

LOWINFOOD

**Multi-actor design of low-waste food value chains
through the demonstration of innovative solutions
to reduce food loss and waste**

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D4.3 – Report on fish supply chain dialogue

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Lowinfood Consortium

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Contents

Lowinfood Consortium	2
Summary.....	5
Introduction to the deliverable	7
1. The stakeholder dialogue: aims, development, and outcome	9
2. The seafood value chain: structure, actors, and waste generation	12
2.1 The seafood value chain in Scotland	12
2.2 The seafood value chain in Germany	13
3. Running the dialogue.....	15
3.1 Stakeholder engagement in the Scottish fish supply chain.....	15
3.1.1 Interviews in Scotland	15
Primary processors.....	18
Secondary processors	19
Retailers (Supermarkets).....	22
Online platform for trading fish	30
3.1.2 Networking events.....	39
3.2 Stakeholder engagement in the German fish supply chain	43
3.2.1 Interviews in Germany	43
3.2.2 Networking events in Germany.....	57
3.3. Initiating a discussion at sector level: Industry surveys	59
3.3.1 Management survey.....	59
3.3.2 Valorisation survey	60
4. Relationship with T4.2 Leroma platform.....	67
4.1 Relationship with the Leroma platform in Scotland.....	67
4.2 Relationship with the Leroma platform in Germany.....	68
4.3. Overall reflections	68
5. Conclusion: Lessons learned and policy implications	70
5.1. Scotland.....	74

5.2 Germany.....	75
5.3 Overall reflections	77
References	79
Annex 1: Table of policy and regulations relevant to the Scottish seafood industry	80
Annex 2: Stakeholder interview script.....	84
Guideline for interview.....	84
Annex 3: Various advertising materials.....	91
Annex 4: Sectorial practices in the UK retail sector.....	93
Annex 5: Industry survey script.....	95



Summary

The deliverable D4.3 illustrates the actions taken in line with the protocol framework (D4.1) to run the dialogues between stakeholders of the fish supply chains in Scotland and Germany. The dialogue aimed to provide an in-depth overview of loss and waste flows along these chains, their economic and policy causes and potential solutions, and favour coordination between stakeholders to address existing challenges. The protocol framework (D4.1) was created as a living document and the approach was reviewed along the process as a result of challenges, mostly in terms of stakeholder recruitment. Initially, Scotland's upstream activities (fishing and processing) were at the core of the dialogue efforts, while in Germany downstream activities (retail and consumption) were considered relevant. However, due to challenges in engaging with stakeholders at the upstream stages (i.e., fishing) in the supply chain, the focus has been extended to the full value chain in Scotland, apart from the consumption stage.

In particular, this deliverable covers the outcome of the recruitment activities, the findings from stakeholder interviews, and the collaboration efforts with the Leroma platform (T4.2). Although it was initially decided that WP4 "Innovations to prevent and reduce fish losses and waste" would focus on the seafood value chain (catch sector, not aquaculture), we realise that shellfish is an important commodity, at least in Scotland, and is therefore included in the scope of analysis. Due to the inclusion of shellfish, we henceforward use the term "seafood" to encapsulate both fish and shellfish throughout this deliverable. For the German value chain, however, we have not applied the exclusion of aquaculture so strictly, since the focus in the German value chain is on rather downstream activities and the differences between caught fish and fish from aquaculture are less important there.

In the framework of the stakeholder dialogue, interviews, workshop and online webinars were organised, and events such as industry expos and conferences were attended so that more stakeholders could be engaged with the project without additional effort from their side. In these stakeholder engagement activities (organised by Lowinfood partners or attended), the Leroma platform (T4.2), other innovations being developed or marketed by the Lowinfood Innovation Platform members among others, and the overall Lowinfood project were promoted and provided more visibility. Additionally, building on the information obtained from the interview and other events, a questionnaire survey about barriers and opportunities to add value to the surplus materials and by-products was developed to collect insights from seafood industry and policy stakeholders not necessarily involved in the dialogue but involved in the supply chain. This survey was promoted in multiple ways, online and in-person, including during the industry expos attended by project partners.

Stakeholders with large market shares in the middle of the supply chain (e.g., retailers) have more control over their supply and flexibility in terms of redistributing their surpluses, either through discounted sale routes or donations to food banks. Their larger trade volumes also

allow them to approach waste avoidance as a part of their corporate social responsibility rather than profitability. Retailers in Scotland are involved in national and international initiatives for improving sustainability and waste reduction, and their efforts are expected to further in response to changing carbon emission reporting requirements in the UK.¹

There are many opportunities and innovations for reducing and revalorising waste, but these are not always economically viable. In addition, there are very few suitable funding opportunities to encourage uptake of such innovations for the seafood sector in Scotland². No specific funding opportunities or subsidies were referenced in the interviews with Scottish stakeholders. However, individuals referred to the 'red tape', the policies and regulations (see Annex 1), impact on the ability to revalorise some of this waste, often without indicating a specific policy or regulation. As a preliminary step, the quantification of material flows at each stage of the supply chain must be improved through better data management and technology. In the German supply chain, when exporting from fisheries in the Global South, insecure connections cause spoilage of raw materials and could be addressed through better supply chain management. The shortage of skilled workers leads to delays in processing, preparation, and sale of the products in both countries. The labour force should be provided with better training and more attractive working conditions, and innovations that enable more automation should be adopted in the processing industry. Additionally, technical innovations in terms of fishing, filleting, sorting, transportation, and refrigeration are required to reduce interruptions in cold chains, the waste of catch fit for human consumption, and the cost of by-product revalorisation.

The collaborations between local producers and innovative users of by-products could be facilitated through local clusters that would reduce logistic costs and transactional issues – one of the top interventions according to our revalorisation survey. Such clusters can work as matchmakers between producers and buyers of surplus and by-products. Fishing quotas and landing obligations should be reconsidered in a way that reduced unwanted catch and does not incentivise discards at sea, which according to the industry survey are the main challenge faced by industry, but better valorisation of landed by-catch. Accordingly, monitoring of unwanted catch and improved scientific understanding of fishing grounds emerged as key interventions and opportunities.

Logistic and policy barriers to waste management need to be addressed to make the trading of seafood products in remote areas easier as well as, in the case of the UK, the trading between Scotland and England. Also, it was suggested that consumers should be educated about aspects such as nutrition and best before and expiry dates, to waste less at home. The

¹ <https://committees.parliament.uk/publications/42316/documents/210501/default/>

² Some of the relevant public funding and programmes to support adoption of innovations can be found in <https://www.zerowastescotland.org.uk/topics/sustainable-business/funding>

preferences of final consumers should be diversified through campaigns to include a wider variety of fish and seafood products in their diets, to reduce the high demand for certain quota species and increase the demand for other commonly caught species out with “the big five”³. Indeed, the mismatch between available catch and customers’ demand emerged as the third most relevant challenge, and widening consumers’ preferences ranked as the main opportunity, both overall and in the single case study countries separately.

Introduction to the deliverable

The Lowinfood consortium comprises 28 entities, located in 13 different countries, and ranging from universities and research institutes to start-ups, foundations, associations, and companies working in the food sector. The Lowinfood project committed to the co-design of low-waste and high value supply chains by supporting the demonstration of a portfolio of innovations targeting the prevention and reduction of food loss and waste. To this end promising innovations at different development and testing stages were selected with the aim to provide the necessary demonstration and upscale to allow market replication. The value chains included in the project are fruits & vegetables; bakery products; fish; and at-home and out-of-home consumption. Each of these value chains corresponds to a single Work Package (WP) of the project.

The “stakeholder dialogue” in WP4 “Innovations to prevent and reduce fish losses and waste” is one of the three social innovations demonstrated within the Lowinfood project, and others were tested in the bakery supply chain in WP3. The methodology presented in D4.1 was used to guide the development of dialogues between actors of the seafood value chains of Scotland and Germany. These two countries have been chosen because they represent an important fish producer, and the biggest consumption market in the EU, respectively. The dialogues were conducted in line with the methodology set in T4.1 of the Lowinfood Grant Agreement, with some refinement based on the specific features of the supply chains in each country.

The main goals of the dialogue were to provide an in-depth overview of waste flows along the chain, their economic and policy causes and potential solutions, and favour stakeholder coordination to address existing challenges. Initially structured by the blueprint set by D4.1, the process had to be modified along the way due to various challenges including recruiting stakeholders and making them discuss between each other in real time. The dialogue lasted for two and half years, until July 2024, and the scope of enquiry was expanded to the industry level by an online survey conducted in the final months.

³ “The big five” are the five key species consumed within the UK (cod, mackerel, salmon, prawns and tuna), there is very little demand for any other seafood products on a large scale.

This report (D4.3) summarises the results of the dialogue but is not the final output of the work package. A policy brief (D4.7 “Policy brief – fish”) providing recommendations to establish a more resource efficient seafood value chain will be published before the end of the project based on the findings of the stakeholder dialogue covered in this document. These outputs will be presented and discussed in the framework of two separate final project conferences held in Scotland (D4.5) and in Germany (D4.6).



1. The stakeholder dialogue: aims, development, and outcome

A large quantity of food loss and waste (FLW) results from: poor coordination along supply chains causing perishable products not to be consumed before the end of their shelf life; power asymmetries between supply chain stakeholders leading to the externalisation of waste from powerful to weaker actors; and lack of alternative chains for specific by-products, so that their nutrient and energy content is lost or used in unprofitable or ecologically non-efficient ways. These have been categorised as “institutional drivers” (related to either “business management”, or “legislation and policy”) by the FUSIONS project (Canali et al., 2014). The seafood value chain is not an exception, although the nature of the “production” process (when dealing with fisheries and not with aquaculture) allows for better adaptation of the supply to the final demand than in farming, where the production cycle is longer. Seafood is highly perishable, and by-products not suitable for human consumption are too, suggesting that this supply chain has a high waste potential if coordination is poor – a hypothesis deserving investigation.

Lowinfood adopted the FAO definition of food waste as “decrease in the quantity or quality of food resulting from decisions and actions by retailers, food service providers and consumers” (FAO, 2020), which also aligns with the EU definition as “any food, and inedible parts of food, removed from the food supply chain to be recovered or disposed” (Östergren et al., 2014). However, preliminary desk research and discussions with stakeholders suggested that in the seafood value chain⁴, due to the high value of by-products not suitable for human consumption, the term “waste” can be misleading. The goal is rather to allocate these products to the most profitable and sustainable use, i.e., to the highest possible level of the waste hierarchy⁵, which can also entail the recovery of high-value nutrients for use by humans. As such, “waste” only represents those products that are sent to landfill or anaerobic digestion and is very limited. Therefore, the dialogue focused on whether an optimal allocation of seafood and seafood by-products is currently achieved or if there are economic, social and policy obstacles to this.

For the above reasons, to achieve a more efficient use of seafood products, it is necessary to facilitate discussion and coordination between stakeholders at different levels of the value chain, from production to retail and consumption. This was the goal of Task 4.1 “Supply chain dialogue to identify hotspots of FLW in the fish sector” that engaged stakeholders of the fish value chain in two European countries, Scotland and Germany. While Scotland is not part of

⁴ In the context of the analysis, the term value chain is more appropriate than the supply chain. While both starts with production and ends with consumption, value chains also consider creation of additional value

⁵ The “waste hierarchy” is referred to as the foundation of the EU waste management directive by the European Commission and details the preferred methods of management and disposal of waste (i.e. from prevention to disposal). For more detail: https://environment.ec.europa.eu/topics/waste-and-recycling/waste-framework-directive_en#:~:text=The%20foundation%20of%20EU%20waste%20management%20is%20the,of%20preference%20for%20managing%20and%20disposing%20of%20waste.

the European Union (EU) anymore, it is still well embedded in the European markets. Since the exit of the United Kingdom from the EU is quite recent, Scottish practices and regulations, including on fisheries and international trade, are still being updated, which could potentially generate high amounts of FLW as the market adapts, and also represents an opportunity window to envisage more effective fisheries management practices.

Scotland is one of the main producers of fish in Europe and in the world. Peterhead in Northeast Scotland is the largest European port by value of the fish landed. In turn, Germany is the largest EU market, with 83 million consumers and a main entry point for local and imported fish (the port of Hamburg). Therefore, the fish value chains in these two countries are complementary, with Scotland being more relevant for upstream activities (production and primary processing), and Germany for downstream activities (secondary processing and retailing). The structure of the supply chains is further explained in Section 3 below. This framework initially looked promising for possible opportunities to exchange seafood products and by-products between the two countries, with the Leroma platform in Task 4.2 “Reducing food losses in the food industry with a digital marketplace” being the ideal marketplace. However, this was not the outcome due to various barriers in terms of high cost of logistics, including transport and need for refrigeration, and lack of markets for by-products that will be further covered in the dialogue outcomes section below.

The social innovation approach was relevant because most of the regulatory and innovation efforts so far mainly focus on technical solutions or on a specific typology of actors, while here we adopted a full-supply-chain approach, focusing on the issues that may emerge from the (lack of) relationships between actors. However, outcome of our engagements indicates that lack of added value in management of surpluses and by-products does not result mainly from lack of connections. On the contrary, at least on the Scottish side of the analysis, the seafood industry is close knit and agile, as demonstrated by their response to large-scale world events (e.g., Brexit, COVID-19, the war in Ukraine) and the resulting labour and inflationary crises. There are many sectorial and inter-sectorial organisations facilitating contact between stakeholders within the supply chain at the same stage (e.g., fishing companies and primary producer organisations and associations), and across various stages of the supply chain (e.g., sectorial organisations at the national level). These organisations have been instrumental contacts in the dialogue.

Alongside the mapping of FLW hotspots and the building of new stakeholder relations, the supply chain dialogue had goals such as advertising the Leroma platform (T4.2) to prospective users among the stakeholders and promoting awareness and possible adoption of other innovative solutions with potential to reduce loss and waste of seafood products. Whilst we also showcased Leroma and various innovations at events we either exhibited at or organised, the success was partial such that there were no adopters among those we engaged with or put Leroma or other innovations in contact with.

The protocol in T4.1 was created as a living document, and the actions were further revised and refined in response to local and current conditions. The main adaptation action was in

terms of data collection, which relied mostly on further individual engagement (interviews) rather than a few interviews in addition to the initially planned collective discussions in focus groups and workshops. Instead, the collective element was introduced through attending well-established industry events and joining efforts with existing organisations pursuing similar sustainability goals. The interviews allowed us to establish initial connections and to identify the most relevant stakeholders at national level. A management survey was designed in line with the framework developed in WP1 “Evaluation of innovations in a multi-actor approach”, and was to be implemented at the beginning (baseline) and at the end of the dialogue (monitoring) for all stakeholders who agreed to be part of the dialogue. While five baseline responses to this management survey were collected thanks to the stakeholder connections established during interviews, only fish oil was exchanged between two companies for testing processes and there was no visible short-term impact in terms of surplus transfers. Therefore, a different format of a final questionnaire was implemented. This questionnaire explored the barriers and opportunities from the perspective of stakeholders and asked about the most promising interventions. This questionnaire was expanded to the whole industry, including policy actors and technology providers. Most participants in the events and surveys were selected because their organisation previously consented to join the stakeholder dialogue and subsequently approved being contacted for further activities, including interviews. Otherwise, individuals were recruited based on their relevant expertise in one or more stages of the fish supply chain.

The structure of the deliverable is as follows: Section 0, based on Subtask 4.1.1 “Analysis of fish supply chain in Scotland and Germany”, briefly describes the supply chains, types of products, and waste hotspots in both countries. In addition, it expands on the profiles of stakeholders recruited from the seafood value chains in Scotland and Germany. Section 3 presents the results of the stakeholder dialogue itself, in line with the Lowinfood Grant Agreements. This section includes summaries from the Scottish interviews, networking events, and further public engagement efforts (3.1); summaries from German interviews and networking events (3.2); and details of the management and industry surveys implemented in the last months of the project (3.3). Section 4 briefly discusses the relationship between the demonstration of the Leroma platform in T4.2 and the activities in the stakeholder dialogue in T4.1. Finally, Section 5 concludes by summarising the outcomes of the dialogue with a critical approach, and discussing barriers, opportunities, and intervention needs within the Scottish and German supply chains and for the sample of industry respondents, mainly from the UK and EU.

The deliverable also includes a number of annexes. Annex 1 includes details of relevant policy and regulations to the Scottish seafood sector. Annex 2 includes the generalised interview scripts used in the stakeholder interviews in Scotland and Germany. Annex 3 presents some of the advertising material used for the recruitment. Annex 4 briefs about the practices and initiatives adopted in the UK retail sector and those mentioned in the stakeholder interviews, while Annex 5 provides the script of the online survey distributed to the industry stakeholders. Each section, as well as the annexes, are structured in two parts which focus respectively on Scotland and Germany, highlighting similarities and differences.

2. The seafood value chain: structure, actors, and waste generation

This section provides an overview of the seafood value chain (products and stakeholders) and of the main waste flows within it. The text is based on desk research implemented in the framework of Subtask 4.1.1, whose goal was to inform the selection of stakeholders for participating in the dialogue.

2.1 The seafood value chain in Scotland

In Scotland, the focus was on the production level, since this is a sector that is relevant for this country (Scottish Government, 2019). A simplified graphic of the seafood value chain can be seen in Figure 1 **Errore. L'origine riferimento non è stata trovata..** Apart from subsistence fishing, represented by the orange arrows, all the other actors and flows are relevant for Scotland, with wild capture and aquaculture representing separated chains.

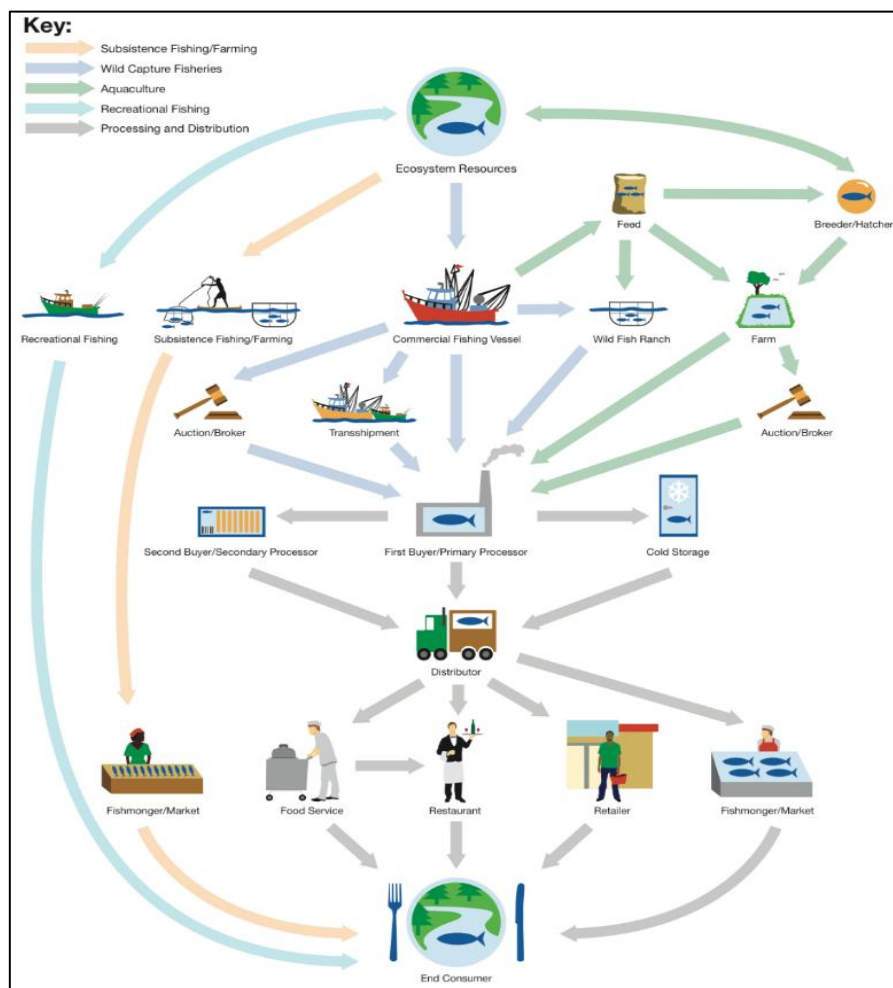


Figure 1. Simplified structure of the fish supply chain (Fishwise, 2017).

After the literature review (included in Section 2 of the D4.1), it was decided that the focus of the dialogue would be on sea fisheries or wild capture (i.e., excluding aquaculture). Aquaculture industry was not included because literature review found that production in fish farming is more efficient compared to wild capture as the output of aquaculture production is more predictable than wild catch, e.g., by-catch is not an issue. Among wild capture demersal fish and shellfish (i.e., excluding pelagic fish) was found to be of particular interest due to their relevant economic value, by-product flows and the higher potential for reducing waste using innovative methods compared to the pelagic industry, which is comparatively quite efficient.

Initially it was decided that the dialogue would take a place-based approach, with participatory events being organised respectively in Peterhead (for demersal fish) and Southern Fife (possibly Pittenweem, a much smaller port and local community) for shellfish. However, despite recurring attempts to engage with ports, fishing industry organisations, and professionals in these locations, we did not get sufficient response or agreement to participate in these locations. Dealing with extraordinary world events, such as COVID-19, Brexit and the war in Ukraine, took priority for the businesses we hoped to engage, especially those exporting outwith the UK and with high levels of employment of foreign workers. These events made it equally difficult to appeal to small businesses which lack additional resources (financial and human) for scientific engagement.

As a result of these recruitment difficulties encountered in the place-specific engagement approach, the focus of the stakeholder analysis was extended to the level of the seafood supply chain in Scotland. The scale of the stakeholder engagement efforts is illustrated in Figure 2 below. Successful outcomes of the recruitment are explained in Section 3.

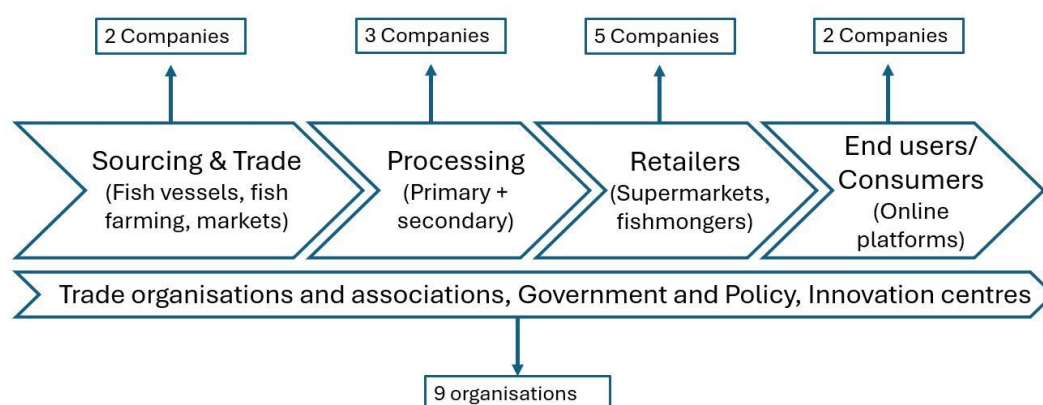


Figure 2. Structure of the seafood value chain in Scotland and stakeholders involved in the dialogue.

2.2 The seafood value chain in Germany

The preliminary literature review showed that the German fishing fleet has become insignificant, while the processing of fish in Germany still plays a moderately important role, and the country is still an important trading centre and a large consumer market for fish. Therefore, it was decided that the focus of the dialogue should be on downstream activities such as fish processing and trading, as well as retail and catering – without completely excluding the primary sector.

