INNOVATIVE BLOCKCHAIN TRACEABILITY TECHNOLOGY AND STAKEHOLDERS' ENGAGEMENT STRATEGY FOR BOOSTING SUSTAINABLE SEAFOOD VISIBILITY, SOCIAL ACCEPTANCE AND CONSUMPTION IN EUROPE

D1.5 - PROTOCOL ON ALIGNMENT OF SEA2SEE TECHNOLOGY WITH THE SEAFOOD CERTIFICATION PRACTICES IN THE EU

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Nature of the deliverable

R	Document, report (excluding the periodic and final reports)	**X**
DEM	Demonstrator, pilot, prototype, plan designs	
DEC	Websites, patents filing, press and media actions, videos, etc.	
DATA	Data sets, microdata, etc.	
DMP	Data management plan	
Ethics	Deliverables related to ethics issues.	

SECURITY	Deliverables related to security issues	
Other	Software, technical diagram, algorithms, models, etc.	

Dissemination level

PU	Public — fully open (automatically posted online on the Project Results platforms)	**X**
SEN	Sensitive — limited under the conditions of the Grant Agreement	

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Current seafood traceability tools and services have the potential to take advantage of novel blockchain technologies to obtain a wide range of data, making sustainable seafood practices more visible to consumers. The Sea2See project will fill in existing seafood traceability gaps through the development of an innovative end-to-end blockchain model and professional and consumer applications to increase trust and social acceptance of sustainably fished and farmed seafood. The project will provide technological solutions to answer the need of a valuable source of data collected throughout the whole seafood value chain, verified, and covering inputs from diverse stakeholders. For that purpose, a specific focus will be put on active commitment of stakeholders and real empowerment of consumers through the implementation of societal and sectoral strategies for co-creation, communication and awareness raising.

More information on the project can be found at: http://www.sea2see.eu/

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EXECUTIVE SUMMARY

Traceability in the seafood sector is a process that involves the tracking of seafood products throughout the supply chain, from the point of origin to their final destination. This process is crucial to ensure food safety, quality control, regulatory compliance and sustainability.

There are several certification schemes in the fisheries and aquaculture industries that take into consideration traceability requirements. In order to evaluate the most important schemes, a comparative scoring matrix was developed, and relevant standards and requirements were analysed.

The analysis identified five categories of traceability requirements for the aquaculture sector, namely: inputs, other records, differentiation, internal traceability, and external traceability. Different certification schemes give varying levels of importance to the different requirement clusters across different steps in the supply chain. GLOBALG.A.P. was rated as the most comprehensive certification scheme in the aquaculture sector, since all clusters are considered for all supply chain steps.

The analysis identified eight categories of traceability requirements for the fisheries sector, namely: production inputs, middle-chain inputs, direct outputs, environmental outputs, social and governance, differentiation, certification schemes accessibility and traceability. None of the certification schemes under analysis considered all clusters for all steps of the supply chain; Naturland Wildfisch is the certification scheme with the higher number of clusters considered.

The study identified two important aquaculture and one fisheries certification schemes that offer trace-and-track solutions for end-consumers. However, these schemes have limitations in providing complete product transparency and traceability. This gap in transparency and traceability presents an opportunity for the development of new and efficient traceability solutions that offer greater information and transparency to the end consumer, such as the Sea2See blockchain traceability tool.

In conclusion, traceability is an essential aspect of the fisheries, aquaculture and the seafood sectors. Further research and development of traceability solutions will help increase transparency and the availability of information to consumers while also contributing for a more sustainable and safe industry.

ABBREVIATIONS

Abbreviation	Description
AI	Artificial Intelligence
ASC	Aquaculture Stewardship Council
ATJ	Alter-Trade Japan
BAP	Best Aquaculture Practices
BE	Bioengineered
BIM	Bord Iascaigh Mhara
BSP	Best Seafood Practices
CoC	Chain of Custody
CS	Certification Scheme
EFCR	Economic Feed Conversion Ratio
FAO	Food and Agriculture Organization
EU	European Union
FOS	Friends of the Sea
GDST	Global Dialogue on Seafood Traceability
GGN	GLOBALG.A.P. number
GM	Genetically Modified
IFA	Integrated Farm Assurance
IRF	Iceland Responsible Fisheries
ISO	International Organisation for Standardization
IUU	Illegal, Unreported and Unregulated
MEL	Marin Ecolabel Japan
MSC	Marine Stewardship Council
NASAA	National Association for Sustainable Agriculture, Australia
NGO	Non-Governmental Organisation
RFM	Responsible Fisheries Management
RSS	Responsibly Sourced Seafood
RSPCA	Royal Society for the Prevention of Cruelty to Animals
SALT	Seafood Alliance for Legality and Traceability
SQF	Safe Quality Food
SSQ	Shrimp Seal of Quality

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1. INTRODUCTION

1.1. SEAFOOD TRACEABILITY

Seafood is the most traded food product in the world (FAO, 2022). Seafood supply chains are characterised by their complexity, high value and lack of transparency (Lawrence et al., 2022), which result in many concerns about seafood trade and consumption including Illegal, Unreported and Unregulated (IUU) fishing sources, ethical issues and human rights violations, human health safety, and food security and fraud (Du et al. 2020; FAO, 2022; Lawrence et al., 2022; Tsolakis et al., 2021; Zhang et al., 2021) and a global call for increased seafood traceability.

Despite the different definitions of seafood traceability, such as the one from the International Organisation for Standardization (ISO) or the European Union (EU), this process can be simply defined as the collection and verification of information on the product's origin and movements. There are different demands and calls on which information should be included in the breadth of traceability and its applicability, but there is a general agreement that digital traceability and increased transparency are solutions to allow seafood trade to be more transparent and safer (Du et al., 2020; Tsolakis et al., 2021; Zhang et al., 2021).

Traceability is increasingly used as a solution to prevent IUU products and illicit fish trade from reaching the markets, to improve information security, and improve seafood governance, since it allows tracking seafood throughout its supply chain and verify information about seafood (Borit and Olsen, 2016; Lewis and Boyle, 2017; Longo et al., 2021; Teh et al., 2019). Additionally, consumers are demanding more sustainable and transparent products (Meise et al., 2014). Food provenance and quality are two of the major concerns for consumers which culminated in a tendency to pay more for products that are certified (Demestichas et al., 2020). A literature review carried out as part of Sea2See (Deliverable 1.2 - Report on the Main Impediments and Potential Incentives for Seafood Blockchain Deployment), showed consumers' concerns regarding seafood traceability. According to the report, blockchain traceability was especially important for aquaculture as it ensures transparent information exchange, reduces the chances of mislabelling and improves the chances of applying for certification and labelling schemes. The advantages of traceability technologies in certification

schemes (CSs) are not restricted to blockchain, all such technologies are important in order to gain consumers' trust in these schemes (Duggan and Kochen, 2016; Lee et al., 2013).

Digital traceability in the seafood sector has, therefore, a significant potential. Regulations by the European Union already reflect the need for this transaction, with the requirement for information on seafood labels (such as species name, production method, area of origin, etc) to be available for consumers (Regulations (EC) No 1224/2009 and (EU) No 1379/2013), and digital traceability expected to be implemented as a part of the EU fisheries control system, in order to ensure food safety and consumers' interests (European Parliament, 2023). In the last few years, the importance of traceability has grown visibly through international certification and is required by importing countries (Dong et al., 2019). CSs are expected to enhance the implementation of traceability in seafood supply chains due to the requirements they impose related to the origin of the product and tracking it (Donnelly et al., 2013; Penca, 2020).

1.2. CERTIFICATION SCHEMES

1.2.1. Certification Schemes in the Fisheries Sector

The globalisation of seafood trade has led consumers to have broader purchase options, and also to the increase of popularity of CSs (which consequently influences consumer preference) (Belson, 2015). CSs associated with social or environmental sustainability are becoming increasingly popular, especially in the "Global North", where large seafood retailers have made sustainability commitments (including ensuring full chain traceability and the disassociating with IUU fisheries) (Pita and Ford, 2023). Additionally, given the costs and logistics of implementing traceability, the "Global North" has been leading the way when it comes to requiring traceability information (Bailey et al., 2016; Charlebois et al., 2014). However, the majority of seafood comes from the "Global South", where governance and sustainability issues are prevalent, therefore, market access might become harder in the future (Bailey et al., 2016; Mol, 2015).

Fisheries certification and ecolabels started by mobilizing the seafood market to create minimum selling prices for sustainable/well-managed fishery products. Nowadays, some of these schemes are recognized as important labels by Non-Governmental Organisations (NGOs) and commercial seafood firms, contributing to informed purchasing decisions (Gutierrez et al., 2016; Parkes et al., 2010). Many requirements of CSs are focused on the targeted species' stock

status, ecosystem conditions, fisheries management, and social and economic performance. Different CSs focus on different aspects and might have different levels of relevancy depending on the fisheries context. For example, in developing countries, social and economic indicators are particularly important, since local middlemen often determine the access fishermen have to income, services and infrastructure (Gutierrez et al., 2016).

A CS allows for a better understanding of the targeted stock status, monitoring of bycatch and the impact of fisheries on ecosystems, improvement of management and research plans and provides economic advantages (Duggan and Kochen, 2016; Gutierrez et al., 2016). Fisheries value chains might benefit from their certified product being sold at a premium price, even though there can be a disadvantage of those economic benefits not being passed down fairly to fishers, which are the ones who have to bear the costs of many requirements related with adopting more sustainable practices (Duggan and Kochen, 2016; Gutierrez et al., 2016). Small-scale fisheries are the ones that face most of the challenges, related mainly with costs of applying and maintaining CSs, sustaining a regular supply of seafood products for retailers to support fisheries, or simply by having other priorities related with daily income/subsistence. However, for those that pursue certification, opportunities emerge in terms of market access, premium prices, livelihood improvement and less environmental impact (leading to the preservation of marine resources) (Duggan and Kochen, 2016; Gutierrez et al., 2016).

1.2.2. Certification Schemes in the Aquaculture Sector

The aquaculture sector globally is playing an increasingly important role in providing animal protein for human diets. However, aquacultures can damage the natural marine environments by depleting fish feed sources or polluting surrounding areas with effluents (Gould et al., 2019). Certification standards in aquaculture help to reduce harmful practices and to verify that aquacultures reflect values and qualities deemed as positive for the consumers and the environment (Gould et al., 2019).

Certification in aquaculture started as a governance tool to address socio-environmental and ethical sustainability challenges (Marschke and Wilkings, 2014; Saha, 2022). Nowadays, there is a wide range of CSs and standards available for aquaculture products, addressing, amongst others, food safety, environmental impact, animal welfare, and worker conditions (Nilsen et al., 2018). The growth in the number of these schemes has been attributed to several factors,

including the improvement of traceability and/or traceability of products, food safety, ensuring healthier production, and providing more information to consumers to improve purchasing decisions (Nilsen et al., 2018; Osmundsen et al., 2020).

