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BEYOND REGULATORY COMPLIANCE
SEAFOOD TRACEABILITY BENEFITS AND SUCCESS CASES

Cover photographs:
Fish is displayed on sale at the Central market of Voronezh, Voronezh, Russian Federation

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SEAFOOD TRACEABILITY BENEFITS AND SUCCESS CASES

Melania Borit, PhD
Associate professor
UiT The Arctic University of Norway, Tromsø, Norway
Consultant, traceability expert, FAO

Petter Olsen, Dr Philos.
Senior scientist, Nofima, Tromsø, Norway
Consultant, traceability expert, FAO

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PREPARATION OF THIS DOCUMENT

This document was commissioned by the Food and Agriculture Organization of the United Nations (FAO) within the framework of Strategic Objective 4: strategic programme for enabling more inclusive and efficient agricultural and food systems. It contributes to equipping value chain actors with technical and managerial knowledge to develop inclusive, efficient and sustainable agricultural and food value chains.

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ABSTRACT

Since the mid-1990s, traceability has become a popular concept in industrial logistics, regardless of the production regime and type of product. Implementing traceability systems across the food supply chain is seen as crucial for increasing food quality and safety, for optimizing production or for documenting sustainability. However, implementation of traceability systems in the seafood sector seems to be stagnating. Against this backdrop, the main objective of this study is to define and analyse in detail seafood traceability benefits related to regulatory compliance, supply chain management improvements, market access facilitation, and risk mitigation. To support this objective, the study collects and compiles policy incentives from governments and industry associations to encourage the establishment of company seafood traceability. In addition, this study updates information regarding existing traceability standards and norms serving various purposes in the seafood sector. Based on a thorough analysis of speciality literature and the extensive experience of the authors, this study formulates several recommendations that are relevant for a wide range of stakeholders in the seafood sector.

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ABBREVIATIONS AND ACRONYMS

BOGI	Blue Ocean Grace International
CoC	chain of custody
CTDS	catch/trade documentations scheme
FBO	food business operator
GDST	Global Dialogue on Seafood Traceability
GFL	General Food Law
ISO	International Organization for Standardization
IUU	illegal, unreported and unregulated (fishing)
FIP	fishery improvement project
GAP	good agricultural practice
MDPI	Yayasan Masyarakat dan Perikanan Indonesia
MSMEs	micro, small and medium-sized enterprises
NGO	non-governmental organization
TRU	traceable resource unit
USAID Oceans	United States Agency for International Development Oceans and Fisheries Partnership

EXECUTIVE SUMMARY

This report was commissioned by FAO's Fisheries and Aquaculture Department to:

- update information regarding existing traceability standards and norms serving various purposes in the seafood sector, including international standards/guidelines, regulatory standards, and non-regulatory standards;
- define and analyse in detail seafood traceability benefits related to regulatory compliance, supply chain management improvements, market access facilitation, and risk mitigation, and present one or two success cases, including some from developing countries, under each category or subcategory of benefits;
- collect and compile policy incentives from governments/industry associations to encourage the establishment of company (corporate and micro, small and medium-sized enterprises) seafood traceability.

As a first step in reaching these objectives, the publication explains the key terms in understanding the concept of traceability (e.g. granularity, transformation and referential integrity etc.). Moreover, the concept of traceability is described in connection with related notions (traceability systems and their elements, analytical methods etc.). In a second step, existing various seafood traceability standards and norms are briefly described, with a focus on the latest developments in the respective areas. Based on a systematic literature review, the next step consists in defining and analysing traceability benefits, with success cases being described in connection with these benefits. In a final step, a rapid literature review is employed to identify incentives to encourage the establishment of company seafood traceability.

This process yields the following results and recommendations:

1. There is still a lack of knowledge about the benefits of introducing a traceability system among the actors in seafood supply chains. Communicating and understanding the benefits of a traceability system are important for successful implementation of traceability. Interested agencies should **fund awareness-raising campaigns** in order to spread the knowledge about these diverse benefits and their implications for value creation.
2. There are cultural differences in benefits perceived by different groups of stakeholders. At the same time, risk communication is more effective if it is adapted to the culture of the audience. Thus, interested agencies should **adapt the communication strategy** of the benefits of traceability raising awareness campaign **to the cultural** specificities of the audience.
3. Organizations can extract significant value from implementing traceability and extend from a "must do" to comply with regulatory requirements to a "must have" to differentiate their products in the marketplace. The **communication strategy** of traceability benefits has to include an awareness-raising campaign that **focuses specifically on the value creation potential of traceability systems.**
4. Besides the lack of knowledge about the benefits of traceability among the actors in seafood supply chains, there is also the need for more cost–benefits studies to be communicated to possible stakeholders. Interested agencies should **commission such cost–benefit** studies and disseminate the results widely.
5. Traceability success stories/cases are little documented, especially for developing countries. Interested agencies should commission studies of such success stories with specific requirements of what has to be recorded in a structured and systematic way in terms of traceability incentives, drivers and benefits.
6. In general, food businesses are not motivated to implement new standards for information exchange and traceability as they perceive this as an additional cost and are not aware of the associated benefits. In addition, companies are not willing to make changes to their current operational practices. Similarly, companies are also concerned about data security and are not willing to share sensitive information unless it is protected in trusted repositories, but this issue is secondary to their reluctance to change their current practices. Interested agencies should

commission a study of the motivations for adopting traceability systems that also explore **possible solutions to the concerns** raised by food businesses.

7. There is still a lack of understanding about what kind of perceptions can influence the internal attitudes and motivations of the firm to implement a traceability system. Interested agencies should **commission a study of the reasons** for not adopting traceability systems.
8. Extrinsic incentives were found to be stronger than intrinsic and social incentives. As such, **extrinsic incentives could be recommended** to businesses, government and social entities for a better implementation of traceability systems in the respective supply chain.
9. Policy targeted at providing firms with incentives to establish efficient recall systems will be less costly to firms and consumers and better targeted than policy mandating traceability. Usually, **performance standards – rather than process standards – ensure the most efficient compliance systems**. Governments and industry associations should focus on formulating policies targeted at providing firms with **incentives to establish efficient actions**, such as recalls. In the example of more efficient recalls, such policies include the following: recall and other food safety performance standards; any policy that increases the likelihood that producers of unsafe food will be identified and punished; and any policy that increases the punishment for producing and selling unsafe foods.
10. Regulatory interventions do not drive the technological evolution of food traceability systems. Interested agencies should **commission a study about the drivers** of implementing traceability systems, to complement this study on benefits and incentives.
11. Contrary to popular belief, traceability is not a method to ensure that information about a certain product is true or accurate; traceability systems contain claims about the food product in question, and these claims may or may not be true. Some of these claims are related to chemical, physical or sensory attributes of the food, and these claims can (to some degree of accuracy, at least) be tested by analytical methods, such as DNA-based analyses or nuclear magnetic resonance spectroscopy. Interested agencies should commission studies **specifically focused on data validation and verification of any types of claims**, in order to avoid the "garbage in, garbage out" problem and thus to increase the value of traceability systems.
12. It has been noted that adoption of safety standards may promote power imbalances, lack of trust and transparency and the easing of minimalistic strategies in dealing with food safety. Thus, when adopting such standards, governments and industry associations should implement initiatives to **counterbalance** such developments. For example, strategies to avoid exclusion include: (i) providing ample education and training to overcome human capital constraints; (ii) fostering the development of the institutional infrastructure necessary to support implementation of traceability systems within a developing-country environment; and (iii) encouraging the participation of producers associations or cooperatives to provide a critical mass in terms of supply, provide a conduit for the dissemination of information on benefits of traceability to smallholders, and improve the bargaining power of individual farmers/fishers vis-à-vis larger retailers or processors.
13. Companies across the supply chain should consider adopting industry-wide use of the standards **using globally unique identification of units** as a significant step forward for electronic and interoperable seafood traceability. If using a globally unique unite code such as the Serial Global Trade Item Number rather than the Lot Global Trade Item Number code, an example of such standard is the Global Dialogue for Seafood Traceability Standards and Guidelines for Interoperable Seafood Traceability Systems, Version 1.0. These industry-developed standards are designed to improve the reliability of seafood information, reduce the cost of traceability, contribute to supply chain risk reduction, and contribute to securing the long-term social and environmental sustainability of the sector.

Underlying many of these recommendations is the fact that what the society needs, and what the consumer prefers, is full chain traceability, from vessel or aquaculture site to plate. What companies tend to focus on is their own internal traceability, largely limited to inputs (raw materials and ingredients) and outputs (products) from their own processes. This difference in perspective has many ramifications, in particular related to the need for unit identification. The traceability systems in most seafood companies are batch-based, and this identification principle is also the basis for most standards

and good practice recommendations in this area. If the focus is internal traceability, batch-based identification is fine, because all units (boxes and cases) from the same batch have the same properties, and it makes sense to identify them in the same way. However, if the focus is full chain traceability, batch-based identification is not a good solution. The reason is that the units in question (the units coming from the same production batch) can only be said to have the same properties when they are physically kept together. In practice, in the seafood industry, the units from a production batch (a cage, a day's slaughter, a catch, or a day's processing) are not kept together throughout the chain. A production batch is often split up, and different units from the same batch may be transported using different vehicles to the same or to different destinations. Once they arrive, if the only available identifier is the batch identifier, it is impossible to say what means of transportation was used, what the unit location was at a given time, or what the temperature was at a given time. Often, other identifiers are temporarily affixed to the units, as when a unit is part of a pallet, and the pallet has a globally unique identifier. However, it is not uncommon that the link to these additional identifiers is lost (e.g. when the pallet wrapping is discarded), so that the batch identifier is the only one that remains when the unit reaches its destination. While this can be used to access information related to the process that produced it, it cannot be used to access information about what happened subsequently, and so it is not a good solution for full chain traceability.

