Analytical framework for marine socio-ecological data curation

Deliverable Number 2.1

24 October 2025 | Version 1

Contributors: Alice Sbrana (CNR), Maria Lazarina (AUTH), Rocco Paolillo (CNR), Athanassios Tsikliras (AUT), Evelina Carmen Sabatella (CNR)

Public

Funded by the European Union

Funded by the European Union under the Horizon Europe Program, Grant Agreement No. 101157456 (SURIMI). Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Climate, Infrastructure and Environment Executive Agency (CINEA). Neither the European Union nor the granting authority can be held responsible for them.

UK Research and Innovation

UK participants in SURIMI are funded by the UK Research and Innovation (UKRI) under the UK government's Horizon Europe funding Guarantee [grant number 10132993].

DOCUMENT INFORMATION

Grant Agreement	101157456
Project Acronym	SURIMI
Project Title	Integration of innovative and reliable socio-ecological models and user-driven solutions into the Digital Twin Ocean, to facilitate what-if scenarios and decision support, under a co-creation approach.
Deliverable Number	D2.1
Work Package Number	WP2
Deliverable Title	Analytical framework for marine socio-ecological data curation
Lead Partner	CNR
Author(s)	Alice Sbrana (CNR), Maria Lazarina *(AUTH),* Rocco Paolillo (CNR), Athanassios Tsikliras (AUT), Evelina Carmen Sabatella (CNR)
Due Date	31-10-2025
Submission Date	31-10-2025
Dissemination Level	Public
Type of Deliverable	Report

Version	Summary of Changes
Version 0	01-10-2025 - version sent to reviewers
Version 1	24-10-2025 – version after the revision

SUMMARY

The SURIMI project aims at developing an integrated framework for marine socio-ecological modelling, grounded in high-quality secondary data and FAIR (Findable, Accessible, Interoperable, Reusable) principles. The SURIMI project emphasizes the integration of socio-economic, environmental, and ecological datasets into a cohesive framework to support decision-making processes and facilitate the European Digital Twin of the Ocean.

A key element of this framework is the SURIMI Data Lake, which provides a single, harmonised access point for the datasets required across the project. The project prioritises the use of secondary data from external repositories through a systematic scoping exercise to identify relevant data sources and assess their quality and completeness. The Data Lake integrates fisheries landings, CPUE estimates, stock assessments, biological and ecological traits and socio-economic data sourced mainly from the EU Data Collection Framework (DCF) and complementary repositories. All acquired datasets are managed according to the SURIMI Data Management and Exploitation Plan (DMEP) and stored in a centralised SURIMI data lake for streamlined use in assessments, models and e-tools.

Within Work Package 2 (WP2), the project focuses on data scoping, acquisition, harmonisation, and the development of socio-economic and ecological indicators to support modelling efforts in WP3, as well as the development of visualisation tools in WP4. Special attention is paid to ensuring coherence in spatial and temporal resolution, as well as to enabling the interoperability of socio-economic and environmental datasets and the reusability of the formulated protocol with other datasets. The integration of these datasets and methodologies within the SURIMI framework enables the project to advance marine ecosystem modelling by tackling long-standing interoperability challenges of combining datasets that differ in resolution and structure, from fine-grained biological and environmental observations to highly aggregated economic statistics. To reconcile these discrepancies, new disaggregation protocols are tested to realign data. The practical application of these methods is demonstrated through two contrasting case studies in the Western Mediterranean: one characterised by comprehensive data availability and another one where data gaps required model-based integration of AIS and DCF/AER information. The results include detailed maps of landings and values, port-level species price estimates, and temporal analyses of price variability by gear and vessel type.

Overall, deliverable D2.1 establishes the methodological basis for the SURIMI modelling suite within the European Digital Twin of the Ocean, offering a scalable approach to data integration that strengthens the analytical capacity for sustainable and adaptive marine governance.

CONTENTS

LIST OF ACRONYMS

Acronyms	Meaning
AER	Annual Economic Report on the EU Fishing Fleet
AIS	Automatic Identification System
ANN	Artificial Neural Network
ASFIS	Aquatic Sciences and Fisheries Information System
CMSY	Catch-MSY (Maximum Sustainable Yield)
CPUE	Catch Per Unit Effort
CSPUL	Crew Share Per Unit of Landing
DAS	Days-at-Sea
DCF	Data Collection Framework for the collection and management of fisheries data
DTO	Digital Twin of the Ocean
DTS	Demersal trawl and demersal seiner
EAFM	Ecosystem Approach to Fisheries Management
EMODnet	European Marine Observation and Data Network
FAO	Food and Agriculture Organization
FDI	Fisheries Dependent Information
FLBEIA	Fisheries Library for Bio-Economic Impact Assessment
GFW	Global Fishing Watch
GSA	Geographical Sub-Area within the Mediterranean and Black Seas
GT	Gross Tonnage
GVA	Gross Value Added
GVL	Gross Value of Landings
ICES	International Council for the Exploration of the Sea
INSPIRE	Infrastructure for Spatial Information in Europe
LOA	Length Overall (maximum length of a vessel's hull)
MAP	Multi-Annual management Plan
MMSI	Maritime Mobile Service Identifier
NLP	Natural Language Processing
OGC	Open Geospatial Consortium
OTB	Bottom Otter Trawler
PS	Purse Seiner
PTM	Midwater Pair Trawler
RCG_Econ	Regional Coordination Group on the collection of economic fisheries data
STECF	Scientific, Technical and Economic Committee for Fisheries
TAC	Total Allowable Catch
TBB	Rapido Beam Trawler
VMS	Vessel Monitoring System

INTRODUCTION

The SURIMI project seeks to transform marine ecosystem management by establishing a comprehensive and interoperable data infrastructure. The SURIMI framework addresses persistent challenges in ecosystem-based fisheries management by enabling high-resolution socio-economic modelling, bridging disciplinary data, and supporting evidence-based decision-making under conditions of climate variability. By integrating diverse datasets and developing scalable protocols, SURIMI aims at establishing a new benchmark for marine socio-ecological data curation and modelling, contributing to more informed, comparable, and sustainable ocean management.

Deliverable D2.1 presents the analytical framework for curating marine socio-ecological data, with a focus on harmonising diverse datasets, integrating multiple sources, and developing methodological protocols that connect socio-economic and environmental information. This report is a key component of Work Package 2 (WP2), which underpins the data acquisition, standardisation, and indicator development necessary to support modelling efforts in WP3 and visualisation tools in WP4. It builds upon insights from previous EU-funded projects.

At the heart of the framework is the SURIMI Data Lake, a centralised repository designed to host curated datasets including fisheries landings, catch-per-unit-effort (CPUE) estimates, biological traits, ICES stock assessments and socio-economic data, primarily sourced from the EU Data Collection Framework (DCF). Harmonisation of taxonomic and spatial references ensures consistency across modelling platforms and decision-support tools. A major challenge addressed in the report is the disparity in data granularity. The majority of biological, ecological and socio-economic datasets were retrieved from external repositories, bibliographic sources, and previous studies and required a, systematic scoping, quality assessment and harmonisation (Task 2.2). These datasets are fully documented in D2.2 (SURIMI DATA LAKE: Collection of all datasets produced with a single point of entry for all SURIMI models).

Biological and environmental datasets are typically fine-grained, while fisheries effort or landing data are often aggregated to a 0.05-degree square cell grid or vessel monitoring system (VMS) tracks. Socio-economic data, on the other hand, are aggregated at coarser levels, such as fleet segments or EU Member States. In addition, mismatch in observation units, particularly between fleet segments[1] and métiers[2], complicates integration. To overcome this issue, the report examined both existing and newly developed methodological disaggregation protocols in order to better align economic and ecological data at the individual vessel level.

Section 2.2 outlines established procedures such as the SECFISH protocol, which disaggregates economic data from fleet segments to métiers using vessel-level correlations. Additional

---

[1] fleet segment: group of vessels with the same length class (LOA, length overall) and predominant fishing gear during a given calendar year (Commission Delegated Decision (EU) 2021/1167 establishing the multiannual Union programme for the collection and management of biological, environmental, technical and socioeconomic data in the fisheries and aquaculture sectors from 2022)

[2] métiers: a group of fishing activities targeting a similar species or assemblage of species, using similar gear, during the same period of the year and/or within the same area, and which are characterised by a similar exploitation pattern (Commission Delegated Decision (EU) 2021/1167)

protocols, such as those from STECF AER and SEAwise projects, provide spatially explicit economic indicators computed from AIS/VMS and logbook data. Section 3 introduces the SURIMI-PELS Protocol for Extracting Species Prices at Landing Ports. It combines EU DCF FDI landings data, the EU Fleet Register, AIS-based effort data from Global Fishing Watch and port information from EMODnet. The protocol enables allocation of landings and prices across ports and spatial cell grid based on vessel-level effort and proportional distribution. This new procedure could be extended to derive fisheries economic indicators at the level of individual vessels and cells by integrating multiple data sources through a structured disaggregation methodology. The application of these protocols is illustrated in two diametrically opposed scenarios in two FAO GSAs in the Western Mediterranean Sea. The FAO GSA6 (Northern Spain) case study presented a scenario where the input dataset is complete, and vessel data can be allocated directly across ports to determine landings and prices, allowing for straightforward mapping of species prices and fishing effort. In contrast, the FAO GSA9 (Northern Tyrrhenian Sea) case study addressed data gaps by relying on AIS data from Global Fishing Watch and merging FDI and AER datasets to estimate Gross Value of Landings (GVL) at the vessel level. This approach enables the generation of port-level species prices through weighted allocation methods. The outputs of the procedures included port-level species prices, time-series data on price trends by gear type and vessel length and spatial maps of landings volume and value. These results and the protocol developed are aimed at supporting simulation models and scenarios testing within the European Digital Twin of the Ocean, offering a powerful tool for adaptive marine governance.

1. THE SURIMI DATA LAKE: DATASET INVENTORY

The SURIMI Data Lake serves as the project's main repository, integrating all curated datasets produced under Work Package 2. It provides a unified access point where marine socio-ecological information is stored in a standardised and harmonised format. Every dataset is accompanied by a metadata file that details its origin, spatial and temporal coverage, processing steps, structure (including a brief description of variables), and the validation procedures applied, in full alignment with FAIR principles. A description of the SURIMI Data Lake is presented in D2.2 (SURIMI DATA LAKE: Collection of all datasets produced with a single point of entry for all SURIMI models), that reports the collection and preparation of datasets retrieved from external repositories, bibliographic sources and previous studies within WP2 Data fit-for-purpose (Task 2.1 Data Scoping, Inventory and Acquisition and Task 2.2 Standardization, Harmonization, and Preparation).

At present, the SURIMI data lake consists of fisheries landings data (Mediterranean and Black Sea, FAO Area 37; North Sea, FAO Area 27), catch-per-unit-effort (CPUE) estimates derived from MEDITS bottom trawl surveys (FAO Area 37) and DATRAS surveys (FAO Area 27); trait-based biological and ecological information for fishes from FishBase and for marine invertebrates from SeaLifeBase; ICES stock assessment data, and raw trawl survey data; CPUE-related tables (North Sea and Baltic Sea); spatial landings and effort data from the EU DCF Fisheries Dependent Information (FDI) (for all the EU member states); the OECD Fisheries Support Estimate (FSE) (OECD, 2024); and the economic and social data from EU DCF by fleet segment and for EU member states.

To ensure consistency across datasets stored in the SURIMI Data Lake, both taxonomic and spatial information were harmonised (see D2.2 for a detailed description). These harmonisation procedures underpin consistency and interoperability within the SURIMI Data Lake, forming a reliable basis for the modelling framework developed in WP3 and the visualisation tools implemented in WP4.

2. METHODOLOGICAL PROTOCOLS TO CONNECT SOCIO-ECONOMIC DATA WITH ENVIROMENTAL DATA

In recent decades, the growing complexity of marine ecosystems, the multifaceted impacts of fishing activities and the broader environmental and economic pressures have revealed the limits of siloed approaches to fisheries science and management. Traditional assessments, often conducted in isolation - biological, environmental, or economic - are increasingly insufficient for addressing the interdependencies that characterise marine socio-ecological systems. Bridging the gap between socio-economic data and environmental information is no longer a theoretical ambition but a concrete requirement to support evidence-based decision-making and to promote sustainable, adaptive fisheries governance.

Efforts to develop methodological protocols that connect socio-economic indicators with environmental data represent a critical step in building integrated models capable of capturing the full complexity of marine resource use. Such protocols are essential not only for informing trade-off analyses and scenario modelling but also for enhancing transparency, reproducibility, and interoperability across scientific disciplines and institutional mandates. They also provide a basis for the development of operational tools that can inform both short-term management advice and long-term strategic planning, particularly in contexts of climate variability and global change.

The integration of socio-economic and ecological dimensions of fisheries is at the heart of ecosystem-based fisheries management (EBFM). Initiatives such as the NOAA Human Dimensions Integrated Ecosystem-Based Fishery Management Research Strategy (2021–2025) underscore this need, outlining a structured plan to integrate social and economic science into climate-informed stock assessments and decision-making processes (NOAA, 2021). The Ecosystem and Socioeconomic Profile (ESP) developed by NOAA Fisheries provides a concrete operational tool in this context: it offers standardised templates and workflows to harmonise ecological drivers and socio-economic responses, ensuring that management advice accounts not only for biological stock status but also for the economic viability of fleets and the resilience of coastal communities (Levin et al., 2018; Koehn et al., 2022).

From the European perspective, the challenge of integration is compounded by the heterogeneity of national data collection systems and the fragmentation of data governance. The European Data Collection Framework (DCF), established in 2001 and progressively revised (European Union, 2017a), has made significant strides in aligning biological and economic data collection (Dorner et al., 2018). However, methodological incompatibilities and gaps in coverage remain.

One of the primary motivations for integrating socio-economic and environmental data is to address the multifaceted objectives inherent in fisheries management. The ICES WKTRADE4 workshop (ICES, 2024) provided critical insights into these trade-offs by analysing how varying levels of fishing pressure affect both seafloor integrity and economic performance. By quantifying relationships between landings, profitability and ecosystem degradation, the workshop demonstrated the importance of robust, spatially explicit metrics and the integration of socio-economic and ecological datasets to support equitable and ecologically sound policy decisions.

Methodological tools and protocols must go beyond static indicators to account for cumulative impacts, adaptive responses and feedback mechanisms. In this context, Sala et al. (2022) provided a detailed analysis of energy efficiency and the carbon footprint of trawl fisheries, directly linking vessel operations with environmental outcomes and economic costs. Similarly, Hilborn et al. (2020) illustrated the global variability in the ecological and economic trade-offs of fishing strategies, underscoring the need for flexible protocols capable of scaling across diverse contexts. These studies point to the importance of integrating high-resolution operational data, such as fuel consumption records, logbook-based spatial fishing effort and energy audits, into bioeconomic models and carbon accounting systems.

Despite these advancements, significant challenges remain in achieving full integration of socio-economic and environmental data. Barriers include persistent data inconsistency, lack of harmonised definitions, limited access to micro-level (fleet- or household-level) socio-economic data and the underrepresentation of economic expertise in scientific advisory bodies. Overcoming these limitations requires institutional reforms that foster interdisciplinary collaboration, ensure long-term stewardship of socio-economic and ecological data, and systematically integrate socio-economic considerations into advisory and governance processes. Complementing these reforms, SURIMI focuses on technical solutions, including the adoption of standardised protocols, interoperable data formats, and application programming interfaces (APIs), to enable seamless integration of economic, social and environmental data within socio-ecological modelling frameworks.

Moreover, developing methodological protocols for data integration must address differences in scale (temporal and spatial), granularity and purpose. Linking high-resolution environmental observations (e.g., from remote sensing or in-situ oceanographic sensors) with low-resolution socio-economic surveys (e.g. aggregated at the gear and/or vessel length level) requires new statistical approaches and modelling techniques capable of managing uncertainty and heterogeneity.

Building on the frameworks, tools, and insights of European and international initiatives, SURIMI aims to provide generalizable methodologies that can be tested in case studies, directly connecting socio-economic and environmental datasets for selected socio-economic modelling applications. The following sections will therefore:

- Present existing technical protocols and their applications.
- Introduce the new SURIMI protocols and demonstrate their application in case studies.

2.1. CHALLENGES TO THE INTEGRATION OF SOCIO-ECONOMIC AND ENVIRONMENTAL DATA

2.1.1. UNIT OF OBSERVATION IN DATA COLLECTION

In the context of the EU Data Collection Framework (DCF), socio-economic and biological data are collected at two distinct but complementary levels, which creates both opportunities and challenges for integrated analyses.

Economic data are collected at the level of the fleet segment, defined as a group of fishing vessels that share the same length overall (LOA) class and predominant fishing gear during a given calendar year (Commission Delegated Decision (EU) 2021/1167). This segmentation scheme is well established and provides a consistent unit for socio-economic monitoring across Member States, facilitating the aggregation of cost, revenue, employment and investment data into categories meaningful for assessing fleet economic performance. Indicators such as profitability, productivity and socio-economic dependency on fisheries are produced at this level (STECF, 2024). However, the current segmentation method, based on technical vessel parameters (LOA and gear), lacks a direct link to fisheries or even fish stocks, which hinders its ability to provide guidance on sustainability and economic efficiency across individual fisheries (Sulanke, E. et al, 2025).

Biological data, by contrast, are collected at the level of the métier, defined as a group of fishing activities targeting similar species or assemblages of species, using similar gear, during the same period of the year and/or within the same area and characterised by a similar exploitation pattern (Commission Delegated Decision (EU) 2021/1167). The métier-based approach is essential for capturing ecological dynamics, including stock composition, distribution of fishing effort, and the impacts on the ecosystem (ICES, 2019a).

This dual system reflects the different nature of the information required: socio-economic data must describe the economic behaviour and structural characteristics of fleets, while biological data must capture the diversity of fishing practices and their ecological outcomes. Yet, the lack of direct alignment between fleet segments and métiers complicates the integration of economic and biological data, as a single fleet segment may operate across multiple métiers, and conversely, a métier may include vessels from different segments (Ulrich et al., 2012; Borges et al., 2016).

To improve this alignment, an innovative fleet segmentation approach based on multivariate statistics has been developed, designed to better reflect the actual activities of fishing fleets. By analysing catch composition with reference to specific stocks, this method generates fleet segments that are more homogeneous in terms of fisheries, catch profiles, and cost structures. To facilitate the segmentation procedure, a machine learning–based automation process using a random forest algorithm has been implemented. The approach was discussed in three dedicated workshops on alternative fleet segmentation under the Regional Coordination Group for DCF coordination (RCG_Econ, 2021; 2022; 2023), culminating in a scientific publication (Sulanke et al., 2025) and the development of an R package for fleet segmentation (https://github.com/ESulanke/FleetSegmentation).

The rationale behind this approach is that vessels with similar technical parameters are often active in different fisheries, targeting distinct stocks and displaying heterogeneous cost and revenue structures. A transferable and systematic multivariate framework, implemented in a user-friendly R package, was tested in specific fisheries to demonstrate its applicability (RCG_Econ, 2021; 2022; 2023). The clustering procedure produced fleet segments suitable for representing groups of vessels performing similar fisheries, thereby reducing the need for post-hoc allocation of economic data (e.g. proportional to landings or effort) and enabling a closer link between economic and biological information.

Four guiding principles were repeatedly emphasised when comparing segmentation approaches:

- Connection to specific fisheries (high priority)
- Cost structure (high priority)
- Feasibility (high priority)
- Compatibility (lower priority)

Compliance with the DCF segmentation dimension “Fishery” has thus far remained optional, hindered by the absence of a clear legal definition and limited practical implementation (STECF, 2023). The introduction of a new segmentation approach offers the potential to make the “Fishery” dimension more operational within fleet segment analysis. Incorporating this methodology into the DCF framework would improve the precision and relevance of segmentation, streamline the number of segments, and ultimately enhance the efficiency of fisheries management.

