

In Added Value to Fisheries Waste

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General introduction about by-products, worldwide situation and French focus

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Introduction:

A direct consequence of traditional fishing practices is the considerable quantities of wastes and by-products that are generated. They represent an economical and environmental problem since not all obtained from the sea is adequately used but thrown back into the sea as a waste. With the aim of classifying and quantifying the by-products, three main groups are considered: discards, wastage on board and by-products and wastage on shore.

1.1. Discards

The definition of discards is adapted from FAO Fisheries Report No. 547 [1] and is as follows:

Discards, or discarded catch is that portion of the total organic material of animal origin in the catch, which is thrown away, or dumped at sea for whatever reason. It does not include plant materials and post harvest waste such as offal. The discards may be dead, or alive.

Some concepts related to discards, whose definitions are taken from the FAO Fisheries Report, are used in this report:

- *Bycatch*. Bycatch is the total catch of non-target animals. We cannot consider that the whole discards are due to bycatch species, since small sized target species are often discarded.
- *Discard rate* is the proportion (percentage) of the total catch that is discarded.
- *Catch*. Catch includes all living biological material retained, or captured by the fishing gear, including corals, jellyfish, tunicates, sponges and other non-commercial organisms, whether brought on board the vessel, or not.
- *Landings*. This term refers to the portion of the total catch brought ashore, or transhipped from the vessel.

1.2. Wastage on board

Nowadays, the number of vessels processing the captures on board is increasing. As a consequence of fish processing on board, an important quantity of subproducts is generated (heads, viscera, skins, etc)

These subproducts, being easily perishable, need to be stabilized immediately by freezing. Only livers and eggs from some species, such as siki and monkfish, have enough commercial value to be sold on land. Therefore, most of the wastage generated on board is discarded to the sea.

1.3. By-products and wastage on land

Fish processing companies employ raw fish as raw material to be processed in order to obtain a final product with higher commercial value. Several operations are involved in fish processing like heading, gutting, filleting, removing tails and peeling. These operations generate many by-products such as heads, viscera, tails, skins, shells and fins which are not put on market due to their low acceptance by consumers or sanitary regulations which avoid their use in human foods.

Other operations involved in fish processing, such as washing, thawing and cooking generate aqueous effluents which are normally discarded. Wastewaters

generated by fish meal industries contain a high organic load due to the presence of oils, proteins (0.5-20 g/l) and suspended solids [2]. Therefore, they should not be discharged without a suitable treatment in order to prevent negative environmental impacts and allow the recovery of high added value products.

1.4. Worldwide situation and regulations concerning discards

Discarded catch represents an environmental problem since valuable living resources are wasted while global marine catches are declining. It receives more and more attention from policy makers, industry and general public.

Discards may be attributed to many factors [1]:

- *Fishing area.* Discard rates vary among different fishing grounds, due to the presence of reproductive areas where small-sized species are abundant, or the different composition of the fish populations on the ground.
- *Fishing gear.* The metiers employed to catch fish are an important factor in the quantities discarded. Two parameters, mesh size and time of immersion, determine the quantity and composition of discards.
- *Fisheries policy.* Regulations concerning minimal landed size or minimal mesh size. There are countries, such as Norway, where no-discard policies are applied, minimizing the quantities of non-target species caught and promoting the use of non commercial species for other applications, mainly fish meal or fish oil.
- *Fish markets.* They determine which species are targeted and which other are discarded. Discards are also composed of small-sized individuals of target species, with weak commercial value, even if the size is higher than that allowed by minimal landing size regulations.

The quantification of discards and knowledge of trends in discarding practices are of value in the design of fisheries management regimes and initiatives to promote responsible fishing operations and catch utilization. FAO is mandated to report periodically to the United Nations on the implementation of the resolutions and to promote efforts to reduce or minimize discards, drawing the attention to wastage of fishery resources.

The last FAO assessment (2004) [3] compiles information on catches and discards from the world's fisheries during the period from 1992 to 2001. This study assumes that discards are a function of a fishery, defined in terms of an area, fishing gear and target species, and has estimated global discards to be 7.3 million tonnes, with a global discard rate (quantity of discards as a percentage of the total catch) of 8 percent.

The highest quantities of discards are found in Northeast Atlantic and Northwest Pacific (fig. 1.a.) which jointly account for 40 percent of the discards

[3]. Regarding the fishing gear (fig. 1.b.) trawl fisheries for shrimp and demersal finfish account for over 50 percent of the total estimated discards.

International instruments, including UN resolutions, the Kyoto Declaration and the *Code of Conduct for Responsible Fisheries* have highlighted the need to reduce, or minimise discards. Regarding the fish wastage on board, this code propose to treat wastes in the vessels where that is possible, or keep them for a later treatment on land, but never dump them into the sea.

European Commission communications COM(2002) 656 [4] and the earliest COM(2007)136 [5] aim to initiate a policy which will reduce unwanted by-catches and progressively eliminate discards in European fisheries. To accomplish this objective, these communications propose to introduce a discard ban, where all finfish and crustaceans caught will have to be landed. A requirement to land all fish will mean that occasionally fish above the quota or below minimum market size will be landed.

Technical solutions to handle these by-catches are to be considered – whether they will be sold through normal market systems, for human consumption, for reduction to fish meal and oil or otherwise. Other supplementary measures are to be introduced, such as encouragement to improve the selectivity of fishing gear, requirements to change fishing ground and real time closures. The implementation principles of this policy will be discussed with Member States in 2007, in order to develop regulations to be applied in specific fisheries from 2008 on.

