DELIVERABLE 2.11

Synthetic summary report on social and economic aspects of fishing for online tool

Version 1.0

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Executive summary

This report synthesises the work conducted under SEAwise on the integration of socio-economic dimensions into mixed-fisheries bio-economic modelling and the operationalisation of Ecosystem-Based Fisheries Management (EBFM) in Europe (SEAwise WP2).

The work focused on two objectives:

- To identify the key social and economic benefits of fisheries, including their role in employment, revenues, food supply, health, and community resilience.
- To assess how management measures affect these benefits, under changing climatic and socio-economic conditions.

The work built on EU and international policy frameworks – including the Common Fisheries Policy (CFP), the FAO Ecosystem Approach to Fisheries (EAF), and the GFCM 2030 Strategy – as well as SEAwise scoping and synthesis workshops. Ten deliverables were integrated, covering literature reviews, enhanced bio-economic sub-models, socio-economic indicators, governance studies, and health assessments. Case studies across four regions (North Sea, Western Waters, Mediterranean, and Baltic) served as testbeds for models and indicators.

The key methodological advances included are:

- Enhanced economic sub-models including, among other things, variable costs, fuel use and price dynamics,
- Behavioural sub-models incorporating fisher decision-making,
- Development of social indicators reflecting employment, wages, vulnerability and community reliance,
- A structured methodology to evaluate health impacts of fish consumption, integrated nutritional benefits and contaminant risks.
- Governance assessments through surveys and case studies.

The work strengthens the capacity of mixed-fisheries models to support EBFM, linking ecological, economic, social, and health objectives. Future priorities include improving gender-disaggregated and community-level socio-economic data, enhancing behavioural modelling, and consolidating governance indicators to ensure more inclusive and adaptive fisheries management in Europe.

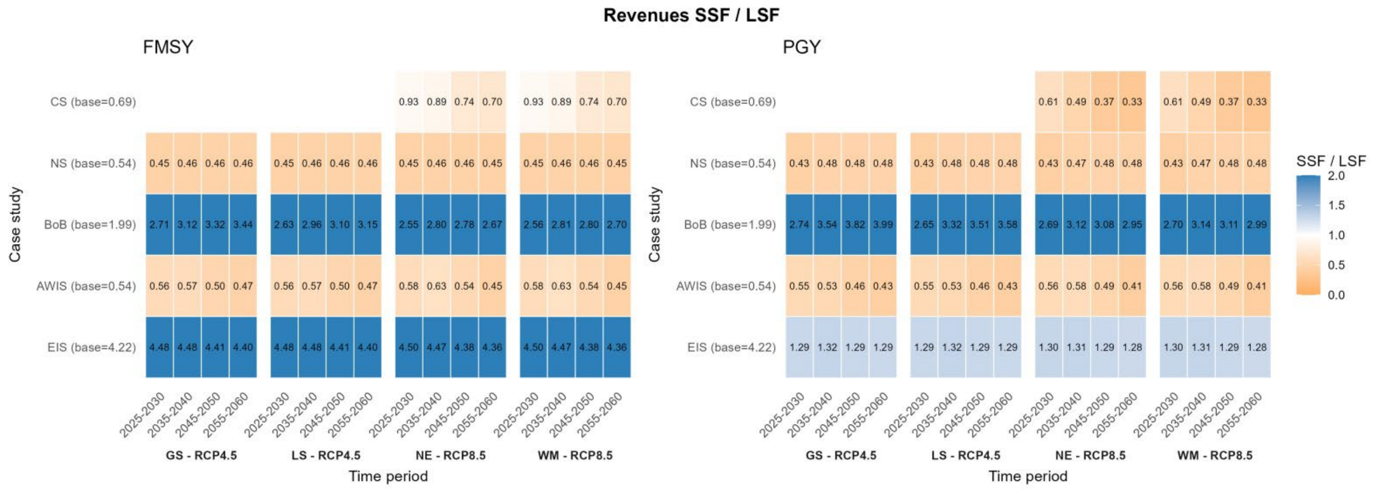
The work confirmed the feasibility of estimating future socio-economic indicators using bio-economic models, while also demonstrating the added value of explicitly linking ecological and social objectives. Across case studies, a consistent pattern emerged: small-scale fisheries (SSF) dominate in terms of vessel numbers and employment, while large-scale fisheries (LSF) contribute more to landings and economic value. The balance between these factors varies considerably between regions, highlighting the importance of tailoring management strategies to local contexts.

The Input–Output analyses revealed that profitability, expressed as Gross Value Added (GVA) to revenues, varies greatly between regions: demersal fleets in the Bay of Biscay showed ratios of around 90%, while in the Eastern Ionian values were as low as 37%. These differences demonstrate how fuel costs, fixed capital intensity, and labour structures shape economic resilience across fleets. Carbon footprint indicators provided additional insights as scenarios consistent with F_{MSY} not only reduced CO_2 emissions per kilogram of fish landed but also preserved larger shares of organic carbon in spawning stock biomass, thereby safeguarding marine blue-carbon functions even under adverse climate projections. In contrast, PGY scenarios sometimes increased overall carbon extraction, particularly when effort levels were higher, demonstrating the importance of effort controls to attain long-term sustainability.

The socio-economic indicators (GVA, wages, meals, revenues SSF-LSF ratio) across management and socio-economic scenarios (CERES) showed that, in several contexts, SSF was crucial in sustaining local jobs and coastal community resilience, but was also more vulnerable to fluctuations in fuel costs and market conditions. Food provision, measured as the number of fish portions generated, highlighted the direct contribution of fisheries to food security,

while health-related analyses showed the dual role of fish as both a nutritional resource and a potential vector for contaminants, with small pelagics and demersals generally offering high benefits at low risk. Governance assessments revealed that inclusivity and trust remain weak points, particularly where top-down structures prevail, yet regional initiatives demonstrated promising pathways for more participatory and adaptive management.

Together, these findings illustrate how socio-economic considerations can be systematically incorporated into fisheries management evaluations, filling critical gaps identified in the literature. SEAwise particularly advanced the state of the art by embedding employment and wage indicators, integrating SSF/LSF differentiation, and linking behavioural dynamics to economic modelling. Moreover, SEAwise extended the analysis to underrepresented regions and explicitly addressed carbon emissions and health impacts, issues previously lacking in fisheries bio-economic studies.



Ratio between SSF revenues and LSF revenues by case study, socio-economic scenario, management strategy and period. The baseline value (SQ–Static Economy–NoCC, 2025–2030) is reported on the y axis. NS: North Sea, CS: Celtic Sea, EIS: Eastern Ionian Sea, AWIS: Adriatic and Western Ionian Sea, BOB: Bay of Biscay. GS: Global Sustainability, LS: Local Stewardship, NE: National Enterprise, WM: Worldwide Markets.

The diversity of the four SEAwise case studies ensured that the approaches developed are robust across contrasting contexts. The work demonstrated that management strategies and socio-economic pathways often exert a stronger influence on outcomes than climate change, and that trade-offs between ecological, social, and economic objectives are inevitably context-specific. Future efforts should aim to improve the availability of socio-economic data at disaggregated levels, enhance behavioural modelling to capture fisher responses more realistically, and further incorporate governance indicators in efforts towards EBFM. The approaches developed within WP2 provide a strong foundation for the operationalisation of EBFM in Europe, supporting policy discussions on the sustainability and resilience of fisheries while ensuring that ecological, economic, social, and health dimensions are jointly considered.

Contents

1. SEAwise background

The SEAwise project works to deliver a fully operational tool that will allow fishers, managers, and policy makers to easily apply Ecosystem Based Fisheries Management (EBFM) in their own fisheries. With the input from advice users, SEAwise identifies and addresses core challenges facing EBFM, creating tools and advice for collaborative management aimed at achieving long-terms goals under environmental change and increasing competition for space. SEAwise operates through four key stages, drawing upon existing management structures and centered on stakeholder input, to create a comprehensive overview of all fisheries interactions in the European Atlantic and Mediterranean. Working with stakeholders, SEAwise acts to:

- Build a network of experts - from fishers to advisory bodies, decision makers and scientists - to identify widely-accepted key priorities and co-design innovative approaches to EBFM.
- Assemble a new knowledge base, drawing upon existing knowledge and new insights from stakeholders and science, to create a comprehensive overview of the social, economic, and ecological interactions of fisheries in the European Atlantic and Mediterranean.
- Develop predictive models, underpinned by the new knowledge base, that allow users to evaluate the potential trade-offs of management decisions, and forecast their long-term impacts on the ecosystem.
- Provide practical, ready-for-uptake advice that is resilient to the changing landscapes of environmental change and competition for marine space.

The project links the first ecosystem-scale impact assessment of maritime activities with the welfare of the fished stocks these ecosystems support, enabling a full-circle view of ecosystem effects on fishing productivity in the European Atlantic and Mediterranean. Drawing these links will pave the way for a whole-ecosystem management approach that places fisheries at the heart of ecosystem welfare. In four cross-cutting case studies, each centered on the link between social and economic objectives, target stocks and management at regional scale SEAwise provides:

- Estimates of impacts of management measures and climate change on fisheries, fish and shellfish stocks living close to the bottom, wildlife bycatch, fisheries-related litter and conflicts in the use of marine space in the Mediterranean Sea,
- Integrated EBFM advice on fisheries in the North Sea, and their influence on sensitive species and habitats in the context of ocean warming and offshore renewable energy,
- Estimates of effects of environmental change on recruitment, fish growth, maturity and production in the Western Waters,
- Key priorities for integrating changes in productivity, spatial distribution, and fishers' decision-making in the Baltic Sea to create effective EBFM prediction models.

Each of the four case studies will be directly informed by expert local knowledge and open discussion, allowing the work to remain adaptive to change and responsive to the needs of advice users.

1.1 The role of this deliverable

This deliverable provides a consolidated overview of the ten outputs produced within WP2, with references to the full deliverables for further detail. The report completes Task 2.6 (Fisheries impacts on society) by identifying the key social and economic benefits provided by fisheries and synthesising the societal effects of specific management measures, building on the framework established in Task 1.6.

Results from Task 2.2 were integrated and synthesised for transfer to Tasks 1.6 and 1.7, where they are operationalised within the EBFM tool and toolbox. Insights from the WP2 synthesis workshop guided the selection of key indicators for inclusion in the tool and informed suggestions for improving the prototype of the EBFM toolbox. A dedicated section of the deliverable addresses dissemination, ensuring that results are shared with stakeholders and presented to relevant working groups for feedback and quality assurance.

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1.3 Acronyms and abbreviations

AER: Annual Economic Report;

CFP: Common Fishery Policy;

DEA: Data Envelopment Analysis

EAF: Ecosystem Approach to Fisheries

EBFM: Ecosystem Based Fisheries Management

FTE: full time equivalent

GFCM: General Fisheries Commission for the Mediterranean;

GSA: Geographical Sub-Area (GFCM sensu);

GVA: gross value added

STECF: Scientific, Technical and Economic Committee for Fisheries;

SSF: Small Scale Fishery;

LSF: Large Scale Fishery.

Three alpha codes are used to indicate the species in the document; the last version can be found here: https://www.fao.org/fishery/en/collection/asfis/en.

2. Introduction

Fisheries generate a wide range of societal benefits including but not limited to the production of food, encompassing economic activity, employment, cultural values and heritage, and contributions to coastal community resilience. Understanding these diverse dimensions guided the definition of the WP2 objectives to identify:

- key social and economic benefits of fisheries and
- the effects of fisheries management measures on these.

The SEAwise work on both aspects was informed by a combination of policy and scientific frameworks. Specifically, WP2 integrates the core principles of the CFP, the outcomes of SEAwise scoping, synthesis and review workshops, the FAO EAF, and the GFCM 2030 Strategy. Together, these frameworks provide the foundation for selecting indicators, that are scientifically robust, policy-relevant, and aligned with international sustainability objectives (Figure 2.1).

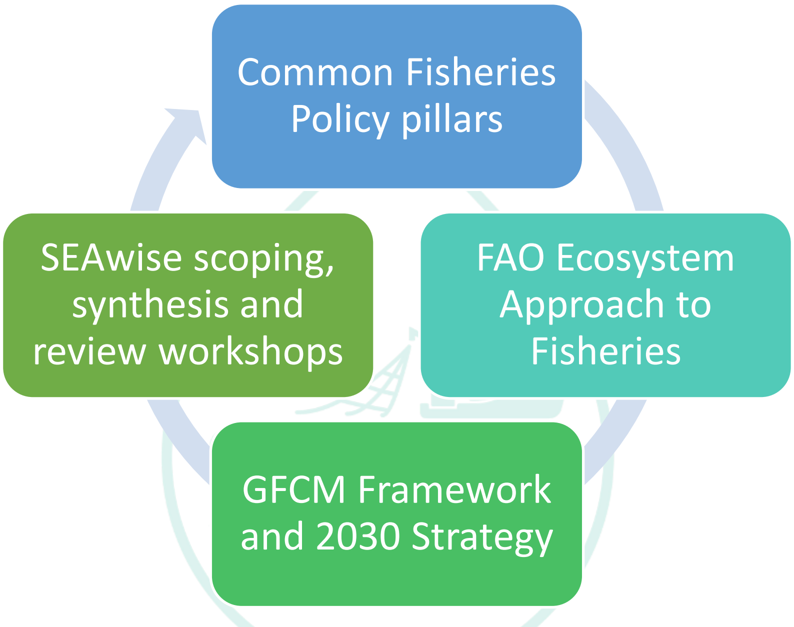

Figure 2.1 Policy and scientific frameworks integrated in SEAwise WP2 to identify the social and economic benefits of fisheries and to identify the effect of management on these.

Within this policy context, the CFP establishes pillars designed to ensure that fisheries contribute to environmental sustainability, economic viability, and social well-being. These objectives are further elaborated by the FAO EAF, which highlights the interdependence of governance (Ability to Achieve), ecological sustainability (Ecological Well-Being), and socio-economic outcomes (Human Well-Being). Accordingly, human well-being and livelihoods are recognized as essential to the long-term viability of fisheries systems, linking fisheries management to dimensions such as food and nutrition security, income generation, employment, diversification of livelihoods, reduction of carbon footprint, and overall quality of life. The SEAwise indicators were selected to align with these dimensions, enabling integrated assessments that support both ecological and societal wellbeing.

At the regional level, the GFCM 2030 Strategy complements these global perspectives by providing a governance framework aimed at reconciling healthy marine ecosystems with socio-economic benefits. Building on this, SEAwise scoping workshops asked stakeholders to identify the aspects of human well-being most in need of attention for the operationalisation of EBFM. The priorities highlighted in the scoping workshops included economy, coastal communities, food supply, health, and employment (Figure 2.2).