Thus, a final recommendation, and one that underlies and supports many of the recommendations above, is:

14. To achieve full chain traceability, a shift in perspective is needed, from a focus on documenting inputs and outputs to specific processes there and then to a focus on the ability to document all properties relating to the product or unit anywhere in the supply chain, including origin, process history, location and any other attributes that might be relevant. For this, batch identification is not sufficient, and unique unit identification is needed. Interested agencies should **commission studies that highlight the benefits of full chain traceability as opposed to internal traceability**, and, in particular, document the value of and benefits related to unique identification of units compared with batch-based identification of units.

1. INTRODUCTION

This report was commissioned by FAO's Fisheries and Aquaculture Department to:

- update information regarding existing traceability standards and norms serving various purposes in the seafood sector, including international standards/guidelines, regulatory standards, and non-regulatory standards;
- define and analyse in detail seafood traceability benefits related to regulatory compliance, supply chain management improvements, market access facilitation, and risk mitigation, and present one or two success cases, including some from developing countries, under each category or subcategory of benefits;
- collect and compile policy incentives from governments and industry associations to encourage the establishment of company (corporate and micro, small and medium-sized enterprise [MSMEs]) seafood traceability.

Following an outline of the methodology (Chapter 2), and as a first step towards reaching these objectives, Chapter 3 explains the key terms in understanding the concept of traceability (e.g. granularity, transformations, referential integrity, etc.). Moreover, the concept of traceability is described in connection with related notions (e.g. traceability systems and their elements, analytical methods etc.). In a second step, Chapter 4 provides a brief description of existing various seafood traceability standards and norms, with a focus on the latest developments in the respective areas. Based on a systematic literature review, Chapter 5 then defines and analyses traceability benefits, with success cases being described in connection with these benefits. In a final step, a rapid literature review is employed to identify incentives to encourage the establishment of company seafood traceability (Chapter 6). Chapter 7 presents the recommendations.

2. METHODOLOGY

2.1. General considerations

This study employed a multi-methods approach that involved the following steps:

1. Conceptualization of key terms (Chapter 3).
2. General description of existing traceability standards and norms serving various purposes in seafood sector, including international standards and guidelines, regulatory standards, and non-regulatory standards, with a focus on the latest developments in the respective areas, based on document analysis (Chapter 4).
3. Detailed analysis of seafood traceability benefits, including success cases, based on a systematic literature review (Chapter 5).
4. Collection and compilation of policy incentives from governments and industry associations to encourage the establishment of company (corporate and MSMEs) seafood traceability, based on a rapid literature review (Chapter 6).

2.2. Systematic literature review

A systematic literature review (Grant and Booth, 2009) was performed in order to identify scientific studies analysing the benefits of seafood traceability. The database used for search was ScienceDirect. The search was conducted in all fields, up to 23 October 2019, within the following article types: research articles, book chapters, conference abstracts, and short communications. Two concepts were used to structure the search query, including: benefits and seafood traceability (search string: benefit* AND "seafood traceability"). No limits were placed on year of publication. Studies were initially screened for relevance to the review topic. Records were excluded if they did not specifically investigate or refer to benefits of seafood traceability or if access to them was restricted. The records identified through this technique were supplemented through: (i) snowball sampling of relevant sources based on the results of the first screening; (ii) a second search with the same input, but using the search string: benefit* AND "food traceability"; and (iii) snowball sampling of relevant sources based on the results of the second search. Figure 1 summarizes the screening process.

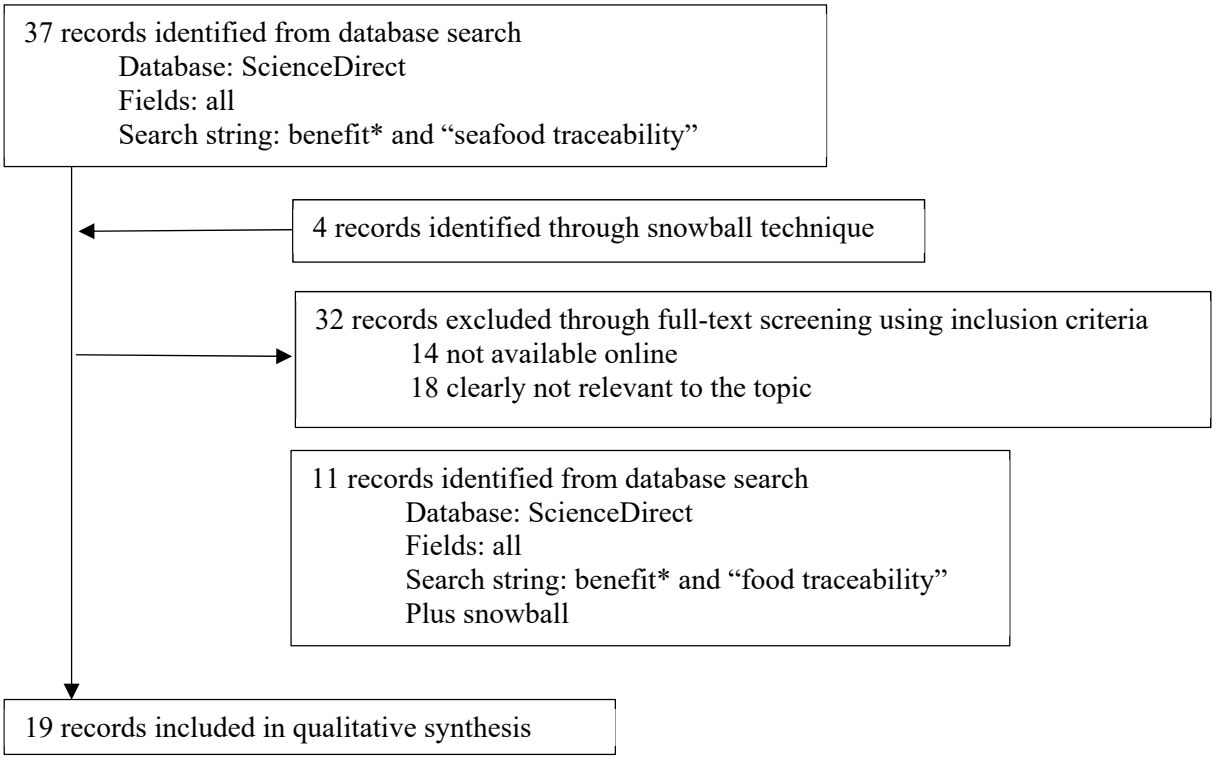
2.3. Rapid literature review

A rapid literature review (Grant and Booth, 2009) was performed in order to identify policy incentives from governments and industry associations to encourage establishment of company seafood traceability. The database used for the search was Google Scholar, and the search was conducted up to 23 October 2019. The search string used was: policy AND incentives AND food AND traceability.

2.4. Document analysis

Document analysis is a systematic procedure for reviewing or evaluating documents, and it requires that requires that data be examined and interpreted in order to elicit meaning, gain understanding, and develop empirical knowledge (Bowen, 2009). This analytic procedure entails finding, selecting, appraising (making sense of) and synthesizing data contained in documents (Bowen, 2009). The technique of coding has been used in this study (Kawulich, 2004), following a coding scheme developed based on the objectives of the study. In order to ensure reliability of results, one rater performed the analysis.

Figure 1. Search process used to identify records to be included in the review of benefits of seafood traceability



3. THEORETICAL FRAMEWORK

3.1. Traceability concept, terms and definitions

The following constitutes a short, but by no means exhaustive, primer on traceability terms and concepts. For some of these terms where there are conflicting or ambiguous views or descriptions, the definitions most consistent with normal practice in the seafood industry, as indicated in key industry documents and standards, have been selected. The definitions and explanations are taken from works by the authors of the present document (Borit and Olsen, 2016; Olsen and Borit, 2018).

Table 1. Definitions and explanations of terms and concepts used in this study

Concept (in alphabetical order)	Definition or explanation
Attribute	The characteristic or distinguishing feature of a product. For more details, see Olsen and Borit (2018).
Batch	The quantity of material prepared or required for one operation. In seafood supply chains, reference is commonly made to raw material batches (the fish component), ingredient batches (other components) and production batches. Batch is an internal term in the company; batch identifiers are often locally generated in the company, and do not normally adhere to any standards. Batches are not necessarily explicitly labelled or identified in the company as long as the company knows what constitutes a given batch.
Chain traceability	Chain traceability is the traceability between links in a supply chain (companies), and it depends on the data recorded in the internal traceability system being transmitted, and then read and understood in the next link in the chain
Drivers	Determinants that lead firms to decide how to allocate their financial resources in implementing different levels of voluntary traceability; a motivating factor. For a summary of traceability drivers, see Borit and Olsen (2016).
Granularity	Granularity refers to the amount of product referred to by the traceable resource unit (TRU) identifier. Granularity depends on the physical size of the TRU; the smaller the TRU, the smaller the granularity. When implementing a traceability system, companies have to make a decision on the granularity they want. A fish processing company can typically choose whether it assigns a new production batch number every day, every shift (e.g. 2–3 times per day) or every time it changes raw materials (e.g. 1–20 times per day). The lower the granularity, the more TRUs the company will have, the more work will be involved, and the more accurate the traceability system will be. Granularity can be a particularly important consideration when planning for potential product recalls; the larger the granularity, the more products will have to be recalled if anything goes wrong.
Identifier uniqueness	Traceable resource units (TRUs) are given identifiers in the form of numeric or alphanumeric codes. These identifiers are either assigned by the company that generates the TRU or they are mutually agreed between trading partners, often with reference to standards. For an identifier to serve as intended, it must be unique within the context where it is used. The context can be the individual production facility, the parent company, the supply chain, nationally or globally. For further details, see Olsen and Borit (2018).
Internal traceability	Internal traceability is the traceability within a link or a company.
Interoperability	The ability of different information technology systems or software programs to communicate seamlessly for the purpose of exchanging and using data. For systems to be truly interoperable, they must have both semantic (common meaning) and syntactic (common format) interoperability (Hardt, Flett and Howell, 2017).
Traceability	The ability to access any or all information relating to that which is under consideration, throughout its entire life cycle, by means of recorded identifications.
Traceable resource unit	This study refers to “that which is under consideration” in the traceability definition as a TRU. For more details, see Olsen and Borit (2018).

