LIFE Project Number
LIFE05 ENV/E000267-BE FAIR

BENIGN AND ENVIRONMENTALLY FRIENDLY FISH PROCESSING PRACTICES TO PROVIDE ADDED VALUE AND INNOVATIVE SOLUTIONS FOR A RESPONSIBLE AND SUSTAINABLE MANAGEMENT OF FISHERIES

LAYMAN REPORT
Report Date
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INTRODUCTION

Estimations of fish captures by FAO Fisheries Resources Division indicate an annual increase of 6% in the decades between 1950 (around 20 million tons) and 1970 (around 60 million tons), to reach an average figure of about 85 million tons in 2005. Actually, this corresponds to the 70% of total fish production, being the remaining 30% fish produced by aquaculture. Catches on-board any fishing vessel both include targeted species as well as by-catch and discards, which usually are thrown back into the sea. The percentage of discards is not homogeneously distributed among the different fishing fleets as it mainly depends on the selectivity of the fishing gears employed, the season of the year or the activity area. In fact it can be as large as 27 million tons per year according to some FAO reports, what would represent near a third of the total fish captures. More conservatives estimations indicate that discards, in average, represent around a 7%-10% of the total catches which gives a figure of around 8 million tons of fish species being discarded per year.

Nowadays, it becomes evident that discard practices constitute **a purposeless waste of valuable living resources** playing an important role in the depletion of fish populations. Furthermore, discard practices may produce a number of **adverse ecological impacts due to ecosystem** changes in the overall structure of trophic webs and habitats which could risk the sustainability of fisheries.

Figure 1. Illustrative representation of the different classes of wastes produced as a result of fish processing activities

Likewise, another source of on-board biomass losses is that derived from fish processing activities. In particular, fish evisceration and cleaning also generates considerable amounts of wastes such as heads, bones, guts, skins etc (Figure 1). When these practices are done on-board such residues are usually returned back to the sea thus contributing to the **accumulation of pollutants** (as PCBs, dioxins or heavy metals) or to the **spread of parasites** present in the viscera (as it is the case of anisakis) in the fishing areas. The percentage of residues produced on-board varies widely as it depends on the target species, fishing fleets and areas. As an example: waste thrown back to the sea by traditional fishing fleets operating is negligible as captures will be mostly processed in-land. Nevertheless and despite the particularities of each fleet average, wastes could range between 15% and 30% of the total catch, increasing in some instance up to the 80%, as in the case of some crustacean fisheries.

In-land, and due to the activity of fishing ports, auctions and fish traders, processors and industries, wastes and sub-products are also generated in-land as a result of the activity of fishing ports, auctions, fish traders, processors or industries. Such wastes will be mostly employed to produce fish meal or fish oil, or when this is not possible, treated like urban solid wastes.

It is in this context, and in the **aim of promoting the responsible and sustainable management of the European fishing activity**, that the European Commission is taking a number of actions oriented to the implementation of "no-discard" and "zero-waste" policies to be followed by the European fishing fleets in the near future. In particular, actions were directed to the development of policies to reduce unwanted by-catches and to eliminate discards in European fisheries, as well as to make the best possible use of the captured resources avoiding its waste.

THE PROJECT

The BEFAIR initiative –co-funded under the **LIFE Environment Program** of the European Union- has been set up in the intention of providing support to the above mentioned EU actions. In this way, the ***main project objective*** aims at contributing to the **minimization of the adverse ecological and environmental impact of fishing activities** (on board as well as on shore), by helping fleets to comply with the so-called "***zero-waste***" production on board. To that purpose, efficient and integral waste management and processing practices both on-board (fishing fleets) and in-land (fish auctions) to recycle and to reuse wastes produced by the fishing industry, including discards and by-catch, were developed and implemented. In particular, two main lines of action have been pursued during the project life:

- The definition of viable management and processing practices for fishing discards, by-catch and wastes so to recover and to produce valuable products of interest in the food, feed, cosmetic and pharmaceutical industries.
- The validation of the approach at the pre-industrial scale by designing and constructing demonstration prototypes of up-grading processes to produce added value products as the ones mentioned above.

In order to achieve the final objective, the project structure was composed of a number of tasks oriented to:

1. The assessment of the availability, volumes and classification of both on-board unused biomass (including discards and by-catch) as well as of sub-products in-land derived from the fishing activity (Tasks 1-3)
2. A prospective analysis of different valorization alternatives and the selection of the most viable. (Tasks 4-5 and Task 7)
3. The construction of pre-industrial valorization process prototypes to demonstrate their viability (Task 6 and 8)

A schematic representation of the different tasks and the interplay between them is presented in Figure 2.

Due to the demonstration character of the BE-FAIR Project and as consequence of the wide variety of fishing gears, fleets, activity areas, etc., a number of case-studies have been selected:

- NAFO Trawlers → Using a no selective gear, which results in a high pre-processing activity on-board.
- Surface longliners → selective fleet. The pre-processing activity on-board is moderate.
- Depth longliners → The selectivity of the gear employed is intermediate and the pre-processing activity is low.
- Vigo Fish Auction.
- Some fish transforming industries.

The project has been promoted and coordinated by Consejo Superior de Investigaciones Cientificas (CSIC) through the Instituto de Investigaciones Marinas, and co-funded by the LIFE - Environment Program of the European Commission.

The consortium, have been conformed by scientific institutions from Spain (CSIC and CETMAR), Portugal (IPIMAR) and France (IFREMER) with contrasted experience in marine research and process technology. In addition it counted with a number of companies and institutions representative of the extractive and transformation sectors, namely APV, ESP, HRG, and Peixesport, S.L.

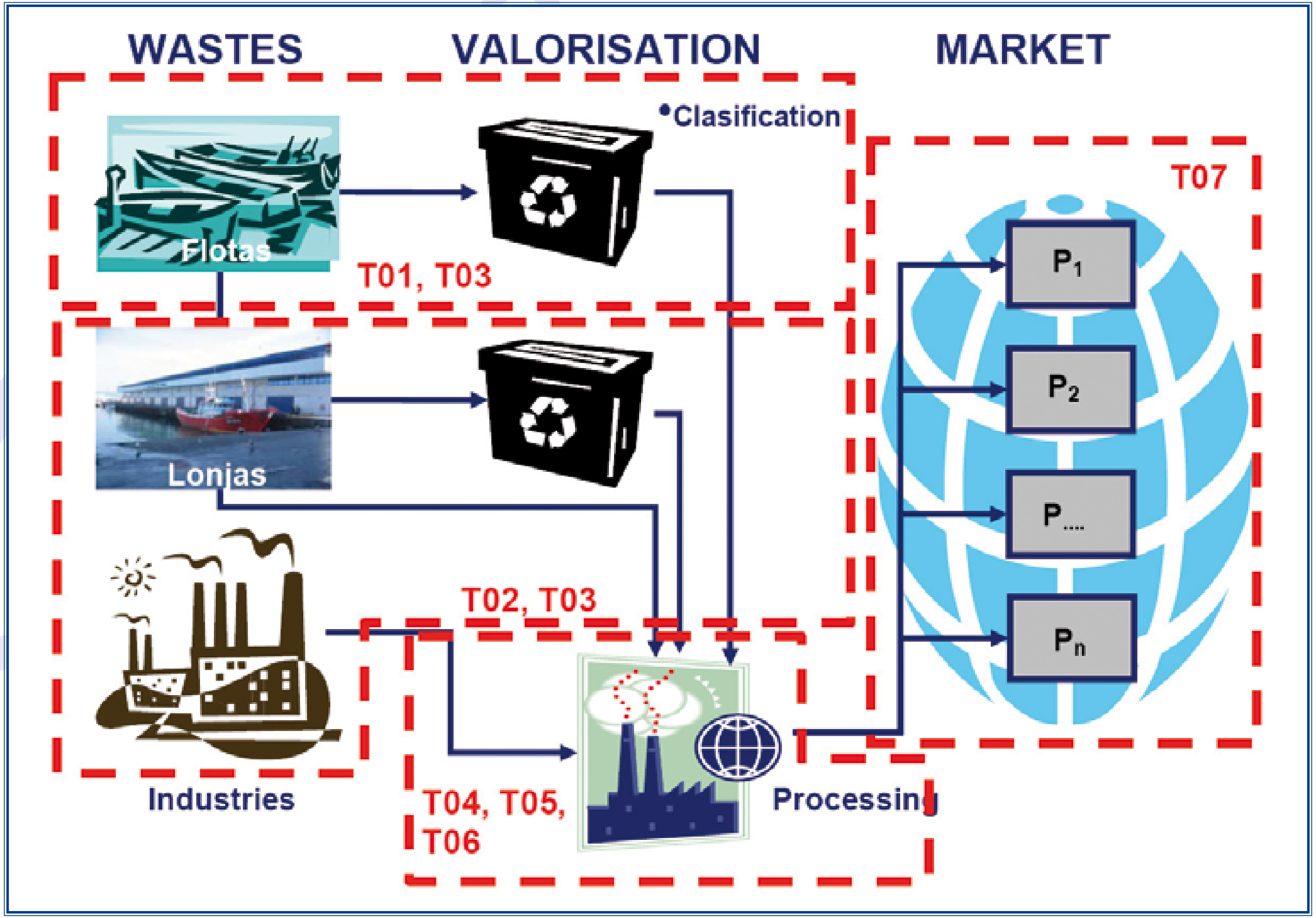

Figure 2 . Schematic showing the interrelation between the different tasks and activities within the project

Finally, as external collaborators, the BE-FAIR project benefitted from ARVI (Ship-owner Association of Vigo), IEO, DILSEA, OPE, ART and TEC. Table 3 collects together with the acronym, the full name of the company, country and activity.

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ACRONYM	NAME	COUNTRY	ACTIVITY
CSIC	Consejo Superior de Investigaciones Científicas	SPAIN	Research
CETMAR	Centro Tecnológico del Mar- Fundación CETMAR	SPAIN	Research
IPIMAR	Instituto de investigaçao das Pescas e do Mar	PORTUGAL	Research
IFREMER	Institute Français de Recherche pour l'Exploitation de la Mer	FRANCE	Research
ESP	Espaderos del Atlántico	SPAIN	Longliners Fleet
PXX	Peixesport, S.L.	SPAIN	Processing
HRG	Hermanos Rodríguez Gómez, S.L.	SPAIN	Mechanical Equipment Construction
APV	Autoridad Portuaria de Vigo	SPAIN	Port Authority
IEO	Instituto Español de Oceanografía	SPAIN	Resarch
ARVI	Asociación de Armadores de Vigo	SPAIN	Ship-owners Association
DILSEA	Dilsea, S.L.	SPAIN	Wastes Processing
OPE	OPESCA - Organização de Produtores de Pescas Industriais	PORTUGAL	Processing Industries Association
ART	ARTESANALPESCA - Organização e Produtos de Pesca, Lda.	PORTUGAL	Processing
TEC	Testa e Cunha, S.A.	PORTUGAL	Processing

Table 3. BE-FAIR Partners and collaborators

RESULTS OF THE MAIN TASKS OF THE PROJECT

1. CHARACTERIZATION OF DISCARDS AND BY-PRODUCTS ON BOARD

The main objective of this task has been the analysis of the present situation of the fishing activities (as for discards and byproducts generated) in order to obtain the required data to define the needs for valorization of the captures, and to limit discards and byproducts.

Results

For the selected fishing fleets (trawlers, long-liners), information on the amounts of unused biomass (mainly discards and by-catch) has been collected and analyzed. Such information has been gathered from general bibliographic sources and data bases (e.g. those in FAO, IEO, IPIMAR), as well as through interviews and questionnaires distributed among the companies participating or collaborating with the project (Espaderos del Atlántico, ARVI etc). As a result of this analysis, the following conclusions can be drawn:

i) The wide variety of fish species accompanying the target catch in trawler fleets. For instance, trawlers operating in NAFO (Figure 4) like the ones depicted in Figure 5 which concentrate their activity on Greenland halibut (Reinhardtius hippoglossoides) usually bring in their nets a rich variety of other species (Figure 6) like grenadier, white hake, witch, American

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plaice, redfish or skates, shrimps, yellowtail or even flounder and cod. Among other examples, Atlantic cod (Gadus morhua) discards are somehow a consequence of the ban imposed on the species to avoid overexploitation. Note that the main sub-products generated by this fishery which include viscera, heads and trims of the target species are usually thrown overboard.