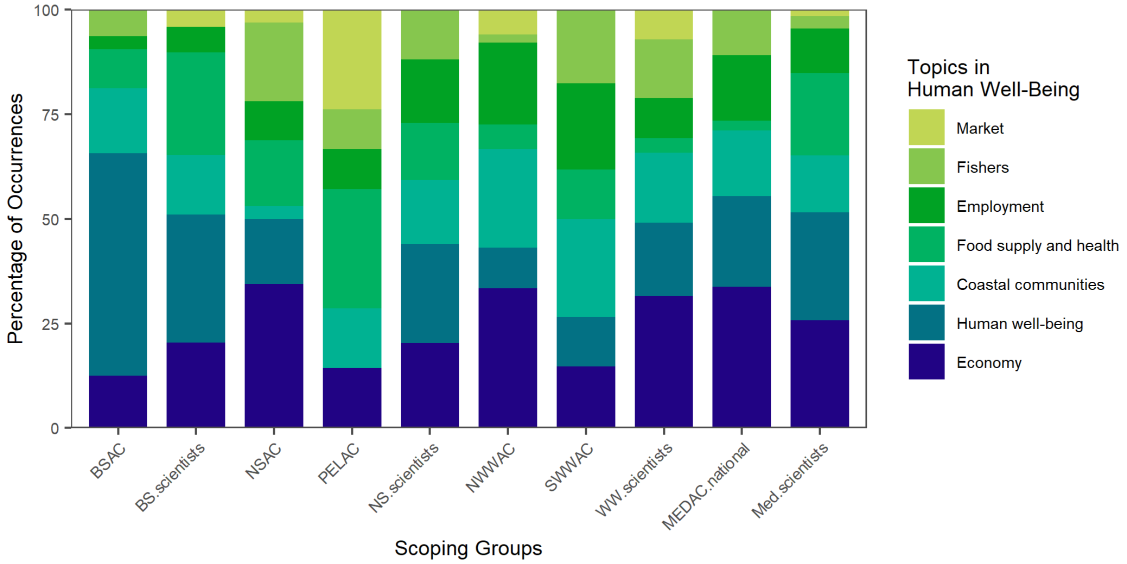

Figure 2.2 Key aspects of human well-being identified during the SEAwise WP2 scoping workshop.

These priorities were then translated into a concrete set of socio-economic indicators through the WP2 synthesis workshop. A targeted questionnaire identified fuel consumption per kilogram of fish and GVA as the most relevant economic indicators, while employment levels and average wages emerged as central for the social dimension. CO_2 emissions were recognised as a cross-cutting indicator, linking environmental and socio-economic performance, complemented by the number of fish portions produced as a proxy of societal contribution. These outcomes confirmed the insights derived from the SEAwise systematic literature review (Task 2.1), showing that topics such as landings, effort, fuel costs, vessel numbers, profits, costs, economic performance, resilience, compliance, and capacity are the most recurrent in existing studies. Importantly, the review also revealed that segmentation between small-scale (SSF) and large-scale fleets (LSF) is consistently addressed in the literature, underlining its importance as a socio-economic dimension (Figure 2.3).

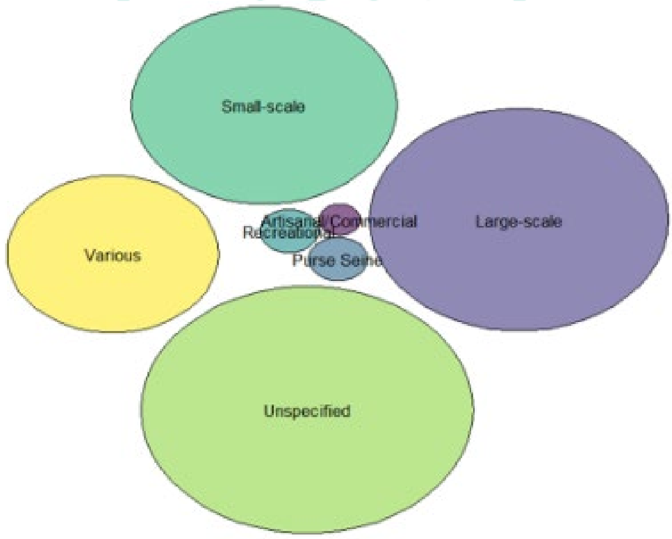

Figure 2.3 Allocation of studies based on fleet scale (from Deliverable 2.1).

Despite this, the SEAwise review identified several gaps in the existing socio-economic literature:

- social well-being indicators such as employment and wages are rarely integrated into impact assessments;
- localised effects on LSF and, in particular, SSF and coastal communities remain underexplored;

- there is a regional bias with strong coverage of the Mediterranean compared to other European seas;
- and adaptive modelling approaches that incorporate fisher behaviour and climate change are infrequently reported.

WP2 addressed these gaps by developing tools and frameworks that reflect the complex socio-economic and ecological realities of European fisheries.

A central dimension emerging from this synthesis is the segmentation of fleets into SSF and LSF, which carries important socio-economic implications (Crilly and Esteban, 2013; Smith and Basurto, 2019). Differences in vessel length and gear type generate heterogeneous impacts on local economies and communities. As a consequence, the European Fisheries and Maritime Fund distinguishes SSF and LSF vessels by defining SSF as vessels under 12 m not using towed gears, a definition consistently applied in the STECF Annual Economic Report (STECF, 2022) to separate socio-economic indicators for small- and large-scale fleets. SSF account for 59% of on-board jobs and contributes to European food security, cultural heritage, and synergies with related sectors such as gastronomy and tourism (GFCM; Pascual-Fernández et al., 2020). At regional level, the evaluation of their sustainability is further supported by GFCM initiatives, including the SSF Friends Platform and the mapping of SSF initiatives. Building on this context, SEAwise adopted operational definitions of SSF and LSF tailored to data availability, distinguishing fleets by gear type and vessel length in the Mediterranean (<12 m non-trawl vs. trawl/longer vessels) and by a 24 m threshold elsewhere, where finer segmentation was not possible.

Fisheries intersect directly with community resilience. Fishing communities have been identified by ICES WGSOCIAL (ICES, 2024) as multi-dimensional entities—geographical, cultural-historical, and practice-related (Clay and Olsen, 2008)—and STECF has further contributed to the development of coastal community profiles (STECF, 2019, 2020). Building on this foundation, SEAwise case studies combined fleet registers, EU-MAP landings, and VMS/AIS data with socio-economic indicators to construct profiles of fishing-dependent communities. These were used to derive indices such as the Social Vulnerability Index and the Fishing Engagement & Reliance Index, which captures both the degree of dependence on fisheries and the resilience of communities to regulatory or environmental change.

Governance provides another critical dimension, shaping how institutions and stakeholders interact to balance ecological sustainability with socio-economic objectives. Within SEAwise, governance was examined through surveys and case studies across European seas to explore how decision-making frameworks, stakeholder engagement, and coordination mechanisms influence fisheries management. Health is also integral, as fish consumption represents both a source of essential nutrients and a potential vector for contaminants. SEAwise addressed this by developing a structured methodology to integrate nutritional benefits and contaminant risks, aligning public health with fisheries management considerations (Caro et al., 2023).

Together, these dimensions—SSF/LSF segmentation, community resilience, governance, and health—frame the socio-economic scope of SEAwise WP2 and provide the basis for the assessment of management impacts in the project's four case studies: Western Waters, North Sea, Baltic Sea and Mediterranean Sea. Within each case study, bio-economic models were parameterized, enhancing and refining the socio-economic components (Bitetto et al., 2024a) and integrating the climate effect on stock productivity (Melià et al. 2024) to quantify the social and economic impacts of management measures.

3. Methodology

To identify **key social and economic benefits of fisheries**, SEAwise scrutinised the current state of different dimensions:

- economic relevance of the fisheries across the considered regions (e.g. profit, costs);
- social impact of fisheries, in terms number of FTE across regions and fishing communities depending of fishing;
- number of meals provided by the fisheries;
- health benefits and risks of fish consumption to support informed choices and integrate health into EBFM.

To investigate **how the management affects social and economic benefits of fisheries,** SEAwise applied bio-economic models, as FLBEIA and BEMTOOL, and analytical methods for performance and volatility assessment, as Data Envelopment Analysis (DEA) and Multivariate Generalized Autoregressive Conditional Heteroskedasticity (MGARCH) across different regions. The investigations considered:

- the differentiation between SSF and LSF;
- calculating socio-economic indicators of food and nutrition security, carbon footprint and economic gain;
- exploring scenarios with changing climate and market conditions;
- exploring where fisheries governance can be improved, to enhance effectiveness and by tailoring governance to each fishery.

The impact of the management scenarios is quantified across the case studies differentiating between SSF and LSF. For the Mediterranean, SSF was defined as vessels using gears other than trawl and with length below 12 m, while LSF are the vessels using trawls (of any length) and vessels longer than 12 m using other gears. For the other case studies, SSF is defined as vessels below 24 m and LSF as vessels above 24 m, reflecting the resolution of the available economic data which did not allow a split between < 12 m and > 12 m.

3.1 Identification of the key social and economic benefits of fisheries

3.1.1 Economic relevance of fisheries

For each case study and country within the case, four key socio-economic variables were quantified: Full-Time Equivalent employment (FTE), landings volume (land), landings value (land_val), and number of vessels. Data were compiled for the 2019–2021 period and expressed as the proportional share of each fleet segment (SSF and LSF) relative to the total for the respective case study or country. This proportional approach enables direct visual comparison between fleet segments across different geographical and fishery contexts.

Building on this comparative framework, the analysis explored economic drivers influencing fleet performance, with a specific focus on the dependency on fuel price and fish price. Correlation analyses were conducted for each case study, considering the main commercial species separately for SSF and LSF. Monthly series of average first-sale prices per species and average fuel prices were compiled for 2019–2021, and linear correlation coefficients were calculated to test whether fluctuations in fuel costs were associated with changes in fish prices ($p < 0.05$).

To further expand the analysis from fleet-level performance to economy-wide effects, the assessment of the societal impacts of fisheries management measures was conducted using an Input–Output (IO) framework, a well-established system that records inter-industry transactions and sales to final consumers (Briggs et al., 1982). This approach distinguishes between direct effects (changes in first-sale revenues), indirect effects (impacts generated through linkages with other industries), and induced effects (income re-spending within the economy). Due to data limitations, Deliverable 2.10 (Bitetto et al., 2024b) focused on direct effects only, applying supply and use tables at the case study level. Fishing activities were disaggregated into SSF and LSF segments by area and Country, with products defined as revenues from the main target stocks (e.g., hake, red mullet). Costs were separated into variable (fuel, other operating expenses) and fixed (repair and maintenance, other fixed costs), establishing explicit links to the corresponding relevant economic sectors. Socio-economic indicators included GVA, FTE, capital costs, and labour costs, all averaged for the 2019–2021 period, with national-level import/export data reported where available.

3.1.2 Social impacts of fisheries

The analysis of the social impacts of fisheries was based on a detailed investigation of the factors influencing the fisher behaviour (Deliverable 2.5, Kraan et al., 2022). Nine fleet-specific case studies were selected to capture the diversity of the following European fisheries:

- Dutch beam-trawl fleet in the southern North Sea;
- English inshore fleet in North Sea;
- German demersal trawlers in North Sea;
- Belgian demersal trawlers in North Sea;
- Scottish creel fishery in North Sea;
- French small scale fishers in English Channel/Celtic Sea and Bay of Biscay (Western Waters);
- French pelagic purse-seiners in Bay of Biscay (Western Waters);
- Southern Adriatic and western Ionian Sea trawlers (Mediterranean Sea);
- Eastern Mediterranean small-scale fleet in the Aegean Islands (Mediterranean Sea);

Each case study adopted a mixed-methods protocol. First, high-resolution VMS/AIS tracks, logbooks and cost–revenue files were assembled to map where, when and at what cost vessels operate. Second, semi-structured interviews, focus groups and—in several ports—short ethnographic stays on board were conducted to uncover socio-cultural drivers that numbers alone cannot reveal (family tradition, peer pressure at the quay, perceived fairness of enforcement, etc.). The quantitative and qualitative evidence was subsequently translated into behavioural rules earmarked for the fleet-dynamics models used in SEAwise simulations.

Deliverable 2.6 (Kraan et al., 2024) investigated the question of who gains, who loses and where when behaviour changes. A harmonised framework that links fleets to the places and people that depend on them was constructed and piloted in the four SEAwise regional case-studies: western Ionian + Adriatic Sea (Mediterranean), Western Waters (Bay of Biscay–Celtic–Irish Seas), North Sea and the Baltic Sea using a stepped, mixed-methods protocol.

Fleet registers, EU-MAP landings and VMS densities were over-laid in GIS to assign each vessel to one or more “home communities” (ports or coastal clusters, depending on regional geography). National profiles (STECF, 2023) were compiled for Netherlands, Spain and Denmark; fishing communities were mapped for North Sea, Adriatic and western Ionian Sea and Western Waters, while community profiles were drafted through desk research and rapid field visits in Brittany, the Greek islands and selected Baltic fishing villages. Further, harmonised datasets — EU-MAP crew statistics, national census micro-data and business surveys — were combined by factor analysis to build two composite indicators: a Social Vulnerability Index and a Fishing Engagement & Reliance Index. The full workflow was completed for England-and-Wales coastal districts, providing a proof-of-concept that will be extended to other basins as data allow. Where hard numbers were still lacking — for example, to gauge the community-level effects of the invasive round goby on Baltic small-scale fishers — a rapid perception survey was conducted to ground-truth and supplement the indicator set.

3.1.3 Health impacts of different fish species

The SEAwise review of health impact of different fish and fish sizes (Deliverable 2.9; Caro et al., 2023) developed a structured methodology to assess the health impacts of consuming different fish species and sizes, integrating nutritional benefits and contaminant risks. The approach combined data collection, database development, and a scoring system, with a specific focus on European population groups and regional case studies (Figure 3.1.3.1).

Key methodological steps included:

- Data Collection: Nutritional composition data were sourced from national and international databases and complemented by a systematic literature review where data gaps existed. Contaminant data (mercury, PCBs, dioxins, PFAS) were obtained from EFSA databases and recent scientific publications.
- Population-Specific Nutritional Requirements: European dietary reference values (DRVs) were used to tailor the analysis to different demographic groups (children, adults, pregnant and lactating women), accounting for specific nutritional deficits prevalent in certain regions.
- Database Creation & Harmonization: A relational database (PostgreSQL) was developed to integrate heterogeneous data sources, ensuring consistency in units, species identification, and descriptors across nutritional and contaminant datasets.
- Scoring System Development: A normalization process was applied to express nutrient contributions relative to DRVs per portion size. Fish species were scored based on their content of key nutrients (EPA, DHA, iodine, selenium, vitamins D and B12), adjusted for specific population needs.
- Contaminant Risk Assessment: A hazard index was calculated by comparing contaminant levels against health-based guidance values (HBGVs). Highly contaminated species had their recommendation downgraded within the scoring system.
- Risk-Benefit Integration: Nutrient scores and hazard indices were combined to produce a comprehensive ranking of fish species, categorizing them into three consumer-friendly tiers: "Best for you", "Very good for you", and "Good for you".
- Regional Case Studies: The methodology was applied to four SEAwise regional case studies (Mediterranean Sea, Western Waters, North Sea, Baltic Sea), ensuring relevance to local species and population nutritional profiles.

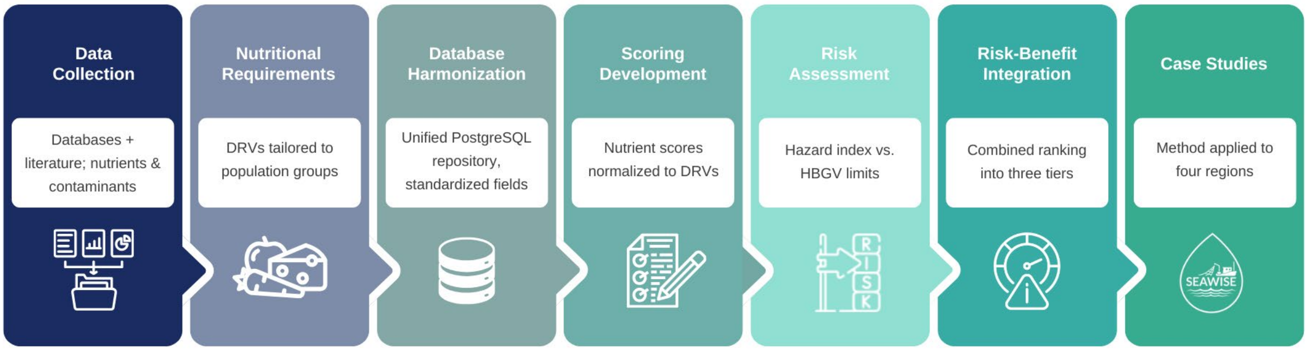

Figure 3.1.3.1 Workflow adopted in SEAwise D2.9: data on fish nutrients and contaminants are gathered, aligned with population-specific dietary needs, harmonised in a relational database, scored for nutritional value, assessed for contaminant risk, combined in a risk-benefit framework, and finally applied to regional case studies to generate consumer-focused fish rankings.