Fishery waste in land is increasing nowadays driven by greater elaboration of fishery products, implantation of new larger industries and less and bigger fish auctions [6]. Although most of this waste is being handled, a more profitable use of waste is possible, since most of it is reduced to fish meal and oil. Main constraints to a higher use of up-graded by products in dietary and

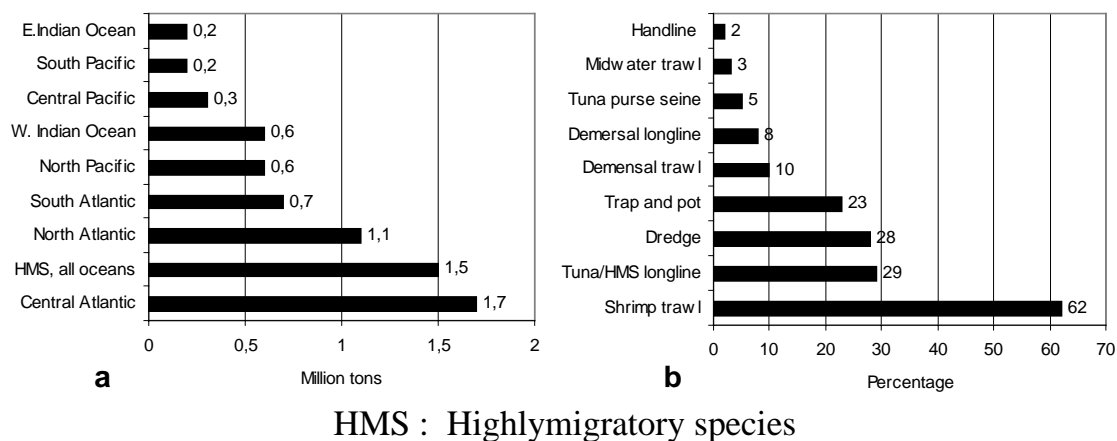


Figure 1. (a) Estimated yearly discards in mayor oceans. (b) Discard rates by major gear type. SOURCE FAO Fisheries Department [3].

nutraceutical products are due to Food Regulations, which are normally restrictive with its employ for human consumption.

2. Report on fish discards and by-products from French fisheries

2.1. Discards from French fisheries

2.1.1. Introduction

In this study, an estimate of discards, wastage on board and by-products from onshore processing was made, focused on French fisheries.

French fisheries provide a great number of target species, with more than sixty species of bony and cartilaginous fish [7]. Most of these species are caught by inshore fishing (92%), with only a few industrial fishing vessels sailing during long periods, and provided with storage and processing systems on board [8,9,10] (fig. 2).

Most of the fleet is concentrated in the Atlantic-North-East; while Mediterranean Sea fisheries target blue fish species (tuna, anchovy, sardine). The main ports, considering the landings, are Boulogne-sur-Mer in the West Channel, and Concarneau, Guilvinec and Lorient in the Bay of Biscay.

Information about discards from finfish and crustacean species has been mainly taken from five previous reports on this subject:

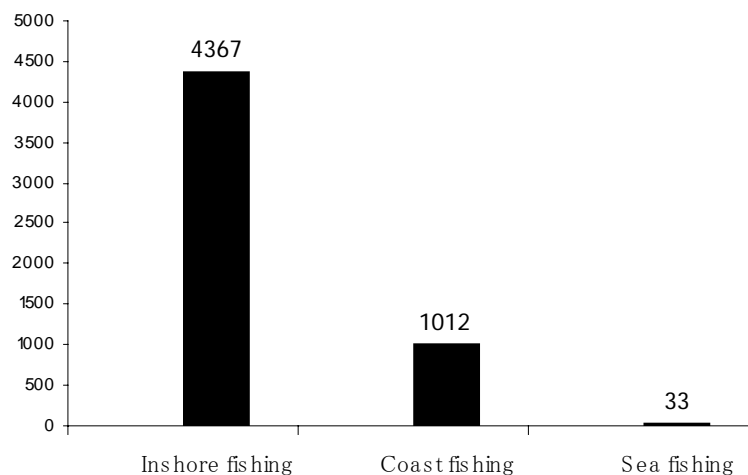


Figure 2. Number of vessels in French fleet. Distribution by fishing practice *SOURCE:* OFIMER 2004 [20].

- *Discards in the world's marine fisheries: an update* [1] Report from the FAO (2005) which evaluates the discard rate for every fishery. The main difference between this report and other previous studies is the fact that this report evaluates the discards for every fishery, while

previous reports try to establish a direct relationship between each target species and its discard rate. This study gives an estimate of 500,000 to 880,000 tonnes in the North Sea in the 1990's.

- *Report of the scientific, technical and economic committee for fisheries (STECF). Discards from Community Vessels* [11]. This report from the STECF group compiles an overview of discards from community vessels in the Mediterranean and the North East Atlantic by fleet, stock and quarter, in order to provide estimates of the total amount of discards due to EU fleet practices. STECF has therefore not been in a position to estimate the overall absolute amount of discards in European fisheries.
- *Les rejets dans la pêche artisanale de Manche Occidentale* [12]. Report from the Department of Fishing Resources of the IFREMER (French Institute for Marine Research). This study was done over a full year and is the first one in the Western Channel. It concerns several French fishing techniques: fixed netting, inshore trawling and offshore trawling.
- *Les rejets de la pêche* [13]. Report from the Department of Fishing Resources of the IFREMER which studies the main fishing techniques used in the Bay of Biscay, focusing on the main target species. It analyses the rate and composition of the discards, taking into account both by-catch species as well as length-frequency distribution of discards from target fish.
- *Estimation des rejets de pêche des chalutiers français en Mer Celtique* [14]. Discards of the French trawler fleet operating in the Celtic Sea in 1997 were studied. The fleet discarded an estimated 30,000 tons in 1997, while landing 63,000 tons. Benthic trawlers discarded mainly by-catch species, whereas demersal and Nephrops trawlers discarded primarily their target species.
- *Scientific articles. Information about discards is often very disperse and related to a specific area or fishery.* Some interesting articles dealing with discards in the West and North Coast of British Islands [15, 16] have been considered as a source of information about mackerel, herring and roundnose grenadier discards.

