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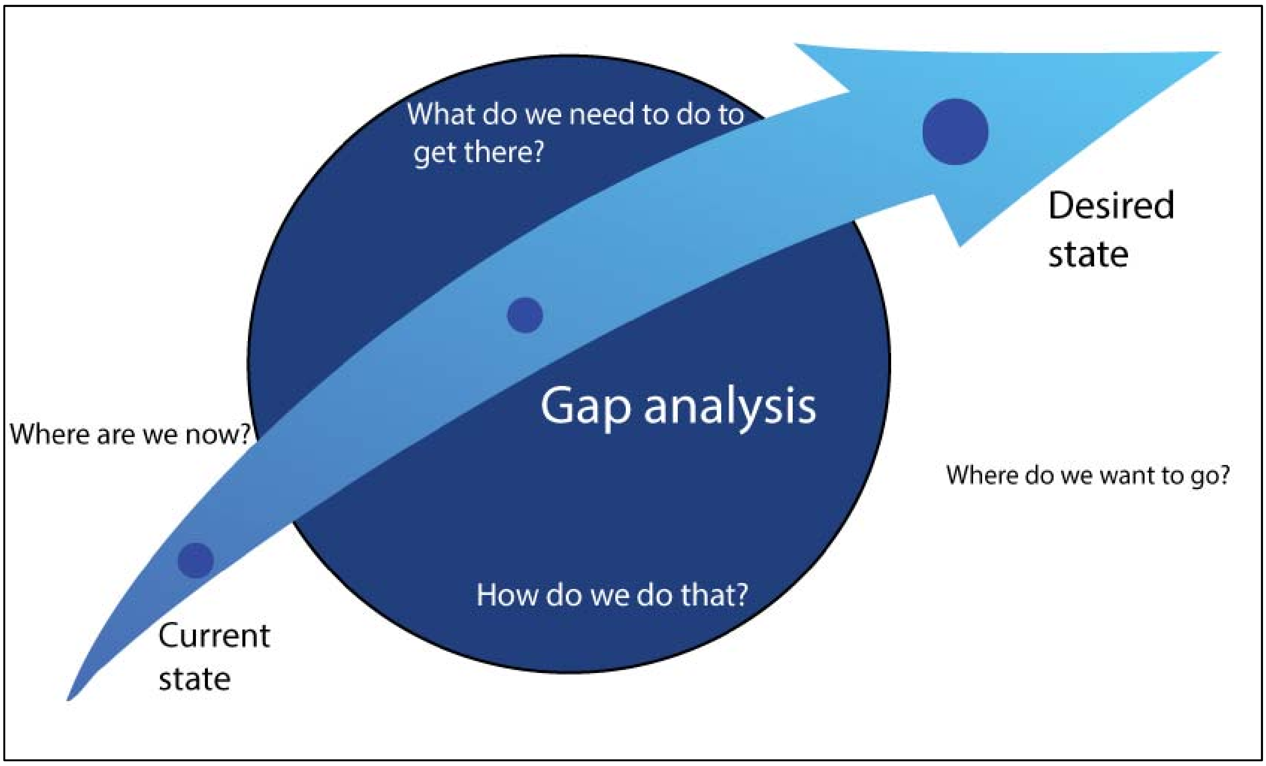
GAP ANALYSIS OF INCONSISTENCIES IN STANDARDS AND NORMS



FAO Fisheries and Aquaculture Circular No. 1123 FIAM/C1123 (En)

SEAFOOD TRACEABILITY SYSTEMS:
GAP ANALYSIS OF INCONSISTENCIES IN STANDARDS AND NORMS

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PREPARATION OF THIS DOCUMENT

FAO member countries requested a study on gap analysis of seafood traceability systems and stipulated the parameters in paragraph 38 of the Report of the thirteenth session of the Sub-Committee on Fish Trade (COFI:FT), held in Hyderabad, India in February 2012. This research was completed by two expert consultants, under the supervision of Victoria Chomo, Fishery Officer, Fisheries and Aquaculture Policy and Resources Division, FAO (victoria.chomo@fao.org), and was presented as an Information Note (English only) to the fifteenth session of COFI:FT in Agadir, Morocco, in February 2016. Member countries expressed satisfaction with the results of this research and it was decided by the COFI:FT Secretariat to disseminate these key findings and recommendations more widely through an FAO Circular.

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Seafood traceability systems: gap analysis of inconsistencies in standards and norms, by Melania Borit and Petter Olsen.
Fisheries and Aquaculture Circular No. 1123. Rome, Italy.

ABSTRACT

FAO member countries requested a study on gap analysis of seafood traceability systems and stipulated the parameters in paragraph 38 of the Report of the thirteenth session of the Sub-Committee on Fish Trade (COFI:FT), held in Hyderabad, India, in February 2012. This research was completed by two expert consultants and initially presented as an Information Note to the fifteenth session of COFI:FT in Agadir, Morocco, in February 2016. The report identifies and analyses gaps and inconsistencies in the current traceability standards and regulations worldwide, taking into account the following traceability specifications requested by member countries, namely: (i) how the integrity of product tracking is maintained; (ii) special consideration for developing countries and small-scale fisheries; (iii) the notion of equivalency; and (iv) the notion of harmonization. The key terms in understanding the concept of traceability are explained. The authors note that previous analysis of seafood traceability practices identified three main categories of traceability standards and regulations that this analysis follows: international standards and guidelines; regulatory standards and industry and NGO non-regulatory standards. This analysis employs a multi-methods approach from a multi- and interdisciplinary perspective, which involves the following steps: (i) conceptualization of key terms; (ii) a comprehensive literature review; (iii) a gap analysis; and (iv) a content analysis. According to the authors, seafood traceability approaches remain underdeveloped and fractured across geographies, jurisdictions and market sectors. The gaps in seafood traceability systems identified in this analysis are: awareness, commitment, implementation, technology and standards. The authors include recommendations on how to address each of these traceability gaps.

CONTENTS

ACRONYMS AND ABBREVIATIONS

CoC	chain of custody
COFI:FT	Committee on Fisheries Sub-Committee on Fish Trade
CTDS	catch/trade documentations scheme
EDI	Electronic Data Interchange
EU	European Union
GFL	General Food Law
IPOA-IUU	International Plan of Action to Prevent, Deter and Eliminate Illegal, Unreported and Unregulated Fishing
ISO	International Organization for Standardization
IUU	illegal, unreported and unregulated (fishing)
FAO	Food and Agriculture Organization of the United Nations
FSMA	Food Safety Modernization Act
NGO	non-governmental organization
OIE	World Organisation for Animal Health (former International Office of Epizootics)
RF-ID	radio-frequency identification
RFMO	Regional Fisheries Management Organization
TRU	traceable resource unit
TU	trade unit
XML	extensible Markup Language

EXECUTIVE SUMMARY

This study was commissioned to identify and analyse gaps and inconsistencies in the current traceability standards and regulations, by taking into account the following traceability specifications: (i) how the integrity of product tracking is maintained; (ii) special consideration for developing countries and small-scale fisheries; (iii) the notion of equivalency; and (iv) the notion of harmonization. As a first step in reaching this goal, the key terms in understanding the concept of traceability were explained (e.g. granularity, transformations, referential integrity), which was described in connection with related notions (e.g. traceability systems, transparency, analytical methods).The second step consisted in performing a comprehensive literature review that served as a basis for building the gap analysis of the traceability standards and regulations. The last step consisted in performing a content analysis of selected international standards and guidelines, regulatory standards, and industry and non-governmental organizations (NGOs) non-regulatory standards. By employing this multi-method analysis, several awareness, commitment, implementation, technology and standards gaps were identified and described. In addition, specific inconsistencies of inter- and intra-institutions were highlighted. Recommendations discussed include:

- Increase awareness of what traceability is, how it is different from other similar concepts, how traceability may add value to a company and a business.
- Develop a self-assessment scheme for seafood traceability where the advantages and disadvantages of each alternative are clearly spelled out and recommendations are made concerning which selections belong together.
- Raise awareness about the utility of using standards.
- Support various levels of complexity and allow a certain degree of variety and of freedom of choice with respect to implementing traceability.

1. BACKGROUND

During the Fourteenth Session of the FAO Sub-Committee on Fish Trade (COFI:FT) held in Bergen, Norway, in February 2014, the member countries requested further work on the analysis of current traceability practices, namely, a gap analysis of seafood traceability systems. This study builds on this request, and is in line with the COFI:FT terms of references:

- provides a brief overview of existing traceability standards and regulations as summarized in Andre (2013);
- provides detailed identification of gaps and inconsistencies in the current standards and regulations, taking into consideration the following traceability specifications:
    - how the integrity of product tracking is maintained;
    - special consideration for developing countries and small-scale fisheries;
    - the notion of equivalency;
    - the notion of harmonization;
- includes practical recommendations for improving transparency and standardization of seafood traceability systems to reduce costs in the international marketplace, especially for developing countries and economies-in-transition seeking market access.

