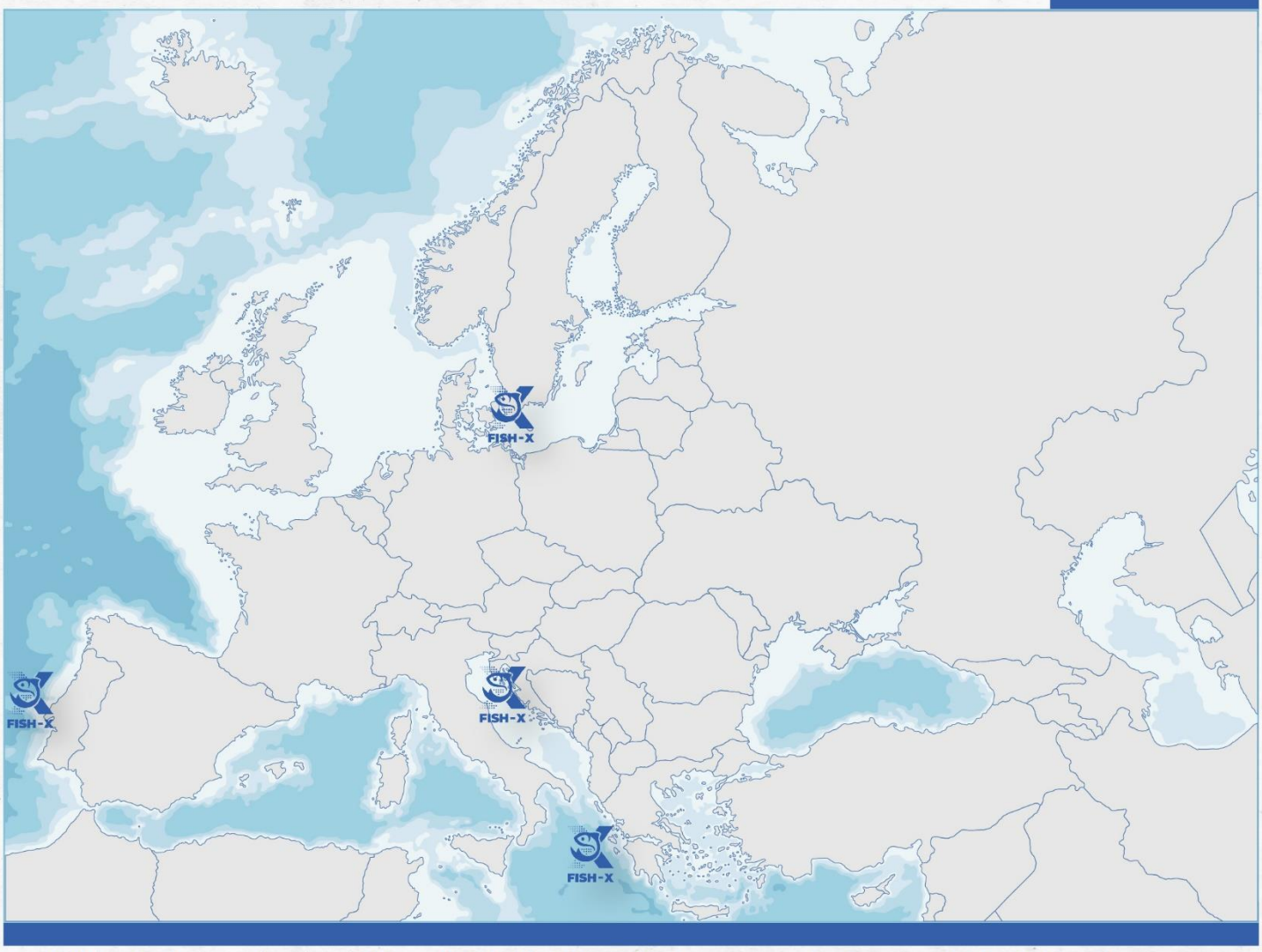
FISH-X

PRELIMINARY EU FISHERIES ROADMAP FOR DIGITALISATION

WP # 2



In addition to the roadmap on EU-level Fish-X will create demo cases in the seas indicated on the map.

Co-funded by the European Union

Preliminary EU Fisheries Roadmap for Digitalisation – WP # 2

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Abstract	In line with the EU Green Deal objectives and Farm-to-Fork Strategy, EU Common Fisheries Policy, and the EU 2030

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	Digital Compass, the Fish-X Project – supported by the Horizon Europe Programme – has been established to make a key contribution for sustainable EU fisheries management by digital transformation. By putting the fishers in the center of the seafood supply chain and to improve data management for monitoring & control and traceability purposes, the Fish-X Project aims to create a new secure and interoperable digital platform, that will comprise of three components: 1) the Fish-X dataspace, 2) the Insight Platform, and 3) the Traceability App. These three components constitute the infrastructure designed under the Gaia-X framework, appropriate to ensure data sovereignty and security for EU fisheries datasets. This preliminary Roadmap for EU Fisheries Digitalisation consolidates the first key findings of the Fish-X consortium to give orientation on who should engage with which actions on identified challenges to support the EU fisheries sector in its digital transformation by 2030. As a result of continued consultation with key actors, this deliverable will be finalised until February 2025 to suggest the necessary steps to better involve EU fisheries and relevant stakeholders into the sector´s digital transition, so to support inspection and control for sustainable fisheries. Fish-X is carried out by seven European organisations, called consortium partners, including TransMarTech Schleswig-Holstein (TMT, Germany), EU Tech Chamber (EUTECH, Germany), Collecte Localisation Satellites (CLS, France), north.io (Germany), Sciaena (Portugal), OURZ (Germany), and WWF EPO (Belgium).

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Acronyms and Abbreviations

Abbreviation	Meaning
AI	Artificial Intelligence
AIS	Automatic Identification System
BBNJ	Biodiversity Beyond National Jurisdiction
BMar	Sea Electronic Counter
CCTV	Close Circuit Television
CFP	Common Fisheries Policy
DCF	Data Collection Framework
DEC Plan	Dissemination, Exploitation, and Communication Plan
DestinE	Destination Earth
DFFU	Deutsche Fisch Fang Union
DG Mare	Directorate-General for Maritime Affairs and Fisheries
DTO	Digital Twin of the Ocean
EAA	European Environment Agency
EAF	Ecosystem Approach to Fisheries
EC	European Commission
eCDS	electronic Catch Document Scheme
EEZ	Exclusive Economic Zone
EMFF	European Maritime and Fisheries Fund
ERS	Electronic Reporting System
EU	European Union
EUMOFA	European Market Observatory for Fisheries and Aquaculture Products
FAO	Food & Agriculture Organisation of the United Nations
GES	Good Environmental Status
GFCM	General Fisheries Commission for the Mediterranean and the Black Sea
ICCAT	International Commission for the Conservation of the Atlantic Tuna
IOTC	Indian Ocean Tuna Commission
IUU	Illegal, Unreported, and Unregulated fishing
JRC	Joint Research Centre of the European Commission
kg	Kilogramme
MCS	Monitoring, Control, and Surveillance

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MPA	Marine Protected Areas
MS	Member States
MSC	Marine Stewardship Council
MSFD	Marine Strategy Framework Directive
MSY	Maximum Sustainable Yield
OECD	Organisation for Economic Co-operation and Development
PO	Producer Organisations
PSMA	Agreement on Port State Measures
PSOEM	Maritime Spatial Planning Situation Plan (in Portuguese)
RFMO	Regional Fisheries Management Organisation
RPOA-SSF	Regional Plan of Action for SSF
SDG	Sustainable Development Goals
SME	Small and Medium Enterprises
STECF	Scientific, Technical and Economic Committee for Fisheries
TAC	Total Allowable Catch
UNCLOS	UN Convention on the Law of the Sea
VMS	Vessel Monitoring System

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1. Introduction

In line with the European Commission's (EC) Green Deal objectives, Common Fisheries Policy (CFP), and the EU 2030 Digital Compass, it is the vision for this preliminary EU Fisheries Roadmap for Digitalisation that, by means of innovative data management and new platforms, the development of better and more sustainable fisheries management can be facilitated in the future. The massive digital transition is ongoing in the European Union (EU) creates an opportunity to reconcile environmental and socio-economic issues in the fisheries and seafood sector, and to turn them into a positive trend for all stakeholders involved.

As part of the Fish-X project, funded by Horizon Europe, this preliminary roadmap is a first step towards the final fisheries roadmap, which will be finalised until February 2025, in consultation with key actors from the public and private sectors, as well as from research, academia, and civil society. The roadmap will be a targeted effort by which the maritime agencies, together with EU fisheries and communities, will use existing and emerging knowledge, tools, and practices to secure and sustainably develop the sector. Until 2030, the roadmap will suggest the necessary steps to better involve EU fisheries and relevant stakeholders into the sector´s digital transition, so to support inspection and control for sustainable fisheries to ensure that fisheries are environmentally, economically, and socially sustainable as well as that they provide a source of healthy food for EU citizens.

As part of the EU´s Farm to Fork Strategy for a fair, healthy, and environmentally friendly food system, the fishing sector has a significant role in terms of food security, cultural identity, employment, and income. Fish and other marine animals are a natural resource, both renewable and mobile. Within this roadmap, only commercial exploitation of wild marine animals, from small to large scale operations, has been considered.

While ownership does begin with its catch, fish stocks are regarded as a common resource that needs to be managed collectively to ensure their protection. The result of this approach has been the emergence of a wide range of policies that govern the amount of fishing at the EU level, and more widely at the level of sea basins, in addition to the different fishing techniques and gears that are allowed.

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In the second chapter, the document describes the background and current developments of policies, regulations, and initiatives for EU fisheries in a global and European context, that are targeted to promote good practices in the sector towards better sustainable management with digital data solutions.

In the third chapter, the socio-economic relevance of the EU fisheries industry and markets in terms of structure, fish landings volumes and values as well as consumption is shown. This is followed by a description of the present rules, conditions, and practices on EU level and for selected EU Member States (MS) that EU fisheries utilise to support the EU and MS maritime authorities on monitoring and traceability of fishing data.

The fourth chapter presents the Fish-X Consortium vision on a Preliminary Roadmap for Digitalisation of EU Fisheries to support the sector in its efforts for more sustainable management. This is based on explaining, first, the benefits and the needs for EU fisheries. Based on first consultations, research, and analysis, the document showcases a first overview of identified key objectives, targets, and action areas for the different stakeholder groups, that will be needed to support the digital transition of EU fisheries.

Then the approach of the Fish-X project, undertaking to support this EU Fisheries Roadmap for Digitalisation, will be showcased. It will build on Gaia-X and in conformity with its infrastructure, the aim is to create a dataspace where fishers are in the centre of the seafood supply chain to increase transparency in the sector, by facilitating more timely collection, processing, and exchange of accurate data amongst fisheries data providers, data consumers, and intermediaries (EU, MS). Once fully implemented and active, the idea is to have additional benefits as Fish-X shall be usable for benchmarking and governance when working with international partners.

Chapter five will present the conclusions and key recommendations from the Fish-X consortium to establish a successful EU Fisheries Roadmap for Digitalisation. For its final version in February 2025, two more chapters are planned to present an analysis and synthesis of already existing roadmaps, initiatives, and plans inside the EU, as well as of the skills and education status in the EU fisheries industry.

As a result of this digital transition, EU fisheries will have a new and more attractive development perspective as they will be able to further optimise their existing operations and business models, in compliance with existing legislations. This will also provide more transparency in this sector, allow for progress in the sustainability and traceability of fishing

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products, and so make use of the full market potential of responsibly sourced seafood products.

2. EU Fisheries Policies and Regulations

This section gives a general description of regulations in relation with fisheries management, in a global and European context. The regulations cited have led to the development of an existing digital infrastructure and digital practices.

2.1 Background

The fishing industry is key in providing food of high nutritional value on a global scale, as well as direct and indirect employment in many of the world's coastal regions. However, according to the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES), fisheries remain the first cause of marine biodiversity decline.[1] While fishers in

[1] This is the case for the Mediterranean Sea where fish stocks are deteriorating at an alarming rate (93% of assessed fish stocks are overexploited and several are on the verge of depletion, according to a RC study in March

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general have become more and more conscious that more sustainable fishing practices are necessary, and that fish stocks are threatened due to natural vulnerability and anthropogenic pressure, the EU has taken a number of steps for more targeted action to support EU fisheries.

This chapter describes the current EU policies and regulations for EU fisheries as well as present discussions to overcome the identified challenges and gaps for sustainable fisheries with digital data solutions.

