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Industry practices for sharing sustainability information in the Norwegian fisheries supply chains

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ABSTRACT

Sustainability and traceability of food products have received increased attention due to food safety, consumer demand on knowledge of the origin of their food and reducing food fraud. In recent years, traceability systems have been used to document and share sustainability information in food supply chains. This paper reviews the current methods of data capture and information sharing practices in the Norwegian fisheries supply chain from catch to consumption. Most Norwegian fishing vessels capture detailed data on the catch and quality of fish electronically. This information is automatically reported to the authorities while most information regarding the quality and sustainability is not communicated further down the supply chain. Significant data gaps include information on fuel and energy consumption, as well as detailed data on the transport routes and modes used. Increasing information sharing could potentially improve supply chain decision making and in-turn have an impact on producing sustainable high-quality fish products.

Keywords: Traceability, Fisheries supply chain, Data capture, Information sharing, Norway.

1. INTRODUCTION

Only a fraction of the information about the catch, processing, and transport of seafood products in Norway is being transferred to other partners across the supply chain. Consumers are becoming more aware about the social and environmental impacts of the food they consume, and demand more information about sustainability, origin, and processing of their food products (Norwegian Seafood Council, 2021b). Food traceability systems plays a key role in storing, sharing, and communicating information about sustainability of food products in a supply chain. Olsen and Borit (2013) 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 identification". This includes the origin of the product, all raw materials and ingredients, the processing of the product as well as when and where it took place. As defined by Olsen and Borit (2013), information flows in both directions of the supply chain, not only downstream.

Traceability in food supply chains is motivated by several drivers including food safety, legal and market requirements, and quality verifications (Wang & Li, 2006). Food traceability systems can reduce waste streams by gaining more knowledge and optimizing the production (Moe, 1998; Wang & Li, 2006). For the producers, traceability systems could potentially reduce costs and labour related to information exchange and data capture by implementing digital systems (Olsen and Borit 2013). Data and information exchange over the supply chain between fishing vessels and processors could optimize the production and improve the catch process (Thakur & Gunnlaugsson, 2018). Both fishing vessels and processors capture and store great amount of data electronically, but the information exchange between these operators are for the moment limited.

The aim of this report is to review the industry practice of sharing sustainability information in the Norwegian fisheries supply chain of whitefish and pelagic fish from catch to retail.

2. METHODS

2.1. Data sources

This paper is mainly based on relevant literature in the field of traceability within the fisheries industry in Norway. The search strings included: 'whitefish', 'pelagic', 'fisheries', 'Norway', 'data capture', 'data collection', 'data storage', 'processing', 'traceability', 'information exchange', 'information sharing' and 'supply chain transparency'. Relevant articles were selected and included in the review. Most articles dated back to before 2018 and even back to 2012. In addition to existing literature, company interviews were conducted to obtain updated information about the data capture and information sharing practices in the catching and landing stages of the fisheries supply chain. The information about processing and distribution stages including transport and retail of seafood products were mostly based on literature findings and current regulations.

The following actors were interviewed in this study:

- A fishing company using deep-sea trawlers with on-board handling of the fish
- Two Norwegian Fishermen's Sales Organizations with one for pelagic fish and one for whitefish

2.2. Modelling and visualisation

Visualisation of information flows and material flows in the fisheries supply chain was done using a simplified version of the MIFMT (material and information flow modelling technique) methodology developed by Islam, Cullen, and Manning (2021). This system allows for both information and material flows be visualized in the same diagram. Fig. 1 presents a generic example of a food traceability system with one food business operator. This diagram consists of several layers, where the top layer represents every food business operator in the supply chain. The flows between each food business operators are therefore external traceability flows. The lower levels consist of the steps of the supply chain within each food business operator, i.e., the internal traceability.

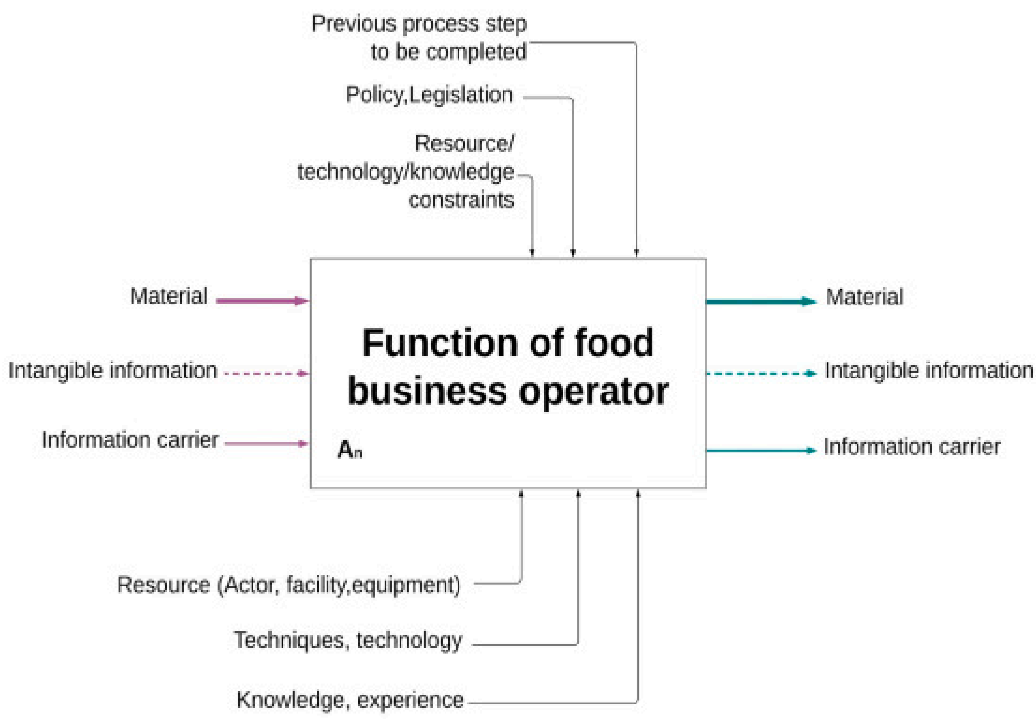

Figure 1: Representation of the MIFMT diagram for a generic food traceability system. Modified from Islam et al. (2021).