Developing methodologies that reconcile fleet-level economic information with métier-level biological data is a key step toward ecosystem-based fisheries management (EBFM), as SURIMI builds on. The EC study on ecosystem-based approaches in the Mediterranean and Black Seas (European Commission, 2022; Mangi et al., 2023) identified the main European commercial fisheries regulated by the CFP. To address the inherent complexity of the sector, these fisheries were grouped into homogeneous métiers based on catch composition and fishing grounds. The assessment drew on data already collected under the EU Data Collection Framework (DCF), complemented by national fleet information, with fisheries classified at the level of geographical subareas. Through this process, 334 fisheries relevant for the application of the Ecosystem Approach to Fisheries Management (EAFM) were identified (European Commission, 2022; Mangi et al., 2023): 156 in the North Sea, Baltic Sea and Western Atlantic, 107 in the Mediterranean and Black Seas, and 71 in the Outermost Regions. These groups of métiers are considered sufficiently homogeneous to be expected to exert comparable effects on ecosystems and their components and thus provide a practical unit for the application of management measures. The introduction of Multi-Annual management Plans (MAPs) under the CFP has further reinforced this approach.

In the SURIMI project, these identified fisheries may serve as key units for integrating socio-economic and ecological data into the DTO. By grouping fisheries with similar catch profiles and habitat use, this framework allows linking fleet data with environmental models, simulating policy scenarios (including MAPs) and evaluating trade-offs between ecological sustainability and socio-economic viability. Using fisheries as tangible observation units also provides a powerful tool for stakeholder engagement, enhancing the uptake of EAFM principles and making complex model outputs more accessible to decision-makers and sector stakeholders.

Beyond identification of fisheries, the methodological issue of the alignment between data at fleet segments and métiers levels has to be properly addressed. An algorithm developed with the SECFISH project (Thünen-Institute, 2019) that allows to derive annual cost data at métier resolution through a multivariate statistics algorithm is described in section 2.2 (existing protocols) and an additional procedure is reported in section 3 (new protocols).

2.1.2. DATA GRANULARITY

The spatial resolution of biological data and economic and social data reflects their distinct purposes and applications. Biological and environmental data are collected at a high spatial resolution. This fine-grained data is gathered at the level of geographical subareas, which are specific marine regions defined for scientific assessment purposes and usually linked to detailed geographic units within the EU's fisheries management. For instance, the EU WestMed MAP (Regulation (EU) 2019/1022) delineates geographical subareas to facilitate precise monitoring and management.

The collection of fisheries data is complemented by the Community Control System established under Regulation (EC) No 1224/2009, which ensures compliance with CFP rules. A key component of this system is the Vessel Monitoring System (VMS), which provides high-resolution spatial and temporal information on the position, course and speed of fishing vessels. VMS data is used to verify reported catches, monitor fishing effort and ensure adherence to area closures, quotas, and technical measures. By integrating VMS data with DCF datasets, researchers and practitioners can enhance the spatial and temporal accuracy of fisheries assessments and support the implementation of ecosystem-based management strategies. A standardised spatial reference for reporting both landings and fishing effort is operationalised through the use of spatial cell units. These cells enable consistent reporting of species-specific landings, total weight, value and fishing effort, even when fishing occurs across complex marine regions.

Finally, economic and social data are collected at a coarser spatial resolution, typically aggregated at higher administrative levels such as “supra-regions” or Member States.

To organise and present both fine and coarse-grained data effectively, the EU DCF employs a geographic hierarchy, structuring geographic units from large regions down to smaller ones (Table 2, Chapter III, Commission Implementing Decision (EU) 2021/1168). Each geographic unit is assigned a unique GEOID, ensuring the unambiguous identification of areas and facilitating accurate data tabulation, analysis, and mapping. GEOIDs are essential for linking biological, economic, and social datasets to their corresponding locations[3]. The data granularity scheme is reported in Table 1.

---

[3] https://dcf.ec.europa.eu/data-calls/definitions-and-terminology

Table 1- Data granularity of different EU fisheries datasets

Dataset	Purpose / Use	Spatial Resolution	Geographic Units	Notes / Standards
Biological Data	Stock assessment, ecosystem monitoring	Fine-grained (high resolution)	Geographical subareas	Includes biological parameters, catches at age/length, species-specific landings and discards
Environmental Data	Habitat mapping, environmental indicators	Fine-grained	Geographical subareas, spatial cell grid (0.5°×0.5°, 0.5°×1°, 1°×1°, 5°×5°), C-square notation	Aligned with biological sampling, supports ecosystem-based assessments
Fishing Effort Data	Effort monitoring, fleet management	Fine-grained (Gibin M., et al, 2024)	Geographical subareas, spatial cell grid (0.5°×0.5°, 0.5°×1°, 1°×1°, 5°×5°), C-square notation	Includes vessel, gear, mesh size, and métiers; linked to VMS for spatial accuracy
Landings Data	Catch monitoring	Fine-grained (Gibin M., et al, 2024)	Geographical subareas, spatial cell grid (0.5°×0.5°, 0.5°×1°, 1°×1°, 5°×5°), C-square notation	Species-specific landings and total value; includes trips for métiers selected for biological sampling
Economic Data	Socio-economic assessment, policy analysis	Coarse-grained	Supra-regions, Member States	Aggregated at a higher administrative level, linked to fleet activity and MAP implementation
Social Data	Employment, socio-economic impacts	Coarse-grained	Supra-regions, Member States	Aggregated data supports socio-economic planning; complements economic data
VMS Data	Compliance, spatial verification	Fine-grained, real-time	Vessel positions with lat/long; can be linked to cells or subareas	Used to verify landings and effort; supports CFP control (Regulation EC No 1224/2009)

SURIMI models rely on fine-grained data, often at the level of individual vessels (e.g. the POSEIDON model). To address the heterogeneous granularity of EU fisheries datasets, existing harmonisation protocols are outlined in Section 3.2, while Section 3.4 introduced an additional procedure featuring newly developed protocols within the project.

2.2. PRESENT EXISTING PROTOCOLS

2.2.1 ECONOMIC DATA DISAGGREGATION METHODS

The EU SEAwise project[4] tested alternative formulations and methodological approaches to strengthen the socio-economic dimension of bio-economic models used to predict the economic impacts of potential fisheries management strategies. These socio-economic model configurations are presented in the deliverable 2.2 (SEAwise report on Carbon footprint, economic and social impacts of management strategies, Bitetto, I. et al., 2023).

---

[4] https://seawiseproject.org/ , EU H20, Grant Agreement No: 101000318

Seven main socio-economic components are considered for bio-economic modelling in fisheries, as summarised in the following Table 2.

Table 2 - Overview of Socio-Economic Sub-Models for Bio-Economic Fisheries Modelling considered in SEAwise

Component	Model	Description	Reference
Fish Price: Nine types of models are used to simulate fish price dynamics, considering factors like landings, imports, product quality, and size	1	Price depends on relative changes in landings	Kell et al., 2016
	2	Price depends on quantity, mean size of landings, and imports	Modified from Lleonart et al., 2003
	3	Price depends on ratio of current to previous year's landings	Modified from Salz et al., 2011
	4	Price depends directly on current landings	–
	5	Constant price (average or last-year price)	–
	6	Base price adjusted by base landings and elasticity, can apply to all métiers or ages	Kraak et al., 2004
	7	Constant size-dependent prices	–
	8	Iso-elastic inverse demand function; price decreases with market supply	–
	9	Market price determined endogenously by supply, demand, stock size, and effort	–
Price Volatility	–	Modeled using GARCH to capture time-dependent variance in prices	Bollerslev, 1986
Variable Costs Five models for simulating the operational costs are here considered. Each model reflects the main hypothesis underlying the model	1	Fuel and other costs depend on fishing days; commercial costs depend on landings	–
	2	Fuel cost depend on fishing days and fuel price, commercial costs depend on revenues, other variable costs depend on fishing days and ice cost per fishing day	Lleonart et al., 2003
	3	Fuel costs depend on fishing days and fuel price; other costs depend on revenues	–
	4	Costs depend solely on fishing days	–
	5	Costs aggregated per unit of effort at metier level, accounting for effort-cost relationship	–
Labour Costs & Wages The definition of the labour costs function depends on the working contract in the specific fishery under analysis. Three sub-models are considered to simulate the labour costs	1	Labour costs depend on revenues minus variable costs (crew share system); can include landing obligation effects	Prellezo et al., 2010
	2	Labour costs directly proportional to revenues	Prellezo et al., 2010
	3	Labour costs computed as crew share per unit of landing (CSPUL) at fleet, metier, stock level; includes fixed and variable parts	Prellezo et al., 2010; FLBEIA

Fixed Costs Three models for simulating the fixed costs are considered	1	Costs depend on gross tonnage (GT), including maintenance and other fixed costs	–
	2	Costs split into essential and maintenance costs; maintenance divided into avoidable/unavoidable	Modified from Lleonart et al., 2003
	3	Costs depend on number of vessels, applied per vessel	Salz et al., 2011
Capital Costs (depreciation costs and interest or opportunity costs). Three models for simulating the capital costs are considered	1	Costs depend on annual GT; includes depreciation and opportunity costs	Modified from Lleonart et al., 2003
	2	Costs depend on capital value; depreciation replaces financial costs	Modified from Lleonart et al., 2003
	3	Costs depend on number of vessels, applied per vessel	Modified from Salz et al., 2011
Fleet Dynamics	–	Models the number of vessels, fishing effort, and adjustments to economic, regulatory, or stock conditions	–

Source: elaboration on Bitetto I., at al. 2023

Finally, three fleet dynamic sub-models are considered in SEAWISE to mimic the strategic behaviour of the fleets, namely, the investment and disinvestment dynamics (and their consequences on the fishing effort) as a response to changes in the profitability of the fishery. The information is reported in the following Table 3:

Table 3 - Summary of fleet dynamic sub-models considered in SEAwise

Sub-model / Tool	Scope & Resolution	Main Mechanism	Investment / Disinvestment Logic	Key Variables & Indicators	Notes
Capital Dynamics (FLBEIA, Garcia, D., et al, 2017)	Fleet-level, annual	Models changes in fleet capacity and catchability via investment/disinvestment in vessels and technology	Driven by profitability relative to **Break-Even Revenue (BER)**. Investment occurs if existing capacity is fully utilised. Disinvestment occurs when revenues fall below BER.	Landings (L), Prices (P), BER, profits, number of vessels, catchability, capacity	Two options: (1) **Fixed Capital**: capacity/catchability fixed inputs; (2) **Simple Capital Dynamics (SCD)**: only capacity updated via economic indicators.
Effort Dynamics (FLBEIA, Garcia, D., et al, 2017)	Fleet and métier level, seasonal within annual resolution	Allocation of fishing effort across métiers to maximize profit under biological and regulatory constraints	Profit-maximization subject to: (i) fleet capacity, (ii) stock TACs, (iii) historical effort allocation bounds.	Effort (E), Effort share (γ), Landings (L), Prices (P), Variable & fixed costs (TVC, TFC),	Introduces seasonality in multispecies fisheries. Suitable for weak or strong seasonal patterns.

				Vessels (V), Capacity (κ), TAC share (QS)	
Bee-Fish	Baltic trawl fleet, single fleet focus	Estimates optimal effort for given objectives	Effort dynamics reflected indirectly: lower optimal effort → fleet contraction; higher → expansion	Fishing effort as a proxy for capacity	Simplified approach; fleet reaction is delayed.
BEMTOOL	Fleet-segment level, annual	Behavioural dynamics of vessels, fishing days, and technology	Vessel numbers, days at sea, and technology adjusted based on the previous year's profitability (vs. BER). Investment/disinvestment is bounded by lower/upper limits.	Revenues (R), BER, vessels (V), fishing days, profit share for investment (p), and technological progress	Behavioral module adapted from Salz et al. (2011). Independent dynamics for vessels and fishing days.

Source: elaboration on Bitetto I., at al. 2023

The performance of the alternative price models can be measured in terms of Root Mean Square Error (RMSE) (Kell et al., 2016).

These sub-models are proposed to produce more realistic fleet performance projections by adopting more flexible sub-models, which move beyond the common assumptions of fixed fuel costs and fixed fish prices. However, most bioeconomic mixed fisheries models present in the literature require the disaggregation of the fleet segments by fishing activity at the metier level.

The SECFISH project (Thünen-Institute, 2019) developed a procedure for disaggregating economic data, particularly variable costs, from the fleet segment to the métier level. Developed within the context of the European Data Collection Framework and validated through case studies on the Italian fleet, this procedure enabled taking into account the difference in variable costs associated with the activity of each metier as well as the difference in the labour costs as depending on the revenues and, thus, indirectly by the metier (Bitetto I. et al, 2022). The procedure applied a two-step statistical model. The first phase involved deriving correlations between variable costs (such as fuel and labour) and transversal variables (like effort and landings) using individual vessel data. In the second phase, these relationships were applied to aggregated fleet segment data to estimate costs at métier resolution.

An additional application of the procedure (ICES, 2019b) demonstrated how the overall costs of fishing activities are influenced by fishing grounds. In particular, the application of the procedure to the Belgian fleet revealed a distinct structure of variable costs, which varied according to the area exploited, particularly in terms of fuel costs. Therefore, this methodology allowed not only to highlight the dependency of the variable costs on the type of metier utilised, but also on the fishing grounds most commonly visited. Indeed, the integration of the fuel cost structure, linked to the fishing area, might allow for designing spatial management measures through bioeconomic modelling. A significant limitation of this procedure is that access to individual vessel data is required to apply the method. However, some assumptions based on literature or expert knowledge can be used as alternatives (ICES, 2024).

The SECFISH methodology is fully implemented in an R package, available via CRAN, and is openly accessible to users (SECFISH on CRAN). The procedure is well-documented in Bitetto et al. (2022), making it both replicable and scalable for broader application within European fisheries.

2.2.2 FUEL AND ENERGY COSTS

Fuel and energy costs are a critical, yet often underappreciated, factor in fisheries management, affecting profitability and livelihoods due to their sensitivity to catch rates, sale prices, and the level of effort (FAO, 2015). Fuel costs account for a significant share of total operating costs in the fisheries sector, amounting to EUR 1.4 billion, or 24% of total costs (STECF, 2024). This makes fuel the second-largest cost component after labour (33% of total costs: EUR 2 billion in personnel costs and EUR 216 million in unpaid labour), and larger than other variable costs (14% of total costs: EUR 865 million) (STECF, 2024). Energy costs have increased sharply as a share of revenue, from 13.4% in 2020 to nearly 24% in 2022, returning to levels comparable to those observed in 2013 (STECF, 2024). This highlights the growing impact of fuel prices on fleet profitability and the economic sustainability of fishing operations.

In the absence of standardised approaches, practical methods have been developed to estimate fuel costs at both local and global scales, differentiating by gear type and fishing effort, and validated with specific data sources.

Sala et al. (2022) conducted energy audits on a test fleet representing three typical Mediterranean trawl fisheries (midwater pair trawl, bottom otter trawl, and Rapido beam trawl) demonstrating that fuel consumption rates vary widely with gear type and vessel size. To obtain fisheries-specific fuel use estimates, datasets combining energy audits and high-resolution logbook information were used to model daily fuel consumption as a function of vessel length overall (LOA). This LOA-based theoretical fuel use model was then scaled to estimate daily fuel consumption across the national fleet and its segments.

Using the parameters published in Sala et al. (2022), the model can estimate mean hourly fuel consumption for each fishery or vessel. The model has been used to infer specific fuel consumption per fishing day, including steaming and towing, for each fishery and vessel segment (ICES, 2024). Importantly, the Sala model can be adapted to estimate fuel costs and consumption at the level of individual vessels per day, or aggregated at any level required for SURIMI models, providing flexibility for scenario analysis and integration into socio-ecological modelling frameworks.

Regression models developed by Sala et al. (2022), summarised in Table 4, link daily fuel consumption (dFC [l/day]) to vessel length (LOA [m]) for single-boat bottom otter trawlers (OTB), midwater pair trawlers (PTM), and Rapido beam trawlers (TBB). The general model takes the form:

$$FC[l/day] = q \times LOA^{m}$$

Table 4 - Daily Consumption (dFC) by Vessel Type

Parameter	***OTB***	***PTM***	***TBB***
Slope (m)	*1.470*	*1.196*	*1.838*
Intercept (q)	*12.811*	*22.104*	*5.973*
F-value (F)	*158.1*	*475.7*	*666.6*
Degrees of Freedom	*19*	*23*	*7*
R-squared (R^2)	*0.893*	*0.954*	*0.990*

Linear regression models to infer daily-fuel consumption, dFC[l/day], from the vessel length overall covariate, LOA[m]. The theoretical LOA-based fuel use models respond to the relationships between daily fuel consumption and vessel length overall (LOA). The model coefficient estimates and summary statistics are reported for single-boat bottom otter trawlers (OTB), midwater pair trawlers (PTM), and Rapido beam trawlers (TBB). General linear model: FC[l/day] = q × LOA^m. Modified and adapted from Sala et al. (2022).

These LOA-based models may provide robust estimates of fuel consumption across fleet segments and can be directly integrated into the SURIMI framework to assess energy costs under varying fleet compositions, fishing efforts, and management scenarios. Importantly, since the model has been tested on Mediterranean fisheries, its application is directly relevant and validated for the region. The study by Sala et al. (2022) included a comparison of fuel use intensity (FUI) and carbon footprint with international fisheries. The indicators estimated for Mediterranean trawl fisheries were broadly consistent with values reported in the literature. Table 10 in Sala et al. (2022) summarises these comparative figures. In general, the relationships observed in Italian trawl fisheries between FUI, target species and gear type reflect patterns previously documented in other regions, underscoring both the robustness of the methodology and the specific application of the model and its parameters in the Mediterranean context.

2.2.3 DISAGGREGATION OF ECONOMIC DATA AT A SPATIAL SCALE

The EU SeaWise project has developed a practical framework for predicting the short-term economic impacts of spatial management measures such as marine protected areas or gear restrictions (Bastardie et al., 2023). This approach relies on combining spatial fishing effort data with economic indicators from the STECF AER database, disaggregating gross value added (GVA) and other economic indicator metrics across fishable zones based on both ecological and operational constraints (e.g. gear type). The project has implemented a method to simulate the redistribution of fishing effort and related economic outputs under different closure scenarios. A merging procedure has been developed to transfer the spatial information to the AER by arranging the link between the two datasets using a shared key (the fleet segment) defined as the combination of a country, fishing technique and vessel size category. A dedicated open-source tool, the FishSpatOverlayTool, was developed and is publicly available on GitHub[5]. This tool enables users to overlay spatial regulatory scenarios with economic fleet data, offering a

---

[5] Open-source tool: FishSpatOverlayTool on GitHub

decision-support instrument for policy-makers and researchers interested in spatial planning and fisheries economics.