Figure 3 below illustrates the structure of the value chain in Germany. For the stakeholder dialogue, actors from all stages of the value chain and with different functions were recruited. It was particularly difficult to win fish processing companies (which are certainly particularly regarding FLW) for the dialogue. Here, it was necessary to take a side path by including a company that manufactures precision machines for fish processing, and a company from the aquaculture sector. The aquaculture sector, though initially not included in the main focus of the analysis, it is becoming increasingly important compared to sea fishing and is confronted with the same challenges with regard to FLW from the processing stage onwards.

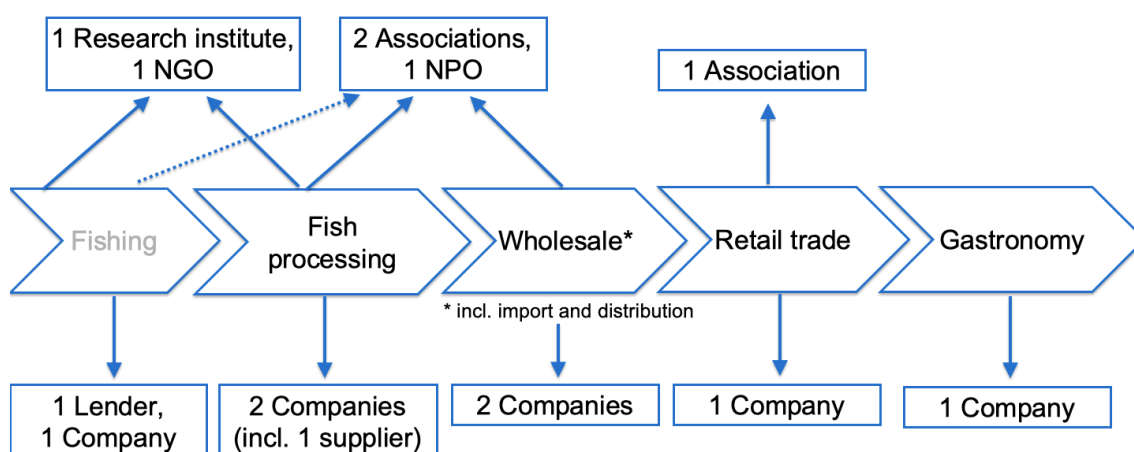


Figure 3. Structure of the seafood value chain in Germany and stakeholders involved in the dialogue.

3. Running the dialogue

The '**stakeholder dialogue**' consisted of a dialogue between researchers and stakeholders and between stakeholders at different levels of the seafood value chain, and particularly between creators of surplus products and by-products and potential users of these flows. Among other goals, the dialogue aimed to understand where most loss and waste are generated in the seafood value chain; their technical, organisational and policy causes; and how these can be addressed.

By creating new connections and establishing a stronger network between stakeholders in the supply chain, we aimed to facilitate reuse and value generation from fish products and by-products. With stakeholder inputs, we sought to identify measures to be potentially taken for creating higher economic value in the fish supply chain and seafood industry. To this end, we engaged in various activities to consolidate a network and to gather qualitative and quantitative insights in both countries, as detailed below.

3.1 Stakeholder engagement in the Scottish fish supply chain

Expert interviews conducted with stakeholders from Scotland and Germany explored: critical aspects of loss and waste generation in the seafood value chain; barriers to reducing loss and waste from the perspective of different stakeholders; and opportunities for attracting higher value from under-valorised materials such as by-products. The aim was to reduce waste through collaboration and communication among stakeholders and to promote the use of current and prospective innovations.

3.1.1 Interviews in Scotland

On the Scottish side of the study, the initial focus was set on primary production, as fishing⁶ is a major industry for Scotland, with Peterhead in Northeast Scotland being the largest port of Europe, meaning high volumes of catch are landed there. Stakeholders identified in the first subtask (4.1.1 – “Analysis of fish supply chain in Scotland and Germany”) were invited to join the stakeholder dialogue via email, letter or phone calls. Further contacts were provided by some of the stakeholders that the project team initially contacted. For stages in the supply chain where there were no or fewer contacts, we conducted further searches to identify potential candidates.

Stakeholders on the Scottish side were recruited throughout the supply chain, starting from primary producers (i.e., local fishing companies); primary processors; secondary processors;

⁶ While Scotland is also a prominent producer in the aquaculture sector, the study here focuses on wild catch and demersal fisheries because aquaculture and pelagic vessels operate in more predictable processes with less by-product flows.

fish mongers; supermarkets operating at national scale; users of fish by-products; online platforms; various industry organisations; as well as policy stakeholders such as local council and government bodies, supporting and networking organisations, and innovation centres.

The fishing sector in Scotland is tight knit and we were advised by multiple stakeholders that being introduced to hard-to-reach primary producer stakeholders (e.g., fishers) by trusted actors in the sector would be the most likely method to receive a response. While various organisations involved directly or indirectly with the seafood value chain in Scotland were successfully recruited, only 2 Northeast fishers (one a representative of a producers' association) were recruited for interviews through consistent recruitment attempts. Due to the lack of response from the fishing community, the JHI project team decided to move its focus onto the entire fish supply chain.

We interviewed a total of 22 stakeholder organisations (two individuals from different departments in the case of a retailer, for a total of 23 interviewees): 13 from companies operating at various stages of the Scottish seafood value chain, and 9 from trade and industry associations, policy, government bodies, and networking and support organisations. Interview scripts were tailored to each of the stakeholders, their respective fields, expertise, and role in their organisation; however, we endeavoured to ask all interviewees the same key questions. The questions were as follows: (1) Do you/Does your company generate waste, and from where?; (2) Are there specific aspects of your activity that cause waste to be generated?; (3) Is any of this waste generated due to your relationship with other stakeholders?; (4) Are there any innovative solutions against waste that you use or you are aware of, or you would like to explore in the future?

A generalised interview script was created both in Scotland and Germany and these were adapted to the specific profile of the stakeholders to allow asking them more detailed questions about the sub-topics relevant to them and avoid wasting time on irrelevant topics (e.g., asking surplus management at shop floor to skippers). The generalised interview scripts can be found in Annex 2 and more information about how these interview scripts were constructed can be found in D4.1. Summaries of the stakeholder interviews can be found below.

Local Fishermen

Stakeholder Profile: Head of a 24-metre vessel with a crew of six people. They fish out of Peterhead and the crew are usually at sea for 6-8 days at a time, dependent on the area they are fishing in and the time of the year. The crew catch a wide range of fish including cod, haddock, whiting, monkfish and hake. Of the fish caught, approximately 90% are landed in Peterhead and go to market there. A phone interview was conducted with the skipper of the vessel.

Fish losses or waste: The only fish losses or waste detailed by the skipper were the guts of the fish they catch and very occasionally small fish which are not fit for human consumption. According to the interviewee, throwing these back into the sea supports the ecosystem as they feed the seabirds. All fish that the crew catch is gutted on board⁷ and no further processing is done on board, in line with the process of other demersal fishing vessels in Scotland. Some prawn vessels will freeze the catch on board and potentially do the same with monkfish. When discussing unwanted catch (not fit for human consumption), the skipper shared that this rarely occurs onboard and is not considered a big problem for his vessel.

Barriers to reducing waste: The low quotas, especially for cod and haddock is a big problem for Scottish vessels. For example, to land undersized fish not fit for human consumption would take up valuable quota and there is no economic gain for the vessels in doing this. It is in fact a loss of quota and therefore prevents the vessel from landing and selling fish that is fit for human consumption⁸. The skipper further shared that often the forecasts of fish by scientists, on which the quotas can be based, often do not match up to what the fishermen observe at sea.

Opportunities for preventing FLW: According to the interviewee, when fish are discarded by any vessel the most likely explanation is due to a lack of quota for that specific species. Fishermen and those working aboard vessels are aware that this is not allowed, however, to have a quota for each individual species results in vessels needing to make the most of what is allowed and therefore only land the best of their catch. To prevent this waste, the best course of action is a bigger and mixed species quota that would provide flexibility for when there is unwanted catch amongst the desired catch. The fish landed that exceed the allocated quota are classified as not fit for human consumption and are sent to be made to fishmeal by the port authorities. This is an economic loss for the vessel and a loss of product fit for human consumption. In terms of policy, the best way to prevent this waste is to up the size of the quotas, especially for cod. In 2022 there was talk of the following years quota being upped by 40%.

Opportunities for using waste materials: Discarding of guts at sea is a legal practice in Scotland. The skipper explained that the only way for guts to be brought ashore for alternative use is for them to have the same economic value as the fish being landed, otherwise there is no incentive to bring them ashore. The vessels have limited storage, for

⁷ During this interview it was also mentioned that whiting is an exception to gutting of all catch onboard as a provisional measure in Scotland. However, we were not able to find any further information in the policy documents related to landing obligation and discarding about this exception.

⁸ For landing obligation in the UK please refer to Landing obligation requirements document in https://assets.publishing.service.gov.uk/media/643816a9773a8a0013ab2c0c/Landing_obligation_general_requirements_v2023.pdf

example, on their vessel they only have space to carry 30 tonnes of fish in boxes. The next issue is how long the guts would stay fresh, part of the reason they are removed on the vessel is to ensure it doesn't lead to the fish being spoiled.

Innovations: In recent years they have changed their nets to allow more fish to get out, but the skipper reflected that more can probably be done. In terms of innovations, the skipper was explicit – for any innovation to be taken up by the vessels, the economic reward has to match the value of the fish itself. Fishermen will never take fish or by-products ashore if they can't sell them, it would create a cycle of waste and economic loss if they continuously catch fish outside of their quota.

Primary processors

Stakeholder profile: One of the main primary processing companies of wild shellfish in Europe and based in Northeast Scotland. It is a subsidiary of an international seafood retailer. They focus on four main species: brown crabs, king scallops, langoustines, and whelks. The company export the majority of their products, except for some small markets, particularly for scampi deals in the UK.

Waste: Waste materials mainly originate from processing and are either recycled or repurposed. Interviewees stated that the company prioritizes effective waste management and has implemented various sustainability strategies to minimize waste and ensure that no product goes to landfill. Guts and other organic waste are sent to their composting centre, where they are transformed and provide a valuable resource for agricultural purposes. General waste is directed towards renewable energy production instead of being disposed of in landfills. This approach ensures that waste is utilized efficiently and reduces the company's environmental footprint.

Opportunity to valorise waste materials: Crabs are sold as whole units, leaving small amount of general waste to the company. Any remaining waste parts, are repurposed as bait for fishermen, ensuring the best possible waste utilization. King Scallops are the main species processed by the company, they are broken down into various components: the top shells, which are collected by local farmers who crush them and utilize them in their fields, and the bottom shells, which are exported to East Asia, particularly China, where they are either used as ornaments or for serving food. Lobsters and Langoustines are usually sold whole resulting in no or minimal waste. However, due to quality assurance, if the lobsters or langoustines lose a body part then they go through further processing (separated into head, claws and tails). The tails, which are rich in chitin, are sent for composting, while the heads and claws are typically supplied to restaurants. The waste shells from whelks are crushed using special equipment, and the resulting material is categorized as "wet waste." This waste is sent to the same composting facilities as the guts and other organic waste.

Barriers to implementing innovations and valorising waste materials: Despite promising advancements of innovations to further revalorise by-products, challenges such as limited space and high costs prevent the company's ability to fully implement innovative practices. For example, producing sustainable bags and biodegradable plastics are not economically feasible now, but the evolving technology may enable their commercial implementation in the future. The production of chitin powder from the shells might negatively affect the air quality of local communities due to resulting dust from this process. Finding effective solutions to these challenges is an ongoing task for the processing company and associated innovators.

Innovation: The company is committed to minimizing waste and exploring the potential uses of shellfish by-products through collaborations with innovators. They conducted a trial in close collaboration with a local composting company to explore the use of soil derived from shellfish waste to treat Potato Cyst Nematode (PCN). Initial experiments successfully cleared the PCN infestation from fields in less than one year, compared to the traditional methods that typically take five years. Our interviewees stated that this has potential to significantly benefit up to 25% of the agricultural land, given the common PCN infestation⁹. The company further engages in collaborations with others in the industry with the goal to develop sustainable bags and biodegradable plastics. They also spoke of a promising innovation to extract chitin and convert it for use in various other products.

Secondary processors

Second processor 1

Stakeholder profile: This stakeholder specialises in secondary food processing and is one of the largest independent value-added seafood manufacturers in the UK. Located in Aberdeen, it has one of the most modern fish manufacturing sites in the country. The business buys in pre-frozen, gutted blocks of product that they use to create products for retailers (e.g., breaded and battered fish, fishcakes, prawns). The majority of this is purchased via Chinese or European processing plants with a small amount from Scottish plants.

Waste: They don't have a set definition for waste but the interviewee did identify three sources of waste for the company; by-products of the processing such as wet fish cuttings and crumbs; low quality supply unsuitable for secondary processing; and unsold finished products. They always look at ways to reduce waste and have a new reduction plan in place for this year.

Wet fish cuttings are an unavoidable by-product for the business and are sold to a company that makes animal feed. There is also unavoidable crumb waste that they are trying to find

⁹ According to our consultation with a senior scientist from the James Hutton Institute working in this field, these tests are very preliminary and there has been no clear randomisation plan, therefore, the cited success rate has to be taken with a lot of caution.

a valorisation route for. Occasionally they will receive fish that is not high enough quality for secondary processing, bones tend to be the main issue. This happens more commonly with suppliers using automatic systems like light boxes to remove the bones, compared to those that handpick the bones out. The automated process is more common among the suppliers from Iceland and manual handling is more common among suppliers from China. The biggest economic loss that the business sees in terms of waste is when their final finished products go unsold. If the product is poor quality (i.e., before leaving their depot) or returned by one of their purchasers it is seen as waste. Large retailers will take their “better” products, while small retailers will take the “B-grade” products (e.g., darker fish) that are sold for less. If no one buys the B-grade products, then they can be donated to a local foodbank.

Barriers to reducing and revalorising waste: Three key barriers were mentioned when it comes to valorising waste flows. Firstly, space is a big issue and it’s significantly easier to let the product go to waste than it is to store it until there is a use for it. For instance, often the crumb remaining from the breeding process is difficult to find a use for due to contamination from oil. There is some avoidable crumb waste but there are issues with logistics, such as storage and sorting.

The business was planning on expanding their factory at the time of interview and hoped this would ease the barrier of storage space. The second barrier noted was human resource to ensure products are segregated properly, checking that the correct products go through the correct valorisation route. Lastly, issues surrounding the management of shelf-life were brought to our attention by the interviewee. The business is directed by the retailers on what the shelf-life on products should be, however if there is a delay in sending product out it can be rejected and sent back, which then makes it even more difficult to sell due to multiple days delay.

Innovation and collaborations: They are in the early stages of working on a pilot project with the Abertay University to see if there are any valorisation potential such as or energy production for the crumb.

Secondary processor 2

Stakeholder profile: This stakeholder is an entirely UK based business, with 3 processing sites in Scotland (Fraserburgh, Livingston, Scottish Borders) and 3 in England (Grimsby as their headquarters). The 3 sites in Scotland cover primary processing of salmon, two produce smoked fish products, and one conducts secondary processing of nephrops into scampi. The company supply retailers in the UK with an array of products, mostly covering smoked fish (haddock, mackerel, kippers, herring), hot and cold salmon products, scampi, frozen coated fish, and value-added products (e.g., fish pies).

Waste: The company class waste as anything that is not fit for human consumption (e.g. Category 3 waste, like skeletons) and try to minimise this as much as possible. Most of their whitefish is sourced from Iceland and Norway, this is due to the volumes being caught in UK waters being too low to supply the national demand. Their salmon is from aquaculture and some materials were sourced from Russia at the time. Haddock and cod are the most popular species for the UK consumer. The company don't do any primary processing of pelagic fish, they receive it as kippers or headed and gutted mackerel, so waste wouldn't be incurred for them at this stage. Demersal is received headed, gutted and frozen mostly, whilst salmon is received head-on and gutted. There's a fundamental difference in pelagic and demersal from shellfish, which is that the shells themselves are very difficult to find alternative disposal routes for rather than going to landfill. The company are interested in the nutrients that can be retrieved from shells (e.g., chitin from shells and collagen from skin) however this is not something that they can take responsibility for investigating, it would have to be their suppliers.

Opportunity to valorise waste materials: In terms of waste management, the heads and skins can be used for fishmeal, whilst the skeletons can be used for bonemeal. The materials from their Scottish site are sent to a fish meal producer in Aberdeen. The materials will usually pay for themselves but make no profit. Anaerobic digestion is used for anything that cannot be sent to fishmeal however this is incredibly small volumes. Of the materials going to fishmeal, there is not a feeling that much value is being lost. The company are more interested in shelf-life extension and deep chilling. In terms of waste coming from distribution, their products will be donated to a food charity if nearing their sell-by date however the frozen products will rarely have this issue as they keep for longer. No financial gain comes from using the charitable organisation, rather it is not wasted and can be donated to foodbanks or homeless charities.

Barriers to reducing and revalorising waste: There is a lack of technology and therefore opportunity for the recovery of materials (such as chitin or collagen) in Scotland. For the recovery of materials fit for human consumption, the challenge is mostly geographical, although developments in infrastructure could improve this. The interviewee pointed out that because the company work over both Scotland and England, some differences in process due to devolved powers for Scotland can cause challenges. For example, Scotland's rules for handling waste are different to England's so this needs to be considered. The biggest difference is due to the geographical spread of the fish and seafood sector in Scotland, this limits opportunities in the waste streams compared to those in other places. Overall, more collaboration and communication are the most important thing for Scotland to find processes to reduce waste production and uses for the waste that is produced.

Fishmonger

Stakeholder profile: A family run business based in Aberdeen that has been running for over 40 years. The business' main products are lemon sole and flatfish. The full product list includes local products such as lemon sole, haddock, cod, monkfish, skate, squid, grey sole sourced from Peterhead and Shetland, and imported exotics such as salmon, prawn, seabass, scallops, tuna, and bass. They have a buyer in Shetland and Peterhead, and source exotics from three different suppliers.

Waste: The skins, skeletons, and heads are considered waste. Waste varies between species, for example flatfish bones are very thin so there is not a big loss, with haddock only the centre bone is lost. Scallops will usually be bought in without the shells unless a special request is put in by a customer. The most waste is generated during the filleting process, when a fish is filleted approximately half of the product is lost with a small amount of water loss. The fishmongers process in-house; a member of staff works on the skinning machine removing the brown side of the fish. The fish is then placed into ice cold water until it is filleted by hand and packed into boxes. The fish fillets are packed and sent out on the same day to their wholesale customers. The most weight lost in processing comes from monkfish, the cheeks can be removed from the head and then only the tail of the remaining monkfish carcass can be used. They will occasionally buy in shellfish such as mussels and oysters, there is no waste for them with these products as they are sold as they are.

Opportunities to revalorise waste materials: As it is a small business, they do not produce as much waste as other Aberdeen-based companies. The waste from in-house filleting (mainly bones and guts) is placed into a yellow pan that is then put into a yellow manure bin and taken away by the major fish meal producer in Aberdeen. On average the fishmonger will fill one of fish meal company's yellow bins a day, whilst our interviewee has witnessed to other companies filling as many as 4 in one day. Sometimes the cod and haddock heads are kept for customers who use them for stock or soup, this is one of the benefits of being a small business, that they are able to respond to requests such as this.

Retailers (Supermarkets)

Four of the largest supermarket chains that are based throughout Scotland and the rest of the UK were interviewed. The supermarkets vary in the type of products they sell and the area of the market and consumer base that they target.

Retailer 1

Stakeholder profile: This stakeholder is branded as a discount supermarket and have over 600 retail outlets throughout the UK.

Waste: The interviewee looks after the sustainability of their supply chain, their focus is mainly on production stage in the supply chain (e.g. inefficiencies in production) while another team look after packaging, however, focus on food loss and waste spans all areas of

the retailer's operations. They, like the other supermarkets interviewed, mainly sell the big five fish species: cod, haddock, salmon, prawns, and tuna. The business use approximately three suppliers who supply them with various products, such as salmon and packed fish. The products become their responsibility when they reach the distribution centre. To be accepted into the distribution centre, products must be labelled properly, have the correct barcodes, correct best before or use by dates, and they must meet to weight criteria. Historically, if the supplier sends more than the business has asked for, such as sending 100 packs instead of 95 for their own ease, then they would have to pull the extra 5 as they haven't been forecasted for and put them in the fridge to await collection by the supplier. Collecting these extra products is often not economical for the supplier, in recent years the retailer has asked their suppliers if they can donate the extra products to charities instead (e.g. Fareshare). If there are labelling or bar code issues, then they outsource Company Shop to correct the mistakes. Suppliers will occasionally come to the distribution centre and relabel too. The first option for revalorisation is in-store discounting then it would be redistribution. Anaerobic digestion is the last resort for food waste, nothing has gone to landfill for years.

Barriers to reducing FWL: Forecasting what consumer demand will be is a complex task, for example for national holidays such as a royal wedding, the business will go back to the most recent royal wedding and inform their forecasting based on demand that occurred at that time to source accordingly to avoid surplus and shortage. Further, bank holidays and heat waves in the UK make a significant difference to what consumers will want to purchase.

The increased demand for specific products due to seasonality (e.g., good weather drives demand for burgers and other products used in barbecuing), trends or events such as the royal wedding requires increased capital investment from the business to stock right products beforehand and rely on accurate forecasting.

Innovations: The business is always reviewing what they can do to reduce food waste, anything that increases the shelf life of a product can give them more marketing opportunities. Their fish waste is already being used for fish meal and salmon oil.

Retailer 2

Stakeholder profile: The UK's "premium supermarket", in 2022 reported having over 300 branches. There has been significant investment into ethics and sustainability by the business, there are upwards of 50 employees who take care of health, agriculture, environment, climate and circular economy.

Waste: The interviewee stated that in the retail sector food is only considered waste when it hits the bin, anything leading up to that is termed surplus if it still has use and is suitable for human consumption. In retail, approximately 0.5% of the total products end up as food

waste, with the highest waste categories (by volume) being bread and fresh produce. They quantify their environmental impact by the volume of product. They are also part of some working groups, for example a fish forum group and an agronomy group. For the “Best before” dates of products, there are guidelines for how many days past the best before they can be donated to charities. Products must leave the customer facing shelves on date but are taken to back of house to be frozen and collected by charities. The hygiene and quality of products is important to retailers, so there are challenges involved for them in finding the balance between date maximisation and quality. WRAP¹⁰ provides guidance in the form of date codes and “Consume within” notes being pushed back, there are also examples of different labelling on products, e.g. “You can freeze me” and blue fridge logos.

Opportunities for reducing waste: If a charity or an online platform can’t take their surplus before expiry, then it will go to anaerobic digestion. So far, they have given 10 million meals to charitable organisations, at the time of interview over 7 tonnes of food had been given to online platforms, and some food is given to staff to prevent it going to waste. Even with these charitable and partner donations, the organisation still plans to move into producing animal feed, this was in the planning phase at the time of the interview. They are also part of the Courtauld Agreement (see Annex 2), from their 2018 baseline levels, the business has seen a 20.878% reduction in food waste with a goal to reduce their waste by 50% in 2030.

The retailer stock mainly the “big five” of fish in the United Kingdom. When sourcing fish, the business has their tier 1 suppliers (farms, fishing boats) and tier 2 suppliers (processors). They are one of only two supermarkets in the United Kingdom that require their suppliers to reduce their food waste by 50%. Although the agreement is voluntary, it is a requirement for their suppliers to aim for this and report this via the WRAP data capture sheet. They are also releasing media campaigns to help their customers half their food waste, for example early in 2022 they released their largest campaign on the social app TikTok.

Innovations: The retailer are always speaking to different innovators, the challenge is in finding cost-effective solutions – if the innovation costs more per tonne than the return, it is difficult to get through. There is both push and pull from the conversations with innovators, and fish suppliers all know each other so it is a very tight knit community. They need to stay competitive but want to go commercial. Logistics is sometimes another issue, for example freezing capabilities can be limiting as it is expensive to run and may not justify keeping products, e.g. trimming.

