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ANALYSIS OF GAPS AND INCONSISTENCIES IN THE SEAFOOD TRACEABILITY STANDARDS AND NORMS

Analysis of gaps and inconsistencies in the seafood traceability standards and norms

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Table of Contents

Abbreviations

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

ISO -> International Organization for Standardization

IUU -> illegal, unreported and unregulated

FAO -> Food and Agriculture Organization of the United Nation

FSMA -> Food Safety Modernization Act

NGO -> non-governmental organisation

RF-ID -> radio-frequency identification

US -> United States

TRU -> traceable resource unit

TU -> trade unit

XML -> eXtensible Markup Language

1. Executive summary

This report analyses gaps and inconsistencies in current seafood traceability standards and regulations and generates recommendations based on those findings. The report was commissioned based on a request from the Sub-Committee on Fish Trade (COFI:FT) of the Food and Agriculture Organization of the United Nations (FAO) *"to compile and analyse best practices and existing standards for a range of traceability purposes, including a gap analysis"*[1]. The following principles were highlighted by COFI:FT as a framework for the analysis of traceability systems: *1) not create unnecessary barriers to trade; 2) equivalence; 3) risk-based; and 4) reliable, simple, clear and transparent.* In addition, the authors address the following specifications: 4) how the integrity of product tracking is maintained; 5) special consideration for developing countries and small-scale fisheries; and 6) the notion of harmonization.

As a first step in performing a gap analysis, the key terms in understanding the concept of "traceability" are defined and explained (i.e. granularity, transformations, referential integrity). The concept of traceability is then described in connection with related notions such as traceability systems, transparency, and analytical methods. A comprehensive literature review seeks to identify scientific papers that analysed gaps and inconsistencies in traceability standards and norms to prevent duplication of work and to identify any common methodologies. The gap analysis of existing seafood traceability standards and regulations was built on the findings of this literature review. The last section of the report is a content analysis of selected international standards and guidelines, regulatory standards, and industry and NGO non-regulatory standards. By employing a multi-method analysis, several gaps are identified, namely: awareness, commitment, implementation, technology and standards. In addition, specific inter- and intra-institutional inconsistencies are highlighted in this report.

Recommendations arising from the seafood traceability gap analysis include the need to:

- Increase awareness, both among governments and the private sector, of what traceability is, how it is different from other concepts that may appear similar to it, how traceability may add value to a company and a business, and how traceability can contribute to prevention and elimination of illegal, unreported and unregulated (IUU) fishing;
- Develop a self-assessment scheme for seafood traceability systems where advantages and disadvantages of each alternative are clearly spelled out. Such a self-assessment scheme for traceability systems would be beneficial to all stakeholders, regardless of whether it is used by developed or developing countries, large or small-scale fisheries, etc.;
- Increase uptake among governments and private sector stakeholders of already existing standards (and possibly extending / adapting them to specific needs), as this report finds that the lack of uptake of standards is a bigger problem for seafood traceability than the use of conflicting standards;
- Allow for diversity and variety when it comes to implementation of traceability systems. The key to reducing gaps is interoperability, i.e. there can be different traceability systems but they should be able to talk to one another, and to exchange the necessary information to combat IUU fish entering markets without significant loss of data at critical points along the value chain.

[1] Report of the XIII Session of the Sub-Committee on Fish Trade, Hyderabad, India, 20-24 February 2012.

2. Background

During the Fourteenth Session of the Sub-Committee on Fish Trade (COFI:FT) of the Food and Agriculture Organization of the United Nation (FAO), held in Bergen, February 2014, the FAO member countries reiterated their invitation for FAO to conduct research and analysis of current traceability practices, and in particular a gap analysis of seafood traceability systems. The present study was commissioned by FAO in response to this request. During the Thirteenth Session of COFI:FT, the following terms of reference were provided for analysis of traceability systems:

1. provide an overview of existing traceability standards and regulations[2] [1];
2. provide detailed identification of gaps and inconsistencies in the current standards and regulations, keeping under consideration the following traceability specifications:
    a. how the integrity of product tracking is maintained;
    b. special consideration for developing countries and small-scale fisheries ;
    c. notion of equivalency;
    d. notion of harmonization.
3. include 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.

Methodology utilized for the gap analysis is discussed in Section 3. Section 4 defines the core concepts that are used in the report. Section 5 briefly describes current international standards and guidelines, regulatory standards, and industry and non-governmental organisations (NGOs) non-regulatory standards that are included in this analysis. Section 6 presents the results of the gap analysis. Section 7 contains the concluding remarks, with recommendations summarized in Section 8.

[2] This work was completed by Mr. Vincent Andre (FAO consultant) and presented as an info note to COFI:FT XIV, Bergen "Review and Analysis of Current Traceability Practices", COFI:FT/XIV/2014/Inf.6.

3. Methodology

3.1. General considerations

To address the complexity of a traceability gap analysis, this study employs a multi-methods approach from a multi- and interdisciplinary perspective that involves the following steps:

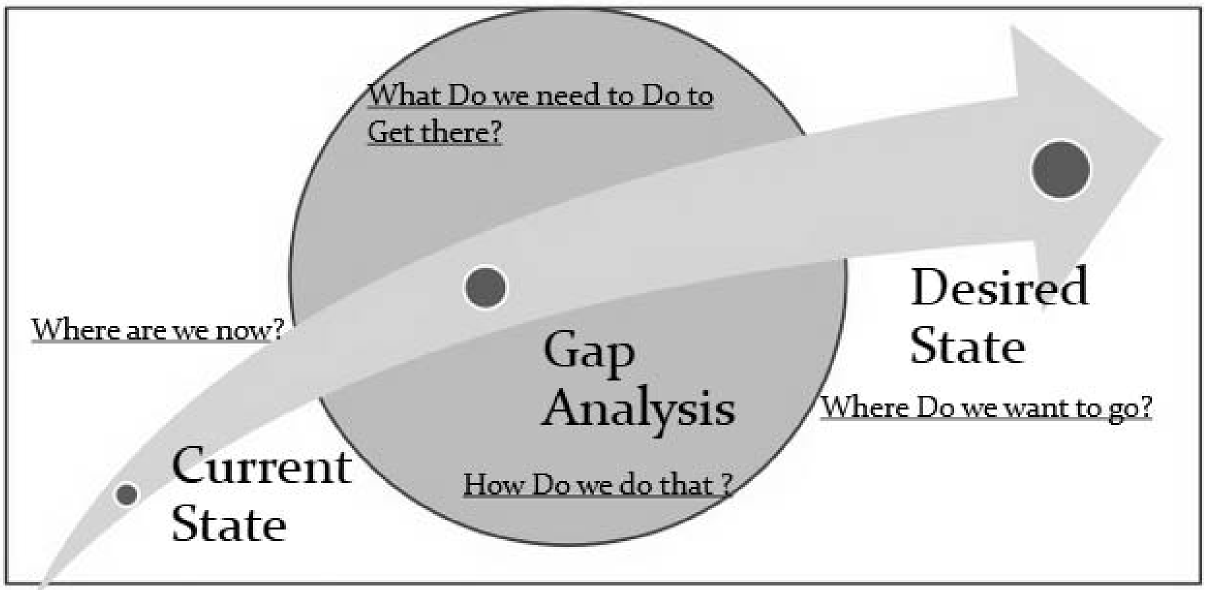
1. Conceptualization of key terms (see Section 4);
2. Comprehensive literature review of traceability systems and gap analysis (see Section 3.1.1);
3. General description of selected international standards and guidelines, regulatory standards, and industry and NGO non-regulatory standards (see Section 5);
4. Gap analysis of the traceability standards and regulations (see Section 6);
5. Content analysis of selected international standards and guidelines, regulatory standards, and industry and NGO non-regulatory standards (see Section 6).