The STECF AER regional data disaggregation approach addresses the challenge of high aggregation in EU fisheries economic data by redistributing variables such as costs and income to more detailed spatial units, such as sea basins. Fleet economic data cannot be collected at higher resolution than defined in the DCF. Only landings (value and weight) and effort data (days-at-sea, fishing days, etc.) are provided by MS at the subregion level by fleet segment. Therefore, protocols for the disaggregation of economic data are implemented at the sea basin level (Baltic Sea, North Sea, NE Atlantic, Mediterranean & Black Sea and Other Fishing Regions). The method relies primarily on effort-based proxies, especially days-at-sea and the value of landings, to estimate the distribution of vessels, costs, and employment across regions. While no dedicated software or package is currently publicly available, the methodology is described in the STECF reports (STECF, 2024, annex 3 Disaggregation of Economic Data at Sea Basin Level). In the STECF report, it is specified that the methodology has not yet been fully validated; therefore, it should be considered a "preliminary analysis" aimed at estimating economic performance indicators at the sea basin level by Member State (MS) and fleet segment. For this purpose, transversal and economic data by fleet segment are allocated using one of three criteria: the number of active vessels, the value of landings, or fishing effort (days-at-sea, DAS), as follows:

- Number of vessels in the region (NReg) – employed to estimate fleet capacity, fixed costs, and capital costs (including annual depreciation and the opportunity cost of capital).
- Value of landings (VaL) – used to distribute income derived from landings.
- Effort in days-at-sea (DAS) – applied to allocate all variable costs, such as labour, fuel, energy, and repair & maintenance. DAS was also used to infer the number of vessels when NReg data were unavailable.

The disaggregation logic is embedded in scripts used internally by ICES expert groups, and the STECF fleet economic data can be accessed via the European Commission's dissemination tools[6].

In the ABIOMMED project[7], a high-resolution, spatially explicit methodology was applied to assess the economic and ecological impacts of management measures, such as spatial closures, on Mediterranean bottom trawl fisheries. The analysis relied on combining AIS/VMS and logbook data at the individual vessel level, allowing for estimation of Landing-per-Unit-of-Effort (LPUE) by species, vessel, and spatial cells. The SMART model (Spatially-explicit Model for the Assessment of trawl Revenues and Technologies) (Russo T., et al., 2014) was used to integrate

---

[6] See STECF dissemination tools and ICES WKTRADE4 report (https://doi.org/10.17895/ices.pub.25288936)

[7] ABIOMMED – "SUPPORT COHERENT AND COORDINATED ASSESSMENT OF BIODIVERSITY AND MEASURES ACROSS MEDITERRANEAN FOR THE NEXT 6-YEAR CYCLE OF MSFD IMPLEMENTATION" is an EU research project funded under DG EN9/M6FD 2020 https://www.abiommed.eu/

LPUE data with price and effort data to estimate landings, revenues, and costs, leading to spatial estimates of Gross Value Added (GVA). The model also estimated fuel consumption using vessel-level parameters from existing literature (e.g., Sala et al., 2022). The entire methodology is implemented in an R package called smartR, available on CRAN (smartR), which provides a modular architecture for processing input data, estimating spatial productivity, and calculating disaggregated economic indicators. GitHub includes example data, overlay methods, and visualisations. This model has proven effective for simulating the effects of alternative spatial management scenarios. An Integrated analysis of VMS , AIS , and logbook data, Identification of the core fishing grounds. This methodological approach has been recently applied to explore spatial-based management scenarios for protecting the seafloor in various areas of the Mediterranean Sea (Sbrana et al., 2025).

Finally, the CABfishMan project[8] focuses specifically on Small-Scale Fisheries (SSF), which are often underrepresented in standard European datasets. The project developed a methodology to align socio-economic indicators, such as income and cost, with high-resolution spatial data on fishing effort. Using data from national sources and georeferenced SSF activity, the method assigns economic variables to a spatial cell grid, enabling a detailed spatial assessment of economic performance. While no R package or standardised tool has yet been published, the methodology is described in the WKTRADE4 (ICES, 2024) report and in internal project deliverables. It represents an innovative attempt to disaggregate SSF economic data with sufficient spatial precision to inform local and regional management, especially in data-limited contexts where SSF plays a critical role in coastal economies.

2.3. GAPS IN EXISTING PROTOCOLS AND CONTRIBUTION OF SURIMI

Existing protocols for socio-economic and spatial fisheries data provide valuable tools for modelling fleet dynamics, economic indicators, fuel and energy costs and spatial distribution of effort and landings. However, several limitations remain.

A first limitation concerns data aggregation. Most methodologies rely on fleet segment-level data or spatial cells, which constrains the precision of economic and ecological analyses since vessel-level resolution is often missing. For instance, some protocols developed in SEAwise and SECFISH focus on the fleet segment or metier-level economic modelling, while other protocols, like the one applied in the ABIOMMED project, provide vessel-level information but only for limited case studies or fleets.

Another issue is the limited interoperability of existing approaches. Socio-economic, biological, and spatial datasets are often processed separately, with no unified protocol for integration, which reduces the potential to conduct fully integrated socio-ecological assessments. For example, Sala et al. (2022) model fuel consumption and economic indicators, but integration with biological data remains limited.

---

[8] https://www.cabfishman.net/, funded by the European Union through the INTERREG Atlantic Area program and the European Regional Development Fund (ERDF)

A third weakness lies in the restricted spatial resolution of disaggregation methods. These typically use proxies such as days-at-sea, vessel counts or landing values to allocate economic data across regions, a practice that may introduce uncertainty in spatial analyses. The STECF AER, for instance, relies on effort or landings proxies to allocate costs and income to sea basins, while SECFISH applies a two-step statistical method for metier-level disaggregation but requires access to individual vessel data.

Accessibility also represents a limitation. Many tools are not standardised or easily replicable, which reduces transparency and hinders reuse across EU fisheries. Finally, many protocols remain only partial automated. Procedures often involve manual steps or ad hoc integration of multiple datasets, which limits scalability and reproducibility for scenario analysis. SEAwise bio-economic models, for instance, require multiple sub-models and manual calibration of fleet dynamics, while ABIOMMED and Sala et al. rely on separate tools for fuel and cost estimation that must be manually merged for comprehensive analysis.

The SURIMI project addresses these limitations by providing a fully integrated, scalable, and replicable framework for vessel-level socio-economic and ecological data analysis. Specifically, SURIMI achives vessel- and port-level resolution by integrating diverse sources, including FDI, AER, the Fleet Register, EMODnet, and GFW datasets. Building on this foundation, it implements a generalizable disaggregation protocol (SURIMI-PELS) applicable to multiple economic indicators, including species prices, thereby increasing the accuracy and consistency of socio-economic assessments. At the same time, the framework ensures full interoperability across socio-economic, biological, and spatial data, making it fully compatible with the EU Digital Twin Ocean and facilitating integration into broader socio-ecological models. An additional strength is its commitment to openness: SURIMI-PELS delivers an open-source tool supported by documented workflows, which enhance reproducibility and scalability for different analytical contexts.

3. SURIMI PROTOCOLS

The EU Horizon SURIMI project aims to deliver a suite of ready-to-use socio-economic and ecological simulation models that are integrated into the EU Digital Twin Ocean. These models leverage a wide range of EU fishery activity data, including datasets from the Fisheries Data Collection Framework (DCF), to support evidence-based policy and sustainable management of marine resources. However, as described in previous sections, most data are generally collected in an aggregated form, which limits their spatial resolution and applicability to the fine-scale assessment and simulation of vessel behaviour. For these reasons, one of the objectives of the SURIMI project is to develop a set of algorithms that disaggregate the socio-economic dataset at a finer spatial and technical level, or even at the level of individual fishing vessels, utilising public data and online resources.

The Protocol for Extracting Species Prices at Landing Ports (SURIMI-PELS) presents a methodological framework for estimating fisheries economic indicators at the resolution of individual vessels and spatial cell grid. This approach integrates multiple data sources through a structured disaggregation process, enabling fine-scale economic analysis across heterogeneous datasets.

3.1 DATA SOURCES

3.1.1 SURIMI DATA LAKE

The input data used in the SURIMI protocols are extracted from the SURIMI data lake, which includes datasets retrieved from public repositories that are accompanied by a metadata file that describes their source (spatial and temporal coverage), processing steps and structure (with a concise description of the variables). Among the different datasets, those derived from the EU DCF Fisheries Dependent Information (FDI) and Annual Economic Report (AER) represent the milestones for the proper implementation of the procedure. FDI and AER are two essential components of the European Union’s data collection and policy-making framework for sustainable fisheries management. Together, FDI and AER provide a comprehensive, evidence-based foundation for managing EU fisheries in a sustainable manner.

Fisheries Dependent Information (FDI) refers to data collected directly from commercial fishing activities. This includes catch data, effort data (e.g., hours at sea, gear type), discards and economic information such as fleet structure and gross value of landings. FDI is gathered through logbooks, on-board observer programs, port sampling and surveys of fishers and fleets. The spatial data included in the FDI database employs a methodology to visualise and disseminate the results that standardises all the data using a c-squares global grid with a resolution of 0.5 x 0.5 degrees. The corresponding landings weight, landings value and fishing effort are also allocated proportionally. The allocation of effort and landings is conducted in accordance with a proportional distribution approach, whereby the total values are allocated equally among the constituent 0.5x0.5 c-squares.

The 2025 Annual Economic Report (AER) on the European Union (EU) fishing fleet provides a comprehensive overview of the latest information available on the structure and economic performance of EU Member State fishing fleets (STECF, 2024). This report covers the period 2008 to 2022 and includes information on the EU fleet’s fishing capacity, effort, employment, landings, income and costs.

3.1.2 OTHER DATASETS USED IN THE PROCEDURE

In addition to datasets retrieved from the internal data lake, the procedure handles additional sources of information (Table 6).

The **EU Fleet Register** is a database provided and managed by the Directorate-General for Maritime Affairs and Fisheries (DG MARE), in which all EU fishing vessels must be registered. The aim of the Fleet Register is to ensure the identification of EU fishing vessels as a reference database to monitor and control fishing fleets. The register contains all descriptive information on individual vessels, such as vessel name, Maritime Mobile Service Identifier (MMSI), vessel length, port of registration, tonnage, power, gear, and other relevant characteristics.

The Fishing Fleet Register is maintained by the European Commission, which collects and consolidates data transmitted by Member States from their national fleet registers. Member States are responsible for maintaining accurate and up-to-date information on their vessels and submitting any updates, changes, or events to the Commission, which then validates and records them in the Union register.

The legal basis for the EU Fleet Register is provided by Regulation (EU) 2017/218 of the Commission of 6 February 2017 on the fishing fleet register (European Union, 2017b). This regulation establishes the obligations of the Commission to maintain the register, defines the responsibilities of Member States to collect and transmit data, sets out the minimum data requirements, and regulates access to the register, including a public version with limited information (European Commission, 2025; Regulation (EU) 2017/218, Articles 1, 2(o), 6, 10).

The European Marine Observation and Data Network (EMODnet) is the European Commission (EC) in situ marine data service of the EC Directorate-General Maritime Affairs and Fisheries (EC DG MARE) and funded by the European Maritime Fisheries and Aquaculture Fund. Established in 2009, EMODnet plays a pivotal role as a trusted source of in situ marine environmental and human activities data and data products, serving a diverse user base across various sectors.

The EMODnetPortal covers seven disciplinary themes – bathymetry, geology, physics, chemistry, biology, seabed habitats and human activities. In particular, the main objective of EMODnet Human Activities is to make available information on the geographical position, spatial extent and attributes of a wide array of marine and maritime human activities throughout Europe.

The EMODnet dataset on maritime transport of goods, passengers and vessels in the European main ports was created in 2014 by Eurofish and Cogea for the European Marine Observation and Data Network (EMODnet). The dataset is the result of the harmonisation and aggregation on an annual basis of the quarterly Eurostat Maritime transport data, provided by ports in the EU Member States, Montenegro, Norway, Turkey and the UK. Eurostat data have been associated to the 'Ports 2013' EUROSTAT GISCO's points georeferenced dataset, when available, or to the ports locations coming from other sources, such as UN/LOCODE, Lloyd’s List, Marine Traffic, VESSEL TRACKER and ports' authorities. Vessel traffic data are reported in units and gross tonnage (thousands) of vessels by vessel size class and vessel type. Where available, the latest update includes data from 1997 up to 2024.

The information provided through the portal is collated from a variety of sources, harmonised and made interoperable. Data are free and free of any restrictions. The portal (currently) offers access to several products, such as fisheries and main ports (Table 5).

Table 5 – Overview of Extracted EMODnet Products

Category	**Spatial Type**	**Attributes**
Fisheries Zones	Polygons	ICES and FAO nomenclature
Fish Catches	Polygons	Tonnes live weight
Fishing Effort	Polygons	Country, Fishing days, Days at sea, GT fishing days, KW fishing days

Fishing Intensity	Polygons	Avg. MW fishing hours, Avg. surface swept area ratio, Avg. subsurface ratio
Fish Sales	Points	Value, Volume, Price
Main Ports	Points	Traffic

Source: elaboration from https://emodnet.ec.europa.eu/en/human-activities

The **Global Fishing Watch** (GFW) is an online public platform that allows users to visualise and analyse fishing activity at sea. The platform utilises the Automatic Identification System (AIS) to analyse the movement of vessels at sea. AIS (Automatic Identification System) provides vessel location data, and GFW (Global Fishing Watch) uses this information to track global vessel movement and apply algorithms to classify vessel behaviour as either "fishing" or "non-fishing" activities, using a convolutional neural network model. A fishing detection algorithm is thus employed in order to identify "apparent fishing activity", as determined by alterations in vessel speed and direction. Users can search for vessels, filter activity by flag state or time period, and identify the port visited. Despite the comparative limitation of AIS's application in the monitoring of fishing activity at sea when compared to VMS, *the Global Atlas of AIS-based fishing activity* (Taconet, M., Kroodsma, D., & Fernandes, J.A. 2019) has demonstrated its potential in this field and is used when more detailed information is missing.

Indeed, when spatially explicit data on fishing activity are required but no direct sources are accessible, Global Fishing Watch (GFW) represents a crucial resource. In the European Union, individual vessel-level data from logbooks and the Vessel Monitoring System (VMS) are not publicly available due to confidentiality and commercial sensitivity, as established under Regulation (EC) No 1224/2009 (EU Control Regulation). While aggregated data are made available through sources such as the STECF FDI and the ICES Regional Database and Estimation System (RDBES), these datasets are spatially coarse, typically reported at the scale of spatial cells, and lack information on individual vessels. Moreover, access to certain datasets is explicitly restricted under the ICES Data Policy, which excludes sensitive commercial catch and effort data, VMS and logbook data, as well as locations of Vulnerable Marine Ecosystems (VMEs), (ICES, 2021). These restrictions limit the availability of high-resolution spatial and temporal data necessary for detailed analyses of fishing effort and fleet behavior. In this context, GFW provides an open-access alternative, offering vessel-tracking information derived from AIS signals that allows for near-real-time mapping of fishing activity while respecting the confidentiality constraints imposed by EU regulations and ICES policies. Consequently, GFW is widely used in research and monitoring efforts where no other spatially explicit data are available, enabling comprehensive analyses of fishing effort patterns, ecosystem impacts, and management effectiveness without compromising the protection of sensitive vessel-level information.

Table 6 – Data needed for the disaggregation procedure

Data	Description
Surimi data lake - FDI effort and landing	Effort and landing data divided by year, country, GSA, gear, vessel length and cell grid. The geographical reference, expressed as cell grid longitude-latitude coordinates, is provided in the shapefiles.
Economic data - AER	Economic indicators by year, country, GSA, gear, and vessel length.
Individual vessel info - Fleet register	Descriptive information on individual vessels: vessel name, MMSI identifier, vessel length, port of registration, tonnage, power, gear, etc.
Main port info - EMODNET main ports for the European Seas	Main ports' locations data from 1997 to 2024
Species info - FAO ASFIS List of Species for Fisheries	The ASFIS (Aquatic Sciences and Fisheries Information System) list for fishery statistics represents the standard taxonomic reference system for the FAO Statistics Team.
Geographical FAO info - FAO Geographical Sub-Areas	FAO GFCM area of application, comprised of the Mediterranean and the Black Sea, as Major Fishing Area 37.

3.2 DESCRIPTION OF THE PROCEDURE

The SURIMI-PELS (SURIMI Port-level Extraction of Landed Species prices) protocol (Figure 1) was developed to derive species-specific prices over time at individual landing ports by integrating landing data, vessel activity and spatial information. This methodology relies on several key datasets and a stepwise procedure to ensure accurate, spatially explicit estimates.

The protocol redistributes aggregated data proportionally by incorporating vessel counts by port and/or cell grid. This includes systematic data merging, cleaning, and pre-processing to ensure consistency and reliability.

Two case studies were illustrated for the protocol:

CS-GSA6– Simplified Scenario: In this scenario, fisheries data (e.g., species prices by port) are disaggregated using complete and cleaned vessel number data. The number of vessels by harbour and landings by spatial cell grid are derived from expert knowledge and access to raw data, and the source dataset is complete, accurate and clean for all gears. Aggregated landing and economic data can be directly allocated to ports and vessel categories, enabling straightforward spatially explicit estimates.

CS-GSA9– Complex Scenario: Here, vessel number data by harbour are unavailable, requiring Global Fishing Watch (GFW) data to estimate vessel counts by harbour and cell grid. Additionally, landing data are partially unreliable, containing outliers and missing values. In this scenario, FDI landings data were matched with the Annual Economic Report of Fisheries (AER) according to vessel length to extract economic indicators, focusing on the Gross Value of Landings (GVL). The approach can be generalized to any economic variable recorded in the AER.

GFW data provide vessel-level fishing effort (hours of fishing) and associated harbour information. Using the Maritime Mobile Service Identifier (MMSI), individual GFW vessels were matched to the EU Fleet Register to assign vessel lengths. Vessels were then grouped by cells and vessel length to align with the structure of the FDI dataset. Public GFW data were used in this demonstration; however, the procedure can be applied to higher-resolution datasets, such as VMS data, when available.

The FDI-AER and GFW datasets were merged using common identifiers (spatial cell and vessel length). Aggregated economic data were then disaggregated by vessel, dividing total values by the number of vessels in each length class and cell. This produced spatially explicit estimates of GVL at the vessel level, which were further aggregated to ports to estimate species prices at the landing site.

Stepwise Methodology

Step 1 – Subsetting and preparing data

The first step involves selecting EU DCF FDI (STECF, 2025) data records relevant to the case study. Landing and Effort data are filtered by country, gear type, year and spatial location using the GSA polygon boundaries. This ensures that only landings within the geographic scope and of interest for the selected fleet segments are considered.

After filtering, total landings (in terms of weight and value) and effort (in terms of fishing days) are calculated for each combination of year, gear type, sub-region, and vessel length. These aggregated summaries enable the visualisation of the spatial distribution of fisheries and provide initial insights into the relative contributions of different gears, vessel lengths, and species.

Step 2 – Cleaning and selecting key species

Once the landing data are subset, the next step is to identify species that are consistently landed over the full study period. Records with zero landings are removed to avoid bias in price calculations. Furthermore, for the case study GSA9, data that were anomalous with the historical series were cleaned up using a series of statistical regressions. For each gear type and vessel length, the top species are selected based on landed weight. The procedure focuses on the top 15 species per gear (in volume) to capture the main contributors to landings while limiting the analysis to manageable subsets.

For these selected species, annual averages of landed weight, total value and price per kilogram are computed. This step ensures that temporal trends are captured and that price estimates are robust, reflecting consistent market activity rather than sporadic or low-volume landings.

Step 3 – Integrating vessel effort and port allocation

To allocate species prices to individual ports, vessel effort data are integrated. For each port, the number of vessels per gear type and vessel length is used to calculate the proportion of total effort represented by that port. The aggregated landing values and weights for each species, gear, and vessel category are then weighted by these proportions to distribute totals across ports. While the CS GSA6 provided detailed information about the number of vessels by gear type and vessel length for each port, the CS GSA9 derived this information from a series of analyses. These analyses included the use and comparison of GFW data, EMODNET, and the Fleet Register. This step relies on the assumption that vessels of the same length and gear type have similar landing patterns and that the distribution of landings across ports is proportional to vessel numbers. It allows the derivation of port-level estimates even when only aggregated fleet data are available.