These studies provide information about discard rates registered in the main fishing areas, West Channel, Celtic Sea, Bay of Biscay and Mediterranean Sea. The most complete information has been found in the studies about discards in West Channel (which focuses on the fishing gears employed) and in the Bay of Biscay (which offers information about discard rates and by-catch composition of the main trawling fisheries). Both studies are briefly expounded in this report to put an example of the kind of data used to evaluate French discards.

2.1.2. Discards in west channel and celtic sea

Most of the information concerning discards in West Channel is reported by Morizur[12]. This study was a first approach for assessing French discards in the Western Channel. It identifies the main species discarded and produces a rough estimate of discard rates and size composition of discards. No data about by-catch composition is reported, only total discard quantities are compiled.

Three métiers are studied in order to compare the discard rates and size composition: fixed netting (small and large mesh nets), inshore trawling and offshore trawling.

- Small mesh nets (<200 mm stretched mesh size) are fixed in the inshore areas. They target principally pollock, ling and cod. Their short immersion time does not produce damaged fish which have to be discarded, so most of the discards are due to by-catch species with low commercial value like red gurnard, spotted dogfish and pout whiting.
- Large mesh nets (270 to 360 mm) are fixed in more offshore areas inside 12 miles during winter and sometimes outside 12 miles in summer. Their immersion time varies from two to six days, which is the main factor explaining discards. Gadoids are the species more sensible to immersion, they start to be discarded from the third day, while a immersion time of five days induces discards in all species.
- Inshore trawling. The discard rate is greater than 50% for some species, due to minimum landing size regulations or economical reasons (small sizes with low commercial value). This métier was found to have a great spatial heterogeneity in the catches and discard practices. There are species, like rays, pouts and spider crab with similar discard rates between fishing grounds. On the other hand, species like sole, red mullet or black bream have different discard rates in West and East sides of the channel, mainly due to the distribution of reproduction areas.
- Offshore trawling. Fishing activities using this métier are developed from West Channel towards Bristol Channel and Smalls, with differences between species composition. Species like gurnards, whiting, pouts and horse mackerel are almost completely discarded, even if they are caught in great numbers.

After characterization of the principal métiers employed in this area, the report concludes that netting is more selective than trawling in species diversity and in size composition. Regarding large mesh nets, an optimal immersion time of 3-4 days may limit fish discards and increase fish landings for the studied area. Data from discard rates recorded by this study, considering the four métiers studied and the main species caught by each technique are presented in table 1.

Table 1. Discard rates and by-catch composition of the fisheries studied by IFREMER.

Species	Discard rate (%)	Small-sized discards Size(percentage)	Discard composition		
			Main by-catch species Species (percentage of total discards)		
Hake	56	< 25 cm (10%)	H. mackerel (67%)	Sardine (7%)	Mackerel (3%)
Anchovy	29	< 10 cm (5%)	Sardine (54%)	H. mack (33%)	Mackerel (3%)
Black seabeam	19	< 23 cm (30%)	Sardine (33%)	Mackerel (28%)	H. mack (8%)
Horse mackerel	17	< 38 cm (67%)	Atl. H. Mack (33%)		
Sardine	6	< 18 cm (15%)	Sprat (78%)	Garpiki (4%)	H. mack (3%)
Albacore	4	< 50 cm (28%)	Bluefin tuna (4%)	Sunfish (65%)	
Seabass	2	< 35 cm (2%)	H. mack (26%)	Sardine (25%)	Lumpsucker (22%)

SOURCE: Les rejets de la pêche. [13]

2.1.3. Discards in the Bay of Biscay

The main study about discards from trawl fishing in the Bay of Biscay was made by IFREMER in collaboration with other European institutes (CTNC, RIVO/DLO, and UCC) [13]. During 379 days scientific observers have studied different fisheries, most of them French, widespread along the Bay of Biscay but also West Channel and Celtic Sea.

This study provides complete information about the discard rate, size composition and by-catch composition of the material discarded. Seven French trawl fisheries are studied, all of them located in the Bay of Biscay.

The percentage of discards (related to the total catch) varies from 5% to 69%, depending on the fisheries and species.

Table 1 shows the main characteristics observed for each French fishery studied, taking into account the discards due to their small size.

2.1.4. Methodology employed to estimate French discard rates.

Taking into account all the discard rates collected from different reports on French fisheries, a mean discard rate for each species can be estimated, considering its geographical distribution along French coast. This methodology can give a rough estimation of the quantities discarded by French vessels, but these results must be taken with care.

Obtaining a mean discard rate for a whole country like France is difficult if a lack of data exists. In order to make an accurate estimation, discard rates should be evaluated for smaller fishing areas, considering the different species and principally the different fishing gears employed. To accomplish with this methodology more studies about discard rates should be undertaken. At this moment, a great effort has been done in order to evaluate discard rates in more areas (Mediterranean fisheries).

These are the main steps followed to obtain this evaluation:

- a) Sample of main target species. 29 different species, belonging to white (which represents 76% of total catches), cartilaginous (98%),

pelagic (100%) and crustacean (95%) species have been selected in order to evaluate their discards. Table 2 shows the mean discard rates considered for each species and main fishing areas.

- b) Mean discard rate for each species. Discard rates have been assigned considering data from Mediterranean, West Channel, Celtic Sea and Gulf of Biscay. Geographical distribution of catches has been considered, in order to estimate discards in Atlantic and Mediterranean fisheries. Two approximations have been used:

Table 2. Mean discard rates for the 29 species considered in the initial sampling.

