities by displacing the effort toward surrounding areas. Only a few areas (Gulf of Cadiz) are susceptible to affecting specific fisheries. By analysing more aggregated data (the FDI dataset) it is confirmed that the Spanish fleet is the most affected (ca. 10% of the GVA), the fleet using the DTS fishing techniques, but also small dredgers (DRB) and longliners (HOK) under the ICES Scenario C.

A slight change affecting GVA may lead to a large change in profitability, given some extensive fixed capital assets engaged in those fisheries, and sometimes negative initial profit. Negative profit might add to the loss of spatial opportunities, possibly affecting the concerned segments' engaged crew if saving on labour costs is seen as a solution to balance losses.

However, the study is not addressing possible important drivers in fleet dynamics, including fishing outside the known historical time series examined here (2018-2021), a change in catch rates (LPUEs) depending on the total effort on sites, and the ecological implications on the marine ecosystem productivity as a consequence of adding extra fishing effort on surrounding habitats. On the other hand, if the tested spatial plans (the 87 polygons implemented in 2022 and the alternative ICES scenarios) have been found to have some potential impact, it does not preclude some future benefits on future fishing opportunities from protecting the VMEs or from displacing away toward more rewarding fishing grounds. The present study has looked at potential short-term effects only and does not know about long-term dynamics or the change in labour costs and engaged crews in the medium term; to investigate this, it would need to use some bioeconomic spatial models that would also include population dynamics and ecological considerations.

Contents

1. Data source used in the present socioeconomic evaluation

1.1 STECF AER datasets

Issued every year, the Annual Economic Report (AER) on the European Union (EU) fishing fleet provides a comprehensive overview of the latest information available on the structure and economic performance of the EU Member States fishing fleets. The AER datasets collate effort, landings and economic information at the fleet segment level. A fleet segment is a group of similar vessels, defined using a combination of a vessel length group, main fishing technology and geo indicator (when applicable), operating predominately in a Supra-region.

There is a 2-year lag in collating the AER data due to the time required to process the data. Hence, the data up to 2021 are available at the time of the present study. In this present study, AER 2023 (held in June 2023) has been used to estimate the possible change in the economic indicators per fleet-segment for the period 2018-2021 induced by the presently investigated fishing restrictions (the 87 VMEs closures implemented in 2022, and alternative ICES scenarios). The final 2021 data received by the EWG AER II 2023 have been used. The 2022 data is partial and preliminary and has therefore not been used here as well as AER 2023 data for 2023, which are all nowcasts at the time of writing.

There are known data issues on the economic variables, but in terms of the completeness of the Member States data submissions, STECF 22-06 noted that most countries submitted most of the parameters requested under the call. In many cases, missing data relates to fleet segments with low vessel numbers for which data are hard to obtain. For confidentiality reasons, Member States may aggregate fleet segments into clusters to provide sensitive economic data. In several cases, clustering may not be enough to guarantee confidentiality, and hence, parts of Member States' fleets are not completely covered. In terms of data quality, inevitably, some unreliable estimates for various parameters were detected by the JRC or the EWG 22-02 and in most cases, rectified by the Member States. Incomplete time series data due to either the non-submission of data, questionable data and/or changes in the methodologies in the data collection and data processing, make trend analysis at the EU level impossible without excluding the Member State fleets that are incomplete. Submissions from France and Spain continue to be somewhat incomplete. Some Member States continue to have problems in collecting comprehensive data sets for the under 10 meters segments. Transversal data sets for some effort and landing variables continue to not be provided at the correct aggregation levels (for e.g. days at sea at FAO fishing areas 3 or 4 or live weight and value of landings by FAO species 3-alpha code).

The present study recalculates the part of the AER economic indicators impacted by the area-based management scenarios tested here with a spatial overlay analysis (see next sections). The re-estimated economic indicators as defined in STECF (2022) are:

- Gross Value Added is the net output of a sector after deducting intermediate inputs from all outputs. It measures the contribution to GDP made by an individual producer, industry or sector. It is expressed as:
  GVA= (LandingsKg * PricePerKg) + OtherIncomes - UnpaidLabour – VarCosts - FixedCosts

- Gross profit is the normal profit after accounting for operating costs, excluding capital costs. Also referred to as gross cash flow, i.e. the flow of cash into and out of a sector or firm over a period of time. It is expressed as:

GrossProfit = GVA –PersonnelCosts

- Net profit is the difference between revenue and explicit costs, and opportunity costs. Explicit costs include all operational costs, such as wages, energy, repair and other variable and non-variable costs. Net profit differs from gross profit in that it includes depreciation and opportunity costs of capital. It measures the efficiency of a producer in society's view by evaluating the total costs of inputs (excluding natural resource costs) in comparison to outputs or revenue. It is expressed as: NetProfit = OperatingProfit – CapitalOpportunityCosts- (valueOfPhysicalCapital * (100.0-AnnualDepreciationRate)/100.0)

1.2 STECF FDI datasets

The Fisheries Dependent Information (FDI) database has been used to retrieve spatial data of effort and landings by c-square at 0.5 x 0.5 degrees of resolution in the NWW and WWW areas. Spatial data are obtained by STECF through an official data call to the MSs, which submitted gridded fishing pressure by c-square after having obtained those data nationally from VMS, AIS or Logbooks information. This information might therefore come with different accuracy. Information about the quality of the data provided by MSs can be found in the STECF EWG 20-10 report available at https://stecf-jrc-ec-europa.eu/reports/fdi.

Some of the data in the FDI database are marked as confidential data by the Member States providing the data., the FDI spatial dataset is publicly disseminated after being aggregated at EU level to preserve the confidentiality of the data [5]. For the present work, it was necessary to access these original FDI data disaggregated at the country level, therefore including confidential and non-confidential data. The FDI datasets Table I (effort data), and Table H (landing data) have been used in the present evaluation.

There are limitations existing in the collection of spatial data for small-scale fisheries; in the FDI dataset, the quality of data for the vessel category below-12m in the Mediterranean and Black Sea and below 10 m for the other waters is lower than the quality of data for the other vessel categories.

The FDI data collect some records that are declared to be issued from the Deep-sea component. However, there are some doubts about the accuracy of this reporting. Hence, the quality of the information provided for deep fishing trips, in the FDI EWG reports it is not mentioned a detailed assessment relating to the DEEP variable. Moreover, in the report STECF-21-12 in the national chapter for Portugal, it was mentioned that "for the year 2020, not all trips were classified for the DEEP indicator, whereby this indicator should be used with reservations by the end user". The DEEP information is likely deduced from aggregating some trips that comply with some threshold (>100kg of deep-sea species per trip) but cannot inform on the remaining trips a given vessel sometimes visiting those areas could do, given the data are not trip and vessel based.

For an economic evaluation, the entire revenue from fishing the vessels did going at sea should be accounted for, including visits to the deep sea c-squares and any others besides them, within a trip or in another season. It is unclear if FDI record aggregation of vessels/records labelled DEEP has only consisted of vessels conducting deep-sea fishing (more likely those records aggregated deep-sea trips, whatever the vessels behind that

[5] Scientific, Technical and Economic Committee for Fisheries (STECF) – Fisheries Dependent Information – FDI (STECF-20-10). EUR 28359 EN, Publications Office of the European Union, Luxembourg, 2020, ISBN 978-92-76-27166-6, doi:10.2760/61855, JRC122995.

conducted those trips). On these grounds, the present evaluation has chosen not to use the DEEP information found in the FDI.

1.3 Aggregated VMS data provided by ICES

The study is complemented with finer spatially resolved data provided by ICES for the period 2018-2021 to increase the accuracy in the landings, effort and economic estimates impacted by the VMEs. An improved geographical resolution with an accurate delineation of the core fishing grounds will improve the estimation of the effort displacement effects compared to the use of the spatial FDI only. Aggregated data reflect more or less the actual distribution of the fishing activity depending on the grid cell resolution in use. However, for large grid cells like the FDI 0.5 c-square grid cell, the fraction of the VME areas typically constitutes only a part of a c-square. A misalignment and overestimation of the effect are very likely at the 0.5 x 0.5-degree resolution of the FDI, which should be less prominent with the 0.05-degree VMS c-squares grid cells.

Aggregated VMS data are issued from the annually collated VMS data via an ICES data call. ICES is mandated to collect and merge VMS/Logbook data for fishing activities in the North East Atlantic to provide ICES advice on the spatial distribution and impact of fisheries. The ICES database is in a more disaggregated format than the format publicly available. The Member States have already submitted the data in question to ICES in the context of the data call on ICES VMS/Logbook data for fishing activities in the North East Atlantic. The collection of this data is co-financed under the European Maritime and Fisheries Fund (EU) 508/2014 and the European Maritime, Fisheries and Aquaculture Fund (EU) 2021/1139 and is subject to the provisions of the Data Collection Framework (EU) 2017/1004, including Article 17 regarding the submission of detailed data for scientific analysis and publication.

The VMS-related data treated for the present study are annual fishing effort and swept area ratio in aggregated 0.05 c-square cells segmented for each type of mobile bottom-contacting gear (metier DCF level 6) and vessel size category (e.g., VL1218, VL1824, VL2440, VL40XX).

This study's aggregated VMS data from ICES comprised country-specific data, including Belgium BEL, Spain ESP, France FRA, United Kingdom GBR, Ireland IRL, and Netherlands NLD. Portugal PRT data were also included but only for segments 12-15m, which is further not likely to be impacted by VMEs tested here.

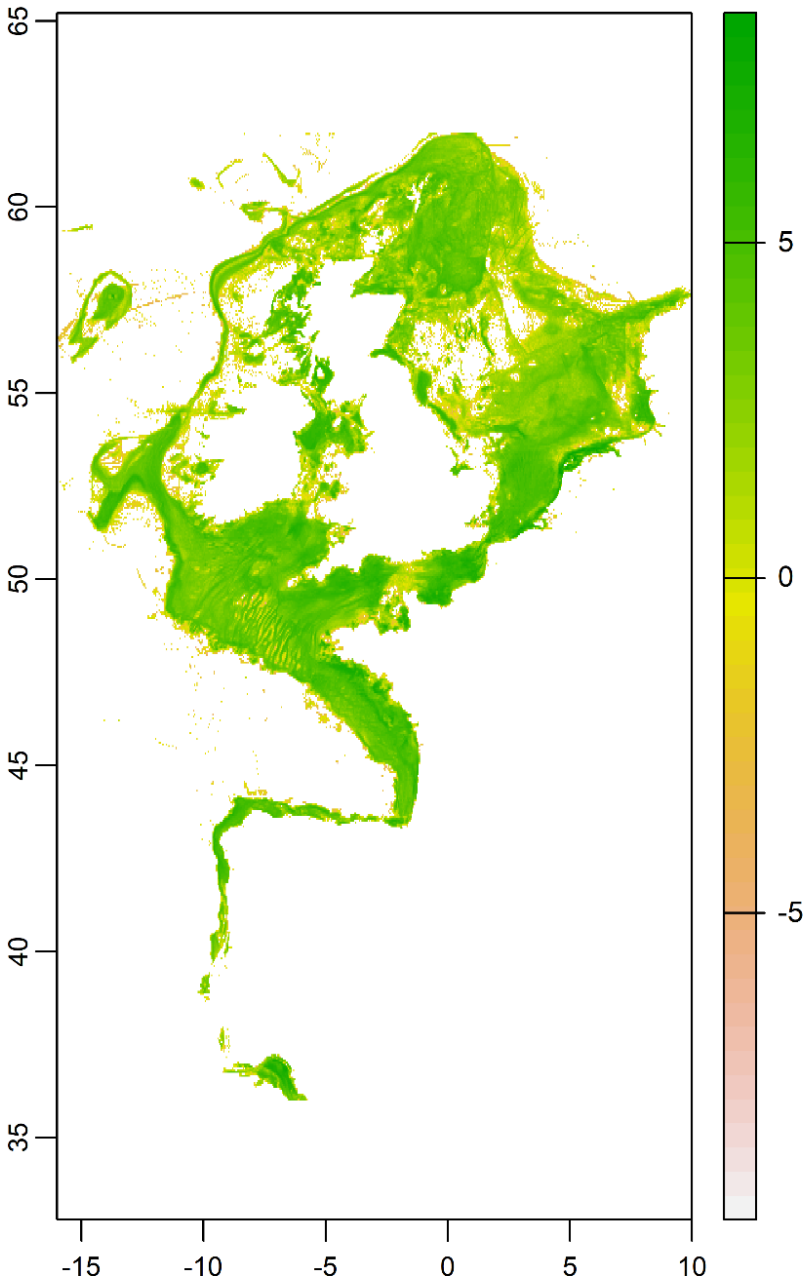

Figure 1. *VMS data in NWW and SWW waters collated by ICES for this study. Extract for countries BEL ESP FRA GBR IRL NLD and mobile-bottom-contacting gears only. Unexpectedly, the data set contained very few PRT records (i.e. PRT is only 12-15m data).*

1.4 Merging AER and FDI datasets

The AER dataset contains the record of landings, effort and economic variables alongside a fleet segmentation that combines the country, the fishing technique, and the vessel size category. Conversely, the FDI dataset contains the information on landings and effort disaggregated over a 0.5-degree c-square grid (in NWW and SWW) and per DCF métier level6. The developed merging procedure here transfers the spatial information to the AER

by arranging the link between the two datasets using a shared key (the fleet segment) defined as the combination of a country, fishing technique and vessel size category. A robust merging procedure is implemented where the merging with a complete key is done first (vesselSizeCategory- FishingTechnique-subRegion), then a degraded key is used on the leftover, unmatched datasets (vesselSizeCategory-FishingTechnique), and finally, a third level of degradation of the key is used (vesselSizeCategory) for the remaining unmatched part.

Once the merging alongside the shared key is done, the FDI effort in each 0.5-degree c-square and for each fleet segment is used to disaggregate the AER landings weight and value, the kWeffort, and the economic variables (i.e. other income, unpaid labour, personnel costs, variable costs, and other non-variable costs) that are eventually used to compute c-square-based GVAs following the equation described in section 1.1. The spatially disaggregated AER economic variables have been expressed in value per unit of kWeffort, which allows recomputing each economic variable in each c-square by multiplying with the disaggregated kWeffort found in the c-square. Some other economic variables do not require spatial disaggregation and have been kept aside from the merging but used later to compute the net profit from any change that would impact c-square-based GVAs (i.e. induced by a displacement of effort, see sections 2.2 and 3.2).

The species information has not been kept along the merging, and species landings have been aggregated per fleet segment before the merging to save extensive computation time. Indicators of the contribution of deep-sea species[6] in terms of revenue in the impacted fleet segments may be later retrieved from the same data treatment.

From the merging, the catch rates in each grid cell are deduced from the recorded landings and effort in the AER, which is further used to recompute hypothetical catches alongside effort displacement scenarios (section 2.2).

***Table 1**. Outcomes (check on the FDI landed tons) of the stepwise, robust merging of the AER dataset with the FDI dataset in the NAO region. The merging is done stepwise by degrading the common key information to merge as much data as possible until it is not possible to match the remaining records.*

Key	year	fditotwghtlandg
Initial FDI landing tons Year 2018	2018	3662950.707
year, country, vessel_length, fishing_tech, sub_reg	2018	2729273.470
year, country, vessel_length, fishing_tech	2018	25718.314
year, vessel_length	2018	906559.061
unfortunate lost	2018	1399.862
finally left in the merged dataset	2018	3661550.845
Initial FDI landing tons Year 2019	2019	3126036.242
year, country, vessel_length, fishing_tech, sub_reg	2019	2253883.822
year, country, vessel_length, fishing_tech	2019	8717.158
year, vessel_length	2019	859824.169
unfortunate lost	2019	3611.093
finally left in the merged dataset	2019	3122425.149
Initial FDI landing tons Year 2020	2020	3058494.703
year, country, vessel_length, fishing_tech, sub_reg	2020	2216145.650
year, country, vessel_length, fishing_tech	2020	51935.791
year, vessel_length	2020	784647.948
unfortunate lost	2020	5765.314

[6] FAO 3-letters code of the Annex I deep-sea species of *https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32016R2336*

Key	year	fditotwghtlandg
finally left in the merged dataset	2020	3052729.389
Initial FDI landing tons Year 2020	2021	2024498.346
year, country, vessel_length, fishing_tech, sub_reg	2021	1787264.619
year, country, vessel_length, fishing_tech	2021	44077.361
year, vessel_length	2021	185645.310
unfortunate lost	2021	7511.056
finally left in the merged dataset	2021	2016987.290

1.5 Merging AER and VMS datasets

The procedure to merge the AER dataset with the aggregated VMS dataset is similar to the one described for merging with the FDI, and it consists of substituting in the same workflow FDI spatial data with the VMS spatial data information. Merging AER with VMS allows for dispatching the AER economic values on a much finer grid of c-squares defined this time by a 0.05 x 0.05-degree resolution. The aggregated VMS data also hold the country information, further refining the accuracy of the AER spatial disaggregation split by country-specific fleet segment.

The robust merging efficiency matched all VMS data with AER data, as 100% is successfully merged with VMS in fishing hours or in kW hours (Table 2 below). The robust merging with the FDI is less successful, which would partly relate to the difficulty in merging the smaller, less-powered vessels (not covered in the VMS dataset).

Table 2. *Outcomes of the stepwise, robust merging of the AER dataset with the VMS dataset. The merging is done stepwise by degrading the common key information to merge as much data as possible until it is not possible to match the remaining records*

Key	year	vmstotfishhours	vmstotKwfishhours
init 2018	2018	4543618.36	1612415176
year, country, vessel_length, fishing_tech, sub_reg	2018	4137647.28	1433357557
year, country, vessel_length, fishing_tech	2018	376263.88	166146009
year, vessel_length	2018	29707.19	12911610
unfortunate lost	2018	0.00	0
finally left	2018	4543618.36	1612415176
init 2019	2019	4313356.02	1547708649
year, country, vessel_length, fishing_tech, sub_reg	2019	3914491.16	1373544388
year, country, vessel_length, fishing_tech	2019	370142.38	163798111
year, vessel_length	2019	28722.48	10366150
unfortunate lost	2019	0.00	0
finally left	2019	4313356.02	1547708649
init 2020	2020	3909610.47	1452073824
year, country, vessel_length, fishing_tech, sub_reg	2020	3545767.47	1295161753
year, country, vessel_length, fishing_tech	2020	328727.15	145915347
year, vessel_length	2020	35115.86	10996723
unfortunate lost	2020	0.00	0
finally left	2020	3909610.47	1452073824
init 2021	2021	4088654.7	1500192241
year, country, vessel_length, fishing_tech, sub_reg	2021	2771784.7	1349474967
year, country, vessel_length, fishing_tech	2021	280014.7	142523409
year, vessel_length	2021	1036855.3	8193865
unfortunate lost	2021	0.0	0
finally left	2021	4088654.7	1500192241

1.6 Deep-Sea Vulnerable Marine Ecosystems

The following datasets were used to define the geography of the areas in Northeast Atlantic where VMEs are known to occur or are likely to occur:

1. The geographical dataset provided by DG MARE with the definitions of 87 VME areas selected among the VME areas in the *Scenario 2 option 1* produced by ICES advice in 2022[7].
This scenario was used in the Implementing Act (EU) 2022/1614. It includes a) 0.05 degrees c-squares[8] between 400–800m depth with VME habitats as well as c-squares with high and medium VME index, regardless of fishing activity, b) c-squares with a low VME index only if adjacent to c-squares with medium to high VME index, and c) low VME index c-squares if bottom-contacting gear fishing intensity (SAR) is also low (SAR < 0.43).

2. Geographical datasets with the definitions of VME areas for *Scenario C* and *Scenario D* produced by ICES advice in 2023[9].
In the ICES advice, VMEs protection polygons were determined (see illustration below) for the scenarios A and B on evidence of VMEs occurrence only; while for scenarios C, D and E they were determined on evidence of both VMEs occurrence and mobile bottom-contacting gear fishing intensity. In particular, scenario C includes a) c-squares with VME habitats and c-squares with high and medium VME index, b) c-squares with low VME index if SAR < 0.43, and c) c-squares with low VME index and SAR ≥ 0.43, but only if adjacent to c-squares with low VME index with SAR < 0.43, or c-squares with VME habitat, high or medium VME index; while scenario D includes c-squares with VME habitats and c-squares with high, medium and low VME index, only if SAR < 0.43.

