Mackerel supply chain from Norway to Japan - Preliminary results from an international traceability project

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Abstract in Norwegian:
Kravet til dokumentasjon av matvarer forsetter å øke. Prosjektet beskrevet i denne artikkel har som mål å "utvikle, teste og måle effekten av et skreddersydd sporbarhetssystem som muliggjør innsamling og deling av matsikkerhetsinformasjon i verdikjeden for makrell mellom Japan og Norge". Studien innbefatter en bred analyse av sporbarhet i verdikjeden, analyser av interessegrupper sine meninger og en detaljert studie av verdikjeden.

Abstract in English:
The demand for documentation of food information continues to increase. The project described in this paper aimed to: 'develop, test and measure the effect of a tailor made traceability system with functionality for recording and sharing food safety related information in the mackerel supply chain between Norway and Japan.' The study involved a broad analysis of traceability across a selection of mackerel supply chains between Japan and Norway, analysis of the stake holder views in the mackerel supply chain and a detailed investigation of one single supply chain.

Introduction

There is an ever greater transparency required in food supply chains (Pettitt, 2001; Kiesel *et al.,* 2005; Carriquiry & Babcock, 2007; Inman 2009). Creating this transparency requires the ability to trace and track ingredients in food stuff rapidly and precisely. This has important consequences for fisheries related industries particularly because they involve large numbers of export and import activities. Fisheries industries are closely scrutinized because they are harvesting a wild resource. 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 the fishing industry traceability and food safety information is still not standardized and most of the information is recorded manually with a high risk for errors (Imran, Altaf *et al.,* 2006; Karlsen & Senneset, 2006; Randrup *et al.,* 2008; Storøy *et al.*, 2008).

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. Norges Sildesalgslag (NSS - The Norwegian pelagic fish sales association) and the pelagic sector will, through this project, establish a functional system for electronic exchange of food safety information. Hence this project is part of the strategic on-going work in NSS.

Through several recent R&D projects, the Norwegian pelagic fish sector has developed both a sector specific "Traceability Guidelines" (Digre & Forås, 2004) and solutions for electronic exchange of traceability and quality information (Forås *et al.*, 2008). Norges Sildesalgslag, (NSS - The Norwegian pelagic fish sales association) the ICT provider for the pelagic fishing fleet, has developed a functional electronic traceability solution that covers the initial steps of the chain from fishing vessels to landing locations (www.sildelaget.no). As part of the fight against illegal unregulated fishing (IUU) the Norwegian Ministry of fishery and coastal affairs has initiated a project to establish full electronic traceability from catch to consumer.

Japan is a major importer of Norwegian mackerel. In Japan food quality and food safety are of great importance 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 *et al.*, 2001; Ozawa *et al.*, 2001). Currently there is a focus on food imported from China. In the beginning of 2008 the company Kouzai Bussan Co. found traces of the pesticide dichlorvos in an imported mackerel product. Initially the mackerel was 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 now had to try to withdraw the remaining units from the retail market. In order to build 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 large 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.

This article summarizes the work carried out as part of the project 'Main Safe Trace Japan' project. The article focuses on the main results from the logistics/information exchange research.

Traceability practice

As a part of the BIP (brukerstyrte innovasjonsprosjekter Norwegian Research Council) project 'MainSafeTraceJapan' FMRIC (Food Marketing Research & Information Center), Nofima (Norwegian Institute of Food Fisheries and Aquaculture research) and SINTEF Fisheries and Aquaculture carried out a simulated recall study focused on mackerel bought in Japan with fish originating from both Norway and Japan.

A method used and peer reviewed in three previous studies was employed (Karlsen & Senneset, 2006; Randrup *et al.,* 2008). This method entails buying randomly selected products in a retail shop and then trying to trace the product back to its origin by using personal contact- telephone, email and fax. This method reveals the effectiveness of traceability for a given product and corresponding food chain and hence reveal areas for improvement.