3.2 Management impacts on social and economic benefits of fisheries

3.2.1 Overview of the models and approaches considered

SEAwise applied a range of bio-economic models and statistical approaches to the four case studies. The bio-economic models across the different regions were expanded in their economic components and specifically on fish price sub-models and (where relevant) on behavioural sub-models, following the results achieved in the Deliverables 2.2, 2.5 and 2.6. In some cases, the economic configuration of the fleets was differentiated according to the fishing activity (e.g. metier) to improve the estimation of revenues, variable costs and GVA.

In the most of case studies, the fish price sub-component was enhanced, due to its key role in economic fleet performance. The models were further updated by integrating the enhanced environmentally-mediated stock-recruitment relationships estimated in Deliverable 3.3 and the growth environmentally driven models estimated in

Deliverable 3.4 were integrated. This allowed the evaluation of management under climate change scenarios and to evaluate the combined impact on the different fleets and fisheries.

In Table 3.2.1.1 the models applied in WP2 across the different case studies are listed, summarising the enhancements for each model and case study. For further details on models, their parameterisation and enhancements in SEAwise, see Deliverable 2.2 (Bitetto et al., 2024a).

Table 3.2.1.1 Models available for SEAwise WP2

Case study	Model name	Spatial extent	Species/stocks included	Fleets/metiers/ fisheries included	Enhanced sub-models
North Sea	Bio-Economic Impact Assessment using FLR (FLBEIA)	ICES areas 4, 7d, 3a20 and 6a for stocks extending to 6a (cod, saithe, haddock)	Cod, whiting, haddock, saithe, plaice (4; 7d), sole (4; 7d), turbot, witch, Nephrops FUs	Demersal Fleets and Metiers (46 fleets and 152 metiers)	- fish price sub-models (price elasticity & split price per age); - Recruitment (EMSRRs) and growth environmentally driven.
Western Waters	FLBEIA	ICES area 8	Albacore, anchovy, anglerfish (black and white bellied), bluefin tuna, blue whiting, hake, horse mackerel, mackerel, megrim, monkfish, sardine, sole, thornback ray, nephrops, seabass, starry smooth-hound, cuckoo ray and undulate ray.	Demersal and Pelagic fleets and metiers	- fish price sub-models - Recruitment and growth environmentally driven; - Behavioural sub-model.
	FLBEIA	ICES area 7	Cod, haddock, whiting, monkfish, megrim, sole, hake	Demersal fleets and metiers	- fish price sub-models.
	FLBEIA	ICES area 7e-k	Hake, black and white-bellied angler, sole (7e and 7fg), megrim, whiting, haddock and cod.	Demersal fleets and métiers	- EMSRR included.
Mediterranean	FLBEIA	GFCM GSA20	European hake, red mullet, deep water rose shrimp, striped red mullet, others (all other commercial stocks caught by the fleets treated as one biomass dynamic stock)	Demersal fleets (OTB, SSF)	- fish price sub-models; - EMSRR included.
	DEA	GFCM GSA20	hake, shrimp, striped, red mullet, and red mullet		
	MGARCH	GFCM GSA20	Hake, Shrimp, Red Mullet and Striped Red Mullet	SSF, LSF	Utilization of the GARCH model to assess price volatility and estimate price elasticities of demand for four target species in GSA 20. This statistical model allowed for a more sophisticated analysis of price variance and its relationship with explanatory variables.
	BEMTOOL	GFCM GSAs 17, 18 and 19 (Adriatic and Western Ionian Sea)	European hake (GSAs 17-18 combined; GSA 19), red mullet (GSAs 17-18 combined; GSA 19), deep water rose shrimp (GSAs 17-18-19 combined) giant red shrimp (GSAs 18-19 combined), blue and red shrimp (GSAs 18-19 combined), Norway lobster (GSA 17 and GSA18), common sole (GSA 17).	Demersal Fleets and Metiers: specifically, 1) Mixed demersal trawlers 2) Mixed deep waters trawlers; 3) Small Scale Fisheries; 4) Longliners. In total: 24 fleet segments and related metier.	- EMSRR included. - fish price sub-models by métier; - energy costs modelled by métier
Baltic Sea	BEE-FISH	ICES SD 22-24, Western Baltic	Cod, herring	Trawl fisheries	Economic component (costs & prices); consumer/producer surplus; ecological sub-model

3.2.2 Scenarios explored

In SEAwise Deliverables 2.3 and 2.4 (Bitetto et al., 2024; Bitetto et al., 2025), a set of integrated socio-economic and management scenarios were developed to assess the impacts of fisheries management strategies under changing environmental and market conditions. Four socio-economic scenarios, adapted from the CERES project, were explored (Figure 3.2.2.1):

- Global Sustainability (GS) (RCP4.5, SSP1): global sustainability is prioritized, aiming to limit climate change to the lower RCP4.5 target while striving to promote welfare by balancing economic, social, and environmental considerations, supported by strong trans-boundary cooperation. Key factors such as a smaller global population, improved fish stock management, cheaper sources of fish meal and oil for aquaculture, and increased competition between farmed and wild fish contribute to a more moderate rise in fish prices compared to other scenarios.
- National Enterprise (NE) (RCP8.5, SSP3): governments prioritize national interests, focusing on maximizing welfare and employment within the fishing industry, but with reduced trans-national cooperation. Fish prices remain high to support national wellbeing and due to an increase in per capita consumption. Global warming is expected to follow the RCP8.5 trajectory, driven by limited technological innovation and a heavy reliance on fossil fuels, resulting in a significant rise in fuel prices.
- Local Stewardship (LS) (RCP4.5, SSP2): this scenario envisions a path where sustainability is pursued through small-scale regional efforts, emphasizing equity, social inclusion, and democratic values.
- World Markets (WM) (RCP8.5, SSP5): this scenario is defined by strong demand for affordable seafood (with a moderate rise in fish prices), increased technological innovation driven by global competition, lower taxes, and a robust private sector. While global warming follows the RCP8.5 pathway, the increase in fuel prices is slower than in the "National Enterprise" scenario, due to greater technological advancements.

These scenarios combined different pathways of climate change (RCP4.5 and RCP8.5) with varying trajectories for fish and fuel prices, reflecting political, economic, social, and technological factors influencing the fisheries sector.

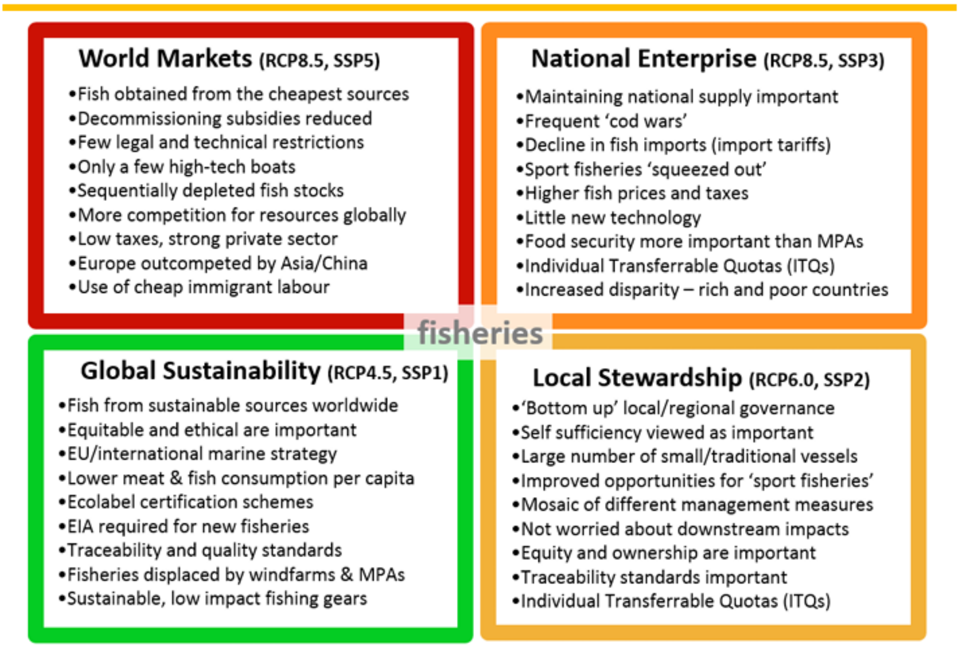

Figure 3.2.2.1 Socio-political scenarios elaborated for European fisheries in CERES project (Peck et al., 2020). Note, no climate projections were made with RCP6.0 in CERES and, for Local Stewardship, RCP4.5 was assumed. RCP4.5 & RCP 6.0 are similar through to 2070.

Management scenarios were tailored to regional contexts. In the Northeast Atlantic, scenarios included: Status Quo effort levels, F_{MSY}-min (strict landing obligation with target fishing mortality), and Pretty Good Yield (PGY), which allows flexible fishing mortality ranges to optimize catches while maintaining sustainability thresholds. In the Mediterranean case studies, scenarios focused on effort control measures aligned with GFCM Multiannual Plans, including status quo effort, effort reduction to reach F_{MSY} or $F_{0.1}$, and multi-species PGY strategies. Additionally, management measures such as gear selectivity improvements, spatial closures and fleet restructuring (e.g., reallocation of effort between static and mobile gears) were explored to assess their implications on economic performance, employment, and carbon emissions. The combination of socio-economic and management scenarios (Table 3.2.2.1) enabled a comprehensive evaluation of trade-offs between ecological objectives, economic viability, and social sustainability under plausible future developments.

Table 3.2.2.1. Socio-Economic and Management Scenarios by Case Study

Case Study	Socio-Economic Scenarios	Management Scenarios	Climate Pathways (RCP)
North Sea	GS, NE, LS, WM	Status Quo, F_{MSY}-min, Pretty Good Yield (PGY), Gear Selectivity Improvements	RCP4.5, RCP8.5
Celtic Sea (Western Waters)	NE, WM	Status Quo, F_{MSY}-min, PGY, Fleet Restructuring (shift to static gears)	RCP8.5
Bay of Biscay (Western Waters)	GS, NE, LS, WM	Status Quo, F_{MSY}-min, PGY, Spatial Closures (dolphin bycatch mitigation)	RCP4.5, RCP8.5
Adriatic and western Ionian Sea (Mediterranean)	GS, NE, LS, WM	Status Quo, Effort Reduction to F_{MSY} or $F_{0.1}$, Multi-Species PGY, Gear Selectivity Improvements	RCP4.5, RCP8.5
Eastern Ionian Sea (Mediterranean)	GS, NE, LS, WM	Status Quo, Effort Reduction to F_{MSY} or $F_{0.1}$, Multi-Species PGY	RCP4.5, RCP8.5

This synthesis focuses on status quo, F_{MSY} and PGY management scenarios, while the extended results for all tested scenarios are reported in Deliverables 2.3 and 2.4 (Bitetto et al., 2025a, Bitetto et al., 2025b).

3.2.3 Selected indicators

The selection of socio-economic and environmental indicators in SEAwise was guided by a structured methodological process, integrating multiple policy and scientific frameworks to ensure relevance, robustness, and alignment with international sustainability objectives. The key reference frameworks included the CFP pillars, the FAO EAF framework, the GFCM Framework and 2030 Strategy, and the outcomes of SEAwise scoping, synthesis, and literature review activities.

Given the WP2 focus on socio-economic and cross-cutting climate impacts, the selected indicators fall predominantly under the Human Well-being domain, and more specifically under its two operational components: Livelihood and Food and Nutrition Security and Carbon Footprint (Figure 3.2.3.1). This mapping ensures that the indicators address both the livelihood dimension – capturing the economic viability of fisheries and the equitable distribution of benefits to coastal communities – and the carbon–food nexus, which integrates climate impacts with the nutritional contribution of fisheries. Such a dual focus responds to the dual imperative of safeguarding socio-economic resilience while reducing the environmental footprint of fishing activities.

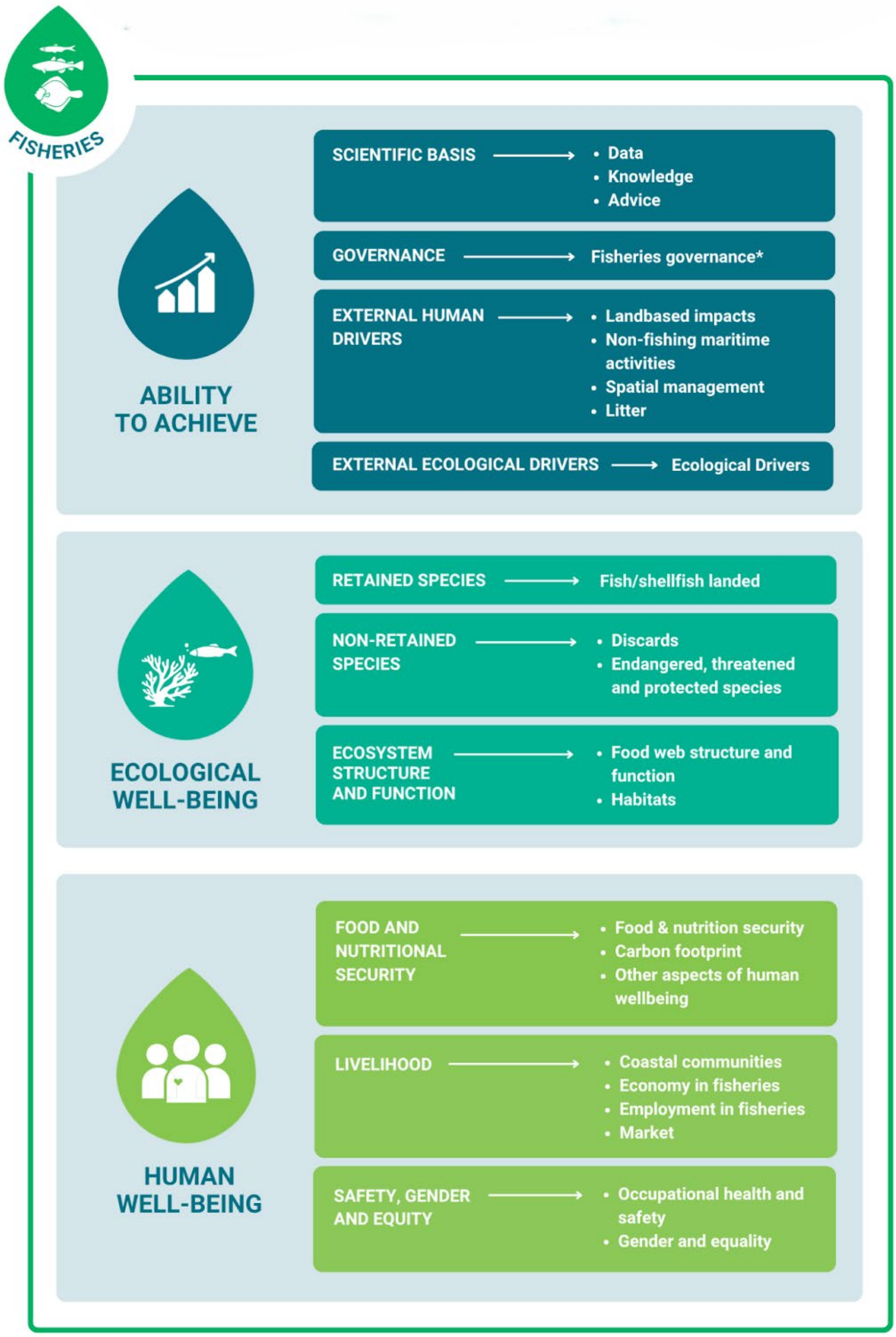

Figure 3.2.3.1 - FAO Ecosystem Approach to Fisheries (EAF) conceptual framework adapted by SEAwise, illustrating the three dimensions – Ability to Achieve, Ecological Well-being, and Human Well-being – and their corresponding operational components.