Concept (in alphabetical order)	Definition or explanation
Trade unit	Trade unit (or trade item) is a quantity of material (e.g. fish product) that is sold by one trading partner to another trading partner. Incoming trade units are often merged or mixed into raw material or ingredient batches, e.g. when captured fish is sorted by size and quality before processing. Production batches are typically large (everything produced of one product type in one unit of time, typically a day or a shift, is common practice for production batches), and are normally split into numerous outgoing trade units.
Transformation	Generation of a new TRU based on existing TRU. Typical transformation types are merges, splits and mixes.

Sources: Based on Borit and Olsen, 2016, and Olsen and Borit, 2018.

3.2. Traceability systems

Traceability systems are constructions that enable traceability; they can be paper-based, they can be computer-based, or they can be a combination of the two. The components of a traceability system are as follows (Olsen and Borit, 2018):

1. a mechanism for identifying traceable resource units (TRUs);
2. a mechanism for documenting transformations, i.e. connections between TRUs.
3. a mechanism for recording the attributes of the TRUs.

As explained in Olsen and Borit (2018), when deciding how to identify TRUs, there is a need to: choose the identifier code type and structure; make choices with respect to granularity and uniqueness of the code; and find a way to associate the identifier with the TRU in question. Once the selection of the type of identifier to use has been made, and a way to associate the identifier to the TRU has been found, it is necessary to document what happens to the TRU as it moves through the supply chain. Thus, a direct or indirect record of transformations of the TRU has to be established, as does the ability to document the sequence of transformations, as one of the most important functions of the traceability system. Some implementations of traceability systems record weights or percentages relating to how much went into, and how much came out of, each transformation. The transformation is the actual joining or splitting of TRUs, whereas the transformation metadata are all the data relating to or describing the transformation (e.g. time or duration of transformation, and temperature or humidity at the location of the transformation). If these parameters are considered relevant, the data in question also have to be recorded. Once the type of identifier to use has been selected and a way to associate the identifier to the TRU has been found, the user would have the ability to record attributes associated with the TRU in question (e.g. fat content, food business operator name and address, and results from organoleptic tests), and to link these attributes to the TRU identifier. For most food business operators, the value of a traceability system lies in obtaining access to the many TRU attributes.

It is important to realize that a traceability system as outlined above keeps track of claims, and these claims may or may not be true. “Claim” in this context is defined as “Statement where a product is said or implied to have a certain characteristic” (European Committee for Standardization, 2019). These claims can be explicit (on the label or in the accompanying information) or implicit (if the product had the characteristic in question, it should have been declared). For this reason, validation and verification of the recorded claims is an important undertaking; see entry on data validation and verification in Table 2.

3.3. Traceability and related concepts

Several concepts are related to traceability, and it is important to clarify the connection between these and the concept of traceability. Table 2 provides such a clarification.

Table 2. Concepts related to traceability

Traceability and … (in alphabetical order)	Comments
… analytical methods	Currently, there are a multitude of analytical methods and instruments in use to measure certain physical and biochemical properties of food products (e.g. DNA fingerprinting, spectroscopy) Analytical methods are essential when it comes to verifying (or falsifying) claims in the traceability systems, but they do not in themselves provide traceability. While analytical methods can be very useful, there are many relevant food product properties that cannot be analytically verified, especially in the captured fish industry. These include properties such as fishing location, gear type, quota allocation, identity of food business operator or owner at various stages in the chain, processing conditions that did not directly influence the food properties, data on yield and economics, as well as properties relating to ethics, sustainability, and legality.
… blockchain technology	Blockchain is a distributed digital ledger architecture that may be suited to support electronic traceability systems for food products. For more details, see Olsen, Borit and Syed (2019).
… catch/trade documentation schemes	There are numerous mandatory and voluntary catch/trade documentations schemes (CTDS) in use around the world, and, while they have properties in common with a traceability system, they do not in themselves constitute traceability systems. They involve some very relevant recorded identifications, but the set of recorded data is limited and often selected for one purpose only (e.g. customs control, document legal provenance of captured fish), and CTDS do not apply throughout the entire life cycle of the product in question. A traceability system is "live" in that one can keep adding data on traceable resource units (TRUs) as long as they exist; a CTDS provides snapshots of a subset of the information at a certain time and place; typically when first-hand sale is conducted or when the product passes a border.
… chain of custody	While traceability and chain of custody (CoC) to some degree have the same goal (well-documented fish products), their approach is different. In a traceability system, anything can be recorded as an attribute of the TRU. In a CoC system, the goal is to document and protect the integrity of one particular attribute. For captured fish, this attribute is typically the fishery (location, vessel type, gear type) that the fish comes from, and a particular fishery is assigned a CoC identifier. In a traceability system, any sort of mixing/joining units is allowed as long as it is documented, while in a CoC system, only units with the same origin can be mixed/joined. After the transformation, a new unit and a new identifier is created in a traceability system, while in a CoC system, units with the same origin retain their CoC identifier.
… data validation and verification	Contrary to popular belief, traceability is not a method to ensure that information about a certain product is true or accurate; traceability systems contain claims about the food product in question, and these claims may or may not be true. Some of these claims are related to chemical, physical, or sensory attributes of the food, and these claims can (to some degree of accuracy, at least) be tested by analytical methods. Examples of analytical methods, approaches and instruments include (European Committee for Standardization, 2019): DNA-based analyses; stable isotope and trace element analyses; liquid chromatography; gas chromatography; nuclear magnetic resonance spectroscopy; vibrational spectroscopy, including near-infrared or Raman spectroscopy; mass spectrometry; microscopy; general food chemistry analysis; sensory analysis.
… harmonization and standardization	Standards are closely connected to chain traceability, because chain traceability requires trading partners to exchange a large amount of information, and unless they agree in great detail about what everything means and how it should be structured and represented, information loss is bound to happen. In principle, the internal traceability in a company can be effective without resorting to standards, but it is the recordings in the internal traceability system that provides the data that are exchanged in the chain traceability system, and, upon reception, the data need to be in standard format if the trading partner is to understand it.

Traceability and … (in alphabetical order)	Comments
… interoperability	Internationally agreed and harmonized data standards and formats are key for enabling interoperable traceability systems. Interoperability among seafood traceability systems will help facilitate business-to-business information exchange, facilitate the verifiability of the data those systems contain, and allow businesses the flexibility to choose the technology solution that best fits their traceability needs. Interoperability is achieved by standardizing the foregoing components and the vocabularies and formats used to share the data across multiple actors. In this domain, the business-to-business platform Global Dialogue on Seafood Traceability has performed substantial work to define these components in terms suited to the seafood sector and in particular for the purposes of helping ensure legal product origin and supporting responsible sourcing practices. For more details, see www.traceability-dialogue.org
… transparency	Transparency of a supply chain is the degree of shared understanding of and access to product-related information as requested by a supply chain's stakeholders without loss, noise, delay or distortion. However, transparency and traceability are not the same thing, because the latter only sets the framework for the former.

Source: Based on Borit and Olsen, 2016.

4. UPDATES REGARDING EXISTING TRACEABILITY STANDARDS AND NORMS

Previous analysis of traceability practices (Andre, 2013; Borit and Olsen, 2016) identified three main categories of traceability standards and norms, which this study also follows: international standards and guidelines, regulatory standards, and industry and non-governmental organization (NGO) non-regulatory standards. All the current traceability standards refer to implementation of traceability and none of them to certification of already implemented traceability systems. Table 3 provides a summary of these standards and norms, together with their latest updates.

Table 3. Summary of existing traceability standards and norms

Standards and norms		Description	Updates
1. International standards and guidelines. These are developed to define and/or to provide best practices in tracing food products through supply chains.	1.1 Codex Alimentarius (the "Food Code")	It was established by FAO and the World Health Organization in 1963 to develop harmonized international food standards, which protect consumer health and promote fair practices in food trade. The definition of traceability used here reduces traceability to following movement of food products only.	Latest update: 2006. Publication of principles for traceability / product tracing as a tool within a food inspection and certification system (FAO and WHO, 2006).
	1.2 Office International des Epizooties (OIE) Aquatic Animal Health Code (the "Aquatic Code")	It sets standards for the improvement of aquatic animal health and welfare of farmed fish worldwide, and for safe international trade in aquatic animals (amphibians, crustaceans, fish and molluscs) and their products. It emphasizes that traceability should be a demonstration of government veterinary services' capacity to exercise control over all animal health matters, and not a description of the responsibility of private stakeholders in the chain.	Latest update: 2016. Provisions ensuring sufficient assurance of traceability in such a way that the history and movements of aquatic animals can be documented and audited (OIE, 2019).
	1.3 FAO Guidelines 1.3.1 Marine capture fisheries – ecolabelling	It summarizes several principles that should be observed by ecolabelling schemes. The difference between traceability and chain of custody (CoC) is relevant here.	Latest update: 2009. Paragraph 16 refers to CoC and traceability (FAO, 2009).
	1.3.2 Aquaculture – certification	It provides guidance for the development, organization and implementation of credible aquaculture certification schemes. The difference between traceability and CoC is relevant here.	No updates since publication in 2011. It uses the Food Code definition of traceability. Paragraph 16 refers to CoC and traceability (FAO, 2011).
	1.3.3 Inland fisheries	It does not include any references to traceability.	No updates since publication in 1997 (FAO, 1997).
	1.4 Catch/trade documentation schemes (CTDS)	These are important fisheries management tools, but are not designed as traceability systems for markets/consumers; for a detailed analysis of this aspect, see MRAG (2010).	For latest updates on CDS and traceability, see (Hosch and Blaha, 2017). FAO has adopted Voluntary Guidelines for CDS (FAO, 2017).
2. Regulations. Binding norms that are set by particular countries. Set the minimum traceability requirements.[1]	2.1 European Union	Relevant regulations: European Commission Regulation 178/2002 (General Food Law), Regulation 1005/2008 and the corresponding Implementation Regulation 1010/2009, Regulation 1224/2009 and the corresponding Implementation Regulation 404/2011. These require a one-step-forward, one-step-back approach as well as lot-based traceability, an approach considered ineffective by speciality literature (Borit and Santos, 2015; Borit, 2016). For a recent summary of the food traceability system in Europe, see (Mania et al., 2018). After the evaluation of the current situation, the European Commission decided to initiate a revision of the fisheries control system. Its proposal to revise the fisheries control system was adopted on 30.05.2018.[2] This proposal includes extensive modifications to traceability provisions. At the moment of publishing this report, this proposal was is the first reading step at the Council of the	Latest consolidated version of Regulation 178/2002: 26.07.2019.[3] Latest consolidated version of Regulation 1005/2008: 09.03.2011.[4] Latest consolidated version of Regulation 1010/2009: 17.09.2013.[5] Latest consolidated version of Regulation 1224/2009: 14.08.2019.[6] Latest consolidated version of Regulation 404/2011: 01.01.2017.[7]