3.2. Gap analysis

3.2.1. 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" and serves as a means to bridge that space by identifying what has to be done in order to reach the desired state. How to reach the desired state for seafood traceability is part of this analysis (Figure 1) [2]. Gap analysis can also be used to compare a process, product or service to another or to specified standards.

Figure 1. The gap analysis concept [3].



The literature review [2], [4] revealed six fields where gaps might appear (each of these fields corresponds to a type of gap):

1. **Awareness:** stakeholders have to be concerned about and have a well-informed interest in a particular situation or development (e.g. advantages of traceability systems);
2. **Knowledge/research:** stakeholders have to 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 in an effective way through standards and norms;
4. **Commitment:** the traceability standards and norms have to be used by the policy makers and industry and not circumvented. This is closely related with point 1 above;
5. **Technology:** tools and operational infrastructures supporting effective traceability are currently available. This is closely related with point 3 above;
6. **Standards:** standards for both implementation and certification of traceability are available and accepted; term and concepts are harmonized. This is closely related with point 3 above.

Inconsistency is a concept closely related to one of the gaps and it refers to lack of harmony between different parts or elements, self-contradiction, and not being the same throughout. In this study, it refers to regulatory inconsistency (see Section 4.3).

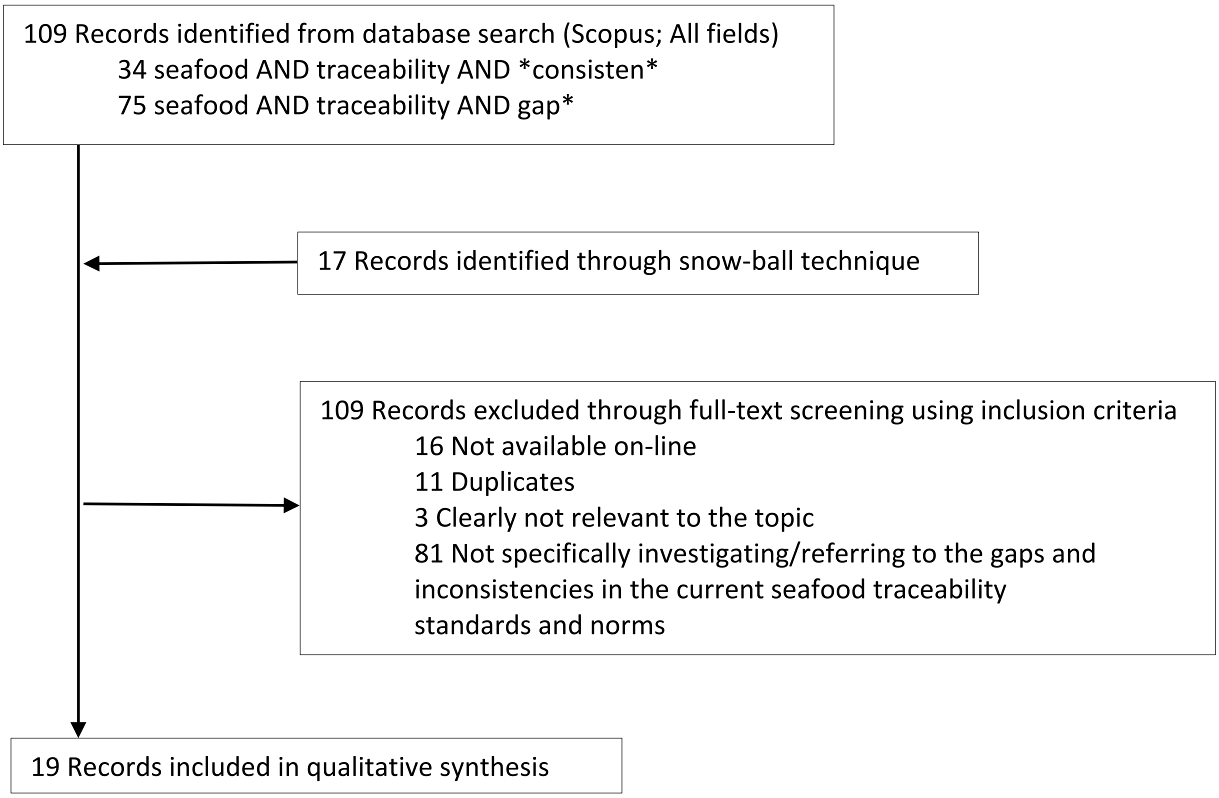
This report:

1. examines the current state of approaches to seafood 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;
2. describes the gaps and inconsistencies between the standards and norms included in the analysis.

3.2.2. Literature review

A systematic literature review was performed in order to identify scientific papers analysing the gaps and inconsistencies in traceability standards and norms. The database search included Scopus and was conducted in all fields, up to the 1st of November 2015, with the earliest year covered being 1960. Three concepts were used to structure the search query, including: seafood, traceability and gap (keywords: gap*, *consistent* [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 snow-ball sampling of relevant sources. The screening process is summarised 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.



4. Theoretical framework

4.1. Traceability and traceability systems

4.1.1. 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 there are conflicting or ambiguous views or definitions; an attempt has been made by the authors to choose the definitions that are most consistent with normal practice in the seafood industry, as well as the most suitable term for the gap analysis.

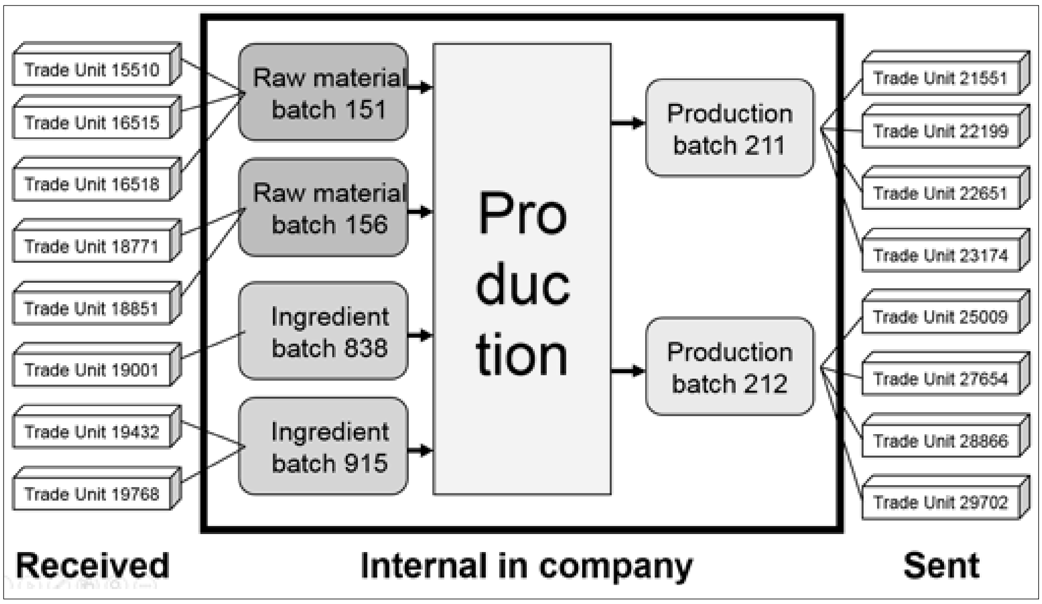
4.1.1.1. Batch

A common dictionary definition of batch (or lot) is “the quantity of material prepared or required for one operation” [5]. In seafood supply chains we commonly refer to 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 within the company, and do not normally adhere to any standards. Batches are not necessarily explicitly labelled or identified within the company as long as the company knows what constitutes a given batch. See Figure 3.