Step 4 – Calculation of species prices at ports

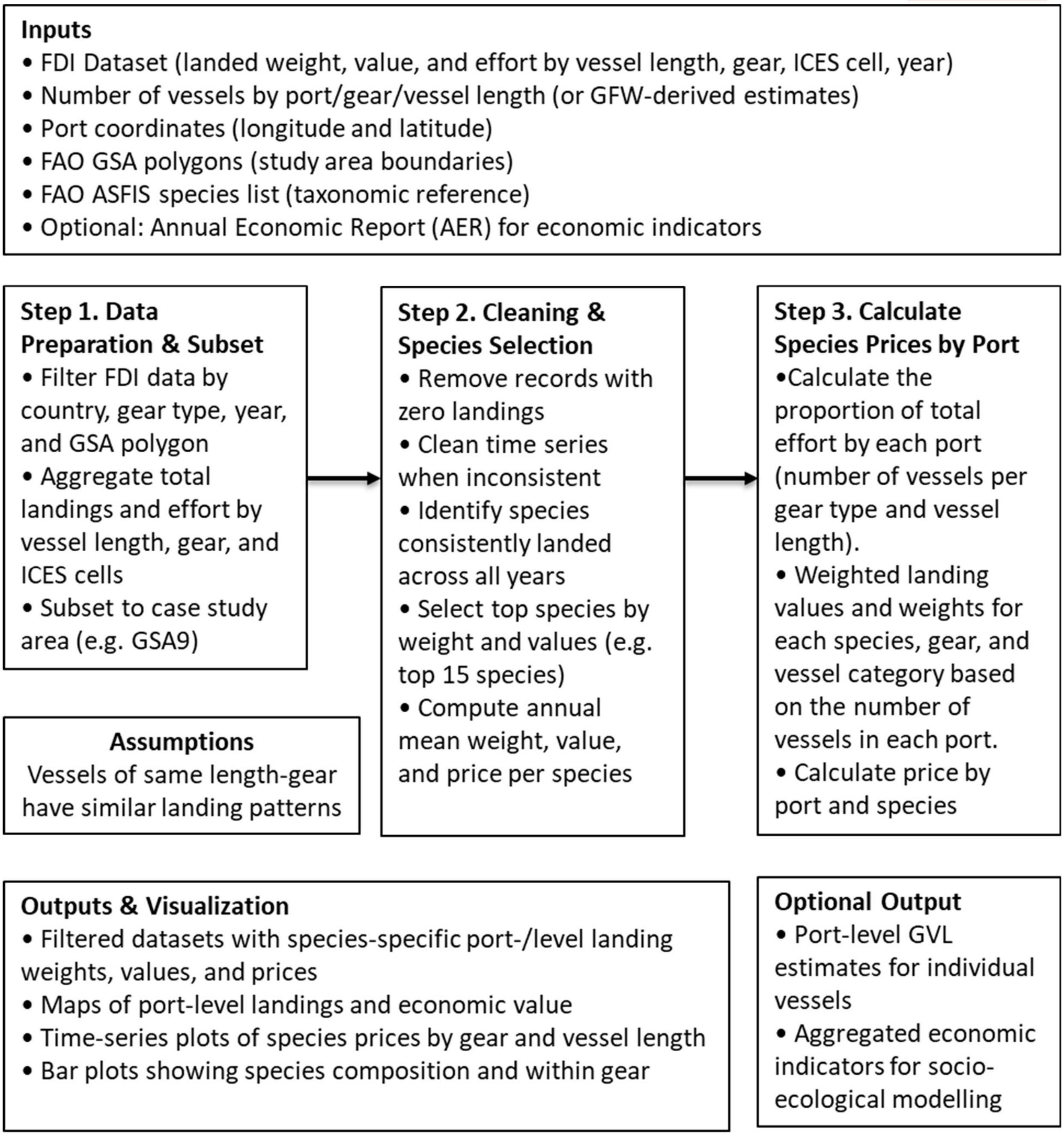
The price per kilogram for each species is recalculated at the port level using the weighted landings. This results in a set of port-specific species prices that account for both temporal trends and the distribution of fishing effort. Outputs include:

- Weighted species value and weight per port
- Derived species price per port
- Total landings and value per port for all selected species

These results can then be visualised through time-series plots of species prices by vessel length and gear, bar plots showing the contribution of each species by gear, and maps indicating the spatial distribution of landing value and quantity at ports.

The final outputs of the protocol comprise filtered landing datasets for the selected case study, which contain landed species (including weight, value, and price) per year, by gear, vessel length, and port. Furthermore, the protocol generates visualisations such as time series of species values, spatial distributions of landing weights by gear, vessel length, cells, and species, as well as spatial maps of port-level landings and prices, with the objective of supporting exploratory data analysis and reporting. Collectively, these outputs provide a robust basis for subsequent analyses, including economic assessments and integration with socio-ecological models of the fishing sector. The fundamental assumptions for the procedure are that vessels of equivalent length and gear type demonstrate analogous landing patterns. Indeed, the procedure considered the allocation of aggregated landings at the port level, proportional to the number of vessels expended by these vessels. Furthermore, in the protocol, Global Fishing Watch (GFW) data are representative of vessel activity when Vessel Monitoring System (VMS) data are unavailable, while acknowledging that coverage is limited to AIS-equipped vessels.

This integrated methodology ensures that SURIMI-PELS produces robust, spatially and temporally explicit estimates of species prices at landing ports, supporting economic analyses and socio-ecological modelling of fisheries.



Inputs

- FDI Dataset (landed weight, value, and effort by vessel length, gear, ICES cell, year)
- Number of vessels by port/gear/vessel length (or GFW-derived estimates)
- Port coordinates (longitude and latitude)
- FAO GSA polygons (study area boundaries)
- FAO ASFIS species list (taxonomic reference)
- Optional: Annual Economic Report (AER) for economic indicators

Step 1. Data Preparation & Subset

- Filter FDI data by country, gear type, year, and GSA polygon
- Aggregate total landings and effort by vessel length, gear, and ICES cells
- Subset to case study area (e.g. GSA9)

Assumptions

Vessels of same length-gear have similar landing patterns

Step 2. Cleaning & Species Selection

- Remove records with zero landings
- Clean time series when inconsistent
- Identify species consistently landed across all years
- Select top species by weight and values (e.g. top 15 species)
- Compute annual mean weight, value, and price per species

Step 3. Calculate Species Prices by Port

- Calculate the proportion of total effort by each port (number of vessels per gear type and vessel length).
- Weighted landing values and weights for each species, gear, and vessel category based on the number of vessels in each port.
- Calculate price by port and species

Outputs & Visualization

- Filtered datasets with species-specific port-/level landing weights, values, and prices
- Maps of port-level landings and economic value
- Time-series plots of species prices by gear and vessel length
- Bar plots showing species composition and within gear

Optional Output

- Port-level GVL estimates for individual vessels
- Aggregated economic indicators for socio-ecological modelling

Figure 1 - SURIMI-PELS Protocol

3.3 LIMITATIONS AND DATA CONSTRAINTS OF THE SURIMI-PELS PROTOCOL

Despite its structured framework and capacity to integrate heterogeneous datasets, the SURIMI-PELS protocol is subject to a number of methodological and data-related limitations that must be acknowledged. First, the procedure relies heavily on aggregated data derived from EU Data Collection Framework (DCF) sources such as the Fisheries Dependent Information (FDI) and the Annual Economic Report (AER). While these datasets are authoritative and harmonised, they are not collected at the individual vessel level and are spatially coarse, usually allocated to spatial cell grid or larger areas. This inevitably constrains the precision of disaggregation, as the underlying assumption is that vessels within the same length class and gear category display comparable fishing and landing patterns. In practice, such assumptions may not hold, as heterogeneity in vessel behaviour, targeting strategies, and market access can lead to substantial variability that remains unaccounted for.

Second, the reliance on Global Fishing Watch (GFW) as a substitute for confidential Vessel Monitoring System (VMS) and logbook data introduces additional biases. GFW is based on Automatic Identification System (AIS) signals, which are not mandatory for all vessels and tend to underrepresent smaller segments of the fleet, especially artisanal and coastal fishing vessels. Moreover, AIS coverage is uneven across regions, with signal gaps in areas of poor reception or where transponders are intentionally switched off. As a result, vessel counts and activity estimates derived from GFW may be incomplete or skewed towards larger, industrial vessels, which could bias the allocation of landings and prices at the port level.

Third, data quality issues such as missing values, inconsistencies, or outliers in the FDI and AER datasets, as highlighted in the case study for GSA9, require statistical cleaning and imputation. While these corrective steps improve usability, they inevitably introduce a level of subjectivity and uncertainty into the analysis. The redistribution of economic indicators across ports and vessels assumes proportionality to vessel numbers or effort, but this proportional allocation neglects potential differences in productivity, market dynamics, and species targeting between ports. Similarly, the estimation of species prices at ports rests on the implicit assumption that landings and effort are proportionally distributed, which may not capture the complexity of real-world fisheries economics.

Fourth, although complementary datasets such as the EU Fleet Register and EMODnet Human Activities provide valuable vessel descriptors and port information, these too present limitations. The Fleet Register, while legally mandated and regularly updated under Regulation (EU) 2017/218, contains primarily descriptive rather than economic information and may not always reflect real-time vessel status due to reporting delays. EMODnet products, although harmonised and open-access, often integrate data at annual or multiannual resolution, which reduces their suitability for capturing short-term fluctuations in fishing activity or price dynamics.

Finally, the protocol remains dependent on the availability of public, open-access datasets. Key high-resolution information, such as logbook entries, VMS data, and commercially sensitive catch and effort statistics, remain restricted under the EU Control Regulation (Regulation (EC) No 1224/2009) and the ICES Data Policy, which explicitly excludes unrestricted public access to sensitive vessel-level data. Consequently, SURIMI-PELS cannot achieve the same level of accuracy as protocols built on confidential microdata, and its outputs should be interpreted as robust approximations rather than exact reconstructions of species prices at individual landing ports.

In summary, while SURIMI-PELS provides a transparent, replicable, and scalable approach to estimating species-specific prices at the port level, its validity is conditioned by the limitations of input data, the assumptions of proportional allocation, and the constraints of open-access spatial information. These limitations underscore the importance of cautious interpretation of results and the need for further refinement of the methodology, particularly through the integration of higher-resolution data sources when access is permitted.

4. CONCLUSIONS

Deliverable D2.1 establishes the analytical foundation for integrating and curating marine socio-ecological data within the SURIMI project. It addresses one of the most persistent challenges in ecosystem-based fisheries management: achieving harmonisation and interoperability across heterogeneous environmental and socio-economic datasets. By providing a coherent methodological structure, the deliverable supports the creation of data systems capable of underpinning integrated analyses and decision-support tools for sustainable marine governance.

A central outcome of D2.1 is the development and implementation of methodological protocols that connect socio-economic and environmental data streams. These protocols tackle long-standing obstacles in cross-domain integration, such as differences in spatial and temporal resolution, inconsistent segmentation of fishing operations and non-comparable units of observation. Through these efforts, SURIMI advances the ability to align and combine information originating from multiple sources and scales, enhancing the analytical basis for ecosystem-based management.

The SURIMI-PELS protocol exemplifies this methodological progress. It provides a structured approach for disaggregating economic and operational data to finer spatial and temporal levels, enabling the derivation of port-level species prices, effort maps, and other key variables that link socio-economic activity to ecological and environmental conditions. This innovation supports a more detailed understanding of the spatial dynamics of marine resource use and the socio-economic implications of management decisions.

The case studies implemented in Mediterranean GSA6 and GSA9 demonstrate the applicability and robustness of these protocols in distinct data contexts. Together, these applications validate the adaptability of the SURIMI approach and its capacity to generate spatially explicit, policy-relevant insights. They also show how integrated workflows can feed directly into scenario modelling, supporting the design and evaluation of management strategies in a changing environmental and socio-economic landscape.

At the core of this work lies the SURIMI Data Lake, which anchors the project's data curation architecture. The Data Lake consolidates and harmonises biological, environmental and socio-economic data, ensuring their interoperability across the project's analytical, modelling and decision-support components.

This harmonised data infrastructure powers the SURIMI modelling suite developed under Work Package 3, where curated datasets are used to construct interoperable socio-ecological models. These models, ranging from system dynamics and agent-based representations to product flow value-chain and ecosystem models, capture the complex feedbacks between human activities and marine ecosystems. By relying on curated, harmonised data, the models can simulate realistic scenarios and quantify trade-offs between ecological sustainability, economic performance and social wellbeing.

The curated datasets also provide the empirical basis for the development of integrated indicators under Task 2.3, which translate model outputs into measurable and policy-relevant metrics. These indicators cover ecological, socio-economic and governance dimensions, enabling the systematic evaluation of management performance, ecosystem health and policy effectiveness. They serve as key inputs for the Management Strategy Evaluation (MSE) framework, where harmonised data are used to test alternative strategies.

In parallel, the visualisation and decision-support tools designed under Work Package 4 build directly on the curated datasets. Through spatial representations of landings, effort and species prices, as well as interactive time-series dashboards, complex multi-dimensional information will be translated into formats that are both accessible and actionable for policymakers, scientists, and stakeholders. Integrated within the SURIMI graphical user interface (GUI) and the MSE environment, these visual tools will facilitate transparency and informed decision-making, promoting dialogue between science, management and society. Collectively, these efforts demonstrate that data curation within SURIMI is not a preliminary activity, but the core enabler of the project's analytical and modelling capacities.

In conclusion, Deliverable D2.1 provides a comprehensive and operational framework for marine socio-ecological data curation and integration. It establishes the methodological backbone for the project's modelling and evaluation activities and contributes to the wider ambition of building an adaptive, evidence-based marine governance system. The protocols, indicators, and tools developed under D2.1 are designed to be transferable and scalable, enabling their use beyond the SURIMI context and supporting a broader shift towards integrated, data-driven, and sustainable ocean management across Europe.

5. REFERENCES

Bastardie, F., Spedicato, M.-T., Bitetto, I., Romagnoni, G., Zupa, W., Letschert, J., Püts, M., Damalas, D., Kavadas, S., Maina, I., Tsagarakis, K., Poos, J. J., Papantoniou, G., Depestele, J., Batts, L., Bluemel, J., Astarloa Diaz, A., van de Wolfshaar, K., Binch, L., and Rindorf, A. (2023): SEAwise report on predicting effect of changes in 'fishable' areas on fish and fisheries, September 2023. Technical University of Denmark. https://doi.org/10.11583/DTU.24331198

Bitetto, I., Spedicato, M. T., Romagnoni, G., Lembo, G., Halkos, G., Plataniotis, A., Koundouri, P., Andrés, M., Sánchez, S., García, D., Ibaibarriaga, L., Voss, R., Liontakis, A., Vasilopoulou, V., Giannoulaki, M., Sgardeli, V., Tsoukali, S., Sys, K., Depestele, J., Kühn, B., Taylor, M., Kempf, A., Binch, L., and Rindorf, A. (2023): SEAwise Report on Carbon footprint, economic and social impacts of management strategies. Technical University of Denmark. https://doi.org/10.11583/DTU.25012085

Bitetto, I., Malvarosa, L., Berkenhagen, J., Spedicato, M. T., Sabatella, E., & Döring, R. (2022). Reconciling the economic and biological fishery data gathered through the European Data Collection Framework: A new R-tool. PLOS ONE, 17(3), e0264334. https://doi.org/10.1371/journal.pone.0264334.

Bollerslev, T. (1986). Generalized autoregressive conditional heteroskedasticity. Journal of Econometrics, 31(3), 307–327. https://doi.org/10.1016/0304-4076(86)90063-1

Borges, L., Gonçalves, J.M.S., Erzini, K., & van Densen, W.L.T. (2016). Fishery discards and bycatch: Solutions for mitigating their impact on ecosystems. Marine Policy, 64, 1–3.

Dorner, H., Casey, J., Carvalho, N., Damalas, D., Graham, N., Guillen, J., Holmes, S.J., Natale, F., Osio, G.C., Ratz, H.-J., 2018. Collection and dissemination of fisheries data in support of the EU Common Fisheries Policy. Ethics in Science and Environmental Politics, 18, 15–25.

European Marine Observation and Data Network (EMODnet). (2023). *EMODnet Human Activities: Main Ports, Goods-Passengers-Vessels Traffic* [Data set]. EMODnet. https://emodnet.ec.europa.eu/en/human-activities

European Commission. (2021). Commission Delegated Decision (EU) 2021/1167 of 27 April 2021 establishing the multiannual Union programme for the collection and management of biological, environmental, technical and socioeconomic data in the fisheries and aquaculture sectors from 2022. Official Journal of the European Union, L 253, 51–90. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32021D1167

European Commission. (2021). Commission Implementing Decision (EU) 2021/1168 of 27 April 2021 establishing the list of mandatory research surveys at sea and thresholds as part of the multiannual Union programme for the collection and management of data in the fisheries and aquaculture sectors from 2022. Official Journal of the European Union, L 253, 92–99. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32021D1168

European Commission (2022). The implementation of ecosystem-based approaches applied to fisheries management under the CFP – Final report. Publications Office of the European Union. [https://data.europa.eu/doi/10.2926/57956]

European Union (2009). Regulation (EC) No 1224/2009 of the European Parliament and of the Council establishing a Community control system for ensuring compliance with the rules of the Common Fisheries Policy.

European Union. (2017a). Regulation (EU) 2017/1004 of the European Parliament and of the Council of 17 May 2017 on the establishment of a Union framework for the collection, management and use of data in the fisheries sector and support for scientific advice regarding the Common Fisheries Policy and repealing Council Regulation (EC) No 199/2008. Official Journal of the European Union, L 157, 1–21. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32017R1004

European Union. (2017b). *Commission Implementing Regulation (EU) 2017/218 of 6 February 2017 on the Union fishing fleet register*. Official Journal of the European Union, L 34, 9–17. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32017R0218

European Union. (2019). *Regulation (EU) 2019/1022 of the European Parliament and of the Council of 20 June 2019 establishing a multiannual plan for the fisheries exploiting demersal stocks in the western Mediterranean Sea and amending Regulation (EU) No 508/2014*. Official Journal of the European Union, L 172, 1–17. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32019R1022

FAO (2015). Fuel and energy use in the fisheries sector – approaches, inventories and strategic implications, by J.F. Muir. FAO Fisheries and Aquaculture Circular No. 1080. Rome, Italy.

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

Gibin, Maurizio; Zanzi, Antonella; Hekim, Zeynep; Adamowicz, Maciej; Kovsars, Maksims (2024): Fisheries landings & effort: data by c-square. European Commission, Joint Research Centre (JRC) [Dataset] PID: http://data.europa.eu/89h/00ae6659-ddde-4314-a9da-717bb2e82582

Hilborn, R., Fulton, E. A., Green, B. S., Hartmann, K., Tracey, S. R., & Watson, R. A. (2020). Integrated management of marine resources: moving more quickly towards sustainability. Marine Policy, 112, 103778.

ICES (2019a). Workshop on Tradeoffs Scenarios between the Impact on Seafloor Habitats and Provisions of catch/value (WKTRADE2). ICES Scientific Reports, 1:63.

ICES (2019b). Working Group on the Social and Economic Dimensions of Fisheries (WGSEDA). ICES Scientific Reports, 1:24.

ICES (2021). ICES Data Policy – Exclusions to unrestricted public access. Retrieved from [https://www.ices.dk/data/guidelines-and-policy/pages/ices-data-policy.aspx]

ICES (2024). Workshop on Trade-offs between the Impact of Fisheries on Seafloor Habitats and their Landings and Economic Performance (WKTRADE4). ICES Scientific Reports, 6:20.

