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Deliverable No. 6.5

DiscardLess

Strategies for the gradual elimination of discards in European fisheries

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Deliverable 6.5

Validation of final solution(s) for best use of unavoidable unwanted catches

(Month 36)

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[1] PU: Public, PP: Restricted to other programme participants (including the Commission Services), RE: Restricted to a group specified by the consortium (including the Commission Services), CO: Confidential, only for members of the consortium (including the Commission Services)

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Summary of D6.5. Validation of final solution(s) for best use of unavoidable unwanted catches.

This document is the fifth deliverable in work package six (WP6) of the DiscardLess project, which aims to contribute to the gradual elimination of the discards in the European fisheries, in agreement with the reformed Common Fisheries Policy of the EU and the implementation of the landing obligation (LO).

In previous deliverables different approaches have been evaluated to minimize the impact of the LO implementation. LO states that only UUC above Minimum Conservation Reference Size can be used for human consumption, but there is a need of designing new fish products while avoiding the promotion of the captures under MCRS and, at the same time, without affecting negatively the existing markets. All the other catches need to be properly managed, but their profitability must be subjected to the avoidance of incentivizing by-catches. At the same time, LO establishes that all species with TAC or MCRS have to be classified, quantified and landed. Each species has to be separated in different boxes, but also fishes under MCRS have to be separated as the LO states that their use for direct human consumption is not allowed.

All these constraints have been evaluated and solutions proposed for different case studies. These deliverable deals with the pilot validation of the proposed solution for the best uses of UUC.

Box 1: Report Highlights

There is a broad range of possibilities to valorise fish and fish compounds, however, not all the solutions are able to deal with the huge variability of the expected landings.

Maintaining the discards in the food chain by the commercialization of by-catches (subjected to legislation), when there is a reasonable amount of UUC above MCRS, the production of new fish products is always the preferred solutions. However, some of these solutions, despite being technically feasible at laboratory scale, might not be economically profitable at industrial scale. Hence, to reduce the risks linked to the industrial implementation of valorisation alternatives, it is important to perform pilot demonstrations to get more accurate data about technical, economic and market feasibilities.

Increasing fish consumption and global consumer trends in industrialized countries towards processed and ready to eat foods and motivations for healthier, convenient, natural and ethical products may lead to the development of many new successful products. The design of fish products must take in consideration the consumer preferences in analysed country.

Other options of less value can be also foreseen and evaluated such as products for industrial uses, the production of energy, composting or incineration, especially for all those parts that cannot be valorised for human food or animal feed. Landfilling UUC is the last option and should not be considered as a valorisation option.

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The methodology has been applied to two different scenarios or case studies: Bay of Biscay, and Iceland. In the case of Iceland, the results will be compared with current situation as the LO was implemented 1977 and will be used as a validation. The North Sea case study of evaluation of final solutions for the best use of UUC is primarily based on interviews and literature research.

Some fish species as mackerel, horse mackerel and blue whiting are considered very important for North-western Cantabrian Fishery in Spain. Due to their low commercial value their commercialization and consumption must be promoted by developing new seafood products or concepts.

The production of fishmeal and fish oil, that are used for animal feed (mainly for aquaculture), is the most common use of fish by-products and is a straight forward option for the treatment of UUC when there is an available facility nearby.

While in the Bay of Biscay, the valorisation of UUC for high value-added application is in its infancy, in Iceland this type of economic activity is already well established. However, there are still opportunities to increase the use and produce more valuable products from these materials. Furthermore, product development is constantly being worked on in R&D institutions, seafood companies and within start-up companies within the Biorefinery concept. As stated in D6.2, many of the processes of UUC valorisation can be obtained together in a biorefinery scheme, increasing the profitability and sustainability of the solutions.

Box 2: The methods/approaches followed

The pilot demonstration includes the UUC data updating, its management on board and in land in terms of required extra material and human resources due to LO and finally, the evaluation of valorisation alternatives with highest implementation potential. The pilot trials allow an accurate definition of the road map and subsequently, it might reduce the required time to market of developed UUC derived products and reduce the risks associated with the implementation of all these valorisation alternatives at large-scale.

In the case of Bay of Biscay, to facilitate the selection of the most suitable option, it is also included a methodology for the valorisation of alternatives with higher potential considering technical, economic and market aspects. Finally, it is also briefly defined the roles and partnership of public and private stakeholders' within UUC valorisation process.

With regards to Iceland study case, as valorisation of UUC is a well-established industry, the analysis has been focused on analysing the existing products and the scope for improving the sector by developing new products with even higher added-value.

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For the North Sea case study, the valorization of UUC has been addressed by engaging industry and UUC uptakers in interviews and by collecting data to assess the potential amount of UUC.

Finally, despite the differences existing in degree of developing among both regions, there are still important economic uncertainties. Thus, from the final pilot demonstration, it is expected to reduce such uncertainties making the overall UCC value-chain more sustainable, competitive and independent from public subsidies.

Box 3: How these results can be used and by who?

The results of pilot demonstration are key to design an accurate road map as any potential logistic or UUC processing setbacks emerge. Hence, a better knowledge of all these potential setbacks will contribute to reducing the economic risk of the adopted final UUC valorisation alternatives as well as estimating the required time to market of UUC origin final products. The validation of the Action Plan through pilot trials can be interesting for:

- Local companies: valorizators, processors and final UUC derived products sellers.
- Local administration bodies to develop integrated valorisation plans for discards.
- Policy makers to promote the implementation of selected strategies.

Box 4: Policy Recommendations

The results issued from these trials will allow validating the procedure for the in-land management of UUC with the objective of retaining the maximum value of these by-catches. The management system proposed, once validated, can be proposed as a best available approach for the management and use of UUC.

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Abbreviations	
BoB	Bay of Biscay
CFP	Common Fishery Policy
EU	European Union
FPC	Fish protein concentrate
FPH	Fish protein hydrolase
ICES	International Council for the Exploration of the Sea
LO	Landing Obligation
MCRS	Minimum Conservation Reference Size
NASBO	National Association of Small Boat Owners
RRM	Rest Raw Material
UUC	Unavoidable Unwanted Catches
WP	Work Package

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1 Introduction

The Common Fisheries Policy (CFP) of the European Commission introduced in 2013 a discard ban which states that all catches of species subjected to catch quotas and/or Minimum Conservation Reference Size (MCRS) will have to be landed and will be counted against quota.

The discard ban, or Landing Obligation (LO), is being gradually implemented, from 2015 to 2019 when all EU fisheries will be required to land all catches. Meanwhile, involved agents may explore and put into practice different strategies first, to minimize the discards and second, to find the most adequate uses for unavoidable unwanted catches (UUC) subjected to the landing obligation to prevent the impact that the LO may have in the harbours and local economies.

The work package six (WP6) of the DiscardLess project deals with the impacts and challenges that the new politics may cause in land. To evaluate and overcome the possible challenges, the following specific objectives are addressed in this WP:

1) Analysing the potential availability of UUC in specific harbours.
2) Evaluating most suitable uses of UUC.
3) Constructing an initial selection of potential uses and solution approach.
4) Ensuring traceability and market acceptance of the products resulting from UUC valorisation.
5) Obtaining a clear and convincing picture of the economic profile and the feasibility of the implementation of the proposed solutions.
6) Validating the solution proposed for best use of UUC by a pilot trial.

This current deliverable D6.5 deals with testing and validating of final solutions for best use of UUC chosen the different scenarios.

The methodology for the selection of best use of UUC was developed and applied in D6.2 to three different scenarios or case studies: Bay of Biscay (BoB), North Sea and Iceland. In the case of Iceland, the results were used to compare the results of the methodology with the actual situation, given that the LO has been implemented since 1977.

For the case study of BoB different issues are then to be considered in pilot studies after the preliminary results obtained with the proposed methodology in D6.2:

- General management in fishmeal facilities.
- Minced fish products for Mackerel.
- Fish protein hydrolysate for Hake.

As stated in the methodology, these results are preliminary and more detailed evaluation of the solution implementation must be performed to evaluate in detail their technical and economic viability. All the detail to validate the proposed solution have to be evaluated and pilot trial performed to detects all the inaccuracies. This deliverable aims thus to develop and implement such pilot trials. This deliverable was sent as a draft in March 2018 and now updated with the actual results of the pilot test that has been performed and the action plan defined upon its conclusions.

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Regarding the Icelandic case study, due to an early adoption of a LO in 1977, the fishery has developed in such a way that today there are hardly any catches that can be defined as UUC. When the LO was first implemented in the Icelandic fishery there were significant discards in place, but with a number of concurrent actions and a change in mentality the sector has progressed so that today all catches are regarded as raw material for valuable products (see deliverable D5.1). While reducing by-catches, the LO also promoted the development of a wide range of solution for a full valorisation of most elements of fish fractions. Today, there is a wide range of valorisation options that help minimise the possible effects of the landing obligation to the fishermen' economy.

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2 Bay of Biscay Case Study

To validate the proposed solutions for best use of UUC, a specific pilot trial was performed during 2018, considering infrastructure and technology needed on board and at land. The specific products to be produced for both animal feeding and human consumptions defined in task 6.3 (described in Deliverable 6.2) have been analysed in the complete management cycle under real operating conditions, from landing of the unwanted species to the destination for each valorisation planned.

The pilot trial includes the operations needed on board (classification, storage, preservation, from task 5.2) as well as operations at land. The pilot trial is focused on the offshore trawlers in the Bay of Biscay, and industrial partners relevant to fish meal and feed applications are also being involved. Critical points detected during the pilot trial were analysed, and when needed, corrective actions were implemented along the proposed valorisation and commercialization chains. The chosen solutions have been investigated to determine whether they are logistically practical and fit for the purpose. The different solution approaches for raw material were followed through the value chain from catch to products ranging from fish feed, valuable by-products to sophisticated consumer products. The methodology used is a direct result of the functionality of the tested logistic set up, followed by discussion of results with stakeholders in the value chain. Adjustments to the cost/benefit analysis were planned if needed to illustrate the potential of the suggested solutions.

2.1 Estimation of ex-discard quantities and management alternatives on board

For the estimation of the future landings of UUC data of deliverable 6.1 has been used bases on standard methodologies. Sampling procedure and the subsequent extrapolation of the discards are carried on according to the methodology agreed in "Workshop on Discard Sampling Methodology and Raising Procedures" (ICES, 2003) and in "Workshop on Discard Raising procedures" (ICES, 2007). Data are collected by observers on board by stratified sampling. It is important to note that sampling by observers involves a high cost and therefore, the sampling coverage is not as broad as might be expected in certain cases.

According to the FAO study, while the average discard percentage is 8 %, in the North-East Atlantic increases up to 13 %. This value shows very important variations depending on the fishing gear, the area and it can reach values up to 90 % in some extreme cases such as in the rod drag in the small Tagus estuary that extract sole and crangon.

The estimation of ex-discards indicates that quantities of whole fishes depend strongly on the fishing gear. The problem related to the minimum sizes is being tackled with selective fishing gear that

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minimizes these captures. Figure 1 shows the average and standard deviation of the estimated data of pelagic fleet discards estimated quarterly during the period 2011-2013. It can be observed that the available data show a great inter-annual variability as well as throughout the year.

