WORKSHOP TO UPDATE AND ASSESS TRADE-OFFS BETWEEN THE IMPACT OF FISHERIES ON SEAFLOOR HABITATS AND THEIR LANDINGS AND ECONOMIC PERFORMANCE (WKD6ASSESS)

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Executive summary

WKD6ASSESS aimed to provide an updated assessment of bottom trawl impact versus financial gain in all European waters, for the status quo and under various future management scenarios. In this, the latest developments made in various ICES working groups and workshops should be integrated, and the entire process should be aligned. Largest changes in the assessment include a new method to represent the financial gain of the fisheries; the inclusion of management scenarios in line with pertinent marine policies, for instance considering the closure of Marine Protected Areas; progress in multiple regions (including the Mediterranean Sea) to enable the assessment across all EU waters; and the development of a new user-friendly layout for the presentation of the assessment results. Unfortunately, the progress (mainly in term of data coverage) for the Mediterranean Sea has not yet reached a level that enables operationalizing the assessment at (eco)regional scales. In addition, the data flows for more accurate economic indicators are not yet guaranteed for coming years. Overall, the improvements implemented and presented in this report forms a solid basis for the establishment of a comprehensible and reproducible assessment of bottom trawl impact in all European waters.

Expert group information

Expert group name	WORKSHOP TO UPDATE AND ASSESS TRADE-OFFS BETWEEN THE IMPACT OF FISHERIES ON SEAFLOOR HABITATS AND THEIR LANDINGS AND ECONOMIC PERFORMANCE (WKD6ASSESS)
Expert group cycle	Annual
Year cycle started	2023
Reporting year in cycle	1/1
Chair(s)	Karin van der Reijden, Denmark
	Lorenzo D'Andrea, Italy
Meeting venue(s) and dates	6,7, & 13 December 2023, ICES HQ and online (33 participants)

1 Introduction

The WKD6ASSESS workshop was organized in the context of a new special request from DGENV, which entails updating the ICES advice reporting the 'EU request on how management scenarios to reduce mobile bottom fishing disturbance on seafloor habitats affect fisheries landing and value' (ICES, 2021). Herein, the European Commission request to ICES is summarized as:

"ICES to advise on a set of management options to reduce the impact of mobile bottom-contacting fishing gears (MBCG) on seafloor habitats, and for each option provide a trade-off analysis between fisheries value and the seafloor impact. The trade-off is to be assessed in relation to the 22 MSFD broad habitat types in each ecological assessment area (subdivision) of the MSFD sub-regions. The advice will inform the setting of threshold values for the environmental quality of seabed habitats under the Marine Strategy Framework Directive."

DGENV now requested an update of this advice, which should be based on the most recent (fisheries) data, but also accounts for the latest developments in both the impact assessment methodology and financial representation of the fisheries. The new advice should, in addition, incorporate the stakeholder feedback on the previous advice, and showcase relevant scenarios management scenarios in line with current policy drivers for Marine Protected Areas (MPAs). Finally, DGENV is keen to receive this advice to the extent possible for all European marine regions, including the Mediterranean and Black Seas. This workshop aims to not only update the ICES Advice in line with the requirements of DGENV, but to also ensure that the impact assessment and subsequent trade-off analysis are clear and reproducible, congruent with the ICES Transparent Assessment Framework (TAF) agreement.

The basis for the ICES Advice on mobile bottom fishing disturbance of the seafloor is provided by the impact assessment methodology developed within the ICES Working Group on Fisheries Benthic Impact and Trade-offs (WGFBIT). This fishing impact is then 'balanced' against the financial gain of the fisheries, using the approach developed within the WKTRADE1-3 workshops, with WKTRADE3 being the foundation of the ICES 2021 advice.

Since the publication of the ICES 2021 advice, members of WGFBIT have widened the spatial coverage of the impact assessment model and refined its methodology (ICES, 2023a). The representation of the financial gain of fisheries has improved within the WKTRADE4 workshop (report not yet available), while the WKSSFGEO2 workshop aimed to improve the coverage and inclusion of small-scale fisheries in the fisheries data (ICES, 2023b). Lastly, the workshop WKD6STAKE provided valuable feedback from stakeholders regarding the entire process of impact assessment and subsequent trade-off analysis and reporting (report not yet available). Apart from developments within the ICES structure, multiple European research projects have been performed that investigated MPAs in the context of fisheries. Their approaches, results, and conclusions could serve as a basis for the creation of realistic management scenarios in the updated advice. Figure 1.1. provides a visual summary of how aforementioned work would flow into the new updated advice.

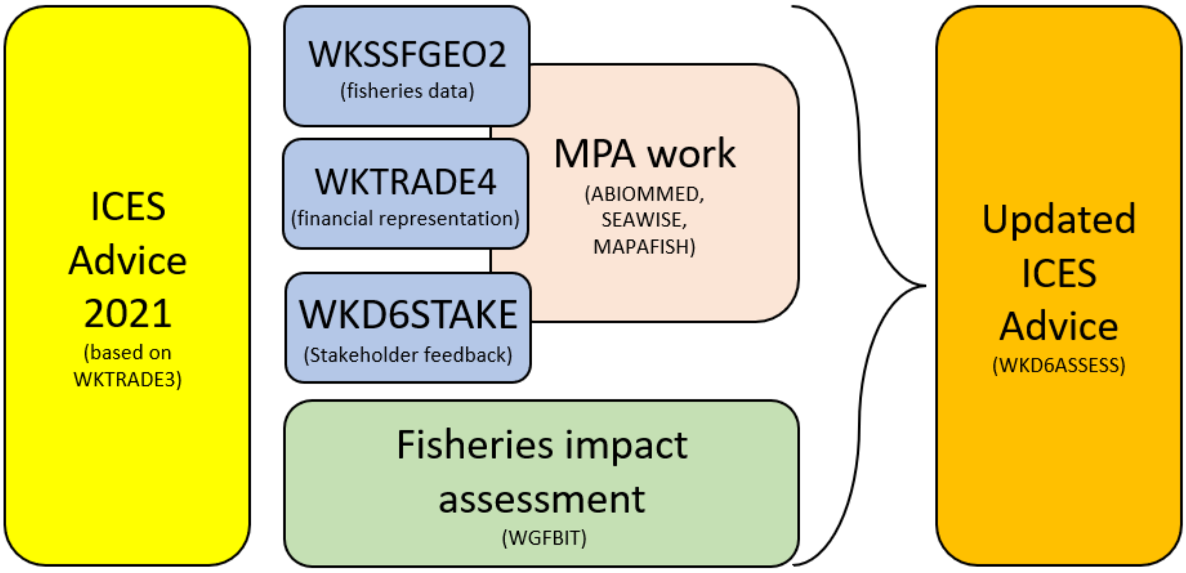

Figure 1.1. A visual summary of how developments within the ICES workshops, working groups, and European research projects since the ICES advice in 2021 could contribute to the updated ICES advice that should be drafted within WKD6ASSESS.

2 Updating the ICES 2021 advice (ToR a and b)

2.1 Establishment of coherent framework

A thorough screening of the various data-processing and analyses steps was performed to see how the different developments could be aligned to establish an updated, reproducible assessment routine.

The current status of the routine reflects its alignment with that of the WGFBIT procedure, since it is built from these outputs. WGFBIT outputs are employed as input in the WKTRADE3 analyses, with subsequent updates from WKTRADE4. In general, the complete workflow requires the processing of the routines developed by WGFBIT (determination of the fishing footprint and calculation of its impact), WKTRADE3 (trade-off between impact and financial gain, presentation of results as HTML + Leaflets), and WKTRADE4 (improved financial fisheries data). The routines are stored within specific repositories, while the data is stored in private databases with controlled access. The process of updating and processing the individual steps needed for the trade-off analyses underlying the ICES Advice is repeatable, however it must be noted that 1) the development is currently subjected to constant updates by methodological integrations and 2) the organization, sharing and documentation of the scripts are not following the ICES Transparent Assessment Framework (TAF) principles (Figure 2.1.).

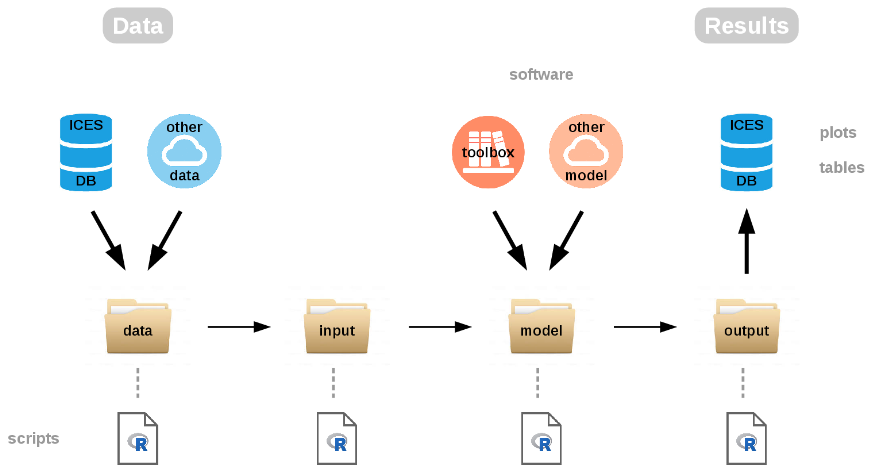

Figure 2.1. A schematic overview of the Transparent Assessment Framework (TAF) system. This structured system is designed to streamline the organization of data, methodologies, and outcomes involved in assessments conducted by ICES. Its primary objective is to bolster transparency, accessibility, and the ability to replicate assessments, thereby fostering a more robust and collaborative approach to data-driven decision-making within the ICES community.

The establishment of a coherent framework that encompasses all the routines in a single integrated approach requires a complete revision of the data analysis pipeline. The TAF system could help to establish such a coherent framework, and ensures its transparency, accessibility, and reproducibility. The TAF system is organized into folders (Figure 2.1.), each serving a specific purpose: data, input, model, output, report, and upload. These folders are governed by corresponding R scripts that orchestrate different stages of the assessment process (Table 2.1.).

Table 2.1. The folders in the TAF system, with their specific contributions to the assessment process.

Folder	Functions
Data.R	Responsible for preprocessing the data. Generates TAF data tables, simple comma-separated values (CSV) text files. Primarily focuses on organizing and structuring the data for subsequent stages.
Input.R	Converts preprocessed data into a format specific to the model being used. Writes out model input files needed for the analysis. Bridges the gap between raw data and the requirements of the chosen model.
Model.R	Executes the analysis, often by invoking a shell command or an R package. Runs the selected model and produces output files. Key stage where the assessment model is applied to the input data.
Output.R	Focuses on extracting and refining the results of interest from the model output files. Typically involves isolating specific information like numbers at age and fishing mortalities. Writes the refined results into text files for further use or reporting.
Report.R	Optional script where scientists can prepare plots and tables intended for the assessment report. Provides a space for customizing visualizations and summarizing key findings for reporting purposes.
Upload.R	Short script describing the data that gets uploaded into the TAF system. Specifies the characteristics and format of the data being introduced into the assessment framework.

Aligning the different procedures with each other and with the TAF approach requires a thoughtful integration of transparent and organized practices. Key aspects involve clearly defining the objectives of each procedure, organizing relevant data sources, comprehensive documentation of its methodologies, archiving results within the TAF, and its integration with existing ICES data services. The TAF framework should accommodate version control, encouraging peer review and collaboration among specialists from diverse fields. Emphasis should be placed on transparently documenting assumptions and uncertainties associated with the assessment methods. A user-friendly interface to present the results is crucial, facilitating effective visualization and interpretation of maps and indicators. Training programs should be provided within the TAF framework to ensure that users, including specialists, can navigate and utilize the advice efficiently.

2.2 The fisheries impact assessment (WGFBIT)

2.2.1 The PD-model

The Working Group on Fisheries Benthic Impact and Trade-offs (WGFBIT) is actively engaged in developing methodologies and conducting assessments to evaluate the impact of fisheries on benthic ecosystems at a regional scale (ICES, 2023a). Several impact assessment methods have been developed by this working group, with the Population Dynamics (PD) model being the approach most used, amongst others in the ICES Advice 2021. In this, the actual impact is depending on both the fishing activity (fishing effort and fishing gear employed) and the affected benthic community (sensitivity to physical disturbance) (Figure 2.2.). The PD-model assumes a logistic growth equilibrium, which is negatively affected by fisheries-caused depletion of organisms and subsequent longevity-based recovery of the community (Pitcher et al., 2017). As such, impact is represented as the Relative Benthic State, i.e. the state of the benthic community relative to its theoretical carrying capacity, in a score ranging from 0 to 1.

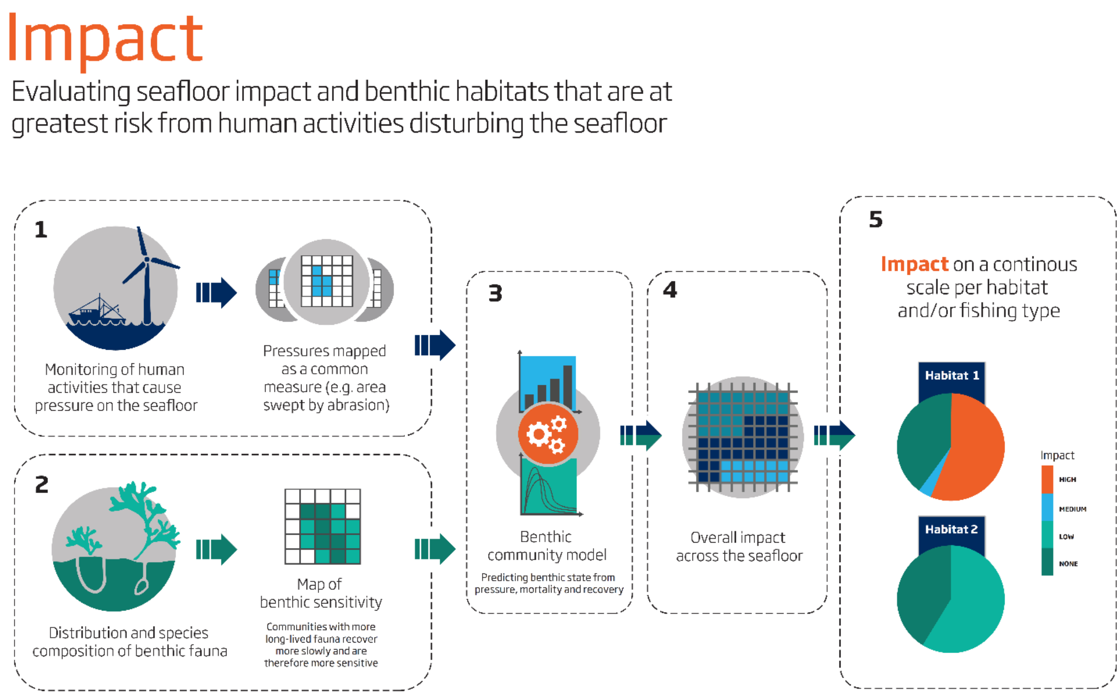

Figure 2.2. Workflow of the PD impact assessment model within the WGFBIT assessments.

In their last official report, WGFBIT has undertaken new fishery benthic impact assessments for several sub-regions, specifically the French Mediterranean and the Celtic Seas (ICES, 2023a). For other regions, the report includes updates to the regional assessment or specific steps within the assessment process. It is acknowledged that model input data varies between regions due to differences in data availability and environmental characteristics, which results in varying stages of model implementation and accuracy between regions or sub-regions. The sensitivity information, for instance, is based on benthic data collected with different gears like trawls, grabs, or video. At this point, impact assessments are available for several regions, including the North Sea, Celtic Sea, Kattegat, Baltic Sea, and the Eastern Mediterranean.

The report emphasizes WGFBIT's commitment to not only conduct impact assessments but also to refine and standardize their methods. For instance, efforts are made to study the effects of regional sampling differences in the type of input data used to estimate local sensitivity. This recognition of regional differences is crucial for ensuring the adaptability of their approach while maintaining a coherent and standardized framework. The emphasis on a detailed overview reflects the group's dedication to transparency and the establishment of a consistent methodology, ultimately contributing to a more comprehensive understanding of benthic impacts from fisheries across diverse regional contexts.

2.2.2 Input data

The WGFBIT employs a detailed and regionally adapted methodology for assessing fishery benthic impact, considering diverse factors such as biological data, trait datasets, fishery data, environmental drivers/models, grid scale, and habitat data layers. While recognizing slight methodological differences among regions due to variations in data availability, environmental characteristics, and implementation possibilities, there is an ongoing effort to standardize certain elements gradually. This approach aims to achieve a more harmonized assessment of fishery benthic impact across EU regions in the coming years, while acknowledging the need for flexibility based on regional characteristics. The PD-model requires multiple data sets at the input stage to conduct a comprehensive impact assessment of mobile bottom fishing (Table 2.2). In addition, the spatial resolution at which model is performed is important for its outcome.

Table 2.2. The various datasets required within the PD-model to assess impact of mobile bottom fishing

Biological data	Source	Trawl, grab, or video data from benthic surveys.
	Content	Information on benthic fauna and their distribution on the seafloor.
	Considerations	Inclusion/exclusion of specific fauna groups, data on catch efficiency for different fauna groups, and adjustments for variations in sampling equipment efficiency.
Trait data	Source	Various sources
	Content	Data on the lifespan of different species present in the benthic ecosystem.
	Considerations	Standardization of longevity data from various sources, adaptation over time, and efforts to create a common trait dataset for use in the assessment.
Fishery data	Source	Vessel Monitoring System (VMS) and logbook data, or AIS data merged with official fleet registers
	Content	Information on fishing activities, including spatial and temporal patterns.
	Considerations	Use of data from reference stations with minimal fishery disturbance, potential inclusion of Swept Area Ratio (SAR), as fishery pressure, into the longevity model and addressing challenges in finding appropriate reference locations.
Environmental data	Source	Various sources, regional specific.
	Content	Environmental data related to the seafloor ecosystem
	Considerations	Application of statistical models, like logistic mixed-effect models, to estimate biomass-longevity distribution in relation to environmental conditions.
Habitat data	Source	EUSEAMAP 2021 habitat data.
	Content	Information on broad habitat types as per the Marine Strategy Framework Directive (MSFD).
	Considerations	Exclusion of rock habitats, adherence to legislative depth boundaries for fishery, and utilization of the habitat layer to delineate MSFD broad habitat types.

2.3 The financial gain of fisheries (WKTRADE4)

WKTRADE4 aimed to better reflect the financial gain of the fisheries, in line with stakeholder feedback on the ICES Advice 2021. Then, the landing's value, when available, was used to represent the financial aspect in the trade-off between fishing impacts and gains. The landing's value, however, does not represent the profitability of the fishery, because it does not account for the operating costs related to the fishing activities as well as the fixed costs. When landing's value was not available, the landing was used as proxy of profitability of the fishery. WKTRADE4 was able to determine a Gross Value Added (GVA) metric, based on merging the STECF AER (Annual Economic Report) data with STECF FDI (Fisheries Dependent Information) by fleet segment (combination of country, supra region, fishing technique, vessel length group and geo-indicator) and with spatial ICES VMS data (by country, year, métier level 6, sub region, and vessel length group) (Figure 2.3.) (ICES 2024a). The GVA can be considered as a measure of the gain of the fishery excluding other variable, repair, and maintenance costs, and non-variable costs (net gain) from the original AER formulation:

GVA = Income from landings + other income – energy costs – repair and maintenance costs – other variable costs – non variable costs

where:

- income from landings are the revenues,
- other income is income not related to the landing sale (e.g. sale for quotas, fishing rights),
- energy costs are costs associated to fuel consumption,
- repair and maintenance costs are related to maintenance and repairs of fishing equipment, gears, and vessel parts,
- the other variable costs are generally depending on the revenues rather than the fishing activity,
- the non-variable costs are fixed costs sustained by vessels independently on the fishing activity, like administration, obligatory insurance, fishing license, harbor charges, etc.