Standards and norms		Description	Updates
		European Union. For an analysis of the EU seafood traceability, see the common report DG SANTE – DG MARE in Alcantara and Nordström (2019).	
	2.2 United States of America	The United States of America has a history of implementing policy aimed at improving seafood traceability and labelling. For a detailed recent analysis, see: Blakistone and Mavity (2019); Stevens (2019).	The United States National Oceanic and Atmospheric Administration enacted the Seafood Import Monitoring Program in an effort to combat illegal, unreported and unregulated (IUU) fishing through mandating improved seafood traceability requirements. This programme requires reporting of fisheries data from harvest to arrival at the United States border (He, 2018; Willette and Cheng, 2018).
	2.3 Japan	Traceability systems for animals and animal products (e.g. cattle and beef) are established, but only for a few foods and other commodities (e.g. rice). Guidelines for developing traceability systems are being established by industry associations rather than by national legislature. For a detailed analysis, see Charlebois *et al.* (2014). There are governmental labelling requirements within the Quality Labeling Standard for Perishable Foods (2000) (Lewis and Boyle, 2017).	Latest update of traceability guidelines: 2007. See FMRIC (2008).
3. Non-regulatory standards. This category includes guidelines for auditing and other measures to ensure successful application of commercial standards that have been delivered by organizations and associations to set traceability requirements, facilitate data	3.1 International Organization for Standardization (ISO)	ISO 8402:1994 Quality management and quality assurance: This standard is considered to contain the least incomplete definition of product traceability: "[t]he ability to trace the history, application or location of an entity by means of recorded identifications." This definition clearly states what should be traced (history, application and location) and how the tracing should be performed by means of recorded identifications. This standard was superseded by ISO 9000. ISO 9000:2015 Quality management systems. Traceability is the ability to identify and trace the history, distribution, location, and application of products, parts, materials, and services. A traceability system records and follows the trail as products, parts, materials, and services come from suppliers and are processed and ultimately distributed as final products and services. ISO 22000:2018 Food safety management systems. Traceability is defined as the ability to follow the history, application, movement and location of an object through specified stage(s) of production, processing and distribution. ISO 22005:2007 Traceability in the feed and food chain. ISO 12875/12877:2011 Traceability of finfish products – Specification on the information to be recorded in captured/farmed finfish distribution chains. ISO 16741/18537:2015 Traceability of crustacean products – Specifications on the information to be recorded in farmed/captured crustacean distribution chains.	ISO 22005:2007 was last reviewed and confirmed in 2016. ISO 12875:2011 was last reviewed and confirmed in 2016. ISO 12877:2011 was last reviewed and confirmed in 2016. Note that in the more recent definitions, the fragment "by means of recorded identifications" has been removed, which has consequences, as explained in Olsen and Borit (2013). ISO 22005 adds: "Terms such as document traceability, computer traceability, or commercial traceability should be avoided."

Standards and norms		Description	Updates
sharing, and adopt product identification standards for commercial purposes.		ISO 18538/18539:2015 Traceability of molluscan products – Specifications on the information to be recorded in farmed/captured molluscan distribution chains. These standards use the ISO definition of traceability, which is: "The ability to trace the history, application or location of that which is under consideration."	
	3.2 Food industry	Several industrial associations have developed their own traceability standards, including: the United States National Fisheries Institute; the European Union Fish Processors Association and the European Union Federation of National Organisations of Importers and Exporters of Fish (AIPCE-CEP); and the British Retail Consortium Global Standard for Food Safety Issue 6. There are also examples of large retailers that have also taken initiatives for implementing traceability systems based on state-of-the art information technology (e.g. the blockchain food traceability system for fresh fish launched by Carrefour [FIS, 2019]). A development observed recently is the emergence of international, business-to-business communities working together to share ideas and collaborate on solutions for legal and sustainable seafood, with a particular focus on traceability. Examples of such entities are the Seafood Alliance for Legality and Traceability (SALT: www.salttraceability.org/) and the Global Dialogue on Seafood Traceability (GDST; https://traceability-dialogue.org/). The main focus of the latter is to advance a unified framework for interoperable seafood traceability practices.	United States National Fisheries Institute – latest update: 2011 (NFI, 2011). For a recent review of relevant industrial practices, see: Crona, Käll and Van Holt (2019); Lewis and Boyle (2017). Version 1.0 of the GDST standard is available as of March 2020 at: https://traceability-dialogue.org/core-documents/gdst-1-0-materials/
	3.3 Non-governmental organizations (NGOs) / non-profit initiatives	Major leading internationally established fishery/aquaculture certification programmes (e.g. National Marine Fisheries Service Dolphin Safe, Marine Stewardship Council) have developed their own certification schemes that also claim to address the traceability issue. Each set of standards has its own focus (e.g. assurance of minimal environmental impacts, organic certification) and its own individual structure and presentation. Other initiatives focus on connecting and convening networks of companies, non-profit organizations, and policymakers involved in key traceability projects and precompetitive collaborations (e.g. FishWise, Future of Fish [Lewis and Boyle, 2017]).	For recent review of traceability-related NGO initiatives, see: Cochrane (2018); Crona, Käll and Van Holt (2019); Lewis and Boyle (2017); Punt et al. (2016).

Standards and norms		Description	Updates
	3.4 Technology providers	As described in Lewis and Boyle (2017), many traceability technology providers are relatively new to seafood compared with other commodities such as produce, where traceability technology and third-party vendors are better established. However, the last decade has seen tremendous growth in the number of companies providing traceability software for seafood data capture, sharing and tracking. These systems can operate within a single company or be linked to track products throughout a supply chain (from harvest to point of sale).	

[1] Ranking scores of 21 countries from Organisation for Economic Co-operation and Development based on comprehensiveness of traceability regulations for domestic and imported products can be found in Charlebois *et al*., 2014.
[2] Text available at: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52018PC0368
[3] Text available at: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32002R0178&qid=1575079574678
[4] Text available at: https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX%3A32008R1005
[5] Text available at: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32009R1010
[6] Text available at: https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX%3A32009R1224
[7] Text available at: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32011R0404
Source: Structure based on Borit and Olsen, 2016, with modifications.

5. BENEFITS AND SUCCESS CASES

5.1. Benefits of implementing a traceability system

For the scope of this chapter, it is important to differentiate between drivers and benefits. As explained in Table 1, a driver is a determinant that leads firms to decide how to allocate their financial resources in implementing different levels of voluntary traceability; a motivating factor. For a summary of traceability drivers, see Borit and Olsen (2016). A benefit is an advantage or profit gained from something, in this case, from the implementation of a traceability system, and, as such, can be evaluated **after** the implementation of the system.

Previous research (Storøy, Thakur and Olsen, 2013) identified that the main obstacle for successful and efficient implementation of traceability in food product chains is organizational, not technical. In general, food businesses are not motivated to implement new standards for information exchange and traceability as they perceive this as an additional cost and are not aware of the associated benefits. Moreover, companies are not willing to make changes to their current operational practices. In addition, companies are also concerned about data security and are not willing to share sensitive information unless it is protected in trusted repositories, but this issue is secondary to their reluctance to change their current practices. Better awareness of various benefits of implementing a traceability system might help change these perceptions. Tables 4 and 5 provide an extensive enumeration of possible benefits of (sea)food traceability, grouped by stakeholders (Table 4) and by main categories (Table 5). It is noteworthy that there are cultural differences in benefits perceived by consumers (van Rijswijk *et al.*, 2008).

There are two main classes of drivers relating to the benefits outlined in Tables 4 and 5, as indicated by the red and green colours:

- "Negative drivers" are related to what the firm must do or more or less feel forced to do. They include meeting specific traceability requirements in legislation, in standards that the firm has adopted, or requested by the buyers, customers, consumers and/or market in question. They also include drivers related to reducing risks, in particular, in relation to food safety and food fraud, and to short-term reduction in costs, resource use, and waste.
- "Positive drivers" are voluntary and relate to the potential for using traceability to add value to the product, to improve quality, and to improve communication and information interchange in the supply chain. In particular, they include drivers related to product differentiation and storytelling, and to sustainability and ethics (beyond what is legally or contractually required).

The negative drivers exist for all companies, and they are linked to minimum requirements related to what the company needs to do to comply with laws, regulations and standards in order to meet market requirements for traceability, transparency and product documentation, and to keep costs low. The positive drivers exist only for companies that want to use traceability and improved product documentation as part of their value-adding and branding strategy. The distinction between negative and positive drivers is not binary; rather, the respective drivers should be viewed as being on a continuous scale, from "absolute requirements, all companies must have this degree of traceability, otherwise they cannot operate" (negative), through drivers that are relevant for many, but not all companies, all the way to drivers only applicable for companies that have traceability and transparency as part of their branding strategy, and that will or might record anything that can add value to the product or the production process (positive).