- **Livelihood indicators**
  - **Socio-economic**: wages (labour costs) and Gross Value Added (GVA), reflecting the direct economic contribution of fisheries and their role in sustaining jobs. GVA quantifies the net economic output of fishing activities, excluding the value of goods and services consumed in the production process:

$$GVA = Revenues - VarCosts - MaintCsts - FixedCosts$$

where VarCosts are the variable costs (fuel costs and other variables costs) and MaintCosts are the repair and maintenance costs.

- **Coastal communities**: Ratio of revenues from SSF to LSF – highlighting the distribution of benefits between SSF and LSF and supporting assessments of equity and resilience in coastal economies.

- **Human well-being indicators** addressing the broader sustainability and societal value of fisheries, integrating environmental performance with social benefits:
  - **Carbon footprint**: CO_2 emissions per kilogram of fish landed, organic carbon (OC) extracted with landings, organic carbon retained in SSB, and CO_2 emissions per meal – providing a cross-cutting measure of climate impact linked to fishing operations, ecosystem state, and final consumption.
    To convert the fuel use efficiency (FUE) to emission intensity (EI) the following relationship, based on Borrello et al. (2013) is used:

$$EI = FUE * 2.853 \left(\frac{kg\ CO_2}{litre}\right)$$

    where Emission Intensity EI is the emission per fishing day and FUE is the fuel consumption per fishing day. The total CO_2 emissions for the fleet segment was estimated just multiplying the EI by the number of fishing days. The CO_2 emissions per kg of fish landed is then derived. The organic carbon extracted with landings is estimated following Martin et al. (2022), assuming a conversion factor of 94% of landed organics carbon to CO_2 emissions (Mariani et al., 2020):

$$OC_{land,f} = Landing_f * 0.113256 * 0.94$$

    the organic carbon in the adult stocks has been estimated to provide highlights on the blue carbon flow due to fish fate influenced by factors different from the fishing. The organic carbon estimation follows the approach used in Martin et al. (2022) as:

$$OC_{SSB} = SSB * 0.113256$$

  - **Food supply**: Number of meals produced – linking landings to their potential nutritional contribution, in line with FAO's emphasis on food and nutrition security. The average numbers of fish meals for an adult was derived from the landings. The edible portion of the landed fish was extracted from FAO (https://www.fao.org/infoods/infoods/tables-and-databases/faoinfoods-databases/en/ and https://www.fao.org/4/t0219e/t0219e01.htm). A standard portion size that an adult would consume has been defined for each country on the basis of the information available on the EU Portal (https://knowledge4policy.ec.europa.eu/health-promotion-knowledge-gateway/topic/food-based-dietary-guidelines-europe_en#nav_Tocch2), with 150 grams of default value. Dividing the edible weight of the fish (landing * edible portion) by the chosen portion size, the number of meals that can be obtained from the landed fish is derived.

3.2.4 Governance Impact on Fisheries

Governance refers to the way public and private actors interact to address societal challenges, create opportunities, and manage shared resources through rules, coordination, and institutions. Effective governance is essential in fisheries management to ensure that diverse stakeholders can coordinate actions, build trust, and develop sustainable solutions that balance ecological health with socio-economic needs.

Governance plays a critical role in advancing Ecosystem-Based Fisheries Management (EBFM), as it provides the structures, processes, and relationships needed to coordinate actions among governments, fishers, scientists, and civil society. EBFM requires managing fisheries not just for stock sustainability, but also considering broader ecosystem interactions and socio-economic impacts. Achieving this balance depends on inclusive governance mechanisms that foster dialogue, trust, and shared decision-making, enabling stakeholders to co-develop adaptive strategies that respond to environmental and social challenges.

SEAwise evaluated fisheries governance in Europe from the perspective of stakeholders, employing a dual research approach: an online survey across the SEAwise Regional Seas (Baltic Sea, North Sea, Western Waters, and Mediterranean Sea) and a set of local/sub-regional case studies.

The survey aimed to capture stakeholders' perceptions on key governance dimensions, including inclusivity, trust, legitimacy, decision-making, information sharing, and coordination. The survey was informed by governance frameworks from the Canadian Fisheries Research Network (CFRN) and the Aquaculture Governance Indicators (AGI), which provided structure for translating broad governance principles into practical survey items. The questionnaire consisted of 31 Likert-scale questions grouped by thematic areas, with optional text fields for qualitative feedback. It was disseminated through purposive sampling, targeting governance actors (fisher representatives, NGOs, academics, policymakers) via direct email invitations and social media. The survey was translated into five languages (English, Greek, Italian, Spanish, and French) to facilitate accessibility. Despite extensive efforts, the survey received a low overall response rate (44 completed responses), limiting cross-regional comparative analysis but allowing for pilot-testing of governance performance indicators.

Complementing the survey, four case studies were conducted at the sub-regional level, providing in-depth qualitative insights into governance dynamics in specific contexts. These included:

- North Sea & Western Waters (Denmark, Belgium, France): Evaluating governance processes for fisheries regulations in Natura 2000 areas through document analysis and semi-structured interviews.
- Baltic Sea (Germany & Denmark): Assessing organizational aspects of high-level advisory commissions via participant observation.
- Mediterranean Sea (Greece): Investigating stakeholder perceptions on fisheries governance in Patraikos Gulf using Q-methodology.
- Mediterranean Sea (Adriatic): Mapping governance of Fisheries Restricted Areas (FRAs) through document analysis and stakeholder surveys using Likert-scale questionnaires.

Case study partners had methodological freedom to tailor approaches suitable to their regional contexts and expertise, which allowed for deep, context-specific findings but limited comparability across cases. Data from the survey and case studies were analysed using descriptive statistics, thematic analysis, and visual matrices (e.g., traffic light approaches) to illustrate governance performance and identify areas for improvement.

4. Results

4.1 Identification of the key social and economic benefits of fisheries

4.1.1 Economic relevance of fisheries

Fleets characterization

Figure 4.1.1.1 shows the percentage share of FTE, landings, landing value and number of vessels of SSF and LSF across the five case studies, with SSF dominates in terms of vessel numbers, while LSF tends to have a greater share of landing value.

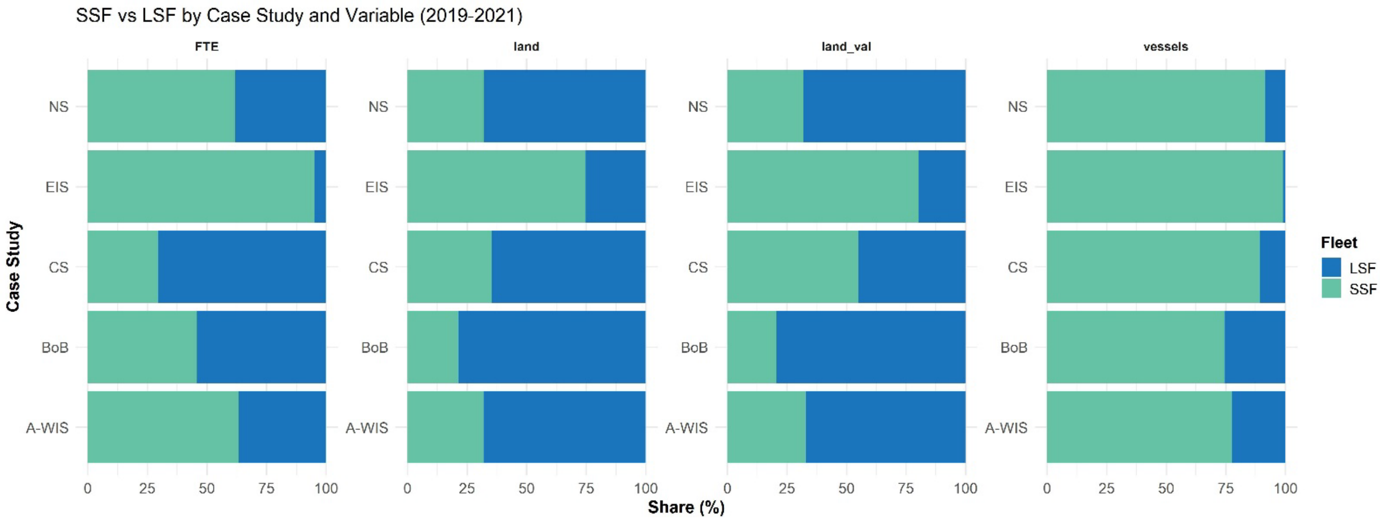

Figure 4.1.1.1- Comparison of Small-Scale Fisheries (SSF) and Large-Scale Fisheries (LSF) by Case Study and Variable (2019–2021) for Full-Time Equivalent (FTE), landing (land), landing value (land_val) and vessels. LSF (dark blue) and SSF (light green) across five case studies: North Sea (NS), Eastern Ionian Sea (EIS), Celtic Sea (CS), Bay of Biscay (BoB) and Adriatic and Western Ionian Sea (A-WIS).

Figure 4.1.1.2 highlights the difference in the balance between SSF and LSF contributions across regions and countries. In the North Sea countries, LSF clearly dominate in terms of landings and landing value (except in Sweden, England and Denmark), while SSF dominates in terms of vessel numbers, with FTE showing mixed patterns across nations. A similar dominance of LSF in landings and value is observed in the Celtic Sea, although here SSF contributions to vessel numbers remain more evident in some countries (e.g. Ireland and France). In the Bay of Biscay, the balance is more heterogeneous, with SSF showing a relatively higher percentage for French fleet, while LSF drive the Spanish and Basque fleets. The Adriatic–Western Ionian Sea case studies are characterised by a strong role of SSF in terms of vessels and FTE, reflecting the prevalence of small-scale fleets in Mediterranean countries, though LSF continue to dominate landing value. In Eastern Ionian Sea, SSF is the dominant fleet for all the indicators.

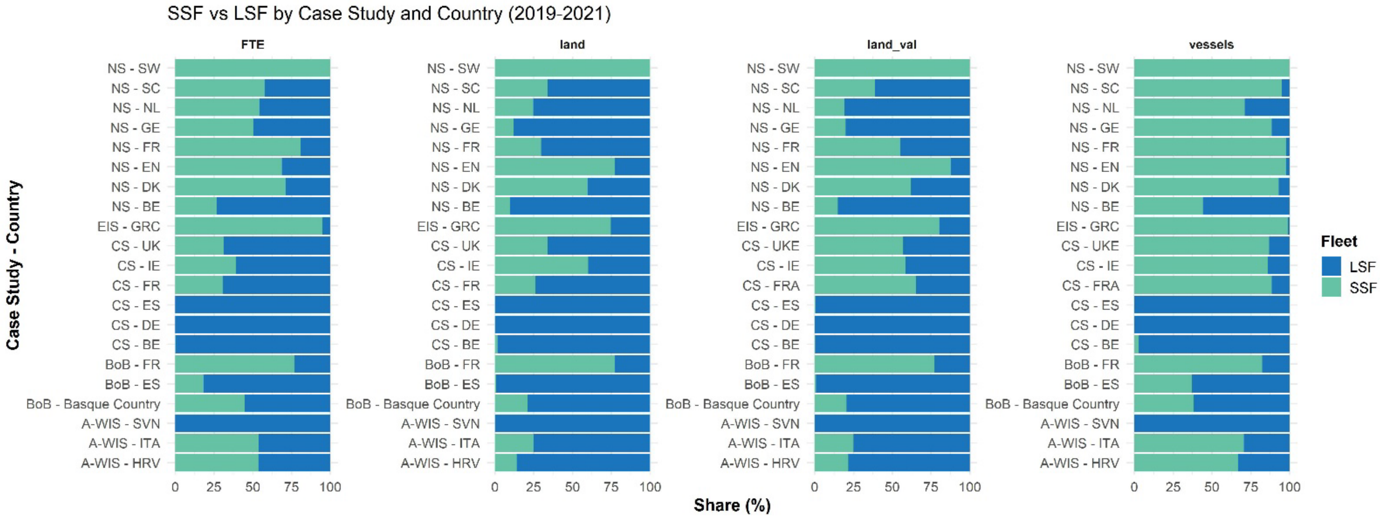

Figure 4.1.1.2- Comparison of Small-Scale Fisheries (SSF) and Large-Scale Fisheries (LSF) by Case Study and Country (2019–2021) for Full-Time Equivalent (FTE), landing (land), landing value (land_val) and vessels. LSF (dark blue) and SSF (light green) across five case studies: North Sea (NS), Eastern Ionian Sea (EIS), Celtic Sea (CS), Bay of Biscay (BoB) and Adriatic and Western Ionian Sea (A-WIS).

Figure 4.1.1.3 shows the relative contribution of SSF and LSF fleets to CO_2 emissions per kg of fish across case studies for the period 2019–2021. LSF dominates emissions in most regions, exceeding 70% in the Adriatic and western Ionian Sea and North Sea and around 60% in the EIS. In contrast, SSF accounts for the majority of emissions in the Bay of Biscay (about 75%) and a substantial share in the Celtic Sea (around 45%). These differences reflect the varying fleet compositions and activity patterns across case studies.

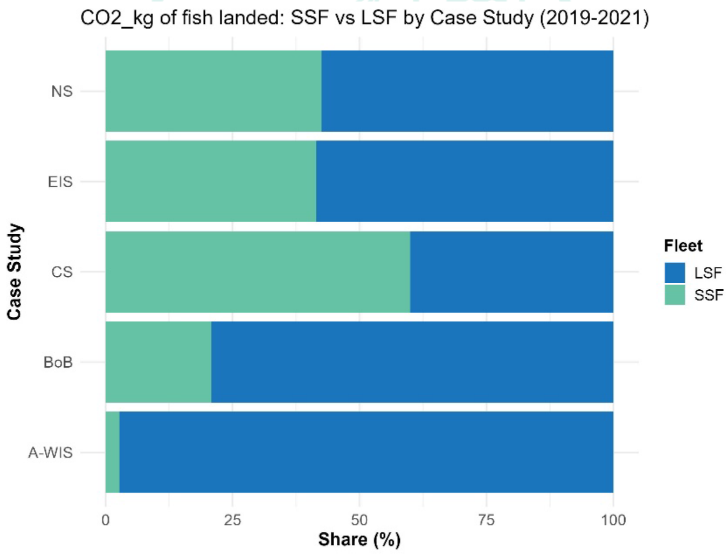

Figure 4.1.1.3- Comparison of Small-Scale Fisheries and Large-Scale Fisheries by Case Study CO2 per kg of fish landed. LSF (dark blue) and SSF (light green) across five case studies: North Sea (NS), Eastern Ionian Sea (EIS), Celtic Sea (CS), Bay of Biscay (BoB) and Adriatic and Western Ionian Sea (A-WIS).

Fuel – fish price dependency

For Spain demersal fleet operating in Bay of Biscay (Western Waters) the fuel price did not affect the fish price of the stocks considered, while for the Basque Country, the linear regression highlighted a weak significant dependence of the fish price of Atlantic mackerel on the fuel price.