4.1.1.2. Trade Unit

Trade Unit (or Trade Item) (TU) 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 are 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. Trade units have to 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 trade units to be identified by the (production) batch number they belong to. This makes traceability more difficult and less effective, as numerous trade units will have the same identifier. Unique identification of trade units requires more work, but it makes traceability easier and it 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 [6].



4.1.1.3. Traceable Resource Unit (TRU)

Traceable Resource Unit (TRU) is "the unit that the company wants to trace" or "the unit that the company records information on in the traceability system". In this document, TRU can be taken as a common term for all types of batches and trade units.

4.1.1.4. Granularity

Granularity depends on the physical size of the TRU; the smaller the TRU the smaller the granularity. When implementing a traceability system, companies have to make a decision 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.

4.1.1.5. 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 they 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 ensures that within that company the same identifier is not used twice. Ensuring uniqueness when many trading partners are involved (typically for trade units) is more difficult, and often the most convenient solution is to use globally unique identifiers 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.

4.1.1.6. Referential integrity

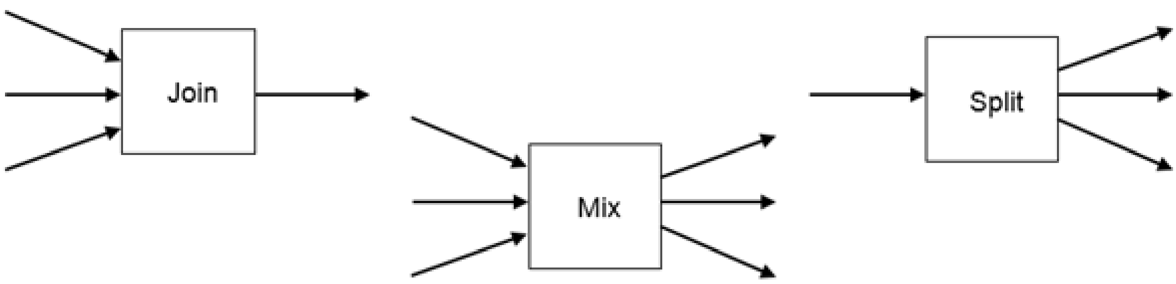
The TRU identifier must be unique within its context, however, practice differs in relation to whether this unique identifier can only be assigned to one TRU, or whether the same unique identifier can be applied to multiple TRUs. The first practice is referred to as "referential integrity", or the licence 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. For example, 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 etc.) referential integrity is lost if that same identifier is used for more than one TRU.

While all these TRUs still will have the original set of properties in common (e.g. they all come from the same vessel and were caught and processed on the same dates), it is not possible to distinguish between TRUs, and it is not possible to record further properties related to each TRU (e.g. date/time and location, date/time and temperature etc.). It is not uncommon in the captured fish industry to use the internal production batch number as identifier for each trade unit that is generated and sold but 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.

4.1.1.7. Transformation

New batches and new trade units are created at specific times, typically when fish is 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 trade units were used to create a new batch or trade unit; often it is also relevant to record the amounts or percentages used. Often trade units are smaller than the internal batches, which means that received trade units are often joined together to make raw material batches. A typical example of a transformation is when the incoming trade unit 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 trade unit is "a box or container of a certain weight, generated from that production batch".

Figure 4. Batches/trade units transformation types [6].



4.1.1.8. Traceability

There are numerous definitions of traceability, most of them 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 [7], who defined traceability as "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". This emphasises 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 when it comes to differentiating between traceability and traceability control mechanisms; i.e. methods and instruments that measure biochemical properties of the food product and are used for authentication and testing whether what is received is what the documentation states; see Sections 4.1.6 and 4.1.7.

Traceability depends on recording all transformations in the supply chain, explicitly or implicitly. If all transformations are recorded, one can always trace back or forward from any given TRU to any other TRU 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 where a given TRU went to ("the progeny"), but also the properties within these TRUs (when and where was it created, weight or volume, what form is it in, what species, fat content, salt content, etc.).

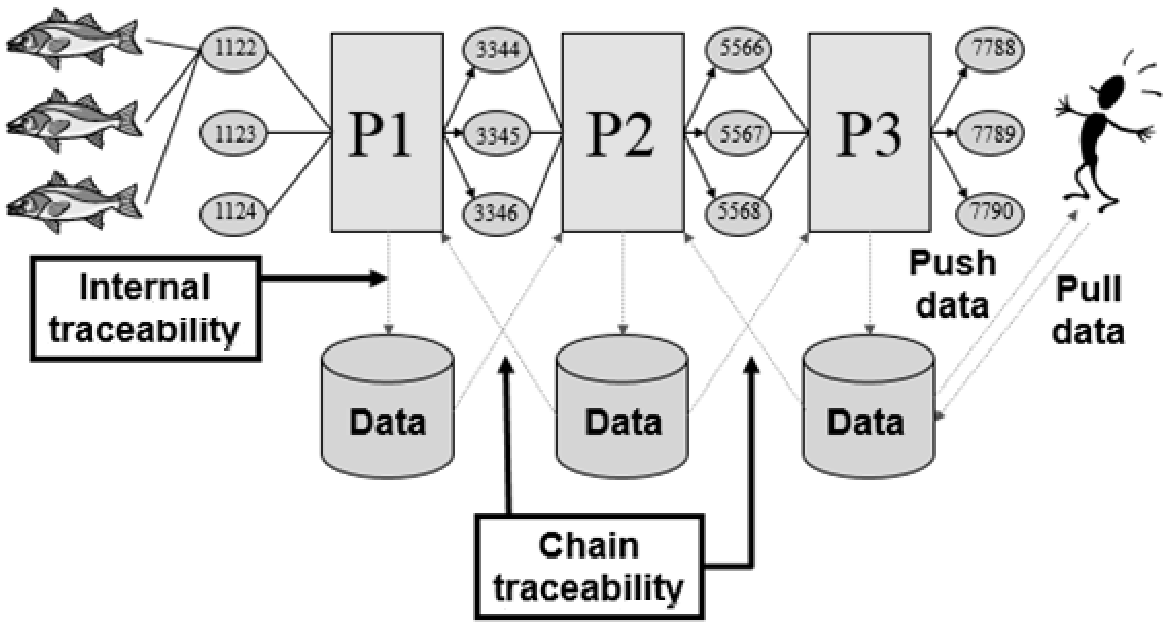
4.1.1.9. Internal traceability

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 trade units. Subsequent information on all the other internal steps needs to be recorded, including all transformations that take place and all relevant properties related to internally generated batches or trade units. Internal traceability is the backbone of traceability in general; everything else depends on each company in the supply chain having good systems and good practices when it comes to recording all the relevant internal information. Internal traceability mainly deals with batches, but the relationship between incoming trade units and raw material (or ingredient) batches needs to be recorded, and also the relationship between production batches and outgoing trade units. Internal traceability is the domain and responsibility of a single company, data confidentiality or access is not a big issue, and several good systems, solutions, practices and standards have been developed in this area.

4.1.1.10. Chain traceability

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 supply chain (Figure 5). Data can be transmitted in various ways; the simplest being by attaching the information physically (on the label) or logically (in accompanying documentation) to the product when it is sent. A more flexible way of implementing supply chain traceability is for trading partners to agree on a way of identifying the trade units, and then to send the required information through another channel (fax, mail, electronically integrated systems) while referring to the trade unit in question. This is commonly referred to as “information push”. As the amount of data grows ever larger, “information pull” has also gained popularity as a way of implementing supply chain traceability. Information pull is when the trading partners agree that the seller should retain and make available information about the trade unit in question on request. It could be a request 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 trade units and the buyer can extract whatever data is needed. Supply chain traceability is much more complex to achieve, because it requires the cooperation and agreement between at least two companies (in practice more as international seafood value chains are complex), and data confidentiality and levels of access is an important issue. Supply chain traceability is often closely related to Electronic Data Interchange (EDI), which in turn depends heavily on the agreement on, and adoption of, standards both when it comes to media, identifiers, content and structure of the data that are to be exchanged.