Table 4. Benefits of (sea)food traceability, grouped by stakeholders

Stakeholder group	Traceability benefits
Fishers	Better able to meet documentation and chain of custody requirements for market access for Marine Stewardship Council and/or Fairtrade certification
	Market intelligence on where fish is sold, by who and how
	Profiling of desirable product characteristics
	Communication with downstream actors
Processors	Platform enables transparency of activities for marketing purposes (e.g. can be used to link product to participation in a fishery improvement project)
	Fulfilling of documentation requirements of export markets
	Profiling of desirable product characteristics
	Added-value of analysis of companies and market
	Reduction of reputational risk associated with sector
	Decreased losses due to potential recalls
	Compliance to various international food safety and environmental standards
	Enhanced product quality
	Enhanced firms' competitiveness
	Reduced reporting and record-keeping requirements
	Enhanced food risks management
Retailers	Transparency about where their fish is coming from
	The information provided adds value to the products
	Reduced reputational risk associated with mislabelling
Consumers	Clear information on source of fish, conscience-free consumerism
	Potential for communication with fishers if traceability is "consumer facing"
	Educated on fishing practices and global trade
	Products manufactured and placed on the market with labels and identification that facilitate increased trust in the brand
	If a safety issue occurs, all dangerous products are properly identified and removed from the market rapidly, thus increased safety, health, well-being
	Product information and statements on labels are accurate
	Product information and statements on labels are verifiable
	Support regional differentiation
Managers	Data available on key fisheries indicators for stock assessment
	Inclusion of small-scale fisheries enables more informed decisions over benefits and allocation
	Economic indicators can be included in management decisions
Government	Data flows available to feed into national and regional databases
	Meeting international obligations set by regional fisheries management organizations
	Better facilitation of fishers to meet illegal, unreported and unregulated (IUU) fishing regulations for export markets
	Improved information on trade and non-fishery related benefits of otherwise unreported fisheries
	Decision-making made under less uncertainty
	Strengthening of trust relationships with import countries for improved trade relations
	Improved prospects for sustainable seafood governance

Stakeholder group	Traceability benefits
Market surveillance authorities	*Facilitates the task of determining whether a dangerous product is on their market*
	Helps trace economic operators that made non-compliant products available on the market
	Helps check compliance with applicable regulations
	Helps verify the presence or absence of product attributes (e.g. wild-caught)
	Helps access the technical specifications of the product and retrace the actual history of the product as necessary to protect consumers health
	Helps proceed with effective risk assessment and corrective measures based on reliable and complete information, ensuring consumer safety while avoiding irrelevant costs for economic operators when removing products from the market
	Helps proceed with enforcement actions with all relevant stakeholders
Actors in the supply chain in general	Access to new markets and competitive advantages, no legal barriers to market access
	Reducing liability costs
	Avoiding penalties for non-compliance
	Waste reduction
	Increased product and company reputation
	Higher quality awareness among employees
	Method of securing jobs and improving income during uncertain time
	Reassurance of consumers, encouraging purchases of such quality-assured products
	More efficient communication with customers/suppliers
	Protection of public health
	Ensuring of environmental sustainability
	Reduced pilfering
	Strengthened sustainability practices
	Strengthened quality assurance and value-chain efficiencies
	Avoidance of short weighting
	Avoidance of species substitution
	Improved customer service, improve customer satisfaction
	Reduced quality variation
	Increased ability to retain existing customers
	Faster detection of difficulties in manufacturing processes by improved process control

Note: Red highlight indicates benefits connected to "negative" drivers, green to "positive" drivers.
Sources: Seafood traceability benefits were compiled from: Asioli, Boecker and Canavari, 2011; Bailey *et al*., 2016; Bush *et al*., 2017; Donnelly and Olsen, 2012; Duggan and Kochen, 2016; He, 2018; Karlsen *et al*., 2012; Mai *et al*., 2010; Sterling *et al*., 2015). Food traceability benefits (in italics) were compiled from: Hobbs, Yeung and Kerr, 2007; Mattevi and Jones, 2016; Parreño-Marchante *et al*., 2014; Regattieri, Gamberi and Manzini, 2007; Saltini and Akkerman, 2012; van Rijswijk *et al*., 2008.

Table 5. Categories of benefits of food traceability

Category	Description/examples
Regulatory	Avoidance of penalties for non-compliance
	No legal barriers to market access
	Avoidance of problems with public authorities
Risk management	More targeted, quicker recall reduces cost
	Reduced cost of liability insurance
	Reduced amount of product destroyed in response to a food safety problem
	Reduced short-term damages: (e.g. logistic costs of recalls, reduced turnover due to out-of-stock items, costs of laboratory analyses, crisis of communication with retailers and consumers, liability claims and improvements in internal processes, etc.)
	Reduced long-term damages: (e.g. costs of corporate image, firm reputation and brand value, costs of product re-launches and intensified marketing, etc.)
	Access to more accurate and timely information needed to make better decisions in relation to how and what to produce
Market response	Reputation, build-up
	Reputation, regain after crisis
	New customers and easier market access
	Real-time information for sales calls
	Increased demand/price for output
	Reduced costs of maintaining consumer and market confidence
	Increasing consumer trust
	Product differentiation based on credence attributes (e.g. organic food)
	Pre-condition to enter in international markets
	Reduced information costs aimed towards consumers associated with quality verification
Supply chain operations	Reduced transaction costs
	Improved inventory management
	More efficient communication with customers and/or suppliers
	Elimination of inefficient practices without value to consumers
	Improved logistics performances and quality communications among stakeholders
	Increased company coordination in supply chain
	Reduced product waste
	Ensuring of a more consistent quality delivery to supply chain end users

Note: Red highlight indicates benefits connected to "negative" drivers, green to "positive" drivers.
Source: Asioli, Boecker and Canavari, 2014.

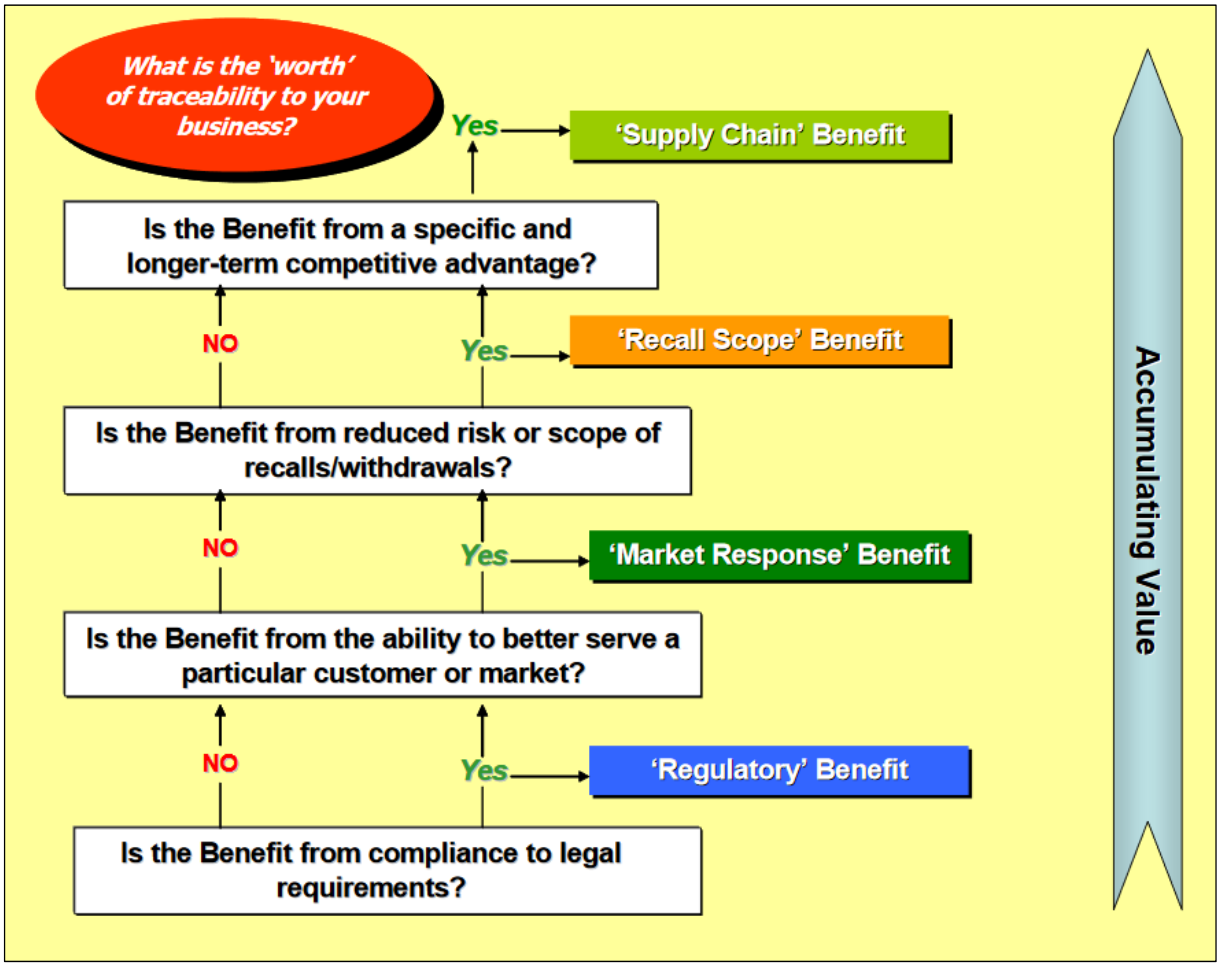
In general, seafood traceability can be improved in two different ways:

- If the focus is on the negative drivers, e.g. by increasing the requirements related to traceability in laws or standards, this will affect the companies with a minimalistic approach towards traceability and product documentation, but it will not largely affect the companies that use traceability as part of their competitive advantage, as these already record a lot more data than the minimum required.
- If the focus is on the positive drivers, e.g. through efforts designed to increase the value added by providing more information through storytelling or through profiling desirable characteristics, this will affect the companies that want to use traceability as part of their competitive advantage, but it will not largely affect the companies that only do the minimum required when it comes to traceability.