Illustration extracted from the ICES 2022 advice on criteria delineating the VMEs. SAR: swept Area Ratio gives the number of time the surface of a c-square have been swept annually. A SAR threshold of 0.43 is based on evidence from the NAFO area indicating that a threshold of that scale was ecologically relevant for sea pens, which are the least sensitive (i.e. most resilient) taxa to bottom trawling.

Scenario	Known VME occurence		Likely VME occurrence						Potentially supports VME
	VME Habitat		VME Index						VME Physical Element
			High		Medium		Low		
	SAR < 0.43	SAR ≥ 0.43	SAR < 0.43	SAR ≥ 0.43	SAR < 0.43	SAR ≥ 0.43	SAR < 0.43	SAR ≥ 0.43	
A									
B									
C									
D									
E									

Included in VME polygon (primary selection).
Included in VME polygon if adjacent to primary selection.
Included in VME polygon if associated with VME habitat or indicator record.

[7] ICES 2021. EU Request to advise on the list of areas where VMEs are known to occur or are likely to occur and on the existing deep-sea fishing areas (ref. (EU)2016/2336.). In Report of the ICES Advisory Committee, 2021. ICES Advice 2021, sr.2021.01. https://doi.org/10.17895/ices.advice.7507

[8] Rees, 2003. "C-squares," a new spatial indexing system and its applicability to the description of oceanographic datasets. Oceanography, 16: 11–19. https://doi.org/10.5670/oceanog.2003.52

[9] ICES 2022. EU request for a Technical Service to provide data output of the ICES 2021 advice on the deep-sea access regulation (ref. (EU)2016/2336) as coordinates for EU waters area only. In Report of the ICES Advisory Committee, 2022. ICES Advice 2022. sr. 2022.02. https://doi.org/10.17895/ices.advice.10039

2. Socioeconomic analysis of the impacted fleets by the closed areas based on the merging of AER and FDI datasets

2.1 The overlay effect of VME closed areas estimated with the coupling of AER to FDI

Based on the findings of the GIS analysis, it is requested to carry out an analysis of landings and landings value by species/stocks and fishing effort in the VMEs closed areas in 2022 at the fleet segment level, based on the AER fleet segmentation. The analysis includes calculating the percentage of the value of landings (by species/stocks and in total) in each VME closure and the reduction of effort using a representative time series, i.e. 2018-2021. The 2021 data from the AER 2023 were made available for this analysis.

An overlay of the disaggregated AER economic indicators with the closed areas is done based on the economic disaggregation over the FDI c-squares grid cell. The disaggregation of the AER variables is described in the section 1.4 "Merging AER with FDI". The overlay assumes that the indicator in each c-square is the result of the activity in the fishable areas within this c-square, which is the fraction of the c-square with bathymetry > -800m for the bottom trawlers, and the entire c-square areas for other gears (i.e. netters and longliners).

The disaggregated GVA in each c-square impacted by the closed area lying within the same c-square is then the product of the GVA in the cell with the ratio of the surface area of the closure in the fishable area over the surface area of the fishable area.

Building on these results and data, economic indicators (gross value added, gross and net profits) have been calculated by fleet segment, comparing the 2022 closures established in Regulation (EU) 2022/1614 to the ones foreseen in the new ICES advice of 18 April 2023 (see section 1.6) for the potential short term effects.

The short-term impact of the closures on employment by fleet segment is further assessed. It is especially quantified the number of crew engaged the closure scenarios would impact, also by looking at a possible change in GVA or profit sign indicating the crew are at risk in the short term.

The estimated spatially disaggregated GVA layers show that most closed areas for VMEs are located at the edge of fishable areas for which positive economic returns have been made during the 2018-2021 period (Figure 2). By nature, ICES scenarios ICES C and D impact additional closed areas in previously fished areas (Figures 3 and 4, 115 polygons for ICES Scenario C), especially off the northern Spanish coast. The possibly impacted GVA can be by several million Euro given the coarse size of the 0.5 c-squares grid cells.

Based on the estimates deduced from the coupling of the AER to FDI dataset, assuming there would be no possibility to displace the effort to other areas to compensate for the losses (but see next section 2.2), the Spanish fleet using bottom fishing techniques (DTS) is found potentially the most affected (6.87% of GVA comprised in the areas specified Closure2022 for ESP_DTS_VL1824, 5.15% for ESP_DTS_VL1218; Figure 5 and Table 3). For this scenario, approximately 3.5% of GVA is potentially affected for Portuguese segments PRT_DTS_VL1218 and PRT_DTS_1824. These latter segments are less affected by ICES Scenario C. For scenario C, The ESP_DTS_VL2440 is one of the most affected, with 7.47% of GVA found within the tested closed areas (Table 3). However, the Spanish fleet segments using nets, dredges or longlines are the most affected in Scenario C, with 6.61% of GVA impacted for ESP_HOK_VL1012 and 6.52% for ESP_DRB_VL1012 (Table 3).

It is observed that the impacted GVA for these fleets come from a few locations (Figure 6, and Annexes), and only from one or two 0.5-degree c-squares for the DTS (Figure 6). Hence, the Closure2022 scenario is potentially the most impacting in the Gulf of Cadíz (Figure 7), the ICES Scenario C on the northern Spanish coast (around the Aviles Canyon, Figure 8), and the ICES Scenario D in the Celtic Seas (around the Porcupine Seabight, Figure 9). Therefore, any mitigation purpose might pay particular attention to those impacting c-squares and maybe less to the chosen scenario.

The Spanish fleets are also found to be the most affected in 2021 (Table 4, 2021 estimates) by the proposals for VME closures with up to -7.20% change in average GVA (representing 7.31 MEuro in 2021) for ESP_DTS_VL1218 and -10.8% for ESP_DTS_VL1824 (representing 18.46 MEuro) induced by the already enforced 2022 closure, and -6.07% of GVA for segment ESP_HOK_VL1218 (representing 8.95 MEuro impacted) or ESP_HOK_VL1012 with -8.93% of GVA (representing 4.68 MEuro) if scenario ICES Sce C would apply. Sce C also affects ESP_DTS_2440 with -7.93% of GVA (representing 56.79 MEuro). GVA of FRA_HOK_VL2440 is also affected by 12.34% by this scenario. With up to seven segments affected by more than 1% change in GVA, ICES Scenario D and Closure2022 affect fewer fleets than the 14 fleets affected by ICES Scenario C (Table 4 and Figure 10).

These changes in GVA translate into bigger gross and net profit changes, given the large operational costs (mainly wages and salaries) and fixed capital invested in those fisheries (Table 4). The engaged crew in these Spanish segments for this level of loss of opportunities is large (Figure 11 "Engaged crew" below). However, such a change might not immediately threaten the crew if it is assumed that saving on labour costs only occurs when the GVA or net profit becomes negative. This is excepting the segment ESP_DTS_VL1218, where the net profit is initially negative, currently engaging 471 crew onboard. Net profit is also negative for the segment ESP_HOK_VL2440 with -11.49 MEuro and FRA_HOK_VL2440 with -9.84 MEuro, which makes any change in GVA threatening the engaged crew (817 and 282 crew members, respectively).

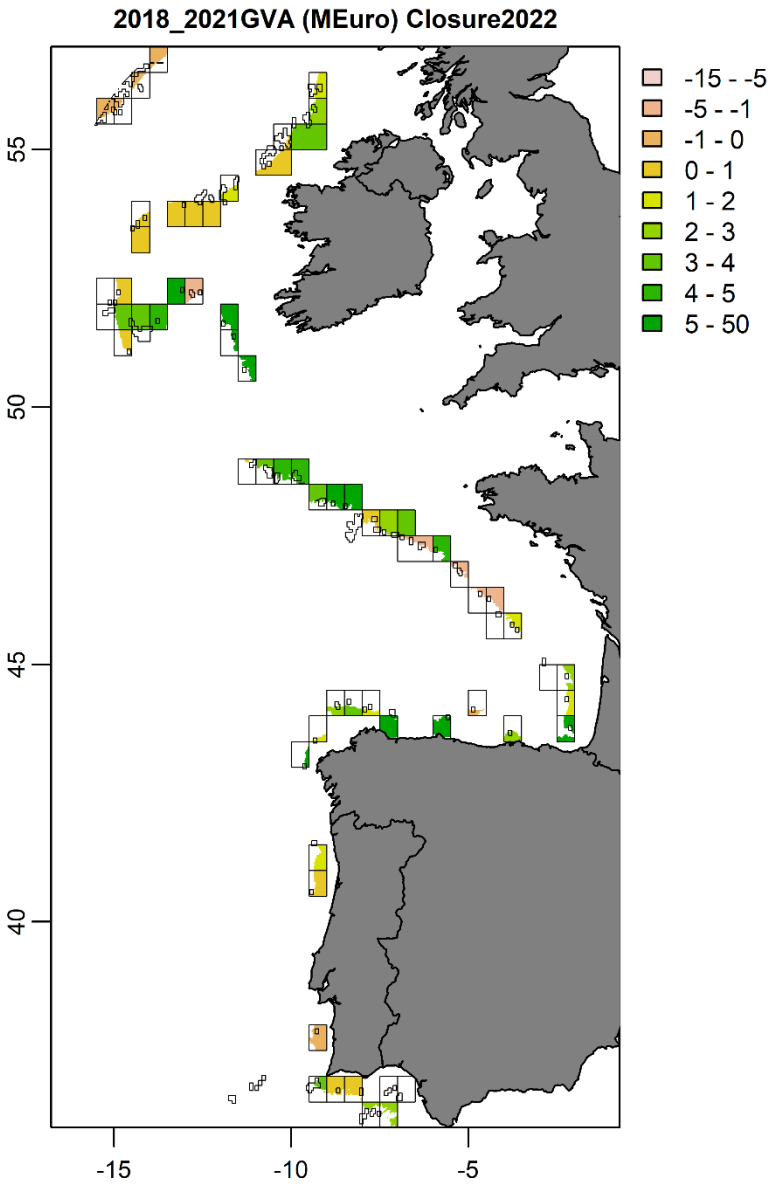

Figure 2. *Gross Value Added (GVA) in each of the fishable area (bathymetry <-800m) lying within the 0.5 x 0.5 degrees c-squares where the VMEs are defined according to* scenario *Closure 2022*.

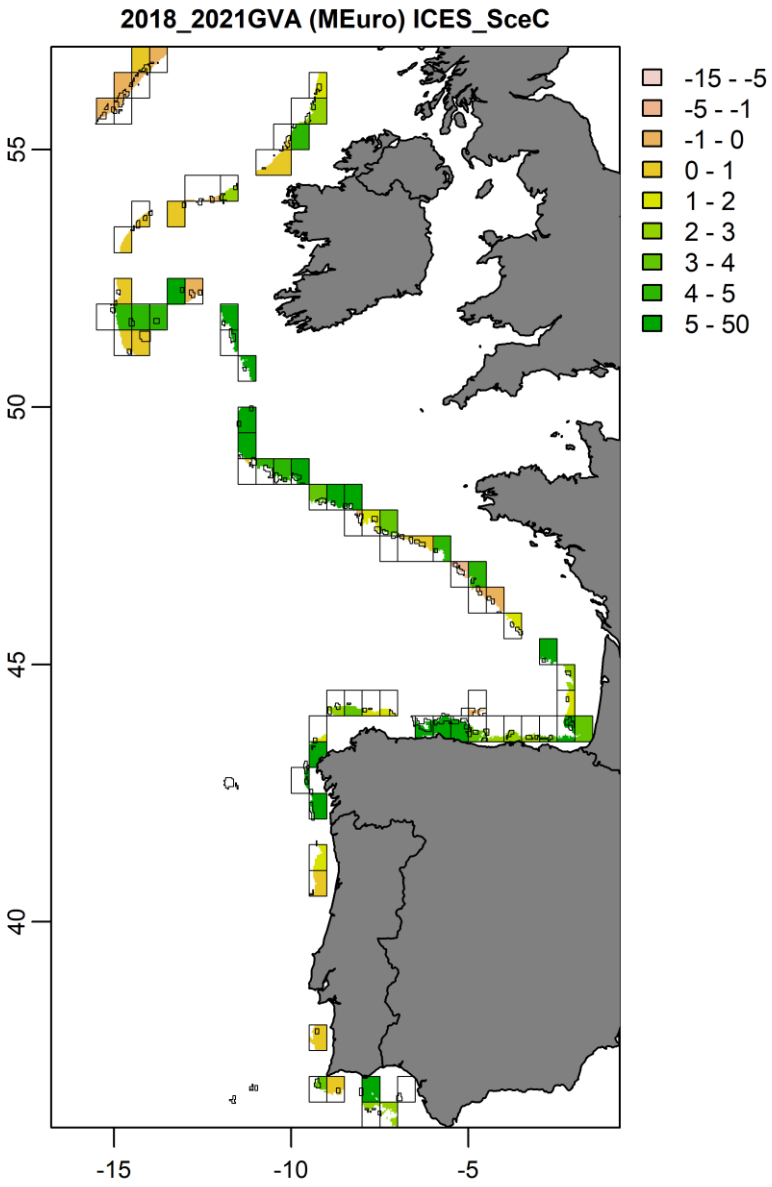

Figure 3. *Gross Value Added (GVA) in each of the fishable area (bathymetry <-800m) lying within the 0.5 x 0.5 degrees c-squares where the VMEs are defined according to scenario ICES Scenario C.*

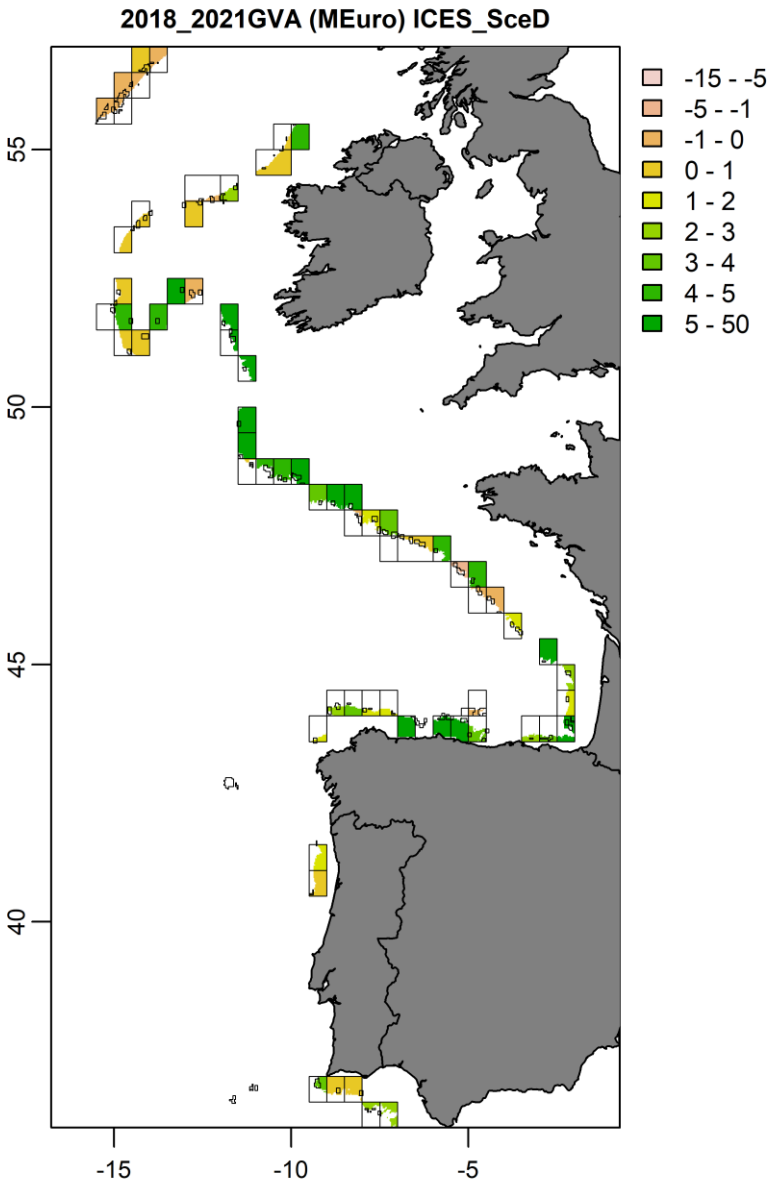

Figure 4. *Gross Value Added (GVA) in each of the fishable area (bathymetry <-800m) lying within the 0.5 x 0.5 degrees c-squares where the VMEs are defined according to scenario Scenario D*

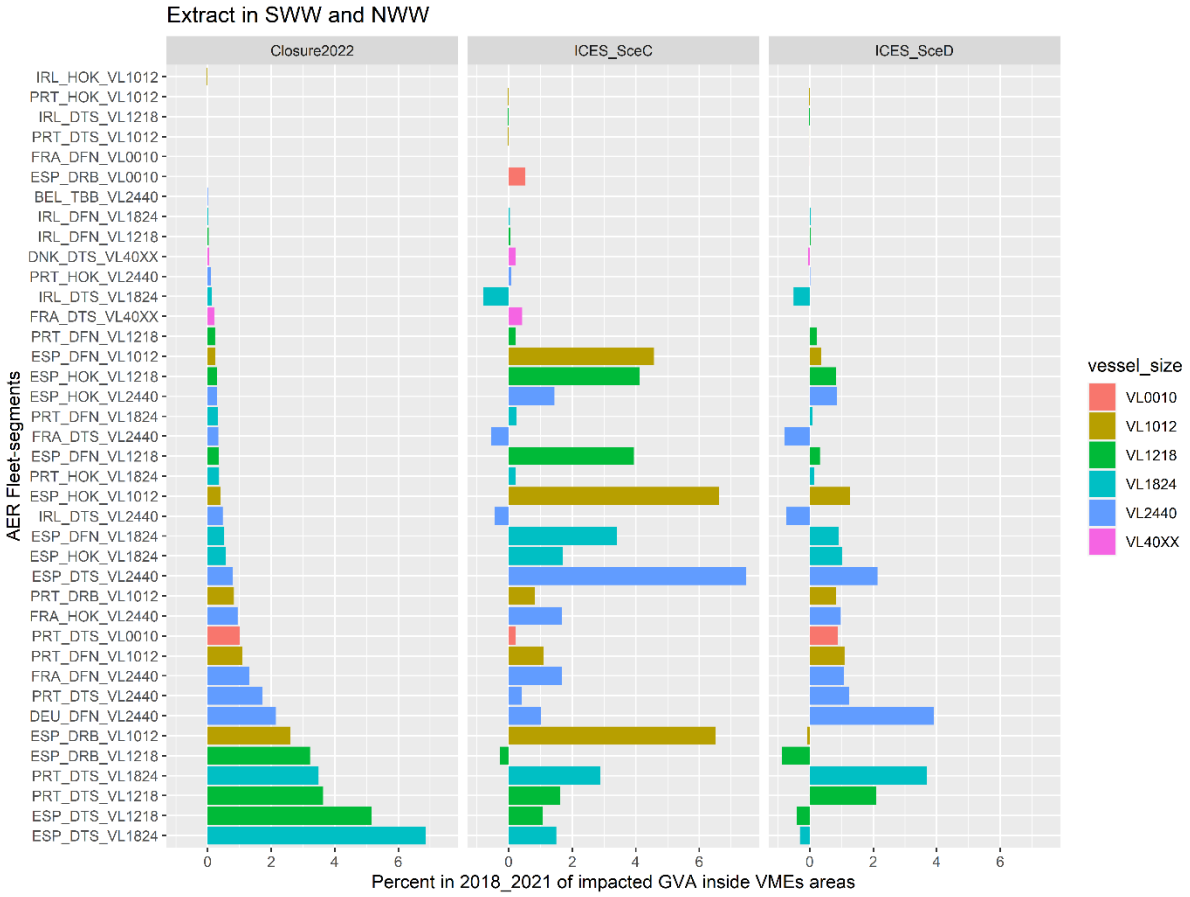

Figure 5. *Percent of the average 2018-2021 fleet-segment GVA impacted by the VMEs depending on the scenario (Closure 2022, ICES Sce. C and ICES Sce D) and of the main AER fleet-segments. To obtain these estimates, the fleet-specific spatially disaggregated GVA over FDI c-squares (see section 1.4) have been used and averaged over years, and the impacted FDI c-square GVA values have been further multiplied by the ratio of the surface area of the VMEs in the cells over the fishable surface area in each cell (the fishable area is defined by the bathymetry >-800m for bottom fishing, or the entire cell area for longliners and netters, and corresponds to the area where the catch is supposed to have occurred, generating the income from landings). Negative percentages arise from negative GVA values.*