Figure 5. Internal versus chain traceability [6].



4.1.2. 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 [7] [8], regardless of whether or not they are utilized by developed or developing countries, large or small-scale fisheries.

Specialty literature [7] underlines that a traceability system for food products should be able to:

a. provide access to all properties of a food product, not only those that can be verified analytically;
b. 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;
c. facilitate traceability both backwards (where did the food product come from?) and forwards (where did it go?).

In order to do so, traceability must be based on systematic recordings and exchange of this information. There are many relevant properties that will be lost if there is no record-keeping system and a way of distributing/sharing the information. In practice, this means that a unit identification system or numbering scheme must be present. Without a unit identification system one cannot achieve several of the goals listed above.

As indicated by Olsen and Borit [7], for this to happen 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 [9] and Kim, Fox, and Grüninger [10] 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 [11] for a more detailed discussion on this;

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, as described and discussed in Sections 4.1.1.4 – 4.1.1.6. 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 the current TRU (and which subsequent TRUs the current TRU in turn will became a 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 we are looking at a company or the supply chain. In a company we have the internal traceability system, often software with ample opportunity for browsing data, visualizing dependencies (which TRUs were based on which TRUs), and creating reports. Even though there are best practice guidelines for traceability [12], getting this functionality for a whole supply chain is a major challenge and probably "the" major challenge. It 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 recorded by the traceability system is of course also very important (see Sections 4.1.6 - 4.1.7), but these are external processes and not part of the traceability system itself.

4.1.3. 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) [13]. Table 1 summarizes different characteristics of traceability systems, including drivers for implementing these.

Table 1. Traceability systems: purpose/driver, objective, attributes, standards and examples [14] [13].

Purpose/Driver	Objective	Attributes	Standard	Example
Safety	Consumer protection (through recall and withdrawal)	Specified in food & 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 food	Voluntary (no common standard)	Brand & product protection
Regulatory Quality	Consumer assurance (through recall and withdrawal)	Specific attributes included in regulations	Regulatory (3)	EC labelling, mandatory consumer information.
Non-regulatory quality & 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 & logistics management	Food chain uniformity & improved logistics	Specific attributes required to food and services suppliers by contract	Private standards (4)	Own traceability systems (e.g. Wal-Mart)
			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 environmenta l protection regulations	Mandatory	EU IUU Regulation
			Voluntary	FAO IPOA-IUU (8)

(1) Recall and withdrawal can become 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) TRACEFISH, "Traceability of Fish Products" (EC funded project) http://www.tracefish.org/
(7) SSCC : Serial Shipping Container Code (UCC)
(8) IPOA-IUU: International Plan of Action to Prevent, Deter and Eliminate Illegal, Unreported and Unregulated Fishing.

4.1.4. Traceability and transparency

As indicated in the specialty literature and directly linked to building trust among the various stakeholders, transparency is a critical element in risk communication [15], [16]. 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 [15]. However, transparency and traceability are not the same thing, because the latter only sets the framework for the former [17]. Depending on whether transparency is aimed at the past, present or future, it can be divided in three types: history-, operations- and strategy transparency [15]. When it comes to products, it can be said that traceability can enable the first two types of transparency, since it addresses the past and the present of the product [18]. A good traceability system can provide product-related information to stakeholders with little loss, noise or delay, but when it comes to distortion we have to remind ourselves that a traceability system basically contains mostly unverified claims, and if we want transparency we also need some mechanisms for verifying the data (see Section 4.1.7).

A traceability system can provide a coherent overview of all the raw materials, ingredients, transformations, processes and products in the supply chain. One cannot really have transparency without traceability but, for transparency, some other components are needed as well. This is related to the fact that the concept of traceability is quite generic and could be summarized as "keep a record of what you are doing in the supply 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 [19].

4.1.5. 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)" [20].This means that while traceability and CoC to some degree have the same goal, well-documented fish products, their approaches are quite different.

Traceability is generic and non-discriminatory. The company receives trade units (or fish from the ocean where the catch is identified in a similar way as a trade unit), splits, joins or merges trade units 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 trade units. At each stage a spilt, join or merge can take place, and this 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 one wants to protect, retain and document (e.g. ecolabels such as dolphin-safe; organic) while not really caring about the rest. 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 etc.) and also assign the CoC identifier. This CoC identifier applies to all fish products produced by this company that satisfy the given set of properties. This 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 practise in the fish industry, there is a difference between traceability and ecolabel type chain of custody [21], as outlined above.

Table 2. Main differences between traceability and chain of custody (CoC).

	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	OK, 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 [22]. While being two different processes, traceability can be used as a tool in the certification process. Documentation of chain of custody is part of what is required for certification, especially certification related to use of ecolabels.

4.1.6. Traceability and catch/trade documentation schemes

The definition we have chosen for traceability in this paper is "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" [7]. There are numerous mandatory and voluntary catch documentations schemes (CDSs) in use around the world, and while they have properties in common with a traceability system, it should be clear that they do not in themselves constitute traceability systems. CDSs 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), and CDSs 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 CDS 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. This is not to say that CDSs are not important in relation to traceability. Firstly, an efficient traceability system will to a large degree automate the generation of the CDS when it is needed, which means that time and effort related to the production of the CDS can be significantly reduced for companies with efficient traceability systems, and this in turn provides a driver for investing in traceability. Secondly, the information on the CDS can serve as input to traceability systems that receive the product in question, and the data there will be in a standard format and often mandatory, which in turn improves the quality of the data available later on in the supply chain.

4.1.7. 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 [23], spectroscopy [24], or magnetic resonance [25]. The first thing to note is that these analytical methods do not provide traceability. Practically all definitions of traceability, including the one chosen in this document, indicate that traceability must entail some sort of historical record keeping. While analytical methods only provide instantaneous measurements, it is of course true that some of these measurements can provide useful and relevant information about the product and process history. Most of the data in a traceability system can be considered as claims, and most of these claims 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. Unfortunately, false claims do occur, both because of errors and because of deliberate fraud, often for economic reasons. Analytical methods are essential when it comes to verifying (or falsifying) claims in 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, it is worth noting that there are many relevant food product properties that cannot be analytically verified, especially in the capture fish industry. These include properties such as identity of food business operator or owner at various stages in the supply 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 [7]. To verify claims and to detect fraud in these areas, paper-trail based methods are needed. The most common methods are mass balance accounting (i.e. detection of unusual claims in relation to yield for a given process) and input-output analysis (i.e. a mismatch between output stated in one place and corresponding input stated another place).

4.1.8. 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 [18]. Traceability is like 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) [26]. 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" [7]. Error and fraud can make the recordings either untrue or incomplete. Thus, the need to verify the claims becomes obvious. Together with comprehensive inspections and certification, analytical methods (see Section 4.1.6) play an important role in this respect [27].

4.2. Harmonization and standardization

Standards are closely connected to supply chain traceability, because supply chain traceability requires trading partners to exchange a large amount of information. Unless they agree in great detail about what everything means and how it should be structured and represented, information loss along the supply chain is bound to happen. For two trading partners to make their own specifications about the information interchange would make little sense, because of the unnecessary work involved. In addition, they both are likely to have numerous suppliers and customers, and the need to make separate agreements with all of them would not be feasible. In principle, the internal traceability within a company can be effective without resorting to standards, but it is the recordings in the internal traceability system that provide the data that is exchanged in the supply chain traceability system, and it is there that the data needs to be in a standard format if the trading partner is to understand it.