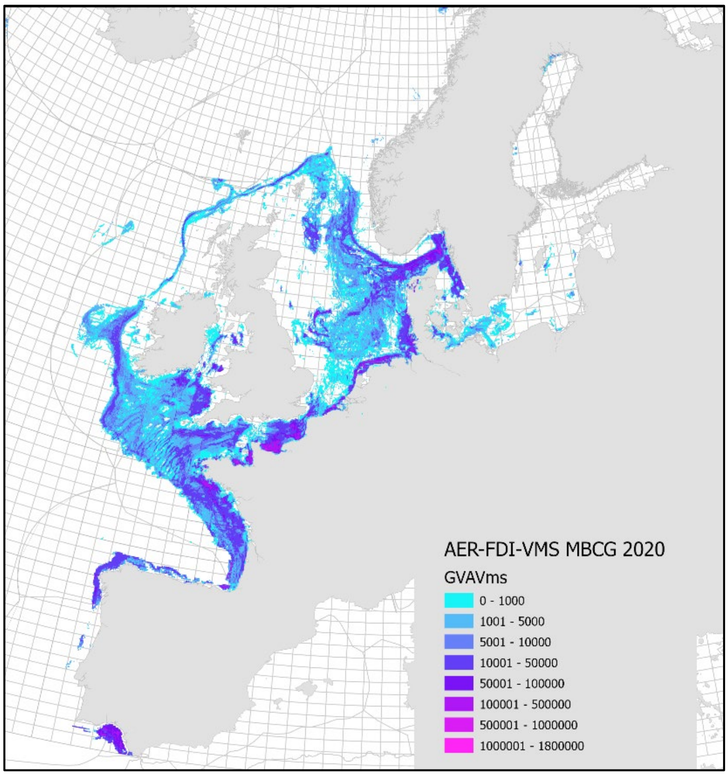

Figure 2.3. Disaggregated Gross Value Added (GVA) on VMS based on kW*Fishing hours from Mobile Bottom-Contacting Gears in 2020, using the VMS data from the ICES VMS/Logbook data call. Note that financial (GVA) data from non-EU countries (UK, Norway, Russia) are not included.

In other words, the GVA is the net output of the fishery sector after deducting intermediate inputs from all outputs. It is a measure of the contribution to the Gross Domestic Product (GDP) made by an individual producer, industry, or sector. WKTRADE4 relied on methods developed within the European SEAwise project, in which the GVA was spatialized based on the spatial distribution of the fishing effort. This approach can be technically applied in all regions, both using AIS and VMS data. It therefore provides a direct improvement for the Spanish and Portuguese fisheries data, as the landing values of these countries were generally missing. However, the method also comes with several limitations:

- While the revenues and the variable costs can be considered depending on the fishing effort, the fixed costs are, by definition, not depending on the fishing effort. Thus, this approach can be more or less accurate depending on the proportion represented by the fixed costs of the total costs.
- The landing in value could potentially have a different spatial distribution than the fishing effort. Thus, the integration of a landing value layer as well as additional national data sources should be considered to improve the accuracy of the spatial GVA layer.
- The calculation of the GVA layer relies on STECF data. Since Brexit, the UK no longer submits data to STECF, and the GVA for UK vessels can therefore not be determined. This comprises a major problem in the trade-off assessments for the Greater North Sea and the Celtic Seas. The current assessments of these regions have included GVA data when available (2017-2019), but still rely on landing values in actual trade-offs and management scenarios.

2.4 Updates in this advice

2.4.1 Stakeholder input (WKD6STAKE)

During the WKD6STAKE workshop, held in October 2023, stakeholders from various levels, including fisheries and environmental sectors at national, regional, and European levels, provided feedback aimed at improving the 2021 Advice. In general, the report underscored the necessity for clearer, more consistent, and comprehensive assessments in fisheries impact studies. Key areas of focus included enhancing the clarity and consistency of information in the HTML product, highlighting shortcomings, and ensuring clear descriptions of methodologies and data sources, and the implications of these for the study's outputs. The workshop also emphasized the need to improve spatial models for assessing net profits, and alignment of the outputs with the Marine Strategy Framework Directive and marine protected area policy targets (ICES 2024b). WKD6STAKE recommendations were deliberated upon by WKTRADE4 participants to assess their implementation potential. WKD6ASSESS revisited the recommendations from WKD6STAKE and WKTRADE4 to make final decisions on their incorporation in the update to the 2021 ICES Advice (Table 2.3). In line with the feedback, the new advice will be based on the latest data. The actual changes in input data are summarized in Table 2.4.

Table 2.3. Summary of recommendations to be incorporated in the WKD6ASSES analysis in response to the stakeholder input received at WKD6STAKE to update the 2021 ICES advice (eu.2021.08)

WKD6STAKE Recommendation	WKTRADE4 and WKD6ASSESS comments/suggestions
Improve consistency and clarity of information presented in HTML product by improving documentation to navigate around pages, tables and figures; improve metadata and table/figure legends; be consistent in use of terminology between HTML pages and the Advice.	WKTRADE4 did not have input yet; WKD6ASSESS proposes to integrate the individual HTML and Leaflet pages into 1 (online) application for easier navigation with a more intuitive layout and responsive design. Include detailed metadata and informative legends for tables and figures to guide users. Standardize terminology across all pages.
Highlight shortcomings up front in the HTML product. Ensure methodologies and data sources are clearly described, with any consequences for the outputs clearly stated.	Implement a 'Read Me' section at the beginning of the HTML template to introduce methodologies and data sources. Implement a traffic light system to highlight key messages or important parts in each region of the report
Improve spatial model regarding the assessment of costs to fish to calculate net profits. These metrics may differ between members states, due to a range of factors, such as disparities in production costs such as fuel and time to fish, and care should be taken in drawing generalised conclusions at the entire European fleet level.	WKD6ASSESS agreed to use the Gross Value Added (GVA) layer, developed in WKTRADE4, to reflect changes in the assessment of costs and net profits for fisheries for the Atlantic. For the Mediterranean Sea (when no VMS data is available) the GVA can be determined by coupling FDI to fisheries data from the Global Fishing Watch. It is tested in the Adriatic, Ionian Sea and Western Med.
Provide outputs showing progress towards Marine Strategy Framework Directive and marine protected area (MPA) policy targets.	The aim is to include relevant scenarios, in line with current and proposed MSFD and MPA policy targets. The scenarios will also account for fisheries displacement.
Include other sources of data on areas closed to fishing activity, including seasonal closures and closures for specific gear types, wind parks, aquaculture, shipping, etc. Create a comprehensive data source if not available.	The inclusion of other activities and /or fishing limitations is not achievable in WKD6ASSESS but could be improved in the future.
Include data for small vessels (<12 m) or assess the significance of this data gap	Despite the efforts of WKSSFGEO2, no changes are made in the update and the issue will be highlighted in the limitation section. Missing data in relation to available data could be quantified.

WKD6STAKE Recommendation	WKTRADE4 and WKD6ASSESS comments/suggestions
Work towards improved resolution of fisheries data (reported at 0.05 degrees c-square) or other approaches to assessing the extent of seabed fishing disturbance.	No changes have been made in the update.
Include the Mediterranean and Black Seas.	Need to test run to see data limitations/ ease of implementing the scripts in a non-ices VMSs workflow
Ensure the updated advice contains the latest available data.	Ensure inclusion of the most recent data and add sections to present temporal trends.
Present trends over the assessment period in the HTML product.	The html already showed spatial trends, but it will be included in a separate section to gain clarity. The assessment period and the estimate of each indicator for each MSFD cycle will also be added.
Distinguish outputs according to new, low-impact gears or other gear modifications, where possible.	Now, BENTHIS metiers are used with fixed, metier-specific depletion estimates. WKTRADE3 work on management scenarios from the North Sea would be sufficient. A datacall for logbook to get to metier on areas with no VMS data (MedSea global fishing watch) should be needed. In this advice, a new scenario will be added that shows the change in fishing impact under gear modification (fishing with low-impact gears).
Monitor effects of management decisions by tracking changes in fishing patterns and seabed state following management changes (before and after metrics).	This is yet beyond the ICES Advice, however, empirical studies and the MAPAfish project might have some case studies.
Improve the assessment of seabed state (further develop and validate indicators), linked to work of the MSFD Technical Group on Seabed Habitats.	The new Advice will replace the LL-indicator with the PD-Sens indicator (WGFBIT), which can be validated with data.
Adopt regional sea convention (RSC) assessment areas to allow better alignment with RSC seabed assessments and MSFD implementation.	In the update, OSPAR reporting units have replaced the ICES WKTRADE3 subdivisions (see Table 2.4). We follow as much as possible in the RSC areas.
Subdivide RSC areas at 800m (Atlantic) and 1000m (Mediterranean) isobaths to reflect where fishing is permitted.	The isobaths of 800 m in the Atlantic and 1000 m in Mediterranean Sea will be added.
Subdivide RSC areas by national EEZs.	ICES will only provide regional Advice, without making statements on the national level. However, the EEZ-boundaries are added in the maps.

Table 2.4. Changes and updates to the WKD6ASSESS process for the Baltic Sea (BS), North Sea (NS), Celtic Seas (CS), and Bay of Biscay and Iberian Coast (BBIC), in comparison to the ICES 2021 Advice.

	ICES 2021 Advice	WKD6ASSESS
Habitat types	EMODNET 2019	EMODNET 2021
Subdivisions	Defined in WKTRADE3	OSPAR area: OSPAR reporting units, HELCOM area: same as in WKTRADE3
VMS ICES datacall	2019	2023
Fishing time series	2009-2018	2009-2022
Assessment period	Average 2013-2018	Average 2017-2022
Regions with a benthic sensitivity layer (Atlantic)	BS, NS	BS, NS, CS, BBIC
VMS issues	n/a	There is no data from Portugal since 2018 and Norway since 2020.
Impact indicator	PD and L1	PD and PD-sens
AER data	No AER data but landing value	AER data for 2017-2021

2.4.2 Update of the Advice Sheet Layout

The Advice Sheet should be a clear and concise presentation of the scientific advice and the complex, large data underlying this advice. Such presentation is essential for sustainable and environmentally responsible marine resource management, wherein decisions are backed by robust scientific data and a clear understanding of ecological consequences. This update is especially focused on providing one central location where all information is gathered in a user-friendly interface. Clear data visualization and intuitive navigation enable stakeholders to easily access, interpret, and analyse key information. Enhanced documentation and metadata will provide greater context and background, making it easier to understand the methodologies behind the data and the implications of various environmental and management scenarios.

WKD6ASSESS has decided to develop a so-called Shiny application to present the official ICES Advice. This Shiny app will be the centralized location where users can find and explore all aspects of the updated ICES advice, somewhat similar to the function of the 'adviceXplorer' app that explores ICES stock assessment advice[1]. Find an elaborated overview of what the Shiny applications have to offer, and how WKD6ASSESS envisions the development process of a dedicated shiny app for benthic impact assessments in Annex 3. This Shiny app has a landing page that provides users with an immediate overview of the area under study (Figure 2.4).

[1] adviceXplorer (shinyapps.io)

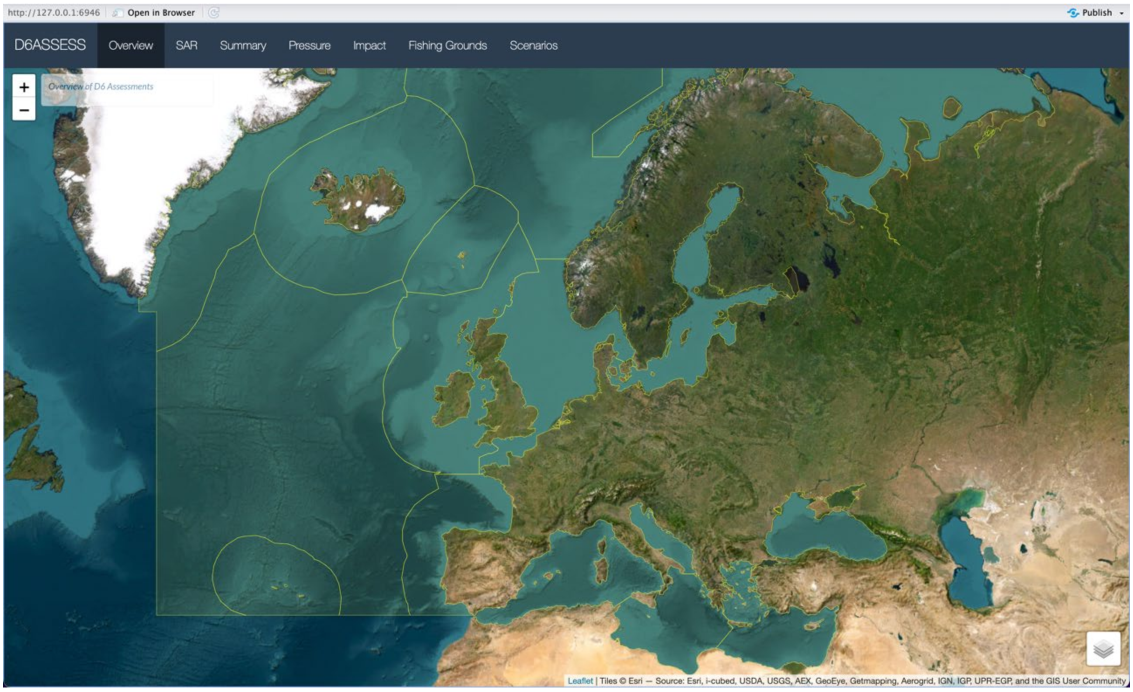

Figure 2.4. Snapshot of the new Shiny app landing page.

From this landing page, intuitive navigation will direct the users to other panels that are constructed using the pre-existing HTML and Leaflet objects (Figure 2.5). Each panel focuses on specific aspects of the data and report, allowing users to delve into detailed environmental assessments, impacts of different management strategies, or explore specific geographic regions.

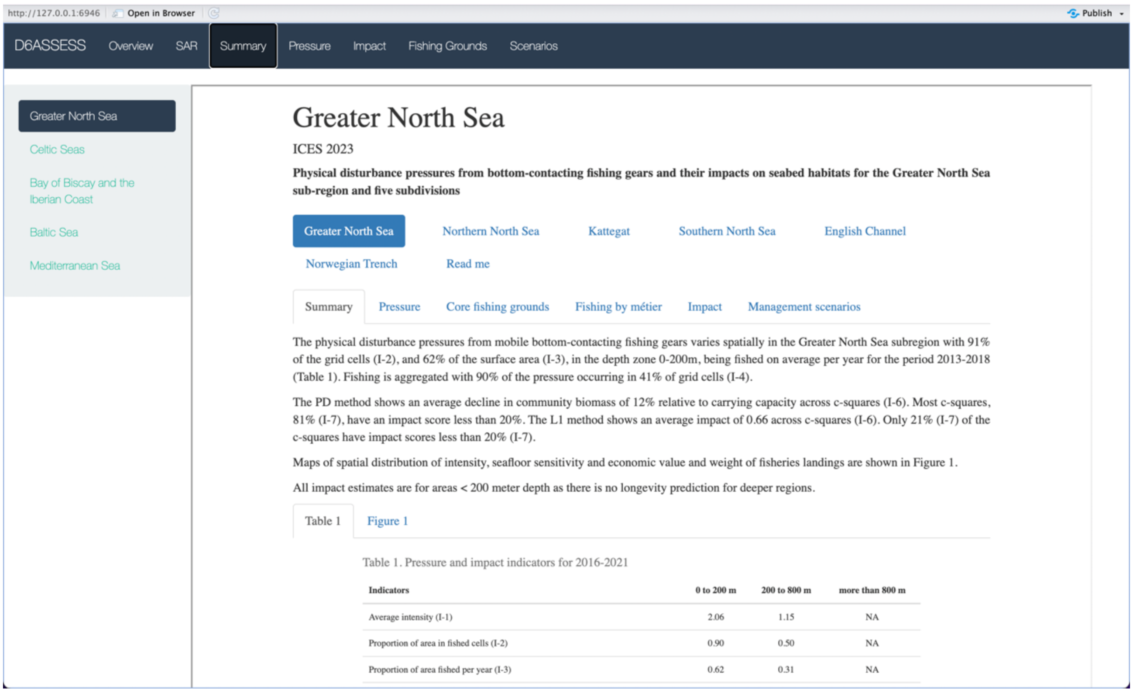

Figure 2.5. Snapshot of a informative panel within the Shiny app, presenting assessment results for the Greater North Sea.

3 MPA Assessment (ToR c)

3.1 Marine Protected Areas

In its request to ICES to provide an updated advice on 'how management scenarios to reduce mobile bottom fishing disturbance on seafloor habitats affect fisheries landing and value', DGENV specifically asked for the integration of realistic scenarios based on currently debated and/or implemented marine policy drivers. This workshop therefore explored how current Marine Protected Areas (MPAs) could be incorporated as scenarios in the advice update (ToR c). In this, ICES heavily considered recent or ongoing European research projects that investigated MPAs in the context of fisheries.

3.1.1 Policy drivers

The EU Biodiversity Strategy for 2030 (European Commission, 2020) set up commitments to achieve by 2030 that included legal protection of 30% of the EU's marine area, implementation of effective management in all protected areas and achieving good environmental status of marine ecosystems via designation of strictly protected areas. To this end, the EU Action Plan (European Commission, 2023) calls for Member States to execute national actions to ban mobile bottom fishing activities in Natura 2000 areas. It is in this context that WKD6ASSESS included the addition of MPAs assessment to evaluate different scenarios aimed to achieve a 30% of protection of the marine environment.

3.1.2 MAPAFISH

The MAPAFISH project is financed by DG MARE and performed by a large consortium of European institutes. It aimed to provide an overview of the current state of play of MPAs and associated fishing activities in the Baltic and North Seas, Atlantic EU Western Waters and Outermost Regions. The project aimed to map all MPA's and their management measures (tasks 1-3), to assess fishing activity in these MPAs and their surroundings (tasks 4-6), and to put this knowledge in the wider perspective of stakeholders and governance to see how MPAs could improve fisheries (management) (tasks 7-9). A total of 819 MPA sites have been identified. To assess fishing activity, two approaches were taken. A cSquare-based approach, based on data in line with the ICES VMS data call, and a polygon-based approach, which relied on VMS-calculated fishing activity for the exact MPA and buffers polygons, obtained from a project-specific data call. MAPAFISH concluded that the differences of both approaches were substantial, and that the polygon-based approach was preferred as that would represent the most exact estimate of the fishing activity. From this, MAPAFISH could conclude that most MPA sites were not fished, while those that were fished dominantly also reported fishing in their direct surroundings (5 km buffer area). The percentage of unfished MPA sites differed per ICES Ecoregion. When fishing was reported, in either the MPA site or their buffer, the per areal fishing effort (in kWdays) was overall higher in the buffer zones but varied also greatly between sites and ecoregions. Lastly, the MAPAFISH project tried to identify 'breakpoints' in the timeseries of fishing effort and landings, to relate these to MPA designation year or the year fishery restrictions were established. This proved, however, impossible. No overall match of trend-change could be identified with the designation of the MPA or the establishment of fishery restrictions.

