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Following the mackerel – Cost and benefits of improved information exchange in food supply chains

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ABSTRACT

Transparency is very important in food supply chains. There is close scrutiny of the fisheries industry because a wild resource, vulnerable to exploitation, is being harvested. These factors together with the need for product differentiation and the need to control the quality of products have emerged as reasons for this sector to focus upon traceability. In Japan, a major importer of Norwegian mackerel, food quality and food safety are taken very seriously. Over the last few years there have been several food scandals. Studies have shown that the main challenges regarding internal traceability in current production systems of mackerel are unique identification and communication of data elements outside the company of origin. This study presents findings regarding the costs and benefits of implementation of strategies for improving these areas. Some companies expressed the desire to voluntarily implement all the recommendations i.e. provide reliable, automated information flow from boat to production.

1. Introduction

Transparency is increasingly important in food supply chains (Carriquiry & Babcock, 2007; Inman, 2009; Kiesel, Buschena, & Smith, 2005; Pettitt, 2001). Creating this transparency requires the ability to trace and track ingredients in food stuff rapidly and precisely. Transparency in the fisheries industries is particularly important due to extensive export and import activities. Fisheries industries are closely scrutinized because they involve harvesting a wild resource. The needs for product differentiation and control of the quality of products have emerged as reasons for this sector to focus upon traceability. This has led to an increased focus on both initial and advanced implementation of traceability systems.

To what degree and whether to attempt to implement advanced traceability systems is a complex area for the seafood industry. One analysis of the interacting factors is described in Fig. 1.

A study of the relevance of information systems in food safety management stated that these systems are vital to assist decision-making in a short time frame (McMeekin et al., 2006). The same work concluded that management of microbial food safety risks is improved when increasingly extensive microbiological databases are combined with information on environmental conditions pertaining to the processing, distribution and storage of food. A review of the chain traceability in the Norwegian pelagic industry in 2004 showed that very little food safety information is associated to traceable units (Storøy et al., 2007).

According to the International Organization for Standardization (NS-ISO 8402) traceability is defined as the ability to trace the history, use and localization of an entity through recorded information. The entity, or item, that should be traced, can be both physical and virtual. To be able to establish a traceability system, all items must have a unique identification. A major focus of the Norwegian eSporing project (Thakur, Karlsen, & Foresti, 2012) has been to establish a traceability solution where companies can use globally, or locally unique (within a company) identifiers to identify the company's items. The eSporing solution will convert locally unique identifiers to globally unique identifiers, enabling individual companies to use existing systems for identification of items. The Electronic Product Code Information Services (EPCIS) standard was chosen as the standard for the eSporing solution where the object and aggregation events were used to model the transformations in the food chain (for example: merge, split and process events). This use of the EPCIS standard has made it possible to standardize the handling and processing of items in the complete food value chain. This enables one common traceability solution, with common use of events for all food types, sub sectors and throughout the whole value chain. Data can only be accessed by external users when the

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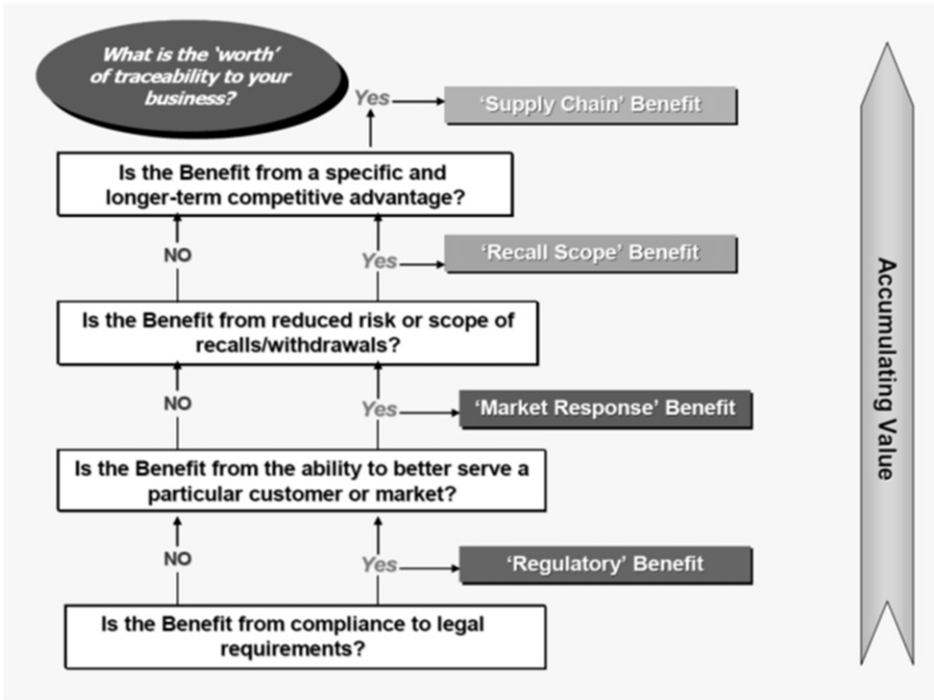