These recalls involved tracing consumer packaged mackerel products from Japan and Norway in order to investigate the current situation with regards to traceability. European Union (EU) food law (Anon, 2002b; Anon, 2002a; Schwägele, 2005) states that the operator must record both receipt and despatch of ingredients. Without internal traceability it can be difficult to connect specific products received to those delivered, which is essential when tracing specific food products.

Table 1 Questions asked during the purchase of the product

Information about the purchase
Date of purchase
Place of purchase
Information about the product both on the packaging and gained in the shop
Describe the product.
Does the product have any special certifications such as MSC, KRAV, Organic?
Who owns the brands?
What is the name of the producers (contact details)
What is the authorisation number?
What is the origin of the product? (country and region)
In which land was the product processed
What is the GS1 code on the product
Is the product marked with any other identifying numbers?
What is the production date?
What is the 'best before' date?
Is there any other information on the product?

Additional questions used in the telephone interviews can be seen in table 2.

Table 2 Questions asked as part of the structured survey

Which part of the value chain is this?
What is the name of the company and the contact person?
How is the information collected (in person via email, via fax via telephone)?
When was the information collected?
What was the time taken to collect information?
How was the information collected?
Have you delivered product (specific) X to the customer Y?
What kind of information can you give me about the product?
Can you tell me exactly where the raw ingredients have come from?
Can you tell me who delivered the raw ingredients to you?
How large was the delivery which included the ingredients for this product?
How do you communicate with your customers?
What is the size of a batch at your company?
What is the estimated time needed to trace back through your company?

The results show that in this study it was possible to trace more of the products originating in Japan. This could be related to the fact that the products were initially bought in Japan and had a less complex supply chain than those with an origin in Norway.

The following broad conclusions from this part of the study are;

- The results do show that the 60% of completed samples were traced back to the boat or boats of origin within one hour.
- The study did not differentiate between products which couldn't be traced and instances where companies were not willing to cooperate, leaving a degree of uncertainty regarding the other 40% of products.
- Dried, pickled and salted products appeared to be easier to trace regardless of origin (Donnelly *et al.*, 2011). We hypothesise that this is related to the stage of processing at which the product is packaged, that is, before leaving the processing company.
- The products of Norwegian origin which could be traced were traceable back to a single boat.

The study also showed that the products of Japanese origin could be traced back to a varied number of boats, due we presume to the number and complexity of transformations (Donnelly *et al.*, 2009). The traceable products of Norwegian origin could be traced back to a single boat. This is one possible area for exploitation with regards to product differentiation.

It could be concluded from this that the traceability may be improved within the Japanese supply chains by increasing awareness of critical traceability points and transformations. Further research into this area may be appropriate. The study also shows that education of shop staff about the information that needs to be maintained for traceability and also perhaps electronic systems for such storage would be appropriate. A further recommendation may be the development of systems and standards for electronic information exchange particularly with regards to problems such as processing in third countries. Such electronic systems would overcome language and cultural barriers when attempting to access traceability information.