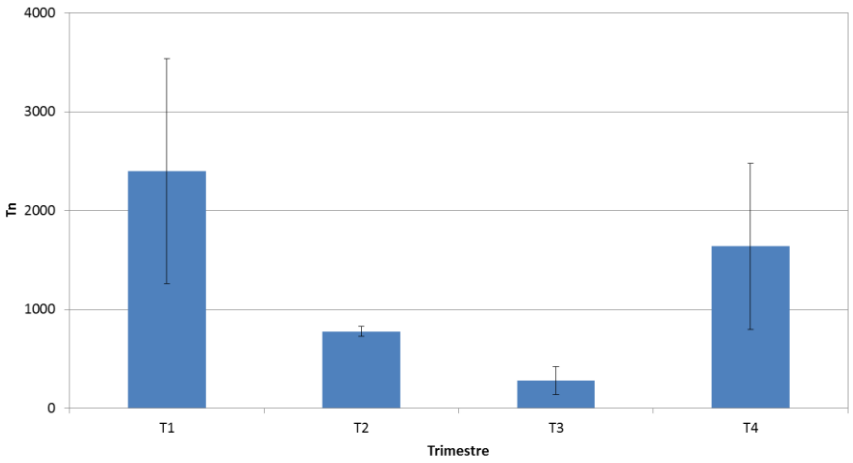

Figure 1. Discard data for the pelagic species for 2011-2013 period

Before the current CFP, the discards were mainly composed of fish species that once captured, were returned to the sea due to their small sizes, low value or excess in the quota. However, the adaptation to the new regulations by applying more selective fishing strategies and other strategies to minimize the accidental catches may expectedly produce a significant reduction.

The Basque's inshore fleet exploits mainly mackerel, bonito, anchovy, sardine, hake and tuna bighorn, using the several fishing techniques such as fence, live bait, longline, or gillnet. The trawling fleet in the Basque Country has as base ports Ondarroa and Pasajes. This fleet, which mainly exploits hake, monkfish and megrim, along with a wide range of other species, uses two types of trawl gear: simple trawl or baka, where a single vessel pulls the net and pair trawl, where two vessels drag the net.

The Baka trawl is used in western Ireland and in the Hebrides, as well as in the Bay of Biscay and performs in all cases a six days the trip. On the other hand, pair-trawling are used in the Bay of Biscay in a six-day trips and in the Cantabrian Sea in 24-hour trips.

The characterization results of these fractions allow to evaluate the technical feasibility of each fraction against the specific valorisation options.

More precisely the trial has been done with an OTD trawler fishing in the VIIIb.

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Figure 2. Baka trawler used for the pilot study.

Catch and discard data of the same ship fishing in the same area and same period of previous years are shown in Table 1. The values show an average catch of 20.000 kg and an average discard ratio of ~45 %. The main discarded species are Blue whiting, Hake, Horse mackerel, Mackerel and Rays.

Table 1: Discard data for the same ship in the same fishing and same period in previous years (R: kg of fish landed; D: kg of fish discarded.

	Sept. 16		Oct. 16		Sept. 17		Oct -17		Nov. 17	
Especie	R (kg)	D (kg)	R (kg)	D (kg)	R (kg)	D (kg)	R (kg)	D (kg)	R (kg)	D (kg)
Anchovy	0	1426	0	0	0	255	0	315	0	2
Anglerfish	774	0	7373	0	2643	0	4392	0	5137	0
Blue whiting	0	1234	0	1082	0	229	0	747	39	926
Boarfish	0	40	0	0	0	77	0	56	0	43
Hake	3108	5906	1430	656	4349	1123	2454	1105	2774	1109
Horse mackerel	0	3403	0	6731	57	2722	0	2126	0	2200
Mackerel	0	927	0	3308	0	67	21	788	0	1766
Megrim	1003	31	2274	29	860	8	1534	37	1517	123
Ray	0	1272	0	2238	0	596	0	2029	0	1197
Sole	142	0	127	0	60	0	5	0	29	0
Total	**5027**	**14239**	**11204**	**14044**	**7970**	**5077**	**8407**	**7203**	**9495**	**7365**

With this data, the logistics and infrestructures needed to process up to 7 tn of discards were put in place.

As stated previously the objective of the trial was to evaluate the production of fish pulps and fish hydrolisates (with several species) and the possibility to obtain a batch of fishmeal of a single specie.

2.2 Existing infrastructures analysis

All the existing infrastructures in ports, as well as in their surroundings, which may be exploitable for short-term management options were firstly evaluated in D6.1. The aim of this analysis is to evaluate their capacity considering the previous characterization (quantitative and qualitative) results and the potential uncertainties linked to rapid changes during the adaptation period to the new CFP.

This technological monitoring has been carried out on the main Basque ports where trawling and purse seine fleets disembark. The information has been organized to be crossed with the expected ex-discards in each port.

For this monitoring, once the preliminary data have been collected, some visits to ports, and meetings with major employer, shipowners, companies, etc. were performed to update the information and make the best decisions. A total of 4 ports (Bermeo, Ondarroa, Getaria and Hondarribia) have been inventiored. Data from Pasaia port, which is currently being re-organised, are from a 2013. Moreover, other facilities of Proyecto Ondarroa S.A. (POSA), the freezer plant of Bermeo, Bakaladera and BARNA S.A. as possible receptors/transformers of these unwanted catches have been also analyzed. Figure 2 shows the location of the all these infrastructures.

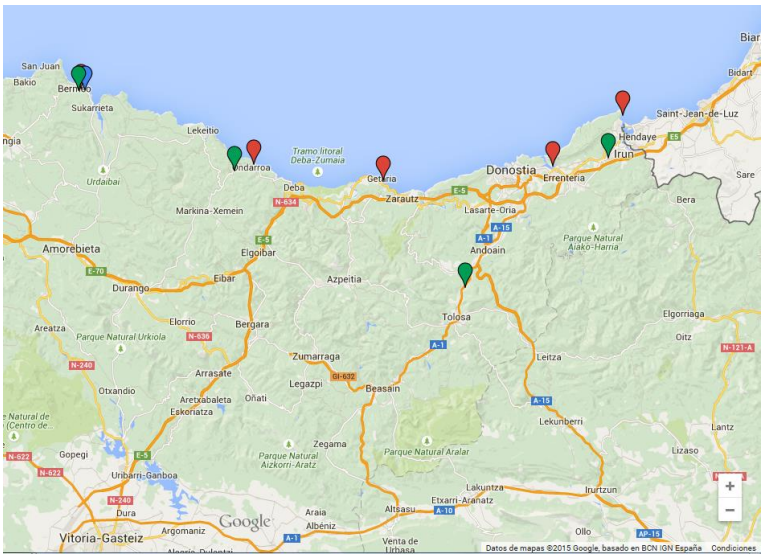

Figure 3. Main infrastructures in the Basque country

As aforementioned in the deliverable 6.1, the distance among the existing infrastructures and the logistic routes are expected to influence deeply the final economic profitability of valorisation alternatives. Hence, it is of utmost importance to optimize all the logistic routes, not only from ports to UUC valorizators, but also when distributing the final developed products to the sale points.

Another important point to highly, is that after the first movement in 2015-2016, where some refrigerated storages were placed in the harbours in prevision of discard landings due to the LO, any

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new infrastructure has been set-up. This is mainly due to the lack of UUC landings during the transition period.

2.3 Action Plan definition

The potential existing alternatives have been identified and evaluated to identify a short-term management solution for ex-discards (in D6.2). Different aspects have been considered and evaluated from the technical, economic, legal, market, environmental and social environment points of view. The final aim of this evaluation was to obtain a portfolio where at least 2 ~ 3 options may become viable solutions in the short-term. The most feasible options were analyzed in depth by making contacts with market agents, visits to interested/involved companies, searches on the internet, and so on. Finally, some *product sheets* were prepared for each alternative to regroup the most relevant information of each alternative.

In this previous work, described in D6.2, the feasibility of different management alternatives were considered. These valorisation alternatives are summarized in Table 2.
Considering the alternatives that allow the maximum volume use and productivity as well as absorbing smaller volumes from other less important species, the most feasible options selected in D6.2 were:

- Fish pulps.
- Fish meal and oil.
- Protein hydrolysates (to use as food ingredient and including peptones due to their similarity).

Considering the technical feasibility and the current availability of facilities, the most suitable and immediate options are the production of fish pulp as an ingredient or intermediate food product, and fishmeal and fish oil productions. Furthermore, the by-products generated by the pulping process are also suitable for being returned to fishmeal and fish oils manufacturers when their facilities are geographically close to each other. Another competitive advantage can be found in the evolution of the fishmeal and fish oils market prices comparing to other important sources of protein and oil used for human food and animal feed.

Once the action plans with the most valuation proposals are established, the pilot trial has been carried out to validate the "Action Plan" linked to the production of fish pulp for human food, fish meal and oil and finally, protein hydrolysates. These options, according to the preliminary data, seem to best options due to their highest economic value comparing to the other less value valorisation options (silage, compost, etc.).

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Table 2: Main valorisation options by categories for UUC

Category	Valorisation option
FOOD	New Fish products
	Surimi
	Fish pulp
BIO-PRODUCTS	Bioactive peptides
	Chitin / Chitosan
	Chondroitin sulphate
	Collagen
	Astaxanthin
	Fat-soluble vitamins
	Gelatine
	Hyaluronic acid
	Insulin
	Minerals
	Pearl essence
	Peptone
	Phospholipids
	Polyunsaturated fatty acids
	Protamine
	Enzymes
	Sterols
	Squalene
FEED	Fishmeal
	Fish oil
	Mink feed
	Marine beef / Bait
	Direct pig feed
	Protein concentrate
	Protein hydrolysate
	Silage
	Insects growth
INDUSTRIAL USES	Leather
	Fish oil
	Minerals
	Chitin / Chitosan
ENERGY	Biogas
	Biodiesel
AGRONOMIC USES	Fertilisers
	Compost

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2.4 Pilot validation of the Action Plan

The pilot validation of the Action Plan involves the following tasks:

- Discards data updating and characterization and measurement of the fishermen effort.
- Definition and sizing of the ex-discards recovery system on board.
- Organization of the operational work at sea.
- Organization and management of unloading and storage of ex-discards in ports.
- Organization and management of ex-discards transportation from the pier to the transformation zone.
- Organization of ex-discards valorisation tests.
- Information and training of all value-chain agents.
- Data collection and final evaluation of pilot demonstration.

At this stage, AZTI is in charge of contacting all the agents involved and also helping to gather all the human and material resources necessary for the pilot demonstration.

2.4.1 Discards data updating

Once the infrastructure and technologies on board and at land have been analyzed, the pilot experience has been carried out along the whole value-chain, from the fishing to the final valorisation of the ex-discard. All this involves the monitoring of a boat during a whole trip, the monitoring of the processing chain in port and finally, the ex-discards valorisation to obtain the final products.

Updating the information on discards volume and composition is of utmost importance to define the most appropriate valorisation options at land. This data update was done by two observers present during the six days trips during the month of October 2018. The delay in sampling works has been mainly due to the ship's tendering process and the long time required (around 6 months) to get the scientific fishing permit by French authorities. The landing of a small pelagic fisheries discards fraction, which include the species under landing obligation from 1 January 2015 (mackerel, herring, whiting, boarfish, anchovy, sardine and sprat), is chosen as the most representative. Once in harbour, all discards should be discharged by a clearly differentiated channel to avoid possible deviations. Currently, there are not available precise guidelines to make this differentiation.

Table 3 shows the results of the trial. Due to the modification of gears and strategies the total amount of catches was reduced by a 50 %. However, the discard ratio was reduced to a 20 % so the effective reduction of commercial fish was only about 15-20 %.

This changes in the amount of discard landed prevented us from being hable to obtain a batch of "discard" fishmeal, as a minimum of 3 tonnes are required.

On the other hand, the discards were all under MCRS and therefore should have been used for non-direct human consumption. With this aim, all the species has been processed to obtain fish hydrolysates for bein used as flavouring agent.

However, and only for research purposes, fish pulp of the different species under MRCS have been produced in other to evaluate their technical feasibility.