The MIFMT visualisation consists of:

A function box: this can be a food business operator in the 0-layer of the diagram. In lower layers the function bow can represent a task, a process, an activity etc. The number of function boxes in the 0-layer equals the number of food business operators in the supply chain.

Input: the input can represent material, intangible information (information that is oral or not necessarily linked to traceable unit), information carrier (information that is linked to a traceable unit such as a QR code, tag, label, barcode etc.).

Output: same as the input. One output will also act as a control for the next step in the chain.

Controls: the control element represents a policy or legislation, or resource constraints.

Mechanisms: a mechanism represents resources (actors, humans, equipment etc.), technologies and knowledge.

Logical connectors: AND, OR, Exclusive OR (XOR) as presented in Fig.2

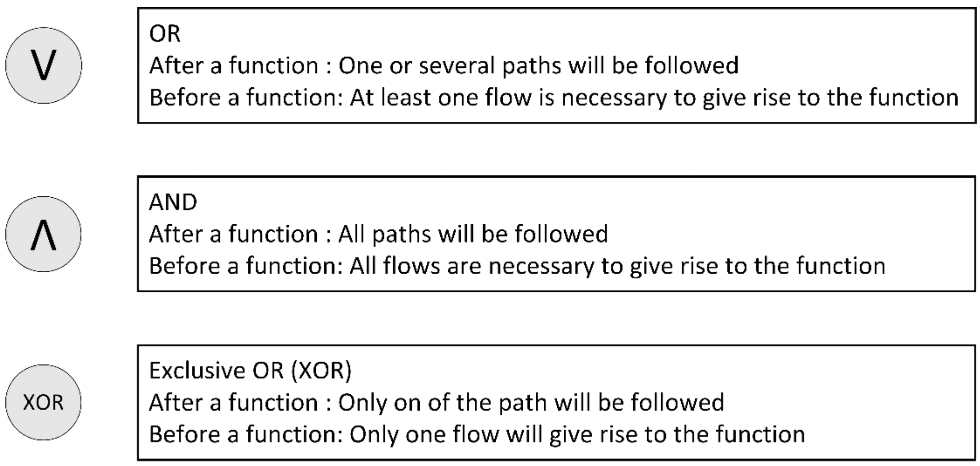

Figure 2: Logical connectors elements.

A simplified version of this diagram has been used to represent the information flows in the selected seafood supply chains. The input and output of material, intangible information, and information carriers as well as the control elements that are rules and legislation have been included as these have been deemed the most relevant elements to analyse the information flows in the fisheries. All other elements in the MIMFT have been excluded in this study.

3. MAIN FINDINGS

3.1. The Norwegian supply chain of whitefish and pelagic fish

The supply chains of whitefish and pelagic fish were analysed from catch to retail. Catch volumes of whitefish including cod, saithe, and haddock amount to 654 431 tonnes in 2020 of which 289 292 tonnes were exported to a value of 11.93 billion NOK (Norwegian Seafood Council, 2021a; The Directorate of Fisheries, 2020). Most cod are exported in salted, dried, and frozen forms which have a lower value than fresh fish (Trondsen, 2012). Catch volumes of pelagic fish, including herring, mackerel, capelin, sprat and others, were 1 441 799 tonnes in 2020, of which 516 935 tonnes were exported to a value of 6.77 billion NOK. Pelagic fish is either consumed directly or sold as a raw material ingredient to fish feed production. Only 44% of the rest raw materials of white fish is currently being utilized, where as 100% of the rest raw materials of pelagic fish are being utilized (Hjellnes, Rustad, & Falch, 2020). Fig. 3 shows the supply chain investigated in this paper including the *Catch operation* with the catch and on-board handling of the fish, the *Landing* of fish, *Processing*, *Transport* and *Retail* of fish to consumers.

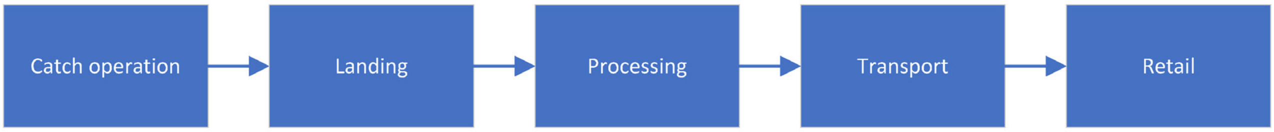

Figure 3. Fisheries supply chain from catch to retail.

3.2. Overview of the information flow in the Norwegian fisheries supply chain

Fig. 4 shows the information and material flow of the Norwegian fisheries supply chain from catch to retail. The functions *Catch operation*, *Landing* and *Processing* are further investigated into sub-functions, presented in Fig. 5-7. The Catch operation includes all activities taking place on the vessel; catching of the fish, sorting, weighting, on-board handling and quality inspection, storage and reporting to the Directorate of Fisheries. The landing of fish includes the sale of fish from the vessel to the processing plant or export of fish. This function is controlled by *Processing* and includes quality inspection of the fish and processing into fillets and rest raw materials ready for transport to retailers. The functions *Transport* and *Retail* do not have any sub-functions. *Transport* includes the transportation from *Processing* to *Retail*, while Retail includes the phase of the seafood being sold to consumers.