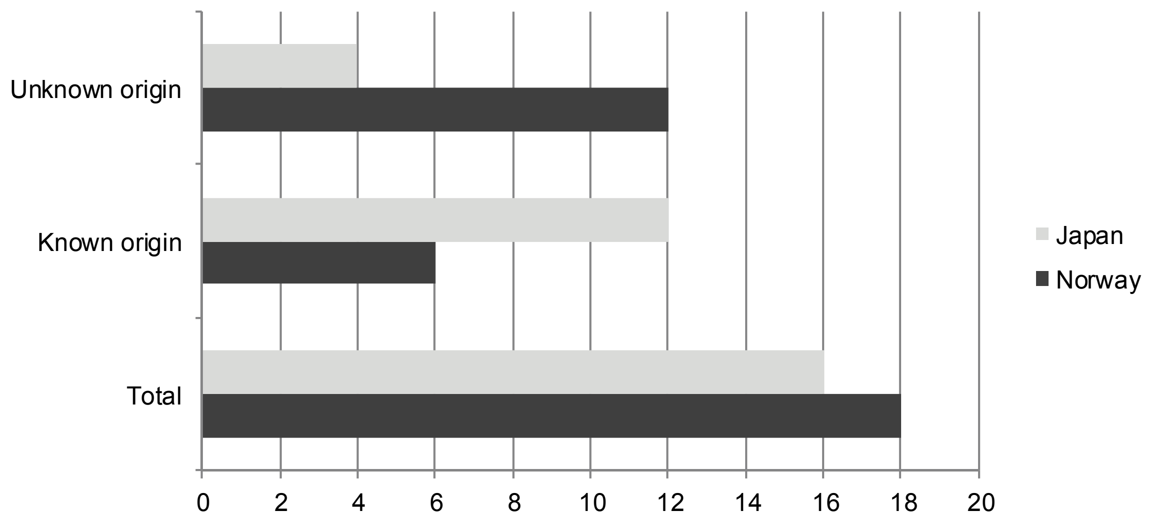

Figure 1 The number of products with known or unknown origin

Mackerel supply chain survey – stakeholder analysis

A stakeholder analysis was conducted to determine the information requirements of the Japanese importers of Norwegian mackerel. The different stakeholders in the MainSafeTraceJapan project are shown in Figure 2. While there are several entities involved in the mackerel value chain, in this project we focus on the Japanese importers and the Norwegian producers.

The stakeholder analysis was conducted by using a questionnaire to obtain responses from Japanese importers and Norwegian producers of mackerel. The stakeholder questionnaire was based on the method developed by Storøy *et al.*, (2008) in the salmon supply chain. The responses were obtained from four Japanese importers and one Norwegian producer/exporter and were used to determine the importance of mackerel product information from each actor in the chain. Table 3 describes the questions asked.

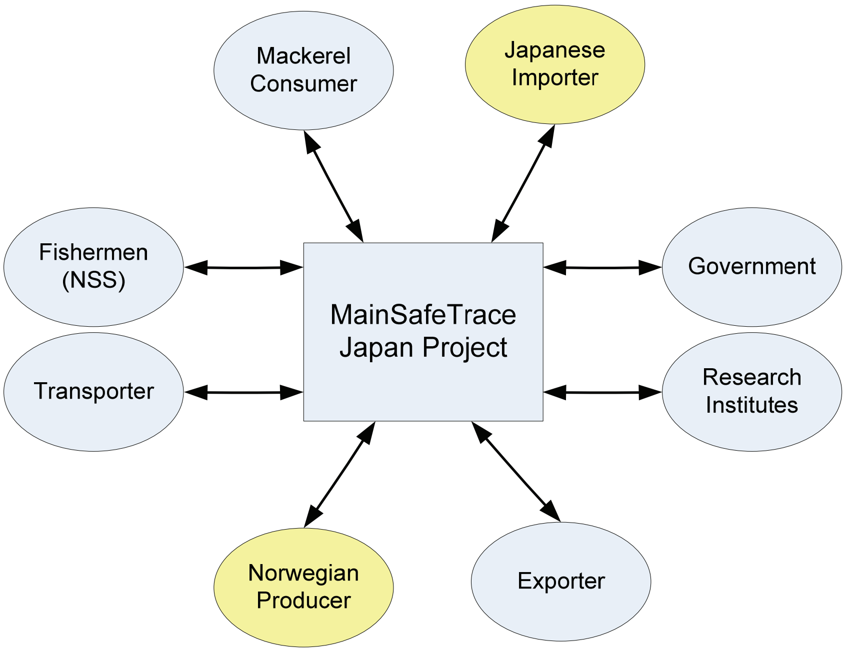

Figure 2 Stakeholders in the MainSafeTraceJapan project

Table 3 Questions asked from the mackerel chain stakeholders

Question	*Possible responses*
1. Do you record this (this being the data element about which the questions are being asked) information?	Yes, Already, No
2. How important is this information?	Scale 1-5 1 = Unimportant, 5 = Very important
3. Do you communicate this information to your customers?	Yes or No
4. How important is this information to your customers?	Scale 1-5 1 = Unimportant, 5 = Very important
5. How important is this information to the end consumers of mackerel?	Scale 1-5 1 = Unimportant, 5 = Very important

Based on the stakeholder responses to the questionnaire, the following list shows the parameters (i.e. those regarded as the most important for exchange) that must be exchanged between the Norwegian producers and Japanese importers.