Many large seafood companies have a mixed strategy on this; they will of course satisfy all the minimum requirements, and they also go beyond these in areas where they can see it is profitable, but they are not first movers or early adopters when it comes to new technologies (e.g. automated identification and data capture, Internet of Things-enabled sensors, or blockchain), new types of data (e.g. details on vessel, fisher or fish farmer, resource use and CO_2 emissions), or new communication strategies (e.g. product detailed description online accessible by scanning QR-code on product, or visualization of supply chain). Still, if value adding and success are demonstrated by companies that focus on positive drivers, the "middle of the road" (often large) companies will gradually adopt technologies and practices when they have been proved to work.

From a value creation perspective, the different categories of benefits have different potential for accumulating value (Figure 2).

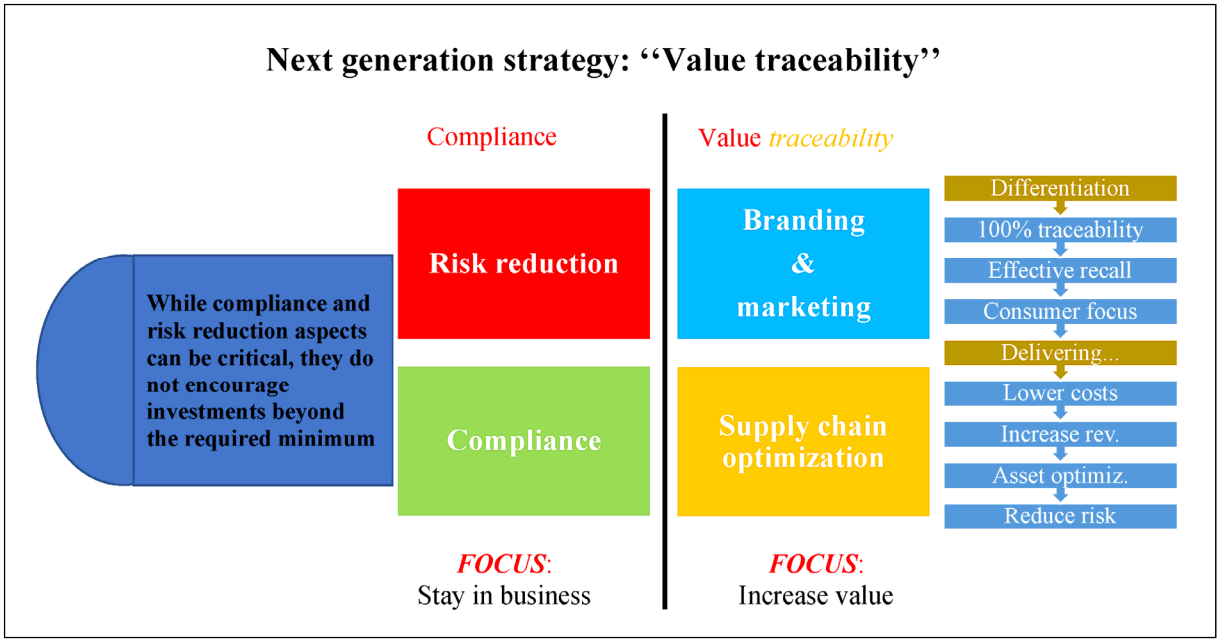
Figure 2. Traceability benefits hierarchy



Source: Sparling and Sterling, 2004.

As such, food business operators can extract significant value from implementation of traceability, and extend from a "must do" to comply with regulatory requirements (i.e. negative drivers) to a "must have" to differentiate their products in the market place and improve supply management to derive cumulative value (i.e. positive drivers), as described in Figure 3 (GS1, 2013).

Figure 3. From "compliance traceability" to "value traceability"



Source: GS1, 2013.

5.2. Success cases

Storytelling is a powerful persuasion tool (Gottschall, 2012) that has been successfully used in domains such as marketing (Vincent, 2002), organizational management (Spear and Roper, 2016) and healthcare (Gray, 2009), and it is considered to have a high impact potential in climate change research (Moezzi, Janda and Rotmann, 2017). Therefore, showcasing traceability success stories might be an effective tool in raising awareness about the benefits of implementing a traceability system. However, comprehensive accounts of traceability success stories are scarce, and where such stories are available, the information that they offer is difficult to differentiate in terms of incentives, drivers or benefits. This study gathered together cases related to some of the main actors in the seafood industry and looked at how they frame their own traceability story. In addition to these descriptions, Table 6 summarizes some selected food traceability success stories, from various world regions, stemming from different initiatives, and expressed in a multitude of forms – from structured reports to short information, from own websites to accounts in online media outlets.

A processor/exporter – importer story: Blue Ocean Grace International (BOGI), Indonesia and Anova, the United States of America (The Oceans and Fisheries Partnership, 2019).

In 2018, Anova, a leading, sushi-quality tuna company from the United States of America, joined the network of partners of the United States Agency for International Development Oceans and Fisheries Partnership (USAID Oceans) to establish full chain traceability for tuna products harvested in Southeast Asia that are imported into the United States of America. This is done by documenting the seafood's journey from its point of catch to its point of sale. To establish full chain traceability, partnerships are required throughout the seafood supply chain, from the fishers who are the first to touch the fish, to the importers – such as – that are the last. Together with its partner and grantee, Yayasan Masyarakat dan Perikanan Indonesia (MDPI), USAID Oceans has recruited small- and large-scale industry partners in USAID Oceans' learning site at Bitung, Indonesia. Anova sources its seafood from an Indonesia tuna processor, Blue Ocean Grace International (BOGI), a USAID Oceans first-mover partner that is participating in the electronic catch documentation and traceability system. In February 2018, BOGI began using TraceTales, a traceability application that allows processors to electronically track their inventory as it moves through the processing factory – from receiving, to filleting, packaging, freezing, and shipping. TraceTales, developed by the MDPI, enabled BOGI to convert its old, 100 percent paper-

based recording system to a fully digital, computer-based system that allows it to electronically capture, store and manage product data.
Reported benefits for Anova are: increased assurance in meeting import requirements; greater ability to meet customer requirements; and enhanced efficiency and business intelligence. Reported benefits for BOGI are: increased accuracy and efficiency in operations and data management; reduced product recalls and waste; increased capacity for data analysis and business decision-making; and reduced operational costs.

A retailer story: Carrefour (FIS, 2019)

Carrefour has designed own strict traceability requirements for the food products sold through its supermarkets. Because of its diversity and quantity, the fisheries sector constitutes a major challenge in terms of sustainability, and Carrefour, therefore, works on requirements such as traceability, selection of fishing grounds, respect for minimum sizes and promotion of local fisheries. In 2017, it started the introduction – for the first time in retail – of blockchain technology, used to enable traceability of product lines (e.g. eggs, honey, cheese and tomatoes), guaranteeing consumers as much transparency as possible. This initiative was driven by the fact that the demand for transparency and traceability is now a core issue for all its consumers, and the blockchain is considered by this retailer to be a thoroughly effective, reliable and innovative solution that meets this requirement. In 2019, Carrefour launched worldwide the first blockchain food traceability system for fresh fish. In Spain, the company announced the application of this technology to the line-caught hake "Quality and Origin," which represented a milestone worldwide as it was the first time that this system had been used on an extractive fishing product. The product sold by Carrefour includes in its labelling a QR code that can be scanned through a smartphone. Thus, the consumer can obtain complete information on each of the hake that arrives at the Carrefour centres as this product is traced unit by unit. For example, the consumer can learn which boat made the catch, the coordinates of the fishing area, the fishing gear used, the exact location of the fish market where it was landed, how it was conditioned and when it was delivered to Carrefour. The line-caught hake offered by Carrefour is available within 24 hours at the chain's fishmongers throughout Spain. The new system is considered to provide transparency, reliability and total information to the consumer.

A seafood traceability software provider story: TraceVerified (FAO and ITU, 2017)

TraceVerified is a transparent information and electronic traceability service in Viet Nam that provides electronic traceability systems for ten supply chains related to shrimp, catfish, blue-fin tuna, rice, tea, sweet potato, frozen vegetable, dragon fruit, fruit syrup, honey and cashew-nut products. It is owned by the 100% Vietnamese Traceability Solutions and Services Joint Stock Company. Launched in 2016, TraceVerified collects and transports verified information from food producers to food buyers, and it allows buyers to verify product information independently and conveniently. An analysis of the impact of this initiative shows that: (i) small and medium-sized enterprises using the system have experienced reduced operational costs, better credibility and improved brand reputation in the market; (ii) smallholder producers have been enabled to communicate transparently their cultivation methods to customers and retailers, which has helped establish stable market links and steady production and sales of their produce, which has improved their income; and (iii) consumers have gained awareness about food safety, and thus been able to make better and more informed purchasing decisions. However, despite these benefits reported by the users of the TraceVerified systems, the interest for using it is rather low, for various reasons, among which lack of awareness about the value and benefits of electronic traceability and lack of mandatory requirements for traceability are considered to play an important role.

A non-profit organization story: Future of Fish (Future of Fish, 2020)

Future of Fish defines itself as a non-profit systems change incubator that works with industry players, technologists and NGOs to create business solutions to ocean challenges. For almost a decade, its approach has been to build strategic, collective impact of entrepreneurs, businesses, governments and NGOs by facilitating collaborations that accelerate traceability technology adoption, better governance,

value chain alignment, and financial investment in fisheries. Its method starts with embedded, ethnographic research that looks at supply chains from the source up. By analysing the choke points and the identified strategies for overcoming them, the syntheses yield insights about overarching challenges that remain unaddressed and how assets can be leveraged among stakeholders to forge progress or develop new structures. Facilitating co-design of systematic solutions, Future of Fish then stays in the system, coordinating players and helping scale projects to achieve sustained and replicable progress.