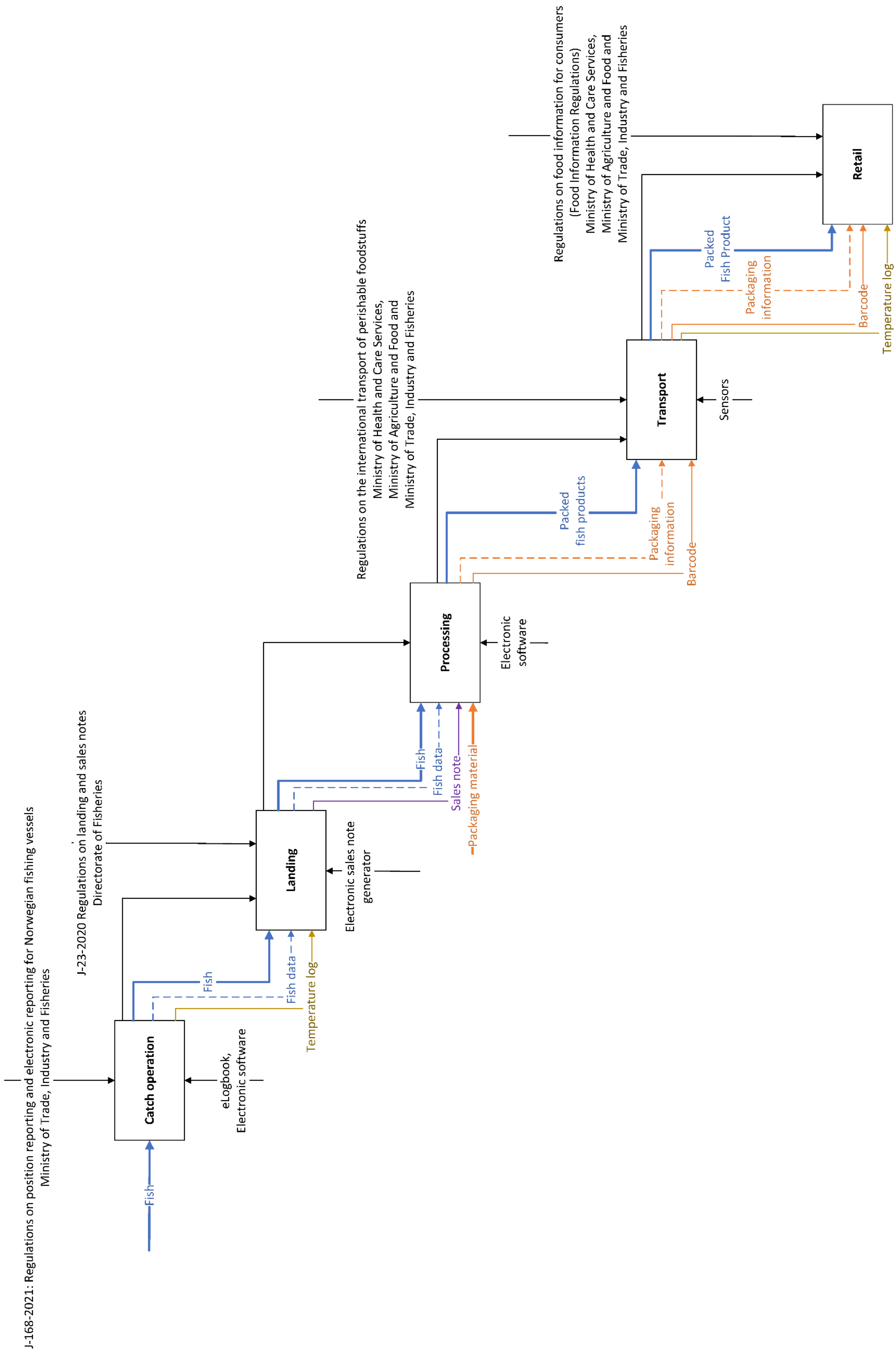

Figure 4: Information and material flow in the Norwegian fisheries supply chain.

3.2.1. Catch operation

Fig. 5 shows the *Catch operation* and includes the sub-functions *Catch,* Sorting, weighting, quality inspection *and on-board-handling, Storage on vessel,* and *Report Catch to Directorate of Fisheries*. The fish caught is then delivered to *Landing*.