2.1.1 Why do we Need to Improve Fisheries Management in the EU?

One of the overarching goals of the strategies related to the environment, biodiversity, Blue Economy, and the CFP is the conservation of marine biological resources and the management of fisheries and fleets exploiting such resources. Our ocean resources are challenged by human activities (fishing pressure, IUU fishing, pollution of the oceans, increasing demand for access to maritime spaces) in a context of climate change. The abundance of natural resources is not a forever asset. There are existing examples of completely extinct stocks because of past mismanagement (e.g., cod in the North-West Atlantic), and climate change is creating further difficulties to stock management, for example in the Atlantic Ocean where warm-favouring species are moving in northern basins such as North Sea and Celtic Sea.[2]

The European Environment Agency (EEA), that publishes indicators of fish stocks, states: *"Overall, the 2020 target of the CFP and Marine Strategy Framework Directive (MSFD) to restore healthy fish and shellfish stocks has not yet been met across Europe. In 2019, of the 188 assessed stocks in European waters, for which information was available to assess GES,[3] only 22% were in good state according to both criteria and a further 34% according to at least one criterion. The state of commercial stocks is especially critical in the Mediterranean and Black seas where only 12% of assessed units were in good state based on a single criterion*

2017. See Scientific, Technical and Economic Committee for Fisheries (STECF) – 2017; Mediterranean Stock Assessments - Part 2 (STECF-17-15); Publications Office of the European Union, Luxembourg, ISBN 978-92-79-67494-5, doi:10.2760/90316, JRC111820

[2] European Environmental Agency (EEA) Indicators - Changes in fish distribution in European seas

[3] Good Environmental Status, EEA indicator. GES was defined in the Article 9(1) of Directive 2008/56/EC, and standards revised in the Commission Decision 2017/848. Criteria for GES are in descriptor 3: *"Populations of all commercially-exploited fish and shellfish are within safe biological limits, exhibiting a population age and size distribution that is indicative of a healthy stock".*

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(eight out of 60 in the Mediterranean and none out of 7 in the Black Sea), and none were in good state based on both criteria. In the North-East Atlantic Ocean and Baltic Sea regions, 51% of the assessed commercial stocks met at least one of the two GES (Good Environmental Status) *criteria considered, while only 12% were not in good state according to both criteria."*

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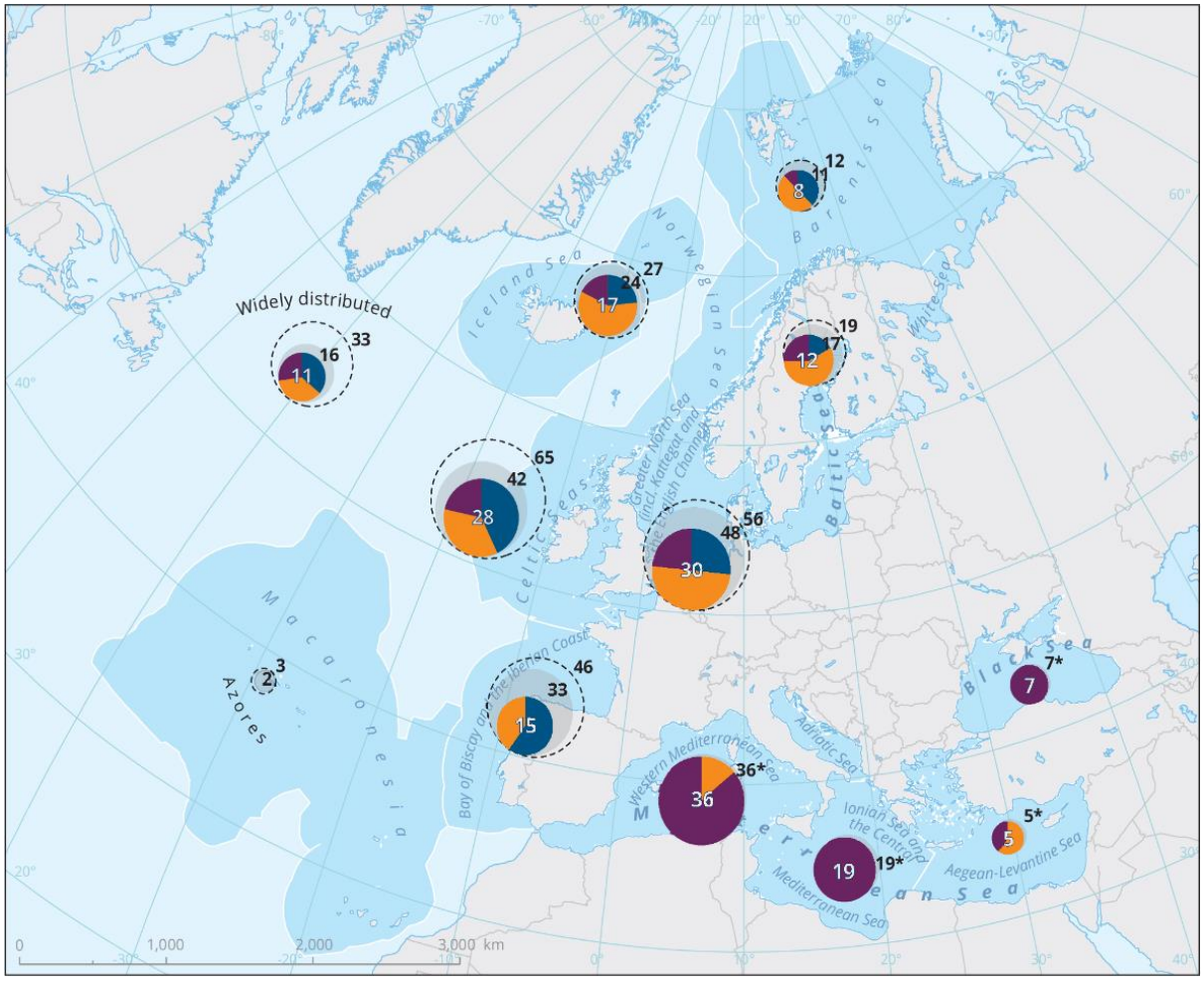

Reference data: ©ESRI

State of European commercial fish and shellfish stocks (for which stock assessments were conducted between 2016-2020), in relation to the Good Environmental Status criteria for fishing mortality and reproductive capacity per marine region

Number of assessed stocks (X) for which adequate information is available to determine

- Stocks meeting both the GES criteria for F and SSB being at MSY [1)]
- Stocks meeting only one of the GES criteria, either F or SSB being at MSY
- Stocks not meeting any of the GES criteria, so F and SSB are not at MSY

Total number of assessed stocks: Y

Total number of stocks: Z

Notes:

1) GES: Good Environmental Status
F: Fishing mortality
SSB: Spawning Stock Biomass
MSY: Maximum Sustainable Yield

** Unknown total number of stocks (Z)*

Figure 1: *State of European commercial fish and shellfish stocks 4*

[4] See EAA

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The sustainable management of fish stocks is a complex objective, and fishing pressure represents only one of several variables on the fish stocks and their ecosystems' health. The CFP aims at adapting the fishing activities to levels in adequation with the sustainable exploitation of fish stocks, obtaining an overall encouraging status, with some significant success cases, and still some failures. Better management of fisheries is obtained through a combination of rules more strictly applied, covering the largest possible portion of the fishing vessels by order of impact caused on stocks, better engagement of stakeholders in order to accept the objectives and rules, and by science-based decisions taken on continuously updated and verified data sets. Fisheries management will require larger amounts of data sets and indicators (in spatial and temporal dimensions), fit for automated analysis, with faster response times, taking the best of modern digital tools and infrastructures.

2.1.2 A Global Trend Towards Digitalisation of Oceans and Fisheries

Digitalisation of ocean science, applied to many sectors including fisheries, is a long term and global trend. For instance, it is supported at a multilateral level by initiatives such as the United Nations' Decade of Ocean Science for Sustainable Development (2021-2030). It defines 10 Ocean Decade Challenges, for the protection of the oceans, restoration of biodiversity, sustainable food supply for the global populations in the context of climate change. One of these challenges aims at developing a comprehensive digital representation of the ocean, with physical and biological variables, to provide free and open access for exploring, discovering, and visualising past, current, and future ocean conditions.

The digital fisheries will develop in parallel with the digital ocean sciences. Leading international organisations such as the Food and Agriculture Organisation of the United Nations (FAO) also investigate how new technologies can support a better understanding of the oceans and the marine ecosystems and contribute to more sustainable fisheries by the Ecosystem Approach to Fisheries (EAF).

The FAO, in its strategy over 2022-2030, aims at the "four betters" (better production, better nutrition, better environment, better life). A better production involves innovation in agriculture and fisheries, "Blue Transformation", better access to resources for Small-Scale Producers. For instance, the FAO Science and Innovation Forum 2022 focused on highlighting the

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centrality of science, technology, and innovation for agri-food systems transformation (including for fisheries). The organisation published a 2022-2030 roadmap for the transformation of aquatic food systems - 'Blue Transformation'[5], which aims at 100% of fisheries under effective management, facilitate the development of innovative data and information systems, regular monitoring, and reporting on the state of fisheries, and phase-out the IUU fishing.

Digital tools applied to fisheries will support the implementation and monitoring of several of the United Nations' Sustainable Development Goals (SDGs). The SDG 14 *"Life Below Water"* target indicator 14.4. calls for ending overfishing and fight IUU fishing, and the indicator SDG14.2, for the sustainable management and protection of marine and coastal ecosystems. The targets 14.a. on increasing scientific knowledge, developing research capacity, and transferring marine technology, and target 14.b. on access for small-scale artisanal fishers to marine resources and markets, directly benefit from and invite the digitalisation of fisheries. Digitalisation of fisheries also contributes to several other SDGs, especially SDG1 (No poverty), SDG 2 (Zero hunger), SDG 3 (Good health), SDG 8 (Decent work and economic growth), SDG 9 (innovation), SDG 10 (Reduced inequalities), SDG 13 (Responsible Consumption and production), and SDG 13 (Climate action).

The FAO produced recommendations for responsible fisheries and science-based management in its 1995 Code of Conduct for Responsible Fisheries, when overexploitation of stocks became visible, with objectives of conservation, management, and development of aquatic ecosystems. While the concept of digitalisation was not yet expressed in 1995, there are clear references to acquisition and management of data which will be dependent of digitalisation. In its article 6, *"States should assign priority to undertake research and data collection in order to improve scientific and technical knowledge of fisheries including their interaction with the ecosystem."* In its article 7, *"States, in conformity with their national laws, should implement effective fisheries monitoring, control, surveillance and law enforcement measures including, where appropriate, observer programmes, inspection schemes and vessel monitoring systems,"*. In its article 8, *"Flag States should maintain records of fishing vessels entitled to fly their Flag…"*.

It took another few years until 2001 to adopt the International Plan of Action to Prevent, Deter and Eliminate IUU fishing (IPOA-IUU).[6] The IPOA-IUU defines measures applicable to flag

[5] Blue Transformation - Roadmap 2022–2030: A vision for FAO's work on aquatic food systems, FAO, 2022.
[6] International Plan of Action to prevent, deter and eliminate illegal, unreported, and unregulated fishing, FAO, 2011.

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states, coastal states and port states and regional organisations to prevent fish from fraudulent origin to access to markets, and these measures can only be implemented through digital data exchanges allowing rapid access to vessel records with delays compatible with port inspections. The Voluntary Guidelines for Securing Sustainable Small-Scale Fisheries[7] in 2015 include recommendations for a rule-of-law approach, secure access rights to the resources, and implementation of management systems.

The Agreement on Port State Measures (PSMA)[8] in 2009 (entering in effect in 2016) is the first legally binding international agreement to specifically target illegal, unreported, and unregulated (IUU) fishing. The agreement gives the right for a port state to deny port access to IUU suspected vessels, and a set of obligations for port states and port authorities to control foreign vessels using their ports and landing their catches, to prevent potential IUU products from entering markets. Vessels have to submit an advanced request to enter ports, with details of catches. The port states have to carry out inspections based on risk rating. The FAO has a Global Information Exchange System (GIES) under development to support all digital exchanges of documents between flag and port states.

All these guidelines or legally binding agreements rely on a strong development of digital tools to collect, analyse, and exchange fishing activities. This is achieved under the responsibility of the states and the Regional Fisheries Management Organisations (RFMOs). For instance, the International Commission for the Conservation of the Atlantic Tuna (ICCAT), the Indian Ocean Tuna Commission (IOTC) and the General Fisheries Commission for the Mediterranean and the Black Sea (GFCM) already all require vessel monitoring systems (VMS) operating in their waters. Within the ICCAT area, an electronic Catch Document Scheme (eCDS) for bluefin tuna is also in place since 2018. Pilot trials for remote electronic monitoring have also been conducted in some RFMOs in cooperation with volunteer shipowners, for instance in ICCAT.

2.1.3 An Overview of the EU Fisheries Regulatory Framework

In order to ensure the environmentally sustainable exploitation of marine biological resources and the long-term viability of the fishing sector, fisheries are managed by the CFP. Based on

[7] Voluntary Guidelines for Securing Sustainable Small-Scale Fisheries in the Context of Food Security and Poverty Eradication, FAO, 2015.

[8] Agreement on Port State Measures to Prevent, Deter and Eliminate Illegal, Unreported and Unregulated Fishing. Revised edition, FAO, 2016.

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several factors, such as scientific advice, socioeconomic needs and the precautionary principle, the EU applies the principles of MSY and relative stability when allocating fishing opportunities to MS.

Digitalisation of the fisheries sector is not something new in the EU. It has been used to help with the implementation of the CFP and the associated EU Fisheries Control System. Recent policy development, driven by the EU Green Deal and the ongoing revision of the EU Fisheries Control Regulation highlight the need to speed up the digitalisation of EU fisheries.

The CFP, as any natural resource management policy, requires more modern monitoring and control rules and tools. The Council Regulation (EC) No 1224/2009 of 20 November 2009 [9] establishing a community control system for ensuring compliance with the rules of the CFP, also known as *"Control Regulation"*. This regulation of 2009 implemented VMS (article 9) and daily electronic catch reporting (article 15) for vessels above 12 meters; Automatic Identification System (AIS) for vessels above 15 meters (article 10); catch sampling at ports for vessels not using logbooks like the SSF vessels (article 16); electronic Sales Notes for buyers above 200.000 euro in the 24 hours of first sales (article 63). But vessels below 15 meters may be exempted of the VMS or Electronic Reporting System (ERS) measures if they operate exclusively in their territorial waters, or at sea less than 24 hours from departure to return to port.

As a result, vessels below 12 meters are not required to report on digital systems. For vessels from 10 to 12 meters, they can submit paper logbooks to report, which makes the aggregation of their activities more time consuming and unreliable.

The article 13 of said directive already invited, in 2009, MS to explore and trial new technologies to improve monitoring and control of EU fleets. The introduction in 2013 of measures such as the EU discard ban (the so-called *"landing obligation"*) made it necessary to reinforce tools to both avoid and monitor discards in EU fisheries. Remote electronic programmes have already been largely trialled in the EU to support the verification of the landing obligation. Likewise, digital tools have also been developed to integrate bio-physical and fisheries data to avoid areas where bycatch is at higher risk.

[9] Council Regulation (EC) N° 1224/2009 of 20 November 2009 establishing a community control system for ensuring compliance with the rules of the common fisheries policy"

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The management of the fisheries data is specified by the EC,[10] with responsibilities given to the MS to implement data collection methods verified by scientific experts, and to share these data with the Commission.

Each Member State keep records of the catches of their national fleet. All the catch data are verified and aggregated at the national level, and the MS are required to share them for scientific studies under the DCF, every year or for multiannual plans. The DCF allows to define science-based management plans to manage the fishing effort as to have the highest catch possible while maintaining stocks at their sustainable levels Maximum Sustainable Yield (MSY). The DCF includes data on catches, by-catches of non-target species, ecosystems, fishing effort and capacity of the fleet, aquaculture data, socioeconomic data of the fisheries and fish processing sector, results of scientific marine surveys. MS are at the source of the data, and they follow regional coordination to contribute to regional databases.