Species	Area of reference	Discard rate (%)	Total Catches (tons)	Estimated discards (tons)
WHITE FISH SPECIES				
Pollack	Bay of Biscay	70	481	337
	Channel	5	3053	153
Plaice	North Atlantic	60	3191	1915
Hake	Bay of Biscay	56	9935	5564
	Channel	12	3078	369
	Mediterranean	8	1195	96
Ling	Bay of Biscay	55	215	118
	Channel	41	1840	754
Black bream	Bay of Biscay	55	532	293
	Channel	31	2445	758
Whiting	North Atlantic	47	13505	6347
Sole	Channel	18	8320	1498
Monkfish	Bay of Biscay	10	5238	524
	Channel	17	15110	2569
	Mediterranean	10	485	49
Grenadier	Channel	21	4613	969
Haddock	North Atlantic	15	5111	767
Megrim	Channel	10	3060	306
Pout	Bay of Biscay	7	718	50
	Channel	9	5167	465
Cod	Bay of Biscay	7	472	33
	Channel	9	5088	458
Conger	Channel	7	5131	359
Saithe	Bay of Biscay	5	61	3
	Channel	5	16731	837
Seabass	Bay of Biscay	2	2776	56
	Channel	1	2674	27
			120225	25670
PELAGIC FISH SPECIES				
Anchovy	Mediterranean	50	2429	1215
	Bay of Biscay	29	1001	290
Sardine	Mediterranean	50	10406	5203
	Bay of Biscay	6	27318	1639
Mackerel	Celtic Sea	18	19230	3461
Horse Mackerel	Bay of Biscay	17	17610	2994
Herring	Celtic Sea	13	40960	5325
Albacore	Bay of Biscay	4	8170	327
			127127	20454
CARTILAGINOUS FISH SPECIES				
Spotted Dogfish	North Atlantic	25	5819	1455
Other sharks	North Atlantic	24	5553	1333
Rays	Channel	15	8792	1319
	Mediterranean	9	333	30
			20497	4136
CRUSTACEAN SPECIES				
Spider Crab	Channel	34	3778	1285
Edible Crab	Channel	24	5076	1218
Crayfish	Channel	2	6764	135
			15618	2638

- When no data about Mediterranean fisheries are available, a main discard rate of 10% (FAO 2005) has been employed in order to quantify discards.
 - Regarding Atlantic fisheries, discards from some species have been estimated taking into account discard rates for only one fishing area (West Channel, Celtic Sea or Bay of Biscay), due to the lack of data. In this case, we have considered only one mean discard rate for the whole catches in Atlantic Ocean.
- c) Once a discard rate for each species has been obtained, we have calculated two mean discard rates, corresponding to Atlantic and Mediterranean fisheries. These have been applied to total French catches in order to estimate the amount of discards generated by French fisheries.

2.1.5. Results and conclusions about French fisheries discards.

- From the sample considered for the study, a mean 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%).
- Extrapolating these mean rates to the whole catches in French fisheries, we conclude that almost 60,000 tonnes of catches have been discarded during 2005, which represents 14% of French catches. This mean rate is lower than that estimated by the FAO report for the period 1992-2001 (21% of discard rate), and this may be attributed to a decrease in catches, as well as more effective regulations and fishing gears, following the general trends in world's global discards.
- After this estimation we conclude that 39,800 tonnes of discards are generated by pelagic fisheries, followed by white fish with 22,850 tonnes.
- Most of discards are due to pelagic species, which represent 59% of discards, followed by white species (34%).
- 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 Bay of Biscay), herring (with low discard rates but high catches), mackerel and monkfish (Fig. 4.a).
- Highest discards rates are observed for 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 Sea (50%) due to the presence of mixed banks of sardine and anchovy (Fig 4.b).
- Species with the lowest discard rates are sardine and albacore in the Bay of Biscay, with discards around 5%, and crayfish fisheries using fixed nets, which have negligible discard rates (2%).

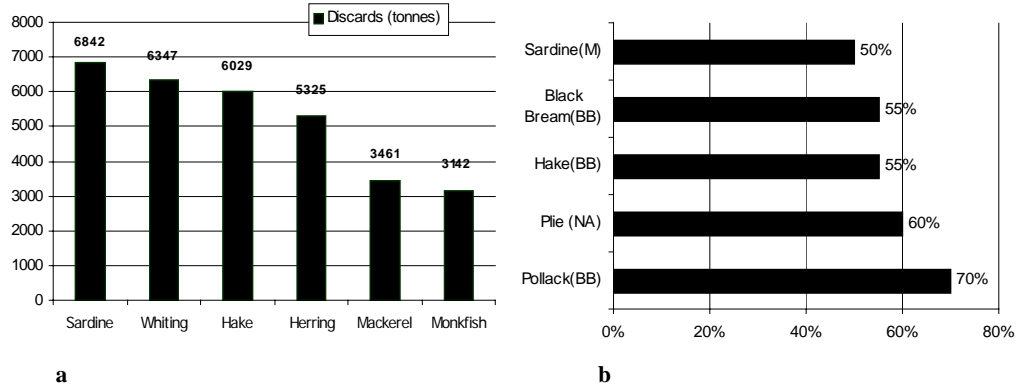


Figure 4. a. Species generating the highest tonnages of discards. b. Species with the highest discard rates. M: Mediterranean Sea, BB: Bay of Biscay, NA: North Atlantic.

Table 3. Mean discard rate for French fisheries.

Group	Atlantic (tons)	Mediterranean (tons)
White Fish	157700	5559
Cartilaginous	20825	149
Pelagic Fish	204746	22587
Crustacean	16476	497
TOTAL	399747	28146
Discards	52002	7742
MEAN RATE	14%	

2.2. Wastes from fish processing on board

2.2.1. Main species processed on board

By-products generated on board of fishing vessels are normally viscera, which must be stabilised by freezing due to their important content in intestinal bacteria. Nowadays, only livers and eggs are sometimes collected to be sold on land. Livers from monkfish and sikis are the most commercialised by-products.

The presence of industrial fishing vessels, equipped with fish processing lines on board(?) and freeze stocking systems is not very usual in French fleet, since most of French fishing vessels practice inshore fishing and do not process catches on board.

Nevertheless, demersal species are traditionally gutted on board (monkfish, cod, conger, haddock, lings, pollacks and whiting) as well as cartilaginous species such as sharks. Other species are headed (black scabbardfish) or tailed (grenadier). As a consequence of these activities an important amount of wastes are generated, and generally discarded into the sea.