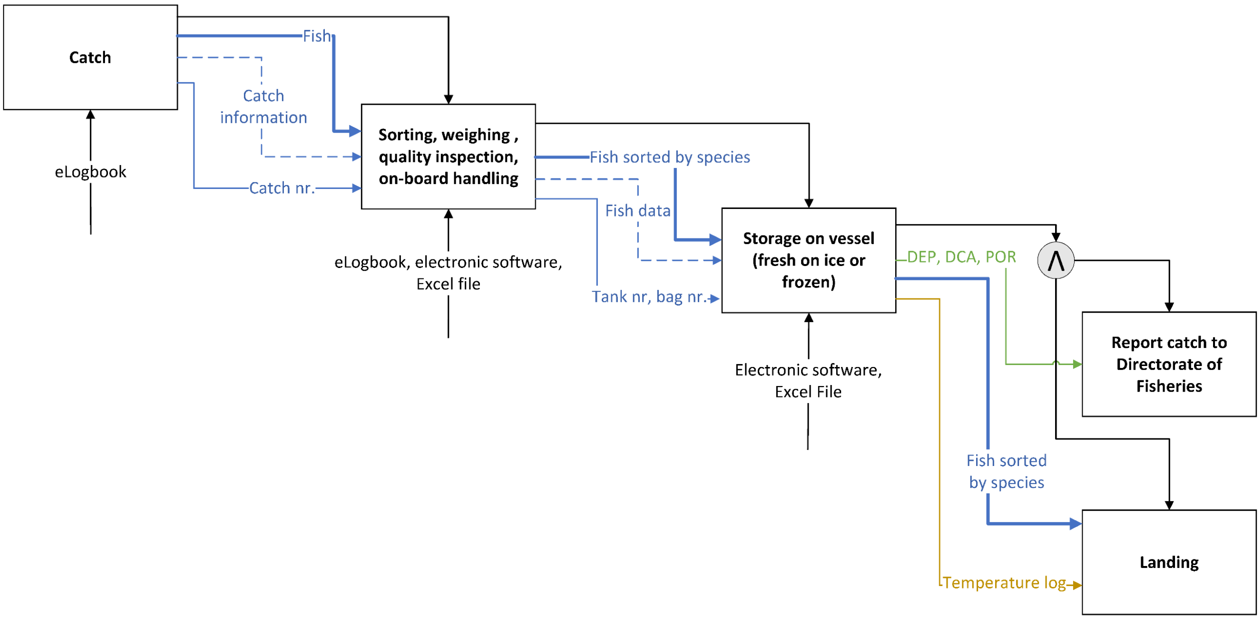

Figure 5: Information and material flow at the *Catching operation*.

All vessels above 15 meters are required to track their routes with Vessel Monitoring System (VMS) every 10 minutes and report on their catch operation and where they are landing the catch with electronic recording and reporting system (ERS) to The Directorate of Fisheries (The Directorate of Fisheries, 2021b). By July 2022 this regulation will also apply to all vessels above 11m. Reporting from the catching operation to the Directorate of Fisheries includes DEP (Departure Report), DCA (Detailed Catch and Activity) and POR (Port Report). DEP contain information on the vessel and when and where it departed from, DCA contains detailed information on the catch and POP contain information on when and where the fish is landed.

Many Norwegian vessels use an eLogbook as their ERS software. The system allows for registering the date and time as well as geographic coordinates for start and stop of the catch (Merrifield et al., 2019). Fishing gear and specification of the gear are recorded, as well as any problems related to the catch can be registered in the application. The estimated total weight of the catch, the species caught and weight per species are also recorded in the eLogbook. Some vessels also have on-board handing of the fish, that can include slaughtering and bleeding of fish, sorting by size and species, freezing and palleting. A specialized software for processing of fish is used by the vessel interviewed in this study, to store data (quality, species, sizes) about the fish. The software automatically updates and corrects the data recorded fish the eLogbook. The relevant data recorded at each step in the *Catch operation* is presented in Table 1.

Table 1: Relevant data recorded in *Catch Operation*.

Function	Relevant data recorded	Data system
Catch	Vessel name, trawling time, species, total weight, catch area, product condition, trawling position (start and end)	eLogbook
Grading by size, sorting species, on-board handling of fish	Weight per species, quality control	Excel or specialized software
Storage on vessel (fresh on ice or frozen)	Freezing duration, Temperature in Tank, Temperature in fish	Manual system, Excel or specialized software
Reporting catch to The Directorate of Fisheries	DEP: Port of departure, international code (ISO), time and date of departure, Vessel name, registration nr., main fishing activity DCA: Catch area, geographical coordinates of start and end of catch, depth of start and end of catch, Time (start and end) and date of catch, Vessel name, registration nr., fishing permit/licence, Fishing gear + specifications, total weight of catch, species, weight per species POR: Port of arrival, international code (ISO), name of landing facility, Weight per species in kg for landed fish and for fish onboard in vessel	ERS, VMS

3.2.2. Landing

The *Landing* of the fish as shown in Fig. 6 includes the sale of fish, either through auction or direct sale at the quay. This function is divided into the sub-functions *Sale at Auction, Direct Sale*, *Report to Fishermen's Sales Org., Report to Directorate of Fisheries*, *Export* and *Landing at Processing Plant*. It is the Fish Sales Act and the Marine Resources Act §48 that regulates the sale of all wild caught fish in Norway (Lovdata, 2008, 2013b). It is illegal to trade wild caught fish outside of the Norwegian Fishermen's Sales Organization. The *Catching operation* and *Processing* are often done by different companies in Norway (Thakur & Gunnlaugsson, 2018). Fish is delivered either fresh or frozen to the processing plant. If the fish is sold directly to the buyer, it is graded by size and quality, and a sales note is written between the fishing company and the processing company. The price is dependent on the fish quality. The sales note serves several purposes. It contains the receipt for the buyer and the guaranteed payment to the fishing crew. It is also a part of Norway's official catch statistics where the total amount of fish caught is recorded and controlled. This information is used to estimate the current size of the fish populations, to determine the fishing quotas, and the environmental certifications of the fish. The relevant data recorded in the quality inspection, the landing/sales notes and catch certificate are presented in Table 2.

Fish exported to the EU are required to have a Catch certificate (Catch Certificate, 2017). The catch certificates have an aim of preventing the sale of IUU fish products in the EU. This document includes information about the species caught, their product code, and the weight per species as well as total weight, name, and registration number of the vessel, catch area, landing date, and the sales note number are all recorded in this document.