The regulation 2017/1004 includes obligations for data sharing among states and aggregation and anonymisation to protect personal data. These data sets are collected by the EC and used by scientific experts to propose the Total Allowable Catches (TAC), which are approved by the Council of fisheries ministers of each Member State. The TACs are then allocated into quotas managed at Member State level. The scientific expertise to define the TACs is provided by the Scientific, Technical and Economic Committee for Fisheries (STECF), and the Advisory Councils such as ICES for the Baltic Sea, North Sea, Atlantic Ocean, and the General Fisheries Commission for the Mediterranean and the Black Sea (GFCM).

The Joint Research Centre of the EC has a mandate for collecting, storing and validating fisheries data from the MS before they are used for scientific advises. These data are less restricted than the Monitoring & Control data. The article 17 of the Regulation 2017/2004 states: *"[Member States] shall refrain from any unnecessary restrictions to the dissemination of detailed and aggregated data to end-users of scientific data and other interested parties"*. The article leaves the opportunity for a broader access to scientific fisheries data from the MS to support more open science.

[10] Refer to procedures defined in the Regulation 2017/1004 for an Union framework for the collection, management and use of data in the fisheries sector. Articles 13, 14 about the data storage and control. Article 15 about data access by the commission.

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2.1.4 The Context of the EU Digital Decade Strategy

In March 2021, the EC published the communication *"The 2030 Digital Compass: the European way for the Digital Decade"*[11] setting digitalisation goals for 2030 of 100% public services available online, more than 90% of European SMEs with at least a basic level of digital practices and relying more on EU infrastructure.

In this context, The EU is strongly engaged with the Destination Earth (DestinE) initiative to develop the Digital Twins, including the Digital Twin of the Ocean (DTO) of interest for fisheries. The DTO will collect, store, and analyse ocean high-quality data sets using models and artificial intelligence (AI), to allow decision makers to test "what if?" scenarios on the ocean and its natural resources evolutions. The future DTO is presently developed by the Iliad project funded by the Horizon 2020 Research and Innovation programme. Blue-Cloud, a EU Horizon 2020 project, has demonstrated a digital platform designed to host fisheries and marine data sources from European services such as EMODnet, and provided researchers with cloud-based analytical tools and computing resources.[12]

2.1.5 Digital Tools for a Sustainable Food System

In 2020 came the Farm to Fork Strategy to implement the EU Green Deal for a fair, healthy and environmental-friendly food system (COM(2020) 381 final).[13] The Farm to Fork Strategy put the fishers in the centre of the seafood supply chain and promote more sustainable methods, serving a triple objective of stock preservation, protection of environment, and socio-economic development. The introduction of digital tools and a more environmentally approach is a way to achieve sustainability of fishing activities and attract new generations in the fisheries related business.

[11] COM(2021)118 final – Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions – 2030 Digital Compass: the European Way for the Digital Decade.

[12] Vera, Julia, et al. Blue-Cloud Strategic Roadmap - Executive Summary (Supporting Material for Final Conference). November 2022

[13] Com(2020)381 final. Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions - A Farm to Fork Strategy for a fair, healthy and environmental-friendly food system

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To support law abiding fishers against the unfair competition of illegal fishers, the EC takes a zero-tolerance approach to IUU fishing. The EC is also working on an EU legislative framework for sustainable food systems for late 2023. This law is part of the Farm to Fork Strategy and aims to integrate sustainability into all food-related policies, while addressing the links between healthy people, healthy societies, and a healthy planet.

2.2 Current Developments

2.2.1 Towards a Revision of the EU Fisheries Control System

To improve the sustainability of EU fisheries, major assessments and revisions of EU fisheries and monitoring and control policies are ongoing. The EC should release early 2023 a report assessing the implementation of the current CFP. The report may also provide information on the future actions that could help better achieving the objectives of the CFP. Furthermore, the European Parliament should also release very soon an initiative report dedicated to the Future of the CFP.[14] The EC will also share a new *"Action plan to conserve fisheries resources and protect marine ecosystems"*[15] very soon. The Action plan should highlight where action is needed to address the by-catch of sensitive species and adverse impacts on sensitive habitats through technical measures such as area closures, gear changes and mitigation measures for sensitive species.

Two consecutive 5-year periodical evaluations (COM(2017) 192 final and COM(2021) 316 final) confirmed that the Council Regulation 1224/2009 was not strong enough and permitted too many exemptions: for vessels below 15 meters, many fishing trips are not monitored, and vessels below 10 meters do not produce any logbook. It results that VMS and electronic logbook coverage for vessels between 12 meters and 15 meters is still low, even if it increased from about 35% in 2015 to 40% in 2019. There are still lots of weighting infringements. The landing obligation is not followed by fishers, and it introduces a bias in fisheries statistics and a risk of stock overexploitation. This can be explained because this regulation is difficult to

[14] https://oeil.secure.europarl.europa.eu/oeil/popups/ficheprocedure.do?reference=2021/2169(INI)&l=en
[15] https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/12953-Action-plan-to-conserve-fisheries-resources-and-protect-marine-ecosystems_en

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control, as it would require cameras onboard the fishing vessels to analyse which type and quantity of by-catch are discarded at sea.

In 2019, the EC published a study on the verification of engine power[16] in 15 MS, which revealed non-compliance widespread across all countries After engine power verification of 68 vessels in 14 MS, 33% were found compliant with their licenses power.

These statements resulted in the EC adopting in May 2018 a proposal COM(2018)368 to revise the EU's fisheries-control system. In November 2022 the proposal is still under discussion. It aims at:

- strengthening the enforcement provisions
- ensuring better quality and better sharing of fisheries data and information, in particular for small-scale and recreational fisheries
- filling the gap with the CFP in control of the landing obligation
- reducing administrative burden
- enhancing synergies with other policies

Some solutions can be easily put into operations, with minimised additional costs, and could be applied to SSF and recreational fisheries as well. For instance, a DG Mare report of 2020[17] demonstrated the potential benefits of electronic catch reporting using smartphone applications, available for free, for the control scheme of recreational catches of sea bass.

2.2.2 The EU Position to Support the International Governance of the Oceans

The EU is highly engaged in international ocean governance and recently expressed its vision at the 5th session of the Intergovernmental Conference at the 2nd UN Ocean Conference, in June 2022 in Lisbon, and at the UN in New York, in August 15-26th, 2022. The EU supports the future international legally binding instrument for the conservation and sustainable use of

[16] European Commission, Directorate-General for Maritime Affairs and Fisheries, Study on engine power verification by Member States: final report, Publications Office, 2019

[17] European Commission, Directorate-General for Maritime Affairs and Fisheries, Control scheme for recreational catches of sea bass: final report, Publications Office, 2020

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marine Biodiversity Beyond National Jurisdiction (BBNJ) under the UN Convention on the Law of the Sea (UNCLOS).

The high seas, the international waters beyond national jurisdictions, outwards of 200 nautical miles from the shoreline, are a place where illegal fisheries by industrial vessels have a higher tendency to occur, being that enforcement and prosecution are more complicated. Due to the necessity of ensuring the sustainable use of the high seas and the overarching need to better protect the ocean, the high seas are being targeted as a crucial part of the *"30 by 30 Initiative"* (protecting 30% of the land and sea by 2030). This will imply the establishment of large Marine Protected Areas (MPAs) in the high seas, and although the enforcement of high seas MPAs is still in discussion, it will certainly rely on the integration of fisheries control systems.

2.2.3 The European Commission's new Approach for a Sustainable Blue Economy

In 2021, the EC published its *"New approach for a sustainable blue economy in the EU: Transforming the EU's Blue Economy for a Sustainable Future"*[18] (COM(2021) 240).[19] Through this approach, the EC aims at making the transition from *"blue growth*" to a *"sustainable blue economy"*. To do so, it looks into biodiversity and nature as well *"as responsible food systems"*. The document puts forward innovative technologies as key drivers of the blue economy transition. It states that *"digitalisation and advanced tools for fisheries [...] may well become standard features in the fishing industry. Promoting an EU-based digital know-how for the fishing industry would create a new generation of jobs."*

Beyond fisheries, the EC document also cast the light on the need to improve the management of space at sea. Especially, it calls for a better management of conflict for sea space user between sectors, but also policies. Maritime Spatial Planning plays a key role in securing this objective, and fisheries should also be part of the discussion. Maritime spatial planning informed by better fisheries data and participation will be necessary to achieve some of the

[18] Com(2021)240 final - Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions on a new approach for a sustainable blue economy in the EU

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Green Deal's policies, such as the Biodiversity Strategy or the offshore renewable energy strategy.

For instance, information of the spatial and temporal distribution of fisheries would greatly help with avoiding conflict of sea space use better fishers and the energy sector when deploying offshore renewables. Likewise, spatial fisheries data would be of great importance to achieve that MPAs targets embedded in the Biodiversity Strategy.

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3. EU Fisheries Industry and Practices

This chapter is divided into the following parts: After characterising the EU fisheries sector in terms of socio-economic relevance the document gives an introduction to the EU Fisheries practices to support the EU and MS maritime authorities on monitoring and traceability of fish data.[20]

This will be followed by a summary of key take-aways that serve as a fundament for the development of Fish-X Consortium´s Vision on the Digital Transformation Roadmap for sustainable EU Fisheries Management.

To remain in the general objectives the Fish-X project, except where the subject relates with vertical integration, this preliminary roadmap will only consider the fisheries industry from the fishing capacity point of view, i.e. the companies which operate fishing vessels, not addressing other components of the sector (post-harvest processing, logistics, retail).

3.1 EU Fisheries and Seafood Market

The EC has put in place the European Market Observatory for Fisheries and Aquaculture (EUMOFA) to provide fisheries market analytical tools and dashboards.[21]

3.1.1 Structure of the Fisheries Industry in the EU

The EU fisheries sector plays an essential role for the achievement of the objectives of the EU Farm to Fork Strategy as it has a high significance in terms of food security, cultural identity, employment, and income generation.

As an effect of fisheries directives, the EU fishing fleet has continuously dropped in number since the early 1990s. In 2019, the number of active vessels in the EU-27 was 75,405 (-6,4%

[20] Unless otherwise specified, statistics are released by Eurostat.

[21] It includes for each country synthetic statistics: total captures, fleet by length and gear It maintains data bases with the weekly prices of main commercial species, either landed or imported. See EUMOFA - European Market Observatory for Fisheries and Aquaculture

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since 2013), with 85% of the fleet being below 12 meters in length, for a total capacity of 1.333.577 GT. In parallel, the volume of aquaculture has remained relatively stable during recent years. In 2018, 163,000 people were employed in the primary fishing industry.[22] Within the EU-27, three quarters of sector's employment was concentrated in Spain, Italy, Greece, France and Portugal.

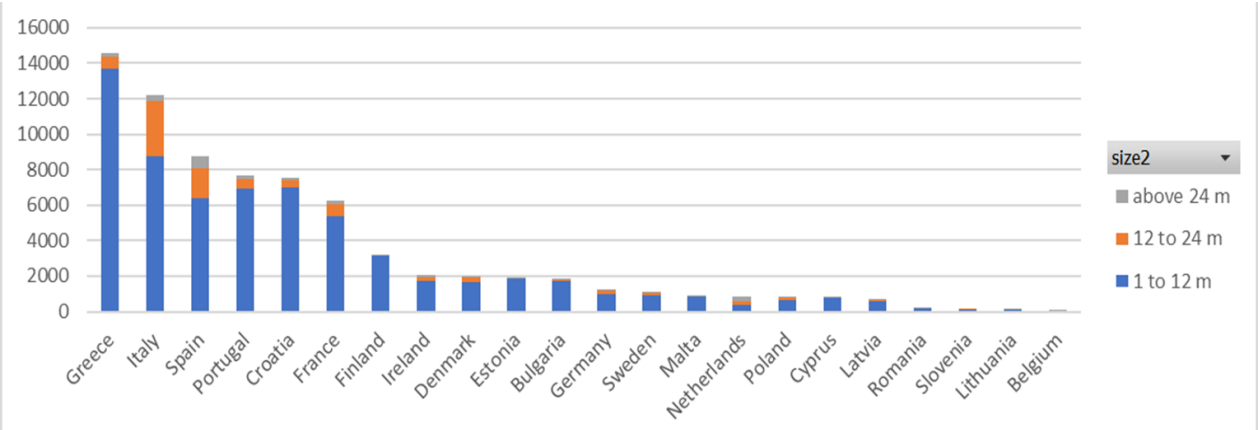

Figure 2: *Fishing fleet by EU Member State* [23]

The EU fishing fleet is heterogeneous, dominated by far by small scale fishing vessels. Very few MS have large ocean-going fishing vessels, generally factory trawlers or tuna purse seiners operating beyond the European Exclusive Economic Zones (EEZ). In the right side of the chart, some MS (Belgium, Netherlands) have developed their industrial fishing capacity and have very few artisanal vessels. While on average Spain has the highest gross tonnage and France the highest-powered fleet, Greece has the highest number of active small vessels.

The vast majority of vessels is below ten meters in length and therefore not covered by the EU's VMS and logbook obligations, while only a small number of vessels exceeds 40 meters in length.

The ratio of industrial vessels within each national fleet varies as illustrated in the following figure.

[22] European Commission. Statistical Office of the European Union. Agriculture, Forestry and Fishery Statistics: 2020 Edition. Publications Office, 2020. See p. 109

[23] The table above aggregates several size categories from the Eurostat tables.