Pelagic species are generally landed as whole fish to be processed on land by fish trade enterprises and canning or smoking industry, so the amount of wastes generated on board by these species can be reduced to those derived from black scabbardfish gutting.

Crustacean are not processed on board. Only 1% of langoustines are tailed before landing. This activity has generated one ton of wastes in 2005.

2.2.2. Methodology used to evaluate wastes on board

In order to evaluate the amount of wastes due to fish processing, conversion coefficients are used. These are factors are employed to estimate the live-weight equivalent of catches. The weight of fish landed is multiplied by a coefficient to offset the lost of weight due to processing on board (gutting, removal of heads, filleting) to arrive at the weight if the fish were whole and alive.

There is an important study about the origin and different values of conversion coefficients in EU [17]. This study attempted to ascertain the origins of the conversion coefficients in the three Member States, France, Denmark and UK. After studying the origin and different values of these coefficients, a method is proposed for revising these coefficients, in order to make a harmonised European list.

Data from landings are disperse or not available, so total catches from two consecutive years, 2004 and 2005, have been used [18] . These total catches include discards, which must be estimated by applying mean discard rates, and afterwards subtracted from total catches in order to quantify the amount of material to be brought ashore.

Table 4 shows the estimation of the tonnage of fish wastage on board. The columns II to IV show the yearly catches as well as the estimated landings ashore, once the discards are subtracted. The columns VI and VII show the

Table 4. Estimation of the tonnage of fish wastes generated by on-board processing applying conversion coefficients.

Species	Catches/04 (tons)	Catches/05 (tons)	Landings/04 (tons)	Landings/05 (tons)	Processing (%)	Presentation	Coef.	Wastes/04 (tons)	Wastes/05 (tons)
Monkfish	21378	20833	18171	17708	100	Gutted	7.25	2506	2442
Cod	7373	5560	6046	4559	99	Gutted	5.55	1078	813
					1	Headed-gut.	3.63	17	13
Conger	5605	5131	5213	4772	100	Gutted	10	521	477
Haddock	7449	5111	6332	4344	100	Gutted	6	1055	724
Saithe	17847	16792	16955	15952	100	Gutted	6.56	2585	2432
Pollack	3067	3534	2914	3357	100	Gutted	6.56	444	512
Blue ling	3975	3133	2186	1723	100	Gutted	6.56	333	263
Ling	2308	2309	1269	1270	100	Gutted	7.67	166	166
Whiting	13588	13505	6386	6347	30	Whole			
					70	Gutted	6.41	697	693
Megrim	2805	3060	2525	2754	100	Gutted	26	97	106
Plaice	3625	3191	1450	1276	20	Whole			
					80	Gutted	10	116	102
Sole	8196	8320	6721	6822	30	Whole-gut.			
					70	Gutted	10	470	478
Hake	12059	14208	6994	8241	95	Gutted	6.88	966	1138
					5	Whole			
WHITE	109275	104687						11052	10358
B.Scabbardfish	3090	3053	2596	2565	100	G-whole	2.76	940	929
PELAGIC	3090	3053						940	929
Sharks	11626	11372	8720	8529	100	Gutted	5.65	1543	1510
CARTILAGINOUS	11626	11372						1543	1510
Langoustine	6318	133	4423	93	99	Whole		0	0
					1	Tailed	1.5	29	1
CRUSTACEAN	6318	133						29	1
TOTAL France	136627	119378						13565	12797

percentage of total landings which is processed (which is not brought ashore as whole fish), as well as the final presentation in markets (as gutted, headed or tailed fish). Applying the conversion coefficients (column eighth) for each processing operation, the amount of wastes (heads, viscera and tails) can be obtained.

2.2.3. Results of waste estimation

Figure 5 shows the estimated quantities of fish wastes on board during years 2004 and 2005, obtained for white, pelagic and cartilaginous fish.

Main conclusions extracted from this evaluation are:

- 12,800 tons of wastes have been generated by on board processing in 2005, which represents a decrease of 5% with respect to 2004, as a result of the decrease in catches during this period.
- 81% of wastes belong to white fish species, most of them demersal which are normally gutted on board before landing, followed by cartilaginous species (sharks).
- Wastes from pelagic species represent less than one thousand tonnes in both years, since these species are normally landed as whole fish, except black scabbardfish which is normally gutted on board.
- The tonnage of wastes from monkfish, saithe, sharks and hake, represents 60% of total wastage on board (fig. 6). Catches from these species are important in quantity and value. These species are generally gutted on board, so wastes correspond entirely to viscera.
- Most of these wastes are generated by industrial fishing vessels, most of them registered in South Brittany and the ports of Boulogne-sur-Mer and Fecamp. On the other hand, wastes on Mediterranean Sea could be considered as negligible in our estimation since French Mediterranean fisheries mainly target pelagic species such as anchovy and sardine which are commonly landed as whole fish.

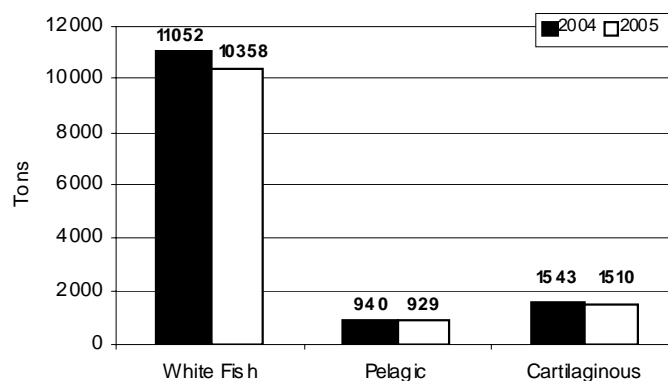


Figure 5. Wastage on board from white, pelagic and cartilaginous species during 2004/2005.