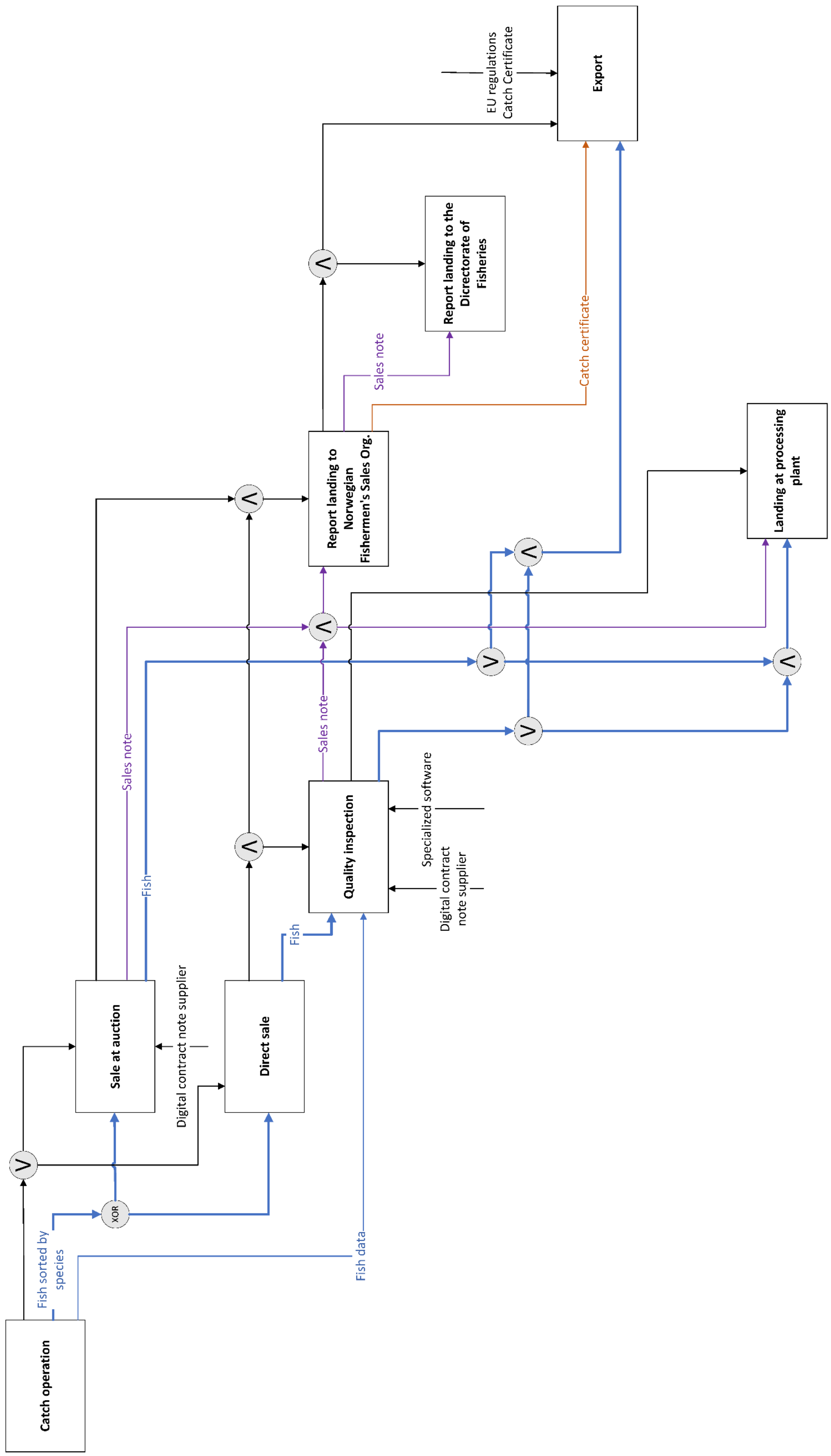

Figure 6: Information and material flow at *Landing.*

Table 2: Relevant data recorded in *Landing*.

Function	Relevant data recorded	Data system / Document
Quality inspection	Registered date, Responsible person Catch information: Vessel, Production code /lot no., First day of catch, Catch area ICES, Approved onboard cooling documentation according to FOR-2008-12-22-1624, Confirmed onboard transportation time according to FOR-2008-12-22-1624 MSC certification Quality control, raw material: Time of inspection, Grading, Core temperature, Feed, Belly, Bruises, Freshness, Anisakis Quality control, finished product: Product, Grading, cut of fish (tail or centre), Colour, Bruises, Bloodspots, Texture, Tail texture	Manual
Reporting to Norwegian Fishermen's Sales Organization	Vessel ID, Vessel name, Company name, catch date, Catch area, Catch method, Landing date, Catch description (species, fresh/frozen, weight, size), Price	Landing/sales note
Export	Transport details: Country of export, Port/ airport/ other place of departure, Vessel name and flag, Flight number/airway bill number, Truck nationality AND REG. NUMBER, Railway bill number, other transport documents Description of exported products: Species, Product code, Product CN code (if provided by exporter), Product weight Exporter references: Name and address of exporter, Signature, Date Fishing vessel and catch details: Fishing vessel name, Registration number, Catch area, Landing date, Sales note number	Catch certificate