- Temperature record during transport of mackerel
- Bacterial count
- Blood spots
- Injuries on skin
- Vessel information

Cold chain management and the transportation link in the mackerel supply chain were reported as most important parts. The importer also expressed that the ability to retrieve food safety and quality information from the tests conducted by Norwegian producer would be very important for them as they would not have to conduct the tests again in Japan. It was also stated that the ability to link the product information to a single vessel or catch instead of a production batch would be preferred. Based on the responses obtained, a list of parameters related to the mackerel product is derived. These parameters and their recording techniques were considered as an input for the technical solution for information exchange in the mackerel supply chain between Norway and Japan that was also developed in the project.

Overall, the following conclusions were drawn from the stakeholder analysis results:

- The temperature records from transportation must be shared with the Japanese importers.
- No quality information is sent from Norway to Japan but it is important for the Japanese importers to receive at least the minimum information including the following parameters: Bacterial count, blood spots, and injuries on skin. The cost to the producer for sending this information is of concern to the importers.
- The ability to link the traceability information to a specific vessel (or catch) would be preferred by the importers. This factor can be good for product promotion to Japanese consumers.

It must be stressed that despite the fact that additional information is preferred by the importers, under normal circumstances the information they receive is adequate but in case of a food safety emergency this information is not enough for conducting an efficient recall.

In depth analysis of the mackerel supply chain - Process mapping

The process mapping in this project was conducted in several stages, by SINTEF and Nofima in the Norwegian part of the chain and by FMRIC (Japanese Food Marketing Research and Information Center) in the Japanese part of the chain. The detailed process mapping was done using the reference method developed for this purpose (Olsen, 2009). The existence of a reference method for this type of work is meant to ensure that the results obtained should be largely independent of whoever is conducting the study and also to ensure that the level of detail is constant, and that nothing is forgotten.

The main conclusions from the detailed process mapping were:

- The production code, which is the key to all recorded information in the processing company, is 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.
- The Japanese processors do not record the numbers on the received boxes when they use them, so no link can be established to information on the box label or linked to the box identifier.

- 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.

Partly based on the recommendations in the process mapping, an improved ICT system for traceability at the processing plant was designed. The objective for this system was to generate electronic messages describing the mackerel products that could be passed from Norway to Japan, so that significantly more information about the product would be made available to the Japanese buyers.

A number of stakeholder interviews were also conducted, and these revealed additional challenges. While the Japanese partners said very clearly that traceability and documentation of the cold chain was very important to them, they regarded this as a much bigger problem in relation to the mackerel that went from Norway via China to Japan. With respect to the quality and the documentation of parameters in the Norwegian part of the chain, the Japanese buyers already had their own quality inspectors in place at the Norwegian plants, and they delivered extensive reports on what happened there. Thus, to some degree many of the project participants felt that the project was an attempt to fix a problem they didn't really feel that they had, and this, to some degree, affected their motivation for participating in the project.