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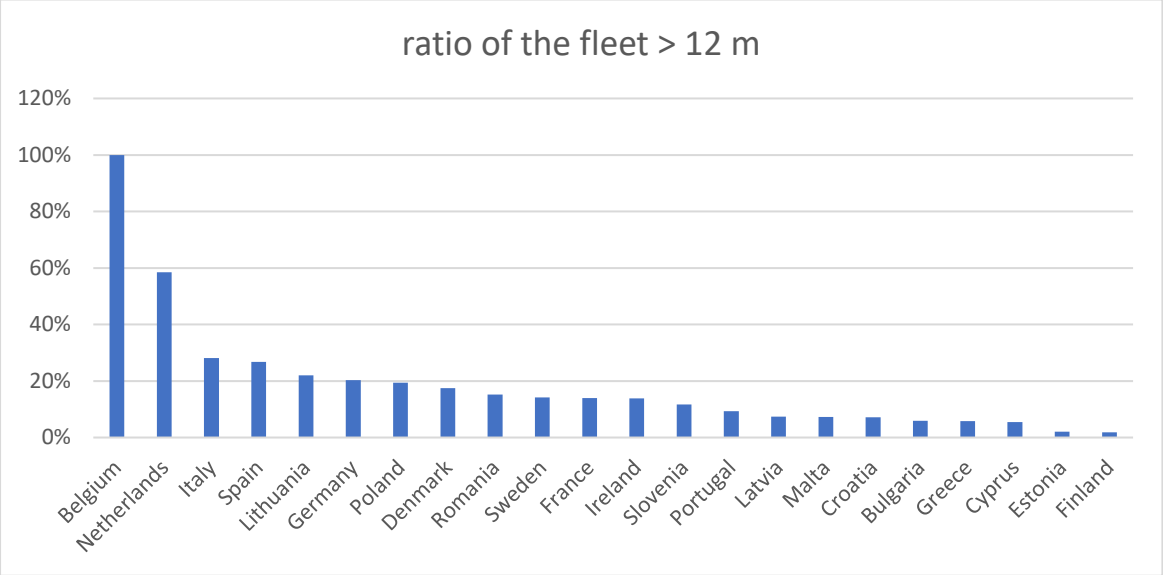

Figure 3: *Ratio of the national fishing fleet above 12 meters by Member State* [24]

As documented into a detailed report of the PECH Committee report covering the fisheries industry in the MS,[25] some predominant trends are visible at the EU level, resulting of the effects of the CFP (all the report figures are of 2017), in a context of small enterprises operating one single vessel in opposition with international conglomerates investing in modern vessels and the fish processing value chain.

[24] The table above aggregates several size categories from the Eurostat tables.

[25] Warmerdam, W, Kuepper, B, Walstra, J, Werkman, M, Levicharova, M, Wikström, L, Skerrit, D, Enthoven, L & Davies, R (2018), Research for PECH Committee – Seafood industry integration in all EU Member States with a coastline, European Parliament, Policy Department for Structural and Cohesion Policies, Brussels.

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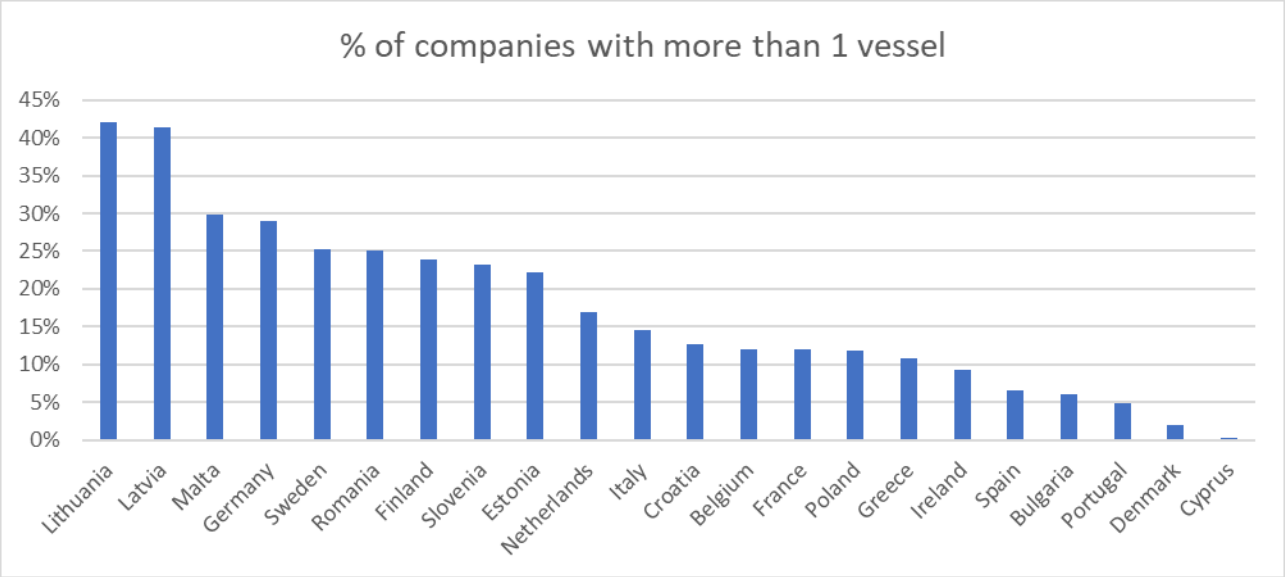

Figure 4: *Ratio of the national enterprises operating more than 1 single vessel by Member State* [26]

Although it is difficult to synthesise the trends in the fisheries sector, due to the variety of fisheries (coastal going low while pelagic fishing is developing), the variety of quota management rules (per vessel, per company, transferable or not), and the history of each MS (Spain and France operating tropical fleets), some major trends can be observed:

- After decades of reduction of the fishing fleet as a consequence of reduction of stocks and quota, overcapacity is still present.
- All over the EU, the average number of vessels by enterprise is close to one, fisheries are most frequently a family business with few investors. In Germany 30% of enterprises own more than one vessel. Even for Belgium which has the largest share of industrial vessels, only 12% of enterprises own two or three vessels, all others only 1 vessel.
- In countries where the Individual ITQ was introduced, companies bought the quotas from others to add them to their vessels' quotas. In Denmark, employment dropped from 4,032

[26] Processed from PECH Committee report in 2017. Warmerdam, W, Kuepper, B, Walstra, J, Werkman, M, Levicharova, M, Wikström, L, Skerrit, D, Enthoven, L & Davies, R (2018), Research for PECH Committee – Seafood industry integration in all EU Member States with a coastline, European Parliament, Policy Department for Structural and Cohesion Policies, Brussels.

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FTE (full time equivalent) in 2002 to 1,489 in 2013, while the fleet was modernised and able to catch more diverse fish species.

- Small-scale fishing is generally facing reduction of catches, lack of investment, aging fishing boats and aging populations. There are cases of conversion into tourism (i.e. in Germany) and initiatives to help the small-scale fisheries investing in fish processing for adding value.

- There is a strong horizontal integration in many MS (Belgium, Germany, Netherlands, Estonia, Spain), as a result of enterprises buying the vessels of others, to acquire more quota. In several cases when the law permits, the quota is transferred to one single vessel and the other vessel is decommissioned or sold abroad. For instance, Spanish companies buy French licences to access to French quota, they flag their vessels in France and transfer the licence to these vessels and sell the French vessel without fishing licence.

- In some MS there is a strong vertical integration, where an enterprise or PO owning the vessels acquires the transformation factory, the logistics or port operations, and sometimes the retail. A retailer cannot depend on one single fishing company to satisfy the variety of consumer's needs, and for instance Intermarché in France buys fish from its own fleet (Scapêche, 22 vessels) and from other suppliers.

- The industrial fishing industry attracts foreign investors: in 2016, the Dutch Parlevliet & Van der Plas (PP Group) acquired French tuna fishing company CFTO, and kept the vessels under French flag. The PP Group is also present in Spain, England, Latvia and the Netherlands. Samherji from Iceland is associated with the PP Group in the Spanish company Pesquera Ancora and French Euronor. Samherji also owns the Deutsche Fisch Fang Union (DFFU) in Germany, which operates two modern stern trawlers, named Cuxhaven and Berlin. Four Swedish companies own just under a quarter of Danish quota. Some Estonian companies have 50% or 100% shares in Finnish fishing companies to get access to Finnish quotas.

3.1.2 EU-wide Fish Landings and Value

In 2020, according to the EUMOFA, 3,55 million tons with a value of EUR 5,36 billion were landed in the EU-27, equivalent to 5,2% of the total global catches. The 2020 landings were

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the lowest in the decade, in part due to the covid pandemic which impacted both the fishing activities (impossibility to travel for crew changes, disruption of logistics) and the consumer demand (restaurants closed and in normal years they represent a large share of seafood use, while frozen products consumption rose).

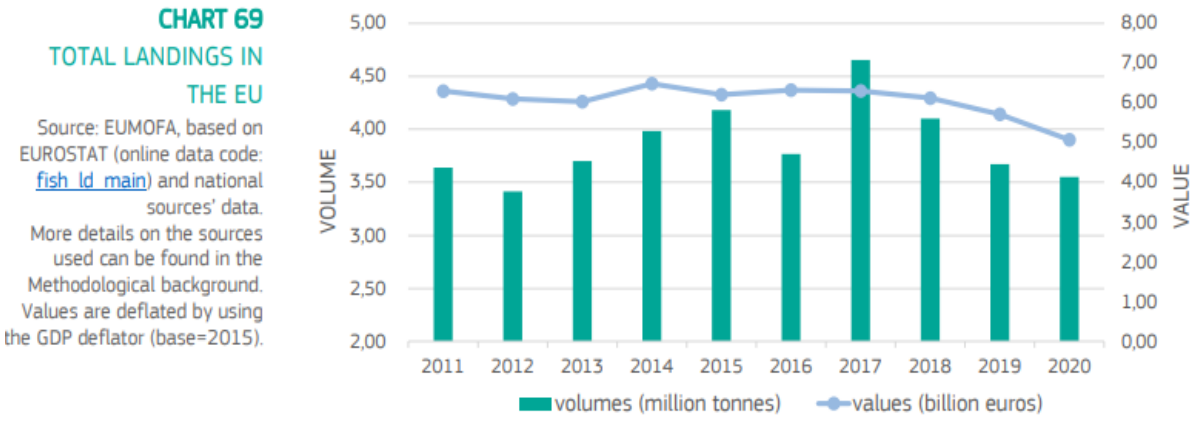

Figure 5: *Total Landings in the EU cited by EUMOFA* [27]

In 2020, the EU has been the world's largest market for imports/exports of fishery and aquaculture products, and became second to China in 2021, due to slight recovery after the covid-19 pandemic.

Total landed value amounted for EUR 6,8 billion euro, also the lowest value of the past 10 years. In 2020, total first sales in EU-27 amounted to 2,44 million tons and EUR 3,61 billion.[28] Three of the five top sales markets are in Denmark.

The highest value for a single commercial species is for hake (EUR 505 million), which could be compared with the values of salmon (EUR 1,341 million) and trout (EUR 677 million) issued from aquaculture (capture fisheries are more diversified where aquaculture focuses on few species).

[27] European Commission. Directorate General for Maritime Affairs and Fisheries. (2022). The EU fish market: 2022 edition. Publications Office. https://doi.org/10.2771/716731

[28] First sales may differ from landings since the former do not cover fish that is landed by vessels owned by processing companies or direct sales to processors.

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There are 164 producer organisations (PO) in fishery sector, and 13 associations of POs in the EU-27 in 2021 (33 in Italy, 30 in Spain). There are 3,589 companies in seafood processing in the EU-28 for EUR 32 billion sales. EU imports 6 million tons in 2020 for EUR 23 billion (including products from aquaculture). Export values are about a third of imports.

3.1.3 Consumption of Fish in the EU

Between 2020 and 2021, the household expenses for seafood products (capture and aquaculture) grew by 7% to EUR 58,5 billion in value, an increase of more than 25% in a decade. Over the past decade, fish products prices have increased with an average of 2,1%/year compared to 1,5% for meat.

In relation, the apparent consumption (production + import - export) dropped, a trend that began in 2018. The EU fish consumption per capita is 24,16 kg/year, almost half of the consumption of Southeast Asian countries.

CHART 11
PER CAPITA APPARENT CONSUMPTION OF FISHERY AND AQUACULTURE PRODUCTS
Source: EUMOFA, based on EUROSTAT (online data codes: fish_aq2a, fish_ca_main and DS-575274), FAO, national administrations and FEAP data. Details on the sources and on the methodological approach used for assessing the production method of imports and exports and the destination use of catches can be found in the Methodological background.

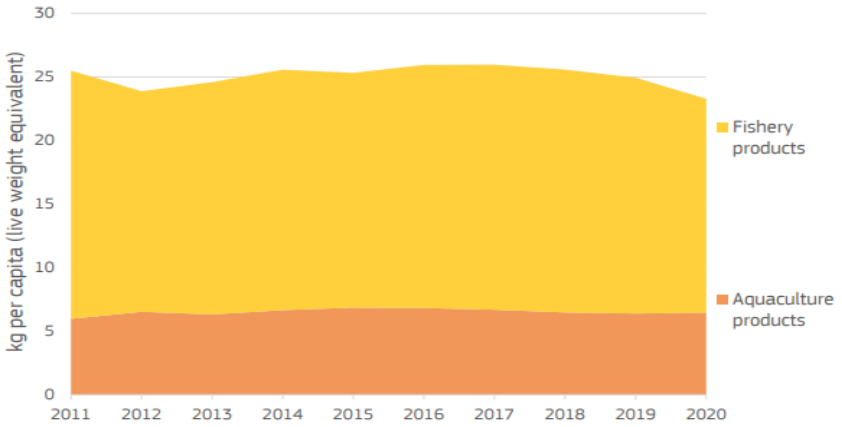

Figure 6: *Per capita apparent consumption of fishery and aquaculture products, by EUMOFA*[29]

The EU increasingly depends on fish imports to cover consumption. As reported by EUMOFA, *"the trade balance deficit in 2021 was 10% or EUR 1,80 billion higher than in 2020. In the 2012-2021 decade, the deficit grew by 31% in real terms. As for imports, values increased more than volumes from 2020 to 2021, due to an increase in the prices. This can be partly explained*

[29] European Commission. Directorate General for Maritime Affairs and Fisheries. (2022). The EU fish market: 2022 edition. Publications Office. https://doi.org/10.2771/716731

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by the EUR's 5% loss of value against the Norwegian drown (NOK) during 2021, which made 2021 imports from Norway more expensive than 2020's".

Between 2020 and 2021, the value of intra-EU exports grew by 15%. Exchanges within the EU mainly consist of products imported in a Member State, transformed, and exported to other MS.

The analysis of consumed products is made difficult because the figures frequently mix products issued from capture and aquaculture. 32% of consumers say they prefer wild products and 45% have no preference or do not know. It is them difficult to consider that wild fish is a strong selling point.