3.2.3. Processing

Fig. 7 shows the *Processing* function which is divided into the sub-functions *Fish arrives at processing plant*, *Sorting by size and weight and quality inspection, Production planning*, *Filleting, Rest raw materials, Other processing, Palleting and labelling, Selling fish to secondary processing*, *Journal on arriving at processing plant*, and *Journal on Transport from processing plant.* The processed seafood products are then sent to *Transport* and *Retail*. The buyer has access to the information available in the sales note and usually can get the temperature log and some supplementary information about the fish and the catch if required. After the fish is landed it is processed into either fillet, rest raw materials, or other fish products at a processing plant. The fish is packed and labelled before being transported either to retail or to industry for secondary processing into value-added products (fish soup, fish sticks etc). The processors are required to write a journal on every fish arriving and leaving the facility (Lovdata, 2014a). The journal consists of two main parts: landing at and transportation from each plant. The main aim of this journal is to prevent illegal sale of fish. Relevant data recorded in each sub-function are presented in Table 3.

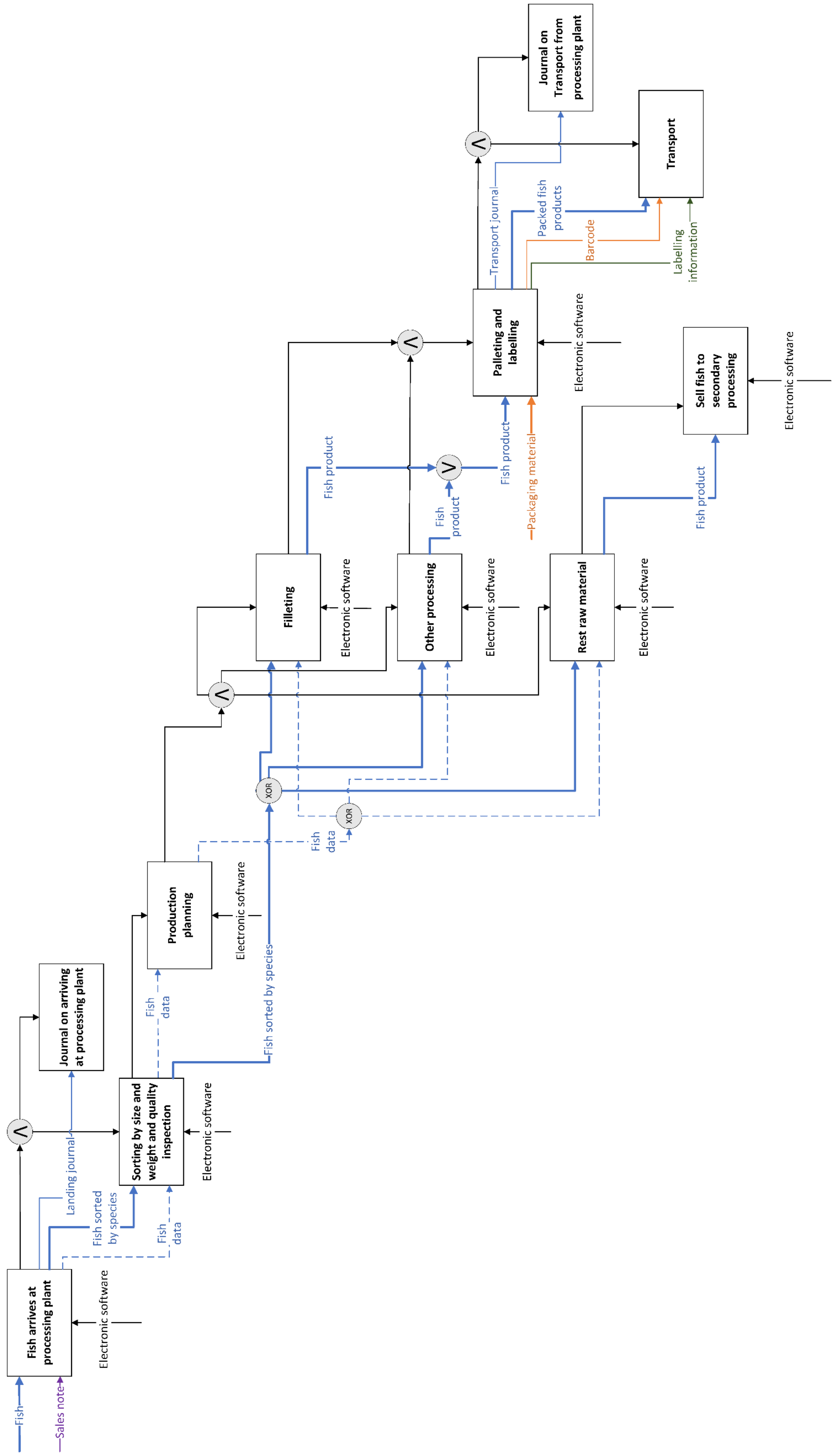

Figure 7: Information and material flow at *Processing*.

Table 3: Relevant data recorded in *Processing*.