Section 2 explains the methodology followed by this study and Section 3 defines the core concepts used here. Section 4 briefly describes the international standards and guidelines, regulatory standards, and industry and non-governmental organizations (NGOs) non-regulatory standards included in the analysis. Section 5 presents the results of the gap analysis. Following the concluding remarks in Section 6, recommendations are made in Section 7.

2. METHODOLOGY

2.1. General considerations

To address the complexity of its aims, this study employed a multi-methods approach from a multi- and interdisciplinary perspective, which involved the following steps:

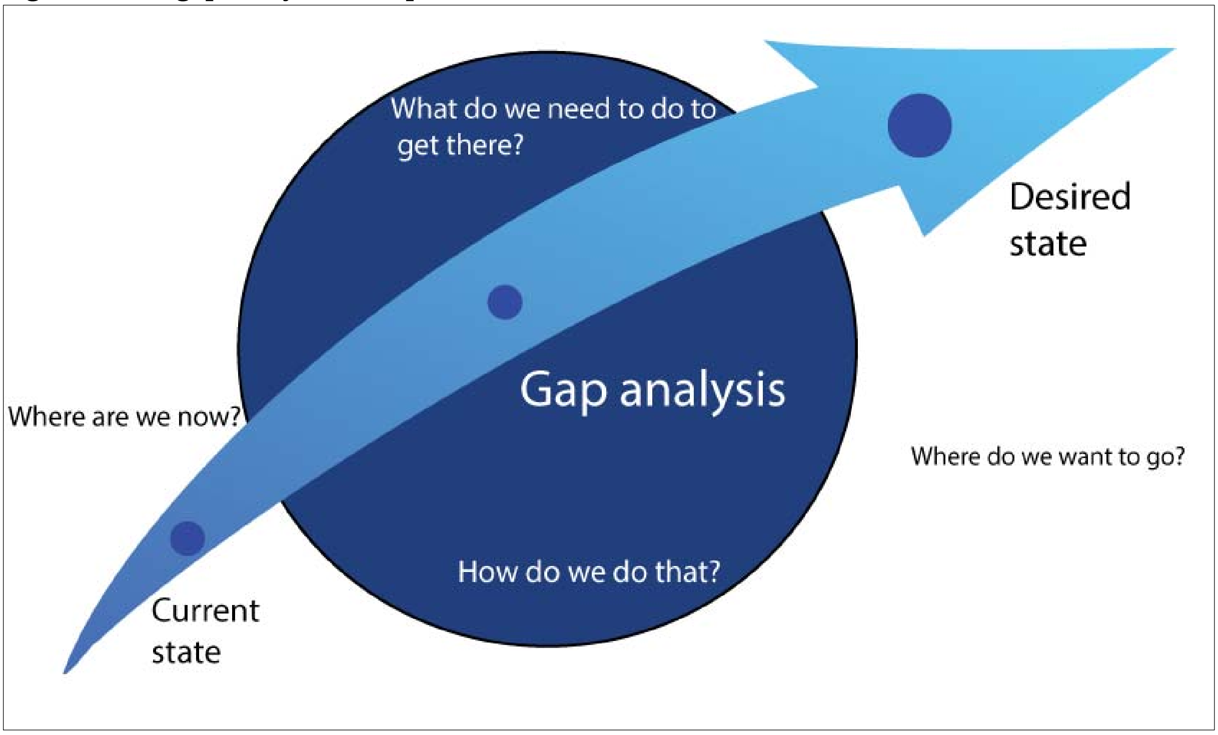
1. Conceptualization of key terms;
2. A comprehensive literature review;
3. A gap analysis of the traceability standards and regulations;
4. A content analysis of selected international standards and guidelines, regulatory standards, and industry and NGO non-regulatory standards.

2.2. Gap analysis

2.2.1. Concept, types of gaps and approach of this study

A gap analysis determines the space between where something is and where it is desired to be. It serves as a means to bridge this space by identifying what has to be done in order to reach this desired state, and how to do this is part of this analysis (see Figure 1) (Gomm and Brocks, 2009). At the same time, gap analysis can be used to compare a process, product or service to another, or to specified standards.

Figure 1. The gap analysis concept



Source: Upadhye (2002).

The literature identifies six general fields where gaps might appear (each of these fields corresponds to a type of gap) (Gomm and Brocks, 2009; Chituc, Toscano and Azevedo, 2008):

1. **Awareness:** Stakeholders must be concerned about, and have a well-informed interest in, a particular situation or development, e.g. the advantages of traceability systems.
2. **Knowledge/research:** Stakeholders must have the right facts and information about the particular situation or development, e.g. what information should be recorded by a traceability system in order to deter illegal, unreported and unregulated (IUU) fishing.
3. **Implementation:** The principles of traceability and traceability systems are of value if they are implemented effectively through standards and norms.
4. **Commitment:** The traceability standards and norms must be used by the policy-makers and industry, and not circumvented. This is closely related to point 1 above.
5. **Technology:** Tools and operational infrastructures supporting effective traceability are currently available. This is closely related to point 3 above.
6. **Standards:** Standards for both implementation and certification of traceability are available and accepted, and terms and concepts are harmonized. This is closely related to point 3 above.

Inconsistency is a concept that is closely related to the concept of gap and refers to a lack of harmony between different parts or elements, and self-contradiction. In this study, we are referring to regulatory inconsistency.

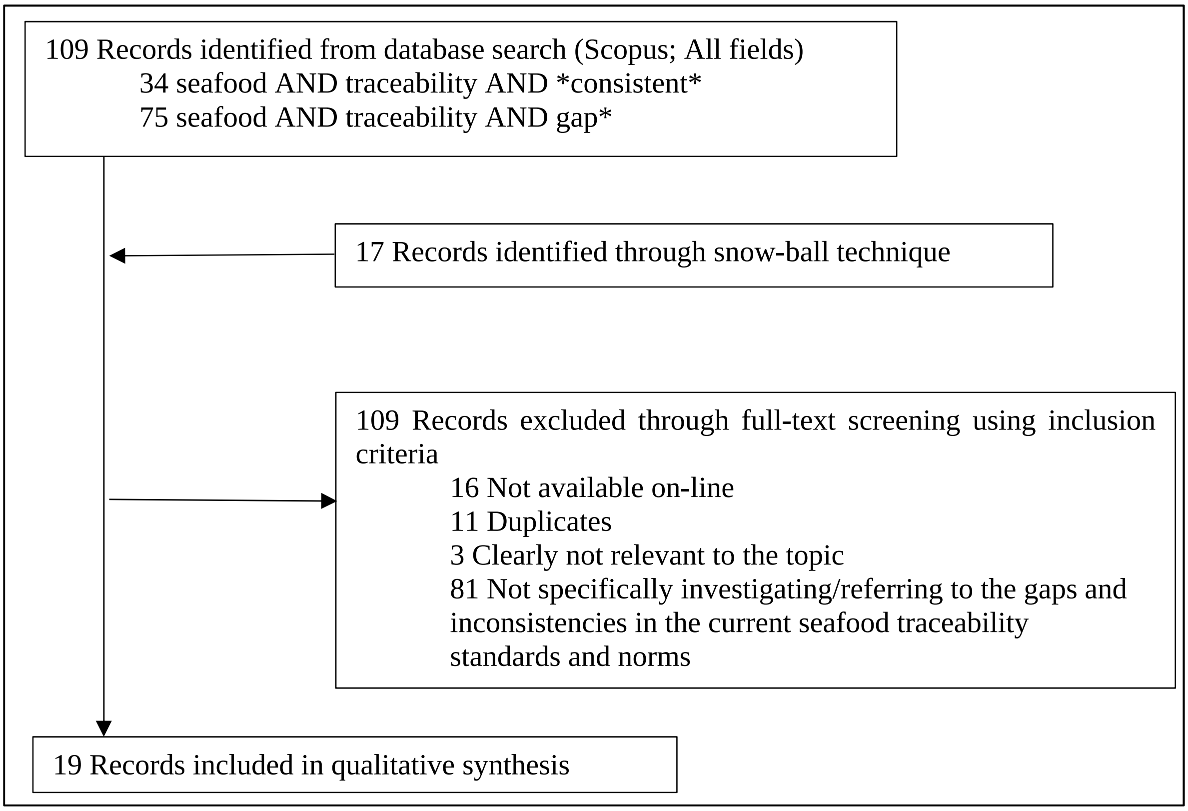
This study:

- examines the current state of approaches to traceability as indicated by the existing traceability standards and regulations versus an ideal approach based on the most relevant definition of traceability for the food domain;
- describes the gaps and inconsistencies between the standards and norms included in the analysis.

2.2.2. Literature review

A systematic literature review was performed in order to identify scientific papers analysing the gaps and inconsistencies in traceability standards and norms. Databases searched included Scopus, and searches were conducted in all fields, up to 1 November 2015, with the earliest year being 1960. Three concepts were used to structure the search query, including: seafood, traceability and gap (keywords: gap*, *consisten* [in/consistent/cy]). No limits were placed on year of publication or country; however, only English language papers were included. Studies were initially screened for relevance to the review topic. Records were excluded if they did not specifically investigate or refer to gaps and inconsistencies in the current seafood traceability standards and norms. The records identified through this technique were supplemented through snowball sampling of relevant sources. The screening process is summarized in Figure 2.