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Table 3: Comparison of catches and disard data of the trial (Oct.18) with results in previous trips.

	octubre-16		octubre-17		octubre-18	
Especie	Catch	Discards	Catch	Discards	Catch	Discards
Anchovy	0	-	315	100%	0	-
Anglerfish	7373	0%	4392	0%	3080	0%
Blue whiting	1082	100%	747	100%	2151	49%
Boarfish	0	-	56	100%	54	100%
Hake	2086	31%	3559	31%	1971	18%
Horse mackerel	6731	100%	2126	100%	525	20%
Mackerel	3308	100%	810	97%	11	100%
Megrim	2303	1%	1571	2%	1080	19%
Ray	2238	100%	2029	100%	519	13%
Sole	127	0%	5	0%	13	0%
Total	**25248**	**56%**	**15610**	**46%**	**9404**	**20%**

2.5 Organization of the operational work

2.5.1 Work on board

In accordance to the LO and CPF, commercial catches and discard should be quatified and stored on board separately and. New processing alternatives for the increasing fish handling due to LO were set up. All these new alternatives are being considered with regards to labour, process, and technological aspects. However, it is expected that technological and process solutions become a priority area as can be easily executed.

All the alternatives were agreed with fishemen and boat howner and contrasted with the sector as its support is key for the future implementation success.

For the trial, the standar process was minimaly modified, increasing the number of classification boxes and the number of fishermen per batch.

Discards were quantified and stored in standard boxes (10 or 20 kg per box) with a sticker that indicates "UUC". These boxes were stored in a differents cameras and refrigerated with ice in the same way as commercial fishes. The objective was to preserve the UUC quality with the aim of being able to recover the maximum value from them.

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2.5.2 Work during landing and in land.

During the landing, the boxes containing UUC have been kept separate and identified at any times. Although the discharge system is the same (on board elevator, and landing crane), a temporary separation is made, so that they are easily differentiated. The boxes containing UUC have been destined to a separate storage and clearly separated from fish to be commercialized for direct human consumption. In the UUC storage, the unwanted catches have been kept under refrigeration using the same methodology as for the rest of the fish in order to keep its properties and quality to the maximum.

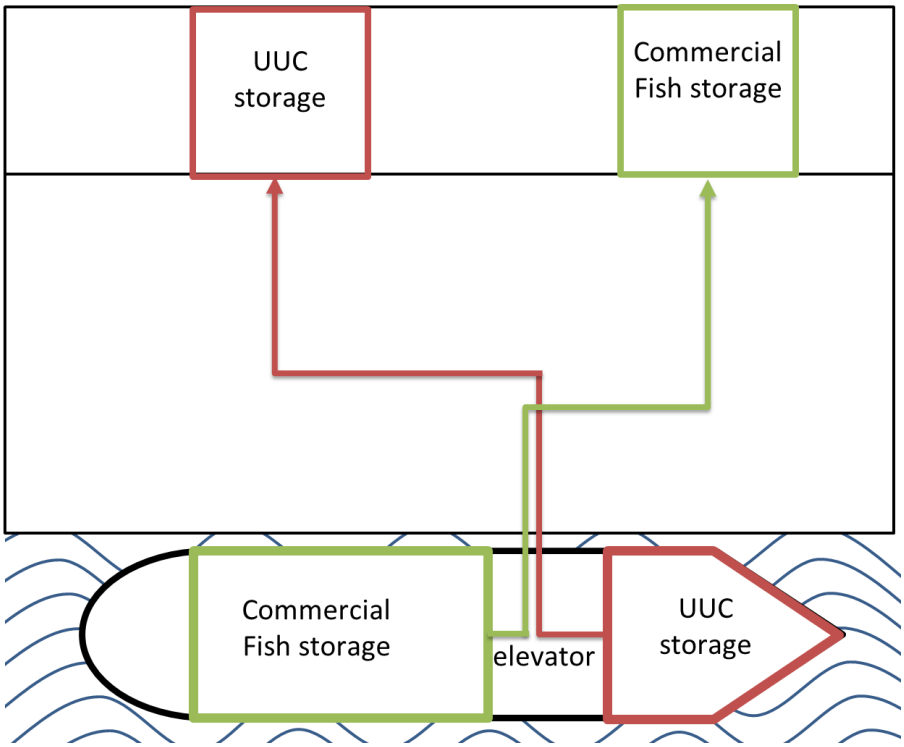

Figure 4. Scheme of the movement of the different fractions during the landing.

In order to transport the unwanted catch, the most convenient schedule was agreed with the ship's owner, avoiding a possible excess of truck traffic by separating the commercial fish collection and the unwanted catch in time. For this reason, it was agreed that transportation of the unwanted catch would take place after 12 noon on Monday, time for which the activity of the port usually decreases.

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Figure 5. UUC transport destined to the production of food products.

Two different transport were envisaged previously, one for the fractions destined to food processes (products and/or ingredients) and another for the production of fishmeal and fish oil. The truck for food products (Figure 5) was refrigerated and in compliance with the food rules.

For the production of fishmeal, a transport in bulk was prepared. However, due to the low amount of UUC landed all the catches were diverted to food products.

Once in the processing facilities, UUC that were stored in refrigeration to be processed withing 24 hours, or congelated to be stored for longer periods.

2.5.3 Documents for discards traceability monitoring

The required documents for traceability monitoring in the pilot demonstration can be divided according to the different phases of the chosen valorisation option. In general, these documents should be linked to:

- Reception of discards in ports:
  - A protocol for traceability and quality control (annex 1) that includes the following information:
    - Type of discard.
    - Origin of discards' suppliers.
    - Date.
    - Discards reception conditions.
    - When proceeding, a batch number will be assigned.

- Transport of discards to the valorisation plant:
  - A document where the total amount of transported discards is registered record of (annex 2). This document should contain the following information:
    - Type and amounts of discards that are transported.
    - Transport origin.

        - Transportation date.
        - Identification of destination.
        - Cleaning conditions of the truck.

- Processing in valorisation plant:
    - The protocol for traceability and quality control (annex 1).

- Storage and packaging of final products (annex 3):
    - Labels for correct identification of final products with the following information:
        - Name of product and composition.
        - Packing format (size and conditions).
        - Production date.
        - Expiration date.
        - Batch number.

2.6 Ex-discard characterization

The unwanted fishing fractions are assessed in a systematized and detailed manner. This has been done considering parameters such as the type of fishery, landing port, quantities, etc.

Analytical studies are also carried out of the basic characterization parameters of these fractions to determine their potential land use. Hence, there is a quantitative and qualitative inventory of the ex-discards in the different ports, which allow to evaluate more precisely the valorisation options of each fraction as well as maximizing the value obtained from those fractions.

2.6.1 Physico-chemical and biological characterization of ex-discards

Based on the final application and legislative and technical requirements of the different valorisation options, different physical-chemical and microbiological analysis have been selected.

Once the fractions of interest have been selected for their valorisation, a sampling protocol has been established and carried out. The aim of this protocol is to guarantee the representativeness of the collected samples with regards to the total fraction. However, it should be considered that fractions composed of UUC have a very heterogeneous composition.

2.7 Discards valorisation management alternatives

The preliminary data of pilot demonstration is expected to support the hypothesis that production of multi-species fish pulp and fish meal and oil seem the best short-term solutions, not least considering the variability and uncertainty in future quantities of landed discards. Previous tests performed by AZTI showed that multi-species fish pulp has good technological and organoleptic properties to be sold as food ingredient. However, the main problem of these type of pulps is the impossibility to guarantee a continuous homogeneous composition, nutritional value and sensory quality. This fact might produce variations in the organoleptic acceptance of the final product despite its high nutritional and culinary value. Hence, when the quantity of each species reaches the required minimum critical mass, the production of mono-species fish pulp (mackerel, horse mackerel, sardine and whiting) might be considered for replication. Previous studies have already demonstrated much better results for mono-

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species fish pulp. Therefore, this option is firstly chosen and secondly, only species of similar characteristics might be mixed to maintain as far as possible the organoleptic homogeneity. All the unwanted catches that cannot be processed due to their small size (12-15 cm) will be sent together with fish-pulp production by-products for fish meal and oil production. Figure 3 shows an examples of raw multi-species fish pulp and of a final product from such pulps:

Figure 6. Raw multi-species fish pulp and hamburgers developed from UUC in AZTI

Regardless the valorisation alternative, a key point to guarantee the Action Plan long-term sustainability is its economic feasibility. Hence, it is key to analyse all the strategies that could increase the profitability of the valorisation alternative. Within this framework, the reduction of processing costs linked to energy consumption by using any potential surplus heat or cooling produced by other type of industries could help to get a more competitive sector. The use of renewable energies to increase or decrease the processing temperature of the product will decrease the fuel consumption and the dependence over non-sustainable energy sources. Moreover, in some cases, if the critical mass is not sufficiently high, geographical boundaries of the study area will be analysed to achieve such critical mass. Finally, search of new markets might emerge as of utmost importance to get more economic value depending on the valorisation alternative.

Considering the existing infrastructures and valorizators in the Basque Country, apart from fish pulp production, fish meal and oil and protein hydrolysates production seem to be the best alternatives for ex-discards valorisation. Hence, the Action Plan for these three valorisation alternatives have been developed as shown below:

2.7.1 Alternative 1: Fish pulp production

The supplier, the carrier and the processing plant, when using discards for human consumption, should be registered in the *General Sanitary Register of food companies* according to the general principles of food legislation, which are regulated by the articles 5 to 10 in the Regulation (EU) 178/2002 and by the European Council on 28 January 2002. These regulations establish the principles and the general requirements of food legislation, the creation of the European Food Safety Authority and the procedures relating to food security. The proposed Action Plan to use discards as a raw material fo r fish pulp production can be summarized as follows:

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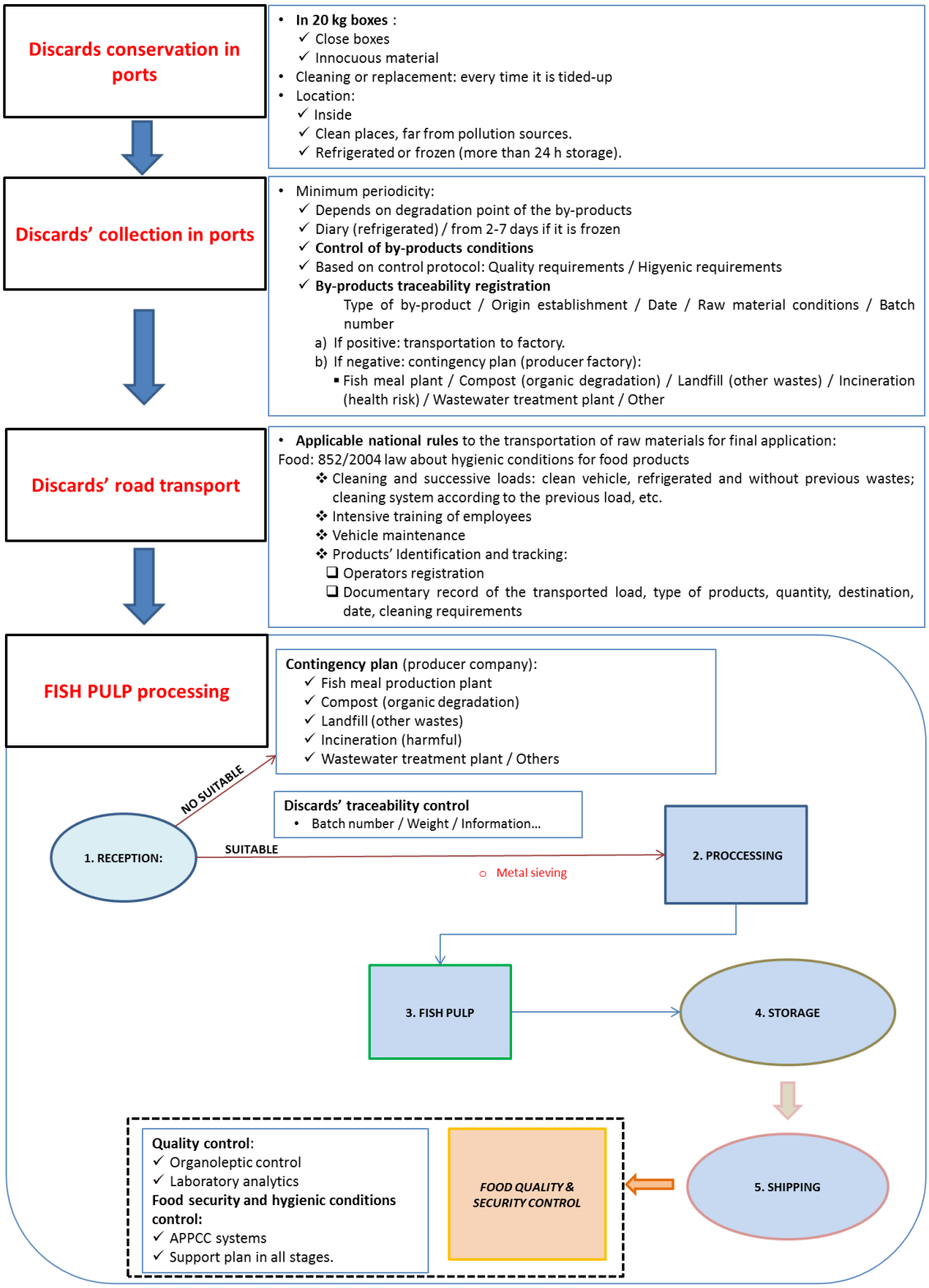

Figure 7. Action Plan for discards valorisation as fish pulp

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Most of the UUC landed during this pilot were under MCRS. Although UUC under MCRS can not be used for direct human consumption, several tests have been carried out to obtain new products in order to verify the technical and economic viability of the process with small size specimens since it is one of the valorisation options of greater value.