Table 3. *Underlying data of the previous figure 5 giving percent of impacted GVA. (in red if >5%).*

fleet segment	Scenario	%	Scenario	%	Scenario	%
ESP_DTS_VL1824	Closure2022	6.87	ICES_SceC	1.49	ICES_SceD	-0.31
ESP_DTS_VL1218	Closure2022	5.15	ICES_SceC	1.07	ICES_SceD	-0.4
PRT_DTS_VL1218	Closure2022	3.63	ICES_SceC	1.63	ICES_SceD	2.1
PRT_DTS_VL1824	Closure2022	3.49	ICES_SceC	2.88	ICES_SceD	3.68
ESP_DRB_VL1218	Closure2022	3.22	ICES_SceC	-0.29	ICES_SceD	-0.88
ESP_DRB_VL1012	Closure2022	2.61	ICES_SceC	6.52	ICES_SceD	-0.07
DEU_DFN_VL2440	Closure2022	2.15	ICES_SceC	1.02	ICES_SceD	3.91
PRT_DTS_VL2440	Closure2022	1.72	ICES_SceC	0.41	ICES_SceD	1.23
FRA_DFN_VL2440	Closure2022	1.32	ICES_SceC	1.67	ICES_SceD	1.08
PRT_DFN_VL1012	Closure2022	1.09	ICES_SceC	1.09	ICES_SceD	1.09
PRT_DTS_VL0010	Closure2022	1.01	ICES_SceC	0.21	ICES_SceD	0.88

FRA_HOK_VL2440	Closure2022	0.94	ICES_SceC	1.67	ICES_SceD	0.98
PRT_DRB_VL1012	Closure2022	0.83	ICES_SceC	0.83	ICES_SceD	0.83
ESP_DTS_VL2440	Closure2022	0.79	ICES_SceC	7.47	ICES_SceD	2.13
ESP_HOK_VL1824	Closure2022	0.56	ICES_SceC	1.7	ICES_SceD	1.01
ESP_DFN_VL1824	Closure2022	0.52	ICES_SceC	3.41	ICES_SceD	0.91
IRL_DTS_VL2440	Closure2022	0.47	ICES_SceC	-0.45	ICES_SceD	-0.74
ESP_HOK_VL1012	Closure2022	0.41	ICES_SceC	6.61	ICES_SceD	1.27
PRT_HOK_VL1824	Closure2022	0.36	ICES_SceC	0.23	ICES_SceD	0.14
ESP_DFN_VL1218	Closure2022	0.35	ICES_SceC	3.94	ICES_SceD	0.32
FRA_DTS_VL2440	Closure2022	0.33	ICES_SceC	-0.55	ICES_SceD	-0.79
PRT_DFN_VL1824	Closure2022	0.32	ICES_SceC	0.25	ICES_SceD	0.09
ESP_HOK_VL2440	Closure2022	0.3	ICES_SceC	1.44	ICES_SceD	0.86
ESP_HOK_VL1218	Closure2022	0.29	ICES_SceC	4.12	ICES_SceD	0.83
ESP_DFN_VL1012	Closure2022	0.24	ICES_SceC	4.57	ICES_SceD	0.36
PRT_DFN_VL1218	Closure2022	0.23	ICES_SceC	0.22	ICES_SceD	0.22
FRA_DTS_VL40XX	Closure2022	0.21	ICES_SceC	0.42	ICES_SceD	0
IRL_DTS_VL1824	Closure2022	0.12	ICES_SceC	-0.8	ICES_SceD	-0.51
PRT_HOK_VL2440	Closure2022	0.09	ICES_SceC	0.07	ICES_SceD	0.02
DNK_DTS_VL40XX	Closure2022	0.04	ICES_SceC	0.21	ICES_SceD	-0.06
IRL_DFN_VL1218	Closure2022	0.03	ICES_SceC	0.04	ICES_SceD	0.04
IRL_DFN_VL1824	Closure2022	0.02	ICES_SceC	0.04	ICES_SceD	0.04
BEL_TBB_VL2440	Closure2022	0	ICES_SceC	0	ICES_SceD	0
ESP_DRB_VL0010	Closure2022	0	ICES_SceC	0.52	ICES_SceD	0
FRA_DFN_VL0010	Closure2022	-0.01	ICES_SceC	-0.01	ICES_SceD	-0.01
PRT_DTS_VL1012	Closure2022	-0.01	ICES_SceC	-0.02	ICES_SceD	-0.01
IRL_DTS_VL1218	Closure2022	-0.02	ICES_SceC	-0.03	ICES_SceD	-0.01
PRT_HOK_VL1012	Closure2022	-0.02	ICES_SceC	-0.02	ICES_SceD	-0.02
IRL_HOK_VL1012	Closure2022	-0.02	ICES_SceC	-0.02	ICES_SceD	0

Figure 6. *Absolute GVA values estimated realised inside VMEs areas decomposed per fleet-segments and in each FDI c-square grid. This illustration reflects the possible foregone GVAs (or avoided loss if GVA is found negative) in each area in case the tested scenarios (Closure2022, ICES Sce C and ICES Sce D) would have applied in during the years 2018-2021.*

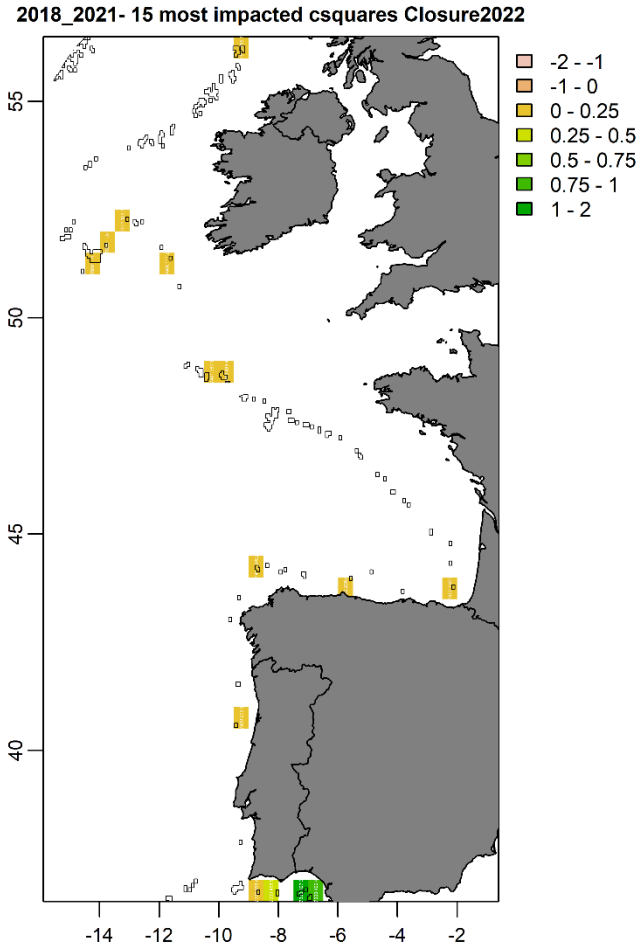

Figure 7. *The 15 most impacted c-squares by the VMEs closed areas alongside the three scenarios. The color scale gives the possibly impacted GVA in MEuro. (see in Appendix the map_impacted_csquares.html for an interactive map)*

C-SQUARE	GVA impacted (Euro)
7300:467:3	1237660
7300:466:4	762681
7300:468:3	253779
7400:489:4	239024
7300:468:4	203968
7501:111:2	167081
7401:380:3	153733
7501:113:4	134878
7400:209:3	122301
7400:235:4	115075
7501:123:1	114382
7400:248:2	95168
7400:132:3	94770
7500:469:1	91685
7501:114:1	90884

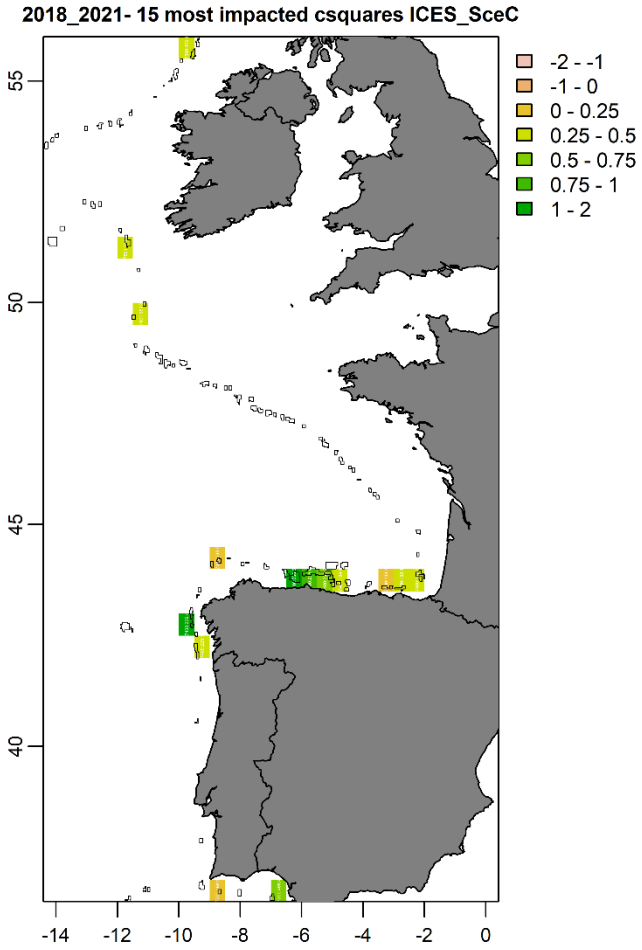

Figure 8. *The 15 most impacted c-squares by the VMEs closed areas alongside the three scenarios.*

C-SQUARE	GVA impacted (Euro)
7400:229:4	1286394
7400:236:3	1043556
7400:235:4	863550
7300:466:4	659677
7400:235:3	596560
7400:132:3	411536
7500:459:4	391184
7400:132:4	369713
7400:229:1	315735
7501:111:2	314288
7400:134:4	280621
7401:391:3	261082
7400:133:3	204864
7300:468:4	203968
7400:248:2	193031

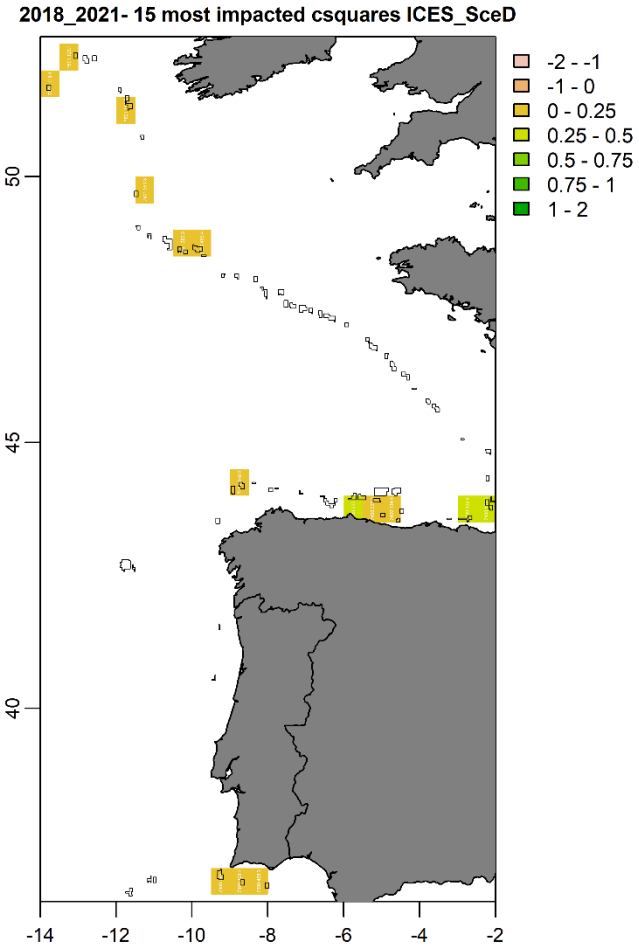

Figure 9. The 15 most impacted c-squares by the VMEs closed areas alongside the three scenarios.

C-SQUARE	GVA impacted (Euro)
7400:132:4	369713
7400:235:4	319070
7400:132:3	312812
7300:468:3	209430
7501:111:2	206956
7300:468:4	203968
7400:248:2	193031
7400:489:4	139783
7401:391:3	135767
7300:469:3	114659
7400:235:3	103912
7400:134:4	102569
7501:123:1	98060
7401:380:3	91704
7501:113:4	72406

Table 4. *Tabulation of the estimated change in economic indicators (for NAO area only) if the closure scenarios had been implemented during 2021 and with the extreme assumption that no effort displacement would have been possible. Subsetting for all fleet segments with a change <-1% in GVA. More than 5% change are highlighted. [caution: only 2021 here, so not consistent with figure 5, e.g. for ESP_DRB_VL1012 not present in the below table]. Segments ordered by decreasing GVA. (in red if >5%)*

Fleet segment	Scenario	GVA (MEuro)	Gross Profit (MEuro)	Net Profit (MEuro)	GVA impacted (MEuro)	% change GVA	% change Gross Profit	% change Net Profit	Engaged crew
ESP_DTS_VL2440	Closure2022	56.79	5.62	-2.64	0.78	-1.38	-3.78	-8.05	1567
ESP_DTS_VL2440	ICES_SceC	56.79	5.62	-2.64	4.50	-7.93	-60.52	-128.68	1567
ESP_DTS_VL2440	ICES_SceD	56.79	5.62	-2.64	1.15	-2.03	-10.38	-22.08	1567
PRT_DTS_VL2440	Closure2022	23.14	6.23	-1.59	0.47	-2.03	-5.16	-20.23	477
PRT_DTS_VL2440	ICES_SceD	23.14	6.23	-1.59	0.24	-1.03	1.24	4.85	477
ESP_DTS_VL1824	Closure2022	18.46	9.96	7.83	1.99	-10.80	-16.79	-21.37	382
ESP_DTS_VL1824	ICES_SceC	18.46	9.96	7.83	0.57	-3.10	-4.38	-5.57	382
ESP_HOK_VL2440	ICES_SceC	15.98	-4.78	-7.84	0.25	-1.59	2.74	-1.67	817
FRA_DFN_VL2440	ICES_SceC	15.10	1.52	-1.86	0.23	-1.53	-1.85	-1.51	352
ESP_HOK_VL1824	ICES_SceC	14.56	10.50	9.59	0.25	-1.71	-2.12	-2.32	197
ESP_HOK_VL1824	ICES_SceD	14.56	10.50	9.59	0.15	-1.01	-1.22	-1.34	197
ESP_DFN_VL1218	ICES_SceC	12.42	4.47	3.00	0.46	-3.74	-6.85	-10.22	843
FRA_DTS_VL40XX	ICES_SceC	9.52	-4.22	-22.70	0.10	-1.06	1.66	-0.31	170
ESP_HOK_VL1218	ICES_SceC	8.95	0.92	-0.34	0.54	-6.07	-47.78	-128.32	570
ESP_HOK_VL1218	ICES_SceD	8.95	0.92	-0.34	0.10	-1.07	-6.05	-16.24	570
ESP_DTS_VL1218	Closure2022	7.31	-0.43	-1.36	0.53	-7.20	5.38	-1.68	471
ESP_DTS_VL1218	ICES_SceC	7.31	-0.43	-1.36	0.34	-4.63	0.98	-0.31	471
ESP_DFN_VL1012	ICES_SceC	5.98	2.94	2.38	0.26	-4.41	-6.30	-7.81	333
ESP_DFN_VL1824	ICES_SceC	4.76	0.70	-0.06	0.07	-1.43	-1.95	-22.85	239
ESP_HOK_VL1012	ICES_SceC	4.68	1.66	0.97	0.42	-8.93	-21.43	-36.65	375
ESP_HOK_VL1012	ICES_SceD	4.68	1.66	0.97	0.06	-1.25	-3.09	-5.28	375
PRT_DTS_VL1824	Closure2022	4.22	1.20	0.57	0.22	-5.20	-5.60	-11.84	81
PRT_DTS_VL1824	ICES_SceC	4.22	1.20	0.57	0.10	-2.43	-2.53	-5.35	81

PRT_DTS_VL1824	ICES_SceD	4.22	1.20	0.57	0.15	-3.46	-3.75	-7.93	81
PRT_DTS_VL1218	Closure2022	2.30	1.03	0.78	0.10	-4.48	-4.57	-6.02	50
PRT_DTS_VL1218	ICES_SceC	2.30	1.03	0.78	0.04	-1.94	-1.93	-2.54	50
PRT_DTS_VL1218	ICES_SceD	2.30	1.03	0.78	0.07	-3.01	-3.09	-4.06	50
PRT_DFN_VL1012	Closure2022	1.60	1.03	0.79	0.02	-1.32	-1.35	-1.77	71
PRT_DFN_VL1012	ICES_SceC	1.60	1.03	0.79	0.02	-1.32	-1.35	-1.77	71
PRT_DFN_VL1012	ICES_SceD	1.60	1.03	0.79	0.02	-1.32	-1.35	-1.77	71
FRA_HOK_VL2440	Closure2022	1.35	-10.42	-13.61	0.08	-6.12	-0.08	0.06	282
FRA_HOK_VL2440	ICES_SceC	1.35	-10.42	-13.61	0.17	-12.34	-0.07	0.06	282
FRA_HOK_VL2440	ICES_SceD	1.35	-10.42	-13.61	0.09	-6.89	-0.43	0.33	282
DEU_DFN_VL2440	ICES_SceD	0.89	0.05	-0.46	0.01	-1.50	-10.38	-1.05	21
PRT_DTS_VL0010	Closure2022	0.52	0.23	0.19	0.01	-1.26	-1.28	-1.59	12
PRT_DTS_VL0010	ICES_SceD	0.52	0.23	0.19	0.01	-1.11	-1.11	-1.39	12
ESP_DRB_VL1012	Closure2022	0.09	-0.39	-0.50	0.00	-1.92	-1.04	0.81	57
ESP_DRB_VL1218	Closure2022	-0.34	-3.27	-4.19	0.00	-1.42	-1.95	1.52	309
ESP_DRB_VL1218	ICES_SceC	-0.34	-3.27	-4.19	-0.01	-2.45	-2.11	1.65	309

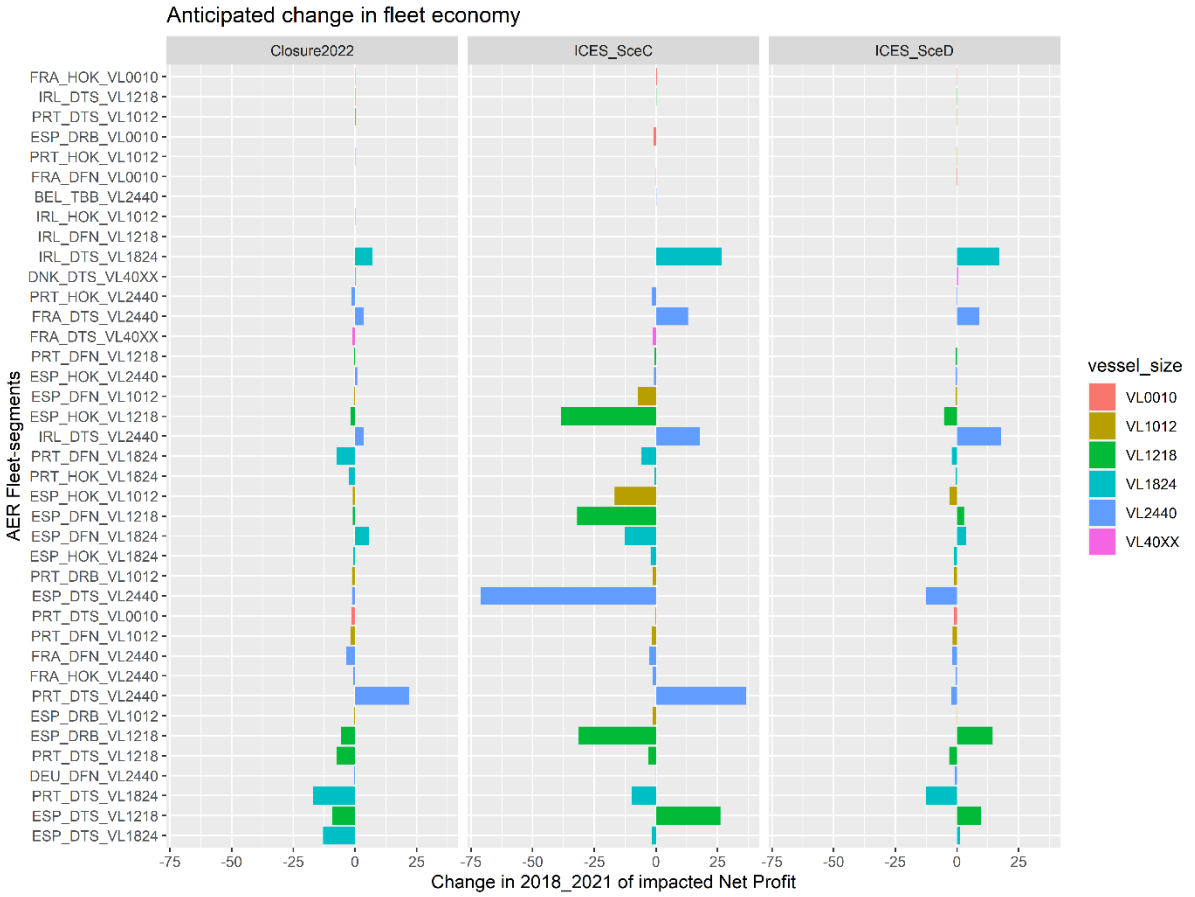

Figure 10. *Estimates of net profit change if scenarios applied to 2018-2021 period. Estimated per fleet segment for the part realised in the NAO area only.*