For the Celtic Sea case study (Western Waters) the testing of linear correlation between fish price and fuel price by stock highlighted a significant dependence of *Nephrops* in area VII and for Sole in area 27.VII.e for the Belgian LSF.

For Germany the correlation was only significant for whiting. For Spain the correlation was weakly significant for haddock SSF and sole LSF. No significant relationship was found for Ireland, while for France a weak significance was observed for haddock and whiting LSF.

For Adriatic and western Ionian Sea (Mediterranean case study), the linear regression results show a positive significant relationship for deep-water rose shrimp (DPS) and red mullet (MUT) prices per kg in the SSF of Croatia (Figure 4.1.1.4). The same significant relationships were found for DPS and MUT in SSF of Italy. For small scale a positive relationship was observed also for HKE, that represents, together with MUT, the most important species in terms of revenues for this fleet. For Slovenia, no significant relationship was found. For Eastern Ionian Sea, a positive significant relationship was found for striped red mullet and red mullet.

In the North Sea, prices of roundfish and lower value flatfish were unaffected by increasing fuel prices for all countries considered. However, flatfish species of higher value such as turbot and sole showed an increase in price with increasing fuel costs. This was evident for the price of turbot for the Danish, Belgian, German and Dutch fleets and for sole for the Belgian fleet. In general, these pattern seemed to exist for both small scale and large scale fleets likewise, with a tendency of stronger prevalence in the small scale fleet, as was the case for the turbot price of the Danish and the Turbot and Sole price in the Belgian SSF.

More details on dependency analysis between fuel and fish price is available in Deliverable 2.10 (Bitetto et al., 2024b).

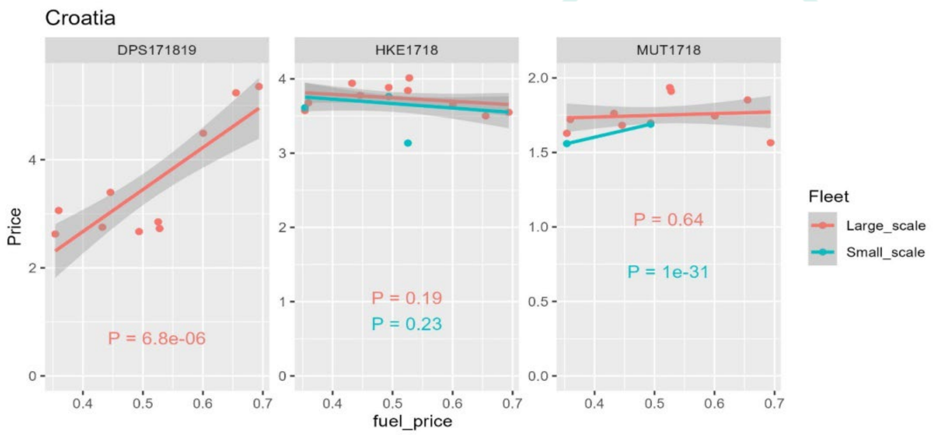

Figure 4.1.1.4 – Example of linear regressions fish price versus fuel price by stock for small and large scale for Croatian and Italian fleets operating in Adriatic and western Ionian Sea.

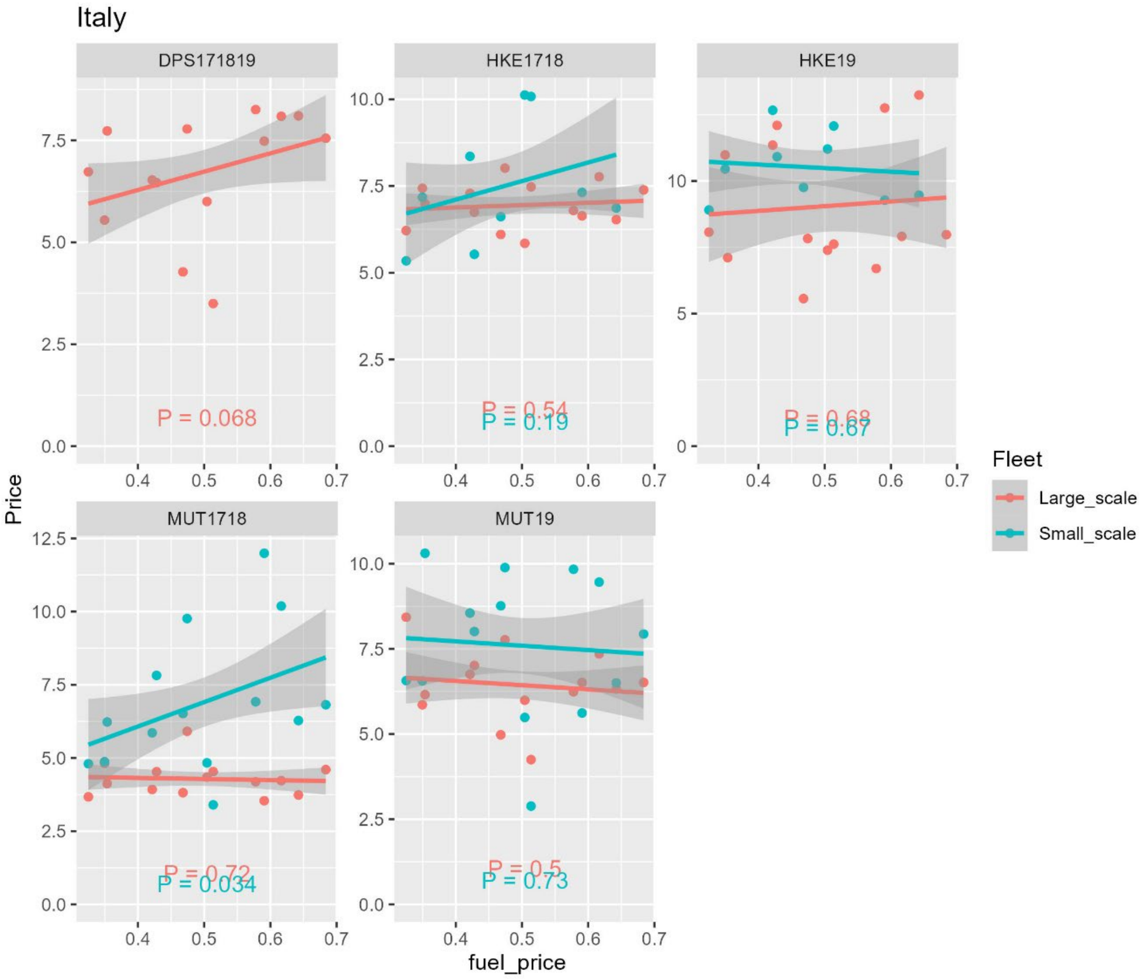

Figure 4.1.1.4 continued – Example of linear regressions fish price versus fuel price by stock for small and large scale for Croatian and Italian fleets operating in Adriatic and western Ionian Sea.

Input/Ouput tables framework

In the Bay of Biscay demersal and pelagic fisheries, the IO analysis shows that both SSF and LSF operate under high variable costs, with fuel emerging as the main driver reducing profitability. French and Spanish fleets display GVA of about 90% of revenues for both SSF and LSF in the demersal fishery. In the pelagic fishery, albacore dominates and GVA is lower, representing roughly 30% of revenues for SSF and 40% for LSF.

In the Celtic Sea, *Nephrops* and sole are the key species underpinning revenues. The IO framework highlights how capital, variable, and labour costs weigh significantly on both SSF and LSF. GVA shares vary across countries: about 70% in Belgium, 44% in Germany (LSF), 72% in Spain (LSF), 68% for French SSF vs 52% for French LSF, and 60% for Irish SSF versus 66% for Irish LSF. Table 4.2.2-4 provides an example of the Input–Output framework applied to the French demersal fishery in the Celtic Sea (average 2019–2021). The results highlight how *Nephrops* dominate revenues for both SSF and LSF, while costs are mainly driven by energy, maintenance, and labour. The GVA/revenues ratio differs substantially between fleet segments, reaching 0.68 for SSF and 0.52 for LSF, confirming the relatively higher economic efficiency of small-scale fleets in this context.

The North Sea case study reveals heterogeneous results across national fleets, reflecting differences in target species and fleet structures. Energy and repair/maintenance costs are recurrent burdens, particularly for LSF, while SSF sustain higher levels of employment. GVA shares include about 55% for Danish SSF versus 62% for LSF, 51% for

Dutch SSF versus 42% for LSF, 63% for English SSF versus 70% for LSF, 54% for French SSF versus 30% for LSF, and roughly 50% for both fleets in Germany.

In the Adriatic and Western Ionian fisheries, fuel costs emerge as the principal constraint on profitability. Croatian fleets show very low SSF GVA of about 4%, compared to 30% for LSF. In Italy, GVA is about 69% for SSF and 52% for LSF, while Slovenia's small LSF-dominated fleet reports GVA of around 67% of revenues. The Eastern Ionian case study confirms the central role of energy costs as the primary driver of profitability, with labour and other variable costs following. Here, GVA represents about 37% of revenues across fleets, highlighting the structural fragility of fleets in this region.

Table 4.1.1.1 Example of Input/Output table: French demersal fishery operating in Celtic Sea for small and large scale (average 2019-2021).

Input/Output sections	Products	Branch of activity	
		Extractive fishing: Small scale fishery (SSF)	Extractive fishing: Large scale fishery (LSF)
Supply	cod.27.7e-k	737.60	651.50
	had.27.7b-k	4 204.14	4 249.45
	hke.27.3a46-8abd	4 009.87	39 287.09
	meg.27.7b-k8abd	2 478.33	7 483.25
	nep.fu.16	121 718.97	299 279.44
	nep.fu.19	10 570.83	148.38
	nep.fu.22	29 338.63	
	sol.27.7e	2 954.01	387.19
	sol.27.7fg	552.24	188.40
	whg.27.7b-ce-k	3 564.07	1 868.49
	Total	126 785 298.29	67 168 671.78
Use	Energy costs	15 173 695	11 306 486
	Repair and maintenance costs	11 042 489	9 171 833
	other fixed costs	14 476 666	11 719 444
	capital costs	17 825 425	8 882 150
	Labour costs	50 870 148	22 185 929
Economic Impact	GVA	86 092 449	34 970 909
	GVA to revenues	0.68	0.52

More details on Input/Output tables results are available in Deliverable 2.10 (Bitetto et al., 2024b).

4.1.2 Social impacts of fisheries

Deliverable 2.5 identified key social, cultural, economic, ecological, and institutional factors that influence fisher behaviour across nine European case studies. A central finding was that fisher behaviour was highly context-dependent, with substantial variability across regions, fleet segments, and even within individual fisheries. Common factors shaping behaviour include business structure (family-owned vs company-operated), work rhythms (weekday vs continuous fishing), and the degree of specialization vs polyvalence in fishing activities. Economic incentives alone did not fully explain fishing decisions. Cultural traditions, personal and family identity, and attachment to fishing grounds ("fishing styles") emerged as significant drivers, often constraining fishers' flexibility to respond to policy or environmental changes. For example, inshore fishers in England exhibited strong cultural attachment to their fishing activity, affecting their willingness to diversify into aquaculture or shift to alternative fishing grounds. In the Mediterranean, the practice of pluriactivity (combining fishing with other economic activities) was identified as a widespread coping strategy among small-scale fishers, influencing their resilience to management measures. Similarly, in the Dutch demersal fleet, variations in business structures (owner-operated vs fleet-managed) and fishing rhythms were shown to impact compliance and adaptation capacity.

Across all case studies, it was evident that social and behavioural factors are under-represented in current modelling approaches, and that a "one-size-fits-all" assumption regarding economic rationality is insufficient. Incorporating these nuanced social dynamics is critical for improving fisheries management models and ensuring that policies are effective and socially acceptable. The identification of key behavioural drivers—such as business structures, work rhythms, specialization levels, and socio-cultural attachments—highlighted the necessity to move beyond purely economic assumptions in modelling fisher behaviour. Deliverable 2.6 built upon these insights by applying them in specific regional contexts, integrating behavioural sub-models into simulation tools (BEMTOOL, FLBEIA) and mapping fishing communities through social indicators. This allowed a more comprehensive assessment of how management measures impact fleets and communities, acknowledging the complex interplay between regulatory frameworks, fisher decision-making, and community resilience across European fisheries. The analysis provided key insights into how social factors and management measures influence fisher behaviour and, consequently, the resilience of fishing communities. Figure 4.1.2.1 illustrates the integration of behavioural sub-models, stakeholder perceptions, social vulnerability assessments, and community profiling to analyse the socio-economic impacts of fisheries management.

Results highlighted substantial differences between regions: in Estonia, stakeholders expressed growing concern over the ecological and economic impacts of non-indigenous species, indicating a need for targeted awareness and adaptation strategies. In the Netherlands, the Social Impact Assessment revealed varying levels of community dependence on fishing activities, with certain coastal areas showing higher vulnerability to regulatory changes. Across the Adriatic, Western Ionian Sea, and Western Waters, the linkage between fleets and their home communities was mapped, allowing for the identification of community profiles based on social indicators. The profiling exercise demonstrated that communities with strong fishing engagement are more sensitive to management decisions, while regions with diversified economies showed greater adaptive capacity.

At a national level, profiles for the Netherlands, Spain, and Denmark provided comparative insights into the socio-economic structures of fishing-dependent areas. In England, the application of the Social Vulnerability Index and Fishing Engagement & Reliance Index highlighted specific coastal communities where social and economic reliance on fishing remains critical, pointing to areas where policy interventions could mitigate social impacts.

Overall, the results emphasized the importance of integrating social dimensions into fisheries management to ensure balanced and community-sensitive decision-making.

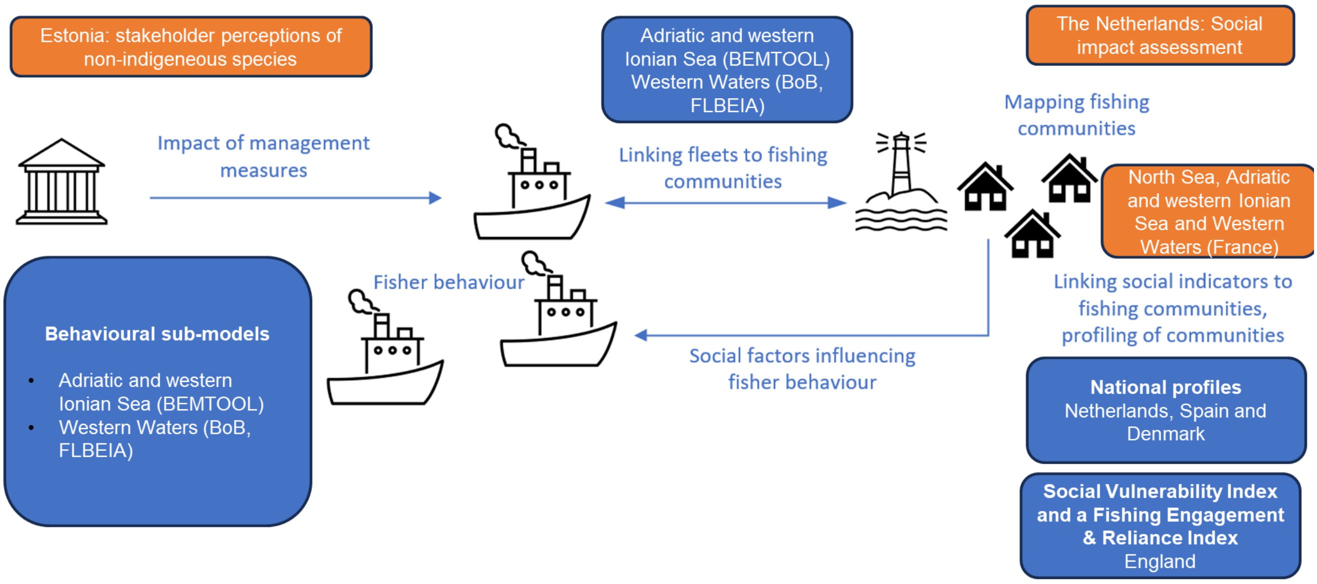

Figure 4.1.2.1 - Framework linking management measures, fisher behaviour, and community-level social indicators across case studies in Estonia, the Netherlands, the North Sea, Adriatic and Western Ionian Sea, and Western Waters.