Kell, L.T., Kimoto, A., & Kitakado, T. (2016). Evaluation of the prediction skill of stock assessment using hindcasting. Fisheries Research, 183, 119–127.

Koehn, L. E., Nelson, L. K., Samhouri, J. F., Norman, K. C., Jacox, M. G., Cullen, A. C., et al. (2022). Social-ecological vulnerability of fishing communities to climate change: A U.S. West Coast case study. *PLoS ONE, 17*(8), e0272120. https://doi.org/10.1371/journal.pone.0272120

Kraak S.B.M., F.C. Buisman, M Dickey-Collas, Poos J.J., M.A. Pastoors, J.G.P. Smit, and N. Daan. How can we manage mixed fisheries? a simulation study of the effect of management choices on the sustainability and economic performance of a mixed fishery. Technical report, 2004.

Levin, P. S., Damon, M., & Samhouri, J. F. (2018). Developing integrated ecosystem assessments: expanding the social dimension. ICES Journal of Marine Science, 75(6), 1965–1971.

Lleonart, J., Maynou, F., Recasens, L., and Franquesa, R. 2003. A bioeconomic model for Mediterranean fisheries , the hake off Catalonia (western Mediterranean) as a case study. Scientia Marina, 67: 337–351.

Mangi, S.C., Hodgson, S., Sabatella, E., Olive, Y., Katsanevakis, S., Andonegi, E., O'Kane, C., Verschuur, X., Boyer, M., Piet, G., Arthur, R., & Wakeford, R.C. (2023). Study on ecosystem-based approaches applied to fisheries management under the Common Fisheries Policy for the Mediterranean and Black Seas. Publications Office of the European Union.

NOAA Fisheries. (2021). *Human Integrated Ecosystem-Based Fishery Management (HI-EBFM): Research Strategy 2021–2025*. NOAA Fisheries. https://www.fisheries.noaa.gov/ecosystems/human-integrated-ecosystem-based-fishery-management-research-strategy-2021-2025

Organisation for Economic Co-operation and Development (OECD). (2024). Fisheries Support Estimate (FSE) Manual. OECD Publishing.

Prellezo, R., Accadia, P., Andersen, J., Andersen, B. S., Buisman, E., Little, A., Nielsen, J. R., Poos, J. J., Powell, J., & Röckmann, C. (2010). Existing bioeconomic models review. In IIFET 2010 Montpellier Proceedings (pp. 1-12)

R.C.G.E.C.O.N., Regional Coordination on Economic Issues (2021). Report of the workshop on an alternative approach to the segmentation of fishing fleets. March 29–31, 2021. [https://datacollection.jrc.ec.europa.eu/docs/other-meetings]

RCG ECON, Regional Coordination on Economic Issues (2022). Report of the second workshop on an alternative approach to the segmentation of fishing fleets. [https://datacollection.jrc.ec.europa.eu/docs/other-meetings]

RCG ECON, Regional Coordination on Economic Issues (2023). Report of the 3rd ISSG workshop on an alternative approach to the segmentation of fishing fleets. Sulanke E., & Berkenhagen, J., editor(s). [https://www.fisheries-rcg.eu/wp-content/uploads/2024/04/2023_05_ISSG_Segmentation_WS-Report.pdf]

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

Sala, A., Damalas, D., Labanchi, L., Martinsohn, J. T., Sabatella, R. F., Russo, T., Nielsen, J. R., Vitale, S., Herrmann, B., & Lucchetti, A. (2022). Energy audit and carbon footprint in trawl fisheries. *Scientific Data, 9,* 428. https://doi.org/10.1038/s41597-022-01478-0

Salz, P., Kell, L. T., & Mardle, S. (2011). Bio-economic fleet modeling in mixed fisheries. In: Proceedings of the 2011 International Congress on Modelling and Simulation (MODSIM2011), Perth, Australia, 12–16 December 2011. Modelling and Simulation Society of Australia and New Zealand. ISBN: 978-0-9872143-0-0.

Sbrana, A., Galli, S., Casini, M., Carlucci, R., Dassenakis, M., Fiorentino, F., Follesa, M. C., Garofalo, G., Georges, V., Isajlovic, I., Klancnik, K., Lauria, V., Maiorano, P., Manfredi, C., Mavric, B., Pagou, K., Papadopoulou, N., Paramana, T., Paraskevopoulou, V., Pulcini, M., Rakaj, A., Ronchi, F., Sabatella, E. C., Scarcella, G., Smith, C. J., Stefani, M., Streftaris, N., Tassetti, A. N., Yahyaoui, A., Vrgoc, N., Raicevich, S., Russo, T. (2025). Exploring spatial-based management scenarios to protect the seafloor in different areas of the Mediterranean Sea. *ICES Journal of Marine Science, 82*(3), fsaf023. https://doi.org/10.1093/icesjms/fsaf023

STECF, Technical and Economic Committee for Fisheries. 2023. The 2023 Annual Economic Report on the EU Fishing Fleet (STECF 23-07), Prellezo, R., Sabatella, E., Virtanen, J., Tardy Martorell, M. and Guillen, J. editor(s), Publications Office of the European Union, Luxembourg, 2023, doi:10.2760/423534, JRC135182.

STECF, Scientific Technical and Economic Committee for Fisheries (STECF). 2024. The 2024 Annual Economic Report on the EU Fishing Fleet (STECF-24-03 & STECF-24-07). Prellezo, R., Sabatella, E.C., Virtanen, J., Tardy Martorell, M., & Guillen, J., editor(s). Publications Office of the European Union, Luxembourg, 2024.

STECF, Scientific, Technical and Economic Committee for Fisheries. 2025. Evaluation of Fisheries Dependent Information (FDI) for EU Fleets (STECF 24-11). Zanzi, A., Motova-Surmava, A., & Hekim, Z., editor(s). Publications Office of the European Union, Luxembourg, 2025.

Sulanke, E., Rubel, V., Berkenhagen, J., Bernreuther, M., Stoeck, T., Simons, S. (2025). Amending the European fishing fleet segmentation based on machine learning and multivariate statistics. Fisheries Research, 281, 107190. [https://doi.org/10.1016/j.fishres.2024.107190]

Taconet, M., Kroodsma, D., & Fernandes, J.A. (2019). Global Atlas of AIS-based fishing activity – Challenges and opportunities. Food and Agriculture Organization of the United Nations (FAO). Available at: https://www.fao.org/3/ca7012en/ca7012en.pdf

Thünen-Institute (2019). SECFISH - Strengthening regional cooperation in the area of fisheries data collection – Socio-economic data collection for fisheries, aquaculture and the processing industry at EU level: D 0.3 Final Technical Report.

Ulrich, C., Reeves, S.A., Vermard, Y., Holmes, S.J., & Vanhee, W. (2012). Reconciling single-species biological and mixed-fisheries economic objectives in management. ICES Journal of Marine Science, 69(7), 1281–1292.

ANNEX 1 - CASE STUDY GSA6[9] SURIMI PELS

The protocol is part of the SURIMI project and is designed to derive the prices of individual species over time for each port of landing.

To implement this methodology effectively, two key datasets are required:

1. The FDI landing dataset, which provides detailed records of landings over time by year, country, GSA, gear, vessel length and spatial cell grid.

2. Dataset containing the number of vessels, divided by port, type of fishing gear used and vessel length:

year	port_code	gear	vlength	n
2013	ESSCR	DTS	VL1218	11
2014	ESSCR	DTS	VL1218	11
2015	ESSCR	DTS	VL1218	10
2016	ESSCR	DTS	VL1218	10

3. Ports coordinates:

port_code	lon	lat
ESSCR	40.582276	0.598944

4. The FAO Geographical Sub-Areas: Area of application, comprised of the Mediterranean and the Black Sea, as Major Fishing Area 37.

5. The FAO ASFIS List of Species for Fisheries, which represents the standard taxonomic reference system for the FAO Statistics Team.

This information is crucial for providing context to the landing data and for connecting fishing effort with species availability and price patterns at the port level.

PROTOCOL - FDI LANDINGS (SPECIES KG AND PRICE) BY PORT

Users could establish parameters for their case study, which will subsequently inform the procedure. Here, an application of the procedure is presented through the examination of bottom otter trawlers (OTB) and purse seiners (PS) operating within the Spanish waters of GSA 6.

STEP 1 - OPEN AND SUBSET FDI LANDING DATA

The FDI data are filtered by gear type, year, and country. The GSA polygon is then used to extract spatial landings for Bottom Otter Trawlers (OTB) and Purse Seiners (PS). Figure 2 and Figure 3 present selected results showing the total landing values by gear type.

---

[9] Major Fishing Area 37 (Mediterranean and Black Sea) - FAO statistical divisions 1.1 (Balearic) – GSA06 (Northern Spain)

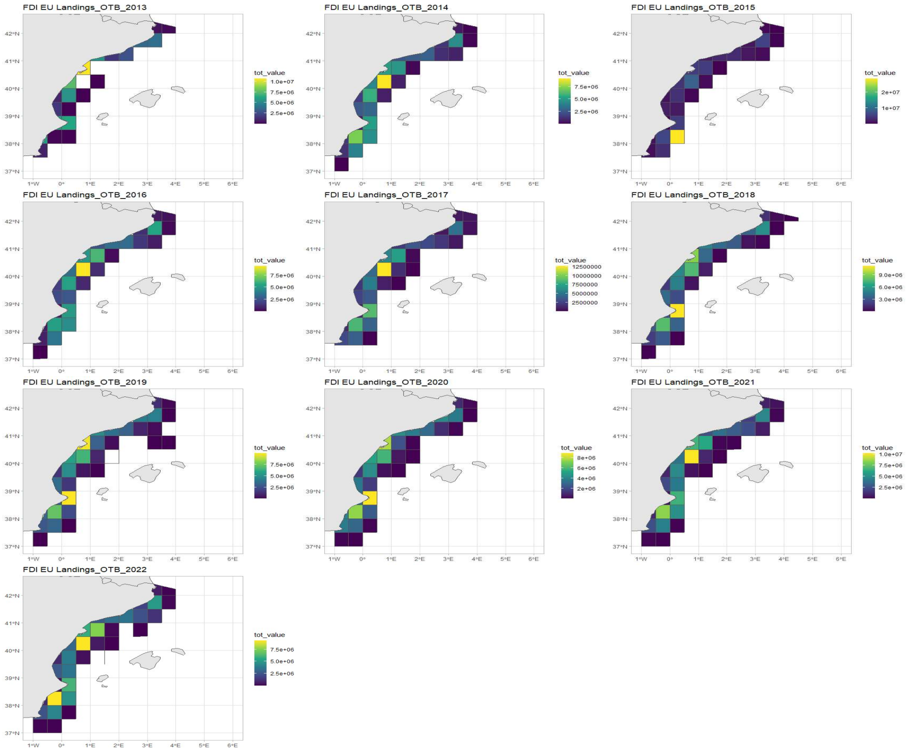


Figure 2 - Total landings coverage by OTB for the case study area (GSA6) - resulting from FDI data

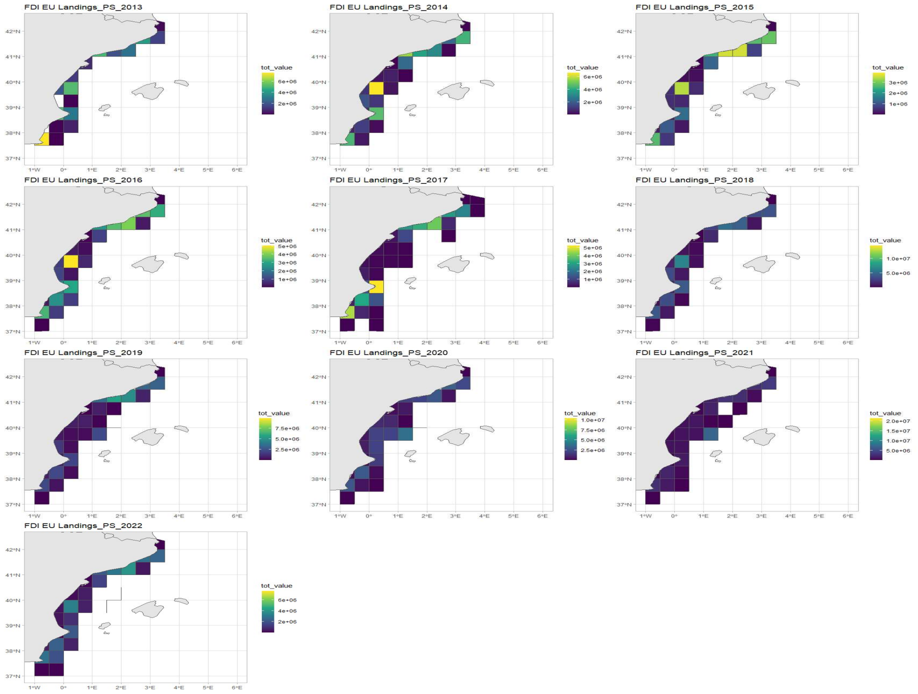


Figure 3 - Total landings coverage by PS for the case study area (GSA6) - resulting from FDI data

STEP 2 - FILTER AND CLEAN LANDING DATA

Landing data are processed to identify the key species consistently landed over time and to calculate their average weights, values and prices. The analysis focuses on catch data by gear type and vessel length (Figure 4) and highlights the top 15 species by landed weight for each gear. Figure 5 presents the time-series of landing values for these selected species, while Figure 6 illustrates the landed kilograms of each species proportionally by gear type.

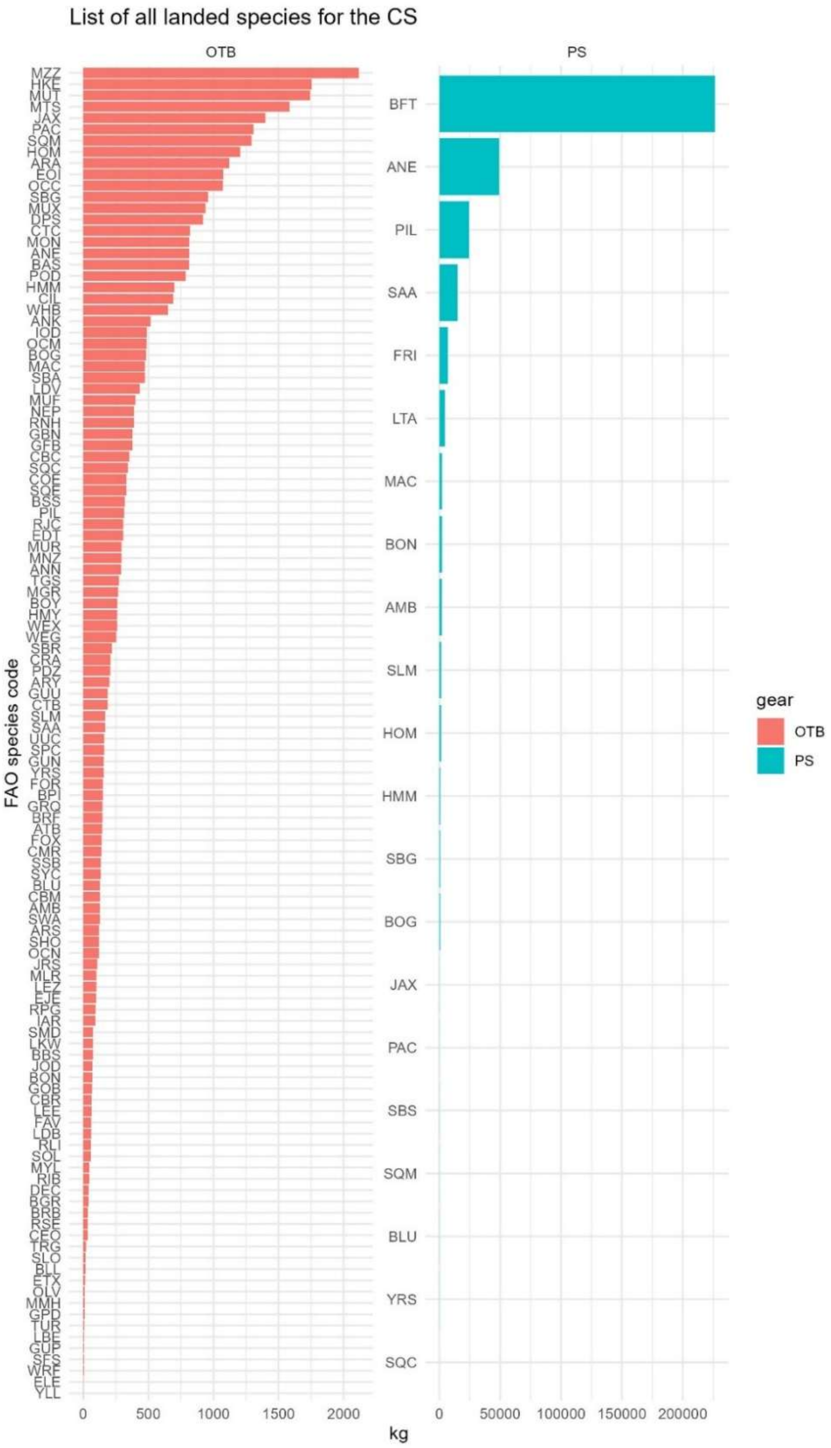


Figure 4 - FDI landing species by Gear (OTB and PS) for the case study area (GSA6).