Third-party certifications are market driven and besides encouraging aquacultures to engage in better practices, they also provide legitimacy over certain food production concerns and influences seafood governance (Vince and Haward, 2019).

Traceability is a requirement increasingly recognized due to the public's awareness and for public health reasons. The aquaculture sector has been investing in traceability technology as a way to provide verifiable data on seafood quality and the industry's practices (Oliveira et al., 2021). Since certification schemes now include traceability practices in their standards, many aquaculture companies are challenging themselves to implement new internal systems to accommodate those traceability and transparency requirements. This is leading to the consolidation and availability of documentation and improved efficiency and management for the aquaculture production, which entails spending time and resources that for some are considered unimportant, but it reflects responsible practices and transparency improvements (Amundsen and Osmundsen, 2020).

1.3. TRACEABILITY IN CERTIFICATION SCHEMES

Traceability was historically driven by food safety and food safety legislation, appearing as a tool that can increase consumers' and producers' trusts, and as a solution to solve food safety alerts effectively (Costa et al., 2013; Regattieri et al., 2007). To implement traceability systems, it is necessary to have means of documenting information, which can range from traditional paper-based methods to more sophisticated computer-based data storage programs (Charlebois et al., 2014). In general, traceability has become an important part of CS to ensure seafood's safety and origin and, therefore, has been integrated in many CS in the form of "chain-of-custody" (Bailey et al., 2016).

Consumers may face different questions when it comes to purchasing wild-caught seafood products and aquaculture products, such as "was it caught/produced without negatively impacting marine ecosystems?" or "did the fishers/aquaculture producers have access to proper work conditions?". Traceability can play an important role by answering these questions and

ensuring information transparency. Ecolabels are often used to decrease these concerns and certify that the product complies with certain traceability requirements.

However, traceability in fisheries and aquaculture is also available for the consumer independently of CS. Many traceability solutions are vertically integrated by value chain enterprises and might display information about the seafood product in a static way or in an update in real-time, with the emergence of new technologies such as Blockchain or Artificial Intelligence (AI). For example, the ThisFish traceability tool already uses a dynamic two-way communication system between fishers and consumers, without necessarily resorting to certification (Bailey et al., 2016).

In small-scale fisheries, and particularly in developing countries, the use of hand-written traceability is commonly reported, but implementing a transparent digital traceability system can be quite challenging. Chain of custody (CoC) requirements for digital traceability demand certain infrastructures and facilities in landing sites, which can have high financial costs and resource incompatibilities (such as lack of electricity in rural areas). Besides, the level of traceability required is often not properly described by the CS, which becomes an obstacle. However, these requirements contribute to a positive push towards data availability, to a reduction of IUU fishing, to access new markets and give fisheries competitive advantages, and acknowledge fishery communities (Duggan and Kochen, 2016).

In aquaculture, an optimal system that transmits precise, comprehensive, and consistent information regarding products throughout the supply chain can result in a significant reduction in operational expenses and an increase in productivity (Regattieri et al., 2007) while simultaneously achieving less risk and costs associated with food borne disease outbreaks (Hobbs, 2003).

1.4. OBJECTIVES OF THE DELIVERABLE

To create efficient and comprehensive certification schemes which include traceability solutions, it is crucial to comprehend the essential information that is required by CS to be traceable by stakeholders at each stage of the supply chain. The objectives of Task 1.3 under the Sea2See project are, therefore to:

1) Identify the most significant CS for traceability and for potential alignment of the Sea2See blockchain tool according to seafood CS and standards;

2) Compare the traceability requirements and standards of the relevant CSs in terms of sustainability and traceability information to the public and in digital form.

2. METHODOLOGY

2.1. CERTIFICATION SCHEMES IDENTIFICATION AND ASSESSMENT

Existing CSs related to fisheries and aquaculture were identified through desktop research and analysis of existing information online. A scoring matrix with several criteria was developed to prioritise schemes and labels with a wider range of geographical coverage, that require traceability and have a label for consumers associated. The criteria considered includes the following categories and scores:

- Geographic coverage of the scheme: If the CS has a worldwide coverage (=4); If the CS has a European Union coverage (=3); If the CS has a Nationwide coverage, in the EU (=2) and Non-EU (=1);
- Traceability requirements: if traceability is required by the CS (=2), if identified by the CS (=1) or non-identified by the CS (=0);
- Label available to consumers: if labelling is available for consumers (=1) or not (=0).

The primary objective of the scoring matrix was to prioritise CS that have a wide geographical range while also recognizing the importance of traceability. The scoring system, justification and description for the criteria used can be found in Table 1. Schemes with a scoring threshold of six or higher were considered to be the most relevant for the Sea2See project. The criteria used for this scoring matrix is subjective as are the CSs prioritized, consequently.

Table 1. Scoring matrix and criteria used for the assessment.

Criteria	Score	Justification
Geographic coverage		
Worldwide	4	A CS with a wider geographical range is more relevant for the Sea2Sea project for developing a traceability solution that can be applied to the seafood supply chains
European Union	3	
Nationwide (EU)	2	
Nationwide (Non-EU)	1	
Traceability		
Required	2	A CS that addresses traceability and has information on traceability requirements is valuable for the Sea2See consortium to understand what our solution must be able to cover and might be suitable to engage within our project
Identified	1	
Not identified	0	
Label available to consumers		
Existent	1	Existence of a label informing consumers about the CS. A label may be an opportunity for the Sea2See solution to provide information on the product to consumers
Not existent	0	

2.2. ADDRESSING TRACEABILITY

Two separate lists were created for the relevant fisheries and aquaculture CSs that scored 6 or more points in the scoring matrix.

All standards identified were analysed for their traceability requirements. For each standard, all the traceability related requirements were listed. This allowed for the creation of a database with detailed information on what each CS requires for each specific step in the supply chain in the case of aquaculture standards (Annex 1) and fisheries standards (Annex 2).

Traceability requirements for the aquaculture sector were clustered as: (A) Inputs; (B) Other Records; (C) Differentiation, (D) Internal Traceability and (E) External Traceability (Table 2). Since wild caught seafood and fisheries involve very different stages throughout their supply chains, different clusters had to be considered, in comparison with the aquaculture industry. Therefore, regarding the fisheries sector, the requirements were clustered as: (A) Production Inputs; (B) Middle-chain Inputs; (C) Direct Outputs; (D) Environmental Outputs; (E) Social & Governance; (F) Differentiation; (G) CS Accessibility; (H) Traceability (Table 3).

Table 2. Traceability clusters for the aquaculture sector and explanation of each cluster.

Clusters	Explanation
(A) Inputs	Requirements related to resources that should be traceable and/or recorded
(B) Other Records	Data that must be recorded, excluding "Inputs" and "Internal Traceability"
(C) Differentiation	Requirements related to product labelling and distinction between certified and non-certified products
(D) Internal Traceability	Information (excluding inputs) that should be traceable within a company at the various stages of the supply chain
(E) External Traceability	Requirements related to sharing and linking of traceable data between stakeholders throughout the supply chain

Table 3. Traceability clusters for the fisheries sector and explanation of each cluster.

Clusters	Explanation
(A) Production Inputs	Information related to the fishing methods, management, and data collection
(B) Middle-chain Outputs	Information related to the methods utilised for the transformation, processing, packaging, and transportation phases
(C) Direct Outputs	Direct impacts of the supply-chain stages on the targeted species
(D) Environmental Outputs	Requirements regarding the impacts on ecosystems and habitats
(E) Social & Governance	Requirements regarding social justice and governance
(F) Differentiation	Requirements related to product labelling and distinction between certified and non-certified products
(G) CS Accessibility	The CS recognizes difficulties to obtain certification due to different contexts and presents solutions
(H) Traceability	Requirements related to sharing and linking of traceable data between stakeholders throughout the supply chain

Standards on the capacity to provide a digital traceability solution for the end consumer to track the labelled seafood product were also evaluated. Information on how to trace the product and how much information the consumer could obtain was accessed for the solutions found.

It is imperative to note that the clusters under consideration are not mutually exclusive, as some requirements may fall under multiple clusters. Nevertheless, an attempt was made to logically separate all identified requirements. For example, all the requirements in the "(A) Inputs" must be internally traceable by the stakeholders. This means that they could also fit into cluster "(D) Internal Traceability". However, we recognized that certain requirements need to be internally traceable but may not necessarily qualify as inputs. Considering this, we created these two distinct clusters.

The “(B) Other Records" cluster was created to encompass only requirements related to data that must be recorded by the stakeholders excluding all the “(A) Inputs” and “(D) Internal traceability” requirements that also need recording. Although we recognize that this cluster mostly contains data that may not require traceability, we included it because certified stakeholders will be audited by third-party organisations that demand these records. A traceability solution that considers the option to include these records will provide a more comprehensive and suitable solution for the stakeholders.

3. CERTIFICATION SCHEMES IDENTIFICATION AND ASSESSMENT

3.1. AQUACULTURE

A total of 27 CSs were identified and evaluated according to the scoring matrix developed for this purpose (Table 4). A total of eight CSs were found to have an equal or higher score than the threshold considered (6 points). These schemes were then selected for further evaluation of specific standards and requirements. Additionally, all schemes that scored equal or higher than six points have a worldwide range of impact and address traceability in some way.

Table 4. Scoring Matrix developed for the aquaculture certification schemes (CSs) prioritisation. **"** ✓ " - Yes; "Blank space" – No.