Figure 2. Search process used to identify records to be included in the review of gaps and inconsistencies in the current seafood traceability standards and norms



3. THEORETICAL FRAMEWORK

3.1. Traceability and traceability systems

3.1.1. Traceability concept, terms and definitions

The following constitutes a short, but by no means exhaustive, primer on traceability terms and concepts. There are conflicting or ambiguous views on, or definitions of, some of these terms; efforts have been made to choose the definitions most consistent with normal practice in the captured fish industry, and also most suitable for the analysis in this study.

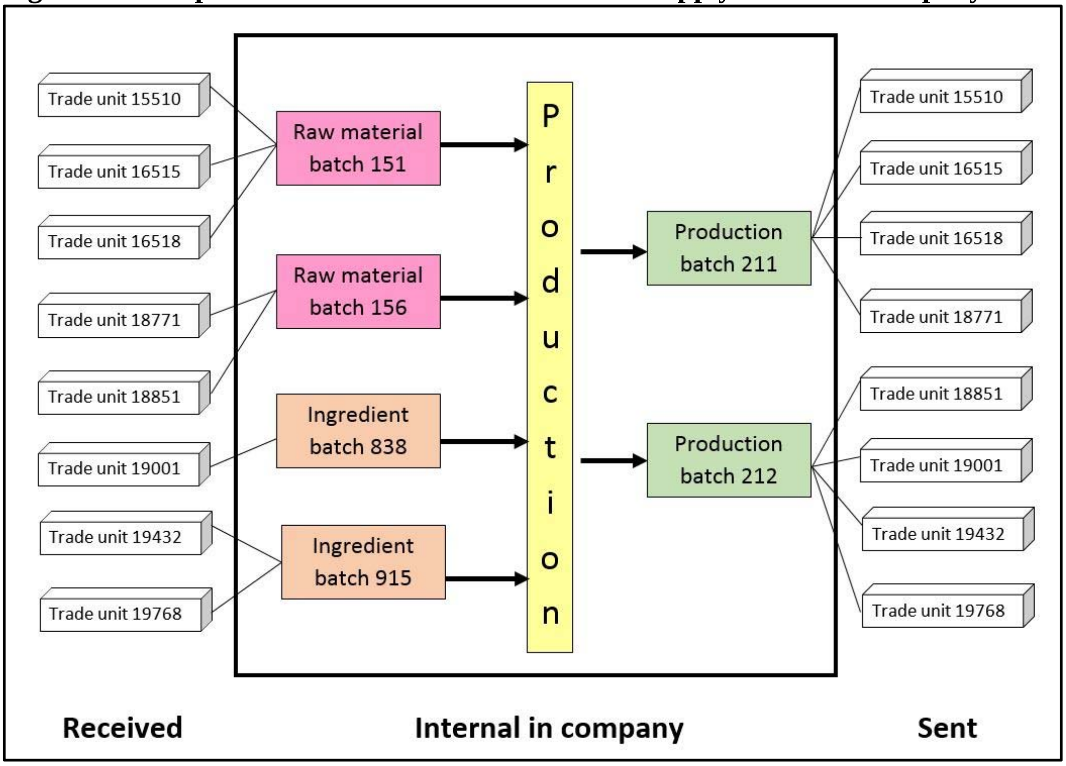
3.1.1.1. Batch

A common dictionary definition of “batch” or “lot” is “the quantity of material prepared or required for one operation” (Farlex, 2015). In seafood supply chains, the following common terms are used: “raw material batches” (the fish component), “ingredient batches” (other components) and “production batches”. “Batch” is an internal term for a given 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 provided that the company knows what constitutes a given batch (see Figure 3).

3.1.1.2. Trade unit

Trade Unit (TU), or Trade Item, is a quantity of material (e.g. fish product) that is sold by one trading partner to another. Incoming TUs 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 that is 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 TUs. TUs must be explicitly labelled and identified by the producing/selling company so that the receiving/buying company can identify the content. It is not uncommon for TUs to be identified by the (production) batch number they belong to. This makes traceability more difficult and less effective, because numerous trade units will then have the same identifier. Unique identification of TUs requires more work, but it makes traceability easier and is becoming more common in companies with effective traceability systems (see Figure 3).

Figure 3. Example of batches and trade units in the supply chain of a company



Source: TraceFood (2008).

3.1.1.3. Traceable resource unit

A traceable resource unit is "the unit that one wants to trace" or "the unit that one records information on in a traceability system". Here, traceable resource unit (TRU) is a common term used for all types of batches and TUs.

3.1.1.4. Granularity

Granularity depends on the physical size of the TRU; the smaller the TRU, the smaller the granularity. When implementing a traceability system, companies must decide on the granularity they want. A fish processing company can typically choose whether they assign a new production batch number every day, every shift (e.g. 2–3 times per day) or every time they change raw materials (e.g. 1–20 times per day). The lower the granularity, the more TRUs they 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.

3.1.1.5. TRU identifiers and uniqueness

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 are mutually agreed between trading partners, often with reference to standards. The identifiers must be unique in their context so that there is no risk of the same identifier accidently being assigned twice. Ensuring uniqueness internally in a company is not too difficult; most companies have defined some coding schemes (normally used on batches) that ensure that, within that company, the same identifier is not used twice. Ensuring uniqueness when many trading partners are involved (typically for TUs) is more difficult; often the most convenient solution is to use globally unique identifiers, which are often constructed by combining country codes with company codes that are unique within the country in question, and using this number as a prefix for the company-specific codes.

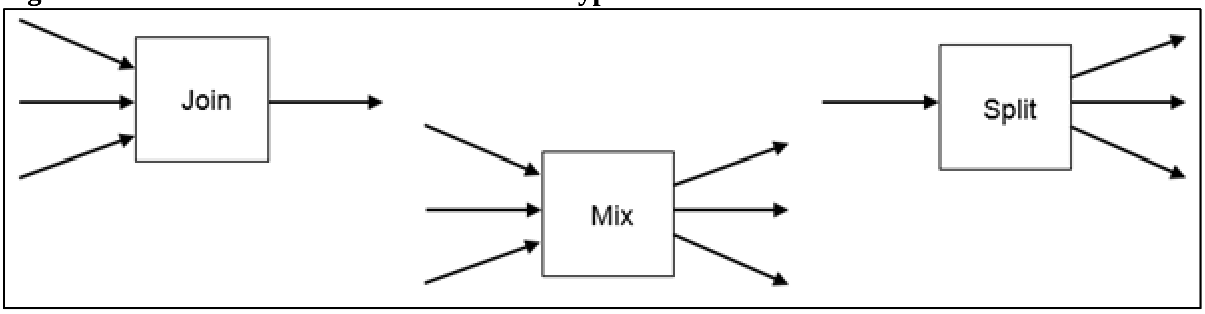
3.1.1.6. *Referential integrity*

While the TRU must be unique within its context, practice differs in relation to whether this unique identifier can only be assigned to one TRU, or whether the same unique identifier can be applied to multiple TRUs. The first practice is referred to as “referential integrity”, or the licence plate (or person number) principle. If referential integrity is present, then each TRU will have its own unique identifier, not to be shared with any other TRUs. If referential integrity is absent, this will limit the effectiveness of the traceability system. Even if the identifier “B12345” is unique in a given context and has a number of properties associated with it (e.g. vessel name, catch date, production date), referential integrity is lost if that same identifier is used for more than one TRU. While all of these TRUs will still have the original set of properties in common (e.g. they all came from the same vessel and were caught and processed on the same dates), it is not possible to distinguish between TRUs, nor to record further properties related to each TRU (e.g. date/time and location, date/time and temperature). It is not uncommon in the captured fish industry to use the internal production batch number as the identifier for each TU that is generated and sold; however, this does not provide referential integrity. Traceability systems that are not based on referential integrity may be simpler (shorter codes) and cheaper (less generation of codes, less reading of codes), but they will inherently suffer from the limitations indicated, and there will be numerous potentially relevant TRU properties that these systems can never keep track of.

3.1.1.7. *Transformation*

New batches and new TUs are created at specific times, typically when fish are caught or received, when processes generate products in a given time period, or when existing TRUs are split up or joined together (Figure 4). When new TRUs are generated based on existing ones, this is called a “transformation”; typical transformation types are merges, splits and mixes. To document a transformation, one needs to document exactly which existing batches or TUs were used to create a new batch or TU; often it is also relevant to record the amounts or percentages used. Trade units are often smaller than the internal batches; i.e. received TUs are often joined together to make raw material batches. A typical example of a transformation is when the incoming TU is “the fish of a given type bought from a given vessel at a given time” and the raw material batch is “the fish of a given type (and possibly size) used as raw material on a given day”. Another typical example of a transformation is when the production batch is “everything produced of a certain product on a certain day” and the outgoing TU is “a box or container of a certain weight, generated from that production batch”.

Figure 4. Batches/trade units transformation types



Source: TraceFood (2008).