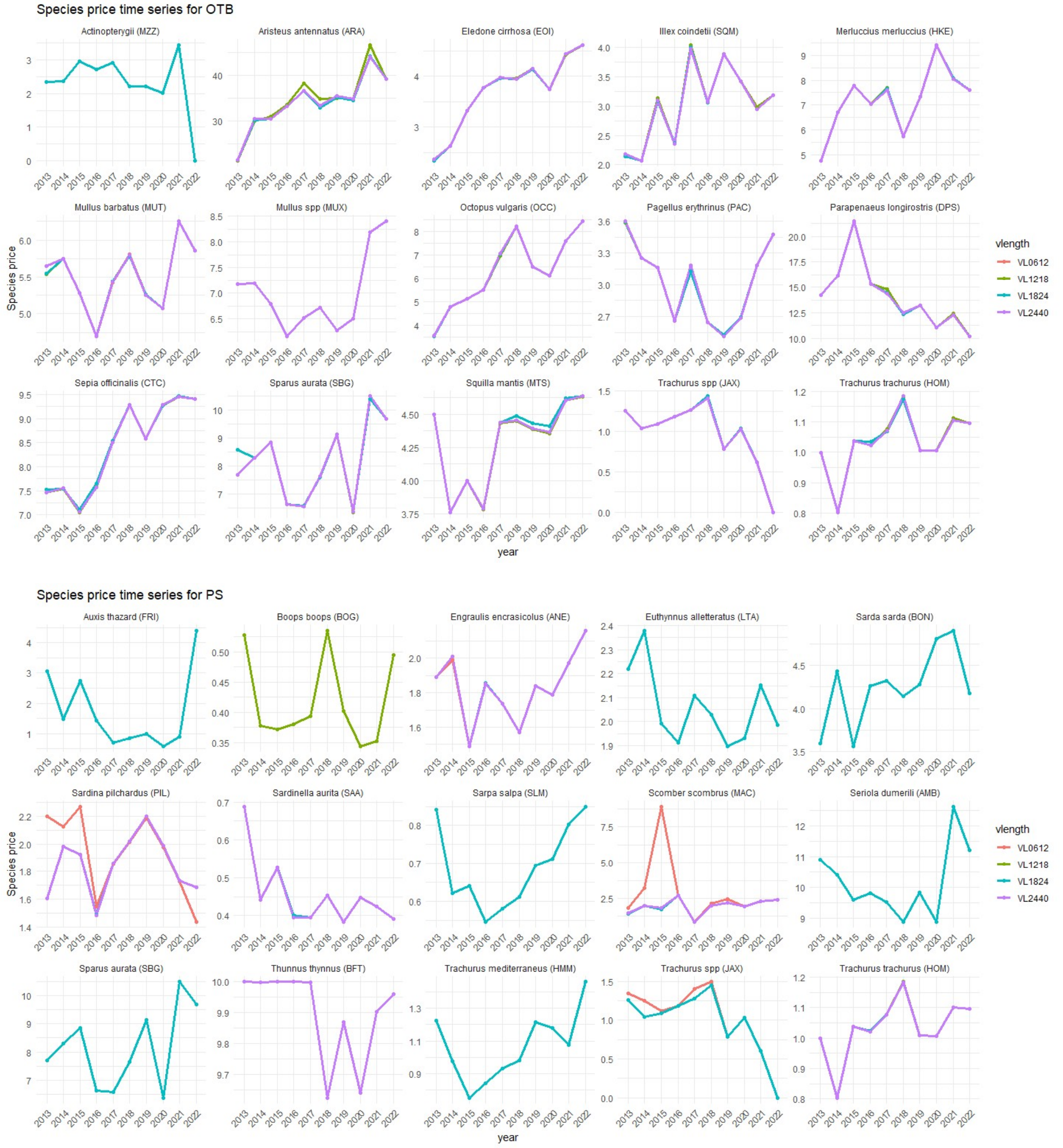


Figure 5 – FDI landing time-series (top 15 species) by gear (OTB and PS) for the case study area (GSA6)

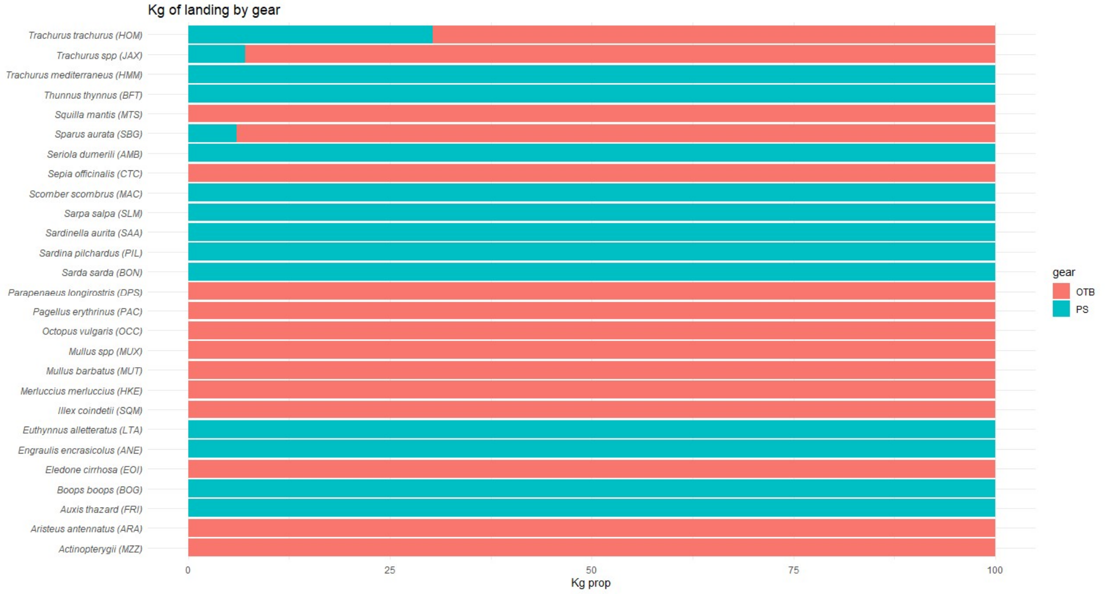


Figure 6 – FDI proportional landing of key selected species by gear

STEP 3 - CALCULATE AND ADD THE PRICE BY SPECIES

After the filtering and selection steps, a dataset containing the number of vessels per port, fishing gear type and vessel length is loaded and used to proportionally allocate landed kilograms and values by species at the port level.

For each port, gear, and vessel length, the relative share number of vessel is calculated by dividing the number of vessels in each category by the total number of vessels present in that port. This produces the weights used to distribute landing values and quantities across ports.

$$weight_{(g,l,p)} = \frac{n.vessel\ by\ port_{(g,l,p)}}{\sum n.vessel\ by\ port_{(g,l,p)}}$$

Where *g* is the gear type, *l* is the vessel length, *p* is the port, and *s* is the species.

The previously calculated weights are then joined with the species price resulting dataset, allowing landings to be distributed across ports. Following this process, the weighted price by species are calculated.

$$Price\ by\ port_{(g,l,p,s)} = Price_{(g,l,s)} * weight_{(g,l,p)}$$

Where *g* is the gear type, *l* is the vessel length, *p* is the port, and *s* is the species.

As shown in Figure 7, the results are compared before and after this disaggregation, based on the number of vessels in each port.

Data are then aggregated and reported by port as the total value of the landed catch (Figure 8). The same information is also presented as species-specific prices by gear and vessel length (Figure 9).

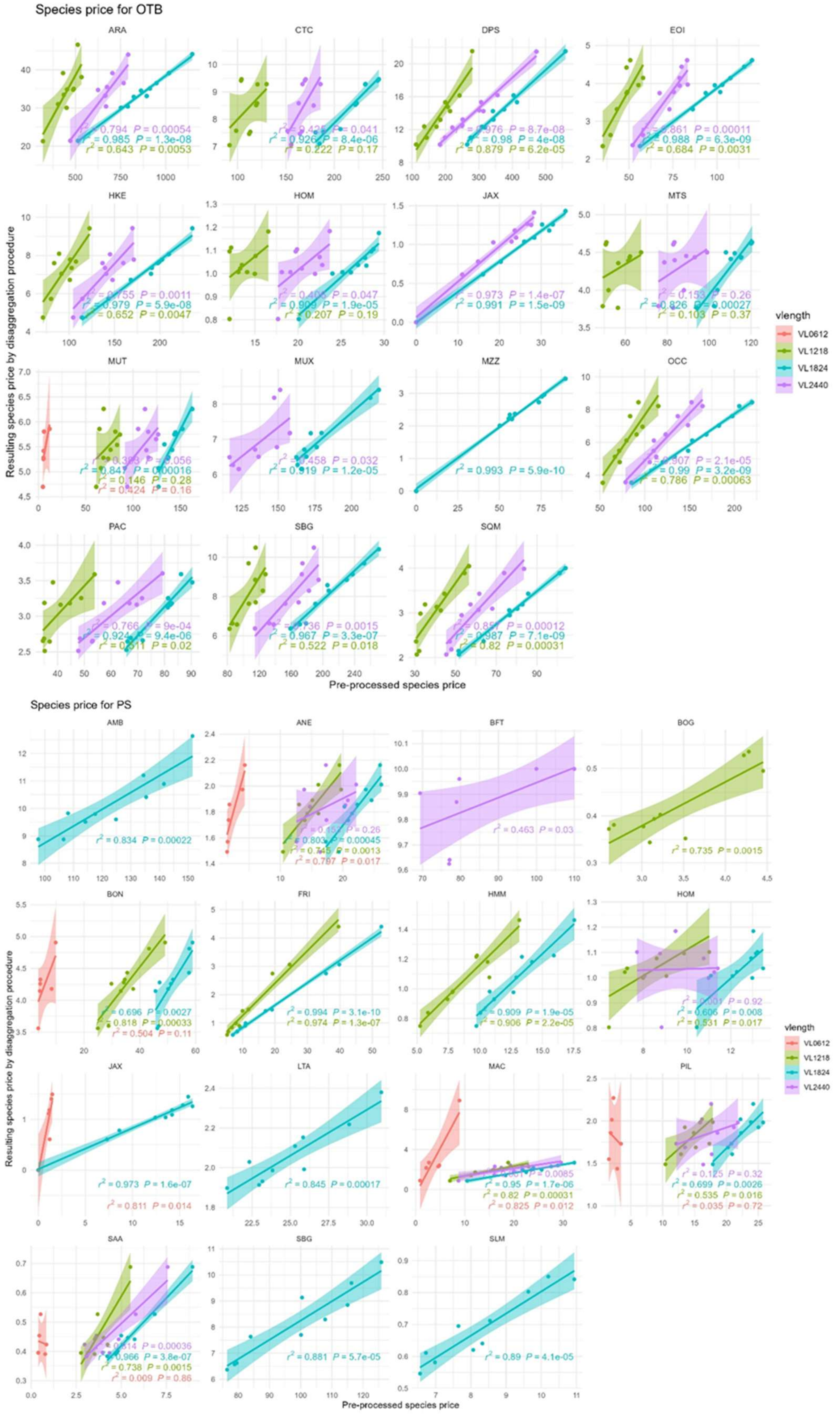


Figure 7 – Pre-post disaggregation procedure for species prices by port

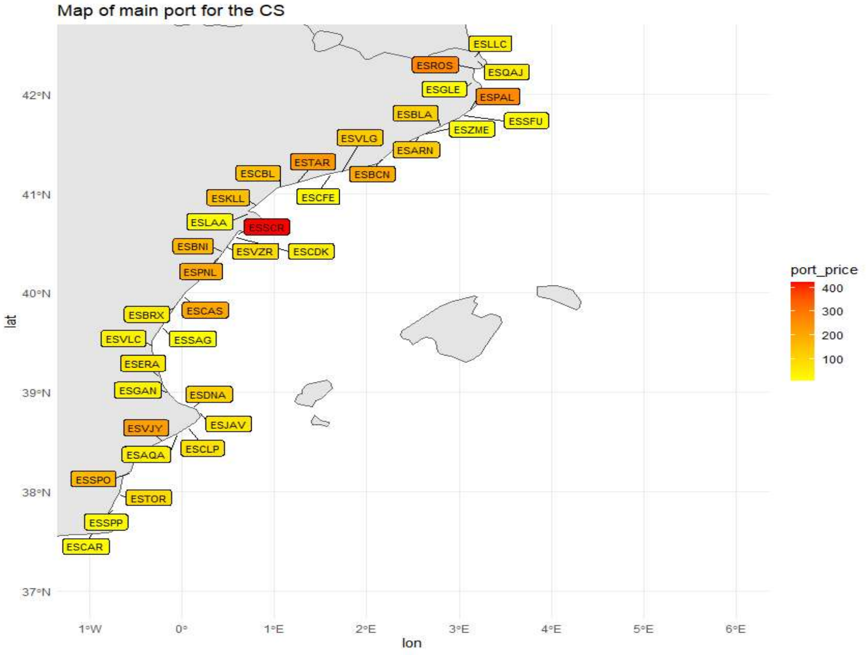


Figure 8 – Total landed price by port

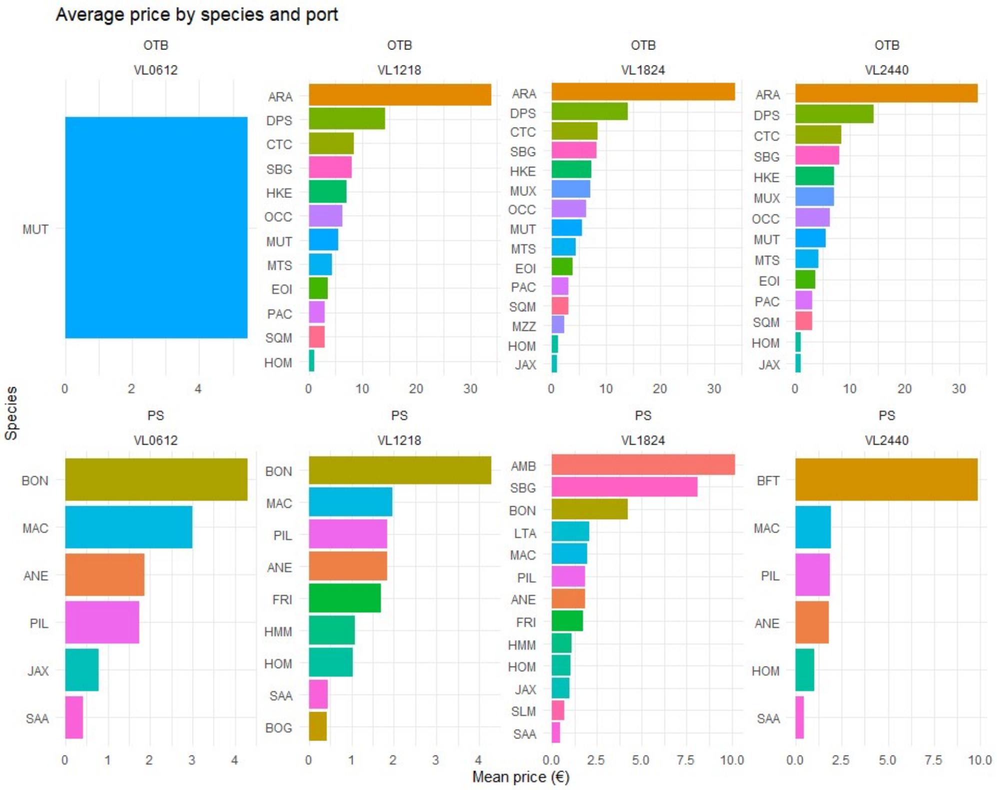


Figure 9 – Species prices by gear and vessel length

ANNEX 2 - CASE STUDY GSA09[10] SURIMI PELS

1ST PROTOCOL - FDI EFFORT BY SPATIAL CELL GRID

In this session, the methodology for disaggregating data will be systematically explained through the application in a specific area: the GSA9 (Northern Tyrrhenian Sea).

Data used in this procedure are reported in Table 7 – Data input for the procedure.

Table 7 – Data input for the procedure

Data	**Description**
FDI effort and landing	Effort and landing data divided by year, country, GSA, gear, vessel length and spatial cells. The geographical reference, expressed as icell longitude-latitude coordinates, is provided in the shapefiles.
AER	Economic indicators by year, country, GSA, gear, and vessel length.
Fleet register	Descriptive information on individual vessels: vessel name, MMSI identifier, vessel length, port of registration, tonnage, power, gear, etc.
EMODNET main ports for the European Seas	Main ports' locations data from 1997 to 2024
FAO ASFIS List of Species for Fisheries	The ASFIS (Aquatic Sciences and Fisheries Information System) list for fishery statistics represents the standard taxonomic reference system for the FAO Statistics Team.
FAO Geographical Sub-Areas	FAO GFCM area of application, comprised of the Mediterranean and the Black Sea, as Major Fishing Area 37.

STEP 1 - DATA MANIPULATION FOR THE CASE STUDY AREA

Users could establish parameters for their case study, which will subsequently inform the procedure.

Here we test Italian Bottom Otter Trawlers (ITA-OTB) in 2021 for GSA09. Firstly, data are filtered for the selected case study. Results for FDI effort data (Figure 10) and AER economic data (Figure 11) are shown.

---

[10] Major Fishing Area 37 (Mediterranean and Black Sea) - FAO statistical divisions 1.3 (Sardinia) – GSA09 (Ligurian Sea and Northern Tyrrhenian Sea)

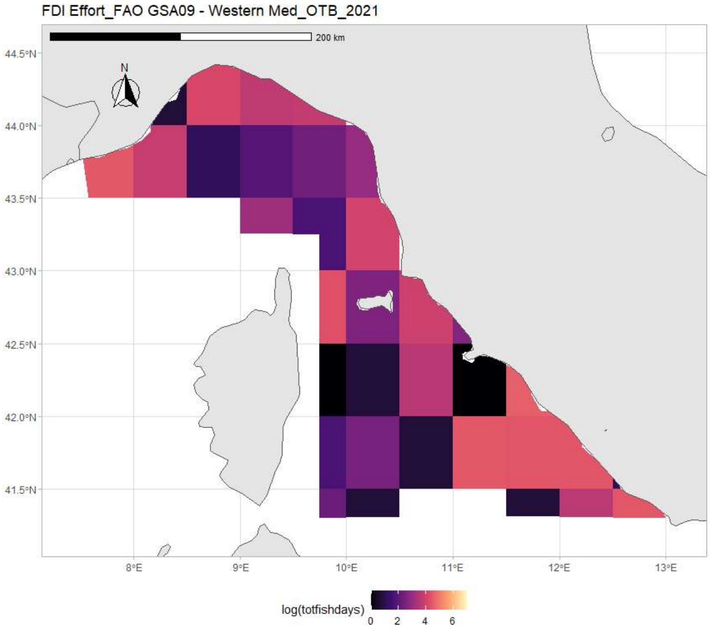


Figure 10 - Total effort coverage for the case study area - resulting from FDI data

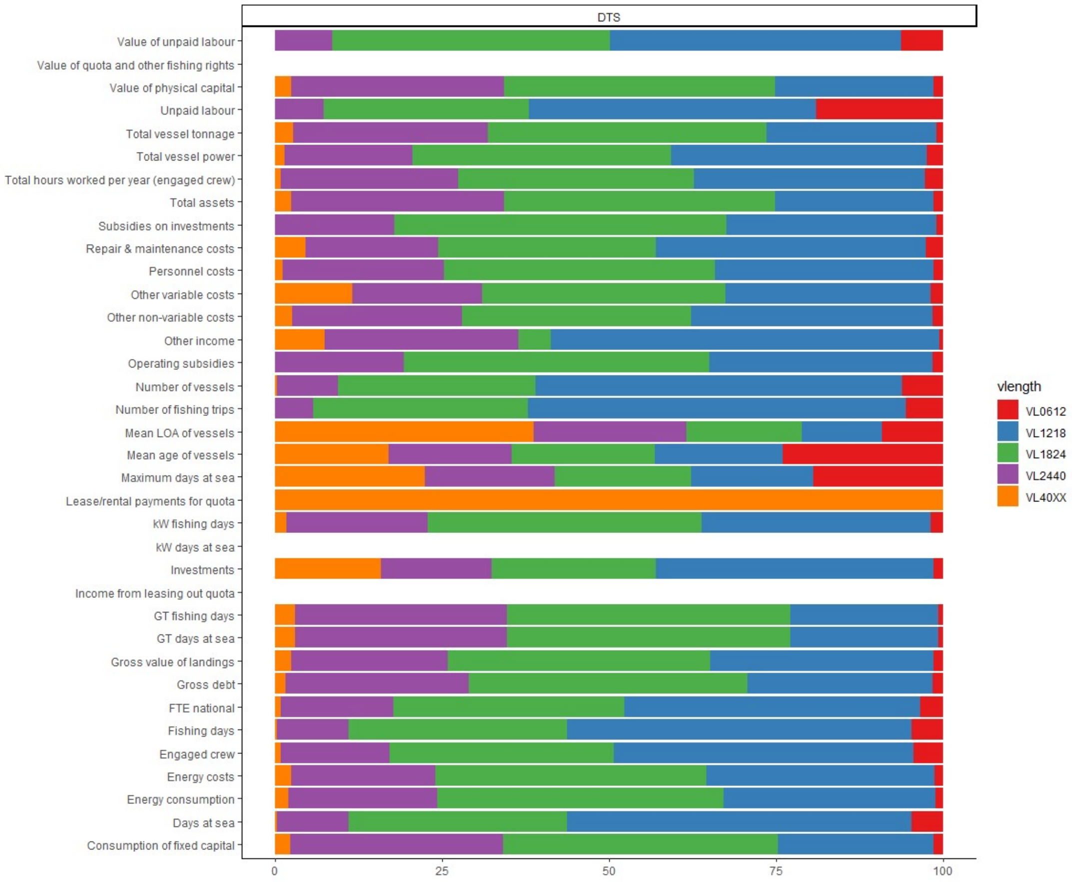


Figure 11 - Total economic indicators coverage for the case study area - resulting from AER data

STEP 2 - FIND THE VESSEL’S TRACK BY GLOBAL FISHING WATCH (GFW)

Extrapolate data

In this step, all vessels present in the CS area at a defined moment (here, we use the year 2021 as an example) are identified. The vessels are extrapolated from the GFW dataset, which uses AIS data to identify vessel tracks, fishing areas, and zones of navigation. Furthermore, it has the capacity to identify the ports visited by individual vessels. For more details, see https://globalfishingwatch.org/our-apis/.