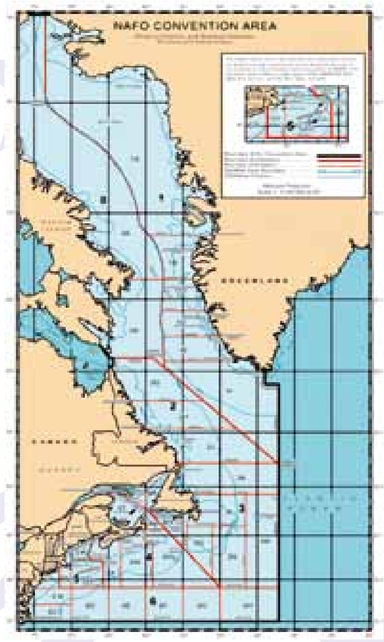


Figure 4. Geographical location of the NAFO area

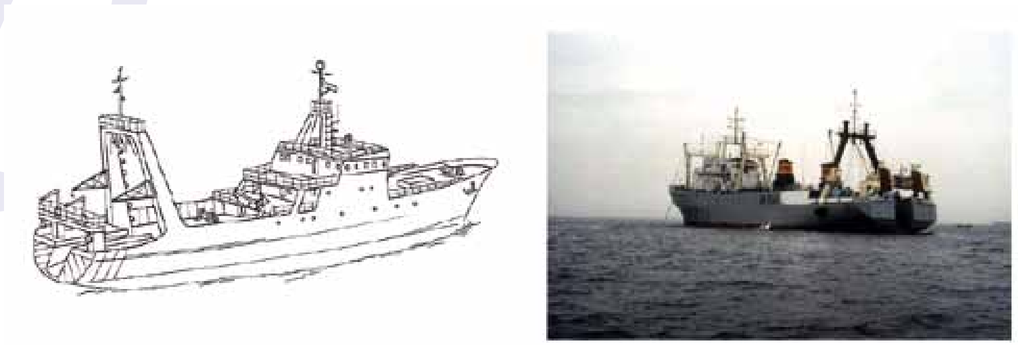
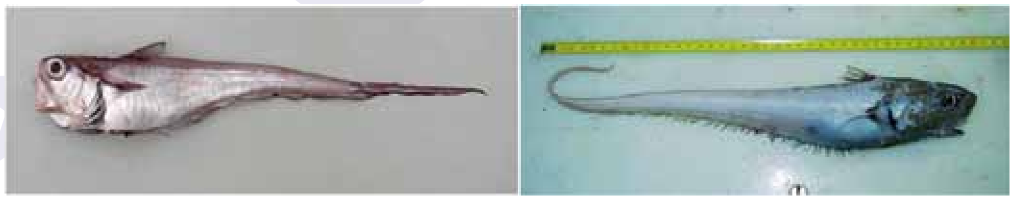


Figure 5 Trawlers operating in the NAFO can be over 45 meters long and even longer



a) b)

c)

Figure 6. Different classes of by-catch and discards. Granadiers as the ones illustrated in (a) and (b) could be used for human consumption although are mostly employed in fish meal production. The Greenland shark (Somniousus microcephalus) constitutes a typical discard due to the toxicity of its flesh

ii) The considerable amounts of discarded species in spanish hake long-liners operating the ICES area (division VIa,b; VIIc,h,j,k; VIIIa,b, VIIIc - Figure 8): The average values of discards for this fishing gear and area range between 8 and 19%.

Figure 7. A long-liner vessel moored in port prepares to return to the fishing banks

Although the target specie is Atlantic hake (Merluccius merluccius), other species are captured and discarded, which amounts depend on the area of capture, as shown in Figure 9. It is noticeable that in the areas considered the main discards correspond with species that might have commercial value (Figure 10) such as the Atlantic mackerel (755 Kg per 100 h of fishing), blue whiting (505 Kg per 100 hours of fishing) or Atlantic argentine (477 kg per 100 hours of fishing).

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iii) The high selectivity of the swordfish longliners in North Atlantic Area due mainly to the selectivity of the fishing gear. This fleet operates in North Atlantic, FAO areas 21, 27, 31 and 34 (see Figure 11) with catching trip spans having an average of 60 days for ships of around 30 meters length. Target species include mostly swordfish, tunas and sharks. Before being frozen (first on a freezing tunnel at -41ºC and then stored at -18ºC) catch is beheaded and gutted, been heads and viscera the main sub-products. Refrigerated fish is not processed on board thus producing no waste.

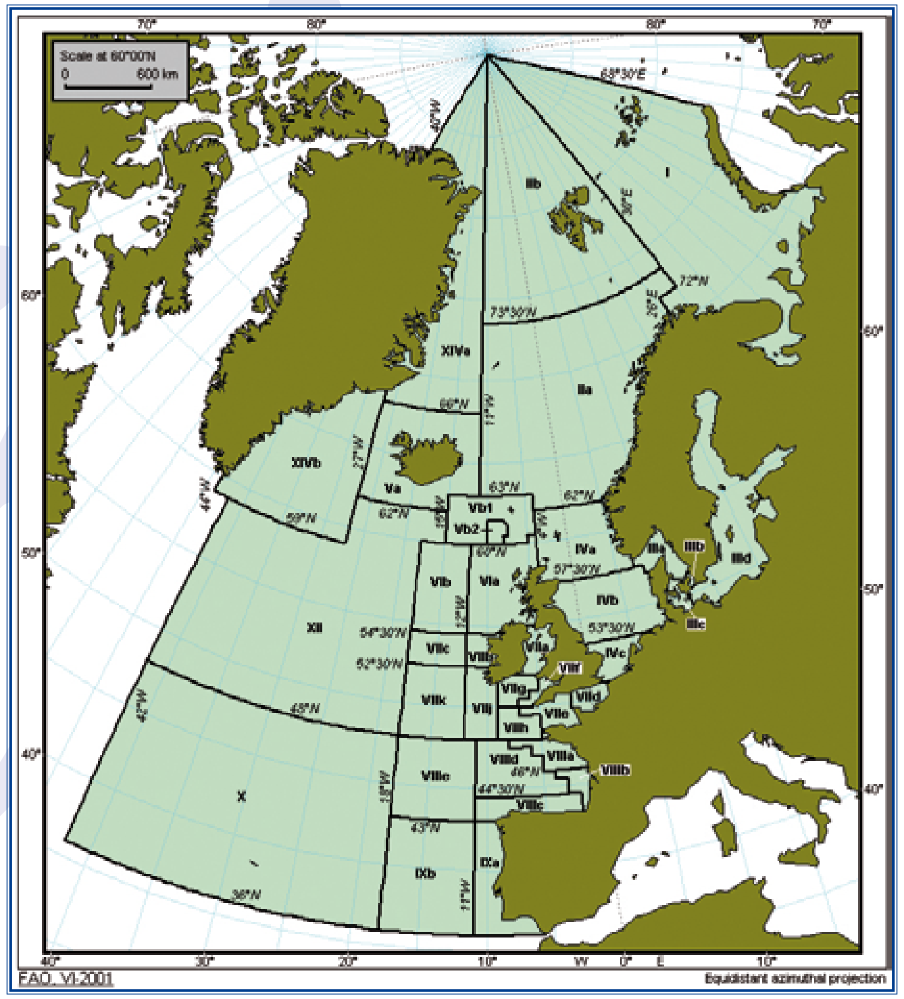

Figure 8. Geographic location of the ICES areas

AREA VI: Kg of captures and discards per 100 hours of fishing **(13 hauls)**			
Species	**Captured**	**Discarded**	**Discard/Captured**
Argentina silus	425	425	100
Micromessistius potassou	354	354	100
Scomber scombrus	316	316	100
Pollachius virens	97	97	100
Gadus morhua	110	52	47
Galeus melastomus	43	43	100
Squalus acanthias	26	26	100
Merluccius merluccius	13034	-	-
Molva molva	2668	-	-

AREA VIII a,b: Kg of captures and discards per 100 hours of fishing **(16 hauls)**			
Species	**Captured**	**Discarded**	**Discard/Captured**
Scomber scombrus	425	425	100
Trachurus trachurus	88	78	89
Micromessistius potassou	66	66	100
Scyliorhinus canicula	54	54	100
Merluccius merluccius	3974	-	-

Table 9. Amounts of discard by areas in the ICES zone

a) b) c)

Figure 10. Typical discarded species in ICES zone. (a) Atlantic mackerel (Scomber scombrus). (b) Blue whiting (Micromesistius potassou). (c) Atlantic argentine (Argentina silos)

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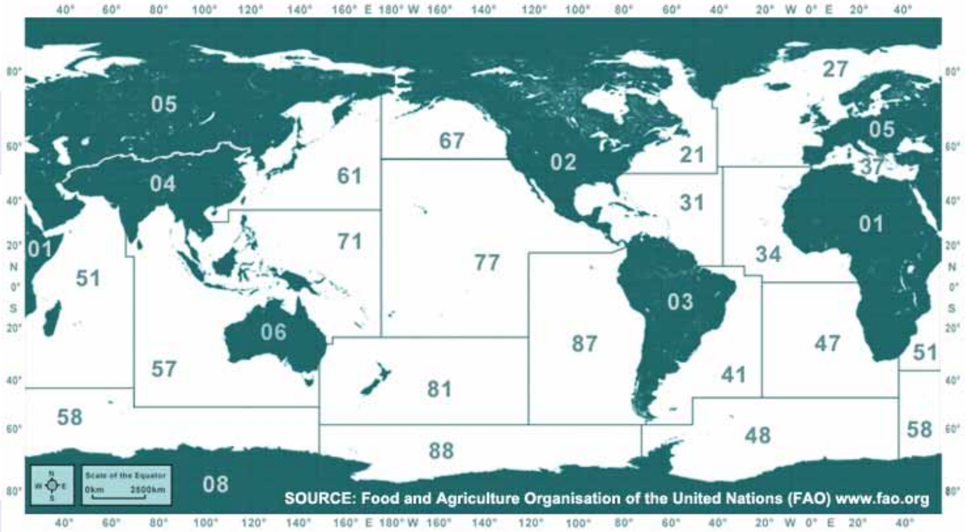

Figure 11. The geographical location of FAO fishing areas. The areas studied in this task (21, 27, 31, 34) belong to the Atlantic Ocean

The analysis carried out on the Spanish trawling and longline fleets has been extended to the French and Portuguese fishing fleets. Next, the most significant conclusions are presented:

French fisheries:

The conclusions extracted from the analysis of the collected data from French fisheries can be summarized as follows:

i) A main discard rate of 13% has been obtained for Atlantic fisheries, and 31% for Mediterranean Sea. Mediterranean discard rate is higher due to the high by-catches registered in anchovy and sardine fisheries (50%).

ii) Extrapolating these mean rates to the whole catches in French fisheries, one can conclude that almost 60,000 tonnes of catches have been discarded during 2005, which represents a 14% of French catches.

iii) Discard rates vary among the different species, estimating the following averages by group: 18% for white fish, 17% for cartilaginous species, 6% for pelagic species and 6% for crustacean species. Lowest discard rates are found for pelagic species and crustaceans. In the case of pelagic species, most of them are targeted in North See fisheries, such as salmon or herring, which have negligible discard rates. The fishing gears employed to catch crustacean are very selective, with small discard rates.

iv) Species generating the highest discards are sardine (with high discard rate in Mediterranean fisheries due to anchovy and sardine by-catches), whiting, hake (with a discard rate of 56% in the Gulf of Biscay), herring (with low discard rates but high catches), mackerel and monkfish.

v) Highest discards rates are observed in pollack in the Bay of Biscay (70%), plaice in North Atlantic (60%) due to by-catch species, hake in the Bay of Biscay (55%) and sardine in Mediterranean See (50 %) due to the presence of mixed banks of sardine and anchovy.

Portuguese fisheries:

According to information gathered from contacts with fishermen, producers and fishery associations and data collected from scientific papers, reports and “grey” literature, the following considerations can be made regarding Portuguese fisheries:

(i) Small-scale fisheries have generally low discard rates than industrial ones. Purse seine and long line fisheries have also low discard rates.

Purse seiners, comprising a large group appearing in different sizes ranging from small boats (“rapas”) to big ones nominated as “traineiras”, are responsible for the catch of the vast majority of small pelagics. Those targeting sardine, which comprise the majority, have low discard rates, since the other most important non-target small pelagics, including horse mackerel, chub mackerel and boopsare usually hauled together with sardine and separated on shore before the transaction in the auction.

Nevertheless, when most of the catch is not sardine or juveniles are present in significant amounts, the discards are higher. Seasonally, the presence of a pelagic crab Polybius henslowi contributes to significant discards. According to a research work, it was stated that in seiners the discarding rates are very much variable, with values that could be of 0 to 100% of total captures, but values up to 27 % are quite often registered.

(ii) crustacean and demersal finfish trawl fisheries have higher discards, although the values can be quite variable, according to the season, fishery and boat type. In fact, these fisheries have the highest discard rate (between a 20 to 60% for fishing trawlers and 70 % for crustacean trawls in the Algarve region – South of Portugal).

2. CHARACTERIZATION OF WASTES AND BY-PRODUCTS IN THE FISH PROCESSORS AND IN THE FISH AUCTION OF VIGO

The aim pursued in this task was to analyze the current situation as for the management of the materials implied (residues and byproducts) in the framework of the typical activities carried out by the fish producer and the fish auction. To that purpose, information relative to the amounts and type of residues in the Vigo auction (Figure 12) was collected.

Results

Figure 12 A panoramic view of the Vigo fishing harbor (APV)

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Fish auctions like the one at Vigo harbor, with high volumes of fish landings and therefore a high volume of residues, represent a good case study for showing the actual situation of wastes and how new strategies could be implemented to provide environmentally benign solutions.

As reported by the BE-FAIR project, the amount of fish wastes generated in this auction is about 10-14 Tm/day, which makes around 4000 Tm/year. Such a figure represents a considerable amount of residues which are difficult to handle because of their heterogeneity.

