Brief for GSDR – 2016 Update

A Horizon Scan on Aquaculture 2015: Traceability

*R. Winkelhuijzen, M. Van Burik[1]**

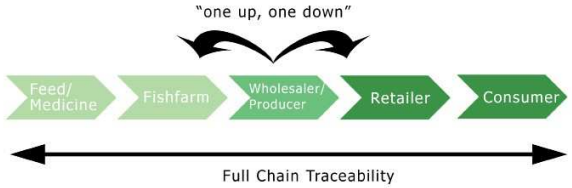
In our globalized world, food supply chains have become complex. To track and trace the food along every step of this chain can be difficult or even impossible. Food safety crises and sustainability concerns have led to an emerging interest in traceability. Low traceability in the supply chain can lead to various problems: (1) mislabeling, (2) illegal practices and (3) lower consumer trust. Benefits of high traceability are (1) food safety, (2) sustainability and (3) transparency. Three possibilities for improving traceability are: coherence and governance by aligning standards through knowledge exchange. Certification as they tend to improve traceability and control via new technologies and traceability systems.

Traceability is the ability to trace the origin of a product at any step of the supply chain, in order to ensure food safety, support sustainable fish farms and fisheries and to fight illegal activities and fraud [1, 2, 3]. As a result of the complex, globalized supply chains and the many different species in aquaculture, it becomes increasingly difficult to ensure traceability.

Global attention for traceability in the food sector is relatively recent. It first emerged because businesses wanted to keep track of their products [3]. In the mid-1990s, traceability became a key issue because of several crises with food safety, most notably the appearance of BSE, or "mad-cow disease" [1,4].
In recent years however, concerns about social and environmental problems and the need to prevent illegal practices have also led to an increased attention for traceability [1,5,6,7].

Supply chains tend to be very complex in the seafood sector. The simplest practices to test traceability are 'one up, one down' business-to-business systems, where the product is traced one step up and one step down the supply chain. More difficult to achieve is full-chain traceability, where the entire supply chain has to be checked entirely for traceability [3,6] (see figure 1).

Implementing traceability remains difficult. In the seafood sector, scientific studies have shown that low traceability results in mislabeling and lacking knowledge about the source [8,9]. Aquaculture and wild fisheries are facing the same problems for traceability because processors and retailers often handle both types [10]. Furthermore, implementation of traceability is costly and requires coordination. As a result, most utilized systems up to now are located in the global North [3]. In developed countries like the EU, the US and Japan, traceability in food is already strongly regulated, while in many developing countries there still is low traceability [1].



This policy brief takes a look at the problems and benefits of traceability in aquaculture and discusses ways to improve.

Figure 1: Aquaculture Supply Chain

[1]A collaboration between Wageningen University and Research Centre (WUR) and the State University of New York (SUNY) College of Environment Science and Forestry.

Benefits of High Traceability

Food Safety

The Food and Agriculture Organization (FAO) states that there is a "need to identify responsibilities as well as to make sure that the source of, for example contamination, is identified and removed" [12]. Traceability does not confirm food safety but strengthens food safety management through increased pressure on the supply chain. The demand for food safety is growing globally.

Transparency

There is an increasing concern of consumers about where their food is coming from [12]. Food chains need to be traceable from farm to fork. The EU and the USA introduced regulation that ensures that consumer and buyers can trace seafood along the supply chain. Without the transparency, seafood cannot be exported to the EU [13]. In addition, transparency benefits the entire supply chain.

Sustainability

Consumers are increasingly aware of sustainability issues in the sourcing or production of food. Sustainability in seafood can stem from social, economic or environmental aspects

Problems with Low Sustainability

Mislabeling

Mislabeling is a global problem related to voluntary and involuntary misconduct when labeling fish according to origin and species. The mislabeling of fish can occur at any stage in the supply chain, from the producer to the retailer. Research suggests that 30% of the global seafood market is mislabeled [9]. In restaurants and specialized fish stores the percentage mislabeled products is higher than in supermarkets [9,14]. Many species are similar in taste and texture, so restaurants and other retailers can substitute a high- value species with a cheaper variant, and making economic profit [8]. A report in December 2015 suggests that the percentage of mislabeled fish in Europe has decreased to 5%, so there are positive developments [15].

Illegal practices and fraud

Traceability is an important issue in wild fisheries to prevent Illegal, Unreported and Unregulated (IUU) practices. Illegal, Unreported and Unregulated fishing threats about 85% of global fish stocks [16]. Aquaculture consumes about one quarter of the global fisheries production as fish feed, straining fish populations [17,18]. This has been difficult to control until now, since in more than 80% of global fishmeal there is low traceability and the species composition is not clear [19].