The species evaluated have been boardfish, blue whiting, horse mackerel, megrim and hake, both in obtaining pulp and in its subsequent processed to obtain products.

First, the fish were eviscerated (elimination of viscera and heads) to avoid its degradation and then frozen. These viscera and heads can be used for the production of fishmeal or the production of silage.

Figure 8. Cleaned fraction and by-products of boardfish, megrim, blue withing and horse mackerel

The fish, once eviscerated, have been vacuum packed and frozen until further processed.

The extraction of pulps is done by using a BAADER, a system able to separate the flesh of the fish from the skin and scales. These skins and spines, as happened with the heads and viscera can be sent for the production of fishmeal. They could also join with the viscera and heads for the production of silage.

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Figure 9. Baader equipment for obtaining fish pulps

The yield of the pulp production process is very variable and depend on the fish specy and on the size of the fish.

Table 4: Yiel of fish pulp production

	Boardfish	Blue whiting	Horse mackerel	Megrim	Hake
Fresh fish weight (kg)	23	62	43	49	46
Ungutted and beheaded fish (kg)	12	43	28	33	34
Fish pulpg	8,2	33,9	19,1	25,5	27,1
Pulp yield	71 %	87 %	76 %	78 %	81 %
Process yield	36 %	55 %	44 %	52 %	58 %

The fish pulps can be further processed to eliminate partial or totally the colour. However, for this trial the objective was to retain as many natural properties as possible, so the products developed where based on raw fish pulp.

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Figure 10. Fish pulps

Table 5: Fish pulp production nutritional composition

Description	Moisture (%)	Ash (%)	Protein (%)	Fat (%)
Megrim	80,00	0,86	18,09	0,61
Blue withing	78,11	0,22	20,34	0,84
Boarfish	77,37	0,49	17,67	3,81
Hake	78,6	1,16	18,99	0,71
Horse mackerel	76,25	1,09	18,39	3,75
Ray	78,76	0,54	19,4	0,84

Several preparations with different shapes (fish-stick, fish balls, burguer fish, sausages…) with and flavour (Mediterranean, thai, shellfish…) formulation were tested (Figure 11).

The results were results were very favourable and the sensorial analysis gave a positive acceptance of the obtained products.

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Figure 11. Fish products

Also, several tests were performed to evaluate the feasibility of using fish in 3D-food printing machine. With this aim, fish pulp was further processed and refined to obtain homogeneous fish paste and tested in a commercial equipment.

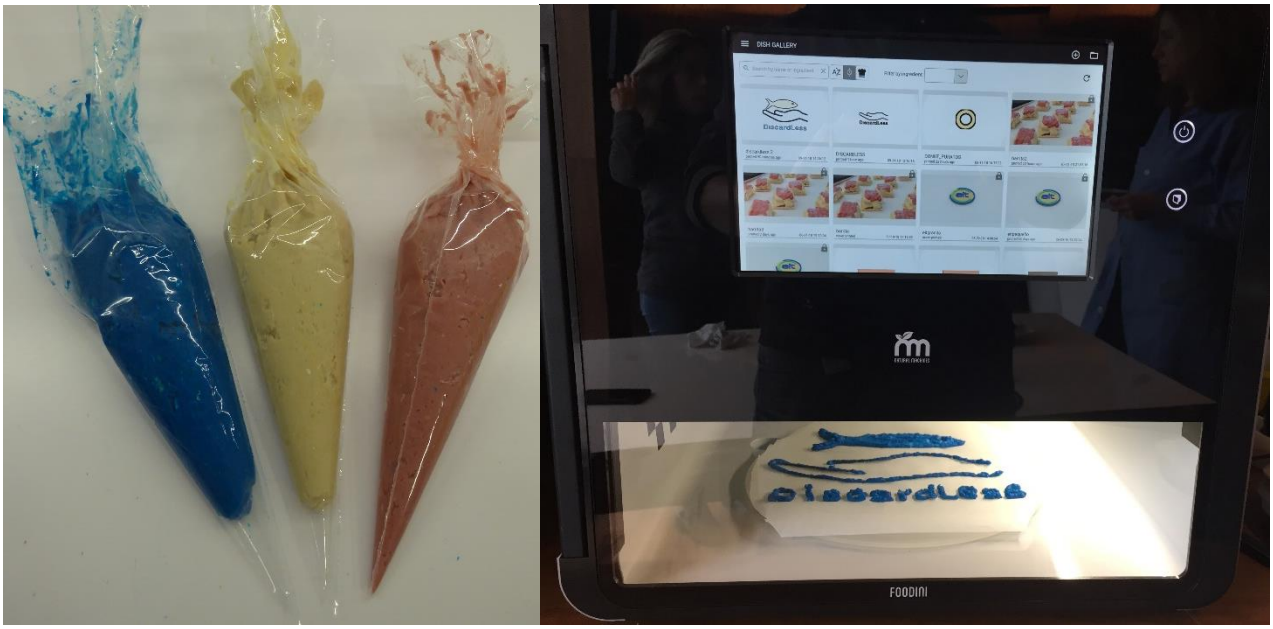

Figure 12. Coloured fish-paste for 3D food printing

While some interesting results were obtained the production of fish products through 3D printing needs further studies and development to be brought to general public.

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2.7.2 Alternative 2: Protein hydrolysates

The supplier, the carrier and the processing plant, when using discards for human consumption, should be registered in the *General Sanitary Register of food companies* according to the general principles of food legislation. The proposed Action Plan for using the discards as a raw material for protein hydrolysates is:

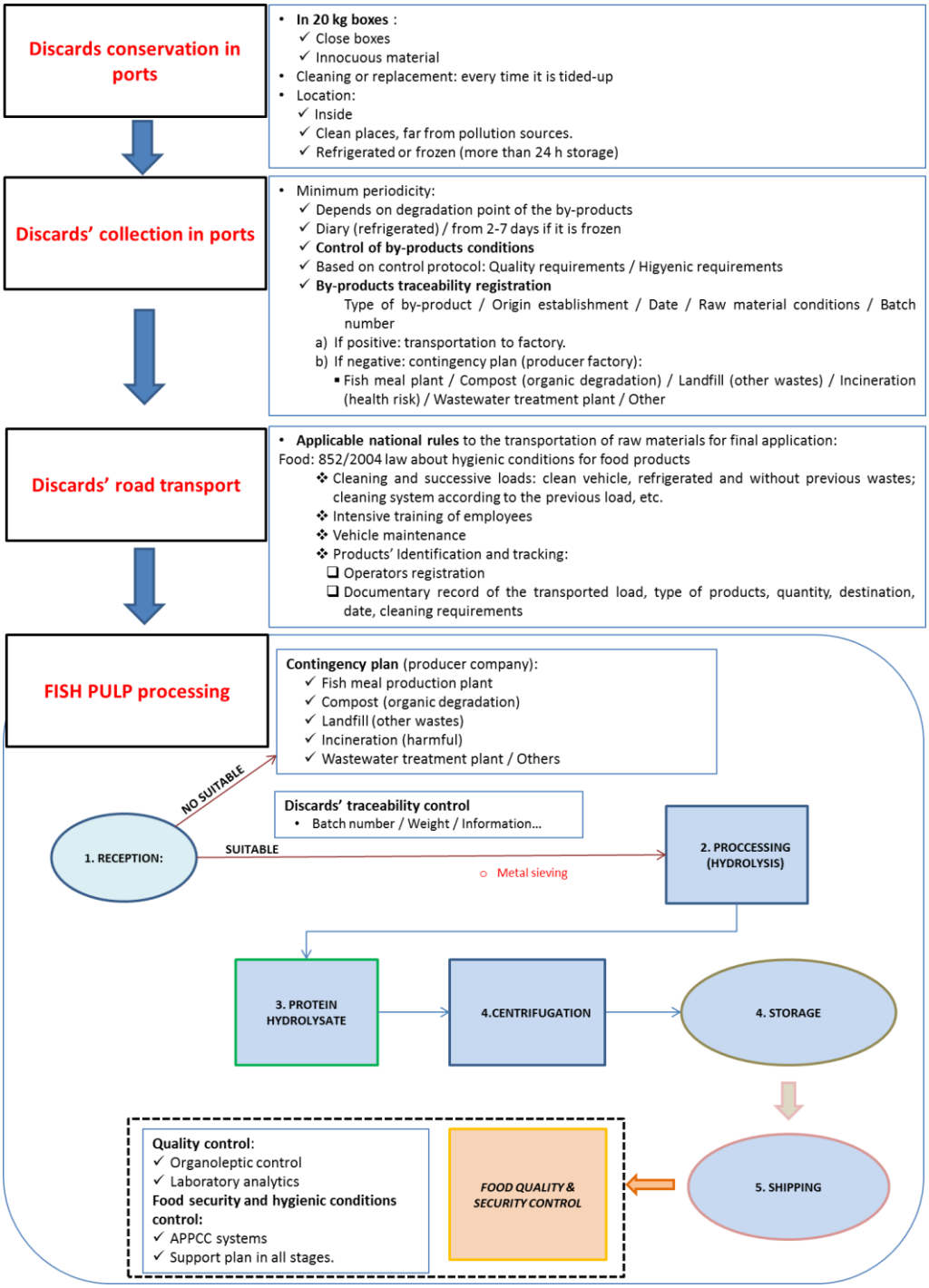

Figure 13. Action Plan for discards valorisation as protein hydrolysate

During the trial the objective was to evaluate the production of flavouring agent from the fish discards. These products are produced from a controlled hydrolysis process as shown in Figure 14.

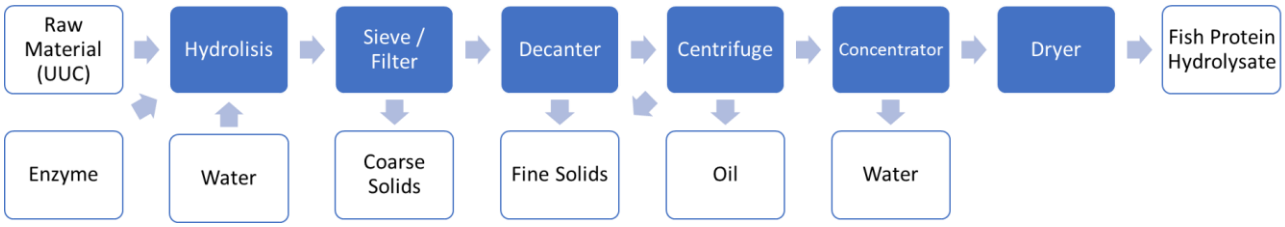

Figure 14. Simplified fish protein hydrolysate production scheme

For the test a pilot plan for protein hydrolysate production was used. It's composed by a 250 litres stirred reactor. The hydrolysis process was carried out using commercial food grade enzymes designed for the production of flavouring agents. Enzymatic reactions were thermally inactivated after the process.