The main advantages of large auctions as the one in Vigo, lies in the high qualification of the infrastructures for handling fresh and frozen catch: i) differentiated rooms for the reception and exhibition of fish and for evisceration and filleting, and ii) a good separation of clean and dirty areas (Figure 13).

Smaller and more specialized fish auctions, usually generates smaller amounts of waste at land. The case of Celeiro auction, in the north coast of Galicia, constitutes a good paradigm: The auction receives the highest amounts of hake landing in Galicia but the amount of residues produced is relatively small (about 80 Tm of residues/year mostly employed for fish meal production). This is due to the fact that the evisceration of hakes produces only about 3% of wastes and that a significant amount of hake landed has been already "cleaned" on board.

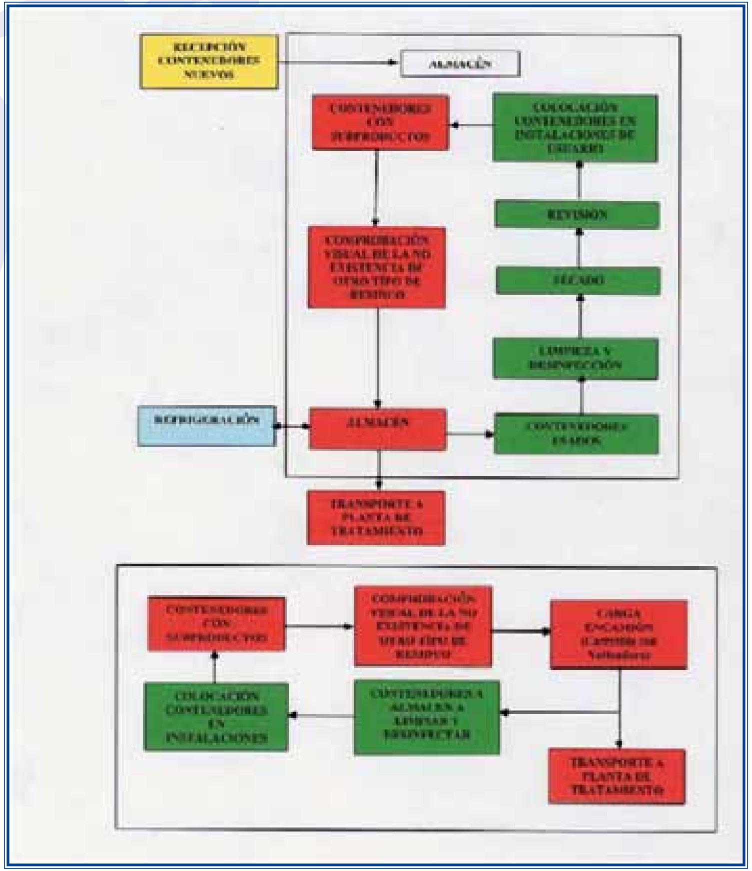

Figure 13. Diagram showing the different processes and raw material flows in Vigo auction

a)

b)

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c)

d)

Figure 14. Tables collecting global figures of wastes produced on board and on shore: a) By fleet; b) by specie; c) by type of waste; d) by specie and type of transforming industry.

Regarding waste generation in the **fish industry**, although it must be considered on a case by case basis, it is possible to assert that the large volumes generated are usually quite homogeneous. Note however that in terms of valorization, the quality of the raw material used by the industry will condition the final use of the wastes, being the further usage and yield of these wastes highly dependent on the species processed, and on the type of process (i.e. filleting, freezing or canning). For instance, most of the sub-products generated in a conventional cannery are sent to fish meal processors what could represent an enourmous amount of material: Depending on the size of the company, a canning plant can produce between 3,000 and 10,000 tons/year of sub-products such as viscera, skins, heads or bones.

Freezing industry also produces significant amounts of wastes. For instance skinning of flatfishes in a mid-size processing industry can produce between 100 and 500 tons/year of fish skin. Sharks and tunas can be also skinned by freezing industry and that can sum up out 50 to 400 tons/year of skins and 500-2,000 tons/year of heads.

A gross figure about the amount of wastes generated by fish processing is about 35% of the total fish catch. However this figure can vary depending on the species. For instance, species like the skates (only wings are consumed) generates large amounts of waste (almost 80% of their weight). Other species like tuna, used by canneries, can produce also as much as 60% of waste since only white muscle is used in canneries, while heads, viscera, skins, bones and red muscle are discarded when processing.

An equivalent analysis of wastes and by-product generation on-shore was made in France and Portugal. These are the main conclusions::

France: It was stated that 215,000 tons of by-products have been generated in France in 2005 as a result of fish trade (representing the 52% of the total amount of by-products) and fish processing activities (canning and smoking industries have generated the 36% and 12%of by-products respectively) as shown in Figure 15.

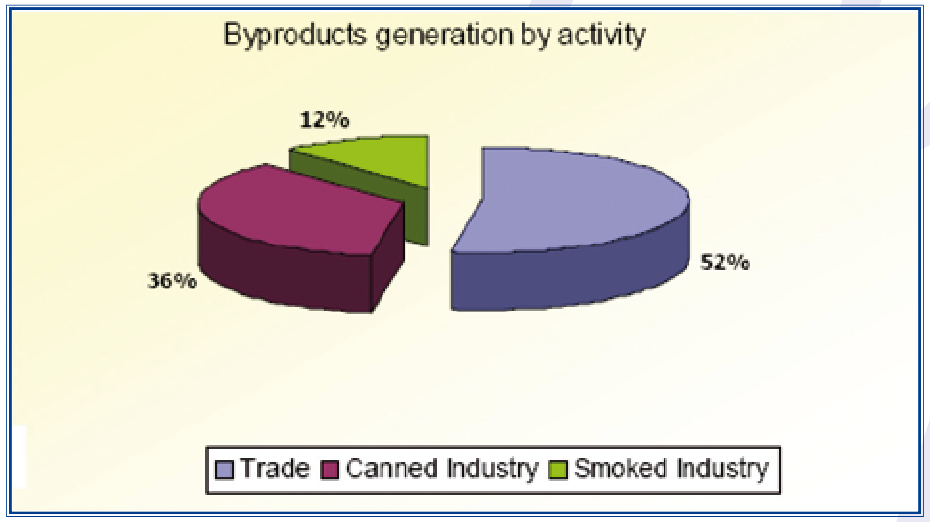

Figure 15. By-product generation by activity

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Pelagic species (to which belong species caught by industrial vessels such as herring, tuna or mackerel) generate about 45% of by-products. These species are destined to Fish Trade and Processing Industry. A 29% of the total amount of by-products belongs to salmonids, which are mainly exported or produced by aquaculture. Finally, white fish, whose species are commonly processed by Fish Trade companies, originates 21% of by-products, followed by by-products from cartilaginous species (5%) – see Figure 16.

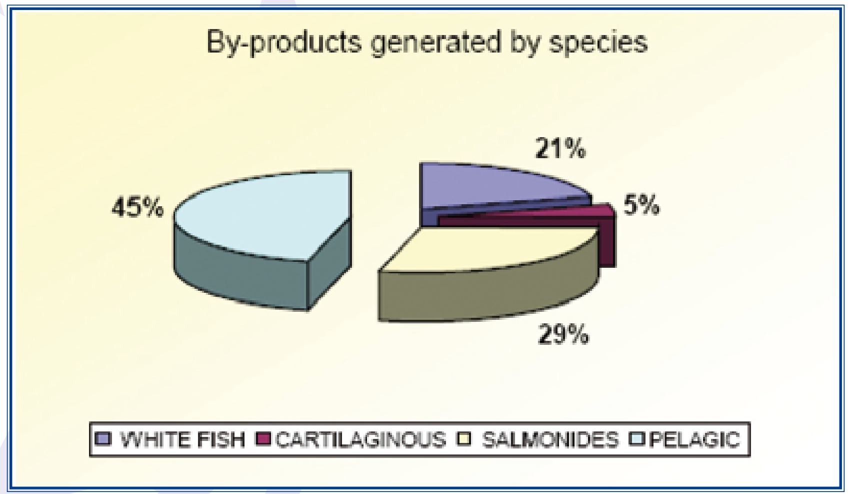

Figure 16. By-product generated by species

Finally, regarding type of by-products, a 40% of by-products correspond to heads, followed by fishbones (27%) and viscera (25%) – Figure 17.

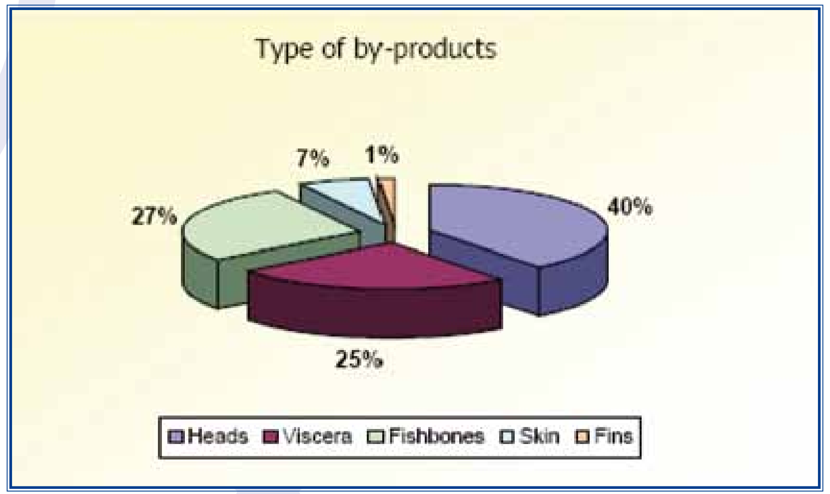

Figure 16. By-product generated by species

Portugal: For the case of Portuguese auctions activity and pre-processing, and more specifically, for the case of purse seiners, fish unloading is usually done by fishermen who also make the separation by species and size, as can seen in Figure 18. Fish to be sold is boxed and marketed in the auction. Fish eventually rejected, due to its small size or lack of demand, is mostly conveyed for fishmeal and oil production or treated as solid urban waste.

Figure 18. Fish pre-processing activities for purse seiners' catches in a Portuguese auction

Over the last year, in a short number of auctions, part or the totality of sardine withdrawals has been frozen and offered to the Portuguese food bank for human consumption purposes. The inherent costs associated to the preparation, freezing, frozen storage and distribution are supported by bank institutions.

Fish from the other fleet segments is presented in the auction, separated by species; when such operation has not been accomplished on board, is graded by size, weighed, boxed and iced. The auction workers are also responsible for the presentation of the fish in the auction hall, ensuring that it is kept in the best possible condition until be presented to the buyers. The amount of discards resulting from this procedure is almost negligible. The amounts of discards with respect of landings in the Portuguese framework are summarized on Figure 19.

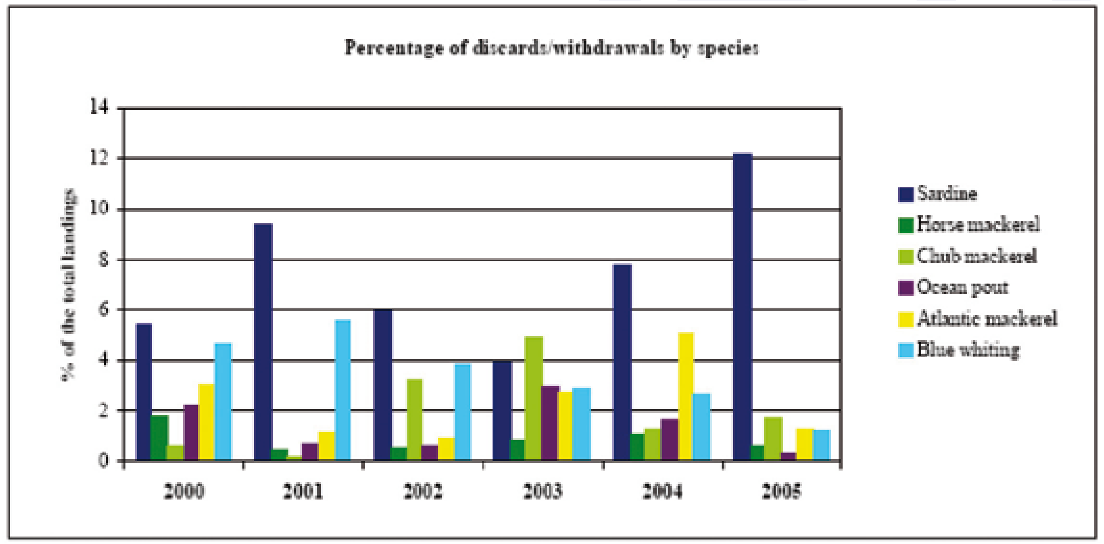

Figure 19. Amounts of discards for different target species in

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Another important result of this task was an evaluation and analysis of the current environmental impact of organic and inorganic wastes directly related with the fishing activity, including the protocols presently employed to handle residues in the Vigo Port Authority, which must be also followed by the processing companies established in the port authority. It also describes the current state of manipulation, valorization and residues elimination activities carried out by the Vigo Port Authority as well as by DILSEA, which is a waste management company working in the Vigo Fish Auction. In what refers to organic residues, manipulation protocols were established. On the other hand, valorization is reduced, partially to the production of fish meal, being most of the residues sent for incineration.