A legislator story: European Commission Regulation 178/2002 (General Food Law) (European Commission, 2019)

At the beginning of 2019, the Directorate General for Health and Food Safety of the European Commission (DG SANTE) published its findings in relation to the Fitness Check of the General Food Law Regulation (EC) No. 178/2000 (GFL Regulation), which had been concluded by the end of 2017.

A fitness check of the regulation was conducted to evaluate whether the established general principles and requirements are appropriate for the purpose by identifying excessive regulatory burdens, overlaps, gaps, inconsistencies and/or obsolete measures. In general, the evaluation found that the GFL Regulation remains relevant and has succeeded in achieving a high level of protection of human health and consumers' interests in relation to food, while contributing to the effective functioning of the internal market. However, the GFL Regulation was found to be less adequate in addressing new challenges such as food sustainability and, in particular, food waste.

According to this study, it has proved difficult to identify quantitative indicators to measure the overall impacts (costs and benefits) of the general principles and requirements laid down in the GFL Regulation. As such, the quantification of benefits for consumers and public health in economic terms requires a case-by-case analysis. However, more than half of consulted food business operators (FBOs) included in the study (57 percent) have indicated that, overall, the benefits of traceability have outweighed the relevant costs. The benefits have mainly been felt by those FBOs trading within the internal market, as they can benefit from harmonization. Nonetheless, 23 percent of FBOs indicated that benefits have not for the most part outweighed costs, while 21 percent did not provide an answer because they were not in a position to know. Those FBOs tended to be smaller and craft enterprises that are more active in national markets. Therefore, they do not benefit from the harmonized requirements of the internal market, but still have to cope with the administrative burden stemming from other secondary food legislation of the European Union. However, given the diversity of the sector, it cannot be concluded that harmonization benefits larger enterprises more than smaller ones, as in practice a large range of operational contexts can prevail.

A vast majority of the small and medium-sized enterprises included in the study indicated the following benefits of the traceability system: it makes it easier to manage risk in food/feed safety incidents (85 percent of respondents); it helps identify which products need to be withdrawn from the market (83 percent); and it maintains consumer trust by providing accurate information on products affected by a food safety incident (75 percent). A smaller majority of respondents indicated that the system prevents unnecessary disruption to trade (54 percent) and improves business management (60 percent), although a relatively important share of respondents did not know whether the traceability system has these particular benefits (23 percent and 13 percent, respectively).

Table 6. Overview of selected success cases

Name	Country/ region	Product / implementation solution	Benefits
e-LOCATE (GS1, 2016; Nolan and O'Brien, 2017)	Ireland	Seafood / GS1	Standardized processes that enable partners to seamlessly share and receive traceability data. Efficient regulatory compliance via automated recording of traceability data. Enhanced analysis of production costs and inventory management. Targeted, improved recall processes for increased food safety. Improved customer service and relationships with a more reliable traceability system.
Fish Stories (OCEANA, 2016)	United States of America	Seafood	Growing products' value. Establishing trust with customers. Reduces the risk of seafood fraud or mislabelling. Helps prevent illegal products from entering the market.
Fresh Food Trace (World Bank, 2017)	Mali	Mango	Standards compliance. Market access. Enhance reputation.
Hermes AS (Fiskebåt, undated)	Norway	Fish products / TraceTracker	Easier and more efficient to collect, distribute and present the information to its customers and consumers. Increased the market value of products and achieve better prices for products by being able to document production and quality in a more detailed way than before. Reduced number of complaints on customer deliveries. Increased transparency in the fight against illegal fishing Establishment of a transparent traceability chain from capture to consumption. Building trust in the market through openness and transparency. Improved production processes internally and help motivate their employees to deliver a better product to their customers.
HTS (AFFA, 2015)	Kenya	Horticulture, flowers, beans, peas	Rapidly identify and isolate food safety incidents. Rapid information sharing and recall. Improve investigation and risk profiling capacity. Enhance speed and efficiency. Enhance market access for primary producers. Protect brand reputation. Engage consumers.
Longline Tuna Fishery Improvement Project (Gilman, 2019)	Micronesia	Tuna / radio frequency identification tags	Market recognition for fishers that complied with fishing gear regulation. Compliance with Marine Stewardship Council standards.

Name	Country/ region	Product / implementation solution	Benefits
Pacific to Plate (Ecotrust, 2012)	Canada	Seafood / ThisFish	Creating new markets. Diversification. Market stabilization Building brand.
ShellCatch (World Bank, 2017)	Chile, Puerto Rico	Seafood	Better monitoring of resources. Provide added value. Reach sustainability. Help demonstrate origin of products.

6. POLICY INCENTIVES TO ENCOURAGE THE ESTABLISHMENT OF COMPANY TRACEABILITY

In this study, incentive is defined as a way to stimulate desired behaviour, in this case, the implementation of a traceability system. It serves as a motivational device for a desired action or behaviour. This section proposes three different categorizations of incentives, from broad incentives to very specific incentives from the food production domain. These categories can be used by interested entities when formulating strategies and specific incentives to encourage the establishment of company seafood traceability.

One common categorization of incentives divides these into three broad classes (Dalkir, 2005):

1. **Remunerative incentives (or financial incentives)** are said to exist where an agent can expect some form of material reward (or gain) – especially money – in exchange for acting in a particular way.
2. **Moral incentives** are said to exist where a particular choice is widely regarded as the right thing to do, or as particularly admirable, or where the failure to act in a certain way is condemned as wrong. A company acting on a moral incentive can expect approval or even admiration from the community; a company acting against a moral incentive can expect a condemnation or even ostracism from the community.
3. **Coercive incentives** are said to exist where a company can expect that the failure to act in a particular way will result in force being used against it by entities with power (e.g. government or industry association).

Drawing on a previous FAO study about incentives for adoption of good agricultural practices (GAPs), among which there is also the implementation of a traceability system (Hobbs, 2007), a second categorization distinguishes among three broad categories of incentives: **economic incentives**, **regulatory/legal incentives**, and **human capital incentives**. These incentives could be extrapolated to the implementation of traceability systems.

The disincentives to adopt GAPs include economic disincentives, institutional infrastructure constraints, and human capital constraints. It is important to note that the disincentives are often the mirror image of the incentives to adopt, in the sense that adoption of GAPs to, for example, achieve price premiums (an incentive) may be accompanied by higher production costs (a disincentive). As such, they may occur simultaneously. Table 7 provides an overview of these incentives and disincentives.

Table 7. Incentives/disincentives to adopt good agricultural practices (GAP), among which the implementation of a traceability systems

Incentive	Farmer incentive	Processor/retailer incentive
Economic		
Price premium	xx	
Access to market / supply chain	xx	
Access to reliable inputs		xx
Product differentiation	x	xx
Stabilize yield/revenue	xx	
Reduce storage losses	x	x
Reduce wastage	x	xx
Increase asset value	x	
Protection against market externalities	x	
Increase variable production costs (e.g. labour)	--	--
Reduce output/increase average cost	--	--

Incentive	Farmer incentive	Processor/retailer incentive
Increase fixed production costs (e.g. equipment)	--	--
Asset-specific investment[1]	-	-
Reduce search costs	x	x
Reduce monitoring cost		x or - [2]
Altruism / social capital	x	x
Regulatory/legal/institutional		
Asserting property rights on scarce resources	x	
Subsidies	x	x
Reduce liability / show due diligence	x	xx
Reliance on institutional infrastructure	-	-
Third-party monitoring	x	x
Human capital		
Expand skill set	x	x?
Record-keeping (literacy)	- -	-

[1] An asset specific investment has little or no value in an alternative use, e.g. inputs or equipment that are specific to one buyer. Having made the investment, the primary producer is vulnerable to the buyer acting opportunistically by reneging on a supply agreement.
[2] Depends on the presence of third-party verification that lowers monitoring costs. Without third-party verification, processors/retailers will probably face higher monitoring costs.
Notes: xx = strong incentive to implement; x = marginal incentive to implement; -- = strong disincentive to implement; - = marginal disincentive to implement.
Source: Hobbs, 2007.

A third categorization of incentives to implement a traceability system is based on (Valluri, 2012) and divides incentives in **intrinsic incentives** (i.e. originate within each entity or an actor of the supply chain depending on their own interest and specialization), **extrinsic incentives** (i.e. originate external to each entity in the supply chain), and **social incentives** (i.e. occur due to the intangible rewards offered by the society - both consumers and non-consumers of the respective food - associated with the supply chain; these originate from the supply chain entity's perceived social relations). An overview of all these incentives can be found in Table 8. Intrinsic, extrinsic, and social incentives are interlinked with each other. However, extrinsic incentives were found to be stronger than intrinsic and social incentives respectively. Extrinsic incentives were recommended to the studied supply chain businesses, government, and social entities for a better implementation of traceability systems in the respective supply chain. From among the extrinsic incentives, transparency demand by its downstream supply chain partner seemed to be the strongest item from this category. Legislation on traceability by the government could act as a stronger incentive than a subsidy from the government. From among the intrinsic incentives, company's commitment to food safety, desire to achieve accuracy and ease of recall, and awareness of past food safety crisis seemed to act as the strongest such incentives, together with envisaged profits. An active role by animal welfare social organizations and media could act as strong social incentives. Likewise, the active role of media producing stories on human and labour rights abuses and/or environmental degradation along supply chains is likely to spur company action in improving traceability.

Table 8. Incentives for implementation of a traceability system

INTRINSIC INCENTIVES
Commitment to food safety
Strategy
Accuracy and ease of recall
Awareness of crisis
Lean thinking (i.e. a practice that considers the expenditure of resources for any goal other than value creation for the end-customer to be wasteful and, thus, there is a target of elimination)
Innovation management of product quality
Process costs
Intention to protect market share
EXTRINSIC INCENTIVES
Transparency demand by the downstream supply-chain partner
Upstream supply-chain partner being transparent
Financial reward
Legislation
Final consumer's food safety concern
Branding of a downstream supply-chain partner
Government subsidies
Technical support by downstream supply-chain entity
SOCIAL INCENTIVES
Satisfaction with being transparent to society
Society's appreciation for animal welfare
Social pressure to practise fair labour standards [NB: Authors' addition.]
Social pride
Pressure from non-governmental organizations
Naming and shaming by media

Note: Entries in bold indicate a strong incentive.
Source: Compiled from Valluri (2012).