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

- **TRU identification.** As indicated in Section 4.1.1.5 – 4.1.1.6, all TRU identifiers need to 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 global level in general, but there are also other alternatives.
- **Physical media for codes and numbers, especially on labels.** Apart from 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 need to agree on what physical media to use. The supplier must have equipment suitable for generating this media type and the buyer must have equivalent equipment and take the necessary time to read these codes. Internationally-agreed upon standards exist for all these media types, but it is fair to say that uptake of the more advanced technologies (RF-ID in particular) have been far slower than anticipated.This is 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 use of these is increasing. To some degree this is driven by the obligatory use of similar standards in some

business situations (e.g. 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 means that XML can be used to exchange data elements that have not been pre-defined. While this is a good and flexible approach, it does not really facilitate traceability. When data is 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 that "weight is 198 g" does not in itself facilitate traceability. The recipient needs to know what this refers to, the weight of what, measured how, when and where. 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. Standards are like commonly-agreed upon dictionaries detailing exactly what all the terms mean and how the terms are interrelated ("ontology" is the technical term for this).

There are a number of standards on these levels. Some standards are for products in general, some for food products, and some 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 one can argue 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 so much. Also, the big challenge when it comes to implementing traceability is not the fact that there are overlapping or conflicting standards and that conversions are needed, the big problem is the fact that standards are not used (or used too little) when designing the food industry systems and practices.

Among the measures to maintain integrity of product tracking and for improving standardization there are [19]: minimum information standards for wild-caught fish products should be adopted; establishment of a harmonized system of "landing authorizations" to provide primary assurances of the legal origin of fish products; and development of a global architecture for interoperability systems.

4.3. Consistency

From a norms perspective, *coherence* relates to "positive connections" or "the construction of a united whole", while *consistency* refers to the absence of contradiction [28]. 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" [28]. 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 [29]. 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" [30]. Nevertheless, the application of the consistency principle has to be flexible enough for regulatory approaches to change due to changes in the context (e.g. the change in the EU regulatory regime for food as a consequence of the mad cow disease [31]). Yet another important aspect is that norms are not only formulated but also applied in a consistent manner [32].

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

1. Intra-institutional regulatory consistency, which refers to the different norms generated by the same institution form part of a whole;
2. Inter-institutional regulatory consistency, which refers to the use of similar concepts and procedures for related items by different entities in the same industry.
3. 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. This can lead to forum shopping [33], confusion among industry and consumers alike [26], and delay in development of valuable products and services [34] that, in our case, could facilitate implementation of seafood traceability.

5. Overview of existing traceability standards and regulations

Previous analysis of seafood traceability practices [1] presented to the COFI:FT identified three main categories of traceability standards and regulations that this study deems to follow: international standards and guidelines, regulatory standards and industry and NGO non-regulatory standards. It is important to note that all the current traceability standards refer to implementation of traceability and none of them to certification of already implemented traceability systems.

5.1. International standards and guidelines

Inter-governmental guidelines [1]**:** 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 attempts to provide guidance to their member states in dealing with illegal, unreported and unregulated (IUU) fishing.

5.1.1. Codex Alimentarius

The *Codex Alimentarius* or "Food Code" was established by FAO and the World Health Organization in 1963 to develop harmonised international food standards which protect consumer health and promote fair practices in food trade [35]. The Codex defines traceability as “the ability to follow the movement of a food through specified stage(s) of production, processing and distribution” [36]. This definition reduces traceability to following only the movement of food products. 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 the traceability definition there is of special importance, even though it is not commonly referred to, at least not in scientific articles [7]. The Codex recognises that at the international level, methods are not harmonised and are often complicated, thus leading to barriers to trade [37]. The approach to traceability taken by the Codex is considered insufficient by the specialty literature, as it does not incorporate essential properties of traceability systems [7].

5.1.2. FAO guidelines

5.1.2.1. Marine capture fisheries - ecolabelling

The *FAO Guidelines for the ecolabelling of fish and fishery products from marine capture fisheries* [20] summarise several principles that should be observed by seafood certification schemes. These Guidelines cover the fishery management system, the status of the target stock and ecosystem considerations within the overarching purpose of identifying sustainable fisheries [1]. Paragraph 16 of the Guidelines state that the chain of custody measures designed by the certification scheme “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, as explained in Section 4.1.5 of this study, even though in theory the two terms might mean very much the same thing, in practise in the seafood industry there is a difference between traceability and ecolabel-type chain of custody.

5.1.2.2. Aquaculture - certification

The *FAO Technical guidelines on aquaculture certification* provide guidance for the development, organization and implementation of credible aquaculture certification schemes [38]. The Guidelines address a range of issues that should be considered as relevant for certification in aquaculture, including: a) animal health and welfare; b) food safety; c) environmental integrity and d) socio-economic aspects associated with aquaculture [1]. The Guidelines state that one of the principles of aquaculture certification schemes is that they should include adequate procedures for maintaining chain of custody and traceability of certified aquaculture products and processes.

5.1.3. RFMO catch/trade documentation schemes

RFMOs are international organisations formed by countries with fishing interests in given areas beyond national jurisdiction (ABNJs). Some RFMOs 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 [39]. Almost all of the global high seas are now covered by at least one RFMO out of the 18 currently existing Fisheries Management Bodies [40]. Of these, five RFMOs are the so-called tuna RFMOs, which manage fisheries for tuna and other large species such as swordfish and marlin [41]. As part of their fight against IUU fishing, RFMOs utilize trade documentation schemes and CDSs. These schemes are important fisheries management tools, but are not designed as traceability systems for markets/consumers [42]. For a detailed analysis of these CDS and seafood traceability, see [43].

5.2. Regulations

Binding norms [1]**:** A second category is formed by the binding norms that are set by particular countries. These are broadly applicable to food products and more specifically to fish products, and are mandatory for export to the major fish importing markets: the European Union (EU), the United States of America (USA) and Japan. These binding norms include laws, regulations, and associated enforcement programs 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. [1]

5.2.1. European Union (Member Organization)

According to Lavelli, the EU legislature works with two different models when it comes to food traceability [44]. The one implemented through the application of the General Food Law [45] leads to a generic (nonspecific) low-warranty traceability of the EU food supply chain. A second, more complex model is followed through norms regulating products such as those derived from genetically modified organism. 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 [46].

According to the text of 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 (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" (so called "internal traceability"). Thus, there is no requirement for records to be kept identifying how product batches are split and combined within a company to create particular products or new batches [47]. In other words, companies have to know where the ingredients came from and where the products went, but not necessarily which ingredients went into which products [48]. As a regulation, this act was directly applicable in the legislation of the EU Member States, without transposition. The approach to traceability taken by the EU GFL is considered non-effective by the specialty literature [26].

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 specially designed to address the IUU fishing problem: the EU IUU Regulation 1005/2008 [15] (and its Implementation Regulation 1010/2009) and the EU Control Regulation 1224/2009. Both norms sought to ensure full traceability "from fishing net to the plate" of all marine fishery products. This aim 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 [26].

Detailed description and analyses of the EU legislative framework related to traceability can be found in [1], [18], [21], [26], [49].