With respect to inorganic residues, in the APV, most of the wastes, managed according to MARPOL guidelines, come from fishing ships, being fundamentally two types:

- Oily residues, which can be employed as fuel.
- Solid wastes, which are managed on a "green point" in the Vigo Port Authority.

Other inorganic residues like plastics, polyspan, cardboard or wood are also managed and treated on the Port of Vigo, as shown in table 20.

Residue	Amount	Final destiny
Magas	Up to 10 ton / day	Feeding stuffs, pharmaceutical industry, etc.
Plastic	No data	In research
Polyspan	180 m^3 / week	Different products of plastic, naval industry.
Cardboard	10 ton / year	Recycled paper / cardboard
Wood	300 ton / year	Briquette, etc.

Table 20. Amounts of organic/inorganic wastes processed in the APV.

3. DEFINITION OF STORAGE, CLASSIFICATION AND PRE-PROCESSING STRATEGIES

The main objective of this task has been the establishment of separation protocols for by-products, its classification and storage plans definition, conservation and, when possible, pre-processing, on board as in land, in order to rationalize and to maintain the materials in the appropriate processing conditions.

Results

The main result achieved in this task has been the elaboration of A Good-Practice Manual for Recovery, Handling and Classification of Discards and By-Products. This manual addresses both the operations and practices needed to change the current procedures both on board as well on-shore towards a sustainable sensitive fishing activity as well as some recommendations for preserving and pre-treating of discards and sub-products.

The objectives of this manual are to:

- Serve as an instrument of reference to help to develop a regulatory framework for the implementation of the practices, procedures and machinery to fishing fleets, aiming at the reduction or elimination of discards and the strategies for the management of wastes onboard.
- Help the sector (ship owners, fishermen, etc.) with the best procedures to use in order to comply with this new perspective of the fishery activity, reducing also the costs of the procedures required.
- Promote standards of conduct in every sector involved in fishery practices, leading to a progress in the awareness of ecological and environmental protection.
- Develop and implement an efficient and integral waste management and processing practices both on-board (fishing fleets) and ashore (fish auctions and fishery industries) in order to recycle and to reuse wastes produced by the fishing activity, including efficient separation, classification, stabilization and conservation practices.
- Contribute to the minimization of the adverse ecological and environmental impact of fishing activities (onboard as well as ashore).

In order to mantain the demonstration charecter of the project despite the considerable diversity of fishing fleets, gears, catching areas, etc., the BE-FAIR initiative concentrated in two types of fihery (trawlers and longliners) representative of the many fishing fleets around the world. For these cases, the intention has been to provide guidelines to handle fish and fish byproducts, which could be later extrapolated to other fishing fleets and areas by adapting the protocols to other fishing vessels, fishing gears or type of catch.

Every fishing vessel, as part of the food production chain, should have implemented an appropriate **HACCP system** (Hazard Analysis and Critical Control Points). This manual will contribute with general rules about procedures for treating fish waste and discards using the approach employed in HACCP manuals (see Figure 21 for some waste management examples extracted from the Good Practice Manual).

Finally, a continuous update of this manual (available in a printed format as well as in CD, in Spanish, Portuguese and French) was made during the BE-FAIR Project life taking into account both the feedback of the different stakeholders (some of them participating in the project, ship owners, fishermen, fish auctions, fish processors) got through two ways:

- Contributions collected on the BE-FAIR Project webpage (www.befairproject.com).
- Meetings and seminars developed between the partners and companies from the fishing sector.

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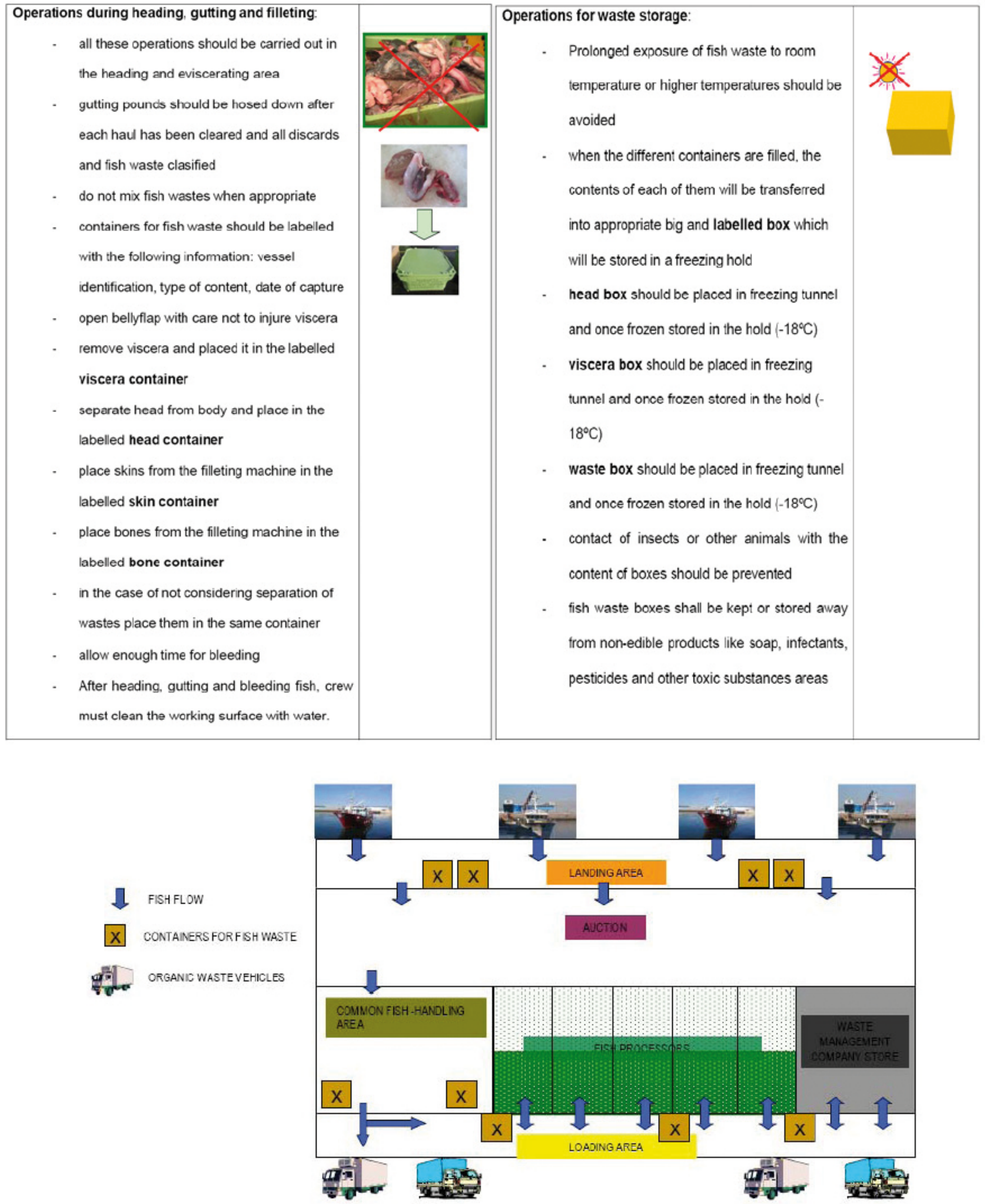

Operations during heading, gutting and filleting:		Operations for waste storage:	
- all these operations should be carried out in the heading and eviscerating area - gutting pounds should be hosed down after each haul has been cleared and all discards and fish waste clasified - do not mix fish wastes when appropriate - containers for fish waste should be labelled with the following information: vessel identification, type of content, date of capture - open bellyflap with care not to injure viscera - remove viscera and placed it in the labelled **viscera container** - separate head from body and place in the labelled **head container** - place skins from the filleting machine in the labelled **skin container** - place bones from the filleting machine in the labelled **bone container** - in the case of not considering separation of wastes place them in the same container - allow enough time for bleeding - After heading, gutting and bleeding fish, crew must clean the working surface with water.		- Prolonged exposure of fish waste to room temperature or higher temperatures should be avoided - when the different containers are filled, the contents of each of them will be transferred into appropriate big and **labelled box** which will be stored in a freezing hold - **head box** should be placed in freezing tunnel and once frozen stored in the hold (-18ºC) - **viscera box** should be placed in freezing tunnel and once frozen stored in the hold (-18ºC) - **waste box** should be placed in freezing tunnel and once frozen stored in the hold (-18ºC) - contact of insects or other animals with the content of boxes should be prevented - fish waste boxes shall be kept or stored away from non-edible products like soap, infectants, pesticides and other toxic substances areas	

Figure 21. Examples of methods and procedures which are part of the Good Practice Manual

In the same line, a report on the definition of storage and conservation procedures for discards and by-products has been also developed, containing a proposal of possible pre-processing techniques to:

- Efficient management of the catch storage space which is available in fishing vessels, which is currently fully allocated to edible commercial fishery products.
- Ensure better storage conditions and stabilization on board by considering refrigeration, freezing, oil extraction or pre-silage and water reduction, processes that will be described in detail later in this report.

4. PROSPECTIVE OF VIABILITY OF DIFFERENT PROCESSES OF VALORIZATION OF DISCARDS, BY-PRODUCTS AND RESIDUES

The objective of this action was to provide the necessary information to quantify the costs of the transformation processes potentially applicable to the raw materials available , as well as the volumes –and if appropriate, qualities– of the final products, evaluating at the same time the environmental impact of the raw material and transformation processes.

Results

The BE-FAIR project made use of a wide range of well established methodologies and techniques taken from biology, chemistry, and chemical and process engineering, which were combined on a systematic way to develop and demonstrate the possibilities of producing added value products from different fish residues and by-products. Among those methods and technologies, the consecution of the demonstration project rested on the following two critical technological aspects:

- ***A well established number of state of the art methods for producing added value products of use in food and pharmaceutical industry from different fish residues and by-products.*** In particular, it has been paid special attention to the following valuable products and their corresponding production processes:

a) Chondroitin sulphate (CS): The process considered to obtain CS from fish cartilage (which has the advantage that the resulting product from marine sources raises less reservations than those obtained from bovine or avian livestock) can be described in the following steps (Figure 22):

1. Hot water treatment of chondrichtyes residues, and trituration of the cartilage thus obtained.
2. Enzymatic hydrolysis of the cartilage. Separation of a solid residue and a clarified hydrolysate.
3. Alkaline hydroalcoholic treatment of the hydrolysate, with precipitation of chondroitin sulfate and solubilization of proteins in the supernatant.
4. Redisolution and neutralization of the sediment, and separation by centrifugation of the insoluble protein residue.
5. Concentration by ultrafiltration, followed by diafiltration to eliminate saline content and remaining low molecular weight solutes.
6. Drying of the concentrate and milling.

a) b) c)

d)

Figure 22 Raw material and intermediate compounds in Chodroitin Sulphate production: (a) Cartilage; (b) Extraction process; (c) Wet product; (d) Final (dry) product

b) *Fish gelatine:* Gelatine is obtained by the hydrolysis of collagen which is the principal protein found in skin and bones. The process to obtain gelatine from fish skins can be summarized as follows (see also Figure 23):

1. Washing of the raw material by using sodium hydroxide, sulphuric acid and citric acid subsequently.
2. Extraction, where skins are treated with water at 40-45 °C during 8 hours plus an extra hour of treatment at high temperature (80 °C).
3. Purification of the product by using an ultrafiltration unit or an evaporator+dryer, in order to achieve the desired humidity of the product.
4. Milling.

a) b) c)

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Figure 23. Gelatine production from fish skins. Raw material and intermediate steps: (a) Pre-processed fish skins; b) Extraction process in the reactor; (c) Drying; (d) Final product (unrefined)

c) *Hyaluronic acid (HA):* This chemical has anti-inflammatory and anti-edematous properties. Production of HA from vitreous humour consists of the following steps:

1. Extraction of the vitreous humor.
2. Concentration by ultrafiltration.
3. Alkaline hydroalcoholic treatment at low temperature, with precipitation of sodium hyaluronate and solubilization of proteins in the supernatant.
4. Redisolution and neutralization of the sediment, and separation by centrifugation of the insoluble protein residue.
5. Concentration by ultrafiltration, followed by diafiltration to eliminate saline content and remaining low molecular weight solutes.
6. Ethanol precipitation (repeated if necessary) of the ultrafiltration retentate.

The advantages of this process are that the HA obtained is of higher quality, and requires less alcohol use, which makes the process easier and more economical.

d) *Enzymatic preparations with proteolytic and colagenolytic activities:* This is a useful technology for stabilizing the wastes, discards and by-catch. The process consist of:

1. Separation of the pancreas from visceral residues of chondrichtyes.

Operate at 4ºC while:

2. Homogenization in an isotonic buffer, pH=6.5-7.5, with 0.2% of Triton X-100, and gentle agitation (~2 hours) of the homogenate.
3. Clarification of the homogenate by centrifugation, and re-extraction of the sediment.
4. Precipitation of the clarified fraction with 3 volumes of chilled (-40ºC) acetone.
5. Recuperation of the sediment by filtration (hydroacetonic filtrate is in part reusable).