The reactor content was then unloaded trough a 1 mm vibrating sieve to remove coarse solids such as bones and scales. The resulting product is pumped to a decanter to remove small solids and the liquid fraction is further centrifugated to remove the oil content of the mix.

The oily fraction is a valuable compound that can be sell for different purposes. Also, solid fractions can be sold to get different valuable products. As less valuable solution all the by-products of this process can be sent to a fishmeal producer.

Figure 15. Pilot Plant used in the fish protein hydrolysate trials

Once the oil is removed different strategies can be followed to get different final products.

The liquid fraction can be further processed by membrane filtration to remove some undesired fraction if present, or to fractionate the hydrolysate if a special functionality is seeked. This fraction can also be

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concentrated, this step can be done by vacuum concentrator or membrane process. In this trial we used vacuum concentration to avoid any product loss.

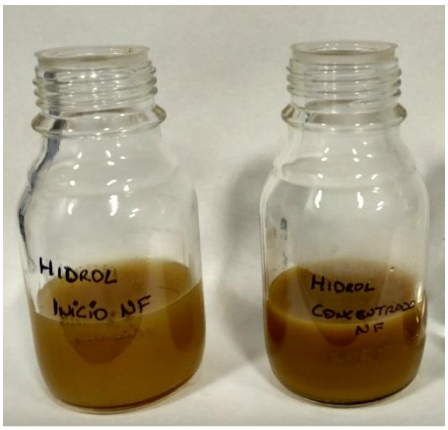

Figure 16. Fish protein hydrolysate before (left) and after (right) concentration

Finally, the product can be used as a concentrate or dried up to a powder. For this trial the products were spray dryer.

2.7.3 Alternative 3: Fish meal and oil production

In this case, the supplier, the carrier and the processing plant, when using discards for animal feed should be registered in the *General Register of Animal feeding producers.* The proposed Action Plan for using the discards as a raw material for fish meal and oil production is summarized in Figure 17.
Previous to the trial the objective set was to produce a batch of fishmeal and fish oil only from UUC, and even if possible, from a single specie to evaluate the differences in the products obtained.
Due to the low amount of UUC obtained the trial was suspended, and small quantities of UUC and by-products of the other trials (fish pulp, and hydrolysate) were rendered in an industrial fishmeal plant. Any impact in the product quality was detected.
As the production of fish meal

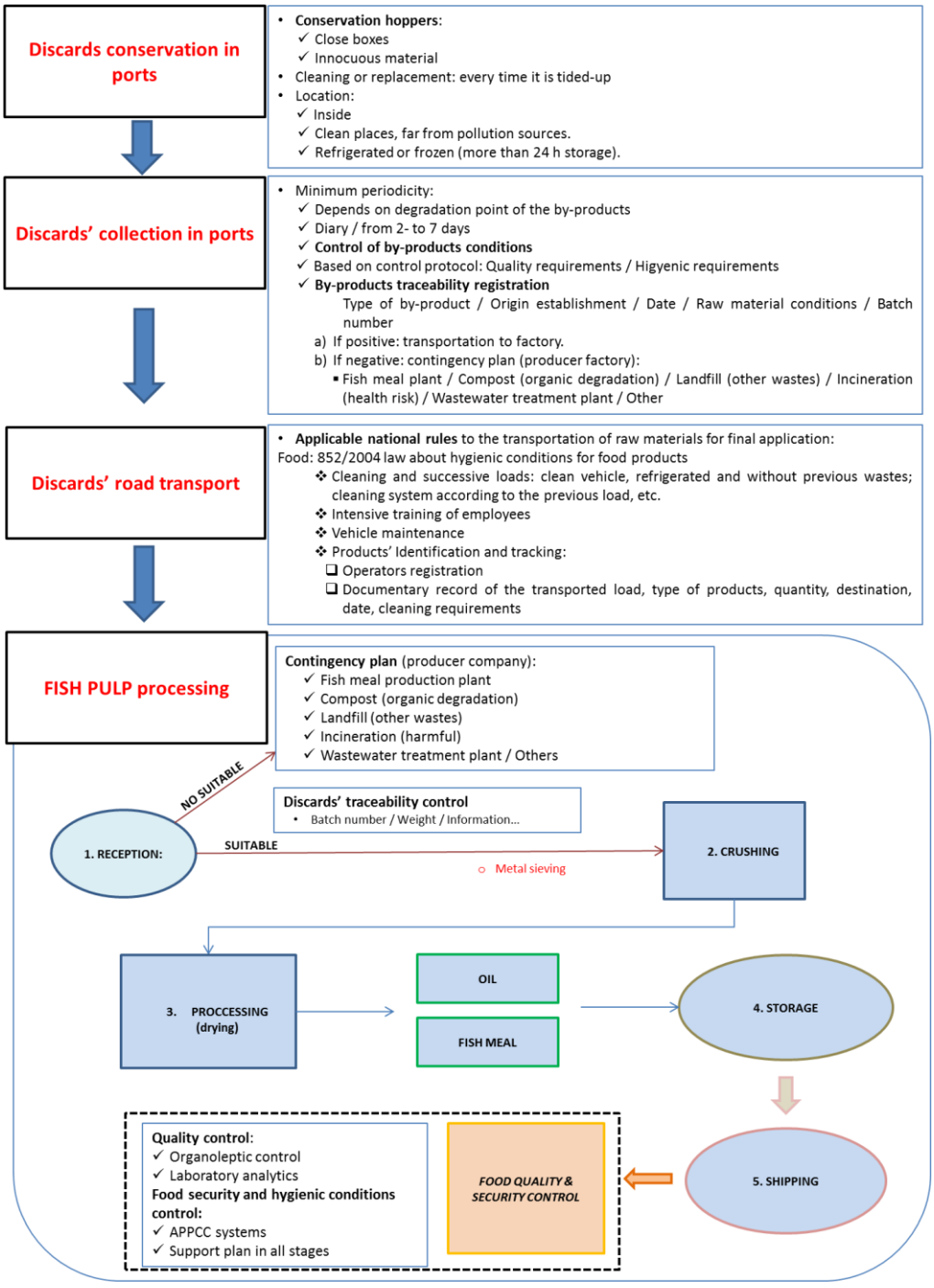

Figure 17. Action Plan for discards valorisation as fish meal and oil

2.8 Road Map

Once the most optimum short-term valorisation option is chosen, the following step is to establish the road map for its implementation. As indicated above, the ex-discards are preferably will be transformed to fish pulp for human food applications. The main points of the road map are:

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- A proposal to include in an official European control plan the ex-discards management plan.
- A review of CFP to promote the inclusion of fish pulp production in the list of recovery options for all ex-discards fractions.
- An agreement, where the work scheme is defined, should be signed between fishermen's guild and the processing plant.
- Economic profitability strategies to reduce logistics' and processing costs, which will help to guarantee the economic feasibility of the process.
- Public-private financing model to assure the self-sustainability of the valorisation activity without incentivizing the ex-discards' fishing.
- Awareness and training.
- Timetable to implement the agreed Action Plan.

This roadmap should be presented to the different public-private agents to be discussed and approved and, if applicable, the necessary steps for its implementation will be also defined. Finally, to achieve the adaptation of the fleet and the ports to the new PPC, it is necessary to hold meetings with sectorial stakeholders' and with public administrations to agree the most appropriate system.

Regarding to **local, regional, national and EU authorities**, their main roles should be:

- Development and implementation of strategic and sectoral plans, as well as the required UCC data updates with the aim of carry on promoting the valorisation of UUC.
- Development and implementation of investment programs for facilities and equipment acquisition, as well as management of business programmes to improve the competitiveness of the sector.
- Promotion of awareness campaigns focused mainly on shipowners and final consumers.

For successful implementation of the road map it is very important to outline the need of an active collaboration between the public administration and private stakeholders involved in the chain-value.

With regards to the private stakeholders, the **shipowners** (ex-discards producers) should provide the required human and material resources to fulfil the specifications defined in the Action Plan: conservation chambers and boxes, storage space on board for the incoming discards, personnel and finally, the compulsory hygienic conditions on board. All the required material will be sized according to the dimensions of the ship. All these duties must be specified in a contract signed among the shipowners and discards' management company

The **discard's management company** will guarantee the collection of discards according to the time-schedule with shipowners to minimize as much as possible the disturbances caused by this activity in the shipowners' day to day business. Additionally, the development of a contingency plan is necessary to manage all the discards that are not suitable for the chosen valorisation alternative. All the human and material resources for this contingency plan execution should be provided by the discards' management company. Finally, if the management company is also the final producer of discards' origin products, it should meet the products' specifications defined by the final product's buyer.

Regarding to the **ex-discard products' buyer**, they should be compromised to maintain the previously agreed market prices, supply quantities and periodicity, nutritional quality, etc. All these obligations

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should be reflected again in a contract signed by the management company and the UUC derived products' buyer.

2.9 Conclusions

The pilot validation of defined Action Plan for ex-discards is being performed on board and in land. The main tasks on board are the ex-discard data updating and the measurement of fishermen metabolic effort to quantify the extra effort linked to the ex-discards management. The collection of all these data allows to define more accurately the technological and process solutions that can be implemented on board for ex-discards management. Thus, to assure success in the implementation, all the actions should be agreed with shipowners.

Regarding discards' landing, the pilot demonstration in conjunction with the existing infrastructure analysis will allow the valorisation process definition (space requirements, equipment definition and sizing) as well as stablishing all the working protocols and the required human resources. From the validation of the action plans through pilot trial, a definitive road map will be developed for each main valorisation alternatives.

As the UUC products will be intended mainly for human food and animal feed, the traceability of all these products will be performed according to the EU regulations. Finally, the own sustainability of the ex-discards valorisation business will require public-private collaboration agreements among the different chain-value agents to achieve the technical, economic, environmental and market goals.

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3 North Sea Case Study

3.1 UUC species handling at Port of Hanstholm

In 2017, the Port of Hanstholm established facilities for storage and delivery of fish which would have been discarded. The storage facility was established in a separate area not connected to the area used for fish auction.