3.1.1.8. *Traceability*

There are numerous definitions of traceability, most of which are recursive in that they define traceability as “the ability to trace” without defining exactly what “trace” means in this context. An attempt to merge the best parts of various existing definitions while avoiding recursion and ambiguity was made by Olsen and Borit (2013), who defined traceability as “[t]he ability to access any or all information relating to that which is under consideration, throughout its entire life cycle, by means of recorded identifications”. This emphasizes that any information can be traced, that traceability applies to any sort of object or item in any part of the life cycle, and that recorded identifications need to be involved. The latter requirement is important with respect to differentiating between traceability and traceability control mechanisms; i.e. methods and instruments that measure biochemical properties of the food product and used for authentication and testing whether what is received is what is indicated in the documentation.

Traceability depends on recording all transformations in the chain, explicitly or implicitly. If all transformations are recorded, one can always trace back or forward from any given TRU to any other one that comes from (or may have come from) the same origin or process. In addition, traceability requires relevant information to be recorded and associated with every TRU in the supply chain, so that not only can one find where a given TRU came from (the "ancestors") or went to ("the progeny"), but also the properties of all of these TRUs (when and where was it created, weight or volume, what form is it in, what species, fat content, salt content, etc.).

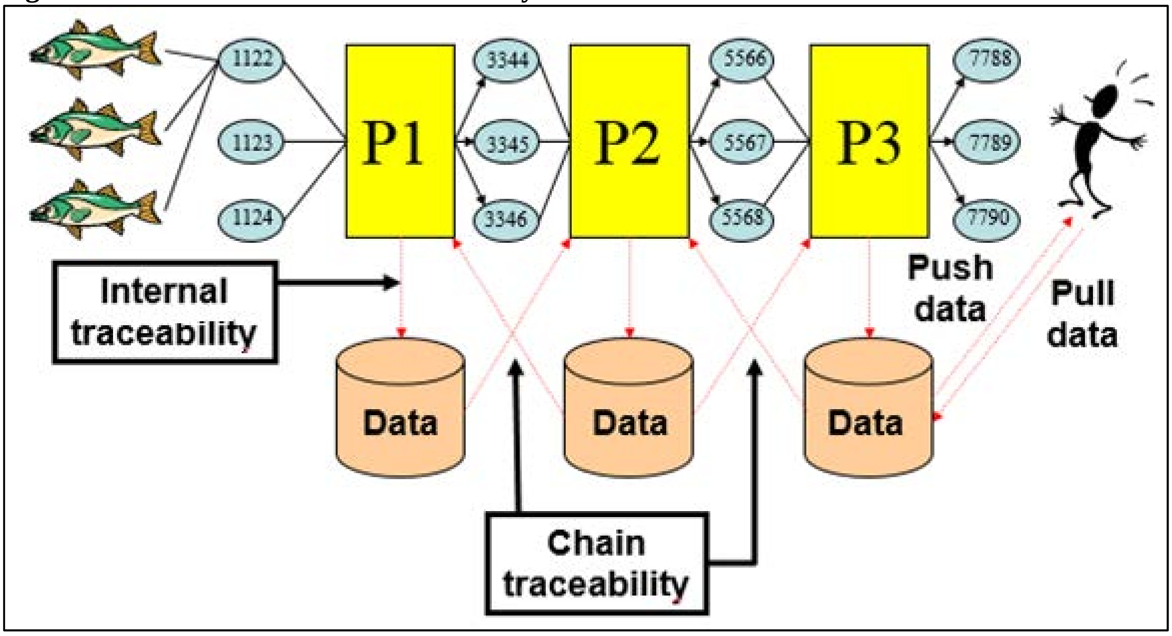
3.1.1.9. Internal traceability

Internal traceability is the traceability within a link or a company (Figure 5). On a fishing vessel, the first step is recording information related to the catch; in the other links, the first step is recording information related to the received TUs. Subsequently, information on all the other internal steps must be recorded, including all transformations that take place and all relevant properties related to internally generated batches or TUs. Internal traceability is the backbone of traceability; all else depends on each company in the chain having good systems and good practices with regard to recording all the relevant internal information. Internal traceability mainly deals with batches, but the relationship between incoming TUs and raw material (or ingredient) batches must be recorded, as well as the relationship between production batches and outgoing TUs. Internal traceability is the domain and responsibility of a single company; data confidentiality or access is not a major issue; and several good systems, solutions, practices and standards have been developed in this area.

3.1.1.10. Chain

Chain traceability is the traceability between links and 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 (Figure 5). Data can be transmitted in various ways; the simplest being by physically (on the label) or logically (in accompanying documentation) attaching the information to the product when it is sent. A more flexible way of implementing chain traceability is for trading partners to agree on how to identify the TUs and then send the required information through another channel (fax, mail, through electronically integrated systems) while referring to the TU in question. This is commonly referred to as "information push"; as the amount of data grows ever larger, the "information pull" also gains popularity as a way of implementing chain traceability. This occurs when the trading partners agree that the seller should retain and make available information on request about the TU in question; the request could be submitted by telephone or fax, but in modern electronic systems, this functionality is typically accomplished by trading partners sharing an intranet, where the supplier provides detailed data on all TUs, and the buyer can extract whatever data is needed. Chain traceability is much more complex to achieve, because it requires the cooperation and agreement between at least two (in practice more) companies, and data confidentiality and levels of access are a major issue. Chain traceability is often closely related to Electronic Data Interchange (EDI), which in turn depends heavily on the agreement on, and adoption of standards, with respect to media, identifiers, content and structure of the data that are to be exchanged.

Figure 5. Internal versus chain traceability



Source: TraceFood (2008).

3.1.2. Traceability systems

Traceability systems are constructions that enable traceability; they can be paper-based, but more and more commonly, they are computer-based. Specialty literature contains several detailed descriptions of traceability systems in various food sectors, and there seems to be a general agreement over what properties these traceability systems could or should have (Olsen and Borit, 2013; Mgonja, Luning and Van der Vorst, 2013). Specialty literature underlines that a traceability system for food products should be able to:

- provide access to all properties of a food product, not only those that can be verified analytically;
- provide access to the properties of a food product or ingredient in all its forms, in all the links in the supply chain, not only on production batch level;
- facilitate traceability both backwards (where did the food product come from?) and forwards (where did it go?) (Olsen and Borit, 2013).

To achieve the above, traceability must be based on systematic recordings and their exchange; there are many relevant properties that will be lost if there is no record-keeping system and a means of distributing/sharing the information. In practice, a unit identification system or numbering scheme must be present; without it, one cannot achieve several of the goals listed above. Accordingly, as indicated by Olsen and Borit (2013), in a supply chain, a traceability system must have the following properties:

1. *Ingredients and raw materials must somehow be grouped into units with similar properties, what Moe* (1998) and *Kim, Fox* and *Grüninger* (1999) *refer to as "traceable resource units".*
2. *Identifiers/keys must be assigned to these units. Ideally these identifiers should be globally unique and never reused, but in practice traceability in the food industry depends on identifiers that are only unique within a given context (typically they are unique for a given day's production of a given product type for a given company). Expanding on this issue is beyond the scope of this paper; see Karlsen, Donnelly, and Olsen (2011) for a more detailed discussion.*
3. *Product and process properties must be recorded and either directly or indirectly (for instance through a time stamp) linked to these identifiers.*
4. *A mechanism must exist to get access to these properties.*

Granularity and whether to have referential integrity or not are important aspects when implementing point 2 above. The recordings mentioned in point 3 must include the documentation of transformations; i.e. the recording of exactly which previous TRUs were used to construct this one (and which subsequent TRUs this TRU in turn became part of). If the transformations are not recorded, it will not be possible to track the TRU along the entire supply chain, and an important aspect of traceability is lost. The mechanism mentioned in point 4 depends on whether it is a company or a chain. A company has an internal traceability system; often software with ample opportunity for browsing data, visualizing dependencies (which TRUs were based on which TRUs), and creating reports. Acquiring such functionality for a whole supply chain is the major challenge, and requires effort, motivation and cooperation, in addition to the presence of technical solutions that build on well-proven and widely adopted standards. Verification and validation of the data in the traceability system is also very important, but these are external processes and not part of the traceability system.

3.1.3. Drivers of traceability systems

Not all traceability systems are equivalent and/or interchangeable, nor can they necessarily be consolidated. Different purposes/drivers also trigger different expectations in producers and consumers that do not always correspond to the traceability system in use (regulatory, contractual or voluntary) (Borit, 2009). Table 1 summarizes different characteristics of traceability systems, including drivers for implementing them.

Table 1. Traceability systems: purpose/driver, objective, attributes, standards and examples

Purpose/Driver	Objective	Attributes	Standard	Example
Safety	Consumer protection (through recall and withdrawal)	Specified in food and fish safety regulations	Mandatory	EU regulation
			Voluntary (1)	US regulation
Security	Prevention of criminal actions (through verifiable identification and deterrence)	Specified in security regulations	Regulatory (2)	US Prevention of Bio-terrorism, regulation
		Verification of selected attributes on package and/or	Voluntary (no common standard)	Brand and product protection
Regulatory quality	Consumer assurance (through recall and withdrawal)	Specific attributes included in regulations	Regulatory (3)	European Commission labelling, mandatory consumer information.