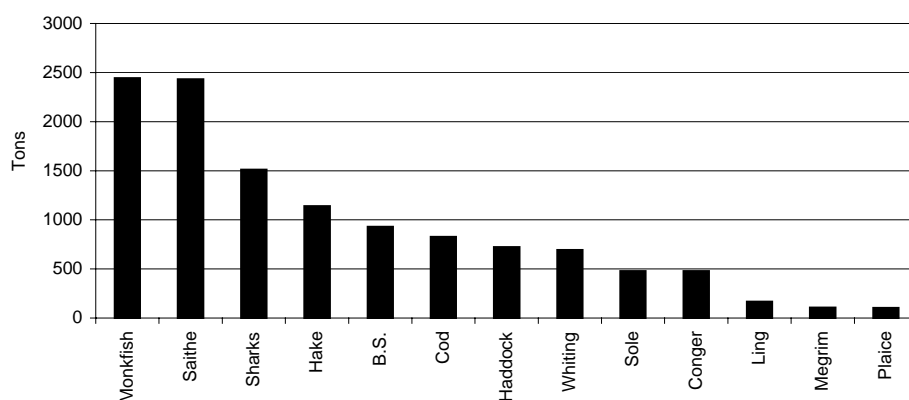


Figure 6. Main species generating waste on board (2005). (B.S. = Black Scabbard fish).

2.3. By-products from fish processing on-shore

2.3.1. Introduction

Fish processing companies employ raw fish to obtain a final product with higher commercial value. Several operations are involved in fish processing: heading, gutting, filleting, removing tails and peeling. These operations generate by-products such as heads, viscera, tails, skins and fins which are not put on market due to their low acceptance by consumers or sanitary regulations which avoid their use as ingredient in human foods.

Other operations involved in Fish Processing, such as washing, thawing and cooking are the origin of aqueous effluents which are normally discarded. Wastewaters generated by fish meal industries contain a high organic load due to the presence of oil, proteins (0.5-20 g/l) and suspended solids. They present high turbidity, strong greenish yellow colour, and stinky odour. Therefore, they should not be discharged without a suitable treatment in order to prevent negative environmental impacts [2].

Only the solid by-products from mechanical processing are considered in this study. They can be classified in heads, viscera, skins and fins, and can be accounted considering conversion factors for each species and processing operation.

2.3.2. Bibliographic references and methodology employed to estimate the amount of by-products generated by ashore fish trade and processing activities

An estimation of the amount of by-products generated by fish processing operations can be obtained taking into account the conversion coefficients, which consider the loss of weight derived from fish processing operations such as heading, gutting, tailing and skinning.

Once the conversion factors for each fish species and processing operation has been applied, we can estimate the quantities of by-products generated on board and on land (fish food trade and industry).

The coefficients employed in this study represent the mass of raw fish to be processed to generate one kilogram of waste. Dividing the tonnage of fish to be processed by the appropriate coefficient, the mass of heads, viscera, skin and fins generated can be obtained.

The methodology and coefficients applied to estimate the amount of by-products were taken from the report from Gaële Andrieux [7]. In this study, fourteen species were studied in order to evaluate the amount of by-products generated by their processing. Extrapolating these results to the whole tonnage of fish processed in France, it has been concluded that 150,000 tons of by-products (heads, tails, viscera) were generated in 2002 by industry and trade processing in land. The different ways to re-use these by-products were also considered, since 96% of by-products are employed afterwards as raw material for different applications, mainly animal feed (fish meal).

Following the methodology employed by this study to quantify the tonnage of by-products, the following steps are to be accomplished:

- 1.° Choose a sample with the main species processed by fish trade, smoking and canning industry. This sample contains 20 species belonging to white, pelagic, cartilaginous and salmonid (from aquaculture) species.
- 2.° The amount of products to be processed before being put on market can be estimated by the following balance:

Data from fish landings in France can be obtained by consulting the following statistics:

- Statistics from OFIMER about auction sells in fish markets [19]. These quantities are representative for most of demersal species, which are almost entirely sent to auction sells in fish markets. The best percentages of auction sells, more than 85%, are those corresponding to saithe, haddock, hake, whiting, megrim, monkfish, pollack and langoustine [17]. On the other hand, data from auction sells are not representative from small pelagic species such as horse mackerel, mackerel and herring, which are sold on hire, imported or exported to foreign countries. Tonnages put on market from these species can be obtained by an indirect way, taking into account the consumption of derived products (canned, smoked fish, fillets, whole fish) [20] and applying conversion coefficients to obtain the whole fish weight before being processed.
- Data from imports-exports of each species are available on OFIMER Statistical Reports from 2005 [21], as well as aquaculture production.

- 3.° Taking into account the proportion of each species which is transformed by each processing technology and applying conversion factors to each raw material, the amount of each by-product generated after processing can be obtained by applying specific conversion coefficients (Table 5).

Table 5. Estimation of the tonnage of fish by-products generated by fish processing in land applying conversion coefficients.