Fig. 1. Illustration of the benefits of traceability implementation and the accumulating values of these things (Sparling & Sterling, 2004).

owner company specifically grants access rights to certain (limited) data for external users.

In Japan, a major importer of Norwegian mackerel, food quality and food safety are a high priority and their management system is well developed. However, over the last few years there have been several food scandals (Elbers et al., 2001; Fallon, 2001; Madec, Geers, Vesseur, Kjeldsen, & Blaha, 2001; Ozawa, Ong, & An, 2001). Currently in Japan there is a focus on food imported from China. At the beginning of 2008 the company Kouzai Bussan Co. found traces of the pesticide 'dichlorvos' in an imported mackerel product. The mackerel had been caught and frozen in Denmark and later sliced and marinated in China. The company had already sold 73,000 packages of the contaminated product and then had to try to withdraw the remaining units from the retail market. In order to rebuild trust Kouzai Bussan Co. also decided to recall 18 other products which are imported from the same Chinese manufacturer. One should also note that the price variation of mackerel in Japan is largely dependent on species, catch area, slaughter methods, preservation method, distribution time, etc. There have been incidents where actors have been tempted to mislabel mackerel products in order to gain extra profit.

Identification of critical control points (CCPs) is very important for traceability as this approach provides information about important food safety hazards and how they must be monitored. A combination of the state-event model, that follows an event approach to identify all states and events in frozen mackerel production, and the use of the Hazard Analysis and Critical Control Points (HACCP) method provides a specific focus on the food safety aspects describing the potential hazards at each critical step in the process. The most important hazard in frozen mackerel production is the Scombrotoxin (Histamine) formation that occurs as a result of time/temperature abuse of mackerel during production. The *product receiving* step is an important CCP where histamine levels must be checked. Since, histamine is produced as a result of time/temperature abuse of mackerel, continuous temperature records must be maintained at the *packing* and *storage* stages.

According to a recent study by Donnelly, Thakur, Forås, Sakai, and Storøy (2012) the main challenges regarding traceability within mackerel production in supply chains from Norway to Japan are;

- The production code, which is the key to all recorded information in the processing company, being proprietary and meaningful only to that company.
- All the boxes produced on the same day have exactly the same identifier on them, even though they might go in different containers and have different cooling chains.
- A lot of relevant information is recorded electronically but not passed on, partly because the label is of limited size.
- Most of the Japanese processors do not record the numbers on the received boxes, so no link can be established to information on the box label.
- In some cases, a retailer label is attached to the processed mackerel in Japan resulting in the link between the processor label and the retailer label not always being maintained.

The research suggested an improved ICT system for traceability at the processing plant be designed. The objective for this system was to generate electronic messages describing the mackerel products that were being sent from Norway to Japan, so that significantly more information about the product would be made available to the Japanese buyers.

While the Japanese partners said very clearly that traceability and documentation of the temperature regulation throughout the supply chain (sometimes referred to as 'cold chain') was very important to them, they regarded the cold chain documentation as a much bigger problem in relation to the mackerel that went from Norway via China to Japan, the reason for this concern was not explicitly stated. With respect to the quality and the documentation of parameters in the Norwegian part of the chain, some of the Japanese buyers already had their own quality inspectors in place at the Norwegian plants and they delivered extensive reports on what happened there, seemingly rendering the need for delivery of further quality information redundant.

Fig. 2 represents the states and events for the frozen mackerel production process. The product, process and quality data collected during production can be linked to one of these states or events and can be used to provide traceability information.