The EU total catch shows a regular decrease over the past years, with variable distribution by EU Member State:

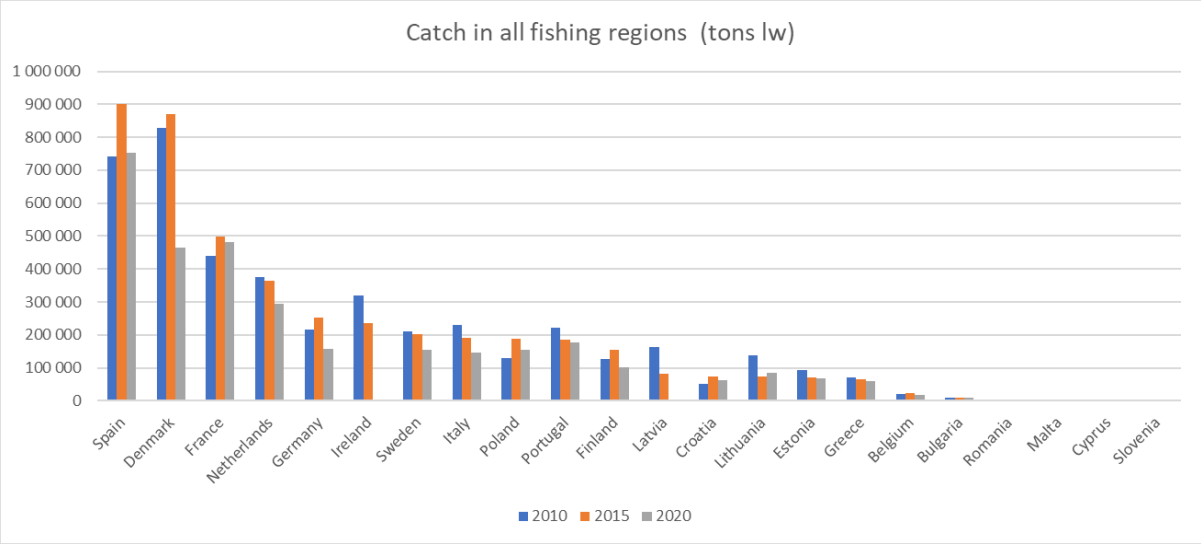

Figure 7: *Catches by Member State, in ton of live weight* [30]

EU is one of the few regions in the world where the fish catch per inhabitant has increased from 2007 to 2017 (+0,2 kg/inhabitant), as illustrated in the following figure by Eurostat.[31]

[30] Processed by Eurostat. Please note some EU Member State statistics are missing in Eurostat (Nov 2022).
[31] Eurostat – The EU in the word, 2020 edition.

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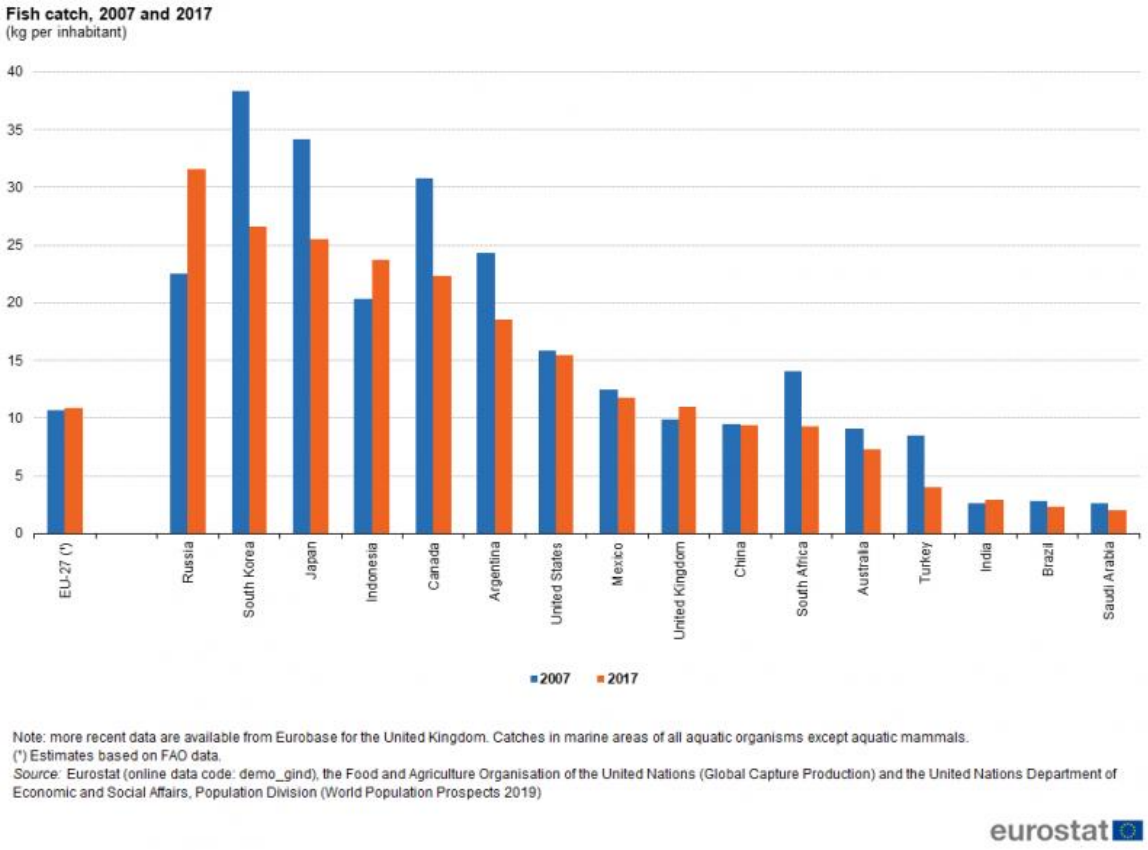

Figure 8: *Fish catch, 2007 and 2017 (kg/inhabitant)* [32]

3.1.4 Transitioning Towards Digital Fisheries: National Level

This transformation of the EU fishing industry is supported by the European Maritime, Fisheries and Aquaculture Fund (EMFAF), which followed the EMFF funding for fisheries, and cover the years 2021 to 2027. It helps implementing the CFP and adapting the European fisheries sector to the new missions of the European Green Deal. In practice, EMFAF supports the modernisation of the fleet (low-carbon fishing, energy-efficiency, improved safety), environmental impact studies, pilot projects, capacity building, with objectives of

[32] See Eurostat.

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environmental protection, quality and healthy seafood, and socio-economic attractiveness to attract the younger generations to fisheries employments.

The total EMFAF budget for 2021-2027 is EUR 6,1 billion, out of which EUR 5,3 billion is implemented in shared management by the MS with a national budget co-financing. The MS publish calls for projects and select the projects that they find relevant for funding. The rule is that at least 15% of the budget must be applied to monitoring, control, and collection of scientific data in support to the CFP, and 30% on mitigation or reduction of climate change.

Projects which improve monitoring, promote a culture of compliance, reduce by-catch and reduce the fishing pressure are eligible, such as:

- Pilot projects with electronic monitoring
- Management of MPAs
- Development or acquisition of more selective fishing gears (a priority area with 100% funding)
- Circular economy based on the collection and recycling of abandoned or lost fishing gears
- Support the application of the landing obligation by appropriate port infrastructure to receive the by-catch

EMFAF funds may also help young fishers to acquire and modernise a second-hand fishing vessel. The EMFAF funds cannot be used for subsidising the building of new vessels or increasing the power or fishing capacity of existing vessels, which would result in increasing the fishing pressure. EU subsidies for building new fishing vessels ended in 2004 as they resulted in counterproductive effects of pressure increase and was detrimental to artisanal fishers. Building a new vessel can be made only with private investment and need to be balanced by de-commissioning an older vessel of equivalent capacity.

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EMFAF funds also support improvements of fishery markets organisation and a vertical integration from producers to retailers, including marketing actions, traceability and certification which add value for the consumer.[33]

While the EU drives the transition of fisheries through policy and regulation, practical changes will be implemented by MS and national actors. Against this background, it is worth exploring the state of play of fisheries digital transition at national levels. Fish-X will run use cases in the Adriatic Sea (Croatia/Greece), the Atlantic (Portugal/Spain) and the Baltic Sea (Germany/Denmark). Insights from local stakeholders are shared below to demonstrate that the digital transition in EU fleets already is a reality.

(1) **Fisheries Digital Transition in Portugal – Atlantic Sea Basin**

Portugal is the fourth EU Member State in number of vessels (7,678 in 2021, Eurostat), with 90% below 12 meters. Portugal's seafood consumption per capita is the highest in the EU (59,91 kg), almost three times as much as the EU average of 24kg.[34]

The Portuguese government is in the process of implementing the *"*digitalisation *of the sea"* programme to promote the digital transition of the national blue economy, with different data collection, process and analysis being available on fisheries and other sectors and natural resources.

This programme includes:

- The Maritime Spatial Planning Situation Plan (PSOEM), which through GIS technology monitors maritime planning and provides an online public accessible tool to visualise the sea utilisation (with data automatically updated by the supply sources). Here information is provided about the distribution of different fishing gears or space restrictions for fishing.

[33] In line with the Regulation 1379/2013 on the Common Organisation of the Markets (CMO), which give to the fishery and aquaculture producer organisations a role in reducing as far as possible access to market for unwanted catch, contribute to eliminating IUU fishing, and promote traceability.

[34] https://oceans-and-fisheries.ec.europa.eu/facts-and-figures/facts-and-figures-common-fisheries-policy/consumption_en

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- The Sea Electronic Counter (BMar) serves for the registration of several activities, including professional (and recreational) fishing licenses. BMar allows the aggregation of information (e.g., titles or vessel registrations) in a single online space, making fishing safer and providing this data for inspection entities.

- *Lota Digital* is a marketplace app (from Docapesca - the semi-public company that manages auctions and first sales) that allows fishers to sell their catch directly to the buyers while still being at sea. The app also creates shopping lists and allows the fishers to input variables that enhance traceability - like species, time of catch, size, and time of availability at auction.

(2) **Fisheries Digital Transition in Croatia – the Adriatic Sea**

Croatia is the fifth EU Member State in number of vessels (7,507 in 2021, Eurostat), with 93% below 12 meters.

In early recognition of the advantages derived from digital data management by the Croatian Directorate for Fisheries the Fisheries Geoinformation System (GISR) was developed. As a result, around 650 vessels have built-in electronic logbooks through which fishermen regularly send information about their fishing. Also, since around 750 vessels have been using VMS devices for monitoring vessel activity, these have become one of the most important fisheries control mechanisms. Also, web shop has been created on the website of the Croatian Fisheries Administration of the Ministry of Agriculture, where users can buy the licenses at their choose.

In addition, the Commercial Fisheries Portal was created. It is a central place, where users can electronically submit data on the transport of fishery products, official data on weighing, first sale. Experience shows that on average 60,000 to 75,000 documents are filled out annually. Today more than 95% of the total catch in commercial fishing is recorded and delivered electronically by modern technologies such as an electronic or mobile logbook application. The mTunaRek mobile application was also developed, which is used by vessels with an assigned quota for hunting bluefin tuna in recreational fishing.

At the beginning of 2020, in Croatia a traceability system for bluefin tuna and sea eel was introduced. It is based on the marking of fish with a barcode (QR code), whereby each actor in the value chain (from fisherman who catches the fish to the final restaurant or fishmonger

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who sells the fish) enters his data. Then, the consumer can use a mobile device for scanning the barcode to view all the data about the purchased fish at the HRiba web application.[35]

As a next step, after the introduction of the system for tuna and eel, it is planned to expand this labelling system to other fish species, and the goal is complete traceability of all fishery products with barcodes.

(3) **Fisheries Digital Transition in Greece**

Greece is a country with a large coastline and a tradition in fisheries. Fisheries are vital to the livelihood and cultural heritage of many coastal communities. Greece has the largest fleet in number of vessels of the MS, and 95% of the Greek fishing fleet is composed of SSF vessels (up to 12 meters) and that 60% of Mediterranean SSF belongs to Greece.

According to Organisation for Economic Co-operation and Development (OECD), 2018 employment in the seafood sector, including processing, accounted for 24,825 jobs. This represented 43% more jobs than in 2008, however in the same period 2008-2018, the average value of production has decreased by 80% in marine fisheries, and the total gross tonnage of the fleet has decreased by 20%.

Greece fisheries suffer of several problems: The entire Mediterranean Sea is significantly overfished, 93% of its fish stocks. Implementing monitoring in Greece is a huge challenge to fight overfishing.

National fisheries are poorly monitored and managed. OECD statistics show that Greek expenses for Management and control, and for research and development, expressed as a ratio of the gross tonnage of the fleet, are far lower than in other OECD countries. This issue is probably made more complex due to the large number of SSF boats, not monitored with VMS, and the age of the fishing communities, as older generations of fishermen express some defiance of technologies. A solution would be to train younger generations to practice fisheries or to support the monitoring and control actions.

The Starfish 4.0 pilot project funded by the European Maritime and Fisheries Fund (EMFF in 2020-2022) permitted to trial new VMS devices and smartphone-based applications for

[35] http://www.ribarstvo.hr/HRiba

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logbooks and collecting feedback from the 70 artisanal fishers involved. The VMS device called NEMO (made by CLS) includes an innovative, solar-powered VMS transponder with an IoT/ satellite/ GSM communications system, a data management software platform, and dedicated mobile applications.

There are national regulations regarding time-periods and areas. Greece has not implemented TAC measures. Also, there are no official MPAs in Greece yet, however there are areas where fishing is allowed only under specific circumstances, e.g. National Parks of Zakynthos, Alonisos, Amvrakikos Gulf.

SSF have to report their catches monthly to responsible authority, but probably this is not enough effective monitoring for sustainable fisheries. While monitoring is low level or we could say none in SSF, Greece managed to implement monitoring on a small percentage of SSF by forcing vessels that fish swordfish and tuna (while being up to 12 metres) as well as beach trawlers to use VMS devices. Authorities decided to give licenses to these vessels only if they put such devices on. These actions reveal the tendency to increase monitoring and control. This might come as a guideline from EU.

Recreational-amateur fisheries are quite present in Mediterranean regions. Same in Greece, recreational fishing is a fact. In the previous years, there were licenses for recreational fishing, however this does not exist anymore. There is a thought about a new regulation with more flexible licenses for recreational fishers, such as 15 day-license. In a study carried out in 2000, 10% of catches in Greece came from recreational fishers. This was calculated according to the *"old"* licensing system. Nowadays, their percentage is unknown, and it is probably not that negligible.