Function	Relevant recorded data	Data system
Journal on arriving at processing plant	Date of landing If landed at processing plant: Vessel name, Register mark of vessel, sales note no. If stored on quay: Fish owner e.g., other plant – name and org. no., Transporter name, Transport method Species, Product condition, Weight per species, Total weight landed, Number of fish, Number of fish weighed, Average weight	Excel or electronic
Production planning	Batch ID, Date, Quality grade	Electronic software
Processing	Temperature, product type	Electronic software
Packaging of finished products	GTIN, Species, Catch area, Lot number, Size, Treatment, Quality, Preservation (fresh/frozen), Packing date, best before date, Net weight, Box number, Pallet number, Catch method	Electronic software
Pallets of finished product	SSCC, Pallet number, Order number, Species, Treatment, Size, Number of boxes, Weight per box	Electronic software
Journal on Transport from processing plant	Date of transport, Name of plant, Name of transporter, Registration mark of transport, Contract note no. if the fish is not processed, Species, Product condition, Weight per species, Total weight	Excel or electronic

3.2.4. Transport

Transport and storage of food is regulated by the Norwegian Food Safety Authority (NFSA) and the Act on quality of Fish and Fish Products (Lovdata, 2013a; Norwegian Food Safety Authority, 2014). The Food Business operator responsible for transport is required to monitor the temperature of fish, and to document that the cold chain has not been broken (Lovdata, 2021; Norwegian Food Safety Authority, 2016; Spurkeland, 2021). If the products are frozen, sensors that automatically monitor temperature are required. The transport routes and modes are usually not communicated to the consumers.

3.2.5. Retail

The general requirements of food labelling for food and specifically for seafood in Norway are summarized in Table 4. The labelling requirement of food are regulated by the Act of Food Information to the Consumers and NFSA (Lovdata, 2014b; Norwegian Food Safety Authority, 2014). The information about the fish is either labelled on packed product or printed on labels for fresh products. Even though some companies provide additional information on their website, the information on the label is considered the communicated information to the consumer, unless they provide a tag that the consumers can scan and lead them directly to the additional information. If the products are exported to the EU, EU requirements for food labelling applies as presented in Fig. 8 and 9.

Table 4: General and specific requirements for food labelling in Norway

Requirements	Information
General information required for food labelling in Norway	Commercial designation and scientific names, Production method, Net quantity, Ingredients (proportion of main ingredients, allergens in bold), Nutrient information per unit, Shelf life – "Best before" date or "Use by" date, Company name, Information on storage and use, Production date – (catch date for fish), Freezing date (if different from production date)
Specific information for labelling of seafood in Norway	Fish species, Catch area or country of origin, Fishing gear, Catch date, Slaughter date (fresh fish products), Production date, Freezing date (if different from production date), Temperature (not canned fish), Identification mark (EFTA)

Figure 8: Example of food label with EU requirements and voluntary elements for a processed seafood product (European Commission, 2015).

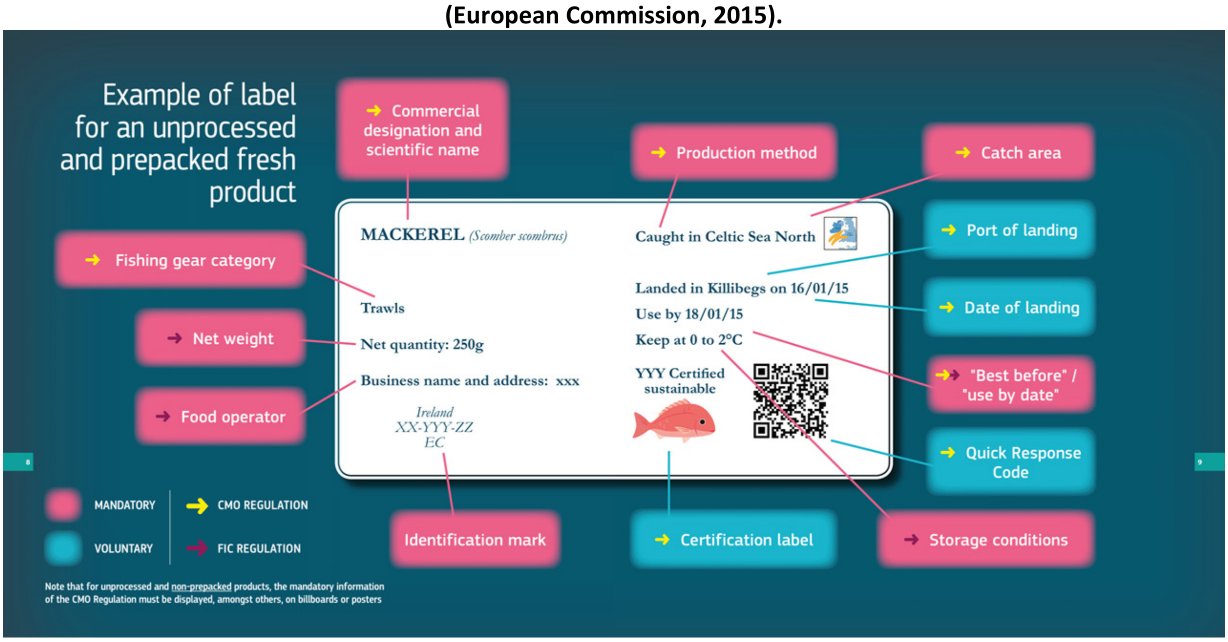

Figure 9: Example of food label with EU requirements and voluntary elements for an unprocessed fresh seafood product (European Commission, 2015).

3.3. Sustainability certificates for wild caught fish in Norway

The most known certification for proving the sustainability of wild caught fish is the Marine Stewardship Council (MSC) certifications. The MSC Fisheries Standard ensures that the fish harvested is from sustainable stocks, that the environmental impacts are minimal and that the fisheries operations are well managed (MSC). However, environmental impacts due to fuel and energy consumption are not included in the assessment. In Norway, 15 species are MSC certified (Kvile, 2021). An independent third-party, Conformity Assessment Bodies, assesses if the fisheries qualify for this certification. The MSC Chain of Custody standard assesses every food business operator in the food supply chain and requires that certified products are traceable to a sustainable source (MSC).