Regarding gender and employment, evidence across SEAwise case studies confirms the traditional low female representation in fisheries, consistent with EU-level estimates. Women are more often engaged in processing, sales, or administrative roles rather than onboard activities, though their contribution to family businesses remains essential. For example, wives in the **Bay of Biscay** co-manage investments and financial risks. In the **North Sea**, available national statistics and qualitative interviews underline that female crew members are rare, but women play an important role through shore-based work and intergenerational transfer of fishing businesses. In the **Adriatic and Western Ionian Sea**, survey evidence suggests women are present in administrative and marketing roles, with pluriactivity in coastal households increasing their involvement in complementary economic activities. Similarly, in the **Eastern Ionian Sea (Greece)**, while fishing remains a male-dominated occupation, balanced gender distribution at community level highlights that women contribute significantly to diversification strategies (tourism, alternative employment) that support household resilience.

Overall, SEAwise case studies reflect the general EU fisheries pattern where female onboard employment is below 10–15% (STECF, 2019), but women's indirect roles are crucial to the social and economic functioning of coastal communities. The representativeness of the case studies lie in capturing this diversity of contexts—ranging from industrialized fleets of the North Sea to highly diversified small-scale fisheries of the Mediterranean—allowing SEAwise to address both structural gender gaps and the broader socio-economic importance of fisheries communities.

Further details are available in Deliverables 2.5 (Kraan et al.2022) and 2.6 (Kraan et al.2024).

4.1.3 Health impacts of different fish species

Table 4.1.3.1 summarises the core findings of Deliverable 2.9 for each SEAwise case study, linking the highest-ranked species to their principal risk considerations and the resulting consumer guidance. This snapshot allows readers to see—at a glance—where nutritional benefits are greatest, which hazards may constrain consumption, and the practical advice that emerges for each regional fishery.

Table 4.1.3.1 - Top-ranked species, dominant contaminant concerns, and headline consumer advice generated by the Deliverable 2.9 risk-benefit assessment for the four SEAwise regional case studies.

Case study	Top nutrient-rich species	Main risk flag	Quick guidance
	Sardine, Red mullet, Anchovy, Atlantic mackerel, Horse mackerel	No hazard thresholds exceeded; minor nutrient gaps filled with EU averages	Rotate small pelagics + demersals; ≥ 1 oily-fish meal per week
	Atlantic herring, Sardine, Atlantic mackerel, Mussel, Saithe	Large tunas → higher MeHg ⇒ auto-downgraded	Favour small pelagics; add shellfish for iodine/selenium; specific limitations for large predators (children and pregnant)
	Herring, Sprat, Saithe, Mackerel	Some large Cod / Plaice near PCB–dioxin limits	Alternate oily–lean; iodine-deficient countries can prioritise saithe
	Sprat, Farmed (non-Baltic) Salmon, cod	Wild salmonids & Baltic herring ↑ PCB–dioxins	Limit Baltic salmonids and herring to 1 meal per week. Read the packaging

*Small Baltic herring remain recommended; > 17 cm follow the same one-meal limit as salmonids.

For all regions, consumers are advised to eat fish 1–2 (up to 3–4) times per week, alternate fatty and lean species, and vary provenance to dilute contaminant exposure. Further details are available in Caro et al., 2023.

4.2 Management impacts on social and economic benefits of fisheries

4.2.1 Comparison between small scale and large scale fishery across case studies and scenarios

4.2.1.1 Livelihood

Wages (labour costs)

For the Bay of Biscay, wages improve in the long term for both scenarios, especially for SSF; within each strategy, GS and LS tend to be the least negative (Figure 4.2.1.1). In the Celtic Sea, F_{MSY} performs better overall, while PGY generally has lower wages in both SSF and LSF across socio-economic settings. In the North Sea, both SSF and LSF show consistent wage gains across periods: under F_{MSY} the increase is more gradual, while under PGY gains are stronger and more accelerated, especially for SSF.

The Adriatic and Western Ionian Sea shows gradual increases over time under both strategies—clearer in later periods and somewhat stronger under F_{MSY}, especially in GS and LS. By contrast, the Eastern Ionian Sea experiences persistent wage losses: about −47% under F_{MSY} for LSF fleets, while of smaller extent for SSF, with long term improvements; under PGY a wider split emerges (roughly −40% for SSF and +60% for LSF), due to reallocation of the effort between the two fleets. Overall, these patterns point to limited within-case sensitivity to socio-economic scenarios, with GS and LS typically cushioning outcomes where declines occur.

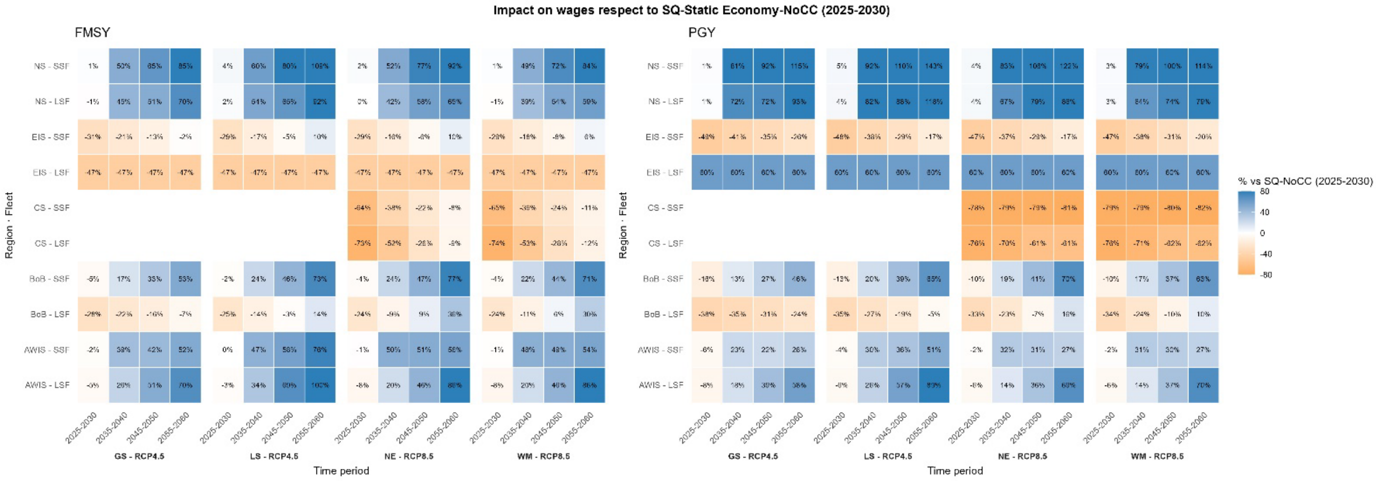

Figure 4.2.1.1 - Change in wages relative to the baseline (SQ–Static Economy–NoCC, 2025–2030) by case study, socio-economic scenario, management strategy and period. NS: North Sea, CS: Celtic Sea, EIS: Eastern Ionian Sea, AWIS: Adriatic and Western Ionian Sea, BOB: Bay of Biscay. GS: Global Sustainability, LS: Local Stewardship, NE: National Enterprise, WM: Worldwide Markets.

Gross Value Added (GVA)

In the Bay of Biscay, GVA improve in the long term for both scenarios, especially for SSF, gradually reducing the gap with the baseline (Figure 4.2.1.2). In the North Sea, both strategies deliver sizeable increases with a clear upward time trend; gains are stronger under PGY and most pronounced in GS and LS. For Celtic Sea the F_{MSY} shows a better situation for both fleet relative to PGY, because the decline in effort is lower. Moreover, PGY results in a decreasing trend for SSF, while F_{MSY} shows an improvement in the long term for this fleet. The Adriatic and Western Ionian Sea exhibits improvements especially in later periods for both the F_{MSY} and PGY scenarios with F_{MSY} performing the best. For the Eastern Ionian Sea, impacts are persistently positive across fleets (roughly +40% to +70%), broadly similar across socio-economic settings and marginally higher under PGY.

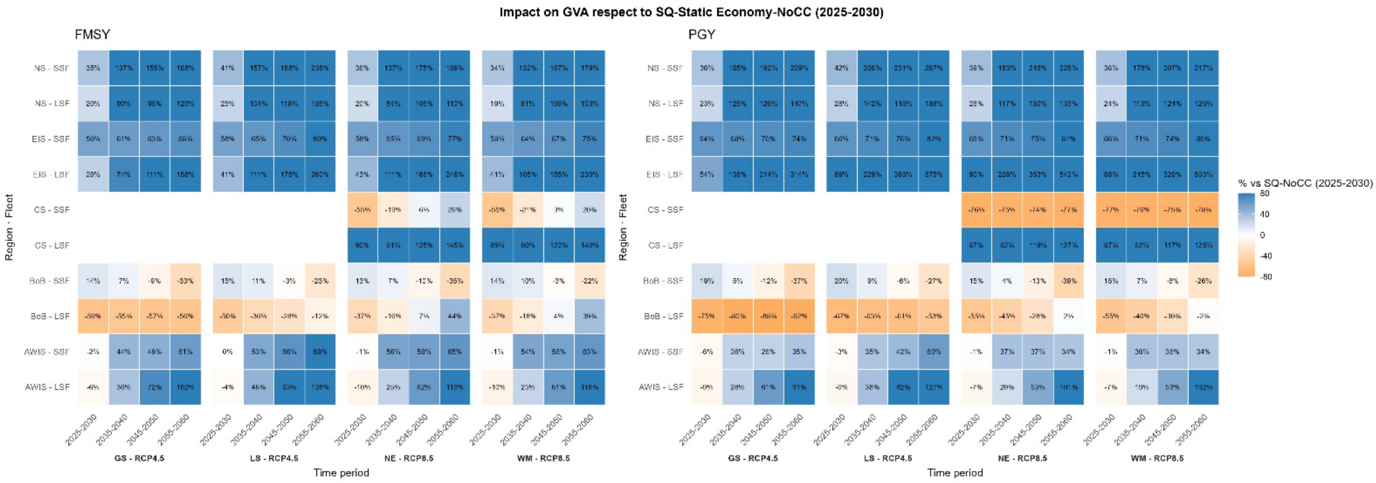

Figure 4.2.1.2 - Change in GVA relative to the baseline (SQ–Static Economy–NoCC, 2025–2030) by case study, socio-economic scenario, management strategy and period. NS: North Sea, CS: Celtic Sea, EIS: Eastern Ionian Sea, AWIS: Adriatic and Western Ionian Sea, BOB: Bay of Biscay. GS: Global Sustainability, LS: Local Stewardship, NE: National Enterprise, WM: Worldwide Markets.

Coastal communities: Revenues SSF/revenues LSF ratio

Across case studies the signal in relative revenue of SSF is case-study specific (Figure 4.2.1.3). Bay of Biscay and Eastern Ionian Sea show SSF-led revenue structures (ratios mostly >1, often markedly so), while Celtic Sea, North Sea and Adriatic and Western Ionian Sea remain <1, indicating LSF-dominated revenues. The indicator suggests that communities linked to Bay of Biscay and Eastern Ionian Sea are more revenue-dependent on SSF, whereas the others remain more reliant on LSF under the scenarios tested. For the Bay of Biscay, both F_{MSY} and PGY raise the SSF/LSF revenue ratio relative to baseline and show an upward time trend. The increase is stronger under PGY, and within each management GS and LS deliver the largest gains. In the Celtic Sea, F_{MSY} is the best performer across periods, while in the North Sea both strategies slightly lower the ratio versus baseline, with similar responses across socio-economic scenarios. The Adriatic and Western Ionian Sea is fairly stable; GS/LS are marginally higher than the other socio-economic settings, and F_{MSY} outperforms PGY, especially in the long term. For the Eastern Ionian Sea, F_{MSY} clearly dominates, yielding ratios well above PGY, where effort reallocation between SSF and LSF dampens the indicator.

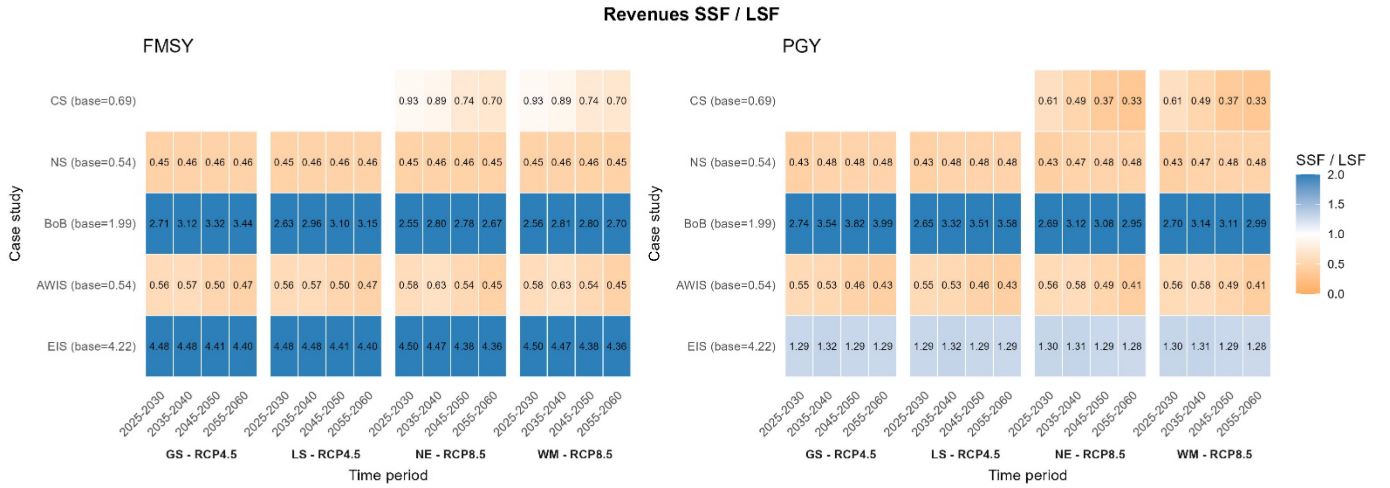

Figure 4.2.1.3 – Ratio between SSF revenues and LSF revenues by case study, socio-economic scenario, management strategy and period. The baseline value (SQ–Static Economy–NoCC, 2025–2030) is reported on the y axis. NS: North Sea, CS: Celtic Sea, EIS: Eastern Ionian Sea, AWIS: Adriatic and Western Ionian Sea, BOB: Bay of Biscay. GS: Global Sustainability, LS: Local Stewardship, NE: National Enterprise, WM: Worldwide Markets.