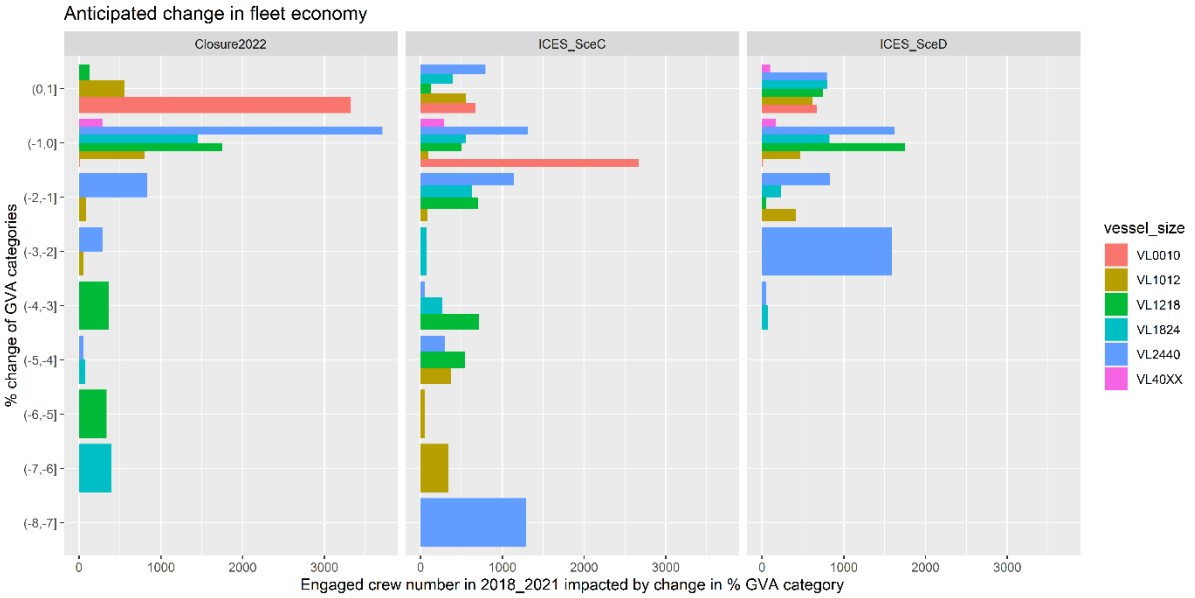

Figure 11. Engaged crew in the fleet segment per category of impact on the GVA induced by the proposals for VME closure in case the effort displacement would be impossible (but see next section). Estimated for the part realised in the NAO area only.

2.2 Displacement effect based on coupled AER-FDI datasets

Based on the findings of the GIS analysis, different scenarios on the possible effort allocation are proposed and analysed, with an effort reallocation differentiated between fishing gears. In case the effort displaced may not compensate for the loss, the minimum effort level required to break even is calculated. The limits and likelihoods of scenarios and the assumptions behind them are further discussed hereafter.

The part of the historical effort impacted by the proposals for the closed areas can be displaced to the surrounding areas. The study evaluates the possible change in catches and then in the economic return that such a displacement could induce. However, the method used (i.e. GIS raster layers) for the displacement effect study prevents distinguishing individual polygons' effect. It is therefore assumed that the effect results from implementing them all.

The study investigated two ways for a hypothetical redistribution of the fishing effort in reaction to the closed areas:

* A uniform (i.e. profit-free) redistribution over areas of the impacted effort toward areas already visited by the fleet segment. In practice, the total impacted effort by the closed areas of a given scenario is evenly re-distributed over all the c-squares visited by the fleet segment during the period 2018-2021.

* A weighted redistribution of the impacted effort alongside the historical c-square GVAs, where more (i.e. on a log scale) effort is displaced toward historically high GVAs recorded for the fleet segment during the period 2018-2021 studied. It should be noted that to avoid bias in case the fleet segment is not used to optimise on expected economic return, this weighted redistribution is not compared to the historical one but to a recalculated baseline (i.e. a comparable counterfactual) that accounts for optimal redistribution of the same amount of the impacted effort alongside spatial GVAs, closed areas included.

After the redistribution occurs, the catches that were historically recorded inside the closed areas are cancelled, and new catches outside the closed areas are computed, accounting for the extra effort added to the c-squares and their specific LPUEs. The economic variables, including the GVA, are also recomputed based on the new catches and spatialised costs.

If the overall GVA for a given fleet segment is found negative after the redistribution, each fleet segment's extra effort required to break even is calculated.

From the redistribution estimates, it can be observed that for most of the fleet segments, there is a possible gain after the redistribution of effort (up to three times more for ESP_DFN_VL1218, which is also the one deploying the greatest effort), either uniformly (Figure 13) or optimised based on the spatialised GVAs (Figure 12). The difference between the two effort redistribution assumptions (uniform vs. spatialised GVA-based) is not large likely because the displaced amount of effort is also not large (Figure 14). Such a gain may result from efforts deployed at the end of the fishing ground that is not rewarding enough compared to the cost induced for operating the fishing in those areas.

There are, however, some fleet segments, the ones using HOK and FPO, that are adversely affected by the redistribution with loss in GVA after the implementation of the closed areas which is not compensated by a redistribution of the effort, whatever the scenarios, and the hypothesis on the way the effort displacement may occur. In such an adverse effect the effort required to break even is up to 23% for ESP_HOK_VL2440 segment when scenario ICES Sce C applies and 17% for the ESP_HOK_VL2440 segment when ICES sce D applies (Table 5).

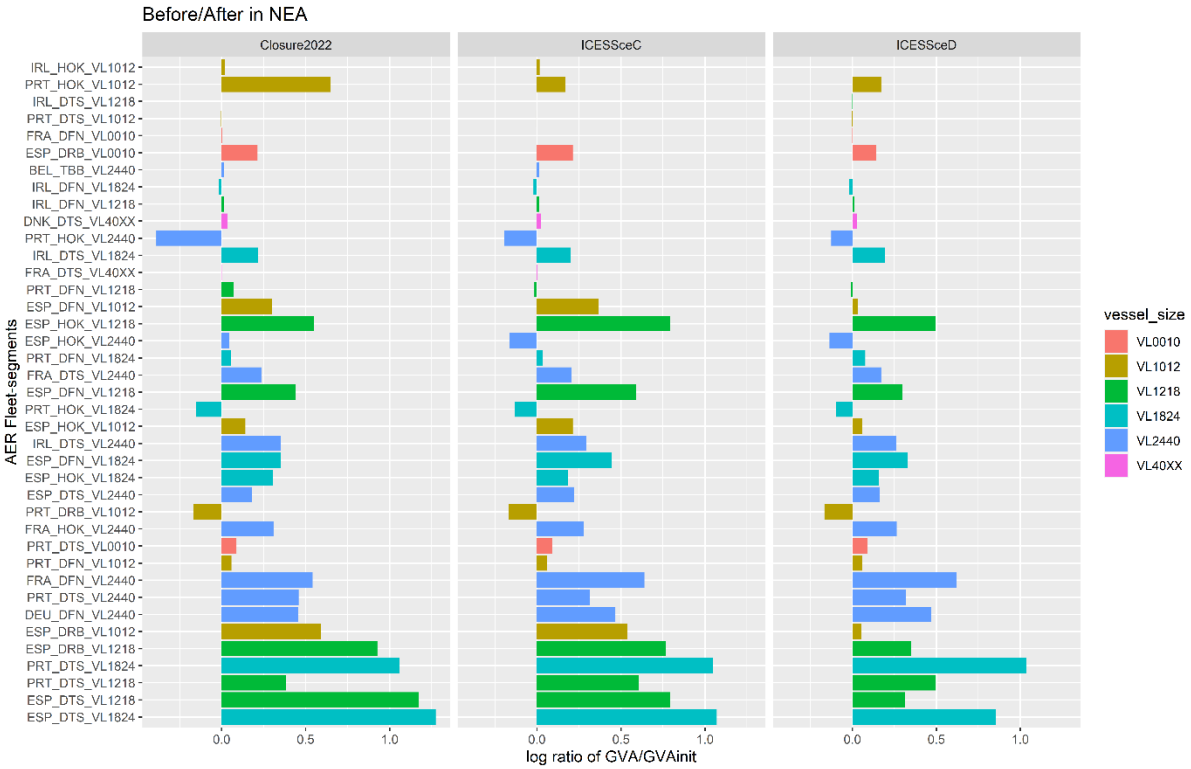

Figure 12. *Fleet-segment-specific effects on GVA of a weighted redistribution of the part of the average 2018-2021 fishing effort impacted by the closed areas for the three scenarios in the SWW and NWW. A positive value on the log scale indicates a larger GVA obtained after the effort redistribution, and vice versa. Exponentiating the log-value gives the factor, e.g. a log-ratio at 1 gives a 2.71 times greater GVA after than before the effort displacement. Only the top 20 fleet segments in overall effort deployed in the region are shown.*

Table 5. *underlying data of the plot of figure 12.*

Fleet segment	Scenario	log-ratio of GVA	Scenario	log-ratio of GVA	Scenario	log-ratio of GVA
ESP_DTS_VL1824	Closure2022	1.28	ICESSceC	1.07	ICESSceD	0.85
ESP_DTS_VL1218	Closure2022	1.17	ICESSceC	0.79	ICESSceD	0.31
PRT_DTS_VL1218	Closure2022	0.38	ICESSceC	0.61	ICESSceD	0.5
PRT_DTS_VL1824	Closure2022	1.06	ICESSceC	1.05	ICESSceD	1.04
ESP_DRB_VL1218	Closure2022	0.93	ICESSceC	0.77	ICESSceD	0.35
ESP_DRB_VL1012	Closure2022	0.59	ICESSceC	0.54	ICESSceD	0.05
DEU_DFN_VL2440	Closure2022	0.46	ICESSceC	0.47	ICESSceD	0.47
PRT_DTS_VL2440	Closure2022	0.46	ICESSceC	0.31	ICESSceD	0.32
FRA_DFN_VL2440	Closure2022	0.54	ICESSceC	0.64	ICESSceD	0.62
PRT_DFN_VL1012	Closure2022	0.06	ICESSceC	0.06	ICESSceD	0.06
PRT_DTS_VL0010	Closure2022	0.09	ICESSceC	0.09	ICESSceD	0.09
FRA_HOK_VL2440	Closure2022	0.31	ICESSceC	0.28	ICESSceD	0.27
PRT_DRB_VL1012	Closure2022	-0.17	ICESSceC	-0.17	ICESSceD	-0.17
ESP_DTS_VL2440	Closure2022	0.18	ICESSceC	0.22	ICESSceD	0.17
ESP_HOK_VL1824	Closure2022	0.31	ICESSceC	0.18	ICESSceD	0.16
ESP_DFN_VL1824	Closure2022	0.35	ICESSceC	0.45	ICESSceD	0.33

IRL_DTS_VL2440	Closure2022	0.35	ICESSceC	0.29	ICESSceD	0.26
ESP_HOK_VL1012	Closure2022	0.14	ICESSceC	0.21	ICESSceD	0.06
PRT_HOK_VL1824	Closure2022	-0.15	ICESSceC	-0.13	ICESSceD	-0.1
ESP_DFN_VL1218	Closure2022	0.44	ICESSceC	0.59	ICESSceD	0.3
FRA_DTS_VL2440	Closure2022	0.24	ICESSceC	0.2	ICESSceD	0.17
PRT_DFN_VL1824	Closure2022	0.06	ICESSceC	0.03	ICESSceD	0.08
ESP_HOK_VL2440	Closure2022	0.04	ICESSceC	-0.16	ICESSceD	-0.14
ESP_HOK_VL1218	Closure2022	0.55	ICESSceC	0.79	ICESSceD	0.5
ESP_DFN_VL1012	Closure2022	0.3	ICESSceC	0.37	ICESSceD	0.03
PRT_DFN_VL1218	Closure2022	0.07	ICESSceC	-0.02	ICESSceD	-0.01
FRA_DTS_VL40XX	Closure2022	0	ICESSceC	0	ICESSceD	0
IRL_DTS_VL1824	Closure2022	0.22	ICESSceC	0.2	ICESSceD	0.19
PRT_HOK_VL2440	Closure2022	-0.39	ICESSceC	-0.19	ICESSceD	-0.13
DNK_DTS_VL40XX	Closure2022	0.04	ICESSceC	0.03	ICESSceD	0.03
IRL_DFN_VL1218	Closure2022	0.01	ICESSceC	0.01	ICESSceD	0.01
IRL_DFN_VL1824	Closure2022	-0.02	ICESSceC	-0.02	ICESSceD	-0.02
BEL_TBB_VL2440	Closure2022	0.01	ICESSceC	0.01	ICESSceD	0
ESP_DRB_VL0010	Closure2022	0.21	ICESSceC	0.21	ICESSceD	0.14
FRA_DFN_VL0010	Closure2022	0.01	ICESSceC	0	ICESSceD	0
PRT_DTS_VL1012	Closure2022	0	ICESSceC	0	ICESSceD	0
IRL_DTS_VL1218	Closure2022	0	ICESSceC	0	ICESSceD	0
PRT_HOK_VL1012	Closure2022	0.65	ICESSceC	0.17	ICESSceD	0.17
IRL_HOK_VL1012	Closure2022	0.02	ICESSceC	0.02	ICESSceD	0

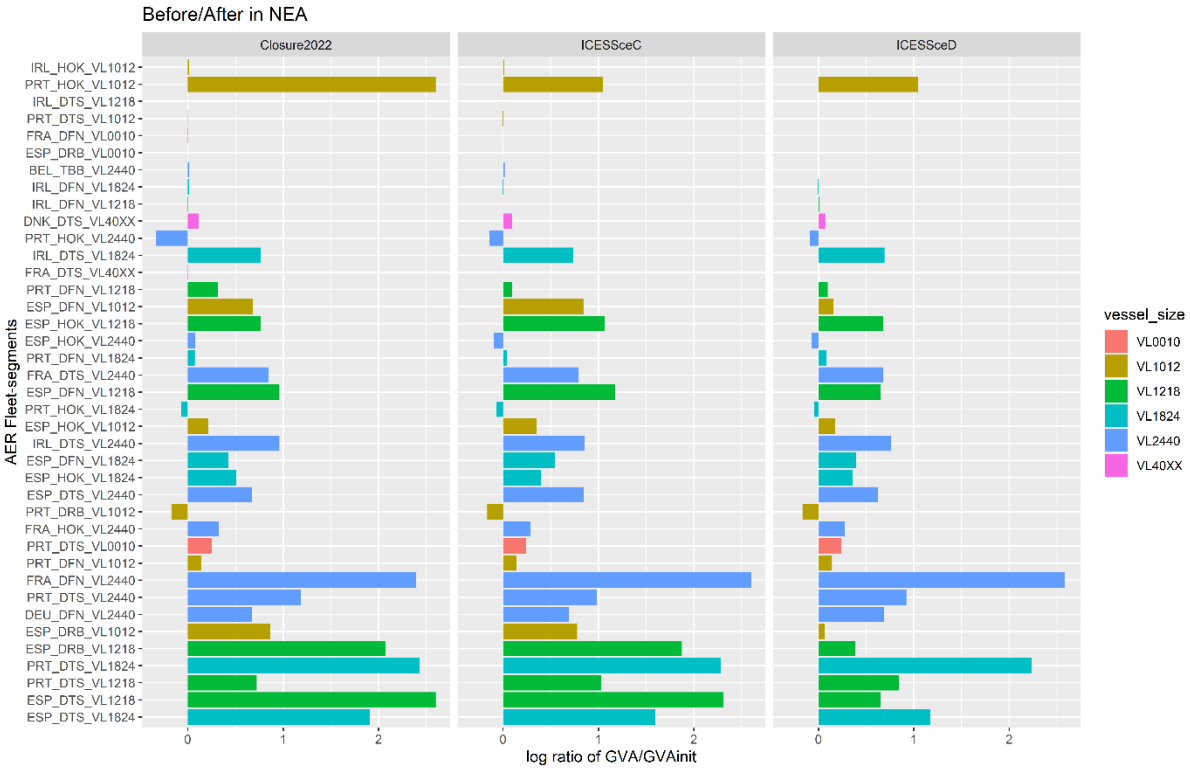

Figure 13. Fleet-segment-specific effects on GVA of a uniform redistribution of the part of the average 2018-2021 fishing effort impacted by the closed areas for the three scenarios in the SWW and NWW. As Figure 11.