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6. Vacuum drying of the cake and mill.

e) _Fish oils extraction:_ Livers represents around of a 5% of the total weight of the body in species like *blue shark* or *shortfin mako*. This organ contains considerable quantities of oil (around 50 % of the weight of the liver), with a high content on omega-3 oils, which represents almost a 40% of the fatty acids present in the oil. The process to obtain these oils can be summarized as follows:

1. Separation of the liver from visceral residues of chondrichtyes.
2. Gridding of the livers.
3. Pressi ng and filtration.
4. Centrifugation, with separation of the oils.
5. Storage of the product (for further purification processes).

f) _Wastes water reduction:_ This procedure aims to treat the fish wastage on board, in order to achieve some main objectives:

- Minimize the volume of solid by-products stored on board.
- Treat the effluents so their discarding causes a minimal environmental impact.

This process involves the following steps:

1. Pre-treatment of raw material to obtain a better yield in the press.
   - Low heating in order to provoke protein coagulation, facilitating its separation from oily phase.
   - Gridding.
2. Pressing of by-catches and wastes from fish processing on board. Two products are obtained:
   - A dry cake of minimum volume to be stored refrigerated (4 °C) or frozen (-18 °C).
   - A press liquor (with a high contain in proteins, lipids and other soluble substances) that is derived to a centrifuge.
3. Filtration/Centrifugation of the liquor, where oils and fine solids are separated. The oils are storage and the solids reintroduced in the press.
4. Centrifugation of the filtrate, obtaining an oily phase (to be storage on board) and an aqueous phase.
5. Ultrafiltration of the aqueous phase: As a result of this operation, a clear filtrate stream which can be directly discharged to sea is obtained.

- ***A virtual plant simulator, developed on a user-friendly and efficient dynamic modeling and simulation environment, to approach industrial operation.***

  An efficient user-friendly dynamic and multipurpose visual interface for the simulation of processing plants was developed on EcosimPro (www.ecosimpro.com). It is an integrated visual environment similar to Microsoft Visio and Visual Studio, which can be used to study both stationary states and transients. EcosimPro provides an object-oriented non-causal approach towards creating reusable component libraries and is based on very powerful symbolic and numerical methods capable of processing complex systems of differential-algebraic equations.

As cited previously, and by taking advantage of EcosimPro's capabilities, the most common components in processing plants were programmed as well as mass and energy connections, which are being included in a library. Therefore, the user can employ them by clicking on the corresponding icon and dragging it to the main window, constructing the overall virtual plant as is illustrated in Figure 25.

Due to the structure of the environment inclusion/exclusion, modification and improvement of both existing and new components is done in a straightforward manner. This virtual scenario allows the user to predict and to analyze possible changes on the product (quantity and quality) as well as possible operational problems caused by given input variations (quantity and quality of raw material), variations over operational parameters (for instance, pH or temperatures, variations on the recycled fraction, etc.) or over the equipment scaling (unit volumes) as well as cost assessment for the different processes' configuration considered.

A virtual plant for gelatine production (Figure 25) was constructed from a library of units with components as the ones represented in Figure 24. On this environment several industrial scenarios could be explored so to take into account the effect on the final product yield and quality of limited availability and quality of raw material, efficiency of water recycling policies or different extraction conditions, for instance. The representation of some of these scenarios and the effect on costs can be seen in Figure 26.

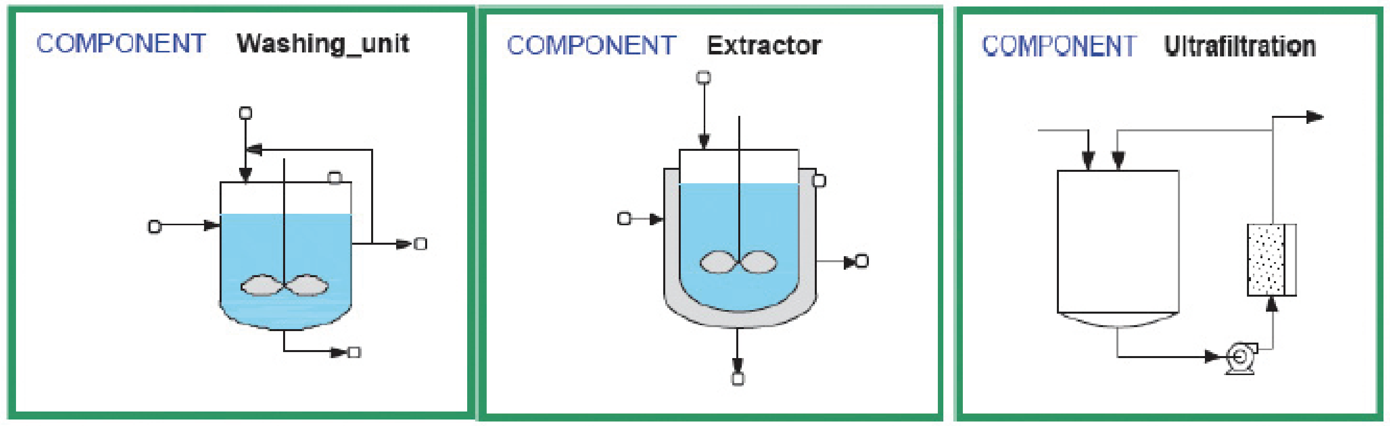

Figure 24. Different components to be employed in the construction of the industrial gelatine production virtual plant.

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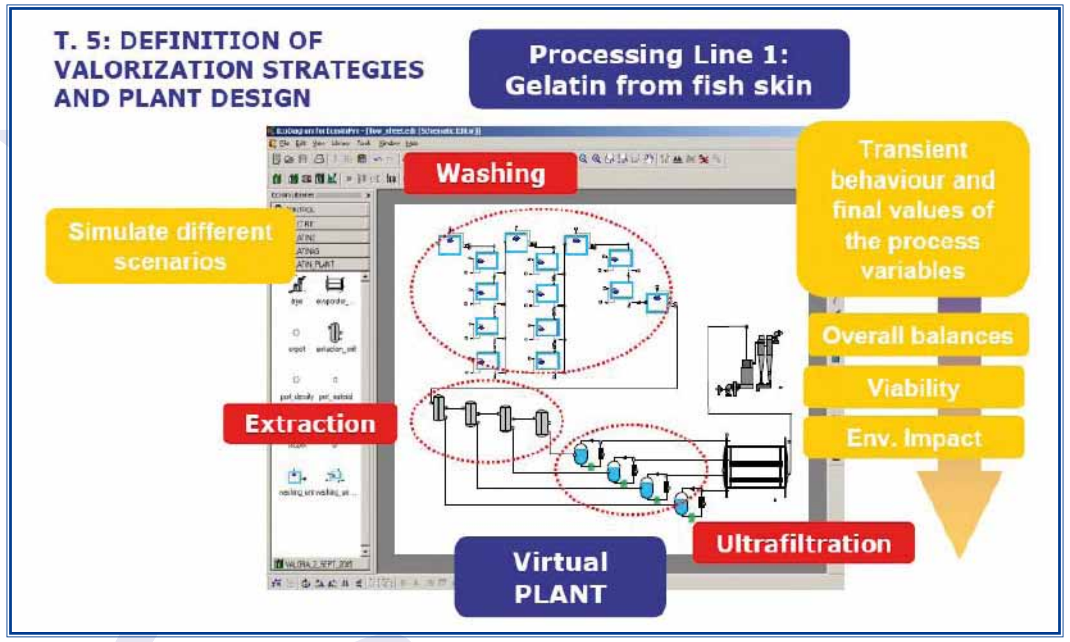

Figure 25. The virtual plant simulation environment

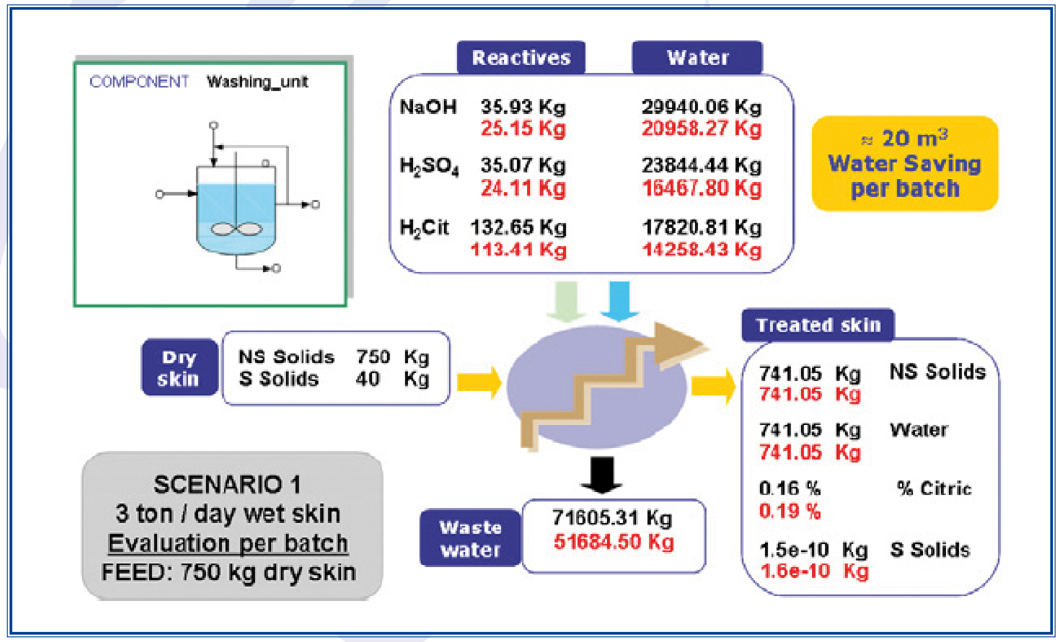

Figure 26. Assessment of different water recycling policies on process costs.

5. DEFINITION OF VALORIZATION STRATEGIES AND PLANT DESIGN

In this task, a reliable design for a flexible and multipurpose plant to process residues on a pre-industrial scale, so to allow the valorization of residues into commercial products, was proposed.

Results

The integral mass and energy flow diagrams and models for the proposed valorization processes were implemented and used in connection with Task 4 to simulate operation scenarios (Figures 27 to 31).