Governments have intervened in food, agricultural and fisheries markets through various support programmes to promote adoption of traceability practices and systems in order to raise food-safety levels and increase industry competitiveness. There are intended and unintended effects of participation in such supporting programmes. Intended effects comprise the impacts on traceability capacity levels, costs and benefits of programme participants vs. comparable non-participants. Unintended effects concern the firm's planning accuracy measured through deviations of actual from expected outcomes. According to an analysis of Italian fishery businesses (Boecker and Asioli, 2016), although recipients of government support have higher average levels of traceability capacity and overall benefits than those who did not receive such support, differences are not statistically significant. In regard to the unintended effects of government support, recipients of government support reported larger deviations of actual from expected benefits than did the non-recipients. While these differences were not significant at the aggregate level, significant differences are found at the level of specific benefit categories. For example, support recipients had overestimated sales- and price-related benefits but severely underestimated efficiency gains in operations. The results suggest that the motivation for participating in a government support programme may not align with the firm's strategic goals. This misalignment may reduce planning accuracy.

According to Golan *et al.* (2003), policies targeted at providing firms with incentives to establish efficient recall systems will probably be less costly and more successful than policies that mandate traceability. Such policies include the following: recall and other food-safety performance standards; any policy that increases the likelihood that producers of unsafe food will be identified and punished; and any policy that increases the punishment for producing and selling unsafe foods. Mandatory traceability may not be the most efficient policy tool because, as most process standards, it precludes efficient innovation by firms by stipulating the method for achieving the objective. Usually, performance standards – rather than process standards – ensure the most efficient compliance systems. In addition, mandatory systems that prescribe one traceability template and fail to allow for variation across systems

are likely to impose costs that are not justified by efficiency gains. The characteristics of an efficient traceability system vary from industry to industry and from firm to firm. Mandatory systems that fail to allow for variation will impose unnecessary costs on firms that are already operating efficient traceability systems. However, it is crucial that companies take into consideration systems interoperability when deciding what traceability system to implement.

7. RECOMMENDATIONS

The recommendations of this study are:

1. There is still a lack of knowledge about the benefits of introducing a traceability system among the actors in seafood supply chains (Parreño-Marchante *et al.*, 2014; Storøy, Thakur and Olsen, 2013). Communicating and understanding the benefits of a traceability system are important for successful implementation of traceability. Interested agencies should **fund awareness raising campaigns** in order to spread the knowledge about these diverse benefits and their implications for value creation. A comprehensive list of benefits of implementation of traceability can be found in Chapter 5 (Tables 4 and 5). Success cases are compiled in Table 6.
2. There are cultural differences in benefits perceived by different groups of stakeholders (van Rijswijk *et al*., 2008). At the same time, risk communication is more effective if it is adapted to the culture of the audience (Renn, 2008). Thus, interested agencies should **adapt the communication strategy** of the benefits of traceability raising awareness campaign **to the cultural** specificities of the audience.
3. Organizations can extract significant value from implementing traceability and extend from a "must-do" to comply with regulatory requirements to a "must have" to differentiate their products in the marketplace (Figure 2) (GS1, 2013). The **communication strategy** of traceability benefits has to include an awareness-raising campaign that **focuses specifically on the value creation potential of traceability systems.**
4. Besides the lack of knowledge about the benefits of traceability among the actors in seafood supply chains, there is also the need for more cost–benefits studies (Karlsen *et al*., 2012) to be communicated to possible stakeholders. Interested agencies should **commission such cost–benefit** studies and disseminate the results widely.
5. Traceability success stories/cases are littles documented, especially for developing countries. Interested agencies should commission studies of such success stories with specific requirements of what has to be recorded in a structured and systematic way in terms of traceability incentives, drivers, and benefits.
6. In general, food businesses are not motivated to implement new standards for information exchange and traceability as they perceive this as an additional cost and are not aware of the associated benefits. In addition, companies are not willing to make changes to their current operational practices. Similarly, companies are also concerned about data security and are not willing to share sensitive information unless it is protected in trusted repositories, but this issue is secondary to their reluctance to change their current practices (Storøy, Thakur and Olsen, 2013). Interested agencies should **commission a study of the motivations** for adopting traceability systems that also explore **possible solutions to the concerns** raised by food businesses.
7. There is still a lack of understanding about what kind of perceptions can influence the internal attitudes and motivations of the firm to implement a traceability system (Abd Rahman *et al*., 2017. Interested agencies should **commission a study of the reasons** for not adopting traceability systems.
8. Extrinsic incentives were found to be stronger than intrinsic and social incentives (Valluri, 2012). As such, **extrinsic incentives could be recommended** to businesses, government, and social entities for a better implementation of traceability systems in the respective supply chain.
9. Policy targeted at providing firms with incentives to establish efficient recall systems will be less costly to firms and consumers and better targeted than policy mandating traceability. Usually **performance standards – rather than process standards – ensure the most efficient compliance systems** (Golan *et al*., 2003). Governments and industry associations should focus on formulating policies targeted at providing firms with **incentives to establish efficient actions**, such as recalls. In the example of more efficient recalls, such policies include the following: recall and other food safety performance standards; any policy that increases the likelihood that producers of unsafe food will be identified and punished; and any policy that increases the punishment for producing and selling unsafe foods.

10. Regulatory interventions do not drive the technological evolution of food traceability systems (Brofman Epelbaum and Garcia Martinez 2014). Interested agencies should **commission a study about the drivers** of implementing traceability systems, to complement this study on benefits and incentives.
11. Contrary to popular belief, traceability is not a method to ensure that information about a certain product is true or accurate; traceability systems contain claims about the food product in question, and these claims may or may not be true. Some of these claims are related to chemical, physical, or sensory attributes of the food, and these claims can (to some degree of accuracy, at least) be tested by analytical methods, such as DNA-based analyses or nuclear magnetic resonance spectroscopy. Interested agencies should commission studies **specifically focused on data validation and verification of any types of claims**, in order to avoid the "garbage in / garbage out" problem and thus to increase the value of traceability systems.
12. It has been noted that "adoption of safety standards may promote power imbalances, lack of trust and transparency and the easing of minimalistic strategies in dealing with food safety" (Ringsberg, 2014; Sodano, Hingley and Lindgreen, 2008; Trienekens and Zuurbier, 2008). Thus, when adopting such standards, governments and industry associations should implement initiatives to **counterbalance** such developments. For example, strategies to avoid exclusion include: (i) providing ample education and training to overcome human capital constraints. (ii) fostering the development of the institutional infrastructure necessary to support implementation of traceability systems within a developing-country environment. (iii) encouraging the participation of producer associations or cooperatives to provide a critical mass in terms of supply, provide a conduit for the dissemination of information on benefits of traceability to smallholders and improve the bargaining power of individual farmers/fishers vis-à-vis larger retailers or processors.
13. Companies across the supply chain should consider adopting **industry-wide use of the standards using globally unique identification of units** as a significant step forward for electronic and interoperable seafood traceability. If using a globally unique unite code such as the Serial Global Trade Item Number rather than the Lot Global Trade Item Number, an example of such standard is the Global Dialogue for Seafood Traceability (GDST) Standards and Guidelines for Interoperable Seafood Traceability Systems, Version 1.0. These industry-developed standards are designed to improve the reliability of seafood information, reduce the cost of traceability, contribute to supply chain risk reduction, and contribute to securing the long-term social and environmental sustainability of the sector.

Underlying many of these recommendations is the fact that what the society needs, and what the consumer prefers is full chain traceability, from vessel or aquaculture site to plate. What companies tend to focus on is their own, internal traceability, largely limited to inputs (raw materials and ingredients) and outputs (products) from their own processes. This difference in perspective has many ramifications, in particular related to the need for unit identification. The traceability systems in most seafood companies are batch-based, and this identification principle is also the basis for most standards and good practice recommendations in this area. If the focus is internal traceability, batch-based identification is fine, because all units (boxes and cases) from the same batch have the same properties, and it makes sense to identify them in the same way. However, if the focus is full chain traceability, batch-based identification is not a good solution. The reason is that the units in question (the units coming from the same production batch) can only be said to have the same properties when they are physically kept together. In practice in the seafood industry, the units from a production batch (a cage, a day's slaughter, a catch, or a day's processing) are not kept together throughout the chain. A production batch is often split up, and different units from the same batch may be transported using different vehicles, to the same or to different destinations. Once they arrive, if the only available identifier is the batch identifier, it is impossible to say what means of transportation was used, what the unit location was at a given time, or what the temperature was at a given time. Often other identifiers are temporarily affixed to the units, as when a unit is part of a pallet, and the pallet has a globally unique identifier. However, it is not uncommon that the link to these additional identifiers are lost (e.g. when the pallet wrapping is discarded), so that the batch identifier is the only one that remains when the unit reaches its destination. While this can be used to access information related to the process that produced it, it cannot be used to

access information about what happened subsequently, and so it is not a good solution for full chain traceability.

Thus, a final recommendation, and one that underlies and supports many of the recommendations above, is:

14. To achieve full chain traceability, a shift in perspective is needed, from a focus on documenting inputs and outputs to specific processes there and then to a focus on the ability to document all properties relating to the product or unit anywhere in the supply chain, including origin, process history, location, and any other attributes that might be relevant. For this, batch identification is not sufficient, and unique unit identification is needed. Interested agencies should **commission studies that highlight the benefits of full chain traceability as opposed to internal traceability**, and in particular document the value of and benefits related to unique identification of units compared with batch-based identification of units.

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