3.1.3 SEAWISE

The SEAwise project has been funded in the context of the EU's Horizon 2020 program and it is the result of a research partnership of 24 institutions representing 12 countries in Europe. This work aimed at delivering a functional tool to easily apply Ecosystem Based Fisheries Management (EBFM) to predict ecosystem effects on and of fishing. This tool is designed to be used by fishers, managers and policy makers directly.

SEAwise spatial bioeconomic model includes new indicators (as social or human health benefits indicators) and aims at helping to predict the effects of spatial fishing restrictions giving a framework on effective economic approaches and governance through management measures in the context of the current fish stock's health indicators and our social system.

Because spatial bioeconomic modelling can be missing or difficult to condition rapidly, the study also used a static approach in anticipating the potential fishing effort displacement to measure the impact of fishing (Bastardie et al., 2023). The analyses were based on a spatialisation of the costs and revenue, and therefore on the expected Gross Value Added (GVA) on zones. This study initiated a tool to assist fisheries researchers and experts in short-term anticipation of possible effort displacement alongside alternative options for spatial management. This work is to predict the effect of changes in 'fishable' areas on the socioeconomic of fisheries, at least on the short-term horizon, given that no prediction on the underlying fished stock trajectories is made. The fishable area is defined as the marine space left for fishing but also the space suitable for fishing given the physical constraints of the marine environment. The study has merged several datasets to conduct an economic impact evaluation of the proposals for fishing restrictions at the fleet-segmentation level defined by the EU STECF AER dataset.

The study applied a segmentation specific to the EU fleet and split the evaluation into two parts:

- A first evaluation of the available fishable areas and the impacted EU fleet segments in terms of GVA, gross and net profits, and the crew engaged in the impacted segments. This also disaggregates the possible socioeconomic impact of each restriction alongside the different scenarios in defining those restrictions.
- The second evaluation was focused on the possibility for compensation and economic implications by displacing the fishing effort toward surrounding areas or other fishing grounds. In such effort displacement, the main driver was assumed to be the economic return the vessel operators may expect from the still-open fishing grounds.
- The opensource spatial tool[2] can be applied to the entire EU fleet or a regional subset of it (e.g. Baltic Sea, Celtic Seas, Bay of Biscay, North Sea, West and East Med). For the entire EU fleet active in the Northeast Atlantic area (for which the coupling of economic data to fine spatial effort data has been done here), the main findings show that overall, by analysing the finely spatially resolved data available, the socioeconomic impact of enforcing the proposed restricted areas would affect certain fleet-segments negatively, while some others will not be affected.

[2] https://github.com/frabas/FishSpatOverlayTool/tree/master

3.2 MPA-scenarios

D6ASSESS will create two scenarios to assess the effects of closing MPAs on fisheries and MSFD habitat protection, based on the MPA polygons obtained within the SEAWISE project and the polygons of Vulnerable Marine Ecosystems (VMEs) as identified by the EU in regulation 2022/1614. Scenario "All MPAs" includes all marine areas that are somehow protecting part of the prevailing marine ecosystem (Fig. 3.1). These include areas designated as Natura2000 sites under both the habitat directive and the bird directive, areas identified as VMEs, and other areas that have protective measures in place. The scenario "sensitive MPAs" only includes a subset of the polygons used in the "all MPAs" scenario, where all areas that are designated to protect some feature/species that is sensitive to bottom trawling are included (Fig. 3.1). In this, we follow the classification of MPAs in 'sensitive' and 'non-sensitive' to bottom trawling from SEAWISE (Bastardie et al. 2023). In addition, we classified all VMEs as 'sensitive'. For both scenarios, we determined i) the total extent covered by (Table 3.1), ii) the total extent of each broad habitat type covered (Table 3.2), and iii) the fishing activity (fishing effort, landings value, landings weight) within the included polygons (Table 3.3). A crucial note here is that ICES is partly depending on the MPA polygons from a research project (SEAWISE), which is also depending on the availability and correctness of MPA-data shared in public databases. During WKD6ASSESS, we have noted that there are some errors in the MPA polygons from SEAWISE. For instance, several Spanish MPAs are mislocated, or falsely classified as 'sensitive', and the Danish Natura2000-areas represent an older version. This is a direct consequence of a lacking central database that keeps track of all MPA areas and regulations. The results of the MPA scenarios should therefore only be used as a first indication/estimation.

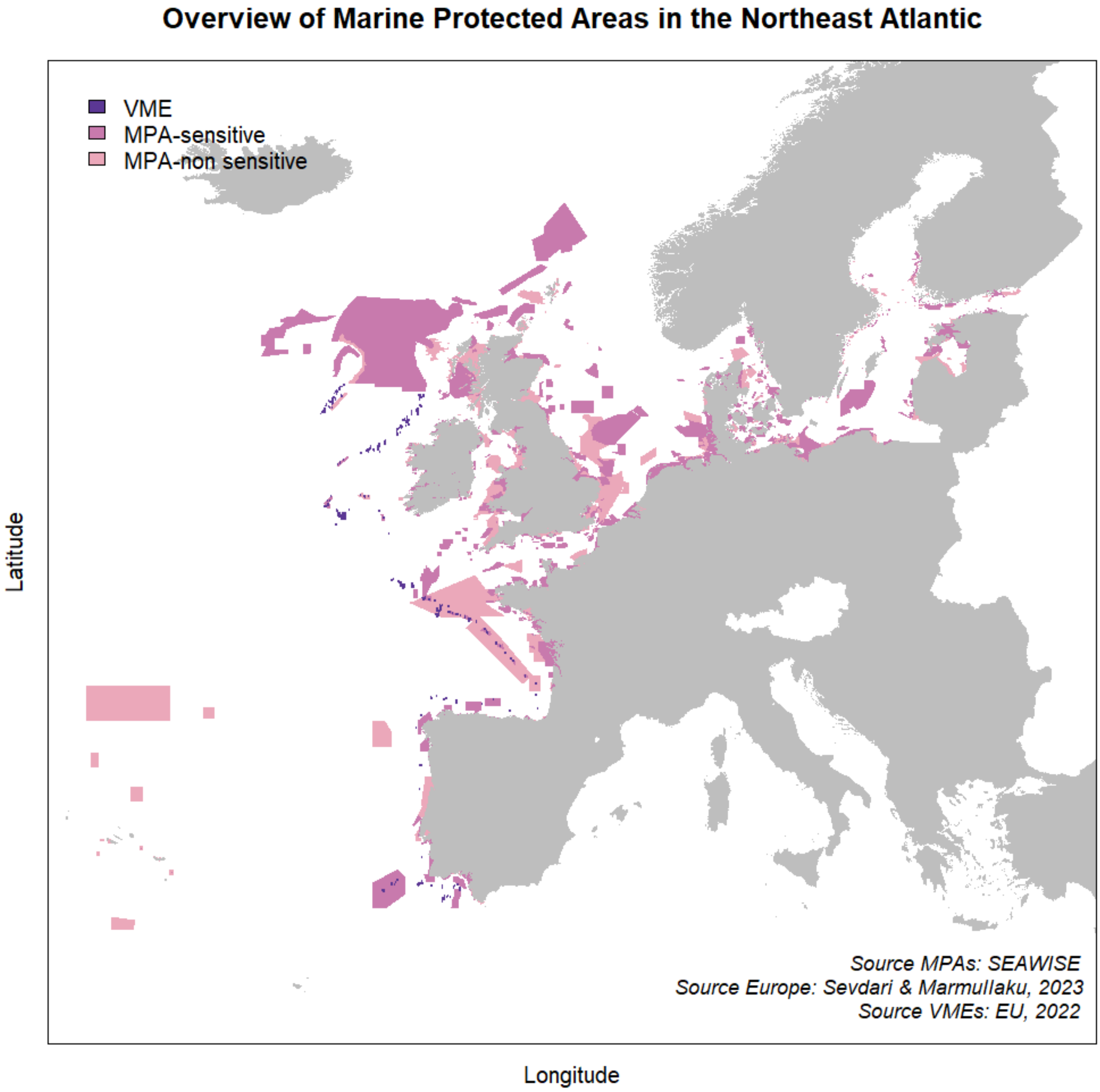

Figure 3.1. Spatial distribution of MPAs in the Northeast Atlantic, showing areas identified as MPA within the SEAWISE project, classified as sensitive and non-sensitive to bottom trawling, and VMEs as established by the European Union in line with regulation 2022/1614. Note that the distinction of sensitive and non-sensitive MPAs does not consider whether (effective/adequate) fishery restrictions are currently in place. Also note that WKD6ASSESS has observed that the SEAWISE-based MPA polygons has several errors, for instance in the Spanish and Danish waters.

Table 3.1. Spatial extent of the Baltic Sea, Bay of Biscay and the Iberian coast, Celtic Seas, and the Greater North Sea areas -per subdivision, and the extent covered by the polygons in the two MPA scenarios.

Area	Subdivision	Spatial extent (km^2)	Extent in all MPA (km^2)	Extent in sensitive MPA (km^2)	Extent in all MPAs (%)	Extent in sensitive MPAs (%)
Baltic Sea	**All combined**	**367275**	**87225**	**45462**	**23,7**	**12,4**
	Bothnian area	114889	6074	2882	5,3	2,5
	Gulf of Finland	17831	4002	1732	22,4	9,7
	Gulf of Riga	19106	17987	7007	94,1	36,7
	Baltic Proper	136149	20280	11781	14,9	8,7
	Arkona & Bornholm Basin	59953	28464	16913	47,5	28,2
	Western Baltic Sea	19264	10417	5145	54,1	26,7
Bay of Biscay and the Iberian Coast	**All combined**	**753778**	**203115**	**62470**	**26,9**	**8,3**
	Gulf of Biscay	84068	69808	9719	83,0	11,6
	North-Iberian Atlantic	388827	90455	19857	23,3	5,1
	South-Iberian Atlantic	268679	37512	27689	14,0	10,3
	Gulf of Cadiz	12204	5339	5205	43,7	42,7
Celtic Seas	**All combined**	**492691**	**90536**	**35349**	**18,4**	**7,2**
	Northern Celtic Sea	245705	25789	20736	10,5	8,4
	Southern Celtic Sea	246986	64746	14613	26,2	5,9
Greater North Sea	**All combined**	**220977**	**102376**	**46476**	**46,3**	**21,0**
	Kattegat	23197	10266	3923	44,3	16,9
	Norwegian Trench	9484	3849	1916	40,6	20,2
	Central North Sea	18991	2737	1671	14,4	8,8
	Southern North Sea	143002	73482	34282	51,4	24,0
	Channel	26089	11747	4596	45,0	17,6

Table 3.2. Spatial extent of each MSFD Broad Habitat Type per ecoregion, and the percentage of extent covered in the two MPA scenarios. NA = not available.

MSFD Broad Habitat Types	Baltic Sea			Bay of Biscay and the Iberian Coast			Celtic Seas			Greater North Sea		
	Total extent (km^2)	Extent in all MPAs (%)	Extent in sensitive MPAs (%)	Total extent (km^2)	Extent in all MPAs (%)	Extent in sensitive MPAs (%)	Total extent (km^2)	Extent in all MPAs (%)	Extent in sensitive MPAs (%)	Total extent (km^2)	Extent in all MPAs (%)	Extent in sensitive MPAs (%)
Infralittoral rock and biogenic reef	3964	33,7	18,6	1647	48,2	40,6	749	76,9	68,8	304	51,8	42,8
Infralittoral coarse sediment	7433	51,6	40,3	450	57,6	47,5	528	64,3	59,3	1226	67,8	52
Infralittoral mixed sediment	18696	30	22,7	301	43,8	41,2	81	60,2	50,7	1110	57,1	22,9
Infralittoral sand	23134	55,9	42,8	1913	42,4	28,8	636	57,6	44,6	8973	72,1	43
Infralittoral mud	2279	37,1	26,7	556	60,3	49,3	155	71,6	34,1	1378	63,6	44,7
Infralittoral mud or Infralittoral sand	2330	52,7	45,4	NA	NA	NA	NA	NA	NA	NA	NA	NA
Circalittoral rock and biogenic reef	6828	17,3	8,5	6883	40,5	29,2	3855	31,7	20,6	425	56,1	45
Circalittoral coarse sediment	9941	16,8	10,8	8537	56,9	25	7474	26,7	22,4	11558	32,6	20,7
Circalittoral mixed sediment	100583	12,5	10,3	2973	75,7	18,8	93	20,6	20,5	4504	16	12,6
Circalittoral sand	28280	17,6	11,4	16241	46,5	23,9	2976	29,6	16,9	58141	35,6	25,5
Circalittoral mud	28308	13,5	7,3	6255	57	45,2	1148	23,4	13,3	6411	35,1	21
Circalittoral mud or Circalittoral sand	49884	7,1	3,2	NA	NA	NA	NA	NA	NA	NA	NA	NA
Offshore circalittoral rock and biogenic reef	162	0,1	0,1	7019	22,6	12,2	3637	5,8	3,4	562	40,1	30
Offshore circalittoral coarse sediment	592	1,9	1,7	11919	40,8	4,7	51989	19	3	19702	23	8,5
Offshore circalittoral mixed sediment	18297	0,4	0,4	3358	39,3	14,1	4109	1,1	0,8	2954	13,9	12,2
Offshore circalittoral sand	2022	10,1	7,9	35045	45	6,7	55419	25,8	2,7	50935	12,1	9
Offshore circalittoral mud	21326	1,9	0,9	31521	29,7	11,7	31985	2,3	2	42521	15,3	3,9
Offshore circalittoral mud or Offshore circalittoral sand	29707	0	0	NA	NA	NA	NA	NA	NA	NA	NA	NA
Upper bathyal rock and biogenic reef	NA	NA	NA	1857	46,4	36,6	26	97,6	84,4	1	72,2	70,9
Upper bathyal sediment	NA	NA	NA	35883	44,9	26,5	63184	15,5	11,3	2476	43,2	41,5
Upper bathyal sediment or Upper bathyal rock and biogenic reef	NA	NA	NA	21413	20,9	13,8	41379	8,7	6,7	NA	NA	NA
Lower bathyal rock and biogenic reef	NA	NA	NA	494	34,7	34,3	11	0	0	NA	NA	NA
Lower bathyal sediment	NA	NA	NA	12066	71	17,8	24228	35,8	29,3	NA	NA	NA
Lower bathyal sediment or Lower bathyal rock and biogenic reef	NA	NA	NA	35843	23	8,8	33162	2,1	2,1	NA	NA	NA
Abyssal	NA	NA	NA	508457	7,7	3,7	133557	4,2	4	NA	NA	NA

Table 3.3. Fishing activity, in terms of swept area (km^2), landings value (10^6 euros), and landings weight (10^6 kg) per larger assessment area and for their subdivisions separately, and the percentage of this fishing activity inside the polygons included in the two MPA scenarios.

Ecoregion	Division	Total extent (km^2)	Swept area (km^2)			Landings value (10^6 euro)			Landings weight (10^6 kg)		
			Total	all MPAs (%)	Sensitive MPAs (%)	Total	all MPAs (%)	Sensitive MPAs (%)	Total	all MPAs (%)	Sensitive MPAs (%)
Baltic Sea	**All combined**	**367275**	**53162**	**13,6**	**10**	**23**	**10,5**	**7**	**31**	**14,7**	**10,8**
	Bothnian area	114889	624	0	0	4	0	0	1	0	0
	Gulf of Finland	17831	0	NA	NA	0	NA	NA	0	NA	NA
	Gulf of Riga	19106	0	NA	NA	0	NA	NA	0	NA	NA
	Baltic Proper	136149	13056	1,4	1,1	4	1	0,7	7	1,2	0,9
	Arkona & Bornholm Basin	59953	28683	14,5	12,2	9	9,7	7,7	12	8,6	6,9
	Western Baltic Sea	19264	10800	26,5	15,8	6	25,8	15,4	11	31,4	22,5
Bay of Biscay and the Iberian Coast	**All combined**	**753778**	**471292**	**42,6**	**21,5**	**102**	**40,8**	**11,4**	**74**	**37,2**	**25,4**
	Gulf of Biscay	84068	300530	41,9	9,6	101	40,4	11,3	27	38,1	7,2
	North-Iberian Atlantic	388827	82437	36,4	33,8	1	85	25,4	40	35,3	34,7
	South-Iberian Atlantic	268679	13994	7,7	4,6	0	NA	NA	2	6,8	3,5
	Gulf of Cadiz	12204	74331	58,8	58,8	0	NA	NA	5	55,6	55,3
Celtic Seas	**All combined**	**492691**	**465311**	**16,8**	**3**	**199**	**15,9**	**5,6**	**67**	**15,4**	**6,4**
	Northern Celtic Sea	245705	125471	2,5	2,4	70	3,8	3,6	24	6,4	6,2
	Southern Celtic Sea	246986	339841	22,1	3,2	129	22,5	6,7	43	20,4	6,5
Greater North Sea	**All combined**	**220977**	**593966**	**27,4**	**15,4**	**552**	**33,3**	**23,8**	**283**	**25,2**	**19,6**
	Kattegat	23197	45411	8,6	7	25	9	7,5	6	7,9	5,7
	Norwegian Trench	9484	56578	35,4	10,5	37	35,4	14,5	8	36	9,7
	Central North Sea	18991	80572	25,7	3,1	46	22,8	4,1	38	7,7	2,2
	Southern North Sea	143002	253252	33,2	23,3	286	41,1	32,4	173	28,8	24,6
	Channel	26089	158038	21,7	13,2	158	25,5	18,5	58	25,9	18,8

3.3 Caveats and limitations

3.3.1 Fishing gears

At European level, and based on VMS data, the only available effort maps that can be currently used in a trade-off analysis are focused exclusively on mobile bottom-contacting gears (MBCGs). The main reason for this is that even when some examples of methods to map the distribution of static gears have been recently published (Fernandez-Arcaya et al., 2024, Mendo et al., 2023), the methods to map these gears are not well developed and have not achieved the level of acceptance that currently exists for MBCG. Furthermore, not all bottom gears have the same impacts on benthic habitats and not all of them will need to be managed in the same way. For example, it is widely accepted that the presence of MBCGs activity at low levels of effort is incompatible with the presence of VMEs (ICES, 2020; van Denderen et al., 2021) and most of the current or future MPAs with these types of biological features will exclude bottom trawling from the areas. However, the impact of other type of bottom fishing such as static gears is not so clear, and impacts differ between fishing methods (e.g. longlines have a different impact than bottom gillnets). As a result, management activities to implement MPAs with presence of VMEs may not necessarily result in a ban on all bottom fishing activities. Therefore, the analyses carried out in this exercise include, exclusively, the fishing effort of MBCGs and the outputs and conclusions will be exclusively applicable for this type of fishing gear.