Retailer 3

Stakeholder profile: The difference between this stakeholder and other supermarkets the Lowinfood team interviewed, is that they are an own-brand retailer with 870 stores in the

¹⁰ Waste and Resources Action Programme (WRAP) is a climate action NGO, more information here: <https://www.wrap.ngo/about-us>

UK. The business sells solely their own products in their retail outlets, meaning they are responsible for sourcing or out-sourcing raw material suppliers, manufacturers, and other producers. This structure makes their relationship with the downstream supply chain stakeholder more direct, and responsibility is higher.

Seafood value chain: When it comes to fish, their manufacturers buy material from approved suppliers – there is an audit process for this, so in turn the vessels and processors are included in this. The business has a relationship with WWF, as part of their work they are partnered with the European Policy Office (WWF EPO), a network within which the purpose is to strengthen legislative measures encouraging sustainable fisheries. Further, the WWF basket matrix (see Annex 2) commits them to reducing their reliance on wild capture fish. They also require fisheries assessment and a vessel list from any fishery that is used as a supplier. If fisheries and their associated vessels are Marine Stewardship Council (MSC)¹¹ certified that is fine for them. The human ethics surrounding fisheries is also hugely important to the business.

Waste: The business is doing what it can to ‘close the loop’, for example working with a company who use their by-products for fishmeal. They consider anything that cannot go to human consumption as food waste. The interviewee labelled the type of waste that not much can be done about as “pure waste” and stated that there is not much of it in their operations. Because they have their own brand, there is the belief that the business is only as good as its weakest link in the supply chain. Within the businesses supply chain, there is a one-way flow and return to manufacture is avoided at all costs. There is a huge process for the suppliers to go through before the products go to depot, if anything that is not standard enters the store it is returned and is considered a failure.

Opportunities for reducing and revalorising waste: Like other retailers, they have charity partners who distribute food that is no longer suitable to be on the store shelves to those in need. A lot of their suppliers send their waste to anaerobic digestion. Their business is also a part of the Courtauld agreement (Annex 2) and has set themselves an ambition to be net zero by 2040 with as little need for offsetting as possible. They have an investment plan, and the business is continually looking at how they can reduce waste in their supply chains, from hatcheries to renewables.

Barriers to reducing and valorising waste: The interviewee stated that current high interest rates increase the cost of borrowing and might discourage innovators and entrepreneurs to invest in innovations.

Innovations: They deem themselves a “curious” business. They provide seed fund innovations with sustainability as the key goal, they recognise the need to invest and think

¹¹ <https://www.msc.org/uk/what-you-can-do/what-does-the-blue-msc-ecolabel-mean>

outside the box. They run a program called Forever Fish, which used to be all about marine sustainability, it now includes human ethics, packaging, fisheries improvement, and innovations. Some examples of these innovations are: using various light frequencies on fishing gear to attract specific species; the Buckie project camera system (which is going through trials) which could lessen impacts on seabed degradation and avoid unwanted catch; and different panels being trialled on nets.

Retailer 4

Stakeholder profile: This stakeholder is a consumer co-operative, meaning it is owned by their members. It is the fifth largest retailer in the UK, reporting over 2,500 outlets in the form of local, convenience and medium-sized stores. The business is a convenience retailer, meaning they stock easy to cook, straightforward products. Different to other three retailers interviewed, in their convenience food model, some shops are supermarkets which do not fall under corner stores, whilst a lot of their stores are independently owned corner shops that sell their products. The supermarket's species stock list includes wild nephrops, mackerel and whitefish processed in Scotland and the majority of the business' fish and seafood sales come from salmon and prawns. They are a member of the Sustainable Seafood Coalition and use its voluntary codes of conduct for the responsible sourcing and labelling of fish and seafood products and contributes to Project UK¹² for increasing sustainability of selected fisheries in the UK as does most other UK retailers. They work with the Sustainable Fisheries Partnership to ensure the business is up to date with the latest industry science. We conducted two interviews with this retailer. We conducted two interviews with members of the retailers' fisheries and sustainability department, respectively.

- Interview 1

Waste: There is no processing done in-house, so they do not deal with by-products. Responsibility of food waste is dependent on the formal code of conduct that retailers adhere to. If the cause is a bad quality of supply, then the onus to deal with it is on the supplier not the retailer. Instead of sourcing directly from fishermen, the retailer sources from both primary and secondary processors. Their sourcing policy requires their suppliers to fit an eligibility criterion such as sustainability certification. Both interviewees stated that the UK retailers are committed to reducing food waste and as an ethical supermarket they do anything they can to ensure this. From the beginning of the supply chain, the business works with suppliers to limit any waste as far as possible because food waste also means

¹² Fisheries Improvement Projects (FIPs) are developed by Project UK as a multi-stakeholder initiative. Its aim is to support the UK fisheries in their sustainability journey within a defined five-year time. Project UK, a collaborative partnership is funded by a group of core organisations including major UK retailers like Aldi, Coop, Lidl, Morrisons, M&S, Tesco, Waitrose, Sainsbury's; processors such as Macduff, Young, Whitby Seafoods, New England Seafood, Lyons Seafood, Falfish Associated Seafoods, Coombe Fisheries, Seafood Ecosse and organisations such as Scottish Fishermen's Association and WWF.

economic loss and additional carbon emissions for the businesses. When it comes to problems retailers have with fish and seafood supply, the most likely scenario will be a broken fridge or freezer. The only other issue with waste of fish and seafood is customers not buying it, e.g., over-ordering.

Opportunity for reducing and revalorising waste: The fillets of fish damaged during processing are still fit for human consumption and can be made into flakes for other products, while the damaged fillets could be used for animal feed. In general, all suppliers will waste as little as possible given that waste removal incurs them additional costs. If they can use material waste for something else, then they will. Retailers work with charitable partners and donate their surplus products. As the second interviewee also stated, at the moment retailers reduce food waste for social responsibility reasons rather than business reasons, but once carbon accounts are incorporated into the business accounts, the UK retailers will be further motivated to reduce their food waste.

Barriers to revalorising waste: As the second interviewee also pointed out, once the product is on the shop floor, the retailers' power to prevent waste diminishes. This particularly applies to products with high perishability like fish and seafood. On the day of the product expiry, the retailers begin gradually reducing its price with intention to sell the product while it can still be consumed. If the product is still not sold at a certain time in the evening, it will be put up for donation before expiry. However, because this time frame is very narrow, charities might not be available to pick it up and cook it in the same evening or have freezer space to store it without breaking the cold chain. In the cases that the surplus food cannot be donated before the closing time, it is collected by a waste management company and sent to anaerobic digestion. It is also mentioned that the unit cost of food waste recycling is considerably higher for small stores according to a feasibility study carried out by another UK retailer and presented at WRAP. Unfortunately, they did not respond to our inquiry to access this document.

- Interview 2

Waste: They follow WRAP guidelines on the definition of food waste. The organisation discusses food waste in terms of what is edible and inedible (by humans), this is most relevant for manufacturing. From the depots and retail stores, approximately 1.4% of all food will go to anaerobic digestion. Within the industry, there is trust that the actors in the supply chain before the "farm gate" (before food leaves the producer, e.g. farms, fishing companies) are acting responsibly in terms of waste and production (e.g., mortality rates). While logistics and retail stores account for very little waste, the most waste is produced at home. However, the organisation wants any waste to go to the best possible end destination, which is now household food waste bins. Although food packaging often encourages customers to freeze food products so they can be saved from potential waste, there is a nervousness about fish being left too long in freezers as it is a higher risk product for food poisoning.

Surplus food is distributed through a variety of channels, such as being given to people, sent for animal feed or pet food, and recently surplus has also been used in novel insect feed trials. Products past their best before and use-by dates, or that are broken or damaged will go to anaerobic digestion or be distributed through community partners (e.g., local charities like breakfast clubs, food banks, food packs). At the depots they partner with organisations to remove surplus products, products past the best before, and damaged products.

Opportunity for reducing and revalorising waste: Their value creation team look at how each product is treated throughout processes such as deboning and coating and evaluate their efficiency. Communication lines with their partners are important in managing and preventing waste. Their fish and seafood products include freezing instructions, fridge temperatures, and recipe ideas in an effort to reduce food waste at home. Other methods of preventing waste include challenging the existing shelf lives of products and how customer's confidence to use yellow sticker products.

Users of waste materials

Producer of fishmeal and oil

Stakeholder profile: This stakeholder is the biggest fish processing company in the Northeast Atlantic. They have approximately 28 factories in which the four divisions/activities of the company are carried out – EPAX (fish oil for human consumption), food factories (for human consumption), feed factories (fish meal and fish oil), and ensiling. They receive discards, trimmings, and industrial waste of whitefish, demersal, pelagic (mackerel, blue whiting) and farmed (mostly Scottish salmon) from processors and fishing vessels. They have four divisions, one of which is ensiling – mainly done with salmon. The final product of their process is fishmeal and fish oil.

Waste: They do not have any fish related waste, but they do use different types of fish by-products and surplus as input. Their input range is wide and it is very rare that any of the materials they receive are not fit for use. The only reasons for rejection are due to there being no potential uses, the products may be full of foreign bodies, chemically contaminated or decomposing – for this, a TVB-N analysis is conducted (Total Volatile Basic Nitrogen) to quantify the presence of any nitrogenous compounds and determine the level of freshness.

Barriers to sourcing waste materials as input: One issue mentioned by the general Manager is transport challenges. Fresh products within a short distance of the processor (<1 hour journey), then it is less likely they will become waste due to unforeseen transport problems, and costs less as they don't need refrigerated. However, if being transported from further then the raw materials will need to be refrigerated during transport which is costly. If a processor or fishing vessel produce large volumes at a further distance this is still economical as the transport will “pay for itself”, but if there are small volumes from far away it is not economical to transport the raw material.

Sources of input: They receive undersized catch, this is landed because it has to be and is declared as discards, however there are only small volumes of it. Bycatch on the other hand, is the unintentional fishing of an undesired species, these can be sold if the vessel is still under quota. Bycatch is only a problem if the quota amounts have already been met. The knock-on effect of this for example is that if a vessel continues to catch small fish over its quota for mackerel, then they will need to stop fishing mackerel altogether at the risk of overfishing. Discards that are landed will cost the vessel as they can not be sold, and the fare costs still need to be covered. There is also the issue of high grading, this is when vessels hear that others are picking up bigger fish than them, so they discard their smaller fish overboard and go to find the bigger catch, it's a wasted product with value in it.

Opportunities: The general manager proposed two opportunities for waste reduction, firstly that their company would pay for the guts that are currently being discarded at sea if they passed the quality criteria. Secondly, a lot of fish are packaged whole which means the trimmings ultimately end up going to household waste, these could be sent to them. However, the average consumers in the United Kingdom are choosy when it comes to fish and are less likely to buy whole fish.

[Producer of fish-oil based surfactants](#)

Stakeholder profile: This stakeholder produces bio-based surfactants using fish oil instead of plant oil like other producers, this reduces the business carbon footprint and requires (and produces) less heat in the process than biosurfactants that are currently in the market. Surfactants are chemical compounds that can decrease the surface tension between two liquids, a liquid and a gas, or a liquid and a solid. They can be used for various purposes, including as emulsifiers and detergents.

Waste: Like the fish meal company above, this stakeholder does not create food waste and uses fish by-products as input. They are currently a start-up and their business is working to have the ability to bulk produce surfactants that will enter at the top of the supply chain and therefore bulk sell their product to the formulators and suppliers at the top of the chain. The scale-up plan will take approximately 2 years and will be completed in collaboration with the several UK universities where they have the ability and equipment to analyse the surfactant produced using fish oil. The goal is to set up a pilot site in the Scottish Highlands and Islands, where fish farms are based, and it will be easier and more economical to access their by-products.

[Mobile app for selling surplus food](#)

Stakeholder profile: This is a mobile application that connects customers to stores that have unsold surplus food. It is a free app for consumers, with a subscription fee for suppliers (e.g. restaurants, supermarkets, coffee shops, bakeries) to be on the platform. Suppliers advertise 'magic bags' of food that is leftover at the end of the day (in the UK this can be after the 'best

before' date, however this will not be the case for all countries) at a discounted price. They aim to help businesses, such as supermarkets and restaurants, reduce food waste and educate households on food waste through the app. They have partners in 15 countries from Europe, Canada and the US.

They do not always know the complete contents of the magic bags. The interviewee stated that on average a magic bag contains 1 kilo of food, and this is equivalent to around 2.5 kilos of CO₂ saved. They encourage supermarkets to include best before products. However, fish and seafood are a challenging product category for their service; it has a strict use by date and a short shelf life to keep the core supply chain alive. Additionally, they cannot ensure whether the cold chain has been maintained throughout the shelf life and transport. Due to possible issues with cold chain, highly perishable products like fish and seafood products are not usually sold through their platform.

[Online platform for trading fish](#)

Stakeholder profile: This stakeholder is a B2B trading company, it connects people in the whole supply chain; their suppliers are primary processors who buy from boats; their operations span 13 different countries across Europe; while their buyers are wholesalers, located wherever there is a demand. The business works within supply and demand, they have one key objective – to reduce food waste. It works in the supply and demand bracket, meaning they are knowledgeable of the impact of macroeconomic events that may cause uncertainty in supply and demand, e.g. Brexit, COVID-19. Most of the problems that have arisen amongst Brexit have been resolved already, there is occasionally technical issues, but these impact less than 0.1% of transactions in their experience.

Waste: If there are any issues on their side, the quality check system will pick them up, thanks to this the business has reduced their rejection levels by 4%. If there is a repeated issue with a supplier, then they will reach out directly and discuss changing the habits and procedures of the supplier. Information about the waste produced by any single company cannot be diffused, the average rejection rates are between 0 – 4% depending on the business – this will add up to be a larger percentage as similar averages are summed up at each stage of the supply chain, on top of this, there is little clarity concerning seafood.

Mismatch and Uncertainty: In terms of systematic mismatch that may cause waste, there are two key issues, firstly that there is a fragmentation of supply chain actors, and secondly is the diversity of products traded in the fish and seafood industry. Every actor in the supply chain is stocking different products and consequently making the supply chain incredibly complicated, resulting in the very nature of the chain making it difficult to get fish to the end consumers. For example, retailers will have a set range of seafood products available, but not every business will stock the same so there is still a huge array of different products.

Opportunities and incentives for reducing waste: Companies care about reducing their waste when it can reduce their costs and increase their margins, if it is profitable for them to do so then they will but preferably not at an extra cost. All the actors across the chain look at their own profit regardless of other stages.

Avoiding waste of by-products: Economically, there is not enough value for boats to hold the by-products and bring them to land, especially if they are out for weeks at a time. This may be different as the protein market continues to improve as it has done with innovations coming from Iceland, for example some newer boats have the ability (e.g., the technology and space) to create protein powder on board before arriving to port. However, most boats in the industry are 15-20 years old and don't have the technology to do this.

[Fishing Industry and Fishermen's Organisations](#)

These organisations covered in this subsection do not deal with waste directly, but the fisheries and primary producer federations/associations are familiar with the loss and waste in the catching sector due to their membership. Trade organisations would have overview of the whole waste and loss in the fish and seafood sector from catch to plate.

[Organisation 1](#)

Stakeholder profile: This stakeholder is a public body that aims to support businesses, organisations, and individuals throughout the seafood value chain by providing services such as promotion, onshore training, business support, and information sharing to support the seafood industry in Scotland and the wider UK. The organisation tackle everything from research to campaigns and insights to training those in the industry, they do whatever they can do to give the industry the support it needs to thrive. The unique non-competitive role the organisation holds means they work in partnership with people from across the seafood sector in the UK to help them overcome challenges and take hold of opportunities.

Waste: In the past they have conducted studies on waste but at the time of interview, there were no current or direct work streams looking at waste. Seafood waste is no different from any other type of food waste; product that is not its intended use, something generated either unusable or unwanted, or is lower than its intended value. There is no clear-cut definition of what waste is in the sector. Historically, crustacean waste and unwanted waste legally went to landfill, now waste largely goes to fishmeal and fish oil production. Fishmeal and fish oil gain the maximum yield from the products with as little waste as possible. The sector is value driven in Scotland, so is always looking for a means to add value, for example fish heads are sent to China as they have a use for them unlike Scotland. A lot of wild caught fish waste is tied up in temperature and time, the proteins are highly perishable and poor time and temperature management will ultimately result in a waste product.

Gutting: There is an obligation on fishing vessels to land what they catch, given its quota of fish. At certain times of year fisherman will exploit this and land certain by products, e.g.

some whitefish are in pre-breeding they have a fat row, particularly cod, cod row will be harvested during pre-breeding, instead of gutting them they specifically keep the rows and landed and sold as whole fish would be. Fisherman won't retain guts as there's not value on that. Gutting fish is a quality issue, the belly cavity and entrails contain digested food so there are spoilage problems due to the remaining enzymes as they will contaminate the fish. In Scotland, sometimes fisherman will land un-gutted whitefish. Because of the nature of the fishing grounds, small whitefish are still marketable, however this is time costly as for the same volume of fish, there are more to gut than if the large fish were caught. Sometimes boats will allow un-gutted fish to save time and effort compared to big fish. It has to be fresh, and temperature controlled with a ready market with quick processing.

Organisation 2

Stakeholder profile: This stakeholder was set up by the industry for the industry as an inter-branch organisation to increase the value of the Scottish seafood sector. Seafood Scotland and undertakes measures of common interest that benefit the seafood sector. Its board consists of representatives from the Scottish catching and seafood processing sectors, with observers from the Scottish Government, Scottish Enterprise and Highlands & Islands Enterprise.

Waste: Anything caught above quota has to go to discards, this cannot be sold and gets put into red bins. These products are marginal in terms of quality and are not allowed to be put into the supply chain, some of these materials can be fit for human consumption so it is a real waste.

Opportunities for better revalorisation of seafood FWL and by-products: They are trying to get funding for a centre of excellence training school and have requested that the discards could be sent to them to train workforce for filleting. There is a problem with haddock now being too small, so they can't be processed using the machinery that processors currently have. In recent months, some of the haddock was selling for as little as £1 a box because it was too expensive to process it, so it would only be sent to fishmeal if not bought. New machinery to handle the smaller haddock is being looked into.

Barriers for better revalorisation of seafood FWL and by-products: Shells of shellfish¹³ are often sent to landfill. For mussels, a lot of the shells will still have meat inside them so will be rejected from other disposal routes. There would be a market for the mussel meat

¹³ Different species of shellfish are trawled for in different areas of Scotland, trawl nephrops (langoustine) are largely caught on the east coast, where most of the super trawlers are. The west coast has more smaller trawls that catch a lot of creels and is where most crab and lobster are caught – these are often grouped together and shipped out live.

but extracting it from the shells is challenging, however technologies in this may be developing.

Innovation: Seafood is a very low margin business; the cost of raw material is very high and appears to be increasing. The costs to fish are high and it is a very labour intensive, Seafood Scotland have started to look at how the sector can become more profitable, for example looking at investing in new technologies and adding value to the supply chain. The main opportunities for this lie with whitefish, followed by shellfish and then pelagic.

The automation processes in Iceland and Norway are incredibly efficient at utilising every piece of fish. While the UK utilise approximately 36% of our fish, Norway is utilising 95% of theirs, the difference between these is likely the use of skins, bones, tongues, and cheeks. Following the example set by the Icelandic Ocean Cluster, the possibility of a virtual Scottish cluster with the same ethos as the Icelandic one would be a welcomed development. With a key aim of fostering communication between all levels of the sector and academia to ensure as much of the products are being utilised as possible. As it stands, aquaculture appears to have a better link than academia and sea fishing or shell fishing.

World events: Following the UK leaving the EU, there have been labour shortages in the Northeast, where most whitefish processing takes place. The average workforce was mostly made up of workers from Eastern Europe, with some company's workforce more than 90%. The impact of the COVID-19 pandemic and the war in Ukraine has further shrunk the available workforce with no real replacements in coastal communities. Brexit did not create a continuous waste problem, but trade flows have been disrupted at the beginning of Brexit period, and while big companies have solved any issues whilst smaller companies had more difficulties exporting to the EU. The push throughout the COVID-19 pandemic to shop local and support Scottish businesses thus benefitted the smaller businesses who had to stop exporting, using new market opportunities such as operating fish vans and website delivery services. The January following Brexit showed a halt in exports due to problems with the new systems in place, they couldn't handle the groupage of products. This was a problem for places such as Shetland where multiple companies exporting small amounts of products to France through logistics companies, such as DFDS, could no longer do so.

Organisation 3

Stakeholder profile: This fishermen's association is the largest fishing association not only in Scotland but in Europe. They represent around 220 vessels and 1,400 fishermen who contribute a collective £158 million to Scotland's economy. Majority of the vessels they represented are from the Northeast of Scotland. The association is the political voice of its members and communicates experiences, concerns, and insights of its members to policymakers and other relevant industry figures to facilitate a sustainable fishing sector which works for the environment, for consumers, *and* for the fishermen. They own and

operate a centre in Fraserburgh, which is set up to accelerate safety and skills training, education and business development, resource efficiency, innovation, and sustainability in the Scottish seafood value chain.

Waste: Waste in the catching sector is defined as the products that are no longer usable in any way, i.e., they cannot be translated to fish meal or any other use alternatives. Bycatch is not specific to any species; it is just an unwanted catch and usually discarded at sea¹⁴. Discarding of bycatch is a major waste problem as these materials could have been saved from wastage if they were not discarded at sea. Since, discarding quota species of any sizes is illegal in Scotland, and many fishermen discard without accounting for as it breaks regulation. Hence, this large share of waste at sea goes unaccounted for.

The value of the fish that is caught by vessels in Peterhead hinges on the size, quality, demand, price, and other characteristics for the market. Prices go up and down in the market, this fluctuation is due to the amount of availability of fish. Changes in fish and conditions in the industry across the years can also lead to wastage. Last year, the lack of workforce from the processors resulted in of 14,000 tonnes of haddock being left in the sea because they did not want to process small haddock fish and devoted their time to larger fish species, which are more profitable.

Barriers to reduction of waste: If the vessels land many quota fish species that they are not allowed to sell, they are using up their quotas, they will not be able sell the catch and yet incur the additional costs from catching and landing of these fish. This gives fishermen economic incentives to not follow the regulations. So in theory, the only ways to track this would be monitoring on the vessels (e.g., some trialling of video feeds on boats or occasionally having a third party on board) but he did not necessarily say this would be a good thing or positive for the industry.

Opportunities to reduce waste: Potential solutions to discards at sea would be that the size of the quotas given should be proportional of abundance of species within the sea. If cod is abundant in the sea, the quotas should be increased for them, and making sure these quotas are scientifically proportional at any given time.

Innovation: Next generation devices will arrive in the future to crack down the problem of catching the undersized fish.

¹⁴ Reasons for the discard is either due to market conditions that the catch has low or no market value or due to management regulations i.e., quota or catch composition restrictions or the fish are below the minimum conversion reference size, a size which if a quota fish is below of, it cannot be sold for human consumption and can only be given to other purposes such as fish meal, and only costs are covered to prevent targeting of undersized fish for profit.

Brexit: Brexit disrupted some of the processes already in place for exporting catch, leading to wastage. Due to Brexit, it is also now more costly and time consuming to send fish across borders to other EU member/European countries for processing.

Organisation 4

Stakeholder profile: This stakeholder is a trade union for fishermen, processors, and wholesalers in Orkney. The organisation advocates for the fishing industry, helps them navigate EU legislation, and shape policy for environmentally and economically sustainable practice going forward. There are 110 boats in Orkney, of those who are members of the Orkney Fisheries Association, 60 of these are under 10 metres long. The majority catch lobster, scallops and crabs, and are largely local boats that land into Orkney, however some also catch mackerel in the summer. There are a couple larger boats (>12 metres) that land their catch elsewhere.