Four CCPs were identified following the HACCP method, namely, *product receiving, packing, refrigerating* and *store*. These CCPs refer to the states presented in the state-event model.

The present study examines the costs and expected benefits of implementation of advanced traceability in the supply chain between Japan and Norway. Previously the degree of traceability between Norway and Japan has been studied together with the changes necessary to achieve the improved levels of traceability and these are outlined in the introduction of this paper. This study builds on previous research and presents new data regarding the quantification of costs and benefits in the frozen mackerel supply chain between Japan and Norway.

2. Method

Findings from previous research (K. A. Donnelly et al., 2012) have enabled the identification of the following areas which need to be addressed in order to improve traceability.

1. There is a need for easier (to some degree automated) data flow between supply chain partners with no re-entering/re punching of information.
2. The information from the catch certificate should be accessible for the downstream parties following landing of the catch.
3. The Japanese producers have a strong interest in receiving information similar to the Catch Certificate used for the products imported to the EU. This certificate contains details of transport method used, description of product including species and amount, vessel name, vessel registration, catch area, landing date and data related to the original sales note
4. Development of a description of all information which it is desirable to exchange and how this information could be presented in Japan.

Specifically with regards to physical reengineering, points are interpreted as follows:

1. Globally unique standard codes for identifying batches and trade units already exist (supplied by GS1)
2. Addition of serial numbers to batch numbers on each box, as there are multiple boxes per batch.
3. Make relevant information available both electronically and externally
4. Implementation of electronic catch certificate on all boats delivering fish

These points constitute the changes which need to be made in order to move from the current situation (Fig. 3) to the desired model (Fig. 4).

Fig. 3 shows the current situation of information exchange between the actors in the mackerel supply chain between Norway and Japan. NSS represents the Norges Sildesalgslag which is the national sales organization for pelagic fish in Norway. The information exchange is represented in a sequential manner in this figure. 'Sluttsedel' is a document that is used for legal reporting of fish catches and landings by each vessel to NSS (This document is based on the Norwegian legal requirements 'råfiskloven' § 7 og 'saltvannsfiskeloven' § 9a).