Table 1. (continued)

Purpose/Driver	Objective	Attributes	Standard	Example
Non-regulatory quality and marketing	Creation and maintenance of credence attributes	Specific attributes included in public standards	Voluntary (common standard) (4)	Public Quality seals (e.g. Label Rouge, France) Organic fish, eco-labelling
Food chain trade and logistics management	Food chain uniformity and improved logistics	Specific attributes required to food and services suppliers by contract	Private standards (4)	Own traceability systems (e.g. Walmart)
			Public standards for encoding information	EAN.UCC 128 (5) (e.g. with TRACEFISH (6) standard) SSCC (7)
Plant management	Productivity improvement and costs reduction	Internal logistics and link to specific attributes	Voluntary (internal traceability; own or public standards)	From simple to complex IT systems.
Documentation of sustainability	Natural resource sustainability	Specified in environmental protection regulations	Mandatory	EU IUU Regulation
			Voluntary	FAO International Plan of Action to Prevent, Deter and Eliminate Illegal, Unreported and Unregulated Fishing (IPOA-IUU) (8)

Notes:

(1) Recall and withdrawal compulsory if a responsible company does not take action.
(2) Includes the possibility of mandatory disposal, recall and withdrawal, legal and police actions, but primary purpose is prevention.
(3) Includes the possibility of mandatory disposal, recall and withdrawal, and administrative actions, but primary purpose is consumer assurance.
(4) Could include voluntary (contractual) recall and withdrawal, and agreed (contractual) sanctions.
(5) GS1 System standardizes bar codes (www.GS1.com).
(6) EAN.UCC: European Article Numbering-Uniform Code Council.
(7) TRACEFISH, “Traceability of Fish Products” (EC-funded project) (www.tracefish.org)
(8) SSCC: Serial Shipping Container Code (UCC)
(9) IPOA-IUU: International Plan of Action to Prevent, Deter and Eliminate Illegal, Unreported and Unregulated Fishing.

Sources: Lupin (2006); Borit (2009).

3.1.4. Traceability and transparency

As indicated in the specialty literature, being directly linked to trust building among stakeholders, transparency is a critical element in risk communication (Hofstede, 2004; Renn, 2008). 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 (Hofstede, 2004). However, transparency and traceability are not the same, because the latter only sets the framework for the former (Egels-Zandén, Hulthén and Wulff, 2014). Depending on whether transparency is aimed at the past, present or future, it can be divided in three types: history, operations and strategy transparency (Hofstede, 2004). With respect to products, traceability can enable the first two types of transparency, because it addresses the past and the present of the product (Borit, 2016). A good traceability system can provide product-related information to stakeholders with little loss, noise or delay, but with respect to distortion, it must be recalled that a traceability system basically contains mostly unverified claims, and to ensure transparency, data verification mechanisms are also needed. A traceability system can provide a coherent overview of all the raw materials, ingredients, transformations, processes and products in the supply chain and one cannot really have transparency without traceability, but for transparency, some other components are also needed. This is related to the fact that the concept of traceability is rather generic and could be summarized as "keep a record of what you are doing in the chain", whereas transparency has a specific application and target audience in mind. One measure to improve transparency is to establish or identify authoritative data sources, including a global record of fishing vessels (Expert Panel on Legal and Traceable Wild Fish Products, 2015).

3.1.5. Traceability and chain of custody

In the context of documenting fish products, FAO defines *chain of custody* (CoC) as:

The set of measures which is designed to guarantee that the product put on the market and bearing the ecolabel logo is really a product coming from the certified fishery concerned. These measures should thus cover both the tracking/traceability of the product all along the processing, distribution and marketing chain, as well as the proper tracking of the documentation (and control of the quantity concerned) (FAO, 2009a).

Hence, while traceability and CoC to some degree have the same goal (well-documented fish products), their approach is rather different.

Traceability is generic and non-discriminatory; the company receives TUs (or fish from the ocean where the catch is identified in a similar way as a TU), splits, joins or merges TUs into raw material batches (e.g. by grading), makes production batches based on the raw material batches, and finally splits the production batches into outgoing TUs. At each stage, a spilt, join or merge can take place, which will be recorded in the traceability system so that all transformations and dependencies are documented. The golden rule in a traceability system is that "you can do 'anything' (as far as the traceability system is concerned), but you must document what you are doing".

With ecolabel type CoC, there is one particular set of properties that it is desired to protect, retain and document (e.g. ecolabels such as dolphin-safe; organic) while other sets are not given importance. The ecolabel in question will normally provide the list of required values for the properties in question (e.g. a given species, a given gear type, a given area or fishery, documentation of various aspects of sustainability) and also assign the CoC identifier. This CoC identifier applies to all fish products produced by a company that satisfy the given set of properties, which may include fish from different vessels caught on different days. The golden rule in a CoC system is that "you can only mix units that have the same CoC number, and if you do so, the CoC number is retained".

The main differences between traceability and CoC are summarized in Table 2. In theory, the two terms might mean very much the same thing, but in practice, in the fish industry, there is a difference between traceability and ecolabel type CoC (Borit and Olsen, 2012), as outlined above.

Table 2. Main differences between traceability and chain of custody

	Traceability	**Ecolabel type chain of custody (CoC)**
Of what?	Anything	With respect to some property
Unit with integrity	The trade unit	The units with the same CoC identifier
Mix/join units	Must document	Only with the same CoC identifier
After mix / join	New unit and new identifier created	Considered same unit, CoC identifier

Certification is the procedure by which a certification body gives written or equivalent assurance that a product, process or service conforms to certain standards (FAO, 2009b). While being two different processes, traceability can be used as a tool in the certification process. Documentation of CoC is part of what is required for certification, especially certification related to use of ecolabels.

3.1.6. Traceability and catch/trade documentation schemes

The definition chosen for traceability in this study is "[T]he ability to access any or all information relating to that which is under consideration, throughout its entire life cycle, by means of recorded identifications" (Olsen and Borit,2013). There are numerous mandatory and voluntary catch/trade documentations schemes (CTDSs) in use around the world, and while they have properties in common with a traceability system, they do not in themselves constitute traceability systems. CTDSs do 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). In addition, CTDSs 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 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. Indeed, CTDSs are important in relation to traceability. First, an efficient traceability system will, to a large degree, automate the generation of the CTDS when needed, hence, time and effort related to the production of the CTDS can be significantly reduced for companies with efficient traceability systems, and this in turn provides a driver for investing in traceability. Second, the information on the CTDS can serve as input to traceability systems that receive the product in question, and its data will be in standard format and often be mandatory, which in turn improves the quality of the data available later on in the chain.

3.1.7. Traceability and analytical methods

Currently, there are a multitude of analytical methods and instruments in use to measure certain physical and biochemical properties of food products, such as DNA fingerprinting (Ogden, 2008), spectroscopy (Ottavian *et al*., 2012) and magnetic resonance (Masoum *et al*., 2007). These analytical methods do not provide traceability; practically all definitions of traceability (including the one chosen in this study) indicate that traceability must entail some historical record keeping. While analytical methods only provide instantaneous measurements, some of these measurements can indeed provide useful and relevant information about the product and process history. Most of the data in a traceability system can be considered to be claims, most of which have no inherent verification connected to them beyond the fact that someone somewhere in the supply chain once entered the data value and implicitly claimed it to be a true property of the TRU in question. However, false claims do occur, both because of errors and because of deliberate fraud, often for economic reasons. Analytical methods are essential with respect to verifying (or falsifying) claims in the traceability systems, especially if a dispute or a court case is involved, as is frequently the case after food safety incidents. 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 the identity of the 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 (Olsen and Borit, 2013). To verify claims and to detect fraud in these areas, paper-trail-based methods are needed; the most common are mass balance accounting, which detects unusual claims in relation to yield for a given process), and input-output analysis, which detects the mismatch between output stated in one place and corresponding input stated in another place.

3.1.8. Traceability and 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 (Borit, 2016). Traceability can be imagined as an infrastructure that can be used by control agencies for retrieving different data for various reasons (e.g. quality assurance) or for verifying these data with their specific means (e.g. genetic identification of species) (Borit and Santos, 2015). As previously mentioned in the specialty literature, "A traceability system is quite similar to a filing cabinet in that they both deal with systematic storing and retrieving of data. Importantly, neither a traceability system nor a filing cabinet care about what types of data are being stored" (Olsen and Borit, 2013). Fraud and error can falsify recordings or render them incomplete; thus, the need to verify these claims becomes obvious. Here, together with comprehensive inspections and certification, analytical methods play an important role (Kelly *et al.*, 2011).

3.2. Harmonization and standardization

Standards are closely connected to chain traceability, because the latter requires trading partners to exchange a large amount of information. Unless the partners agree in great detail about what everything means and how it should be structured and represented, information loss is bound to occur. It would not make sense for two trading partners to establish their own specifications for exchanging information, because of the unnecessary work involved and because they both would have numerous suppliers and customers. Making separate agreements with all of them would not be feasible. In principle, the internal traceability in a company can be effective without resorting to standards, but it is the recording in the internal traceability system that provides the data that are exchanged in the chain traceability system, which must be in standard format if the trading partner is to understand them.