Another specific issue are the invasive non-indigenous species which entered the Mediterranean Sea from the Suez Canal. Crete and Rhodes islands reported a big proportion of catches of Lionfish. Most fishermen discard these species at sea (as some are poisonous) which make it difficult to study them and identify areas more exposed to invasive species.

(4) **Fisheries Digital Transition in Germany – the Baltic Sea**

When it comes to the process of digitisation for small-scale fisheries in Germany (in the Baltic, but also the Northern Sea), there still seems to be a long way to go, and there are several different factors that come into play here. For the Baltic Sea, most of the fishing vessels are

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below 12 meters. They have very little or only basic technical equipment on board, sometimes do not even have a cabin, and often fight bad weather conditions, which make it difficult to manually operate e.g. mobile devices during their work. On top of this, the demographic profile of these fishers is characterised by middle-aged to older men that might not necessarily be very tech-savvy. Further, the large community of recreational fishers that the small-scale fisheries are directly competing with, as well as the already low catch quota (for the Baltic), are not making it any easier for the few professional fishermen left in the region. For most of them, fishing is already just a side job, and the relations on a political level are extremely tensed. Simply put, there is no incentive or willingness of this group to share more than a monthly catch-report on paper with the regional authorities.

Nevertheless, in 2017, the Thünen Institute Rostock [36] (which is leading the official scientific advisory for determining the yearly catch quota in Germany), together with the Danish company Anchor Lab K/S,[37] developed the mobile fisheries log "Mofi".[38] The goal was to provide fishermen a simple and affordable catch reporting application to document their fishing activities. The App could be used in two different ways. First, it could be used to report fishing activities to the German Federal Office for Agriculture and Food,[39] as a control mechanism for fishers who wanted to be granted an exempt for fishing during the closed season for cod. Second, the app could be used to provide anonymised catch data to the Thünen Institute, for research purposes only. How successful the Mofi App was or is being used, is something that still needs to be determined through additional stakeholder engagement activities in the further process of the Fish-X Project.

Another example of digitisation on the German fishing industry is the startup "Frisch Gefischt".[40] The company (located in Hamburg in the north of Germany) has started to establish itself with a retail system that aims at selling regionally caught fish to the regional market. The goal is to provide a fair and sustainable trading platform, as an alternative to the big and untransparent fish market with multiple intermediaries. So far, the startup is focused on supplying regional restaurants, but also aims at serving private end consumers in the near future. Also here, as part of the project's stakeholder engagement activities, the Fish-X

[36] https://www.thuenen.de/en/
[37] http://www.anchorlab.dk/
[38] https://play.google.com/store/apps/details?id=anchorlab.mofi&hl=gsw&gl=US
[39] https://www.ble.de/EN/Home/home_node.html
[40] https://frischgefischt.de/

This project has received funding from the European Union's Horizon Europe programme under grant agreement No 101060879.

consortium is in contact with Frisch Gefischt, to get a better understanding of the current situation, needs and future challenges.

3.2 Monitoring and Traceability Practices in the EU Fisheries Industry

3.2.1 Separation Between LSF and SSF

The large-scale fishing (LSF) [41] vessels are for most of them well equipped with navigational instruments, electronic navigation charts and plotters, fish finding sounders, radio and satellite telecommunications allowing Internet-like connectivity (although more limited in bandwidth than terrestrial networks), and routing and fisheries supporting applications. The companies operating these vessels have the financial capacity to maintain up-to-date instruments and frequently replace an aging equipment by a new generation one if it can improve the productivity. For most modern vessels, all instruments are digitally integrated at the bridge, allowing piloting the vessel with a joystick.

As far as instruments dedicated to control are concerned, the present technologies found onboard the EU vessels have frequently been acquired five to ten years ago to comply with the Control regulation 1224/2009. These control systems are generally independent, not connected to other electronic devices onboard the vessels. All EU fishing vessels will progressively be concerned by the new Control directive now under preparation and expected in 2023, and depending on their size, they may have to include new sensors.

As this is the case in all fishing countries in the world, the control regulations presently operational in the EU have targeted in priority the industrial or semi-industrial fishing vessels. In Europe, a typical threshold is based on the overall length of vessels. The vessels above 12 meters have the obligation to be equipped with VMS and ERS, if their fishing trips last more than 24 hours out of coastal waters. The vessels above 15 meters also carry an AIS.

[41] There is not an official definition. When related to EU fleets, we will consider that the vessels above 12 meters presently under Regulation 1224/2009 represent the LSF vessels, by opposition to the SSF.

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The VMS and ERS technologies have now been used for a decade in the EU large scale fleets, fishing over all oceans, and they have shown the added value for monitoring of fishing efforts, application of RFMO conservation measures, and detections of irregularities, in combination with the other control instruments (onboard observers, inspections at sea, in port).

(1) **Vessel Monitoring Systems (VMS)**

VMS are designed to automatically acquire and transmit the position, speed and heading of the vessel. Because the reporting interval is mandatory (every hour for vessels above 12 meters in the EU), and the VMS equipment cannot be switched off, any interruption of VMS signal reception can raise an alert in the control room of the flag state and may be analysed as potential attempt to fraud. The VMS data set is encoded and sent over satellite link to the only authorised recipients. The flag state is the primary recipient, then sharing with coastal states or RFMOs during the period when the vessels operate in the coastal state EEZ or the RFMO convention area.

Because of its high level of data security, VMS is fit for the purpose of fishing effort estimate, distant control and possible at-sea inspections.

(2) **Electronic Reporting System (ERS)**

The VMS data link is also used to transmit the ERS, or e-logbook. The e-logbook is a computer or tablet application used by the ship master to report each fishing trip details once a day (start, end, capture species and quantities, description of bycatch, transhipment activities where applicable, quantities in hold when entering or exiting a zone). These data are used for quota management and fishing effort statistics. Each data set is coded using standardised formats so they can be interpreted by external applications. The present ERS declarations rely on manual entries in the app, so the number of events reported has to remain limited, and data quality is not always perfect.

All MS today operate a Fisheries Monitoring Centre (FMC) for their national fleet, to manage a digital vessel register, monitor the fishing efforts, compare with the licences and authorisations, detect suspicious activities and exchange data with the EC and with RFMOs.

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Data exchanges through UN approved formats (FLUX) and cybersecurity are becoming standards.

(3) **Automatic Identification Systems (AIS)**

AIS is another technology which has progressively been installed on most vessels above tonnage thresholds under the SOLAS regulation V/19 as a collision avoidance system supporting safety of life at sea. Like VMS, AIS also transmits the vessel position and movements but more frequently and in open broadcast format, so that everyone with an appropriate AIS receiver can pick up the messages. While the initial concept allowed reception in proximity only (ship-to-ship to avoid collision) or through institutional coastal systems (port authorities), the AIS usage has greatly changed with introduction of web-based AIS data providers and commercial satellite-AIS constellations. These systems now make the vessels movements a commodity which can be purchased by any entity, including fishing companies to monitor the activities of their competitors, shipping companies to evaluate the traffic in ports etc. Some fishers prefer not to disclose the best fishing grounds and turn off the system, some others engaged in illegal activities may switch off[42] or purposely tamper their AIS device to send false identifiers or positions (called AIS spoofing). Using AIS alone for control would not be efficient.

(4) **Remote Electronic Monitoring (REM)**

Remote Electronic Monitoring is another technology of interest in deterrence of IUU fishing at sea. It is not mandatory yet except for some specific long-distance or highly protected fisheries as an alternative to onboard observers. REM consists in the automatic monitoring of various devices onboard the fishing vessel, including Close Circuit Television (CCTVs) for four or six cameras located at strategic places to observe net hauling and fish conveyors, and activity sensors on winches, conveyors and freezers, etc. In most of installations, the cameras do not capture the crew faces and are focused on instruments.

In REM systems, the data are precisely time-coded and stored on hard discs onboard the vessel for transfer to authorities at the next stop in port, generating several weeks of delay

[42] H. Weelch, T. Clavelle et al 2022. Science Advances Hot Spots of unseen fishing vessels.

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between the observations and the analysis by dedicated experts. Increasingly, REM is coupled with broadband satellite connectivity or cellular modems to ensure near real time transfer to shore. For many fishing vessels however, the installations of cameras would be challenging as the space is limited and the deck installation does not allow to separate the fish sufficiently for cameras to measure and count them before the fish entered in holds.

The analysis of all data will be a heavy task, and progressively AI will be used for image analysis (detection of deck operations, in particular for recognition of captured species and by catch species).

The bycatch represents the non-targeted organisms captured while fishing for the targeted species, and it is tempting to discard it at sea to save limited hold space for commercial species, or to avoid a complete fisheries closure in the case of mixed fisheries where the vessel has reached its quota for a given species (the choke species) and cannot take the risk to continue fishing for the commercial species. The bycatch is by nature underestimated and underreported, so that REM appears to be the only alternative to onboard observers to enforce the landing obligation of by-catch.

Where onboard observers were mandatory, their replacement by cameras has been increasingly considered, even more after the covid pandemic which prevented boarding by observers. Presently less than 1% of global fisheries are subject to REM. It is a complex system to adapt to each individual vessel, and it may generate huge amount of information, for which AI is necessary to extract relevant events from hours of video footage. A European workshop in 2021 concludes that institutions need to build trust on REM with the fishing industry and develop *"win-win"* use cases where the REM will also contribute to fishers' activities and profit (e.g. business analytics to avoid discard hot spots).[43]

In an industry consultation of 2018 updated in 2020, The Nature Consultancy has counted about 1500 fishing vessels fitted with REM over the globe, a relatively small number.[44] The study includes scenarios for the growth of REM systems, which could reach up to 51,400 vessels in 2028 for the global fishing fleet, the EU representing about a fifth of it. Considering

[43] van Helmond, A.T.M., 2021, Research for PECH Committee – Workshop on electronic technologies for fisheries – Part II: Electronic monitoring systems, European Parliament, Policy Department for Structural and Cohesion Policies, Brussels (https://www.europarl.europa.eu/RegData/etudes/STUD/2021/690862/IPOL_STU(2021)690862_EN.pdf)

[44] Michelin, M., Eliott, M., Bucher, M., Zimring, M., 2018. Catalyzing the growth of electronic monitoring in fisheries, Building Greater Transparency and Accountability at Sea. California environmental associates, California, US.

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the difficult implementation of the landing obligation in the EU, the study states: "*A large portion of MSC certified fish come from Europe, and with the lack of implementation of the landing obligation some of this supply could be at risk of losing certification. Highlighting the threat of decertification while also pushing for stronger risk-based data requirements in the MSC standard can ratchet up pressure to advance EM and to reach a broader agreement on the landing obligation.*"

3.2.2 Current Situation of Digitalisation for Monitoring of EU SSF

The SSF, which represent up to 90% of the vessels and 50% of the catch, are yet unmonitored in Europe for most of them. MS (Croatia, France, Spain Portugal) start to implement specific measures to address these SSF vessels where they are most exposed to overexploitation of stocks and conflicts of marine space use with other activities (to monitor the exclusion of MPAs or wind farms sites for instance).

The financial capacity of the artisanal fishers is not comparable with the industry capacities, and they cannot be asked to invest in new technologies that would not be immediately productive for them. Their fishing vessels are frequently old, with reduced space to accommodate new instruments without compromising the deck operations. The SSF Vessel Monitoring Systems will have to be designed specifically to use minimal space, and installation and activation tasks should be delegated to the fishers themselves. As many of these small boats do not have an electrical generator, the VMS device should run on its own power supply in most cases.

ERS should also be designed specifically for artisanal fishers, allowing them to use the devices in the course of the fishing trip, entering pre-coded data sets (fish species, quantities) with tools to minimise the risk of error.

REM appear to be more challenging for SSF than for LSF, because of their costs (even if the number of cameras can be reduced to one or two), the exposure to risk of damage, and also the privacy issues. The fishers' movements will necessarily be difficult to protect.

Considering that control of SSF vessels could increase the number of fishing vessels under surveillance by a factor of almost ten, the Fishery Monitoring Centres will need to be adapted, to process more data and execute more quality control on very diverse data sets. A variety of

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vessel monitoring solutions may be deployed on tens of thousands of small-scale vessels, so standards need to be specified for position reporting, fishing activity reporting etc in order to collect all VMS data with the same formats. The FLUX standard presently used by the DG Mare could provide such standards. The use of AI may soon become necessary to analyse vessel activities, detect the fishing activities, evaluate the fishing effort, and provide actionable information both for enforcement and stock management. The large amount of information that could be obtained from tracking and digital logbook solutions would bring added value to all parties: the fishing industry, the monitoring authorities, the scientific institutions with a main objective to produce sustainable management measures.

3.2.3 Monitoring and Traceability Practices in the EU Fisheries Industry

When it comes to fisheries, traceability can be understood as the ability to track and verify information about the origin and journey of seafood products as they pass through the supply chain. Effective traceability allows for better management of stocks and improved monitoring of fishing practices. Moreover, it can ensure that the fish caught is of a high quality, and that it is caught in a sustainable manner. Traceability can also help to reduce IUU fishing as well as improve the transparency of the supply chain, allowing for better information to the consumers and improved consumer confidence in the quality of the fish. Given the growing awareness of consumers regarding the environmental and social impact of their food choices, this becomes increasingly important.

In recent years, EU fisheries have seen a rapid development in digital traceability. The EC is taking various steps to address the issues of traceability, with the main efforts being implemented through the EMFAF. Yet while digital traceability in EU fisheries is increasing, there is still a lot of work to be done, especially with regard to the harmonisation across countries and the lack of standardisation in data collection.