	Geographic Range				Traceability			Label available to consumers		
Certifications schemes/Labels (Score)	**Worldwide (4)**	**European Union (3)**	**Nationally EU (2)**	**Nationally Non-EU (1)**	**Required (2)**	**Identified (1)**	**Not identified (0)**	**Existent (1)**	**Not existent (0)**	**Total Score**
Aquaculture Stewardship Council (ASC)	✓				✓			✓		**7**
Best Aquaculture Practices (BAP)	✓				✓			✓		**7**
Friends of the Sea (FOS)	✓				✓			✓		**7**
GLOBALG.A.P.	✓				✓			✓		**7**
Naturland	✓				✓			✓		**7**
Bio-grow	✓				✓			✓		**7**
Safe Quality Food (SQF)	✓				✓				✓	**6**
MarinTrust	✓				✓				✓	**6**
Label Rouge, France			✓		✓			✓		5
Organic Food Federation				✓	✓			✓		4
Soil Association certification				✓	✓			✓		4
Australian Certified Organic				✓	✓			✓		4
Bio-Suisse			✓		✓			✓		5

KRAV			✓			✓		✓		4
Bord Iascaigh Mhara (BIM) / Ireland's Seafood Development Agency			✓		✓				✓	4
Royal Society for the Prevention of Cruelty to Animals (RSPCA)/ Freedom Food Ltd.				✓	✓			✓		4
Marin Eco-Label Japan (MEL)				✓	✓			✓		4
Shrimp Seal of Quality (SSOQ)				✓			✓	✓		2
Accredited Fish Farm Scheme				✓			✓	✓		2
Bioland, Germany		✓					✓	✓		4
Debio			✓				✓	✓		3
Irish Quality salmon and trout			✓				✓	✓		3
Agriculture Biologique			✓				✓	✓		3
National Association for Sustainable Agriculture, Australia (NASAA)				✓			✓	✓		2
Alter-Trade Japan (ATJ)				✓			✓	✓		2
SIGES Fundación Chile / CBPA				✓			✓		✓	1

3.2. FISHERIES

For the fisheries sector, a total of 14 CSs were identified and evaluated according to the same scoring matrix (Table 5). A total of seven CSs were found to have an equal or higher score than the threshold considered. Just like it was described for the aquaculture sector CSs, these schemes were then selected for further evaluation of specific standards and requirements.

Table 5. Scoring Matrix developed for the fisheries certification schemes (CSs) prioritisation. **"** ✓ " - Yes; "Blank space" – No.

	Geographic Range				Traceability			Label available to consumers		
Certifications schemes/Labels (Score)	**Worldwide (4)**	**European Union (3)**	**Nationally EU (2)**	**Nationally Non-EU (1)**	**Required (2)**	**Identified (1)**	**Not identified (0)**	**Existent (1)**	**Not existent (0)**	**Total Score**
Marine Stewardship Council (MSC)	✓				✓			✓		**7**
Friend of the Sea (FOS)	✓				✓			✓		**7**
FairTrade	✓				✓			✓		**7**
Responsible Fisheries Management (RFM)	✓				✓			✓		**7**
OceanWise	✓					✓		✓		**6**
Naturland Wildfisch	✓					✓		✓		**6**
BIM's Responsibly Sourced Seafood (RSS)			✓		✓			✓		5
Seafood Watch - Monterey Bay Aquarium	✓					✓			✓	5
Dolphin Safe	✓						✓	✓		5
Best Seafood Practices (BSP)	✓					✓			✓	5
Iceland Responsible Fisheries (IRF)				✓	✓			✓		4
Marine Eco-label Japan (MEL Japan) V2				✓	✓			✓		4

G.U.L.F. - Audubon Gulf United for Lasting Fisheries				✓		✓			✓	2

4. TRACEABILITY REQUIREMENTS

Traceability is becoming more prevalent in the seafood supply chains, as it can tackle various issues and concerns among stakeholders such as consumers, seafood companies, government agencies, and non-profit organisations regarding the legality and sustainability of seafood products (Lewis and Boyle, 2017).

4.1. AQUACULTURE

Table 6 presents the full list of standards examined in our study to ascertain their respective traceability requirements. We identified and enumerated a total of 23 standards for the most significant CSs.

We found that the number of applicable standards varied among the different CS. Only three of the most relevant labels were found to have Chain of Custody (CoC) standards (Aquaculture Stewardship Council, GLOBAL G.A.P. and MarinTrust), meanwhile we found a high number (N=5) of standards that focused on feed production stages. This indicates that aquaculture CSs are more focused on tracing the early stages of the aquaculture supply chain. The evaluation of farm or other specific stages was conducted in conjunction with CoC standards, to provide an overview of the requirements from each CS across the whole supply chain.

Table 6. List of certification schemes (CSs) and their standards applicable in the aquaculture industry.

Certification Schemes	Standards
1. Aquaculture Stewardship Council (ASC)	Salmon Farm Standard
	MSC CoC
2. Best Aquaculture Practices (BAP)	Feed Mills Standard
	BAP Farm Standard
	Hatchery Standard
	Seafood Processing Standard
3. Friends of the Sea (FOS)	Land-based aquaculture
	Sustainable marine aquaculture
	Sustainable farmed crustaceans
	Farmed shellfish

	Seaweeds and algae products
4. GLOBALG.A.P.	Integrated Farm Assurance (IFA) for Aquaculture
	Compound Feed Manufacturing
	GG CoC
5. Naturland	Aquaculture Standards
	Processing Standards
6. BioGro	Organic aquaculture production
	Processing Standard
	Distribution Standard
	Retail Standard
7. Safe Quality Food (SQF)	Food Safety Code: Aquaculture
8. MarinTrust	Marine Ingredients
	CoC Standard

In the analysis of the various standards, we have identified a total of 54 requirements related to traceability. To facilitate a more effective comparison of traceability requirements across different CSs, we identified and categorised such requirements across the various standards. Comparing requirements across different standards was a challenging task due to variations in the structure and language used within each standard. Often, it was difficult to clearly identify for each stage of the supply chain if a certain traceability requirement would be applicable and, due to the diverse nature of traceability-related factors, it was not always a straightforward process to discern what constituted a traceability requirement. Therefore, we classified all the traceability requirements identified into five distinct clusters (Table 7) to facilitate a better understanding of the different types of traceability requirements that can be found in each standard and allow for easier comparison between CSs requirements across the supply chain.

Some requirements were more challenging to group than others. For example, the requirement "Effective Management System" appears to be a subjective requirement where a stakeholder must operate a management system that effectively addresses all the standard requirements. Although this requirement could fall simultaneously into all the clusters considered, we decided to include it in cluster "(B) Other Records". Finally, an interdependence between the clusters "(C) Differentiation" and "(E) External Traceability" was also identified. We tried to include requirements only related to product labelling and distinction between certified and non-certified products in cluster "(C) Segregation", while topics related to sharing and linking of traceable data between stakeholders throughout the supply chain as "(E) External Traceability".

However, we understand that requirements related to the identification and labelling of the product are also related to external traceability since the correct identification and labelling of the product will be fundamental for tracking products throughout the supply chain and will allow stakeholders to trace them back to their source when required. This could potentially create a false impression that CSs have no control over the transfer of products between different stakeholders in the supply chain.

We found that most of the traceability requirements belong to "(A) Inputs", followed by "(D) Internal Traceability". To fully understand the specifics of each traceability requirement, please refer to Appendix 1 and Appendix 2 where we have provided additional information and context for each of the 54 requirements.

Table 7. Clustering of identified traceability requirements from the different aquaculture certification schemes (CSs).

Clusters				
(A) Inputs	**(B) Other Records**	**(C) Differentiation**	**(D) Internal Traceability**	**(E) External Traceability**
● Seed source; ● Feed source; ● Raw material source; ● Marine feed ingredients origin and sustainability; ● Species characteristic specifications; ● Soy complete track; ● Feed Ingredients source; ● Fish meal and oil; ● Seedling from certified suppliers; ● Responsible sourcing of feed materials; ● Marine ingredients source; ● Processing inputs; ● Chemicals; ● Therapeutic treatments; ● Certified products are purchased from certified suppliers.	● Risk events record keeping; ● Customer complaints; ● Feed conversion index; ● Energy Consumption; ● Water quality; ● Accidents or injuries; ● Economic Feed Conversion index; ● Effective management system; ● Environmental monitoring record; ● Product management system; ● Document changes reporting.	● Differentiation; ● Proper identification in all the processing steps; ● Product identification; ● Clear and accurate product labelling; ● Certified products are identifiable; ● Correct identification and labelling.	● Effective and accurate record-keeping system (digital or not); ● Records kept for each unit in each production cycle; ● Transmission and verification of electronic data; ● Results of feed quality and safety analyses; ● Farmed aquatic species movements; ● Laboratory test results; ● Net traceability; ● Production records; ● Harvest records; ● Retail records; ● Distribution records; ● Ice supply traceability; ● Residue testing.	● Blockchain technology; ● Tracking system; ● Transportation traceability; ● Traceability from broodstock to packaging; ● Product traceability; ● Efficient traceability code; ● Entire manufacturing process traceability; ● Transaction and transport documentation; ● Information flow; ● Full traceability of marine ingredients.

Table 8 shows the distribution of the traceability clusters that are required for each label throughout the supply chain. Each traceability cluster can have a maximum of 48 occurrences, since a total of 8 CSs and 6 stages of the supply chain were considered, as can be seen in Table 8. From all the traceability clusters considered, "(C) Differentiation" and "(D) Internal Traceability" were the most important, with 32 and 30 occurrences, respectively, out of 48 possible ones. The clusters "(A) Inputs", "(B) Other Records" and "(E) External traceability" occur 22, 26 and 21 times, respectively.

Our analysis revealed that most CSs examined in this study appeared to require a greater number of traceability clusters in the early stages of the supply chain, as indicated by the higher density of clusters for these stages in Table 8. This might suggest that aquaculture CSs are placing greater emphasis on the initial stages of the supply chain.

Although the feed production stage is not traditionally viewed as the principal step in the supply chain, it is of critical importance for the aquaculture industry. As such, we made the decision to include it in our study to ensure a comprehensive analysis of traceability requirements. Regarding this specific step in the supply chain, we can see in Table 8 that GLOBALG.A.P. and MarinTrust are the CSs that require a higher diversity of clusters for this initial stage. This could be attributed to the fact that GLOBALG.A.P. has a specific standard focusing on Feed Manufacturing (Table 6) and MarinTrust is a CS that sets standards for the responsible sourcing and production of marine ingredients which likely requires more detailed traceability measures for the feed production stage.

In terms of cluster "(C) Differentiation" requirements, not all the identified CSs seem to require stakeholders to differentiate certified from non-certified products in every step of the supply chain. It is recommended as a best practice to ensure traceability and prevent mixing of certified and non-certified products. However, it is challenging for each part of the supply chain to implement differentiation. Commonly, the responsibility for differentiation and traceability of certified products primarily lies within the certified companies in the supply chain, primarily in the production/farms. Some retailers or buyers may choose to differentiate certified products from non-certified products to demonstrate their commitment to sustainability and to provide consumers with more informed choices.

Table 8. Traceability clusters required across the supply chain from the different aquaculture certification schemes (CSs).