To support the data interchanges that chain traceability builds on, standards are needed on many levels:

- **TRU identification.** All TRU identifiers must be unique within the given context, and if the given context involves several companies and countries, the best way to ensure uniqueness is to use an internationally agreed upon standard for generating globally unique TRU identifiers. GS1 is the most relevant organization for unique identifiers on a global level in general, but there are also other alternatives.
- **Physical media for codes and numbers, especially on labels.** In addition to the obvious "clear text" option, there are, among others, bar codes, two-dimensional bar codes, QR-codes and radio-frequency identification (RF-ID) tags (active and passive). The trading partners must agree on what physical media to use. The supplier must have equipment suitable for generating this media type and the buyer must have equipment and take the time needed to read these codes. Internationally agreed upon standards exist for all these media types, however, uptake of the more advanced technologies (RF-ID in particular) have been far slower than anticipated, probably due to cost and lack of motivation in large parts of the seafood stakeholders.
- **Electronic data interchange,** especially based on various types of eXtensible Markup Language (XML) messages. Various internationally agreed upon standards exist, and their use is increasing, to some degree driven by the obligatory use of similar standards in some business situations. (For example, some states have made the use of these standards obligatory when submitting bids for government contracts.)

- **Data element names.** This is an area where there have been fewer attempts at standardization; ISO 12875 and ISO 12877 are among the exceptions. Most of the electronic standards are based on XML, and the "eXtensible" part of XML allows XML to be used to exchange data elements that have not been pre-defined. While this is a good and flexible approach, it does not, in reality, facilitate traceability. When data are recorded somewhere in the seafood supply chain, a value is generated (e.g. "198"), often a unit of measurement (e.g. "grams"), and these attributes are then associated with a data element name (e.g. "weight"). However, transmitting the information, for example, that "weight is 198 g" does not in itself facilitate traceability; the recipient needs to know what this refers to, the weight of what, and how, when and where it was measured. To facilitate efficient and error-free communication, there is clearly a need for trading partners to agree on what the data element names should be, and exactly what they should refer to. This is what standards for data element names are used for; they are like commonly agreed upon dictionaries (ontologies) detailing exactly what all the terms mean and how they are interrelated.

There are a number of standards on the above levels; some for products in general, others for food products, and others still, for seafood in particular. In addition, there are implicit and explicit traceability requirements in standards and in regulation where traceability is not the main focus, but rather food quality, food safety, food processing, or similar. Ideally, it can be argued that the standards should be merged or at least harmonized, but in practice this is an unrealistic goal precisely because the scope of the standards varies greatly. Also, the major challenge in implementing traceability is not the fact that there are overlapping or conflicting standards and that conversions are needed, but rather, that standards are not used (or used too little) when designing the food industry systems and practices.

According to the Expert Panel on Legal and Traceable Wild Fish Products (2015), some of the measures to maintain integrity of product tracking and for improving standardization are: the adoption of minimum information standards for wild-caught fish products; establishment of a harmonized system of "landing authorizations" to provide primary assurances of the legal origin of fish products; and the development of a global architecture for interoperability systems.

3.3. Consistency

From a norms perspective, "coherence" refers to "positive connections" or "the construction of a united whole", while "consistency" refers to the absence of contradiction (Hillion, 2014). The latter refers to ideas of compatibility and of making good sense, whereas the former relates more to synergy and added value. "Hence, coherence in law would be a matter of degree, whereas consistency would be a static notion in the sense that concepts of law can be more or less coherent but cannot be more or less consistent. They are either consistent or not" (ibid.). From a theoretical point of view, the meaning of norms consistency has been refined as horizontal consistency and vertical consistency. The latter applies, for example, to the relations between the Member States and the European Union (EU), while the former focuses on implementation and refers to consistency at the EU level, either inter-institutional or inter-policy (Minkova, 2011). In terms of this second aspect, consistency can be defined as "the way in which the substance of different policies generated by the EU forms part of whole" (Portela and Raube, 2008). Nevertheless, the application of the consistency principle has to be flexible enough for regulatory approaches to change due to changes in the context, for example, the change in the EU regulatory regime for food as a consequence of the mad cow disease (Vos, 2000). Yet another important aspect is that norms are not only formulated, but also applied in a consistent manner (Cody and Stretch, 2014).

Building on these aspects, this study uses the following concepts:

- *intra-institutional regulatory consistency*, which refers to the different norms generated by the same institution form part of a whole;
- *inter-institutional regulatory consistency*, which refers to the use of similar concepts and procedures for related items by different entities in the same industry.
- *application consistency*, which refers to the similar application of the same norms.

One important consequence of the lack of regulatory inter-institutional consistency is fragmentation (i.e. the increased proliferation of standards and norms with overlapping jurisdictions and ambiguous boundaries), which can lead to forum shopping (Benvenisti and Downs, 2007), confusion among industry and consumers alike (Borit and Santos, 2015), as well as delay in the development of valuable products and services (Mandel, 2004) that could facilitate implementation of traceability.

4. OVERVIEW OF EXISTING TRACEABILITY STANDARDS AND REGULATIONS

Previous analysis of traceability practices (Andre, 2013) identified three main categories of traceability standards and regulations that this study also follows: international standards and guidelines, regulatory standards, and industry and 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.

4.1. International standards and guidelines

Inter-governmental guidelines: International standards and guidelines are developed to define and/or to provide best practices in tracing food products through supply chains. This category includes standards and guidelines developed by the Regional Fisheries Management Organizations (RFMOs) and other natural resource management inter-governmental organizations in their aim to provide guidance to their member states in dealing with illegal, unreported and unregulated (IUU) fishing (ibid.).

4.1.1. The Codex Alimentarius

The *Codex Alimentarius*, or "Food Code", 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 (WHO and FAO, 2015). The Codex defines traceability as “the ability to follow the movement of a food through specified stage(s) of production, processing and distribution” (Codex Alimentarius Commission, 2006). This definition reduces traceability to following movement of food products only. The Codex Alimentarius is recognized by the World Trade Organization as an international reference point for the resolution of disputes concerning food safety and consumer protection, so its traceability definition is of special importance, even though it is not commonly referred to, at least not in scientific articles (Olsen and Borit, 2013). The Codex Alimentarius recognizes that, at the international level, methods are not harmonized and are often complicated, thus also leading to barriers to trade (Codex Alimentarius Commission, 2007). The approach to traceability taken by the Codex Alimentarius is considered insufficient by the specialty literature, because it does not incorporate essential properties of traceability systems (Olsen and Borit, 2013).

4.1.2. The International Office of Epizootics

The *World Organisation for Animal Health (OIE) Aquatic Animal Health Code (the “Aquatic Code”)* 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. The health measures in the Aquatic Code should be used by the Competent Authorities of importing and exporting countries for early detection, reporting and control of agents that are pathogenic to aquatic animals and for the prevention of their transfer via international trade in aquatic animals and their products, while avoiding unjustified sanitary barriers to trade (OIE, 2005). OIE supports its Member Countries and Territories in implementing animal identification and traceability systems in order to improve the effectiveness of their policies and activities relating to disease prevention and control, animal production food safety, and the certification of exports. The Aquatic Code 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 (Andre, 2013).

4.1.3. FAO guidelines

4.1.3.1. Marine capture fisheries – ecolabelling

The *FAO Guidelines for the ecolabelling of fish and fishery products from marine capture fisheries* (2009) summarize several principles that should be observed by ecolabelling schemes. These guidelines cover the fishery management system, the status of the target stock and ecosystem considerations, with the overarching purpose of identifying sustainable fisheries (Andre, 2013). Paragraph 16 of the Guidelines states that the CoC measures designed by the ecolabel "should cover both the tracking/traceability of the product all along the processing, distribution and marketing chain, as well as the proper tracking of the documentation (and control of the quantity concerned)". However, even though in theory the two terms might have the same meaning, in practice, in the industry, there is a difference between traceability and ecolabel-type CoC.

4.1.3.2. Aquaculture – certification

The *FAO Technical guidelines on aquaculture certification* provide guidance for the development, organization and implementation of credible aquaculture certification schemes (FAO, 2011). The guidelines addresses a range of issues that should be considered relevant for certification in aquaculture, including: (i) animal health and welfare; (ii) food safety; (iii) environmental integrity and (iv) socio-economic aspects associated with aquaculture (Andre, 2013). These guidelines state that one of the principles of aquaculture certification schemes is that they should include adequate procedures for maintaining CoC and traceability of certified aquaculture products and processes. This study has the same approach to traceability and CoC as in the ecolabelling guidelines.

4.1.4. RFMO catch/trade documentation schemes

RFMOs are international organizations formed by countries with fishing interests in areas beyond national jurisdiction (ABNJs). Some of them manage all the fish stocks found in a specific area, while others focus on particular highly-migratory species, notably tuna, throughout vast geographical areas. While some RFMOs have a purely advisory role, most have management powers to set catch and fishing effort limits, technical measures, and control obligations (European Commission, 2015). Almost all of the global high seas are now covered by at least one RFMO out of the 18 current Fisheries Management Bodies (Cullis-Suzuki and Pauly, 2010). Of these, five are the tuna RFMOs, which manage fisheries for tuna and other large species such as swordfish and marlin (The PEW Charitable Trusts, 2012). As part of their fight against IUU fishing, RFMOs are using catch and trade documentation schemes. These schemes are important fisheries management tools, but are not designed as traceability systems for markets/consumers (Clarke, 2012). For a detailed analysis of these CTDSs and seafood traceability, see MRAG (2010).