The use of the gfwr library in R requires a GFW API token, which users can request from the GFW API Portal. *Save this token to your Renviron file using usethis::edit_r_environ() and adding a variable named GFW_TOKEN to the file (GFW_TOKEN=“PASTE_YOUR_TOKEN_HERE”). Save the Renviron file and restart the R session to make the edit effective.*

STEP 3 - FIND THE PORT VISITED BY GLOBAL FISHING WATCH (GFW)

After obtaining vessels within a specified area for a particular type of gear in a given year, the ports visited by these vessels can be downloaded. This process is undertaken in accordance with a methodology that has been described and validated by GFW. This provides a comprehensive overview of the port's operational dynamics, including the place of landing and the number of vessels arriving at each port (Figure 12).

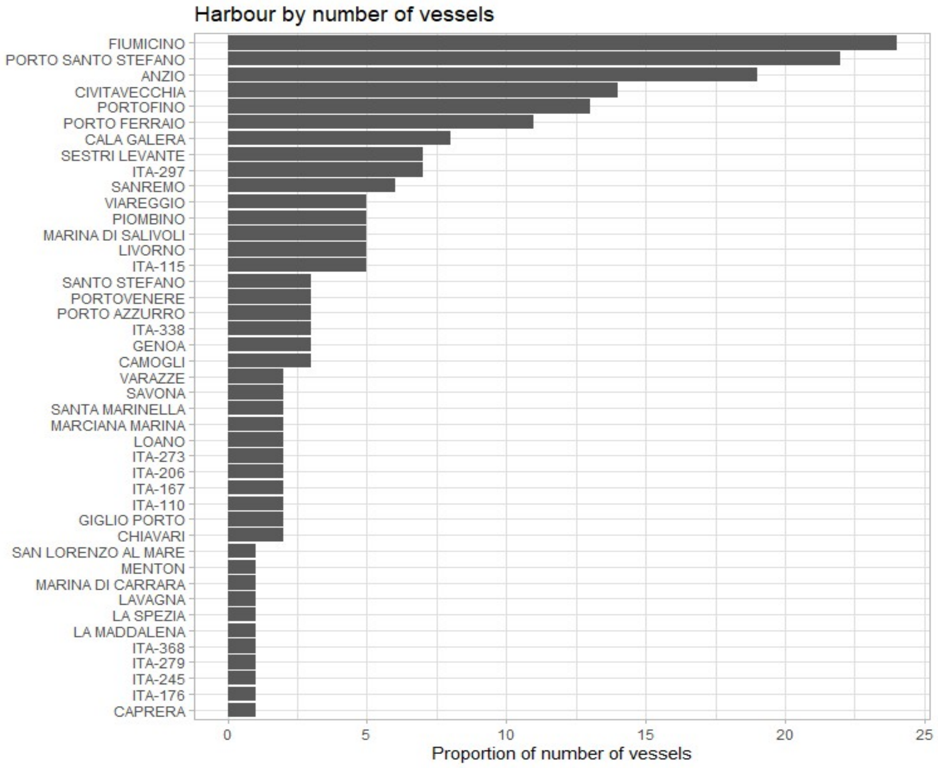


Figure 12 – Number of vessels by port for the CS – resulting from Global Fishing Watch

OPEN FLEET REGISTER AND ADD VESSEL LENGTH (LOA) BY MMSI - VESSEL NAME FOR GFW DATA

At this stage of the process, the port of landing has been established for each vessel. However, vessel length is still needed to complete the FDI data linkage.

It should be noted that data on the length of each vessel can be extracted from the fleet register. To this end, it is recommended that the information on the vessel's length be identified in the fleet register and joined with the MMSI reported in the GFW data.

➔ Unfortunately, we lost ~ 50 vessels because they do not have an MMSI associated with the fleet register

CHECK FOR MAIN PORTS

Subsequently, the landing ports are cleaned, keeping only the main ones. The main ports can be filtered from the EMODNET Main Ports database (Vessels Traffic by Type 1997-2024).

Since the two datasets are not perfectly comparable, all the GFW ports that are also present in the EMODNET dataset shall be identified by performing a joint search on the port name. Then, a buffer of 3 km is created around the EMODNET ports, and the GFW ports within that buffer are assigned the same name as the EMODNET ports.

During this phase, it is essential to consult a Case Study expert who will be able to manually modify the port name in the GFW dataset, where feasible.

Figure 13 – Venn diagram represents port names from EMODNET (Emo_port), Global Fishing Watch (GFW_port) and the resulting overlap.

Finally, the GFW ports are double-checked for those without a valid port name, and the correct nearest port name was assigned to each one. See the leaflet map as an example (Figure 14). GFW ports without ID are in red, while correct ports are in blue. The blue pin represents the correct port. As illustrated in Table 8, a comprehensive overview of all port name reassignments is provided.

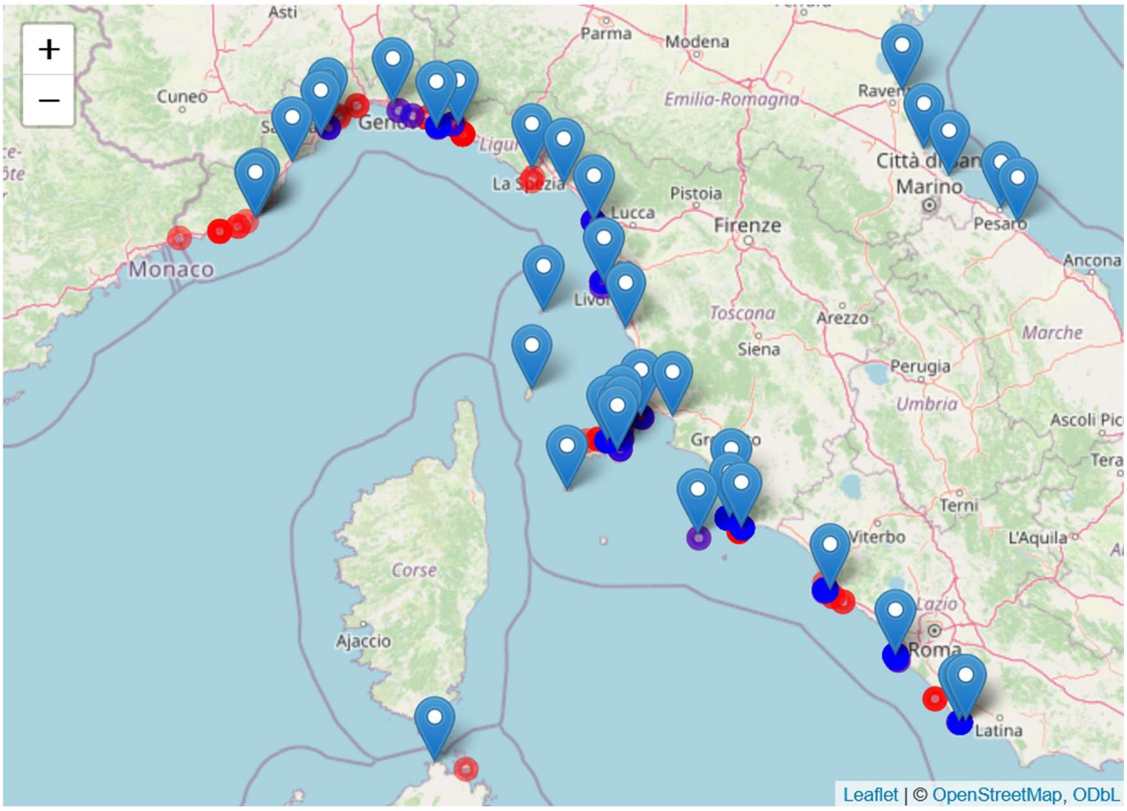


Figure 14 – Leaflet map example to correct the port name.

Table 8 – Port name reassignment and rationale – for FAO GSA9 case study.

Pre-processed Port Name	Resulting Port Name	Rationale
CALA GALERA	PORTO ERCOLE	Name correction
GENOA	GENOVA	Name correction
GIGLIO PORTO	ISOLA DEL GIGLIO	Name correction
PORTO FERRAIO	PORTOFERRAIO	Name correction
ITA-110	RIO MARINA	EMODNET port buffer
ITA-167	CAVO	EMODNET port buffer
ITA-338	ANZIO	Spatial correction
ITA-206	CIVITAVECCHIA	Spatial correction
SANTA MARINELLA	CIVITAVECCHIA	Spatial correction
ITA-368	CIVITAVECCHIA	Spatial correction
ITA-297	PORTO ERCOLE	Spatial correction
ROMA	FIUMICINO	Name correction
ITA-115	PORTOFERRAIO	Spatial correction
MARCIANA MARINA	PORTOFERRAIO	Spatial correction
MARINA DI SALIVOLI	PIOMBINO	Spatial correction
PORTOVENERE	LA SPEZIA	Spatial correction
LAVAGNA	CHIAVARI	Spatial correction
SESTRI LEVANTE	CHIAVARI	Spatial correction

CAMOGLI	GENOVA	Spatial correction
ITA-273	GENOVA	Spatial correction
VARAZZE	SAVONA	Spatial correction
SAN LORENZO AL MARE	IMPERIA	Spatial correction
SANTO STEFANO	IMPERIA	Spatial correction
SAN REMO	IMPERIA	Name correction
SAN REMO	IMPERIA	Spatial correction

As a result of the procedure, the main port of landing for each vessel is defined (Figure 15 – Map of the main port for the GSA9 case study.), and the next step is to link the effort to each port.

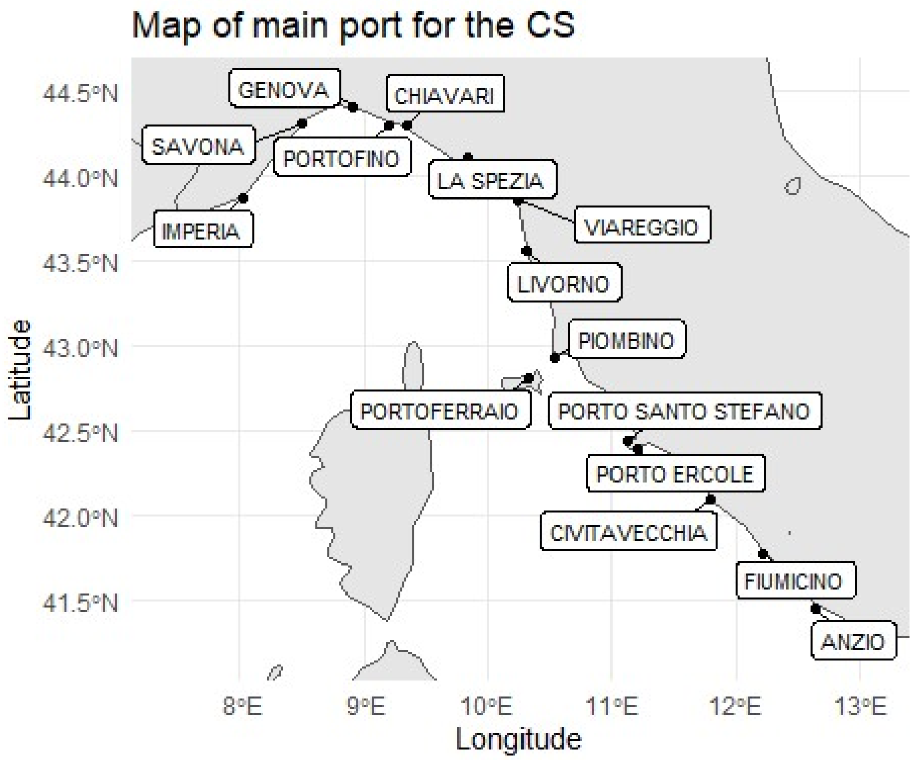


Figure 15 – Map of the main port for the GSA9 case study.

FIND THE NUMBER OF VESSELS AT EACH PORT

At this phase, the number of fishing vessels by each port is calculated for each type of fishing gear and length of vessel.

- ➔ Remove quarter: The data is aggregated by year, and the seasonal variation is removed because the AIS data in this case study does not have optimal resolution.

STEP 4 - DISAGGREGATION PROCESS

EU DCF Economic AER disaggregation by spatial unit (cell)

Compute the disaggregation of the economic data for each cell. Here, the disaggregation of the Gross Value of Landing (GVL) is presented.

The disaggregation of the GVL is carried out by distributing the aggregate value across spatial cells in proportion to the distribution of fishing effort. Specifically, the effort share is derived as the ratio of fishing days recorded within a given cell to the total fishing days corresponding to the relevant vessel length class. The resulting share is then applied to the overall GVL, yielding the value attributable to each cell. This approach ensures that the spatial allocation of economic value is systematically aligned with observed fishing activity, thereby providing a consistent and methodologically sound basis for economic analysis at a disaggregated spatial scale.

$$GVL\ by\ cell\ _{(g,l,icell)} = GVL_{(g,l)} \times Effort\ shared_{(g,l,icell)}$$

$$Effort\ shared = \frac{Fishing\ days_{(g,l,icell)}}{\sum Fishing\ days_{(g,l,icell)}}$$

Where *g* is the gear type, *l* is the vessel length, and *icell* is the cell.

Note: It is recommended to add GFW data by gear and vessel length, and to check differences between GFW effort data (hours of fishing) and FDI data (days of fishing) (Figure 16) to ensure consistency and reliability.

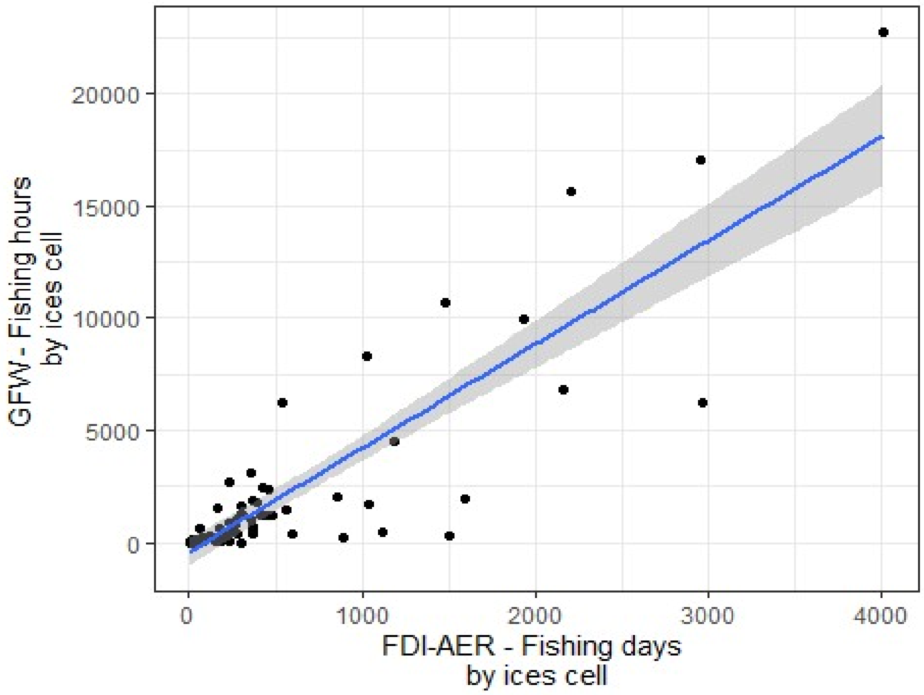


Figure 16 - Correlation between fishing days reported by FDI-AER and fishing hours estimated by GFW per cell. Black dots represent observations, the blue line indicates linear regression, and the grey area indicates the confidence interval.

FDI EFFORT - AER DISAGGREGATION BY SPATIAL CELLS

Since there is a linear relationship between GFW effort and FDI fishing days, we can simply divide the FDI data by cell by the number of vessels in a given cell. The resulting map is indicative of spatial variations in the GVL within the designated case study area (Figure 17 and Figure 18).

$$GVL\ by\ vessel = \frac{GVL\ by\ cell_{\ (g,l,icell)}}{n.vessel_{(g,l,icell)}}$$

Where *g* is the gear type, *l* is the vessel length, and *icell* is the cell.

OUTPUT

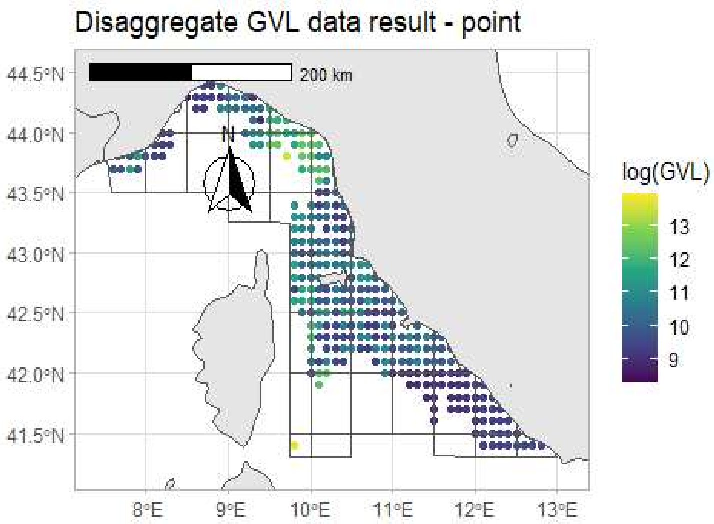


Figure 17 - Map of the Gross Value of Landings (GVL) resulting from the disaggregation process – by points

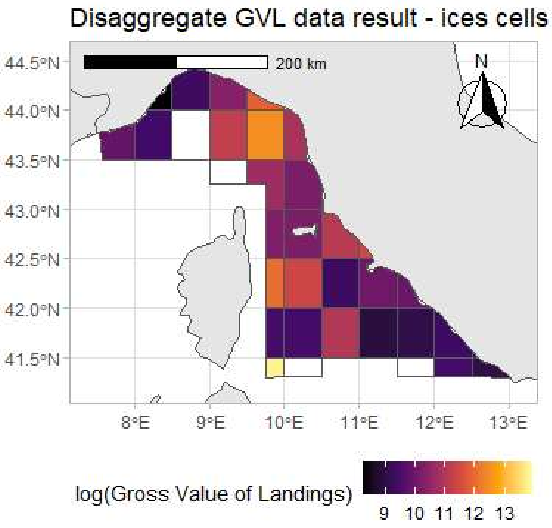


Figure 18 - Map of the Gross Value of Landings (GVL) resulting from the disaggregation process – by spatial cell

The same disaggregation procedure can be applied to each port. Given the availability of vessel counts by port, the data can be disaggregated by port, gear type, and vessel length (Figure 19).

$$GVL\ by\ port_{(g,l,p)} = GVL_{(g,l)} * weight_{(g,l,p)}$$

$$weight_{(g,l,p)} = \frac{n.\,vessel\ by\ port_{(g,l,p)}}{\sum n.\,vessel\ by\ port_{(g,l,p)}}$$

Where *g* is the gear type, *l* is the vessel length, and *p* is the port.