Certification Scheme	Supply Chain Step																													
	Feed production					Hatchery					Farm					Processing					Distribution					Retail/Market				
ASC	A					A	B	C	D		A	B	C	D		A	B	C	D		A	B	C	D		A	B	C	D	
BAP	A			D		A	B	C	D	E	A	B	C	D	E	A		C	D	E										E
FOS												B	C	D																
GLOBALG.A.P.	A	B	C	D	E	A	B	C	D	E	A	B	C	D	E	A	B	C	D	E	A	B	C	D	E	A	B	C	D	E
Naturland	A	B				A	B	C			A	B	C				B	C				B								
Bio-Gro											A	B		D		A		C	D				C	D				C	D	
SQF							B	C	D	E	A	B	C	D	E		B	C	D	E		B	C	D	E			C		E
MarinTrust		B	C	D	E			C	D	E			C	D	E		B	C	D	E			C	D	E			C	D	E

Legend:

(A) Inputs

(B) Other Records

(C) Differentiation

(D) Internal traceability

(E) External traceability

Regarding particular CSs, GLOBALG.A.P. seems to be one of the most comprehensive aquaculture CSs since it covers all 5 clusters across all supply chain stages. Interestingly, ASC seems to cover all the clusters except for "(E) External Traceability" from the hatchery until the market. Overall, we can see a higher density of clusters required in the early stages of the supply chain ("Hatchery", "Farm" and "Processing") indicating that CSs may be emphasising their standards more into the production stages. Clusters required showed a decrease from processing to market stages which could be partly attributed to the limited number of CSs with CoC standards (N=3; Table 6) which are standards that focus directly on the supply chain itself.

Based on the assessment, only two out of the eight CSs analysed revealed to have an online or digital form to trace-and-track their certified products (Figure 1). Only ASC and GLOBALG.A.P. seem to have a solution for the end-consumer to track their labelled seafood products. We could not find any traceability solutions available to end consumers for the remaining CSs.

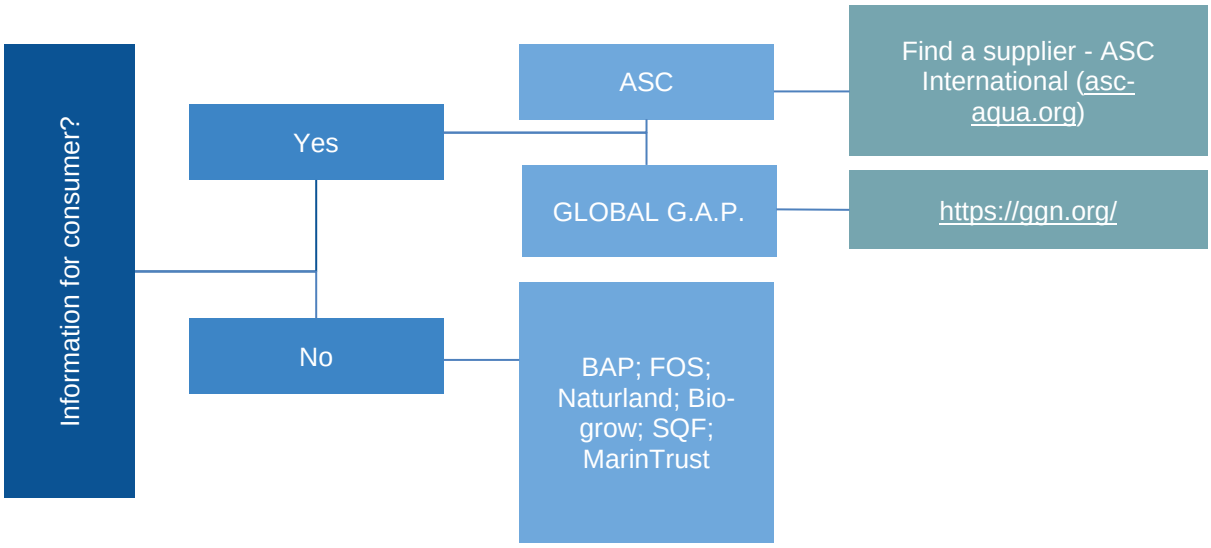

Figure 1. Availability of trace-and-track solutions for end-consumers in aquaculture certification schemes (CS).

The Aquaculture Stewardship Council (ASC) employs a Chain of Custody (CoC) Standard developed by the Marine Stewardship Council (MSC) to authenticate the provenance of seafood marketed as ASC certified. In May of 2022, ASC introduced the ASC CoC Module, which became effective on May 30, 2023. ASC is currently undertaking an ongoing project, known as the "Key Data Element (KDE) project" which aims to enhance supply chain transparency and improve assurance of traceability. It involves using software to capture and convey relevant KDEs from the certified farm origin throughout the supply chain to the end users. This project will yield a comprehensive list of KDEs that may be considered for integration into Sea2See's traceability solution**.**

It is interesting to note that most schemes under analysis, except Safe Quality Food (SQF) and MarinTrust, obtained the maximum score in the conducted evaluation (Table 4). This suggests that these schemes are particularly relevant in promoting sustainability and traceability worldwide in the seafood supply chain. Having in mind that the developed scoring matrix used in this study is a subjective method to prioritise aquaculture CSs, we can conclude that the results from the scoring matrix highlighted the importance of traceability.

In conclusion, our analysis has shown that different CSs place varying levels of importance on different stages of the supply chain. To achieve a comprehensive traceability system, we should take into consideration the requirements of different CSs in the different stages of the supply chain. In Table 8, we can observe that GLOBAL G.A.P. and MarinTrust cover most traceability clusters on the feed production stage, while ASC, BAP and SQF give more importance to the hatchery, farm, and processing stages. The number of CSs with traceability requirements for the distribution and retail/market stages is lower, with ASC, GLOBAL G.A.P., and MarinTrust being the most complete in the later stages of the value chain. Due to this broader scope, ASC, GLOBAL G.A.P., and MarinTrust are the CSs that should be given priority for the Sea2See platform, with BAP and SQF being considered for the production stages.

It is important to acknowledge that standards and CSs are dynamic and tend to evolve over time, potentially including new traceability requirements. An example of this is the new ASC CoC Module that has recently included new traceability requirements. Although there is a BAP CoC standard, its specific requirements could not be analysed as the standard document was not found. However, from the Global Seafood Alliance website we understood that it requires traceability one step back and one step forward for certain inputs from the hatchery until the

processing plants, which would fall under the "(E) External traceability" cluster, altering the results presented in Table 8.

Online or digital solutions for tracing a labelled seafood product have recently received attention in the food industry. The increased transparency and trust in the supply chain is very important for consumers, as they want to get more information about the products they purchase. In this study, we identified two aquaculture CSs that provide an online tracking and traceability solution for the certified aquaculture products. These are ASC and GLOBAL G.A.P., that have solutions that allow the consumer to have access to more information about the certified product. ASC uses a unique code printed on the product packaging with a series of letters and numbers, usually located next to the ASC logo. To trace the certified product, the consumer can go to the website[1] and enter the unique code from the product packaging into the search box and click "search". The system will then display information about the product, including the name of the certified farm or processing facility, the species of the seafood, and date and location of harvest. Additionally, the consumer can also view the ASC certification status of the farm or processing facility that produced the product. This provides more detailed information about the facility's compliance with ASC standards.

On the other hand, GLOBAL G.A.P. has an online database called "GGN Database" that allows consumers to trace products back to certified farms or producers. The GLOBAL G.A.P. label present on the product packaging includes a GGN (GLOBAL G.A.P. Number) code, in which a unique identifier is assigned to each certified producer. The GGN code can be pasted in the search box in two websites[2]. The database will display information about the certified producer, including the name, location and product categories. There is also an option for the consumer to view the producer's status and audit history to get detailed information about their compliance with GLOBAL G.A.P. standards.

These two CSs have a system that provides consumers with some degree of transparency and traceability for the fish and seafood products they acquire. Although their online system is very helpful and useful for consumers, the specific information provided by each database or system may vary depending on the product and on the availability of the information they get from each step in the supply chain. To conclude, the digital traceability solutions identified for aquaculture have limitations in providing complete transparency and traceability of the

[1] https://www.asc-aqua.org/what-you-can-do/take-action/find-a-supplier/
[2] ggn.org - certified, responsible farming and transparency or https://database.globalgap.org/globalgap/search/SearchMain.faces?init=1

product's journey until it reaches the end consumer. This gap presents an opportunity for the development of new and more efficient traceability solutions that offer greater information and transparency for the end consumer, such as the Sea2See solution.

4.2. FISHERIES

The standards examined for the fisheries CSs are described in Table 9. It was possible to identify 11 standards for the six CSs with the highest score on the Scoring Matrix. It was more difficult to identify to what stages of the value chain the more generalistic standards (MSC Fisheries Standards, FOS Standards, FairTrade Standards, RFM Certification Program and Naturland Standards - Sustainable Capture Fishery) were referring to, but most of the requirements were more focused on the fishery itself, the first stage of the supply chains. In this sector, only three CSs include Chain of Custody (CoC) standards, however some CSs mention traceability requirements (such as the FairTrade Standards and FOS Fish aggregating device (FAD) FREE Tuna Products).

Table 9. List of certification schemes (CS) and their standards applicable in the fisheries industry.

Certification Scheme/Label	Standards
1. Marine Stewardship Council (MSC)	MSC Fisheries Standards
	MSC Chain of Custody (CoC)
2. Friend of the Sea (FOS)	FOS Standards
	FOS Chain of Custody (CoC)
	FOS Fish aggregating device (FAD) FREE Tuna Products
3. FairTrade	FairTrade Standards
4. Responsible Fisheries Management (RFM)	Unified RFM CoC (Chain of Custody) Standard
	RFM Certification Program
5. OceanWise	Standard for Captured Fisheries
	Rapid Assessment Standard
6. Naturland Wildfisch	Naturland Standards - Sustainable Capture Fishery

In total, 58 requirements were identified for the fisheries standards analysed (Annex 3). Most of these requirements are focused on the fishing activity, and not so much on the rest of the supply chain. However, it was possible to distinguish very different clusters, regarding all

supply chain actors and aspects. In total, seven different clusters were identified (Table 10), which allowed for a better understanding of the requirements that each CSs includes.

A distinction was made between different sources of inputs (either from the production/fishery stage of the value chain, cluster "(A) Production Inputs", or from the middle-chain actors, cluster "(B) Middle-chain Inputs"), given the disparity of methods and management. Additionally, different system outputs were considered: the direct ones (cluster "(C) Direct Outputs") that are focused on the targeted species caught and the environmental ones (cluster "(D) Environmental Outputs") that refer to more indirect consequences (for the environment) caused by the supply chain. Cluster "(E) Social and Governance" included not only requirements about ensuring labour and human conditions, but also cooperation between entities and the endorsement of international, national or regional laws and regulations. Cluster "(F) Differentiation" includes both the explicit inclusion of standards that aim to improve the CS accessibility, and the effort to develop requirements within the CS that apply to specific parts of the sector that might have different characteristics, such as small-scale fisheries.