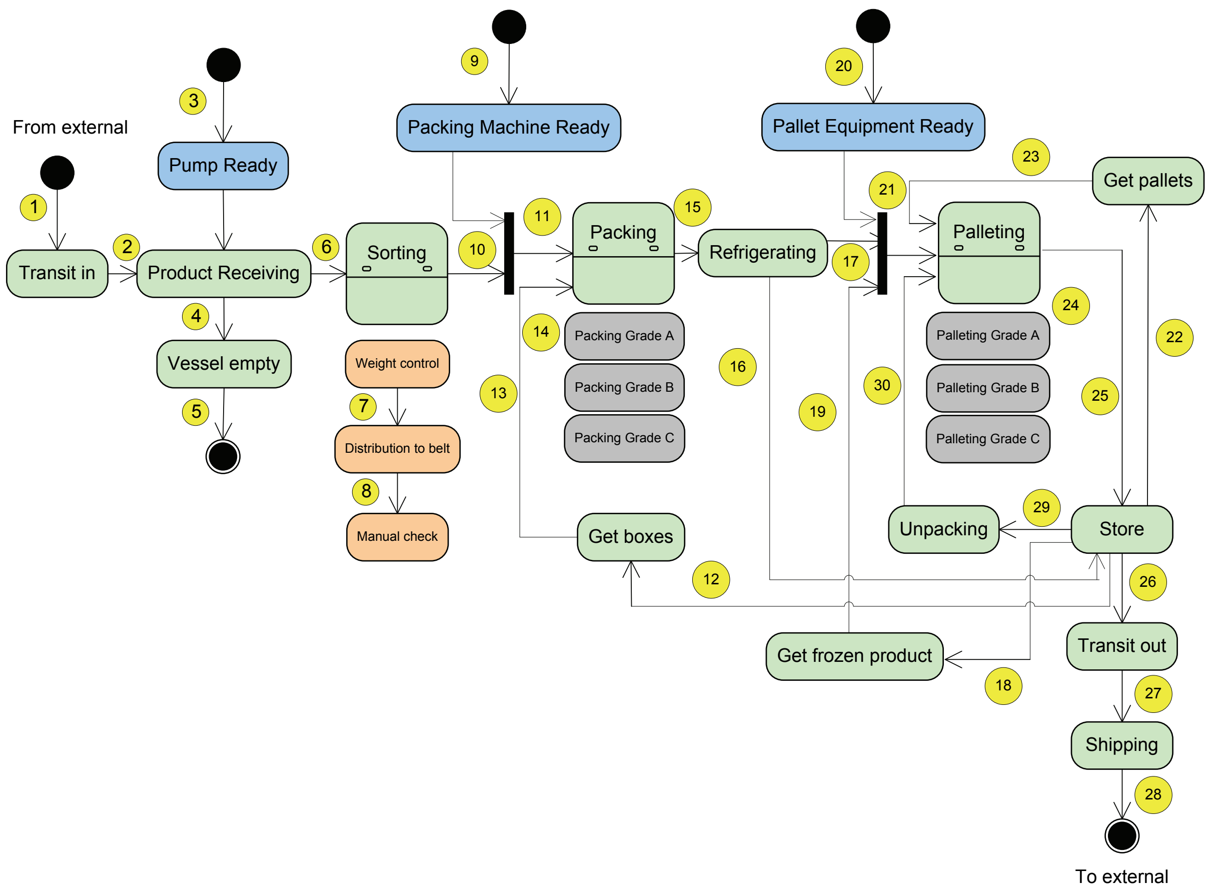

Figure 3 State-event model for frozen mackerel production

Critical Control Points

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 CCP is a point where major errors affecting the food safety may occur and hence the risk for food contamination or fraud is large. It is a point at which controls must be applied to prevent, eliminate or reduce a food safety hazard to acceptable levels. The Hazard Analysis and Critical Control Points (HACCP) method was used for identification of potential food safety hazards and CCPs at all stages in frozen mackerel production. The hazards include physical, chemical and biological hazards. The monitoring of each hazard at the CCP was described along with the corrective actions. Figure 3 represents the states and transitions for the frozen mackerel production process.

The CCPs in the frozen mackerel production process are listed in Table 4 along with corresponding potential hazards. 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.