Waste: Shellfish boats have very little waste at all, if any. Shellfish can all be landed live and usually are as it means it will be higher quality. Any waste in the shellfish value chain will come from processing at factory, any shells, or pieces of the product that consumers won't eat. There are two crab processing factories in Orkney so most processing takes place on the island, some will land the shellfish live and send them to wholesalers so there is no processing. By-catch or unwanted catch is not a problem in the shellfish sector on Orkney, there are low levels and the only thing that may be counted is, for example, catching a lobster instead of a crab, however this is still viable. Further, if the boats do feel that they need to discard anything undersize (under 140mm), crab and lobster have a very high chance of survival (~99%) so this isn't a problem.

Opportunities to revalorise waste materials: Crab shell would be the main waste on Orkney but there are different things that can be done with this, it can be transformed and used as biofuel to power the factories, there is interest in the chitin being removed and used in various products, and there is also the option to legally dump the shells back at sea under the appropriate license from the government.

Barriers to revalorise waste materials: The issue with shells is that it is not economically viable to transport them from Orkney to the mainland for any of these purposes and there is no user of these products on the island itself.

Policy and government organisations

These organisations covered in this do not deal with waste directly, however in their policy-maker role, they oversee the fishing industry and have a deep understanding of the dynamics of the sector especially in terms of complex fishing quotas, landing obligations and other marine environment related legislation that apply to the Scottish catching sector.

Local Council

Stakeholder profile: This stakeholder is the local authority for Northeast Scotland outwith Aberdeen City. Initially, in 2008, their role was focused on solely land-based industries but came to include fisheries from 2012. They host cross party, cross-sectoral Northeast Scotland Fisheries Development Partnership (NESFDP) to provide a communication channel between the wider industry and its political representatives at all levels.

The Hutton Lowinfood team interviewed their Rural and Maritime Industries Development Officer. Our interviewee's role within council is focused on economic development, the specific sectors they work with are the land-based sector (agriculture, forestry), fishing and seafood industries, and any related areas (e.g., tourism, food & drink). His duties with regards to the fishing and seafood industries includes working closely with Scottish Fishermen's Federation and the Scottish Seafood Association to try and advance the interests of the whole sector.

Waste: It's difficult to define waste, but it is a problem that starts before sea with the impact of quotas and policies. The science that provides the logic for quotas is imperfect, and mismatch between what fishermen are allowed to catch at sea and what is actually there is a key factor in waste or difficulties the industry face. The landing obligation, although well-intentioned, is a poorly thought-out piece of legislation, it means that the ability to catch certain species is limited by what other species they are legally allowed to catch. This is a problem specifically in the North Sea in comparison to other fishing grounds due to the mix of species present, brings the challenge of dealing with choke species¹⁵. In order to avoid over-fishing of some species, e.g., North Sea cod, they have to pull their nets and find somewhere else to fish which costs them time and money, especially with the rising costs of fuel in the previous year.

Barriers to valorisation of waste materials: The key issue is storage on the boats, so most guts go back into the sea. Fishermen would further argue that any value from the guts or offal is outweighed by the cost of storage and refrigeration to get them to a market. Another potential issue with bringing guts ashore is that there are natural parasites in fish, for example Anisakis, a parasitic worm that can be a problem in some high value stocks like monk fish and cod. This is a larger problem in Spain than it is in the North Sea, there is less prevalence of Anisakis in Scottish waters, to remove the risk of these worms the Spanish boats are either microwaving the guts to kill the parasite or bringing them ashore. So, in considering the use of fish guts in innovations, the risk associated with the whole biosphere of guts needs to be taken into account.

¹⁵ Choke species are when there is an abundance of a target species with a high quota (e.g. North Sea haddock) in the same waters as a non-target catch with a lower quota (North Sea cod), this prevents fishermen from being able to continue fishing due to risk of over-fishing the low-quota species.

Mismatch with the quotas and scientific predictions: To decipher if something is not quite right with quota or scientific predictions, it is possible to check how much of the quotas have been taken up in proportion to how far through the year the industry is. For example, the interviewee checked the North Sea haddock quota around halfway through the year and only approximately 26% of the allowed quota had been taken up, half of what is expected at that point in the fishing year.

Innovation and science: The science will never be perfect and there will always be at least a short a delay in conducting the science to recommendations from the results. Recently, the Scottish Government has announced plans for offshore wind farms and the amount of ground promised was significantly higher than the fishing sector anticipated. The physical displacement of some of these potential fishing grounds is a blow to the sector, and although it is possible and legal to fish between the wind turbines it is unlikely that boats will. It is further, reasonable to surmise that there is proportionately less support for marine science as it relates to commercial fish stocks, instead much of the focus is on renewables. More investment in science as it relates to commercial fish stocks would be a great help, the better the science the more efficient catches can be.

Brexit: The aforementioned lack of take up of North Sea haddock could partly be attributed to Brexit. Due to there being less staff in the processing factories, managers need to be careful with how they utilise their work force, and small haddock is low on the list of priorities. The abundance of cod and the lack of labour on shore (due to there being less workers from the EU) means that the market demand for small haddock is very weak right now.

General: Cultural change within the fishing industry is the most important thing. Most fishermen don't think much about what happens after landing, their appreciation of the downstream supply chain is quite poor. For them to extract maximum value of supply chain they need to understand this and to meet expectations of customers, and down the line, the customers of their customers. Graded, gutted, sorted, stored & presented well fish, will sell for higher, it's apparent that some skippers understand this, and others do not.

Government body

Stakeholder profile: This stakeholder is a branch of the Scottish Government concerned with providing information on the Scottish marine environment.

Waste in the supply chain: There is not a set definition in use that our interviewee was aware of, however it is a continuous topic for discussion, especially in exploring innovation and efficiency in the fish and seafood sector. The Scottish Government are keen to prioritise environmental sustainability through a range of policies and the definition of waste is tied into efficiency and profitability. Mismatch between available fish and seafood and the

consumer demand is usually a short-term problem and with pelagic fish specifically. In their perspective this does not cause waste as most is frozen so there is a bigger window for them to find other markets if there is mismatch initially. Unwanted catch discarded guts and processing by-products are three topics of regulation relevant to loss and waste in catching and processing sectors.

Unwanted catch: All catches of species, including unwanted catch or by-catch, that are subject to quotas caught during fishing activities in Union waters or by Union vessels outside of Union waters in the fisheries and geographical areas (given these waters are not subjects to third countries' sovereignty or jurisdiction), must be brought on board, recorded, landed and counted against quotas where applicable.

Discarding guts: Discarding of guts (or offal) at sea is a licensable marine activity¹⁶ within the Scottish marine area under the Marine (Scotland) Act 2010, however this only applies when it is from any of the following: a vehicle, vessel, aircraft, or marine structure; a container floating in the sea; or a structure on land constructed or adapted wholly or mainly for the purpose of depositing solids in the sea. The Animal by-product Regulations¹⁷ will dictate what aquatic animal by-products can and cannot be legally disposed of – this includes fish and shells from shellfish that contain soft tissue. Shells must be stripped of any and all soft tissue before being disposed appropriately at sea, and operators must be able to demonstrate that this has been meticulously removed to the standard required for the activity.

Processing by-products: Animal by-products are not categorised as food, so do not fall under Food Standards Scotland's remit, instead they fall under the Agricultural and Rural Economy Directorate (ARED) ensure that these by-products stay within regulations.

Innovation centres

The organisations interviewed in this category are not directly involved in the seafood value chain or representative of the companies or interests involved in the supply chain, but they bring industry stakeholders together and are essential for creating collaboration and cooperation. These interviews resulted in establishing other valuable connections.

Innovation centre 1

Stakeholder profile: This cluster was founded in 2012 with a focus on the whole blue economy not just fisheries. It houses a total of 70 companies; 60 of which are local and international start-ups. They aim to bring industry together and open up the barriers between companies involved to help with each other and create new opportunities that relate back to fisheries. They promote improved valorisation of fish materials including

¹⁶ Processing and discarding offal (e.g., tails and guts) and non-quota species at sea is legal <https://www.gov.scot/publications/sea-fisheries-discards-advice-and-guidance/>

¹⁷ <https://www.gov.scot/policies/animal-health-welfare/animal-by-products/>

revalorisation of all by-products e.g., skin from various fish species can be used to extract gelatine and collagen and address logistic and other challenges but establishing local connections. This approach has attracted a lot of attention worldwide and other ocean clusters such those in the United States and Denmark were established or cofounded with them. They provided us examples about how the fish can be utilised 100% and insights for how successful dialogue can be created among the stakeholders in the fish and seafood industry.

Innovation centre 2

Stakeholder profile: This stakeholder is a private organisation that coinvest and co-fund with regional and national partners to maximise opportunities in growth sectors such as digital tech; food, drink and agriculture; life sciences and tourism and to diversify the regional economy in Northeast Scotland.

Innovation centre 3

Stakeholder profile: This stakeholder is a networking and support organisation funded by the Scottish Funding Council and supported by Scottish Enterprise and Highlands and Islands Enterprise that connects industry, academia, and government to bring biotechnology processes and products to the global market. They provided us wider context for fishing sector and bioeconomy in Scotland and introduced us to potential contacts among which are some stakeholders included in this document.

3.1.2 Networking events

Stirling Bioeconomy Stakeholder Event:

Building a Sustainable Seafood Sector Through Collaboration In January 2023, the Industrial Bioeconomy Innovation Centre (IBIoC), in partnership with the University of Stirling, Opportunity North East, Seafood Scotland and Zero Waste Scotland, hosted a meeting to bring together stakeholders of the biotechnology, waste valorisation and seafood sectors. The Hutton Lowinfood team presented in a 15-minute slot about addressing waste reduction in the seafood industry.

Scottish Skipper Expo 2023

The Scottish Skipper Expo is an annual event (now bi-annual) for the fishing industry, hosted by The Skipper at P&J Live conference Centre in Aberdeen. It is a 2-day event where exhibitors can engage with and promote their products to members of the public and others working in the seafood sector. The range of exhibitors include fishermen's associations, ports, fishing-related businesses (e.g., selling fishing equipment), and marine services. The aim for the team's attendance in 2023 was to network, promote the Lowinfood project and our partners, and gain more seafood sector stakeholders in the stakeholder dialogue.

[Scottish Skipper Expo 2024](#)

The aim for the attendance at the Scottish Skipper Expo in 2024 was to still to promote the work on the Lowinfood project and our partners' organisations, but also to advertise and gain further responses on the short industry survey.

[North East Scotland Fisheries Development Partnership \(NESFDP\)](#)

The NESFDP is a cross party, cross-sectoral group hosted by the local council to provide a communication channel between the wider industry and its political representatives at all levels. The group gathers regularly to host communication between the wider fishing industry and its political representatives. JHI team invited to the partnership, and attended several meetings as an observer, on the 15th of March the Hutton Lowinfood team presented at the meeting to discuss adding value to the biomaterials in the seafood value chain and promote the short industry survey.

[Nourish Scotland event in Glasgow \(Seafood+\)](#)

Nourish Scotland are a charity that focus on food policy and practice. In January 2024, they hosted a conference in partnership with Seafood Scotland entitled "Fish+". The goal of the conference was to bring people from the fish+¹⁸ industry to discuss how seafood fits into the Scottish Government's wider Good Food Nation policy.

[Scottish Bioeconomy Week in Glasgow – expert panel \(2024\)](#)

In March of 2024, the Hutton Lowinfood team hosted an expert panel online as part of IBioIC's Scottish Bioeconomy Week. The panel consisted of representatives from: Aberdeenshire Council; Pelagia (a fishmeal and oil processing company); Seafood Scotland, Fishery Innovations Scotland; Opportunity North East; and the Icelandic Ocean Cluster.

[Aquaculture and Fisheries Working group of EU SUBMARINER Network for Blue Growth](#)

In August 2024, the Hutton Lowinfood team presented the highlights of the WP4 and promoted the industry survey at the Aquaculture and Fisheries Working Group of the EU SUBMARINER network, the cooperation platform for promoting innovative approaches to use of marine resources in the Baltic Sea Region and beyond for blue growth. The aim of the specific meeting was to bring together different EU projects and innovative companies working in seafood side-streams valorisation.

[Plans for final conference](#)

The plans for the final conference are in development, with numerous possible venues being scouted within Aberdeen City. The goal of the conference is to bring together stakeholders from the seafood industry to present the results from the stakeholder dialogue, to facilitate further connection between stakeholders and to explore directions for future research.

¹⁸ "Fish+" is the terminology used by Nourish Scotland and Seafood Scotland at this event to encompass the seafood sector, inclusive of e.g. seaweed businesses and shellfish.

3.1.3 Further public engagement efforts In efforts to promote the Hutton team's work on the Lowinfood project, and to advertise the online industry survey, a series of press releases were published in various news and fishing publications based in Aberdeen and wider Scotland. A list of press releases (see Table 1 below), where they were published and a link (where applicable) to the publication, can be found in the table below. *Table 1. Press releases/Publications to promote Lowinfood*

Press release	Place published	Link
North-east researchers seek seafood sector insight to unlock by-product prize	Grampian online/Banffshire Journal	North-east researchers seek seafood sector insight to unlock by-product prize (grampianonline.co.uk)
Researchers seek seafood sector insight to unlock by-product prize	Fish Farmer Magazine	Researchers seek seafood sector insights to unlock by-product prize - Fish Farmer Magazine
Researchers seek to unlock hidden opportunities in seafood supply chain	Fish Farming Expert	Researchers seek to unlock hidden opportunities in seafood supply chain (fishfarmingexpert.com)
Researchers seek seafood sector insight to unlock by-product prize	Fish Focus	Researchers Seek Seafood Sector Insight Fish Focus

Researchers Seek Seafood Sector Insight to Unlock By-Product Prize	The Fishing Daily	Researchers Seek Seafood Sector Insight to Unlock By-Product Prize (thefishingdaily.com)
Seafood industry input sought for by-product potential	The Fish Site	Seafood industry input sought for by-product potential The Fish Site
-	BBC Radio Shetland	Local Radio
-	BBC Radio Orkney	Local Radio
Aberdeen researchers seek seafood sector insight to help unlock by-product potential	The Skipper (hosts of the Scottish Skipper Expo)	Aberdeen Researchers Seek Seafood Sector Insight to Help Unlock By-Product Potential The Skipper
-	Seafood Source	Email newsletter
Aberdeen researchers seek seafood sector insight to help unlock	Aberdeen Business News	Aberdeen researchers seek seafood sector insight to help unlock by-product potential - Aberdeen Business News

by-product potential		
-	Fishing News	Print (May 1 st 2024)
-	Buchan Observer	Print (April 23 rd 2024)
-	Aberdeen and Grampian Chamber of Commerce	TBC
Our best bits from the Scottish Skipper Expo	Press and Journal	https://www.pressandjournal.co.uk/fp/business/6465104/our-best-bits-from-scottish-skipper-expo-in-aberdeen/
Are you making the most of your catch, fishermen asked	We Love Stornoway	https://www.welovestornoway.com/index.php/news/general-news/34624-are-you-making-most-of-your-catch-fisherman-asked#google_vignette

3.2 Stakeholder engagement in the German fish supply chain

3.2.1 Interviews in Germany

The stakeholders in the German side are concentrated more on the import and processing side of the supply chain. Various associations from food and fishing industries have been recruited as well as a fishmonger, a wholesale and distribution company, a large-scale caterer with many outlets throughout Germany specialised in seafood and fish products; a mechanical engineering company producing high precision filleting machines and a lender to small and medium size fisheries overseas which might supply to the German market.

With some effort, ISUN team spoke to actors from all parts of the seafood value chain that are significant in Germany and were able to attract a considerable variety of stakeholders, including companies, multiple associations, and research organisations. However,

unfortunately they were unable to engage fishing vessels with primary processing on board, primary processing factories on land and the gastronomic industry associations as they initially intended. However, some companies from the above-mentioned stakeholder groups were persuaded to participate in a stakeholder/focus group workshop.

For the stakeholder dialogue in Germany, in consultation with the JHI team, the ISUN team considered all stages of the value chain from landing at German ports or import to catering and retail. In this respect, they paid less attention to fishing. Indeed, Germany is a significant location for fish processing and, above all, trade of fish products as well as being a large consumer market. However, it has a fishing fleet of minor international importance. In addition to the expert interviews, the stakeholder dialogue in Germany also included a stakeholder workshop/focus group discussion in June 2023 in Bremen. There, key statements that the ISUN team had previously distilled from the various interviews were subjected to critical examination and discussion again in the group.

Similar to the recruitment difficulties experienced in T4.1 by JHI and ISUN, the recruitment of (potential) users of their platform and motivating them to fill out questionnaires was also difficult for the operators of LEROMA in T4.2. It is hard to speculate the reasons for the disinterest of certain stakeholder types compared to others engaging with project. Smaller companies might not have had the resources to support a research project, while others might not have seen any value in investing time engaging with researchers who were outsiders to the industry. Some might have already been involved in other similar projects to reduce their FLW or had a preference to avoid talking about sensitive topics.

Wholesale and distribution

Wholesaler and distributor

Stakeholder profile: This stakeholder is part of larger group and one of Germany's largest retailer for fish and seafood. By offering products refined in-house, the company is also included in secondary processing.

Waste definition: There are three levels: 1. use for a new primary product for human consumption, 2. utilisation for the animal food industry, especially for aquaculture, 3. waste, e.g. offal. So waste in the narrow sense is defined as that which can no longer be used for human consumption or animal feed.

Use of by-products and zero waste: Offal is thrown away, but the head, skin and centre bones are used. Offal no longer has the nutritional-physiological effect of containing any proteins or omega-3 fatty acids. The chilled sections (the cold chain must not be interrupted here either in order to avoid any loss of quality) are then transported directly in containers from the filleting plant to further processors (e.g., pet food, fish oil).

The aim is to maximise the use of raw materials, to make full use of the increasingly expensive raw materials. This can be seen more and more in the company's product range. For example, there are no longer just smoked salmon (salmon is the Germans' favourite fish species), but more and more is being made from the leftovers from smoking, and therefore there's now smoked salmon tartare or smoked salmon flakes or small cubes of smoked salmon. Companies are trying to create a product from the smallest of things that people will end up consuming. Salmon oil is produced from leftovers that cannot be consumed directly, and the manufacturer in Cuxhaven produces an animal protein from the small amount of waste from salmon oil production, so that in the end the salmon is completely utilised and zero waste is achieved.

Losses in the value chain upstream (fisheries): Illegal practices are a problem outside Europe, especially discards and unregistered and undocumented fishing, which also distorts fish stocks, but also shark finning, for example. In Europe, a lot has already been done to regulate more and find a use for every fish that is caught.

Losses in secondary processing: A lot can happen in secondary processing too. Marinade or smoked products are usually vacuum-packed, there is a tray with foil on top and air in it, this is called MAP packaging, and if the packaging is not properly sealed, the product no longer has a best before date of 7 days, but only 2. Or if the mayo tips over for some reason and the herring is already in it, then the product as a whole becomes inedible. The more the product is refined, the more scope there is for the product to go bad.

Losses during transport and logistics: This is particularly the case when cold chains are not guaranteed and goods have to be destroyed, how much often depends on the weather. The fish is usually transported by ship from Norway to Denmark and from there to the filleting plant. If the weather conditions are extreme, for example as it was in 2018 with high temperatures for a long period, then the raw product suffers, and primary processing can no longer take place because it no longer meets the freshness standards. Cold chains are incredibly important, whether from the ship to the filleting plant or then from the filleting plant to the customer, and are also very tightly synchronised, between 0 and 2 °C for fresh fish. A lorry may drive to more than one location, then it stands open for a while, and then the heat comes in during a warm summer, which was a real problem in 2018, so routes were also optimised afterwards. However, in times of a shortage of skilled labour and rising fuel prices, it's not easy to distribute tours across more trucks. The company tests the goods for freshness (e.g. eyes, gills) and if they are not fresh, they unfortunately have to be blocked and then it can be considered how to process them further, e.g. turn them into fishmeal or give them to a zoo.

Losses in the value chain downstream (restaurants): The people in the company's filleting plants do it like clockwork, they're really good at it. But less and less is prepared in

the kitchen, which can also be seen from the company's pre-made products, and if there is someone who doesn't really know how to fillet, it can of course also be the case that too much is cut off and then simply ends up in the rubbish – which is even worse for a product that is already quite far downstream in the value chain.

Gastronomy

System caterer

Stakeholder profile: This stakeholder is a large quick service system caterer specialized in fish and seafood with several hundred fast food restaurants all over Germany. By offering products refined in-house, the company is also included in (a little) primary and (a little more) secondary processing. In addition, fresh fish is sold at counters, which means the company can also be classified as a retailer.

Waste definition: Waste is defined in business terms: Anything that is not sold at full price. However, this does not necessarily mean that it is thrown away; it can also be resold via “too good to go”, for example.

Where does FLW occur in the company?

Primary processing: Especially for the restaurant business unit, they also get large pieces of fish delivered with skin on the salmon, and they have to be skinned, and for this case there is waste, they can't sell it anyway, and it's not planned to reuse it, it goes straight into the bin, similar to rotten tomatoes. The employees have a good skinning technique, so the wastage here is also low, but the interviewee can't say the exact quantities. The purchasing department obliges the suppliers to ensure that the products are saleable, so rotten products are extremely rare.

Transports and logistics: Theoretically, nothing is lost here (practically approx. 1%), they try to avoid this by optimising the logistics process and storage, either by donating to the food bank or by optimising the logistics network and warehouse, so they can deliver in line with the short shelf life.

Retail: There are reprocessing recipes that do not apply to all products, e.g. fish soup can be made from fresh fish, but it is very difficult to reprocess the transformed products and snacks that are produced in advance. They work here with “Too good to go” and various discounts to sell the remaining quantities that are still good. Some waste is actually generated at this point.

Restaurants: Significant waste (approx. 6.5 % – excluding plate leftovers). The interviewee describes this as logical, because at the end of the chain not everything is always sold and there are laws regarding hygiene, freshness and quality of the products. The evening take-

away of leftover goods that can no longer be sold the next day by employees could contribute to reducing FLW as a sensible social innovation.

FLW reduction potentials: The company could save the most in the restaurant on prepared food. Competitors, McD, BK, Subway, have managed to do it so quickly that there's hardly any waiting time (it's a question of effort and difficult during rush hour), but the company produces in advance, and that means if ten items are produced in advance, then ten items have to be sold, and that's not rocket science, sometimes the forecasts are wrong, there are fewer people in the shopping mall, it's sunny, etc.

The interviewee has also built doggy bag stations where guests can take a bag themselves if they don't finish their plate. He thinks they won an award from "Zu gut für die Tonne" ("Too good for the bin", a national initiative to reduce FLW) for this in 2019.

Possibility of valorising side streams: Relatively small amount of removed parts, which also cannot be sold in full. It has to be disposed of, and it is difficult to store it in a special bag, and once a week someone comes to collect the bags, it stinks, it is not edible waste, and processing this waste would be more difficult than simply throwing it away as waste. There are also cost issues and questions of company ownership. The company would have to come up with a model that works for both company owned and franchisee. The interviewee thinks it's too difficult with primary processing and it's just not worth it yet. If the prices for by-products rise, this assessment could change in the future.

Technical supplier

Producer of filleting machines

Stakeholder profile: This stakeholder is a mechanical engineering company that supplies high-precision filleting machines to the fish processing industry. This stakeholder is part of the fish value chain in a broader sense, but provides an important technical prerequisite for low-loss processing of fish and is well versed in the possibilities and limits of loss avoidance in the context of technical processing of fish.