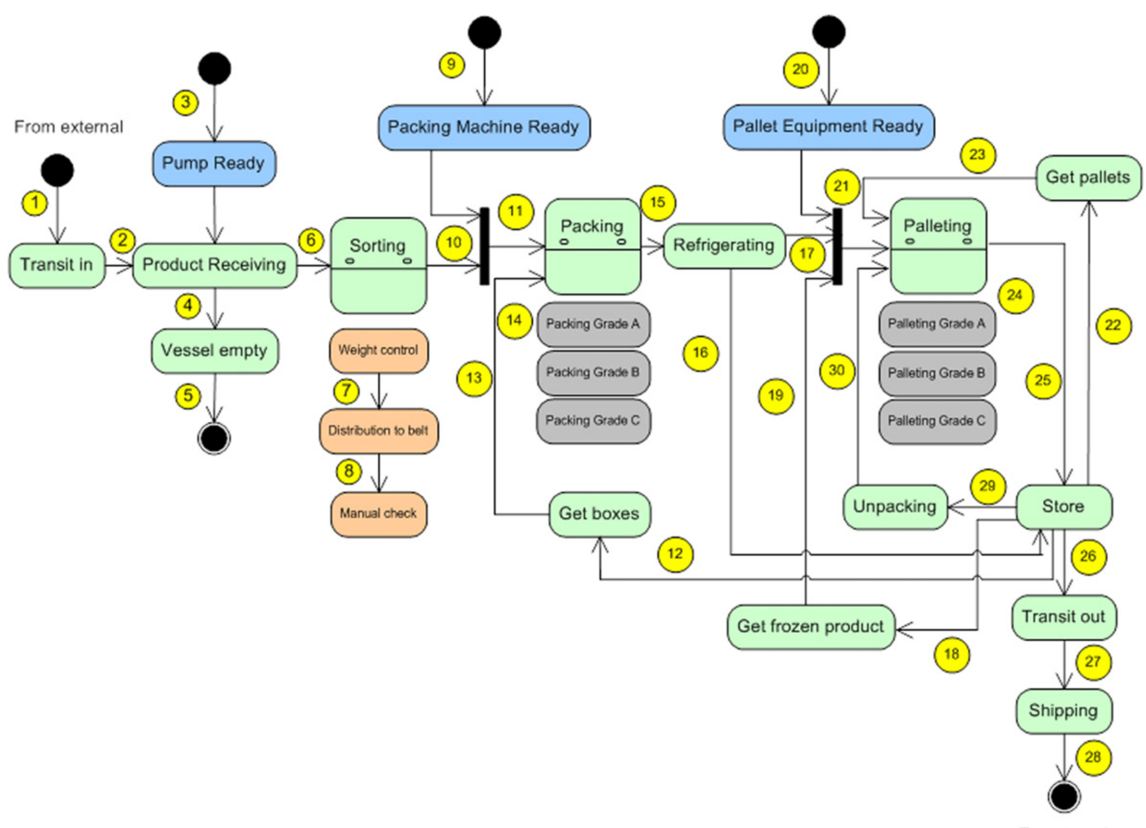

Fig. 2. State-event model for frozen mackerel production (Thakur, Sørensen, Bjørnson, Forås, & Hurburgh, 2011).

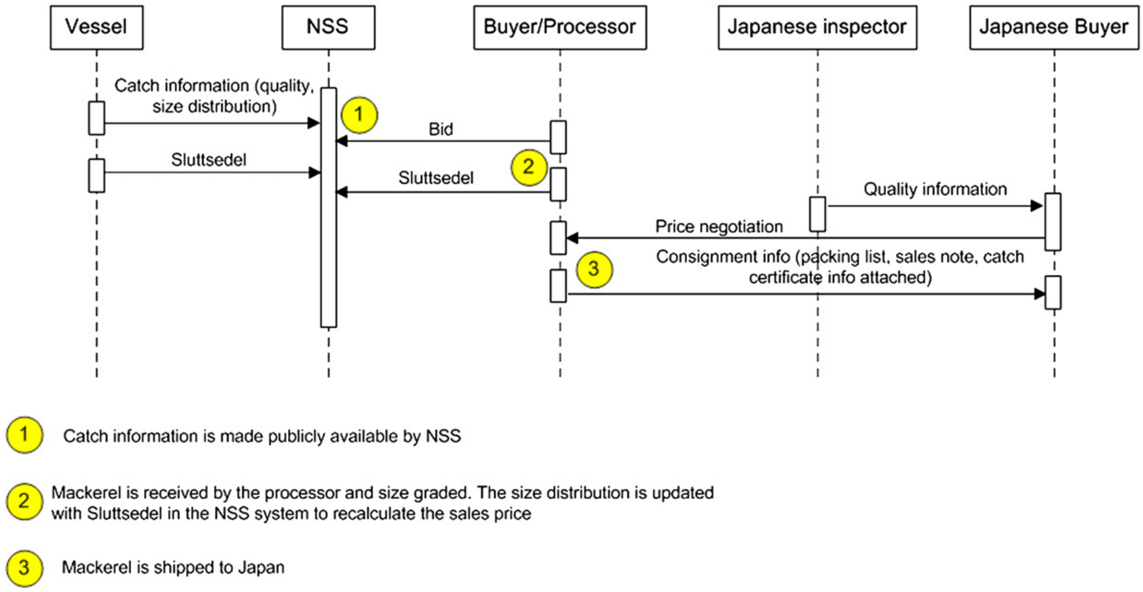

Fig. 3. AS-IS model for information exchange in mackerel value chain between Norway and Japan representing the current situation (Thakur et al., 2011).

A TO-BE model, representing the desired situation, based on input from stakeholders and application of eSporing system for traceability where each stakeholder can upload traceability data (including identity and transformation data) to the eSporing system and perform tracking and tracing of any traceable units.

3. Results

The results are presented regarding the reengineering suggestions both physically and electronically. The results were also divided into the costs and the benefits. First the quantitative