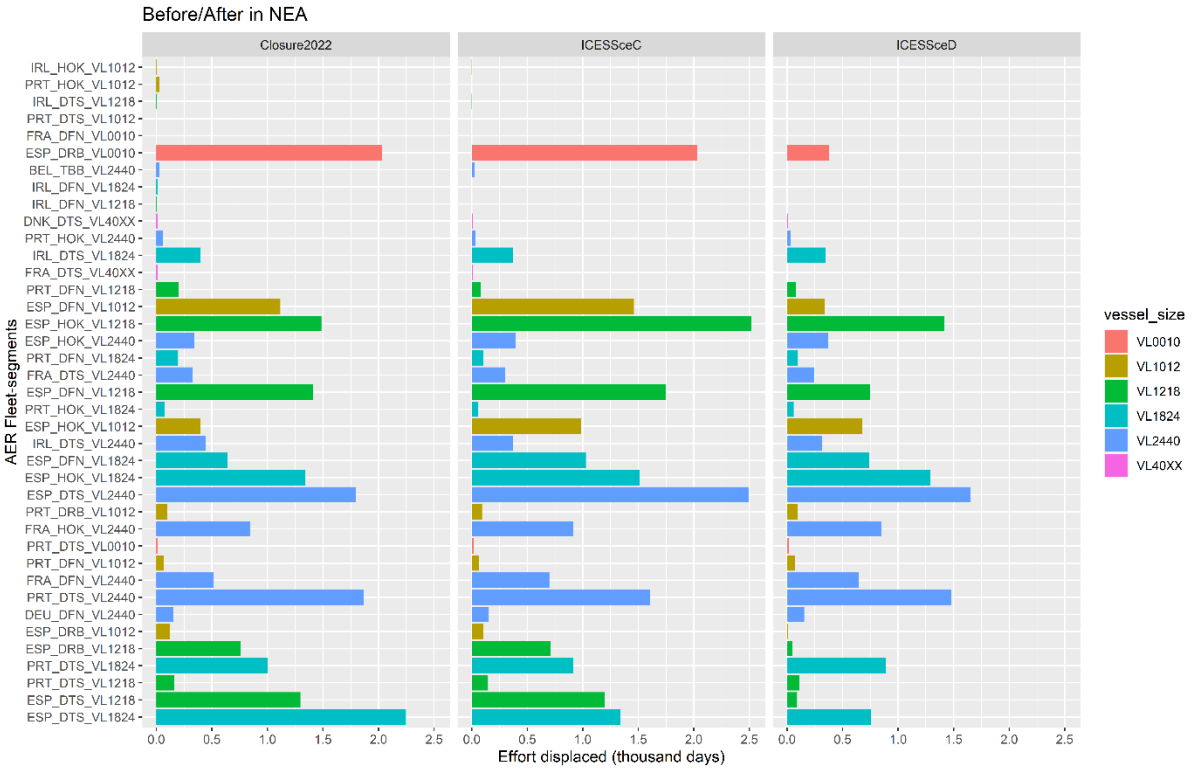

Figure 14. *Fleet-segment-specific amount of average 2018-2021 effort impacted by the closed areas for the three scenarios in the SWW and NWW.*

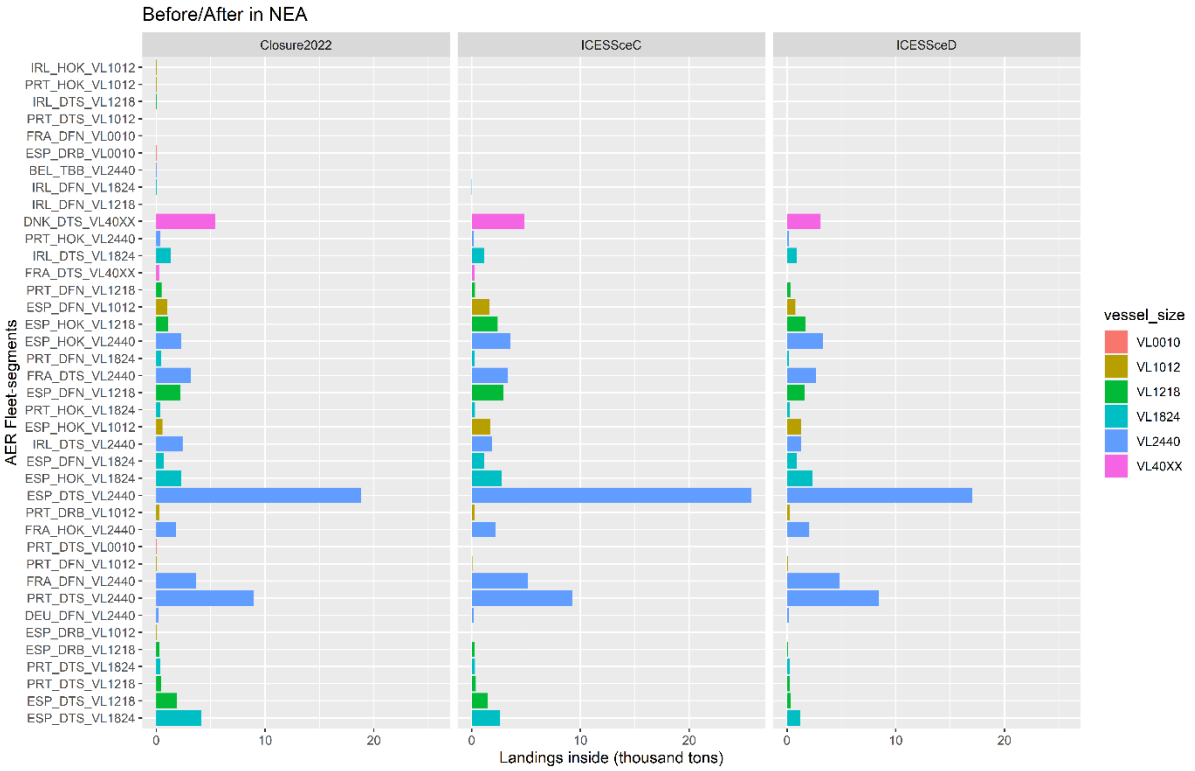

Figure 15. *Fleet-segment-specific amount of average 2018-2021 landings impacted by the closed areas for the three scenarios in the SWW and NWW.*

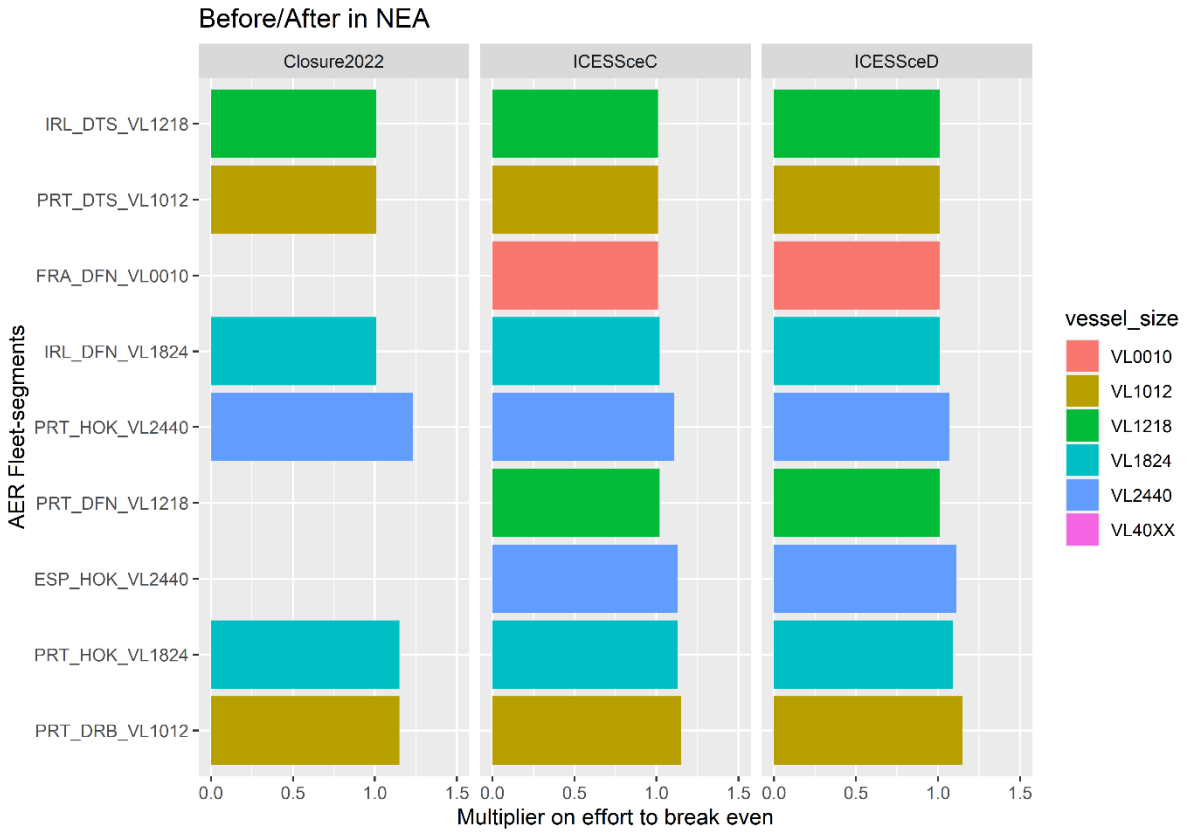

Figure 16. *Fleet-segment-specific extra-effort multiplier required to compensate and break even in reaction to impact from the closed areas for the three scenarios in the SWW and NWW. Only segments with possible losses when reallocating effort (see Figure 15)are shown.*

Table 6*. Underlying data on effort multiplier to breakeven for Figure 16. For example 1.15 means 15% extra effort is needed to break-even.*

Fleet segment	scenario	Effort multiplier
PRT_DRB_VL1012	Closure2022	1.15
PRT_HOK_VL1824	Closure2022	1.15
PRT_HOK_VL2440	Closure2022	1.23
IRL_DFN_VL1824	Closure2022	1.01
PRT_DTS_VL1012	Closure2022	1.01
IRL_DTS_VL1218	Closure2022	1.01
PRT_DRB_VL1012	ICESSceC	1.15
PRT_HOK_VL1824	ICESSceC	1.13
ESP_HOK_VL2440	ICESSceC	1.13
PRT_DFN_VL1218	ICESSceC	1.02
PRT_HOK_VL2440	ICESSceC	1.11
IRL_DFN_VL1824	ICESSceC	1.02
FRA_DFN_VL0010	ICESSceC	1.01
PRT_DTS_VL1012	ICESSceC	1.01
IRL_DTS_VL1218	ICESSceC	1.01
PRT_DRB_VL1012	ICESSceD	1.15
PRT_HOK_VL1824	ICESSceD	1.09
ESP_HOK_VL2440	ICESSceD	1.11
PRT_DFN_VL1218	ICESSceD	1.01
PRT_HOK_VL2440	ICESSceD	1.07
IRL_DFN_VL1824	ICESSceD	1.01
FRA_DFN_VL0010	ICESSceD	1.01
PRT_DTS_VL1012	ICESSceD	1.01
IRL_DTS_VL1218	ICESSceD	1.01

3. Analysis based on the bottom-contacting gears ICES VMS dataset

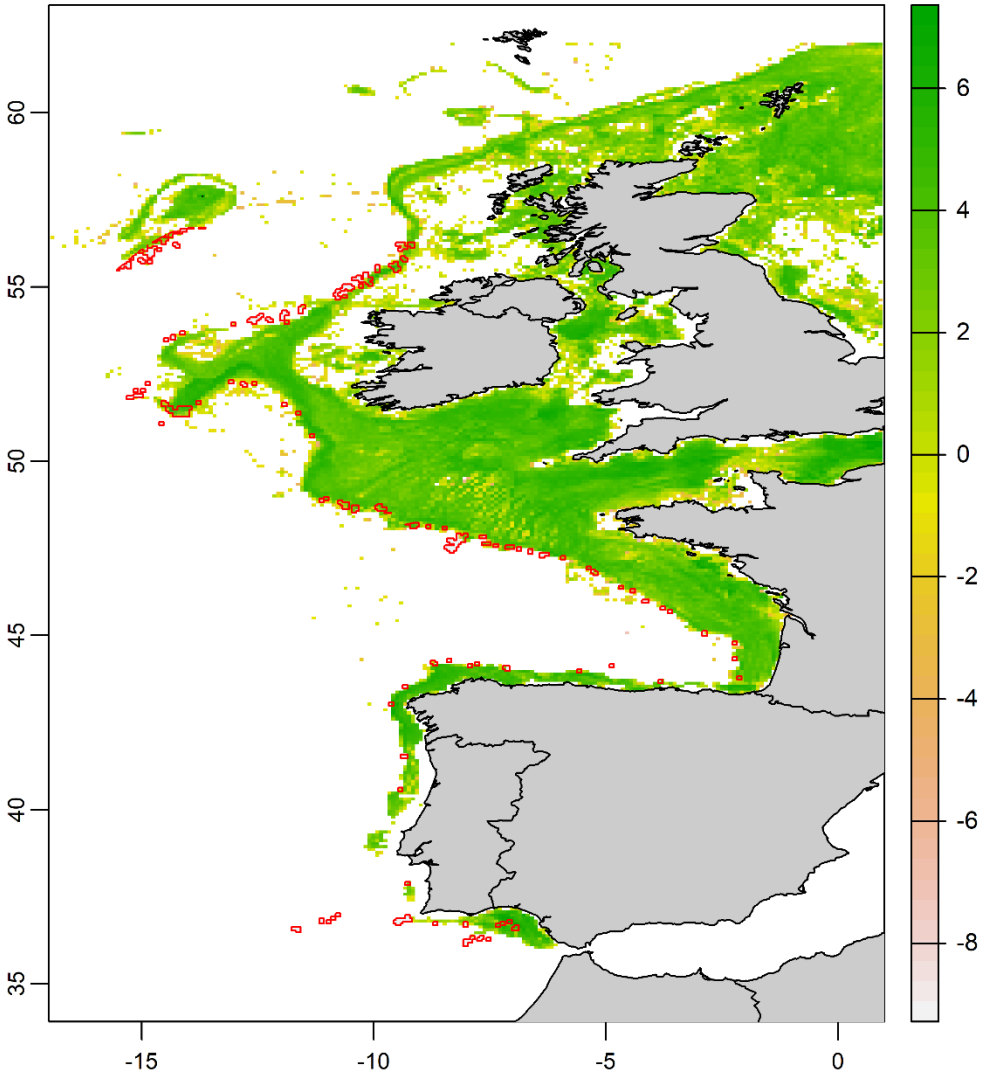

Figure 17. *2018-2020 VMS effort (log of fishing hours gridded in c-square of 0.05 degrees) overlaid with Scenario Closure 2022 (red polygons)*

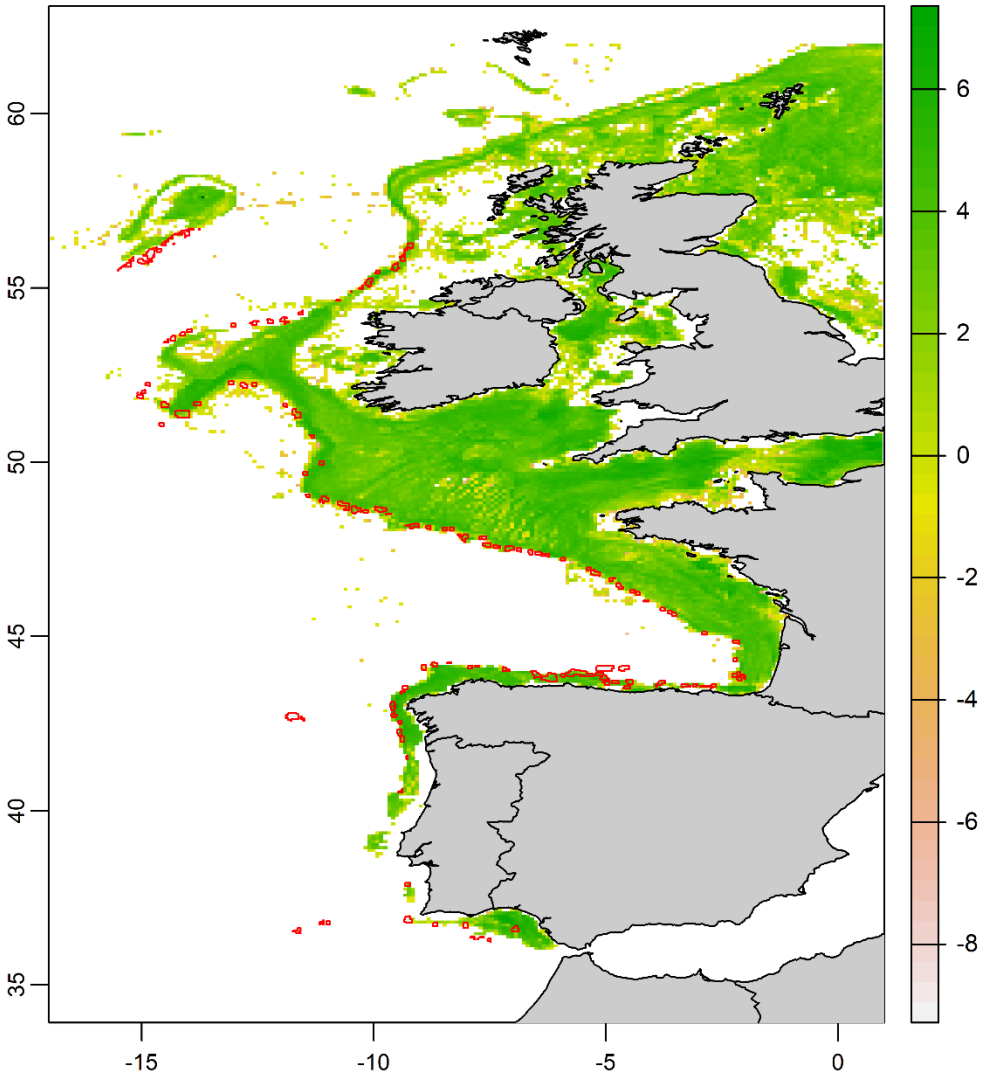

Figure 18. *2018-2020 VMS effort (log of fishing hours gridded in c-square of 0.05 degrees) overlaid with Scenario ICES SceC (red poygons).*

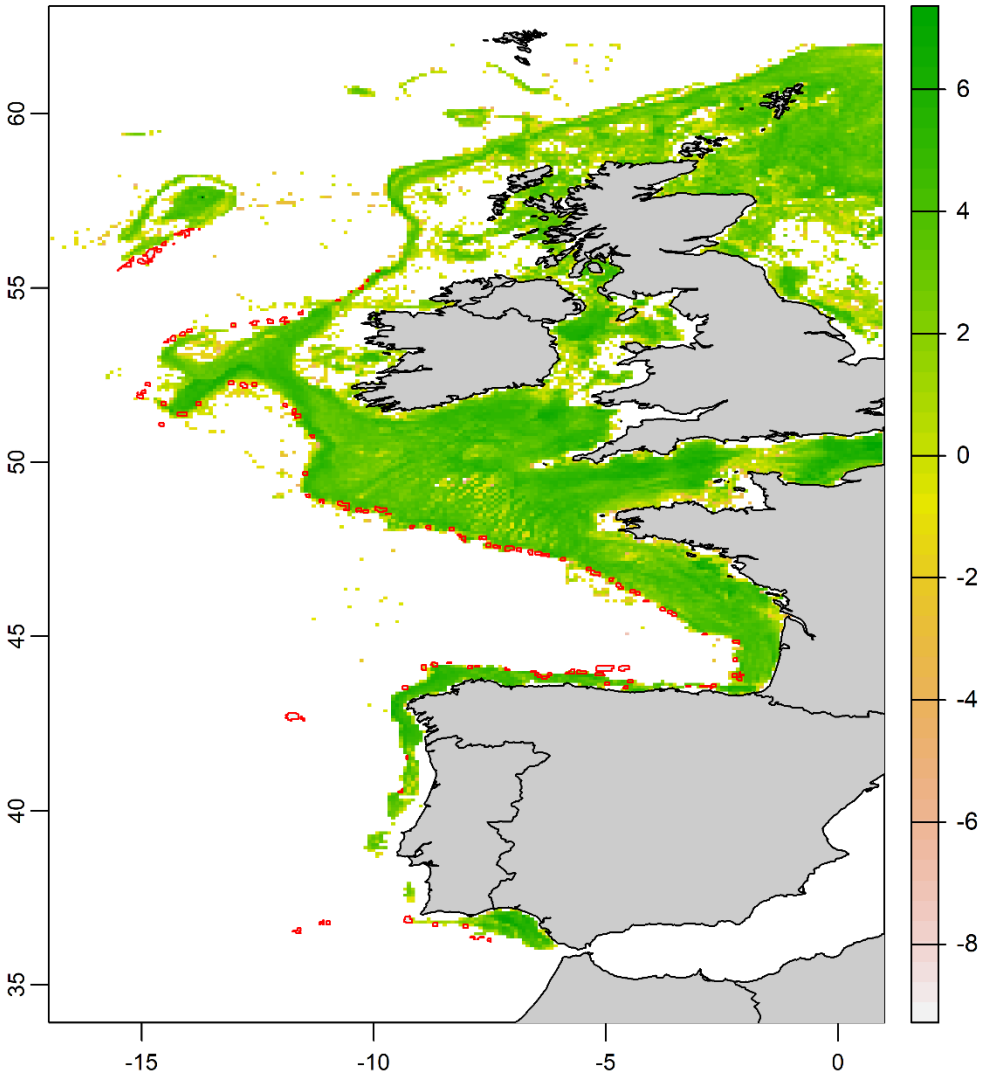

***Figure 19**. 2018-2020 VMS effort (log of fishing hours gridded in c-square of 0.05 degrees) overlaid with Scenario ICES Sce D (red polygons)*

3.1 The overlay effect of VME closed areas estimated with the ICES VMS dataset

The main findings of the static AER-VMS overlay study show that ESP_DTS_VL2440 is the most impacted fleet segment (Figure 20), especially by the ICES Scenario C, with 7.78% of its GVA made within the closed areas on average over 2018-2021 (Figure 19 and Table 8), which corresponds to a change of -19.20% in 2021 Net Profit. The most impacting scenario of closed areas for VMEs is ICES Scenario C, having the largest impacted surface closed (Table 7). Looking at the spatial dimension, the effect comes from restricting fishing in the Northern Basque country off the Spanish coast (Figure 23 and Table 10). The second most affected fleet segment is the ESP_DTS_VL1824 segment, with an impact of 3.44% of the GVA made during 2018-2021, corresponding to a change in Net profit of -36.8% in 2021. Looking at the spatial dimension, the effect comes from restricting fishing in the Gulf of Cadiz area off the Spanish coast in Scenario Closure2022 (Figure 22 and Table 9). The engaged crew of the adversely impacted fleets represent about 382 and 1567 persons for ESP_DTS_VL1824 and ESP_DTS_VL2440, respectively (Figure 27).

Other fleets than ESP_DTS_VL2440 and ESP_DTS_VL1824 among the ones using bottom contacting gears are found only marginally affected (i.e. <2% of the GVA), whatever the considered spatial scenarios.