Waste definition: Particularly in the fish sector, there are not yet any firm regulations as to when a by-product may be added to human consumption. For example, when a by-product stream leaves the factory, is it still suitable for human consumption or not? The interviewee has also discussed this question with many customers. It's not really well answered. They had the example with high quality meat between the bones. There are very few regulations. Then it's very widely spread. Faroe Islands, Iceland, Norway, Alaska. These are all different legislations that also play a role.

Influence of the company's products on the efficient use of the fish resource along the value chain:

Fishing: The company has committed themselves to not building machines that process smaller fish than permitted. The interviewee calls it a code of honour, he says that if the company offers something like this, then people will start catching smaller fish. And if they can process it industrially, then they will. Whether they are allowed to or not.

Primary processing: The production itself is of course a critical point. Resources can also be wasted there. But that is a small percentage range. A whole fish across all fish species has a yield of 30-40%. That ends up in the fillet. The other 60% are heads, offal, bones, tails, skins, etc. Producers can of course get more out of these individual by-product streams. In production itself it is about the smallest percentages. Half a percent here, half a percent there. But the biggest lever is in the consumer sector, where the most fuss occurs. So, everything that takes place after production.

Retail: They bought a company that developed the super chilling process. This also affects the overall value chain to a certain extent. A relatively large amount of fish is destroyed in supermarkets or in private households because it then simply expires. A very large part of the value chain where products are lost is ultimately the expiration date. Using the super chilling process, the core temperature of the fish is brought to around minus 1 degree. This ensures (unfortunately he doesn't have any figures yet) that the shelf life is extended. This is also an approach where they say that the longer it lasts, the higher the chance that it will be sold to a supermarket and not thrown away.

Market environment and market opportunities: For years, companies have focused mainly on the main product. It was all about producing the best fillet possible. All by-product streams flowed out of the factory more or less as quickly as possible so that they didn't have to deal with them. In recent decades, the political and social pressure on companies to behave sensibly has increased - due, among other things, to fishing quotas. As a result, this hype for ever faster, ever more fillets has been curbed a bit. Companies thought about: "How can we actually grow?" Many companies jumped into the area of by-product flows and said: "We still have such high-quality products that are falling down to our left and right. Which we actually leave lying around, which we don't even use, which we don't even look at. What do we do with them?" As a result, various organizations have been founded, he is thinking of the Iceland Ocean Cluster in Iceland, where the company is also a member. They have made it their mission to create a higher quality product from the by-products. This has gone so far that by-product flows have been analysed, each individual product, to determine what they can actually do with it. This resulted in high-quality products.

One example is leftover meat hanging between the fish bones. When the bones are cut out, producers don't pull the bones out, but cut past them. Accordingly, it is inevitable that some residual meat remains in this by-product. A machine was then developed that can separate solid and soft substances, so that meat-free bones on one side and bone-free meat on the

other side can be separated. The company's machines can process certain marginal areas. This is a bit of a game between "What are people willing to invest?" and "What is technically feasible?" Every fish is a little different and it is important to find a balance between processing the natural product in a profitable yet safe way. This means that if processors want a boneless fillet, then it should be boneless. And not "because that's the way it is" that there are still three or four bones left in it. For many fish species, they really have to make cuts in their yield. If they want to sell different products, small and large mixed and have to adjust to one area, then they lose yield in the other. Or they have to pre-sort properly or have to buy two machines. One that works for small fish and one that works for big fish. Often customers do not invest this money for a little more return. A lot of things are technically feasible. As an example, in large Alaska pollack factories in America or in herring factories, products in different sizes are landed there. There is a relatively complex pre-sorting process, i.e. they sort the millions of fish that are in a ship according to size. Then they have a relatively large machine park. A herring factory could have 20 machines that are then set to different sizes. This means they have a relatively good chance of working in a yield-oriented manner. For example, the Trident company in America, which is one of the largest fish producers in the world, has huge factories that ultimately do exactly that. They deliberately collect an incredibly high amount of data: what do they get from what size of fish, in what sorts, in what settings?

In Europe, very high-quality things are now also used. The filleting machine in the salmon area measures each individual fish based on various parameters. And also adapts to each individual fish. The company uses X-ray technology within fish processing to find bones. Five or ten years ago, their customers would have said: "We won't pay you anything for something like that. X-ray technology, what nonsense. Then we cut a little wider." Times have changed. The technology has become more (slightly) affordable and the fish has become (way) fewer and more expensive. He just read that the price of salmon is at a 23-year high right now. People always say that it has to end somewhere, but somehow there doesn't seem to be an end.

Future opportunities for more efficient processing of by-products: One problem is that machines for processing by-products still do not have the system integration of the established machines for processing the main product, where processors can buy an entire process – coordinated solutions - from the company. In the by-product area, these are still single machines. But that is what will happen sooner or later. He sees great potential there. They really need to invest research into this. That's a lot of effort and the question is whether they will ever get it back. The fish processing companies can't hire five people at once for a by-product line.

On the one hand, they can no longer find people who want to work in the fish factory, and on the other hand, it would not be economically worthwhile. They do this as a nice-to-have,

or to show off how sustainable they are. But if this economic idea cannot be implemented, then the whole thing dies. Nevertheless, nothing is actually left unused at the moment. They then sell it to some animal feed producer. He also knows many examples where crazy efforts are made. Where fish bones are taken and flown to Vietnam where people sit with spoons and scrape off this meat. It's amazing how much work goes into it. Heads in Iceland are dried and go to Africa where they are often used in soups or similar. Nobody actually throws anything away in onshore factories. He excludes the ship factories, where the work is relatively wasteful due to the lack of space.

The fact that these by-product hubs are being built around companies is increasing. It can also be seen in Holland. Where there are five or six fish factories in one place and a by-product factory was built next door, which receives the side streams from all factories and processes them further.

Industry and trade associations

Association 1

Stakeholder profile: This stakeholder is an association that represents the interests of companies in the fish processing and wholesale sectors.

Waste: The stakeholder defines waste restrictively in the sense that losses are only defined as waste once the fish has been caught and slaughtered and its edible parts are therefore classified as food. According to the stakeholder, only small avoidable losses occur both in the narrow definition of food waste and upstream in the area of fishing (for example undersized fish that cannot be used for human consumption) due to strict regulation and the effort to use the high-priced resource of fish as efficiently as possible.

Primary production mainly takes place outside of Germany (for example, fish from Russian waters is often filleted by hand in China, where this is done very thoroughly with a high yield), so possible waste is generated in the primary production countries, whereby the inedible remains are mostly used for production of fish meal for aquaculture (if handled in a single-variety manner, possibly also as fish oil for human consumption with a correspondingly high added value).

During further processing (e.g. sawing up frozen fillet blocks for portioning into canned goods or producing fish fingers), no waste is created because the work is carried out with high precision.

Bycatch: The stakeholder does not see bycatch as a major problem because the fishing company usually has a quota for the fish caught unintentionally. Since bycatch has to be landed and reduces the remaining quota for fish caught unintentionally, fisheries have an interest in having as little bycatch as possible in their nets. However, undersized fish are problematic. These must not be processed for human consumption so as not to create an

incentive to catch fish that have not yet been able to reproduce. However, since undersized fish also have to be landed, these can only be sold to fish meal manufacturers, which is not financially attractive for the fisheries.

For more specific information regarding losses in the fishing sector (including, for example, the problem of ghost nets in which fish and other aquatic animals get caught and die), the ISUN team was referred to fishing companies. Unfortunately, they didn't get an interview with any fishing company.

Association 2

Stakeholder profile: This stakeholder is an association that represents the interests of food retail companies. The ISUN team spoke to two different people from the association in separate interviews.

Definition of waste: No official definition provided by the association that appears in a public glossary, but certain definitions are used in practice. On the one hand, losses are recorded, which are sales losses and to be distinguished from waste. It contains everything that is not sold, which does not have to mean that it is thrown away, for example passing it on to processing or charitable institutions. So the association differentiates losses from waste, and then there is the question of avoidable and unavoidable. Speaking from practice: It could be avoided if the food was still edible, but perhaps no longer sellable. One tries to counteract this with good merchandise management planning and ordering systems. The interviewees note that it is not so easy to process leftover fish (as one can process fruit into smoothies or fruit salads, for example) and do not know how trading companies deal with fish here; food from animal sources is more complex to handle when it comes to food safety. Further processing also includes affiliated restaurants, but the interviewees don't know how often or how much animal products are processed (e.g. herring salad). Unavoidable FLW occur if it happens for reasons of food security, which is the top priority. (Author's note: so FLW is also defined as unavoidable even if, due to negligence, the use-by date is exceeded, and they then have to throw it away).

Extent of the problem and avoidance measures: No data available, in general the data situation for FLW is not good and there is a need to build on this - improving the data situation is an objective of the Wholesale and Retail sub-forum in the National Dialogue. The members of the sub-forum have differentiated between product groups in the so-called monitoring, but broader product groups, here: Meat, fish and poultry. At a more detailed level, this would be overly complex and impractical; even at product group level, it is a major challenge.

FLW may then relate more to the upstream stages - wholesale or processing. Specialist retailers often also fillet the fish, so that they make cuts and have trimmings, but the aim is

to utilise everything to the maximum, e.g. processing into fish soup or sauces, which are then also sold, and in the counters, there are also some homemade products made from leftovers. The interviewees are not sure if there are distribution channels for inedible leftovers as bones, skins etc. that are produced in specialised shops. There will certainly still be leftovers, they can imagine that this is very small-scale and is then disposed of conventionally.

Overall, the utilisation of fish in retail is very good. What is canned or in the chiller cabinet has a relatively long shelf life, so there is certainly little loss. One sensitive area is certainly the fresh counter (fresh fish, fillets and the like), but even there seems to be good utilisation, the ultra-fresh items are sold directly, and if a product is no longer super-fresh, there are still ways of utilising it, for example, it can be used for salads, fish soups, sauces, and so on. There are also counters with a catering corner, and there can fish fillets be deep-fried or be processed as fish patties, the traders are very creative here.

Dealing with goods that are approaching their best before date or use-by date, where these options for further recycling do not exist, e.g. in the discount sector: The interviewees have no figures or experience, statistics, evaluation, but notice that the products are in high demand and are then also partly out of stock in the evening, so they don't think that many products really have to be sorted out there either. They also think the quantities are very well balanced and are not aware of any large quantities of FLW. Companies of course want to sell the products and not destroy them, so the aim is to produce as little waste as possible and maximise the sale of the goods, which is also a major concern, especially now with the discussion about food waste. And there are also 5 or 6 different products on offer so that customers can switch if something is out of stock. Incorrect order quantities occur only in exceptional cases (e.g. unforeseen changes in the weather), retailers are getting better at dealing with them thanks to good ERP systems, ordering systems and digitalised processes. And if there is too much fresh fish in the chiller cabinets, shops try to get rid of it through discounts (rather than through donations, for reasons of hygiene).

Best before date as a problem: The best before date is a critical point; when it comes to distribution and further processing of fresh food short before the best before date, there are hygiene regulations and legal hurdles that make distribution or further processing impossible. Safety is also the top priority for retailers here.

Conflicts of objectives: *Where exactly do significant FLW occur? Delivery, storage/cold chain, too much ordered?* No significant losses, but where food is traded, losses are incurred, possibly due to batch recalls, which cannot be avoided and is also justified because food safety is the top priority. In day-to-day business, not every case of an interrupted cold chain, for example, can be avoided. It is also important to point out conflicts of objectives that arise

from customer requirements and political guidelines. For example, packaging should be reduced, but packaging helps to extend shelf life. Reducing packaging waste can therefore unintentionally lead to more FLW. Similarly, the focus on fresh products, which customers and politicians want, is of course also more perishable. Then a decision must be made in favour of one or the other or a middle way and accept that it may have consequences for the FLW.

Spoilage: Fish is largely a perishable food, so spoilage is a huge issue, the shelf life is relatively short, refrigeration is demanding, it has to be cooled more than meat, for example, it is simply a very sensitive product, the requirements are high, the legal regulations are also strict, and the interviewees believe that this is also taken into account, and the product is also very expensive, so that everyone is endeavouring to control the processes so well that there is as little spoilage as possible and these high-quality products can be sold and used in the best possible way. But they don't have figures collected at association level.

[Research and non-profit organizations](#)

[Research institute](#)

Stakeholder profile: This stakeholder is a federal authority for research of sustainable development, e.g., in fisheries.

Data on FLW: Data on FLW is collected, but only differentiated to a limited extent. For example, meat, fish and poultry are analysed in a common product group without disaggregated values for fish and seafood. Research is therefore currently unable to make a reliable statement as to whether there are significantly different hotspots for FLW along the value chain, as well as if there are different proportions of FLW in the total share for fish than other foodstuffs.

[Non-profit organisation](#)

Stakeholder profile: This stakeholder is a non-profit organisation for agricultural industry. The ISUN team spoke to two interviewees in one interview.

FLW along the fish value chain: There is no concrete knowledge about FLW hotspots along the German fish value chain. As some primary processing already takes place on the fishing vessels at sea, where storage and refrigeration capacities are limited, a considerable amount of by-products may be thrown overboard. It is therefore advisable to enquire about this with the fishing companies themselves (unfortunately the ISUN team was unable to obtain interviews with fishing companies).

A critical interface in food value chains is always between retailers and their suppliers. Here, the retailer usually has the power to only buy the goods that meet exactly the defined requirements, although this is slowly changing. However, the interviewees do not know to

what extent this also applies to fresh sea fish and whether there are often returns and refusals to accept goods (or whether certain goods are not even offered to retailers), as is sometimes the case with fruit, for example.

Lender

Financial institution

Stakeholder profile: This stakeholder finances development projects, including loans and grants to small and medium-sized fisheries in developing countries. The stakeholder is also only part of the German fish value chain in a broader sense. However, it should be noted that the fish that is processed, traded and consumed in Germany mostly comes from abroad (and often from the global south) and the downstream stations have a significant influence on the efficiency of fishing in developing countries.

Avoidance of FLW and prioritizing the use of side streams: The priority is human use: long shelf life, if possible, no post-harvest losses, uninterrupted cold chains. If necessary, alternative source of income, e.g. leather from fish skin. There is never a problem on the production side, but there is always a problem on the marketing side. In Costa Rica, they are very far advanced, this could work because they have a lot of tourists as customers. It didn't work out on Lake Victoria. Although there was an endless supply of fish leather, demand for the products never really took off because the distribution structures in the global West didn't work. Things haven't really taken off in India either.

Stages of the value chain and their interfaces where FLW occurs and reduction strategies:

Fishing: A problem in the fishing sector is high grading - fish that are too small are illegally thrown overboard in order to be able to fill the quota with larger fish. High grading is a huge topic, but it requires industrial fishing. In small fisheries, everything is landed, no matter how small, because they usually already have far too little catch and far too high production costs. They don't have the capacity to be selective. Another example on the subject of sizes: China's trade in swim bladders for fish bladder soup, and they target the mega spawner, and in some cases, they pay such high prices for the fish bladders that the rest of the fish rots, they just tear out the fish bladder and throw the rest overboard. This is a specialty that people don't hear about in Europe.

The landing requirement is incredibly important, a very important step in EU fishing policy. But it is incredibly difficult to control. Cameras are standard, but can sometimes fail or fog up, or the light can be broken, or exactly one flap can't be seen, or it takes place below deck.

Certifications such as the MSC can help to reduce unwanted by-catches and overall help to professionalize processes and therefore make them more efficient. A huge topic for the institution is: How far does MSC go? Isn't that a little too lame? Take bottom trawls, for

example: The MSC specifies that there must be rollers and no chains, there must be escape doors, and at the moment the motto is: Everything is better than nothing, and the hope is that if enough companies are MSC certified, the sector will then develop and take off. This opinion can also be criticized: MSC is not enough by far, you should be much stricter right from the start, e.g. Naturland standards, so that makes sense for wild catches. But the scientific basis at MSC is very, very good. It's a pity that they're still going too far towards helping the industry when it comes to bottom trawling.

Primary processing: If the slaughter waste is created on board, the interviewee can well imagine that they don't collect it directly for fish meal and oil and it goes straight overboard. MSC enables the professionalization of the value chain. 30-40% of the world's waste (post-harvest) comes from unhygienic handling, i.e. the fish is not cooled after being caught or ends up on the beach, and once it is on the sand you can cool it however you want, it spoils fast. From the moment you become MSC certified and connect to the international market, you automatically have international hygiene standards, a cold chain and local processing, and have a much greater added value, and that is also because there is hard currency (even if only the smallest part reaches the producer side), and that makes it very interesting for the producers.

The largest margins arise from import and trade within Europe – the smallest is in the producer country, which is why small price surcharges of 5 or 10 cents due to certifications are of interest to producers. What happens to the waste? The simple solution would be to shred them all and process them into aquaculture feed, because fishmeal and fish oil have increased eight or ninefold in the last 15 years due to the global aquaculture boom. But the solution was that the institution didn't want to prevent the supply of this animal protein under any circumstances; the solution was hygienic processing with concrete surfaces and clean drying racks. These fish frames make animal protein sources possible even for the poorest (here using the remains of Nile perch as an example, but possibly also transferable to sea fish).

Secondary processing: Fish finger production in Bremerhaven is absolutely impressive: highly efficient, super hygienic, there is no more room for improvement. The fish arrives at them as a block of ice, the slaughter waste is created on board.

The stakeholder is happy when processing takes place in the partner country, be it smoking, sun-drying, preserving in some way so that the fisherman does not have to sell at any price. It often happens that he has to sell, there is no merger in the form of a cooperative, and therefore there is very little added value locally. And there is a real lack in this area – in management, access restrictions, but also in the cold chain so that more income remains in the fishing villages. They usually overuse because they have no other options at all. The lack of further processing is a huge part of this problem. So processing in Germany creates little

waste, but the fact that processing takes place in Germany can contribute to overuse of resources upstream.

There is a lack of investment in the coastal zone, it is remote, it is left behind, there is more and more migration to the coastal zone, there are two main migration directions, one is into the urban area, the other is from the hinterland towards the coast, for different reasons: climate change effects, poor harvests, civil war, division of inheritance, and then fishing is always an income of last resort. Most megacities are near the coast, which means that there is increasing and strong overexploitation of marine resources, and then people don't even earn anything from them because there is no professional processing and connection to the markets. That's why there is an imbalance in the negotiation of prices. And it is extremely difficult to bring investments into the coastal regions. These are the poorest of the poor, they have migrated, there is a lack of vocational training, there is a lack of everything, there is a lack of alternatives, and the brutal overuse of resources is then the income of last resort.

Retailer

Fishmonger at weekly markets

Stakeholder profile: This stakeholder is a family run medium-sized market trader in Ibbenbüren in the wider Münster area which sells its goods primarily at weekly markets in the region.

Processing: The stakeholder sells both whole (gutted) fish and fillets. In the case of fillets – and this seems to be the norm for German fish mongers – the product is delivered already filleted, so that the parts that do not belong to the fillet remain at the place of primary processing, for example in Norway. The stakeholder sources the fillets from fish brokers (with whom the ISUN team unfortunately did not get an interview).

Further processing takes place at the stakeholder to a small extent, for example by producing fish salads. This mainly happens with fish that should not be kept fresh on the ice for another day and whose shelf life is extended by a few days by being placed in salad dressings.

Waste: The parts that do not belong to the fillet remain at the place of primary processing, for example in Norway. So there are no leftovers from primary production at the stakeholder. Waste therefore only arises from unsold goods. However, the interviewee estimates this waste in the low per mile range, around 3 kg per market stall per day with a product throughput of 2 tons. This very low proportion is justified, on the one hand, by the fact that fresh fish can still be processed into fish salads at the end of its shelf life. On the other hand, the company receives fresh supplies every day and doesn't order more than it expects to sell. In this context, the interviewee does not see any major problems with FLW

directly upstream, i.e. with the fish brokers, because they also do not have large stocks, but rather the goods are not available.

3.2.2 Networking events in Germany

In addition to the expert interviews, the stakeholder dialogue in Germany also included a stakeholder workshop/focus group discussion in June 2023 in Bremen. For this event, the preference was for the group to be composed of participants that represented large parts of the value chain with different roles and interests, rather than a homogeneous group (as is often used in focus groups). Key statements, that the ISUN team had previously distilled from the various interviews, were subjected to critical examination and discussion in the group. Most findings from the interviews were confirmed in the expert workshop, while others were questioned or relativized, thus producing new insights. The results are included in section 5.2.

The LEROMA team made continuous efforts, not only to attract companies from the fish sector as customers but also, to interest them in participating in the stakeholder dialogue. Next to direct conversations with trade fair visitors, LEROMA spread out leaflets advertising Lowinfood activities around the fair areas. To this end, they have tried to reach and approach potential participants at several events as listed below.

Biofach in Nuremberg, 26-29/7/2022

Biofach is the world's leading trade fair for organic food, held annually in Nuremberg, Germany. It brings together international stakeholders from the organic food and natural cosmetics industry to network, exchange ideas, and explore industry trends. The event features a diverse program, including exhibitions, sensory experiences, and a congress focused on knowledge transfer and discussions about the future of organic markets. Attendees can engage in various activities such as product tastings, learning sessions, and networking opportunities. Biofach aims to inspire and drive innovation within the organic sector. LEROMA spent one full day meeting as many potential customers as possible by exploring the different halls. Fish not being a particular focus of Biofach, no promising contacts were gained in the fish domain.

Fish International in Bremen, 4-6/9/2022

Fish International is Germany's only trade fair for fish and seafood, held biannually in Bremen. It provides a platform for industry professionals to explore new products, innovations, and trends. The event attracts over 10,000 trade visitors and 320 exhibitors from more than 50 countries, emphasizing sustainable practices, new market ideas and trends and general product displays within the seafood industry. It serves as a crucial meeting point for the fish industry to network, exchange ideas, and conduct business.

It was LEROMA's first attendance at this trade fair. Also, it was the first trade fair LEROMA visited that evolved around one specific product group instead of a broader topic, such as

"Organic food" or "Food raw materials". Mostly, companies didn't have concrete information regarding currently emerging surplus products. The general feedback was that if surpluses emerge, they are made use of fully or are sold. However, some people at the trade fair gave concrete examples of surplus products. Such an example was provided by a Bulgarian fish processing company with a processing capacity of 60 tons per week. Of that volume, 58% of waste in the form of trimmings and skeletons is regularly generated, according to the trade fair attendee. They sell these by-products to Eastern Europe.

Another direct example of surplus products was given by a Dutch company that had 10 tons of mussel shells as surplus. Interestingly, LEROMA met a German company that was looking for an alternative raw material for the production of concrete, such as mussel shells. Unfortunately, this deal never happened, despite efforts made by LEROMA. In the end, the potential customer stopped pursuing the opportunity and closed the topic. In general, it was interesting to get a close-up look at the industry and to hear first-hand impressions on the topic of surpluses.

[ANUGA in Cologne, 4-8/10/2023](#)

Anuga is the world's leading food and beverage trade fair, held biannually in Cologne, Germany. It brings together industry professionals to explore trends, innovations, and business opportunities across 10 specialized trade shows under one roof. Anuga features product showcases, conferences, and networking events, emphasizing sustainability and future-oriented food industry solutions. With over 7,900 exhibitors and 140,000 visitors from around the globe, Anuga fosters international trade and collaboration within the food sector.

As Anuga is a trade fair displaying end-consumer products, most of the exhibitor staff were marketing or sales employees, who had little information regarding raw materials. In general, Anuga being a general trade fair without a specific product focus, fish was not a prominent topic.

["Ideenfutter" local trade fair \(in Neuss, 13/9/2023\)](#)

The Ideenfutter Expo is an innovation expo for the agriculture and food industry in Neuss, Germany. It focuses on sustainable and digital innovations for transforming the food system. The event facilitates hands-on experiences, networking, and discussions among startups, farmers, producers, retailers, investors, and researchers. Attendees can explore exhibitor stands, engage in roundtable discussions, and gain insights from industry experts. The expo emphasizes personal interaction and collaboration to drive the future of the agri-food sector. It is much smaller than a typical trade fair and focuses more on interaction and networking than on exhibiting company's product portfolios.