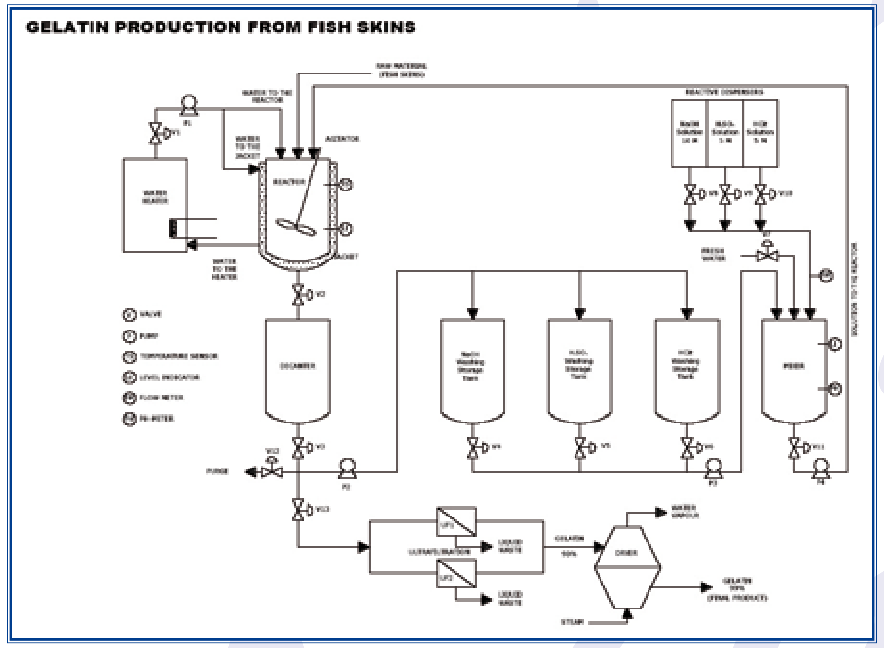

Figure 27. Diagram for the gelatine production plant

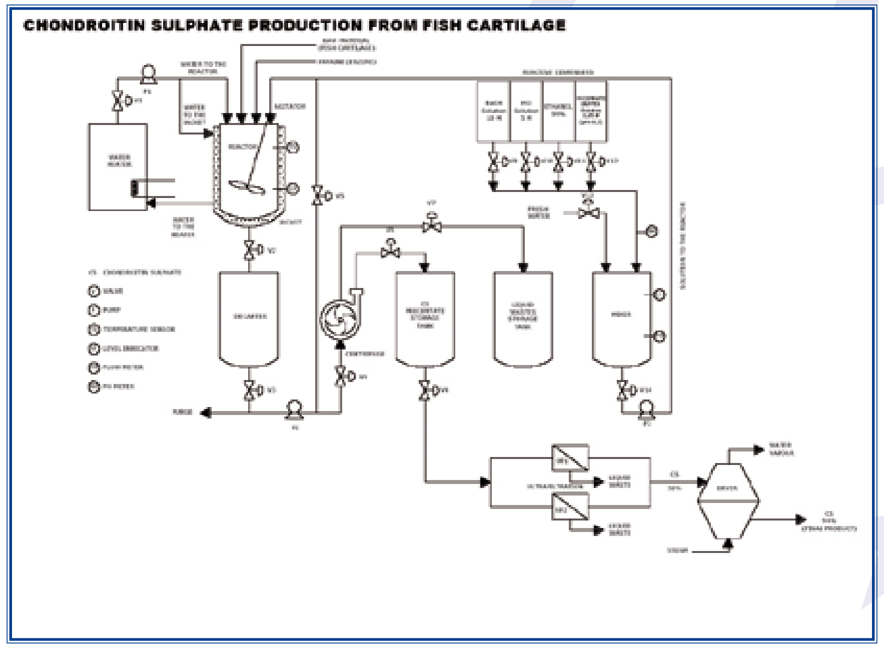

Figure 28. Diagram for the chondroitin sulphate production plant

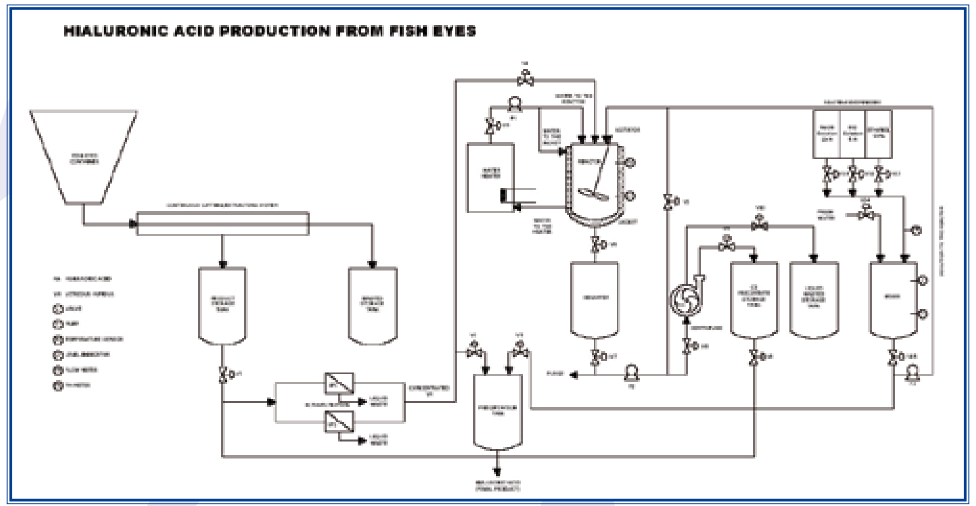

Figure 29. Diagram for extraction and purification of hialuronic acid

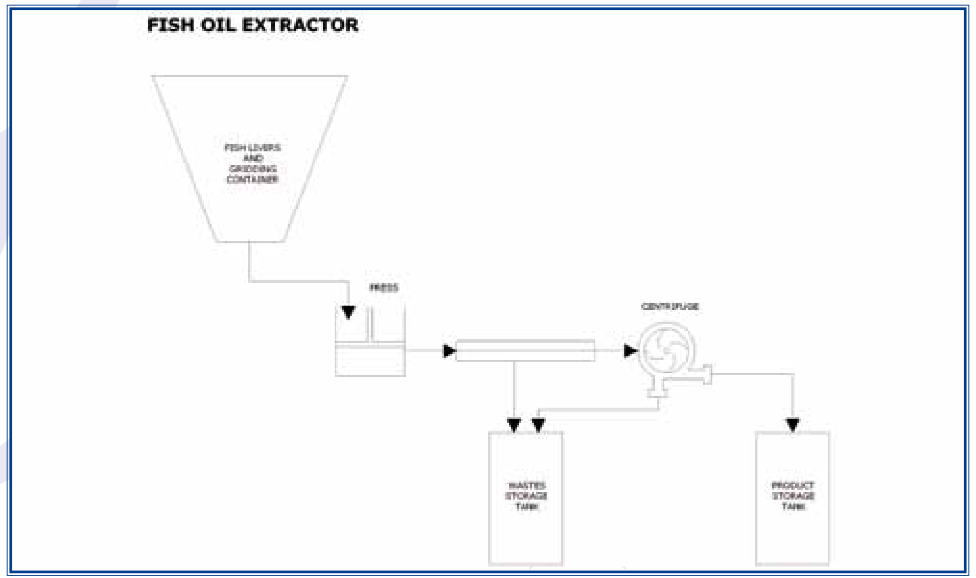

Figure 30. Schematic representation of the fish oil extractor

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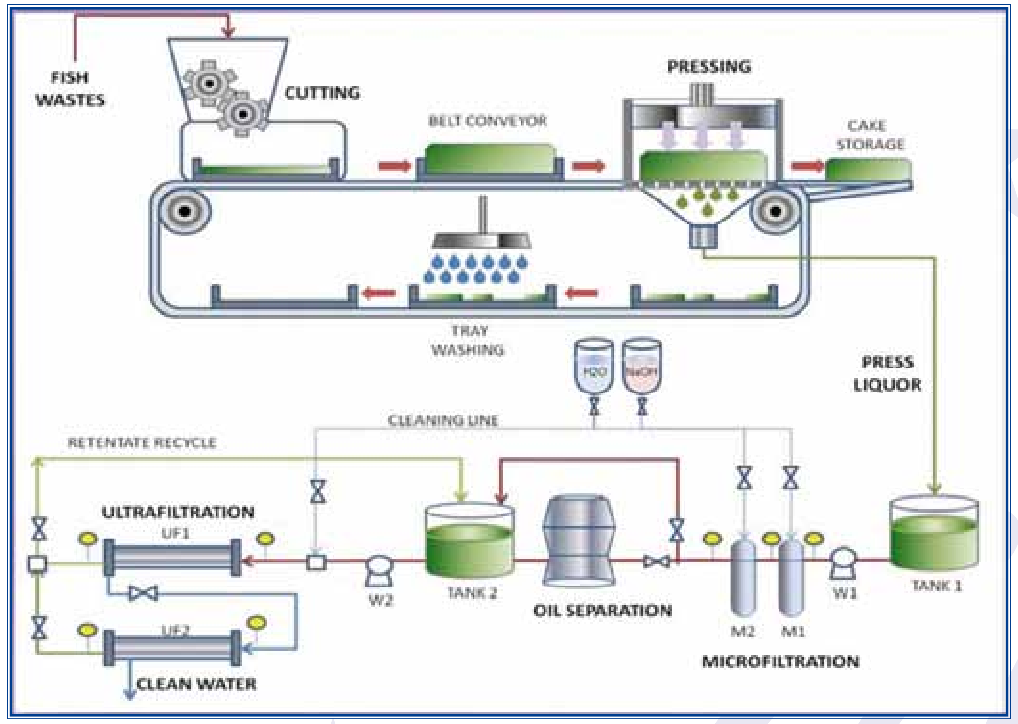


Figure 31. Schematic representation of the water reduction process

As a result of the actions described previously in this Task, design parameters for the different equipment to be constructed were selected. Equipment includes:

- A multipurpose pre-industrial plant for obtaining gelatine/chondroitin sulphate/enzymes (Figure 32).

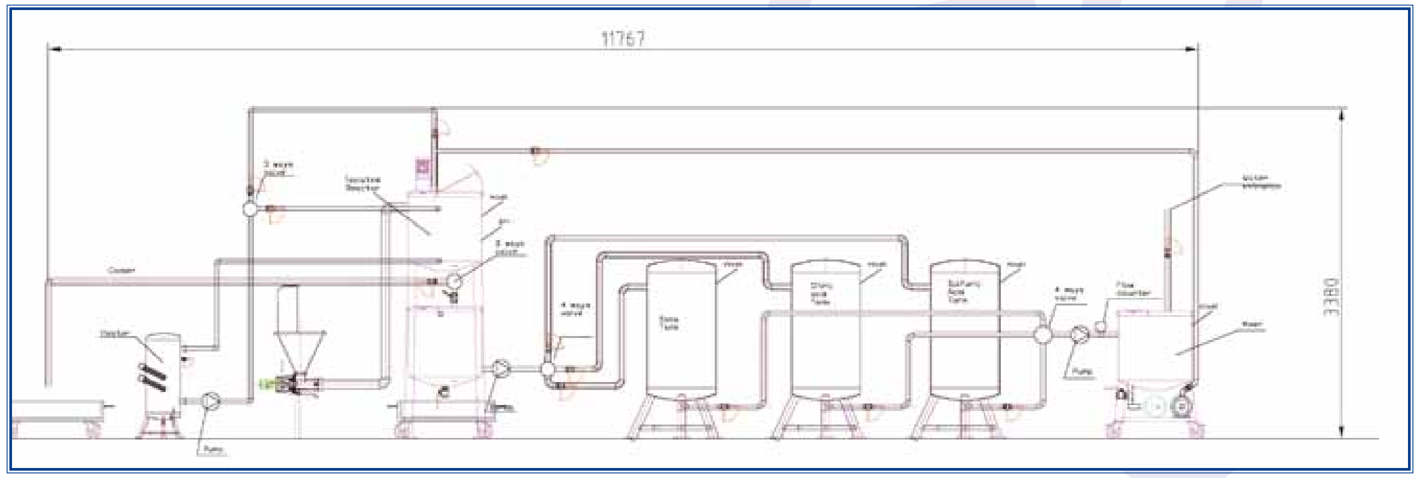
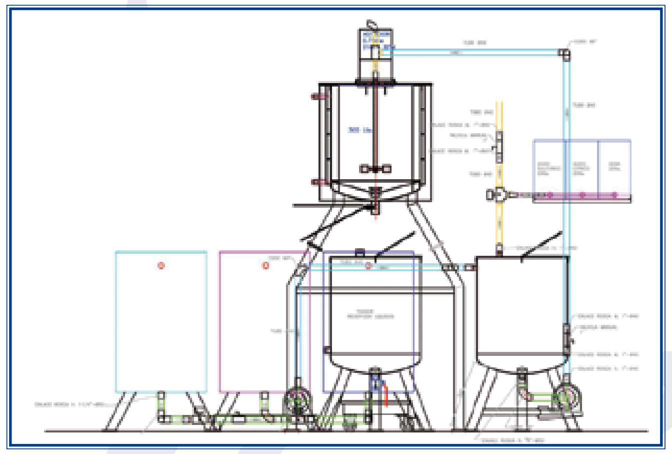


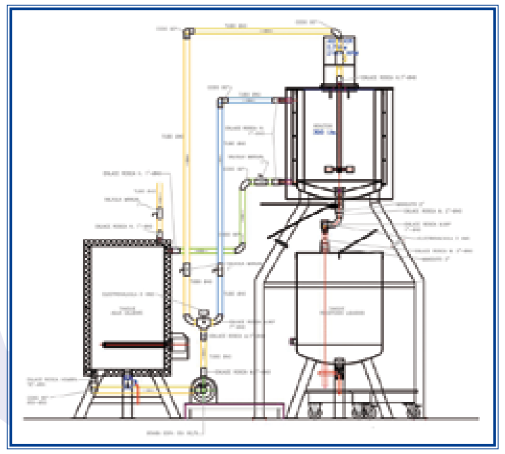
Figure 32. Design for a multipurpose plant to produce gelatine/chondroitin sulphate/enzymes

The designed prototype for these processes can be divided into two main sections:

Reaction section - Figure 33(a): It is composed by a jacketed stirred reactor, the decanter, the mixer and the washing products storage tanks.



a)



b)

Figure 33. Detail of the different processes and equipment involved in the multipurpose plant: (a) Reaction unit; (b) Heating section

Heating section - Figure 33(b): It is constituted mainly by the heater, the jacket which supplies heat to the reactor and the hot water circuit.

Once the recipies to produce the cited products have been executed, these will be purified through standard evaporation+drying or ultrafiltration procedures, which have been simulated and analyzed by using the developed virtual environment previously presented. One of the main aims achieved in the prototypes' design was to define and scale a ***multi-purpose plant,*** maximizing the use of equipments to be employed. The automation system allowing flexible plant operation is shown in Figure 34. Note that the supervision and control system drastically reduces both the equipment and installation costs as well as the space needed to allocate the plant.

Figure 33. Detail of the different processes and equipment involved in the multipurpose plant: (a) Reaction unit; (b) Heating section

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- A continuous cutting-extraction system to collec vitreous humour from fish eyes (Figure 35).