4.2. Regulations

Binding norms (Andre, 2013)**:** A second category is formed by the binding norms that are set by particular countries, that are broadly applicable to food products and more specifically to fish products, and that are mandatory for export to the European Union (EU), the United States of America and Japan. They include laws, regulations and associated enforcement programmes for traceability of fish products. These norms set the minimum traceability requirements for all trading of food products, as well as fish-specific requirements focused on preventing trade in illegally caught fish (ibid.).

4.2.1. European Union (Member Organization)

According to Lavelli (2013), the EU legislature works with two different models with respect to food traceability. The model implemented through the application of the General Food Law (European Commission, 2002) leads to a generic (non-specific) low-warranty traceability of the EU food supply chain. A second, more complex model is followed in norms regulating products such as those derived from genetically modified organisms. The application of this second model leads to a specific, high-warranty traceability system for any product unit in the food supply chain. In general, the EU traceability systems are considered insufficient (van Ruth, 2014)

According to Article 18 of the European Commission Regulation 178/2002 laying down the general principles and requirements of food law, establishing the European Food Safety Authority and laying down procedures in matters of food safety (usually referred to as the General Food Law, or GFL), the legal requirements rely on the "one step back – one step forward" approach to traceability. This approach implies that food business operators have to establish two types of links: a link "supplier-product" (which products supplied from which suppliers); and a link "customer-product" (which products supplied to which customers). Nevertheless, operators do not have to identify the immediate customers when they are final consumers. The Regulation does not expressly constrain operators to establish a link "incoming and outgoing products" ("internal traceability"). Thus, there is no requirement for records to be kept that identify how product batches are split and combined within a business to create particular products or new batches (European Commission, 2010). Companies therefore have to know where the ingredients came from and where the products went, but not necessarily which ingredients went into which products (Van Der Meulen and Van Der Velde, 2008). Being a regulation, this piece of legislation was directly applicable in the legislation of the Member States, without transposition. The approach to traceability taken by the EU GFL is considered non-effective by the specialty literature (Borit and Santos, 2015).

Following the principles of the FAO International Plan of Action to Prevent, Deter and Eliminate Illegal, Unreported and Unregulated Fishing (IPOA-IUU), in 2008 the EU adopted new fisheries regulations, specifically designed to address the IUU fishing problem: the EU IUU Regulation 1005/2008 (Renn, 2008) (and its Implementation Regulation 1010/2009) and the EU Control Regulation 1224/2009. Both norms sought to ensure full traceability from the fishing net to the plate of all marine fishery products. This was hoped to be achieved by means of a catch certification scheme. This approach to traceability is also considered non-effective by the specialty literature (Borit and Santos, 2015).

Detailed description and analyses of the EU legislative framework related to traceability can be found in Andre (2013), Borit (2016), Borit and Olsen (2012); Borit and Santos (2015) and Charlebois *et al.* (2014).

4.2.2. United States of America

The United States has traceability regulations pertaining to livestock identification and movement, and generally lacks regulations on other agricultural commodities; however, it has identification and labelling regulations on packaged food products. In 2011, as a part of the Food Safety Modernization Act (FSMA), the United States Department of Agriculture introduced Animal Disease Traceability requirements. Despite the passage of the FSMA and the opportunity to strengthen traceability, the United States still lacks regulations on national traceability of food products in general. While the new FSMA is expected to improve food traceability capabilities, the development of regulations is still in the early stages (Charlebois *et al*., 2014). The United States federal food safety oversight is considered to be fragmented (Zach *et al*., 2012).

One of the latest developments in the United States regarding IUU fishing and traceability is the establishment of a Task Force to identify and develop a list of the types of information and operational standards needed for an effective seafood traceability programme to combat seafood fraud and IUU seafood in US commerce (Presidential Task Force on Combating IUU Fishing and Seafood Fraud, 2014). This traceability programme will be risk-based and will be developed through "notice-and-comment rulemaking", i.e. a common rulemaking procedure under which a proposed rule is published in the Federal Register and is open to comment by the general public. This rulemaking will address data requirements, the design of the programme, and the species to which the first phase of the programme will be applied (National Oceanic and Atmospheric Administration, 2015).

A detailed description and analyses of the US legislative framework related to traceability can be found in Charlebois *et al*. (2014) and Andre (2013).

4.2.3. Japan

Japan has established traceability systems for animals and animal products (e.g. cattle and beef), but only for a few foods and other commodities (e.g. rice) (Charlebois, 2014). Guidelines for developing traceability systems are being established by industry associations rather than by national legislature. For example, the Japanese Handbook for Introduction of Food Traceability Systems is a set of guidelines for the traceability of commodities such as fruits and vegetables, shellfish, eggs and farmed fish.

A detailed description and analyses of the Japan legislative framework related to traceability can found in Andre (2013) and Charlebois *et al*. (2014).

4.3. Non-regulatory standards

Parallel to the above-mentioned standards and norms, commercial standards have been delivered by organizations and associations to set traceability requirements, facilitate data sharing and adopt product identification standards for commercial purposes (Dabbene, Gay and Tortia, 2014). **Non-governmental/industry standards (contractual)** (Andre, 2013)**:** Non-regulatory standards developed by NGOs, industry and other standards, such as the International Organization for Standardization (ISO), are included in a third category. This category include guidelines for auditing and other measures to ensure successful application of the standards.

4.3.1. International Organization for Standardization

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 (Olsen and Borit, 2013). However, this standard was superseded by ISO 9000.

ISO 9000:2000 Quality management systems, ISO 22000:2005 Food safety management systems, and 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 16741/18538:2015 Traceability of crustacean/molluscan products: These standards use a slightly less specific definition of traceability: "[T]he ability to trace the history, application or location of that which is under consideration". In this newer definition, 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." ISO 12875/12877:2011 are generated from the TraceFish standard.

4.3.2. Industry

Several industrial associations have developed their own traceability standards, including: the US National Fisheries Institute; the EU Fish Processors Association and the EU Federation of National Organisations of Importers and Exporters of Fish (AIPCE-CEP); and British Retail Consortium Global Standard for Food Safety Issue 6. For a detailed description and analyses of these initiatives, see Andre (2013.)

4.3.3. Non-governmental organizations

Major leading internationally established fishery/aquaculture certification programmes (e.g. World Wildlife Fund Smart Fishing Initiative, 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. For a detailed description and analyses of these initiatives, see Andre (2013).

5. GAP ANALYSIS RESULTS

5.1. Gaps

Despite the many tools and practices for seafood traceability, approaches remain underdeveloped and fractured across geographies, jurisdictions and market sectors (Sterling and Chiasson, 2014). There are traceability-related gaps with respect to awareness, commitment, implementation, technology and standards. Based on our gap analysis, the most important are indicated below.

Awareness gaps:

- There is a lack of understanding of what traceability is, and how it differs from other concepts that are viewed to be similar, e.g. CoC or catch/trade documentation schemes.
- There is a lack of understanding of how traceability can streamline companies' internal processes and improve financial performance (Sterling and Chiasson, 2014).
- There is a lack of understanding of the fact that many of the main obstacles for adoption of traceability in seafood chains are cultural and organizational rather than technical (ibid.).
- There is a lack of understanding of the fact that traceability needs to cover the entire seafood chains, from catch or farming through all types of processing and transport all the way to the retailer and the consumer. For instance, for fisheries, "*the gaps in the system occur at many levels: at sea, where monitoring, control and surveillance remain frequently inadequate; in ports, where systems to document catch landings are often weak or non-transparent; and in market countries, where effective systems to require traceability and proof of legal origin are lacking* (Pramod, 2014)". This is connected to the lack of understanding (both at government and private sector levels) of the difference between internal traceability and chain traceability. While the former may be effective in a given company, it is the chain traceability the entire supply chain, and a company cannot achieve this alone.
- There is a lack of understanding (both at government and private sector levels) of the importance of documenting transformations, and how the chain of transformations is essential in order to trace backward or forward to a company or through a chain of companies. This relates to the lack of understanding of the importance of referential integrity; it is much easier to document and visualize the chain of transformations if all TRUs have unique identifiers.

Commitment gaps:

The commitment gap with respect to implementing seafood traceability systems is significant, and probably related to the many awareness gaps. While there are still challenges related to availability of technology, solutions and standards, it is clear that most companies have less traceability than they could have, and also probably less traceability than they should have, given their strategy, their priorities and their own economic interests. In addition, the most significant commitment gap is related to companies not understanding how traceability can benefit them financially. There is increasing documentation of the fact that not only can a good traceability system reduce operating costs and fulfil legislative and commercial requirements, but it can also underpin company branding and marketing strategies, and give the company a competitive advantage. A cost-benefit analysis of investments in improved traceability systems is difficult to perform, and credible conclusions in this area are fragmented and anecdotal. However, it is clear that many of the benefits related to improved traceability were not anticipated by the companies in question before the investment. Typically, companies invest in traceability because they are required to either fulfil legislative or commercial requirements to enter markets, and are then surprised to observe that some of the side-effects of their investment in traceability is better industrial statistics, a faster turnover of ingredients, raw materials and products, and a reduced amount of goods in storage. Although these are positive effects, many companies are not aware of them; otherwise, they would have invested in better traceability. This is a major explanation for the industries lack of motivation and commitment to traceability systems.