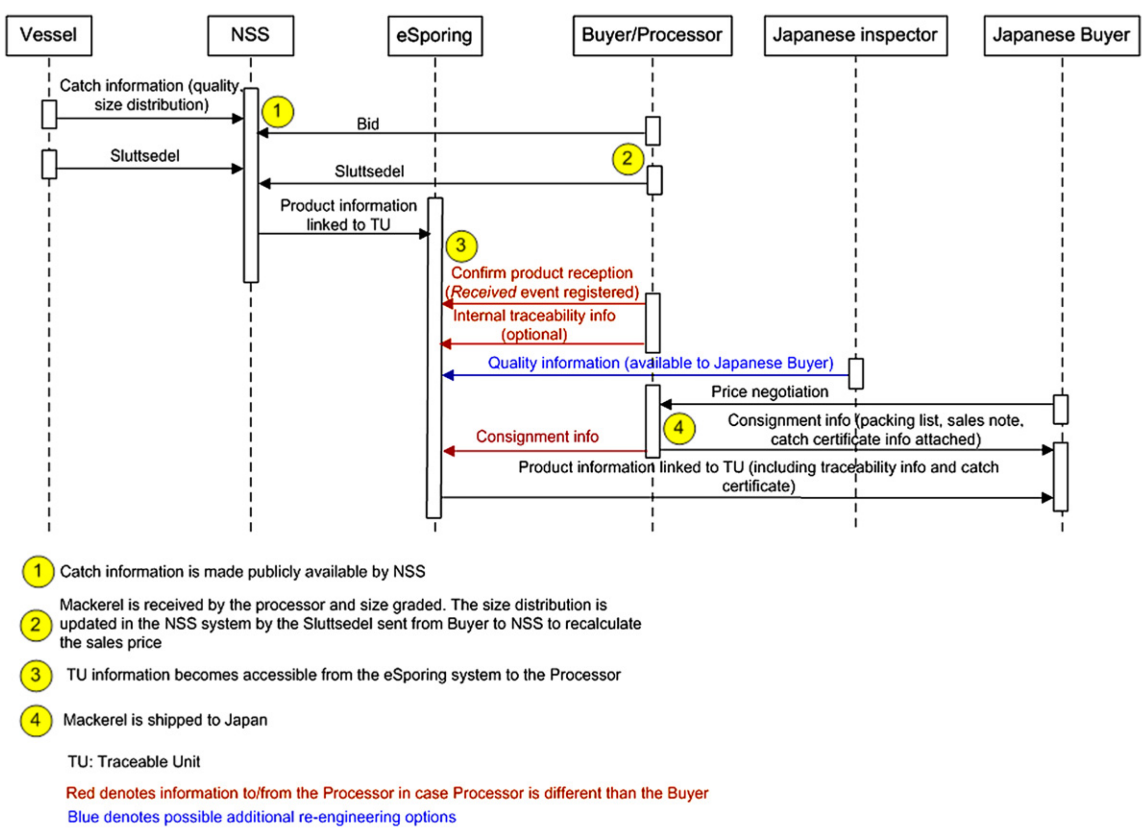

Fig. 4. TO-BE model for information exchange in mackerel value chain between Norway and Japan based on 'eSporing' implementation.

Table 1
Table of identified costs. The costs outlined here are classified by type as follows: System cost (S), implementation (I), Training (T), Consultant (C), Labor (L) Equipment (E).

Measure	Type of cost	Description of reengineering	Estimated work for reengineering
1	S, C,	1.1. Establish GS1 codes for all products for batches and trade units.	1.1. 2–5 h consultancy work to re-program existing systems to produce serial numbers and batches to each box
2	S,T,C,	2.1. Establish GS1 Codes serial number for each box 2.2. Invest in appropriate printers for GS1 codes 2.3. Configure printers and relevant software for printing 2.4. Staff training	2.1. Can be carried out as part of measure 1. 2.2. Cost of each new printer 2.3. Can be carried out as part of measure 1 2.4. 2–8 h of consultancy time and staff training
3	S, I, T, C,	3.1. Ensure that serial numbers reach the relevant customers 3.2. Create electronic database containing all relevant data 3.3. Staff training 3.4. Create user interface available via the web 3.5. Inform/advertise availability of information to appropriate groups	3.1–3.3 Carried out in reengineering of measure 1 and 2 3.4. Design and implementation of web interface 3.5. Extremely variable cost depending upon strategy
4	S, I, T	4.1. Buy appropriate software and licenses 4.2. Install Up dating	4.1 & 4.2. Licenses for the basic catch certificate software are on average

aspects are presented followed by the qualitative aspects where appropriate. The data is presented first for the Norwegian part of the chain followed by the Japanese data Tables 1 and 2.

3.1. Norway

3.1.1. Costs Norway

3.1.2. Benefits Norway. Other qualitative benefits could also be listed, such as good brand recognition, assuming the company can differentiate and market its product based on the "transparency" in the supply chain while marketing to consumers who value traceability.