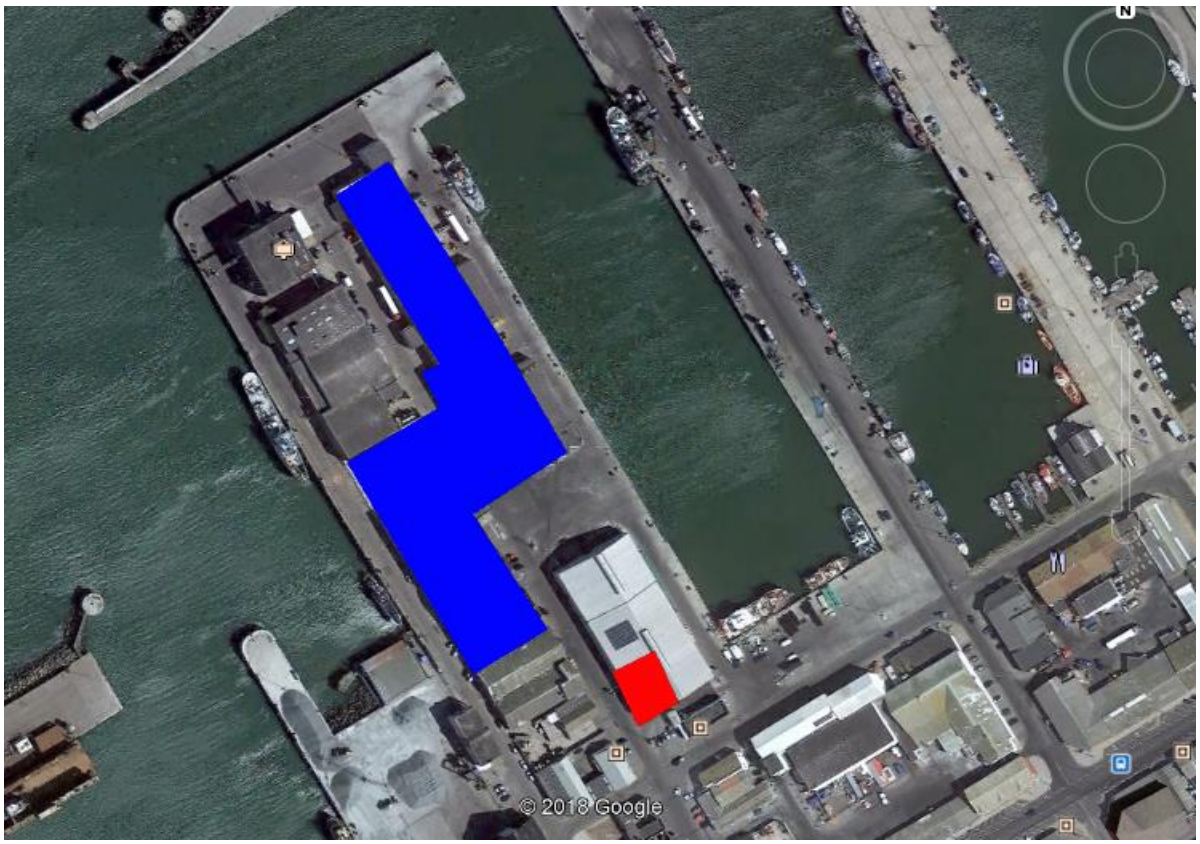

Figure 18. UUC storage facility marked in red and fish auction facility market in blue, Port of Hanstholm. Courtesy of Port of Hansholm

The room is located separately from the auction halls and the logistic services moving from there. The intention is that fish stored in the room are to be collected early in the day, allowing for the fish to be processed in the beginning of production. During this time, the auction will typically have begun and the handover of fish to companies and vehicles commenced, which makes it necessary for UUC species not to be handled in the auction building. In Figure 19, the discard storage is depicted. As can be seen in the picture, the current use of the room as of 2018 is the storing of fishing boxes in need of cleaning. The reasons for this is that no need has yet been necessary for the original intend with the room.

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Figure 19. UUC storage room layout and current usage

3.2 Usage of UUC at Port of Hanstholm

UUC fish are currently handled by the company E. Grønkjær Fiskeeksport A/S. The company typically collect the fish in tubs at the ports two fish collectors[2]. Forklifts are used for collection and transport of crates as the amount of UUC is relatively minute.

Together with fish wastage from fish processesor's in the area, the UUC fish is transported to the company Dansk Pelsdyr Foder A/S in Holstebro. Just like the fishers, this company has an interest in an increased usage of the UUC fish, as the payment for UUC fish is at the same level as industrial fish. It should be noted that the production facilities for feed production to the fur industry can take up UUC fish for production all year, unlike the fishmeal production facilities in Hanstholm which only operate from April to October. The rest of the year the industrial fish is transported to Skagen in lorries, approx. 180 km.

[2] A fish collector is a specific Danish activity which recieve the landed fish and then sort these according to size and quality.

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3.3 Possible usage of UUC catches

There is a whole suite of possible usages of UUC species but not all are feasible from an economic perspective.

UUC catches cannot be used directly as human consumption but has to be treated according to a number of regulations in order to suffice as part of products intended for human consumption. Such applications are if UUC were to be used for dietary supplements e.g. as protein or fish oil. Such processing and treatment will allow for the UUC material to be used as human consumption in specific products although not directly as whole or parted fish.

Using UUC catches for non-human consumption is likely to be the most widespread usage and covers several possible applications such as animal feed, fishmeal, bait, feed for the fur industry and even cosmetics, fertilizer and biogas production.

It is still unresolved how high a level of treatment is required by regulation before UUC catches can be used for human consumption. Accordingly, it cannot be said for sure whether usage of UUC catches for soups or broth will be acceptable.

Table 6 show a number of possible UUC usages divided by four overall categories

Table 6: Possible usages of fish resources

Non-human consumption • Feed and nutrients	• Fishmeal for aquaculture and other animal feeds • Fish oil for animal feed, including pet food • Feed for fur (mainly mink) • Bait • Silage and compost •
Non-human consumption • Non nutrient usages	• Extraction of chitin and chitosan • Pigments • Enzymes • Pharmaceuticals: cosmetics and chemicals •

Indirect human consumption	• Dietary supplements such as:
	  ○ Fish oil (OMEGA 3 and 6)
	  ○ Proteins

Others	• Collagen • Gelatine
Source: Inspiration from SeaFish 2001: Fish Waste Production in the UK	

Using UUC for silage offers the possibility of production on the actual fishing vessels as well as ashore. Silage production ashore require icing of the UUC on the fishing vessels in order to decrease decay before the beginning of the silage process. Production is done by chopping the fish into smaller bits and adding hydrochloric acid or formic acid to preserve the fish. Production facilities for fishmeal would typically be able to take in silage and process the product further in order to produce fishmeal or fish oil. Companies like TripleNine produce a range of fishmeal products which are used as animal feed for

pigs, aquaculture or mink in the fur industry. Additionally, silage may be bought directly by the consumer, for instance a mink farm, who then mix the silage with other feed products on site.

3.4 The most likely usage of UUC

The actual potential usage of UUC is governed by the circumstances under which the fish is landed and processed. Several aspects influence the potential usage of UUC:

- Geographical placement of landing site
- Food processing industry available in the area
- Distance to potential users such as up takers of animal feed
- Necessary logistics and the facilities available for handling of UUC

Additionally, the potential price any consumers are willing to pay and what other alternative sources they have is of great importance. Using UUC as fishmeal or fish oil as well as for fur feed result in specific price ranges which cannot be exceeded. This mean the UUC catch must have very specific qualities in if it is to exceed the price possible to obtain for industrial fish.

Figure 20 show the trend in prices for industrial fish landings from 2009 to 2018. This gives an indication of the expected price level for UUC catches. Values on x-axis are years, values on y-axis is DKK/kg.

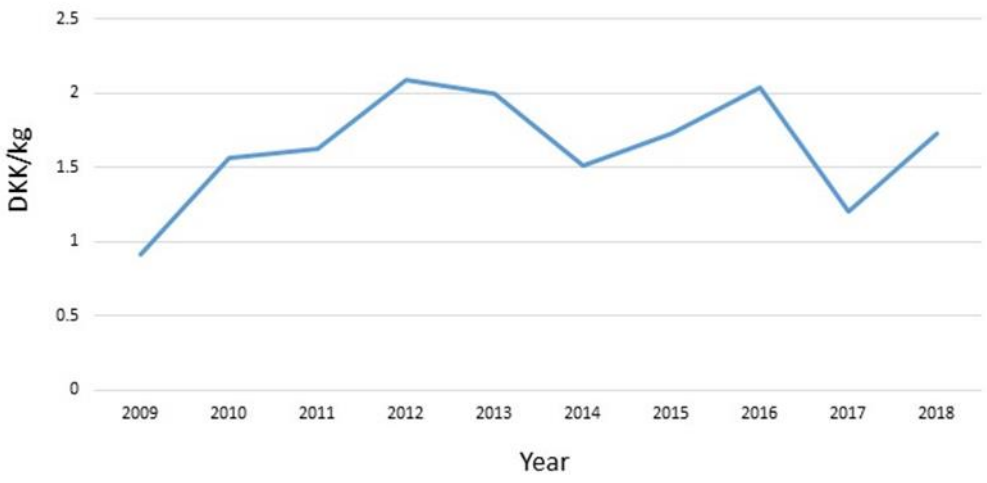

Figure 20. Trend line for landed price settings of industrial fish from 2009 to 2018 in DKK/kg. Ref.:Danish Fisheries Agency statistical records, https://fiskeristyrelsen.dk/fiskeristatistik/.

The figure shows that a certain amount of fluctuation in price can be expected for industrial fish. These mainly relate to supply and demand and range from roughly 1 DKK/kg to 2 DKK/kg in the investigated period. The price settings are global and are mainly influenced by Peruvian and Chilean catches of small fatty fish species.

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Feed for the fur industry require a higher level of quality and can be expected to set the price level at roughly 0.2 DKK/kg higher than the regular price set for industrial fish.

The most likely consumers of UUC catches can be expected to be:

- Fishmeal and fish oil producers
- The fur production industry
- Pet food producers

3.5 Interview with potential UUC uptakers (identical to section 3.3 in D. 6.4)

3.5.1 Industrial fish

Two major companies dominate the fishmeal market in Denmark: "TripleNine" and "FF Skagen". Local small scale production of fishmeal do occur but is of minor importance for the fishmeal market. Located in Hanstholm, the "FF Skagen" subsidiary "FF Hanstholm" is the most obvious partner for taking UUC fish at the Port of Hanstholm.

Interviews with several employees from "FF Hanstholm" have been conducted as well as the attendance of a "FF Hansholm" employee at a workshop regarding the handling and usage of UUC at the Port of Hanstholm. Additionally, dialogue with the Danish branch organization "Marine Ingredients" which represent the producers of fishmeal and fish oil in Denmark have been ongoing in the project.

Fishmeal producers do see UUC as an obvious supplement to the current resource and would like to take this in. There is no expectation of specific challenges in the increased amount of resource uptake from UUC in their production.

Depending of the species, fishmeal producers are willing to set the price of UUC fish at roughly the current level of 2 DKK/kg. The view of the fishmeal producers is that it is unlikely that a higher price can be given for UUC fish intended for fishmeal than the price given to industrial fishers.

In the event that some of the UUC species have a low content of oil or do not have the right composition of proteins, it is possible that the price level for UUC fish will be lower than that of industrial fish.

The landing, handling and processing of industrial fish and products from this as will consolidated in Denmark. In 2016, more than 90 % of all Danish industrial fish landings occurred in the four harbours Thyborøn, Skagen, Hanstholm and Hvide Sande. The processing of the resource to fishmeal and fish oil is done in Thyborøn, Skagen and Hanstholm. In order to keep costs for logistics and transport it is essential that UUC landings occur close to one of these processing facilities.

3.5.2 Feed for the fur industry

Production of feed for the fur industry (mainly mink) take a significant amount of industrial fish in Denmark and thereby a potential buyer of UUC fish. In Denmark, 14 mink feed centrals produce 99 % of all fur feed. All of these are organized under "Dansk Pelsdyr Foder a.m.b.a" which is the trade organisation for Danish fur feed. Uptake, import and distribution of resources for feed production is coordinated through this trade organisation.

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The production of mink fur has been in growth in Denmark through several years, with approx.. 18 million mink produces in 2016, compared to 13.5 million in 2006. In addition to the increased number of mink, the production has also shifted to production of large sizes of mink, meaning that the production and feeding period has increased. More feed is therefore needed per mink per year, the required feed need has thereby increased from roughly 33 kg per mink per year to 47 kg per mink per year during the last 15 years.

Fish constitute roughly 40 % of the mink feed, either as fresh fish supplied directly from a port, frozen fish from other countries such as Iceland or the Faroe Islands or in as cut-offs or wastage from a fish processing facility. Different raw material from animals and plants constitute the remaining 60 % of mink feed.

Specific requirements apply to the fish resource used in the production of mink as a significant amount of fresh feed of high quality is needed. The natural diet of mink mainly consist of fish and it is important for the quality of the fur. Therefore, mink feed producers are willing to pay a higher price for fish than that of the price given for fish intended for fishmeal or fish oil.