LEROMA took part in a round table discussion with participants from different backgrounds. These were, for example, engineers for plastic alternatives, farmers, and food business consultants. Although the exchange was interesting, no experts representing the fish industry were present.

Fi Europe, 28-30/11/2023

Fi Europe is a leading global trade fair for food ingredients, held biennially in Frankfurt, Germany. It unites suppliers, buyers, R&D experts, and production specialists from the food and beverage industry. The event features over 1,500 exhibitors and attracts around 25,000 attendees from more than 135 countries. It showcases innovative ingredients and solutions across various categories, including natural and organic ingredients, food manufacturing, and health ingredients. Fi Europe also offers extensive networking opportunities, conferences, and showcases the latest industry trends.

Fi Europe is the most interesting trade fair for LEROMA since almost all the exhibitors are raw material suppliers and thus potential customers for the platform. Many raw material suppliers and producers encounter surpluses regularly and are open to the idea of LEROMA's surplus exchange. Regarding the seafood industry, Fi Europe is not the ideal fair, as mostly ingredients such as sweeteners, thickeners, hydrocolloids, proteins and similar are presented and discussed.

3.3. Initiating a discussion at sector level: Industry surveys

3.3.1 Management survey

In line with the protocol for the dialogue (D4.1) and given the need of assessing the efficacy and socio-economic and ecological impact of the innovations, a baseline questionnaire including the questions of the “management survey” and those of the “participant survey” (see the WP1 deliverables for more details) was distributed among the stakeholders who had joined the Scottish dialogue and consented to complete it. However, despite sending several reminders, only five stakeholders (all processors) submitted their responses. These included two primary processors (one of fish, and one of fish, by-products and/or waste), and three secondary processors (two of fish, and one of by-products and/or waste). These ranged from small, young companies with a turnover of under £30,000, to large ones with a turnover of over £50M with more than 100 years of activity. Given the small and diverse sample size, we will not present even aggregated data for confidentiality reasons, in addition to their responses not being comparable. Nevertheless, the responses to the questions of the “participant survey”, meant to assess awareness and attitude towards food waste, are included in the Lowifood participant survey dataset and the results are presented, at the level of wider innovation typology, in D1.6. As for the waste management aspect, we report one single figure as an example. Stakeholders were asked to report the weight of fish materials removed from the value chain for human consumption (for example, during processing) for up to three final products. While this figure was nil or <0.02% for most products, also due to the nature of the companies, in one case it amounted to 18.5% of the quantity of fish inputs, suggesting that there is a significant scope for adding value.

While our intention was to assess the efficacy of the dialogue by monitoring the exchange of products and by-products at risk of becoming waste, and then disseminate a final survey to assess the changes in practices after the “implementation” of the innovation, only one such exchange took place between stakeholders during our dialogue (5 litres of fish oil to explore innovative uses). In turn, it became clear that we should not have expected any measurable short-term impacts of the innovation. Therefore, to reduce stakeholder fatigue, we decided not to disseminate the final survey, but to develop a shorter revalorisation survey for wider dissemination, as detailed in Section 3.3.2 below.

3.3.2 Valorisation survey

To assess the challenges, opportunities, and potential interventions detected during our qualitative interviews with stakeholders more systematically; after discussing with the whole Lowinfood Scientific Board, we developed a short survey to be disseminated online and at relevant industry events in Scotland and Germany. The questionnaire was meant to replace the post-implementation survey used in other tasks of the project to assess the impact of the innovations. Indeed, the nature of the dialogue could not result in a tangible short-term impact, and while our intention, according to D4.1, was to incentivise exchange of products between stakeholders, only one such exchange took place during T4.1.

Drawing on the lessons learned during the dialogue, we kept the questionnaire short (8.4 minutes according to the Qualtrics platform, where it was coded), using a non-technical language that could be understood by any stakeholder along the value chain, regardless of the level where they operate. The questionnaire was developed in English and then translated to German, with a series of interactions and backtranslation to ensure consistency: like this, the stakeholders from our case study countries could compile it in their mother language. The survey obtained ethical approval from ISUN. The English version of the questionnaire is provided as Annex 5.

The JHI, ISUN, and LER teams disseminated the survey in person, using tablets, respectively at the Fish International 2024 fair (Bremen, Germany, 25/27 February 2024) and at the Scottish Skipper Expo 2024 (Aberdeen, Scotland UK, 9-10 May 2024). On top of this, a press release was prepared and published on relevant local and industry magazines in both countries, and posts were published on Twitter and Facebook, both on the Lowinfood profile and in relevant Facebook groups: potential respondents could access it using a weblink or a QR code. All the stakeholders who took part in the dialogue were contacted and asked to both compile the survey and disseminate it among their networks. A prize draw (gift cards) was foreseen as a further incentive. Here, we present the responses received as of 25 July

2024; nevertheless, the survey will remain open for further dissemination, including at the final T4.1 events.

While the initial plan was to limit the sample to Scottish and German respondents, the highly international nature of the value chain, and therefore of the industry events, resulted in wider uptake. Overall, 120 people accessed the survey, but after filtering for those who did not answer at least one of the three ranking questions (challenges, opportunities and interventions), the sample size was 85 (for challenges), reducing to 79 for interventions, and 77 for opportunities, due to respondents exiting before the end of the survey. As shown in Figure 4, a plurality of respondents came from Scotland (36 (42% of the sample)), which together with the rest of the UK (9) account for more than half of the sample. There were 12 German respondents (14%), while 28 respondents (33%) came from the rest of the world, including EU and other European countries (primarily Norway and Iceland). There was a predominance of male respondents (78%), and 45-54 was the most represented age group (29%), with a rather fair distribution between 25 and 64 years, which together accounted for 90% of the total – a younger population than, for instance, farmers.

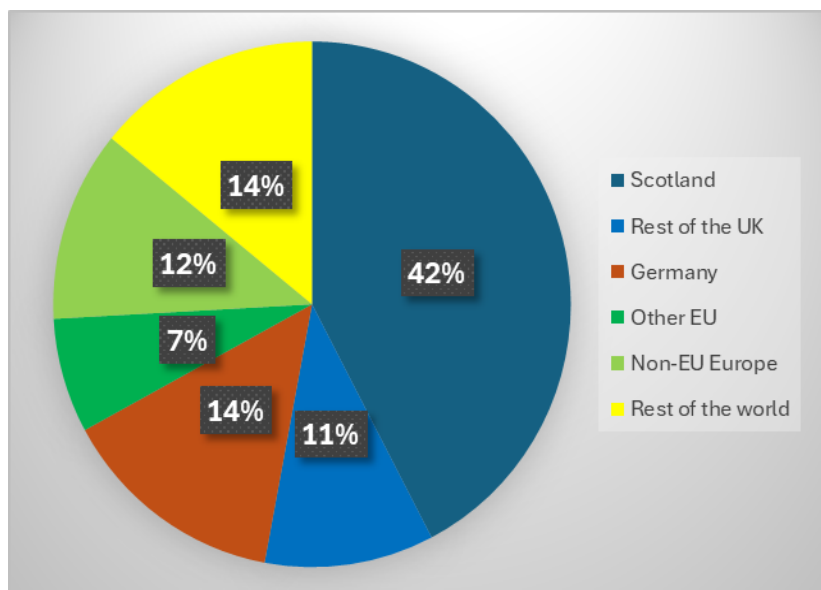


Figure 4. Origin of the respondents to the revalorisation survey.

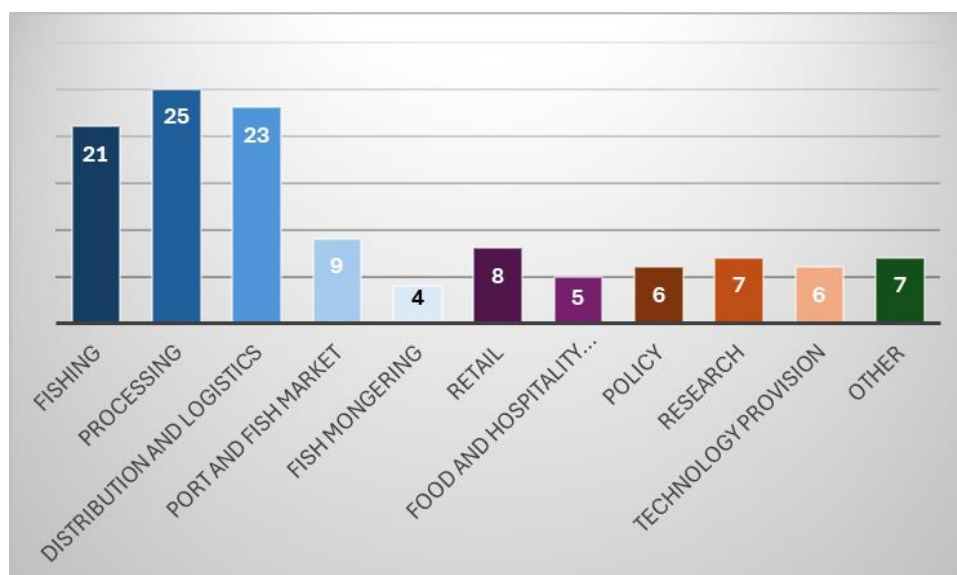


Figure 5. Sectors where the organisations of the respondents to the valorisation survey operate.

Respondents could indicate one or more sectors for their organisations. On average, they indicated 1.4 sectors, which are listed in Figure 5 above. Fishing, processing, and distribution and logistics are the most represented, with over 20 respondents' organisations engaging in each of them; port authorities and fish markets, retail, food and hospitality services, and fish mongering were less represented, with 9 to 4 responses. Other options were entered by the respondents as "other", with policymakers, researchers and technology providers (e.g., vessel equipment, refrigeration) being all well-represented. Concerning the position in the company or organisation, 31% were department managers, 24% permanent contract staff

without managerial duties, 16% executive managers, and 15% owners (including two retired owners); 9% were contract or temporary workers, and 5% retired employees. Therefore, most of our respondents had some level of responsibility over the operations of their organisations. We also asked if they engaged, directly or indirectly, with loss and waste of material resources. A large group (26 respondents (31%)) engaged directly, e.g. through filleting, and even more respondents (31 (36%)) indirectly, either via company-level or sectoral-level decisions in the FLW realm. The rest either did not engage with waste or were currently retired.

After the above profiling questions, people were asked to answer three “ranking” questions which represented the core of the survey. In the first question, they were provided with a list of **challenges** to creating higher value from materials that were currently lost or wasted in the fish supply chain; the second one provided them with a list of interventions (e.g., innovations and policy changes) to reduce or prevent the loss and waste of resources; the third focused instead on **opportunities** to create higher value from materials that were currently lost or wasted. While there is a clear overlap between these three aspects, the inclusion of three questions was conceived as a robustness check, to verify whether the respondents would provide coherent responses along the survey. Indeed, the most relevant challenges were expected to correspond to the most relevant opportunities, and to the most promising interventions. People were asked to rank “up to five” elements that they deemed most relevant/promising (but they could rank as little as one) from 1 to 5. The challenges and opportunities were 7 each, the interventions 10, all derived from the stakeholder interviews, however the respondents could specify and rank up to three additional elements in each question. The order in which the elements were shown was randomised for each respondent to reduce the bias towards the first elements.¹⁹

A composite scoring of the challenges is shown in Figure 6 below. Unwanted catch (including bycatch and discards) scored first, having been selected by 63 respondents with an average ranking of 2.66. This was followed by the high cost of storing, sorting, and moving the surplus materials, which was selected by 59 but had the highest ranking of 2.51 among the latter. At some distance, we find the mismatch between available catch and customer demand, selected by 61 but with an average ranking of 3.00. The geographical distance from potential buyers was also selected by many (58), but with lower ranking, while the lack of flexibility of the fishing quotas achieved a higher ranking (2.75) but was selected by few. The losses during processing were deemed the least relevant challenge. Among the “other” challenges entered by the respondents were the presence of a sustainable and reliable market demand for new products, and the knowledge of such new markets. The scoring of the challenges differs if we consider Scottish and German respondents separately. In Scotland, unwanted catch scored

¹⁹ Before implementing the following analysis, the “other” elements were re-categorised according to elements provided, if at all possible.

highest, followed by the high cost of storing, sorting, and transporting the material, and the mismatch between available catch and customer demand; whilst in Germany the high cost of storing, etc., scored highest, followed by the strict standards of retailers and other buyers, and then unwanted catch. These different rankings reflect the structure of the supply chain, with fishing being relatively more important in Scotland, and retail in Germany. Noteworthy, the standards of buyers scored lowest in Scotland, the difference being significant at the 5% level; whilst processing losses ranked quite low in both countries. It is also worth mentioning that the scores of the single challenges differed much more in Germany, suggesting a clearer and more coherent vision of priorities among the industry.

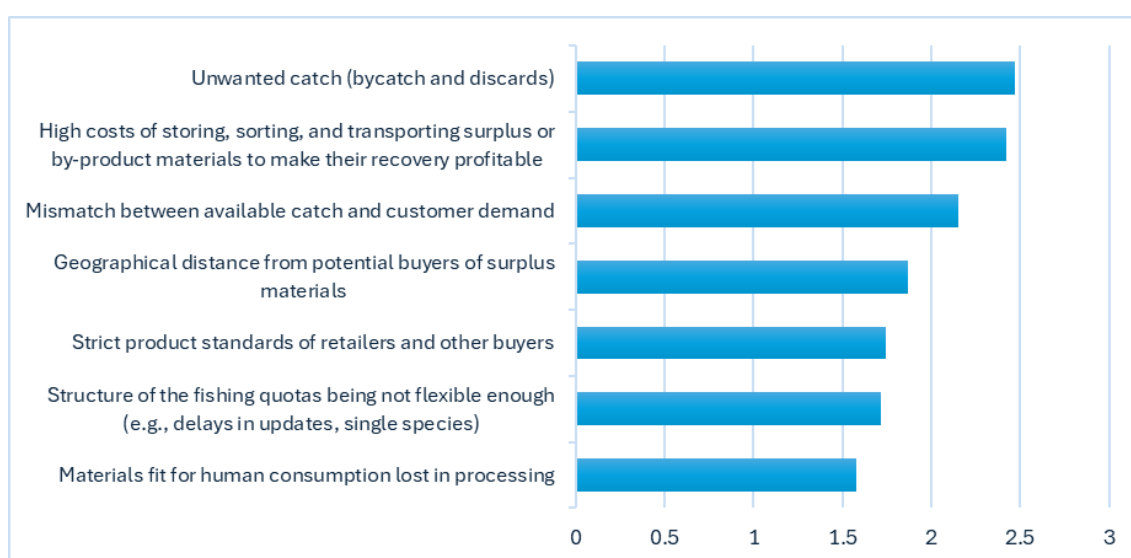


Figure 6. Ranking of the challenges to creating higher value from seafood materials.²⁰

The question about challenges was followed by the interventions, whose scores are reported in Figure 7 below. Coherently with the challenges, innovations for monitoring and reducing unwanted catch scored highest, being selected by 43 people with an average ranking of 2.63. This was followed by policy and legislative changes to reduce the cost of valorisation for small to medium enterprises (SMEs) (40 selections and the highest ranking of 2.58); innovations to balance supply and demand (41 selections and a ranking of 2.66); the creation of localised clusters between industry and innovators (again 41 selections, average ranking of 3.00); and development of digital market-places to match buyers and sellers of surpluses (41 selections, average ranking of 3.12). This latter intervention was introduced to assess, indirectly, the attractiveness of **Leroma** for the industry: while it did not rank very high, it did not rank very

²⁰ To summarise all the information (number of respondents selecting each statement, and average ranking) within a single indicator, we assigned a value of zero to the challenges not selected by a respondent, a value of 5 to those ranked first, 4 to those ranked second, etc.; then, we calculated the average across all respondents. As a result, the score varies between 5 (if a challenge were selected and ranked first by all respondents) and 0 (if no one had selected a statement).

low either, with 52% of those who answered the question selecting it. In turn, “product traceability software”, such as the one created by the Lowinfood Innovation Platform member Sedna Technologies, scored very low. Again, the scores differed between Scotland and Germany, although none of the differences were statistically significant.

In Scotland, the top interventions were those against unwanted catch, followed by more precise (and automated) processing machines; methods to balance supply and demand; and policy and legislative changes helping SMEs in valorisation. Instead, innovations that reduce the costs of handling surplus material scored rather low (opposite to the high score of the relative challenge); and traceability software, even lower. According to German respondents, the top interventions were instead the creation of localised clusters, which supports the findings of our dialogue, and the development of digital marketplaces, pointing to the potential role of Leroma in this country. Better processing machineries and social interventions scored very low, instead. Like for challenges, the scores assigned to the single interventions differed much more among German than among Scottish respondents.

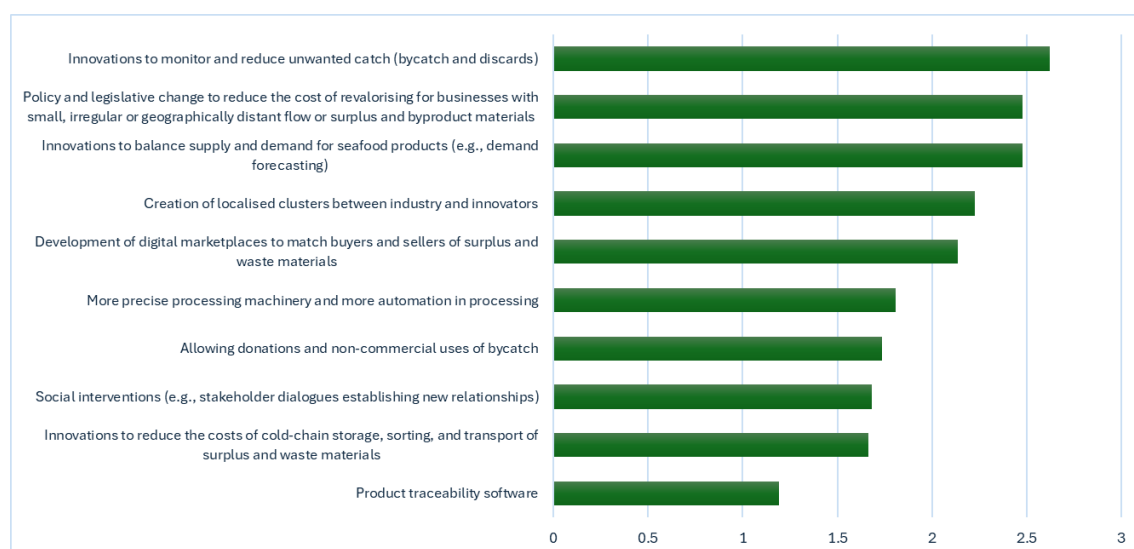


Figure 7. Ranking of the interventions to reduce or prevent loss and waste.²¹

Finally, people were asked to rank the opportunities, whose scores are reported in

Figure 8. Asking about opportunities was meant to make people think “out of the box” and indeed, the results differ slightly from the previous questions, suggesting that some routes that have not yet been extensively explored could be equally promising. In particular, promotional activities for widening consumers’ preferences beyond currently demanded species scores highest, with 58 respondents selecting it and an average ranking of 2.34. In

²¹ The scores were generated using the same procedure of the challenges; however, the result was multiplied by 10/7 to allow comparability, accounting for the fact that the larger number of interventions resulted in a lower probability of each of them being selected.

line with the top challenges and interventions, it was followed by the opportunity of improving scientific understanding of fishing grounds in real-time (59 selections and a ranking of 2.73) and exploring innovative uses of high-value seafood materials in international markets (56 selections and a ranking of 2.75).

Confirming the low score of traceability software, the development of blockchain and similar technologies scored quite low. Interestingly, the possibility of negotiating fishing quotas autonomously following Brexit, which did not emerge from the interviews but was included in the list to test an important argument in the UK political discourse, scored very low – even considering that it was only shown to those who compiled the questionnaire in English (the average score was just 1.65, even among UK respondents). Scottish and German respondents were more aligned in terms of opportunities than challenges and interventions, with the diversification of consumers' preferences scoring highest for both; whilst improved scientific understanding of fishing grounds scored second in Scotland and third in Germany. In Germany, exploration of international markets was deemed more relevant, compared to a fourth position in Scotland (a difference significant at 5%). In turn, increasing automation and AI in processing scored third in Scotland but last (apart from the Brexit-centred item) in Germany.

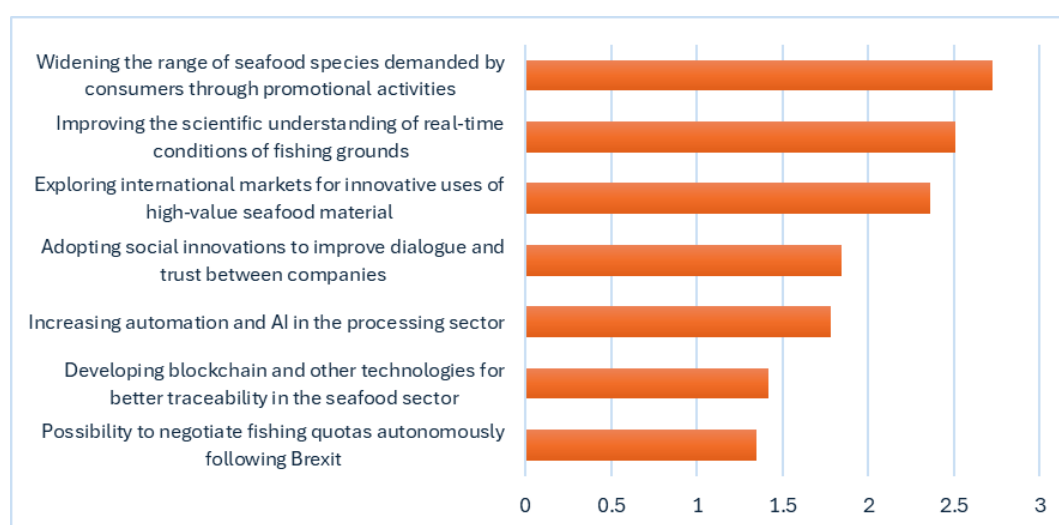


Figure 8. Ranking of the opportunities to create higher value from currently lost materials.²²

To conclude, our survey revealed a certain coherence between the perceived challenges, opportunities, and promising interventions among industry stakeholders, despite some differences between countries deriving from the structure of the value chains and, therefore, the type of respondents. Unwanted catch emerged as a persisting challenge, calling for better monitoring and improved understanding of real-time fishing grounds. Respondents tended

²² The scores were calculated using the same procedure of the challenges.

to agree that the diversification of consumers' preferences beyond major species represents a key opportunity. Instead, the high costs of handling surplus material remain a barrier, and policy and legislative changes are required to facilitate SMEs in exploring valorisation options. In turn, traceability did not emerge as a serious issue. Our respondents were divided on the role of the innovations proposed in Lowinfood, namely social interventions (T4.1), although localised clusters of industry and innovators ranked quite high, and digital marketplaces like the Leroma platform (T4.2).

4. Relationship with T4.2 Leroma platform

In both Scotland and Germany, the stakeholder dialogue in T4.1 (M9-48) ran in parallel with the demonstration of the Leroma platform in T4.2 (M12-42). Indeed, most of the actors that would register in the Leroma platform are likely to be involved in the dialogue, and vice versa – the users of Leroma were invited to join the dialogue. This approach was adopted to create positive synergies in terms of exchange of food products as well as data collection.