4.2.1.2 Human well-being

Carbon footprint

Overall, F_{MSY} delivers the largest reduction in CO_2 per kg of fish in most regions and fleets, while PGY tends to yield comparable but slightly lower gains (Figure 4.2.1.4). In the Eastern Ionian Sea (EIS), declines under F_{MSY} are moderate and fairly stable over time (about −8% to −12% for SSF; about −7% to −9% for LSF), whereas PGY achieves smaller declines in SSF (about −6% to −7%) and near-zero to slightly positive changes for LSF (0% to +3%). The Adriatic and western Ionian (A-WIS) shows a clear advantage under F_{MSY}, especially for LSF, where reductions range from about −7% to −17% across periods; SSF declines are modest under both strategies, though still more pronounced with F_{MSY}. In the Bay of Biscay (BoB), F_{MSY} again leads to reater improvement than PGY as SSF falls by roughly −13% to −16% and LSF by −10% to −11%, while PGY brings smaller SSF cuts (about −10% to −11%) and leaves LSF close to zero or slightly positive. The North Sea (NS) exhibits the strongest improvements under F_{MSY}, where CO_2 intensity drops by about −45% to −59% across fleets and periods. PGY also achieves large reductions (about −42% to −56%) but these remain lower than under F_{MSY}. The main exception is the Celtic Sea (CS), where PGY outperforms F_{MSY} for both fleets and strengthens over time (SSF about −44% to −55%; LSF about −44% to −58%) compared with F_{MSY} (about −35% to −46%), due to the lower effort for PGY respect to F_{MSY}.

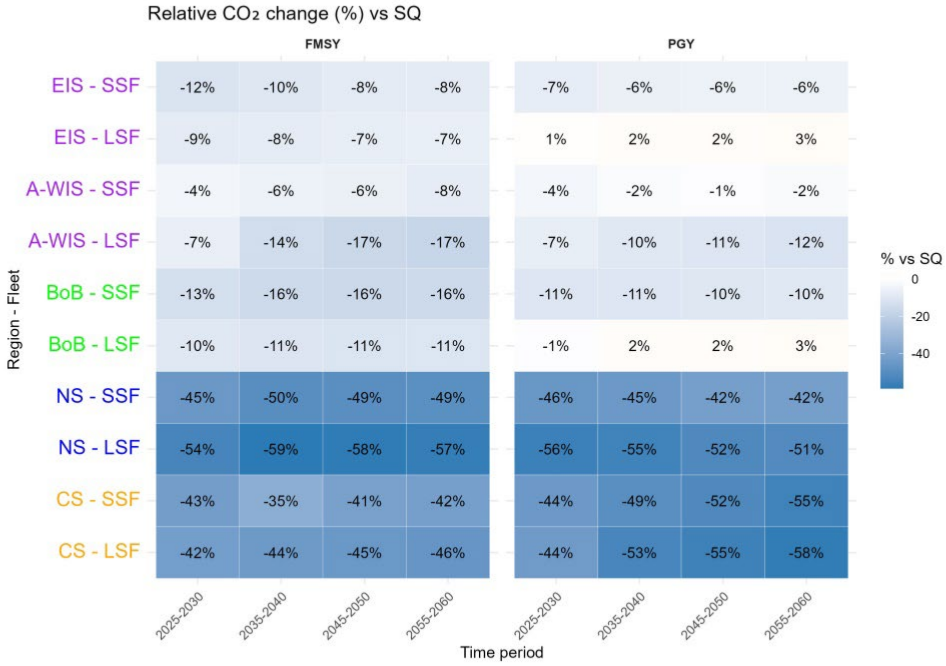

Figure 4.2.1.4 – Relative CO2 change by case study, scenario and time period. Case studies: Eastern Ionian Sea (EIS), Adriatic and western Ionian Sea (A-WIS), Bay of Biscay (BoB), North Sea (NS) and Celtic Sea (CS). The results are differentiated for small-scale (SSF) and large scale fleet (LSF). The percentages are estimated on the status quo in 2025-2030.

Across case studies, PGY generally yielded higher organic-carbon extraction than F_{MSY}, reflecting greater stock availability combined with higher effort in most regions; the magnitude varies by fleet and area (Figure 4.2.1.5). In the Eastern Ionian Sea (EIS), F_{MSY} led to extraction well below SQ for both fleets (about −40% to −43%), while PGY led to diverging results of the fleets. SSF declined further (about −57% to −58%), but LSF increased strongly (about +56% to +58%). In the Adriatic and western Ionian (A-WIS), responses were small. Under F_{MSY}, SSF change was near zero to slightly positive and LSF showed modest declines; PGY produced slight SSF reductions and larger LSF reductions (roughly −12% to −21%). In the Bay of Biscay (BoB), organic-carbon extraction consistently declined under both strategies. PGY showed greater declines for both fleets (SSF roughly −29% to −23%; LSF roughly −53% to −39%). Under F_{MSY}, the North Sea (NS) SSF extraction was modestly below SQ (about −15%- −8% across periods), while LSF showed increases of about 3% to 13%. Under PGY, SSF increased to 10% above SQ, whereas LSF increased from 9% to 37%. In the Celtic Sea (CS), PGY used lower effort than F_{MSY}, yet SSF organic-carbon extraction decreased sharply (about -62% to -79%), and LSF extraction declined to less than under F_{MSY} (about −64% to −57%).

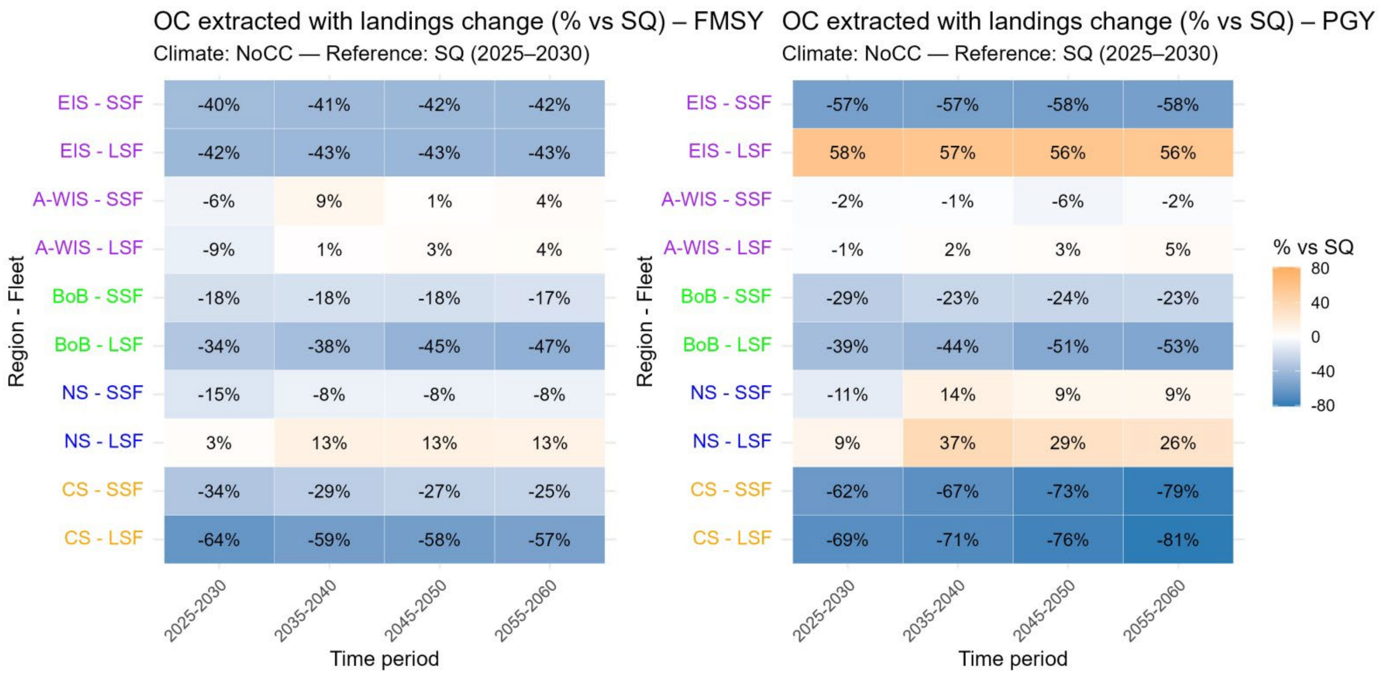

Figure 4.2.1.5 – Relative organic carbon extracted with landings change by case study, scenario and time period. Case studies: Eastern Ionian Sea (EIS), Adriatic and western Ionian Sea (A-WIS), Bay of Biscay (BoB), North Sea (NS) and Celtic Sea (CS). The results are differentiated for small-scale (SSF) and large scale fleet (LSF). The percentages are estimated on the status quo in 2025-2030.

Across case studies, F_{MSY} was consistently more effective in mitigating climate-driven increases in CO_2 intensity, particularly when combined with effort reductions in both fleets (Figure 4.2.1.6). In all case studies except the Celtic Sea, both SSF and LSF showed substantial and persistent decreases under F_{MSY} across all periods and climate scenarios, with PGY also delivering reductions though generally of smaller magnitude. F_{MSY} systematically limited OC removal through landings compared with PGY, though the extent varied by region and fleet type (Figure 4.2.1.7). In the EIS, differences between strategies were small for SSF, while for LSF, PGY led to both higher OC extraction and increased carbon emissions, reflecting the influence of effort reallocation between fleets. In the Bay of Biscay and North Sea, the benefits of F_{MSY} is evident for both indicators, maintaining large reductions for both fleets. The Celtic Sea (CS) provided an exception, where PGY's lower effort on LSF reduces CO_2 intensity more than F_{MSY}, yet still results in much higher OC extraction for SSF.

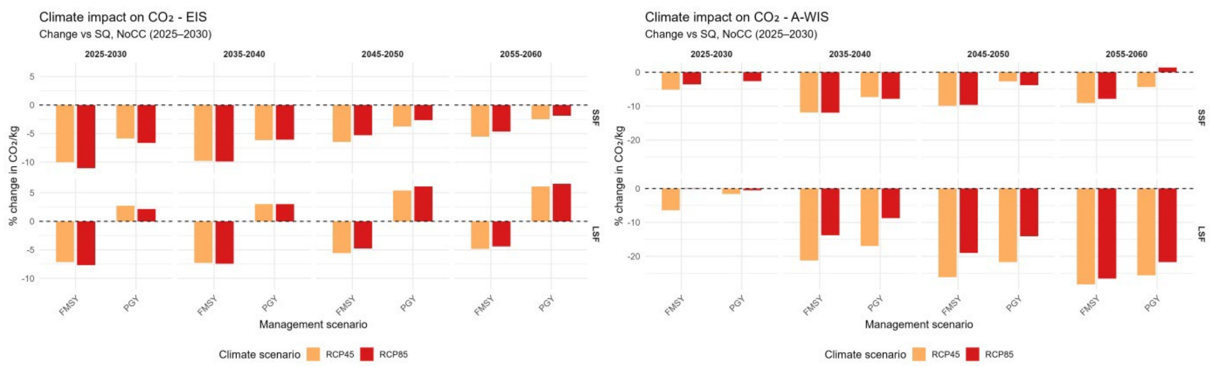

Figure 4.2.1.6 – Relative CO2 emissions change by case study, management and climate scenario and time period. Case studies: Eastern Ionian Sea (EIS), Adriatic and western Ionian Sea (A-WIS), Bay of Biscay (BoB), North Sea (NS) and Celtic Sea (CS). The results are differentiated for small-scale (SSF) and large scale fleet (LSF). The percentages are estimated on the status quo in 2025-2030.

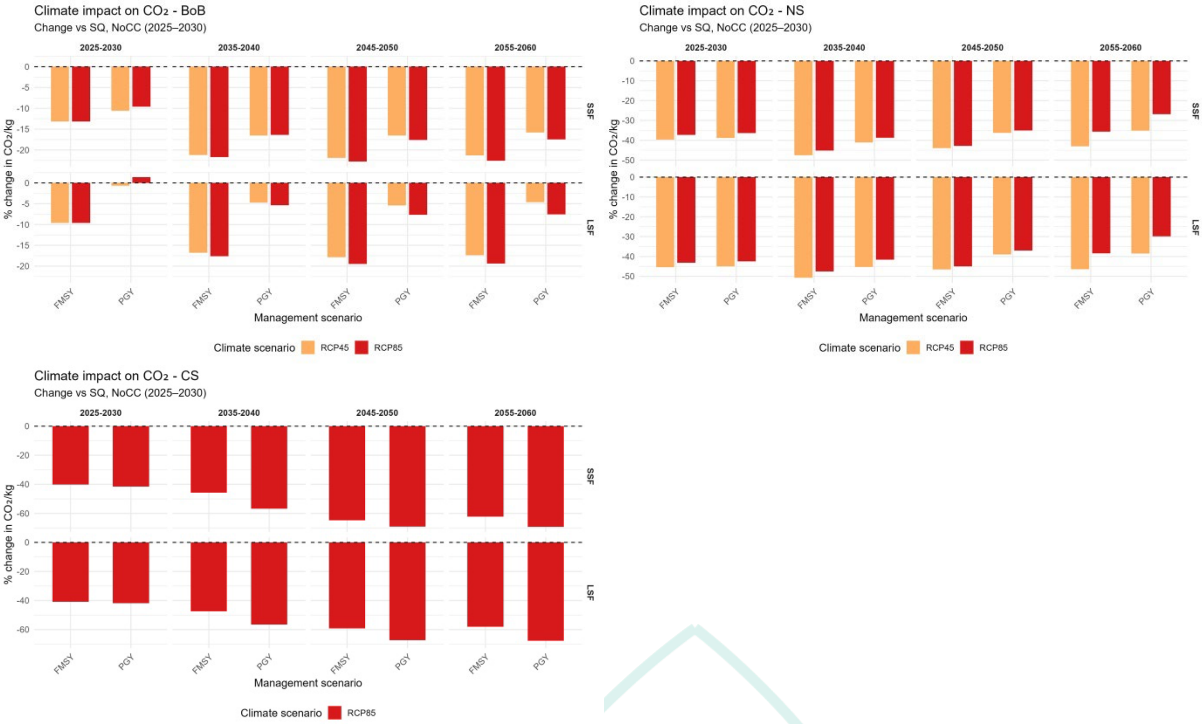

Figure 4.2.1.6 continued – Relative CO2 emissions change by case study, management and climate scenario and time period. Case studies: Eastern Ionian Sea (EIS), Adriatic and western Ionian Sea (A-WIS), Bay of Biscay (BoB), North Sea (NS) and Celtic Sea (CS). The results are differentiated for small-scale (SSF) and large scale fleet (LSF). The percentages are estimated on the status quo in 2025-2030.

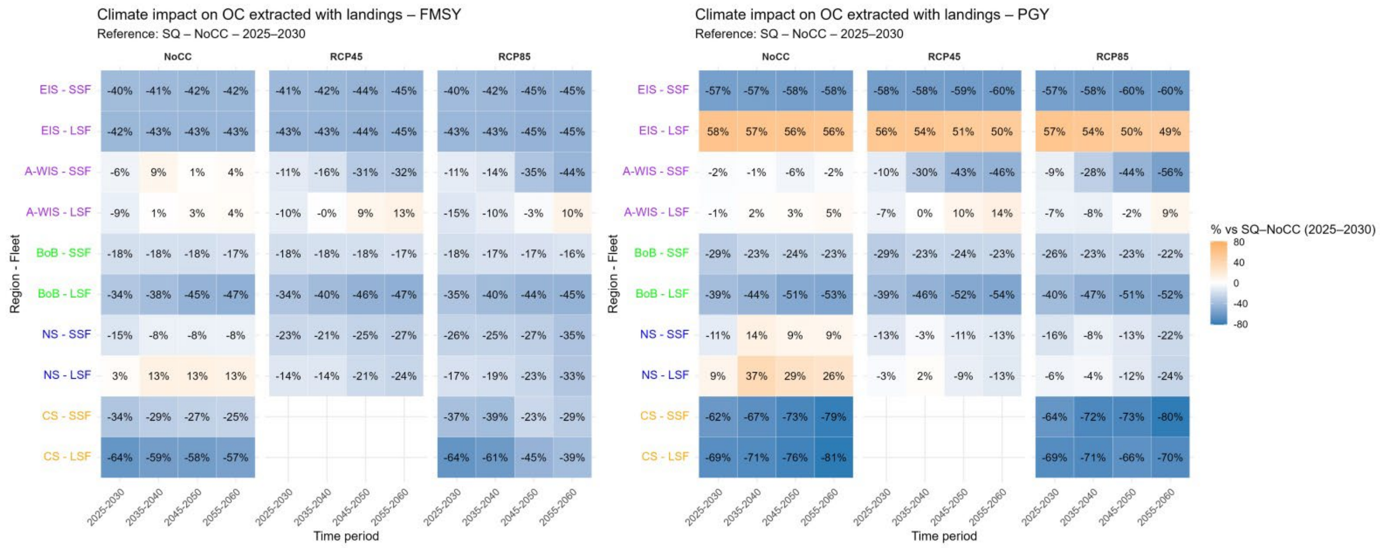

Figure 4.2.1.7 – Relative organic carbon extracted with landings change by case study, management and climate scenario and time period. Case studies: Eastern Ionian Sea (EIS), Adriatic and western Ionian Sea (A-WIS), Bay of Biscay (BoB), North Sea (NS) and Celtic Sea (CS). The results are differentiated for small-scale (SSF) and large scale fleet (LSF). The percentages are estimated on the status quo in 2025-2030.