3.3.2 Spatial resolution

This trade-off assessment is restricted to fisheries data at a spatial resolution of 0.05 longitude latitude degree (hereafter termed c-squares), as that is the lowest resolution ICES has fishing data available. In the North Sea, this represents a surface area of around 15 km^2. For large-scale assessments, at the level of entire eco-regions, this is not a problem. However, when this c-squares-based information is used to assess fishing impact and revenue at smaller scales this introduces uncertainty.

Marine Protected Areas do often not align with the c-squares. To obtain estimates of the fishing metrics (effort, landings, revenue) for an MPA is therefore estimated based on the proportional overlap of the MPA with the c-squares. This means that a proportion of the recorded fishing metric within the c-square is assigned to the MPA, relative to their spatial overlap. So, if an MPA covers 15 % of a c-square, it will be assigned 15 % of the recorded fishing metric from that c-square. In this, we assume that the fishing has been distributed evenly over the entire c-square, while we know that fisheries often have more specific distributions within c-squares (Hintzen et al., 2019). Especially for MPA sites that are small, and thus cover less c-squares completely, the uncertainty of the assigned fishing metrics will be large.

3.3.3 Partial restrictions

WKD6ASSESS wanted to emphasize that fishery restrictions within MPA sites can be partial, meaning that fishery restrictions are in place for only a part of the area delineated by the MPA polygon. This is often directly resulting from the fact that many MPA polygons are protecting a particular feature/habitat type that has a smaller size than the actual MPA. In the management scenarios presented, this is not taken into consideration. Here, MPA sites are considered to their full extent.

3.3.4 Integration of relevant spatial information

The current MPA scenarios does not yet consider other spatial restrictions to fishing activities. Most importantly, offshore wind farm areas should be included as non-available areas.

3.3.5 Trade-off beyond direct monetary value

MPAs that exclude direct use as commercial and industrial activities like fishing (bottom trawling), exploration, and extraction of oil, gas, and deep-sea minerals may provide additional benefits for which market prices do not exist. These indirect use values typically include regulating services like CO2 sequestration, water circulation, nutrient cycling, and nursery grounds for fish recruitment. In addition, there are non-use values, such as existence and bequest values, which must be monetized. Choice experiments are typically used to elicit peoples' existence (and bequest) values for VMEs and other seafloor attributes. Lastly, there are option values, which represent values that are not realized but that potentially may be utilized by humans in the future e.g. bioprospecting. The option values can be monetized using existing market prices. None of these values are currently included in the D6ASSESS assessment workflow.

4 Progress in the Mediterranean Sea

In general, the Mediterranean Sea, as assessed within the WGFBIT, WKTRADE3, and WKTRADE4 reports, presents a complex and diverse picture of the impact of fisheries on benthic habitats. The region has seen significant progress in standardizing approaches for assessing these impacts, thanks to initiatives from ICES, DG ENV, and various research projects. Since the inception of the BENTHIS project, countries in the Mediterranean and Black Sea regions have been actively involved. However, despite this ongoing engagement, there has been a noticeable gap in the integration of case studies from these regions into the FBIT script. This lack of integration highlights a crucial area of improvement in the efforts to assess fisheries' impact on benthic habitats in these regions.

The current focus on collating information and integrating it into both the Advice Sheet output template and future FBIT procedures is a crucial step towards a more inclusive and comprehensive understanding of fisheries' impact on benthic habitats in these regions. This involves gathering and organizing data, making VMS and logbook data available for the assessment for a transparent use of information and replicability of analyses, and integrating methodologies and findings from various national and regional studies conducted as part of the WGFBIT activities. The aim is to create a comprehensive repository that accurately reflects the fisheries' impact on benthic environments in this region. The next significant step is the integration of these outputs into the HTML output template. This integration will ensure that the data and insights from the Mediterranean and Black Sea regions are accessible and available for analysis within a unified framework. Moreover, it will allow for the comparison and contrast of these regions with others, thereby providing a more global perspective on fisheries' benthic impact.

4.1 Recap from WKTRADE4

The WKTRADE4 report's section on the Mediterranean and Black Seas region delves into the evaluation of the impact of bottom trawling on the seafloor through various modelling approaches. The WKTRADE4 report provides an overview of the status of the Mediterranean Sea, focusing on different areas and methodologies used to assess the impact of fishing activities. Three main case studies are presented, two from Italy and one from Spain.

Table 4.1 Mediterranean case studies data, methods and results presented in WKTRADE4

Case Study	ABIOMMED (Italy)	Southern Adriatic Sea (Italy)	Western Mediterranean (Spain)
Objectives	Explore management scenarios to balance seafloor protection and economic sustainability		Examine fishing impact
Area of study	• Western Mediterranean Areas GSA 09-11.2 • Central Mediterranean Areas GSA 12-19 • Adriatic Sea Areas GSA 17&18	• Adriatic Sea Areas GSA 17&18	• Focus on Spanish waters: Areas GSA 01, 02, 05 & 06
Data	• Integrated VMS/AIS databases, logbook datasets and European Common Fleet Register • Economic indicators from different sources	• Aggregated AIS from Global Fishing Watch and FDI data • Benthic status as estimated in FBIT	• ICES VMS/Logbook data (2016-2018) including vessel, location, catch weight and sales notes

Case Study	ABIOMMED (Italy)	Southern Adriatic Sea (Italy)	Western Mediterranean (Spain)
Methods	• Analysis of fishing effort, resource productivity and economic indicators • SMART model: estimation of the effects of management scenarios and fleet adaptations like redistribution of fishing efforts and catch by species		• VMS and logbook processed alongside sales notes and STECF AES data for SAR calculation to analyse trawling frequency and correlation with landings weight and value • Vessels categorized by size in 6 ranges • Analysis at a 0.05-degree resolution
Main findings	• Concentrated fishing activities in areas along the coasts and at certain depths in the Western and Central Mediterranean • Proved feasibility of using advanced spatial analyses to evaluate trawling impacts	• Preliminary results suggest an improvement in benthic state with effort reallocation	• High fishing intensity on continental shelf regions like the Guld of Valencia. Low fishing pressure in Balearic Islands • Significant physical disturbance from fishing gears in shallow areas with variation in fishing intensity across different habitats
Limitations	• The study does not integrate data on longevity and benthic community status	• Coarse resolution of FDI data and absence of landing value information. • Data limitations and mismatches in aggregation levels • Unavailability of VMS and logbook data to working group	

4.1.1 ABIOMMED project in the GSA09-19

The study simulates different management scenarios, including networks of existing and new spatial closures, to understand their potential effects on the fishing industry in this region. Two key modelling frameworks are used: the first analyses fishing effort, resource productivity, and economic indicators to prioritize areas for balancing seafloor protection and economic sustainability. The second, using the SMART model, estimates the effects of different management scenarios and explores fleet adaptations, such as the redistribution of fishing efforts and catch by species.

Data for this study comes from integrated VMS/AIS databases, Logbook datasets, and the European Common Fleet Register. The Italian Ministry of Agriculture, Food Sovereignty and Forests, and the FAIRSEA project provided data for Italian and Croatian trawlers, respectively. AIS data from Global Fishing Watch were also used. These data sources helped achieve high spatial and temporal resolutions for fishing effort and other key parameters. The project validated its findings through cross-validation at the single-vessel level and comparison with external data from NISEA.

SMART's application allowed for the reconstruction of key biological and economic features, including monthly maps showing LPUE (Landing Per Unit Effort) for each species, fishing effort, SAR (Swept Area Ratio), and spatial landing, costs, and GVA (Gross Value Added) of each vessel. Core fishing ground analysis, based on SMART outputs, ranked grids by annual LV (Landing Value) and GVA. This analysis, combined with spatial statistics, identified core fishing areas as those essential for maintaining 90% of the current GVA, minimizing spatial fragmentation. This approach, inspired by Ban and Vincent's work, uses the Marxan algorithm to efficiently allocate fishing areas, striking a balance between conservation and economic sustainability.

The findings highlight the concentration of fishing activities in specific areas, as core fishing grounds often overlap with regions of high SAR. Notably, in the Western and Central Mediterranean Seas, core grounds are predominantly located along the coast and at specific depth ranges. The Adriatic Sea shows a focus on shallow grounds, while the Ionian Sea displays a more balanced distribution.

The ABIOMMED project demonstrates the feasibility of applying advanced spatial analyses to assess the impact of trawling in the Mediterranean Sea. The availability of VMS, AIS, and Logbook data enables a detailed understanding of trawling pressure, fishing ground characteristics, and potential management strategies. Although integrating these results with data on longevity and benthic community status was not within the project's scope, collaborations are in progress to apply these methodologies across all Mediterranean basins. This represents a significant step forward in the regional study of fisheries management and conservation.

4.1.2 Southern Adriatic Sea (GSAs 17 and 18)

The WKTRADE4 report's section on the Southern Adriatic Sea (GSAs 17 and 18), focuses on the challenges and methodologies in analysing fishing impacts in this region. The study provides valuable insights into the potential effects of fishing effort reallocation on benthic states. Its findings are constrained by data limitations, with mismatches in aggregation levels presenting challenges. The effort to validate and cross-check data quality is a positive step. AER data is generally available at the country level, with GSA-level data accessible upon request to the Italian Ministry. VMS and logbook data were not available to the working group, and STECF FDI data offers coarse resolution and incomplete information (on landing's value). AIS data from Global Fishing Watch spans 2017-2022, and economic data aligned with AER definitions is available from 2008-2021. However, spatial landing value data for GSAs 17 and 18 is not available. Moreover, the FDI spatial data for the Eastern side of the Adriatic were not available.

The approach involves using high-resolution AIS effort data to derive the spatial distribution of trawlers' efforts. The data, aggregated at a finer resolution (0.05° c-square), helps understand the displacement of the fishing footprint. This effort data is linked with economic data by crossing AIS information with the EU Fleet Register. The project also utilized relative benthic state (RBS) data estimated in the frame of the SeaWise project and further presented in the latest WGFBIT 2023, combining it with spatial landings and value data from FDI. The spatial landing data was redistributed at a higher resolution to align with AIS data, based on the effort distribution. The study explored the effects on benthic state by reallocating current effort only in core fishing grounds. This reallocation aimed to understand the impact on benthic state under different fishing scenarios, comparing the baseline and effort reallocation scenarios through ANOVA tests. Preliminary results indicate an improvement in benthic state across all habitats under the hypothesized effort reallocation.

4.1.3 Western Med case study (Spain)

The Western Mediterranean case study, focusing on Spain, examines fishing impact in this region using various data sources. These include ICES VMS/Logbook data, providing vessel and location information along with catch weight, and sales notes detailing catches and sale prices. The study area encompasses GSA01 (Northern Alboran Sea), GSA02 (Alboran Island), GSA05 (Balearic Islands), and GSA06 (Northern Spain). For analysis, VMS and logbook data from 2016 to 2018 were processed alongside sales notes. The data were categorized into six vessel length ranges and analysed at a 0.05-degree resolution. The integration of sales notes allowed for a direct correlation between each vessel and its catches, an approach particularly useful in areas with specific protection status. Swept Area Ratio (SAR) was calculated to determine the frequency of trawling in each grid cell per year. SAR, along with landings weight and value data, provided an average for each grid cell over the three years. This data was further used to analyse variations in core fishing areas based on SAR, landings weight, and landings value.

The study identified three trawl métiers in the Mediterranean. However, due to identification issues during the study, it was decided not to discriminate between different métiers until further verification. Some key findings include: 1) High fishing intensity in the Western Mediterranean, particularly on the continental shelf, notably south of the Ebro Delta and the center of the Gulf of Valencia; 2) Less trawling pressure around the Balearic Islands, with catch values increasing relative to effort; 3) The Alboran Sea, Northern Alboran Sea, and Balearic Islands experience lower fishing effort compared to the northern Gulf of Valencia.

The physical disturbance from mobile bottom-contacting fishing gears showed high average intensity and coverage in areas less than 200m deep. The intensity was lower but still significant in deeper areas, up to 800m. Trawling was notably concentrated in shallow areas, particularly on flat continental shelves. The report highlights clear differences in fishing intensity between sedimentary shelf habitats and other areas, with some habitats experiencing intense fishing pressure. The study demonstrates a robust approach to assessing fishing impacts in the Western Mediterranean using detailed spatial and economic data. However, challenges such as discrimination between different fishing métiers and reliance on specific data sources like sales notes may limit the generalizability of findings. The focused approach on specific geographical sub-areas and depth ranges provides valuable insights into fishing practices and their environmental impacts in these regions. The integration of economic data with physical disturbance indicators offers a more comprehensive understanding of the fisheries' impact, crucial for informed management and conservation efforts.

4.2 Recap from WKTRADE3

This technical report presents a summary of the data and methodologies used by various countries around the Mediterranean and Black Seas for assessing the impact of fisheries on benthic habitats. Each country's approach is characterized by its specific methodologies, data resolution, and analysis techniques to assess the impact of fisheries on benthic habitats, with varying degrees of detail and accuracy (Table 4.2). The common use of EMODnet for habitat data indicates a shared resource, but accuracy issues are noted. SAR analysis and macrofauna impact assessments are common, although approaches and data resolutions vary. The availability of STECF data also varies, affecting the granularity of landings and value assessments. This report highlights the diversity in approaches and the challenges in standardizing methodologies across different regions. It collates data sources and processes used by participating countries (Greece, Italy, Spain, Bulgaria, France, and Romania, with the latter two participating offline) in the WKTRADE workshop. It details the grid sizes used, methodologies for calculating Swept Area Ratio (SAR), impact assessment approaches, sources of habitat data, and landings and value data. The report highlights the diverse challenges faced by countries in the Mediterranean and Black Sea regions in assessing fisheries' impact on benthic habitats. Common issues include inadequate spatial resolution of data, underrepresentation of certain fishing practices, uncertainties in habitat mapping, and a lack of baseline data for unfished areas. These challenges underscore the need for improved data collection, integration of different data sources, and development of tailored methodologies that consider the unique ecological characteristics of each region. Addressing these limitations is crucial for effective management and conservation strategies in these sensitive marine environments.

A notable observation from the report is the progress made towards standardized approaches in the Mediterranean, largely influenced by initiatives from ICES, DG ENV, and research projects like BENTHIS, MedRegion, and ABIOMMED. Despite these advancements, there remains a lack of consistency in methodologies among countries. This inconsistency is evident in various aspects, including the definition of grid scales, methodologies for assessing SAR, the faunal components used for impact assessment, the quality of habitat mapping, and the presence of large unfished deep-water areas. Moreover, the report highlights that while official EU assessments are conducted nationally, more detailed assessments within countries may be sporadic and informal. This inconsistency can lead to challenges in creating a harmonized regional assessment for Mediterranean EU waters, with potential difficulties at sub-regional levels as well. The differences in approaches and the complexity of the marine environments in these regions indicate that harmonizing assessments will require significant effort and close coordination, particularly among neighbouring countries sharing sub-regions.

Table 4.2 Different methodologies and data used by countries in the Mediterranean Region.

Country	Greece	Italy	Spain	Bulgaria	France	Romania
Habitat data source	EUSeaMap 2019 (EMODnet) *accuracy issues	EUSeaMap 2019 (EMODnet) *accuracy issues	EUSeaMap 2019 (EMOD-net) *uncertainty in habitat's nature and delineation	EUSeaMap 2019 (EMODnet) *accuracy issues	EUSeaMap 2019 (EMOD-net) *uncertainty in habitat's nature and delineation	EUSeaMap 2019 (EMOD-net) *accuracy issues
Landings and Value data	STECF available at a coarser resolution	STECF for landings and bioeconomic models for some areas	STECF for landings and value; landings at a finer resolution	STECF-20-10 reports landing figures at a 0.05 deg. resolution	STECF for landings at GSA level with LPUE data at 3' x 3' grid resolution for French fleet	Not provided information for the STECF-20-10; landings only available as total values
Data resolution	0.05 deg^2	1km x 1km grid	0.05 deg2	Varying from 0.5 km to 5 km grid	1' x 1' grid	
Methodology for SAR calculation	Based on VMS data for all trawl vessels, focus on one metier	Integrated VMS and high frequency AIS data	Based on VMS and logbook data for all trawl vessels and metiers		SAR data publicly available *lacks uncertainty assessment	GIS Spatial analysis in the Black Sea, based on partial VMS data
Impact assessment approach	- Macrofauna assessment using grab samples and FBIT PD2 methodology - Greek Sea as a single unit - VMS data processed with ICES FBIT method - Depletion rates from FBIT methods are used. The analysis is currently at a national level, lacking sub-regional or MRU granularity.	Epi-megabenthos impact is analysed using samples from otter trawls and trawl surveys	- Macrofauna assessment based on diverse surveys - Approach based on longevity within FBIT	Macrofauna assessment uses grab samples.	Epi-megabenthos impact analysed from trawl surveys and benthic video surveys. Focus on longevity	Macrofauna assessment from national monitoring programs limited samples

Country	Greece	Italy	Spain	Bulgaria	France	Romania
Working on	- Assessing impact of MBCFG - Better habitat types' representation and validation of longevity models - Future work will focus on refining assessments and matching scales, as well as exploring AIS data for fleets with no available data	- Testing methods to assess fishing abrasion impact - Development of analysis of biological traits, including longevity - Definition of Good Environmental Status (GES) and avoidance of direct interactions between mobile bottom-contacting gears and biogenic habitats	- Improvement of data analysis, focus on static gears and small-scale fisheries - Monitoring activities for mega-epifauna and development of biological trait lists - Economic values in assessment and focus on refining pressure indicators and trade-off analysis.	Testing new methodologies for macrofauna assessment	- SAR estimates based on VMS data · Indicators and methods to assess impact of fishing activity on seafloor integrity - Risk analyses and participating in WGFBIT to test different approaches - A framework has been proposed to detect and quantify habitat-specific impact thresholds.	
Challenges	- Complications due to the presence of other fleets (Italy and Turkey) and policies regarding unfished or unfishable squares, particularly in deeper waters - Deeper waters (>200 m) lack verified depletion rates, and there are concerns about the accuracy and resolution of available habitat maps.	- Poor representation of hydraulic dredging and otter trawling for vessels <12-15m - Need to refine integration of VMS to AIS data for higher spatial resolution; focus on narrow shelves areas.	Limitations on swept area data availability (2010-1012 & 2019) and problems with swept area algorithm near coasts and isolated areas.		- Underestimated coastal and small-scale fishery pressure due to lack of VMS data and no use of AIS. - Challenges in areas below 200 m, a lack of unfished/undisturbed sites in shallower areas, and widespread chronic overfishing affecting data contrast. - Management scenarios need to account for ongoing national and international spatial fisheries management approaches.	- Absence of a standardized methodology for the Black Sea basin at the EU Member State level in the region. - Lack of complete VMS and landings data

Italy: Monitoring activities for specific habitats are in place, and ongoing research explores indicators and risk analyses, particularly for deeper habitats. There's a need to consolidate empirical relationships for fishing gear width to estimate SAR and develop approaches tailored for Mediterranean biota, especially in deeper areas. Other issues include the lack of unfished/undisturbed sites, widespread chronic overfishing, and the need to consider existing spatial fisheries management approaches in management scenarios.