Lower consumer trust

Mislabeling misleads the consumer and has a negative impact on consumer trust and the industry. Farmed fish already has a more negative consumers' perception than wild fish. It is seen as less healthy, less natural, less fresh and containing more antibiotics [20]. Food safety scandals also lead to lower consumer trust [21]. Transparency in the entire supply chain can enhance the consumer perception of food safety and food quality [22].

It is clear that high traceability has important advantages for the sector and has the potential to improve it. However, traceability in itself cannot relieve all the problems mentioned. How transparency in the food chain should be organized and arranged in order to achieve food safety and sustainability needs to be considered [23].

Improving Traceability

This section gives an overview of the most promising initiatives across the globe to improve traceability.

Coherence and Governance

International standard practices for collecting/ sharing traceability information do not exist for the seafood sector [24]. A global framework of practices, technology and standardized requirements would enable the creation of a traceability system in the seafood sector. However, there is no blueprint for policy or regulation. Geographic regions, cultural/historical backgrounds, moral rules and many other aspects influence to what extent policy is going to be successful. Nevertheless, regulatory bodies are necessary to control food traceability. Currently, national bodies are responsible for the regulation and enforcement of seafood [25] (see box 1)

Governance tends to be shared and inclusive with a decentralized structure. This suggests 'consensus rather than consent', indicating that outcomes are agreed upon rather than accepted [26]. Thus, as situations change, there must be continual institutional and legislative adaptation. For example, in addition to ongoing regulatory adjustments, governance reforms may incorporate stakeholder participation and decentralization if these processes increase effectiveness and efficiency (see Annex 1). In addition aquaculture falls globally under different departments, causing misalignment of expertise and priorities.

Effective policy and regulation need coherency across sectors and borders, which can be achieved through dialogue. On a global scale there are platforms such as 'This Fish' and 'Seafish' addressing the issue of information exchange between the public and private sector as well as on an intergovernmental stage. On the national level there is a need for more interaction between farmers, industry and the government. It is therefore crucial that stakeholders across the supply chain exchange knowledge and interests (see annex 2). Within segments of the supply chain data transfer platforms are very effective. System software and media allow for rapid exchange of information and aid in the creation of traceability systems [11].

The European "carding system"

The EU can give yellow or red cards to countries where the quality of exported food cannot be guar- anteed [6]. Examples of infringements are weak traceability, catch certification system, for a lack of control of fishing activities [13].

A yellow card is a warning and entails cooperation with the EU of about 6 months in order to improve the situation causing the infringement. Green cards given to countries that have improved their practices. Red cards can result in economic sanctions or consequences on trade [13].

This system helps develop improvements to public as well as private areas of the supply chain. This 'carrot and stick' approach reaches out to producers but maintains strict regulation.

Certification

Certification is a tool to stimulate the aquaculture sector in becoming more sustainable. Certified products tend to improve traceability as well. The amount of certified seafood in aquaculture is growing over the last years, with around 5% of the market being currently certified [27].

Certification is mostly carried out by private actors, but public bodies also play a role. Private actors generally aim for the most sustainable 15-30% of the sector – rewarding the best farmers [28,29]. These schemes aim at the international trade market.

Certification schemes that are run by the state set a minimum standard that farmers have to obtain, or sanctions will follow. They are therefore aiming at the worst performers in terms of sustainability [29]. An interesting observation is that the average part in between these extremes - which is always the biggest part - is not targeted within the current schemes [6]. Most of the certified products are sold in developed regions such as Europe and the US, where the demand for sustainable certification is highest. In developing countries, by far the largest aquaculture producers and consumers in the world, there is less demand for sustainable certification [27,29]. The demand for sustainability will probably not change in the near future but in some countries, e.g. China, food safety is becoming a main concern and could be a reason for traceability and certification [30]. Seafood consumption is expected to increase in developing countries. This can affect export to the global North; also hampering the possibilities for developed countries to demand producing countries to have sustainable practices with certification schemes [30].

Certification companies are continuously striving to improve the auditing of their member farms. Third-party auditors are independent actors that test farms for the certification standards. As aquaculture farms can have different certificates at the same time, certification companies are currently looking into possibilities for joint auditing [28]. One perceived disadvantage of certification is that it mostly targets the richer, and therefore larger farms that can afford to buy the certificate. Small-scale farmers often do not have the means to get certified by themselves but are finding ways to enter the market and obtain certification by forming clusters, reducing the costs for each member (see box 2). Certification companies want to stimulate this involvement of smallholders and programs to achieve this are being launched [28].