Table 7. *Impacted fishable surface area in km^2 for each VMEs protection scenario for all segments using mobile bottom contacting gears (deduced from the ICES dataset). Note that the estimate varies over the years depending on the year-specific spatial fishing footprint and the spatial overlap's accuracy.*

scenario	year	Impacted surface closed (km^2)	Total surface closed (km^2)	%
Closure2022	2018	290	16400	1.77
ICES_SceC	2018	542	14300	3.79
ICES_SceD	2018	277	9750	2.84
Closure2022	2019	264	16400	1.61
ICES_SceC	2019	552	14300	3.86
ICES_SceD	2019	230	9750	2.36
Closure2022	2020	313	16400	1.91
ICES_SceC	2020	566	14300	3.96
ICES_SceD	2020	225	9750	2.31
Closure2022	2018_2020	306	16400	1.87
ICES_SceC	2018_2020	537	14300	3.75
ICES_SceD	2018_2020	397	9750	4.07

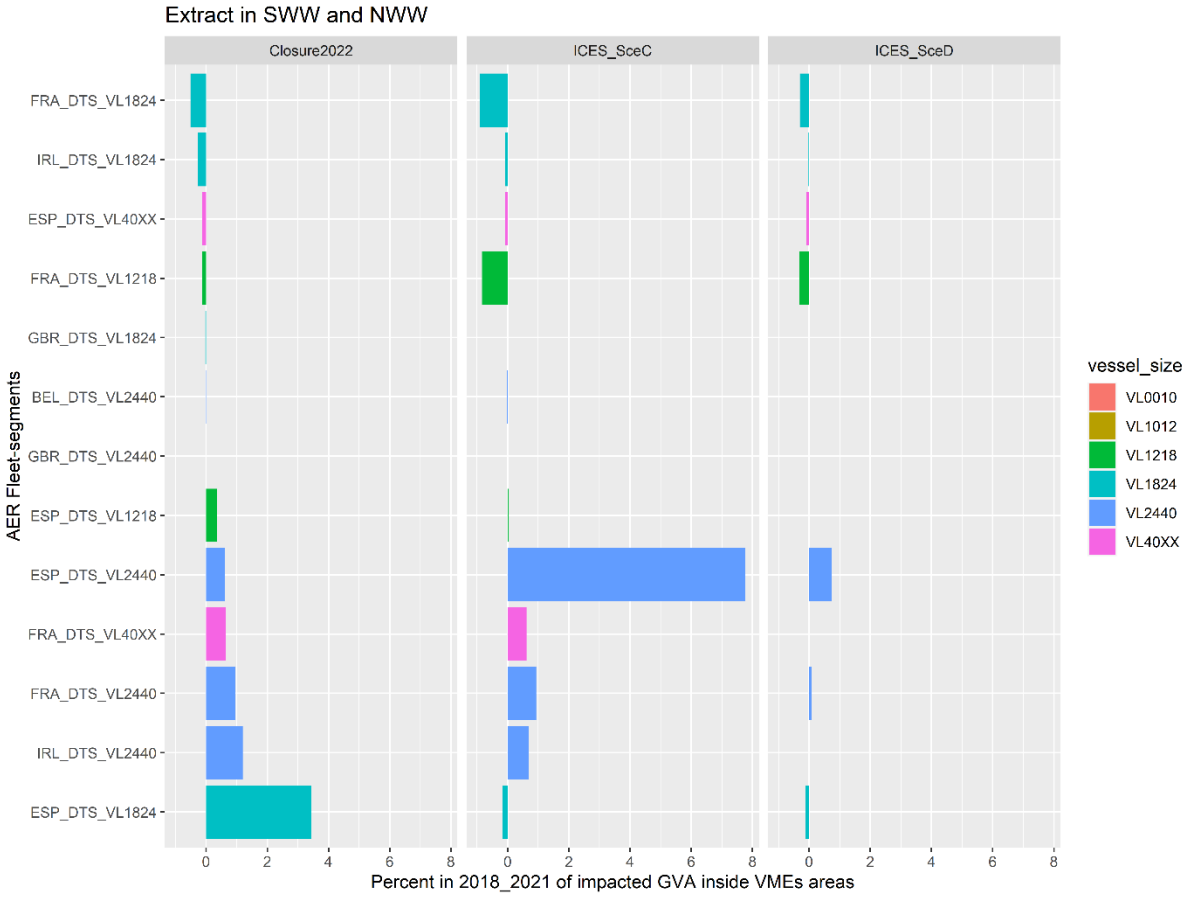

Figure 20. *Percent of the 2018-2021 overall fleet-segment GVA impacted by the VMEs depending on the scenario (Closure 2022, ICES Sce. C and ICES Sce D) and of the top 15 AER fleet-segments. To obtain these estimates, the fleet specific spatially disaggregated GVA over ICES VMS csquare (see section 1.5) have been used, and the impacted VMS c-square GVA values have been further multiplied by the ratio of the surface area of the VMEs in the cells over the fishable surface area in each cell (the fishable area is defined by the bathymetry >-800m and corresponds to the area where the catch could have occurred, generating the income from landings). Negative percentages arise from initial negative GVA values.*

Table 8*. Underlying data for figure 20*

fleet segment	Scenario	%	Scenario	%	scenario	%
ESP_DTS_VL1824	Closure2022	3.44	ICES_SceC	-0.17	ICES_SceD	-0.12
IRL_DTS_VL2440	Closure2022	1.2	ICES_SceC	0.69	ICES_SceD	0
FRA_DTS_VL2440	Closure2022	0.95	ICES_SceC	0.93	ICES_SceD	0.07
FRA_DTS_VL40XX	Closure2022	0.63	ICES_SceC	0.62	ICES_SceD	0.74
ESP_DTS_VL2440	Closure2022	0.6	ICES_SceC	7.78	ICES_SceD	0
ESP_DTS_VL1218	Closure2022	0.37	ICES_SceC	0.04	ICES_SceD	0
GBR_DTS_VL2440	Closure2022	0	ICES_SceC	0	ICES_SceD	0
BEL_DTS_VL2440	Closure2022	-0.02	ICES_SceC	-0.02	ICES_SceD	0
GBR_DTS_VL1824	Closure2022	-0.03	ICES_SceC	-0.01	ICES_SceD	0
FRA_DTS_VL1218	Closure2022	-0.12	ICES_SceC	-0.84	ICES_SceD	-0.33
ESP_DTS_VL40XX	Closure2022	-0.13	ICES_SceC	-0.08	ICES_SceD	-0.08
IRL_DTS_VL1824	Closure2022	-0.28	ICES_SceC	-0.08	ICES_SceD	-0.02
FRA_DTS_VL1824	Closure2022	-0.51	ICES_SceC	-0.91	ICES_SceD	-0.31

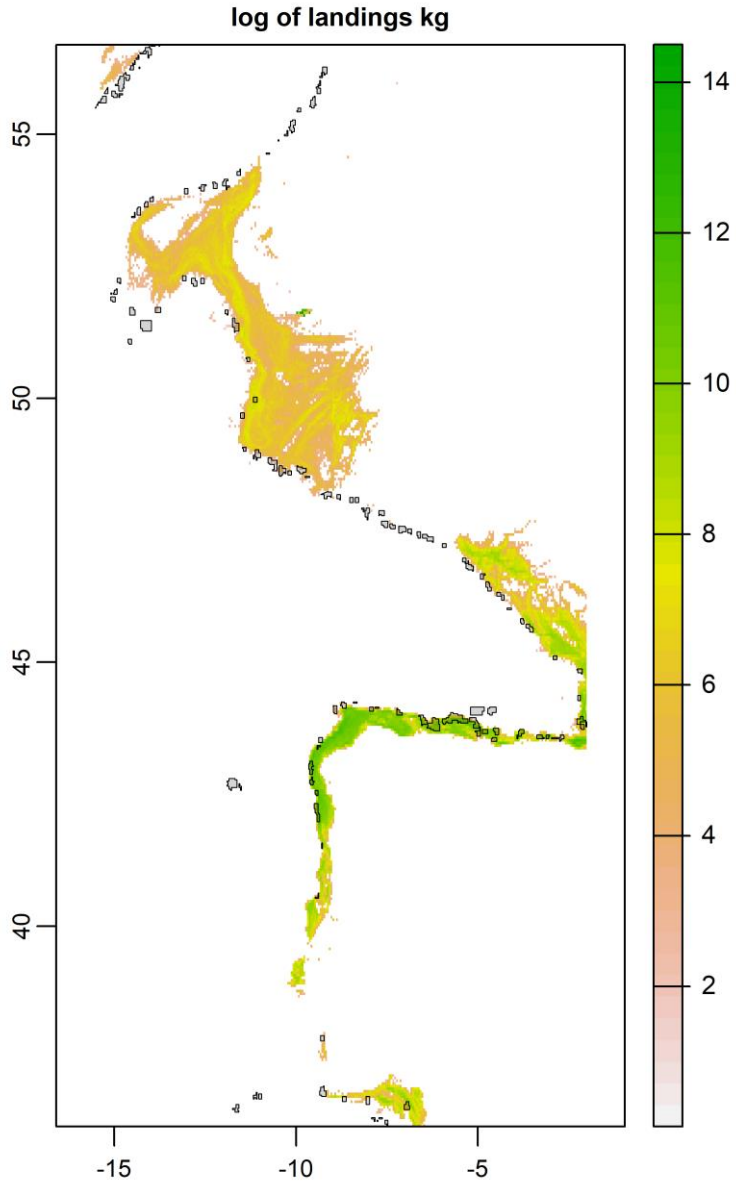

***Figure 21**. Log-transformed 2018-2020 spatial landings (deduced from 0.05-degree VMS coupled to AER) of the most impacted fleet segment i.e. ESP_DTS_VL2440, by the closed areas defined by the ICES Sce C (black polygons).*

Figure 22. *Effect of scenarios on 2018-2021 average GVAs per 0.05 c-square split per fleet segment (keeping only main impacted 0.05 c-squares with a threshold at >15keuros per c-square for a given fleet segment)*

Table 9. *10 most impacting 0.05 C-SQUARE for the Scenario Closure2022 deduced by the AER economic costs disaggregation and overlay with ICES VMS data.*

C-SQUARE	GVA impacted (Euro)
7300:467:370:4	246914
7300:467:370:3	180420
7500:459:455:4	87680
7300:466:468:2	75947
7300:467:363:3	47115
7500:459:455:2	46880
7500:459:465:1	46107
7400:239:205:2	44323
7300:467:362:3	39158
7500:459:465:2	35423

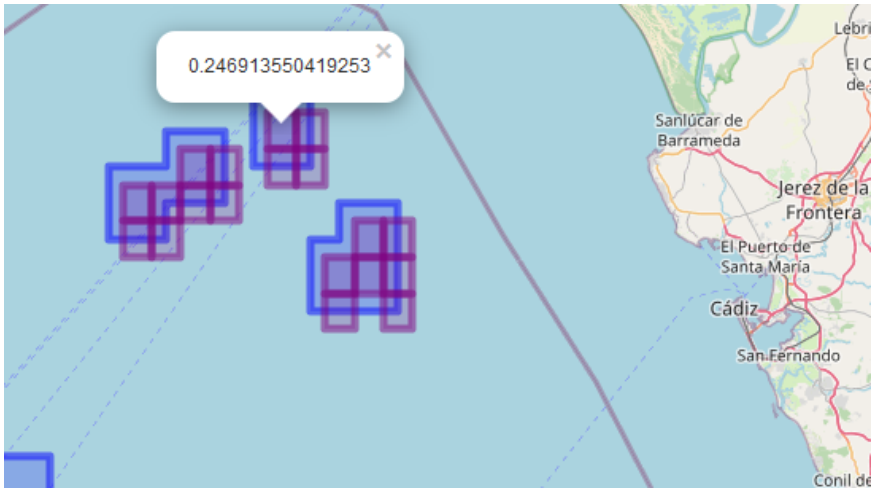

Figure 23*. A screenshot of an interactive map embedded into an html page to look at the impacted GVA (in MEuro) in each of the impacted 0.05 Csquare (in purple) alongside each closed polygon (scenario Closure2022 in blue) (the html map is provided in Appendix). Map focus and label the most impacted c-square for this scenario. (note that a query tool for an individual c-square can be retrieved at http://www.cmar.csiro.au/csquares/about-mapper.htm)*

***Table 10**. 10 most impacting 0.05 C-SQUARE for the Scenario ICES SceC*

C-SQUARE	GVA impacted (Euro)
7400:229:495:2	178065
7400:235:383:3	140230
7400:235:383:4	138989
7400:229:475:2	122966
7400:239:205:4	118758
7400:235:384:3	116536
7400:229:103:4	113834
7400:229:354:1	113827
7400:229:103:2	112071
7400:235:370:3	105217

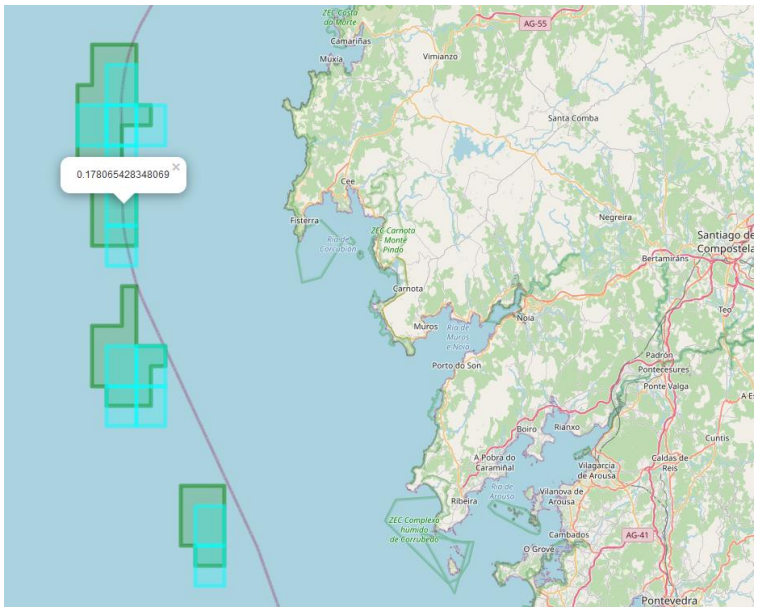

***Figure 24.** A screenshot of an interactive map embedded into an html page to look at the impacted GVA (in MEuro) in each of the impacted 0.05 Csquare (in cyian) alongside each closed polygon (scenario C in green) (the html map is provided in Appendix). Map focus and label the most impacted c-square for this scenario.*

Table 11. *10 most impacting 0.05 C-SQUARE for the Scenario ICES SceD*

C-SQUARE	GVA impacted (Euro)
7400:236:384:1	42841
7400:236:373:3	42607
7400:235:495:2	32520
7400:235:497:1	23516
7400:248:216:1	23464
7400:235:495:1	21674
7400:236:382:3	19371
7400:235:394:2	16234
7400:236:372:4	15159
7400:236:383:2	13566

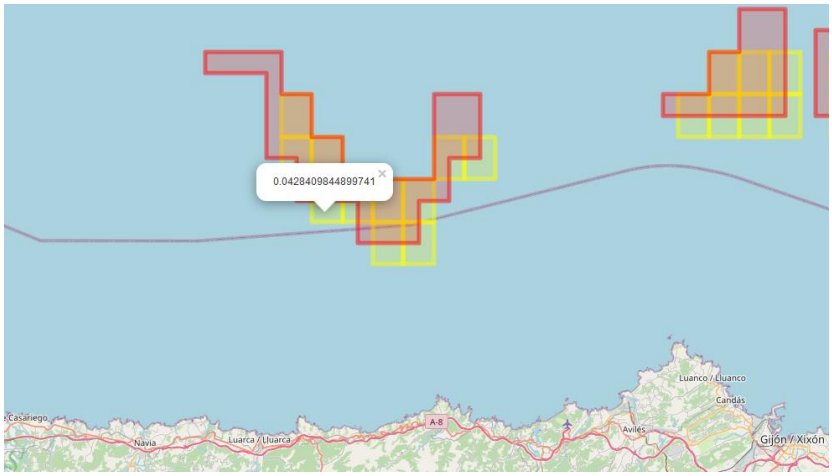

Figure 25. *A screenshot of an interactive map embedded into an html page to look at the impacted GVA (in MEuro) in each of the impacted 0.05 Csquare (in yellow) alongside each closed polygon (Scenario D in red) (the html map is provided in Appendix). Map focus and label the most impacted c-square for this scenario.*

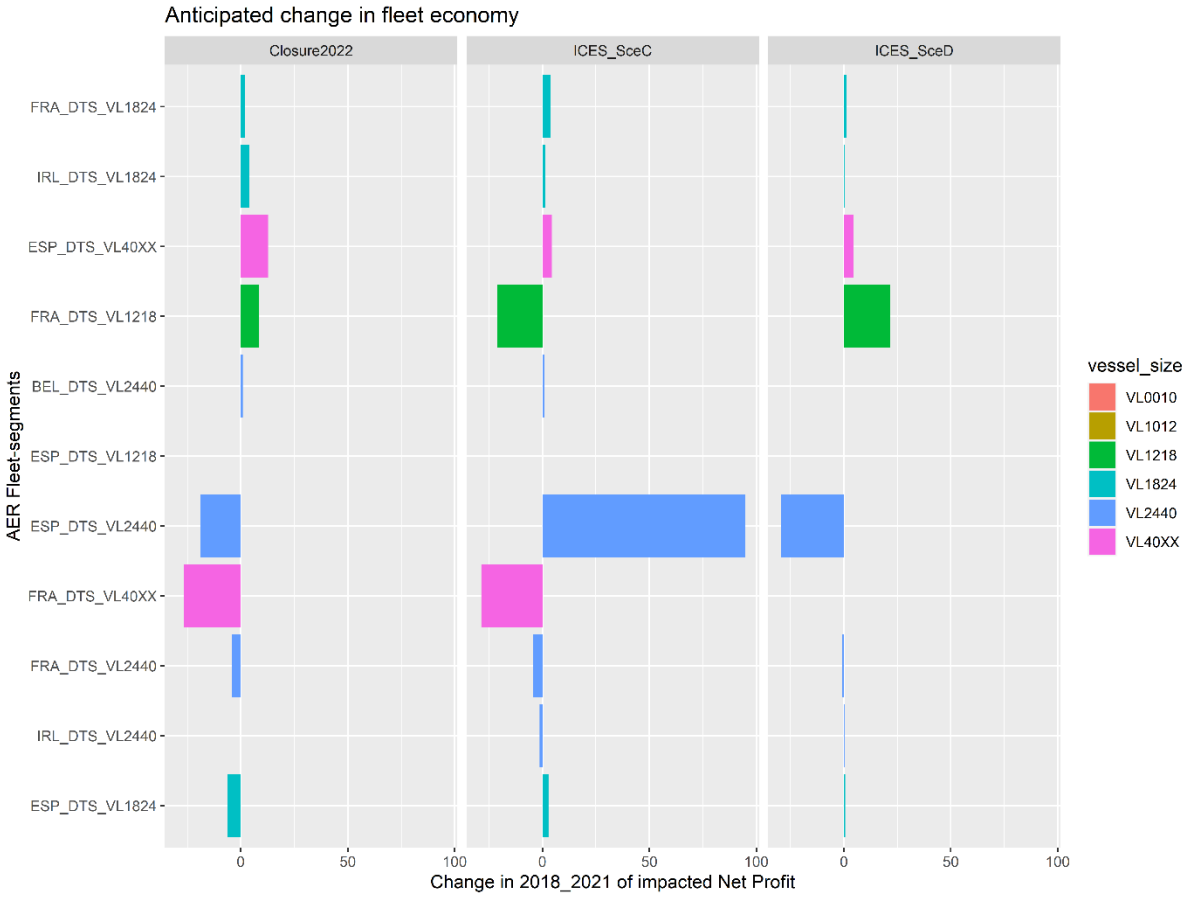

Figure 26. *Anticipated average Net Profit change if the VMEs closed areas scenarios would have been implemented during the 3y period 2018-2020. Estimated from using the 2022 AER dataset coupled to 2018-2020 ICES VMS data for bottom contacting gears only.*