5.2.2. United States of America

The United States of America (US) has traceability regulations pertaining to livestock identification and movement, but generally lacks regulations on other agricultural commodities. However, the US has identification and labelling regulations on packaged food products. In 2011, as a part of the Food Safety Modernization Act (FSMA), the US Department of Agriculture introduced Animal Disease Traceability requirements. Despite the passage of the FSMA and the opportunity to strengthen traceability, the United States is still lacking regulations dealing with 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 [49]. The US federal food safety oversight is considered to be fragmented [50].

Among the latest developments in the US regarding IUU fishing and seafood 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 program to combat seafood fraud and IUU seafood entering US commerce [51]. This traceability program itself 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). That rulemaking will address data requirements, the design of the program, and the species to which the first phase of the program will be applied [52]

Detailed description and analyses of the US legislative framework related to traceability can be found in [1], [49].

5.2.3. 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) [49]. Guidelines for developing traceability systems are being established by industry associations rather than by the 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.

Detailed description and analyses of the Japan legislative framework related to traceability can be found in [1], [49].

5.3. Non-regulatory standards

Parallel to the already mentioned standards and norms, commercial (voluntary) standards have been delivered by organisations and associations to set traceability requirements, facilitate data sharing and adopt product identification standards for commercial purposes [53]. **Non-governmental/ industry standards (contractual)** [1]**:** Non-regulatory standards developed by NGOs, the industry and other standards, such as the International Organization for Standardization (ISO), are included in this category. These documents include guidelines for auditing and other measures to ensure successful application of the standards.

5.3.1. ISO

ISO 8402:1994 Quality management and quality assurance: This standard is considered to contain the less incomplete definition of product traceability: “The 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 also how the tracing should be done (by means of recorded identifications) [7]. 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: "The 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, and this has consequences as explained in [7]. ISO 22005 adds that "Terms such as document traceability, computer traceability, or commercial traceability should be avoided." ISO 12875/12877:2011 are generated from the TraceFish standard.

5.3.2. Office International des Epizooties (OIE)

The *OIE Aquatic Animal Health Code (the Aquatic Code)* sets out 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 pathogenic to aquatic animals and to prevent their transfer via international trade in aquatic animals and their products, while avoiding unjustified sanitary barriers to trade [54]. OIE helps its Member Countries and Territories to implement 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 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 [1].

5.3.3. Industry

Several industrial associations have developed their own traceability standards. Among these:: National Fisheries Institute GS; EU Fish Processors Association and EU Federation of National Organisations of Importers and Exporters of Fish (AIPCE-CEP); British Retail Consortium Global Standard for Food Safety: Issue 6. For a detailed description and analyses of these initiatives, see [1].

5.3.4. NGOs

Major leading internationally established fishery/aquaculture certification programs (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 each set of standards has its own individual structure and presentation [1]. For a detailed description and analyses of these initiatives, see [1].

6. Gap analysis results

6.1. Gaps

Despite the many tools and practices for seafood traceability, approaches remain underdeveloped and fractured across geographies, jurisdictions, and market sectors [55]. There are traceability-related gaps both when it comes to awareness, commitment, implementation, technology and standards. Based on the authors' analysis, the most important gaps are indicated below.

Awareness gaps:

- Lack of understanding (both at government and private sector levels) of what traceability is, and how it differs from other concepts that are viewed to be similar, e.g. chain of custody or trade / catch documentation schemes.
- Lack of understanding of how traceability can streamline companies internal processes and thus improve financial performance [55].
- Lack of understanding (both at government and private sector levels) of the fact that many of the main obstacles for adoption of traceability in seafood supply chains are cultural and organizational, rather than technical [55].
- Lack of understanding (both at government and private sector levels) of the fact that traceability needs to cover the entire seafood supply 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 within countries, where effective systems to require traceability and proof of legal origin are lacking [56]". This is connected to the lack of understanding (both at government and private sector levels) of the difference between internal traceability and supply chain traceability. While the first may be effective in a given company, it is the entire supply chain traceability that really matters, and that is not something a given company can achieve on their own.
- Lack of understanding (both at government and private sector levels) of the importance of documenting transformations, and how the chain of transformations is essential if we want to trace backward or forward to or through companies. This is connected to the lack of understanding (both at government and private sector levels) of the importance of referential integrity. Namely, it is much easier to document and visualize the chain of transformations if all TRUs have unique identifiers.

Commitment gaps:

- The commitment gap when it comes to implementing seafood traceability systems is significant (both at government and private sector levels), 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 fulfill legislative and commercial requirements, it can also underpin company branding and marketing strategies and give the company a competitive advantage. Cost/benefit analysis of investments in improved traceability systems is difficult to do, and credible conclusions in this area are fragmented and anecdotal. But it seems 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 have to, either to fulfill legislative or commercial requirements to enter target markets, and thus are surprised to learn that a side-effect of the investment in traceability is that they have better industrial statistics, faster turnover of ingredients, raw materials and products, and reduced amount of goods in storage. While this comes as good news, it means that many companies that would have invested in better traceability if they knew about these side-benefits, do not do so. This is an important explanation behind the industry's lack of motivation and commitment to tracebility systems.

Implementation gaps:

- There is the gap between regulatory requirements and the feasibility of industry implementation [57]. At the EU level this might be due to several gaps in traceability requirements [58], such as: lack of a robust fishery control-based catch certificate, inadequate document security for split consignments, and insufficient maintenance of batch integrity (here referential integrity plays an important role [59]).

Technology gap [45]:

- Lack of verification procedures that integrate with monitoring of food authenticity [55]. This lack of verification procedures means that it may be possible to follow a product back and forth through the food chain and yet still not have certainty that the product is what it has claimed to be. For example, IUU fish may enter the chain fraudulently, yet once in the seafood supply, it is sufficiently traced along the chain.
- 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 provide referential integrity. No two tags ever have the same identifier and the quality of the traceability system will be significantly improved when the bulk of the industry adopts RF-ID tags as a common practice.
- 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. This is frequently performed manually. 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 would simplify and speed up the process and reduce the number of errors. This could also 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:

- This 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 (see Section 6.2 for details).
- Lack of uniform requirements or standards for information-gathering and information-sharing that are needed for effective traceability [46], [55]. This gap, to some degree, inhibits interoperability of technology systems along the supply chain, thereby increasing business risks and costs when choosing and adopting traceability and information systems.
- Lack of a "standardised 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 [60].

6.2. Inconsistencies

6.2.1. Intra-institutional inconsistency

When it comes to EU specific legislation related to traceability, recent research considers that this legislation suffers from intra-institutional inconsistency, as different norms have different approaches to traceability depending mainly on the drivers of these 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, it was found that EU legislation normally imposes effective traceability systems [26]. This finding is similar with the conclusion that can be inferred from the analysis performed in [1], 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 be inferred from [1] in the case of FAO Guidelines described in Section 5.1.3. 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 consistency can be inferred, too, 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 [7].

The traceability systems proposed by Codex Alimentarius, EU GFL, and ISO 8402, 9000 and 22005 suffer from inter-institutional inconsistency. As explained in the specialty literature [7], they do not refer to traceability in the same way. All of these standards and norms use a verb phrase that is either recursive (i.e. traceability means to trace) or vague (i.e. traceability means to follow). There are additional 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 only mentioning one property (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 [1], the provisions of international standards and guidelines vary substantially with regards to unique identification requirements and data communication requirements, while they are more consistent with regards to data management and capture requirements. The provisions of the EU, US and Japan are consistent with regards to data communication requirements, but are less consistent with regards to unique identification and data capture and management requirements. The provisions of the non-regulatory standards with regards to data capture and management are consistent among documents and with the respective ones from international standards and guidelines, except in the case of the RFMO documentation schemes. The provisions for unique identification requirements and for data communication requirements vary among these non-regulatory standards.