Inclusion of small-holders: Case study of South East Asia

"Small-scale aquaculture producers in developing countries are facing new opportunities and challenges related to market liberalization, globalization and increasingly stringent quality and safety requirements for aquaculture products, making it harder for small scale producers to access markets" [31]. The government of Indonesia has successfully promoted the inclusion of smallholders through the clustering of farms/communities as well as providing financial incentives [12].

Clusters or farmers organizations (FOs) are conglomerates of farmers or communities working together to facilitate production processes and information exchange. Cluster management is used to implement appropriate better management practices (BMPs), which can be an effective tool to improve the aqua- culture management of the concerned cluster. Better disease control, access to market, empowerment/ bargaining power and exchange of knowledge are some of the examples showing improvement [31].

Sometimes clusters are formed too fast eventually leading to failure. Three main reasons that determine the success of the cluster are: (1) there should be a match between the existing capacity, skills and experience of members and what is required to undertake joint activities; (2) internal cohesion and a membership-driven agenda; and (3) successful, commercially oriented integration of the FO into the wider economy [32].

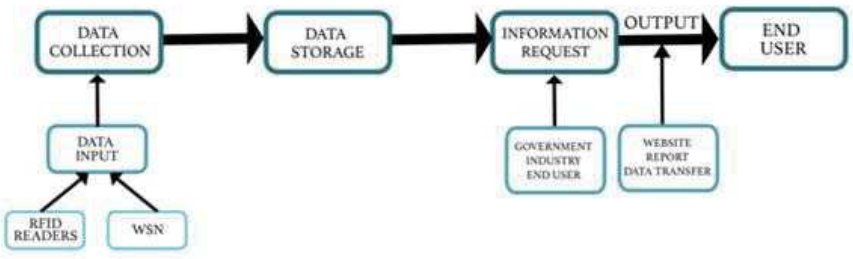


Figure2: Traceability System

Control

The control of traceability needs to answers three questions: (1) what species it is; (2) where it is from and (3) whether it is wild or farmed [34]. New technologies are emerging to make control more specific and faster. Costs are a factor to take into account in order to allow these technologies to trace across the whole supply chain.

Technologies

There is a large number of different technologies available to test for the authenticity of fish [33]. It depends on the purpose of testing which option is preferred. DNA-based techniques have been widely used over the last years [9,34]. This technique is very helpful for identification of species, even when they are closely related. DNA shows high stability and can still be used for identification in highly processed foods [9,35]. PCR sequencing is the most common method currently used [35].

An emerging technology in genetics is next-generation sequencing (NGS) or high-throughput sequencing. It comprises several recent technologies that are able to identify separate species in mixtures of different fish as well [25,36,37]. Also, NGS can be used for species identification in fish feed, to test whether endangered species were used and prevent illegal fishing [37]. A disadvantage of using DNA is the relatively high price, but this is already decreasing and is expected to decrease further [38].

The DNA of species within a region often does not show enough differences to ascertain the exact geographical origin. Biochemical techniques are better suited for this purpose, testing hard tissues, mostly the fish ear-stones (otoliths), for chemical properties that are unique to a geographical area [38,39]. Even over relatively short geographical distances, the discrimination power of otolith chemistry has been shown [34].

To test for antibiotic and pesticide residues, mass spectrometry is used. With this very accurate technology quantities up to picogram levels are detected[25].

Traceability systems

The concept of traceability systems is relatively new, especially regarding the marine environment. Internal traceability systems are simpler and cheaper to implement as they focus on a specific part of the supply chain. External systems are more extensive but allow tracing along the whole supply chain.

New technologies allow for increased efficiency. One important trend in the food sector is the use *electronic traceability and monitoring using Radio* Frequency Identification (RFID) and Wireless Sensor Networks (WSN) [40]. RFID and WSN technologies are in use in all stages, starting from fish farms up to the delivery to the retail [41].

RFID in traceability systems improves management by tracking quality problems, improving management recalls, improving visibility of products and processes, automate scanning, reduce labor, enhance stock management and reduce operational costs [42,43,44].

Traceability systems can process a lot of information/ data, necessary to create output. This is an advantage for companies who can afford this system. For small-holders and smaller companies this is not always the case. In addition the processing of data requires infrastructure and technical knowledge, which is not always available.