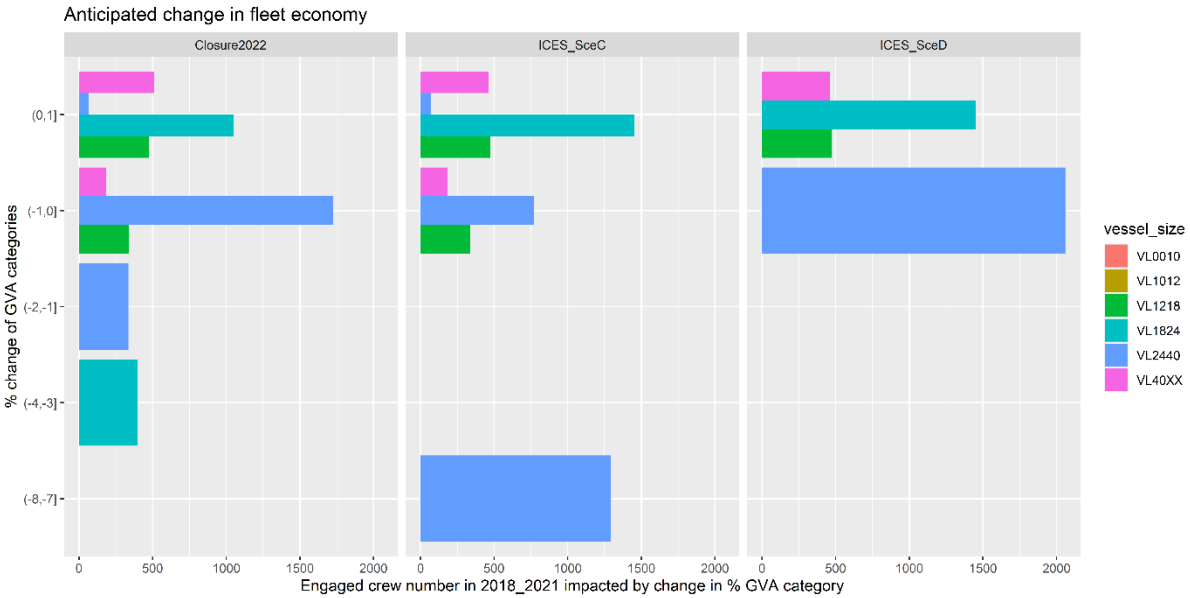

Figure 27. *Engaged crew impacted by different levels of changes on GVAs averaged over 2018-2021*

Table 12. *Summary of findings for the most impacted fleet segments- scenario combinations by the closed areas scenarios (i.e. >1% on GVA change among the segments comprised in the ICES VMS dataset).*

year	Feet segment	scenario	GVA (MEuro)	Gross Profit (MEuro)	Net Profit (MEuro)	GVA impacted (MEuro)	% change GVA	% change Gross Profit	% change Net Profit	Engaged crew
2021	ESP_DTS_VL2440	ICES_SceC	57.27	6.10	-2.16	4.91	-8.57	-67.73	-191.52	1567
2021	ESP_DTS_VL1824	Closure2022	18.46	9.96	7.83	0.61	-3.31	-5.14	-6.54	382
2021	FRA_DTS_VL40XX	Closure2022	10.58	-3.16	-21.63	0.17	-1.60	4.03	-0.59	170
2021	FRA_DTS_VL40XX	ICES_SceC	10.58	-3.16	-21.63	0.16	-1.48	3.75	-0.55	170
2020	ESP_DTS_VL2440	ICES_SceC	59.27	12.15	3.96	4.20	-7.09	-28.63	-87.87	1240
2020	FRA_DTS_VL2440	Closure2022	36.52	11.18	-5.56	0.47	-1.28	-2.03	-4.08	407
2020	FRA_DTS_VL2440	ICES_SceC	36.52	11.18	-5.56	0.44	-1.21	-1.94	-3.91	407
2020	ESP_DTS_VL1824	Closure2022	15.57	6.54	4.54	0.55	-3.54	-6.68	-9.64	386
2019	ESP_DTS_VL2440	ICES_SceC	57.56	8.39	0.55	4.58	-7.96	-45.97	700.17	1259
2019	IRL_DTS_VL2440	Closure2022	23.92	12.67	4.30	0.52	-2.19	-1.99	-5.85	381
2019	IRL_DTS_VL2440	ICES_SceC	23.92	12.67	4.30	0.25	-1.04	-1.28	-3.76	381
2019	ESP_DTS_VL1824	Closure2022	18.87	14.07	13.02	0.68	-3.58	-4.27	-4.62	426
2018	ESP_DTS_VL2440	ICES_SceC	67.65	19.02	10.88	5.10	-7.54	-23.31	-40.76	1099
2018	FRA_DTS_VL2440	Closure2022	47.31	17.32	1.60	0.52	-1.10	-1.11	-12.00	436
2018	FRA_DTS_VL2440	ICES_SceC	47.31	17.32	1.60	0.54	-1.14	-1.18	-12.77	436
2018	IRL_DTS_VL2440	Closure2022	22.17	7.89	1.88	0.25	-1.15	-1.15	-4.83	417
2018	ESP_DTS_VL1824	Closure2022	21.15	18.39	17.18	0.71	-3.34	-3.56	-3.81	404

3.2 Displacement effect estimated with the ICES VMS dataset

The AER-VMS displacement study's main findings show that the most impacted segment ESP_DTS_VL2440 and some others can compensate for the possible loss of spatial opportunities by displacing their fishing effort toward the surrounding areas (Figure 27).

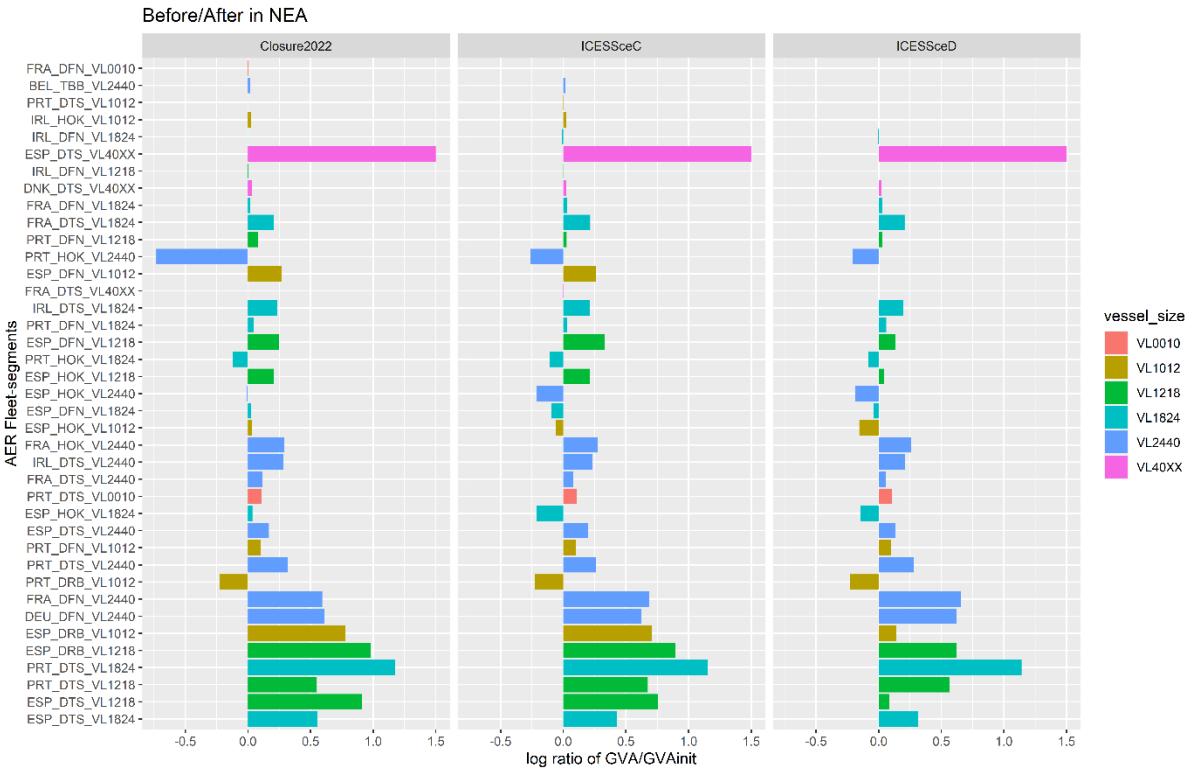

Figure 28. *Anticipated GVA change after a weighted redistribution of the average 2018-2021 fishing effort to the surrounding areas based on their expected GVAs. The x-axis is a log-ratio to ease the comparison (for example, a log ratio of 0.20 represents a percent change of exp(0.2)*100=+22.1%).*

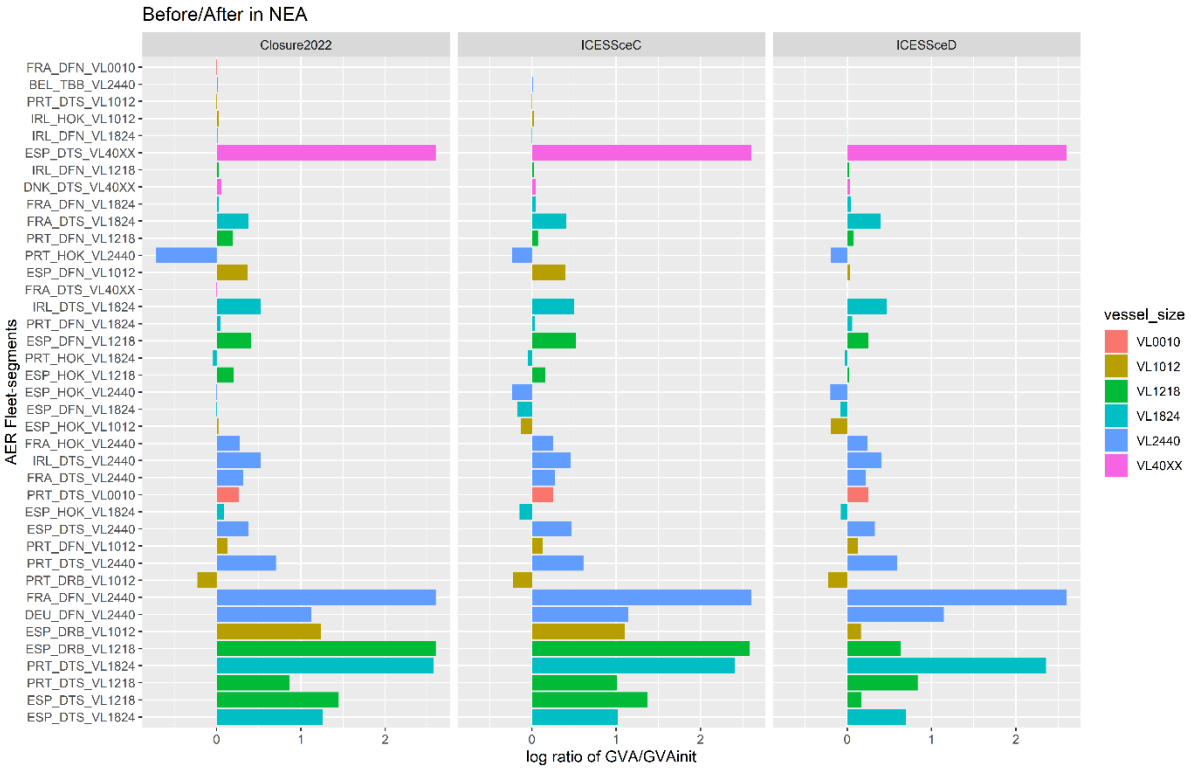

***Figure 29**. Estimated GVA change after uniform redistribution of the VMS effort in the surrounding areas.*

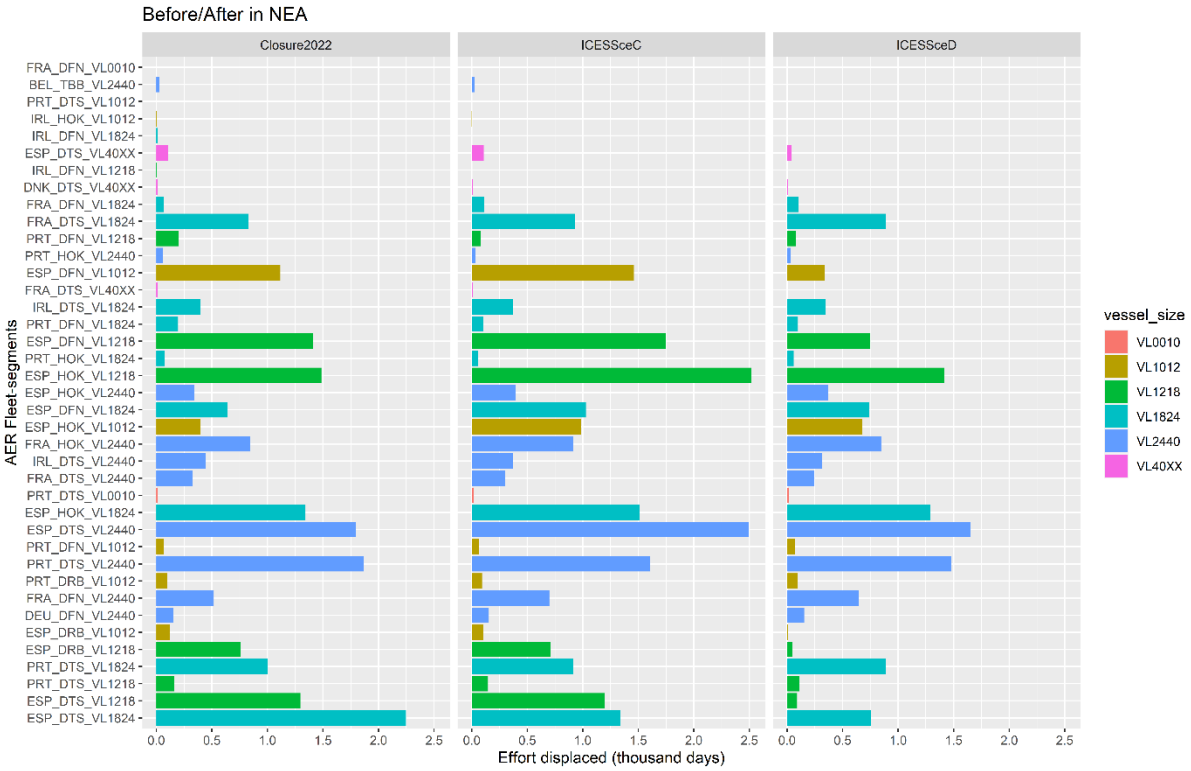

***Figure 30.** Estimated EFFORT displaced by the spatial plans for each fleet segments using mobile bottom contacting gears (i.e. the ones comprised in the ICES dataset).*

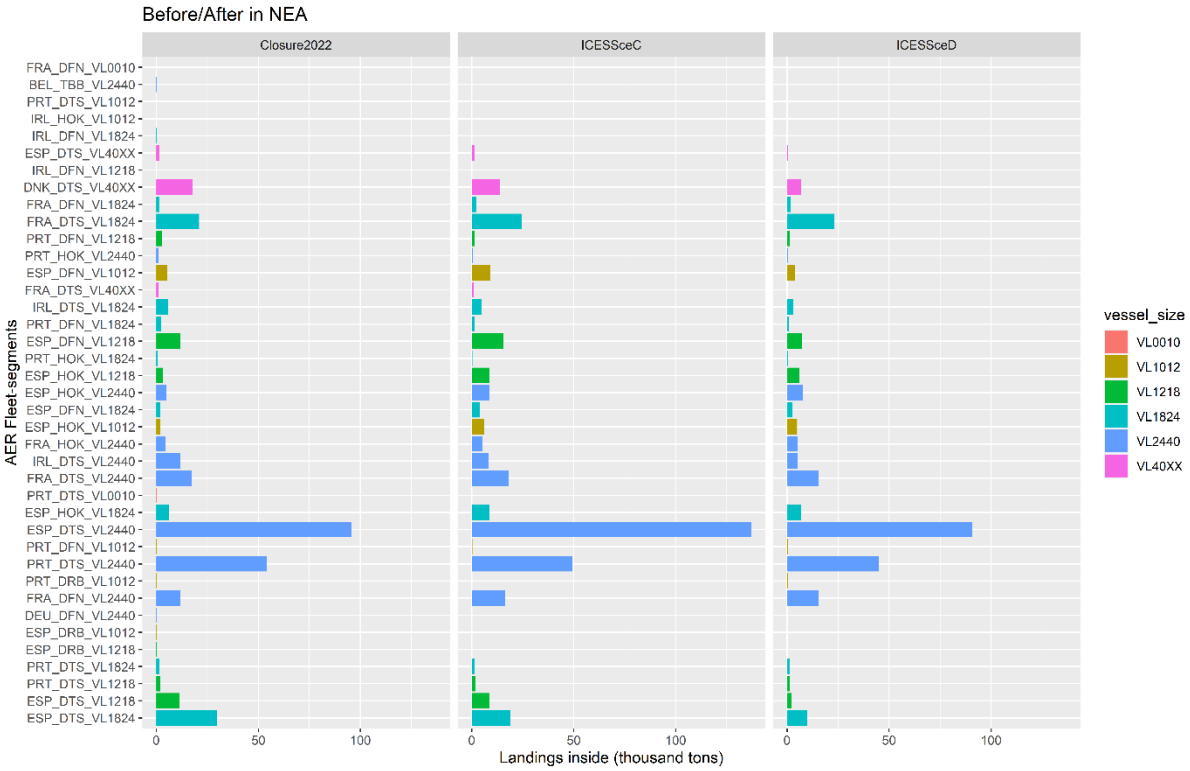

***Figure 31**. Estimated landings displaced by the spatial plans for each fleet segment using mobile bottom contacting gears (i.e. the ones comprised in the ICES dataset)*

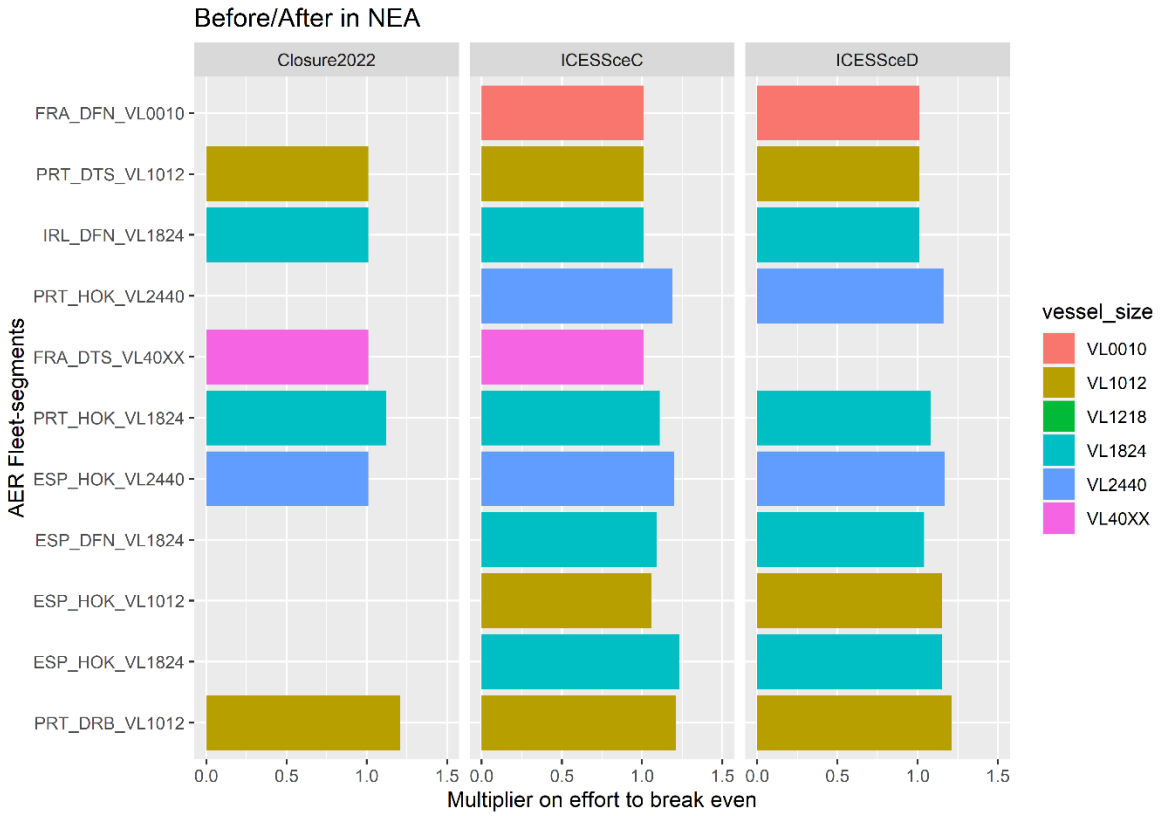

Figure 32 *Fleet-segment-specific extra-effort multiplier required to compensate and break even in reaction to impact from the closed areas for the three scenarios in the SWW and NWW.'*

Fleet segment	scenario	Effort multiplier
PRT_DRB_VL1012	Closure2022	1.21
ESP_HOK_VL2440	Closure2022	1.01
PRT_HOK_VL1824	Closure2022	1.12
FRA_DTS_VL40XX	Closure2022	1.01
IRL_DFN_VL1824	Closure2022	1.01
PRT_DTS_VL1012	Closure2022	1.01
PRT_DRB_VL1012	ICESSceC	1.21
ESP_HOK_VL1824	ICESSceC	1.23
ESP_HOK_VL1012	ICESSceC	1.06
ESP_DFN_VL1824	ICESSceC	1.09
ESP_HOK_VL2440	ICESSceC	1.20
PRT_HOK_VL1824	ICESSceC	1.11
FRA_DTS_VL40XX	ICESSceC	1.01
PRT_HOK_VL2440	ICESSceC	1.19
IRL_DFN_VL1824	ICESSceC	1.01
PRT_DTS_VL1012	ICESSceC	1.01
FRA_DFN_VL0010	ICESSceC	1.01
PRT_DRB_VL1012	ICESSceD	1.21
ESP_HOK_VL1824	ICESSceD	1.15
ESP_HOK_VL1012	ICESSceD	1.15
ESP_DFN_VL1824	ICESSceD	1.04
ESP_HOK_VL2440	ICESSceD	1.17
PRT_HOK_VL1824	ICESSceD	1.08
PRT_HOK_VL2440	ICESSceD	1.16
IRL_DFN_VL1824	ICESSceD	1.01
PRT_DTS_VL1012	ICESSceD	1.01
FRA_DFN_VL0010	ICESSceD	1.01

4. Limitations of the study

The geographical scale at which the evaluation is done can be determinant in providing accurate estimates. Using coarser spatial resolution, such as the FDI data (resolved at the 0.5-degree grid cells) compared to the finer VMS dataset (0.05 degrees), demonstrated that FDI-only estimates lead to comparable estimation of the possible short-term socioeconomic impact of the closed areas on the impacted fleet-segments, as long as an account of the fishable area per 0.5 c-square is done, but also to higher estimates for some fleet-segments. If ICES (2022) considers the aggregated VMS 0.05 spatial grid resolution is appropriate to map mobile bottom contacting gears fishing activity, given the minimum frequency of VMS position collection and average fishing speeds of vessels towing those gears, inherent uncertainties in vessel positioning and therefore impact arise disaggregating spatial data from a coarser 0.5-degree grid.