3.1.3. Findings from case studies using these models – studies in Norway. 'PelagicPro,' (a company handling pelagic fish in Norway) was engaged to participate in this study. PelagicPro made the following comments regarding the suggested changes. The solution suggested above would save time when creating catch certificates for example and permit Pelagicpro to carry out automatically tasks which are currently carried out manually thereby saving time and improving data quality. Manually inputting data into the system in order to create the number on the packing list creates a little more work and is also expected to increase the risk of data errors (an id of 8 digits makes plenty of room for mistakes) and therefore reduces the expected data quality. The general manager of PelagicPro felt that offering greater detail in the information to Japanese consumers would increase the amount of contact and queries rather that reduce them. Concern was expressed relating to the spread of information beyond immediate customers and more general confidentiality issues. This problem is addressed in eSporing by password protected access to the users. The owner of the data can specify access rights on a product level for its customers so that companies can only access information related to the products that they received from a particular supplier. PDF's are currently demanded and more electronic integration could save time. Currently no other customers ask for this type of information; however there is increasing demand for certification such as British Retail Consortium (BRC), Marine Stewardship Council (MSC), GlobalGap, and 'eSporing'. It is thought that these solutions will become more important in the future. Costs of multiple revisions and certifications are considered to be extremely high. Costs related to alteration of software are foreseen and thought to be high at 50 h consultancy work in order to carry out modifications.

Table 2
Table of associated identified costs in the Norwegian part of the chain.

Measure	Cost of initial reengineering	Costs associated with implementing eSporing 'solutions'[a]
1	2000–5000 NOK	System cost – 150.000 NOK Implementation – 60.000 NOK Training – 50.000 NOK Consultant – 100.000 NOK Labor – not a significant additional time needed for use of the system
2	17,000–88,000 NOK + 600 NOK total staff needing training	
3	50,000–1,000,000 NOK Extremely variable cost depending upon strategy 250,000–400,000+	
4	13,900 NOK and yearly costs on average 3427 NOK	

[a] The costs here are not broken down as the costs are spread across the different measures.

3.2. Japan

3.2.1. Costs Japan. The following scenarios were selected for estimating the costs and benefits of using the eSporing system by the Japanese importers:

1. Japanese importer sends the incoming data to eSporing when it receives a consignment.
2. Japanese importer traces back through eSporing when information about product history and catch certificate information is needed. For example if there are questions related to the quality of the fish which the importer suspects maybe related to the catch phase of operations.

3.2.2. Benefits Japan. The following table summarizes the benefits observed from the supply chain perspective in Japan Table 5.

4. Discussion

This study presents findings regarding the cost and benefits of traceability system implementation both electronically and practically in a mackerel supply chain between Japan and Norway.

Table 3
Quantification of the benefits.

Measure	Estimated benefits	Estimated benefit in terms of actions	Cost level of scenario High/Low/Medium
1	1.1. Information can be uniformly and easily exploited by customers. Involves little new investment or change to working practices.	Improved accuracy and time saved with regards to re punching data.	Low
2	2.1–2.4. Similar benefits to those in case 1	Improved accuracy and time saved with regards to re punching data. In addition the ability to make use of information for customers and regulatory authorities.	Medium
3	3.1–3.5. Relatively expensive to carry out and needs appropriate solutions for each individual customer	This would allow exploitation of cases 1,2& 4 and increase the value of these. This strategy for marketing is currently relatively rarely seen and little tested	High
4	4.1. Similar to 1.1 with greater advantages in terms of time and accuracy savings	Improved accuracy and time saved with regards to re punching data.	Low

The challenges faced by the seafood industry and in particular, the pelagic sector have been outlined in the introduction and it was clear from the results of this study that companies were aware of the need for more information with regards to food safety, quality and meeting customer demands. The companies interviewed were less aware of the benefits associated with implementation and therefore these did not play a role in their motivation to undertake advanced implementation. Table 6.

In the results the costs and benefits were presented to the industry during the semi structured interviews, however not all of the changes and resulting costs were thought to be equally relevant to the industry in Norway. Industry attitude to changes suggested that not all companies were convinced that all changes were important to their business strategy. Points 3 (make relevant information available both electronically and externally) and 4 (implementation of electronic catch certificate on all boats delivering fish) in Table 4 were the most important. Interviewees also highlighted the importance of information exchange in two specific areas: better automated information exchange from vessels to buyers and information to end customers.