With Regulation (EC) No 178/2002 the EU describes its ambition and that all lots of fisheries and aquaculture products shall be traceable at all stages of production, processing, and distribution, from catching or harvesting to retail stage. To achieve this, the EU asks the MS to ensure that operators have systems and procedures in place, so that each lot is adequately

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labelled to ensure the traceability.[45] The EU's seafood traceability requirements for fisheries control purposes are currently outlined in Regulation 1224/2009 (the Control Regulation).[46] Traceability requirements for imported seafood products, on the contrary, are embedded in Regulation 1005/2008 (the IUU Regulation).[47]

Typically, these are the steps to be taken care of for traceability of fish catches:

As a first step, to ensure traceability, fishers are to declare their name and address, type of species, date of catch, and production method (whether it was caught in ocean, freshwater, or farmed, and geographic area of the catch). These declarations are to be made to business operators for their record and disclosure at a later stage.[48]

As a second step, MS have to ensure that business operators put a system in place that allows tracing of the buyer/supplier and the seller both with lots of fisheries and aquaculture products. It is the core purpose of traceability and relevant authorities may ask for this information at will and business operators have to comply with the demand.

As a third step, business operators have to establish a system in place that ensures complete transparency and traceability throughout the stages defined by the Farm to Fork strategy. Business operators must put adequate labelling of fisheries and aquaculture products before reaching the market so the traceability can be ensured for each lot. The labelling requirements

[45] See Council Regulation (EC) No 1224/2009 of 20 November 2009 establishing a Community control system for ensuring compliance with the rules of the common fisheries policy, amending Regulations (EC) No 847/96, (EC) No 2371/2002, (EC) No 811/2004, (EC) No 768/2005, (EC) No 2115/2005, (EC) No 2166/2005, (EC) No 388/2006, (EC) No 509/2007, (EC) No 676/2007, (EC) No 1098/2007, (EC) No 1300/2008, (EC) No 1342/2008 and repealing Regulations (EEC) No 2847/93, (EC) No 1627/94 and (EC) No 1966/2006 (europa.eu) p. 24

[46] See Council Regulation (EC) No 1224/2009 of 20 November 2009 establishing a community control system for ensuring compliance with the rules of the common fisheries policy.

[47] Council Regulation (EC) No 1005/2008 of 29 September 2008 establishing a community system to prevent, deter and eliminate illegal, unreported and unregulated fishing.

[48] The minimum labelling and information requirements for all lots of fisheries and aquaculture products shall include: (a) the identification number of each lot; (b) the external identification number and name of the fishing vessel or the name of the aquaculture production unit; (c) the FAO alpha-3 code of each species; (d) the date of catches or the date of production; (e) the quantities of each species in kilograms expressed in net weight or, where appropriate, the number of individuals; (f) the name and address of the suppliers; (g) the information to consumers provided for in Article 8 of Regulation (EC) No 2065/2001: the commercial designation, the scientific name, the relevant geographical area and the production method; (h) whether the fisheries products have been previously frozen or not. 6. Member States shall ensure that the information listed in points (g) and (h) of paragraph 5 is available to the consumer at retail sale stage. See Council Regulation (EC) No 1224/2009, p. 24

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for all lots of fisheries and aquaculture products include: identification number of each lot (exempted in case of import); external identification number and name of the fishing vessel or the name of the aquaculture production unit; FAO alpha-3 code of each species; date of catches or the date of production; quantities of each species in kilograms expressed in net weight or, where appropriate, the number of individuals; name and address of the suppliers (exempted in case of import); the commercial designation, the scientific name, the relevant geographical area, and the production method (to be mentioned to consumers at retail sale stage); and whether the product has been previously frozen or not (to be mentioned to consumers at retail sale stage).

As a fourth step, the EU, as per the Regulation (EC) No 1005/2008, has established a community control system [26] to combat IUU Fishing. It is a legal binding to track IUU fishing and applicable on all fishing vessels. It ensures compliance with the traceability regulation and strives for full traceability of fishery products traded within the EU. It also protects the consumers' right to information reading the fishing products and allows complete tracking of the products through a comprehensive labelling system as mentioned in step 3.

The digital transition in the fisheries sector comes with significant challenges for some actors, especially SSF. In the last decades, traditional approaches to MCS – on board observers, logbooks, and surveillance planes – have been supplemented by a range of new technological tools. In turn, large-scale fisheries and fleets have adopted various kinds of technologies to improve compliance with fishery regulations, self-report catches, and provide clear data that can be utilised for better business planning. This is also in line with the CFP, which requires all commercial fisheries to be traceable. However, this does not apply to small-scale fisheries. To develop appropriate management measures for small-scale fisheries, it is important to have accurate and sufficient information on their scope, stakeholders, operations, and impacts. Unfortunately, when it comes to small-scale vessels, that knowledge is far from satisfactory, as current EU fisheries control rules exempt them from accurately reporting their catches and their position while fishing.[49]

Recent EU fisheries policy revision seeks to introduce significant changes in the working practices of both small operators and fishing authorities. New policies are being designed to leverage the digital transition with a view to improve the sustainability of EU fisheries. For instance, amendments currently discussed to modify Regulation (EC) No 1224/2009 (the

[49] https://oceans-and-fisheries.ec.europa.eu/fisheries/rules/small-scale-fisheries_en

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"Control Regulation") could lead to the introduction of new digital MCS tools in the EU fisheries system, as well to the extension of existing MCS measures to SSF. While these measures are needed to improve the sustainability of EU fisheries and better protect marine ecosystems, the introduction of some digital tools may be difficult to put in practice in small boats. This can be for practical reasons (space, increased exposure to a rough environment, etc.), or financial ones (access to technology and training). Additionally, these efforts also face additional resistance due to the perception that some of the technologies used could be intrusive. Therefore, there is a need to ease the adoption of those new technologies for SSF by tailoring them to their specific needs and context. This is also expressed by the current focus of the EMFAF which provides funding to support the implementation of digital traceability systems in the EU and highlights that small scale coastal fisheries should be given preferential treatment.[50]

Hence, while traceability certainly is an important tool for the sustainable and effective management of SSF in the EU it is still in its early stages. Some EU countries now have some form of traceability in place to track large scale fisheries, however smaller-scale fisheries have not always been able to access the same data and technology. As a result, traceability for small scale fisheries has been limited to manual, paper-based systems, which are often inefficient and unreliable. In recent years, however, there has been an increase in the availability of digital traceability solutions for small-scale fisheries as well as individual efforts from some countries, for example France or Spain. The EU has also joined other high-level representatives from the Mediterranean and Black Sea in adopting, in 2018, a Regional Plan of Action for SSF (RPOA-SSF), which covers a wide range of actions specifically tailored to small-scale fisheries.[51] Overall, digital traceability is becoming increasingly important in small-scale fisheries in Europe, as it provides a way to monitor and enforce regulations, as well as ensuring that consumers receive safe and traceable products.

An example is the tracking and catch reporting tool developed by the scientific institution AZTI.[52] This tool, named EBArtesa,[53] aims to give the small-scale fishing fleet of the Spanish part of the Basque Country more visibility and show its socio-economic importance to all stakeholders. EBArtesa is a device similar to a tablet which includes a SIM card that monitors

[50] See Regulation (EU) 2021/1139 of the European Parliament and of the Council of 7 July 2021 establishing the European Maritime, Fisheries and Aquaculture Fund and amending Regulation (EU) 2017/1004, p. 7, (33)
[51] https://oceans-and-fisheries.ec.europa.eu/fisheries/rules/small-scale-fisheries_en
[52] https://www.azti.es/en/
[53] https://www.azti.es/en/proyectos/ebartesa/

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the position of the vessel in real time and a touchscreen where fishers can easily submit an electronic report of their catches and discards, even when wearing gloves.

Despite some first promising examples, most of the small-scale fishing fleet in the EU is exempt from requirements for using electronic devices. Indeed, vessel tracking systems and electronic reporting of fish catches are currently not mandatory for vessels under 12 metres length in the EU. Even though roughly 75% of the EU fishing fleet is made up of small-scale vessels, there remains a substantial lack of information on their activity, which compromises both their safety and their future.[54] The final version of the roadmap will showcase some examples building on planned consultations and interviews and research.

[54] https://europe.oceana.org/blog/electronic-monitoring-devices-enhance-safety-sea-and-traceability-small-scale-fishing-fleets/

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4. The Fish-X Consortium Vision on the Digital Transformation for Sustainable EU Fisheries Management

4.1 Digitalisation and its Benefits

Digitalisation can be defined as the modification of business models by adopting digital technologies to create value by using advanced technologies.[55] It can transform a business to realise untapped potentials as digitalisation provides opportunities for better and faster management decisions. The decisions are supported through automation, faster and shorter work cycles, efficient data management, and high-performance computing. While digitalisation relates to upgrading processes by utilising technology, it needs to be distinguished from digitisation that can be described as the process of transforming information from an analogue format to a digital version (i.e. computer-readable).[56]

Worldwide economies, societies and businesses are experiencing a digital transformation nowadays. It has become a general need to remain or become economically competitive. The risk for businesses, that do not go for digital transformation, is that they may not be able to compete in the future.

Flexible Infrastructure	We can have a flexible and scalable IT infrastructure through it. As a result, we get shorter work processes with efficient outcomes.
Automated Production	We get automated and short by allocating production tasks through mobile and web apps.

[55] See What is Digitalisation, its Opportunities, and Challenges? - Techylem

[56] For example, organisations may start from a simple paperless environment and move towards heavy digital transformations like VR, IoT, and Blockchain, etc. See Digitization vs Digitalization: What's The Difference? (theecmconsultant.com)See Digitization vs Digitalisation: What's The Difference? (theecmconsultant.com), Digitization - Wikipedia

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Better Marketing	Improved and better marketing of the brand through spending less on ads, shorter time-to-market, and better targeting.
Increased Sales	By having a customised sales portal, we can automate it. And increase the number of sales by spending less time on it.
Controlled Finances	Efficiently using resources can reduce personnel costs. Also, by having an automated system, we can reduce the cost spent on human resources.
Improved Management	Managing things digitally is easier than managing them manually. It gives you to manage your business while you are not physically present in your workplace.
Enhanced Customer Service	Interacting with customers has now become so smooth and efficient. It is due to the presence of digital solutions like portals, tools for analysing customer behaviour, and prompt feedback.
Managed HR	Customised applications to manage your employees, track their activities, count their working hours, etc.

Table 1: *Benefits of digitalisation for businesses* [57]

4.2 Why do EU Fisheries Need Digitalisation?

As described above, digitalisation cannot and should not be ignored by EU fisheries, as it offers several specific opportunities to collectively overcome the sector´s challenges by efficient and more sustainably managing the full value chain from ´hook to plate´.

[57] See What is Digitalisation, its Opportunities, and Challenges? - Techylem

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(1) **Preparing a new Development Perspective for Fisheries**

Digitalisation paves the ground for being able to create a new generation of jobs in the EU requiring digital and high-tech know-how applied to fisheries who with improved professional skills and competences can support the blue economy. Empowered, engaged and educated fishers, supported by data and with full documentation and accountability of their operations, will discuss with decision makers and other stakeholders openly, in order to find social and economic tools that will allow them to find solutions to new challenges that may occur and ensure the social, economic and environmental resilience in their communities.

(2) **Transforming the Fishing Sector Towards Sustainability**

If properly managed by access to timely and accurate data, there is the opportunity to find a good balance for catching the right proportions of fish in terms of location, quantity, and quality that will allow for renewal and thereby via the digital transformation will enable in particular the SSF to not deprive itself from livelihood but to adapt its business and operation models.

(3) **Safeguarding Better Compliance with Regulations**

Through full VMS coverage and electronic logbooks, fishers will be able to deliver precise, real-time data to authorities and researchers, who in turn will be able to provide answers and solutions to minimise environmental impacts and move towards low impact fishing.

(4) **Combatting IUU fishing**

As a result of more transparency, better data and digital trainings to fisheries, the idea is to make the compliant fisheries more competitive by creating a level playing field against non-compliant operators. In this way, these new possibilities for monitoring and control will increase the cost of entry of fish sourced from IUU fishing into the EU market.

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(5) **Meeting the Customers' Needs With Full Traceability**

Through *"hook to plate"* full traceability, fishers will be able to adapt their business models to ensure to their buyers and to the end consumer that the seafood they are getting is from a specific area and caught by a specific fleet. This will allow their catch to be positively differentiated when compared to products where the origin and fishing method is unclear. Getting more scientific support to prepare for new challenges in the future.

A long standing and frequent interaction with researchers will allow the identification of trends, unexpected changes and, as a result, will allow them to adapt without profit loss or damage to stocks and the environment they depend on. Furthermore, scientists will be able to provide assessments with estimations of figures for catches that correctly consider ecosystem elements and ensure that fishing does not hinder the health of the ecosystems.

4.3 Action Areas for Digitalising EU Fisheries

In support to EU fisheries in its development towards more sustainable management the table shows a draft proposal for an EU Fisheries Roadmap for Digitalisation, whereas for each sector (public and private, research/development and civil society) individual objectives to support EU Farm to Fork Strategy are proposed.[58] It is based on a started analysis by the Fish-X Consortium that will be continued as described after.

As digitalisation is key for the roadmap, these general objectives are detailed by supporting targets and by four action areas *("governance and policy", "data collection & traceability framework", "digital infrastructure and equipment", and "EU fisheries skills, behaviour, and practices")* with first suggestions for activities per stakeholder group to support fine-tuning and implementation.

Fish-X forms part of this action plan as it will interact with all sectors, so to foster synergies between authorities, fisheries, R&D, consumers, and other supply chain actors by regular

[58] With its focus on the need for a fair healthy and environmentally friendly food system, the EU Farm to Fork Strategy is stated here as the mainly relevant policy. For reasons of simplification, the European Green Deal, EU Common Fisheries Policy and EU Blue Growth Strategy are left out here but are also fundamental for better fisheries management in Europe.

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stakeholder engagement (events, workshops, training) in order to support with a full operable Fisheries dataspace (Fish-X), Insight Platform, and Traceability App.

Fish-X does not regard itself as solely responsible for achieving these, but its leadership, work and stakeholder engagement will drive involved partners and sector actors towards the achievement.[59]

[59] With its focus on the need for a fair healthy and environmentally friendly food system, the EU Farm to Fork Strategy is stated here as the mainly relevant policy. For reasons of simplification, the European Green Deal, EU Common Fisheries Policy, and EU Blue Growth Strategy are left out here but are also fundamental for better fisheries management in Europe.