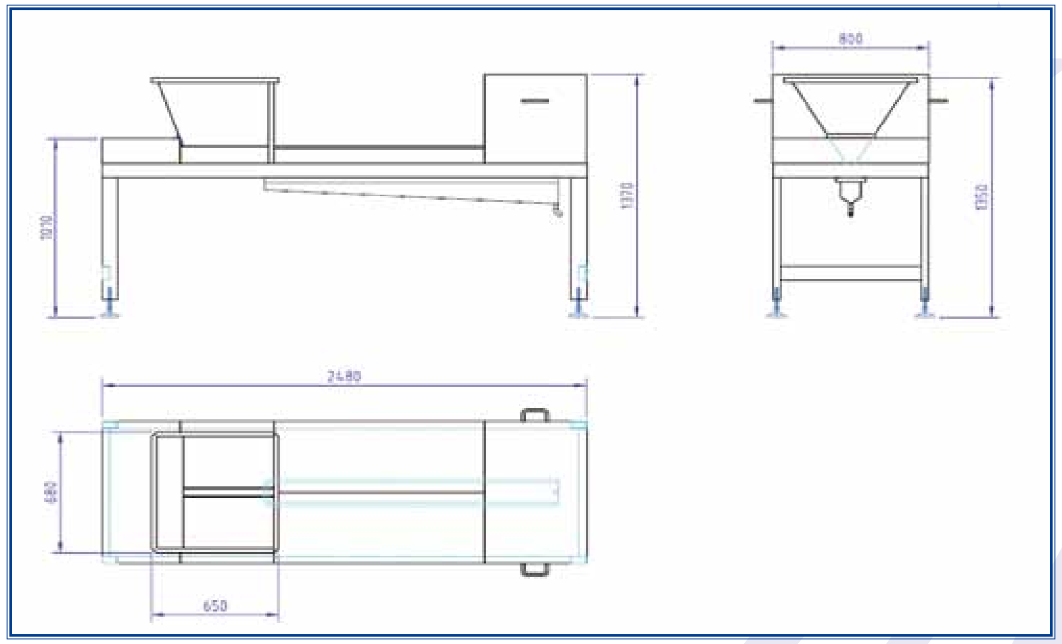

Figure 35. Construction details of the vitreous humor extractor

- The prototype defined for the vitreous humor extraction is a very simple mechanical device which consists of a storage fish eys container that feeds a conveyor belt integrated with cutting and squeezing systems. The apparatus will continously cut the eyes and extrac the vitreous humour, respectively. The desired product and solid residues are stored in separate tanks. This prototype must be considered as a pre-treatment equipment, being the starting point of the hialuronic acid process (Figure 29).

- Accessory equipment such as a centrifuge (to separate phases based on their different densities), a decanter (used to separate mixes from the reactor) mixing and storage tanks, pure reactants dispensers, heat exchangers and heating devices (boilers), valves, pumps.

- The water reduction unit, including a cutting system, a press and a purification section formed by microfiltration + ultrafiltration (Figure 36).

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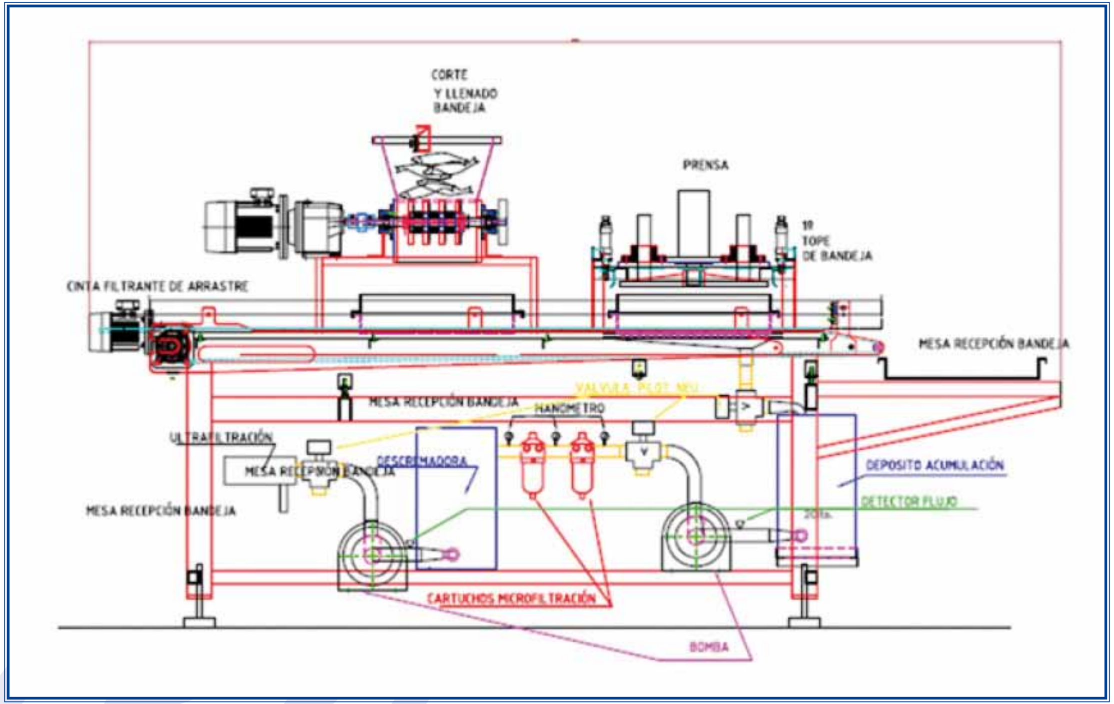

Figure 36. Construction details for the water reduction process

In the proposed design, raw material is pre-treated in order to obtain a better yield in the press. The selected option is a grinding since this operation can be easily done in a continuous mode on board. After this, raw material, composed by by-catch species and wastes (guts, skins, etc.) from fish processing on board are fed into the press. As a result of pressing operations, two phases are obtained: a dry cake whose volume must be minimal in order to be stored at +4°C (refrigerated) or -18°C (frozen), and a press liquor which is derived to a filtration system. This liquid effluent presents an important content in oil, as well as fine solids which can be removed by means of a filtration cartridge. The cartridge consists on a cylindrical outer filter having an axial bore and a surrounding side wall structure. The inner surface is perforated with pore diameters varying from 15 to 850 microns, disposed to allow the passage of the water through into the axial bore and thus retain fine solids. These fine solids can be added back to the press cake and stored on board.

- A fish oil extractor (Figure 37), which includes a grinding system with a defined pore-size sieve and a pressing system to separate the oils from the solid matrix.

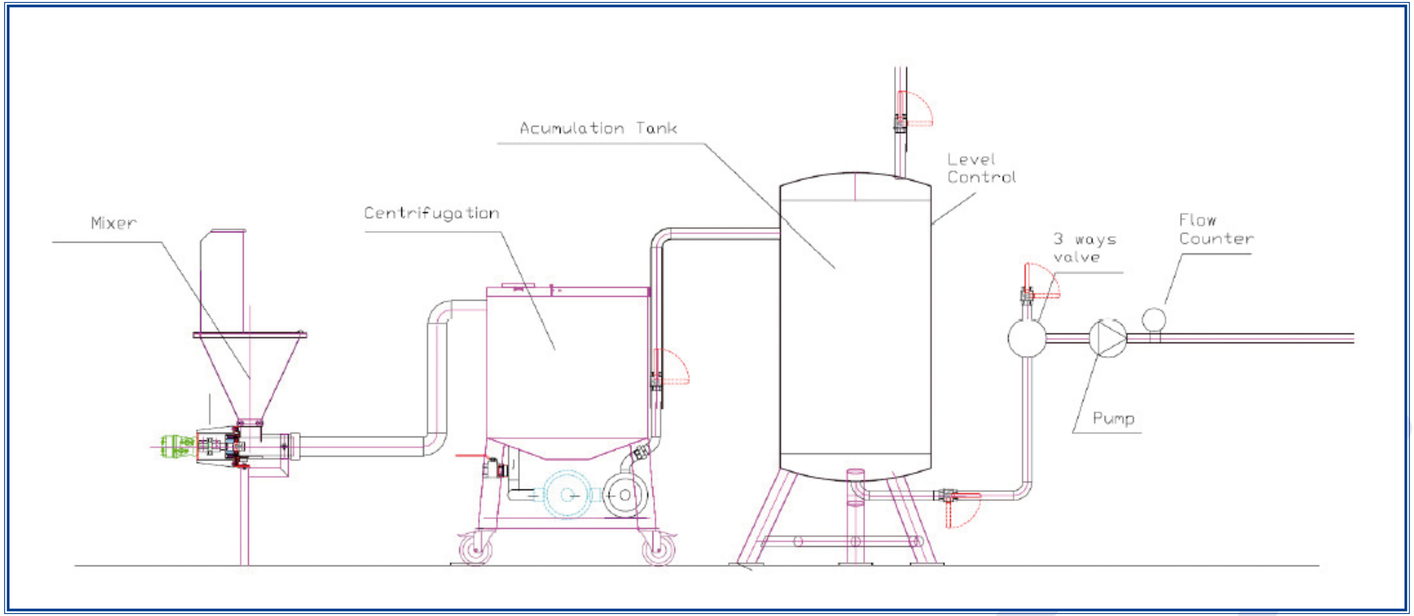

Figure 37. Construction details for the oil extractor

This prototype includes a container for livers with a gridding system in the outlet and a centrifuge, where the oily and no-oily phases are separated based on their different densities. The liquid residues as well as the remaining solid particles are removed from the centrifuge and sent to post-process units for further treatment and inertization. The oils are stored in a tank, where a small quantity of antioxidant (as BHT, propyl gallate, etc.) is added to avoid undesirable oxidation processes of the oil components. From the storage tanks, the oil is pumped to refinement units in order to get the desired component (i.e squalen, fatty acids, etc.) from the oily phase.

6. DESIGN-CONSTRUCTION OF EQUIPMENT FOR PROCESSING ON BOARD AND ASHORE

The objective of this task was the construction of prototypes and final machinery for the execution of the processes of transformation that has been defined as a result of the previous tasks.

Results

All the prototypes built have been properly checked and finely adjusted after several tests carried out during the BE-FAIR Project life in order to ensure the production of valuable target products from fish wastes and discards, achieving the quantities and qualities estimated during Tasks 4 and 5.

The prototypes that have been constructed are presented next:

1. Multipurpose prototype for gelatine extraction/chondroitin sulphate/enzyme processes (Figure 38).
2. A mechanical device to extract vitreous humor from fish eyes (Figure 39).
3. A Fish oil extractor to obtain oils from fish liver on-board (Figure 40).
4. A water reduction unit (Figure 41).

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Figure 38. Details of the multipurpose plant prototype

Figure 39. Details of the vitreous humor extraction equipment

Figure 40. Details of the fish oil extraction unit.

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Figure 41. Details of the water reduction unit

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The mechanical construction of all designed prototypes was carried out by Hermanos Rodríguez Gómez, S.L., partner of the project.

In order to disseminate the capabilities and benefits of the constructed prototypes, diffusion material consisting on explicative sheets for each of them (including the flow diagram, the mechanical design and representative photos of the main parts of each equipment) was ellaborated, as shown in Figure 42.

Figure 42. Diffusion material elaborated to present the prototype's capabilities among the fishing sector

Due to the demonstration character of the BE-FAIR Project, all these prototypes were presented to the fishing sector actors during different demonstration sessions carried out in:

1. Vigo (Spain): 3 sessions were developed for presenting the gelatine, chondroitin sulphate (see their programs on Figure 43) and fish oil production equipments.
2. Nantes (France): 1 session to present the water reduction unit.
3. Lisbon (Portugal): 2 sessions to present to the Portuguese fishing sector all the prototypes developed in the BE-FAIR framework.

An impressive response in terms of attendance and interest for the results and equipments proposed in BE-FAIR has been got from all the actors of the fishing activity (fleets, ports, auctions, fish processors, etc.), as exemplified in Figure 44.

Figure 43. Program of the demonstration sessions carried out in Vigo (June, 2008) for the gelatine and chondroitin sulphated multipurpose plant.

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Figure 44. Selected pictures showing moments of the BE-FAIR demonstration sessions.

7. MARKET POSSIBILITIES STUDY

The main objective pursued in this task was the search of economical and commercial feasible alternatives for the optimization of the use of residues and byproducts originated by the marine-fishing industry, in order to lighten the problems (environmental as well as the management of prices) that the existence of these residues causes in the fishing sector.

Results

In order to achieve this objective, a compilation and processing of information regarding product applications (i.e., food, cosmetics, pharmacy, etc.) and markets, including the degree of market viability (identifying the threats and opportunities) associated to the considered products were carried out for gelatine, chondroitin sulphate, hyaluronic, fish oil, enzymatic preparations, peptones, biological silages and hydrolizates.

Use and management of by-products and residues

Threats:

- Shortage of resources due to the reduction of fishing activity can jeopardize the yield of some applications of these by-products and residues.
- Use of by-products as an alternative for a differentiation strategy in the sector can be developed in the medium and long term, so new competition will come up.
- The fact that developing countries were placed in the top of the global fishing and aquaculture production, make us suppose that these areas will also sooner or later carry out technology initiatives for valorization and use of by-products.
- Competition of third countries which have at their disposal own raw material or a tariff system more favourable for the import of marine – fishing by-products with more permissive environmental conditions.

Opportunities:

- European regions with a bigger volume and concentration of fishing industries have an important advantage in relation with supply availability and stability..
- Topics about recycling and waste management are generally positively appreciated and supported by governments and by the whole society.
- Some new and promising alternatives of by-product uses have been well developed and there is an important industrial interest as compared with other traditional ways of valorization (especially in the case of fish meal and oil).
- It is likely that the legislation related with returning discards to the sea will be much more restrictive in the mean term what will force fishing vessels to unload those discards in land. In this context, the implementation of methods for upgrading aimed at reducing costs and producing benefits should be particularly atractive.
- The implementation of processes for the use of fish waste reduces significantly their accumulation at docks and contributing to minimize the environmental pollution.