In some cases, CSs requirements were difficult to associate with just one cluster. For example, the Naturland Wildfisch referred to several different "sustainable management methods", and included different sustainability standards, such as energy consumption, type of materials used, and social responsibility. All of these can be associated with different stages of the supply chain. Therefore, this was associated with cluster "(A) Production Inputs", but also "(B) Middle-chain Inputs" and it seemed to have concerns about clusters "(C) Direct Outputs", "(D) Environmental Outputs" and "(E) Social and Governance". In some cases, some criteria might be a bit too ambiguous to be associated directly to a specific cluster. For instance, regarding the material used in different supply chain stages, one could consider it was linked to seafood safety, but it could also be linked to environmental concerns. Annex 4 describes the requirements considered for each CS and how they relate to the fishery's supply chain and respective cluster.

Analysing the results from Table 11 and taking into consideration the process of analysis of each CS, it is possible to observe that:

- The CSs considered for the fishery sector were less than the ones considered for the aquaculture sector. Some initially found labels were later not considered for the analysis

because their standards were based in another CS; they had no standards available online; or they served just as a third-party certification for other CSs;

- No CS had all clusters present throughout the different supply chain steps. The fishery stage was the one with the higher presence of different clusters. Most CSs consider the same clusters for the processing, distribution and retail/market stages. This shows the lack of CSs requirements differentiation between all stages except for the fisheries stage. In fact, in all CSs analysed, the fishery stage was the one with more clusters considered;
- Cluster "(F) Differentiation" was the most represented cluster within all supply chain stages and CSs (appearing 20 times). In fact, OceanWise was the only CS that doesn't mention it anywhere. Cluster "(G) CS Accessibility" was the less represented cluster (only mentioned twice), only appearing in the OceanWise and Responsible Fisheries Management (RFM)'s standards, even though fisheries' socio-economic differences might be relevant to determine a fair access to these CSs and obtain access to certain markets;
- RFM is the CS that considers the most clusters, since the fishery stage includes all clusters except cluster "(B) Middle-chain Inputs". The only CS that actually considers that same cluster is Naturland Wildfisch. OceanWise is the CS that includes the least variety of clusters: only four clusters are mentioned (cluster "(A) Production Inputs", "(C) Direct Outputs", "(D) Environmental Outputs" and cluster "(G) CS Accessibility") and only for the fishery stage;
- The cluster "(H) Traceability" is considered for most CSs standards (except OceanWise and Naturland Wildfisch) and in all supply chain steps. Regarding outputs, cluster "(D) Environmental Outputs" seems to be more considered by CSs than cluster "(C) Direct Outputs". Showing a concern regarding the impact of the activity on the ecosystem itself, rather than the target species.

Table 10. Clustering of identified traceability requirements from the different fisheries certification schemes (CSs).

Clusters							
(A) Production inputs	**(B) Middle-chain inputs**	**(C) Direct outputs**	**(D) Environmental outputs**	**(E) Social and Governance**	**(F) Differentiation**	**(G) CS accessibility**	**(H) Traceability**
● Standards have in consideration stock status; ● Fishing is in accordance with available information (more precaution might be applied if less information is available); ● The use of logbooks; ● Gear selectivity; ● Periodic species scientific assessment; ● Scientific data used for the fishery's management; ● Periodical monitoring and evaluation of fishing practices; ● Fishing and landings' legal compliance.	● Correct preservation and manipulation; ● Temperature variation; ● Chemicals and other possible contaminants; ● Safety and quality control; ● Efficiency assessment; ● Materials in use; ● Document changes reporting.	● Stock and population impacts; ● Seafood safety.	● Bycatch and discards; ● Introduced species; ● Ghost gear; ● Energy requirements and carbon footprint; ● Food-chain disruption; ● Impacts on seabed; ● Waste management; ● Pollution (e.g. residues from processing); ● Energy consumption and carbon footprint; ● Eco-packaging; ● Recycling, reuse, re-process or proper disposal of fishing gear.	● Human rights and labour conditions; ● Stakeholders participation in decision-making; ● Social disputes; ● Stakeholders' relationships and sense of fairness; ● Food security; ● Possibility for consumers' complaints; ● Social accountability; ● Gender equity; ● Transparency in management; ● Freedom of association; ● Certification compliance verification and auditing; ● Stakeholders celebrate trade and traceability agreements.	● Proper identification in all the processing steps; ● Product identification; ● Clear and accurate product labelling; ● Certified products are identifiable; ● Correct identification and labelling.	● Recognized differences between small- and large-scale fisheries; ● Measures to improve fisheries' access to CS.	● Blockchain technology; ● Tracking system; ● Traceability at any stage of the supply chain; ● Consumer's access to the product's information (e.g. origin); ● Information flow; ● Chain of custody.

Table 11. Traceability clusters required across the supply chain from the different fisheries certification schemes (CS).

Certification Scheme	Supply Chain Step																											
	Fishery								Processing								Distribution								Retail/Market							
MSC	A			D	E	F		H					E	F		H					E	F		H					E	F		H
FOS	A			D	E	F		H				D		F		H				D		F		H				D		F		H
FairTrade					E	F		H					E	F		H					E	F		H					E	F		H
RFM	A		C	D	E	F	G	H					E	F		H					E	F		H					E	F		H
OceanWise	A		C	D			G																									
Naturland Wildfisch	A	B	C	D	E	F			A	B	C	D		F			A	B	C	D		F			A	B	C	D		F		

Legend:

- (A) Production inputs
- (B) Middle-chain inputs
- (C) Direct Outputs
- (D) Environmental Outputs
- (E) Social and Governance
- (F) Differentiation
- (G) CS Accessibility
- (H) Traceability

Regarding online/digital traceability to the consumer, very little information was found in general, with the exception of MSC, as can be seen in Figure 2.

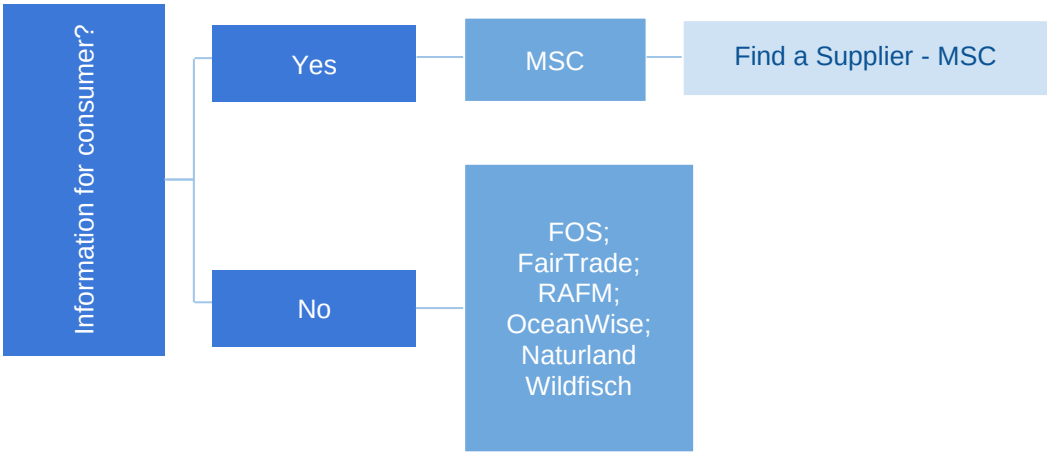

Figure 2. Availability of trace-and-track solutions for end-consumers in fisheries certification schemes (CSs).

Like is the case for ASC for aquaculture products, MSC products have an online tool[3] available to find an online supplier around the world. This website provides information regarding the supplier such as the contact, location, seafood species, supplier activity type, sales contact and certification details. These results might be found by searching the location, the supplier's name, species or the certificate code presented in the certificated seafood label. However, there is not a scannable option associated with the MSC label for consumers to quickly access more traceability information.

None of the other CSs had a digital option for consumers to have further traceability information about their certified wild-caught seafood options. This means that, even though most CSs have traceability requirements, the final consumer generally has no access to this information, which incapacitates the ability to make informed purchase decisions. In comparison, the aquaculture products seem to have a more developed technological traceability system available for consumers.

Just like it was mentioned for the aquaculture sector, the developed matrix highlighted traceability requirements in CSs. However, they do not seem to be investing in available digital tools for consumers, which demonstrates a lack of digital transition strategy by the CSs and their offered services.

[3] https://cert.msc.org/supplierdirectory/VController.aspx?Path=be2ac378-2a36-484c-8016-383699e2e466

As opposed to the aquaculture CSs analysed, there is not a particular certification scheme that can be highlighted as the most comprehensive one, and that considers all clusters for all supply chain steps. Naturland Wildfisch is the one with the higher number of clusters considered (6 in the fishery part of the value chain and 5 in the processing, distribution, and retail/market steps).

To conclude, just like for the aquaculture CSs, different fisheries CSs give different levels of importance to different requirements throughout the different steps of the supply chain. Traceability requirements seem to focus mainly on the production/fisheries stage. The RFM certification seems to be the most inclusive in terms of cluster inclusion (Table 11) and it also has the maximum score in terms of its geographical range, traceability and the presence of an Ecolabel (Table 5).

Even though MSC offers a digital platform where it is possible to have access to detailed supplier information regarding fishery products, it lacks a comprehensive platform for the consumer to check seafood products end-to-end traceability. Therefore, we consider that all fisheries CSs considered would benefit from the adoption of the Sea2See blockchain platform, particularly MSC, FOS, FairTrade and RFM, since they already have traceability requirements in their standards.

5. CONCLUSIONS

We acknowledge that the scoring matrix developed for the analysis is a subjective method that can result in certain CSs being prioritised over others. Changing the score given to any criteria could have affected the final results. For example, we included the criteria “Label available to consumers” because it allows consumers to easily identify products which are part of a CS. This criterion allowed us to prioritise CSs focused on sustainable practices and easily identified by consumers. Most of the CSs analysed, both for fisheries and aquaculture products, had a label available for the end consumer (Table 4 and 5). We opted to include this criterion with a score=1 (instead of a higher score) to be able to prioritise CSs with a wider range of geographical impact and simultaneously relevant for traceability, without discarding a sustainability label.

Some organisations of importance for improving traceability in seafood supply chains were not included in our matrix, as they were not considered as a certification scheme or label for the

seafood sector, namely Global Dialogue on Seafood Traceability (GDST)[4] and Seafood Alliance for Legality and Traceability (SALT)[5].

GDST is dedicated to developing standards for interoperable seafood traceability systems. Traceability solutions that pass the GDST's Capability Test can carry a "GDST Capable" logo. Therefore, having a traceability platform that complies with GDST's standards would be a crucial step towards enhancing the success of a traceability solution and passing the GDST capability test would be a fundamental factor to consider in the development of the Sea2see Traceability platform.