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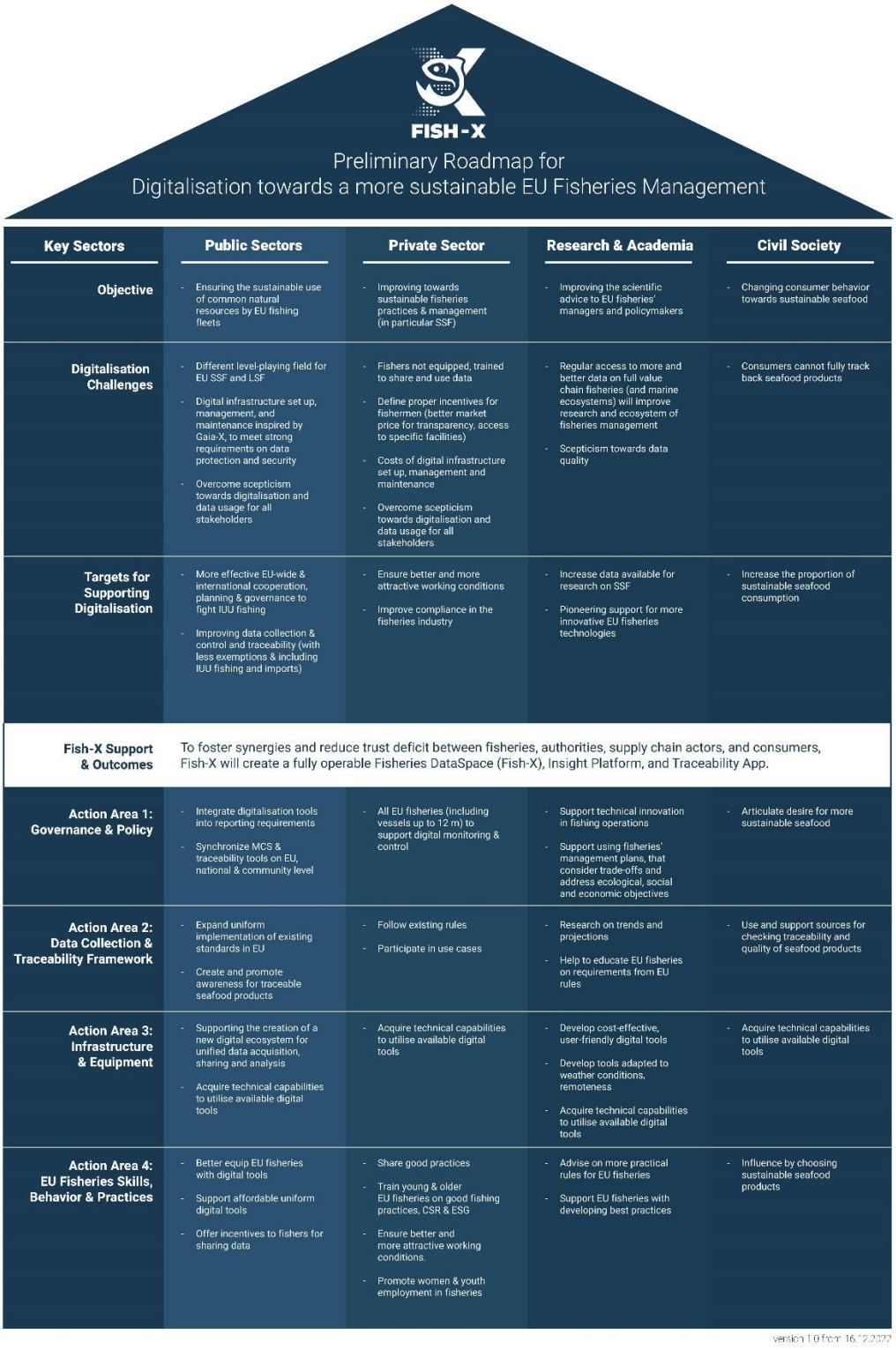

Table 2: *Objectives, challenges, and action areas for EU fisheries digitalisation*

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4.4 Fish-X - How to get There?

It will be important to collaborate on a regular level multidisciplinary and cross-sectorally with the identified key actors across the EU fisheries countries to achieve a long-term robustness of the Fish-X solution. To facilitate such continued exchanges Fish-X will hold regular events for stakeholder consultation and knowledge exchange as well as carry out surveys and interviews with key players.

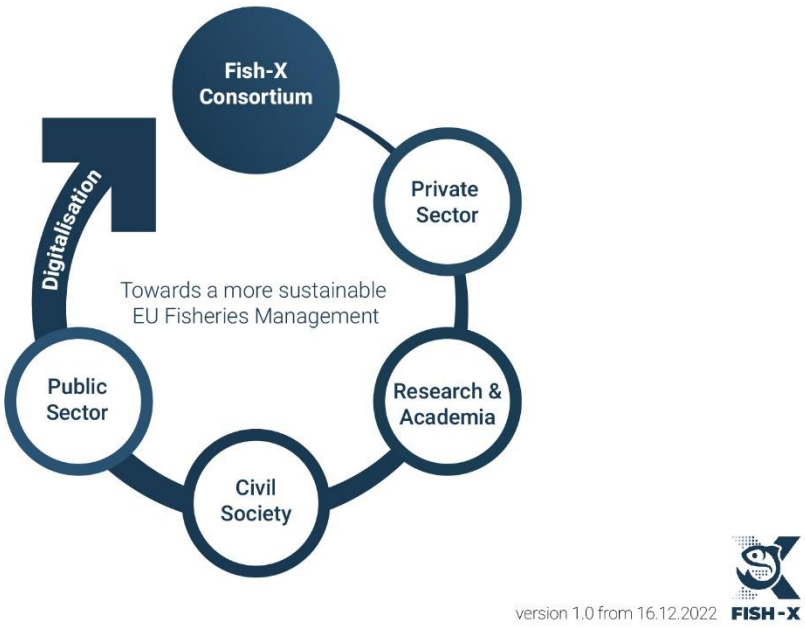

Figure 9: *Model for stakeholder engagement by Fish-X*

4.4.1 Fish-X Dataspace

Fish-X has been initiated to identify chances and bottlenecks in the digitalisation of EU fisheries and develop an interoperable technical framework to support this digitalisation process. This is done with stakeholder engagement, involving partners and sector actors, towards this pursued objective.

The Fish-X project builds on the development of a Fisheries dataspace (Fish-X) and Insight Platform – based on a smart orchestrated architecture and open interoperable technology via

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the Gaia-X initiative. By doing so, participants from the fisheries industry will be enabled to exchange fisheries data, with an emphasis to the use of data for the benefit of all stakeholders. The Fish-X dataspace will offer a consultative approach where fisheries data providers will be able to make their own choices with whom, in what format, to what terms and conditions and which data will be made accessible to data consumers, somewhat like an online market. This also includes software services responsible for processing (anonymisation, aggregation) data to comply with privacy and security regulations.

4.4.2 Guiding Principles of Digitalisation

The above-mentioned digitalisation objectives actively address vessel monitoring, data collection and strategies to utilise the contained information towards a common goal of sustainable practice to the benefit of stakeholders in the public, private, scientific sectors and civil society.

Once the willingness to digitalise can be established, the involved stakeholders require technical capabilities to share and optimally use collected data. Yet, the adoption of technical capabilities and the transfer of data between parties need their willingness as well as ethical and legally safe possibility to make data sharing possible.

(1) **FAIR Principles**

For data accessibility, commonly accepted guiding principles are described in the FAIR guidelines that can be broken down into the properties of the Findability, Accessibility, Interoperability, and Reuse of digital assets. A FAIR and federated dataspace can be defined as a software process that allows multiple databases to function as one in a versatile and transparent way.[60]

[60] https://www.go-fair.org/fair-principles/

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(2) Gaia-X – European Standards for Data Security, Sovereignty, and Trust

In addition, the willingness to make data more accessible does not only rely on the FAIR principles, but requires the establishment of Trust, the safeguarding of Data sovereignty and consideration of Data security. This implies that the data owner should have full control of the data it shares with third parties; full control with whom the data is shared and full control of the terms and conditions of data usage.

(3) Gaia-X and the Fish-X Dataspace

Gaia-X is a project that develops a software framework of control and governance as well as implements a common set of policies and rules that can be applied to any existing cloud/edge technology stack to obtain transparency, controllability, portability and interoperability across data and services. Gaia-X enables the creation of dataspaces through trusted platforms that comply with common rules, allowing users and providers to trust each other on an objective technological basis, to safely and freely share and exchange data across multiple actors.

The Gaia-X roadmap clarifies ethical and legal framework conditions for data exchange between science and industry. In addition, the project develops common technical foundations and demonstrates the use of Gaia-X technologies for the provision and use of research data along FAIR principles in various scientific disciplines and industries.

The technical development of Gaia-X is well under way with core components being developed in 2022. Over the course of 2023, dataspaces are rolled out providing marketplaces where data, but also software services and hardware will be made available for a range of industries. 2024 and 2025 are laid out to expand the use of the Gaia-X services.

4.4.3 Third Party Data Users, Platforms, and Contributions to Sustainability

With the ability to make existing fisheries data more accessible to third parties, it can be utilised to an infinite number of cases to support not only regulatory means, but also to the benefit of scientific purposes and the addition of value to EU fisheries commodities and the

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establishment of trust between fisheries, authorities, and the civil society in the pursuit of sustainable fisheries.

The Fish-X dataspace will rely on information gathered from several use cases, implemented in various areas of the EU, where small-scale vessels will be equipped with monitoring and reporting equipment. The dataspace will provide data which will be used to analyse the use of fishing areas, fishing pressure, catch per unit effort (based on catch data), and other relevant information for fisheries management.

Aside from uses for control and monitoring, the information coming from the use cases will also be used for traceability purposes, helping to determine how to overcome the challenges in being able to provide transparent information to the consumers about the area and gear used to catch a given product.

Within the Fish-X project, two platforms (Insight platform, Traceability App) will be supplied with fisheries data to demonstrate such application, targeting transparent fisheries and seafood traceability.

(1) **Insight Platform Description**

The Insight Platform is intended to complement existing national monitoring systems for fisheries administrations, or for research projects (providing authorisations). A dedicated portal will be available for general audience with free access data and simple maps in relation with fish stocks status, level of overexploitation, application of good practices by fishing companies in given regions.

In addition, post-project a for-profit version of the Insight platform is planned for fisheries industry and governmental use enabling optimisation of process, better sustainability monitoring, and increasing integrated MCS protocols. The project developments will follow the recommendations of fish traceability standards, enabling recognition of fishing companies with sustainable practices in a global market.

(2) **Traceability App**

As to pave the way towards a system that allows all actors in the supply chain to track a specific seafood product, Fish-X will develop a traceability application with information

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coming from use cases and specific stakeholders. This will be built based on needs expressed by partners who will be consulted along the project and will serve as a baseline for a future where seafood products can be easily traced, enabling the mapping of fisheries supply chains and consumers to make informed decisions, avoid IUU activities and promote seafood coming from responsible fisheries.

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5. Conclusion and First Key Recommendations by Fish-X Consortium

Building on the analysis of the current and upcoming EU Policies and Regulatory Frameworks and EU Fisheries Industry and Practices, it has become evident that the likeliness to realise the full potential for sustainable fisheries management is significantly higher with the support of digitalisation. Indeed, digitalisation offers more efficient ways for multi-stakeholder cooperation to improve data management for monitoring & control and traceability purposes.

The chapters 2 and 3 have given a brief overview of EU policies and fisheries industry main structures. For the large-scale fishing vessels, the digitalisation of monitoring and control is already well implemented, although the landing obligation still lacks appropriate monitoring tools. For the SSF, the digitalisation has just started, and not included in the present EU control directive.

Some MS have already tested digital tools such as electronic logbooks and fishing gear sensors in first individual attempts towards the digital transformation of SSF. These initiatives will have to be coordinated in order to facilitate data gathering and comparison at European level.

The new directive issued from the proposal COM(2018)368 should be adopted in 2023 and will apply to a much larger number of vessels compared to the current directive. Fish-X arrives at a strategic moment to demonstrate its operationality, help to gain small-scale fishers' acceptance, and implement traceability tools.

By putting the fishers in the centre of the seafood supply chain, Fish-X is a key contribution to the EU roadmap 2030 towards the digital transition of EU fisheries and the farm-to-fork strategy.

Fish-X is supported by the Horizon Europe Programme to create a new secure and interoperable digital platform, that will be made of three components: 1) the Fish-X Dataspace, 2) the Insight Platform, and 3) the Traceability App. These three components constitute the infrastructure designed under the Gaia-X framework, appropriate to ensure data sovereignty and security for EU fisheries datasets. Fish-X is not going to replace the existing monitoring & control systems presently operational in the MS, but will illustrate a parallel

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option for collection, AI-supported analysis and sharing of fisheries data, able to cover the high numbers of SSF vessels.

The Fish-X platform will only work out if the following challenges are addressed:

- Electronic catch reporting & control by means of reliable and cost-efficient tools designed for SSF, ensuring quality data that can support stock management
- Demonstrate added value of these electronic tools for fishers, in particular SSF (traceability, safety, access to environmental data, access to certification)
- Onboarding of all four identified key sectors (public, private, science, and civil society) to take advantage of more accessible fisheries and seafood datasets

During the project period until May 2025, the Fish-X platform will be used during trials with SSF groups in at least three MS (Croatia, Greece, Portugal) to demonstrate its benefits.

It is also recommended that the platform will be designed in a way that it can be replicated and upscaled later for all EU fishery segments and used for benchmarking and governance when working with international partners. For these reasons "*Guiding Principles of Digitalisation*" have been formulated, that will be complemented by use cases, policy recommendations, trainings, and workshops.

To kick-off next steps, the Fish-X consortium has created a preliminary Roadmap for EU Fisheries Digitalisation, that shall give orientation on who should engage on what challenges to support the EU fisheries sector in its digital transformation.

Four Action Areas have been identified: *"governance and policy", "data collection & traceability framework", "digital infrastructure and equipment" and "EU fisheries skills, behaviour, and practices"*. The roadmap will be further developed throughout the project period with these action areas with the active involvement of the four above mentioned key sectors.

The Fish-X consortium will establish a consultative process with the key sectors, to avoid duplication of work and synchronise with ongoing initiatives related to SSF digitalisation. This roadmap will be step-by-step further developed based on findings from continued stakeholder consultations, and on integration of relevant aspects addressed by already existing fisheries roadmaps and initiatives on regional, national, or local level.

Fish-X will make a tangible contribution to empower EU fishers for sustainable fisheries management.

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