3.4. Information exchange practices in the Norwegian fisheries supply chain

The operators interviewed in this study pointed to a lack of willingness in sharing data as the biggest challenge to increase the information shared in the supply chain. Although, there are several technological challenges where not all operators have come as far as to automize information sharing with electronic traceability systems, these are problems that can be fixed by either regulations or industry’s willingness. The fishing vessel interviewed expressed a wish to have control over the whole supply chain, ensuring that their fish has a high quality and that the customers receive the correct product. However, increasing traceability and data capture internally in the catch operation would be a priority. Several companies are taking steps to reduce emissions and becoming more sustainable. Having a well-functioning traceability system is essential to both document and communicate sustainability information to the consumers. Since there is often limited space on product packaging, some producers add a code, e.g., a QR code, that the consumer can scan or look up to read supplementary information about the product. Most of these tools are targeted towards the consumer of the product and provides information about the origin of the product, specifically the catch area. Other information regarding the catch, processing and transport is not communicated. In some cases, more detailed information about the product, specifically about transport routes and processing, is available on the producer's web pages. This information could easily be added to an already existing traceability tool if processing and transport does not differ from the unique products.

3.5. Information gaps – transparency, traceability, and sustainability

It is not common practice to monitor and store data on fuel and energy consumption in any of the steps in the supply chain. For the catch operation, measuring these aspects would require advanced and expensive sensors. However, estimates and averages could be calculated for the different fishing gears and species, e.g., trawling vs. purse seining and cod vs. mackerel etc. (Ziegler, Jafarzadeh, Skontorp Hognes, & Winther, 2021). Monitoring emissions is an important step to develop strategies to reduce emissions in the fisheries sector (Turrell, 2019). Some vessels are already monitoring the speed and oil use from the catching operation and are working on converting this information into environmental indicators such as carbon footprint. One of the companies interviewed expressed a wish to track data on fuel and energy consumption, with the primary motivation of reducing their environmental impact, by optimising the production and gain insight on when to fish with the least impact. They also wanted to use this information to communicate the environmental impact of their products to the consumers. The cost of sensors required for these measurements were mentioned as one of the main barriers to implement this next level of data capture. Monitoring waste streams and bycatch are also important to reduce the environmental and biodiversity impacts of the fisheries industry (Moan, Skern-Mauritzen, Vølstad, & Bjørge, 2020).

3.6. Stakeholder perspectives

Crew at fishing vessels report that they must guess the volume of catch that are being controlled on land- and if it's not correct, they risk penalties. Having an authorized and automatic system would be a much better solution. Increased traceability will also give back control to the crew, when mistakes in reporting due to human error is presented as fraud (The Directorate of Fisheries, 2021a). If the fishing vessels reported the information on the fish quality to the processors, the processors could start the production planning before receiving the fish and thereby optimise production (Thakur & Gunnlaugsson, 2018). Based on the data collected in the processing plant, the fishing vessels could gain valuable insights in where and when to fish for optimal quality. The transport routes and modes and fuel consumption are only known for the logistics companies and is not communicated to the consumers. In Helsingborg municipality in Sweden, the authorities wanted more knowledge on where the seafood comes from, after discovering that the imported cod had a detour to China and was not arriving directly from Norway. Their demand of product origin and processing and transport history was the background for a pilot that uses blockchain based traceability system, so that the consumers can track every step the fish takes from catch to fork (Sjømatbedriftene, 2021). A report on seafood consumer trends stated that consumers are willing to pay up to 35% more if producers can document sustainability of the product (Norwegian Seafood Council, 2021b). It is however worth noting that the term "sustainable" has different cultural interpretation. It can mean organic, healthy, and local, as well as having minimised environmental impacts.

3.7. Novel technologies for enhanced traceability and sustainability in the fisheries supply chain

Several companies are now looking into traceability systems that can trace seafood products from catch to fork with the use of the distributed ledger technology blockchain (Olsen, Borit, & Syed, 2019). Blockchain is a digital recording of transactions or information. Every user has a copy of the blockchain and the information within the blockchain cannot be changed or overwritten. New information is added as a new block in the blockchain. However, some information is regarded sensitive, such as names of the fishing crew and prices of the fish and is not essential information for the consumers. Another important point is to keep track of the ownership of data. Each food business operator should keep ownership of their data, even though it is shared with other operators and customers in the supply chain. This technology allows for swift information exchange between different food business operators, and in cases of diminished food safety, history of the product can be easily retrieved. Another advantage is that this technology can communicate with more advanced Internet of Things (IoT) sensors, that could measure real-time fuel and energy consumption. If sensors were included over the whole supply chain, the complete carbon footprint of the seafood product could be calculated.

4. CONCLUSION

Increasing the amount of data recorded and shared in the fisheries supply chain could increase quality of the seafood products as well as reducing the emissions. Especially more information on environmental data should be estimated and communicated in a comprehensible form (such as environmental indicators e.g., carbon footprint) to the consumers of seafood products, at least for individual step in the supply chain such as the catch operation. Transport routes and mode should be easily accessible for consumers as this is demanded knowledge. This information could be accessible through QR-codes or other labels connected to the fish products. Next steps for the industry could include the use of more advanced technology with sensors over the whole supply chain that could measure real-time data on energy and fuel consumption and calculate the emissions from the different steps in the supply chain. This could enhance the sustainability of the products by allowing the producers to gain insight in where they could reduce emissions and waste streams. If this information is shared, in the form of understandable sustainability indicators, it can help consumers choose the most sustainable products.

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