Across regions, F_{MSY} generally provided the best safeguards of the blue-carbon sink, maintaining higher levels of organic carbon stored in spawning stock biomass (SSB) across all climate conditions tested (Figure 4.2.1.8). Gains were particularly consistent in the North Sea, Celtic Sea and Adriatic and Western Ionian in every period and climate scenario. In some areas, such as the Celtic Sea (CS), trade-off strategies (PGY scenario) still left substantial SSB in the sea while supporting higher landings. Climate change reduced the carbon sink capacity in all regions, with the RCP8.5 pathway having the strongest negative impact, especially visible in long-term projections for EIS and BoB.

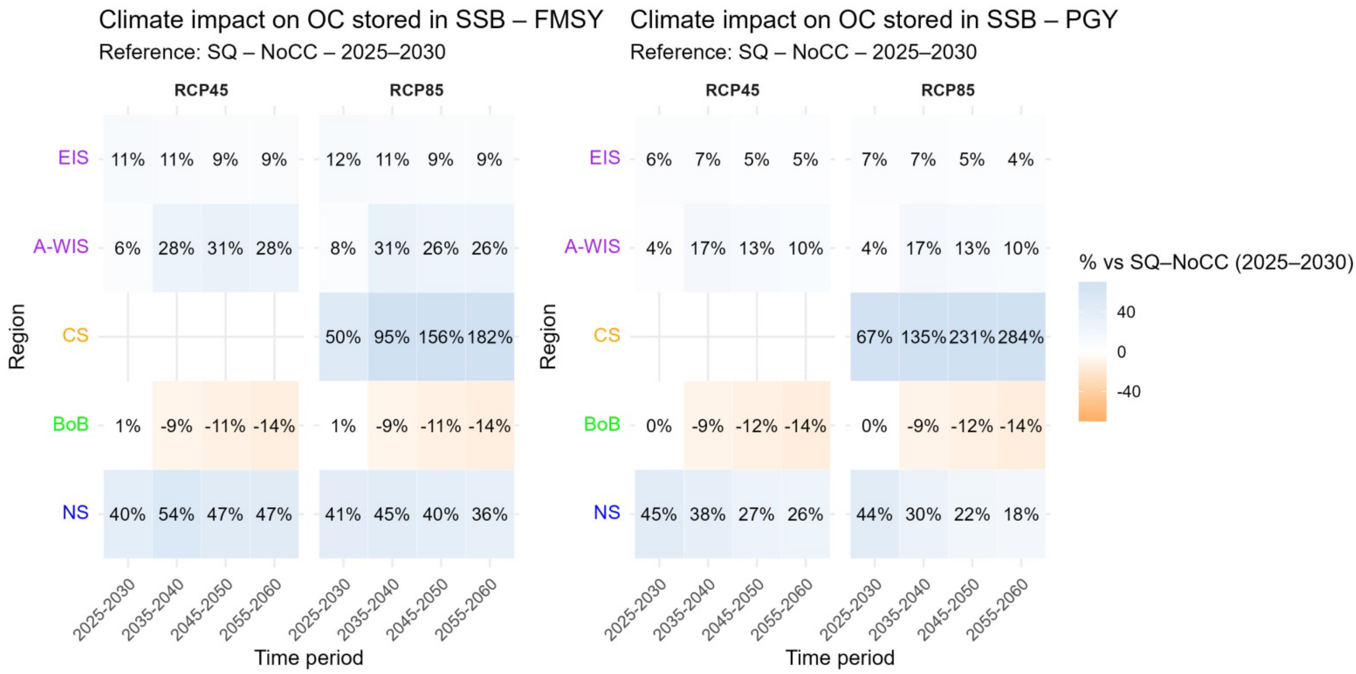

Figure 4.2.1.8 – Relative organic carbon stored in SSB change by case study, management and climate scenario and time period. Case studies: Eastern Ionian Sea (EIS), Adriatic and western Ionian Sea (A-WIS), Bay of Biscay (BoB), North Sea (NS) and Celtic Sea (CS). The percentages provide the level relative to status quo management in 2025-2030.

Food and nutrition security: Number of meals

In Figure 4.2.1.9, the change in number of meals provided relative to the baseline (SQ–Static Economy–NoCC, 2025–2030) is reported by case study, socio-economic scenario, management strategy and period. For the Bay of Biscay, number of meals decreased for both management scenarios, more pronounced for PGY and for LSF, with no clear time trend. The North Sea remained near baseline overall, with small negatives impacts under F_{MSY} and marginal positive impacts for LSF under PGY. The results for the Celtic Sea showed a decrease in the number of meals provided by both fleets for all management and socio-economic scenarios, more marked for PGY scenario. The Adriatic and Western Ionian Sea showed modest increases especially for F_{MSY}; for the improvements were more concentrated in the short term, for LSF in the medium-long term. In the Eastern Ionian Sea, F_{MSY} yields uniform important declines for both fleets, whereas PGY produces a pronounced fleet split where SSF shifts further negative, and LSF turns positive, consistent with effort reallocation between fleets.

Figure 4.2.1.9 – Relative change in number of meals provided by case study, management and climate scenario and time period. Case studies: Eastern Ionian Sea (EIS), Adriatic and western Ionian Sea (A-WIS), Bay of Biscay (BoB), North Sea (NS) and Celtic Sea (CS). The percentages are estimated on the status quo in 2025-2030.

4.2.2 Evaluation of governance effectiveness in EU Fisheries

The evaluation of governance effectiveness in EU fisheries revealed insights into how fisheries governance is currently perceived by actors within EU fisheries management and functions across European regional seas. The online survey, despite a low response rate (44 completed surveys across European sea regions), highlighted potential challenges within governance effectiveness such as low stakeholder trust, limited inclusivity, and fragmented coordination mechanisms, especially in regions where governance processes are perceived as top-down and not fully transparent. The Mediterranean Sea, which had the highest survey response and most broadly representative spread of types of respondents, served as an example for visualizing governance performance using a 'traffic light' approach (Table 4.2.2.1). The approach showed low levels of effectiveness for inclusivity, trust, and legitimacy and high levels of effectiveness for the ability of people/organisations to work independent and together. There was a medium of level of governance effectiveness across dimensions of decision-making/information sharing, relationship between people's action and behaviour in rulemaking, and managing fisheries at different scales (Table 4.2.2.1). It is important to note that the low response rate was a key limitation in being able to make robust conclusions about governance effectiveness. A key conclusion from the survey was that understanding effectiveness governance in European fisheries management, particularly from a social science perspective, is lacking and needs further attention and resources. The approach taken in the survey can provide inspiration for future research involving a larger number of respondents across the European regional seas, including the opportunity to supplement the survey or adapt the survey questions for use in semi-structured interviews.

Table 4.2.2.1 - Governance effectiveness across key themes in fisheries management for the Mediterranean Sea region.

Governance theme	Level of effective governance		
	Low	Medium	High
A. Inclusivity, trust and legitimacy	■ (red)		
B. Decision-making and information sharing		■ (yellow)	
C. Relationship between people’s action and behaviour and rulemaking		■ (yellow)	
D. Managing fisheries at different scales		■ (yellow)	
E. Ability for people/organisations to work independently and together			■ (green)

Complementing the survey, four sub-regional case studies provided in-depth qualitative findings. In the North Sea and Western Waters, the adoption of fisheries measures in Natura 2000 areas revealed the importance of transparent stakeholder consultations, yet highlighted difficulties in balancing environmental and socio-economic objectives. The German-Danish Baltic case emphasized that effective advisory commissions depend on clear mandates, realistic timelines, and strong leadership, which are essential to address complex fisheries governance challenges. In Patraikos Gulf (Greece), stakeholder perceptions exposed a governance system suffering from low trust, centralized decision-making, and lack of engagement, exacerbating dissatisfaction amid declining fish stocks. Conversely, the Adriatic FRA case study demonstrated a governance process considered transparent and participatory by stakeholders, leading to significant seabed protection outcomes through Fisheries Restricted Areas (FRAs), although it also emphasized the time-consuming nature of consensus-building processes.

Overall, the results underline that governance effectiveness is highly context-dependent, requiring adaptable approaches that foster inclusivity, trust-building, and multi-level coordination. The findings also point out that while structured governance frameworks exist, their practical implementation often falls short, especially in ensuring that stakeholders feel meaningfully included in decision-making processes.

Further information and analysis can be found in Deliverable 2.8 (Asif et al., 2025).

5. Quality assurance

The methodologies used in the enhanced socio-economic sub-models on fish price and variable costs by metier, including the use of key indicators (e.g. CO_2 emissions) were presented to ICES WGECON in 2024 and to WGMIXFISH–Methods in 2025. In addition, the work on fishing communities carried out within SEAwise, and summarised in Chapters 3.1.2 and 4.1.3, builds directly on the contributions of WGSOCIAL and represents an important step forward beyond their earlier work.

5.1 ICES WGECON

An introduction of the methodological work developed in SEAwise WP2 was presented at the ICES WGECON meeting, held on 2nd in October 2024, to collect the feedback from European economists. During the presentation it was stressed how the approach enhances the parameterization of bio-economic models by explicitly modelling fish price and variable costs (e.g. fuel) and by integrating behavioural sub-models and relevant socio-economic indicators. It was highlighted that across regions, existing models (e.g. FLBEIA, BEMTOOL, BEE-Fish, OSMOSE) were adapted or extended in SEAwise building on WP2 work, incorporating carbon emission estimates and linking WP2 outputs with ecological, spatial, and management evaluation work packages. A request was made for external review and quality assurance to ensure consistency, transparency, and alignment with international standards. Two WGECON experts conducted a voluntarily review the work made in Mediterranean case study, including R scripts and relevant results and assumptions. Through personal communication and mail exchange, they provided the following suggestions to improve the work carried out in the WP2: 1) To better specify if the data were cleaned from the outliers; 2) To clarify the sub-models selection process. These aspects will be addressed in the synthesis paper "Enhancing bio-economic models, with fisher behaviour models".

5.2 ICES MIXFISH-METHODS

During WGMIXFISH–Methods, held from 16th to 20th June 2025, the advances made by SEAwise WP2 in the integration of socio-economic submodels into mixed-fisheries applications were presented. The presentation highlighted how the enhanced parameterization of variable costs and fish prices, the introduction of behavioural submodels, and the inclusion of socio-economic indicators (e.g. CO_2 emissions) improved the realism of bio-economic simulations and support Management Strategy Evaluations. It was shown how existing modelling platforms (e.g. FLBEIA, BEMTOOL) were adapted or extended to incorporate these components, ensuring closer alignment with policy-relevant questions.

The case studies in the Celtic Sea, North Sea and Bay of Biscay (integrated in the 5.2 ICES MIXFISH-METHODS work) and Adriatic and Ionian Sea (presented during the June 2025 meeting) demonstrated how the new modules can be applied in practice, with a particular focus on assessing trade-offs between ecological and socio-economic objectives under alternative management, climate and socio-economic scenarios. The presentation also stressed the importance of transparency and reproducibility, with R code and tutorials made available to WGMIXFISH to facilitate uptake and external review.

6. Discussion and conclusions

Previous literature has demonstrated limited integration of social indicators such as employment and wages, underrepresentation of small-scale fisheries and coastal communities, strong geographical biases towards the Mediterranean, and scarce adoption of adaptive modelling approaches. SEAwise contributed to filling these gaps by embedding social indicators into bio-economic models, extending the analysis to underrepresented areas such as the Baltic and North Sea, and developing behavioural sub-models that improve the realism of Management Strategy Evaluations. Furthermore, the participatory scoping and synthesis workshops ensured that stakeholders' priorities (employment, food provision, health, governance) were explicitly captured, strengthening the policy relevance of the results.

A major innovation was the integration of carbon emissions and blue carbon indicators in the indicators estimated. Scenarios with lower fishing effort, such as F_{MSY}, combine reduced fuel use per unit effort with stock rebuilding, which raises catch rates and landings and thereby lowers emissions per kilogram of fish landed. By contrast, PGY scenarios often increase overall OC extraction relative to F_{MSY}, particularly where higher effort and biomass availability can be exploited. However, this effect is dampened or reversed where effort is constrained or benefits are unevenly distributed across fleets. Moreover, managing at F_{MSY} while controlling total effort is a robust strategy to mitigate the climate impacts on fleet CO_2 intensity and to minimise the removal of OC through landings. Even under severe climate projections, F_{MSY} consistently preserved the largest share of organic carbon in spawning stock biomass, reinforcing its role as a potential approach for safeguarding blue-carbon functions in marine ecosystems.

SSF derived proportionally higher benefits in terms of income and labour intensity in many cases, while LSF dominated absolute revenue flows. Employment indicators (FTE, wage levels) confirmed the central role of SSF in sustaining coastal jobs, but also highlighted their vulnerability to fuel price fluctuations and management restrictions. Food provision, expressed as the number of fish portions generated, was a useful integrative metric linking fisheries to food security. Governance and social vulnerability indicators further demonstrated that case-specific institutional capacity and community dependence shape the distribution of impacts across fleets and regions. Together, the results confirm the feasibility of embedding socio-economic indicators into bio-economic models and demonstrate the added value of assessing ecological, social, and economic trade-offs jointly. While the four case studies are not statistically representative of all EU fisheries, their diversity in fleet structures, socio-economic contexts, and governance settings ensured robust testing of the methods. This is a substantial advancement of the parameterisation of bio-economic models, linking ecological and social dimensions in ways that were previously not available.

Future work should focus on expanding data coverage of particularly gender-disaggregated employment and community-level dependencies, improving the robustness of socio-economic projections, and consolidating the integration of blue carbon flow into MSE frameworks. The approaches developed in SEAwise provide a strong methodological foundation for future applications and support ongoing policy discussions on the sustainability and resilience of European fisheries.

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Work Package Leader	Isabella Bitetto			
Work Participants	Bitetto, I., Altuna, M., Andrés, M., Asif, F., Batts, L., Caro, M., Depestele, J., Frangoudes, K., García, D., Halkos, G., Hamon, K., Hegland, T. J., Kempf, A., Koundouri, P., Kraan, M., Kühn, B., Landis C., Le Grand, C., Lembo, G., Liontakis, A., Muench, A., Pedreschi, D., Plataniotis, A., Riekhof, M., Sgardeli, V., Spedicato, M. T., Sys, K., Taylor, M., Vasilopoulou, V., Voss, R., and Rindorf, A.			

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