Bulgaria performed a pilot study focused on the physical disturbance to the seabed from mobile bottom-contacting fishing gear in the Black Sea shelf for 2017. The assessment was done for areas < 200 m depth. VMS data was analysed to reconstruct trawling lines aggregating all vessels and gears, and physical disturbance intensity was assessed using SAR. A threshold was established for low and high pressure. The study revealed that nearly 60% of the Bulgarian Black Sea shelf was trawled, with varying levels of physical disturbance across habitat types. Specific habitat types, such as circalittoral mud and mixed sediments, were more affected. The analysis is conducted at the national level, focusing on the Bulgarian Black Sea shelf delimited by 200 m depth.

4.3 Recap from FBIT report 2022

The FBIT report's assessment of the Mediterranean Sea's benthic habitats presents a nuanced picture, marked by regional variations and methodological diversity. Overall, the report underscores the complexity and variability in assessing fishing impacts on benthic habitats across the Mediterranean. It emphasizes the importance of refining assessment techniques, enhancing data collection, and addressing limitations in current approaches to ensure effective management and conservation of these critical marine ecosystems. Three main areas are analysed, two of which are presented as the standard Advice Sheet Template (Greece and Italy).

In the French Mediterranean region, the study analyses the impact of trawling and other seabed disturbances on mega-epifaunal benthic invertebrates. Data from various trawl surveys are utilized, focusing on the classification of benthic biomass into longevity categories and assessing seabed abrasion using updated SAR data. The findings indicate that bottom trawling is the main source of seabed abrasion, with notable habitat condition differences between regions like the Gulf of Lion and Corsica. However, the challenge lies in establishing RBS thresholds to differentiate between good environmental status and adverse effects, suggesting a future focus on contrasting RBS predictions in reference and impacted areas.

Table 4.3

	Eastern Mediterranean Sea	North/Central Adriatic Sea	French Mediterranean Sea
Area	Eastern Ionian, Aegean and Cretan Seas	North/Central Adriatic Sea	French Mediterranean Sea
Focus	Greek Areas	Italian dn international waters in GSA17	All region
Methodology: · SAR · Sensitivity · Longevity	Sensitivity analysis of benthic macroinfauna, otter trawl swept area ratios (SAR) from VMS data and habitat maps	Two models uing SAR data and benthic samples	SAR: VMS: 2012- 2020 Sensitivity: combined trawl surveys, fussy-coding longevity – GLMM with environmental parameters.
Findings	· Early stage validation and absence of data on non-greek fleets · BCFG as the predominant	· Significant impact of trawling on benthic habitats.	- Gulf of Leon exhibited a gradient of worsening conditions towards the

	Eastern Mediterranean Sea	North/Central Adriatic Sea	French Mediterranean Sea
	activity impacting seabed. · Generally low trawling impacts, except high intensity in Northern areas and coastal gulfs of Greece	· Ciscalittoral mud habitat is the most impacted	coastline, while Corsica's habitats were generally in better states - Significant variability in longevity estimates and RBS predictions across habitats
Limitations		Depth range constraint to 100m	
Challenges		· Use of two different methods with different data sources, habitat mapping versions and modelling approaches · Undisturbed condition longevity assessment	- Setting thresholds for Good Environmental Status using RBS-estimates.
Need for	More comprehensive ecological indicator estimates for better validation	An integrated approach and method standardization	

4.3.1 Eastern Mediterranean Sea

The ICES seafloor assessment for the Eastern Mediterranean region, encompassing the Eastern Ionian, Aegean, and Cretan Seas, offers an insightful analysis of the impact of mobile bottom fishing on benthic habitats. This assessment, specifically focusing on the Greek sea areas, employs a methodology based on the sensitivity of benthic macroinfauna obtained from grab samples, otter trawl swept area ratios derived from Vessel Monitoring by Satellite (VMS) data, and habitat maps. It follows the guidelines established in ICES (2022). The results of this assessment were published in Smith et al. (2023)

The assessment highlights that the bottom contact fishery is the predominant activity impacting the seafloor in this region, overshadowing other seabed interactions such as dredging, coastal defense, shipping, and tourism. The impact threshold for this assessment is set at 0.2, and the assessment spans the years 2015 to 2018. Hotspots of trawling intensity (SAR greater than 5) are mainly concentrated in the northern part of the North Aegean Sea where shallow waters are more extensive, and in Evoikos and Saronikos Gulfs in the Central Aegean, as well as in the outer Patraikos Gulf in the Ionian Sea. In the areas where the fishing intensity is higher, the landings were also the highest in terms of weight, peaking in northern Aegean waters and gulfs. Values of landings also followed a similar picture. Core fishing grounds are also presented and follow a similar pattern as trawling intensity. Across most of the area, values for the relative benthic status are over 0.9, while below 0.8 were in only 0.03 % of the area.

However, the assessment also acknowledges its limitations and the early stage of validation. Future plans include estimating ecological indicators used in the Water Framework Directive (WFD) and the Marine Strategy Framework Directive (MSFD), such as AZTI's Marine Biotic Index (AMBI), multivariate AMBI (M-AMBI), and Biotic Index (BENTIX). These will be compared with the Relative Benthic State indicator to enhance the assessment's validity. In addition, an attempt to determine the Gross Value Added (GVA) metric in the study area will be done. One significant limitation is the lack of data on vessels from other national fleets that fish in the Greek sea area, which currently are not included in the assessment. For a comprehensive Mediterranean regional assessment, it's crucial to standardize methodologies and data selection across different national fleets.

4.3.2 North/Central Adriatic Sea

The assessment summary for the Adriatic Sea, a highly exploited area in the Mediterranean due to intense trawling activities, involves two distinct seafloor assessments in the Northern-Central Adriatic Sea (GSA17, Italian waters, and international waters). These assessments, referred to as "Model 1" and "Model 2," differ in their data sources, EUSeaMap versions used for broad benthic habitat types (BBHT), and other specific elements employed in the model applications. Both models extend their estimates to GSA18 based on SAR and the same BBHT within a similar depth range. Model 1 and Model 2 share the study area but differ in the depth range, pressure layer information, benthic samples, longevity classification, and modelling basis. While both use VMS data and include otter trawl (OTB) and beam trawl (TBB) in their pressure layer information, Model 1 utilizes SAR data on a 1 km*1 km grid and incorporates data from 2017 to 2019. In contrast, Model 2 integrates VMS and AIS data on the same grid resolution but focuses on data from 2014 to 2016.

The results of these assessments show that the impact of trawling on benthic status in this region is significant, particularly in areas with high fishing intensity, such as the northern part of Greece and large coastal gulfs. The methodologies applied in the models differ slightly, with Model 1 utilizing Generalized Linear Mixed-Effect Models (GLMMs) including MSFD habitat type as fixed effects, while Model 2 includes depth as an additional fixed effect. The longevity estimation also varies between the two models, reflecting different approaches to assessing benthic habitat impact. Despite these differences, both assessments identify circalittoral mud habitat as the most impacted. They highlight the need for a common assessment approach integrating various benthic datasets and applying a standardized methodology. This would allow for a broader spatial scope and the exploration of temporal trends in Relative Benthic State (RBS).

The assessments also reveal limitations in the available data and methodologies. These include differences in sampling procedures, sample analyses, and the longevity classification adopted. Furthermore, both assessments are constrained to the 100m depth range, limiting the applicability of RBS results to deeper habitats. There is also a general challenge in assessing longevity in undisturbed conditions due to the limited number of representative unfished sites across BBHT. The report underscores the need for future analyses to test the latest version of EUSeaMap and to include SAR in the models, as well as the collection of more data from less impacted areas covering a broader range of benthic habitat distribution. Caution is advised in interpreting habitat sensitivity distribution maps in the Southern Adriatic Sea due to the limitations of the sampling area and the lack of direct assessment and ground truthing data for GSA18.

4.3.3 French Mediterranean Sea

The assessment of the French Mediterranean region's benthic environment reveals a comprehensive analysis of the impact of trawling and other seabed disturbances on mega-epifaunal benthic invertebrates. Using data from MEDITS, EPIBENGOL, and NOURMED trawl surveys, benthic invertebrates' biomass was calculated, excluding cephalopods, and classified according to a fuzzy coding longevity system. Most of the taxa could be directly associated with longevity, indicating a robust correlation between biomass and organism lifespan.

Updated Swept Area Ratio (SAR) data from 2012 to 2020 encompassing all fishery vessels operating in the region showed that bottom trawling was the predominant source of seabed abrasion, overshadowing other gears like dredge or beam trawl. Biological observations were related to SAR metrics over different time frames to understand recovery patterns post-trawling impacts. A strict criterion (SAR<0.1) was used to identify pristine state reference stations, essential for assessing habitat conditions and impacts accurately. The study focused on various habitat types, such as circalittoral mud and offshore circalittoral mud, among others. However, not all habitats had sufficient reference stations for a comprehensive assessment, underscoring the need for more extensive data collection in certain habitats. The analysis also incorporated environmental predictors like depth, bottom temperature, sediment grain size, and chlorophyll-a concentration to avoid model overfitting and capture habitat variability more accurately. Generalized Linear Mixed Models (GLMM) were fitted for each habitat type, considering factors like abrasion and environmental predictors. The best models were selected based on the Bayesian information criterion, ensuring parsimony and reducing the risk of overfitting. These models were then used to predict median longevity for different habitats, revealing variations in sensitivity to trawling disturbance among them.

The Relative Benthic State (RBS) indicator, predicting the ecological state of seabeds, showed notable differences between regions like the Gulf of Lion and Corsica. The Gulf of Lion exhibited a gradient of worsening conditions towards the coastline, while Corsica's habitats were generally in better states. These findings aligned with previous studies, indicating a strong correlation between RBS and abrasion intensity. The assessment also explored the implications of using different abrasion metrics, finding significant variability in longevity estimates and RBS predictions across habitats. This highlights the influence of specific environmental conditions on habitat sensitivity and the potential impacts of trawling activities.

Despite the comprehensive nature of the assessment, the study acknowledges the limitations in distinguishing RBS thresholds that differentiate between good environmental status and adverse effects. Future steps include identifying such thresholds in reference areas and contrasting them with impacted areas, although the strong correlation between RBS and abrasion suggests that setting direct pressure thresholds might be equally effective.

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Annex 2: Resolutions

2020/OT/HAPISG02 The workshop to update and assess trade-offs between the impact of fisheries on seafloor habitats and their landings and economic performance (WKD6ASSESS), chaired by Karin van der Reijden (Denmark) and Lorenzo D'Andrea (Italy) will meet at ICES HQ and online, 6, 7 and 13 December 2023 to:

a) Update the 2021 ICES advice (eu.2021.08) outputs using available scripts with new data, and ensure the routine for assessing trade-offs is repeatable, by development and documentation of the code by applying the ICES TAF principles. The scripts should be aligned as far as possible with that of the WGFBIT procedure.

b) Build on the most recent available data and evolving science (WKSSFGEO2, WKTRADE4, WKD6STAKE) to improve the routine by:

    i. reviewing and incorporating proposed (WKTRADE4) approaches to better estimate spatial fisheries performance indicators (including revenue, costs, landings, value added, etc.) at local, habitat and regional scales and for different fishing gear/metiers given the available data and cross regional applicability. The purpose being to demonstrate which indicators can be used in the WGFBIT procedure to describe trade- offs.

    ii. evaluating stakeholder input received during WKD6STAKE to make concrete recommendation for updates to the 2021 ICES advice (eu.2021.08) and outputs.

c) Engage with WGMPAS to explore methods to

    i. perform a broad-scale assessment of the various fishing activities as well as the associated trade-offs that occur in and around MPAs.

    ii. evaluate the impacts of scenarios related to policies such as protecting 30% by 2030, and banning all bottom fishing in NATURA 2000 areas.

d) Address ToRs a-c in all European marine regions, including the Mediterranean and Black Seas, to the extent possible.

Annex 3: Development process shiny app

Summary

The development of a dedicated Shiny application for the FBIT workflow and benthic impact assessment is being considered due to the complex nature of the scientific advice and the extensive data that underpins it. The overarching goal of this initiative is to ensure that the Advice Sheet serves as a clear, concise, and accessible presentation of the scientific advice. This clarity is vital for sustainable and environmentally responsible marine resource management, where decisions need to be informed by robust scientific data and a thorough understanding of the ecological consequences.

One of the key reasons for this update is the necessity to provide a centralized location for all relevant information. The Shiny application aims to gather all pertinent data and resources in a user-friendly interface. This approach not only streamlines access to information but also significantly enhances the user experience by allowing stakeholders to easily navigate, interpret, and analyze crucial information. Another important aspect of the Shiny application is its focus on clear data visualization and intuitive navigation. These features are critical in enabling stakeholders from various backgrounds – including those who may not have extensive technical expertise – to easily engage with and understand the data. By presenting complex information in a more digestible and visually appealing format, the application ensures that the insights and recommendations are more accessible to a broader audience. Furthermore, the inclusion of enhanced documentation and metadata within the Shiny application will provide users with greater context and background. This enhancement is essential for understanding the methodologies behind the data collection and analysis, as well as the implications of various environmental and management scenarios. This deeper understanding is crucial for informed decision-making and policy development.

The decision to develop a Shiny application is inspired by the success of tools like the **adviceXplorer** app used for exploring ICES stock assessment advice. The **adviceXplorer** has proven effective in presenting complex data and advice in an accessible format, and WKD6ASSESS aims to replicate this success. By adopting a similar approach, the new Shiny application for the FBIT assessment will play a pivotal role in enhancing the dissemination and understanding of ICES advice, ultimately contributing to more informed and responsible marine resource management.

The development of the Shiny application is a multifaceted process that requires careful consideration of various technical and operational aspects. The main focus is to create a user-friendly, efficient, and policy-compliant tool that will enhance decision-making in marine resource management. This development is guided by the "**ShinyApps hosting and publication: Context and process**" from the ICES Guidelines and Policies, ensuring alignment with best practices. The development of Shiny applications at ICES is a deliberate process aimed at creating dynamic tools that enhance marine resource management. The focus is on building user-friendly, secure, and efficient applications that can handle complex data and offer interactive features for better decision-making. The application of Shiny in this context represents a significant step towards leveraging modern technology in environmental assessment and management.

Development Aspects:

- **User Interface and Experience:** The application aims to be intuitive, catering to users with different expertise levels.
- **Data Visualization:** Effective visualization tools are essential for simplifying complex data.
- **Data Integration and Management:** The app will manage large datasets from diverse sources.
- **Performance and Scalability:** Ensuring robust performance and scalability is crucial.
- **Security and Data Privacy:** Adherence to privacy laws and security protocols is vital.
- **Feedback and Iterative Development:** Ongoing improvements based on user feedback are part of the development strategy.

Shiny and ShinyApps Overview:

- **Shiny** is an R package for creating web applications from R scripts.
- **ShinyApps** is a platform for hosting Shiny web applications in the cloud, facilitating easy deployment.
- **Shiny's Strengths**: It is known for fast prototyping, interactive data exploration, ease of iteration, accessible data visualization, collaboration facilitation, customization, and flexibility.

Shiny App Features:

- Reactive programming model allows for dynamic interaction and instant updates.
- User Interface customization is possible through various R packages.
- Server-side script can leverage R's capabilities for data processing and visualization.

Hosting and Deployment:

- ICES has a standard subscription to ShinyApps, offering unlimited applications, user authentication, and a significant active app allowance.
- Shiny apps can be hosted on Posit servers or other cloud platforms, offering flexibility in deployment.
- Options include local/offline use, local intranet hosting, various tiers of cloud hosting, and alternatives like custom servers or containers.

Interactive Web Applications:

- Web applications perform tasks over the internet and offer a dynamic, interactive experience.
- They are accessible, interactive, server-side processed, and functional.
- Web applications facilitate remote information exchange and service delivery.

Clarifications and Workflow Design:

- The design phase should define the scope of each app, set data and information access policies, and clarify that Shiny apps are tools, not just publications.
- Addressing the concern of overwhelming scenarios, it is emphasized that the best use case for a Shiny app, other than the final distribution of a static assessment, is as a facilitative tool for exploration during assessment definition, not a final decision-making platform.
- Limitation of scenarios in the final phase is essential, focusing on the most relevant and defendable ones.
- Clear communication and expert oversight are critical in managing expectations and maintaining the assessment's quality.

Shiny Apps development guidelines

The development of the Shiny application involves a careful evaluation of various options and potential caveats associated mainly with technicalities about shared information, data privacy, performance, accessibility, and output. The working group responsible for this development is actively engaged in studying, applying, and reviewing different aspects of the project to ensure the final product is policy compliant, effective, and user-friendly.

General Information

One of the key resources guiding this process is the "**ShinyApps hosting and publication: Context and process**" document from the ICES Guidelines and Policies, Version 01 of April 2023. This document provides crucial insights and protocols that are instrumental in shaping the development of the Shiny application. By adhering to these guidelines, the working group aims to align the application's development with established best practices and standards. Several factors are being considered in the development process:

- **User Interface and Experience:** Ensuring that the application is intuitive and easy to navigate is paramount. The working group is exploring different design layouts and interactive features that can make the application more engaging and accessible to users with varied levels of expertise.

- **Data Visualization:** Given the complexity of the data involved in benthic impact assessments, finding effective ways to visualize this information is crucial. The group is looking into various visualization tools and techniques that can help convey complex data in a simpler, more understandable manner.
- **Data Integration and Management:** The application will need to handle large datasets from diverse sources. Evaluating the best methods for integrating and managing this data is a key part of the development process.
- **Performance and Scalability:** The application must be robust enough to handle the actual volumes of user interactions and data processing. This involves assessing the application's performance and ensuring it can scale effectively.
- **Security and Data Privacy:** Adhering to data privacy laws and ensuring the security of the application and its data is critical. The group is reviewing security protocols and privacy guidelines as outlined in the ICES document.
- **Feedback and Iterative Development:** The working group is committed to an iterative development process, which includes gathering feedback from potential users and stakeholders and making continuous improvements to the application.

By addressing these aspects and following the ICES guidelines, the working group could work towards a Shiny application that is not only a central repository of information but also a dynamic tool for exploration and analysis, enhancing the decision-making process in marine resource management.

Clarifications

While the basic information is provided, it is important to not overlook a more detailed analysis and description of the 'Shiny Framework' for fast prototyping and application development. We emphasize the need to review, update and share the current state of art of the system under scrutiny.

What is Shiny and ShinyApps?

Shiny is an R package that enables the easy creation of web applications directly from R scripts.

ShinyApps i s a platform as a service (PaaS) for hosting Shiny web apps. It runs in the cloud and allows users to deploy Shiny apps without needing local infrastructure, i.e. an in-house Shiny server.