3.5.3 Pet food

The pet food industry consist of several large international food producers of which several have production facilities in the Netherlands and Germany. These producers use fishmeal and fish cut-off for the pet food production. Several minor Danish producers exist that base their production on whole fish or cut-off which is processed and added to the final pet food products in different quantities.

Dry pet food for dogs and cats mainly contain fishmeal and fish oil for certain producers. Most producers of dry pet food buy fishmeal from the fishmeal producers and add their own feed mixture in ranging quantities. For this pet food type, the fish species and origin has no interest and UUC fish would only serve as a share of the fishmeal production.

Some pet food brands want to separate their product from the rest by having a higher focus on the usage of certain species or by guaranteeing a higher quality for their product. UUC catches may be relevant for this specific segment and there is a willingness to pay a higher price for raw materials among these pet food producers too.

A few of the interviewed pet food producers believed UUC catches could be of interest to their pet food production. However, price and quality is of great importance and the logistic arrangements currently in use in the business may be difficult to rearrange. Several suppliers of the raw material have a large influence and the input and accordingly it is rarely the demand from food producers that secure new input material to the pet food production.

Several interviewed company representatives stressed that there is a high focus in the pet food industry on securing a low level of harmful substances, especially heavy metals, in the fish material used for production. Dogs and cats consume a substantial share of fish whereby an increased level of harmful substances will lead to bioaccumulation throughout the animals life. Especially fatty fish species where pointed to as the best fish input for pet food due to their high oil content. However, because heavy metals as well as other harmful substances tend to accumulate in fat tissue, the fish species with a high fat

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content will also be the most prone to higher levels of harmful substances compared to leaner species with a lower fat content. Overall, the level of heavy metals and thereby in the fish inhabiting the water body has been higher in the Baltic Sea, Inner Danish waters and Kattegat compared to for instance the North Sea. This is know in the feed and pet food industry and this may be a challenge for the usage of UUC catches from these areas.

Some pet food producers prefer to procure the fish in blocks of ice and rarely pay more for the resource than fur feed producers. Most of the time there is an overlap in the species used by fur feed producers and any additional payment would be to cover the costs of freezing and potential transport-related costs.

Engagement with the different pet food producers has not resulted in a cooperation for the usage of UUC catches. This is primarily due to the lack in amount of landed UUC, way below the threshold level for a stable supply in the specific industry.

3.5.4 Summary of potential usage of UUC

Fish subject to the landing obligation are mainly going to be used for mink feed and the price level will be at the level set for industrial fish. Mink feed producers can take up UUC catches year round, unlike the fishmeal producers where a seasonal component typically apply.

Using a share of UUC catches for pet food will give this specific catch type a market advantage and thereby a likely increase in price level. However, this is unlikely to be as high that of fish intended for human consumption.

Figure 21present possible usages of UUC catches. The x-axis represents the price level as an index and the y-axis represent the amount of UUC as an index. Blue colour represents industrial fish (large amount/low price per kg). Red colour represents UUC used for fur feed (small amount/low price per kg). Yellow colour represents UUC used as pet food (small amount/medium price per kg). Green represent fish used for human consumption (medium amount/high price per kg). Circle size is the relative expected amount for each type compared to the other and thereby illustrate that the expected amount of UUC is relatively small compared to for instance industrial fish.

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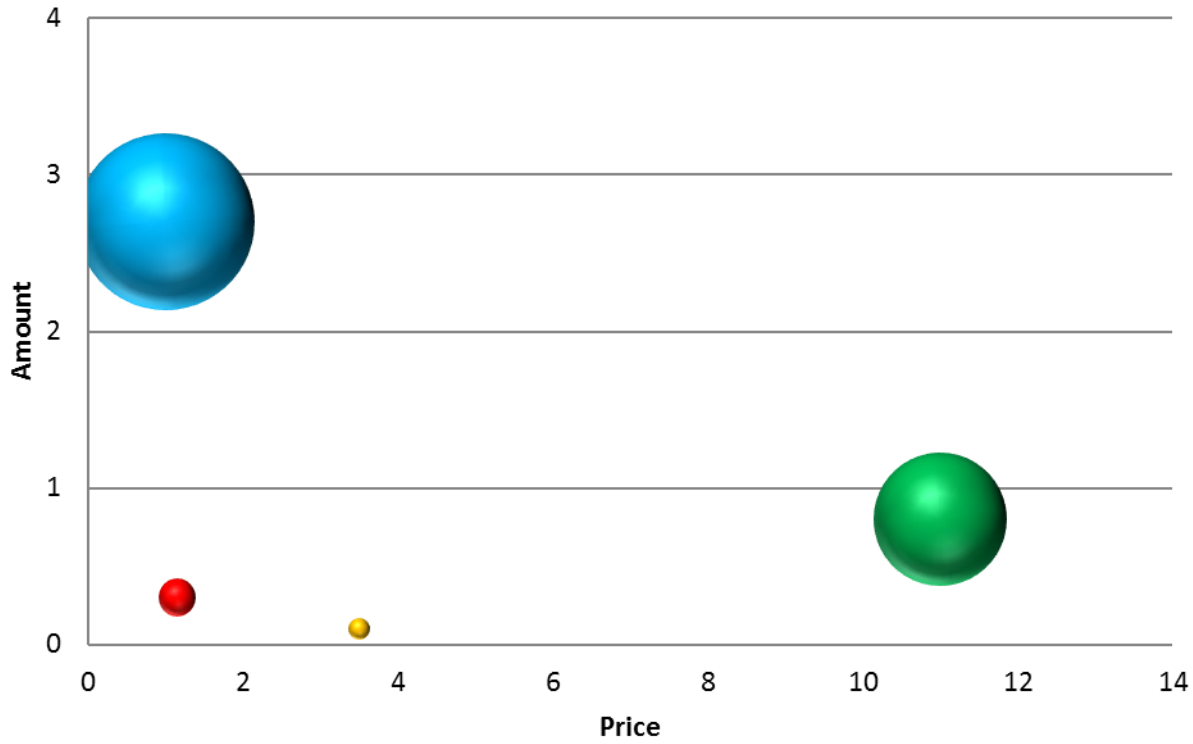

Figure 21. Assessment of potential price and amount of UUC fish depending on usage type.

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5 Icelandic Case Study

The analyses performed in D6.2 pointed out that the highest scores for product valorisation were obtained for

- new fish products
- fish oil and fish meal
- fish pulp
- protein concentrate / hydrolysate.

This chapter describes how this is occurring in practice in Iceland.

5.1 Icelandic experience of utilising UUC

A discard ban has been a part of the Icelandic fisheries management system since 1977 (EC, 2007). In the beginning the ban only applied to few species, but it has been gradually extended and since 1996 there has been a total discard ban on all commercially important species.

Fishing regulations are enforced through on-board and on-shore observers and by the coast guard. Electronic log books and VMS are also mandatory. Area closures are used to protect juveniles and vulnerable areas, and gear selectivity devices have been made mandatory in some fisheries and areas.

Estimates indicate that discard rates are well-below 5 % in the Icelandic fishery (Pálsson, Björnsson, Guðmundsson and Ottesen, 2015), which is contributed to a number of factors. One of the more important factors is that discarding has become socially unacceptable by fishermen, authorities and the general public alike (see also Deliverable D5.1). The ITQ system has played its part in the development as well, as fishing companies with limited quota allocations have gradually disappeared from the industry; meaning that the mainstay of the companies operating in the fishery have now adequate quotas and do therefore rarely run into problems with choke species. There are a number of measures provided within the fisheries management act that contribute to minimising discards and incentivise fishermen to land all catches. There are also a number of initiatives that have been implemented in the past that are aimed at specific fisheries or fleets. These initiatives are for example the establishment of the "bycatch bank", the landing obligation on lumpfish, catch ban on halibut, landing obligation on cod heads, allowance to land catches without deduction from quotas / partial deduction of quotas, and development of decision support systems to minimise discards. Many of these have been initiated by the authorities, but some have also been driven by the industry. Following is a discussion of some of the solutions that have been tried in the Icelandic fishery to reduce discards and incentivise utilisation of UUC. Some of these have been successful and others not so much.

5.2 Flexibility within the fisheries management system

The Icelandic fishery has developed in such a way that today there are not really any catches that can be defined as UUC. This is however a development that has taken decades to gradually change. When the discard ban was first implemented in the Icelandic fishery there were significant discards in place (Palsson O.K., 2003), but with a number of concurrent actions and a change in mentality the sector has progressed so that today all catches are regarded as raw material for valuable products. The ITQ system

and overall management measures have probably played the most important part in this progress, as incentives for discarding have been removed and efforts placed on developing products from all catches.

The ideology with a "pure" ITQ system is that the companies best fit to utilise the fisheries resources will gradually accumulate the fishing rights. This has been the case in Iceland, where the 10 largest companies control now 50 % of the overall quotas; and the 30 largest control 88 % of the quota (Íslandsbanki, 2017). As results the incentives for discarding due to choke species, high-grading and because of personal interests of the fishermen have for the most parts been removed. Majority of fishing vessels have adequate quotas for all the species they are likely to catch, and if they run into chocking on a species, they usually can just rent additional quotas for that species. Today, there are only exceptional cases where the vessel owners are in the crew of the fishing vessels, which reduces the likelihood of personal interests of the owners becoming an issue i.e. renting of quotas is solely the issue of the vessel owner as the crew does not take any part in paying for the rental. Most fishermen are employee by large seafood companies that are returning substantial profits, and are therefore not needing any sympathy for having to rent quotas.

A certain flexibility is built into the ITQ system, where quotas can be sold or leased to cover catches, even few days after the fish has been landed. A thriving market is for rental of quotas, which allows vessel owner to buy exactly the amount of quotas they need at each time. It also allows them to swap quotas for the same purposes. Up to 5 % of the quotas for the following year can be transferred between years, in order to cover catches exceeding quotas; and up to 10 % can be transferred to the next quota year. All of these provide some flexibility that is intended to reduce incentives for discarding.

Another regulatory incentive that has been applied is to allow for undersized catches to be only counted 50 % against quota. These have provided fishermen with the incentives to land small fish, instead of discarding it.

5.3 VS-catches

Another regulatory mechanism that has been implemented to incentivise landing of UUC is the so-called VS-catches. These allow fishermen to land up to 5 % of their annual catches without deducting them from quota; but the fishermen will then have to forfeit majority of the catch value. The vessel then receives 20 % of the value and 80 % is allocated to a research fund called Verkefnasjóður Sjávarútvegsins (e. Research project fund of the Seafood Industry). These VS catches have amounted to around 2,000 tonnes a year, which otherwise would have possibly been discarded. These catches have as well provided significant funds to marine research, which benefits the industry in the long-run.

5.4 Ban on targeting Atlantic halibut

A total ban on targeting of Atlantic halibut was regulated in Icelandic waters in 2012 (Icelandic Ministry of Fisheries, 2012). The ban entailed that accidental bycatches of halibut should be released if assessed likely to survive, but otherwise to be landed and the entire landing value forfeited and allocated to a research fund. This has resulted in a 90 % reduction in reported halibut landings, but there are indications that this has created a "black market" for halibut. Buyers at auction markets have also

complained that quality of what little halibut is available is very poor, due to the fact that fishermen do not have any economic incentives to land top quality.

5.5 Discard ban on cod heads

A regulation obligating Icelandic fishing vessels with on-board processing to bring a shore a certain proportion of cod heads that derive from catches within Icelandic waters came into force in 2012 (Viðarsson & Þórðarson, 2015). During preparation on the regulation the Ministry had gone from demanding that all cod heads and cod livers should be landed, down to only a 30-40 % landing obligation on the cod heads alone. The reason why the regulation was initiated in the first place was perhaps more contributed to moral responsibility i.e. that if a vessel is allowed to fish from a resource owned by the nation as a whole, it should utilise the whole catch.