This study was not able to create a full quantitative matrix of costs and benefit. This could be due to lack of long term implementation. Lack of motivation within companies to fully implement the changes needed leads to a lack of qualitative data. This is a recurring theme in the literature around traceability. Sparling, Henson, Dessureault, and Herath (2006) observed that the motivations for implementation were related to risk reduction, while after implementation the main perceived benefits were related to improved perception by customer, buyers and regulators.

Another interesting finding from this study is that there is great industrial variance in what is required by companies in the same sectors, this means that creating general findings is difficult due to there being so many internal and external variables.

One important observation made by both the Norwegian and Japanese participants in this project was that in these particular supply chains quality information was gathered directly by the Japanese buyers having people inspecting during production, this seemed to make the need for electronic transmission of quality information redundant. This further highlights the need for speedy, detailed and reliable transmission of information and the potential for using this as a market advantage. Effective and ‘trusted’ data may remove the need for the buyer’s inspectors to be physically present.

With regards to specific electronic implementation and use of the proposed ‘eSporing’ system three main limitations have been identified which have implications for this assessment. These are:

- The reaction time of eSporing system seems slow for business use.
- eSporing sometimes stops by error. This is an obstacle if importer uses eSporing in food safety accident
- The menu for the importer needs to be simpler, if it uses the system for the limited scenarios.

The benefits are outlined in Tables 3 and 7 having considered these it is difficult to see why pelagic companies currently seem reluctant to consider them (K. A. M. Donnelly & Olsen, 2012). This study highlighted a number of limitations such as companies being unaware of the benefits. Currently the companies don’t have a detailed picture of their internal processes, so cannot quantify

Table 4
Costs observed in Japan.

Measure	Cost of reengineering
1&2	• Training cost for Japanese consultant: 8 h per year (costs below) • Time for implementation and consulting for an importer: 8 h per year • Labor cost for use of the system: 5 min per consignment. Assuming 60 consignments per year is 5 h additional time per year. • The average hourly wage for the Japanese staff is 3600 yen/hour, equivalent to 280 NOK per hour. 5 h additional time equals a cost of 1400 NOK per year for the Japanese importer

Table 5
Benefits of implementation in Japan.

Type of benefit	Description
Regulatory	Catch certificate information generated by eSporing available electronically
Internal logistics	Time Saving -The eSporing solution will decrease time to search the file this saves 5 min/consignment.
Recall and risk management	Quick response to accident. The importer can check the possibility of influence by accident (e.g. sea pollution)
Supply chain operations	Supply chain transparency. The importer can show documentation of the origins of the product using the information in negotiations with the client. It helps to exclude illegal, unreported and unregulated (IUU) fishery and misrepresentation of country-of-origin-labeling.

Table 6
In summary the study produced the following costs and benefits faced by companies in the mackerel/pelagic sector.

Summary of costs	Summary of benefits
System cost IT implementation	Production efficiency
Implementation	Data quality improvement
Staff training	Information available electronically to national systems such as catch certificate and can be shared with customers without sending the product information to them manually.
Consultancy work	Electronic track and trace functionality: quicker and targeted recalls – cost reduction
	Efficient communication with customers
Hardware investment	–

Table 7
Summary of qualitative benefits of implementation based upon the frame work developed by Sparling and Sterling (2004).

Type of benefit	Description from case study
Regulatory	Catch certificate information generated by eSporing available electronically
Internal logistics	No need for manual re-entering of data
Recall and risk management	Electronic track and trace functionality: quicker and targeted recalls – cost reduction
Market and customer response	Efficient communication with customers, Quality information linked to specific TUs
Supply chain operations	Information available in eSporing system and can be shared with customers electronically. Supply chain transparency, Catch certificate information generated by eSporing available electronically

benefits in detail. This leads in turn to scepticism about the advantages of implementation. Such scepticism is an important factor when considering future implementation routes, i.e. market forces or regulatory enforcement.

5. Conclusions

While the data presented here moves the frontiers of the science of traceability implementation forward it also highlights the lack of interest in the industry and the need for greater knowledge regarding motivational factors and the validity and usefulness of solutions such as those presented here.

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