Table 4 CCPs and hazards

CCP	*Potential Hazard*	*Hazard classification*
Product receiving	Dioxins	Chemical
Product receiving	Heavy metals	Chemical
Product receiving	Pesticides	Chemical
Product receiving	Natural toxins	Chemical
Product receiving	Scombrotoxin	Chemical
Packing	Scombrotoxin	Chemical
Packing	Metal inclusion	Physical
Refrigerating	Parasites	Biological
Store	Scombrotoxin	Chemical

Table 5 presents the application of HACCP system to the frozen mackerel production process. A modified version of the method is used to include only the critical limit, monitoring method and corrective action for each CCP and corresponding hazard. Food safety is one of the most important drivers of traceability. Identification of CCPs is very important for traceability as this approach provides information about important food safety hazards and how they must be monitored. In combination with the state-event model that follows an event approach to identify all states and events in frozen mackerel production, the use of the 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.

Table 5 HACCP for frozen mackerel production

CCP	*Hazard*	*Critical Limit*	*Monitoring*	*Corrective Action*
Product receiving	Dioxins	PCDD/F: 4 ng TEQ*/ kg Dioxins + dioxinlike PCB: 8 ng TEQ*/ kg	Monitored externally by NIFES[1] for Mattilsynet[2]	Corrective action decided and taken by Mattilsynet
Product receiving	Heavy metals	Lead: 0.2 mg/kg Cadmium: 0.05 mg/kg Mercury: 0.5 mg/kg	Monitored externally by NIFES for Mattilsynet	Corrective action decided and taken by Mattilsynet
Product receiving	Pesticides	Aldrine: 50 μg/kg HCH: 50 μg/kg Heptachlor: 50 μg/kg Oxy-chlordane: 100 μg/kg Total DDT: 500 μg/kg	Monitored externally by NIFES for Mattilsynet	Corrective action decided and taken by Mattilsynet
Product receiving	Natural toxins	No fish may be harvested from an infected area**	Identify the catch area	Reject catch if fish caught in infected area
Product receiving	Scombrotoxin formation	**Histamine:** Mean value ≤ 100 ppm; Two samples may have value between 100-200 ppm; All individual samples ≤ 200 ppm	- Vessel fish handling records - Histamine analysis on one incoming catch during a mackerel season (requirement) OR on each incoming catch (this practice followed by some producers) - Nine samples must be taken from each batch	Reject catch if histamine levels exceed the critical limit
Packing	Scombrotoxin formation	Product not exposed to temperatures above 4°C for more than 4 hours cumulatively	Temperature-time records during packing	Destroy lot if temperature is above 4°C for more than 4 hours cumulatively
Packing	Metal inclusion	No detectable metal fragments in finished product	Every package checked with the metal detector	Destroy any product rejected by the metal detector
Refrigerating	Parasites	Freeze at -18 °C and hold until solid	Temperature of freezer and length of time held frozen	Adjust temperature Refreeze if needed Optimum temperature is -18 °C
Store	Scombrotoxin formation	Product completely covered in ice throughout storage	- Visual examination - Temperature-time records during storage	Destroy lot if temperature is above 4°C for more than 4 hours cumulatively

1 More information about NIFES (National Institute Nutrition and Seafood Research)
2 More information about Mattilsynet (Norwegian Food Safety Authority)
*Toxic Equivalent.
** Natural toxins are not commonly found in the Norwegian mackerel.

Conclusions

This project integrates analysis from several different fields to provide an complete analysis of the mackerel supply chain between Norway and Japan. The main conclusions in this project give a full picture of the challenges and opportunities for the trade of fish between Japan and Norway.

- It can be seen, in line with many previous studies, that the longer the supply chain the more difficult the tracing of a product can become.
- The stage of packaging is influential with regards to the ability to trace products. For example products which were packaged before they reached the supermarket has info and id's which could link them to the suppliers. Two of the studies carried out here found that the loss of id often occurred where the product was processed further, for example in a supermarket.
- In the case of Mackerel (and other products) maintenance of the cold chain is extremely important as is documentation of this cold chain.
- The importance of exchange of quality information throughout the supply chain from vessel to consumer was shown.

The project aims to further to address the findings so far and create appropriate solutions for information exchange from catch to consumer.

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