Species	Destination	Tonnage	Heads	Viscera	Fishbones	Skin	Fins	Total by-products
Cod	Trading	16138	3676	1968	4637	807	0	11088
Monkfish	Trading	15487	8282	1889	0	0	0	10170
Saithe	Trading	14399	2738	850	3645	418	0	7650
Whiting	Trading	7620	1171	0	2988	353	0	4512
Lings	Trading	8219	1563	479	1916	493	0	4450
Pollack	Trading	3922	746	231	993	114	0	2084
Hake	Trading	2538	390	0	995	118	0	1503
Bass	Trading	2778	1111	383	0	0	0	1494
Sebastes	Trading	1268	152	216	412	51	0	830
Sole	Trading	815	272	81	0	41	0	394
<i>WHITE FISH</i>		73183	20099	6096	15587	2394	0	44176
Sharks	Trading	9047	433	1601	0	543	2717	5294
Rays	Trading	7756	1533	1070	2288	0	0	4891
<i>CARTILAGINOUS</i>		16803	1966	2671	2288	543	2717	10184
Salmon	Smoking	36811	3553	4941	6657	2279	0	17430
	Trading	30741	2967	4126	5559	1903	0	14556
Herring	Canning	31255	6045	3350	5581	0	0	14977
	Smoking	7814	1511	837	1395	0	0	3744
Trout	Smoking	3445	320	475	623	213	0	1631
	Trading	19132	1776	2639	3460	1185	0	9059
<i>SALMONIDS</i>		129198	16174	16369	23275	5581	0	61398
Tunas	Canned	84781	17962	11365	12413	5477	0	47217
	Trading	80615	17080	10806	0	0	0	27886
Anchovy	Canning	20126	6155	4994	0	0	0	11149
Mackerel	Canning	13009	2516	1394	2251	0	0	6161
Sardine	Canned whole	6785	1696	678	1180	0	0	3554
	Canned filets	2262	565	226	393	0	0	1185
Haddock	Smoking	1776	245	0	756	56	0	1057
	Trading	1513	209	0	644	48	0	900
<i>PELAGIC FISH</i>		210866	46428	29464	17636	5581	0	99109
TOTAL		430050	84666	54600	58786	14098	2717	214867

2.3.3. Results and conclusions about by-products from fish processing on-shore

By-products generated by trade, canning and smoking industries.

- 215,000 tons of by-products have been generated in France in 2005 as a result of fish trade and fish processing activities.

- Fish trade is the activity which has generated the highest amount of by-products, 106,762 tons which represents a 52% of the total amount of by-products (fig.7).
- Canning and smoking industries have generated 85,000 (36%) and 27,000 tons (12%) of by-products respectively (fig.7).
- 48% of total tonnage to be processed by Fish Trade and Fish Smoking Industry are by-products, this percentage is lightly lower in Canning Industry (46%). We can conclude that processing activities generate similar quantities of final processed fish and by-products.

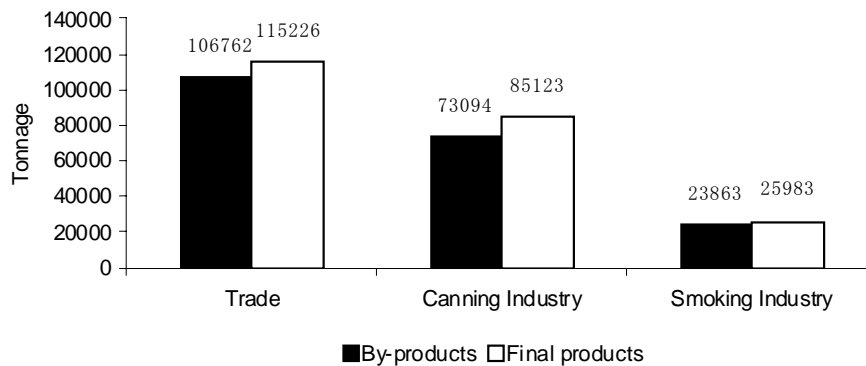


Figure 7. Tonnages of by-products and final products generated by each fish processing activity.

Origin of by-products (Fig. 8.a)

- Pelagic species, to which belong species caught by industrial vessels such as herring, tuna or mackerel, generate 45% of by-products. These species are destined to Fish Trade and Processing Industry.
- 29% of the total amount of by-products belong to salmonids, which are mainly imported or produced by aquaculture.
- White Fish, whose species are commonly processed by Fish Trade companies, originates 21% of by-products, followed by by-products from cartilaginous species (5%).

Type of by-products (Fig. 8.b)

- 40% of by-products correspond to heads, followed by fishbones (27%) and viscera (25%). Comparing to the processing operations on board, the proportion of viscera in the total waste is lower. This is due to the fact that most of demersal species are gutted on board before being landed, so their viscera cannot be quantified as a by-product from fish processing in land.

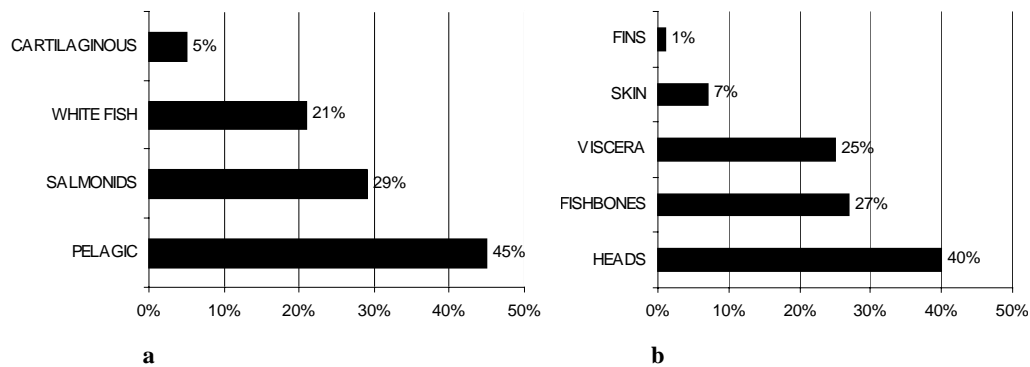


Figure 8. a. Percentage of by-products generated by fish group. b. Percentag of by-products by type.

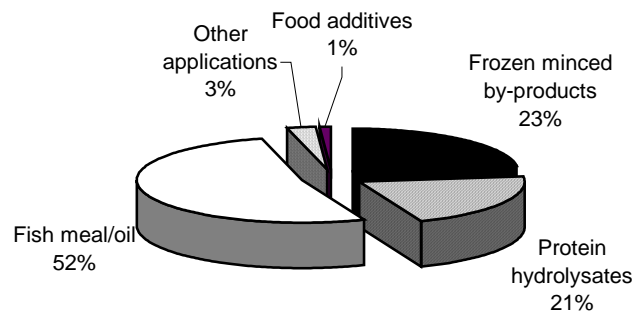


Figure 9. Different applications for up-graded by-products. SOURCE: Gaëlle Andrieux [7].