Implementation gaps:

- There is the gap between regulatory requirements and the feasibility of industry implementation (Zhang and Bhatt, 2014). At the EU level, this might be due to several gaps in traceability requirements (MRAG Asia Pacific, 2012), such as: lack of a robust fishery control-based catch certificate; inadequate document security for split consignments; insufficient maintenance of batch integrity (here referential integrity plays an important role [McEntire *et al.*, 2010]).

Technology gap:

- There is a lack of verification procedures that integrate with monitoring of food authenticity (Sterling and Chiasson, 2014). This lack means that we might be able to follow a product back and forth through the food chain and yet still not have certainty that the product is what it is claimed to be. For example, IUU fish may enter the chain fraudulently, yet once in the supply chain, it is sufficiently traced along the chain.
- There is a lack of cheap, functional and robust radio-frequency identification tags. The time and work involved in reading a number of bar codes is significant, whereas RF-ID tags can be read instantaneously and from a distance. The cost of reading is a very important factor which to some degree prevents the introduction of smaller granularity TRUs, and in particular it makes it expensive to implement referential integrity. RF-ID tags inherently provides referential integrity; no two tags ever have the same identifier, and the quality of the traceability systems will be significantly improved when the bulk of the industry adopts RF-ID tags as common practice.
- There is a lack of cheap, functional and robust technologies for automatic data capture. A significant cost related to the running of a traceability system is the cost associated with initial data entry that is frequently performed manually. It would simplify and accelerate the process, and reduce the number of errors if technologies existed that could automatically extract the relevant data, enter them into the traceability system, and associate them with the TRU in question. This could be partly an implementation gap. To some degree, these technologies exist, but they are underused and they are in general not seamlessly connected to the traceability system.

Standards gaps:

- The analysis of traceability standards and norms revealed a series of inconsistencies, both between the standards/norms issued by the same institution and those issued by different institutions but referring to the same topic.
- There is a lack of uniform requirements or standards for information gathering and sharing that are needed for effective traceability (van Ruth, 2014; Sterling and Chiasson, 2014). This gap to some degree inhibits interoperability of technology systems along the supply chain, increasing business risks and costs when choosing and adopting traceability and information systems.
- There is a lack of a “standardized seafood attribute naming list”. Different countries often have different “seafood attribute lists”, and the use of standards in this area is not prevalent. For instance, in different countries different names can be applied to the same species, or the same name can be applied to different species (Cawthorn *et al*., 2015).

5.2. Inconsistencies

5.2.1. Intra-institutional inconsistency

With respect to EU specific legislation related to traceability, recent research shows intra-institutional inconsistency, because different norms have different approaches to traceability depending mainly on the drivers of the norms. Thus, when the main driver for implementing traceability relates to, or can impact on, human health as opposed to product quality or environmental sustainability, EU legislation normally imposes effective traceability systems (Borit and Santos, 2015). This finding is similar to the conclusion that can be inferred from the analysis performed in Andre (2013) regarding the consistency of the provisions referring to data capture and management requirements for the EU GFL and EU IUU Regulation.

The same type of inconsistency can also be inferred from Andre (ibid.) in the case of FAO guidelines. While the provisions of the two documents are the same for data capture and management requirements, they differ for unique identification requirements and are opposite regarding data communication requirements.

Intra-institutional inconsistency can also be inferred, in the case of transition from ISO 8402 to ISO 9000 and 22005, with the provisions of the newer standards lacking the accuracy of the older one (Olsen and Borit, 2013).

5.2.2. Inter-institutional inconsistency

The traceability systems proposed by Codex Alimentarius, EU GFL, and ISO 8402, 9000 and 22005 lack inter-institutional consistency. As explained in the specialty literature (Olsen and Borit, 2013), they do not refer to traceability in the same way. In addition to the problem of all of these standards and norms using a verb phrase that is either recursive (i.e. traceability means to trace) or vague (i.e. traceability means to follow), there are problems such as: not identifying exactly what the TRUs are (Codex); not indicating which stages of production should be covered by traceability (ISO) or limiting this coverage to specific stages (Codex); not explaining how to trace (all except ISO 8402); and not mentioning what properties should be recorded by the traceability system (EU GFL), or just mentioning only one (Codex).

The same inter-institutional inconsistency can be seen in the three main categories of traceability standards and regulations that this study follows: international standards and guidelines, regulatory standards, and industry and NGO non-regulatory standards. As indicated in Andre (2013), the provisions of international standards and guidelines vary substantially with regard to unique identification requirements and data communication requirements, while they are more consistent with regard to data management and capture requirements. The provisions of the EU, the United States and Japan are consistent with regard to data communication requirements, but are less consistent with regard to unique identification and data capture and management requirements. The provisions of the non-regulatory standards with regard to data capture and management are consistent among documents and with the respective ones from international standards and guidelines, except in the RFMO documentation schemes. The provisions for unique identification requirements and for data communication requirements vary among these non-regulatory standards.

6. CONCLUSIONS

This study was commissioned to identify and analyse gaps and inconsistencies in the current traceability standards and regulations, taking into account the following traceability specifications: (i) how the integrity of product tracking is maintained; (ii) special consideration for developing countries and small scale fisheries; (iii) the notion of equivalency; and (iv) the notion of harmonization. As a first step in reaching this goal, the key terms in understanding the concept of traceability were explained (e.g. granularity, transformations, referential integrity) and the concept was described in connection with related notions (e.g. traceability systems, transparency, analytical methods etc.). The second step consisted in performing a comprehensive literature review on which the gap analysis of the traceability standards and regulations was built. The last step in this study was performing a content analysis of selected international standards and guidelines, regulatory standards, and industry and NGO non-regulatory standards. By employing this multi-method analysis, several awareness, commitment, implementation, technology and standards gaps were identified and described. In addition, specific inter- and intra-institutions inconsistencies were highlighted. Filling in the gaps and addressing the inconsistencies are not easy tasks. Several practical recommendations for action are made in Section 7.

7. RECOMMENDATIONS

- **Increase awareness of what traceability is, how it is different from other concepts that may appear similar to traceability and how traceability may add value to a company or a business.** An important challenge is to communicate to companies that their belief that their traceability systems are good (enough) is only partly true; companies normally only think of their internal traceability when they assess their own capabilities. There are several ways of accomplishing this awareness, such as: writing scientific and popular science articles about traceability; having presentations on traceability in relevant forums, in particular government and industry events; and including traceability in the syllabus both for government and industry training and for relevant academic courses. In most instances, the focus should be on the benefits that traceability provides rather than on the technical details involved when implementing traceability. Previous experience has shown that if motivation is present both at the managerial and operational level in a company, then any technical difficulties will be overcome, and (most often) successful implementation will follow.
- Traceability is now an *à la carte* menu, where a company has to make multiple choices, for instance, on granularity, on whether to have referential integrity, on what data elements to record, on how to name and transmit them, on whether to use a standard, and on what standard(s) to use in that case, and so on. **A self-assessment scheme for seafood traceability would be useful** (whether the user is from a developing or developed country large or small-scale fishery**,** a small company or international enterprise) in which the different alternatives are clearly spelled out, the advantages and disadvantages of each alternative are indicated, and recommendations are made in relation to which selections belonged together, and so on. This would allow companies to make informed decisions before investing, based on their economic constraints and their level of ambition. It would also enable benchmarking between companies, so that a given company could ascertain their current situation, and compare it with where they want to be.
- Standardization and harmonization is a challenge, but the lack of uptake of standards is a bigger problem than the use of conflicting standards. Thus, **raising awareness about the utility of using already existing standards and possible extending/adapting them if needed, rather than creating new systems or standards**.
- A global framework for legal and traceable seafood, especially in the captured fishery sector, has been recommended by some important actors, especially World Wildlife Fund. If the goal is to reduce IUU fishing by making it difficult for products with IUU origin to enter the legal supply chain, such a global framework is a logical recommendation. However, this goal is not the same as the goal of deciding on the optimal level of traceability for a company or a chain. Reducing IUU fishing is an idealistic goal, and more prevention is obviously better (provided that the cost is not too high). Deciding on level of traceability is a pragmatic goal, and there is room both for ambitious companies that regard transparency as part of their branding and that want as good a traceability system as possible, as well as for companies that only want to satisfy minimum requirements. For this reason, a global framework or even a global standard for traceability is less relevant; **various levels of ambition must be supported, and a certain degree of variety and of freedom of choice are needed with respect to how to perform the implementation**. **In this context the point is interoperability. There could be different traceability systems, but they should be able to communicate relevant information without loss of key data.**

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