7. Conclusions

This report was tasked with analysing gaps and inconsistencies in current seafood traceability standards and regulations and to generate recommendations based on those findings. Several gaps in seafood traceability standards and norms were identified by employing a multi-method analysis, namely: awareness, commitment, implementation, technology and standards. In addition, specific inter- and intra-institutional inconsistencies were also noted.

8. Recommendations

Recommendations arising from this traceability gap analysis include the need to:

- **Increase awareness both at government and private sector levels of what traceability is, how it is different from other concepts that may appear similar to traceability, how traceability may add value to a company, and contribute to prevention of IUU fish entering markets.** An important challenge is to communicate to governments and companies that the common misunderstanding that traceability systems are good (enough) is only partly true. Normally these entities only think of internal traceability when assessing their own capabilities and needs. There are several ways to increase awareness: writing scientific and popular science articles about seafood traceability, presentations on traceability in relevant stakeholder forums (in particular government and industry events), include traceability in the syllabus both for government/industry capacity building workshops, and in relevant academic courses. In most instances, the focus should be on the benefits that traceability provide rather than on the technical details involved when implementing traceability. Previous experience has shown that if motivation is present both on managerial and on operational level in a company, then any technical difficulties will be overcome, and most often, successful implementation will follow.

- Traceability is currently an *à la carte* menu, where a company must make multiple choices: on granularity, whether to have referential integrity, what data elements to record, how to name and transmit them, whether to use a standard, which standards to use, and so on. **A self-assessment scheme for seafood traceability would be useful both at government and private sector levels. This self-assessment scheme** would clearly spell out the different alternatives, advantages and disadvantages of each alternative, recommend which selections belong together, and so on. Such a self-assessment scheme would be beneficial regardless of whether the user is a developed or developing country, a large or small-scale fishery, a small company or international enterprise, etc. This self-assessment scheme would allow companies and governments to make informed decisions before investing, based on their economic constraints and their level of ambition. It would also enable benchmarking between options, so that a given company/government could ascertain their current situation and compare that with where they would like to be.

- Standardization and harmonization are a challenge, but the lack of uptake of standards is a bigger problem than the use of conflicting standards. Thus, an important aspect is **raising awareness among government and private sector about the utility of using already existing standards** and possibly extending / adapting them if needed rather than creating new systems or standards.

- A global framework for legal and traceable seafood, especially in the capture 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 trying to decide on the optimal level of traceability for a company or a supply chain. Reducing IUU fishing is an idealistic goal, and more prevention is obviously better as long as the cost is not too high. Deciding on level of traceability is a pragmatic goal, and there is room both for ambitious companies who regard transparency as part of their branding and who want as a good a traceability system as possible, as well as for companies who only want to satisfy minimum requirements to enter markets. For this reason, a global framework or even a global standard for traceability is less relevant. There is a need **to support various levels of ambition, and that requires a certain degree of variety and a certain degree of freedom of choice when it comes to how to perform the implementation. In this context, the key is interoperability. There will be different traceability systems, but they should be able to talk to one another, and to exchange information without significant loss of data.**

8. References

[1] V. Andre, “COFI:FT/XIV/2014/Inf.6 - Review and Analysis of Current Traceability Practices,” 2013.

[2] M. Gomm and H. Brocks, “PARSE.Insight. Deliverable D 4.1. Specification of gap analysis schema and tool support.” 2009.

[3] A. Upadhye, “Gap analysis.” SlideShare, 2012.

[4] C.-M. Chituc, C. Toscano, and A. Azevedo, “Interoperability in Collaborative Networks: Independent and industry-specific initiatives – The case of the footwear industry,” *Comput. Ind.*, vol. 59, no. 7, pp. 741–757, Sep. 2008.

[5] I. Farlex, “The Free Dictionary,” 2015. [Online]. Available: http://www.thefreedictionary.com/batch. [Accessed: 24-Oct-2015].

[6] TraceFood, “GTP:Defining traceable units,” 2008. [Online]. Available: www.tracefood.org. [Accessed: 24-Oct-2015].

[7] P. Olsen and M. Borit, “How to define traceability,” *Trends in Food Science & Technology*, vol. 29, no. 2. pp. 142–150, 2013.

[8] J. T. Mgonja, P. Luning, and J. G. A. J. Van der Vorst, “Diagnostic model for assessing traceability system performance in fish processing plants,” *J. Food Eng.*, vol. 118, no. 2, pp. 188–197, Sep. 2013.

[9] T. Moe, “Perspectives on traceability in food manufacture,” *Trends Food Sci. Technol.*, vol. 9, no. 5, pp. 211–214, May 1998.

[10] H. M. Kim, M. S. Fox, and M. Grüninger, “An Ontology for Quality Management — Enabling Quality Problem Identification and Tracing,” *BT Technol. J.*, vol. 17, no. 4, pp. 131–140.

[11] K. M. Karlsen, K. A.-M. Donnelly, and P. Olsen, “Granularity and its importance for traceability in a farmed salmon supply chain,” *J. Food Eng.*, vol. 102, no. 1, pp. 1–8, Jan. 2011.

[12] FAO, “COFI:FT/XIV/2014/7 - Best Practice Guideline on Traceability.” 2013.

[13] M. Borit, “Application of traceability in deterrence of illegal, unreported and unregulated fishing : an analysis model of EU Regulation 1005/2008 and EU Regulation Proposal 2008/0216 (CNS).” University of Tromsø, 15-May-2009.

[14] H. Lupin, “Traceability,” 2006.

[15] G. J. Hofstede, *Hide or confide?: the dilemma of transparency*, no. 248 p. ’s-Gravenhage: Reed Business Information, 2004.

[16] O. Renn, *Risk governance: coping with uncertainty in a complex world*. Earthscan, 2008.

[17] N. Egels-Zandén, K. Hulthén, and G. Wulff, “Trade-offs in supply chain transparency: the case of Nudie Jeans Co,” *J. Clean. Prod.*, May 2014.

[18] M. Borit, “Legal requirements for food traceability in the European Union,” in *Advances in Food Traceability Techniques and Technologies (Forthcoming)*, M. Espiñeira and F. J. Santaclara, Eds. Elsevier Ltd, 2016.

[19] Expert Panel on Legal and Traceable Wild Fish Products, “Recommendations for a Global Framework to Ensure the Legality and Traceability of Wild-Caught Fish Products.” 2015.

[20] FAO, "Guidelines for the Ecolabelling of Fish and Fishery Products from Marine Capture Fisheries." 2009.

[21] M. Borit and P. Olsen, "Evaluation framework for regulatory requirements related to data recording and traceability designed to prevent illegal, unreported and unregulated fishing," *Mar. Policy*, vol. 36, no. 1, pp. 96–102, 2012.

[22] FAO, "Private standards in fisheries and acquaculture: current practice and emerging issues (Report 97/2009)," 2009.

[23] R. Ogden, "Fisheries forensics: the use of DNA tools for improving compliance, traceability and enforcement in the fishing industry," *Fish Fish.*, vol. 9, no. 4, pp. 462–472, Dec. 2008.

[24] M. Ottavian, P. Facco, L. Fasolato, E. Novelli, M. Mirisola, M. Perini, and M. Barolo, "Use of near-infrared spectroscopy for fast fraud detection in seafood: application to the authentication of wild European sea bass (Dicentrarchus labrax).," *J. Agric. Food Chem.*, vol. 60, no. 2, pp. 639–48, Jan. 2012.

[25] S. Masoum, C. Malabat, M. Jalali-Heravi, C. Guillou, S. Rezzi, and D. N. Rutledge, "Application of support vector machines to 1H NMR data of fish oils: methodology for the confirmation of wild and farmed salmon and their origins.," *Anal. Bioanal. Chem.*, vol. 387, no. 4, pp. 1499–510, Feb. 2007.