SALT aims to improve the transparency and accountability of the seafood supply chain by encouraging better traceability, monitoring, and enforcement practices for seafood. SALT provides support to seafood companies to adopt strong traceability systems, as well as guidance and assistance to those who are already using such systems, with the aim of enhancing their performance and complying with the industry's evolving standards and commitments.

GDST and SALT share a common objective of promoting the adoption of electronic catch documentation and traceability (eCDT) systems worldwide, with the aim of making traceability a standard practice in the seafood industry. Therefore, being updated on their requirements and guidelines will help in the development of a comprehensive seafood traceability solution that can be applied globally.

With this analysis, we can conclude that:

1) The importance assigned to different stages of the supply chain by CSs varies, making it necessary to consider requirements from multiple CSs to create a comprehensive certification system. The same happens particularly for traceability requirements, since different CSs consider them in different steps of the supply chain. For instance, for aquaculture, there are traceability requirements for all stages of the supply chain in GLOBALG.A.P., and MarinTrust, but for BAP traceability seem to be particularly relevant for the production and processing stages;
2) Most CSs used for both the aquaculture and the fisheries industries have traceability requirements more focused on the production stages of the supply chain. The complexity of the aquaculture production made us consider different initial stages of

[4] https://traceability-dialogue.org/
[5] https://fishwise.org/salt/

the supply chain (feed production, hatchery and farm). We can also note that in the case of fisheries, even though there is only one supply chain step regarding the production phase (the "fishery"), there is a higher number of traceability clusters considered for this step (across all CSs) than for the processing, distribution and retail/market steps (as can be seen in Table 10);

3) Comparing aquaculture and fisheries clusters, we can see that fisheries CSs have more requirements outside production and characteristics of products, such as environmental and social sustainability, than aquaculture CSs. These requirements place an emphasis on fisheries as more than just a way of obtaining food, but also as a primary economic activity for many coastal communities and an activity of extreme social and cultural importance;
4) CSs appear to lack a complete track-and-trace solution for end consumers to track their labelled seafood products. This gap presents an opportunity for the Sea2See project, particularly as most of the CSs are promoting the adoption of blockchain technology by the stakeholders in the supply chain.

The Sea2See blockchain tool can potentially contribute to CSs that do not yet have traceability requirements into consideration (cluster "(H) Traceability" for fisheries and cluster "(E) External traceability" for aquaculture). These CSs are, in the case of CSs for fisheries, OceanWise and Naturland Wildfisch and, in the case of CSs for aquaculture, FOS, ASC, Naturland and Bio-Gro (and potentially BAP and SQF, that lack that cluster for some of the supply chain steps considered in aquaculture). These CSs might benefit from the Sea2See traceability as an innovative tool to improve CSs and market requirements. Additionally, this could also represent an opportunity for industries that aim to comply with CSs that already have traceability requirements (such as MSC, FOS, FairTrade and RFM for fisheries and BAP, GLOBALG.A.P., SQF and MarinTrust for aquaculture) to seek the Sea2See solution and enhance their seafood traceability.

With this analysis we aimed to produce a report that constitutes a relevant way to assess how traceability is being integrated in some of the most relevant CSs for the seafood industry, highlighting that there are still possibilities to better promote traceability amongst their requirements. These possibilities underline the importance of solutions such as the Sea2See blockchain tool that showcase the opportunities that traceability can bring to the seafood industry. CSs with traceable products might contribute to increase awareness and good practices amongst consumers and retailers and stimulate the transformation of seafood systems.

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ANNEXES

Annex 1. Traceability requirements for the aquaculture sector from each standard across the supply chain. Clusters: (A) Inputs, (B) Other Records, (C) Differentiation, (D) Internal Traceability, (E) External traceability.

Certification Schemes	Standard	Traceability Requirements	Cluster	Supply chain Step					
				Feed Manufacturer	Hatchery	Production	Processing	Distribution	Retail/ Market
Aquaculture Stewardship Council (ASC)	Salmon Farm Standard	Feed source	A			x			
		Raw materials source	A	x		x			
		Net traceability	A			x			
		Risk events Record	B			x			
		Marine feed ingredients origin and sustainability	A			x			
	MSC Chain of Custody (CoC)	Certified products are purchased from certified suppliers, fisheries, or farms	A		x	x	x	x	x
		Document changes reporting	B		x	x	x	x	x
		Effective Management system	B		x	x	x	x	x
		Differentiation	C		x	x	x	x	x
		Certified products are identifiable	C		x	x	x	x	x
		effective and accurate record-keeping system (digital or not)	D		x	x	x	x	x
Best Aquaculture Practices (BAP)	Feed Mill Standard	Soy complete track	A	x					
		Effective and accurate record-keeping system (online or not)	D	x					
		Results of feed quality and safety analyses	D	X					
		Transmission and verification of electronic data	D	X					
	BAP Farm standard	Seed source	A			x			
		Feed source	A			x			
		Therapeutic treatments	A			x			
		Chemicals	A			x			
		Species characteristic specifications	A			x			
		Buyer complaints	B			x			
		Differentiation	C			x			
		effective and accurate record-keeping system (digital or not)	D			x			

		Records Kept for each unit in each Production cycle	D			x			
	Hatchery Standard	Seed source	A		x				
		Feed source	A		x				
		Therapeutic treatments	A		x				
		Chemicals	A		x				
		Species characteristic specifications	A		x				
		Differentiation	C		x				
		Harvest records	D		x				
		Effective and accurate record-keeping system (digital or not)	D		x				
		Records Kept for each unit in each Production cycle	D		x				
		Buyer complaints	B		x				
	Seafood Processing Standard	Raw material source	A				x		
		Chemicals	A				x		
		Differentiation	C				x		
		Proper identification in all the processing steps	C				x		
		Effective and accurate record-keeping system (digital or not)	D				x		
		Transmission and verification of electronic data	D				x		
BioGro	Organic aquaculture production	Seed source	A			x			
		Feed source	A			x			
		Disease and veterinary drugs (Therapeutic treatments)	A			x			
		Chemicals	A			x			
		Environmental monitoring record	B			x			
		Production records	D			x			
		effective and accurate record-keeping system (digital or not)	D			x			
		Residue testing	D			x			
	Processing	Processing inputs	A				x		
		Clear and accurate product labelling	C				x		
		Differentiation	C				x		
		Production records	D				x		
	Distribution	Clear and accurate product labelling	C					x	
		Differentiation	C					x	
		Distribution records	D					x	
	Retail	Differentiation	C						x

		Retail Records	D						x
Friends of the Sea (FOS)	Land-based Aquaculture	Risk events Record	B			x			
		feed conversion index	B			x			
		Differentiation	C			x			
		Effective and accurate record-keeping system (digital or not)	D			x			
	Sustainable marine aquaculture	Water quality	B			x			
		Risk events Record	B			x			
		feed conversion index	B			x			
		Energy consumption	B			x			
		Differentiation	C			x			
		Effective and accurate record-keeping system (digital or not)	D			x			
	Sustainable farmed crustaceans	Water quality	B			x			
		Risk events Record	B			x			
		feed conversion index	B			x			
		Energy consumption	B			x			
		Differentiation	C			x			
		Effective and accurate record-keeping system (digital or not)	D			x			
	Farmed shellfish	Water quality	B			x			
		Energy consumption	B			x			
		Differentiation	C			x			
		Effective and accurate record-keeping system (digital or not)	D			x			
	Seaweeds and algae products	Energy consumption	B			x			
		Accidents or injuries	B			x			
		Differentiation	C			x			
		Effective and accurate record-keeping system (digital or not)	D			x			
GLOBALG.A.P.	Integrated Farm Assurance (IFA) for Aquaculture	Raw materials source	A			x			
		Seed source	A	x	x	x	x	x	x
		Seedling from certified suppliers	A			x			
		Feed source	A			x			
		Laboratory test results	B			x			
		Feed conversion index	B			x			
		Risk events Record	B			x			
		Buyer complaints	B			x			
		Distinction from Certified and non-certified products	C			x			

		Records Kept for each unit in each Production cycle	D			x			
		Effective and accurate record-keeping system (digital or not)	D			x			
		Farmed aquatic species movements	D	x	x	x	x	x	x
		Transportation traceability	E			x			
		Traceability from broodstock to packaging	D			x			
	Compound Feed Manufacturing	Responsible sourcing of feed materials	A	x					
		Marine ingredients source	A	x					
		Entire Manufacturing process traceability	E	x					
		Effective Management system	B	x	x	x	x	x	x
	Chain of Custody	Differentiation	C	x	x	x	x	x	X
		Correct identification and Labelling	C	x	x	x	x	x	x
		Effective and accurate record-keeping system (digital or not)	D	x	x	x	x	x	X
		Efficient Traceability code	E	x	x	x	x	x	x
		Transaction and transport documentation	E	x	x	x	x	x	x
		Traceability from broodstock to packaging	D		x	x			
MarinTrust	Marine Ingredients	Record keeping system	B				x		
		Differentiation	C				x		
	Chain of Custody	Full traceability of marine ingredients	A	x	x	x	x	x	x
		Product management system	B	x			x		
		Product management system	B	x			x		
		Differentiation	C	x	x	x	x	x	x
		Correct identification and Labelling	C	x	x	x	x	x	x
		Effective and accurate record-keeping system (digital or not)	D	x	x	x	x	x	x
		Tracking system	E	x			x	x	x
		Tracking system	E	x	x	x	x	x	x
Naturland	Aquaculture Farms	Seed source	A		x	x			
		Feed source	A		x	x			
		Risk events record	B		x	x			
		Economic Feed Conversion Index	B		x	x			
		Differentiation			x	x			
		Marine feed ingredients origin and Sustainability	A		x	x			
		Therapeutic treatments	A		x	x			
	Processing (Feed)	Raw materials source	A	x					
		Effective Management System	B	x	x	x	x	x	
		Differentiation			x	x			
	Aquaculture	Therapeutic treatment	A			x			

Safe Quality Food (SQF)		Chemicals	A			x			
		Seed source	A			x			
		Feed source	A			x			
		Harvest records	A			x			
		Effective Management System	B		x	x	x	x	
		Customer complaints	B			x			
		Effective and accurate record-keeping system (digital or not)	D		x	x	x	x	
		Ice supply traceability	D			x			
		Product Traceability	E		x	x	x	x	x
		Product identification	C		x	x	x	x	x

Annex 2. Aquaculture traceability requirement description, additional information and context.