The regulation has though had limited effects on the volume of landed cod heads, as most factory vessels subjected to the regulation had already met with the requirements before it came into effect. The cod heads have become a valuable part of these vessel's catches, but the capacity of the freezers and available space in the freezing hold is however a limiting factor, which is why parts of the cod heads are still being discarded. As results the industry and R&D have been looking into possibilities to process the most valuable parts of the cod heads at sea, such as tongues and cheeks.

5.6 Discard ban on lumpfish

The utilisation of lumpfish is a good example of where regulatory measures have been successful in reducing discards and creating value from UUC. The lumpfish fishery in the N-Atlantic has traditionally been focused almost solely at harvesting of the roes (Þórðarson, Pálmason, & Reykdal, 2013). The male and the carcases of the female, which account for approximately 70 % of the weight of the female, have subsequently been discarded at sea. The Icelandic authorities however decided in 2010 to impose a landing obligation on the lumpfish fishery, which took effect in 2011. At that time there were very little opportunities for processing any kind of marketable products from the catch. The industry and the R&D community was simply given the task to find solutions, which they did. New markets were developed in China, where the National Association of Small Boat Owners (NASBO) in Iceland took the lead in getting all of the necessary players on-board. The fishermen for example agreed to sell the carcases to the R&D and processing companies for almost nothing, during the development phase (2 years). As results the fishery is now "discard-free", as valuable products in the form of either whole frozen lumpfish or frozen fillets are being produced from previously discarded catches and new job opportunities have been created. The Lumpfish is a therefore a newly discovered delicacy in China. Its white meat and thick gelatine-like skin offers a wide variety of cooking options. It is also well suited for sushi and sashimi. In 2014 were almost 2,700 tonnes of these products, valued at 4.0 million EUR exported from Iceland to China (Statistics Iceland, 2018).

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Figure 22. Chinese dish with Lumpfish that would probably have been discarded if not for the discard ban

The introduction of the discard ban on lumpfish, had the effects that the gutting processes were moved on-shore to fish processing plants. The main challenge in this, was to change and old procedure and mind-sets of fisherman in the industry. This new approach has proven to be important for many small communities in Iceland, as it has provided job opportunities and increased value creation in coastal communities.

5.7 The bycatch bank

In 1989 the Icelandic government launched a pilot project called “the bycatch bank” (Clucas, 1997). The primary aim of the bank was to demonstrate to fishermen and the fishing sector that there were markets for unusual species of fish caught as bycatch and where necessary introduce and promote those new species to consumers. This was done by such activities as "strange fish weeks" in restaurants, manuals which assist in identification of new species and recipe booklets. The bank also bought and collected together small volumes of marketable fish, creating larger batches that would be more attractable for processors. The bank organised to purchase blocks of frozen fish of “non-commercial” species from fishing boats, arranged taste panels, promotion schemes and sales to restaurants etc. As results of the project, a number of species that had previously been discarded because they had little or non-commercial value are now landed and sold for good value. An example of such catches is the common dab, thorny skate, dogfish, rock grenadier, common Atlantic grenadier and longnose velvet dogfish, megrim.

5.8 Bycatch, UUC and fish under MCRS

There are many opportunities for the Icelandic seafood sector when comes to utilising UUC and MCRS catches. There are no legal restrictions on the use of MCRS, which allows the industry to maximise value of all catches. The fact that MCRS is of lower value than larger fish are adequate incentives to make sure that juvenile fish is not targeted; and the MCS (Monitoring Control and Surveillance) is also efficient enough to ensure that juveniles are protected e.g. real-time closures and permanent area closures. The trend with MCRS catches has been towards bulk freezing for foreign markets, filleting & freezing or drying. Low value fish fillets from MCRS catches are for example widely available in Icelandic retail stores. Figure 8 shows for example frozen cod peace’s/nuggets made from MCRS that are available in Icelandic retail stores.

Figure 23. Cod peace's/nuggets made from undersized fish

UUC species that have little commercial value are commonly dried whole (gutted), these are species such as starry ray, dab, megrim, flounder and even gurnard. The drying was traditionally performed outside, but has been moving towards indoor mechanical drying in more controllable environment which results in much better and more stable end products. These products are then sold to foreign markets, mostly in Africa. A key component in this development is that the Icelandic Industry has access to cheap geothermal energy source to power the drying, so the production cost is relatively low. Figure 9 shows dried starry ray, which is a good example of UUC that previously would have been discarded but is now considered valuable catch.

Figure 24. Dried starry ray

5.9 Rest raw materials

Production of innovative products for human consumption and high value bio technical ones is currently to a large extent limited to RRM from cod. An example of that are leather made from fish skins, pharmaceuticals and cosmetics made from bioactive compounds extracted from different parts of the cod (and other fish species), collagen made from fish skin, supplements and protein made from different by-products, mineral supplements made from fish bones, enzyme extracted from viscera, skin and tissue repair patches made from fish skin, extracts from RRMs made into powder or bouillon (i.e. for making soups and sauces), silage made from viscera used for animal feed or as fertiliser, swim bladder and milt. Despite previous utilisation being mostly limited to cod products the landscape is slowly changing towards utilisation of other fish species as the operators have started to realize the hidden value in RRMs. Figures 10 and 11 show some examples of UUC and RRM that previously would have been discarded but are now considered valuable products.

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Figure 25. Example of products made from UUC and RRM

Figure 26. Dried Icelandic fish products intended for human consumption, fresh cod head served at Icelandic restaurant, chandelier made from cod, cod oil and omega-3 from pelagic species are all examples of product development where previously discarded materials are used

Regarding the current utilisation of UUC and RRM in Icelandic the focus has been more towards production of more valuable products for human consumption and bio technical products. Other UUC and RRM that are not readily applicable for added value production are commonly frozen for mink feed. It can be claimed that everything that is landed is utilized, there are however materials that are not landed, these are particularly viscera from fresh fish vessels and parts of the heads and frames from the processing vessels. This is though changing now, as vessels are being fitted with equipment that allows for collection and storage of these UUC and RRM.

This development indicates that the utilisation of RRM may increase in near future in Iceland, particularly on larger processing vessels. Smaller fishmeal plants have also been set-up around harbours in Iceland, they receive RRM from the aquaculture industry and from larger fish processing plants. This development may indicate that fishmeal production of RRM may increase in near future.

5.10 Collagen

Fish skin, especially salmon and cod skin, are often used after processing for the production of various high value products, such as collagen, gelatine and various nutraceutical and pharmaceutical ingredients. Some biotechnological products made from fish skin are already on the market. Cod skin is for example being processed by the Icelandic company Kerecis and sold as skin plasters for treatment of wounds and skin problems. The cod skin wound patches have many favourable properties in

comparison with competing products, both from clinical point of view and for ethical/religious reasons as other similar products on the market contain pig tissue.

The protein collagen can be extracted from fish skin and then used as ingredients for various products. The collagen can be further processed to collagen hydrolysates and used then as ingredient in food products, supplements, cosmetics and nutraceuticals. Some small-scale production is already in place in Iceland, but the company Codland is planning to start large scale collagen extraction in the near future; and has been doing small scale laboratory trial production in Iceland and larger scale trial production in collagen factories abroad (Björnsdóttir, 2017). The factory that Codland is planning to build will have the capabilities of processing all fish skins that are available within the Icelandic fishing industry. Among the products made from Icelandic collagen already on the market are collagen tablets and powders sold as nutraceuticals, cosmetic creams that are claimed to reduce wrinkles, soda drinks containing collagen which are supposed to have various health effects; some of these products are shown in Figure 12.

Figure 27. Collagen is used as ingredient in variety of products and is particularly popular in food supplements, pharmaceuticals and cosmetics

Gelatine is derived from collagen and is primarily used as gelling agent in food, pharmaceuticals and cosmetics. Gelatine made from cold water fish skin is well known for their extremely good emulsifying and film forming properties, which makes them popular for making pharmaceutical fast-dissolving tablets. But they are also popular as protein additives for nutraceutical, cosmetic and food applications. Gelatine from fish skin have also competitive advantage over most other gelatines on the market in the respect that they are not made from pigs, beef or other farm razed animals; and are therefore more acceptable by those that have religious or ethical preferences.

Furthermore, In Iceland fish skin is as well processed into leather for fashion and textile items. Shoes, purses, valets, belts, clothing, lamp screens and other such fashion items are extremely popular among high paying "fashion conscious" consumers.

5.11 Silage

Silage production is an interesting alternative for the Icelandic industry when it comes to utilising UUC and RRM that is likely to be explored further in the near future. There is though some opposition amongst the industry to try silage production, which is mostly contributed to some failed attempts in the 80's and 90's. Potential new markets within a growing aquaculture sector in Iceland for silage, fish

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protein concentrate (FPC) and fish protein hydrolase (FPH) may however result in the industry trying this solution again.

Fish silage is a liquid product processed from RRM like viscera, heads, frames, cut-offs and also from non-market value catches. Formic acid, enzymic action and naturally braked down under the right conditions limits the growth of spoilage bacteria and increases the shelf-life of the silage. The silage can then be used as a raw material in fish meal and oil, animal feed / aquaculture feed and can be used to produce fertilizer (Jayawardena *et al*. 1980). There is a significant production of silage in Scandinavia from RRM in the fish industry, especially in Norway and Denmark. Production of fish silage in Iceland has been almost no-existent for a long time, but some export is recorded in the 80's. There was also a period in the 80's when a number of Icelandic vessels experimented with an onboard silage production. But the fishermen thought this was a waste of time, producing such low value product (Jónsson and Viðarsson, 2016). FPC and FPH are to a point "advanced versions" of regular fish silage. The production process and the necessary equipment is though much more complicated, but the products are consequently of higher quality and can be used for more valuable products, such as food supplements, pet food and higher quality aquaculture feed.

5.12 Discussion

The aim of this report is to validate the suggested solution for the best use of UUC (presented in D6.3). In the case of Iceland, where a discard ban has been in place for over four decades, the validation has to be more "after the fact" explaining what has actually been done to mitigate discarding and utilise UUC. This has been done in this chapter, where most of the currently applied uses of UUC in Iceland have been identified and discussed. The utilisation of UUC has not really required much investment in infrastructure, as the already available vessels, processing facilities and expertees have for the most parts been already available within the sector. Some of the more novel approaches introduced in the last few years have however required investment in technology and infrastructure i.e. collagen factory. There are though still opportunities to increase the utilisation and produce more valuable products from these materials. Product development is constantly being worked on in R&D institutions, seafood companies and within start-up companies. Already available "well known" solutions are also regularly explored, as an example of such is surimi production. There is no surimi plant in Iceland, but the option has been investigated a number of times and laboratory testing's have been done regularly; but the economic justification has been lacking.

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7 ANNEXES

7.1 ANNEX 1

DATE	
GENERATION SOURCE	
TYPE OF DISCARD	
BATCH NUMBER	
DISCARDS' CONDITIONS	
Fresh / Frozen	
Clean / Mix with other species	
Others	
SUITABLE / NON-SUITABLE In case of non-suitability, discards must be managed according to the contingency plan	
Compost	
Landfill	
Incineration	
Dumping	
Others	

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7.2 ANNEX 2

TRANSPORTATION DATE		
DESTINATION		
TYPE OF UUC	ORIGIN	QUANTITY (kg)
1.-		
2.-		
3.-		
4.-		
5.-		
6.-		
7.-		
8.-		
9.-		
10.-		
11.-		
12.-		
13.-		
14.-		
15.-		
TRUCK CLEANING		
YES / NO		
Type of cleaning		

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7.3 ANNEX 3

NAME OF PRODUCT	
PACKING FORMAT	
COMPOSITION	
BATCH NUMBER	
PRODUCTION DATE	
EXPIRATION DATE	
STORAGE LOCATION	