Due to lack of interest from the seafood value chain stakeholders in Germany and Scotland, the reasons for which are detailed in D4.4 “Dataset from demonstration – Leroma fish”, it was decided by WP4 partners that the Leroma platform would target any potential suppliers or consumers of surplus seafood products, regardless of the type of product traded (pelagic, demersal fish, or shellfish) and the country location. Indeed, one of the strengths of Leroma is its international outreach. In line with this, it was agreed that the sample of users for the evaluation in T4.2 would include all seafood transfers, regardless of whether the origin or the destination of products was outside of Germany or Scotland. Leroma was the assigned data controller for the data collected on the Leroma platform, while the James Hutton Institute was meant to act as data facilitator by interviewing (via phone or web conference if required) the Scottish or UK companies who would join the platform. The details of the recruitment, data collection, and analysis can be found in D4.4.

4.1 Relationship with the Leroma platform in Scotland

Leroma was mentioned in all the advertising material used for the dialogue in Scotland, i.e., leaflets, email templates, and information sheets and consent forms for the dialogue proper and the participatory events (although the latter were not used). The stakeholders contacted were informed of the possibility to register on the platform for free, and in case they expressed an interest, they were provided additional information. The platform was also described to the interviewees during the qualitative interviews.

Leroma provided a leaflet to advertise the platform, which includes the weblink and the contact details of Lowinfood partners in both Scotland and Germany. The leaflet was sent to the stakeholders who expressed an initial interest. Furthermore, while the invitations to join

the T4.1 dialogue were being sent according to the stakeholder typology and the need to hold qualitative interviews first, all the stakeholders (industry, and associations which could then pass the information to their members) were sent the leaflet by post between April–June 2022. No response was required, however Leroma would have known if any Scottish company had registered, which was not the case apart from the instances mentioned above.

Leroma was advertised during stakeholder events, such as the Scottish Skipper Expo, using leaflets and other materials provided by the company. Further, the platform was suggested to all relevant stakeholders the JHI came in contact with and that were likely to have surplus seafood, as a potential solution for adding value to their unwanted surplus materials.

4.2 Relationship with the Leroma platform in Germany

Like in Scotland, Leroma was mentioned in all the advertising material used for the dialogue in Germany, i.e., leaflets, email templates, and information sheets and consent forms for the dialogue proper and for participatory events. The stakeholders who were contacted were informed of the possibility to register on the platform for free, and in the case, they expressed an interest, they were provided additional information.

Leroma provided a leaflet to advertise the platform, which includes the weblink and the contact details of Lowinfood partners in both Scotland and Germany. The leaflet was distributed at several events (see chapter 3.2.2 “Networking events in Germany”) and sent to potential participants in the stakeholder dialogue, as well as potential users of the Leroma platform. No response was required, however Leroma would know if any German company registers. Leroma was also advertised during the expert workshop in Bremen, where the Leroma team described how the platform works, and answered stakeholder’s questions.

To our knowledge, only one company to which we advertised Leroma registered with the platform. Additionally, the only entry relevant to the seafood value chain in the platform during the scope of the dialogue was a considerable amount of fish skins from a processor based in Bremerhaven in Germany. This was not a contact initiated by the stakeholder dialogue partners.

4.3. Overall reflections

Despite having difficulties mediating perishable goods such as fresh fruit, vegetables and fish, Leroma had continuous success mediating different raw materials to the food and other industries. For instance, surpluses that have a longer shelf life than fresh fruit, and are easy to store, have proven much easier to mediate. In 2024 alone, Leroma managed to mediate over 50 tonnes of different raw material surplus, such as soy protein isolate, rapeseed oil, carrageenan, tara gum, and sorbic acid. Except for rapeseed oil, these are all dry raw materials in powder form. Even when the shelf life had come to an end, Leroma could extend

it by six months thanks to extra analyses proving the surplus was still fit for human consumption. The general experience was that if goods are stored properly (dry and cool, which is the case most of the time), they can still be used, even after the official shelf life has expired.

In some cases, where raw materials were not fit for human consumption anymore, they could still be used in other industries. Approximately 11 tonnes of rapeseed oil is an example of one of these cases. Due to an expired shelf life, it could not be used in the food industry anymore. Leroma found a solution where the oil could still be used in a technical application, where standards are much lower compared to the food industry. Consequently, Leroma has proven successful when it comes to the mediation of “easy-to-store” products. Hopefully, through a broader customer network in the future, Leroma will be able to also mediate perishable goods.

Given the absence of seafood value chain users of Leroma whose transactions could be monitored to assess the suitability of the platform for the sector, we have included, among the interventions available for ranking in the revalorisation survey, the “development of digital marketplaces to match buyers and sellers of surplus and waste materials”. This intervention was selected by 41 out of 79 respondents to the question (52%) and among them, it achieved an average ranking of 3.12/5. The composite score put it in the fifth position out of 10, while among German respondents it achieved the second position (7 selections, with an average score of 2.71/5). Hence, while it did not represent one of the top interventions, it bears a potential for reducing the loss and waste of fish products and by-products which is still worth being explored.

5. Conclusion: Lessons learned and policy implications

The timeline for the activities that took place are summarised in Figure 9 and 10.



Figure 9. Gantt chart showing activity timeline in Scotland and Germany.

	Apr-Jun 2022	Jul-Sept 2022	Oct-Dec 2022	Jan-Mar 2023	Apr-Jun 2023	Jul-Sept 2023	Oct-Dec 2023	Jan-Mar 2024	Apr-Jun 2024	Jul-Sept 2024	Oct-Dec 2024
Scotland			Bioeconomy Event, Stirling	Scottish Skipper Expo, Aberdeen				Seafood+, Nourish Scotland event, Glasgow Scottish Bioeconomy Week Panel, Glasgow	Scottish Skipper Expo, Aberdeen		Final Stakeholder Conference, Aberdeen
Germany	Biofach, Nuremberg	Fish International, Bremen ANUGA, Cologne		Lowinfood Stakeholder workshop / focus group, Bremen	Ideenfutter Local Trade Fair, Neuss	FI Europe					

Figure 10. Timeline of networking events in both Scotland and Germany.

The findings of the stakeholder dialogue could be summarised under two key categories. The first is the themes that emerged from the one-to-one and in-depth stakeholder interviews, the nature of this engagement allowed us to delve further into detail during these discussions. The findings from the interviews were specific to each country. The second is the responses to the online survey, which was eventually created to assess more systematically the challenges and opportunities for valorisation, and the innovation needs that arose during the interviews. The Table 3 summarises the findings in both Scottish and German side of the dialogue.

Table 3. Summary of results from the stakeholder dialogue in Scotland and Germany categorised according to the stage of the value chain they concern

Value chain stage	Challenges/issues	Solutions/opportunities
Scotland		
Production (Fishing vessels, producer organisations)	Mismatch between the scientific forecasts and observed presence of fish at sea leads to by-catch. Parasites found in guts of fish limits storage of guts onboard and transport ashore. Low quotas and lack of skilled workforce in processing prevents undersized fish being landed.	Investment in science and forecasting and monitoring. Policy changes to enable mixed species quotas and donations of by-catch for human consumption when possible Investigating ways to collect guts and other by-product materials from vessels at sea Incentivising landing undersized fish by creating suitable economic conditions
Processing (Primary & Secondary)	Losses occur in processes like filleting fish or deshelling shrimps. Contamination of by-products in secondary processing limit their further use. Lack of space for storage, high costs of refrigeration and transport preventing transfers of small amounts or for from further distances; lack of technology and labour for sorting by-product materials limit efforts to add value. Products returned to suppliers, by processors or more commonly by-retailers to processors, due to quality or other contractual and	Adopting innovative solutions and automation to address the reasons for losses and spoilage of products intended for human consumption in processing and along the supply chain. Extension of shelf-life and deep chilling. Centralising and automating processing stages and sorting of by-products to reduce and share costs associated with sorting, storing and sorting by products Donating returned products fit for human consumption to charitable organisations for redistribution.

	logistic issues and lead to surplus downstream.	
Wholesalers (including online platforms)	Perishability of seafood products and value of wild catch being highly linked to refrigeration temperature and transport time.	Better traceability and storage of products to retain high value of primary production for human consumption.
Retailers (including fishmongers)	In retail, two main categories of challenges lead to surplus products initially intended for human consumption: 1) Logistic issues: Complexity of forecasting consumer demand; balancing product quality with shelf-life maximisation; low freezing and storage capabilities; receiving low quality or surplus amount of products from suppliers; labelling and bar code issues 2) Feasibility issues: cost-effectiveness of adopting innovations; high unit cost of saving food from being wasted for smaller businesses and at smaller branches of supermarkets; limited window of time between being able to sell seafood at shop floor at discounted prices and its expiry date after which it is unfit for donation for human consumption	1) Large retailers adopting innovations to better forecast consumer demand and to better monitor and communicate with their suppliers and downstream supply chain. Collaborating and funding their suppliers to innovate Repurposing damaged fillets for other products (more applicable to independent and specialised stores like fishmongers) 2) Incorporating carbon accounts in company accounts to make food waste an issue beyond social corporate responsibility for large companies
Innovations	Lack of market demand limiting the feasibility of adopting innovations to add value to by-products	Creations of clusters to facilitate inter-sectorial matchmaking and cost-sharing More collaboration between innovators, scientists and industry to understand the potential for and the effectiveness of specific innovations

	High interest rates and cost of borrowing money limiting businesses' interest and ability to innovate	Providing subsidies and other economic incentives for creators and adopters of innovative solution
Germany		
Production	The spoilage of catch and overexploitation of resources in overseas are linked to interconnected reasons such as inefficiency on vessels; difficulty to quantify losses and spoilage before catch arrives in Germany; interruption of cold chains; difficulty to enforce the EU regulations and standards to the producers in Global South.	Securing value chain connections between fishing in the Global South and markets in the Global North Using certifications and eco labels to professionalise value chain stages before import to Germany
Processing	In processing stage there are two main types of issues/challenges 1. Issues linked with lack of skilled workers 2. Lack of interest for valorising side streams	1) Making employment conditions in seafood supply chain favourable to attract and retain skilled workers locally and improving social and regulatory conditions for the immigration of skilled 2) Addressing the regulatory gaps in the usability of side streams for human consumption to encourage further processing to take place in Germany
Wholesale and retail	The interruption of the cold chains especially during heat waves or personnel shortages in processing is the main reason for spoilage.	Making sure cold chains remain uninterrupted in all situations Creating conditions to mitigate the shortage of skilled worker
Consumers	Household consumer preference for fresh fish over frozen fish leads to spoilage downstream.	Diversification of retail household consumers' preferences beyond major fresh produce

While a portion of these surveys were filled in during live events and in the presence of researchers, most participants completed them online without the ability to ask for

clarifications. Equally, due to the anonymous nature of the participation, researchers were not able to get back to participants to inquire further about their responses either. Additionally, participation was not limited to Scotland and Germany: 12% of the responses come from the wider UK, 33% from Europe and elsewhere.

5.1. Scotland

There was no consensus about the definition of waste and loss among the stakeholders in, or working closely to, the Scottish seafood value chain. Some stakeholders defined waste as “any materials that leave the supply chain due to not being fit for human consumption”. Others, mostly in retail, defined it as “materials sent to landfill”. The lack of consensus is understandable considering the difference in stakeholders’ operations and perspectives.

From an economic perspective, the lost and wasted materials can be grouped in two overall categories. The first category is the products at different stages of the supply chain that are initially intended for human consumption but become unfit for this purpose. Causes of this loss and waste include: regulations (e.g., undersized fish, unwanted catch of quota species); lost value due to industry standards (e.g., products rejected by buyers and retailers); and logistics (e.g., deteriorating quality of materials due to long journeys or failing equipment, misbranding, mislabelling, faulty packing, and products reaching their end of shelf life due to overstocking). All the organisations involved in the dialogue were interested in preventing the loss of high value seafood materials and products.

The second category is the generation of by-products through processing (e.g., heads, tails and gut, skins, shells, bones, trimmings, expired goods at retail, etc.). These materials have little or no current market value and generating additional income from their valorisation is hardly possible due to challenges with storage, transport, refrigeration, and labour needs. In most instances, the producers of by-products would be content to give these materials away free of charge for disposal. In the interviews, we identified such arrangements between local fishmongers and a company producing fish meal.

World events such as Brexit, the war in Ukraine and the COVID-19 pandemic have not created any long-term impacts on the supply chain, net of a redirection of trade flows (e.g., from Russia to China as a supplier, or from Ukraine to other countries as a buyer). However, even though they did not cause any food waste directly, the indirect impacts and transition period lead to the supply chain suffering inefficiencies such as labour shortages (especially in the processing sector), increased fuel and electricity costs, and limited the possibility of overseas trade for smaller companies. These issues might also put material use efficiency on the back burner for industry SMEs and prevent these companies from wanting to innovate due to uncertainties in the stability of the supply chain.

The overall stakeholder dialogue efforts in Scotland revealed a number of challenges and opportunities to reducing loss and waste in what is an already innovative sector/supply chain. A key challenge in conducting the dialogue itself, was the mistrust of external researchers by the seafood industry. The seafood industry in Scotland is tight-knit, and many of the actors throughout the supply chain have existing relationships with or awareness of one another. Negative portrayal of the sector by the media, especially in the context of Brexit, has made them wary of outsiders who have little understanding of the industry. Despite this, we managed to conduct an informative and wide-ranging stakeholder dialogue, particularly thanks to the support of industry associations willing to debunk this perception, and policy actors and networking organisations that recognised the value of our efforts.

The interviews revealed that key challenges to revalorising and preventing waste are the geography and coordination of the supply chain, costs and economic motivation, policy (especially the landscape surrounding quotas and landing obligations), and mismatch between supply and demand (e.g., scientific forecasting of fishing grounds). Many of the opportunities to revalorisation aim at moving by-products further up the waste hierarchy and extracting higher value for these products. Networking events represented fundamental opportunities to meet in person the stakeholders we contacted and interviewed online, which is highly valued by many in the sector over online discussions. The events also allowed us to promote the Lowinfood project and to become more visible to those engaged in the sector. Finally, the survey has given insight from stakeholders in the fishing and seafood industry about challenges, opportunities, and opinions on interventions.

5.2 Germany

In principle, all stakeholders agreed that there are hardly any losses in the value chain stages relevant for Germany (i.e., especially processing, trade and distribution, and catering), simply because fish resources have become so expensive (and in some cases rare) and the price of fish continues to increase. After digging deeper into the stakeholders' respective topics, however, it was discovered that certain losses exist, as the summaries of the interviews above show.

A fundamental difficulty for the stakeholder dialogue in Germany was that the value chain stages that were particularly relevant seem to be responsible for rather small amounts of FLW in the fish sector, as already stated. In this context, the high FLW volumes in consumers' households were mentioned, as also shown in the FLW literature (Parfitt et al., 2010; Office for National Statistics, 2021; WRAP, 2023). Reference was also made to the effects of consumer behaviour in the upstream value chain stages, for example spoilage of fresh produce due to consumers' desire for fresh (and not frozen) fish.

The stakeholders discussed the influence of the downstream value chain levels on fishing (particularly in developing countries) in different ways. During the Bremen focus group,

some stakeholders identified more formal positions, pointing out that losses before processing cannot officially be classified as food losses, but also that the influence of the German value chain on fishing is not that sizeable. Conversely, other stakeholders emphasised the importance of secure connections between fishing in the Global South and markets in the Global North. In this context the problem is that a lot of spoilage and overexploitation of marine resources occurs because processing steps (especially secondary processing, refining) cannot be carried out directly in developing countries. Demanding certifications such as MSC or Naturland eco labels could contribute to the professionalisation of the value chain and thus to the reduction of FLW in the upstream value chain before import to Germany.

The statements of stakeholders about the importance of regulations for reducing FLW were somewhat different. On one hand, for example, state regulations such as the landing requirement for by-catch, alongside the professionalisation of fishing and primary processing (i.e., through labels such as MSC), were emphasized. The regulatory gaps in the usability of side streams for human consumption were also criticised as preventing further processing in Germany. On the other hand, there was a certain scepticism as to whether more regulation or stricter rules could actually reduce FLW or, on the contrary, could create risks of new unintended sources of FLW. Most stakeholders saw an implementation problem rather than a regulation problem but emphasised that EU regulations for the use of side streams are in need of reform. They proposed uptake of government guidelines or recommendations for uniform reporting, like the EU directive on green claims. Since the complete enforcement of EU regulations is seen as difficult, labels such as MSC or Naturland may be a substitute or supplement.

The best before date was considered a problematic regulatory aspect. In this regard, technical solutions such as the super-chilling process, which extends the shelf life, were mentioned, but also non-technical approaches such as nutrition and consumer education in kindergartens, schools and beyond (perhaps supported by influencers in social media).

An aspect that has already been mentioned in the context of spoilage in developing countries has to do with the issue of uninterrupted cold chains. Cold chains are a critical aspect along the entire value chain, especially at the interfaces of different value chain stages, which was emphasised by several stakeholders. Even though these cold chains generally work very well in Germany, it has been acknowledged that there can be situations, e.g., heat waves or personnel shortages, that can push the processes to their limits, which in the worst case leads to losses due to spoilage.

The stakeholders along the value chain did not entirely agree on whether the utilisation of side streams was, economically speaking, sufficiently interesting for processors. Most stakeholders think that by-products are used relatively extensively, save where filleting takes

place already on fishing vessels. On fishing vessels, it is assumed that the fish resources are used rather inefficiently, although in this context it was also noted that slaughter waste thrown overboard serves as food for wild animals and is thus returned to the natural nutrient cycle. Even those who assumed extensive use of by-products admitted that the full potential value of these products is not always realised (especially for human nutrition, if possible). The shortage of skilled workers contributes to the problem of products not being used optimally, just as it contributes to other problems described here, for example that the cold chain cannot be optimally maintained in all situations, or that products cannot always be processed, sold or prepared in time.

None of the stakeholders in the German value chain considered disruptive external events such as Brexit, the COVID-19 pandemic or the war in Ukraine to be significant factors in the emergence of FLW, as these events tend to lead to short-term supply shortages, but not to surpluses. Deviating from this general statement, only limited effects were reported, for example the disposal of small stocks in restaurants that had to close due to lockdowns, or fish shipments from Asia that got spoiled in ports at the beginning of the pandemic because they were not approved by the authorities.

5.3 Overall reflections

Stakeholders in the German and Scottish value chain similarly consider that their organisations do not create large quantities of waste, even though loss and waste occur at each stage of the supply chain. Landing obligations and difficulty monitoring discards have come up in both supply chains, while in Scotland the stakeholders were more critical of the way quotas are structured. The fish for the German market often goes through primary processing on board or in foreign countries, while only the catch of demersal vessels in Scotland will be gutted at sea, with further primary processing taking place onshore. Primary processors might face contemporary technical challenges to reduce loss of materials on the bones and shells, yet their large and continuous volume of by-products from filleting processes are in high demand by large scale users such as producers of fish feed, fish oil, and pet food industries.

Results from the Scottish dialogue pointed to the lack of demand for by-products from high-value users; the geographical distance between producers and innovative users; the lack of quantification of by-product flows; and the mismatch between fishing quotas and fish availability at sea leading to unwanted catch. German stakeholders mentioned, alongside profitability and technical considerations, the shortage of skilled workers, which can lead to cold chains being interrupted, as well as goods in retail and catering not being sold on time or fully consumed.

The findings of the qualitative stakeholder engagement adopted in both countries led to a holistic understanding of the seafood value chain, and then to a further industry enquiry in the form of an online survey. The survey identified the main challenges, opportunities, and promising interventions for valorising seafood products and by-products at risk of becoming waste. The results of the survey aligned well with the qualitative findings of the dialogue, as unwanted catch (bycatch and discards) ranked very high among the challenges, calling for related interventions, while the diversification of consumers' preferences beyond the major species currently demanded was deemed a key opportunity. Our respondents were cautious on the importance of the innovations tested in Lowinfood WP4, namely social interventions such as a stakeholder dialogue (T4.1) – although the creation of localised clusters of industry and innovators, like the Icelandic Ocean Cluster, ranked quite high – and digital marketplaces like the Leroma platform (T4.2), which ranked high in Germany.

The efficient use of fish resources is a key component for achieving sustainable, low-waste food systems. Our work covered a novel area of study in the social science literature on food waste. Our efforts have hopefully provided a small yet relevant contribution to setting the ground for a more fruitful collaboration between industry stakeholders and researchers to develop and disseminate valuable solutions that can benefit food security while protecting the environment in EU and beyond.

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Annex 1: Table of policy and regulations relevant to the Scottish seafood industry

Current Regulation(s) Relevant to Waste in the Seafood Industry	
Area of waste concerned	Details
Dead fish from aquaculture	EU regulation 1069/2009 lays down the health rules on animal by-products not intended for human consumption. This is the regulation that defines category 1, 2 and 3 waste which determines what it can be used for and how it has to be disposed of, e.g. animals slaughtered for disease control purposes are classed as category 2. It looks like this regulation was retained post-Brexit as there are amendments to it under SI 2020/1388 , but a consolidated version is not yet available on HMSO.
Unwanted catch (e.g., fish which is below the marketable size) in terms of landing and potential uses to extract an economic value	All catches of species which are subject to catch limits and, in the Mediterranean, also catches of species which are subject to minimum sizes as defined in Annex III to Regulation (EC) No 1967/2006, caught during fishing activities in Union waters or by Union fishing vessels outside Union waters in waters not subject to third countries' sovereignty or jurisdiction, in the fisheries and geographical areas shall be brought and retained on board the fishing vessels, recorded, landed and counted against the quotas where applicable, except when used as live bait.
Discarding of guts at sea	Under the Marine (Scotland) Act 2010 it is a licensable marine activity to deposit any substance or object within the Scottish marine area, either in the sea or on or under the seabed, from any of the following— (a) a vehicle, vessel, aircraft or marine structure, (b) a container floating in the sea, or

	(c) a structure on land constructed or adapted wholly or mainly for the purpose of depositing solids in the sea. It is unclear if the shells or fish (waste) are deposited from any of the above, and whether this is a licensable activity depends on that. If a licensable activity of deposit of shells was taking place, a marine licence would be required. An application would have to be accompanied by a Best Practicable Environmental Option (BPEO) which assesses practical availability of any alternative method of dealing with the substance or object. This means that the applicant would have to provide robust justification and evidence that all alternative ways of dealing with the waste have been exhausted before we would consider granting a licence for the deposit at sea. It is the general understanding that the Animal by-product Regulations regulate the disposal of aquatic animal by-products, including fish and shells from shellfish that contain soft tissue or flesh (Disposal of aquaculture animal by-products - Animal by-products: disposal guidance - gov.scot (www.gov.scot)). Any shells containing soft tissue or flesh needs to be disposed appropriately and would not be allowed to be disposed of at sea. For shells with flesh stripped off, the operator would have to demonstrate that all soft tissue has been meticulously removed to an acceptable standard for the activity to be permitted. This would need to be done before applying for a marine licence and again, the BPEO consideration would apply. Exemptions from the requirement for a marine licence exist for fishing (not aquaculture) for both inshore and offshore region. Fishing – deposits. This article applies— (a) to the deposit by way of return to the sea— (i) of any fish during the course of a fishing operation; or (ii) of any other object during the course of a fishing operation, provided that the fish or other object has not been landed before being so returned;
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	(b) to the deposit by way of return to the sea of any fish during the course of fish processing at sea.
Disposal of by-products from processing and current regulation concerning uses not for human consumption	Animal by-products do not fall within the definition of food and therefore do not fall under the remit of Food Standards Scotland (FSS). The Agriculture and Rural Economy Directorate (ARED) ensure animal by-products comply with regulations, and act as competent authority in certain circumstances, to protect animal and public health. Scottish Government information and guidance on the regulation of animal by-products, including the by-products of fish, can be found here: Animal by-products - Animal health and welfare - gov.scot (www.gov.scot). FSS is the competent authority for feed controls and all businesses wishing to use, produce, distribute and/or sell feed should be registered and approved with FSS: Registration and approval of feed businesses form Food Standards Scotland. While the ARED would be best placed to assist you with understanding the relevant regulations on animal by-products it would still be worth consulting the following legislation: • Retained EU Regulation 1069/2009 lays down health rules as regards animal by-products and derived products not intended for human consumption. Article 10 of this legislation describes what kinds of aquatic animal by-products are considered Category 3 materials. • Retained EU Regulation 142/2011 implements Retained EU Regulation 1069/2011. • Chapter VI of Annex II of Retained EU Regulation 852/2004 lays out the general hygiene requirements for all food business operators with regards to food waste, which includes requirements for the storage and disposal of non-edible by-products. • Section VIII of Annex III of Retained EU Regulation 853/2004 sets out specific requirements for fishery products; requirements of interest include those found in Chapter I to Chapter IV of that Section.