By-products up-grading (Fig. 9)

- Fishery waste ashore is increasing nowadays driven by a greater processing, implantation of new larger industries and less and bigger fish auctions (Blanco et al., 2007) [6]. Although most of this waste is being handled, a more profitable use of waste is possible, since most of it is reduced to fish meal or fish oil.
- French fishing and aquaculture up-grades 96% of by-products. 75% of them are to be used in animal feeding as fish meal and oil (52%) or frozen minced by-products (23%).
- Fish meal is one of the major products obtained from fish by-products, with a high content of protein (70%) and low fat content (9%). Fish meal is mostly used as an ingredient in feeds for fish and crustaceans.
- Other applications with higher added-value are protein hydrolysates (21%) and food additives (1%). Main constraints on a stronger incorporation in dietary and nutraceutical markets are due to French Food Regulations, which are more restrictive than those of other European countries.

3. General conclusions

- The unintentional capture of non-target species, which are not retained for sale, but thrown back into the sea because of their low commercial value or regulations concerning catch quantities or size, may provoke an important ecological impact. Regarding trawling practices, nearly all fish, about half the non-commercial crustaceans and 98% of non-commercial cephalopods are dead when discarded [22]. Discarded catch represents also a conservation problem because valuable living resources are wasted while global marine catches are declining.
- Quantification and knowledge of general trends in discarding practices is of value in the design and implementation of fishing regulations which promote minimal discards and a more responsible catch utilization. This is a very difficult task, as the information concerning discards is disperse and incomplete. The studies considered to compile discard rates are focused on some specific areas and metiers, two factors which affect enormously the discard rate. Considering the main areas covered by this report (West Channel, Celtic Sea, Bay of Biscay), an extrapolation to larger territories implies a lack of accuracy, since the factors determining discards in an specific area (fish ground, fishing gear, season in which the study was undertaken...) are not completely reproducible to other areas. A more exhaustive methodology would require compiling discard rates from smaller areas, covering all the fisheries and taking into account species and principally fishing gears employed. Even if a great effort has been done in order to evaluate discard rates in more areas (Mediterranean fisheries), the lack of data avoid us to do a more accurate study.
- Considering all these precautions, we conclude that almost **60,000 tons of catches have been discarded during 2005, which represents a 14% of French catches in Atlantic and Mediterranean Sea**, most of them due to trawling practices and pelagic species, with a discard rate of 18% related to total catches. On the other hand, fixed netting, employed in inshore areas to target species like crustaceans, pollock or ling, is more selective in species diversity and in size composition, with negligible discard rates.
- Concerning the wastage on board, the application of conversion coefficients, which are specific for each unit operation and species, is the key to obtain the amount of wastes after fish processing. As a result of fish processing on board, it can be estimated that **12,800 tons of wastes have been generated, most of them (81%) belonging to demersal fish species**, which are normally brought ashore gutted.

- Fishery wastes in land are increasing nowadays due to the greater elaboration of fish products, with larger industries and fish auctions. This report concludes that **215,000 tons of by-products** have been generated in France in 2005 as a result of fish trade, canning and smoking industry. The different activities considered generate similar quantities of by-products and final products. By-products from fish trade activities represent more than the half of the total by-products generated by fish processing in France. These belong mainly to pelagic (45%) and salmonid species (29%).
- The up-grading of these by-products has also been considered, since 96% are handled to produce mainly fish meal and oil (52%) or frozen minced by-products (23%). The proportion of by-products treated to produce protein hydrolysates is important (21%), related to other European countries.
- As a summary of the estimates carried out by this study, fig. 10 shows the weight proportions, related to the total catch, of discarded fish, wastage on board, by-products from processing in land and final products put on market for the main species.

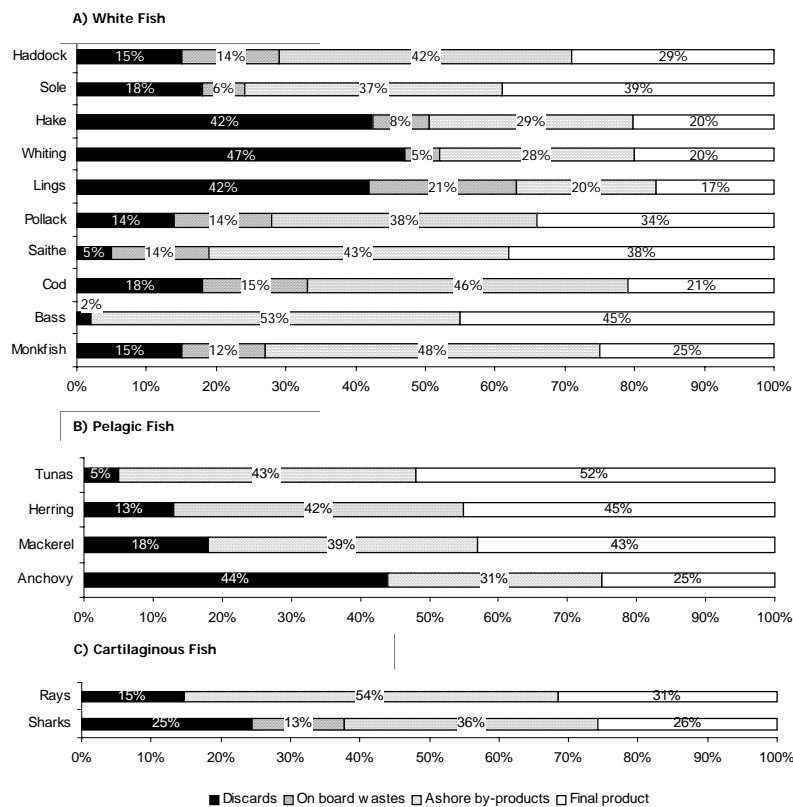


Figure 10. Weight proportion, related total catches of discards, on board wastage, and ashore processing by-products from main species.

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