[26] M. Borit and J. Santos, "Getting traceability right, from fish to advanced bio-technological products: a review of legislation," *J. Clean. Prod.*, vol. 104, pp. 13–22, Oct. 2015.

[27] S. Kelly, P. Brereton, C. Guillou, H. Broll, I. Laube, G. Downey, A. Rossman, S. Hozl, and G. van der Veer, "New approaches to determining the origin of food," in *Food chain integrity. A holistic approach to food traceability, safety, quality and authenticity*, 2011.

[28] C. Hillion, "Tous pour un, un pour tous! Coherence in the External Relations of the European Union," *SSRN Electron. J.*, Mar. 2014.

[29] V. Minkova, *Horizontal Consistency in the Areas of the European Union s External Action*. diplom.de, 2011.

[30] C. Portela and K. Raube, "Six authors in search of a notion: (In) Coherence in EU foreign policy and its causes," *Hambg. Rev. Soc. Sci.*, vol. 3, no. 1, pp. 1–10, 2008.

[31] E. Vos, "EU Food Safety Regulation in the Aftermath of the BSE Crisis," *J. Consum. Policy*, vol. 23, no. 3, pp. 227–255, 2000.

[32] M. M. Cody and T. Stretch, "Position of the Academy of Nutrition and Dietetics: food and water safety.," *J. Acad. Nutr. Diet.*, vol. 114, no. 11, pp. 1819–29, Nov. 2014.

[33] E. Benvenisti and G. W. Downs, "The Empire's New Clothes: Political Economy and the Fragmentation of International Law," *Stanford Law Rev.*, vol. 60, no. 2, 2007.

[34] G. N. Mandel, "Gaps, Inexperience, Inconsistencies, and Overlaps: Crisis in the Regulation of Genetically Modified Plants and Animals - viewcontent.cgi," *William Mary Law Rev.*, vol. 45, no. 5, 2004.

[35] WHO and FAO, "CODEX Alimentarius: Home," 2015. [Online]. Available: http://www.codexalimentarius.org/. [Accessed: 11-Nov-2015].

[36] Codex Alimentarius Commission, "Principles of traceability/ product tracing as a tool within food inspection and certification system. CAC/GL 60-2006." 2006.

[37] Codex Alimentarius Commission, "Joint FAO/WHO food standards program Codex Committee on food import and export inspection and certification systems. Discussion paper on the need for further guidance on traceability/product tracing CX/FICS 07/ 16/7." 2007.

[38] FAO, "Technical Guidelines on Aquaculture Certification." 2011.

[39] European Commisssion, "Regional fisheries management organisations (RFMOs)," 2015. [Online]. Available: http://ec.europa.eu/fisheries/cfp/international/rfmo/index_en.htm. [Accessed: 11-Nov-2015].

[40] S. Cullis-Suzuki and D. Pauly, "Failing the high seas: A global evaluation of regional fisheries management organizations," *Mar. Policy*, vol. 34, no. 5, pp. 1036–1042, Sep. 2010.

[41] The PEW Charitable Trusts, "FAQ: What is a Regional Fishery Management Organization?," 2012. [Online]. Available: http://www.pewtrusts.org/en/research-and-analysis/fact-sheets/2012/02/23/faq-what-is-a-regional-fishery-management-organization. [Accessed: 11-Nov-2015].

[42] S. Clarke, "An Assessment of RFMO Catch Documentation Schemes" in *7th IUU Fishing Forum*, 2012.

[43] MRAG, "Best practice study of catch documentation schemes (WCPFC 7 - 2010 - IP / 03)," 2010.

[44] V. Lavelli, "High-warranty traceability system in the poultry meat supply chain: A medium-sized enterprise case study," *Food Control*, vol. 33, no. 1, pp. 148–156, Sep. 2013.

[45] European Commisssion, "Regulation (EC) No 178/2002 of the European Parliament and of the Council of 28 January 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 saf," *EUR-Lex*, 2002. [Online]. Available: http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex:32002R0178. [Accessed: 01-Aug-2015].

[46] S. van Ruth, Y. Weesepoel, M. Muilwijk, F. Butler, C. Fauhl-Hassek, K. H. Laursen, R. Home, G. Melzer, J. Riedl, and H. Stolz, "Overview of Scientific gaps with regard to the application of analytical methodology for assurance of food integrity (D3.1 Food Integrity)." 2014.

[47] EC, "Guidance on the implementation of articles 11, 12, 14, 17, 18, 19 and 20 of Regulation (EC) N° 178/2002 on general food law. Conclusions of the standing committee on the food chain and animal health." 2010.

[48] B. Van Der Meulen and M. Van Der Velde, *European Food Law Handbook*. Wageningen Academic Publishers, 2008.

[49] S. Charlebois, B. Sterling, S. Haratifar, and S. K. Naing, "Comparison of Global Food Traceability Regulations and Requirements," *Compr. Rev. Food Sci. Food Saf.*, vol. 13, no. 5, pp. 1104–1123, Sep. 2014.

[50] L. Zach, M. E. Doyle, V. Bier, and C. Czuprynski, "Systems and governance in food import safety: A U.S. perspective," *Food Control*, vol. 27, no. 1, pp. 153–162, Sep. 2012.

[51] Presidential Task Force on Combating IUU Fishing and Seafood Fraud, "Action Plan for Implementing the Task Force Recommendations." 2014.

[52] National Oceanic and Atmospheric Administration, “Presidential Task Force on Combating Illegal Unreported and Unregulated (IUU) Fishing and Seafood Fraud Action Plan,” *Federeal register*, 2015. [Online]. Available: https://www.federalregister.gov/articles/2015/10/30/2015-27780/presidential-task-force-on-combating-illegal-unreported-and-unregulated-iuu-fishing-and-seafood. [Accessed: 17-Nov-2015].

[53] F. Dabbene, P. Gay, and C. Tortia, “Traceability issues in food supply chain management: A review,” *Biosyst. Eng.*, vol. 120, pp. 65–80, Apr. 2014.

[54] OIE, “Aquatic code: OIE - World Organisation for Animal Health.” 2015.

[55] B. Sterling and M. Chiasson, “Enhancing Seafood Traceability - Issues Brief,” in *Presidential Task Force on Illegal, Unreported, Unregulated Fishing & Seafood Fraud*, 2014.

[56] G. Pramod, K. Nakamura, T. J. Pitcher, and L. Delagran, “Estimates of illegal and unreported fish in seafood imports to the USA,” *Mar. Policy*, vol. 48, pp. 102–113, Sep. 2014.

[57] J. Zhang and T. Bhatt, “A Guidance Document on the Best Practices in Food Traceability,” *Compr. Rev. Food Sci. Food Saf.*, vol. 13, no. 5, pp. 1074–1103, Sep. 2014.

[58] MRAG Asia Pacific, “An Analysis of Traceability Systems Documenting the Legal Provenance of Russian Salmon and Whitefish.” 2012.

[59] J. C. McEntire, S. Arens, M. Bernstein, B. Bugusu, F. F. Busta, M. Cole, and S. Ohlhorst, “Traceability (product tracing) in food systems: an IFT report submitted to the FDA, volume 1: technical aspects and recommendations,” *Compr. Rev. Food Sci. Food Saf.*, vol. 9, no. 1, pp. 92–158, 2010.

[60] D.-M. Cawthorn, J. Duncan, C. Kastern, J. Francis, and L. C. Hoffman, “Fish species substitution and misnaming in South Africa: An economic, safety and sustainability conundrum revisited,” *Food Chem.*, vol. 185, pp. 165–181, Oct. 2015.