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The information already available in the developed market analysis includes:

- Product description.
- Possible applications.
- Global market figures and trends such as volume and value of the production, prices and availability of raw material, or main competitors.

Gelatine

This product is a high-quality protein which combines many positive properties for a healthy diet, thus the main application of gelatine is in the food market, which concentrates the 65% of the total production. This is a market with a low influence under possible economic fluctuations, therefore the demand of this product maintains a steady trend.
Due to its versatility, gelatine is used in a wide range of **applications**, in areas such as *food industry* (dairy products, candies, and desserts and confectionery products, nutritional complements, packaging, etc.), *pharmaceutical industries* (medical excipient in capsules, pills, tablets, gelatine sponges, etc.), *chemical industry* (detergents, elastic adhesive, matches, therapies with mother cells, etc.), *photography industry* (graphic films, X-ray films, color papers) or *cosmetic industry* (hair and dermohydratant treatments).

Regarding **market and trends**, and according to the data of The Gelatine Manufacturers of Europe (GME) for the 2006, world production of gelatine is over 315.000 tons, of which 119.800 tons are produced in Europe. Fish gelatine accounts only around 1-2% of the global production in volume terms (Figure 45).

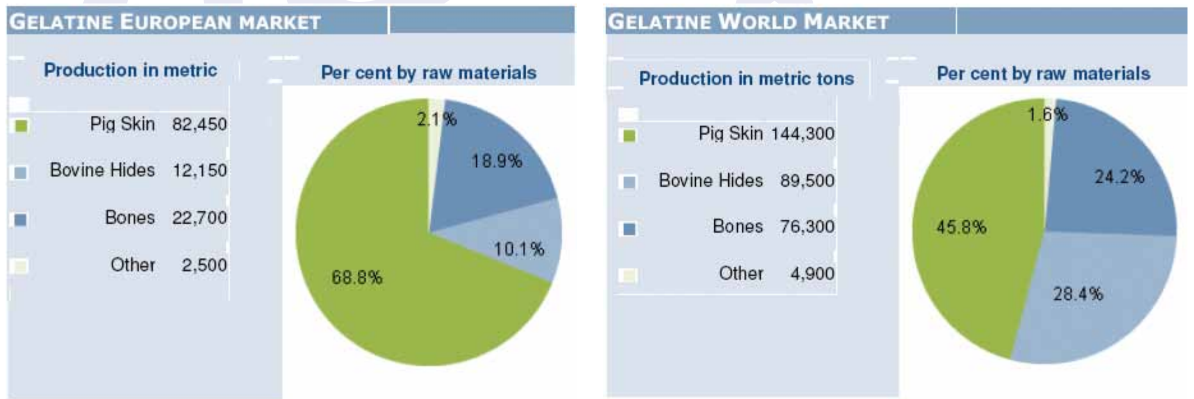

Figure 45. European and World Gelatine markets by raw material origin

The **price of gelatine** varies according to the raw material, specific application or technical characteristics. Generally, fish gelatine is more expensive than the obtained from cattle or pigs, and, by the application of the product, gelatine for photographic uses is the most expensive.

The world sector of gelatine is formed by a small number of companies with a great market quote. During the last years, one of the significant trends in the gelatine market is the acquisition of small companies by biggest firms in a generalized merging process. As a common characteristic, these firms have a large internationalization degree which is as high as the size of the company. That internationalization degree not only is referring to sales, but also to the origin of raw materials, so some companies must import them from third countries, with an increased cost due to the adaptation to the regulations on quality and safety requirements.

Finally, it must be pointed out that most of produced gelatine is obtained of pigs and cattle, from skins and bones of sacrificed animals for their human consumption. As the global consumption of this foodstuff is reduced whereas the demand of their skins for the textile industries is increased, the fish gelatine has the chance of being a good replacement product. This fact constitutes an additional advantage for the fish gelatine market, since the world consumption of fish is growing and thus the raw material available for this way of obtaining gelatine. As an example, consumption of gelatine is approximately increasing at a annual rate of 3%. Furthermore, after the ***"mad cow"*** disease problem the demand of foodstuff from cattle meal has been diminishing, coinciding with a growing demand of raplacement products.

Chondroitin sulphate

The chondroitin sulfate is extracted from the animal cartilage, in the case of the fish product, is especially obtained from cartilage of chondrichthyes such as ray or shark.

Its is employed in *veterinarian industry* (supplementary dietetic and for intra-articular treatments), *nutraceutical industry* as dietetic supplement, and in *pharmaceutical industry* (for treatment of osteoarthritis and arthrosis and as anti-inflammatory agent).

In the emergent nutraceutical industry the **trend** exists for using only marine chondroitin, obtained exclusively from fish or crustaceans, for its application in dietetic supplements. At the present moment these products are sold without a medical regulation, only as dietetic supplements, thus their quality is very variable.

According to the Annual Ingredients Market Overview, in 2005, the glucosamine and chondroitin market notched up €940 million in consumer sales and about €100 million in raw-material sales. These products were in short supply in 2004-05, causing prices to soar. The shortage was caused by poor weather that affected the aquaculture industry, US tariffs on shrimp, and price hedging in China, which supplies an estimated 75% of the world market. At the same time, warnings about arthritis drugs boosted demand for these products in USA.

Hyaluronic acid

The main source of Hyaluronic acid (HA) is from the cock's comb, but also is extracted from the vitreous-humor and synovial joint fluid of bovine and pigs. Fish species are not yet a common source for HA but, as alternative sources, HA could be obtained from the vitreous humor of some species, like swordfish, hake, tuna, shark, ling or redfish. However, economically feasible production volumes based exclusively on fish sources would not be achievable.

Regarding its **applications**, these are focused in the *pharmaceutical industry* (osteoarthritis and arthrosis, ophthalmology, scaring process, odontology, dermatology, urology, etc.), *cosmetic industry* (aesthetic treatments and implants, cosmetics) and *nutritional industry* (dietetic complements).

The **market** of HA is growing, especially in developed countries with a growing level of elder population, due to the presence of osseous diseases and the increasing interest in anti-aging and beauty treatments. But the **market opportunities** of HA which is exclusively produced from fishes are low, not only for the complex procedure of obtaining by-products in good conditions for their use, but because by itself is not a source able to achieve enough production volumes for its introduction and developing in the market. However, using this way of obtaining HA as a complement to other sources could be a good option.
In terms of commercial value, the HA world market in is more than €500 millions and it's sold for up to €100.000 per kilogram. We can mention, amongst factors with importance for the dynamization of the HA market the complexity of the pharmaceutical market, which is controlled by multinational firms or the difficulty, high cost and low versatility of obtaining procedures.

Fish oils

Fish oil is a lipid blend extracted from the tissues of oily fishes such as mackerel, sardine, anchovy, tuna, herring, lake trout, etc. It has a complex chemical composition that depends on diverse factors like the structure of fatty acids, the kind of species used for its production, the type of plankton and the season of the year. All these factors will have influence on the oil properties, its applications and on the processing techniques for its production.
Its main applications can be summarized as follows: *chemical industry* (paints, varnishes, lubricants, detergents), *veterinarian industry* as a component in the animal nutrition and in the enrichment of products, *pharmaceutical industry* (capsules of pure oil), cosmetic industry (moisturizing products, and *nutritional industry* (enrichment of alimentary products as vegetable oils, dairy products, sauces, chips, sweets and candies, soups, etc.).

According to Globefish, the unit in the FAO Fisheries Department responsible for information on international fish trade, in 2005 the **fish oil production** declined a 12% in all main producing countries with the exception of Iceland. The estimated production for that year is about 570.000 tons in the five main exporting countries (Peru, Denmark, Chile, Iceland and Norway). (Figure 46).

Fish Oil production in the five main exporting countries (tons)

	2000	2001	2002	2003	2004	2005
Peru	593000	304000	193000	208000	352000	290000
Denmark	137000	146000	105000	109000	67000	72000
Chile	171000	143000	146000	130000	142000	122000
Iceland	95000	108000	80000	92000	49000	55000
Norway	83000	66000	62000	51000	37000	31000
TOTAL	1079000	767000	586000	590000	647000	570000

Figure 46. Fish oil production by country

Fish oil prices showed strength, especially when compared with soy oil prices. In the opening months of 2006, fish oil prices were €900/tone, exceeding those of the competing vegetable oil by 240 €/ton (Figure 47). This differential seems to be bound to be even wider in the near future. Fish oil experiences a strong and growing demand by the aquaculture industry, where it's essential in the diet of carnivorous species.

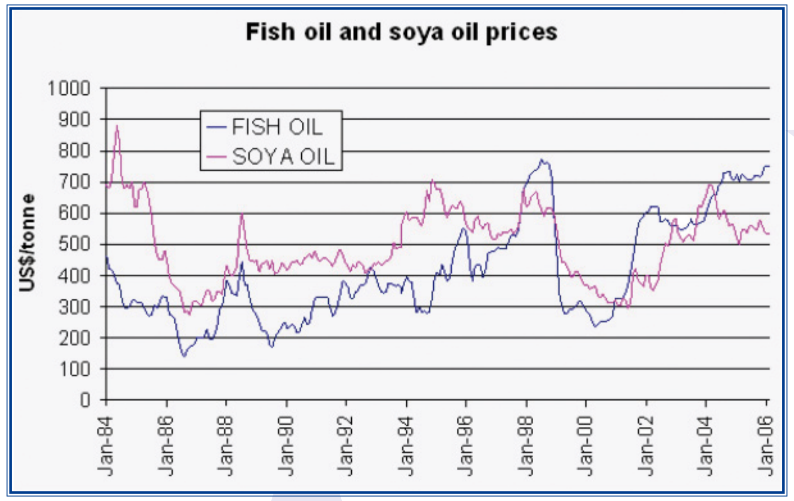

Figure 47. Evolution of fish and soy prices over the last decades

ENVIRONMENTAL IMPACT AND COSTS-BENEFITS ANALYSIS OF THE PROJECT

The need to reduce discards in European fisheries was identified by the Commission as an important objective for the future of the Common Fisheries Policy. Nowadays it becomes evident to the industry and to the society the need to minimize the adverse ecological and environmental impact of fishing activities (on-board as well as on-shore) as they constitute a purposeless waste of valuable living resources contributing to the depletion of fish populations. This might occur by a number of different mechanisms:

- The capture of juvenile individuals of target species results in lower catch opportunities for those in the future (increased overfishing). Furthermore, the juveniles caught will not contribute to future spawning seasons.
- The discard of mature individuals of target species represents a waste and immediately reduces the spawning biomass of that stock.
- The capture and discard of fish, crustacean, sea bird or sea mammal species which are not targeted by fisheries, has an unnecessary negative impact on the marine ecosystem as it affects both its functioning as well as its biodiversity without providing any benefits to society.

On the other hand, and from an economic perspective, the fishing industry can be negatively affected in two main ways:

- Fish killed without contributing to the income of the sector will not contribute to the income in the future either. Note that fish left to live and grow in the sea would be available as an economic resource in the future.
- The fishing industry will be affected because of its high degree of depending on the health of the marine ecosystem.

Note that enforcing a zero-waste policy necessarily requires a readjustment of the cost-benefit balance, since bringing discards and wastes to land implies an increment on the transportation costs of the fleets. Storage capacity on a vessel is an expensive asset usually reserved for the storage of the targeted species.

The results of BE-FAIR Project will contribute to the reduction of the environmental impact and the minimization of the cost related to the management of discards by proposing alternatives which will add economic value to the wastes (by defining well-established valorization technologies) while at the same time will reduce the costs associated to storage capacity and transportation. Such reduction will be possible through the application of appropriate on-board management protocols for discards and wastes as well as by pre-treatment processes and equipment to reduce volumes and to maintain the material in the best possible conditions for further valorisation.

TRANSFERABILITY

One of the strategies towards a responsible management of fisheries is to promote policies of no-discard and zero-waste production both on-board of fishing vessels as well as in-land (harbors, transforming industry, etc.). In order to ensure sustainability of fisheries and fishing related industry, such policies must be accompanied by up-grading strategies for the fish wastes and by-products. In this aim, the BE-FAIR Project constitutes an integrated framework where to accomplish these objectives by both defining a set of valorization technologies to obtain valuable chemicals from discards/by-catch/wastes and to asses their viability at a pre-industrial level.

The possibilities offered by well established technologies and methods from chemical and process engineering to produce added value products from different fish residues and by-products have been demonstrated in the context of Atlantic fishing fleets and industries. In particular, at to some extent, data from Portuguese and French industry has been included in the evaluation, the demonstration of viability has been mostly assessed on Galician companies representative of the different agents that constitute the fishing sector.

Finally, it must be noted that by the nature the systematic employed, the results of this project, including the methodologies developed can be extended and be transferable to other regions of the EU and of the world where industrial fish activities are being held. Furthermore, the techniques derived from this project when properly adapted, could be employed in the management of residues in fishing activities of coastal fishing and aquaculture.

PARTNERS

EXTERNAL COLLABORATORS