Figure 19 - Distribution of gross value of landings (GVL) weighted by port and vessel length class.

2nd PROTOCOL - FDI LANDINGS (SPECIES KG AND PRICE) BY PORT

The protocol is designed to disaggregate FDI landing data for a time-series.

STEP 1 - OPEN AND SUBSET FDI LANDING DATA

Total landings coverage for the case study area - resulting from FDI data (Figure 20).

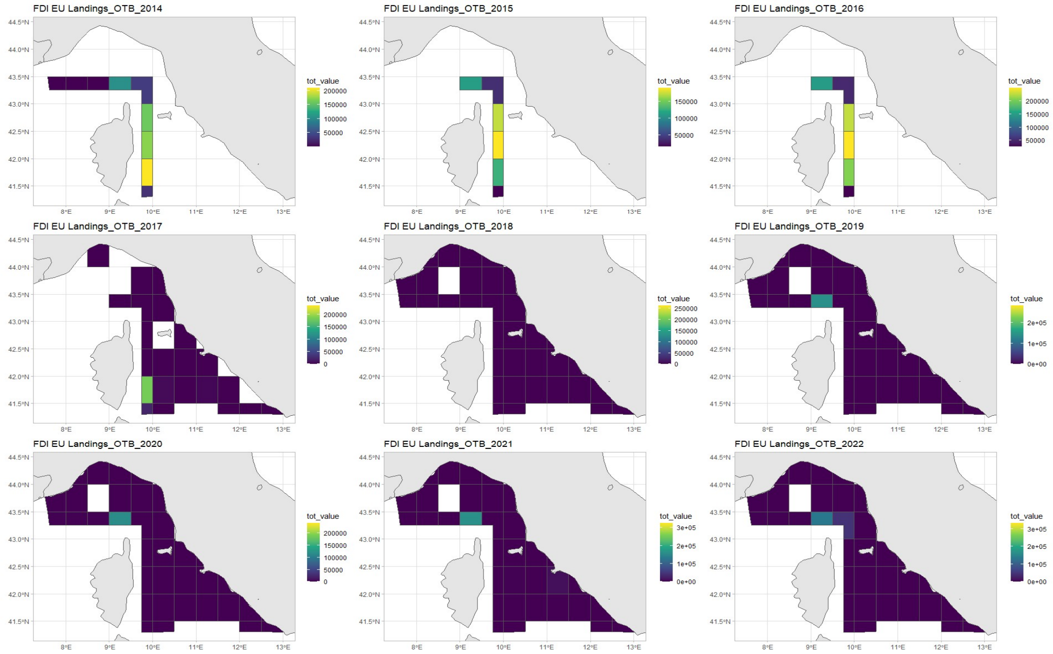


Figure 20 – FDI landings coverage for the case study area

Firstly, the first three years (2014–2016) were removed due to a lack of data.

STEP 2 - FILTER AND CLEAN LANDING DATA

Following this, only species with values in all years of the time series were selected. An outlier check was then performed. Figure 21 represents an example of a time-series showing annual price trends for 29 marine species in the top panel. While the bottom panel represent a scatter plot for each species illustrating the relationship between annual catch (yearly_kg) and price for the same species. Red points reveal potential correlations between supply and economic value, offering insights into market actions and resource management.

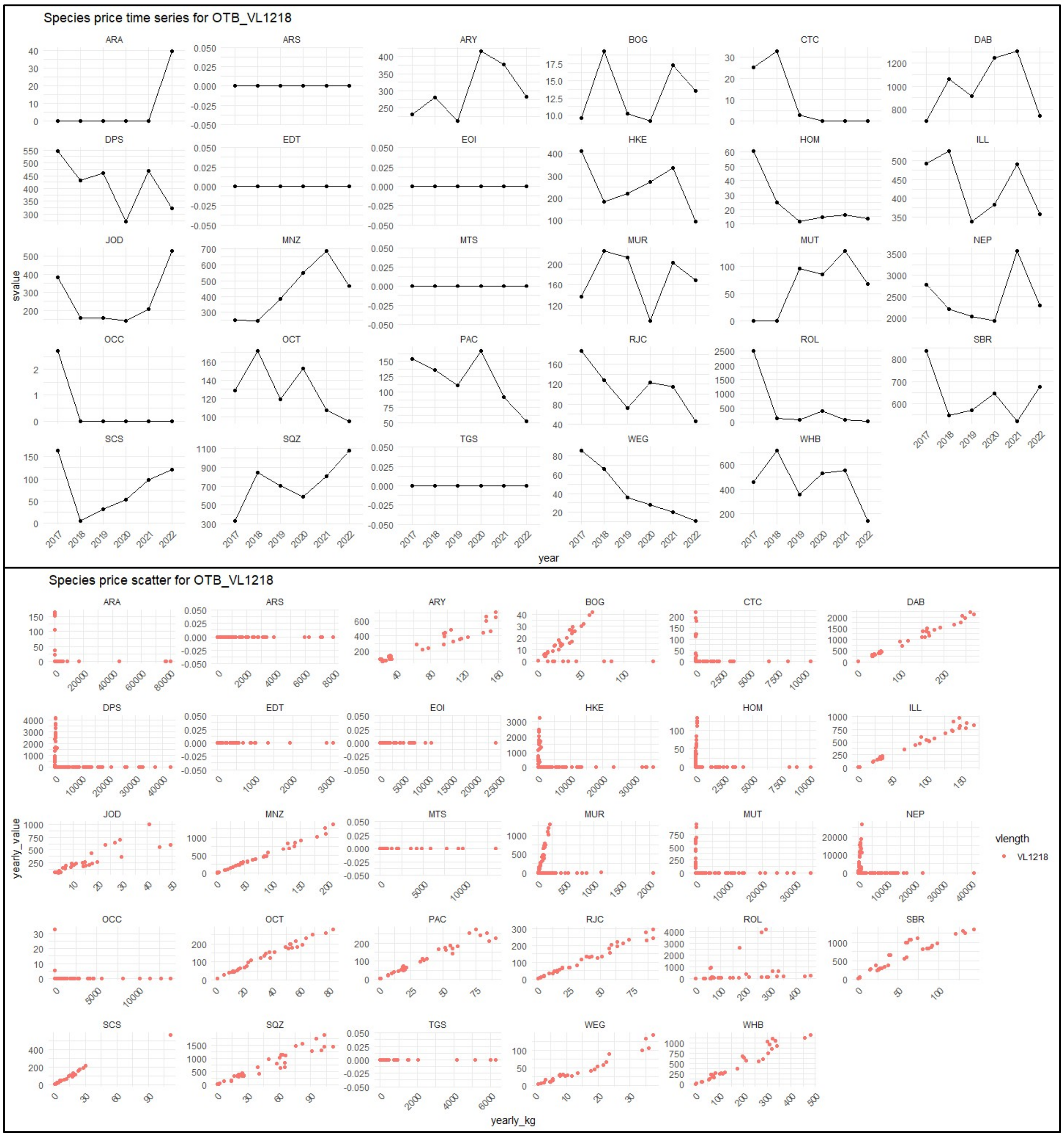


Figure 21 – on the top panel: FDI landing value time-series for 29 marine species caught in the GSA9; on the bottom panel: scatter plot of the relationship between species-gear-vlength landing value and abundance – example for OTB Vessel length between 12-18 m (VL1218).

Some species exhibit zero values across the entire time series for specific gear and vessel length combinations; these cases are excluded. For other species, data are missing in certain years. A strong positive correlation is observed between value and kilograms. To address the missing data, the linear relationship between value and kilograms is estimated for each species and used to impute the missing points in the time series.

If the relationship between value and kilograms proved to be non-linear for a given gear–vessel length–species combination, missing values are instead estimated using a simplified linear regression that do not account for vessel length. In these cases, the regression is applied at the gear–species level to impute the missing data (Figure 22).

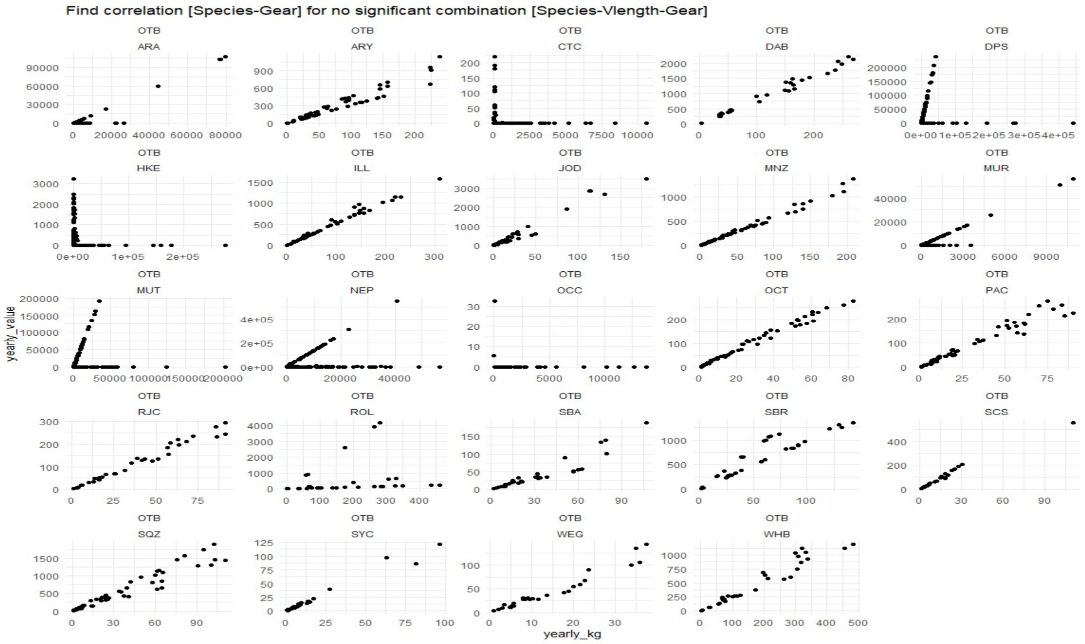


Figure 22 - scatter plot of the relationship between species-gear landing value and abundance – example for OTB.

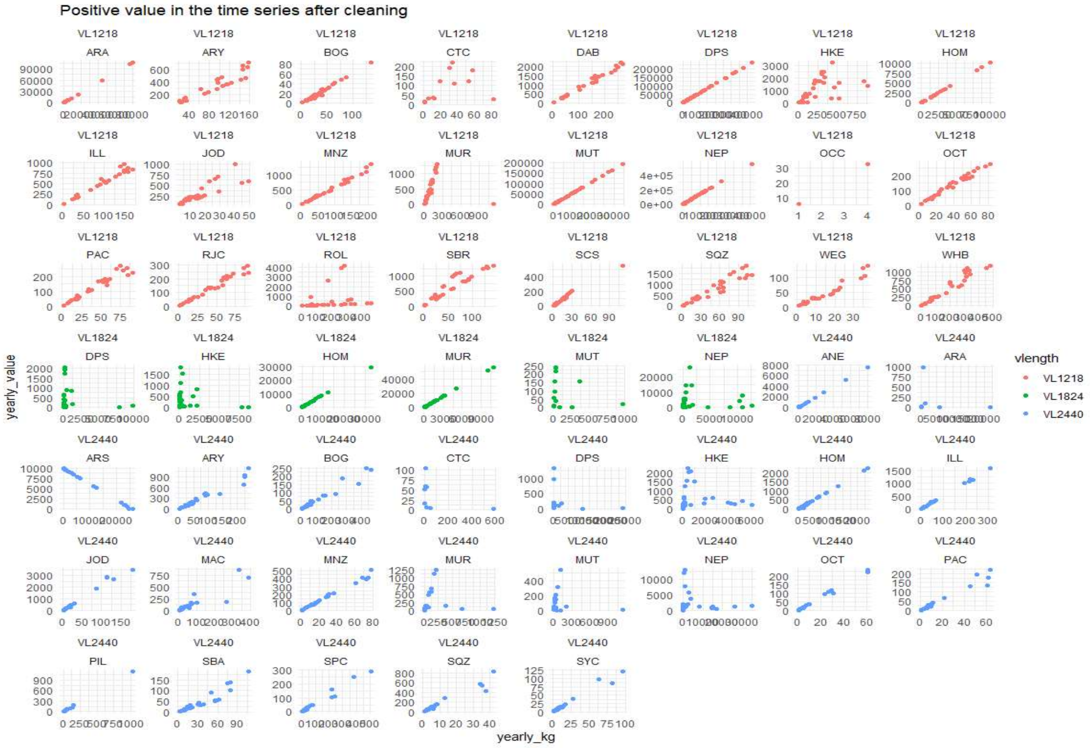


Figure 23 – Resulting relationships between species landing value and abundance after cleaning.

Now we are ready for disaggregate data by landing port (Figure 23). First, we remove the remaining zero values, and we calculate the price as:

$$Price_{(g,l,s)} = \frac{value_{(g,l,s)}\ (€)}{abundance_{(g,l,s)}\ (Kg)}$$

Where *g* is the gear type, *l* is the vessel length, and *s* is the species.

Before disaggregation, only the first 20 species by landing abundance are selected (Figure 24 and Figure 25).

Figure 24 – Species price time-series by vessel length for the selected species in the GSA9 case study.

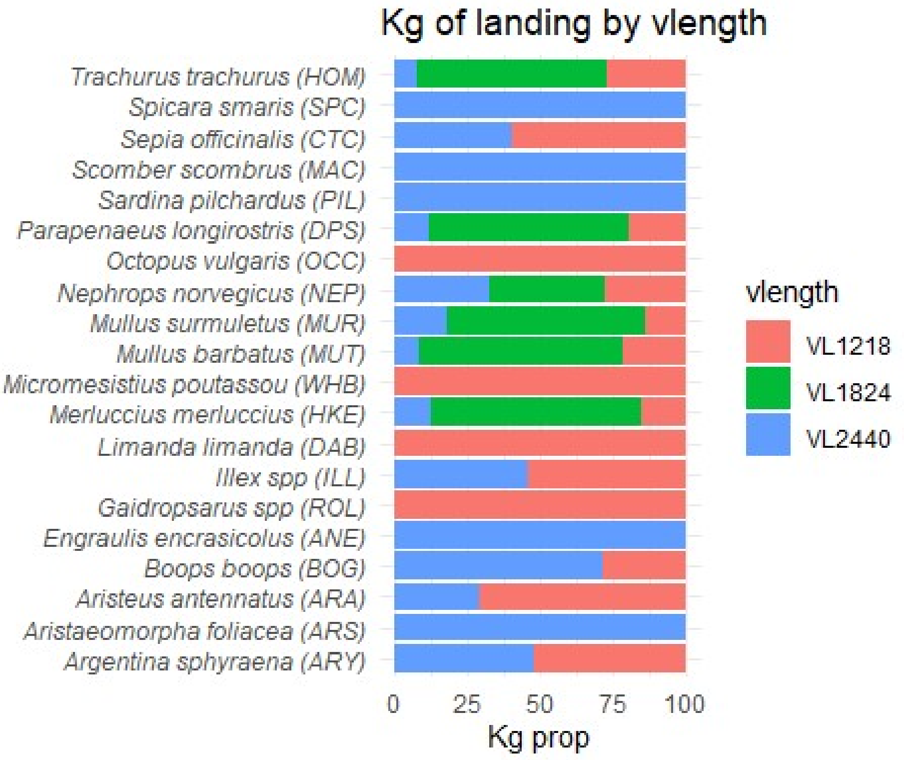


Figure 25 – Species kg proportion by vessel length for the selected species in the GSA9 case study.

STEP 3 - CALCULATE AND ADD PRICE BY SPECIES

For each port, gear, and vessel length, the relative share number of vessel is then calculated by dividing the number of vessels in each category by the total number of vessels present in that port. This produces the weights used to distribute landing values and quantities across ports.

$$weight_{(g,l,p)} = \frac{n.\,vessel\ by\ port_{(g,l,p)}}{\sum n.\,vessel\ by\ port_{(g,l,p)}}$$

Where *g* is the gear type, *l* is the vessel length, *p* is the port, and *s* is the species.

The previously calculated weights are then joined with the species price resulting dataset, allowing landings to be distributed across ports. Following this process, the weighted price by species are calculated (Figure 26).

$$Price\ by\ port_{(g,l,p,s)} = Price_{(g,l,s)} * weight_{(g,l,p)}$$

Where *g* is the gear type, *l* is the vessel length, *p* is the port, and *s* is the species.

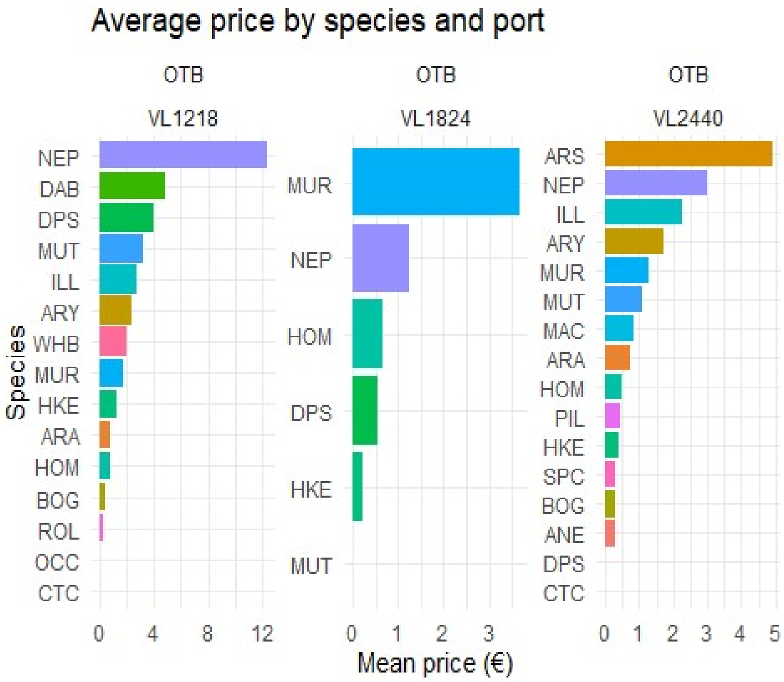


Figure 26 – Species price by vessel length for the selected species in the GSA9 case study.

CONCLUDING REMARKS FOR THE PELS PROTOCOL

Overall, the disaggregation protocol provides a replicable and adaptable framework to enhance the spatial granularity and analytical potential of fisheries socio-economic data. While subject to certain limitations, chiefly related to data availability and resolution, the approach demonstrates the feasibility of integrating heterogeneous data sources (FDI, AER, GFW, and fleet register) to derive vessel-level and port-level indicators. This not only improves the precision of fisheries monitoring and assessment but also strengthens the foundational data layer required for advanced socio-ecological modeling within the Digital Twin of the Ocean. Future work will focus on validating this methodology across multiple regions and fleet segments, with the goal of operating it within broader simulation workflows and policy support tools.

Scientific Coordinator

Patrycja Antosz | paan@norceresearch.no

Project Management

Claudia Zoller | PMO-SURIMI@norceresearch.no

Press and Communications

Pamela Cardillo | pamela@erinn.eu

Ladina Jeisy | ladina@erinn.eu

More Information

Website | surimi-project.eu

X | @surimi_project

LinkedIn | SURIMI Project

Bluesky | @surimi-project.bsky.social

Funded by the European Union

Funded by the European Union under the Horizon Europe Program, Grant Agreement No. 101157456 (SURIMI). Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Climate, Infrastructure and Environment Executive Agency (CINEA). Neither the European Union nor the granting authority can be held responsible for them.

UK Research and Innovation

UK participants in SURIMI are funded by the UK Research and Innovation (UKRI) under the UK government's Horizon Europe funding Guarantee [grant number 10132993].