Shiny, a still growing but already popular package in R for creating **interactive web applications** (that's a foundational concept which clarify the need for a shiny app), fundamentally operates on a **reactive** programming model and it is widely recognized for its exceptional capability in **fast prototyping**. This core strength of Shiny lies in its ability to quickly and efficiently turn analyses conducted in R into interactive web applications. The Shiny package's ability to facilitate fast prototyping is a combination of its rapid development capabilities, interactive nature, ease of iteration, and effective data visualization and sharing functionalities. These attributes make it an invaluable tool in quickly bringing data analyses to life and enabling a collaborative and dynamic development process. This feature is particularly advantageous for several reasons:

- **Rapid Development and Deployment:** Shiny allows for the speedy transformation of R scripts into interactive web applications. This means that data analysts and scientists can quickly create prototypes and share their analyses without the need for extensive web development skills. The turnaround time from concept to functional prototype is significantly reduced.
- **Interactive Data Exploration:** Shiny applications enable users to interact with the data and analyses in real-time. This interactivity is a key aspect of fast prototyping as it allows for immediate feedback and iterative development. Users can manipulate data inputs, parameters, and filters to see the effects of these changes instantly, which is invaluable for exploring data and refining analyses.
- **Ease of Iteration:** With Shiny, making modifications and updates to the application is straightforward. This ease of iteration supports a dynamic development process, where changes based on user feedback or new data can be rapidly implemented and tested.
- **Accessible Data Visualization:** Shiny integrates seamlessly with R's powerful data visualization libraries, such as ggplot2. This integration allows for the creation of rich, interactive visualizations that can be easily modified and updated, making it an excellent tool for presenting complex data in an accessible manner.
- **Facilitates Collaboration and Sharing:** Since Shiny apps can be hosted and shared as web pages, they provide an effective platform for collaboration. Stakeholders can access and interact with the latest versions of the app from anywhere, providing immediate inputs and suggestions that can be quickly acted upon.
- **Customization and Flexibility:** Shiny offers a high degree of customization and flexibility, allowing developers to create tailored applications that suit specific project needs. This adaptability is essential in prototyping, as it enables the exploration of various approaches and features without extensive redevelopment.

In Shiny, users interact with the app through various input mechanisms like text boxes, radio buttons, sliders, and drop-down lists. These inputs create a reactive context where changes in user inputs immediately trigger **re-computation of outputs**. For example, adjusting a slider can instantly update a graph or table displayed in the app. The reactive nature of Shiny means that computations and visualizations are re-executed or re-rendered almost instantly as the input variables change. This provides a highly interactive and responsive experience to the user. The **UI part** of a Shiny app defines its appearance. It specifies how the inputs and outputs are laid out and how the app will look to the users. While the appearance is influenced by default settings, it can be extensively customized using additional R packages like `shinydashboard` for more sophisticated layouts. The **server-side** computations and the code to generate plots and other outputs. It is where the app's logic is defined, including how inputs are processed and how outputs are generated. This server script can harness the full range of R's capabilities, from data processing to creating complex visualizations.

Hosting and Deployment

The ICES Secretariat has a subscription plan to the cloud-based ShinyApp (type: standard) that allows:

- *Unlimited applications.*
- *User authentication.*
- *2000 active apps per month.*

Not currently included are:

- *Account sharing*
- *Custom domains*
- *Development or testing capabilities*'*
  *(*The shinyapp.io service is a production platform and is not intended for the publication of development, test, or draft apps; personal accounts or local hosting should be used for these purposes.)*

Shiny apps can be hosted on Posit servers (RStudio Inc. announced in July 2022 its name change to Posit, PBC, a public-benefit corporation). Posit and RStudio have no formal connection to the R Foundation, a not-for-profit organization, which is responsible for overseeing development of the R environment for statistical computing), or small-scale or personal use, Posit offers free hosting with certain usage limits. This is an excellent option for prototypes, personal projects, or small-scale applications. For more intensive use, such as commercial applications or apps requiring more resources, Posit offers paid plans. These plans provide more capacity and features suitable for larger-scale deployments. While Posit's servers are a common choice for hosting Shiny apps, it's possible to deploy these apps on other cloud computing platforms or even locally to single machines. This might require more setup and maintenance but can offer cost benefits and greater control over the hosting environment. However, other than the Shinyapps.io solution, the hosting and distribution of a Shiny App could be accomplished through several different options which should be tailored on the specific needs of the workflow to be applied. For example, there could be local or remote hosting; offline, intranet or cloud servers; free/paid solutions; or a combination of the above.

- Local/Offline use
- Local/Intranet RStudio Shiny Server
- Remote/Online Cloud Hosting
  - Free Tiers
  - Paid Tiers

  - Open Access Tiers
  - Restricted Access Tiers
- Alternative Hosting Options
  - Custom Server
  - Docker
  - AWS
  - Azure
  - Combination of…

Shiny apps offer versatile hosting options to cater to different scales and purposes. One common hosting solution is Posit's servers, which provide both free and paid hosting services. However, Shiny app developers have a range of hosting options at their disposal, from free tiers suitable for small-scale, low-traffic apps to more robust, paid solutions for commercial or resource-intensive applications. Alternative hosting solutions like cloud platforms, local servers, or containers offer additional flexibility, allowing developers to choose the best fit for their application's needs and constraints.

For individuals or small-scale projects, RStudio offers a free hosting tier on its Shinyapps.io platform. This option is particularly appealing for prototypes, personal projects, or applications that are not resource-intensive. The free tier allows users to host Shiny apps without any financial commitment, making it accessible for experimentation or low-traffic applications. However, it comes with limitations in terms of usage and resources, which might include constraints on the number of active hours the app can run per month or on the amount of data traffic it can handle. For larger, commercial applications or those requiring additional resources, Posit provides paid plans. These plans are designed to cater to apps with higher demands for computing power, storage, and bandwidth. They offer increased capacity and additional features, such as better performance, more storage, and enhanced security, making them suitable for more extensive deployments where reliability and resource availability are crucial. While Posit's Shinyapps.io service is a popular choice for hosting Shiny applications, developers have the flexibility to deploy their apps on various other cloud computing platforms. This option might involve more complexity in terms of setup and maintenance but can offer advantages in terms of cost, scalability, and control over the hosting environment. For instance, developers might choose to use cloud platforms like Amazon Web Services (AWS), Microsoft Azure, or Google Cloud Platform, depending on their specific requirements and preferences. These options are all compatible with the like Docker containers system, which offer a way to package the Shiny app with all its dependencies into a single container. This makes the app portable and consistent across different computing environments, simplifying deployment and scaling.

In addition to cloud-based solutions, Shiny apps can also be hosted locally. This can be on an individual's computer for personal or offline use, or on an organization's intranet server, providing access within a corporate or institutional network. Local hosting can be a good option for apps that handle sensitive data or for scenarios where internet connectivity is unreliable. The choice among these hosting options should be made based on the specific requirements of the Shiny app and its intended audience. Factors such as the expected number of users, data security needs, scalability requirements, and budget constraints play a critical role in determining the most suitable hosting solution. The description provided in the development guidelines could be further detailed to highlight specific features of Shiny apps and their hosting. In particular the 'User authentication', 'Custom Domains' and 'Shinyapps.io service' capabilities offer significant advantages in terms of security and flexible development. These features support the creation of tailored, secure, and continuously evolving Shiny applications that meet specific user needs and integrate seamlessly into existing web ecosystems.

User Authentication:

This feature is vital for developing and deploying applications intended for a specific group of users. By implementing user authentication, you can restrict access to the app, making it available only to authorized individuals. This is particularly useful for apps that are meant for internal use within an organization, for evaluation purposes, or for applications that contain sensitive data. User authentication ensures that only a defined user base can access the app, adding a layer of security and privacy. This is important in scenarios where the app is still in the development phase, being evaluated for feedback, or containing proprietary or confidential information.

Custom Domains:

On platforms like Shinyapps.io, you can host multiple apps under a single account, with each app having its unique web address. This is akin to having custom domains for each app, allowing for easy identification and access. If you have a separate domain name, you can redirect users to your Shiny app. This means that you can integrate the Shiny app seamlessly into your existing web infrastructure, making it accessible through a familiar and branded URL. It enhances the app's professional appearance and can make it easier for users to remember and access the app.

Development or Testing Capabilities:

Shinyapps.io allows for the hosting of applications not just in their final, production-ready state but also during their development and testing phases. This flexibility is crucial in the context of continuous development and integration, where apps are frequently updated and improved. Hosting development, test, or draft versions of apps is important for iterative development processes, such as agile methodologies. It enables developers to quickly release updates and new features, gather feedback, and make continuous improvements. Combined with user authentication, this allows for controlled testing and feedback gathering from a specific user group, enhancing the app's development process by ensuring that updates are well-informed and relevant to the user's needs.

Accessibility

Every hosted application is public by definition under the creative commons license (CC BY 4.0) that ICES has adopted for all publications, data products, advice outputs, and open access public data. It is recommended that the underlying code for the app also be under an open public license.

While the commitment to open access and transparency is required and mandatory for publications or (already public) data products, it is important to recognize that the scope and nature of some applications might necessitate a more nuanced approach. Furthermore, web applications designed for interactive use, involving real-time re-computing and re-rendering of data, often deal with sensitive or restricted-access data. These applications serve a specific set of users, such as researchers, policymakers, or stakeholders, who require controlled access to data due to privacy or confidentiality concerns. In these cases, it might be more appropriate to consider 'closed' applications, where access is limited to a controlled user list and are currently available by the platform. Also, this approach already aligns with the data sharing process currently in place, which involves private repositories granting access to sensitive data to authorized users only (i.e. vms, landing, economic and other datasets).

The distinction here is between interactive applications that require dynamic data processing and fundamentally static web pages that display precomputed numerical results and associated graphics. Static pages, by their nature, are more suited to open access as they present finalized data in a non-interactive format. However, interactive applications, especially those dealing with ongoing research, preliminary data, or sensitive information, might require a more restricted access approach to ensure data security and integrity. Adopting a flexible approach to licensing and access for hosted applications will allow ICES to maintain its commitment to openness and transparency, while also respecting the need for confidentiality and data protection in specific scenarios. It is important to consider the specific use case and data sensitivity of each application before determining the most appropriate access and licensing strategy. This approach ensures that the diverse needs of the scientific and policy-making community are met, while upholding the high standards of data management and dissemination that ICES is known for.

Interactive web applications

A web application is a dynamic, interactive program that is accessed through the web. A web application is a computer program that uses web browsers and web technology to perform tasks over the internet. Unlike traditional desktop applications, which are launched by the underlying operating system and run locally on the user computer, web applications run on web browsers. This means they can be accessed and used from any device with an internet connection and a web browser, such as a computer, smartphone, or tablet. It can perform a variety of tasks and is designed to provide a more interactive user experience compared to traditional websites and encompass re-computing and re-rendering. A web application usually includes some or several common characteristics, such as:

- **Accessibility:** Web applications are accessible from anywhere, provided there is internet connectivity. This makes them highly convenient for users who need to access the application from different locations or devices.

- **Interactivity:** Unlike static websites, web applications are designed to interact with users. They respond to user inputs and can perform a wide range of functions, from processing data to updating content dynamically.
- **Server-Side Processing:** In a web application, most of the processing takes place on a remote server. The web browser acts as a client, sending requests to the server and displaying the information returned by the server.
- **Functionality:** Web applications often include functionalities such as user authentication, data retrieval, and data storage. They can be as simple as a message board or as complex as a multi-functional e-commerce site.

These applications have become integral in facilitating remote exchanges of information and delivery of services, connecting businesses with customers in a convenient and secure environment. One of the distinguishing features of web applications is their ability to offer complex functionalities that are typically associated with desktop applications, but without the need for users to install or configure additional software on their devices. This ease of access and use is one of the key reasons for their widespread popularity and utility. For instance, features commonly seen on websites, such as shopping carts, product search and filtering capabilities, instant messaging systems, and social media newsfeeds, are all examples of web applications by design. These functionalities represent the interactive elements of the web that go beyond the static display of information, enabling users to perform specific tasks, interact with the content, and get immediate feedback based on their actions. The use of web applications allows users to access and manipulate data, engage in transactions, communicate, and share information, all within the familiar environment of their web browser. This seamless integration of complex functionalities within a website is what sets web applications apart from more traditional, static web pages. By running in the browser, web applications overcome the limitations of device-specific software and ensure a broader reach and accessibility. This adaptability makes web applications a vital tool for businesses looking to connect with a diverse and widespread audience, offering a level of interactivity and functionality that enhances user experience and engagement.

Conversely, a website is essentially a collection of interconnected webpages, typically accessible through a single URL. The structure of a website is usually segmented into various sections or pages, each serving a distinct purpose. The most fundamental of these is the home page, which acts as the portal to the rest of the website. It provides an overview of what the website offers and includes links to other pages, facilitating easy navigation for users. Websites serve a variety of functions depending on the needs and objectives of the business or individual. They can be instrumental in presenting detailed and appealing information about products, services, and the overarching vision of an organization.

Observations

The current usage of Shiny apps in this context appears to align more closely with the traditional role of a website rather than exploiting the full capabilities of a web application. This observation is based on the nature of the content and interactivity provided by these Shiny apps. Shiny, as a framework, is primarily designed for building interactive web applications that perform server-side computations in real-time. These computations are typically triggered by user interactions, such as input selections or data queries, which then dynamically generate new content, data visualizations, or analytical results. This process is a key characteristic that differentiates a web application from a static website. However, if the Shiny apps in use are primarily displaying final reports without significant real-time computation or interactive data processing, they are functioning more like dynamic websites. While they may offer some level of interactivity, such as navigation between different sections or viewing precomputed results, they don't fully utilize the interactive, computational potential of Shiny. Essentially, these apps are not performing complex, real-time data processing or analysis in response to user inputs, which is a core strength of the Shiny framework. This underutilization implies that the current deployment could potentially be restructured as dynamic websites. These websites would still offer interactive elements and engaging user interfaces but wouldn't require the server-side computational capabilities that Shiny apps are known for. The consequence of this approach is that the true power of Shiny as a tool for real-time data processing and interactive analysis is not being fully leveraged. For a more effective use of Shiny, it would be beneficial to incorporate features that require server-side computations based on user inputs. This could include real-time data analysis, interactive visualizations that adjust based on user-selected parameters, or other dynamic content that responds to user interactions. Thus, while the current Shiny apps provide a valuable digital platform for report dissemination, there is an opportunity to enhance their functionality by incorporating more of the real-time, interactive computational features that are central to what Shiny apps can offer. This shift would transform these digital platforms into true web applications, fully utilizing the capabilities of the Shiny framework and providing a more dynamic, interactive user experience.

The observation points to a significant and practical need within the working groups: the requirement for a user-friendly system that empowers experts who are not proficient in coding to access and interact with data effectively. This need stems from the presence of numerous field experts who play a crucial role in analyzing, interpreting, and interacting with data for assessment purposes. These experts, while highly skilled in their respective fields, may not possess extensive coding skills, which can be a barrier in accessing and utilizing data effectively. Currently, these field experts often rely on static, paper versions of reports for their assessments. While these reports provide valuable information, they lack the interactivity and dynamic analysis capabilities that could significantly enhance the experts' ability to engage with the data more deeply and intuitively. There is a considerable disparity in the number of field experts compared to those proficient in coding, which underscores the need for a system that bridges this gap. By developing an interactive, user-friendly system, these field experts could have direct access to important computational capabilities without the need for advanced coding skills. Such a system would ideally allow them to:

- **Visualize Data:** Interactively explore data through visualizations that can be manipulated based on different parameters or filters.
- **Run Basic Analyses:** Perform essential data analyses through simple interfaces, enabling them to test hypotheses or explore trends without writing code.
- **Generate Intermediate Reports:** Easily compile and customize reports based on the data they interact with, enhancing the efficiency and relevance of their output.

- **Share Insights:** Collaborate and share their findings with other team members, contributing to a more inclusive and comprehensive assessment process.

In essence, the creation of such a system would enable a more direct, controllable, and feasible access to data and computational tools, allowing field experts to contribute more effectively to the assessment process. This approach not only elevates the quality of the assessments by leveraging the expertise of these professionals but also fosters a more collaborative and inclusive environment within the working groups. The Shiny app should be viewed as an empowering tool that enhances the assessment process by enabling comprehensive exploration and analysis. Its role in generating multiple scenarios is a part of the iterative process of refining the assessment, leading to a final output that is well-considered, expertly vetted, and defensible. This approach ensures that the tool is used effectively to support ICES's mission of providing scientifically sound and sustainable marine resource management advice.

Workflow Design

The current discussions and uncertainties surrounding the development and deployment of Shiny apps within various working groups of the organization reflect a need for more clarity and alignment with the state-of-the-art practices. To address these misunderstandings, we could organize sessions aimed at clarifying the scope and potential uses of Shiny apps in our context. These sessions should focus on:

- **Defining the Scope of Each App:** It's important to recognize that a Shiny app is not a one-size-fits-all solution. Different working groups may have varying requirements. Therefore, we can consider developing multiple apps tailored to specific purposes. For instance:
  - An app for **data collection**, management, and integration would focus on gathering and organizing data from various sources, providing a platform for data entry, and ensuring data consistency and reliability.
  - An app for **scenario exploration** and **assessment drafting** would enable users to manipulate data, explore different scenarios, and draft preliminary assessments. This tool would be particularly useful for experts in the early stages of analysis and decision-making.
  - An app for **assessment distribution** would serve as the final stage where the refined and finalized assessments are disseminated to relevant stakeholders.
- **Data and Information Access Policies:** Each app can have different policies regarding data and information access. Depending on the sensitivity of the data, the intended audience, and the specific purpose of the app, access can be open to all, restricted to certain user

groups, or completely private. It's crucial to decide these access levels in advance, based on the nature of the data and the objectives of the app.

- **Shiny Apps as Tools, Not Publications:** It is important to underline there isn't any misconception that every Shiny app should be a publication that must be made public. This is not the case. Shiny apps are tools that can be used internally within the organization for data analysis, scenario testing, and decision support. While some apps might be suitable for public release, others might be more appropriate for internal use only. The decision to make an app public should be based on its content, purpose, and the audience it is intended for.
- **Educational Component:** These clarifying sessions should also have an educational component, explaining the technical capabilities of Shiny apps, their potential applications, and best practices for their development and deployment. This will help team members understand the possibilities and limitations of these tools, leading to more informed decisions about their use.
- **Realignment with International Standards**: Drawing parallels with other international public and private initiatives, we can benchmark our approach and ensure that our use of Shiny apps aligns with global best practices. This comparison may also provide insights into innovative uses of these tools.

For example, addressing the concern that a Shiny app might generate an overwhelming number of scenarios which ICES may not be prepared to support or defend is essential. The key point to emphasize here is the intended use and role of the Shiny app in the context of ICES's work. Firstly, it's crucial to understand that the Shiny app is a tool designed to aid the assessment process, not to replace it. Its primary function is to facilitate exploration and analysis during the assessment definition phase. By enabling experts to interact with data and test various scenarios, the Shiny app enhances the depth and breadth of the analysis, leading to more informed and robust assessments. However, it's important to delineate the scope and use of the app clearly:

- **Exploration and Definition:** During the initial stages, the app allows experts to explore a wide range of scenarios. This flexibility is crucial for thorough investigation and understanding of the data and potential outcomes. It aids experts in identifying the most relevant and plausible scenarios for detailed examination.
- **Finalization and Limitation:** Once the assessment reaches the finalization stage, the scope of the Shiny app should be narrowed. This means limiting the scenarios to those that are most relevant and have been thoroughly vetted and understood. The final output provided to the commission or other stakeholders would be based on these selected scenarios, ensuring that each one is defendable and well-supported by data and expert analysis.
- **Clear Communication:** It's essential to communicate clearly that the multitude of scenarios generated by the Shiny app during the exploratory phase are part of the process of refining and defining the assessment. They are not all equally viable or intended for presentation to decision-makers. This clarification helps manage expectations and underscores the rigorous process of narrowing down to the most pertinent scenarios.

- **Expert Oversight:** The involvement of field experts throughout the process ensures that the scenarios explored and eventually chosen are grounded in expert knowledge and practical relevance. This oversight is crucial in maintaining the quality and credibility of the assessments.