	All feed regulations that might apply to feed products placed on the market or used in feed which fall within the FSS remit can be found here: Animal feed regulations Food Standards Scotland. These regulations concern feed hygiene, feed safety, feed contaminants and feed standards, labelling and composition for feed materials and feed additives
Donation of unsold fish products that are fit for human consumption (close to the end of their shelf life), e.g. to foodbanks, canteens, etc.	All redistributed food must comply with the following regulations: • The Food Safety Act 1990; • Retained EU Regulation 178/2002, which lays down the general principles governing food and feed in general, and food and feed safety in particular; • Retained EU Regulation 852/2004, which lays down general rules for food business operators on the hygiene of foodstuffs; • Retained EU Regulation 853/2004, which lays down specific rules on the hygiene of food of animal origin for food business operators. Zero Waste Scotland provide information and guidance on food redistribution, which can be found here: Surplus Food Redistribution & Donation Zero Waste Scotland.
Disposal and/or alternative uses of fish products which are past their expiry date	In accordance with Article 24 of retained EU Regulation 1169/2011 on the provision of Food Information to Consumers, the date of minimum durability shall be replaced by the 'use by' date where, from a microbiological point of view, the food is highly perishable and after a short period likely to pose an immediate danger to human health. After the 'use by' date a food shall be deemed to be unsafe in accordance with Article 14 (2) to (5) of Regulation (EC) No 178/2002 and in accordance with Article 14(1) shall not be placed on the market if it is unsafe.

Annex 2: Stakeholder interview script

Guideline for interview

This is the full list of question used in the interviews. The script would be modified in advance according to the sector and type of organisation with regards to the topics that would be relevant to them. This means we would usually omit some questions or sub-topics irrelevant to the specific interviewee and sometimes include additional questions that would be specific only to their sector or organisation.

Guideline for Scotland:

Introduction. Thank participant for their time, introduce yourself and explain the research aims. Ensure they understand the consent form.

About your organisation.

1. Could you please tell us about your organisation and its role in the fishing industry?
2. Do you engage, directly or indirectly, with waste reduction?
3. Which type of fish are mainly caught by your member companies?

Your perception of waste. *The FAO defines waste as any food or part of food removed from the supply chain for human consumption to be used for other purposes, but of course the situation is much more complex.*

4. How is waste defined in your sector, including avoidable and unavoidable waste?

Waste generation points. *Our literature review highlighted that there are four main points (causes) where waste is generated within the fish supply chain: (1) guts discarded at sea; (2) parts (heads, skin, guts, bones, shells) removed during primary processing; (3) dead fish from mortality; (4) by-catch.*

5. Do you think that they reflect the situation of the sector well, or would you add any other important waste flow?

Estimate of waste types. *We know that waste flows are different depending on the typology of fish – demersal, pelagic, shellfish. Please consider the supply chains that are relevant for your organisation.*

6. Making 100% the fish caught, which would be the relevance of each of the above waste flows?
7. And where are the biggest economic losses and the biggest opportunities concentrated?

Discards at sea. *Let start with the first typology of waste flow.*

8. Why is this done, and for what species?
9. What is the policy regulation for this in Scotland and the UK?
10. Do you think that these regulations may be changed/updated following Brexit?
11. How are the species caught assessed against quotas in this case?
12. Do you think that it would be possible to extract more value by moving these operations onshore?
13. If so, which potential uses would you see for these parts of fish?

Cuts removed during primary processing. *These are probably those which can generate most value. We know that waste flows are different depending on the typology of fish – demersal, pelagic, shellfish. Please consider the supply chains that are relevant for your organisation. Please specify if what you say is valid in general, or changes between fishing ports, and therefore which ports you are referring to.*

14. Could you mention the cuts that could generate the most value if reused/recovered/recycled?
15. Who removes them, the single fishing company or some on shore processors? Please provide an overview depending on the type of processing.
16. How are they collected to be recovered, is this a responsibility of each fishing company is there a responsible organisation?

Barriers and opportunities for extracting value.

17. For each of the main parts mentioned, could you describe potential uses?
18. As far as you know, are these cuts going to the use that can generate the most value, or are there other uses that could be more valuable but for some reasons are not feasible?
19. Let's discuss the reasons that act as barriers and thus the opportunities for extracting more value: which are the reasons of this unfeasibility?
 - Are there any policy regulations (and at which level – Scotland, UK, EU/international) that make some potential uses impossible or more difficult?
 - Are there economic reasons that make some uses non-convenient, for example distance (transport costs), storage cost (including space and time), lack of companies that could use these parts, etc.?
 - Is this related to fragmentation of supply (i.e., the fact that these parts are generated by many fishing companies), or is cooperation well developed?
 - Could you please name the main areas where these parts are initially located, where the firms that transform them are mainly located, and where the users of their final products are located?

Innovations. *The Lowinfood project aims at testing innovative solutions against food waste, including both tools to actively reduce its amount and to make better use of unavoidable waste.*

20. Are you aware of any innovations that could help increase the value extracted from the parts that are currently not fully exploited? These innovations could social, managerial,

technical, etc.) which are yet being developed, or simply ideas you have to increase the value extracted.

21. Could you name/describe one or more? For example, we have read about fertilisers, cosmetics, keratin produced from fish shell, bones, etc.
22. Do you think that a B2B digital marketplace could help allocate fish parts and by-products to better uses?

By-catch.

23. Could you describe the type of bycatch currently landed, and if some is fit for human consumption?
24. Is this bycatch used to generate value for fishing companies, or are there any policies, or socioeconomic reasons hindering this route?
25. Are there any innovations or ideas in development that you are aware of to reduce bycatch, or to increase the value extracted from bycatch? Are any of your members using these innovations?
26. And if you could change the current regulations concerning bycatch, how would you change them?
27. Do you think that fishing companies would be willing to discuss the issue of by-catch issue with us?

Mortalities. *Our understanding is that they can only be used for anaerobic digestion, composting or landfill.*

28. Could you list potential uses of mortalities?
29. At which point(s) in the activity of fishing companies do mortalities mostly occur?
30. Are there any policy, economic, or social reasons that make some potential uses unfeasible?
31. Could you name any existing innovations to increase the value extracted from mortalities?

Supply and demand. *The Covid pandemic, Brexit and, last but not least, the war in Ukraine, have represented additional causes of waste because of the mismatch between supply and demand.*

32. What has been the effects of these events on waste creation in the Scottish fishing sector?
33. Are there any other systematic reasons of mismatch between supply and demand?
34. Are these fish surpluses currently recovered on a regular basis, e.g. by charitable organisations? Or are there any obstacles to donations?
35. And if it is not recovered, which are the potential and the most profitable uses?

Help for focus groups. *We would like to discuss some of these issues within focus groups with fishing companies. Would you be willing to help us get in touch with fishing companies to organise*

one focus groups of 6 to 8 participants? We would like to organise the focus group in a location which is easily accessible by the participants, however we can reimburse travel costs and pay organisation expenses such as venue hire and catering. Our idea is to discuss waste and under valorisation of catch in shellfish and demersal fish in two separate focus groups.

- 36. Do you think it is a good idea, or would you structure the discussions differently?
- 37. Which of the points touched in our discussion could be more interesting for fishermen to discuss during the focus groups?

Thank participant for their time. Leave them your contact details should they have further thoughts.

Explain what will happen next.

Remind them that we will anonymise the transcript and use the findings for our research...



Guideline for Germany (retranslated):

About your organisation

1. Could you please give us brief information about your organization?
2. What “place” does your organization have in the supply chain?
3. What do you have to do with food waste and losses? and Waste , FLW) and its reduction?

Definition of waste

4. How is waste defined in your organization, including avoidable and unavoidable waste?
5. Do you work with different levels of waste and its use (e.g. for indirect human consumption (aquaculture, animal feed), technical purposes, energy use, landfilling?

Places where FLW occurs: stages of the value chain and their interfaces

6. From your perspective, what are the main points of FLW along the different stages of the fish supply chain (at the stages or at the interfaces)?
7. Which of these stages can you give us some advice on FLW (reduction)?
8. What options can you think of to avoid FLW at the levels you are familiar with?
9. Where do you see opportunities for more efficient utilization of waste or by-products?
10. Where are the greatest economic losses and greatest opportunities concentrated?
11. Do you know any other experts for the levels mentioned?

Marketability

12. Are there fish species that are more prone to FLW?
13. Are there sections where FLW occurs more frequently?

Bycatch

14. Can you describe the type of bycatch currently landed and whether any of it is fit for human consumption?
15. What happens to bycatch that has to be landed and cannot be sold regularly (e.g. because bycatch quotas have already been exhausted)?
16. Is this bycatch used for value creation or are there political or socio-economic reasons that hinder this?
17. Do you think this bycatch is being used efficiently? Do you see potential for improvement?
18. Do you think regulations should be changed? And if you could change the current bycatch regulations, how would you change them?
19. Are there any innovations or ideas in development that you are aware of to increase the value of bycatch? Are you (or companies you know) using these innovations?

Parts to be removed during primary processing

20. Which cuts cannot be used for human consumption? Can you tell us the proportion of these sections (mass and/or value)?
21. Who removes the cuts?
22. How are different cuts used? From whom?
23. Are these cuts being used in a way that generates the most value possible, or are there other uses that could be more valuable but are not feasible for certain reasons?
24. What are the reasons for possible infeasibility?
 - Are there political regulations (and at what level – regional, German, EU/international) that make some potential uses impossible or more difficult?
 - Are there economic reasons that make some uses impractical, e.g. B. Distance (transportation costs), storage costs (including space and time), lack of companies that could use these parts, etc.?
 - Is this related to the fragmentation of supply (ie the fact that these parts are produced by many fishing companies) or is cooperation well developed?
 - Could you please name the main areas where these parts are originally located, where the companies that convert them are mainly located, and where the users of their end products are located?

Innovations

25. Do you know of any innovations that could help increase the value derived from the parts that are currently not fully utilized? These innovations can be social, managerial, technical, etc.).
26. Do you think a B2B digital marketplace could help put fish parts and by-products to better use?

Spoilage

27. Is spoilage an issue in the German fish supply chain? If so, at which stages of the chain, how much?
28. How could it be avoided?
29. Are there ways to put spoiled fish to good use?

Recycling options

30. Can you name/describe one or more? For example, we read about fertilizers, cosmetics, keratin from fish skins, bones, etc.

Supply and demand/ mismatch

31. Did or do events such as Covid, Brexit or the war in Ukraine have an impact on FLW in the German fish supply chain? If yes, can you please specify that?
32. Are there other systematic reasons for a mismatch between supply and demand?

- 33. Are any edible fish surpluses currently being used regularly, e.g. B. from non-profit organizations? Or are there barriers to donations?
- 34. And if they are not recycled, what are the (potentially) most profitable uses?
- 35. Do you think an innovation to exchange surpluses could help?

Dialog formats

- 36. Can you tell us something about existing dialogue formats (formats, topics, participants, intensity...)?

Focus group help

We would like to discuss some of these topics in focus groups with companies along the value chain (especially processing). Would you be willing to help us contact companies so we can organize a focus group with 6-8 participants?

- 37. Which of the points raised in our discussion might be of most interest to fish processors (and other companies along the value chain)?
- 38. Do you see any other topics related to FLW (reduction) that could be interesting for companies?

Annex 3: Various advertising materials

Clippings from some of the various articles/press releases in Scotland, as detailed in text in

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Researchers seek to unlock hidden opportunities in seafood supply chain

Editorial team

PUBLISHED Friday 12. April 2024 - 17:31

Researchers from the James Hutton Institute in Aberdeen are asking Scotland's seafood sector to help them identify why it may be missing out on realising the full value potential of its by-products.

Fish oil and fish meal are already being produced from by-products of the fishing and fish farming industries in Scotland but more unusual examples of by-products from other countries include extracting insulin from fish eyes, using fish skin for leather and even skin grafts, and using shellfish shells for land drainage.

The team of economic and social science researchers at the Hutton want members of the seafood sector to [take an online survey](#) to help them understand what the untapped potential of Scottish by-products might be.

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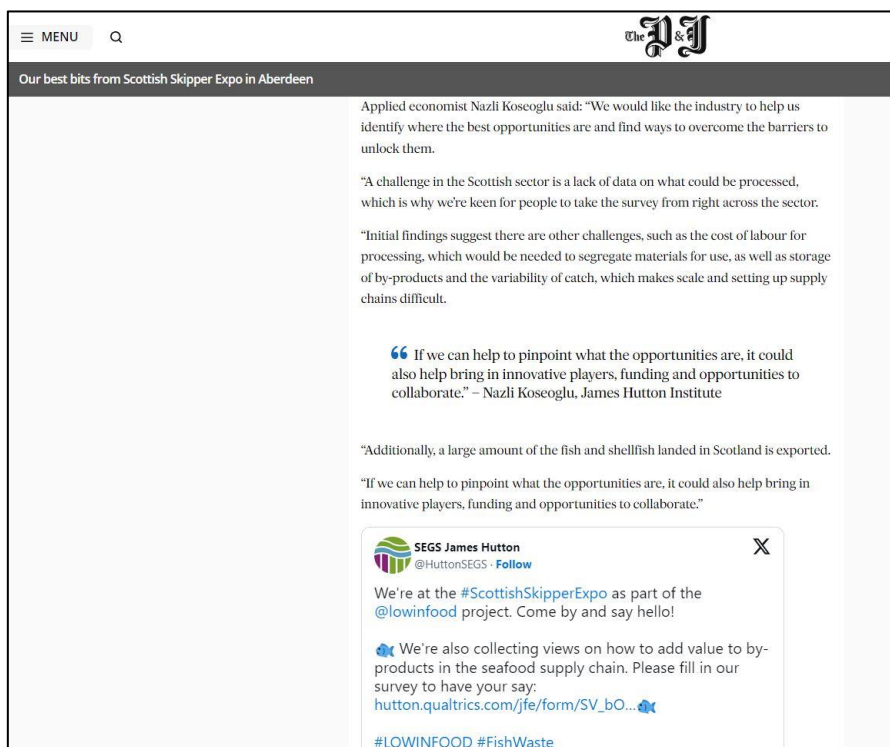
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Seafood industry input sought for by-product potential

Seeking to unlock the economic value of seafood by-products, Scottish researchers have called for industry input, with prizes available for participants.



Focus group/stakeholder workshop in Bremen, June 2023. Photograph: Melanie Schultz



Annex 4:

Sectorial practices in the UK retail sector

The World Wide Fund for Nature (WWF) UK Basket Outcomes and Measures

The WWF Basket sets out a series of Outcomes and Measures to support the goal of halving the environmental impacts of UK shopping baskets by 2030, and a Blueprint for Action, which outlines priority actions that WWF for retailers to address climate and nature impacts. WWF is working with a number of UK retailers to deliver on these outcomes and measures to meet the aim of halving the environmental impact of UK shopping baskets by 2030²³.

The Ocean Disclosure Project (ODP)

The ODP was launched in 2015 by Sustainable Fisheries Partnership as a reporting framework for seafood companies including retailers, suppliers, fish feed manufacturers and more, to voluntarily disclose their wild-caught seafood sourcing alongside information on the environmental performance of each source. The project started with the support and participation of three UK retailers, ASDA (the first company to report via the ODP), Morrisons and The Co-operative Food and currently six of major UK are members of the project²⁴.

The Courtauld Commitment 2030

²³ WWF Basket, 2024 [accessed on 31.07.24] <https://www.wwf.org.uk/wwf-basket>

²⁴ <https://oceandisclosureproject.org>

The Courtauld Commitment is a voluntary agreement set up by WRAP that promotes collaborative action throughout the United Kingdom's food chain to “deliver farm-to-fork reductions in food waste, greenhouse gas emissions and water stress that will help the UK food and drink sector achieve global environmental goals.” These goals are based on the United Nation's Sustainable Development Goals, for food waste this is goal 12.3: a 50% per capita reduction in food waste by 2030 (versus the United Kingdom's 2007 baseline). The delivery mechanism of the Courtauld Commitment 2030's food waste goals is the UK Food Waste Reduction Roadmap of WRAP²⁵.

²⁵ <https://wrap.org.uk/resources/guide/introduction-food-waste-reduction-roadmap-and-how-get-involved>

Annex 5: Industry survey script

Lowinfood WP4 Revalorisation Survey

Welcome and thank you for supporting our research efforts! We are warmly inviting you to complete a **survey about barriers and opportunities to adding values to biomaterials in the seafood supply chain**. This survey is conducted by a team of social scientists from **The James Hutton Institute** in Scotland (UK) and the **Institute of Sustainable Nutrition (iSuN)** in Germany, as a part of the European project LOWINFOOD, “Multi-actor design of low-waste food value chains through the demonstration of innovative solutions to reduce food loss and waste”. The survey has obtained ethical approval from the Institute of Sustainable Nutrition.

Filling out the survey is expected to take around **10 minutes**. You will be asked questions about major barriers to valorise unused material, needs for innovation, and opportunities to achieve the highest return from seafood products. Your participation is **voluntary**. We will not be able to identify you from your responses once the survey is submitted. For this reason, it will not be possible to locate and withdraw your responses after submission.

To thank you for your contribution, you are invited to take part in a **prize draw to win one of the five £50 gift cards** to spend in a store of your choice. If you would like to take part in the prize draw, please include your email at the end of the survey. Prizes will be drawn on 1st December 2024 and the winning entrants will be notified by email.

You can find more detailed information about the research project and how we will handle your data in the Information sheet and Privacy notice. If you have any questions at any time,



or would like to provide your feedback, please feel free to contact us at lowinfood@hutton.ac.uk or (+44) 01224 395399.

To proceed to the questionnaire, please tick both boxes below. If you do not want to proceed, simply close the webpage.

- ☐ I confirm that I have read and understood the above information about the study, and how the data I provide will be used thereby.

I agree to take part.

What does the company you work for or own do in the seafood supply chain? Please select all the relevant options.

- ☐ Fishing (e.g., fishing boats and trawlers)
- ☐ Processing (e.g., first buyer/primary processing such as filleting; secondary processing such as smoking, brining, pickling, canning)
- ☐ Distributor and other logistic enterprises (e.g., storage, transport, import and export companies and platforms)
- ☐ Port/harbour authority and/or auctions/fish market
- ☐ Fish mongering
- ☐ Retailer selling fresh and frozen fish products
- ☐ Food and hospitality service (e.g., restaurants, bars and cafes, workplace and other canteens, hotels and other commercial establishments serving food)
- ☐ Other (please explain in your own words) _____

What level does your job operate at within your organisation?

- ☐ Contract or temporary worker
- ☐ Permanent contract staff without managerial duties
- ☐ Department manager
- ☐ Executive level manager (e.g., Chief Operating Officer)

- ☐ Owner
- ☐ Retired owner
- ☐ Retired employee

To what extent do you engage with the loss and waste of materials resources in the Scottish seafood supply chain?

The Food and Agriculture Organisation of the United Nations (FAO) defines fish loss and waste as “fisheries and aquaculture products which are intended for human consumption but are ultimately not eaten or consumed by people, or that have incurred a reduction in quality”.

- ☐ I directly engage with material losses and waste (e.g., filleter)
- ☐ I indirectly engage with material losses and waste, i.e. I make company-level decisions about how waste and loss resources are handled
- ☐ I indirectly engage with material losses and waste, i.e. I make sector/national decisions about how waste and loss resources are handled
- ☐ I do not engage with material waste or losses in my role
- ☐ Not applicable (e.g., retired)
- ☐ Other (please specify) _____

Which of the options below best describes your gender?

- ☐ Female
- ☐ Male
- ☐ Prefer to self-describe _____
- ☐ Prefer not to say

What is your age group?

- ☐ 18-24
- ☐ 25-34
- ☐ 35-44
- ☐ 45-54
- ☐ 55-64
- ☐ 65-74
- ☐ 75 or more

Where do you live?

- ☐ Scotland
- ☐ Rest of UK (please specify) _____
- ☐ Germany
- ☐ International (please specify) _____

If you live in Scotland, please select your region.

- ☐ Aberdeen, Aberdeenshire, and Moray
- ☐ Highlands and Islands including Outer Hebrides
- ☐ Orkney and Shetland
- ☐ Another part of Scotland (please specify) _____

Below is a list of **challenges** to creating higher value from materials that are currently lost or wasted in the fish and seafood supply chain. Please **rank up to 5** challenges that you deem most relevant, from the most (1) to the fifth most serious one (5).

- _____ Unwanted catch (bycatch and discards)
- _____ Mismatch between available catch and customer demand
- _____ Structure of the fishing quotas being not flexible enough (e.g., delays in updates, single species)
- _____ Materials fit for human consumption lost in processing
- _____ Strict product standards of retailers and other buyers
- _____ High costs of storing, sorting, and transporting surplus or by-product materials to make their recovery profitable
- _____ Geographical distance from potential buyers of surplus materials
- _____ Other (please explain in your own words) _____

Below is a list of existing **interventions** (e.g., innovations and policy changes) to reduce or prevent the loss and waste of seafood resources. Please **rank up to 5** interventions that you deem most promising, from the most (1) to the fifth most (5) effective in terms of reducing and/or revalorising waste.

- _____ Innovations to monitor and reduce unwanted catch (bycatch and discards)
- _____ Allowing donations and non-commercial uses of bycatch
- _____ Innovations to balance supply and demand for seafood products (e.g., demand forecasting)
- _____ Policy and legislative change to reduce the cost of revalorising for businesses with small, irregular or geographically distant flow or surplus and byproduct materials
- _____ More precise processing machinery and more automation in processing
- _____ Product traceability software
- _____ Innovations to reduce the costs of cold-chain storage, sorting, and transport of surplus and waste materials
- _____ Creation of localised clusters between industry and innovators
- _____ Development of digital marketplaces to match buyers and sellers of surplus and waste materials
- _____ Social interventions (e.g., stakeholder dialogues establishing new relationships)
- _____ Other (please explain in your own words) _____

Below is a list of **opportunities** to create higher value from materials that are currently lost or wasted in the fish and seafood supply chain. Please **rank up to 5** opportunities

that you deem most relevant, from the largest (1) to the fifth largest (5) potential impact in terms of reducing and/or revalorising waste.

- _____ Improving the scientific understanding of real-time conditions of fishing grounds
- _____ Widening the range of seafood species demanded by UK consumers through promotional activities
- _____ Possibility to negotiate fishing quotas autonomously following Brexit
- _____ Developing blockchain and other technologies for better traceability in the seafood sector
- _____ Increasing automation and AI in the processing sector
- _____ Adopting social innovations to improve dialogue and trust between companies
- _____ Exploring international markets for innovative uses of high-value seafood material
- _____ Other (please explain in your own words) _____

What would an ideal intervention to create higher value from currently underutilised materials? Please explain in your own words. It does not need to be an existing intervention.

The findings from this research will be communicated to policymakers at national and European levels. **Is there anything else you want to add?**

Once ready, the report with the results of this study will be available at <https://lowinfood.eu/>. If you are interested in taking part in future events of the LOWINFOOD project, please send us an email at lowinfood@hutton.ac.uk. If you would like to take part in the **prize draw** to win one of the **five £50 gift cards**, please enter your email address here:

Many thanks for your time and input!