Key Messages

- Traceability is an emerging topic, relatively new to the seafood sector. Complex supply chains in a globalized world pose challenges for tracking and tracing seafood.
- High traceability helps to achieve food safety, transparency and sustainability
- Demand for traceability is increasing but demand for sustainable certification will not grow substantially. However, food safety will become more important globally
- Consumption will increase in producing countries, limiting export to the global North. This can have implications for the influence certification schemes of developed countries can have
- Traceability should be tackled from a technical as well as policy angle in order to address the whole supply chain effectively
- More communication and cooperation within the sector is vital for coherent and effective policy outcomes (interplay between industry and public bodies).
- Traceability is a means to achieve sustainable aquaculture but traceability in itself is not enough.

References

[1] FAO (2014). The state of world fisheries and aquaculture. 243 p.

[2] Helyar, S. J., Lloyd, H. A. D., de Bruyn, M., Leake, J., Bennett, N., & Carvalho, G. R. (2014). Fish product mis-labelling: failings of traceability in the production chain and implications for illegal, unreported and unregu- lated (IUU) fishing.

[3] Bailey, M., Bush, S. R., Miller, A., & Kochen, M. (2016). The role of traceability in transforming seafood gov-ernance in the global South. Current Opinion in Environmental Sustainability, 18, 25-32.

[4] Jensen, H.H. and D.J. Hayes (2006). Private sector approaches to secure traceability, transparency and quality assurance in food chains. IATRC Summer Symposium "Food Regulation and Trade: Institutional Framework, Concepts of Analysis and Empirical Evidence", Bonn, Germany.

[5] Boyle, M. D. (2012). Without a Trace II: An Updated Summary of Traceability Efforts In the Seafood Indus- try.

[6] Interview Doddema, M. 11 December 2015, Skype call, interviewees: Burik, van, M., Winkelhuijzen, R.

[7] Panel discussion Richter, A. 2 December 2015, Wageningen, the Netherlands. Interviewees: Winkelhui-jzen, R., Stoffelen, T., Kempchen, L.

[8] Warner, K., Timme, W., Lowell, B., & Hirshfield, M. (2013). Oceana study reveals seafood fraud nationwide. Oceana. Retrieved on August, 11, 2014.

[9] Pardo, M. Á., Jiménez, E., & Pérez-Villarreal, B. (2015). Misdescription incidents in seafood sector. Food Control.

[10] Panel discussion, 2 December 2015, Wageningen, the Netherlands. Interviewees: Winkelhuijzen, R., Stof- felen, T., Kempchen, L.

[11] McEntire, J.C. (2010) Traceability (Product Tracing) in Food Systems: An IFT Report Submitted to the FDA, Volume 1: Technical Aspects and Recommendations.

[12] FAO (2014) Policy and governance in aquaculture Lessons learned and way forward.
[13] Lewis, S. (2015) Latest round of IUU red and yellow cards issued by the European Commission. FishWise.

[14] Panel discussion Schram, E., 25 November 2015, Wageningen, the Netherlands. Interviewees: Stoffelen, T., Winkelhuijzen, R., Kempchen, L., Ching, A.

[15] Mariani, S., Griffiths, A. M., Velasco, A., Kappel, K., Jérôme, M., Perez-Martin, R. I., ... & Boufana, B. (2015). Low mislabeling rates indicate marked improvements in European seafood market operations. Frontiers in Ecology and the Environment, 13(10), 536-540.

[16] WWF (2015). Illegal Fishing: Which fish species are at highest risk from illegal and unreported fishing?

[17] FAO, 2007, The State of World Fisherie and Aquaculture, Rome

[18] Diana, J. S. (2009). Aquaculture production and biodiversity conservation.Bioscience, 59(1), 27-38.

[19] Tacon, A. G. J. (2004). Use of fish meal and fish oil in aquaculture: a global perspective. Aquatic Re- sources, Culture and Development, 1(1), 3-14.

[20] Claret, A., Guerrero, L., Ginés, R., Grau, A., Hernández, M. D., Aguirre, E., ... & Rodríguez-Rodríguez, C. (2014). Consumer beliefs regarding farmed versus wild fish. Appetite, 79, 25-31.

[21] Wognum, P. N., Bremmers, H., Trienekens, J. H., van der Vorst, J. G., & Bloemhof, J. M. (2011). Systems for sustainability and transparency of food supply chains–Current status and challenges. Advanced Engineer- ing Informatics, 25(1), 65-76.