Annex 4: Report of the Review Group on trade-offs between fisheries impact on sea-floor habitats and economic performance (RGD6TRADE)

Participants: Adriaan Rijnsdorp, Jeppe Olsen, Mark Tasker (chair)

Meeting: By correspondence 17-26 January 2023

Request: Review group participants were asked to review four reports:

1. ICES Workshop on Small Scale Fisheries and Geo-Spatial Data 2 (WKSSFGEO2);

2. ICES workshop on stakeholder input to refine the basis of trade-off assessments between the impact of fisheries on sea-floor habitats and their landings and economic performance (WKD6STAKE);

3. ICES Workshop on trade-offs between fisheries and seafloor (WKTRADE4);

4. ICES Workshop to update and assess trade-offs between the impact of fisheries on seafloor habitats and their landings and economic performance (WKD6ASSESS).

and draft HTML material that may form part of the future advice.

We evaluated the response from the workshops and technical service to their terms of reference, focusing on the completeness of that work and questioning whether the workshop missed important points the degree to which we agreed or disagreed with the conclusions made.

Overall Summary

Good progress has been made in the North Atlantic supra-region, the addition of analysis of MPA management is needed, and we suggest that other (fisheries-excluding) activities could be added in the future. The Mediterranean-Black Sea supra-region lags behind for fully understandable historical and cultural reasons, but good progress has been made and the review group considers that further progress is possible with continued effort.

The work of these workshops is of a sufficiently high standard that ICES advice can be based upon it.

Background

All four workshops were convened to respond to a request from the European Commission (DG Env) to

a) Scope/Explore the spatial and temporal distribution and intensity of fishing using bottom-contacting fishing gears, relating in particular to the Mediterranean and Black Seas, and to vessels <12 m in length, or without VMS.

b) Advise on how the economic value of each fishery (gross and net) is related spatially to the distribution of the fishing activity, to identify ‘core’ and ‘peripheral’ fishing grounds.

c) Advise on the potential costs to fisheries of achieving various proportions of each MSFD broad habitat type per MSFD subdivision free from bottom fishing.

d) Update the 2021 ICES advice (eu.2021.08) on these topics for all European marine regions, to the extent possible.

ICES was requested to build upon their 2021 ICES advice (eu.2021.08), with a particular focus on extending the established approaches to the EU waters of the Mediterranean and Black Seas, and further developing the approaches and updating the data for the Baltic and North-east Atlantic regions. This should:

a. Provide analyses of the spatial and temporal distribution and intensity of fishing using bottom-contacting fishing gears. This should include using data from VMS/logbooks and, to provide an explorative analysis of data available and methods development for vessels lacking VMS (i.e. <12m in length, ‘day’ vessels >12m), supplementing with data from other sources (e.g. AIS, Global Fishing Watch, national initiatives, other projects) where possible. The data should cover at least the most recent 6-year period, but could extend further back where data are available, and be analysed per métier. The gaps in the data used (by area, by vessel type) should be clearly documented to estimate the likely level of under reporting of fishing effort in the analyses.

b. Provide analyses of the economic value of the bottom fisheries linked spatially to their distribution, in order to define the distribution of fishing value and distinguish ‘core’ and ‘peripheral’ fishing grounds per métier following the approach of ICES 2021 advice and determine the spatial variation in ‘core fishing grounds’ over time. The analysis should assess, as far as possible, the gross (landings value and weight) and net (revenues, profits, contribution margin, accounting for fuel, salaries, maintenance costs and fishing effort/time) value of each fishery.

c. Provide the same analysis to point (b) for bottom fisheries in existing marine protected areas (designated under Natura 2000 and through regional and national mechanisms) to define the economic value per métier inside and outside MPAs and, if possible, to distinguish core and peripheral fishing grounds.

d. Provide a trade-off analysis of the potential costs to fisheries of achieving various proportions, expressed in 10% intervals (as % reduction in effort, and in euros), of each MSFD broad habitat type per MSFD subdivision free from bottom fishing. The trade-offs should maximise overall gain in benthic sea-floor status and minimise lost revenue/profit (catch/value). The analysis should include scenarios for removal of fishing effort.

This report combines comments from the three reviewers: Jeppe Olsen, Adriaan Rijnsdorp and Mark Tasker. Each of the reviewers had different backgrounds and expertise and each of us reviewed the documents before agreeing the contents of this combined report.

Summary against the above four parts of the Request

Although the Review Group was asked to individually review the four workshop reports and the draft HTML, we felt that it might be useful to summarise the overall progress against the request.

a. Provide analyses of the spatial and temporal distribution and intensity of fishing using bottom-contacting fishing gears.

Good progress has been made in mapping distribution of bottom-contacting fishing gear, with nearly complete updates in the North Atlantic (NAO) supra-region, and progress being made in the Mediterranean-Black Sea (MBS) supra-region, mostly in the form of case studies rather than systematic gathering of data. We note that HELCOM has formed a data hub for AIS data in its area and wonder if ICES might work with them and possibly encourage others (nations/organisations) to form similar data hubs for other seas. We felt that a better evaluation of the gaps in the data used (by area, by vessel type) could have been made to estimate, or at least describe, the likely level of under reporting of fishing effort in the analyses. The varying presence or absence of UK data in the analyses is confusing, and it might be best, given the (very regrettable) current and likely future lack of UK data, to remove UK waters entirely from the analyses.

b. Provide analyses of the economic value of the bottom fisheries linked spatially to their distribution

This has been done well for the NAO, and in case-studies for the MBS area.

c. Provide the same analysis to point (b) for bottom fisheries in existing marine protected areas

This analysis has proved difficult to complete and is missing from the products, with the mismatch between the polygon shapes of MPAs and c-square availability of fishing data proving challenging. It is also striking that the request does not specify that only MPAs containing protected features susceptible to bottom fishing may need management of Mobile Bottom Contacting Gears. For example, large MPAs solely for marine mammals or seabirds are unlikely to need such management.

d. Provide a trade-off analysis of the potential costs to fisheries of achieving various proportions…

This has been carried out in the HTML where possible, dependent on the availability of data from the above bullet points.

Review of the four workshops

1. ICES Workshop on Small Scale Fisheries and Geo-Spatial Data 2 (WKSSFGEO2)

This review evaluates the contribution of WKSSFGEO2 to the EU request and is focussed on the completeness of the work and on how well the conclusions are supported by the results. WKSSFGEO2 made good progress and all terms of reference were addressed. The aim of WKSSFGEO2 was to continue the work developed during WKSSFGEO, namely on analysis of the high-resolution geo-spatial data in small-scale fisheries (SSF), as well as large-scale fisheries (LSF) taking into consideration low duration fishing events. During this workshop, an open database of examples of SSF across the EU, including a script to anonymize the data, was produced. The data set currently available has 9 full case studies from different countries, gears, geo-position recordings and temporal intervals, is fully functional and openly available on ICES github. Various methods to infer fishing activities were compared, and the main issues and recommendations were dis-cussed. Testing of the effect of temporal resolution in the data using the example data base was initiated but further work is required on this aspect. Based on preliminary analysis, it was concluded that a conservative approach of a 'ping rate' of 30 secs (to obtain a 1 min temporal interval) is recom-mended if a generalisation is to be made that is applicable in all Metiers and that can be used to estimate all EU Multiannual Programme for data collection variables. Based on available data sources (EU FDI, ICES VMS/Logbook Data Call, Global Fishing Watch AIS) an overview of small-scale fisheries (SSF) in EU Waters, visualized in figures, maps and tables was created. It was clear that it is difficult to directly compare data from the three available sources as each have different issues, e.g., different vessel length groups, covering fisheries from different countries and different legislation behind the data sources. Based on FDI data we can see that the passive gears are responsible for most fishing effort and that around ⅓ fishing effort from EU vessels in area 27 (North Atlantic) is from mobile bottom-contacting gears. In area 37 (Mediterranean and Black Sea) the proportion of fishing effort from mobile bottom-contacting gears is smaller. With regards to position data from the SSF, the VMS data can provide good coverage for vessels larger than 12 m, and the AIS could supplement for the smaller vessels, but the analysis comparing the fishing days by vessel length classes for the three data sources show that it is not a complete picture. The Global Fishing Watch data has shown another useful additional source which could be useful in future analysis. The resulting maps indicate significant gaps in data or data availability and a complete profile of SSF in EU cannot yet be produced with these data. WKSSFGEO2 discussed the opportunities, challenges and benefits for an EU-wide tracking system for small-scale fisheries vessels and this report provides a guidance document with various recommendations on ways forward.

Review

a) Build up from WKSSFGEO

i) Create an open data set of case studies (anonymised) to test the methods, with different gear types and locations.

10 datasets are described in the report, which have all been anonymised. If they are to be used beyond the workshop, it would be recommendable to publishing them in the WGSSFGEO2 github repository, where only four datasets can be found, consisting of 332 – 9115 positions and 3 gears (nets, dredge and pots & traps), see figure 1. How to use them was not very clear, as the file that is referred to in the report (WKSSFGEO2_examples_data_base.Rmd) was not found.). Also, it would be informative if a vignette/tutorial or a more elaborate readme file were added to the repository.

In page 26, Case studies are described, but the approaches of inferring activity in each point differ from each case study. I would recommend that the group decide on a range of default methods and test them on all available datasets. Also, if possible, larger data sets should be obtained, to be able to assess the methods in depth and achieve greater confidence that the methods will work globally (or at least for the gears/métiers they were designed for). The group themselves states that this is beyond the scope of the WGSSFGEO2 workshop, and recommends that a project, like the vmstools project (Hintzen, N. T., et all, 2012), should be conducted. This would be highly recommended, if we are to further evaluate and quantify the effect of small-scale fisheries in European waters.

ii) Test and compare methods to classify positions into fishing activities (i.e. random forest, machine learning, geocomputing) on different types of vessel tracking data and gear types to infer relevant effort parameters.

The report describes in qualitative ways how machine learning algorithms can be used to identify fishing behaviour, and that neural networks could potentially be used in the future. Four case studies are described, but it seems that they are treated in different ways. It would be recommended that each case study/dataset was subjected to a range of standard methods, and that the performance be presented in a table. This would also require that "performance" is defined, for example % pings correctly classified / % pings false positives / % pings false negatives, like the table presented in page 31. This would give a more quantitative measure of which methods is applicable on which kind of gears and in which regions.

iii) Recommend the optimal/maximum frequency of acquisition of geopositional data (time between pings) by gear types to infer relevant fishing activities

The workshop recommended a 30 secs ping interval (p. 39) and lists 5 reasons that all relate to the fact that intervals between pings should be small enough to correctly identify where the fishing is taking place. The report does not supply much quantitative testing of this. At p. 2 the Portuguese case study reports the best performance for the raw (30 seconds) ping rate. But none of the other case studies evaluates their models on different ping rates. From Figure 4. In page 39, it seems that neither accuracy nor precision is much affected by change in ping rate, but that gear and region is the categories which drives the differences. This indicates that the methods used are optimized for a single use, and not ready as a default method that could be applied to all gears and regions.

For the 0.05° c-squares presently used in WKSFD, the 120 minutes interval is adequate, which means that if 1-minute intervals were available, the resolution could be roughly down to 0.0005° (0.05° divided to 100) which would equal about 50x30 meters in northern Europe. The report mentions 0.01° (p. 70) but does not elaborate on why this resolution would be adequate / desired. In p. 40 the report states that to calculate an appropriate ping rate, the minimum no. of pings required for robust analysis (the report mentions 50) divided with the minimum trip duration (here the report mentions 2 hours) = 3.6-minute intervals. But the report does not mention why 50 points are needed, and for which models this target applies.

A suggestion to further investigate the ping rate would be that all datasets were down sampled to a range of ping rates and tested with the models used in the case studies. 30 Seconds seems like a reasonable solution, but we need more evidence before an exact interval can be recommended.

b) Using data already available:

The FDI/Logbook/AIS datasets are obviously very different and made for different purposes. This makes them difficult to compare, and it seems much of it does not agree. It is especially a big problem that for the year used (2021), UK did not supply any data because of Brexit. Using this year makes it difficult to make a clear comparison that could provide an estimate on how much SSF is included in logbooks for regions where UK has fishing. Using another year as an example would have been preferable. The workshop does a good job of mitigating other differences, like gear groups and length groups that do not match.

Fishing days are used as an approximation of fishing pressure, and the fact that smaller vessels have smaller footprint than larger vessels is not considered; future work might consider using kW*days. Fishing days are not defined in the report. This may refer to days at sea or days fishing (this is how it is defined in the logbook from WGSFD) or simply 24 hours of fishing. If the definition is not consistent, this could explain some of the discrepancies that occur between the three datasets.

The total fishing impact in European waters is difficult to estimate. Ideally, a swept area on a fine scale for all vessels would be preferred, but currently that is not possible to achieve. To estimate the missing impact, we need a more detailed picture of the missing data, namely the small-scale fishery, since impact from vessels longer than 12 meters is well covered in most regions. FDI uses specific declarative forms, logbooks sales notes or surveys from the SSF, but it is not clear how large a proportion of the total fisheries are included in this data, which will also be highly difficult to estimate. Furthermore, SSF fisheries have a different footprint than LSF, a different spatial extent and different fishing patterns. If we are to better understand SSF, the work done in WGSSFGEO2 needs to be continued on a larger scale.

Data sources like global fishing watch could help provide this missing data, for vessels carrying AIS, but this would require an analysis using raw data and vessel identification, which is not possible with the current interpretation of the GDPR rules in Europe and would nonetheless require a huge analytical effort. The interpretation of GDPR for fishing vessels have changed with the new resolution, which could mean that ICES would be able to ask for raw positional/logbook data, and then do the calculations at the ICES Data Centre. This would ensure competent coding skills, but lacking knowledge of the local fisheries.

Another source that could be worth investigating is where global fishing watch is uses satellite imagery to infer fishing and estimates that 75 percent of the world's industrial fishing vessels are hidden from public view (Paolo, F., Kroodsma, 2024).

In annex 4, the proportion of fishing days for vessels smaller than 12 meters is calculated. This is highly relevant and could very well be incorporated into the assessment html description. It does not supply a direct coverage, but mentioning this percentage in the summary for each subregion would improve the confidence.

Discussion

The regional assessment does not explain how is fishing intensity linked to MSFD broad-scale habitat type. Since fishing effort is calculated on a c-square (0.05°x0.05°) and habitats are polygon-shaped, they do not match. Linking them can be done by either dividing sar values into each habitat, by considering a c-square to be the most abundant habitat in that c-square or the habitat that is occurring in the centre of each c-square (which is most easy to calculate). Each approach has its limitations, since fishing intensity will often be aggregated in a c-square, often in specific habitat types, see. K.J. van der Reijden et al. 2023. WGSFD is planning to mitigate this problem by merging the habitats to the raw fishing positions at a national level.

The regional assessments do not consider that not all fishing from mobile bottom contacting gears is present in the data. A large and unknown proportion of data from small-scale fisheries is missing, where the spatial extent is often different from the large-scale fisheries. This impacts how certain we can be on the conclusions.

The report describes accurately the current state of fisheries data in Europe, where the fishing patterns of vessels larger than 12 meters are well understood, since position data is available (VMS), and methods for analysing the data is developed. But for smaller vessels, data is only available in patches, and the method for analysing SSF is not yet operational. The report calls for a EU to implement a EU wide tracking system for smaller vessels, which would enable a qualitative assessment of all fisheries. A solution could be that each member state was obliged to supply EU, through the EU data collection framework, with information on fishing trips and of coverage by fleet segment. This is apparently required in Regulation 2023/2842 (https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=OJ:L_202302842). The EU could ask for minimum coverage, and each country could implement measures to meet the requirements, without losing what is already implemented.

The conclusion that 10% less effort leads to more than 40% untrawled in each MSFD broad habitat type in each subdivision is dependent on how much coverage the fisheries dataset has. And since this is not clear, it would be advisable to caveat to the sentence, that makes it clear that this statement is dependent on the currently available data, and that it is not certain how much is missing in that dataset.

References

van der Reijden, K.J., Ernstsen, V.B. Olsen, J., Dinesen, G.E., and Leth, J.O. 2023. Replicate data for: Improving seabed substrate mapping with high-resolution bottom trawl data. Technical University of Denmark. Dataset. https://doi.org/10.11583/DTU.21602280.v1

Hintzen, N.T., Bastardie, F., Beare, D., Piet, G.J., Ulrich, C., Deporte, N., Egekvist, J., and Degel, H. WKD6STAKE2012. VMStools: Open-source software for the processing, analysis and visualization of fisheries logbook and VMS data. Fisheries Research, 115-116, 31-43. https://doi.org/10.1016/j.fishres.2011.11.007

Paolo, F., Kroodsma, D., Raynor, J. et al. 2024. Satellite mapping reveals extensive industrial activity at sea. Nature 625, 85–91. https://doi.org/10.1038/s41586-023-06825-8

2. ICES workshop on stakeholder input to refine the basis of trade-off assessments between the impact of fisheries on sea-floor habitats and their landings and economic performance (WKD6STAKE)

This review evaluates the contribution of WKD6STAKE to the EU request and is focussed on the completeness of the work and on how well the conclusions are supported by the results. WKD6STAKE made good progress and all terms of reference were addressed.

The workshop was attended by representatives from fisheries and environmental stakeholders from different countries as well as representatives of international organisations which warrant input from all relevant perspectives.

The ICES 2021 advice made reference to 5 management scenario's (gear design and switching, effort and spatial controls, and impact quotas). The subsequent work of ICES focussed on three of these (habitat effort reduction, gear modifications and MPA closing). Scenario's relating to gear switching, impact quotas and other forms of spatial control (i.e. coastal and/or small-scale sensitive habitats) were not taken forward to the trade-off analysis. It might be useful to document why, the reviewers understand that reasons include the absence of knowledge and data and difficulty in assessing at a small-scale level, in essence EUNIS levels 4 – 6 (ICES Advice 2021).

The workshop noted that the results of the regional assessment required further in-depth analysis before taking management decisions. As the science of the regional assessments is still developing, it is expected that the understanding of the results will deepen over time. It is further noted that the regional assessment model is a support tool and not a decision tool.

The workshop proposed to monitor effects of management decisions and improve the assessment of seabed state (further develop and validate indicators). Although this can be achieved within the current framework using high resolution pressure data (increasing the spatial resolution) and impact indicators (improving on the empirical basis of the trait composition of the benthic community), it will be a difficult task to validate the indicators in empirical field studies given the spatial extent of the estimated indicators and the feasibility of long-term and large scale monitoring programs of the benthic status. The need expressed by stakeholder to validate the indicator system highlights the importance of benthic monitoring programmes. ICES could ask the appropriate expert group to comment on its feasibility and the sampling requirements.

The workshop agreed that the regional assessments, in particular the socioeconomic analysis of the impact of fleets from individual countries would improve if finer-resolution data could be used. Although the quality of the advice and its scientific basis would certainly improve if the EU MS countries would agree on providing fisheries data at a resolution that will allow ICES to conduct the analysis without the need to make strong assumptions on how to downscale input data to a finer resolution, confidentiality issues may cause delays in the realisation. As a possible intermediate solution, ICES could consider to (if necessary) adjust and streamline the scripts used for the regional assessments and make them available (e.g. on github if not already there) for others to use in assessments at a smaller local scale and with higher resolution data.