Longliners and netters may also contact the seafloor when operating the fishing. It should be mentioned that, unfortunately, no VMS data were available for these fishing techniques during this analysis, and therefore the impact assessement is based on the AER coupled to the FDI dataset only. Future analysis with VMS could include those fishing techniques specifically. For now, longliners, netters and small dredgers are covered by the FDI dataset, which was found helpful for disaggregating the AER economic variables spatially.

By nature, the FDI and VMS datasets describe the fishing activities at the DCF métier Level 6, which is close to what defines "fisheries" (i.e. combinations of a fishing technique used during a specific season for specific target species). On the other side, the AER data is aggregated at a coarser level which constrained the final resolution of the fleet segment used in the present study, even if the AER economic variables have been disaggregated spatially, accounting for the spatial effort distribution per DCF métier Level 6. Impacted AER fleet-segments could, in most cases, encapsulate several different fisheries which will not be impacted the same way by the spatial plans, some potentially more impacted than the study could show if targeting deep-sea species specifically. However, aligning to the coarser AER fleet segment level was unavoidable to account for the entire fleet economy and compute profit indicators. Besides, there are inherent uncertainties linked to the method for spatially disaggregating the AER economic variables, as these variables are not spatial by nature. Hence it is assumed that the travelling or distance-to-coast effect is neglectable (one unit of effort of a given fleet segment has the same cost whatever this distance), and therefore only the cost per unit of time effort is considered in disaggregating costs spatially, which in some occurrences might make the possibility for effort displacement overly optimistic.

It is recalled that the goal of the protection of VMEs is to ensure the long-term conservation of deep-sea fish stocks and their supportive vulnerable habitats by limiting significant adverse impacts on VMEs and therefore contribute to the objectives of the EU Common Fisheries Policy. To account for effects in the medium to the longer-term horizon, the analysis should be complemented with some ecological considerations not to underestimate the benefits of such closed areas. Those considerations are, for now, missing and were out of the scope of the present evaluation.

It is also expected that the population dynamics of the target stocks will also influence the future allocation of fishing effort in space in response to changes in stock distribution which is not captured here when looking at historical effort allocation only. Developing a bioeconomic Management Strategy Evaluation (MSE) would make it possible to test, for the biological side, for alternative natural mortality rate and future changes, alternative somatic fish body growth and future change, the effect of differences in age-composition and variation in catchability of fish of varying size, changes in spatial distribution, changes in ocean's carrying capacity and effects of recovering stocks. On the economic side, an MSE would inform on various changes in the economic context of exploitation (price, costs,

capital, etc.). Hence, it should be clear that no benefit is shown here from protecting the VMEs and recovery, etc., only because only short-term effects are investigated here. The evaluation does not know about long-term dynamics; to investigate this, it would need to use some bioeconomic spatial models in an MSE setting and including e.g. spatial connectivity modelling.

Concerning the socioeconomic evaluation, it should be noted that it is not straightforward to translate a change in an economic variable into a short-term or long-term impact on the engaged crew or a change in the number of engaged crew. Such a relationship is highly hypothetical and has not been used here, also because the evaluation found that there is no negative GVA induced by the spatial plans that would indeed possibly lead some stakeholders to reduce the engaged crew in order to save on labour costs.
How the single operators could react facing closed areas is not entirely known. A spectrum of reactions might be expected from redistributing the effort toward other highly profitable fishing grounds, toward fishing grounds that are already well known, or ceasing or reducing the effort at sea during a certain period of the year if the economic gain is expected not worth it. However, a redistribution assuming fisheries involved in deep-sea are profit-optimiser fishing, as has been done in the present evaluation, seems the most reasonable hypothesis in the possible skipper's decision-making given the small extent of the closed areas investigated (i.e. 1.87 to 4.07% of the surface area closed, or proposed to be closed, has a potential impact).

5. Conclusion

Overall, by analysing the finely spatially resolved data, the socioeconomic impact of enforcing the proposed VME areas would not exceed 10% of the average Gross Value Added (GVA), all scenarios combined, and mainly affects the ESP_DTS_VL2440 and the ESP_DTS_1824 fleet segments with a possibility of offsetting the loss of spatial opportunities by displacing the effort toward surrounding areas. Only a few areas are susceptible to affecting specific fisheries, with some impact that can be offset by displacing the effort toward other fishing grounds. It also depends on the type of proposals (ICES Scenario C vs ICES Scenario D) as eventually not impacting the same segments. It is found, however, that ICES Scenario C is impacting more than other scenarios. However, the adverse effect arises from a few locations. Therefore, a possible mitigation measure might pay particular attention to those impacting c-squares and maybe less to the chosen scenario.

By analysing more aggregated data (the FDI dataset) it is confirmed that the Spanish fleet is the most affected, the fleet using the DTS fishing techniques but also small dredgers and longliners (HOK) (only for ICES scenario C). Comparing for DTS-related segments, it is shown that estimates of area protection effects depend on the geographical resolution of the source data, and using the FDI dataset led to slightly estimating larger socioeconomic impacts than the one deduced from the finer VMS dataset. However, the FDI data coverage, including the smaller vessels (<12 m), is more extensive by nature. Indeed small vessel categories have also been found to be affected by the closures, especially by VME areas that are closer to the shore (Iberian waters or Gulf of Cadíz). In our specific case, the FDI also included the longliners and netters that may be impacted by the protection of VME areas. Potential impacts on the GVA of longliners and netters are found to be greater than for other métiers (for ICES scenario C).

It is observed that on some occasions, a slight change affecting GVA can lead to a large change in profitability, given some extensive personnel costs and fixed capital assets engaged in those fisheries, and sometimes with negative initial profit. Negative profit might add to the loss of spatial opportunities, possibly affecting the concerned segments' engaged crew if saving on labour costs is seen as a solution to balance losses.

If the tested spatial plans have been found to have some impact, it does not preclude some future benefits on future fishing opportunities from protecting the VMEs or from displacing fishing effort away toward more rewarding fishing grounds. The present study has looked at short-term effects only and does not know about long-term dynamics or the change in labour costs and engaged crews in the medium term; to investigate this, it would need to use some bioeconomic spatial models that would also include population dynamics and ecological considerations.

Appendix

Output tables for the economic indicators are attached to the report in HTML format (which can be easily copied/pasted toward any Excel sheet), for:

1. Spatial overlay analysis:

   - agg_eco_fs_with_impacted_gva_2018_2021.html
   - collector_extraction_per_fs_per_boxID_2018_2021.RData
   - map_impacted_csquares.html for an interactive map with GVA (MEuro) per impacted 0.05-degree c-square

2. Spatial effort displacement analysis per fleet segment:

   - before_after_output_2018_2021.html

Annexe 1- Estimation of Impacted GVA per polygon ID and scenario deduced from the AER-VMS overlay analysis

[Note that the polygons IDs are specific to a given scenario and therefore do not correspond to the same area across scenarios]

CLOSURE 2022 – AER-VMS

BoxID	**6**	**78**	**57**	**5**	**4**	**85**	**18**	**23**	**77**	**81**	**20**	**17**	**66**	**28**	**80**	**25**	**50**	**22**	**45**	**79**
Impacted GVA(Euro)	468695	236559	176608	168948	132259	96054	73549	67723	64798	50453	46055	40595	29764	28472	23218	18596	13554	12654	9029	6730
BoxID	**51**	**43**	**13**	**14**	**19**	**75**	**46**	**76**	**60**	**11**	**15**	**21**	**26**	**24**	**29**	**32**	**38**	**39**	**53**	**52**
Impacted GVA(Euro)	5923	4212	2200	1452	1043	343	39	38	8	0	0	0	0	0	0	0	0	0	0	0
BoxID	**56**	**62**	**65**	**64**	**63**	**70**	**72**	**67**	**82**	**86**	**84**	**83**	**87**	**2**	**1**	**3**	**10**	**8**	**12**	**69**
Impacted GVA(Euro)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-14
BoxID	**34**	**30**	**31**	**33**	**42**	**61**	**55**	**73**	**59**	**9**	**44**	**7**	**74**	**41**	**37**	**27**	**58**	**40**	**71**	**68**
Impacted GVA(Euro)	-14	-46	-84	-90	-97	-100	-107	-149	-167	-184	-185	-238	-286	-305	-357	-397	-707	-805	-914	-1007
BoxID	**36**	**49**	**48**	**54**	**47**	**16**	**35**													
Impacted GVA(Euro)	-1452	-1956	-2583	-8386	-18989	-36334	-46739													

SCENARIO ICES C – AER-VMS

BoxID	**42**	**43**	**41**	**27**	**40**	**38**	**112**	**31**	**36**	**45**	**32**	**111**	**39**	**20**	**28**	**47**	**90**	**114**	**30**	**53**
Impacted GVA(Euro)	1186550	724236	569044	468203	360931	230642	218835	121659	86084	67982	67578	64954	63345	56312	39981	38106	33459	29683	29458	28472
BoxID	**115**	**116**	**49**	**37**	**46**	**73**	**113**	**79**	**68**	**24**	**99**	**25**	**44**	**55**	**74**	**110**	**7**	**92**	**1**	**2**
Impacted GVA(Euro)	20651	19537	18596	16329	12654	9029	6730	5923	4212	2200	1747	1481	1043	217	39	38	23	8	0	0
BoxID	**3**	**4**	**5**	**8**	**10**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**22**	**26**	**50**	**54**	**57**	**65**	**66**
Impacted GVA(Euro)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BoxID	**81**	**84**	**87**	**94**	**95**	**96**	**97**	**98**	**100**	**103**	**105**	**106**	**108**	**118**	**119**	**120**	**121**	**122**	**102**	**56**

Impacted GVA(Euro)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-14	-84
BoxID	**70**	**93**	**86**	**107**	**29**	**78**	**91**	**23**	**71**	**72**	**109**	**21**	**60**	**64**	**52**	**51**	**61**	**58**	**48**	**11**
Impacted GVA(Euro)	-97	-100	-107	-149	-149	-165	-167	-184	-185	-199	-237	-238	-250	-357	-395	-397	-486	-514	-516	-640
BoxID	**77**	**69**	**67**	**104**	**9**	**101**	**6**	**59**	**88**	**63**	**89**	**117**	**80**	**76**	**85**	**75**	**82**	**83**	**35**	**34**
Impacted GVA(Euro)	-656	-696	-805	-914	-964	-1007	-1291	-1293	-1434	-1452	-2265	-2632	-4818	-7079	-12343	-18989	-23918	-27217	-36334	-57603
BoxID	**62**	**33**																		
Impacted GVA(Euro)	-124942	-175692																		

SCENARIO ICES D – AER-VMS

BoxID	**34**	**35**	**36**	**44**	**24**	**40**	**26**	**37**	**31**	**39**	**69**	**28**	**32**	**88**	**30**	**22**	**33**	**46**	**79**	**64**
Impacted GVA(Euro)	118499	69867	52590	28472	22877	18596	12967	12654	8687	7040	5923	4959	2904	1747	1682	1481	1043	217	201	39
BoxID	**99**	**10**	**81**	**1**	**2**	**3**	**4**	**5**	**7**	**8**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
Impacted GVA(Euro)	38	23	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BoxID	**23**	**41**	**42**	**45**	**48**	**56**	**57**	**70**	**71**	**73**	**76**	**83**	**84**	**85**	**86**	**87**	**89**	**92**	**94**	**95**
Impacted GVA(Euro)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BoxID	**97**	**100**	**101**	**103**	**104**	**105**	**106**	**107**	**91**	**65**	**47**	**82**	**75**	**61**	**96**	**25**	**9**	**80**	**21**	**62**
Impacted GVA(Euro)	0	0	0	0	0	0	0	0	-14	-68	-84	-100	-107	-137	-149	-149	-158	-167	-184	-185
BoxID	**63**	**59**	**98**	**51**	**55**	**43**	**52**	**68**	**49**	**38**	**67**	**60**	**78**	**58**	**93**	**6**	**90**	**50**	**54**	**102**
Impacted GVA(Euro)	-199	-222	-237	-250	-357	-395	-486	-500	-514	-516	-656	-696	-707	-805	-914	-964	-1007	-1293	-1452	-2632
BoxID	**77**	**66**	**74**	**72**	**27**	**53**	**29**													
Impacted GVA(Euro)	-3851	-5778	-5897	-23918	-36334	-46312	-70671													

Annexe 2- Estimation of Impacted GVA per polygon ID and scenario deduced from the AER-FDI overlay analysis

[warning: as polygons are much smaller than the FDI grid resolution, the impacted GVA can be counted several times whenever a FDI 0.5 c-square grid would encompass more than one polygon ID]

	Closure2022 - AER-FDI																			
BoxID	**6**	**5**	**4**	**80**	**81**	**49**	**48**	**77**	**76**	**50**	**8**	**17**	**7**	**20**	**54**	**47**	**51**	**58**	**75**	**14**
Impacted GVA(Euro)	1535134	1535134	1115427	754832	445493	329439	329439	285535	285535	278398	263052	243748	218626	167708	128579	128040	124307	118591	115457	110250
BoxID	**61**	**71**	**57**	**13**	**72**	**36**	**55**	**16**	**28**	**45**	**46**	**27**	**23**	**53**	**67**	**22**	**56**	**24**	**11**	**29**
Impacted GVA(Euro)	102995	72381	71212	60177	57262	53163	49745	40297	31837	17395	17357	14659	11563	9829	4992	3929	2263	714	0	0
BoxID	**32**	**52**	**10**	**12**	**1**	**3**	**65**	**26**	**25**	**33**	**84**	**83**	**44**	**21**	**82**	**38**	**39**	**30**	**31**	**86**
Impacted GVA(Euro)	0	0	0	0	-512	-512	-1763	-3095	-3095	-3323	-3323	-3323	-4398	-9165	-11185	-13578	-13578	-14205	-14205	-21886
BoxID	**34**	**60**	**59**	**66**	**73**	**41**	**19**	**37**	**35**											
Impacted GVA(Euro)	-23137	-28728	-28728	-34204	-34204	-46087	-51112	-136716	-158564											

	ICES_ScenarioC - AER-FDI																			
BoxID	**42**	**43**	**38**	**40**	**20**	**36**	**82**	**83**	**28**	**30**	**115**	**32**	**27**	**112**	**77**	**78**	**114**	**116**	**22**	**29**
Impacted GVA(Euro)	1258520	1238081	1089123	1038441	964783	702307	560394	560394	433596	433596	408065	394348	385788	342987	302340	302340	302083	302083	263052	248819
BoxID	**85**	**110**	**111**	**45**	**76**	**117**	**33**	**35**	**75**	**89**	**79**	**93**	**101**	**104**	**60**	**24**	**52**	**53**	**25**	**86**
Impacted GVA(Euro)	241864	228331	228331	220964	201930	201930	174986	174986	106102	99028	94006	88298	69892	69892	67978	67340	64577	64577	58361	53649
BoxID	**105**	**88**	**72**	**113**	**23**	**63**	**109**	**81**	**102**	**48**	**74**	**108**	**51**	**47**	**84**	**46**	**87**	**54**	**118**	**119**
Impacted GVA(Euro)	53179	40585	37858	36551	35062	33238	28111	24105	16863	16418	15848	15829	14659	12849	9829	3929	2263	0	0	0
BoxID	**120**	**121**	**122**	**94**	**96**	**16**	**18**	**19**	**97**	**80**	**4**	**49**	**50**	**71**	**57**	**58**	**3**	**10**	**14**	**6**
Impacted GVA(Euro)	0	0	0	-323	-323	-512	-512	-512	-1551	-2468	-2526	-2532	-2532	-4296	-7125	-7125	-9211	-9211	-9211	-10815
BoxID	**12**	**65**	**66**	**55**	**56**	**91**	**92**	**107**	**70**	**2**	**69**	**44**	**59**	**61**	**62**	**64**				
Impacted GVA(Euro)	-10815	-13221	-13221	-18589	-18589	-28421	-28421	-31239	-36547	-37690	-43862	-48419	-59845	-161738	-161738	-185264				

	ICES_ScenarioD - AER-FDI																			
BoxID	**35**	**36**	**72**	**20**	**28**	**30**	**25**	**66**	**102**	**32**	**19**	**67**	**68**	**74**	**26**	**27**	**29**	**82**	**69**	**24**
Impacted GVA(Euro)	465007	465007	291414	263052	256698	256698	248819	192658	192658	180881	180421	166069	166069	159266	133008	133008	133008	88298	87955	82615

BoxID	**90**	**93**	**43**	**44**	**51**	**78**	**22**	**75**	**21**	**54**	**79**	**98**	**77**	**63**	**91**	**38**	**97**	**65**	**64**	**73**
Impacted GVA(Euro)	69892	69892	64577	64577	64307	63663	58361	53649	35062	33238	31909	28111	18967	17394	16863	16418	15829	14641	11316	9829
BoxID	**39**	**99**	**100**	**76**	**42**	**45**	**70**	**71**	**101**	**103**	**104**	**105**	**106**	**107**	**83**	**85**	**15**	**17**	**18**	**86**
Impacted GVA(Euro)	5139	3015	3015	2263	0	0	0	0	0	0	0	0	0	0	-323	-323	-512	-512	-512	-1551
BoxID	**4**	**40**	**41**	**62**	**8**	**48**	**49**	**3**	**7**	**13**	**61**	**56**	**57**	**46**	**47**	**80**	**81**	**96**	**9**	**2**
Impacted GVA(Euro)	-2526	-2532	-2532	-3425	-3613	-7125	-7125	-9211	-9211	-9211	-11712	-13221	-13221	-18589	-18589	-28421	-28421	-31239	-34130	-37690
BoxID	**60**	**33**	**50**	**52**	**53**	**55**														
Impacted GVA(Euro)	-46094	-48419	-59845	-130012	-130012	-185264														