[22] Van Rijswijk, W., & Frewer, L. J. (2008). Consumer perceptions of food quality and safety and their rela- tion to traceability. British Food Journal, 110(10), 1034-1046.

[23] Mol, A.P.J., and Oosterveer, P. (2015) Certification of Markets, Markets of Certificates: Tracing Sustain- ability in Global Agro-Food Value Chains. Sustainability through the Lens of Environmental Sociology

[24] Olsen, P., & Borit, M. (2013). How to define traceability. Trends in Food Science & Technology, 29(2), 142-150.

[25] Interview Kannuchamy, N., 15 December 2015, written response to questionnaire, interviewee: Winkel-huijzen, R.

[26] Gray, T. (2005). Participation in fisheries governance (Vol. 4). Springer Science & Business Media.

[27] Bush, S. R., Belton, B., Hall, D., Vandergeest, P., Murray, F. J., Ponte, S., ... & Kruijssen, F. (2013). Certify sus- tainable aquaculture. Science, 341(6150), 1067-1068.

[28] Interview Geerts, B., 1 December 2015, Utrecht, the Netherlands, interviewees: Stoffelen, T., Burik, van, M., Winkelhuijzen, R.

[29] Interview Staniford, D., 16 November 2015, Skype interview, interviewees: Huisman, Y., Winkelhuijzen, R., Schmitz, L.

[30] Panel discussion, 2 December 2015, Wageningen, the Netherlands. Interviewees: Winkelhuijzen, R., Stof- felen, T., Kempchen, L.

[31] Kassam, L., Subasinghe, M., Phillips, M. (2011) Aquaculture farmer organizations and cluster manage- ment Concepts and experiences. FAO Fisheries and aquaculture technical paper 563.

[32] Stringfellow, R., Coulter, J., Hussain, A., Lucey, T., & McKone, C. (1997). Improving the access of small- holders to agricultural services in sub-Saharan Africa. Small Enterprise Development, 8(3), 35-41.

[33] Martinsohn, J. T. (2011). Deterring illegal activities in the fisheries sector.European Commission-Joint Re- search Centre, 72.

[34] Martinsohn, J., & Brereton, P. (2013). Using new analytical approaches to verify the origin of fish. New Analytical Approaches for Verifying the Origin of Food, 189.

[35] Griffiths, A. M., Sotelo, C. G., Mendes, R., Pérez-Martín, R. I., Schröder, U., Shorten, M., ... & Mariani, S. (2014). Current methods for seafood authenticity testing in Europe: Is there a need for harmonisation?. Food Control, 45, 95-100.

[36] De Battisti, C., Marciano, S., Magnabosco, C., Busato, S., Arcangeli, G., & Cattoli, G. (2013). Pyrose- quencing as a Tool for Rapid Fish Species Identification and Commercial Fraud Detection. Journal of agri- cultural and food chemistry, 62(1), 198-205.

[37] Galal-Khallaf, A., Osman, A. G., Carleos, C. E., Garcia-Vazquez, E., & Borrell, Y. J. (2016). A case study for assessing fish traceability in Egyptian aquafeed formulations using pyrosequencing and metabarcoding. Fisheries Research,174, 143-150.

[38] Interview Leal, M., 11 December 2015, Skype interview, interviewees: Winkelhuijzen, R., Burik, van, M.

[39] Campana, S. E. (2005). Otolith science entering the 21st century. Marine and Freshwater Research.

[40] Myhre, B., Netland, T., Vevle, G., (2009) The footprint of food – a suggested traceability solution based on EPCIS. In: Proceedings of the 5th European Workshop on RFID Systems and Technologies (RFID SysTech 2009), Bremen, Germany.

[41] Mol, A. P., & Oosterveer, P. (2015). Certification of Markets, Markets of Certificates: Tracing Sustainability in Global Agro-Food Value Chains.Sustainability, 7(9), 12258-12278.

[42] Sarac, A., Absi, N., & Dauzère-Pérès, S. (2010). A literature review on the impact of RFID technologies on supply chain management. International Journal of Production Economics, 128(1), 77-95.

[43] Regattieri, A., Gamberi, M., & Manzini, R. (2007). Traceability of food products: General framework and experimental evidence. Journal of food engineering,81(2), 347-356.

[44] Michael, K., & McCathie, L. (2005, July). The pros and cons of RFID in supply chain management. In Mo- bile Business, 2005. ICMB 2005. International Conference on (pp. 623-629). IEEE