The workshop recognised that spatial fisheries management scenario's need to take account of other human activities that compete for space. Reviewers consider this to be a priority area for the further collation of the data layers and the development of the tools to model displacement of fishing effort. The reviewers understand that a project led by Germany may be doing this for the North Sea already https://maritime-spatial-planning.ec.europa.eu/media/document/15065.

The workshop noted that the distribution of the core fishing areas may vary over time in relation to environmental changes or changes in management measures and that the core areas may be differ among sub-groups of the fishery considered in the analysis. These are valuable remarks that can be tackled in case studies of specific fisheries for which higher resolution input data are available. As the science supporting the regional assessment is still developing such case studies can be very helpful to explore the sensitivity of the regional impact assessments and support the credible interpretation of the results.

Gear modification will likely affect the economic parameters as well as the species selectivity / catch efficiency of the gear for specific target species, which will affect the spatial distribution of the fisheries. To take account of these complexities require rather sophisticated models (example of tickler chain beam trawl and pulse trawl). The currently implemented modelling approach does not take account of these complexities. This should be taken into account when interpreting the results of the management scenario analysis.

The workshop proposed to apply additional area definitions RSC regional sea convention to allow better alignment with RSC seabed assessments and MSFD implementation, to subdivide the RSC areas at 800m or 1000m isobath to reflect where fishing is permitted and to subdivide RSC areas by national EEZs. Although these amendments are technically possible, the results will be equally affected by the uncertainties introduced in the downscaling of the economic data collected at (far) larger geographic scales to the areas of interest to the stakeholders and managers.

3. ICES Workshop on trade-offs between fisheries and seafloor (WKTRADE4);

This review evaluates the contribution of WKTRADE4 to the EU request and is focussed on the completeness of the work and on how well the conclusions are supported by the results. WKTRADE4 made good progress and all terms of reference were addressed. The results provide a sound basis to update the 2021 advice, although data deficiencies precluded regional assessments for the Mediterranean and Black Seas. Regional assessments for the Northeast Atlantic Ocean (NAO) supra-region were updated up to 2022, The management scenario's considered included habitat effort reduction, gear modifications and MPA closing, although the results of the latter two are pending and not yet available for review. This review comments on sections in the report where the clarity of the presentation could be improved and lists a number of possible inconsistencies and errors.

WKTRADE4 built on the group's previous work and estimated economic performance indicators by linking VMS data on the spatial distribution and economic data available in the Fisheries Dependent Information (FDI) data base and Annual Economic Report (AER) compiles by STECF. The analysis was done for the main mobile bottom contacting fisheries in management areas in the NAO and the Mediterranean and Black Sea (MBS) supra-regions. Management measures to be evaluated included effort controls, spatial controls (MPA) and fishing gear regulations. The trade-off analysis used a series of well-established pressure and impact indicators: I-1 intensity; I-2 proportion of grid cells fished; I-3 proportion of area fished; I-4 aggregation of fishing pressure; I-5: persistently unfished areas; I-6: average impact across grid cells; I-7: proportion area with impact <0.2. The impact was estimated with the well-established PD method. Following WGFBIT the previously used L1 method, that was considered overly precautious, was replaced by a PD indicator for sensitive species (PD-sens). The economic performance indicator used is the gross value added (GVA). It is noted that indicators are not consistently labelled. For example, the labels for the pressure indicators used in section 5 of the WKTRADE4 report deviates from those used in the HTML product and the previous WKTRADE3 report.

The quality of the analysis depends on the quality of the input data. The group carried out a number of consistency checks between the data sets and found in general a good agreement except for the fishing effort of the small fleet segment (<12m vessel length). The lack of spatial information of this fleet segment corresponds to less than 9% of the fishing effort in the VMS data base (kW*fishing days) but varies substantially between subregions. The under representation of small vessels may introduce a serious bias, in particular as this fleet often operates in other and more coastal areas than the larger fleet segments.

The quality of the analysis is further critically dependent on the level of resolution of the input data in particular the classification of the fisheries and the spatial resolution. Since the resolution of the economic data is rather coarse in terms of the distinction between areas (supra region) and fleet segments (gear groups), the economic data had to be downscaled from the level of the supra-region to the region and then to the level of the c-square resolution of the VMS effort distribution data. The procedure used to downscale and link the economic and VMS data set is described in section 1 of the report and illustrated in Figure 1. In section 3, the report continues with a presentation of different techniques to disaggregate economic data, or other methods, to obtain higher resolution estimates. This section is confusing as it is not explained which of the presented techniques were actually used in the regional assessments (and which were not used) and how these techniques relate to the steps shown in Figure 1. It is further noted that the strength and limitations of the various techniques is presented but no conclusion about the best way to move forward is drawn.

In downscaling the economic data to the c-square level a number of assumptions were made. First it was assumed that the landings and fishing costs scale with fishing effort. It is noted that the assumption is consistent with the Ideal Free Distribution theory which predicts that fishers will distribute themselves in proportion to the abundance of the fisheries and fishers will receive equal benefits (review IFD in Gillis, 2003. Can. J. Zool. 81: 177–187). It would be informative if additional studies were done to test this assumption for fisheries for which higher resolution data sets are available (VMS spatial data and catch data by set/tow such as in Rijnsdorp et al. 2022 ICES Journal of Marine Science, Volume 79: 2093–2106). These studies could also reveal to what extent neglecting the distance to port bias economic performance measures.

The group developed an R-script to take account of effort displacement in response to area closures assuming effort would be evenly redistributed or in proportion to the GVA and used the scripts in an exploratory analysis.

WKTRADE4 discussed the recommendations made by WKSTAKE and were able to take some into account in the analysis.

Clarity of presentation

The presentation of the procedure of downscaling the economic data to the level of the c-square was sometimes difficult to follow. It would help if the relevant characteristics of the data sets (resolution of the data set in terms of: spatial area, fleet segment/gear group, country, time scale and the level of aggregation (individual vessel, fleet segment) were tabulated.

Several figures have used a small font size which hampered the readability. Panels in several figures, for example in Figure 14, are very small. It is difficult to see the location of the MPA polygons and the influence on the GVA. Better to illustrate by zooming in on a smaller area. The font size used in several figures is too small.

Page 7. Does “but some variation in the proportion of the kW*Fishing days from MBCG from vessels below 12 m in length” means that the match is less in GSA area with a high% of effort of small vessels?

Page 15. Section 2.1. 3rd bullet point. Somewhat more information would be helpful to understand. It is unclear why there is a problem if the WKTRADE data call used the list of gears in the first bullet point above.

Page 18. "On average, 90% of the total annual landing value corresponds to 40% of the area currently exploited by the different metiers in the different ecoregions (Figure 8). This estimate, however, is probably an overestimate given the low resolution of the FDI data." Comment: no explanation is given why this might be an overestimate.

Page 25. The final paragraph is unclear. "The results showed that this type of analysis is technically applicable to FDI data, but the results highlight important limitations. First of all, the low spatial resolution of the FDI data results in a correspondingly low resolution of the outputs, which then fragment the areas into large, internally inhomogeneous polygons. Furthermore, when applied to Level 5 metiers and over entire ecoregions, core fishing ground analysis can return (as in the example image) a highly polarised pattern in which large tracts of coastal fishing ground are defined as 'marginal' "

Page 33 2nd paragraph. Does the assumption of an even redistribution of the effort includes both fished and unfished c-squares? Based on the introductory information, one would think that using the gross profit to be a better metric to redistribute effort than the GVA.

Page 42. Clarify message in following sentence. "This is due to the non-accessibility of some basic data (VMS, Logbook), forcing to make strong assumptions that are not reflected in the literature and in the available data".

Inconsistencies

Page 9-10. In Figure 2 of the report there are several areas with a substantial Value for Landings whereas Figure 3 or Figure 4 does not show any kW*Fishing hours, such as in the NW North Sea and along the west coast of Scotland. If this correct, I couldn't find where this is mentioned/discussed?

Page 17. Last sentence. 46 differs from the number in Table 6. What criteria were used to select which metiers to include in the further analysis? Inspecting the bubble plots seems to suggest that the selection differed between ecoregions.

Figure 7. Are these maps correct? They only show core areas in coastal waters but not in offshore areas of the North Sea where core fishing grounds are expected.

Section 5.1. It is noted that in the Mediterranean and Black Seas region specific analysis, the core fishing grounds are defined differently among studies: e.g. the area where a certain proportion of effort is concentrated (c-square sorted from high to low); the area where a certain proportion of GVA or LV is concentrated; the set of cells associated with 90% of the LVs or GVAs and with the lowest level of spatial fragmentation (following Ban and Vincent, 2009).

Section 5.2. It is inconsistent that for the southern Adriatic Sea VMS and logbook data were not available whereas these were used in 5.1.

Table 9. Proportion grid cells fished / unfished does not add up to 1.0 for "Total area" & "More than 800m"

Editorial comments

Page ii bullet e. peacemeal should be piecemeal

Page 6. '… the percentage of kW*fishing days from EU MS fishing with MBCG is around 3%." Include 'of vessels <12m'.

Page 15. Section 2.1. 4th bullet point. Include 'metiers' in "presence of 797 metiers in FDI data used".

Page 16. Table 5. Add "Example of the" to the "Structure of the processed FDI data in which data are aggregated by spatial unit (c-square), Metier of level 5, and Ecoregion"

Figure 6. Surprised to see Ecoregions beyond the Med-BlackSea as the introduction mentioned the Med BlackSea only. Also I don't see 46 combinations as mentioned in text.

Figure 15. Legend in some of the panels are incomplete which may lead to confusion between core (YES) and peripheral fishing grounds (NO).

Terminology need to be standardised. For instance; Figure 8 uses Percentage of area fished versus Landing value (euro); Figure 16 uses rarefaction curve.

Figure 19. panels and labels/text are unreadable / blurred.

Page 49. Response of WKTRADE4 to WKD6STAKE is incomplete for the 3rd entry line

4. ICES Workshop to update and assess trade-offs between the impact of fisheries on seafloor habitats and their landings and economic performance (WKD6ASSESS).

This review evaluates the contribution of WKD6ASSESS to the EU request and is focussed on the completeness of the work and on how well the conclusions are supported by the results. WKD6ASSESS made good progress and all terms of reference were addressed.

This workshop aimed to synthesise the output of the other workshops above and progress towards the provision of advice. The report that we initially received for review was not complete, but an updated report was received towards the end of the review period. Comments were re-assessed with the new version of the report but some may not have been changed and may now be out of date.

Section 2.1. It is unclear how and when the routines used will become TAF compliant. Some statement on the reliability and testing of the routines is required. The last paragraph in Section 2.2 is a statement of what TAF is about, rather than how TAF will be achieved.

Section 2.2.1. The ADG may need to ensure that WGFBIT's report has been peer reviewed, given the reliance on its work here. An alternative would be to refer to ICES 2021 advice.

Section 2.2.1 Should the penultimate paragraph last sentence include the Western Mediterranean (not the Eastern Mediterranean), given earlier in the paragraph there is description of the French Mediterranean, and (if relevant) what exactly is the Eastern Mediterranean (many would say it is waters off Turkey/Syria/Lebanon/Israel/Gaza/Egypt)? The wording in this sentence ("including") implies there are more areas with impact assessments – why not just list all areas that have impact assessments?

Section 2.3 (from WKTRADE4) has two definitions of GVA:

The GVA can be considered as a measure of the gain of the fishery excluding other variable, repair and maintenance costs, and non-variable costs (net gain) from the original AER formulation:

GVA = Income from landings + other income – energy costs – repair and maintenance costs – other variable costs – non variable costs

Is the verb "excluding" wrong in the first definition? Should this be something like "after subtracting"?

There is another definition further on in the report that might usefully be harmonised "*the GVA is the net output of the fishery sector after deducting intermediate inputs from all outputs*" (what is an "intermediate input"?)

Figure 2.3 looks odd. It appears that few if any UK (Scottish?) data are used – possibly a result of Brexit, but this needs to be clarified in the figure caption. If EU only, should say so, with caveat on any non-assessed UK fishing in EU waters. Is all flatfish trawling data in the south-eastern North Sea present? As a matter of principle, figure captions should at least summarise any caveats to the figure. There is a (new) bullet point in the text saying that the GVA layer relies on STECF data that no longer has UK data, but the figure caption says nothing about STECF data. Summary: Greater clarity required!

It is unclear how important the sentence "*The landing in value could potentially have a different spatial distribution than the fishing effort*." is. Surely this could be quite important to the advice? A little more explanation/interpretation would help.

Section 2.4 – A useful demonstration of improvements/updates. A summary of these, and a set of recommendations (e.g. deriving from: "*The inclusion of other activities and /or fishing limitations is not achievable in WKD6ASSESS but could be improved in the future*") would be useful for the ADG.

It is a pity that the response to the considerable effort to improve small boat data is "*Despite the efforts of WKSSFGEO2, no changes are made in the update and the issue will be highlighted in the limitation section. Missing data in relation to available data could be quantified*". A proposal for how to address this issue would be welcome.

As above, the response to efforts to improve the Mediterranean and Black Sea data with "*Need to test run to see data limitations/ ease of implementing the scripts in a non-ices VMSs workflow*" is disappointing. How/when will this addressed?

"*The new Advice will replace the LL-indicator with the PD-Sens indicator (WGFBIT), which can be validated with data*." illustrates the need to peer-review the WGFBIT report.

In Table 2.4, should UK be added to the VMS issues line?

Section 2.4.2. The Shiny App has not been reviewed, but the landing page seems to show the ICES ecoregions as opposed to the (OSPAR etc) areas used in this advice.

Section 3.1.2 (and 3.1.3) – need a (www??) reference as to where to find the MAPAFISH (and SEAWISE) project.

It would be useful to clarify if the important conclusion of MAPAFISH "*No overall match of trend-change could be identified with the designation of the MPA or the establishment of fishery restriction*" relates solely to MBCG and to those MPAs established to protect bottom habitats or whether irrelevant matches are being tested (e.g. bottom contacting gear and MPAs established for marine mammals or seabirds). There has been rather a lot of non-discriminatory comparisons made in the media/by NGOs. This whole paragraph could do with more precision on fishing types that were assessed under MAPAFISH.

Figure 3.2 needs clarity over the inclusion or otherwise of UK sites/data in the analysis.

We note that a planned analysis of MPAs (a section 3.2.1.3) was not eventually conducted. It would be useful to recommend that such an analysis is done in the future. Ditto with an analysis section (was 3.2.4). A draft section 3.2.5 was removed from the final report – this contained some potentially useful recommendations that the ADG might consider.

Much of an original version of Section 4 on the Mediterranean has been removed. It is unclear as to why as the original version provided much more detail on progress.

Comments on HTML products

These products are an excellent idea!

The HTML products with the regional assessments restricted to the NAO supra-region. Although spatial fisheries data and economic data were compiled for several Mediterranean and Black Sea regions, poor data coverage precluded the running of regional assessments (VMS/Logbook data were unavailable; the spatial resolution of the FDI data is very low and there are gaps in the data (landing value)). Results of exploratory analysis show that WKTRADE methodologies can be applied in the MBS supra-regions. Results of the core fishing grounds analysis are presented for regions in the MBS supra-region, corroborating the patterns found in regions in the NAO.

The HTML products for regional assessment of the NAO supra-region were updated and the time period extended up to 2022. The management scenario's considered included habitat effort reduction, gear modifications and MPA closing, although the results of the latter two are pending and not yet available for review. Because no threshold has been set for the seafloor quality, an arbitrary threshold was used for illustrative purposes.

It is noted that in the updated HTML product the text on the impact indicators has not been updated and still present the L1 indicator which has been replaced by the PD-sens indicator as shown in the Figures.

Given the detailed comments below, and the nature of them likely extending into other unexamined HTML, and noting that HTML was provided as a demonstration in the last ICES advice in 2021, it may be wise to fully develop one region's HTML and issue as advice, rather than attempt to complete all NAO supra-region HTML.

More detailed comments (not enough time to look at all HTML):

Baltic, Read-me

Heading should be Mobile bottom-contacting gear

Any hint of scale/distribution of Russian fishing activity to put missing info in context? Is the information pre-2013 needed since not used in analysis?

"Depletion rate" needs explaining in Table 2

FTBIT Report should read ICES 2018 (which needs a DOI too)

Can we assume the Baltic divisions and their names have been agreed with Helcom? They differ from the divisions used by Helcom.

Baltic, Baltic Sea

"constrained" implies something outside is limiting footprint, how about "restricted"? Ditto elsewhere??

Baltic, Bothnian Area, Pressure

Wonder if it is worth saying (if we know) about any other non-MBCG fishing – e.g. if there is a lot of netting going on?

Is there a difference between "fishing intensity" and "fishing pressure"? If not, there is repetition, if so, may need defining.

Baltic, Gulf of Finland (and Gulf of Riga)

Worth repeating that Russian data is absent (and possible consequences if known)

When is "negligible" (cf not said in Bothnian area)? And other gears?? Maps need updating? Or is there no fishing pressure?

Baltic, Arkona & Bornholm

Typo in last line of Pressure – not Baltic proper

Management scenario texts still needed

Bay of Biscay etc Read me

Where is Figure 1? (found under summary, but perhaps needs better reference from Read me?)

The GVA data for Portugal appears to be absent – add comment to caption?

Pressure

"*Areas of higher intensity occur in the shallower part of the French Bay of Biscay, and across the shelf break of the wester Iberian peninsula, mainly in areas of Galicia and central and south Portugal. Areas with lower intensity occur in central Cantabrian Sea and in the Gulf of Cadiz.*" Appears not to be correct. Portugal seems to have low pressure while Gulf of Cadiz has high pressure, or are some Portuguese data missing?

Figure 3 – is 2009-2010 increase real or an artifact? If the latter, suggest removal. The sentence "*There is a large increase in intensity in offshore circalittoral sand and upper bathyal sediment in the period 2012-2014, which may be due to erroneous data*" does not seem obvious in Figure 3#

Are we sure that "*More than 90% of the fishing effort (swept area) and more than 90% of the landings and value, occur in only 20% of the surface area of the Bay of Biscay and the Iberian Coast*" is correct? Figure 4 seems to show 60% not 90%.

Gulf of Biscay

Unclear as to what is wrong with weights

What is "*Bay of Biscay shallow*"? (see Pressure section)

Commentary on Figure 4 in Pressure also looks to be wrong.

Figure 8 is not referred to under Core Fishing Grounds

North Iberian Atlantic

Portuguese waters appear not to be included, so reference to North Portuguese waters is wrong. Does this mean Western Galicia? Other comments appear to be odd when referred to Figure 2.

"*There is a large peak in intensity in most of the habitats, which may be due to erroneous data. Both average trawling intensity and proportion of area fished show a similar trend with a negative peak in 2010 and minor changes in the rest of years (Figure 3, compare left and middle panel).*" Is not really supported by Figure 3, neither is "*Fishing pressure is aggregated, both at the regional level as well as at the level of the habitat (Figure 3, right panel). The smallest proportion of habitat with 90% of effort varies between 40-60%*"

Figure 4 summary not right either "reaching values of 70% of landings with only 30% of total area"

South Iberian Atlantic

South Iberian Atlantic really means Portuguese waters

GVA seems to be the problem, not weight???

Gulf of Cadiz

Quite a few geographic oddities in Figure 1