Traceability Requirement	Description
Seed source	Bloodstock, eggs, post-larvae, juveniles, and fingerlings origin.
Feed source	Types and quantities, feed manufacturer (including their certification status) and location.
Therapeutic treatments	Dose, treatment duration, and treatment completion date (antibiotics, drugs, and chemical agents used in the treatment of the disease).
Chemicals	Disinfectants, fungicides, parasiticides, herbicides, algicides and other pesticides/chemical additives.
Harvest Records	Complete and accurate records regarding the harvest date, harvest quantity, movement document number (if applicable) and processing plant(s) or purchaser(s).
Species characteristic specifications	Non-native, specific pathogen-free, specific pathogen-resistant, hybrid, triploid, sex-reversed, genetically modified (GM) or bioengineered (BE).
Records kept for each unit in each production cycle	Culture unit identification number, unit area and volume, species.
Customer complaints	Complaints about products should be recorded.
Raw material source	Source of the raw material from both wild-caught and farm-raised sources shall properly identify, segregate, and label products from different wild-caught and/or aquaculture sources and shall indicate any relevant certifications.
Proper identification in all the processing steps	Proper identification shall be maintained for each lot, for each wild-caught and farm-raised source, on all documents and at each step of the process flow from raw material receiving, handling, processing, packaging, storage, and dispatch.
Effective and accurate record-keeping system (digital or not)	Facility shall operate a traceability record-keeping process that provides timely, organised, accurate entries. Regarding GAP and MSC CoC standards, companies should have a traceability system that allows any product or batch sold as certified to be traced back from the sales invoice or point of serving to a certified supplier.
Transmission and verification of electronic data	The information shall be transferred to a computer database or spreadsheet to allow for transmission and verification of electronic data.
Feed ingredients source	Ingredient types, sources, and lot numbers.

Soy complete track	Traceability to country of origin; verification of CoC; exclusion of material derived from illegal deforestation, and exclusion of material derived from ecologically sensitive areas.
Results of feed quality and safety analyses	Results of feed quality and safety analyses by accredited laboratories shall also be included.
Net traceability	For salmon.
Risk events Record keeping	Record keeping and reporting of risk events (e.g. holes, infrastructure issues, handling errors, reporting and follow up of escape events).
Marine feed ingredients origin and sustainability	Ingredients come from sustainable fisheries and/or aquaculture.
Feed conversion Index	Recorded at least every 6 months.
Water quality	Water quality record keeping.
Energy Consumption	Recorded at least once a year.
Accidents or injuries	Human accidents or injuries should be recorded.
Fish meal and oil	Percentage of fish meal and oil in feed should be recorded.
Farmed aquatic species movements	Stock movements for all stages in the aquatic species life cycle.
Seedling from certified suppliers	Seedlings originate from a supplier with GLOBALG.A.P. certification for IFA aquaculture.
Laboratory test results	Laboratory test results should be traceable to the specific batches or production units identification.
Transportation traceability	When transportation is the responsibility of the producer, traceability should be ensured.
Traceability from broodstock to packaging	If the farm is also responsible for the processing and packaging, it must ensure traceability of the harvested aquatic animals from the packing case to the bloodstock.

Responsible sourcing of feed materials	Feed manufacturer shall provide information proving that feed ingredients derived from soy and oil palm are not sourced from areas of high conservation value turned into agricultural areas and do not originate from illegally deforested areas; Documentation shall provide information that fishmeal and fish oil do not originate from illegal, unreported, and unregulated fishing as defined by the FAO code of conduct for responsible fisheries.
Marine ingredients source	When requested, the feed manufacturer shall provide information to the feed buyer on the origin, composition, and content of marine ingredients in the finished compound feed. Information on the country of origin is needed when marine ingredients are from reduction fisheries. Species and country are needed when marine ingredients come from industrial by-products.
Entire manufacturing process traceability	Records shall be maintained for the entire manufacturing process from feed ingredients to delivery to customers. These records should be able to provide traceability one step back and one step forward.
Economic feed conversion Index	Economic feed conversion ratio (EFCR) must be calculated and recorded every year for every harvest cycle terminating within a calendar year.
Product identification	Products are clearly identified during all stages of receipt, operations, storage, shipping, and transportation.
Product traceability	Product is traceable to the customer (one up) and provides traceability through the process to the input supplier and date of receipt of inputs, materials, and other inputs (one back).
Ice supply traceability	Records/traceability of ice supply including a copy of certificate of analysis from ice source.
Differentiation	Certified products shall not be physically mixed with non-certified products by using differentiation methods and/or identity preservation method (only for GLOBAL G.A.P. CoC). Certified products are traceable back to the supplier, fishery or farm.
Efficient traceability code	Traceability code shall associate a trade item with relevant information for its traceability.
Correct identification and labelling	Companies shall be identified, and products shall be labelled to allow traceability and certified status validation. If applicable, CoC number (companies in the post-production stages) and "GGN" (GLOBAL G.A.P. number) of the producer should be included in product labelling and for sales and transport documents.
Transaction and transport documentation	Transaction and transport documentation should include: CoC number, product name, traceability code, certification status.
Certified products are purchased from certified suppliers	The organisation shall have a process in place to ensure that all certified products are purchased from certified suppliers, fisheries, or farms. The supplier needs to give clear information that a certain product is certified (e.g. delivery notes, invoices, bills of lading, or electronic information from the supplier).

Certified products are identifiable	Certified products shall be identified as certified at all stages of purchasing, receiving, storing, processing, packing, labelling, selling and delivering, except for sales invoices to final consumers.
Document changes reporting	Where records are changed, these changes shall be clearly documented including the date and name or initials of the person making the changes.
Effective management system	The organisation shall operate a management system that is effective in addressing all requirements of the standard.
Processing inputs	Inputs, chemicals, additives, preservation methods.
Full traceability of marine ingredients	Ensure that marine ingredients used come from certified sources and that full traceability is maintained throughout the supply chain.
Production records	Number and source of fingerlings introduced to ponds/cages; type, source (including batch number) and quantity of food used in each fish-raising unit; fish deaths and estimated mortality in each unit; diagnosis for significant mortalities and any treatment administered; numbers of fish transferred between units or harvested; even moving and handling must be recorded to trace fish stress/welfare.
Retail records	A copy of the current organic certificate or similar objective evidence that each organic product has a certified supplier; complete product list showing all products sold, their certification status, and if mixed or blended by the distributor then the ingredients and recipes for such products; Accounts that demonstrate the origin, nature, and quantity of all lots purchased, and details of transport arrangements from the product's supplier. Accounts that demonstrate the nature, quantities and consignees of each lot sold, and details of how they were transported and if applicable, stored end route. Retail sales shall be accounted for on a set time period that must not exceed one week.
Distribution records	Product list showing all certified products available for sale, their certification status, and certifier. For each organic product, a copy of the current organic certificate or other objective evidence of certification. Retailers must be able to demonstrate a system to verify current certification of organic products. For each product mixed or blended by the retailer, a record of the recipe and ingredients. Records that demonstrate the origin, nature and quantity of all products purchased. Records that demonstrate the quantities of goods sold. Annual stock takes records. A record of formal complaints and how they were resolved.
Residue testing	For traceability of pesticides, heavy metals, antibiotics, etc.
Blockchain technology	Blockchain technology offers full traceability and transparency to its customers. Traceability on origin and quality; nutritional composition and potential presence of allergens and controversial substances; traceability shared across the whole supply chain in the event of a product recall, a health issue or non-compliance with specifications or a particular label.
Tracking system	A system that allows them to demonstrate the traceability back to the accepted improver programme fishery and accepted MarinTrust factory that is handling the improver programme fishery material.

Environmental monitoring record	Record of data obtained from environmental monitoring undertaken by the manager or industry or regulatory bodies, e.g., water temperature, oxygen content and pH.
Clear and accurate product labelling	Approved labelling that includes a list of processing procedures, product information, etc.

Annex 3. Traceability requirements for the fisheries sector from each standard across the supply chain. Clusters: (A) Production Inputs, (B) Middle-chain Outputs, (C) Direct Outputs, (D) Environmental Outputs, (E) Social & Governance, (F) Differentiation, (G) CS Accessibility, (H) Traceability.

Certification Schemes	Standard	Traceability Requirements	Cluster	Supply Chain Step			
				Fishery	Processing	Distribution	Retail/Market
Marine Stewardship Council (MSC)	MSC Fisheries Standards	Sustainable target fish stocks	A	x			
		Environmental impact of fishing	D	x			
		Effective management	A	x			
		Labour eligibility requirements	E	x			
	MSC Chain of Custody (CoC)	Certified products are purchased from certified suppliers	F		x	x	x
		Certified products are identifiable	F	x	x	x	x
		Certified products are segregated	F	x	x	x	x
		Certified products are traceable, and volumes are recorded	H		x	x	x
		Management and Training	E		x	x	x
Friends of the Sea (FOS)	FOS Standards	Non-overexploited target stock according to FAO	A	x			
		No significant impact on the seabed	D	x			
		Selective fishing gear	A	x			
		No bycatch listed as vulnerable or worse in the IUCN Red List	D	x			
		Compliance with legal requirements	E	x			
		Waste and energy management	D	x	x	x	x
		Social accountability	E	x			
	FOS CoC	Product and batch identification	F	x	x	x	x
		Specific traceability system in place	H	x	x	x	x
		Detailed information on the origin of the products	F	x	x	x	x
		Records documenting compliance to all CoC requirements	H	x	x	x	x
		FoS logo only used in association with products whose raw material is certificated	F	x	x	x	x
	FOS Fish aggregating device (FAD) FREE Tuna Products	Separation of FAD caught tuna from FAD FREE or FREE SCHOOL	F	x			
		Identification of the origin of the product	F	x			
		Identification in case of transshipment	F	x			
		Lot identification	F	x	x	x	x
		Traceability system in place all throughout the processing	H		x		
FairTrade	FairTrade Standards	Certified product's differentiation	F	x	x	x	x
		Traceability system in place	H	x	x	x	x
		Signed agreements between entities are celebrated	E	x	x	x	x

		Assessment verification and auditing	E	x	x	x	x
Responsible Fisheries Management (RFM)	Unified RFM CoC (Chain of Custody) Standard	Traceability system throughout the supply chain	H	x	x	x	x
		Negotiation and collaboration for establishing commitments	E	x	x	x	x
		Use of a distinctive logo, trademark or seal.	F	x	x	x	x
	RFM Certification Program	Social sustainability	E	x			
		Determination of consequences for the species and ecosystem	C, D	x			
		Targeted species status and environmental consequences are considered	A, D	x			
		Collaboration in fisheries' management	E	x			
		Interests of all types of stakeholders are considered	G	x			
		All fisheries' laws are obeyed	A	x			
Ocean Wise	Standard for Captured Fisheries	Impacts on the stock (abundance and fishing mortality)	C	x			
		Impacts on other captured species (abundance, fishing mortality and discard and bait use rate)	D	x			
		Management effectiveness	A	x			
		Impacts on habitat and ecosystems	D	x			
	Rapid Assessment Standard	Small-scale fisheries specific	G	x			
		Stock health	A	x			
		Bycatch and bait	D	x			
		Management effectiveness	A	x			
		Habitat and ecosystem	D	x			
Naturland Wildfisch	Naturland Standards - Sustainable Capture Fishery	Regulation to obtain the certification can involve collaboration	E	x			
		Recording keeping throughout the value chain	F	x	x	x	x
		Proper label identification	F	x	x	x	x
		Ensuring seafood safety	C	x	x	x	x
		Storage conditions	B	x	x	x	x
		Separate bookkeeping	F	x	x	x	x
		Sustainable management methods	A, B	x	x	x	x
		Social sustainability	E	x	x	x	x
		Fishery regulation	A	x			
		Environmental regulation	D	x	x	x	x

Annex 4. Fisheries traceability requirements description, additional information and context.

Traceability Requirement	Description
Sustainable target fish stocks	A fishery must be conducted in a manner that does not lead to overfishing or depletion of the exploited populations. For those populations that are depleted, the fishery must be conducted in a manner that demonstrably leads to their recovery.
Environmental impact of fishing	Fishing operations should allow for the maintenance of the structure, productivity, function, and diversity of the ecosystem on which the fishery depends. The ecosystem includes habitat and associated dependent and ecologically related species.
Effective management	The fishery is subject to an effective management system that respects local, national, and international laws and standards, and incorporates institutional and operational frameworks that require the use of the resource to be responsible and sustainable.
Labour eligibility requirements	The fishery, CoC applicant or certificate holder shall not have been convicted for a forced or child labour violation in the last 2 years.
Certified products are purchased from certified suppliers	The organisation shall have a process in place to ensure that all certified products are purchased from certified suppliers, fisheries, or farms.
Certified products are identifiable	Certified products shall be identified as certified at all stages of purchasing, receiving, storing, processing, packing, labelling, selling and delivering, except for sales invoices to final consumers.
Certified products are segregated	There shall be no substitution of certified products with non-certified products.
Certified products are traceable and volumes are recorded	The organisation shall have a traceability system that allows any product or batch sold as certified to be traced back and forward from the sales invoice or point of purchase to point of sale or serving.
Management and training	The organisation shall operate a management system that is effective in addressing all requirements in the MSC Fisheries Standard.
Non-overexploited target stock according to FAO	The state of the stock shall be assessed by the fisheries management organisation.
No significant impact on the seabed	The fishery or fleet shall use fishing gears that do not affect the seabed unless proven that such impact is negligible.
Selective fishing gear	The organisation collects and maintains current data and/or other information about the effects of the fishery on endangered and non-target species and discards.

No bycatch listed as vulnerable or worse in the IUCN Red List	Bycatch shall not include species listed in the IUCN red list of endangered species as vulnerable or higher risk.
Compliance with legal requirements	The organisation complies with national and international fisheries regulations. Compliance with the following regulations in particular has to be confirmed and verified: total allowable catches, use of a logbook, minimum net mesh size, minimum legal size of the target species, distance from the shore, measures for the reduction bycatch, no fishing in protected habitats, use of forbidden gears, chemical substances and explosives.
Waste and energy management	The organisation recycles, reuses or reprocesses all materials used during fishing, conservation and transport of the fish up to the selling point, including packaging. The organisation shall keep a register of all energy sources and their use, updated at least once a year.
Social accountability	The Organisation shall respect human rights, complying with the following requirements: compliance with national regulations and international labour organization standards on child labour, pay the employees adequate salaries compliant at least with minimum legal wages, grant access to healthcare, apply safety measures required by the law.
Product and batch identification	The auditor shall list what method and which system either administrative, physical or both is used for unique identification of the consignment. To verify this requirement, the auditor shall follow at least one sample of consignment in different stages of the process and trace back (to the supplier/raw material) and forward (to the point of sale) asking for the documents, records and or data entry of the consignments.
Specific traceability system in place	Auditors shall establish that appropriate measures are taken by the organisation to segregate, identify and prevent mixing between certified and non-certified products. If subcontractors are used, auditors shall verify that appropriate systems are in place to ensure identification and traceability of certified products at point of dispatch and receipt.
Detailed information on the origin of the products	Each of the actors involved in the distribution chain in the scope of certification shall generate and hold the information necessary for traceability. The information is to be held on paper or electronically, keyed to the unit IDs, that shall contain a minimum of the following information: vessel ID (flag state, name and registration number of the vessel), species (scientific name or FAO 3 alpha code or taxonomic serial number), area/country of origin (FAO area/Regional Fisheries Management Organisations area from marine fish or country of origin for fish from inland waters), fishing gear (FAO alpha code).
Records documenting compliance to all CoC requirements	The auditor shall verify that the organisation documents comply with all traceability criteria required by the FOS standards for a period that exceeds the shelf life of the certified product and the periodicity between audits. References to the reviewed documentation shall be made in the audit report and a brief description of the procedure may be included.
FoS logo only used in association with products whose raw material is certificated	If the applicant uses the FOS logo on their own products or for a customer, the auditor shall verify that the client is authorised to use the trademark by confirming that: a) the applicant can show a licence agreement with FOS signed by both parties; and/or b) the applicant can show proof of product approval from FOS for packaging designs for a sample of products.

Separation of FAD caught tuna from FAD FREE or FREE SCHOOL	The organisation has a trained independent observer onboard which can identify a FAD FREE or FREE SCHOOL tuna set. In alternative the organisation can use a CCTVs system which allows for verification of FAD FREE or FREE SCHOOL tuna sets. The organisation separates FAD caught tuna from FAD FREE or FREE SCHOOL tuna by means of well differentiation or use of nets on the same well. The organisation must maintain a written report of wells' location of the FAD and FAD FREE or FREE SCHOOL caught tuna. This report can be included in the logbook or on a separate report.
Identification of the origin of the product	The organisation provides a detailed identification of the origin of products, including: vessel name and registration number, fishing area and fishing method.
Identification in case of transshipment	In case of transshipment, the qualified FAD and FAD FREE or FREE SCHOOL tuna lots must be identified, kept segregated and their batch locations reported and verified by a trained independent observer.
Lot identification	The organisation identifies FAD and FAD FREE lots at time of unloading. New lot identifications are confirmed by a trained independent observer.
Traceability system in place all throughout the processing	The organisation ensures the presence of a specific traceability system through all the processing line which assures that the final product labelled as FAD FREE or FREE SCHOOL originates from a FAD FREE or FREE SCHOOL set and that there is no possibility of mixing with FAD caught tuna lots. The Organization checks the functionality of the system, at least once a year.
Certified product's differentiation	FairTrade seafood is differentiated from non-Fair Trade certified seafood. It is clearly marked and can be identified as Fair Trade Certified at all supply chain stages.
Traceability system in place	Certified seafood sales documentation and records are properly kept (ID, volume, date of transactions, and information about how the product is caught, bought, processed, and sold). This process ensures traceability, starting at the fishing association level (vessel level) all through the supply chain.
Signed agreements between entities are celebrated	Trade and certification agreements are properly documented and legally signed.
Certification compliance verification and auditing	There is assurance and verification of seafood's compliance with certificate rules by specific entities (reliable auditing and verification process).
Traceability system throughout the supply chain	A CoC certification provides a product identity system, traceability system and differentiation system.
Negotiation and collaboration for establishing commitments	Contracts with requirements and commitments are formulated between the certification body and the company.

Use of a distinctive logo, trademark or seal	There is a distinctive logo, trademark or seal to verify the fish has been sourced from and is traceable back to a certified fishery.
Social sustainability	Human rights and labour conditions are considered to obtain the certification.
Determination of consequences for the species and ecosystem	Fisheries' interactions and impacts on the ecosystems should be based in science, local knowledge and a risk-based management approach should determine the most probable adverse impacts.
Targeted species status and environmental consequences are considered	Fisheries management system has the targeted species stock and marine environment under consideration, based on a precautionary approach.
Collaboration in fisheries' management	The fisheries management system should foster cooperation and be organised in a transparent way.
Interests of all types of stakeholders are considered	The interests of small producers (including those engaged in subsistence, small-scale, and artisanal fisheries) are taken into account.
All fisheries' laws are obeyed	Fisheries management goes according to international, national and local fishery laws.
Impacts on the stock (abundance and fishing mortality)	Abundance of target and incidentally captured stocks/species is maintained over the long term at levels that sustain the species, and its ability to fulfil its ecological role.
Impacts on other captured species	This CS has criteria related to impacts on other capture species, including abundance, fishing mortality and discard and bait use rate.
Management effectiveness	Management effectiveness criteria includes strategy and implementation, bycatch strategy, data collection/analysis, enforcement/compliance and stakeholder inclusion.
Impacts on habitat and ecosystems	Impacts on habitat, mitigation of gear impacts and ecosystem-based fisheries management are considered.
Small-scale fisheries specific	In order to tackle certain challenges that small-scale fisheries encounter when trying to access certification, the Rapid Assessment Standard provides a rapid assessment methodology that is less costly, yet maintains scientific rigour.
Stock health	Information contained in the Fishery Audit such as stock health, fishing mortality, logbook records, dockside monitoring, and rebuilding plans are used.
Bycatch and bait	The bycatch and bait criteria has in consideration the location and gear type used for the catch.

Management effectiveness	This criteria includes management strategy and implementation, bycatch strategy, data collection/analysis, and enforcement/compliance with management regulations, just like in the Standard for Captured Fisheries.
Habitat and ecosystem	Has location and fishing methods in consideration and allows to include the impacts on habitat, mitigation of gear impacts and ecosystem-based fisheries management into the scoring.
Regulation to obtain the certification can involve collaboration	Certification procedure includes several rules and requisites for establishing contracts with producers, to which amendments can be proposed.
Recording keeping throughout the value chain	All records regarding product flow (e.g. sales) and inspections across the value chain must be recorded and be in accordance with Naturland's Standards.
Proper label identification	All products are properly identified through labelling to enable legal trade.
Ensuring seafood safety	Measures to ensure seafood safety should be taken (environmental analysis, materials in use, non-use of nanomaterials and genetically modified organisms, etc).
Storage conditions	Seafood should be properly stored throughout the value-chain.
Separate bookkeeping	Separate bookkeeping for all the purchased merchandise has to be done, with unequivocal label associated
Sustainable management methods	Sustainable management methods should be promoted (energy efficiency, sustainable use of natural resources, social responsibility and economic performance).
Social sustainability	Social sustainability and labour rights are considered.
Fishery regulation	There is regulation for sustainable capture fisheries.
Environmental regulation	There is regulation regarding the environmental impact throughout the supply chain (materials used, energy requirements, fisheries impact evaluation, etc).